SPIDER-80X + SPIDER-80Xi

8 to 512 Channel Expandable Dynamic Measurement Systems

Dynamic Measurement Solutions

CRYSTAL
INSTRUMENTS

Expandable Systems: Up to 512 Channels

The Spider-80X & Spider-80Xi Dynamic Measurement Systems

The Spider-80X is designed for applications in three fields: dynamic data acquisition, vibration control, and machine monitoring. Each front-end features eight analog input channels and two channels that may be software selected as analog outputs for vibration control or tachometer inputs for the analysis of rotating machinery.

A single Spider-80X front-end is a complete two-output controller with the same high quality patented dual ADC input technology of the Spider-81 series. The Spider-80X inputs provide single-end/differential and AC/DC/IEPE coupling choices; charge mode is an available option that can be installed at the factory. The Spider-80X also provides the same time sync Ethernet connectivity and 4 GB flash memory for data and program storage. Multiple Spider-80X front-ends may be

linked together using the Spider-HUB Ethernet switch from Crystal Instruments. The data storage can be increased to 250 GB by adding a Spider-NAS mass storage device.

The Spider-80X front-ends are onsite swappable. Each front-end is metal-shielded. The user can quickly configure a system with an arbitrary number of front-ends.

The Spider-80SG strain sensing device has the same mechanical form factor as the Spider-80X. These two systems can combine into a system that measures various dynamic signals, including strains or other sensors requiring excitation. Multiple Spider-80X or Spider-80SG front-ends can be hosted in a 64-input chassis.
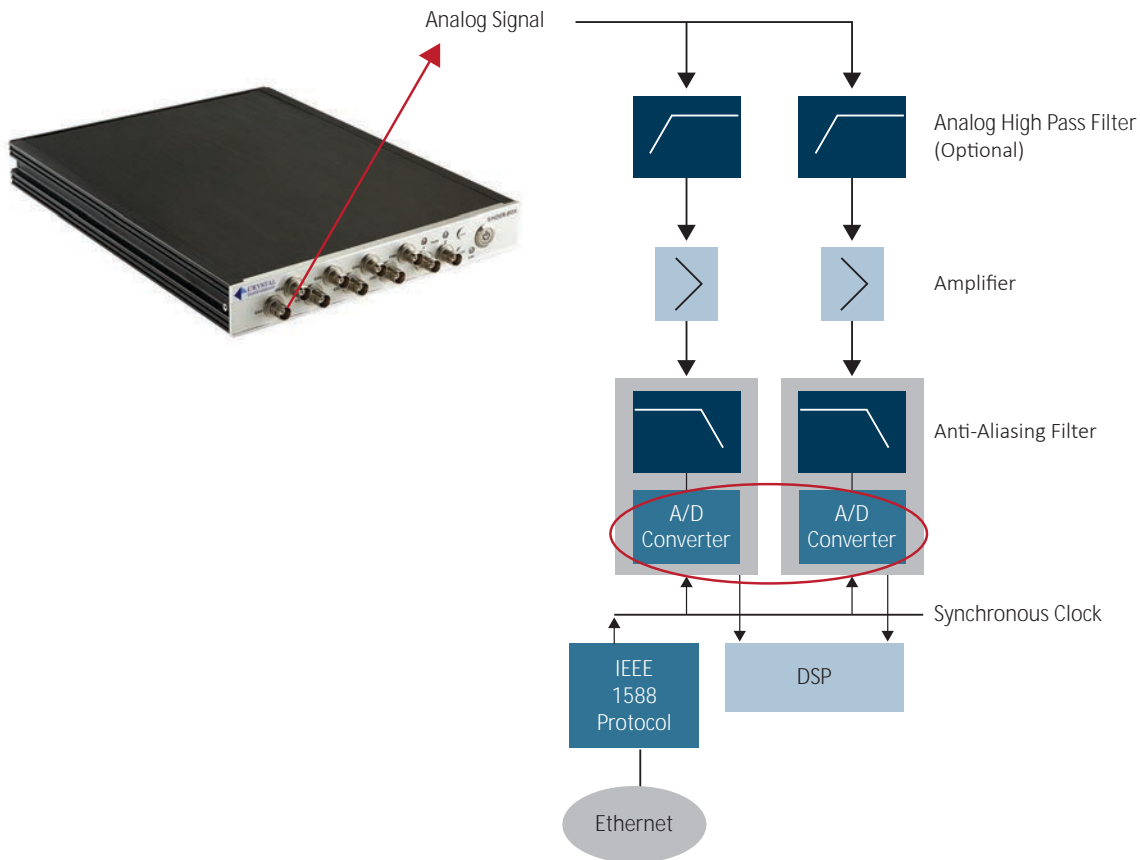
Fan
Button

SPIDER-80Xi
DYNAMIC MEASUREMENT SYSTEM

Fan off

Power
Button

LED Link
Indicator

Stop & Start
Buttons

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Removable
Hard Drive Slot

Stop
Button
LAN Indicator

Power
Button

Start
Button

2 Tacho/Output
Channels

8 Channels

Ethernet

Digital I/O

Power
Input

Ground
Connection

Digital IO
RS-485 Serial Port
USB
Master/Slave Switch
Reset Button
Ethernet Port
DC 15V/3A

The Spider-80Xi is a compact version of Spider-80X with an extremely lightweight form factor. Featuring a 64 channel chassis weighing less than 10.5 kg, the Spider-80Xi can be carried in one hand and is optimal for field environment testing where portability is essential.

Like the Spider-80X, multiple chassis combine to create a system up to 512 channels, all sampled simultaneously. A dedicated massive storage hard disk (a solid state hard-drive with a capacity of 250GB) allows the time signals of all input channels to record at up to 102.4 kHz/channel. Accurate time synchronization results in excellent phase match in the frequency domain between all channels, either on the same Spider front-end

or across different front-ends. Real time FFT, octave, order tracking or vibration control functions can be enabled. The modular boards of the Spider-80Xi are installed at the factory and are not onsite swappable.

The Spider-80Xi system consisting of the 64 channel chassis is powered by AC power, at 100 to 240 VAC. The Spider-80Xi system consisting of the 32 channel chassis is powered by the DC power, at 10V to 22V. The latter is also easily operable with an external battery pack. With the Spider-Battery, (developed by Crystal Instruments) a 32 channel Spider-80Xi system operates up to 4 hours without interruption.

Analog Signal

Analog High Pass Filter (Optional)

Amplifier

Anti-Aliasing Filter

A/D Converter   A/D Converter

Synchronous Clock

IEEE 1588 Protocol

DSP

Ethernet

High Precision Front-end Design
The Spider-80X/Xi analog input channels provide extremely high precision measurements. Each channel has single-ended or differential AC or DC input coupling. It can also provide IEPE (ICP™) input mode (AC coupling with a 4 mA constant current from a 22 VDC source) for use with industry-standard accelerometers with built-in amplifiers. The ability to read TEDS (Transducer Electronic Data Sheet) identification from the attached transducer completes the channel's compliance with IEEE 1451.4. Each channel provides an unprecedented dynamic range of 150 dBFS, detecting voltages as small as 600 nV and up to 20 V. This is accomplished by applying two 24-bit analog-to-digital converters to each channel and combining their outputs in accordance with our United States Patent number 7,302,354.

In the Spider-80X, built-in charge amplifiers are available. With Spider-80Xi the external charge amplifier, CA-08, can be used if charge mode is desired.
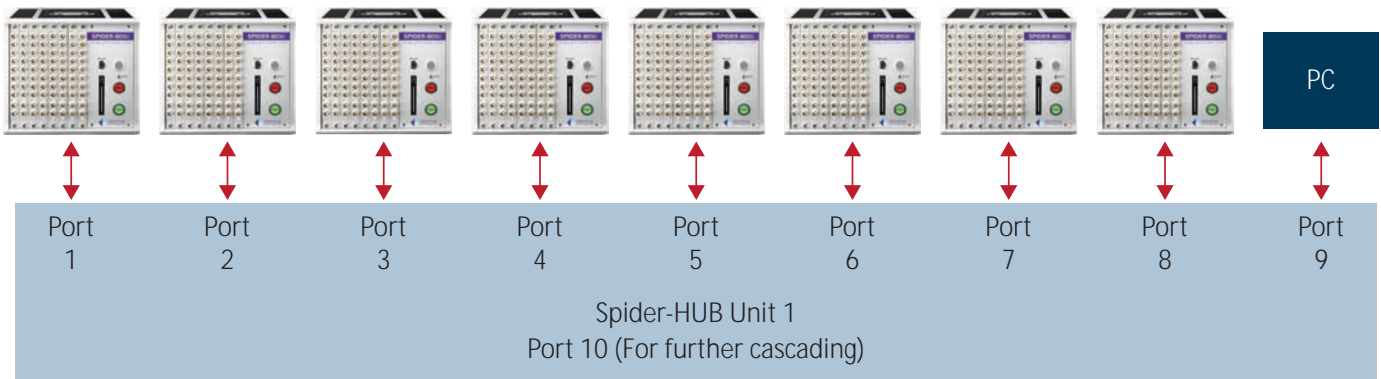
Black Box Mode
Black Box mode enables Spider-80X/80Xi operation without a PC. In this mode, a PC is used only to configure the control system before the system starts operation and to download data after the test is completed. During the test, the data acquisition system operates autonomously, according to a preset schedule or in response to external events such as input trigger or digital input.

Simple Network Connection
Ethernet connectivity allows Spiders to be located far from their host PC. This distributed structure greatly reduces noise and electrical interference in the system.

Spider-80Xi System (512 Channel Count)

Port 1	Port 2	Port 3	Port 4	Port 5	Port 6	Port 7	Port 8	Port 9

Spider-HUB Unit 1
Port 10 (For further cascading)

Spider-HUB Industrial Ethernet Switch

Spider-NAS Storage Device

Spider-HUB Ethernet Switch

The Spider-HUB Ethernet switch made by Crystal Instruments supports the latest IEEE 1588v2 technology. The Spider-HUB guarantees time-stamping accuracy within 50 nanoseconds and can be configured for 1588v2 Master, Boundary Clock, and Transparent Clock functionality. Accurate phase match between all measurement channels across the modules are guaranteed. In a Spider-80Xi chassis the Spider-HUB is installed internally.

Spider-NAS Storage Device

The Spider-NAS (Network Attached Storage) is a dedicated storage device designed to work with Crystal Instruments Spider front-ends, including the Spider-80X and the Spider-81. Each Spider-NAS device supports up to eight Spider front-ends to collect both streaming time waveform data and spectral data. An Ethernet connection in back connects to a computer for data download and configuration. At the center of the Spider-NAS sits a removable 250 GB serial ATA (SATA) Solid State Disk (SSD). This SSD not only provides greater shock protection than a classic hard drive but it also features a faster boot up time (less than 15 seconds) and is particularly energy efficient. In a Spider-80Xi chassis the Spider-NAS is installed internally.

	Spider-80X	Spider-80Xi
Total Channels Per System	8 to 512	8 to 512
Input Mode	AC, DC, IEPE (ICP®), optional charge	AC, DC, IEPE (ICP®)
Charge Amplifier Solution	Internal charge can be installed at the factory Can use external amplifier	Use external charge amplifier
Main Application	Vibration control, dynamic testing, remote monitoring 8 to 512 channels	Portable dynamic signal data acquisition and real-time processing with relatively large channels. Some applications may require battery power
Software Applications	VCS, DSA, RCM	DSA, RCM
Strain Gage	Can install strain gage front-end in the same chassis	N/A
Modularity	Front-end is shielded with its own chassis hence swappable on site	Board modules are installed at factory and are not swappable
Weight of 8 Channel Front-end	2 kg	N/A
Dimension of 8 Channel Front-end	240 x 35 x 310 mm (w x h x l)	N/A
Weight of a 32 Channel System	23 kg for 32 channels 25 kg for 40 channels	8 kg
Dimension of a 32 Channel System	343 x 310 x 407 mm (w x h x l)	194 x 259 x 298 mm (w x h x l)
Weight of a 64 Channel System	36.5 kg	10.4 kg
Dimension of a 64 Channel System	470 x 310 x 407 mm (w x h x l)	274 x 259 x 298 mm (w x h x l)
Power of a 64 Channel System	AC powered, 100W	AC powered, 90W
Power of a 32 Channel System	N/A	DC powered, 50W
Battery Power	N/A	Available (with Spider-Battery)

VCS: Vibration Control System
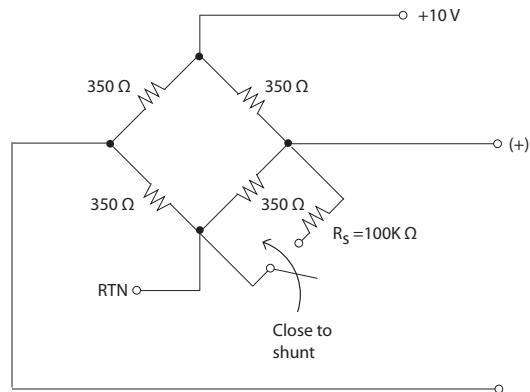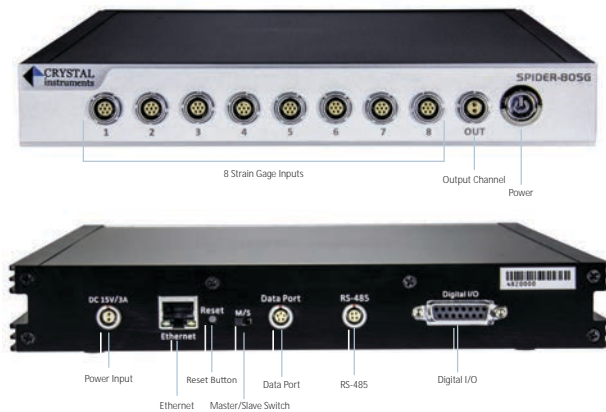*DSA: Dynamic Signal Analysis*
RCM: Remote Condition Monitoring

Strain Gage Measurement

The Spider-80SG Strain Gage Measurment System

The Spider-80SG is the newest addition of the Spider series of data acquisition products. As a result, it incorporates all of the latest technological features of the Spider data collection systems including superior networkability.

Named for their networkable ability, the Spider series as well as the Spider-80SG share the flexibility of scaling up in channel count and functionality. Users can easily couple multiple Spider-80SG front-ends together or combine them with the Spider-80X dynamic signal analyzer or the Spider-81 vibration controller.

- Support for full-bridge, half-bridge and quarter-bridge

- Fully integrated, simultaneous strain measurement with any VCS and DSA tests.

- High channel count supports up to 512 input channels

- Customizable excitation within the range of -10V to 10V

- 24-bit ADCs with sampling rate up to 102.4 kHz

- High precision 7-pin Lemo input channels

- Input channel adapter to eliminate the need for soldering

- User-friendly shunt calibration and offset-nulling

- Customize configuration and set-up independently for each input channel

- Remote sensing function for distant measurement

- Expandable units to increase portability

SPIDER-80SG

1 2 3 4 5 6 7 8 OUT

8 Strain Gage Inputs

Output Channel

Power

DC 15V/3A Ethernet Reset M/S Data Port RS-485 Digital I/O

Power Input Reset Button Data Port RS-485 Digital I/O

Ethernet Master/Slave Switch

+10 V

350 Ω 350 Ω

(+)

350 Ω 350 Ω

$R_S = 100K\ \Omega$

RTN

Close to shunt

User-friendly Shunt Calibration and Offset Nulling

The Spider-80SG features an easy-to-use and flexible shunt calibration wizard.

This will allow the user to select any available leg of the strain gage bridge, depending on the bridge type (i.e. quarter, half, full bridge,) for shunt calibration. As a result the shunt resistor, which is integrated into the Spider-80SG hardware, will now be connected to the specific leg defined by the user.

Not all strain gages are designed equally. In fact, there are many different manufacturers, each with dozens of models and types of gages. This is why the Spider-80SG allows users to customize the voltage excitation on each individual pin within every input channel.

The Spider-80SG supports, amongst others, rosette, rectangular, T, delta, linear, and shear strain gages.

Offset-nulling is made even easier as a part of the calibration function integrated into the software accompanying the Spider-80SG. All that needs to be done is to connect the strain gage to any input on the Spider-80SG and click the enable offset-nulling function while the strain gage is at rest. The Spider-80SG will take care of the rest.

Input Channels
8 channels per front-end, expandable to 512

channels in a system

Connector Type
7-pin LEMO

Input Range
±5mV, ±10mV, ±50mV, ±100mV, ±10V

Sampling Rate Per Channel
0.48 Hz to 102.4 kHz, with 54 stages

Shunt Calibration
Internal 100K Ω (0.1%, 25ppm/c)

Excitation Sense
Local and remote sensing

Zero Suppression/Auto Balancing/Offset Nulling

Strain Functions
Quarter-120, Quarter-350, Half bridge, Full bridge

Bridge Completion
120 Ω: 0.05%, 5ppm/c
350 Ω: 0.05%, 5ppm/c
Back Half resistor: 10K/10K, 0.1% (or 0.02%), 2ppm/c

Excitation Voltage
±2.5V, ±5V, ±10V
Current: 30mA max/channel

General Data Acquisition & FFT Spectral Analysis

## Comprehensive Data Acquisition with the Spider System

The FFT Spectral Analysis provides comprehensive data acquisition and FFT analysis functions. **Acquisition Mode** controls how the data is acquired block-by-block and processed with the signal analyzer functions. These time blocks can be either gap-free, overlapped, or with gaps, depending on the acquisition mode selection. **Sampling Rate** can be set from control panel directly. 54 sampling rate stages available and can be changed without stopping data acquisition. 3D waterfall processing allows the data acquired and processed in real time with either RPM or time as additional axis. Output has a dozen of signal source types to excite the testing articles.

With the **Frequency Analysis Functions** the

FFT with block size from 256 to 32,768 for all input channels can be applied simultaneously.

The data window type includes Hann, Hamming, Flattop, Uniform, Kaiser-Bessel, Blackman, Force, Exponential and Force-Exponential. The Spectrum Types include linear spectrum, auto power spectrum, frequency response function, coherence, cross power spectrum and phase spectrum. Hundreds of FRF signals with MIMO model can be computed simultaneously.

With extremely fast DSP, the processing overlap ratio can go as high as 75% or 90%. A special function enables to search the resonant frequency on any FRF signals.
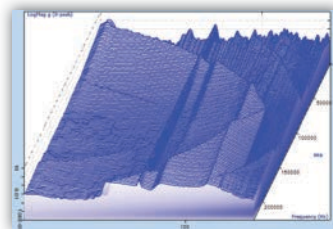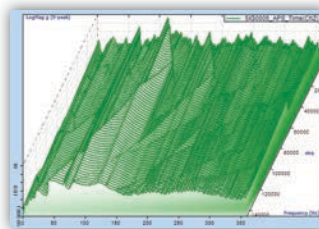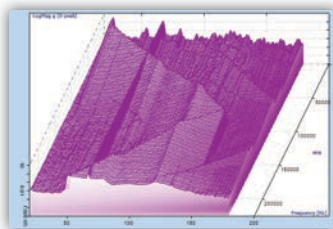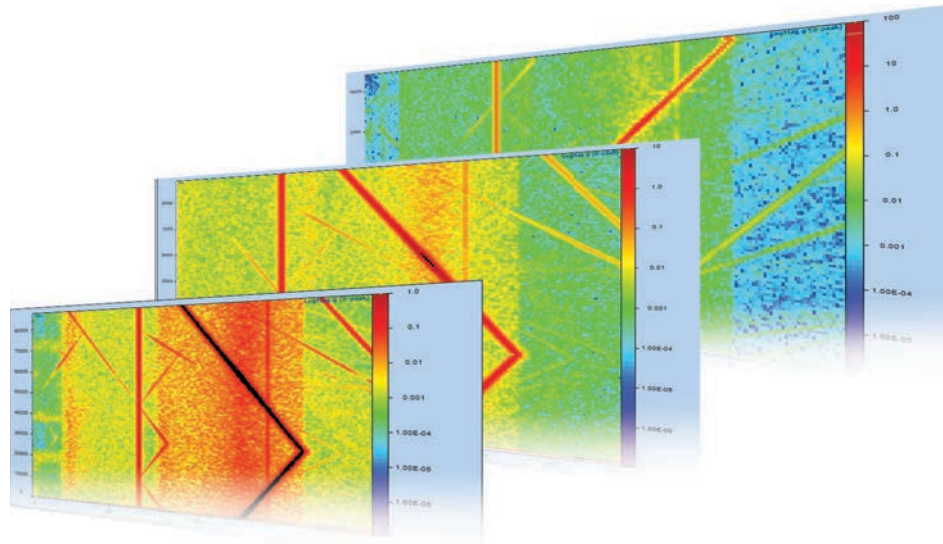
Acquisition Mode includes free-run, continuous after trigger, single shot with trigger, single shot without trigger, auto-arm trigger and manual-arm trigger.

3D signal waterfall displays are available for block signals in all types of tests. 3D signals can be plotted with reference to Time or RPM (when tachometer input is available). User customizable trace number and reference axis settings are available for both Time and RPM reference axes.

With Spider some statistics signals can be computed and recorded into PC with "infinite time". **RMS:** apply RMS estimation to an input data stream and generate a continuous output time stream; **Peak:** extract the peak or peak-peak value over a period of time and generate a time stream.

Math Functions applied to the signals includes

operations such as abs, +, -, *, /, square, square-root, log, and offset scale.

Test Sequence creates a list of tests and run them sequentially. Test sequences can be initiated and controlled by a user command, digital input event, or Windows socket message.

Send Emails and IM as Event-Actions is the ability to send emails or instant messages as custom actions in response to a system or user event. Content of emails can be customized.

Remote Operation Communication using Socket Messages allows to communicate with and control Spider systems remotely with Window socket messages. Socket messages also allow communication with other hardware, such as temperature chambers. Please refer to the Socket Message document for detailed specifications.
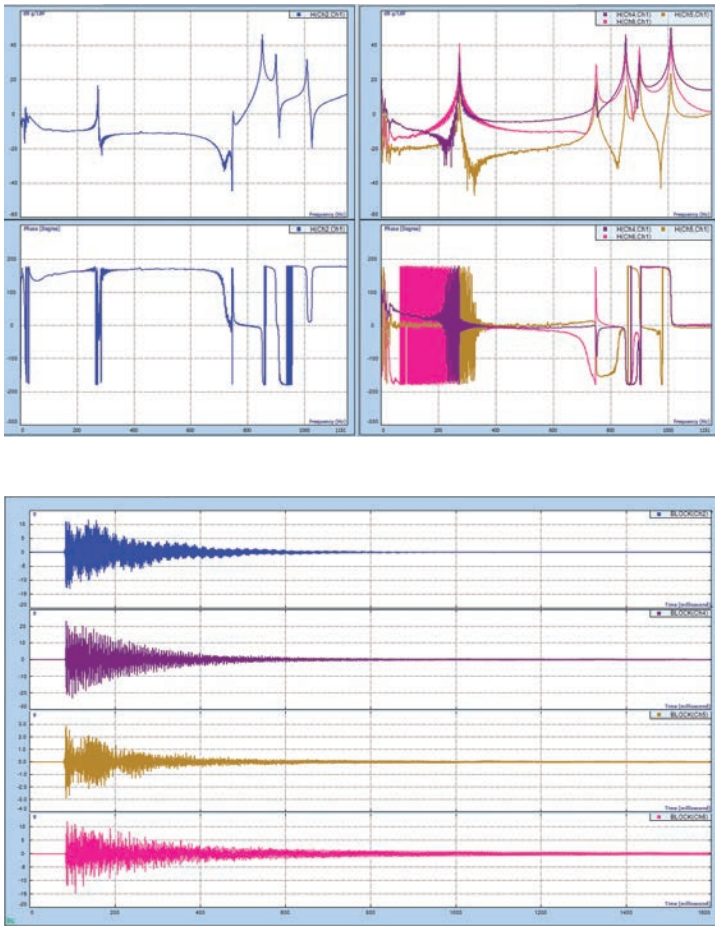
The Spider has strong System Failure Protection. With its *Power Loss Emergency Shutdown*, when a power loss is detected, the system will save all test data into non-volatile flash memory and safely shut down. With its *Ethernet Connection Loss Detection*, when a network loss is detected, the system can be configured to either save all data and ramp down the test or continue running the test in Black Box mode.

Each Spider has 4 pair of **DIO** ports which is used to send and receive low level electrical signals to and from other devices to coordinate their operation during a test.

The **output channels** provide signal sources and generate user determined waveforms. Multiple output channels may generate signals independently or simultaneously. The Spider-80X is equipped with two output channels but only one

is enabled. An option (S80-P09) is available to enable the second output. Output Types include Sine, Triangle, Square, White noise, DC, Chirp, Swept sine, Arbitrary waveform, Shaped random, Playback

The **EDM App for iPad** by Crystal Instruments is available from the Apple App Store. The EDM App allows access to the Spider-80X front-end when operating in Black Box mode. Users will be able to access a preloaded test on their iPad to run and control the Spider-80X as long as they are within the range of a wireless network. The display window shows one or multiple signals. Users can print or email screen shots.

With Spider the software can compute the **SRS** for all channels using maxi-max, maximum negative, and maximum positive analysis techniques. A reference profile is available.

Octave Analysis & Sound Level Meter

Acoustic Measurements with the Spider Series

Acoustics measurements are performed for a variety of reasons, including: product design, production testing, machine performance, and process control. Crystal Instruments' Spider series has capable acoustic measurement facilities including real-time octave, 1/3 octave filters, and sound level meter functions. Crystal Instruments provides an easy to use yet powerful toolbox for acquiring and viewing acoustic signals. Digital octave band filters and raw time data recording can be performed simultaneously for a detailed investigation of noise problems.

The Spider series meets the requirements for measurements from 4 input channels going up to 512 channels!

Onboard IEPE (ICP®) transducer power capability allows for direct connection to pre-polarized microphones when used with an ICP microphone preamplifier. Traditional condenser microphones are also easily accommodated by connecting the direct voltage signal from the microphone power supply into an input channel. White and pink noise signals can be produced using the waveform generator. This feature is very useful when performing absorption measurements using a speaker.
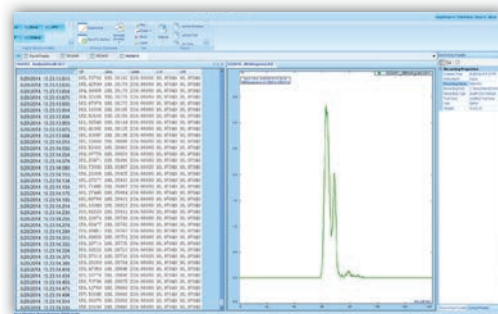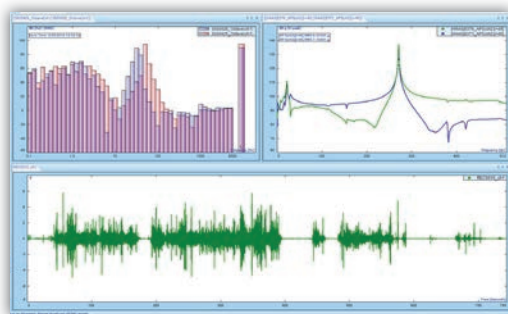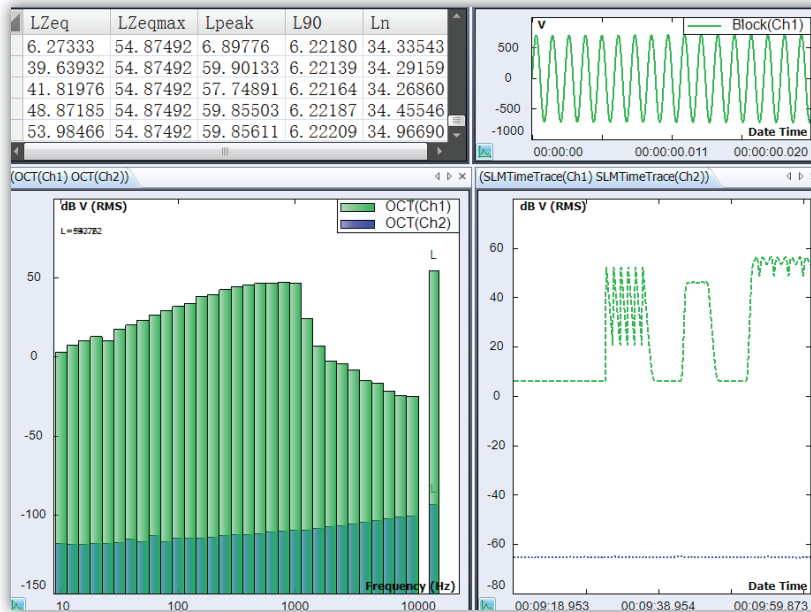
Real-time Octave Analysis
The acoustic data acquisition software option for

Spider hardware includes real-time octave filters, sound level meters, and microphone calibration functions. These three operations allow users to perform many acoustic measurement operations.

The octave analysis option applies a bank of real-time filters with 1/1, 1/3rd, 1/6th, or 1/12th octave resolution. The input time stream is split into fractional frequency-band signals (octave bands) which can be saved. Frequency weighting can be applied to the octave bands to simulate human hearing, and time weighting can be applied to adjust sensitivity to short duration events. The resulting octave spectra can be saved periodically and displayed on a waterfall plot to observe how the spectrum changes in time. The RMS time history can also be saved as a time trace of a given octave band.

The 1/1 and 1/3 octave analysis is implemented using a real-time band-pass filtering with decimation technique. The data stream is processed continuously, and fed into a bank of decimation filters. Band-pass filters are then applied to the output of each stage of the decimation filters. This provides extremely accurate filter shapes that comply with worldwide acoustic standards: ANSI std. S1.11:2004, Order 3 Type 1-D and IEC 61260-1995.

LZeq	LZeqmax	Lpeak	L90	Ln
6. 27333	54. 87492	6. 89776	6. 22180	34. 33543
39. 63932	54. 87492	59. 90133	6. 22139	34. 29159
41. 81976	54. 87492	57. 74891	6. 22164	34. 26860
48. 87185	54. 87492	59. 85503	6. 22187	34. 45546
53. 98466	54. 87492	59. 85611	6. 22209	34. 96690

Acoustic Measurement: Sound Level Meter

The Sound Level Meter (SLM) is a related application in the acoustic data acquisition software. This module is also referred to as an Overall Level Meter. The SLM applies a frequency weighting filter to the input signal and time weighting to the filter's output. Various acoustic measurements are then extracted from both the input and output signals of this frequency weighting filter.

All of the features that you would expect from an acoustic measurement device are present… and then some! A, B, C, and linear weighting functions; fast, slow, impulse, and peak detectors; and user selectable high and low-pass filtering. The tremendous dynamic range that all Crystal Instruments products offer take the worry out of setting voltage ranges precisely to avoid under-range or overload conditions.
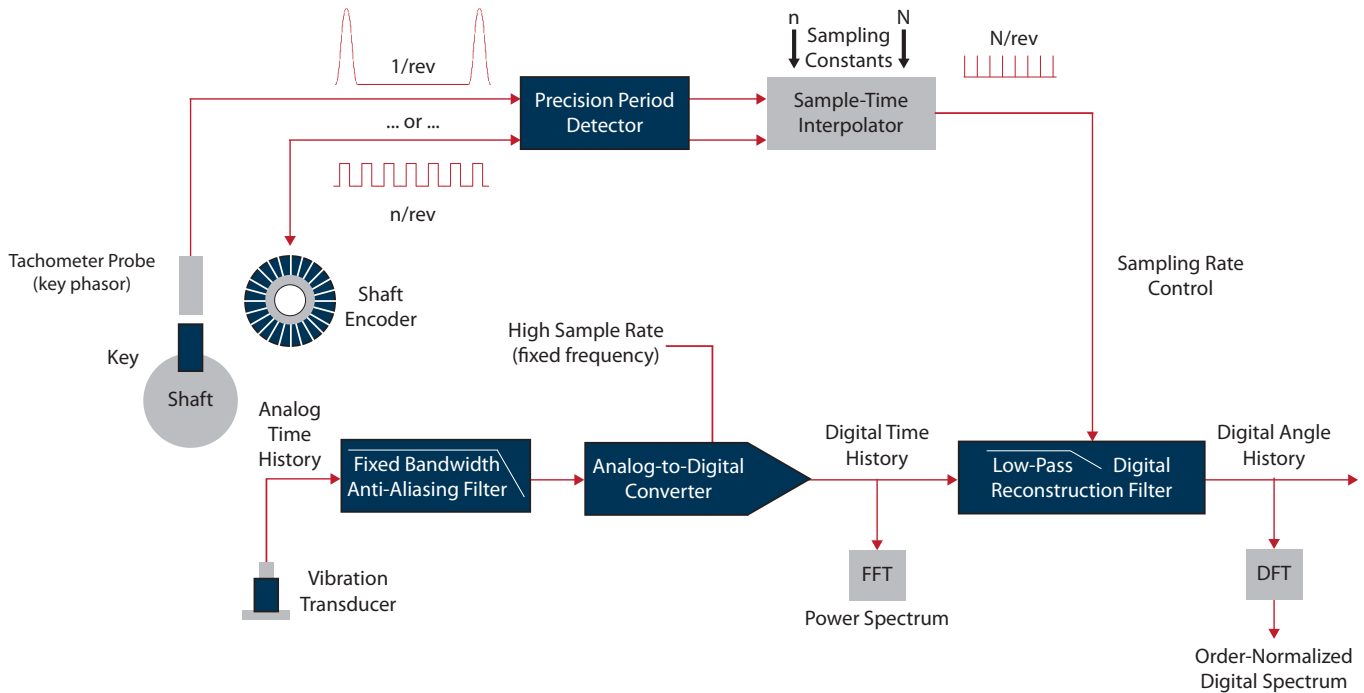
Built-in Microphone Calibration

Microphone calibration is easily handled by using a traditional microphone calibrator together with the online calibration feature. Simply define the frequency and amplitude of the reference signal, and the Crystal Instruments system will automatically detect the input channel that the calibration signal is applied to and then calculate the necessary calibration constants. Offsets are calculated and stored for later reference.

Simultaneous Recording and Octave Analysis

The Spider series is designed with simultaneous time-stream recording capability. While the acoustic analysis is processed in real time, the raw time data of the Spider can be recorded into internal flash memory or an external dedicated Spider-NAS storage device.

The raw time data of all input channels can be recorded at full analysis frequency band. After recording, the saved files can be processed by using EDM Post Analyzer which provides the identical analysis algorithm to those available in the real time mode.

Diagram labels:
- 1/rev
- ... or ...
- n/rev
- Precision Period Detector
- n N Sampling Constants
- Sample-Time Interpolator
- N/rev
- Sampling Rate Control
- Tachometer Probe (key phasor)
- Shaft Encoder
- Key
- Shaft
- Analog Time History
- High Sample Rate (fixed frequency)
- Fixed Bandwidth Anti-Aliasing Filter
- Analog-to-Digital Converter
- Digital Time History
- Low-Pass Reconstruction Filter / Digital
- Digital Angle History
- Vibration Transducer
- FFT
- Power Spectrum
- DFT
- Order-Normalized Digital Spectrum

Rotational Dynamic Acquisition & Analysis

Providing Real-time Order Tracking

The high channel count Spider systems provide a wide range of real-time order tracking capability to understand the noise and vibration induced within rotating and reciprocating machines. Fixed and variable speed machines are accommodated as are both structural vibration and condition monitoring diagnostics. Multiple tachometer inputs can be processed for accurate speed tracking during analysis. Spectral mapping, order tracking, time history and orbit data analysis are all available.

Additionally, Crystal Instruments provides post processing order tracking capability in its Post Analyzer (PA) that generates the same analysis results as real-time order tracking. The user can simply record the raw data together with tachometer signals and process them later.

Advanced Digital Processing
All measurements in the order domain are derived from an advanced digital resampling method. High speed DSP processing allows synchronization of the analyzer's sampling rate to a tachometer signal. The analyzer's sampling rate continuously adjusts to track variation in shaft speed. After data sampling, a flexible radix FFT converts the time/angle data into the frequency/order domain. The flexible radix algorithm provides a much broader choice of resolutions and spans than does a power-of-2 FFT for extraction of the order amplitude values as a function of RPM.

Order tracking extracts the amplitude at a single order and plots it against machine speed (RPM). Real-time order tracking offers advantages over fixed sample rate techniques. It provides better tracking performance when the RPM varies quickly. Additionally, it provides precise control over the order resolution of the measurement. For instance, users can specify that the order resolution be 1/10 of an order for all measurements.

There are also significant benefits in order amplitude estimation provided by the real-time order tracking method. Since the sampling rate is synchronized to the tachometer signal, the data in each frame is always exactly periodic with respect to the fundamental speed. That is, there are always an integer number of cycles for the fundamental and its harmonics in each data frame. Because of this periodicity, there is no need to use a spectral window, such as a Hann window, in the tracking calculation. This results in a more accurate estimate of the amplitude for each order.
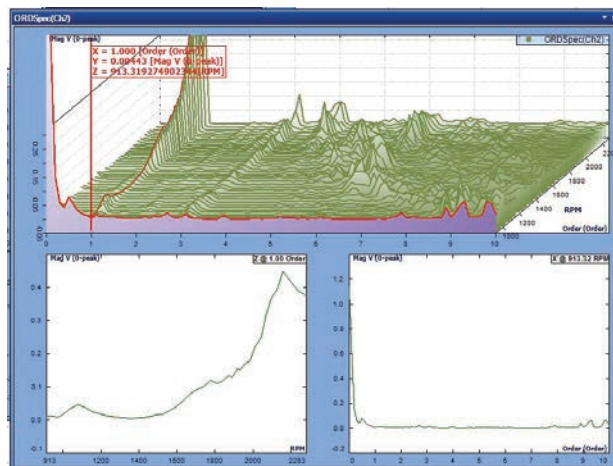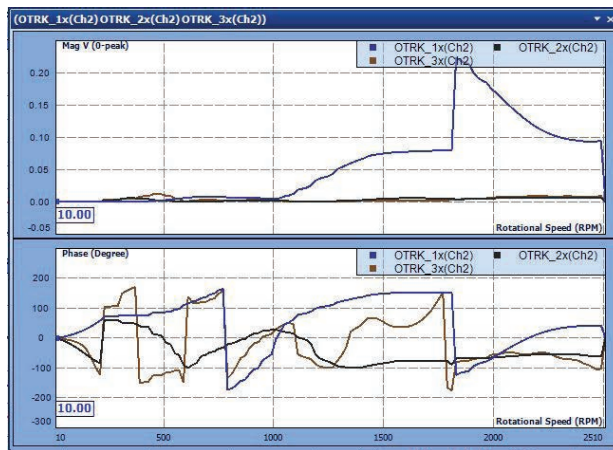
Real-Time Order Tracks and Order Spectra

Real-Time order tracks are the amplitude history signals of certain "rotational orders" graphed against the machine's RPM. Multiple order tracks can be measured, displayed, and saved. Order spectra are auto power spectra that are normalized to orders. All order tracks can have the optional phase which is phase measurement relative to the tachometer signal.

The RPM range can be from 10 to 10,000. The acquisition modes include: Free Run, Run Up, Run Down, Run Up and Down, Run Down and Up order tracks can be scaled with linear peak, linear RMS, or power scaling.

Constant Band Frequency Spectra

Constant band frequency spectrum displays the auto power spectrum of the selected fixed band of frequencies and is computed using FFT analysis within the fixed band of interest. 3D plots using time or RPM as the reference are available along with 3D extractions of desired orders of interest.

The available spectrum amplitude units includes EUpk, EUrms, EU^2rms, EU2/Hz, and $EU^2 \cdot s/Hz$

Order Tracks with Phase

Order tracks with phase are order spectra with the associated phase measurement relative to the tachometer signal. All the measurement specifications are the same as real-valued order tracks, except that order tracks with phase can also be displayed as Bode, Polar, or Nyquist plots. Furthermore, with this option the orbit display can be enabled for any two data channels.

Tachometer Processing

The tachometer is stored as a time history. The user may view either the original tachometer input waveform or the resulting RPM-versus-time translation. A tachometer channel can be used to extract the order track of any input channel or channels. Tachometer signal processing automatically eliminates any "glitches" in the tachometer pulse train and reconstructs the best estimate pulse signal for phase measurement.
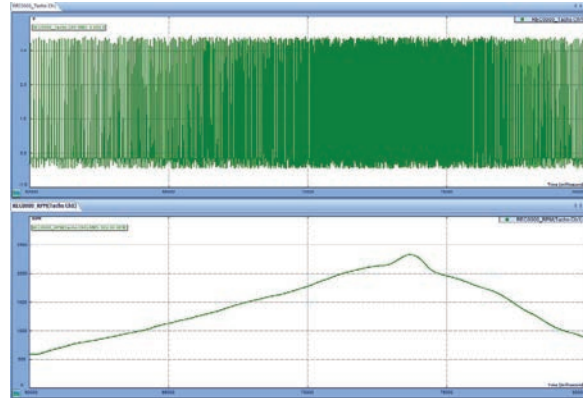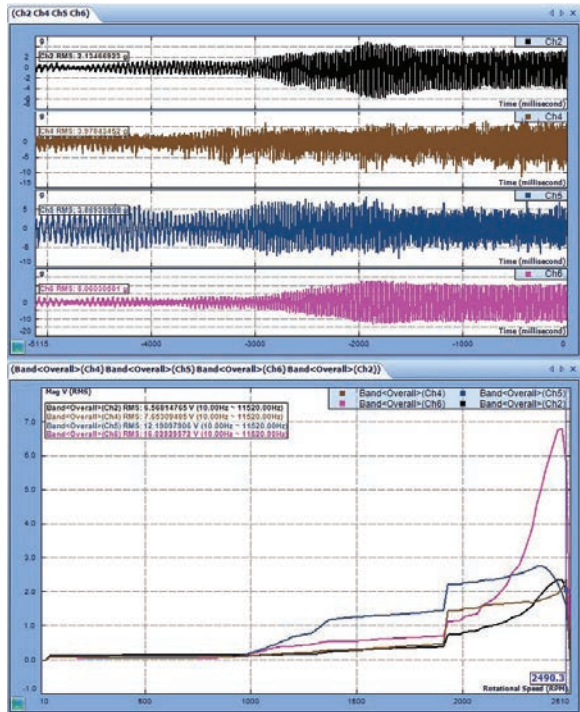
Orbit Analysis

Online orbits can be displayed and monitored on a standard two-channel orbit diagram chart. For advanced analysis a throughput recording including a tachometer or vibration signal can be post-processed using the orbit analysis tool in Post Analyzer. This provides averaging, filtering and order based orbit displays with a replay feature for visualizing changes over a change in machine speed.

Display Flexibility

Measurements can be viewed in real time as the data is being acquired and analyzed. On line displays include the time histories, orbit plots, order spectra, order tracks, waterfalls, spectrograms, and contour plots. Users can also view the instantaneous RPM as a function of time.

Waterfall displays provide a good overview of an entire run-up or run-down measurement. To better understand the measurement results, users can easily change the viewing angle so that effects of order related excitation and structural resonance excitation are immediately obvious.

Waterfall displays include a "slice" mode that provides a plot of a cut across the order or RPM axes. To view a particular slice, simply position the 3D cursor. Users can view the order track for a given order, or fractional order, or view the amplitude-versus-order spectrum at a given RPM. This capability allows the user to quickly zero in on the problem's root cause.

Color map presentations further enhance problem diagnosis capabilities. For example, spectrograms, or color intensity plots make it very easy to differentiate order related responses from excitation due of a structural resonance. Color contour, or topographic maps, also provide added graphic insight into the nature of a vibration or acoustic response.

A full complement of cursors – single, dual, peak, valley, harmonic and sideband provide precise numeric readout of critical data features. Users also have complete and easy control of the orientation, scaling, colors, etc., enabling the creation of insightful data visualizations.

Automated Production Testing Solutions

Analyzer & Controller - Spider-80X & Spider-80Xi

Automated production testing is critical in today's competitive manufacturing environment. Companies can no longer rely on variable costs, non-uniformity, and potential health hazards that come with a laborer-based manufacturing line. This is no less true for sound and vibration tests, ranging from in-process burn-in tests to product validation and verification tests. The measurement tools and intelligence behind present day manufacturing include data acquisition equipment as well as closed-loop control. And while these systems may not take part in the assembly of any goods, they are just as important to ensure quality control for both components coming into an assembly line and products going out.

Crystal Instruments has evolved a synergistic solution to such testing involving custom hardware and application-focused software. The Spider-80X system is a complete multi-channel analyzer/controller with IEEE 1588 Precision Time Protocol (PTP) Ethernet communication.

It can be programmed to accomplish multiple complex measurement tasks using a workstation or PC in combination with Engineering Data Management (EDM) software. Thereafter, the PC can be (optionally) disconnected and tests run in "Black Box" mode without an attached computer. Control of the Spider front-end may be accomplished through an Apple iPad™ tablet using the EDM App for iPad.

EDM serves as the standardized human interface to all Crystal Instruments' vibration control systems (VCS) and dynamic signal analyzers (DSA). Regardless of the specific application, channel count or language (English, Japanese, Chinese, Russian) the user interface presents the same "look and feel". Through EDM, the user can create custom interfaces and greatly simplified operating interfaces for specific product tests. Users can also generate custom reports using XML, OpenOffice, PDF, and Microsoft Word templates.

Step 1:
EDM sets the alarm limit together with a special message string, such as "Exceeding Limit".
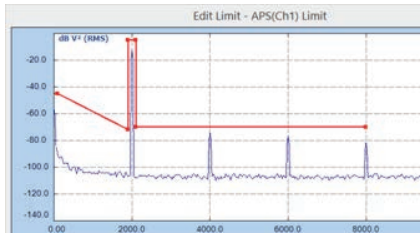
Step 2:
When an alarm event happens, the customized string, "Exceeding Limit" will be sent to the EDM Cloud email service.

Step 3:
User will receive an alarm email

EDM or EDM Cloud Email Service

Testing status can be viewed on any PC, iPad or even smart phone.

The Spider API is the gateway to integration with LabView, Matlab and other scripting software. Spider front-ends operate from Android, Linux and iOS in addition to Microsoft Windows. A single iPhone, tablet or PC can control multiple Spider front-ends at distributed locations running disparate tests from a single control screen.

Event-Action Rules (EAR) allows users to customize the system's response to every test event. User defined events include: signal exceeds a limit profile, signal is less than a limit profile, normal end-of-test, loss-of-signal or any of number of the events encountered during a VCS test. Responses include: halting a test, starting a different test, flashing the control screen, initiating a recording, sending a screen message, sending a text message, or sending an email. Users can program loops using EAR. Every event is logged on a cloud server and is identified by the text of a customized event string (only on EDM Cloud).

Limit Testing (LT) may be applied to a Time Block, Auto Spectrum, FRF, Coherence, Octave Spectrum, Sound-Level Measurements, RMS or Peak value. Spectra and time histories are tested by comparing against a custom test signal; a template which must bound the measured signal. Each test signal may be either an upper or lower limit and may contain up to 64 segments. Up to 64 test signals may be applied to a single measurement.

Burn-in testing for electronic products is a type of testing that is easily automated with sound and vibration instrumentation. For example, consider cell phones, a consumer product produced in the thousands which contains both a microphone and a speaker. These two audio components almost always need to be run through a burn-in test, which is easily automated using the Spider-80X. The Spider-80X provides a stimulating programmable function generator and data collecting input channels.

The methods for testing vary but the principles remain the same. One of the two output channels of the Spider-80X runs through a series of tones or pulses to test the phone's receiver while the input channels listen to a prerecorded sound clip played out through the speaker. Either time waveform data or spectral data can be collected and pass/fail tolerances set within Crystal Instruments Engineering Data Management (EDM) software.

Limit signals display

Setup

Compare the signals and their limits in runtime.

Events and Report
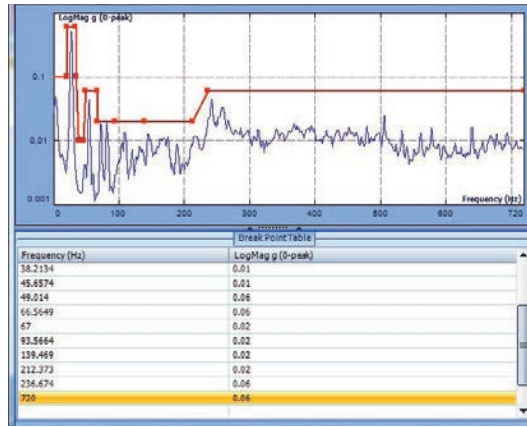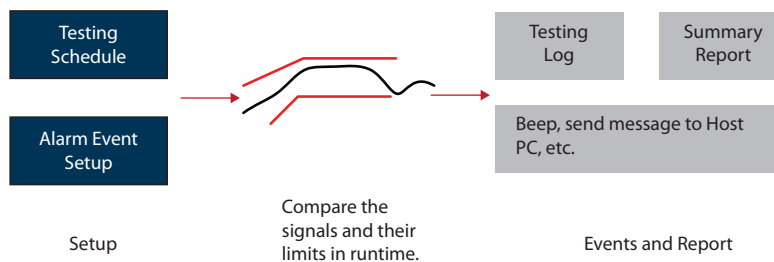
An illustration of the automatic testing process.

Scalability is a one of the benefits of automation and this is why the Spider-80X is designed as a networked device. With an Ethernet connection on the Spider-80X, multiple front-ends are connected to test tens if not hundreds of cell phones at a time. This may seem a bit excessive until one considers using not just a single microphone per cell-phone but rather using a microphone array to capture and map a planer response or even a 3-dimensional hemisphere of sound around the cell phone.
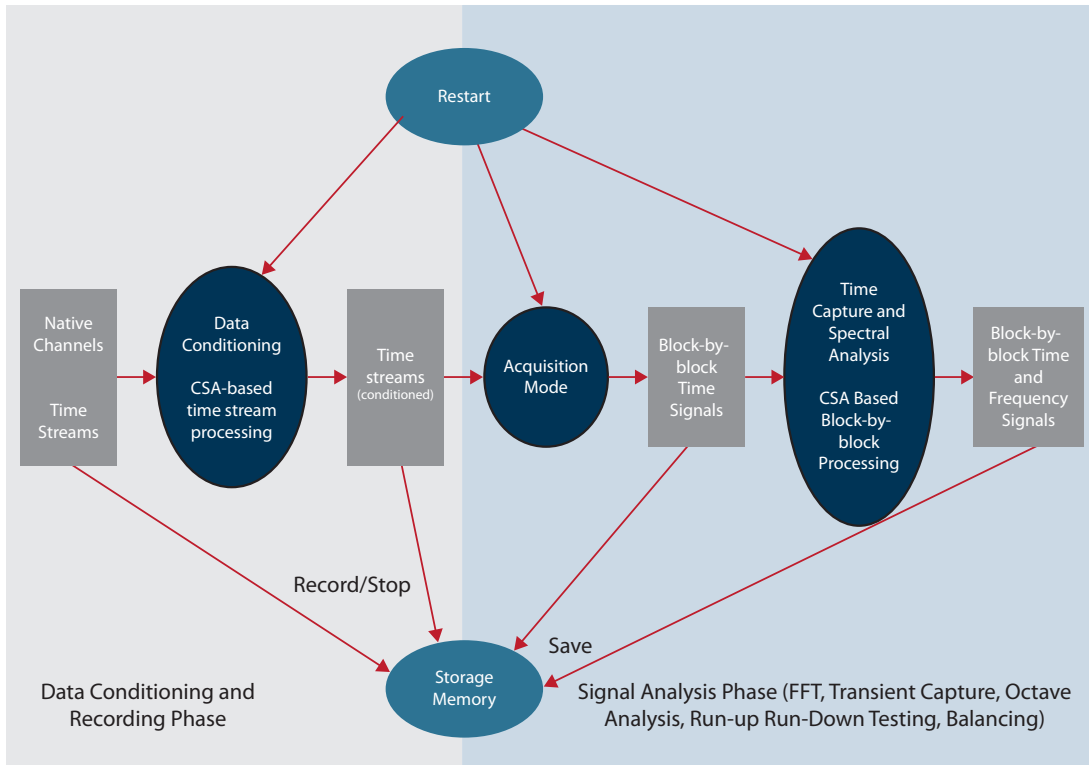
However, burn-in tests are not the only type of automated production tests performed with sound and vibration instrumentation. Product validation and verification are also an important part of production line testing. Such tests range from validating incoming components to verifying a finished product assembled from them.

Virtually all turbine manufacturers carefully match-tune the component blades of their steam and gas turbines. This involves accurately measuring the natural frequency of one or more vibration modes of each blade individually, while the blade is root-restrained by a standardized fixture. Different manufacturers implement such tests in various manners, but all rely upon measuring

the forced vibration response of the blade. The most accurate frequency determinations are made from frequency response functions (FRF), wherein both the stimulating force and resulting vibration are simultaneously measured.

Other products are quality-audited for consistent natural frequencies, to indicating consistent geometry. Often, the damping factor of each mode is also measured and used as an indication of proper assembly and freedom from cracked components. As an example, large artillery shells are impulse-tested using an instrumented hammer and a microphone. When struck, the shell rings like a bell. Each shell must exhibit natural frequencies within an acceptable scatter-band. Shells with high damping factors are subsequently inspected for cracks.

Frequency response functions characterize the linear relationship between a measured input and output and conveys an enormous amount of information. An accompanying two-channel measurement, the coherence function, determines if two signals are linearly related. It is an ideal indicator of throughput linearity, an important characteristic of most electronic circuits and many mechanical structures.

Data Conditioning and Recording Phase

Signal Analysis Phase (FFT, Transient Capture, Octave Analysis, Run-up Run-Down Testing, Balancing)

Continuous Data Recording & Post Analysis
Analyzer & Controller - Spider-80X & Spider-80Xi

Introduction

In a time-critical test, it is highly desirable to record the raw time data continuously, so that the data can be analyzed later when more time is available for a complete review. Integral raw data recording eliminates the need for a separate recording device so necessary just a few years ago.

The Spider platform simultaneously performs both real-time processing and continuous data recording. In most of real-time applications, the raw data can be recorded at any desired sampling rate with full 32-bit floating point precision. To increase the reliability of data recording, a special check sum algorithm is always applied to the measurements.

For example in a typical FFT process, the raw data time streams (full bandwidth, sampled at the instrument's highest sample rate) and/or the continuous output of a bandwidth-reducing data conditioning process can be recorded at a lower sample rate on the system's storage media while the real-time filtering and spectral analysis is in progress. This same design philosophy is

incorporated in the Spider high channel count systems.

While being recorded, the measured values can be graphically displayed as y/t or y/x diagrams, as bar charts, as waterfalls, FFT, PSD, tachometer speed, or numerical statistics displays with a simple mouse-click. EDM software allows users to design an individual graphical visualization for each desired real-time measurement.

The recording system processes virtually every physical quantity, including: temperature, voltage, stress, strain, pressure, force, acceleration and frequency. Even high channel count applications using hundreds of channels can be configured within a very short time and are handled safely and efficiently.

The recording function is driven by user-defined events. On Spider front-ends the recording "action" can be initiated via various events, including: hard button press, user software command, defined trigger-condition event, digital input event, third party software command, defined alarm limit event, fixed timer, etc.

The Spider-NAS features eight dedicated high-speed data buses and a removable 250 GB serial ATA (SATA) Solid State Disk (SSD).

High Channel Count Solution Using Spider Front-ends

For high channel count applications, the data recording can be realized on Spider systems via either of two approaches: record the time-stream data into the flash memory on each of Spider front-end or, record the time-stream data into an external storage device, such as the Spider-NAS. (One Spider-NAS can service up to eight Spider-80X data acquisition front-ends simultaneously.) Either way, the data recording path does not involve the system's Ethernet connection. This provides robust recording while preserving network communication bandwidth.

The Spider-NAS (Network Attached Storage) is a dedicated storage device that works with front-end modules from Crystal Instruments, including the Spider-80X, Spider-80SG, Spider-81, and Spider-DAQ. Eight dedicated high-speed data buses interface directly with each Spider front-end. Each Spider-NAS dedicated data port communicates at speeds up to 480 MB/second. The Spider-NAS can store simultaneous data from all (64 maximum) attached dynamic measurement channels at a sample rate as high as 102.4 kHz, or as low as a few samples per second. An Ethernet port is used to configure and control the Spider-NAS.

Remote Operation on Recorded Data

The recorded data can be remotely accessed and downloaded to an authorized PC anywhere in the world. This feature is particularly useful for remote machine monitoring or structure health monitoring. Multiple Spider front-ends can be installed throughout a processing factory or at a single machine location. The vibration signals and their extracted characteristic values can be recorded continuously.

Typical Data Storage on the Spider-NAS	
General Functions	■ NTFS file system: Supports single large data file (2 TB max) ■ Data format: ASAM ODS data format ■ Data samples are in 32-bit single precision floating point ■ Data file access: EDM, FTP, removable disk ■ Configuration Tool: EDM software from Crystal Instruments
Storage Speed	■ Up to 64 channels, each sampled at up to 102.4 kHz sampling rate retained with 32-bit floating point format (per IEEE 754-2008) ■ Aggregate speed is greater than 26 MB/second
Typical Storage Duration for a 250 GB Disk	■ 4 channel at 1 kHz/ch sampling rate: 4660 hours ■ 8 channel at 5 kHz/ch sampling rate: 466 hours ■ 8 channel at 102.4 kHz/ch sampling rate: 23 hours ■ 64 channel at 102.4 kHz/ch sampling rate: 3 hours
Management	■ Wake-on LAN, Keyboard Power-on, Timer Power-on ■ System power management, AC power failure recovery ■ Watch Dog Timer
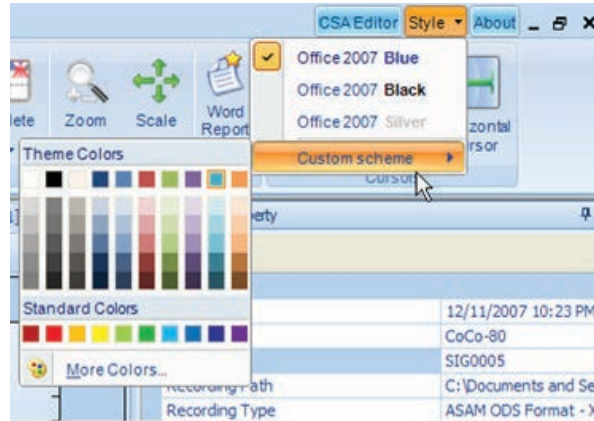
Customizable Styles: EDM is built completely upon the Microsoft.NET technology. The user interface has a modern look and is customizable per individual preferences.
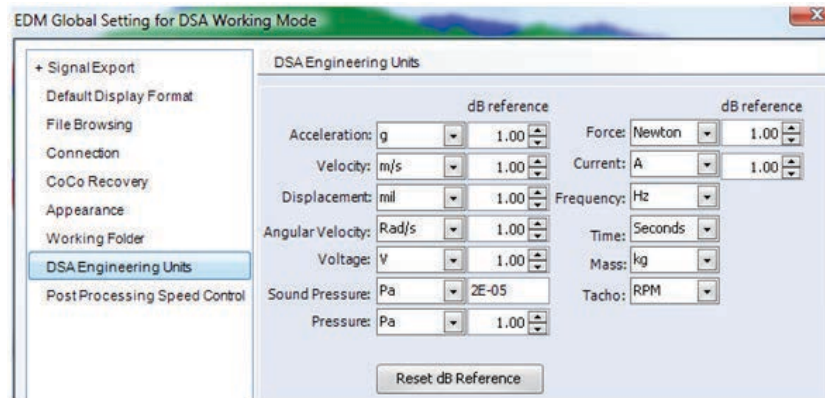
Customizable Engineering Units: Since the data model is built on ASAM-ODS, signal engineering units are carefully handled. The user displays the signals with user selectable quantity and units.

User Interface

EDM is a computer software tool that is used to manage one or more CoCo-80 devices connected to the PC. The physical connection is made through either USB or Ethernet. The EDM software intelligently searches through the connected hardware devices and browses into the remote device to look at its hardware property or software files. Data files are downloaded by drag-and-drop. The user is able to download multiple files and to view the files simultaneously.

EDM is also used as a terminal to configure the CoCo devices. Project files are uploaded with one mouse click.

Post Processing

EDM Post Processing includes a convenient tool to browse through raw data files and make selections for additional post processing. The selected time data is then analyzed using the CSA technique where the process is created using graphic functional elements designed for filtering, spectral analysis, and time-frequency analysis.

Data File Browsing and Selection

A unique algorithm is developed to help users quickly browse through any segment of raw data files even when the files include gigabytes of data.

Vibration Control Software Solutions

High Channel Count Vibration Control - Up to 512 Channels

A Wide Range of Software Functions in Vibration Control and Signal Analysis

The Crystal Instruments vibration control system (VCS) software is designed for a wide range of vibration and shock testing customers. The same software suites support from as few as two inputs up to 512 input channels with multiple drive output capability. Software solutions for vibration control include Sine, Resonance Search Track & Dwell (RSTD), Oscillator, Random, Sine-on-Ransom (SoR), Random-on-Random (RoR), Swept Random-on-Random (SRoR), Classical Shock, Transient, Seismic, Shock Response Spectrum (SRS) Synthesis, Time Waveform Replication, Highly Accelerated Life-Testing/Stress-Screening (HALT/HASS) and multi-drive control. These suites facilitate

testing to virtually all current environmental test standards. Customizable report templates allow the user to generate reports in XML, OpenOffice, PDF or Microsoft Word with a single click. With the Application Programming Interface (API), Crystal Instruments' controller can be directly accessed from LabView, Matlab or other customized software. Spider front-ends run on Linux, iOS, and Windows operating systems. The VCS software also supports a wide range of dynamic data acquisition and real time processing functions including Fast Fourier Transform (FFT), Frequency Response Function (FRF), real-time filters, octave and sound level meters, order tracking, automated limit testing, transducer calibration and more.
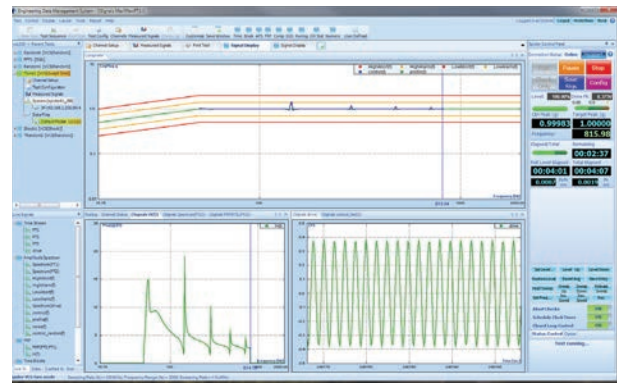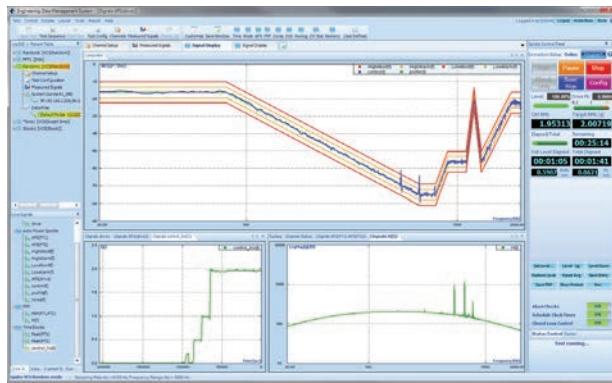
*EDM (Engineering Data Management) is available in **English, Japanese, Simplified Chinese, Traditional Chinese, and Russian.***

Common User Interface

Our Engineering Data Management (EDM) software comes with each system. EDM provides a common user interface for both VCS and Dynamic Signal Analysis (DSA) applications. A single interface with the same look and feel means that test specifications can be transferred from engineering to production without change or error and test data can be compared directly between one system and another. EDM provides a consistent user interface regardless of the application and independent of the number of hardware channels.

Multi-Language Support

We work in a multi-lingual world. Crystal Instruments' EDM fully supports operations using English, Japanese, Simplified Chinese, Traditional Chinese or Russian (others on request) user interfaces. The selected language can be changed at any time with one mouse click.

Versatile Report Functions

The advanced report function allows users to create a report in several formats including OpenOffice, XML, Microsoft Word, ActiveX and PDF. The report is template-based. Users can customize the logo, margins, orientation of the paper, font, and the content. Microsoft Word/ Office is not required to be installed to create reports. In the Review Mode, batch report can generate reports for the signals saved in multiple runs. With ActiveX reporting, signal displays in the report can be rescaled, analyzed, and zoomed.

Easy Network Configuration

Intelligence has been built into the software so that the hardware devices on the network can be detected and accessed with little effort. A Security Access Code (SAC) is used to protect unauthorized access to the hardware on the network.

Multi-Tab and Multi-Screen Support

To support the high channel count system that may display up to hundreds of signals, the software is designed to support multiple tabs and multiple screens. The highly flexible online display capabilities are expandable, making monitoring high-channel count systems quicker and easier. Display layouts for each tab and screens can be set up and stored for rapid access.
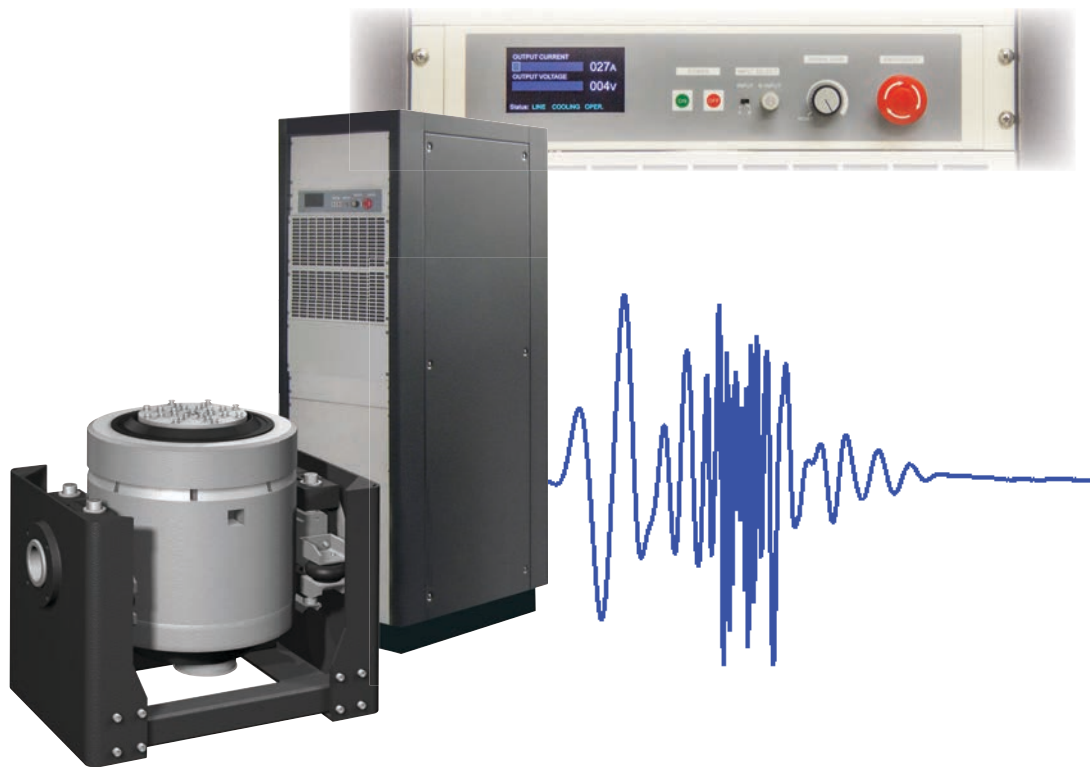
Safety First

Our software and hardware utilizes many safety features to ensure reliable closed-loop vibration control – from pretest checks to abort checking, notching and controlled shutdown during a test. The check-only mode allows checking the connection of sensors and verifies the amplifier status before turning the drive output on. This pretest function is an extremely powerful tool for detecting possible set-up problems before your test is started. During closed-loop control the VCS software performs RMS and line-by-line abort checks, sigma clipping and drive limitation and continuously checks for open channels and overloads. The software carefully checks for open-loop conditions such as failure of a sensor connection and verifies proper response during the initial drive ramp-up. During every test, the shaker limits (peak acceleration, velocity, displacement), maximum drive voltage and sensor connection status are continuously monitored and will initiate an emergency shutdown in case of any deficiency.

Multi-Tasking

With DSP centralized hardware architecture, the real-time measurement and control processes are all run on the front-end hardware; users can utilize all of the capabilities of the host computer for other tasks. This multi-tasking concept guarantees powerful and time efficient vibration testing, even with time critical tests. More importantly, it provides a unique and important safety feature: any computer or network failure will not affect the vibration control.

Test Sequence

A Test Sequence provides the capability to automatically execute a sequence of tests. The user can Run, Pause or Stop the testing at any time and the software keeps a detailed log of the actions and results.

Event-Action Rules

Event-Action Rules is a new way to customize the controller behavior. Many events that can occur during the course of test operation, including certain response levels being reached, limits being exceeded, and user events such as Pause or Stop. Event-Action Rules define the response of the controller to these test events. Many actions are available as custom responses, such as sending an e-mail, send a digital output signal to the climate chamber or stopping the test.
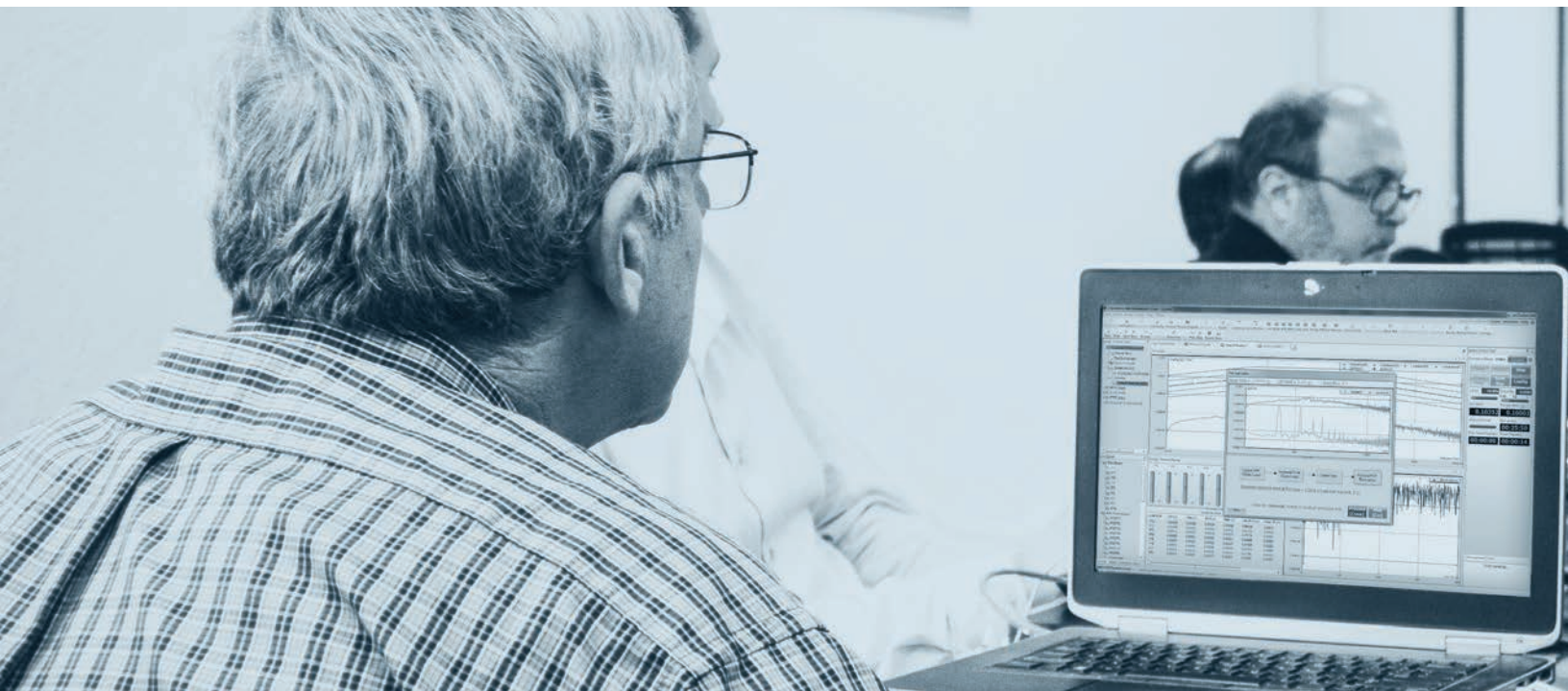
Engineering Data Management

EDM Post Analyzer Software

Crystal Instruments offers EDM Post Analyzer software, a powerful adjunct to your Spider-based analysis tool kit, allowing you to analyze Time Stream recordings made using your Dynamic Signal Analyzer. The beauty of this approach is that it lets you analyze and reanalyze 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 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.

To offer a complete package of both real-time analysis and post processing, Crystal Instruments developed three separate but related software modules: Post Analyzer, Waveform Editor, and File Converter. 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 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.

Waveform Editor is an independent Windows application that allows the user to cut, edit or merge the time waveforms. File Converter is an independent Windows application that converts files in various data formats to standard ATFX format.

For convenience of ordering, we also 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 Waveform Editor, File Converter, offline sine reduction, real-time filters, octave filters and order tracking.

Engineering Data Management (EDM) is a complete suite of turn-key solutions for both real-time processing and post analysis. Shown below are typical screen shots of EDM PA functions, in the following order: Post Processing, PA Spectra, and PA Projects.
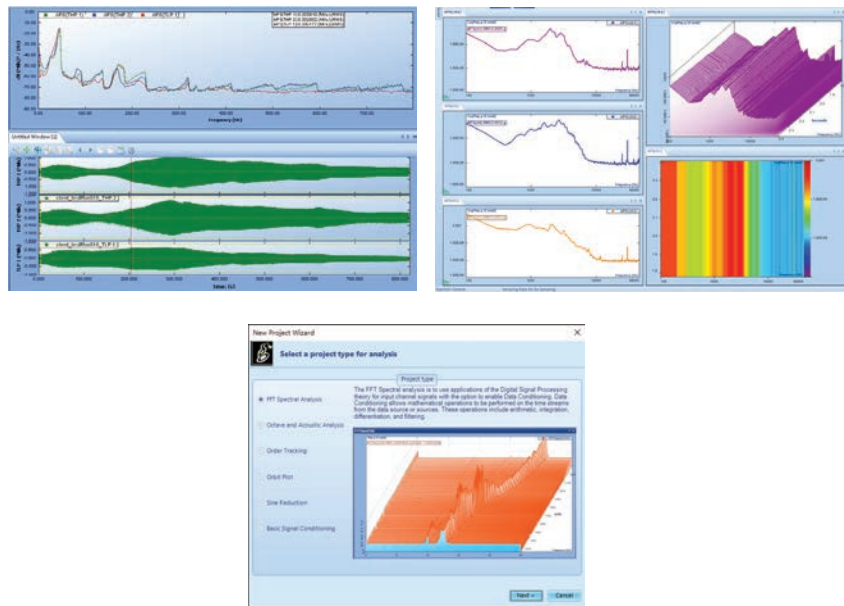
Function	PA Viewer	PA Basic	PA Premium
Browse, display, and edit long waveform files	√	√	√
Signal display with different spectrum unit and X-Y scale	√	√	√
Signal annotation, cursor, play sound, calculate RMS, THD, ZOOM-in, ZOOM-out, auto scaling	√	√	√
Create template-based report in HTML, Excel, Word 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)			√

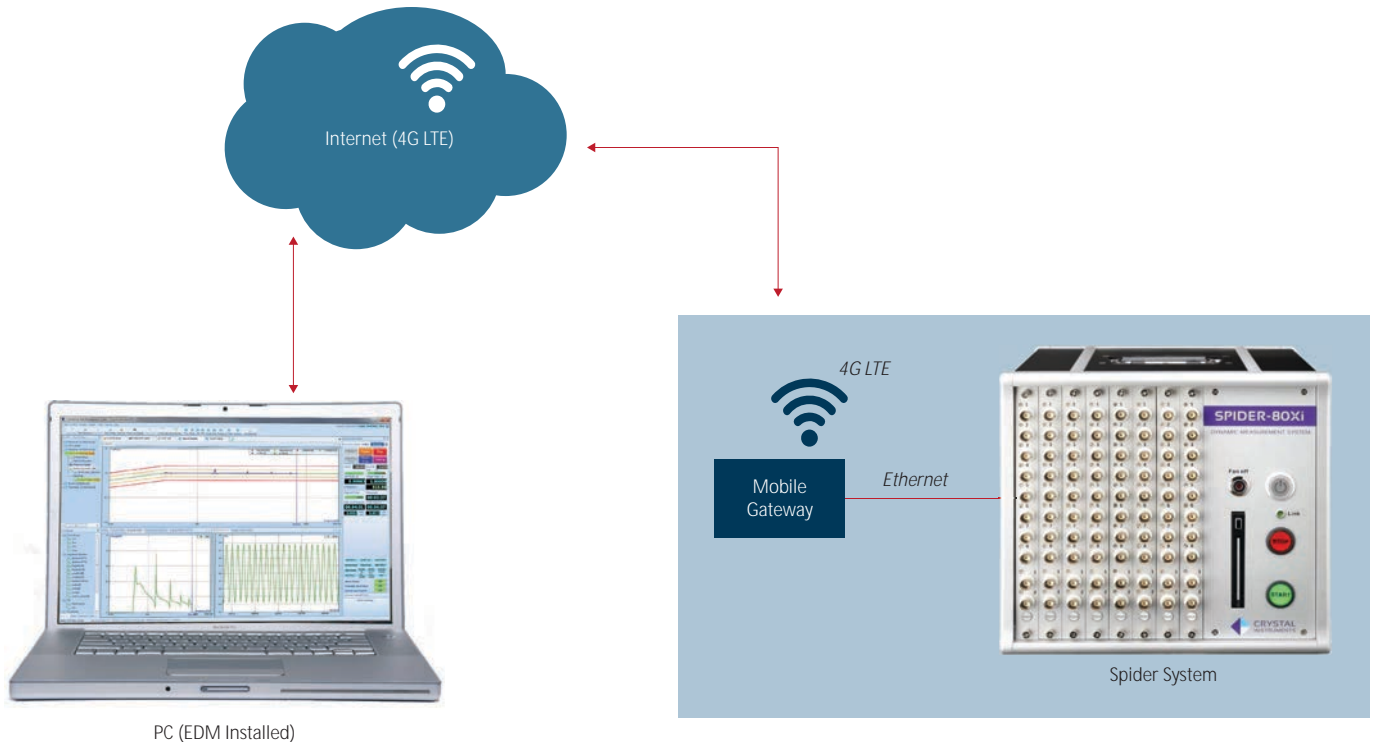**EDM Post Analyzer Ordering Information**
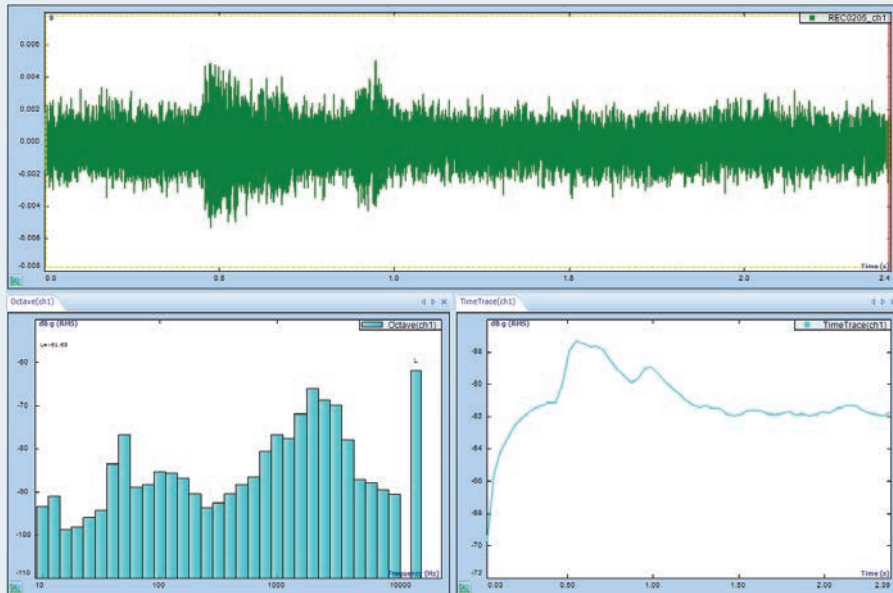
EDM - PA Software	
Part Number	**Description**
PA-05	User Defined Signal Conditioning
PA-06	Digital Filters and Resampling
PA-07	Shock Response Spectrum
PA-08	Octave Analysis and SLM Analysis
PA-09	Order Tracking and Rotating Machinery Analysis
PA-10	Offline Sine Data Reduction

EDM - PA Bundles	
Part Number	**Description**
EDM-01	PA Viewer: View data, export data to UFF, BUFF, MATLAB, user-defined ASCII, and wave files. Generate reports. Option is included with all CoCo or Spider purchases. Includes File Converter and Waveform Editor.
EDM-02	PA Basic bundle: In addition to functions of PA Viewer, PA Basic includes 3D display, File import, File export, trigger, FFT post-analysis.
EDM-03	PA Premium bundle: In addition to PA Basic, PA Premium includes signal conditioning, digital filter and resampling, SRS, octave analysis and SLM, order tracking, offline sine reduction.

Internet (4G LTE)

4G LTE

Mobile Gateway

Ethernet

SPIDER-80Xi

Spider System

PC (EDM Installed)

Wireless Remote Condition Monitoring
Hardware and Software Solutions

Sometimes a test conducted at a proving ground in Michigan needs to be controlled by engineer in California or a wind turbine in Germany requires observation by designers in Japan. That's when wireless remote monitoring is the tool of choice and wireless service providers have expanded rapidly to support worldwide connectivity.
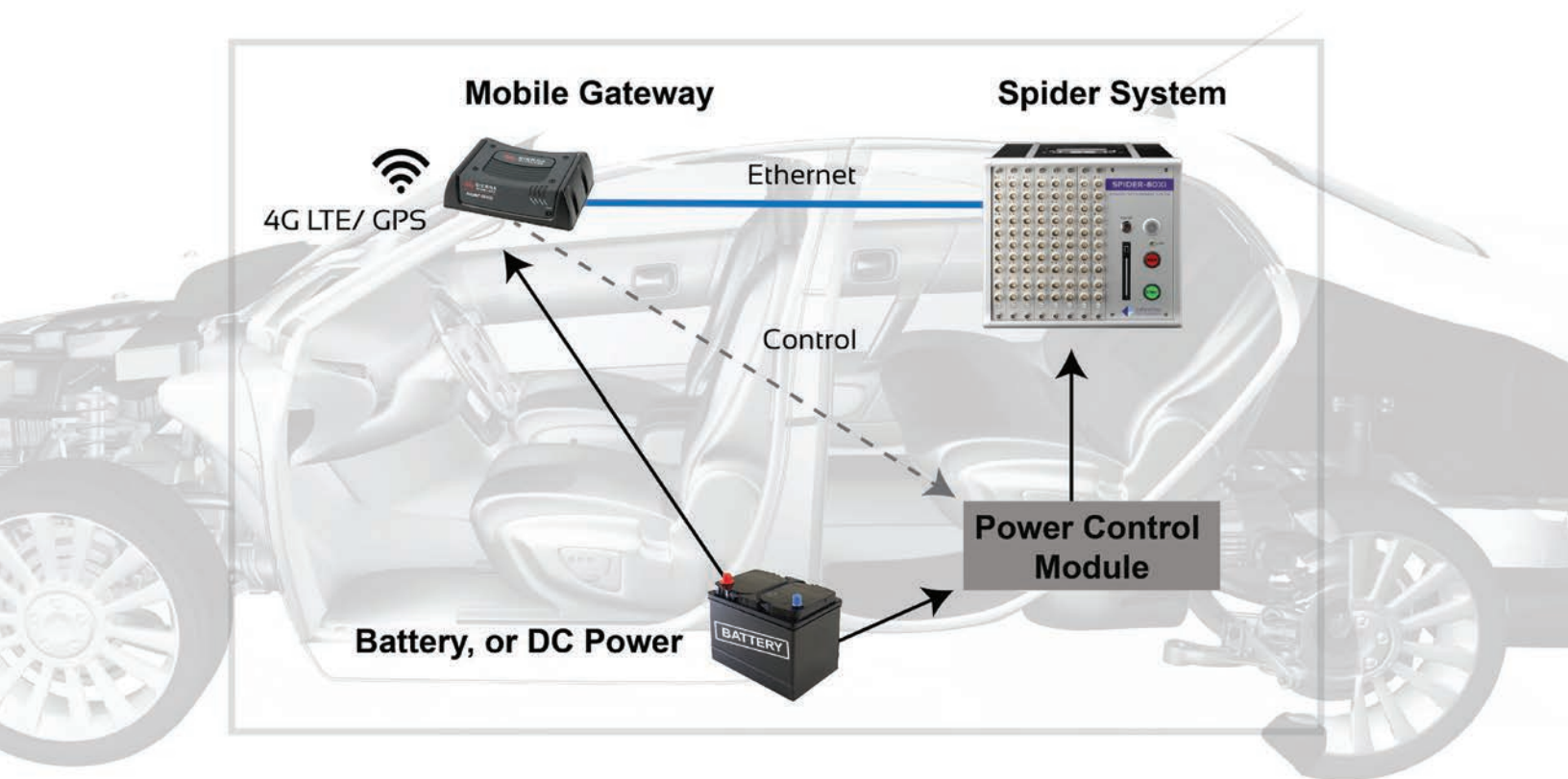
In the United States, cellular carriers such as Verizon, AT&T and Sprint have covered the most populated areas of the country with 4G LTE technology and the transmission bandwidth can easily reach to 10 to 20Mb/s. Other developed countries have wireless networks that reach and surpass that of the United States' and even developing countries are rapidly expanding wireless internet connectivity.

A Crystal Instruments Spider system connected to a Mobile Gateway modem can be wirelessly linked to a PC in an office which is running EDM (Engineering Data Management Software). This means that a Spider system placed in a moving car can be remotely monitored and controlled by a PC with an internet connection running EDM software. The Mobile Gateway modem makes the remote in-vehicle operation of Spider system possible. Crystal Instruments has developed

several competitive features that help its line of Spiders succeed at wireless remote condition monitoring.

The hardware and software of the Spider system are designed so that the network control terminal (comprised of EDM and the PC) is not in the critical control loop. If the connection fails or slows due to limitations in the transmission, such as the wireless connection becoming bad, neither the data acquisition nor the monitoring functions on the Spider system will be interrupted. The Spider would default into "Black Box mode" which is a self-sufficient system. The design function resilience of the Spider system assures that no external failures will compromise its smooth operation.

Power consumption is a big concern for remote monitoring and the Spider excels in this area. A Spider has an internal flash memory that stores all the software code, configuration parameters and the measurement data. This design runs the system at a low power consumption. A typical Spider-80X unit, which can acquire data at 102.4 kHz with 8 inputs will only consume about 10 watts of power and a four input Spider-20E only consumes about 6 watts.

Mobile Gateway

4G LTE/ GPS

Ethernet

Control

Spider System

Power Control Module

Battery, or DC Power

BATTERY

Wireless Remote Monitoring Features

- Low Power Consumption
- 150 dbFS Dynamic Range
- "Black Box" Mode (No PC Required)
- Reliable in All Circumstances

Another advantage of the Spider system is its independence of a PC in a remote area. All of its input channels use patented dual A/D technology that can achieve more than 150 dBFS dynamic range, completely eliminating the input gain setting.

Signals as low as a few microvolts or as high as 20 Volts can all be accurately measured without human attention to their amplitude. This unique feature is especially beneficial when the measurement is taken remotely without attendants. Applications could include a test performed on a train traveling long distances over a railroad, a test performed high in a wind turbine,

or a test of a vehicle conducted by a professional driver.

Reliability, low power consumption, "Black Box mode," and a very high dynamic range make the Spider system uniquely capable of wireless remote condition monitoring.

Providing Power to the Spider and Wireless Gateway Modem

The active power consumption of one eight-channel Spider module is less than 10 watts. The power consumption of wireless gateway modem is 1 watt or less. The modem also has an idle mode that consumes much less power. It is feasible to use battery power, or solar assisted power source to power the units.

Crystal Instruments developed an intelligent power control module that can shut down and power on the Spider system through the modem.

Versatile Report Functions

Fully Customizable - Generate Reports Quickly & Easily

In the EDM software, the report function allows users to create a report in several formats including OpenOffice, XML, Microsoft Word, ActiveX and PDF. The report is template-based and completely customizable.

Users can customize the logo, margins, orientation of the paper, font, and the content. Microsoft Word/Office does not need to be installed in order to create reports. In Review Mode, batch reports can be made for the signals saved in multiple runs. Using ActiveX reporting, signal displays in the report can be rescaled, analyzed, and zoomed.

- User can select from various templates for creating reports
- Plot reports can be generated by simply right-clicking the mouse
- Company logos can be inserted into the template header or footer
- Reports can be in WORD, XML or PDF format
- "Active Report" allows the user to ZOOM in and out like a graph on the report
- Generate typical hardware calibration reports
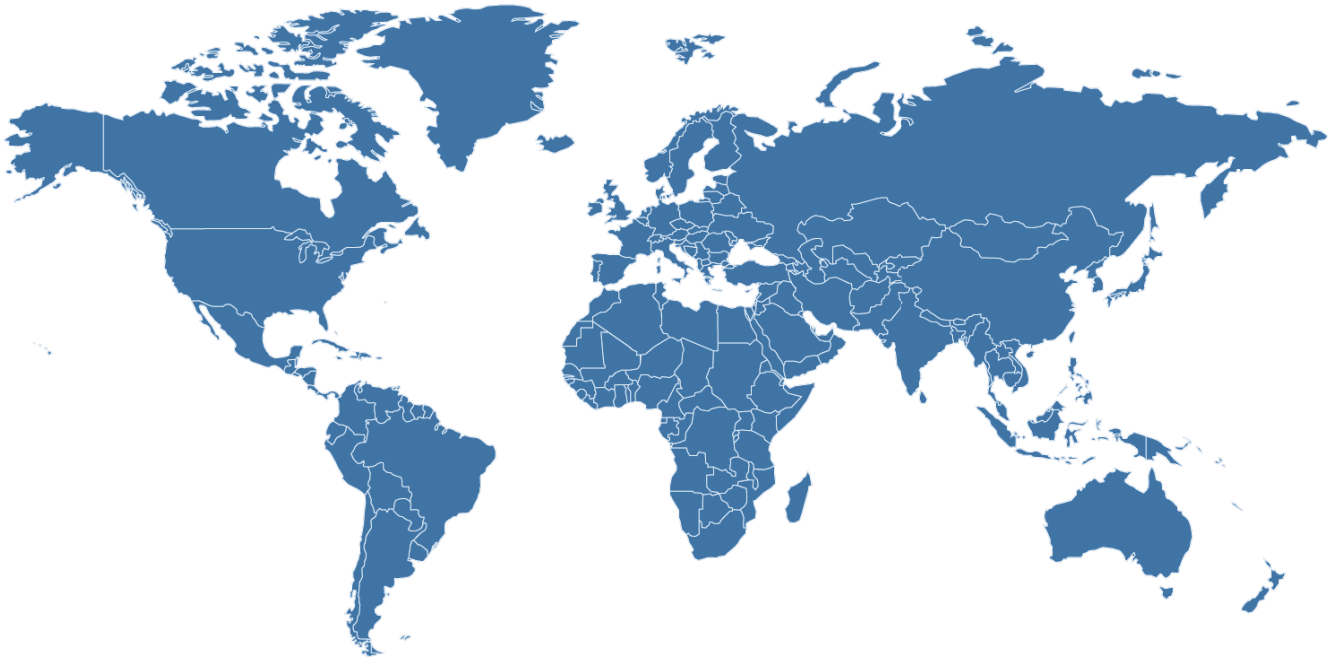
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