VIBRATION CONTROL SOLUTIONS

WIRELESS & HIGH CHANNEL COUNT SYSTEMS

CRYSTAL INSTRUMENTS

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Crystal Instruments provides the most highly advanced shaker control systems available in the market today.

VIBRATION CONTROL SYSTEM HARDWARE PLATFORMS

INTRODUCTION

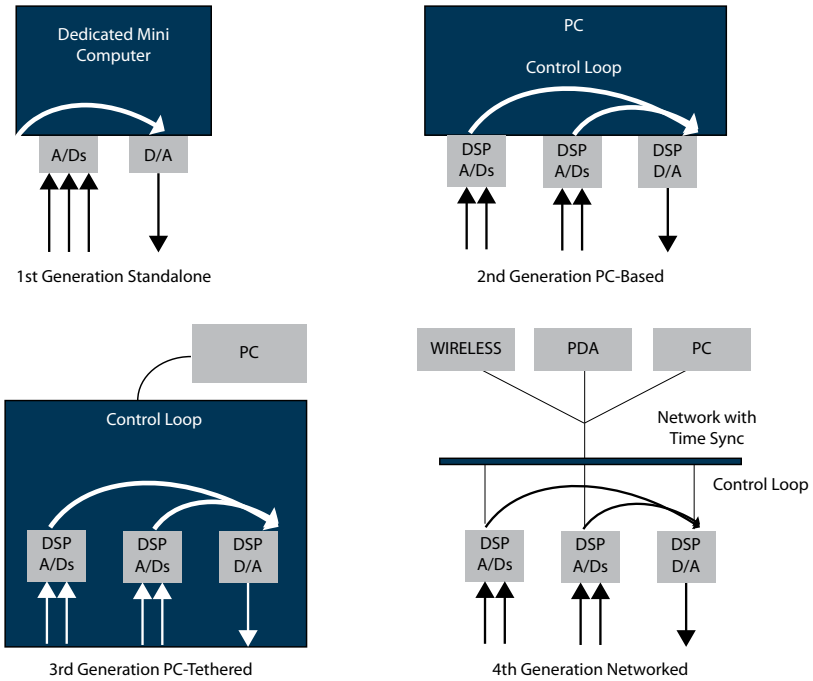
In shaker vibration testing, the device-under-test (DUT) is rigidly mounted to the table of an electro-dynamic (or hydraulic) shaker. A closed loop control system causes a test object to experience a prescribed vibratory motion of sinusoidal, random or transient form (or a combination of these). How well this is done is determined by the controller's hardware, firmware and architecture. How simply and elegantly it is accomplished is determined by the system's software.

Latest Hardware Design

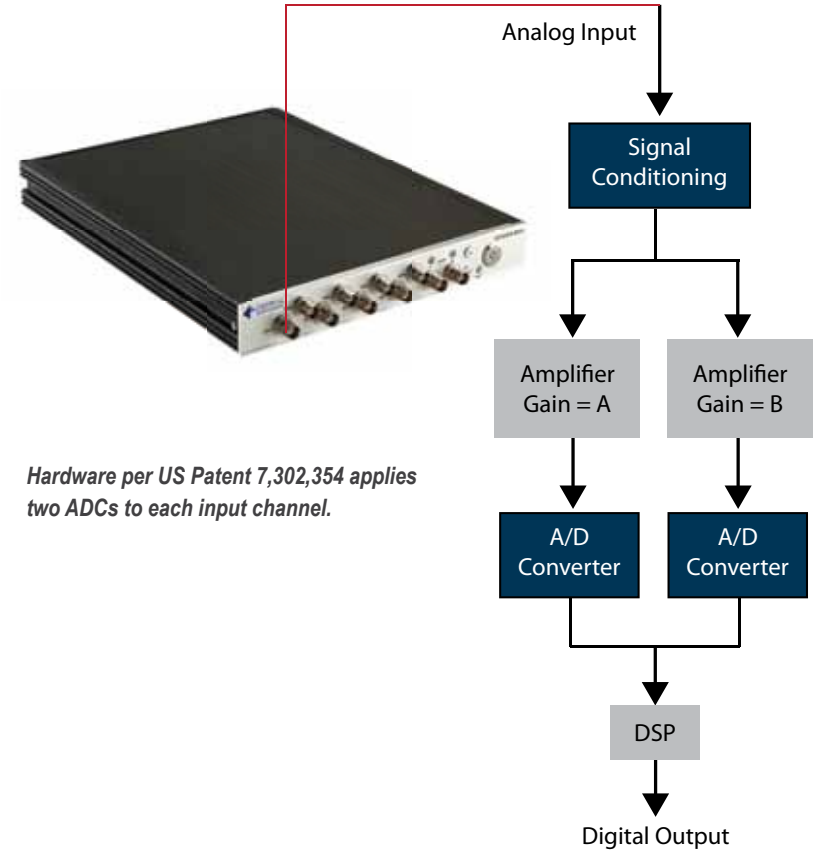
The Spider front-ends have voltage, IEPE and charge inputs which are ideal for shock, vibration, and acoustic measurement, strain or general purpose voltage measurement. The internal flash memory stores test configuration data for controlling up to hundreds of channels simultaneously and stores real-time analysis data. Multiple output channels provide various signal output waveforms that are synchronized with the input sampling rate. Ten monitoring connections on each unit are used to read analog input and output signals. There is a built-in isolated digital I/O to interface with other hardware. Our scalable architecture allows users to employ as many as 512 input channels for the utmost spatial resolution. Sampling to 102.4 kHz provides excellent time resolution while spectra with up to 12,800 lines may be controlled. Data is stored into 4 GB of internal lash memory. Increased storage space is possible with the addition of a 250 GB external unit.

DSP Centralized Architecture

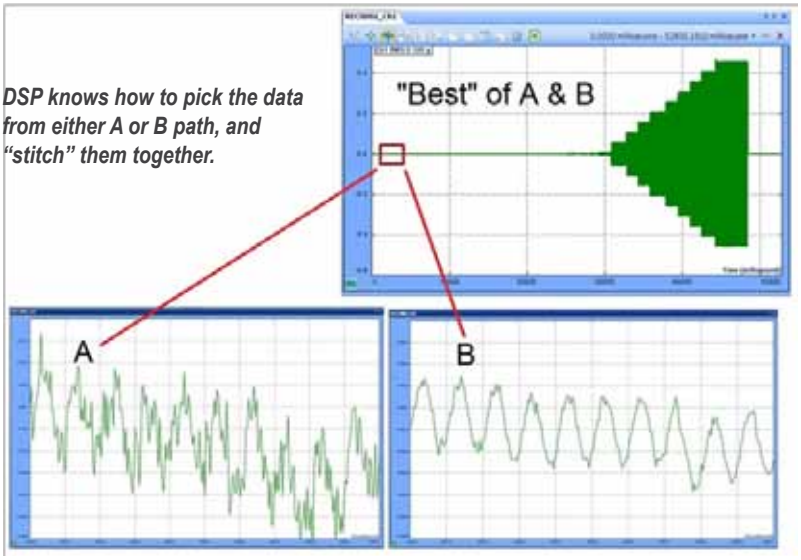
Unlike traditional controllers that rely heavily on an external computer for real-time operations, the Spider is the first controller that directly integrates time-synchronized Ethernet connectivity with embedded DSP technology. This greatly increases the control performance, system reliability, and failure protection of the controller. It also allows a large number of channels to be configured without sacrificing system performance.



The Spider platform is based on a fourth generation DSP centralized architecture.



Hardware per US Patent 7,302,354 applies two ADCs to each input channel.



DSP knows how to pick the data from either A or B path, and "stitch" them together.

High Precision Front-End Design

The Spider 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 24 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.

In some models, built-in charge amplifiers are available. For pyrotechnic and other high-shock applications or tests involving very high DUT temperatures, each input channel can accept a charge-mode piezoelectric sensor input directly without using an expensive external charge amplifier.

It is unnecessary to adjust the input sensitivity of any channel; these are fixed at ±20 volts. Each channel provides an unprecedented dynamic range of 150 dBFS, detecting voltages as small as 600 nV. 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.

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. A single PC can monitor and control multiple controllers over a network. Since the control processing and data recording are executed locally inside the controller, the network connection does not affect control reliability. With wireless network routers, a PC connects easily to the Spiders remotely via Wi-Fi.

Time Synchronization between Multiple Hardware Front-ends with only Ethernet Cable

The Spider is built on IEEE 1588 Precision Time Protocol (PTP) time synchronization technology. Spider modules on the same network can be synchronized within 50 ns accuracy, which guarantees ±1° cross-channel phase match up to 20 kHz across the complete system. With this unique technology and high-speed Ethernet data transfer, the distributed components on the network truly act as one integrated system.

Black Box Mode

Black Box mode enables Spider 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 controller operates autonomously, according to a preset schedule or in response to a connected iPad.

On-Board LCD Display
The Spider-81 and 81A are equipped with a bright front-panel LCD and intuitive information navigation controls. Real-time status such as control RMS or sweeping frequency is instantly viewed on the LCD.

Designed for High Reliability
The Spider is the very first vibration control system designed for fail-safe operation even in the event of network or power loss. Advanced safety routines allow sensor failures to be detected within milliseconds. All Spider hardware pass strict environmental tests including EMI, temperature, drop shock, sine and random vibration. The system is built to withstand the rigors of the testing environment with long-lasting durability. The unique floating ground design reduces ground loop problems typically found in testing laboratories. Power backup circuitry based on a super-capacitor is installed to handle any disastrous power loss.

Designed for High Accuracy
Using our patented parallel dual analog-to-digital converter (ADC) design, each measurement channel can detect signals as small as 600 nV and as large as 20 V. This design completely eliminates the need for the input range or gain settings found on traditional controllers. Crystal Instruments engineers have also raised many related hardware specifications to establish new industry performance standards. These include total harmonic distortion (THD), cross-channel phase match, frequency flatness, linearity, cross-talk and frequency accuracy.

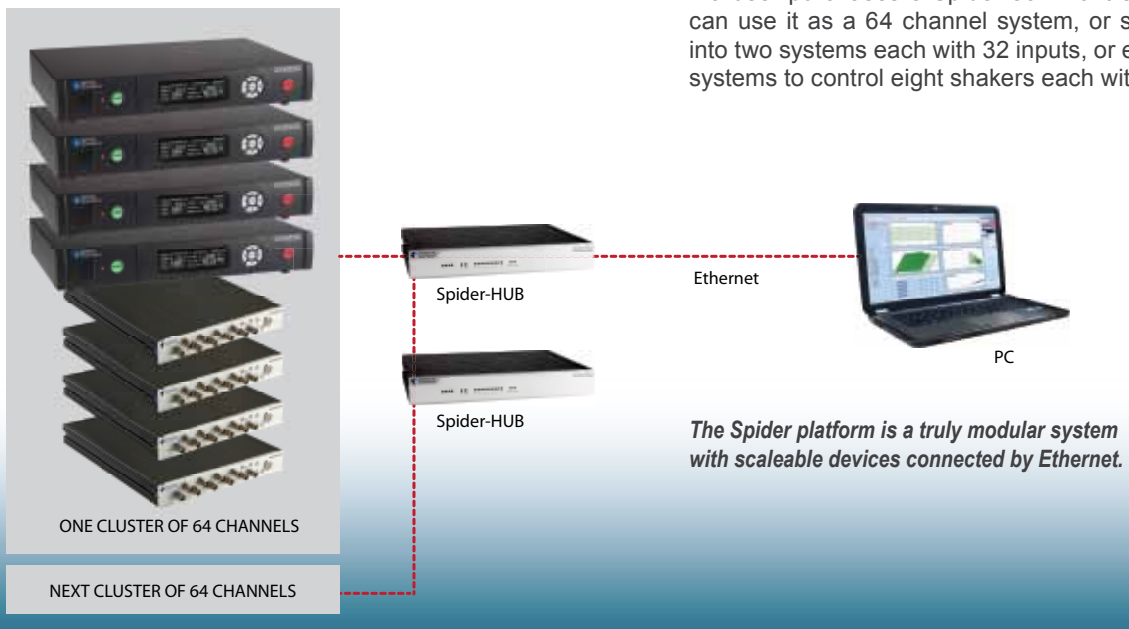
Designed for High Performance Control
By using enhanced control algorithms and a simplified DSP architecture, the feedback loop time of Sine and Random control are greatly reduced to a 10 ms latency. Reduced control loop time improves performance for resonance search and tighter control for a structure with high-Q resonances. It also provides faster adaptive responses for better safety protection.

Ease of Use
The Spider software is further improved at the user interface level. More graphical guidance, wizards, and tools are available to simplify test setup. The interface has been reformatted to be more intuitive. Event-Action Rules, Abort-Sensitivity, and numerous other new concepts are introduced in the software to simplify operation. Keyword searching through a large number of tests is easy. A smart network detection tool makes hardware installation very simple.

Complete Software Solutions
The Spiders have complete software solutions available for vibration control, including Sine, RSTD, Oscillator, Random, SoR, RoR, SRoR, Classical Shock, Transient, Seismic, Shock Response Spectrum analysis and SRS Synthesis, Time Waveform Replication, HALT/HASS and multi-drive control. They cover testing to virtually all current environmental test standards. Customizable report templates allow the user to generate reports in XML, OpenOffice, PDF or MS-Word with one click. With the Application Programming Interface, Crystal Instruments' controller can be directly accessed from LabView, Matlab or other customized software. The Spiders can operate from Linux and iOS in addition to Windows.

Integrated Control and Dynamic Signal Analysis
With appropriate software, the same Spider-80X hardware used for vibration control can also be used for dynamic signal analysis including machine monitoring, order tracking, modal analysis, and acoustic analysis. Multiple Spider front-ends can work together to form one integrated system. Long waveform data recording is a built-in function. An optional hardware front-end (Spider-80SG) integrates monitoring of strain gages and thermocouples.

Designed for High Scalability and Expandability
With the Spider architecture, it is possible to make the hardware system ultimately scalable and expandable. A testing lab that purchases multiple front-ends of the Spider-81 or Spider-80X can freely move around their units and configure their own systems. For example, if a user purchases 8 Spider-80X front-ends, the user can use it as a 64 channel system, or separate them into two systems each with 32 inputs, or even into eight systems to control eight shakers each with 8 inputs.



The Spider platform is a truly modular system with scaleable devices connected by Ethernet.

From the top: Spider-81B, Spider-81, and Spider-81A

Spider-81
The Spider-81 is the flagship model; all other Crystal Instruments controllers have evolved from it. This 4th generation hardware is highly modular, distributed and scalable. Each Spider-81 has 8 analog input and 4 analog output channels. Analog monitoring channels serve an attached oscilloscope. Eight digital I/O pairs are provided for custom applications. The Spider-81 features a bright front panel LCD that displays system status and test information. Real-time status such as control RMS or sweeping frequency is instantly viewed on the LCD.

The Spider-81 does not just use Ethernet for data communication, it employs IEEE 1588v2 time-synchronized Ethernet connectivity. This technology allows (300 meter!) remote input modules to be connected solely by Ethernet (no dedicated "sync" cable required), yet still provides sampling and triggering synchronized within the accuracy of 50 ns. The Spider-80X front-ends and the Spider-HUB industrial Ethernet switch may be used to expand the Spider-81 controller up to 512 input channels. All input channels across the system are amplitude matched within 0.1 dB and phase matched within 1° over a 20 kHz bandwidth.

All Spider front-ends contain a 4 GB flash memory for the storage of data and test processing instructions. If longer recording is required, the Spider-NAS (Network Attached Storage) provides 250 GB of solid state disk (SSD) storage in a removable SATA cartridge. One Spider-NAS records streamed time waveforms and spectra from up to eight Spider front-ends at the speed of 102.4 kHz per channel. The rapid transfer rate allows continuous recording of all channels at a measurement front-end's highest sample rate.

Multiple Spider-81 front-ends and the Spider-80X front-ends can integrate to construct a higher channel system. The Spider-81A, 81B and 81C front-ends are not expandable by design.

Spider-81A
The Spider-81A front-end is a dedicated 16 channel controller. It matches all of the specifications of the landmark Spider-81, but adds eight more input channels and a built-in network switch in a slightly larger package. This controller cannot be expanded beyond its 16 input channels. The Spider-81A is ideal for the testing lab that prefers an integrated solution without the need to interconnect separate modules.

Spider-81B
The Spider-81B front-end is a smaller, simplified system featuring 4 input channels and 1 output. This system provides everything needed to run Sine, Random or Shock tests measuring the control and up to 3 monitor signals. The Spider-81B has 4 pairs of DIO. This basic system actually provides a very comprehensive facility with the same control quality, safety assurance, measurement precision, expandability and human interface that distinguish all Crystal Instruments controllers. The Spider-81B is ideal for educational institutions and small R&D laboratories.

The Spider-80X is designed for vibration control, machine monitorings, and data acquisition.

Shown here is the Spider-80X-A35, the Spider-HUB, the Spider-NAS, and 9 Spider-80X front-ends.

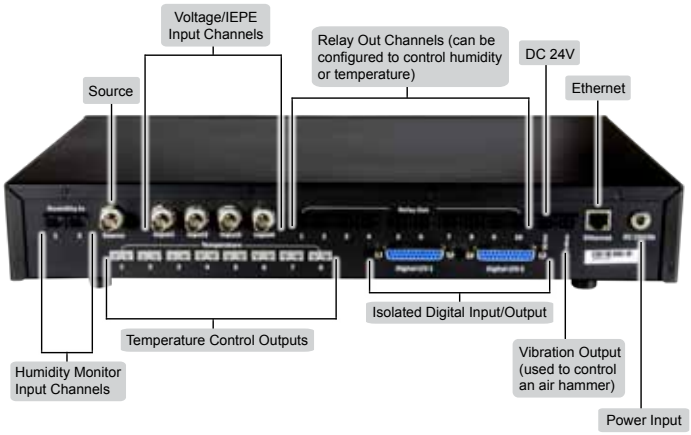
Spider-80X

The Spider-80X, a compact package, is designed for application in three fields: dynamic data acquisition, vibration control, and machine monitoring. It 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 as the Spider-81 series. The Spider-80X inputs provide absolute/differential and AC / DC / IEPE coupling choices; charge mode is an available option. The Spider-80X 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 (eight-into-one) Spider-HUB module and storage can be increased to 250 GB by adding a Spider-NAS mass storage module.

Spider-80X-A35

The Spider-80X-A35 is a dedicated eight-bay frame that houses up to eight Spider-80X front-ends. It has built-in Spider-HUB circuitry and built-in Spider-NAS mass storage capability. The Spider-80X-A35 includes a line-powered power supply and internal cables to integrate all the front-ends installed. You can build systems with 8 to 64 input channels and 2 to 16 outputs. Up to eight Spider-80X-A35 boxes may be integrated using a single Spider-HUB to achieve a system with 512 inputs and 128 output or tachometer channels. This system provides the ultimate in flexibility. It may be used as one large system, or separated into eight smaller systems. The entire system or any of its component Spider-80X front-ends may be used to run controlled vibration tests or to execute signal analysis functions.

The Spider-81C connects directly to an iPad with a built-in Wi-Fi router.



The Spider-H is a highly advanced, powerful HASS/HALT controller.

Spider-81C

The Spider-81C is the perfect answer for automotive Squeak & Rattle testing and other applications where the operator needs to be free to move about and interact with the DUT, while remaining in complete control of his test. This compact system incorporates a built-in Wi-Fi router (IEEE 802.11a/b/g/n; dual-channel; 2.4 & 5 GHz band) in lieu of wired Ethernet connectivity. It communicates with an Apple iPad® running Crystal Instruments Engineering Data Management software (EDM App for iPad) that serves as the operating interface to control an uploaded Random, Sine-on-Random (SOR), Random-on-Random (ROR), Sine or Resonance Search, Track and Dwell (RSTD) test. The Spider-81C provides 2 analog input channels, one output (the drive) and 4 pairs of DIO.

Spider-H

The Spider-H is specifically designed for Highly Accelerated Stress Screening (HASS) and Highly Accelerated Life Testing (HALT). The DUT is subjected to simultaneous vibration, temperature cycling and variable humidity. The Spider-H controls all aspects of such a test. The Spider-H controls a test using either an electrodynamic or hydraulic shaker or a pneumatic hammer-excited vibrator table. The Spider-H provides four input channels and one shaker drive output for linear shaker control. When a pneumatic hammer table is used, the controller commands the RMS vibration level via its 4-20 mA current-loop output to the table's pressure control valve. Additionally it provides inputs for two humidity sensors and eight thermocouples. Ten dedicated function switch closures control the heaters, valves and fans of the chamber. Sixteen dedicated digital ports convey test status to other systems. Eight pairs of programmable digital I/O are available for user-defined applications.

SIX STANDARD CONTROLLER MODELS AT A GLANCE

Features	Analog Inputs	Analog Outputs	Digital I/O Pairs	LCD Panel & Controls	Special Features
Spider-81	8	4	8	yes	expandable to 512 inputs using Spider-HUB
Spider-81A	16	4	8	yes	dedicated 16 channel controller
Spider-81B	4	1	4		high-quality low-cost basic controller
Spider-81C	2	1	4		built-in wireless router (no Ethernet)
Spider-H	4	1	dedicated		controls Halt/Hass chamber temperature & humidity
Spider-80X	8	2	8		Dual-function DSA and VCS module expandable to 512 channels

Crystal Instruments EDM (Engineering Data Management) software is designed for a wide range of vibration and shock testing.

EDM (Engineering Data Management) is available in English, Japanese, Simplified Chinese, Traditional Chinese, and Russian.

VIBRATION CONTROL SOFTWARE SOLUTIONS

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.

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

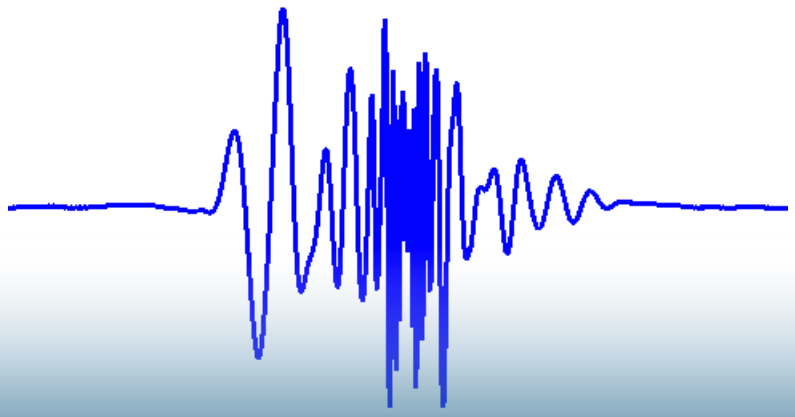
We work in a multi-lingual world. Crystal Instruments' EDM fully supports operations using English, Japanese, Simplified Chinese, Traditional Chinese or Russian (others on request) user interfaces. The selected language can be changed at any time with one mouse click.

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.

Connectivity to Other Software, Hardware and You
Various approaches have been developed to establish the connectivity between the EDM software and other applications, such as climate chamber software or an amplifier controller. Socket messages, a common language that runs on nearly all operating systems and hardware platforms, is used to send and receive messages between EDM and other software. A digital input/output hardware interface is also provided on every Crystal Instruments product, which enables interfacing to other hardware devices. You can also automatically control the power amplifier - shut it down at a test's end and switch it on when a new vibration test is to be started. When the system is left running but unattended (e. g. for an overnight or weekend run), you still remain in control. Test status reports can be sent via email or SMS text message to your mobile phone, enabling you to decide whether to return to work or not within minutes of the test stopping.

Continuous Time Data Recording
The Spider platform is capable of recording the data of 512 control/monitor input channels sampled at up to 102.4 kHz. The storage can be either internal flash memory or a dedicated SATA hard-disk. The reliability of the software for such real-time data transfer has been fully validated. Continuous recording happens in parallel with vibration control and neither is affected by the other.

Database Technology
By using latest database technology, EDM can quickly search, index and organize the testing setup and data. On the company network different testing stations can share the same database.

Pure flexibility is possible with EDM installed into Apple's iPad for versatile vibration control.

iPad Control
The EDM (Engineering Data Management) App for iPad is a software program designed for vibration control and real time data processing on the Apple iPad. It supports FFT, Random, and Sine tests uploaded by EDM PC software. The EDM App also creates tests directly on the iPad.

Through a wireless connection between your iPad and any Spider units on the wireless network, the EDM App for iPad allows engineers to monitor and control test settings and measurements, flip through existing measurement setups and past measurements runs, or create new test configurations from scratch. A wide range of display types and layouts offers online data viewing and real time interaction.

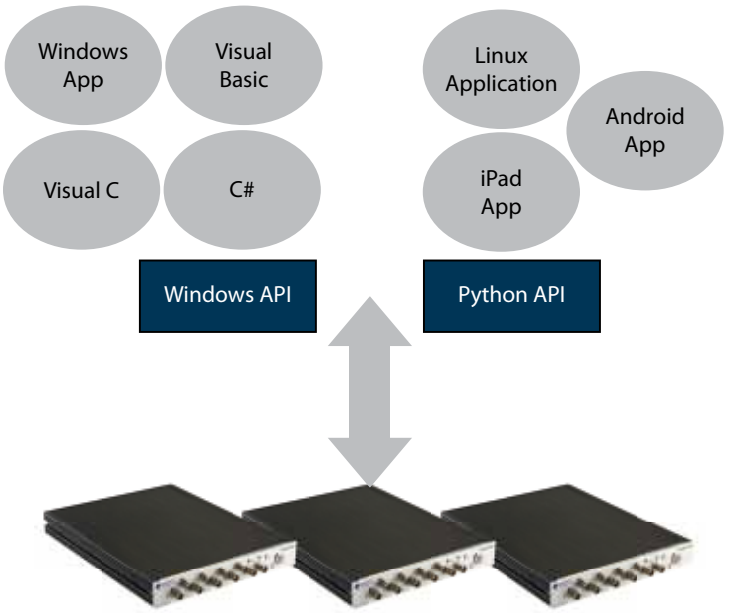
Screen shots together with testing status can be emailed as a testing report to multiple recipients with one command. The EDM App for iPad is available for download at the Apple iTunes Store.

Using the iPad brings additional freedom to test engineers, making it possible to control any shaker table in the lab while walking around freely during a test monitoring signals on the iPad in real time. The EDM App for iPad is the only software required to run the Spider hardware.

Application Programming Interface (API)
Crystal Instruments' Spider Application Programming Interface (API) is a collection of Windows Dynamic-Linked Libraries (DLL) or Python API providing an easy path for external applications to access and control the Spider-80X hardware.

If Windows OS is used, the user can develop their own applications in Windows App, VC, VB or C# languages. If Linux, iOS or Android is used, a Python API serves as the control interface.

The Spider API defines a set of command structures based on character strings. This implementation is widely compatible with various connection tools such as APIs, scripts, socket messages and handheld devices, facilitating future technical support.

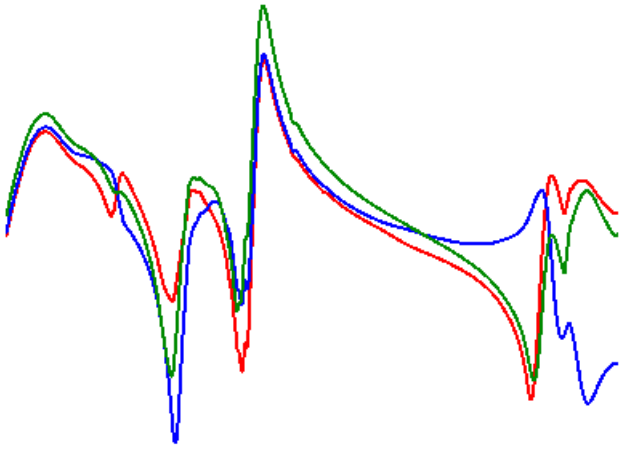


Location ID and Customized Signal Labeling
In EDM, signals can be clearly labeled with names conveying physical meaning, such as "Top" or "Front". All related signals will be renamed with such labeling automatically.

Check List for the Initial Startup
EDM can show an overview of the critical parameters to be verified before a test is actually started.

Instant Color and Style Change of UI
EDM provides a wide selection range of colors and styles for text, signals and backgrounds.

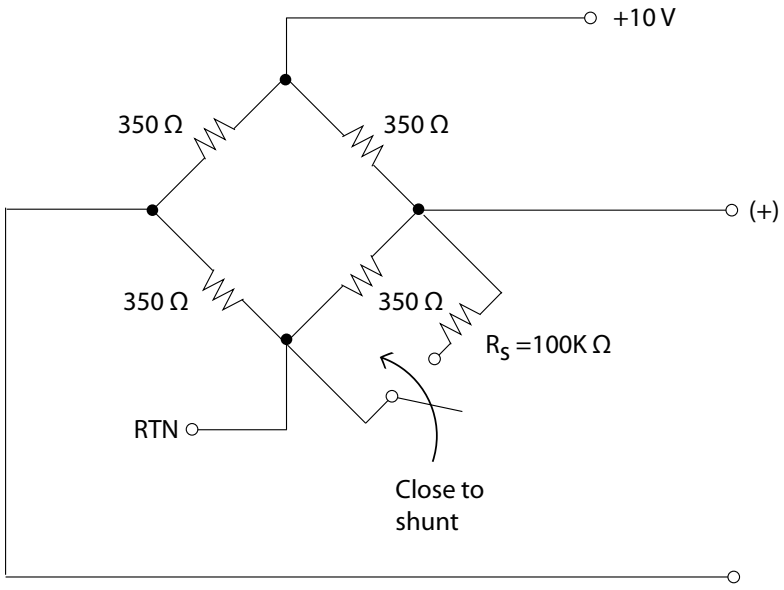
Complex FRF/Transmissibility
EDM software has a very flexible setup to measure the matrix of complex motion/force FRF (or g/g transmissibility's) which are critical for modal analysis,

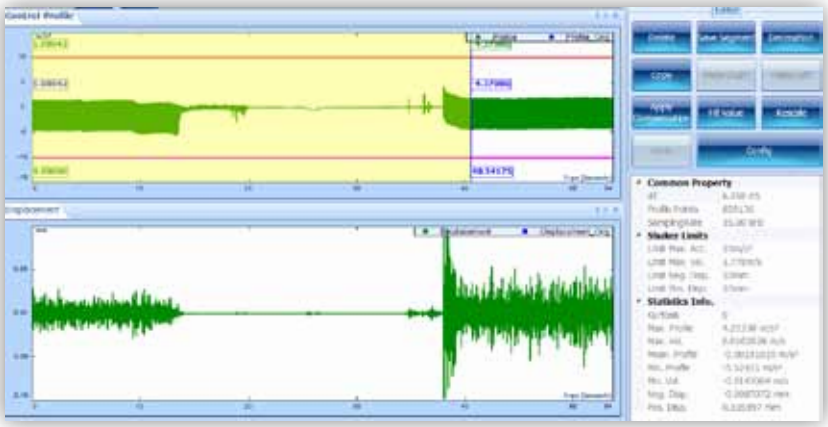


Flexible Math function
EDM software provides flexible math functions to perform block arithmetic on signals using +, -, *, / or other arithmetic operations. Math functions can be applied in both time and frequency domains.

Non-Acceleration Measurements
Any input channel can measure any type of physical signal such as displacement, temperature or pressure.

Non-Acceleration Control
The target profile may be set in various physical quantities such as angular acceleration, force or sound pressure. When controlling a low frequency test, displacement or velocity sensors (instead of accelerometers) can be used as the Control signal.





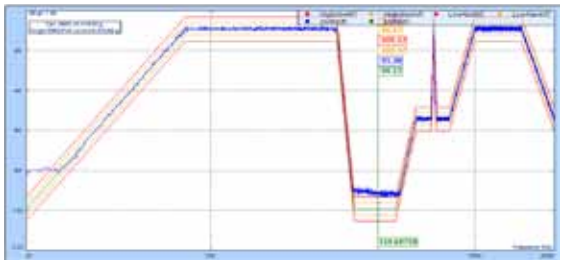
Strain Gage Hardware Expansion
Strain gage measurement can be directly integrated into DSA and VCS tests using the Spider-80SG module. This enables the user to measure strain during a controlled vibration test or analysis simultaneously. Force control and limiting can be achieved by using the strain measurement as a Limit channel.

Review and Compare Mode
After data is saved to a disk, the user can conveniently recall and review any previous testing data. The review mode allows the user to print out all control status readouts, such as level and gRMS, at the instant when the data was saved.

Waveform Editing Tool
The Waveform Editor is a “hands-on” tool to modify time waveforms so that they fit all requirements for replication on a shaker. It can splice, crop, filter, and apply compensation to acceleration, velocity, and displacement waveforms.

Remote Operation Communication using Socket Messages
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 document for Socket Message for detail specs. 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.

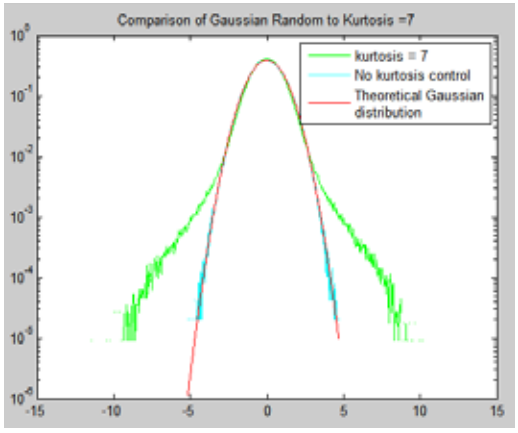
Shaker Parameters
Shaker limits are calculated from the shaker parameters and the weight of the Unit Under Test (UUT). Shaker Parameters include maximum amplifier input voltage, shaker acceleration, velocity, displacement, force, drive frequency, and mass of UUT. Shaker library settings are saved to a library and used repeatedly in different tests. Shaker parameters are imported from or exported to a Microsoft Excel spreadsheet.



Random control dynamic range of up to 90dB

Random Vibration Control

Random Vibration Control provides precise multi-channel control in real time. The device under test is subjected to true random noise with a precisely shaped spectrum with either Gaussian or non-Gaussian amplitude statistics. With a control dynamic range up to 90 dB, up to 512 channels can be enabled for Control, Notching, Monitoring and time data recording. The recording option records time-stream data at the full sample rate on all input channels. A unique hardware/firmware/software design featuring spectral overlapping provides a fast loop time of less than 15 ms in a typical test.

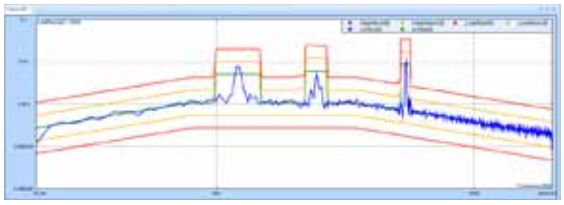


Kurtosis Control & Drive Clipping

Kurtosis control can provide a more damaging non-Gaussian random control time history. A unique patent pending technology can generate a non-Gaussian control time history while precisely maintaining its spectrum shape. Drive clipping clamps the drive signal to maximize the power rating of the power amplifier.

Non-linear and Non-acceleration Control

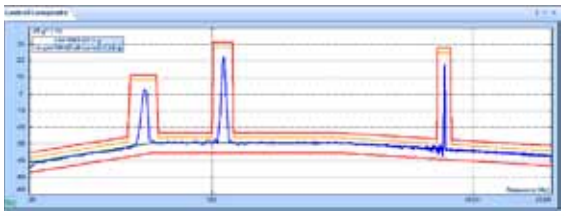
Non-linear control provides improved performance at frequencies near sharp resonances by using a unique error correction algorithm. Non-acceleration control allows measuring and controlling of physical measures other than acceleration. Displacement sensors and velocity sensors can be used together with accelerometers.



Up to 12 independent random narrow band signals

Random on Random Control

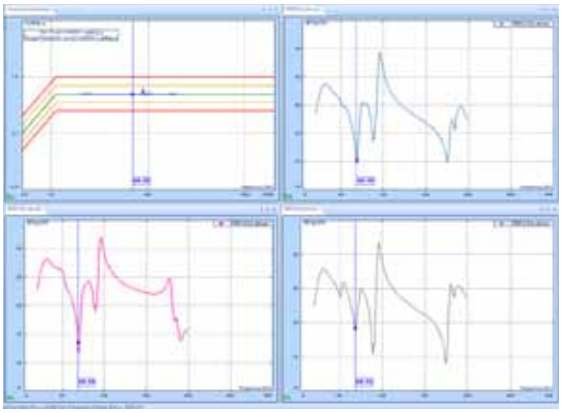
Up to 12 independent (stationary or sweeping) random narrow-band signals may be superimposed on the broadband random signal. Each narrow-band has its own sweeping schedule and range. They can be turned on and off by a predefined schedule or manually.



Up to 12 indepedently sweeping sine tones

Sine on Random Control

Up to 12 independently sweeping sine tones may be controlled in addition to the broadband random signal. Each sine tone has its own sweeping schedule and range. Tones can be turned on and off manually or by a predefined schedule.



Sine: Provides precise multi-channel control in real time.

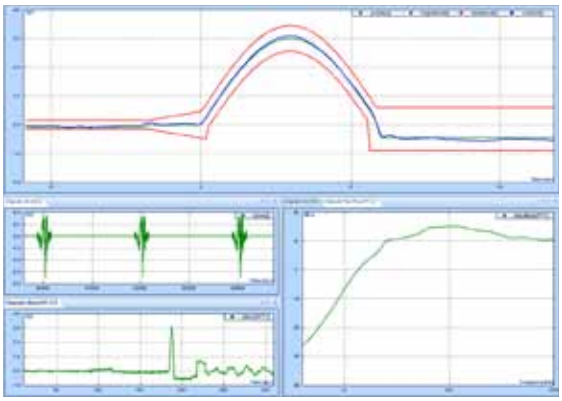
Swept Sine Control
Swept Sine Vibration Control provides precise multi-channel control in real time. It provides a spectrally pure undistorted sine wave and a control dynamic range of up to 100 dB. As many as 512 channels can be enabled for Control, Notching, Monitoring and time-data recording. The recording option records a time-stream at the full sample rate on all input channels. A unique hardware design and spectral overlapping provides a fast loop time of less than 10 ms.

A random signal can be applied during pretest for checking the loop. Precise tracking filters are often applied to each channel with either fixed or proportional bandwidth. Spectral display resolution is from 256 to 4096 lines. Linear and logarithmic Sweep-speeds can be defined in Oct/Min, Hz/Sec, Dec/Min, Sweeps/Min, Sweep Time/ Sweep or Cycles/Min. Non-acceleration control allows measuring and controlling on velocity or displacement sensors in lieu of acceleration. Multi-Drive control can drive more than one shaker. FRF measurement allows measuring the transmissibility between any channel-pair with high phase match. The standard frequency range is up to 4,900 Hz (up to 46 kHz optional). Notching, Alarm or Abort criteria can be set on each channel.

Step Sine Control
Step Sine uses a sequence of short dwells within a frequency range. The steps are uniformly distributed in a log or linear frequency scale. Step Sine Entry in Run Schedule includes user defined frequency range, step resolution and dwell duration (or cycles) at each frequency.

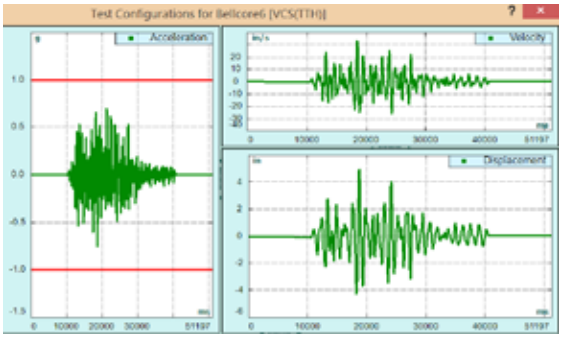
Resonance Search and Tracked Dwell (RSTD) Control
The resonance search function determines resonant frequencies from the peaks of a transmissibility signal. Dwell type (Fixed dwell, Tracked dwell, Phase tracked dwell) may be specified manually (with a list of resonance frequencies) or automatically executed after a resonance search is done. Under real-time control, the tracked dwell entry tracks each resonant frequency as it shifts with time, temperature or damage. Phase Tracked Dwell allows tracking the resonance frequency by seeking both a peak transmissibility and a specified phase angle. Dwelling continues until time duration is reached or the resonance frequency changes outside of specified limits.

Total Harmonic Distortion (THD) Measurement for Sine
This option adds the ability of computing Total Harmonic Distortion (THD) of the control and Input signals. THD plots can be generated while drive signal either steps through multiple discrete frequencies or a swept sine tone within a predefined range.



Provides precise, real-time, multi-channel control

Classical Shock Control
Classical Shock Control provides precise, real-time, multi-channel control and analysis of transient time domain motion. Classical pulse shapes include half-sine, haversine, terminal-peak sawtooth, initial-peak saw tooth, triangle, rectangle, and trapezoid. The recording option records time stream data at the full sample rate on all input channels. Shock response spectrum (SRS) analysis can be applied to any input signal; optionally control of the DUT's SRS may be executed. Applicable Test Standards include MIL-STD-810F, MIL-STD-202F, ISO 9568 and IEC 60068 (plus user-defined specifications).

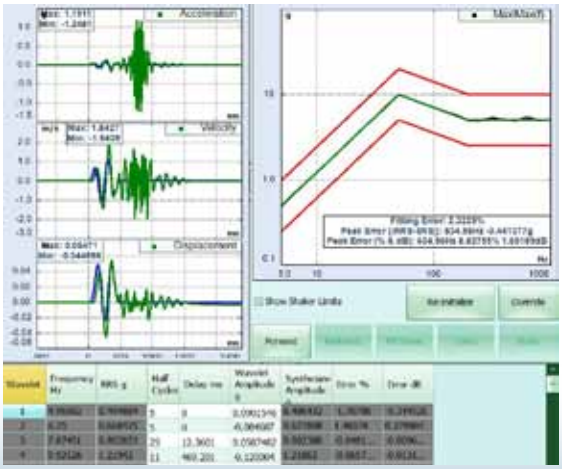


Controls shaker motion to match a defined transient waveform

Transient Time History Control (TTH)
Targeting seismic simulation applications, TTH controls shaker motion to match any user defined transient waveform.

Time waveforms can be imported to EDM in various formats. Scaling, editing, digital re-sampling, high-pass, low-pass filtering and compensation will tailor the waveform so that it may be duplicated on a particular shaker. Compensation varies the waveform so that it does not exceed the maximum shaker displacement. Methods include pre-pulse, post-pulse, pre & post-pulse, DC removal and high-pass filters. Pre-stored profiles include Bellcore Z1, Z2, Z3 and Z4; Sine; Chirp; Burst Sine and others. An option is available to run profiles requiring sampling frequency lower than 120 Hz. Large block sizes up to 64,000 samples are provided.

Shock Response Spectrum analysis can be applied to any input time signals to generate SRS instantaneously. SRS Type includes maxi-max, primary, residual and composite. A low frequency option supports imported profiles with a sampling rate lower than a few Hz.

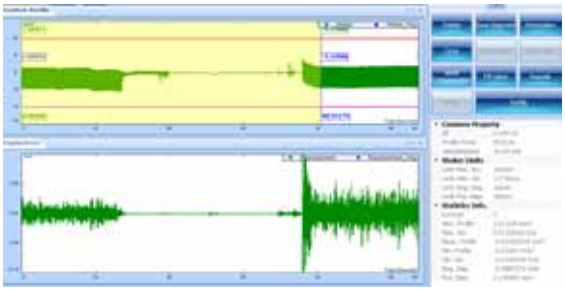


Shock Response Spectrum (SRS) Synthesis & Control
The SRS synthesis and control package provides the means to control the measured SRS of the DUT to match a target SRS, the Required Response Spectrum (RRS). The necessary drive time-history is synthesized from damped-sine or sine-beat wavelets. Damped Sine Parameters include frequency, amplitude, critical damping factor, and delay. Waveforms may be automatically synthesized from a user-specified SRS reference profile. The Transient Control option allows control using imported transient files. High frequency waveforms, Alarm and Abort tolerances may be applied to any active channel to provide an extra degree of safety for delicate test articles.

Provides precise, real-time, multi-channel control for long waveform duplication

Time Waveform Replication
Time Waveform Replication (TWR) provides precise, real-time, multi-channel control for long waveform duplication. TWR includes the Waveform Editor, a flexible importing and editing tools for long waveform signals. The Recording option records time-stream data at the full sample rate on all input channels.

Multiple waveform recordings can be available in the same test to automatically run, one after the other on the test specimen. The maximum number of points is subject to the internal flash memory space available for storing profile data (currently 3.7 GB), which corresponds to approximately 1 billion data points. At a sampling rate of 200 samples/second it can replicate a waveform of about 50 days.



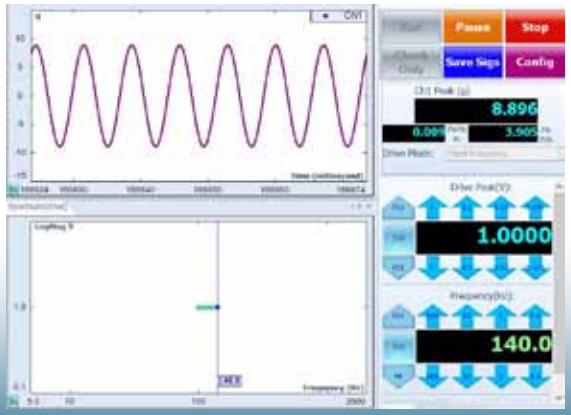
Waveform Editing for TTH and TWR
Profile Definition: Any existing signal is treated as a profile and is imported and defined as a control.

Profile Import: Waveforms with any of the following file types are imported into Waveform Editor: UFF ASCII (.uff, .unv), UFF Binary (.buff, .bunv), CI-ODS format (*.ods), EDM View Project (.vpj), TIM format (*.tim), RSP format (*.rsp), ASCII data format (*.asc), User defined ASCII format (*.txt, *.csv) and ODS ATF/XML Format (.atfx). Waveforms with any of the following file types are imported to EDM directly: ODS ATF/XML Format (.atfx), CI-ODS format (*.ods), and User defined ASCII format (*.txt, *.csv).

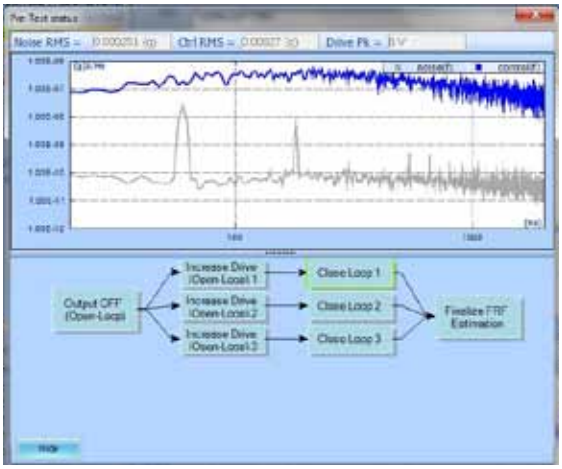
Profile Editing: Waveforms with any sampling rates are digitally re-sampled, rescaled, filtered, and different compensation techniques are applied to edit the profile using the EDM – Waveform Editor tool. Also contains options for cropping, appending and inserting parts of waveforms.

AVD Plot: Calculation of other two quantities among Acceleration, Displacement or Velocity when profile imported is of any quantity.

Profile Maximum: calculation of maximum expected acceleration, velocity and displacement, checked against shaker limits.



Sine Oscillator
Sine Oscillator is a diagnosis tool with manual control of the sine output while the system displays various time signals and frequency spectra. Random excitation can be enabled as a checkup function. When the close-loop option is enabled, the Sine Oscillator is essentially a limited sine controller with more manual control functions.



Multi-shaker Control for Sine or Random
This option enables the system to output two random drive signals simultaneously, to control two shakers. The phase difference between each drive and control signal is calculated and taken into account during real-time operation. This option supports two shaker systems mounted either in push-pull or parallel-drive configurations.

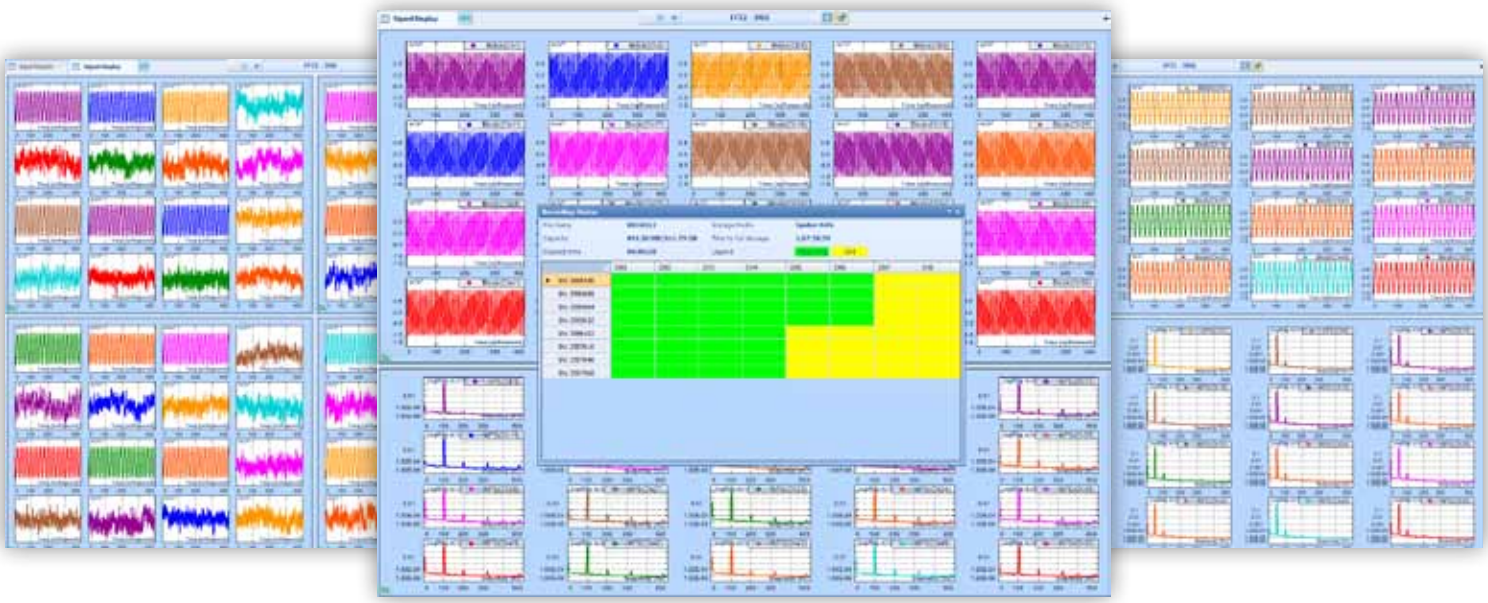
Non-acceleration Control
With this option, a non-acceleration measurement quantity can be applied to the control signal. This provides an option of choosing from multiple quantities including force, sound pressure, and voltage to be controlled when appropriate sensors are used. Angular acceleration can be controlled in sine and random tests using the appropriate selection. The controller is also capable of using mixed displacement, velocity and acceleration sensors to synthesize a control signal in the acceleration domain.

Real-time Sine Reduction
Real-time sine reduction offers a solution to extend the number of measurement channels of a vibration controller system in a swept sine test. This software is run by a Spider dynamic signal analyzer (DSA) system while an independent vibration controller controls the shaker. The sine reduction application calculates the same time and frequency functions as the controller, but using its own input signals. This function requires a COLA signal from the vibration controller system for instantaneous frequency, phase detection, and spectrum analysis.

Spider Front-end Calibration Software
The front-end is calibrated at the factory prior to shipping and should be recalibrated annually by a factory authorized calibration service. EDM has an optional calibration tool that is operable by either the user or a calibration specialist. Calibration data is stored inside of the Spider front-end.

- ***Calibration Software Functions:*** The calibration software calibrates the signal source and adjusts the DC and AC gains and offset. It also calibrates the input channels at all coupling types and adjusts the DC and AC error. The report includes the model number, text for the calibration meter, and the calibration operator's name. The report is viewed or printed from the host PC.

Sensor Calibration
The Sensor Calibration tool is used to calculate the sensitivity of sensors while the measurements of the sensors are compared against referenced sine-wave input signals. The user enters the following information: calibration signal nominal frequency, either RMS reading or dB RMS, and a reference (0 dB) value. The front-end automatically calculates the RMS levels and updates the sensitivity table. The user accepts or rejects the calibration results and views the reports.



CONTINUOUS DATA RECORDING AND POST ANALYSIS

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.

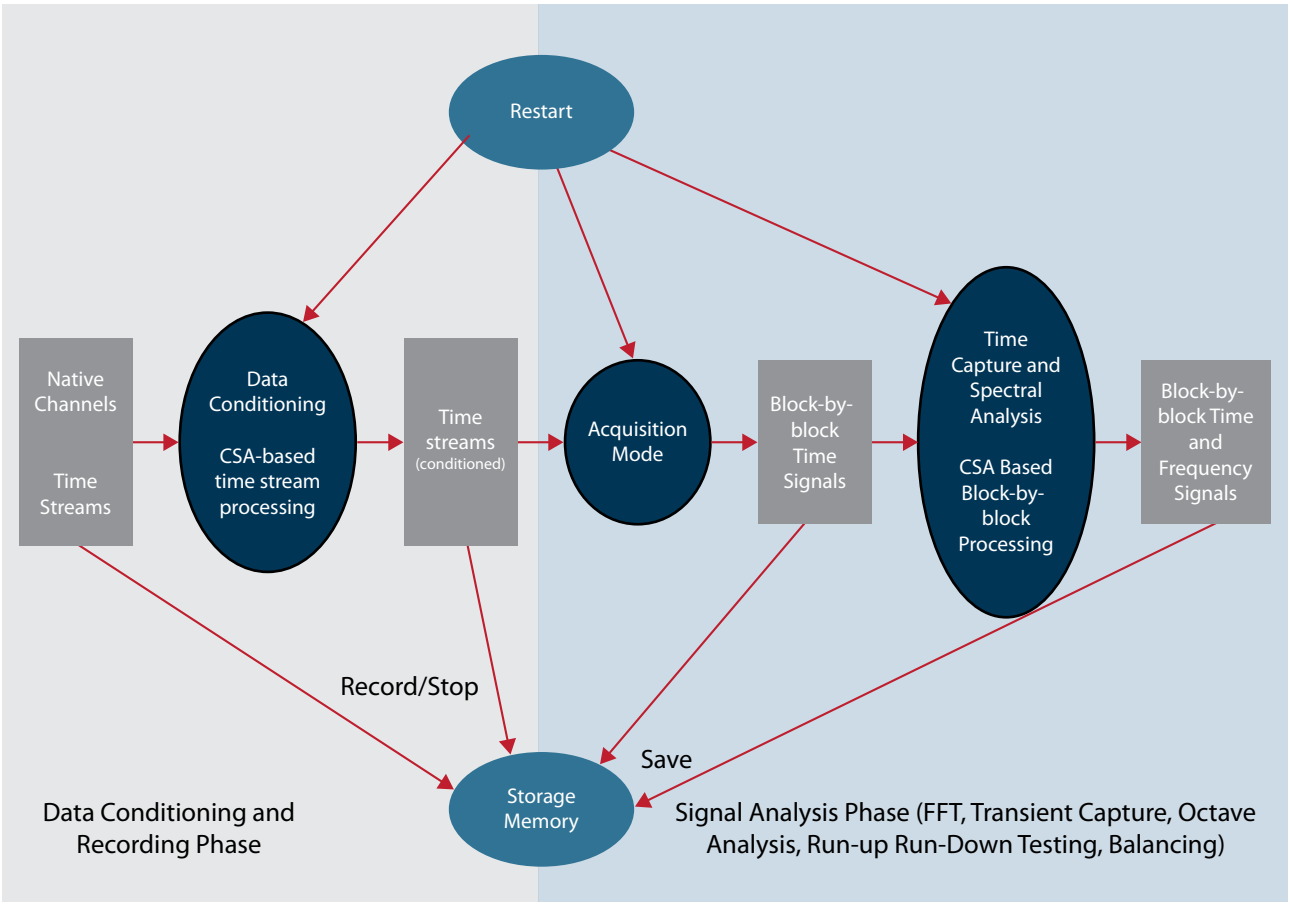
The CoCo and Spider platforms simultaneously perform both real-time processing and continuous data recording. In most of real-time applications, the raw data can be recorded at any desired sampling rate with full 32-bit floating point precision. To increase the reliability of data recording, a special 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 both CoCo portable devices and 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 both CoCo and 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.

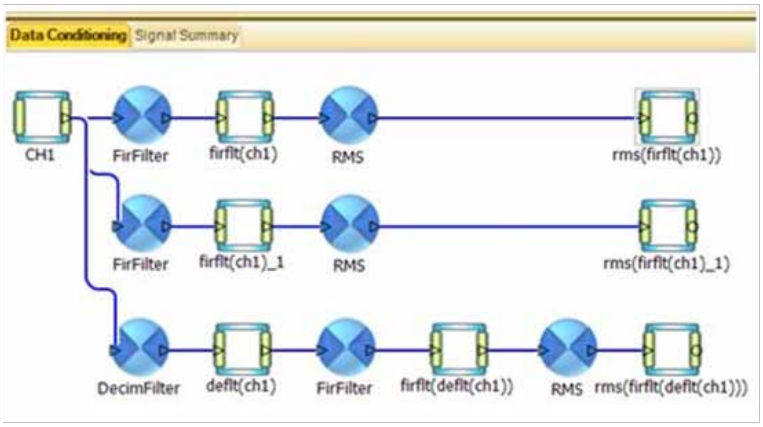


The CoCo handheld data recorders are a portable solution for continuous data recording.

Portable Recording Solution

The CoCo provides a portable solution for continuous data recording. Dedicated record and stop buttons are provided on the front panel enabling the user to initiate or terminate recording at any time. The storage media can be user selected as either the internal flash memory or the removable SD card. Using Configurable Signal Analysis (CSA) on the PC, the user can cause the CoCo to record not only selected raw time-streams, but also any filtered or processed time-streams such as RMS or peak values. The maximum data recording rate of the CoCo-80 is 102.4 kHz for 8 channels simultaneously. When less precision is required and longer duration is needed, a special compression function can be enabled to double the recording time. After the recording, there are two ways to make data easily available for post processing: Using EDM software to transfer the data into PC or, physically moving the CoCo SD card to the PC.

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 system for data recording diagram.

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

Using EDM Cloud, a web-based software tool, 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. Using EDM Cloud, the data files can be downloaded to any user site for periodic evaluation or interplant comparison.

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 1k Hz/ch sampling rate: 4660 hours ■ 8 channel at 5k Hz/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

ENGINEERING DATA MANAGEMENT (EDM) POST ANALYZER

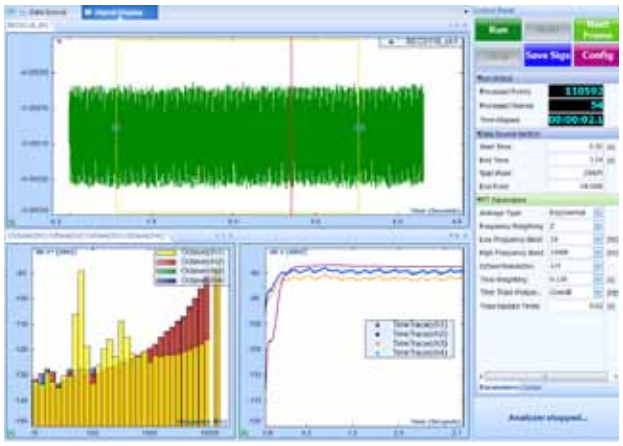
Crystal Instruments has developed EDM supportive applications including three separate software modules: Post Analyzer, Waveform Editor, and File Converter. After the raw time data are recorded, they can be viewed and processed at any time using the Post Analyzer (PA). Post Analyzer contains many powerful post-processing tools with batch processing capability. On the PC, PA completely re-implements those algorithms realized on the Spider DSP. Therefore any processing results on a real-time analyzer can be recreated again and again with the PA analyzer. Many users prefer to record the raw time stream data beforehand and perform analysis later with PA instead of implementing real-time processing due to time restrictions during the test.

The PA software can analyze the data recorded from hundreds of measurement channels using the familiar operator interface of EDM. The report function of PA is also in the same format as EDM. PA is available in three versions: PA Viewer allows the user to view data and create reports; PA Basic adds FFT spectral analysis and 3D signal display functions; PA Premium provides more advanced functions such as FRF, real-time filters, sound level meter, octave filters and order tracking.

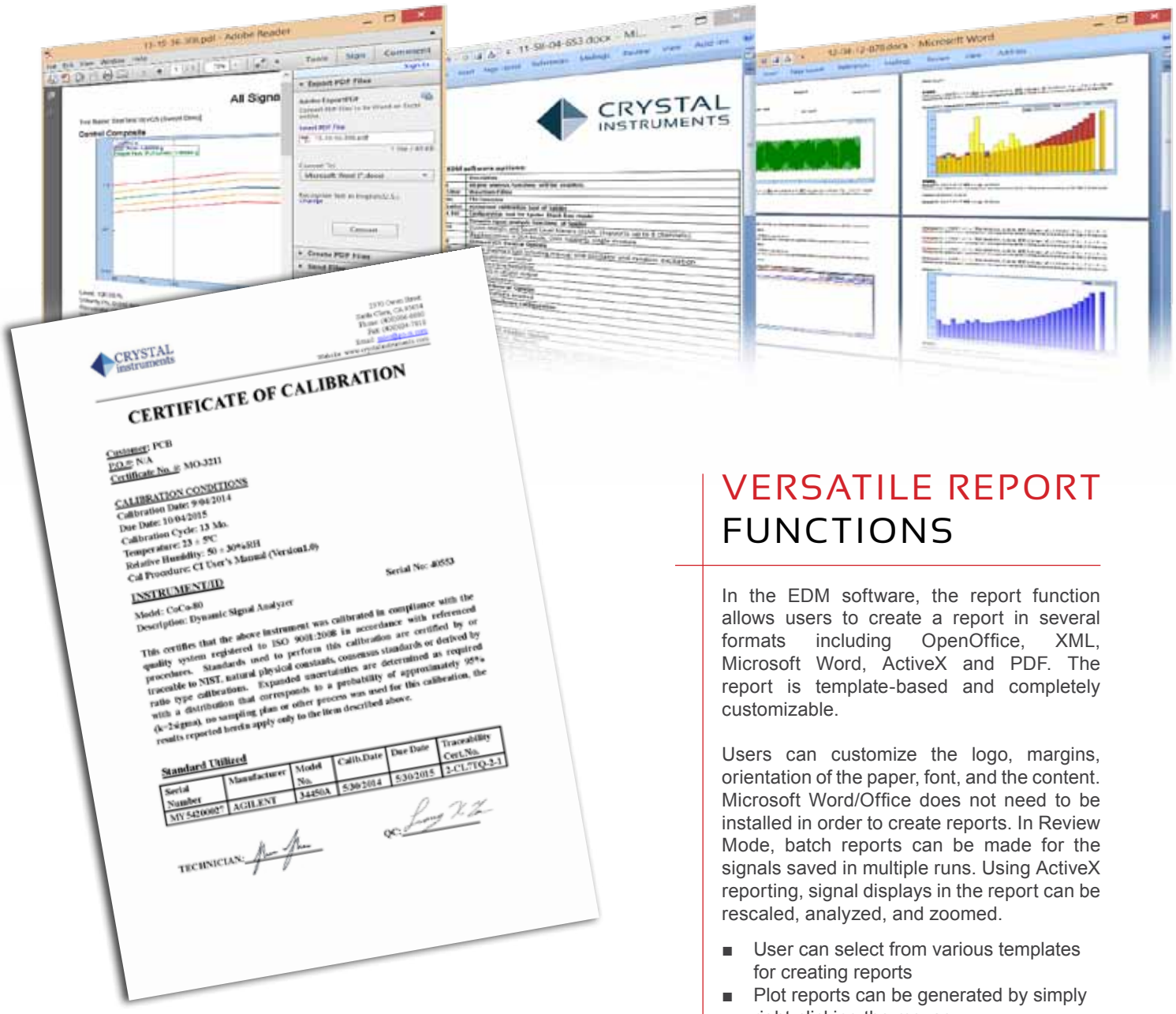
Waveform Editor is an independent Windows application that allows the user to cut, edit or merge time waveforms. It may also be used to compare the safety limits of a profile signal against a given shaker table.

File Converter is an independent Windows application that converts files in various data formats to standard ATFX format.

Functions	PA Viewer	PA Basic	PA Premium
Time domain signal display and playback	√	√	√
3D display: waterfall, color map	√	√	√
Create reports in Word, PDF, Open XML formats with template	√	√	√
Export to standard formats including ASAM-ODS, UFF, BUFF, MATLAB, user-defined ASCII, Excel CSV, and wave files	√	√	√
Data file batch processing		√	√
Acceleration, velocity and displacement display conversion		√	√
FFT Spectral analysis: FFT, auto power spectra, cross power spectra, frequency response function		√	√
User defined data conditioning modules			√
Digital Filters: IIR, FIR, LPF, HPF, BPF			√
Digital re-sampling			√
Octave filter analysis			√
Order Tracking			√
Shock Response Spectrum			√
Sine Reduction			√
Orbit plot			√
Polynomial Curve Fit			√



Analyze recorded data using the highly intuitive and easy-to-use interface of EDM Post Analyzer.



VERSATILE REPORT FUNCTIONS

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

PREMIER TECHNOLOGY SUPPORT AGREEMENT

Crystal Instruments understands the enormous investment our clients put into our products. We match their investment by offering the most comprehensive technical support agreement in the industry. From support calls to staff training, Crystal Instruments provides solutions to our customers' needs.

The "Premier Technology Support Agreement" offered by Crystal Instruments is fairly priced as a small percentage of the total purchase value. The services offered and included in the agreement are for the duration of 1 year. The agreement is renewable at a locked in rate as a subscription. Rates are subject to increase if a subscription is not continued at the time of renewal and signed up for at a later time. Please contact Crystal Instruments for pricing information.

Services offered are:

- Annual software upgrade program - accessible by convenient online downloads
- Annual hardware calibration
- Priority phone/email/live video support from highly trained engineers
- Temporary replacement unit for hardware in 48 hours
- Data recovering services
- Hardware repair when the total service hours required is less than 4 hours per incident

ANNUAL HARDWARE CALIBRATION

Crystal Instruments has ISO:9001 certified facilities and highly trained engineers to perform harware calibrations. Hardware calibrations are also performed at the customer's site upon request. Customers with a Premier Technology Service Agreement will receive standard annual hardware calibration services at no additional cost (a $1500 value).

ANNUAL SOFTWARE UPGRADES

Crystal Instruments provides convenient solutions for software upgrades. Users are able to download the latest versions of Crystal Instruments' Engineering Data Management (EDM) software through the support website.

Other options include emailed links to download software updates, physical CD-ROMs sent to your location, and installation instructions provided over the phone by our highly qualified Applications Engineers. Customers with a Premier Technology Service Agreement will receive standard software update services at no additional cost.

TEMPORARY REPLACEMENT UNITS

Crystal Instruments strives to minimize any inconvenience to our customers' operations. Temporary replacement units are often provided to customers as a solution. Units will usually be assigned to customers within 48 hours or less.

LIVE PRODUCT SUPPORT

Crystal Instruments support staff is based in Santa Clara, CA at our corporate headquarters. Our support staff provides phone and email support from 8am to 5pm PST, Monday through Friday. All support is provided by highly trained engineers, not technicians. After hours support is also available upon request.

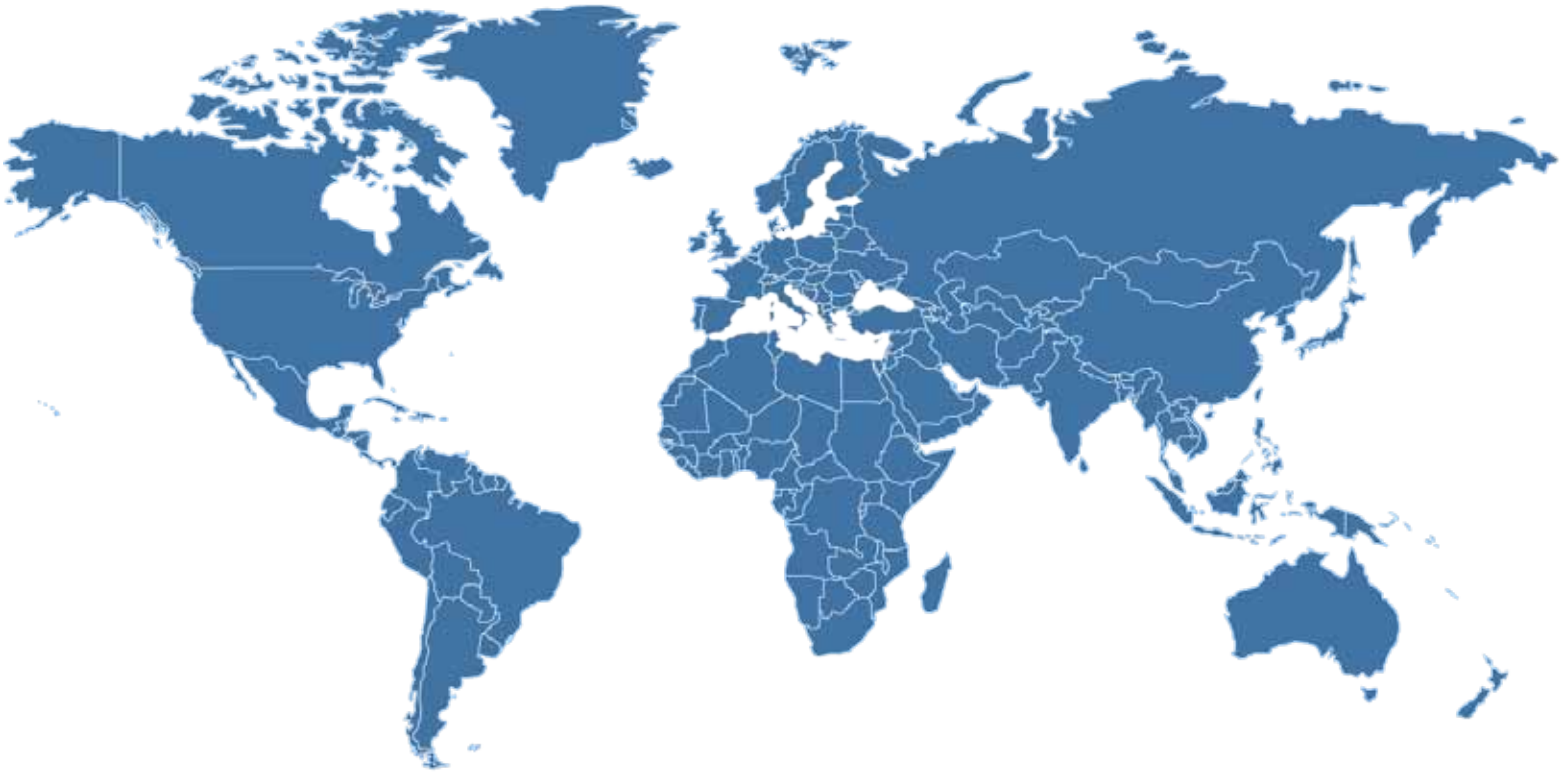
Crystal Instruments' highly diverse staff provides native language support in English, Spanish, Mandarin, Cantonese, Japanese, Taiwanese, Persian, Hindi, and Vietnamese.

HARDWARE REPAIR SERVICES

Crystal Instruments provides hardware repair for units estimated to have a 4 hour or less repair service period. Additional hours required for repairs are charged at an hourly rate. Replacement parts are discounted by 30% under the Premier Technology Support Agreement. All hardware repair takes place at Crystal Instruments headquarters in Santa Clara, CA. Our highly trained technicians will accurately and efficiently repair your equipment in our ISO:9001 certified facilities.

DATA RECOVERY SERVICES

Crystal Instruments understands the importance of recovering any lost data safely and securely. Our staff is ready and available to assist you through any data loss crisis.



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