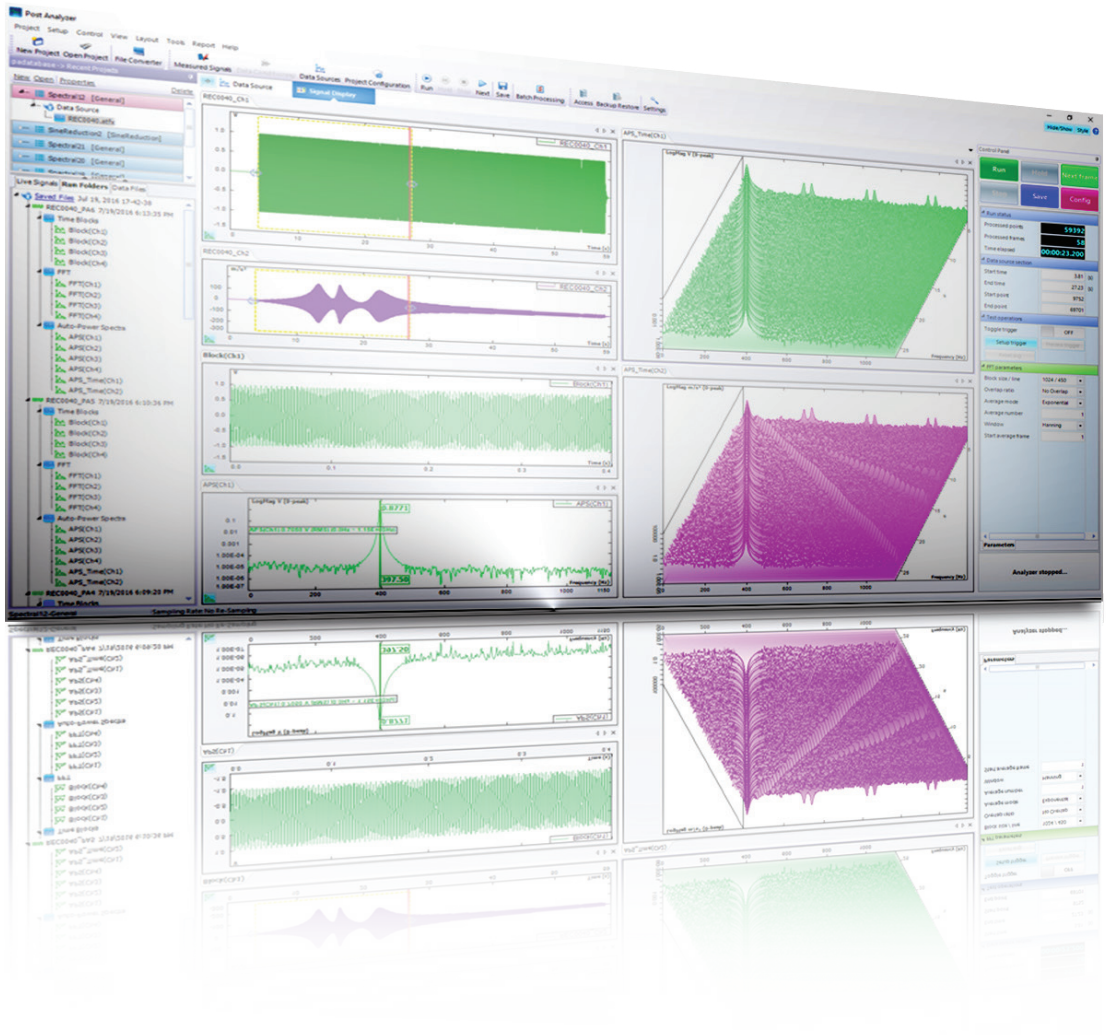
CRYSTAL INSTRUMENTS

EDM POST ANALYZER (PA)
SOFTWARE SPECIFICATIONS (v6.0)



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ENGINEERING DATA MANAGEMENT (EDM) POST ANALYZER

Crystal Instruments offers EDM Post Analyzer software, a powerful adjunct to your CoCo or Spider-based analysis tool kit, allowing users to analyze Time Stream recordings made with a Dynamic Signal Analyzer. The beauty of this approach is that it lets you analyze and re-analyze digitally recorded data after the recording event.

Recording first and analyzing second makes great sense to first-responding problem solvers. Simply recording does not require all of the tactical measurement decisions to be made before data is taken. Often a new problem requires some "get acquainted" measurements to really define the difficulty and its root cause. We are often not smart enough to guess what causes our new challenge. We need to look at some representative measurements from different analytic viewpoints to begin to understand the problem and home in on its solution. The approach is eminently suitable for a team effort. A recording technician can acquire data using minimum equipment while the analyst can remain on post with his analytic workstation.

Post Analyzer (PA) contains many powerful post processing tools with batch processing capability. Post Analyzer is an independent Windows application that analyzes recorded data files on a computer using various algorithms. Most of the algorithms implemented in PA are identical to those used in the real-time DSP of the Spider or CoCo hardware. The user should expect the same or very similar calculation results using PA to those computed in the hardware in real-time. This document describes the PA functions.

File Converter is an independent Windows application that converts files in various data formats to standard ATFX format. FC is included in each installation of PA.

For the convenience of ordering, we created three bundles of PA: ***PA Viewer*** allows the user to view data and create reports; ***PA Basic*** has FFT spectral analysis, curve fitting, demodulation spectrum and 3D signal display functions; ***PA Premium*** has more advanced functions including File Converter, offline sine reduction, real-time filters, octave filters and order tracking.

After the user has purchased the PA Basic, advanced functions can be ordered separately.

LICENSE METHOD OF POST ANALYZER

Traditionally, the PA installation is managed through a license key issued by the factory. The license key is associated with a particular serial number for a piece of hardware produced and sold by Crystal Instruments.

For release 6.0 and subsequent releases, the PA license shall be ordered and managed through the Online License Management system (OLM). With OLM, you can initiate a purchasing request. After the purchase order is processed, the proper number of licenses will be granted. The user can install the PA to multiple PCs without using any hardware. Through OLM, the user can de-activate or re-activate the license of PA installation on any PC.

POST ANALYZER VIEWER (EDM-01: PA VIEWER)

Signal Display Types

- Overlaid Plot: signals of the same type can be plotted together in the same window
- Stack Plot: multiple panes may be allocated within the same window
- Bode Plot: display the magnitude and phase of complex signals
- Waterfall Plot: displays a set of signals (Amplitude versus frequency versus time or RPM) in 3D waterfall format
- Colormap: display the 3D signals in a color-map (spectrogram)
- Text Window: display the signal values in text

Window Operation

- ZOOM and Scale: Zoom Back, Un-Zoom All, Auto Range X, Auto Range Y, Auto Range X-Y, Restore Scale, X and Y Fixed Scaling Setting
- Cursor and Markers: up to two vertical cursors; peak, valley, harmonic, and custom markers. Cursor(s) are moved using the mouse or arrow keys on the keyboard. Hot keys are provided for fast moving cursors and peak/valley detection
- Vertical axis: dBMag, Mag, LogMag
- Horizontal axis: Linear, Log
- Spectrum Type and Scaling: EU_{rms}^2, EU_{peak}, EU_{rms}, EU^2/Hz, EU^2s/Hz
- Signal Color: set the color for each signal.
- Annotation: Annotations can be added to any window and associated with a particular point of data. Cursor values can be converted into annotation.

Engineering Units

The user selects the preferred physical quantity and the corresponding Engineering Units (EU) for each input channel. Transducer sensitivity (mV/EU) can be set for each input channel. Typical physical quantities include acceleration, velocity, displacement, force, strain, torque, temperature, voltage, angle, phase, resistance, tachometer speed, pressure, voltage, current, time, frequency, angular velocity, and sound pressure.

Report

Testing reports are created directly in the Open XML format that can be read by Microsoft Word or many open source Office tools. Fields and attributes are customizable. Logo and report layout preview is provided.

Data File Export

A data file may contain multiple signals or time streams. Data files can be exported into other formats using EDM software. The user can choose to export a single data file, multiple data files in batches, or portions of the data file into another format. Files or signals will be exported according to the appropriate signal attribute settings under Global Settings.

Export File Format

- UFF ASCII: Universal File Format 58; ASCII format header and data.
- UFF Binary: Universal File Format 58b; ASCII header, binary format data.
- ASCII: user-defined format and selected attributes. User enables the signal attributes and the format of ASCII data and specifies template for future use.
- Excel CSV: Coma Separated Variables (CSV) file can be opened directly in Microsoft Excel.
- MATLAB: *.mat binary format that can be opened and analyzed using MATLAB. Both single and double floating point precision supported.
- .WAV: sound files that can be played by media players found on most computers. Exported wave files do not contain file

header information. Only time signals are exported in this format.

Import Test Settings from EDM
EDM setup can be exported and opened in PA. Users are able to save or record data using EDM in real time and use the recorded/saved data for post processing using the same test settings.

Controller Area Network (CAN) Bus Data Management
CAN Bus Data Analysis allows the user to view and analyze time signals recorded by a CoCo-80X from an automotive On Board Diagnostic (OBD II connector) bus or other source of ISO 11898 compliant data. CAN Bus data (such as vehicle speed and hundreds of other SAE J1962-specified variables) may be viewed in lock-step with analog signals simultaneously acquired. The CAN Bus data can be displayed in a variety of formats including analog or digital meters and tabular listings as well as time histories.

Display and Report for GPS Signals
With GPS capability, the CoCo-80X is able to put a location and time stamp on recorded signals. When EDM PA displays such signals, the GPS trace identifies when and where the signal was recorded.

BASIC POST ANALYZER (EDM-02: PA BASIC BUNDLE)

PA Basic includes all the features in PA Viewer and the following additional functions:

Acceleration, Velocity, and Displacement
- Math Conversions for Time Streams: acceleration to velocity, acceleration to displacement, velocity to displacement
- High-Pass Filters: user-defined cutoff frequency to filter out the DC and low frequency
- Math Conversions for Spectra: convert any acceleration, velocity or displacement signal from one measure and to another by synthetic integration or differentiation.

FFT Spectral Analysis
Provides all of the spectrum analysis options your DSA provides for live signals, but allows them to be applied to recorded Time Streams and Block Signals instead.

- Block Size/Line: 128/56, 256/112, 512/225, 1024/450, 2048/900, 4096/1800, 8192/3600, 16384/7200, 32768/14400, 65536/28800 time samples/spectral lines
- Overlap Ratio: no overlap, 10%, 25%, 40%, 50%, 75%, 80%, 90%
- Average Mode: exponential, linear, peak hold
- Window: Hann, Hamming, Flattop, Uniform, Kaiser-Bessel, Blackman, Force, Exponential, Force-exponential
- Acquisition Trigger Mode: Free Run, Continuous after Trigger, Single Shot with Trigger, Single Shot without Trigger, Auto-Arm Trigger, Manual-Arm Trigger
- Auto Spectrum Type and Scaling: linear spectrum with peak or RMS scaling, power spectrum or power spectrum density with RMS scaling (Spectrum Units: EU_{pk}, EU_{rms}, EU_{rms}^2, EU^2/Hz, EU^2•s/Hz), sqrt(EU^2•s/Hz))
- APS view: as FFT or Octave of 1/1, 1/3, 1/6, 1/12, 1/24
- Average Non-contiguous Sections of Time Stream Signals: position block section cursors to select parts of a signal to be analyzed. The selected parts do not need to be adjacent. With this feature, users are able to process data excluding undesired parts of signals.
- Save Time Streams Absolute Time: processed time, recorded time
- Correlation Functions: auto and cross correlation functions derived from the Inverse Fourier transforms of the power spectra.
- Cepstrum: Inverse Fourier transform of the logarithm of the estimated spectrum of a signal.

Polynomial Curve Fit
Polynomial curve fitting is an analytic process by which an equation is least-squares fitted to a frequency domain measurement. The fitted equation is more properly termed a “rational fraction of polynomials”, as it is the quotient of a numerator and denominator polynomial (i.e. A(S)/B(S)). Such fits are most frequently used in Modal Analysis as a structure’s natural frequencies and damping factors can be determined from the roots of denominator polynomial. However, polynomial fits are also useful in servomechanism analysis and filter design. The independent variable of each polynomial is the complex frequency variable.

Calculation of Polynomial by PA
By entering the number of modes to be found and specifying a frequency range to search for them, a rational fraction of polynomials may be fitted to a measured Frequency Response Function (FRF). A graphic overlay plot shows the “goodness of fit”. A proper fit literally overlays the central values of an acceleration/force FRF. The results may be output as a list of numerator and denominator coefficients, or as a list of poles and zeros, or as a list of natural frequencies and viscose damping factors. For servo and electronic studies, the desired curve form may be defined by the order of the desired numerator and denominator polynomials. Polynomial curve fitting may also be applied to power and cross spectra.

User Defined Curve Synthesis
The polynomial curve fitter may also be used to synthesize an FRF or other complex spectrum. The user simply enters the frequency span of the synthesis and either the numerator and denominator coefficients or the (equivalent) poles and zeros. Such synthesis is a very powerful design tool applicable to many disciplines.

Orbit Plot
An Orbit Plot is a cross-plot of the amplitudes of two Time Streams. The signals plotted normally come from perpendicularly-mounted shaft displacement probes or bearing-cap accelerometers. An Orbit provides insight into shaft clearances, lubrication pressure and other operating characteristics of a rotating machine.

Demodulation Spectrum
Bearing and gearing problems often manifest as amplitude modulation of a narrow carrier frequency. By demodulating the amplitude at a cursor-identified peak, problems such as a chipped gear or worn out bearing are often found.

Demodulation Bandwidth: 24 bandwidth options from 0.0 Hz to 720 Hz

Batch Processing
An unlimited number of signals with the same attributes can be sequentially processed in the same manner automatically, in sequence. Processed results can be saved by a predefined schedule.

PREMIUM POST ANALYZER (EDM-03: PA PREMIUM BUNDLE)

PA Premium is a bundle that includes signal conditioning, digital filtering and re-sampling, Shock Response Spectrum analysis (SRS), octave analysis and sound level meter (SLM) functions, order tracking, offline sine-reduction and File Converter. These options can also be ordered separately in addition to PA Basic.

User Defined Signal Conditioning Modules (PA-05)

Math Modules: abs, +, -, *, /, square, square-root, log, and offset scale.

- Offset Scale: apply a multiplier gain and an offset to any input data stream and generate the output stream continuously

Statistic Modules: peak, Peak-to-Peak, Root Mean Square (RMS), Histogram, Statistics

- RMS: apply RMS estimation to an input data stream and generate a continuous RMS output data stream
- Peak/Peak-Peak: extract the instantaneous peak or peak-to-peak and output it as a time stream
- Histogram: generate and display the histogram of a time stream signal for statistical analysis.
- Statistics: calculate the overall RMS, peak, peak-peak, and Ln. EDM PA offers 4 Ln's for user-defined.

Integration/Differential Modules: integration with low-pass, integration with high-pass, double integration with low-pass, double integration with high-pass, differentiation, double differentiation

DIGITAL FILTERS AND RESAMPLE MODULES (PA-06)

Digital filters are advanced signal conditioning modules that are applied in the data conditioning phase. The user can cascade digital filters or other data conditioning modules to construct powerful post analysis functions. The user designs the filter model with a graphic design tool provided in the Data Conditioning tab and uses the filter design parameters for execution.

- ***Filter Design Display:*** the user enters the filter type, filter order, cutoff frequencies and criteria for attenuation and ripple. The design tool provides the frequency response of the filter in a graphic format.
- ***Decimation Filter:*** 2:1 decimation with built in anti-aliasing filter. Anti-aliasing attenuation is more than -80 dB which provides sufficient removal for high frequency noise. User sets decimation stages. Each stage decimates data by 2.
- ***Finite Impulse Response (FIR) Filter Using Window Method:*** An FIR filter is designed multiplying the Sync (Sin(x)/x) shaped impulse response of a perfect "brickwall" filter by a window function and sampling the resultant product. The available window types are: Hanning, Hamming, Flattop, Uniform, Kaiser-Bessel, and Blackman. The user selects either low-pass, high-pass, band-pass or band-stop filter type; sets one or two cutoff frequencies (either relative to the sampling rate or in fixed value); and sets the filter length (the number of samples or "taps") between 11 and 127.
- ***FIR Filter Using Remez Method:*** the Remez FIR Filter design block implements the Parks-McClellan algorithm to design and apply a linear-phase filter with an arbitrary multiband magnitude response. The user selects low-pass, high-pass, band-pass or band-stop filter type; sets one or two cutoff frequencies (either relative to sampling rate or in fixed value); and sets the filter length between 11 and 127 taps.
- ***IIR Filters (3 types):*** Butterworth, Chebyshev I, Elliptic: the user selects one of the infinite impulse response (IIR) filter types above, selects low-pass, high-pass, band-pass or band-stop characteristic; sets one or two cutoff frequencies (either relative to the sampling rate or in fixed value); and sets the filter length between 1 and 20.
- ***Digital Resampling:*** The user does not need to provide arguments to this filter. The input signal is low-pass filtered to prevent aliasing and the filter's output is decimated by two, retaining only every other sample. This results in a signal of half the bandwidth sampled at half of the input sample rate. Higher decimation ratios may be obtained by cascading decimation filters.

SHOCK RESPONSE SPECTRUM (PA-07)

Calculate the shock response spectrum from the selected resource file.

- SRS spectrum: Positive SRS, Negative SRS, Maximax SRS.
- Parameters: 1/1, 1/3, 1/6, 1/12, 1/24, 1/48 octave, low frequency, high frequency, reference frequency, damping ratio.

OCTAVE AND SOUND LEVEL METER (PA-08)

Both Octave filter and Sound Level Meters are implemented based on high precision real-time filters. FFT spectral analysis, octave analysis and Sound Level Meter analysis can be executed at the same time.

Octave Analysis

- Standards: conforms to ANSI std. S1.11:2004, Order 3 Type 1-D and IEC 61260-1995
- Filter Implementation: real-time digital filters
- Frequency Weighting: A, C, Z comply with IEC 61672-2002 class 1. B complies with IEC 60651-1979 type 0.
- Octave Fractional Resolution: 1/1, 1/3, 1/6, 1/12
- Frequency Range (Band centers):
  - 1/1 Octave: 0.125 Hz to 16 kHz
  - 1/3 Octave: 0.1 Hz to 20 kHz
  - 1/6 Octave: 0.1 Hz to 20 kHz
  - 1/12 Octave: 0.1 Hz to 20 kHz
  - 1/24 Octave: 0.1 Hz to 20 kHz
- Midband Frequencies: base 10 complies with ANSI std. S1.11:2004 Annex A.
- Average Type: linear, exponential, peak hold, time linear, time exponential
- Time Weighting: fast, slow, impulse, 2, 10, 100, 500, 1000
- Y-axis Scaling: Linear, Logarithmic, Decibels(dB), Phons and Sones

Sound Level Meter Analysis

- Standards: conforms to IEC 61672-1 2002
- Filter Implementation: real-time digital filters
- Frequency Weighting: A, C, Z comply with IEC 61672-2002 class 1. B complies with IEC 60651-1979 type 0
- Time Weighting: fast, slow, impulse (complies with IEC 61672-2002)
- Average Time Interval: from 0.125 seconds to 24 hours. Unique moving linear averaging method allows independent setting averaging time interval and time trace update rate.
- Measurement Types: time-weighted sound level (L), time-averaged sound level (L_{eq}), sound exposure level (L_E), peak sound level (L_{peak}), peak C sound level (LC_{peak}), maximum time-weighted sound level (L_{max}), minimum time-weighted sound level (L_{min}), maximum time-averaged sound level ($L_{eq\text{-}max}$), minimum time-averaged sound level (L_{eqmin}), statistical sound level (L_N) and statistical sound level distribution (dB Histogram).

	Time Weighting	Frequency Weightings			
		Z	A	B	C
Time-Weighted Sound Level (L)	**F (Fast)**	L_{ZF}	L_{AF}	L_{BF}	L_{CF}
	S (Slow)	L_{ZS}	L_{AS}	L_{BS}	L_{CS}
	I (Impulse)	L_{ZI}	L_{AI}	L_{BI}	L_{CI}
	User-Defined	L_{ZU}	L_{AU}	L_{BU}	L_{CU}
Time-Averaged Sound Level (L_{eq})		L_{eq}	L_{Aeq}	L_{Beq}	L_{Ceq}
Sound Exposure Level (L_E)		L_{ZE}	L_{AE}	L_{BE}	L_{CE}
Statistical Level (L_N)		L_1	L_5	L_{50}	L_{95}
Peak Sound Level		L_{peak}		L_{CPeak}	

- Measure Time Control: free run, user-defined
- Decay Time Constant for F and S time-weighted Sound Levels: 34.7 dB/s (by standard, >25 dB/s) and 4.34 dB/s (by standard, between 3.4 – 5.3 dB/s)

ORDER TRACKING AND ROTATING MACHINE ANALYSIS (PA-09)

Developed and based on a precise tachometer measurement of rotating speed, the Order Tracking in Post Analyzer uses fast digital re-sampling at a multiple of the shaft rotating speed and a proprietary DFT method to acquire any required fractional orders of interest at a fast slew rate. The following measurements can be made in the Order Tracking option: raw time streams, real-time order tracks and order spectra, narrowband RPM spectra and fixed band RPM spectra, overall RPM spectrum, and order tracks with phase relative to tachometer signals.

Order Tracks and Order Spectra

Order tracks are the frequency amplitude signals graphed against the RPM variable. Multiple order tracks can be measured, displayed, and saved. Order Spectra are auto power spectra that are normalized to orders.

- Max Order Tracks: up to 28 tracks
- Max Order of Interest: 200
- Order Tracks Scaling: linear spectrum with peak or RMS scaling, or power spectrum with RMS scaling
- Spectrum Units: EUpk, EUrms, EUrms2
- Tracking RPM Range: 3 – 300,000 RPM (0.05 Hz – 5 kHz)
- RPM Resolution: 10 – 10,000 RPM
- Delta Order of Order Spectrum: 0.025 to 1
- Acquisition Mode: Free Run, Run Up, Run Down, Run Up and Down, Run Down and Up
- Order Spectrum View Mode: 2 dimensional, waterfall, or spectrogram (with RPM as z-axis)

Narrowband RPM Spectra

Narrowband RPM spectra are 3D signals that display the auto power spectra changing with RPM. Fixed Band RPM spectra are RMS measurements extracted from the 3D RPM spectrum within fixed frequency bands.

- FFT Block Sizes: 256 to 4,096
- Data Window Functions: Hanning, Hamming, Flat-top, Kaiser-Bessel, Blackman
- Auto Power Spectrum Type and Scaling: linear spectrum with peak or RMS scaling, power spectrum or power spectrum density with RMS scaling (Spectrum Units: EU_{pk}, EU_{rms}, EU_{rms}^2, EU^2/Hz, $EU^2 \cdot s/Hz$)
- RPM Range: 3 – 300,000 RPM (0.05 Hz – 5 kHz)
- RPM Resolution: 10 – 10,000 RPM
- Average Mode: linear, exponential, peak hold
- Acquisition Mode: free run, run up, run down
- Fixed Band RPM Spectra: user-definable band range. The instrument calculates the total power within the fixed band versus RPM. Spectrum Units, EU_{rms}, EU_{rms}^2.

Order Tracks with Phase

Order Tracks with phase are order spectra with the phase measurements that are relative to the tachometer signals as reference. All the specifications are the same as real order tracks except that order tracks with phase can also be displayed as Bode, Polar, or Nyquist plots. With this option the orbit display can be enabled for any two data channels.

Tachometer Processing

The user can view either the original tachometer input waveform or the translated RPM signal. The user sets the RPM trigger threshold, rising or falling edge detection, and the number of tachometer pulses per shaft revolution. Tachometer signal processing automatically removes unwanted noise and glitches.

OFFLINE SINE DATA REDUCTION (PA-10)

The Offline Sine Data Reduction function analyzes the time streams recorded during the vibration control process. Before Offline Sine Reduction is applied, a DSA system is used to record time streams of the additional signals desired. It must also record the time stream of the VCS Constant Output Level Adaptor (COLA) output signal, a constant amplitude sine wave at the same frequency as the sweeping Drive applied to the shaker. This offline function calculates all response spectra and the transmissibility FRFs between pairs of signals. The signal processing is exactly the same as that employed by the VCS; the recorded COLA synchronizes the analysis of the DSA signals.

Analysis Parameters:

- Pulse Edge Type: falling, rising
- Pulse Edge Value: threshold voltage for edge detection
- Frequency Range: up to 46 kHz analysis frequency range of the COLA signal
- Spectrum Display Resolution: 256 to 4096
- Sweep Type: Log, Linear
- Measurement strategy: tracking filter, RMS, Mean, Peak
- Tracking Filters: proportional: 7%, 12%, 25%, 50%, 100%, Fixed (Hz): 1-500Hz

Analysis Signals:

- Measured Signals: sweep spectrum, up sweep spectrum, and down sweep spectrum of each channel, complex transmissibility signals, and the time trace of sweeping frequency
- Complex Transmissibility Signals: may be calculated from any two channels and both classical estimators “H1 and H2” are provided.

FILE CONVERTER (EDM-FC)

File Converter is a Windows application that converts various files into standard ATFX-ODS format. The user can save the file attributes into a template for future use. Batch processing allows the user to convert the same type of files automatically.

The following file types can be read and converted:

- ASAM-ODS XML: ASAM Open Data Source binary format (default, recommended)

- UFF ASCII: Universal File Format 58; ASCII format header and data.
- UFF Binary: Universal File Format 58b; ASCII header, binary format data.
- ASCII: user defined format and selected attributes. User enables the signal attributes and the format of ASCII data and specifies template for future use.
- Excel CSV: Coma Separated Variables (CSV) file can be opened directly in Microsoft Excel.
- MATLAB: *.mat binary format that can be opened and analyzed using MATLAB. Both single and double floating point precision supported.
- .WAV: sound files that can be played by media players found on most computers. Exported wave files do not contain file header information. Only time signals can be exported in this format.
- .RAW: this is a proprietary file format from Pacific Instruments Company
- RPC III: sequential, fixed length, 512-byte record files, which contain a standard header that is followed by data. Supported extensions are tim and rsp.
- .SIG: a file format from Dactron software (RTPro or Shaker control)

COMPUTER REQUIREMENTS

- Operating System Support: Windows 7 or higher
- Operating System Type: 64-bit
- Processor: Intel Core i7, 2.0GHz or Higher
- RAM: 8G DDR3 1600 or more
- PC storage: SSD or faster

FUNCTIONS PROVIDED BY EDM POST ANALYZER BUNDLES

Function	PA Viewer (EDM-01)	PA Basic (EDM-02)	PA Premium (EDM-03)
Browse, display, and edit long waveform files	√	√	√
Signal display with different spectrum unit and X-Y scale	√	√	√
Signal annotation, cursor, play sound, calculate RMS, THD, ZOOM-in, ZOOM-out, auto scaling	√	√	√
Create template-based report in XML, Word or PDF	√	√	√
Engineering unit conversion, dB reference	√	√	√
Export to standard formats including ASAM-ODS, UFF, BUFF, MATLAB, user-defined ASCII, and wave files	√	√	√
3D display: waterfall, colormap	√	√	√
Import user-defined ASCII file, wave file, Pacific Instrument file		√	√
Acceleration, velocity and displacement conversion		√	√
Polynomial Curve Fit		√	√
FFT Spectral analysis: FFT, auto power spectra, cross power spectra, frequency response function		√	√
Math Functions: abs, +, -, *, /, square, square root, log, integration, differentiation, RMS, peak, offset and scale		√	√
User defined data conditioning modules (PA-05)			√
Digital Filters: IIR, FIR, Low-pass, High-pass, Band-pass (PA-06)			√
Shock Response Spectra (SRS) (PA-07)			√
Fractional octave filters and SLM: 1/1, 1/3, 1/6, 1/12 (PA-08)			√
Order Tracking: RPM spectra, order spectra (PA-09)			√
Offline Sine Data Reduction (PA-10)			√

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