

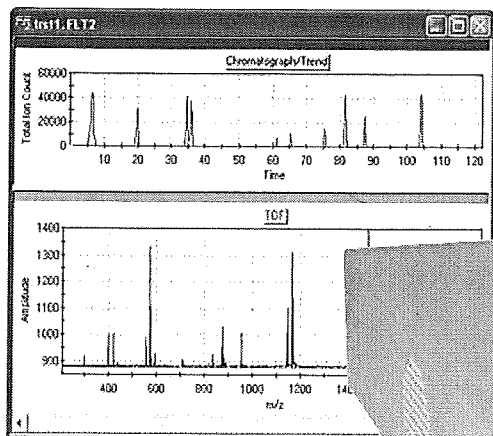
# SIGNAL RECOVERY

**FASTFLIGHT<sup>®</sup>-2**  
Digital Signal Averager

TOF-MS

*Separate Product Line*

Acquire up to 100 Spectra/second with the 4 GHz  
**FASTFLIGHT-2 Digital Signal Averager**



**Exceptionally fast LC/TOF-MS or GC/TOF-MS data acquisition. . .  
with a simple USB-2 connection to your computer!**

- 250 ps interleaved and 500 ps real-time sampling intervals  
– helps resolve the narrowest peaks
- Sustained TOF-MS rates up to 100 averaged spectra/s (with negligible dead time) in the Chromatograph/TOF-MS mode  
– for super-fast chromatographs
- Simple cable connection to the USB-2 port on your PC  
– no need to find scarce space inside your computer
- Automatic data compression by factors up to 400:1  
– greatly reduces the chromatograph/TOF-MS file size
- Automatic correlated noise suppression to <0.004% of full scale  
– resolves a 25,000:1 concentration range
- Rapid Protocol Port for changing acquisition modes within 10  $\mu$ s  
– for multiplexed, multimode chromatographs
- Includes Windows<sup>™</sup> XP/2000 software for control, acquisition, display and data analysis, and Programmer's Toolkit for developing custom application software  
– start taking data immediately after installation

# FASTFLIGHT<sup>®</sup>-2

Digital Signal Averager

A POWERFUL SOLUTION for:

- Chromatograph/TOF-MS
- MALDI TOF-MS
- Ion-Trap/TOF-MS
- and even QqTOF-MS

With its ability to process up to 100 averaged spectra per second, while responding proportionally to multiple ions in each detector pulse, the FASTFLIGHT-2 is a superior solution for data acquisition in LC/TOF-MS and GC/TOF-MS applications. Chromatograph technology is advancing towards shorter retention times, and this pushes the time-of-flight mass spectrometer (TOF-MS) to acquire averaged spectra much more rapidly. FASTFLIGHT-2 improves the TOF spectra processing rate by a factor of 10 compared to first-generation digital signal averagers, thus enabling much faster chromatographs.

Because it employs a sampling ADC and a hardware digital signal averager, FASTFLIGHT-2 can handle the high ion rates encountered in LC/TOF-MS, GC/TOF-MS, Ion-Trap/TOF-MS and MALDI TOF-MS without suffering the dead-time distortions inherent in a time-to-digital converter (TDC). Compared to transient digitizers and digital sampling oscilloscopes, which suffer from slow software averaging, FASTFLIGHT-2 delivers averaged spectra many orders of magnitude faster.

The innovative, automatic correlated noise subtraction feature means FASTFLIGHT-2 can also be a productive solution for the lower ion rates encountered in quadrupole/quadrupole/TOF mass spectrometers (QqTOF-MS), previously considered to be the exclusive domain of TDCs and time digitizers.

## FASTFLIGHT-2 does it all!

### How Does It Achieve Such Impressive Performance?

Starting With the Chromatograph/TOF-MS, the sample from the chromatograph is typically injected into the acceleration region of the TOF-MS through an electrospray nozzle. Although the detail is not depicted in Figure 1, the result is a cloud of ionized molecules between the acceleration electrode and the grounded grid in the source region of the TOF-MS. Periodically, a brief high-voltage pulse is applied to the acceleration electrode. This causes the ionized molecules to accelerate and travel along the field-free drift tube. The molecules are separated according to mass, with the lighter molecules attaining higher velocities and arriving at the detector before the heavier molecules reach that end of the flight path. The flight time is proportional to the square root of the mass-to-charge ratio,  $m/z$ , of the ionized molecule. As a group of molecules of a particular  $m/z$  arrives at the detector, it causes the detector to generate an analog output pulse whose amplitude is nominally proportional to the number of molecules in that group. Thus, the time at which the detector pulse is produced represents the  $m/z$  value, and the amplitude is proportional to the number of ions of that specific mass and charge. Accordingly, the spectrum of flight times is measured to generate the mass spectrum.

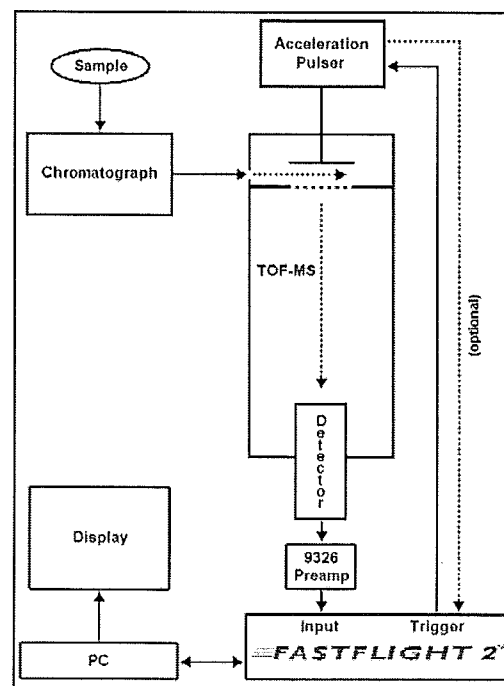


Figure 1. A simplified representation of the FASTFLIGHT-2 Digital Signal Averager applied to data acquisition with an electrospray TOF-MS receiving the output of a chromatograph.

FASTFLIGHT-2 uses an 8-bit flash ADC to sample the amplitude of the detector output signal at 500 ps intervals. For a complete scan through the time period of interest, this converts the analog input signal into a digital representation, i.e., a series of digital values representing the sampled amplitude at 500 ps intervals. The start of each scan is synchronized with the acceleration pulse in the TOF-MS, and the scan spans the minimum to maximum flight times. Because of the modest number of ions contained in each detector pulse, a single scan through the time range yields a rather noisy record of the signal. Multiple records must be summed or averaged to form a time-of-flight spectrum with improved signal-to-noise ratio. This summing is accomplished instantaneously in the Averager Memory.

As each record is received, it is added, sampled point by sampled point, to the sum of all previous records in the Averager Memory. As the last record for the spectrum is being added, the point-by-point sum is also written to the Output Buffer Memory. Thus, the Averager Memory is immediately available to acquire the next spectrum, while the Output Buffer Memory transmits the most recent spectrum to the supporting computer. The reset time required to start the next scan is nominally 0.8  $\mu$ s, and this same minimal reset time applies to the end of a spectrum. Consequently, the end-of-scan and end-of-spectrum dead times are a negligible 0.8% of the typical 100  $\mu$ s scan length.

As the spectra flow to the supporting computer, the Data Formatter and Compressor provides data compaction, and the 8 M Word FIFO Memory acts as a temporary-storage buffer to smooth sporadic communications over the high-speed USB-2 link.

Altogether, the components in this data pipeline enable the FASTFLIGHT-2 to deliver an unprecedented, sustained data rate of 100 averaged spectra/second.

### Choose the Sampling Interval to Suit Your Spectrum

FASTFLIGHT-2 offers hardware real-time sampling intervals of 500, 1000 and 2000 ps, and an interleaved 250 ps sampling. In addition, the software can display 250 ps interpolated spectra based on data acquired with 500 ps hardware sampling. Adequate definition of the peak shapes in the spectrum normally requires at least 1.2 samples spanning the FWHM (Full Width at Half Maximum height) of the peak<sup>1</sup>. Thus, 250 ps sampling accommodates peaks as narrow as 300 ps FWHM. At the other extreme, 2-ns sampling can be used to dramatically reduce the spectrum file size for peak widths >2.4 ns FWHM.

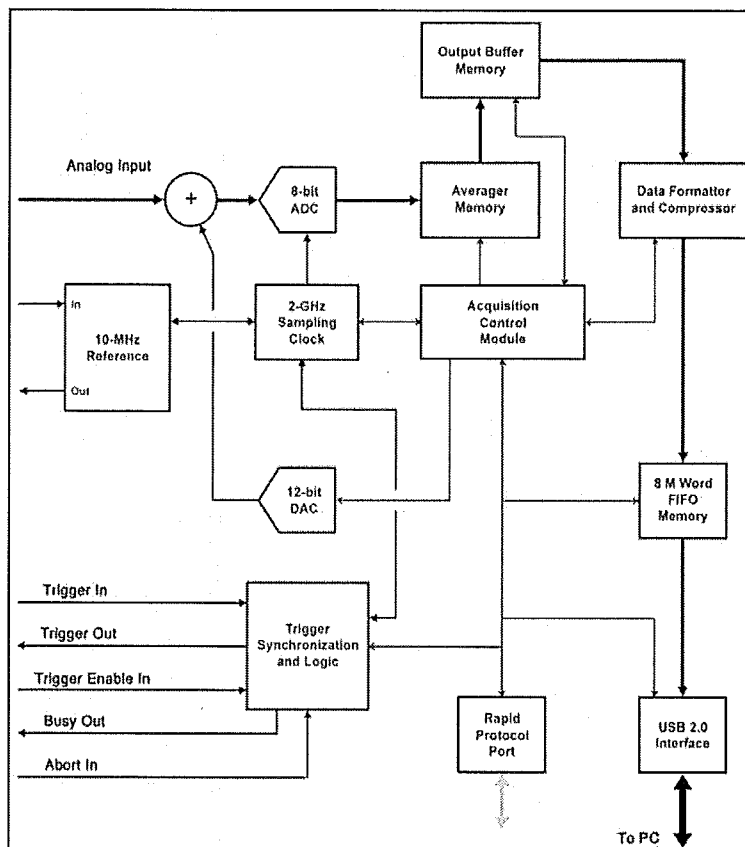


Figure 2. The Basic Architecture of the FASTFLIGHT-2 Hardware.

<sup>1</sup>ORTEC Application Note AN61, *How Counting Statistics and the ADC Sampling Interval Control Mass Accuracy in Time-of-Flight Mass Spectrometry*, (2001).

### **Trigger the TOF-MS, or Accept the TOF-MS Trigger**

For mass spectrometers that cannot accept an external signal to initiate each acceleration pulse, FASTFLIGHT-2 can accept a trigger signal derived from the acceleration pulse of the TOF-MS. When using the external Trigger Input on the FASTFLIGHT-2, the minimum hardware sampling interval is 500 ps, and the jitter between the trigger and the first sampled point in the spectrum is 0 to 500 ps. This uncertainty represents the time from the random arrival of the Trigger Input to the next sampling clock pulse.

An order of magnitude lower jitter can be achieved by using the Trigger Output from the FASTFLIGHT-2 to initiate the acceleration pulse in the TOF-MS. This scheme also enables 250 ps interleaved sampling by alternately delaying the Trigger Output by 0 and 250 ps relative to the sampling clock on successive scans. Two scans are used to complete each record in the 250 ps interleaved sampling mode.

### **Choose Data Compression Ratios from 2:1 to 400:1**

A 15-minute chromatograph composed of TOF spectra taken every 10 ms, with a 50  $\mu$ s maximum flight time and 500 ps sampling, will generate 36 GBytes of data, . . . if not compressed by some means. Just a few chromatographs will fill a hard disk. Consequently, data compression schemes are a vital strategy for reducing the file size. FASTFLIGHT-2 offers three innovative data compression options.

The **Lossless Compression Mode** takes spectra that would normally occupy 4 Bytes in the computer for each sampled data point and compacts them into mostly 2-Byte data. The data is compressed by a factor very close to 2:1 without losing any raw data. This is feasible because most of the spectrum consists of background which can be encoded in 2 Bytes.

In the **Peak-Preserving and Background-Suppressing (Lossy) Mode**, the Data Formatter and Compressor in the hardware identifies the peaks in the spectrum. The information in the peaks is preserved, together with a few background points on either side of each peak, and is transmitted to the supporting computer. The background between the peaks is decimated by cyclically suppressing 200 adjacent background points and transmitting the next 4 background points. An additional compression by a factor of 10 to 30 (depending on peak density) is possible by this method.

In the **Peak Centroid and Area Mode**, the output from the previous method is processed further to compute the centroid and net area above background for each peak region. All background data is suppressed, and only two numbers are saved for each peak, the centroid and net area. The software displays the spectrum as a stick diagram, with the horizontal coordinate identifying the m/z value and the height of the stick designating the net area of the peak. An additional compression by a factor of about 9 is available with this final step.

Overall, compression ratios up to 400:1 are possible in spectra dominated by background. All of these compression options are implemented in high-speed hardware, so that spectra transmission rates are not degraded.

### **Improve Detection Limits with Automatic Correlated Noise Subtraction and/or a Duet**

When a low number of scans are averaged in each spectrum, the dominant noise in the spectrum is caused by random fluctuations in the detected number of ionized molecules. This noise is not correlated with the trigger at the start of the scan nor with the sampling clock. For a low number of scans averaged in a spectrum, this statistical fluctuation in the ions counted in the peak, and in the background surrounding the peak, limits the detection of low-concentration peaks.

Averaging a large number of records in a spectrum reduces the relative amplitude of these random fluctuations and improves detection limits. However, noise sources that are correlated with the trigger and the sampling clock are not reduced by averaging, and they eventually become the limiting factor for detecting small peaks when the number of records averaged in a spectrum is very large.

# FASTFLIGHT<sup>®</sup>-2

## Digital Signal Averager

An **Automatic Correlated Noise Subtraction Algorithm** in the FASTFLIGHT-2 Data Formatter and Compressor assesses the correlated noise in each spectrum and subtracts it. The algorithm begins anew in each spectrum, and adapts to changes throughout the spectrum. Because it is implemented in high-speed hardware, it does not impede the rate of data transmission. Correlated noise suppression by factors up to 20 is possible when correlated noise dominates.

The **Duet Mode** can also be employed to reduce the importance of correlated noise by an additional factor of 10. In this scheme, two FASTFLIGHT-2 units are used to analyze the same detector signal. Unit A operates with normal signal gain, while the signal is amplified by an additional factor of 10 before it is supplied to unit B (Fig. 8). This lowers the importance of correlated noise in unit B by a factor of 10. The 10 MHz clock inputs and outputs are used to synchronize the two units. The spectrum from unit A is analyzed for the taller peaks, and the smaller peaks are extracted from unit B. This scheme can lower the detection limit arising from correlated noise by a factor of 10.

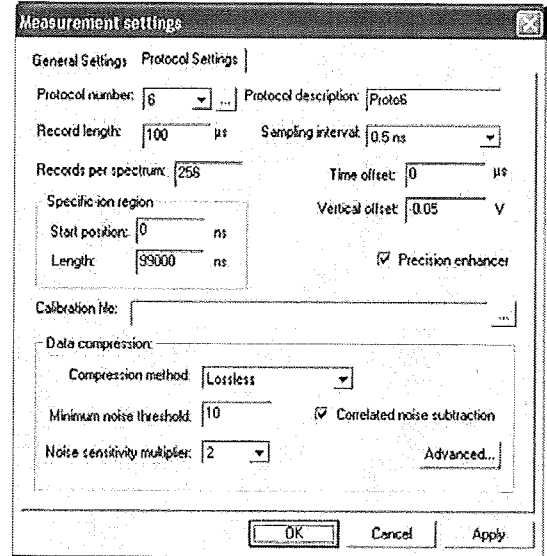


Figure 3. The Protocol Settings Tab (protocol 6 shown).

### Rapid Protocol Port for Multiplexed, Multimode Chromatographs

The Rapid Protocol Port can be used during a chromatograph/TOF-MS acquisition to change the FASTFLIGHT-2 operating parameters as TOF spectra are acquired across a peak in the chromatograph. One typical use is to alternate the TOF-MS between a) the fragmentation mode and b) the precursor-ion mode. This permits collecting both types of molecular analysis during a single chromatograph. The electronic interface permits the FASTFLIGHT-2 operating parameters to be changed within 10 µs, a speed that is not possible via software commands. The pre-determined operating parameters are stored in the hardware under 16 designated protocol numbers. Before or during acquisition, the operator can select any protocol number for the live chromatograph display, while the data for all designated protocols is collected and saved.

On this same port, any one of 16 different tag numbers can be captured at the start of each spectrum to identify a unique condition in the rest of the TOF-MS. The relevant tag number is displayed when the marker hovers on a point in the chromatograph.

### Precision Enhancer Improves Resolution and Linearity

With the Precision Enhancer turned on, the 12-bit DAC in Figure 2 is incremented at the end of each record by a pseudo-random integer multiple of 123 µV (referred to the summing node at the input to the 8-bit ADC). This randomly shifts the baseline on the analog signal by that same voltage. Because 123 µV represents 1/16 LSB at the ADC input, the randomly shifting dc offset extends the digitizing resolution of the ADC by a factor of 16 when ≥16 records are averaged. When averaging analog signals with inherent noise less than 1.96 mV (1 LSB), this method makes the 8-bit ADC offer the digital resolution of a 12-bit ADC.

The random steps in the baseline cover a range of ±15.7 mV (±8 LSB). When circa 256 or more records are summed in a spectrum, this stepping improves the differential non-linearity by a factor of 16. The differential non-linearity of the ADC is a measure of how much the width of each digitized voltage interval deviates from the average width.

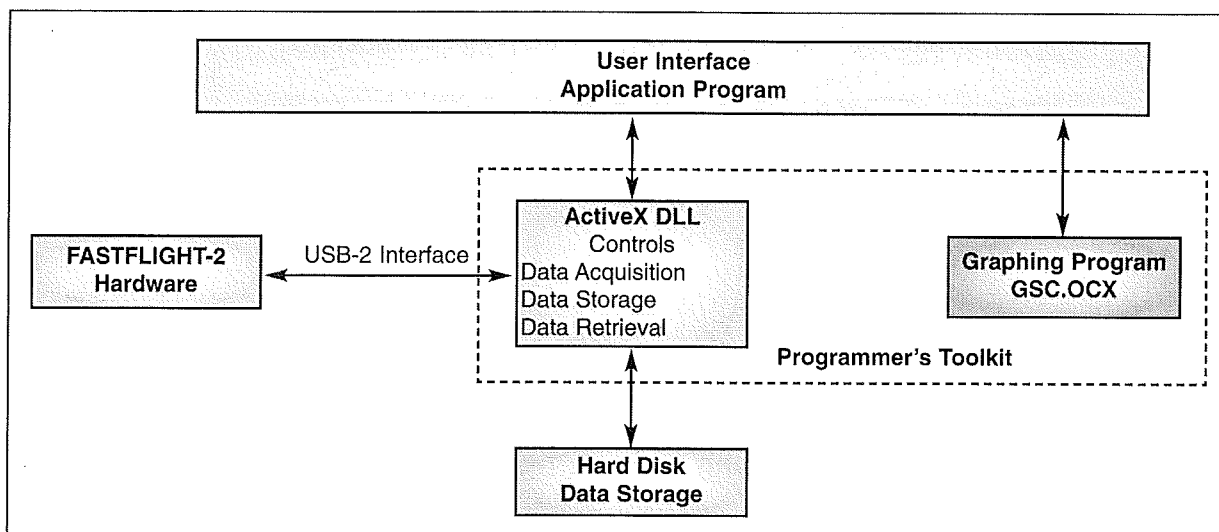


Figure 4. FASTFLIGHT-2 Software Architecture.

### Plug it in, Install the Software, and Acquire Spectra

No programming is needed to immediately acquire and process data. The FASTFLIGHT-2 is supplied with comprehensive application software that controls the hardware, acquires TOF-MS spectra and chromatographs, saves the data on hard disk, and provides convenient features for displaying and manipulating the data. The software runs under Windows® 2000 Professional and XP® Professional SP-2.

### Includes a Programmer's Toolkit with ActiveX® Controls

For those who wish to integrate the FASTFLIGHT-2 into their own software for operating the TOF-MS, the software is structured to provide easy access to the programmer's toolkit. The ActiveX.DLL controls all the parameters of the hardware, the data acquisition, data storage and data retrieval. A Graphing Program (GSX.OCX) can be used to generate the spectral displays and the graphical user interface. All of the illustrated features are generated by the standard User Interface Application Program calling those two toolkit programs. Your custom software simply replaces the standard User Interface Application Program. The instruction manual includes a complete description of the ActiveX<sup>2</sup> methods, properties and events, as well as all the data formats. The software features described herewith are provided by the standard software, and are also accessible with the programmer's toolkit.

### Choose the TOF or the Chromatograph/TOF Mode

The **TOF Mode** repetitively acquires TOF-MS spectra and displays them on the computer screen. Each new spectrum replaces the previous spectrum, and the spectra are not automatically saved. This is a convenient mode for adjusting the TOF-MS operating conditions while viewing the changes in the spectra. A spectrum can be saved by stopping

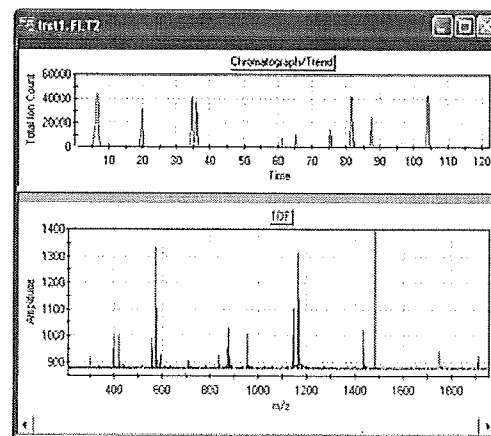


Figure 5. The Chromatograph and TOF-MS displays.

<sup>2</sup>ActiveX Controls are supported by Microsoft C++, Visual Basic, Visual Studio.NET, and National Instruments® LabVIEW™.

# FASTFLIGHT<sup>®</sup>-2

## Digital Signal Averager

the acquisition and saving the last spectrum to hard disk. The acquisition can be preconditioned to stop after any number of spectra (1 to  $\infty$ ) have been processed.

The **Chromatograph/Trend Mode** acquires sequential TOF-MS spectra and automatically saves them to hard disk. For each TOF-MS spectrum the hardware computes the total area above background for all the peaks in the spectrum. The software displays this number as the vertical coordinate in the Total Ion Chromatograph. The horizontal coordinate is the time at which the TOF-MS spectrum was acquired.

The operator can also set a window around a specific peak in the TOF-MS spectrum to generate a **Specific Ion Chromatograph**. The net area above background for the selected peak is plotted as the vertical coordinate in the Specific Ion Chromatograph. The specific peak can be selected prior to data acquisition or the acquired data can be re-analyzed with a different peak in a post-acquisition display mode.

Both chromatographs can be displayed simultaneously. The number of chromatograph points acquired can be controlled by setting a limit on the number of TOF-MS spectra, and/or by pre-selecting a time limit. When the operator clicks the cursor on a point in the chromatograph (during or after acquisition), the TOF-MS spectrum which generated that point appears in the TOF display below the chromatograph.

### Peak Information and Calibration in m/z Units

Software controls are provided for expanding and contracting the TOF and chromatograph displays, and for selecting a particular peak. The gross area, net area above background, and centroid are automatically calculated and displayed for the selected peak. Placing the cursor on a particular point in a spectrum generates a readout of the vertical and horizontal coordinates for that point. The horizontal scale in the TOF spectrum can be toggled between flight time in nanoseconds and the mass/charge ratio in user selected units. For the latter units, the operator can activate a least squares fitting calibration on a known spectrum. The user marks the appropriate calibration peaks and enters the known values for m/z, then selects either a linear, quadratic or cubic curve for the least squares fit to the data. This calibration curve can be saved and recalled. It is automatically saved with any spectra to which it is applied.

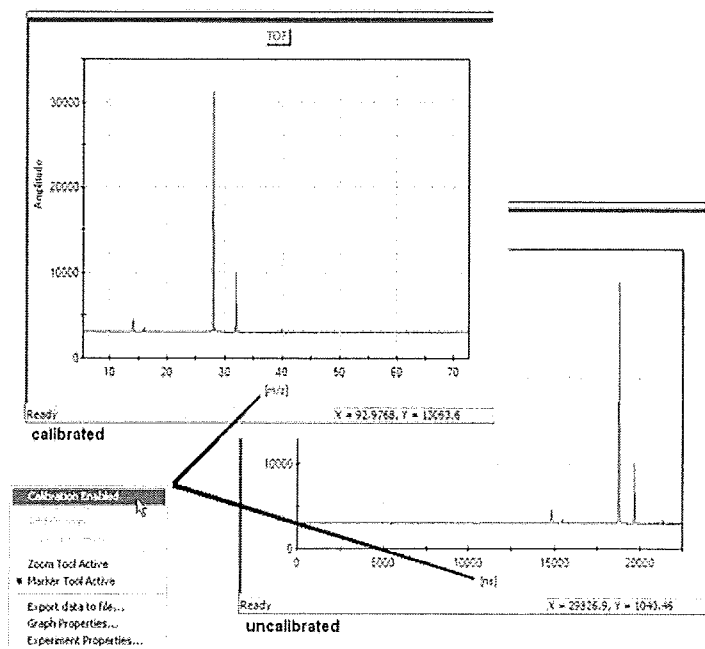


Figure 6. Switching the X-axis Between m/z units and nanoseconds.

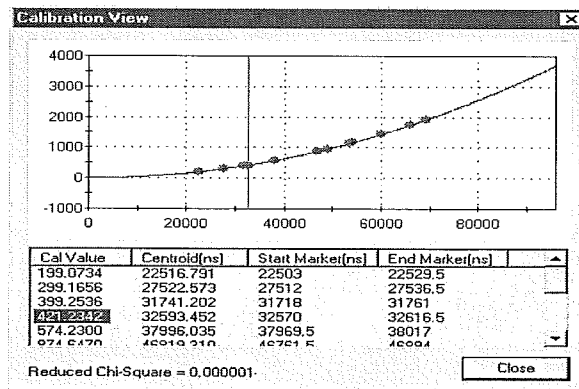


Figure 7. Viewing the Quality of the Calibration Curve.

# Specifications

## HARDWARE

### PERFORMANCE

**Amplitude Digitizing Resolution** 8-bit ADC nominally spans 500 mV at the Analog Input.

**Precision Enhancer** Extends the limiting ADC resolution to 12 bits (for input noise <2 mV) when circa 256 or more records are averaged<sup>3</sup>. Optionally, on or off.

**Differential and Integral Non-Linearity (DNL and INL)** Measured from 5% to 95% of full scale using a 500 mV, 70  $\mu$ s ramp, with the Precision Enhancer on.

**DNL** within  $\pm 0.1$  LSB referred to the 8-bit ADC.

**INL** within  $\pm 0.4\%$  of full scale.

**Analog Input Bandwidth** DC to 500 MHz; rise and fall times <1 ns.

**Equivalent Input Noise** (Measured with 500 ps sampling and 50  $\mu$ s record length.)

**Uncorrelated with the Trigger** <2 mV rms.

**Correlated with the Trigger** <0.02 mV rms (typically 0.01 mV rms) with Automatic Correlated Noise Subtraction.

**Automatic Correlated Noise Subtraction** Automatically assesses the correlated noise in each spectrum and subtracts it without compromising data throughput rates. Optionally, on or off.

**Analog DC Offset (Vertical Offset)** Zero offset of the ADC is computer adjustable from -250 mV to +250 mV with 0.03 mV resolution, referred to the Analog Input.

### Sampling Intervals

**Hardware** 500 ps, 1 ns or 2 ns real-time sampling with one scan per record; 250 ps interleaved sampling with two scans per record<sup>4</sup>.

**Software** can display 250 ps interpolated sampling from a spectrum sampled at 500 ps.

**Record Size (Hardware)** 8 bits per sampled point and up to 1.5 M points per record (at 250, 500, 1000 or 2000 ps/point). Record length selectable from a minimum of 10  $\mu$ s to a maximum of 1.5 M points in steps of 512 points.

**Spectrum Size (Hardware)** Identical to Record Size, except 24 bits per sampled point, providing rapid hardware summing of up to 65,535 records in a spectrum.

ADC Sampling Interval (ps)	Min. Spectrum Length ( $\mu$ s)	Max. Spectrum Length ( $\mu$ s)
250	10	375
500	10	750
1000	10	1500
2000	10	3000

**Data Acquisition Delay (Time Offset)** Computer selectable digital delay after trigger from 0 to 1048.56  $\mu$ s in 16-ns steps. The record starts after the selected delay.

### Dead Time

**End-of-Scan** 0.8  $\mu$ s.

**End-of-Spectrum** 0.8  $\mu$ s.

**Sampling Clock** 2 GHz  $\pm 5$  ppm; temperature sensitivity: within  $\pm 2.5$  ppm, 0°C to 50°C.

### Trigger-to-First-Sample Jitter

**Trigger Input** within 500 ps (next clock pulse).

**Trigger Output** <50 ps FWHM. (The Trigger Output is alternately delayed by 0 and 250 ps relative to the sampling clock in the 250 ps interleaved sampling mode.)

**Operating Temperature Range** 0 to 50°C.

**Averaging Method** Linear summation of sequential records.

### Selectable Stop-Acquisition Limits

**Maximum Time** 1 second to 65,535 seconds ( $\approx 18$  hr.), in 1-second steps, or disabled.

**Max. Number of Spectra** >18,000. Limited only by available memory in the supporting PC and the data storage disk.

**Data Compression** Implemented in the hardware with no compromise in data throughput.

**Lossless** Compression down to 2/3 the normal 24-bit file size in spectra dominated by background, and with no loss of original data.

### Peak-Preserving and Background-Rejecting<sup>5</sup>

Automatically separates peaks from background.

Transmits peaks and adjacent background points.

Typically decimates 98% of the background points between peak regions. Data compression by a factor of 10 to 30, depending on peak density.

<sup>3</sup>U.S. Patent No. 6,028,543

<sup>4</sup>U.S. Patent No. 6,094,627

<sup>5</sup>U.S. Patent No. 5,995,989

# FASTFLIGHT<sup>®</sup>-2

## Digital Signal Averager

**Peak Centroid and Net Area** Transmits only the centroid and net area of automatically detected peaks. Provides an additional factor of 9 data compression relative to Peak-Preserving and Background-Rejecting compression.

**Maximum Data (Spectra) Transfer Rate** Up to 100 spectra/s transferred to PC RAM and hard disk for a 50  $\mu$ s spectrum length and 500 ps sampling in the Chromatograph/TOF-MS mode.

**Total-Ion/Specific-Ion Chromatographs** Automatic hardware computation of real-time Chromatograph displays with each point in the chromatograph linked to the supporting time-of-flight spectrum. Provides exact time synchronization of the chromatograph with the TOF-MS when analyzing the output of an LC or GC. The vertical chromatograph coordinate is:

**Total-Ion Chromatograph** The sum of the areas above background for all peaks in each spectrum.

**Specific-Ion Chromatograph** The net area above background in the TOF-MS peak selected by the operator. Optional pre- and post-acquisition selection.

**Time Stamp** 42 bits in the spectrum header are allocated to recording the starting time of each spectrum with 10  $\mu$ s precision. Maximum: circa 1.4 years.

**Spectrum Number** 21 bits in the spectrum header are allocated to recording the sequential spectrum number. Maximum limit is circa 2 million. Reset to zero on each acquisition start. Otherwise, this counter runs continuously, even when software stops reading the 32 MB FIFO output.

**Output Buffering** During the last record in each spectrum the sum of all records in the spectrum is written to a one-spectrum-deep output buffer, and the summing memory is released to acquire the next spectrum. This limits end-of-spectrum dead time to 0.8  $\mu$ s. After data processing in the compressor, the spectrum is loaded into a 32 MB output FIFO memory to accommodate intermittent data transfer over the USB-2 bus to the PC without loss of spectra. The output FIFO has a capacity of at least 7 spectra.

**Rapid Protocol Selection** Provides a hardware interface to change acquisition parameters in real time within 10  $\mu$ s. Includes 4 bits to select the hardware parameters defined in one of 16 protocols, and an additional 4 bits to insert one of 16 tags in the spectrum header. The tags can be used to identify unique acquisition conditions from other parts of the mass spectrometer.

## HARDWARE CONTROLS AND INDICATORS

**Trigger** Front-panel LED flashes when the Trigger Output is generated.

**Acquire** Front-panel LED is on when data acquisition has been enabled.

**Readout** Front-panel LED flashes when data is transferred to the PC.

**Under Range** Front-panel LED flashes whenever the sampling ADC reads zero for the analog input signal.

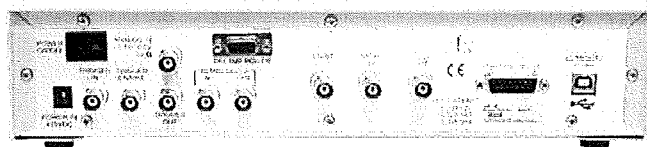
**Over Range** Front-panel LED flashes when the analog signal meets or exceeds the maximum code (255) of the ADC.

**Power** Front-panel LED is on when the rear-panel power switch is on and power is supplied to the unit.

**Power On/Off** Rear-panel on/off switch connects/disconnects the FASTFLIGHT-2 to/from the external dc power supply.

## INPUTS AND OUTPUTS

All inputs and outputs reside on the rear panel.



**Analog Input** BNC connector accepts the analog signal for time-sequenced sampling. Input impedance is 50  $\Omega$ , dc-coupled. The sampling ADC code from 0 to 255 spans an input range from 0 to -500 mV, with code zero adjustable over a  $\pm$ 250 mV range with a 0.03 mV resolution. Negative pulses are displayed by the software as positive peaks in the spectrum.

**Trigger Enable Input** BNC connector accepts a TTL input to enable or disable both the Trigger Output and the Trigger Input. Automatically pulled to the high level if no input is supplied. Computer-selectable assignment of the "enable" condition to either the high or low TTL state. Holding the Trigger Enable Input in the "disabled" state prevents triggering. Used for synchronizing data acquisition when the Rapid Protocol Port is used, or in duet operation. Minimum enable duration: 40 ns.

**Trigger Input** BNC connector accepts analog or logic signals to trigger the start of each scan from an external source for real-time sampling. Synchronizes the first sampled point in the record within 500 ps. The triggering threshold is software adjustable from  $-2.5$  to  $+2.5$  V in 10 mV steps, with selectable positive or negative slope. Maximum linear input is  $\pm 5$  V. Protected against overloads to  $\pm 5$  V DC, and  $\pm 15$  V for pulse widths  $\leq 25$  ns. Minimum pulse width at threshold: 25 ns.

**Trigger Output** BNC connector provides a TTL output for triggering an external instrument from the FASTFLIGHT-2. The leading edge of the rising pulse is synchronized with the first sample point in the scan, with  $< 50$  ps jitter. The width of the output pulse is computer selectable from 64 to 5120 ns. Either the leading edge or the trailing edge can be used to trigger the TOF-MS with the same jitter. The Trigger Output is generated immediately after the end-of-scan dead time, if the Trigger Input has not been activated, the BUSY signal is low, and the Trigger Enable Input is in the enabled state. The Trigger Output is alternately delayed by 0 and 250 ps relative to the sampling clock in the 250 ps interleaved sampling mode.

**10 MHz Clock Input** Accepts a 10 MHz ( $\pm 9$  ppm) signal and automatically phase locks the sampling clock to that external clock input. Minimum and maximum peak-to-peak amplitudes for detection and automatic phase locking are 500 mV and 2.5 V, respectively. Input impedance is  $50 \Omega$  ( $150 \Omega$  to dc ground in parallel with  $75 \Omega$  to ac ground). Used for synchronizing the sampling clocks in the Duet Mode.

**10 MHz Clock Output** Provides a 10 MHz clock output that is phase-locked to the 2 GHz sampling clock. Output is standard 0 to  $+3.3$  V logic, dc-coupled, with  $50 \Omega$  output impedance. Used to synchronize the sampling clock in another FASTFLIGHT-2 in the Duet Mode.

**Start Output** BNC connector provides a high TTL voltage when the Start software button is active, and a low TTL voltage when the Stop software button is active.

**Abort Input** BNC connector accepts a high TTL voltage to immediately terminate spectrum acquisition during the current scan. Minimum duration of the Abort signal in the high state is 50 ns. Input impedance is  $1 \text{ k}\Omega$  to ground.

**Busy Output** BNC connector provides a high TTL voltage when FASTFLIGHT-2 has accepted a Trigger Enable Input and/or an external Trigger Input and has started a scan. BUSY returns to the low state at the end of each scan, when FASTFLIGHT-2 can process another trigger. BUSY is also held high whenever the digital

signal averager is not able to respond to a Trigger Input or a Trigger Enable Input.

**Preamp. Power** Female, 9-pin, D connector provides the dc power for a preamplifier:  $+12$  V on pin 4,  $-12$  V on pin 9, and ground on pins 1 and 2.

**Rapid Protocol Selection Port** Male, 15-pin, D connector permits the TOF-MS hardware to select the FASTFLIGHT-2 operating protocol in  $< 10 \mu\text{s}$ . Protocol numbers 0 to 15 are defined by 4 binary bits. In addition, there are 4 Tag bits on this connector that are strobed by the first Start pulse in each spectrum, for use in identifying other conditions in the mass spectrometer. Handshake signals are included: Select Protocol (input), Protocol Accepted (output), and Acquiring TOF Spectrum (output).

**Computer USB-2** Standard USB-2 Type B connector for communication with the supporting computer over the USB-2 bus.

**Power In** 5.5 mm OD x 2.5 mm ID dc power jack accepts the  $< 3$  Amp.,  $+15$  V DC power from an external power supply.

## ELECTRICAL AND MECHANICAL

**Power Requirements** External ac-to-dc power supply provides the  $< 3$  Amp.,  $+15$  V DC, power input to the FASTFLIGHT-2 enclosure. The external power supply accepts 90 to 264 V AC at 47 to 63 Hz and can deliver up to 70 W at  $+15$  V to the FASTFLIGHT-2 chassis. AC in-rush current is  $< 50$  A @ 264 V AC; continuous ac current is  $< 1.5$  A. Provides an IEC320/C14 connector compatible with international ac power cords. DC plug: 5.5 mm OD x 2.5 mm ID x 12 mm long, compatible with jack on FASTFLIGHT-2 rear panel. External power supply operating temperature range: 0 to  $40^\circ\text{C}$ .

### Weight

**FASTFLIGHT-2 chassis net weight** 4.9 kg (10.9 lb.)

**External Power Supply net weight** 0.45 kg (1.0 lb.)

**Total shipping weight** 6.3 kg (13.9 lb.)

### Package and Dimensions

**FASTFLIGHT-2 chassis width x depth x height**

330 mm x 340 mm x 74 mm (12.9 x 13.3 x 2.9 inches)

**External Power Supply** 132 mm x 58 mm x 30 mm  
(5.20 x 2.29 x 1.18 inches)

**CE** Complies with CE low-voltage directives and CE regulations for susceptibility and emissions (level B).

# FASTFLIGHT<sup>®</sup>-2

## Digital Signal Averager

### SUPPORTING COMPUTER

FASTFLIGHT-2 requires a supporting computer. Any IBM,-compatible PC meeting or exceeding the following specifications should suffice. Choosing a PC with higher speed and capacity may improve performance.

- Windows 2000 Professional or XP Professional (Service Pack 2, or later)
- >2.0 GHz microprocessor
- ≥512 MB SDRAM at ≥400 MHz
- At least one USB-2 port that can be dedicated to the FASTFLIGHT-2
- For the chromatograph mode, a hard drive with at least 20 GB of free space and the 20 MB/s sustained writing speed necessary to support 100 spectra/s acquisition rates.
- CD drive
- VGA display

### Ordering Information

To order, specify:

Model	Description
FASTFLIGHT-2	Digital Signal Averager (includes software, external ac to dc power supply and 3-meter USB-2 type A/B cable)

#### Accessories

9326 Fast Pre-amplifier (includes power cable)	
RG-58A/U 50 Ω Coaxial Cables with BNC Connectors	
C-25-1	30 cm (1 ft.) length
C-25-2	61 cm (2 ft.) length
C-25-4	1.2 m (4 ft.) length
C-25-8	2.4 m (8 ft.) length

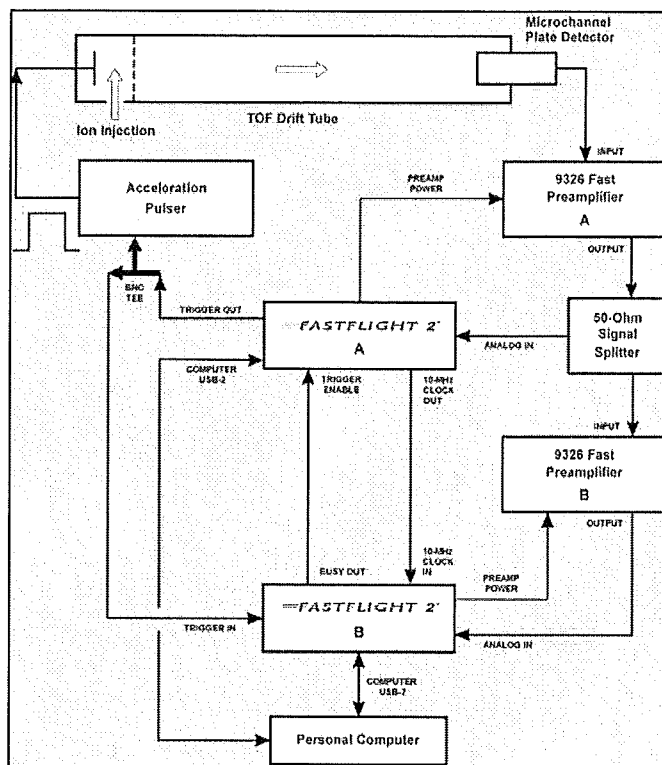


Figure 8. Duet Arrangement for Increased Dynamic Range.

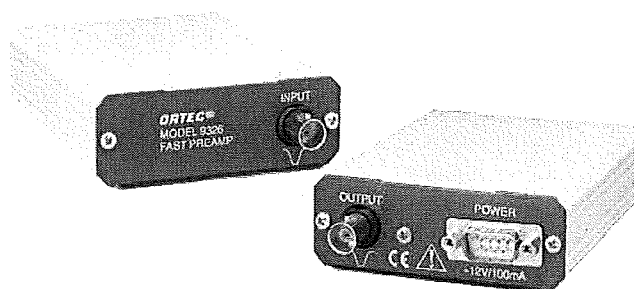


Figure 9. Model 9326 Fast Pre-amplifier.

# FASTFLIGHT<sup>®</sup>-2

Digital Signal Averager

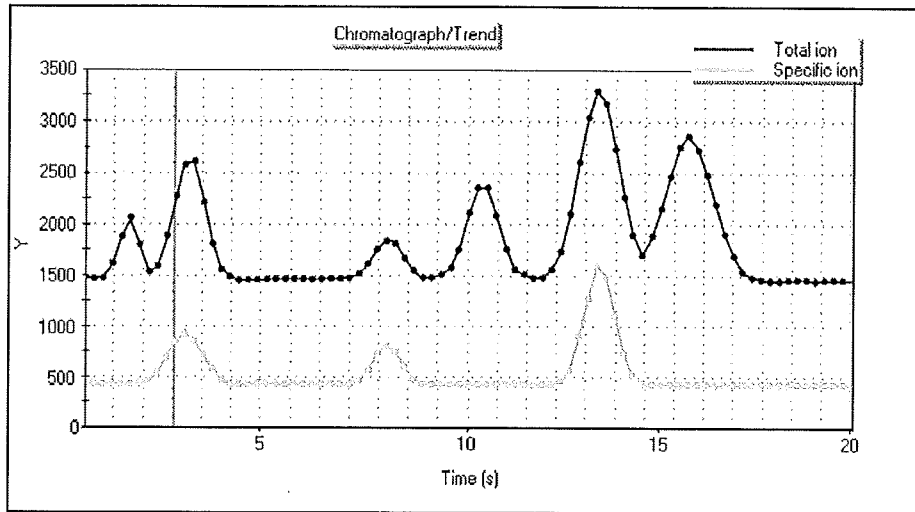


Figure 10. Simultaneous Display of the Single-Ion and Total-Ion Chromatographs.

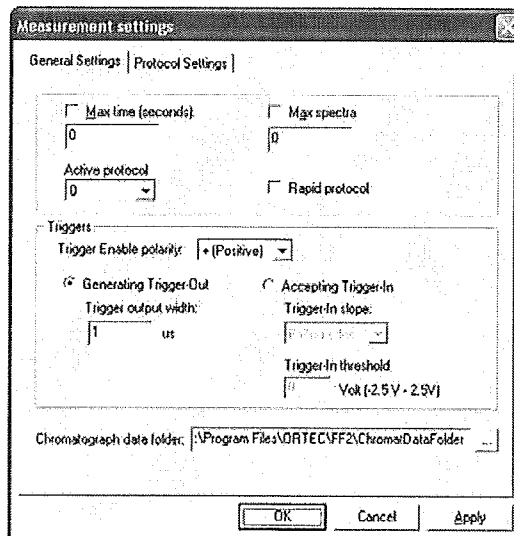


Figure 11. The General Instruments Properties Tab.

To find out more, visit our dedicated web site at  
[www.signalrecovery.com/ms](http://www.signalrecovery.com/ms)

SIGNAL RECOVERY is pleased to offer the complete range of ORTEC-branded products for data acquisition in time-of-flight mass spectrometry (TOF-MS).

Specifications subject to change  
051105

**SIGNAL RECOVERY**

**ORTEC<sup>®</sup>**

AMETEK<sup>®</sup> Advanced Measurement Technology, 801 S. Illinois Avenue, Oak Ridge, TN 37831-0895, USA  
USA: 800-366-2741 Japan: 047-392-7888 Europe: +44 (0) 118 936 1218