

What's in this Catalog?

Tutorial Information makes this more than just a catalog. "What You Need to Know About Modular Electronic Instruments" takes you through the basics of the modular standards, and defines the types of analog and digital signals, along with the coaxial cables and connectors needed to make interconnections. This section also provides block diagrams that illustrate a wide variety of applications. You can likely find stimulating ideas for your own measurements among these application examples.

Instruments Are Grouped by Function into subsections as listed in the Table of Contents. Each subsection begins with a tutorial that explains the basics of the function. Neophytes will find that these tutorials open up a solid understanding of signal processing. The experienced user will find reminders of important principles and equations. Each tutorial leads to a selection guide that assists in narrowing the choice to a few prospects for the intended application. A final choice can be made by consulting the detailed data sheets that follow the selection guides in each subsection.

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Who Needs this Catalog?

Anyone needing Pulse-Processing Electronics for:

- Time Spectrometry
- Counting
- Amplitude Spectrometry
- Charge Spectrometry
- Energy Spectrometry
- Coincidence Measurements

... whose signal source originates from:

- Optical photons
- X rays
- Gamma rays
- Alpha particles
- Beta particles
- Ions or ionized molecules
- Neutral atoms or molecules

... and has been detected by any of these detector types:

- PMTs
- Electron multipliers
- Microchannel plates
- Microchannel plate PMTs
- Ge semiconductor
- Si semiconductor
- Gas proportional
- Geiger tubes
- Scintillation detectors
- Neutron detectors

- **OR ANY** detector signal of duration from 0.5 ns to 50 μ s, and of amplitude <10 V.

Modular Electronic Instruments

What You Need to Know About Modular Electronic Instruments

Contents

Finding (and Understanding) the Function You Need
NIM and CAMAC Standards for Modular Instrumentation
Linear and Logic Signal Standards and Connections
Examples of Systems Assembled Using Modular Electronics

By concentrating specific functions in separate modules, the modular electronic instruments from ORTEC offer virtually unlimited options for configuring a solution to a wide variety of measurement problems. Examples of such solutions are illustrated in the next few pages for a number of typical applications. Also included is a brief introduction to the standards that apply to the signals and the interconnections between modules.

Finding (and Understanding) the Function You Need

In this catalog, the modules are grouped into major categories by function. Each category is preceded by a brief tutorial which explains the operating principles and the important performance characteristics of the function. **The tutorial culminates in quick-reference charts which serve as application guides and selection guides.** From these charts one can usually select one or more candidates for the application. Reference to the data sheets that follow the charts provides the details necessary to choose the optimum solution.

The categories for modular electronic instrumentation are:

- Photomultiplier Tube Bases
- Preamplifiers
- Amplifiers
- Fast-Timing Discriminators
- Time-to-Amplitude Converters and Time Calibrator
- Multichannel Scalers, Multiple-Stop Time Spectrometers, and Digital Signal Averagers
- Counters/Timers/Ratemeters
- Single-Channel Pulse-Height Analyzers
- Multichannel Analyzers (MCA), Multichannel Buffers (MCB), and Associated Software
- CAMAC ADCs, Memories, and Associated Software
- Delays/Gate and Delay Generators/Logic Modules/Linear Gates
- Pulse Generators and Special Instruments
- HV Bias/NIM Power Supplies and Bins
- Integrated Electronics Packages
- Cables and Accessories

To find a specific category, consult the contents on the previous page. These instrument categories, as well as the product model numbers, are listed in the index at the back of this catalog.

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NIM and CAMAC Standards for Modular Instrumentation

Most of the nuclear electronic instrumentation manufactured by ORTEC is designed in accordance with either the NIM standard or the CAMAC standard for modular instrumentation. Both of these international standards encompass a wide range of mechanical and electrical definitions to provide cost and convenience advantages to users of the instruments.

Two of the most important advantages of the NIM and CAMAC concepts are flexibility and interchangeability. The user may configure the optimum system for a particular application, and later easily restructure the instruments as required for different experiments or measurements. In addition, an existing system can be updated with a few new modules, thereby augmenting the value of instrumentation on hand. As experimental demands increase, or as advancing technology makes new instruments available, new modules can be added to the system with assurance of compatibility.

Both the NIM and CAMAC standards incorporate modular instruments that plug into a "bin" or "crate," and derive their power from a standard power supply attached to the rear of the bin (crate). The CAMAC standard differs from the NIM standard in two important ways. First, the CAMAC crate has a built-in, digital data bus to provide computer communications with the modules. Second, the narrowest CAMAC modules are exactly half the width of the minimum NIM module width. Power plug adapters are available from several manufacturers to permit NIM modules to slide into a CAMAC crate and derive their power from the CAMAC power supply. For information on NIM and CAMAC standards, see the following box.

Some of the ORTEC products are manufactured in "bench-top" or "stand-alone" packages for applications that demand a specific solution. In such cases the unit typically draws power from 90 V ac, 117 V ac, or 240 V ac, and generates its own dc voltages internally. The rechargeable, battery-operated, field-portable spectrometers are an example of this packaging. For the stand-alone and bench-top packages the analog and digital signals also conform to the NIM, ECL, and TTL standards described on the following pages.

As a result of the popularity of personal computers, many of the NIM, stand-alone, and bench-top instruments provide their own interface to a personal computer. Such interfaces can be made via the IEEE-488, RS-232-C, Ethernet, USB, and printer-port standards, or by the ORTEC Dual-Port Memory Interface. A number of the data control and acquisition products are also available on cards that plug into the ISA or PCI bus inside the personal computer.

NOTE

NIM Standard

All ORTEC NIM instrumentation conforms to the May 1990 Revision of the NIM standard [formerly TID 20893 (Rev) and NIM/GPIB]. Please refer to DOE/ER-0457T, U.S. NIM committee, May 1990; *Standard NIM Instrumentation System*, NTIS, U.S. Department of Commerce, Springfield, Virginia 22161.

CAMAC Standard

All ORTEC CAMAC instrumentation conforms to the CAMAC standard: IEEE Standard 583-1982, reaffirmed 1994, *IEEE Standard Modular Instrumentation and Digital Interface System (CAMAC)*, Institute of Electrical and Electronics Engineers, Inc., P.O. Box 1331, 445 Hoes Lane, Piscataway, NJ 08855-1331.

Linear and Logic Signal Standards and Connections

Because many ORTEC instruments utilize both linear and logic signals, it is important to distinguish between linear and logic connections when setting up the equipment. The amplitude of a linear signal contains information about the charge or energy deposited by a detected event. Therefore, linear signals vary over a range of amplitudes. The analysis of linear signal amplitudes from an instrument reveals the pulse-height spectrum of the detected events. In contrast, logic signals have a fixed amplitude and shape. They are used to count events, provide timing information, and to control the function of subsequent instruments in a system. Both linear and logic signal connections are made by coaxial cables and standard BNC, LEMO, or SMA connectors. Some logic signal connections are made with ribbon or multi-wire cable terminated in multi-pin connectors.

Slow Linear Signals

Slow linear signals generally have rise times longer than 50 ns, and durations ranging from 0.5 to 100 μ s. In ORTEC modules, these signals conform to the NIM-Standard Preferred Practices for 0 to 10-V spans. Slow linear signals may be unipolar and positive in polarity, or bipolar with the positive polarity occurring first. In either case, it is the range from 0 to +10 V that is analyzed for pulse amplitude information.

Standard polarity and span do not apply to the linear signal between the preamplifier and the amplifier. This signal must be variable in span and polarity to accommodate particular applications. However, ORTEC charge-integrating preamplifiers typically furnish a 50- μ s (or greater) time-constant tail pulse to the main amplifier. The main amplifier accommodates this standardized input pulse with a compatible pole-zero cancellation circuit. In addition, ORTEC main amplifiers designed for energy or pulse-height spectroscopy accept either positive or negative input polarities.

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Most ORTEC instruments provide the slow linear output signals through a very low source impedance, typically $<1\ \Omega$. The low impedance allows connection of almost any load without loss of signal amplitude. For example, a $100\text{-}\Omega$ load may be driven to the full 10-V span. The low-impedance outputs are simple to use, because they permit paralleled multiple loads without loss of span. A $93\text{-}\Omega$ coaxial cable, such as RG-62A/U, is normally used to connect slow linear signals between modules.

A potential problem with the low-impedance output is oscillation caused by reflection from unterminated cables more than 1.5 meters in length. For this reason, long $93\text{-}\Omega$ coaxial cables should be terminated at the receiving end by a $93\text{-}\Omega$ load. This is usually accomplished by adding a Tee connector and a $100\text{-}\Omega$ terminator on the input to the module at the receiving end. The $100\text{-}\Omega$ terminator in parallel with a $1000\text{-}\Omega$ or larger input impedance in the module provides adequate termination of the $93\text{-}\Omega$ cable.

An alternative solution to the oscillation problem is to use the $93\text{-}\Omega$ output. This slow linear output is provided, in addition to the low-impedance output, on many ORTEC instruments. The receiving end can be left unterminated. The $93\text{-}\Omega$ output provides termination of the cable at the signal source. The $93\text{-}\Omega$ output can be used for full-span signal transfer only if the impedance of the load at the receiving end is very large compared to $93\ \Omega$. If the $93\text{-}\Omega$ source must drive a $93\text{-}\Omega$ or $100\text{-}\Omega$ load, half the span will be lost. The chief virtue of the $93\text{-}\Omega$ output is stability against oscillation for variable cable conditions.

ORTEC preamplifiers for energy spectroscopy usually employ a $93\text{-}\Omega$ output impedance to facilitate the use of long cables between the preamplifier and the main amplifier. Normally a $93\text{-}\Omega$ cable should be used on these preamplifiers, and the $100\text{-}\Omega$ terminator should be omitted at the receiving end.

Fast Linear Signals for Timing

Fast linear signals for timing measurements typically have rise times less than a few nanoseconds, and durations less than $1\ \mu\text{s}$. Historically, these signals were often derived from the anode of a photomultiplier tube, and this usage dictated the convention of using a negative polarity signal. The amplitude span for these signals may be 0 to $-1\ \text{V}$, 0 to $-5\ \text{V}$, or 0 to $-10\ \text{V}$, depending on the device generating the signals. Because of the fast rise time, interconnections between modules are always made with a $50\text{-}\Omega$ coaxial cable, and the cable is always terminated with a $50\text{-}\Omega$ load at the receiving end. Modules intended for use with these signals normally have a $50\text{-}\Omega$ input impedance. For modules with a high input impedance, a Tee and $50\text{-}\Omega$ terminator can be added at the input to properly terminate the cable. Devices generating the negative, fast, linear signals can have either a very high output impedance (current source) or a very low output impedance ($<1\ \Omega$). An example of the very high output impedance is the anode output of a photomultiplier tube. At the opposite extreme, fast amplifiers for use with these signals commonly have an output impedance of $<1\ \Omega$.

Signals exhibiting rise times $>1\ \text{ns}$ can employ any of a variety of $50\text{-}\Omega$ coaxial cable types and BNC or LEMO connectors. However, signals with sub-nanosecond rise times demand high-quality RG-58A/U coaxial cable terminated in SMA connectors in order to maintain the rise time. Cable length can also be important in avoiding degradation of signal rise time. For example, the total length of the RG-58A/U cable must be restricted to <1.7 meters to preserve the 350-ps rise time from a Model 9306 Preamplifier delivering signals from a microchannel plate detector. For signals having 2-ns rise time, significant degradation of the rise time is experienced for coaxial cable lengths longer than 4 meters. In general, the limiting rise time of a coaxial cable is proportional to the square of its length.

NIM-Standard Positive Logic Signals

The NIM-standard, positive logic signal is used for slow-to-medium-speed logic signals with repetition rates from dc to 1 MHz. The NIM-standard Preferred Practice provisions define this signal by the following amplitude limits:

	Output (must deliver)	Input (must respond to)
Logic 1	+4 to +12 V	+3 to +12 V
Logic 0	+1 to -2 V	+1.5 to -2 V

In addition, ORTEC imposes the following further standards on the NIM-standard, positive logic signals:

Pulse width:	nominally $0.5\ \mu\text{s}$
Source impedance:	nominally $\leq 10\ \Omega$
Input impedance:	nominally $\geq 1000\ \Omega$

Connection of the NIM-standard, positive logic sources and loads should be made with $93\text{-}\Omega$ coaxial cable. RG-62A/U cables with UG-260/U (BNC) connectors are recommended. For cable lengths under 1.5 m, impedance-matching cable termination is not usually required, because reflections are not a problem. With longer cable lengths, proper termination with a $100\text{-}\Omega$ terminator at the receiving end is advisable to prevent cable reflections.

NIM-Standard Fast Negative Logic Signals

The NIM-standard, fast negative logic signal is normally used when rise time or repetition rate requirements exceed the capability of the positive logic pulse standard. The NIM Preferred Practice provisions define this signal as one that is furnished into a $50\text{-}\Omega$ impedance with the following characteristics:

	Output (must deliver)	Input (must respond to)
Logic 1	-14 to $-18\ \text{mA}$	-12 to $-36\ \text{mA}$
Logic 0	-1 to $+1\ \text{mA}$	-4 to $+20\ \text{mA}$

Because of the fast rise time, the fast negative logic signal must be used with properly terminated cables to prevent reflections. Therefore, $50\text{-}\Omega$ cables terminated in $50\ \Omega$ at the receiving end must be used. RG-58A/U cables with UG-88/U (BNC) connectors, or RG-174 cable with LEMO connectors, are recommended. Most inputs that are designed to accept the

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NIM fast negative logic pulse have a 50- Ω input impedance. For inputs with a high input impedance, proper termination can be achieved using a Tee and a 50- Ω terminator on the module input.

The rise time of the NIM fast negative logic pulse is not specified in the NIM Preferred Practice provisions. In ORTEC instruments the rise time is typically 2 ns. The leading edge is normally used for all triggering, and pulse width is unimportant except for repetition rate considerations.

In systems that mix the use of NIM fast negative logic and ECL logic, the NIM fast negative logic is sometimes referred to as a NIM output.

ECL Logic Signals

In experiments employing a very large number of identical detectors, duplication of the functions in each detector channel makes mass connection of the similar signals desirable. Instruments developed for such applications usually incorporate up to 16 channels of the same function in a single module. A convenient method of interconnecting these channels from module to module incorporates a 34-pin (in two 17-pin rows) connector, and either a ribbon cable or a cable containing 100- Ω twisted pairs. The standard used for fast logic signals with this system is the ECL standard. The signal standard for ECL logic at 25°C is:

	Output (must deliver)	Input (must respond to)
High state	-0.81 to -0.98 V	-0.81 to -1.13 V
Low state	-1.63 to -1.95 V	-1.48 to -1.95 V

The ECL output driver provides complementary outputs. As one output switches from the high state (nominally -0.9 V) to the low state (nominally -1.8 V), the complementary output switches from the low state to the high state. Usually, differential receivers are used for ECL inputs to a module to take advantage of the complementary outputs from the ECL output driver. This has the benefit of avoiding ground loops between modules, and minimizing common mode noise interference. ECL signals have rise times less than 2 ns. Therefore, the twisted pair of wires conveying the complementary signals must be terminated at the receiving end with a 100- Ω resistor connected between the pair of wires. When several modules are driven through connectors placed part way along the cable, the 100- Ω termination should be included only in the last module at the receiving end of the cable.

TTL Logic Signals

The slow logic functions inside the instruments are usually designed with integrated circuits employing the TTL logic standard. The standard signal levels for TTL logic are:

	Output (must deliver)	Input (must respond to)
Logic 1	+2.4 to +5 V	+2 to +5 V
Logic 0	0 to +0.4 V	0 to +0.8 V

Comparison of the signal definition tables show that TTL logic levels are not guaranteed to be compatible with the NIM-standard positive logic levels. For this reason the TTL levels are normally converted to the NIM positive logic standard for the module's inputs and outputs. Pragmatically, one often finds that the NIM positive inputs or outputs have been designed in such a way that they will work with the TTL logic levels. In fact, suppliers of NIM modules have counted on that situation to eliminate the expense of NIM inputs and outputs on the instrument. In such cases the user should be cautious and check to ensure compatibility under all operating conditions.

Of course, TTL logic levels are frequently used for interconnections occurring on proprietary buses between modules. An example is the bus used in the ORTEC Dual-Port Memory Interface.

Detector Bias Voltage Cables and Connectors

The detectors used for photons, ions, and other charged particles normally require a bias voltage in order to function properly. Detector bias voltages range from a few volts up to several thousand volts, depending on the type of detector. For photomultiplier tubes, the bias voltage is applied to the cathode, dynodes, and anode through the resistive network in a photomultiplier tube base. Other types of detectors receive their bias voltage through a filter network built into the preamplifier assembly. For voltages up to 5 kV dc, the connection from the bias power supply to the preamplifier, or to the photomultiplier tube base, is made with RG-59A/U coaxial cable and SHV connectors.

With detectors that receive their bias voltage via the preamplifier input connector, several types of cables and connectors are used. The choice of cable and connectors is usually controlled by voltage limits, and by the connectors offered on the detector and the preamplifier. For detectors with Microdot connectors, a 100- Ω Microdot cable (Microdot 293-3913) with compatible connectors is normally employed. Although this cable can handle voltages up to 2500 V dc, the preamplifier input rating normally limits the bias to less than 1000 V dc. Frequently, an adapter to convert from the Microdot connector to a BNC connector is necessary in order to accommodate the preamplifier input connector. For bias voltage up to 1000 V dc, RG-62A/U cable with BNC connectors can be used. This is particularly convenient for detectors and preamplifiers equipped with BNC connectors. For bias voltages from 1 to 5 kV, RG-59A/U cable with SHV connectors must be used. Consequently, preamplifiers that are rated for bias voltages above 1 kV have SHV input connectors.

A long cable connection between the detector and the preamplifier adds input capacity, and also makes the electronics more susceptible to picking up environmental noise. Both effects can cause a degradation of the amplitude resolution and the timing performance. Therefore, the detector-to-preamplifier connection should be kept as short as possible. Because of noise considerations and the high voltages involved, cables delivering bias voltages are not terminated in their characteristic impedance.

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Examples of Systems Assembled Using Modular Electronics

The modular electronics from ORTEC can be configured to serve a wide range of applications in counting, time spectroscopy, pulse-height spectrometry, energy spectroscopy, and coincidence measurements. The examples that follow serve as a quick guide to assembling similar solutions to fit your specific needs. In these block diagrams, many of the instruments are designated with a particular model number. In most cases, other models that serve the same function can be substituted. Please consult the selection guides and the data sheets in the remainder of this catalog for further assistance in choosing the optimum model for each function.

Counting

Figures 1 and 2 illustrate fast and slow systems for counting events versus time. In Fig. 1, single photons are detected by a

photomultiplier tube. The excellent pulse-pair resolution of the photomultiplier tube is preserved by using fast amplifiers to process the anode output pulses. The discriminator in the Model 9302 is adjusted to reject the low-amplitude noise, while allowing virtually all of the photon pulses to be counted. The events can be recorded on a simple counter controlled by a timer (Model 994), or a multichannel scaler (MCS-pci™) can be used to measure the profile of counting rate versus time.

Fig. 2 illustrates a counting system wherein pulse-pair resolving time has been compromised in favor of achieving better pulse-height (energy) resolution. The Model 113 charge-integrating Preamplifier and the Model 575A Amplifier provide the slower pulse shaping needed for acceptable energy resolution with the NaI(Tl) scintillation detector. A narrow range of pulse amplitudes corresponding to a particular gamma-ray energy can be selected by the Model 550A Single-Channel Pulse-Height Analyzer (SCA) or the SCA built into the multichannel scaler. The selected events are recorded in either a counter/timer or the multichannel scaler.

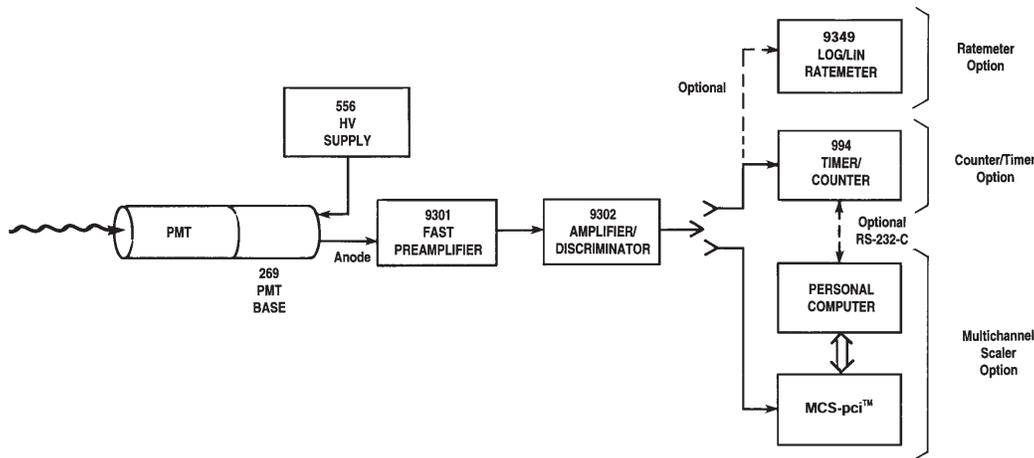


Fig. 1. Counting Fast Single-Photon Pulses from a Photomultiplier Tube Anode.

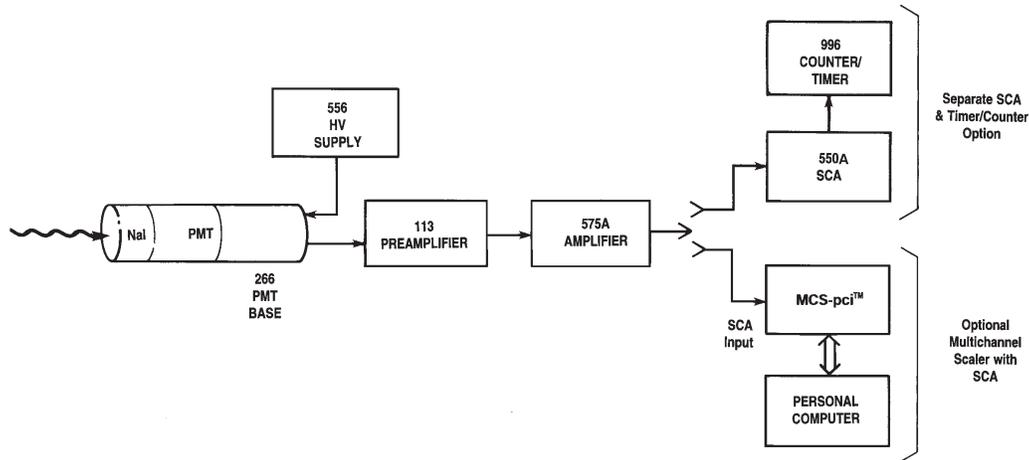


Fig. 2. Counting Selected Amplitudes of Slow Linear Signals from a NaI(Tl) Scintillation Detector.

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Pulse-Height, Charge, or Energy Spectroscopy

Figures 3 through 10 show systems for pulse-height spectrometry with a variety of detector types. The following types are included:

- Microchannel plate detector (Fig 3).
- Microchannel plate photomultiplier tube (Fig. 3).
- Nal(Tl) scintillation detector (Fig. 4).
- Conventional photomultiplier tube (Fig. 5).
- Proportional counter (Fig. 6).
- Silicon charged-particle detector (Fig. 7).
- Si(Li) detector (Fig. 8 and 10).
- Ge detector (Figs. 8, 9, and 10).

If nuclear or x-ray radiation is being detected, the pulse-height is usually calibrated in terms of the energy of the radiation. Hence the term “energy spectroscopy” is used. For other types of signal sources, the pulse height simply represents the charge deposited in the detector by the event. Consequently, the measurement process can be considered to be either “charge” or “pulse-height” spectrometry. In Figures 3 and 5 through 9, a preamplifier integrates the charge deposited in the detector, an amplifier shapes the pulses for pulse-height measurement, and a multichannel buffer (ADC plus memory) sorts the pulse heights into a spectrum (histogram of energy vs. counts). Figure 4 uses an integrated package complete

with preamplifier, high voltage supply, and a digital signal processor all powered by the USB interface to the PC.

In Fig. 6, the low-noise 142PC Preamplifier has about a factor of 6 higher sensitivity than the standard 142IH Preamplifier. This higher sensitivity allows operation of the proportional counter at a lower gas gain. The benefit is less dependence of the gas gain on counting rate in the proportional counter. As a result, the proportional counter can be operated at higher counting rates before peak shifting occurs in the recorded energy spectrum.

In Figures 8 and 9, connection of the BUSY and PUR signals between the amplifier and MCB is essential for achieving accurate dead time correction with the Gedcke-Hale Live-Time Clock in the MCB.

In Fig. 9, the gated integrator amplifier (973U) compensates for variations in the charge collection time to allow operation of coaxial germanium detectors at ultra-high counting rates (and shorter shaping times) with good energy resolution. The Transistor Reset Preamplifier (TRP) can also be critical for operation at ultra-high energy rates. Note that special resistive feedback type preamplifiers can offer a balance to maximize system throughput.

Figure 10 shows the use of an integrated electronics package for x-ray or gamma-ray spectrometry. In this case the preamplifier output is sampled and our digital systems provide digital signal processing for improved performance.

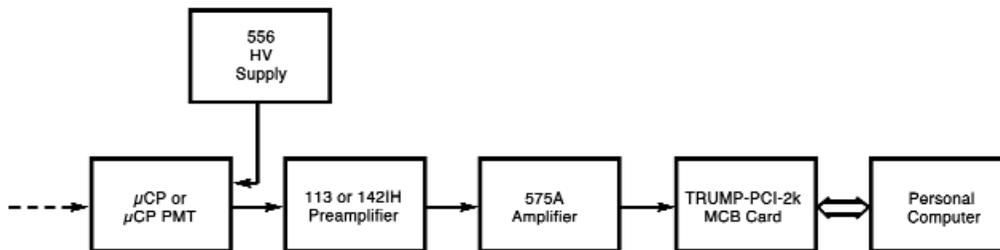


Fig. 3. Pulse-Height (Charge) Spectroscopy with a Microchannel Plate (μCP) Detector, or a Microchannel Plate Photomultiplier Tube (μCP PMT).

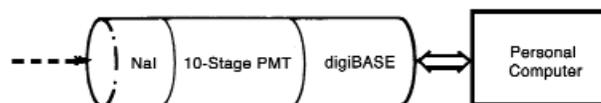


Fig. 4. Pulse-Height (Energy) Spectroscopy with a NaI(Tl) Scintillation Detector

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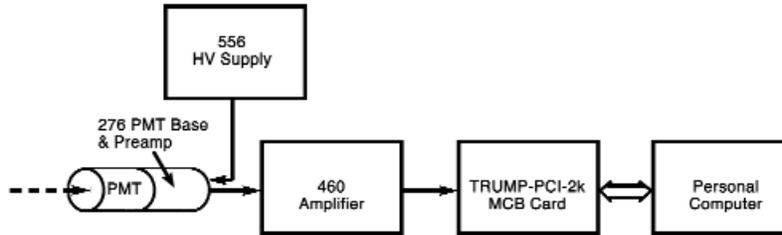


Fig. 5. Pulse-Height (Charge) Spectroscopy with a Photomultiplier Tube.

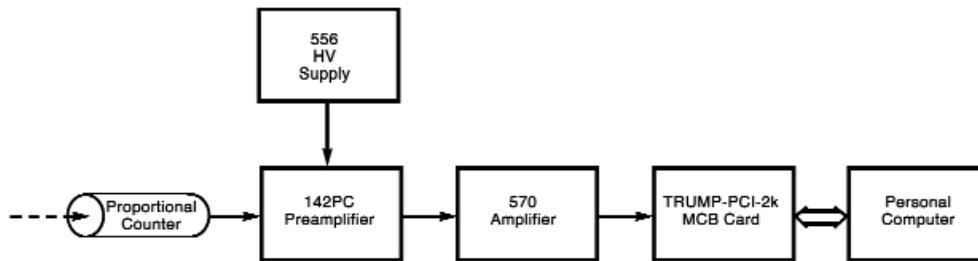


Fig. 6. Pulse-Height (Energy) Spectroscopy with a Proportional Counter.

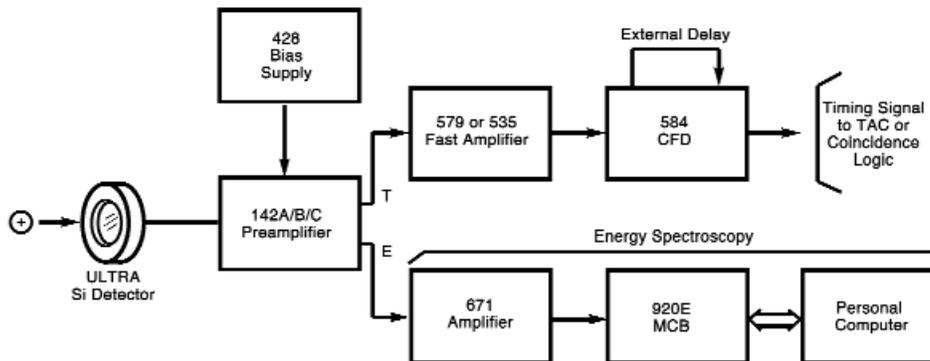


Fig. 7. Pulse-Height (Energy) Spectrometry with a Si Charged-Particle Detector, Including Derivation of an Optional Timing Signal.

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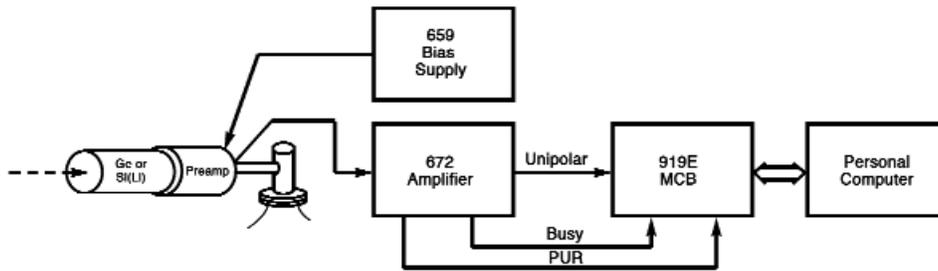


Fig. 8. Pulse-Height (Energy) Spectroscopy with a Ge Detector for Gamma Rays, or a Si(Li) Detector for X Rays.

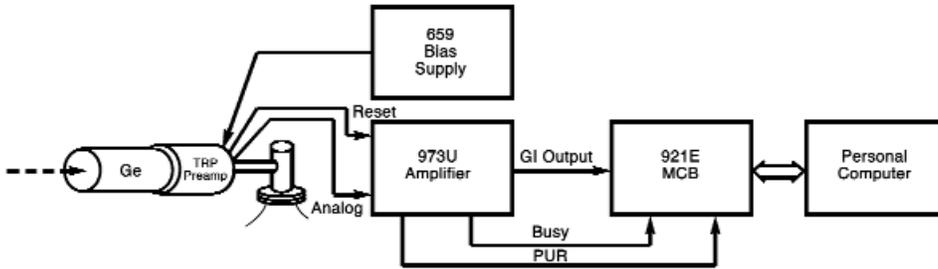


Fig. 9. High-Rate Energy Spectroscopy with Gamma Rays and a Coaxial Ge Detector.

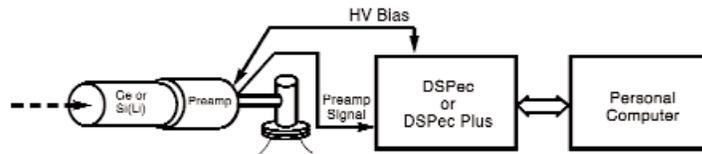


Fig. 10. Pulse-Height (Energy) Spectroscopy with a Ge Detector for Gamma Rays, or a Si(Li) Detector for X Rays, Using Digital Signal Processing (DSP).

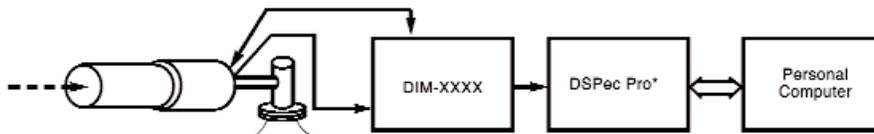


Fig. 10a. Pulse-Height (Energy) Spectroscopy with a Ge Detector for Gamma Rays, or a Si(Li) Detector for X Rays, Using SMART-1 Detector Interface Module and Digital Signal Processing (DSP).

*May also use DSPec jr 2.0, DSPec jr, or DigiDART

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Picosecond Time Resolution with Single Photons

Figure 11(A) illustrates a system for obtaining picosecond time resolution in Fluorescence Lifetime measurements. A pulsed laser excites fluorescence in the sample, and individual fluoresced photons are detected by the microchannel plate photomultiplier tube. The time spectrometer records the profile of fluorescence decay by measuring the time interval between the laser pulse (sensed by the photodiode) and the fluoresced photon detected in the microchannel plate PMT. (See the TAC section in this catalog for the benefit of the reversed start and stop inputs in Fig. 11[A].) Fluorescence lifetimes from tens of picoseconds to tens of nanoseconds can be measured. For the longer lifetimes the microchannel plate detector can be

replaced with a conventional photomultiplier tube, as shown in Fig. 11(B), and a nanosecond flashlamp can be substituted for the laser. For measuring phosphorescence lifetimes of the order of tens of microseconds, the Model T914 Turbo-MCS can be substituted for the TAC and Multichannel Analyzer in Figure 11(A). If the entire range of lifetimes from picoseconds to microseconds must be measured, the Model 9308 picosecond TIME ANALYZER should be used in place of both the Turbo-MCS and the TAC/Multichannel Analyzer (see Fig. 12). For the T914 and the 9308 the Start/Stop connections in Figure 11A should be interchanged to achieve the conventional Start/Stop configuration, and the Model 425A should be moved to the conventional Stop input as shown in Figure 12. **Ask for the AN50 and AN52 Application Notes for more information.**

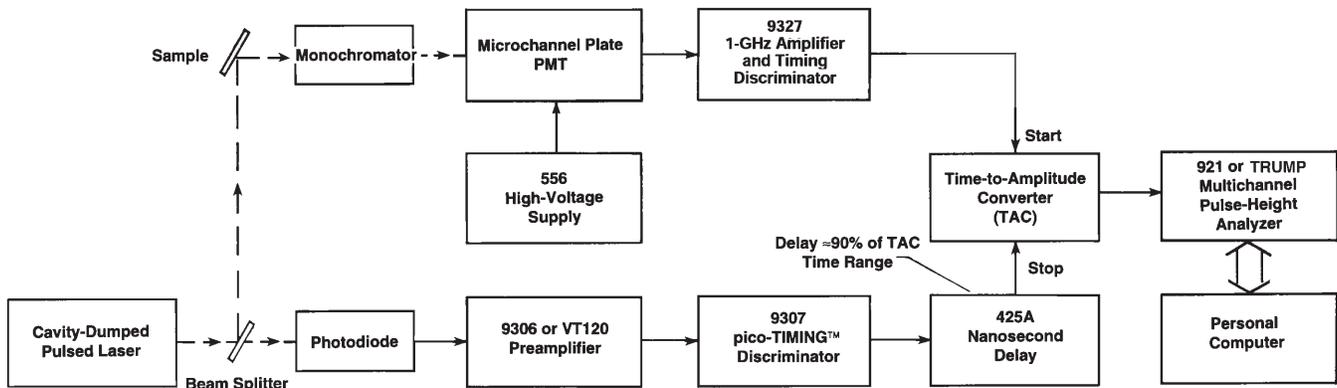


Fig. 11(A). Typical Block Diagram for a Fluorescence Lifetime Spectrometer, Utilizing a Microchannel Plate PMT, a TAC, and an MCA.

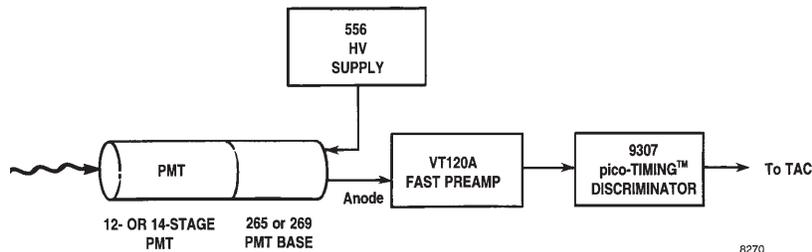


Fig. 11(B). An Alternate Time Pick-Off Scheme for Single-Photon Timing Replaces the Microchannel Plate PMT in Fig. 11(A) with a Conventional Photomultiplier Tube.

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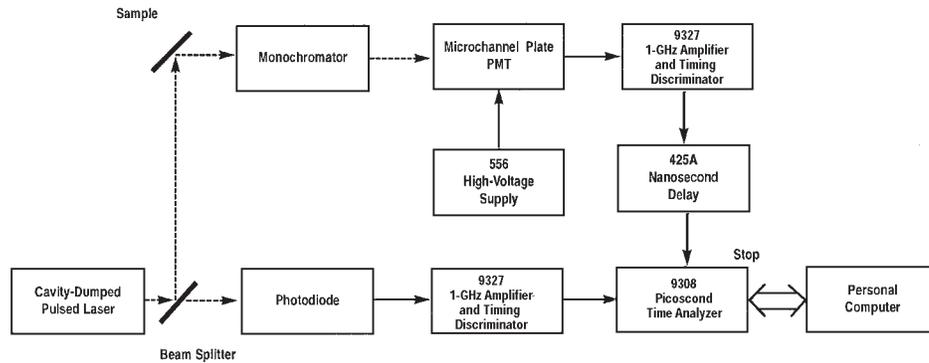


Fig. 12. The Conventional Start/Stop Arrangement for Fluorescence/Phosphorescence Lifetime Spectrometry using the Model 9308.

Simultaneous Time and Pulse-Height Spectroscopy with Detectors Having a Single Output

When a detector offers only a single output, but both time and pulse-height spectrometry are required, the system in Fig. 13 provides a practical solution. The Model 142A Preamplifier accepts the single detector output and delivers separate preamplifier outputs for timing (T) and pulse-height or energy (E) measurements. This scheme preserves the low noise required for pulse-height spectrometry, while offering a fast rise time for time spectrometry. The method is useful for microchannel plate detectors, microchannel plate PMTs, Si charged-particle detectors, and Ge detectors. For best performance, the length of the connection between the detector and the preamplifier should be as short as possible.

The AD413A Quad ADC records both time and energy information for each detected event. To minimize dead time, the start and stop inputs to the TAC are reversed. The low rate signal from the detector is applied to the start input, while the higher rate signal from the pulsed excitation source is delayed and fed to the stop input.

Time Spectrometry Beyond 10 μ s: Time-of-Flight Mass Spectrometry and LIDAR

For time ranges beyond 10 μ s, the Turbo-MCS is a much more productive solution than a time-to-amplitude converter, because a multichannel scaler (MCS) can record multiple stop pulses following a single start pulse. The benefit is much higher data collection rates without distortion of the time spectrum.

Fig. 14(A) shows the typical application of a Turbo-MCS to a time-of-flight mass spectrometer (TOF-MS). When the ions are accelerated by the excitation pulse, the multichannel scaler starts its scan. As the ions arrive at the microchannel plate detector, they are counted in the MCS channel that corresponds to the ion's flight time through the TOF-MS. Repeating the excitation and scanning process builds a time spectrum in the memory of the MCS. The pulse starting the scan in an MCS corresponds to the start pulse in a TAC, while the discriminator input of the MCS serves as the stop pulse input. The MCS accepts and records multiple stop pulses during each scan.

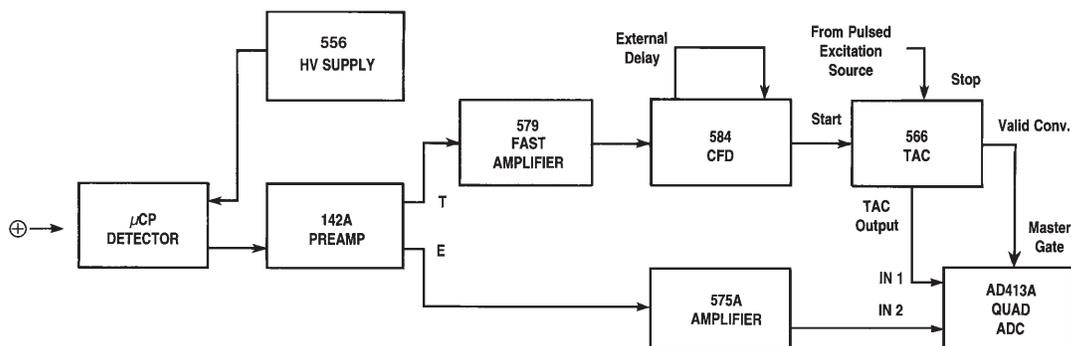


Fig. 13. Simultaneous Time and Pulse-Height Measurement With a Microchannel Plate Detector.

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From the measured flight time, t , the mass of the ion can be computed as

$$m = \frac{2 z V_{\text{acc}} t^2}{s^2} \quad (1)$$

where z is the charge on the ion, V_{acc} is the accelerating voltage, and s is the length of the flight path.

To achieve sub-nanosecond digital resolution, substitute the Model 9327 1-GHz Amplifier and Timing Discriminator and the Model 9308 picosecond TIME ANALYZER for the VT120A Preamplifier and the Turbo-MCS. See Figure 14(B) and **Application Note AN52**.

Because there is a dead time associated with the processing of each detected event in the Turbo-MCS and the Model 9308,

these two products are limited to operating in the single-ion counting/timing mode in the TOF-MS application. When the input is busy processing one event, it cannot respond to additional events arriving during the dead time. This means that the probability of detecting an event in the dominant peak in the time-of-flight spectrum must be limited to less than 1% during any scan. Mathematical dead time corrections can raise this limit to 10%. But in either case, the allowable ion rates are very low. This results in >10% statistical uncertainties for the counts in the peak, when the data acquisition period is much shorter than 1 second.

Ion rates can be increased by a factor of more than 100 by employing the *FASTFLIGHT*[™] Digital Signal Averager, as illustrated in Figures 15 (A) and (B). This results in a factor of 10 improvement of statistical precision and detection limits.

FASTFLIGHT eliminates the event-processing dead time by using a flash ADC to sample and digitize the analog signal from the detector at 0.5, 1, or 2-ns intervals. Multiple ions arriving within the detector pulse width are fully counted, because the detector and flash ADC respond linearly to the number of ions in the pulse. For more information, see the section on Multichannel Scalers, Multiple-Stop Time Spectrometers, and Digital Signal Averagers in this catalog, and ask for **Application Notes AN53 and AN54**.

Fig. 16(A) shows the application of the Turbo-MCS to a LIDAR system for studying the concentration of compounds as a function of altitude in the atmosphere. Laser pulses scattered by molecules in the atmosphere are detected by a photomultiplier tube. The round-trip flight time of the photons is measured by the Turbo-MCS to determine the altitude at which the scattering took place. The counting rate of the detected photons can be used to measure the concentration of specific compounds. In practice, the laser and the photomultiplier tube are incorporated into a system of lenses, designed to limit the field of view and to guaranty overlap between the volume excited by the laser and that viewed by the photomultiplier tube. Typically, two parallel systems are used to measure the response at different wavelengths. This allows differential absorption

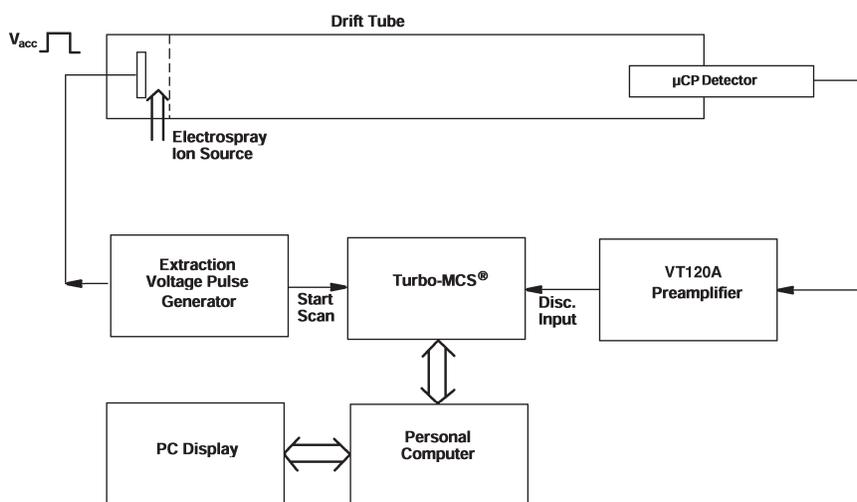


Fig. 14(A). Simplified Diagram of a Time-of-Flight Mass Spectrometer Using the Turbo-MCS as a Multiple-Stop Time Spectrometer.

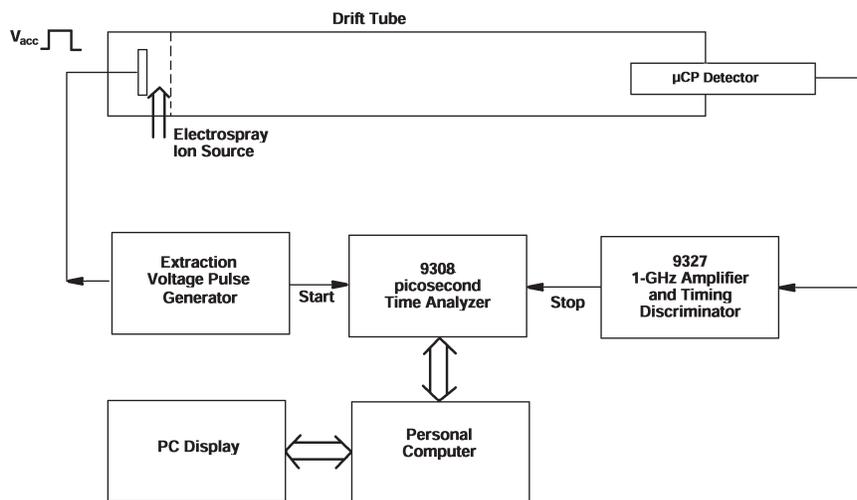


Fig. 14(B). Simplified Diagram of a Time-of-Flight Mass Spectrometer Using the Model 9308 Picosecond Time Analyzer as a Multiple-Stop Time Spectrometer.

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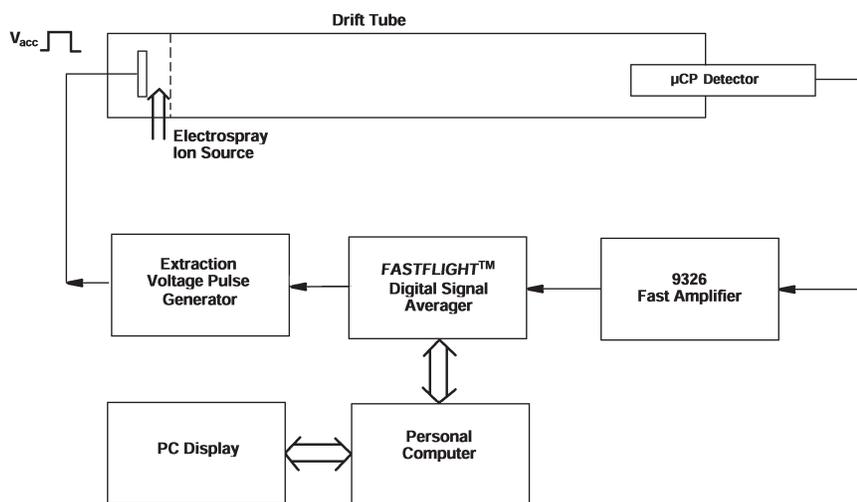


Fig. 15(A). A Simplified Representation of an Electrospray TOF-MS Interfaced to the FASTFLIGHT Digital Signal Averager.

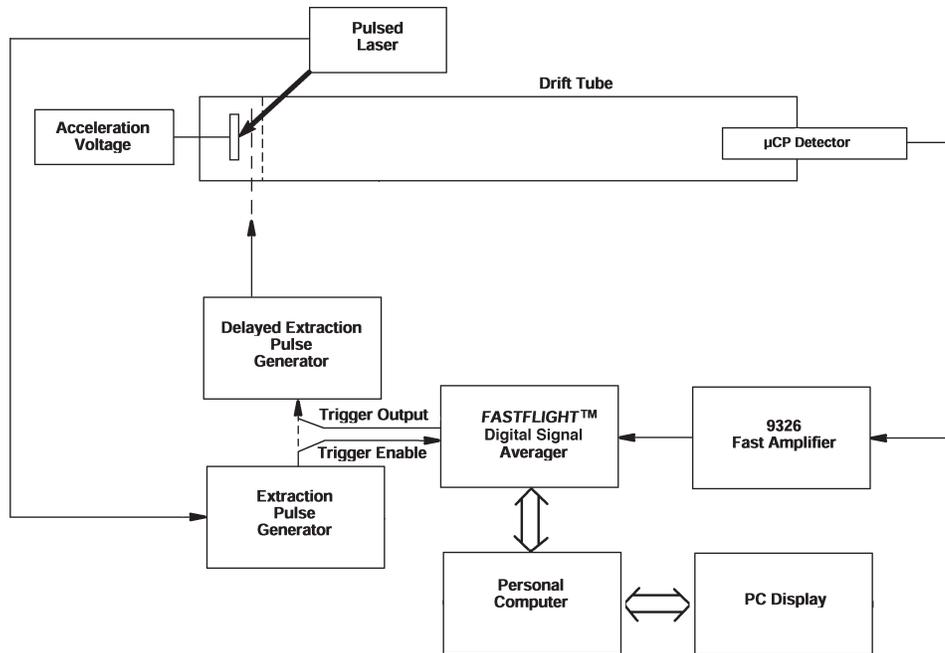


Fig. 15(B). A Simplified Illustration of a MALDI TOF-MS with a Delayed Extraction Grid Interfaced to the FASTFLIGHT Digital Signal Averager.

corrections to be applied. The latter technique is called Differential Absorption LIDAR (DIAL).

For sub-nanosecond resolution in LIDAR choose the instrumentation in Figure 16(B).

Timing with Scintillation Detectors

Figures 17, 18, and 19 are examples of high-resolution time spectrometry with scintillation detectors. Coincident pairs of gamma rays from the radioactive source are detected in opposite scintillation detectors. Fig. 17 represents a "fast/slow" timing system. "Fast" refers to the fact that the fast anode signals from the photomultiplier tubes are used to derive the timing information. The dynode outputs are integrated by the 113 Preamplifier, processed as "slow" pulses in the 460 Amplifiers, and fed to the 551 SCAs to select the desired range of pulse heights (energies) in each detector. Strobing the TAC by the 414A Fast Coincidence output ensures that only pulses within the selected energy windows will contribute to the recorded time spectrum. Fig. 18 shows the effect of varying the width of the energy windows on the measured time resolution.

Fig. 19 illustrates a "fast/fast" timing system, wherein the fast anode signal is used for both functions: 1) to derive the timing information, and 2) to select the range of pulse amplitudes. The upper and lower level discriminators in the Model 583A Constant-Fraction Differential Discriminator select the range of pulse amplitudes, while the constant-fraction zero-crossing discriminator adds the timing information. The advantage of this fast/fast system is the capability of operating at higher counting rates than is possible with the fast/slow system in Fig. 17.

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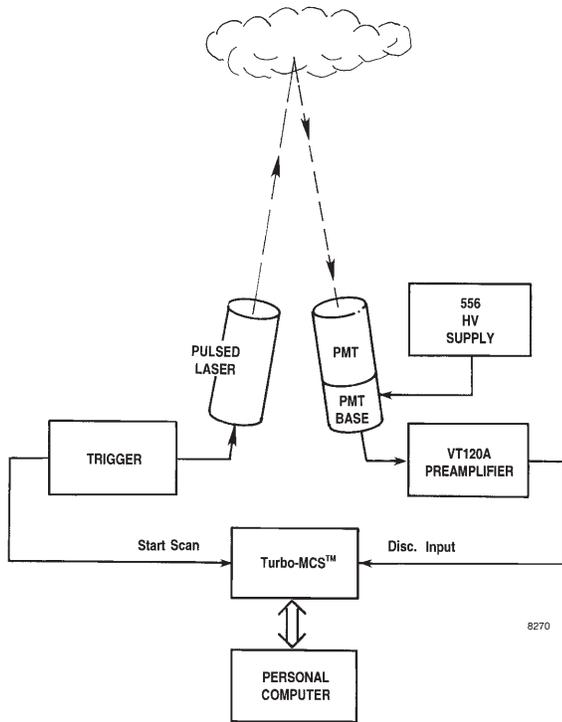


Fig. 16(A). A Simplified Diagram of the Application of Turbo-MCS™ to Atmospheric Measurements by LIDAR.

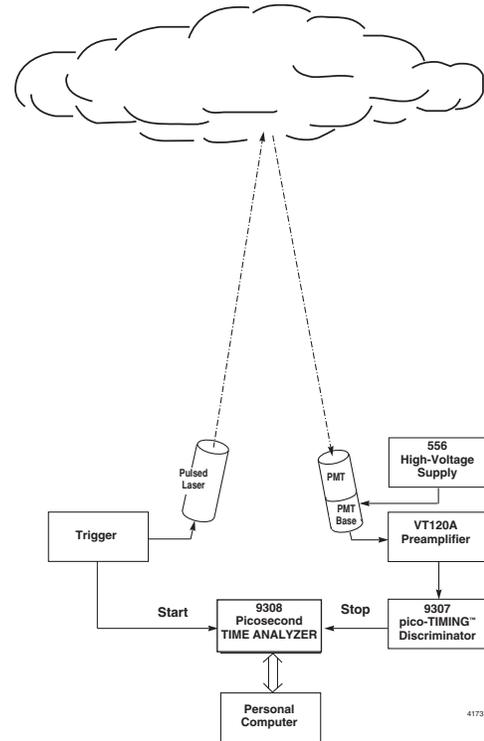


Fig. 16(B). A Simplified Diagram of the Model 9308 Picosecond Time Analyzer Applied to Atmospheric Measurements by LIDAR.

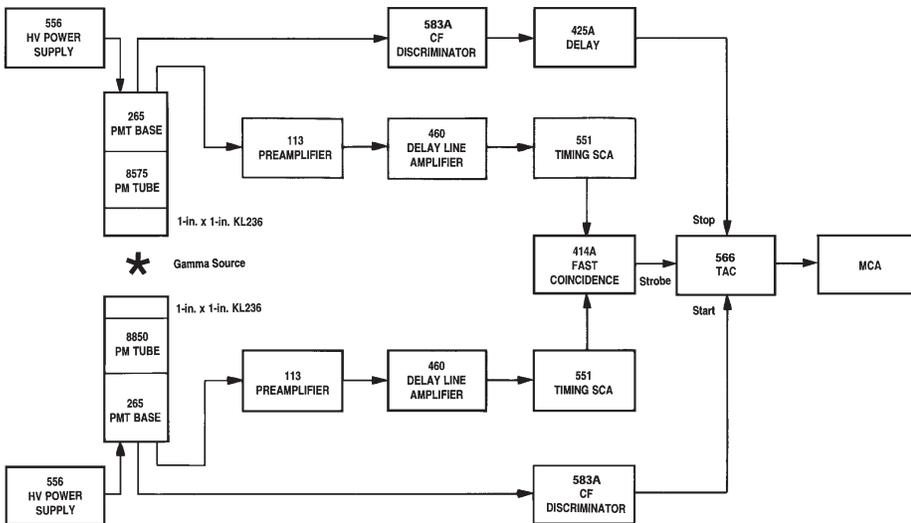


Fig. 17. Typical Fast/Slow Timing System for Gamma-Gamma Coincidence Measurements with Scintillators and Photomultiplier Tubes.

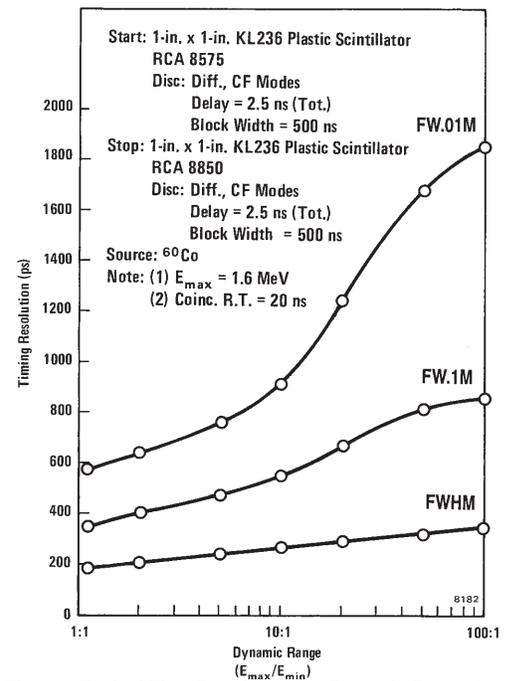


Fig. 18. Typical Time Resolution vs. Dynamic Range for a ^{60}Co Source Using the ORTEC Model 583 Constant-Fraction Discriminator.

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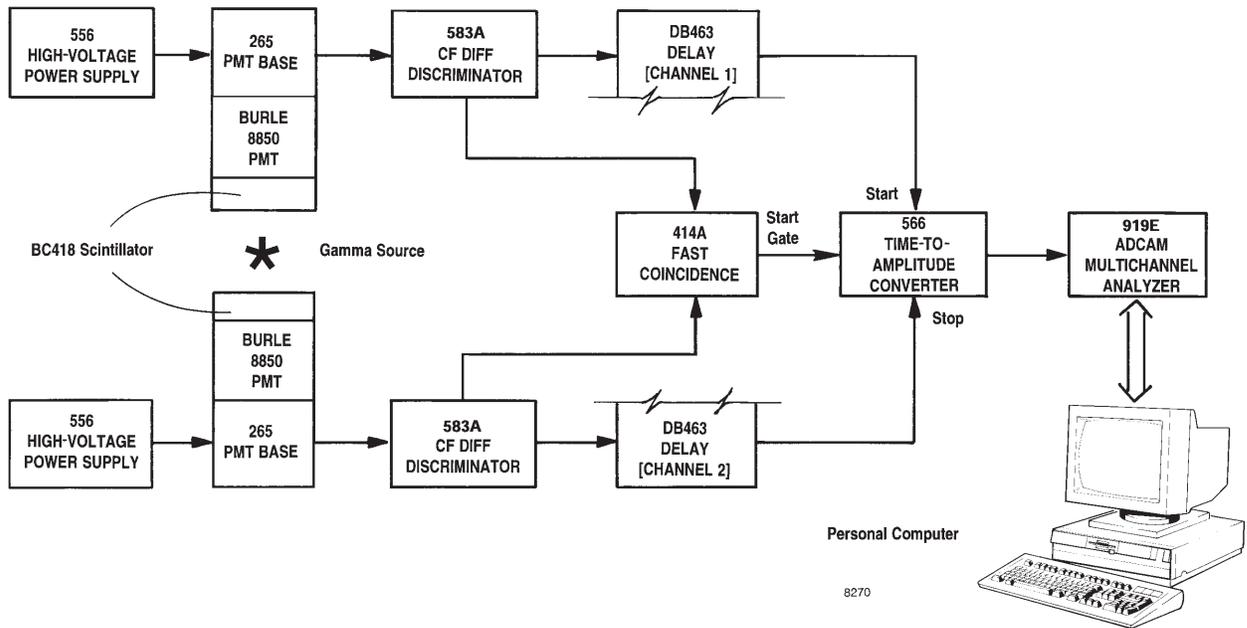


Fig. 19. Time Spectroscopy with Fast Scintillation Detectors Using the 583A Differential CFD in a Fast/Fast Timing System.

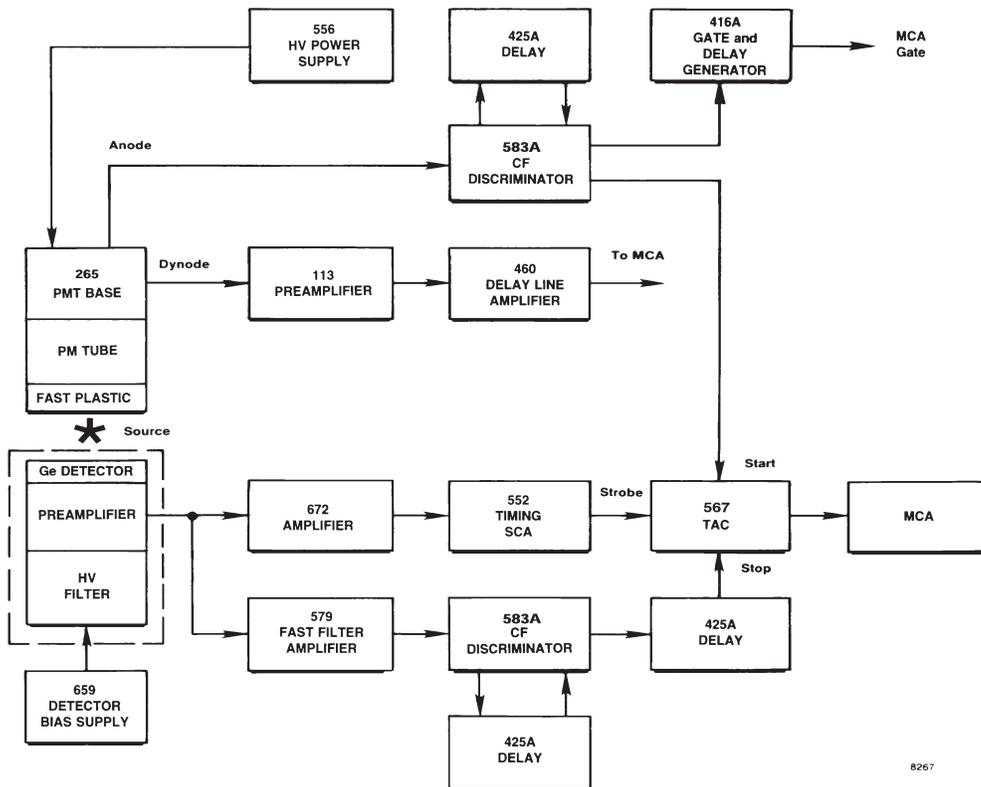


Fig. 20. Time Spectrometry with a Ge Detector. Typical time resolutions are listed in Tables 1 and 2.

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Time Spectroscopy with Germanium Detectors

The system in Fig. 20 can be used to measure the timing characteristics of Ge detectors. Since the time resolution of the fast plastic scintillation detector is small compared to that of the Ge detector, the peak recorded in the time spectrum is characteristic of the Ge detector. Tables 1 and 2 summarize the time resolutions obtained with Ge detectors over a wide range of detector sizes. For further details see the sections in this catalog on Amplifiers, and Fast-Timing Discriminators.

Timing with Silicon Charged-Particle Detectors

Silicon detectors, with either Surface Barrier or Ion Implanted contacts, are used for detecting and measuring the energy of charged particles. In many cases, the arrival time of the charged particle also must be measured. Figure 21 includes a block diagram of the scheme used for extracting the timing signal along with the energy signal. The output of the 572 amplifier is usually fed to an ADC to record the energy spectrum, while the output of the 584 drives the Stop input of a Time-to-Amplitude Converter (TAC). If multi-parameter analysis is the aim of the experiment, the TAC output is delivered to a second input of the multi-parameter ADC in order to record the time spectrum. Because the charge collection time is uniformly short for a Si

detector, it is possible to simulate the effect of the charged particle by using a Laser diode with a sub-nanosecond pulse width. Figure 22 demonstrates the typical time spectrum obtained from Figure 21. Figures 23 and 24 show the dependence of the time resolution on the energy of the charged particle (simulated by the light pulse intensity), and on the capacitance of the detector. Time resolutions in the range of 30 to 700 ps are possible. The time resolution is determined by the noise/slope ratio, as explained in the section on Fast Timing Discriminators in this catalog. See also the 142A/B/C data sheet.

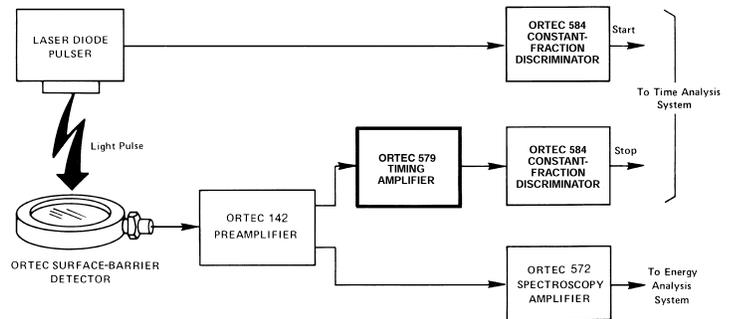


Fig. 21. Block Diagram for Timing System Using Surface-Barrier Detectors.

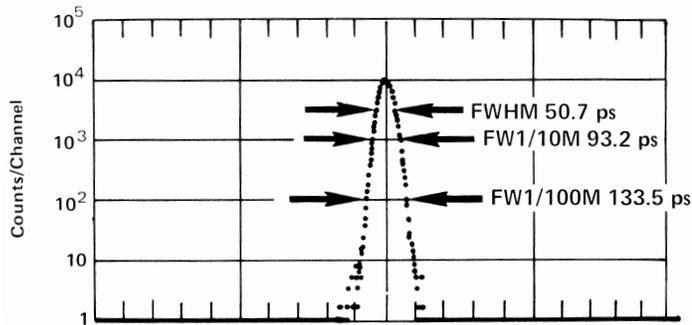
Table 1. Typical Timing Results Measured with ORTEC's Coaxial Detectors.

Detector System	Detector Type	Efficiency (%)	Optimum Delay (ns)	Measure	Timing Resolution (ns)									
					Mean Energy (keV) Using ²² Na				Mean Energy (keV) Using ⁶⁰ Co					
					150	250	350	511	511	750	950	1170	1330	
1	HPGe-P	11.0	24	FWHM	9.2	6.7	5.8	4.0	3.9	3.0	2.6	2.0	1.7	
				FW.1M	-	45.3	22.2	9.9	10.2	8.4	7.5	5.6	5.1	
2	HPGe-N	19.8	23	FWHM	12.5	8.6	7.0	4.5	4.9	3.7	3.1	2.2	2.0	
				FW.1M	84	33	18.1	10.2	11.8	8.6	7.7	5.5	4.9	
3	HPGe-P	28.0	34	FWHM	11.3	8.8	7.7	5.6	6.2	5.7	4.0	3.6	3.4	
				FW.1M	-	55.8	27.1	12.8	13.4	12.3	11.8	9.8	9.0	

Table 2. Timing Resolution for Large Germanium Detectors Using 583A CFDD/SCA, 474 TFA, and ⁶⁰Co.

Detector	Efficiency	FWHM Energy Resolution (keV)	Constant Fraction Delay (ns)	Timing Resolution (ns)			
				E > 100 keV		E = 1332 ± 50 keV	
				FWHM	FW.1M	FWHM	FW.1M
N30526A	73%	2.03	34	5.4	19.4	3.7	8.8
P20171	81%	1.97	34	5.5	27.0	4.7	13.8
N20366A	88%	2.34	36	5.8	21.2	5.5	16.4

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Calibration: 2.070 ps/channel.
Excitation Source: Laser diode pulser with 66-MeV equivalent energy.
Start Channel: Time pickoff from laser diode pulser.
Stop Channel: ORTEC detector BF-035-300-60, 440pF
Preamp: ORTEC Model 142

Fig. 22. Typical Timing Spectrum for Surface-Barrier Detector System.

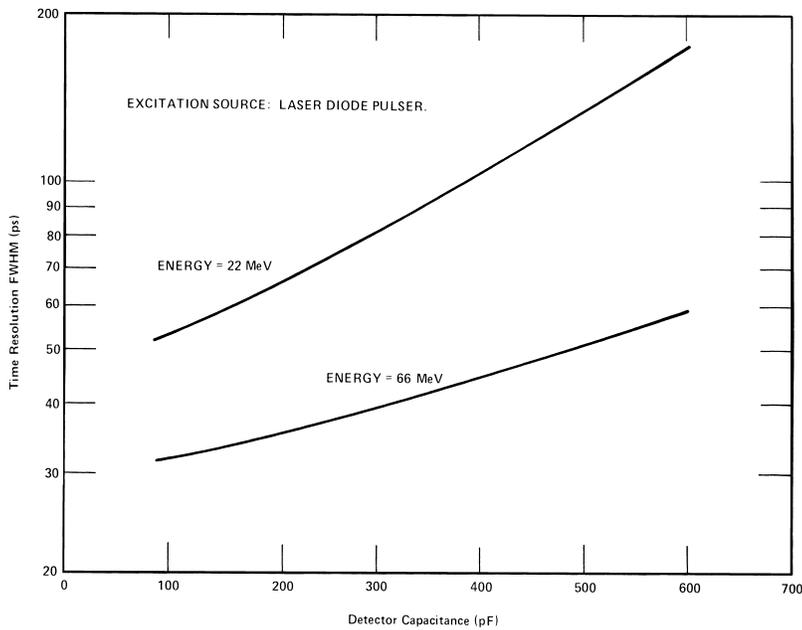


Fig. 23. Typical Time Resolution vs. Detector Capacitance.

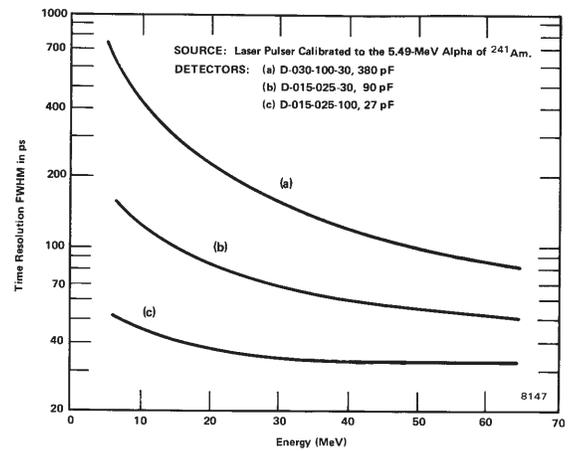


Fig. 24. Typical Time Resolution vs. Energy for Different Capacitance Detectors.

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Coincidence Spectroscopy Systems

Figures 25 and 26 are examples of coincidence spectroscopy systems intended for studying radioisotopes that emit multiple quanta of radiation in a single decay.

The Model 551 Timing Single-Channel Analyzers in Fig. 25 provide the slow timing information for determining that the gamma rays striking the two detectors are truly coincident. The Timing SCA for Detector A is operated with a wide-open window to allow measurement of the entire energy spectrum for Detector A on the MCB. For Detector B, the window on the Timing SCA is adjusted to select a single gamma-ray energy. Consequently, the MCB records the energy spectrum from Detector A for all the gamma rays that are in coincidence with the gamma ray selected from Detector B.

The system in Fig. 26 offers more powerful data acquisition capability than the scheme in Fig. 25. With Option 1, a true two-parameter data acquisition yields a 3-dimensional picture of the coincidence spectra from the two detectors. In addition, coincidence-gated singles spectra from each detector can be recorded simultaneously via Option 2. Multi-parameter data acquisition and display is supported by the Kmax™ software on either a Macintosh or an IBM-compatible personal computer.

In Fig. 26 a Model 567 TAC/SCA is used to set the fast coincidence resolving time. This is more convenient than the

scheme in Fig. 25, because the TAC time spectrum can be displayed via an ADC that is gated by the TAC/SCA while the SCA window is adjusted to accept only the true coincidence peak. The optional start gate on the TAC/SCA can be used to reduce dead time in the TAC.

Selecting the Type of Radiation by Pulse-Shape Analysis

Some scintillators respond to different types of radiation by exhibiting different decay times. In such situations pulse-shape analysis can be used to identify and selectively analyze one particular type of radiation. Fig. 27 demonstrates the application of pulse shape analysis to the task of counting neutrons in the presence of an unwanted gamma-ray background. The 552 Pulse-Shape Analyzer and the 567 TAC measure the fall time of the pulse from the 460 Amplifier. Since the Model 460 is a delay-line-clipped amplifier, the fall time is identical to the rise time of the pulse, and this rise time corresponds to the decay time of the scintillator. Fig. 28 shows the rise time spectrum at the TAC output. By setting the TAC SCA window across the neutron peak and gating the MCA with the SCA output, the system will record only the energy spectrum caused by neutrons. For further details, ask for the application note, "Neutron-Gamma Discrimination with Stilbene and Liquid Scintillators". This method can be applied to other

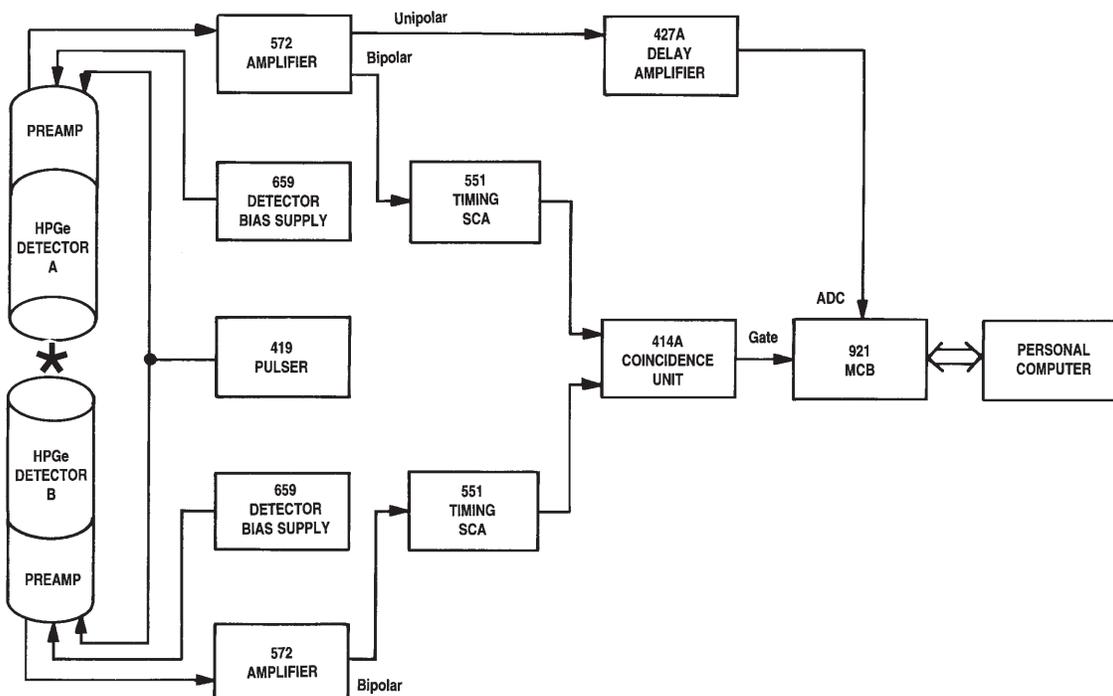


Fig. 25. A Simple Gamma-Gamma Coincidence System with Energy Spectroscopy Performed on One of the Two Ge Detectors.

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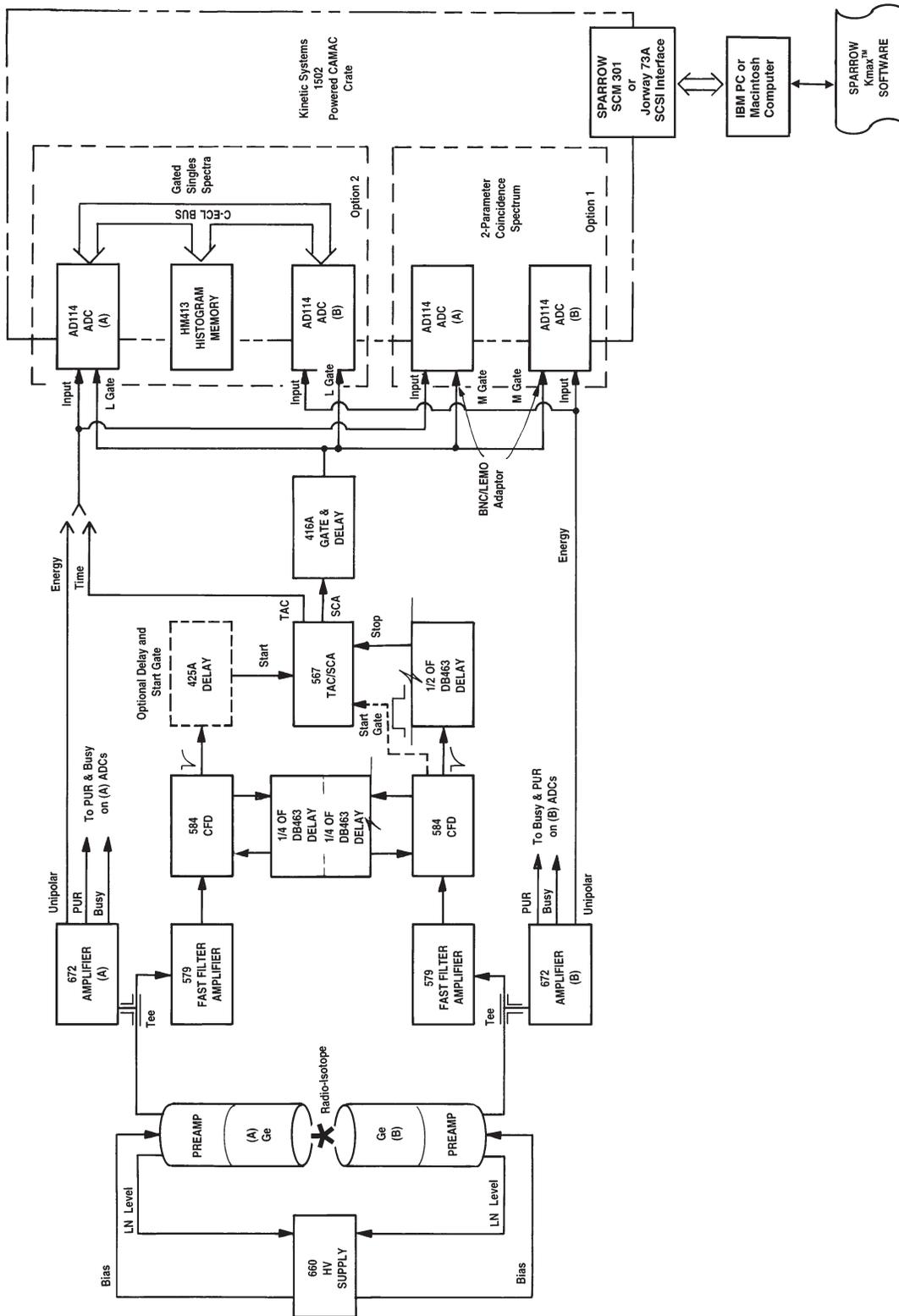


Fig. 26 . A Gamma-Gamma Coincidence System Utilizing Ge Detectors with Two-Parameter Energy Spectroscopy.

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types of detectors, such as sandwiches of two types of scintillators (Phoswich detector) for the purpose of identifying the type of radiation by its penetration depth.

Energy Measurement by Time-of-Flight

It is difficult to design a detector in which fast neutrons interact to produce a signal that yields good energy resolution. Consequently, neutron energies are normally determined by measuring the flight time of the neutron over a fixed distance. If the distance is s and the flight time is t , the energy of the neutron can be calculated as

$$E = \frac{m s^2}{2 t^2} \quad (2)$$

where m is the mass of the neutron.

Conversely, Equation (2) can be used to determine the mass of an unidentified particle, if the energy E is controlled. The method can be used to identify charged particles in nuclear reactions, or the molecular species in a time-of-flight mass spectrometer (see Figures 14 and 15).

Fig. 29 shows a typical neutron time-of-flight spectrometer. Deuterium ions (${}^2_1\text{H}^+$) are boosted to an energy of about 200 keV in an electrostatic accelerator, and directed to a target containing Tritium (${}^3_1\text{H}$). The resulting nuclear reaction, ${}^3_1\text{H} ({}^2_1\text{H}^+, n) {}^4_2\text{He}$, produces neutrons having an energy of 14.2 MeV, and recoiling alpha particles (${}^4_2\text{He}$) with an energy of 3.6 MeV. After scattering from the sample, the neutrons exhibit discretely different energies depending on (a) the nuclear states excited in the sample by inelastic scattering, and (b) the scattering angle.

The time-of-flight spectrum is measured by the time interval between the alpha particle arriving at the ULTRA™ detector and the neutron arriving at the neutron detector. The high counting rate signals from the alpha-particle detector are delayed and used as the stop pulse, while the lower counting rate signals from the neutron detector are fed to the start input of the TAC. This reversed start/stop scheme reduces dead time in the TAC. A pulse shape analyzer, as described in Fig. 27, is used to reject gamma-ray background. The Model 552 SCA also serves to define the lower pulse-height threshold for accepting neutron signals. This threshold is critical in determining the detection efficiency of the neutron detector.

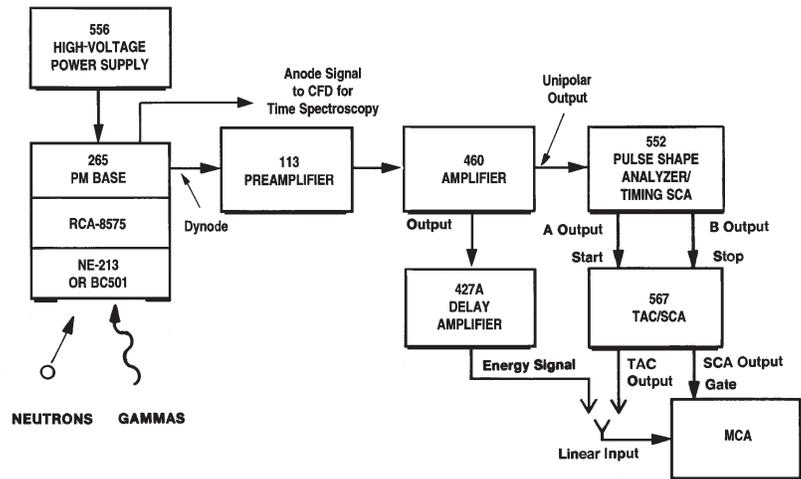


Fig. 27. Neutron/Gamma-Ray Discrimination by Pulse-Shape (Rise Time) Analysis.

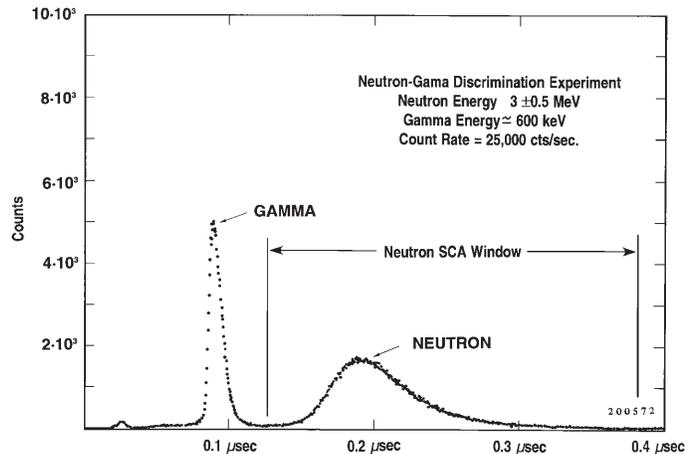
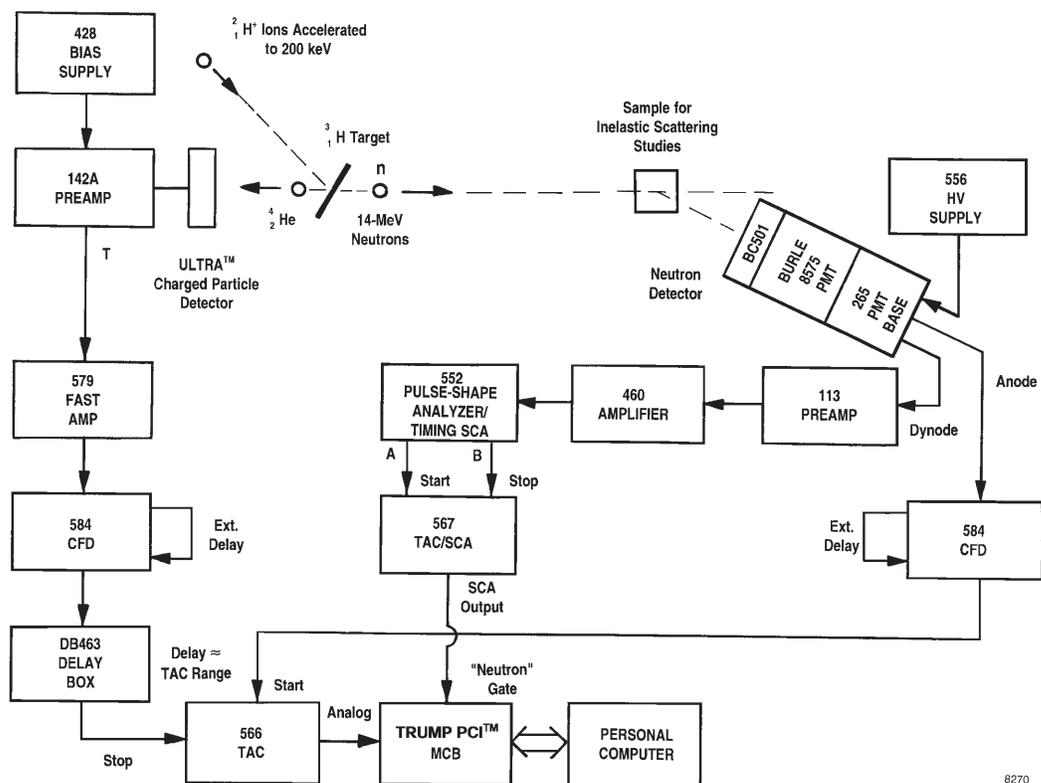


Fig. 28. The Neutron/Gamma-Ray Rise Time Spectrum from the TAC Output in Fig. 27.

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Fig. 29. A Neutron Time-of-Flight Spectrometer with Neutron/Gamma-Ray Pulse-Shape Discrimination.

Photomultiplier Tube Bases

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Introduction

Photomultiplier tubes are used to convert flashes of light into an electrical signal whose integrated area is proportional to the number of photons in the flash of light. Also, the time at which the electrical pulse is produced can be used to infer the arrival time of the light pulse. The light can come from a distant source, such as a fluoresced sample in single-photon counting experiments, or from a scintillator that is tightly coupled to the PMT photocathode and excited by nuclear radiation.

Scintillation detectors produce light as they absorb energy, and these light flashes result in the release of a proportionate number of photoelectrons at the cathode of a photomultiplier tube (PMT). The PMT amplifies this signal, producing a current pulse that is larger in amplitude at each of its successive dynodes, and culminating in an output signal at its anode.

Each of the ORTEC Photomultiplier Tube Bases is designed to accommodate a particular type of PMT to distribute the operating voltages to all its elements, and to derive signals from its anode and from a selected dynode. The high-voltage accommodation in a PMT base is adequate for the requirements of any of the compatible tubes listed in the Comparison Chart; the tube types listed represent those most commonly used in these applications.

The Model 276 Photomultiplier Tube Base incorporates an integral low-noise preamplifier, and an anode output for either timing or auxiliary energy analysis. The Model 296 ScintiPack has all the features of the Model 276, but adds an integral high-voltage bias supply with active dynode voltage regulation. The ScintiPack is ideal for high counting rates and portable applications. Both the Model 276 and the Model 296 are compatible with Model 905 Series Scintillation Detectors.

The other photomultiplier tube bases in this group also include two outputs: a signal obtained from the anode and a signal obtained from a dynode. The anode signal is typically used for time measurements. The dynode is intended for making energy measurements through a preamplifier and a pulse-shaping amplifier.

Photomultiplier Tube Bases

Photomultiplier Tube Base Comparison Chart

Model	High Voltage (V_{max})	Bleeder Current (mA)	PM Output Signals		Control	Compatible with PMT Type	Dimensions
			Anode	Dynode			
265A PMT Base	-3000	≤ 2	Neg. timing signal, 0.5 A; max, 50 Ω dc-coupled	Pos linear signal $Z_o \sim 1 \text{ M}\Omega$; capacitive coupling	Voltage adj for focus and for 2nd and 12th dynodes	12-stage PMTs that fit standard 21-pin sockets, including Hamamatsu R329 R1332, and R1333. Burle (formerly (RCA) 8575, 8850 8852, and C31000M.	7.6-cm (3-in.) diam, 20.3-cm (8-in.) length
266 PMT Base	+2500	≤ 1.67	Negative signals $Z_o \sim 1.1 \text{ M}\Omega$; capacitive coupling	Pos signals $Z_o \sim 1.2 \text{ M}\Omega$; capacitive coupling	External control for focus voltage	All 10-stage PMTs that fit standard 14-pin sockets including: Hamamatsu PM55, R208, R550, R594, R877, R878, R1507, R1512, R1513, R1612, R1791, R1836, R1847-07, R1848-07, and 7696. Burle (formerly RCA) 4900, 5819, 6342A, 6655A, S83006E, S83013F, S83019F, S83020F, S83021E, S83022F, S83025F. Philips XP2202B, XP2203B, XP2412B. ADIT B51B01, L51B01, V51B01, B51D01, B51C01, B76B01, V76B01, B76C01 B89B01, B89C01, B89D01, B133D01, B133C01, V133B01.	5.6-cm (2.2-in.) diam, 10.2-cm (4-in.) length
269 PMT Base	-3000	≤ 2	Negative timing signal, 0.5 A; max, 50 Ω dc-coupled	Pos linear signal $Z_o \sim 1 \text{ M}\Omega$; capacitive coupling	Voltage adjust for focus and deflection and for 14th dynode	14-stage PMTs that fit standard 20-pin sockets, including: Hamamatsu, R1828-01, R2059, Philips XP2020, XP2020Q, XP2040, XP2040Q, XP2041, XP2041Q, XP2212B, XP2230B, XP2233B XP2262B. EMI 9813K.	7.6-cm (3-in.) diam, 20.3-cm (8-in.) length
276 PMT Base with Pre-amplifier	+2000	≤ 1.67	Negative signals $Z_o \sim 1 \text{ k}\Omega$; capacitive coupling	Pre-amplifier internally connected to dynode 10; dc-coupled output	External control for focus voltage	(Same as the Model 266 Tube Base)	5.6-cm (2.2-in.) diam, 10.2-cm (4-in.) length
296 ScintiPack PMT Base with Pre-amplifier and HV Supply	+1100	Active dynode voltage regulation	Negative signals $Z_o \sim 1 \text{ k}\Omega$; capacitive coupling	Pre-amplifier internally connected to dynode 10; ac-coupling	Internal HV supply adjustable from +600 V to +1100 V. Focus voltage is 1/2 of dynode 1 voltage.	(Same as the Model 266 Tube Base)	5.6-cm (2.2-in.) diam, 17-cm (6.7-in.) length

265A Photomultiplier Base

- For use with 12-stage PMTs that fit standard 21-pin sockets
- Designed for fast-timing applications
- Excellent pulse fidelity for a wide range of signal currents
- High-impedance linear signal from dynode, and dc-coupled anode signal at 50- Ω impedance for timing
- Excellent for single-photon counting
- Magnetic shield available



The ORTEC Model 265A Photomultiplier Base is a mechanical assembly and a resistive voltage divider network, with appropriate capacitive decoupling, for operation of 12-stage photomultiplier tubes (PMTs). It is particularly suited to applications requiring fast timing or single photon counting. The Model 265A accommodates the following types of PMTs.

12-stage PMTs that fit standard 21-pin sockets, including:

Hamamatsu R329, R1332, R1333

Burle 8575, 8850, C31000M.

These PMTs offer excellent characteristics for both timing and energy resolution. The Model 265A PMT Base structure complements the tube characteristics by maintaining good pulse fidelity through a wide range of signal currents (Fig. 1).

Negative high voltage is applied to the cathode, and the anode is operated essentially at ground potential. This facilitates the incorporation of several

features that augment the fast-timing performance. The anode output is dc-coupled, with the anode connected to ground through a 50- Ω load resistor. This eliminates the base-line shift caused by varying counting rates in ac-coupled systems. It also suppresses reflections by providing back-termination for the anode output connection. Each of the last four dynodes is also available externally through the contacts of the auxiliary connector. These connections allow external voltage stabilization for the last four dynodes of the PMT by using external voltage supplies. Internal trimmer controls permit optimum adjustment of the voltage distributed to the focus electrode, and to the second and twelfth dynodes.

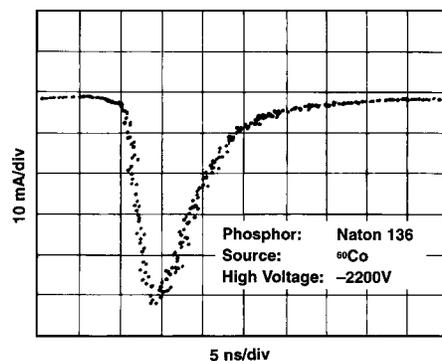


Fig. 1. Typical Anode Output with a Burle 8575 Photomultiplier Tube.

Two outputs are furnished from the Model 265A. The negative signal from the anode is optimized for timing applications, while the positive, linear signal from the ninth dynode is intended for energy measurements. For fast scintillator applications, the anode signal is connected directly to the input of a constant-fraction timing discriminator via a 50- Ω coaxial cable. For single-photon counting a fast amplifier is typically inserted between the anode output and the discriminator. In scintillator applications the ninth dynode output is normally connected to the input of a preamplifier, such as the ORTEC Models 113 or 142IH. The output pulses from the preamplifier are amplified and shaped for energy spectroscopy through an amplifier such as the ORTEC Models 460 or 575A.

Excellent results for both timing and energy measurements can be obtained with fast plastic scintillators, fast liquid scintillators, and NaI(Tl). The Model 265A PMT Base is also ideal for single-photon applications (**ask for Application Note AN51**).

265 Photomultiplier Base

Specifications

PERFORMANCE

All photomultiplier tube specifications are furnished by the PMT manufacturer. The Model 265A Base includes an appropriate voltage divider network for the tube elements.

CONTROLS

Internal adjustments are included for the focus electrode and for the second and twelfth dynodes.

INPUTS

HIGH VOLTAGE -3 kV maximum at 2 mA maximum for bleeder network. SHV connector.

AUXILIARY Last four dynodes are available at pins in the Auxiliary connector for optional external voltage stabilization; MS3112E12-10-S or Bendix PT02E-12-10S connector.

OUTPUTS

ANODE Negative timing signal, 50 Ω , dc-coupled, back-terminated; very good pulse quality for signal currents to 0.5 A with the Burle 8575; BNC connector.

DYNODE Positive linear signal from the ninth dynode, capacitively-coupled, high impedance ($Z_o \sim 1 \text{ M}\Omega$); BNC connector.

ELECTRICAL AND MECHANICAL

WEIGHT (Net)

265A PM Base 0.63 kg (1.4 lb).
218 Shield 0.45 kg (1 lb).

WEIGHT (Shipping)

265A PM Base 1.3 kg (3 lb).
218 Shield 0.9 kg (2 lb).

DIMENSIONS

265A PM Base 7.62 cm (3 in.) diam X 20.32 cm (8 in.) long.
218 Shield 7.62 cm (3 in.) diam; assembled Models 265A and 218, 33.0 cm (13 in.) long.

Related Equipment

The anode timing signal should be furnished to a fast discriminator such as the ORTEC Models 583B, 584, or 935, when using either NaI(Tl), liquid, or plastic scintillators. A Model C-25-12 50- Ω cable assembly is available as an accessory for this purpose.

For single-photon counting insert a fast amplifier, such as the Model VT120, between the anode output and the discriminator input.

The linear output from the ninth dynode is normally processed through an ORTEC Model 113 Scintillation Preamplifier and a shaping amplifier such as the ORTEC Models 460, 570, 572A, or 575A.

An ORTEC Model 218 Magnetic Shield is recommended to reduce the interference from either the earth's magnetic field or from stray-magnetic fields from other equipment.

High voltage, at the level recommended by the manufacturer of the PMT, can be furnished from a high-voltage power supply such as the ORTEC Model 556. The mating cable, C-36-12, is also available for connecting the Model 265A to the Model 556; C-36-12 consists of 3.66 m (12 ft) of RG-59A/U 75- Ω cable with two SHV connectors assembled and ready to use.

Ordering Information

To order the Model 265A Photomultiplier Base or related accessories, use the following model numbers and descriptions:

Model	Description
265A	Photomultiplier Base
218	Magnetic Shield
C-25-12	RG-58A/U 50- Ω Cable with two BNC male plugs, 12-ft length
C-36-12	RG-59A/U 75- Ω Cable with two SHV female plugs, 12-ft length

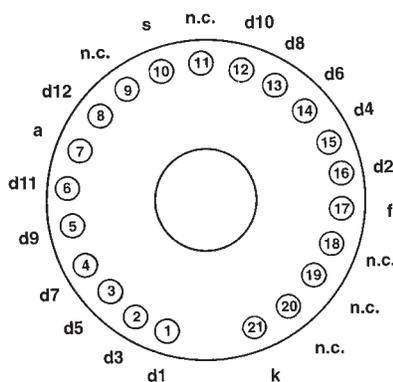


Fig. 2. Pin Assignments.

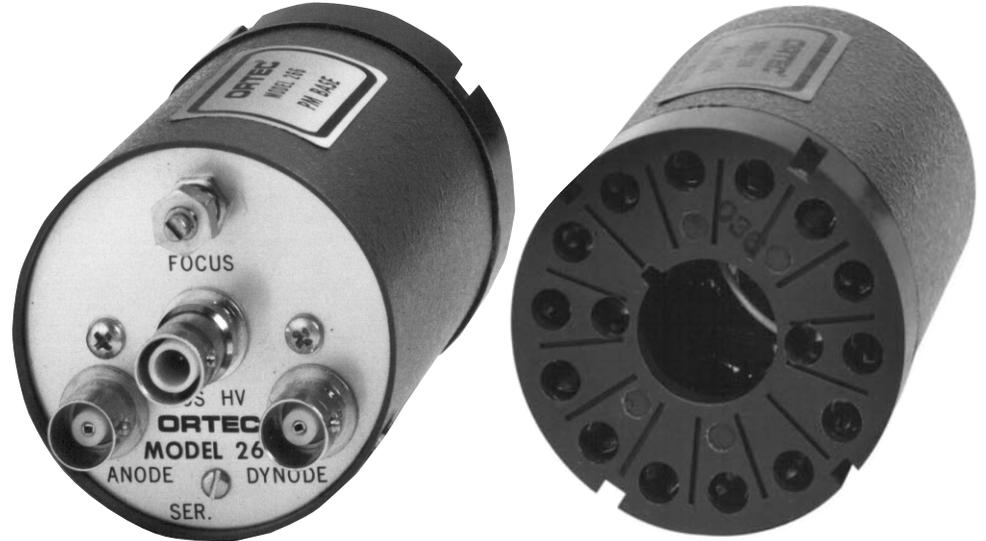
d1 - d12	dynodes 1 to 12
a	anode
n.c.	no connection
f	focus
s	shield
k	cathode

218 Magnetic Shield



An accessory magnetic shield (Model 218) is available for the Model 265A Photomultiplier Tube Base. The magnetic shield isolates the photomultiplier tube from ambient magnetic fields that would introduce error into the output signal; it also isolates the sides of the PMT from ambient light. The magnetic shield complies with standard photomultiplier tube dimensions.

- For use with 10-stage PMTs that fit standard 14-pin sockets
- Linear output available from anode or tenth dynode
- Focus control for optimum performance



The ORTEC Model 266 Photomultiplier Base provides voltage distribution to essentially all 10-stage photomultiplier tubes (PMTs) that fit its standard 14-pin tube socket. It provides capacitively-coupled linear output signals from the anode and the tenth dynode that can be used in either timing or linear pulse height analysis systems. This arrangement allows the use of either polarity of output without an inverting amplifier. High-quality signals are maintained when these outputs are fed through 50-Ω terminated cables or directly into a linear preamplifier such as the ORTEC Model 113 Scintillation Preamplifier. The Model 113 output is fed into one of the ORTEC main amplifiers, where it can be either active-filter- or delay-line-shaped for analysis. The focus control on the Model 266 allows optimum adjustments for the best performance of the particular PMT.

The Model 266 is compatible with most standard 10-stage PMTs that fit standard 14-pin sockets, including those listed in Table 1.

Other compatible tubes may be determined by comparison with those that are listed (also see Figs. 1 and 2). Note that all photomultiplier tube specifications are given by the PMT manufacturer.

Table 1. Compatible Photomultiplier Tubes.

ADIT	Burle (formerly RCA)	Hamamatsu	Phillips	Electron
B51B01	4900	PM55	XP2202	9266K
L51B01	5819	R208	XP2203B	9272K
V51B01	6342A	R550	XP2412B	9250K
B51D01	6655A	R594		9256K
B51C01	S83006E	R877		9305K
B76B01	S83013F	R878		9265K
V76B01	S83019F	R1507		9269K
B76C01	S83020F	R1512		9273K
B89B01	S83021E	R1513		9274K
B89C01	S83022F	R1612		9306K
B89D01	S83025F	R1791		9390K
B133D01		R1836		9275K
B133C01		R1847-07		
V133B01		R1848-07 7696		

Specifications

PERFORMANCE

BLEEDER RESISTANCE 1.5 MΩ total, tapped to provide proportional bias steps to successive tube elements.

CONTROL

FOCUS The voltage to the focus electrode in the tube is available as an external trim adjustment using a screwdriver potentiometer.

INPUTS

POS HV SHV connector accepts positive bias voltage to 2.5 kV maximum.

PMT SOCKET TRW 3B14. Fits JEDEC B14-38 PMT pin base (see Fig. 2).

OUTPUTS

ANODE BNC connector provides negative linear output through $Z_o \sim 1.1 \text{ M}\Omega$, capacitively-coupled.

DYNODE BNC connector provides positive linear output from the tenth dynode through 1.1 MΩ, capacitively-coupled.

ELECTRICAL AND MECHANICAL

WEIGHT

Net 0.37 kg (0.81 lb).

Shipping 0.96 kg (2.12 lb).

DIMENSIONS 5.6 cm (2.2 in.) diam x 10.2 cm (4 in.) long.

Related Equipment

Either the anode or dynode signal may be processed through an ORTEC Model 113 Scintillation Preamplifier that is connected to a main shaping amplifier such as ORTEC Models 450, 460, 570, 571, 572, 575A, or 590A. These signals may also be connected through 50-Ω coaxial cables and amplified by fast amplifiers to be used in timing applications with the ORTEC Model 473A Constant-Fraction Discriminator or other fast discriminators. If one of the outputs is not used, it should be terminated with a C-27 100 Ω terminator to prevent distortion on the other outputs. The ORTEC Model 556 High-Voltage Power Supply is recommended for supplying the positive high voltage. A C-24-1 Cable is recommended for connecting the dynode output to a Model 113 Preamplifier. A

C-24-12 Cable can be used between the preamplifier output and the input to the main shaping amplifier. For timing from the anode use a C-25-12 Cable. The C-36-12 Cable is recommended for the high voltage connection.

Ordering Information

To order the Model 266 Photomultiplier Base or related accessories, use the following model numbers and descriptions:

Model	Description
266	Photomultiplier Base
C-24-1	RG-62A/U 93-Ω Cable with two BNC male plugs, 1-ft length
C-24-12	Same as above, 12-ft length
C-25-12	RG-58A/U 50-Ω Cable with two BNC male plugs, 12-ft length
C-36-12	RG-59A/U 75-Ω Cable with two SHV female plugs, 12-ft length
C-27	Terminator, 100 Ω, BNC male plug

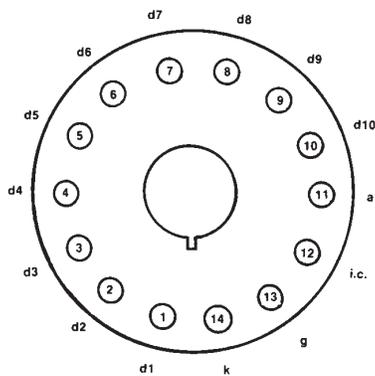


Fig. 2. JEDEC B14-38 PMT Pin Base, with Pin

Assignments:

- d1 – d10 dynodes 1 to 10
- a anode
- i.c. internal connection
- g grid
- k cathode

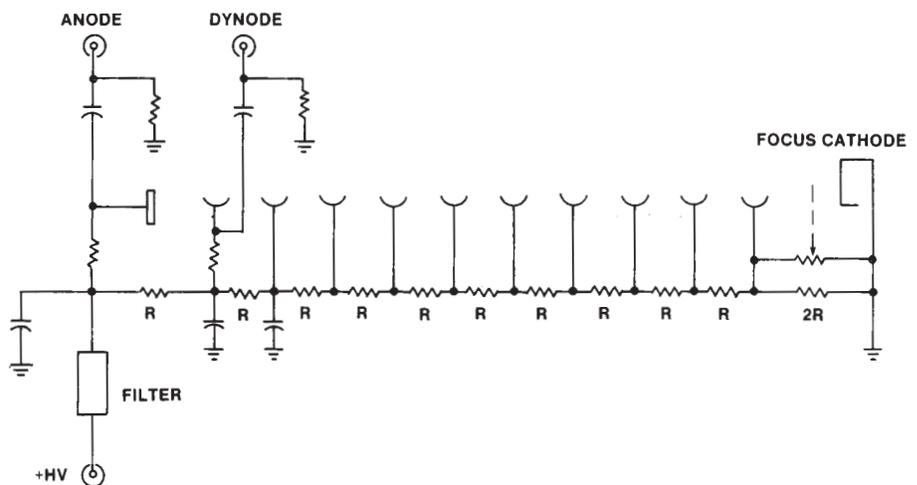


Fig. 1. Simplified Schematic Diagram of ORTEC Model 266 Photomultiplier Base.

Specifications subject to change
100906



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Photomultiplier Base

- For use with 14- and 12-stage PMTs that fit standard 20-pin sockets
- For high-pulse current, fast-timing applications, and energy measurements
- Excellent pulse fidelity for a wide range of signal currents
- Excellent for single-photon counting



The ORTEC Model 269 Photomultiplier Base structure is a mechanical assembly and resistive voltage divider network, with appropriate capacitive decoupling for operation of 14- and 12-stage PMTs that fit standard 20-pin sockets, including:

Hamamatsu R1250.

Philips XP2020, XP2020Q, XP2040, XP2040Q, XP2041, XP2041Q, XP2212B, XP2230B, XP2233B, XP2262B.

EMI 9813K.

Internal trimmer controls permit optimum adjustment of the voltage distributed to the focus and deflection electrodes and to the last dynode.

All of the above photomultiplier tubes are capable of producing high-current timing output pulses, and the Model 269 PMT Base structure complements the tube characteristics by maintaining the excellent pulse fidelity through a wide range of signal currents (Fig. 1).

Two outputs are furnished from the Model 269: the negative signal from the anode is intended for timing or single-photon counting, while the linear signal from the tenth dynode is for energy measurements.

Each of the last four dynodes is also available externally through contacts of the Auxiliary connector. These connections permit external voltage stabilization for the last four dynodes of the PMT.

Excellent results for both timing and energy measurements can be obtained with NaI(Tl), fast liquid scintillators, or fast plastic scintillators. The Model 269 Base is also ideal for single-photon counting applications (**ask for Application Note AN51**).

All photomultiplier tube specifications are furnished by the manufacturer.

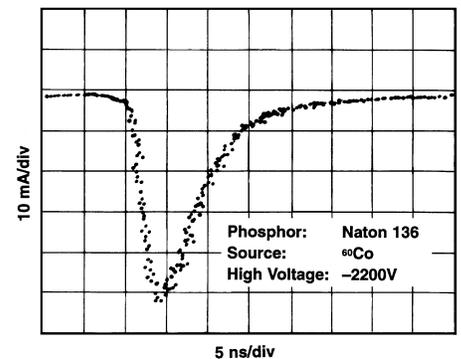


Fig. 1. Typical Anode Output Pulse.

Photomultiplier Base

Specifications

BASE

HIGH VOLTAGE Negative, 3 kV maximum.

BLEEDER CURRENT 2-mA maximum (last four dynodes available for voltage stabilization).

SIGNAL

ANODE Negative timing signal, 50 Ω, dc-coupled, back-terminated; very good pulse quality for signal currents to 0.5 A for Philips tubes.

DYNODE Positive linear signal from the eighth or tenth dynode (pin 13); capacitive-coupled; impedance ~1 MΩ.

INTERNAL CONTROLS Voltage adjustment for focus and deflection electrodes and for the last dynode.

CONNECTORS

ANODE BNC.

DYNODE BNC.

HIGH VOLTAGE SHV AMP 51494-2.

AUXILIARY MS3112E12-10S or Bendix PT02E-12-10S.

PMT SOCKET 20-pin JEDEC B20-102.

Related Equipment

The anode timing signal should be furnished to an ORTEC Fast Discriminator (such as Models 473A, 583, 584, or 935) using a 50-Ω coaxial cable (C-25-12). For single-photon counting insert a fast amplifier, such as the Model 574 or VT120, between the anode output and the discriminator input.

The linear output from pin 13 is normally processed through an ORTEC Model 113 Scintillation Preamplifier and a Shaping Amplifier (such as Models 450, 460, 570, 571, 572, or 575A) for energy spectroscopy.

High voltage, at the level recommended by the manufacturer of the PMT, can be furnished from an ORTEC Model 556 High-Voltage Power Supply. The C-36-12 Cable is available for this connection.

ELECTRICAL AND MECHANICAL

EG&G ORTEC

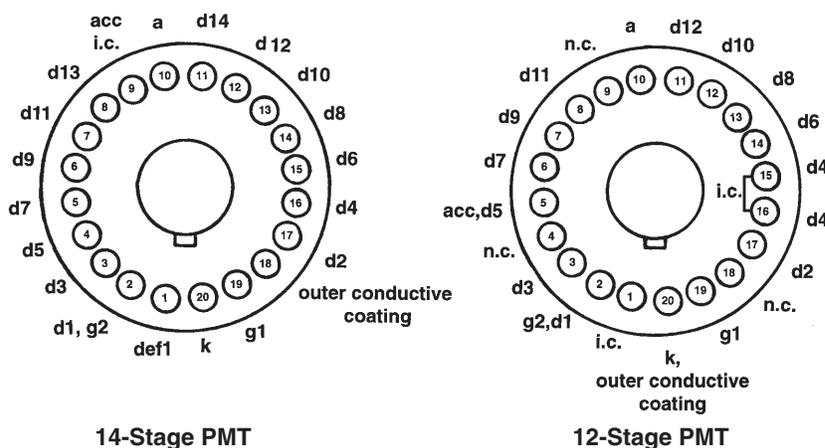
Models	Weights		Dimensions
	Net	Shipping	
269 PM Base	0.63 kg (1.4 lb)	1.37 kg (3.0 lb)	7.62 cm (3 in.) diam 20.32 cm (8 in.) long

Ordering Information

To order the Model 269 Photomultiplier Base or related accessories, use the model numbers and descriptions below:

Model Description

- 269** Photomultiplier Base
- C-25-12** RG-58A/U 50-Ω Cable with two BNC male plugs, 12-ft length
- C-36-12** RG-59A/U 75-Ω Cable with two SHV female plugs, 12-ft length



14-Stage PMT

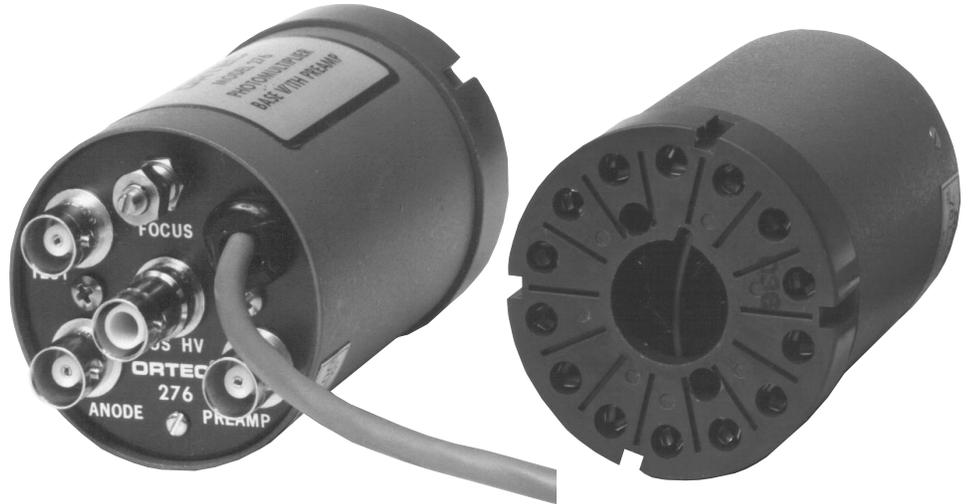
12-Stage PMT

- d1 – d14 dynodes 1 to 14
- a anode
- i.c. internal connection
- n.c. no connection
- defl deflection
- g1 grid 1
- g2 grid 2
- acc accelerator
- k cathode

Fig. 2. The Model 269 Socket Fits the JEDEC B20-102 20-Pin PMT Bases for 14-Stage PMTs (or 12-stage PMTs that have an internal short between pins 15 and 16).

276 Photomultiplier Base with Preamplifier

- For use with 10-stage PMTs that fit standard 14-pin sockets
- Built-in low-noise preamplifier
- Both preamplifier output and anode output
- Test input for system testing
- Protection circuit for internal transistors
- Internal gain adjustment



The ORTEC Model 276 Photomultiplier Tube Base and Preamplifier incorporates an integral low-noise preamplifier, a PMT base with voltage divider network, and a focus control for optimum performance in scintillation detector applications. The unit provides two outputs: the preamplifier output for energy analysis and the anode output for either timing or auxiliary energy analysis. The preamplifier is dc-coupled to simplify pole-zero cancellation in the main amplifier. A Test input accepts the output of a pulse generator to calibrate and test the preamplifier and the following system. The Model 276 has a diode protection network to prevent damage to the internal transistors due to sudden application or removal of high voltage to the unit. A simple internal modification in the unit allows the gain to be adjusted for any value desired by the user. The Model 276 is powered from any ORTEC main amplifier or pre-amplifier power supply.

The Model 276 is directly compatible with 10-stage PMTs that fit standard 14-pin sockets including those listed in Table 1 of the Model 296 data sheet (page 1.11).

The Model 276 is also compatible with other 10-stage tubes not listed in Table 1 (see Fig. 1). Compatibility may be determined by comparison with those listed.

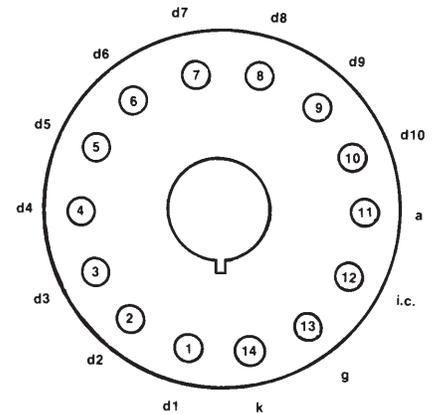


Fig. 1. JEDEC B14-38 PMT Pin Base, with Pin Assignments:

- | | |
|----------|---------------------|
| d1 – d10 | dynodes 1 to 10 |
| a | anode |
| i.c. | internal connection |
| g | grid |
| k | cathode |

276 Photomultiplier Base with Preamplifier

Specifications

PERFORMANCE

PREAMPLIFIER

Integral Nonlinearity $<\pm 0.02\%$, 0 to +10 V.

Temperature Instability $<\pm 0.005\%/^{\circ}\text{C}$, 0 to 50°C .

Output Rise Time <100 ns for test input or fast scintillator.

Output Fall Time Time constant of $50 \mu\text{s}$.

Output Noise $<50 \mu\text{V}$ rms with ORTEC Model 572 Amplifier and time constant of $1 \mu\text{s}$.

Conversion Gain Nominally $5 \mu\text{V}/\text{eV}$ with 2-by 2-in. NaI(Tl) crystal and PMT gain of 10^6 ; the typical output for a 511-keV x ray with a 10-stage PMT gain of 10^5 will be ~ 250 mV.

Saturation Level +10 V into an open circuit; +5 V into $93\text{-}\Omega$ load.

VOLTAGE DIVIDER Resistor-divider connected to 10-stage PMT base. Total resistance $1.49 \text{ M}\Omega$, resulting in bleeder current of 0.6 mA with typical high voltage of 1 kV . The distribution is linear to all stages with the focus adjustment on the grid.

CONTROL

FOCUS Single-turn locking potentiometer on panel for external adjustment of PMT grid potential.

INPUTS

POS HV SHV connector, AMP 51494-2, for distribution of positive high voltage to PMT base; +2000 V maximum.

TEST BNC connector, accepts pulses from an ORTEC pulse generator for testing and calibration.

SIGNAL Preamplifier input is connected internally to dynode 10.

POWER Captive 3-m (10-ft) power cable terminated in Amphenol 17-20090 connector accepts preamplifier operating power; compatible with all ORTEC main amplifiers and the Model 4002P Portable Power Supply.

PM SOCKET TRW 3B14. Fits JEDEC B14-38 PMT pin base (see Fig. 1).

OUTPUTS

PREAMP BNC connector, furnishes preamplifier positive output pulse to an ORTEC main shaping amplifier for linear energy analysis; $Z_o = 93 \Omega$, dc-coupled.

ANODE BNC connector, furnishes negative anode output pulse for use either in timing or auxiliary energy analysis; $Z_o = 1 \text{ k}\Omega$, ac-coupled.

ELECTRICAL AND MECHANICAL

POWER REQUIRED For preamplifier, +24 V, 16 mA ; -24 V , 16 mA ; for PMT base, +2000 V maximum (use rated voltage for the tube that is installed).

WEIGHT

Net 0.65 kg (1.5 lb).

Shipping 1.3 kg (3.0 lb).

DIMENSIONS 5.6 cm (2.2 in.) diam X 10.2 cm (4 in.) long plus 3 m (10 ft) captive power cable.

Accessories

A C-36-12 Cable is required for connection to a high-voltage supply. A C-24-12 Cable is recommended for connecting the preamplifier output to the spectroscopy amplifier. For timing signals from the anode, use a C-25-12 Cable.

Ordering Information

To order the Model 276 Photomultiplier Base with Preamplifier or related accessories, use the following model numbers and descriptions:

Model	Description
276	Photomultiplier Base with Preamplifier
C-24-12	RG-62A/U $93\text{-}\Omega$ Cable with two BNC male plugs, 12-ft length
C-25-12	RG-58A/U $50\text{-}\Omega$ Cable with two BNC male plugs, 12-ft length
C-36-12	RG-59A/U $75\text{-}\Omega$ Cable with two SHV female plugs, 12-ft length

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Matching the Preamplifier to the Detector and the Application

The primary function of a preamplifier is to extract the signal from the detector without significantly degrading the intrinsic signal-to-noise ratio. Therefore, the preamplifier is located as close as possible to the detector, and the input circuits are designed to match the characteristics of the detector. Different pulse processing techniques are typically employed, depending on whether the arrival time or the amplitude (energy) of the detected event must be measured. Pulse shaping for either application is normally implemented in a subsequent module. This module can be located at some distance from the preamplifier, provided that the signal fidelity is not degraded due to the length of the interconnecting coaxial cable.

Several types of detectors produce moderately large signals at their outputs, and this relaxes the restrictions on the noise contribution from the preamplifier. Detectors that typically fall in this category are: photodiodes operating with intense light pulses, photomultiplier tubes (PMT), scintillation detectors (scintillator mounted on a PMT), microchannel plate PMTs, microchannel plates, channeltrons, and electron multipliers. For such detectors, a wideband amplifier with a low input impedance can be used directly at the detector output to generate short, fast-rising pulses for timing or counting purposes. For pulse-amplitude (or energy) spectroscopy, a

relatively inexpensive preamplifier, such as the Model 113 or the Model 142IH, can be used to integrate the charge in the pulse at the detector output.

Detectors with much better resolution are frequently used for energy spectroscopy with x rays, gamma rays, and charged particles. Typical detectors in this category are: Si(Li) (planar), germanium (coaxial, LO-AX™, and planar), silicon charged-particle detectors, and gas proportional counters. Because such detectors produce very small output signals, it is essential that the input stage of the preamplifier contribute little noise. The requirement for low noise and stable sensitivity with these detectors is met by using a charge-sensitive preamplifier with an FET (Field-Effect Transistor) input stage. For silicon charged-particle detectors and proportional counters the entire preamplifier usually is operated at room temperature. However, the excellent resolution of the cooled germanium and Si(Li) detectors necessitates lowering the temperature of the FET input stage of the preamplifier to reduce the noise. Operation at a temperature near 120° K is accomplished by mounting the FET near the detector inside the cryostat. Specifications for these cooled preamplifiers are incorporated with the relevant detector in the ORTEC Detector Catalog. The room-temperature preamplifiers are described on the next few pages. The signal at the output of the charge-sensitive

Preamplifiers

preamplifier can be used for either timing or energy spectroscopy.

ORTEC manufactures a preamplifier to fit your detector, your application, and your budget. The applications information and selection guides in this section will help you to choose the optimum preamplifier for your task.

Preamplifier Types

Three basic types of preamplifiers are available: the current-sensitive preamplifier, the parasitic-capacitance preamplifier, and the charge-sensitive preamplifier. The following paragraphs describe their functions and primary performance characteristics.

Current-Sensitive Preamplifiers

Several detector types, such as photomultiplier tubes and microchannel plates, generate a moderately large and fast-rising output signal through a high output impedance. Pulse processing for timing or counting with these detectors can be rather simple. A properly-terminated 50-Ω coaxial cable is attached to the detector output, so that the current pulse from the detector develops the desired voltage pulse across the 50-Ω load presented by the cable. For scintillators mounted on 14-stage photomultiplier tubes, this voltage signal is usually large enough to drive the input of a fast discriminator without further amplification. For single-photon counting, 10-stage photomultiplier tubes, or microchannel plate PMTs, additional amplification is needed between the detector and the discriminator, and this is the function of the current-sensitive preamplifier.

The 50-Ω input impedance of the current-sensitive preamplifier provides proper termination of the 50-Ω coaxial cable, and converts the current pulse from the detector to a voltage pulse. If the rise time of the preamplifier is negligible compared to the detector rise time, and the voltage gain of the preamplifier is A, the amplitude of the voltage pulse at the preamplifier output will be

$$V_{\text{out}} = 50 I_{\text{in}} A \quad (1)$$

where I_{in} is the amplitude of the current pulse from the detector. For counting applications this signal can be fed to a fast discriminator, whose output is recorded by a counter/timer.

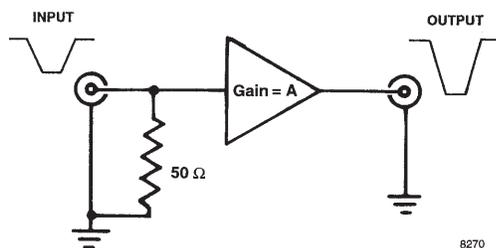


Fig. 1. A Simplified Schematic of the Current-Sensitive Preamplifier.

For timing applications the dominant limitation on timing resolution with photomultiplier tubes and microchannel plates is fluctuation in the transit times of the electrons as they cascade through the detector. This causes a jitter in the arrival time of the pulse at the detector output. However, if the detector signals are small enough to require a current-sensitive preamplifier, the effect of preamplifier input noise on time resolution must also be considered.

The noise added to the signal by the preamplifier causes an uncertainty or jitter in the time at which the pulse crosses the threshold of the timing discriminator. The result is a degradation of the time resolution. Therefore, it is important to choose a current-sensitive preamplifier whose rise time is similar to the rise time of the pulse at the detector output.¹ A preamplifier rise time that is much faster than the detector rise time does not improve the signal rise time. But, it does contribute extra noise, because of the unnecessarily wide bandwidth. This excess noise will increase the timing jitter. Choosing a preamplifier rise time that is much slower than the detector rise time reduces the preamplifier noise contribution, but not enough to overcome the degradation in pulse rise time and amplitude. Consequently, the timing jitter becomes worse.

Although the optimum choice depends on the rise time and amplitude of the detector signal, as well as the characteristics of the preamplifier input stage, a good guideline is to choose a preamplifier rise time that is within a factor of 2 of the detector rise time (faster or slower). Rise times for photomultiplier tubes range from 1.5 to 10 ns, making the Models VT120, 9301, and 9305 Preamplifiers appropriate for consideration. The Model 9306 1-GHz Preamplifier is the optimum choice for timing with the 150-ps rise times encountered with microchannel plate PMTs.

Most fast preamplifiers with gains in excess of 10 must employ ac-coupling between internal amplifying stages to achieve fast rise times and to eliminate dc drift with temperature. This is an excellent solution if the average spacing between pulses is greater than 100 times the individual pulse width. But, when the average spacing between pulses becomes comparable to the pulse width, the ac-coupling causes the baseline between pulses to shift so that the preamplifier output signal circumscribes as much area above ground potential as it does below ground. This effect distorts the amplitude measurement in subsequent modules. The Model 9305 Preamplifier offers a solution to this problem in cases where lower gain ($A=10$) and a slightly slower rise time (3 ns) is acceptable. The Model 9305 is dc-coupled and exhibits excellent dc stability. By operating a photomultiplier tube with the cathode at high voltage, the anode can be dc-coupled to the input of the Model 9305 Preamplifier. This scheme eliminates the baseline shift at high counting rates, and permits operation at much higher counting rates.

¹S. Cova, M. Ghioni, and F. Zappa, *Rev. Sci. Instrum.* **62** (11), Nov. 1991, pp. 2596–2601.

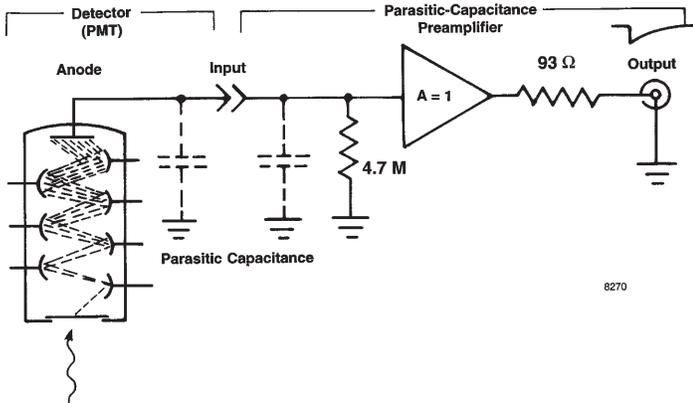


Fig. 2. A Simplified Diagram of the Parasitic-Capacitance Preamplifier.

Most current-sensitive preamplifiers designed for timing applications have ac-coupled time constants in the range of a few hundred nanoseconds. This makes them unsuitable for use with the *FASTFLIGHT*[™] Digital Signal Averager, due to noticeable undershoot after each pulse. The model 9326 overcomes that limitation by offering a low-frequency roll-off at an exceptionally low 10 kHz.

Parasitic-Capacitance Preamplifiers

Photomultiplier tubes, electron multipliers, microchannel plates, and microchannel plate PMTs produce moderately large output signals with very fast rise times. Therefore, the most cost-effective preamplifier for pulse-amplitude measurements or energy spectroscopy with these detectors is the parasitic-capacitance preamplifier illustrated in Fig. 2.

Parasitic-capacitance preamplifiers have a high input impedance (~5 MΩ). Hence, the current pulse generated by the detector is integrated on the combined parasitic capacitance present at the detector output and the preamplifier input. This combined capacitance is typically 10 to 50 pF. The resulting signal is a voltage pulse having an amplitude proportional to the total charge in the detector pulse, and a rise time equal to the duration of the detector current pulse. A resistor connected in parallel with the input capacitance causes an exponential decay of the pulse with a time constant ~50 μs. An amplifier having a high input impedance and unity gain is included as a buffer to drive the low impedance of a coaxial cable at the output. The 93-Ω resistor in series with the output absorbs reflected pulses in long cables by terminating the cable in its characteristic impedance.

Parasitic-capacitance preamplifiers are not used with semiconductor detectors because the gain of this type of preamplifier is sensitive to small changes in the parasitic capacitance. For partially-depleted semiconductor detectors the detector capacitance varies with the bias voltage applied to the detector diode. In addition, small movements of the interconnecting cable can change the input capacitance by a few tenths of a pF. The gain changes caused by these effects are significant for semiconductor detectors, which have energy

resolutions better than 1%. However, parasitic-capacitance preamplifiers, such as the ORTEC Model 113, provide more than adequate performance with photomultiplier tubes, microchannel plate PMTs, or scintillation detectors, and are highly recommended for those applications.

Charge-Sensitive Preamplifiers

These preamplifiers are preferred for most energy spectroscopy applications. The signal from a semiconductor detector or ion chamber is a quantity of charge delivered as a current pulse lasting from 10⁻⁹ to 10⁻⁵ s, depending on the type of detector and its size. For most applications the parameters of interest are the quantity of charge and/or the time of occurrence of an event. A charge-sensitive preamplifier (Fig. 3) can deliver either or both. Because it integrates the charge on the feedback capacitor, its gain is not sensitive to a change in detector capacitance, and in the ideal case, the rise time of the output pulse is equal to the detector current pulse width.

The output voltage from the preamplifier has an amplitude V_o , and a decay time constant τ_f , given respectively by

$$V_o = \frac{Q_D}{C_f} \text{ and } \tau_f = R_f C_f \quad (2)$$

where Q_D is the charge released by the detector, C_f is the feedback capacitor (0.1 to 5 pF), and R_f is the feedback resistor. R_f is a noise source and in direct-coupled system, is made as large as possible consistent with the signal energy-rate product and the detector leakage current. The preamplifier package is kept small to permit mounting it as close as practical to the detector, thus reducing input capacitance caused by cabling and decreasing microphonic noise, ground loops, and radio frequency pickup, all of which are sources of noise for the charge-sensitive preamplifier.

In the selection chart, sensitivity is generally expressed in mV per MeV of energy deposited in a given detector material. The charge released by the detector is a function of the photon or particle energy and the detector material, and is given by

$$Q_D = \frac{E e \times 10^6}{\epsilon} \quad (3)$$

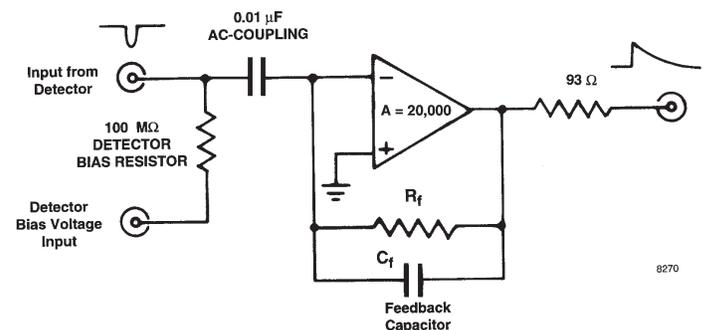


Fig. 3. Simplified Schematic of the AC-Coupled Charge-Sensitive Preamplifier. (For a dc-coupled preamplifier, the detector bias resistor is removed, and the 0.01 μF capacitor is replaced by a wire.)

Preamplifiers

where E is the energy in MeV of the incident radiation, e is the charge of an electron (1.6×10^{-19} coulomb), 10^6 converts MeV to eV, and ϵ is the amount of energy required to produce an electron-hole pair in the detector. Approximate values for ϵ for various detectors are given in Table 1. For the special case of a proportional counter, the right hand side of Equation (3) must be multiplied by the gas gain of the proportional counter.

Table 1. Values of ϵ for Various Detectors.

Detector	ϵ (eV)
Silicon	3.62 (300° K)* to 3.71 (77° K)
Germanium	2.96 (77° K)
Proportional Counters	
Argon	26.4
Methane	29.2

*Values in parentheses are temperatures at which the energy values were determined.

From Eqs. (2) and (3) the output voltage produced by a charge-sensitive preamplifier is

$$V_o = \frac{E(10^6)(1.6 \times 10^{-19})}{C_f \epsilon} \quad (4)$$

Therefore, the preamplifier gain can be expressed as

$$\frac{V_o}{E} = \frac{e(10^6)}{C_f \epsilon} \quad (5)$$

The sensitivity of a preamplifier with $C_f = 1 \times 10^{-12}$ F connected to a room-temperature silicon detector is

$$\frac{V_o}{E} = \frac{(1.6 \times 10^{-19})(10^6)}{(1 \times 10^{-12})(3.62)} = \frac{44 \text{ mV}}{\text{MeV}} \quad (6)$$

The input of the preamplifier appears as a large capacitor to the detector because the effect of the feedback capacitor at the input is magnified by the open loop gain of the charge loop. This input capacitance must be much greater than the other sources of capacitance connected to the preamplifier input (such as the detector or input cabling) in order for the preamplifier sensitivity to be unaffected by external capacitance changes. Since C_f is generally $\sim 1 \times 10^{-12}$ F, the preamplifier open loop gain must be very large, usually greater than 10,000. The stability of the preamplifier sensitivity is dependent on the stability of C_f (the feedback capacitor), and the preamplifier open loop gain. C_f is selected for good temperature stability, and the open loop gain is made very large so that small changes in it can be neglected. Preamplifier sensitivity variations can contribute to the error in measuring the energy of the detected radiation.

Noise in charge-sensitive preamplifiers is generally controlled by four components: the input field effect transistor (FET), the total capacitance at the input (C_f , the detector capacitance, etc.), the resistance connected to the input, and input leakage currents from the detector and FET. The FET is selected for low-noise performance, and in some applications it is cooled to near liquid-nitrogen temperature to improve its performance. In cooled-FET applications the detector and preamplifier are generally built as an integral assembly. With room-temperature preamplifiers, the user controls the major sources of input capacitance in most applications, because the preamplifier is designed with minimum internal circuit capacitance. These sources are from the detector selected for an experiment and from the cabling between the preamplifier and the detector. Figure 4 is a graph showing the noise versus external capacitance for a typical preamplifier.

The noise of a charge-sensitive preamplifier can be measured by the system shown in Fig. 5. Charge Q , equivalent to the known energy, E , must be injected into the preamplifier, and the amplitude of the pulse V_p resulting from this charge must be measured at the output of the filter amplifier to determine the system gain V_p/E . The charge can be injected by a detector and radiation source or a step pulse generator

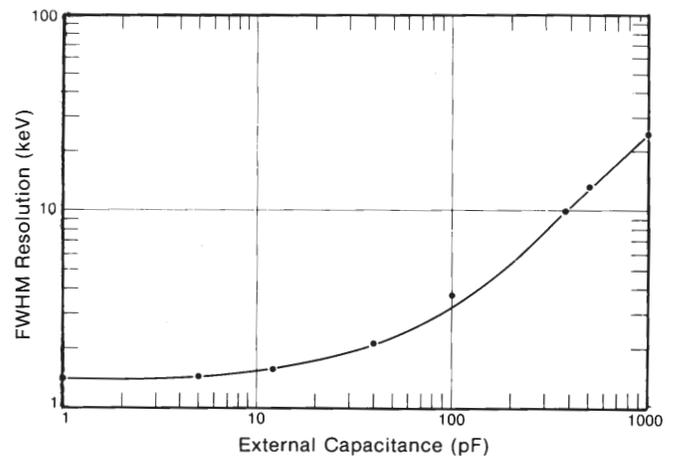


Fig. 4. Noise vs. External Capacitance for a Typical Charge-Sensitive Preamplifier.

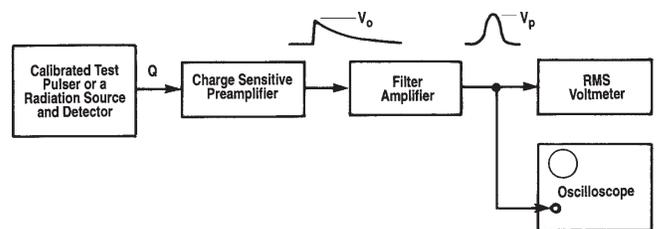


Fig. 5. System for Measuring Charge-Sensitive Preamplifier Noise.

connected to the preamplifier input through a capacitor, sometimes referred to as a charge terminator. The preamplifier noise can be determined by measuring the root-mean-square (rms) noise voltage V_{rms} at the output of the filter amplifier in the absence of any pulses, and using the following equation:

$$\text{FWHM noise} = 2.35 \frac{E}{V_p} V_{rms} \quad (7)$$

Charge-sensitive-preamplifier noise performance is generally specified as the full width at half maximum (FWHM) of the energy line generated in the spectrum by a test pulser injecting charge into the preamplifier input. This value is normally given in keV. The parameter V_{rms} must be multiplied by 2.35 to convert it to a FWHM specification.

The rise time of the voltage pulse V_o at the output of the charge-sensitive preamplifier, in the ideal case, is equal to the charge collection time of the detector. When detectors with very fast collection times or large capacitances are used, the preamplifier itself may limit the rise time of V_o . If a time reference mark is being determined from V_o , it is desirable that the rise time t_r of V_o be as short as possible. For silicon detectors, the time resolution of the timing system following charge-sensitive preamplifiers is generally limited by the ratio of the FWHM preamplifier output noise e_{no} to the slope dV_o/dt of V_o at the timing threshold:

$$\text{timing resolution (FWHM)} = e_{no}/(dV_o/dt) \quad (8)$$

A plot of a charge-sensitive-preamplifier output rise time versus detector capacitance is shown in Fig. 6. It is desirable to keep the external capacitance at a minimum to obtain the best timing resolution, as well as the best energy resolution.

To estimate the maximum counting rate r_{max} that can be accommodated by a charge-sensitive preamplifier at a particular energy, it is necessary to identify the type of preamplifier being considered (see IEEE Standard 301-1988). With charged-particle detectors, the signal is normally extracted from the same detector electrode that accepts the

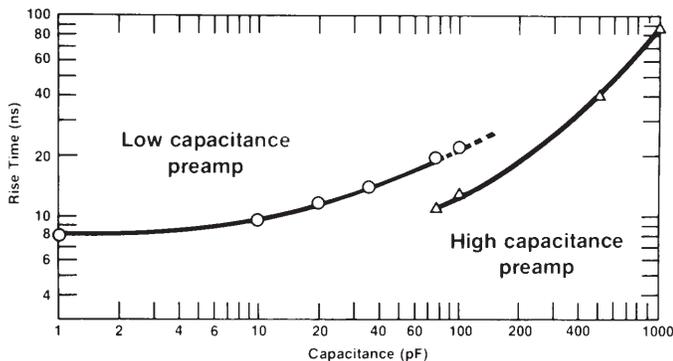


Fig. 6. Typical Rise Time as a Function of Input Capacitance.

bias voltage, and the preamplifier input is ac-coupled to the detector. The maximum counting rate tolerated by ac-coupled preamplifiers ($r_{max,ac}$) is controlled by the signal fluctuations and the maximum voltage V_m allowed at the charge loop output:

$$r_{max,ac} = \frac{1.2 V_m^2 \epsilon^2 C_f \times 10^{25}}{E^2 R_f} \quad (9)$$

The units are: $r_{max,ac}$ in s^{-1} , V_m in volts, ϵ in eV, E in MeV, C_f in farads, and R_f in ohms. If the "energy-squared count-rate product" (i.e., $E^2CRP = E^2 r_{max,ac}$) is listed for the ac-coupled preamplifier, the maximum counting rate tolerated at the energy E can be calculated by dividing the E^2CRP value by E^2 .

The charge-sensitive preamplifiers used with germanium gamma-ray detectors and Si(Li) x-ray detectors are normally dc-coupled to the detector. For dc-coupled preamplifiers, the maximum counting rate accommodated at the energy E is controlled by R_f and V_m .

$$r_{max,dc} = \frac{\epsilon V_m \times 6.25 \times 10^{12}}{E R_f} \quad (10)$$

If the "energy count-rate product" (i.e., $ECRP = E r_{max,dc}$) is specified for the dc-coupled preamplifier, the maximum counting rate tolerated at the energy E can be calculated by dividing the ECRP value by E .

With pulsed-reset preamplifiers (see Amplifiers tutorial), the maximum counting rate limit for the preamplifier is the counting rate at which the percent dead time caused by the resetting becomes intolerable. The percent dead time resulting from preamplifier resetting is computed from

$$\text{Percent Reset Dead Time} = 100 E r T_{reset}/E_{reset} \quad (11)$$

where r is the counting rate of the events of energy E , E_{reset} is the total energy accepted between resets, and T_{reset} is the dead time caused by each reset. A rough approximation for T_{reset} can be obtained by adding the preamplifier reset time to the amplifier overload recovery time. Typically, amplifier overload recovery from the large reset pulse is the major contribution to the reset dead time.

Creating a Differential Output to Cancel Environmental Noise

When the coaxial cable connecting the preamplifier output to the shaping amplifier input is long and the cable runs through an electrically noisy environment, it is advantageous to employ differential signal transmission. Several amplifiers (Models 450, 671, 672, 973, and 973U) offer differential inputs for this purpose. A few preamplifiers include differential outputs to accommodate this function. If the preamplifier does not provide differential outputs, the box depicted in Figure 7 can be used to create a differential output.

Preamplifiers

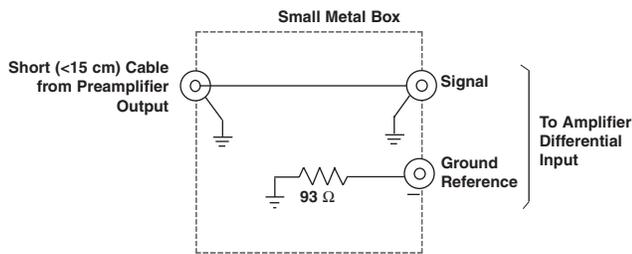


Fig. 7. An Add-On Box to Convert a Single Preamplifier Output to a Differential Output.

All the components shown in Figure 7 are mounted in a small metal box located close to the preamplifier. Care must be exercised to ensure low-impedance grounds. The input on the left side of the box is connected to the normal preamplifier signal output with a coaxial cable that is as short as possible. This short cable must provide a low impedance path from the preamplifier ground to the metal box. The center conductor of this short cable transmits the normal preamplifier output signal through the box to the normal input of the shaping amplifier. The 93-Ω resistor in the box is used to transmit the preamplifier ground signal to the differential reference input of the amplifier. Both the “normal” and the “differential reference” cables are RG-62A/U, 93-Ω coaxial cables. Thus, the 93-Ω resistor in the box provides reverse termination of the differential reference cable. This termination matches the 93-Ω reverse termination included inside the preamplifier for the normal output signal.

To ensure that both cables are affected in the same way by electrical interference, the two cables are twisted together in a spiral as they are routed to the amplifier. When connected to the amplifier inputs, the normal signal includes the desired preamplifier signal plus any interfering noise from ground loops or the environment. The differential reference signal includes only the interfering noise. Hence, when the amplifier subtracts the differential reference from the normal signal, the interfering noise is removed from the signal. Amplifiers with differential inputs usually incorporate a differential gain balancing adjustment to allow matching of the gains on the two inputs for exact cancellation of the interfering noise.

Whatever your application, the following selection charts will help you choose the appropriate ORTEC preamplifier.

Preamplifier Applications Guides

Semiconductor Charged-Particle Detectors

Application	Recommended Preamplifier
Energy or Timing Spectroscopy	Models 142A, 142B, or 142C are best. Final choice depends on capacitance of detector. Also see Model 142AH for special applications.
General	Model 142IH, a general-purpose, economical choice.

Proportional Counters and Ionization Chambers

Application	Recommended Preamplifier
Energy Spectroscopy, or Counting	Model 142PC is optimum. Model 142IH is the most cost-efficient choice for general-purpose applications.

Photomultiplier Tubes, Electron Multipliers, Scintillation Detectors, Microchannel Plate PMTs, Microchannel Plates, Channeltrons, and Photodiodes

Application	Recommended Preamplifier
Time Spectroscopy	<p>Model VT120 (0 to -5 V output; rise time <1 ns) is the best for fast PMTs and Electron Multipliers. It can also be used with Photodiodes, Microchannel Plate PMTs, Microchannel Plates, and Channeltrons.</p> <p>Model 9301 has ±0.7 V output, rise time <1.5 ns.</p> <p>Model 9305 has variable gain, ±5 V output drive, dc-coupled (for high count rates), rise time <3 ns.</p> <p>Model 9306 (0 to -2 V output; rise time = 350 ps) is best for Microchannel Plates and Channeltrons. It can also be used with fast PMTs and Photodiodes.</p> <p>Model 9326 (+0.25 to -1 V output; rise time <1 ns) is ideal for use with the FASTFLIGHT Digital Signal Averager, due to the 10 kHz low-frequency roll-off.</p>
Energy Spectroscopy	<p>Models 142A and 142AH are the ideal choices for Channeltrons, Microchannel Plate PMTs, Microchannel Plates, and Photodiodes.</p> <p>Model 113 is a low-cost solution for PMTs and Scintillation detectors.</p> <p>Model 142IH is a general-purpose, economical choice.</p>

Preamplifier Selection Guides

These charts are intended as selection guides only. For complete and precise specifications, consult the data sheets for each model.

Charged-Particle Spectroscopy with Semiconductor Detectors

Model No.	For Detector Type	Features	Sensitivity		Equivalent Input Noise (FWHM)*Energy		Rise Time (ns at pF)	Range (MeV)*	E ² CRP (MeV ² /s)*	Detector Bias Resistor (MΩ)	Maximum Detector Bias Voltage (Volts)
			(mV/MeV)	(μV/e-h pair)	keV at pF	Electrons at pF					
142A	Si	Excellent timing and low noise for 0 to 100 pF detectors; high sensitivity and small size	45	0.16	<1.6 at 0 <3.4 at 100	442 at 0 939 at 100	<5 at 0 <12 at 100	0–200	1.5 x 10 ⁷	100 or 10	±1000
142B	Si	Excellent timing and low noise for detector capacitances >100 pF; small size	20	0.07	<3.2 at 100 <19 at 1000	884 at 100 5249 at 1000	<5 at 100 <25 at 1000	0–100	3 x 10 ⁷	100 or 10	±1000
142C	Si	Excellent timing and low noise for detector capacitances >400 pF; small size	20	0.07	<7.2 at 400 <27 at 2000	1989 at 400 7459 at 2000	<11 at 400 <20 at 1000	0–400	3 x 10 ⁷	100 or 10	±1000
142AH	Si	Excellent timing and low noise for deep detectors; high bias voltage capability and high sensitivity	45	0.16	<1.75 at 0 <3.6 at 100	483 at 0 994 at 100	<5 at 0 <12 at 100	0–100	1.5 x 10 ⁷	100	±5000
142IH	Si	General-purpose, low-cost preamplifier	45	0.16	1.9 at 0 4.6 at 100 35 at 1000	524 at 0 1270 at 100 9660 at 1000	<20 at 0 <50 at 100	0–100	7 x 10 ⁷	100 or 10	±3000

*Energies are referenced to 3.62 eV/e-h pair in silicon detectors and 2.96 eV/e-h pair in germanium detectors.

Spectroscopy With Proportional Counters

Model No.	Type	Features	Sensitivity	Equivalent Input Noise		Rise Time (ns at pF)	Output Linear Range (V)	Detector Bias Resistor (MΩ)	Detector Bias Voltage (Volts)
			(μV/ Electron-ion pair)	FWHM* (Electrons at pF)	rms* (Electrons at pF)				
142IH	PC	General-purpose, low-cost preamp suitable for use with charged-particle detectors, scintillation detectors, or proportional counters	0.16	524 at 0 1270 at 100	223 at 0 540 at 100	<20 at 0 <50 at 100	±7	100 or 10	±3000
142PC	PC	Low-noise, high-gain, charge-sensitive unit designed for use with proportional counters	1.0	<800 at 0 <1140 at 100	<340 at 0 <485 at 100	25 at 0 150 at 100	±7	30	±3000

*Note: FWHM = 2.35 X rms

Preamplifiers

Energy Spectroscopy With Scintillation Detectors, PMTs, Electron Multipliers, Microchannel Plates, Microchannel Plate PMTs, Channeltrons, and Photodiodes

Model No.	Features	Sensitivity ($\mu\text{V}/\text{Electron}$)	Noise (rms)	Rise Time (ns)	Output Linear Range (V)
113	Economical parasitic-capacitance preamplifier with selectable input capacitance to vary sensitivity	3.6×10^{-3} to 1.5×10^{-4}	Output noise: $<100 \mu\text{V}$	<60	± 7
142A	Fast rise time, charge-sensitive preamplifier for energy and time spectroscopy with microchannel plates, channeltrons, and photodiodes	1.6×10^{-1}	Input noise: 188 electrons at 0 pF 400 electrons at 100 pF	<5 at 0 pF <12 at 100 pF	± 7
142AH	Use instead of Model 142A when a 1000-V to 3000-V bias voltage must be supplied through the preamplifier	1.6×10^{-1}	Input noise: 206 electrons at 0 pF 423 electrons at 100 pF	<5 at 0 pF <12 at 100 pF	± 7
142IH	General-purpose, charge-sensitive preamplifier; insensitive to variations in detector capacitance	1.6×10^{-1}	Input noise: 223 electrons at 0 pF 540 electrons at 100 pF	<20 at 0 pF <50 at 100 pF	± 7
276 (see index)	Parasitic-capacitance preamplifier incorporated in a 14-pin PMT base for 10-stage PMTs	1.6×10^{-3}	Output noise: $<50 \mu\text{V}$	<100	0 to +10
296 (see index)	Parasitic-capacitance preamplifier incorporated with a detector bias supply in a 14-pin PMT base for 10-stage PMTs	2.7×10^{-4} or 1.6×10^{-3}	Output noise $<300 \mu\text{V}$	<100	0 to +6.5

Fast Timing and Fast Counting With Scintillation Detectors, Photomultiplier Tubes, Electron Multipliers, Microchannel Plates, Microchannel Plate PMTs, Channeltrons, and Photodiodes

Model No.	Features	Gain (V/V)	Input Impedance (Ω)	Equivalent Input Noise ($\mu\text{V rms}$)	Output Rise Time (ns)	Coupling	Output Linear Range (V)
VT120 A/B/C	Very fast rise time for use with PMTs, microchannel plates, microchannel plate PMTs, channeltrons, electron multipliers, and photodiodes	A: 200 B: -200 C: 20	50	<20	<1	ac	0 to -5
9301	Very fast rise time for use with PMTs, microchannel plates, microchannel plate PMTs, channeltrons, electron multipliers, and photodiodes	10	50	<25	<1.5	ac	$>\pm 0.7$
9305	Fast rise time for use with PMTs and electron multipliers. DC-coupled for baseline stability at high counting rates.	Variable 5 to 10	50	<30	<3	dc	± 5
9306	Ultra-fast rise time for use with microchannel plate PMTs, microchannel plates, channeltrons, and photodiodes	100	50	<100	0.35	ac	0 to -2
9326	Very fast rise time, and 10-kHz low-frequency roll-off for use with FASTFLIGHT in TOFMS. Use with microchannel plates, PMTs, electron multipliers, channeltrons, and photodiodes	Selectable 5, 10 or 20	50	<100	<1	ac	0 to -1

Scintillation Pre-amplifier

- Designed for photomultiplier tubes
- Input capacitance switch for selectable sensitivity
- Input protected
- Economical



The ORTEC Model 113 Scintillation Pre-amplifier is designed for use with dynode or anode signals from photomultiplier tubes. The charge in the photomultiplier output pulse is integrated on the input capacitance of the pre-amplifier to produce a voltage pulse. A non-inverting voltage amplifier (gain ≈ 1) drives this pulse into the output load. Switch selection of the input capacity permits control of the sensitivity of the pre-amplifier. The input capacity of the Model 113 is ~ 45 pF plus the capacity selected by a front-panel switch (0, 100, 200, 500, or 1000 pF).

The Model 113 should be used with a shaping main amplifier, such as ORTEC Model 460, 570 Series, 671, 672, and 590A.

A diode network prevents destruction of the input transistor if a sudden positive or negative high voltage is applied to the input.

Specifications

PERFORMANCE

RISE TIME < 60 ns.

PREAMPLIFIER FALL TIME Fall time constant is designed for $50 \mu\text{s}$, assuming a signal source impedance of $1 \text{ M}\Omega$.

INTEGRAL NONLINEARITY $\leq \pm 0.02\%$.

TEMPERATURE COEFFICIENT $\pm 0.01\%/^{\circ}\text{C}$, 0 to 50°C .

COUNTING RATE The gain shift of a 250-mV reference pulse is $< 0.25\%$ with the application of an additional count rate of 65,000 counts/s of 200-mV random pulses.

NOISE < 0.1 mV rms at output.

CONTROL

INPUT CAP Switch selects desired input capacity: 0, 100, 200, 500, or 1000 pF.

INPUTS

INPUT BNC connector; isolated for 1000 V; positive or negative polarity; input impedance is 45 pF plus the capacity selected by the front-panel switch (0, 100, 200, 500, or 1000 pF), shunted by the resistance needed to preserve a $50\text{-}\mu\text{s}$ decay time constant (see Fig. 1).

TEST BNC connector accepts a pulse generator output with fast rise and slow decay to check operation of the electronics; input impedance 100Ω .

OUTPUT

BNC connector; output impedance adjustable from 40 to 140Ω . Output saturation level ± 10 V into open circuit; ± 5.1 V into $100\text{-}\Omega$ load. Linear output ± 7 V into open circuit; ± 3.5 V into $100\text{-}\Omega$ load.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V dc, 17 mA; -24 V dc, 17 mA. Supplied through ORTEC's 121-C1 cable (furnished) from any ORTEC main amplifier or pre-amplifier power supply.

WEIGHT

Net 0.65 kg (1.5 lb).

Shipping 1.05 kg (2.3 lb).

DIMENSIONS 4.5 X 10.2 X 15.3 cm (1.75 X 4 X 6 in.).

Related Equipment

The Model 113 can be operated with any ORTEC shaping main amplifier. Test input pulses can be furnished from any ORTEC Pulse Generator.

Ordering Information

To order, specify:

Model	Description
113	Scintillation Pre-amplifier

Suggested cable accessories:

C-24-1/2	RG-62A/U 93- Ω Cable with two BNC male plugs; 6-in. length
C-24-12	RG-62A/U 93- Ω Cable with two BNC male plugs; 12-ft length

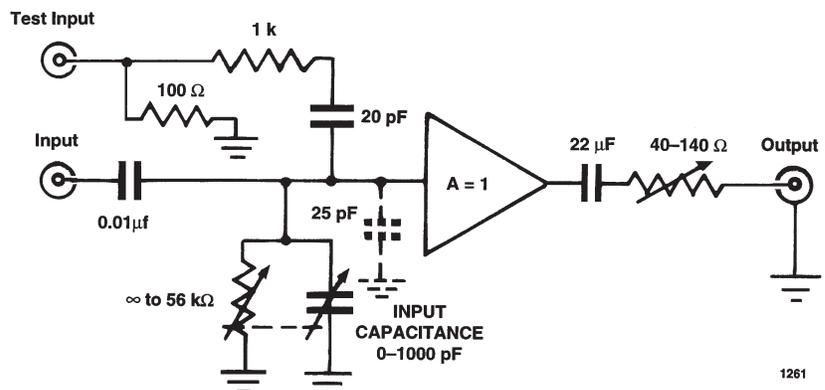


Fig. 1. Simplified Schematic of the Model 113.

142A, B, and C Preamplifiers

The ORTEC Models 142A, 142B, and 142C Preamplifiers are low-noise, fast-rise-time, charge-sensitive pre-amplifiers designed for optimum performance with charged-particle or heavy-ion detectors.

The Model 142A is optimized for extremely low noise and fast timing for detectors with capacitance up to 100 pF. This makes it the ideal selection for high-resolution alpha- and beta-particle spectroscopy applications.

Model 142B is optimized for extremely low noise and fast timing for detectors with capacitance greater than 100 pF but less than 400 pF.

Model 142C is optimized for extremely low noise and fast timing for detectors with capacitance greater than 400 pF.

These preamplifiers have a separate fast-timing output with pulse widths of ~50 ns and rise times ranging from less than 5 ns for 0 pF detectors to less than 20 ns for 1000 pF detectors. This timing output, when used in conjunction with ORTEC's standard electronics, provides excellent time resolution (Fig. 1); also, its fast-differentiated shape often permits direct coupling to the timing discriminator.

The performance of many spectroscopy systems can be enhanced by these preamplifiers being able to operate in vacuum enclosures. This allows the input cable length to be minimized. The

small size of the preamplifiers is of significant importance when operating in such enclosures due to the limited space available.

Specifications

PERFORMANCE*

NOISE (see Fig. 2)

Model	Detector Capacitance (pF)	Maximum Noise (keV) (Si)
142A	0	1.60
142A	100	3.40
142B	100	3.20
142B	1000	19.00
142C	400	7.20
142C	1000	14.50
142C	2000	27.00

INTEGRAL NONLINEARITY $\leq 0.03\%$, 0 to ± 7 V open circuit or ± 3.5 V terminated in 93Ω .

TEMPERATURE INSTABILITY

142A $< \pm 50$ ppm/ $^{\circ}\text{C}$ from 0 to 50°C .

142B $< \pm 100$ ppm/ $^{\circ}\text{C}$ from 0 to 50°C .

142C $< \pm 100$ ppm/ $^{\circ}\text{C}$ from 0 to 50°C .

OPEN LOOP GAIN

142A $> 40,000$.

142B $> 80,000$.

142C $> 80,000$.

CHARGE SENSITIVITY (Si equivalent)

142A Nominally 45 mV/MeV.

142B Nominally 20 mV/MeV.

142C Nominally 20 mV/MeV.

*Performance specifications apply to E output unless stated otherwise.

- Optimum performance for (A) low-, (B) medium-, and (C) high-capacitance charged-particle or heavy-ion detectors
- Extremely low noise
- Accepts 0 to ± 1 kV bias
- Separate fast-timing output signal with rise time from < 5 ns
- Operates in vacuum
- Small size

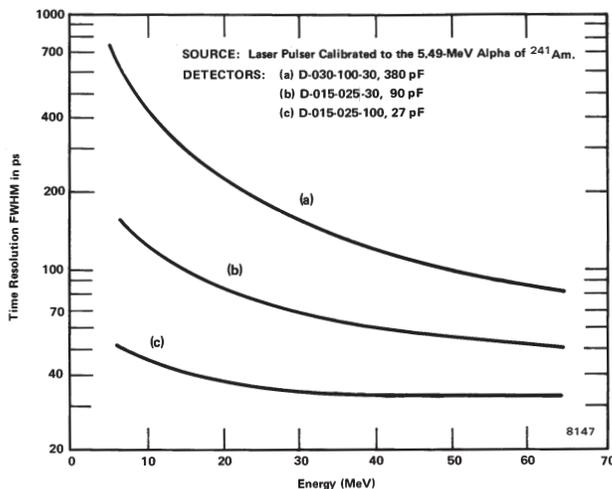


Fig. 1. Typical Time Resolution vs. Energy for Different Capacitance Detectors Using ORTEC Standard Electronics.

142A, B, and C Preamplifiers

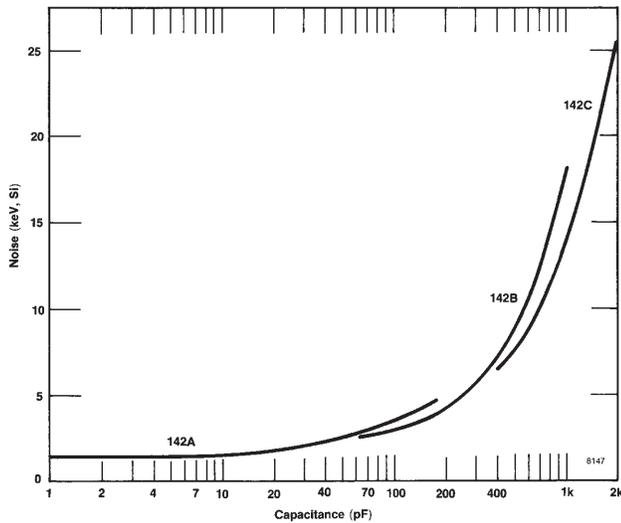


Fig. 2. Typical Noise as a Function of Input Capacitance Measured with an ORTEC Model 572 Amplifier and 2- μ s Time Constant.

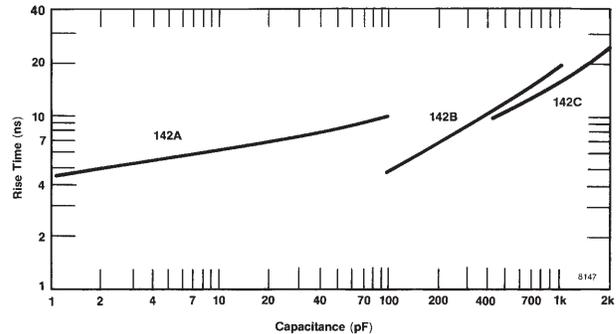
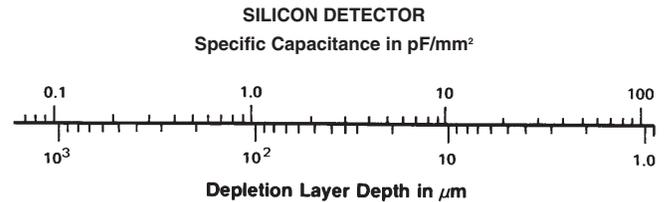


Fig. 3. Typical Rise Time as a Function of Input Capacitance with Rise Time Compensation Optimized at Each Data Point. (Values given are for a +0.5-V signal into 93 Ω from the E channel.)



ENERGY RANGE

142A 0–200 MeV.

142B 0–400 MeV.

142C 0–400 MeV.

E²CRP Maximum energy-squared count-rate product:

142A 1.5×10^7 MeV²/s.

142B 3×10^7 MeV²/s.

142C 3×10^7 MeV²/s.

RISE TIME (0 to 0.5 V pulse at E output on 93- Ω load)

142A <5 ns at 0 pF; <12 ns at 100 pF.

142B <5 ns at 100 pF; <25 ns at 1000 pF.

142C <11 ns at 400 pF; <20 ns at 1000 pF.

DECAY TIME

142A Nominally 500 μ s.

142B Nominally 1000 μ s.

142C Nominally 1000 μ s.

RECOMMENDED RANGE OF INPUT CAPACITANCE

142A 0 to 100 pF.

142B 100 to 400 pF.

142C 400 to 2000 pF.

DETECTOR BIAS VOLTAGE ± 1000 V maximum.

INPUTS

INPUT Accepts positive or negative charge input (normally from a semiconductor detector) from any type detector; BNC connector.

BIAS Accepts detector bias from bias supply and applies it to detector through the INPUT connector; maximum ± 1000 V; SHV connector or ORTEC type C-38.

TEST Input for pulse generator to test and calibrate the system; BNC connector.

POWER Input power through 10-ft captive power cable from ORTEC main amplifier or ORTEC Model 4002P Portable Power Supply.

OUTPUTS

E Positive or negative linear tail pulse for energy measurement. BNC connector.

T Negative or positive linear fast-clipped pulse for timing. This output is generated using an inverting transformer that differentiates the energy output. Its rise time ranges from <5 ns to <25 ns. BNC connector.

ELECTRICAL AND MECHANICAL

POWER REQUIRED

142A +24 V, 20 mA; –24 V, 10 mA; +12 V, 15 mA; –12 V, 15 mA.

142B +24 V, 40 mA; –24 V, 10 mA; +12 V, 15 mA; –12 V, 15 mA.

142C +24 V, 40 mA; –24 V, 10 mA; +12 V, 15 mA; –12 V, 15 mA.

WEIGHT

Net 0.32 kg (0.75 oz).

Shipping 1.25 kg (2.75 lb).

DIMENSIONS 3.81 X 6.10 X 13.3 cm (1.5 X 2.4 X 5.25 in.).

SELECTION GUIDE TO 142A, 142B, OR 142C

To choose among Models 142A, 142B, or 142C:

1. Find the depletion depth of your detector. If it is an ORTEC detector, the last group of 2 to 4 digits is the depth in μ m.
2. Find the depletion depth on the graph above and read the capacitance in pF/mm² on the top of the chart.

3. Multiply by the area of your detector in mm². This is the middle 3-digit number for an ORTEC detector. Choose a Model 142A if the capacitance is less than 100 pF, a Model 142B if the capacitance is more than 100 pF but less than 400 pF, or a Model 142C if the capacitance is greater than 400 pF. Example: An ORTEC D-025-200-100 detector will have about 1 pF/mm² for its 100- μ m depletion depth. This, then, is 200 pF for the 200 mm² area, and a Model 142B Preamplifier is preferred.

Ordering Information

To order, specify:

Model	Description
142A	Preamplifier (for 0 to 100 pF)
142B	Preamplifier (for 100 to 400 pF)
142C	Preamplifier (for 400 to 2000 pF)

142AH Preamplifier

The ORTEC Model 142AH Preamplifier was designed to meet the needs of experimenters who require optimum performance from their charged-particle or heavy-ion detectors. This requirement is satisfied by the charge-sensitive Model 142AH through its extremely low noise and fast-timing characteristics. It is particularly suitable for high-energy charged-particle spectroscopy where high-resolution detectors with capacitances of up to 100 pF and bias voltages of up to 5000 V are involved.

Model 142AH has a separate fast-timing output signal approximately 50 ns wide with rise times ranging from <5 ns for 0 pF detectors to <12 ns for 100 pF detectors. This feature enables it to be directly coupled to a timing discriminator for some applications.

When the Model 142AH is used in conjunction with ORTEC's standard electronics, excellent timing resolution is obtained (Fig. 1).

Specifications

PERFORMANCE*

NOISE (see Fig. 2)

Typical and Warranted Noise Values		
Detector Capacitance (pF)	Noise (kev) (Si)	
	Typical	Warranted
0	1.55	1.75
20	1.65	—
50	2.35	—
100	3.35	3.60

INTEGRAL NONLINEARITY $< \pm 0.05\%$ for 0 to ± 7 V open circuit, or ± 3.5 V terminated in 93Ω .

TEMPERATURE INSTABILITY $< \pm 50$ ppm/ $^{\circ}\text{C}$ from 0 to 50°C .

OPEN LOOP GAIN $> 40,000$.

CHARGE SENSITIVITY (Si equivalent)
Nominally 45 mV/MeV.

RISE TIME (Fig. 3) < 5 ns at 0 pF; < 12 ns at 100 pF; with a 0 to +0.5-V pulse at the ENERGY output and a $93\text{-}\Omega$ load.

DECAY TIME $\sim 500 \mu\text{s}$.

RECOMMENDED INPUT CAPACITY RANGE 0 to 100 pF.

PERMISSIBLE OUTPUT CABLE LENGTH
Limited only by cable losses (recommended cable: ENERGY output, RG-71A/U or RG-62A/U; TIMING output, RG-58).

E²CRP Maximum energy-squared count rate product: 1.5×10^7 MeV²/s.

DETECTOR BIAS VOLTAGE ± 5000 V.

*Performance specifications are for ENERGY output unless stated otherwise.

- Optimum performance for charged-particle or heavy-ion detectors requiring high bias voltage with capacitances of up to 100 pF
- Extremely low noise
- Accepts 0 to ± 5 kV bias
- Separate fast-timing output signal with rise time from < 5 ns

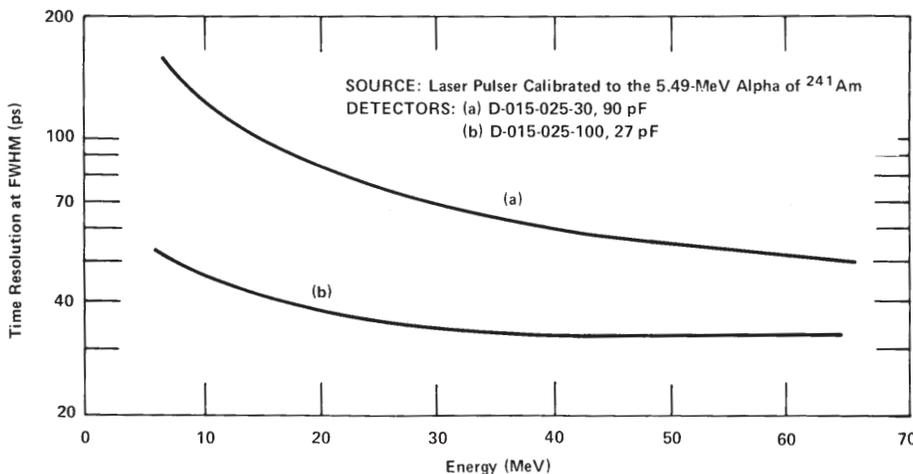


Fig. 1. Typical Time Resolution vs. Energy for 90 and 27 pF Detectors with ORTEC Standard Electronics.

142AH

Preamplifier

OUTPUT LEVELS AND LOADING All specifications are stated for open-circuit output and remain unchanged for 93- Ω termination or cable loading, except terminated output levels are half the open-circuit values. Saturated output level, ± 10 V; integral nonlinearity specified to ± 7 V.

INPUTS

INPUT Accepts positive or negative charge input from any type of detector (normally from a semiconductor detector); SHV connector.

BIAS Accepts detector bias from bias supply and applies it to the detector through a filter network via the INPUT connector; maximum ± 5000 V; SHV connector or ORTEC C-38.

TEST Input for pulse generator to test and calibrate the system; BNC connector.

POWER Input power through 3-m (10-ft) captive power cable from any ORTEC main amplifier or from an ORTEC Model 4002P Portable Power Supply.

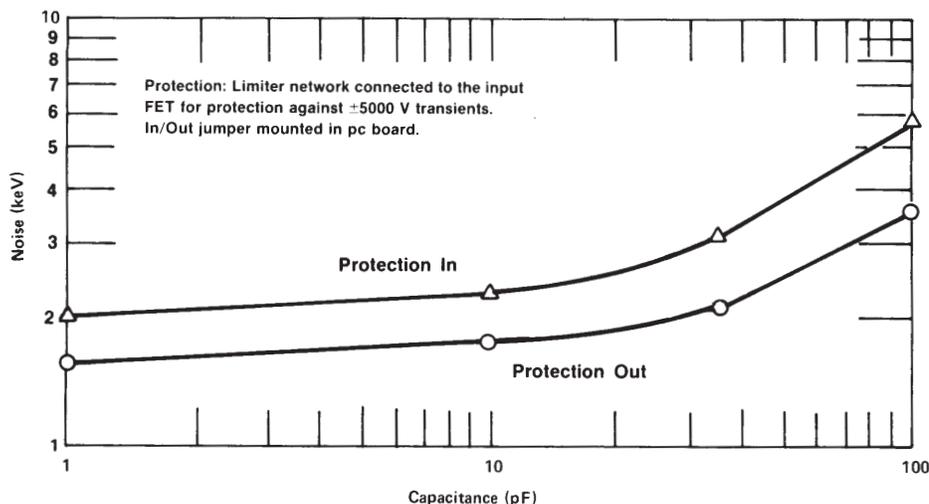


Fig. 2. Noise as a Function of Input Capacitance, Measured with an ORTEC Model 572 Amplifier and 2- μ s Time Constant.

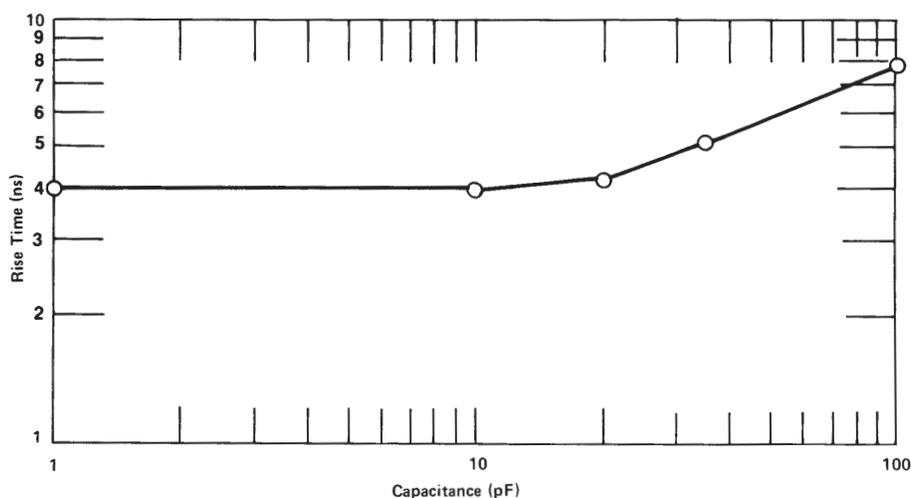


Fig. 3. Typical Rise Time as a Function of Input Capacitance with Rise Time Compensation Optimized at Each Data Point.

(Values given are for a +0.5-V signal into 93 Ω from the ENERGY channel.)

OUTPUTS

ENERGY Positive or negative linear tail pulse for energy measurement; BNC connector.

TIMING Negative or positive linear fast-clipped pulse for timing. Output generated by using an inverting transformer which differentiates the energy output. Rise time approximately equal to the rise time of the energy output (Fig. 3). BNC connector.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 30 mA;
-24 V, 10 mA; +12 V, 15 mA; -12 V, 15 mA.

WEIGHT

Net 0.45 kg (1 lb).
Shipping 1.3 kg (3 lb).

DIMENSIONS 4.45 X 10.16 X 13.21 cm (1.75 X 4.0 X 5.2 in.).

Ordering Information

To order, specify:

Model	Description
142AH	Preamplifier

Suggested cable accessories:

- C-24-12** RG-62A/U 93- Ω Cable with two BNC male plugs; 12-ft length
- C-25-12** RG-58A/U 50- Ω Cable with two BNC male plugs; 12-ft length
- C-36-2** RG-59A/U 75- Ω Cable with two SHV female plugs, 2-ft length
- C-36-12** RG-59A/U 75- Ω Cable with two SHV female plugs, 12-ft length

142IH Preamplifier

The ORTEC Model 142IH charge-sensitive Preamplifier is an economical and general-purpose instrument that can be used for universal applications such as x-ray, low- and high-energy γ -ray spectroscopy, and also for alpha and other charged-particle spectroscopy.

The Model 142IH may be used with semiconductor radiation detectors, proportional counters, ionization chambers, and low-gain photomultiplier tubes.

It will accommodate any detector capacitance up to 2000 pF. Thus the unit is ideally suited for high-resolution spectroscopy applications.

The preamplifier includes a built-in protection network to prevent damage to the input FET from inadvertently applied overvoltages. Its small size also allows it to operate in experimental vacuum enclosures when required.

Specifications

PERFORMANCE

NOISE Increases with increasing input capacitance. Typical slope, 0 to 100 pF = 27 eV/pF; 100 pF to 1000 pF = 34 eV/pF. Typical performance values, based on silicon equivalent of $\epsilon = 3.6$ eV at $\tau = 2$ μ s, are 1.9 keV at 0 pF; these become 4.6 keV at 100 pF and 35 keV at 1000 pF.

RISE TIME Based on a +0.5 V signal through either output into a 93- Ω circuit and measured from 10% to 90% of peak amplitude; <20 ns at 0 pF and <50 ns at 100 pF.

SENSITIVITY Nominal, measured through either output, 45 mV/MeV Si.

ENERGY RANGE 0 to 100 MeV Si.

E²CRP Maximum energy-squared count-rate product: 7×10^7 MeV²/s.

DYNAMIC INPUT CAPACITANCE 10,000 pF.

INTEGRAL NONLINEARITY $\leq \pm 0.05\%$ for 0 to ± 7 V open circuit or ± 3.5 V terminated in 93 Ω .

TEMPERATURE INSTABILITY $\leq \pm 100$ ppm/ $^{\circ}$ C, 0 to 50 $^{\circ}$ C.

DETECTOR BIAS ISOLATION ± 3000 V.

OPEN LOOP GAIN $\geq 40,000$.

INPUTS

INPUT Accepts input signal from a detector and extends operating bias to the detector.

BIAS Accepts the bias voltage for the detector from a bias supply.

TEST Accepts input voltage pulses from a pulse generator for instrument and system check and calibration; $R_{in} = 93 \Omega$.

OUTPUTS

E AND T (for Energy and Timing) 2 connectors furnish identical signals through 2 output paths; either or both of these outputs can be used as required, and they are interchangeable. $R_o = 93 \Omega$ through each connector, and the output polarity is opposite from the input pulse polarity (output pulse polarity is the same as bias polarity).

CONNECTORS

INPUT AND BIAS SHV.

TEST, E, AND T BNC.

POWER CABLE 3-m (10-ft) captive power cable, ORTEC 121-C1; longer lengths available on special order.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 30 mA; -24 V, 10 mA; +12 V, 15 mA; -12 V, 15 mA. Furnished from NIM bin and power supply through any ORTEC main amplifier or from an ORTEC Model 4002P Portable Power Supply; built-in captive cable is compatible with either source.

WEIGHT

Net 0.45 kg (1 lb).

Shipping 1.3 kg (3 lb).

DIMENSIONS 3.8 X 6.1 X 13.3 cm (1.5 X 2.4 X 5.25 in.) plus 3-m (10-ft) cable.

Ordering Information

To order, specify:

Model **Description**

142IH Preamplifier

Suggested cable accessories:

C-24-12 RG-62A/U 93- Ω Cable with two BNC male plugs; 12-ft length

C-36-2 RG-59A/U 75- Ω Cable with two SHV female plugs, 2-ft length

C-36-12 RG-59A/U 75- Ω Cable with two SHV female plugs, 12-ft length

- Charge-sensitive for universal applications
- Economical and general purpose
- Accepts 0 to ± 3 kV bias
- Low noise and fast rise time
- Built-in protection network
- Small size
- Operates in vacuum



142PC Preamplifier

- Ideal for proportional counters
- High sensitivity and very low noise for soft x-ray and low-energy gamma spectroscopy
- Accepts 0 to ± 3 kV bias



The ORTEC Model 142PC Preamplifier is a low-noise charge-sensitive unit especially designed for use with proportional counters requiring up to ± 3000 V detector bias.

The high sensitivity of this unit often allows operating the proportional counter at reduced voltages, thus greatly minimizing peak position shifts and peak broadening with changing count rates.

The low-noise performance for this type of preamplifier greatly improves the resolution of the spectroscopy system. The separate energy and timing outputs enhance instrument flexibility.

The Model 142PC incorporates a protection circuit for the input FET to prevent damage from inadvertently applied overvoltages. The unit is shipped with the protection circuit in place; better resolution, however, will be obtained when the protection is removed (Fig. 1).

Specifications

PERFORMANCE

NOISE	PERFORMANCE	
	Typical	Guaranteed
0 pF	295 rms electrons	<340 rms electrons
100 pF	450 rms electrons	<485 rms electrons

RISE TIME Based on a +0.5 V signal through either output into a 93- Ω circuit and measured from 10% to 90% of peak amplitude; 25 ns at 0 pF and 150 ns at 100 pF.

SENSITIVITY Nominal, measured through either output, 6.5 V/pC.

DYNAMIC INPUT CAPACITANCE 1000 pF.

INTEGRAL NONLINEARITY $\leq \pm 0.05\%$ for 0 to ± 7 V open circuit or ± 3.5 V terminated in 93 Ω .

OUTPUT LINEAR RANGE ± 7 V.

TEMPERATURE INSTABILITY $\leq \pm 50$ ppm/ $^{\circ}$ C, 0 to 50 $^{\circ}$ C.

DETECTOR BIAS ISOLATION ± 3000 V.

OPEN LOOP GAIN $\geq 40,000$.

INPUTS

INPUT Accepts input signals from a proportional counter and extends operating bias to the proportional counter.

BIAS Accepts the bias voltage for the proportional counter from a bias supply.

TEST Accepts input voltage pulses from a pulse generator for instrument and system check and calibration; $R_{in} = 93 \Omega$.

OUTPUTS

ENERGY AND TIMING 2 connectors furnish identical signals through 2 output paths; either or both of these outputs can be used as required, and they are interchangeable. $R_o = 93 \Omega$ through each connector, and the output

polarity is opposite from the input pulse polarity (output pulse polarity is the same as bias polarity).

CONNECTORS

INPUT AND BIAS SHV.

TEST, ENERGY, AND TIMING BNC.

POWER CABLE 3-m (10-ft) captive power cable. ORTEC 121-C1; longer lengths available on special order.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 30 mA; -24 V, 10 mA; +12 V, 15 mA; -12 V, 15 mA. Furnished from NIM bin and power supply through any ORTEC main amplifier or from an ORTEC Model 4002P Portable Power Supply; built-in captive cable is compatible with either source.

WEIGHT

Net 0.65 kg (1.5 lb).

Shipping 1.3 kg (3.0 lb).

DIMENSIONS 4.5 X 13.2 X 10.0 cm (1.75 X 5.2 X 4.0 in.) plus 3-m (10-ft) cable.

Ordering Information

To order, specify:

Model	Description
142PC	Preamplifier

Suggested cable accessories:

C-24-12	RG-62A/U 93- Ω Cable with two BNC male plugs; 12-ft length
C-36-2	RG-59A/U 75- Ω Cable with two SHV female plugs; 2-ft length
C-36-12	RG-59A/U 75- Ω Cable with two SHV female plugs; 12-ft length

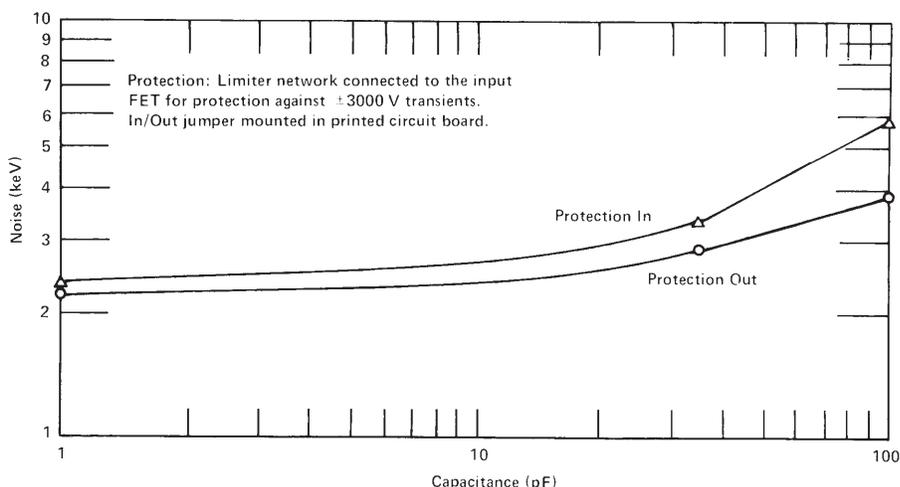


Fig. 1. Noise as a Function of Input Capacitance, Measured with an ORTEC Model 572 Amplifier and 2- μ s Time Constant.

9301 Fast Preamplifier

The ORTEC Model 9301 low-noise, fast-rise-time Preamplifier has been designed for use with photomultipliers, electron multipliers, and other detectors employed in photon counting, ion counting, or fast-timing applications. When connected to the detector, the 50- Ω input resistance of the Model 9301 provides a load resistance for the detector output current pulse.

In addition to its fast rise time of 1.5 ns, this preamplifier has a voltage gain of 10 and an output impedance of 50 Ω . Because of its compact size and light weight, the Model 9301 is ideal for mounting directly or close to a detector. Consequently, low-level signals, which would otherwise be susceptible to pickup of noise or interference, are boosted to a suitable level for cable connection to the main amplifier. Connection to a power supply is through the 3-m (10-ft) long captive power cable furnished with the Model 9301.

Model 9301 is fitted with a power cable connector (Amphenol 17-20090) that is compatible with other ORTEC NIM-standard modules.

Specifications

PERFORMANCE

INPUT IMPEDANCE 50 Ω .
VOLTAGE GAIN 10 ($\pm 2\%$) noninverting.
RISE TIME <1.5 ns.
INPUT RMS NOISE EQUIVALENT <25 μ V.
OUTPUT IMPEDANCE Typically 50 Ω .
OUTPUT DYNAMIC RANGE > ± 0.7 V into 50 Ω .
NONLINEARITY < $\pm 1\%$.
TEMPERATURE GAIN INSTABILITY < $\pm 0.1\%/^{\circ}$ C.
INPUT CONNECTOR Front-panel BNC.
OUTPUT CONNECTOR Rear-panel BNC.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 30 mA; -12 V, 30 mA.
WEIGHT
Net 0.17 kg (6 oz).
Shipping 0.9 kg (~2 lb).
DIMENSIONS 3.1 X 5.0 X 7.3 cm (1.25 X 2 X 2.875 in.) plus 3-m (10-ft) cable.

Ordering Information

To order, specify:

Model	Description
9301	Preamplifier

Suggested cable accessories:

C-25-1/2	RG-58A/U 50- Ω Cable with two BNC male plugs; 6-in. length
C-25-12	RG-58A/U 50- Ω Cable with two BNC male plugs; 12-ft length

- Used with photomultipliers, electron multipliers, etc., in photon or ion counting applications
- 1.5-ns rise time
- Voltage gain of 10
- Output of ± 0.7 V into 50 Ω
- Compact and lightweight



9305 Fast Preamplifier

- Used with photomultiplier tubes, electron multipliers, etc., in photon or ion counting applications
- <3-ns rise and fall times
- DC-coupled, with excellent dc and gain stability
- Voltage gain adjustable from 5 to 10
- Output of ± 5 V into 50 Ω
- Input protection
- <5-ns overload recovery time

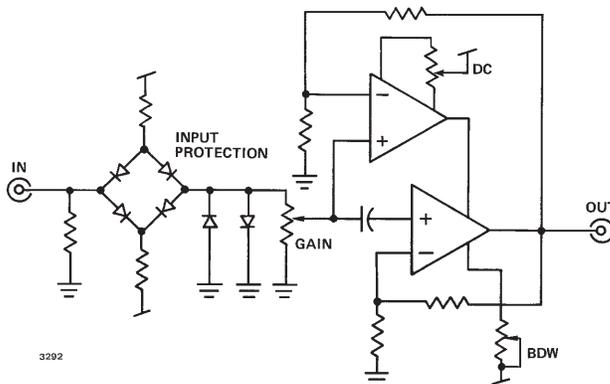


The ORTEC Model 9305 Fast Preamplifier contains a direct-coupled wideband hybridized amplifier suitable for use with photomultipliers, electron multipliers, and other detectors used in photon counting, ion counting, or fast-timing applications.

In addition to the fast rise time (<3 ns), Model 9305 has a variable voltage gain of 5–10 and can drive ± 5 V into a 50- Ω load. The 9305 also features excellent dc and gain stability along with low noise and <5 ns overload recovery time. Overload input protection is provided also.

Hybrid circuit technology gives the Model 9305 high performance and reliability. For operator convenience independent bandwidth (BDW), output dc offset (DC), and fine gain (GAIN) adjustments are included.

Because of its compact size and light weight, the Model 9305 is ideal for mounting directly on or close to a detector. Consequently, low-level signals which would otherwise be susceptible to distortion by noise or interference are amplified to a suitable level for cable connection to the main amplifier. Connection to a power supply is through a 10-ft cable furnished with the Model 9305.



The Model 9305 Fast Preamplifier Circuit.

Specifications

PERFORMANCE

NOMINAL VOLTAGE GAIN 5–10, non-inverting.

RISE TIME <3 ns to ± 5 V into 50 Ω ; bandwidth >120 MHz.

NOISE <25 μ V referred to the input measured with an HP3400A true rms voltmeter. Wideband noise (200 MHz) <30 μ V referred to the input.

INTEGRAL NONLINEARITY Typically $\leq \pm 1\%$ for output to ± 5 V.

PULSE OVERLOAD RECOVERY Typically ± 5 ns for a X10 overload.

GAIN INSTABILITY Typically $\leq \pm 0.05\%/^{\circ}\text{C}$.

DC INSTABILITY Typically $\leq \pm 150$ μ V/ $^{\circ}\text{C}$ referred to the output.

INPUT IMPEDANCE 50 Ω , dc-coupled.

OUTPUT IMPEDANCE <1 Ω , dc-coupled.

OUTPUT LINEAR RANGE ± 5 V into 50 Ω .

OPERATING TEMPERATURE RANGE 0 to 50 $^{\circ}\text{C}$.

CONTROLS

BDW 20-turn potentiometer adjusts the output bandwidth and overshoot. Front-panel mounted.

DC 20-turn potentiometer adjusts the output dc offset. Front-panel mounted.

GAIN 20-turn potentiometer adjusts the voltage gain from typically 5 to 10. Front-panel mounted.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 67 mA; -12 V, 67 mA.

WEIGHT

Net 0.32 kg (12 oz).

Shipping 1.25 kg (2 lb 12 oz).

DIMENSIONS 3.81 X 6.1 X 8.89 cm (1.5 X 2.4 X 3.5 in.).

Ordering Information

To order, specify:

Model Description
9305 Fast Preamplifier

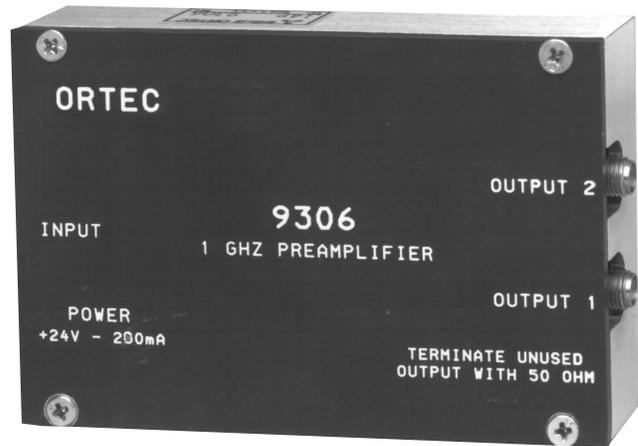
Suggested cable accessories:

C-25-1/2 RG-58A/U 50- Ω Cable with two BNC male plugs; 6-in. length

C-25-12 RG-58A/U 50- Ω Cable with two BNC male plugs; 12-ft length

9306 1-GHz Preamplifier

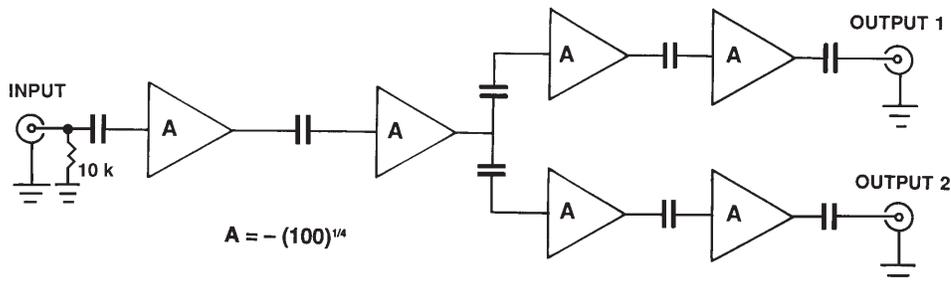
- 1-GHz preamplifier for timing applications with pulses from ultra-fast detectors (microchannel plates, microchannel-plate photomultipliers, channeltrons, silicon diodes, photomultipliers, and electron multipliers)
- 350-ps rise time
- Gain ≈ 100 (non-inverting)
- 100-kHz to 1-GHz bandwidth
- Two identical outputs deliver 0 to -2 V pulses on $50\text{-}\Omega$ loads
- $50\text{-}\Omega$ input and output impedances, ac-coupled



The ORTEC Model 9306 1-GHz Preamplifier is optimized for fast timing and counting applications with detectors that deliver pulses with ultra-fast rise times. An output rise time of 350 ps and a non-inverting gain of 100 make the Model 9306 ideal for use with microchannel plates, microchannel-plate photomultipliers, channeltrons, silicon diodes, fast photomultiplier tubes, and electron multipliers. The compact preamplifier case with captive power cord permits close coupling to the detector to minimize sensitivity to environmental noise.

To preserve the ultra-fast rise time, the Model 9306 is designed to accept and deliver signals on high-quality, $50\text{-}\Omega$ coaxial cables with SMA connectors and $50\text{-}\Omega$ terminations. The input is ac-coupled, with a $50\text{-}\Omega$ input impedance, and is protected to a maximum of ± 1 V. Two identical outputs are provided for convenient, simultaneous connection to two different instruments. Both outputs are ac-coupled, short-circuit protected, and capable of driving pulse amplitudes from 0 to -2 V into $50\text{-}\Omega$ loads.

The Model 9306 1-GHz Preamplifier derives its $+24\text{-V}$ dc power from a NIM module or power supply via the captive power cord and standard, 9-pin, D connector. The ORTEC Model 4002P Portable Power Supply and most NIM amplifiers provide the required power on a compatible preamplifier power connector.



Simplified Functional Block Diagram of the Model 9306.

9306

1-GHz Preamplifier

Specifications

PERFORMANCE

All specifications are measured with a pulser having a pulse width of 2 ns FWHM, and a rise time of 150 ps. Where significant, the measurement is corrected for the rise times of the pulser, coaxial cable, and oscilloscope. The specifications are identical for OUTPUTS 1 and 2.

GAIN Nominally 100 (50 to 150), non-inverting, into a 50- Ω output load.

OUTPUT RISE TIME Typically 350 ps.

BANDWIDTH (3 dB) Typically 100 kHz to 1 GHz.

NOISE <100 μ V rms equivalent input noise over the full bandwidth.

INPUTS AND OUTPUTS

INPUT SMA input connector with 50- Ω input impedance (ac-coupled) and a 10-k Ω resistance to ground. Input protected to a maximum of ± 1 V.

OUTPUT 1 SMA output connector provides a linear output range from 0 to -1.75 V and a maximum output of -2 V into a 50- Ω load. Output impedance is 50- Ω , ac-coupled, and short-circuit protected. The unused output must be terminated with a 50- Ω load for proper operation of the other output. An optional SMA 50- Ω terminator is available for this purpose.

OUTPUT 2 Identical to OUTPUT 1.

POWER Input power is supplied through a captive cable (length: 3 m) with a standard preamplifier power connector (9-pin D type). Compatible with ORTEC instruments that provide a preamplifier power connector.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V at 200 mA. Captive power cord with standard 9-pin D connector derives power from any ORTEC instrument equipped with the standard preamplifier power plug (e.g., spectroscopy amplifiers, 4002P Portable Power Supply, 9307 pico-TIMING Discriminator, etc.).

WEIGHT

Net 0.2 kg (0.4 lb).

Shipping 1.1 kg (2.4 lb).

DIMENSIONS Aluminum housing 9.5 X 6.4 X 2 cm (3.75 X 2.5 X 0.8 in.).

Optional Accessories

The Model 9306 is designed for use with 50- Ω coaxial signal cables having SMA connectors. The desired optional cables and adapters can be selected from the ordering information. To avoid degradation of the 350-ps rise time through long signal cables, the total length of the input and output signal cables should be ≤ 1.7 m. If one of the outputs is not used, it must be loaded with an SMA50 terminator.

The Model 9306 should be used with the Model 9307 pico-TIMING™ Discriminator for optimum time resolution with ultra-fast detectors.

Ordering Information

To order, specify:

Model	Description
9306	1-GHz Preamplifier
SMA50	50- Ω SMA Terminator (male). Required to load the unused output with 50 Ω .
SMA58-0.15	RG-58A/U (50- Ω) Coaxial Cable with SMA Connectors, 0.15-m length
SMA58-0.5	RG-58A/U (50- Ω) Coaxial Cable with SMA Connectors, 0.5-m length
SMA58-1.5	RG-58A/U (50- Ω) Coaxial Cable with SMA Connectors, 1.5-m length
SMA/BNC	SMA to BNC Adapter with male SMA and female BNC
BNC/SMA	BNC to SMA Adapter with male BNC and female SMA

9326 Fast Preamplifier

- Sub-ns rise time for pulse amplification with:
 - Microchannel-plate detectors
 - Electron multipliers
 - Photomultiplier tubes
 - Fast photodiodes
 - Silicon charged-particle detectors
- Selectable gain: 5, 10, or 20 V/V (non-inverting)
- Low-frequency roll-off <10 kHz
- 0 to -1 V output into 50 Ω
- Input overload protection
- Compact 9 x 13 x 3 cm preamplifier box



The Model 9326 Fast Preamplifier is optimized for amplifying the pulses from microchannel-plate detectors, electron multipliers, photomultiplier tubes, fast photodiodes, and silicon charged-particle detectors. The fast rise times of these detectors are preserved by the <1-ns rise time of the Model 9326 output, which can supply 0 to -1-V pulse amplitudes into a 50- Ω load. The compact size permits placement close to the detector in order to avoid ground loop and environmental noise interference with the small signals produced by the detector. Gains of 5, 10, or 20 volts/volt (non-inverting) can be selected via a board jumper.

A low-frequency roll-off less than 10 kHz is unusual for a preamplifier intended for processing fast detector pulses. This low-frequency response was incorporated in order to virtually eliminate pulse undershoot when used with the **FASTFLIGHT™** Digital Signal Averager in the Electrospray Time-of-Flight Mass Spectrometry application.

To minimize damage caused by large transients from the detector, the input incorporates overload protection. The output is also short-circuit protected. Any 9-pin D preamplifier power connector meeting the ORTEC standard pin

assignments can be used to supply the +12-V power via the standard power cable supplied with the Model 9326.

Specifications

PERFORMANCE

INPUT NOISE <100 μ V rms.

OUTPUT RISE TIME <1 ns.

LOW FREQUENCY ROLL-OFF <10 kHz.

GAIN Selectable by board jumpers for 5, 10, or 20 V/V. The overall gain is non-inverting.

OPERABLE TEMPERATURE RANGE 0–50°C.

CONTROLS

COARSE GAIN Board jumper selection of low (5 V/V), medium (10 V/V), or high (20 V/V) gain.

INPUTS

ANALOG INPUT Front-panel BNC connector accepts negative-polarity analog signals in the range of 0 to -200 mV. Input impedance: 50 Ω ac, <1000 Ω dc to ground. Diode clamps provide protection against overload to \pm 2 V dc, or \pm 10 V for a 50-ns-wide pulse at a duty cycle of <1%.

OUTPUTS

ANALOG OUTPUT Rear-panel BNC connector provides a negative-polarity output

pulse. Linear range is nominally +0.25 V to -1 V on a 50- Ω load. AC-coupled and short-circuit protected.

ELECTRICAL AND MECHANICAL

POWER REQUIREMENTS The required +12 V at 100 mA dc power can be supplied from any ORTEC preamplifier power connector via the 3-m (9.8-ft) long power cord included with the Model 9326. The mating connectors on the ends of the power cord are ORTEC-standard, 9-pin D, preamplifier power connectors. Pin assignments for the male connector on the preamplifier case are +12 V on pin 4, and ground on pins 1 and 2.

WEIGHT

Net 0.39 kg (0.85 lb).

Shipping 1.3 kg (2.9 lb).

PACKAGE AND DIMENSIONS Compact preamplifier box: 8.6 cm W x 13.3 cm D x 3.0 cm H (3.4 in. W x 5.3 in. D x 1.2 in. H).

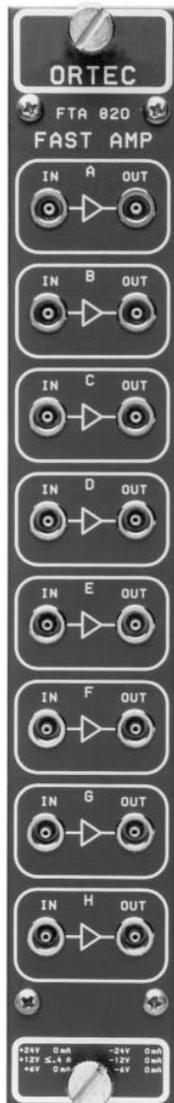
Ordering Information

To order, specify:

Model	Description
9326	Fast Preamplifier (includes power cable)

FTA820A Octal Fast Timing Amplifier

- For amplifying fast analog signals from photomultipliers, electron multipliers, photodiodes, micro-channel plates, and silicon charged-particle detectors
- ≤ 1 ns rise time
- Gain: 200
- Output drives -5 V into 50Ω
- Eight separate and identical amplifiers in a single-width NIM
- $\leq 20 \mu\text{V}$ rms equivalent input noise



The FTA820A Amplifier is a high-performance, wide-bandwidth amplifier designed for boosting very fast linear signals from photomultipliers, electron multipliers, silicon charged-particle detectors, and other detectors used in fast timing applications. The rise time is < 1 ns with a 5-V output, enabling excellent timing resolution.

The FTA820A provides eight separate and identical amplifiers in a single-width NIM module. Each FTA820A amplifier section has a gain of 200, noninverting. LEMO type 00C50 connectors are used for all signal connections.

Specifications

PERFORMANCE

GAIN FOR EACH CHANNEL (10% gain tolerance) 200, noninverting.

NUMBER OF CHANNELS 8

RISE TIME ≤ 1 ns.

NOISE $\leq 20 \mu\text{V}$ rms equivalent input noise.

BANDWIDTH 10 to 350 MHz.

PROPAGATION DELAY $\leq 30\text{-ps}$ variation between channels.

OUTPUT RANGE 0 to -5 V with $50\text{-}\Omega$ load.

INPUTS One for each channel. LEMO connector; input impedance 50Ω .

OUTPUTS One for each channel. LEMO connector; 0 to -5 V output with a $50\text{-}\Omega$ load. Output impedance $\leq 1 \Omega$.

ELECTRICAL AND MECHANICAL

POWER REQUIRED $+12$ V, 400 mA, FTA820A; $+12$ V, 200 mA, FTA420C.

DIMENSIONS Standard single-width NIM module 3.43×22.13 cm (1.35×8.714 in.) per DOE/ER-0457T.

WEIGHT

Net 1 kg (2.2 lb).

Shipping 2.7 kg (5.9 lb).

Ordering Information

To order, specify:

Model	Description
FTA820A	Octal Fast Timing Amplifier (200 gain, noninverting)

427A Delay Amplifier

The ORTEC Model 427A Delay Amplifier is suitable for any general-purpose variable delay of linear or logic signals within the range from 0.25 through 4.75 μ s. All signals, of either polarity and up to 10 V in amplitude, are delayed by the selected time and are reproduced at the outputs. Two outputs are included, one with an impedance nominally 1 Ω and the other 93 Ω .

The convenient switch-selectable steps of delay permit the time to be normalized between two or more signal paths to simplify coincidence and gating system adjustments. Each signal is subject to normal delays as it is processed through a signal path. The Model 427A can delay the earlier of two signals such that the pair of signals will coincide in a subsequent analysis.

The input impedance is not affected by the selected delay so that no signal loading change occurs. The dc-coupled input is furnished through a buffer amplifier that eliminates any interference from the delay selection network. The input impedance is more than 1 k Ω .

The Model 427A accommodates very high count rates without distortion because the instrument is completely dc-coupled. This, together with the fact that the gain from input to output is unity, ensures that the only function it will provide will be a controlled delay for each signal furnished through it.

Specifications

PERFORMANCE

GAIN Unity $\pm 2\%$ at zero delay.

GAIN VARIATION WITH DELAY +10%, -2% for any combination of delays (1- μ s DRC-shaped pulse).

FEEDTHROUGH AND DELAY RIPPLE <2% (1- μ s DRC-shaped pulse).

DELAY LINE TOLERANCES $\pm 5\%$.

NONLINEARITY Integral nonlinearity $< \pm 0.05\%$ from 0.1 to 10 V.

TEMPERATURE INSTABILITY Gain shift of amplifier is $< \pm 0.01\%/^{\circ}\text{C}$; an additional shift of $-0.013\%/^{\circ}\text{C}$ should be expected for each μ s of delay used.

RISE TIME AND BANDWIDTH AS A FUNCTION OF DELAY

Delay	Rise Time (ns)	Bandwidth (MHz)
0	280	1.25
0.25	280	1.25
0.5	290	1.20
1.0	310	1.13
2.0	340	1.03
3.0	360	0.972
4.0	370	0.945
4.5	380	0.920
4.75	400	0.875

OPERATING TEMPERATURE 0 to 50 $^{\circ}\text{C}$.

CONTROLS

LINEAR DELAY Any combination of the following: 0.25, 0.5, 1.0, 1.0, and 2.0 μ s.

MINIMUM (ZERO) DELAY 60 ns.

MAXIMUM DELAY 4.75 μ s.

INPUTS

POLARITY Either positive or negative.

SIGNAL SPAN ± 10 V linear range.

INPUT IMPEDANCE >1 k Ω , dc-coupled.

CONNECTOR Front-panel BNC.

OUTPUTS

AMPLITUDE Equal to input pulse amplitude; linear range 0 to ± 10 V; 0 to ± 11 V maximum.

OUTPUT IMPEDANCE ~ 1 Ω front panel and 93 Ω rear panel.

CONNECTORS Front- and rear-panel BNC.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 30 mA; -24 V, 30 mA.

WEIGHT

Net ~ 1.25 kg (2.6 lb).

Shipping ~ 2.60 kg (5.6 lb).

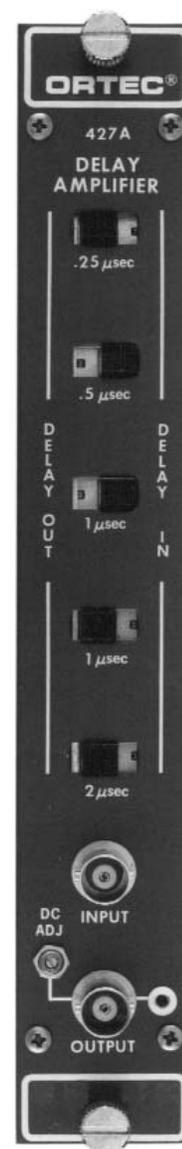
DIMENSIONS Single-width NIM module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
427A	Delay Amplifier

- Variable delay of linear or logic signals
- Provides arrival time alignment for pulses in coincidence and gating systems
- Delay range: 0 to 4.75 μ s
- Completely dc-coupled
- Rise time ≤ 400 ns



Delay Line Amplifier

- Delay-line shaping for energy and time spectroscopy with scintillation detectors
- Ideal for n - γ discrimination by pulse-shape analysis
- Excellent high-counting rate performance
- Optimum timing capabilities
- Selectable integration time constants



The ORTEC Model 460 Delay Line Shaping Amplifier is intended for energy and time spectroscopy with scintillation detectors. It can also be used with proportional counters, semi-conductor detectors, and position-sensitive proportional counters. Its delay-line-shaped output signal is particularly well-suited for high-counting rate and timing applications. This particular type of output signal offers a more rapid baseline recovery than is possible with semi-Gaussian shaping amplifiers. The Model 460 provides excellent timing capabilities, either for leading-edge or zero-crossing timing techniques, particularly when it is used with an ORTEC Model 552 Pulse-Shape Analyzer/Timing Single-Channel Analyzer. Double-delay-line shaping exhibits less timing jitter when compared with either the classical RC-shaping network or active-filter networks, primarily due to the fast rise time and fall time of the double-delay-line shaped output pulse.

The Model 460 also offers the unique feature of a selectable integration time constant to optimize the signal-to-noise ratio in any particular experimental configuration. The optimum integration time constant depends on such factors as the noise in the system and the counting rate in the particular experiment. The Model 460 is well suited for applications where overload pulses are involved, as it will recover to within 2% of its rated maximum output in <5 nonoverloaded pulse widths from a X500 overload.

The Model 460 exhibits <1 ns of crossover walk for a 20:1 dynamic range of its output signal. Therefore it is useful in precise fast coincidence timing applications that employ the crossover timing or constant-fraction timing techniques. The Model 460 offers both prompt and delayed outputs and therefore can store the unipolar outputs temporarily if desired for energy analysis after the timing and coincidence evaluation has taken place. The baseline-restored unipolar output can be

either delayed or prompt as selected by a switch on the rear panel.

The ORTEC Model 460 is the amplifier recommended for use with pulse-shape analysis applications such as neutron-gamma separation when using the ORTEC Model 552 Pulse Shape Analyzer/Timing SCA.

Specifications

PERFORMANCE

GAIN RANGE 7-position Coarse Gain selection from 10 through 1000 and single-turn Fine Gain control from 0.3 through 1; total gain is the product of Coarse and Fine Gain settings.

SHAPING FILTER Front-panel switch permits selection of integration time constant with $\tau = 0.04, 0.1, \text{ or } 0.25 \mu\text{s}$ (40, 100, or 250 ns).

INTEGRAL NONLINEARITY $\leq \pm 0.05\%$.

NOISE $\leq 20 \mu\text{V rms}$ referred to input using $0.25 \mu\text{s}$ Integrate and maximum Gain of 1000; $\leq 25 \mu\text{V}$ for Gain = 50; $\leq 60 \mu\text{V}$ for Gain = 10.

CROSSOVER WALK For constant gain, walk $< \pm 1 \text{ ns}$ for 20:1 dynamic range; $< \pm 2 \text{ ns}$ for 50:1; $< \pm 2.5 \text{ ns}$ for 100:1. Crossover shifts $< \pm 4 \text{ ns}$ for any adjacent Coarse Gain switch settings.

COUNT RATE STABILITY A pulser peak at 85% of analyzer range shifts $< 0.2\%$ in the presence of 0 to 10^5 random counts/s from a ^{137}Cs source with its peak stored at 75% of the analyzer range.

TEMPERATURE INSTABILITY

Gain $\leq \pm 0.01\%/^{\circ}\text{C}$, 0 to 50°C .

DC Level $\leq \pm 0.1 \text{ mV}/^{\circ}\text{C}$, 0 to 50°C .

OVERLOAD RECOVERY Bipolar recovers to within 2% of rated maximum output in <5 nonoverloaded pulse widths from X500 overload; unipolar recovers in same time from X100 overload.

DELAY LINE SHAPING 1- μs . Both delay lines have the same value.

CONTROLS

FINE GAIN Front-panel single-turn potentiometer for continuously variable gain factor of X0.3 to X1.

COARSE GAIN Front-panel seven-position switch selects gain factors of X10, 20, 50, 100, 200, 500, and 1000.

INTEG Front-panel slide switch selects an integration time constant of 0.04, 0.1, or $0.25 \mu\text{s}$. For $0.04\text{-}\mu\text{s}$ setting amplifier rise time is $< 75 \text{ ns}$.

PZ ADJ Front-panel potentiometer adjusts pole-zero cancellation for decay times from 25 μ s to ∞ .

POS/NEG Front-panel slide switch sets input circuit for either input polarity.

DC ADJ Front-panel potentiometer adjusts the dc-level for single-delay-line shaped unipolar output pulses.

DELAY IN/OUT Rear-panel slide switch selects either delayed (In) or prompt (Out) timing for unipolar output pulses. Delay is equal to the width of the unipolar output pulse.

INPUT

BNC Connector on front panel accepts either positive or negative inputs with rise time of 10 to 1000 ns and decay time of 25 to 2000 μ s; $Z_i \cong 1000 \Omega$, dc-coupled; linear maximum 3.3 V; absolute maximum 20 V.

OUTPUTS

UNIPOLAR Prompt or delayed with full-scale linear range from 0 to +10 V; single-delay-line shaped; baseline restored level adjustable to ± 1 V; $Z_o < 1 \Omega$, dc-coupled through front-panel BNC connector; $Z_o = 93 \Omega$, dc-coupled through rear-panel BNC connector. Short-circuit protected.

BIPOLAR Prompt output with positive lobe leading, double-delay-line shaped with full-scale linear range of 0 to 10 V; $Z_o < 1 \Omega$, dc-coupled through front-panel BNC connector; $Z_o = 93 \Omega$, dc-coupled through rear-panel BNC connector. Short-circuit protected.

PREAMP Standard ORTEC power connector for mating preamplifier; rear-panel Amphenol 17-10090 connector.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 90 mA; -24 V, 90 mA; +12 V, 75 mA; -12 V, 60 mA.

WEIGHT

Net 1 kg (2.25 lb).

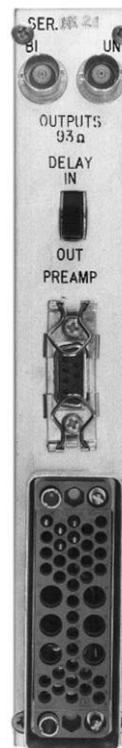
Shipping 1.9 kg (4.25 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
460	Delay Line Amplifier



Timing Filter Amplifier

- Timing with germanium detectors
- Energy spectroscopy at ultra-high count rates
- Selectable filter for pulse shaping
- Signal-to-noise ratio optimization
- Continuously adjustable gain, X2 to X250
- Pole-zero cancellation
- DC-coupling



The ORTEC Model 474 Timing Filter Amplifier is especially designed to shape pulses and permit optimizing the signal-to-noise ratio for timing measurements. The Model 474 is particularly suited for use with an ORTEC Constant-Fraction Timing Discriminator in timing applications with germanium or silicon charged-particle detectors (Fig. 1). It derives its input signal directly from the preamplifier output. The timing spectrum in Fig. 2 illustrates the performance obtainable with the Model 474 shaping the germanium detector pulses before they are furnished to the discriminator. Tables 1 and 2 give typical performance data for various ORTEC germanium detectors.

The fast rise time, high output drive, and high gain capabilities of the Model 474 make it useful for other applications, such as timing with systems utilizing low-gain photomultiplier tubes. In addition, the pole-zero cancellation network, the dc-coupling, and the time-invariant baseline restorer permit energy spectroscopy with scintillation detectors and Si charged-particle detectors at ultra-high count rates.

A wide variety of input pulse shapes can be filtered as required for optimum signal processing. The Model 474 combines continuously adjustable gain (X2 to X250) with separately selectable Integrate (τ_i) and Differentiate (τ_d) time constants for proper pulse shaping, making this unit an important asset for time measurement.

Specifications

PERFORMANCE

INPUT AMPLITUDE RANGE 0 to ± 1 V signal, 0 to ± 5 V dc offset; maximum input ± 5 V total.

OUTPUT AMPLITUDE RANGE 0 to ± 5 V with a 50- Ω load.

NOISE For maximum gain, rms noise referred to the input is ≤ 10 μ V with $\tau_i = \tau_d = 200$ ns or ≤ 50 μ V with filter out; measured using a Hewlett-Packard 3400A true rms meter.

RISE TIME ≤ 10 ns with filter Out or $\sim 2.2 \tau_i$ for other selections.

NONLINEARITY $\leq \pm 0.05\%$ at midband frequency over ± 5 V range.

TEMPERATURE INSTABILITY

DC Level $\leq \pm 25$ μ V/ $^{\circ}$ C referred to the output.

Gain $\leq \pm 0.06\%$ / $^{\circ}$ C.

Specifications over 0 to 50 $^{\circ}$ C range.

CONTROLS

COARSE GAIN Front-panel 6-position switch for selection of X1, X2, X4, X6, X10, or X20.

FINE GAIN Front-panel single-turn potentiometer, continuous from X2 to X12.5.

POLE ZERO ADJ Front-panel screwdriver adjustment to compensate for the preamplifier decay time constant.

TIME CONSTANT Two 6-position switches on front panel:

Integrate RC time constants: Out (equivalent to 4 ns), 20, 50, 100, 200, and 500 ns.

Differentiate RC time constants: Out (equivalent to 0.2 ms), 20, 50, 100, 200, and 500 ns.

NOTE: With Differentiate and Integrate in the Out position, the passband is 1 kHz to 35 MHz.

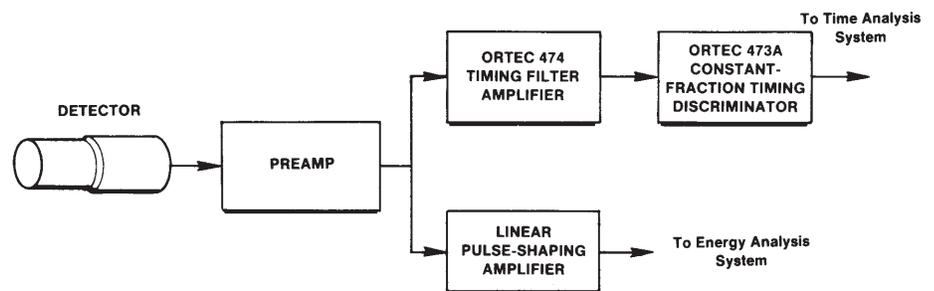


Fig. 1. Simplified Timing System.

Timing Filter Amplifier

NON INV/INV Selects inversion or non-inversion of the input signal.

INPUT

Positive or negative polarity selectable by front-panel switch; amplitude 0 to ± 1 V; protected to ± 6 V dc and to ± 100 V at 10% duty factor integrated over 1 s; impedance 100 Ω , dc-coupled; front-panel BNC connector. Accepts a ± 5 V dc offset, maximum input (signal plus offset) limited to ± 5 V.

OUTPUTS

OUTPUT Front-panel BNC connector. Amplitude 0 to ± 5 V; rise time ≤ 10 ns for filter out ($2.2 \tau_i$ for other filter selections). Impedance $< 1 \Omega$, dc-coupled.

PREAMPLIFIER POWER Rear-panel standard ORTEC power connector, Amphenol 17-10090.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 65 mA; -24 V, 45 mA; +12 V, 160 mA; -12 V, 180 mA.

WEIGHT

Net 1.0 kg (2.4 lb).
Shipping 2.5 kg (5.4 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

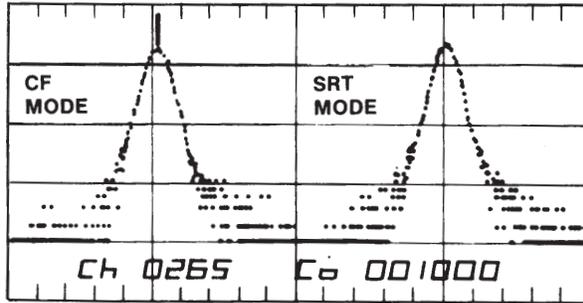


Fig. 2. Timing Spectrum for a Narrow Dynamic Range Using a Germanium Detector. (Resolution values are given in Table 1.)

²²Na
 Start: KL236 (1 X 1), RCA 8575 Photomultiplier Tube
 Stop: Ge Coax, 12.5%, 62.3 cc
 1.1:1 Dynamic Range
 473A Discriminator



Ordering Information

To order, specify:

Model	Description
474	Timing Filter Amplifier

Table 1. Timing Resolution for Various Sizes of Germanium Detectors Using ²²Na.

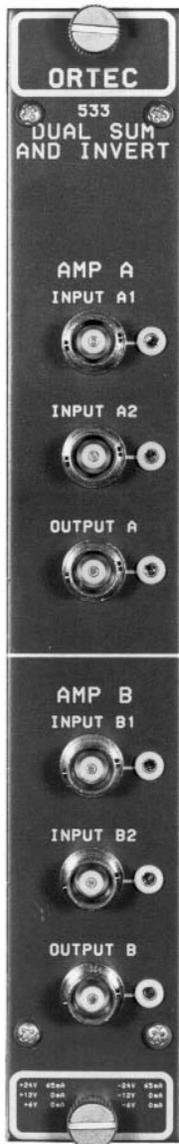
Detector	Dynamic Range	Timing Resolution (ns)						
		CF Mode			SRT Mode			
		FWHM	FW.1M	FW.02M	FWHM	FW.1M	FW.02M	FW.01M
8.6% HPGe 52.6 cc	1.1:1	4.4	10.1		4.3	10.1		21.6
	10:1	4.2	13.6		4.2	10.5		23.4
	20:1	4.7	13.5		4.7	12.8		30.4
12.5% HPGe 62.3 cc	1.1:1	5.0	10.0		5.0	9.5		17.6
	10:1	4.5	13.2		4.4	9.4		17.8
	20:1	5.1	14.3		5.0	12.0		24.8
19.6% HPGe 103 cc	1.1:1	7.9	16.4		8.1	16.0		27.3
	10:1	8.4	24.0		7.9	17.0		30.0
	20:1	8.4	26.0		8.4	23.0		40.0
8.6% HPGe	1.1:1	6.4	12.6	29.1	6.5	14.1	29.6	
	5:1	7.6	18.0	59.4	7.3	18.0	45.6	
	10:1	7.6	22.7	63.2	7.6	21.7	50.1	

Table 2. Timing Resolution for Large Germanium Detectors Using 583 CFDD/SCA, 474 TFA, and ⁶⁰Co.

Detector	Efficiency	FWHM Energy Resolution (keV)	Constant Fraction Delay (ns)	Timing Resolution (ns)			
				E > 100 keV		E = 1332 ± 50 keV	
				FWHM	FW.1M	FWHM	FW.1M
N30526A	73%	2.03	34	5.4	19.4	3.7	8.8
P20171	81%	1.97	34	5.5	27.0	4.7	13.8
N20366A	88%	2.34	36	5.8	21.2	5.5	16.4

Dual Sum and Invert Amplifier

- Sums up to four linear inputs, inverting or noninverting
- Two independent amplifiers, each with a gain of -1
- Wide bandwidth, dc to 7 MHz
- Wide dynamic range, 0 to ± 10 V
- Excellent temperature stability



The ORTEC Model 533 Dual Sum and Invert Amplifier is a single-width NIM that incorporates two wideband unity-gain amplifiers. Amplifier A has four summing inputs and Amplifier B has two summing inputs. Both amplifiers invert the signals. If a noninverting output is required, Amplifier A can be cascaded through Amplifier B to form the noninverting 4-input summing amplifier. By connecting A inputs in parallel and B inputs in parallel, the Model 533 can be used as a non-inverting amplifier with a gain of 1, 2, 3, 6, or 8.

The wide dynamic range and wide bandwidth make the Model 533 useful for summing and/or inverting any signals that fall within the dc to 7 MHz bandwidth, such as most NIM-standard linear or logic signals. A convenient oscilloscope monitor test point is located next to each of the six front-panel connectors.

Specifications

PERFORMANCE

VOLTAGE GAIN -1 for each input; tolerances $\leq \pm 2\%$.

BANDWIDTH Dc to 7 MHz ($t_r \leq 50$ ns).

INTEGRAL NONLINEARITY $< \pm 0.05\%$.

TEMPERATURE INSTABILITY

Gain $\leq \pm 0.005\%/^{\circ}\text{C}$.

Output DC Level $\leq \pm 50 \mu\text{V}/^{\circ}\text{C}$.

INPUTS

Four identical inputs for Amplifier A and two for Amplifier B; each accepts 0 to 10 V rated span, 12 V maximum, positive or negative, unipolar or bipolar; $Z_{in} \sim 666\Omega$, dc-coupled; Inputs A1, A2, B1, and B2 on front panel; Inputs A3 and A4 on rear panel; all BNC connectors.

OUTPUTS

One output for each Amplifier, A and B, completely independent of each other; range 0 to ± 10 V linear; $Z_o \sim 0.1 \Omega$; Outputs A and B on front panel; BNC connectors.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 65 mA; -24 V, 65 mA.

WEIGHT

Net 0.9 kg (2 lb).

Shipping 2.2 kg (5 lb).

DIMENSIONS Standard single-width NIM 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model **Description**

533 Dual Sum and Invert Amplifier



The ORTEC Model 570 Amplifier is a general-purpose spectroscopy amplifier that offers excellent performance for varying counting rates at an economical price.

The low noise, wide-gain range and selectable shaping networks make this instrument ideally suited for operation with semiconductor detectors, proportional counters, and scintillation detectors in a wide variety of high-resolution spectroscopy applications.

The Model 570 incorporates an

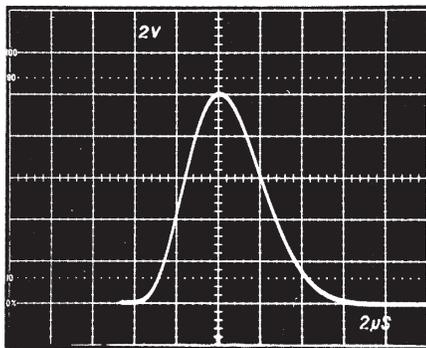
automatic gated baseline restorer, which causes the system resolution to be nearly independent of input counting rates. Figure 1 illustrates the peak shift and resolution for a typical γ -spectroscopy system.

The gated baseline restorer (BLR) includes a discriminator that operates the sensing circuits that normally establish the baseline reference for the MCA. Performance of the spectrometer often depends on the precision of the setting of the BLR threshold. The Model 570 offers the convenience of an automatic threshold control, which typically gives as good or better results than those the most experienced operator could achieve manually.

The active filter networks of the Model 570 generate a very symmetrical unipolar output with optimal signal-to-noise ratio over a wide range of time constants.

The excellent dc stability of the Model 570 output eliminates spectrum broadening caused by dc drift and ensures that the high-resolution capability of germanium detectors is realized.

- General-purpose amplifier for energy spectroscopy with all types of detectors
- Unipolar output
- Low noise, wide-gain range and front-panel selectable time constants
- Gated BLR with automatic threshold control for excellent counting rate performance



2 V/cm, 2 μ s/cm
UNIPOLAR OUTPUT

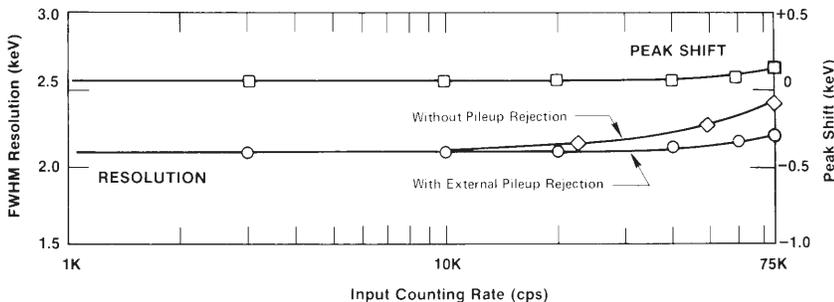


Fig. 1. Typical Resolution and Baseline Stability vs. Counting Rate for the Model 570 in a γ -Spectroscopy System.



570 Amplifier

Specifications

PERFORMANCE

GAIN RANGE Continuously adjustable from 1 to 1500.

PULSE SHAPE Semi-Gaussian on all ranges with peaking time equal to 2.2τ and pulse width at 0.1% level equal to 2.9 times the peaking time.

INTEGRAL NONLINEARITY For 2- μ s shaping time, $<\pm 0.05\%$.

NOISE Typically $<5 \mu\text{V}$ for unipolar output referred to the input, using 2- μ s shaping and Coarse Gain ≥ 100 .

TEMPERATURE INSTABILITY

Gain $\leq \pm 0.0075\%/^{\circ}\text{C}$, 0 to 50°C .

DC Level $\leq \pm 50 \mu\text{V}/^{\circ}\text{C}$, 0 to 50°C .

BIPOLAR CROSSOVER WALK $\leq \pm 3 \text{ ns}$ at 0.5 μs for 50:1 dynamic range, including contribution of an ORTEC Model 552 Single-Channel Analyzer.

OVERLOAD RECOVERY Recovers to within 2% of rated output from X300 overload in 2.5 nonoverloaded pulse widths using maximum gain for Unipolar Output.

SPECTRUM BROADENING Typically $<16\%$ FWHM for a ^{60}Co 1.33 MeV gamma line at 85% of full scale for an incoming count rate of 1 to 75,000 counts/s (Unipolar Output, 2- μ s shaping).

SPECTRUM SHIFT Peak position shifts typically $<0.024\%$ for a ^{60}Co 1.33-MeV gamma line at 85% of full scale measured from 1 to 75,000 counts/s (Unipolar Output, 2- μ s shaping).

CONTROLS

FINE GAIN 10-turn precision potentiometer with graduated dial for continuously variable direct-reading gain factor of X0.5 to X1.5.

COARSE GAIN 6-position switch selects feedback resistors for gain factors of 20, 50, 100, 200, 500, and 1k. Jumper on the printed wiring board (PWB) selects X0.1 attenuation.

INPUT POLARITY Locking toggle switch selects either Pos or Neg input pulse polarity.

SHAPING TIME 6-position switch selects time constants for active pulse-shaping filter network from 0.5, 1, 2, 3, 6, and 10 μs .

PZ ADJ Screwdriver adjustable potentiometer to set the pole-zero cancellation to compensate input decay times from 40 μs to ∞ .

BLR 3-position locking toggle switch selects the source of control for the gated baseline restorer discriminator threshold from:

Auto The BLR threshold is automatically set to an optimum level, as a function of the signal noise, by an internal circuit.

PZ Adj The BLR threshold is determined by the threshold potentiometer. The BLR time constant is also greatly increased to facilitate PZ adjustment; this position may give the lowest noise for count rates under 5000 counts/s and/or longer shaping times.

Threshold The BLR threshold is manually set by the threshold potentiometer.

DC Screwdriver adjustable potentiometer to set the Unipolar Output dc level; range $\pm 100 \text{ mV}$.

INPUT

INPUT Front-panel BNC connector accepts either positive or negative pulses with rise times of 10 to 650 ns and decay times of 40 μs to ∞ , $Z_{in} \cong 1000 \Omega$ dc-coupled; linear maximum 10 V; absolute maximum 20 V.

OUTPUTS

UNIPOLAR Front-panel BNC connector with $Z_o < 1 \Omega$, short-circuit proof; prompt with full-scale linear range of 0 to +10 V; active filter shaped; dc-restored; dc-level adjustable to $\pm 100 \text{ mV}$.

PREAMP POWER Rear-panel standard ORTEC power connector. Amphenol 17-10090, mates with captive and noncaptive power cords on all ORTEC pre-amplifiers.

BUSY OUTPUT Rear-panel BNC connector with $Z_o < 10 \Omega$ provides a +5 V logic pulse for the duration that the input pulse exceeds the baseline restorer discriminator.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 60 mA; -12 V, 30 mA; +24 V, 80 mA; -24 V, 85 mA.

WEIGHT

Net 1.5 kg (3.3 lb).

Shipping 3.1 kg (7.0 lb).

DIMENSIONS Standard single-width NIM module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
570	Amplifier



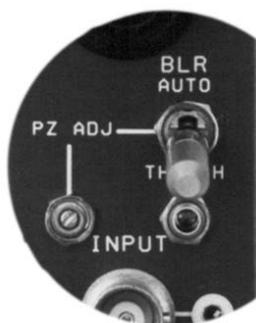
572A Amplifier

The ORTEC Model 572A Amplifier is ideally suited for use with germanium detectors, silicon charged-particle detectors, proportional counters, scintillation counters, and pulsed ion chambers. It includes an automatic gated baseline restorer and a built-in pile-up rejector to provide exceptionally stable performance over a very wide dynamic range. System resolution is nearly independent of input counting rate (Fig. 1).

The gated baseline restorer (BLR) includes a discriminator that operates the sensing circuits that normally establish the baseline reference for the MCA. Performance of the spectrometer depends on the precision of the setting of the BLR threshold. The Model 572A offers the convenience of an automatic threshold control, which typically gives as good or better results than those the most experienced operator could achieve manually. The gate logic generates a Busy signal that can be used for dead-time correction.

The active filter networks permit the Model 572A to generate very symmetrical unipolar outputs with optimum signal-to-noise ratios over a wide range of time constants. The instrument also provides a bipolar output for timing and gating applications.

Any dc drift in an amplifier output causes spectrum broadening. The excellent dc stability of the Model 572A eliminates spectrum broadening caused by dc drift and ensures that the high-resolution capability of germanium detectors is realized.



BLR Auto Control.

- General-purpose amplifier for energy spectroscopy with all types of detectors
- Built-in pile-up rejector and gated BLR with automatic thresholds for excellent performance at high counting rates
- Unipolar and bipolar outputs
- Active filter networks with wide range of time constants
- Wide gain range

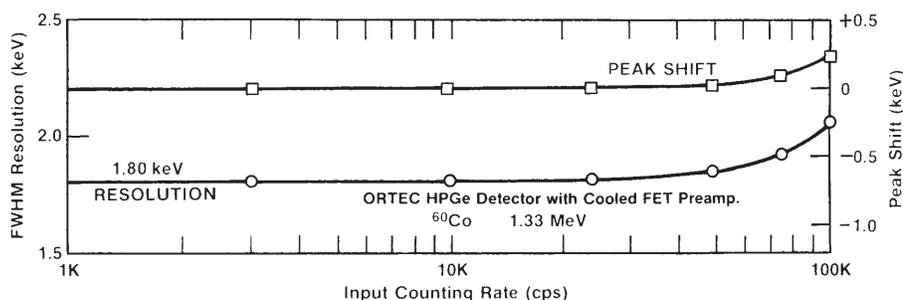


Fig. 1. Typical Resolution and Baseline Stability vs. Counting Rate for the Model 572A in a γ -Spectroscopy System.

572A Amplifier

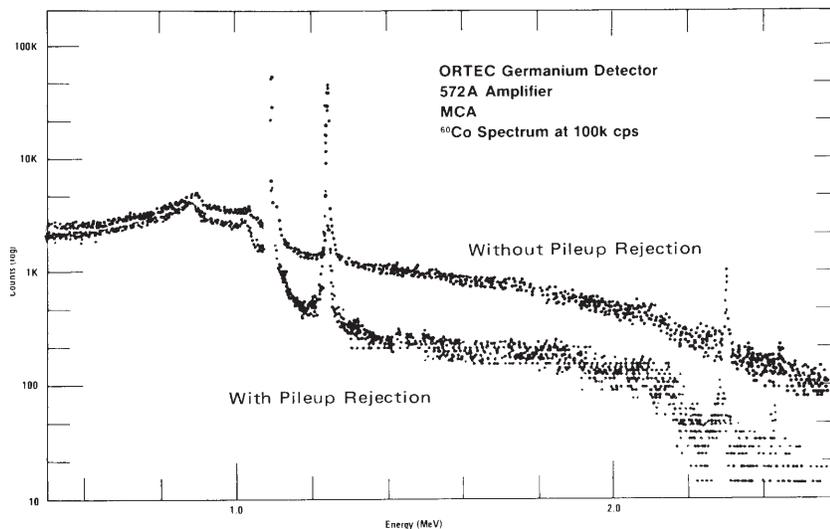
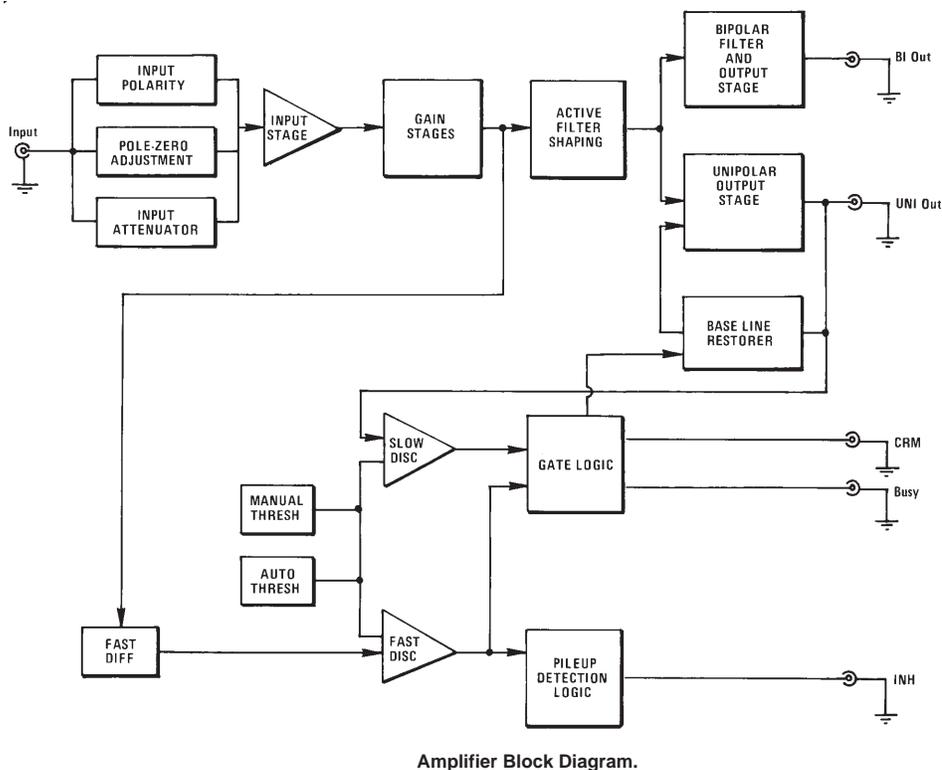


Fig. 2. Background Reduction Obtained from Pile-Up Rejection.



Amplifier Block Diagram.

Pile-Up Rejector

The pile-up rejection circuit incorporated into the Model 572A generates an inspection period immediately following every signal equal to the duration of the Busy output. If a second event were to occur within this inspection interval, an inhibit signal, INH Output, would be generated to gate-off the MCA and thus discard the distorted amplifier output. Figure 2 shows the background reduction that takes place in a γ -ray spectrum as pile-up rejection is used. Figure 3 illustrates the timing relationship between the amplifier input, output, and pile-up rejector logic signals.

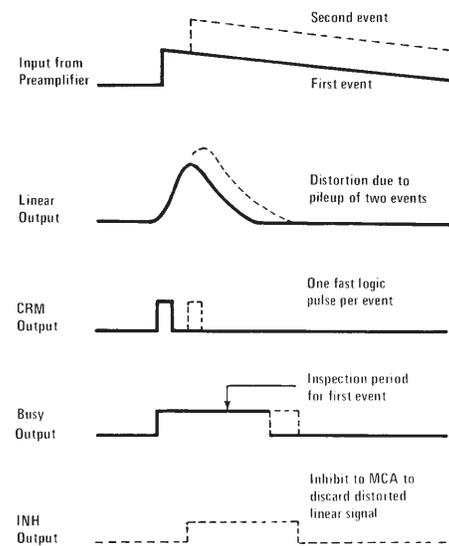


Fig. 3. Amplifier and Pile-Up Rejector Signals.

572A Amplifier

Specifications

PERFORMANCE

GAIN RANGE Continuously adjustable from 1 to 1500.

PULSE SHAPE Semi-Gaussian on all ranges with peaking time equal to 2.2τ and pulse width at 0.1% level equal to 2.9 times the peaking time.

INTEGRAL NONLINEARITY For 2- μ s shaping time, $<\pm 0.05\%$.

NOISE Typically $<5 \mu\text{V}$ for unipolar output referred to the input, using 2- μ s shaping and Coarse Gain ≥ 100 .

TEMPERATURE INSTABILITY

Gain $\leq \pm 0.0075\%/^{\circ}\text{C}$, 0 to 50°C .

DC Level $\leq \pm 50 \mu\text{V}/^{\circ}\text{C}$, 0 to 50°C .

BIPOLAR CROSSOVER WALK $\leq \pm 3$ ns at 0.5- μ s shaping, 50:1 dynamic range when used in conjunction with an ORTEC Model 552 Single-Channel Analyzer.

OVERLOAD RECOVERY Recovers to within 2% of rated output from X300 overload in 2.5 nonoverloaded pulse widths using maximum gain for unipolar output. Same recovery from X1000 overload for bipolar.

SPECTRUM BROADENING Typically $<16\%$ FWHM for a ^{60}Co 1.33-MeV gamma line at 85% of full scale for an incoming count rate of 1 to 100,000 counts/s. Unipolar output, 2- μ s shaping.

SPECTRUM SHIFT Peak position shifts typically $<0.024\%$ for a ^{60}Co 1.33-MeV gamma line at 85% of full scale measured from 1 to 100,000 counts/s at the unipolar output, 2- μ s shaping.

CONTROLS

FINE GAIN 10-turn precision potentiometer with graduated dial for continuously variable direct-reading gain factor of X0.5 to X1.5.

COARSE GAIN 6-position switch selects feedback resistors for gain factors of 20, 50, 100, 200, 500, and 1k. Jumper on the printed wiring board (PWB) selects X0.1 attenuation.

SHAPING TIME 6-position switch selects time constants for active pulse-shaping filter network from 0.5, 1, 2, 3, 6, and 10 μ s.

INPUT Locking toggle switch selects either Pos or Neg input pulse polarity.

PZ ADJ Screwdriver adjustable potentiometer to set the pole-zero cancellation to compensate input decay times from 40 μ s to ∞ .

BLR 3-position locking toggle switch selects the source of control for the gated baseline restorer discriminator threshold from:

Auto The BLR threshold is automatically set to an optimum level, as a function of the signal noise, by an internal circuit.

PZ Adj The BLR threshold is determined by the threshold potentiometer. The BLR time constant is also greatly increased to facilitate PZ adjustment; this position may give the lowest noise for count rates under 5000 counts/s and/or longer shaping times.

Threshold The BLR threshold is manually set by the threshold potentiometer.

DC Screwdriver adjustable potentiometer to set the unipolar output dc level; range ± 100 mV.

INPUTS

INPUT BNC front- and rear-panel connectors accept either positive or negative pulses with rise time of 10 to 650 ns and decay times of 40 μ s to ∞ ; $Z_{in} \cong 1000 \Omega$ dc-coupled; linear maximum 10 V; absolute maximum 20 V.

OUTPUTS

UNI Front-panel BNC connector with $Z_o < 1 \Omega$ and rear-panel connector with $Z_o = 93 \Omega$, short-circuit proof; with full scale linear range of +10 V; active filter shaped; dc-restored, dc level adjustable to ± 100 mV.

BI Front-panel BNC connector with $Z_o < 1 \Omega$ and rear-panel connector with $Z_o = 93 \Omega$, short circuit proof; prompt output with positive lobe leading and linear range of ± 10 V; active filter shaped.

CRM Rear-panel BNC connector with Z_o

$<10 \Omega$ provides a nominally +5 V, 300 ns logic pulse every time the input signal exceeds the baseline restorer discriminator threshold.

INH Rear-panel BNC connector with $Z_o < 10 \Omega$ provides a nominally +5 V (width equal to X6 shaping time) logic pulse when the internal pile-up rejection logic detects a distortion of the input signal due to pile-up.

BUSY Rear-panel BNC connector with $Z_o < 10 \Omega$ provides a +5 V logic pulse for the duration that the input pulse exceeds the baseline restorer discriminator.

PREAMP POWER Rear-panel standard ORTEC power connector, Amphenol 17-10090, mates with captive and noncaptive power cords on all ORTEC pre-amplifiers.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 85 mA; -12 V, 50 mA; +24 V, 100 mA; -24 V, 105 mA.

WEIGHT

Net 1.5 kg (3.3 lb).

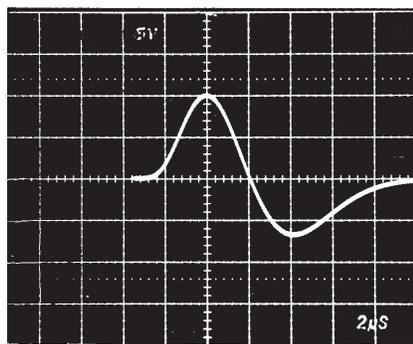
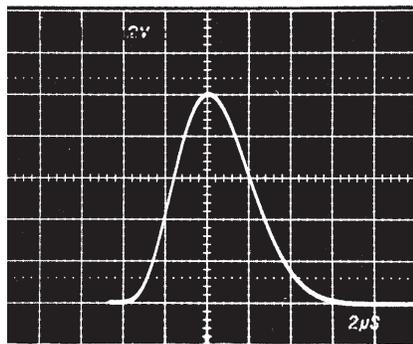
Shipping 3.1 kg (7.0 lb).

DIMENSIONS Standard single-width NIM module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
572	Amplifier



575A Amplifier

- Low-cost, general-purpose amplifier, for semiconductor detectors, scintillation detectors, and proportional counters
- Gated active baseline restorer with automatic threshold control
- Selectable shaping time constants
- Positive or negative input



The Model 575A Amplifier is ORTEC's most economical, general-purpose NIM amplifier. The low input noise, selectable shaping time constants, and gain range allow operation with semiconductor detectors, proportional counters, and scintillation detectors in a variety of applications. The performance capability of the Model 575A, coupled with its low cost, allows a wide range of uses in such fields as research, environmental monitoring, and teaching.

The Model 575A incorporates an automatic gated baseline restorer (BLR) that causes the system resolution to be nearly independent of input counting rates. The gated baseline restorer includes an automatic noise discriminator that operates the sensing circuits that normally establish the baseline reference for the multichannel analyzer. Performance of the spectrometer often depends on the precision of the setting of the BLR threshold. The Model 575A offers the convenience of an automatic threshold control that typically gives results as good as, or better than, those the most experienced operator could achieve manually.

The pulse-shaping networks in the Model 575A produce semi-Gaussian-shaped output pulses resulting in improved noise performance and reduced amplifier resolving time. The shorter resolving time permits higher counting rates than in amplifiers with classical RC pulse-shaping networks. The Model 575A provides a 10-V linear output with excellent dc stability for both unipolar and bipolar output pulses.

Specifications

PERFORMANCE

GAIN RANGE Continuously adjustable from 5 to 1250.

PULSE SHAPE Semi-Gaussian on all ranges with peaking time equal to 2.2τ , 50% pulse width equal to 3.3τ , and pulse width at 0.1% level equal to 4.0 times the peaking time. Bipolar crossover = 1.5τ .

INTEGRAL NONLINEARITY For 1.5- μ s shaping time, $\leq \pm 0.05\%$.

NOISE $< 5\ \mu\text{V}$ rms referred to the input using 3- μ s unipolar shaping; $< 7\ \mu\text{V}$ using 1.5- μ s shaping; both for a gain ≥ 100 .

TEMPERATURE INSTABILITY

Gain $\leq \pm 0.0075\%/^{\circ}\text{C}$, 0 to 50°C .

DC Level $\leq \pm 30\ \mu\text{V}/^{\circ}\text{C}$, 0 to 50°C .

BIPOLAR CROSSOVER WALK $\leq \pm 5\ \text{ns}$ at 0.5- μ s shaping for 50:1 dynamic range, including contribution of an ORTEC Model 552 Single-Channel Analyzer.

OVERLOAD RECOVERY Recovers to within 2% of rated output from X300 overload in 2.5 nonoverloaded pulse widths using maximum gain for unipolar output. Same recovery from X500 overload for bipolar.

RESTORER Gated active baseline stabilizer with automatic threshold circuit to provide the threshold level as a function of signal noise to the baseline restorer discriminator.

SPECTRUM BROADENING* Typically $< 10\%$ FWHM for a ^{60}Co 1.33-MeV gamma line at 85% of full scale for an incoming count rate of 1,000 to 50,000 counts/s (Unipolar output, 1.5- μ s shaping).

SPECTRUM SHIFT* Peak position shifts typically $< 0.02\%$ for a ^{60}Co 1.33-MeV gamma line at 85% of full scale (measured at the unipolar output, 1.5 μ s shaping, 1,000 to 50,000 counts/s).

*These count-rate specifications were measured with a 10% HPGe detector. Detectors with a large number of slow rise-time signals will most likely give poorer results.

575A Amplifier

CONTROLS

FINE GAIN Ten-turn precision potentiometer with graduated dial for continuously variable direct-reading gain factor of X2.5 to X12.5.

COARSE GAIN Six-position switch selects feedback resistors for gain factors of 2, 4, 10, 20, 40, and 100.

SHAPING TIME Three-position printed wiring board (PWB) jumpers, easily accessible through side panel, select time constants for active pulse-shaping filter network of 0.5, 1.5, or 3 μ s.

POS/NEG Toggle switch selects either Pos or Neg input pulse polarity.

PZ ADJ Screwdriver adjustable potentiometer to set the pole-zero cancellation to compensate input decay times from 30 μ s to ∞ .

INPUT

INPUT BNC front- and rear-panel connectors accept either positive or negative pulses with rise times of 10 to 650 ns and decay times of 30 μ s to ∞ ; $Z_{in} = 1000 \Omega$ dc-coupled; linear maximum 2 V; absolute maximum 20 V.

OUTPUTS

UNI Front-panel BNC connector with $Z_o < 1 \Omega$ and rear-panel connector with $Z_o = 93 \Omega$. Short-circuit proof; full-scale linear range of 0 to +10 V; active filter shaped; dc-restored with dc level adjustable to ± 15 mV.

BI Front-panel BNC connector with $Z_o < 1 \Omega$ and rear-panel connector with $Z_o = 93 \Omega$. Short-circuit proof; positive lobe leading and full-scale linear range of 0 to +10 V; active filter shaped.

PREAMP POWER Rear-panel standard ORTEC power connector (Amphenol 17-10090) mates with captive and noncaptive power cords on all ORTEC preamplifiers.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 55 mA; -24 V, 40 mA; +12 V, 70 mA; -12 V, 75 mA.

WEIGHT

Net 1.5 kg (3.3 lb).

Shipping 3.1 kg (7.0 lb).

DIMENSIONS Standard single-width NIM module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

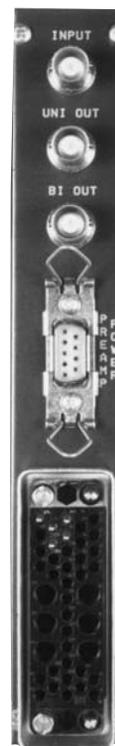
Related Equipment

The ORTEC Model 575A Amplifier accepts linear pulses from, and furnishes power to any standard ORTEC preamplifier or equivalent. Its output pulses may be used for linear signal analysis, using any of the ORTEC modular instruments and multichannel analyzers.

Ordering Information

To order, specify:

Model	Description
575A	Amplifier



Fast-Filter Amplifier

- For fast timing with germanium and other semiconductor detectors
- Fast <8 -ns rise time
- Independent integration and differentiation
- Gated baseline restorer
- Pole-zero cancellation
- $50\text{-}\Omega$ delay cable clipping
- Voltage gain X0.9 to X500
- Output drives to ± 5 V on a $50\text{-}\Omega$ load



The ORTEC Model 579 wideband Fast-Filter Amplifier with gated baseline restorer (Fig. 1) enhances fast-timing measurements by improving the noise-to-slope ratio and providing ultra-high count rate spectroscopy capability.

A fast rise time (<8 ns), high output drive (± 5 V into $50\ \Omega$), and wide voltage gain range (X0.9–X500) make the Model 579 useful for many timing applications, including those utilizing low-gain photomultiplier tubes. The Model 579 is particularly suited for use with ORTEC Constant-Fraction Discriminators such as Models 583, 935, or 473A in timing applications with high-purity germanium (HPGe) or silicon charged-particle detectors (Figs. 2 and 9 and Tables 1 and 2). Excellent dc and gain stability ($\pm 50\ \mu\text{V}/^\circ\text{C}$ and $\pm 0.05\%/^\circ\text{C}$, respectively) eliminate the need for a dc level adjustment. A Busy LED and Busy Output are included to aid in BLR adjustment and system interfacing.

In addition, the wideband gated baseline restorer and pole-zero cancellation network permit ultra-high output counting rates. A wide variety of pulse filtering is available for improved signal processing. The Model 579 combines continuously

variable gain, independently selectable integration and differentiation time constants (Out, 10, 20, 50, 100, 200, and 500 ns), and cable clipping capability (external cable delay), making this versatile unit an important asset for sophisticated time and energy spectroscopy.

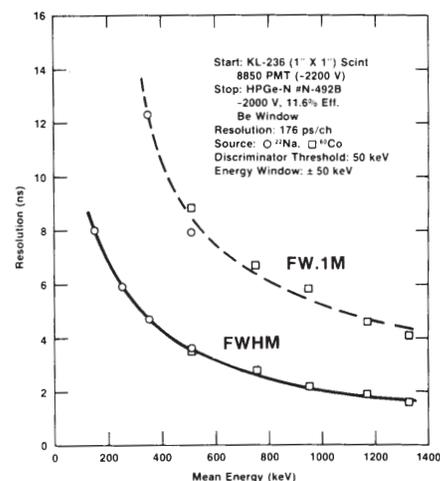


Fig. 2. Timing Resolution FWHM and FW.1M as a Function of Energy an Energy Window of ± 50 keV.

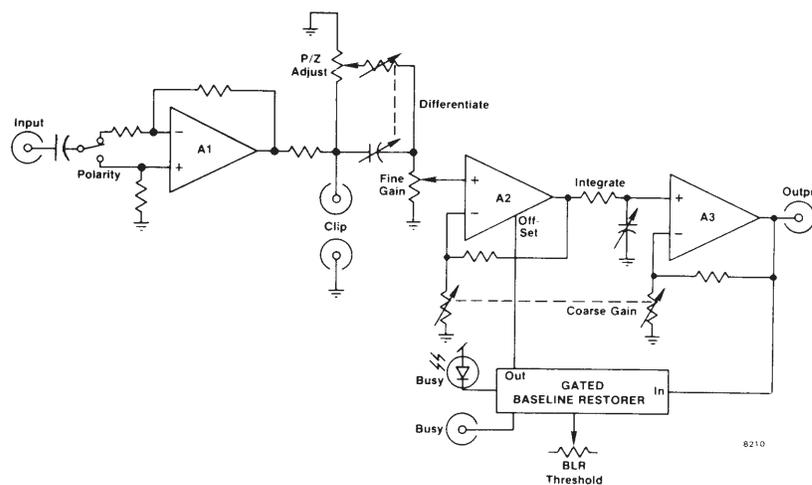


Fig. 1. Block Diagram of the Model 579 Fast-Filter Amplifier.

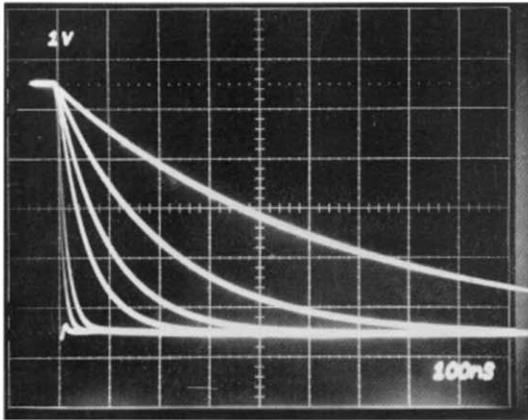


Fig. 3. Model 579 Output Signals for $\tau_o = \text{Out}$ and $\tau_i = \text{Out}, 10, 20, 50, 100, 200,$ and 500 ns .

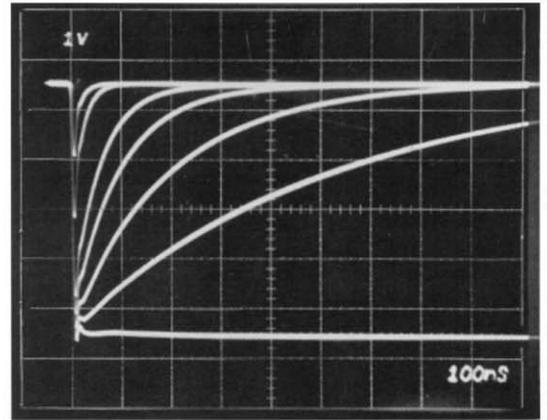


Fig. 4. Model 579 Output Signals for $\tau_i = \text{Out}$ and $\tau_o = \text{Out}, 10, 20, 50, 100, 200,$ and 500 ns .

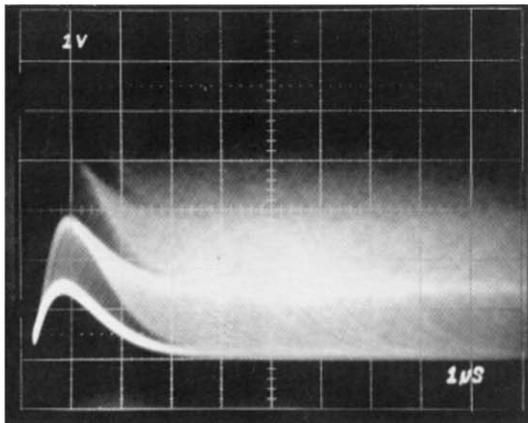


Fig. 5. Example of Model 579 Ultra-High Output Count Rate Capability. Input Signal from a BNC Random Pulse Generator at Approximately 1 Million Counts per Second. Fast-Filter Amplifier $\tau_i = \tau_o = 500 \text{ ns}$.

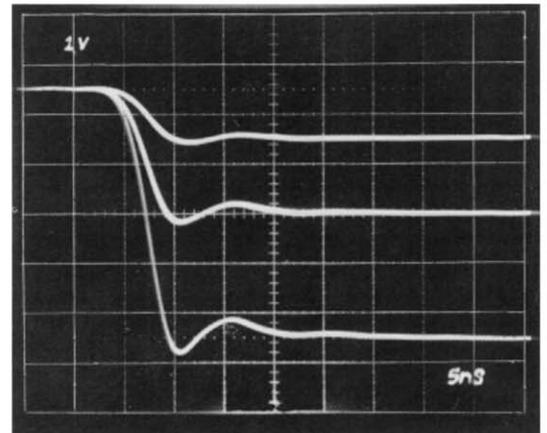


Fig. 6. Model 579 Output Signals for $\tau_i = \tau_o = \text{Out}$ at 1, 2, and 5 V.

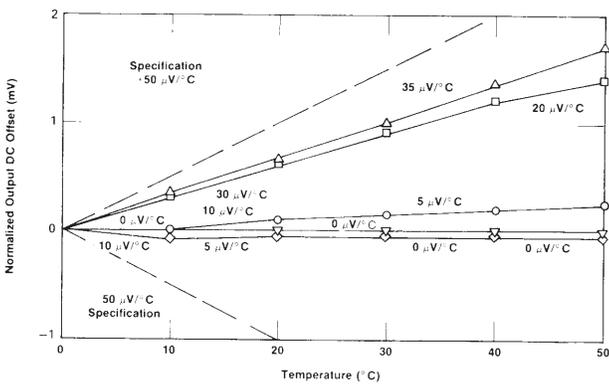


Fig. 7. DC Output Offset vs. Temperature Measured on Five Typical Units.

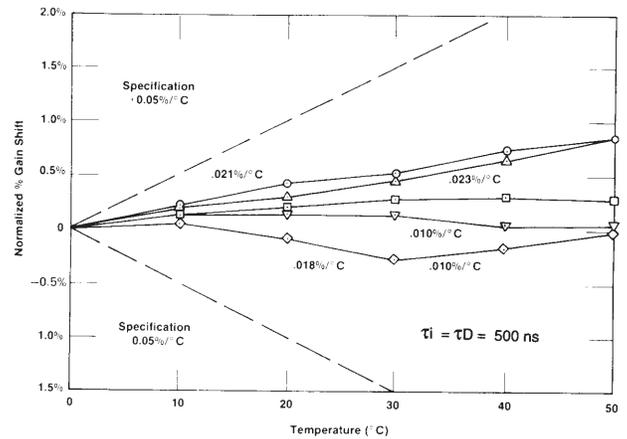


Fig. 8. Percentage Gain Shift vs. Temperature Measured on Five Typical Units.

Fast-Filter Amplifier

Specifications

PERFORMANCE

INPUT SIGNAL AMPLITUDE RANGE

± 1 V ac, ± 5 V ac with X5 internal attenuator; ± 35 V dc; input impedance 100 Ω , ac-coupled; 50 Ω optional.

OUTPUT AMPLITUDE RANGE 0 to ± 5 V linear into a 50- Ω load.

RISE TIME < 8 ns with Integrate and Differentiate Out, or $\approx 2.2 \tau_i$ for other integrate settings and Differentiate Out.

OVERSHOOT $< 10\%$ with Integrate Out, or $< 2\%$ for any selected integration.

NOISE For maximum gain, rms noise referred to the input is < 10 μ V (typically 5 μ V), with $\tau_i = \tau_D = 200$ ns, measured with an HP3400A true rms voltmeter. Wideband (200 MHz) noise for $\tau_i = \tau_D =$ Out is < 50 μ V (typically 40 μ V).

INTEGRAL NONLINEARITY $< \pm 1\%$ (typically 0.5%) over ± 5 V range into 50- Ω load.

TEMPERATURE INSTABILITY

DC Level $< \pm 50$ μ V/ $^{\circ}$ C referred to the output; factory-set within ± 5 mV.

Gain $< \pm 0.05\%$ / $^{\circ}$ C.

OPERATING TEMPERATURE RANGE 0 to 50 $^{\circ}$ C.

CONTROLS

COARSE GAIN Front-panel 6-position switch to select X15, X25, X50, X125, X250, and X500 gain factor. When internal X5 attenuator is used, the coarse gain factors represent X3, X5, X10, X25, X50, and X100, respectively. A continuously variable voltage gain of X0.9 to X500 can be obtained. (Gain reduced by factor of two when cable clip is used.)

FINE GAIN Front-panel single-turn potentiometer, continuously adjustable from 0.3 to 1.0.

P/Z Front-panel screwdriver adjustable potentiometer to adjust pole-zero cancellation for decay time constants from 25 μ s to ∞ .

DIFF Front-panel 7-position switch selects a differentiation time constant to control the decay time of the pulse. Decay time $\approx 2.2 \tau_D$ with $\tau_i =$ Out. The τ_D settings include Out, 10, 20, 50, 100, 200, and 500 ns.

INT Front-panel 7-position switch selects an integration time constant to control the rise time of the output pulse. The rise time is $\approx 2.2 \tau_i$ with $\tau_D =$ Out. The τ_i settings include Out, 10, 20, 50, 100, 200, and 500 ns. Rise time in the Out position is < 5 ns, equivalent to a $\tau_i < 2.3$ ns.

INV/NONINV Front-panel locking toggle switch selects inversion or noninversion of the input signal.

BLR ADJ Front-panel screwdriver adjustment to set the Gated BLR threshold from ± 50 mV to ± 500 mV referred to the output.

BLR GATED/UNGATED Printed wiring board (PWB) jumper selects gated or ungated BLR operation. Factory-set in gated position.

BLR LED This feature enables the user to quickly adjust the BLR threshold setting near the noise peak. Front-panel LED indicates an output amplitude has exceeded the BLR threshold. The BLR LED can be used as a visual indicator of the output counting rate.

COUNT RATE

High/Low PCB jumper selects minimum BLR dead time of typically 400 ns in high position and typically 1 μ s in low position. Factory-set in low position.

ATTENUATOR PWB jumper select to pass with unity Gain or Attenuate by a factor of 5. Jumper select B to C and A to F will pass with unity Gain. Jumper select C to D and E to F will attenuate by a factor of 5. Factory-set at unity Gain.

INPUTS

INPUT Front-panel BNC accepts input signals of either polarity. ± 1.0 V ac or ± 5.0 V ac with X5 attenuator. Maximum dc voltage ± 35 V. Input impedance 100 Ω (to match preamplifiers), ac-coupled.

CLIP Two front-panel BNC connectors to provide delay line clipping of the input pulse. Cable impedance must be 50 Ω . Delay line clip is 2X the cable propagation delay. Gain is reduced by factor of 2 when using cable clip.

OUTPUTS

OUTPUT Front-panel BNC connector furnishes the amplified and shaped signal through $Z_o < 1$ Ω . Amplitude 0 to ± 5 V into 50 Ω ; rise time and decay time constants controlled by the integrate and differentiate filter settings.

BUSY Rear-panel BNC furnishes NIM-standard positive logic signal during the BLR busy time.

PREAMP POWER Rear-panel standard ORTEC power connector, Amphenol type 17-80090-15.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 80 mA; -24 V, 80 mA; +12 V, 160 mA; -12 V, 140 mA.

WEIGHT

Net 1.5 kg (3.3 lb).

Shipping 3.1 kg (7.0 lb).

DIMENSIONS Standard single-width NIM module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
579	Fast-Filter Amplifier



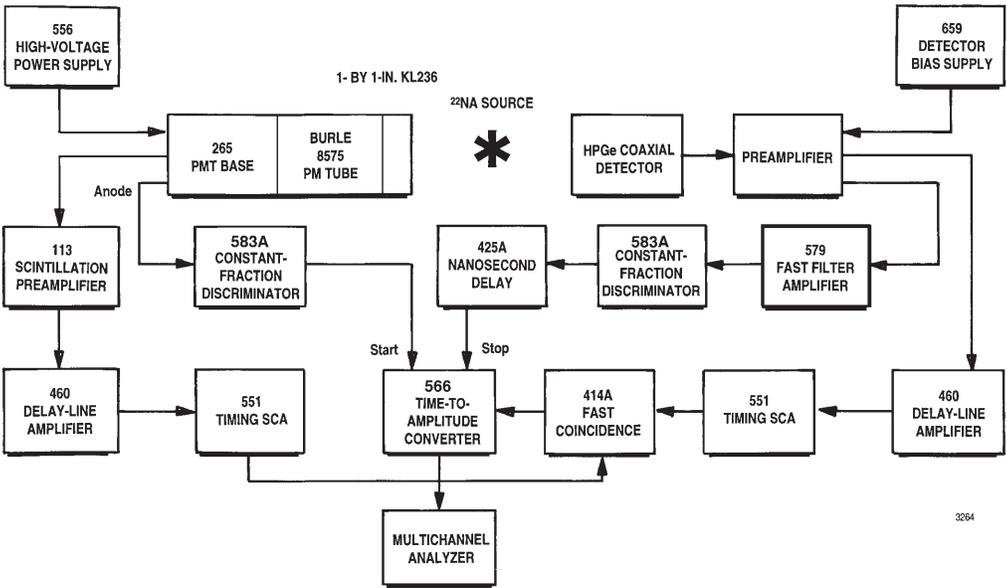


Fig. 9. Gamma-Gamma Coincidence System Using a Plastic Scintillator and a Large HPGe Coaxial Detector.

Table 1. Timing Resolution in ns as a Function of Energy for an Energy Window of ± 50 keV.

Detector System	Detector Type	Efficiency (%)	Constant-Fraction Delay (ns)	Measure	Timing Resolution (ns)								
					Mean Energy (keV) Using ^{22}Na				Mean Energy (keV) Using ^{60}Co				
					150	250	350	511	511	750	950	1170	1330
1	HPGe-P	17.7	26	FWHM	9.2	6.9	5.6	4.2	4.2	3.7	2.8	2.6	2.2
				FW.1M		41.2	12.8	9.0	9.9	8.6	7.6	6.0	5.8
2	HPGe-P	28.0	34	FWHM	11.3	8.8	7.7	5.6	6.2	5.7	4.0	3.6	3.4
				FW.1M		55.8	27.1	12.8	13.4	12.3	11.8	9.8	9.0
3	HPGe-P	11.0	24	FWHM	9.2	6.7	5.8	4.0	3.9	3.0	2.6	2.0	1.7
				FW.1M		45.3	22.2	9.9	10.2	8.4	7.5	5.6	5.1
4	HPGe-N	11.6	23	FWHM	8.0	5.9	4.7	3.6	3.5	2.8	2.1	1.9	1.6
				FW.1M		78	27.5	12.3	7.9	8.8	6.7	5.8	4.6
5	HPGe-N	19.8	23	FWHM	12.5	8.6	7.0	4.5	4.9	3.7	3.1	2.2	2.0
				FW.1M		84	33	18.1	10.2	11.8	8.6	7.7	5.5
6	HPGe-N	16.4	24	FWHM	8.6	6.7	5.6	4.1	4.2	3.1	2.7	2.3	2.0
				FW.1M		77.3	22.5	16.2	9.7	10.7	8.1	7.4	5.5

Table 2. Timing Resolution for Large Germanium Detectors.

Detector	Efficiency	FWHM Energy Resolution (keV)	Constant Fraction Delay (ns)	Timing Resolution (ns)			
				E > 100 keV		E = 1332 \pm 50 keV	
				FWHM	FW.1M	FWHM	FW.1M
N30526A	73%	2.05	34	5.4	19.4	3.7	8.8
P20171	81%	1.97	34	5.5	27.0	4.7	13.8
N20366A	88%	2.34	36	5.8	21.2	5.5	16.4

590A Amplifier and Timing Single-Channel Analyzer

- For counting, timing, and energy spectroscopy with scintillation detectors and proportional counters
- Selectable shaping times (0.5, 1.5, and 3.0 μs)
- High count-rate capability
- Gated active baseline restorer
- Selectable window range
- Integral/Window mode



The ORTEC Model 590A Amplifier and Timing Single-Channel Analyzer includes both a low-noise shaping amplifier and a timing single-channel analyzer.

The amplifier employs active-filter shaping (0.5, 1.5, and 3.0 μs shaping times) for use with various types of radiation detectors. It is particularly well suited for use with the proportional counters and scintillation detectors normally used in x-ray and nuclear spectroscopy, as well as in x-ray diffraction and Mössbauer experiments. High amplifier gain improves operation of proportional counters because they can be used with lower operating potentials, thus improving the stability of gas gain vs count rate. The amplifier's short resolving time provides high count-rate capability without sacrificing the energy resolution of the proportional counter.

The amplifier has a single output that can be switch-selected for either unipolar or bipolar pulse shaping. The unipolar output is used for spectroscopy in systems where dc-coupling can be maintained from the Model 590A to the analyzer. A baseline restorer, (BLR) circuit is included in the amplifier for improved performance at all count rates. Baseline correction is applied only during intervals between input pulses, and the discriminator level to identify input pulses is automatically adjusted. The unipolar output dc-level is within the range from -5 mV to $+5$ mV. This output permits the use of the direct-coupled input of the analyzer with a minimum amount of interface problems.

The timing single-channel analyzer, (TSCA), in the Model 590A is dc-coupled to maintain the peak in an adjusted window without shifts due to changes of count rates. This permits stable operation with narrow window widths over wide variations of count

rates, such as those that are usually present during x-ray diffraction studies. The lower level can be adjusted with a front-panel control, or it can be set by an external voltage.

The TSCA output occurs ~ 500 ns after the peak of the amplifier output signal. The walk of this signal is very small over a wide range of input amplitudes, making the Model 590A ideal for use in slow coincidence or gating applications.

The External Lower Level, (Ext LLD), input of the Model 590A can be used with an external voltage to set the lower level. It can also be used with a slowly varying voltage to change the lower level as a function of time or other measurement parameters.

Specifications

Amplifier

PERFORMANCE

SHAPING Semi-Gaussian on all ranges with peaking time equal to 2.2τ and pulse width at 0.1% level equal to 4 times the peaking time. Bipolar crossover equal to 1.5τ .

GAIN RANGE Continuously adjustable from X5 through X1250.

INTEGRAL NONLINEARITY $< \pm 0.05\%$ using 1.5- μs shaping.

NOISE < 5 μV rms referred to the input using 3- μs unipolar shaping, and ≤ 7 μV using 1.5- μs shaping, both for gain ≥ 100 .

TEMPERATURE INSTABILITY

Gain $\leq \pm 0.0075\%/^{\circ}\text{C}$, 0 to 50°C .

DC Level $< \pm 50$ $\mu\text{V}/^{\circ}\text{C}$, 0 to 50°C .

COUNT-RATE STABILITY The 1.33-MeV gamma-ray peak for a ^{60}Co source, positioned at 85% of the analyzer range, typically shifts $< 0.02\%$, and its FWHM broadens $< 10\%$ when its incoming count rate changes from 1000 to 50,000 counts/s using 1.5- μs shaping. The amplifier will hold the baseline reference up to count rates in excess of 75,000 counts/s.

OVERLOAD RECOVERY Recovers to within 2% of rated output from X300 overload in 2.5-nonoverloaded unipolar pulse widths using maximum gain; same recovery from X500 overload for bipolar pulses.

BASELINE RESTORER (BLR) Gated active baseline stabilizer, with automatic threshold circuit, which provides the threshold level as a function of signal noise to the baseline restorer discriminator.

590A Amplifier and Timing Single-Channel Analyzer

CONTROLS

COARSE GAIN Six-position switch to select Coarse Gain factor for amplifier; factors are 10, 20, 50, 100, 200, and 500.

FINE GAIN Single-turn potentiometer for direct reading, continuous adjustment of Fine Gain factor from 0.5 to 2.5.

PZ ADJ Front-panel screwdriver adjustment to match the amplifier shaping to the preamplifier decay time; adjustable for preamplifier decay times from 30 μ s to ∞ . Factory set at 50 μ s.

SHAPING Three, 3-position printed wiring board (PWB) switches, easily accessible through the side panel, select shaping times of 0.5, 1.5, and 3.0 μ s.

POS/NEG Front-panel toggle switch selects input circuit for either polarity of input pulses from the preamplifier.

UNI-BI Front-panel toggle switch selects unipolar or bipolar output shape.

INPUT

AMP INPUT BNC front- and rear-panel connectors accept either positive or negative pulses, selectable by front-panel toggle switch, with rise times in the range from 10 to 650 ns and decay times from 30 μ s to ∞ ; $Z_{iV} = 1000 \Omega$, dc-coupled; linear maximum, 2 V; absolute maximum, 20 V.

OUTPUT

AMP Front-panel BNC, $Z_o < 1 \Omega$. Short-circuit proof; prompt full-scale linear range, 0 to +10 V; active filter shaped and dc-restored for unipolar output; dc level 0 to ± 5 mV.

PREAMPLIFIER POWER

Rear-panel standard ORTEC power connector; Amphenol 17-10090 or equivalent, mates with captive and noncaptive power cords on all standard ORTEC preamplifiers.

Timing Single-Channel Analyzer

PERFORMANCE

INPUT DYNAMIC RANGE 200:1.

PULSE-PAIR RESOLVING TIME Minimum pulse-pair resolving time $\leq 2 \mu$ s with 0.5- μ s shaping time.

OUTPUT TIMING ≈ 500 ns after peak of output pulse from amplifier.

TIME SHIFT vs PULSE HEIGHT (Walk)

Walk $< \pm 10$ ns for a 50:1 change in output amplitude for 0.5- μ s shaping time.

THRESHOLD TEMPERATURE

INSTABILITY $\leq \pm 0.01\%/^{\circ}\text{C}$ of full scale (1 mV/ $^{\circ}\text{C}$). 0 to 50 $^{\circ}\text{C}$ using a NIM Class A power supply (referenced to -12 V).

DISCRIMINATOR NONLINEARITY $\leq \pm 0.25\%$ of full scale (integral) for both discriminators.

WINDOW WIDTH CONSTANCY $< 0.1\%$ variation of full-scale window width over the linear 0 to 10-V range.

MINIMUM INPUT THRESHOLD 50 mV for lower-level discriminator.

EXT LLD When the rear-panel-mounted Lower-Level Reference switch is on EXT, this rear-panel BNC connector accepts the lower-level biasing (an input of 0 to -10 V on this connector corresponds to a signal in the range of 0 to +10 V for the lower-level discriminator setting). Input impedance 2000 Ω .

CONTROLS

LOWER LEVEL Front-panel 10-turn potentiometer adjustable from 0 to +10 V; when the rear-panel LL Ref mode switch is set on INT, determines the threshold setting for the lower-level discriminator. When the LL Ref mode switch on the rear panel is in the EXT position, this control is ineffective.

WINDOW 10-turn precision potentiometer on front panel for adjustment of analyzer window width (0 to 10 V or 0 to 1 V as selected by an internal jumper. Factory set at 0 to 10 V).

INT/WINDOW Front-panel toggle switch selects operating mode.

Window LL sets the baseline level (0 to 10 V) and the Window control sets the window width between 0 to 1 V or 0 to 10 V.

INT Integral LL sets a single discriminator threshold (0 to 10 V) and the Window control is disabled.

LOWER-LEVEL REFERENCE Toggle switch mounted on the rear panel selects the source of lower-level bias. INT position selects front-panel control; EXT selects lower-level bias through rear-panel connector.

INPUTS

SCA Internally connected to amplifier output; impedance level of 1000 Ω .

EXT LLD Input from 0 to -10 V, 2000- Ω input impedance; rear-panel connector.

OUTPUTS

SCA OUT Front- and rear-panel BNC connectors provide NIM standard output nominally +5 V, 500 ns wide; typically 50- Ω output impedance.

DISC OUT Rear-panel BNC connector provides NIM standard output, nominally +5 V, 500 ns wide; typically 50- Ω output impedance. Output occurs as leading edge of linear input crosses the window threshold.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 35 mA; -24 V, 25 mA; +12 V, 115 mA; -12 V, 85 mA.

WEIGHT

Net 1.3 kg (3.0 lb).

Shipping 2.25 kg (5.0 lb).

DIMENSIONS Single-width NIM-standard module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
590A	Amplifier and Timing Single-Channel Analyzer



671 Spectroscopy Amplifier

- High-performance energy spectroscopy with all types of detectors (Ge, Si, scintillation; proportional counters)
- Compact, single-width NIM module
- Choice of triangular and Gaussian filters effectively doubles the time constants available for optimum resolution
- Automatic noise discriminators on both the pile-up rejector and the baseline restorer eliminate screwdriver adjustments
- Automatic baseline restorer rate for optimum performance at both low and high counting rates
- Differential input for reduction of ground loop noise
- Automatically compensates for reset recovery with transistor-reset preamplifiers



The ORTEC Model 671 high-performance, energy spectroscopy amplifier is ideally suited for use with germanium, Si(Li), and silicon charged-particle detectors. It can also be used with scintillation detectors and proportional counters. The Model 671 input accepts either positive or negative polarity signals from a detector preamplifier and provides a positive 0 to 10-V output signal suitable for use with single-channel or multichannel pulse height analyzers. Its gain is continuously variable from 2.5 to 1500.

Automation of critical adjustments makes the Model 671 easy to set up with any detector, while minimizing the required operator expertise.

A front-panel switch on the Model 671 provides the choice of either a triangular or a Gaussian pulse shape on the UNI output connector (Fig. 1). The noise performance of the triangular pulse shape is equivalent to a Gaussian pulse shape having a 17% longer shaping time constant. In applications where the series noise component is dominant (short shaping time constants), and the pile-up rejector is utilized, the triangular shape will generally offer the same dead time and slightly lower noise than the Gaussian pulse shape. A front-panel switch permits selection of the optimum shaping time constant for each detector and application. Six time constants in the

range of 0.5 to 10 μ s, and the TRI/GAUSS switch combine to offer 12 different shaping times. A bipolar output is also provided for measurements requiring zero cross-over timing.

To minimize spectrum distortion at medium and high counting rates (Fig. 2), the unipolar output incorporates a high-performance, gated, baseline restorer with several levels of automation. Automatic positive and negative noise discriminators ensure that the baseline restorer operates only on the true baseline between pulses in spite of changes in the noise level. No operator adjustment of the baseline restorer is needed when changes are made in the gain, the shaping time constant, or the detector characteristics. Negative overload recovery from the reset pulses generated by transistor-reset preamplifiers and pulsed optical feedback preamplifiers is also handled automatically. A monitor circuit gates off the baseline restorer and provides a reject signal for a multichannel analyzer until the baseline has safely recovered from the overload.

Several operating modes are selectable for the baseline restorer. For making a PZ adjustment, the PZ position is selected. This position can also be used where the slowest baseline restorer rate is desired. For situations where low-frequency noise interference is a problem, the HIGH rate can be chosen. On detectors where perfect PZ cancellation is impossible, the AUTO baseline restorer rate provides the optimum performance at both low and high counting rates.

A front-panel limit (LIM) push button is included with the unipolar output to facilitate monitoring the accuracy of the PZ adjustment on an oscilloscope. When pressed, this button inserts a diode limiter in series with the unipolar output connector. This prevents overload distortions in the oscilloscope when using the more sensitive amplitude scales required for observing the PZ adjustment.

An efficient pile-up rejector is incorporated in the Model 671 spectroscopy amplifier. It provides an output logic pulse for the associated multichannel analyzer to suppress the spectral distortion caused by pulses piling up on each other at high counting rates (Fig. 3). The fast amplifier in the pile-up rejector includes a gated baseline restorer with its own automatic noise discriminator. A multicolor pile-up rejector LED on the front panel indicates the throughput efficiency of the amplifier. At low counting rates the LED flashes green. The LED turns yellow at moderate counting rates and red when pulse pile-up losses are >70%.

When long connecting cables are used between the detector preamplifier output and the amplifier input, noise induced in the cable by the environment can be a problem. The Model 671 provides two solutions. For low to moderate interference frequencies the differential input mode can be used with paired cables from the preamplifier to suppress the induced noise. At high frequencies a common mode rejection transformer built into the Model 671 input reduces noise pick-up. The transformer is particularly effective in eliminating interference from the display raster generators in personal computers.

All toggle switches on the front panel lock to prevent accidental changes in the desired settings.

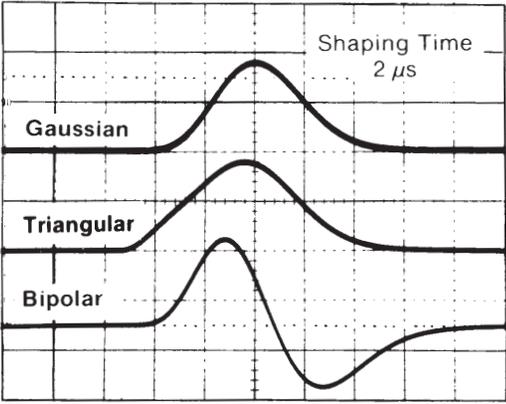


Fig. 1. Gaussian, Triangular, and Bipolar Output Pulse Shapes for a 2- μ s Shaping Time. Vertical scale, 5 V per division; horizontal scale, 2 μ s per division.

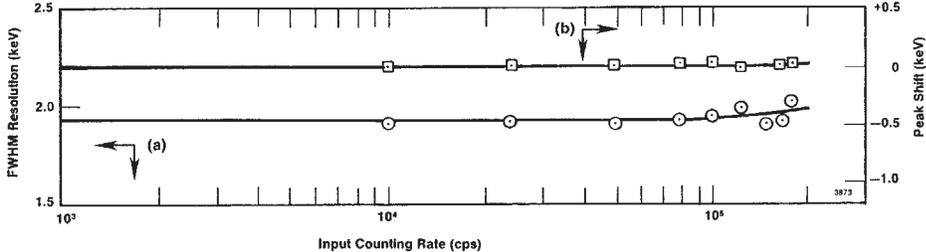


Fig. 2. (a) Resolution and (b) Peak Position Stability as a Function of Counting Rate. See specifications for spectrum broadening and spectrum shift.

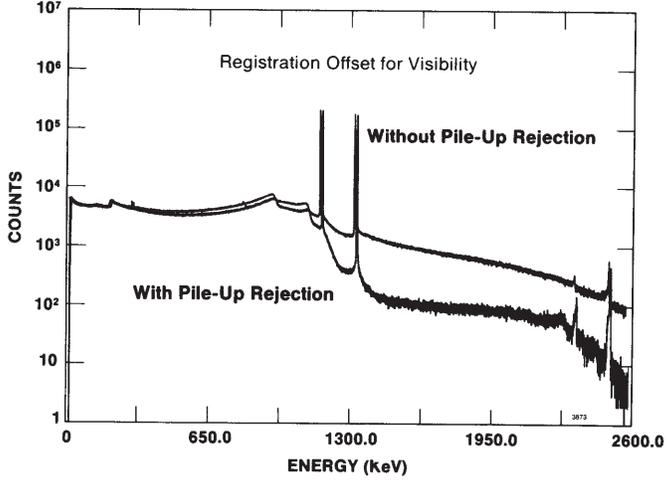


Fig. 3. Demonstration of the Effectiveness of the Pile-Up Rejector in Suppressing the Pile-Up Spectrum. See Pulse Pile-Up Rejector specification.

Specifications

PERFORMANCE

Note: Unless otherwise stated, performance specifications are measured on the unipolar output with 2- μ s Gaussian shaping and the AUTO BLR mode.

GAIN RANGE Continuously adjustable from 2.5 to 1500. Gain is the product of the COARSE and FINE GAIN controls.

UNIPOLAR PULSE SHAPES Switch selection of a nearly triangular pulse shape or a nearly Gaussian pulse shape at the UNI output (Fig. 1, Table 1).

BIPOLAR OUTPUT PULSE SHAPE Rise of the bipolar output pulse from 0.1% to maximum amplitude is 1.65 times selected SHAPING TIME. Zero cross-over of the bipolar output pulse is delayed from the maximum amplitude of Gaussian unipolar output by 0.33 times the selected SHAPING TIME.

INTEGRAL NONLINEARITY (UNI Output) $\leq \pm 0.025\%$ from 0 to +10 V.

NOISE Equivalent input noise $< 5.0 \mu\text{V rms}$ for gains > 100 , and $< 4.5 \mu\text{V rms}$ for gains > 1000 .

TEMPERATURE COEFFICIENT (0 to 50°C)
Unipolar Output $\leq \pm 0.005\%/^{\circ}\text{C}$ for gain, and $\leq \pm 7.5 \mu\text{V}/^{\circ}\text{C}$ for dc level.

Bipolar Output $\leq \pm 0.007\%/^{\circ}\text{C}$ for gain, and $\leq \pm 30 \mu\text{V}/^{\circ}\text{C}$ for dc level.

WALK Bipolar zero cross-over walk is $\leq \pm 3$ ns over a 50:1 dynamic range.

OVERLOAD RECOVERY Unipolar and bipolar outputs recover to within 2% of the rated output from a X1000 overload in 2.5 nonoverloaded pulse widths using maximum gain.

SPECTRUM BROADENING[†] (Fig. 2) Typically $< 8\%$ broadening of the FWHM for counting rates up to 100,000 counts/s, and $< 15\%$ broadening for counting rates up to 200,000 counts/s. Measured on the 1.33-MeV gamma-ray line from a ^{60}Co radioactive source under the following conditions: 10% efficiency ORTEC GAMMA-X PLUS detector, 8.5-V amplitude for the 1.33-MeV gamma ray on the unipolar output.

SPECTRUM SHIFT[†] (Fig. 2) Peak position typically shifts $\leq \pm 0.018\%$ for counting rates up to 100,000 counts/s, and $\leq \pm 0.05\%$ for counting rates up to 200,000 counts/s. Measured on the 1.33-MeV line under conditions specified for SPECTRUM BROADENING.

[†]Results may not be reproducible if measured with a detector producing a large number of slow rise-time pulses or having quality inferior to the specified detector.

Table 1. Unipolar Pulse Shape Parameters for the Triangular and Gaussian Pulse Shapes.

Time Interval	Shaping Time Multiplier*	
	Triangular	Gaussian
From start of input pulse to maximum amplitude of unipolar output pulse	2.6	2.8
Rise of output pulse from 0.1% to maximum amplitude	2.4	2.0
Width of output pulse at 50% of maximum amplitude	2.5	2.0
Width of output pulse at 1% of maximum amplitude	5.6	5.0
Width of output pulse at 0.1% of maximum amplitude	6.9	6.3

*Time interval equals the selected front-panel SHAPING TIME multiplied by the Shaping Time Multiplier.

DIFFERENTIAL INPUT Differential nonlinearity $\leq \pm 0.012\%$ from -9 V to $+9$ V. Maximum input ± 10 V (dc plus signal). Common mode rejection ratio > 1000 .

PULSE PILE-UP REJECTOR
Threshold Automatically set just above noise level on fast amplifier signal. Independent of slow amplifier BLR threshold.

Minimum Detectable Signal Limited by detector and preamplifier noise characteristics.

Pulse Pair Resolution Typically 500 ns. Measured using the ^{60}Co 1.33-MeV gamma ray under the following conditions: 10% efficiency germanium detector, 4-V amplitude for the 1.33-MeV gamma ray at the unipolar output, 50,000 counts/s (Fig. 3).

CONTROLS AND INDICATORS

FINE GAIN Front-panel, 10-turn precision potentiometer with locking, graduated dial provides continuously variable, direct reading, gain factor from 0.5 to 1.5.

COARSE GAIN Front-panel, eight-position switch selects gain factors of 5, 10, 20, 100, 200, 500, and 1000.

SHAPING TIME Six-position switch on the front panel selects shaping times of 0.5, 1, 2, 3, 6, and 10 μ s for the pulse-shaping filter network.

MODE Two-position locking toggle switch on the front panel selects either GAUSS (Gaussian) or TRI (Triangular) pulse shaping for the UNI (unipolar) output.

INPUT POS/NEG Front-panel, two-position locking toggle switch accommodates either positive or negative input polarities.

NORM/DIFF Two-position slide switch mounted on the printed circuit board selects the normal (NORM) or differential (DIFF) input modes. In the NORM position, both front- and rear-panel INPUT connectors function as the same normal input for the preamplifier signal cable. In the DIFF mode the rear-panel INPUT connector becomes a differential ground reference input, and the front-panel

INPUT remains the normal input for the preamplifier signal cable. In the DIFF mode the preamplifier signal cable is connected to the front-panel INPUT and a cable having its center conductor connected to the preamplifier ground through an impedance matching resistor is connected to the rear-panel INPUT. The impedance matching resistor must match the output impedance of the preamplifier.

BAL (Differential Input Gain Balance) A 20-turn potentiometer mounted on the PC board inside the module allows the gains of normal and differential reference inputs to be matched for maximum common mode noise rejection in DIFF mode.

PZ ADJUSTMENT 20-turn potentiometer on the front panel permits screwdriver adjustment of the PZ cancellation. The adjustment covers preamplifier exponential decay time constants from 40 μ s to ∞ . For transistor-reset preamplifiers or pulsed optical feedback preamplifiers, set the PZ adjustment fully counterclockwise.

LIM PUSH BUTTON Inserts a diode limiter in series with the front-panel UNI output connector. Prevents overload distortions in the oscilloscope when observing the accuracy of the PZ adjustment on the more sensitive oscilloscope ranges.

BLR A front-panel, three-position, locking, toggle switch selects the baseline restorer rate. PZ position offers lowest fixed rate for adjusting PZ cancellation. AUTO position matches the rate of the PZ position at low counting rates, but increases the restoration rate as the counting rate rises. HIGH rate position is provided for suppressing low-frequency interference.

PUR ACCEPT/REJECT LED Multicolor LED indicates percentage of pulses rejected because of pulse pile-up. LED appears green for 0–40%, yellow for 40–70%, and red for $> 70\%$ rejection.

INPUTS

INPUT (Front Panel) BNC connector accepts preamplifier signals of either polarity with rise times less than the selected SHAPING TIME, and exponential decay time constants from 40 μ s to ∞ . For the NEG INPUT switch setting, the input impedance is 1000 Ω on a coarse gain of 5, and 465 Ω at coarse gain settings ≥ 10 . For the POS INPUT switch setting, the input impedance is 2000 Ω for a coarse gain of 5, and 1460 Ω for coarse gains ≥ 10 . Input is dc-coupled, and protected to ± 25 V.

INPUT (Rear Panel) BNC connector. Identical to front-panel INPUT when PWB-mounted NORM/DIFF slide switch is in the NORM position. When operating in the differential input mode with the slide switch set to DIFF, the rear-panel INPUT is used for the preamplifier ground reference connection. For the DIFF and POS INPUT switch settings, the input impedance is 1000 Ω on a coarse gain of 5, and 465 Ω at coarse gain settings ≥ 10 . For the DIFF and NEG INPUT switch settings, the input impedance is 2000 Ω for a coarse gain of 5, and 1460 Ω for coarse gains ≥ 10 . Input dc-coupled; protected to ± 25 V.

INH IN Rear-panel BNC inhibit input connector accepts reset signals from transistor-reset preamplifiers or pulsed optical feedback preamplifiers. Positive NIM standard logic pulses or TTL levels can be used. Logic is selectable as active high or active low via a printed circuit board jumper. Inhibit input initiates the protection against distortions caused by the preamplifier reset. This includes turning off the baseline restorers, monitoring the negative overload recovery at the unipolar output, and generating PUR (reject) and BUSY signals for the duration of the overload. The PUR and BUSY logic pulses are used to prevent analysis and correct for the reset dead time in the associated ADC or multichannel analyzer.

OUTPUTS

UNI Front- and rear-panel BNC connectors provide positive, unipolar, shaped pulses with a linear output range of 0 to +10 V. Front-panel output impedance $< 1 \Omega$. Rear-panel output impedance selectable for either $< 1 \Omega$ or 93 Ω using a printed circuit board jumper. Outputs are dc-restored to 0 ± 5 mV and short-circuit protected.

BI Front- and rear-panel BNC connectors provide bipolar shaped pulses with the positive lobe leading. The linear output range is 0 to ± 10 V. Front-panel output impedance $< 1 \Omega$. Rear-panel output impedance selectable for either $< 1 \Omega$ or 93 Ω using a printed circuit board jumper. Baseline between pulses has a dc level of 0 ± 10 mV. Short-circuit protected.

CRM The Count Rate Meter output has a rear-panel BNC connector and provides a 250-ns-wide, +5-V logic signal for every linear input pulse that exceeds the pile-up inspector threshold. Output impedance is 50 Ω .

BUSY Rear-panel BNC connector provides a +5-V logic pulse for the duration that the linear signals exceed the positive or negative baseline restorer thresholds, or the pile-up inspector threshold, or for the duration of the INH IN input signal. Useful for dead-time corrections with an associated ADC or multichannel analyzer. Positive NIM standard logic pulse is selectable as active high or active low via a printed circuit board jumper. Output impedance is 50 Ω .

PUR Pile-Up Reject output is a rear-panel, BNC connector. Provides a +5-V NIM standard logic pulse when pulse pile-up is detected. Output also present for a pulsed reset preamplifier during reset, and reset overload recovery. Output pulse is selectable as active high or active low by means of a printed circuit board jumper. Output impedance is 50 Ω . Used with an associated ADC or multichannel analyzer to prevent analysis of distorted pulses.

PREAMP Rear-panel standard ORTEC connector (Amphenol 17-10090) provides power for the associated pre-amplifier. Mates with power cords on all standard ORTEC preamplifiers.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model 671 derives its power from a NIM Bin supplying ± 24 V and ± 12 V, such as the ORTEC Model 4001A/4002A Bin/Power Supply. The power required is +24 V at 100 mA, -24 V at 200 mA, +12 V at 325 mA, and -12 V at 180 mA.

WEIGHT

Net 1.5 kg (3.3 lb).

Shipping 3.1 kg (7.0 lb).

DIMENSIONS Standard single-width NIM module, 3.43 X 22.13 cm (1.35 X 8.714 in.) front panel per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
671	Spectroscopy Amplifier



672 Spectroscopy Amplifier

- High-performance energy spectroscopy with all types of detectors (Ge, Si, scintillation; proportional counters)
- Automatic Pole-Zero Adjustment* makes setup with any detector easy
- Choice of triangular and Gaussian filters effectively doubles the time constants available for optimum resolution
- Automatic noise discriminators on both the pile-up rejector and the baseline restorer eliminate all screwdriver adjustments
- Automatic baseline restorer rate for superior performance at both low and high counting rates
- Differential input for reduction of ground loop noise
- Automatically compensates for reset recovery with transistor-reset preamplifiers



The ORTEC Model 672 high-performance, energy spectroscopy amplifier is ideally suited for use with germanium, Si(Li), and silicon charged-particle detectors. It can also be used with scintillation detectors and proportional counters. The Model 672 input accepts either positive or negative polarity signals from a detector preamplifier and provides a positive 0 to 10-V output signal suitable for use with single or multichannel pulse-height analyzers. Its gain is continuously variable from 2.5 to 1500.

Automation of all the critical adjustments makes the Model 672 easy to set up with any detector, and provides a performance that is nearly independent of operator expertise.

The Automatic Pole-Zero Adjustment feature significantly simplifies the tuning of the amplifier to compensate for the decay time of the preamplifier pulse. This minimizes the operator skill and effort needed to achieve good energy resolution and peak position stability at moderate to high counting rates (Fig. 1). When changing time constants or detectors, an accurate pole-zero (PZ) adjustment is achieved by simply pushing the AUTO PZ button and waiting a few seconds for the AUTO PZ BUSY LED to turn off. No oscilloscope is required for this procedure. The AUTO PZ memory is protected against power failures.

*U.S.A. Patent No. 4,866,400

In extreme situations, where the preamplifier pulse shape is deformed from the normal exponential decay, complete PZ cancellation is not possible. In such cases, a slight improvement in the high counting rate performance can sometimes be achieved using the manual PZ adjustment mode to arrive at a compromise solution.

A front-panel switch on the Model 672 provides the choice of either a triangular or a Gaussian pulse shape on the UNIPOLAR output connector. The noise performance of the triangular pulse shape is equivalent to a Gaussian pulse shape having a 17% longer shaping time constant. In applications where the series noise component is dominant (short shaping time constants), and the pile-up rejector is utilized, the triangular shape will generally offer the same dead time and slightly lower noise than the Gaussian pulse shape. A front-panel switch permits selection of the optimum shaping time constant for each detector and application. Six time constants in the range from 0.5 to 10 μ s, and the TRIANGULAR/GAUSSIAN switch combine to offer 12 different shaping times. A bipolar output is also provided for measurements requiring zero cross-over timing.

To minimize spectrum distortion at medium and high counting rates (Fig. 2), the unipolar output incorporates a high-performance, gated, baseline restorer with several levels of automation. Automatic positive and negative noise discriminators ensure that the baseline restorer operates only on the true baseline between pulses in spite of changes in the noise level. No operator adjustment of the baseline restorer is needed when changes are made in the gain, the shaping time constant, or the detector characteristics. Negative overload recovery from the reset pulses generated by transistor-reset preamplifiers and pulsed optical feedback preamplifiers is also handled automatically. A monitor circuit gates off the baseline restorer and provides a reject signal for a multichannel analyzer until the baseline has safely recovered from the overload.

Several operating modes are selectable for the baseline restorer. For making either a manual or automatic PZ adjustment, the PZ position is selected. This position can also be used where the slowest baseline restorer rate is desired. For situations where low frequency noise interference is a problem, the HIGH rate can be chosen. On detectors where perfect PZ cancellation is impossible, the AUTO baseline restorer rate provides the optimum performance at both low and high counting rates.

An efficient pile-up rejector is incorporated in the Model 672 Spectroscopy Amplifier. It provides an output logic pulse for the associated multichannel analyzer to suppress the spectral distortion caused by pulses piling up on each other at high counting rates (Fig. 3). The fast amplifier in the pile-up rejector includes a gated baseline restorer with its own automatic noise discriminator. A multi-color pile-up rejector LED on the front panel indicates the throughput efficiency of the amplifier. At low counting rates the LED flashes green. The LED turns yellow at moderate counting rates and red when pulse pile-up losses are >70%.

When long connecting cables are used between the detector preamplifier output and the amplifier input, noise induced in the cable by the environment can be a problem. The Model 672 provides two solutions. For low to moderate interference frequencies the differential input mode can be used with paired cables from the preamplifier to suppress the induced noise. At high frequencies a common mode rejection transformer built into the Model 672 input reduces noise pick-up. The transformer is particularly effective in eliminating interference from the display raster generators in personal computers.

All toggle switches on the front panel lock to prevent accidental changes in the desired settings.

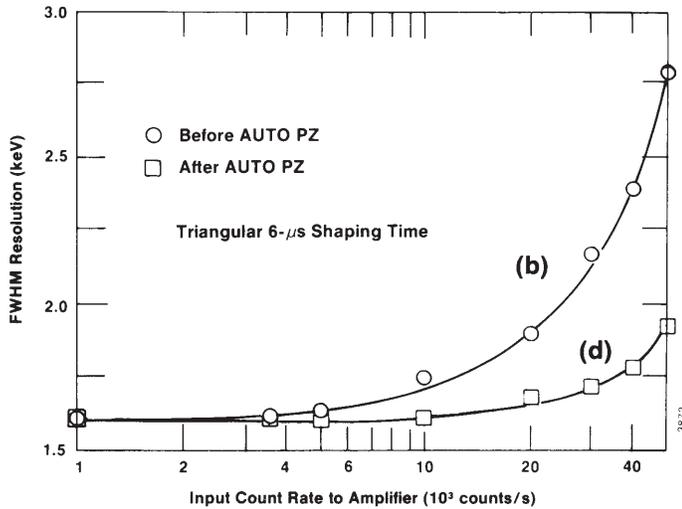
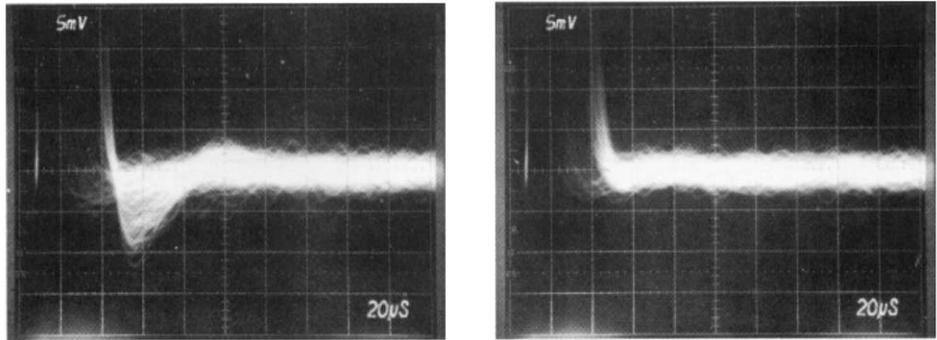


Fig. 1. Effectiveness of the Automatic Pole-Zero Feature. (a) An uncancelled pole produces an undershoot on the amplifier output pulse, which, in turn, causes (b) premature degradation of the resolution in the energy spectrum as the counting rate increases. (c) After pushing the AUTO PZ button, the undershoot is automatically removed, resulting in (d) better resolution at high counting rates. Measured on an ORTEC 16% detector.

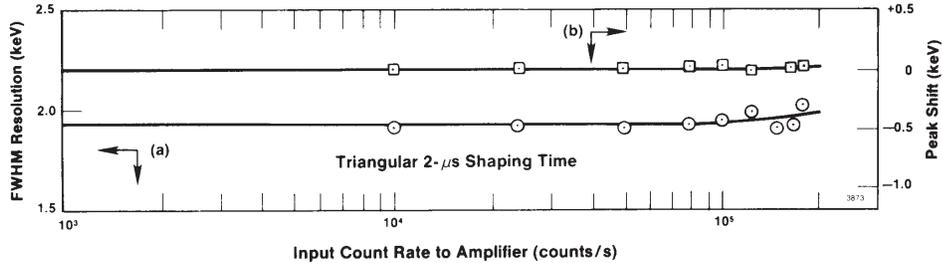


Fig. 2. (a) Resolution and (b) Peak Position Stability as a Function of Counting Rate. See specifications for spectrum broadening and spectrum shift.

Specifications

PERFORMANCE

Note: Unless otherwise stated, performance specifications are measured on the unipolar output with 2- μ s Gaussian shaping, the manual PZ mode, and the AUTO BLR mode.

GAIN RANGE Continuously adjustable from 2.5 to 1500. Gain is the product of the COARSE and FINE GAIN controls.

UNIPOLAR PULSE SHAPES Switch selection of a nearly triangular pulse shape or a nearly Gaussian pulse shape at the UNIPOLAR output (Table 1).

BIPOLAR OUTPUT PULSE SHAPE Rise of the BIPOLAR output pulse from 0.1% to maximum amplitude is 1.65 times selected SHAPING TIME. Zero cross-over of the bipolar output pulse is delayed from the maximum amplitude of the Gaussian UNIPOLAR output by 0.33 times the selected SHAPING TIME.

INTEGRAL NONLINEARITY (UNIPOLAR Output) $\leq \pm 0.025\%$ from 0 to +10 V.

NOISE Equivalent input noise $< 5.0 \mu\text{V rms}$ for gains > 100 , and $< 4.5 \mu\text{V rms}$ for gains > 1000 in manual PZ mode, or $< 6.0 \mu\text{V}$ for gains > 100 in AUTO PZ mode.

TEMPERATURE COEFFICIENT (0 to 50°C) Unipolar Output $\leq \pm 0.005\%/^{\circ}\text{C}$ for gain, and $\leq \pm 7.5 \mu\text{V}/^{\circ}\text{C}$ for dc level.

Bipolar Output $\leq \pm 0.007\%/^{\circ}\text{C}$ for gain, and $\leq \pm 30 \mu\text{V}/^{\circ}\text{C}$ for dc level.

WALK Bipolar zero crossover walk is $\leq \pm 3$ ns over a 50:1 dynamic range.

OVERLOAD RECOVERY Unipolar and bipolar outputs recover to within 2% of the rated output from a X1000 overload in 2.5 nonoverloaded pulse widths using maximum gain.

SPECTRUM BROADENING† (Fig. 2)

Typically $< 8\%$ broadening of the FWHM for counting rates up to 100,000 counts/s, and $< 15\%$ broadening for counting rates up to 200,000 counts/s. Measured on the 1.33-MeV gamma-ray line from a ^{60}Co radioactive source under the following conditions: 10% efficiency ORTEC GAMMA-X PLUS detector, 8.5-V amplitude for the 1.33-MeV gamma-ray on the unipolar output.

SPECTRUM SHIFT† (Fig. 2) Peak position typically shifts $\leq \pm 0.018\%$ for counting rates up to 100,000 counts/s, and $\leq \pm 0.05\%$ for counting rates up to 200,000 counts/s.

†Results may not be reproducible if measured with a detector producing a large number of slow rise-time pulses or having quality inferior to the specified detector.

Table 1. Unipolar Pulse Shape Parameters for the Triangular and Gaussian Pulse Shapes.

Time Interval	Shaping Time Multiplier*	
	Triangular	Gaussian
From start of input pulse to maximum amplitude of unipolar output pulse	2.6	2.8
Rise of output pulse from 0.1% to maximum amplitude	2.4	2.0
Width of output pulse at 50% of maximum amplitude	2.5	2.0
Width of output pulse at 1% of maximum amplitude	5.6	5.0
Width of output pulse at 0.1% of maximum amplitude	6.9	6.3

* Time interval equals the selected front-panel SHAPING TIME multiplied by the Shaping Time Multiplier.

Measured on the 1.33-MeV line under conditions specified for SPECTRUM BROADENING.

DIFFERENTIAL INPUT Differential nonlinearity $\leq \pm 0.012\%$ from -9 V to $+9$ V. Maximum input ± 10 V (dc plus signal). Common mode rejection ratio > 1000 .

PULSE PILE-UP REJECTOR

Threshold Automatically set just above noise level on fast amplifier signal. Independent of slow amplifier BLR threshold.

Minimum Detectable Signal Limited by detector and preamplifier noise characteristics.

Pulse Pair Resolution Typically 500 ns. Measured using the ^{60}Co 1.33-MeV gamma ray under the following conditions: 10% efficiency germanium detector, 4-V amplitude for the 1.33-MeV gamma ray at the unipolar output, 50,000 counts/s (Fig. 3).

CONTROLS AND INDICATORS

FINE GAIN Front-panel, 10-turn precision potentiometer with locking, graduated dial provides continuously variable, direct reading, gain factor from 0.5 to 1.5.

COARSE GAIN Front-panel, eight-position switch selects gain factors of 5, 10, 20, 100, 200, 500, and 1000.

SHAPING TIME Six-position switch on the front panel selects shaping times of 0.5, 1, 2, 3, 6, and 10 μs for the pulse-shaping filter network.

UNI SHAPING Two-position locking toggle switch on the front panel selects either GAUSSIAN or TRIANGLE pulse shaping for the UNIPOLAR output.

INPUT Front-panel, four-position switch accommodates either + or - input polarities, and selects the differential (DIFF) or normal (NORM) input modes. In the NORM mode only the NORM input connector is used. In the DIFF mode the preamplifier signal cable is connected to the NORM input, and a cable having its center conductor connected to the preamplifier ground through an impedance matching resistor is connected to the DIFF REF input. The impedance matching resistor must match the output impedance of the preamplifier.

BAL (Differential Input Gain Balance) A 20-turn potentiometer mounted on the PC

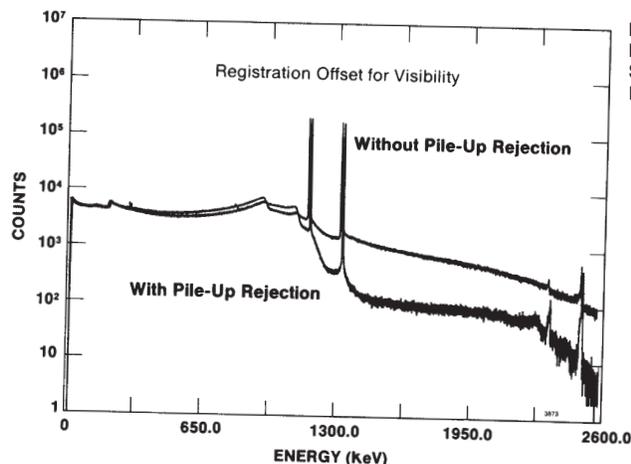


Fig. 3. Demonstration of the Effectiveness of the Pile-Up Rejector in Suppressing the Pile-Up Spectrum. See Pulse Pile-Up Rejector specification.

board inside the module allows the gains of NORM and DIFF REF inputs to be matched for maximum common mode noise rejection in DIFF mode.

PZ AUTO/MAN SWITCH Locking toggle switch selects either the AUTO (automatic) or MAN (manual) pole-zero cancellation adjustment mode. Both modes permit PZ cancellation for preamplifier exponential decay time constants from 40 μ s to ∞ .

AUTO PZ BUTTON With PZ switch in AUTO PZ position, momentarily pressing AUTO PZ button turns on the BUSY LED and initiates automatic adjustment of the PZ cancellation circuit. BUSY LED turns off when adjustment is complete. Once completed, the PZ adjustment is held until the button is pushed again. Memory of the last PZ adjustment is protected against unforeseen power outages.

MANUAL PZ ADJUSTMENT 20-turn potentiometer on the front panel permits screwdriver adjustment of the PZ cancellation. The screwdriver-adjusted value is effective whenever the PZ switch is in the MAN (manual) position. For transistor-reset preamplifiers or pulsed optical feedback preamplifiers, use manual PZ adjustment set fully counterclockwise.

LIMIT PUSHBUTTON Inserts a diode limiter in series with the front-panel UNIPOLAR output connector and test point. Prevents overload distortions in the oscilloscope when observing accuracy of the PZ adjustment on the more sensitive oscilloscope ranges.

BLR RATE A front-panel, three-position, locking, toggle switch selects the baseline restorer rate. PZ position offers lowest fixed rate, for adjusting PZ cancellation. AUTO position matches the rate of the PZ position at low counting rates, but increases the restoration rate as the counting rate rises. HIGH rate position is provided for suppressing low frequency interference.

PUR ACCEPT/REJECT LED Multicolor LED indicates percentage of pulses rejected because of pulse pile-up. LED appears green for 0–40%, yellow for 40–70%, and red for >70% rejection.

INPUTS

NORM Front-panel, BNC connector accepts preamplifier signals of either polarity with rise times less than the selected SHAPING TIME and exponential decay time constants from 40 μ s to ∞ . For the – INPUT switch setting, the input impedance is 1000 Ω on a coarse gain of 5, and 465 Ω at coarse gain settings ≥ 10 . For the + INPUT switch setting, the input impedance is 2000 Ω for a coarse gain of 5, and 1460 Ω for coarse gains ≥ 10 . Input is dc-coupled, and protected to ± 25 V.

LINEAR Rear-panel connector. Identical to NORM input.

DIFF REF Front-panel BNC connector is used for the preamplifier ground reference connection when operating in the differential input mode. Operative only with the INPUT switch in the DIFF mode. For the + DIFF INPUT switch setting, the input impedance is 1000 Ω on a coarse gain of 5, and 465 Ω at coarse gain settings ≥ 10 . For the – DIFF INPUT switch setting, the input impedance is 2000 Ω for a coarse gain of 5, and 1460 Ω for coarse gains ≥ 10 . Input dc-coupled; protected to ± 25 V.

INHIBIT Rear-panel BNC input connector accepts reset signals from transistor-reset preamplifiers or pulsed optical feedback preamplifiers. Positive NIM standard logic pulses or TTL levels can be used. Logic is selectable as active high or active low via a printed circuit board jumper. INHIBIT input initiates the protection against distortions caused by the preamplifier reset. This includes turning off the baseline restorers, monitoring the negative overload recovery at the unipolar output, and generating PUR (reject) and BUSY signals for the duration of the overload. The PUR and BUSY logic pulses are used to prevent analysis and correct for the reset dead time in the associated ADC or multichannel analyzer.

OUTPUTS

UNIPOLAR, UNI Front- and rear-panel BNC connectors provide positive, unipolar, shaped pulses with a linear output range of 0 to +10 V. Front-panel output impedance <1 Ω . Rear-panel output impedance selectable for either <1 Ω or 93 Ω using a printed circuit board jumper. Outputs are dc-restored to 0 \pm 5 mV and short-circuit protected.

BIPOLAR, BI Front- and rear-panel BNC connectors provide bipolar shaped pulses with the positive lobe leading. The linear output range is 0 to ± 10 V. Front-panel output impedance <1 Ω . Rear-panel output impedance selectable for either <1 Ω or 93 Ω using a printed circuit board jumper. Baseline between pulses has a dc level of 0 \pm 10 mV. Short-circuit protected.

CRM The Count Rate Meter output has a rear-panel BNC connector and provides a 250-ns-wide, +5-V logic signal for every linear input pulse that exceeds the pile-up inspector threshold. Output impedance is 50 Ω .

BUSY Rear-panel BNC connector provides a +5-V logic pulse for the duration that the linear signals exceed the positive or negative baseline restorer thresholds, or the pile-up inspector threshold, or for the duration of the INHIBIT input signal. Useful for dead-time corrections with an associated ADC or

multichannel analyzer. Positive NIM standard logic pulse is selectable as active high or active low via a printed circuit board jumper. Output impedance is 50 Ω .

PUR Pile-Up Reject output is a rear-panel, BNC connector. Provides a +5-V NIM standard logic pulse when pulse pile-up is detected. Output also present for a pulsed reset preamplifier during reset, and reset overload recovery. Output pulse is selectable as active high or active low by means of a printed circuit board jumper. Output impedance is 50 Ω . Used with an associated ADC or multichannel analyzer to prevent analysis of distorted pulses.

PREAMP Rear-panel standard ORTEC connector (Amphenol 17-10090) provides power for the associated preamplifier. Mates with power cords on all standard ORTEC preamplifiers.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model 672 derives its power from a NIM bin supplying ± 24 V and ± 12 V, such as the ORTEC Model 4001A/4002A Bin/Power Supply. The power required is +24 V at 90 mA, –24 V at 170 mA, +12 V at 330 mA, and –12 V at 190 mA.

WEIGHT

Net 2.3 kg (5.0 lb).

Shipping 3.6 kg (8.0 lb).

DIMENSIONS NIM-standard double-width module, 6.90 X 22.13 cm (2.70 X 8.714 in.) front panel per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
672	Spectroscopy Amplifier



673 Spectroscopy Amplifier and Gated Integrator

- **Dual purpose: High-rate and low-rate energy spectroscopy with Ge detectors**
- **Both Semi-Gaussian and Gated Integrator outputs**
- **Gated Integrator compensates for charge collection time variations in Ge detectors for improved energy resolution and throughput at high counting rates**
- **Semi-Gaussian output offers optimum resolution at low counting rates**
- **Shaping time constants from 0.25 to 6 μ s**
- **Built-in gated BLR and pile-up rejector**



The ORTEC Model 673 Spectroscopy Amplifier and Gated Integrator is a dual purpose amplifier for high-resolution energy spectroscopy with germanium detectors at both low and high counting rates. In addition to a conventional, semi-Gaussian shaping amplifier, the Model 673 includes a Gated Integrator to achieve excellent energy resolution at high throughputs.¹ The UNIPOLAR output of the semi-Gaussian amplifier is identical to the ORTEC Model 572, except that the shaping time constants range from 0.25 to 6 μ s. The longer shaping time constants on this output provide the best energy resolution at low counting rates.

At high counting rates, short shaping time constants are necessary to achieve high throughput. Normally, the charge collection time variations in the Ge detector would severely degrade the energy resolution at such short time constants (Fig. 1a). The Gated Integrator solves this problem (Fig. 1b) by integrating the area under the unipolar pulse and by setting an integration period that ensures complete integration of the longer pulses that result from slower charge collection in the Ge detector (Figs. 2 and 3). The result is significantly improved energy resolution

(Figs. 1b and 4) at a throughput that is approximately four times the maximum counting rate achievable with conventional semi-Gaussian shaping (Fig. 5). The Model 673 Gated Integrator output can maintain excellent resolution and peak position stability to a much higher counting rate than is feasible with semi-Gaussian shaping (Figs. 6 and 7).

A pile-up rejector is included to minimize the spectral distortion caused by two or more photons arriving at the detector within one amplifier pulse width. The pile-up rejector connects to the anti-coincidence gate of a multichannel analyzer, and provides protection for either the UNIPOLAR or the Gated Integrator output. A front-panel switch allows either manual or automatic adjustment of the noise threshold for the pile-up rejector and the baseline restorer. The manual mode is useful for transistor reset preamplifiers.

The Model 673 accommodates both resistive feedback preamplifiers and transistor reset preamplifiers (TRP). With transistor reset preamplifiers a logic pulse derived from the preamplifier reset signal can be provided to the GATE INPUT of the Model 673 for the duration of the overload caused by the preamplifier reset. The GATE INPUT is "ORed" with the pile-up rejector signal at the GI INH output and is used by the multichannel analyzer to prevent the analysis of pulses distorted by the reset.

The UNIPOLAR output also functions as a high-performance semi-Gaussian shaping amplifier that can be used with a variety of detector types, including germanium detectors, silicon charged-particle detectors, Si(Li) detectors, proportional counters, and scintillation detectors.

¹T.H. Becker, E.E. Gross, R.C. Trammell, "Characteristics of High-Rate Energy Spectroscopy Systems with Time-Invariant Filters," *IEEE Trans. Nucl. Sci.*, **NS-28**, 598 (1981).

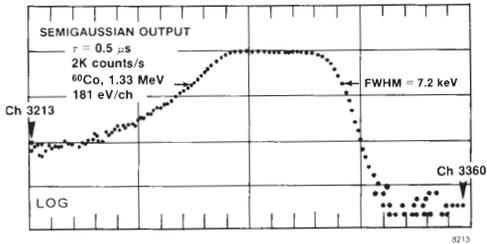


Fig. 1a. Energy Resolution with Semi-Gaussian Shaping and a 0.5 μs Shaping Time Constant.
Maximum throughput capability is the same as for Fig. 4.

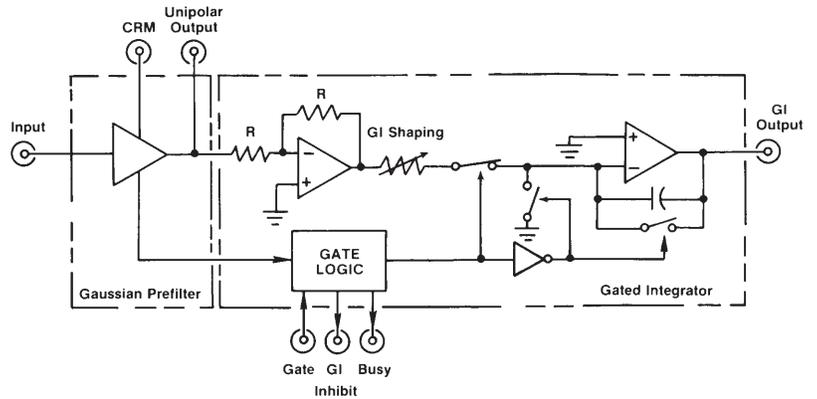


Fig. 3. Simplified Block Diagram of the Model 673 Spectroscopy Amplifier and Gated Integrator.

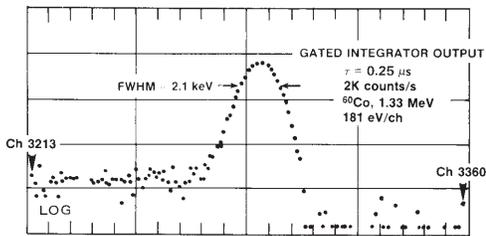


Fig. 1b. Energy Resolution at the Gated Integrator Output with a 0.25 μs Shaping Time Constant.

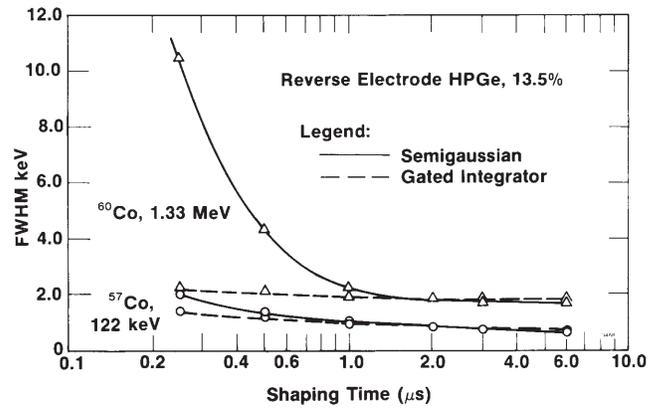


Fig. 4. Resolution as a Function of Shaping Time Constant for Semi-Gaussian and Gated Integrator Pulse Shaping.

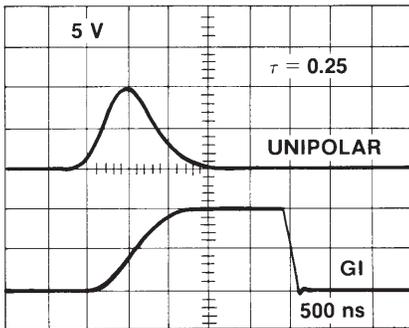


Fig. 2. Gated Integrator (GI) Output and Unipolar Output.

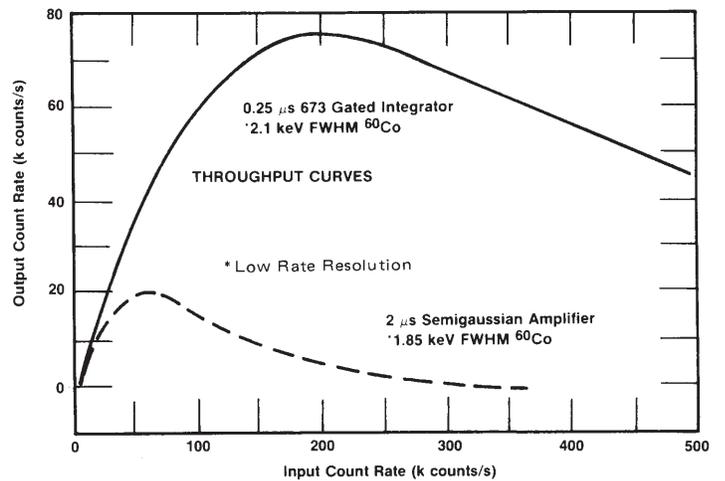


Fig. 5. Example of the Throughput Improvement Using the Gated Integrator Technique.

673 Spectroscopy Amplifier and Gated Integrator

Specifications

PERFORMANCE

GAIN RANGE Continuously adjustable, X1 through X1500.

UNIPOLAR PULSE SHAPING Unipolar, Gaussian on all ranges with peaking time equal to 2.2τ and pulse width at 0.1% level, equal to 2.9 times the peaking time.

GI PULSE SHAPING Time variant gated integrator.

INTEGRAL NONLINEARITY $<\pm 0.05\%$ (0.025% typical) at the unipolar output using 2- μ s shaping.

NOISE $<4 \mu\text{V}$ referred to the input using 3- μ s shaping; gain >100 , unipolar output.

TEMPERATURE INSTABILITY (Unipolar Output)

Gain $\leq \pm 0.0075\%/^{\circ}\text{C}$, 0 to 50°C .

DC Level $<\pm 10 \mu\text{V}/^{\circ}\text{C}$, 0 to 50°C .

UNIPOLAR COUNT RATE INSTABILITY

The 1.33-MeV gamma-ray peak from a ^{60}Co source, positioned at 85% of analyzer range, typically shifts $<0.024\%$, and its FWHM broadens $<14\%$ when its incoming count rate changes from 0 to 100,000 counts/s using 2- μ s shaping. The amplifier will hold the baseline reference up to count rates in excess of 150,000 counts/s.

GI THROUGHPUT AND RESOLUTION

The Gated Integrator allows operation at short time constants, which permits higher throughput rates while maintaining excellent resolution. Typical results for a 10% HPGe detector with transistor-reset preamplifier using a ^{60}Co source and 200,000 counts/s input:

Output	Time Constant	Dead Time	Max Throughput	Resolution
Unipolar	0.5 μs	5 μs	74k c/s	7.5 keV
GI	0.25 μs	5 μs	74k c/s	2.3 keV

OVERLOAD RECOVERY Unipolar output recovers to within 2% of rated output from X300 overload in 2.5 nonoverloaded unipolar pulse widths, using maximum gain.

CONTROLS

FINE GAIN Ten-turn precision potentiometer for continuously variable direct-reading gain factor of X0.5 to X1.5.

COARSE GAIN Six-position switch selects feedback resistors for gain factors of 20, 50, 100, 200, 500, and 1k.

INPUT ATTENUATOR Jumper on printed wiring board selects an input attenuation factor of 1 to 10 (gain factor of X1 or X0.1).

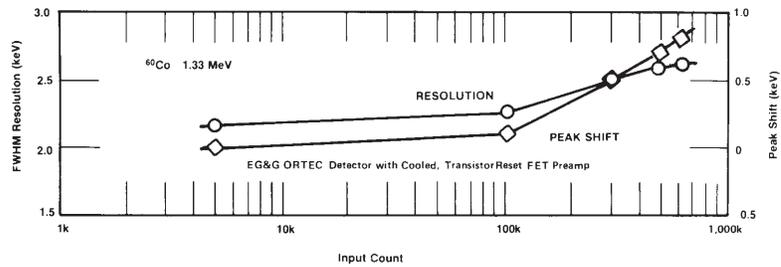


Fig. 6. Resolution and Baseline Stability vs Counting Rate for the GI Output of the Model 673 Using 0.25- μ s Shaping Time, Measured on a 10% Relative Efficiency GMX Detector.

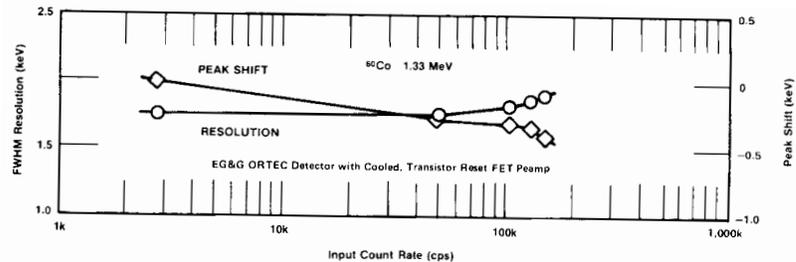


Fig. 7. Resolution and Baseline Stability vs Counting Rate for the Unipolar (Semi-Gaussian) Output of the Model 673 Using 2- μ s Shaping Time, Measured on a 10% Relative Efficiency GMX Detector.

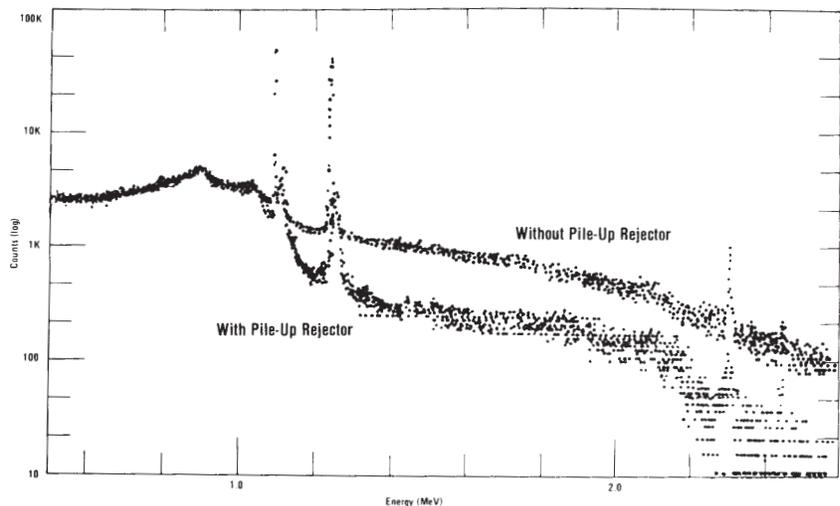


Fig. 8. Background Reduction Obtained from Pile-Up Rejection.

673 Spectroscopy Amplifier and Gated Integrator

POS/NEG Toggle switch selects Pos or Neg input.

SHAPING TIME Two six-position switches select the time constant for active-filter-network pulse shaping; selections are 0.25, 0.5, 1, 2, 3, and 6. Switch settings should be set equally for normal operation.

PZ Two potentiometers to adjust pole-zero cancellation for decay times from 40 μ s to ∞ . Fine PZ corresponds to approximately 10% of coarse PZ.

BLR Toggle switch selects a source for the gated baseline restorer discriminator threshold level from one of three positions:

Auto The BLR threshold is automatically set to an optimum level as a function of the signal noise level by an internal circuit. This allows easy setup and very good performance.

PZ Adj The BLR threshold is determined by the threshold potentiometer. The BLR time constant is greatly increased to facilitate PZ adjustment. This position may give the lowest noise for conditions of low count rate and/or longer shaping times.

Threshold The BLR threshold is set manually by the threshold potentiometer. Range, 0 to 300 mV referred to the positive output signal. The BLR time constant is the same as for the Auto switch setting.

DC Screwdriver potentiometer adjusts the unipolar output baseline dc level; range, +100 mV to -100 mV. Adjust to 0 for proper Gated Integrator operation.

INPUTS

LINEAR Positive or negative signal through either front- or rear-panel BNC connectors. Accepts pulses with rise times in the range from 10 to 650 ns and decay times from 40 to 2000 μ s; $Z_{in} \cong 1$ k Ω , dc-coupled; linear maximum 1 V (10 V with attenuator jumper set at X0.1); absolute maximum 20 V.

GATE Rear-panel BNC connector accepts standard positive NIM signal to produce a pile-up reject signal at the GI INH output during the reset interval of a pulsed-reset preamplifier. Input polarity selectable with printed wiring board jumper.

OUTPUTS

UNI Front-panel BNC with $Z_o < 1$ Ω and rear-panel BNC with $Z_o = 93$ Ω . Short-circuit proof; full-scale linear range 0 to +10 V; active-filter-shaped and dc-restored; dc level adjustable to ± 100 mV.

GI Front-panel BNC with $Z_o < 1$ Ω and rear-panel BNC with $Z_o = 93$ Ω . Short-circuit proof; full-scale range 0 to +10 V; dc level 0 ± 5 mV.

BUSY Rear-panel BNC with $Z_o < 10$ Ω provides a +5 V logic pulse for the duration that the input pulse exceeds the baseline restorer discriminator level. Connects to the ORTEC MCA Busy Input for dead time correction.

UNI INH Rear-panel BNC with $Z_o < 10$ Ω provides a nominal +5 V logic signal when an internal pulse pile-up occurs; to be used for an MCA anticoincidence input to prevent storage of pile-up data in the spectrum when using the unipolar output.

GI INH Rear-panel BNC with $Z_o < 10$ Ω provides a nominal +5 V logic signal when an internal pulse pile-up occurs; to be used for an MCA anticoincidence input to prevent storage of pile-up data in the spectrum when using the GI output. PWB polarity selection. (Shipped in positive position).

CRM (Count Ratemeter) Rear-panel BNC furnishes a nominal +5 V logic signal for every linear input pulse; width 300 ns; to be used as an input to a ratemeter or counter.

ELECTRICAL AND MECHANICAL

PREAMP POWER Rear-panel standard ORTEC power connector; Amphenol 17-10090; mates with captive and noncaptive power cords on all standard ORTEC preamplifiers.

POWER REQUIRED +24 V, 125 mA; -24 V, 105 mA; +12 V, 150 mA; -12 V, 75 mA.

WEIGHT

Net 1.4 kg (3 lb).

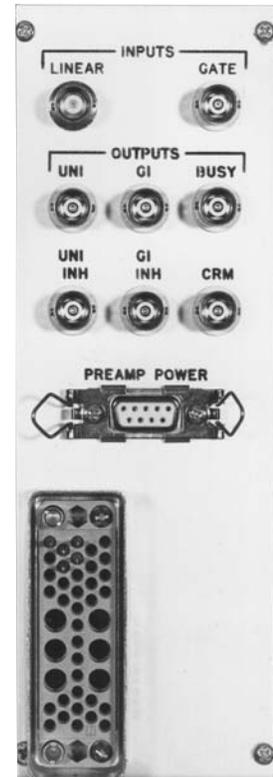
Shipping 3.2 kg (7 lb).

DIMENSIONS NIM-standard double-width module 6.90 X 22.13 cm (2.70 X 8.714 in.) front panel per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
673	Spectroscopy Amplifier and Gated Integrator



- Two Model 575A Amplifiers in a one-wide NIM for energy spectroscopy with multiple detectors
- For scintillation detectors, proportional counters, and semiconductor detectors
- Selectable shaping time constants (0.5, 1.5, and 3 μ s)
- Gated active baseline restorer for high-count-rate applications
- Automatic baseline restorer threshold control



The ORTEC Model 855 Dual Amplifier is an economical, general-purpose dual amplifier in a one-wide NIM module. The low-input noise, selectable shaping time constants, and gain range allow operation with semiconductor detectors, proportional counters, and scintillation detectors in a variety of applications. The high performance and low cost of the Model 855 allow a wide range of uses in such fields as research, environmental monitoring, and teaching.

The Model 855 incorporates an automatic gated baseline restorer (BLR) that causes the system resolution to be nearly independent of input counting rates. The gated baseline restorer includes a discriminator that operates the sensing circuits, that normally establish the baseline reference for the multichannel analyzer. Performance of the spectrometer often depends on the precision of the setting of the BLR threshold. The Model 855 offers the convenience of an automatic threshold control that typically gives results as good as, or better than, those the most experienced operator could achieve manually.

The pulse-shaping networks in the Model 855 produce semi-Gaussian-shaped output pulses resulting in improved noise performance and reduced amplifier resolving time. The shorter resolving time permits higher counting rates than in amplifiers with classical RC pulse-shaping networks. The Model 855 provides a 10-V linear output with excellent dc stability for both unipolar and bipolar output pulses.

Specifications*

PERFORMANCE

GAIN RANGE Continuously adjustable from 5 to 1250.

PULSE SHAPE Semi-Gaussian on all ranges with peaking time equal to 2.2τ , 50% pulse width equal to 3.3τ , and pulse width at 0.1% level equal to 4.0 times the peaking time. Bipolar crossover = 1.5τ .

INTEGRAL NONLINEARITY For 1.5- μ s shaping time, $\leq \pm 0.05\%$.

NOISE $< 5 \mu$ V rms referred to the input using 3- μ s unipolar shaping; $< 7 \mu$ V using 1.5- μ s shaping; both for a gain ≥ 100 .

TEMPERATURE INSTABILITY

Gain $< \pm 0.0075\%/^{\circ}\text{C}$, 0 to 50°C .

DC Level $< \pm 30 \mu\text{V}/^{\circ}\text{C}$, 0 to 50°C .

BIPOLAR CROSSOVER WALK $< \pm 5$ ns at 0.5- μ s shaping for 50:1 dynamic range, including contribution of an ORTEC Model 552 Single-Channel Analyzer.

OVERLOAD RECOVERY Recovers to within 2% of rated output from X300 overload in 2.5 nonoverload pulse widths using maximum gain for unipolar output. Same recovery from X500 overload for bipolar.

RESTORER Gated active baseline restorer with automatic threshold circuit to provide the threshold level as a function of signal noise to the baseline restorer discriminator.

SPECTRUM BROADENING[†] Typically $< 10\%$ FWHM for a ^{60}Co 1.33-MeV gamma line at 85% of full scale for an incoming count rate from 1 to 50,000 counts/s. Unipolar output, 1.5- μ s shaping.

SPECTRUM SHIFT[†] Peak position shifts typically $< 0.02\%$ for a ^{60}Co 1.33-MeV gamma line at 85% of full scale (measured at the unipolar output, 1.5- μ s shaping, 1 to 50,000 counts/s).

CONTROLS

FINE GAIN Ten-turn precision potentiometer with graduated dial for continuously variable direct-reading gain factor of X2.5 to X12.5.

COARSE GAIN Six-position switch selects feedback resistors for gain factors of 2, 4, 10, 20, 40, and 100.

*These specifications apply to each section of the Model 855 Dual Amplifier.

[†]Measured with an HPGe detector having good rise time characteristics.

SHAPING TIME Three-position printed wiring board (PWB) jumpers, easily accessible through side panel, select time constants for active pulse-shaping filter network of 0.5, 1.5, or 3 μ s.

POS/NEG A PWB jumper selects either Pos or Neg input pulse polarity.

PZ ADJ Screwdriver-adjustable potentiometer to set the pole-zero cancellation for input decay times from 30 μ s to ∞ .

INPUT

INPUT BNC Front- and rear-panel connectors accept either positive or negative pulses with rise times of 10 to 650 ns and decay times of 30 μ s to ∞ ; $Z_{in} = 1000 \Omega$ dc-coupled; linear maximum $2 V$; absolute maximum 20 V.

OUTPUTS

UNI Front-panel BNC connector with $Z_o < 1 \Omega$ and rear-panel connector with $Z_o = 93 \Omega$. Short-circuit proof; full-scale linear range from 0 to +10 V; active filter shaped; dc-restored with dc level adjustable to ± 15 mV.

BI Front-panel BNC connector with $Z_o < 1 \Omega$ and rear-panel connector with $Z_o = 93 \Omega$. Short-circuit proof; positive lobe leading and full-scale linear range of 0 to +10 V; active filter shaped.

PREAMP POWER Rear-panel standard ORTEC power connector (Amphenol 17-10090) mates with captive and noncaptive power cords on all ORTEC pre-amplifiers.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 83 mA; -24 V, 70 mA; +12 V, 125 mA; -12 V, 140 mA.

WEIGHT

Net 1.5 kg (3.3 lb).

Shipping 3.1 kg (7.0 lb).

DIMENSIONS Standard single-width NIM module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

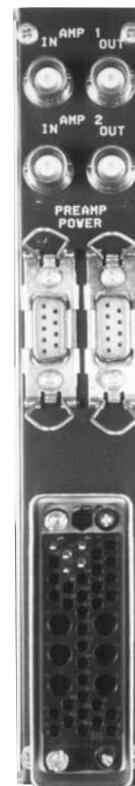
Related Equipment

The ORTEC Model 855 Amplifier accepts linear pulses from, and furnishes power to, any standard ORTEC preamplifier or equivalent. Its output pulses may be used for linear signal analysis, using any of the ORTEC modular instruments and multichannel analyzers.

Ordering Information

To order, specify:

Model	Description
855	Dual Amplifier



863

Quad Timing Filter Amplifier

- Optimum pulse shaping and amplification for timing with germanium and other solid-state detectors
- Four amplifiers in a single-width NIM for experiments with a large number of detectors
- Selectable integration and differentiation filters
- Selectable cable clipping of the input signal
- Rise time <10 ns for outputs from 0 to ± 5 V on a 50- Ω load
- Front-panel pole-zero adjustment



The ORTEC Model 863 Quad Timing Filter Amplifier incorporates four separate timing filter amplifiers in a single-width NIM module. This design provides a compact and cost-effective solution for experiments where timing is required on a number of detectors. Together with an ORTEC Model 935 Quad Constant-Fraction Timing Discriminator, the Model 863 can provide optimum timing for up to four germanium detectors. The unit can also be used for timing with other solid-state detectors, or operate as a general-purpose wideband amplifier with selectable bandwidth.

The signals from germanium or silicon detectors at the preamplifier output are not always optimum for achieving good timing resolution. Before presentation to a timing discriminator, the signals normally require amplification with a wideband amplifier, and they may need additional pulse shaping to minimize the noise contribution to the time resolution. The Model 863 provides a flexible approach in serving these two functions in order to handle a wide variety of solid-state detector types.

The Gain can be selected as either inverting or noninverting and is adjustable over the nominal range from 2 to 250. The Fine Gain is adjustable from 2 to 50 using a front-panel screwdriver potentiometer, while a printed wiring board (PWB) jumper selects a Coarse Gain of either 1 or 5. The output will drive a 50- Ω load to ± 5 V with good linearity. This ensures that the full -50 mV to -5 V dynamic range of a constant-fraction timing discriminator can be used. Excellent dc stability of the output is maintained by a continuous baseline restorer.

Several means of bandpass limiting are included to achieve the pulse shaping

that yields the optimum time resolution. With all jumpers in the Out position, the Model 863 is a wideband amplifier with an output rise time <10 ns. To reduce low frequency noise and shorten the output pulse width, the CR differentiation time constant can be decreased from 0.1 ms (Out position) to 200 ns using a PWB jumper. Alternatively, two front-panel connectors can be employed (using a 50- Ω coaxial cable) to add delay line clipping. This results in a more abrupt termination of the output pulse duration while reducing low frequency noise. Both the CR differentiation and the cable clip can be used together to yield a bipolar output signal for fast, zero-crossing timing.

In some cases it is beneficial to select a 50-ns RC integration time constant using the PWB jumper provided for that purpose. This reduces the high frequency noise while slowing the output rise time to 110 ns.

In addition to the two standard jumper selections incorporated into each of the Differentiation and Integration controls, a third position is provided for both jumpers. By adding the appropriate components to each third position, it is possible for the user to select a customized set of integration and differentiation time constants.

In order to ensure that the output pulse returns to baseline as quickly as possible, the differentiation circuit includes a front-panel pole-zero trimmer. This control permits compensation for the preamplifier decay time constant.

Each section of the Model 863 has five sets of PWB jumpers to control the various functions of the unit. These jumpers are accessible by removing the left side panel of the module.

863 Quad Timing Filter Amplifier

Specifications

PERFORMANCE

INPUT SIGNAL AMPLITUDE RANGE 0 to ± 1.0 V ac signal; 0 to ± 2 V dc offset; maximum input ± 2 V signal plus offset.

OUTPUT AMPLITUDE RANGE 0 to ± 5 V linear into a 50- Ω load. Output dc-coupled with dc offset $< \pm 10$ mV.

RISE TIME < 10 ns with Integration and Differentiation time constants set to Out, or $\approx 2.2\tau$ for other Integration settings and Differentiation Out.

CROSS TALK $< 0.01\%$ from any output to any input measured at maximum gain with Integration and Differentiation time constants set to Out.

NOISE For maximum gain, rms noise referred to the input < 50 μ V with Integration and Differentiation set to Out; measured using a Hewlett-Packard 3400A true rms meter.

INTEGRAL NONLINEARITY $< \pm 0.5\%$ over ± 5 V into a 50- Ω load.

TEMPERATURE SENSITIVITY Dc level $< \pm 10$ μ V/ $^{\circ}$ C referred to the output. Gain sensitivity $< \pm 0.05\%/^{\circ}$ C.

OPERATING TEMPERATURE RANGE 0° C to 50° C.

CONTROLS

Each section of the Model 863 Quad Timing Filter Amplifier has separate controls for Coarse Gain, Fine Gain, P/Z, Differentiation, and Integration time constant.

COARSE GAIN PWB jumper selectable for nominally X1 or X5. The Model 863 is shipped with this jumper in the X5 position. Gain is reduced by a factor of 2 when using the cable clip.

FINE GAIN Front-panel screwdriver potentiometer continuously adjustable from nominally X2 to X50.

P/Z Front-panel screwdriver-adjustable potentiometer to adjust pole-zero cancellation for decay time constants from 25 μ s to ∞ .

DIFFERENTIATION Time constant PWB jumper selectable as either Out (equivalent to 0.1 ms) or 200 ns. A third position is available for custom modification. The Model 863 is shipped with this jumper in the Out position.

INTEGRATION Time constant PWB jumper selectable as either Out or 50 ns. A third position is available for custom modification. In the Out position, the 10% to 90% rise time is < 10 ns. The Model 863 is shipped with this jumper in the Out position.

INVERT/NONINVERT PWB jumper selectable to Invert or Noninvert the Output signal relative to the Input signal. The Model 863 is shipped with this jumper in the Noninvert position.

INPUT

INPUT Positive or negative polarity selectable with a PWB jumper; amplitude 0 to ± 1 V ac signal; 0 to ± 2 V dc offset; maximum input ± 2 V signal plus offset. Input impedance is 100 Ω , protected to ± 6 V. Front-panel LEMO connector.

CLIP Two front-panel LEMO connectors to provide delay line clipping of the input pulse using an external 50- Ω coaxial cable. Delay line clip is two times the cable propagation delay. Gain is reduced by a factor of two when using the cable clip.

OUTPUT

OUTPUT Front-panel LEMO connector furnishes the shaped and amplified signal through $Z_0 < 1$ Ω ; amplitude to ± 5 V, rise time and decay time controlled by the Integration and Differentiation time constant settings. Output is dc-coupled and controlled by a continuous baseline restorer.

ELECTRICAL AND MECHANICAL

POWER The Model 863 unit does not have an internal power supply and must obtain power from a NIM-standard power supply such as the ORTEC Model 4001A/ 4002D NIM Bin/Power Supply.

POWER REQUIREMENTS +24 V, 83 mA; -24 V, 83 mA; +12 V, 167 mA; -12 V, 167 mA; +6 V, 320 mA; -6 V, 320 mA.

WEIGHT

Net 1.5 kg (3.3 lb).

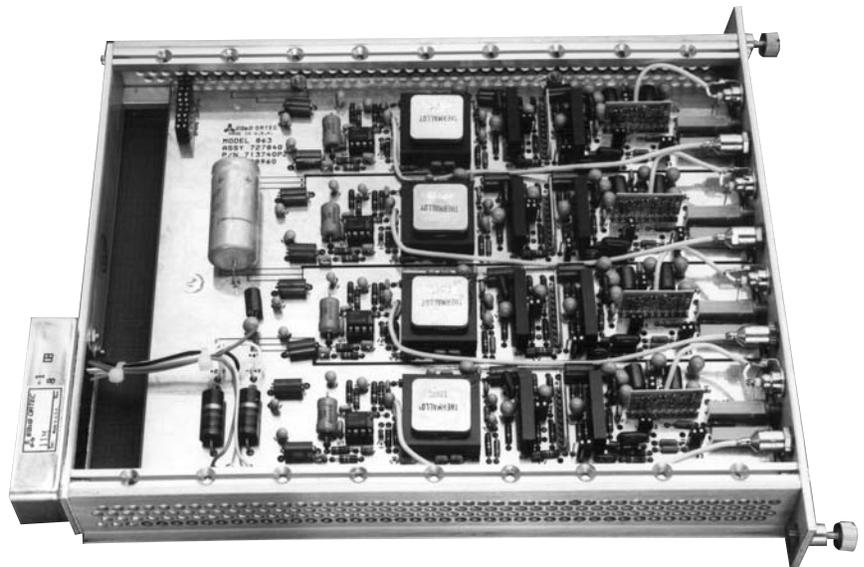
Shipping 3.1 kg (7.0 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
863	Quad Timing Filter Amplifier



Model 863, with Side Panel Removed, Shows the Four Separate Timing Filter Amplifier Circuits.

9302

Amplifier Discriminator

- Fast amplifier and discriminator for photon, electron, or ion counting applications
- 100-MHz counting rate capability
- Includes rate monitor facility



The ORTEC Model 9302 is a fast Amplifier and Discriminator in a single-wide NIM-standard module designed for use with photomultiplier or electron multiplier tubes in photon, ion, or electron counting applications. Features of the Model 9302 include a wideband, high-gain amplifier and an integral discriminator capable of counting rates up to 100 MHz.

Incorporated into the module is a rate monitor system. This facility can be used to perform external switching when the pulse counting rate is modulated. At counting rates equal to or above those selected by the monitor rate discriminator, a voltage of $>+2$ will be present at the signal monitor connector. At counting rates below the rate selected, 0 V will be present at the connector. The threshold value is selected by the front-panel switch.

The amplifier section of the Model 9302 is ac-coupled with input and output impedances of 50 Ω . The amplifier has a rise time of typically 3 ns at a gain setting of 200 and <2 ns when the gain is set at 20.

The discriminator section of the Model 9302 is a leading-edge discriminator whose level can be adjusted through a range from 50 mV to 1 V.

Specifications

PERFORMANCE

Amplifier

RISE TIME Typically 3.0 ns.

NOISE ≤ 10 μ V for maximum gain setting.

OUTPUT VOLTAGE RANGE 0 to -500 mV, on a 50- Ω load.

GAIN X20 or X200, noninverting.

NONLINEARITY $\leq \pm 1\%$.

TEMPERATURE INSTABILITY

Gain $< \pm 0.1\%/^{\circ}\text{C}$.

DC Level $< \pm 50$ μ V/ $^{\circ}\text{C}$, referred to input.

Discriminator

THRESHOLD RANGE 50 mV to 1 V.

PULSE PAIR RESOLUTION < 10 ns; typically 9 ns.

WALK ≤ 2.0 ns from X2 to X20 threshold.

CONTROLS

GAIN 2-position slide switch on front panel for selecting amplifier gain of 20 or 200.

DISC LEVEL Front-panel potentiometer for selecting discriminator level, ranging from 50 mV to 1 V.

MONITOR RATE DISC Front-panel rotary switch for selecting pulse-rate discriminator threshold with settings of 1 kHz, 10 kHz, 100 kHz, and 1 MHz.

INPUT

AMPLIFIER IN Rear-panel BNC connector accepts negative input signals; protected to ± 100 V at 10% duty factor; $Z_{in} = 50$ Ω .

OUTPUTS

AMP OUT Rear-panel BNC connector provides linear analog output; $Z_o = 50$ Ω .

DISC OUT Two independent rear-panel BNC connectors provide negative current pulse of 16 mA into 50 Ω ; width ≤ 5 ns; rise time 1.5 ns.

SIGNAL MONITOR Rear-panel BNC connector provides 0 ± 0.2 V when discriminator count rate is below threshold and $\geq +2$ V when it is above threshold.

PREAMP POWER Amphenol 17-10090 rear-panel connector provides necessary power for 9301 Fast Preamp.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 140 mA; -12 V, 205 mA; +24 V, 85 mA; -24 V, 90 mA.

WEIGHT

Net 0.9 kg (2.0 lb).

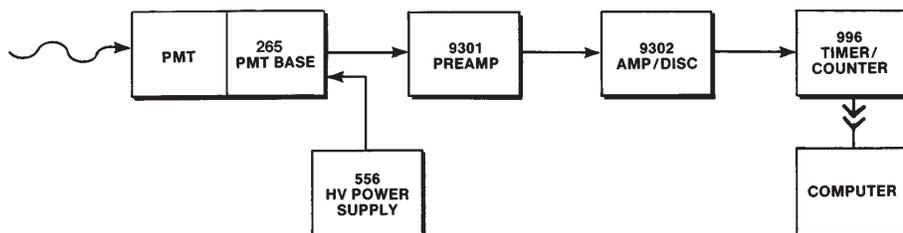
Shipping 2.25 kg (5.0 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
9302	Amplifier Discriminator



Typical 100-MHz Counting System.

Single-Channel Pulse-Height Analyzers

Contents

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	Single-Channel Analyzer Applications Guide	4.3
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550A	Single-Channel Analyzer	4.5
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552	Pulse-Shape Analyzer/Timing SCA	4.9
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590A	Amplifier and Timing Single-Channel Analyzer	3.40
850	Quad Single-Channel Analyzer	4.12

Introduction

The amplitude of the analog pulse at the output of a spectroscopy amplifier is typically proportional to the charge released in the detector or to the energy of the detected event. Selection of a range of signal levels at the output of the amplifier is equivalent to the selection of a range of energies or charge for these events. This selection can be accomplished by the use of discriminators and single-channel analyzers (SCAs). A discriminator produces an output logic pulse only if its input signal exceeds a preset threshold level. A single-channel analyzer produces an output logic pulse only if the peak amplitude of its input signal falls within the pulse-height window that is established with two preset threshold levels.

Figure 1 shows three pulses that might be provided from a main amplifier to an integral discriminator. The first pulse has an amplitude less than the adjusted discriminator threshold and generates no output logic signal. Each of the last two pulses has sufficient amplitude to produce an output logic signal. The output signals indicated in Fig. 1 are generated when the leading edge of the input signal crosses the

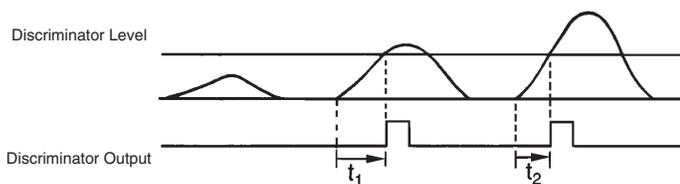


Fig. 1. Integral Discriminator Output Triggering.

discriminator threshold level. Therefore, the time of the output response is a function of the amplitude and rise time of the input signals. This amplitude and rise time dependence leads to "time walk" of the output signal relative to the beginning of the input pulse. The discriminator output is produced earlier by pulses with larger amplitudes and later by pulses with lower amplitudes.

Figure 2 shows three pulses that might be provided from a main amplifier to an SCA. Only the B pulse satisfies the conditions necessary to produce an SCA output logic signal.

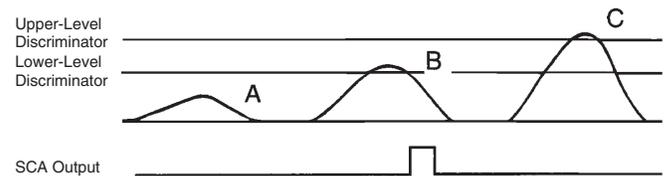


Fig. 2. Single-Channel Analyzer Function.

Removal of the upper-level-discriminator restrictions from the SCA allows it to be used as an integral discriminator. If the upper-level restrictions were removed from the unit whose output is shown in Fig. 2, both pulses B and C would be marked by logic outputs.

Single-Channel Pulse-Height Analyzers

Three primary modes of discriminator operation are available in ORTEC SCAs: Integral, Normal, and Window. In the Integral mode of operation, the SCA can function as an integral discriminator, as indicated in the preceding paragraph. In the SCA Normal mode of operation, the upper-level and lower-level thresholds are independently adjustable. In the SCA Window mode, the upper-level threshold control is used to establish a voltage level that is added to the lower-level threshold voltage to yield the upper-level discriminator (ULD) threshold level. Thus, when the lower-level setting is changed, the upper-level threshold changes by the same amount. An external voltage reference for the lower-level discriminator (LLD) can be supplied to scan the window through a preselected range of pulse heights.

Unlike an integral discriminator, the output logic signal from a single-channel analyzer must be produced after the input pulse reaches its maximum amplitude. This timing sequence must provide sufficient time for the SCA logic circuitry to determine if the input signal exceeded the upper-level threshold.

ORTEC provides two basic types or classifications of SCAs: non-timing SCAs and timing SCAs. The technique used to produce the output logic signals from an SCA determines its classification. Non-timing units, such as the Models 550A, and 850, produce an SCA output pulse if the input signal is within the window settings. The output occurs when the trailing edge of the input signal recrosses the lower-level threshold. Figure 3 shows two superimposed output pulses from a main amplifier that meet the window requirements of the single-channel analyzer. The output from the non-timing SCA for each pulse is shown below the pulses. Since the linear input pulses are referenced to the same starting time, it is clear that the output logic signals exhibit "time walk" relative to the input pulses.

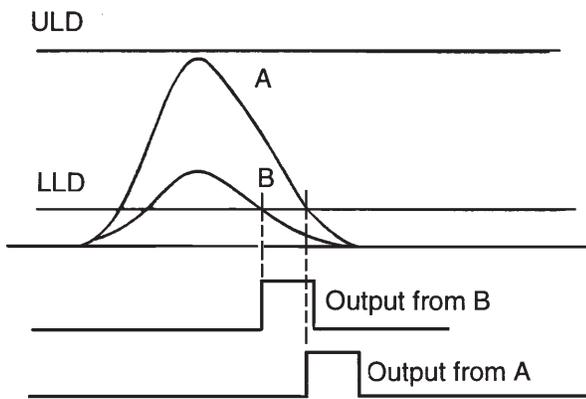


Fig. 3. Non-Timing SCA Output Triggering.

Timing SCAs, such as the ORTEC Models 551, 552, and 590A, produce SCA output logic signals that are precisely related in time to the occurrence of the event being measured. This time relationship implies that the time of occurrence of the SCA output signal is "walk-free" or nominally independent of the amplitude of the input signal, for a given rise time. In addition to simple counting applications, the time-related output can be used for coincidence measurement, pulse-shape discrimination, and other applications where the precise time of occurrence is important.

Figure 4 shows two pulses from a main amplifier and the response for a peak-detection single-channel analyzer such as the Model 590A Amplifier and Timing Single-Channel Analyzer. Although the amplitudes of the amplifier pulses differ, their peaks occur at approximately the same time, and the SCA outputs are produced when the peaks of the input pulses are detected.

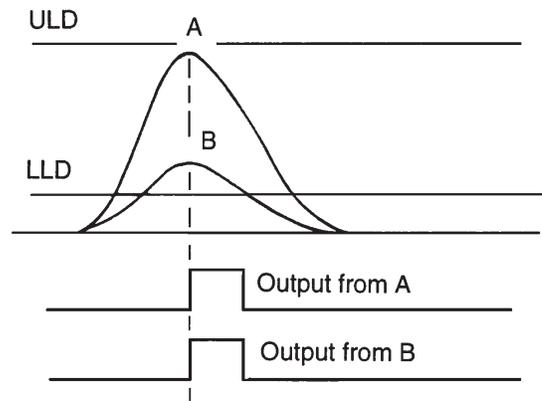


Fig. 4. Peak-Sensing SCA Output Triggering.

The conventional zero-crossing technique has been widely used for timing single-channel analyzers. This technique utilizes the zero-crossing of the bipolar output signal from a pulse-shaping amplifier to derive timing information, and uses the peak amplitude of the pulse for the energy range information. Figure 5 shows two bipolar pulses provided from a main shaping amplifier. Both pulses meet the SCA window requirements. Each output signal is generated when the corresponding input signal crosses the baseline. Figure 5 illustrates that the time of occurrence of the SCA output signals is precisely related to the occurrence of the detected event and is independent of input signal amplitude. Either double-delay-line-shaped pulses or RC-shaped pulses may be used, but the former provide better timing resolution. The bipolar output from delay-line amplifiers such as the Model 460 is well suited to zero-crossover timing with the ORTEC Model 552, because the input signal crosses the baseline with a large slope even when the pulse amplitude is low.

Single-Channel Pulse-Height Analyzers

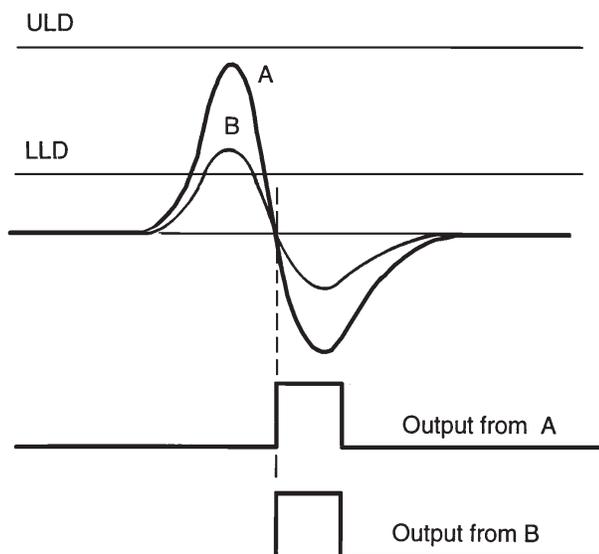


Fig. 5. Zero-Crossover SCA Output Triggering.

The bipolar output signal from a double-delay-line shaping amplifier crosses the baseline at a fixed fraction that is effectively 50% of the charge collected from the detector. Thus, conventional zero-crossing timing can be considered as timing at a constant fraction of the input signal amplitude. A trailing-edge constant-fraction technique* can be used with either unipolar or bipolar signals to derive a time-pickoff pulse after the peak time of the signal from the shaping amplifier. This technique is extremely useful when incorporated in timing single-channel analyzers. Figure 6 illustrates the trailing-edge constant-fraction technique for two unipolar input signals of identical rise times but different amplitude. The time of occurrence of the output signals is independent of output signal amplitudes.

The trailing-edge constant-fraction timing technique is available with two ORTEC SCAs: Models 551 and 552.

The Model 552 can also be used as a pulse-shape analyzer. The best known application of this technique is in the separation of the neutron and gamma responses of some scintillators (see page A.18). Collection time differences for the two types of radiation result in shape or rise time variations in the signals from a spectroscopy amplifier. When used with an ORTEC Time-to-Amplitude Converter, the Model 552 can resolve these shape variations over a 200:1 dynamic range of input signal amplitudes. The Model 552 accomplishes the shape measurement of the input signals by evaluating the timing at two different fractions.

*The basic circuit for implementing this technique is patented by ORTEC, U.S. Patent No. 3,714,464.

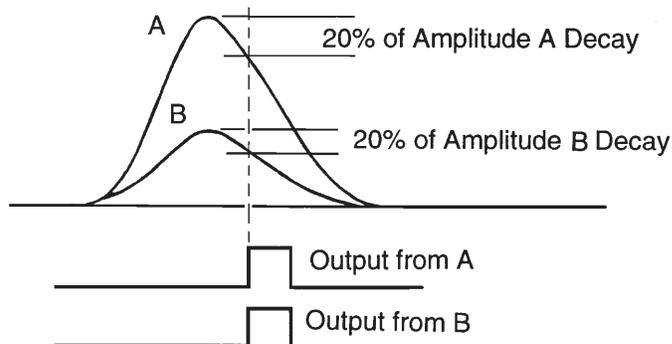


Fig. 6. Constant-Fraction SCA Output Triggering.

The SCA function can also be applied to fast analog signals in rising-edge constant-fraction discriminators. See the Fast-Timing Discriminators Section for details.

The following Selection Guide provides comparative data for all ORTEC Single-Channel Analyzers.

Single-Channel Analyzer Applications Guide

Model	Recommendations
550A	Versatile, economical, general-purpose counting.
551	SCA plus constant-fraction timing.
552	SCA plus constant-fraction timing and pulse-shape analysis.
583A	SCA function in a fast-timing constant-fraction discriminator for signals from a photomultiplier anode.
590A	Cost efficient, includes built-in amplifier.
850	Economical, four SCAs in a single-width module for general-purpose counting.

Single-Channel Pulse-Height Analyzers

Single-Channel Analyzer Selection Guide

Model No.	SCA Output Trigger	Modes	Lower-Level Range (V)	Upper-Level Range (V)	Delay Range	Input Coupling	External Strobe	External Baseline	Integral Non-linearity (%)	SCA Output Polarity
550A	LLD reset	Asymmetric window symmetric, window, normal, or integral	0.02–10 (10turn)	0–10 or 0–1 (10-turn)	None	dc	No	Yes	$\leq \pm 0.25$	Positive
551	Constant fraction (50%)	Window, normal, or integral	0.05–10 (10-turn)	0–10 or 0–1 (10-turn)	0.1–1.1 μ s 1–11 μ s (10-turn)	ac or dc	Yes	Yes	$\leq \pm 0.25$	Positive and negative
552	Selectable constant fractions (2), or zero crossing	Window, normal, or integral	0.04–10 (10-turn)	0–10 or 0–1 (10-turn)	0.1–1.1 μ s (10-turn)	dc	Yes	Yes	$\leq \pm 0.25$	Positive and negative
583A	See Fast-Timing Discriminator Section									
590A	Peak detect	Window or integral	0.05–10 (10-turn)	0–10 or 0–1 with internal jumper (10-turn)	None	Input directly coupled to amplifier output	No	Yes	$\leq \pm 0.25$	Positive
850	LLD reset	Window normal, or integral	0.02–9.99	0.02–9.99	None	dc	No	Yes	$\leq \pm 0.25$	Positive

550A Single-Channel Analyzer

The ORTEC Model 550A Single-Channel Analyzer is ideally suited for selecting a range of output pulse amplitudes from a spectroscopy amplifier for subsequent counting on a ratemeter or a counter/timer. It provides the excellent stability, resolution, and dynamic range needed for measurements with high-resolution germanium and silicon detectors. These same features provide more than adequate performance with scintillation counters, proportional counters, and ionization chambers. The entire instrument is dc-coupled to ensure that the discriminator levels are not affected by changes in the counting rate, even at very high counting rates.

The versatility of the Model 550A is enhanced by four basic operating modes. In the INTEGRAL mode, all input pulse amplitudes above the lower level produce an SCA output logic pulse. This mode is useful for counting all pulses above the noise level, or above a well-defined lower amplitude limit. The INTEGRAL mode can also be used for leading edge timing, or pulse routing logic. In the NORMAL mode, the upper- and lower-level discriminators are independently variable over the full +20 mV to +10 V range. The SCA output is generated only for pulse amplitudes that occur between the upper and lower levels. This mode is useful when a wide range of pulse heights must be selected for counting. In the ASYMMETRIC WINDOW mode, the upper-level dial becomes a window width control with a 0 to +1 V range. The lower-level dial controls the lower limit of the window over a +20 mV to +10 V range. Pulse amplitudes between the upper and lower limits of the window produce an SCA output. This mode is useful when a narrow range of pulse heights must be

- **Ideal for selecting a range of pulse amplitudes from a spectroscopy amplifier for counting on a ratemeter or counter/timer**
- **Provides the excellent stability, resolution, and dynamic range demanded by high-resolution detectors**
- **Four operating modes:**
 - Integral**
 - Normal (independent upper and lower levels)**
 - Asymmetric window**
 - Symmetric window**
- **DC-coupled for high counting rates**
- **SCA output generated when the input signal falls below the lower level**

selected. In the SYMMETRIC WINDOW mode, the upper-level dial still controls the window width over the range of 0 to +1 V, but the lower-level dial sets the position of the center of the window over a range of +20 mV to +10 V. The SYMMETRIC WINDOW mode is useful when the window has been centered on a peak in the spectrum and it is desirable to widen (or narrow) the window to accept more (or less) of the peak width.

Rear-panel connectors provide separate outputs for the upper- and lower-level discriminators. These logic outputs are generated at the instant the input signal exceeds the corresponding discriminator level. The SCA output logic pulse is generated when the input signal falls through the lower-level threshold.

An external input for the lower-level setting is switch selectable to allow recording the entire pulse-height spectrum utilizing a scanning technique. A narrow window is selected, and an external voltage source is employed to slowly scan the lower level through the 0 to 10 V range. A ratemeter counts the SCA output and draws the spectrum on a strip chart recorder.



550A

Single-Channel Analyzer

Specifications

PERFORMANCE

DYNAMIC RANGE 500:1.

PULSE-PAIR RESOLVING TIME 100 ns plus output pulse width.

THRESHOLD TEMPERATURE

SENSITIVITY <0.01% of full scale per °C, from 0 to 50°C, using a NIM Class A power supply (referenced to -12 V).

WINDOW WIDTH CONSTANCY Variation <±0.1% of full-scale window width over the +20 mV to +10 V linear input range.

DISCRIMINATOR NONLINEARITY <±0.25% of full scale for both discriminators.

INDICATORS

SCA OUT LED Front-panel LED flashes whenever an SCA output pulse is generated.

CONTROLS

WINDOW OR UPPER LEVEL Front-panel, 10-turn, locking dial determines the window width (0 to 1 V) in the WINDOW modes, or the upper-level threshold (0 to +10 V) in the NORMAL and INTEGRAL modes.

LOWER LEVEL Front-panel, 10-turn, locking dial determines the threshold setting (+20 mV to +10 V) for the lower-level discriminator when the rear-panel LL REF switch is in the INT position. The LOWER-LEVEL control is disabled when the EXT position is selected on the rear-panel LL REF switch.

INT, ASYM WINDOW, SYM WINDOW, NORM Front-panel, four-position rotary switch selects one of four operating modes:

INT In the INTEGRAL mode, the lower level and upper level are independently adjustable from +20 mV to +10 V. The SCA OUT is generated for all pulse amplitudes exceeding the lower-level threshold.

NORM In the NORMAL mode, the lower level and upper level are independently adjustable from +20 mV to +10 V. The SCA OUT is generated for pulse amplitudes that exceed the lower-level threshold, but do not exceed the upper-level threshold.

ASYM WINDOW In the ASYMMETRIC WINDOW mode, the **lower limit** of the window is adjustable from +20 mV to +10 V using the LOWER LEVEL dial. The WINDOW dial adjusts the width of the window from 0 to 1 V. The SCA OUT is generated for pulse amplitudes between the upper and lower limits of the window.

SYM WINDOW In the SYMMETRIC WINDOW mode, the **center** of the window is adjustable from +20 mV to +10 V using the LOWER LEVEL dial. The WINDOW dial

adjusts the width of the window from 0 to 1 V. The SCA OUT is generated for pulse amplitudes between the upper and lower limits of the window.

INT/EXT LL REF A rear-panel locking toggle switch selects either the front-panel LOWER LEVEL dial (INT position), or the rear-panel LL REF input (EXT position) for controlling the lower-level threshold.

INPUTS

INPUT Front-panel BNC connector accepts unipolar or bipolar linear signals for pulse amplitude selection in the range of +20 mV to +10 V (dc-coupled). The minimum input pulse width is 100 ns. The maximum amplitude of signal plus dc offset is ±12 V. Input impedance is approximately 1000 Ω. Front-panel test point wired to the INPUT connector through a 470-Ω resistor.

IN Rear-panel BNC connector identical to INPUT connector.

LL REF Rear-panel BNC connector accepts a dc voltage from an external source for controlling the lower-level threshold when the INT/EXT LL REF switch is in the EXT position. The input range of -20 mV to -10 V corresponds to a lower-level threshold range of +20 mV to +10 V. The input is overload protected to ±15 V.

OUTPUTS

SCA OUT Front- and rear-panel BNC connectors provide a NIM-standard, positive logic pulse output: nominally +5 V amplitude and 500-ns width. Output impedance <15 Ω. Front- and rear-panel outputs have separate output drivers. The output pulse occurs when the trailing edge of the linear input pulse crosses the lower-level threshold. See description under CONTROLS for output logic modes. Front-panel test point wired to the SCA OUT connector through a 470-Ω resistor.

LL OUT Rear-panel BNC connector provides a NIM-standard, positive logic pulse output: nominally +5 V amplitude and 500-ns width. Output impedance <15 Ω. The output pulse occurs when the leading edge of the linear input pulse crosses the lower-level threshold (INT or NORMAL modes), or the lower limit of the window (WINDOW modes).

UL OUT Rear-panel BNC connector provides a NIM-standard, positive logic pulse output: nominally +5 V amplitude and 500-ns width. Output impedance <15 Ω. The output pulse occurs when the leading-edge of the linear input pulse crosses the upper-level threshold (INT or NORMAL modes), or the upper limit of the window (WINDOW modes).

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V at 75 mA, -12 V at 35 mA.

WEIGHT

Net 0.9 kg (2.0 lb)

Shipping 2.3 kg (5.0 lb)

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 4.714 in.) front panel per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
550A	Single-Channel Analyzer



Timing Single-Channel Analyzer

The ORTEC Model 551 Timing Single-Channel Analyzer performs the dual functions of single-channel pulse-height analysis and timing signal derivation.

The patented* trailing-edge constant-fraction timing technique provides unexcelled timing on either unipolar or bipolar signals and shows better results than are possible with conventional leading-edge discriminators.

With SCAs that utilize leading-edge timing, the rise time of the input pulses causes degradation of time resolution because the pulses have varying amplitudes.

Constant-fraction timing compensates for varying amplitudes and essentially eliminates this timing shift, giving consistently better timing results.

For the internally set 50% fraction, the output occurs soon after the midpoint on the linear input trailing edge to facilitate gating and accumulation of data at very high input rates. This technique also minimizes timing shift and dead time when used with sodium iodide, silicon, and germanium detectors, thereby allowing better system time resolution and higher counting rates.

The constant-fraction technique makes it possible to realize significant improvements in time resolution in most timing applications. Notice that analysis is made of the main amplifier output. This technique allows optimization of time resolution and extension of dynamic range for neutron-gamma discrimination and other timing applications. Walk of <3 ns for 100:1 dynamic range using input pulses from a pulser is possible.

The Model 551 is versatile, with three basic operating modes provided. In the Window mode, the unit operates as a high-resolution, narrow (0 to 10%) window, single-channel analyzer. For wide-window applications, the Normal mode is used. In this mode the upper-level and lower-level controls are independently variable from 0 to 10 V, and an output is generated for pulses analyzed between the levels. Through use of the separate rear-panel LL Out

- **Single-channel analyzer and timing signal derivation**
- **Trailing-edge constant-fraction timing provides walk $<\pm 3$ ns for 100:1 dynamic range**
- **Integral, normal, and window modes**
- **Separate lower-level and upper-level discriminator outputs**
- **DC-coupled**
- **Adjustable delay 0.1 to 11 μ s**
- **Provision for external baseline sweep**

and UL Out outputs, the unit can operate as a dual wide-dynamic-range integral discriminator for leading-edge timing or for pulse routing.

The dc-coupled input of the Model 551 makes it possible to take full advantage of the baseline restoration of the main amplifier for maximum performance at widely varying counting rates.

The continuously adjustable output delay (two ranges covering 0.1 to 11 μ s) makes it possible to align output signals that have actual time differences without a need for additional delay devices or modules. Alternatively an External strobe input can be used to cause an SCA output at the desired time.

For an application where it is desirable to scan an entire spectrum, an external base-line sweep input is provided via the rear-panel LL Ref Ext BNC connector. In this mode of operation, the baseline (lower-level threshold) on which a window is riding is swept through an energy range and the count rate is recorded as a function of energy.

*U.S. Patent No. 3,714,464.



Timing Single-Channel Analyzer

Specifications

PERFORMANCE

DYNAMIC RANGE 200:1.

PULSE-PAIR RESOLVING TIME Output pulse width plus Delay (as selected by the front-panel Delay controls), plus 100 ns for fast NIM output or plus 200 ns for positive NIM output. Minimum resolving time for negative output 220 ns; for positive output 800 ns.

THRESHOLD TEMPERATURE

INSTABILITY $\leq \pm 0.01\%/^{\circ}\text{C}$ of full scale, 0 to 50°C using a NIM Class A power supply (referenced to -12 V).

DISCRIMINATOR NONLINEARITY $\leq \pm 0.25\%$ of full scale (integral) for both discriminators.

DELAY TEMPERATURE INSTABILITY $\leq \pm 0.03\%/^{\circ}\text{C}$ of full scale, 0 to 50°C .

DELAY NONLINEARITY $< \pm 2\%$ of delay range.

WINDOW WIDTH CONSTANCY $\leq \pm 0.1\%$ variation of full-scale window width over the linear range 0 to 10 V.

MINIMUM INPUT THRESHOLD 50 mV for lower-level discriminator.

TIME SHIFT vs PULSE HEIGHT (WALK)

Walk (ns)		Dynamic Range
System A	System B	
± 1.0	± 2.0	10:1
± 2.5	± 4.0	50:1
± 3.0	± 4.0	100:1

System A: Using an ORTEC Model 460 Amplifier, single delay-line mode, integrate $\leq 0.1\ \mu\text{s}$ with $1\text{-}\mu\text{s}$ delay line.

System B: Using an ORTEC Model 570, 571, or 572 Amplifier, unipolar output with $0.5\text{-}\mu\text{s}$ shaping time. Input from ORTEC Model 419 Pulser.

CONTROLS

LOWER LEVEL Front-panel 10-turn potentiometer adjustable from 0 to 10 V; when the rear-panel LL Ref mode switch is set on Int, determines the threshold setting for the lower-level discriminator. When the LL REF mode switch on the rear panel is in the EXT position, this control is ineffective.

WINDOW OR UPPER LEVEL Front-panel 10-turn potentiometer determines the window width (0 to +1 V) in the Window mode or the upper-level (0 to +10 V) threshold in the Normal mode. This control is disabled in the Integral mode.

INT/NOR/WIN Front-panel 3-position locking toggle switch selects one of three operating modes:

Integral LL sets a single-discriminator threshold (0 to +10 V) and UL is disabled.

Normal UL and LL are independently adjustable levels (0 to +10 V).

Window LL sets the baseline level (0 to +10 V) and UL sets the window width (0 to +1 V).

DELAY RANGE Front-panel locking toggle switch selects delay ranges of 0.1 to $1.1\ \mu\text{s}$ or 1.0 to 11 μs .

DELAY Front-panel 10-turn potentiometer for continuous adjustment of output delay over selected range. In the external strobe mode the delay control adjusts the automatic reset time from $\approx 5\ \mu\text{s}$ to 50 μs .

WALK ADJUST Front-panel screwdriver adjustment for precise setting of walk compensation.

LL REF MODE Rear-panel 2-position locking toggle switch selects either the front-panel LL potentiometer or the voltage signal applied to the rear-panel LL REF EXT connector as the LL discriminator reference threshold.

STROBE Rear-panel 2-position locking toggle switch selects either Internal or External source for the SCA output signal strobe function.

INPUTS

SIGNAL INPUT Front-panel dc-coupled BNC connector accepts positive unipolar or bipolar signal, 0 to +10 V linear range, $\pm 12\text{ V}$ maximum; width 100 ns; $1000\text{-}\Omega$ input impedance. Rear-panel ac-coupled BNC connector accepts positive unipolar or bipolar signal, 0 to +10 V linear range, $\pm 100\text{ V}$ maximum; width 0.2 to 10 μs ; $1000\text{-}\Omega$ input impedance.

LL REF EXT When the rear-panel LL REF mode switch is on EXT, the rear-panel LL REF EXT BNC connector accepts the lower-level biasing (an input of 0 to -10 V on this connector corresponds to a range of 0 to 10 V for the lower-level discriminator setting). Input protected to $\pm 24\text{ V}$.

EXT STROBE INT When the rear-panel EXT/INT STROBE locking toggle switch is in EXT, the rear-panel EXT STROBE IN BNC connector accepts a positive NIM-standard input, nominally +5 V, 500 ns wide, to cause an output to occur from the SCA. The external strobe should be given within 5 μs (or 50 μs as determined by the front-panel Delay control) of the linear input. At the end of this period, the Model 551 resets its internal logic without producing an output signal.

OUTPUTS

SCA POS OUT Front- and rear-panel BNC connectors provide positive NIM-standard output, nominally +5 V; 500 ns wide; $10\text{-}\Omega$ output impedance. For internal strobe the output occurs at the midpoint of the linear input trailing edge plus the output Delay as selected by the front-panel controls. For external strobe the output occurs at the time of strobe signal.

SCA NEG OUT Front-panel BNC connector provides fast NIM-standard output, nominally -16 mA (-800 mV on $50\text{-}\Omega$ load); width $\leq 20\text{ ns}$; rise time $\leq 5\text{ ns}$; $\leq 10\text{-}\Omega$ output impedance. Output occurs at the mid-point of the linear trailing edge plus the output Delay as selected by the front-panel controls.

LL OUT Rear-panel BNC connector provides positive NIM-standard output, nominally +5 V, 500 ns wide; $\leq 10\text{-}\Omega$ output impedance. Output occurs as leading edge of linear input crosses the LL threshold.

UL OUT Rear-panel BNC connector provides NIM-standard output, nominally +5 V, 500 ns wide; $\leq 10\text{-}\Omega$ output impedance. Output occurs as leading edge of linear input crosses the UL threshold.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 160 mA; -12 V , 110 mA; +24 V, 90 mA; -24 V , 50 mA.

WEIGHT

Net 1.1 kg (2.5 lb).

Shipping 2.25 kg (5.0 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 4.714 in.) per DOE/ER-0457T.

Related Equipment

The Model 551 is compatible with all ORTEC amplifiers and other amplifiers having a 0 to 10 V positive, linear output range.

Ordering Information

To order, specify:

Model	Description
551	Timing Single-Channel Analyzer

Pulse-Shape Analyzer/Timing SCA

- Pulse-height analysis, timing signal derivation, and pulse-shape analysis
- Trailing-edge constant-fraction timing with two independent timing channels
- Walk $\leq \pm 250$ ps for a 10:1 dynamic range
- DC-coupled
- Resolves shape variations over a 200:1 dynamic range
- Adjustable delay 0.1 to 1.1 μ s
- Provision for external baseline sweep



The ORTEC Model 552 Pulse-Shape Analyzer and Timing Single-Channel Analyzer is a valuable instrument for experimentalists performing pulse-height analysis, timing signal derivation, and determination of pulse shapes. The single-width NIM module offers many features normally requiring the use of several separate instruments. A patented* trailing-edge constant-fraction (CF) timing technique is used, providing excellent timing on either unipolar or bipolar signals and giving better results than are possible with conventional leading-edge discriminators. Two independent CF time-derivation channels are used to evaluate the shape of the input waveform. When, for example, these discriminators are set to 10 and 90% fractions, the time interval between the two outputs thus generated will be a measure of the input signal fall time.

The versatility of the Model 552 is evidenced by the three functions it can be used for: time derivation, pulse-height analysis, and adjustable output delay.

Time derivation is an important parameter in many experiments. With SCAs that utilize leading-edge timing, the rise time of the input pulses causes degradation of time resolution due to their amplitude variations. Trailing-edge constant-fraction timing, on the other hand, compensates for varying amplitudes and essentially eliminates this time shift, giving consistently better results. Figure 1 shows that walk with the Model 552 is $\leq \pm 250$ ps for a 10:1 dynamic range when the output of the main amplifier is being directly analyzed. A built-in input attenuator is provided so that the front-panel walk controls can be

adjusted rapidly and precisely, to achieve excellent timing performance.

Pulse-height analysis with the Model 552 can be done in three different basic operating modes: as a high-resolution, narrow (0 to 10%) window, single-channel analyzer; as a wide-window SCA in which the upper-level and lower-level controls are independently variable from 0 to 10 V and an output is generated for pulses analyzed between the levels; and as a wide-dynamic-range integral discriminator for leading-edge timing or pulse routing via the separate rear-panel LL OUT and UL OUT outputs.

Another feature that makes the Model 552 a versatile instrument is a continuously adjustable output delay, which allows output signals with actual time differences to be aligned without the need for additional delay devices or modules. Alternatively, an external strobe input can be used to produce an SCA output at the desired time.

When it is desirable to scan an entire spectrum, a rear-panel connector can be used to provide an external baseline sweep input. With the lower-level REF switch in the EXT position, the baseline (lower-level threshold) on which a window is riding can be swept through an energy range and the count rate recorded as a function of energy.

Analysis of the amplifier pulse shape can be useful in separating the detected events from different types of radiation. The best known example is the difference in the neutron and gamma-ray response in some scintillators. In these cases, stringent conditions are imposed on the electronics because of the nonlinear response of the scintillator as a function of neutron energy. For example, for neutrons with energies from 200 keV to 10 MeV the response of an NE-213 scintillator can vary over a 500:1 range. The Model 552, in conjunction with the ORTEC Model 457, 566, or 567 Time-to-Amplitude Converter, will satisfactorily resolve shape variations over a 200:1 dynamic range in such neutron-gamma applications.

*U.S. Patent No. 3,714,464.

Pulse-Shape Analyzer/Timing SCA

Other applications for this feature of the Model 552 are its use with gaseous detectors for particle identification, with large germanium detectors to help optimize their energy resolution, and for determining the position of interaction in a position-sensitive proportional counter.

In all cases, the Model 552 provides a measurement of the input signal shape by evaluating its timing at two different fractions.

Specifications

PERFORMANCE

INPUT DYNAMIC RANGE 200:1.

PULSE-PAIR RESOLVING TIME Output pulse widths plus Delay (as selected by the front-panel Delay potentiometer), plus 200 ns for negative NIM output or plus 740 ns for positive NIM output. Minimum resolving time for negative output 260 ns; for positive output 800 ns.

THRESHOLD TEMPERATURE

INSTABILITY $\leq \pm 0.005\%/^{\circ}\text{C}$ of full scale, 0 to 50°C .

DISCRIMINATOR NONLINEARITY $\leq \pm 0.25\%$ of full scale (integral) for both discriminators.

DELAY TEMPERATURE INSTABILITY $\leq \pm 0.01\%/^{\circ}\text{C}$ of full scale, 0 to 50°C .

TIME SHIFT vs PULSE HEIGHT (Walk) (Specified for Channels A and B at 50% fraction.)

Input Dynamic Range	Walk (ns)	
	System I*	System II*
10:1	± 0.5	± 2.0
50:1	± 1.5	± 2.5
100:1	± 2.0	± 3.0
200:1	± 2.5	± 4.0

*Using an ORTEC Model 460 Amplifier, single delay line mode, integrate $0.1 \mu\text{s}$ with $1\text{-}\mu\text{s}$ delay line.

**Using an ORTEC Model 572 Amplifier, unipolar output, $0.5\text{-}\mu\text{s}$ shaping.

WINDOW WIDTH CONSTANCY Variation $\leq \pm 0.1\%$ of full-scale window width over the linear range 0 to 10 V.

MINIMUM INPUT THRESHOLD 40 mV for lower-level discriminator.

CONTROLS

LOWER LEVEL Front-panel 10-turn potentiometer adjustable from 40 mV to 10 V. The potentiometer determines the threshold setting for the lower-level discriminator when the rear-panel LL REF mode switch is set on. When the LL REF mode switch is in the EXT position, this control is ineffective.

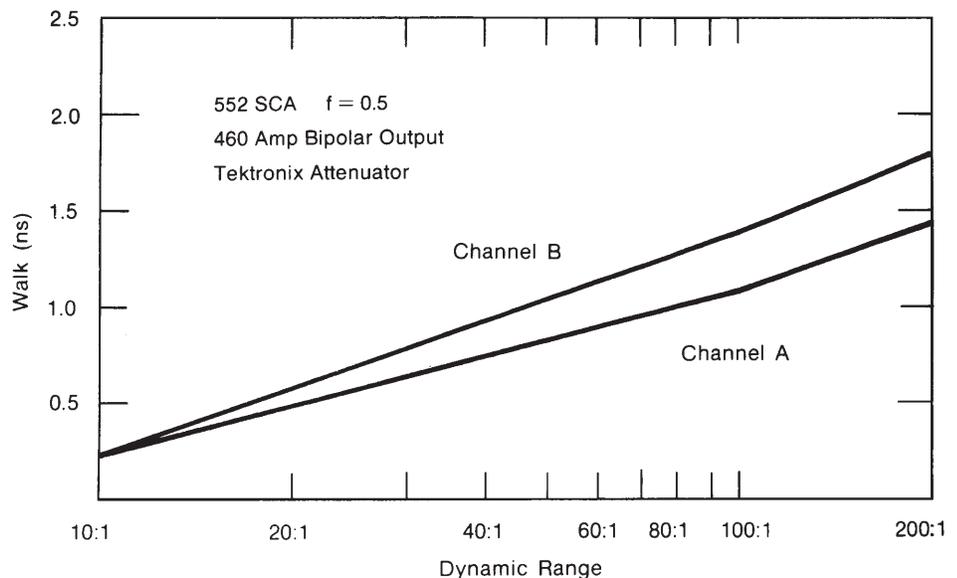


Fig. 1. Typical Walk vs. Dynamic Range.

UPPER LEVEL OR WINDOW Front-panel 10-turn potentiometer determines the window width (0 to +1 V) when the operating mode switch is set at WIN or the upper-level (0 to +10 V) threshold when the operating mode switch is set at NORM. This control is disabled when the operating mode switch is set at INT.

INT/NORM/WIN Front-panel 3-position locking toggle switch selects one of three operating modes:

INT In this position, the lower-level threshold is set, from 0 to +10 V, and the upper-level discriminator is disabled.

NORM In this position, the upper-level and lower-level controls can both be adjusted independently, from 0 to +10 V.

WIN In this position, the lower-level control defines the baseline and can be set from 0 to +10 V, and the upper-level control defines the window width, from 0 to +1 V.

B-FRACTION Front-panel switch selects the B discriminator fraction from 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, to 0.9 for trailing-edge constant-fraction timing with unipolar or bipolar inputs. In the BI mode, zero-crossing timing is performed on bipolar inputs.

A-FRACTION A printed wiring board (PWB) jumper selects the A discriminator fraction from 0.1, 0.2, or 0.5 for trailing-edge constant-fraction timing with unipolar or bipolar inputs; jumper is factory-set at 0.1 fraction.

ATTN X1, X10, X100 Front-panel switch selects attenuation factor of high-quality built-in attenuator network for precise walk adjustment setting. Note: The normal operating mode is the X1 position.



Pulse-Shape Analyzer/Timing SCA

DELAY Front-panel screwdriver 10-turn potentiometer for continuous adjustment of output delay over a 0.1- to 1.1- μ s range.

WALK ADJ Two front-panel screwdriver adjustments for precise setting of walk compensation for timing channels A and B.

LL REF Rear-panel 2-position locking toggle switch (INT/EXT) selects either the front-panel lower-level potentiometer or the voltage signal applied to the rear-panel LL REF EXT connector as the lower-level-discriminator reference threshold.

STROBE Rear-panel 2-position locking toggle switch (INT/EXT) selects either internal or external source for the SCA output-signal strobe function. The automatic reset time is $\sim 10 \mu$ s.

INPUTS

INPUT Front-panel dc-coupled BNC connector accepts positive unipolar or bipolar signals, 0 to +10 V linear range, ± 12 V maximum; width 100 ns; 1000- Ω input impedance.

LL REF IN When the rear-panel LL REF mode switch is on EXT, the rear-panel LL REF IN BNC connector accepts the lower-level biasing (an input of 0 to -10 V on this connector corresponds to a range of 0 to +10 V for the lower-level discriminator setting); input protected to ± 24 V.

STROBE IN When the rear-panel Strobe locking toggle switch is in the EXT position, the rear-panel STROBE IN BNC connector accepts a positive NIM-standard input, nominally +5 V, 500 ns wide, to cause an output to occur from the SCA. The external strobe should be given within 10 μ s of the linear input. At the end of this period, the Model 552 resets its internal logic without producing an output signal.

OUTPUTS

OUTPUT B (SCA, Positive)/SCA OUT Front and rear-panel BNC connectors provide positive NIM-standard outputs for channel B, nominally +5 V; 500 ns wide; ≤ 10 - Ω output impedance. For internal strobe, the outputs occur at the selected fraction point of the linear input trailing edge plus the output Delay as selected by the front-panel control. For external strobe the outputs occur at the time of the strobe signal.

OUTPUTS (SCA, Negative) Two front-panel BNC connectors provide negative NIM-standard outputs for timing channels A and B respectively; nominally -16 mA (-800 mV on 50- Ω load); rise time ≤ 5 ns; width ≤ 20 ns. The A Output occurs at the selected fraction point of the linear input trailing edge; the B output occurs at the selected fraction point of the linear input trailing edge plus the output Delay as selected by the front-panel control.

LL OUT Rear-panel BNC connector provides positive NIM-standard output, nominally +5 V, 500 ns wide; ≤ 10 - Ω output impedance. Output occurs as leading edge of linear input crosses the lower-level threshold.

UL OUT Rear-panel BNC connector provides NIM-standard output, nominally +5 V, 500 ns wide; ≤ 10 - Ω output impedance. Output occurs as leading edge of linear output crosses the upper-level threshold.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 90 mA; -24 V, 90 mA; +12 V, 190 mA; -12 V, 190 mA.

WEIGHT

Net 1.1 kg (2.5 lb).

Shipping 2.25 kg (5.0 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 4.714 in.) per DOE/ER-0457T.

Related Equipment

The Model 552 input is compatible with all amplifiers having a 0 to 10-V positive linear output range. The outputs are compatible with ORTEC's timing and counting equipment.

Ordering Information

To order, specify:

Model	Description
552	Pulse-Shape Analyzer/Timing SCA

850

Quad Single-Channel Analyzer

The ORTEC Model 850 Quad Single-Channel Analyzer (SCA) has the exceptionally wide dynamic range, the stability, and the high resolution necessary for use in high-resolution HPGe spectroscopy experiments. These same features provide more than adequate performance with scintillation counters and ionization chambers. DC-coupled input and integrated circuit discriminators, are employed to obtain these characteristics and to assure maximum performance at high counting rates.

The Model 850 consists of four completely independent SCA channels. Each channel is versatile, with three basic operating modes provided. In the Window mode, each channel operates as a high-resolution, narrow (0 to 10%) window, single-channel analyzer. For wide-window applications, the Normal mode is used. In this mode, the upper-level and lower-level controls of each channel are independently variable from 20 mV to 9.99 V, and an output is generated for pulses analyzed between the levels. A front-panel green LED indicates activity. Through the use of separate rear-panel LL OUT and UL OUT outputs, each channel can operate as a dual, wide-dynamic-range integral discriminator for leading-edge timing or for pulse routing.

For an application where it is desirable to scan an entire spectrum, an external baseline sweep input is provided via the rear-panel LL REF EXT BNC connector. Printed wiring board jumpers select which of the four channels will use the external baseline sweep. In this mode of operation, the baseline (lower-level threshold) on which a window is riding is swept through an energy range and the count rate is recorded as a function of energy.

The Model 850 has an easy-to-use, built-in digital voltmeter for setting the lower-level and upper-level thresholds of each channel. A front-panel push button selects which of the four channels is being read. A second front-panel push button selects either the lower-level or upper-level reading. The digital voltmeter display flashes on overrange.

Specifications

Specifications apply to each of the four independent channels.

PERFORMANCE

DYNAMIC RANGE 500:1.

PULSE-PAIR RESOLVING TIME 200 ns plus output pulse width.

THRESHOLD TEMPERATURE

INSTABILITY $\leq \pm 0.01\%/^{\circ}\text{C}$ of full scale, 0 to 50°C using a NIM Class-A power supply (referenced to -12 V).

WINDOW WIDTH CONSTANCY $\leq \pm 0.1\%$ variation of full-scale window width over the linear 0- to 10-V input range.

DISCRIMINATOR NONLINEARITY $\leq \pm 0.25\%$ of full scale (integral) for both discriminators.

CONTROLS

WINDOW OR UPPER LEVEL Front-panel screwdriver potentiometer determines the window width (0 to 1 V) in the Window mode or the upper-level threshold (20 mV to 9.99 V) in the Normal mode. This control is disabled in the Integral mode. The built-in voltmeter is used to read the Window or upper-level setting.

LOWER LEVEL Front-panel screwdriver potentiometer adjustable from 20 mV to 9.99 V. When the printed wiring board (PWB) LL REF mode jumper is set on INT, this potentiometer determines the threshold setting for the lower-level discriminator. When the LL REF mode jumper is in the EXT position, the control is ineffective.

INTEGRAL/NORMAL/WINDOW Two printed wiring board jumpers select one of three operating modes:

Integral LL sets a single discriminator threshold (20 mV to 9.99 V) and UL is disabled.

Normal UL and LL are independently adjustable levels (20 mV to 9.99 V).

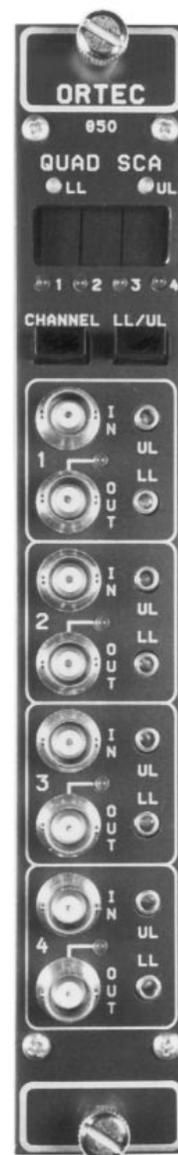
Window LL sets the baseline level (20 mV to 9.99 V) and UL sets the window width (2 mV to 0.999 V). The Digital Voltmeter reading must be divided by 10 to determine the Window setting.

LL REF MODE A printed wiring board jumper selects either the front-panel LL potentiometer or the voltage signal applied to the rear-panel LL REF EXT connector as the LL discriminator reference threshold.

DIGITAL VOLTMETER Channel Front-panel push button to select channel 1 through 4. Front-panel red LED indicates the selected channel.

LL/UL Front-panel push button selects lower-level or upper-level threshold for viewing on the Digital Voltmeter. Front-panel yellow LED indicates the selected threshold. **Inaccuracy** ± 1 digit.

- Four completely independent channels for counting selected energies from four detectors
- Dynamic range 500:1
- Integral, normal, and window modes
- DC-coupled input
- LED display of thresholds
- Provision for external baseline sweep



Quad Single-Channel Analyzer

INPUTS

SIGNAL INPUTS Front-panel BNC connector accepts positive, unipolar or bipolar signal, 0- to 10-V linear range. PWB jumper selects either dc- or ac-coupled input. For dc-coupled input, ± 12 V maximum; width >100 ns; $Z_{in} = 1$ k Ω . For ac-coupled input, ± 100 V maximum, 0.2- to 10- μ s width; $Z_{in} = 1$ k Ω .

LL REF EXT When the PWB jumper is on Ext, the rear-panel BNC connector accepts the lower-level biasing. (An input of -20 mV to -9.99 V on this connector corresponds to a range of 20 mV to $+9.99$ V for the lower-level discriminator setting.) Input protected to ± 24 V.

OUTPUTS

SCA OUT Front-panel BNC connector provides positive NIM-standard output, nominally $+5$ V; 500 ns wide; $Z_o \leq 10$ Ω . Output occurs as the trailing edge of linear input crosses the LL threshold.

LL OUT Rear-panel BNC connector provides positive NIM-standard output, nominally $+5$ V; 500 ns wide; $Z_o \leq 10$ Ω . Output occurs as the leading edge of linear input crosses the LL threshold.

UL OUT Rear-panel BNC connector provides positive NIM-standard output, nominally $+5$ V; 500 ns wide; $Z_o \leq 10$ Ω . Output occurs as the leading edge of linear input crosses the UL threshold.

ELECTRICAL AND MECHANICAL

POWER REQUIRED $+12$ V, 145 mA; -12 V, 140 mA; $+6$ V, 400 mA.

WEIGHT
Net 0.91 kg (2.0 lb).
Shipping 2.27 kg (5.0 lb).

DIMENSIONS NIM-standard single-width module, 3.43 X 22.13 cm (1.35 X 4.714 in.) per DOE/ER-0457T.

Related Equipment

The Model 850 is compatible with all ORTEC amplifiers and other amplifiers having a 0- to 10-V positive, linear output range.

Ordering Information

To order, specify:

Model	Description
850	Quad Single-Channel Analyzer



449/449-2 Log/Lin Ratemeter

- Linear and logarithmic modes
- 10 to 10^6 counts/s ranges
- 5-decade log range
- 0 to 100% zero suppression
- Positive or negative inputs (50 ns minimum width)
- Wide choice of time constants
- Optional audible output
- Accessory alarm capability



The ORTEC Model 449 is the same module as shown, except that it has no audio volume or threshold control.

The ORTEC Model 449 Log/Lin Ratemeter provides two modes of operation: linear and logarithmic. The linear mode has 11 full-scale ranges from 10 to 10^6 counts/s in 1-3-10 steps. The 5-decade log mode covers the range from 10 to 10^6 counts/s in a single span. These selections permit logical operation of the instrument when measuring low, medium, or high steady pulse rates or when monitoring rates that vary through a wide range.

The unique, circular front-panel meter provides excellent readability for both modes because of the longer effective scale inherent in its 240° movement and because of the 2% accuracy of its indications.

Zero suppression is provided for up to 100% of any linear range. Any relatively constant background in the counting rate can be subtracted from the data by adjusting this control. Also, a suppressed zero will permit observation of rates that are beyond the nominal full-scale limit with greater accuracy than could be obtained by switching to a higher range. The choices between 7 linear and 2 log time constants is a further aid in accurately reading the rate of incoming signals.

The Model 449 measures the rate of either positive or negative input signals with a wide variety of pulse shapes. This provides the user with maximum flexibility in the selection of sources for input signals.

In addition to the front-panel meter indications, outputs are provided for both current and voltage recorders, as well as a high-level voltage output for control or monitor applications.

The Model 449 is available with an optional built-in audible output (Model 449-2), which has a sound frequency that is variable as a function of count rate. The range of sound frequencies is effectively 0 to 500 Hz and corresponds directly to the full-scale range of the front-panel meter. The audible output includes a threshold control to totally suppress all sound until the input rate exceeds the preselected audio threshold and a separate audio volume control to

allow either local or relatively remote audible monitoring of observed rates.

For control and/or alarm applications, the Model 449 can operate an accessory ORTEC Model 461 Alarm Control or other device through its analog output.

Specifications

PERFORMANCE

LINEAR RANGES 11 ranges from 10 to 10^6 counts/s full scale in 1-3-10 steps.

Dead Time <100 ns on the 10^6 range; <0.3% of average pulse spacing up to the 3×10^4 range; $\leq 1\%$ on the 10^5 and 3×10^5 ranges.

Rated Overload Maintains full-scale output for X300 overload or 10^7 counts/s, whichever is smaller.

Temperature Instability $< \pm 0.05\%/^{\circ}\text{C}$.

Nonlinearity $\leq \pm 0.15\%$ from 10 to 3×10^4 counts/s range; $\leq \pm 1.5\%$ from 10^5 to 10^6 counts/s.

Time Constants 7 selectable time constants, 0.03 to 30 s in 1-3-10 steps.

Zero Suppression 0 to 100% of full scale; nonlinearity of $\leq \pm 0.25\%$.

LOGARITHMIC RANGE One 5-decade range for 10 to 10^6 counts/s.

Temperature Instability $\leq \pm 0.25\%$ of full scale per $^{\circ}\text{C}$.

Analog Output Error $\leq \pm 2.5\%$ of full scale.

Standard Deviation $\sim 15\%$ with Log Short time constant; $\sim 5\%$ with Log Long time constant.

Slewing Rate Dependent on input rate; for any rate change. Log Short-time constant provides 10 times faster response than Log Long-time constant.

CONTROLS

RANGE 12-position switch selects the full-scale range and either linear or logarithmic mode; linear ranges are 0 to 10 counts/s through 0 to 10^6 counts/s in 1-3-10 steps; log range is 10 to 10^6 counts/s.

TIME CONSTANT 9-position switch selects an integrating time constant of 0.03, 0.1, 0.3, 1, 3, 10, or 30 s for linear ranges from 10 to 3×10^4 counts/s or for any of these values divided by 10 for 10^5 , 3×10^5 , and 10^6 ranges; Short and Long for the log range.

ZERO SUPPRESSION 10-turn precision potentiometer to suppress the zero-reference level for any linear range from 0 to 100%; the same full-scale span is effective above the preselected zero-reference level.

INPUTS

Accepts either positive or negative input signals with amplitude $\geq \pm 3$ V and width ≥ 50 ns; ± 30 V maximum; UG-1094/U BNC connectors on both front and rear panels.

449/449-2 Log/Lin Ratemeter

OUTPUTS

PANEL METER 240° circular movement with 8.9 cm (3.5 in.) deflection; accuracy 2% of full scale; three scale markings, 0–1 and 0–3 for linear ranges and 10–10⁶ in five decades for log range.

ANALOG OUTPUT 0 to +10 V full scale, dc-coupled with 100-Ω output impedance; UG-1094/U BNC connector on rear panel.

RECORDER OUTPUT (A) Voltage output with 100-mV full scale; dc-coupled with 100-Ω output impedance; binding post connectors on rear panel.

RECORDER OUTPUT (B) Current output with 1-mA full scale; dc-coupled with 10-kΩ output impedance; binding post connectors on rear panel.

OPTION

449-2 AUDIBLE OUTPUT OPTION This option is in addition to the regular specifications of Model 449.

AUDIO OUTPUT A tone of variable frequency is furnished through a chassis-mounted speaker; the frequency increases from essentially 0 to 500 Hz, corresponding to the proportional meter deflection.

AUDIO THRESHOLD A 1-turn control mutes the audible output until the input rate exceeds the setting of the control and permits the output to be heard for all higher rates; range is 0 to 100% of selected full scale, linear, and log.

AUDIO VOLUME A 1-turn control adjusts the amplitude of the audible output from a near-inaudible level to a level that can be heard above normal laboratory ambient noise.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 50 mA; –24 V, 35 mA; +12 V, 30 mA; –12 V, 45 mA.

WEIGHT

Net 1.5 kg (3.5 lb).

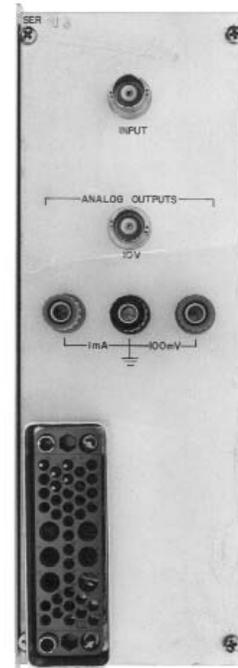
Shipping 2.5 kg (5.5 lb).

DIMENSIONS NIM-standard double-width module 6.90 X 22.13 cm (2.70 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
449	Log/Lin Ratemeter
449-2	Log/Lin Ratemeter with audible output



661 Ratemeter

- Measures counting rates up to 10^7 counts/s
- 18 full-scale meter ranges from 25 counts/s to 10^7 counts/s
- Fast, medium, and slow response selections offer <1%, <3%, or <10% standard deviation in the measurement
- Fast response circuit permits settling to 1% precision in a fraction of the normal time
- Positive and negative inputs
- Adjustable positive input discriminator
- Flexible analog output for strip chart recorders



ORTEC Model 661 Ratemeter measures the counting rate of randomly arriving pulses, or the frequency of periodic signals in the range of 0 to 10^7 counts/s (0 to 10 MHz). This range of counting rates is covered with 18 different scales. The scales are arranged in a 25, 50, 100 sequence from 25 counts/s to 10^7 counts/s full scale.

A positive input accepts and counts signals in the amplitude range of +150 mV to +10 V. The signals can be either positive unipolar pulses or bipolar pulses. With bipolar pulses, only the positive lobe will be counted. The positive input includes a discriminator whose threshold can be adjusted over the range of 150 mV to 10 V. In many cases, this eliminates the need for an external precision discriminator. Only those pulses whose amplitudes exceed the positive discriminator threshold are counted.

A negative input is provided to count NIM-standard fast negative logic pulses in the amplitude range of -600 to -1800 mV. The negative input threshold is fixed at -250 mV. Pulses as narrow as 4 ns can be counted through this input.

A front-panel switch permits selection of the ratemeter response time, which determines the random error in the measurement. Three response times are provided: FAST, MED, and SLOW. When measuring the steady-state counting rate of randomly arriving pulses, the standard deviation of the instantaneous meter reading is <1% on the SLOW response, <3% on the MED response, and <10% on the FAST response setting (Table 1).

The settling time for 1% precision on the SLOW response time can be quite long at low counting rates. To overcome this limitation, the Model 661 Ratemeter includes a special, fast response circuit. With this feature, the measurement can be started with the RESPONSE switch in the FAST position. When the meter has settled, the RESPONSE switch is moved to the MED position, and then to the SLOW setting. This technique significantly reduces the time to settle to

1% precision, since the FAST, MED, and SLOW response times are maintained in a 1:9:100 ratio.

A rear-panel ANALOG OUTPUT is included for use with strip chart recorders. The full-scale output can be selected to be 100 mV, 1 V, or 10 V. A $\pm 10\%$ fine-adjustment potentiometer is provided for the calibration of this output.

Specifications

PERFORMANCE

COUNTING RATES Measures counting rates in the range from 0 to 10 MHz (0 to 10^7 counts/s).

METER RANGES Provides 18 full-scale meter ranges from 25 counts/s to 10^7 counts/s in a 25, 50, 100 step sequence.

ANALOG OUTPUT RANGES Same as meter ranges. Full-scale output can be selected as 100 mV, 1 V, or 10 V.

PULSE-PAIR RESOLUTION <40 ns on both positive and negative inputs.

STANDARD DEVIATION The ratemeter time constants yield a standard deviation in the instantaneous meter reading of <10% for the FAST RESPONSE, <3% for the MED RESPONSE, and <1% for the SLOW RESPONSE setting, when measuring the steady-state counting rate of randomly spaced events. See Table 1 for details.

CALIBRATION ACCURACY

Meter: <2% of full scale.

Analog Output: <1% of full scale.

NONLINEARITY $\pm 0.1\%$ of full scale at the analog output.

TEMPERATURE SENSITIVITY <0.02% of full scale per $^{\circ}\text{C}$, 0 to 50°C .

CONTROLS AND INDICATORS

METER Front-panel meter provides visual reading of the counting rate. Actual value for the full-scale reading is determined by the product of the RANGE and MULTIPLIER switch settings.

RANGE Front-panel six-position switch provides the coarse selection of the full-scale counting rate. Coarse ranges of 50, 500, 5000, 50,000, 500,000, and 5,000,000 counts/s are selectable.

MULTIPLIER Front-panel three-position switch provides a fine adjustment of the full-scale value selected by the RANGE switch. The full-scale counting rate is the product of the RANGE and MULTIPLIER values. The MULTIPLIER switch selects a multiplying factor of 0.5, 1.0, or 2.0.

RESPONSE Front-panel 3-position switch selects the ratemeter response time. The three response times are also controlled by the RANGE switch to ensure standard deviations of <10% on the FAST setting, <3% on MED, and <1% on the SLOW setting. See Table 1 for details. The FAST, MED, and SLOW response times are maintained in a 1:9:100 ratio. A special circuit permits using the advantage of the shorter time constants on the FAST and MED switch positions to significantly reduce the time taken to settle to 1% precision on the SLOW position. Using this feature, the measurement is started with the RESPONSE switch in the FAST position. When the meter has settled, the RESPONSE switch is moved to the MED position. After the meter has settled again, the switch is moved to the SLOW setting. This technique provides a significantly shorter response time than would be obtained by leaving the ratemeter in the SLOW RESPONSE setting.

THRESH (Threshold) A front-panel 20-turn potentiometer provides screwdriver adjustment of the positive input discriminator threshold over the range of 150 mV to 10 V.

ANALOG OUTPUT RANGE Printed circuit board jumper, W1, allows selection of a 100-mV, 1-V, or 10-V full-scale output for the ANALOG OUTPUT.

FULL SCALE ADJ A rear-panel 20-turn potentiometer provides a $\pm 10\%$ adjustment of the full-scale output voltage for the selected range of the ANALOG OUTPUT.

INPUTS

POS IN Front- and rear-panel BNC connectors accept positive polarity inputs for counting. Input signals can be unipolar or bipolar. The ratemeter will count signals whose amplitudes are more positive than the input discriminator threshold (THRESH) setting. Linear input range is 0 to +10 V. Inputs protected to ± 25 V. Minimum pulse width above threshold is 20 ns at a 50% duty cycle. Input impedance is 1000 Ω to ground, dc-coupled.

NEG IN Front-panel BNC connector accepts NIM-standard, fast negative logic pulses with amplitudes in the range of -600 to -1800 mV. Negative input discriminator has a fixed threshold of -250 mV. Minimum pulse width at threshold is 4 ns. Input impedance is 50 Ω to ground. Input protected to ± 25 V at a 10% duty cycle.

OUTPUTS

METER 5.08-cm (2-in.) edge reading meter with a 2% meter movement.

ANALOG OUTPUT Rear-panel BNC connector provides an output voltage proportional to the measured counting rate for use with a strip chart recorder. Output is selectable for a 0 to 100 mV, 0 to 1 V, or 0 to 10 V range, using the analog output range jumper. A calibration adjustment of $\pm 10\%$ of full scale is possible with the FULL SCALE ADJ potentiometer. Output impedance is 50 Ω , with short-circuit protection. Maximum output current is 10 mA.

THRESH (Threshold) Front-panel test point adjacent to the THRESH potentiometer monitors the threshold voltage of the positive input discriminator. Test point voltage measured with a high-impedance voltmeter is 1/10 the actual threshold voltage of the positive input discriminator. Output impedance is 15,000 Ω .

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model 661 Ratemeter derives its power from a NIM bin supplying ± 12 V and ± 24 V, such as the ORTEC Model 4001A/4002A NIM Bin/Power Supply. The power required is +12 V at 95 mA, -12 V at 40 mA, and +24 V at 10 mA.

WEIGHT

Net 0.68 kg (1.5 lb).

Shipping 1.6 kg (3.5 lb).

DIMENSIONS Standard single-width NIM module, 3.43 X 22.13 cm (1.35 X 8.714 in.) front panel per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
661	Ratemeter

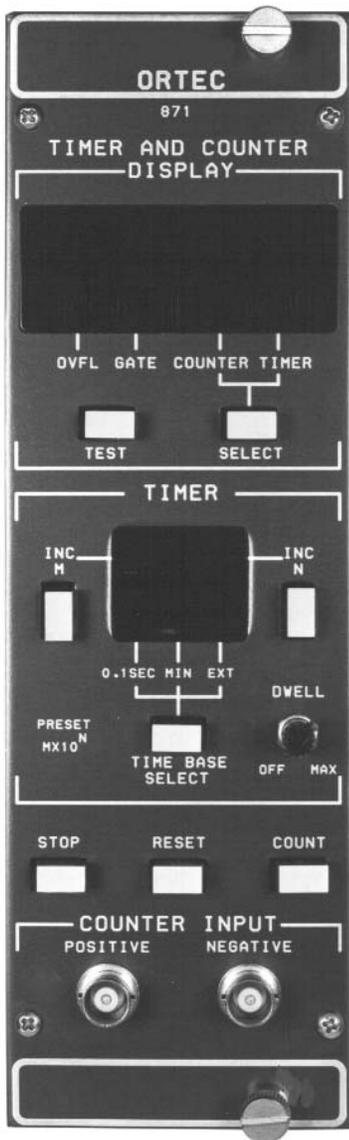
Table 1. Standard Deviation for Various Scale and Response Settings.

Full-Scale Frequency	STANDARD DEVIATION (%)		
	SLOW	MED	FAST
25 Hz	1.0	3.0	10.0
50 Hz	0.7	2.0	7.0
100 Hz	0.5	1.5	5.0
250 Hz	1.0	3.0	10.0
500 Hz	0.7	2.0	7.0
1 kHz	0.5	1.5	5.0
2.5 kHz	1.0	3.0	10.0
5 kHz	0.7	2.0	7.0
10 kHz	0.5	1.5	5.0
25 kHz	1.0	3.0	10.0
50 kHz	0.7	2.0	7.0
100 kHz	0.5	1.5	5.0
250 kHz	0.3	1.0	3.0
500 kHz	0.22	0.7	2.0
1 MHz	0.16	0.5	1.6
2.5 MHz	0.1	0.3	1.0
5 MHz	0.07	0.2	0.7
10 MHz	0.05	0.15	0.5



Timer and Counter

- 8-decade presetable timer and counter
- 25-MHz positive or negative input count rate
- Crystal-controlled time base
- Auto recycle dwell time control



The ORTEC Model 871 is a nonprinting timer and counter and may be used in any system as a counter and presetable timer, timer and presetable counter, or as two counters. Integrated and hybrid circuitry, combined with an 8-decade light-emitting diode (LED) display, give excellent operational reliability at a very economical cost. A 1-MHz crystal-controlled oscillator, which serves as the standard time base for the unit, provides substantially improved timing accuracy over timers using a line frequency time base. The 8-decade LED display is a highly legible count or time indicator, further enhanced by suppression of the leading zeros, which minimizes the possibility of errors in readout. An LED below the 8-digit display indicates if the reading is for the counter or the timer, and a push-button below the display allows the user to alternate reading the counter or the timer. LED digits are also used to indicate the presets in an $M \times 10^N$ format.

The display test is activated by pressing the front-panel Display Test switch, which illuminates all "8s," thereby providing a test for all segments of each display.

The Model 871's two sections accept NIM-standard slow positive logic signals. The counter section also accepts NIM-standard fast negative input logic pulses. The input count rate is guaranteed to 25-MHz with a 40-ns pulse pair resolution. An overflow output pulse is available from each of the counters, which indicates that the 8-decade capacity of either counter has been exceeded.

Preset is accomplished by two front-panel push-buttons labeled INC M and INC N. The displayed information includes two digital characters to indicate the current selection of the values for M and N. Any value from 0 through 9 can be selected for M, and any value from 0 through 7 can be selected for N, thus giving preset capability from 1 through 9×10^7 . The Time Base Select push-button allows the operator to choose whether the time base is set for 0.1-s intervals, 1-min intervals, or whether the time base is to be derived from an external source. A

decimal point is included in the Time Display to facilitate ease of reading directly in seconds or minutes.

For applications where a number of counts are to be preset and the time required to reach the preset count is of interest, it is possible to furnish pulses at 0.1-s intervals from the internal time base into the nonpresetable portion of the instrument and use the presetable portion as a counter.

Other applications include using the Model 871 as a ratio counter by furnishing pulses from external sources to the presetable portion as well as the nonpresetable counter and setting the preset portion for 100 to get the ratio relationship between the two external sources.

The Dwell control can be rotated to select a delay of <1 s to about 15 s following a preset condition. During the delay period, the contents of the counter can be read. At the end of the dwell interval, the instrument is reset and another counting interval is started immediately.

Specifications

PERFORMANCE

COUNT CAPACITY Eight decades in each of the two sections.

COUNTING RATE 25 MHz guaranteed, both sections.

TIME BASE 0.1-s and 1-min increments derived from a 1-MHz crystal-controlled oscillator; instability $<\pm 2$ ppm/ $^{\circ}\text{C}$, 0 to 50 $^{\circ}\text{C}$; inaccuracy $<\pm 5$ ppm; time base register controlled by counting gate.

PULSE PAIR RESOLUTION 40 ns minimum.

AUTOMATIC RESET Generated when power is applied.

INDICATORS AND CONTROLS

COUNTER/TIMER DISPLAY 8 characters, 7-segment LED per character, plus decimal point.

TIMER PRESET 2 characters, 7-segment LED per character.

GATE LED illuminates when the unit is in the counting condition.

OVFL LED illuminates from the first overflow of the counter or timer that is currently being displayed.

COUNTER LED illuminates when counter data are being displayed.

TIMER LED illuminates when timer data are being displayed.

0.1 SEC LED illuminates when the time base is 0.1 second.

MIN LED illuminates when the time base is 1 minute.

EXT LED illuminates when the timer section counts pulses that are input through a rear-panel connector.

TEST Push-button switch illuminates all 7 segments in each of the 10 digital characters in the displays; a character reads 8 when the push-button is pressed.

SELECT Push-button switch in the Display portion of the front panel permits alternate selection of the register whose counts are displayed, either Counter or Timer.

INC M Push-button used to select the significant digit of a preset value where preset = $M \times 10^N \times \text{Time Base}$. This switch increments the value of M, indicated in the adjacent display, each time it is pressed. M = 0 is preset Off; M = 9 is maximum value.

INC N Push-button used to select the power of 10 for the value of N in the preset formula. This switch increments the value of N, as indicated in the adjacent display, each time it is pressed. N can be any digit, 0 through 7.

TIME BASE SELECT Push-button switch in the Timer portion of the front panel permits selection of the source of counts for the timer portion of the instrument and selection of the source of output through the rear-panel Time Base connector; selection of the three possible choices is made when this switch is pressed.

DWELL Single-turn control with switch at full counterclockwise setting for Off. Off inhibits recycled operation of a preset counting interval. With the control turned clockwise, recycling is permitted with a dwell time between counting intervals that can be adjusted from about 0.3 to 15 s.

STOP Push-button switch stops counting in both portions of the instrument.

RESET Push-button switch resets the internal registers for both counting portions of the instrument and for the time base register, and turns off the OVFL indicator.

COUNT Push-button switch enables counting conditions for both portions of the instrument, provided the timer is not at its preset level and the Gate input is not held below +1.5 V.

INPUTS

COUNTER POSITIVE Front- and rear-panel BNC connectors; either accepts positive unipolar or bipolar signals to ± 10 V linear, ± 25 V maximum; threshold set at +1.5 V; minimum pulse width above threshold 20 ns. $Z_{in} = 1$ k Ω to ground, dc-coupled.

COUNTER NEGATIVE Front-panel BNC connector accepts NIM-standard fast negative logic pulses, 16 mA into 50 Ω ; threshold set at -250 mV; minimum pulse width over threshold 4 ns; input protected to ± 25 V at 10% duty cycle.

EXT TIMER Rear-panel BNC connector; accepts positive unipolar or bipolar signals to ± 10 V linear, ± 25 V maximum, and counts these pulses in the timer portion of the instrument if the Time Base Select is set at EXT; threshold set at +1.5 V; minimum pulse width above threshold 20 ns. $Z_{in} = 1$ k Ω to ground, dc-coupled. When using the Ext Timer input and Preset operation, the minimum setting is M = 1 and N = 1 for 25-MHz operation.

GATE Rear-panel BNC accepts NIM-standard slow positive logic or dc level to control the input gate for both counting sections; $> +3$ V or open circuit allows counting; $< +1.5$ V inhibits counting; 25 V maximum; driving source must be capable of sinking 0.5 mA positive current during inhibit.

COUNT Rear-panel BNC accepts NIM-standard slow positive logic signal to remotely initiate a counting condition; $> +3$ V for > 100 ns to start the counting condition; 25 V maximum. $Z_{in} = 6$ k Ω to ground, dc-coupled.

RESET Rear-panel BNC accepts NIM-standard slow positive logic signals to remotely reset both counting sections and the time base register to zero; $> +3$ V to reset; $< +1.5$ V or open to not reset; 25 V maximum; pulse width > 100 ns. $Z_{in} = 6$ k Ω to ground, dc-coupled.

OUTPUTS

Note: All outputs are through rear-panel BNC connectors and are short-circuit protected.

END OF PRESET Provides a NIM-standard slow positive logic pulse at the end of each preset interval; nominally +5 V, 5 μ s wide, through < 10 Ω , dc-coupled.

END OF DWELL Provides a NIM-standard slow positive logic pulse at the end of each dwell interval; nominally +5 V, 500 ns wide, through < 10 Ω , dc-coupled.

INTERVAL Provides a positive level signal through the duration of each counting condition interval; nominally +5 V through < 30 Ω , dc-coupled.

TIME BASE Provides NIM-standard slow positive logic pulses at intervals that are determined by the Time Base Select function on the front panel. For 0.1 SEC or MIN selections, the signals through the connector are the same as those that are furnished to the Timer section, and these are present only when the Gate input is not held below +1.5 V and the preset condition has not been reached. For the EXT selection, the signals through the rear panel connector are at 0.1-s intervals and are furnished from a free-running oscillator and countdown circuit. Nominally +5 V, 500 ns wide, through < 10 Ω , dc-coupled.

TIMER OVERFLOW Provides a NIM-standard slow positive logic pulse at each overflow of the Timer section from 99,999,999 to 0. Nominally +5 V, 500 ns wide, through < 10 Ω , dc-coupled.

COUNTER OVERFLOW Provides a NIM-standard slow positive logic pulse at each overflow of the Counter section from 99,999,999 to 0. Nominally +5 V, 500 ns wide, through < 10 Ω , dc-coupled.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 280 mA; -12 V, 117 mA; +24 V, 161 mA; 110 V, 40 mA.

WEIGHT

Net 1.5 kg (3.5 lb).

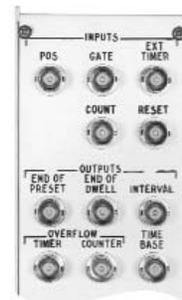
Shipping 2.7 kg (6.0 lb).

DIMENSIONS NIM-standard double-width module, 6.90 X 22.13 cm (2.70 X 8.714 in.) front panel, per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
871	Timer and Counter (nonprinting)



974 CCNIM™ Quad 100-MHz Counter/Timer

- Four 8-decade counters with full computer control and readout (CCNIM™)
- One counter that can function as a presettable timer or counter
- One counter can function as a timer
- 100-MHz negative or 25-MHz positive input count rate
- RS-232-C and IEEE-488 interfaces
- Crystal-controlled time base
- Auto Recycle dwell time control



The ORTEC Model 974 is a four-channel, 100-MHz Counter/Timer in a CCNIM™ (computer-controlled NIM) package. It can be computer-controlled or manually operated. The Model 974 may be used as a three-channel counter with one presettable timer, a four-channel counter (one counter channel presettable), or as a three-channel counter (one counter channel presettable) with one timer. Any one of the four 100-MHz counter/timer channels can be monitored on the large, 8-decade LED display. In addition to the four 100-MHz channels, the Model 974 incorporates an 8-decade, presettable Event counter that can only be controlled or read through one of the computer interfaces.

Standard computer interfaces built in to the Model 974 include the IEEE-488, RS-232-C, and 20-mA loop. The command format (Table 1) adheres to the Standard NIM Digital Bus,* an easy-to-use language for programming NIM instruments. All front-panel functions (with the exception of Display Test) may be remotely controlled via a computer or dumb-terminal. In addition, several functions not accessible via the front panel are accessible with computer interfaces. The front panel may be locked out by the ENABLE_REMOTE command from a terminal or computer.

The input polarity to each of the four counting channels may be independently set using internal connectors. The maximum count rate for negative signals is 100 MHz; the maximum count rate for positive signals is 25 MHz. Each counting channel can be independently, externally gated through the Gate 1, 2, 3, and 4 inputs. All four counting channels may be simultaneously, externally gated through the Master Gate input.

The architecture of the ORTEC Model 974 Quad 100-MHz Counter/Timer (Fig. 1) is designed for maximum flexibility. Counter channel 1 acts as the gate controller for counter channels 1, 2, 3, and 4. When counting is started, the input gates to counting channels 1, 2, 3,

and 4 are opened. When the accumulated counts in counting channel 1 equal the selected preset value (selected and displayed on the front panel), the counting interval is terminated and the input gates to counting channels 1, 2, 3, and 4 are closed. If the Dwell control is turned fully counter-clockwise to the Off position, no new counting cycle will be initiated. If, however, the Dwell control is set for a chosen dwell time, a new counting cycle will be automatically initiated after the end of the chosen dwell time and automatic reset. Since the input to counting channel 1 can be selected as the internal 0.1-second time base, the internal 1-minute time base, or an external source, channel 1 can act as a presettable timer or a pre-settable counter.

The Event counter, which is accessible only through one of the computer interfaces, is primarily intended as a means of labeling printouts or listings of counting cycles. After the Model 974 receives an ENABLE_EVENT_AUTO command, the Event counter will increment one count at the end of each preset counting interval. The contents of the Event counter, along with the contents of each of the four 100-MHz counting channels, are output during the implementation of a SHOW_COUNTS command. This results in an integer labeling of the counting cycle printout. The Event counter may be used alternately as a counter of external pulses by using the ENABLE_EVENT_EXTERNAL command. The maximum count rate input to the Event counter must be <4 kHz; its capacity is 8 decades. The ENABLE_EVENT_PRESET command allows the Event counter to control the total number of counting cycles in a given counting run. After an Event preset value is set via computer interface, the Event counter will allow continuous counter interval recycling until the accumulated value equals the preset value. The complete command file of the Model 974 is shown in Table 1.

*Please refer to "Standard NIM Digital Bus (NIM/488)," DOE/ER-0457T, U.S. NIM committee, May 1990; Standard NIM Instrumentation System, NTIS, U.S. Department of Commerce, Springfield, Virginia 22161.

Quad 100-MHz Counter/Timer

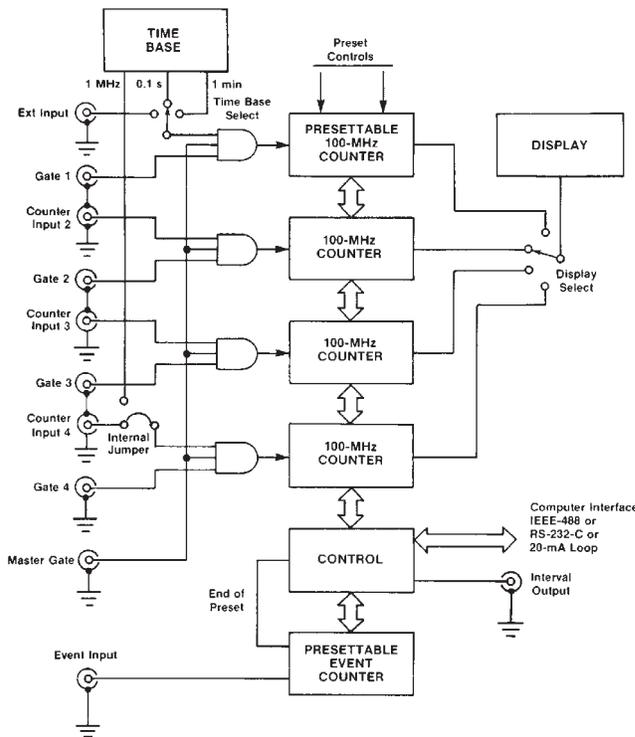


Fig. 1. ORTEC Model 974 Counter/Timer Architecture.

Table 1. Model 974 Standard NIM Digital Bus Commands.

CLEAR_ALL	SET_MODE_EXTERNAL
CLEAR_COUNTERS <MASK>	SET_MODE_MINUTES
CLEAR_COUNT_PRESET	SET_MODE_SECONDS
CLEAR_EVENT_PRESET	SET_DISPLAY <VALUE>
COMPUTER	SHOW_ALARM
DISABLE_ALARM	SHOW_COUNTS <MASK>
DISABLE_EVENT	SHOW_COUNT_PRESET
DISABLE_EVENT_PRESET	SHOW_DISPLAY
DISABLE_TRIGGER_START	SHOW_EVENT
DISABLE_TRIGGER_STOP	SHOW_EVENT_PRESET
ENABLE_ALARM	SHOW_MODE
ENABLE_EVENT_AUTO	SHOW_RADIX
ENABLE_EVENT_EXTERNAL	SHOW_VERSION
ENABLE_EVENT_PRESET	INIT
ENABLE_LOCAL	SET_RADIX_BINARY
ENABLE_REMOTE	SET_RADIX_DECIMAL
ENABLE_TRIGGER_START	START
ENABLE_TRIGGER_STOP	STOP
SET_COUNT_PRESET M,N	TERMINAL
SET_EVENT_PRESET <VALUE>	TEST NUMBER

Specifications

PERFORMANCE

COUNT CAPACITY 8 decades, all sections.

COUNTING RATE 100 MHz for negative inputs, all sections; 25 MHz for positive inputs, all sections.

TIME BASE 0.1-second or 1-minute increments derived from an internal 1-MHz crystal-controlled oscillator. Also accepts external input through rear-panel BNC labeled Ext In. Selectable from front panel or through computer control.

PULSE PAIR RESOLUTION 10 ns for negative inputs, 40 ns for positive inputs.

INDICATORS

COUNTER DISPLAY 8 characters, 7 LED segments per character plus decimal point.

TIMER PRESET 2 characters, 7 LED segments per character. Presettable from front panel or through computer control. Displayed in an $M \times 10^n$ format.

DISPLAYED COUNTER Single-digit display indicates which counter channel is being displayed.

CONTROL 2 LEDs indicating either Remote mode operation (front-panel controls locked out) or Local mode operation (front-panel controls operative).

0.1 SEC Single LED illuminates when the 0.1-second time base is selected.

1 MIN Single LED illuminates when 1-minute time base is selected.

EXT Single LED illuminates when Ext time base is selected or when using counter channel 1 as a counter.

COUNTER OVERFLOW 1, 2, 3, AND 4 Four separate LEDs illuminate when the corresponding counting channel exceeds the capacity of the counting channel.

GATE Single LED illuminates during an active counting interval.

CONTROLS

DISPLAY TEST Push-button switch illuminates all segments of every 7-segment display.

RESET Push-button switch resets the internal counting channels to zero and turns Off the overflow indicators.

STOP Push-button switch selects the noncounting condition for all counting channels.

COUNT Push-button switch enables the counting condition for all counting channels provided the Gate input is not held below +1.5 V and the time is not at the preset count condition.

DISPLAY SELECT Push-button switch selects the counting channel whose contents will be displayed.

DWELL TIME Single-turn control with a switch at the full counterclockwise setting for Off. Off inhibits recycle operation of a preset counting interval. When the control is turned clockwise away from Off, it permits recycling with a dwell time between counting intervals that can be adjusted from 0.3 s to ~15 s. This control is disabled when computer control is in effect.

Quad 100-MHz Counter/Timer

M Push-button switch used to set the timer preset value. The "M" preset value [preset = (M X 10ⁿ) time base] is incremented each time the button is pressed. Maximum value = 9.

N Push-button switch used to set the timer "N" preset value. The N preset value is incremented each time the button is pressed. Maximum value = 7.

TIME BASE SELECT Push button used to select the internal time base of 0.1 Sec or 1 Min or the Ext In rear-panel input for external time base.

IEEE CONTROL SWITCH (S-1) An 8-position slide switch accessible through cutout in left side panel. Sections 1 through 5 select the talk and listen address to which the Model 974 responds on the IEEE-488 bus. Section 6 selects the recycle/one-cycle mode. In recycle, a reset is automatically generated after the counter contents are transferred to a buffer. In one-cycle, a reset must be generated by an external command. Section 7 is not used. Section 8 selects the interface that will be used to communicate with the computer or terminal. "On" selects RS-232-C; "Off" selects the IEEE-488 interface.

SERIAL INTERFACE CONTROL (S-2) An 8-position slide switch accessible through a cutout in the left side panel. Sections 1 through 4 select the counting channels whose contents will be transmitted when data is transferred to the computer or terminal. If the corresponding switch is set for print, the data for that counting channel will be transmitted; if set to the skip position, the data will not be transmitted. Section 5 selects the length of the data byte that will be transmitted over the serial communications interface. "On" selects 7 data bits; "Off" selects 8 data bits. Section 6 is used to enable or disable the parity generation and checking when characters are sent or received over the serial interface. If parity is enabled, Section 7 selects either odd or even parity mode. Section 8 selects whether one or two stop bits are added to the character transmitted over the serial interface.

BAUD RATE SELECT (S-3) A 4-position slide switch accessible through a cutout in the left side panel. This switch selects the baud rate at which characters are transmitted and received over the serial communications interface.

INPUTS

COUNTERS 2, 3, AND 4 Front-panel BNC connectors accept positive unipolar signals; minimum pulse width above threshold, 20 ns at 50% duty cycle. $Z_{in} = 1 \text{ k}\Omega$ to ground. Threshold is fixed at +1.5 V. Input protected to +25 V, dc-coupled.

Changing the input connector to the counter board permits independent selection of NIM-standard fast negative logic pulses, 14 mA into 50 Ω . Minimum pulse width above threshold is 4 ns. Input is dc-coupled, 250-mV fixed threshold.

COUNTER 1 OR EXT Rear-panel BNC connector accepts NIM-standard positive unipolar signals; minimum pulse width above threshold, 20 ns at 50% duty cycle. $Z_{in} = 1 \text{ k}\Omega$ to ground. Threshold is fixed at +1.5 V. Input protected to +25 V, dc-coupled.

Changing the input connector to the negative input permits selection of NIM-standard negative logic pulses, 14 mA into 50 Ω . Minimum pulse width above threshold is 4 ns; threshold fixed at -250 mV; input is dc-coupled.

MASTER GATE Rear-panel BNC connector accepts NIM-standard positive logic signal to control counter input gate for all counting sections and the front-panel count LED indicator. A signal >+3 V or open circuit allows counting; a level of <+1.5 V inhibits counting. Protected to +25 V. Driving source must be capable of sinking 0.5 mA positive current during inhibit.

GATES 1, 2, 3, AND 4 Rear-panel BNC connectors accept NIM-standard positive logic signal to control individual counting channel inputs. A signal >+3 V or open circuit allows counting; 25 V maximum. A level of <+1.5 V inhibits counting. Driving source must be capable of sinking 0.5 mA of positive current during inhibit.

EVENT Rear-panel BNC connector accepts standard positive logic pulse to increment the event counter. Signal must exceed a level of +2.5 V for a period of >100 ns to increment the event counter. Maximum frequency of input signal is 4 kHz.

RESET Rear-panel BNC connector accepts standard positive logic pulse to remotely reset all counting sections to zero. A signal of >+3 V is needed to reset; a signal of <+1.5 V or open circuit is required to not reset. Protected to +25 V; minimum pulse width is 100 ns; $Z_{in} = 6 \text{ k}\Omega$ to ground, dc-coupled.

OUTPUT

INTERVAL Rear-panel BNC connector furnishes a positive level during the counting interval. Nominally +5 V; $Z_o = 30 \Omega$.

INTERFACES

IEEE-488 24-pin, rear-panel-mounted standard IEEE-488 bus connector.

SERIAL RS-232-C or 20-mA current loop signal on a single, 25-pin rear-panel-mounted connector.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +6 V, 1.6 A; +12 V, 70 mA; -12 V, 290 mA.

WEIGHT

Net 2.4 kg (5.2 lb).

Shipping 3.7 kg (8.2 lb).

DIMENSIONS NIM-standard double-width module 6.90 X 22.13 cm (2.70 X 8.714 in.) front panel per DOE/ER-0457T.

Ordering Information

To order, specify:

Model Description

974 Quad 100-MHz Counter/Timer

OPTIONAL CABLE ASSEMBLIES

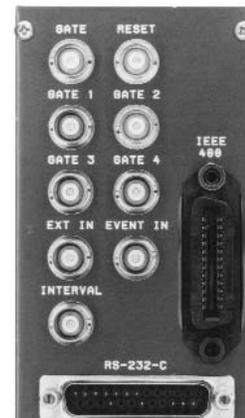
Model Description

C-75 Female-to-female RS-232-C null modem cable (3-meter length)

C-80 Male-to-female RS-232-C extension cable (3-meter length)

C-488-2 IEEE-488 interface cable (2-meter length)

C-488-4 IEEE-488 interface cable (4-meter length)



Dual Counter and Timer

The ORTEC Model 994 Dual Counter and Timer incorporates two eight-decade counters and a blind preset timer. Considerable functional flexibility is designed into the instrument, allowing it to be configured for a variety of measurement tasks. Typically, it can be used as two counters recording separate events under the control of the preset blind timer. When continuous readout of the time is needed, Counter A can be diverted to count the time while Counter B records external events. This provides the function of a counter and a displayed preset timer. In some applications, the time taken to count a preset number of events must be measured. For this application, Counter A, coupled with the preset blind counter, can be used as a preset counter while Counter B records the time in 0.01-second intervals. In measurements where it is important to correct for the dead time of the detector and its associated electronics, the Gate A input can be switched to also gate the time clock On and Off with a 100-ns time resolution. A positive logic signal that defines the system live time is connected to the Gate A input. This configuration provides a live-time clock (Counter A) and a counter (B).

Excellent flexibility in setting the preset value is offered by the $MN \times 10^P$ selection. The M and N values provide two-digit precision, while P selects the decade. Presets can be chosen in the ranges of 0.01 to 990,000 seconds, 0.01 to 990,000 minutes, or 1 to 99,000,000 counts.

The basic Model 994 includes an 8-decade LED display that offers instantaneous visual readout of the full contents of Counter A or B, even in a dimly lighted room. By adding field-installable options, considerably enhanced readout and control capabilities can be incorporated.

The full power of CCNIM (Computer-Controlled NIM) can be obtained by adding the IEEE-488 option or the RS-232-C option. These plug-in boards allow computer control of all functions normally selectable from the front panel, including start and stop count, readout, reset, setting the preset value, selecting

- **Two 8-decade counters and a timer with the configuration flexibility to serve a variety of measurement needs**
- **IEEE-488 and RS-232-C options provide CCNIM capability with full computer control and readout**
- **Can directly drive printers having RS-232-C or IEEE-488 ports**
- **An 8-decade LED display provides instantaneous readout of the entire counter capacity, even in dimly lighted rooms**
- **All commonly used controls are easily accessible on the front panel**
- **100-MHz counting rate capability**
- **Preset time or counts set with the precision of a two-digit and decade selection**
- **All options are field-installable**

the displayed counter, and selecting the desired time base. To eliminate accidental operator interference, the computer can disable all front-panel controls in the Remote mode. Computer readout with either of the two CCNIM options includes A and B counts, the preset value, and which counter is being displayed. The IEEE-488 option also reads the overflow status for both counters. Implementation of the IEEE-488 interface in the Model 994 is compatible with the Standard NIM Digital Bus.* The CCNIM options can directly drive printers having RS-232-C or IEEE-488 ports.

The inputs to Counters A and B are individually selectable as either positive or negative sensing inputs by changing the Input Polarity Jumpers on the counter printed wiring board (PWB). The negative input mode is designed to accept NIM-standard, fast-negative logic pulses with a fixed threshold of -250 mV on a $50\text{-}\Omega$ input impedance. The negative inputs can handle counting rates up to 100 MHz. The positive input mode can accept counting rates up to 25 MHz on a $1000\text{-}\Omega$ input impedance. To enhance the flexibility of the positive input mode, precision discriminators are included on both counters. The discriminator thresholds are variable over the range from $+100$ mV to $+9.5$ V using

*Please refer to "Standard NIM Digital Bus (NIM/488)," DOE/ER-0457T, U.S. NIM committee, May 1990; Standard NIM Instrumentation System, NTIS, U.S. Department of Commerce, Springfield, Virginia 22161.



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front-panel, 25-turn trimpots. The thresholds can be adjusted to suit the amplitude of a specific source of logic pulses or used as precision integral discriminators on analog pulses. For the latter application, the TTL logic outputs of the discriminators are provided as test points on the front panel. These outputs can be used to trigger an oscilloscope while viewing the analog signal at the counter input on the oscilloscope. The oscilloscope trace will show the signals that are being counted by the Model 994, thus permitting a very selective adjustment of the threshold.

All the commonly used functions are conveniently accessible on the front panel. Manual control of the Count, Stop, and Reset functions is via three push-buttons. The Gate LED is illuminated when the Model 994 is enabled to count. Selection of the 0.01 second, 0.01 minute, or external time base is made by the Time Base push-button. In the external mode, the preset counter counts the events at the counter A input. The Display push-button switches the display to show the contents of Counter A, the preset stop value, or the contents of Counter B. To change the preset value, the Preset mode must first be selected with the Display push-button. Subsequently, the Preset Select push-button is used to choose M, N, or P for adjustment. Changing the value of M, N, or P is accomplished with the Preset Advance push-button. The display contains LED flags to indicate whether M, N, or P has been selected, to warn when overflows have occurred in Counter A or Counter B, and to advise when the front-panel controls are disabled by the computer in the Remote mode. When the Model 994 is used in the automatic recycle mode, the Dwell knob adjusts the dwell time of the display from 1 to 10 seconds.

The counting function of the entire module can be disabled by holding the Enable input below +1.5 V using an external signal source. This condition also turns Off the Gate LED. Open circuit or $>+3$ V at the Enable input allows the instrument to count, if the Count mode has been activated. The

Interval output of another ORTEC timer can perform this function to synchronize the Model 994 counting with the other timer. The Interval outputs on all ORTEC timers provide nominally +5 V when counting and $<+0.5$ V when counting is inhibited.

Independent gating of the A and B Counter inputs can be achieved with the Gate A and Gate B inputs on the rear panel. Interface connectors for the IEEE-488, RS-232-C, and print loop options are also located on the rear panel. Each counter has a rear-panel output dedicated to signaling overflows. Counting these overflows on another counter extends the counting capacity of the Model 994.

The Model 994 derives its power from the ± 12 V and +6 V supplies in a standard NIM bin with power supply. For bins that do not contain a +6 V supply, an Internal +6 V Supply option is available. This option is field-installable and derives its power from the 117 V ac lines in the bin.

Specifications

PERFORMANCE

COUNT CAPACITY 8 decades for counts ranging from 0 to 99,999,999 in each of 2 counters.

MAXIMUM COUNTING RATE 100 MHz for negative inputs, 25 MHz for positive inputs.

TIME BASE 10-MHz clock with minimum preset or displayed intervals of 0.01 seconds or 0.01 minutes. Synchronizing error is nominally 100 ns. Also accepts an external input from the Counter A input (In A) when the Ext (External) mode is selected.

TIME BASE INACCURACY $\leq \pm 0.0025\%$ over the 0 to 50°C operating temperature range.

PRESET TIME/COUNTS The module stops counting when the preset value $MN \times 10^P$ is reached on the blind preset register. M and N are digits ranging from 0 to 6. With the 0.01-second time base, preset times from 0.01 to 990,000 seconds can be used. Preset times from 0.01 to 990,000 minutes are available using the 0.01-minute time base. In the Ext time base mode preset counts in the range of 1 to 99,000,000 can be used.

POSITIVE INPUT DISCRIMINATOR

Threshold variable from +100 mV to +9.5 V with a 25-turn trimpot.

PULSE PAIR RESOLUTION <10 ns for negative inputs; <40 ns for positive inputs.

INDICATORS

COUNTER DISPLAY 8-digit, 7-segment LED display with leading zero suppression. When displaying time, 2 digits to the right of a decimal point are included.

OVERFLOW INDICATORS LED indicators labeled OVFL A and OVFL B illuminate when the corresponding A or B Counter exceeds its capacity of 8 decades. The indicator remains on until a reset is generated.

M, N, AND P INDICATORS 3 LED indicators aid in the selection of the preset value. When the Preset display function is activated, the Select push-button selects which of the 3 LEDs is illuminated. When one of these LEDs is On, that digit of the preset value can be incremented using the Advance push-button.

DISPLAY 3 LEDs labeled A, B, and Preset indicate the information being displayed in the counter display. Counter A, Counter B, or the Preset value may be displayed by repeatedly pressing the Display push-button until the desired LED is illuminated.

TIME BASE 3 LEDs indicate the selected time base source. By repeatedly pressing the Time Base push-button, 0.01 Sec, 0.01 Min, or the Ext mode can be chosen.

GATE A single LED indicates that the entire instrument is enabled to count. For the Gate



LED to be illuminated, the module must be placed in the Count mode (either manually or via the interface option), the Enable input must be above +3 V, and the preset stop condition must not have been reached.

REMOTE A single LED labeled REM indicates that the Model 994 is under computer control, and all front-panel controls are disabled. This mode is set by the ENABLE_REMOTE command.

CONTROLS

DISPLAY Push-button selects the contents of Counter A or B, or the Preset value for presentation in the 8-decade display. Repeatedly pushing the button cycles the selection through the three choices as indicated by the A, B, and Preset LEDs.

SELECT Push-button chooses the M, N, or P digit in the display of the preset value. Pushing the button advances the selection through the three choices as indicated by the illuminated LED. The Select push-button operates only if the Preset mode has been selected by the Display push button.

ADVANCE Push-button increments the preset digit selected by the Select push-button once each time the Advance button is depressed. The M and N digit ranges are both 0 to 9. The P digit range is from 0 to 6. The Advance push-button operates only if the Preset mode has been selected by the Display push-button.

TIME BASE Each push on this button advances the selection one step through the three time base choices of 0.01 Sec, 0.01 Min, and Ext to determine the time base source for the preset register.

STOP This push-button stops all sections of the instrument from counting.

RESET Depressing this button resets both counters to zero counts and turns Off both overflow indicators. It also clears any counts accumulated in the blind preset counter, but does not change the selected preset value. When power is turned On to the Module, a Reset is automatically generated.

COUNT Pushing this button enables the counting condition for the entire instrument, providing the Enable input is not held below +1.5 V and the preset value has not been reached.

THRESH ADJUST (A and B) Front-panel mounted, 25-turn trim pots to adjust the positive input thresholds for Counters A and B. The range is from +100 mV to +9.5 V. Adjacent test points provide the TTL logic signal outputs from the discriminators to facilitate adjustment using an oscilloscope.

DWELL A one-turn potentiometer on the front panel with an On/Off switch at the fully counterclockwise position. Adjusts the display dwell time over the nominal range from 1 to 10 seconds. When the instrument is in the Recycle mode, dwell time occurs after the preset value has been reached. Turning the switch Off at the fully counterclockwise position selects the Single Cycle mode. If the print loop option is used, the Dwell control is disabled when the print loop controller is active and controlling the dwell time.

INPUT POLARITY JUMPERS Two jumpers located on the printed wiring board (PWB) separately select the desired input polarities for inputs In A and In B. P = positive, N = negative.

A COUNTER/TIMER JUMPER Two-position jumper located on the PWB. In the Counter position, Counter A always counts and displays the events connected to In A. When set to the Timer position, Counter A counts and displays the time if either the 0.01-Sec or the 0.01-Min time base is selected. If the Ext time base is selected, Counter A will count and display the events from In A.

B COUNTER/TIMER JUMPER Two-position jumper located on the PWB. In the Counter position, Counter B always counts and displays the events from In B. In the Timer position with the Ext time base selected, Counter B counts and displays the time in 0.01-second intervals. With either a 0.01-Sec or 0.01-Min time base selected, Counter B counts and displays the events from In B.

GATE A (LIVE TIME/NORMAL) JUMPER Two-position jumper mounted on the PWB. In the Normal position, the signals from the rear-panel Gate A connector gate the events from the In A connector. In the Live Time position, the signals from the Gate A connector gate the 10-MHz clock to form a live-time clock.

1 CYCLE/RECYCLE Selection of either the 1 Cycle or the Recycle mode can be made via an 8-pin DIP switch on the IEEE-488 and the RS-232-C interface boards. The Recycle mode can be used when the computer is able to respond with a data transfer when the Model 994 reaches the preset value. Upon reaching preset, the Model 994 latches its data into a buffer, resets the counters, and starts the next counting interval. This process takes ~50 μ s. The computer reads the data in the buffer before the next counting interval ends. In the 1 Cycle mode, the Model 994 simply stops counting and waits for further commands when the preset value is reached.

INPUTS

IN A Use of this input is affected by the A Counter/Timer Jumper.

Positive Input Front-panel BNC connector for Counter A accepts positive unipolar signals; minimum width above threshold, 20 ns at a 50% duty cycle. The threshold is adjustable from +100 mV to +9.5 V via a front-panel 25-turn trim pot. $Z_{in} = 1000 \Omega$ to ground; dc-coupled.

Negative Input Changing the Input Polarity Jumper position on the counter board permits selection of the NIM-standard fast-negative logic input which is designed to accept -600 to -1800 mV pulses with a fixed discriminator threshold of -250 mV. $Z_{in} = 50 \Omega$; dc-coupled. Minimum pulse width above threshold is 4 ns.

IN B Identical to In A except that it feeds Counter B. Use of this input is affected by the B Counter/Timer Jumper.

ENABLE Front-panel BNC input connector accepts NIM-standard, slow-positive logic pulses to control the counting condition of the entire module. A level of >+3 V or open circuit allows counting provided the instrument is in the Count mode and has not reached the preset value; <+1.5 V inhibits counting. The driving source must be capable of sinking 5 mA of positive current during inhibit; input protected to +25 V.

GATE A Rear-panel BNC input connector is identical to the Gate B input with the following exception. With the Gate A jumper on the PWB set to the Normal position, the Gate A input controls counting of the In A events in Counter A. By moving the PWB Gate A jumper to the Live Time position, the Gate A input also controls the 10-MHz clock to form a live-time clock with a 100-ns resolution. A level >+3 V or an open circuit allows counting of the clock. A level <+1.5 V is used to inhibit counting of the clock during dead-time intervals.

GATE B Rear-panel BNC connector accepts NIM-standard, slow-positive logic signals to control the counting in Counter B. A level >+3 V or open circuit allows counting; <+1.5 V inhibits counting; input protected to +25 V. The driving source must be capable of sinking 5 mA of positive current during inhibit.

OUTPUTS

INTERVAL Front-panel output BNC connector furnishes a positive level during the counting interval. The level is nominally +5 V when counting is enabled and <+0.5 V when counting is disabled. $Z_o \sim 30 \Omega$.

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OVFL A Rear-panel output BNC connector provides a NIM-standard, slow-positive logic signal each time Counter A overflows its 8-decade capacity. The signal has a nominal amplitude of +5 V; width ~20 μ s.

OVFL B Rear-panel output identical to OVFL A except it monitors overflows from Counter B.

INTERFACES

IEEE-488 When the IEEE-488 option board is plugged in, it furnishes a rear-panel, standard, IEEE-488 bus connector. This 24-pin, AMP CHAMP™ female connector allows the Model 994 to be controlled from a computer via the IEEE-488 bus. The field-installable option provides computer control of the following functions: Count, Stop, Reset, Remote, setting the preset value, selecting the displayed counter, and selecting the desired time base. In the Remote mode, the computer can disable all front-panel controls. Computer readout includes: A and B counts, the preset value, which counter is being displayed, and the overflow status for both counters.

SERIAL When the RS-232-C option board is plugged in, it furnishes a rear-panel, 25-pin, male, D connector containing all signals for standard RS-232-C communications. It also contains connections for 20-mA current loop communications. The field-installable RS-232-C option provides computer control of the following functions: Count, Stop, Reset, Remote, setting the preset value, selecting the displayed counter, and selecting the desired time base. In the Remote mode, the computer can disable all front-panel controls. Computer readout includes: A and B counts, the preset value, and which counter is being displayed.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The basic Model 994 derives its power from a NIM bin furnishing ± 12 V and +6 V. For NIM bins that do not provide +6 V, an optional Internal +6 V Supply is available. This option is field-installable and draws its power from the 117 V ac lines in the bin. With the Internal +6 V Supply installed, the power requirements are shown in column 4 and not required in column 3.

	+12 V	-12 V	Bin Supplied +6 V	Internal +6 V Supply 117 V ac
Basic Model 994	35 mA	115 mA	1300 mA	110 mA
Model 994 plus IEEE-488 option	45 mA	120 mA	1800 mA	145 mA
Model 994 plus RS-232-C option	54 mA	130 mA	1800 mA	145 mA

WEIGHT

Net 2.4 kg (5.2 lb).

Shipping 3.7 kg (8.2 lb).

DIMENSIONS NIM-standard double-width module, 6.90 X 22.13 cm (2.70 X 8.714 in.) front panel per DOE/ER-0457T.

Ordering Information

NOTE: Both interface option boards use the same position in the module. Only one can be plugged in at a given time. To order, specify:

Model	Description
994	Basic module without plug-in options.
99X-1	RS-232-C Interface option (cable not included).
99X-2	IEEE-488 Interface option (cable not included).
99X-4	Internal +6 V Supply option.
C-75	Female-to-female RS-232-C null modem cable (3-meter length).
C-80	Male-to-female RS-232-C extension cable (3-meter length).
C-488-2	IEEE-488 interface cable (2-meter length).
C-488-4	IEEE-488 interface cable (4-meter length).

The ORTEC Model 995 Dual Counter incorporates two 8-decade counters and an 8-decade LED display that offers instantaneous visual readout of the full contents of Counter A or B, even in a dimly lighted room. By adding field-installable options, considerably enhanced readout and control capabilities can be incorporated.

The full power of CCNIM™ (Computer-Controlled NIM) can be obtained by adding the IEEE-488 option or the RS-232-C option. These plug-in boards yield computer control of all functions normally selectable from the front panel, including start and stop count, readout, reset, and selecting the displayed counter. To eliminate accidental operator interference, the computer can disable all front-panel controls in the Remote mode. Computer readout with either of the two CCNIM options includes A and B counts, and which counter is being displayed. The IEEE-488 option also reads the overflow status for both counters. Implementation of the IEEE-488 interface in the Model 995 is compatible with the Standard NIM Digital Bus.* The CCNIM options can directly drive printers having RS-232-C or IEEE-488 ports.

The inputs to Counters A and B are individually selectable as either positive or negative sensing inputs by changing the Input Polarity Jumpers on the counter printed wiring board (PWB). The negative input mode is designed to accept NIM-standard, fast-negative logic pulses with a fixed threshold of -250 mV on a 50-Ω input impedance. The negative inputs can handle counting rates up to 100 MHz.

The positive input mode can accept counting rates up to 25 MHz on a 1000-Ω input impedance. To enhance the flexibility of the positive input mode, precision discriminators are included on both counters. The discriminator thresholds are variable over the range from +100 mV to +9.5 V using front-panel, 25-turn trimpots. The thresholds can be adjusted to suit the amplitude of a specific source of logic pulses or used as precision integral discriminators on analog pulses. For the latter application,

- **Two 8-decade counters with the configuration flexibility to serve a variety of measurement needs**
- **IEEE-488 and RS-232-C options provide CCNIM™ capability with full computer control and readout**
- **Can directly drive printers having RS-232-C or IEEE-488 ports**
- **An 8-decade LED display provides instantaneous readout of the entire counter capacity, even in dimly lighted rooms**
- **All commonly used controls are easily accessible on the front panel**
- **100-MHz counting rate capability**
- **All options are field-installable**

the TTL logic outputs of the discriminators are provided as test points on the front panel. These outputs can be used to trigger an oscilloscope while viewing the analog signal at the counter input on the oscilloscope. The oscilloscope trace will show the signals that are being counted by the Model 995, thus permitting a very selective adjustment of the threshold.

All the commonly used functions are conveniently accessible on the front panel. Manual control of the Count, Stop, and Reset functions is via three push buttons. The Gate LED is illuminated when the Model 995 is enabled to count. The Display push button switches the display to show the contents of Counter A, or the contents of Counter B. The display contains LED flags to indicate whether overflows have occurred in Counter A or B, and to advise when the front-panel controls are disabled by the computer in the Remote mode.

The counting function of the entire module can be disabled by holding the Enable input below +1.5 V using an external signal source. This condition also turns Off the Gate LED. Open circuit or >+3 V at the Enable input allows the instrument to count, if the Count mode has been activated. The Interval output of another ORTEC timer can perform this function to synchronize the Model 995 counting with the other timer. The Interval outputs on all ORTEC timers provide nominally +5 V when



*Please refer to "Standard NIM Digital Bus (NIM/488)," DOE/ER-0457T, U.S. NIM committee, May 1990; Standard NIM Instrumentation System, NTIS, U.S. Department of Commerce, Springfield, Virginia 22161.

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counting and $<+0.5$ V when counting is inhibited.

Independent gating of the A and B Counter inputs can be achieved with the Gate A and Gate B inputs on the rear panel. Interface connectors for the IEEE-488, RS-232-C, and print loop options are also located on the rear panel. Each counter has a rear-panel output dedicated to signaling overflows. Counting these overflows on another counter extends the counting capacity of the Model 995.

The Model 995 derives its power from the ± 12 V and +6 V supplies in a standard NIM bin with power supply. For bins that do not contain a +6 V supply, an Internal +6 V Supply option is available. This option is field-installable and derives its power from the 117 V ac lines in the bin.

Specifications

PERFORMANCE

COUNT CAPACITY 8 decades for counts ranging from 0 to 99,999,999 in each of 2 counters.

MAXIMUM COUNTING RATE 100 MHz for negative inputs, 25 MHz for positive inputs.

POSITIVE INPUT DISCRIMINATOR Threshold variable from +100 mV to +9.5 V with a 25-turn trimpot.

PULSE PAIR RESOLUTION <10 ns for negative inputs; <40 ns for positive inputs.

INDICATORS

COUNTER DISPLAY 8-digit, 7-segment LED display with leading zero suppression.

OVERFLOW INDICATORS LED indicators labeled OVFL A and OVFL B illuminate when the corresponding A or B Counter exceeds its capacity of 8 decades. The indicator remains On until a reset is generated.

DISPLAY Two LEDs labeled A and B indicate the information being displayed in the counter display. Counter A or Counter B value may be displayed by repeatedly pressing the Display push-button until the desired LED is illuminated.

GATE A single LED indicates that the entire instrument is enabled to count. For the Gate LED to be illuminated, the module must be placed in the Count mode (either manually or via the interface option), and the Enable input must be above +3 V.

REMOTE A single LED labeled REM indicates that the Model 995 is under

computer control, and all front-panel controls are disabled. This mode is set by the ENABLE_REMOTE command.

CONTROLS

DISPLAY Push-button selects the contents of Counter A or B for presentation in the 8-decade display. Repeatedly pushing the button cycles the selection through the two choices as indicated by the A and B LEDs.

STOP This push-button stops all sections of the instrument from counting.

RESET Depressing this button resets both counters to zero counts and turns Off both overflow indicators. When power is turned On to the module, a reset is automatically generated.

COUNT Pushing this button enables the counting condition for the entire instrument providing the Enable input is not held below +1.5 V.

THRESH ADJUST (A and B) Front-panel mounted, 25-turn trimpots to adjust the positive input thresholds for Counters A and B. The range is from +100 mV to +9.5 V. Adjacent test points provide the TTL logic signal outputs from the discriminators to facilitate adjustment using an oscilloscope.

INPUT POLARITY JUMPERS Two jumpers located on the printed wiring board (PWB) separately select the desired input polarities for inputs In A and In B. P = positive, N = negative.

INPUTS

IN A

Positive Input Front-panel BNC connector for Counter A accepts positive unipolar signals; minimum width above threshold, 20 ns at a 50% duty cycle. The threshold is adjustable from +100 mV to +9.5 V via a front-panel, 25-turn trimpot. $Z_{in} = 1000 \Omega$ to ground; dc-coupled.

Negative Input Changing the Input Polarity Jumper position on the counter board permits selection of the NIM-standard fast-negative logic input, which is designed to accept -600 to -1800 mV pulses with a fixed discriminator threshold of -250 mV. $Z_{in} = 50 \Omega$; dc-coupled. Minimum pulse width above threshold is 4 ns.

IN B Identical to In A except that it feeds Counter B.

ENABLE Front-panel BNC input connector accepts NIM-standard, slow-positive logic pulses to control the counting condition of the entire module. A level of $>+3$ V or open circuit allows counting, provided the instrument is in the Count mode; $<+1.5$ V inhibits counting. The driving source must be capable of sinking 5 mA of positive current during inhibit; input protected to +25 V.

GATE A Rear-panel BNC input connector is identical to the Gate B input.

GATE B Rear-panel BNC connector accepts NIM-standard, slow-positive logic signals to control the counting in Counter B. A level $>+3$ V or open circuit allows counting; $<+1.5$ V inhibits counting; input protected to +25 V. The driving source must be capable of sinking 5 mA of positive current during inhibit.

OUTPUTS

OVFL A Rear-panel output BNC connector provides a NIM-standard, slow-positive logic signal each time Counter A overflows its 8-decade capacity. The signal has a nominal amplitude of +5 V; width $\sim 20 \mu\text{s}$.

OVFL B Rear-panel output identical to OVFL A except that it monitors overflows from Counter B.

INTERFACES

IEEE-488 When the IEEE-488 option board is plugged in, it furnishes a rear-panel, standard, IEEE-488 bus connector. This 24-pin, AMP CHAMP female connector allows the Model 995 to be controlled from a computer via the IEEE-488 bus. The field-installable option provides computer control of the following functions: Count, Stop, Reset, Remote, and selecting the displayed counter. In the Remote mode, the computer can disable all front-panel controls. Computer readout includes: A and B counts, which counter is being displayed, and the overflow status for both counters.

SERIAL When the RS-232-C option board is plugged in, it furnishes a rear-panel, 25-pin, male, D connector containing all signals for standard RS-232-C communications. It also contains connections for 20-mA current loop communications. The field-installable RS-232-C option provides computer control of the following functions: Count, Stop, Reset, Remote, and selecting the displayed counter. In the Remote mode, the computer can disable all front-panel controls. Computer readout includes: A and B counts and which counter is being displayed.



ELECTRICAL AND MECHANICAL

POWER REQUIRED The basic Model 995 derives its power from a NIM bin furnishing ± 12 V and +6 V. For NIM bins that do not provide +6 V, an optional Internal +6 V Supply is available. This option is field-installable and draws its power from the 117 V ac lines in the bin. With the Internal +6 V Supply installed, the power requirements are shown in column 4 and not required in column 3.

	Power Required		Bin Supplied	Internal
	+12 V	-12 V	+6 V	+6 Supply 117 V ac
Basic Model 995	20 mA	110 mA	700 mA	75 mA
Model 995 plus IEEE-488 option	30 mA	120 mA	1300 mA	105 mA
Model 995 plus RS-232-C option	45 mA	135 mA	1300 mA	105 mA

WEIGHT

Net 2.4 kg (5.2 lb).

Shipping 3.7 kg (8.2 lb).

DIMENSIONS NIM-standard double-width module, 6.90 X 22.13 cm (2.70 X 8.714 in.) front panel per DOE/ER-0457T.

Ordering Information

NOTE: Both interface option boards use the same position in the module. Only one can be plugged in at a given time.

To order, specify:

Model	Description
995	Basic module without plug-in options.
99X-1	RS-232-C Interface option (cable not included).
99X-2	IEEE-488 Interface option (cable not included).
99X-4	Internal +6 V Supply option.
C-75	Female-to-female RS-232-C null modem cable (3-meter length).
C-80	Male-to-female RS-232-C extension cable (3-meter length).
C-488-2	IEEE-488 interface cable (2-meter length).
C-488-4	IEEE-488 interface cable (4-meter length).

996 CCNIM™ Timer and Counter

- 100-MHz, 8-decade counter and a blind timer
- Field-installable output options to serve a variety of measurement needs
- Available as a nonprinting counter and timer
- IEEE-488 and RS-232-C plug-in options, providing CCNIM™ capability with full computer control and readout
- Can directly drive printers having RS-232-C or IEEE-488 ports



The ORTEC Model 996 Timer and Counter incorporates a 100-MHz, 8-decade counter and a blind preset timer. The basic model offers visual readout via an 8-decade LED display. By plugging in field-installable options, considerably enhanced readout and control capability can be added at any time.

The full power of CCNIM™ (Computer Controlled NIM) is obtainable by adding the IEEE-488 option or the RS-232-C option. These plug-in boards yield computer control of all functions normally selectable from the front panel, including start and stop count, readout, reset, setting the preset value, displaying the preset value, displaying the counter contents, and selecting the desired time base. To eliminate accidental operator interference, the computer can disable all front-panel controls in the remote mode. Computer readout with either of the two CCNIM options includes the contents of the counter, the preset value, and the current display mode. The IEEE-488 option also reads the overflow status for the counter. Implementation of the IEEE-488 interface in the Model 996 is compatible with the Standard NIM Digital Bus.* The CCNIM options can directly drive printers having RS-232-C or IEEE-488 ports.

Excellent flexibility in setting the preset value is offered by the MN X 10^P selection. The M and N values provide two-digit precision, while P selects the decade. Presets can be chosen in the ranges of 0.01 to 990,000 seconds, 0.01 to 990,000 minutes, or 1 to 99,000,000 counts. In the external (EXT) time base mode, the 996 becomes a displayed, preset counter. The 996 can function as a displayed, preset timer by changing the position of a circuit board jumper and

using the 0.01-SEC or 0.01-MIN time base.

Both positive and negative sensing inputs to the counter are available on the front panel. The negative input is designed to accept NIM-standard fast negative logic pulses with a fixed threshold of -250 mV on a 50-Ω input impedance. The negative input can handle counting rates up to 100 MHz. The positive input can accept counting rates up to 25 MHz on a 1000-Ω input impedance. To enhance the flexibility of the positive input, a precision discriminator is included. The discriminator threshold is variable over the range of +100 mV to +9.5 V using a front-panel, 25-turn trimpot. The threshold can be adjusted to suit the amplitude of a specific source of logic pulses or used as a precision integral discriminator on analog pulses. For the latter application, the TTL logic output of the discriminator is provided as a test point on the front panel. This output can be used to trigger an oscilloscope while viewing the analog signal at the counter input on the oscilloscope. The oscilloscope trace will show the signals that are being counted by the Model 996, thus permitting a very selective adjustment of the threshold.

All the commonly used functions are conveniently accessible on the front panel. Manual control of the COUNT, STOP, and RESET functions is via three push-buttons. The GATE LED is illuminated when the Model 996 is enabled to count. Selection of the 0.01-s, 0.01-min, or external time base is made by the TIME BASE push button. In the external mode, the preset counter counts the events from the front-panel positive or negative inputs.

The DISPLAY push-button switches the display to show the contents of the counter or the preset stop value. To change the preset value, the preset mode must first be selected with the DISPLAY push button. Subsequently, the PRESET SELECT push button is

*Please refer to "Standard NIM Digital Bus (NIM/488)," DOE/ER-0457T, U.S. NIM committee, May 1990; Standard NIM Instrumentation System, NTIS, U.S. Department of Commerce, Springfield, Virginia 22161.

used to choose M, N, or P for adjustment. Changing the value of M, N, or P is accomplished with the PRESET ADVANCE push button. The display contains LED flags to indicate whether M, N, or P has been selected, to warn when an overflow has occurred in the counter, and to advise when the front-panel controls are disabled by the computer in the remote mode.

When the Model 996 is used without a plug-in option, jumpers on the circuit board can select automatic recycling of the counting interval with a display dwell time of either 1 or 10 s at the end of each counting interval. The plug-in options disable the dwell/automatic recycle function, when enabled by an external controller.

The counting function of the entire module can be disabled by holding the GATE input below +1.5 V using an external signal source. This condition also turns off the GATE LED. Open circuit or greater than +3 V at the GATE input allows the instrument to count, if the COUNT mode has been activated. The INTERVAL output of another ORTEC timer can perform this function to synchronize the Model 996 counting with the other timer. The INTERVAL outputs on all ORTEC timers provide nominally +5 V when counting and less than +0.5 V when counting is inhibited.

Interface connectors for the plug-in IEEE-488, RS-232-C, and print loop options are located on the rear panel. The overflow output for the counter is also located on the rear panel. Counting these overflows on another counter effectively extends the counting capacity of the Model 996.

The Model 996 derives its power from the ± 12 V, and +6 V supplies in a standard NIM bin with power supply.

Specifications

PERFORMANCE

COUNT CAPACITY 8 decades for counts ranging from 0 to 99,999,999.

MAXIMUM COUNTING RATE 100 MHz for negative input; 25 MHz for positive input.

TIME BASE 10-MHz clock with minimum preset or displayed intervals of 0.01 s or 0.01 min. Synchronizing error is nominally 100 ns. Also accepts an external input from the counter input when the EXT (external) mode is selected.

TIME BASE ACCURACY Within $\pm 0.0025\%$ over the 0–50°C operating temperature range.

PRESET TIME/COUNTS The module stops counting when the preset value $MN \times 10^P$ is reached on the blind preset register. M and N are digits ranging from 0 to 9. P is a digit ranging from 0 to 6. With the 0.01-SEC time base, preset times from 0.01 to 990,000 s can be used. Preset times from 0.01 to 990,000 min are available using the 0.01-MIN time base. In the EXT time base mode, preset counts in the range of 1 to 99,000,000 can be used.

POSITIVE INPUT DISCRIMINATOR Threshold variable from +100 mV to +9.5 V with a 25-turn trimpot.

PULSE PAIR RESOLUTION <10 ns for negative input; <40 ns for positive input.

INDICATORS

COUNTER DISPLAY 8-digit, 7-segment LED display with leading zero suppression. When displaying time, two digits to the right of a decimal point are included.

OVERFLOW INDICATOR An LED indicator labeled OVF illuminates when the counter exceeds its capacity of 8 decades. The indicator remains on until a reset is generated.

M, N, AND P INDICATORS Three LED indicators aid in the selection of the preset value. When the PRESET display function is activated, the SEL (select) push-button will select which of the three LEDs is illuminated. When one of these LEDs is on, that digit of the preset value can be incremented using the ADV (advance) push-button.

DISPLAY Two LEDs labeled COUNTS and PRESET indicate the information being displayed in the counter display. The counter or the PRESET value may be displayed by repeatedly pressing the DISPLAY push-button until the desired LED is illuminated.

TIME BASE Three LEDs indicate the selected time base source. By repeatedly pressing the TIME BASE push-button, 0.01 SEC, 0.01 MIN, or the EXT mode can be chosen.

GATE A single LED indicates that the entire instrument is enabled to count. For the GATE LED to be illuminated, the module must be placed in the COUNT mode (either manually or via the interface option), the GATE input must be above +3 V or open circuit, and the preset stop condition must not have been reached.

REMOTE A single LED labeled REM indicates that the Model 996 is under computer control and that all front-panel controls are disabled. This mode is set by the ENABLE_REMOTE command.

CONTROLS

DISPLAY Push-button selects the contents of the counter or the PRESET value for presentation in the 8-decade display. Repeatedly pushing the button alternates the selection between the two choices as indicated by the COUNTS and PRESET LEDs.

SEL (Select) Push-button chooses the M, N, or P digit in the display of the preset value. Pushing the button advances the selection through the three choices as indicated by the illuminated LED. The SEL push-button operates only if the PRESET mode has been selected by the DISPLAY push-button.

ADV (Advance) Push-button increments the preset digit selected by the SEL push-button once each time the ADV button is depressed. The M and N digit ranges are both 0 to 9. The P digit range is from 0 to 6. The ADV push-button operates only if the PRESET mode has been selected by the DISPLAY push-button.



996 CCNIM Timer and Counter

TIME BASE Each push on this button advances the selection one step through the three time base choices (0.01 SEC, 0.01 MIN, and EXT) to determine the time base source for the preset register.

STOP This push-button stops all sections of the instrument from counting.

RESET Depressing this button resets the counter to zero counts and turns off the overflow indicator. It also clears any counts accumulated in the blind preset register, but does not change the selected preset value. When power to the module is turned on, a RESET is automatically generated.

COUNT Pushing this button enables the counting condition for the entire instrument, providing the GATE input is not held below +1.5 V and the preset value has not been reached.

THRESH ADJ Front-panel mounted, 25-turn trimpot to adjust the positive input threshold for the counter. The range is from +100 mV to +9.5 V. Adjacent test point provides the TTL logic signal output from the discriminator to facilitate adjustment using an oscilloscope.

AUTOMATIC RECYCLE WITH DISPLAY DWELL Normally the Model 996 stops counting at the end of a counting interval and displays the contents of the counter until the RESET button is pushed. Alternatively, an automatic recycle counting mode can be enabled using jumper W1 on the printed circuit board. When the automatic recycle mode is selected, the display dwells for 1 or 10 seconds at the end of the counting interval. At the end of the display dwell period, the Model 996 is reset and the next counting/display dwell cycle begins. Using jumper W2 on the printed circuit board, either a 1- or 10-s display dwell can be chosen. The display dwell/automatic recycle mode is disabled automatically when the Model 996 is under print loop control or computer control.

COUNTER/TIMER JUMPER A two-position jumper (W3) located on the printed circuit board determines the information accumulated and displayed by the counter. With W3 in the COUNTER position, the counter always counts and displays the events connected to the front-panel input (POS IN, NEG IN). With W3 set to the TIMER position, the counter counts and displays the time if either the 0.01-SEC or the 0.01-MIN time base is selected. If the EXT time base is selected, the counter will count and display the events from the front-panel inputs (POS IN or NEG IN).

1 CYCLE/RECYCLE Selection of either the 1 CYCLE or the RECYCLE mode can be made via an 8-pin DIP switch on the IEEE-488 and the RS-232-C interface boards. The RECYCLE mode can be used when the computer is able to respond with a data transfer when the Model 996 reaches the preset value. Upon reaching preset the Model

996 latches its data into a buffer, resets the counters, and starts the next counting interval. This process takes approximately 50 μ s. The computer reads the data in the buffer before the next counting interval ends. In the 1 CYCLE mode the Model 996 simply stops counting and waits for further commands when the preset value is reached.

INPUTS

POS IN (Positive Input) Front-panel BNC connector for the counter input accepts positive unipolar signals with a minimum width above threshold of 20 ns at a 50% duty cycle. Threshold is adjustable from +100 mV to +9.5 V via a front-panel 25-turn trimpot. $Z_{in} = 1000 \Omega$ to ground; dc-coupled.

NEG IN (Negative Input) Front-panel BNC connector for the counter to accept NIM-standard, fast-negative logic signals -600 to -1800 mV with a fixed discriminator threshold of -250 mV. $Z_{in} = 50 \Omega$; dc-coupled. Minimum pulse width above threshold is 4 ns.

GATE Front-panel BNC input connector accepts NIM-standard slow positive logic pulses to control the counting condition of the entire module. A level of >+3 V or open circuit allows counting provided the instrument is in the COUNT mode and has not reached the preset value. A level of <+1.5 V inhibits counting. The driving source must be capable of sinking 5 mA of positive current during inhibit. The input is protected to +25 V.

OUTPUTS

INTERVAL Front-panel output BNC connector furnishes a positive level during the counting interval. The level is nominally +5 V when counting is enabled and <+0.5 V when counting is disabled. $Z_o \sim 30 \Omega$.

OVFL Rear-panel output BNC connector provides a NIM-standard slow positive logic signal each time the counter overflows its 8-decade capacity. The signal has a nominal amplitude of +5 V; width ~20 μ s.

INTERFACES

IEEE-488 When the IEEE-488 option board is plugged in, it furnishes a rear-panel, standard, IEEE-488 bus connector. This 24-pin, AMP CHAMP, female connector allows the Model 996 to be controlled from a computer via the IEEE-488 bus. The field-installable option provides computer control of the following functions: COUNT, STOP, RESET, REMOTE, setting the preset value, selecting the display mode, and selecting the desired time base. In the remote mode the computer can disable all front-panel controls. Computer readout includes: counts, the preset value, the display mode, and the overflow status.

SERIAL When the RS-232-C option board is plugged in, it furnishes a rear-panel, 25-pin, male, D connector containing all signals for standard RS-232-C communications. It also

contains connections for 20-mA current loop communications. The field-installable RS-232-C option provides computer control of the following functions: COUNT, STOP, RESET, REMOTE, setting the preset value, selecting the display mode, and selecting the desired time base. In the remote mode the computer can disable all front-panel controls. Computer readout includes: counts, the preset value, and the display mode.

ELECTRICAL AND MECHANICAL

DIMENSIONS NIM-standard single-width module, 3.43 X 22.13 cm (1.35 X 8.714 in.) front panel per DOE/ER-0457T.

WEIGHT

Net 0.908 kg (2.0 lb)

Shipping 1.4 kg (3.1 lb)

POWER REQUIRED The Model 996 and the plug-in options derive power from a NIM bin furnishing ± 12 V and +6 V. The power required depends on the installed option as shown in the Power Requirements Table.

POWER REQUIREMENTS TABLE

	+12 V	-12 V	+6 V
Basic Model 996	25 mA	50 mA	475 mA
996 plus IEEE-488 option	35 mA	55 mA	1000 mA
996 plus RS-232-C option	45 mA	70 mA	1000 mA

Ordering Information

NOTE: Both interface option boards use the same position in the module. Only one can be plugged in at a given time.

To order, specify:

- 996** Basic module without plug-in options.
- 99X-1** RS-232-C Interface option (cable not included).
- 99X-2** IEEE-488 Interface option (cable not included).
- C-75** Female-to-female RS-232-C null modem cable (3-m length).
- C-80** Male-to-female RS-232-C extension cable (3-meter length).
- C-488-2** IEEE-488 interface cable (2-meter length).
- C-488-4** IEEE-488 interface cable (4-meter length).

Designed for photon or ion beam applications, the ORTEC Model 9349 Log/Lin Ratemeter provides two modes of operation: linear and logarithmic. The linear mode has 11 full-scale ranges from 10 to 10^6 counts/s in 1-3-10 steps. The 5-decade log mode covers the range 10 to 10^6 counts/s in a single span. These choices permit optimum measurement of low, medium, or high steady pulse rates or monitoring of rates that vary through a wide range.

The input signal to the Model 9349 is normally obtained from a discriminator having a NIM-standard, fast-negative logic output signal.

Because of the longer effective scale inherent in its 240° movement and its high accuracy, the unique circular front-panel meter provides excellent readability for both modes.

Zero suppression is provided for up to 100% of any linear range. Any relatively constant background in the counting rate can be subtracted from the data by adjustment of this control. Also, a suppressed zero permits rates that are beyond the nominal full-scale limit to be observed with greater accuracy than could be obtained by switching to a higher range. The choice between 7 linear and 2 log time constants is a further aid to accurate reading of the rate of incoming signals.

In addition to the front-panel meter indications, outputs are provided for both current and voltage recorders, as well as a high-level voltage output for control or monitor applications.

Specifications

PERFORMANCE

LINEAR RANGES 11 ranges from 10 to 10^6 counts/s full scale in 1-3-10 steps.

DEAD TIME <100 ns on the 10^6 range; <0.3% of average pulse spacing up to the 3×10^4 range; $\leq 1\%$ on the 10^5 and 3×10^5 ranges.

RATED OVERLOAD Maintains full-scale output for X300 overload or 10^7 counts/s, whichever is smaller.

TEMPERATURE INSTABILITY $\leq \pm 0.05\%/^{\circ}\text{C}$.

NONLINEARITY $\leq \pm 0.15\%$ from 10 to 3×10^4 counts/s range; $\leq \pm 1.5\%$ from 10^5 – 10^6 counts/s.

TIME CONSTANTS 7 selectable time constants, 0.03 to 30 s in 1-3-10 steps.

ZERO SUPPRESSION 0 to 100% of full scale, nonlinearity $\leq \pm 0.25\%$.

LOGARITHMIC RANGE One 5-decade range for 10 to 10^6 counts/s.

TEMPERATURE INSTABILITY $\leq \pm 0.25\%$ of full scale per $^{\circ}\text{C}$.

ANALOG OUTPUT ERROR $\leq \pm 2.5\%$ of full scale.

STANDARD DEVIATION ~15% with Log Short time constant; ~5% with Log Long time constants.

SLEWING RATE Dependent upon input rate; for any rate change, Log Short time constant provides 10 times faster response than Log Long time constant.

CONTROLS

RANGE 12-position switch selects the full-scale range and either linear or logarithmic mode; linear ranges are 0–10 counts/s through 0– 10^6 counts/s in 1-3-10 steps; log range is 10– 10^6 counts/s.

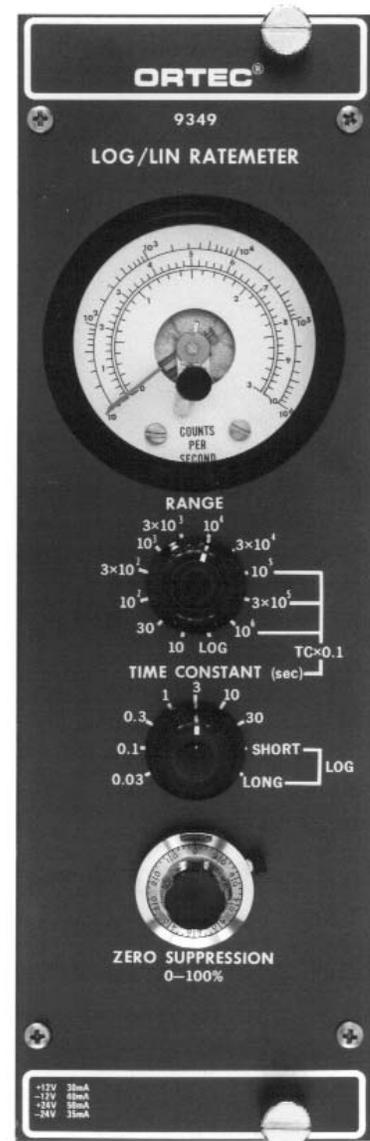
TIME CONSTANT 9-position switch selects the time constant for the integrating network; 0.03 to 30 s in a 1-3-10 series for all linear ranges; Short and Long for the log range.

ZERO SUPPRESSION 10-turn precision potentiometer to suppress the zero-reference level for any linear range from 0 to 100%; the same full-scale span is effective above the preselected zero-reference level.

INPUT

INPUT Rear-panel BNC connector accepts NIM-standard, fast-negative logic signals, –600 to –1800 mV. $Z_{in} = 50 \Omega$. Minimum pulse width is 4 ns FWHM.

- For counting rate measurements with photons or ion beams
- 10^6 counts/s full scale
- Linear or logarithmic operation
- Fast negative NIM input



9349 Log/Lin Ratemeter

OUTPUTS

PANEL METER 240° circular movement with 8.9 cm (3.5 in.) deflection; accuracy, 2% of full scale; 3 scale markings; 0–1 and 0–3 for linear ranges and 10–10⁶ in 5 decades for log range.

ANALOG OUTPUTS BNC connector on rear panel provides 0 to 10 V full scale, dc-coupled with 100- Ω output impedance.

RECORDER OUTPUTS Binding post connectors on rear panel:

100 mV Provides voltage output with 100 mV full scale; dc-coupled with 100- Ω output impedance.

1 mA Provides current output of 1 mA full scale; dc-coupled with 10 k Ω output impedance.

ELECTRICAL AND MECHANICAL

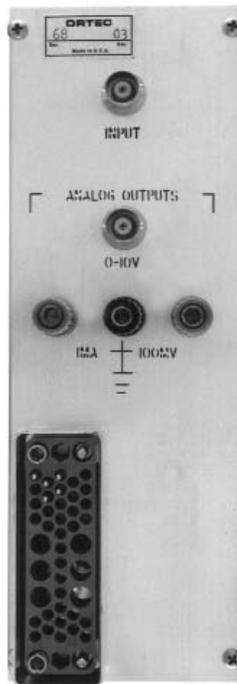
POWER REQUIRED +24 V, 50 mA; –24 V, 35 mA; +12 V, 30 mA; –12 V, 45 mA.

WEIGHT

Net 1.5 kg (3.5 lb).

Shipping 2.5 kg (5.5 lb).

DIMENSIONS NIM-standard double-width module 6.90 X 22.13 cm (2.70 X 8.714 in.) per DOE/ER-0457T.



Ordering Information

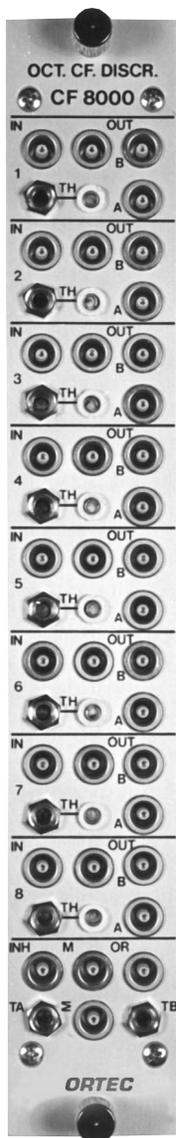
To order, specify:

Model	Description
9349	Log/Lin Ratemeter

CF8000

Octal Constant-Fraction Discriminator

- Good time resolution with a wide range of pulse amplitudes
- Internal delay — no cable necessary
- Automatic walk adjustment
- Multiplicity and OR logic outputs
- Analog sum output
- Inhibit input
- ECL outputs
- Energy outputs



The flexible ORTEC CF8000 Octal Constant-Fraction Discriminator has the performance and convenience features necessary for ease of use in even the most demanding timing or coincidence experiments with multiple detectors. It contains eight constant-fraction discriminators in a single-width NIM module. The constant-fraction technique provides optimum time resolution over a wide range of pulse amplitudes.

Exclusive features of the CF8000 discriminator include internal shaping delay, automatic walk adjustment, an analog summation output, and built-in logic functions to minimize external logic requirements.

The input signals can range from 0 to -5 V. Each input has a separate threshold adjustment (with front-panel monitor), which may range from -10 mV to -1 V.

For each channel, there are three Fast-NIM logic outputs — one "A" and two "B" outputs. All outputs have adjustable widths. There is a single-width adjustment for all eight "A" outputs, and another width adjustment for all 16 "B" outputs. There are also eight rear-panel ECL outputs that have the same width as the "B" outputs. LEMO connectors are used for maximum packing density.

Each channel has a rear-panel "E" output that buffers the input signal.

External delay cables are not necessary on the CF8000 discriminator. Each channel has an internal shaping-delay circuit that can be set for 2, 4, 6, 8, or 10 ns. Optional delay line plug-ins are available for changing the shaping delay ranges to 5, 30, or 50 ns. For all delay plug-ins, there are five possible delay settings. (See Accessories section.)

The automatic-walk adjustment of the CF8000 instrument simplifies set-up and reduces the effects of ground-loops on the incoming signal.

Other front-panel connections include: (1) an analog sum output (Σ), which provides an attenuated summation of all inputs; (2) a multiplicity output (M), which

provides a voltage proportional to the number of valid "B" outputs; (3) an OR logic output that provides a logic output for every active "B" output; and (4) an inhibit input (INH), which disables all "B" outputs.

The constant-fraction ratio is factory set at 0.4.

Specifications

PERFORMANCE

WALK $< \pm 250$ ps from -50 mV to -5 V for a pulse rise time of 1 ns, a pulse width of 10 ns, a 2-ns delay, and the threshold set at minimum.

CONSTANT-FRACTION RATIO 0.4.

INPUT/OUTPUT RATE 20 MHz maximum.

PULSE/PAIR RESOLUTION < 50 ns.

TRANSMISSION DELAY

"A" Outputs 13 ns, typically.

"B" Outputs 16 ns, typically.

THRESHOLD TEMPERATURE

SENSITIVITY $< \pm 100$ ppm/ $^{\circ}$ C from 0 to $+50^{\circ}$ C.

CONTROLS

THRESHOLD CONTROL (TH) 20-turn front-panel screwdriver adjustment for each discriminator channel; nominally variable from -30 mV to -1 V.

THRESHOLD MONITOR Front-panel test point located to the right of the threshold control. Outputs actual threshold voltage.

WIDTH ADJUSTMENTS (TA and TB) 20-turn front-panel screwdriver adjustments to set the width of the "A" and "B" Fast-NIM logic outputs. Adjustment range: nominally 20–200 ns.

DELAY Internal PCB jumper setting allows the proper shaping delay to be selected. Five possible positions: 2, 4, 6, 8, or 10 ns. Other delays available on order.

INPUTS

INPUTS Front-panel LEMO connector for each channel.

INPUT RANGE 0 to -5 V.

PROTECTED TO -100 V for pulse duty cycles $< 0.05\%$.

IMPEDANCE 50 Ω , dc-coupled.

INHIBIT INPUT Front-panel LEMO connector accepts negative Fast-NIM signal. Active-low signal disables "B" logic outputs.

Octal Constant-Fraction Discriminator

OUTPUTS

"A" LOGIC OUTPUTS (A) Eight front-panel LEMO connectors provide adjustable-width, updating Fast-NIM logic signals for inputs above threshold setting.

Amplitude -0.7 V minimum with $50\text{-}\Omega$ load.

Width Settable from nominally $20\text{--}200$ ns by 20-turn front-panel screwdriver adjustment (TA).

"B" LOGIC OUTPUTS (B) Sixteen front-panel LEMO connectors provide adjustable-width, updating Fast-NIM logic signals for inputs above threshold setting.

Amplitude -0.7 V minimum with $50\text{-}\Omega$ load.

Width Settable from nominally $20\text{--}200$ ns by 20-turn front-panel screwdriver adjustment (TB).

MULTIPLICITY OUTPUT (M) Front-panel LEMO connector provides a pulse signal with amplitude proportional to the number of "B" logic outputs active at any instant.

Amplitude Range Nominally 0 to -0.5 V with $50\text{-}\Omega$ load.

OR OUTPUT (OR) Front-panel LEMO connector provides logical OR of all "B" logic outputs. Negative Fast-NIM signal.

ANALOG SUM OUTPUT (Σ) A front-panel LEMO connector provides an analog summation of all input channels divided by an attenuation factor of approximately 16, with a $50\text{-}\Omega$ load.

ENERGY OUTPUTS Eight, rear-panel LEMO connectors provide the buffered input signal from each channel.

Output Impedance $50\text{-}\Omega$, ac-coupled.

ECL OUTPUTS Rear-panel 2×8 differential ECL logic connector that provides an ECL version of the eight "B" outputs.

Line Impedance $112\ \Omega$.

ELECTRICAL AND MECHANICAL

POWER REQUIRED $+12$ V, 40 mA; -12 V, 40 mA; $+6$ V, 250 mA; -6 V, 1000 mA.

WEIGHT 1.5 kg (3.3 lbs).

DIMENSIONS Standard single-width NIM module, 3.43×22.13 cm (1.35×8.714 in.) front panel per DOE/ER-0457T.

Optional Accessories

CFD-DELAY-5 ns Delay plug-in for 1, 2, 3, 4, or 5-ns delay settings.

CFD-DELAY-10 ns (Factory installed in the instrument) Delay plug-in for 2, 4, 6, 8, or 10-ns delay settings.

CFD-DELAY-30 ns Delay plug-in for 6, 12, 18, 24, or 30-ns delay settings.

CFD-DELAY-50 ns Delay plug-in for 10, 20, 30, 40, or 50-ns delay settings.

Ordering Information

To order the NIM module, specify:

Model	Description
CF8000	Octal Constant-Fraction Discriminator

To order delay options, specify:

CFD-DELAY-5 ns, CFD-DELAY-10 ns, CFD-DELAY-30 ns, or CFD-DELAY-50 ns.

Order eight delay options to populate all 8 discriminator channels.

584 Constant-Fraction Discriminator

- Good time resolution over a wide range of pulse amplitudes with scintillation and semiconductor detectors
- 50-MHz count-rate capability
- 5 mV minimum threshold
- Time walk ≤ 100 ps for 100:1 dynamic range
- Constant-fraction, leading-edge, and slow-rise-time reject modes



The ORTEC Model 584 Constant-Fraction Discriminator allows good time resolution to be obtained from all commonly used detectors such as HPGe, silicon charged-particle, fast plastic, NaI(Tl), and photomultiplier tubes. Three timing modes are provided in the Model 584: constant-fraction, constant-fraction with slow-rise-time reject, and leading-edge. This economical unit has a minimum threshold of -5 mV, allowing good timing measurements to very low energies. The maximum input signal acceptable without saturation is -5 V, which provides a 1000:1 input dynamic range. The Model 584 is useful in high-count-rate applications to 50 MHz with ≤ 20 ns pulse-pair resolving time. The time walk of the Model 584 is ± 100 ps for a 100:1 input dynamic range.

A variety of controls is provided, allowing optimization of the Model 584 in various applications. A precision 10-turn potentiometer sets the threshold from -5 mV to -1 V. The blocking time set by the Blocking Output Width is continuously adjustable from ≤ 10 to ≥ 1000 ns. This feature is useful for preventing multiple triggering on pulses from scintillators having long decay time, e.g., NaI(Tl). A front-panel LED indicates that the discriminator has been triggered and can therefore be used to set the threshold just above the noise. Walk is adjusted by a front-panel 20-turn potentiometer. The Constant-Fraction Monitor on the front panel can be used to optimize walk adjustment. Since the constant-fraction shaping delay is selected by external cable, the optimum delay for a specific detector application is easily selected.

Four NIM-standard output signals are available from the Model 584. The positive output signal is continuously variable from ≤ 0.5 to ≥ 2.5 μ s by means of a printed wiring board (PWB) potentiometer. The polarity of the positive output is PWB selectable to be either a NIM-standard positive output signal or the complement signal. The two timing output signals are NIM-standard fast negative logic signals, each having a 2-ns rise time and a 5-ns width FWHM. The blocking output signal

is a NIM-standard fast negative logic signal whose width is adjustable from ≤ 10 to ≥ 1000 ns.

The Model 584 can be gated externally. A rear-panel locking toggle switch selects either Gated or Ungated operation. In the Gated Mode, a printed wiring board jumper selects the Bin Gate line in the NIM bin, a NIM-standard positive signal via the rear-panel BNC connector, or a NIM-standard negative signal via the rear-panel BNC connector.

Logic current for the Model 584 is selected from either the -6 V or -12 V NIM supply by means of a rear-panel locking toggle switch. The Model 584 is within the allotment of current for a single-width NIM module for a NIM Class V power supply when the logic current is obtained from -6 V.

Specifications

PERFORMANCE

INPUT Accepts negative input signals from 0 V to -5 V without saturation; dc-coupled; $Z_{in} = 50 \Omega$; reflections $\leq \pm 5\%$ for $t_r \leq 2$ ns.

THRESHOLD RANGE -5 mV to -1 V.

THRESHOLD INTEGRAL NONLINEARITY $\leq \pm 0.25\%$ of full scale.

THRESHOLD INSTABILITY $\leq \pm 100 \mu$ V/ $^{\circ}$ C, 0 to 50° C.

PROPAGATION DELAY Nominally 25 ns, with external CF Delay ≈ 2 ns.

MINIMUM PULSE-PAIR RESOLUTION ≤ 20 ns.

DEAD TIME Nominally 20 ns or Blocking Output Width, whichever is greater.

BLOCKING OUTPUT WIDTH Adjustable from ≤ 10 to ≥ 1000 ns.

TIME WALK $\leq \pm 100$ ps for the 100:1 input range from -20 mV to -2 V. Conditions: External CF Delay = 2 ns; input rise time ≤ 1 ns; input pulse width = 10 ns.

CONTROLS

THRESHOLD Front-panel 10-turn precision locking potentiometer determines the discriminator threshold setting in the range from -5 mV to -1 V.

TIMING MODE SWITCH Front-panel 3-position locking toggle switch selects one of the three timing modes:

CF (Constant-Fraction) Attenuation factor is internally set at $f = 0.2$ (can be changed upon request). An external 50- Ω coaxial cable must be provided for the constant-fraction shaping delay (CF Delay).

584

Constant-Fraction Discriminator

SRT (Slow-Rise-Time) Reject Provides constant-fraction timing and inhibits output signals that would be produced by leading-edge timing from the leading-edge arming discriminator. An input signal that does not cross the discriminator threshold before the constant-fraction zero-crossing time does not produce an output pulse.

LE (Leading-Edge) Inhibits timing from the constant-fraction circuitry. The timing is derived as the leading edge of the input signal crosses the discriminator threshold level.

CF DELAY Two front-panel BNC connectors accept 50- Ω coaxial cable to set the required constant-fraction shaping delay for the CF and SRT Modes: total delay is ≈ 0.8 ns plus the delay of the external cable. In the LE Mode, the user may either connect a piece of 50- Ω coaxial cable between these two connectors or connect a 50- Ω termination to each of the two connectors.

WALK Front-panel 20-turn screwdriver adjustment sets the walk compensation for each application.

CF MON Front-panel BNC connector permits observation of the constant-fraction bipolar timing signal; $Z_0 = 50 \Omega$. 50- Ω coaxial cable required; 50- Ω termination suggested.

WIDTH Front-panel 20-turn screwdriver adjustment sets the width of the Blocking Output pulse. Variable from ≤ 10 to ≥ 1000 ns. Sets the instrument dead time for widths greater than nominally 20 ns.

GATING MODE SWITCH Rear-panel 2-position locking toggle switch controls the use of the Gate Inputs. (One of three Gate Input signal paths is selected by a PWB jumper.)

Gated A "true" logic level from the selected Gate Input permits output signals to be generated by the discriminator. A "false" logic level from the selected Gate Input inhibits output signals from being generated by the discriminator. A set of Output signals already in progress is not terminated prematurely by a logic "false" signal from the selected Gate Input.

Ungated The signal level of the selected Gate Input does not inhibit normal generation of output signals from the discriminator (i.e., the discriminator is always enabled).

LOGIC CURRENT SWITCH Rear-panel 2-position locking toggle switch selects either the -6 V or the -12 V NIM supply line for providing current for the high-speed ECL logic used in the discriminator.

NOTES:

(1) The module is within the current allotment for a single NIM width when using the -6 V position with a NIM Class V power supply or equivalent.

(2) The module exceeds the current allotment for a single NIM width on the -12 V supply when using the -12 V position. However, this position permits using the discriminator in bins with power supplies not providing -6 V.

GATE INPUT JUMPER (G+, G-, or BG) PWB jumper selects one of three Gate Input signal paths:

G+ Selects the rear-panel BNC Gate Input connector to accept slow positive NIM input signal levels for gating; dc-coupled; $Z_{in} > 1 \text{ k}\Omega$.

G- Selects the rear-panel BNC Gate Input connector to accept fast negative NIM input signal levels for gating; dc-coupled; $Z_{in} = 50 \Omega$.

BG Selects the Bin Gate line (pin 36 of the NIM power connector block) to accept slow positive NIM input signal levels $> +2 \text{ V}$ for gating; dc-coupled; $Z_{in} > 1 \text{ k}\Omega$.

POSITIVE OUTPUT WIDTH (+ Width) PWB 4-turn potentiometer sets the width of the slow positive NIM output signal in the range from ≤ 0.5 to $\geq 2.5 \mu\text{s}$.

POSITIVE OUTPUT SIGNAL POLARITY (PO or $\overline{\text{PO}}$) PWB jumper selects the slow positive NIM output signal (PO) or the complement output signal ($\overline{\text{PO}}$).

INPUTS

INPUT Front-panel BNC connector accepts fast negative input signals from 0 V to -5 V without saturation; dc-coupled; $Z_{in} = 50 \Omega$; reflections $\leq \pm 5\%$ for $t_r \geq 2 \text{ ns}$.

GATE INPUT Rear-panel BNC connector; input signals accepted according to PWB Gate Input Jumper.

G+ Jumper Position Accepts slow positive NIM input signal levels for gating; dc-coupled; $Z_{in} > 1 \text{ k}\Omega$.

G- Jumper Position Accepts fast negative NIM input signal levels for gating; dc-coupled; $Z_{in} = 50 \Omega$.

OUTPUTS

TIMING Two front-panel BNC connectors provide simultaneous NIM-standard fast negative logic signals; $t_r \approx 2 \text{ ns}$; $t_f \approx 3 \text{ ns}$; $t_w \approx 5 \text{ ns}$.

BK OUT Front-panel BNC connector provides a NIM-standard fast negative logic pulse that occurs simultaneously with the Timing Outputs; width variable by front-panel adjustment from ≤ 10 to ≥ 1000 ns; $t_r \approx 2 \text{ ns}$.

POSITIVE Front-panel BNC connector provides NIM-standard slow positive logic pulse simultaneously with Timing Outputs; $Z_0 < 10 \Omega$; width variable by PWB width adjustment from ≤ 0.5 to $\geq 2.5 \mu\text{s}$. The associated LED is triggered for approximately 3 ms (updating) by each positive output pulse.

ELECTRICAL AND MECHANICAL

WEIGHT

Net 1.2 kg (2.6 lb).

Shipping 2.25 kg (5.0 lb)

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

POWER REQUIRED

	Logic Current Switch*	
	-6 V (mA)	-12 V (mA)
+12 V	100	100
-12 V	100	500
+6 V	0	0
-6 V	400	0
+24 V	0	0
-24 V	80	80
117 V ac	0	0

*See "NOTES" on Logic Current Switch, "Controls" Section of Specifications.

Ordering Information

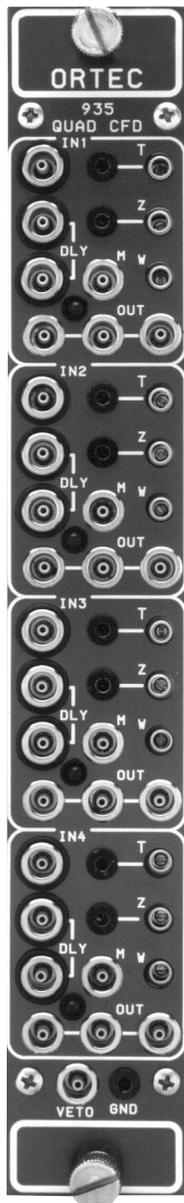
To order, specify:

Model	Description
584	Constant-Fraction Discriminator



935 Quad 200-MHz Constant-Fraction Discriminator

- **Constant-fraction timing on signals as narrow as 1 ns FWHM — ideal for microchannel plates, fast photomultiplier tubes, fast scintillators, and fast silicon detectors**
- **Ultra-low walk, guaranteed $<\pm 50$ ps (typically $<\pm 25$ ps) over a 100:1 dynamic range**
- **Pulse-pair resolving time <5 ns**
- **Quick and accurate walk adjustment with a zero-crossing signal monitor that displays the full amplitude range**
- **Blocking or updating outputs with adjustable widths**
- **Selectable functions for each of the four channels include a fast veto input, individual gates with coincidence/anticoincidence options, and a bin gate**



The Model 935 Quad 200-MHz Constant-Fraction Discriminator incorporates four separate and independently adjustable timing discriminators in a single-width NIM module. Except where indicated otherwise, the descriptions and specifications apply to each of the four channels in the module.

The ability of the Model 935 to provide constant-fraction timing on fast, negative-polarity signals as narrow as 1 ns (FWHM) makes it ideal for use with microchannel plates, fast photomultiplier tubes, fast scintillators, and fast silicon detectors. The exceptionally low walk delivered by the Model 935 is vital in achieving the excellent time resolution inherent in these fast detectors over a wide dynamic range of pulse amplitudes. The Model 935 can also be used with scintillators such as NaI(Tl) which have long decay times. To prevent multiple triggering on the long decay times, the width of the blocking output can be adjusted up to 1 μ s in duration.

The Model 935 uses the constant-fraction timing technique to select a timing point on each input pulse that is independent of pulse amplitude. When properly adjusted, the generation of the output logic pulse corresponds to the point on the leading edge of the input pulse where the input pulse has risen to 20% of its maximum amplitude. To achieve this constant-fraction triggering, the input pulse is inverted and delayed. The delay time is selected by an external delay cable (DLY) to be equal to the time taken for the input pulse to rise from

20% of maximum amplitude to maximum amplitude. Simultaneously, the prompt input signal is attenuated to 20% of its original amplitude. This attenuated signal is added to the delayed and inverted signal to form a bipolar signal with a zero crossing. The zero crossing occurs at the time when the inverted and delayed input signal has risen to 20% of its maximum amplitude. The zero-crossing discriminator in the Model 935 detects this point and generates the corresponding timing output pulse.

"Walk" is the systematic error in detecting the time for the 20% fraction as a function of input pulse amplitude. Minimizing walk is important when a wide range of pulse amplitudes must be used, because walk contributes to the time resolution. The Model 935 uses a transformer technique for constant-fraction shaping to achieve the exceptionally wide bandwidth essential for processing input signals with subnanosecond rise times. As shown in Fig. 1, this results in a walk guaranteed $<\pm 50$ ps and typically $<\pm 25$ ps over a 100:1 dynamic range of input pulse amplitudes. The patented shaping technique also provides a zero-crossing monitor output that facilitates quick and accurate walk adjustment, because it displays the full input signal amplitude range.

The extremely short pulses from microchannel plate multipliers and ultrafast photomultiplier tubes require very short constant-fraction shaping delays. To accommodate these detectors, the Model 935 incorporates a selectable compensation for the inherent internal delay.

The Model 935 includes a number of controls that considerably broaden its utility. The threshold discriminator is useful for rejecting low-level noise. A front-panel test point permits precise measurement of its setting in the range from -20 to -1000 mV. Each channel provides three bridged timing outputs. These are standard, fast negative NIM outputs. The outputs can be selected to have either updating or blocking characteristics. The updating mode is useful for reducing dead time in overlap coincidence experiments. The blocking

935 Quad 200-MHz Constant-Fraction Discriminator

mode simultaneously minimizes multiple triggering and dead time on scintillators with long decay times. The output pulse width is adjustable from <4 ns to >200 ns in the updating mode, and from <5 ns to >1 μ s in the blocking mode. The pulse-pair resolution is <5 ns at minimum pulse width in the updating mode.

Switches on the printed circuit board allow selection of which channels will respond to the front-panel fast-veto input. Additional fast gating capability is provided by individual gate inputs for each channel on the rear panel. The mode of these separate gate inputs can be individually selected to be either coincidence or anticoincidence via DIP switches on the printed circuit board. Each channel can also be programmed to ignore or respond to the slow bin gate signal on pin 36 of the power connector for NIM bins incorporating that signal.

Specifications

The Model 935 contains four independent and identical constant-fraction discriminators. Except where stated otherwise, the descriptions and specifications are given for an individual channel, and apply to each of the four channels.

PERFORMANCE

WALK Guaranteed $\leq \pm 50$ ps (typically $\leq \pm 25$ ps) over a 100:1 dynamic range. Measured under the following conditions: input pulse amplitude range from 50 mV to 5 V, rise time <1 ns, pulse width 10 ns, external shaping delay approximately 1.6 ns (33 cm or 13 in.), internal offset delay enabled, threshold approximately 20 mV.

CONSTANT FRACTION 20%.

PULSE-PAIR RESOLUTION <5 ns in the updating mode, <7 ns in the blocking mode.

INPUT/OUTPUT RATE Operates at burst rates >200 MHz in the updating mode, and >150 MHz in the blocking mode.

TRANSMISSION DELAY Typically <13 ns with 1.6-ns external delay.

OPERATING TEMPERATURE RANGE 0 to 50°C.

THRESHOLD TEMPERATURE

SENSITIVITY <0.01%/°C, from 0 to 50°C. Threshold referenced to the -12 V supply level supplied by the NIM bin.

TRANSMISSION DELAY TEMPERATURE SENSITIVITY $\leq \pm 10$ ps/°C from 0 to 50°C.

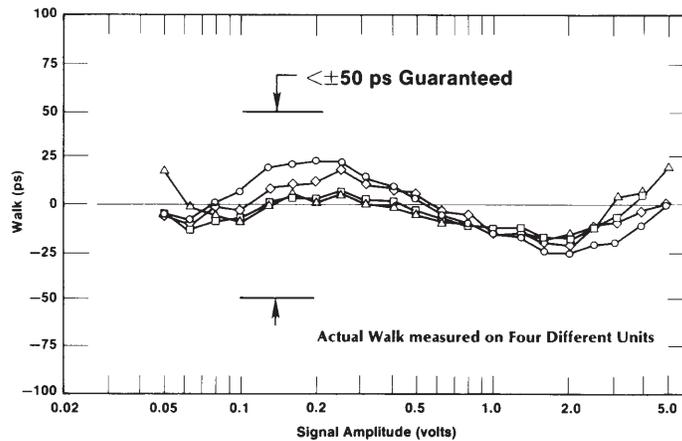


Fig. 1. Actual Walk Measured on Four Different Units. See Walk Specification for Measurement Conditions.

CONTROLS

THRESHOLD (T) A front-panel, 20-turn screwdriver adjustment for each discriminator channel sets the minimum pulse amplitude that will produce a timing output. Variable from -20 to -1000 mV. A front-panel test point located to the left of the threshold adjustment monitors the discriminator threshold setting. The test point voltage is 10X the actual threshold setting. Output impedance: ≤ 2 k Ω .

WALK ADJUSTMENT (Z) A front-panel, 20-turn screwdriver adjustment for fine-tuning the zero-crossing discriminator threshold to achieve minimum walk. Adjustable over a ± 15 mV range. A front-panel test point located to the left of the walk adjustment monitors the actual setting of the zero-crossing discriminator. Output impedance, 1 k Ω .

OUTPUT WIDTH (W) A front-panel, 20-turn screwdriver adjustment for each discriminator channel sets the width of the three output logic pulses. The range of width adjustment depends on the positions of jumpers W2 and W3.

B GATE ON/OFF Rear-panel switch turns the Bin Gate on or off for all channels programmed to accept the Bin Gate.

GATE COIN/ANTI A printed wiring board DIP switch selects either the coincidence or anticoincidence mode for the individual channel's response to the rear-panel gate input.

VETO YES/NO A printed wiring board DIP switch selects whether or not an individual channel will respond to the front-panel VETO input.

BIN GATE YES/NO A printed wiring board DIP switch selects whether or not an individual channel will respond to the bin gate

Table 1. The Dependence of the Output Pulse Width Range on W2 and W3 Jumper Positions.

W3 Jumper Position	Output Pulse Width Adjustment Range W2 = U Updating	W2 = B Blocking
open	<4 to >100 ns	<5 to >100 ns
S	<4 to >200 ns	<5 to >200 ns
S + L	Not functional	<30 ns to >1 μ s

signal.

INTERNAL OFFSET DELAY (W1) Printed wiring board jumper W1 is normally omitted to enable the 1.7-ns internal offset delay. This delay compensates for internal delays and makes it possible to implement the very short shaping delays required with 1-ns input pulse widths. With jumper W1 installed, the minimum shaping delay is limited by a +0.7-ns internal contribution. With W1 omitted, the internal delay contribution is effectively -1.0 ns. The Model 935 is shipped from the factory with the W1 jumper omitted. Spare jumpers for this position are located in the storage area towards the rear of the module.

UPDATING/BLOCKING MODE (W2) The printed wiring board jumper W2 selects either the updating mode (U), or the blocking mode (B) for the output pulse widths. In the blocking mode, a second input pulse will generate no output pulse if it arrives within the output pulse width W caused by a previous input pulse. In the updating mode, a second input pulse arriving within the output pulse width W from a previous pulse will extend the output pulse, from the time of arrival, by a length W. The Model 935 is shipped from the factory in the updating mode.

935 Quad 200-MHz Constant-Fraction Discriminator

OUTPUT PULSE WIDTH RANGE (W3) The printed wiring board jumper W3 selects the range of output width adjustment as listed in Table 1. The Model 935 is shipped from the factory with the W3 jumper omitted. Spare jumpers for this position are located in the storage area towards the rear of the module.

INPUTS

IN1, IN2, IN3, or IN4 A front-panel LEMO connector input on each channel accepts the fast linear signal from a detector for constant-fraction timing. Linear range from 0 to -10 V. Signal input impedance, $50\ \Omega$, dc-coupled; input protected with diode clamps at ± 10 V. Input reflections $<10\%$ for input rise times >2 ns.

GATE INPUTS 1, 2, 3, or 4 A rear-panel BNC connector for each channel accepts a negative, fast NIM logic signal to gate the respective constant-fraction timing output. Coincidence or anticoincidence gating is selected by a printed wiring board DIP switch (See GATE COIN/ANTI). Input impedance, $50\ \Omega$. For proper gating operation, the leading edge of the GATE INPUT should precede the IN1 (IN2, IN3, or IN4) signal by 1 ns and have a width equal to the CF Shaping Delay plus 5 ns.

VETO A single, front-panel LEMO connector accepts NIM negative fast logic pulses to inhibit the timing outputs on all the channels chosen with the VETO YES/NO switch. Input impedance, $50\ \Omega$. For proper FAST VETO operation, the leading edge of the VETO signal must precede the IN1 (IN2, IN3, or IN4) signal by 3 ns and have a width equal to the CF Shaping Delay plus 5 ns.

BIN GATE A slow master gate signal enabled by the rear-panel B GATE ON/OFF switch permits gating of the timing outputs when the Model 935 is installed in a bin that provides a bin gate signal on pin 36 of the NIM power connector. Clamping pin 36 to ground from $+5$ V inhibits operation of all channels selected by the BIN GATE YES/NO switch.

OUTPUTS

CF SHAPING DELAY (DLY) A front-panel pair of LEMO connectors for selecting the required constant-fraction shaping delay. A $50\text{-}\Omega$ cable is required. For triggering at a 20% fraction, the length of the shaping delay is approximately equal to the time taken for the input pulse to rise from 20% of its full amplitude to full amplitude.

CF MONITOR (M) Permits observation of the constant-fraction shaped signal through a LEMO connector on the front panel. Output impedance, $50\ \Omega$, ac-coupled. The monitor output is attenuated by a factor of approximately 5 with respect to the input when driving a terminated $50\text{-}\Omega$ cable.

OUT Three bridged, updating or blocking, fast negative NIM output signals, furnished through front-panel LEMO connectors, mark the CF zero-crossing time. Amplitude -800 mV on $50\text{-}\Omega$ load. Each output connector has its own $51\text{-}\Omega$ resistor in series with the common output driver.

GND Front-panel test point provides a convenient ground connection for test probes.

EVENT-OCCURRED LED Front-panel LED for each channel indicates that an output signal has occurred.

ELECTRICAL AND MECHANICAL

POWER REQUIREMENTS The Model 935 derives its power from a NIM bin/power supply. Required dc voltages and currents are: $+24$ V at 0 mA; $+12$ V at 33 mA; $+6$ V at 225 mA; -6 V at 1400 mA; -12 V at 169 mA; -24 V at 55 mA.

WEIGHT

Net 1.1 kg (2.6 lb).

Shipping 2.0 kg (4.4 lb).

DIMENSIONS NIM-standard single-width module, 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.



Ordering Information

To order, specify:

Model	Description
935	Quad 200-MHz Constant-Fraction Discriminator

9307 pico-TIMING™ Discriminator

The ORTEC Model 9307 pico-TIMING Discriminator defines the arrival time of analog pulses from ultra-fast detectors with picosecond precision. Moreover, this superb performance is delivered over an extremely wide range of pulse heights with negligible influence of pulse amplitude on the timing output. With the Model 9307, the difficult task of adjusting pulse-shaping cables has been eliminated. The internal pulse shaping in the pico-TIMING Discriminator is optimum for single-photon or single-ion time measurements with microchannel plate detectors, microchannel plate photomultiplier tubes (PMTs), channeltrons, fast photomultiplier tubes, and fast silicon photodiodes.

The pico-TIMING Discriminator accepts analog input pulses with amplitudes ranging from -50 mV to -5 V, and pulse widths from 400 ps to 5 ns FWHM. The amplitude threshold for generating a timing output is adjustable from -25 mV to -1 V with a 10-turn locking dial.

Ultra-fast circuits are incorporated in the pico-TIMING Discriminator to minimize time slewing. As a result, input amplitudes can vary over as much as a

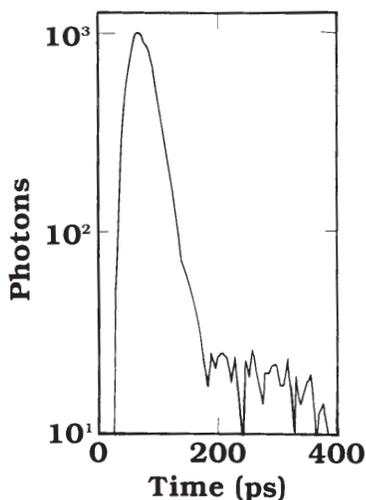


Figure 1. The Fluorescence Lifetime Instrument Response Function Recorded with a Model 9306 1-GHz Pre-amplifier and the Model 9307 pico-TIMING Discriminator.

Time resolutions from 30 to 60 ps FWHM are possible with the system shown in Figure 2.

- **Ideal for microchannel plate detectors, microchannel plate photomultiplier tubes, channeltrons, fast silicon photodiodes, and fast photomultiplier tubes**
- **Accepts input pulse widths from 400 ps to 5 ns, and pulse amplitudes from -50 mV to -5 V**
- **Time slewing $<\pm 20$ ps from -150 mV to -1.5 V**
- **Optimized internal pulse shaping eliminates cable adjustment**
- **One TTL output and two fast negative NIM timing outputs**
- **Threshold adjustable from -25 mV to -1 V**

100:1 range with negligible shift in the timing output. This ensures excellent time resolution, even when the signal source produces a wide range of randomly varying signal amplitudes. A front-panel screwdriver adjustment permits fine-tuning the slewing compensation to match the characteristics of a particular detector. An adjacent test point makes it easy to monitor the adjustment with a voltmeter.

Two fast negative NIM outputs provide the flexibility to trigger a time-to-amplitude converter (TAC) while simultaneously driving other instruments. The 500-ns-wide TTL output can be used with instruments that require a positive logic signal, such as counters and ratemeters. A front-panel LED flashes with each output pulse to indicate triggering.

For detectors having rise times less than 1 ns, the ORTEC Model 9306 1-GHz Pre-amplifier should be used to amplify small signals before presentation to the input of the Model 9307 pico-TIMING Discriminator. For rise times ≥ 1 ns, the Model VT120 Fast-Timing Pre-amplifier should be substituted for the Model 9306. The Model 9307 incorporates a compatible, 9-pin D connector on its rear panel to supply power to either pre-amplifier.



9307 pico-TIMING Discriminator

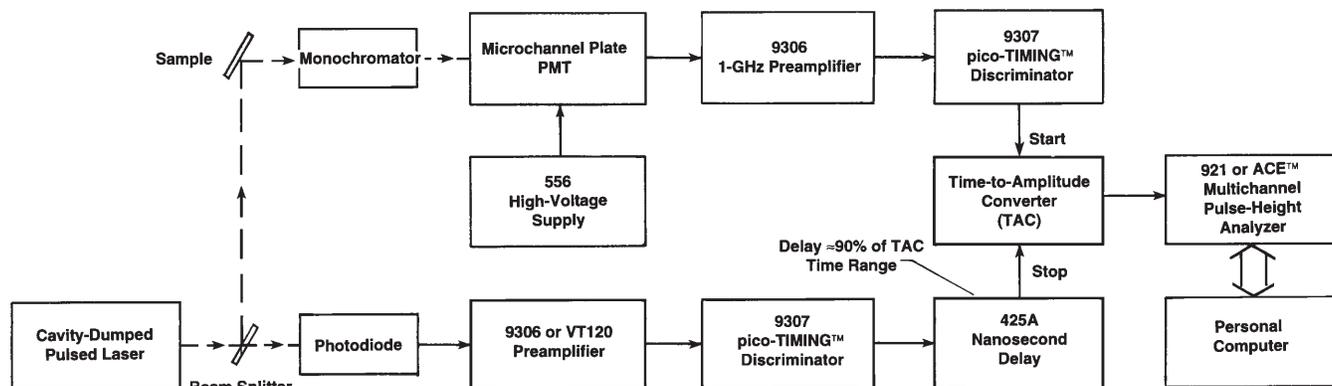


Figure 2. Typical Block Diagram for a Fluorescence Lifetime Spectrometer.

Specifications

PERFORMANCE

TIME SLEWING (Walk) $< \pm 20$ ps shift in the timing output for input signal amplitudes from -150 mV to -1.5 V. (Typically $< \pm 50$ ps for signal amplitudes from -50 mV to -5 V.) Measured using a 1-ns-wide input pulse with 350-ps rise and fall times.

PULSE-PAIR RESOLUTION < 10 ns at the fast negative NIM outputs.

MAXIMUM INPUT/OUTPUT RATE Accepts burst rates up to 100 MHz.

OPERATING TEMPERATURE RANGE 0 to 50°C .

THRESHOLD TEMPERATURE SENSITIVITY $< \pm 0.1$ mV/ $^\circ\text{C}$ (0 to 50°C).

TRANSMISSION DELAY TEMPERATURE SENSITIVITY $< \pm 10$ ps/ $^\circ\text{C}$ (0 to 50°C).

CONTROLS AND INDICATORS

THRESHOLD Front-panel, 10-turn potentiometer with locking dial allows adjustment of the input discriminator threshold from -25 mV to -1 V.

SLEWING COMPENSATION Front-panel, 20-turn, screwdriver fine-tuning to minimize time slewing as a function of input pulse amplitude. Adjustable over a range of approximately ± 30 mV. A front-panel test point located next to the potentiometer facilitates monitoring the actual setting. Test point output impedance: 100Ω .

OUTPUT LED Front-panel LED flashes on each output pulse to indicate active triggering.

INPUTS

INPUT Front-panel SMA connector accepts unipolar input signals with amplitudes in the range of -50 mV to -5 V. Minimum input pulse width: 400 ps (FWHM). Maximum input pulse width: 5 ns (FWHM). Input impedance: 50Ω . The input is protected to ± 5 V.

OUTPUTS

FAST NEGATIVE NIM OUTPUTS Front-panel BNC connectors provide two independent, fast negative NIM output logic pulses. Output amplitude is nominally -800 mV into a $50\text{-}\Omega$ load. Pulse width is nominally 2.5 ns.

TTL OUTPUT Front-panel BNC connector provides a positive TTL pulse, triggered by the fast negative NIM output. The 500-ns width of the TTL pulse is non-updating. Output impedance: $< 1 \Omega$, short-circuit protected.

PREAMP POWER Rear-panel, 9-pin D connector provides $\pm 12\text{-V}$ and $\pm 24\text{-V}$ power for the ORTEC Model 9306 1-GHz Preamplifier, the Model VT120 Fast-Timing Preamplifier, or other preamplifiers utilizing the industry-standard preamplifier power plug.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model 9307 derives its power from a NIM bin/power supply, such as the ORTEC Model 4001A/4002D. Required dc voltages and currents are: $+12$ V at 35 mA, $+6$ V at 70 mA, -6 V at 360 mA, and -12 V at 100 mA.

WEIGHT

Net 0.9 kg (2.0 lb).

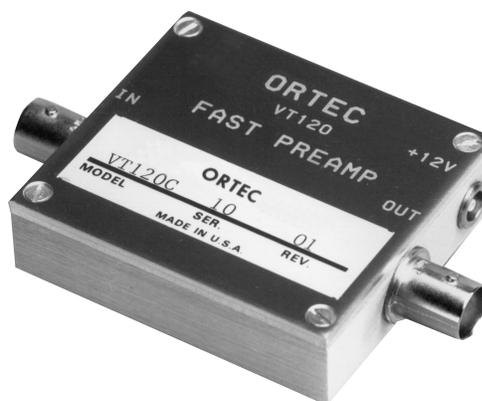
Shipping 1.8 kg (4.0 lb).

DIMENSIONS NIM-standard single-width module, 3.43 X 22.13 cm (1.35 X 8.714 in.) front panel per DOE/ER-0457T.

Optional Accessories

The **Model 9306 1-GHz Preamp** is recommended for amplifying ultra-fast analog signals before presentation to the input of the Model 9307 pico-TIMING Discriminator. These ultra-fast analog signals require the use of 50-Ω coaxial cable with SMA connectors. To preserve the 350-ps rise time of the 9306, the total cable length from the detector to the preamplifier, and from the preamplifier to the 9307 should be <1.7 m. Consult the ordering information below for the appropriate SMA cables and adapters.

For detectors having rise times >1 ns, the **Model VT120 Fast-Timing Preamp** should be substituted for the Model 9306. In that case, 50-Ω coaxial cables with BNC connectors can be used. Consult the list below for BNC to SMA adapters, and refer to the Cables and Accessories section of the ORTEC catalog for the desired cables.



Ordering Information

To order, specify:

Model	Description
9307	pico-TIMING™ Discriminator
SMA58-0.15	RG-58A/U (50-Ω) Coaxial Cable with SMA Connectors, 0.15-m length
SMA58-0.5	RG-58A/U (50-Ω) Coaxial Cable with SMA Connectors, 0.5-m length
SMA58-1.5	RG-58A/U (50-Ω) Coaxial Cable with SMA Connectors, 1.5-m length
SMA/BNC	SMA to BNC Adapter with male SMA and female BNC
BNC/SMA	BNC to SMA Adapter with male BNC and female SMA



9327 1-GHz Amplifier and Timing Discriminator



- For picosecond timing with mV signals from
Microchannel Plate Detectors
Microchannel Plate PMTs
Fast Photodiodes
Fast Photomultiplier Tubes
- 1-GHz Amplifier and Timing Discriminator are internally matched for minimum walk and timing jitter
- Walk typically $\leq \pm 40$ ps over the top 90% of full scale
- Jitter < 20 ps FWHM at 50% of full scale
- Optimized for pulse widths from 250 ps to 1 ns; accepts pulse widths up to 5 ns
- Selectable input pulse height range: 0 to -30 mV, or 0 to -150 mV full scale
- 2:1 Fine Gain control
- Over-Range LED for precise gain adjustment without an oscilloscope

The Model 9327 1-GHz Amplifier and Timing Discriminator combines into one compact preamplifier sized package the two functions normally needed for picosecond timing with ultra-fast detectors. It is ideal for Fluorescence/Phosphorescence Lifetime Spectrometry (Fig. 1), Time-of-Flight Mass Spectrometry (Fig. 2) and LIDAR applications. The Model 9327 is optimized for use with the millivolt signals produced by microchannel plate detectors, microchannel plate photomultiplier tubes, fast photodiodes, and fast, discrete-dynode photomultiplier tubes. The compact package avoids degradation of the sub-nanosecond signals from these detectors by enabling an exceptionally short cable connection between the detector and the amplifier. The timing discriminator output logic pulse can be transmitted over much longer cables to the rest of the time spectrometer without compromising the picosecond time resolution.

The amplifier provides a 1-GHz bandwidth to minimize the noise and rise time contributions to timing jitter on detector pulses having widths as narrow as 250 ps. The 50- Ω amplifier input includes diode clamps to protect against overload pulses. A PC-board-mounted jumper controls the coarse gain to yield two ranges for full-scale input pulse amplitudes: 0 to -30 mV and 0 to -150 mV. A fine gain control permits varying the gain over nominally a 2:1 range. An oscilloscope is not needed to adjust the gain, because an over-range LED indicates when pulse amplitudes have exceeded the full-scale limit of the amplifier. Detector and/or amplifier gain can be increased until the over-range LED turns on, and then decreased until the LED just turns off. This ensures that the pulses utilize all of the amplifier's linear range.

The timing discriminator employs a zero-crossing technique that processes pulse widths from 250 ps to 5 ns without the

need to adjust pulse-shaping cables. The zero-crossing technique results in minimal timing jitter and walk as a function of pulse amplitude. It is optimized for sub-nanosecond pulse widths, but will accommodate pulses up to 5 ns wide. The shift in the timing output (walk) as a function of pulse amplitude is typically less than ± 40 ps over the top 90% of full scale when employing a 300-ps input pulse width (Fig. 3). The typical contribution of the 9327 to timing jitter is illustrated in Figure 4. With such a small contribution from the 9327, the detector normally becomes the dominant source of timing jitter. The Model 9327 includes a noise discriminator adjustable over a major fraction of full scale. With the source of detector events turned off, the discriminator threshold can be adjusted until the associated LED is turned on by triggering on noise. Subsequently, the threshold is adjusted until the LED just turns off, thus ensuring that the discriminator will not trigger on noise.

9327 1-GHz Amplifier and Timing Discriminator

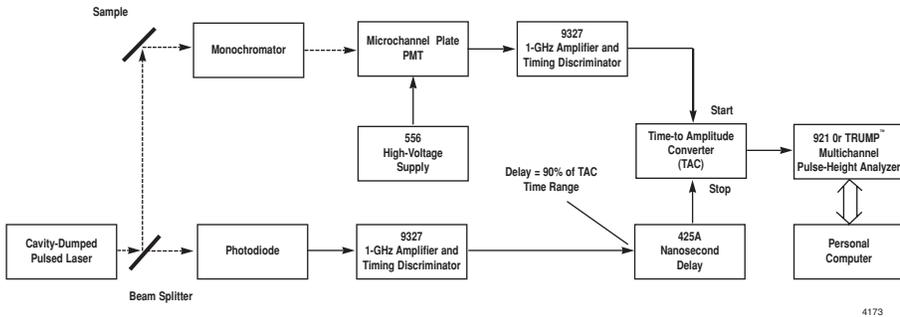


Fig. 1. Typical Block Diagram for a Fluorescence Lifetime Spectrometer (with reversed start/stop assignments).

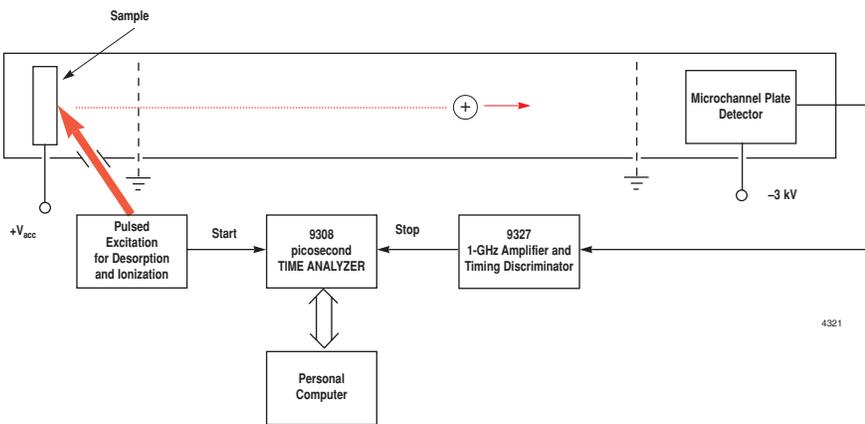


Fig. 2. The Model 9327 in a Simplified Illustration of a Time-of-Flight Mass Spectrometer.
The Model 9308 picosecond TIME ANALYZER functions as a multiple-stop time spectrometer.

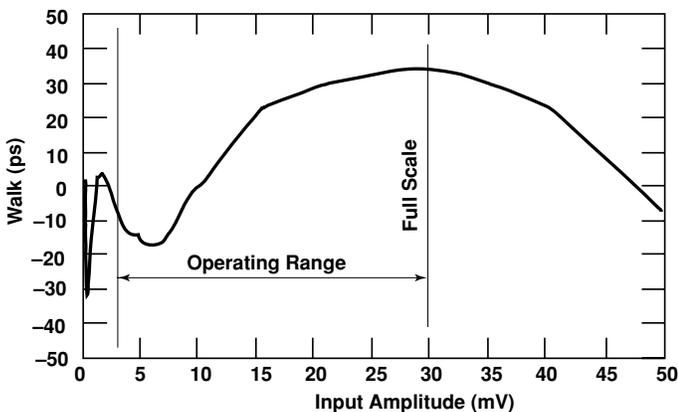


Fig. 3. Typical Walk vs. Pulse Amplitude. Full scale is denoted by the Over Range LED turning on. Measured with a pulse width of 300 ps FWHM.

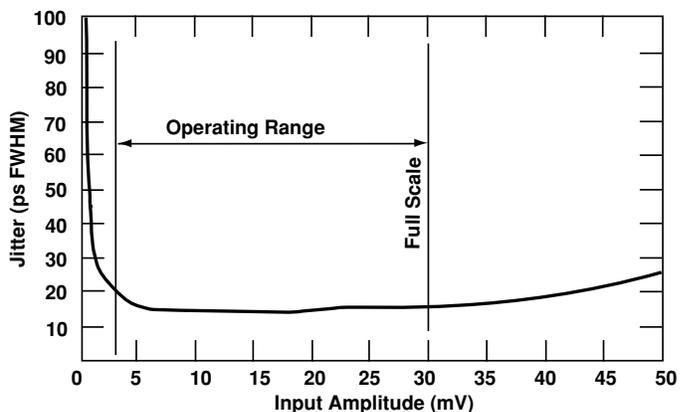


Fig. 4. Timing Jitter vs. Pulse Amplitude. Measured with the system in Fig. 1 by replacing the detectors with a pulser having a pulse width of 300 ps FWHM. Full scale is denoted by the Over Range LED turning on.

9327

1-GHz Amplifier and Timing Discriminator

Specifications

PERFORMANCE

Performance is measured on the 0 to -30 mV input range unless specified otherwise.

INPUT RANGE 0 to -30 mV (full scale) or 0 to -150 mV (full scale), selectable via a circuit board jumper.

EQUIVALENT INPUT NOISE <100 μ V rms on the 0 to -30 mV range.

TIME SLEWING (Walk) Typically ± 40 ps shift in the timing output as a function of pulse amplitude over the top 90% of full scale. Includes the contribution of both the amplifier and the timing discriminator. Measured with an input pulse width of 300 ps FWHM.

TIMING JITTER <20 ps FWHM for a pulse amplitude at 50% of full scale. Measured with the same pulse shape listed under TIME SLEWING.

PULSE-PAIR RESOLUTION <10 ns at the fast negative NIM outputs.

OPERATING TEMPERATURE RANGE 0 to 50°C .

TRANSMISSION DELAY TEMPERATURE SENSITIVITY <10 ps/ $^{\circ}\text{C}$ from 0 to 50°C . Measured at 50% of full scale with the pulse shape listed under TIME SLEWING.

INPUTS AND OUTPUTS

INPUT (Amplifier) Rear-panel SMA connector for negative input pulses. Accepts pulse widths from 250 ps to 5 ns FWHM. Optimized for sub-nanosecond pulse widths. Input range is jumper selectable for 0 to -30 mV or 0 to -150 mV. Input impedance: $50\ \Omega$ ac, $<1000\ \Omega$ dc to ground. Diode clamps provide protection against overload to ± 2 V dc, or ± 10 V for a 50 ns-wide pulse at a duty cycle $<1\%$.

AMP OUT Rear-panel SMA test point suitable for oscilloscope monitoring via a $50\text{-}\Omega$ coaxial cable terminated in $50\ \Omega$. Test point output impedance: $1000\ \Omega$. The amplifier drives the timing discriminator input in parallel with the output monitor via an internal connection.

NIM OUT Front- and rear-panel BNC connectors provide two independent, fast-negative NIM output logic pulses. Output amplitude is nominally -800 mV into a $50\text{-}\Omega$ load. Pulse width is nominally 4 ns.

TTL OUT Rear-panel BNC connector provides a positive TTL pulse, triggered by the fast-negative NIM output. The 100-ns width of the TTL pulse is non-updating. Output impedance: $<50\ \Omega$, short-circuit protected.

THRESH Front-panel test-point jack near the THRESH control permits monitoring of the threshold setting with a voltmeter for resettability. Output impedance is $1000\ \Omega$. Nominal output range is -10 mV to -1 V.

WALK Front-panel test-point jack near the WALK adjustment for monitoring the walk (time slewing) adjustment. See WALK under Controls and Indicators.

GND Front-panel test-point jack for connecting the ground lead of a voltmeter.

CONTROLS AND INDICATORS

INPUT RANGE (Coarse Gain) Circuit board jumper near the amplifier INPUT permits input range selection for 0 to -30 mV or 0 to -150 mV.

FINE GAIN Front-panel, 15-turn screwdriver adjustment to calibrate the full-scale sensitivity. Can be used as a fine gain control with approximately a 2:1 range of gain adjustment.

THRESH Front-panel, 15-turn screwdriver adjustment to set the input discriminator threshold. Adjustable from $<2\%$ to $>50\%$ of full scale. THRESH test-point jack permits monitoring the setting with a voltmeter.

WALK Front-panel, 15-turn, screwdriver fine tuning to minimize time slewing as a function of input pulse amplitude. Adjustable over a range of approximately ± 150 mV. A WALK test jack permits monitoring the actual voltage setting through an output impedance $<100\ \Omega$.

OUTPUT LED Front-panel, LED flashes on each output pulse to indicate active triggering. Used to set the threshold beyond the noise level.

OVER RANGE LED Front-panel, LED flashes on each preamplifier pulse that has an amplitude exceeding full scale. Used during detector gain adjustment to avoid overloads while maximizing pulse amplitudes.

PWR LED Front-panel LED indicates when power is being supplied to the unit.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model 9327 derives its power through a 3-meter long (9-ft.) captive power cable terminated with a 9-pin D, preamplifier power connector. This connector is compatible with the preamplifier power connectors on ORTEC Models 9308, 4003, 4002P, or most ORTEC spectroscopy amplifiers. Power required is $+12$ to $+15$ V at 350 mA (Pin 4) and ground (Pins 1 and 2).

WEIGHT

Net 0.48 kg (1.1 lb).

Shipping 1.1 kg (2.5 lb).

DIMENSIONS Approximately 3.3 cm x 12.5 cm x 13.5 cm (1.3 in. x 4.9 in. x 5.3 in.).

MISCELLANEOUS Meets EEC standards (CE) for emissions, susceptibility, and power.

Ordering Information

To order, specify:

Model	Description
9327	1-GHz Amplifier and Timing Discriminator

Suggested Cable Accessories:

SMA58-0.15	RG-58A/U (50- Ω) Coaxial Cable with SMA connectors, 0.15-m length
SMA/BNC	SMA to BNC Adapter with male SMA and female BNC
BNC/SMA	BNC to SMA Adapter with male BNC and female SMA
C-25-12	RG-58A/U (50- Ω) Coaxial Cable with BNC connectors, 3.7-m (12-ft) length

Time-to-Amplitude Converters and Time Calibrator

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Choosing the Right TAC

The following topics provide the information needed for selecting the right time-to-amplitude converter (TAC) for the task. The basic principles of operation are described, and the critical operating characteristics are delineated. The selection guide chart just prior to the data sheets provides a quick reference to the major features of the full range of ORTEC models. Details are listed in the data sheet for each product.

Timing with TACs

When a timing application demands picosecond precision, a time-to-amplitude converter is a prime candidate. A TAC can achieve such exceptional precision because it uses an analog technique to convert small time intervals to pulse amplitudes. Figure 1 illustrates the principle. (Although the actual circuitry in a TAC employs sophisticated transistor switches, the devices in Fig. 1 have been represented as toggle switches for a simpler description.)

Before a time measurement starts, all the switches in Fig. 1 are closed. The arrival of the leading edge of the "start" signal opens the "start" switch, and the converter capacitor begins to charge at a rate set by the constant-current source. The leading edge of the "stop" signal opens the "stop" switch and prevents any further charging of the capacitor. Because the charging current I is constant, the voltage developed on the capacitor is given by

$$V = \frac{I t}{C} \quad (1)$$

where t is the time interval between start and stop pulses and C is the capacitance of the converter capacitor. Consequently, the voltage is proportional to the time interval. This voltage pulse is passed through the buffer amplifier to the linear gate. A short time after the stop pulse arrives, the linear gate switch opens to pass the voltage pulse through the output amplifier to the TAC output. After a few microseconds, all the switches return to the closed condition. This terminates the output pulse and discharges the capacitor to ground potential in preparation for the next pair of start and stop events. The result is a rectangular output pulse with a width of a few microseconds and an amplitude that is proportional to the time interval between the start and stop pulses. This pulse is typically fed to an ADC or a multichannel analyzer for pulse-height measurement.

As the conversion and measurement process is repeated for additional pairs of start and stop pulses, a time spectrum grows in the multichannel analyzer memory. The shape of this spectrum will depend on the time correlations between the start and stop events. For strongly correlated events, as experienced in gamma-gamma coincidence experiments, the spectrum is usually a well-defined peak with a shape that is nearly Gaussian. In fluorescence lifetime measurements, the time peak has a sharp rise at "zero" time followed by an exponential decay. In the case of totally uncorrelated start and stop events, the shape of the spectrum is determined by the Interval Distribution, which describes the probability of the length of time intervals between randomly arriving events.¹ If

¹Ron Jenkins, R. W. Gould, Dale Gedcke, Quantitative X-Ray Spectrometry, Marcel Dekker, New York, 1981, First Edition, Chapter 4.

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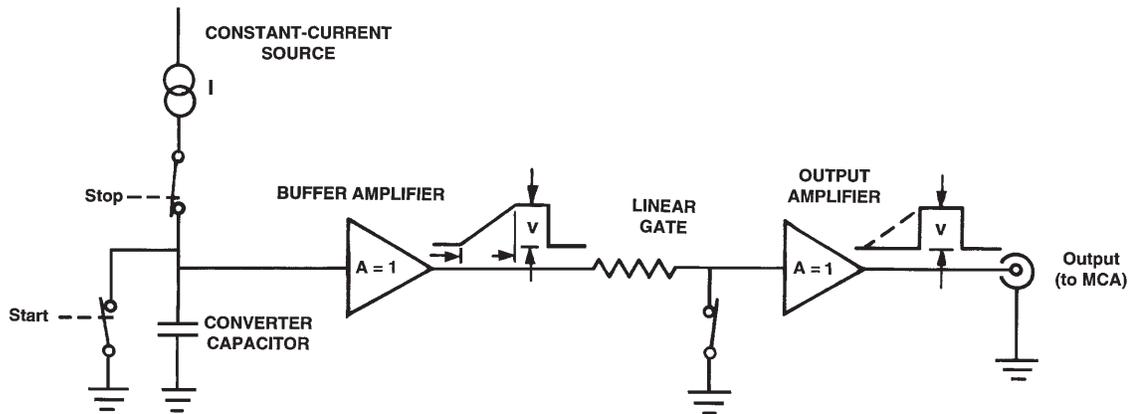


Fig. 1. A Functional Diagram of a Time-to-Amplitude Converter.

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n_{start} is the number of valid start pulses accepted by the TAC and MCA during the measurement of the time spectrum, and r_{stop} is the average counting rate of the random, uncorrelated stop pulses, the number of counts recorded between times t and $t + dt$ in the time spectrum will be

$$dN = n_{\text{start}} r_{\text{stop}} e^{(-r_{\text{stop}} t)} dt \quad (2)$$

If r_{stop} is very small compared to the reciprocal of the TAC time range, the spectrum from the uncorrelated events will appear to be a flat background.

Typically, the start and stop inputs of time-to-amplitude converters are designed to accept the fast logic signals from timing discriminators. Each timing discriminator, in turn, derives its signal from the amplified output of some type of detector or transducer. (See the sections in this catalog on Fast Timing Discriminators and Single-Channel Pulse-Height Analyzers.) On the shortest time ranges, time-to-amplitude converters can deliver exceptionally fine time resolution (~10 ps). Under such circumstances, the controlling factors for time resolution are normally the timing jitter and walk contributed by the sources of the start and stop signals.

Adding Delays and Biased Amplifiers

Because of the nature of the TAC circuitry, it is difficult to measure time intervals <10 ns with good linearity. However, many measurements involve start and stop signals that arrive within ± 10 ns of each other. The solution for these situations is to insert an appropriate delay in the stop signal path. Selecting a delay in the range of 10 to 30 ns on an ORTEC Model 425A Nanosecond Delay is usually sufficient to move the timing peak into the linear region of the time spectrum. The stop delay can also be adjusted to center the features of interest in the time spectrum.

In some cases, it is desirable to expand a particular feature in the time spectrum for examination on a magnified time scale. This function can be achieved by replacing the output amplifier

in Fig. 1 with a biased amplifier. (See the Amplifier section of this catalog for a description of the biased amplifier function.) The bias level is set adjacent to the feature, and the gain of the biased amplifier is used to magnify the time scale of the feature. The Model 457 TAC includes a biased amplifier for this purpose.

A TAC Makes Coincidence Set-Ups Much Easier

By adding a single-channel pulse-height analyzer (SCA) to the output of a TAC, the time-to-amplitude converter can be used to identify coincident events between two detectors. To appreciate the power of this method, one must compare it to the alternative technique, the simple overlap coincidence circuit. Figure 2 illustrates the principle behind the overlap coincidence function offered in the ORTEC Models CO4020, 414A, and 418A. The overlap coincidence circuit is simply a two-input AND gate. As depicted by the waveforms in Fig. 2, the AND gate generates a "logic 1" output only when "logic 1"

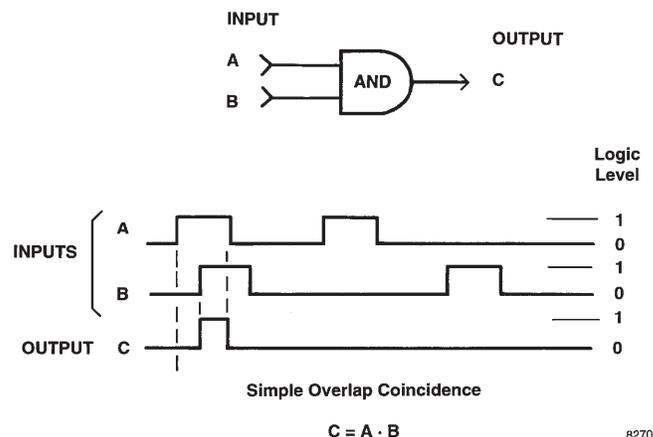


Fig. 2. The Basic Principle of an Overlap Coincidence Circuit.

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Time-to-Amplitude Converters and Time Calibrator

pulses are present on both the A and B inputs. In fact, the output is generated only for the time during which the A and B pulses overlap. This is the reason the circuit is known as an overlap coincidence.

Detecting truly coincident pulses places special restrictions on pulses A and B. First, the delays through the electronics producing the pulses must be the same for both detectors, so that both pulses arrive at the AND gate at the same time. Second, the width of each pulse must be equal to the maximum timing uncertainty for its respective detector. If the pulse width is too narrow or the delays are not quite matched, some of the truly correlated pulses will not overlap, and the C output will be missing. This represents a loss of coincidence detection efficiency. If the A or B pulses are too wide, uncorrelated events will have a higher probability of generating an output due to accidental overlap, and that is contrary to the purpose of the scheme. Choosing the proper pulse widths and delays to achieve 100% efficiency for identifying correlated events, while minimizing the sensitivity to uncorrelated events, requires a laborious series of trial-and-error measurements. Experimenters often avoid this task by making the pulse widths much larger than the "best guess" for the detector's timing uncertainty. Of course, the quality of the experiment will suffer if these pulses are either too wide or too narrow.

Figure 3 shows how a TAC with an SCA (i.e., Model 567 TAC/SCA) can be used to simplify the selection of the optimum coincidence resolving time. The prompt timing pulse from the germanium detector operates the start input of the TAC, while the delayed pulse from the scintillation detector

triggers the stop input. When the analog output of the TAC is analyzed by the multichannel analyzer, the spectrum in Fig. 4 is observed. There is a peak formed by the correlated gamma-ray events from the two detectors. This peak sits on an essentially flat background caused by the uncorrelated events from the two detectors. (See the comments following Equation 2.)

By connecting the logic output of the SCA to the gate input of the MCA, only those TAC pulses which fall within the SCA window will be analyzed by the MCA. With minimal effort, the SCA thresholds can be adjusted to ensure that only the events in the peak are accepted. Subsequently, the SCA output is used as the coincidence gate when analyzing the energy spectrum from the germanium detector on the MCA. By replacing the overlap coincidence with a TAC and SCA, the optimum coincidence resolving time can be selected quickly and with full knowledge of the intrinsic time resolution of the system.

Note that the SCA window for "correlated events" in Fig. 4 includes a background contribution from "uncorrelated events". The contribution of these uncorrelated events to the energy spectrum can be assessed by setting another SCA window of equal width in the uncorrelated background region of the time spectrum. This second SCA is used to gate a second MCA, which will record the energy spectrum corresponding to uncorrelated events. Subtraction of the two energy spectra will yield a spectrum free of the uncorrelated events. (NOTE: A minor correction to the second SCA window width based on Equation 2 may be required at high counting rates.)

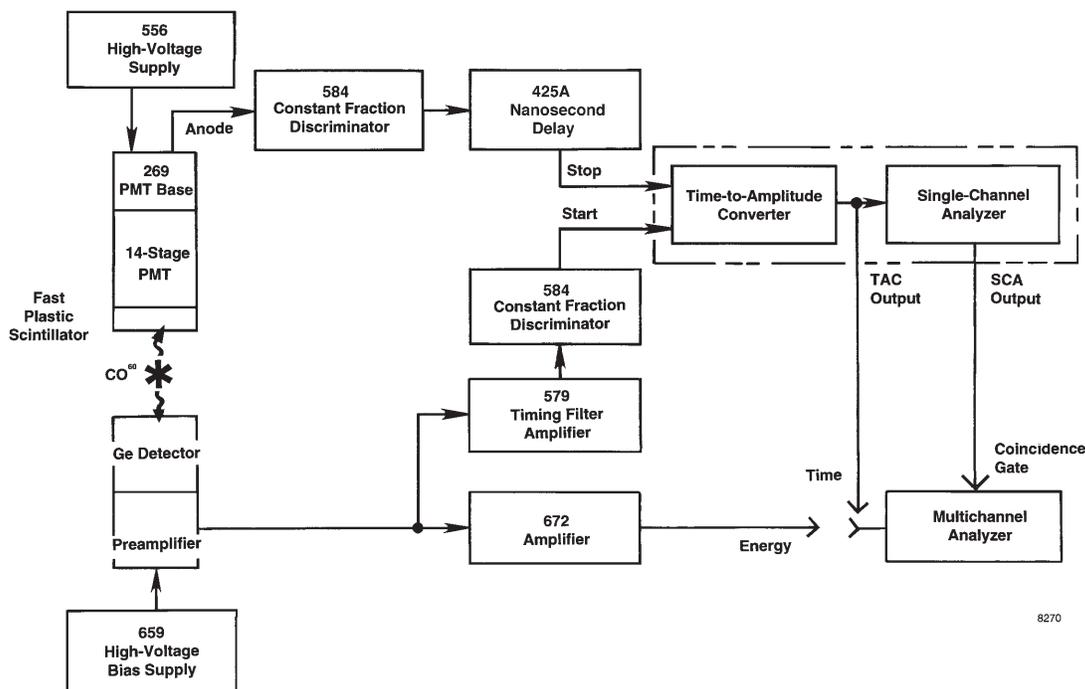


Fig. 3. The Use of a TAC and SCA for Coincidence Gating.

Time-to-Amplitude Converters and Time Calibrator

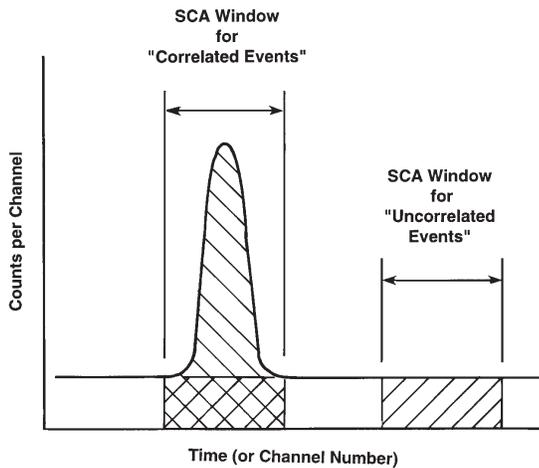


Fig. 4. The Time Spectrum from the TAC in Figure 3.

At extremely high counting rates the processing time of the TAC and SCA may contribute noticeably to the dead time losses of the coincidence spectrometer. In this rare case, an overlap coincidence with updating inputs and outputs is the better choice because of its inherently lower dead time for identifying coincident events.

Assigning Start and Stop Inputs for Lower Dead Time

If a very high counting rate is provided to the start input while an extremely low counting rate is supplied to the stop input, the TAC will spend a lot of time responding to start pulses that have no associated stop pulse within the selected time range. Starts with no stops will cause excessive dead time in the TAC without producing useful data. Reversing the input assignments so that the higher counting rate is on the stop input will minimize this dead time.

Reversing the start and stop inputs is particularly important in applications where a sample is excited by a periodic pulse and

the time spectrum of the reaction products emitted by the sample is to be recorded. Usually, the repetition rate of the periodic pulse is high and the counting rate of the reaction products is extremely low. Logically, one would expect the excitation pulse to be the start pulse and the reaction products to provide the stop pulses. But, this creates too much dead time in the TAC. To reduce the dead time, the reaction products should drive the start input while the excitation pulse is delayed and fed to the stop input. The length of the stop delay should be approximately 90% of the time range selected on the TAC. Fig. 5 is an example of the reversed start/stop technique applied to a fluorescence lifetime spectrometer.

Limiting the Counting Rate to Avoid Spectrum Distortion

A high-resolution TAC measures the time interval from the first accepted start pulse to the next stop pulse. It ignores all subsequent start pulses and any additional stop pulses until it has finished converting the first pair of start and stop pulses. If either input is receiving randomly distributed pulses at a very high counting rate, the TAC will prefer to analyze the pulses arriving earlier on that input and will suppress the pulses that arrive later. This will distort the measured time spectrum for correlated start and stop events. The distortion can be controlled by limiting the counting rates at the start and stop inputs. From Poisson statistics,¹ it can be shown that limiting the average random counting rate r at both start and stop inputs to

$$r < 0.01 / T_{\text{range}} \quad (3)$$

will ensure that the number of suppressed pulses in the analyzed time range T_{range} will be less than 0.5% of the number of accepted pulses on the respective input. This condition is adequate to ensure less than a 1% distortion of the time spectrum.

For a short time range, $T_{\text{range}} = 50 \text{ ns}$, the condition in Equation 3 limits the counting rate to 200,000 counts/s at both

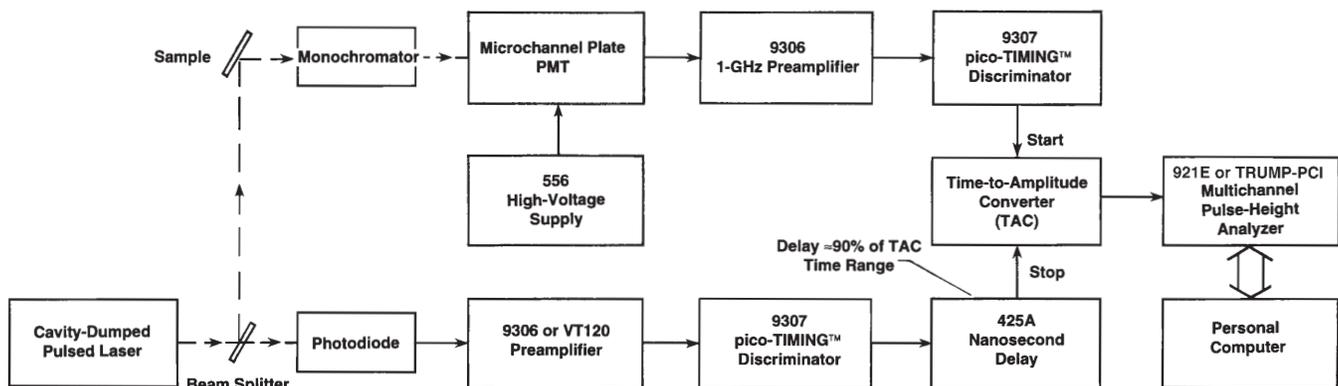


Fig. 5. A Typical Block Diagram for a Fluorescence Lifetime Spectrometer with Reversed Start/Stop Assignments.

Time-to-Amplitude Converters and Time Calibrator

the start and stop inputs to the TAC. This counting rate is still high enough to require an MCA with a conversion time of 5 μ s or less in order to keep up with the data from the TAC.

When an MCS is a Better Choice than a TAC

A time-to-amplitude converter is a productive solution for measurements on time ranges less than 10 μ s when time resolutions from 10 ps to 50 ns are required. However, a TAC can measure only a single time interval for each start pulse, and this limits its utility on the longer time ranges. For example, the condition in Equation 3 restricts the input rates to <1,000 counts/s on a 10- μ s time range. This is a low data acquisition rate. On a 1-ms time range, the input rate is limited to 10 counts/s, an extremely low data acquisition rate! Obviously, a time-to-amplitude converter is handicapped by low data acquisition rates on the longer time ranges when distortion of the time spectrum must be avoided.

Most measurements that require time ranges in excess of 10 μ s involve a controlled, pulsed source of excitation. In such circumstances, a multichannel scaler (MCS) is advantageous because it can accept multiple stop pulses for each start pulse. The pulsed excitation source starts the time scan on the MCS, and the events caused by the excitation are counted as a function of time on the counting input of the MCS. The result is a spectrum of the number of events versus the time after excitation. With a pulse-pair resolving time of 1 ns, the ORTEC Model 9353 is able to process average "stop" rates up to 10 MHz with less than 1% dead time losses, and burst rates up to 1 GHz. Of course, the period between excitation (start) pulses must be longer than the time interval being measured.

Clearly, the MCS is the more productive instrument for measuring time ranges longer than a few microseconds. However, the performance for some MCS models on shorter time ranges is limited by the intrinsic time resolution of set by the minimum possible dwell time.

Another alternative is offered by the Model 9308-pci picosecond TIME ANALYZER. The Model 9308-pci can measure time ranges down to 80 ns with resolutions and dead times equal to or better than a TAC. (Although, the TAC and MCA combination can be much less expensive.) Compared to the 9353, the Model 9308-pci can measure short time ranges with at least 80 times better digital resolution. The Model 9308-pci gains this advantage over the 9353 by sacrificing pulse-pair resolving time (50 ns in the 9308 contrasted with 1 ns for the 9353). However, the 9353 can accommodate significantly longer time ranges.

A TAC combined with the CAMAC multi-parameter ADCs is an ideal solution for measurements requiring correlated sampling of amplitude and time data from one or more detectors. The 9308-pci and 9353 are not suited for multi-parameter measurements.

Generally, one should consider a TAC for time ranges <1 μ s and multi-parameter measurements, the Model 9308-pci picosecond TIME ANALYZER for time ranges <164 μ s, and the 9353 for time ranges from microseconds to milliseconds. For further information on the latter two instruments see the Multichannel Scaler and Multiple-Stop Time Spectrometer section of this catalog.

Calibrating the Time Scale

The simplest way to calibrate the time scale of the spectrum recorded on the multichannel analyzer is to insert cable delays of known length between the timing discriminator output and the TAC input. The additional delay will shift the peak in the time spectrum. The amount of shift can be calibrated against the known value for the inserted delay. The Model 425A Nanosecond Delay is a convenient source of adjustable delays for this purpose.

For higher accuracy in calibrating the time scale, the Model 462 Time Calibrator is the better choice. This unit uses an accurate digital clock to produce stop pulses at precisely spaced intervals after a start pulse. A short data acquisition with the Model 462 connected to the TAC inputs results in multiple peaks in the spectrum. The spacing between these peaks corresponds to the period selected by the controls on the Model 462.

Accounting and Correcting for Dead Time in the TAC and MCA

The sources of dead time in a time spectrometer employing a TAC and MCA are easily identifiable, although the derivation of the throughput equations is somewhat more complicated. The time-to-amplitude converter is only able to process one pair of start and stop pulses in each conversion. Once a start pulse has been accepted all further start pulses are ignored until the conversion and reset processes are finished. Similarly, the TAC responds to the first stop pulse that arrives after the accepted start pulse, and ignores all subsequent stop pulses until the next valid start pulse has been accepted. As a result, subsequent start pulses find the start input to be dead from the time of acceptance of the last valid start pulse until the end of the TAC reset. Additional stop pulses find the stop input to be dead from the time the first stop pulse is accepted (following a valid start pulse) until the time of acceptance of the next start pulse.

If the multichannel analyzer dead time is longer than the TAC dead time, the MCA can also contribute to the dead time losses, because the MCA will not always be ready to accept the next TAC output. Choosing an MCA conversion time that is less than the minimum TAC dead time eliminates the MCA dead time contribution. If the MCA dead time is longer than the TAC dead time, one can gate off the TAC start input with the MCA busy signal in order to use the throughput equations developed below.

Time-to-Amplitude Converters and Time Calibrator

The following throughput equations relate the time spectrum viewed by the detector to the spectrum actually recorded by the TAC and MCA. They can be used for three purposes: a) to predict the distortions caused by dead time losses, b) to determine the counting rate limits that render the distortion negligible or, c) to implement dead time correction algorithms that permit data acquisition at higher counting rates. The four most common cases are summarized below.

Case 1: Periodic Start and Random Stops, $T_s > T_d$

To avoid excessive complication, consider a periodic start pulse whose period T_s is longer than the combined TAC/MCA dead time T_d . In this case, no start pulses occur when the TAC/MCA cannot respond. The start pulse normally corresponds to the time at which a process is stimulated. The stop input is used to record the time spectrum of the products emitted from that stimulation. The apparatus must be designed to restrict the intensity of the product events so that statistical sampling of the time distribution is possible via single-ion or single-photon counting.

The MCA sorts the analog output of the TAC into a histogram, whose length is equal to the maximum number of channels offered by the MCA. Thus, each channel spans a time interval, Δt , and the start-to-stop time represented by channel i is

$$t = i \Delta t \quad (4)$$

where i extends from $i = 0$ to $i = i_{\max}$. The maximum channel number i_{\max} is typically in the range of 1000 to 16,000.

To demonstrate the minor effect of the detector and timing discriminator dead time, a single, extending dead time, T_e , will be ascribed to that source. T_e is represented in channel numbers by τ_e (rounded to the nearest integer value), where

$$T_e = \tau_e \Delta t \quad (5)$$

If a time spectrum is accumulated for a preset number of valid start pulses, n_1 , and the number of events recorded in channel i is q_i , then the probability of recording an event in channel i for a single valid start pulse is given² by equation (6).

$$\frac{q_i}{n_1} = \frac{Q_i}{n_1} \exp \left[-\sum_{j=0}^{i-1} \frac{Q_j}{n_1} \right] \exp \left[-U(\tau_e - i) \sum_{j=i-\tau_e}^{-1} \frac{Q_j}{n_1} \right] \quad (6)$$

The right-hand side of equation (6) is composed of three probabilities. The probability of an event impinging on the detector and destined for channel i (before dead time losses) is Q_i / n_1 . This event cannot be recorded in channel i if it was preceded by any stop events since the start pulse. The probability of no stop pulses from channel $j = 0$ to $i - 1$ is given by the first exponential term in equation (6). If the counting rate at the stop input is absolutely zero for $i < 0$ (no stop pulses preceding the start pulse) the last exponential term in equation (6) becomes 1. However, most detectors have some

low level of background counting rate caused by thermal excitation. Hence, a background stop pulse occurring in the interval from $t = -T_e$ to $t = 0$ would prevent the desired stop pulses from being detected in the interval from $t = 0$ to $t = T_e$. To account for this effect, the last exponential term in equation (6) is the probability of no stop pulses preceding $i = 0$ in the time interval τ_e . The step function is defined by

$$U(\tau_e - i) = \begin{cases} 1 & \text{for } \tau_e - i > 0 \\ 0 & \text{for } \tau_e - i \leq 0 \end{cases} \quad (7)$$

Equation (6) can be used to correct the acquired spectrum, q_i , for dead time losses in order to generate the corrected time spectrum, Q_i . One starts at channel 0 and presumes all Q_j preceding channel 0 are zero. As one moves channel by channel to the right in the spectrum the Q_j become available from the Q_i calculated for the previous channels. This calculation is repeated until the maximum channel, i_{\max} , has been treated. The resulting set of Q_i is the time spectrum corrected for dead time losses, with one exception. Because the values of Q_i for $i \leq 0$ were unknown and presumed zero, the corrected spectrum will be underestimated for values of i up to several times τ_e . This shortcoming can be easily overcome by adding sufficient cable delay to the stop input to move the spectral features of interest out of the affected region. This allows one to ignore the timing discriminator dead time if it is small compared to the measured time span.

Because the counts q_i are sampled from a preset number of start pulses, n_1 , the statistical variance in q_i is given by²

$$\sigma_{q_i}^2 = n_1 \frac{q_i}{n_1} \left(1 - \frac{q_i}{n_1} \right) \approx q_i \quad \text{for } q_i / n_1 \ll 1 \quad (8)$$

Moreover, the variance in the sum of the counts from any channels from $j = h$ to k is

$$\sigma_m^2 = m = \sum_{j=h}^k q_j \quad (9)$$

By using a straight-forward propagation-of-errors computation, while ignoring the timing discriminator dead time, the variance in the Q_i calculated via equation (6) is²

$$\sigma_{Q_i}^2 = Q_i \left(\frac{Q_i}{q_i} \right) \left[1 + \left(\frac{q_i}{n_1} \right) \sum_{j=0}^{i-1} \frac{\sigma_{Q_j}^2}{n_1} \right] \approx Q_i \left(\frac{Q_i}{q_i} \right) \quad (10)$$

The approximation in the last line of equation (10) is highly accurate, because the second term in the square brackets is negligible compared to 1 for practical applications. An alternative expression of the relationship in equation (10) is

$$\frac{\sigma_{Q_i}}{Q_i} = \frac{\sigma_{q_i}}{q_i} = \frac{1}{q_i^{1/2}} \quad (11)$$

²D.A. Gedcke, Development notes and private communication, Nov.–Dec. 1996.

Time-to-Amplitude Converters and Time Calibrator

In other words, the relative standard deviation in the calculated counts Q_i is determined by the relative standard deviation in the measured counts q_i .

Case 2: Random Start and Periodic Stop, $T_s > T_d$

Case 2 arises from the same application as Case 1, except the Reversed Start/Stop method is employed to reduce the TAC/MCA dead time. As described earlier with reference to Figure 5, the periodic stimulation pulse is delayed by a time interval D and applied to the TAC stop input. The delay is typically 90 to 95% of the time span selected on the TAC. The detected pulses from the products of the stimulation are fed to the start input.

The delay D is expressed in terms of a number of channels by

$$D = \delta \Delta t \quad (12)$$

where δ is rounded to the nearest integer value.

If there truly are no detected product events before the time of the original stimulation pulse, then the probability of recording an event in channel i for a single stimulation pulse is

$$\frac{q_i}{n_2} = \frac{Q_i}{n_2} \exp\left(-\sum_{j=i+1}^{i_{\max}} Q_j / n_2\right) \quad (13)$$

where q_i is the number of events recorded in channel i as a result of n_2 stimulation pulses. Note that n_2 is the number of delayed stimulation pulses presented to the stop input, whether or not they were accepted by the stop input. It is presumed that the period between stimulation pulses, T_s , is longer than the TAC/MCA dead time, T_d , so that the TAC and MCA are always ready to process the events from the next stimulation pulse. (See Case 3 for the opposite situation: $T_s < T_d$.)

The probability of a recorded event is composed of two probabilities on the right-hand side of equation (13). The probability of an event arriving at the detector at a time destined to be categorized in channel i is Q_i / n_2 . The exponential term describes the probability that no start pulses will precede the desired start pulse in the time interval between the undelayed stimulation pulse and the arrival time of the start pulse in channel i . Because of the reversal of the start and stop inputs, the summation in the exponential must extend from $j = i + 1$ to $j = \delta$. For convenience, the summation has been extended past $j = \delta$ to $j = i_{\max}$. If there truly were no detected start events prior to the undelayed stimulation pulse, the counts will be zero for all channels from δ to i_{\max} .

To calculate the corrected counts, Q_i , from the measured counts, q_i , equation (13) must be applied by starting at i_{\max} and working channel by channel to $i = 0$. Thus, the values needed for Q_j are available from the Q_i already calculated for higher channel numbers.

If there are significant uncorrelated background pulses arriving at the start input prior to the undelayed stimulation pulse the modification to equation (13) can be rather complicated². One

can avoid this complication by holding the start input gate closed until the undelayed stimulation pulse occurs. The start input gate is opened only for the interval from the occurrence of the undelayed stimulation pulse until the arrival of the delayed stimulation pulse at the stop input. This permits the valid application of equation (13). In practice, a delay of the order of T_e may need to be inserted in the stop input to shift the prompt portion of the spectrum clear of the gating at $i = \delta$.

As for Case 1, the statistical variance in the recorded counts is

$$\sigma_{q_i}^2 = q_i \quad (14)$$

The variance in the calculated corrected counts is

$$\sigma_{Q_i}^2 = Q_i (Q_i / q_i) \quad (15)$$

and

$$\frac{\sigma_{Q_i}}{Q_i} = \frac{\sigma_{q_i}}{q_i} = \frac{1}{q_i^{1/2}} \quad (16)$$

Case 3: Random Start and Periodic Stop, $T_s < T_d$

This case is the same as Case 2, except that the period between stimulation pulses, T_s , is less than the TAC/MCA dead time, T_d . Fluorescence lifetime spectrometry (Fig. 5) is a typical application. For simplicity in demonstrating the critical points, the discriminator dead time, T_e , is ignored. If q_i is the number of events recorded in channel i for n stimulation pulses, then the probability of recording an event in channel i for a single stimulation pulse is²

$$\frac{q_i}{n} = \frac{Q_i}{n} \exp\left(-\sum_{j=i+1}^{\tau_s} Q_j / n\right) [1 - \beta_I \sum_{k=0}^{\tau_s} q_k / n - U\{i - (1 - \beta_F) \tau_s\} \sum_{k=0}^{\tau_s} q_k / n]$$

The channel summation limit, τ_s , is defined by

$$T_s = \tau_s \Delta t \quad (18)$$

and τ_s is rounded to the nearest integer value.

The right-hand side of equation (17) consists of three probability factors. The first two are the same as in Case 2, except that n_2 has been replaced with n , and the summation limit is set by the period between stimulation pulses, τ_s . (It is presumed that the time span of the TAC is selected to be slightly longer than τ_s .) The third factor consists of the terms in the square brackets, and this factor represents the probability of not accepting start events because the TAC/MCA is busy processing a previous event.

The dead time of the TAC and MCA can be written as the sum of the variable, measured, start-to-stop time, t_{ss} , and the constant processing time, t_d . (A constant conversion-time MCA is presumed.)

$$T_d = t_{ss} + t_d \quad (19)$$

Note that t_d always begins on an accepted stop pulse and ends when the TAC/MCA combination can accept the next start pulse. (It is presumed that the MCA Busy signal gates the TAC Start Input.)

Time-to-Amplitude Converters and Time Calibrator

It is convenient to express the results in terms of β , which is the ratio of t_d to T_s .

$$t_d = \beta T_s = (\beta_I + \beta_F) T_s \quad (20)$$

where β_I is the integer part of β , and β_F is the fractional part of β . With this definition in mind, the terms in the square brackets in equation (17) are explained as follows.

The second term in the square brackets is the probability that an event has been accepted in the previous β_I intervals of T_s , causing the TAC/MCA to be busy when the desired start pulse arrives. The third term is the same probability, but for interval number $\beta_I + 1$ prior to the desired start pulse. This latter interval is important because it generates a busy period, t_d , that extends by an amount $\beta_F T_s$ into the period that contains the desired start pulse. Consequently, only the earlier start pulses in the desired start-pulse interval are suppressed by this term. That fact is described in equation (17) by the unit step function

$$U \{i - (1 - \beta_F) \tau_s\} = 1 \text{ for } i > (1 - \beta_F) \tau_s \\ = 0 \text{ for } i \leq (1 - \beta_F) \tau_s \quad (21)$$

This third term in the square brackets causes a distortion of the spectrum that is extremely difficult to correct, because it is difficult to measure and predict $\beta_F \tau_s$. The practical solution is to restrict the counting rate so that the error caused by the third term is less than 1%. This restriction requires

$$\frac{\tau_s}{\sum_{k=0}^{\tau_s} q_k/n} < 0.01 \quad (22)$$

Note that equation (22) also guarantees that the distortion expressed by the exponential term in equation (17) will be <1%. It also ensures that the dead time effects of the timing discriminator are negligible, provided $T_e < T_s$.

For efficient throughput¹ the TAC/MCA dead time losses should be restricted to <50%. Because the second term in the square brackets dominates the dead time losses, this leads to the second restriction

$$\beta_I \sum_{k=0}^{\tau_s} q_k/n < 0.5 \quad (23)$$

which typically requires $\beta_I < 50$. The restrictions in equations (22) and (23) are easy to check by summing the counts recorded in the time spectrum and dividing by the corresponding number of stimulation pulses.

Clearly, Case 3 does not lead to a practical correction algorithm. Instead, equations (22) and (23) define the limits on the operating parameters necessary to avoid distortion. If it is sufficient to simply measure the shape of the time spectrum one can verify that conditions (22) and (23) are met and then use the recorded spectrum, q_i .

If the absolute value of Q_i/n is required, one can apply a simple live time clock that turns off whenever the TAC/MCA combination is unable to respond to a start pulse. This will require feeding the TAC Busy signal to the MCA live time clock and connecting the MCA Busy signal to the Start Input Gate on the TAC so that the TAC/MCA combination is dead whenever the TAC or the MCA is busy. The live time clock corrects for the dominant dead time losses caused by the second term in the square brackets in equation (17). Under conditions (22) and (23) all other losses and distortion will be <1%. The basic principle of the live time clock¹ is expressed by

$$\frac{Q_i}{t} = \frac{q_i}{t_L} \quad (24)$$

Dividing the counts, q_i , recorded in the live time, t_L , yields the corrected event rate, Q_i/t . It follows that

$$Q_i/n = (Q_i/t) / (n/t) = (q_i/t_L) / (n/t) \quad (25)$$

In other words, one divides the recorded counts by the livetime and by the known repetition rate of the stimulation pulses, n/t , in order to calculate Q_i/n . Because the q_i events are counted for a preset live time, the relative standard deviation in q_i , Q_i , and Q_i/n is given by equation (16)¹.

Case 4: Random Starts and Random Stops

Random events are typically encountered at both the start and stop inputs when it is not possible to periodically stimulate the process to be measured. An example is the measurement of the lifetime of an excited state in a nucleus when the excited state is populated as the result of radioactive decay. For example, consider the emission of an alpha particle from a radioactive sample signaling the decay which forms the excited state, followed by the emission of a gamma ray marking the decay of the excited state to the ground state. The alpha particle detector supplies the pulse for the TAC start input, and the gamma ray detector feeds the stop input. Since the detection probability for both types of radiation is modest, there is a moderate probability that 1) a start event will be detected without detecting the correlated stop pulse, 2) a stop pulse will be detected without detecting the correlated start event, and 3) an uncorrelated pair of start and stop events will be recorded. These actions can cause dead time or uncorrelated background in the measured time spectrum.

If it is sufficient to measure the correct shape of the decay curve to extract the lifetime, then equations (4) through (11) of Case 1 provide an adequate description of the measurement. If the absolute probability of detecting a particular start-to-stop time interval is also required, the effect of dead time losses for the start input must be accounted for.

If the start events are randomly and uniformly distributed in time (constant counting rate), the throughput relationship is expressed by^{1,2}

Time-to-Amplitude Converters and Time Calibrator

$$\frac{N_1}{n_1} = \exp(R_1 T_e) + U(T_d - T_e) R_1 (T_d - T_e) \quad (26)$$

where N_1 is the number of start events at the detector (before dead time losses) and n_1 is the number of start pulses accepted by the TAC/MCA combination. $U(T_d - T_e)$ is the previously defined step function, and R_1 is the counting rate of start events at the detector, i.e.,

$$R_1 = \frac{N_1}{t} \quad (27)$$

Normally $T_e \ll T_d$, and equation (26) simplifies to the form for non-extending dead time.

$$\frac{N_1}{n_1} = 1 + R_1 T_d = \frac{1}{1 - r_1 T_d} \quad (28)$$

where

$$r_1 = \frac{n_1}{t} \quad (29)$$

The simplest way to account for the relation in equation (28) is to use a simple livetime clock that turns off for the combined dead time of the TAC and MCA. The relationship between live time, t_L , and real time, t , is given by¹

$$\frac{n_1}{t_L} = \frac{N_1}{t} = R_1 \quad (30)$$

Consequently, the joint probability of detecting a start pulse and a stop pulse such that the start-to-stop time interval is destined for channel i is

$$P_i = R_1 \frac{Q_i}{n_1 \Delta t} = \frac{n_1}{t_L} \frac{Q_i}{n_1 \Delta t} = \frac{Q_i}{t_L \Delta t} \quad (31)$$

The division by t_L and Δt expresses both the start and stop probabilities on a per-unit-time basis.

If the live time, t_L , required to record n_1 accepted start pulses is measured, the relative standard deviation in t_L is given by¹

$$\frac{\sigma_{t_L}}{t_L} = \frac{\sigma_{n_1}}{n_1} = \frac{1}{(n_1)^{1/2}} \quad (32)$$

Applying a propagation-of-errors calculation leads to the expression for the relative standard deviation in P_i

$$\frac{\sigma_{P_i}}{P_i} = \left[\frac{1}{n_1} + \frac{1}{q_i} \right]^{1/2} \quad (33)$$

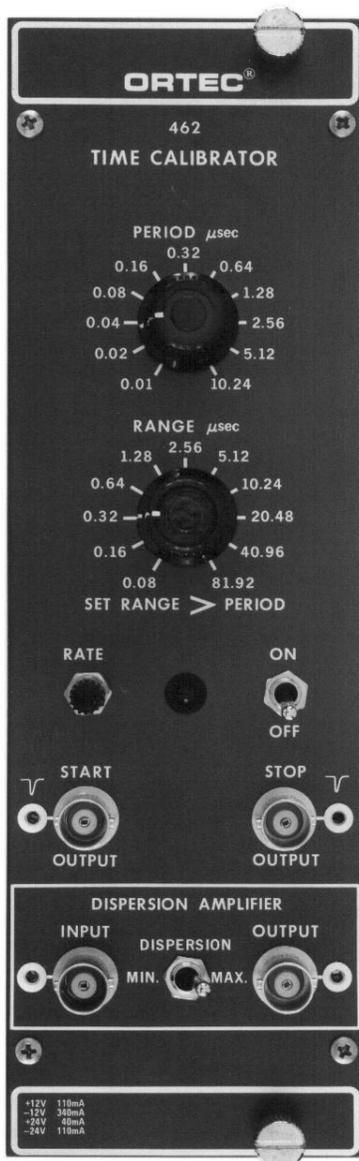
Because $q_i \ll n_1$, the relative standard deviation in equation (33) will be dominated by q_i .

Time-to-Amplitude Converters and Time Calibrator Selection Guide

Model	Function	Package and Width	Time Range		Start/Stop Input Logic	Input Gates	Calibrator Period	
			Minimum	Maximum			Minimum	Maximum
462	Time Calibrator	NIM-2	80 ns	81.92 μ s	—	—	10 ns	10.24 μ s
566	TAC	NIM-1	50 ns	2 ms	+NIM, or -NIM	Start Gate	—	—
567	TAC and SCA	NIM-2	50 ns	2 ms	+NIM, or -NIM	Start Gate, Stop Gate	—	—

462 Time Calibrator

- Provides fast, easy calibration of time-to-amplitude converters
- Absolute accuracy ± 10 ps for a 10-ns period
- Long-term stability, 100 ppm/year
- Calibrates time periods from 10 ns to 10 μ s on 80 ns to 80 μ s ranges



Fast, easy calibration of timing equipment such as time-to-amplitude converters is a routine operation with the ORTEC Model 462 Time Calibrator. The start and stop pulses from the Model 462 are separated by an integral multiple of a precise time period that can be selected by the operator. The accuracy of this time period is ± 10 ps for a 10-ns period and is $\pm 0.005\%$ of the total period for longer periods. The long-term stability of this signal is better than 100 ppm.

Operation of the Model 462 Time Calibrator is simplified by controls that enable the operator to set the time period from 10 ns to 10.24 μ s in 11 binary steps, with the range in time over which these intervals occur selectable from 80 ns to 81.92 μ s in the same number of steps. The average repetition rate of the output pulses can be controlled to enable slower or faster count rates to match the user's experiment, and an external gate input allows remote or automatic control of the output.

A Dispersion Amplifier on the Model 462 front panel can mix semi-Gaussian noise with the output of the time-to-amplitude converter. Use of this circuit spreads each peak in the time spectrum to identify the exact centroid of each peak. This peak dispersion noise can be switched into or out of the circuit without any cable reconnections.

The Model 462 is a double-width NIM module and all signal levels from it are standard, making it compatible with any NIM modular instrumentation system.

Specifications

PERFORMANCE

CALIBRATION PERIOD ACCURACY The absolute accuracy is ± 10 ps for 10 ns period and $\pm 0.005\%$ of total period for all other selections; factory-calibrated against National Bureau of Standards WWV.

CALIBRATION PERIOD INSTABILITY Within $< \pm 10$ ppm/ $^{\circ}$ C of selected period; 100 ppm/year.

CONTROLS

PERIOD μ sec 11-position switch selects the basic interval steps between Start and Stop Outputs; selections are 10, 20, 40, 80, 160, 320, and 640 ns and 1.28, 2.56, 5.12, and 10.24 μ s.

RANGE μ sec 11-position switch selects the total calibration time scale in binary multiples of 80 ns; selections are 80, 160, 320, and 640 ns and 1.28, 2.56, 5.12, 10.24, 20.48, 40.96, and 81.92 μ s.

RATE Single-turn, front-panel trim potentiometer adjusts the random Start-Stop rate from about 100 to 50,000 counts/s.

ON/OFF Toggle switch disables the Model 462 output for the Off position or enables the output (except when gated off) for the On position; the adjacent lamp lights when the output is enabled.

DISPERSION Toggle switch marked Min and Max selects the internal circuit effect between the Input and Output of the Dispersion Amplifier. The Min position selects a reproduction of the Input with a gain of 1 at the Output. The Max position provides for the addition of semi-Gaussian noise to the Input before it is furnished through the Output; the purpose is to reduce the resolution of the spectrum in order to calculate the peak centroid within a fraction of one channel.

INPUTS

EXTERNAL ENABLE INPUT Rear-panel BNC connector accepts gating logic to control unit when On/Off switch is set at On; >2 V or open enables; nominal ground disables.

DISPERSION AMPLIFIER INPUT Front-panel BNC connector accepts ± 10 V linear signals, typically from a time-to-amplitude converter; $Z_{in} \sim 2$ k Ω .

OUTPUTS

START OUTPUT Front-panel BNC connector furnishes a NIM-standard fast negative logic pulse, which occurs at a random time with respect to the preceding start pulse; $Z_o \sim 1$ k Ω .

STOP OUTPUT Front-panel BNC connector furnishes a NIM-standard fast negative logic pulse, which occurs at an integral multiple (≥ 2) of the selected period following each Start output pulse; $Z_o = 1$ k Ω .

BUSY OUTPUT Rear-panel BNC connector furnishes a signal that is at -0.8 V for a 50- Ω load during the interval from each start pulse until its subsequent stop pulse; $Z_o = 1$ k Ω .

PERIOD OUTPUT Rear-panel BNC connector furnishes a NIM-standard fast negative pulse at a fixed rate of 1/period; can be used to check calibration or as a stable external time base; $Z_o = 1$ k Ω .

DISPERSION AMPLIFIER OUTPUT Front-panel BNC connector provides ± 10 V linear output, same polarity as the Dispersion Amplifier Input; Dispersion switch selects whether signal is an exact reproduction of the input or has ~ 100 mV FWHM random noise mixed with it; $Z_o < 1$ Ω .

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 110 mA; -12 V, 340 mA; +24 V, 40 mA; -24 V, 110 mA.

WEIGHT

Net 1.5 kg (3.5 lb).

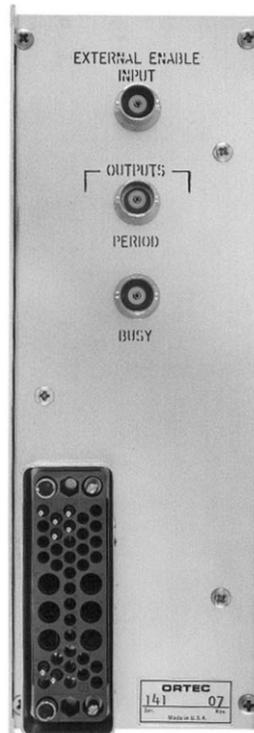
Shipping 2.9 kg (6.5 lb).

DIMENSIONS NIM-standard double-width module 6.90 X 22.13 cm (2.70 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
462	Time Calibrator



Time-to-Amplitude Converter

- For time spectroscopy in the range from 10 ns to 2 ms
- Valid Start and Valid Conversion outputs
- Selectable output delay and width
- Output synchronized with a stop or external strobe signal
- Provision to reject unwanted start input signals
- Positive or negative input signals



The ORTEC Model 566 Time-to-Amplitude Converter (TAC) measures the time interval between pulses to its start and stop inputs and generates an analog output pulse proportional to the measured time. Timing experiments requiring time ranges from 10 ns to 2 ms may be performed, giving the experimenter flexibility in analyzing random nuclear events that occur within a selected time range. Time ranges from 50 ns to 2 ms are provided via the front-panel controls.

The Model 566's start input can be inhibited by a pulse or a dc level at the rear-panel Gate Input connector.

Valid Start and Valid Conversion outputs are provided for each accepted start and stop input, respectively. The duration of the Valid Start output indicates the interval from the accepted start until the end of reset. The Valid Conversion output occurs from the end of the internal delay after stop to the end of reset.

The selectable TAC output width and variable delay, which are easily adjusted, further serve to make the Model 566 a flexible instrument, easily adapted into many time spectroscopy systems. The output of the TAC may be synchronized with the stop signal or an external strobe signal to further enhance its versatility.

The Model 566 is dc-coupled and gated so that input count rates will not paralyze or otherwise hinder normal operation. The TAC output should be connected to the dc-coupled input of a multichannel analyzer for optimum high-count-rate performance.

Specifications

PERFORMANCE

TIME RESOLUTION FWHM $\leq 0.01\%$ of full scale plus 5 ps for all ranges.

TEMPERATURE INSTABILITY $\leq \pm 0.01\%/^{\circ}\text{C}$ (± 100 ppm/ $^{\circ}\text{C}$) of full scale or ± 10 ps/ $^{\circ}\text{C}$ (whichever is greater), 0 to 50 $^{\circ}\text{C}$.

DIFFERENTIAL NONLINEARITY Typically, $< 1\%$ from 10 ns or 2% of full scale (whichever is greater) to 100% of full scale.

INTEGRAL NONLINEARITY $\leq \pm 0.1\%$ from 10 ns or 2% of full scale (whichever is greater) to 100% of full scale.

RESET CYCLE Fixed 1.0 μs for X1 and X10 Multipliers, fixed 5 μs for X100 Multiplier, and fixed 50 μs for X1K, and X10K Multipliers. Occurs after Over Range, Strobe cycle, or Ext Strobe Reset cycle.

START-to-STOP CONVERSION TIME
Minimum ≤ 5 ns.

INPUT COUNT RATE > 30 MHz.

CONTROLS (Front Panel)

RANGE (ns) Three-position rotary switch selects full scale time interval of 50, 100, or 200 ns between accepted Start and Stop input signals.

MULTIPLIER Five-position rotary switch extends time range by a multiplying factor of 1, 10, 100, 1K, or 10K.

DELAY (μs) 20-turn screwdriver-adjustable potentiometer varies the delay of the TAC output from 0.5 μs to 10.5 μs , relative to an accepted Stop input signal; operable in the Int Strobe mode only.

STROBE MODE Two-position locking toggle switch selects either Internal or External source for initiating the strobe cycle to strobe valid information from the TAC output.

CONTROLS (Rear Panel)

GATE MODE Two-position locking toggle switch selects Coincidence or Anticoincidence mode of operation for the Start circuitry. Start circuitry is enabled in the Coinc position or inhibited in the Anti position during the interval of a Gate input signal.

LOG CURR Two-position locking toggle switch selects the use of ± 6 V or ± 12 V bin lines to provide current for the internal logic circuitry.

In the ± 6 V position, the Model 566 is within the current allotment for a single NIM width when using a NIM Standard Class V power supply. In the ± 12 V position, the Model 566 exceeds the current allotment for a single NIM width on the +12 V and -12 V bin lines. However, this position allows the Model 566 to be used with power supplies not providing +6 V and -6 V.

Time-to-Amplitude Converter

INPUTS

All four inputs listed below are dc-coupled, edge triggered, and printed wiring board (PWB) jumper selectable to accept either negative or positive NIM standard signals. Input impedance is 50 Ω in the negative position and >1k in the positive position. The threshold is nominally -400 mV in the negative position and +2 V in the positive position.

STROBE Front-panel BNC connector provides an external means to strobe a valid output signal from the TAC in the Ext Strobe mode. The input signal, exceeding threshold within the Ext Strobe reset interval after the Stop input, initiates the read cycle for the linear gate to the TAC output. Factory-set in the positive input position. Ext Strobe reset interval has a minimum value of ~0.5 μs and a maximum value of nominally 10 μs.

START Front-panel BNC connector initiates time conversion when Start input signal exceeds threshold. Factory-set in the negative input position.

STOP Front-panel BNC connector terminates time conversion when Stop input signal exceeds threshold. Factory-set in the negative input position.

GATE Rear-panel BNC connector provides an external means of gating the Start circuitry in either Coincidence or Anticoincidence with the Start input signal. Gate input signal must cross threshold ≥10 ns prior to the Start input signal and must overlap the trigger edge of the Start input signal. Factory-set in the positive input position.

OUTPUTS

TAC OUTPUT Front-panel BNC connector provides unipolar pulse.

Amplitude 0 V to +10 V proportional to Start/Stop input time difference.

Time End of delay period in Int Strobe mode; prompt with Strobe input in Ext Strobe mode.

Width Adjustable by PWB potentiometer from ≤1 μs to ≥3 μs.

Impedance $Z_o < 1 \Omega$.

Rise Time ~250 ns.

Fall Time ~250 ns.

VAL ST Rear-panel BNC connector provides NIM-standard slow positive logic level signal.

Amplitude Nominally +5 V. Complement signal selectable by PWB jumper.

Time and Width From accepted Start input to end of reset.

Impedance $Z_o < 10 \Omega$.

Rise Time ≤50 ns.

Fall Time ≤50 ns.

VALID CONV Rear-panel connector provides NIM-standard slow positive logic level signal to indicate a Valid Conversion.

Amplitude Nominally +5 V. Complement signal selectable by PWB jumper.

Time and Width From end of internal delay after Stop to end of reset.

Impedance $Z_o < 10 \Omega$.

Rise Time ≤50 ns.

Fall Time ≤50 ns.

ELECTRICAL AND MECHANICAL

POWER REQUIRED

Logic Current Switch

±6 V

+24 V, 45 mA; +12 V, 95 mA; +6 V, 140 mA; -24 V, 50 mA; -12 V, 140 mA; -6 V, 300 mA.

±12 V

+24 V, 45 mA; +12 V, 210 mA; -24 V, 50 mA; -12 V, 405 mA.

WEIGHT

Net 1.5 kg (3.3 lb).

Shipping 3.0 kg (7 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

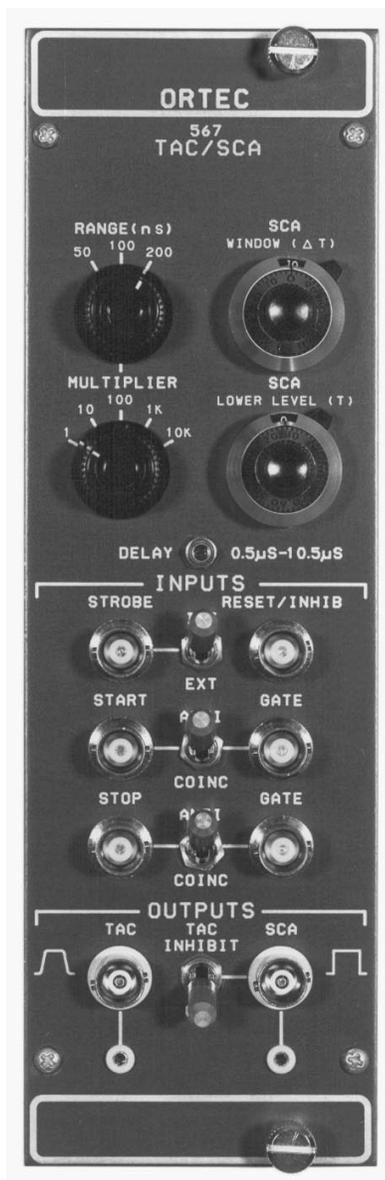
To order, specify:

Model	Description
566	Time-to-Amplitude Converter



Time-to-Amplitude Converter/SCA

- For time spectroscopy in the range from 10 ns to 2 ms
- Includes SCA to set a time window for coincidence experiments
- Valid Start and Valid Conversion outputs
- Selectable output delay and width
- Output synchronized with a stop or external strobe signal
- Provision to reject unwanted start or stop input signals
- Positive or negative input signals



The ORTEC Model 567 Time-to-Amplitude Converter/Single-Channel Analyzer (TAC/SCA) measures the time interval between start and stop input pulses, generates an analog output pulse proportional to the measured time, and provides built-in single-channel analysis of the analog signal. Additional gating modules are not necessary with this unit, and timing experiments requiring time ranges of 10 ns to 2 ms may be performed with single-channel analysis, giving the experimenter unparalleled flexibility in analyzing random events that occur within a selected time range.

Separate gating (anticoincidence or coincidence) of the start and stop inputs eliminates unwanted events from the time spectra via externally imposed energy or timing restrictions. The Model 567 also incorporates a built-in SCA inhibit feature in which a TAC output is available only if the output pulse falls within the window restrictions imposed by the SCA. This feature may be switched in or out by a convenient front-panel switch.

In addition to its start and stop input gating capabilities, the Model 567 provides for a pulsed or dc-level Reset/Inhibit signal via a front-panel input connector. A Reset/Inhibit input signal terminates the conversion cycle and maintains a reset condition, inhibiting further TAC conversions for the duration of the Reset/Inhibit pulse. A TAC output pulse that is in process at the time a Reset/Inhibit input is received will be completed before converter reset is initiated.

Valid Start and Valid Conversion outputs are provided for each accepted start and stop input respectively. The duration of the Valid Start output indicates the interval from the accepted start until the end of reset. Valid Conversion occurs from the end of the internal delay after stop to the end of reset.

The selectable TAC output width and variable delay, which are easily adjustable, further serve to make the Model 567 a flexible instrument. The output of the TAC may be synchronized with the stop signal or an external strobe signal to further enhance its versatility.

The single-channel analyzer section of the Model 567 allows the experimenter to place very specific time restrictions on the timing spectrum. The SCA is operated in the Window mode, where the upper-level discriminator setting is added to that of the lower-level discriminator. The SCA output pulse width is equal to the time from the occurrence of the TAC output until the end of the reset pulse or the end of the TAC output. The synchronization of the SCA output with the stop input virtually eliminates any time walk in the SCA output.

All Model 567 inputs are printed wiring board (PWB) jumper-selectable to accept either negative or positive NIM standard signals. All inputs and outputs are dc-coupled so that changing input count rates will not hinder normal operation of the Model 567. The TAC output should be connected to the dc-coupled input of a multichannel analyzer (MCA) for optimum high count-rate performance.



Time-to-Amplitude Converter/SCA

Specifications

PERFORMANCE

Time-to-Amplitude Converter

TIME RESOLUTION FWHM $\leq 0.01\%$ of full scale plus 5 ps for all ranges.

TEMPERATURE INSTABILITY $\leq \pm 0.01\%/^{\circ}\text{C}$ (± 100 ppm/ $^{\circ}\text{C}$) of full scale or 10 ps/ $^{\circ}\text{C}$ (whichever is greater), 0 to 50 $^{\circ}\text{C}$.

DIFFERENTIAL NONLINEARITY Typically $< 1\%$ from 10 ns or 2% of full scale (whichever is greater) to 100% of full scale.

INTEGRAL NONLINEARITY $\leq \pm 0.1\%$ from 10 ns or 2% of full scale (whichever is greater) to 100% of full scale.

RESET CYCLE Fixed 1.0 μs for X1 and X10 Multipliers, fixed 5 μs for X100 Multiplier, and fixed 50 μs for X1K and X10K Multipliers. Occurs after Over Range, Strobe cycle, or Ext Strobe Reset cycle.

START-to-STOP CONVERSION TIME
Minimum ≤ 5 ns.

Single-Channel Analyzer

THRESHOLD INSTABILITY $\leq \pm 0.01\%/^{\circ}\text{C}$ (± 100 ppm/ $^{\circ}\text{C}$) of full scale, 0 to 50 $^{\circ}\text{C}$ (referenced to +12 V NIM bin).

THRESHOLD NONLINEARITY $\leq \pm 0.5\%$ of full scale.

CONTROLS (Front Panel)

RANGE (ns) Three-position rotary switch selects full scale time interval of 50, 100, or 200 ns between accepted Start and Stop input signals.

MULTIPLIER Five-position rotary switch extends time range by a multiplying factor of 1, 10, 100, 1K, or 10K.

DELAY 20-turn screwdriver-adjustable potentiometer varies the delay of the TAC and SCA outputs from 0.5 μs to 10.5 μs , relative to an accepted Stop input signal; operable in the Int Strobe mode only.

STROBE MODE Two-position locking toggle switch selects either Internal or External source for initiating the strobe cycle to strobe valid information from the TAC and SCA outputs.

START GATE MODE Two-position locking toggle switch selects Coincidence or Anticoincidence mode of operation for the Start circuitry. Start circuitry is enabled in the Coinc position or inhibited in the Anti position during the interval of a Start Gate input signal.

STOP GATE MODE Two-position locking toggle switch selects Coincidence or Anticoincidence mode of operation for the Stop circuitry. Stop circuitry is enabled in the Coinc position or inhibited in the Anti position during the interval of a Stop Gate input signal.

SCA WINDOW (ΔT) 10-turn precision locking potentiometer sets the SCA upper-level discriminator threshold from 0.05 V to 10.05 V above the Lower Level (T) setting.

SCA LOWER LEVEL (T) 10-turn precision locking potentiometer sets the SCA lower level discriminator threshold from 0.05 V to 10.05 V.

TAC INHIBIT Two-position locking toggle switch. In the Inhibit position, the TAC output is available only if the output amplitude is within the SCA window. In the Out position, the SCA has no effect on the TAC output.

CONTROLS (Rear Panel)

EXT STROBE RESET Two-position locking toggle switch allows the converter to be reset nominally 10 μs or 100 μs after an accepted Stop input signal if an Ext Strobe signal has not been received.

INPUTS

All six front-panel inputs listed below are dc-coupled, edge-triggered, and printed wiring board (PWB) jumper selectable to accept either negative or positive NIM-standard signals. Input impedance is 50 Ω in the negative position and $> 1\text{k}$ in the positive position. The threshold is nominally -400 mV in the negative position and +2 V in the positive position.

STROBE Provides an external means to strobe a valid output signal from the TAC in the Ext Strobe mode. The input signal, exceeding threshold within the Ext Strobe Reset interval after the Stop input, initiates the read cycle for the linear gate to the TAC output. Factory-set in the positive input position. Ext Strobe Reset interval has a minimum value of ~ 0.5 μs and a maximum value of nominally 10 μs or 100 μs , switch-selectable on rear panel.

START Time conversion initiated when Start input signal exceeds threshold. Factory-set in negative input position.

STOP Time conversion terminated when Stop input signal exceeds threshold. Factory-set in negative input position.

RESET/INHIB Terminates conversion cycle and maintains reset condition, inhibiting further TAC conversions, for the duration of the reset cycle or the Reset/Inhib pulse, whichever is longer. A TAC output pulse in process at the time of a Reset/Inhib signal will be completed before converter reset is initiated. Factory-set in the positive input position.

START GATE Provides an external means of gating the Start circuitry in either Coincidence or Anticoincidence with the Start input signal. Start Gate input signal must cross threshold ≥ 10 ns prior to the Start input signal and overlap the trigger edge of the signal. Factory set in the positive input position.

STOP GATE Provides an external means of gating the Stop circuitry in either Coincidence or Anticoincidence with the Stop input signal. Stop Gate input signal must cross threshold ≥ 10 ns prior to the Stop input signal and overlap the trigger edge of the signal. Factory set in the positive input position.

OUTPUTS

TAC Front- and rear-panel BNC connectors provide bipolar pulse.

Amplitude 0 to +10 V proportional to Start/Stop input time difference.

Time End of delay period in Int Strobe mode; prompt with Strobe input in Ext Strobe mode.

Width Adjustable by PWB potentiometer from 1 μs to 3 μs .

Impedance Front panel $Z_o < 10 \Omega$; rear panel 93 Ω .

Rise Time ~ 250 ns.

Fall Time ~ 250 ns.

VALID START Rear-panel BNC connector provides NIM-standard slow positive logic level signal.

Amplitude Nominally +5 V. Complement signal selectable by PWB jumper.

Time and Width From accepted Start input to end of reset.

Impedance $Z_o < 10 \Omega$.

Rise Time ≤ 50 ns.

Fall Time ≤ 50 ns.

VALID CONV Rear-panel BNC connector provides NIM-standard slow positive logic level signal to indicate a Valid Conversion.

Amplitude Nominally +5 V. Complement signal selectable by PWB jumper.

Time and Width From end of internal delay after Stop to end of reset.

Impedance $Z_o \leq 10 \Omega$.

Rise Time ≤ 50 ns.

Fall Time ≤ 50 ns.

SCA Front- and rear-panel connectors provide NIM-standard slow positive logic level signals.

Amplitude Nominally +5 V. Complement signal selectable by PWB jumper.

Time and Width From start of TAC linear output to either end of reset or end of linear output, PWB selectable. Factory-set at end of reset.

Impedance $Z_o \leq 10 \Omega$.

Rise Time ≤ 50 ns.

Fall Time ≤ 50 ns.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 95 mA; +12 V, 210 mA; -24 V, 165 mA; -12 V, 330 mA.

WEIGHT

Net 1.4 kg (3 lb).

Shipping 3.2 kg (7 lb).

DIMENSIONS NIM-standard double-wide module 6.90 X 22.13 cm (2.70 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
567	Time-to-Amplitude Converter/SCA

Multichannel Analyzers, Multichannel Buffers, and Associated Software

Contents

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The MCA/MCB Function

A multichannel pulse-height analyzer (MCA) consists of an ADC, a histogramming memory, and a visual display of the histogram recorded in the memory. The purpose of the analog-to-digital converter (ADC) is to measure the maximum amplitude of an analog pulse and convert that value to a digital number. This digital output is a proportional representation of the analog amplitude at the ADC input. For sequentially arriving pulses, the digital outputs from the ADC are fed to a dedicated memory and sorted into a histogram to record the number of events counted in each pulse-height interval. This histogram represents the spectrum of input pulse heights. If the input pulses come from an energy spectroscopy amplifier, the histogram corresponds to the energy spectrum observed by the associated detector. When the output of a time-to-amplitude converter is connected to the ADC input, the histogram represents the time spectrum measured by the time-to-amplitude converter. The combination of the ADC, the histogramming memory, and a display of the histogram forms a multichannel analyzer (MCA). If a computer is employed to display the spectrum, then the combination of the ADC and the histogramming memory is called a multichannel buffer (MCB).

*ADCAM is an acronym for ADC And Memory.

Further details on the structure and performance of the various components of an MCA can be found in the CAMAC ADCs, Memories, and Software sections of this catalog.

The ADCAM* Architecture of MCAs

The ADCAM® architecture of MCAs was introduced to the world as a concept by ORTEC in 1983. Essentially the concept involves the separation of the MCA functionality into two parts: (1) data acquisition and storage performed by a hardware component, known as a "multichannel buffer" (MCB), and (2) the control and display function, carried out by software (often referred to as "MCA Emulation Software") running on a personal computer, interfaced to the MCB.

Figure 1 shows a functional block diagram of an ADCAM MCA system.

The ORTEC MCB product range, as can be seen in the following pages, is large. In addition to the original "ADC And Memory" MCBs, which were two-wide NIM modules, a variety of packages are now available.

In low-cost plug-in cards, such as the TRUMP and MicroACE, the MCB resides within the computer backplane.

Multichannel Analyzers, Multichannel Buffers, and Associated Software

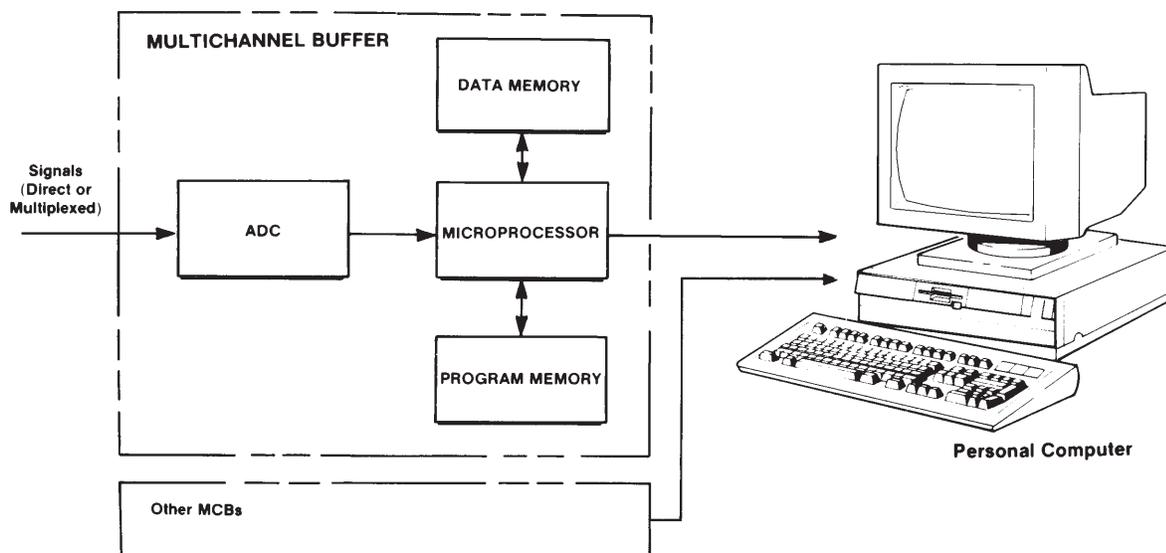


Fig. 1. Functional Block Diagram of an ADCAM MCA System.

Integrated systems such as the DART™, NOMAD Plus, MicroNOMAD, DSPEC, DSPEC-PLUS and OCTÊTE PC (see other sections of this catalog), provide complete computer-controlled high-performance packages which, by virtue of their degree of integration and use of PC technology, offer an unsurpassed price-to-performance ratio.

The ADCAM Promise

It was stated in 1983 at the introduction of the ADCAM concept that a key benefit of this approach was that, as systems evolved by the addition of better PCs and improved software, the hardware would stay current. This has certainly been true. Many systems today running the latest-generation software on the latest PCs are using MCBs purchased many years ago. The earliest MCB hardware is still compatible with that available today. As systems expand, and are enhanced, the latest hardware and software can be added to existing installations simply and inexpensively.

MCA Emulation Software

The ORTEC MCBs are available with standard hardware interfaces to IBM® personal computers and to other computers that are compatible with the IBM PC architecture and operating software. Control of the MCBs, display of the recorded spectra, and manipulation of the data are all accomplished on the

personal computer by means of an MCA Emulator program. The MAESTRO™-32 MCA Emulation Software operates as an application under the Windows environment. The MCA Emulator is described in the next few pages, prior to the data sheets on the MCB hardware. MAESTRO-32 offers extensive data manipulation capabilities in addition to the control and display functions.

Those wishing to incorporate control of the MCB into a customized Windows program they have written to control multiple instruments in the measurement process will find the A11-B32 CONNECTIONS Programmer's Toolkit to be a helpful resource. The MCB manuals list the desired HARDWARE commands.

For applications requiring detailed reporting of radioactive isotopes detected in the environment, quantitative analysis programs for alpha spectrometry and gamma-ray spectroscopy, such as AlphaVision™, and GammaVision™, are available for use with ORTEC MCBs on a PC. For descriptions of these software packages, ask for the specific brochure.

Multichannel Analyzers, Multichannel Buffers, and Associated Software

MCB* Hardware Selection Guide

Features	TRUMP	TRUMP-PCI	MicroACE	919E	920E	921E	926
Format	ISA Card	PCI CARD	ISA Card	2-NIM	2-NIM	2-NIM	1-NIM
ADC Conversion Gain (Max.)	2k or 8k	2k or 8k	512 or 2048	16k	4k	16k	8k
ADC Conversion Time†	8 μ s	8 μ s	<7 μ s or < 30 μ s (80-MHz Wilkinson ADC)	7 μ s	15 μ s	1.5 μ s	8 μ s
Number of Inputs	1	1	1 (Direct to ADC or through internal amplifier)	4, with independent control and conversion gain	8 or 16 with independent control, conver- sion gain, and digital offset	1	1
Memory Size	8k	8K	2048	64k	16k	16k	8k
Nonvolatile Memory	Standard	Standard	No	Standard	Standard	Standard	Standard
Counts per Channel	>2000M	>2000M	>2000M	>2000M	>2000M	>2000M	>2000M
Live Time Clock							
Simple	Yes	Yes	No	No	No	No	Yes
Pile-Up Compensated	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Presets							
Real Time	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Live Time	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regions of Interest							
Peak Count	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Integral Count	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Data Overflow	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Peak Uncertainty	No	Yes	No	Yes	Yes	Yes	No
Nuclide MDA	No	Yes	No	Yes	Yes	Yes	No
Digital Spectrum Stabilizer	No	No	Yes	Yes	No	Yes	No
Computer Interfaces							
PCI Slot	No	Yes	No	No	No	No	No
ISA Slot	Yes	No	Yes	No	No	No	No
Dual Port to ISA-Bus	No	No	No	Yes	Yes	Yes	Yes
Serial RS-232-C	No	No	No	Yes	Yes	Yes	No
Parallel (Printer) Port	No	No	No	No	No	No	Yes
Ethernet	No	No	No	Yes	Yes	Yes	No
MCA Emulator Software							
MAESTRO-32	Included	Included	Included	Option	Option	Option	Option
Sample Changer Port	No	No	No	Yes	No	Yes	No

*ORTEC also has an extensive range of integrated hardware that combines the functionality of an MCB with other required functions such as amplifier and bias supply. Please refer to the Integrated Electronics Packages Section of this catalog.

†All ADCs are of the Successive Approximation, Fixed Conversion type unless specified otherwise.

Multichannel Analyzers, Multichannel Buffers, and Associated Software

ADCAM Computer Interfaces

A variety of computer interfaces are available for connecting the ADCAM products to a Personal Computer (PC). Plug-in ISA cards such as the TRUMP, MicroACE, and MCS-plus connect directly to the ISA Bus upon installation in the computer. Cards such as the TRUMP-PCI and the MCS-pci plug directly into the PCI bus of the computer. Most NIM and bench-top models offer a Serial Interface via RS-232-C and a network-compatible Ethernet interface. The Model 926 provides a Parallel (Printer) Port Interface for computers having no other accessible port. For models equipped with the Dual-Port Memory connector, the PRNCBL1 Printer Port Interface can be used to make the conversion to a Parallel (Printer) Port Interface. The ORSIM II MCB Server adapts the Dual-Port Memory connector to the Ethernet, which provides networked systems for remote control with ORTEC *CONNECTIONS* software. (For more information on ORSIM III and *CONNECTIONS* ask for the *CONNECTIONS* brochure.) The majority of MCBs already in use employ the Dual-Port Memory Interface.

Dual-Port Memory Interface

Implementing the Dual-Port Memory Interface involves inserting a half-slot ISA card into the PC and making the connection between this card and the MCB with a multi-wire cable. The following models include the plug-in card and the cable. Consult the data sheet or brochure for the MCB, multichannel scaler, time digitizer, or spectrometer to select the appropriate interface model number.

PCBCBL1 ISA Interface and cable for a single MCB, MCS, time digitizer, or spectrometer to an IBM PC or compatible.

PCBCBLN Same as for PCBCBL1, but for up to four non-NIM units. Includes a 92X-DPF Non-NIM Fan-Out Box. (For more than four units per PC, please contact the factory.)

PCBCBLM Same as for PCBCBL1, but for up to four NIM units. Includes the 918-DPF Fan-Out Box which is a double-width NIM module that requires no power. The PCBCBLN can be substituted for the PCBCBLM to avoid using 2 NIM slots.

Parallel (Printer) Port Interface

The PRNCBL1 interface converts the Dual-Port Memory connector to a Parallel (Printer) Port Interface for computers lacking any other port. The PRNCBL1 does not support the Turbo-MCS nor the OCTÈTE PC. It requires 5-V power.

PRNCBL1 Interface and cable to connect single unit to a standard PC printer port.

Configuration Guidelines for Multiple MCBs

The MCB Hardware Selection Guide summarizes the features of the various Multichannel Buffers (MCBs) available from ORTEC. Due to the standardization of interfacing maintained across the product ranges, creating a system configuration incorporating one or more MCBs is remarkably easy. A few basic configuration guidelines apply:

- (1.a) **For plug-in cards, such as the TRUMP, MicroACE, and MCS-plus**, 2/3 to 1-1/2 ISA option slots are needed for each card. (See the specific data sheet or brochure for details.) Each card has a jumper or a switch to select an identifying address from 1 to 8. Up to eight cards can be installed in a single PC provided each card has a unique address selected. For computers with fewer than 8 ISA slots available, a PC expansion chassis may be needed. If more than 8 units are required, the additional cards can be installed in another PC, with both computers controlled over the Ethernet by ORTEC *CONNECTIONS* software.
- (1.b) **For PCI-Bus plug-in cards**, up to eight can be attached at one time to a single PC. To prevent conflicts in multiple-MCB systems, each MCB must be assigned a unique hardware address. This is done automatically in the TRUMP-PCI and MCS-pci cards, so there are no jumpers or DIP switches to set.
- (2) **The Dual-Port Memory Interface Card** that plugs into the personal computer occupies one half of an ISA slot and incorporates eight address switches. For each connected MCB a jumper inside the MCB must be set to a unique address (from 1 through 8), and the corresponding address must be enabled on the interface card serving that MCB. The maximum MCB memory that may be associated with a single address is 16k channels.

Up to eight MCBs may be connected to a personal computer in this way via the appropriate Dual-Port Memory Interfaces. For ISA-Bus computers, more than one Dual-Port Memory Interface is allowed as long as each has a unique address setting (1 through 8).
- (3) **Multiple MCBs Connected to a Single Interface Card:** All MCBs, except those mentioned in item (1) above, can be connected to an ISA-Bus PC in multiple units through a single Dual-Port Memory Interface card using the cable packs PCBCBLM or PCBCBLN. Each pack includes an interface card that occupies one half of an ISA slot, a cable fan-out box, and cables capable of supporting up to 4 MCBs. For the PCBCBLM the fan-out box is a double-width NIM module that requires no power. The fan-out box for the PCBCBLN is an 8.3 cm x 16.5 cm x 5.8 cm stand-alone box.

Multichannel Analyzers, Multichannel Buffers, and Associated Software

- (4) **MAESTRO II and the Model 919***: The MAESTRO II MCA Emulator (no longer offered for sale) does not support local area networks. It is capable of supporting only “locally attached” MCBs, up to a maximum of eight. An MCB directly connected via a Dual-Port Memory cable to the computer on which the MCA Emulation Software is running is considered to be “locally attached.”

The Model 919 MCB is unique in that its memory consists of FOUR 16k-channel “pages.” It can support up to **four** detectors, but because only one page at a time of the Model 919 memory is mapped into the Dual-Port Memory, only a single hardware address is needed for support. It is viewed as four MCBs by MAESTRO II MCA Emulation Software, even though it occupies a single hardware address. MAESTRO II is restricted to supporting a maximum of eight MCBs, no matter how many hardware addresses are physically used. MAESTRO II therefore supports a limit of two “fully utilized” Model 919 modules. However, if not all of the Model 919 inputs are enabled, MAESTRO II can support other MCBs at the same time, up to a maximum of 8.

An upgrade from MAESTRO II to MAESTRO-32 is highly recommended.

- (5) **MAESTRO-32, and GammaVision** are capable of supporting up to 250 detectors, although the physical limit of 8 hardware addresses per PC still applies to MCBs using the Dual-Port Memory Interface. The hardware addresses limit the number of Models 921 and 926 to 8 locally attached units. However, a PC operating with MAESTRO-32 could support up to 8 locally attached Model 919 MCBs. This allows up to 32 detectors to be served by the 8 units of the Model 919.
- (6) **The Models 920-8* and 920-16*** differ from the Model 919 in that they are **segmented** MCBs. They each contain a single 16k-channel memory, and can therefore be associated with a unique address on the Dual-Port Memory Interface. Up to eight 920-8 or 920-16 MCBs may be “locally attached” to a single PC. The OCTÊTE-PC Integrated Alpha Spectrometer may be configured as if it

were a 920-8. On a single PC one can serve up to 64 detectors with 8 units of the 920-8 or OCTÊTE-PC, or 128 detectors with 8 units of the 920-16. This latter statement is valid for MAESTRO II, MAESTRO-32, and GammaVision.

- (7) **The Ethernet** can be used to connect multiple MCB/PC nodes into a network for remote control from any PC on the network via the ORTEC *CONNECTIONS* software. An MCB/PC node consists of a PC and its locally attached MCBs. Model A65-BI MAESTRO for Windows Version 3.0 or later incorporates the *CONNECTIONS* networking software. MAESTRO software running on the controlling PC makes it appear as if the controlled MCB is connected directly to the controlling PC.

In addition, the ORTEC ORSIM III can be used to connect up to 8 MCBs of any mix of MCB type to the Ethernet. The ORSIM III replaces a PC on the network and is controlled remotely by another PC on the network. If a single-input MCB such as a Model 921* is used, up to 8 detectors can be connected to the ORSIM III. If the Model 920-16 is employed, 128 detectors can be served by a single ORSIM III. Any number of ORSIM III modules can be on the network. Up to 250 detectors from all sources can be connected to a single network.

- (8) **MCBs that incorporate an Ethernet interface** can be connected to PCs on a network in any number up to 250 detectors. Examples are the 919E, 920E, 921E, DSPEC, DSPEC-PLUS, and OCTÊTE-PC.
- (9) **The Model 926 Parallel (Printer) Port** permits daisy-chaining up to 8 units of the Model 926, while still driving the normal PC printer at the end of the daisy chain.

*The models 919, 920-8, 920-16, and 921 are no longer manufactured. They have been replaced with the new EtherNIMS: 919E, 920E, and 921E.

919E EtherNIM™ Multichannel Buffer

The ORTEC Model 919E is a member of the EtherNIM family of multichannel buffers. Combined with appropriate computer hardware, ORTEC signal-processing electronics, and ORTEC CONNECTIONS applications software running under Windows® 95, 98, NT, or 2000, EtherNIM multichannel buffers are the ideal data acquisition hardware for a wide variety of applications in pulse-amplitude spectrometry.

The Model 919E provides the following functions (see block diagram):

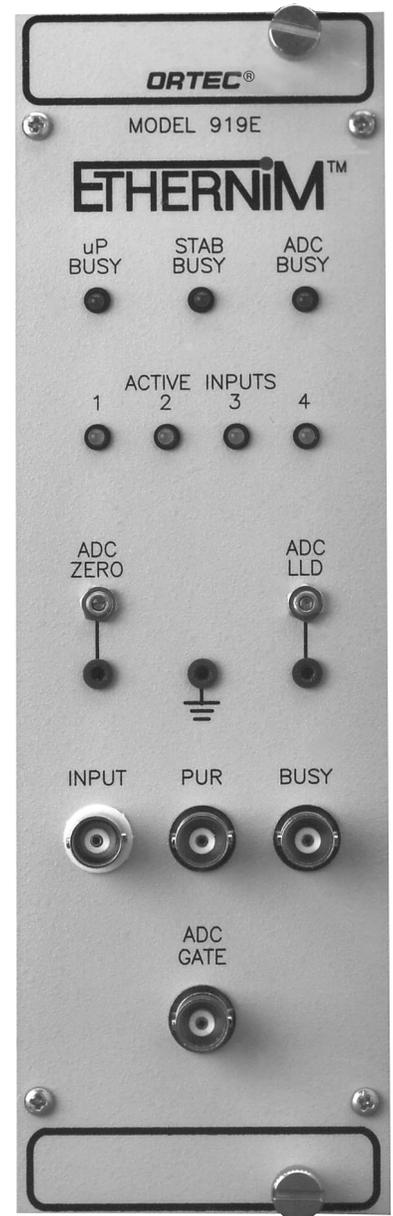
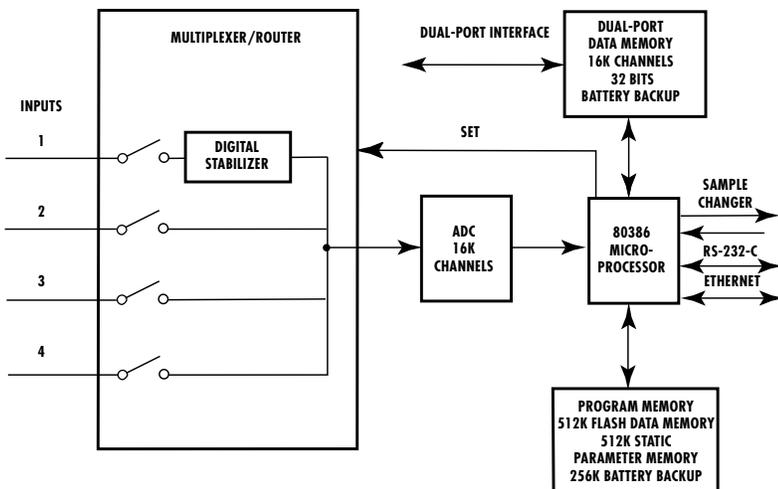
1. High-speed, 4-input multiplexer/router, with individual start/stop/preset/conversion gain control of each input
2. 16k successive-approximation ADC, with fixed conversion time of <7 μs
3. Digital Spectrum Stabilizer (for input 1 only)
4. Nonvolatile data memory: 64k channels, 2³¹-1 (2 billion) counts per channel

The 919E, a two-wide NIM, is readily connected into an Ethernet environment under Windows 95, 98, NT, or 2000. It may be integrated easily into existing networks. Control and spectral display is achieved by the use of a suitable ORTEC CONNECTIONS-32 applications package such as MAESTRO™, Gamma-Vision™, ScintiVision, AlphaVision, or Renaissance.

- High-performance MCA in a two-wide NIM
- Integral Ethernet connection for instant integration into CONNECTIONS spectroscopy networks
- FOUR independently-controlled inputs, with independent conversion gains
- 64k-channel data memory, 2³¹-1 (2 billion) counts per channel
- 16k-channel, <7 μs conversion time ADC
- Digital spectrum stabilizer
- Sample changer control port

The 919E may be employed in two modes: In the first mode, the use of the four independently-controlled inputs make the 919E an extremely cost effective way to configure systems for environmental counting; if required, the full 16k resolution of the ADC is available on each input. Segments need not be set to the same resolution; therefore, a single 919E can support “mixed” detectors, for example NaI and Ge. Each input has its own pile-up rejection and live-time clock circuitry.

In the second mode, the 919E can be used as a single input device for moderate-throughput applications with up to 16k resolution. In this mode the digital spectrum stabilizer is often useful. The dual Direct Memory Access (DMA) architecture employed allows a maximum average data throughput after pileup rejection of ~60,000 counts/sec; the Gedcke-Hale¹ live-time clock ensures high accuracy even well beyond the point of maximum throughput.



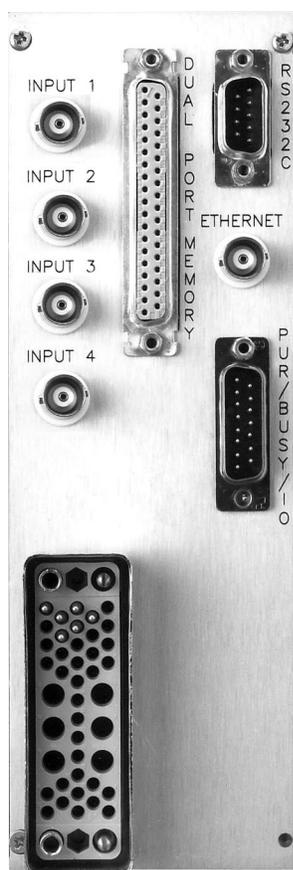
919E

EtherNIM™

Multichannel Buffer

The communications protocol used by the 919E is the “traditional” NIM digital bus NIM/488² per DOE/ER-0457T (formerly NIM/GPIB) protocol used for several years in all ORTEC MCB products.³

For the “do-it-yourself” programmer, software toolkits are available to simplify the task of having a user-written application communicate with the Model 919E.



Specifications

PERFORMANCE

ADC Successive-approximation type with sliding-scale linearization.

Max Resolution 16,384 channels, software selectable as 16,384, 8192, 4096, 2048, and 1024.

Conversion Time Per Event <7 μ s fixed.

Integral Nonlinearity $\leq \pm 0.025\%$ over top 99% of full scale.

Differential Nonlinearity $\leq \pm 1\%$.

Gain Instability $\leq \pm 50$ ppm/ $^{\circ}$ C.

Dead Time Correction Extended Live Time correction according to Gedcke-Hale method.

Throughput Average maximum rate 60,000 counts/sec stored in memory.

Data Memory 64k channels of NON-volatile memory; $2^{31}-1$ counts per channel (2 billion); may be partitioned as up to four segments of equal or unequal size in the range of 1k to 16k channels each.

Presets

Real Time/Live Time Multiples of 20 ms.

Region of Interest Peak count/integral count.

Data Overflow Terminates acquisition when any channel exceeds 2 billion.

Peak Uncertainty

Nuclide MDA

MULTIPLEXER/ROUTER

Inputs One to four; software selectable.

Signal Isolation Typically >90 db rejection of unselected input.

Input Threshold Automatically adjusted above noise level for each input to the multiplexer/router.

Gain Nominally One; segments 2, 3, and 4 are fixed. Segment 1 controlled by internal Digital Gain Stabilizer, $\pm 1\%$.

DC Level Instability ≤ 20 μ V/ $^{\circ}$ C.

Integral Linearity 0.05%.

Gain Instability 50 ppm/ $^{\circ}$ C.

DIGITAL SPECTRUM STABILIZER

Peak centroid stabilization for input 1; either zero, gain, or both. Window width, for both and gain: ± 1 to ± 256 channels.

Correction Resolution At 16k ADC resolution: 0.04 channels (for gain); <0.08 channels (for zero).

ADC Word Size 14 bits (16k channels) maximum.

Setup/Enable/Disable From computer.

FRONT-PANEL INDICATORS

ADC BUSY Red, busy-rate LED flashes once for each pulse digitized by ADC.

CPU BUSY Red, busy-rate LED; intensity indicates the relative activity of the microprocessor.

ACTIVE INPUT Each active segment indicated by green LED.

STAB BUSY LED indicates when stabilizer is active.

CONTROLS

ADC ZERO Screwdriver potentiometer adjusts the ADC zero offset ± 250 mV.

¹Ron Jenkins, R.W. Gould, and Dale Gedcke, *Quantitative X-Ray Spectrometry* (New York: Marcel Dekker, Inc.), 1981, pp 266–267.

²Please refer to “Standard NIM Digital Bus (NIM/488),” DOE/ER-0457T, U.S. NIM committee, May 1990; Standard NIM Instrumentation System, NTIS, U.S. Department of Commerce, Springfield, Virginia 22161.

³The 919E also provides the ORTEC Dual Port Memory connector on the rear panel. DPM communications are still supported by ORTEC applications packages for historical reasons, but Ethernet communications are recommended in most cases as more convenient (especially over large distances) and, in most cases, less expensive. An RS-232-C port is provided for diagnostic purposes.

ADC LLD Screwdriver potentiometer adjusts the ADC lower level discriminator from 0 to 50% of full scale.

INPUTS

INPUT 1–4 Accepts positive unipolar, positive gated integrator, or positive leading bipolar analog pulses in the dynamic range of 0 to +10 V; +12 V maximum; semi-Gaussian-shaped or gated-integrator-shaped time constants of 0.25 to 30.0 μ s, or delay-line-shaped with width ≥ 0.25 μ s. $Z_{in} \sim 1000 \Omega$, dc-coupled. No internal delay. INPUT 1: BNC connectors on front and rear panels. INPUT 2, INPUT 3, and INPUT 4: BNC connectors on rear panel only.

ADC GATE Optional, slow-positive NIM input. Computer-selectable Coincidence or Anticoincidence. Signal must occur prior to and extend 0.5 μ s beyond peak detect; front-panel BNC connector. GATE control for all active segments.

PUR 1–4 Pile-up rejection input; accepts slow-positive NIM signal; signal must occur prior to peak detect. $Z_{in} \geq 1$ k Ω . PUR 1: BNC connector on front panel. PUR 1–4: Rear-panel PUR/ BUSY/IO connector. An optional pigtail cable (919-OPT1) converts rear-panel 15-pin D connector to multiple BNCs.

BUSY 1–4 Busy input used by multiplexer/router and live-time correction circuits. Accepts slow positive NIM signal, $Z_{in} \geq 1$ k Ω . BUSY 1: BNC connector on front panel. BUSY 1–4: Rear-panel PUR/BUSY/IO connector. An optional pigtail cable (919-OPT1) converts rear-panel 15-pin D connector to multiple BNCs.

SAMPLE READY TTL input signal, on rear-panel PUR/BUSY/IO connector. An optional pigtail cable (919-OPT1) converts to multiple BNCs.

OUTPUTS

CHANGE SAMPLE TTL output signal, on rear-panel PUR/BUSY/IO connector, software addressable. An optional pigtail cable (919-OPT1) converts to multiple BNCs.

INTERFACES⁴

Ethernet Rear-panel BNC connector, accepts IEEE 802.3 10BASE2 (thin-wire coax).

PUR/BUSY/IO 15-pin D male connector. Provides BUSY and PUR inputs for each of four segments. Two sample-changer signals included on this connector are Change Sample output and Sample Ready input.

ELECTRICAL AND MECHANICAL

POWER REQUIREMENTS +12 V, 370 mA; –12 V, 175 mA; +24 V, 185 mA; –24 V, 150 mA; +6 V, 1.20 A.

DIMENSIONS NIM-standard two-wide 6.90 X 22.13 cm (2.70 X 8.714 in.) front panel per DOE/ER-0457T.

WEIGHT

Net 2.25 kg (5 lb).

Shipping 3.1 kg (7 lb).

Option

919-OPT1 Pigtail Cable containing 12 BNC cables to connect up to four amplifiers with pile-up rejector (PUR) and live-time clock to the Model 919E. (ORTEC 671/672 highly recommended.)

⁴The following connectors are also available:

Dual-Port Memory — ORTEC dual-port interface, 37-pin D connector.

RS-232-C — Serial standard RS-232-C 25-pin; male wired as DTE to run at 38.4k baud maximum, with modem control. Software selectable baud rate. (For diagnostics)

Ordering Information

To order, specify:

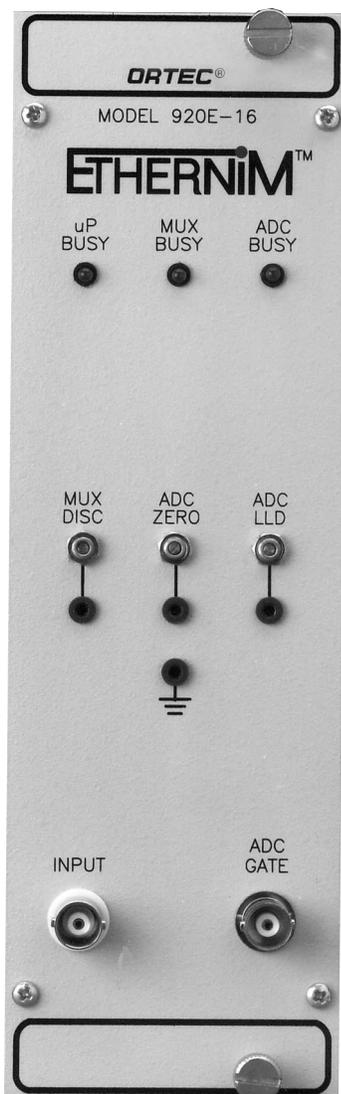
Model	Description
919E	919 EtherNIM™ High-Performance Multichannel Buffer (includes 64k-channel, nonvolatile memory, 16k-channel ADC, 4-input multiplexer, and digital spectrum stabilizer)
919-OPT1	Pigtail Cable containing 12 BNC cables to connect up to four amplifiers with pile-up rejector (PUR) and live-time clock to the Model 919E. (ORTEC 671/672 highly recommended.)

920E

EtherNIM™

16-Input Multichannel Buffer

- 16-input, high-performance MCA in a two-wide NIM
- Integral Ethernet connection for instant integration into *CONNECTIONS* spectroscopy networks
- 16k-channel data memory, $2^{31}-1$ counts per channel
- 4k-channel ADC (15- μ s fixed conversion time)



The ORTEC Model 920E is a member of the EtherNIM family of multichannel buffers. Combined with appropriate computer hardware, ORTEC signal-processing electronics, and ORTEC *CONNECTIONS* applications software running under Windows® 95, 98, NT, or 2000, EtherNIM multichannel buffers are the ideal data acquisition hardware for a wide variety of applications in pulse-amplitude spectrometry. The 920E, a two-wide NIM, accommodates up to 16 inputs, with independent start/stop/preset control. The unique “dynamic routing” feature enhances flexibility.

The Model 920E provides the following functions (see block diagram):

1. High-speed multiplexer/router with 16 inputs
2. 4k-channel, successive-approximation ADC, with fixed conversion time of <math><15 \mu\text{s}</math>; memory divisible into 1, 2, 4, 8, or 16 segments; memory size selectable as 1024, 2048, 4096, or 16,384 channels. Connection between physical input and memory segment allocated under software control (“dynamic routing”).

3. Nonvolatile memory; 16k channels, $2^{31}-1$ counts per channel

The 920E is readily connected into an Ethernet environment under Windows 95, 98, NT, or 2000. It may be integrated easily into existing networks. Control and spectral display is achieved by using a suitable ORTEC *CONNECTIONS-32* applications package such as MAESTRO™, AlphaVision™, Scinti-Vision™, or Renaissance™.

The 920E employs a dual Direct Memory Access (DMA) architecture to maximize system throughput. The unique “dynamic routing” feature allows any one, or any group of inputs to be routed to any memory segment. This has many applications in areas as diverse as whole-body counting and fuel-pin scanning.

The communications protocol used by the 920E is the “traditional” NIM digital bus NIM/488¹ per DOE/ER-0457T (formerly NIM-GPIB) protocol used for several years in all ORTEC MCB products.²

For the “Do it yourself” programmer, software toolkits are available to simplify the task of making a user-written application communicate with the Model 920E.

¹Please refer to “Standard NIM Digital Bus (NIM/488),” DOE/ER-0457T, U.S. NIM committee, May 1990; Standard NIM Instrumentation System, NTIS, U.S. Department of Commerce, Springfield, Virginia 22161.

²The 920E also provides the ORTEC Dual-Port Memory connector on the rear panel. DPM communications are still supported by ORTEC applications packages for historical reasons, but Ethernet communications are recommended in most cases, for convenience (especially over large distances) and for ease and reduced cost of implementation. An RS-232-C port is also provided for diagnostic purposes.

Specifications

PERFORMANCE

ADC Successive-approximation type with sliding scale linearization.

MAXIMUM RESOLUTION 4096 channels, software selectable independently for each segment as 64, 128, 256, 512, 1024, 2048, and 4096.

DIGITAL OFFSET Independent for each segment in increments of 1 channel from 0 to 4096.

CONVERSION TIME PER EVENT 15 μ s (fixed).

INTEGRAL NONLINEARITY $\leq \pm 0.025\%$ over top 97% of dynamic range.

DIFFERENTIAL NONLINEARITY $\leq \pm 1\%$ over top 97% of dynamic range.

GAIN INSTABILITY < 50 ppm/°C.

DEAD TIME CORRECTION Extended Live-Time correction according to Gedcke-Hale method.³

DATA MEMORY 16k channels of nonvolatile memory; 2³¹-1 counts per channel (over 2 billion).

PRESETS

Real Time/Live Time Multiples of 20 ms.

Region of Interest Peak count/integral count.

Data Overflow Terminates acquisition when any channel exceeds 2 billion.

Peak Uncertainty

Nuclide MDA

MULTIPLEXER/ROUTER

Inputs One to 16, software selectable.

Signal Isolation Typically > 72 db rejection of unselected inputs.

Input Threshold Set by front-panel screwdriver adjustment. Range is from 100 to 500 mV and is common to all inputs.

Gain Nominally unity.

DC Level Instability ≤ 20 μ V/°C.

Integral Linearity 0.05%.

Gain Instability 50 ppm/°C.

FRONT-PANEL INDICATORS

CPU BUSY Red LED's intensity indicates the relative activity of the microprocessor.

MUX BUSY Red LED's intensity indicates the relative activity of the multiplexer/router.

ADC BUSY Red LED flashes once for each pulse digitized by ADC.

CONTROLS

MUX DISC Screwdriver potentiometer from 100 to 500 mV.

ADC ZERO Screwdriver potentiometer adjusts the ADC zero offset ± 250 mV.

ADC LLD Screwdriver potentiometer adjusts the lower level discriminator from 0 to 50% of full scale.

INPUTS

INPUT 1 Front-panel BNC accepts positive unipolar, positive gated integrator, or positive-leading bipolar, +10 V, pulse; +12 V maximum; semi-Gaussian-shaped or gated-integrator-shaped time constants of 0.50 to 30 μ s. $Z_{in} = 1000 \Omega$, dc-coupled. No internal delay.

AMPLIFIER INPUTS Accepts positive unipolar, positive gated integrator, or positive-leading bipolar +10 V; +12 V maximum; semi-Gaussian-shaped or gated-integrator-shaped time constants of 0.50 to 30 μ s. $Z_{in} = 1000 \Omega$, dc-coupled. No internal delay. Inputs 1 to 16 are on rear-panel, 50-pin Amplifier Input connector. Optional cable (920-16-OPT1) converts 50-pin D connector to multiple BNCs.

ADC GATE Optional, slow positive NIM input. Computer-selectable Coincidence or Anticoincidence. Signal must occur prior to and extend 0.5 μ s beyond peak of input pulse. Front-panel BNC connector. Gate control for all active inputs.

INTERFACES⁴

ETHERNET Rear-panel BNC connector, accepts IEEE 802.3 10BASE2 (thin-wire coax).

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 165 mA; -24 V, 165 mA. +12 V, 160 mA; -12 V, 110 mA; +6 V, 1.2 A.

WEIGHT

Net 2.25 kg (5 lb).

Shipping 3.1 kg (7 lb).

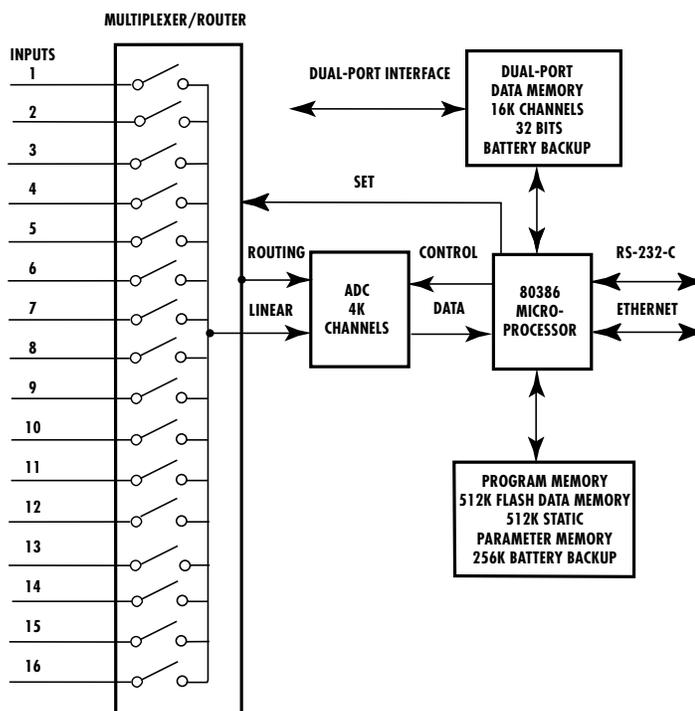
DIMENSIONS NIM-standard double-width 6.90 X 22.13 cm (2.70 X 8.714 in.) front panel per DOE/ER-0457T.

³Ron Jenkins, R.W. Gould, and Dale Gedcke, *Quantitative X-Ray Spectrometry* (New York: Marcel Dekker, Inc.), 1981 pp 266-267.

⁴The following connectors are also available:

Dual-Port Memory — ORTEC dual-port interface, 37-pin D connector.

RS-232-C — Serial standard RS-232-C 25-pin; male wired as DTE to run at 38.4k baud maximum, with modem control. Software selectable baud rate. (For diagnostics)



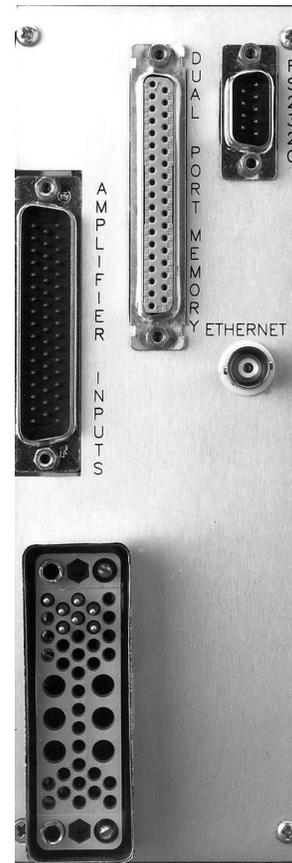
920E BLOCK DIAGRAM

920E EtherNIM™ 16-Input Multichannel Buffer

Ordering Information

To order, specify:

Model	Description
920E	920-16 EtherNIM Multichannel Buffer with 16 detector inputs
920-16-OPT1	Optional cable to convert 50-pin D connector to multiple BNCs for Model 920E



921E EtherNIM™ High-Rate Multichannel Buffer

The ORTEC Model 921E is a member of the EtherNIM family of multichannel buffers. Combined with appropriate computer hardware, ORTEC signal-processing electronics and ORTEC CONNECTIONS applications software running under Windows® 95, 98, NT, or 2000, EtherNIM multichannel buffers are the ideal data acquisition hardware for a wide variety of applications in pulse-amplitude spectrometry.

The Model 921E provides the following functions (see Fig. 1):

1. Fast, 16k-channel, successive-approximation ADC, with fixed conversion time of <math><1.5 \mu\text{s}</math>
2. Digital Spectrum Stabilizer
3. Nonvolatile data memory: 16k channels, $2^{31}-1$ (2 billion) counts per channel

The 921E is simply connected into an Ethernet environment under Windows 95, 98, NT, or 2000. It may be integrated easily into existing networks. Control and spectral display is achieved by the use of a suitable ORTEC CONNECTIONS-32 applications package such as MAESTRO™, GammaVision™, Scinti-Vision™, or Renaissance™.

- **High-speed MCA in a two-wide NIM**
- **Integral Ethernet connection for instant integration into CONNECTIONS spectroscopy networks**
- **Ultra-fast, 16k-channel <math><1.5 \mu\text{s}</math> conversion time ADC**
- **16k-channel data memory, $2^{31}-1$ (2 billion) counts per channel**
- **Digital spectrum stabilizer**
- **Sample changer control port**

The two-wide NIM 921E employs a dual Direct Memory Access (DMA) architecture to maximize system throughput. It provides the very best in throughput performance for ultra-high-rate spectrometry with a germanium detector. Figure 2 shows some actual performance data taken with a Model 921E used in conjunction with its companion product, the Model 973U Ultra-High Count-Rate Amplifier. The upper curve shows the throughput to memory when the integration time of the 973U is at its lower setting, 1.5 μs . The lower curve depicts the throughput to memory when the integration time of the 973U is at its higher setting of 3 μs . In

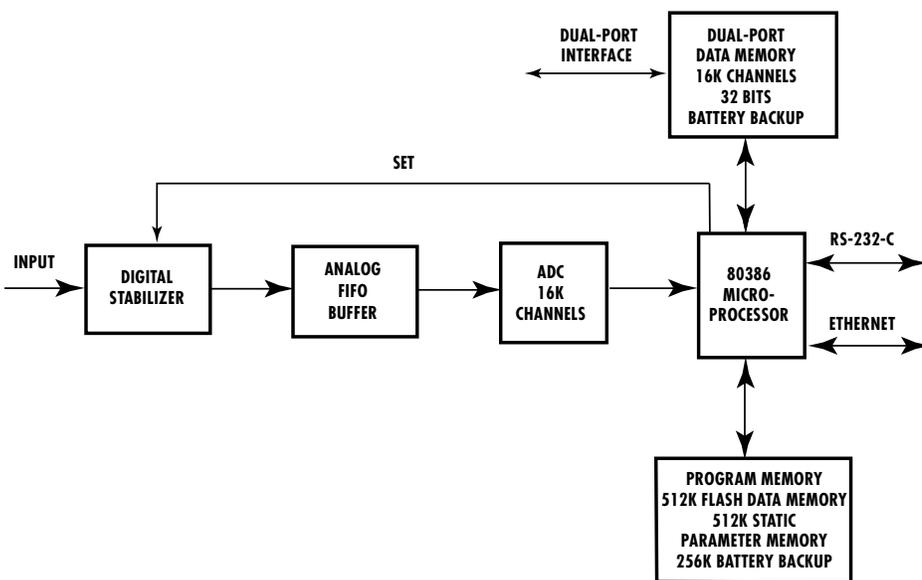
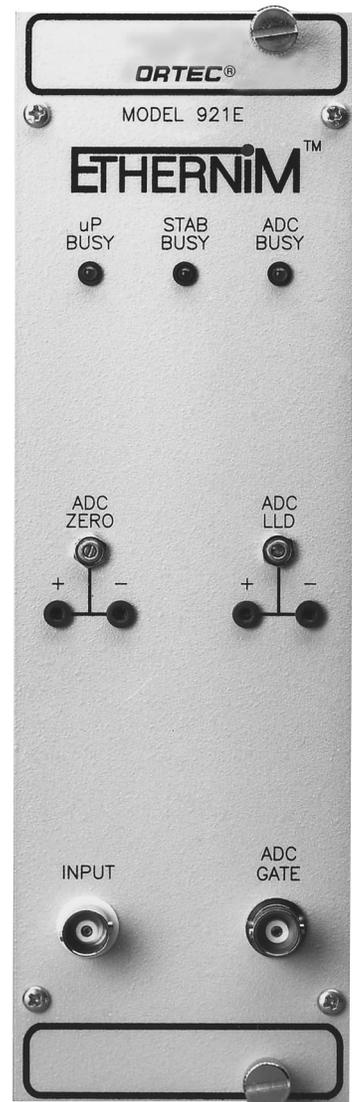


Fig. 1. 921E Block Diagram.



921E EtherNIM™ High-Rate Multichannel Buffer

both cases the pile-up rejection circuitry of the 973U and 921 were enabled. The maximum throughput to memory is almost 100k counts/sec. At this maximum throughput, the accuracy of the livetime clock is $\pm 3\%$.

The high pile-up-free throughput and highly accurate deadtime correction make the 921E EtherNIM MCB the instrument of choice for ultra-high count-rate spectrometry with germanium detectors.

The communications protocol used by the 921E is the "traditional" NIM digital bus NIM/488¹ per DOE/ER-0457T (formerly NIM/GPIB) method used for several years in all ORTEC MCB products.²

For the "do-it-yourself" programmer, software toolkits are available to simplify the task of making a user-written application communicate with the 921E.

¹Please refer to "Standard NIM Digital Bus (NIM/488)," DOE/ER-0457T, U.S. NIM committee, May 1990; Standard NIM Instrumentation System, NTIS, U.S. Department of Commerce, Springfield, Virginia 22161.

²The 921E also provides the ORTEC Dual-Port Memory connector on the rear panel. DPM communications are still supported by ORTEC applications packages for historical reasons, but Ethernet communications are recommended in most cases as more convenient (especially over large distances) and, in most cases, less expensive to implement. An RS-232-C port is also provided for diagnostic purposes.

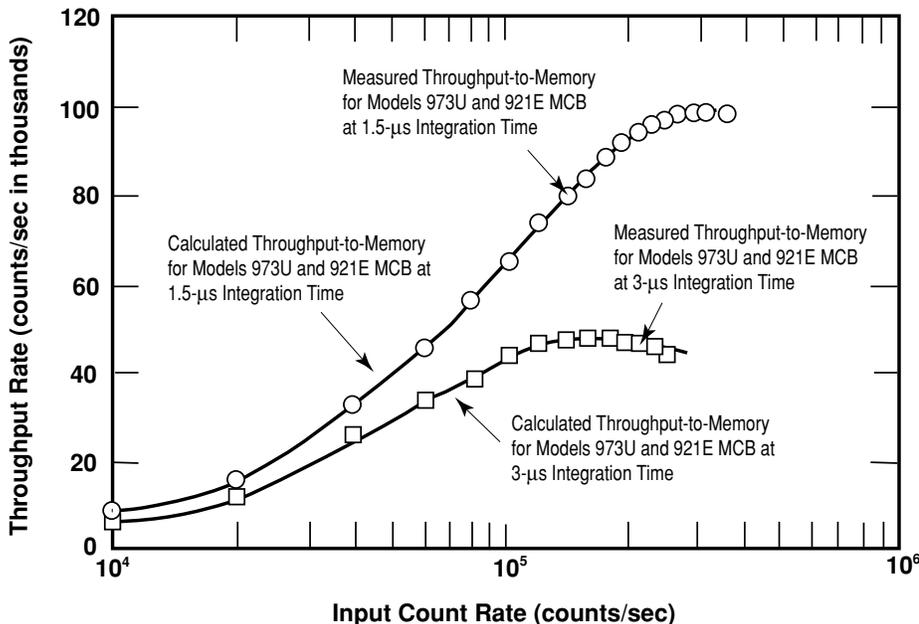


Fig. 2. Throughput to Memory of the Model 921E When Used in Conjunction with Model 973U Ultra-High-Rate Amplifier.

Specifications

PERFORMANCE

ADC Successive-approximation type with sliding-scale linearization.

MAX RESOLUTION 16,384 channels, software selectable as 16,384, 8192, 4096, 2048, 1024, and 512.

DEAD TIME PER EVENT 1.5 μ s, including memory transfer; measured at 5 μ s shaping with ORTEC Model 973 High-Rate Spectroscopy Amplifier at 100,000 counts/sec input count rate.

INTEGRAL NONLINEARITY $\leq \pm 0.025\%$ over the top 99% of the dynamic range.

DIFFERENTIAL NONLINEARITY $\leq \pm 1\%$ (typical).

GAIN INSTABILITY $\leq \pm 50$ ppm/ $^{\circ}$ C.

DEAD TIME CORRECTION Extended Live Time correction according to Gedcke-Hale method.³

DATA MEMORY 16k channels of NON-volatile memory; 2³¹-1 (over 2 billion) counts per channel.

PRESETS

Real Time/Live Time Multiples of 20 ms.

Region of Interest Peak count/integral count.

Data Overflow Terminates acquisition when any channel exceeds 2 billion.

Peak Uncertainty

Nuclide MDA

DIGITAL SPECTRUM STABILIZER Peak centroid stabilization: either zero, gain, or both. Window width, for both zero and gain: ± 1 to ± 256 channels.

Correction Resolution At 16k ADC resolution: 0.04 channels (for gain); <0.08 channels (for zero).

ADC Word Size 14 bits (16k channels) maximum.

Setup/Enable/Disable From computer.

FRONT-PANEL INDICATORS

CPU BUSY Red, busy-rate LED; intensity indicates the relative activity of the microprocessor.

STAB BUSY Red LED indicates when stabilizer is active.

ADC BUSY Red, busy-rate LED flashes once for each pulse digitized by ADC.

CONTROLS

ADC ZERO Screwdriver potentiometer adjusts ADC zero offset ± 250 mV.

ADC LLD Screwdriver potentiometer adjusts lower level discriminator from 0 to 10% of full scale.

INPUTS

INPUT Accepts positive unipolar, positive gated integrator, or positive leading bipolar analog pulses in the dynamic range from 0 to +10 V; +12 V maximum; semi-Gaussian-shaped or gated-integrator-shaped time constants from 0.25 to 30.0 μ s, or delay-line-shaped with width >0.25 μ s. $Z_{in} \sim 1000 \Omega$, dc-coupled. No internal delay. BNC connector on front and rear panel.

ADC GATE Optional, slow-positive NIM input. Computer-selectable Coincidence or Anticoincidence. Signal must occur prior to and extend 0.5 μ s beyond peak detect; front-panel BNC connector.

PUR Pile-up rejection input; accepts slow-positive NIM signal; signal must occur prior to peak detect. $Z_{in} > 1 \text{ k}\Omega$. BNC connector on rear panel.

BUSY Busy input used by live-time correction circuits. Accepts slow positive NIM signal, $Z_{in} > 1 \text{ k}\Omega$. BNC connector on rear panel.

SAMPLE READY TTL input signal to BNC connector on rear panel.

OUTPUTS

CHANGE SAMPLE TTL output signal to BNC connector on rear panel; software addressable.

INTERFACES⁴

ETHERNET Rear-panel BNC connector, accepts IEEE 802.3 10BASE2 (thin-wire coax).

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 160 mA; -24V, 240 mA; +12 V, 900 mA; -12 V, 260 mA; +6 V, 1.0 A.

WEIGHT

Net 2.25 kg (5 lb).

Shipping 3.1 kg (7 lb).

DIMENSIONS NIM-standard double-wide 6.90 x 22.13 cm (2.70 x 8.714 in.) front panel per DOE/ER-0457T.

Ordering Information

To order, specify:

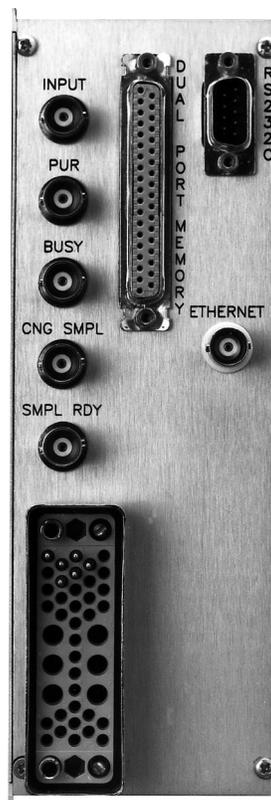
Model	Description
921E	921 EtherNIM™ High-Rate Multichannel Buffer

³Ron Jenkins, R.W. Gould, and Dale Gedcke, *Quantitative X-Ray Spectrometry* (New York: Marcel Dekker, Inc.) 1981, pp 266–267.

⁴The following connectors are also available:

Dual-Port Memory — ORTEC dual-port memory, 37-pin D connector.

RS-232-C — Serial standard RS-232-C 25-pin; male wired as DTE to run at 38.4 kbaud maximum, with modem control. Software selectable baud rate. (For diagnostics)



CAMAC ADCs, Memories, and Associated Software

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Multi-Parameter ADCs and Memories

Leap over the Barrier to Multi-Parameter Experiments

Incorporating ADCs into a multi-parameter experiment can be a difficult task involving the development of suitable ADCs, computer interfaces, and special software. Typically, the project demands substantial effort from analog and digital electronics engineers, software programmers, and systems engineers. Traditionally, the magnitude of the project has been a significant barrier to implementation.

Now there is a simple solution. CAMAC/FERAbus ADCs from ORTEC and supporting SPARROW Kmax™ Software enable you to leap over the multi-parameter barrier with ease.

Off-the-Shelf, Standard CAMAC ADCs

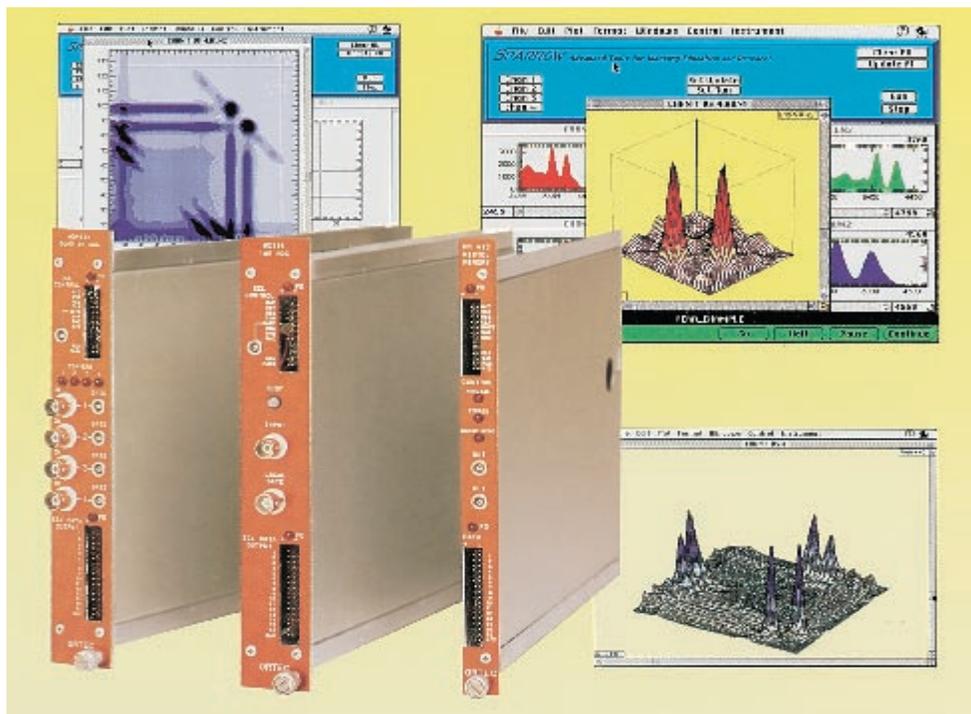
The ADCs are standard CAMAC modules. This guarantees compatibility with the numerous CAMAC products supplied by other manufacturers. Compatible CAMAC products include crates, power supplies, crate controllers, computer interfaces, and a variety of modular functions. The digital data bus in the CAMAC crate provides computer control and readout for the ADCs. Data transfer rates to a PC up to 1000 ADC data words per second are possible over the CAMAC bus. For

applications requiring higher data rates and a large number of parameters, the ADCs offer FERAbus readout. The FERAbus readout is fully compatible with the LeCroy product line of CAMAC/FERAbus modules for fast, multi-parameter data acquisition. Data transfer rates to a PC up to 200,000 ADC data words per second can be accommodated over the FERAbus. The availability of standard CAMAC products for interfacing the ORTEC ADCs to a computer eliminates the need for analog and digital electronics engineers.

Standard CAMAC Software, with Ready-to-Run Programs

Kmax Software from SPARROW supports the ORTEC ADCs with ready-to-run programs for the Macintosh® computer, the IBM PC, and IBM-compatible PCs. Standard programs for data acquisition, display, and control are available for 1- to 4-parameter systems. SPARROW can also provide customized programs for more than four parameters, or for any configuration of CAMAC modules you desire. Kmax software offers unprecedented expandability, with Module Description Resource files that support the specific command set of every commercial CAMAC module. For the ORTEC ADCs, Kmax software provides all the features you need for acquiring, sorting, displaying, and analyzing single- or multi-parameter data. With Kmax, you don't need a software programmer.

CAMAC ADCs, Memories, and Associated Software



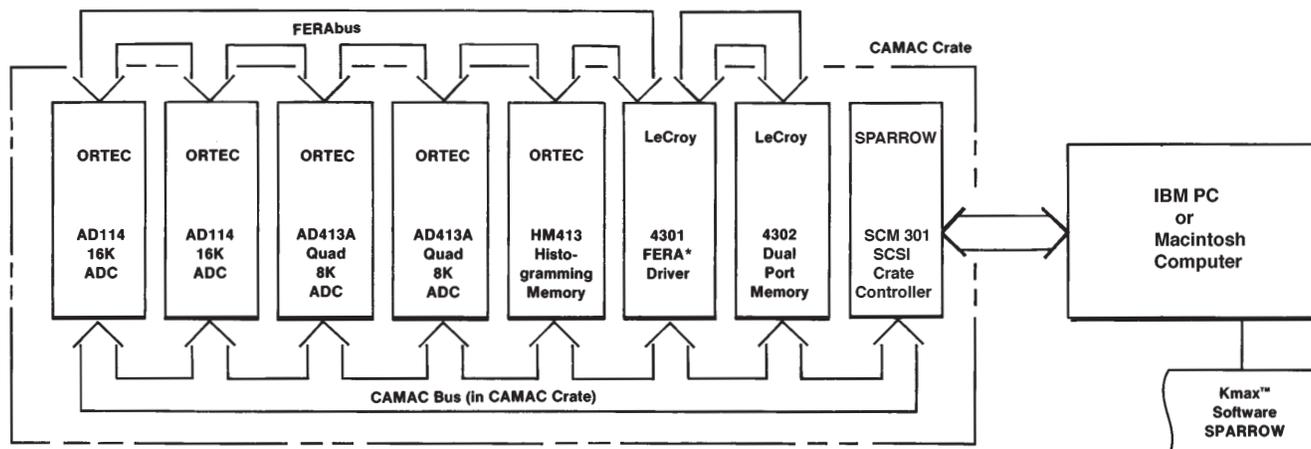
Combining SPARROW software with ORTEC ADCs provides a simple solution for even your most complex multi-parameter requirements.

CAMAC FERAbus ADCs from ORTEC are standard products that can be combined with SPARROW Kmax software to build a powerful multi-parameter data collection system. **These ADCs eliminate the need for electronic design engineers.**

- Fast multi-parameter data collection
- Peak-sensing ADCs with 13- or 14-bit resolution
- Throughput to 100,000 data words per second
- Expandable from 1 to 1024 parameters

Kmax software from SPARROW supports the ORTEC CAMAC ADCs with ready-to-run programs for the Macintosh computer and IBM PCs. **Kmax eliminates the need for software programmers and system engineers.**

- Powerful single- and dual-parameter displays
- Event-by-event data acquisition and sorting
- Unprecedented system expandability (standard package for 1 to 4 parameters; customized solutions available for up to 1024 parameters)
- For details contact www.sparrowcorp.com.



The ADC Function

An analog-to-digital converter (ADC) measures the maximum amplitude of an analog pulse and converts that value to a digital number. The digital output is a proportional representation of the analog amplitude at the ADC input. For sequentially arriving pulses, the digital outputs from the ADC are fed to a dedicated memory, or a computer, and sorted into a histogram. This histogram represents the spectrum of input pulse heights. If the input pulses come from an energy spectroscopy amplifier, the histogram corresponds to the energy spectrum observed by the associated detector. When the output of a time-to-amplitude converter is connected to the ADC input, the histogram represents the time spectrum measured by the time-to-amplitude converter. The combination of the ADC, the histogramming memory, and a CRT display of the histogram forms a multichannel analyzer (MCA). If a computer is employed to display the spectrum, then the combination of the ADC and the histogramming memory is called a multichannel buffer (MCB).

ADC Types

Three types of ADCs are available: the flash ADC, the Wilkinson ADC, and the successive-approximation ADC. Only the latter two are used for high-resolution pulse-height spectroscopy.

The Wilkinson ADC

The operation of the Wilkinson ADC is illustrated in Figs. 1 and 2. The lower-level discriminator (Figs. 1a and 1b) is used to recognize the arrival of the amplifier output pulse. Usually, the lower-level discriminator threshold is set just above the noise level to prevent the ADC from spending time analyzing noise. When the input pulse rises above the lower-level discriminator threshold, the input linear gate is open and the rundown capacitor is connected to the input (Fig. 2a). Thus, the capacitor is forced to charge up so that its voltage follows the amplitude of the rising input pulse (Fig. 1c). When the input signal has reached its maximum amplitude and begins to fall (Fig. 1c), the linear gate is closed and the capacitor is disconnected from the input (Fig. 2b). At this point, the voltage on the capacitor is equal to the maximum amplitude of the input pulse. Following peak amplitude detection, a constant current source is connected to the capacitor to cause a linear discharge (rundown) of the capacitor voltage (Figs. 1c and 2b). At the same time, the address clock is connected to the address counter (Figs. 1d and 2b) and the clock pulses are counted for the duration of the capacitor discharge. When the voltage on the capacitor reaches zero, the counting of the clock pulses ceases. Since the time for linear discharge of the capacitor is proportional to the original pulse amplitude, the number N_c recorded in the address counter is also proportional to the pulse amplitude. During the memory cycle (Figs. 1e and 2c), the address N_c is located in the histogramming memory, and one count is added to the contents of that location. The

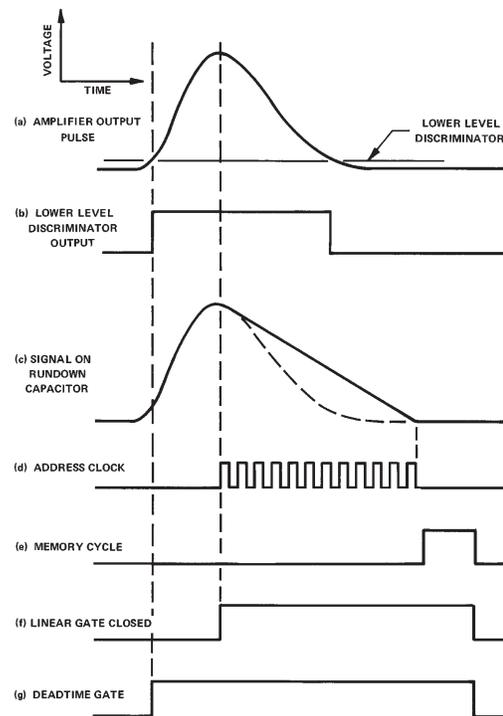


Fig. 1. Signals in the Wilkinson ADC During the Pulse Measurement Process.

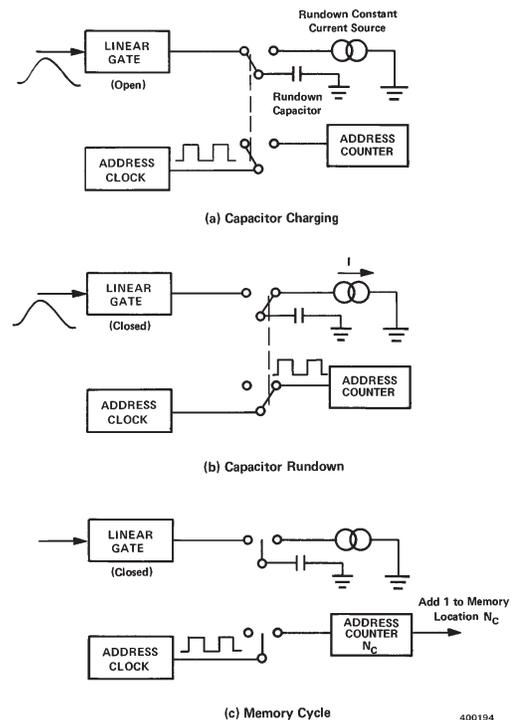


Fig. 2. Operation of the Wilkinson ADC During the Three Stages of Pulse Amplitude Measurement. (a) Charging of the rundown capacitor, (b) Capacitor rundown, and (c) The memory cycle.

CAMAC ADCs, Memories, and Associated Software

value N_c is usually referred to as "the channel number." ADCs are commonly available with as few as 256 channels for low-resolution applications, and as many as 16,384 channels for high-resolution requirements.

For the Wilkinson ADC, the measurement time of the MCA contributes a non-extending dead time as expressed in Equation (1).

$$T_M = (N_c / f_c) + T_{MC} \quad (1)$$

The MCA dead time depends on the clock frequency f_c , the channel number N_c , and the memory cycle time T_{MC} . Clock frequencies in the range from 50 to 400 MHz are typical, and memory cycle times from 0.5 to 2 μ s are common. As a result, maximum conversion times for an 8192-channel Wilkinson ADC range from 20 to 165 μ s. The advantage of Wilkinson ADCs is low differential nonlinearity (typically <1%). The disadvantage is the long conversion time, which is dependent on pulse amplitude.

The Flash ADC

Figure 3 depicts the principle of the flash ADC. The ADC is constructed by stacking a series of comparators so that each comparator's threshold is a constant increment in voltage ΔV above the previous threshold. The flash ADC is essentially a stack of single-channel pulse-height analyzers with equal window widths and shared thresholds. When the analog input signal is at its maximum amplitude, the outputs of the comparators are strobed into the digital output encoder. The

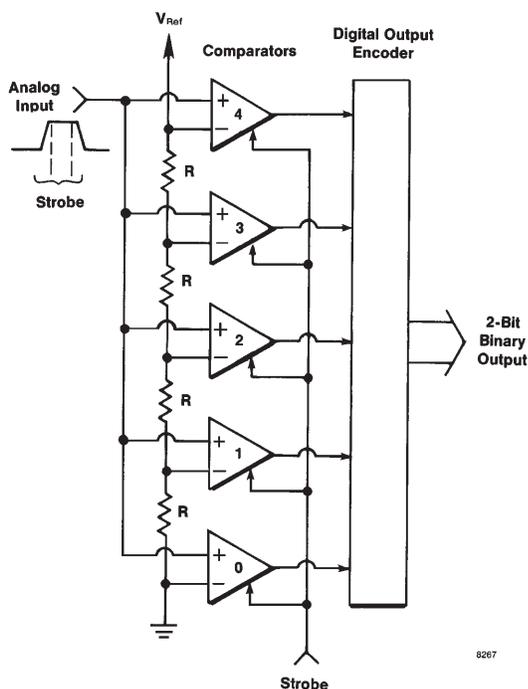


Fig. 3. The Principle of a Flash ADC.

illustration in Fig. 3 is a two-bit (or four-channel) flash ADC. If, for example, the amplitude of the analog pulse falls between the levels of comparators 2 and 3, the binary output code generated is 10 (equivalent to the decimal number 2). The advantage of flash ADCs is speed. Conversion times are in the nanosecond range. The disadvantage is large differential nonlinearity (non-uniformity of channel widths), which generally limits the flash ADC to a resolution of less than eight bits. Because of the large differential nonlinearity and the limited number of bits, the flash ADC is not applicable for high-resolution pulse-height spectroscopy.

The Successive-Approximation ADC

The successive-approximation ADC is illustrated in Fig. 4. During the rise of the analog input pulse, the switch S_1 is closed and the voltage on capacitor C_1 tracks the rise of the input signal. When the input signal reaches maximum amplitude, S_1 is opened, leaving C_1 holding the maximum voltage of the input signal. After detection of the peak amplitude of the input pulse, the successive-approximation ADC begins its measurement process. First, the most significant bit of the digital-to-analog converter (DAC) is set. If the comparator determines that the DAC output voltage is greater than the signal amplitude V_s , the most significant bit is reset. If the DAC output voltage is less than V_s , the most significant bit is left in the set condition. Subsequently, the same test is made by adding the next most significant bit. This process is repeated until all bits have been tested. The bit pattern set in the register driving the DAC at the end of the test is a digital representation of the analog input pulse amplitude. This binary number N_c is the address of the memory location to which one count is added to build the histogram representing the pulse-height spectrum. If the ADC has n bits (2^n channels), n test cycles are required to complete the analysis, and this is the same for all pulse amplitudes.

The number of test cycles can be reduced by replacing the single comparator with a flash ADC. For example, in a 16-bit successive-approximation ADC a 6-bit flash ADC is used to determine 5 bits in the first cycle, 5 bits in the second cycle, and the remaining 6 bits in the third cycle. This improves the overall conversion time by reducing the number of cycles from 16 to 3.

Although successive-approximation ADCs are available with the number of bits required for high-resolution spectroscopy,

CAMAC ADCs, Memories and Associated Software

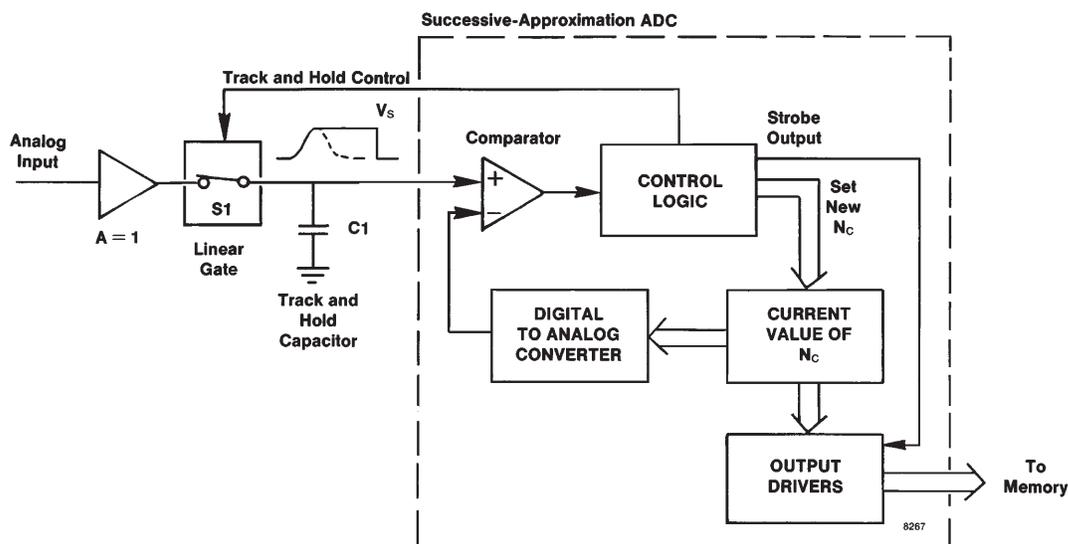


Fig. 4. The Basic Circuits Used with a Successive-Approximation ADC.

their differential nonlinearity is not adequate. The differential nonlinearity is typically 1/2 of the least significant bit (i.e., 50%). This problem is overcome by adding the sliding scale linearization shown in Fig. 5. After each pulse is analyzed, the 8-bit counter is incremented. This results in an analog voltage being added to the analog input signal before analysis by the successive-approximation ADC. If the number in the 8-bit counter is m , this results in the successive-approximation ADC reporting the analysis m channels higher than normal. By digitally subtracting m at the output of the successive-approximation ADC, the digital representation is brought back to its normal value. As the 8-bit counter increments through its range after each input pulse, it averages the analysis of each

pulse height over 256 adjacent channels in the successive-approximation ADC. This reduces the differential nonlinearity to <1%.

The advantages of the successive-approximation ADC with sliding scale linearization are low differential nonlinearity, and a short conversion time that is independent of the pulse amplitude. Conversion times in the range from 2 to 20 μ s are available, with ADC resolutions ranging from 1,000 to 16,000 channels.

Input Features

The analog input to the ADC is normally dc-coupled to avoid

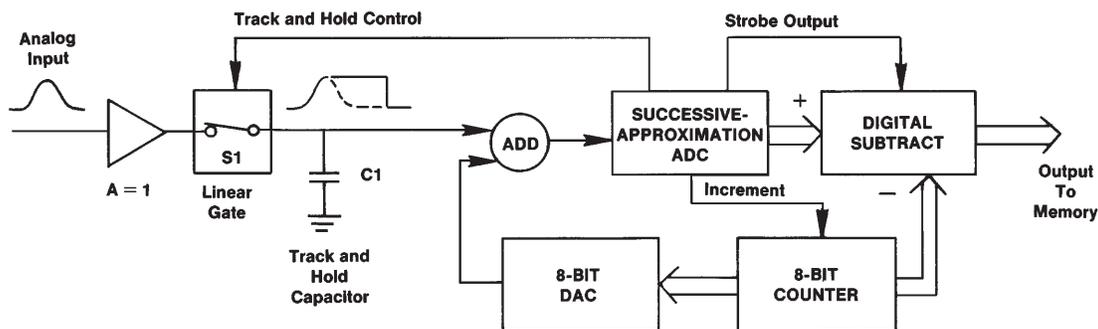


Fig. 5. The Successive-Approximation ADC with Sliding Scale Linearization.

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baseline shifts caused by varying counting rates. A lower-level discriminator is adjustable to prevent analysis of noise, while accepting the lowest possible signal amplitudes. An upper-level discriminator is also employed to prevent the ADC from wasting time converting signals outside the range of allocated memory. This is more important with the longer conversion times, particularly on Wilkinson ADCs.

Typically, logic inputs are provided for coincidence or anti-coincidence gating. The pile-up rejector (PUR) input is a special anticoincidence gate input that is frequently provided to facilitate the use of the pile-up rejector incorporated in many spectroscopy amplifiers. This input permits suppression of the analysis of an analog pulse if a second pulse arrives before the peak amplitude of the first pulse has been detected.

Types of Readout

A variety of readout configurations is available for ADCs that are not inextricably connected to a dedicated memory. ADCs in a NIM package usually offer TTL outputs on a specially defined bus. The CAMAC modular package provides greater flexibility for readout to a computer in larger experiments. It can also offer computer control of the adjustable ADC parameters. For experiments requiring readout of a large number of ADCs with coincident events, the CAMAC package with list-mode readout on the FERABus is a fast and efficient solution, particularly when zero suppression is employed. The FERABus readout is able to skip ADCs presenting no information in 3 ns, find the ADCs with active information, and read them out at a rate of 100 ns per word. For example, finding and reading out five nonzero outputs in a 40-input array of ADCs takes about 1.1 μ s.

Dead-Time Effects

When a detector, preamplifier, spectroscopy amplifier, and ADC are combined to form a spectroscopy system, the dead times of the amplifier and the ADC are in series. The combination of the amplifier extending dead time followed by the ADC non-extending dead time T_M yields a throughput described by

The rate of events arriving at the detector is r_i , and r_o is the

$$r_o = \frac{r_i}{\exp [r_i (T_W + T_P)] + r_i [T_M - (T_W - T_P)] U [T_M - (T_W - T_P)]} \quad (2)$$

rate of analyzed events at the output of the ADC. T_W is the width of the amplifier pulse at the noise discriminator threshold (Fig. 6). T_P is the time from the start of the amplifier pulse to the point at which the ADC detects peak amplitude and closes the linear gate. $U [T_M - (T_W - T_P)]$ is a unit step function that changes value from 0 to 1 when T_M is greater than $(T_W - T_P)$. For successive-approximation ADCs, T_M is the fixed conversion time of the ADC and includes the time required to transfer the data to the subsequent memory. With a Wilkinson

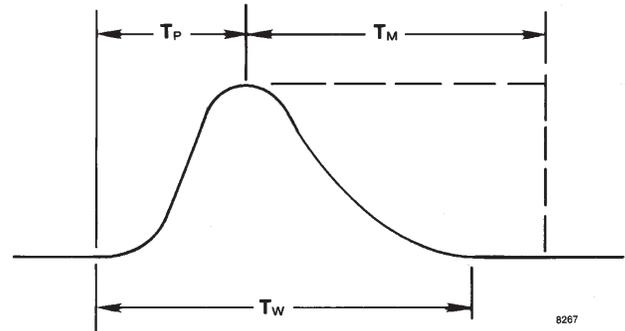


Fig. 6. The Sources of Dead Time with an Amplifier and ADC.

ADC, the value of T_M is given by Eq. 1. At high counting rates, it is desirable to have an ADC conversion time that is less than the time taken for the amplifier pulse to return to the baseline after peak amplitude.

Correction for the dead-time losses implied by Eq. 2 can be accomplished by several methods. Those ORTEC ADCs, MCAs, and MCBs incorporating live-time clocks typically utilize the Gedcke-Hale livetimer.¹ In that case, the livetimer subtracts time during the time interval T_P in order to compensate for pile-up losses. The live-time clock is turned off from the time of peak detection until the pulse returns to baseline ($T_W - T_P$), or until the ADC dead-time interval T_M is over, whichever interval is longer.

For ADCs without live-time clocks, the scheme in Fig. 7 can be used to correct for dead-time losses. A pulser with a 93- Ω output impedance, a fast rise time, and an adjustable, exponential decay time injects reference pulses into the amplifier input in parallel with the preamplifier output. First, the amplifier pole-zero cancellation is adjusted on the signals from the preamplifier with the pulser turned off. The amplifier pole-zero adjustment is left in that position for the remainder of the operation. Second, the pulser is turned on, and its decay time

¹Ron Jenkins, R.W. Gould, and Dale Gedcke, *Quantitative X-Ray Spectrometry*, (New York and Basel: Marcel Dekker, Inc.,) 1981, pp. 209-287, First Edition.

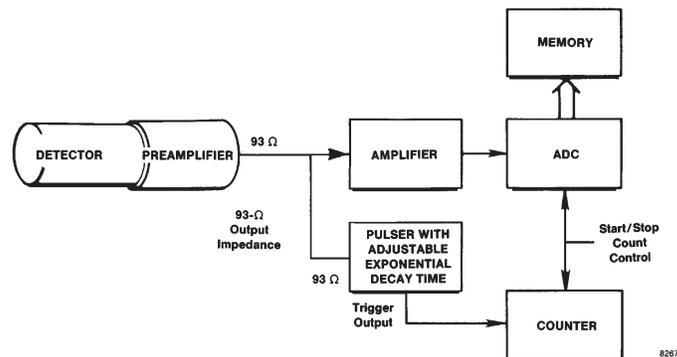


Fig. 7. Dead-Time Correction by Pulse Injection.

CAMAC ADCs, Memories, and Associated Software

is adjusted to achieve perfect pole-zero cancellation on the pulse at the amplifier output. Third, the pulser amplitude is adjusted to place the pulser peak near the high-energy end of the spectrum, where it will not interfere with radiation peaks that must be analyzed. During the measurement time, the ADC will accumulate pulser events in the spectrum, along with real events from the detector. The pulses from the pulser experience the same dead-time effects as do the real events from the detector. If the counter is turned on and off at the same time as the ADC, the number in the counter represents the number of pulses presented to the amplifier by the pulser. The counts in each channel of the spectrum must be multiplied by the ratio of the number in the counter to the number of counts in the spectrum's pulser peak to correct for the dead-time losses.

For pulsed-reset preamplifiers, the exponential-decay-time pulser must be replaced with a low-frequency (<100 Hz) square wave generator, whose output is fed to the preamplifier test input. The rise and fall times of the square wave must be similar to the detector charge collection time.

Counting Statistics with Finite Dead Time

If the amplifier and multichannel analyzer had zero dead time, the statistical variance in the counts recorded in any channel of memory would be $\sigma_q^2 = q$, where q is the number of counts recorded in the channel during a counting time t . However, the dead times in the amplifier and the MCA not only suppress the recorded counts according to equation (2), but they alter the variance as well. Several authors have calculated the effect of the dead time on the variance for systems incorporating a single dead time of either the extending or non-extending type.¹ Although the equation for cascaded dead times is not readily available, the single dead time equations indicate that the variance for the recorded counts can be expected to be less than q . Furthermore, this deviation from $\sigma_q^2 = q$ is highly sensitive to the percent dead time losses.

One way to correct for the dead time losses is to measure the counts, q , recorded in the "real" time t , and use equation 2 to calculate the counts, Q , that would have been observed with zero dead time. (The "real" time is the time measured by a clock that does not turn off during dead time intervals.) Under those circumstances, the statistical variance in the corrected counts calculated via equation (2) will be larger than $\sigma_Q^2 = Q$, and the magnification will escalate with increasing percent dead time.¹ In other words, dead time losses degrade the accuracy of the calculated detector counting rate.

A more practical alternative is to use a live time clock to correct for the dead time losses. An "ideal" live time clock¹ is a clock that a) is turned off for the entire time that the spectrometer is unable to record an event arriving at the detector, and b) records one event for each dead time interval.

A live time clock is applicable only to random events uniformly distributed in time (constant counting rate). If the events at the detector obey Poisson statistics, then it can be shown that the variance in the number of events, m , recorded in the live time, t_L , is¹

$$\sigma_m^2 = m \quad (3)$$

The counts at the detector before dead time losses can be calculated as

$$M = \frac{m}{t_L} t \quad (4)$$

or the counting rate at the detector can be computed as

$$r_i = M/t = m/t_L \quad (5)$$

It follows rather simply that the percent standard deviation in r_i , r_o , M or m is given by

$$\begin{aligned} \frac{\sigma_m}{m} \times 100\% &= \frac{100\%}{m^{1/2}} \quad (6) \\ &= \frac{\sigma_M}{M} \times 100\% \\ &= \frac{\sigma_{r_o}}{r_o} \times 100\% \\ &= \frac{\sigma_{r_i}}{r_i} \times 100\% \end{aligned}$$

Table 1 summarizes the number of counts required to reach a desired level of precision in measuring the counting rate, r_i .

Table 1. Statistical Precision with an Ideal Live Time Clock.

Number of Counts in Live Time t_L	Percent Standard Deviation
1	100%
100	10%
10,000	1%
1,000,000	0.1%

Equation (3) can also be extended to the sum of the counts over any number of channels in the MCA memory, i.e.,

$$\sigma_N^2 = N = \sum_{i=j}^k m_i \quad (7)$$

where N is the sum of the counts m_i in channels j through k . Reference 1 shows how this variance applies to the subtraction of background under peaks.

CAMAC ADCs, Memories, and Associated Software

Linearity

As with spectroscopy amplifiers, the linearity of the ADC's response to input signals is an important performance parameter. Two different linearity specifications are required to define the performance of the ADC: the integral nonlinearity, and the differential nonlinearity.

Figure 8 demonstrates the measurement of an ADC's integral nonlinearity. Using a precision pulser with adequately low nonlinearity, a calibration curve of channel number versus input pulse amplitude is plotted. A straight line is fitted to this calibration curve using a least-squares fitting method. The integral nonlinearity is specified as the maximum deviation ΔC_{\max} of the measured calibration curve from the straight line, expressed as a percentage of full scale. It is a measure of the deviation from an ideal, straight-line calibration curve.

The differential nonlinearity specifies the non-uniformity of channel widths. For the measurement, a sliding pulser is injected into the ADC input. As the pulse amplitude slowly slides from 0 to 10 V and back to 0 V in repeated cycles, counts are recorded in all channels. In order to reduce the statistical error, the measurement typically takes at least 10 hours to collect sufficient data. If the channel widths are all equal, the counts recorded in each channel will be identical. The differential nonlinearity is computed as the maximum deviation of the counts, in any of the channels, from the

average counts in all the channels, expressed as a percentage of the average counts. This is actually a measure of the maximum deviation of channel width from the average channel width, expressed as a percentage of the average channel width.

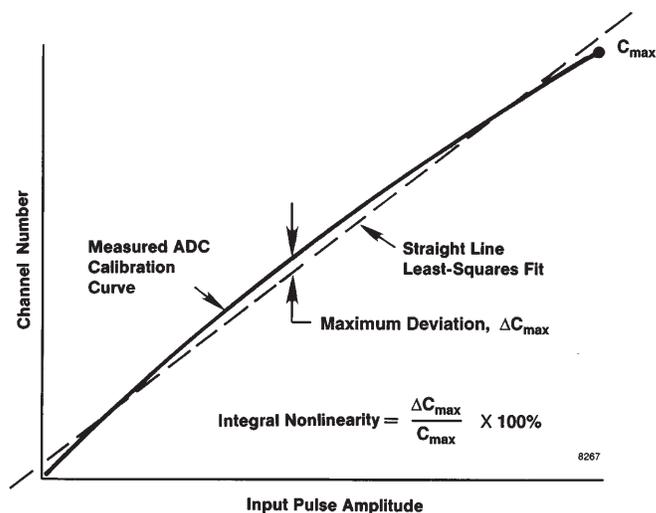


Fig. 8. Measurement of Integral Nonlinearity in an ADC.

Selection Guide for ADCs

Feature	AD114	AD413A
Primary Applications	Coincidence or singles measurements with multiple detectors. Fast readout via FERAbus. Live-Time clock	Coincidence or singles measurements with multiple detectors. Fast readout via FERAbus
Package Width	CAMAC-2	CAMAC-2
Number of Channels	16,128	8064
Input Range	0 to +10 V	0 to +10 V
Number of Inputs	1	4
Gating Inputs	Master gate, local gate, PUR	Master gate, individual gates, individual PUR
Type	Peak amplitude sensing; successive-approximation ADC with sliding scale linearization	Peak amplitude sensing; successive-approximation ADC with sliding scale linearization
Conversion Time	5 μ s	6 μ s per active input
Digital Offset	No	No
Live-Time Clock	Yes	No
Readout	CAMAC or fast FERAbus	CAMAC or fast FERAbus
Compatible Memories	ORTEC HM413 (Histogram) LeCroy 4302 (FIFO) CES HSM8170 (FIFO)	ORTEC HM413 (Histogram) LeCroy 4302 (FIFO) CES HSM8170 (FIFO)
Multi-Parameter Software	Kmax™ from SPARROW	Kmax from SPARROW

AD114 CAMAC 16k ADC

The ORTEC Model AD114 CAMAC 16k ADC is a 14-bit analog-to-digital convert (ADC) with CAMAC and fast FERAbus readout. It is a very productive solution for high-multiplicity multi-parameter experiments, because it has a conversion time of 5 μ s, and a 100-ns-per-word FERAbus readout that skips ADCs with zero information in 3 ns. The 16,128-channel digital resolution provides excellent peak definition when analyzing wide energy ranges with high-resolution germanium detectors. In four-fold coincidence experiments a dead time as low as 15% for each detector channel results in a coincidence dead-time loss of 48%. Consequently, the live-time clock included in each Model AD114 is vital for calculating the true coincidence rate. The flexibility of the computer-controlled functions also makes the Model AD114 useful for silicon charged-particle detectors, scintillation detectors, proportional counters, and ionization chambers.

The dc-coupled analog input employs a peak amplitude stretcher, and accepts pulses in the linear range from 0 to +10 V. A 14-bit, successive-approximation ADC with sliding scale linearization provides the conversion to a digital number in 5 μ s. The analog input accepts unipolar and bipolar pulses from standard spectroscopy amplifiers with shaping times from 0.25 to 20 μ s. A differential input is incorporated to suppress ground-loop noise when connected to systems with multiple power supplies and grounds. CAMAC control of the input dc-offset, the lower-level discriminator, and the upper-level discriminator facilitates computer adjustment of the analog operating parameters.

Several types of gating are provided. For coincidence experiments employing the FERAbus readout, the master GATE input is delivered to all ADCs through the ECL CONTROL bus. This gate synchronizes the ADCs on coincident events and forces all ADCs to wait for a common clear at the end of event readout. In the CAMAC readout mode, the master GATE can be delivered to all ADCs as a TTL input on the front-panel

- **16,128-channel ADC with CAMAC and fast FERAbus™ readout for: single- or multi-parameter experiments, high counting rates, and wide energy ranges**
- **5- μ s conversion time**
- **FERAbus readout can skip ADCs with no information in 3 ns, and read each active ADC in 200 ns**
- **Gedcke-Hale Live-Time Clock includes dead-time correction for amplifier pulse pile-up losses**
- **CAMAC control of: live-time clock, FERAbus/CAMAC readout, zero and overflow suppression, master gate, local gate, singles/coincidence modes, upper- and lower-level discriminators, and input dc-offset**
- **Differential input suppresses ground-loop noise**

LEMO connector. Using only the master GATE to define coincident events can lead to the random analysis of unrelated events at individual ADC inputs. These unwanted events can be suppressed by providing a LOCAL GATE input to each ADC only when there is a valid, coincident event at the ADC INPUT. The rear-panel PUR input is an anticoincidence gate for use with the pile-up rejector logic pulse from a spectroscopy amplifier. It can also be used as a general-purpose veto input. CAMAC commands permit enabling and disabling the module's response to the master GATE or the LOCAL GATE inputs. This is useful when selecting the coincidence mode or the singles mode for the Model AD114 under CAMAC control.

Additional modes selectable by CAMAC command are: CAMAC or FERAbus readout, zero-suppression or no zero-suppression during readout, overflow suppression, and singles or coincidence analysis.

Each Model AD114 includes its own live-time clock for correction of dead-time losses. The Gedcke-Hale live-time clock¹ corrects for the pile-up losses occurring in the spectroscopy amplifier, and for the dead time of the ADC conversion and readout. It provides complete dead-time correction for amplifiers directly presenting their unipolar output pulse, and/or amplifiers providing the appropriated BUSY and PUR logic signals. Via CAMAC

¹Ron Jenkins, R.W. Gould, Dale Gedcke, *Quantitative X-Ray Spectrometry*, (New York and Basel: Marcel Dekker) 1981, pp. 266–271.



20 μ s, or delay-line-shaped with widths $>0.25 \mu$ s. Maximum input is ± 12 V. No internal delay. Center conductor input impedance is 2000 Ω to ground, dc-coupled. The floating BNC connector shield is used with a differential input amplifier to suppress common-mode input noise caused by ground loops. The common-mode rejection ratio is nominally 99:1 with a zero-impedance source, and nominally 22:1 with a 93 Ω signal source.

LOCAL GATE Front-panel BNC connector provides individual gating for the associated analog input. A low TTL logic level (0 to +0.8 V) prevents analysis of the analog signal at the INPUT connector. A high TTL logic level (+2 to +5 V) permits analysis of the analog signal. Resides in the high state with no input connected. The LOCAL GATE signal must be at the desired logic level prior to the peak amplitude of the analog pulse, and must extend $\geq 0.5 \mu$ s beyond peak detection. Input impedance is 1000 Ω . Response to the LOCAL GATE connector can be enabled/disabled by CAMAC commands.

GATE Front-panel LEMO connector accepts the master gate signal for coincidence mode operation with CAMAC readout. See ECL GATE for function. A low TTL logic level (0 to +0.8 V) prevents analysis, and a high TTL logic level (+2 to +5 V) permits analysis. Resides in the low state with no input connected. Input impedance is 1000 Ω .

PUR Rear-panel BNC connector accepts the pile-up rejecter logic signal from the spectroscopy amplifier supplying the associated analog input pulses. A high TTL logic level (+2 to +5 V) causes rejection of the analog signal; a low TTL logic level (0 to +0.8 V) permits analysis of the analog signal. Defaults to a low state with no input connected. For required timing see LOCAL GATE. Input impedance is 1000 Ω .

BUSY Rear-panel BNC connector accepts the Busy output logic signal from the spectroscopy amplifier supplying the analog input pulses. Either a high TTL logic level (+2 to +5 V) at the BUSY input, or the analog input pulse exceeding the ADC lower-level discriminator will cause the live-time clock to start counting backwards. The live-time clock turns off when the stretcher detects peak amplitude on the analog input pulse, or when a PUR input occurs. The live-time clock resumes counting forward after BUSY, PUR, and the lower-level discriminator all become inactive, and readout of the conversion has been completed. The BUSY input is inactive at a low TTL logic level (0 to +0.8 V) when no input is connected. Input impedance is 1000 Ω .

ECL INPUTS/OUTPUTS

The fast FERAbus readout utilizes the front-panel ECL CONTROL bus and the ECL DATA OUTPUT bus. Differential input impedances are 100 Ω with termination resistors installed. Only one module should have the termination and pull-down resistors installed (See PD LED and Fig. 1).

ECL LOGIC LEVELS Nominal differential ECL logic levels (into 100 Ω differential load) are:

	Left (+) Pin	Right (-) Pin
Logic 0	-1.8 V	-0.9 V
Logic 1	-0.9 V	-1.8 V

ECL DATA OUTPUT Front-panel 17- by 2-pin connector (AMP 1-103326-7) provides the digitized ADC outputs for connection to the FERA data readout bus. Differential ECL outputs are employed, with bit 1 assigned to the two pins in row 1, and bit 16 occupying the two pins in row 16. Row 17 is not connected. See READOUT FORMAT. Interconnection between ADC modules and the FERA Driver (LeCroy 4301) requires construction of a 34-conductor ribbon cable (3M part number 3365/34) with 17- by 2-pin headers (3M 3414-6006 or AMP 499498-9) spaced to match the configuration of modules (Fig. 1).

ECL CONTROL BUS Front-panel 8- by 2-pin connector accommodates the control bus for synchronizing data acquisition among multiple ADCs, and for ECL readout. Except where noted otherwise, the inputs to the Model AD114 are provided from the LeCroy 4301 FERA Driver connected to the bus. A row of two pins is assigned to each differential ECL input or output. Interconnection between ADC modules and the FERA Driver (LeCroy 4301) requires construction of a 16-conductor ribbon cable (3M part number 3365/16) with 8- by 2-pin headers (3M 3452-6006 or AMP 499497-3) spaced to match the configuration of modules (Fig. 1). The logic signals in the ECL CONTROL bus are listed below.

N/C No connection.

WST The Write Strobe output indicates when each output word is valid on the ECL DATA OUTPUT connector. WST is released 15 ns after the Write Acknowledge (WAK) is received.

REQ The Request output indicates that the module has completed its conversions, and is ready to take control of the ECL DATA OUTPUT bus for readout. REQ can be asserted only if FERAbus readout is enabled.

CLR Clears stored data and conversions in progress for all ADCs connected to the ECL CONTROL bus. Required in the coincidence mode at the end of readout to simultaneously release all ADCs for the next conversion. CLR is not required in the singles mode. Minimum width, 5 ns. Clear can also be initiated from the CAMAC interface. If Clear is asserted during ADC conversion, up to 5 μ s are required to clear the module.

GATE The Gate input simultaneously provides the master gate signal to all ADCs connected to the ECL CONTROL bus for coincidence mode operation. The logic 1 state enables acceptance of the analog input signal for conversion, and forces all ADCs to wait for a common clear (CLR) after analyzing coincident events. With no signal connected, the GATE input remains in the logic 0 state. See LOCAL GATE for required timing. The ECL GATE input is OR'ed with the TTL GATE input from the LEMO connector. Response to the GATE input can be enabled/disabled by CAMAC commands.

WAK The Write Acknowledge input signal indicates through the readout controller (LeCroy 4301) that the associated memory has read the current word and that the next word may be sent. WAK minimum width is 30 ns.

GND Connected to ground.

N/C No connection.

REN The Readout Enable input is a front-panel, 1- by 2-pin connector. It accepts the PASS output from a previous module, or the REO output from the LeCroy 4301, to enable readout of the Model AD114. Interconnection requires construction of a 100- Ω , twisted-pair cable with a 2-pin socket and housing (AMP 1-87756-8 and AMP 5-87456-3) on each end.

PASS The PASS output is provided on a front-panel, 1- by 2-pin connector. It indicates completion of the module's readout cycle on the ECL bus. The PASS output is normally connected to the REN input on the next module to enable readout of the next module (Fig. 1). In the zero-suppression mode, the Model AD114 generates the PASS signal typically within 3 ns of receiving the REN signal if the Model AD114 has no data to read out. The PASS signal from the last Model AD114 in the readout loop is used to generate the CLR signal via the external master trigger logic for the experiment and/or the LeCroy 4301.

AD114

CAMAC 16k ADC

CAMAC COMMANDS

Z	Initializes module. Clears the module and sets all bits of the control register to zero. Sets the LLD register to 36 (72 mV), the ULD register to 255 (10.5 V), and the offset register to 128 (0 V). Enables the ADC [F(26)-A(0)], and clears the live-time clock.
C	Performs the same function as the CLR input.
I	Inhibits subsequent conversions and stops the live-time clock when asserted. Conversions and readouts already in progress are not affected. Used to start or stop data acquisition on all ADCs in the CAMAC crate at the same time.
X	Generated by the module for all valid functions.
Q	Generated by the module if the function can be executed.
L	Indicates LAM is set. Occurs after the end of conversion, if there are data to be read (provided CAMAC readout is enabled, and LAM is enabled). See CONTROL REGISTER FORMAT.
F(0)-A(0)	Read Control Register.
F(1)-A(0)	Read lower-level discriminator (LLD) setting. The value returned is in units of 2 mV. Only the lower 8 bits are valid.
F(1)-A(1)	Read upper-level discriminator (ULD) setting. Multiply the lower 8 bits by 0.008 V and add 8.5 V to calculate the voltage setting.
F(1)-A(2)	Read the input dc offset setting. Subtract 128 from the lower 8 bits and multiply the resulting 8-bit number by 0.312 mV to calculate the voltage setting.
F(2)-A(0)	Read ADC converted digital output. If the zero-suppression mode is disabled (Control Register B9 = 1), and the CAMAC readout mode is selected (B10 = 1), the command is issued once to read the ADC data. If zero-suppression is enabled (B9 = 0) with the CAMAC readout mode (B10 = 1), the command is issued twice, or until Q = 0. Q = 1 for a valid readout.

F(3)-A(0)	Read the lower 16 bits of the live-time clock. The value is returned in units of 10 ms. When this command is issued the highest 8 bits of the live-time clock are simultaneously captured and stored for a subsequent F(3)-A(1) command.
F(3)-A(1)	Read the higher 8 bits of the live-time clock. This command reports the value of the higher 8 bits captured by the last F(3)-A(0) command.
F(8)-A(0)	Test LAM. Q = 1 if LAM is present.
F(9)-A(0)	Clear Module. Performs the same function as the C command, except only for the single module being addressed through CAMAC.
F(10)-A(0)	Test and clear LAM. Q = 1 if LAM was set.
F(12)-A(0)	Reset live-time clock to zero.
F(16)-A(0)	Write into the Control Register.
F(17)-A(0)	Write lower-level discriminator value. See F(1)-A(0) for format.
F(17)-A(1)	Write upper-level discriminator value. See F(1)-A(1) for format.
F(17)-A(2)	Write input dc-offset value. See F(1)-A(2) for format.
F(24)-A(0)	Disable ADC. Performs the same function as the Inhibit (I) command, but only for the addressed ADC. Stops the live-time clock and prevents further conversions from occurring until F(26)-A(0) is issued.
F(26)-A(0)	Enable the ADC. Enables conversions and starts the live-time clock when the Inhibit (I) command is not active.
F(27)-A(0)	Test current status of the ENABLE/DISABLE flag as set by the F(26)-A(0) and F(24)-A(0) commands. Q = 1 if the ADC is enabled.

CONTROL REGISTER FORMAT

Bit	Function
B1 to B8	Virtual Station Number. Index Source for readout with zero-suppression. (Lower eight bits of header word.)
B9	Zero-suppression enable. When B9 = 0, ADCs with zeros for data are skipped during readout.
B10	ECL port enable. When B10 = 0, ECL port readout is enabled. When B10 = 1, CAMAC readout is enabled.
B11	Enable LOCAL GATE (B11 = 0). When B11 = 1, the LOCAL GATE input is ignored, and all analog pulses are converted, unless gated by the master GATE or by PUR.
B12	Enable master GATE (B12 = 0) for the coincidence mode. When B12 = 1, the master GATE signal is ignored, and all analog pulses are converted, unless gated by the LOCAL GATE or by PUR. B12 = 1 is used only in conjunction with the singles mode (B13 = 1).
B13	Selects the Coincidence mode or the Singles mode. When B13 = 0, the coincidence mode is selected (requires B12 = 0). When B13 = 1, the singles mode is selected (typically with B11 = 1, B12 = 1). When in the singles mode, the zero-suppression mode must be selected (B9 = 0) for all ADCs, if the FERAbus readout loop includes more than one ADC.
B14	Not used.
B15	CAMAC LAM enable. When B15 = 1, LAM is enabled.
B16	Overflow-suppression enable. When B16 = 0, overflows are converted to zeros in the ADC output data. Readout will be suppressed only if the zero-suppression mode (B9 = 0) is selected.

AD114 CAMAC 16k ADC

READOUT FORMAT

The readout format of the Model AD114 is identical in both the CAMAC and the FERAbus ECL readout modes.

WITHOUT ZERO-SUPPRESSION

B16	B15	B14	B1
0	0		DATA

WITH ZERO-SUPPRESSION

When zero-suppression is enabled and valid data are received, two data words are output. The first is always a header word:

B16	B15	B14	B13	B12	B11	B10	B9	B8	...	B1
1	0	0	WRDCNT	0	0	0	0	0	VSN	

Followed by one data record with the following format:

B16	B15	B14	B1
0	0		DATA

DEFINITIONS

WRDCNT The word count defines the number of data records that follow the header word in the readout. The word count is always 01 for a Model AD114.

VSN The Virtual Station Number (0 to 255) identifies the module number during zero-suppressed readout. VSN is set via CAMAC command in the lower 8 bits of the Control Register.

DATA Fourteen bits of ADC conversion data. DATA over 16,128 indicates an overflow.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The model AD114 derives its power from a CAMAC crate supplying ± 24 V and ± 6 V. The power required is +24 V at 160 mA, +6 V at 1.4 A, -6 V at 0.9 A, and -24 V at 170 mA.

WEIGHT

Net 1.1 kg (2.5 lb).
Shipping 2.0 kg (4.5 lb)

DIMENSIONS CAMAC-standard double-width module, 3.42 X 22.15 cm (1.35 X 8.72 in.) front panel IEEE/583-1982 (Reaff 1988).

Optional Accessories

The C-ECLBUS Cable Kit is recommended as an accessory to facilitate the FERAbus interconnections. Each kit contains:

Quantity	Description
1	16-conductor ribbon cable with 23 headers installed at 7.6 cm intervals for the ECL Control Bus.
1	34-conductor ribbon cable with 23 headers installed at 7.6 cm intervals for the ECL Data Bus.
1	51-cm long twisted pair cable with 2-pin sockets and headers on each end for the PASS to CLI connection.
23	15-cm long twisted pair cables with 2-pin sockets and headers on each end for the REO to REN, and the PASS to REN connections.

The ribbon cables will serve an entire crate full of FERAbus modules, and can be cut to handle smaller groups of modules.

Ordering Information

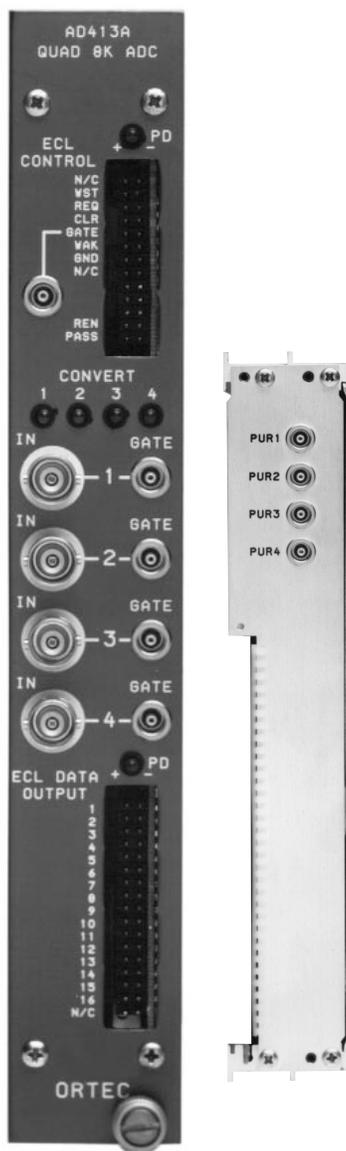
To order, specify:

Model	Description
AD114	CAMAC 16k ADC
C-ECLBUS	Cable Kit for the ECLBUS



AD413A CAMAC Quad 8k ADC

- Multiplexed, 4-input, 8064-channel ADC with CAMAC and fast FERAbus™ readout for multi-parameter experiments
- 6- μ s conversion time per active input, and 100 ns/word FERAbus readout
- FERAbus readout can skip ADCs with no information in 3 ns
- CAMAC control of: FERAbus/CAMAC readout, zero and overflow suppression, master gate, individual gates, singles/coincidence modes, and each lower-level discriminator
- Differential inputs suppress ground-loop noise



The ORTEC Model AD413A CAMAC Quad 8k ADC is a multiplexed, four-input, 13-bit analog-to-digital converter (ADC) with CAMAC and fast FERAbus readout. It is a very productive solution for high-multiplicity multi-parameter experiments because it has a conversion time of 6 μ s per active input, and a 100-ns-per-word FERAbus readout with the ability to skip ADCs with zero information in 3 ns. This 8064-channel ADC can be used with Ge detectors, silicon charged-particle detectors, scintillation detectors, proportional counters, and ionization chambers.

Each of the four analog inputs has its own peak amplitude stretcher, and accepts pulses in the linear range from 0 to +10 V. The stretchers are multiplexed on a first-come, first-served basis to a 13-bit, successive-approximation ADC with sliding scale linearization. If two or more inputs receive coincident pulses, the pulse amplitudes are stored in their respective stretchers, so that the ADC can successively convert each input. The dc-coupled analog inputs accept unipolar and bipolar pulses from standard spectroscopy amplifiers with shaping times from 0.25 to 20 μ s. Differential inputs are incorporated to suppress ground-loop noise when connected to systems with multiple power supplies and grounds.

Each analog input has its own gate input (GATE 1, 2, 3, 4) to suppress analysis of unrelated events when the master gate in the FERA (Fast Encoding and Readout ADC) ECL CONTROL bus is used to synchronize coincident events. The master gate is also available as a TTL input on a LEMO connector, for use in the coincidence mode with CAMAC readout. CAMAC commands permit

enabling and disabling the module's response to any gate input. This is useful when selecting the coincidence mode or the singles mode for the Model AD413A under CAMAC control. Four LEMO connectors on the rear panel accept the pile-up rejector logic signals from the four spectroscopy amplifiers supplying the associated analog input pulses.

Additional modes selectable by CAMAC command are: CAMAC or FERAbus readout, zero suppression or no zero suppression during readout, overflow suppression, singles or coincidence analysis, and random access versus sequential access during CAMAC readout. Each analog input has its own lower-level discriminator, separately adjustable by CAMAC command over the range from 0 to 512 mV with 2 mV/bit resolution.

The Model AD413A is compatible with the standard LeCroy FERA control and data output busses. This system can provide very fast readout of the ADCs with non-zero events in a CAMAC crate full of ADCs. For both data acquisition and readout, the control bus synchronizes all ADCs with the experiment's master trigger. This permits identification of all the ADC outputs from the same event and their subsequent assimilation into a common block of data. To the standard FERAbus features, ORTEC has added the ability to select the singles or coincidence analysis mode for any Model AD413A. This feature allows checking the functionality of a detector via the singles spectrum at any time during an experiment.

Normally, all the ADCs in the crate are connected to a LeCroy Model 4301 FERA Driver for control and readout (Fig. 1). The FERA Driver, in turn, delivers the data to either a LeCroy Model 4302 Dual Port Fast Memory in CAMAC, or a CES Model HSM8170 High Speed Memory in VMEbus. Both memories operate in the list mode to assemble the block of coincident events for further processing by an event builder.

To facilitate making the interconnection

AD413A CAMAC Quad 8k ADC

between the FERAbus Modules, the C-ECLBUS Cable Kit is recommended as a separately ordered accessory. This kit contains the cables and connectors needed for a crate full of FERAbus Modules.

Specifications

PERFORMANCE

ADC ANALOG INPUTS Four inputs, each with its own peak amplitude stretcher, accept analog input pulses in the range from 0 to +10 V. The stretchers are multiplexed to a single, successive-approximation ADC with sliding scale linearization.

RESOLUTION 8,064 channels (1.25 mV/channel).

CONVERSION TIME 6 μ s per active channel input (5 μ s for conversion plus 1 μ s settling time for the multiplexer).

INTEGRAL NONLINEARITY $<\pm 0.025\%$ over the top 99% of the dynamic range.

DIFFERENTIAL NONLINEARITY $<\pm 1\%$ over the top 99% of the dynamic range.

TEMPERATURE SENSITIVITY 0 to 50°C.

Gain <50 ppm/°C.

Zero Offset <50 ppm of full scale per °C.

LOWER-LEVEL DISCRIMINATOR RANGE

CAMAC controlled from 0 to 512 mV (2 mV/bit).

UPPER-LEVEL DISCRIMINATOR Common to all channels and factory set to approximately +10.2 V.

CAMAC CONTROL OF READOUT MODES

Selection of: CAMAC or FERAbus (ECL bus) readout, sequential readout of all ADCs or suppression of ADCs with zeros (zero-suppression mode), overflow-suppression option, singles or coincidence modes, random access or sequential CAMAC readout.

READOUT TIME

Zero-Suppressed Readout Mode Two to five words at 100 ns per word for FERAbus readout, or at 1 μ s per word for CAMAC readout.

Sequential Readout Mode 0.8 μ s for initialization plus four words at 100 ns per word for FERAbus readout, or at 1 μ s per word for CAMAC readout.

CONTROLS AND INDICATORS

CONVERT 1, 2, 3, 4 Four front-panel red LEDs, one for each channel. Each LED blinks once for each pulse that is accepted for conversion.

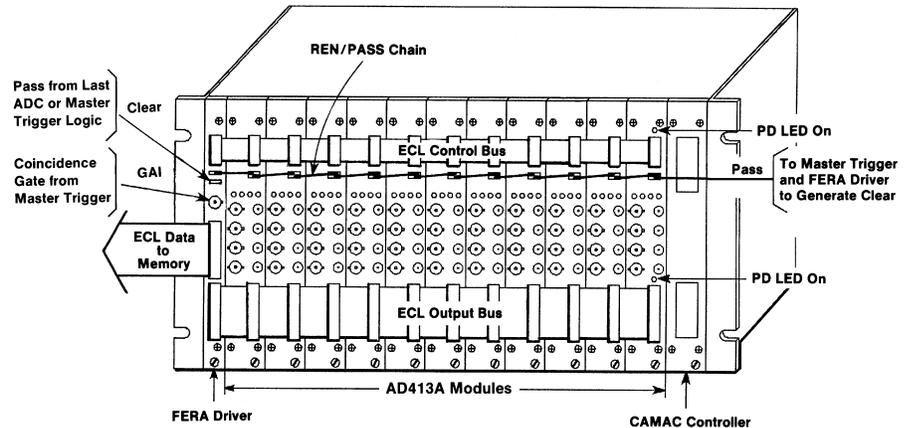


Fig. 1. Interconnection of Multiple AD413As and LeCroy 4301 FERA Driver for FERAbus Readout.

PD Two front-panel red LEDs, one for the ECL CONTROL connector, and one for the ECL DATA OUTPUT connector. Turned on when the ECL pull-down resistors or termination resistors are installed for the respective connector.

STRETCHER ZERO OFFSET A 12-turn potentiometer mounted on each of the stretcher printed circuit boards permits adjustment of the stretcher dc offset so that zero pulse amplitude is digitized into channel zero. Maximum input offset compensation is ± 20 mV.

INPUTS

IN 1, 2, 3, 4 Four separate front-panel BNC connectors accept analog pulses for pulse amplitude digitization in the linear range from 0 to +10 V. Each input has its own peak amplitude stretcher multiplexed to the common ADC. Inputs accept positive unipolar pulses, positive gated integrator pulses, or bipolar pulses, with the positive lobe leading. Pulse shapes can be semi-Gaussian or triangular, with shaping time constants from 0.25 to 20 μ s, or delay-line-shaped with widths >0.25 μ s. Maximum input is ± 12 V. No internal delay. Center conductor input impedance is 2000 Ω to ground, dc-coupled. The floating BNC connector shield is used with a differential input amplifier to suppress common-mode input noise caused by ground loops. The common-mode rejection ratio is nominally 99:1 with a zero-impedance source, and nominally 22:1 with a 93- Ω signal source.

GATE 1, 2, 3, 4 Four front-panel LEMO connectors provide separate gating for each analog input. Inputs are compatible with TTL logic levels. A low logic level (0 to +0.8 V) prevents analysis of the analog signal at the associated IN connector; a high logic level (+2 to +5 V) permits analysis of the analog signal. With no input connected, the GATE input remains at the high logic level. The GATE signal must be at the desired logic level prior to the peak amplitude of the analog pulse, and must extend ≥ 0.5 μ s beyond peak detection. Input impedance is 1000 Ω . Response to each GATE connector can be enabled/disabled by CAMAC commands.

GATE Front-panel LEMO connector accepts the master gate signal for coincidence mode operation with CAMAC readout. See ECL GATE for function. A low TTL logic level (0 to +0.8 V) prevents analysis, and a high TTL logic level (+2 to +5 V) permits analysis. With no input connected, the GATE input remains at the low logic level. Input impedance is 1000 Ω .

PUR 1, 2, 3, 4 Four rear-panel LEMO connectors accept the pile-up rejector logic signals from the four spectroscopy amplifiers supplying the associated analog input pulses. The inputs are compatible with TTL logic levels. A high logic level (+2 to +5 V) causes rejection of the analog signal; a low logic level (0 to +0.8 V) permits analysis of the analog signal. The circuit defaults to a low logic level if no input is connected. The PUR signal must be at the desired logic level prior to the peak amplitude of the analog pulse, and must extend ≥ 0.5 μ s beyond peak detection. Input impedance is 1000 Ω . Can be used as veto inputs.

AD413A

CAMAC Quad 8k ADC

ECL INPUTS/OUTPUTS

The fast FERAbus readout utilizes the front-panel ECL CONTROL bus and the ECL DATA OUTPUT bus.

ECL LOGIC LEVELS Nominal differential ECL logic levels (into 100 Ω differential load) are:

	Left (+) Pin	Right (-) Pin
Logic 0	-1.8 V	-0.9 V
Logic 1	-0.9 V	-1.8 V

ECL DATA OUTPUT Front-panel 17- by 2-pin connector (AMP 1-103326-7) provides the digitized ADC outputs for connection to the FERA data readout bus. Differential ECL outputs are employed, with bit 1 assigned to the two pins in row 1, and bit 16 occupying the two pins in row 16. Row 17 is not connected. See READOUT FORMAT. Interconnection between ADC modules and the FERA Driver (LeCroy 4301) requires construction of a 34-conductor ribbon cable (3M part number 3365/34) with 17- by 2-pin headers (3M 3414-6006 or AMP 499498-9) spaced to match the configuration of modules (Fig. 1). Only one module on the ECL DATA OUTPUT bus should have the pull-down resistors installed (See PD LED and Fig. 1).

ECL CONTROL BUS Front-panel 8- by 2-pin connector accommodates the control bus for synchronizing data acquisition among multiple ADCs, and for ECL readout. A row of two pins is assigned to each differential ECL input or output. Interconnection between ADC modules and the FERA Driver (LeCroy 4301) requires construction of a 16-conductor ribbon cable (3M part number 3365/16) with 8- by 2-pin headers (3M 3452-6006 or AMP 499497-3) spaced to match the configuration of modules (Fig. 1). Only one module on the ECL CONTROL bus should have the pull-down and termination resistors installed (See PD LED and Fig. 1). The logic signals in the ECL CONTROL bus are listed below. Except where noted otherwise, the inputs to the AD413A are provided from the LeCroy 4301 FERA Driver connected to the bus.

N/C No connection.

WST The Write Strobe output indicates when each output word is valid on the ECL DATA OUTPUT connector. WST is released 15 ns after the Write Acknowledge (WAK) is received.

REQ The Request output indicates that the module has completed its conversions, and is ready to take control of the ECL DATA OUTPUT bus for readout. REQ can be asserted only if FERAbus readout is enabled.

CLR The Clear input clears stored data and conversions in progress for all ADCs connected to the ECL CONTROL bus. It is required in the coincidence mode at the end of readout to simultaneously release

all ADCs for the next conversion. CLR is not required in the singles mode. The differential ECL input impedance is 100 Ω . Minimum width, 5 ns. Clear can also be initiated from the CAMAC interface. If clear is asserted during ADC conversion, up to 5 μ s are required to clear the module.

GATE The GATE input simultaneously provides the master gate signal to all ADCs connected to the ECL CONTROL bus for coincidence mode operation. This ECL GATE input is OR'ed with the TTL master GATE input from the LEMO connector. The logic 1 state enables acceptance of the analog input signal for conversion, and forces all ADCs to wait for a common clear (CLR) after analyzing coincident events. With no signal connected, the GATE input remains in the logic 0 state. The GATE signal must arrive before the peak amplitude on the analog input signal, and extend $\geq 0.5 \mu$ s beyond peak amplitude detection. With termination resistors installed, the differential ECL input impedance is 100 Ω . Response to the GATE input can be enabled/disabled by CAMAC commands.

WAK The Write Acknowledge input signal indicates through the readout controller (LeCroy 4301) that the associated memory has read the current word and that the next word may be sent. The differential ECL input impedance is 100 Ω . WAK minimum width is 30 ns.

GND Connected to ground.

N/C No connection.

REN The Readout Enable input is a front-panel, 1- by 2-pin connector. It accepts the PASS output from a previous module, or the REO output from the LeCroy 4301, to enable readout of the Model AD413A. The ECL differential input impedance is 100 Ω . Interconnection requires construction of a 100- Ω , twisted-pair cable with a 2-pin socket and housing (AMP 1-87756-8 and AMP 5-87456-3) on each end.

PASS The PASS output is provided on a front-panel, 1- by 2-pin connector. It indicates completion of the module's readout cycle on the ECL bus. The PASS output is normally connected to the REN input on the next module to enable readout of the next module (Fig. 1). In the zero-suppression mode, the Model AD413A generates the PASS signal typically within 3 ns of receiving the REN signal if the Model AD413A has no data to read out. The PASS signal from the last Model AD413A in the readout loop is used to generate the CLR signal via the external master trigger logic for the experiment and/or the LeCroy 4301.

CAMAC COMMANDS

- Z** Initializes module. Clears the module, sets all bits of control registers 1 and 2 to zero, and sets all LLD registers to 36 (72 mV).
- C** Performs the same function as the CLR input on the ECL CONTROL bus.
- I** Inhibits subsequent conversions when present. Conversions and readouts already in progress are not affected. Used to start and stop data acquisition.
- X** Generated by the module for all valid functions.
- Q** Generated by the module if the function can be executed.
- L** LAM is set (if CAMAC readout is enabled, and if LAM is enabled) after the end of conversion, if there are data to be read. See CONTROL REGISTER FORMAT.

- F(0)-A(0)** Read Control Register 1.
- F(0)-A(1)** Read Control Register 2.
- F(1)-A(0)** Read Channel 1 lower-level discriminator setting.
- F(1)-A(1)** Read Channel 2 lower-level discriminator setting.
- F(1)-A(2)** Read Channel 3 lower-level discriminator setting.
- F(1)-A(3)** Read Channel 4 lower-level discriminator setting.
- F(2)-A(0-3)** Read ADC conversions. When the Random Access mode is selected, A = 0, 1, 2, or 3 selects the ADC to be read (ADC 1, 2, 3, or 4, respectively). When the Sequential CAMAC readout mode is selected, the value given for A is ignored, and the command is issued four times to read the four ADCs in sequence. See B14 of Control Register 1. If zero-suppression is active in the Sequential CAMAC readout mode, the command is issued two to five times until Q = 0. Q = 1 if valid data is available.
- F(8)-A(0)** Test LAM. Q = 1 if LAM is present.
- F(9)-A(0)** Clear Module. Performs the same function as the C command, except only for the single module being addressed through CAMAC.

AD413A

CAMAC Quad 8k ADC

- F(10)-A(0)** Test and clear LAM. Q = 1 if LAM was set.
- F(16)-A(0)** Write into Control Register 1.
- F(16)-A(1)** Write into Control Register 2.
- F(17)-A(0)** Write Channel 1 lower-level discriminator value.
- F(17)-A(1)** Write Channel 2 lower-level discriminator value.
- F(17)-A(2)** Write Channel 3 lower-level discriminator value.
- F(17)-A(3)** Write Channel 4 lower-level discriminator value.

CONTROL REGISTER 1 FORMAT

- | Bit | Function |
|-----------------|---|
| B1 to B8 | Virtual Station Number. Index Source for readout with zero suppression. (Lower eight bits of header word.) |
| B9 | Zero-suppression enable. When B9 = 0, ADCs with zeros for data are skipped during readout. |
| B10 | ECL port enable. When B10 = 0, ECL port readout is enabled. When B10 = 1, CAMAC readout is enabled. |
| B11 | Not used. |
| B12 | Not used. |
| B13 | Coincidence/Singles selection for all 4 inputs. When B13 = 0, the coincidence mode is selected. When B13 = 1, the singles mode is selected. When in the singles mode, the zero-suppression mode must be selected for all ADCs in the same FERAbus readout loop. |
| B14 | CAMAC random access enable. When B14 = 1 and B10 = 1 and B9 = 1, random access CAMAC readout is enabled. |
| B15 | CAMAC LAM enable. When B15 = 1, LAM is enabled. |
| B16 | Overflow-suppression enable. When B16 = 0, overflows are converted to zeros in the ADC output data. Readout will be suppressed only if the zero-suppression mode is selected. |

CONTROL REGISTER 2 FORMAT

- | Bit | Function |
|-----------|---|
| B1 | Enable GATE 1 (B1 = 0). When B1 = 1, the GATE 1 input is ignored and all analog pulses in channel 1 are converted, unless gated by the master GATE in the ECL CONTROL bus, or by PUR 1. |

- | | |
|-----------|--|
| B2 | Enable GATE 2 (B2 = 0). Function similar to B1. |
| B3 | Enable GATE 3 (B3 = 0). Function similar to B1. |
| B4 | Enable GATE 4 (B4 = 0). Function similar to B1. |
| B5 | Enable master GATE (B5 = 0) for the coincidence mode. When B5 = 1, the master GATE signal in the ECL CONTROL bus is ignored, and all analog pulses are converted, unless gated by GATE 1, 2, 3, or 4, or by PUR 1, 2, 3, or 4. B5 = 1 is used with the singles mode. |

READOUT FORMAT

The readout format of the Model AD413A is identical in both the CAMAC and the FERAbus ECL readout modes.

WITHOUT ZERO-SUPPRESSION

B16	B15	B14	B13 B1
0	0	0	CHANNEL 1 DATA
0	0	0	CHANNEL 2 DATA
0	0	0	CHANNEL 3 DATA
0	0	0	CHANNEL 4 DATA

WITH ZERO-SUPPRESSION

When zero-suppression is enabled and valid data are received, two to five data words are output. The first is always a Header word:

B16	B15	B14	B13 . . . B12	B11	B10	B9	B8 . . . B1
1	0	0	WRDCNT	0	0	0	VSN

Followed by 1 to 4 data records, each with the following format:

B16	B15 . . . B14	B13 B1
0	SUBADDR	DATA

DEFINITIONS

WRDCNT The word count is a value from 0 to 3 that defines the number of data records that follow in the readout. A value of 0 indicates that four data records follow.

VSN The Virtual Station Number (0–255) identifies the module number during zero-suppressed readout. VSN is set via CAMAC command in the lower 8 bits of Control Register 1.

SUBADDR The Subaddress (0–3) indicates with which of the four input channels the data is associated. NOTE: the data records are in no particular order in zero-suppression mode. Therefore, the subaddress should always be

used to determine which channels are delivering data.

- | | |
|-------------|----------------|
| SUBADDR = 0 | Channel 1 data |
| SUBADDR = 1 | Channel 2 data |
| SUBADDR = 2 | Channel 3 data |
| SUBADDR = 3 | Channel 4 data |

DATA Thirteen bits of ADC conversion data. DATA over 8064 indicates overflow.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model AD413A derives its power from a CAMAC crate supplying ± 24 V and ± 6 V. The power required is +24 V at 380 mA, +6 V at 2 A, –6 V at 1.2 A, and –24 V at 430 mA.

WEIGHT

- Net** 1.1 kg (2.5 lb).
- Shipping** 2.0 kg (4.5 lb).

DIMENSIONS CAMAC-standard double-width module 3.42 X 22.15 cm (1.35 X 8.72 in.) front panel per IEEE/583-1982 (Reaff 1988).

Optional Accessories

The C-ECLBUS Cable Kit is recommended as an accessory to facilitate the FERAbus interconnections. Each kit contains:

Quantity Description

- | | |
|----|--|
| 1 | 16-conductor ribbon cable with 23 headers installed at 7.6-cm intervals for the ECL Control Bus. |
| 1 | 34-conductor ribbon cable with 23 headers installed at 7.6-cm intervals for the ECL Data Bus. |
| 1 | 51-cm long twisted pair cable with 2-pin sockets and headers on each end for the PASS to CLI connection. |
| 23 | 15-cm long twisted pair cables with 2-pin sockets and headers on each end for the REO to REN, and the PASS to REN connections. |

The ribbon cables will serve an entire crate full of FERAbus modules, and can be cut to handle smaller groups of modules.

Ordering Information

To order, specify:

Model	Description
AD413A	CAMAC Quad 8k ADC
C-ECLBUS	Cable kit for the ECLBUS

HM413 CAMAC FERAbus Histogramming Memory

- **Fast histogramming of spectral data from CAMAC ADCs equipped with FERAbus™ readout**
- **TWO modes of operation: Monitor mode and Readout Control mode**
- **MONITOR MODE** histograms spectra from preselected ADCs in multi-parameter coincidence experiments, while listening to list-mode readouts on the FERAbus
 - Relieves the central computer of time- and memory-consuming histogramming tasks*
- **READOUT CONTROL MODE** operates as the readout controller for histogramming singles spectra from multiple ADCs
 - A powerful, cost-effective solution for multiple MCAs and high counting rates*
- **CAMAC programmable to histogram thirty-two 1k ADCs, sixteen 2k ADCs, eight 4k ADCs, four 8k ADCs, or two 16k ADCs**
- **CAMAC control of: histogramming start/stop, readout of selected segments, memory clear, ADC assignments, and FERAbus functions**

The ORTEC Model HM413 CAMAC FERAbus Histogramming Memory provides histogramming of the spectral data from ADCs equipped with the standard FERAbus™ readout port. The Model HM413 has two modes of operation: (a) the Monitor mode, and (b) the Readout Control mode. In the Monitor mode, the Model HM413 histograms spectra from pre-selected ADCs while listening to list-mode readouts on the FERAbus. This is an efficient solution for monitoring the spectra from various ADCs during a multi-parameter coincidence experiment. It relieves the data processing computer of the time-consuming and memory-consuming histogramming tasks. In the Readout Control mode, the HM413 functions as the readout controller for histogramming *singles* spectra from multiple ADCs. This is a powerful and cost-effective solution when the *singles* spectra from a large number of detectors must be analyzed at high counting rates.

The histogramming memory has a length of 32,768 channels and a capacity of 16,777,215 counts per channel (24 bits). It can be configured by CAMAC commands to histogram two

16,384-channel ADCs, four 8192-channel ADCs, eight 4096-channel ADCs, sixteen 2048-channel ADCs, or thirty-two 1024-channel ADCs. CAMAC commands assign the memory segments to histogram particular ADCs on the basis of the Virtual Station Number of the ADC module and the Subaddress of each ADC within the module. Depending on the number of bits delivered by the ADCs, each Model HM413 serves all ADCs located in one or two ADC modules.

The Model HM413 supports all CAMAC ADCs that provide the standard FERAbus control and data output formats, as defined in the ECL Inputs/Outputs section of the Model HM413 specifications. This includes the CAMAC/FERAbus series of ORTEC ADCs and the LeCroy 4300B 16-Input ADC. All ADCs must operate in the zero-suppressed readout mode in order to provide the Virtual Station Number, the Subaddress, and the Header Word that the Model HM413 uses to identify the assigned ADCs. The Model HM413 supports both the Singles and Coincidence modes featured in the ORTEC FERAbus ADCs. The LeCroy



HM413 CAMAC FERAbus Histogramming Memory

4300B operates only in the Coincidence mode.

In the Monitor mode, the Model HM413 simply listens to the ADC readouts occurring on the FERAbus, while the LeCroy 4301 acts as the readout controller for the list-mode readout (Fig. 1a). The WST (Write Strobe) signal on the ECL Control Bus causes the Model HM413 to read each word on the ECL Data Bus into a fast FIFO memory. This buffer memory allows the Model HM413 to track the readout of a crate full of ADCs at 100 ns per word. The Model HM413 continuously unloads the FIFO memory, and histograms only the data corresponding to its assigned ADCs.

In the Readout Control mode, the Model HM413 acts as the readout controller (Fig. 1b). This mode is used for histogramming the *singles* spectra from multiple ADCs. ADC data acquisition can be either gated by the master GATE, or ungated. The GAI gate inputs of the Model HM413 allow ECL, fast negative NIM, TTL, or slow positive NIM logic signals to be used for the master GATE

input. When an ADC has data ready for readout, it generates a Readout Request (REQ) on the ECL Control Bus. The Model HM413 enables the readout by sending a Readout (REO) Signal, via a twisted-pair cable, to the Readout Enable (REN) input of the first ADC in the readout loop. The Model HM413 reads the data from the ADC in the same way as in the Monitor mode, except that the Model HM413 accepts and generates the handshake signals that control the data transfer. When the ADC has finished its readout, it sends a PASS signal to the REN input of the next ADC. If the next ADC is not requesting a readout, it delivers a PASS signal to the REN input of the following ADC. The PASS output from the last ADC is sent to the CLI input of the Model HM413 to generate a Clear (CLR) signal on the ECL Control Bus. The CLR signal releases all ADCs to accept the next event. The CLI input connection is not required with ORTEC ADCs operating in the Singles mode, but is required for the Coincidence mode. Use of the CLI signal

is mandatory for the LeCroy 4300B ADC.

CAMAC controls are provided for starting and stopping the histogramming process, for reading the contents of a selected memory segment, and for erasing the spectral data in the entire memory. These functions can be executed without interfering with the continuous operation of the FERAbus readout, providing the F(26)·A(1) and F(24)·A(1) commands are used to start and stop data acquisition. When it is necessary to synchronize the live-time clocks in the ADCs with the data acquisition in the Model HM413, the "I" command can be used to start and stop data acquisition simultaneously on all modules in the same crate. Front-panel LEDs indicate when the HM413 is enabled to accept data, when data is accepted for histogramming, and when a CAMAC communication is occurring.

CAMAC commands are also provided for configuring the FERAbus functions.

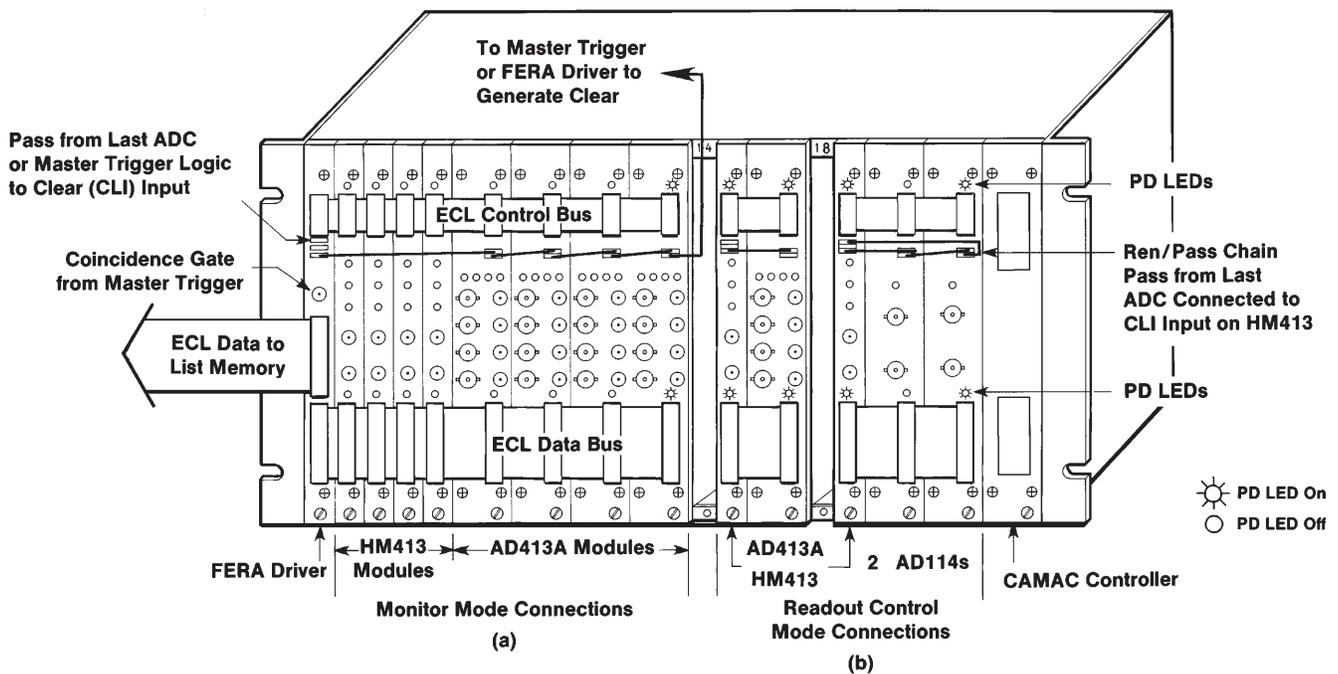


Fig. 1. Interconnection of the Model HM413 with FERAbus ADCs for (a) the Monitor mode, and (b) the Readout Control mode.

HM413

CAMAC FERAbus

Histogramming Memory

CAMAC readout of selected memory segments proceeds as a block transfer in the Q-Stop mode. For ADC identification, the first channel of a segment readout contains the Segment Number and the Virtual Station Number of the ADC. A LAM output can be used to signal the need for readout when the counts in one of the memory channels have exceeded the memory capacity.

The Model HM413 automatically solves the problem of the "occasionally missing readout request" in the Coincidence mode. When a standard FERAbus system operates in the zero-suppressed readout mode, the master GATE from the readout controller (e.g., LeCroy 4301 FERA Driver) signals the ADCs to analyze the coincident events at their inputs, and to wait for a common Clear (CLR) after readout. Occasionally, all of the ADCs produce a zero response, because they fail to detect any analog input signals. In this case, no readout request is generated, and the standard readout controller will not produce the Clear signal required to release the ADCs for the next event. The Model HM413 detects this situation, and prevents lock-up by initiating a readout request 10 μ s after the end of the master GATE signal. The readout controller responds to the readout request by issuing a readout command, which results in a CLR signal being generated.

To facilitate making the interconnections between the FERAbus modules, the C-ECLBUS Cable Kit is recommended as a separately ordered accessory. This kit contains the cables and connectors needed for a crate full of FERAbus modules.

Specifications

PERFORMANCE

OPERATING MODES To provide the Virtual Station Number and Subaddress information required by the Model HM413, all FERAbus ADCs must operate in the zero-suppressed readout mode.

Monitor Mode The Model HM413 histograms spectra from preselected ADCs while listening to list-mode readouts on the FERAbus. The LeCroy 4301 FERA Driver functions as the readout controller (Fig. 1a). Typically used for multi-parameter coincidence measurements, with multiple ADCs providing list-mode readout. Accepts either Coincidence- or Singles-mode readout.

Readout Control Mode The Model HM413 operates as the readout controller for histogramming *singles* spectra from several ADCs (Fig. 1b). Data acquisition can be gated or ungated.

CAMAC-CONTROLLED FUNCTIONS

Histogramming start/stop, readout of selected segments, clear memory, ADC/segment assignments, and FERAbus functions.

MEMORY LENGTH 32,768 channels.

MEMORY CAPACITY 24 Bits (16,777,215 counts per channel).

PROGRAMMABLE MEMORY CONFIGURATIONS

Two 16,384-channel segments, four 8192-channel segments, eight 4096-channel segments, sixteen 2048-channel segments, or thirty-two 1024-channel segments. Selected by CAMAC commands to match the ADCs being histogrammed.

FERAbus DATA TRANSFER RATE 100 ns per word.

MAXIMUM NUMBER OF ADCs ON THE FERAbus

One CAMAC crate full of ADCs in the Monitor mode. Limited to the ADCs specified by the segment assignments in the Readout Control mode.

OPERATING TEMPERATURE RANGE

0 to 50°C.

CONTROLS AND INDICATORS

CONTROL SIGNAL SWITCH The DIP switch on the printed circuit board serves two functions: (a) disconnection of the CLR, GATE, and WAK outputs from the ECL Control Bus, and (b) switching the cable termination for the REQ signal. Position assignments and settings are in Table 1.

FAST NIM/TTL LOGIC JUMPERS Two circuit-board jumpers select the logic convention for the GAI and CLI LEMO inputs. The fast negative NIM logic position is towards the front of the module; the TTL position is towards the rear. Each jumper controls the input attached to the adjacent coaxial cable.

PD Two front-panel red LED indicators (one for the ECL CONTROL connector, and one for the ECL DATA connector) are turned ON when the ECL pull-down resistors are installed for the ECL CONTROL connector, or when the termination resistors are installed for the ECL DATA connector. See ECL Inputs/Outputs.

ANALYZE Front-panel LED indicates that the Model HM413 is enabled to process data from the ADCs.

STORED Front-panel LED flashes for approximately 1 ms each time valid data is identified and stored in the appropriate memory segment. The relative brightness indicates the rate at which events are being stored.

CAMAC READ Front-panel LED indicates that a CAMAC read or write communication is in progress.

INPUTS

GAI Front-panel LEMO connector accepts the master GATE signal for distribution to the ADCs on the ECL Control bus. See GATE description for function. A circuit-board jumper selects NIM-standard fast negative logic (50- Ω input impedance), or TTL logic (also compatible with NIM-standard positive logic; 1-k Ω input impedance). The LEMO GAI input is OR'ed with the ECL GAI input.

CLI Front-panel LEMO connector accepts the Clear Input (CLI) signal for distribution to the ADCs as the CLR signal on the ECL CONTROL bus. See the CLI description under ECL Inputs/Outputs for functional definition. A circuit-board jumper selects NIM-standard fast negative logic (50- Ω input impedance), or TTL logic (also compatible with NIM-standard positive logic; 1-k Ω input impedance). The LEMO CLI input is OR'ed with the ECL CLI input.

ECL INPUTS/OUTPUTS

FERAbus communication with the ADCs utilizes ECL logic levels on the front-panel CONTROL and DATA connectors. All pull-down and termination resistors must be removed from the Model HM413 when

Table 1. Control Signal Switch.

	SIGNAL							
	REQ		CLR		GATE		WAK	
Switch Position Number	-	+	-	+	-	+	+	-
Cable Termination	ON	ON	-	-	-	-	-	-
No Termination	OFF	OFF	-	-	-	-	-	-
Outputs Connected	-	-	ON	ON	ON	ON	ON	ON
Outputs Disconnected	-	-	OFF	OFF	OFF	OFF	OFF	OFF

Set all Switches: OFF for the Monitor mode, ON for the Readout Control mode

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operating in the Monitor mode, and installed when operating in the Readout Control mode (see PD LED, CONTROL SIGNAL SWITCH, and Fig. 1). Only one ADC on each ECL bus should have the pull-down and termination resistors installed. The termination resistors are normally installed at the receiving end for each pair of ECL signal lines. The CLI, GAI, and REO connectors require construction of 100-Ω, twisted-pair cables, with a 2-pin socket and housing (AMP 1-87756-8 and AMP 5-87456-3) on each end.

ECL LOGIC LEVELS The nominal ECL logic levels (into a 100-Ω differential load) are:

	Left (+) Pin	Right (-) Pin
Logic 0	-1.8 V	-0.9 V
Logic 1	-0.9 V	-1.8 V

For single-ended operation (-) pin is grounded in the receiving module.

ECL DATA INPUT Front-panel, 17- by 2-pin connector (AMP 1-103326-7) accepts the digitized ADC outputs in the form of single-ended ECL signals from the ECL Data Bus. Up to 16 parallel bits can be accepted and stored into the FIFO memory at the time of the Write Strobe (WST) signal. Bits are sequentially assigned, with bit 1 assigned the two pins in row 1 and bit 16 occupying the two pins in row 16. Row 17 is not connected. Interconnection between the Model HM413 and other modules utilizing the ECL Data Bus requires the construction of a 34-conductor ribbon cable (3M part number 3365/34) with 17- by 2-pin headers (3M 3414-6006 or AMP 499498-9) spaced to match the configuration of modules. Two removable termination resistor packs provide 100-Ω input impedances on the (+) inputs for the Readout Control mode. The readout from the ADCs on the ECL Data Bus must conform to the following format. Each ADC must operate in zero-suppression mode and deliver 2 to 17 data words during readout. The first is always a header word:

B16 B15 B12 B11 B10 B9 B8 B1

1	WRDCNT	0	0	0	VSN
---	--------	---	---	---	-----

followed by 1 to 16 data records, each with the format:

B16 B15 BN B(N-1) B1

0	SUBADDR	DATA
---	---------	------

according to the following definitions:

B16 The Model HM413 uses bit 16 to distinguish header words from data records. For a header word B16 = 1. For a data word B16 = 0.

WRDCNT The word count is a value from 0 to 15, which defines the number of data records that follow in the readout. The WRDCNT information is not used by the Model HM413.

VSN The Virtual Station Number (0–255) identifies the ADC module number during zero-suppressed readout. The Model HM413 uses the VSN to identify the ADC data it must histogram.

BN, BN-1 The value of N is determined by the maximum subaddress provided by the ADC module (number of ADC inputs per module).

ADC Inputs per Module: 1 2 4 8 16

BN: B15 B15 B14 B13 B12

SUBADDR The subaddress identifies the individual ADC within the module having the VSN designated in the header word. The Model HM413 decodes the SUBADDR to histogram ADCs in their sequentially assigned segments of memory.

DATA The conversion data from the ADC identified by the SUBADDR and VSN. The number of bits of data depends on the number of ADC inputs per module and the number of bits in the individual ADCs.

ECL CONTROL BUS The 8- by 2-pin connector at the top of the front panel accommodates the ECL Control Bus for synchronizing data acquisition among multiple ADCs, and for controlling ECL data transfer. A row of two pins is assigned to each differential ECL input or output, with the top 8 rows forming the ECL Control Bus. Interconnection between ADC modules and the Model HM413 requires the construction of a 16-conductor ribbon cable (3M part number 3356/16) with 8- by 2-pin headers (3M 3452-6006 or AMP 499497-3) spaced to match the configuration of modules. The logic signals in the ECL Control Bus are listed below. If a LeCroy 4301 FERA Driver is connected to the bus, the CLR, GATE, and WAK output drivers in the Model HM413 must be disconnected from the ECL Control Bus by the CONTROL SIGNAL SWITCH for operation in the Monitor mode.

N/C No connection.

WST The Write Strobe input is provided by the ADC presenting data for readout on the bus. WST indicates when each word on the ECL Data Bus is valid, and causes the Model HM413 to read the word into a FIFO memory. The leading edge of the WST pulse must fall inside the data pulse and must arrive at least 10 ns after the data are valid. The minimum WST width is 40 ns. Minimum data transfer time is 100 ns/word. The 100-Ω termination resistor (R7) on the (+) input must be removed for the Monitor mode, and installed for the Readout Control mode. The (-) input is always grounded.

REQ The readout Request signal is both an ECL input and an ECL output on the Model HM413. When an ADC has data ready for readout, the ADC issues an REQ signal. The Model HM413 recognizes the

REQ signal, waits for a fixed delay (factory set to 200 ns), then issues the REO signal on a separate connector. In the Readout Control mode, the REO signal is connected to the Readout Enable (REN) input on the first ADC in the readout chain to initiate the the readout sequence. The REO signal is not used in the Monitor mode. In either mode, the Model HM413 monitors the master GATE and CLR lines on the ECL Control Bus. If a CLR signal is not detected within 10 μs of the end of a master GATE signal, the Model HM413 will generate an REQ signal. This initiates a readout cycle, which generates a CLR, thus preventing lock-up of the analyze/readout cycle when none of the ADCs detected an event. REQ is terminated by the CLR signal. The REQ output can be enabled for the Coincidence mode by the F(26)-A(2) CAMAC command, or disabled for the Singles mode by the F(24)-A(2) command. Terminations of 100 Ω on the (+) input and ground on the (-) input must be connected by the CONTROL SIGNAL SWITCH for the Readout Control mode.

CLR In the Readout Control mode, the CLR output is issued by the Model HM413 at the end of ADC readout. This signal clears the ADCs and releases them to analyze the next event. Normally, the CLR signal is generated by connecting the PASS signal from the last ADC in the readout loop to the CLI input on the Model HM413. The CLR signal can also be generated by the CAMAC command F(9)-A(1). The CLR connector on the Model HM413 serves as an ECL input and an ECL output. The input function contains no termination resistors. For the Monitor mode, the CLR output and its pull-down resistors must be disconnected by the CONTROL SIGNAL SWITCH. In the Readout Control mode, the CLR output is enabled for the Coincidence mode by the F(26)-A(2) CAMAC command, or disabled for the Singles mode by the F(24)-A(2) command.

GATE The master GATE output is distributed to all ADCs connected to the ECL Control Bus for gating in the Readout Control mode. The GATE output is an ECL version of the input provided to the Model HM413 on the GAI connector. The logic 1 state enables acceptance of analog inputs by the ADCs for conversion, and forces all ADCs to wait for a common Clear (CLR) after readout. The master GATE signal is not required by ORTEC ADCs operating in the Singles mode. The GATE connector on the Model HM413 serves as an ECL output and an ECL input (see REQ). The input function contains no termination resistors. For the Monitor mode, the GATE output and its pull-down resistors must be disconnected by the CONTROL SIGNAL SWITCH. In the Readout Control mode, the GATE output is enabled for the

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Histogramming Memory

Coincidence mode by the F(26)-A(2) CAMAC command, or disabled for the Singles mode by the F(24)-A(2) command.

WAK The Write Acknowledge output is used only in the Readout Control mode. When an ADC has data ready for transfer on the ECL Data Bus, it issues a Write Strobe (WST) signal on the ECL Control Bus. After a 35-ns delay, the Model HM413 responds with a 40-ns-wide WAK signal. The WAK signal indicates completion of the transfer, and enables the next word to be asserted on the bus by the ADCs. For the Monitor mode, the WAK output and its pull-down resistors must be disconnected by the CONTROL SIGNAL SWITCH.

GND Both pins connected to ground.

ROW 8 No connection.

CLI Front-panel 1- by 2-pin connector accepts the Clear Input (CLI) signal for distribution to the ADCs as the CLR signal on the ECL Control Bus. The ECL CLI input is OR'ed with the LEMO CLI input. At the end of ADC readout, a logic 1 signal is applied to clear the ADCs and release them to accept the next event. CLI is normally derived from the PASS output of the last ADC in the readout loop. CLI is required in the Readout Control mode with LeCroy 4300B ADCs, and ORTEC ADCs set to the Coincidence mode. CLI is not required by the Model HM413 with ORTEC ADCs set to the Singles mode, or all ADCs in the Monitor mode. Differential input impedance is nominally 100 Ω .

GAI Front-panel 1- by 2-pin connector accepts the master GATE signal for distribution to the ADCs on the ECL Control Bus. See GATE description for function. Differential input impedance is nominally 100 Ω . The ECL GAI input is OR'ed with the LEMO GAI input.

REO Front-panel 1- by 2-pin connector provides the Readout ECL output for initiating readout at the REN input on the first ADC in the readout loop. REO is used only in the Readout Control mode. See REQ description for function. The CONTROL PD LED is on when the REO pull-down resistors are installed for operation in the Readout Control mode.

NC No connection.

CAMAC COMMANDS

Z	Initializes the module. Clears the LAM flip-flop, disables data collection, sets all registers to zero, disables the Coincidence mode, and clears the data memory to zero. The Q response is inhibited while the memory is being cleared.	F(9)-A(0)	Causes the Model HM413 to clear the contents of every channel of memory to a value of zero. This takes approximately 5 ms. No Q responses will be generated for further commands while clearing memory. Segment 0 must be selected via F(17)-A(3) before issuing F(9)-A(0).
I	Inhibits the Store function as long as the I signal is present. Used to stop and start data acquisition simultaneously for all ADCs and HM413 modules in the same crate.	F(9)-A(1)	Generates a Clear signal (CLR) on the ECL Control Bus, if positions 3 and 4 of the CONTROL SIGNAL SWITCH are set ON for the Readout Control Mode.
X	The module responds with X = 1 for all valid function commands.	F(10)-A(0)	Tests and clears LAM. A Q = 1 response is generated if a LAM is present and the LAM is cleared.
Q	The module responds with Q = 1 if the function command can be executed when issued.	F(16)-A(0)	Writes the memory address (W1 to W15) to be read by a subsequent F(0)-A(0) command.
L	A LAM is generated when the content of any channel exceeds the capacity of the memory. Active only if the LAM is enabled [see F(24)-A(0) and F(26)-A(0)].	F(17)-A(0)	Writes to the VSN1 Register (W1 to W8).
F(0)-A(0)	Initiates reading the entire memory segment (as specified by the Segment Register) in the Q-Stop mode. Reads the 24-bit (R1 to R24) data word at the current memory address, and increments the address by one at S2. A Q = 0 response is generated when the address pointer exceeds the current segment block while reading a segment. The Segment Register must be loaded by the F(17)-A(3) command before reading memory. Load segment 1 through 32 (depending on the number of segments selected) to read the desired segment. The data for the first channel in the readout is replaced with a word that contains the Segment Number in bits 9 to 16 and the Virtual Station Number for the segments in bits 1 to 8. Subsequent words contain the channel-by-channel histogram data for the segment.	F(17)-A(1)	Writes to the VSN2 Register (W1 to W8).
F(1)-A(0)	Reads the Configuration Register (R1 to R5).	F(17)-A(2)	Writes to the Configuration Register (W1 to W5).
F(8)-A(0)	Tests LAM. Q = 1 if LAM is present.	F(17)-A(3)	Writes to the Segment Register (W1 to W8).
		F(24)-A(0)	Disables LAM.
		F(24)-A(1)	Stops the Analyze mode (data histogramming). Data transfer on the ECL Data Bus continues, independent of this command.
		F(24)-A(2)	Disables the Coincidence mode for operation in the Singles mode. Disables the generation of REQ by the Model HM413 following the termination of the master GATE signal. Also disables the CLR and GATE output signals. The Z command also disables the Coincidence mode.
		F(26)-A(0)	Enables LAM. LAM is generated when any channel exceeds the capacity of the memory.
		F(26)-A(1)	Starts the Analyze mode (data histogramming).
		F(26)-A(2)	Enables the Coincidence mode. Enables the master GATE and CLR outputs. Enables the generation of an REQ signal by the Model HM413 if a CLR signal is not detected within 10 μ s after the GATE signal is terminated (see the REQ description).

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REGISTERS

VSN1 REGISTER The Virtual Station Number of the ADC module that the Model HM413 will histogram in the first half of memory must be written into this register. This value is compared to the virtual station number in the header words from the ADCs to determine whether the Model HM413 should respond to the data. In some cases the ADC with VSN1 will occupy the entire data memory. The command F(17)-A(0) writes to the VSN1 Register (W1 to W8). To accept data, the VSN1 comparator must always be enabled (see Configuration Register).

VSN2 REGISTER The function of this register is the same as the VSN1 Register, but it allows the data from two separate modules to be processed. The data that matches this register will be placed in the top half of the data memory. The command F(17)-A(1) writes to the VSN2 Register (W1 to W8). The VSN2 comparator must be disabled when the ADC with VSN1 occupies the entire data memory (see Configuration Register).

CONFIGURATION REGISTER The Configuration Register is a 5-bit register that allows the operator to enable the VSN (Virtual Station Number) comparators for ADC identification, and select the number of segments that the data memory is divided into. Command F(1)-A(0) reads, and F(17)-A(2) writes to the Configuration Register. The bit assignments are:

Bit	Function
1	Disable 1st VSN comparator. Enable = 0, disable = 1. Must always be enabled in order to accept ADC data.
2	Disable 2nd VSN comparator. Enable = 0, disable = 1. Must be disabled when the entire memory is assigned to a single VSN (i.e., a single ADC module).
3	Segment select 1
4	Segment select 2
5	Segment select 3

} See Segment Assignments

Segment Assignments

Configuration Register Bits	Number of Segments			Channels per Segment
	5	4	3	
0 0 0	2	16,384		
0 0 1	4	8,192		
0 1 0	8	4,096		
0 1 1	16	2,048		
1 0 0	32	1,024		

SEGMENT SELECT REGISTER This register allows the operator to select an individual segment for readout by loading the number of the segment (1 to 32). Care should be taken not to load a value greater than the number of segments selected by the Configuration Register. Segments are sequentially assigned in the order of the ADC Subaddress numbers. The command F(17)-A(3) writes to the Segment Select Register (W1 to W8).

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model HM413 derives its power from a CAMAC crate supplying ± 6 V. The power required is +6 V at 2.1 A, -6 V at 1.0 A.

WEIGHT

Net 0.81 kg (1.8 lb).

Shipping 1.8 kg (4.0 lb).

DIMENSIONS CAMAC-standard single-width module, 1.70 X 22.15 cm (0.67 X 8.72 in.) front panel per IEEE/583-1982 (Reaff 1988).

Optional Accessories

The C-ECLBUS Cable Kit is recommended as an accessory to facilitate the FERAbus interconnections. Each kit contains:

Quantity	Description
1	16-conductor ribbon cable with 23 headers installed at 7.6-cm intervals for the ECL Control Bus.
1	34-conductor ribbon cable with 23 headers installed at 7.6-cm intervals for the ECL Data Bus.
1	51-cm long twisted pair cable with 2-pin sockets and headers on each end for the PASS to CLI connection.
23	15-cm long twisted pair cables with 2-pin sockets and headers on each end for the REO to REN, and the PASS to REN connections.

The ribbon cables will serve an entire crate full of FERAbus modules, and can be cut to handle smaller groups of modules.

Ordering Information

To order, specify:

Model	Description
HM413	CAMAC FERAbus Histogramming Memory
C-ECLBUS	Cable Kit for the ECL Bus

Application Addendum

The Model HM413 is compatible with the following LeCroy modules for readout on the FERAbus™.

4300B	16-Input Fast Encoding & Readout Charge ADC
4301	Fast Encoding & Readout Driver Module
4302	Dual Port Memory
3341	8-Input, 12-Bit Charge-Integrating ADC
3351	8-Input, 12-Bit Peak-Sensing ADC
3371	8-Input, 12-Bit TDC
3377*	Drift Chamber Time-to-Digital Converter

*When operating the LeCroy 3377 on the FERAbus (ECLbus) with the HM413, the "4300B mode" and the "Single-Word Readout Mode" must be selected in the 3377. This allows the HM413 to histogram the thirty-two separate time digitizers in the 3377 with 10-bit time resolution.

A special setup is also required on the HM413 to accommodate thirty-two spectra of 1k length from a single 3377 module (single Virtual Station Number). Set the HM413 to process 4 spectra of 8k length. The subaddress bits supplied by the 3377 will ensure that the thirty-two 1k spectra get stored in the right locations in the HM413 memory. The HM413 memory must subsequently be read into the computer memory as four blocks of 8k length. In the computer one can readily pull out the individual 1k spectra.

The 3377 can deliver more than 32 data words for a single START trigger, because the 3377 can record multiple STOP events for a single START pulse. This is no problem for the HM413. The HM413 identifies a header word by noting that bit 16 is set to 1. The Virtual Station Number (VSN) included in the header word is captured by the HM413 and compared to the VSN the HM413 has been told to accept for histogramming. If the comparison results in a match, the HM413 histograms all subsequent data words until a new header word is detected. Data words are identified by bit 16 being set to zero.

FERAbus™ is a trademark of the LeCroy Corporation.

CMC203

CAMAC FERA Driver, Memory, and Histogrammer

The LeCroy FERA ADCs and the SILENA/ORTEC 4418Q/V/T ADCs require a delay in the response to the Readout Request from the earliest ADC, to avoid skipping other, slower-converting ADCs during readout. In the CMC203, the delay for issuing the Readout Enable is digitally programmable from 400 ns to 160 ms.

To facilitate making the bus connections between the CMC203 and the FERAbus ADCs, the ORTEC C-ECLBUS Cable Kit is recommended as a separately ordered accessory. This kit contains the cables and connectors needed for a crate full of FERAbus modules.

Specifications

PERFORMANCE

LIST-MODE/HISTOGRAMMING MEMORY SIZE: 1,048,576 sixteen-bit words.

HISTOGRAMMING RATE: 5-MHz maximum sustained rate. A 3000-word FIFO buffers the FERA bus from the histogramming function to handle the 10-MHz burst rate of the FERA bus.

MAXIMUM HISTOGRAM COUNTS: Selectable for 16 bits (65,535 counts/bin) with 1 M bins, or 32 bits (4,294,967,295 counts/bin) with 512k bins.

MAXIMUM NUMBER OF HISTOGRAMMED ADC MODULES:

		Maximum Number of ADC Modules Histogrammed	
Bits of Conversion	Inputs per Module	16-bit Max. Counts	32-bit Max. Counts
10	16	64	32
11	16	32	16
12	8	32	16
13	4	32	16
14	1	64	32

DAC OUTPUT: Programmable from 0 to 10.2375 V with 12 bits. Differential non-linearity: 1/2 LSB. Endpoints factory calibrated within 1/2 LSB. Serves as test voltage for LeCroy FERAbus ADCs. Available on pin 15 of the FERA Control Bus.

INDICATORS

N: Red, front-panel LED indicates the module is being addressed via the CAMAC bus.

FULL LED (A): Yellow, front-panel LED normally indicates when the FIFO memory is full. It can be programmed to indicate other conditions via the LED Assignment Register.

BUSY LED (B): Green, front-panel LED normally indicates the BUSY period starting with either a GATE or REQ signal and terminating with the end of REQ, the end of CLR, or after the Busy Delay, depending on register settings.

LEMO INPUTS/OUTPUTS

The LEMO inputs and outputs employ the fast negative NIM logic standard. Logic "0" is nominally 0 mV, and logic "1" is nominally -800 mV on the 50-Ω input impedance.

G (External Gate Input)⁴: Front-panel LEMO connector delivers the GATE logic pulse to all ADCs in the FERA readout loop. The GATE signals all ADCs in the FERA readout loop to sample the analog signals at their respective inputs. This signal synchronizes the analog

sampling, analog-to-digital conversion, and readout of all ADCs in the FERA readout loop to form one block of correlated data for the event. The duration and arrival time of the GATE input pulse must meet the requirements of the ADCs in the FERA readout loop. CLR (CLEAR) is required at the end of the readout to enable acquisition of the next event. G, GATE and TESTGATE signals are ORed together on the ECL Control Bus.

C (External Clear Input)⁴: Front-panel LEMO connector delivers the CLR logic pulse to all modules in the FERA readout loop. ORed with the ECL CLR input.

I (External Inhibit Input)⁴: A NIM logic "1" signal applied to this front-panel LEMO connector inhibits readout of all modules in the FERA readout loop. ORed with the ECL RINH input.

A (External Write Acknowledge Input)⁴: Front-panel LEMO connector delivers an external WAK pulse to the FERA readout loop. ORed with the ECL WAK input.

Q (External REQ Output)⁴: Front-panel LEMO connector produces an external Readout Request, signaling that at least one ADC in the FERA loop is requesting a readout. See also the ECL RQO output.

S (External Write Strobe Output)⁴: Front-panel LEMO connector produces an external Write Strobe Output, signaling that the data on the FERA bus is valid and can be read by the downstream module. See also the ECL WSO output.

ECL INPUTS/OUTPUTS

The fast FERAbus readout of ADC modules utilizes the FERA Control Bus, the FERA Auxillary Signals, the FERA Data Bus Input (all on the front panel), and the FERA Data Bus Output (on the rear panel). All four ports employ ECL logic levels. Nominal differential ECL logic levels (into a 120-Ω differential load) are:

	Left (+) Pin (Odd Numbered)	Right (-) Pin (Even Numbered)
Logic 0	-1.8 V	-0.9 V
Logic 1	-0.9 V	-1.8 V

Differential ECL outputs have 390-Ω pull-down resistors to -5.2 V. Differential ECL inputs are terminated with 120 Ω between the two conductors. Single-ended ECL inputs are terminated with 60 Ω to -2 V.

FERA CONTROL BUS: Front-panel 8- by 2-pin connector accommodates the control bus for synchronizing data acquisition and readout among multiple ADCs. A row of 2 pins is assigned to each differential ECL input or output. Interconnection between ADC modules and the CMC203 requires construction of a 16-conductor ribbon cable (3M part number 3365/16) with 8- by 2-pin headers (3M 3452-6006 or AMP 499497-3) spaced to match the configuration of modules. The logic signals in the ECLBUS are listed below (top to bottom). Outputs are differential ECL, while inputs are single-ended ECL (active input on "+" pin). Only one module on the control bus should have the pull-down resistors installed.

Pin + -	Name	Direction	Description
1,2	+ -	ground	both pins connect to ground
3,4	WST	input	Write Strobe from ADC indicates data is ready to be read
5,6	REQ	input	Readout Request from ADC indicates that the module has completed its conversions, and is ready to take control of the FERA Data Output Bus. CMC203 responds with REO to the REN input on the first ADC in the FERA loop.

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Pin ±	Name	Direction	Description
7,8	CLR	output	Clears all ADCs after the readout cycle is completed to enable accepting the next event.
9,10	GATE	output	Gate to all ADCs on the FERA bus. Causes sampling of the analog signals, and initiates the conversion and readout cycle.
11,12	WAK	output	Write Acknowledge to ADCs on FERA bus. Confirms data has been read, and releases ADC to produce the next data word.
13,14	GND	ground	both pins connect to ground
15,16	DAC	analog	Pin 15: DAC voltage output. Pin 16: ground. See DAC OUTPUT under PERFORMANCE.

FERA AUXILIARY SIGNALS: Front-panel 8- by 2-pin connector located directly below the FERA Control Bus connector. Provides signals for connecting the REN/PASS daisy chain, and other logic signals that can be individually routed to other modules. All inputs and outputs are differential ECL. Interconnection of each 2-pin signal with other modules requires construction of a 120-Ω, twisted pair cable, with a 2-pin socket and housing (AMP 1-87756-8 and AMP 5-87456-3) on each end. Ensure that the + pin on the CMC203 is connected to the + pin on the other module. Listed from top to bottom, the pin assignments are:

Pin	Name	Direction	Description
1,2	CLR	input	External Clear input ⁵ . See also LEMO C input.
3,4	GATE	input	External Gate input ⁵ . See LEMO Gate Input. Can be used to control data acquisition with cascaded CMC203 readout loops.
5,6	RINH	input	External read inhibit input ⁵ . See also LEMO I input. Used by receiving memory module to inhibit readout when not ready.
7,8	WAK	input	External write acknowledge input ⁵ . See also LEMO A input. Used by external memory module to release CMC203 to present the next data word.
9,10	WSO	output	External write strobe output ⁵ . See also LEMO S output. Triggers external memory module to read the valid data.
11,12	RQO	output	External Readout Request output ⁵ . See also LEMO Q output. Used with cascaded CMC203 readout loops.
13,14	REO	output	Readout enable to first module on FERA bus.
15,16	PSI	input	Pass input ⁵ from last module on FERA bus. If bit 3 of the Control Register = 1, the PSI input accepts the PASS or NEXT signal from the last ADC in the FERA readout loop to determine completion of the readout. If bit 3 = 0, the end of REQ determines completion of the readout. In either case, completion terminates REO. Termination of REO initiates a CLR, if bit 4 of the Control Register = 1. The duration of CLR is determined by the Clear Width Register (F16 A4).

DATA IN (FERA Data Bus Input): Front-panel 17- by 2-pin connector (AMP 1-103326-7) accepts the digitized ADC outputs from the FERA data readout bus. Single-ended ECL inputs are used, with only the left column of pins (odd-numbered) active. Bit 1 is assigned to the two pins in row 1, and bit 16 occupies the two pins in row 16. Pins 33 and 34 in row 17 are connected to ground through 1-kΩ resistors. Interconnection between ADC modules and the CMC203 requires construction of a 34-conductor ribbon cable (3M part number 3365/34) with 17- by 2-pin headers (3M 3414-6006 or AMP 499498-9) spaced to match the configuration of modules.

FERA DATA BUS OUTPUT: Rear-panel 17- by 2-pin connector (AMP 1-103326-7) forwards the data from the front-panel DATA IN connector to a subsequent module. The transfer can be immediate (operating mode 0), or buffered with a 2k FIFO (operating modes 1 and 2). Differential ECL outputs are employed, with bit 1 assigned to the two pins in row 1, and bit 16 occupying the two pins in row 16. Pins 33 and 34 in row 17 are connected to ground through 1 kΩ resistors. Interconnection between the CMC203 and the receiving module requires construction of a 34-conductor ribbon cable (3M part number 3365/34) with 17- by 2-pin headers (3M 3414-6006 or AMP 499498-9) spaced to match the configuration of modules. Only one module on the ECL DATA BUS should have the pull-down resistors installed. The 390-Ω pull-down resistors in the CMC203 can be unsoldered and removed, if necessary.

CAMAC COMMANDS

- Z** Initializes the module. Clears the LAM flip-flop, disables data collection, and clears all registers to zero.
- C** Produces the same results as the Z command. Z and C do not clear the histogram memory. Use F9 A2 to clear the histogram memory.
- I** Inhibits operation of the list mode and the histogramming as long as the I signal is present. Used to stop and start data acquisition simultaneously for the CMC203 and all ADCs in the same crate. See functions F26 A1 and F26 A2 for honoring/ignoring the CAMAC Inhibit.
- X** The module responds with X = 1 for all valid function commands.
- Q** Q = 1 indicates valid data in response to read commands, and signals the “true” reply for the test commands (F27 A0 and F8 A0). Q = 0 for all other commands.
- L** A LAM (Look At Me) is generated when the list-mode FIFO becomes half full. Active only if the LAM is enabled. See F24 A0, F26 A0, F8 A0, and F10 A0.

See Table 1. for additional CAMAC commands and functions.

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Table 1. CAMAC COMMANDS AND FUNCTIONS

F&A	Command	Description	F&A	Command	Description
F0 A0	Readdac	read 12 bit DAC (register is 24 bits, r/w)	F5 A0	FASTrdhist	FASTCAMAC level 1 read of histogram memory
F0 A1	Readcsr	read control register	F5 A1	FASTrdFIFO	FASTCAMAC level 1 read of FIFO memory
F0 A2	Readreqd	read request delay register	F8 A0	Testlam	test LAM (LAM set when FIFO becomes half full)
F0 A3	Readgatw	read test gate width register	F9 A0	F9fclr	send FERA bus CLEAR (width from width register)
F0 A4	Readclrw	read FERA clear width register	F9 A1	F9data	reset data FIFO and counters
F0 A5	Readblks	read histogram readout block size register	F9 A2	F9hist	reset histogram data (this takes 200 ms)
F0 A6	Readmult	read multi histogram address register	F9 A3	F9addr	reset memory readout address counter to zero
F0 A7	Readgto	read gate time out	F9 A4	F9all	reset everything, like C or Z
F0 A8	Readbdl	read busy end delay	F10 A0	Clearlam	Clear LAM
F0 A9	Readvsn	read 8-bit VSN for special headers and trailers	F16 A0	Writedac	Write 12 bit DAC, 0 to 10.2375 V
F0 A10	Readvn	read FPGA firmware version number	F16 A1	Writecsr	Write control register
F0 A11	Readpp	read ping-pong register	F16 A2	Writereqd	Write request delay register, 40 ns LSB
F0 A12	Readleds	read LED selection register	F16 A3	Writegatw	Write test gate width register, 10 ns LSB
F0 A13	Readext	read external output selection register	F16 A4	Writeclrw	Write FERA clear width register, 40 ns LSB
F0 A14	Readeto	read event time out register	F16 A5	Writerblks	Write histogram readout block size register
F0 A15	Readexin	read external input selection register	F16 A6	Writemult	Write multi histogram register
F1 A0	rdmemory	read memory at address counter, increment address	F16 A7	Writegto	Write gate timeout register, 40 ns LSB
F1 A1	Readaddr	read address counter	F16 A8	Writebdl	Write busy end delay register, 40 ns LSB
F1 A2	Rdmnobmp	read memory at address counter, no increment	F16 A9	Writevsn	Write 8-bit VSN for header and trailer
F1 A3	Rdhistmode	read histogram mode register	F16 A11	Writepp	Write ping-pong register, 40 ns LSB
F1 A4	Rdhistmask	read histogram mask	F16 A12	Writeleds	Write LED selection register
F1 A5	Rdhistsize	read histogram size	F16 A13	Writextout	Write external output selection register
F2 A0	ReadFIFO	read next word from FIFO, Q = 0 when empty	F16 A14	Writeeto	Write event time out register, 640 ns LSB
F2 A1	RdFIFOcount	read number of words in FIFO	F16 A15	Writeextin	Write external input register
F2 A2	Readgatcnt	read number of gates since last reset, LS 24 bits	F17 A0	Writemem	Write memory at address counter
F2 A3	Readgatcnta	read number of gates since last reset, MS 24 bits	F17 A1	Writeaddr	Write memory address counter
F2 A4	Readreqcnt	read number of FERA requests since last reset, LS 24 bits	F17 A3	Wrhistmode	Write histogram mode register
F2 A5	Readreqcnta	read number of FERA requests since reset, MS 24 bits	F17 A4	Wrhistmask	Write histogram mask
F2 A6	Readclrcnt	read number of FERA clears since last reset, LS 24 bits	F17 A5	Wrhistsize	Write histogram size
F2 A7	Readclrcnta	read number of FERA clears since last reset, MS 24 bits	F24 A0	Disalam	disable LAM
F2 A8	Readhrcnt	read number of FERA headers since last reset, LS 24 bits	F24 A1	Disa0	disable Gate/Request/Clear detection. See F26 A1
F2 A9	Readhrcnta	read number of FERA headers since last reset, MS 24 bits	F24 A2	Disa1	disable Gate/Request/Clear detection. See F26 A2
F2 A10	Readhstcnt	read number of hits in the histogram array, LS 24 bits	F25 A0	Sendtestgate	send gate to FERA control bus, width from width register
F2 A11	Readhstcnta	read number of hits in the histogram array, MS 24 bits	F25 A1	Incrmemaddr	increment memory address counter
F2 A12	Readevtto	read number of event timeouts, LS 24 bits	F26 A0	Enablam	enable LAM
F2 A13	Readevttoa	read number of event timeouts, MS 24 bits	F26 A1	Enab0	enable Gate/Request/Clear detection. Honors CAMAC inhibit. See F24 A1
F2 A14	Readgateto	read number of gate timeouts, LS 24 bits	F26 A2	Enab1	enable Gate/Request/Clear detection. Ignores CAMAC inhibit. See F24 A2
F2 A15	Readgatettoa	read number of gate timeouts, MS 24 bit	F27 A0	Tstmerase	test memory erase in progress
			F30	F30	Enter special mode to program the FPGAs

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REGISTERS

CONTROL REGISTER: A 12-bit register to select the operating modes and other features. Read with F0 A1 and write with F16 A1. Bit 0 is the least significant bit, and bit 11 is the most significant bit.

Bit(s)	Binary Value	Decimal Value	Meaning
0-2	000	0	4301 emulation mode, this is power up default mode
0-2	001	1	modified 4301, with 2k FIFO
0-2	010	2	modified 4301, with 2k FIFO, with external REN/PASS
0-2	011	3	1M FIFO mode, CAMAC readout
0-2	100	4	16 bit histograms
0-2	101	5	32 bit histograms
0-2	110	6	
0-2	111	7	
3		8	REN mode: 0 = normal, 1 = pass mode
4		16	send clear at end of event
5		32	WST detection and deglitch mode
6		64	Busy mode
7		128	end busy after clear, else end after REN
8		256	insert gate header in data stream
9		512	insert request header in data stream
10		1024	insert clear header in data stream
11	msb	2048	

Bits 0-2, Operating Modes:

- 0: Power up as a FERA Driver (Equivalent to LeCroy 4301).
- 1: FERA Driver with a 2k-word FIFO buffer between data input and output.
- 2: FERA Driver with a 2k-word FIFO buffer and external REN/PASS.
- 3: FIFO mode directs all data to a 1-M-word FIFO, read by CAMAC.
- 4: 16-bit histogram mode, maximum value 65,535 counts/bin.
- 5: 32-bit histogram mode, maximum value 4,294,967,295 counts/bin.
- 6,7: Not used.

Bit 3, REN/PASS Mode:

- 0 = Normal REN (Readout Enable, REO output on front panel) mode ends REN when REQ input ends.
- 1 = Pass mode ends REN only when PASS input (PSI input on front panel) is received.

Bit 4, Send CLEAR at End of Event:

- 0 = CLEAR not automatically sent at end of readout.
- 1 = Send CLEAR when readout is complete. Event ends when REQ ends, PASS (PSI) returns, or when gate timeout ends (if no REQ).

Bit 5, WST Detection Mode:

- 0 = WST always detected, regardless of GATE, REQ or REO (default mode).
- 1 = WST ignored unless REO is asserted (event readout in progress), and WST is deglitched (WST must be >10 ns long).

Bit 6, BUSY Mode:

- 0 = Normal. BUSY is asserted during readout, when FIFO is full, and when the module is disabled.
- 1 = BUSY is also asserted when the FIFO count is greater than 7/8 of full (about 917k). BUSY stays on until the FIFO count drops below 1/2 of full (about 512k).

Bit 7, Select End of BUSY:

- BUSY begins when GATE or REQ arrives.
- 0 = End BUSY when Readout Enable (REO) ends.

- 1 = End BUSY after end of CLEAR. If end-of-busy delay register is non-zero, also wait until end of delay (delay starts at end of REO or end of CLEAR).

Bit 8, Insert Special Diagnostic Gate Header in Data Stream:

- 0 = No insertion (normal mode).
- 1 = Insert gate header (format: 11000VVVVVVVVVVVV), when GATE is detected. VVVVVVVVVVVV is the VSN from the register at F16 A9.

Bit 9, Insert Special Diagnostic Request Header in Data Stream:

- 0 = No insertion (normal mode).
- 1 = Inserted when REQ is detected. Request header format: 11100VVVVVVVVVVVV, where V is the VSN from the register at F16 A9.

Bit 10, Insert Special Diagnostic Clear Header in Data Stream:

- 0 = No insertion (normal mode).
- 1 = Insert Clear header at the beginning of CLEAR. Format: 11111CCCCVVVVVVVV, where V is the VSN from the register at F16 A9, and C identifies the reason for the clear:

CCCC	the Source of the Clear
0000	Clear at the end of a normal event, when REO is deasserted.
0001	external Clear input
0010	Clear from F9 A0 command
0011	Clear from gate time out
0100	Clear from event time out

Bit 11: not used, reserved

REQUEST DELAY REGISTER: Sets the delay between REQ (in, from the earliest ADC) and REO (out). Write with F16 A2 (12 bits, 40 ns resolution, 160 microseconds maximum). Read with F0 A2. Default (when register value = 0) is 400 ns. Minimum delay settings to avoid skipping ADCs during readout:

Manufacturer	Models	Minimum REQ-REO Delay
LeCroy	4300B	4.8 μ s (10 bits); 8.5 ms (11 bits)
SILENA/ORTEC	4418Q, 4418V, 4418T	33 μ s
ORTEC	AD114, AD413A	0.5 μ s

DAC REGISTER: Sets the DAC Output for testing LeCroy ADCs from 0 to 10.2375 Volts with 12-bit resolution. Write to the register with F16 A0. Read with F0 A0. The full register length is 24 bits, and can be used to test the CAMAC read and write lines.

TEST GATE WIDTH REGISTER: Determines the width of the test Gate pulse injected into the the ECL Control bus by the F25 A0 command. Selectable up to 40 μ s maximum with a 12-bit, 10-ns resolution. Write to this register with F16 A3, and read with F0 A3.

FERA CLEAR WIDTH REGISTER: Sets the width of the CLEAR pulse on the ECL Control bus up to 160 μ s with 40-ns, 12-bit resolution. Default is 200 ns when the register value = 0. Write with F16 A4, and read with F0 A4.

HISTOGRAM CONTROL REGISTER: Write to the register with F17 A3, and read with F1 A3.

- 0 = Employs the entire 1-M memory to histogram data from ADCs in the zero-suppressed mode, with memory allocation determined by the VSN and sub-address.
- 1 = Records a time-sequence of histograms for each sub-address of one ADC module. Requires zero-suppressed mode.
- 2 = Histograms spectra from multiple ADCs and sub-addresses according to readout sequence, when the ADCs are in the non-zero-suppressed readout mode.

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HISTOGRAM READOUT BLOCK SIZE REGISTER: Sets the Q-stop limit for reading out a block of data. Normally set equal to the length of the histogram to be transferred. Write to the register with F16 A5, and read with F0 A5. Default = 1M (all of memory).

MULTI HISTOGRAM REGISTER: Provides the base address for histogramming. For histogramming mode 0, bits 0 to 4 become bits 15 to 19 of the histogramming base address. For histogramming modes 1 and 2, bits 0 to 19 become the histogramming base address. Write to the register with F16 A6, and read with F0 A6.

GATE TIME-OUT REGISTER: Provides recovery from no REQ after a GATE. The time-out value must be set longer than the maximum expected delay between GATE and REQ. REQ cancels the time-out. Otherwise, a CLEAR is issued at the end of time-out regardless of the value of bit 4 in the control register. Selectable from 40 ns to 160 μ s with 40-ns, 12-bit resolution. A value of 0 disables this function. Write to the register with F16 A7, and read with F0 A7.

BUSY END-DELAY REGISTER: Sets the extension of BUSY beyond the end of CLEAR to provide additional ADC recovery time before the next event (busy must be used with external logic to block the gate). Selectable from 0 to 160 μ s with 40-ns, 12-bit resolution. Default is zero delay, i.e., BUSY ends at the end of CLEAR. Write to the register with F16 A8, and read with F0 A8.

VSN REGISTER: Holds the unique, 8-bit, VSN identification number assigned by the user for insertion in optional diagnostic headers (gate, request, clear) in the output data stream. Write to the register with F16 A9, and read with F0 A9.

PING PONG INTERVAL REGISTER: Sets the interval between 40-ns-wide alternating output pulses for COM inputs on a pair of LeCroy 3377 TDCs to measure extremely-long time ranges. Interval selectable from 40 ns to 160 μ s with 12-bit, 40-ns resolution. Write to the register with F16 A11, and read with F0 A11.

LED ASSIGNMENT REGISTER: Assigns the function of the front-panel LEDs. Bits 0 to 5 control the yellow, A LED (default = Full). Bits 6 to 11 control the green, B LED (default = Busy). Write to the register with F16 A12, and read with F0 A12.

Value	LED A (0–5)	LED B (6–11)	Description
000000	Full	Busy	Default status
000001	Enable	Enable	
000010	Busy	Busy	
000011	Busreq	Busreq	
000100	Buswst	Buswst	
000101	Buswak	Buswak	
000110	Extwst	Extwst	
000111	Extwak	Extwak	
001000	Ren	Ren	
001001	Psi	Psi	
001010	Full	Full	(FIFO is full)
001011	LAM	LAM	
001100	Empty	Empty	(FIFO is empty)
001101	Fifo14	Fifo14	(1M FIFO is 1/4 full)
001110	Fifo12	Fifo12	(1M FIFO is 1/2 full)
001111	Fifo34	Fifo34	(1M FIFO is 3/4 full)

EXTERNAL OUTPUT SELECTION REGISTER: Programs the signals assigned to the front-panel outputs, WSO, RQO, S and Q. Write to the 12-bit register with F16 A13, and read with F0 A13. A register value of 0 defaults to WSO or S = Write Strobe Output and RQO or Q = Readout Request Output.

Register Bit Assignments											
LSB						MSB					
0	1	2	3	4	5	6	7	8	9	10	11
WSO			RQO			S			Q		

Output Signal Assignment Codes				
Value	Output WSO	Output RQO	Output S	Output Q
000	wso	Request	wso	request
001	request	Wso	request	wso
010	extpass	Extpass	extpass	extpass
011	ppout1	Ppout2	ppout1	ppout2
100	foinpr	Foinpr	foinpr	foinpr
101	begfo	Begfo	begfo	begfo
110	endfo	Endfo	endfo	endfo
111	busy	Busy	busy	busy

- ppout1 & ppout2 are an alternating pair of pulses, spaced by the value in the ping-pong register
- begfo (begin FERA out) and endfo (end FERA out) are a pair of pulses indicating the beginning and end of the event to an external receiver for the FERA output data.
- foinpr (FERA out in progress) begins at begfo and ends at endfo.

EVENT TIME-OUT REGISTER: Prevents readout loop lock-up when the natural CLEAR is missing. The time-out delay following assertion of BUSY can be selected with 12-bit, 640-ns resolution up to 2.4 ms. (The default is zero, which disables the time-out.) CLEAR is asserted at the end of the time-out interval (independent of bit 4 in the control register). The time-out value must be set longer than the maximum delay expected between the gate and the end of the event. Write to the register with F16 A14, and read with F0 A14.

EXTERNAL REN (EXTREN) INPUT SIGNAL SELECT REGISTER: Assigns an input connector to be used for the external REN signal input, as required when employing operating mode 2 (see Control Register). Write to the register with F16 A15, and read with F0 A15.

Value	Port used for REN
1	ecl CLR
2	ecl readinh (RINH)
4	ecl WAK
8	ecl PSI
16	nim clear (C)
32	nim readinh (I)
64	nim wak (A)

ELECTRICAL AND MECHANICAL

POWER REQUIRED: The Model CMC203 derives its power from a CAMAC crate supplying ± 24 V, and ± 6 V. The power required is +24 V at 0.01 A, +6 V at 1.5 A, -6 V at 1.4 A, and -24 V at 0.01 A.

WEIGHT

Net: 0.7 kg (1.5 lb).

Shipping: 1.4 kg (3 lb).

DIMENSIONS: CAMAC-standard single-width module 1.70 cm x 22.15 cm (0.67 x 8.72 in.) front panel per IEEE/583-1982 (Reaff. 1988).

CE: Compliant with EEC CE regulations.

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Optional Accessories

The C-ECLBUS Cable Kit is recommended as an accessory to facilitate the FERAbus interconnections. Each kit contains:

Quantity	Description
1	16-conductor ribbon cable with 23 headers installed at 7.6-cm intervals for the ECL Control Bus.
1	34-conductor ribbon cable with 23 headers installed at 7.6-cm intervals for the ECL Data Bus.
1	51-cm long twisted pair cable with 2-pin sockets and headers on each end for the NEXT (PASS) to CLR connections.
23	15-cm long twisted pair cables with 2-pin sockets and headers on each end for the REO to RDE (REN), and the NEXT (PASS) to RDE (REN) connections.

The ribbon cables will serve an entire crate full of FERAbus modules, and can be cut to handle smaller groups of modules.

Ordering Information

To order, specify:

Model	Description
CMC203	FERA Driver, Memory and Histogrammer
C-ECLBUS	Cable kit for the ECLBUS

Delays/Gate and Delay Generators/ Logic Modules/Linear Gates

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425A	Nanosecond Delay	11.11
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542	Linear Gate and Stretcher	11.13

Delays

In experiments involving several sources of analog and logic signals, the signals from different paths usually must be aligned to arrive simultaneously at the decision points. This is the function of delay modules. For analog signals the pulse amplitude information must be preserved. Consequently, coaxial cables or lumped-parameter delay lines are used to generate the delay.

With logic pulses, three methods can be used. For short delays, coaxial cables can be employed. A more compact solution uses lumped-parameter delays with logic gates acting as buffers between the many delay sections. These first two solutions minimize the dead time following each pulse. If dead time is not a problem, the simplest method of achieving long delays with logic pulses is to use a "gate and delay generator." In this case, the original logic signal triggers a "one-shot" circuit. The width of the one-shot pulse sets the delay, and the trailing edge of the one-shot signal triggers the output pulse. Typically, another one-shot is used to set the width of the output pulse.

To choose the appropriate solution, consult the DELAY and the GATE AND DELAY GENERATOR selection guides in this section. See also the AMPLIFIER section of this catalog for delays suited to slow analog signals.

Logic Modules

In coincidence measurements, logic signals from various parts of the experiment must often be combined to determine which events are to be accepted for analysis. Logic modules provide a flexible means of making these decisions. The selection guide for LOGIC MODULES shows the variety of logic functions available.

Linear Gates

When some analog signals must be blocked, and some must be selected to pass on to a subsequent instrument, a linear gate is required. Linear gates usually provide a variety of ways to use a logic pulse in blocking or passing the analog signal. See the LINEAR GATE selection guide and the individual data sheets for further information.

Delays/Gate and Delay Generators/ Logic Modules/Linear Gates

Delay Selection Guide

	DB463 Delay Box	425A Nanosecond Delay
Type of Signal	Analog or logic	Analog or logic
Number of Duplicate Channels	4	1
Delay Range per Channel	0 to 63.5 ns	2 to 65 ns
Minimum Delay Adjustment	0.5 ns	1 ns

Gate and Delay Generator Selection Guide

	GG8010 Octal Gate and Delay Generator	416A Gate and Delay Generator
Number of Duplicate Channels	8	1
Module Width	NIM-1	NIM-1
Input	Fast negative NIM logic pulse	Slow positive NIM, or fast negative NIM logic pulse
Outputs	Fast negative NIM and TTL logic pulses	Positive and negative delayed outputs with amplitude adjustable from 2 to 10 V; delay period (+5 V); delay marker (fast negative NIM)
Output Delay	70 ns to 10 μ s	100 ns to 110 μ s
Output Width	50 ns to 10 μ s	400 ns to 4 μ s

Logic Module Selection Guide

	CO4020 Quad, 4-Input Logic Unit	414A Fast Coincidence	418A Universal Coincidence
Number of Duplicate Channels	4	1	1
Module Width	NIM-1	NIM-2	NIM-1
Logic Functions	AND, OR	AND, anti- coincidence	Majority AND, NAND
Number of Inputs Per Channel	4	3	5
Input Level	Fast negative NIM	Slow positive NIM	Slow positive NIM
Outputs	TTL and Fast negative NIM	Slow positive NIM	Slow positive NIM
Special Features	Adjustable output widths	Adjustable resolving time widths	Majority logic

Linear Gate Selection Guide

	426 Linear Gate	542 Linear Gate and Stretcher
Input Pulse Amplitude Range	+200 mV to +10 V	+100 mV to +10 V
Minimum and Maximum Rise Time	<0.3 μ s to dc	0.1 to 10 μ s
Input Coupling	ac-coupled with passive, symmetric BLR; can be dc-coupled	dc-coupled, or ac- coupled with active BLR
Output Reshaping	None	Input peak amplitude stretched and gated out as a rectangular output pulse
Gating Functions	Pulse pass, pulse inhibit, dc inhibit	Normally open, coincidence, anticoincidence, external strobe

CO4020 Quad 4-Input Logic Unit

The ORTEC Model CO4020 Quad 4-Input Logic Unit has the flexibility to satisfy the logic requirements of most coincidence experiments without additional logic modules. The logic functions it can perform are: coincidence (AND), anticoincidence (veto), fan-in (OR), fan-out, fast negative NIM-to-TTL conversion, and pulse lengthening. The Model CO4020 contains four identical, independent channels of 4-input logic in a single-width NIM module.

Each of the four inputs (A, B, C, and D) accepts NIM fast negative logic pulses. Front-panel, three-position slide switches select the logic requirements separately for each input. The various combinations of logic functions that can be implemented are illustrated in Fig. 1 and in the specifications for the control switches.

The X output is a NIM fast negative logic pulse whose width is determined by the width and overlap of the active input pulses. The complement of the X output is available at the \bar{X} output. The updating Y outputs can be set to trigger on either the leading edge or the trailing edge of the X output pulse. The width of the Y outputs can be adjusted from 40 ns to 40 μ s in two selectable ranges. Two of the Y outputs provide NIM fast negative

logic pulses. The third Y output delivers a positive TTL logic pulse that is suitable for gating ADCs and multichannel analyzers. Front-panel LEDs indicate which channel is generating an output.

Specifications

The Model CO4020 incorporates four separate channels with identical functions. The specifications apply to each of the four channels unless stated otherwise.

PERFORMANCE

NUMBER OF IDENTICAL CHANNELS 4.

MAXIMUM COUNT RATE

X and \bar{X} Outputs 100 MHz.

Y Outputs $1/(1.1 \times \text{width})$.

MINIMUM PULSE OVERLAP 3 ns.

PROPAGATION DELAY

Input to X, \bar{X} <8 ns.

Input to Y (Neg) <13 ns.

Input to Y (Pos) <20 ns.

DEAD TIME OF Y OUTPUTS 110% of width setting.

CONTROLS AND INDICATORS

WIDTH ADJUST (W) Front-panel screwdriver adjustment allows width adjustment of Y outputs. Two ranges can be selected by the front-panel slide switch:

S (40–1200 ns) or L (1–40 μ s).

LED INDICATOR Front-panel, red LED lights when output has been activated.

- General-purpose logic module for AND, OR, Veto, Fan-Out, and Gating functions
- Four independent channels
- Overlap outputs and adjustable-width outputs
- 3-ns overlap resolution
- TTL and fast negative NIM outputs

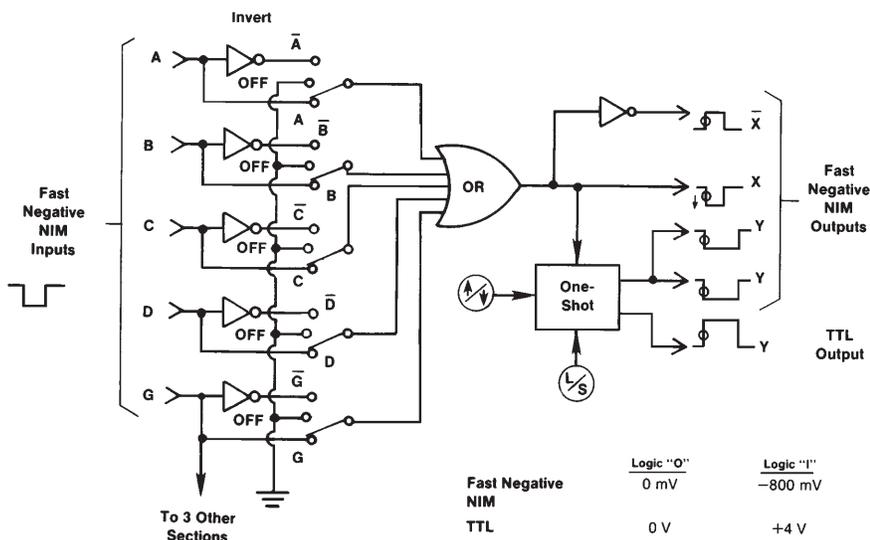
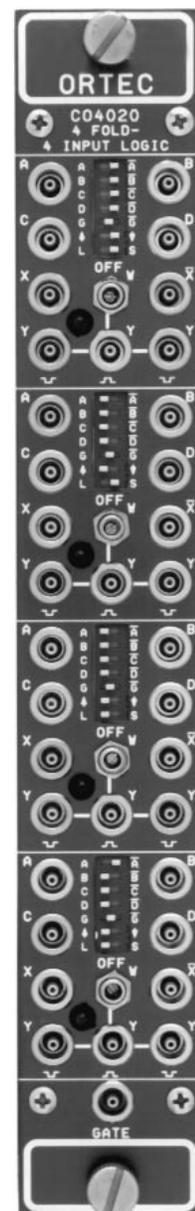


Fig. 1. Block Diagram of the Model CO4020 Logic Unit.

CO4020

Quad 4 Input Logic Unit

CONTROL SWITCHES Front-panel 7- by 3-position slide switch selects logic function definition, gate operation, Y output trigger point, and Y output width adjustment range as follows:

Input Logic Switches (A/OFF/ \bar{A} , B/OFF/ \bar{B} , C/OFF/ \bar{C} , D/OFF/ \bar{D} , AND G/OFF/ \bar{G}) As defined in Fig. 1, these switches select variations of the following basic logic functions. In the OFF position, the state of that input is ignored. With switches set to the A, B, C, D, and G positions, the module performs the OR function at the X output.

$$X = A + B + C + D + G$$

Setting the switches to the \bar{A} , \bar{B} , \bar{C} , \bar{D} , and \bar{G} positions provide the AND (coincidence) function at the X output.

$$\bar{X} = A \cdot B \cdot C \cdot D \cdot G$$

Changing the \bar{G} switch to G implements the common-gate veto (anticoincidence).

$$\bar{X} = A \cdot B \cdot C \cdot D \cdot \bar{G}$$

See Fig. 1 to determine other possible logic combinations.

Trigger Switch for Y Outputs (\downarrow or \uparrow) Allows either the negative transition (\downarrow) or the positive transition (\uparrow) of the X output to trigger the constant-width Y outputs.

Y Output Width Range Switch Sets either to S (40–1200 ns) or L (1–40 μ s).

INPUTS

A, B, C, AND D INPUTS Front-panel LEMO connectors accept negative fast-NIM logic signals.

Minimum Amplitude –600 mV.

Minimum Width 3 ns.

Input Impedance 50 Ω .

GATE INPUT (G) Front-panel LEMO connector accepts negative Fast-NIM logic signals. The GATE input is delivered to all four sections.

Minimum Amplitude –600 mV.

Minimum Width 3 ns.

Input Impedance 50 Ω .

OUTPUTS

X AND \bar{X} OUTPUTS Front-panel LEMO connectors provide the noninverted (X) and the inverted (\bar{X}) result of the logic satisfied by the input signals. Logic requirements are set by the front-panel slide switches A/OFF/ \bar{A} , B/OFF/ \bar{B} , C/OFF/ \bar{C} , D/OFF/ \bar{D} , and G/OFF/ \bar{G} . X and \bar{X} are Fast-NIM logic signals.

Amplitude –20 mA.

Rise Time <4 ns.

Output Width Determined by duration of input signals and logic selection.

Y OUTPUTS (\downarrow and \uparrow) Front-panel LEMO connectors provide two updating Fast-NIM logic outputs (\downarrow) and one updating positive TTL logic output (\uparrow) per channel. Output width of all three Y outputs is set by WIDTH adjustment. Y outputs are triggered by either the negative transition (\downarrow) or positive transition (\uparrow) of the X overlap output as selected by the front-panel slide switch.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model CO4020 derives its power from a standard NIM bin and power supply. The required power is +6 V, 200 mA; –6 V, 1000 mA.

WEIGHT

Net 1.3 kg (2.3 lb).

Shipping 2.2 kg (4.8 lb).

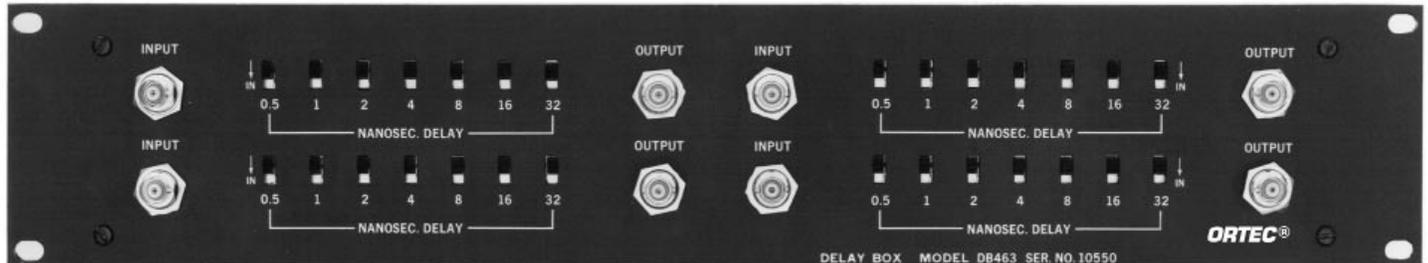
DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
CO4020	Quad 4-Input Logic Unit

DB463 Delay Box



- Aligns fast-timing channels that incorporate coincidence circuits or TACs
- Four independent sections
- 50-Ω calibrated cable delay for linear or logic signals
- 0 to 63.5-ns delay in 0.5-ns steps

The ORTEC Model DB463 furnishes a 50-Ω calibrated cable delay, providing relative delays from 0 to 63.5 ns with 0.5-ns increments in each of four identical sections. Longer delays may be achieved by cascading several Model DB463 Delay Box sections.

The Model DB463 is convenient for aligning fast-timing channels that incorporate coincidence circuits or time-to-amplitude converters.

Specifications

INPUTS (4) 50 Ω; either polarity; 1500 V maximum. BNC connectors.

OUTPUTS (4) 50 Ω; delay between In and Out is sum of delays. BNC connectors.

DELAY TIMES 0.5, 1, 2, 4, 8, 16, and 32 ns.

DELAY ACCURACY $< \pm 0.1$ ns or $\pm 1.0\%$ for each switch, whichever is greater.

REFLECTIONS $< 3\%$ at any delay setting for 1-ns rise time step.

CABLE RG-58A/U.

WEIGHT

Shipping 4.0 kg (9 lb).

DIMENSIONS 48.2 cm (19 in.) wide for relay rack mounting, 8.9 cm (3.5 in.) high, and 20.3 cm (8 in.) deep.

Ordering Information

To order, specify:

Model Description

DB463 Delay Box

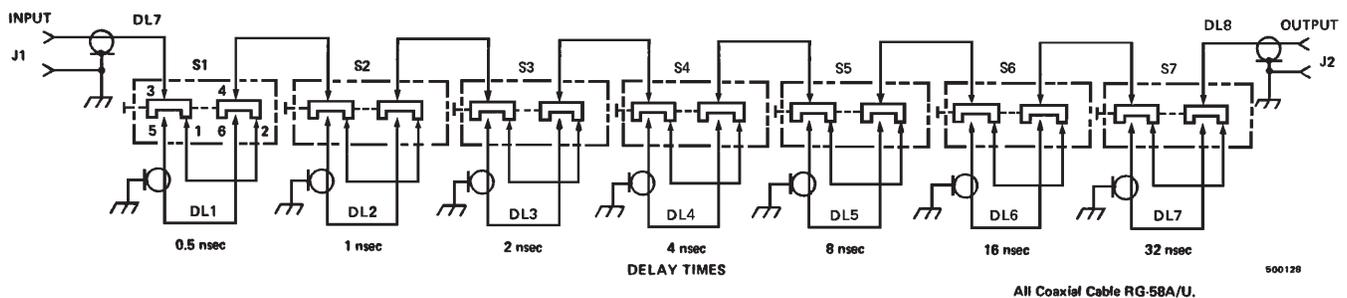


Fig. 1. Typical Schematic for One Section of Model DB463 (Four Sections Included).

GG8020

Octal Gate and Delay Generator

- For adjusting the delay and width of coincidence and gating pulses
- Eight, independent, duplicate channels in a compact package
- TTL outputs and NIM-standard fastnegative outputs
- Output delay adjustable from 70 ns to 10 μ s
- Output width adjustable from 70 ns to 10 μ s



The ORTEC Model GG8020 Octal Gate and Delay Generator provides a compact and versatile solution for gating and coincidence logic requirements in large experiments. It contains eight independent channels of gate and delay generators in a single-width NIM module.

Each channel accepts NIM-standard, fast negative logic pulses at its input. The leading edge of the input signal triggers a delay period, that can be adjusted separately for each channel. At the end of the delay period, an output pulse is generated. The width of this pulse can be adjusted independently for each channel. Delay ranges from 70 to 1000 ns or from 0.4 to 10 μ s can be selected separately for each channel by one of eight jumpers on the printed wiring board. A second set of eight jumpers independently select ranges from 70 to 1000 ns, or 0.4 to 10 μ s for the output pulse widths.

Each channel produces two NIM-standard, fast negative logic pulse outputs, and one positive TTL output. The fast negative outputs provide fan-out capability, and are particularly useful for driving overlap coincidence modules that require NIM-standard, fast negative logic levels. They can also be used as delayed inputs to timing instruments, or as gating signals on modules that require fast negative inputs. The TTL output is compatible with modules requiring either TTL inputs, or NIM-standard, slow positive logic pulses. The TTL output is ideal for gating ADCs and multichannel analyzers.

Specifications

PERFORMANCE

NUMBER OF DUPLICATE CHANNELS 8.

OUTPUT DELAY Adjustable from <70 to >1000 ns, or from <0.4 to >10 μ s. Temperature coefficient <0.04%/°C from 0 to 50°C.

OUTPUT PULSE WIDTH Adjustable from <70 to >1000 ns, or from <0.4 to >10 μ s. Temperature coefficient <0.04%/°C from 0 to 50°C.

DEAD TIME Typically equal to the Delay plus the Output Pulse Width plus 20 ns.

DELAY JITTER <0.04% of the selected delay.

CONTROLS

DELAY, S OR L Eight jumpers on the printed wiring board permit independent selection of a Short (S) or Long (L) delay time range for each channel. The delay range is 70 to 1000 ns

on the Short setting and 0.4 to 10 μ s on the Long setting.

DELAY Eight front-panel, 12-turn, screwdriver adjustments provide independent fine adjustment of the delay within the range selected by the respective S OR L DELAY jumper.

WIDTH, S OR L Eight jumpers on the printed wiring board permit independent selection of a Short (S) or Long (L) width range for each channel. The width range is 70 to 1000 ns on the Short setting and 0.4 to 10 μ s on the Long setting.

WIDTH Eight front-panel, 12-turn, screwdriver adjustments provide independent fine adjustment of the width within the range selected by the respective S OR L WIDTH jumper.

INPUTS

IN Eight front-panel LEMO connectors (one for each channel) accept NIM-standard, fast negative logic signals to trigger the delayed output pulses. The input pulse minimum amplitude is -600 mV; minimum width is 10 ns. The input is dc-coupled with 50- Ω input impedance.

OUTPUTS

OUT Two front-panel LEMO output connectors for each channel deliver NIM-standard, fast negative logic signals. The output delay relative to the input is set by the DELAY adjustment, and the output duration is set by the WIDTH control. The outputs are typically -16 mA (-800 mV into a 50- Ω load), with rise and fall times <4 ns.

TTL One front-panel LEMO connector for each channel delivers a TTL version of the signal from the OUT connectors. The TTL output provides <+0.4 V in the quiescent state, and nominally +4 V into a 50- Ω load during the output pulse. The rise time is <20 ns.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model GG8020 derives its power from a standard NIM bin and power supply. The required power is +6 V at 150 mA, and -6 V at 2 A.

WEIGHT

Net 1.3 kg (2.3 lb).

Shipping 2.2 kg (4.8 lb).

DIMENSIONS NIM-standard, single-width module, 3.43 X 22.13 cm (1.35 X 8.714 in.) front panel per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
GG8020	Octal Gate and Delay Generator

414A Fast Coincidence

The ORTEC Model 414A Fast Coincidence is a modular threefold coincidence unit that allows fast coincidence determination between any two or three input signals. The term "fast" indicates the general nature of the coincidence circuit; that is, input pulses are reshaped, and the actual coincidence determination is made on the leading edge, or leading portion, of the pulses. A dc-coupled anticoincidence input is provided to inhibit the coincidence output by a dc voltage or a pulse that overlaps the period of coincidence of the coincident pulses. The coincidence inputs are ac-coupled, and all four inputs are controlled by In/Out toggle switches.

The resolving time, 2τ , of the fast coincidence unit may be varied over a 10- to 110-ns range by a 10-turn control for accurate resettability of the resolving time. The resolving time of the anticoincidence circuit is set by the width of the input pulse.

Specifications

PERFORMANCE

PULSE PAIR RESOLUTION <100 ns on any single input; for coincidence events, <1 μ s on the coincidence output.

RESOLVING TIME (2τ) Continuously variable from 10 to 110 ns for coincidence signals; set by the width of the input pulse for the anticoincidence signal.

TEMPERATURE INSTABILITY 2τ changes $<\pm 0.2\%/^{\circ}\text{C}$ from 0 to 50°C .

CONTROLS

RESOLVING TIME (10–110 ns) Front-panel 10-turn locking potentiometer for controlling resolving time for inputs A, B, and C over a range from 10 to 110 ns.

INPUT CONTROLS Toggle switches for using any input combination desired and for disabling input signals to the coincidence and anticoincidence circuits without input coaxial cables having to be removed.

INPUTS

COINC Front-panel BNC connectors provide 3 ac-coupled coincidence inputs (A, B, C) of positive polarity; 2-V threshold, 20-ns minimum width required; absolute maximum input 50 V; impedance $>3000\ \Omega$.

ANTICOINC Front-panel BNC connector provides one dc-coupled anticoincidence input (D) for inhibiting coincidence output; +2 V threshold, 20-ns minimum width required; absolute maximum input 50 V; impedance $>3000\ \Omega$.

OUTPUTS

OUTPUT Two separate buffered coincidence output signals through front-panel BNC connectors provide positive pulses ≥ 500 ns wide with 5-V minimum amplitude; ac-coupled with $<10\text{-}\Omega$ impedance; monitored through oscilloscope test points on front panel.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model 414A derives its power from a standard NIM bin/power supply. The power required is +24 V, 30 mA; -24 V, 30 mA; +12 V, 120 mA; and -12 V, 85 mA.

WEIGHT

Net 1.09 kg (2.4 lb).

Shipping 2.0 kg (4.4 lb).

DIMENSIONS NIM-standard double-width module 6.90 X 22.13 cm (2.70 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

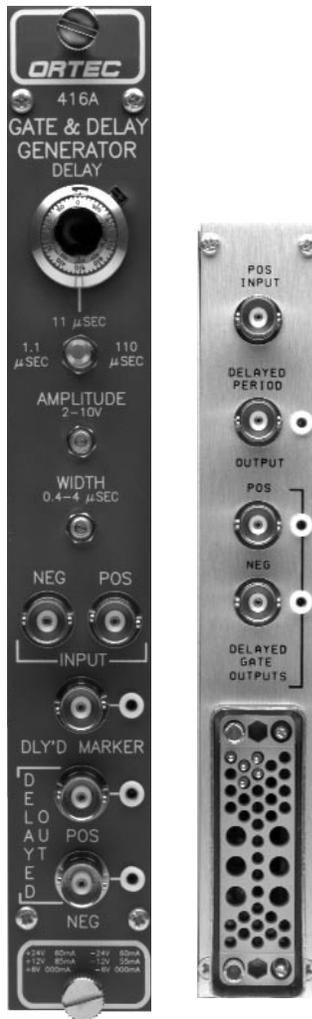
Model	Description
414A	Fast Coincidence

- Provides fast coincidence determinations with adjustable resolving time
- Three selectable, positive-polarity coincidence inputs
- One selectable, positive-polarity anticoincidence input
- Adjustable 10 to 110 ns resolving time



416A Gate and Delay Generator

- Provides adjustment of the delay, width, polarity, and amplitude of gating pulses
- Positive or negative polarity input pulse
- Time delay from 0.1 to 110 μ s
- Output pulse width from 0.4 to 4 μ s
- Excellent time delay stability



The ORTEC Model 416A Gate and Delay Generator accepts either polarity of input logic pulse, provides a delay of up to 110 μ s, and furnishes an output logic pulse with selected amplitude, polarity, and width. The combination of functions provided by this module satisfies various logic requirements, such as gating multichannel analyzers and alignment of coincidence timing between two channels using dissimilar pulse-shaping modes. Auxiliary outputs include a Delay Period output, with a width equal to the delay time, and a NIM-standard Fast-negative Delayed Marker pulse. Excellent time stability allows application in systems that require nanosecond time precision.

Instruments producing either positive or negative NIM-standard logic signals may be used to drive the Model 416A. Because of the versatility of its amplitude and width adjustments and its dual-polarity output connections, the output can be set for compatibility with essentially all nuclear instrumentation. It can also be used as a logical interface between ORTEC equipment and any other instruments.

Specifications

PERFORMANCE

DELAY NONLINEARITY $\leq \pm 2\%$.

DELAY TEMPERATURE INSTABILITY $\leq \pm 0.03\%$ of adjusted Delay per $^{\circ}\text{C}$.

DELAY GENERATOR DEAD TIME Adjusted Delay plus 200 ns on 1.1- μ s range, 300 ns on 11- μ s range, and 1 μ s on 110- μ s range.

OUTPUT GENERATOR DEAD TIME Adjusted Width plus 0.2 μ s.

DELAY JITTER $\leq 0.02\%$ of selected range.

CONTROLS

DELAY 10-turn locking potentiometer with direct-reading duo-dial for continuous adjustment within the range selected by the locking 3-position toggle switch:

1.1 μ s Selects the range of 0.1 to 1.1 μ s for the Delay potentiometer.

11 μ s Selects a 1 to 11 μ s range.

110 μ s Selects a 10 to 110 μ s range.

AMPLITUDE Front-panel screwdriver control, permits the output pulse amplitude to be adjusted within the range of 2 to 10 V, both polarities (i.e., +2 to +10 V and -2 to -10 V).

WIDTH Front-panel screwdriver control permits the width of output pulses to be adjusted within the range of 400 ns to 4 μ s.

INPUTS

POS Front- and rear-panel BNC connectors; +2 V pulse minimum, 12 V maximum; 100-ns minimum width, dc-coupled; impedance 1000 Ω .

NEG Front-panel BNC connector accepts NIM-standard fast negative logic pulses; -250 mV pulse minimum; 5 ns minimum width, dc-coupled; impedance 50 Ω .

OUTPUTS

DELAYED OUT, POS/NEG Front- and rear-panel BNC connectors, with test points, provide simultaneous output pulses with identical characteristics except for opposite polarity; impedance $\leq 10 \Omega$.

DELAYED PERIOD Rear-panel BNC connector, with test point, provides positive pulse width equal to the adjusted Delay; amplitude +5 V; rise time ≤ 50 ns; impedance $\leq 10 \Omega$.

DLY'D MARKER Front-panel BNC connector, with test point, provides NIM-standard fast negative logic pulse at the end of delay time. Amplitude, -0.6 V into 50 Ω load; rise time ≤ 10 ns; width ≤ 25 ns; impedance $\leq 10 \Omega$.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model 416A derives its power from a standard NIM bin/power supply. The power required is +24 V, 60 mA; -24 V, 60 mA; +12 V, 85 mA; and -12 V, 85 mA.

WEIGHT

Net 1.3 kg (2.8 lb).

Shipping 2.2 kg (4.8 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model Description

416A Gate and Delay Generator

418A Universal Coincidence

The ORTEC Model 418A is a Universal Coincidence unit with five dc-coupled inputs. Each input is accepted through a convenient front-panel connector.

Input A accepts an input signal with a width of 50 ns or more and regenerates an internal signal that will be used for coincidence comparisons. The Input A signal width is adjustable for a resolving time of 100 ns to 2 μ s, and this range is available with a front-panel control.

The function of each input is selectable, and its signal can be used for coincidence or anticoincidence or can be disabled. This permits various combinations of input signal relations to be selected without adding or removing cables in the system.

Another feature that simplifies operating flexibility without changing any cables is a selectable number of inputs that are required to satisfy a coincidence. For example, if the selector shown is set at 2, an overlap between any two inputs that are selected for the coincidence function will cause an output to be generated. If any one or more inputs are selected for anticoincidence, all outputs are inhibited while such signals are present. Because any combination of input signal effects can be selected easily at the front panel, the Model 418A is a Universal Coincidence unit that can be adapted to any coincidence system arrangement.

Specifications

PERFORMANCE

INPUT A RESOLVING TIME 100 ns to 2 μ s; controlled by a front-panel, 20-turn, screwdriver adjustable potentiometer; inputs B, C, D, and E controlled by input pulse width.

TEMPERATURE INSTABILITY

Input A Change in resolving time, τ , $< \pm 0.1\%/^{\circ}\text{C}$.

Inputs B, C, D, E Change in resolving time, τ , $< \pm 0.05\%/^{\circ}\text{C}$ for $\tau = 500$ ns.

OPERATING TEMPERATURE 0 to 50°C.

CONTROLS

COINCIDENCE REQUIREMENTS Selects number of inputs necessary to satisfy a coincidence requirement (majority logic).

INPUT CONTROLS Five 3-position toggle switches select Coincidence, Anticoincidence, or Off (disabled).

INPUTS

POLARITY +2 V minimum, 30 V maximum.

PULSE WIDTH 50 ns to dc.

CONNECTORS BNC on front panel.

INPUT IMPEDANCE > 1.5 k Ω , dc-coupled.

OUTPUTS

AMPLITUDE +5 V.

PULSE WIDTH 500 ns.

CONNECTORS BNC on front and rear panels.

OUTPUT IMPEDANCE < 10 Ω , dc-coupled.

ELECTRICAL AND MECHANICAL

POWER REQUIREMENTS The Model 418A derives its power from a standard NIM bin/power supply. The power required is +24 V, 105 mA; -24 V, 95 mA; +12 V, 50 mA; and -12 V, 30 mA.

WEIGHT

Net 0.9 kg (2.0 lb).

Shipping 2.25 kg (5.0 lb).

DIMENSIONS Standard single-width NIM module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

- Provides coincidence determinations using majority logic
- Five, positive-polarity, dc-coupled inputs
- Coincidence, Anticoincidence, or Off selectable for each input



418A

Universal Coincidence

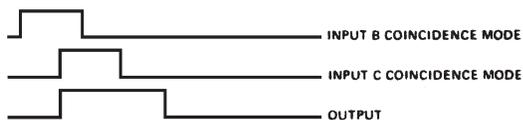
Related Equipment

Input signals to the Model 418A can be from any timing instrument providing a positive output signal from 2 to 30 V. The output of the Model 418A provides a logic signal suitable for driving any of the medium-speed logic modules in the ORTEC product line, but it is more typically used as a gating signal such as a gate-enable signal to a multichannel analyzer.

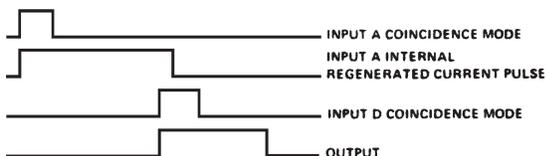
Ordering Information

To order, specify:

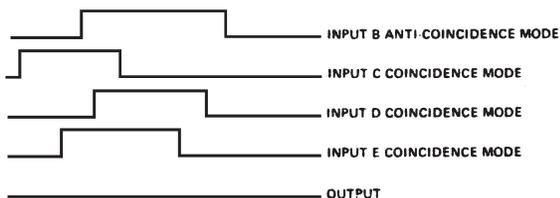
Model	Description
418A	Universal Coincidence



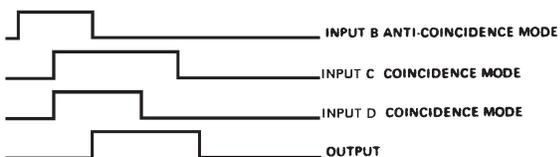
Coincidence Requirements When Switch Setting is 2.



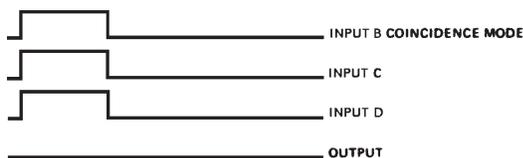
Coincidence Requirements When Switch Setting is 2.



Coincidence Requirements When Switch Setting is 3.



Coincidence Requirements When Switch Setting is 2.



Coincidence Requirements When Switch Setting is 4.

425A Nanosecond Delay

The ORTEC Model 425A Nanosecond Delay provides a calibrated delay for any type of signal in 1-ns steps from 0 to 63 ns. Longer delays can be obtained by cascading several Model 425As. The delays are accomplished with RG-58A/U coaxial cables that are interconnected by stripline sections. No power is required to operate the instrument.

The Model 425A has many uses. For example, it can be used for aligning fast-timing channels to operate coincidence circuits or time-to-pulse-height converters. And, because of the high accuracy of the delays, it can be used to calibrate that equipment.

The input and output impedances of the Model 425A are 50 Ω , making it fully compatible with related signal sources and loads in other NIM-standard modular nuclear instruments.

Specifications

PERFORMANCE

DELAY ACCURACY ± 100 ps or $\pm 1\%$ for each delay section used.

MINIMUM DELAY (All Switches Out) 2.0 ns.

IMPEDANCE MISMATCH REFLECTION $\leq \pm 2\%$ from any of the delay switches.

CONTROLS

Six slide switches, each with an Out position and an In position, permit selection in any combination for total delay; switches select 1, 2, 4, 8, 16, and 32 ns.

INPUT

BNC connector accepts signal of either polarity to ± 600 V maximum; impedance, 50 Ω .

OUTPUT

BNC connector furnishes input signals with the delay selected by the switches that are set at IN; impedance, 50 Ω .

ELECTRICAL AND MECHANICAL

POWER REQUIRED None.

WEIGHT

Net 1.0 kg (2.2 lb).

Shipping 1.4 kg (3.0 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

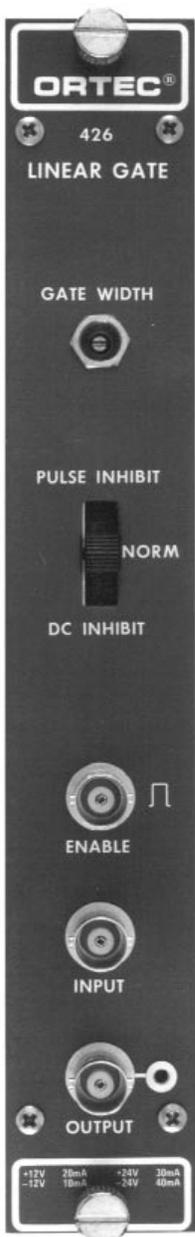
Model	Description
425A	Nanosecond Delay

- Aligns fast-timing channels that incorporate coincidence circuits or TACS
- 50- Ω calibrated delay cable for linear or logic signals
- 2- to 65-ns delay in 1-ns steps



426 Linear Gate

- For passing and blocking analog signals in the range from +0.2 to +10 V
- Ungated or gated with coincidence or anticoincidence gating
- External or internal control of gate pulse width



The ORTEC Model 426 Linear Gate provides a variable gate duration with width controlled by a single-turn front-panel-mounted potentiometer. The nominal gate duration is from 0.3 to 4 μ s. Operation of the linear gate is controlled by a positive enable pulse. It is useful for selecting or inhibiting linear signals according to chosen coincidence or timing requirements.

The ORTEC Model 426 has two operating modes: all input signals not accompanied by an enable pulse are blocked or all signals are passed unless accompanied by an inhibit signal. The inhibit signal can be fed into the front-panel Enable connector for Pulse Inhibit operation or into the DC Inhibit connector for dc or continuous inhibit operation. The DC Inhibit mode provides external control of the gating period.

Specifications

PERFORMANCE

GAIN Unity.

INTEGRAL NONLINEARITY $\leq \pm 0.15\%$ from 0.2 to 10 V.

PULSE FEEDTHROUGH < 10 mV with a 10-V input pulse.

TEMPERATURE INSTABILITY $< \pm 0.015\%/^{\circ}\text{C}$, 0 to 50 $^{\circ}\text{C}$.

COUNTING RATE The gain shift of a 4-V reference pulse is $< 0.25\%$ with the application of an additional count rate of 65,000 counts/s of 6-V random pulses.

CONTROLS

GATE WIDTH Continuously variable from 0.3 to 4 μ s.

OUTPUT PEDESTAL Adjustable to < 1 mV.

PULSE INHIBIT/NORM/DC INHIBIT 3-position mode switch permits selection of the function of any pulse or dc level furnished through the front-panel Enable Input connector, or the rear-panel DC Inhibit connector.

Norm Input pulse will be gated through to the output during a gate width interval following the leading edge of each Enable Input pulse.

Pulse Inhibit Input pulses will be inhibited from passing through the output during a gate width interval following each Enable Input pulse.

DC Inhibit Input pulses will be inhibited from passing through the output during intervals of pulses or dc levels through the rear-panel DC Inhibit connector.

INPUTS

LINEAR INPUT Unipolar or bipolar with positive portion leading. Rated range 0.2 to 10 V, 12 V maximum. Input impedance $> 5000 \Omega$; BNC connector. Input is ac-coupled with a passive symmetric baseline restorer. BLR can be bypassed for dc-coupling.

ENABLE OR INHIBIT INPUT Any positive input > 2 V, maximum input 20 V. Enable impedance 1000Ω , dc-coupled; Inhibit impedance 650Ω , dc-coupled; BNC connector for each.

OUTPUT

Rated output range 0.2 to 10 V positive; 12 V maximum. Output impedance $\sim 2 \Omega$, dc-coupled, short-circuit protected; BNC connector.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model 426 derives its power from a standard NIM bin/power supply. The power required is +24 V, 30 mA; -24 V, 49 mA; +12 V, 16 mA; -12 V, 4.9 mA.

WEIGHT

Net 0.96 kg (2.1 lb)

Shipping 1.82 kg (4.0 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
426	Linear Gate



The ORTEC Model 542 Linear Gate and Stretcher accepts a linear input pulse through an input linear gate, stretches the peak amplitude of the input pulse, and generates an output pulse with amplitude equal to the input, and shaped to a uniform rise time and width. It is useful for selecting and inhibiting linear signals according to chosen coincidence or timing conditions. The Model 542 features excellent temperature stability, integral linearity, response to high counting rates, and simplicity of operation. In addition, the Linear Gate section features total dc-coupling with essentially zero pedestal and feedthrough.

Each linear input pulse must exceed the adjustable discriminator level to enable generation of an output pulse. The linear output pulse has a fixed rise time, a 100:1 dynamic range, an adjustable width, and is delayed by an adjustable interval (0.5–5 μ s) after the peak of the linear input pulse. Operating in either coincidence or anticoincidence mode, the input linear gate can be disabled or enabled for an adjustable gate period following a Gate Input logic pulse. A switch-selectable external strobe input permits strobing the output during an adjustable interval (5–50 μ s) after the input pulse peak. A slide switch on the front panel permits selection of any one of three input connections: DC Couple, BLR Low, or BLR High. These features make the Model 542 suitable for inclusion directly after the linear amplifier in a system.

The pulse from a Busy Output on the rear panel indicates the time duration from the peak of a Linear Input pulse until the end of the output pulse, as set by the pulse Width control, or until the input discriminator has been reset, whichever is longer. This output can be counted in a scaler to indicate how many pulses are furnished through the system, or it can be integrated to indicate relative dead time.

Specifications

PERFORMANCE

NOISE CONTRIBUTION <20 μ V rms, referred to input.

GATE FEEDTHROUGH <0.005% of signal amplitude with gate closed.

GATE PEDESTAL Essentially zero, factory-calibrated.

STRETCHER DROOP

Typically <0.1 mV/ μ s/V output.

PILEUP REJECTION After the input pulse has reached its peak, subsequent inputs are rejected until both the output pulse has terminated and the input has recovered to the baseline.

GAIN Unity (nominal).

INTEGRAL NONLINEARITY $\leq \pm 0.2\%$ for pulse rise time >100 ns and pulse width >400 ns.

TEMPERATURE INSTABILITY Gain shift $< \pm 0.01\%/^{\circ}\text{C}$, 0 to 50 $^{\circ}\text{C}$ for $V_o = 5$ V.

COUNTING RATE dc-coupled throughout when DC Couple input is selected. The centroid of a pulser spectrum at 85% of full scale will shift <0.1% when modulated by 5×10^4 counts/s of random signals from ^{137}Cs source- detector combination with photopeak at 70% of full scale (DC Couple mode and amplifier shaping time $\tau = 1$ μ s).

CONTROLS

INPUT

Slide Switch Front-panel 3-position slide switch selects input circuit desired: BLR High, BLR Low, or DC Couple.

Disc Level Front-panel screwdriver potentiometer adjusts sensitivity level for input discriminator; range +0.1 to +1 V; discriminator remains triggered while input level exceeds adjusted sensitivity.

- For passing and blocking analog signals in the range from +0.1 to +10 V
- Ungated or gated with coincidence or anticoincidence gating
- Strobed linear output with internal or external strobe
- Adjustable output delay and width



Linear Gate and Stretcher

OUTPUT

Delay Front-panel screwdriver potentiometer; adjusts delay period from peak detect to the start of the output pulse; typical range 0.5 to 5 μ s. (Delay ranges up to 50 μ s available on special request.)

Width Front-panel screwdriver potentiometer adjusts width of the output pulse; typical range 0.5 to 5 μ s.

NORMAL/GATED Front-panel locking toggle switch selects exclusion (Normal) or inclusion (Gated) of external gating function.

GATE PERIOD Front-panel screwdriver potentiometer adjusts duration of gating control from leading edge of Gate Input pulse; range 0.5 to 5 μ s, includes test point for monitoring adjusted gate period.

COINC/ANTICOINC Front-panel locking toggle switch selects effective mode for Input Gate function.

OUTPUT DC ADJ Front-panel screwdriver potentiometer permits adjustment of output dc level between ± 1.5 V.

EXT/INT Rear-panel locking toggle switch selects between (External) strobe operation or (Internal) normal/gated operation.

INPUTS

GATE Front-panel BNC connector for optional external control for switch-selectable coincidence or anticoincidence mode triggering. NIM-standard slow logic pulse triggers selected gate function at +3 V (100 ns minimum width), protected to ± 25 V.

LINEAR Front-panel BNC connector.

Polarity Positive unipolar or bipolar with positive portion leading.

Amplitude +0.1 to +10 V linear; ± 12 V maximum.

Rise Time 100 ns to 10 μ s.

Impedance $\sim 1000 \Omega$.

EXT STROBE Rear-panel BNC connector for optional external control of the output pulse timing. NIM-standard slow positive logic pulse triggers the strobe function at +3 V (100 ns minimum width), protected to ± 25 V.

OUTPUTS

OUTPUT Front-panel BNC connector furnishes linear positive output pulses through $Z_o < 1 \Omega$; rise time 300 ns; includes test point.

Polarity Positive.

Amplitude +0.1 to +10 V, equal to peak amplitude of the accepted linear input pulse.

Delay Adjusted by front-panel control; range 0.5 to 5 μ s after peak detect.

Width Adjusted by front-panel control; range 0.5 to 5 μ s.

Impedance $< 1 \Omega$ on front panel.

DC Offset Adjust ± 1.5 V.

93 Ω OUTPUT Rear-panel BNC connector furnishes the same linear signals as the front-panel output, except the output impedance is 93 Ω .

BUSY Rear-panel BNC connector furnishes +5 V nominal through $Z_o < 10 \Omega$ through all periods when input pulses cannot be accepted; may be used to control external equipment or for monitoring internally created dead time.

Busy +5 V nominal, linear pulse cannot be accepted.

Not Busy 0 V nominal, linear pulse can be accepted.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model 542 derives its power from a standard NIM bin/power supply. The power required is +24 V, 83 mA; -24 V, 80 mA; +12 V, 130 mA; -12 V, 30 mA.

WEIGHT

Net 0.9 kg (2.0 lb).

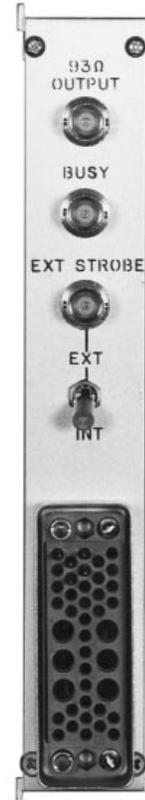
Shipping 1.9 kg (4.0 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
542	Linear Gate and Stretcher



Pulse Generators and Special Instruments

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439	Digital Current Integrator	12.5

Introduction

Pulse Generators are used with pulse processing systems to simulate the detection of an event in the detector with an electronic pulse. The amplitudes of the pulses from the pulse generator can be normalized so that the pulse-height selector setting corresponds directly with the energy of a simulated event. Thus normalized, the pulse generator becomes a useful tool for setting the discriminator levels in single-channel analyzers, and for other system calibrations. When the pulse generator is connected to both detectors in a coincidence system, it supplies a true coincidence signal that simplifies the adjustment of the system delays required to obtain optimum coincidence resolving times. Pulse generators are also useful in verifying that individual components of a system are operating properly.

A charge terminator and a 100- Ω voltage terminator are provided with each pulse generator. The use of the charge terminator allows the voltage pulse to be converted to a charge pulse for subsequent amplification by a charge-sensitive preamplifier. The use of the voltage terminator allows the voltage pulse to be input directly to other instruments such as amplifiers, discriminators, and ADCs.

The ORTEC Model 419 Pulse Generator has adjustable rise times to simulate the rise time of the detector signal. Pulse generators may be left connected to the system.

The **Digital Current Integrator** was designed to accurately measure dc currents or the average value of pulse currents such as produced by accelerator beams. It digitizes the input current by producing an output pulse for specific values of input charge. When combined with a preset counter, the digital current integrator forms a digital charge integrator. When it is combined with a counter and timer, a digital electrometer is obtained.

419

Precision Pulse Generator

- Simulates detector output signals
- Precision dial may be calibrated to read directly in terms of equivalent energy deposition in semiconductor detectors
- Exponential pulse shape with 5- to 250-ns rise time and 200- or 400- μ s decay time constant
- Line frequency or 70-Hz pulse rate
- Positive or negative polarity
- Direct 0 to 1-V output (0 to 10 V with external reference voltage)
- Attenuated output with 2000:1 attenuation range
- Internal or external reference voltage



The ORTEC Model 419 is a Precision Pulse Generator that simulates the detection of a nuclear particle reaction in a semiconductor or scintillation detector, as well as serving as a specialized pulse generator for use with pulse processing instrumentation. It can be calibrated to read directly in terms of equivalent energy deposition in semiconductors, and the rise time of the pulse may be varied to simulate the collection time constant in the detector.

The pulses are generated with a mercury-wetted relay that can be operated asynchronously from the line frequency for measurement of spectral broadening caused by hum and ripple of the ac line.

A charge terminator and a 100- Ω voltage terminator are provided with this instrument. The use of the charge terminator allows the voltage pulse to be converted to a charge pulse for subsequent amplification by a charge-sensitive preamplifier. The use of the voltage terminator allows the voltage pulse to be input directly to other instruments such as amplifiers, discriminators, and ADCs. A holder is

provided on the rear panel to store the charge terminator when it is not in use.

The Model 419 maintains the selected amplitude through long experiments because of excellent stability against changes in line voltage and ambient temperature.

Using the Internal Reference Voltage, the output peak amplitude can be adjusted from 0 to ± 1 V when both outputs are terminated with 100 Ω loads. The Attenuation Factor affects only the Attenuated Output, and permits reducing the amplitude for driving the input of a high-gain amplifier

An external reference voltage may be used, up to 20 V maximum, to generate arbitrary waveforms, such as a ramp input, to check overall system linearity. The output level is 50% of the input.

Specifications

PERFORMANCE

PULSE AMPLITUDE Output peak adjustable from 0 to ± 1 V. This converts to 0–2 pC, using the charge terminator supplied, and is equivalent to 0–44 MeV referred to a silicon semiconductor detector. Rise time is selected by front-panel switch; fall time is an exponential decay time constant of 200 μ s (terminated) or 400 μ s (unterminated).

TEMPERATURE INSTABILITY $< \pm 0.005\%/^{\circ}\text{C}$ from 0 to 50 $^{\circ}\text{C}$.

LINE VOLTAGE INSTABILITY $< \pm 0.001\%$ per 10% change in power line voltage.

RIPPLE AND NOISE $\leq 0.003\%$ of pulse amplitude.

PULSE REPETITION RATE Either the ac power line frequency, or 70 ± 10 Hz using the internal oscillator.

INTERNAL OSCILLATOR

Temperature Instability $< \pm 0.05\%/^{\circ}\text{C}$, 0 to 50 $^{\circ}\text{C}$.

Time Instability $< \pm 1\%/ \text{day}$.

CONTROLS

PULSE HEIGHT 10-turn potentiometer with a duo-dial adjusts the output pulse amplitudes at both outputs within a total range; the range is a combined function of the reference and the setting of the Normalize control. Linearity $\pm 0.1\%$ of full scale.

NORMALIZE 10-turn potentiometer adjusts the total range for the Pulse Height control when using Ref Voltage Int switch; full-scale range from ± 0.5 V to ± 1 V; linearity, $\pm 0.1\%$ of full scale.

RELAY 3-position slide switch selects the ac power line frequency or the internal 70-Hz oscillator for the output repetition rate, and includes an Off position to set the pulser at standby.

REF VOLTAGE 2-position slide switch selects either the internal reference voltage for a 100% normalized full-scale range of 0 to ± 1 V or the external reference voltage for an output full-scale range and polarity that are determined by the level furnished through the rear-panel BNC connector.

POLARITY 2-position slide switch selects either polarity for the output pulses when using the internal reference.

RISE TIME (nsec) 5-position rotary switch selects the rise-time shaping for the output pulses to simulate various types of detectors; selections are MIN (~ 5 ns), 20, 50, 100, and 250 ns.

ATTENUATION FACTOR 5 toggle switches select a step attenuation for output pulses furnished through the Attenuated Output connector; the factors are 2, 2, 5, 10, and 10. They may be used in any combination to cover a 2000:1 dynamic range using 0.1% tolerance resistors.

INPUT

EXT REF Rear-panel BNC connector accepts an external reference voltage to control the full-scale Pulse Height control range and polarity when the front-panel Ref Voltage switch is set at Ext; maximum, ± 20 V; output full-scale range, 50% of reference level with output terminated in 100Ω .

OUTPUTS

DIRECT Front-panel BNC connector with an adjacent test point furnishes the adjusted and normalized full amplitude output pulses through an output impedance of 100Ω .

ATTENUATED Front-panel BNC connector with an adjacent test point furnishes the same output pulses as above, with amplitudes attenuated by the factor selected with the 5 toggle switches.

PULSE HEIGHT VOLTAGE Two test points on the rear panel permit a dc voltmeter or oscilloscope to monitor the voltage level that is applied to the pulse-forming relay.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 45 mA; -24 V, 25 mA; +12 V, 0 mA; -12 V, 5 mA; 117 V ac, 10 mA.

WEIGHT

Net 2.0 kg (4.5 lb).

Shipping 2.9 kg (6.5 lb).

DIMENSIONS Standard double-width NIM module 6.90 X 22.13 cm (2.70 X 8.714 in.) per DOE/ER-0457T.

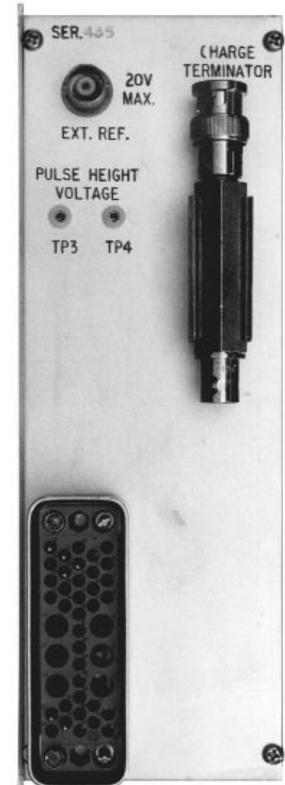
Included Accessories

VOLTAGE TERMINATOR A standard $100\text{-}\Omega$ resistive terminator is attached to the Direct Output connector on the front panel to terminate the output correctly when only the Attenuated Output is being used.

CHARGE TERMINATOR A specially constructed terminator is mounted in a rear-panel clip and should be used to properly terminate the pulser output and feed a charge signal into the signal input of a charge-sensitive preamplifier when the output pulses are being furnished for this type of test.

Ordering Information

Model	Description
419	Precision Pulse Generator



480 Pulser

- Simulates detector output signals
- May be calibrated to read directly in terms of equivalent energy deposition in semiconductor detectors
- Exponential pulse shape with <10-ns rise time and 200- or 400- μ s decay time constant
- Line frequency pulse rate
- Positive or negative polarity
- Direct 0 to 10-V output
- Attenuated output with 1000:1 attenuation range



The ORTEC Model 480 Pulser simulates the output signal from a solid-state or scintillation detector and provides a means of checking electronic instruments in a pulse processing system. It has 1% overall accuracy, good stability as a function of temperature and time, and front-panel controls that allow the instrument to be calibrated to read directly in terms of equivalent energy deposited in a detector. The Model 480 has a stable internal reference voltage that is effectively independent of any modular power supply or ac line voltage changes. Four toggle switches in a pi-attenuator arrangement in the attenuated output line provide a maximum attenuation of 1000:1. The direct output precedes the attenuator switches and provides a means of stable oscilloscope triggering. A charge terminator and a 100- Ω voltage terminator are provided with this instrument. The use of the charge terminator allows the voltage pulse to be converted to a charge pulse for subsequent amplification by a charge-sensitive preamplifier. The use of the voltage terminator allows the voltage pulse to be input directly to other instruments such as amplifiers, discriminators, and ADCs. A holder is provided on the rear panel to store the charge terminator when it is not in use.

The Model 480 Pulser is designed to meet the interchangeability standards of DOE/ER-0457T. An ORTEC NIM bin and power supply provides all necessary power through the rear module connector. All signal levels and impedances are compatible with all other ORTEC NIM-standard modules.

Specifications

PERFORMANCE

TEMPERATURE INSTABILITY $\leq \pm 0.01\%/^{\circ}\text{C}$, 0 to 50 $^{\circ}\text{C}$.

LINE VOLTAGE INSTABILITY $\leq \pm 0.005\%$ per 10% change in line voltage.

RIPPLE AND NOISE 0.003% of pulse amplitude.

NONLINEARITY $\leq \pm 0.25\%$ of full scale.

RISE TIME Exponential waveform, <10 ns (10 to 90%).

FALL TIME Exponential decay with 200- or 400- μ s time constant (depending on whether or not the direct output is terminated).

CONTROLS

CAL 22-turn potentiometer on front panel covers 62:1 amplitude span for normalization of Pulse Height control to read directly in equivalent energy. Adjusts both outputs.

PULSE HEIGHT Front-panel potentiometer controls output pulse height from 0 V to the maximum determined by the Attenuator switches, the Cal control setting, and the termination load. Adjusts the amplitudes of both outputs.

ATTENUATOR Front-panel switches provide step attenuation over 1000:1 range with 1% resistors (X2, X5, X10, X10).

OFF/ON Front-panel slide switch allows internal mercury-wetted relay to be driven from the ac line.

NEG/POS Front-panel slide switch determines polarity of the output signal.

OUTPUTS

ATTEN Front-panel BNC connector provides positive or negative attenuated dc-coupled output with an impedance of 100 Ω . Amount of attenuation is set by the Attenuator switches.

DIRECT Front-panel BNC connector provides positive or negative dc-coupled 0 to 10 V pulse into a high impedance and 0 to 5 V maximum pulse into 100 Ω . This is equivalent to a range of 0 to 220-MeV energy referred to a silicon detector, when used with associated charge terminator.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 60 mA; -24 V, 60 mA; +12 V, 0 mA; -12 V, 0 mA; 117 V ac, 8 mA (used only to drive relay).

WEIGHT

Net 0.9 kg (2.1 lb).

Shipping 1.8 kg (4.1 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Included Accessories

VOLTAGE TERMINATOR A standard 100- Ω resistive terminator is attached to the Direct Output connector on the front panel to terminate the output correctly when only the Attenuated Output is being used.

CHARGE TERMINATOR A specially constructed terminator is mounted in a rear-panel clip and should be used to properly terminate the pulser output and feed a charge signal into the signal input of a charge-sensitive preamplifier when the output pulses are being furnished for this type of test.

Ordering Information

Model	Description
480	Pulser

The ORTEC Model 439 Digital Current Integrator was designed to accurately measure dc currents or the average value of pulse currents such as produced by accelerator beams. It digitizes the input current by producing an output pulse for specific values of input charge. A front-panel switch permit the selection of three different amounts of charge (10^{-10} , 10^{-8} or 10^{-6} coulomb) required to produce an output pulse. The instrument has a digitizing rate from 0 to 10 kHz to provide wide dynamic range on each setting and high-resolution readout without meter interpolation.

The Model 439, when combined with a preset counter, forms a digital charge integrator. When it is combined with a counter and timer, a digital electrometer is obtained.

A front-panel meter is provided to read the input current. Full-scale analog outputs of 1 mA, 100 mV, and 10 mV are provided on rear-panel binding posts. Full-scale readings for the front-panel meter and the analog outputs can be selected in 15 steps from 1×10^{-9} to 1×10^{-2} A. The input is protected from damage by application of a large input charge.

Front- and rear-panel BNC connectors are provided for the application of a Gate signal to inhibit the digitized output. This Gate may be used to remotely control the Model 439 or it may be used to inhibit the digitized output with a multichannel analyzer dead time output signal.

Specifications

PERFORMANCE

LEAKAGE IMPEDANCE FROM INPUT TO GROUND $>1 \times 10^{10} \Omega$.

INPUT LEAKAGE CURRENT $<1 \times 10^{-12}$ A.

TEMPERATURE INSTABILITY $\leq \pm 0.05\%/^{\circ}\text{C}$, 0 to 50°C .

DIGITIZED OUTPUT INACCURACY

Readings from 100 nA to 10 mA dc, $\leq \pm 0.2\%$; for 50 nA, typically $\pm 0.3\%$ (count rate on 10^{-10} coulomb/pulse range limited to 1 kHz).

DIGITIZED REPRODUCIBILITY 0.01%.

ANALOG ACCURACY Front-panel meter 2%; rear-panel binding posts 0.5%.

CONTROLS AND INDICATOR

MULTIPLIER Front-panel switch determines the multiplier to be applied to the Current F.S. reading to produce a full-scale deflection on the Ampere Meter.

CURRENT F.S. AND COUL/PULSE Front-panel switch, controls amount of charge that must be injected at the input to obtain a digital output pulse (low, medium, and high selection for each).

TEST-OPERATE Front-panel 3-position switch controls the function of the Model 439:

Test Internal test current is provided to produce an output of ~ 1000 Hz on all coulomb/pulse ranges.

Standby Grounds the input of the Model 439 preventing application of transients to the input amplifier.

Operate Position in which the Model 439 will normally be used; connects the input amplifier to the front- and rear-panel SHV input connectors.

POLARITY Front-panel switch selects the polarity, Pos or Neg, of the input current to be measured.

BAL/TRIG Front-panel switch used in conjunction with Bal/Trig Meter and Test-Operate switch balances and adjusts the Model 439 input amplifier.

OFFSET/CURRENT Rear-panel potentiometer adjusts the input offset current over a range of $\sim \pm 10$ pA.

INPUTS

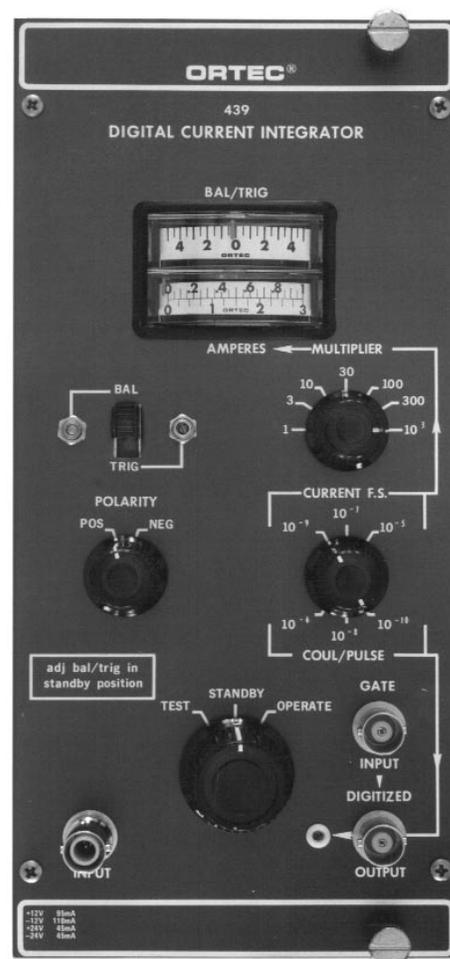
SIGNAL INPUT Through front- and rear-panel SHV connectors.

Impedance Virtually ground with maximum excursion of $< \pm 5$ mV.

Current Polarity Positive or negative.

Current Range 1×10^{-9} to 1×10^{-2} A.

- Measures dc or average value of pulse currents
- Usable as digital current integrator, digital charge integrator, or digital electrometer
- Wide dynamic range
- Input protected to ± 1000 V ($0.01 \mu\text{F}$) or ± 2000 V ($0.001 \mu\text{F}$)



Digital Current Integrator

GATE Signal normally enabled in absence of an input or when the dc value is nominally +6 V; front- and rear-panel BNC connectors.

To Enable Output +3 V or greater.

To Inhibit Output +1.5 V or less (e.g., can be shorted to ground by a relay).

Maximum Input +25 V, -10 V.

Duty Cycle Limitation None, dc-coupled.

Input Impedance >1000 Ω ; driving source must be capable of sinking 1 mA of current from a positive source.

OUTPUTS

DIGITIZED Signal +5 V, 500 ns wide; 0 to 10 kHz; front- and rear-panel BNC connectors.

ANALOG

Front-Panel Meter 0-1 and 0-3 scales serving all multiplier ranges. There are 15 full-scale ranges.

Rear-Panel Binding Posts 0 to 1 mA full scale; 0 to 100 mV full scale; 0 to 10 mV full scale. There are 15 full-scale ranges.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model 439 derives its power from a standard NIM bin/power supply, such as the ORTEC Model 4001A/4002A. Required power is +24 V, 45 mA; -24 V, 45 mA; +12 V, 95 mA; -12 V, 110 mA.

WEIGHT

Net 1.7 kg (3.75 lb).

Shipping 3.06 kg (6.75 lb).

DIMENSIONS NIM-standard triple-width module 10.28 X 22.13 cm (4.05 X 8.714 in.) front panel per DOE/ER-0457T.

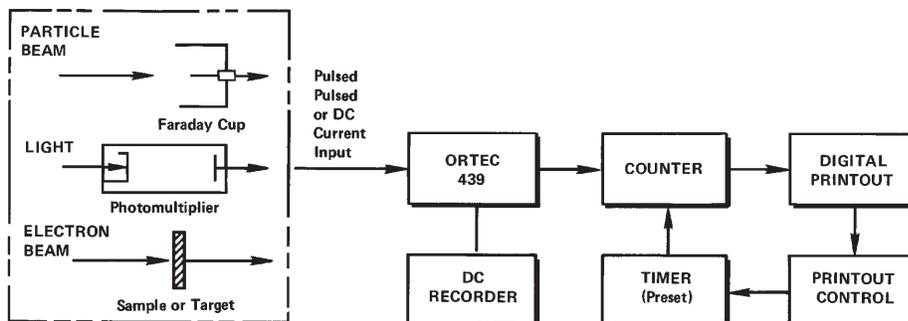
Related Equipment

The Model 439 may be combined with an ORTEC preset counter to form a digital charge integrator or with a counter and timer to form a digital electrometer.

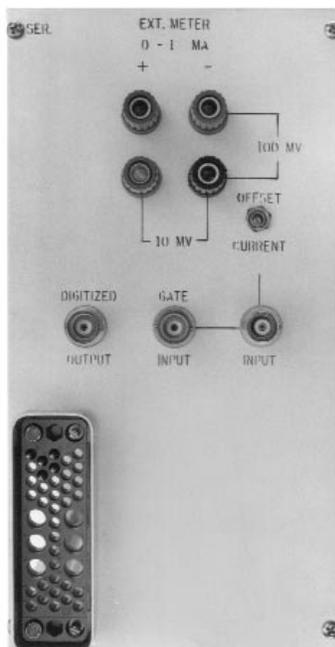
Ordering Information

To order, specify:

Model	Description
439	Digital Current Integrator



Typical Current Digitizing System



HV Bias/ NIM Power Supplies and Bins

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Types of Power Supplies

ORTEC offers two types of power supplies for use with NIM instrumentation: power supplies that provide operating voltages for a detector (more properly called detector bias supplies) and power supplies that provide the necessary operating voltages for electronic instruments.

HV Bias Supplies

Most detectors used with pulse processing instrumentation require a high-voltage bias supply for operation. Care must be taken in the selection of a detector bias supply to ensure that it has sufficient voltage and current ratings for the detector (or detectors) with which it is to be used. The Models 556 and 556H are normally used with photomultiplier tubes, electron multipliers, and similar devices, which require a large amount of current at an extremely stable voltage. The Models 428, 659, 660, and 710 are normally used with semiconductor detectors, which require very little current.

NIM Power Supplies and Bins

ORTEC offers a choice of NIM-standard power supplies and bins to accommodate any instruments manufactured to these standards. All details conform to (and most exceed) the specifications of DOE/ER-0457T. NIM power supplies are available separately or can be combined with an ORTEC NIM bin to form a single operating unit.

All modules built to the NIM-standard are designed to be housed in a NIM bin and receive their power through a standard rear-panel connector. NIM bins are available to accommodate 6 or 12 single-width NIM modules.

NIM Standard

All ORTEC NIM instrumentation conforms to the May 1990 Revision of the NIM standard (formerly TID 20893 (Rev) and NIM/GPIB). Please refer to DOE/ER-0457T, U.S. NIM committee, May 1990; Standard NIM Instrumentation System, NTIS, U.S. Department of Commerce, Springfield, Virginia 22161.

HV Bias/ NIM Power Supplies and Bins

Bias Supply Applications Guide

Detector Type	Model	Function
Electron Multipliers, Microchannel Plates, Photomultiplier Tubes, Microchannel Plate PMTs, Scintillation Detectors, Geiger-Mueller Tubes, Proportional Counters	556/556H	0 to ± 3 kV, 0 to 10 mA
Ionization Chambers	659	0 to ± 5 kV and 0 to ± 500 V, 100 μ A
	660	Dual 0 to ± 5 kV and 0 to ± 500 V, 100 μ A
	710	Quad 0 to ± 1 kV, 20 μ A
	556/556H	0 to ± 3 kV, 0 to 10 mA
Semiconductor Charged-Particle Detectors	428	Dual 0 to ± 1 kV
	710	Quad 0 to ± 1 kV, 20 μ A
Semiconductor Photon Detectors [Ge and Si(Li)]	659	0 to ± 5 kV and 0 to ± 500 V, 100 μ A
	660	Dual 0 to ± 5 kV and 0 to ± 500 V, 100 μ A
Photodiodes	710	Quad 0 to ± 100 V or 0 to ± 1 kV, 20 μ A

NIM Bins and Power Supplies Selection Guide

Model	Function	Module Connectors	Maximum Power (W)	Amperes Available @ Voltage					
				+6	-6	+12	-12	+24	-24
495	Add-On 6 V Power	N/A	36	6 or 6					
4001A	Standard NIM Bin	12	N/A						
4001C	High-Current NIM Bin	12	N/A						
4002A	Bin Power without ± 6 V	N/A	96			2	2	1	1
4002D	Bin Power with ± 6 V	N/A	160	10	10	3	3	1.5	1.5
4002E	Extra-High Bin Power	N/A	300	12	12	4	4	2	2
4002P	Portable Preamp Power	1 (plus 4 to 12 preamps)	48			1	1	0.5	0.5
4003	Preamplifier Power Output	(6 preamps)	N/A						
4006	Minibin and Power Supply	6 (plus 2 preamps)	120 W	4	4	1.5	1.5	0.75	0.75

Detector Bias Supply

The ORTEC Model 428 Detector Bias Supply provides bias voltage of either polarity for two semiconductor detectors, and the current in each detector is externally monitored through jacks on the front panel. The outputs are short-circuit proof, with an impedance of approximately 1.3 MΩ, and each has a range from 0 to 1000 V. These outputs are selected independently by 10-turn direct-reading potentiometers. Constant bias voltage is supplied by high-grade circuits with <0.0002% noise and ripple.

This detector bias supply is compatible with all ORTEC preamplifiers that have provisions for an external detector bias voltage.

Specifications

PERFORMANCE

NOISE AND RIPPLE <0.0002%.

TEMPERATURE INSTABILITY $\leq \pm 0.02\%/^{\circ}\text{C}$, 0 to 50°C.

LINE INSTABILITY Directly proportional to dc power supply instability ($< \pm 0.02\%$ for 105 to 125 V ac when using one of the ORTEC Model 4002 Series Power Supplies).

CONTROLS AND INDICATORS

A/B (0-1000 V) Front-panel 10-turn direct-readout potentiometers for bias control.

POS/OFF/NEG Front-panel switch selects positive or negative outputs for both detectors.

CURRENT MONITOR Front-panel jacks for accommodating external meter in each output circuit.

OUTPUTS

A/B SHV connectors on front panel provide short-circuit-proof outputs for each detector; range 0-1000 V; positive or negative polarity for both detectors; impedance ~1.3 MΩ.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +24 V, 165 mA; -24 V, 165 mA.

WEIGHT

Net 1.82 kg (4.0 lb).

Shipping 3.3 kg (7.25 lb).

DIMENSIONS NIM-standard double-width module 6.90 X 22.13 cm (2.70 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

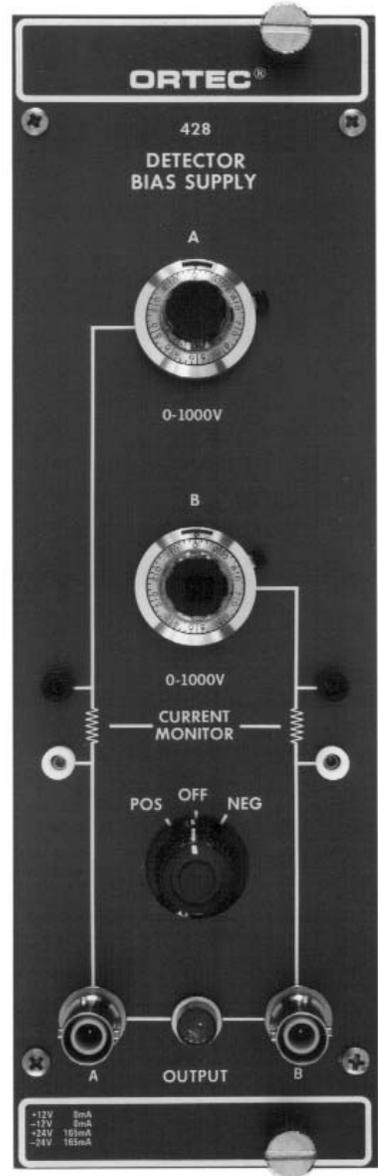
To order, specify:

Model	Description
428	Detector Bias Supply

OPTIONAL CABLE ACCESSORY

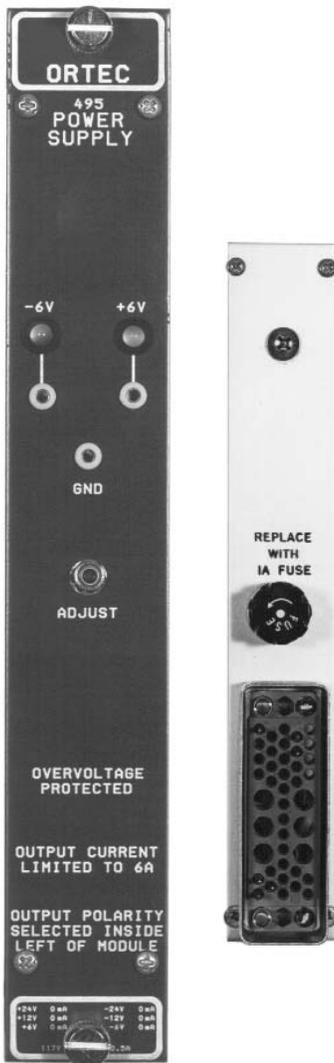
Model	Description
C-36-12	RG-59A/U 75-Ω Cable with two SHV female plugs, 12-ft length

- For use with silicon surface barrier detectors
- 0 to ±1 kV
- Two individually adjustable outputs
- 1.3 MΩ output impedance
- Current monitoring capability
- Precision dials



495 Power Supply

- Adds +6 V or –6 V to existing NIM bin
- 6-A output
- Adjustable from 5 to 6 volts
- Over-voltage crowbar protection
- Foldback current limiting



The ORTEC Model 495 Power Supply is a single-width NIM module that adds 6 V to existing NIM-bin/power supply combinations. The Model 495 takes power from the 117 V ac bus on the bin and energizes either the +6 V or –6 V bus, depending on the internal polarity selection. Front-panel LEDs indicate which output polarity is active. The Model 495 is factory shipped in the +6 V output condition. In the event the Model 495 is inserted into a bin that already has ± 6 V outputs, no damage will occur to any instrument. The Model 495 will indicate the presence of both outputs on the front panel.

Designed for reliable service life, the Model 495 uses only high-quality components. State-of-the-art switching conversion circuits give the Model 495 high efficiency and cool operating temperatures, and the input and output circuits are filtered for very low noise.

Protection circuits include an input line fuse and filter, an output over-voltage crowbar, and foldback current limiting. Polarity selection is accomplished by printed wiring board (PWB) jumpers without the need for special keys or tools.

Specifications

PERFORMANCE

INPUT 103–130 V ac, 47–63 Hz, 0.95 A maximum input current for 6-A output current. (NOTE: Maximum input current may exceed the capacity of some NIM bin power supplies, necessitating operation at reduced output current.)

OUTPUTS +6 V or –6 V (adjustable from 5 to 6 V) at 0–6 A (polarity PWB selectable).

REGULATION AND INSTABILITY $\leq \pm 0.1\%$ for specified line and load ranges.

OPERATING TEMPERATURE RANGE 0 to +60°C.

TEMPERATURE COEFFICIENT ± 200 ppm/°C maximum.

NOISE AND RIPPLE <30 mV peak-to-peak at 20-MHz bandwidth.

OUTPUT IMPEDANCE $< 0.12 \Omega$ for $f < 100$ kHz.

RECOVERY TIME <2 ms to within $\pm 1\%$ after full-load to no-load, or vice versa.

TURN-ON, TURN-OFF TRANSIENTS <5% of nominal output.

PROTECTION

Over-Voltage Accomplished with latching crowbar set to $6.8 \text{ V} \pm 0.5 \text{ V}$.

Short-Circuit and Overload Accomplished with automatic recovery after fault removal. Also included are Fused Input and Input Line Filter protection.

MECHANICAL

WEIGHT

Net 1.2 kg (2.7 lb).

Shipping 2.7 kg (6.1 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
495	Power Supply

556 and 556H High-Voltage Power Supply

The ORTEC Models 556 and 556H High-Voltage Power Supplies provide the noise-free, well-regulated, very stable high voltage necessary for proper operation of photomultipliers, ionization chambers, semiconductor detectors, electron multipliers, and many other devices. The Model 556 is housed in a double-width NIM module (per DOE/ER-0457T). The Model 556H is a stand-alone instrument designed for bench-top operation. The low-noise output is continuously adjustable from ± 10 to ± 3000 V dc with 0 to 10 mA load current. Noise on the output is <10 mV peak-to-peak, thereby ensuring the highest performance in high-resolution, semiconductor or scintillation spectroscopy systems.

The front-panel digital meter allows visual monitoring of either the output voltage or the output current.

The output voltage can be controlled from ± 10 to ± 3000 V by application of an external input voltage of 0 to ± 6.9 V dc. This feature is desirable for control applications and is standard on all units.

The input power for Models 556 and 556H is taken directly from the ac line, either 115 or 230 V ac, 47 to 63 Hz.

Overload and short-circuit protection networks permit operation into short circuits without damage to the instrument.

Specifications

PERFORMANCE

OUTPUT POLARITY Positive or negative, selected by switch on rear panel.

OUTPUT RANGE 50 to 3000 V; minimum usable voltage 10 V.

OUTPUT LOAD CAPACITY 0 to 10 mA.

REGULATION $\leq 0.0025\%$ variation in output voltage for combined line and load variations within operating range at constant ambient temperature.

TEMPERATURE INSTABILITY $< \pm 50$ ppm/ $^{\circ}\text{C}$ after 30-minute warmup; operating range 0 to 50°C .

LONG-TERM DRIFT $< 0.01\%$ /hour and $< 0.03\%$ /24-hour variation in output voltage at constant input line voltage, load, and ambient temperature after 30-minute warmup.

OUTPUT RIPPLE < 10 mV peak-to-peak, 20 Hz to 20 MHz.

OVERLOAD PROTECTION Internal circuitry protects against overloads including short circuits.

RESETTABILITY Output voltage can be reset to within 0.1%.

CONTROLS

POWER Front-panel toggle switch energizes unit when power cord is connected to appropriate source, and an adjacent red LED lamp indicates when power is applied.

OUTPUT VOLTAGE One 6-position switch, one 5-position switch, and one 10-turn precision potentiometer; output voltage is the sum of the 3 settings.

METER Front-panel toggle switch selects display of output voltage in V or load current in mA.

POLARITY Rear-panel switch selects either positive or negative output polarity.

CONTROL Rear-panel locking toggle switch selects the reference source for the output voltage.

INT Selects the internal reference source; the front-panel controls select the output voltage.

EXT Selects the external reference source; output voltage is proportional to magnitude of reference input.

AC VOLTAGE Rear-panel slide switch selects either 115 V or 230 V ac input voltage.

INPUTS

AC POWER 103–129 V or 206–258 V, 47–63 Hz, 70 W nominal at full output power; supplied through international standard IEC power connector on rear panel. Fuse rating: 1.5 A, 250 V fuse for 115 V ac operation or 0.75 A, 250 V fuse for 230 V ac operation.

EXTERNAL CONTROL Full range of output voltage can be based on an external dc

• For use with photomultiplier tubes, microchannel plates, proportional counters, and Geiger-Mueller tubes

• 0 to ± 3 kV

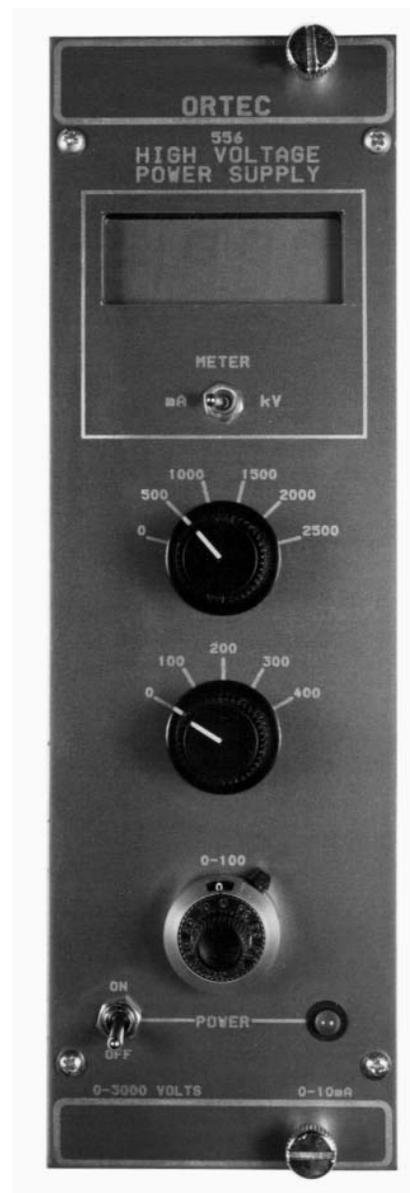
• 0 to 10 mA

• Digital meter reads output voltage or current

• Overload and short-circuited protected

• External control of output voltage

• 115 or 230 V ac, 47 to 63 Hz input power



556 and 556H High-Voltage Power Supply

reference level furnished through a rear-panel BNC connector; control voltage range is 0 through ± 6.9 V dc; control voltage polarity must be the same polarity as that selected by the rear-panel Polarity switch; this input protected against over-voltages $>\pm 7$ V. Input impedance >45 k Ω .

OUTPUTS

REGULATED DC OUTPUT The adjusted and regulated voltage, with selected polarity, is furnished simultaneously to the two SHV connectors on the rear panel.

INDICATOR

METER Front-panel LCD display indicates output voltage in kV ± 10 V or load current in mA ± 10 μ A. Load current is sum of external load current and internal load current. Internal load resistance is ~ 5 M Ω .

ELECTRICAL AND MECHANICAL

POWER REQUIREMENTS 115 or 230 V ac, 47–63 Hz, 70 W nominally at maximum output load.

WEIGHTS

Net

556 3.6 kg (8.0 lb).

556H 5.7 kg (12.6 lb).

Shipping

556 4.5 kg (10.0 lb).

556H 6.6 kg (14.6 lb).

DIMENSIONS

556 Standard double-width NIM module, 6.90 X 22.13 cm (2.70 X 8.714 in.).

556H 11.43 X 22.35 X 29.21 cm (4.5 X 8.8 X 11.5 in.).

Ordering Information

To order, specify:

Model	Description
556	High-Voltage Power Supply
556H	High-Voltage Power Supply

OPTIONAL CABLE ACCESSORIES

Model	Description
C-34-12	RG-59A/U 75- Ω Cable with one SHV female plug and one MHV male plug, 12-ft length
C-36-12	RG-59A/U 75- Ω Cable with two SHV female plugs, 12-ft length



556H "Bench-Top" High-Voltage Power Supply.



5-kV Detector Bias Supply

The ORTEC Model 659 5-kV Detector Bias Supply furnishes bias voltage for germanium detectors, silicon detectors, or ionization chambers. It can be used with any detector that draws less than 100 μA of current, and whose gain is insensitive to the applied voltage. The output voltage is continuously adjustable from zero to full scale with a calibrated and locking 5-turn dial. Separate outputs are provided for the 0–5 kV and the 0–500 V ranges. A 10-segment bargraph indicator verifies that the selected voltage is being supplied at the output.

Security against accidentally changing the output polarity to the wrong state is ensured by two features. The selected output polarity is indicated by front-panel LEDs whenever the NIM bin power is turned on. Thus, the correct polarity can be verified before the HV ON/OFF switch is used to turn on the bias voltage to the detector. In addition, the side panel must be removed in order to alter the output polarity. This discourages unintentional changes.

The Model 659 includes a remote shutdown feature to protect the preamplifier FET against damage when a cooled germanium or Si(Li) detector warms up. A BIAS SHUTDOWN input that is compatible with the standard warmup sensor output on ORTEC preamplifiers is provided. When the preamplifier signals a warmup condition, the Model 659 shuts off the bias voltage and turns on a SHUT-DOWN indicator light. The bias voltage remains off, independent of the signal from the preamplifier warmup sensor, until the shutdown mode is manually cancelled by pressing the RESET pushbutton. This protects the preamplifier FET if the detector is cooling down with the HV ON/OFF switch accidentally left on. For further protection against operator error in the ORTEC shutdown mode, the bias shutdown input interprets a disconnected cable or a shorted cable as a warm detector, and responds by turning off the bias voltage. Some detector manufacturers provide a TTL logic level output from their detector warmup sensor. A board-mounted jumper in the Model 659 can be moved

- Bias voltage for germanium and silicon detectors
- 0–5 kV or 0–500 V at 0–100 μA
- Remote shutdown feature compatible with ORTEC and TTL outputs from warmup sensors on germanium detectors
- Reset safety feature on remote shutdown minimizes risk of preamplifier FET damage
- Selected output polarity indicated before bias voltage is turned on
- Automatic overload protection and overload indicator

to the TTL position to make the bias shutdown input compatible with detectors supplying a TTL output. It is also possible to disable the bias shutdown feature by moving the board jumper to the BYPASS position. The Model 659 is shipped from the factory in the ORTEC mode.

Both high voltage outputs are protected against overload. When the bias supply senses an excessive output current demand, it turns on the overload light and reduces the output voltage until the output current is within tolerable limits. Recovery from overload is automatic when the excessive current demand is eliminated.

Specifications

PERFORMANCE

BIAS VOLTAGE RANGES 0–5 kV, or 0–500 V, on separate outputs, with each output controlled by a common, 5-turn, direct-reading, precision potentiometer located on the front panel.

BIAS VOLTAGE POLARITY Positive or negative. Internally selectable. Polarity indicated by front-panel LEDs whenever bin power is on.

RATED OUTPUT CURRENT 0–100 μA .

OUTPUT LINEARITY Within $\pm 3\%$ of dial setting from 10% to 100% of full range.

TEMPERATURE SENSITIVITY OF OUTPUT VOLTAGE $< \pm 0.08\%/^{\circ}\text{C}$ through 10° to 50°C operating range.

VOLTAGE STABILITY $< \pm 0.1\%/h$ variation in output voltage with constant temperature, constant load, and constant input voltages from the bin supply.

NOISE AND RIPPLE < 10 mV peak-to-peak from 5 Hz to 50 MHz.

OUTPUT VOLTAGE RISE TIME Nominally 500 ms.



5-kV Detector Bias Supply

INDICATORS

0 kV–5 kV Front-panel, 10-segment, bargraph display indicates actual output voltage at the 0–5 kV output. Each segment corresponds to a 0.5-kV increment in output voltage, starting with 0.5 kV to turn on the first segment, and ending with 5 kV to turn on the tenth segment.

POS Front-panel LED is lit when the bin power is on, if the positive output polarity has been selected.

NEG Front-panel LED is lit when the bin power is on, if the negative output polarity has been selected.

ON Front-panel LED indicates when the output bias voltage is turned on. This LED turns off when the HV ON/OFF switch is turned off, the bin power is off, or the shutdown mode has been activated.

OVERLOAD Front-panel LED turns on when the bias supply senses an excessive output current demanded by the external load. Under overload, the output voltage is reduced automatically until the output current is within a tolerable limit. Recovery from overload is automatic when the overload is eliminated.

SHUTDOWN Front-panel LED turns on when the shutdown mode has been activated to turn off the output voltage. The shutdown mode is activated by the appropriate signal level on the rear-panel, BIAS SHUTDOWN input, or whenever the bin power is turned off and on.

CONTROLS

0–5 kV Front-panel, 5-turn, direct-reading, locking potentiometer with 500 dial divisions adjusts the output voltages simultaneously for the 0–500 V and the 0–5 kV outputs.

HV ON/OFF Front-panel toggle switch turns the 0–500 V and the 0–5 kV outputs on or off. For added safety, the RESET push button must be pressed after turning the HV ON/OFF switch to the ON position, in order to turn on the output voltage. The output voltage will not turn on if a shutdown condition is present at the BIAS SHUTDOWN input.

RESET Pressing this front-panel push-button switch enables the high voltage to turn on after the bin power has been turned on, the HV ON/OFF switch has been turned on, or the supply has been disabled by the BIAS SHUTDOWN input. If a shutdown condition is still present at the BIAS SHUTDOWN input, the RESET button will be ineffective.

ORTEC/TTL/BYPASS Internal printed wiring board jumper selects the operating mode of the BIAS SHUTDOWN input for compatibility with the warmup sensor in the associated Ge detector. The ORTEC position is used for ORTEC detectors. The TTL position is for detectors employing TTL levels. The BYPASS position disables the BIAS SHUTDOWN input, but does not alter the function of the RESET button. The Model 659 is shipped with this jumper in the ORTEC mode.

OUTPUT VOLTAGE POLARITY The output polarity is changed between positive and negative by changing the position of a daughter board in the module.

INPUTS

BIAS SHUTDOWN INPUT Rear-panel BNC connector accepts signals from warmup sensors in cooled germanium detectors. When a warmup is signaled, this input turns off the detector bias voltage in order to protect the preamplifier FET input. The ORTEC/TTL/BYPASS jumper selects the operating mode of the BIAS SHUTDOWN input for compatibility with the warmup sensor in the associated Ge detector.

ORTEC Mode The input is compatible with the warmup sensor output on ORTEC germanium detectors. For added safety, an open or shorted coaxial cable on the BIAS SHUTDOWN input will also cause the supply to shut down.

TTL Mode A source supplying $>+2$ V or an open circuit will allow the Model 659 to produce the full output voltage. A source supplying $<+0.8$ V and capable of sinking 700 μ A will shut down the high voltage output.

BYPASS Mode The BIAS SHUTDOWN input is rendered inactive, and cannot trigger a bias shutdown.

OUTPUTS

0–5 kV Rear-panel SHV connector furnishes the adjusted output voltage in the 0 to 5 kV range through an output impedance of approximately 2 M Ω . A voltage foldback circuit protects the output against demands for excessive output current. Recovery from overload is automatic when the overload is eliminated.

0–500 V Rear-panel SHV connector furnishes the adjusted output voltage in the 0 to 500 V range through an output impedance of approximately 700 k Ω . A voltage foldback circuit protects the output against demands for excessive output current. Recovery from overload is automatic when the overload is eliminated.

ELECTRICAL AND MECHANICAL

POWER REQUIREMENTS The Model 659 derives its power from a NIM bin power supply. Required dc voltages and currents are +24 V, 80 mA; +12 V, 80 mA; –24 V, 35 mA; and –12 V, 65 mA.

WEIGHT

Net 0.68 kg (1.5 lb).

Shipping 1.1 kg (2.5 lb).

DIMENSIONS Standard single-width NIM module, 3.43 X 22.13 cm (1.35 x 8.714 in.) front panel per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
659	5-kV Detector Bias Supply

OPTIONAL CABLE ACCESSORIES

Model	Description
C-24-12	RG-62A/U 93- Ω Cable with two BNC male plugs; 12-ft length
C-36-12	RG-59A/U 75- Ω Cable with two SHV female plugs; 12-ft length



Dual 5-kV Detector Bias Supply

The ORTEC Model 660 Dual 5-kV Detector Bias Supply contains two independently adjustable power supplies for furnishing the bias voltage to germanium detectors, silicon detectors, or ionization chambers. It can be used with any detector that draws less than 100 μA of current, and whose gain is insensitive to the applied voltage. The output voltages are continuously adjustable from zero to full scale with calibrated and locking 5-turn dials. Each supply provides two outputs controlled by the same dial: a 0 to 5 kV output, and a 0 to 500 V output. Two 10-segment bar-graph indicators verify that the selected voltages are being supplied at the outputs.

Security against accidentally changing the output polarity to the wrong state is ensured by two features. The selected output polarity for each supply is indicated by front-panel LEDs whenever the NIM bin power is turned on. Thus, the correct polarity can be verified before the HV ON/OFF switch is used to turn on the bias voltage to the detector. In addition, the side panel must be removed in order to alter the output polarity. This discourages unintentional changes.

The Model 660 includes a remote shutdown feature to protect the preamplifier FET against damage when a cooled germanium or Si(Li) detector warms up. Each supply includes a BIAS SHUTDOWN input that is compatible with the standard warmup sensor output on ORTEC preamplifiers. When the preamplifier signals a warmup condition, the Model 660 shuts off the bias voltage to that detector, and turns on a SHUTDOWN indicator light. The bias voltage remains off, independent of the signal from the preamplifier warmup sensor, until the shutdown mode is manually cancelled by pressing the RESET push button. This protects the preamplifier FET if the detector is cooling down with the HV ON/OFF switch accidentally left on. For further protection against operator error in the ORTEC shutdown mode, the bias shutdown input interprets a disconnected cable or a shorted cable as a warm

- **Two independent bias supplies in a single module for germanium and silicon detectors**
- **0–5 kV or 0–500 V at 0–100 μA**
- **Remote shutdown feature compatible with ORTEC and TTL outputs from warmup sensors on germanium detectors**
- **Reset safety feature on remote shutdown minimizes risk of preamplifier FET damage**
- **Selected output polarity indicated before bias voltage is turned on**
- **Automatic overload protection and overload indicator**

detector, and responds by turning off the bias voltage. Some detector manufacturers provide a TTL logic level output from their detector warmup sensor. A board-mounted jumper in the Model 660 can be moved to the TTL position to make the bias shutdown input compatible with detectors supplying a TTL output. It is also possible to disable the bias shutdown feature by moving the board jumper to the BYPASS position. The Model 660 is shipped from the factory with both supplies set to the ORTEC mode.

The high voltage outputs are protected against overload. When the bias supply senses an excessive output current demand, it turns on the overload light and reduces the output voltage until the output current is within tolerable limits. Recovery from overload is automatic when the excessive current demand is eliminated.

Specifications

Channels A and B are independent supplies. The specifications listed below apply to either channel.

PERFORMANCE

BIAS VOLTAGE RANGES 0–5 kV, or 0–500 V, on separate outputs, with each output controlled by a common, 5-turn, direct-reading, precision potentiometer located on the front panel.

BIAS VOLTAGE POLARITY Positive or negative. Internally selectable. Polarity indicated by front-panel LEDs whenever bin power is on.

RATED OUTPUT CURRENT 0–100 μA .

OUTPUT LINEARITY Within $\pm 3\%$ of dial setting from 10% to 100% of full range.



Dual 5-kV Detector Bias Supply

TEMPERATURE SENSITIVITY OF OUTPUT VOLTAGE $\leq \pm 0.08\%/^{\circ}\text{C}$ through the 10 to 50°C operating range.

VOLTAGE STABILITY $\leq \pm 0.1\%/h$ variation in output voltage with constant temperature, constant load, and constant input voltages from the bin supply.

NOISE AND RIPPLE < 10 mV peak-to-peak from 5 Hz to 50 MHz.

OUTPUT VOLTAGE RISE TIME Nominally 500 ms.

INDICATORS

0 kV–5 kV Front-panel, 10-segment, bargraph display indicates actual output voltage at the 0–5 kV output. Each segment corresponds to a 0.5-kV increment in output voltage, starting with 0.5 kV to turn on the first segment, and ending with 5 kV to turn on the tenth segment.

POS Front-panel LED is lit when the bin power is on, if the positive output polarity has been selected.

NEG Front-panel LED is lit when the bin power is on, if the negative output polarity has been selected.

ON Front-panel LED indicates when the output bias voltage is turned on. This LED turns off when the HV ON/OFF switch is turned off, the bin power is off, or the shutdown mode has been activated.

OVERLOAD Front-panel LED turns on when the bias supply senses an excessive output current demanded by the external load. Under overload, the output voltage is reduced automatically until the output current is within tolerable limits. Recovery from overload is automatic when the overload is eliminated.

SHUTDOWN Front-panel LED turns on when the shutdown mode has been activated to turn off the output voltage. The shutdown mode is activated by the appropriate signal level on the rear-panel, BIAS SHUTDOWN input, or whenever the bin power is turned off and on.

CONTROLS

0–5 kV Front-panel, 5-turn, direct-reading, locking potentiometer with 500 dial divisions adjusts the output voltages simultaneously for the 0–500 V and the 0–5 kV outputs.

HV ON/OFF Front-panel toggle switch turns the 0–500 V and the 0–5 kV outputs on or off. For added safety, the RESET push button must be pressed after turning the HV ON/OFF switch to the ON position, in order to turn on the output voltage. The output voltage will not turn on if a shutdown condition is present at the BIAS SHUTDOWN input.

RESET Pressing this front-panel push-button switch enables the high voltage to turn on after the bin power has been turned on, the HV ON/OFF switch has been turned on, or

the supply has been disabled by the BIAS SHUTDOWN input. If a shutdown condition is still present at the BIAS SHUTDOWN input, the RESET button will be ineffective.

ORTEC/TTL/BYPASS Internal printed wiring board jumper selects the operating mode of the BIAS SHUTDOWN input for compatibility with the warmup sensor in the associated Ge detector. The ORTEC position is used for ORTEC detectors. The TTL position is for detectors employing TTL levels. The BYPASS position disables the BIAS SHUTDOWN input, but does not alter the function of the RESET button. The Model 660 is shipped with this jumper in the ORTEC mode.

OUTPUT VOLTAGE POLARITY The output polarity is changed between positive and negative by changing the position of a daughter board in the module.

INPUTS

BIAS SHUTDOWN INPUT Rear-panel BNC connector accepts signals from warmup sensors in cooled germanium detectors. When a warmup is signalled, this input turns off the detector bias voltage in order to protect the preamplifier FET input. The ORTEC/TTL/BYPASS jumper selects the operating mode of the BIAS SHUTDOWN input for compatibility with the warmup sensor in the associated Ge detector.

ORTEC Mode The input is compatible with the warmup sensor output on ORTEC germanium detectors. For added safety, an open or shorted coaxial cable on the BIAS SHUTDOWN input will also cause the supply to shut down.

TTL Mode A source supplying $> +2$ V or an open circuit will allow the Model 660 to produce the full output voltage. A source supplying $< +0.8$ V and capable of sinking 700 μA will shut down the high voltage output.

BYPASS MODE The BIAS SHUTDOWN input is rendered inactive, and cannot trigger a bias shutdown.

OUTPUTS

0–5 kV Rear-panel SHV connector furnishes the adjusted output voltage in the 0 to 5-kV range through an output impedance of approximately 2 M Ω . A voltage foldback circuit protects the output against demands for excessive output current. Recovery from overload is automatic when the overload is eliminated.

0–500 V Rear-panel SHV connector furnishes the adjusted output voltage in the 0 to 500-V range through an output impedance of approximately 700 k Ω . A voltage foldback circuit protects the output against demands for excessive output current. Recovery from overload is automatic when the overload is eliminated.

ELECTRICAL AND MECHANICAL

POWER REQUIREMENTS The Model 660 derives its power from a NIM bin power supply. Required dc voltages and currents are: +24 V at 135 mA, +12 V at 150 mA, –12 V at 100 mA, –24 V at 75 mA.

WEIGHT

Net 0.90 kg (2.0 lb).

Shipping 1.4 kg (3.0 lb).

DIMENSIONS Standard single-width NIM module, 3.43 X 22.13 cm (1.35 X 8.714 in.) front panel per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
660	5-kV Detector Bias Supply

OPTIONAL CABLE ACCESSORIES

Model	Description
C-24-12	RG-62A/U 93- Ω Cable with two BNC male plugs; 12-ft length
C-36-12	RG-59A/U 75- Ω Cable with two SHV female plugs; 12-ft length



710 Quad 1-kV Bias Supply

The Model 710 Quad 1-kV Bias Supply contains four high-voltage power supplies that have independently selectable output voltages and polarities. Each supply can deliver an output voltage that is continuously adjustable over the range from 0 to ± 100 V or from 0 to ± 1 kV, with a maximum output current of $20 \mu\text{A}$. The Model 710 is ideal for providing the bias voltage for solid-state, charged-particle detectors. It can also be used with ionization chambers and proportional counters that operate within the range of voltage and current delivered by the Model 710.

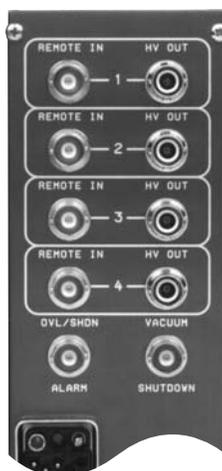
On each supply, a 10-turn, locking dial adjusts the output voltage with a control resolution of 0.05% of full scale. Feedback regulation ensures an output voltage accuracy within $\pm 0.25\%$ of full scale. The output voltage or output current of any of the four supplies can be selected for monitoring on the 3-1/2-digit LED display. This is useful when initially determining the correct bias voltage for a solid-state detector. Detector bias currents from 0.01 to $19.99 \mu\text{A}$ can be measured with a $0.01\text{-}\mu\text{A}$ resolution.

On each supply, a three-position, locking toggle switch selects the 1-kV or the 100-V range of output voltage, or disables operation of that supply. The outputs of all active supplies are also controlled by the MASTER ON/OFF switch. A red LED on each supply indicates when its bias voltage is turned on.

Several features are incorporated to protect the detectors served by the Model 710, and to ensure the integrity of the data they are collecting. Green LEDs indicate the polarity of the output voltage for each supply whenever the bias power is on, and the output polarity selection jumpers are mounted on the printed circuit board. If the detector current exceeds $20 \mu\text{A}$, the bias voltage for that detector turns off, and the yellow overload LED turns on to indicate a shutdown condition. That particular channel remains shut down until the fault is cleared and the OVERLOAD RESET button is pushed. To protect the detectors and their associated preamplifiers against discharges in a

- **Bias voltage for solid-state, charged-particle detectors**
- **Four supplies, with independently selectable polarity and voltage from 0 to ± 100 V and from 0 to ± 1 kV**
- **Automatic shutdown if the detector current exceeds $20 \mu\text{A}$**
- **Detector protection in case of vacuum failure**
- **Alarm output for stopping data collection if a detector or vacuum failure occurs**
- **LED display for convenient digital readout of the current or voltage of any supply**

partial vacuum, the vacuum shutdown feature can be utilized. A relay closure to ground, or a low TTL signal from a trip level on a vacuum gauge can be applied to the VACUUM SHUTDOWN input to turn off all bias supplies in the case of a vacuum failure in the detector vacuum chamber. A yellow, front-panel LED turns on to indicate that the vacuum shutdown has been activated. The rear-panel overload/shutdown alarm output generates a low TTL level whenever an overload or vacuum shutdown has occurred in the Model 710. This output can be connected to a computer, or other suitable alarm, to stop the measurement and prevent the collection of faulty data. The overload/shutdown alarm outputs from a number of Model 710 modules can be connected together to generate a common alarm signal.



710

Quad 1-kV Bias Supply

Specifications

The Model 710 contains four identical bias supplies with independently adjustable voltage and polarity. The specifications apply to each of the four channels unless noted otherwise.

PERFORMANCE

POLARITY Positive or negative polarity, independently selectable for each channel by printed circuit board jumpers.

OUTPUT VOLTAGE RANGE Front-panel switch selectable as 0 to 100 V, or 0 to 1 kV.

OUTPUT CURRENT RANGE Internally limited to 20 μ A on each output.

OUTPUT VOLTAGE ACCURACY $\pm 0.25\%$ of full scale.

VOLTAGE CONTROL RESOLUTION 0.5 V on 1000-V range, 0.05 V on the 100-V range.

OUTPUT VOLTAGE REGULATION $< 0.001\%$ or 1 mV (whichever is greater).

OUTPUT VOLTAGE TEMPERATURE SENSITIVITY < 30 ppm/ $^{\circ}$ C for 0 to 50 $^{\circ}$ C.

OUTPUT VOLTAGE LONG-TERM INSTABILITY $< 0.001\%$ /24 hours.

OUTPUT RIPPLE < 2 mV peak-to-peak, 5 Hz to 100 MHz.

OUTPUT RISE TIME Nominally 100 ms.

DISPLAY RANGES 0 to 100 V in 0.1-V steps on the 100-V range, 0 to 1000 V in 1-V steps on the 1000-V range, and 0 to 19.99 μ A in 0.01- μ A steps for current.

DISPLAY NONLINEARITY $\leq \pm 0.05\%$ of full scale for voltage from 0 to 100 V or from 0 to 1 kV, and current from 0 to 10 μ A.

DISPLAY UNCERTAINTY $\pm 1/2$ least significant digit.

DISPLAY TEMPERATURE SENSITIVITY ≤ 50 ppm/ $^{\circ}$ C for 0 to 50 $^{\circ}$ C.

CONTROLS AND INDICATORS

MASTER ON/OFF (common to all channels) Front-panel, two-position, toggle switch enables or disables all four supplies.

OVERLOAD RESET (common to all channels) Front-panel, momentary, push-button switch that clears the overload shutdown on any channel after a current overload. (See OVL LED.)

VOLTS/CURRENT (common to all channels) Front-panel, eight-position, rotary switch selects the parameter to be read from the display. Either the output voltage or the output current of each of the four supplies can be selected.

DISPLAY (common to all channels) Front-panel, 3-1/2-digit, LED display monitors either the voltage or current of the supply selected by the VOLTS/CURRENT rotary switch.

POLARITY JUMPER (1 per channel) Internal, printed circuit board jumper selects either positive or negative output polarity.

POS/NEG LEDs (2 per channel) Front-panel, green LEDs indicate the polarity of the HV OUTPUT. POS is on for positive, or NEG is on for negative output polarity.

RANGE (1 per channel) Front-panel, three-position, locking toggle switch selects a full-range output voltage of 0 to 100 V or 0 to 1 kV, or disables the output.

ON LED (1 per channel) Front-panel, red LED is on if the supply is enabled and has not experienced a vacuum shutdown or current overload.

VOLTAGE CONTROL (1 per channel) Front-panel, 10-turn, precision potentiometer with locking, graduated dial provides a continuously variable output voltage from 0 to 100 V or from 0 to 1 kV, depending upon the VOLTAGE RANGE setting. (Also see VOLTAGE CONTROL JUMPER.)

VOLTAGE CONTROL JUMPER (1 per channel) Internal, printed circuit board jumper selects either the REMOTE INPUT or the front-panel VOLTAGE CONTROL potentiometer as the source that sets the output voltage. Normally set to the VOLTAGE CONTROL potentiometer position.

OVL LED (1 per channel) Front-panel, yellow LED is on if the supply has been shut down because the current demanded from the HV OUTPUT exceeded 20 μ A. (See OVERLOAD RESET.)

VACUUM SHUTDOWN LED (common to all channels) Front-panel, yellow LED is on if a vacuum shutdown has been triggered. (See VACUUM SHUTDOWN input.)

INPUTS

VACUUM SHUTDOWN (common to all channels) Rear-panel, BNC connector disables all supplies and turns on the VACUUM SHUTDOWN LED if a low TTL signal or a resistance to ground less than 75 Ω is applied. The supplies are enabled and the VACUUM SHUTDOWN LED turns off when a high TTL signal or a resistance to ground greater than 5 k Ω is connected to this input. Used with the trip level on a vacuum gauge to turn off the detector bias voltage when vacuum is lost in the chamber containing the detectors.

REMOTE INPUT (1 per channel) Rear-panel, BNC connector accepts a 0 to +10-V input that controls the output voltage from 0 to full scale. Active only when the REMOTE INPUT is selected by the VOLTAGE CONTROL JUMPER.

OUTPUTS

HV OUTPUT (1 per channel) Rear-panel, SHV connector supplies the 0 to ± 100 V or 0 to ± 1 kV bias voltage output.

OVL/SHDN ALARM (common to all channels) Rear-panel, BNC connector provides an open-collector, active-low, TTL-compatible signal if a vacuum shutdown or an overcurrent shutdown on any of the four channels has occurred. An external pull-up resistor to +5 V is required. OVL/SHDN ALARM outputs from other Model 710 modules can be connected in parallel to produce a common alarm to signal a detector failure or a vacuum failure in the experiment.

ELECTRICAL AND MECHANICAL

POWER REQUIRED The Model 710 derives its power from a NIM bin supplying ± 24 V and ± 12 V, such as the ORTEC Model 4001A/4002A NIM Bin/Power Supply. The power required is +24 V at 90 mA, +12 V at 390 mA, -12 V at 360 mA, and -24 V at 90 mA.

WEIGHT

Net 1.4 kg (3.2 lb).

Shipping 2.9 kg (6.4 lb)

DIMENSIONS Standard double-width NIM module, 6.90 X 22.13 cm (2.70 X 8.714 in.) front panel per DOE/ER-0457T.

Ordering Information

To order, specify:

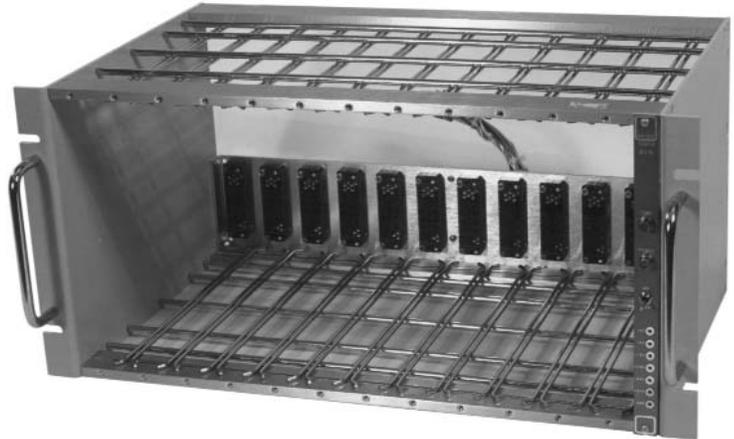
Model	Description
710	Quad 1-kV Bias Supply

OPTIONAL CABLE ACCESSORIES

Model	Description
C-24-12	RG-62A/U 93- Ω Cable with two BNC male plugs; 12-ft length
C-36-12	RG-59A/U 75- Ω Cable with two SHV female plugs; 12-ft length

4001A and 4001C NIM Bins

- Mounting and power distribution for standard NIM modules
- Compatible with 4002A, 4002D, and 4002E NIM Bin Power Supplies
- Adjustment-free bin construction
- Exceeds DOE/ER-0457T recommended specifications
- Low-impedance, bus bar, power distribution with the 4001C



The ORTEC 4001A and 4001C NIM Bins accommodate any equipment modules that have been manufactured to NIM standards as defined in DOE/ER-0457T. The bins are constructed of wire-form grids to ensure unimpeded ventilation for the instruments operated in the enclosure. The adjustment-free module guides are superior to the requirements specified in DOE/ER-0457T. These hardened steel guides feature generous openings and, because of their highly-polished nickel plating, offer a low friction coefficient. Aluminum alloy side plates are precision-formed and protected with a painted finish. Secure mounting for the 4002A, 4002D, or 4002E Power Supplies is furnished by the precision-stamped, plated-steel, connector mounting plate.

The ORTEC 4001A Bin distributes all dc and ac power levels from the power supply to the module connectors through a wiring harness. The 4001C Bin distributes the power through heavy-duty copper bus bars, wire, and a printed wiring board (PWB), ensuring a uniform voltage output to even high-power modules. The 4001C Bin is recommended for use with the higher-current power supplies (the 4002D and 4002E).

The 4001A and 4001C NIM Bins can be ordered as separate bins for use with existing power supplies, or ordered assembled with the appropriate ORTEC NIM bin power supply. See the Ordering Information for details. The NIM bins incorporate the necessary brackets for rack mounting.

Specifications

4001A BIN

MODULE CONNECTORS 12 each as specified by DOE/ER-0457T.

INSTALLED WIRING All connectors wired in parallel for +12 V, -12 V, +24 V, -24 V, +6 V, -6 V, high-quality ground, power-return ground, and 117 V ac, in accordance with DOE/ER-0457T pin assignments. An interface connector is supplied as required by DOE/ER-0457T for connecting control and power supply.

CONTROL PANEL A control panel with On/Off switch, power-indicating lamp, and thermal warning lamp for mating power supply. The thermal warning lamp is illuminated when the operating temperature approaches the design limit. Voltage test points are provided for convenient monitoring of the power supply outputs.

CONSTRUCTION Aluminum alloy side plates with nickel-chromium-plated handles on front-panel mounting flanges. Top and bottom members are high-tensile steel rod weldments, nickel plated, containing module guides. Rear connector plate is steel, cadmium plated.

4001C BIN

MECHANICAL Identical to 4001A Bin.

ELECTRICAL Meets specifications for laminated busses as outlined in DOE/ER-0457T.

4001A and 4001C NIM Bins

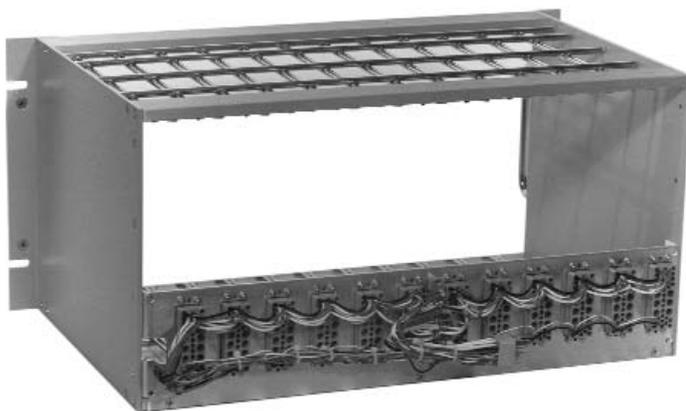
DIMENSIONS AND WEIGHT

Model	Dimensions			Weight (approx.)	
	Height	Width	Depth	Shipping	Net
4001A or 4001C Bin	22.2 cm	48.3 cm	27.3 cm	8.2 kg	5.0 kg
	8-3/4 in.	19 in.	10-3/4 in.	18 lb	11 lb
4001A/4002A Assembled	22.2 cm	48.3 cm	40.6 cm	15.9 kg	11.8 kg
	8-3/4 in.	19 in.	16 in.	34 lb	26 lb
4001A/4002D Assembled	22.2 cm	48.3 cm	54.0 cm	24 kg	16.3 kg
	8-3/4 in.	19 in.	21-1/4 in.	53 lb	36 lb
4001C/4002D Assembled	22.2 cm	48.3 cm	54.0 cm	24 kg	16.3 kg
	8-3/4 in.	19 in.	21-1/4 in.	53 lb	36 lb
4001C/4002E Assembled	22.2 cm	48.3 cm	54.0 cm	26.3 kg	18.6 kg
	8-3/4 in.	19 in.	21-1/4 in.	58 lb	41 lb

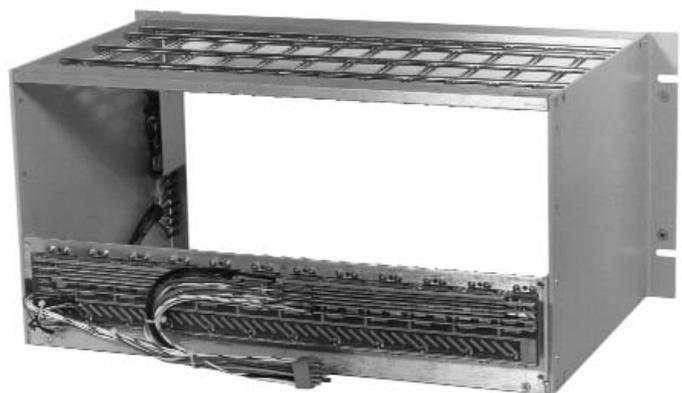
Ordering Information

The 4001A and 4001C NIM Bins may be ordered separately, or assembled with a power supply, using the model numbers shown below.

Model	Description
4001A	NIM Bin
4001C	NIM Bin (with copper bus bars)
4001A/4002A	NIM Bin and 96-W Power Supply (with ± 12 V, ± 24 V)
4001A/4002D	NIM Bin and 160-W Power Supply (with ± 6 V, ± 12 V, ± 24 V)
4001C/4002D	NIM Bin (with copper bus bars) and 160-W Power Supply (with ± 6 V, ± 12 V, ± 24 V)
4001C/4002E	NIM Bin (with copper bus bars) and 300-W BLACK MAX™ Power Supply (with ± 6 V, ± 12 V, ± 24 V)
401-C3	Module Extender Cable, 3-ft length



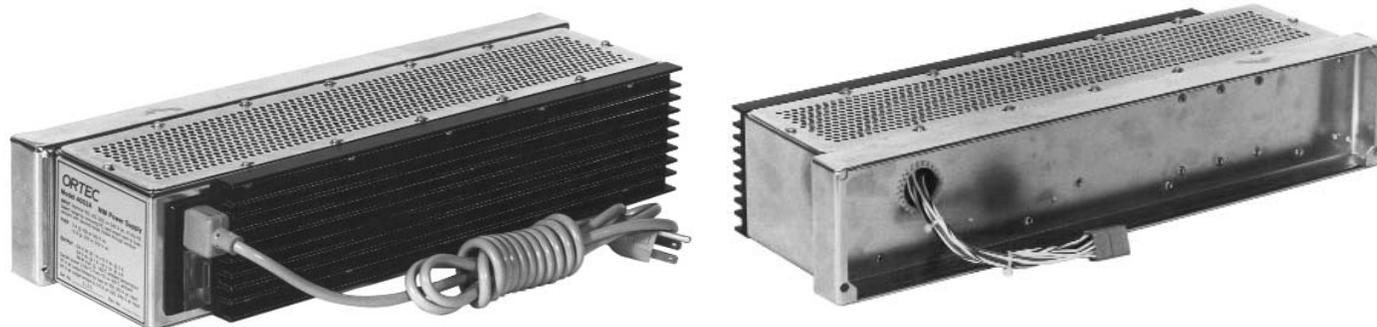
4001A



4001C

4002A 96-W Power Supply for NIM Bins

$\pm 12/\pm 24$ V



- Regulated dc power of ± 12 V @ 2 A, and ± 24 V @ 1.0 A; 117 V ac @ 0.4 A
- 96 W of dc output up to 50°C
- Short-circuit and overload protected
- Operates from 100, 120, 220, or 240 V ac at 47 to 63 Hz
- Attaches to 4001A or 4001C NIM Bins

The ORTEC Model 4002A Power Supply is designed to supply dc power to a NIM bin when the application requires ± 12 V and ± 24 V power. The 4002A Power Supply can be purchased separately for use with existing NIM bins, or it can be ordered attached to either a 4001A NIM Bin or a 4001C NIM Bin. The Model 4002A Power Supply is compatible with all ORTEC NIM bins, and with most standard NIM bins from other manufacturers. The 4002A Power Supply is designed to exceed recommended power supply specifications for Type 1 Class A supplies as defined in DOE/ER-0457T.

Regulated dc power supplied to the attached bin by the 4002A is rated at +12 V @ 2 A, -12 V @ 2 A, +24 V @ 1 A, and -24 V @ 1 A. The maximum output power is 96 W at ambient temperatures up to 50°C. In addition, 117 V ac is available up to 0.43 A.

Protection against overload is provided in several ways. When the heat sink temperature exceeds 82°C, the red warning indicator is illuminated on the attached bin control panel. When the heat sink temperature exceeds 95°C, the power supply is automatically shut down, causing both the power and temperature indicator lights to turn off. Recovery from thermal overload is automatic when the thermal load is reduced. Output currents from the dc supplies are internally limited to 120% of their rated values by foldback circuits. This provides overload and short-circuit protection. Fuses protect the ac inputs to the power supply.

Designed for international use, the 4002A Power Supply can accept input voltages of 100, 120, 220, or 240 V ac at 47–63 Hz. A connector block at the rear of the 4002A is used to select the intended voltage range. The connector block also functions as a fuse holder and

power cord connector. An international standard IEC power connector (CEE-22*) permits power cords and plugs that meet local electrical standards to be used for the input power. Control of the primary power is provided by the On/Off switch on the NIM bin control panel.

Connection of power and control lines to the NIM bin is provided by the standard interface connector specified in DOE/ER-0457T. Mechanical mounting of the power supply to the bin is with bolts utilizing the standard bolt pattern specified in DOE/ER-0457T.

*International Commission on Rules for the Approval of Electrical Equipment, standard number 22.

4002A

96-W Power Supply for NIM Bins

Specifications

INPUT

Nominal Voltage (ac)	Regulation Range (V ac)
100	88–110
120	103–129
220	191–239
240	206–258

Frequency Range 47–63 Hz.

Input Current At 120 V ac is typically 1.8 A rms with a 96-W load (43% efficiency).

DC OUTPUT +12 V at 2 A, –12 V at 2 A, +24 V at 1 A, –24 V at 1 A. Combined maximum output power 96 W at +50°C. Derates to 72 W at +60°C.

117-VOLT AC OUTPUT Limited only by the supply fuse when operating from 100 or 120 V ac. Output is limited to 50 VA at 96-W dc load while operating from 220 or 240 V ac.

REGULATION $\leq \pm 0.05\%$ over combined range of zero to full load and input voltage of 88% to 110% of rated input over any 24-h period at constant ambient temperature after a 60-minute warmup.

INSTABILITY $\leq \pm 0.3\%$ over a 6-month period at constant line, load, and ambient temperature after a 24-h warmup.

OUTPUT IMPEDANCE $< 0.3 \Omega$ at any frequency up to 100 kHz.

TEMPERATURE COEFFICIENT $< 0.01\%/^{\circ}\text{C}$ from 0 to 60°C.

NOISE AND RIPPLE < 3 mV peak-to-peak, as observed on 50-MHz bandwidth oscilloscope.

VOLTAGE ADJUSTMENT $\pm 0.5\%$ minimum range; resetability $\pm 0.05\%$ of supply voltage (typical ± 1 V).

RECOVERY TIME $< 50 \mu\text{s}$ to return to within $\pm 0.1\%$ of rated voltage for any change in rated input voltage and load current from 10% to 100% of full load.

CIRCUIT PROTECTION Input power line fused. Power supply is automatically cut off by an internal switch if the temperature exceeds a maximum safe limit. Output current foldback limiting with automatic recovery when demand is removed.

DIMENSIONS AND WEIGHT

Model	Dimensions			Weight (approx.)	
	Height	Width	Depth	Shipping	Net
4002A Power Supply (with $\pm 12/24$ V)	8.6 cm 3-3/8 in.	42.9 cm 16-7/8 in.	14.0 cm 5-1/2 in.	10.0 kg 22 lb	6.8 kg 15 lb
4001A/4002A (Assembled)	22.2 cm 8-3/4 in.	48.3 cm 19 in.	40.6 cm 16 in.	15.9 kg 34 lb	11.8 kg 26 lb

Ordering Information

The Model 4002A Power Supply may be ordered separately or assembled with a NIM bin, using the model numbers shown below.

Model	Description
4001A/4002A	NIM Bin and 96-W Power Supply (with $\pm 12/24$ V)
4002A	96-W Power Supply (with $\pm 12/24$ V)

4002D 160-W Power Supply for NIM Bins

$\pm 6/\pm 12/\pm 24$ V

The ORTEC Model 4002D Power Supply is designed to supply dc power to a NIM bin when the application requires ± 6 V, ± 12 V, and ± 24 V power. The 4002D Power Supply can be purchased separately for use with existing NIM bins, or it can be ordered attached to either a 4001A NIM Bin or a 4001C NIM Bin. Mounting hardware is supplied to make the Model 4002D compatible with all ORTEC NIM bins. With minor mounting modifications the 4002D can be used with most standard NIM bins. The ORTEC 4001C NIM Bin is recommended for use with Model 4002D because Model 4001C distributes the power with copper bus bars to minimize the voltage drop at each module's power plug. The 4002D Power Supply is designed to exceed recommended power supply specifications for Type V-H supplies as defined in DOE/ER-0457T.

Regulated dc power supplied to the attached bin by Model 4002D is conservatively rated at $+6$ V @ 10 A, -6 V @ 10 A, $+12$ V @ 3 A, -12 V @ 3 A, $+24$ V @ 1.5 A, and -24 V @ 1.5 A. These maximum output currents can be delivered in any combination, provided the total output dc power does not exceed 160 W at ambient temperatures up to 50°C . In addition, 115 V ac is available up to 0.5 A.

Protection against overload is provided in several ways. When the heat sink temperature exceeds 95°C , the red warning indicator is illuminated on the attached bin control panel. When the heat sink temperature exceeds 110°C , the power supply is automatically shut down, causing both the power and temperature indicator lights to turn off. Recovery from thermal overload is automatic when the thermal load is reduced. Output currents from the dc supplies are internally limited to 120% of their rated values by foldback circuits. This provides overload and short-circuit protection. On the $+6$ V and -6 V dc supplies, crowbar circuits limit the output voltage to 7.5 V to protect integrated circuits. Fuses protect the ac inputs to the power supply.

- **Regulated dc power of ± 6 V @ 10 A, ± 12 V @ 3 A, and ± 24 V @ 1.5 A; 115 V ac @ 0.5 A**
- **160 W of dc output up to 50°C**
- **Over-voltage protection to avoid damage to $+5$ -V and -5.2 -V integrated circuits**
- **Short-circuit and overload protected**
- **Operates from 100, 115, 200, or 220 V ac at 47 to 63 Hz**



An external slide switch allows selection of either 115 or 220 V ac as the power input. By changing pins on an internal connector, this selection can be altered to 100 and 200 V ac. An international standard IEC power connector permits the use of power cords and plugs that meet local electrical standards to be used for the input power. Control of the primary power is provided by the On/Off switch on the NIM bin control panel.

Connection of power and control lines to the NIM bin is provided by the standard interface connector specified in DOE/ER-0457T. Mechanical mounting of the power supply to the bin is with brackets utilizing the standard bolt pattern specified in DOE/ER-0457T.

4002D

160-W Power Supply for NIM Bins

Specifications

INPUT 103–129 or 200–258 V ac, 47–63 Hz. An external slide switch selects nominal input voltages of 115 or 220 V ac. Changing pins on an internal connector allows operation at 88–110 V or 191–239 V ac, 47–63 Hz, with the external slide switch selecting nominal voltages of 100 or 200 V ac. Input current at 115 V ac is nominally 4 A for a 160-W dc output simultaneous with a 0.5-A, 115-V ac output. Dual fuse input uses 8-A SB U.S.A. standard fuses for 100 or 115 V ac, 60 Hz and 5-A SB metric fuses for 200 and 220 V ac, 50 Hz operation.

DC OUTPUTS Maximum rated output currents are:

DC Voltage	Maximum Current	DC Voltage	Maximum Current
+6 V	10 A	-6 V	10 A
+12 V	3 A	-12 V	3 A
+24 V	1.5 A	-24 V	1.5 A

Maximum dc output power from 0 to 50°C is 160 W. Derate 3%/°C for 50 to 60°C.

115 V ac OUTPUT Unregulated voltage. Maximum current limited only by the input fuses when operated in the 100- or 115-V ac settings. Limited to 0.5 A on the 200- and 220-V ac settings when the dc load is 160 W. Output voltage is nominally 115 V ac in the 115-V and 220-V input modes. Output voltage is nominally 100 V ac in the 100-V and 200-V input modes.

REGULATION $<\pm 0.1\%$ (typically $\pm 0.05\%$) for ± 12 V and ± 24 V, and $<\pm 0.2\%$ (typically $\pm 0.1\%$) for ± 6 V over the combined range of zero to full load with the specified input voltage range for measurements made within a 1-minute period. Regulation $<\pm 0.3\%$ for ± 12 V and ± 24 V, and $<\pm 0.6\%$ for ± 6 V over any 24-hour period at constant ambient temperature for the same load and input ranges after a 60-minute warmup.

LONG-TERM STABILITY DC output voltages change $<\pm 0.5\%$ (after a 60-minute warmup) over a 6-month period at constant load, line voltage, and ambient temperature.

OUTPUT IMPEDANCE $<0.3 \Omega$ at any frequency up to 100 kHz for the dc outputs.

TEMPERATURE COEFFICIENT $<0.02\%/^{\circ}\text{C}$, 0 to 60°C.

NOISE AND RIPPLE <3 mV peak-to-peak for any output as observed on a 50-MHz bandwidth oscilloscope.

VOLTAGE ADJUSTMENT $\pm 2\%$ minimum range. Resettability $<\pm 0.05\%$ of the supply voltage.

RECOVERY TIME $<100 \mu\text{s}$ to return to within $\pm 0.1\%$ of the rated voltage for all dc outputs for any input voltage change within the rated range or for a change of load current from 10% to 100% of full load.

CIRCUIT PROTECTION Both input power lines include fuses. The power supply is automatically turned off by an internal switch if the temperature of the heat sinks exceeds 110°C. Recovery is automatic when the temperature decreases to a safe value. Provision is made for activating a temperature warning light on the NIM bin control panel to advise that the temperature limit is being approached. This warning occurs at and above a heat sink temperature of 95°C. All dc outputs include a current foldback circuit to limit the output current to nominally 120% of the rated value. This feature provides short-circuit and overload protection. Recovery is automatic after removal of the overload condition. Over-voltage protection for the ± 6 -V outputs prevents these outputs from exceeding ± 7.5 V, respectively, to protect the integrated circuits that are commonly powered by these supply voltages.

WEIGHT

Net 11.3 kg (25 lb).

Shipping 15.9 kg (35 lb).

DIMENSIONS 43.2 cm (17.0 in.) wide, 26.9 cm (10.6 in.) deep, and 8.9 cm (3.5 in.) high.

RECOMMENDATIONS FOR ATTACHED BIN

The 4002D Power Supply is designed to provide high currents to NIM modules that contain heavy loads. The NIM bin used with this power supply must be capable of handling the large currents demanded by those loads. The power On/Off switch mounted on the bin and its associated primary circuit wiring must be rated to handle 5 A. The bin wiring distributing the dc voltages must also have an impedance low enough to yield negligible voltage drops at the rated currents for the supply. The ORTEC Model 4001A NIM Bin will function acceptably with the 4002D Power Supply, but the Model 4001C NIM Bin is recommended as the more desirable choice. The ORTEC Model 4001C NIM Bin employs copper bus bars for power distribution. This typically results in more than a factor of 10 lower voltage drop at maximum current.

Ordering Information

The 4002D Power Supply may be ordered separately or in combination with a NIM bin, using the model numbers shown below.

Model	Description
4002D	160-W Power Supply (with $\pm 6/\pm 12/\pm 24$ V)
4001A/4002D	NIM Bin and 160-W Power Supply (with $\pm 6/\pm 12/\pm 24$ V)
4001C/4002D	NIM Bin (with copper bus bars) and 160-W Power Supply (with $\pm 6/\pm 12/\pm 24$ V)

4002E
BLACK MAX™
Power Supply for NIM Bins

$\pm 6/\pm 12/\pm 24$ V



- Higher power for high-density NIMs
- Regulated dc power of ± 6 V @ 12 A, ± 12 V @ 4 A, and ± 24 V @ 2 A; 115 V ac @ 0.5 A
- 300 W of dc output power from 0 to 50°C
- Over-voltage protection
- Short-circuit and overload protected
- Operates from 100, 115, 200, or 220 V ac at 47 to 63 Hz

The ORTEC Model 4002E BLACK MAX™ Power Supply is designed to supply dc power to a NIM bin when the application demands exceptionally high power. The BLACK MAX power supply can be purchased separately for use with existing NIM bins, or it can be ordered attached to a Model 4001C NIM Bin. Mounting hardware is supplied to make the Model 4002E compatible with all ORTEC NIM bins. With minor mounting modifications the Model 4002E can be used with most standard NIM bins. The ORTEC Model 4001C NIM Bin is strongly recommended for use with the Model 4002E because the Model 4001C distributes the power with copper bus bars to minimize the voltage drop at each module's power plug. The BLACK MAX Power Supply is designed to exceed recommended power supply specifications for Type V-H supplies as defined in DOE/ER-0457T.

Regulated dc power supplied to the attached bin by the BLACK MAX is conservatively rated at $+6$ V @ 12 A, -6 V @ 12 A, $+12$ V @ 4 A, -12 V @ 4 A, $+24$ V @ 2 A, and -24 V @ 2 A, provided the total output dc power does not exceed 300 W at ambient temperatures up to 50°C. In addition, 115 V ac is available up to 0.5 A.

Protection against overload is provided in several ways. When the heat sink temperature exceeds 95°C, the red warning indicator is illuminated on the attached bin control panel. When the heat sink temperature exceeds 110°C, the power supply is automatically shut down, causing both the power and temperature indicator lights to turn off. Recovery from thermal overload is automatic when the thermal load is reduced. Output currents from the dc supplies are internally limited to 120% of their rated values by foldback circuits. This provides overload and short-circuit

protection. On the $+6$ V and -6 V dc supplies, crowbar circuits limit the output voltage to 7.5 V to protect integrated circuits. Fuses protect the ac inputs to the power supply.

An external slide switch allows selection of either 115 or 220 V ac as the power input. By changing pins on an internal connector, this selection can be altered to 100 and 200 V ac. An international standard IEC power connector permits power cords and plugs that meet local electrical standards to be used for the input power. Control of the primary power is provided by the On/Off switch on the NIM bin control panel.

Connection of power and control lines to the NIM bin is provided by the standard interface connector specified in DOE/ER-0457T. Mechanical mounting of the power supply to the NIM bin is with brackets utilizing the standard bolt pattern specified in DOE/ER-0457T.

4002E

BLACK MAX™

Power Supply for NIM Bins

Specifications

INPUT 103–129 or 200–258 V ac, 47–63 Hz. An external slide switch selects nominal input voltages of 115 or 220 V ac. Changing pins on an internal connector allows operation at 88–110 V or 191–239 V ac, 47–63 Hz, with the external slide switch selecting nominal voltages of 100 or 200 V ac. Input current at 115 V ac is nominally 7 A for a 300-W dc output simultaneous with a 0.5-A, 115-V ac output. Dual fuse input uses 8-A SB U.S.A. standard fuses for 100 or 115 V ac, 60 Hz and 5-A SB metric fuses for 200 and 220 V ac, 50 Hz operation.

DC OUTPUTS Maximum rated output currents are:

DC Voltage	Maximum Current	DC Voltage	Maximum Current
+6 V	12 A	-6 V	12 A
+12 V	4 A	-12 V	4 A
+24 V	2 A	-24 V	2 A

Maximum dc output power from 0 to 50°C is 300 W. Derate 3%/°C for 50 to 60°C.

115 V ac OUTPUT Unregulated voltage. Maximum current limited only by the input fuses when operated in the 100- or 115-V ac settings. Limited to 0.5 A on the 200- and 220-V ac settings when the dc load is 300 W. Output voltage is nominally 115 V ac in the 115-V and 220-V input modes. Output voltage is nominally 100 V ac in the 100-V and 200-V input modes.

REGULATION $<\pm 0.1\%$ (typically $\pm 0.05\%$) for ± 12 V and ± 24 V, and $<\pm 0.2\%$ (typically $\pm 0.1\%$) for ± 6 V over the combined range of zero to full load with the specified input voltage range for measurements made within a 1-minute period. Regulation $<\pm 0.3\%$ for ± 12 V and ± 24 V, and $<\pm 0.6\%$ for ± 6 V over any 24-hour period at constant ambient temperature for the same load and input ranges after a 60-minute warmup.

LONG-TERM STABILITY DC output voltages change $<\pm 0.5\%$ (after a 60-minute warmup) over a 6-month period at constant load, line voltage, and ambient temperature.

OUTPUT IMPEDANCE $<0.3 \Omega$ at any frequency up to 100 kHz for the dc outputs.

TEMPERATURE COEFFICIENT $<0.02\%/^{\circ}\text{C}$, 0 to 60°C.

NOISE AND RIPPLE <3 mV peak-to-peak for any output as observed on a 50-MHz bandwidth oscilloscope.

VOLTAGE ADJUSTMENT $\pm 2\%$ minimum range. Resettability $<\pm 0.05\%$ of the supply voltage.

RECOVERY TIME $<100 \mu\text{s}$ to return to within $\pm 0.1\%$ of the rated voltage for all dc outputs for any input voltage change within the rated range or for a change of load current from 10% to 100% of full load.

CIRCUIT PROTECTION Both input power lines include fuses. The power supply is automatically turned off by an internal switch if the temperature of the heat sinks exceeds 110°C. Recovery is automatic when the temperature decreases to a safe value. Provision is made for activating a temperature warning light on the NIM bin control panel to advise that the temperature limit is being approached. This warning occurs at and above a heat sink temperature of 95°C. All dc outputs include a current foldback circuit to limit the output current to nominally 120% of the rated value. This feature provides short-circuit and overload protection. Recovery is automatic after removal of the overload condition. Over-voltage protection for the ± 6 -V outputs prevents these outputs from exceeding ± 7.5 V, respectively, to protect the integrated circuits that are commonly powered by these supply voltages.

WEIGHT 13.6 kg (30 lb) net weight, 18.1 kg (40 lb) shipping weight.

DIMENSIONS 43.2 cm (17.0 in.) wide, 26.9 cm (10.6 in.) deep, and 8.9 cm (3.5 in.) high, except for rear-mounted, 15.2-cm-(6.0-in.-) high heat sink.

REQUIREMENTS FOR ATTACHED BIN

The Model 4002E Power Supply is designed to provide very high currents to NIM modules that contain heavy loads. The NIM bin used with this power supply must be capable of handling the large currents demanded by those loads. The power On/Off switch mounted on the bin and its associated primary circuit wiring must be rated to handle 8 A. ORTEC NIM bins that can handle 8-A primary current have a label inside the bin near the On/Off switch that states "8 A Power Switch." A kit (ORTEC P/N 735110) is available to upgrade older NIM bins to an 8-A power switch. The bin wiring distributing the dc voltages must also have an impedance low enough to yield negligible voltage drops at the rated currents for the supply. Although the ORTEC Model 4001A NIM Bin will function acceptably with the Model 4002E Power Supply, the Model 4001C NIM Bin is strongly recommended as the more desirable choice. The ORTEC Model 4001C NIM Bin employs copper bus bars for power distribution. This typically results in more than a factor of 10 lower voltage drop at maximum current.

Ordering Information

The Model 4002E Power Supply may be ordered separately or in combination with a NIM bin, using the model numbers shown below.

Model	Description
4002E	300-W BLACK MAX Power Supply (with $\pm 6/\pm 12/\pm 24$ V)
4001C/ 4002E	NIM Bin (with copper bus bars) and 300-W BLACK MAX Power Supply (with $\pm 6/\pm 12/\pm 24$ V)
P/N 735110	4001A/C Retrofit Kit, 8-A Switch

4002P Portable Power Supply

$\pm 12/\pm 24$ V



- Power for four preamplifiers and a NIM module in a remote location
- Can power up to 16 preamplifiers using optional power fan-out cables
- Operates from 100, 120, 220, or 240 V ac; 47–63 Hz
- DC outputs: +12 V @ 1 A, -12 V @ 1 A, +24 V @ 0.5 A, -24 V @ 0.5 A
- Compact, portable size: 21.5 X 26 X 10.2 cm

The ORTEC Model 4002P Portable Power Supply is ideally suited for providing power to preamplifiers or NIM modules, in remote locations. It is an effective solution when the additional power, size, or cost of a standard NIM bin is inconvenient.

DC power is provided by the Model 4002P for four preamplifiers through standard 9-pin connectors on the rear panel. These connectors deliver ± 12 and ± 24 V dc, and are compatible with ORTEC standard preamplifier power cables, as well as those of most NIM manufacturers. The Model 4002P can supply power for up to 16 preamplifiers by adding an optional Model 4002P-C1 Preamp Power Fan-Out Cable to each connector. The fan-out cable converts a single preamp power output connector to four separate preamp power output connectors.

A standard NIM bin power connector is incorporated for supplying ± 12 V dc, and ± 24 V dc to a NIM module. Connection between the 4002P and the NIM module is made with the ORTEC Model 401-C3 Module Extender Cable, which can be ordered as an accessory. The output power is sufficient to operate a NIM module and four preamplifiers.

Designed for international use, the 4002P Portable Power Supply can accommodate input voltages of 100, 120, 220, and 240 V ac at 47 to 63 Hz. A connector block on the rear panel is used to change and display the selected input voltage. Also incorporated in this connector block are a fuse holder and the input power cord connector. The 4002P uses an international standard IEC power connector to permit the use of power cords and plugs that meet local electrical standards.

The Model 4002P has maximum output current ratings of 1 A on +12 V, 1 A on -12 V, 0.5 A on +24 V, and 0.5 A on -24 V.

There are three levels of protection against overload. A fuse on the ac power connector limits the input current. All dc outputs include a current foldback circuit to limit the output current to nominally 150% of the rated value. This feature

provides short-circuit and overload protection. Recovery is automatic after removal of the overload condition. Test points are conveniently located on the front panel to allow monitoring the status of the dc outputs. A temperature warning light on the front panel turns on when the heat sink temperature rises above 82°C. When the temperature of the heat sink exceeds 95°C, the power supply is automatically turned off. Recovery is automatic when the load is reduced and the temperature decreases to a safe value.

4002P Portable Power Supply

Specifications

PERFORMANCE

INPUT AC VOLTAGE The primary voltage selection card and indicator located in the AC POWER connector assembly permit operation with 100 V, 120 V, 220 V, or 240 V nominal input voltages. Input voltage ranges accommodated on each setting are:

Nominal Input Voltage Selected (V ac)	Allowed Input Voltage Range (V ac)
100	88–110
120	103–129
220	191–239
240	206–258

FREQUENCY RANGE Operating range for ac input voltage frequency is 47–63 Hz.

INPUT CURRENT Typically 0.8 A rms with a 48-W dc load and a 120-V ac input. Protected with a 2-A fuse on the 100- and 120-V ac settings, and by a 1-A fuse on the 220- and 240-V ac settings.

DC OUTPUTS Maximum rated output currents are:

DC Voltage	Maximum Current
+12 V	1 A
–12 V	1 A
+24 V	0.5 A
–24 V	0.5 A

Maximum dc output power from 0 to 50°C is 48 W. Derate 2.5%/°C for 50 to 60°C.

DC REGULATION Variations in dc output voltages are $\leq \pm 0.1\%$ over the combined range of zero through full load and input voltages from the minimum to maximum limits of the allowed input voltage range. Measurements are made within a 1-minute period. Regulation $\leq \pm 0.3\%$ over any 24-hour period at constant ambient temperature for the same load and input voltage ranges, after a 60-minute warmup.

LONG-TERM STABILITY DC output voltages change $\leq \pm 0.5\%$ (after a 60-minute warmup) over a 6-month period at constant load, input voltage, and ambient temperature.

OUTPUT IMPEDANCE $< 0.3 \Omega$ at any frequency up to 100 kHz for the dc outputs.

TEMPERATURE COEFFICIENT $< 0.02\%/^{\circ}\text{C}$ from 0 to 60°C for the dc outputs.

NOISE AND RIPPLE < 3 mV peak-to-peak for any dc output, as observed on a 50-MHz bandwidth oscilloscope.

VOLTAGE ADJUSTMENT $\pm 5\%$ minimum range. Range typically ± 1 V about the nominal supply voltage. Resettability $\leq \pm 0.05\%$ of the supply voltage.

RECOVERY TIME $< 50 \mu\text{s}$ to return to within $\pm 0.1\%$ of the rated voltage for all dc outputs for any input voltage change within the rated range, or for a change of load current from 10 to 100% of full load.

THERMAL PROTECTION The red, front-panel, TEMP light turns on when the temperature of the side-panel heat sink is within 13°C of the maximum operating temperature limit. When the heat sink temperature exceeds the 95°C maximum limit, a thermal switch automatically turns off the power supply. Under this thermal shut-down condition, both the TEMP and the POWER lights are turned off. Recovery from thermal shut-down is automatic once the load is reduced, so that the heat sink temperature drops below the maximum operating limit.

CIRCUIT PROTECTION The input ac power line is protected with a fuse (2-A fuse for 100- and 120-V ac input power; 1-A fuse for 220- and 240-V ac input power). All dc outputs include a current foldback circuit to limit the output current to nominally 150% of the rated value. This feature provides short-circuit and overload protection. Recovery is automatic after removal of the overload condition.

CONTROLS AND INDICATORS

POWER Front-panel two-position toggle switch turns power on or off. Adjacent red light indicates power On condition when illuminated. Power indicator light and output power turn off if the heat sink temperature exceeds 95°C.

TEMP Front-panel red light turns on when the heat sink temperature exceeds 82°C to warn that the shut-down temperature limit is being approached. TEMP light turns off if power has been shut off by exceeding the heat sink temperature limit.

INPUTS

AC POWER Rear-panel, international standard IEC power connector, type CEE-22, accepts power cables wired according to local electrical standards. A power cable is shipped with the 4002P. The CEE-22 connector meets standard 22 of the International Commission on Rules for the Approval of Electrical Equipment. The primary voltage selection card and the primary fuse are incorporated into the AC POWER connector. The primary voltage selected (100, 120, 220, or 240 V) is visible through the plastic window. U.S.A. standard in-line fuse is 2 A for 100 or 120 V ac, and 1 A for 220 or 240 V ac.

OUTPUTS

PREAMP 1, PREAMP 2, PREAMP 3, PREAMP 4 Rear-panel, 9-pin, "D" connectors (Amphenol 17-10090) provide power for up to four preamplifiers. Connectors mate with power cords on all standard ORTEC preamplifiers. Compatible with preamplifier power cables of most other NIM manufacturers. Pin assignments are listed in Table 1. Each preamp power output connector can be expanded to four output connectors by using the optional Model 4002P-C1 Preamp Power Fan-Out Cable. Using four of the Model 4002P-C1 allows the 4002P to supply power to 16 preamplifiers.

Table 1. Pin Assignments for Preamp Power Connectors.

Pin Number	Power Voltage
1	Ground
2	Ground
3	No connection
4	+12 V
5	No connection
6	–24 V
7	+24 V
8	No connection
9	–12 V

NIM POWER Rear-panel, NIM-standard bin connector compatible with the power connector on the rear of NIM modules, per DOE/ER-0457T. For use with a Module Extender Cable, such as ORTEC Model 401-C3, to power a single NIM module. Pin assignments are listed in Table 2. Pins not listed have no connection in the Model 4002P, but may be assigned to a specific function by DOE/ER-0457T.

OUTPUT TEST POINTS Front-panel jacks provide test points to monitor each of the dc voltages delivered to the rear-panel connectors.

4002P Portable Power Supply

Table 2. Pin Assignments as Wired for the NIM POWER Connector on the Model 4002P.

Pin Number	Power Voltage
16	+12 V
17	-12 V
28	+24 V
29	-24 V
34	Power Return Ground
42	High-Quality Ground

ELECTRICAL AND MECHANICAL

WEIGHT

Net 10.9 kg (24 lb).

Shipping 13 kg (29 lb).

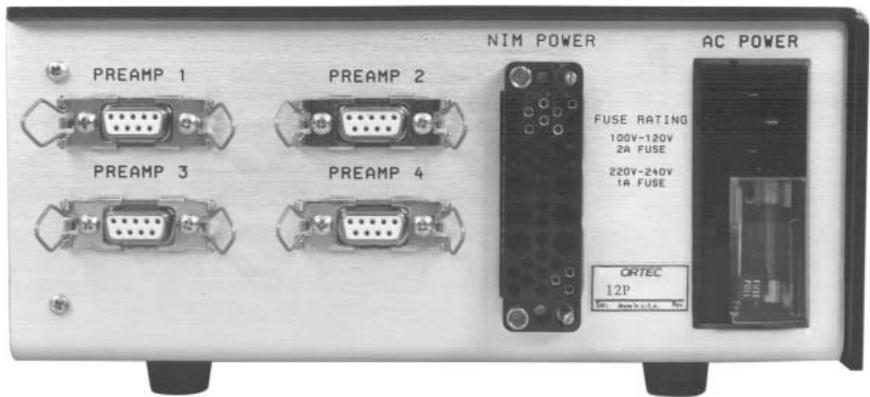
DIMENSIONS 21.5 cm (8.4 in.) wide, 26 cm (10.2 in.) deep, and 10.2 cm (4.0 in.) high.

Optional Accessories

121-C1 PREAMPLIFIER POWER CABLE EXTENDER Provides a 3-m (10-ft) extension cable to connect a preamplifier power cable to the PREAMP 1, 2, 3, or 4 power output on the 4002P Portable Power Supply. Compatible with all standard ORTEC preamplifiers.

401-C3 MODULE EXTENDER CABLE Connects the 4002P NIM POWER output to the standard bin power connector on the rear of a NIM module. Permits powering a NIM module in a remote location using the 4002P Portable Power Supply. Cable length is 91 cm (3 ft).

4002P-C1 PREAMP POWER FAN-OUT CABLE Plugs into a standard ORTEC preamplifier power output connector and provides four preamplifier power output connectors. Use four of the optional 4002P-C1 with the 4002P to power 16 preamplifiers.



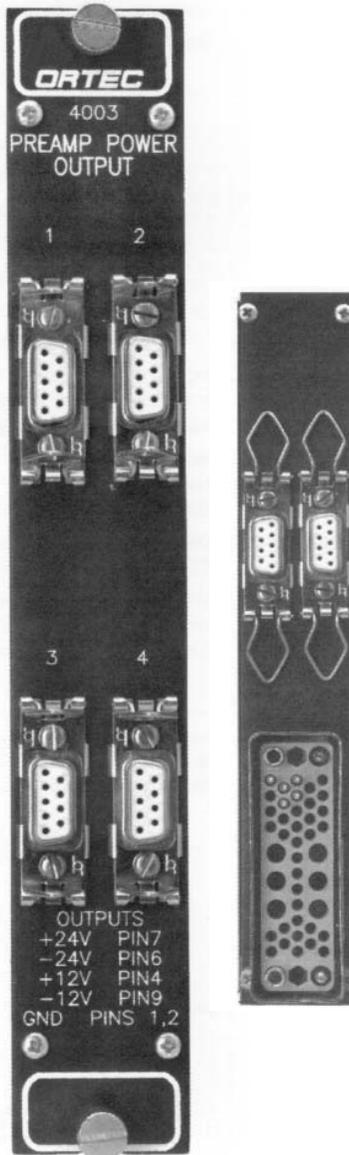
Ordering Information

To order the Model 4002P Portable Power Supply and/or accessories, specify the following model numbers and descriptions.

Model	Description
4002P	48-W Portable Power Supply (with $\pm 12/24$ V)
121-C1	Preamplifier Power Cable Extender
401-C3	Module Extender Cable
4002P-C1	Preamp Power Fan-Out Cable

4003 Preamplifier Power Output

- Convenient NIM bin power outlet for 6 preamplifiers
- Individual filtered outlets ensure low noise
- Standard 9-pin D connectors deliver +12-V and +24-power



The Model 4003 Preamplifier Power Output module provides a convenient way to deliver dc power from a NIM bin to preamplifiers when appropriate connectors are not available on other modules installed in the bin. Up to 6 preamplifiers can be accommodated via the standard, 9-pin "D" connectors on this single-width NIM module.

Low-noise preamplifiers require dc power that is free of interference generated by other modules inserted in the bin. The Model 4003 protects this low-noise capability by filtering the power lines separately at each connector.

Each preamplifier power plug delivers ± 12 -V and ± 24 -V dc power on the pins designated under OUTPUTS. The Model 4003 derives its power from a NIM bin/power supply such as the Models 4001A/4002A, 4001A/4002D, 4001C/4002D, 4001C/4002E, 4001M, or 4006.

Specifications

Outputs Standard ORTEC preamplifier power plugs (female, 9-pin D connectors), with four located on the front panel and two located on the rear panel. Each pin is separately filtered with the π network shown in Figure 1. The pins are wired to deliver the assigned voltages as shown.

Pin Number	DC Voltage
1	Ground
2	Ground
3	No connection (reserved for +6 V)
4	+12 V
5	No connection (reserved for -6 V)
6	-24 V
7	+24 V
8	No connection
9	-12 V

POWER REQUIRED The Model 4003 derives its power from a NIM bin power supply, such as the Models 4001A/4002A, 4001A/4002D, 4001C/4002D, 4001C/4002E, 4001M, or 4006.

WEIGHT

Net 0.74 kg (1.6 lb).

Shipping 2.1 kg (4.6 lb).

DIMENSIONS NIM-standard single-width module, 3.43 x 22.13 cm (1.35 x 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
4003	Preamp Power Output

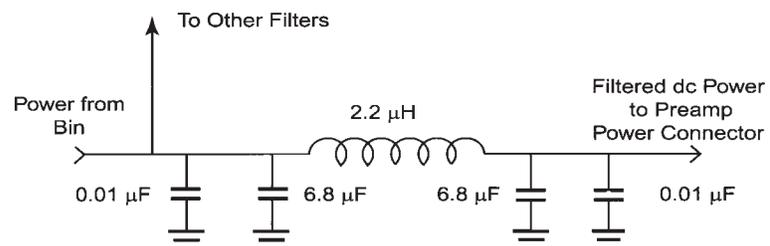


FIG. 1. A Separate π Filter Is Employed at Each Output.

Integrated Electronics Packages

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A66-B32	GammaVision-32 Gamma-Ray HPGe Spectral Analysis	14.17

Compact, Integrated Functions

Some of the modular functions described in the other sections of this catalog can be conveniently combined into compact packages for specific applications, such as gamma-ray and x-ray spectrometry. The integrated electronics packages listed in this section are intended for laboratory or portable assay of radioisotopes using NaI(Tl) or Ge detectors for gamma-ray spectrometry. Most can also be used with Si(Li) and CdZnTe and Ge detectors for x-ray applications.

Except for the MicroNOMAD, the packages that incorporate the MCA function connect to a PC and include the MAESTRO-32 MCA emulator software. The MicroNOMAD includes ScintiVision-32, which is both an MCA emulator and a spectral analysis program for NaI(Tl) detectors. Analysis applications software such as GammaVision-32, ScintiVision-32, Isotopic-32, MGA++ Isotopic Ratio, PC/FRAM Isotopic Ratio, Renaissance-32, Nuclear Materials Holdup Measurement and CZTU

Safeguards are available as options for some or all of the integrated electronics packages. Ask for the brochure on these products to get complete information.

For those who want to program special software applications, the A11-B32 CONNECTIONS Programmer's Toolkit is available. See the MCA/MCB section of this catalog for details.

Gamma-ray and x-ray applications with the above electronic packages require a Ge, NaI(Tl), Si(Li) or CdZnTe detector.

For complete information on the above products ask for the specific brochures, consult the ORTEC Applied Spectroscopy catalog, or visit the ORTEC website at www.ORTEC-online.com.

Integrated Electronics Packages

Packages for High-Purity Germanium Detectors (HPGe)

Germanium detectors are, in fact, extremely large, reverse-biased diodes. When a gamma-ray stops in the detector, the detector converts the deposited energy to a proportional amount of charge formed by a cloud of electron-hole pairs. Due to the applied bias voltage, the electrons are collected at the positive electrode and the holes drift to the negative electrode. This charge is collected on a small capacitor by the preamplifier to form a voltage pulse, whose amplitude is proportional to the energy deposited by the gamma-ray. The output of the preamplifier is sent to the pulse-shaping amplifier, and the output of the amplifier is sorted into the pulse-height (or energy) spectrum by a multichannel pulse-height analyzer.

Ge detectors are constructed in a coaxial electrode geometry for optimum detection efficiency for high-energy gamma-rays, or in a planar, IGLET™, or LO-AX™ structure for optimum energy resolution at low x-ray energies.

Compared to a NaI(Tl) detector, the Ge detector has the advantage of a factor of 30 better energy resolution. However, the Ge detector must be cooled by a liquid nitrogen reservoir, or a cryogenic cooler, to achieve that spectacular advantage. This results in a package for the Ge detector that is significantly larger than a compact 3- x 3-inch NaI(Tl) detector. In spite of the size disadvantage, the Ge detector is frequently used as a portable instrument for field surveys, because the finer resolution results in a factor of 6 lower detection limits, or orders of magnitude better when peaks from several isotopes overlap.

At high energies the percent resolution of a Ge detector improves in inverse proportion to the square root of the gamma-ray energy. At the very low energies typical of x-ray spectrometry, the resolution is limited by the thermal noise at the input of the preamplifier.

For laboratory installations the DSPEC and DSPEC PLUS are excellent choices. The DigiDART is recommended for field measurements with Ge detectors, where portability is important, or when dual-purpose (field and laboratory) service is desired.

Packages for NaI(Tl) Detectors

NaI(Tl) detectors are based on a large NaI(Tl) crystal mounted on a photomultiplier tube (PMT). When the gamma-rays are stopped in the crystal, the energy deposited by the gamma-ray is converted to light at a wavelength of approximately 415 nm. The intensity of the flash of light is proportional to the gamma-ray energy. This light pulse is converted to photoelectrons at the cathode of the PMT, and amplified to a much larger signal through the chain of dynodes in the PMT. Finally, the electronic charge is collected on a small capacitor at the anode output to

form a voltage signal proportional to the gamma-ray energy. A preamplifier collects the signal and passes it to the main pulse-shaping amplifier. The output of the shaping amplifier is either counted to measure the gross counting rate, or analyzed by a Multichannel Pulse-Height Analyzer (MCA) to generate the gamma-ray or x-ray energy spectrum.

NaI(Tl) detectors have the advantage of being relatively compact and not requiring any cooling. They have a moderately good energy resolution, typically 7 to 8% FWHM at 662 keV. The energy resolution varies approximately in inverse proportion to the square root of the energy.

The Model 296 ScintiPack PMT Base is a convenient choice for meeting the high-voltage, bias network and preamplifier requirements of a NaI(Tl) detector. The preamplifier output of that detector and PMT base combination can be fed to a variety of integrated electronics packages. The ACE Mate can be used to count gamma-rays from a specific energy range, or it can be combined with a multichannel analyzer, such as the TRUMP-PCI to record the complete spectrum of energies. The MicroACE, DSPEC and DSPEC PLUS offer several additional choices for laboratory installations. For portable applications, the DigiDART and MicroNOMAD provide a wide range of features to choose from.

Packages for Si(Li) Detectors

Si(Li) detectors are manufactured in a planar electrode geometry similar to the Ge detectors that are intended for x-ray spectrometry. Both types are optimized for low noise and optimum energy resolution with low-energy x-rays. For laboratory installations, the DSPEC and DSPEC PLUS are excellent choices. The DigiDART is a good candidate for portable applications.

Packages for CdZnTe Detectors

Sometimes referred to as CZT detectors, the CdZnTe detector is made from an alloy of the elements in its name. To date, such detectors are extremely small and are therefore used primarily in the x-ray energy range from a few keV to 122 keV. Energy resolutions are in the range of 1 to 5 keV. The attractive feature of the CZT detector is its operation at room temperature, in contrast to the requirement to operate Ge and Si(Li) detectors in the vicinity of 77°K. Room-temperature operation eliminates the bulky liquid nitrogen reservoir.

In laboratory operations, the CZT detector can be used with the DSPEC and DSPEC PLUS. The DigiDART and MicroNOMAD can be used for portable applications.

Analog Versus Digital Pulse Processing

Instruments such as the ACE Mate, MicroACE, and MicroNOMAD, employ traditional pulse-shaping amplifiers with analog circuits to filter and shape the pulses. At the noise-corner time constant, where series and parallel noise sources from the preamplifier yield equal contributions, the optimum pulse shape for the maximum signal-to-noise ratio is the cusp. At shorter shaping time constants, where the series noise source from the preamplifier dominates, the optimum pulse shape for the maximum signal-to-noise ratio is a triangle. On top of this, the variations in the charge collection times with a Ge detector demand a flat-top pulse to eliminate the ballistic deficit effect. This is essential for achieving reasonable energy resolution with shorter pulse widths. All of these ideal pulse-shape requirements are virtually impossible to meet with analog pulse shaping. The best that is possible is an approximation to the required pulse shape. Consequently, the semi-Gaussian pulse shape is the best approximation near the noise-corner time constant, and the quasi-triangular pulse shape is the best approximation at shorter shaping time constants. Similarly, the gated-integrator amplifier is used to overcome the ballistic deficit effects at short shaping time constants with Ge detectors.

With the advent of fast flash ADCs and rapid Digital Signal Processors (DSP), it became possible to use digital pulse processing for pulse shaping. For example, the DSPEC PLUS uses a 10-MHz, 14-bit, flash ADC to directly digitize the output of the detector preamplifier. Essentially, the flash ADC converts the analog signal to a digital representation of the waveform. All the filtering, pulse-shaping, and sorting into a pulse-height histogram (energy spectrum) is accomplished in real time at a 10-MHz rate via a Digital Signal Processor (DSP).

Because of this rapid digital methodology, the DSPEC PLUS can implement a more ideal pulse-shaping function as illustrated in Figure 1. The flat top on the pulse is long enough to accommodate the variation in charge collection times from the Ge detector. This eliminates the resolution degradation that would otherwise occur because of ballistic deficit effects. At the longer shaping time constants needed for best energy resolution, the length of the flat top appears negligible compared to the pulse width. Thus, the pulse shape becomes a close approximation to a "cusp", . . . the optimum pulse shape for achieving the best signal-to-noise ratio at the noise-corner time constant. At the much shorter pulse widths needed for higher counting rates, straight lines are used for the rising and falling edges of the pulse shape. The resulting trapezoidal pulse shape yields the optimum signal-to-noise ratio for those shorter pulse widths. With this exceptional flexibility in pulse shaping, DSPEC PLUS can provide optimum performance over a wider range of counting rates than is typically possible with an amplifier that uses analog pulse shaping.

DSPEC, DSPEC PLUS, and DigiDART all use digital pulse shaping, the ACE Mate, MicroACE, and MicroNOMAD use analog pulse shaping.

Livetime Clocks Versus ORTEC's Zero Dead Time Technique

DSPEC PLUS provides a choice between the conventional Gedcke-Hale livetime clock, and the ZDT dead time correction mode for loss-free counting. The ZDT mode makes the spectrometer behave as if it has Zero Dead Time. This is useful in cases where the counting rate changes significantly during the measurement of the gamma-ray spectrum, such as in Neutron Activation Analysis and real-time monitoring systems. Because a livetime clock corrects for dead time losses by extending the counting time, it only yields the correct answer for the calculated counting rate (recorded counts divided by live time) when the counting rate is constant throughout the measurement. The ZDT mode overcomes the problem with rapidly changing counting rates by sequentially making dead time corrections over extremely short time intervals as the data is being acquired. In each minuscule time interval, the microprocessor estimates the dead time losses and computes the factor that corrects the measured counting rate to the true counting rate. The counts measured in the next infinitesimal time interval are multiplied by this factor before being stored in memory. The spectrum is acquired for a preset real time, and the recorded counts in the spectrum accurately represent the counts that would have been accumulated during the measurement period if the system had no dead time.

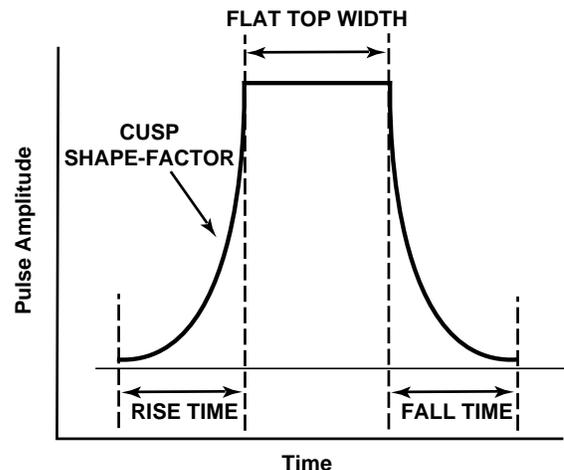


Fig. 1. Digital Filter Response.

Integrated Electronics Packages

When acquiring a spectrum for a preset live time in the livetime clock mode, the statistical uncertainty in the recorded counts in any region of the spectrum is

$$\sigma = N^{1/2} \quad (1)$$

where N is the number of counts in that region. However, equation (1) is no longer true when acquiring spectra for a preset real time in the ZDT mode. In the ZDT mode, σ increases compared to the value in equation (1) as the percent dead time increases. DSPEC PLUS overcomes this difficulty

by calculating the actual value of σ^2 on a pulse-by-pulse and channel-by-channel basis and storing that set of values as a σ^2 -spectrum.* When summing the counts in a region of the N-spectrum, the statistical uncertainty for those counts can be reported by summing the same region in the σ^2 -spectrum, and taking the square root of the latter sum.

*Patent pending

Gamma-Ray/X-Ray Spectrometer Selection Guide for Portable Electronics

Feature	DigiDART	MicroNOMAD
For Detector Type:	Ge, NaI(Tl), Si(Li), CZT	NaI(Tl), CZT
Pulse Filtering	Digital (DSP)	Analog
Pulse Shapes	Trapezoid	Bipolar
Shaping Time Constants (μ s)		2
Rise-/Fall-Times (μ s)	0.8 to 20 in steps of 0.2	
Flat Top (μ s)*	0.5 to 2.0 in steps of 0.1	
Integrated Functions	HV Bias Preamp. Power Amplifier MCA, PUR	Preamp. Power Amplifier MCA
Auto PZ*	Yes	No
Dead Time Correction	Livetime Clock	Livetime Clock
Spectrum Stabilizer	Gain & Zero	Gain
Maximum Channels in Spectrum Histogram	32,768	2,048
Computer (PC) Interface	USB	Parallel (Printer), RS-232-C, RS-485
MAESTRO-32 Software included	Yes	No. Includes ScintiVision-32
Programmer's Toolkit	A11-B32	A11-B32
Power Source	Battery or AC	Batteries or AC
Battery Operating Time	>9 hr.	>8 hr.
Package Size (cm)	15 X 10 X 6	7 X 7 X 21
Weight (kg)	0.7	0.7

DPM = Dual-Port Memory Interface.

*U.S.A. Patents: 5,821,533; 4,866,400; 5,872,363

Integrated Electronics Packages

Gamma-Ray/X-Ray Spectrometer Selection Guide for Laboratory Electronics

Feature	925-SCINT	DSPEC	DSPEC PLUS	MicroACE-32
For Detector Type:	Nal(Tl)	Ge, Nal(Tl), Si(Li), CZT	Ge, Nal(Tl), Si(Li), CZT	Nal(Tl), CZT
Pulse Filtering	Analog	Digital (DSP)	Digital (DSP)	Analog
Pulse Shapes	Bipolar	Trapezoid or Flat-Top Cusp	Trapezoid or Flat-Top Cusp	Bipolar
Shaping Time Constants (microseconds)	1			2
Rise-/Fall-Times (microseconds)		0.8 to 25.6 in steps of 0.8	0.2 to 23.0 in steps of 0.2	
Flat Top (microseconds)*		0.8 to 2.4 in steps of 0.4	0.3 to 2.4 in steps of 0.1	
Cusp Parameter (rise/fall curvature)		0.4, 0.5, 0.6, 0.7, 0.8, 0.9, and 1.0	0.4, 0.5, 0.6, 0.7, 0.8, 0.9, and 1.0	
Integrated Functions	HV Bias Preamp. Power Preamp. Amplifier SCA Ratemeter	HV Bias Preamp. Power Amplifier MCA PUR	HV Bias Preamp. Power Amplifier MCA PUR	Preamp. Power Amplifier MCA
Auto PZ*	No	Yes	Yes	No
Dead Time Correction	None	Livetime Clock	Livetime Clock, ZDT	Livetime Clock
Spectrum Stabilizer	No	Gain & Zero	Gain & Zero	Gain
Maximum Channels in Spectrum Histogram		16,384	16,384	2,048
Computer (PC) Interface	No	Ethernet, DPM, RS-232-C	Ethernet, RS-232-C	ISA Plug-in Card
MAESTRO-32 Software included	No	Yes	Yes	Yes
Programmer's Toolkit	No	A11-B32	A11-B32	A11-B32
Power Source	AC	AC	AC	PC

DPM = Dual-Port Memory Interface.

*U.S.A. Patents: 5,821,533; 4,866,400; 5,872,363

ACE Mate™ Preamplifier, Amplifier, Bias Supply and SCA



- Stand-alone instrument designed for bench-top operation
- Interfaces directly to photomultiplier tube bases such as Models 266, 276, and 296
- Protected against sudden positive or negative high-voltage spikes
- Amplifier provides a 10-volt linear output and features low input noise and a wide gain range to allow a variety of applications
- Lower Level and Upper Level can be set over a 200:1 dynamic range from 50 mV to 9.99 V
- Front-panel push-button selects setting in volts, or count rate in kcps, 3-digit display
- High-voltage supply is continuously adjustable from 50 to 2000 V dc, and the output polarity is selectable

The ACE Mate Preamplifier, Amplifier, Bias Supply, and SCA provides the link between scintillation detectors and ORTEC's ACE Multichannel Analyzers (or most other MCAs). ACE Mate, a stand-alone instrument designed for bench-top operation, incorporates a low-noise preamplifier, a spectroscopy-type shaping amplifier, a single-channel analyzer, count-rate monitor, HV power supply, and a digital display to monitor these functions. The ACE Mate module interfaces directly to ORTEC photomultiplier tube bases such as the Models 266, 276, and 296, which can be coupled with the 905 series of scintillation detectors.

The preamplifier is noninverting and is intended for use with photomultiplier tubes. The input is ac-coupled and diode-protected against sudden positive or negative high-voltage spikes. A Printed Wiring Board (PWB) switch is

provided to bypass the preamplifier when using external preamplifiers, thereby allowing the signal to be connected directly to the internal shaping amplifier.

The spectroscopy shaping amplifier provides a 10-V linear output and features low input noise and a wide gain range to allow a variety of applications. Semi-Gaussian bipolar shaping is used to eliminate baseline shift with count rate change. Bipolar pulse shaping also eliminates the need for pole-zero adjustments, thus simplifying the setup of the ACE Mate.

A single-channel analyzer (SCA) is incorporated in the ACE Mate. The input to the SCA is obtained from the amplifier output. The SCA operates in Window mode; the Lower Level and Upper Level can be set over a 200:1 dynamic range from 50 mV to 9.99 V. The lower-level reference is selected by a PWB jumper for either the front panel potentiometer

or an external signal.

A three-digit display on the front panel allows the user to monitor either the high voltage (in kV), the lower-level and the upper-level SCA discriminator settings (in volts), or the count rate (in kcps). A front-panel push-button selects among these three choices.

The high voltage supply provides the voltage necessary for the photomultiplier tubes. The output is continuously adjustable from 50 to 2000 V dc and internal PWB jumpers select the output polarity. Front-panel LEDs indicate the presence of high voltage and the polarity. The maximum load current is 1 mA to 2000 V. A front-panel On/Off switch controls the high voltage.

A preamp power connector provides power to tube bases with internal preamplifiers.

ACE Mate™ Preamplifier, Amplifier, Bias Supply and SCA

Specifications

PREAMPLIFIER

INPUT Input stage is ac-coupled. Diode protected against sudden positive or negative voltage spikes.

IN/OUT PWB slide switch provides preamplifier selection. The IN position allows the internal preamplifier to function. The OUT position allows an external preamplifier to be directly connected to the amplifier using the Input BNC connector.

AMPLIFIER

GAIN RANGE Continuously adjustable from 5 to 1250 using six-position front-panel COARSE GAIN switch and a ten-turn direct reading FINE GAIN potentiometer.

PULSE SHAPE Peaking time equals 2 μ s and is semi-Gaussian bipolar.

POS/NEG PWB slide switch selects either positive or negative input pulse polarity.

INPUT Accepts either the output of the internal preamplifier or a signal from the rear-panel BNC connector. External input signals can be positive or negative, with rise times <1 μ s and decay times >40 μ s; $Z_{in} = 1000 \Omega$; ac-coupled; linear maximum input 2 V; absolute maximum 20 V.

OUTPUT Rear-panel BNC connector with $Z_{out} < 1 \Omega$ is short-circuit proof and positive lobe leading, with a full-scale linear range from 0 to 10 V. Active filter shaping is incorporated.

PREAMP POWER Rear-panel standard ORTEC preamp power connector (Amphenol 17-10090) mates with captive and noncaptive power cords on all ORTEC preamplifiers.

SINGLE-CHANNEL ANALYZER

DYNAMIC RANGE 200:1.

UL Front-panel screwdriver-adjustable potentiometer determines the upper level (0.05–9.99 V). Control setting is read on the front-panel digital display.

LL Front-panel screwdriver-adjustable potentiometer determines the lower level (0.05–9.99 V). Control setting is read on the front-panel digital display.

LOWER LEVEL REFERENCE CONTROL A PWB jumper selects either the front-panel LL potentiometer or the positive voltage signal applied to the rear-panel EXT LL REF BNC connector. SCA INPUT is internally connected to the amplifier output.

SCA OUTPUT Rear-panel BNC connector provides TTL compatible signal; output amplitude >3 V, pulse width approximately 0.5 μ s. Output occurs as the trailing edge of the amplifier output crosses the LL threshold.

SCA INPUT Internally connected to the output of the amplifier.

RATEMETER

INPUT Ratemeter input is internally connected to the SCA output.

OUTPUT Ratemeter output can be read on the front-panel 3-digit digital display. The range is from 0 to 99.9 kcps.

HIGH-VOLTAGE SUPPLY

OUTPUT PWB jumper selects either positive or negative high-voltage output and is available at rear-panel SHV connector.

OUTPUT RANGE 50 to 2000 V.

OUTPUT LOAD CAPACITY 1 mA to 2000 V.

HV CONTROL A front-panel HV ON/OFF switch provides control of the high-voltage supply when the main ac power switch is on.

OUTPUT ADJUST A 3-turn precision potentiometer adjusts the output from 0 to 2000 V.

REGULATION <0.02%.

OUTPUT RIPPLE <15 mV rms at 1 kV, 1 mA load.

STABILITY <0.01%/°C.

ELECTRICAL AND MECHANICAL

POWER REQUIRED 115 V ac or 230 V ac. Separate internal tap connection for 100 V ac or 200 V ac. AC power <50 VA at 2 kV, 1 mA load.

DIMENSIONS 9.2 X 30.5 X 27.9 cm (3.6 X 12 X 11 in.).

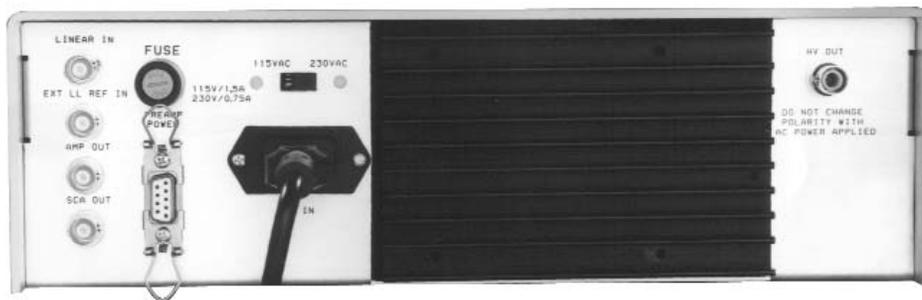
WEIGHT 4 kg (9 lb).

SHIPPING WEIGHT 5 kg (11 lb).

Ordering Information

To order, specify:

Model	Description
925-SCINT	ACE Mate Preamplifier, Amplifier, Bias Supply, and SCA



DigiDART™

Portable Digital MCA

with MAESTRO®-32 Software

Bringing DIGITAL Performance to Portable, High Resolution, HPGe Gamma-Ray Spectroscopy

- **Performance Optimized for both HPGe and NaI(Tl)**
- **Lighter for compact portability:** 1.5 lbs (0.7 kg), including battery; 15 x 10 x 6 cm
- **Increased Battery Life:** >9 hr. with typical Ge detector. Battery can be replaced in the field without loss of data.
- **Built-in LCD display for spectra, keypad, and control menus:** acquisition, display, and storage without a PC in the field.
- **Superior DIGITAL stability** for long counts, high rates, and variable temperature environments
- **High maximum throughput:** >80,000 counts/s, when required
- **Acquires and saves >40 spectra at 8,192 channels to >550 spectra at 512 channels . . .without a PC**
- **Convenient USB interface port for PC connections**
- **Easy to hold and carry:** Hand-held or hung from the belt
- **Rugged ABS plastic case** with cushioning elastomer over-mold
- **Complete with MAESTRO®-32 MCA Emulator software for Windows® 98/NT/2000**
- **Optional applications software packages:**
 - A35-B32** ScintiVision™-32 spectral analysis for NaI(Tl) detectors
 - A66-B32** GammaVision,-32 spectral analysis for HPGe detectors
 - A11-B32** CONNECTIONS Programmer's Toolkit
 - MGA-B32** MGA++ Isotopic Ratio (Safeguards)
 - PC/FRAM-B32** Isotopic Ratio (Safeguards)
 - HMS3-BI** Nuclear Materials Holdup Measurements



DSPEC PLUS™

Digital Gamma-Ray Spectrometer with MAESTRO®-32 Software

Second-Generation Digital Gamma-Ray Spectrometry Offers Even Higher Performance and Flexibility for HPGe and Other Gamma/X-Ray Detectors

All the features and benefits of DSPEC™ . . . **PLUS:**

- A factor of 4 greater flexibility in the selection of Rise Time and Flat Top settings to precisely match application needs to detector performance capability
- Innovative ZDT™ (Zero Dead Time) "loss-free counting" correction, . . . including statistical uncertainty reporting. Extracts accurate answers from rapidly changing counting rates.
- Throughput increase to 133,000 cps
- Rock-solid stability versus counting rate and temperature (typically 30 ppm/°C)
- Unique integrated Input Counting Rate Meter Display
- Includes MAESTRO-32 software for data acquisition and spectral storage
- Add GammaVision® software for quantitative activity analysis



MicroNOMAD™

Portable, Miniature MCA with ScintiVision™ -32 Software

For NaI(Tl), CZT, and other Moderate-Resolution Detectors

- Compact portability: 7 x 7 x 21 cm, 0.7 kg
- More than 8 hours of operation with 8 AA batteries
- Includes amplifier, spectrum stabilizer, ADC and memory
- Interfaces to computer via high-speed parallel printer port
- Single-cable operation with optional ScintiPack™ PMT base and NaI(Tl) detector
- "Field Mode" operation without PC: stores up to 63 spectra internally
- Sample data may be read via Bar Code Reader
- Standard A35-B32 ScintiVision-32 analysis software provides live spectral display and quantitative analysis of spectra
- Automatic Job streaming
- ADC operates as 256, 512, 1024, or 2048 channels
- Multiple MicroNOMADs may operate from a single PC
- Optional power pack for operation from ac power



Cables and Accessories

Contents

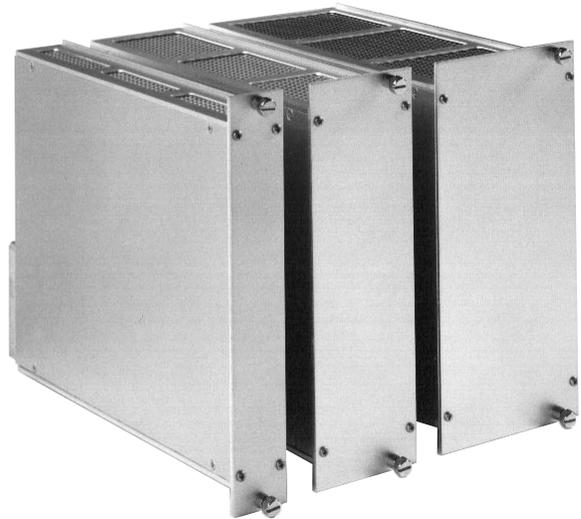
	Introduction	15.1
400A–400C	Blank NIM Modules	15.1
400-1B–400-3B	Blank Panels	15.2
MT050	50- Ω Matched Tee Signal Splitter	15.2
218	Magnetic Shield	15.2
	Cable Assemblies and Bulk Cable	15.3
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	Adapters	15.5
	Bulkhead Mounted Jacks	15.6
	Terminators	15.6
	Plugs	15.7
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Introduction

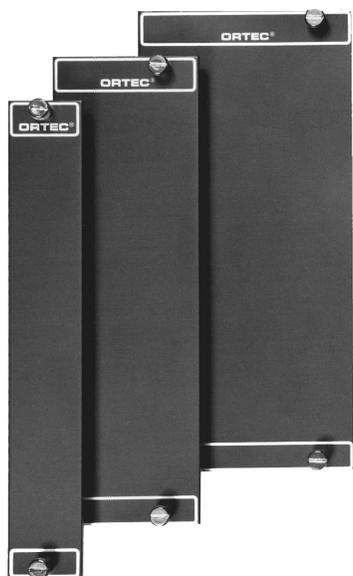
In order to facilitate the use of pulse processing, ORTEC offers a wide variety of accessories, such as cables, connectors, blank NIM modules, and blank panels. The cables are available in various convenient lengths and standard impedances for linear and fast-timing signals and high-voltage applications.

Models 400A, 400B, and 400C Blank NIM Modules

ORTEC offers blank modules in three standard NIM widths, single-width through triple-width (400A, 400B, 400C, respectively), to provide the experimenter with the option of packaging special-purpose electronics in a standard configuration. They are shipped fully assembled, and each one is provided with 10 connector pins that are prewired with 25.4-cm (10-in.) leads for easy integration with the experimenter's electronics.



Cables and Accessories



Models 400-1B-400-3B Blank Panels

- 400-1B** Blank Panel, single-width NIM
- 400-2B** Blank Panel, double-width NIM
- 400-3B** Blank Panel, triple-width NIM

Model MT050 50-Ω Matched Tee Signal Splitter

One input provides two equal half-amplitude outputs and still preserves 50-Ω termination; reflection, typically 10% (dc to over 500-MHz equivalent bandwidth); rise time, 1 ns; continuous input power, 1 W.



Model 218 Magnetic Shield

Magnetic shields are recommended for use with photomultiplier tubes to reduce the interference from either the earth's magnetic field or from stray magnetic fields from the other equipment. The Model 218 is for use with 2-in. diameter photomultiplier tubes and the ORTEC Model 265 Tube Base.

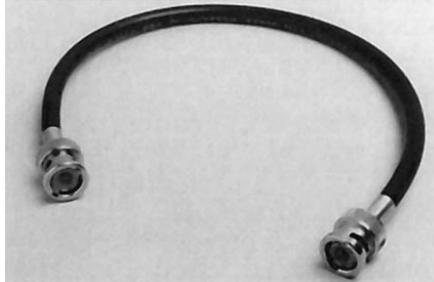
Shield Model No.	Nominal Length	Maximum Outside Diameter
218	12.7 cm (5 in.)	7.6 cm (3 in.)

Cable Assemblies and Bulk Cable



C-18-0 Microdot 100-Ω Miniature Cable with two Microdot male plugs; 5-cm (2-in.) length

C-18-2 Microdot 100-Ω Miniature Cable with two Microdot male plugs; 0.61-m (2-ft) length



BNC Plug — RG-62A/U (93 Ω) — BNC Plug

C-24-1/2 15 cm, 6-in. length

C-24-1 30 cm, 1-ft length

C-24-2 0.61 m, 2-ft length

C-24-4 1.2 m, 4-ft length

C-24-8 2.4 m, 8-ft length

C-24-12 3.7 m, 12-ft length



C-36-2 RG-59A/U 75-Ω Cable with two SHV female plugs, 0.61-m (2-ft) length

C-36-12 RG-59A/U 75-Ω Cable with two SHV female plugs, 3.7-m (12-ft) length



C-19-2 Microdot 100-Ω Miniature Cable with one BNC male plug and one Microdot male plug; 0.61-m (2-ft) length



BNC Plug — RG-58A/U (50 Ω) — BNC Plug

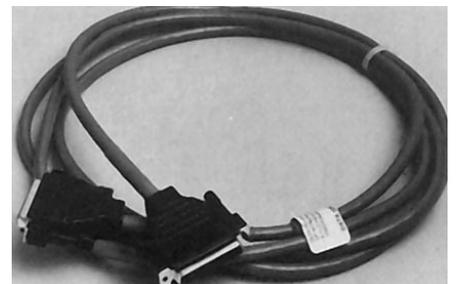
C-25-1 30 cm, 1-ft length

C-25-2 0.61 m, 2-ft length

C-25-4 1.2 m, 4-ft length

C-25-8 2.4 m, 8-ft length

C-25-12 3.7 m, 12-ft length



C-75 RS-232-C Null Modem Cable, female-to-female, 3-m length



C-21 Microdot 293-3913 Miniature 100-Ω Cable; specify length

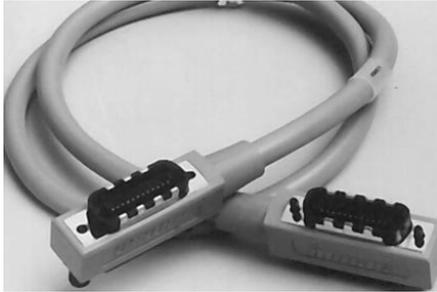


C-34-12 RG-59A/U 75-Ω Cable with one SHV female plug and one MHV male plug, 3.7-m (12-ft) length



C-80 RS-232-C Extension Cable, male-to-female, 3-m length

Cables and Accessories



C-488-2 IEEE-488 Interface Cable, 2-m length

C-488-4 IEEE-488 Interface Cable, 4-m length

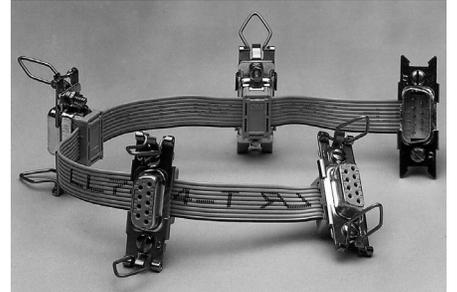


SMA58 RG-58A/U (50-Ω) Coaxial Cable, with SMA Connectors

SMA58-0.15 0.15-m length

SMA58-0.5 0.5-m length

SMA58-1.5 1.5-m length



4002P-C1 Preamp Power Fan-Out Cable



C-VT120 Power Cable Assembly for VT120A/B/C, 3-m length



121-C1 Preamplifier Power Cable Extender 3-m (10-ft) length



PRN-C-2 Printer Port Cable, male to female, 25 conductor; 0.61-m (2-ft) length

PRN-C-10 Printer Port Cable, male to female, 25 conductor; 3-m (10-ft) length



LL174 Signal Cables RG-174 50-Ω Cable with two LEMO male plugs

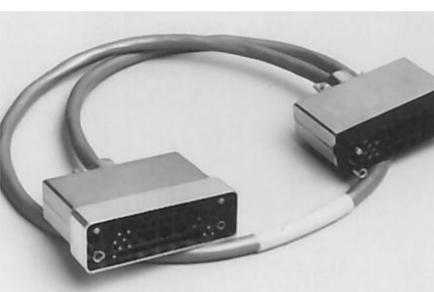
LL174-0 0.1-m length

LL174-1 0.25-m length

LL174-2 0.5-m length

LL174-3 1-m length

LL174-4 2-m length



401-C3 Module Extender Cable, 0.91-m (3-ft) length

Cables and Accessories

Custom Cable Assemblies

The following custom-built cables can be ordered by specifying the desired length in feet in place of an X in the model number. For example, to order a 25-ft. long C-18-X-S Cable, specify C-18-25-S on the order. (1m = 3.28 ft.)

C-18-X-S	Microdot 100- Ω Miniature Cable with two Microdot male plugs	C-34-X-S	RG-59A/U 75- Ω Cable with one SHV female plug and one MHV male plug	C-45-X-S	RG-62A/U 93- Ω Cable with one SHV female plug and one BNC male plug; mates Model 807 Vacuum Chamber to Models 142AH, 142IH, and 142PC Preamplifiers
C-19-X-S	Microdot 100- Ω Miniature Cable with one Microdot male plug and one BNC male plug	C-36-X-S	RG-59A/U 75- Ω Cable with two SHV female plugs	121-C1-X-S	Preamplifier Power Cable Extender
C-24-X-S	RG-62A/U 93- Ω Cable with two BNC male plugs	C-43-X-S	RG-59A/U 75- Ω Cable with one SHV female plug and one open end	401-C3-X-S	Module Extender Cable
C-25-X-S	RG-58A/U 50- Ω Cable with two BNC male plugs				

Adapters



C-16 Microdot to BNC Adapter with male Microdot and female BNC



C-29 BNC Tee Connector



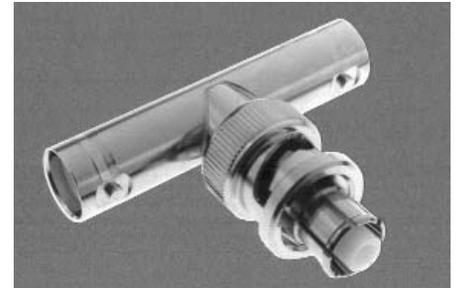
C-31 BNC to Microdot Adapter with male BNC and male Microdot



C-17 BNC to Microdot Adapter with male BNC and female Microdot



C-30 Microdot to Microdot Connector with female Microdot on both ends



C-46 SHV Tee Connector



C-62 BNC Connector, female-to-female



C-63 SHV Connector, male-to-male



BL050 BNC/LEMO Adapter with male BNC and female LEMO

Cable and Accessories



LB050 LEMO/BNC Adapter with male LEMO and female BNC



IT100 Inverting Transformer A compact pulse-inverting transformer for use in a 50- Ω system; has low distortion; good linearity, freedom from overload effects, 0.8-ns rise time capability, and 7% tilt in 100 ns.



TA050 Tee Adapter, LEMO



BNC/SMA BNC to SMA Adapter with male BNC and female SMA



SMA/BNC SMA to BNC Adapter with male SMA and female BNC

Terminators



C-27 Terminator, 100 Ω , BNC male plug
C-28 Terminator, 50 Ω , BNC male plug



LT050 Terminator, 50 Ω , LEMO



T50 Terminator, 50 Ω , BNC. Provides a high-quality 50- Ω ($\pm 1\%$) 1/2-W termination.



TF50 Feedthrough terminator, 50 Ω , BNC. Provides 50- Ω ($\pm 2\%$) 1-W feedthrough termination of 50- Ω cable at high-impedance inputs.



MT050 50- Ω Matched Tee Signal Splitter
 One input provides two equal half-amplitude outputs and still preserves 50- Ω termination; reflection, typically 10% (dc to over 500-MHz equivalent bandwidth); rise time, 1 ns; continuous input power, 1 W.



SMA50 Terminator, 50 Ω , SMA (male)

Bulkhead Mounted Jacks

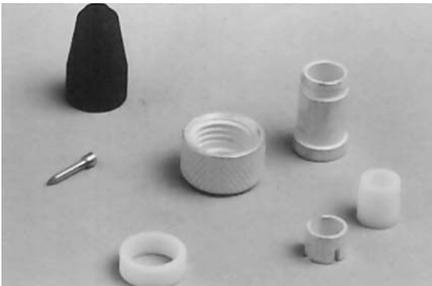


C-13 BNC to Microdot Vacuum Feed-through with female BNC and male Microdot



C-38 SHV Male Bulkhead Jack

Plugs

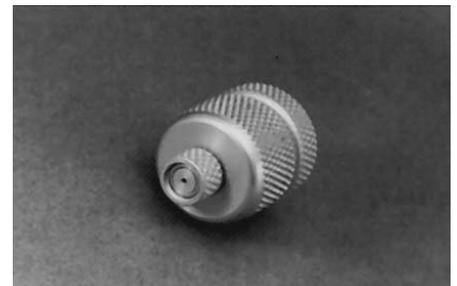


C-22 Microdot Male Plug for Miniature 100-Ω Cable



C-37 SHV Female Plug

Tools



C-23 Assembly Tool for C-21 and C-22 Microdot T32-11

ORTEC Warranty

ORTEC's liability on any claim of any kind, including negligence, for loss or damages arising out of, connected with or resulting from this agreement, or from the performance or breach thereof, or from the manufacture, sale, delivery, resale, repair or use of any item or services covered by or furnished under any agreement shall in no case exceed the price allocable to the item or service or part thereof which gives rise to the claim. In the event ORTEC fails to manufacture or deliver items other than standard products that appear in ORTEC's catalog, ORTEC's exclusive liability and Buyer's exclusive remedy shall be release of the Buyer from the obligation to pay the purchase price. **IN NO EVENT SHALL ORTEC BE LIABLE FOR SPECIAL OR CONSEQUENTIAL DAMAGES.**

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All other trademarks used herein are the property of their respective owners.

Specification Changes

All precautions have been taken to insure complete accuracy of the information in this catalog. In its ongoing effort to increase the capabilities of its products ORTEC may, without notice, change product specifications.

4-PORT USB HUB

Specifications

Ports: 4-Port

Data Transfer:

High Speed: 12 Mbps

Low Speed: 1.5 MBps

Features:

- Each downstream port is rated for both high & low speed USB operations
- Supports suspend & resume operations
- Warning LED for fault or dummy USB port
- Each port provides protection against current overload
- Reliable transmission for up to 5-meter USB cable segments
- Connectors: 1 "B" Root Port; 4 "A" Device Ports
- Max Devices Supported: 127 (when daisy-chaining hubs together)

Dimensions (WxDxH): 6-3/4 x 3-1/4 x 1-1/4in

System Requirements:

486, Pentium, or Compatible Computer with USB Support, Windows 95 Rev B, 98, or 2000

Includes:

USB Hub
Power Adapter
6ft AB Cable
Manual

Ordering Information

Model No.

C-USB-HUB-4B 4-Port USB Hub

7-PORT USB HUB

Specifications

Ports: 7-Port

Data Transfer:

High Speed: 12 Mbps

Low Speed: 1.5 MBps

Features:

- Each downstream port is rated for both high & low speed USB operations
- Supports suspend & resume operations
- Warning LED for fault or dummy USB port
- Each port provides protection against current overload
- Reliable transmission for up to 5-meter USB cable segments
- Connectors: 1 "B" Root Port; 7 "A" Device Ports
- Max Devices Supported: 127 (when daisy-chaining hubs together)

Dimensions (WxDxH): 6-3/4 x 3-1/4 x 1-1/4in

System Requirements:

486, Pentium, or Compatible Computer with USB Support, Windows 95 Rev B, 98, or 2000

Includes:

USB Hub
Power Adapter
6ft AB Cable
Manual

Ordering Information

Model No.

C-USB-HUB-7B 7-Port USB Hub

With Model USBEXT the USB signals going in and out of the extension cable are buffered to assure signal quality. Both low speed and high speed USB devices will function with the USBEXT. No additional power supply is required (extension cable is powered by USB).

Specifications:

Cable Length: 5 m (16.4 ft)

Max Current Draw: 5 mA at 40°C (typically <3 mA)

Max. Cable Voltage Drop: 0.095 V at 500 mA

VCC and GDN Wire Size: 20 AWG

D+ and D- Wire Size: 28 AWG (stranded — twisted pair, 90 Ω characteristic impedance)

Cable Shield: Aluminized wrap foil with 28 AWG drain wire and copper mesh over foil

High Speed Mode: 12 Mbs (when used with high-speed peripheral)

Low Speed Mode: 1.5 Mbs (when used with a low-speed peripheral)

Operating Temperature Range: 0 to + 85°C

Storage Temperature Range: -40 to + 85°C

Downstream Connector: Type "A" (female)

Upstream Connector: Type "A" (male)

Operating System Requirements: USB compatible (Windows[®] 98, 2000, XP)

Note: Limit to 25 m total length for each USB device. For a digiBASE or microBASE , up to four extenders may be added for a total length of 25 m (82 ft.)

Includes:

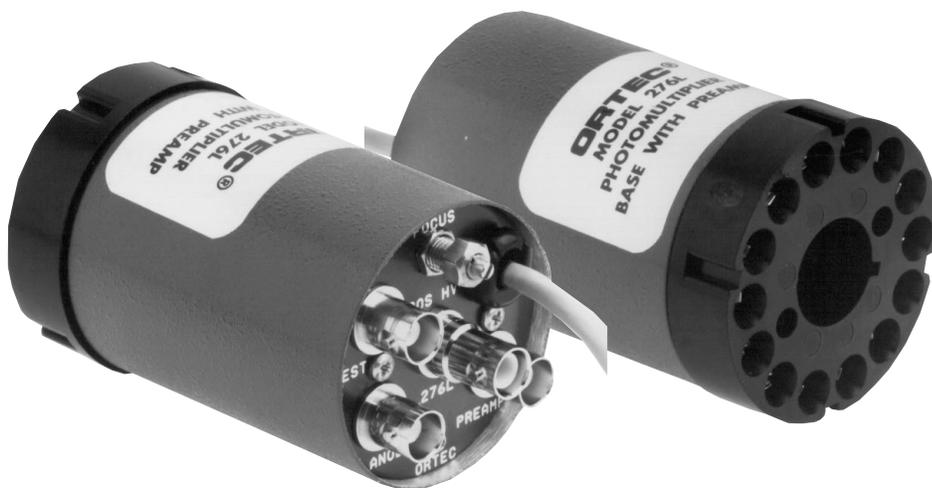
5 m cable, datasheet, minimal instructions.

Ordering Information

Model No.

USBEXT USB Active Extension Cable

- For use with 10-stage PMTs that fit standard 14-pin sockets
- Built-in low-noise preamplifier and focus control
- Both preamplifier output and anode output
- Test input for system testing
- Protection circuit for internal transistors
- Internal gain adjustment



The ORTEC Model 276L Low-Power Photomultiplier Tube Base and Preamplifier incorporates an integral low-noise preamplifier, a PMT base with a low-power voltage divider network, and a focus control for optimum performance in scintillator detector applications. The unit is ideally suited for use with NaI(Tl) detectors and the ORTEC DART or NOMAD Plus Portable Spectrometers.

The Model 276L provides two outputs: the preamplifier output for energy analysis, and the anode output for either timing or auxiliary energy analysis. The preamplifier is dc-coupled to simplify pole-zero cancellation in the main amplifier. A Test input accepts the output of a pulse generator to calibrate and test

the preamplifier and the system that follows. The Model 276L has a diode protection network to prevent damage to the internal transistors due to sudden application or removal of high voltage to the unit. A simple internal modification in the unit allows the gain to be adjusted to any value desired by the user. The Model 276L is powered from the DART, NOMAD Plus, or any ORTEC main amplifier or preamplifier power supply.

The Model 276L is directly compatible with many commercially available integrated NaI-PMT assemblies including:

ORTEC Model 905-1, -2, -3, -4
NaI(Tl) Scintillation Detector
Assemblies;

Bicron Model 2M2 and 3M3 Monoline Spectrometers;
Harshaw Model S288 and S332 Integral Line Assemblies;
Teledyne S-88-I and S-1212-I Integral Assemblies.

Also, the Model 276L is directly compatible with 10-stage PMTs that fit standard 14-pin sockets including those listed in Table 1.

The Model 276L is also compatible with other 10-stage tubes not listed in Table 1 (see Fig. 1). Compatibility may be determined by comparison with those listed.

Table 1. Compatible Photomultiplier Tubes.

ADIT		Burle (formerly RCA)		Hamamatsu		Philips
B51B01	B76C01	4900	S83020F	PM55	R1513	XP2202
L51B01	B89B01	5819	S83021E	R208	R1612	XP2203B
V51B01	B89C01	6342A	S83022F	R550	R1791	XP2412B
B51D01	B89D01	6655A	S83025F	R594	R1836	
B51C01	B133D01	S83006E		R877	R1847-07	
B76B01	B133C01	S83013F		R878	R1848-07	
V76B01	V133B01	S83019F		R1507	7696	
				R1512		

Specifications

PERFORMANCE

PREAMPLIFIER

Integral Nonlinearity $\leq \pm 0.02\%$, 0 to +10 V.

Temperature Instability $\leq \pm 0.005\%/^{\circ}\text{C}$, 0 to 50°C .

Output Rise Time < 100 ns for test input or fast scintillator.

Output Fall Time Time constant of 50 μs .

Output Noise < 50 μV rms with DART or NOMAD Plus Portable Spectroscopy System or with ORTEC main amplifier such as Model 672 and time constant of 1 μs .

Conversion Gain Nominally 5 $\mu\text{V}/\text{eV}$ with 2-by 2-inch NaI(Tl) crystal and PMT gain of 10^6 ; the typical output for a 511-keV gamma ray will be 250 mV at a PMT gain of 10^5 .

Saturation Level +10 V into an open circuit; +5 V into 93- Ω load.

VOLTAGE DIVIDER Resistor-divider connected to 10-stage PMT base. Total resistance 5.6 M Ω resulting in bleeder current of 200 μA with typical high voltage of 1 kV. The distribution is linear to all stages with the focus adjustment on the grid.

CONTROL

FOCUS Single-turn locking potentiometer on panel for external adjustment of PMT grid potential.

INPUTS

POS HV SHV connector, AMP 51494-2, for distribution of positive high voltage to PMT base; +2000 V maximum.

TEST BNC connector, accepts pulses from an ORTEC pulse generator for testing and calibration.

SIGNAL Preamp input is connected internally to dynode 10.

POWER Captive 4-m (12-ft) power cable terminated in Amphenol 17-20090 connector accepts preamp operating power; compatible with the DART or NOMAD Plus Portable Spectrometer and with all ORTEC main amplifiers and the Model 4002P Portable Power Supply.

PMT SOCKET TRW 3B14. Fits JEDEC B14-38 PMT pin base (see Fig. 1).

OUTPUTS

PREAMP BNC connector furnishes pre-amplifier positive output pulse to the DART or NOMAD Plus Portable Spectrometer or any ORTEC main shaping amplifier for linear energy analysis, $Z_o = 93 \Omega$, dc-coupled.

ANODE BNC connector furnishes negative anode output pulse for use for either timing or auxiliary energy analysis; $Z_o = 1 \text{ k}\Omega$ ac-coupled.

ELECTRICAL AND MECHANICAL

POWER REQUIRED For preamplifier, +24 V, 16 mA; -24 V, 16 mA; for PMT base, +2000 V maximum (use rated voltage for the tube that is installed).

WEIGHT

Net 0.65 kg (1.5 lb).

Shipping 1.3 kg (3.0 lb).

DIMENSIONS 5.6 cm (2.2 in.) diameter X 10.2 cm (4 in.) long; equipped with 4-m (12-ft) captive power cable.

Accessories

The following accessories are required for connection to the DART or NOMAD Plus: a C-24-12 cable for the preamplifier output signal, a C-36-12 cable for the high voltage, and a T50 terminator for the remote HV shutdown (SD) on the DART or NOMAD Plus.

Ordering Information

To order, specify:

Model	Description
276L	Low-Power Photomultiplier Base with Preamplifier
C-36-12	RG-59A/U 75- Ω Cable with two SHV female plugs, 12-ft length
C-24-12	RG-62A/U 93- Ω Cable with two BNC male plugs, 12-ft length
T50	50- Ω Terminator, BNC

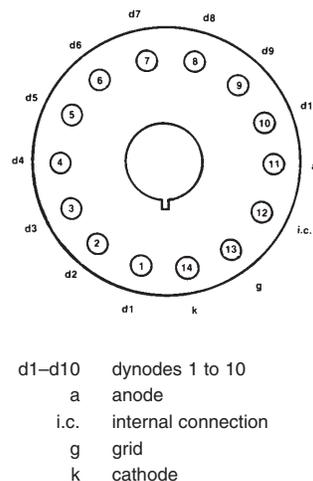


Fig. 1. JEDEC B14-38 PMT Pin Base, with Pin Assignments:

ORTEC[®]

800-251-9750 • www.ortec-online.com

info@ortec-online.com • Fax (865) 483-0396

801 South Illinois Ave., Oak Ridge, TN 37831-0895 U.S.A. • (865) 482-4411

For International Office Locations, Visit Our Website

AMETEK[®]
ADVANCED
MEASUREMENT
TECHNOLOGY

- Constant-fraction timing with fast SCA pulse height selection
- Excellent time resolution over a wide range of pulse amplitudes with scintillation and semiconductor detectors
- Differential, integral, constant-fraction, and slow-rise-time reject modes
- Upper- and lower-level thresholds adjustable from -30 mV to -5 V
- Time walk ± 75 ps over 100:1 dynamic range
- Adjustable output pulse width

The ORTEC Model 583B Constant-Fraction Differential Discriminator is a versatile, and high-performance unit suitable for the most exacting applications in timing spectroscopy. When operated in the Differential Mode, the Model 583B is ideal for use with fast scintillators and photomultiplier tubes. The dual discriminator levels allow this unit to function as a fast single-channel analyzer (SCA) in a fast-timing coincidence system, thus eliminating the need for separate slow-energy side channels. When used in the Integral Mode, the Model 583B is ideal for use with large-volume HPGe detectors and silicon charged-particle detectors operated in the traditional fast/slow coincidence system.

The input constant-fraction circuit uses a transformer and passive circuit pulse shaping technique to achieve better walk performance. It also provides a Monitor Output signal that is a linear representation of the constant-fraction shaped signal. This greatly simplifies the walk adjustment for optimum timing.

The use of surface-mount circuits in the Model 583B has greatly improved the time resolution obtainable at wide dynamic range when using fast scintillators. The excellent time resolution vs. dynamic range obtainable with this unit is shown in Fig. 1. The block diagram of the fast-timing coincidence system in which the Model 583B was used to obtain these results is shown in Fig. 2.

An additional benefit of the Model 583B is that it can greatly improve the data rate capability of a timing experiment. As shown in Fig. 2, the energy selection and coincidence decisions can be made before the time-to-amplitude conversion. This means the time-to-amplitude converter (TAC) must provide conversions only at the true coincidence rate rather than at the much higher single-event rate. Thus, high-count-rate problems in the TAC circuit are significantly reduced.

At the same time, the Model 583B provides simple and convenient operation. Only a few adjustments are needed for normal operation. The upper- and lower-level discriminators set the energy window for energy selection. The Integral/Differential switch determines whether the unit is to be used as a fast SCA or as an integral discriminator. The Constant-Fraction/

Slow-Rise-Time Reject control gives the user the flexibility to achieve good timing even where some relatively slow-rise-time signals are present. An adjustable output pulse width is provided to prevent multiple triggering on scintillation detectors with long decay times, such as NaI(Tl). The external Constant-Fraction Shaping Delay and Walk Adjustment should be optimized for each application.

Specifications

PERFORMANCE

INPUT PULSE Accepts negative input pulses from 0 V to -10 V without saturation; input protected against overload; reflections $\leq 10\%$ for input rise time ≥ 2 ns.

DISCRIMINATOR RANGES

Upper Level -30 mV to -5 V.

Lower Level -30 mV to -5 V.

THRESHOLD INTEGRAL NONLINEARITY $\leq \pm 0.5\%$ of full scale.

THRESHOLD INSTABILITY $\leq \pm 0.1$ mV/°C, 0 to 50°C.

TIME WALK ± 75 ps for 100:1 dynamic range; Integral Mode, with external shaping delay ~ 2 ns, input rise time ≤ 1 ns, input pulse width ~ 10 ns, threshold = 30 mV.

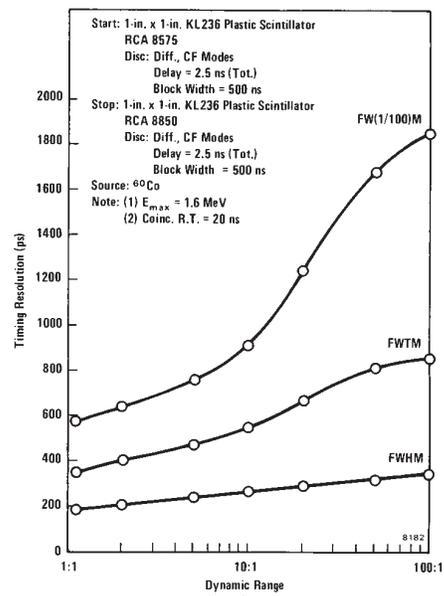


Fig. 1. Timing Resolution as a Function of Dynamic Range for Two Constant-Fraction Differential Discriminators in a Fast-Timing Coincidence System.

PROPAGATION DELAY Nominally 18 ns, with external shaping delay ~2 ns.

BLOCKING WIDTH Variable from ≤ 15 to ≥ 1000 ns.

MINIMUM PULSE-PAIR RESOLUTION

~50 ns for input pulse width ≤ 10 ns, or pulse width at the arming threshold +40 ns for input pulse width ≥ 10 ns.

CONTROLS

UPPER LEVEL Front-panel 5-turn precision locking potentiometer used to determine the threshold setting for the Upper-Level discriminator.

LOWER LEVEL Front-panel 5-turn precision locking potentiometer used to determine the threshold setting for the Lower-Level discriminator. Also automatically adjusts the threshold level for the constant-fraction pickoff arming discriminator. Adjustable internally from 0.5 to 1.0 times the Lower-Level threshold (factory set to 0.5).

DISCRIMINATOR MODE Front-panel 2-position locking toggle switch selects one of two modes:

Diff (Differential) Functions as a single-channel analyzer (SCA). The Lower-Level (LL) and Upper-Level (UL) thresholds are each independently adjustable from -30 mV to -5 V. To produce an output pulse, the input signal must cross the LL threshold and must not cross the UL threshold within approximately 10 ns after the constant-fraction zero-crossing time.

Int (Integral) Functions as an integral discriminator. The LL threshold sets the minimum input signal amplitude required to produce an output pulse. The UL discriminator is not used to determine the timing response from the instrument.

TIMING MODE Front-panel two-position locking toggle switch selects one of two modes:

CF (Constant Fraction) The instrument operates in the constant-fraction timing mode. The constant-fraction attenuation factor is internally set at 0.2. An external 50- Ω cable must be provided for the constant-fraction shaping delay.

SRT (Slow Rise Time) Rejects inhibits output signals that would be produced by leading-edge timing from the LL and UL discriminators. An input signal that does not cross the LL threshold before the constant-fraction zero-crossing time does not produce an output pulse. In the Diff Mode, an input signal that does not cross the UL threshold before the constant-fraction zero-crossing time will not be inhibited by the UL discriminator from producing an output pulse.

DELAY A pair of front-panel BNC connectors that accept 50- Ω coaxial cable to set the required constant-fraction shaping delay; total delay is ~0.7 ns plus the delay of the external cable.

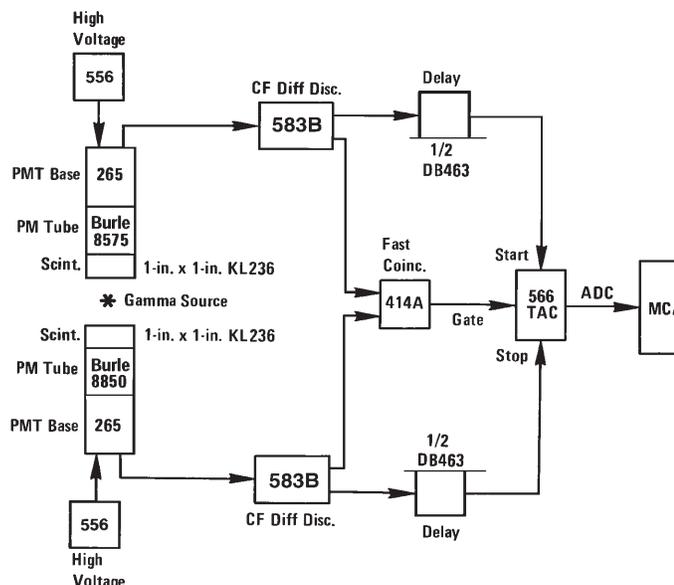


Fig. 2. A Fast Coincidence System for Gamma-Gamma Coincidence Measurements with Scintillators and Photomultiplier Tubes.

WALK ADJUST Front-panel 20-turn screwdriver adjustment to set the walk compensation for each application.

WALK MONITOR Front-panel test point, adjacent to the Walk Adjust potentiometer, permits monitoring the actual dc voltage that is set for the zero-crossing reference; normally set in the range from -0.5 mV to +2.0 mV.

CF MONITOR Front-panel BNC connector to permit observation of the constant-fraction bipolar timing signal; 50- Ω cable and 50- Ω termination required.

WIDTH ADJUST Front-panel 20-turn screwdriver adjustment to set the width of the pulse at the blocking output; variable from ≤ 15 to ≥ 1000 ns.

INPUT

Front-panel BNC connector accepts negative input signals from 0 V to -10 V without saturation; 50 Ω , direct-coupled; input protected against overloads; reflections $\leq 10\%$ for input rise time ≥ 2 ns.

OUTPUTS

TIMING Two front-panel BNC connectors provide simultaneous NIM-standard fast negative logic signals.

BLOCKING (BK) Front-panel BNC connector provides a NIM-standard fast negative logic signal that occurs simultaneously with the Timing Outputs; inhibits further timing pulses from being generated during the blocking period; variable from ≤ 15 to ≥ 1000 ns.

POSITIVE SCA Rear-panel BNC connector provides a NIM-standard slow positive logic signal. Occurs simultaneously with timing outputs.

UPPER LEVEL (UL) Rear-panel BNC connector provides a NIM-standard fast negative logic signal. Occurs as the leading edge of the input signal crosses the UL threshold.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 120 mA; -12 V, 80 mA; +24 V, 0 mA; -24 V, 0 mA; +6 V, 0 mA; -6 V, 650 mA.

WEIGHT

Net 0.85 kg (1.9 lb).

Shipping 1.85 kg (4.1 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Ordering Information

To order, specify:

Model	Description
583B	Constant-Fraction Differential Discriminator/SCA

Specifications subject to change
102105

14-Pin PMT Tube Base with Integrated Bias Supply, Preamplifier,
and MCA (with Digital Signal Processing) for NaI Spectroscopy

USB Interface. . . All In One. . . Digital Signal Processing

GO DIGITAL. . . Power Up With digiBASE. . .

- Full featured digital MCA and gain stabilizer for ultimate stability
- Fast data acquisition for maximum throughput
- The ultimate in Fine Time Resolution with "List Mode"
- Multi-detector arrays made simple with USB Connection
- 0 to +1200-V Detector Bias Voltage
- Software included: ORTEC's MAESTRO-32 advanced MCA software. ScintiVision or InterWinner (optional)



The digiBASE is a 14-pin photomultiplier tube base for gamma-ray spectroscopy applications with NaI(Tl) scintillation detectors. The unique concept of the digiBASE combines a miniaturized preamplifier and detector high voltage (0 to +1200 V bias) with powerful digital signal processing, multichannel analyzer, and special features for fine time resolution measurements — all contained in a low-power (<500 mA), lightweight (10 oz, 280 g), small-size (63 mm diameter x 80 mm length) tube base with a USB connection. Everything you need to connect to your NaI(Tl) detector is included in the tube base. Furthermore, there is no need to open your computer to install an interface card, or for using external NIM-based components. The digiBASE includes MAESTRO-32 MCA emulation software and is available with ScintiVision-32 and InterWinner for complete quantitative analysis.

Simple Installation

Installation is simple via the USB interface of the PC. Just load the software, establish communications using ORTEC CONNECTIONS-32 software and begin making measurements. It's that simple!

MCA Emulation and Spectral Analysis

MAESTRO-32 MCA Emulator Included

The MAESTRO-32 software provides a graphical user interface for all the controls needed to adjust the acquisition parameters, acquire the data and save the spectra. MAESTRO-32 is a member of the *CONNECTIONS* family of ORTEC products, thus providing full networking with other ORTEC spectrometers and supporting computers.

MAESTRO-32 includes features for identifying peaks, editing libraries, and creating, printing and saving Regions of Interest (ROI), performing energy calibrations, automating tasks via using simple "Job Streams", AND MORE!

MAESTRO-32 is simply the finest MCA emulator that you can buy — and it is included with digiBASE.

Spectral Analysis Made Simple with ScintiVision-32

For applications requiring isotope identification and activity quantification, the optional ScintiVision-32 advanced gamma-ray analysis software can be added easily. ScintiVision-32 offers all the features of the MAESTRO-32 MCA emulator, including automation of tasks through Job Streams, but adds the power of peak search and fit spectral analysis engines for more complex analysis needs for NaI gamma-ray spectra. You need only a minimum input for maximum output with ScintiVision-32! After analysis, results can be reviewed easily and quickly using a variety of on-screen, informative, interactive plotting routines.

Not only does ScintiVision-32 provide extensive menus and controls for the operation of all acquisition and analysis features, it also includes the Quality Assurance features that you need to monitor system performance — all stored conveniently in a Microsoft Access® database for easy retrieval and review.

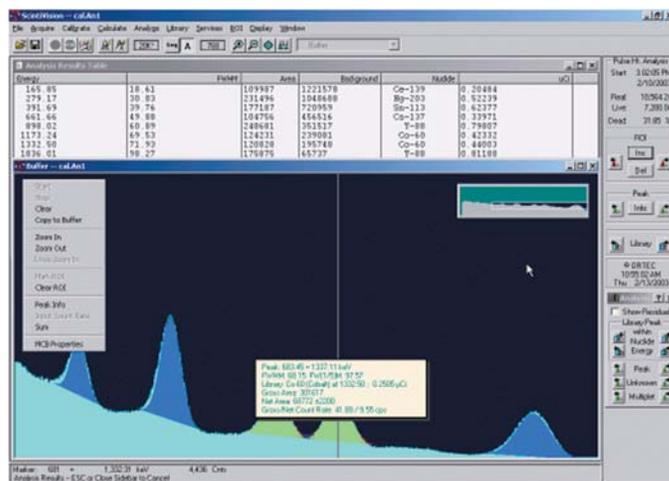
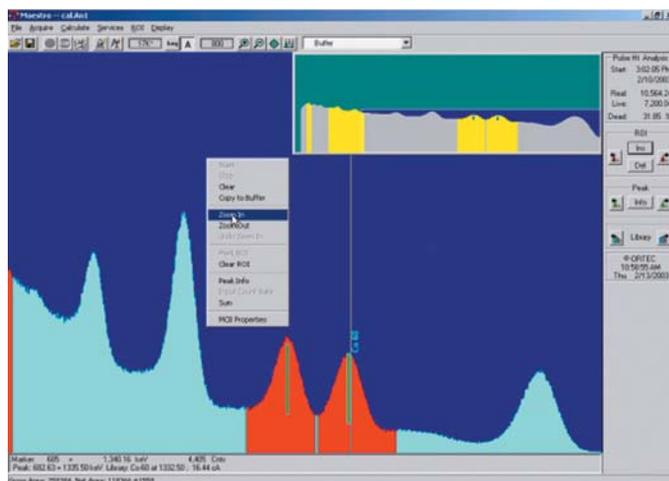
ScintiVision-32 combines the features of the finest MCA emulator with a complete spectral analysis and Quality Assurance package for the complex needs of today's counting laboratory. Combine that with the digiBASE for the most up-to-date complete solution for NaI measurements available!

Create Your Own Custom Software with the A11-B32 Toolkit

The A11-B32 *CONNECTIONS*-32 Programmer's Toolkit is also available for those who wish to integrate the digiBASE into their own software systems. The Toolkit offers ActiveX Controls to simplify programming with LabVIEW, Visual C++, and Visual Basic. For more information on the Toolkit, ask for copies of the A11-B32 Programmer's Toolkit brochure.

Superb Spectral Stability

NaI(Tl) detectors have a gain that is sensitive to changes in the ambient temperature and magnetic fields. DigiBASE incorporates a gain stabilizer to significantly diminish this sensitivity. It works by monitoring the centroid of a designated peak in the energy spectrum. The fine gain is automatically and continuously adjusted to maintain the centroid of the peak at its desired position. If you are interested in superb gain stability, the digiBASE is your answer!



Automate complex spectral analysis with ScintiVision

Specifications

Performance

Conversion Gain: 1024 channels

Coarse Gain: Gain settings of 1,3 and 9 (controlled by jumper)

Fine Gain: 0.4–1.2

Integral Non-Linearity: $\leq \pm 0.05\%$ over the top 99% of the range

Differential Non-Linearity: $\leq \pm 1\%$ over the top 99% of the range

Dead Time Accuracy: <5% error up to 50k cps input count rate. Deadtime is measured with a Gedcke-Hale Livetime clock.

Detector Voltage: 0 to +1200 V dc in steps of 1.25 V under computer control. Readback of High voltage is available.

Offset Drift: <50 ppm of Full-scale range per °C

Gain Drift: <150 ppm per °C

Shaping Time: Bipolar shaping adjustable under computer control from 0.75 to 2 μ s in steps of 0.25 μ s

Special Performance Features

The Ultimate in Fine Time Resolution

List Mode Acquisition: If you need the ultimate in fine time resolution, the digiBASE features "List Mode" operation, in which each valid input signal is converted to a digital value and that value is transmitted to the computer along with the time that the event occurred. Time is measured to the nearest microsecond. Each event causes a 32-bit word to be transmitted to the computer. The bits of the word are decoded as follows:

Bit	Description
31(msb)	TimeStampFlag (0=Normal Data, 1=Time Stamp)
30-21	Amplitude of the event
20-0	Time event arrived in units of microseconds

In addition, every second a "time stamp" word is transmitted. This time stamp word is used to track rollovers in the 21-bit time stamp in the normal data word.

Bit	Description
31 (msb)	TimeStampFlag (0=Normal Data, 1=Time Stamp)
30-0	Current time in microseconds

Number of List Mode Units per Computer: When multiple units are used in a list mode application, the limited bandwidth of the USB bus sets a practical limit on the number of units that can send data to a single computer. The total data rate of all units should be kept less than 200 kcps. The following chart gives typical maximum pulse rates for various numbers of units.

Number of digiBase's	Maximum Pulse rate (typical)
4	50 kcps
5	40 kcps
6	33 kcps
8	25 kcps

Histogram Mode Acquisition: Data is histogrammed inside the digiBASE. Data channels are 31-bits. Most significant bit is ROI bit.

Presets:

Livetime: up to 8.5×10^7 seconds in steps of 20 ms

Realtime: up to 8.5×10^7 seconds in steps of 20 ms

Flawless Spectrum Stabilizer: The digiBASE features built-in gain and offset stabilization circuitry. Stabilization is performed by providing a reference peak in the spectrum, which the MCA can monitor, should drift be detected, the gain and offset of the system are adjusted automatically to correct for the drift! The stabilizer can correct for 10% of FSR error in offset and uses the full-range of the Fine Gain to correct for gain errors.

ENABLE Input: The SMA connector accepts a TTL signal, whose function depends on the GATE setting on ADC tab under Adjust Controls in MAESTRO-32. When set to "Enable" when input is low, realtime, livetime, and data acquisition is stopped — left open, or high realtime, livetime, and data acquisition is enabled. If set to "Coincidence," when input is low, realtime and livetime operate normally, but no counts are stored in memory. When high, normal acquisition occurs. If set to "Event", rising edges are counted by a 32-bit event counter. The contents of the counter can be monitored on the Status tab under Adjust Controls in MAESTRO-32. Input impedance is 1-k Ω to +5 V protected to ± 10 V.

Interface: Full-speed (12 Mbps) USB 1.1 Interface. The unit is powered from the USB cable

Computer Controls

Fine Gain
Spectrum Stabilizer Setup
Enable and Set HV
Real and Live Presets
Pulse Width
Upper and Lower level Discriminators
Enable Input function

Electrical, Mechanical and Environmental

Dimensions: 63 mm diameter x 80 mm length

Weight:

Net (digiBASE only): 10 oz., 280 g
Shipping: ~ 5 lb., 2.27 kg

Power Requirements: <500 mA from USB connection

Ambient Operating Environment: -10 to 50°C at 0 to 80%; non-condensing humidity. Note: Unit will operate at -10°C, however, at power on, it should be at least 0°C for proper startup.

CE: Conforms to CE standards for radiated and conducted emissions, susceptibility and low-voltage power directives.

Computer Requirements and Recommendations

IBM-compatible PC with:
USB Connection required
Minimum 400 MHz processor recommended
At least 64 MB of memory
Hard drive (at least 20 MB on disk; 1 GB recommended)
CD-ROM (software is supplied on CD)
Windows 98, 2000, XP

Ordering Information

Model	Description
DIGIBASE	digiBASE with A65-B32 MAESTRO-32 MCA emulator
DIGIBASE-PKG-1	digiBASE with A65-B32 MAESTRO-32 and A35-B32 ScintiVision-32 software

Optional Software/Hardware

A35-B32 ScintiVision-32: advanced analysis software for identification and quantitative analysis of radioisotopes using NaI(Tl) detectors.

IW-B32 InterWinner: advanced analysis software for identification and quantitative analysis of radioisotopes using NaI(Tl) detectors.

A11-B32 CONNECTIONS-32 Programmer's Toolkit with ActiveX Controls: Write your own special software to control the digiBASE from LabView, Visual C++, or Visual Basic. List mode operations are available only using your own custom software.

USB HUB: Powered USB hub includes connections for up to seven digiBASE inputs. Configuration functions are the same as any other CONNECTIONS-32 device. Available in 4-input and 7-input models.

Specify:

C-USB-HUB-4B	4 Port USB Hub
C-USB-HUB-7B	7 Port USB Hub
USBEXT	USB Active Extension Cable (powered by USB)

Specifications subject to change
032405



- A simple CONNECTIONS solution to long-distance connection between PCs and ORTEC USB interfaced MCBs such as digiDART, digiBASE and DSPEC jr
- Easy implementation of remote networks involving ORTEC MCBs
- Enables centralized monitoring of remote MCBs
- Extends existing wired or wireless Ethernet ORTEC CONNECTIONS-32 networks to remotely attach USB MCBs to any host PC on the LAN — without distance limitations
- Breaks the traditional "five meter USB cable distance barrier," allowing remote users to experience the ease and reliability of USB
- No intermediate PC required
- One extender connects up to five USB MCBs
- Multiple extenders can be used with single or multiple PC's

The USB connection is the fast, new way to communicate to ORTEC Digital Multichannel Buffer (MCB) or multichannel analyzer products such as digiDART, microBase and DSPEC jr. USB is an excellent way to connect instruments to a PC, especially laptops for portable use. However in some cases, it is desirable to connect one or more instruments over large distances, beyond what can be achieved by USB extension cables. USB-CONC is a "USB to Ethernet concentrator" which can interface up to 5 ORTEC MCBs to a PC using ethernet hardware and the TCP/IP protocol. Multiple USB-CONC devices can be connected to a single PC or a network of PC's. The USB-CONC connects to the PC using the ethernet port

The USB-CONC concentrators 5 USB ports become local ports on a single computer on the Ethernet. The ORTEC USB drivers operate on the remote USB ports in the same way as the ones implemented on the PC. In other words, the application program, such as MAESTRO-32, and the USB hardware, such as a digiBASE operate as normal. The USB to Ethernet "conversion" is invisible to software and to MCA.

USB-CONC uses TCP/IP communication between the host computer and the USB concentrator hardware. Only one PC can communicate with the remote MCBs directly; the remaining PCs on the network can access the remote MCBs through the ORTEC CONNECTIONS-32 software. The configuration can be as simple as a PC and USB-CONC connected by an ethernet cable (crossover), or as complicated as any laboratory network.

The USB-CONC is neatly packaged and is supplied with a "plug in the wall" power supply.

USB-CONC

CONNECTIONS-32 Distance Extender for ORTEC USB MCA Products

Specifications

FEATURES

- Supports data rates up to 12 Mbps for USB device attachments
- 500 mA downstream power per device
- Individual port power management
- USB 1.1 compatible
- No additional IRQ or memory address requirements
- Plug-and-play compliant and hot-swappable

SYSTEM REQUIREMENTS

Windows 2000 or XP operating on host PC and
1 available Ethernet port

POWER REQUIREMENTS

Includes 5 V dc power supply with input voltage
requirement of 120 V ac, 60 Hz or 230 V ac, 50 Hz

ENVIRONMENTAL REQUIREMENTS

Ambient Temperature: 0–400°C (32–104°F)
Relative Humidity: 0–95% non-condensing

DIMENSIONS

11.05 cm L x 2.61 cm H x 18.29 cm W
(4.35 in L x 1.03 in H x 7.2 in W)

WEIGHT

10 oz. (283.49 g)

CONNECTORS

Ethernet: 10BASET RJ45 single connection

USB: 5 (five) USB 1.1 Host Connectors

CERTIFICATION AND SAFETY

- FCC Part 15, Class B
- CE Certified
- EN 55022
- EN 55024
- EN 60950
- UL 1950
- CSA 22.2 No. 950
- IEC-950

ORDERING INFORMATION

For 110V/60Hz operation order **USB-CONC-110**

For 220v/50Hz operation order **USB-CONC-220**

Specifications subject to change
090803

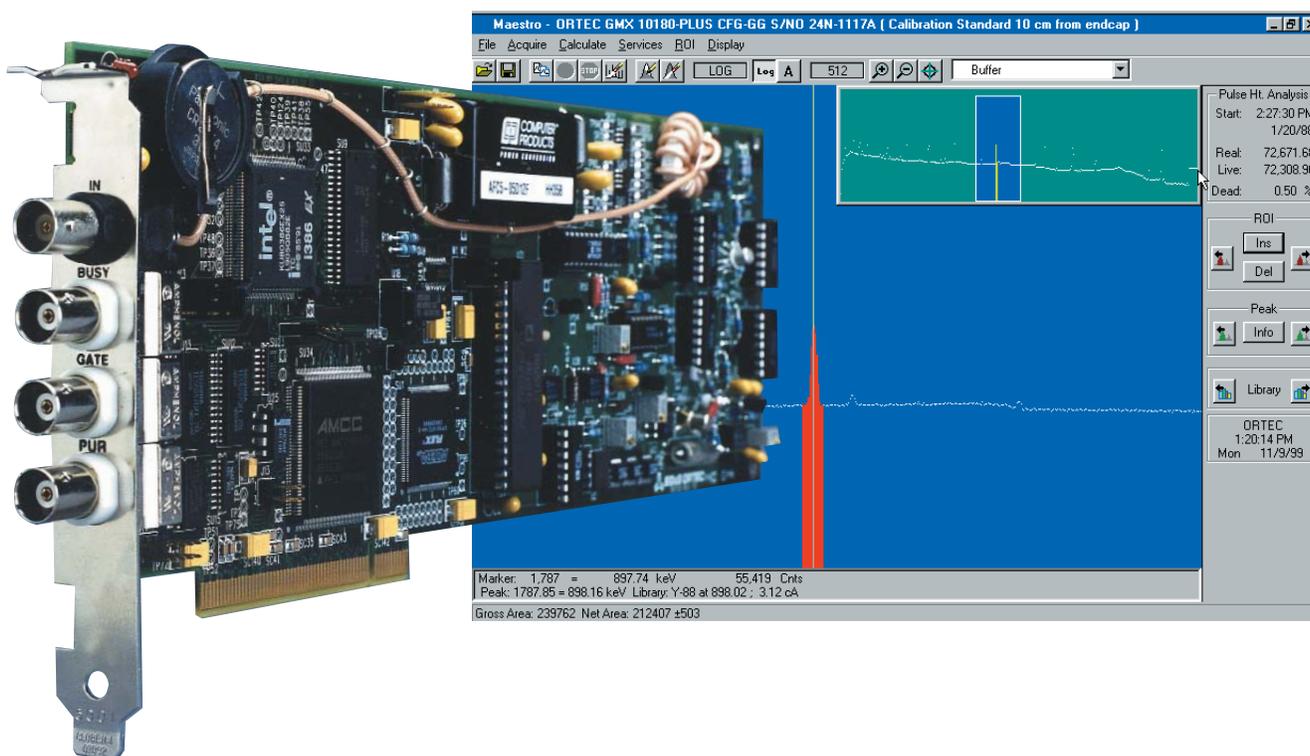
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801 South Illinois Ave., Oak Ridge, TN 37831-0895 U.S.A. • (865) 482-4411
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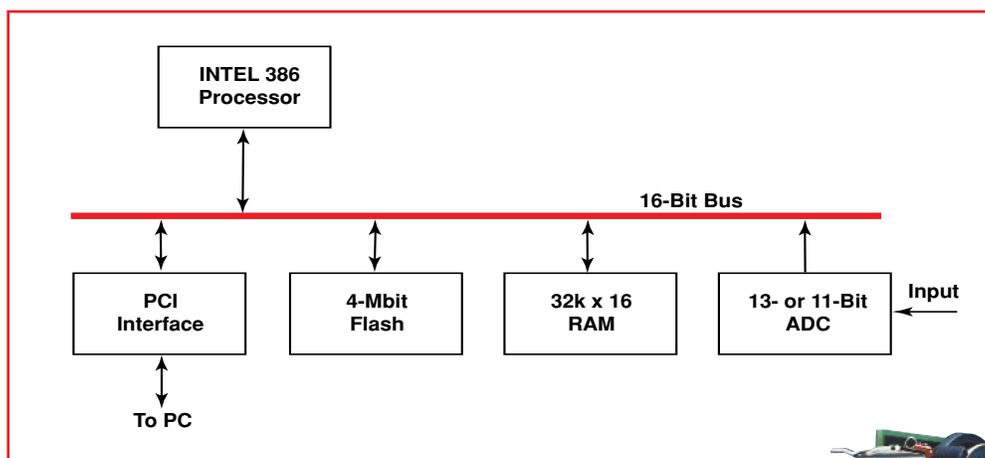
AMETEK[®]
ADVANCED
MEASUREMENT
TECHNOLOGY

MCA-on-a-Card for the Latest PCI-Bus PCs with CONNECTIONS MAESTRO®-32 MCA Emulation Software



- Fast (8 μ s) ADC and memory on a PCI-Bus plug-in card
- Computer control of all MCA functions
- High-resolution, powerful, easy-to-use MAESTRO-32 MCA Emulation program
- Highly-accurate dead-time correction method¹
- PUR, BUSY, and GATE inputs
- Easy to control via mouse or keyboard
- True live display of data being acquired
- Advanced analysis capabilities
- Two versions . . . 8k and 2k channels

The ORTEC TRUMP-PCI MCA brings the highly-successful TRUMP MCA on a card into PCI format. TRUMP-PCI plugs into a PCI option slot on the latest PCs to provide a computer-controlled multichannel pulse-height analyzer (MCA). Each TRUMP-PCI card consists of a single-slot plug-in card and MAESTRO-32 software. The TRUMP-PCI hardware comprises an ADC, microprocessor with data and program memory, and PCI-Bus interface, on a single PCI format plug-in card.

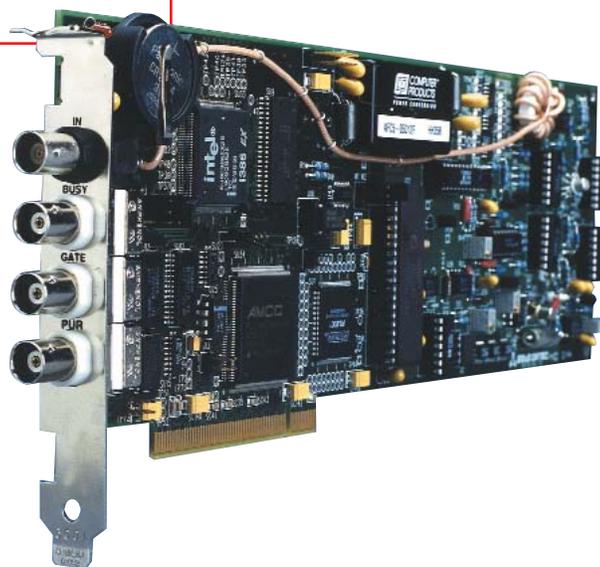


A successive-approximation ADC (8k or 2k) and matched data memory with a capacity of $2^{31}-1$ (over 2 billion) counts per channel is provided. Dead time per event is only 8 μ s, including time to add one to memory. The conversion gain is computer selectable as 512, 1024, and 2048 for the 2k TRUMP-PCI, with additional choices of 4096 and 8192 for the 8k version.

Two methods of dead time correction are available. Either Extended Live-Time correction according to the Gedcke-Hale¹ method or Simple Live-Time correction with the clock turned off during the conversion time can be selected using printed wiring board (PWB) jumpers.

In addition to the Input signal, the TRUMP-PCI Card accepts an ADC GATE input, a PUR pile-up rejection input, and a BUSY input used by the live-time correction circuits.

Up to eight TRUMP-PCI Cards can be controlled from the same PC under one copy of the MCA Emulator program (MAESTRO-32) with no overhead on the PC resources. During data acquisition the computer is entirely free to run other tasks.



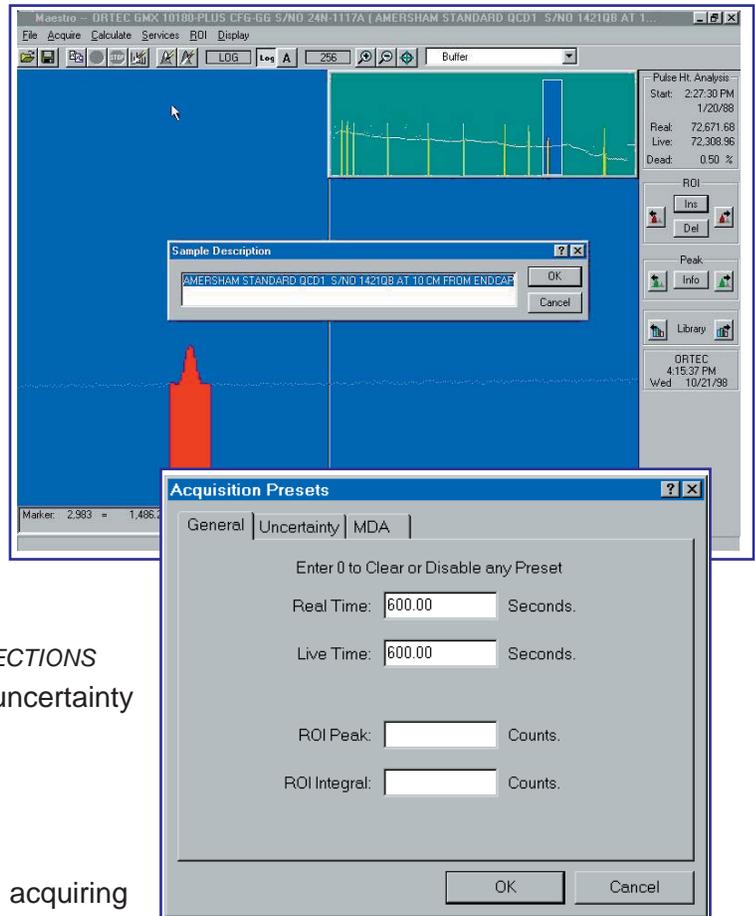
¹Ron Jenkins, R.W. Gould, and Dale Gedcke, *Quantitative X-Ray Spectrometry* (New York: Marcel Dekker, Inc.), 1981, pp. 266–267.

MAESTRO-32 MCA Emulation Software

TRUMP-PCI operates within the ORTEC *CONNECTIONS* environment under the latest version of the popular MAESTRO-32 MCA emulation software for Windows 98/2000/XP. A large number of ORTEC application software packages support the TRUMP-PCI and developer's toolkits are also available.

MAESTRO-32 provides an advanced MCA emulator that is easy to use by mouse or keyboard and features the latest Windows GUI enhancements. *CONNECTIONS* networking capabilities allow remote control and live display from remote PCs. Data security is assured by the provision of password-protected detector locking.

The truly live spectral display is easily manipulated with the mouse; rapid peak searches, ROI settings, and nuclide activity calculations are just a button click away. "Hot" keys are included for many functions. Up to 16k-channel full display, with logarithmic and variable-linear vertical display scale, is available.



Advanced MAESTRO-32

Features Include:

- Full networking capabilities under ORTEC *CONNECTIONS*
- Multiple acquisition preset types, including peak uncertainty and nuclide MDA
- Mariscotti² fast peak search and nuclide ID
- Index to next ROI or peak in spectrum
- Automatic operation through job file feature
- Live update of key peak parameters while data is acquiring
- Peak centroid and shape calculation
- Net Area and Gross Area for peaks
- Spectrum Sum
- Spectrum Smooth
- Quadratic energy calibration, with shape parameter, stored to disk
- Supports up to 8 TRUMP-PCI cards

²A Method for Automatic Identification of Peaks in the Presence of Background and its Application to Spectrum Analysis," *Nucl. Instrum. Methods* 50 pp. 309-320 (1967).

TRUMP™-PCI-8k/2k

PCI Format MCA Plug-In Card and Software

Specifications

Performance

ADC Successive-approximation type with sliding scale linearization.

MAX RESOLUTION 8k: 8192 channels, software selectable as 8192, 4096, 2048, 1024, 512, and 256. 2k: 2048 channels, software selectable as 2048, 1024, 512, and 256.

DEAD TIME PER EVENT 8 μ s, including memory transfer.

INTEGRAL NONLINEARITY $\leq \pm 0.025\%$ over the top 99% of the dynamic range.

DIFFERENTIAL NONLINEARITY $< \pm 1\%$ over the top 99% of the dynamic range.

GAIN INSTABILITY $\leq \pm 50$ ppm/ $^{\circ}$ C.

DEAD-TIME CORRECTION Printed wiring board (PWB) jumper selects either Extended Live-Time correction according to the Gedcke-Hale method, or Simple Live-Time correction with the clock turned off during the conversion time.

DATA MEMORY 8k channels of battery backed-up memory; $2^{31}-1$ counts per channel (over 2 billion).

PRESETS

Real Time/Live Time Multiples of 20 ms.

Region-of-Interest Peak count/Integral count.

Data Overflow Terminate acquisition when any channel exceeds $2^{31}-1$.

Peak Uncertainty

Nuclide MDA

MICROPROCESSOR Intel 386; 32k x 16 RAM with battery backup; 4 Mbit flash memory.

Controls

ADC ZERO Computer controlled, ± 125 mV.

ADC LLD Computer controlled, from 0 to 100% full scale.

ADC ULD Computer controlled, from 0 to 100% full scale.

Inputs and Outputs

INPUT Accepts positive unipolar, positive gated integrator, or positive leading bipolar analog pulses in the dynamic range from 0 to +10 V; +12 V maximum; semi-Gaussian-shaped or gated-integrator-shaped time constants from 0.25 to 30 μ s, or delay-line-shaped with width > 0.25 μ s. $Z_{in} \approx 1$ k Ω , dc-coupled. No internal delay. BNC connector on rear panel.

ADC GATE Optional, slow-positive NIM input. Computer selectable Coincidence or Anticoincidence. Signal must occur prior to and extend 0.5 μ s beyond the peak of the pulse; rear-panel BNC connector. $Z_{in} \approx 1$ k Ω .

PUR Pile-up rejection input; accepts slow-positive NIM signal; signal must occur prior to peak detect. $Z_{in} \approx 1$ k Ω . BNC connector on rear panel.

BUSY Busy input used by live-time correction circuits. Accepts slow-positive NIM signal; signal must occur prior to peak detect. $Z_{in} \approx 1$ k Ω . BNC connector on rear panel.

Electrical and Mechanical

POWER REQUIRED +5 V, 1.5 A.

DIMENSIONS Standard full-slot PCI card.

Weight

Net 1.4 kg (3.1 lb)

Shipping 2.3 kg (5 lb)

Software Prerequisites

MAESTRO-32 will run on any PC that supports Windows 98/2000/XP.

Ordering Information

To order, specify:

Model	Description
TRUMP-PCI-2K	2k MCA PCI Plug-In Card with MAESTRO-32 Software
TRUMP-PCI-8K	8k MCA PCI Plug-In Card with MAESTRO-32 Software

Specifications subject to change
021005

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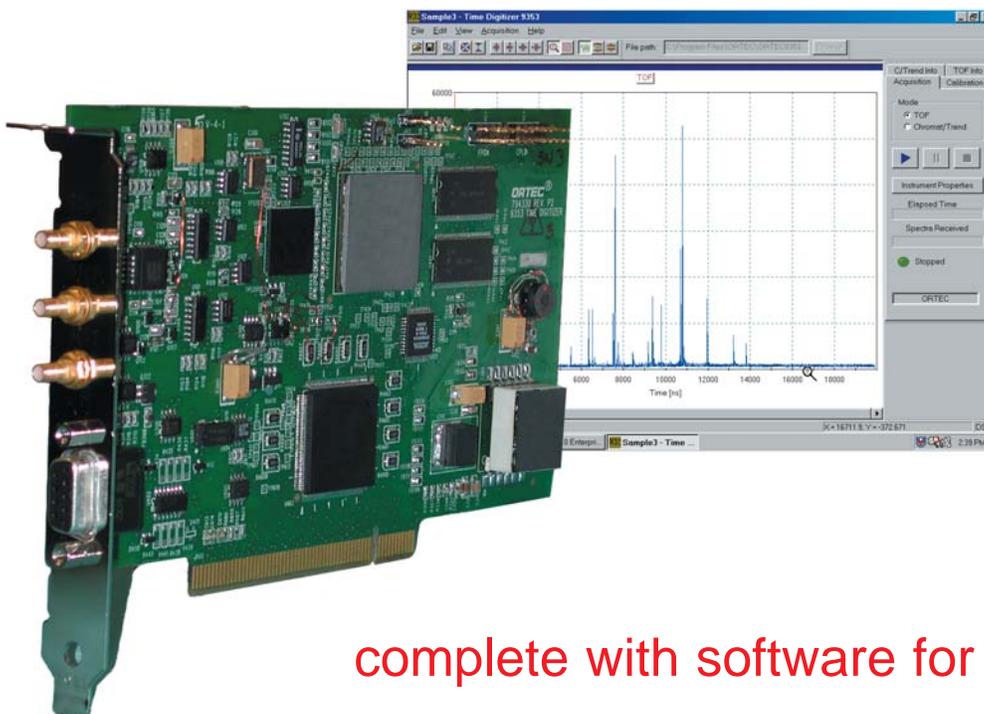
info@ortec-online.com • Fax (865) 483-0396
801 South Illinois Ave., Oak Ridge, TN 37831-0895 U.S.A. • (865) 482-4411
For International Office Locations, Visit Our Website



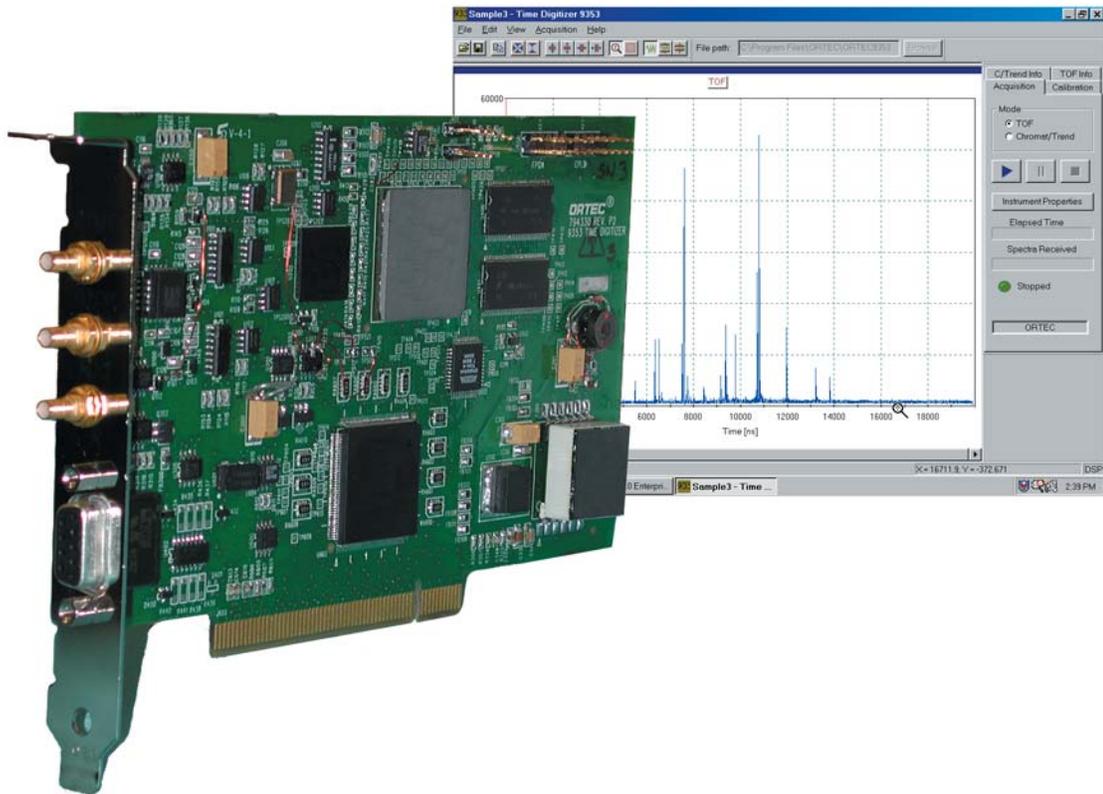
AMETEK
ADVANCED
MEASUREMENT
TECHNOLOGY

High-Burst-Rate Time Spectrometry...***from nanoseconds to milliseconds...******with 100-ps Precision***

- **Time-of-Flight Mass Spectrometry**
Exceptionally high data rates and superb digital resolution!
- **LIDAR**
1.5-cm digital resolution for 0 to 1,000 km!
- **Fluorescence/Phosphorescence Lifetime Spectrometry**
Measure lifetimes from ns to ms with one instrument!

All in a half-length PCI plug-in card . . .**complete with software for your PC**

100-ps Time Digitizer / MCS



- **1-GHz Burst Rates: Multiple Stop capability with 1-ns pulse-pair resolving time**
- **Digital resolution selectable from 100 ps to 13 μ s**
- **Time spans from 51.2 ns to 6.7 ms, (or to ∞ with customized roll-over monitoring)**
- **512 to 67 M time bins**
- **Dead time correction function enables a factor of 10 higher event rates**
- **Half-length PCI card; up to 4 units in the same computer**
- **Histogramming, List, Trend, and Chromatograph Modes implemented in software**
- **Complete with data acquisition, control, display and analysis software running under Windows[®] 98, NT, 2000 and XP¹**
- **ActiveX[™] controls provide an easy-to-use programmer's toolkit**

High Data Rates and High Resolution for the Most Demanding Applications

The Model 9353 100-ps Time Digitizer / MCS is a plug-in PCI card that functions as a time digitizer or a multichannel scaler. It measures the arrival times of Start pulses and multiple Stop pulses with a precision of 100 ps. Exceptional digitizing precision, speed and time span² make it ideal for Electrospray Time-of-Flight Mass Spectrometry, Orthogonal-Acceleration MALDI TOF-MS, LIDAR, and Fluorescence/Phosphorescence Lifetime Spectrometry.

The Model 9353 measures the arrival times of multiple Stop pulses after the most recent Start pulse. Deep, cascaded FIFO buffers accommodate burst rates up to 1 GHz and sustained rates up to 10 MHz. The pulse-pair resolving time for Stop events is 1 ns. A dead time correction algorithm, implemented in software, permits increasing the Stop event rate by an order of magnitude, while keeping dead time distortions of the time spectrum insignificant.

Flexible Time Spans and Bin Widths to Suit any Application

The time span following each Start pulse can be as short as 51.2 ns or as long as 6.7 ms, with the selected span distributed over as few as 512 time bins, or as many as 67,000,000 bins. The maximum time span can be extended to infinity utilizing the auto roll-over monitoring with customized software. The width of each time bin can be adjusted from 0.1 ns to 13.1072 μ s.

Minimize the Data File Size by Selecting List Mode or Histogramming Mode

The Time Digitizer / MCS can store the time information using either of two modes:

In the List Mode, the Start and Stop events are streamed to the supporting computer and onto hard disk as a list of 32-bit time stamps. This is a productive way to produce a compact file when the Stop event rates are low, and changes in the time spectrum occur over periods shorter than a few seconds. Each time stamp in the list marks the arrival time of a Start or Stop pulse with a precision of 0.1 ns. The time stamp for each Start pulse is referenced to the time at which the data acquisition commenced. For Stop pulses, the time stamp is referenced to the most recent Start pulse. The maximum value of the time stamp is approximately 6.7 ms for Stop pulses, and 125 hours for Start pulses. Either during or after acquisition, specific segments of the list can be selected and histogrammed by the software to display a time spectrum.

The Histogramming Mode produces a more compact file size when the data rates are high. In this mode, the software in the PC sorts and combines the Stop events following multiple Start pulses to form a spectrum of the number of Stop events versus their Start-to-Stop time. This spectrum is a histogram, because the horizontal axis is grouped into bins of 100-ps width. The resulting histogram is saved on hard disk. When the time digitizer is measuring the flight times of photons or charged particles over a fixed distance, this histogram is called the time-of-flight (TOF) spectrum.

More specifically, each Start pulse marks the beginning of a scan through the selected time span. The time stamps for the Stop pulses are expressed with zero time corresponding to the arrival of the prior Start pulse. The arrival time of a Stop pulse determines the appropriate bin in the histogram to which one count is added. This process of adding Stop events to the histogram is repeated for each scan until the desired number of scans has been completed. The resulting histogram is displayed as the number of Stop events (vertical axis) versus Start-to-Stop time (horizontal axis).

Histogramming improves the statistical precision of the data by summing the data from multiple scans. The precision improves in proportion to the square root of the number of scans summed. Histogramming can be performed on the data as it is being acquired, or on the list-mode data recalled from the hard disk.

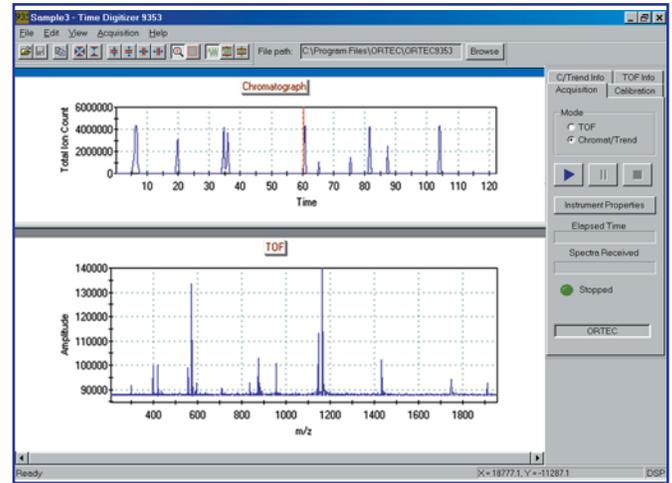
¹All trademarks used herein are the property of their respective owners

²US Patent Number 6,785,194

100-ps Time Digitizer / MCS

Perform Chromatograph/TOF-MS Acquisitions or Track Trends with the Chromatograph/Trend Mode

In the Chromatograph or Trend mode, the short-term changes in the Stop-pulse counting rate are tracked in a graph that displays the Trend or Chromatograph. Clicking on any point in this graph causes the TOF spectrum for that point to be displayed. The total number of Stop events in this TOF spectrum determines the ordinate for the corresponding point in the Chromatograph/Trend graph, while the first Start time stamp from the TOF spectrum specifies the abscissa. The TOF spectra from multiple points in the Trend graph can be summed and saved to improve the statistical precision.



Chromatograph/Trend Mode.

Ready-to-Run Application Software and a Programmer's Toolkit

The hardware comes complete with standard software for controlling data acquisition, display, manipulation, and storage on hard disk. The software runs under Windows 98, NT, 2000 and XP. In addition to the standard Windows features, the software provides:

- TOF X-axis calibration in user-defined units via least squares fitting to a linear, quadratic or cubic calibration curve.
- Post-acquisition dead time correction.
- Summing multiple TOF spectra to improve statistics
- 3-point and 5-point data smoothing to improve viewing statistics.
- Overlaying and comparing spectra.
- Exporting data in ASCII format.
- Copying display graphs to a file.
- Determining centroid, gross area and net area of a peak.

The software supports up to 4 Model 9353 cards operating simultaneously in the same computer.

ActiveX[®], Controls provide a programmer's toolkit to facilitate the writing of custom software. Custom software can take advantage of special combinations of the extensive hardware functions to add different features, or to integrate the 9353 into software controls for a larger system.

Supporting Electronics

Both the Start and Stop inputs of the 9353 include leading-edge timing discriminators capable of processing positive or negative detector pulses in the 50-mV to 5-V amplitude range, with widths as brief as 500 ps. Usually, the detector signal will need some amplification to optimize the timing performance with the 9353. Check the optional equipment list at the end of this brochure for suitable, fast amplifiers.

For applications where the desired time resolution is less than the rise time of the Stop pulse and the pulse amplitudes vary, a low-walk timing discriminator, such as the ORTEC model 935, 9307 or 9327, must be inserted before the Stop input. See the section on optional equipment or the ORTEC catalog for further information.

SPECIFICATIONS

Hardware

PERFORMANCE

TIME-STAMP CLOCK FREQUENCY: 10 GHz; 100-ps digital time resolution, with no interpolator. Arrival of the input pulse leading edge captures the clock time. Accuracy: within 20 ppm from 0 to 50°C. Temperature sensitivity <1 ppm/°C.

TIMING JITTER: FWHM analog timing jitter is <200 ps +0.05 ppm of the Start-to-Stop time interval. (Typically <145 ps FWHM from 0 to 200 μ s.)

INPUT DEAD TIME: 1-ns pulse-pair resolving time for the Stop Input. Dead time after the Start Input < 5 ns.

DIFFERENTIAL NON-LINEARITY³: For Start-to-Stop times >25 ns, bin widths are uniform within $\pm 1\%$ of the average bin width, or within ± 2 ps, whichever is larger.

INTEGRAL NON-LINEARITY⁴: The time scale is linear from 0.25 μ s to 200 μ s within 20 ps rms (i.e., 0.1 ppm of 200 μ s).

FIFO BUFFER MEMORIES: A fast FIFO handles bursts up to at least 256 input events at a maximum rate of 1 GHz (4 GB/s). The fast FIFO is drained at 78 M words/s into a 128-word FIFO, with Start events occupying 3 words and Stop events employing one word. The 128-word FIFO is drained at >15 M words/s into a slow FIFO having a depth of 8-M-words. The data is streamed from the slow FIFO to the computer through the PCI bus in a list mode at a maximum burst rate of 33 M words/s (132 MB/s). Note that the computer software or operating system can become the limiting bottleneck for extracting the data from the PCI bus. For a bus availability >50%, the time digitizer is capable of sustaining an average data transfer rate >10⁷ Stop events per second. The maximum rate for Start events is 1/3 the maximum rate for Stop events.

WORD LENGTH: 4 Bytes at the PCI bus. Each accepted Start pulse generates three, successive, 32-bit words. The first word incorporates the lower-order bits of the arrival time in bits 0 to 25. The second word contains the higher-order bits of the arrival time in bits 0 to 25. The third word contains the Start Pulse Number in bits 0 to 25. Each accepted Stop pulse generates one 32-bit word, with the arrival time in bits 0 to 25. A roll-over tracking word is automatically inserted in the data stream every 3.355443 ms, if there is no Start or Stop event within 12 ns of that time stamp. A data-padding word (contains no useful information) may be inserted occasionally to complete a desired array length. For all Stop and roll-over words, the arrival time is measured with respect to the preceding Start pulse (mod 6.710886 ms). For Start pulses, the time is measured relative to the most recent Reset before starting acquisition. Moving from the most significant bits (MSB) to the least significant bits (LSB), the bits in each word are reserved as follows:

- **31:** Warning Flag. See FIFO Overflow Warnings.
- **30:** Set to 1 for Start events. Set to 0 for Stop events, clock roll-over tracking words, and data padding words.
- **29 & 28:** On Start words, these two bits reflect the TTL input tag bits that can be used to specify one of 4 external operating conditions. The TTL inputs are strobed by the Start pulse. Both bits are forced to zero on Stop events. On clock roll-over tracking words, bits 30 and 28 are set to 0, and bit 29 is set to 1. For data padding words, bit 30 is set to zero, while bits 29 and 28 are set to 1.
- **27 & 26:** Identification of the three Start words. Bits 26 and 27 are both zero in the first Start word, which contains the lower-order bits of the time stamp in bits 0 through 25. Bit 26 is 1 and bit 27 is 0 for the second Start word, which incorporates the higher order bits of the time stamp in bits 0 through 25. Bits 26 and 27 are both 1 on the third Start word, which contains the sequential Start number in bits 0 through 25.
- **25 to 0:** Used for capturing the arrival time from the 10-GHz clock on all Stop pulses, roll-over tracking words, data-padding words, and for the first two words of each Start pulse. With 26 bits, the clock rolls over at 6.710886 ms on Stop pulses, and at approximately 125 hours on Start pulses. On the third word for Start pulses, the information in bits 0 to 25 is replaced by the Start Pulse Number from the Start Pulse Counter.

³Measured as a \pm deviation of the counts per bin relative to the average counts per bin, using uncorrelated start and stop pulse generators, with sufficient counts to render the random error negligible compared to the inherent differential non-linearity.

⁴Measured with pulser peaks at 0.25- μ s intervals by calculating the deviation of each peak's centroid from a straight line drawn between the centroids of the peaks nominally at 0.25 μ s and 200 μ s.

100-ps Time Digitizer / MCS

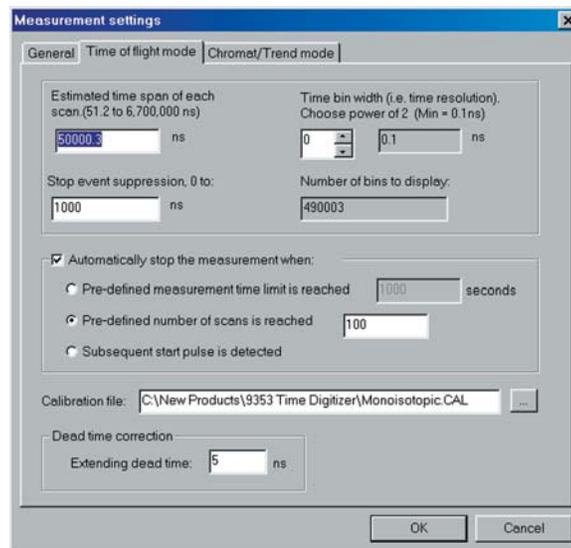
START PULSE COUNTER: A counter records the sequential number of the Start pulse received at the Start Input. This counter runs continuously with a roll-over established by the 26 bits allocated in the Word Length above. Start pulses that arrive when the computer has disabled acquisition do not increment the counter. The value in this register is substituted for the time stamp in bits 25 to 0 in the third word from each Start pulse. The register can also be read and reset to zero by the computer.

TIME SPAN OF EACH SCAN: The hardware discards Stop events with time stamps larger than the selected limit. This can reduce data processing rates for the PC. With the standard software, the limit can be set from 51.2 ns to 6,700,000 ns in 0.1-ns steps. For customized software, this feature can be enabled or disabled by setting/resetting a bit in the control register. When the limit is disabled, the time interval between Start events determines the maximum Stop time.

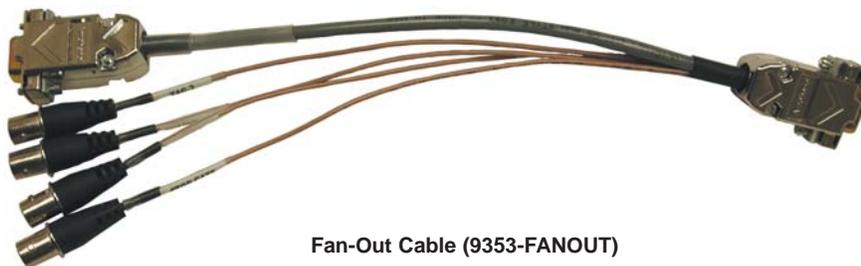
STOP EVENT SUPPRESSION: The hardware discards Stop events with time stamps smaller than the selected limit. With the standard software, the limit can be set from 0 to 6,700,000 ns in 0.1-ns steps. But, the limit must be at least 512 bins less than the Time Span of Each Scan. This feature significantly reduces the data rates for the PC, and also minimizes the memory required for acquiring and saving the time spectrum, when only the last portion of the time span is of interest. For customized software, this feature can be enabled/disabled by setting/resetting a bit in the control register.

SLOW FIFO OVERFLOW RECOVERY: When the 8-M-word slow FIFO is 7/8 full, the next Start event and all events following the next Start event are discarded. Once the FIFO is drained to less than half full, the FIFO resumes processing Start and Stop events, commencing with the next Start event. This process ensures that no partial scans are accepted when there is a slow FIFO overflow due to data blockage in the supporting computer, thus avoiding spectra distortion. To flag the missing scans, error bit 31 is set on the first Start event when processing resumes, and is automatically cleared immediately thereafter. The standard software displays a warning when a FIFO overflow has occurred.

INTERFACE TO PC: Packaged as a half-length PCI-bus plug-in card. The 8-MB FIFO buffer memory depth permits 4 time digitizers to be serviced simultaneously by the same PC at essentially the same total data rate that is possible with a single card.



Controls for the TOF Mode.



Fan-Out Cable (9353-FANOUT)

INPUTS AND OUTPUTS

START INPUT: Rear-panel SMA connector with 50-Ω input impedance. Input comparator threshold adjustable from –2.5 V to +2.5 V in nominally 10-mV steps with a DAC under software control. Trigger polarity is selectable by software for positive or negative slope. Maximum linear input: ±5 V. Protected against overloads to ±5 V dc, and ±15 V for pulse widths <25 ns. Minimum pulse width at threshold: 0.5 ns.

STOP INPUT: Rear-panel SMA connector with 50-Ω input impedance. Input comparator threshold adjustable from –2.5 V to +2.5 V in nominally 10-mV steps with a DAC under software control. Trigger polarity is selectable by software for positive or negative slope. Maximum linear input: ±5 V. Protected against overloads to ±5 V dc, and ±15 V for pulse widths <25 ns. Minimum pulse width at threshold: 0.5 ns.

ENABLE ACQUISITION GATE: Rear-panel TTL input (SMA connector) provides a means of rejecting Start and Stop input signals by setting the gate input to the low TTL state. Input impedance is 5 kΩ to +3.3 V. Pulling the input low rejects Start and Stop pulses, commencing with the next Start pulse.

Returning the input to the high state enables the collection of Start and Stop pulses, commencing with the next Start pulse. The gate pulse must precede the first Start pulse to be rejected by >50 ns and persist until >10 ns after the leading edge of the last Start pulse to be rejected.

STOP INPUT GATE: TTL input provides a means of rejecting Stop input signals by setting the gate input to the low TTL state. Input impedance is 5 kΩ to +3.3 V. This can be used to block Stop events in specific portions of the scan. The gate pulse must precede the first Stop pulse to be blocked by >50 ns and persist until >10 ns after the leading edge of the last Stop pulse to be blocked. The gate input is provided on the 9-pin D connector via signal and ground pins.

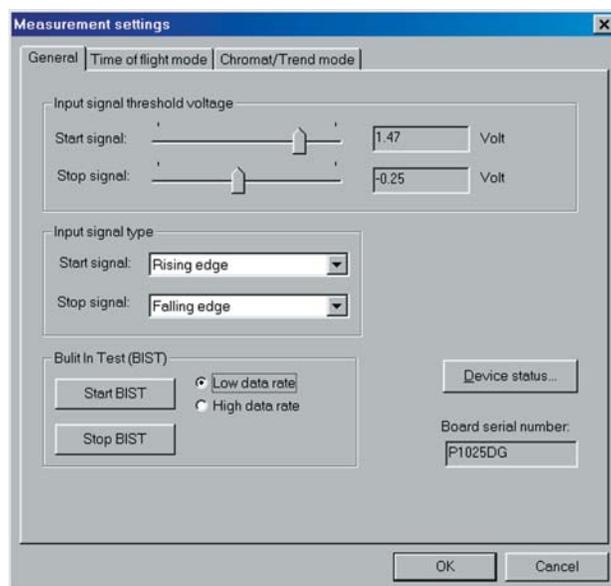
TAG INPUTS: Two pairs of signal and ground pins on the 9-pin D connector accept TTL tag signals to identify one of 4 external measurement conditions that applies to the current scan. Each Start pulse strobes and captures the state of the 2 tag inputs. Input impedance is 5-kΩ to ground. Protected to ±10 V. The Tag pulses must precede the Start pulse by >50 ns and persist until >10 ns after the leading edge of the Start pulse.

PREAMPLIFIER POWER OUTPUT: One set of pins on the 9-pin D connector provides +12 V power and ground for a 9326 Fast Preamplifier, a VT120 Fast-Timing Preamplifier, or a 9327 1-GHz Amplifier and Timing Discriminator.

9-PIN D CONNECTOR: Mounted on the rear panel of the PCI plug-in card. Provides access to the Stop Input Gate, the Enable Acquisition Gate, two Tag Inputs, and the preamplifier power. Pin assignments are:

Pin Number	Function
1	Preamplifier ground
2	Preamplifier ground
3	Logic signal ground
4	+12 V dc Preamplifier Power
5	Logic Signal ground
6	Stop Gate
7	Enable Acquisition Gate
8	Tag 0
9	Tag 1

FAN-OUT CABLE (Optional): Converts the 9-pin D connector to one standard ORTEC 9-pin D preamplifier power connector and 4 BNC connectors for the Stop Gate Input, Enable Acquisition Gate, and the Tag Inputs.



Input Discriminator Settings and General Controls.

100-ps Time Digitizer / MCS

COMPUTER CONTROLS AND INDICATORS

DATA ACQUISITION CONTROL: ActiveX Controls provide the interface between the application software and the hardware, providing access to and control of all of the hardware features. Notably, the supporting computer can stop and start data acquisition at the input to the Fast FIFO. It can also clear the FIFOs, and clear any warning bits that are set in the status register. All FIFOs can feed their data to the PC until they are empty.

FIFO OVERFLOW WARNINGS: Bit 31 in the time-stamp word is set when any of the warning flags are set. Reading the status register will clarify the condition causing bit 31 to be set. The computer can read and clear these warning flags. The status register includes the following flags.

Slow FIFO Overflow: Set on the first accepted Start pulse after the slow FIFO has recovered from an overflow. Automatically reset otherwise.

Fast FIFO Overflow: An overflow sets this flag, and a reset command from the computer is required to clear it.

When an excessive, sustained data rate or a PC bottleneck has caused a FIFO overflow, the standard software uses the overflow flags to advise the operator.

POWER AND PACKAGE

POWER SOURCE: Nominally 1.7 A at +5 V plus the current drawn by any attached preamplifier from the +12-V supply. Power obtained from the PC power supply via the PCI bus connector.

MECHANICAL PACKAGE: Half-length PCI-bus plug-in card, 10.7 cm x 17.7 cm.

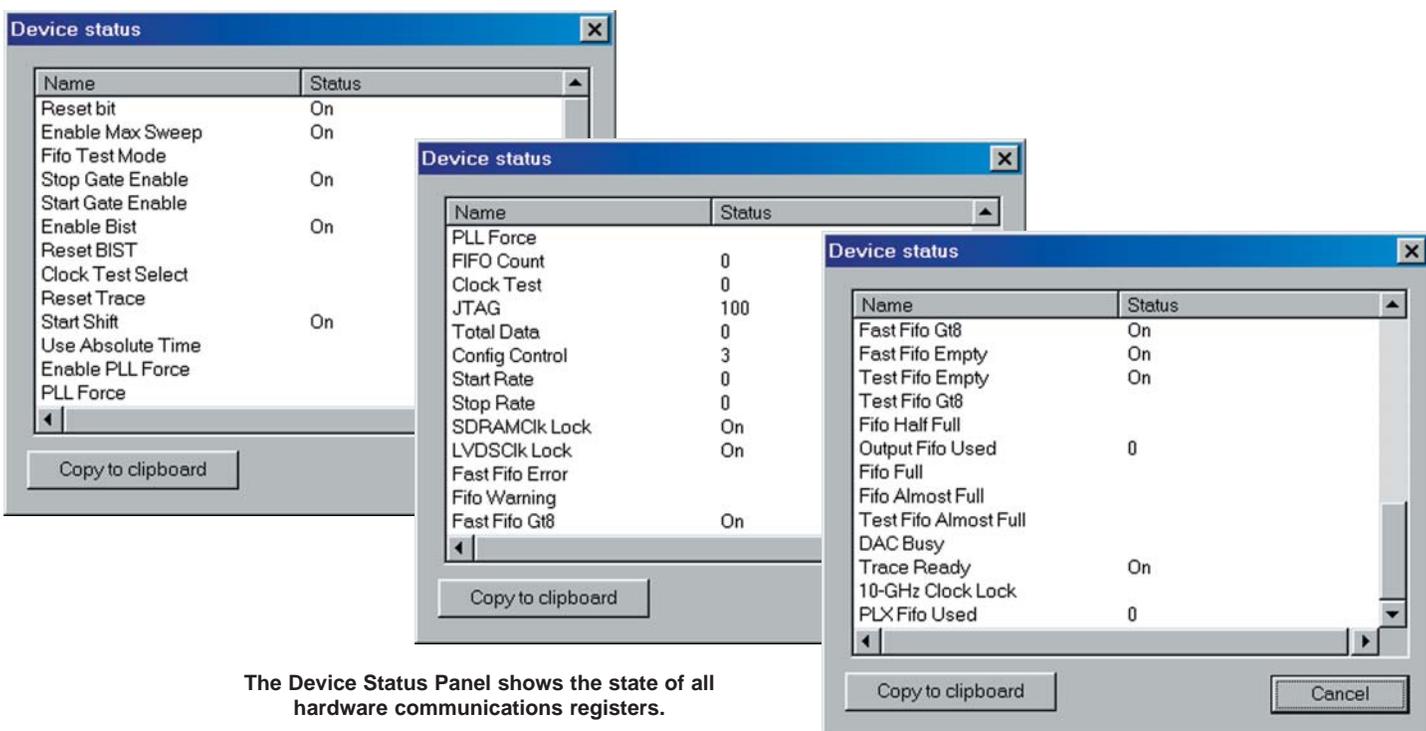
WEIGHT:

Net: 0.14 kg (0.32 lb.)

Shipping: 1 kg (2.3 lb.)

AMBIENT OPERATING ENVIRONMENT: 0 to 50°C at 0 to 80% non-condensing humidity.

CE: Conforms to CE standards for radiated and conducted emissions, susceptibility, and low-voltage power directives.



Standard Application Software

The standard application software provided with the 9353 hardware runs under Windows® 98, NT, 2000, and XP with no programming required. The software provides control of all functions (see hardware specifications) plus data acquisition, display, and manipulation. Important controls and features are summarized below.

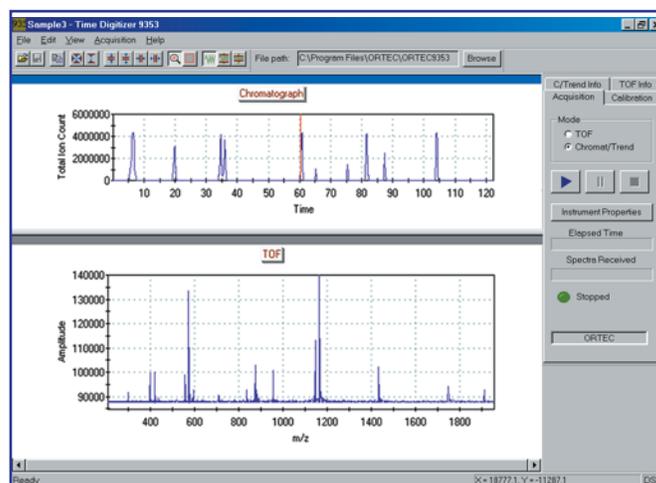
TOF Mode: Provides the ability to collect a single time-of-flight spectrum for a specified number of Start pulses. The data is histogrammed in software, and the updating results are displayed live during data acquisition. Number of Start pulses (scans) per spectrum is selectable from 1 to 10^{10} .

Chromatograph/Trend Mode: Multiple time-of-flight spectra are acquired and saved on hard disk in rapid succession. The operator can select the number of Start pulses or scans per spectrum from 10 to 10^7 . The Chromatograph/Trend display shows the total Stop event count in each successive TOF spectrum versus the time stamp for the first Start pulse in each TOF spectrum. For chromatograph/TOF-MS applications this display is the total-ion chromatograph. Clicking on a point in the Chromatograph/Trend display causes the corresponding TOF spectrum to appear in the bottom portion of the display. The operator can choose a limit for the number of TOF spectra to be acquired (1 to 3,600,000). One of two methods for data storage on hard disk can be selected in the Chromatograph/Trend mode. The Software Histogramming Mode produces the most compact data storage file at high counting rates, whereas the List Mode yields a smaller file for low data rates.

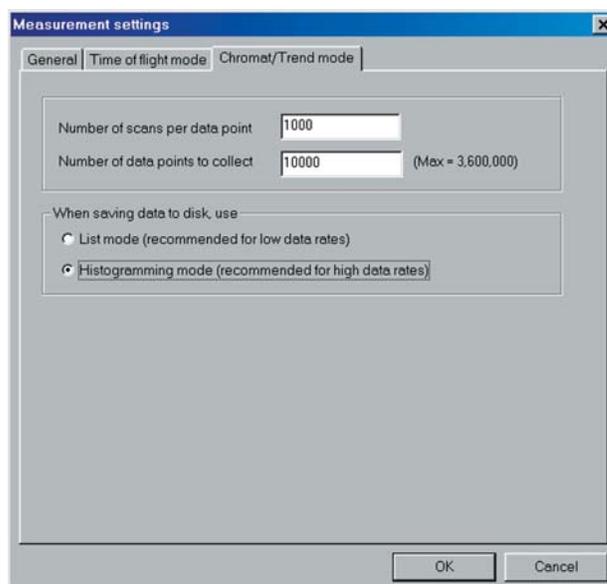
Software Histogramming Mode: The incoming data is histogrammed in the PC memory for intervals determined by the number of Start pulses prescribed by the operator. The result is a sequence of histogrammed time-of-flight spectra that are stored in a common file on hard disk.

List Mode: The list of Start and Stop time stamps from the hardware are stored directly on hard disk without histogramming. The ordinate for each point in the Chromatograph/Trend display is generated by summing all the Stop counts for a prescribed number of sequential Start pulses. The time for each point is obtained from the first Start pulse in each summed sequence. Clicking on any chromatograph/trend point causes the software to histogram and display the corresponding TOF spectrum by recalling the appropriate segment of the list of time stamps from the hard disk.

CHANGING DISPLAY LABELS AND FORMAT: The displays can be customized to suit the application. Right-clicking on the TOF or Chromatograph/Trend display opens a menu that permits the operator to change most aspects of the graphical display. This includes changing the text used for the titles and the X- and Y-axes labels, choosing the symbols for the points, selecting a logarithmic or linear Y axis, and altering the colors for the titles, labels, axes, lines, grids and symbols.



The Chromatograph/Trend Mode with the TOF-MS Spectrum Calibrated in Units of m/z.



Controls for the Chromatograph/Trend Mode.

100-ps Time Digitizer / MCS

TOF HORIZONTAL SCALE CALIBRATION: The TOF X-axis can be accurately calibrated in appropriate units for the application. A choice of linear, quadratic or cubic function is offered for least squares fitting of a calibration curve in user-specified units for the horizontal axis.

DEAD TIME CORRECTION ALGORITHM: A software dead time correction algorithm⁵ offers post-acquisition corrections of any TOF spectrum for the known value of extending dead time in the system. This permits a factor of 10 higher data acquisition rates with negligible dead time distortion of the time spectrum.

DISPLAYED TIME RESOLUTION: Software selectable from 0.1 ns per bin to 13.1072 μ s per bin in a 1, 2, 4, 8, ... binary sequence.

TIME SPAN: 51.2 ns minimum to 6.7 ms maximum. Minimum number of bins: 512. Maximum number of bins⁶: 67,000,000.

STOP EVENT SUPPRESSION: Software selectable limit from zero up to the selected time span minus 512 bins. Stop events with time stamps less than this limit are discarded before the slow FIFO in the hardware to reduce data rates and the size of allocated memory. Useful when measuring a small time interval near the end of a long flight time.

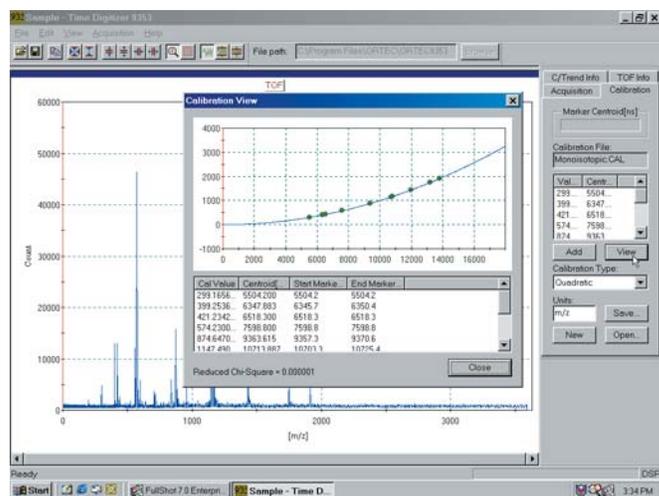
TOF INFO AND C/TREND INFO: Peak centroid, gross area, and net area above background are displayed when a peak region is marked in either the TOF or the Chromatograph/Trend display.

TOOLBAR: Buttons provide controls for magnifying and contracting the displayed regions of the spectra, performing a 3-point or 5-point smooth on the data to reduce statistical noise, plus the normal Windows functions.

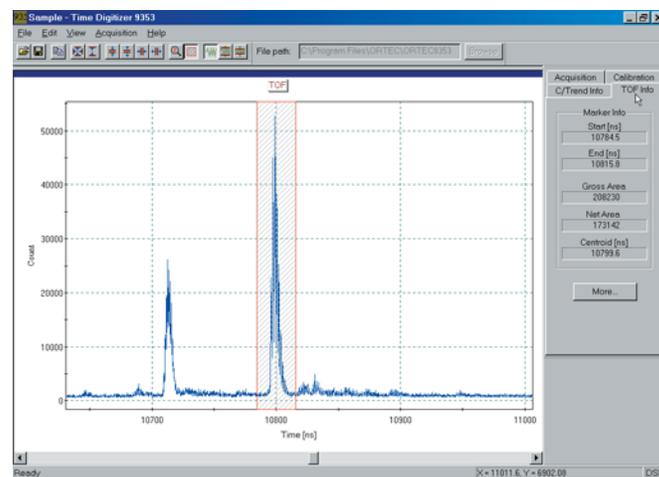
ADDITIONAL FUNCTIONS are available from menus or by right-clicking the mouse to:

- perform dead time corrections
- toggle between uncorrected and corrected spectra
- implement horizontal scale calibration
- toggle between calibrated and uncalibrated scales
- overlay and compare spectra
- sum multiple TOF spectra to achieve better statistics
- save spectra
- export data to file in an ASCII format
- copy the graphs to a file
- view or set the instrument operating properties

PROGRAMMER'S TOOLKIT with ActiveX[®], controls is provided along with the standard data acquisition, control, display and manipulation software to facilitate development of custom software.



Viewing the Quality of the Fit for the Calibration Curve.



Viewing the Centroid, Gross Area and Net Area above Background for the Peak Bounded by the Start and End Markers.

⁵ORTEC Application Note AN57 Dealing with Dead Time Distortion in a Time Digitizer, February 2001.

⁶Each data point requires 16 Bytes of free PC RAM beyond that required for software programs. For 67,000,000 time bins at least 1.072 GB of free RAM is required for the TOF spectrum.

COMPUTER PREREQUISITES

Hardware

IBM-compatible PC with:

- One available PCI-bus slot with space for a 17.7-cm card length,
- >200 MHz CPU,
- At least 500 MB of memory⁶,
- 20-GB Hard drive or larger,
- CD-ROM (Software is supplied on a CD.)

Software

Windows[®] 98, NT V 4.0, 2000 or XP

OPTIONAL AND RELATED EQUIPMENT

Typically, the signal from the detector must be amplified before presentation to the Stop Input of the 9353. The following ORTEC Models should be considered for that purpose:

- VT120 Fast Timing Preamplifier
- 9305 Fast Preamplifier
- 9306 1-GHz Preamplifier
- 9326 Fast Preamplifier

For detector signals exhibiting substantial variations in pulse amplitude, inserting a timing discriminator between the amplifier output and the 9353 Stop Input can reduce the resolution broadening caused by varying amplitudes. This is important when the desired time resolution is less than the rise time of the Stop pulses. Consider the following ORTEC models:

- 935 Quad, 200-MHz, Constant-Fraction Discriminator
- 9307 pico-TIMING™ Discriminator
- 9327 1-GHz Amplifier and Timing Discriminator

Because of space and rise time considerations, the 9353 uses SMA connectors for some signals. SMA-to-BNC adaptors may be needed depending on the connectors on the supporting electronics. For 50-Ω coaxial cables, cable adapters, and other options, consult the ORTEC catalog.

ORDERING INFORMATION

To order, specify:

- 9353** Time Digitizer / MCS (includes 9353-B32 software and instruction manual)
- 9353-FANOUT** Fan-Out Cable (optional)

100-ps Time Digitizer/MCS

Model 9353

Specifications subject to change
051605

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TECHNOLOGY

• **Save Your Investment – Convert these ORTEC MCA's to USB:**

919	921	DSPec
919E	921E	92X-P (NOMAD)
920-8	926	NOMAD-Plus
920-16	92X	OCTETE-PC
920E	92X-II	



- **Simple Install – Connect the cable and update the drivers!**
- **No external cable required – powered from the USB.**
- **USB 2.0 Compatible.**

Since the inception of the personal computer, ORTEC has provided MCB's which couple to the PC via a flat ribbon cable to an ISA card in the computer. The ISA (Industry Standard Architecture) Bus is now almost completely extinct. Today's modern PC's often do not have option slots of any type, but all have USB ports. An enhancement to the *CONNECTIONS-32* product family, the DPM-USB interface provides a means to convert the ORTEC Dual-Port Memory (DPM) communication to USB.

For ORTEC MCA owners the conversion from the ORTEC DPM to USB preserves their hardware investment and allows PC upgrades. The model DPM-UPGRADE-USB includes the hardware for the USB connection and the driver update for the software. The upgrade provided with the model DPM-UPGRADE-USB will also update drivers for any user-developed programs written using the *CONNECTIONS* Programmers' Toolkit (Model A11-B32). Of course updating the MAESTRO, GammaVision, ScintiVision, or AlphaVision software would be advisable to take full advantage of all the features of the latest ORTEC analysis products.

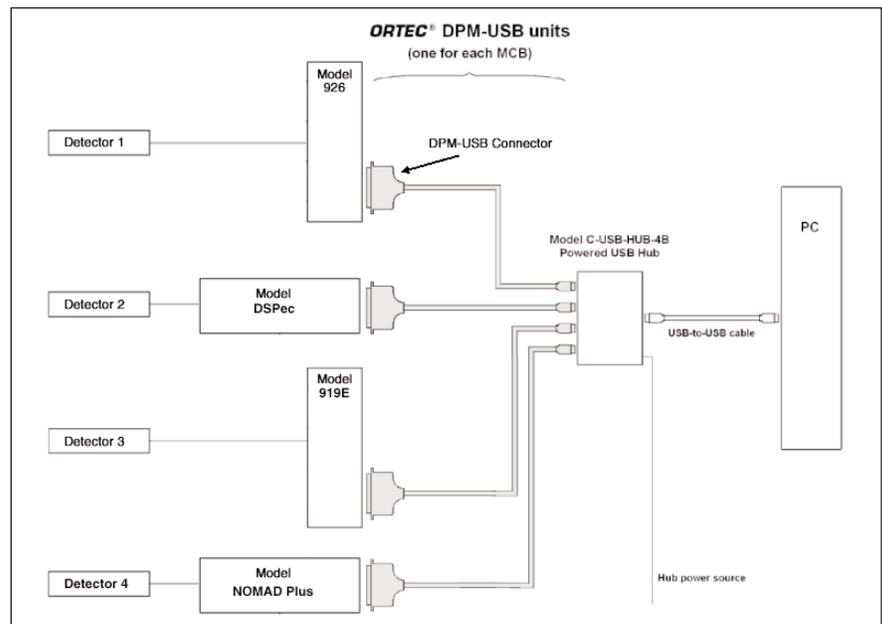
The model DPM-USB connects directly to the 37-pin D-connector on the rear panel of ORTEC MCA hardware (NIM and non-NIM) and to the USB port of a PC. The Model DPM-USB is fully compatible with USB 2.0 and operates at a maximum data transfer rate of 12-Mb/second.

Multiple USB connections to a single PC can be achieved by use of a powered USB hub. ORTEC offers two models of powered USB hubs (see Accessories). Up to eight MCB units can be connected to a single PC in this manner.

The DPM-USB interface converter adapts any of the below listed ORTEC MCB instruments to a PC with an available USB port. Installing the model DPM-USB is accomplished by simply plugging in the connectors. Be sure to install the software and any upgrades before connecting this interface.

Compatible ORTEC models:

919	920E	92X	92X-P (NOMAD)
919E	921	92X-II	NOMAD-Plus
920-8	921E	DSPec	OCTETE-PC
920-16	926		



DPM-USB

ORTEC Dual-Port Memory to USB Converter

Example:

For remote operation, ORTEC offers the model USB-CONC-110 or model USB-CONC-220. These units will interface USB connections to the Ethernet using TCPIP protocols. The USB-CONC-110 or USB-CONC-220 provides connections for up to 5-each USB devices.

Specifications

Input/Output: Female 37-pin D-connector with captive 5 meter (15-ft.) USB cable.

Power Required: Provided by the USB connection.

Dimensions: 2.75-in. (7-cm) W, 2.75-in. (7-cm) D, and 0.75-in (1.9-cm) H 37-pin D-connector with captive 5-m USB cable.

Net Weight: 1-lb. (0.45-kg), shipping weight 5-lb. (2.27-kg).

Ordering Information

Model	Description
DPM-USB	Dual-Port Memory to USB Interface Converter
DPM-UPGRADE-USB	DPM-USB and CONNECTIONS-32 Driver Update to MAESTRO-32
DPM-M32-USB	DPM-USB with MAESTRO-32 software

Accessories

C-USB-HUB-4B	4-port powered USB hub
C-USB-HUB-7B	7-port powered USB hub
USB-CONC-110	5-port USB to Ethernet converter – 110V/60Hz
USB-CONC-220	5-port USB to Ethernet converter – 220V/50Hz

Specifications subject to change
031506

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The Complete, Economical, and Easy to Install Multichannel Analyzer System

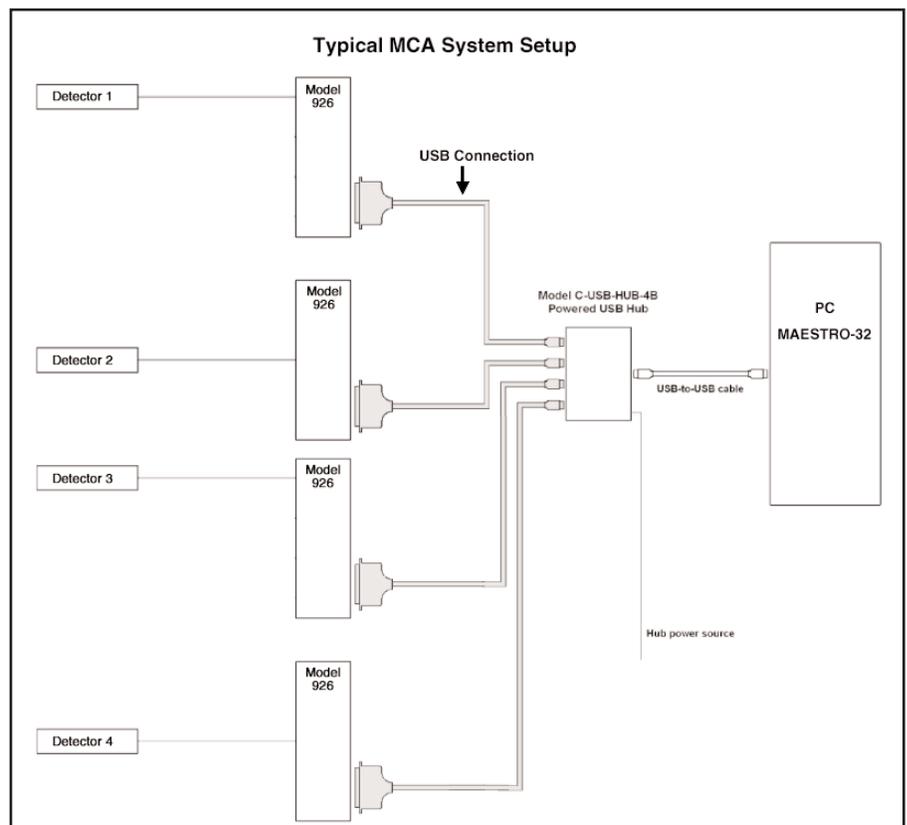
- **926 MCB in a one-wide NIM**
 - 8000-channel ADC (8 μ s)
 - Two methods for Dead-Time correction
 - 2 billion counts/channel
 - Multiple presets
 - Multiple computer interfaces
 - GATE, BUSY, and PUR Inputs
- **USB connectivity**
 - Simple to install USB Interface
 - Direct connection to legacy ORTEC devices
 - Optional interface for PC parallel port connection
- **MAESTRO-32 MCA emulation software**
 - Advanced peak search algorithms
 - Windows graphical user interface



The ORTEC Model 926 Multichannel Buffer (MCB) is a single-wide NIM module designed for high performance in real-time data acquisition. The 926 is a hardware component that provides Analog-to-Digital Conversion (ADC) and Memory. A personal computer is interfaced, through the provided USB connector, to utilize the data acquisition, storage, display, and analysis functions. This is accomplished by issuing ASCII commands from the PC to the 926 MCB's internal 80C188 microprocessor.

Extended Live-Time correction according to the Gedcke-Hale method,¹ or Simple Live-Time correction with the clock turned off during the conversion time, can be selected using printed wiring board jumpers.

MAESTRO-32 MCA Emulation software and quantitative analysis software are available for use with a variety of personal computers in the Windows environment. The easy-to-use command language complies with the standard NIM digital bus NIM/488 per DOE/ER-0457T (formerly NIM/GPIB) protocol definitions.² Control of all functions, including acquisition, presets, and ADC conversion gain are provided using this protocol.



USB Connectivity

The USB connector allows you to operate the 926 MCB from any supported computer that has an available USB port. The cable provided has a 37-pin D-connector that is attached to the rear of the 926 MCB. The USB connector is then plugged into the PC USB port. You can even connect multiple 926 MCBs into a single PC, through a powered USB hub.

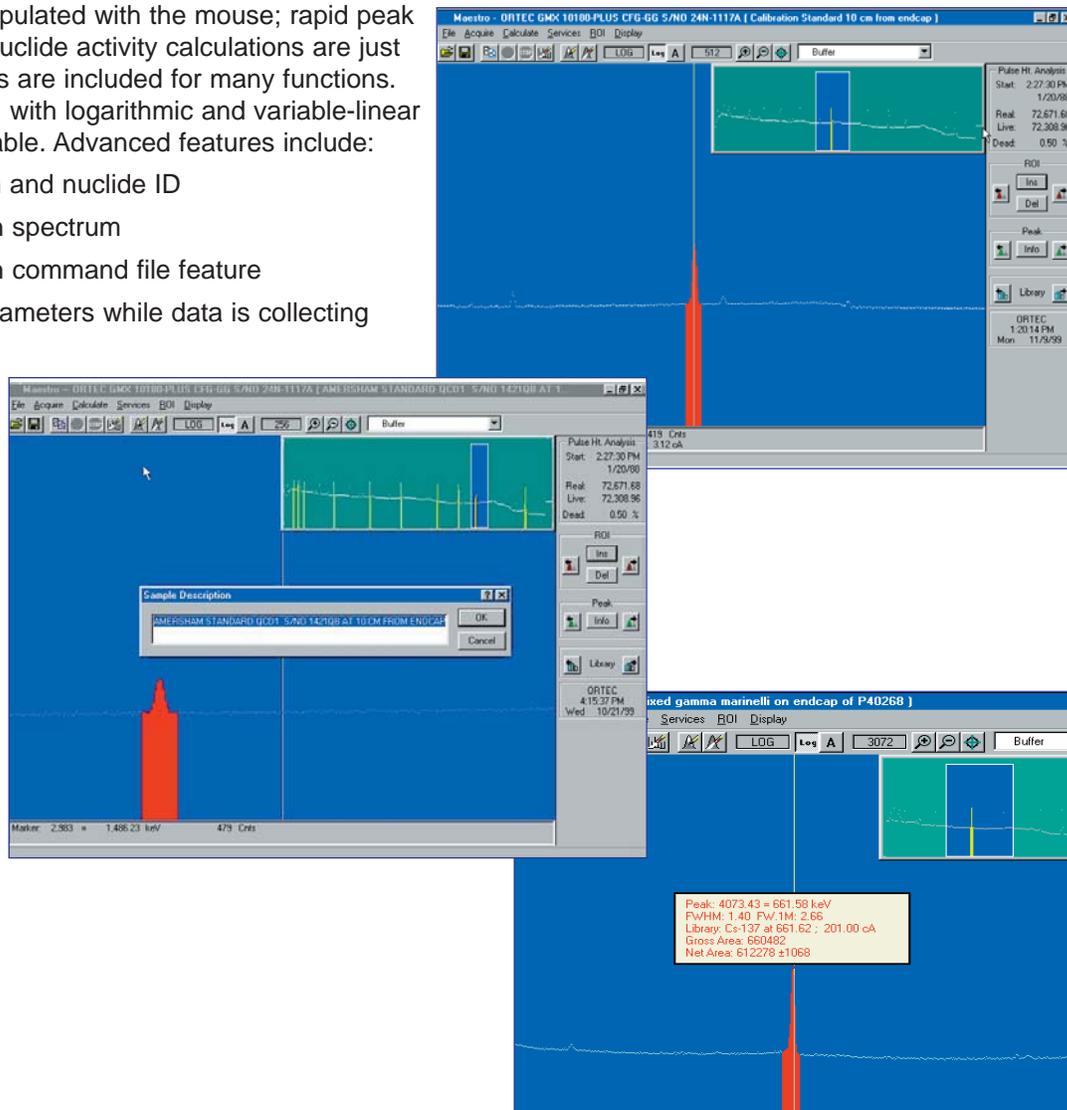
If you have an older PC that does not have USB ports, an optional female 25-pin D-connector is provided. To utilize, simply remove the manufacturer installed connector and mount the optional female connector. Attach the 926 MCB to your PC using the optional Interface/Cable Pack.



The 926 Operates with the Latest MCA Emulation Software . . .

MAESTRO-32 MCA Emulation provides, under the popular Windows Graphical User interface, an advanced MCA Emulator that is easy to use by keyboard or mouse. The truly live spectral display is easily manipulated with the mouse; rapid peak searches, ROI settings, and nuclide activity calculations are just a button click away. "Hot" keys are included for many functions. Up to 16k-channel full display, with logarithmic and variable-linear vertical display scale, is available. Advanced features include:

- Mariscotti2 fast peak search and nuclide ID
- Index to next ROI or peak in spectrum
- Automatic operation through command file feature
- Live update of key peak parameters while data is collecting
- Peak centroid and shape calculation
- Net Area and Gross Area for peaks
- Spectrum Sum
- Spectrum Smooth
- Quadratic energy calibration, with shape parameter, stored to disk



926-M32-USB

Multichannel Analyzer

Specifications

PERFORMANCE

ADC Successive-approximation type with sliding-scale linearization.

MAX RESOLUTION 8192 channels, software selectable as 8192, 4096, 2048, 1024, and 512.

DEAD TIME PER EVENT 8 μ s, including memory transfer.

INTEGRAL NONLINEARITY $\leq \pm 0.025\%$ over the top 99% of the dynamic range.

DIFFERENTIAL NONLINEARITY $< \pm 1\%$ over the top 99% of the dynamic range.

GAIN INSTABILITY $\leq \pm 50$ ppm/ $^{\circ}$ C.

DEAD TIME CORRECTION Printed wiring board jumper selects either Extended Live Time correction according to the Gedcke-Hale method, or Simple Live Time correction with the clock turned off during the conversion time.

DATA MEMORY 8k channels of battery backed-up memory; $2^{31}-1$ counts per channel (over 2 billion).

PRESETS

Real Time/Live Time Multiples of 20 ms.

Region of Interest Peak count/Integral count.

Data Overflow Terminates acquisition when any channel exceeds $2^{31}-1$.

MICROPROCESSOR Intel 80C188; 32k Dual-Port RAM with battery backup; 16k "scratchpad" RAM with battery backup. 32k program memory.

FRONT-PANEL INDICATORS AND CONTROLS

CPU BUSY Red, busy-rate LED; intensity indicates the relative activity of the microprocessor.

ADC BUSY Red, busy-rate LED flashes once for each pulse digitized by ADC.

ADC ZERO Screwdriver potentiometer, ± 250 mV.

ADC LLD Screwdriver potentiometer, from 0 to 10% full scale.

INPUTS AND OUTPUTS

INPUT Accepts positive unipolar, positive gated-integrator, or positive-leading bipolar analog pulses in the dynamic range from 0 to +10 V; +12 V maximum; semi-Gaussian-shaped or gated-integrator-shaped time constants from 0.25 to 30 μ s, or delay-line-shaped with width > 0.25 μ s. $Z_{in} \approx 1$ k Ω , dc-coupled. No internal delay. BNC connectors on front and rear panel.

ADC GATE Optional, slow-positive NIM input. Computer-selectable Coincidence or Anticoincidence. Signal must occur prior to and extend 0.5 μ s beyond the peak of the pulse; front-panel BNC connector. $Z_{in} \sim 1$ k Ω .

PUR Pile-up rejection input; accepts slow-positive NIM signal; signal must occur prior to peak detect. $Z_{in} > 1$ k Ω . BNC connector on rear panel.

BUSY Busy input used by live-time correction circuits. Accepts slow-positive NIM signal; signal must occur prior to peak detect. $Z_{in} > 1$ k Ω . BNC connector on rear panel.

DUAL-PORT MEMORY (ORTEC) 37-pin D-connector provides the PC with a communication link and direct access to the Model 926's internal data memory.

PARALLEL PORT Provides for control of the instrument and access to the data memory from a standard IBM PC printer port; male 25-pin D-connector.

PRINTER User installed connection provided to attach either another 926 MCB or a printer to the system; jumper selectable; female 25-pin D-connector.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 200 mA; -12 V, 200 mA; +6 V, 600 mA.

WEIGHT

Net 0.9 kg (2 lb).

Shipping 2.25 kg (5 lb).

DIMENSIONS NIM-standard single-wide 3.43 x 22.13 cm (1.35 x 8.714 in.) front panel per DOE/ER0457T.



926-M32-USB

Multichannel Analyzer

Ordering Information

To order, specify:

Model	Description
926-M32-USB	926 Multichannel Buffer MAESTRO-32 for Windows MCA Emulation Software Driver update (CONNECTIONS-32) DPM to USB interface converter (5 meters) Female 25-pin D-connector
926-USB	926 Multichannel Buffer DPM to USB interface converter (5 meters) Female 25-pin D-connector
926-M32:	926 Multichannel Buffer MAESTRO-32 for Windows MCA Emulation Software Female 25-pin D-connector
926	926 Multichannel Buffer Female 25-pin D-connector

Interface/Cable Packs

Printer Port Operation

926-C-10	Cable, RS-232-C, 25 conductor, 10 feet (3 m), male to female
926-C-2	Cable, RS-232-C, 25 conductor, 2 feet (0.6 m), male to female

Optional Integrated Software

A66-B32	GammaVision Gamma-Ray Analysis with Ge
Global Value	Gamma Spectroscopy Automation and Custom Reporting

Additional hardware options:

USB HUB: Powered USB hub includes connections for up to seven 926 inputs. Configuration functions are the same as any other Connections-32 device. Available in 4-input and 7-input models.

C-USB-HUB-4B	4 Port USB Hub
C-USB-HUB-7B	7 Port USB Hub
USBEXT	USB Active Extension Cable (powered by USB)

¹Ron Jenkins, R.W. Gould, and Dale Gedcke, Quantitative X-Ray Spectrometry (New York: Marcel Dekker, Inc.), 1981, pp. 266–267.

²Please refer to "Standard NIM Digital Bus (NIM/488)," DOE/ER-0457T, U.S. NIM committee, May 1990; Standard NIM Instrumentation System, NTIS, U.S. Dept. of Commerce, Springfield, Virginia 22161.

Specifications subject to change
022306

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At Last, an Economical Dual-Input Multichannel Analyzer System in a Single Width NIM Module.

- Dual fast (1.25- μ s) ADC and memory in a single width NIM
- Dual 16k ADC's, compatible with MAESTRO-32 for Windows MCA emulation program
- Live time corrections including ZDT
- PUR, BUSY, and GATE inputs
- Interfaces via USB-2.0
- True live display of data
- Synchronize this unit with your sample changer or process control
- On board memory allows fast downloads to your PC
- Two inputs in a single wide NIM

The ORTEC Model ASPEC-927 interfaces to a personal computer via the USB-2.0 interface and includes MAESTRO-32 emulation software. Each ASPEC-927 is presented in a single width NIM chassis and includes two independent 16k ADCs, and 512 kb of memory. The successive-approximation 16,384 channel ADCs with 1.25- μ s conversion time has selectable conversion gain settings for 8,192, 4,096, 2,048, 1,024, or 512. Dead time corrections can be accomplished using the Gedcke-Hale Extended Live-Time method or the ZDT method.

A single computer subject to the USB-2.0 speed of data transfer can control multiple units using USB-2.0 hubs.

Specifications

PERFORMANCE

ADCs: Successive-Approximation type with sliding scale linearization.

MAX RESOLUTION: 16k: 16,384 channels, software selectable as 16,384, 8,192, 4,096, 2,048, 1,024, and 512.

DEAD TIME PER EVENT: 2 μ s including memory transfer.

INTEGRAL NONLINEARITY: <+0.025% over the top 99% of the dynamic range.

DIFFERENTIAL NONLINEARITY: < \pm 1% over the top 99% of the dynamic range.

GAIN INSTABILITY: <+50 ppm/ $^{\circ}$ C.

DEAD-TIME CORRECTION: Software selectable for extended Live-Time correction according to the Gedcke-Hale method or ZDT Live-Time corrections which monitors the counting rate and adjusts the dead-time for fluctuating counting rates.

DATA MEMORY: 512 kb.

USB INTERFACE: Interfaces to a PC via USB 2.0. Data transfer speed is 480 Mbps maximum.

INPUTS AND OUTPUTS

INPUTS: Accepts positive unipolar, positive gated integrator, or positive leading bipolar analog pulses in the dynamic range from 0 to +10 V; +12 V maximum; semi-Gaussian-shaped time constants from 0.25 to 30 μ s, gated-integrator-shaped time constants from 3 to 30 μ s, or delay-line-shaped with widths >0.25 μ s. $Z_{in} = 1 \text{ k}\Omega$, dc-coupled. No internal delay, BNC connector.

ADC GATE: Optional TTL input. Computer selectable Coincidence mode, Anti-coincidence mode, or Off. Signal must occur prior to and extend 0.5- μ s beyond the peak of the pulse; BNC connector. $Z_{in} = 1 \text{ k}\Omega$.

PUR: Pile-up rejection input; accepts TTL signal; signal must occur prior to peak detect. $Z_{in} = 1 \text{ k}\Omega$. BNC connector.

BUSY: Busy input used by live-time correction circuits. Accepts TTL signal; signal must occur prior to peak detect. $Z_{in} = 1 \text{ k}\Omega$. BNC connector.



SAMPLE CHANGE IN: 9-pin "D" connector. $Z_{in} = 1 \text{ k}\Omega$.

Input for ADC 1 is pin 1.

Input for ADC 2 is pin 5.

Ground is pin 9.

SAMPLE CHANGE OUT: 9-pin "D" connector.

$Z_{out} = 1 \text{ k}\Omega$.

Output for ADC 1 is pin 3.

Output for ADC 2 is pin 7.

Ground is pin 9.

USB-2.0: Standard USB connection via a supplied 10-ft. cable.

INDICATORS

ADC1: Indicates activity for ADC-1.

ADC2: Indicates activity for ADC-2.

SOFTWARE CONTROLS

(Operates with included MAESTRO-32 — see data sheet for details.)

ADC LLD: Computer controlled from 0 to 100% full scale.

ADC ULD: Computer controlled from 0 to 100% full scale.

PRESETS

REAL TIME/LIVE TIME: Multiples of 20-ms.

REGION OF INTEREST: Peak count/Integral count.

DATA OVERFLOW: Terminates data collection when any channel exceeds $2^{31}-1$.

PEAK UNCERTAINTY: Stops acquisition when the statistical or counting uncertainty of a user-selected net peak reaches the specified value.

NUCLIDE MDA: Stops data collection when the value of the Minimum Detectable Activity (MDA) for a user-specified MDA reaches the specified value.

LIVE TIME CORRECTION: Gedcke-Hale, ZDT.

GATE: Coincidence, Anti-Coincidence, Off.

ELECTRICAL AND MECHANICAL

POWER REQUIRED: +6 V, 250 mA; +12 V, 165 mA; -12 V, 165 mA.

WEIGHT

Net 0.9 kg (2 lb).

Shipping 2.25 kg (5 lb).

DIMENSIONS NIM-standard single-wide 3.43 x 22.13 cm (1.35 x 8.714 in.) front panel per DOE/ER0457T.

Ordering Information

Model	Description
ASPEC-927	Dual 16k ADCs in a single wide NIM. Includes MAESTRO-32 and 10-ft. USB interface cable.
927-OPT1	Female BNC adapter cable for Sample Change I/O. This option provides cable connections to the Sample Changer inputs and outputs.



Specifications subject to change
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Everything Needed for a Scintillation Detector . . .

- For scintillation detectors employing 10-stage PMTs that fit standard 14-pin sockets
- Internal, adjustable, high-voltage bias supply eliminates high-voltage cables
- Integral spectroscopy preamplifier avoids dangling boxes
- Active bias network minimizes peak shifts at high counting rates
- Anode timing output for coincidence measurements
- Low power consumption (240 mW) for portable applications
- Convenient, single-cable connection for most applications



. . . In One Compact Package

The ScintiPack Photomultiplier Base (Model 296) includes everything needed for scintillation detectors in one compact package: a low-power, adjustable, high-voltage supply, an active bias network, and a spectroscopy preamplifier. Incorporating the bias supply in the photomultiplier base eliminates high-voltage cable connections to bulky, external, HV supplies. As a result, the ScintiPack operates with extremely low power consumption (240 mW). This makes the ScintiPack attractive for portable applications, as well as for high-density detector arrays.

Because the preamplifier output signal is bundled into the power cable, only a single cable is required between the photomultiplier base and the main amplifier location. The optional Signal Break-Out Adaptor can be used with amplifiers that do not offer signal interfacing through the preamplifier power plug. The adaptor attaches to the preamplifier power plug at the amplifier, and supplies the preamplifier signal on a coaxial cable for connection to the front-panel input of the amplifier. This approach maintains a single-cable connection from the ScintiPack to the amplifier location.

The ScintiPack biases the cathode of the associated photomultiplier tube at ground potential, and the anode at a positive voltage. The voltage applied to the anode can be optimized within the range of +600 V to +1100 V via a 20-turn screwdriver adjustment. This provides a cost-effective means of adjusting and matching photomultiplier gains in large arrays of scintillation detectors. The dynode bias network applies 1/6 of the anode voltage between the cathode and first dynode, and 1/12 of the anode voltage between the remaining pairs of

electrodes. To provide excellent gain stability at high counting rates, the voltages applied to dynodes 8, 9, and 10 are transistor regulated. Feedback regulation is also applied to the anode voltage to achieve optimum gain stability for the entire photomultiplier tube.

The signal from dynode 10 is integrated on a 500-pF capacitor at the preamplifier input, amplified by the preamplifier gain, and presented as a positive-polarity pulse at the PREAMP output. A jumper on the printed circuit board allows selection of a preamplifier gain of X1 or X6. The preamplifier output signal can be accessed on pin 3 of the power connector, or at the BNC connector on the rear panel of the ScintiPack.

The anode signal is available on a rear-panel BNC connector to facilitate high resolution timing in coincidence measurements. This output is intended to drive a 50-Ω coaxial cable to a timing amplifier or a timing discriminator. By moving a jumper on the printed circuit board, the anode output connector can be converted to a test input for the preamplifier. A pulser can be applied to the test input to check the operation of the entire chain of electronics, starting from the preamplifier input.

The PMT socket is a standard JEDEC B14-38 socket that fits 10-stage photomultiplier tubes with 14 pins. Figure 1 defines the pin assignments, and Figure 2 illustrates the connections. The Model 296 ScintiPack Photomultiplier Base is compatible with the photomultiplier tubes listed in Table 1. Compatibility with tubes not listed in Table 1 can be checked by reference to Figures 1 and 2, and by comparison with the photomultipliers listed in the table.

Table 1. Compatible Photomultiplier Tubes.				
ADIT	Burle (formerly RCA)	Hamamatsu	Phillips	Electron
B51B01	4900	PM55	XP2202	9266K
L51B01	5819	R208	XP2203B	9272K
V51B01	6342A	R550	XP2412B	9250K
B51D01	6655A	R594		9256K
B51C01	S83006E	R877		9305K
B76B01	S83013F	R878		9265K
V76B01	S83019F	R1507		9269K
B76C01	S83020F	R1512		9273K
B89B01	S83021E	R1513		9274K
B89C01	S83022F	R1612		9306K
B89D01	S83025F	R1791		9390K
B133D01		R1836		9275K
B133C01		R1847-07		
V133B01		R1848-07 7696		

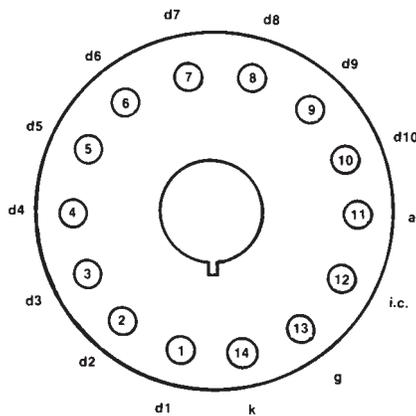


Fig. 1. JEDEC B14-38 PMT Pin Base, with Pin Assignments:

- d1–d10 dynodes 1 to 10
- a anode
- i.c. internal connection
- g grid
- k cathode

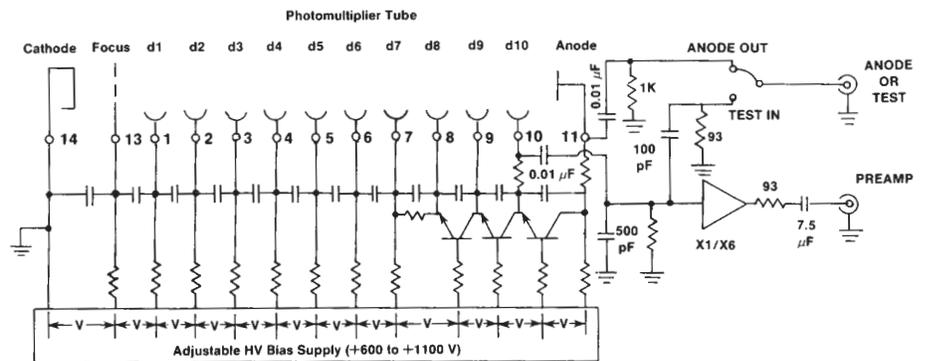


Fig. 2. Simplified Schematic Diagram of the ORTEC Model 296 Photomultiplier Base.

296 ScintiPack™ Photomultiplier Base with Preamplifier and HV Supply

Specifications

PERFORMANCE

PMT Bias

CATHODE-TO-ANODE VOLTAGE Adjustable from +600 V to +1100 V (grounded cathode, positive anode) with feedback regulation.

BIAS DISTRIBUTION 1/12 of the cathode-to-anode voltage is applied between: the cathode and focus electrode, the focus electrode and the first dynode, each pair of dynodes, and between the tenth dynode and the anode. Voltages on dynodes 8, 9, and 10 are transistor regulated for improved stability at high counting rates.

TEMPERATURE SENSITIVITY The cathode-to-anode voltage changes <100 ppm/°C over the operating temperature range of 0 to 50°C.

BIAS VOLTAGE DECAY TIME Nominally 3 minutes, when the HV switch is turned off.

Preamplifier

OUTPUT POLARITY Positive.

OUTPUT RISE TIME <100 ns for a fast pulser at the TEST input, or for a fast scintillator.

OUTPUT DECAY TIME CONSTANT Nominally a 50- μ s exponential time constant.

CONVERSION GAIN Typically 1 μ V/eV or 6 μ V/eV (jumper selectable) for a 3-in. x 3-in. NaI(Tl) crystal and a PMT gain of 10^6 .

OUTPUT NOISE <300 μ V rms. Measured using an ORTEC Model 671 Amplifier under the following conditions: HV on, no PMT installed, X6 preamplifier gain, and a 1- μ s amplifier shaping time constant.

INTEGRAL NONLINEARITY $\pm 0.1\%$ from 0 to +6.5 V into a 1-k Ω load; measured via the TEST input. Maximum output is +7 V into an open circuit, or +3 V into a 93- Ω load. Overall linearity depends on the nonlinearity of the scintillator/photomultiplier combination.

TEMPERATURE SENSITIVITY Gain changes ± 50 ppm/°C from 0 to 50°C, measured via the TEST input. Overall temperature sensitivity depends on the scintillator/photomultiplier combination and the bias supply.

SPECTRUM SHIFT Limited by the photomultiplier. Typically $\pm 2\%$ shift of the 662-keV peak position from a ^{137}Cs source for a change in counting rate from 0 to 100,000 counts/s in the entire spectrum. Measured using an ORTEC Model 671 Amplifier set to a 0.5- μ s shaping time constant, and an ORTEC TRUMP-2k Multichannel Analyzer.

SPECTRUM BROADENING Limited by the scintillator/photomultiplier combination. Typically <10% broadening of the FWHM of the 662-keV peak from a ^{137}Cs source for a change in counting rate from 0 to 100,000 counts/s. Measured under the same conditions as SPECTRUM SHIFT.

CONTROLS AND INDICATORS

HV Rear-panel, 22-turn potentiometer provides adjustment of the HV bias voltage from +600 V to +1100 V. The adjacent test point permits monitoring of the actual bias voltage with a digital voltmeter. A digital voltmeter reading of 1.000 V corresponds to an actual bias voltage of 1000 V. The output impedance of the test point is <14 k Ω .

ON Rear-panel push-button switch turns on the preamplifier and HV bias power when depressed. Pushing a second time releases the button and turns the power off.

X1/X6 A two-position jumper, located on the preamplifier printed circuit board, selects the preamplifier gain to be X1 or X6. Shipped set to X1.

ANODE OUT/TEST IN A two-position jumper, located on the preamplifier printed circuit board, selects the function of the rear-panel, ANODE OR TEST connector. With the jumper in the ANODE OUT position, the anode signal is routed to the BNC connector for timing applications. Testing of the preamplifier function can be accomplished by moving the jumper to the TEST IN position and applying an external pulser to the rear-panel connector. Shipped in the ANODE OUT position.

INPUTS AND OUTPUTS

ANODE OR TEST Rear-panel, BNC connector functions as either the anode output for timing applications, or as a test input for inserting test pulses into the preamplifier input. (See ANODE OUT/TEST IN jumper description.)

Anode Output With the internal jumper set to ANODE OUT, the negative-polarity anode signal is ac-coupled to the rear-panel BNC output, with an output impedance of 1 k Ω . Intended for driving a 50- Ω coaxial cable terminated in 50 Ω .

Test Input With the internal jumper set to TEST IN, the rear-panel BNC connector is connected to the preamplifier test input. Input impedance is nominally 93 Ω in parallel with 83 pF.

PREAMP A rear-panel, BNC connector delivers the preamplifier output signal for applications where a separate signal cable is desired. The same signal is also available on pin 3 of the power cable connector for systems that accommodate a single-cable connection to the spectroscopy amplifier. Both outputs have a common, ac-coupled, 93- Ω , output impedance, and are short-circuit protected. The signal from dynode 10 is integrated on a 500-pF capacitor at the preamplifier input, amplified by the preamplifier gain, and presented as a positive-polarity pulse at the PREAMP output.

PMT SOCKET TRW 3B14. Fits the standard JEDEC B14-38 photomultiplier tube pin base for 14-pin, 10-stage PMTS. See Figures 1 and 2 for pin assignments.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V at 20 mA. Supplied via a captive power cord terminated in a standard preamplifier power plug (9-pin, D connector). Power cord length is nominally 3 m. The preamplifier power plug is compatible with the standard preamplifier power-connector provided on most nuclear spectroscopy amplifiers. An optional Signal Break-Out Adaptor is available for extracting the preamplifier signal at the power connector.

WEIGHT

Net 0.5 kg (1.1 lb).

Shipping 1.2 kg (2.6 lb).

DIMENSIONS 5.6 cm (2.2 in.) diameter X 17 cm (6.7 in.) length.

296 ScintiPack™ Photomultiplier Base with Preamplifier and HV Supply

Optional Accessories

296-ADAPT SIGNAL BREAK-OUT ADAPTOR Connects to the end of the power cable from the Model 296 and separates the preamplifier signal cable from the power cable. The 9-pin D connector on the adaptor plugs into the standard preamplifier power connector on the rear of most spectroscopy amplifiers. The 60-cm-long preamplifier signal cable from the adaptor terminates in a BNC connector for connection to the input of a spectroscopy amplifier.

C-24-12 93- Ω , coaxial cable for connecting the PREAMP output to an amplifier input. (Not necessary when the when the 296-ADAPT is employed.) RG-62A/U 93- Ω cable (3.7-m length) with two BNC connectors.

C-25-12 50- Ω , coaxial cable for connecting the ANODE output to timing instruments. RG-58A/U 50- Ω cable (3.7-m length) with two BNC connectors.

Ordering Information

To order the Model 296 ScintiPack Photomultiplier Base or related accessories, use the following model numbers and descriptions:

Model	Description
296	ScintiPack™ PMT Base (with Preamplifier and HV Supply)
296-ADAPT	Signal Break-Out Adaptor
C-24-12	RG-62A/U 93- Ω Cable with two BNC male plugs; 12-ft length
C-25-12	RG-58A/U 50- Ω Cable with two BNC male plugs; 12-ft length

Specifications subject to change
100906

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AMETEK®
ADVANCED MEASUREMENT
TECHNOLOGY

- Accommodates up to 6 NIM-Standard modules with a compact 24 cm x 32 cm table-top footprint
- Regulated dc power: ±6 V @ 4 A, ±12 V @ 1.5 A, ±24 V @ 0.75 A, and 120 V ac @ 0.5A
- 120 W of dc power at 23°C and 80 W up to 50°C
- Overvoltage protection to avoid damage to +5-V and -5.2-V integrated circuits
- Short-circuit and overload protection accompanied by LED fault indicators
- Operates from 100, 120, 220, or 240 V ac at 50 or 60 Hz
- Two standard preamplifier power outlets



The compact Model 4006 Minibin and Power Supply is the ideal solution where a small number of NIM modules must be located close to the action in a measurement system. Its slim 24-cm x 32-cm footprint minimizes the space required on a table top. It can operate at full power while sitting on a solid surface, because rear intake and exhaust of cooling air eliminates the need to provide free air flow from below. The Model 4006 accommodates up to 6 standard, single-width NIM modules, or a proportionately smaller number of double-width modules. In addition to the standard ±24-V and ±12-V dc power, ±6 V is provided to serve the high-current demands of TTL and ECL logic used extensively in newer NIM modules. The full load of 0.75 A on both of the 24-V supplies, 1.5 A on both of the 12-V supplies, and 4 A on both of the 6-V supplies can be drawn at room temperature (23°C) for a total of 120 W dc power. A total load of 80 W dc can be driven at ambient temperatures up to 50°C. The standard 60 VA of 120 V ac is also available on the module power connectors, independent of the actual ac voltage applied to the main power cord. Two 9-pin D connectors on the rear panel provide a convenient source of ±6-V, ±12-V and ±24-V power for preamplifiers via the industry-standard preamplifier power plug.

Extensive protection is designed into the Model 4006 power supply. Crowbar circuits are included on the ±6-V power lines to protect TTL and ECL integrated circuits against overvoltage. All six of the dc power lines incorporate protective fold-back circuits that automatically reduce the output voltage in case of an excessive load current or a short circuit. Green LED indicators turn red when the supply voltage is reduced by an overload. The LEDs extinguish if the voltage is reduced to zero by a low-impedance short circuit. Thermal cut-out switches protect the power supply against excessive temperature. When the heat sink temperature is within 15°C of the maximum safe temperature, the red TEMP warning indicator turns on. When the maximum safe temperature is exceeded, all power to the unit is automatically turned off. Power is recovered automatically when the temperature is reduced below the safe limit. There are no hot, external heat sinks that can be accidentally touched. All heat sinks are internal to the unit and cooled by forced air. The ac power input is protected with a fuse, and the unit meets all CE requirements.

A power input module with the standard IEC connector and selectable 100, 120, 220 and 240 ac input voltages at 50 or 60 Hz makes the Model 4006 compatible with power cords and ac power outlets in virtually all countries.

Specifications

BIN

MECHANICAL TOLERANCES in accordance with DOE/ER-0457T, providing for interchangeability of all NIM standard modules.

MODULE CONNECTORS 6 each. Connectors as specified by DOE/ER-0457T.

MODULE-CONNECTOR WIRING All module connectors are wired in parallel for +6 V, -6 V, +12 V, -12 V, +24 V, -24 V, power return, high-quality ground return, and 120 V ac, in accordance with DOE/ER-0457T pin assignments.

PREAMPLIFIER POWER

CONNECTORS Two, industry-standard, female, 9-pin D connectors are mounted on the rear panel and wired with the following pin assignments. These connectors mate with the standard preamplifier power connectors on ORTEC preamplifiers, and preamplifiers supplied by most other NIM manufacturers.

Pin Number	DC Voltage
1	Ground
2	Ground
3	+6 V
4	+12 V
5	-6 V
6	-24 V
7	+24 V
8	No Connection
9	-12 V

CONSTRUCTION Painted aluminum enclosure with cadmium-plated steel perforated top/bottom module-retainer plates and connector mounting plate. Plastic front bezel and guide-rail inserts. Rubber feet for table-top protection. All heat sinks are internal and cooled by a forced-air fan. Cooling air flows from the lower rear intake, through the power supply and modules to exhaust at the top rear.

POWER SUPPLY

INPUT 100, 120, 220, 240 V ac, 50 or 60 Hz, 400 VA max., EMI filtered per IEC801. Overvoltage category II, Pollution degree 2. Voltage regulation allows a range of +10% to -12% of the nominal voltage. Input current at 120 V ac is typically 3 A rms for a 120-W dc load. A power-entry module on the rear provides a standard IEC plug for

connecting power cords that are compatible with local ac voltage outlets. The power-entry module provides selection of the required input voltage, and contains the input fuse. Fuse ratings are 4 A, 250 V (SLO-BLO) size 3AG for 100 or 120 V ac, and 2 A, 250 V (T) size 5 x 20 mm for 220 or 240 V ac.

DC OUTPUT Maximum rated currents for each voltage supplied to the 6 module power connectors and 2 preamplifier power connectors are:

DC Voltage	Maximum Current	DC Voltage	Maximum Current
+24 V	0.75 A	-24 V	0.75 A
+12 V	1.5 A	-12 V	1.5 A
+6 V	4 A	-6 V	4 A

Maximum total dc output power: 120 W at 23°C, 80 W up to 50°C ambient air temperature.

120 V AC OUTPUT Limited only by the power entry fuse when operating from 120 V ac. Limited to 60 VA when the dc load is 80 W and the input voltage is 100, 220, or 240 V ac.

DC REGULATION $\leq \pm 0.1\%$ (typically $\pm 0.05\%$) for ± 12 V and ± 24 V, and $\leq \pm 0.2\%$ (typically $\pm 0.1\%$) for ± 6 V over the combined range of zero to full load with the specified input voltage range for measurements made within a 1-minute period. Regulation $\leq \pm 0.3\%$ for ± 12 V and ± 24 V, and $\leq \pm 0.6\%$ for ± 6 V over any 24-hour period at constant ambient temperature for the same load and input ranges after a 60-minute warm-up.

OUTPUT IMPEDANCE $< 0.3 \Omega$ at any frequency up to 100 kHz.

LONG-TERM STABILITY DC output voltages change $\leq \pm 0.5\%$ (after a 60-minute warm-up) over a 6-month period at constant load, line voltage and ambient temperature.

TEMPERATURE COEFFICIENT DC output voltages change $\leq \pm 0.02\%/^{\circ}\text{C}$ over a range of 0 to 50°C.

NOISE AND RIPPLE < 3 mV peak-to-peak as observed on an oscilloscope with a 50-MHz bandwidth.

VOLTAGE ADJUSTMENT $\pm 5\%$ minimum range. Resetability $\leq \pm 0.05\%$ of the supply voltage.

RECOVERY TIME $< 100 \mu\text{s}$ to return to within $\pm 0.1\%$ of the rated voltage for all dc outputs for any voltage change within the rated range or for a change of load current from 10% to 100% of full load.

CIRCUIT PROTECTION The input power line includes a fuse. The power supply is automatically turned off by an internal switch if the temperature of the internal heat sink exceeds 110°C. Recovery is automatic when the temperature decreases to a safe value. A red light on the front panel turns on when the heat sink temperature exceeds 95°C to warn that the maximum temperature is being approached. All dc outputs include a current foldback circuit to limit the output current to nominally 120% of the rated value. This feature provides short-circuit and overload protection. Recovery is automatic after the overload is removed. Over-voltage protection for the ± 6 -V outputs prevents these outputs from exceeding ± 7.5 V, respectively, to protect the integrated circuits that are commonly powered by these supply voltages.

COOLING Rear-panel fan forces cooling air over the internal power supply heat sinks and up through any installed NIM modules to exhaust at the top rear. Consequently, there are no hot external heat sinks exposed for accidental contact.

ENVIRONMENTAL Temperature 0 to 50°C. Indoor use. 95% maximum relative humidity, non-condensing. Altitude up to 2,000 meters. Installation category II. Pollution degree 2. Meets all CE requirements.

CONTROLS AND INDICATORS

POWER Front-panel, two-position, rocker switch turns both sides of the ac power to the unit ON or OFF.

AC Front-panel, green light indicates the AC Power ON condition when illuminated. Power indicator light and output power turn off if the internal heat-sink temperature exceeds 110°C.

TEMP Front-panel red light turns on when the internal heat-sink temperature exceeds 95°C to warn that the shut-down temperature limit is being approached. The TEMP light turns off if power has been shut off by exceeding the heat-sink temperature limit.

4006

Minibin and Power Supply

STATUS Six, front-panel lights indicate when the respective dc voltage is out of regulation because of a current overload or a short circuit. Green indicates normal operation (within $\pm 5\%$ of the nominal voltage), while red indicates an out-of-regulation fault, and a light turned off implies zero voltage due to a short circuit or lack of ac input power. The lights are labeled with the supply voltage (-6 V, $+6$ V, -12 V, $+12$ V, -24 V, and $+24$ V) and the maximum rated load current for each supply voltage.

CALIBRATION Six potentiometers mounted inside on the printed wiring board permit precise adjustment of the six dc output voltages.

MECHANICAL

WEIGHT

Net 12 kg (26 lb)

Shipping 14 kg (31 lb)

DIMENSIONS

24.0 cm W x 32.0 cm D x 35.2 cm H
(9.4 in. W x 12.6 in. D x 13.9 in. H)

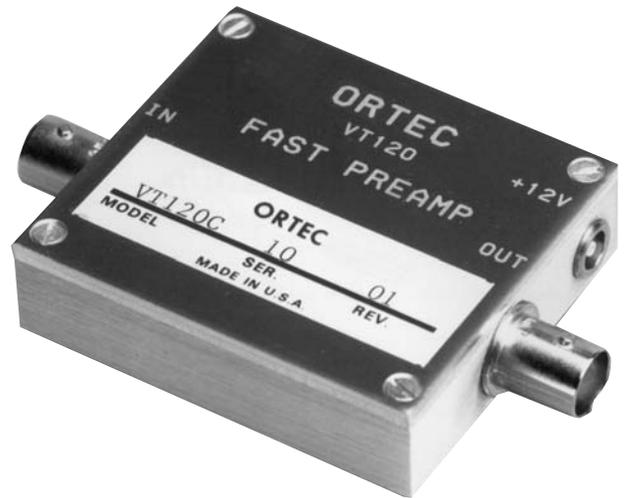
Ordering Information

To order, specify:

Model	Description
4006	Minibin and Power Supply



- For amplification of signals with very fast rise times from microchannel plates, photomultiplier tubes, and silicon detectors
- ≤ 1 ns rise time
- Output drives -5 V into 50Ω
- Compact preamplifier box for operation close to the signal source
- ≤ 20 μ V rms equivalent input noise
- Gain of (A) 200, (B) -200 , or (C) 20



The Model VT120 Fast-Timing Preamplifier is a high-performance, wide-bandwidth preamplifier designed for boosting very fast linear signals from microchannel plates, photomultipliers, electron multipliers, silicon detectors, and other detectors used in fast timing applications. The rise time on all versions is < 1 ns with a 5-V output, enabling excellent timing resolution.

The Model VT120 is a single-channel unit in a small preamplifier package. It is available with a gain of 200, noninverting (A version); a gain of 200, inverting (B version); or a gain of 20, noninverting (C version). BNC connectors are used for signal connections on the Model VT120. A cable is available (Model C-VT120) for connecting power between the Model VT120 and conventional preamplifier power outputs using Amphenol-type 17-80090 connectors.

PERFORMANCE

GAIN (10% gain tolerance on all versions):

A Version 200, noninverting.

B Version 200, inverting.

C Version 20, noninverting.

RISE TIME ≤ 1 ns.

NOISE ≤ 20 μ V rms equivalent input noise.

BANDWIDTH 10 to 350 MHz.

OUTPUT RANGE 0 to -5 V with $50\text{-}\Omega$ load.

INPUT BNC connector; input impedance 50Ω .

OUTPUT BNC connector; 0 to -5 V output with a $50\text{-}\Omega$ load. Output impedance $\leq 1 \Omega$, ac-coupled.

ELECTRICAL AND MECHANICAL

POWER REQUIRED $+12$ V, 50 mA (uses LEMO power connector that is compatible with accessory cable C-VT120).

DIMENSIONS Aluminum housing 5.8 X 5.1 X 1.6 cm (2.3 X 2.0 X 0.63 in.).

WEIGHT

Net 0.2 kg (0.4 lb).

Shipping 1.1 kg (2.4 lb).

Optional Accessories

C-VT120 cable assembly with connections between VT120 power input (LEMO) and Amphenol-type 17-80090 preamplifier power connectors that are compatible with other ORTEC NIM-standard modules.

Ordering Information

To order, specify:

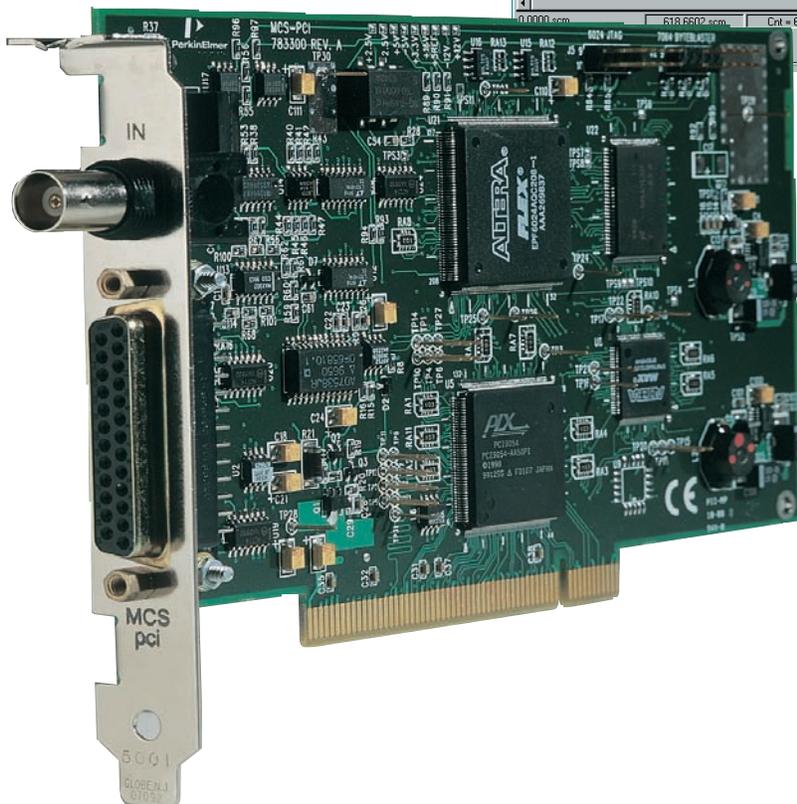
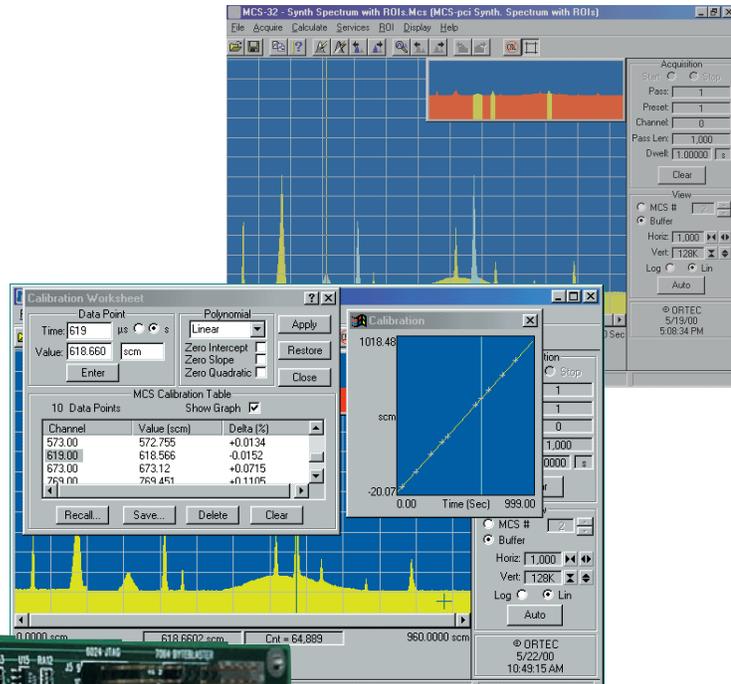
Model	Description
VT120A	Fast-Timing Preamplifier (200 gain, noninverting)
VT120B	Fast-Timing Preamplifier (200 gain, inverting)
VT120C	Fast-Timing Preamplifier (20 gain, noninverting)
C-VT120	Power Cable Assembly for VT120A/B/C (3-m length)

Suggested cable accessories:

C-25-1/2	RG-58A/U 50- Ω Cable with two BNC male plugs, 6-in. length
C-25-12	RG-58A/U 50- Ω Cable with two BNC male plugs, 12-ft length

Profiling Counting Rates up to 150 MHz with 15 ppm Time Resolution

- Dwell times from 100 ns to 1,300 s per channel
- Up to 65,536 channels
- Exclusive SCA Sweep mode for recording pulse-height spectra
- Complete with operating, display and analysis software



The ideal solution for:

- Time-resolved single-photon counting
- Phosphorescence lifetime spectrometry
- Atmospheric and satellite LIDAR
- Laser-induced chemical reactions
- Scanning mass spectrometers
- Time-of-flight spectrometry
- Scanning X-ray diffractometers
- Mössbauer experiments

MAJOR FEATURES

Hardware

- PCI-bus plug-in card, 10 cm x 18 cm
- Dwell time selectable from 100 ns to 1,300 seconds per channel
- Number of channels per scan selectable from 4 to 65,536
- Accepts counting rates up to 150 MHz at the fast analog input
- 1-MHz single-channel analyzer input with computer controlled upper- and lower-level discriminators independently adjustable from 0 to +10 V
- Computer adjustable discriminator thresholds on the fast analog input and the external channel advance input
- Zero dead time between channels: absolutely no lost counts and no double counting at channel boundaries
- No end-of-pass dead time
- Sum mode for signal averaging; Replace mode for single-scan data; Replace then Sum mode circumvents reset dead time between acquisitions
- Up to 1,073,741,823 counts per channel in single or multiple passes
- Automatic termination of data acquisition after a preset number of passes (up to 4 billion)
- The start of the scan can trigger the experiment, or the experiment can trigger the start of the scan
- Includes a ramp output with computer-adjustable sawtooth and triangular waveforms

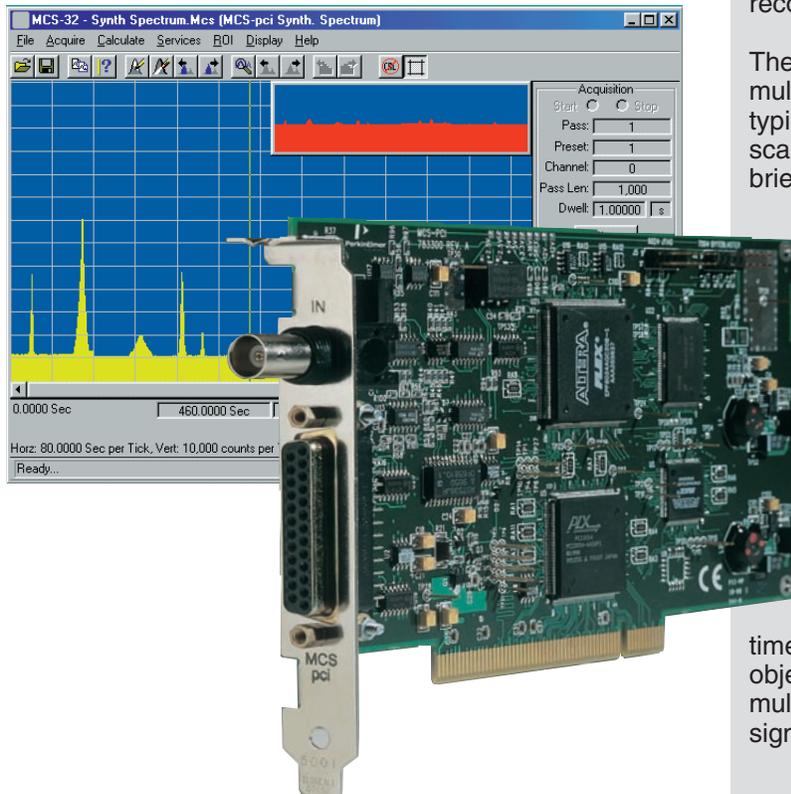
Software

- Complete with operating, display and analysis software
- All functions are computer-controlled
- SCA Sweep mode for recording pulse-height spectra and selecting accurate SCA windows
- Spectra and instrument settings can be saved on disk and recalled for further processing
- Software features include smooth, sum, strip, compare, and normalize spectra; peak-search, report, and user-defined job streams
- Horizontal scale calibration by least squares fitting to user-defined units
- A11-B32 Programmer's Toolkit available for ActiveX™ programming under LabVIEW®, Visual Basic, or Visual C++

All trademarks used herein are the property of their respective owner.

MCS-pci™

The MCS-pci is a 10-cm x 18-cm PCI-bus plug-in card that converts your personal computer into a powerful and flexible Multi-Channel Scaler (MCS) or a multiple-stop time spectrometer. Powerful software operating under Windows, allows all controls and spectral manipulations to be implemented via on-screen displays. A dual-port memory on the card permits quick computer access to the spectral data for display purposes, without interrupting data acquisition by the MCS-pci. With dwell times from 100 ns to 1300 s, a memory length of 65,536 channels, and input counting rates up to 150 MHz, the MCS-pci has the flexibility to handle a wide variety of counting and timing applications.



What is a Multichannel Scaler?

A Multi-Channel Scaler (MCS) records the counting rate of events as a function of time. When a scan is started, the MCS begins counting input events in the first channel of its digital memory. At the end of the preselected dwell time, the MCS advances to the next channel of memory to count the events. This dwell and advance process is repeated until the MCS has scanned through all the channels in its memory. A display of the contents of the memory shows the counting rate of the input events versus time. In repetitive measurements, where the start of the scan can be synchronized with the start of the events, multiple scans can be summed to diminish the statistical scatter in the recorded pattern.

The MCS can also function as a multiple-stop time spectrometer. In a typical LIDAR application, the MCS scan is started when a LASER emits a brief flash of light. The light photons are reflected back to the detector located near the LASER as they encounter objects at various distances in the line of sight. The resulting "stop" pulses generated in the detector are counted as input events by the MCS. Thus a spectrum of the number of photons versus their round-trip flight times is recorded in the MCS memory. By design, the MCS can accept multiple stop pulses in each scan. The channel numbers in memory can be calibrated to read in terms of round-trip flight time, or in distance to the reflecting object. Summing the spectra from multiple LASER flashes improves the signal-to-noise ratio.

An Abundant Choice of Time Ranges

The MCS-pci employs a crystal-controlled clock with 100-ppm accuracy and high-speed digital electronics to achieve a wide range of accurate operating parameters. With the dwell time per channel selectable from 100 ns to 1300 seconds, and a scan length variable from 4 to 65,536 channels, time scans ranging from 400 ns to 2.7 years can be selected.

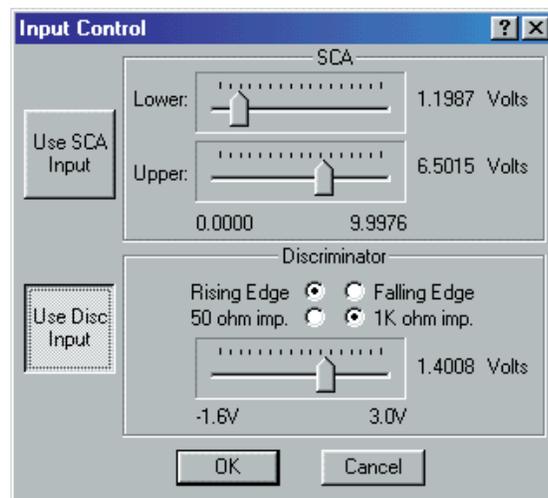
No Dead Time Between Channels, and Zero End-of-Pass Dead Time

MCS-pci employs sophisticated digital circuits to eliminate the dead time between channels that is typically encountered in lower-performance multi-channel scalers. The result is absolutely no loss of counts and no double counting as the multichannel scaler advances from one time channel to the next. Fast digital processing also ensures that there is no end-of-pass dead time before starting a new scan.

Versatile Counting Inputs

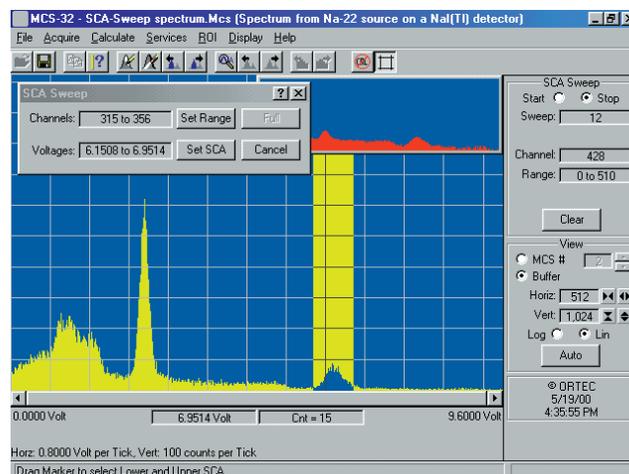
Two different types of counting inputs make the MCS-pci adaptable to virtually any source of signals. The fast analog signal input (IN) accommodates both analog and digital signals with pulse widths >3.5 ns and counting rates up to 150 MHz. The input discriminator threshold is computer adjustable from -1.6 V to +3 V in steps of 1.5 mV. This facilitates the preferential selection of larger pulses for counting, and the rejection of noise. Triggering can be selected for either positive or negative slope to match pulses of either polarity.

For counting rates up to 1 MHz with positive analog signals, MCS-pci offers the pulse-amplitude selectivity of the SCA input. This "Single-Channel-Analyzer" input features two computer-controlled discriminators, whose thresholds can be set anywhere between 0 and +10 V with 12-bit resolution. MCS-pci counts only the analog pulses that rise above the lower-level threshold without exceeding the upper-level threshold. This input is ideal for analog signals whose amplitudes are proportional to a measurement parameter, such as the number of photons in a pulse. Pulse widths from 0.5 to 100 μ s can be readily accommodated.



The Power of the SCA Sweep Mode

The SCA Sweep mode makes the setting of the SCA thresholds quick, easy, and accurate. In this mode the window width between the lower and upper SCA thresholds is held constant (at 1/512 of 10 V) while the computer repeatedly sweeps the position of the window from 0 to +10 V in 512 equal steps. In synchronism, the multichannel scaler repeatedly scans from channel 0 to 511, while counting the SCA output. The result is a display of the pulse-amplitude spectrum present at the SCA input. The mouse can be used to mark the lower and upper limits of a spectral feature in this display for selective counting in a subsequent multichannel scaler mode. Once these limits are marked, clicking the mouse on the "Set SCA" button in the display locks the lower and upper thresholds of the SCA into the exact settings that bracket the feature.



Improved Precision by Signal Averaging

For any selected dwell time and memory length, the data collected in each scan can either replace the data stored in memory, or can be added to the data in memory. The latter mode is useful for reducing statistical scatter. Effectively, it improves the signal-to-noise ratio by signal averaging. For random noise (noise that is not correlated with the Start trigger or the dwell-time clock), the signal-to-noise ratio improves in proportion to the square root of the number of scans added together. Selection of a "Preset Pass Count" programs the instrument to collect data for the desired number of scans (or passes), and then automatically stops data acquisition. Once data acquisition commences, the computer is free to run other software programs. To permit repetitive data addition to high precision, the preset pass count can be set to any value from 1 to 4,294,967,295, with a memory capacity of 1,073,741,823 counts per channel.

Versatile Scan Synchronization

MCS-pci offers two methods for synchronizing the scans with the start of the events to be counted. Either the start of a scan in the MCS-pci can provide the trigger for the events (internal trigger mode), or an external trigger for the events can start the scan (external trigger mode).

Internal Trigger Mode

The Start Output is a 160-ns wide, positive TTL signal, produced in synchronization with the start of a scan. This output can be used to trigger the external events. For example, this signal can trigger a LASER, whose output light pulse is used to excite phosphorescence in a sample. The decaying counting rate of photons emitted by the sample after each LASER pulse is counted by the MCS-pci.

For measurements requiring analog control of a parameter (e.g., Mössbauer experiments), MCS-pci provides a Ramp Output voltage proportional to the channel number in the scan. The ramp can be operated with either a sawtooth pattern or a triangular waveform. In the sawtooth mode, the ramp voltage varies linearly from the beginning voltage to the ending voltage as the scan progresses. At the end of the scan the voltage abruptly changes back to the beginning voltage. With the triangular pattern, the ramp voltage changes linearly from the beginning voltage to the mid-point voltage during the first half of the scan. During the second half of the scan, it makes another linear transition from the mid-point voltage to the ending voltage. All three voltages (Begin, Mid, and End) are adjustable via the computer from 0 to +10 V in 65,536 steps. For precise repeatability, the ramp profile is stored as a digital image in half the memory. This limits the memory length available for counting events to 32,768 channels when the ramp is active.

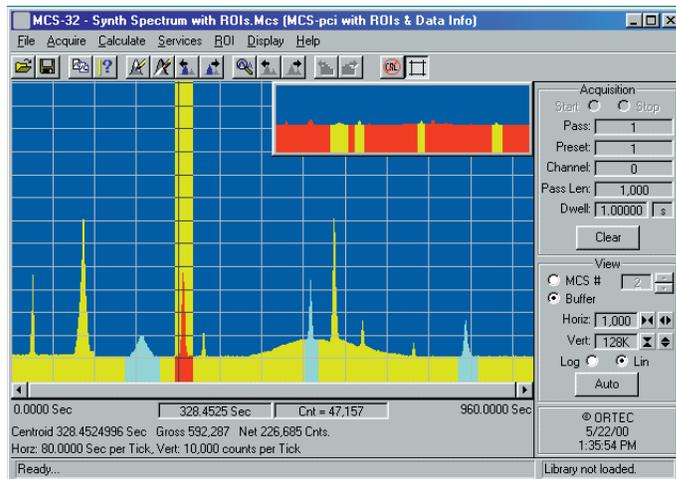
External Trigger Mode

In the external trigger mode, a positive TTL logic pulse delivered to the Start Input will initiate the scan in the MCS-pci. The scan can proceed based on the internal dwell-time clock in the MCS-pci, or the channel advance can be implemented by supplying pulses to the Channel Advance Input.

Using the internal dwell time, the scan starts on the first edge of the internal 50-MHz clock following the rising edge of the Start Input pulse. When the external channel advance is used, the scan starts as the rising edge of the first channel advance input pulse crosses its discriminator threshold, subsequent to the rising edge of the Start Input. The external channel advance input includes a computer-controlled discriminator threshold selectable from -1.6 V to +3 V in 1.5-mV steps. This discriminator permits adaptation to a variety of signal sources at the external channel advance input. The minimum interval between external channel advance pulses is 100 ns.

Instrument Control at the Click of a Mouse

The MCS-pci software operating under Windows, provides a powerful graphical user interface for spectral data display and for control of the instrument. All controls can be instantaneously activated on the computer display via the mouse. The most commonly used controls are always displayed alongside the spectrum. The less frequently used set-up parameters are easily accessed from drop-down menus. In addition to the quick action offered by the mouse, most controls can also be activated by keystrokes. For protection against power outages, all control settings are automatically stored on disk when the scan is started. In addition, settings can be saved in disk files, so that specific operating conditions can be recalled for later use.



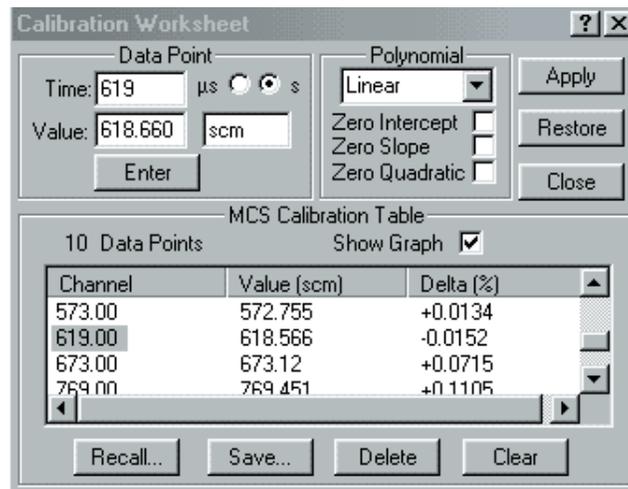
Quick Access to Multiple Spectra

An on-screen control allows the operator to view either the spectrum being acquired in the MCS-pci dual-port memory, or a spectrum previously transferred to the buffer memory in the computer. The full power to display and manipulate can be applied to the spectra in either of these memories. Spectra can also be saved as disk files for recall and examination later, or for further processing.

Full and Expanded Displays Reveal Quantitative Details

Two views of the selected spectrum are displayed. The box in the upper, right-hand corner always shows the full spectrum. A region selected and marked on this small display is expanded in the larger display for better resolution of details. By using the mouse pointer, a marker can be moved through the spectrum to a feature of interest. Simultaneously, the computer displays the horizontal coordinate for the channel designated by the marker position, and the number of counts recorded in that channel. By default, the horizontal coordinate is displayed as the channel number in the external dwell-time mode. In the internal dwell-time mode, the default horizontal coordinate corresponds to the selected dwell time. The horizontal scale can be easily calibrated in user-defined units through least squares fitting to a linear, quadratic, or cubic function. In that case, the marker position reads out in the calibrated units. Once calibration is accomplished, the operator can quickly toggle back and forth between the default and calibrated units.

The marker also serves to paint a "Region Of Interest" (ROI) on the spectrum. Typically, this is a colored region that marks the entire area under a peak in the spectrum. Single or multiple ROIs can be marked in a spectrum. Using the Data Info command under the Calculate menu, the marker can be positioned within an ROI to trigger the computer to display the centroid of the ROI, the gross (total) counts in the ROI, and the net counts above background in the peak.



More Options for Analysis

Further software features allow the operator to compare two spectra, subtract or add two spectra, normalize the vertical scale, subtract a flat background, or smooth statistical fluctuations. Also available is a routine that automatically finds each peak in a spectrum and marks it with an ROI. The centroids, gross counts, and net counts from all the ROIs in a spectrum can be printed, either with or without library matching. If the computer has been asked for a match to a user-defined library of peak locations, the library information will be printed along with the matching ROI data. In addition to the standard .MCS file format, spectra can be imported and exported as ASCII text.

Programmed Data Acquisition

Some measurements require changes in the data acquisition conditions as different spectra are acquired. The Start Job command under the Services menu provides an easy way for the operator to define a stream of Job Commands that varies the instrument settings and controls acquisition of multiple spectra. The Job Stream can be simple or sophisticated. Once the Job Stream is defined and implemented, data acquisition proceeds automatically under the Job Control.

Other software programs can activate the MCS-pci for a specific operation by calling the MCS-pci software with a Job file name specified on the command line. Alternatively, the A11-B32 CONNECTIONS Programmer's Toolkit can be purchased and used to program the MCS-pci at the command level. The use of ActiveX™ Controls in A11-B32 makes programming orders-of-magnitude easier with LabVIEW®, Visual Basic, or Visual C++.

Specifications*

Performance

Maximum Counting Rate 150 MHz at the IN connector;
1 MHz at the SCA IN connector.

Discriminator Thresholds (IN and CHN ADV IN) Software controlled and variable from -1.6 V to +3 V in 1.5-mV steps. Triggering selectable for either positive or negative slopes on the fast analog signal IN connector. The external channel advance input triggers only on a positive slope.

SCA IN Thresholds Upper and lower thresholds independently selectable via the computer from 0 to +10 V with 12-bit resolution.

Dwell Time

Internal Clock Dwell time per channel is computer selectable from:
100 ns to 1.3 ms in 20-ns steps,
1.3 ms to 1.3 s in 20- μ s steps,
1.3 s to 1300 s in 20-ms steps.

Accuracy: within ± 100 ppm over the operating temperature range.

External Clock Input The external channel advance input (CHN ADV IN) determines the dwell time. The minimum external dwell time is 100 ns per channel.

Channel-Width Uniformity Systematic dwell-time variations over the entire pass length are <0.1% for the worst case of 100 ns dwell time.

Pass Length The number of time bins (channels) in a single pass is computer selectable from 4 to 32,768 with the ramp turned on, or up to 65,536 with the ramp turned off.

Pass Preset The instrument can be programmed to stop data acquisition after a preset number of scans. The Pass Preset can be selected from 1 to 4,294,967,295 or turned OFF.

Memory Capacity 1,073,741,823 counts per channel (30 bits).

Acquisition Modes

Sum The data set from each pass is added to the sum of the data sets from the previous passes.

Replace The data set from the current pass replaces the data set from the previous pass.

Replace/Sum Data acquisition operates in the Replace mode on the first pass, and then switches to the Sum mode for subsequent passes. This eliminates the need to clear memory between acquisitions, and reduces the end-of-acquisition dead time when alternating data acquisition between two units of the MCS-pci.

Maximum Counts/Channel in a Single Pass 1,073,741,823

Dead Time Between Channels There is no dead time between channels, i.e., no counts are lost at the time of channel advance. The event is always counted in exactly one of the two adjacent channels.

End-of-Pass Dead Time There is no dead time between passes during an acquisition.

Ramp Output Linear ramps with "begin", "mid", and "end-of-pass" voltages computer selectable from 0 to +10 V with 16-bit resolution, and a 2- μ s settling time.

Computer Controls and Indicators

The following controls and indicators are provided as software-generated control panels or pull-down menus on the computer display. The functions are most conveniently selected and activated using a mouse, but are accessible via keystrokes.

Acquisition

Start Displayed button starts data acquisition in synchronization with the next internal clock pulse.

Stop A single click on the displayed button stops data acquisition at the end of the current pass. A second click stops data acquisition immediately.

Clear Displayed button clears the data and the pass count for the spectrum currently being viewed (Buffer or MCS memory).

Pass Displays the number of the current pass or scan (1 to 4,294,967,295).

Preset Displays the preset pass number that will terminate data acquisition.

Channel Displays the channel number into which counts are currently accumulating, starting with channel 0.

Pass Length Displays the number of channels selected for the pass length.

Dwell Displays the selected dwell time per channel.

View

MCS# Selects the number of the MCS for viewing the spectrum in the card's memory, either during or after an acquisition. The software supports up to 8 units of the MCS-pci. To simultaneously view multiple MCS-pci units in a single PC the software must be opened multiple times.

Buffer Displayed button selects the buffer memory in the computer for viewing the previous spectrum while the MCS is collecting the next spectrum.

Horiz Indicates the number of channels viewed in the larger, expanded spectrum, and the width of the window in the small full-scale spectrum display. Displayed arrow buttons permit expansion or contraction.

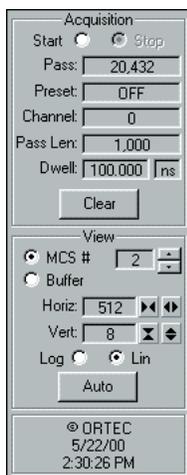
Vert Indicates the maximum number of counts in the vertical scale currently selected for the large, expanded spectrum. Displayed arrow buttons permit scale changes.

Log Displayed button selects a logarithmic vertical scale for the large, expanded display.

Lin Displayed button selects a linear vertical scale for the large, expanded display.

Auto Displayed button automatically adjusts the vertical scale and centers the window around the marker in the large display for optimum viewing of the spectrum.

Marker The vertical line can be dragged left or right in the display by the mouse. The vertical coordinate of the data (counts) at the marker position is displayed to the right of center under the large spectrum. The horizontal coordinate is displayed



to the left of center under the spectrum. The horizontal scale is expressed in time, channel number (Chan), or in any units selected during calibration of the horizontal scale. The marker can be used to mark regions-of-interest, and to read out peak centroids and gross or net peak areas within each region-of-interest.

Input Control

Use SCA Input Displayed button enables use of the SCA input. See SCA and SCA IN.

Use Disc Input Displayed button enables use of the fast discriminator input. See Discriminator and IN.

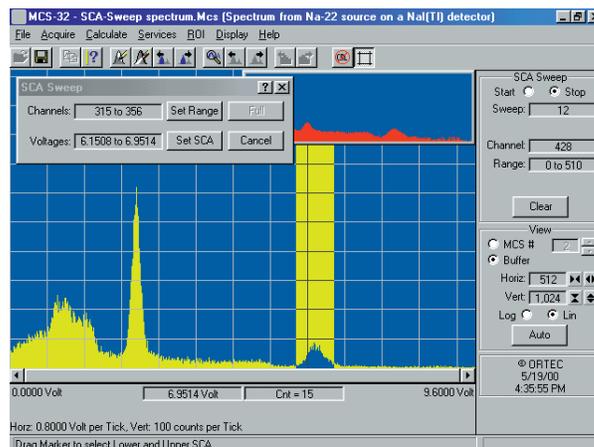
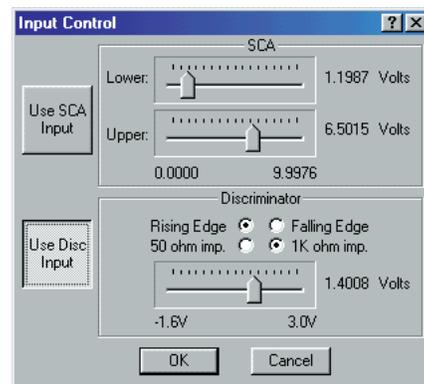
SCA: Lower, Upper Two displayed slide bars permit

independent selection of the SCA lower- and upper-level thresholds from 0 to +10 V in 4096 steps. See SCA IN.

Discriminator Displayed slide bar selects the Discriminator threshold from -1.6 V to +3 V in 1.5-mV steps for the IN connector. Two displayed buttons select counting of the discriminator crossing on either the Rising Edge (positive slope) or the Falling Edge (negative slope). Two displayed buttons select input impedance: 50 Ω or 1k Ω . See IN.

SCA Sweep Control

This control provides an efficient method for choosing the optimum SCA settings without resorting to an oscilloscope. An SCA window (with a width of 19.5 mV between upper and lower levels) is swept from 0 to +10 V as the MCS scans through a pass length of 512 channels. The resulting histogram displays the pulse-height spectrum presented at the SCA Input. By using the cursor to mark a region over the feature of interest in the spectrum and clicking the mouse on the Set SCA button, the SCA levels are automatically set at the upper and lower limits of the selected region. This is a quick and accurate method for setting up the SCA for a conventional MCS scan. A single pulse height scan lasts 5 to 20 seconds, depending on the speed of



the computer. To improve the counting statistics in the histogram, scans are automatically repeated until the acquisition is stopped, or the SCA levels are set.

Pass Control

Acq Mode: Sum, Replace, Rep/Sum

The alternatives for data acquisition are selected via 3 displayed buttons. See Acquisition Modes under Performance.

Trigger: Internal, External

Two displayed buttons control whether the Start Output from the MCS will trigger the external instruments for the start of each scan (Internal Trigger), or a Start Input from the external instruments will start each scan (External Trigger).

Pass Length Data entry box, with up/down arrows for adjustment, selects the number of channels in a single pass (scan) from 4 to 32,768 (with ramp output active) or up to 65,536 (with ramp output inactive).

Pass Count Preset Data entry box, with up/down arrows for adjustment, selects the number of passes that will be executed before data acquisition automatically stops. Selectable from 1 to 4,294,967,295 passes, or OFF to disable.

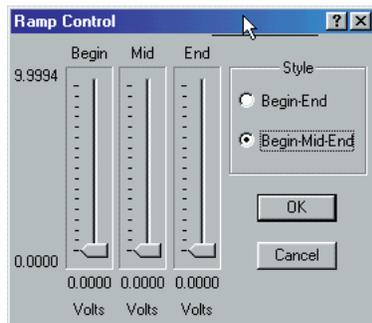
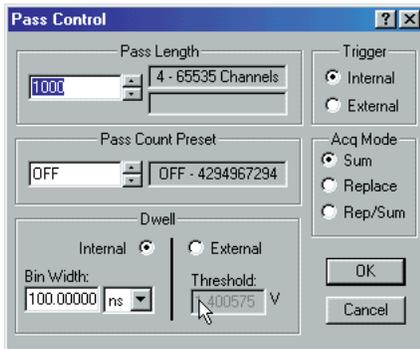
Dwell Two displayed buttons permit selection of the Internal dwell-time clock or an External channel advance input. The Bin Width data entry box provides selection of a range of internal dwell times. See Dwell Time under Performance. A data entry box permits adjustment of the external channel advance input Threshold from -1.6 to +3 V in 1.5-mV steps.

Ramp Control

Style: Begin-End, Begin-Mid-End

Two displayed buttons select either a single-segment ramp or a two-segment ramp. The single-segment ramp moves linearly from the specified starting voltage at the beginning of each pass to the specified ending voltage at the completion of each pass. The two-segment ramp makes a linear transition from the specified starting voltage at the beginning of the pass to a specified Mid voltage at the mid-point of the pass. It makes another linear transition from the mid-point voltage to the specified ending voltage at the completion of the pass.

Begin, Mid, End Three displayed slide bars select the begin-, mid-, and end-point ramp voltages from 0 to +10 V with 16-bit resolution.



Pull-Down Menu

Clicking the mouse on the menu titles at the top of the display generates pull-down menus that provide access to other displays and additional functions. Many of these functions are also accessible from the toolbar, the status sidebar, or by using the mouse directly on the display.

File Allows saving and recalling of spectrum data files to/from the computer disk. Permits comparison of a spectrum on disk with a spectrum in the Buffer memory.

Allows saving and recalling the instrument settings. Selects regions of the spectrum for printing. Creates reports describing acquisition conditions and the contents of all ROIs for printing or filing on disk. Includes the functions for exporting or importing the data in ASCII format.

Acquire Offers menu selection of the Start, Stop, and Clear controls, live adjustment of the thresholds, and selection of the MCS or Buffer memory. Provides access to the SCA Sweep mode and the display panels for Pass Control, Input Control, and Ramp Control.

Calculate Includes an automated peak search, and offers calculation of the centroid, gross area, and net area of a peak within boundaries selected by the marker. Provides Sum, Smooth, Strip, and Normalize operations on the spectrum. Implements linear, quadratic, or cubic calibration of the horizontal scale in user-defined units via least-squares fitting. Allows subtraction of a flat background to extract small peaks from a high background.

Services Provides menu access to user-defined Job programs, the Library Files for peak identification, and the Sample Description.

ROI Provides menu access to recalling, saving, marking, and unmarking Regions Of Interest (ROI).

Display Offers menu selection of all the functions listed under View. Allows coloring of the ROI areas and/or the entire spectrum. Provides selection of the colors used for the various features in the displays. Selects uncalibrated versus calibrated marker readout. Displays or hides grid lines in the expanded display.

INPUTS

All inputs, except the fast analog IN are supplied on the 25-pin D connector on the rear panel. The MCS-PCI-OPT2 option offers convenient BNC connections to the D connector.

IN Fast analog signal input accepts analog or digital pulses up to ± 5 V in amplitude on a rear-panel BNC connector. Pulses are counted as they cross the discriminator threshold. Computer selection of triggering on either positive or negative slope. Threshold is computer adjustable from -1.6 V to +3 V in steps of 1.5 mV. Computer selection of either 50- Ω or 1000- Ω input impedance, dc-coupled. Minimum input pulse width is 3.5 ns at the discriminator threshold. Maximum counting rate is 150 MHz.



SCA IN 1-MHz window discriminator (Single-Channel Analyzer) accepts linear signals from 0 to +12 V for counting. SCA input is dc-coupled with a 1000- Ω input impedance. Minimum input pulse width is 500 ns. The upper- and lower-level thresholds are independently adjustable from 0 to +10 V in 4096 steps via the computer. A signal that rises above the lower-level threshold, without exceeding the upper-level threshold, will be counted as it falls below the lower-level threshold.

START IN Accepts a TTL signal to start the scan on the next clock edge after the rising edge of the 0 to +2.5-V transition is detected on the START IN. In the Internal Dwell mode the next clock edge is obtained from the 50-MHz internal time base. For the External Dwell mode the next clock edge is obtained from the External Channel Advance Input. The START IN edge is ignored during a scan, or when disabled by the Start Enable Input. Input impedance is 1000 Ω to ground. Minimum pulse width is 10 ns.

STOP IN Accepts an external TTL input rising from 0 to +2.5 V to stop scanning at the end of the current scan. Minimum pulse width is 10 ns. Input impedance is 5000 Ω to ground.

CHN ADV IN (Channel Advance Input) Accepts an analog or digital pulse to cause a channel advance when the signal crosses the threshold with a positive slope (provided External Dwell has been selected). Threshold is adjustable from -1.6 to +3 V in 1.5-mV steps via the computer. Minimum dwell time is 100 ns. Minimum pulse width is 10 ns. Input impedance is 1000 Ω to ground.

GATE IN Accepts a TTL input to prevent counting of the signals at the IN and SCA IN connectors. When the GATE IN is <0.8 V, counting is inhibited. Counting is enabled when the GATE IN level is >2 V, or when the GATE IN is not connected to a signal source. Input impedance is 1000 Ω to +5 V.

TTL (START ENABLE INPUT) Accepts a TTL input to enable/disable response to a START IN trigger. When the START ENABLE INPUT is <0.8 V, triggering is inhibited. Triggering is enabled when the START ENABLE INPUT level is >2 V, or when the START ENABLE INPUT is not connected to a signal source. Input impedance is 5000 Ω to +5 V. START ENABLE INPUT must be at the desired level when the rising edge of the START IN arrives.

OUTPUTS

All outputs are supplied on the 25-pin D connector on the rear panel. The MCS-PCI-OPT2 option offers convenient BNC connections to the D connector.

START OUT This TTL output rises from <+0.4 V to >+2.4 V when a scan starts, and returns to <+0.4 V after 160 ns. Useful for synchronizing external instruments with the start of the scan. The output is short-circuit protected, and can drive impedances $\geq 50 \Omega$.

CHN ADV OUT (Channel Advance Output) This TTL output rises from <+0.4 V to >+2.4 V when the MCS-pci advances from one channel to the next. The pulse width is approximately 20 ns. The output is short-circuit protected, and can drive impedances $\geq 50 \Omega$.

SCA OUT A TTL output pulse for every SCA Input signal that occurs between the upper and lower discriminator thresholds.

The output rises from <+0.4 V to >+2.4 V as the SCA Input signal falls through the lower discriminator threshold. The pulse width is nominally 250 ns. The output is short-circuit protected, and can drive impedances $\geq 50 \Omega$.

MIDPASS OUT This TTL output rises from <+0.4 V to >+2.4 V after half the channels in a pass have been scanned. It returns to <+0.4 V at the end of the pass. If the number of channels in a pass is odd, the MIDPASS OUT remains low for one more channel than it stays high. The output is short-circuit protected, and can drive impedances $\geq 50 \Omega$.

RAMP OUT Provides an analog voltage ramp from a digital-to-analog converter to drive external devices. See Ramp Control for a description. The output voltage range is computer adjustable from 0 to +10 V with 16-bit resolution. Minimum voltage step size is approximately 0.15 mV for any range. Settling time is 2 μ s. The output impedance is 100 Ω , short-circuit protected

Electrical and Mechanical

Power Requirements

The MCS-pci derives its power from the computer in which it is installed. The required power is:

Voltage	Current	Power
+5 V	600 mA	3 W
+12 V	100 mA	1.2 W

Operating Environment

Same as for the host PC: 16°C to 32°C (61°F to 90°F); 8% to 80% relative humidity, non-condensing. Altitude up to 2,000 meters. Installation category II. Pollution degree 2. Meets all CE requirements.

Dimensions

MCS-pci is a 10-cm x 18-cm plug-in card for the PCI-bus slot in an IBM-compatible PC.

Weight

Net 0.13 kg (0.29 lb.).
Shipping 1 kg (2.2 lb.).

Computer Prerequisites

IBM-compatible PC with:
One available PCI slot with space for an 18-cm card length
At least 64 MB of memory
Hard drive
CD-ROM drive (software is supplied on CD)
Microsoft Windows 2000/XP

Optional and Related Equipment

MCS-PCI-OPT2 Fan-Out Cable This cable converts the 25-pin D connector on the MCS-pci into a separate BNC cable connection for each input and output signal. This option is strongly recommended.

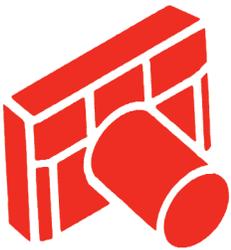
A11-B32 CONNECTIONS Programmer's Toolkit with ActiveX™ Controls Write your own special software to control the MCS-pci from LabVIEW®, Visual C++, or Visual Basic.

Ordering Information

To order, specify:

Model Number	Description
MCS-PCI	MCS-pci™ with software and documentation
MCS-PCI-OPT2	Fan-Out Cable

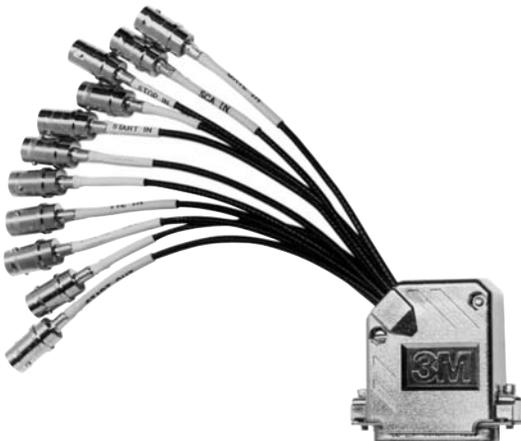
FullShot™ Screen Capture and Graphics Printing



Screen capture and graphic printing are easy with MCS-pci, . . . thanks to the FullShot™ Image Capture and Printing Utility. FullShot is manufactured by Inbit™, and is supplied by ORTEC as a standard part of the MCS-pci software package.

With FullShot, a whole screen, a window, or a portion of a window can be captured and sent directly to the printer. The output can be produced in color with different scales and sizes, as required. All Windows-supported printers and plotters may be used, and FullShot may be used for other applications also.

Print your spectral displays in color with FullShot.



MCS-pciTM

Specifications subject to change
010907

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Choosing the Right Counting Solution

ORTEC offers a variety of instruments to configure counting systems for many applications, from simple to complex. The following descriptions and selection charts will help identify the functions and data interfaces needed for the application.

The Basic Functions of Counting Systems

There are five general classes of counting systems: counters, timers, ratemeters, multichannel scalers and time digitizers, and digital signal averagers. Counters simply count the number of input pulses received during the counting period. ORTEC offers four of the five. Counters simply count the number of input pulses received during the counting period. Timers count pulses generated by an internal clock and are used to measure elapsed time or to establish the length of the counting period. Ratemeters provide a meter readout of the pulse count rate and convert this frequency to a DC voltage or current proportional to the average count rate per unit of time. This is normally expressed in counts per second (counts/s).

Two types of ratemeters are available from ORTEC: linear scale (Model 661), or combined logarithmic and linear scales (Models 449 and 9349). The Model 449 has positive and negative inputs with an optional audible alarm. The Model 9349 has a rear-panel, fast, negative input.

All ORTEC NIM timers contain preset controls to establish the duration of the counting period. When counting is initiated, the internal clock pulses are counted until the preset condition is reached; at that time, counting is stopped in all counters connected to the common gate line of the master timer. If the external input is used, the preset control will apply to counting of the pulses at the external input and will result in preset count operation.

Multichannel Scalers counts the number of events that occur during the time interval t to $t + \Delta t$ as a function of time. The interval Δt is called the dwell time. The time t is quantized into channels or bins by the relation $t = i \Delta t$, where i is the bin number (an integer). Dwell times can be selected from fractions of a nanosecond to hours, and the total number of bins ranges from 4 to 67 million. When the scan is started, the MCS begins counting input events in the first channel of its digital memory. At the end of the selected dwell time the MCS advances to the next channel of memory to count the events. This dwell and advance process is repeated until the MCS has scanned through the preset number of memory channels. The display shows a graph of counts versus dwell channels from zero time on the left to end of the scan on the right.

Time digitizers measure the arrival time of individual events with a quantization precision, Δt , selectable from picoseconds to nanoseconds. The time spectrum is represented by $t = i \Delta t$, where i is the bin number (an integer). The number of bins is typically on the order of 65,000 to 67 million. Time digitizers can measure the time spectrum with a quantization precision that is at least three orders of magnitude smaller than is offered by multichannel scalers. This exceptional advantage in time resolution is sometimes gained at the expense of pulse-pair resolution. For example, the MCS-pci delivers a 6.7-ns pulse-pair resolving time, whereas the Model 9308-pci time digitizer is limited by interpolator dead time to 50 ns.

Both multichannel scalers and time digitizers are triggered by a start pulse that defines zero time. Typically, the start pulse corresponds to the stimulation of a process. The "products" of the process are counted as a function of time by the MCS, or their emission times are measured by the time digitizer. In a single pass through the selected time span, both instruments can record multiple events. If the process is repeatable, the data from multiple passes through the time span can be summed to improve the statistical precision. The final result is a histogram showing the probability of observing the product events as a function of time.

Multichannel scalers often have the advantage over time digitizers when dwell times much larger than a few nanoseconds are required, particularly in applications that demand pulse-pair resolving times much better than 50 ns. A time digitizer is the preferred solution when the measurement demands sub-nanosecond time quantization.

The Model 9353 straddles the time digitizer and MCS functions. It behaves like a time digitizer with 1-ns pulse-pair resolving time for 100-ps digital resolution. For digital resolution >1 ns it acts like an MCS, counting multiple stop pulses in a bin on each scan.

MCS vs. a Counter and Timer

Although a computer-controlled counter and timer can also be used to record counting rate as a function of time, the MCS technology offers several important advantages. The time taken to read, clear, and start a conventional counter at the end of each counting interval can range from microseconds to milliseconds. This dead time causes significant gaps in the recorded data. High performance multichannel scalers have negligible dead time between counting intervals (channels), and this avoids blank regions in the recorded time profile. Conventional counters and timers rarely handle time intervals shorter than 10 ms, whereas multichannel scalers are available with minimum dwell times ranging from 2 μ s down to 5 ns. Furthermore, the MCS products in this section include standard operating software to acquire, display, and manipulate the data. With a conventional counter and timer one must develop custom software for the intended application.

Counters/Ratemeters/ Multichannel Scalers

Multiple Stop Advantages over a Time-to-Amplitude Converter (TAC)

Both an MCS and a time digitizer can operate as a multiple-stop time spectrometer. On each scan through the selected time span, both instruments can record multiple stop events. In the case of the MCS this is achieved by counting "stop" events in the appropriate bin as they arrive. For the time digitizer, the arrival time for each event is recorded as the event occurs. Clearly, both instruments can record multiple stop events following each start trigger. In contrast, a time-to-amplitude converter (TAC) can record only one stop event for each start trigger. (See the Time-to-Amplitude Converters introduction.) The multiple stop capability allows the Model 9308-pci Picosecond Time Analyzer to acquire data at much higher rates than a TAC/MCA system for time spans >250 ns. The 9353 has this same advantage over a TAC for time spans ≥ 50 ns. **For example, on a time span of 81.92 μ s, a 9353 can acquire data 42,000 times faster than a TAC, and a Model 9308 picosecond TIME ANALYZER can exceed the TAC data acquisition rate by a factor of 1600.** These comparisons are based on minimizing spectrum distortion by maintaining <1% dead time losses. The advantages are even greater for longer time spans.

Multichannel scalers and time digitizers have an upper limit on the event rate as a result of the dead time caused by the pulse-pair resolving time. Generally, the probability of detecting a single event within the pulse-pair resolving time must be kept less than 2% during each scan, in order to limit the dead time losses and distortions to less than 1%. In the application Time-of-Flight Mass Spectrometry (TOF-MS) analyzing the output of a chromatograph (LC or GC), this places an unproductive limit on the ion rates that can be accommodated. As a result, TOF-MS spectra collected for 100-ms time intervals contain circa 20 counts in the largest peaks. This leads to statistical errors in excess of 22%, and correspondingly high detection limits. A Digital Signal Averager would be a much more appropriate solution for this type application.

Accounting and Correcting for Dead Time Effects

With both multichannel scalers and time digitizers, dead times in the counting system can cause distortion of the measured time spectrum. One means of minimizing the distortion is to operate at counting rates low enough to keep dead time losses below 1%. Usually this strategy ensures that the spectrum distortion will be <1%. To achieve this goal one must know the equations linking counting rate, dead times, and dead time losses. Fortunately, these equations lead one to correction algorithms that can be applied in several practical cases to enable operation at significantly higher counting rates.

Case 1: $\Delta t \ll T_d$

Cascaded Dead Times:

As explained in the introduction to the Fast Timing Discriminators section, the dead time experienced in the counting chain is typically composed of two cascaded components, T_e and T_{ne} . T_e is the extending dead time caused by the duration of the analog signal from the detector at the noise threshold of the timing (or counting) discriminator. It is an extending dead time because a second analog pulse occurring during a preceeding pulse extends the dead time by one pulse width from the arrival time of the second pulse. The non-extending dead time, T_{ne} , can be caused by the pulse width of the discriminator output driver, or it can be a longer dead time contributed by a circuit in the MCS or time digitizer. Sufficient accuracy^{1,2} will be achieved if one chooses the longer of these two dead times to represent T_{ne} . A second pulse occurring during T_{ne} is ignored and does not affect the dead time. It is convenient to define the approximate dead time in the system as

$$T_d \approx T_e + U(T_{ne}-T_e) (T_{ne}-T_e) \quad (1)$$

where $U(T_{ne}-T_e)$ is a unit step function defined by

$$\begin{aligned} U(T_{ne}-T_e) &= 1 \text{ for } T_{ne} > T_e \\ &= 0 \text{ for } T_{ne} \leq T_e \end{aligned} \quad (2)$$

Under that definition, the equations for Case 1 are valid if the quantization interval, Δt , is insignificant compared to T_d . This is the practical situation encountered in the Model 9308 picosecond TIME ANALYZER. For the Model 9308, $T_d \approx 45$ ns and the maximum size of the bin width, Δt , is 2.5 ns.

Presume a time digitizer that has summed the repetitive spectra from n start triggers. The counts in the i th bin of the resulting spectrum (after suffering dead time losses) are defined to be q_i , and the time, t , is related to the bin number by

$$t = i \Delta t \quad (3)$$

¹Jörg W. Müller, *Nucl. Instr. Meth.* 112, (1973), 47–57, Fig. 3.

²D.R. Beaman, et al., *J. of Physics E: Sci. Instr.* (1972), 5, 767–776.

Counters/Ratemeters/ Multichannel Scalers

By analogy to equation (3) it is convenient to define the quantized dead times, τ_e , τ_{ne} , and τ_d , by equations (4).

$$T_e = \tau_e \Delta t \quad (4a)$$

$$T_{ne} = \tau_{ne} \Delta t \quad (4b)$$

$$T_d = \tau_d \Delta t \quad (4c)$$

Note that i , τ_e , τ_{ne} and τ_d are all rounded to integer values.

The number of counts that would have been recorded in bin i if the dead time were zero is defined to be Q_i . The distorted spectrum recorded in the measurement is represented by q_i , whereas Q_i is the undistorted spectrum that is sought.

When the counting rates are low enough to yield single-ion or single-photon counting, one can apply statistical sampling theory. Poisson Statistics can also be applied directly, provided the dead time losses are negligible³.

In equation (5), q_i/n is the probability of recording an event in the i th bin during a single pass through the time span. It is composed of three probabilities⁴, as described in the right hand side of the equation.

Cascaded Dead Time Equation:

$$\frac{q_i}{n} = \frac{Q_i}{n} \exp \left\{ - \sum_{j=i-\tau_e}^{i-1} Q_j/n \right\} \left[1 - U(\tau_{ne} - \tau_e) \sum_{j=i-\tau_{ne}}^{i-\tau_e-1} Q_j/n \right] \quad (5)$$

The first term, Q_i/n is the probability that an event will arrive at the detector at a time suitable to be categorized in bin i . In order to be recognized as distinct from previous analog pulses there must be no pulses arriving at the detector in the time interval τ_e preceding the pulse for bin i . That probability is given by the exponential term in equation (5). If a pulse had been counted by triggering the non-extending dead time in the time interval τ_{ne} preceding the pulse for bin i , the pulse for bin i would be lost. Consequently, the term in the square brackets is the probability that no pulses are recorded in the preceding time interval τ_{ne} . Note that the sum stops at $j = i - \tau_e - 1$ because the exponential term already guarantees no pulses occurred in the time interval from $j = i - \tau_e$ to $i - 1$.

Equation (5) can be rearranged to get the formula for computing the corrected spectrum, Q_i , from the distorted spectrum, q_i .

$$Q_i = \frac{q_i}{\exp \left\{ - \sum_{j=i-\tau_e}^{i-1} Q_j/n \right\} \left[1 - U(\tau_{ne} - \tau_e) \sum_{j=i-\tau_{ne}}^{i-\tau_e-1} Q_j/n \right]} \quad (6)$$

One applies the correction algorithm by starting at bin $i = 0$, while presuming that q_i , q_j , and Q_j are all zero for negative values of i and j . For each i , the value Q_i is calculated from equation (6) using the recorded values q_i and q_j along with the Q_j values calculated for the previous values of i . This correction calculation is applied bin by bin until the maximum bin in the spectrum has been treated. At that point the list of Q_i values is the corrected spectrum.

If there truly were no counts to be detected for negative values of i , then the Q_i data near $i = 0$ will represent the true spectrum before dead time losses. If the detector was actually responding to events for negative values of i , then Q_i will be underestimated until the bin number exceeds several times τ_d . Frequently, this shortcoming can be eliminated by inserting a coaxial cable delay of the appropriate length between the detector and the stop input on the time digitizer.

Single, Extending Dead Time:

For a system where the detector pulses are longer than any other dead times in the system ($\tau_e > \tau_{ne}$), equation (5) simplifies to the equation for a single, extending dead time⁴.

$$q_i = Q_i \exp \left\{ - \sum_{j=i-\tau_e}^{i-1} Q_j/n \right\} \quad (7)$$

³Ron Jenkins, R.W. Gould, and Dale Gedcke, *Quantitative X-Ray Spectrometry*, Marcel Dekker, New York, (first edition), 1981, Chap. 4.

⁴D.A. Gedcke, Development notes and private communication, Nov.–Dec. 1996.

⁵P.B. Coates, *Rev. Sci. Instrum.* 63 (3), March 1992, 2084.

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Single, Non-extending Dead Time:

The other extreme is a system in which detector pulse widths are negligible compared to the non-extending dead time in the MCS or time digitizer. In that case, equation (6) simplifies to^{4,5}

$$Q_i = \frac{q_i}{1 - \sum_{j=i-\tau_{ne}}^{i-1} q_j/n} \quad (8)$$

Accuracy of the Dead Time Correction:

It can be demonstrated by substituting known values into equations (6), (7) and (8) that all three equations yield predictions of Q_i / q_i that are within 1% of each other provided $Q_i / q_i < 1.15$ (i.e., **a dead time correction < 15%**), and provided τ_d is substituted for the single dead times in equations (7) and (8). This allows a simpler correction algorithm to be implemented using equation (8). In fact, the algorithm using equation (8) can start at the maximum value of i and proceed towards $i = 0$, while replacing q_i with Q_i in the data file. This is the procedure used in the **Model 9308** software.

Without the dead time correction algorithm, one would have to limit the counting rate to achieve <1% dead time losses in order to limit the spectrum distortion to <1%. By applying the dead time correction algorithm, one can typically operate at a factor of 10 higher dead time loss, while still achieving <1% spectrum distortion. This implies **a factor of 10 higher data rates**. However, the accuracy of the correction is limited by the factors discussed next.

If the time spectrum is constant across all bins, it is easy to show that a 10% error in the assumed value for the dead time in equations (6), (7), or (8) will lead to < 1% error in the corrected counts if $Q_i / q_i < 1.10$. A more serious case is a narrow peak centered at bin i , and preceded by an intense, narrow peak centered at bin $j = i - \tau_d$. A small error in the presumed value for τ_d can result in either including or excluding the peak at bin j in the dead time corrections. This can make a large difference in the dead time correction applied to the peak at bin i . An additional issue is the error in rounding off the presumed dead time to the nearest integer value. This leads to round-off errors at the two limits of the sums in the equations. That effect can be restricted to an error <1% if one ensures that $q_j / n < 0.005$ for all j . Clearly, it is important to use an accurately measured dead time in the correction formula.

By applying basic probability theory, it can be shown that the statistical variance in the recorded counts q_i is given by⁴

$$\sigma_{q_i}^2 = q_i (1 - q_i/n) \approx q_i \quad \text{for } q_i/n \ll 1 \quad (9)$$

Moreover, for the sum of the recorded counts in any number of bins, such as

$$M = \sum_{j=i-\tau}^{i-1} q_j \quad (10)$$

the statistical variance in the sum is

$$\sigma_M^2 = M = \sum_{j=i-\tau}^{i-1} q_j \quad (11)$$

A straight forward propagation-of-errors computation predicts the statistical variance in the corrected counts Q_i calculated from equation (8) to be^{4,5}

$$\sigma_{Q_i}^2 = Q_i k_i \quad (12)$$

where k_i defines the magnification factor arising from the variances in the q_i and q_j in equation (8), i.e.,

$$k_i = (Q_i / q_i) + (Q_i / q_i)^2 [(Q_i / q_i) - 1] (q_i / n) \quad (13)$$

The effect of k_i is small for dead time corrections $Q_i / q_i < 1.15$, but the second term of k_i escalates rapidly for higher dead time corrections.⁵

Counters/Ratemeters/ Multichannel Scalers

Case 2: $T_d \ll \Delta t$, with Counts Essentially Constant Across Δt

This solution is applicable to multichannel scalers. Typically the dead time T_d is < 20 ns. If the dwell time is large compared to 20 ns (for example: 2000 ns) and the counting rate varies insignificantly during the dwell time of a bin, then one can transform equation (6) into the form that applies for approximately constant counting rate.⁴ The result is

Cascaded Dead Times:

$$Q_i = \frac{q_i}{\exp\left\{\frac{-Q_i T_e}{n \Delta t}\right\} \left[1 - U(T_{ne} - T_e) q_i \left(\frac{T_{ne} - T_e}{n \Delta t}\right)\right]} \quad (14)$$

Note that Q_i appears on both sides of the equation. So equation (14) must be solved by iteration. If one substitutes the instantaneous counting rates defined by equation (15) in equation (14), the constant counting rate formula in the Fast Timing Discriminator section are generated.

$$R_i = \frac{Q_i}{n \Delta t} \quad (15a)$$

$$r_i = \frac{q_i}{n \Delta t} \quad (15b)$$

In some applications the detector pulse width will exceed the non-extending dead time ($T_e > T_{ne}$) leading to

Single, Extending Dead Time:

$$q_i = Q_i \exp\left\{\frac{-Q_i T_e}{n \Delta t}\right\} \quad (16)$$

If the detector pulse width is negligible compared to the non-extending dead time, equation (14) becomes

Single, Non-extending Dead Time:

$$Q_i = \frac{q_i}{1 - (q_i/n)(T_{ne}/\Delta t)} \quad (17a)$$

or

$$q_i = \frac{Q_i}{1 + (Q_i/n)(T_{ne}/\Delta t)} \quad (17b)$$

As in Case 1, it is convenient and adequate to use equation (17a) when the dead time losses are less than 15%, provided T_{ne} is replaced with T_d . Most of the caveats in Case 1 concerning accuracy apply here as well. The one exception is the statistical variance in the recorded counts q_i which is given by³

$$\sigma_{q_i}^2 = q_i (q_i / Q_i)^2 \quad (18)$$

for the case of non-extending dead time. The statistical variance in the Q_i calculated from equation (17a) is given by³

$$\sigma_{Q_i}^2 = Q_i (Q_i / q_i) \quad (19)$$

Note that large dead time corrections magnify σ_{Q_i} (the standard deviation in the corrected counts) by the square root of the correction factor, Q_i / q_i . Equations (18) and (19) are valid if $\Delta t \gg T_d$ and Δt is large compared to the mean spacing between pulses. The expressions for the σ_{q_i} and σ_{Q_i} corresponding to extending dead time are approximately the same as equations (18) and (19) for $Q_i / q_i < 1.1$, but diverge wildly from the non-extending case for large correction factors³. This provides an incentive for limiting dead time losses to $< 10\%$.

Counters/Ratemeters/ Multichannel Scalers

Case 3: $T_d \sim \Delta t$

In this case there is not a practical algorithm for making accurate dead time corrections in the time histogram. However, one can use the equations above and the equations in the Fast Timing Discriminators section to predict the severity of the dead time losses and to determine the limitations on the counting rates that guarantee negligible dead time losses.

Case 4: Counting Rates Vary Significantly Across Δt

The statements under Case 3 apply.

Software Programmer's Toolkits

Each multichannel scaler and time digitizer includes a complete software package to operate the instrument in virtually all applications. Occasionally, it is advantageous to integrate the instrument into a software program specific to a unique application. ORTEC offers the Programmer's Toolkits summarized in the table below to facilitate special programming.

Software Programmer's Toolkits

Toolkit	Supports	Operating Environment
A11-B32 (CONNECTIONS Programmer's Toolkit)	MCS-pci	Windows 2000/XP
A69-BX (pTA Software included with each 9308-pci)	9308-pci pTA	Windows 2000/XP
9353-B32 (included with each 9353)	9353	Windows 2000/XP

MCS Selection Guide

Feature	MCS-pci
Package	Plug-In PC Card
Bus	PCI
Dwell Time	
Minimum	100 ns
Maximum	1300 s
Memory Length (channels)	65,536
Time Span (Full Memory Length)	
Minimum	6.55 ms
Maximum	2.7 years
Inputs and Rates	
Fast +/- Discriminator	150 MHz
SCA	1 MHz
SCA or Discriminator Controls	Computer
SCA Sweep Mode	Yes
Dead Time Between Channels	Zero
End-of-Pass Dead Time	Zero
Ramp	Standard. Sawtooth or Triangular with Computer Adjustable Start/Mid/End Points
Software Base	Microsoft® Windows™
User-Defined Calibration of Horizontal Axis	Linear, Quadratic, or Cubic
Programmer's Toolkit	A11-B32

Counters/Ratemeters/ Multichannel Scalers

Time Digitizer Selection Guide

Feature	Model 9308-pci picosecond TIME ANALYZER	Model 9353 100-ps Time Digitizer/MCS
Package	2-wide NIM Module with PCI-bus interface	Plug-in PCI Card
Time Quantization		
Minimum	1.221 ps	100 ps
Maximum	2.5 ns	13 μ s
Memory Length (bins)	65,536	67,000,000
Time Span		
Minimum	80 ns	51.2 ns
Maximum	163.84 μ s	6.7 ms
Time Offset		
Minimum	0 ns	0 ns
Maximum	324.92 μ s	6.7 ms
Input and Rates	Fast Negative NIM: 20 MHz burst; 2 MHz continuous	Positive or Negative: 1 GHz burst; >10 MHz continuous
End-of-Pass Dead Time	<1 μ s	0
Software Base	Microsoft Windows	Microsoft Windows
User-Defined Calibration of Horizontal Axis	Linear, Quadratic, or Cubic	Linear, Quadratic, or Cubic; Least Square Fit
Dead Time Correction	Included in Software	Included in Software
Programmer's Toolkit	Included	Included
Operating Modes	Histogramming or List Modes	Histogramming List, Chromatograph, and Trend Modes

Ratemeters Selection Guide

Model	Type	Full Scale Ranges		Input Types	Pulse-Pair Resolution	Audible Output	Recorder Output	Package and Width	Special Feature
		Minimum	Maximum						
449	Log/Linear	10 counts/s	10 ⁶ counts/s	+/-Logic pulses >3 V high & >50 ns wide	<100 ns, or <1% of average pulse spacing	449-2 option	YES	NIM-2	0 to 100% zero suppression
661	Linear	25 counts/s	10 ⁷ counts/s	Positive discriminator; Negative NIM	<40 ns	NO	YES	NIM-1	Fast Response circuit
9349	Log/Linear	10 counts/s	10 ⁶ counts/s	Negative NIM >4 ns wide	<100 ns, or <1% of average pulse spacing	NO	YES	NIM-2	0 to 100% zero suppression

Counters/Ratemeters/ Multichannel Scalers

Counters and Timers Selection Guide

Feature	Model Number				
	871	974	994	995	996
Timer (T) and/or Counter (C)	Dual T and C	Quad T and C	Dual T and C	Dual C	T and C
Number of Counters	2 or 1	3 or 4	2	2	1
Number of Timers	0 or 1	1 or 0	1	0	1
Max Rate (MHz)	25	100	100	100	100
Positive Input	Y	Y	Y	Y	Y
Negative Input	Y	Y	Y	Y	Y
Discriminator	Y	Y	Y	Y	Y
Digits Displayed	8	8	8	8	8
Time Base	1 MHz	1 MHz	10 MHz		10 MHz
Gate	Y	Y	Y	Y	Y
+6 V Required		Y	Y*	Y*	Y
Computer Controllable		Y	Opt	Opt	Opt
IEEE-488		Y	Opt	Opt	Opt
RS-232-C (20 mA)		Y	Opt	Opt	Opt
NIM Width	2	2	2	2	1

NOTE: BLANKS INDICATE "NO" or "NONE."

*Internal +6 V option available (Option 99X-4).

Specifications subject to change
041207

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Choosing the Right Amplifier for the Application

The amplifier is one of the most important components in a pulse processing system for applications in counting, timing, or pulse-amplitude (energy) spectroscopy. Normally, it is the amplifier that provides the pulse-shaping controls needed to optimize the performance of the analog electronics. Figure 1 shows typical amplifier usage in the various categories of pulse processing.

When the best resolution is needed in energy or pulse-height spectroscopy, a linear pulse-shaping amplifier is the right solution, as illustrated in Fig. 1(a). Such systems can acquire spectra at data rates up to 7,000 counts/s with no loss of resolution, or up to 86,000 counts/s with some compromise in resolution.

The linear pulse-shaping amplifier can also be used in simple pulse-counting applications, as depicted in Fig. 1(b). Amplifier output pulse widths range from 3 to 70 μ s, depending on the selected shaping time constant. This width sets the dead time for counting events when utilizing an SCA, counter, and timer. To maintain dead time losses <10%, the counting rate is typically limited to <33,000 counts/s for the 3- μ s pulse widths and proportionately lower if longer pulse widths have been selected.

Some detectors, such as photomultiplier tubes, produce a large enough output signal that the system shown in Fig. 1(d) can be used to count at a much higher rate. The pulse at the output of the fast timing amplifier usually has a width less than 20 ns. Consequently, maximum counting rates in excess of a few MHz are feasible without suffering more than 10% dead time losses.

The two common schemes for deriving signals to achieve nanosecond and sub-nanosecond time resolution are outlined in Fig. 1(c) and (e). Both applications utilize a fast timing amplifier. Fig. 1(e) illustrates the preferred solution for single-photon or single-ion detection and timing with photomultiplier tubes, electron multipliers, microchannel plates, microchannel plate PMTs, and channeltrons. Although the scheme designated in Fig. 1(c) can also be used with these same types of detectors, it is more commonly employed with high-resolution semiconductor detectors, since such detectors require a low-noise, charge-sensitive preamplifier.

Whatever your application, the brief descriptions of performance characteristics on the next few pages and the selection guide charts that follow will help you to choose the best amplifier for your situation.

Fast-Timing Amplifiers

When a detector signal from the preamplifier or photomultiplier tube is of sufficient amplitude, direct coupling of that output to a timing discriminator provides the best available rise time, and minimizes the effects of noise on time resolution. When a detector signal must be amplified or shaped before deriving the time information, an amplifier specifically designed for timing should be used.

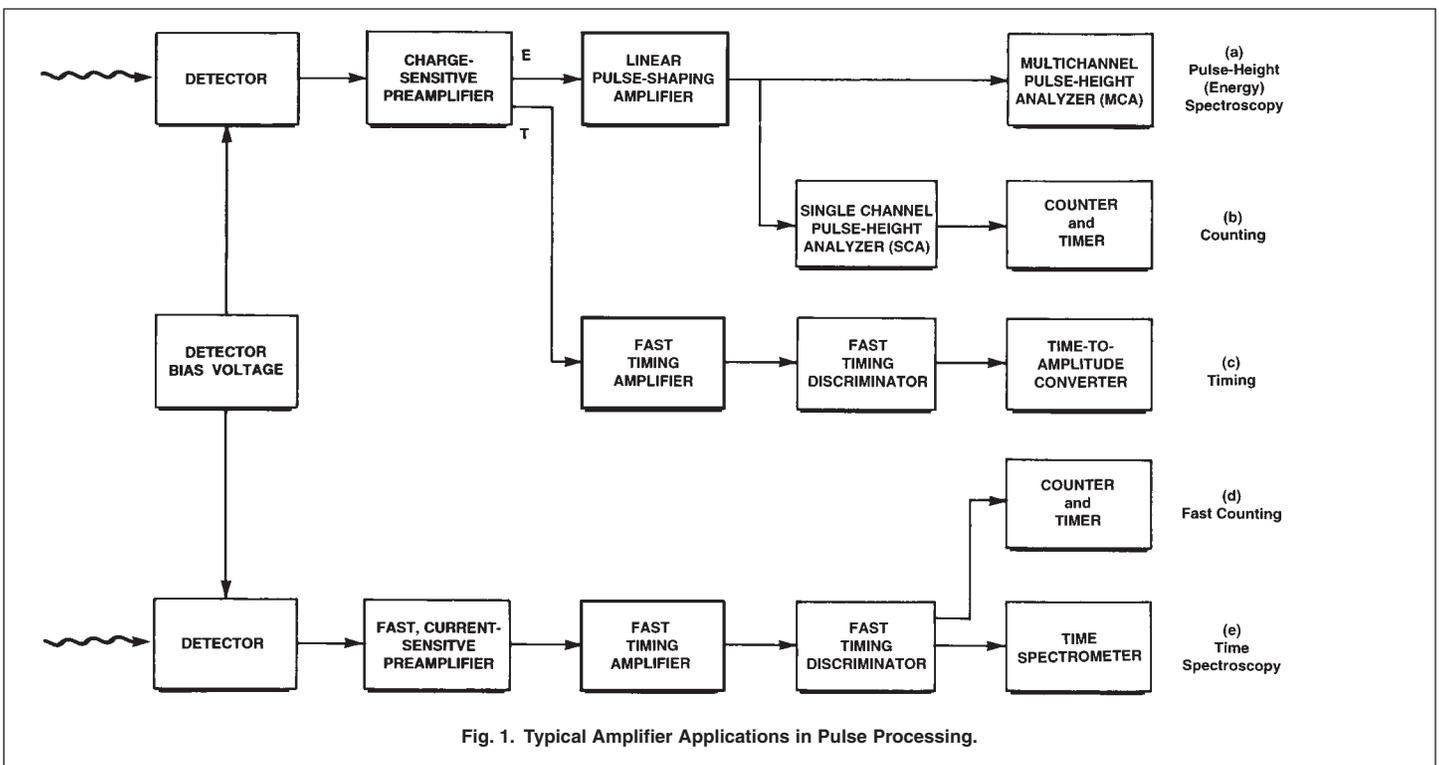


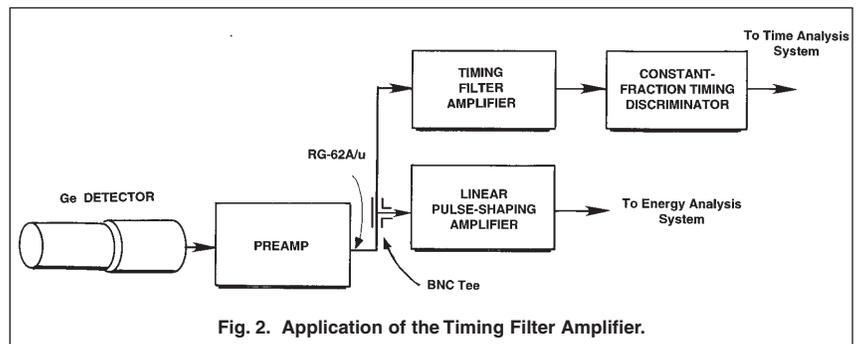
Fig. 1. Typical Amplifier Applications in Pulse Processing.

Amplifiers

Timing amplifiers are designed to have output rise times in the low nanosecond or sub-nanosecond range. Achieving such fast rise times usually compromises linearity and temperature stability. The latter parameters are not as important as low noise and fast rise times in timing applications. The output pulse polarity is normally negative for compatibility with fast timing discriminators, which were historically designed to work directly with the negative output pulses from photomultiplier tube anodes.

Two types of fast amplifiers are available: wideband amplifiers and timing filter amplifiers. Wideband amplifiers offer no control over the rise time or the decay time of the signal. They are typically used with photomultiplier tubes [Fig. 1(e)], and silicon charged-particle detectors [Fig. 1(c)], where the fastest rise times are required for good time resolution. Wideband amplifiers rely on the preceding electronics to limit the pulse length. Timing filter amplifiers offer independent CR differentiator and RC integrator controls for adjustable pulse shaping. The timing filter amplifier is used with germanium detectors (Fig. 2), or for any other application requiring adjustment of the pulse shaping. Both types of amplifiers may be either ac- or dc-coupled. The timing filter amplifiers typically include a baseline restorer.

For timing applications with either type of amplifier, the rise time should be selected to be less than the inherent rise time of the preamplifier so that there will be no degradation of the signal rise time. Excessively fast amplifier rise times should be avoided, since they will result in more noise and no improvement in the signal rise time. If adjustment of the differentiator time constant is available, it should be set just long enough to avoid significant loss of signal amplitude.



Linear, Pulse-Shaping Amplifiers for Pulse-Height (Energy) Spectroscopy

For pulse-height or energy spectroscopy, the linear, pulse-shaping amplifier performs several key functions. Its primary purpose is to magnify the amplitude of the preamplifier output pulse from the millivolt range into the 0.1- to 10-V range. This facilitates accurate pulse amplitude measurements with analog-to-digital converters, and single-channel pulse-height analyzers. In addition, the amplifier shapes the pulses to optimize the energy resolution, and to minimize the risk of overlap between successive pulses. Most amplifiers also incorporate a baseline restorer to ensure that the baseline between pulses is held rigidly at ground potential in spite of changes in counting rate or temperature.

Frequently, the requirement to handle high counting rates is in conflict with the need for optimum energy resolution. With many detector-preamplifier combinations, achieving the optimum energy resolution requires long pulse widths. On the other hand, short pulse widths are essential for high counting rates. In such cases a compromise pulse width must be selected which optimizes the quality of information collected during the measurement.

The following sections describe the various techniques available for pulse shaping in the linear amplifier. Each method has benefits for specific applications.

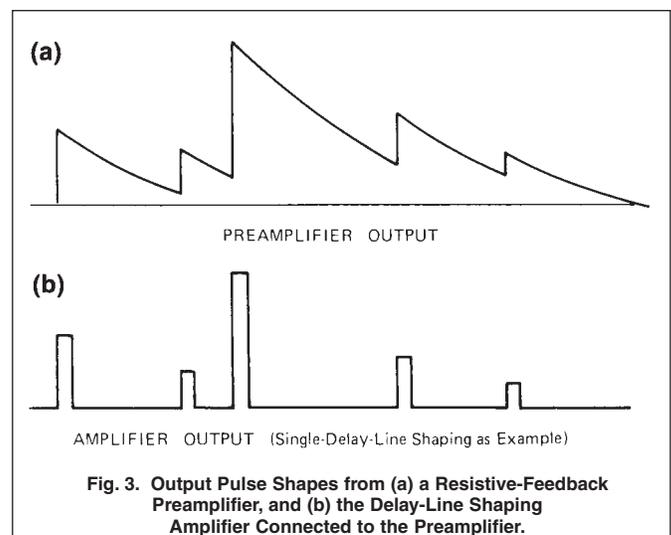
Accepting Preamplifier Pulse Shapes

The linear, pulse-shaping amplifier must accept the output pulse shapes provided by the preamplifier and change them into the pulse shapes required for optimum energy spectroscopy. Two general types of charge-sensitive preamplifiers are in common use: the resistive-feedback preamplifier,* and the pulsed-reset preamplifier. Each of these places slightly different demands on the amplifier's functions.

The Resistive-Feedback Preamplifier

Figure 3(a) illustrates the typical output pulse shapes from a resistive-feedback preamplifier. The output for each pulse consists of a rapidly rising step, followed by a slow exponential decay. It is the amplitude of the step that represents the energy of the detected radiation. The exponential decay time constant is normally determined by the

* Pulse shapes from a parasitic-capacitance preamplifier are similar to those from a resistive-feedback, charge-sensitive preamplifier.



Amplifiers

feedback resistor in parallel with the feedback capacitor. Decay time constants of 50 μs are prevalent, but longer time constants are encountered on some preamplifiers.

For detectors with very short charge collection times, the rise time of the preamplifier output pulse is controlled by the preamplifier itself, and the rise time is usually in the range from 10 to 100 ns. For detectors with long charge collection times, such as NaI(Tl) detectors, proportional counters, and coaxial germanium detectors, the output rise time of the preamplifier is controlled by the detector charge collection time. The output rise time can range up to 700 ns for large coaxial germanium detectors, and into the microsecond range for positive ion collection with proportional counters. For NaI(Tl) detectors, the scintillator decay time causes a preamplifier output rise time of approximately 500 ns.

In normal operation at ordinary counting rates, the rising step caused by each detector event rides on the exponential decay of a previous event, and the preamplifier output does not get a chance to return to the baseline. Since the amplitude of detector events is usually variable and the time of occurrence is random, the preamplifier output is usually irregular, as shown in Fig. 3(a). As the counting rate increases, the piling up of pulses on the tails of previous pulses increases, and the excursions of the preamplifier output move farther away from the baseline. The power supply voltages eventually limit the excursions, and determine the maximum counting rate that can be tolerated without distortion of the output pulses.

Before amplification, the pulse-shaping amplifier must replace the long decay time of the preamplifier output pulse with a much shorter decay time. Otherwise, the acceptable counting rate would be severely restricted. Figure 3(b) demonstrates this function using the simple example of a single-delay-line, pulse-shaping amplifier. The energy information represented by the amplitudes of the steps from the preamplifier output has been preserved, and the pulses return to baseline before the next pulse arrives. This makes it possible for an analog-to-digital converter (ADC) to determine the correct energy by measuring the pulse amplitude with respect to the baseline. With the shorter pulse widths at the amplifier output, much higher counting rates can be tolerated before pulse pile-up again causes significant distortion in the measurement of the pulse heights above baseline.

Pulsed-Reset Preamplifiers

Pulsed-reset preamplifiers were developed to eliminate the noise contributions of the preamplifier feedback resistor, and to improve the high counting rate capability of the preamplifier. There are two types: Pulsed optical feedback preamplifiers are often employed with Si(Li) detectors for x-ray spectrometry,¹ and transistor-reset preamplifiers are used to achieve high counting rates with germanium detectors.^{2,3} In both cases the feedback resistor is replaced with a feedback device that is turned on only for the very short time needed to reset the preamplifier output back to the baseline. The behavior at the output of the preamplifier is illustrated in Fig. 4(a).

With no feedback resistor to remove the charge from the feedback capacitor between detector events, each event steps the preamplifier output up to a higher dc voltage. Eventually, the staircase of pulses approaches the power supply voltage, and the voltage across the feedback capacitor must be reset back to the starting value. A voltage comparator in the preamplifier senses the upper limit of the staircase, and turns on the reset device just long enough to discharge the feedback capacitor back to the starting condition. By this method, the preamplifier output is maintained within its linear operating range, even at high counting rates. The limitation on counting rate with a pulsed-reset preamplifier is the percent dead time caused by the reset. At higher counting rates the reset must happen more frequently. When the percent dead time from resetting becomes too high to tolerate, the upper limit on counting rate has been reached.

Although the preamplifier output looks different from that with resistive-feedback preamplifiers, the function of the amplifier with pulsed-reset preamplifiers is similar. The pulse-shaping amplifier

¹Ron Jenkins, R.W. Gould, Dale Gedcke, Quantitative X-Ray Spectroscopy, Marcel Dekker Inc, New York, 1981, pp 175-177.

²D.A. Landis, C.P. Cork, N.W. Madden, F.S. Goulding, *IEEE Trans. Nucl. Sci.*, NS-29(1), 619 (1982).

³C.L. Britton, T.H. Becker, T.J. Paulus, R.C. Trammell, *IEEE Trans. Nucl. Sci.*, NS-31(1), 455 (1984).

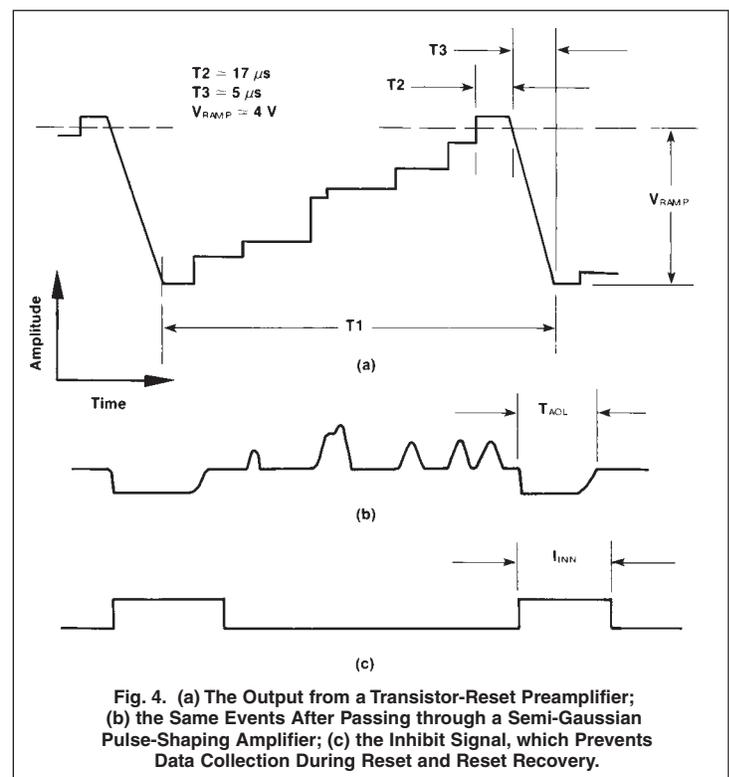


Fig. 4. (a) The Output from a Transistor-Reset Preamplifier; (b) the Same Events After Passing through a Semi-Gaussian Pulse-Shaping Amplifier; (c) the Inhibit Signal, which Prevents Data Collection During Reset and Reset Recovery.

Amplifiers

must preserve the amplitude of the steps from the preamplifier, and cause the pulses to return to baseline quickly between the steps. This function is demonstrated in Fig. 4(b) using a semi-Gaussian, pulse-shaping amplifier. Although slightly rounded in shape to improve the signal-to-noise ratio, the amplitudes of the amplifier output pulses are proportional to the step amplitudes from the preamplifier.

One additional characteristic shows up at the amplifier output with a pulsed-reset preamplifier. Each preamplifier reset causes a large, negative polarity, output pulse to be generated. The duration of this reset recovery pulse is determined by the pulse-shaping circuits in the amplifier, the gain of the amplifier, and the voltage swing of the reset. Typically, it lasts two to three times as long as the positive polarity pulses from detector events. During the reset-recovery pulse, data collection must be inhibited to prevent measurement of distorted pulse heights. The inhibit logic signal in Fig. 4(c) is generated by the preamplifier and/or the amplifier, and is used to inhibit data acquisition in the pulse-height analyzer during reset recovery.

With both the resistive-feedback preamplifier and the pulsed-reset preamplifier, the amplifier input must be able to accept the voltage swings of the preamplifier output without causing any distortion of the pulse amplitudes.

Delay-Line Pulse Shaping

Amplifiers employing delay-line pulse shaping are well suited to the pulse processing requirements of scintillation detectors. The propagation delay of distributed or lumped delay lines can be combined into suitable circuits to produce an essentially rectangular output pulse from each step-function input pulse. For pulse pile-up prevention, this shaping method is close to ideal because an immediate return to baseline is obtained. With scintillation detectors, the signal-to-noise ratio of the preamplifier and amplifier combination is seldom a limitation on the energy resolution. As a result of the high gain of the photomultiplier tube, the energy resolution is determined by the statistics of light production in the scintillator and the conversion to photoelectrons at the cathode. However, for detectors having no internal gain, delay-line shaping is seldom appropriate, because the signal-to-noise ratio for preamplifier noise with delay-line shaping is inferior to that obtained with simple CR-RC or semi-Gaussian shaping.

There are many circuits that can be used for delay-line shaping, and the circuit shown in Fig. 5 is typical of one that is very tolerant of delay-line imperfections. The step pulse from the preamplifier is inverted, delayed, and added back to the original step pulse. The result is a rectangular output pulse with a width equal to the delay time of the delay line. In practice, the value of the resistor labeled $2R_D$ is made adjustable over a small portion of its nominal value to allow compensation for the exponential decay of the input pulse. With proper adjustment, the output pulse will return to baseline promptly without undershoot. The main advantage of delay-line shaping is a rectangular output pulse with fast rise and fall times. In fact, the falling edge of the pulse is a delayed mirror image of the rising edge. These characteristics make delay-line pulse shaping ideal for timing and pulse-shape discrimination applications with scintillation detectors at low or high counting rates.

By following one delay-line shaper with a second, a doubly-differentiated delay-line shape is obtained, as illustrated in Fig. 6. The result is an output pulse shape that has a positive rectangular lobe followed by a negative rectangular lobe with equal amplitude and duration. The double-delay-line shaping is ideal for use with scintillation detectors in systems incorporating ac-coupling. The baseline shift caused by changing counting rates in ac-coupled systems is virtually eliminated by the two lobes having equal area above and below the baseline. This benefit is gained at the expense of doubling the pulse width. Double-delay-line shaping is often useful for simple zero-crossover timing with scintillation detectors at low or high counting rates. Double-delay-line shaping is not a good choice for detectors having a substantial preamplifier noise. Its signal-to-noise ratio is worse than single-delay-line shaping, and much worse than semi-Gaussian shaping.

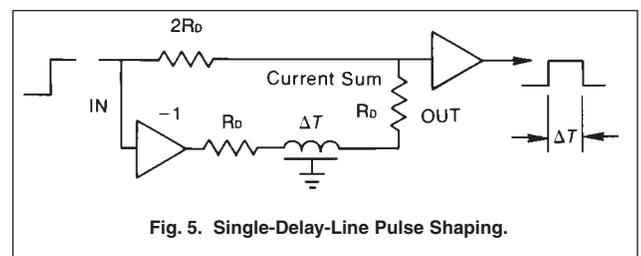


Fig. 5. Single-Delay-Line Pulse Shaping.

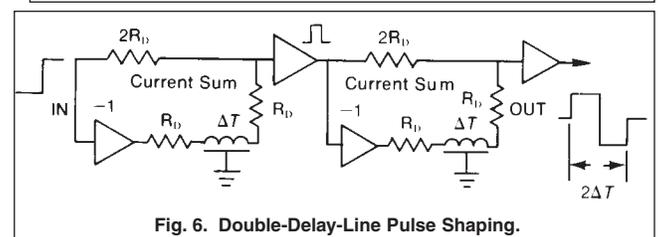


Fig. 6. Double-Delay-Line Pulse Shaping.

CR-RC Pulse Shaping

The simplest concept for pulse shaping is the use of a CR high-pass filter followed by an RC low-pass filter. Although this rudimentary filter is rarely used, it encompasses the basic concepts essential for understanding the higher-performance, active filter networks.

In the amplifier, the preamplifier signal first passes through a CR, high-pass filter (Fig. 7). This improves the signal-to-noise ratio by attenuating

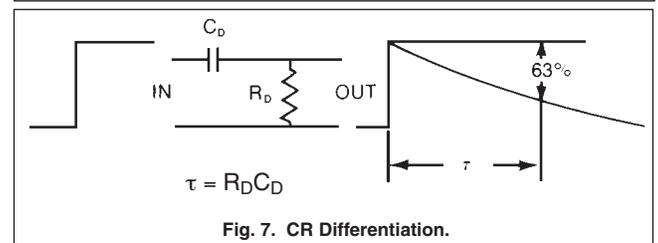


Fig. 7. CR Differentiation.

Amplifiers

the low frequencies, which contain a lot of noise and very little signal. The decay time of the pulse is also shortened by this filter. For that reason, it is often referred to as a "CR differentiator." (Note that the differentiation function is not a true mathematical differentiation.)

Just before the pulse reaches the output of the amplifier, it passes through an RC low-pass filter (Fig. 8). This improves the signal-to-noise ratio by attenuating high frequencies, which contain excessive noise. The rise time of the pulse is lengthened by this filter. Although this filter does not perform an exact mathematical integration, it is frequently called an "RC integrator."

Figure 9 demonstrates the effect of combining the high-pass and low-pass filters in an amplifier to produce a unipolar output pulse. Typically, the differentiation time constant $\tau_D = C_D R_D$ is set equal to the integration time constant $\tau_I = R_I C_I$, i.e., $\tau_D = \tau_I = \tau$. In that case, the output pulse rises slowly and reaches its maximum amplitude at 1.2τ . The decay back to baseline is controlled primarily by the time constant of the CR differentiator. In this simple circuit there is no compensation for the long decay time of the preamplifier. Consequently, there is a small amplitude undershoot starting at about 7τ . This undershoot decays back to baseline with the long time constant provided by the preamplifier output pulse.

This pulse-shaping technique can be used with scintillation detectors. For that application, the shaping time constant τ should be chosen to be at least three times the decay time constant of the scintillator to ensure complete integration of the scintillator signal. The disadvantage in using CR-RC shaping with scintillation detectors is the much longer pulse duration compared with that of single-delay-line shaping.

On silicon and germanium detectors, the electronic noise at the preamplifier input makes a noticeable contribution to the energy resolution of the detector. This noise contribution can be minimized by choosing the appropriate amplifier shaping time constant. Figure 10 shows the effect. At short shaping time constants, the series noise component of the preamplifier is dominant. This noise is typically caused by thermal noise in the channel of the field-effect transistor, which is the first amplifying stage in the preamplifier. At long shaping time constants the parallel noise component at the preamplifier input dominates. This component arises from noise sources that are effectively in parallel with the detector at the preamplifier input (e.g., detector leakage current, gate leakage current in the field-effect transistor, and thermal noise in the preamplifier feedback resistor). The total noise at any shaping time constant is the square root of the sum of the squares of the series and parallel noise contributions. Consequently, the total noise has a minimum value at the shaping time constant where the series noise is equal to the parallel noise. This time constant is called the "noise corner time constant." The time constant for minimum noise will depend on the characteristics of the detector, the preamplifier, and the amplifier pulse shaping network. For silicon charged-particle detectors, the minimum noise usually occurs at time constants in the range from 0.5 to 1 μ s. Generally, minimum noise for germanium and Si(Li) detectors is achieved at much longer time constants (in the range from 6 to 20 μ s). Such long time constants impose a severe restriction on the counting rate capability. Consequently, energy resolution is often compromised by using shorter shaping time constants, in order to accommodate higher counting rates.

Figure 11 demonstrates the bipolar output pulse obtained when a second differentiator is inserted just before the amplifier output. Double differentiation produces a bipolar pulse with equal area in its positive and negative lobes. It is useful in minimizing baseline shift with varying counting rates when the electronic circuits following the amplifier are ac-coupled. It is also convenient for zero-crossover timing applications. The drawbacks of double differentiation relative to single CR differentiation are a longer pulse duration and a worse signal-to-noise ratio.

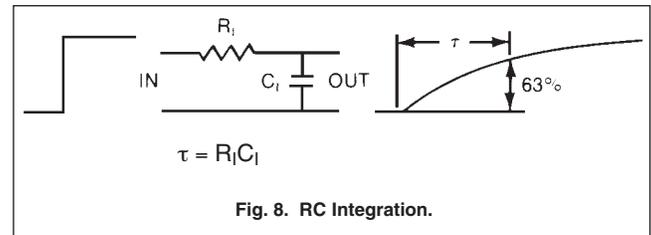


Fig. 8. RC Integration.

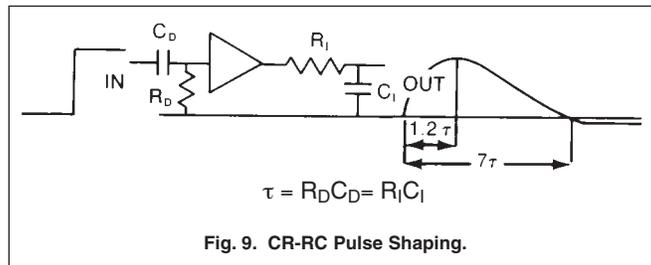


Fig. 9. CR-RC Pulse Shaping.

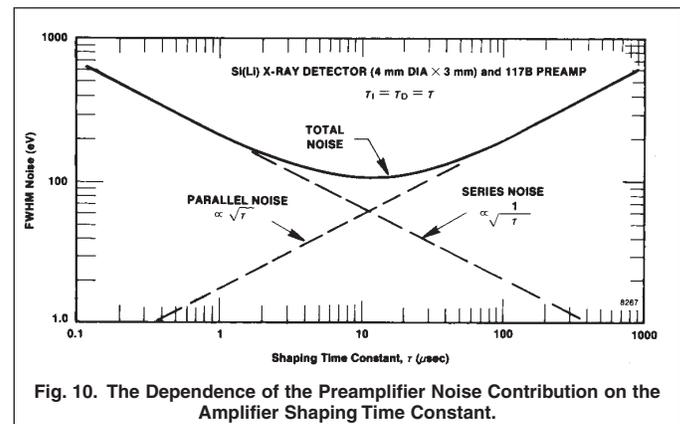


Fig. 10. The Dependence of the Preamplifier Noise Contribution on the Amplifier Shaping Time Constant.

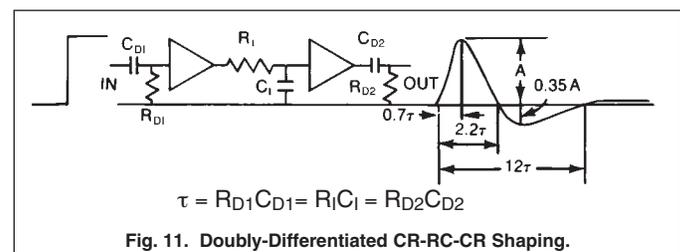


Fig. 11. Doubly-Differentiated CR-RC-CR Shaping.

Pole-Zero Cancellation

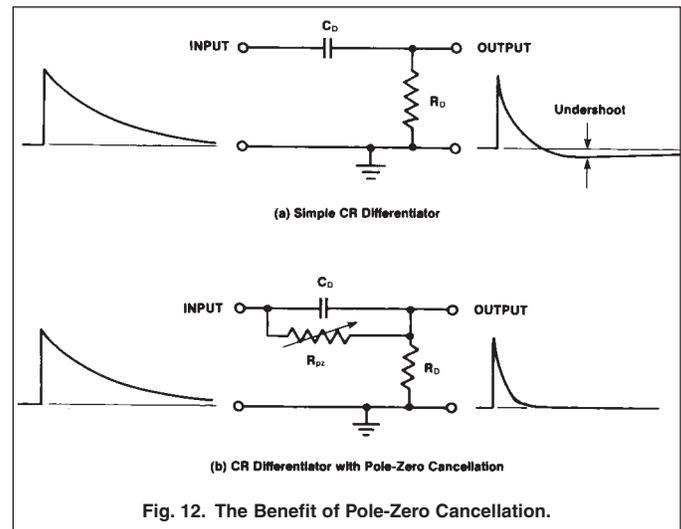
In the simple CR-RC circuit described in Fig. 9, there is a noticeable undershoot as the amplifier pulse attempts to return to the baseline. This is a result of the long exponential decay on the preamplifier output pulse. At medium to high counting rates, a substantial fraction of the amplifier output pulses will ride on the undershoot from a previous pulse. The apparent pulse amplitudes measured for these pulses will be too low, which leads to a broadening of the peaks recorded in the energy spectrum. Most spectroscopy amplifiers incorporate a pole-zero cancellation circuit to eliminate this undershoot. The benefit of pole-zero cancellation is improved peak shapes and resolution in the energy spectrum at high counting rates.

Figure 12 illustrates the pole-zero cancellation network, and its effect. In Fig. 12(a), the preamplifier signal on the left is applied to the input of the normal CR differentiator circuit in the amplifier. The output pulse from the differentiator exhibits the undesirable undershoot. The following equation applies:

$$\frac{\text{Undershoot Amplitude}}{\text{Pulse Amplitude}} = \frac{\text{Differentiator Time Constant}}{\text{Decay Time Constant of Preamp Pulse}}$$

For a given preamplifier decay time constant, longer amplifier shaping time constants yield larger undershoots.

In Fig. 12(b), the resistor R_{pz} is added in parallel with capacitor C_D , and adjusted to cancel the undershoot. The result is an output pulse exhibiting a simple exponential decay to baseline with the desired differentiator time constant. This circuit is termed a "pole-zero cancellation network" because it uses a zero to cancel a pole in the mathematical representation by complex variables. Virtually all spectroscopy amplifiers incorporate this feature, with the pole-zero cancellation adjustment accessible through the front panel. Exact adjustment is critical for good spectrum fidelity at high counting rates. Some of the more sophisticated amplifiers simplify this task with an automatic PZ-adjusting circuit.

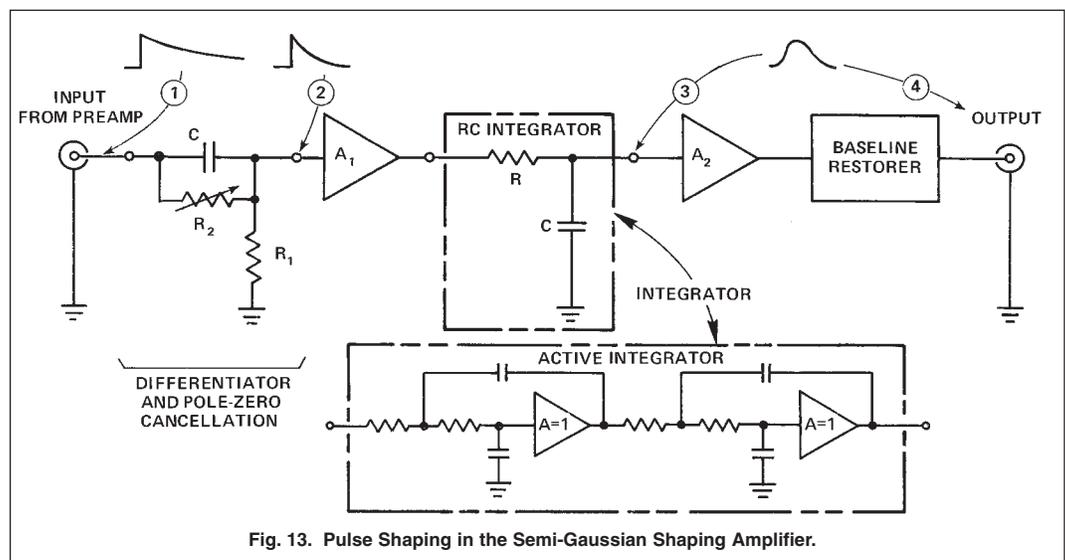


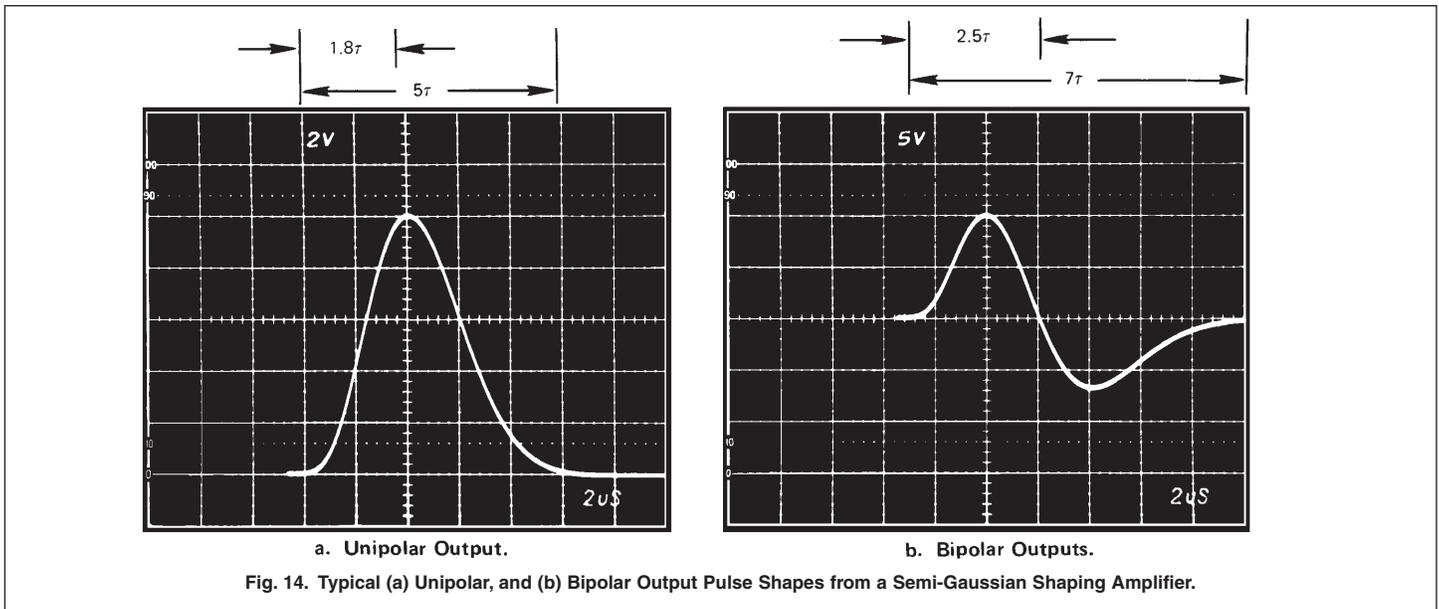
Semi-Gaussian Pulse Shaping

By replacing the simple RC integrator with a more complicated active integrator network (Fig. 13), the signal-to-noise ratio of the pulse-shaping amplifier can be improved by 17% to 19% at the noise corner time constant. This is important for semiconductor detectors, whose energy resolution at low energies and short shaping time constants is limited by the signal-to-noise ratio. Amplifiers incorporating the more complicated filters are typically called "semi-Gaussian shaping amplifiers" because their output pulse shapes crudely approximate the shape of a Gaussian curve [Fig. 14(a)]. A further advantage of the semi-Gaussian pulse shaping is a reduction of the output pulse width at 0.1% of the pulse amplitude.

At the noise corner time constant, semi-Gaussian shaping can yield a 22% to 52% reduction in output pulse width compared with the CR-RC filter. This leads to better baseline restorer performance at high counting rates. The reduction in pulse width corresponds to a 9% to 13% reduction in the amplifier dead time per pulse.

Although the unipolar output pulse from a semi-Gaussian shaping amplifier is normally the better choice for energy spectroscopy [Fig. 14(a)], a bipolar output is typically also





available [Fig. 14(b)]. The bipolar output is useful in minimizing baseline shift with varying counting rates when the electronic circuits following the amplifier are ac-coupled. It is also convenient for zero-crossover timing applications. The drawbacks inherent in the bipolar output relative to the unipolar output are a longer pulse duration and a worse signal-to-noise ratio.

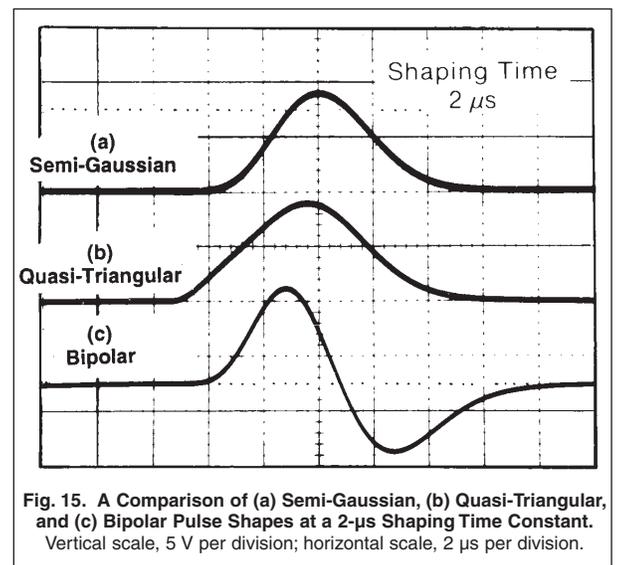
Quasi-Triangular Pulse Shaping

By summing contributions from the various filter stages in a semi-Gaussian amplifier, a unipolar output pulse with a much more linear rise can be generated [Fig. 15(b)]. This pulse shape is referred to as quasi-triangular because it is a crude approximation to a true triangular pulse shape. The quasi-triangular pulse shaping is advantageous at shaping time constants shorter than the noise corner time constant. Under these conditions, the series noise component is dominant. Consequently, the quasi-triangular pulse shape yields approximately 8% lower noise than the semi-Gaussian pulse shape, with virtually identical dead time per amplifier pulse.

Gated-Integrator Pulse Shaping

With germanium detectors, the time required to collect all of the charge from a gamma-ray interaction in the detector depends on the location of the interaction in the detector. The charge collection time can vary from 100 to 200 ns in a small detector, and by as much as 200 to 700 ns in a large germanium detector. As a result, the preamplifier output pulses have rise times varying over that same time range. In conventional pulse-shaping amplifiers (e.g., semi-Gaussian pulse shaping), these variations in rise time can affect the amplitude of the amplifier output pulse and cause degradation of the energy resolution. The longer rise times on the preamplifier output pulse cause a lower amplitude on the amplifier output pulse. This effect is called the "ballistic deficit." For shaping time constants in the range from 6 to 10 μ s, the effect is negligible, because the peaking time of the amplifier output pulse is very long compared with the longest charge collection time in the germanium detector. However, when high counting rates are anticipated, much shorter shaping time constants must be used. The contribution of ballistic deficit to resolution degradation increases rapidly as the shaping time constant is reduced below 2 μ s. Consequently, ballistic deficit becomes the dominant limitation on energy resolution at high counting rates using conventional, semi-Gaussian, or triangular pulse-shaping amplifiers.

The gated-integrator amplifier solves the ballistic deficit problem by integrating the signal until all the charge is collected from the detector. Figures 16 and 17 illustrate the principle. For simplicity, the prefilter has been depicted as a delay-line shaping amplifier. The width of the prefilter pulse determines the shaping time for the entire gated-integrator amplifier. For illustration purposes, two extreme



Amplifiers

rise times are drawn for the preamplifier pulse: zero rise time (solid line) and a long rise time (dashed line). At the output of the prefilter, the zero rise time pulse produces a rectangular pulse shape, while the longer rise time pulse generates a trapezoid. The duration of the trapezoid is longer than the rectangular pulse by an amount equal to the preamplifier pulse rise time.

The gated-integrator portion of the amplifier serves two functions. It reduces the high-frequency noise contribution, and it eliminates the ballistic deficit. Before the prefilter pulse arrives, switch S1 is open and switch S2 is closed, causing the gated-integrator output to be at ground potential. At the instant the prefilter pulse arrives, switch S1 closes and switch S2 opens, and the prefilter signal is integrated on capacitor C_i . The integration period is set to last as long as the longest prefilter pulse duration. Consequently, all pulses generate the same output pulse amplitude from the gated integrator, independent of their rise time at the preamplifier output. At the end of the integration period, S1 opens and S2 closes to return the output pulse to baseline quickly. Because the filter characteristics are switched at certain points in time, the gated integrator is called a time-variant filter. In contrast, the amplifiers previously discussed have time-invariant filters.

The signal-to-noise ratio of the gated integrator approaches the performance of a time-invariant filter with a true triangular pulse shape. This makes it virtually the ideal filter for the short shaping times required for high counting rates.

Because it is difficult to implement a delay-line prefilter with a quality that is adequate for germanium detectors, practical gated integrator amplifiers typically utilize active RC networks in the prefilter. This results in the pulse shapes shown in Fig. 18. The deviation from a rectangular prefilter shape and the extra integration time required to accommodate the longest charge collection times causes a minor loss of signal-to-noise ratio compared with an ideal triangular pulse shape. However, the signal-to-noise ratio is less important than elimination of ballistic deficit for optimum energy resolution at the short shaping times required for high counting rates.

Gated-integrator amplifiers permit operation at ultra-high counting rates with germanium detectors without a substantial sacrifice of energy resolution (Fig. 19).

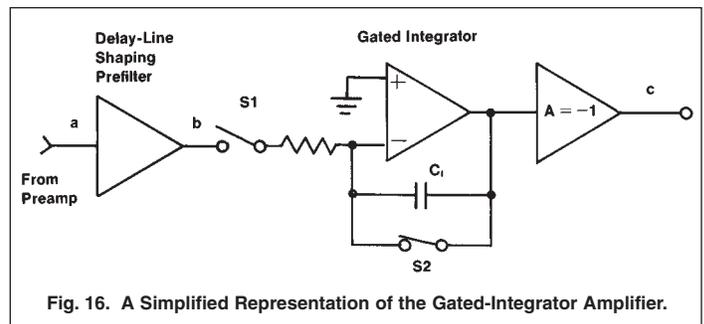


Fig. 16. A Simplified Representation of the Gated-Integrator Amplifier.

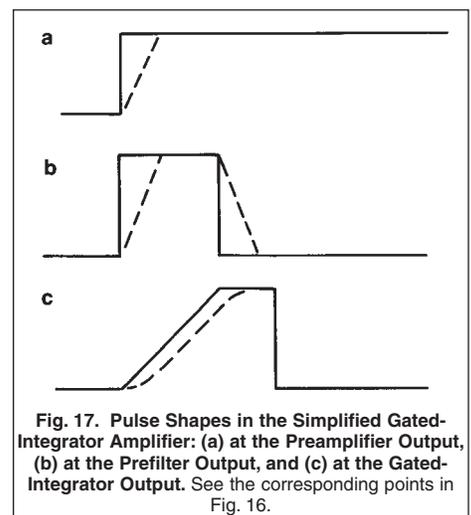


Fig. 17. Pulse Shapes in the Simplified Gated-Integrator Amplifier: (a) at the Preamplifier Output, (b) at the Prefilter Output, and (c) at the Gated-Integrator Output. See the corresponding points in Fig. 16.

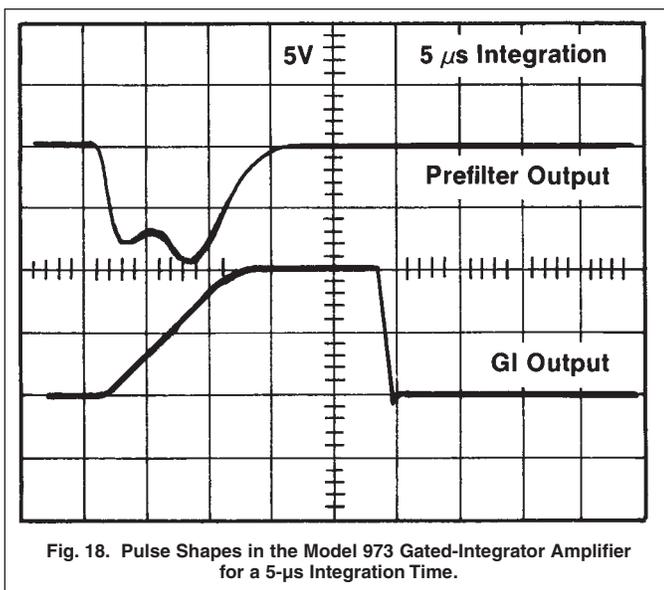


Fig. 18. Pulse Shapes in the Model 973 Gated-Integrator Amplifier for a 5- μ s Integration Time.

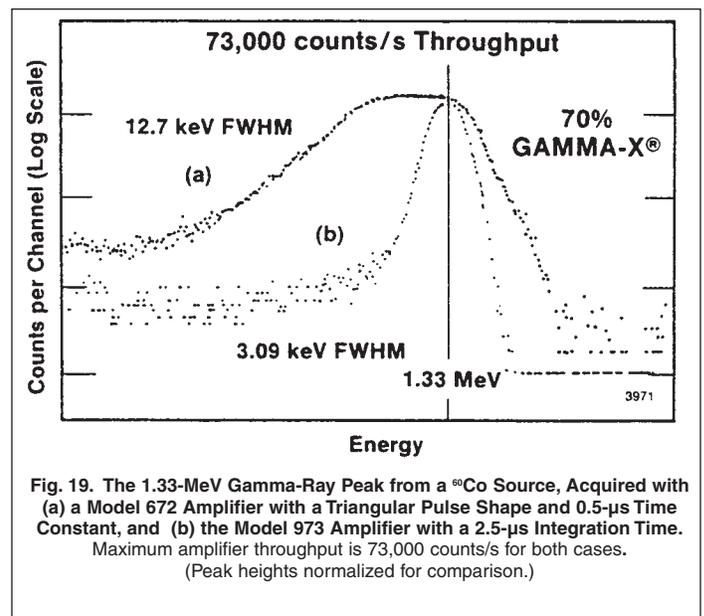


Fig. 19. The 1.33-MeV Gamma-Ray Peak from a ^{60}Co Source, Acquired with (a) a Model 672 Amplifier with a Triangular Pulse Shape and 0.5- μ s Time Constant, and (b) the Model 973 Amplifier with a 2.5- μ s Integration Time. Maximum amplifier throughput is 73,000 counts/s for both cases. (Peak heights normalized for comparison.)

The Baseline Restorer

To ensure good energy resolution and peak position stability at high counting rates, the higher-performance spectroscopy amplifiers are entirely dc-coupled (except for the CR differentiator network located close to the amplifier input). As a consequence, the dc offsets of the earliest stages of the amplifier are magnified by the amplifier gain to cause a large and unstable dc offset at the amplifier output. A baseline restorer is required to remove this dc offset, and to ensure that the amplifier output pulse rides on a baseline that is securely tied to ground potential.

Figure 20 illustrates the basic principle of a baseline restorer. In the case of the simpler, time-invariant baseline restorers, switch S1 is always closed. The time-invariant baseline restorer behaves just like a CR differentiator. The baseline between pulses is returned to ground potential by resistor R_{BLR} . In order not to degrade the signal-to-noise ratio of the pulse-shaping amplifier, the $C_{BLR} R_{BLR}$ time constant must be at least 50 times the shaping time constant employed in the amplifier.

The simple, time-invariant baseline restorer does not adequately maintain the baseline at ground potential at high counting rates. Since the time-invariant baseline restorer is really a CR differentiator, the average signal area above ground must equal the average signal area below ground at the baseline restorer output. At low counting rates, the spacing between pulses is extremely long compared with the pulse width. Consequently, the baseline between pulses remains very close to ground potential. As the counting

rate increases, the baseline must shift down, so that the area of the signal remaining above ground potential is equal to the area between ground potential and the shifted baseline. The amount of baseline shift increases as the counting rate increases. Diode networks are typically incorporated to reduce this shift, but such solutions are unable to make the shift negligible.

The gated baseline restorer virtually eliminates the baseline shift caused by changing counting rates. In Fig. 20, switch S1 is opened for the duration of the amplifier pulse, and closed otherwise. Therefore, the CR differentiator function is active only on the baseline between pulses. The effect of the signal pulse is essentially eliminated. The gated baseline restorer perceives that it is operating at zero counting rate, and maintains the baseline firmly at ground potential, independent of the actual counting rate.

The stability of baseline restoration at very high counting rates with the gated baseline restorer depends on the ability of the gating control circuits to distinguish between the pulses and the baseline. In the simpler circuits, this is accomplished with a discriminator whose threshold is manually adjusted to sit just above the noise that surrounds the baseline. The more sophisticated amplifiers include automatic noise discriminators and more complicated pulse detection methods to perform this task more effectively. Figure 21 is an example of the results obtained on a high-performance baseline restorer. Peak shift and resolution broadening are both negligible over a very wide range of counting rates. At some upper limit on counting rate, there is inadequate baseline between pulses for the baseline restorer to control. Above that counting rate, the baseline will shift strongly with increasing counting rate. If counting rates must be processed above this limit, then a shorter amplifier shaping time constant must be selected.

Pile-Up Rejection

When two gamma rays arrive at the detector within the width of the spectroscopy amplifier output pulse, their respective amplifier pulses pile up to form an output pulse of distorted amplitude [Fig. 22(a)]. For detectors whose charge collection time is very short compared to the peaking time T_P of the amplifier output pulse, a pile-up rejector can be used to prevent analysis of these distorted pulses.

The pile-up rejector is implemented by adding a "fast" pulse shaping amplifier with a very short shaping time constant [Fig. 22(b)] in parallel with the "slow" spectroscopy amplifier. In the fast amplifier, the signal-to-noise ratio is compromised in favor of improved pulse-pair resolving time. A fast discriminator is set above the much higher noise level at the fast amplifier output to convert the analog pulses into digital logic pulses [Fig. 22(c)]. The trailing edge of the fast discriminator output triggers an inspection interval T_{INS} [Fig. 22(d)] that covers the width T_W of the slow amplifier pulse.

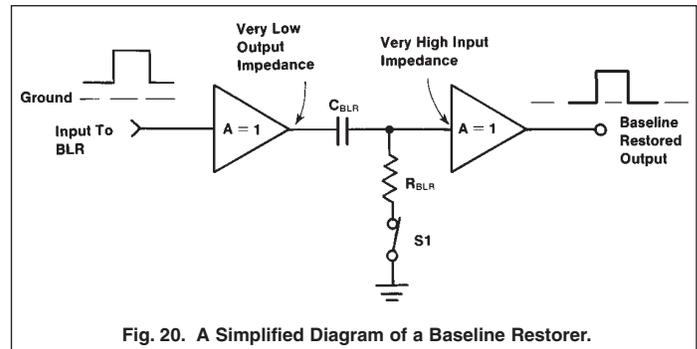


Fig. 20. A Simplified Diagram of a Baseline Restorer.

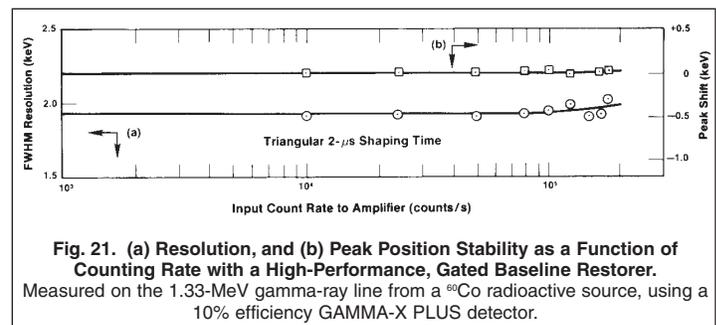


Fig. 21. (a) Resolution, and (b) Peak Position Stability as a Function of Counting Rate with a High-Performance, Gated Baseline Restorer. Measured on the 1.33-MeV gamma-ray line from a ^{60}Co radioactive source, using a 10% efficiency GAMMA-X PLUS detector.

If a second fast discriminator pulse from a pile-up pulse arrives during the inspection interval, an inhibit pulse is generated [Fig. 22(e)]. The inhibit pulse is used in the associated ADC or multichannel analyzer to prevent analysis of the piled-up event.

As demonstrated in Figure 23, the pile-up rejector can deliver a substantial reduction in the pile-up background at high counting rates with germanium and Si(Li) detectors.

Amplifier Throughput

The pulse shape from the spectroscopy amplifier contributes to the dead time of the spectrometry system. The dead time attributable to the amplifier pulse shape is

$$T_D = T_P + T_W$$

where T_W is the width of the pulse above the noise level, and T_P is the time from the start of the pulse until the point at which the subsequent ADC detects peak amplitude and closes its linear gate (Fig. 22). Note that the period T_P receives double weighting because a second pulse that arrives during this period also causes the first pulse to be rejected due to pile-up. The dead time is an extending dead time, and the unpiled-up output rate r_o for the amplifier is related to the input counting rate r_i from the detector by the throughput equation

$$r_o = r_i \exp[-r_i (T_P + T_W)] .$$

Figure 24 illustrates this equation for amplifier shaping time constants ranging from 0.5 to 10 μ s. The amplifier output counting rate reaches its maximum when $r_i = 1/T_D$. It is clear from Fig. 24 that higher counting rates require shorter shaping time constants.

When the ADC is part of the spectroscopy system, the dead times of the amplifier and the ADC are in series. The combination of the amplifier extending dead time followed by ADC non-extending dead

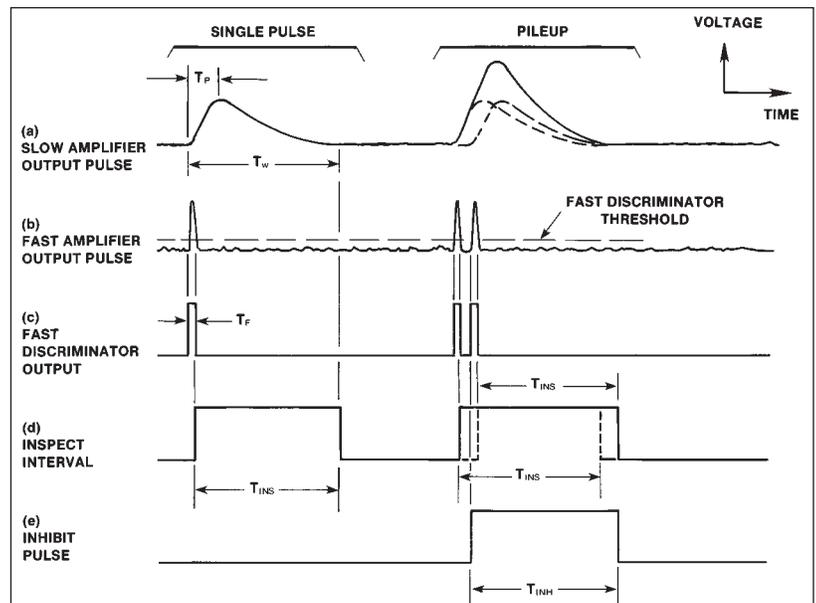


Fig. 22. Basic Waveforms in the Pile-Up Rejector.

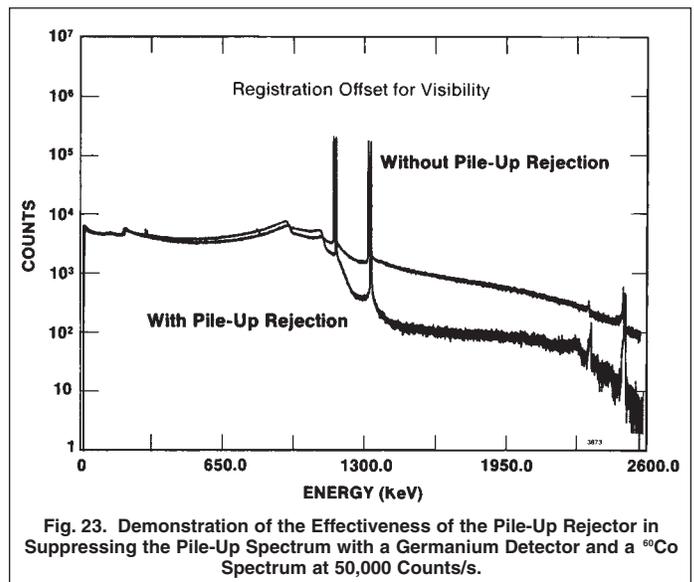


Fig. 23. Demonstration of the Effectiveness of the Pile-Up Rejector in Suppressing the Pile-Up Spectrum with a Germanium Detector and a ^{60}Co Spectrum at 50,000 Counts/s.

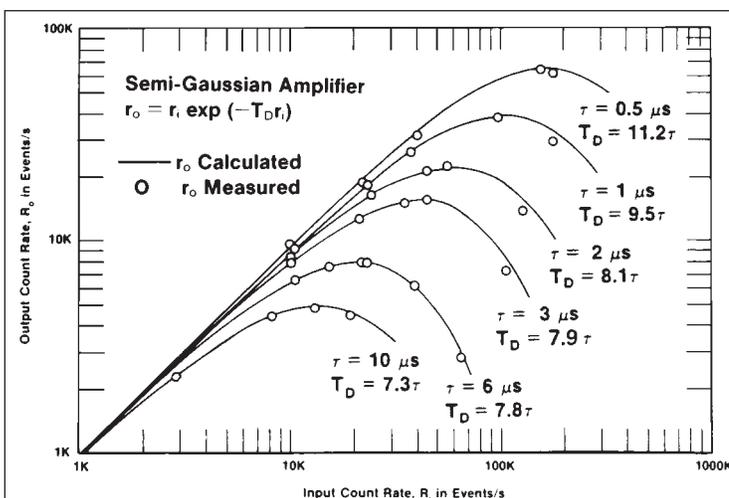


Fig. 24. Plot of the Unpiled-Up Amplifier Output Rate as a Function of Input Rate for Six Values of Shaping Time Constants.

time T_M yields a throughput described by

$$r_o = \frac{r_i}{\exp[r_i(T_W + T_P)] + r_i [T_M - (T_W - T_P)] U [T_M - (T_W - T_P)]}$$

where $U [T_M - (T_W - T_P)]$ is a unit step function that changes value from 0 to 1 when T_M is greater than $(T_W - T_P)$.

Digital Signal Processing (DSP)

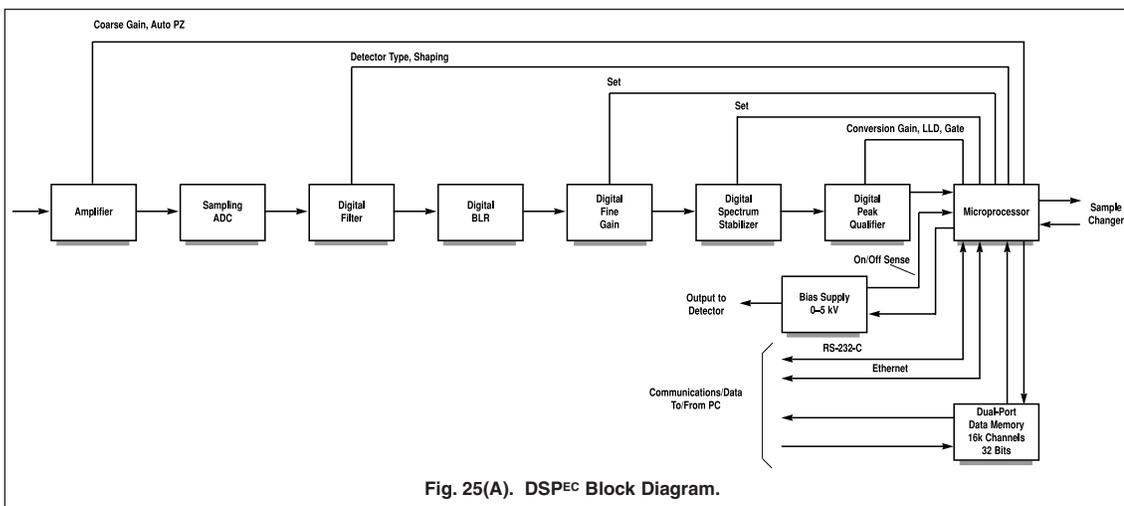
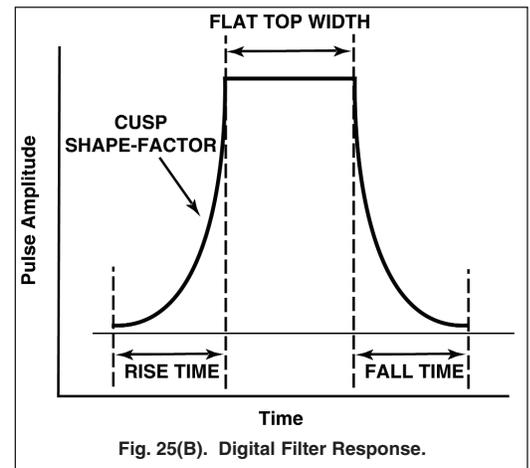
In the previous few pages the functions incorporated in linear pulse-shaping amplifiers have been described in terms of analog signal processing components. Alternatively, most of these functions can be implemented by means of Digital Signal Processing (DSP). Basically, the DSP method converts the continuous analog signal at the output of the preamplifier to a stream of digital numbers representing the history of the preamplifier output voltage. The technique is implemented by using a flash ADC to repeatedly sample and digitize the preamplifier signal. The constant interval between samples is typically small so that the digital numbers represent the pulse profiles with reasonable accuracy. For every analog pulse processing function in the continuous time domain, one can construct an equivalent function in the discrete time domain of the digital representation. Thus, the equivalent signal processing can be implemented in a computer. Because software computation would be too slow to keep up with the data rates, the processing is done in a hardware circuit known as a DSP (Digital Signal Processor).

Figure 25(A) shows the block diagram of a typical DSP MCA, which is a complete digital signal processing system for gamma-ray spectrometry. The digital signal processing in this system incorporates the low- and high-pass filters, automatic pole-zero adjustment, the baseline restorer, fine gain adjustment, a spectrum stabilizer, and means for measuring and histogramming the amplitudes of the digital pulses. This latter function replaces the multichannel analyzer normally used with analog signal processing.

Figure 25(B) illustrates the typical digital filter response in the DSPEC. The flat top is employed to eliminate the degradation of energy resolution normally caused by the variations in charge collection time in HPGe detectors (ballistic deficit). For very wide pulse widths, the flat top becomes negligible, and the pulse shape approaches a cusp. The cusp is the ideal filter for achieving the optimum signal-to-noise ratio at the noise-corner time constant. A reasonable approximation to the cusp can be readily implemented in digital signal processing, whereas it is virtually impossible to achieve using analog signal processing. The cusp shape can be easily changed to a trapezoid, which yields optimum energy resolution for shaping-time constants that are small compared to the noise-corner time constant (for higher counting rates).

The benefits of digital signal processing are:

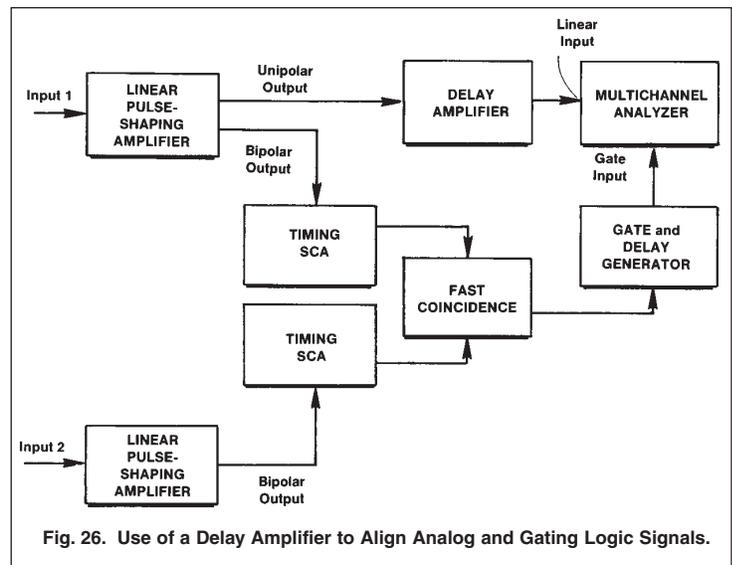
- greater flexibility in realizing the optimum pulse-shaping filter over the entire range of shaping time constants,
- improved temperature stability,
- ballistic deficit correction at short shaping time constants and optimum energy resolution at long shaping time constants, and
- computer automated optimization of the pulse-shaping filter to suit the detector and data acquisition conditions.



Amplifiers

Delay Amplifiers

Frequently, it is necessary to delay an analog signal to align its arrival with the arrival time of a gating logic signal. This is the function of a delay amplifier. It provides an adjustable delay of the analog signal while preserving the shape and amplitude of the analog pulse. Figure 26 is a typical example involving a coincidence measurement between two detectors. Coincidence timing information is derived from the bipolar zero crossing on the two amplifier outputs using timing single-channel analyzers. The coincidence gating signal would normally arrive at the multichannel analyzer gate input too late to straddle the peak amplitude of the unipolar amplifier output pulse from detector 1. The delay amplifier is used to delay the unipolar output pulse until its peak amplitude is synchronized with the logic pulse at the gate input of the multichannel analyzer.



Applications Guide for Timing Amplifiers

Detector Application	Amplifier Model Number Ranked in Order of Desirability (1 = optimum solution)									Alternate Methods	
	FTA820A	VT120	9301	9305	9306	9302	474	579	863	Feed Detector Output Directly to Timing Discriminator	Use Timing SCA with Spectroscopy Amplifier Output
Single Photon Counting		2	3	2	2	1			3		
Single Photon Timing		1	2		1						
Microchannel Plates, Microchannel Plate PMTs, and Channeltrons		2			1						
Fast Plastic or Liquid Scintillators	2	2	4	4	4					1	5
Nal(Tl) and Slow Scintillators	4	4		2	5			3		1	4
Proportional Counters							3	2	3		1
Si Charged-Particle Detectors	1	1	2	2	4		4	3	4		5
Si(Li) Detectors							2	1	2		3
Ge Planar & LO-AX Detectors							2	1	3		
Ge Coaxial Detectors (GEM, GAMMA-X)							2	1	3		

Amplifiers

Selection Guide for Timing Filter Amplifiers*

Model	Number of Channels	Output Minimum Rise Time	Shaping Time Constants		Gain (for each channel)	Baseline Restorer	Output Range	Comments (Package width)
			Integration	Differentiation				
474 Timing Filter Amplifier	1	≤10 ns	Out, 20, 50, 100, 200, and 500 ns	Out, 20, 50, 100, 200, and 500 ns	±2 to ±250	time-invariant	0 to ±5 V	(1-wide NIM)
579 Fast-Filter Amplifier	1	<5 ns	Out, 10, 20, 50, 100, 200, and 500 ns	Out, 10, 20, 50, 100, 200, and 500 ns; also 50-Ω cable clip.	±0.9 to ±500	gated	0 to ±f V	(1-wide NIM)
863 Quad Timing Filter Amplifier	4	<10 ns	Out, 50 ns, and optional	Out, 200 ns, and optional; also 50-Ω cable clip.	±2 to ±250	time-invariant	0 to ±5 V	Requires ±6 V power (1-wide NIM)

*For all models:

- 100-Ω input impedance to match 93-Ω cable from preamplifier. For 50-Ω cables add a tee and 100-Ω terminator to the input.
- Outputs drive a 50-Ω load.
- Differentiator includes adjustable PZ cancellation.

Selection Guide for Wideband Timing Amplifiers*

Model	Number of Channels	Output Rise Time	Output Range	ac/dc Coupling	GAIN (for each channel)	rms Equivalent Input Noise	Comments (Package Width)
VT120 Fast Timing Preamplifier	1	≤1 ns	0 to -5 V	ac	A: +200 B: -200 C: +20	<20 μV	(Preamp)
9301 Fast Preamplifier	1	<1.5 ns	0 to ±0.7 V	ac	+10	<25 μV	(Preamp)
9302 Amplifier and Discriminator	1	3 ns	0 to -500 mV	ac	+20 or +200	≤10 μV	Amplifier Z _{OUT} = 50 Ω. Incorporates fast discriminator and rate monitor. (1-wide NIM)
9305 Fast Preamplifier	1	<3 ns	0 to ±5 V	dc	+5 to +10	<30 μV	Excellent gain and dc stability. Adjustable gain. (Preamp)
9306 1-GHz Preamplifier	1	0.35 ns	0 to -2 V	ac	100	<100 μV	Optimized for micro-channel plates and microchannel-plate PMTs. (Preamp)
9326 Fast Preamplifier	1	<1 ns	0 to -1 V	ac	5, 10, or 20	<100 μV	10-kHz low-frequency roll-off, optimized for use with FASTFLIGHT™

*For all models:

- 50-Ω input impedance.
- Outputs drive a 50-Ω load.

Amplifiers

Amplifiers for Pulse-Height or Energy Spectroscopy

Applications Guide Ranked in order of desirability (1 = optimum solution)

Detector Application	Amplifier Model Number								
	460	570	572A	575A	590A	671	672	673	855
PMTs, Microchannel Plates, Microchannel Plate PMTs, Channeltrons	1	2	3	1	1	3	3		1
Scintillation Detectors	1	2	3	1	1	3	3		1
Proportional Counters	4	2	3	1	1	3	3		1
Si Charged-Particle Detectors		2	3	2	4	3	3		2
Si(Li) Detectors		4	3			2	1		
Ge Planar and LO-AX Detectors									
Up to 3000 counts/s		2	3			4	4		
Up to 100,000 counts/s			3			2	1	3	
Up to 300,000 counts/s						2	1		
Ge Coaxial Detectors (GEM, GAMMA-X)									
Up to 3000 counts/s		1	1			1	1	2	
Up to 30,000 counts/s			3			2	1	3	
Up to 100,000 counts/s								1	

Selection Guide for Delay and Summing Amplifiers

Model	Features	Package Width
427A Delay Amplifier	Variable delay of linear signals from 0 to 4.75 μ s in 0.25- μ s steps. Used to align arrival times of linear and logic signals.	1-wide NIM
533 Dual Sum and Invert Amplifier	Provides summing of signals for up to 4 inputs. Inverting or non-inverting.	1-wide NIM

Amplifiers

Selection Guide for Linear Pulse-Shaping Amplifiers

Model	Differential Input	Gain	Pulse Shaping	Shaping Time Constants	Baseline Restorer	Pile-Up Rejector	PZ Adjust	Comments (Package Width)
460 Delay Line Amplifier	No	±3 to ±1000	Single and double delay-line shaping (unipolar and bipolar)	1-μs delay-line clip. Separate 0.04, 0.01, and 0.25 μs RC integration	Time-invariant	No	Manual	Selectable 1-μs unipolar output delay (1-wide NIM)
570 Amplifier	No	±1 to ±1500	Semi-Gaussian unipolar	0.5, 1, 2, 3, 6, and 10 μs	Gated; auto or manual noise discriminator	No	Manual	(1-wide NIM)
572A Amplifier	No	±1 to ±1500	Semi-Gaussian unipolar; bipolar	0.5, 1, 2, 3, 6, and 10 μs	Gated; auto or manual noise discriminator	PUR noise discriminator level set by BLR noise discriminator	Manual	(1-wide NIM)
575A Amplifier	No	±5 to ±1250	Semi-Gaussian unipolar; bipolar	0.5, 1.5 and 3 μs (PWB switches)	Gated, with auto noise discriminator	No	Manual	(1-wide NIM)
590A Amplifier and Timing Single-Channel Analyzer	No	±5 to ±1250	Semi-Gaussian unipolar; bipolar	0.5, 1.5, and 3 μs (PWB switches)	Gated, with auto noise discriminator	No	Manual	Incorporates timing SCA (1-wide NIM)
671 Spectroscopy Amplifier	Yes	±2.5 to ±1500	Semi-Gaussian and quasi-triangular unipolar; bipolar	0.5, 1, 2, 3, 6, and 10 μs	Gated, with auto noise discriminator. Auto or high BLR rate.	PUR with separate auto noise discriminator and % rejection LED	Manual	Auto overload protection for pulsed-reset preamplifiers (1-wide NIM)
672 Spectroscopy Amplifier	Yes	±2.5 to ±1500	Semi-Gaussian and quasi-triangular unipolar; bipolar	0.5, 1, 2, 3, 6, and 10 μs	Gated, with auto noise discriminator. Auto or high BLR rate.	PUR with separate auto noise discriminator and % rejection LED	Auto* or manual	Auto overload protection for pulsed-reset preamplifiers (2-wide NIM)
673 Spectroscopy Amplifier and Gated Integrator	No	±1 to ±1500	Gated-integrator and semi-gaussian unipolar	0.25, 0.5, 1, 2, 3, and 6 μs semi-Gaussian prefilter	Gated; auto or manual noise discriminator	PUR noise discriminator level set by BLR noise discriminator	Coarse and fine; manual	Combines semi-Gaussian and Gated-integrator amplifiers in one module (2-wide NIM)
855 Dual Amplifier	No	±5 to ±1250	Semi-Gaussian unipolar, bipolar	0.5, 1.5, and 3 μs (PWB jumpers)	Gated with auto noise discriminator	No	Manual	Two Model 575A Amplifiers in a single module (1-wide NIM)

For all models:

- Input impedances in the range from 465 to 2000 Ω.
- Linear outputs drive 0 to +10 V (unipolar), 0 to +10 V (bipolar) on a 93-Ω load.

*U.S. Patent No. 4,866,400

Choosing the Right Timing Discriminator for the Application

Fast timing discriminators are useful in two different applications: a) counting narrow pulses at very high counting rates, and b) precisely marking the arrival time of these same pulses. Fast timing discriminators are designed to achieve the best time resolution and the highest counting rates by operating on the fast-rising detector signal. Somewhat worse time resolution at much lower counting rates is available by applying timing single-channel analyzers to the slow output pulse from a linear pulse-shaping amplifier. This slow timing solution is described in the Single-Channel Pulse-Height Analyzer introduction. The fast timing solution is discussed here.

Historically, fast timing discriminators were designed to work with negative pulses from the photomultiplier tube anode fed directly to the discriminator on a terminated 50-Ω coaxial cable. Consequently, a negative input polarity on a 50-Ω impedance has become the standard. Following this convention, "rise time" refers to the time taken to make the transition from 10% to 90% of the pulse amplitude on the leading edge of the pulse, and "fall time" specifies the transition time from 90% to 10% of the amplitude on the trailing edge of the pulse.

Counting

In counting applications, the analog input pulses that cross the discriminator threshold are converted to standard logic pulses at the output of the timing discriminator. These logic pulses can be counted in a counter/timer or in a multichannel scaler. Usually, the discriminator threshold is set just above the noise level, so that all the real events are counted without counting noise pulses. If a narrow band of pulse-heights must be selected for counting, the Model 583B can provide that function with its dual discriminator thresholds.

The maximum permissible counting rate can be restricted by the pulse-pair resolving time of the system. When the inherent width of the detector pulse is not the limiting factor, timing discriminators can offer pulse-pair resolving times in the range of 5 to 65 ns. If dead time losses must be restricted to <10%, a 5-ns pulse-pair resolving time permits average counting rates up to 20 MHz. This same pulse-pair resolving time will handle burst rates up to 200 MHz, provided there is a 5-ns spacing between pulses.

The fast detectors commonly used in single-photon and single-ion counting (photomultiplier tubes, microchannel plate detectors, microchannel plate PMTs, and channeltrons) usually have pulse widths short enough to attain the 5-ns pulse-pair resolution of the fastest discriminators. Other types of detectors, such as scintillation detectors, germanium detectors, and silicon charged-particle detectors, deliver pulse widths that limit the pulse-pair resolving time to much longer values. In most applications the maximum counting rate is limited by the detector and the electronics that precede the timing discriminator because of factors other than pulse-pair resolving time. In such cases, although the pulse-pair resolving time of the timing discriminator does not determine the maximum permissible counting rate for the system, it still affects how closely randomly arriving pulses can occur and yet be recognized as two separate events. This, of course, determines the dead-time losses in a counting experiment.

Dead Time Effects in Counting or Timing

The dead time loss experienced when using fast timing discriminators for either counting or timing measurements is typically controlled by the counting rate and two dominant cascaded dead times, T_e and T_{ne} . T_e is the extending dead time caused by the width of the analog pulse at the noise discriminator threshold. It is an extending dead time because a second analog pulse occurring during a preceding pulse extends the dead time by one pulse width from the second pulse's arrival time, and the second pulse will not be counted. T_e is normally determined by the detector response and any pulse shaping added by an amplifier interposed between the detector and the discriminator. T_{ne} is the longest non-extending dead time following the noise discriminator. Non-extending dead time implies that a pulse arriving during the dead time created by a previous pulse will not be recorded and will not extend the dead time. The minimum value for T_{ne} is the dead time set by the output driver for the discriminator. If the discriminator drives another device which also contributes a non-extending dead time, T_{ne} is assigned the value of the larger of the two non-extending dead times. This latter assignment is an adequately accurate representation of T_{ne} for most practical cases.^{1,2}

For the general case in time spectrometry where $R(t)$ (the instantaneous counting rate of photons or ions at the detector) varies with time, the instantaneous counting rate after dead time losses, $r(t)$, is given by³

Cascaded Dead Times, Variable Counting Rate:

$$r(t) = R(t) \exp\left[-\int_{t-T_e}^t R(t_1) dt_1\right] \left[1 - U(T_{ne}-T_e)\int_{t-T_{ne}}^{t-T_e} r(t_1) dt_1\right] \quad (2a)$$

¹Jörg W. Müller, *Nucl. Instr. Meth.* 112, (1973), 47-57; Figure 3.

²D.R. Beaman, et al., *J. of Physics E: Sci. Instr.* (1972), 5, 767-776.

³D.A. Gedcke, Development notes and private communication, Nov. 1996.

Fast-Timing Discriminators

where time t_1 is distinguished from t only for the purpose of integration over the time interval, and $U(T_{ne}-T_e)$ is a unit step function defined by

$$\begin{aligned} U(T_{ne}-T_e) &= 0 \text{ for } T_{ne} \leq T_e \\ &= 1 \text{ for } T_{ne} > T_e \end{aligned} \quad (2b)$$

In this special case of variable counting rate, $R(t)$ and $r(t)$ can be interpreted as the probability per unit time of observing an event at the input to the detector and at the output of the cascaded dead times, respectively, at the time t . In a practical measurement, a process is stimulated at time $t = 0$, and $R(t)$ represents the probability of events from the process arriving at the detector as a function of time. Because of the cascaded dead times, the probability of recording events as a function of time is given by $r(t)$. To build up a statistically significant time spectrum, one must repeat the stimulation n times (where n is a large number) while summing the resulting time spectra. Generally, this is accomplished in a digital histogramming memory, which has finite time bin widths, Δt . Consequently, the number of counts recorded in a bin at time t is predicted to be

$$q(t) = n r(t) \Delta t \quad (3)$$

The time spectrum recorded in histogram form is described by $q(t)$. The practical application of equations (2) and (3) to time digitizers is explained in the introduction to Counters, Ratemeters, and Multichannel Scalers.

For the simplifying case where $R(t)$ is constant over time, $R(t) = R$ and $r(t) = r$, leading to

Cascaded Dead Times, Constant Counting Rate:

$$r = R \exp[-RT_e] [1 - U(T_{ne}-T_e) r (T_{ne}-T_e)] \quad (4a)$$

$$= \frac{R}{\exp[RT_e] + U(T_{ne}-T_e) R (T_{ne}-T_e)} \quad (4b)$$

If the extending dead time is larger than the non-extending dead time, then the non-extending dead time is irrelevant and equations (2) and (4) become:

Extending Dead Time, Variable Counting Rate:

$$r(t) = R(t) \exp \left[-\int_{t-T_e}^t R(t_1) dt_1 \right] \quad (5)$$

Extending Dead Time, Constant Counting Rate:

$$r = R \exp[-RT_e] \quad (6)$$

Equations (5) and (6) are the equations for a single, extending dead time.

If the extending dead time is negligible compared to the non-extending dead time, then equations (2) and (4) simplify to the relations for a single non-extending dead time:

Non-Extending Dead Time, Variable Counting Rate:

$$r(t) = R(t) \left[1 - \int_{t-T_{ne}}^t r(t_1) dt_1 \right] \quad (7)$$

Non-Extending Dead Time, Constant Counting Rate:

$$r = R [1 - rT_{ne}] \quad (8a)$$

$$= \frac{R}{1 + RT_{ne}} \quad (8b)$$

The above equations allow one to estimate the dead time losses when the counting rate is known (or predicted) and the dead times T_e and T_{ne} have been measured (either by an oscilloscope or by graphing r versus R). These equations can also be used to correct

Fast-Timing Discriminators

for the dead time losses if the losses are not excessive. If the dead time losses are less than 15%, the extending, non-extending, and cascaded dead time equations all yield values of $r(t)/R(t)$ that agree within 1%, provided

$$T = T_e + U(T_{ne}-T_e) (T_{ne}-T_e) \quad (9)$$

is substituted for the single dead time in the extending and non-extending equations. This permits considerable simplification of the computation in exchange for a tolerable limit on the dead time loss.

Timing

Marking the arrival time of detected events with precision and consistency is the primary function of a timing discriminator. Achieving the optimum time resolution is important whether the application is time spectroscopy, or simply determining that events from two different detectors occurred simultaneously. The technique for deriving optimum time resolution depends on the type of detector. Therefore, one must choose the right timing discriminator based on the detector characteristics and the intended application. The descriptions and selection charts that follow will guide you to the best choice.

Jitter, Walk and Drift: The Limiting Factors in Timing

Jitter, walk and drift are the three major factors limiting time resolution. These characteristics are most readily described by reference to a simple leading-edge timing discriminator, as illustrated in Fig. 1.

A leading-edge timing discriminator incorporates a simple voltage comparator with its threshold set to the desired voltage (Fig. 1). When the leading edge of the analog pulse crosses this threshold the comparator generates a logic pulse. The logic pulse ends when the trailing edge of the analog pulse crosses the threshold in the opposite direction. The initial transition of the logic pulse is used to mark the arrival time of the analog pulse, and this time corresponds to the threshold crossing on the leading edge of the analog pulse.

In the absence of noise and amplitude variations, the leading-edge discriminator would mark the arrival time of each analog pulse with precision and consistency. However, many systems include a non-negligible level of electronic noise, and this noise causes an uncertainty or jitter in the time at which the analog pulse crosses the discriminator threshold. If e_n is the voltage amplitude of the noise superimposed on the analog pulse, and dV/dt is the slope of the signal when its leading edge crosses the discriminator threshold, the contribution of the noise to the timing jitter is

$$\text{Timing jitter} = e_n / (dV/dt). \quad (10)$$

If the noise cannot be reduced, the minimum timing jitter is obtained by setting the discriminator threshold for the point of maximum slope on the analog pulse. If a low pass filter is applied to reduce the noise by slowing down the pulse rise time, the slope in Equation (10) normally decreases more rapidly than the noise diminishes, and the net result is an increase in timing jitter. Therefore, it is best to preserve the fastest possible rise time from the signal source. For further guidance on choosing the appropriate rise time for the preamplifier and amplifier that precede the timing discriminator, see the introduction on Preamplifiers and Amplifiers. Electronic noise makes a significant contribution to timing jitter with silicon charged-particle detectors, fast photodiodes, Si(Li) detectors, and germanium detectors, and to a somewhat lesser extent with microchannel plates, microchannel plate PMTs, and channeltrons.

With scintillation detectors (scintillators mounted on photomultiplier tubes) the noise contribution is usually negligible, but there is another important contribution to timing jitter: statistical fluctuations in the arrival time of the pulse at the detector output. The optimum solution for this application is discussed below. Germanium detectors also bring a special problem to the timing task, because the rise times of the pulses from these detectors vary over a wide range, and this variation is a dominant source of timing jitter. The special solution for timing with germanium detectors is described later in this section.

"Walk" is the systematic dependence of the time marker on the amplitude of the input pulse. Fig. 1 shows two pulses which have exactly the same shape, but one has twice the amplitude of the other. The higher amplitude pulse crosses the discriminator threshold earlier than the smaller pulse. This is the source of "walk" or time slewing. With a leading-edge timing discriminator, smaller pulses produce an output from the discriminator later than larger pulses do. When observed on an oscilloscope, the timing discriminator output pulses appear to "walk" back and forth on the time axis in response to the variations in the input pulse amplitudes. Obviously, "walk" can seriously degrade the time resolution when a wide range of pulse amplitudes must be processed. The constant-fraction discriminator, ARC timing, and other zero-crossing techniques are highly recommended for eliminating or minimizing "walk".

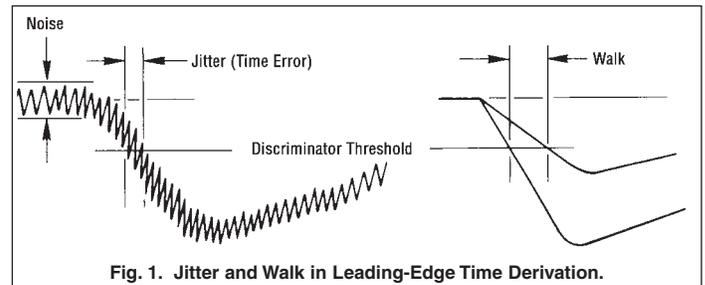


Fig. 1. Jitter and Walk in Leading-Edge Time Derivation.

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Drift is the long-term error introduced by component aging and by temperature variations in the discriminator circuits. This is a significant contributor to the timing error only when the temperature changes noticeably during long measurement periods.

Optimum Timing Solutions for Scintillation Detectors

In scintillation/photomultiplier timing systems, jitter is influenced by the generation rate of photons in the scintillator, variations in the photon transit times through the scintillator, the transit time variations of photo electrons from the photocathode to the first dynode, statistical fluctuations in the gains of the individual dynodes, and, to a much smaller degree, the width of the single-electron response of the PMT. Normally, the signal amplitude at the anode output is large enough to make the input noise of the succeeding electronics a negligible contributor. Best time resolutions are obtained from scintillators with small mechanical size, efficient light collection, high light output, and short fluorescence decay times. The photomultiplier should be chosen for high photocathode yield, small photocathode diameter, high first-dynode yield, minimal transit-time spread, and a reasonably narrow single-electron response. With a 14-stage PMT the anode output pulse is usually large enough to be connected directly to the input of the timing discriminator. Eight- or ten-stage PMTs may require some amplification, as described in the introduction to Preamplifiers and Amplifiers.

Leading-Edge Timing

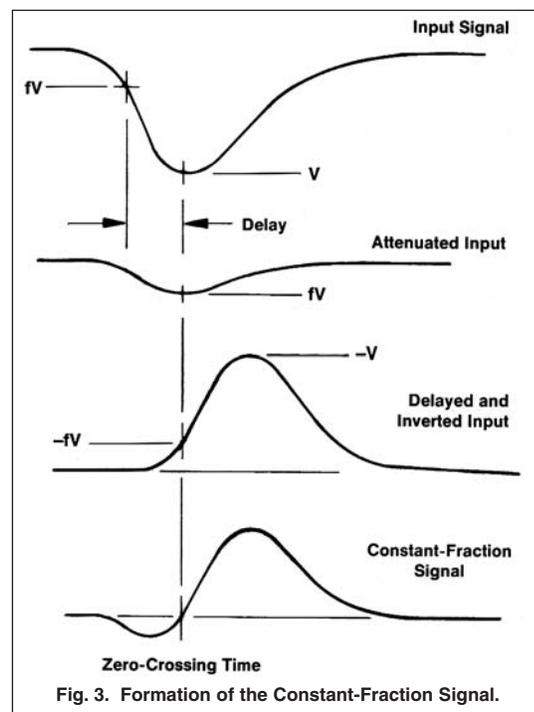
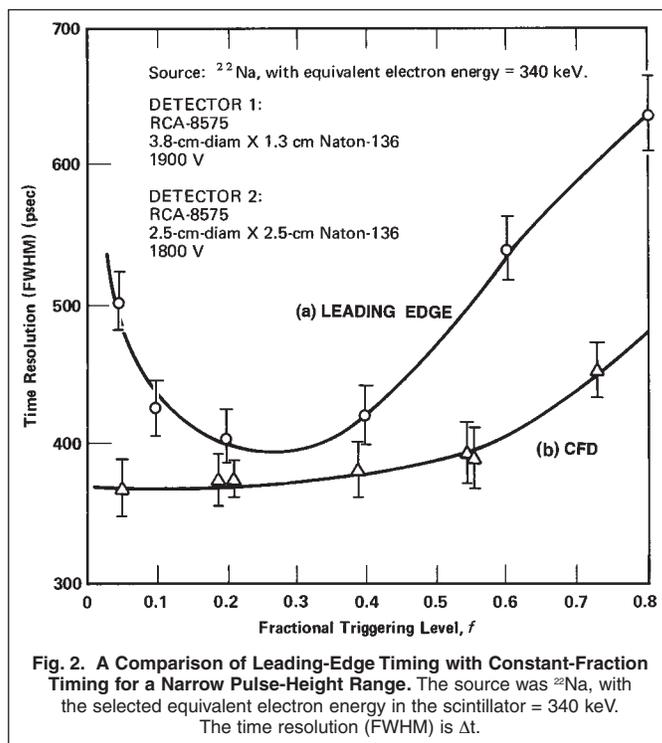
A leading-edge timing discriminator is appropriate when the optimum time resolution is not essential. "Walk" is normally the dominant limitation on time resolution with this method. The rise time of the analog pulse at the discriminator input can be used as a rough estimate of the contribution "walk" will make to the time resolution when a wide range of pulse amplitudes must be processed.

The intrinsic timing jitter of a scintillation detector is inversely proportional to the square root of the pulse amplitude. Consequently, the discriminator threshold can be set to cut off the lowest pulse amplitudes, which have the worst intrinsic jitter. If a very narrow range of pulse amplitudes is being analyzed, the "walk" contribution will be very small, and the discriminator threshold can be set at the level that yields the best time resolution. As shown in Fig. 2(a), the minimum time resolution will typically occur when the threshold is set somewhere between 10% and 40% of the anode pulse-height.

Constant-Fraction Timing

The existence of an optimum triggering fraction for leading-edge timing with scintillation detectors stimulated the design of a circuit that would always trigger at the optimum fraction of the pulse height for any pulse height.^{4,5} This circuit is now known as a Constant-Fraction Discriminator (CFD). An additional benefit of the constant-fraction discriminator is that it essentially eliminates amplitude-dependent time walk for signals having consistent rise times. The net result is optimum time resolution over a wide dynamic range of pulse heights.

The pulse shaping employed in a constant-fraction timing discriminator is shown in Fig. 3. The input signal is split into two parts. One part is attenuated to a fraction f of the original amplitude, and the other part is delayed and inverted. These two signals are subsequently added to form the constant-fraction timing signal. The



⁴D. A. Gedcke and W. J. McDonald, *Nucl. Instr. and Meth.* 55(2): 377 (1967).

⁵D. A. Gedcke and W. J. McDonald, *Nucl. Instr. and Meth.* 58(2): 253 (1968).

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delay is chosen to make the optimum fraction point on the leading edge of the delayed pulse line up with the peak amplitude of the attenuated pulse. Consequently, adding the two signals yields a bipolar signal with a zero-crossing that corresponds to the original point of optimum fraction on the delayed signal. The constant-fraction discriminator incorporates a timing discriminator that triggers on the zero-crossing, thus providing a time marker at the optimum fraction of pulse height. Since the time of zero-crossing is independent of pulse amplitude, the constant-fraction discriminator delivers virtually zero walk. (In practice, a minuscule amount of walk is still experienced for pulse amplitudes below 200 mV, because the zero-crossing comparator requires a finite amount of charge to move its output from the "0" to the "1" state.)

A functional representation of the circuits in a constant-fraction discriminator is shown in Fig. 4. As previously discussed, the input signal is delayed and inverted, and a fraction of the undelayed signal is subtracted from it. A bipolar pulse is generated, and its zero-crossing is detected and used to produce an output logic pulse. A leading-edge arming discriminator provides energy selection and prevents the sensitive zero-crossing comparator from triggering on any noise inherent in the baseline preceding the pulse. The attenuation factor f is the fraction of the pulse height at which timing is desired. Walk and jitter are minimized by proper adjustment of the zero-crossing reference, and by selection of the correct attenuation factor and delay.

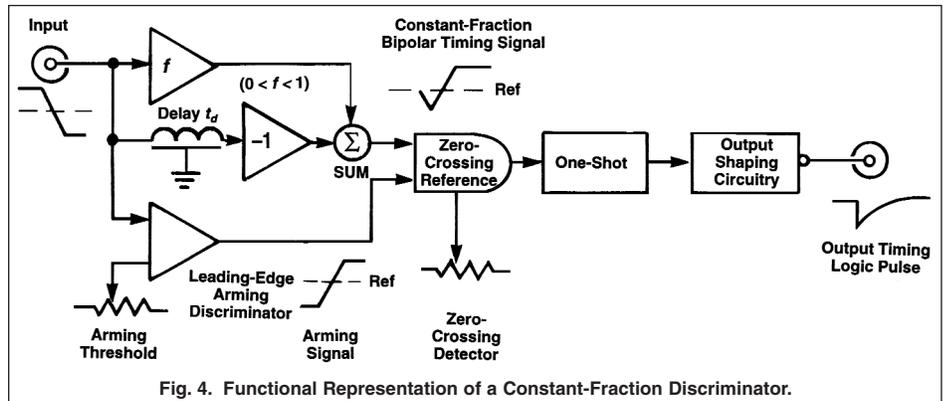


Fig. 4. Functional Representation of a Constant-Fraction Discriminator.

As shown in Fig. 2(b), **the timing resolution from a constant-fraction discriminator is better than that from a leading-edge timing discriminator**, even for a narrow range of pulse heights. Also, the time resolution with a CFD is remarkably insensitive to the choice of triggering fraction. In the scintillation detector application, a fraction somewhere between 0.2 and 0.4 is a reasonable choice. For further examples of actual performance, see the data sheets on Constant Fraction Discriminators.

Avoiding Multiple Triggering with Slow Scintillators

The scintillation decay time constant for NaI(Tl) detectors is 230 ns. That is a factor of 20 to 100 times longer than is typical of the fast scintillators that are best for timing. As a result, the last portion of each anode pulse from a NaI(Tl) detector consists of individual, single-photon pulses. If the dead time of the timing discriminator is as short as 10 ns, the discriminator will trigger once on the leading edge of the anode pulse and then multiple times at the end of the anode pulse. This multiple triggering on a single pulse can be prevented by choosing a timing discriminator that allows selecting a non-extending dead time of approximately 1 μ s. The blocking outputs of the Models 583B, 584, and 935 offer that capability. Several other slow scintillators (e.g., CsI(Na), CsI(Tl), and BaF₂) require a similar solution.

Faster scintillators, exhibiting decay times of the order of 5 ns, do not require a special dead time setting.

Timing with Silicon Charged-Particle Detectors

With silicon charged-particle detectors the timing signal is normally accessible at the output of the charge-sensitive preamplifier. Because the signal is fast and small, a fast amplifier must be employed in front of the timing discriminator. The Preamplifier and Amplifier sections of this catalog should be consulted for the proper choice of amplification. It is important to select a low-noise, charge-sensitive preamplifier with minimum rise time, followed by a fast amplifier with a similar rise time.

The timing jitter with this type of detector is dominated by the noise and slope contributions described in Equation (10). Consequently, the best timing resolution can be obtained with a constant-fraction discriminator, whose fraction and delay are selected for triggering at the point of maximum slope on the leading edge of the pulse. Use of the constant-fraction discriminator will also

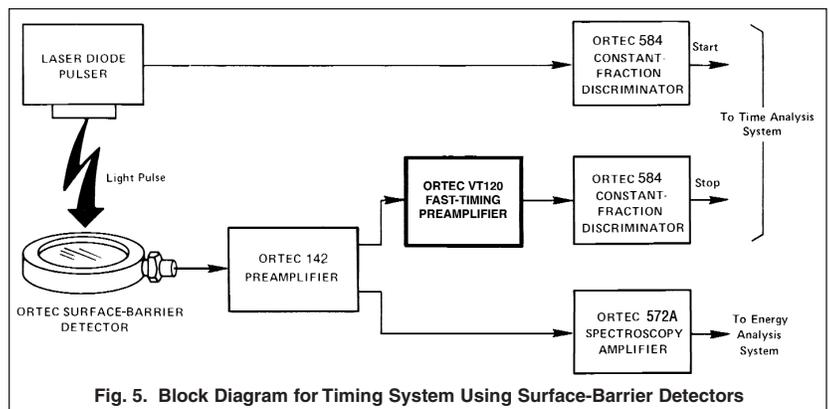


Fig. 5. Block Diagram for Timing System Using Surface-Barrier Detectors

Fast-Timing Discriminators

minimize the walk over a large dynamic range of pulse amplitudes. For practical examples of performance, see the data sheets for the Models 142A/B/C and 142AH.

Data for timing with surface barrier detectors are shown in Figs. 5–7. This information was obtained with a laser diode pulser and standard ORTEC electronics as shown in Fig. 5. Figures 6 and 7 show a typical timing resolution versus detector capacitance for this system.

Picosecond Timing with Microchannel Plates, Microchannel Plate PMTs, and Channeltrons

Microchannel plates and channeltrons are often used for single-ion counting and timing, while microchannel plate photomultiplier tubes find application in single-photon counting and timing. The amplification mechanisms in these detectors are similar to those in a conventional photomultiplier tube, except that the discrete dynodes of the normal PMT are replaced by a continuous dynode formed by a resistive glass tube. The intrinsic contribution to timing jitter in these detectors comes from variations in electron transit times through the device, and fluctuations in secondary-electron yields throughout the glass channel. The microchannel plate structure offers much smaller transit times and proportionately less transit time spread compared to a conventional photomultiplier tube. Consequently, these faster detectors also deliver better time resolution than a conventional PMT.

Microchannel plates, microchannel plate PMTs, and channeltrons produce very small output pulses with ultra-short pulse widths. Rise times are typically 150 to 700 ps, and the pulse widths (FWHM) are equally brief. Therefore, an amplifier with an extremely fast rise time is needed between the detector and the timing discriminator. The Pre-amplifier section of this catalog should be consulted for the proper choice of amplification. Because of its wide bandwidth, the preamplifier contributes electronic noise to the signal, and this adds to the timing jitter via the mechanism described in Equation (10). Best timing resolution is usually achieved when the amplifier rise time is comparable to the detector rise time.

For single-ion and single-photon timing, the amplitude fluctuations at the detector output are extreme, and one would expect that this situation demands a constant-fraction discriminator to minimize walk. Unfortunately, conventional constant-fraction discriminators do not have adequate bandwidth to properly process signals with rise times as short as 150 ps and pulse widths of the order of 400 ps. **The Model 9307 pico-TIMING™ Discriminator was developed to solve this problem. It accommodates the ultra-short pulse widths and incorporates a special circuit to eliminate walk (time slewing) over a wide range of pulse amplitudes.** Pairing the Model 9306 1-GHz Preamplifier with the Model 9307 pico-TIMING Discriminator is the best solution for achieving optimum time resolution with microchannel plates, channeltrons, and microchannel plate PMTs. Actual performance is documented in the Model 9307 data sheet. The 9327 is a more convenient solution that combines the 9306 and 9307 functions in one compact preamplifier package.

Single-Photon Timing with Photomultiplier Tubes

The solution for single-photon timing with conventional photomultiplier tubes is similar to that recommended above for microchannel plate PMTs. The significant difference is that conventional photomultiplier tubes have slower rise times (~2 ns) and higher gains. A fast preamplifier is still needed between the detector output and the input to the timing discriminator, but the preamplifier gain can be lower, and the preamplifier rise time can be in the neighborhood of 1 to 3 ns. As a result, the preamplifier input noise normally does not contribute significantly to the timing jitter.

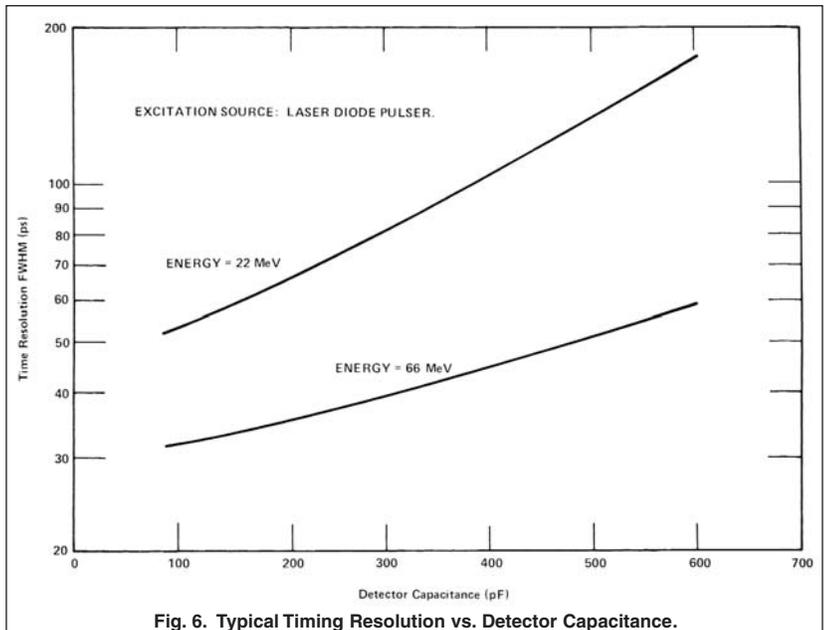


Fig. 6. Typical Timing Resolution vs. Detector Capacitance.

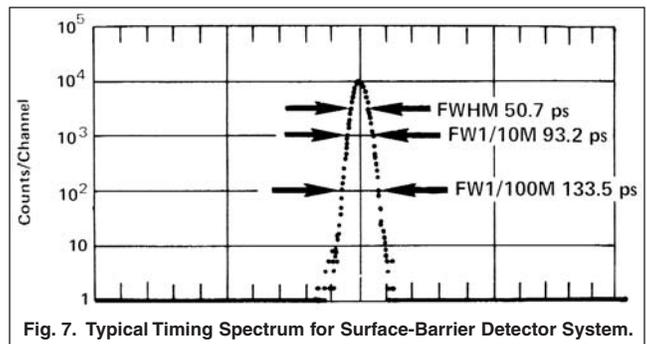


Fig. 7. Typical Timing Spectrum for Surface-Barrier Detector System.

Fast-Timing Discriminators

The PMT should be selected for low transit time spread from the cathode to first dynode, high first dynode gain, and a moderately fast single-electron response. For such a PMT, the timing jitter will usually be controlled by (a) the transit time spread from cathode to first dynode, and (b) the amplitude fluctuations caused by variations in secondary electron yields at the first dynode.

In this application, the signal rise time is slow enough that a conventional constant-fraction discriminator will provide optimum time resolution while minimizing the walk from the wide range of pulse heights produced by the detector. Alternatively, the Model 9307 pico-TIMING Discriminator can be used instead of the constant-fraction discriminator or the Model 9327 can be employed.

ARC Timing with Germanium Detectors

With germanium gamma-ray detectors, the best time resolution can be achieved by deriving the timing signal from the output of the charge-sensitive preamplifier. This signal requires amplification before presentation to a timing discriminator, and a Timing Filter Amplifier is the optimum choice for the task. (See the Amplifier introduction.) The rise time of the Timing Filter Amplifier is typically selected to be similar to the preamplifier rise time⁶ (measured with a fast pulser applied to the preamplifier TEST input).

Two factors control the intrinsic time resolution of germanium detectors: (a) variations in the charge collection time, and (b) the noise/slope effect described by Equation (10). The former so overwhelms the latter that the timing technique must be focused on overcoming the charge collection time variations, with the resulting noise/slope contribution simply being tolerated. The top diagram in Fig. 8 depicts the variation in pulse shapes observed at the preamplifier output for a germanium detector. The longest charge collection times (illustrated by pulse C) are caused by gamma rays that produce electron-hole pairs in the detector at a location close to one of the electrodes. In this case, one of the charge carriers has to "drift" the entire distance between electrodes. The minimum charge collection time (pulses A and B) results when the gamma ray interacts in the detector at a position midway between the electrodes. In that situation, the holes and the electrons each drift to their respective electrodes through half of the inter-electrode distance. Consequently, the charge collection time for pulses A and B is about half the charge collection time of pulse C. Gamma rays interacting at other locations in the detector produce charge collection times that are between the limits set by pulses B and C. The longest charge collection time (pulse C) exhibited by a specific germanium detector ranges from 50 ns for the thinnest planar detectors to 600 ns for very large coaxial detectors.

When a leading edge discriminator is used for timing with germanium detectors, the time resolution is about equal to the charge collection time, because of the long and variable charge collection time. Application of a conventional constant-fraction discriminator, as analyzed in Fig. 8, eliminates the walk caused by the difference in A and B pulse heights, but it does not eliminate the timing uncertainty caused by the difference in charge collection times between pulses B and C. The constant-fraction zero-crossing signals for pulses B and C cross the baseline at different times, t_1 and t_2 .

The Amplitude and Risetime Compensated timing technique (ARC timing) minimizes the effect of charge collection time variations from Ge detectors by an unconventional adjustment of a constant-fraction discriminator.^{7,8} The fraction is left at its normal setting (0.2 to 0.3), but the constant-fraction shaping delay is significantly shortened. Instead of selecting the delay per Fig. 3, the rise times of detector pulses are measured at the preamplifier output, and the delay is set to approximately 30% of the minimum rise time. The result is illustrated in Fig. 9. With the shorter delay, the bipolar signals for all three pulses (A, B, and C) cross the baseline at the same time, in spite of different amplitudes or rise times. Thus, the zero-crossing trigger in the modified constant-fraction discriminator delivers amplitude and rise time compensated timing.

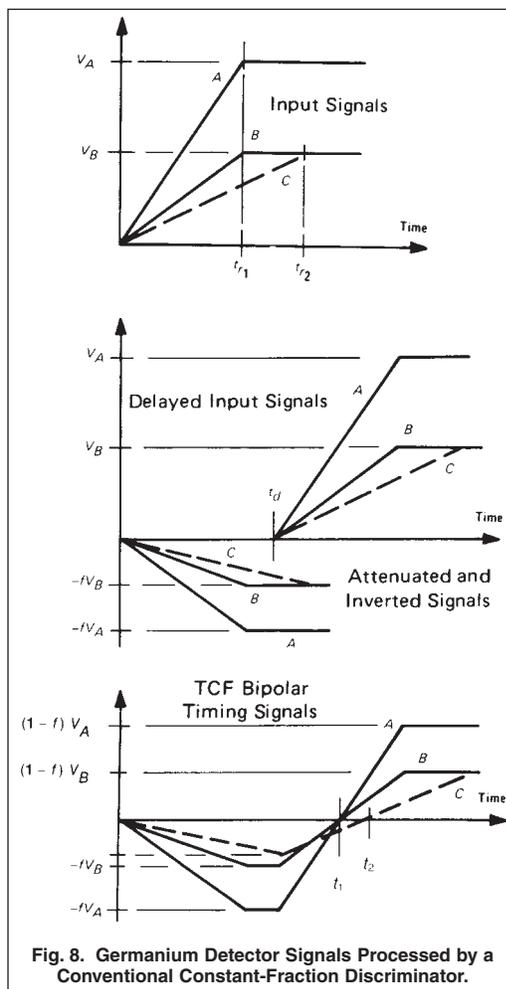


Fig. 8. Germanium Detector Signals Processed by a Conventional Constant-Fraction Discriminator.

⁶T. D. Douglas and C. W. Williams, *IEEE Trans. Nucl. Sci.* **NS-16** (1), 87 (1969).

⁷R. L. Chase, *Rev. Sci. Instrum.* **39**(9), 1318 (1968).

⁸Z. H. Cho and R. L. Chase, *Nucl. Instrum. Methods* **98**, 335-347 (1972).

Fast-Timing Discriminators

Theoretically, ARC timing generates a timing marker that is independent of amplitude and rise time, provided each pulse has a constant slope throughout its leading edge. Real pulses from planar Ge detectors exhibit constant slope only for the pulses with either minimum or maximum rise time. Pulses with intermediate rise times start with the maximum slope, but abruptly lower their slope by a factor of two when the charge carrier that experiences the shorter drift distance reaches its electrode. ARC timing will not completely compensate for the rise time if the slope changes before the time of zero crossing. The shaping delay is purposely kept short to minimize the sensitivity to abrupt slope changes.

Because of their coaxial structure, large Ge detectors produce pulse shapes that deviate somewhat from the linear rise depicted in Fig. 9. The shape of each pulse depends on where the hole-electron pairs were created in the detector.⁹ On a pulse-to-pulse basis, the shape of the leading edge varies from convex to concave, and many pulses are a mixture of these two shapes. As a result of this deviation from the ideal linear rise, ARC timing does not provide perfect compensation for the rise time variations on coaxial Ge detectors. Still, it is the most productive method for minimizing the dominant timing errors, which are caused by charge collection time variations and amplitude swings.

ARC Timing with Slow Rise Time Rejection

State-of-the-art manufacturing techniques have virtually eliminated exceptionally slow rise times in germanium detectors. However, one may still encounter older detectors that produce pulses with rise times much longer than those described above. Usually, these pulses are caused by gamma rays interacting in regions of the detector that have a weak field and slow charge collection. When the ARC timing method is applied to these pulses, the zero-crossing detector can trigger before the leading-edge arming discriminator (Fig. 4). As a result, the timing output of the constant-fraction discriminator will correspond to the leading-edge trigger instead of the zero-crossing detection. These events have excessive "walk" associated with them, and cause a long tail on the timing peak (Fig. 10). Pulses with normal rise times, but with amplitudes close to the leading-edge arming discriminator threshold, cause similar behavior.

Some constant-fraction discriminators have a Slow Rise Time rejection mode (SRT) that can be used to reject these errant events, thus improving the symmetry of the peak in the time spectrum¹⁰ (Fig. 10). The SRT mode blocks the timing output when the zero-crossing detector triggers before the leading-edge arming discriminator. Although the SRT mode improves the shape of the timing peak, it does so by rejecting events that would appear in the full-energy peak of the analyzed energy spectrum. Thus, detection efficiency can be compromised in favor of time resolution, or vice versa. The SRT mode can be enabled or disabled on the ORTEC modules that offer this feature.

For practical examples of the time resolution obtained with ARC timing on germanium detectors, see the data sheets on the Models 474 and 579.

Optimization of Timing Discriminators

Several controls are available on timing discriminators to optimize performance. Common to all discriminators is the Threshold adjustment. All ORTEC discriminators have front-panel adjustable potentiometers for threshold control, except those that incorporate a computer-controlled DAC. The Threshold should be adjusted above the noise to reduce false triggering.

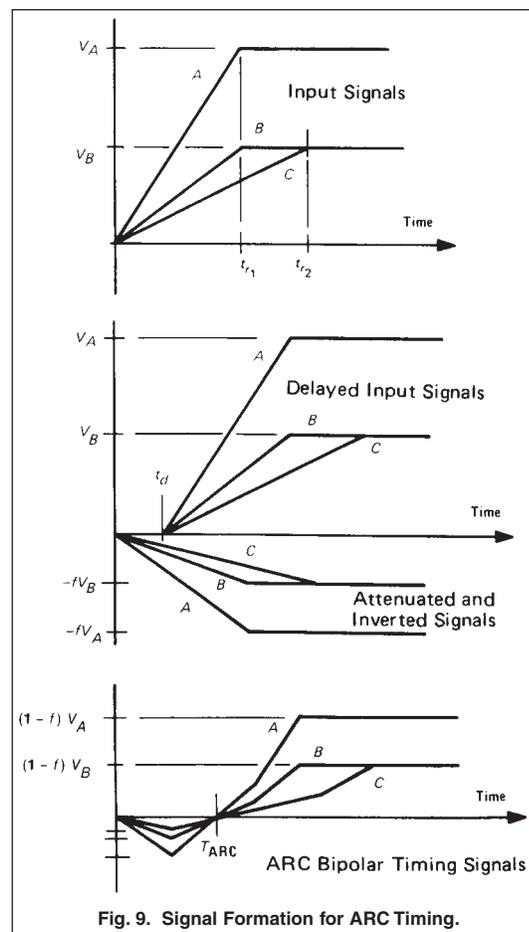


Fig. 9. Signal Formation for ARC Timing.

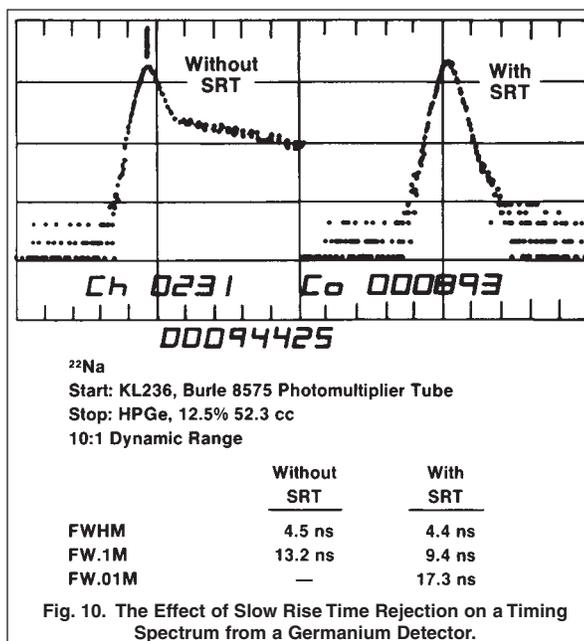


Fig. 10. The Effect of Slow Rise Time Rejection on a Timing Spectrum from a Germanium Detector.

⁹E. Sakai, *IEEE Trans. Nucl. Sci.* **NS-15** (3), 310 (1968).

¹⁰M. Bedwell and T. J. Paulus, *IEEE Trans. Nucl. Sci.* **NS-23** (1), 234 (1976).

Fast-Timing Discriminators

In some timing applications, it may be desirable to raise the Threshold and eliminate the lower pulse amplitudes which typically produce worse timing resolution.

Constant-fraction discriminators, used either in the constant-fraction or the ARC timing mode, have additional adjustments. Of principal importance is the delay selection. Various models have external cable delays, internal cable delays, or internal lumped-constant delay lines. Internal delays are the most convenient, but external cable delays allow better optimization of the timing performance in exacting experiments.

When using detectors having a constant rise-time signal, the delay is nominally equal to the time taken by the detector signal to rise from the intended triggering fraction (e.g., 20%) to 100% of its maximum amplitude. As the selection of the delay is critical, experimentation is appropriate to determine the optimum value. For example, a 36-cm delay cable was found to be optimum when using a Hamamatsu R1332 or Burle 8850 PMT with the Model 583B CFD and a 12.9 cm³ BC418 scintillator.

Selection of the delay for germanium detectors is more difficult and can best be determined experimentally. In general, the larger the germanium detector, the longer the delay. A 10% HPGe detector may require a 20-ns delay, while a 70% relative efficiency detector may require a 35-ns delay. However, there is still a large spread in optimum delay, even among detectors of similar size. Often a delay unit consisting of various lengths of high-quality coaxial cable is used to set the delay for a germanium detector. When using an external delay unit, its insertion delay as well as the delay of the interconnecting cables must be counted as part of the delay.

The optimum delay when timing with silicon charged-particle detectors is dependent on the preamplifier. Generally, the charge collection time for this type of detector is much faster than the rise time of the preamplifier. Because the preamplifier output delivers the signal to the constant-fraction discriminator, the proper delay is based on the rise time of the preamplifier output signal. If additional amplification follows the preamplifier, the delay must be appropriate for the signal fed to the constant-fraction discriminator.

The final critical adjustment on a constant-fraction discriminator is the Walk Adjustment. Referring to Fig. 4, the Walk Adjustment corresponds to setting the Zero-Crossing Reference. Most units have the Walk Adjustment available on the front panel, while in a few units the walk must be adjusted using a printed wiring board potentiometer.

Most constant-fraction discriminators have a special Monitor output, which can be used to optimize the walk adjustment. The constant-fraction discriminator is connected as shown in Fig. 11 when its input is taken from an actual detector and its output is used to trigger a fast oscilloscope. The Monitor output signal is delayed a few nanoseconds and connected to a 50-Ω input on the oscilloscope. The Monitor signal will generally be one of two types. ORTEC Models 583B and 935 have a well-shaped monitor signal like that shown in Fig. 12a. Other discriminators provide a truncated monitor signal from the zero-crossing detector output like that shown in Fig. 12b. The well-formed Monitor signal is an output from the transformer pulse shaping circuit used in Models 583B and 935. In Fig. 12a, the walk adjustment is optimized when all pulse amplitudes cross through the baseline at the same time. In Fig. 12b, the walk adjustment is optimized when the noise on the baseline between pulses is centered between the high and low logic levels of the zero-crossing detector output. A further fine tuning of the walk adjustment can be achieved by minimizing the peak width observed in the time spectrum from a time-to-amplitude converter.

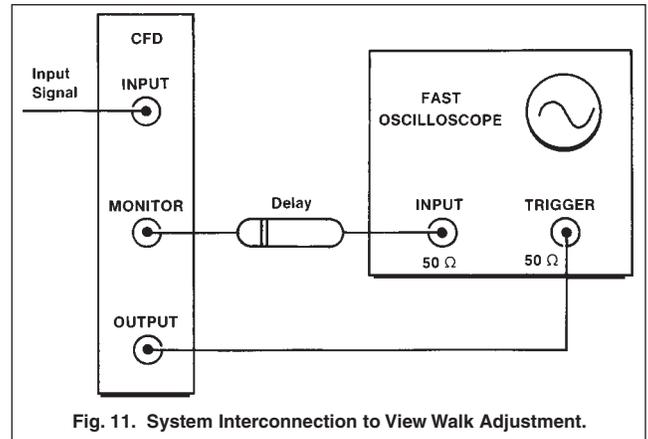
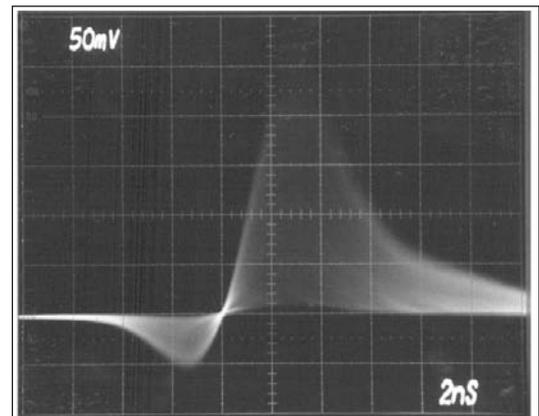
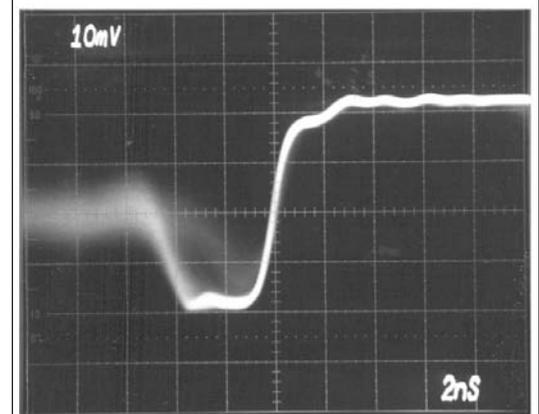


Fig. 11. System Interconnection to View Walk Adjustment.



(a)



(b)

Fig. 12. Monitor Signals when Triggered by the Constant-Fraction Discriminator Output Signal for (a) Passive Pulse Shaping and (b) for Active Pulse Shaping.

Fast-Timing Discriminators

Application Guide for Timing and Counting with Fast Discriminators

Application	Discriminator Model Number						
	CF8000	583B	584	935	9302	9307	9327
Scintillation Detectors	CFD	CFD SCA	CFD	CFD	AMP/LE		
Silicon Charged-Particle Detectors	CFD	CFD SCA	CFD	CFD	AMP/LE		
Microchannel Plates, Microchannel Plate PMTs, Channeltrons			LE	(CFD)	LE	pT	pT
Single-Photon Counting/Timing with Photomultiplier Tubes	CFD	CFD SCA	CFD	CFD	LE	pT	pT
Germanium Detectors	ARC	ARC SRT	ARC SRT	ARC			
Fast Photodiodes			LE	(CFD)	LE	pT	pT

Selection Guide for Fast Discriminators

Model	Number of Channels	Package-Width	Max. Burst Rate	Pulse-Pair Resolving Time	Modes	Selectable Fractions	Shaping Delay	Special Notes
CF8000	8	NIM-1	20 MHz	50 ns	CFD, ARC	0.4	Internal, selectable	Auto-walk adjust, Special outputs
583B	1	NIM-1	20 MHz	50 ns	SCA, CFD, ARC, SRT, BKO	0.2	External cable	Upper and lower level discriminators
584	1	NIM-1	50 MHz	20 ns	CFD, ARC, SRT, LE, BKO	0.2	External cable	Min. threshold = 5 mV, Input gate
935	4	NIM-1	200 MHz	5 ns	CFD, ARC, (LE), BKO	0.2	External cable	Accepts input widths as short as 1 ns. Individual gates and common veto.
9302	1	NIM-1	100 MHz	10 ns	LE			Fast amplifier and LE discriminator. See Amplifier section.
9307	1	NIM-1	100 MHz	10 ns	pT			Optimized for single-photon and single-ion timing with microchannel plate/PMTs.
9327		1	Preamp	100 MHz	10 ns	pT		Optimized for single-photon and single-ion timing with microchannel plate detectors. Also fast photodiodes and fast PMTs. Includes 1-GHz amplifier.

Codes:

AMP = Includes fast amplifier	LE = Leading-edge discriminator mode
ARC = Amplitude and rise time compensated timing	SCA = Single-channel analyzer (upper and lower level discriminators)
BKO = Blocking output	SRT = Slow rise time rejection option
CFD = Constant-fraction discriminator mode	pT = pico-Timing™ discriminator

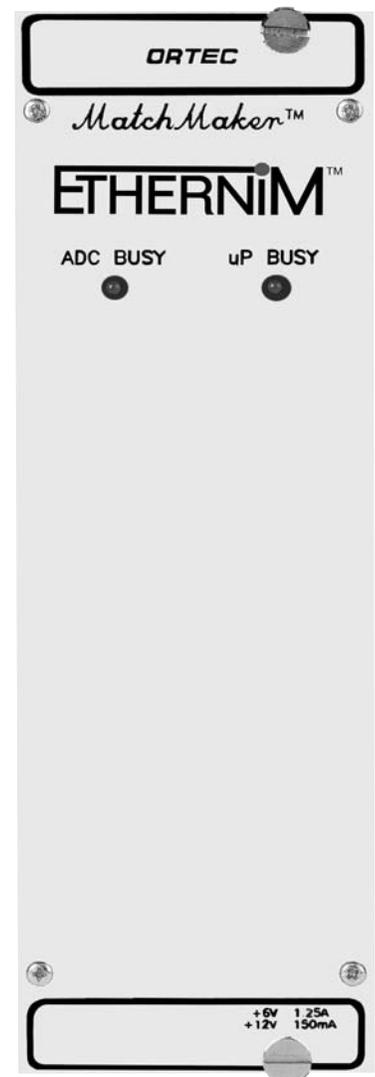
MatchMaker: an *EtherNIM* Interface Module for the **ORTEC CONNECTIONS** Applications Environment

MatchMaker propels your existing MCA instrumentation into ORTEC's world of **GammaVision™-32** and other 32-bit spectroscopy applications — easily and quickly via the Ethernet.

MatchMaker's Benefits . . .

- An interface between a variety of non-ORTEC ADCs and your computer
- Ethernet computer connection
- Fully *CONNECTIONS* compliant — add any ORTEC MCB, now or later
- Battery backed-up data memory — outside the computer
- Simultaneous live time, real time, ROI count, ROI integral, overflow, and statistical presets
- Includes sample changer hardware control
- Economical software options for MAESTRO-32, GammaVision-32, and ScintiVision-32
- Optional utilities to convert spectral files from one format to another

The MatchMaker EtherNIM Acquisition Interface gives many people currently using non-ORTEC MCA products¹ the widest possible benefit of ORTEC's *CONNECTIONS-32* open architecture. Not only does this give you the benefit of economical PC hardware and off-the-shelf applications software, it also gives the benefit of spectroscopy software applications such as MAESTRO-32, GammaVision-32, ScintiVision-32, AlphaVision-32, Renaissance-32, MGA, Isotopic, and PC/FRAM. MatchMaker, an EtherNIM product, is a full member of the ORTEC family of *CONNECTIONS*-compliant modules.



¹Currently supported are many ADC models from Canberra Industries, Nuclear Data, and Silena.

All ORTEC MCBs (multichannel buffers), from the Model 918 (vintage-1983) to the digital DSPEC, have integral ADCs. MatchMaker provides all the benefits of the MCB and a connection to external ADCs from a variety of vendors. This makes system upgrades economical and easy — only the outdated computer and software are replaced. The link between MatchMaker and an ADC is a ribbon cable (supplied).

With MatchMaker's integral Ethernet Port, just a simple coaxial connection connects you to the network. After that, the *CONNECTIONS* auto-configure utility will seek out the MatchMaker and configure the system correctly: you only need set the ADC type! The time between unpacking the computer to taking data is less than 10 minutes. You can connect a virtually unlimited number of MatchMakers to one PC.

As an otherwise "traditional" MCB, MatchMaker is compatible with all applications developed using the ORTEC UMCBI (Unified Multichannel Buffer Interface). With this open architecture and two Programmer's Toolkits, programming the MatchMaker is easy and convenient, either in C or Visual Basic®.

Program It Yourself?

Are you faced with the need to develop Windows spectroscopy applications to control hardware and want to be up and running *FAST*?

ORTEC's Programmer's Toolkits allow you to take control of the MatchMaker and your ADC **EASILY** from, for example, Visual Basic or C++. For you the mystery of Ethernet communications is solved.

Supported ADC Hardware

MatchMaker supports the following ADCs:

Canberra — Models **8075, 8077, 1510, 8701, 8706, 8713, 8715** (May be components in: CI Series 30/35 [external ADC option]; Series 85/90/95 [external ADC option]; S100.)

Canberra/Nuclear Data — **560, 570, and 580 Series** (May be components in: Genie "AIM" systems [NOT ICB NIM]; Genie 9900; Accuspec "B"; μ MCA module; ND62 [External ADC option, including top mount version]; ND65 series [external ADC option]; ND66/76 series; ND6600, ND6700, ND6680 Series.)

Silena — Models **7411, 7423** (May be components in Silena's Cicero; Varro; Livius; SIMCAS; NIM Series 8900; Memory Buffer 7328.)

MatchMaker™

EtherNIM™ Acquisition Interface Module

Specifications

Memory

Up to 16384 channels are accessible depending on the ADC resolution. Memory is nonvolatile, capacity $2^{31}-1$ (2 billion) counts per channel.

Presets

Real Time In multiples of 20 ms.

Live Time In multiples of 20 ms.

Region-of-Interest Peak count.

Region-of-Interest Integral count.

Data Overflow Terminates when any channel exceeds 2 billion.

Statistical Preset Allows setting the required statistical accuracy on a key peak net area.

Front-Panel Indicators

CPU BUSY Red LED, intensity indicates the activity of the microprocessor.

ADC BUSY Red LED, flashes once for every pulse digitized by ADC.

Interface Connectors*

Ethernet Rear-panel BNC connector, accepts IEEE 802.3 10BASE2 (thin-wire coax).

ADC Interface

- J1** 34-pin header, labeled J1, connects to Nuclear Data or Canberra ADCs with a 34-pin interface connector.
- J2** 26-pin header, labeled J2, connects to Canberra ADCs that have a 26-pin interface connector.
- J3** 36-pin header, labeled J3, connects to ORTEC 800 and Seiko ADCs.
- J4** 38-pin header, labeled J4, connects to Silena ADCs.

Sample Changer Connectors

Change Sample and Sample Ready Rear-panel BNC connectors for change sample and sample ready, respectively; software controlled.

Electrical and Mechanical

Power Requirements +12 V, 150 mA; +6 V, 1.25 A.

Dimensions NIM-standard double width 6.90 x 22.13 cm (2.70 x 8.714 in.) front panel per DOE/ER-0457T.

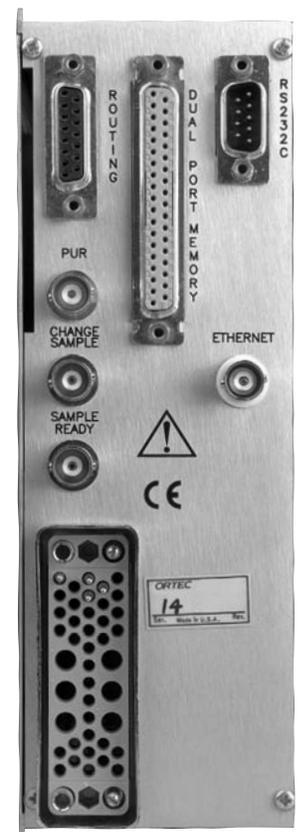
Weight

Net 2.25 kg (5 lb).

Shipping 3.1 kg (7 lb).

PC Prerequisites

Windows 2000/XP operating system. Ethernet capability.



*The following connectors are also available:

Dual-Port Memory — ORTEC dual-port interface, 37-pin D connector.

RS-232-C — Serial standard RS-232-C 25-pin; male wired as DTE to run at 38.4 kbaud maximum, with modem control. Software selectable baud rate. (For diagnostics)

MatchMaker™

EtherNIM™ Acquisition Interface Module

Ordering Information

1. **The first MatchMaker** in a system should normally be ordered as a package, including an appropriate software application. Currently available packages are:

Model Number	Description
MM-A65	NIM MatchMaker with MAESTRO-32† (standalone or first network copy)
MM-A66	NIM MatchMaker with GammaVision-32† (standalone or first network copy)
MM-A35	NIM MatchMaker with ScintiVision-32† (standalone or first network copy)

2. **To add additional MatchMakers** to a system, standalone hardware may be added:

MatchMaker	MatchMaker hardware only, NIM version
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3. MatchMaker Connectivity

ETHRJ45	10Base2 to 10BaseT Hub with four 10BaseT connections and one 10Base2 connection with cables, tee connector, and 50-Ω terminator for MatchMaker connection directly to any thin-wire Ethernet installation.
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4. **MatchMaker Application Packages** are “MatchMaker-only” versions of the latest releases of various ORTEC software products. The MatchMaker-only versions are easily and economically upgraded to support ALL ORTEC hardware, as well as the MatchMaker:

A35-B32-MM	ScintiVision for MatchMaker only
A35-G32-MM	Documentation for A35-B32-MM
A35-K32-M	Upgrade from A35-B32-MM to A35-B32
A35-N32-MM	ScintiVision for MatchMaker only additional network copies
A35-U32-MM	Update for A35-B32-MM
A65-B32-MM	MAESTRO-32 for MatchMaker only
A65-G32-MM	Documentation for A65-B32-MM
A65-K32-M	Upgrade from A65-B32-MM to A65-B32
A65-N32-MM	MAESTRO-32 for MatchMaker only additional network copies
A65-U32-MM	Update for A65-B32-MM
A66-B32-MM	GammaVision-32 for MatchMaker only
A66-G32-MM	Documentation for A66-B32-MM
A66-K32-M	Upgrade from A66-B32-MM to A66-B32
A66-N32-MM	GammaVision-32 for MatchMaker only additional network copies
A66-U32-MM	Update for A66-B32-MM

Programmer's Toolkit

A11-B32	32-bit UMCBI Programmer's Toolkit
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†MatchMaker Application Packages are “MatchMaker-only” versions of the latest releases of various ORTEC software products. The MatchMaker-only versions are easily and economically upgraded to support ALL ORTEC hardware, as well as the MatchMaker.

Specifications subject to change
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