CRYSTAL INSTRUMENTS

DYNAMIC TEST & MEASUREMENT SOLUTIONS

WWW.CRYSTALINSTRUMENTS.COM

TABLE OF CONTENTS

CRYSTAL INSTRUMENTS

"We believe in innovation. Innovation leads to higher quality, better solutions, and superior products. Our team's commitment to leading innovation in our industry is a great source of pride for Crystal Instruments." - ***James Zhuge Ph.D, President and CEO of Crystal Instruments***

TECHNOLOGY AND INNOVATION DRIVES OUR SUCCESS

In 1993, only two years after I came to the USA, I read about a new technology that was just introduced into the consumer industry. Microsoft began to support the sound card with their early version of Windows. A small start-up company, m-Wave (I still remember its name), used an ADC chip which claimed to have a digital (instead of analog) anti-aliasing filter. When I looked at the existing dynamic measurement instruments, I found that the size of their digital processors was getting smaller and smaller. But the analog circuitry (and its controls) remained bulky, dominating an instrument's packaging. I also noted that high-performance analog anti-aliasing filters occupied a disproportionate amount of an instrument's printed circuit board area. These complex circuits also required careful final adjustment and tuning. The analog filter size represented a real barrier to miniaturizing a modern digital device. I thought that if we could adopt the same technology that m-Wave used in its sound card in our testing instruments, we could probably build a very small dynamic signal analyzer.

With the support of my wife, I quit my job and partnered with an ingenious hardware engineer, Gang Fang. We successfully integrated the analog-to-digital-converter (ADC) with this digital anti-aliasing filter into a type 2 PCMCIA card. It was only 5 mm thick but could do everything a HP5420 signal analyzer could. In 1996, Crystal Instruments was officially formed and we introduced the "smallest dynamic signal analyzer in the world". That product was widely used by many companies and was adopted by the US Navy. Years later, an independent company did a survey that concluded: "Crystal Instruments was the first company to adopt the sigma-delta A/D converter in this industry." Nowadays, 100% of dynamic measurement systems use sigma-delta ADCs.

In 1996, I co-founded another company, Dactron Inc. Lansmont, a well established Monterey-based manufacturer of test equipment, became its major shareholder. I identified an opportunity to build the next generation of vibration controllers. At that time, there were no controllers using Microsoft Windows programming technology or floating point signal processors in the market. Additionally, the now ubiquitous USB bus was unknown to controller users. Providing complete new hardware and software solutions for the user interface, DSP processing and external connectivity, Dactron's vibration controllers grew to take more than 50% of the world market (measured by unit sales). Dactron was then acquired by Bruel & Kjær/LDS.

When I speak with vibration people, it sometimes seems like they come from two worlds, speaking the same words but often inferring quite a different meaning. For example, the guy who is doing rotor balancing refers to spectrum amplitude in peak units, while the user doing general dynamic signal analysis may use six different ways to describe the spectral amplitude, including power spectral density (EU2/Hz). In 2004, I thought it would be a great idea if we could make a single handheld device to meet the requirements of both the machine vibration diagnosis and dynamic signal analysis worlds. Rather than repeat the "let's educate the user" blunder, we chose to make two completely different user interfaces in the same instrument.

The CoCo-80 was a great success owing to this concept. With two different working modes, one device performs simple route data collection or advanced acoustic real-time processing. It speaks to its user in familiar words which he understands in both cases.

While we were designing the portable vibration analyzer, we became aware of a high-resolution measurement technology developed by Cisco that acquired and analyzed radio-frequency data using multiple A/D converters. In the same era, Bruel & Kjær introduced its Dyn-X® front-end that claimed very high dynamic range in the measurement. Following this direction, Crystal Instruments developed a unique new algorithm to cross-calibrate multiple ADCs viewing the same signal through different input gains and to "stitch" their time–histories into a single glitch-free high resolution measurement. This technology completely eliminated the need for user operated gain settings in an instrument. This solved a very frustrating problem encountered when using a handheld instrument or a high channel count system. The user no longer had to optimize the input range for each channel. In a Crystal Instruments product, real-time processing does this for you automatically, providing 150 dBFS of input dynamic range.

In 2005, we saw an interesting development in the telecommunications field. Methods and standards evolved that allowed multiple network devices to be time-synchronized very accurately using nothing but the Ethernet bus itself. I was really fascinated with this idea because time synchronization is a big issue when building a distributed high channel-count dynamic signal measurement system. I met with John Eidson who invented this technology when he was employed by Agilent. John was awarded high honors by Agilent for this invention. Coincidently, we both go to the same gym in Palo Alto, CA. We talked from time to time while John was weight lifting. I decided to adopt this technology in our next high channel count measurement system. The concepts for the Spider platform were nearly formed by then. After years of hard work by our engineering team, Crystal Instruments became one of a few first companies to incorporate IEEE 1588 PTP technology in a networked measurement platform. Measurement devices can now be time-synchronized within tens of nanoseconds while separated by hundreds of meters without using a dedicated hardware clock cable.

We provide innovative solutions in a very traditional market place. Our customers delve into the mysteries of acoustics, they solve vibration problems and they keep process machines running smoothly by tracking and diagnosing their signature variables. These are old problems, traditional problems. The joy of our industry is being able to bring exciting new solutions to these problems. We love to craft sharper tools for better measurement!

- James Zhuge, President and Chief Executive Officer

TIMELINE OF ACHIEVEMENTS

- 1996: Crystal Instruments released the world's smallest dynamic signal analyzer in a type-II PCMCIA form factor. It was the first vibration analyzer in the world using sigma-delta A/D converters.
- 2007: Crystal Instruments introduced the CoCo-80, the first handheld data recorder, real-time dynamic signal analyzer, and vibration data collector that matched the performance of high end lab quality instrumentation.
- November 2007: The US patent office granted Crystal Instruments an important patent, #7302354. This innovation provided an advanced technique that can greatly increase measurement dynamic range and accuracy. All Crystal Instruments products use this patented technology today.
- 2009: Crystal Instruments introduced the Spider-80, a highly scalable network-based dynamic measurement system that can measure up to 512 dynamic input channels with full data recording capability.

- 2011: Crystal Instruments introduced the 4th generation of vibration controllers, the Spider-81.
- 2012: Crystal Instruments received ISO 9001:2008 certification, reaffirming our dedication to high quality products. Crystal Instruments India Private Limited is established.
- 2012: Crystal Instruments released the Spider-HUB, an industrial ethernet switch with networked accuracy up to 50 ns.
- 2013: Spider-80X is released, based on the Spider-80 design. Features two additional tachometer channels and the ability to stream data directly to a network attached storage device (Spider-NAS).
- 2014: Spider-80SG strain gage measurement system is introduced. It includes support for quarter-bridge, half-bridge, and full-bridge installations.

INDUSTRIES WE SERVE

MACHINE CONDITION MONITORING

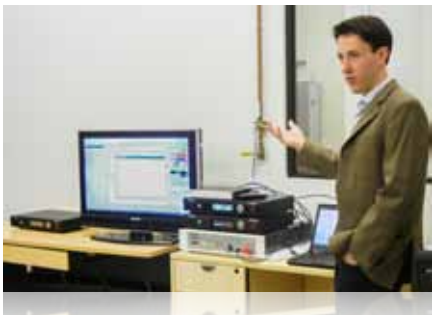
Smooth running process machinery buoys and maintains the world's economy. Products ranging from gasoline and chemicals to paper and steel are produced by continuous manufacturing processes. Nuclear, coal-fired, natural gas fueled, hydroelectric, wind powered or tidal-driven, power generation plants must produce continuously. Unexpected stoppages are the anathema of all these industries and vibration monitoring is a proven means of preventing them. Effectively monitoring the operating health and rapidly diagnosing the occasional mechanical woes of production machines is a vital survival mission in today's competitive business world. Today's monitoring technology has divided to follow two equally important strategic paths. Expensive plants and critical machines are continuously monitored by permanently installed systems. Less critical machines (and plants monitored by external contractors) are protected by routed periodic measurements made using handheld data collector/analyzers guided by advanced database and analysis software. Crystal Instruments produces innovative offerings in support of both strategies.

Web-Based Continuous Condition Monitoring

- Continuous measurement of shaft-to-case gaps
- Continuous measurement of case accelerations
- Track bearing temperatures, lubricant debris
- Share data anywhere, anytime via Internet
- Local recording to solid-state mass memory
- Automatic record-on-alarm operation

Route-Based Periodic Condition Monitoring

- Design and manage monitoring relational database
- Measure consistent error-free data along route
- Make voice-annotated data recordings of problems
- Upload data to PC; generate alarms and reports
- Make at-machine diagnostic measurements
- Perform 1 and 2 plane rotor balancing



AUTOMOTIVE

Automotive applications span a broad range of technology from design through product quality auditing. Manufacturers are under enormous competitive pressure to provide increasingly improved quality, safety, mileage, luxury, and economy. This places a heavy burden on automotive NVH Engineers to accomplish more, faster. Fast-paced development cycles in the modern car, truck, and coach industry demand the use of functionally flexible measurement equipment with friendly intuitive operation to unravel the dynamic and acoustic mysteries of the modern vehicle.

Data Acquisition and Analysis

- In-vehicle data recording and analysis with GPS
- Dynamometer testing and chassis tuning
- Drive-line balance and stability tests
- Component and body-in-white modal tests
- Pass-by acoustic monitoring
- NVH and whole body vibration

Vibration Control

- Component shake tests with road-recorded loads
- Material and component fatigue evaluations
- Component durability testing
- Transport simulation, time waveform replication
- Finite element model verification
- Multi-drive with multi-shaker test

AEROSPACE

Development of space vehicles, satellites, fixed wing aircraft and helicopters is a technologically leading business calling for the most advanced analysis and control instrumentation. Design verification of hardware and mathematical models is an all important activity. The high cost of aerospace structures and the uniqueness of prototypes demand the most careful conduct of every controlled vibration investigation. Probing the edges of the unknown calls for extreme dynamic range and analysis flexibility in the measurement hardware employed.

Data Acquisition and Analysis

- Ground Vibration Tests (GVT)
- Wind tunnel dynamic studies
- High channel reliable data recording
- Flight stress and vibration recording
- External and internal acoustical surveys
- Engine durability testing

Vibration Control

- Sine, RSTD, Random, SoR
- Durability tests using recorded flight data
- Launch and separation simulation
- Payload dynamic qualification
- Proof-of-performance component stress screening
- MIL-Spec testing

EDUCATION

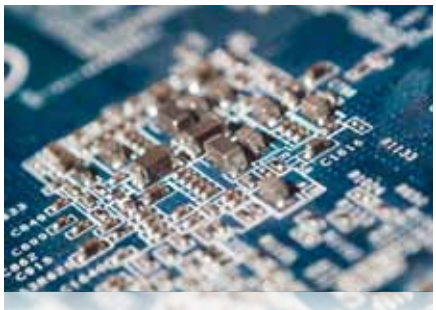
Producing first-rate engineers is a daunting responsibility. More and more, experimental skill and experience with technologically advanced instrumentation is demanded by industry. Today's engineer needs to be both analytically competent and experimentally capable. Leading universities have broadened their curricula and softened the edge between electrical and mechanical studies to serve this need. Economic constraints place a premium on cost-effective instruments that can perform a variety of task by changing software. Flexible licensing that allows hardware modules to be used separately around the campus or to be brought together to form a large channel count system is now essential.

Data Acquisition and Analysis

- Introduction to digital signal processing
- Observing vibration and acoustic phenomena
- Characterizing analog electronic circuits
- Rotating machinery analysis
- Modal testing and analysis
- Real-time digital filters with configurable signal analysis

Vibration Control

- Introduction to electro-dynamic shakers
- Introduction to hydraulic shakers
- Concepts in shaker control
- Swept-sine testing
- Random testing
- Shock testing



MILITARY

The military forces of the United States design and acquire a variety of specialized hardware and systems for use on land, in the air and at sea. Military acquisitions range from miniaturized electronics packages to surface ships and aircraft. All of this material is subjected to rigid incoming inspection and testing in accordance with military specifications.

Data Acquisition and Analysis

- Ship and submarine silencing
- Helicopter and jet vibration
- Vehicle dynamic strain recording
- Flight/road test recording
- Engine/driveline analysis
- Route-based vibration data collection

Vibration Control

- Random shake testing
- Swept-sine shake testing
- Classical shock testing
- Drop-table shock testing
- Pyrotechnic shock tests and SRS
- Flight and launch simulations

TESTING LABS

Commercial testing laboratories provide capital facilities and in-depth testing expertise to industry. They often represent the least expensive means to qualify a product and prove its compliance to a broad range of specifications and codes. Leading test laboratories have an extensive range of shaker and shock test facilities supported by the most modern control and analysis electronics available.

Data Acquisition and Analysis

- Stress and vibration recording
- CE requirement testing
- Product vibration surveys
- Component modal studies
- Servomechanism verification
- Circuit performance tests

Vibration Control

- Product durability testing
- Random, SoR, RoR shake testing
- Swept-sine, RSTD shake testing
- Shock-on-shaker testing
- Seismic testing and earthquake simulation
- Combined thermal and stress testing

ELECTRONICS

The electronics industry spans and affects every aspect of human life. It is an extremely broad industry ranging from military hardware to personal entertainment products and everything in between. Personal computers, tablets and smart cellular telephones are part of everyone's life and of many industrial systems. Chronometers, radar, sonar and GPS let us navigate our world precisely. Radios, television and the internet keep us informed and communicating. All of these things have analog components to be understood and packaging concepts to be qualified.

Data Acquisition and Analysis

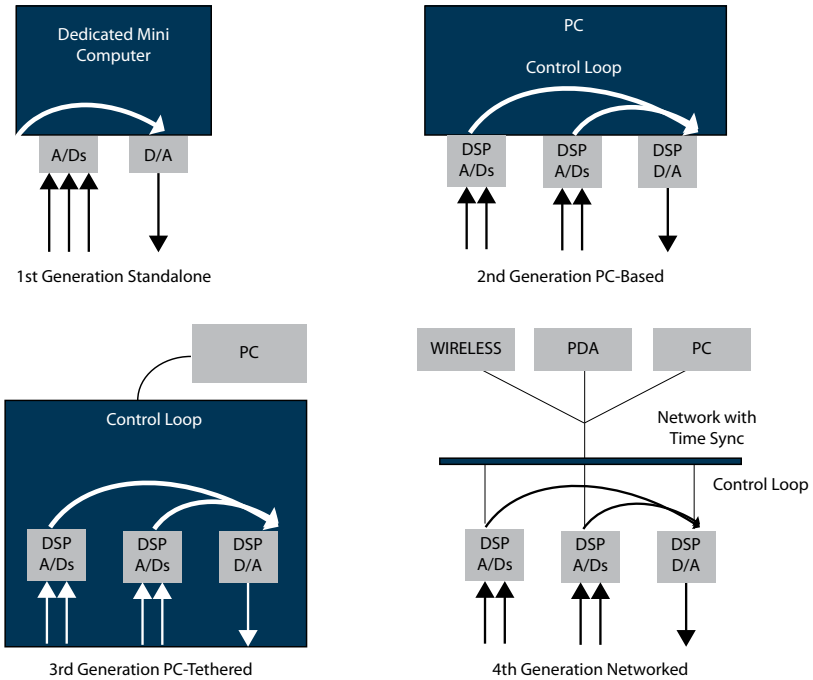
- Analog circuit bench testing
- Analog network analysis and tuning
- Characterizing component background noise
- Measuring gain, phase and linearity
- Magnetic field frequency response
- Verifying system poles and zeros
- Automated production test

Vibration Control

- Highly accelerated stress screening (HASS)
- Highly accelerated life-testing (HALT)
- Package design verification
- Spec-qualifying a module, chassis or rack
- Environmental simulations; packaging tests
- Drop-testing shock response analysis
- Sine and dwell test for qualification

VIBRATION CONTROL SYSTEM HARDWARE PLATFORMS

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



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

INTRODUCTION

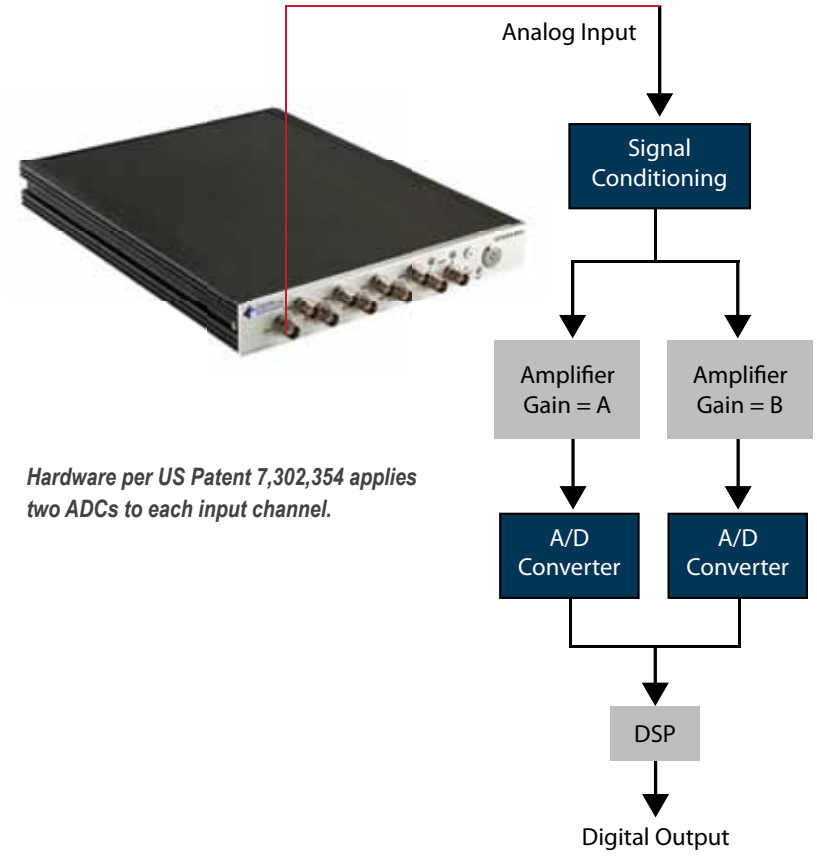
In shaker vibration testing, the device-under-test (DUT) is rigidly mounted to the table of an electro-dynamic (or hydraulic) shaker. A closed loop control system causes a test object to experience a prescribed vibratory motion of sinusoidal, random or transient form (or a combination of these). How 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

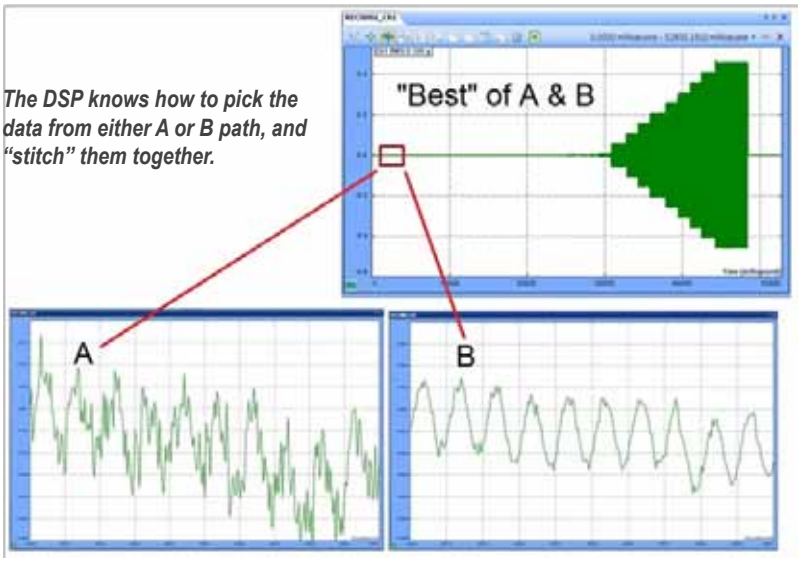
The Spider front-ends have voltage, IEPE and charge inputs which are ideal for shock, vibration, and acoustic measurement, strain or general purpose voltage measurement. The internal flash memory stores test configuration data for controlling up to hundreds of channels simultaneously and stores real-time 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.



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



The 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 passes 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.

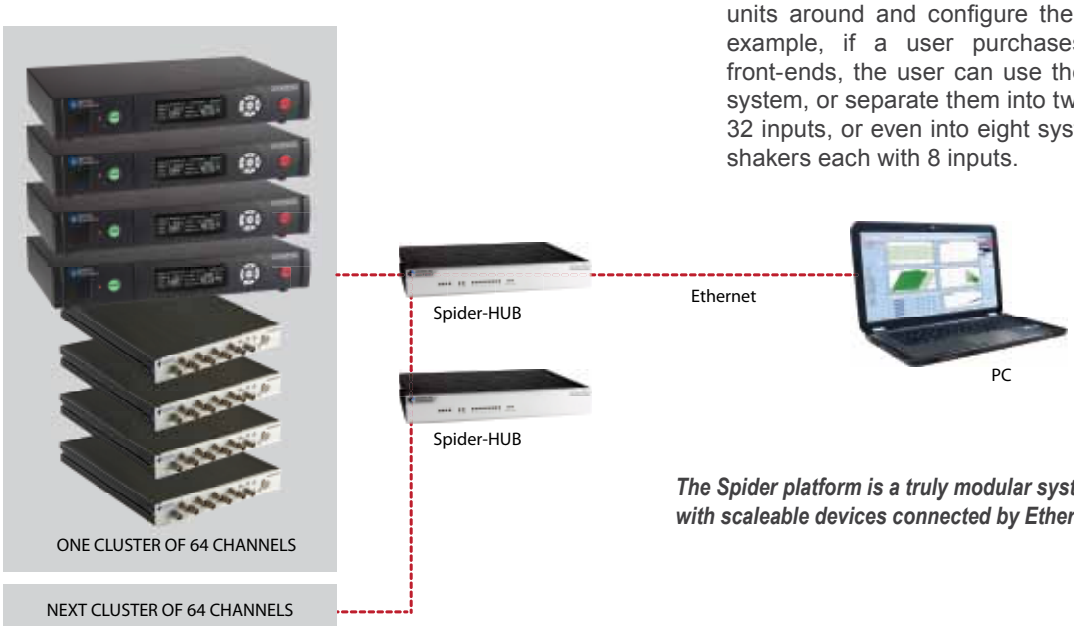
Designed for High Performance Control
By using enhanced control algorithms and a simplified DSP architecture, the feedback loop time of Sine and Random control are greatly reduced to a 10 ms latency. Reduced control loop time improves performance for resonance search and tighter control for a structure 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 their units around and configure their own systems. For example, if a user purchases eight Spider-80X front-ends, the user can use them 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 50 ns accuracy. 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 are the Spider-80X-A35, the Spider-HUB, the Spider-NAS, and 9 Spider-80X front-ends.

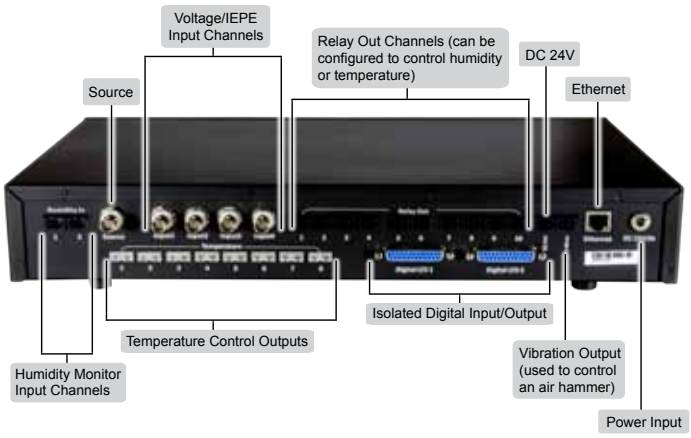
Spider-80X

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, or a Track and Dwell (RSTD) test. The Spider-81C provides 2 analog input channels, one output (the drive) and 4 pairs of DIO.

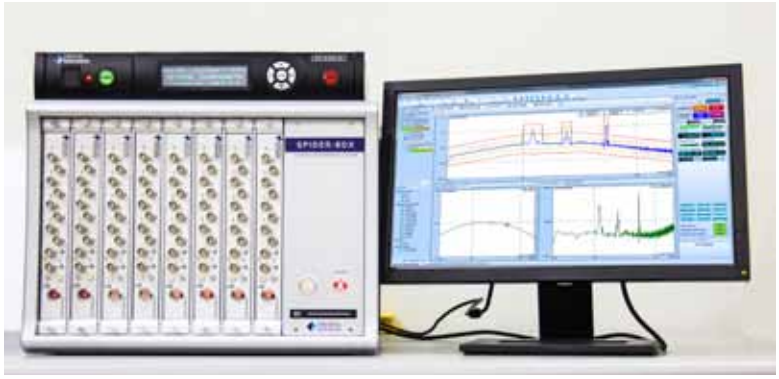
Spider-H

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

VIBRATION CONTROL SOFTWARE SOLUTIONS



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.

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 Spectum (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

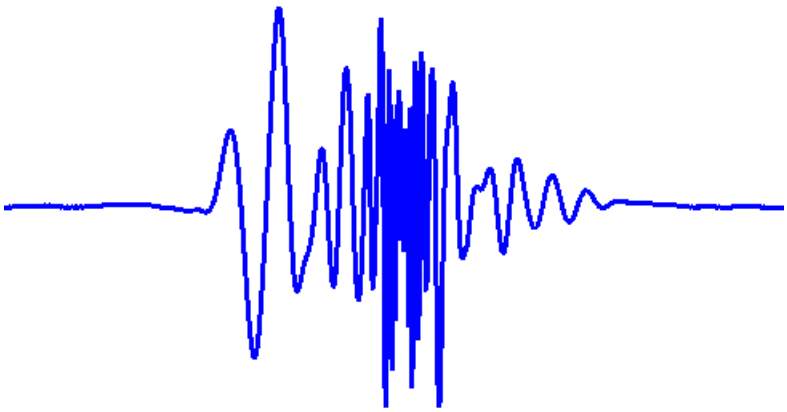
We work in a multi-lingual world. Crystal Instruments' EDM fully supports operations using English, Japanese, Simplified Chinese, Traditional Chinese or Russian (others on request) user interfaces. The selected language can be changed at any time with one mouse click.

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 prevent unauthorized access to the hardware on the network.

Multi-Tab and Multi-Screen Support
To support a 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.

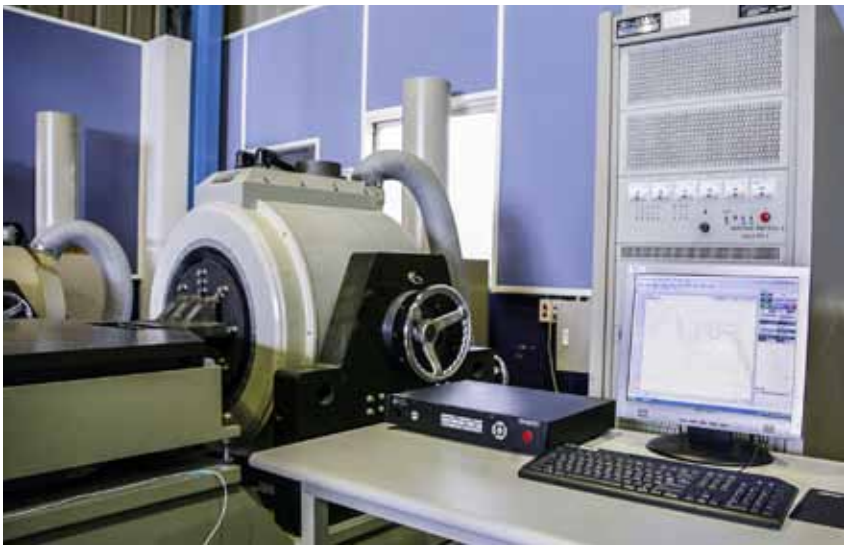
Test Sequence
A Test Sequence provides the capability to automatically execute a sequence of tests. The user can Run, Pause or Stop the testing at any time and the software keeps a detailed log of the actions and results.

Event-Action Rules
Event-Action Rules is a new way to customize controller behavior. Many key events can occur during the course of test operation, including certain response levels being reached, limits being exceeded, and user initiated events such as Pause or Stop. Event-Action Rules define the response of the controller to each of these test events. Many actions are available as custom responses, such as sending an e-mail, sending 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. Thus, the user 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), the user still remains in control. Test status reports can be sent via email or SMS text message to a mobile phone, enabling the user 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 for 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.

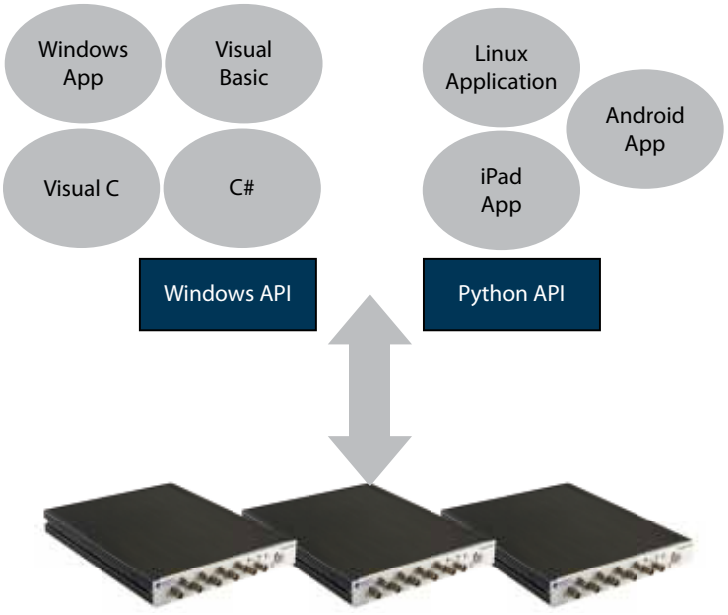
Screen shots together with testing status can be emailed as a testing report to multiple recipients with one command. The EDM App for iPad is available for download at the Apple iTunes Store.

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.

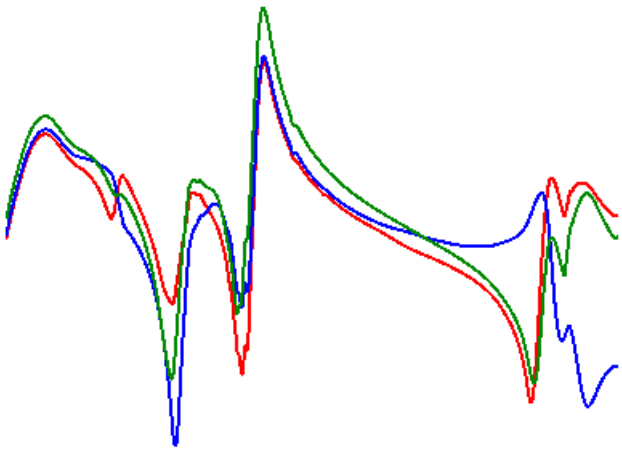


Location ID and Customized Signal Labeling
In EDM, signals can be clearly labeled with names conveying physical meaning, such as "Top" or "Front". All related signals will be renamed with such labeling automatically.

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.

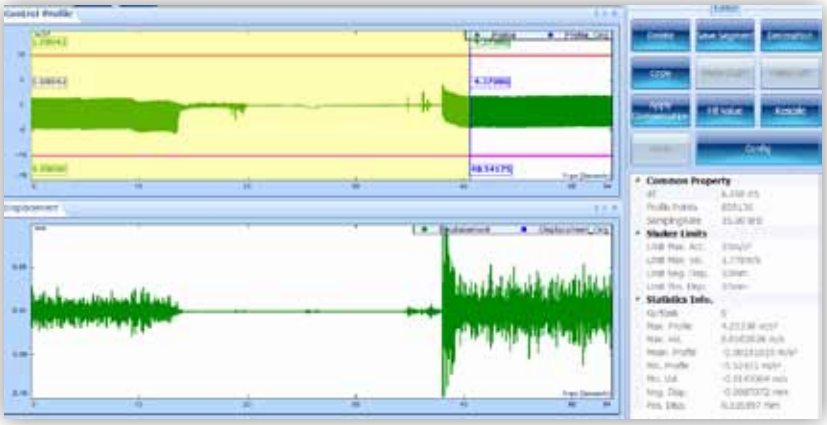
Complex FRF/Transmissibility
EDM software has a very flexible setup to measure the matrix of complex motion/force FRF (or g/g transmissibility's) which are critical for modal analysis,



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.



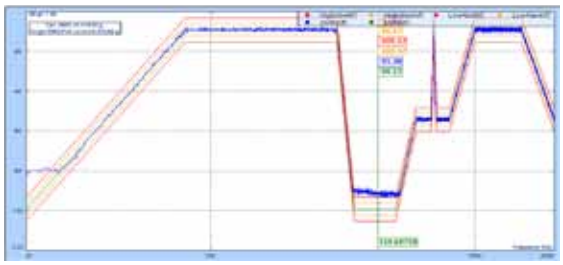
Strain Gage Hardware Expansion
Strain gage measurement can be directly integrated into DSA and VCS tests using the Spider-80SG module. This enables the user to measure strain during a controlled vibration test or analysis simultaneously. Force control and limiting can be achieved by using the strain 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 Socket Message documentation for detailed specifications.) The ability to send emails or instant messages as custom actions in response to a system encountered event facilitates remote user monitoring of the system. Content of such emails can be customized for each event.

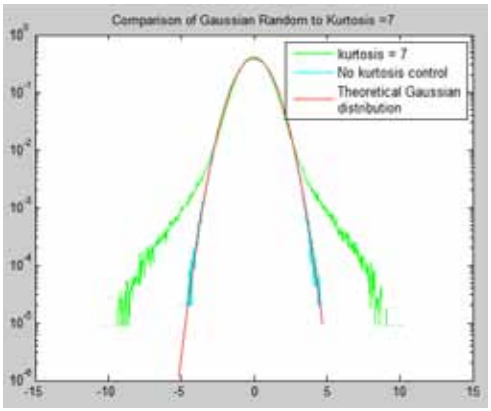
Shaker Parameters
Shaker limits are calculated from the shaker parameters and the weight of the Device Under Test (DUT). Shaker parameters include maximum amplifier input voltage, shaker acceleration, velocity, displacement, force, drive frequency, and mass of DUT. Shaker parameters are saved to a library and used repeatedly in different tests. Shaker parameters may be 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 selectable 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.

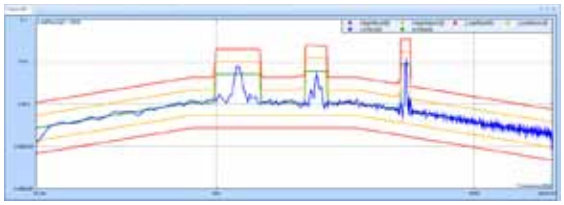


Kurtosis Control & Drive Clipping

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

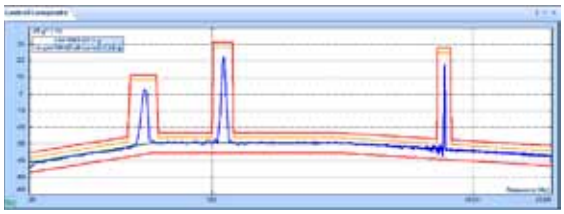
Non-linear control provides improved performance at frequencies near sharp resonances by using a unique error correction algorithm. Non-acceleration control allows measuring and controlling of physical measures other than acceleration. Displacement sensors and velocity sensors can be used together with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



Up to 12 independent random narrow band signals

Random on Random Control

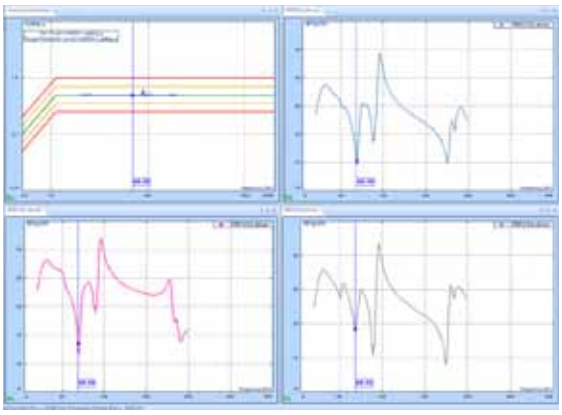
Up to 12 independent (stationary or sweeping) narrow-bands of random noise may be superimposed on the broadband random signal. Each narrow-band has its own sweeping schedule and range. They can be turned on and off manually or by a predefined schedule.



Up to 12 independently sweeping sine tones

Sine on Random Control

Up to 12 independently sweeping controlled sine tones may be added 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.

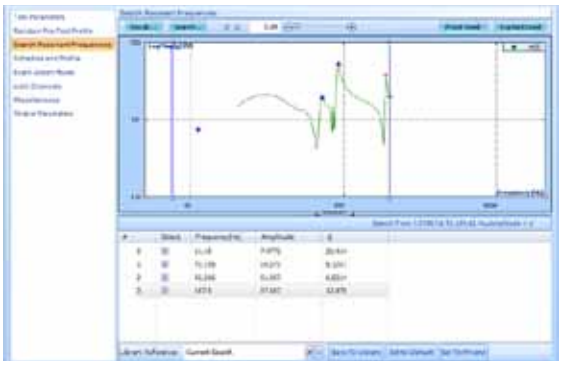
Swept Sine Control

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 (or other dynamic parameters) 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 precision. 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 sine dwells within a frequency range. The steps are uniformly distributed on a log or linear frequency scale. Step Sine Entry in a Run Schedule includes: user defined frequency range, step resolution and dwell duration (or cycles) at each frequency.



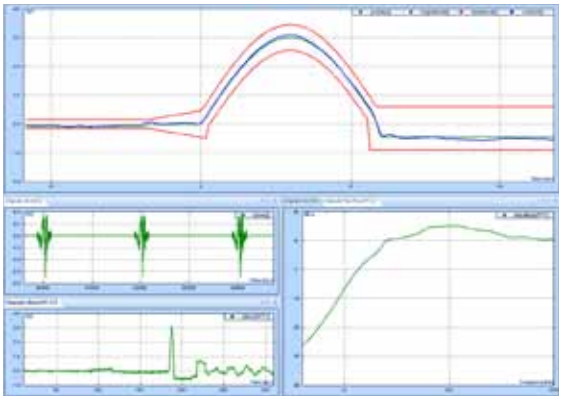
Resonance Search and Tracked Dwell (RSTD) Control

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 a specified time duration is reached or the resonance frequency changes beyond specified limits.

Compute THD of the control and input signals

Total Harmonic Distortion (THD) Measurement for Sine

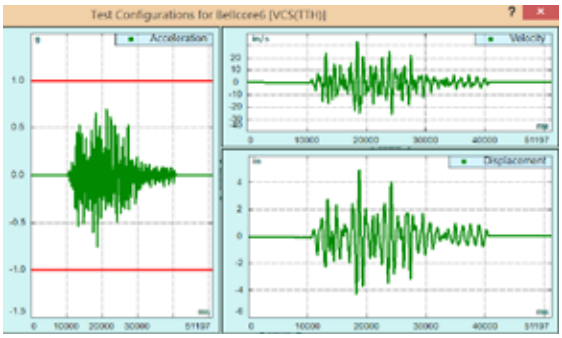
This option adds the ability to compute Total Harmonic Distortion (THD) of the control and Input signals. THD plots can be generated while the drive signal either steps through multiple discrete frequencies or sweeps a sine over a predefined range.



Provides precise, real-time, multi-channel control

Classical Shock Control

Classical Shock Control provides precise, real-time, multi-channel control and analysis of a transient motion in the time domain. 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 for 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).



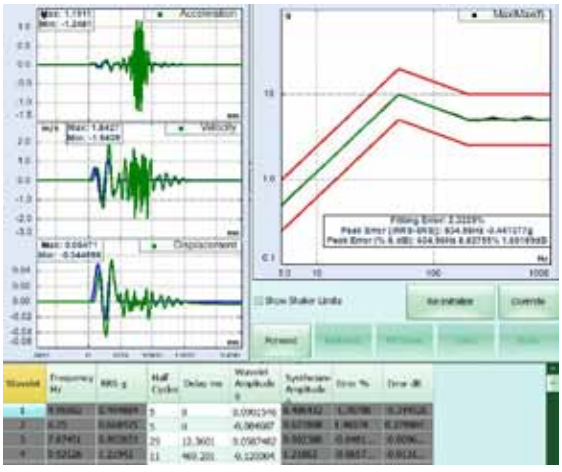
Controls shaker motion to match a defined transient waveform

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 or low-pass filtering and compensation will tailor the waveform so that it may be duplicated on a particular shaker. Compensation appropriately modifies the acceleration waveform so that it does not exceed the shaker stroke available. 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 time signals to generate an SRS instantaneously. SRS Types includes maxi-max, primary, residual and composite. A low frequency option supports imported profiles with a sampling rate lower than a few Hz.



Control the measured SRS of the DUT to match a target SRS

Shock Response Spectrum (SRS) Synthesis & Control

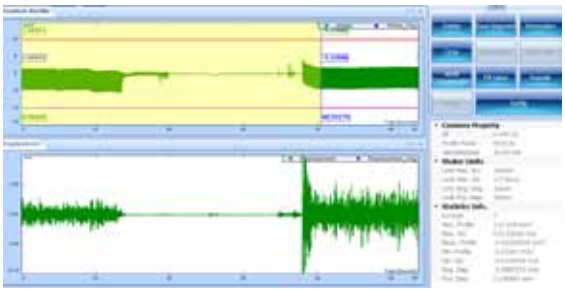
The SRS synthesis and control package provides the means to control the measured SRS of the DUT to match a target SRS, the Required Response Spectrum (RRS). The necessary drive time-history is synthesized from damped-sine or sine-beat wavelets. Damped Sine Parameters include frequency, amplitude, critical 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 duration 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 used 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

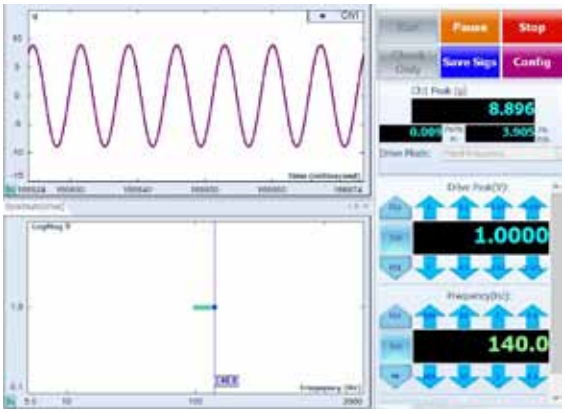
Profile Definition: Any existing signal is treated as a profile and is imported and defined as a control.

Profile Import: Waveforms with any of the following file types may be 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, re-scaled, filtered, and different compensation techniques may be applied to edit the profile using the EDM – Waveform Editor tool. Options for cropping, appending and inserting parts of a waveform are also provided.

AVD Plot: Calculation of the other two quantities among Acceleration, Displacement or Velocity are provided when a Control profile is imported (in A, V or D units).

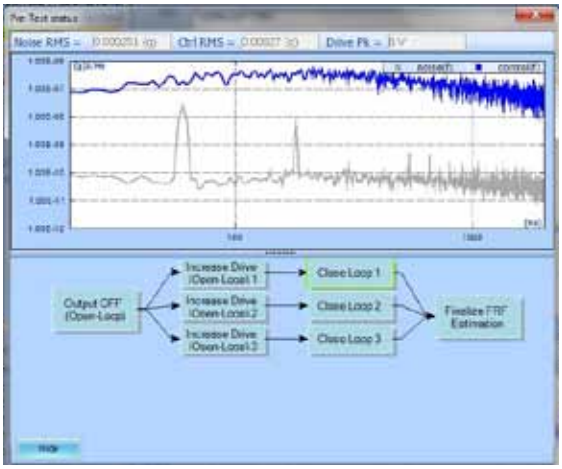
Profile Maximum: Calculation of maximum expected acceleration, velocity and displacement, checked against shaker limits.



Sine Oscillator diagnosis tool

Sine Oscillator

Sine Oscillator is a diagnostic tool providing 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 augmented 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 the 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 as the control signal. This provides an option of choosing from multiple quantities including force, sound pressure, and voltage to be controlled when appropriate response 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 uses 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 within each 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 for 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. The sensor measurements are compared against reference sensor controlled 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.

CUSTOMIZABLE & HANDHELD
DYNAMIC SIGNAL ANALYZERS

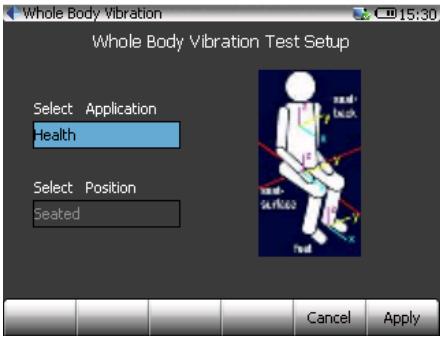
CoCo-80 & CoCo-90
The CoCo is a handheld data recorder, dynamic signal analyzer, and vibration data collector. The CoCo is ideal for a wide range of industries; including machine condition monitoring, automotive, aviation, aerospace, electronics, and military. These industries demand easy, quick, and accurate data recording in addition to real-time processing in the field. The CoCo units are lightweight, battery powered, handheld systems with unparalleled performance and accuracy. The intuitive user interface is specifically designed for easy operation while still providing a wide variety of analysis functions.

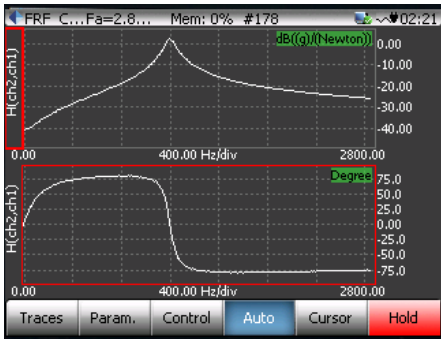
The CoCo hardware platform supports two different software working modes: Dynamic Signal Analyzer (DSA) and Vibration Data Collector (VDC). Each working mode has its own user interface and navigation structure. DSA mode is designed for mechanical structure analysis, testing and optimization, electrical measurements, geophysics studies, and a wide range of other applications. VDC mode is dedicated to route-based machine condition monitoring, vibration data collection, and trending.

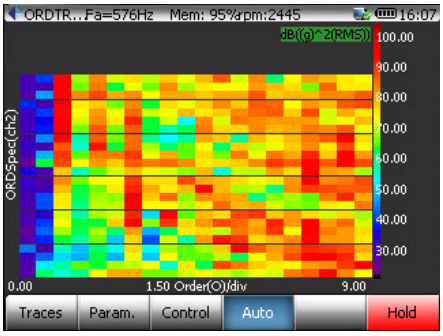
Performance
The CoCo hardware utilizes a dual processor architecture. An XScale CPU handles the user interface, project configuration, power management, network communication, and all peripherals. A high-speed floating point DSP manages the data input/output and real-time processing. The CoCo is also configured with large RAM and NAND flash memory for mass data storage. The patented design eliminates the need for multiple front-end gain settings, while at the same time delivering a dynamic range of more than 150 dBFS.

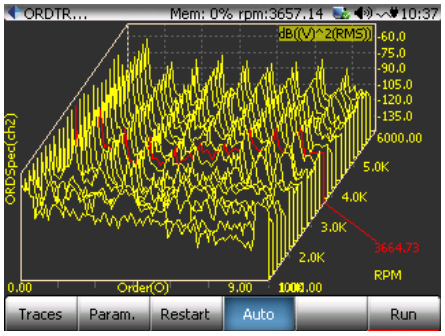
Reliability
The CoCo battery lasts up to 10 hours. Special thermodynamic and low power design eliminates the need for a cooling fan, which increases the battery operating time.

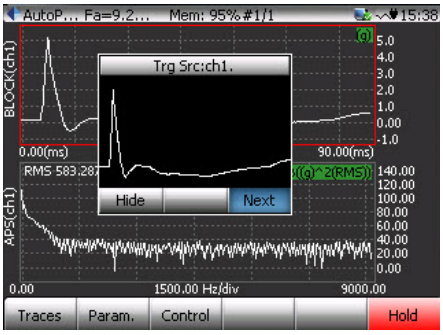


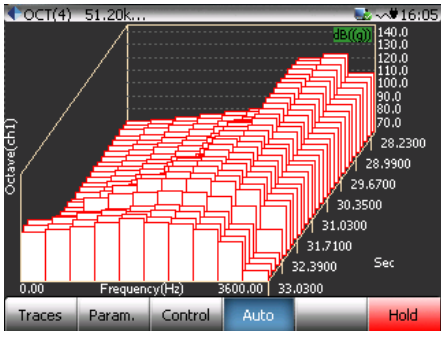












DYNAMIC SIGNAL ANALYZER SOFTWARE FEATURES

Data Recorder

Max Data Recording Rate: 102.4 kHz, 8 channels simultaneously

Real-Time Spectral Bandwidth: 46 kHz

Real-Time Frequency Response + Recording Rate: 1 excitation plus 7 response inputs with sampling rate up to 102.4 kHz (streaming recording disabled); up to 64 kHz when simultaneous streaming recording is enabled.

Frequency Response Function (FRF)

The CoCo performs FRF analysis, a standard feature.

Acoustic Analysis

The CoCo performs octave analysis and also operates as a sound level meter (SLM).

Order Tracking

Raw time streams, real-time order tracks and order spectra, narrow band RPM spectra and fixed band RPM spectra, overall RPM spectrum, and order tracks with phase relative to tachometer signals can all be measured.

Whole Body Vibration

Standard: Conforms to ISO 2631-1:1997

Channel Count: Analysis on 3 channels (x, y, z axis)

Applications: Health, Comfort, Perception, Motion Sickness

Testing Positions: Seated, Standing, Recumbent (laying)

Zoom FFT

Compute FRF, coherence, auto power spectra and phase spectra within a user-defined frequency band. With Zoom Spectrum Analysis, user can achieve very high frequency resolution without computing the entire spectrum.

Acquisition Mode

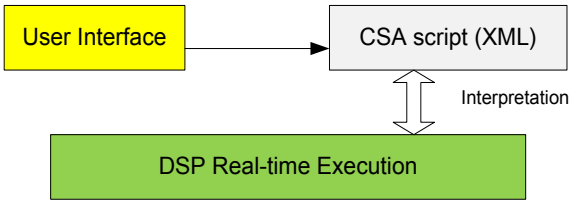
Trigger Setup Display: A special display view is created for trigger setup. The user selects the acquisition mode, trigger source, trigger level, trigger delay and trigger condition. The arrow buttons serve one of three functions: window scaling, window moving, and trigger threshold position change. Trigger delay is operated by the left-right buttons.

Trigger Run-Time Display: In manual arm-mode, a smaller window will pop up for the user to accept or reject the transient signals captured. Only accepted signals are averaged into the spectra.

CONFIGURABLE SIGNAL ANALYSIS
FOR DYNAMIC SIGNAL ANALYZERS

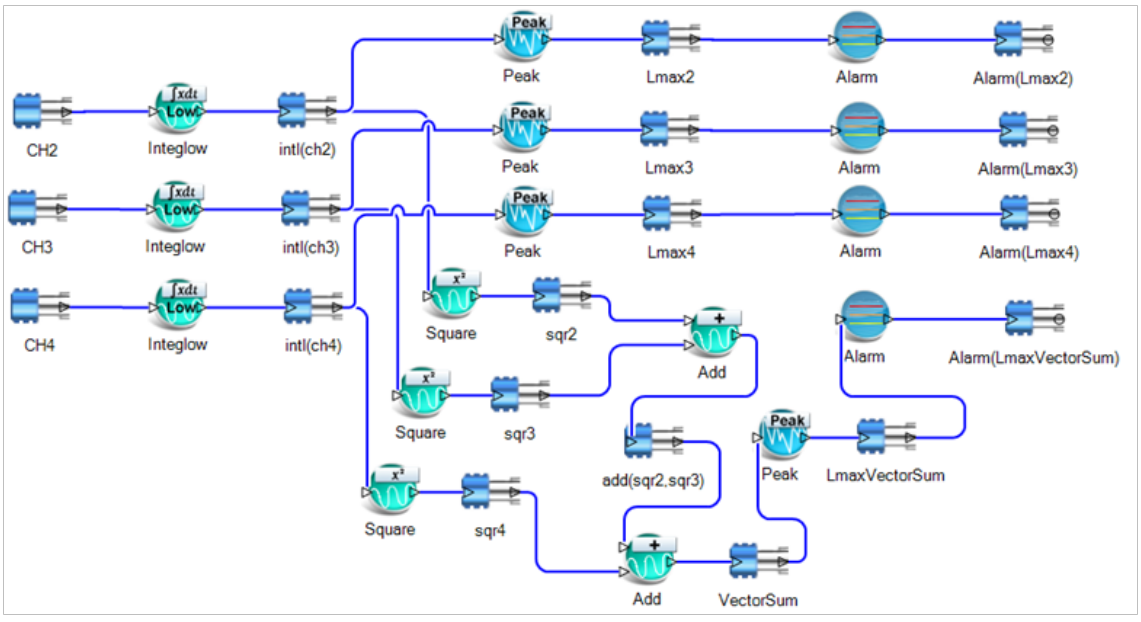
Configurable Signal Analysis (CSA) is a new concept introduced and adopted by Crystal Instruments in its newest generation of dynamic signal analyzer systems, including the CoCo-80. It allows the user to dynamically configure the DSP (Digital Signal Processing) functions so that the data processing flow can be customized from application to application. The result is a portable, customizable handheld signal analyzer which includes specialized, powerful functions while maintaining a very clean and simple user interface for day to day operation. CSA is a unique feature that is currently available only in Crystal Instruments products.

Unlike the traditional approach, CSA is user customizable. With CSA, the user can flexibly apply various math operations to live data streams without changing the installed program. The processing algorithm is a combination of user customizable math functions. Most of these algorithms are fairly simple, such as add, subtract, multiply and divide operations. Some others are very sophisticated, such as calculating the Frequency Response Functions (FRFs), between all the channels. The user can choose and apply the analysis functions of their choice, or combine them to meet their particular needs. The user can also cascade these algorithms in sequence combining several functions to generate a very advanced new function. With this approach, the CoCo DSP systems are enabled with "unlimited" application functionality.

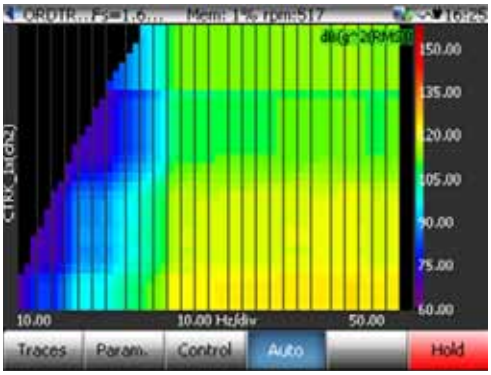


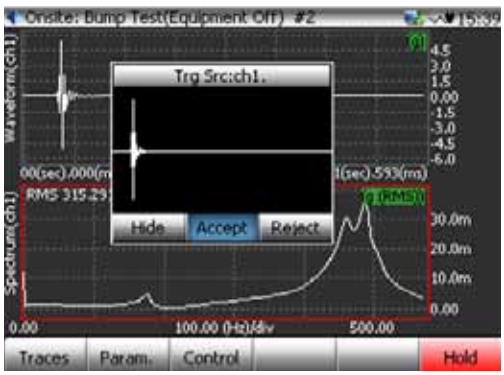
CSA Editor

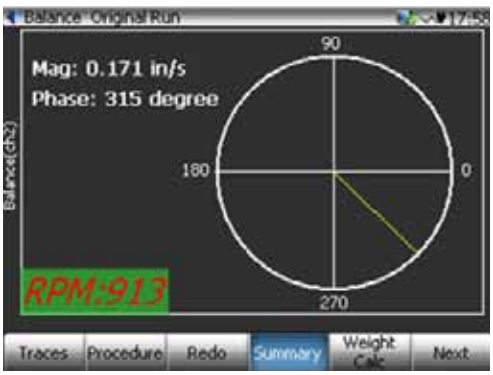
Customization of a CSA script is done within the CSA Editor which is integrated into the Crystal Instruments EDM software. The CSA Editor uses an intuitive drag and drop graphic interface that makes configuring the CSA an easy-to-learn visual process.



A typical CSA (configurable signal analysis) script







VIBRATION DATA COLLECTOR
SOFTWARE FEATURES

Route Based Condition Monitoring
Measurement Channels: 1 or 3 channels (tri-axis) with tachometer enabled or disabled

Route Collection Control: Easy navigation from the UI (user interface) level to routes. View or hold live signals, review saved data, previous measurement entry, next measurement entry, previous point, next point, point and route management.

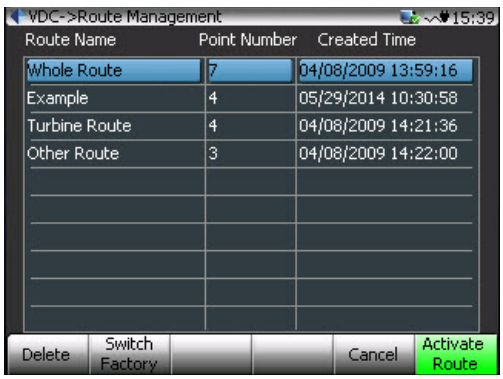
Demodulated Spectrum
Available in both route collection and onsite mode

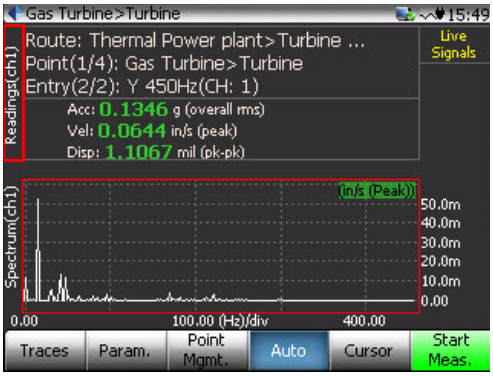
Demodulation Bandwidth: 24 bandwidth options ranging from 125 Hz -1.44 kHz, to 32 kHz - 46.08 kHz

Coast-Down/Run-Up
Trigger setting to collect data when increasing (run-up) or decreasing (coast-down) speed. 3D display for order spectrum data.

Rotor Balancing
Enables users to correct the imbalance without dismantling the machine. It is possible to balance rotors of any size with either 1 or 2 plane balancing. Using the multiple channel option, parallel measurements on 2 sensors are possible, resulting in a faster, safer, and more accurate procedure. The user interface allows stopping and starting balancing as needed and to repeat any single operation without repeating the whole procedure.

Bump Test
Auto power spectra within user-defined frequency band.





CoCo PRODUCT SPECIFICATIONS

The CoCo-80 is equipped with 2, 4, or 8 input channels through BNC connectors. It can accurately measure and record both dynamic and static signals. The mass flash memory can record 8 channels of streaming signals simultaneously (up to 102.4 kHz) while computing real-time time and frequency based functions. An embedded signal source channel provides various signal output waveforms that are synchronized with the input sampling rate.

The CoCo-90 is equipped with 16 input channels employing LEMO connectors. It can accurately measure and record both dynamic and static signals. The mass flash memory can record 16 channels of streaming signals simultaneously (up to 51.2 kHz) while computing real-time time and frequency based functions. An embedded signal source channel provides various signal output waveforms that are synchronized with the input sampling rate. LEMO to BNC adapters are provided.

The CoCo-80 is configured with 2, 4, or 8 channels. The CoCo-90 features 16 channels in the same form factor as the CoCo-80.

Inputs of CoCo-80
Up to 8 BNC connectors, built-in IEPE current source, single-ended or differential, AC or DC coupling, 150 dBFS dynamic range, dual 24-bit A/D converters, range ±10 Volts (Optional ±20 Volts range)

Inputs of CoCo-90
16 LEMO connectors, built-in IEPE current source, single-ended, AC or DC coupling, 100 dB dynamic range, 24-bit A/D converters, range ±10 Volts

Output
1 SMB connector, 100 dB dynamic range, 24-bit A/D converter

Audio
3.5 mm Audio Jack Stereo connector for earphones, plus built-in speaker and microphone

Dimensions
231 x 170 x 69 mm

Weight
1.71 kg including battery

Power
AC Adapter: 110-240 Volts AC
Max Power Consumption: 14 watts
Battery Operations: up to 10 hours in automatic mode

Host Interface
2 USB ports, 100 Base-T Ethernet, SD Card

Maximum Sampling Rate
102.4 kHz simultaneously (CoCo-80 only)

Flash Memory
4 GB used for system and data storage

LCD
5.7 inch LED backlight, 320 x 240 resolution, color

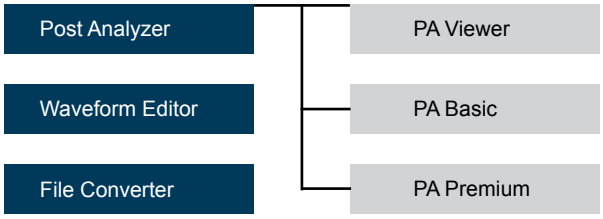
Typical Real-time Analysis Functions
Math (+,-,*, /), integration, differentiation, FFT, averaging, windowing, auto power spectra, cross spectra, FRF, coherence, real-time filters, RMS, octave, order tracking, swept sine, limiting, alarm/abort and much more.

Vibration Data Collection Functions
RMS, true-RMS, overall-RMS, waveforms, spectrum, demodulated spectrum, trending and alarm, 2 plane balancing. Measure acceleration, velocity, displacement and tachometer.

CoCo HARDWARE DIAGRAM

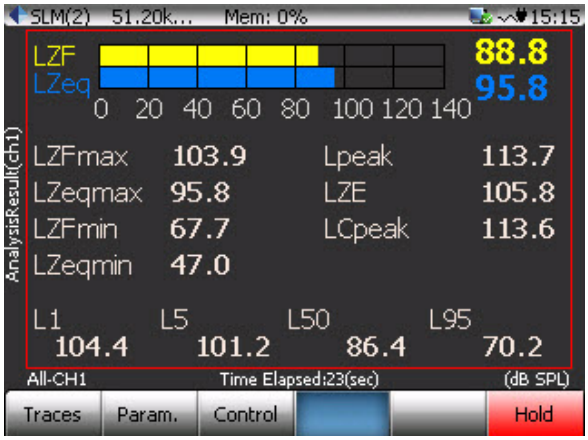
EDM POST ANALYZER

To offer a complete package of both real-time analysis and post processing, Crystal Instruments developed EDM supportive applications to include three separate software modules: Post Analyzer, Waveform Editor, and File Converter. Post Analyzer (PA) contains many powerful post processing tools with batch processing capability. The basic structure of supportive applications is:

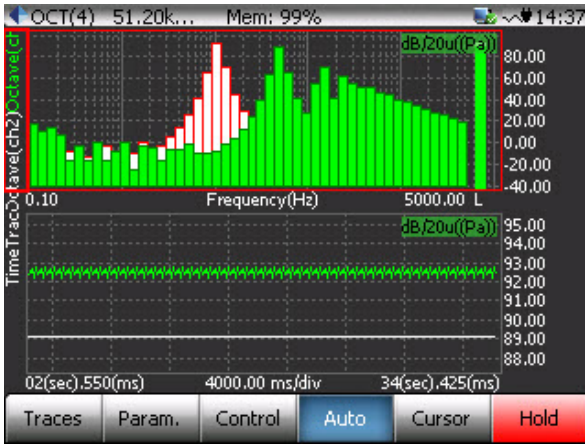


Post Analyzer is an independent Windows application that analyzes the data files on a computer using various algorithms. PA has three versions: PA Viewer allows the user to view data and create reports; PA Basic has FFT spectral analysis and 3D signal display functions; PA Premium has more advanced functions such as octave filters and order tracking.

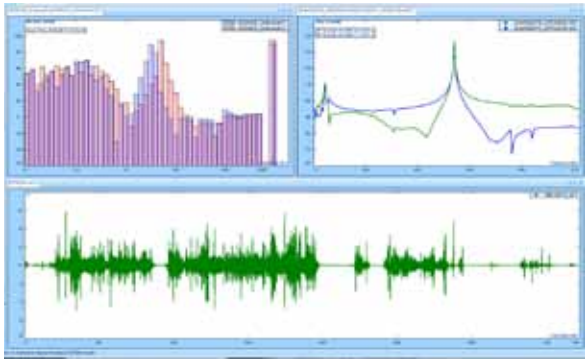
- Waveform Editor is an independent Windows application that allows the user to cut, edit, or merge the time waveforms.
- File Converter is an independent Windows application that converts files in various data formats to standard ATFX format.
- PA Viewer is standard while PA Basic and PA Premium are optional.



Sound Level Meter (SLM) results



Overlaid Spectra with Time Trace



EDM Octave-APS-Waveform overlaid composite

OCTAVE ANALYSIS & SOUND LEVEL METER (SLM)

Acoustics measurements are performed for a variety of reasons, including: product design, production testing, machine performance, and process control. Crystal Instruments' CoCo and Spider series have 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 CoCo series hardware is ideal for portable applications that require acoustic measurements from 2 to 16 channels. 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.

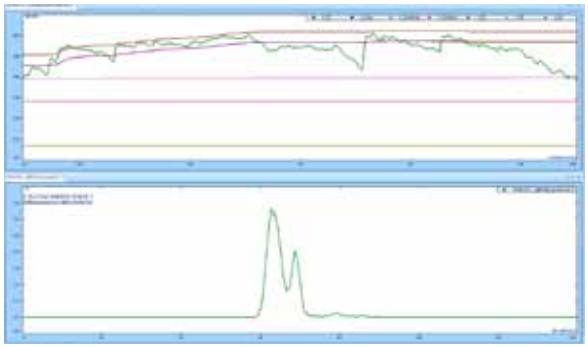
Real-time Octave Analysis

The acoustic data acquisition software option for CoCo and 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.

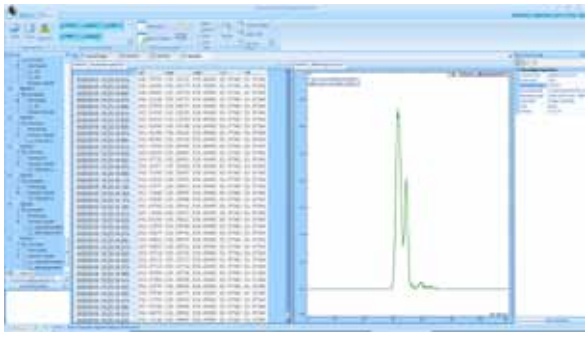
The octave analysis option applies a bank of real-time filters with 1/1, 1/3rd, 1/6th, or 1/12th octave resolution. The input time stream is split into fractional frequency-band signals (octave bands) which can be saved. Frequency weighting can be applied to the octave bands to simulate human hearing, 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.

The CoCo-80 combines with a microphone to take measurements inside an anechoic chamber



Sound Level Meter (SLM) results



More Sound Level Meter (SLM) results

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. Calibration can also be accomplished by entering microphone sensitivity values directly in the channel parameter setup page.

Simultaneous Recording and Octave Analysis
Both the CoCo and Spider series are designed with simultaneous time-stream recording capability. While the acoustic analysis is processed in real time, the raw time data of the CoCo can be recorded onto either internal flash memory or an SD card, and that 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.

The Spider-81 being used in a "pass/fail" test

Preloaded tests run without an attached computer

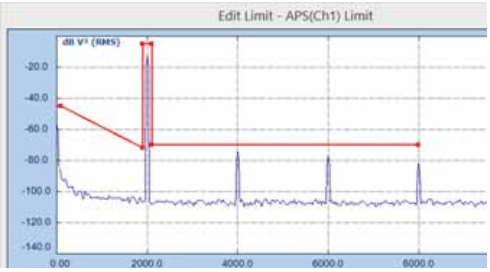
AUTOMATED PRODUCTION TESTING SOLUTIONS

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.

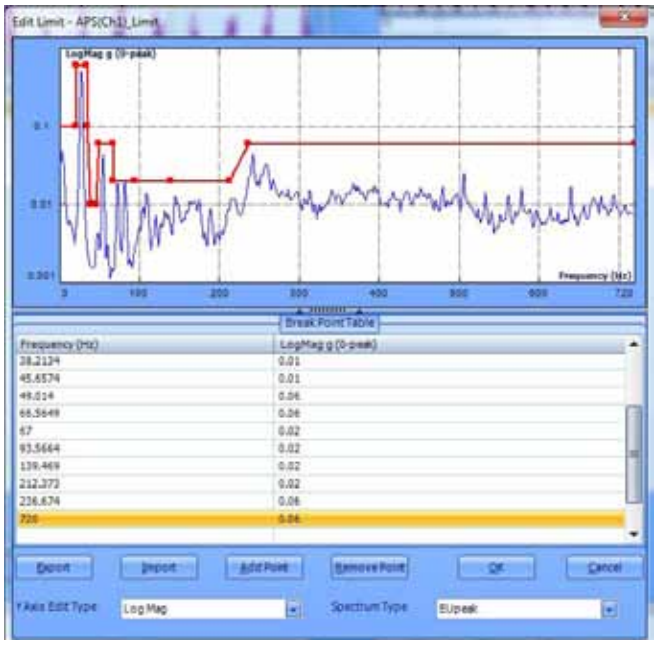
The Spider API is the gateway to integration with LabView, Matlab and other scripting software. Spider front-ends operate from Android, Linux and iOS in addition to Microsoft Windows. A single iPhone, tablet or PC can control multiple Spider front-ends at distributed locations running disparate tests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

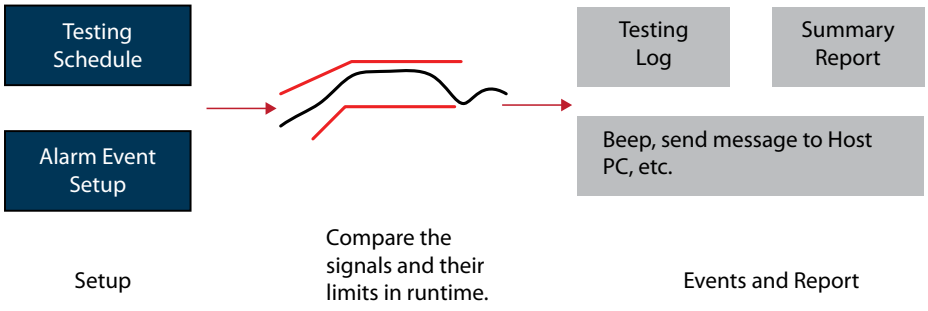
Limit Testing (LT) may be applied to a Time Block, Auto Spectrum, FRF, Coherence, Octave Spectrum, Sound-Level Measurements, RMS or Peak value. Spectra and time histories are tested by comparing against a custom test signal; a template which must bound the measured signal. Each test signal may be either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



An illustration of the automatic testing process.

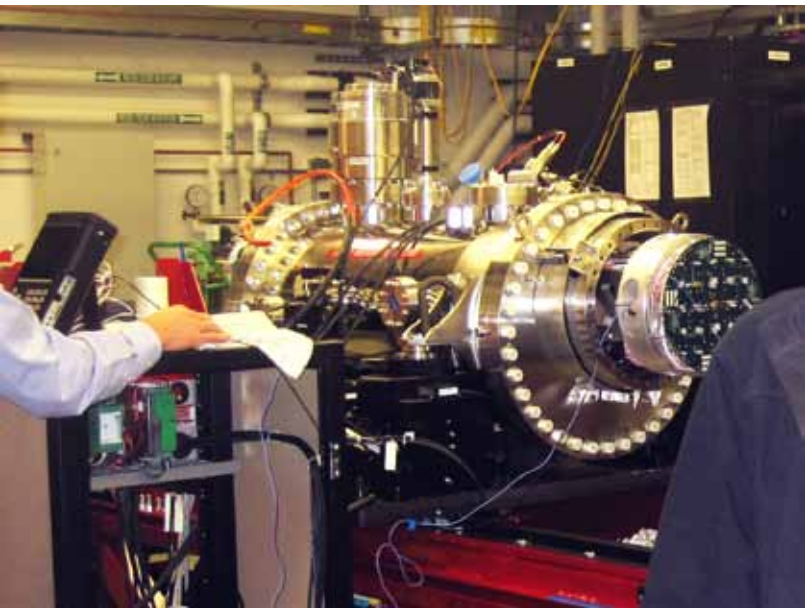
Scalability is a one of the benefits of automation and this is why the Spider-80X is designed as a networked device. With an Ethernet connection on the Spider-80X, multiple front-ends are connected to test tens if not hundreds of cell phones at a time. This may seem a bit excessive until one considers 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.



ROTATIONAL DYNAMIC ACQUISITION & ANALYSIS

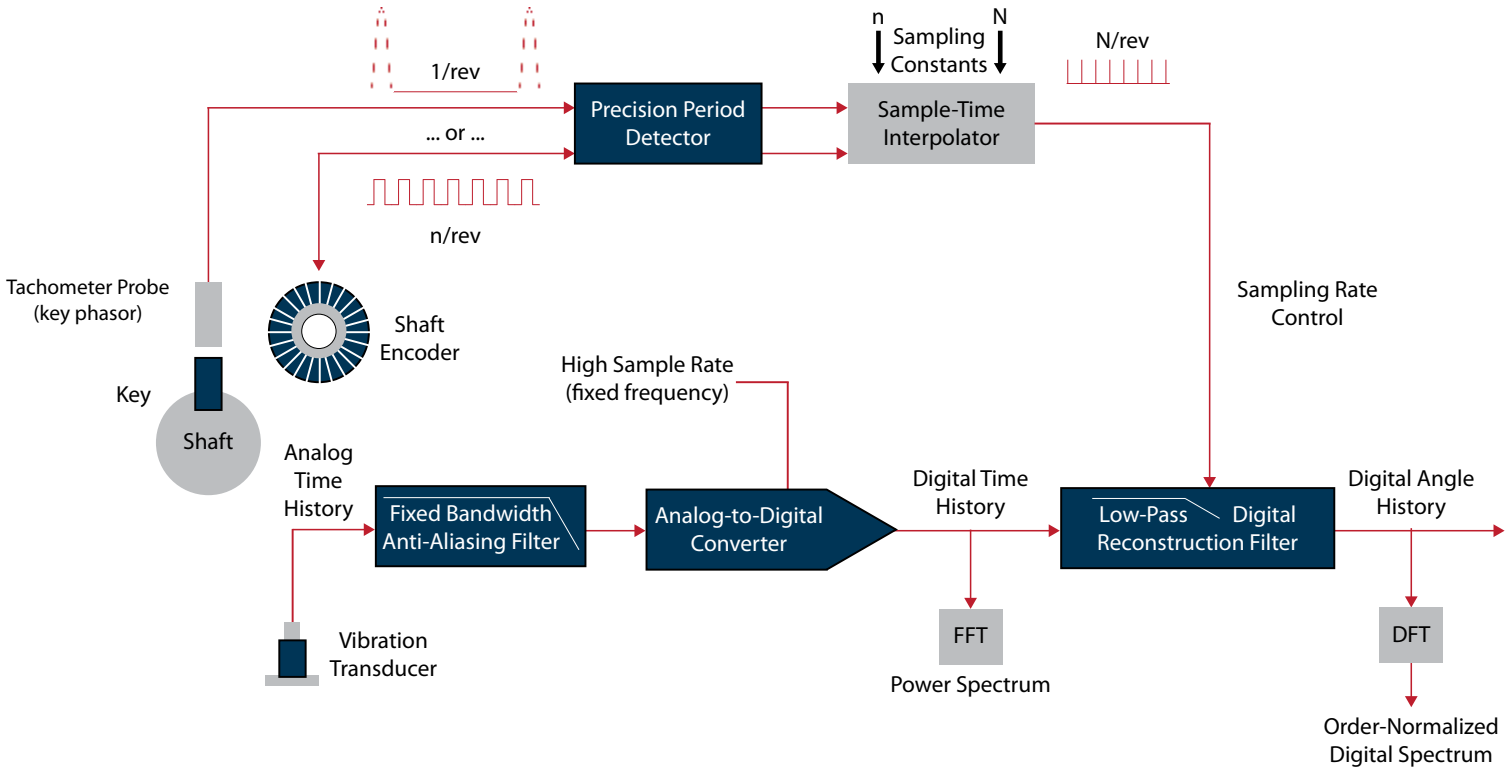
The high channel count Spider systems and CoCo portable instruments provide a wide range of real-time order tracking capability to understand the noise and vibration induced within rotating and reciprocating machines. Fixed and variable speed machines are accommodated as are both structural vibration 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.

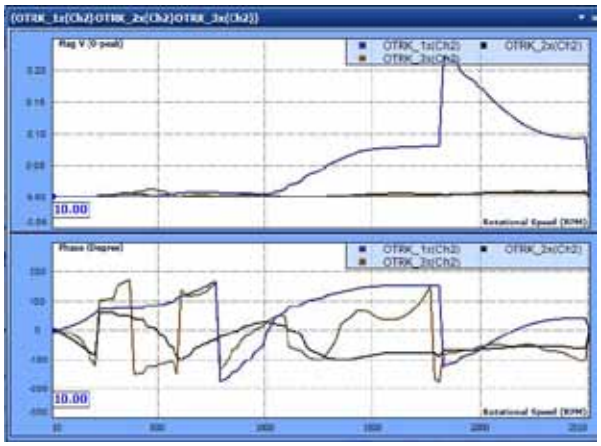
Additionally, Crystal Instruments provides post processing order tracking capability in its Post Analyzer (PA) that generates the same analysis results as real-time order tracking. The user can simply record the raw data together with tachometer signals and process them later.

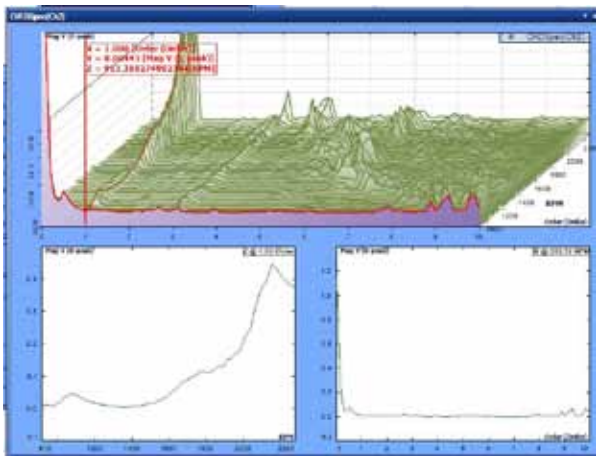
Advanced Digital Processing
All measurements in the order domain are derived from an advanced digital resampling method. High speed DSP processing allows synchronization of the analyzer's sampling rate to a tachometer signal. The analyzer's sampling rate continuously adjusts to track variation in shaft 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.







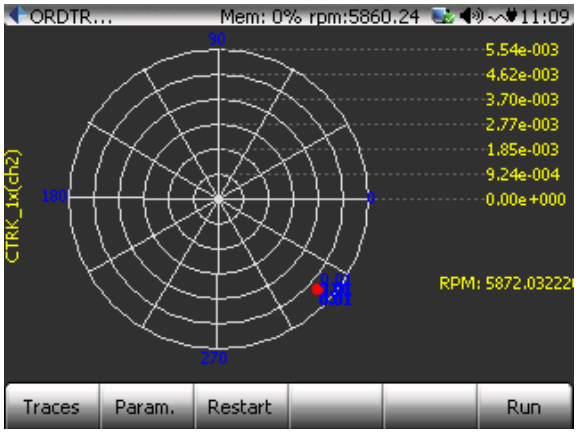
Real-Time Order Tracks and Order Spectra
Real-Time order tracks are the amplitude history signals of certain "rotational orders" graphed against the machine's RPM. Multiple order tracks can be measured, displayed, and saved. Order spectra are auto power spectra that are normalized to orders. All order 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.

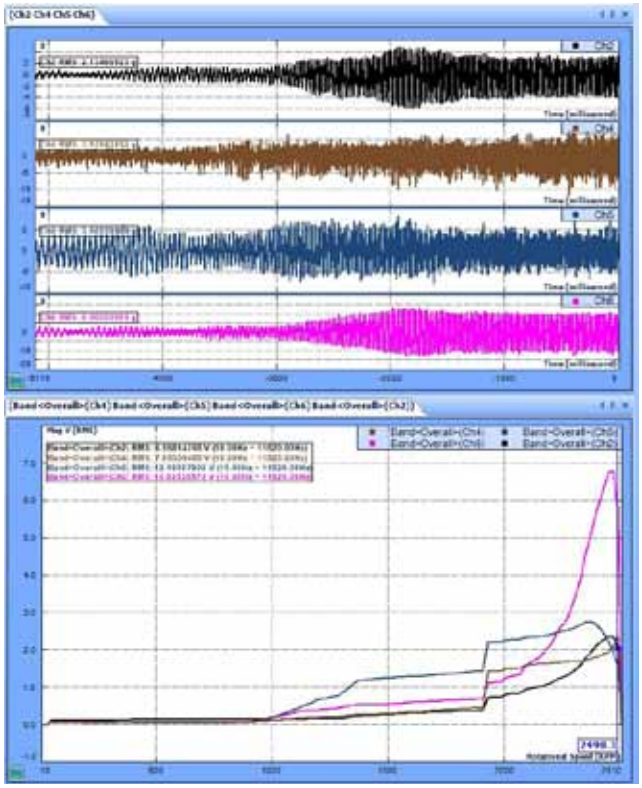
Constant Band Frequency Spectra
Constant band frequency spectrum displays the auto power spectrum of the selected fixed band of frequencies and is computed using FFT analysis within the fixed band of interest. 3D plots using time or RPM as the reference are available along with 3D extractions of desired orders of interest. The available spectrum amplitude units includes EUpk, EUrms, EU^2rms, EU2/Hz, and EU^2•s/Hz

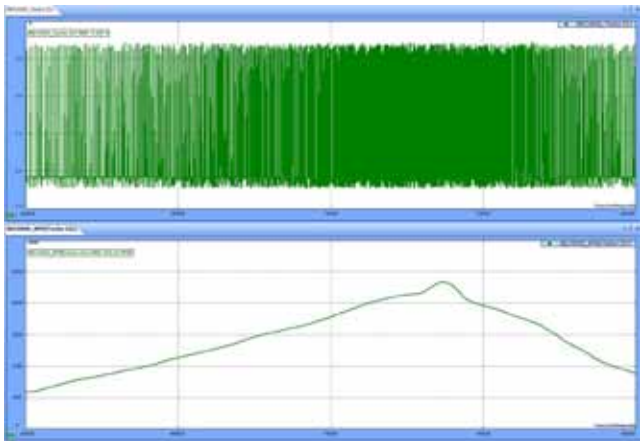
Order Tracks with Phase
Order tracks with phase are order spectra with the associated phase measurement relative to the tachometer signal. All the measurement specifications are the same as real-valued order tracks, except that order tracks with phase can also be displayed as Bode, Polar, or Nyquist 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.



Polar Plot screenshot from the handheld CoCo-80.





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.

STRAIN GAGE MEASUREMENT

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 100kHz
- 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

Ideal for: Wind turbine testing, aircraft structural testing, wind tunnel testing, material testing, civil engineering testing (buildings, beams, bridges) and more.

USER-FRIENDLY SHUNT CALIBRATION & OFFSET NULLING

USER-FRIENDLY SHUNT CALIBRATION AND OFFSET-NULLING

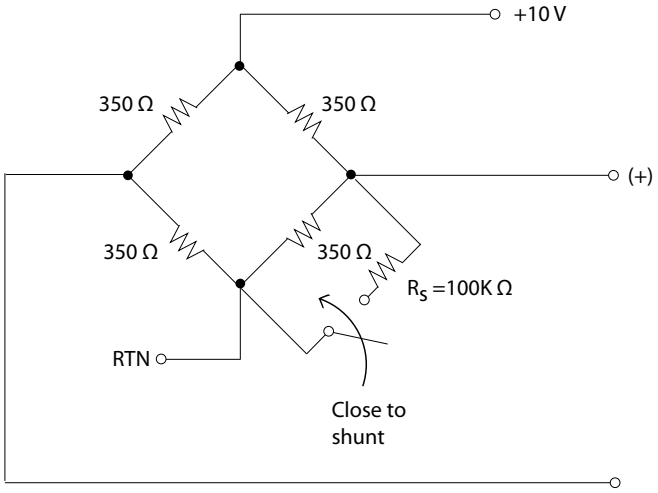
The Spider-80SG features an easy-to-use and flexible shunt calibration wizard.

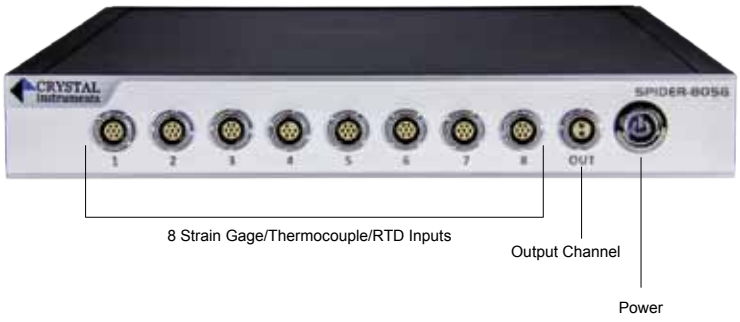
This will allow the user to select any available leg of the strain gage bridge, depending on the bridge type (i.e. quarter, half, full bridge,) for shunt calibration. As a result the shunt resistor, which is integrated into the Spider-80SG hardware, will now be connected to the specific leg defined by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





SPIDER-80SG
PRODUCT SPECIFICATIONS

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

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.

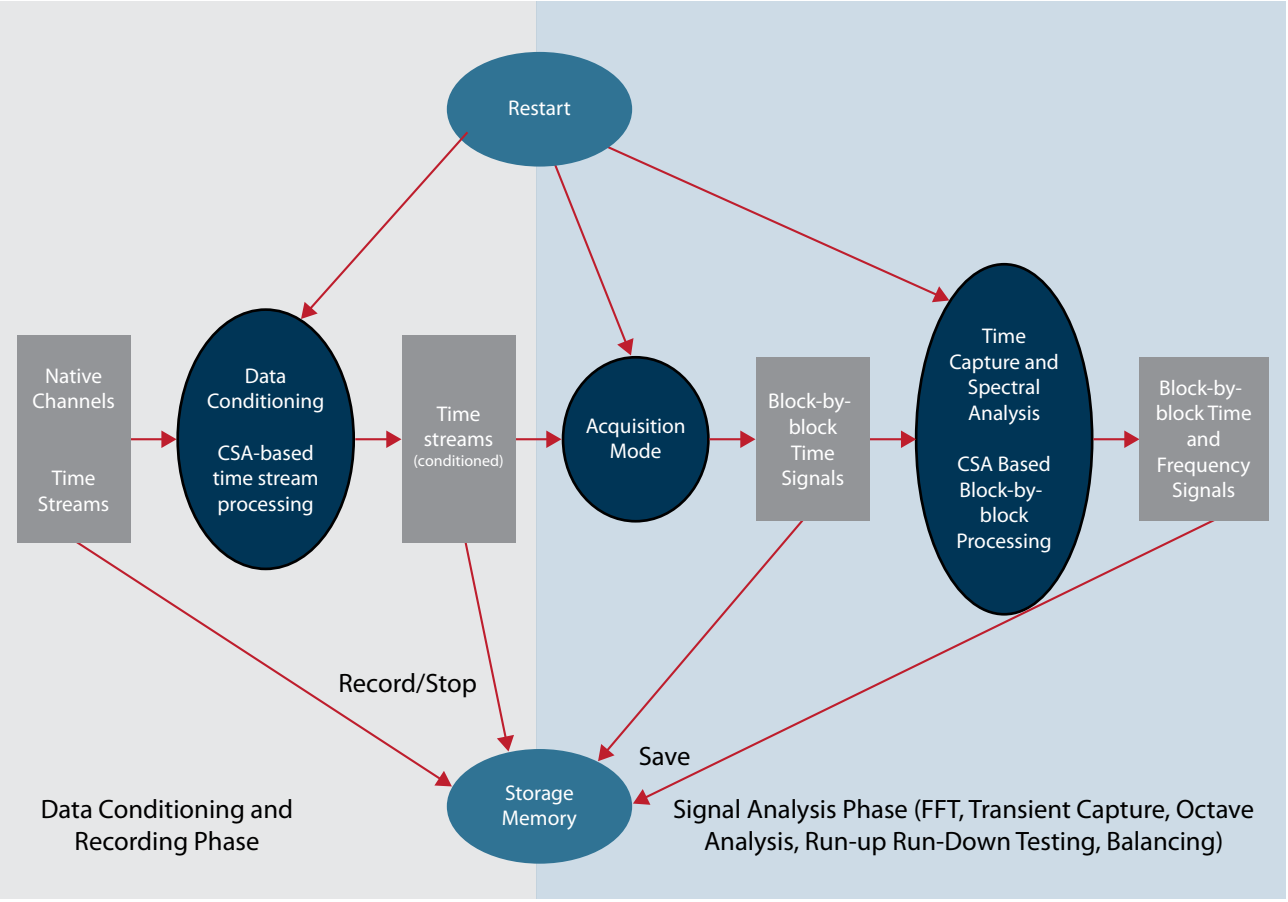
The CoCo and Spider platforms simultaneously perform both real-time processing and continuous data recording. In most of real-time applications, the raw data can be recorded at any desired sampling rate with full 32-bit floating point precision. To increase the reliability of data recording, a special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

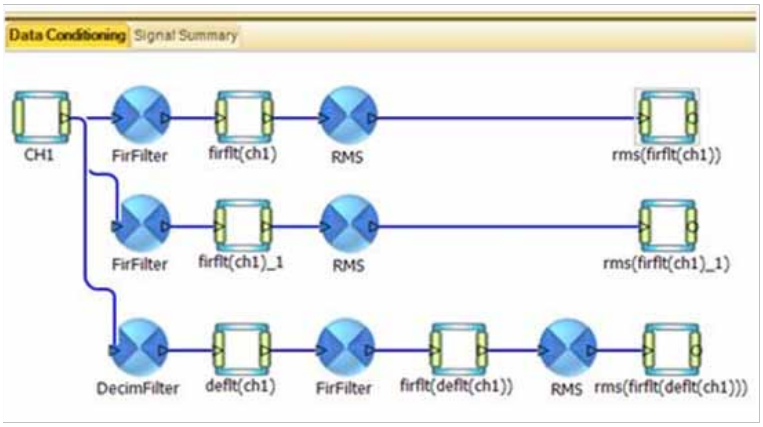


The CoCo handheld data recorders are a portable solution for continuous data recording.

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

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			√

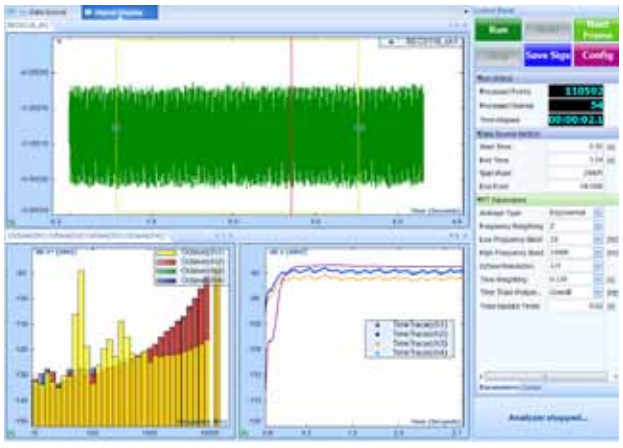
ENGINEERING DATA MANAGEMENT (EDM) POST ANALYZER

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.



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

EDM, Engineering Data Management, is a complete suite of turn-key solutions for both real-time processing and post analysis.

SOFTWARE CONNECTIVITY

Crystal Instruments' software is available in a variety of forms:

1. EDM, Engineering Data Management, is a complete suite of turn-key solutions for both real-time processing and post analysis. EDM runs on a personal computer or workstation.
2. EDM App is a thin client application developed for Apple's iOS platform. It is used to access and control Spider front-ends.
3. EDM Cloud is a client/server software suite providing a web-based user interface that can run on any web-browser.
4. CoCo Software is the embedded software resident on the CoCo hardware platform.

While most customers acquire their specific application software from Crystal Instruments, others prefer to develop their own custom applications or to interface their software to one of Crystal Instruments' software modules. Crystal Instruments provides software connectivity at three levels of sophistication: Data File Import/Export, Socket Message exchange and Application Programming Interface (API) communication.

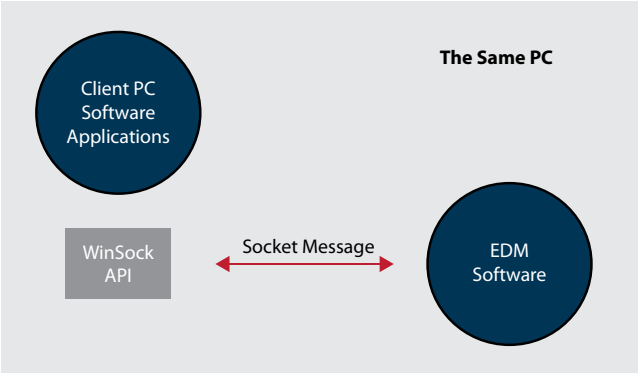
EDM App is a thin client application developed for Apple's iOS platform. It is used to access and control of Spider front-ends.

SOCKET MESSAGES

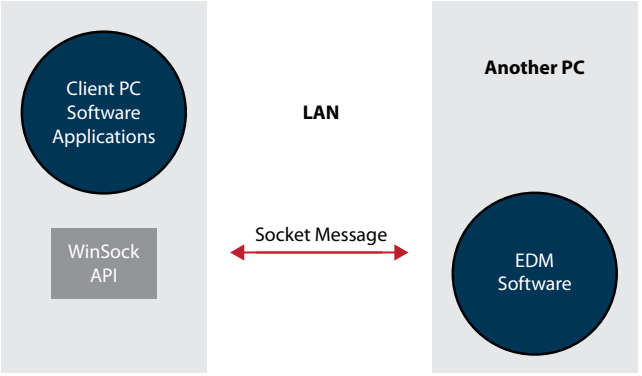
Socket Messages, a powerful modern communication tool, improves communication between EDM and other software. Socket Messages are a means by which two processes on the same or different computers can communicate with each other. This communication can be for data sharing, synchronization, or control. Communication can occur between processes on the same computer or across a network.

Socket Messages use the network interface of the host computer. Socket connections use a client/server architecture, where one process offers a service to another. In general, the client process initiates a connection with the server. Network protocols handle the connection, transport, and routing services, supplying the applications with a robust communication channel.

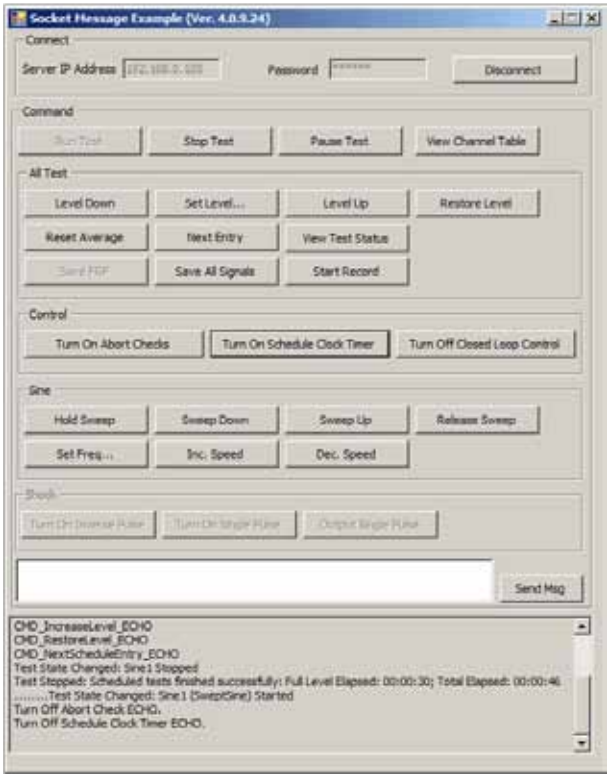
When one application process establishes a connection with another application process, it opens a socket to the remote host. This socket is uniquely identified by the remote address, transport protocol, and local and remote port number. The port number is used to differentiate multiple connections that may exist between the same hosts. For any connection, there are two sockets – the Client Socket on the client end and the Server Socket on the server end.



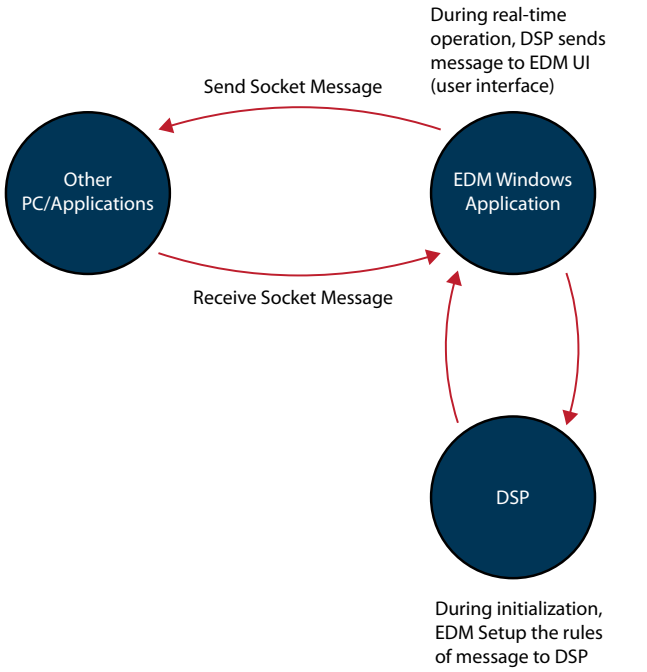
Communication on the same computer



Communication on different computers



Example of client software using socket messages to control the EDM.



Socket Server Setup Panel

APPLICATION PROGRAMMING INTERFACE
SPIDER API

Spider API allows third party software to communicate directly with Spider front-ends.

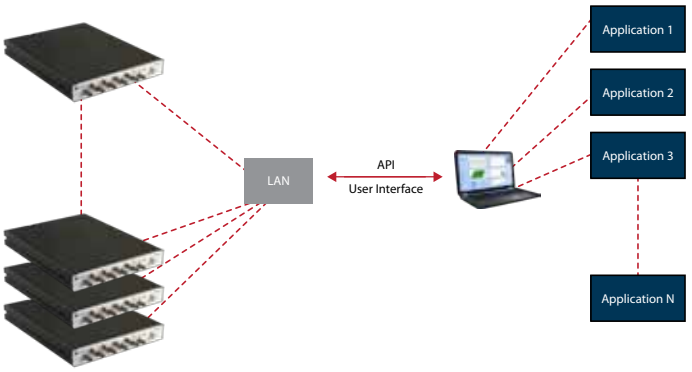
Crystal Instruments Spider Application Programming Interface (API) is a collection of Windows Dynamic-Linked Libraries (DLL) or Python API, providing external applications with an easy interface to access and control the Spider front-ends.

If a Windows OS is used, users can develop their own application using the Windows App, VC, VB or C#, LabView, MEScope languages. If Linux, iOS or Android is used, the Python (language) API provides the interface.

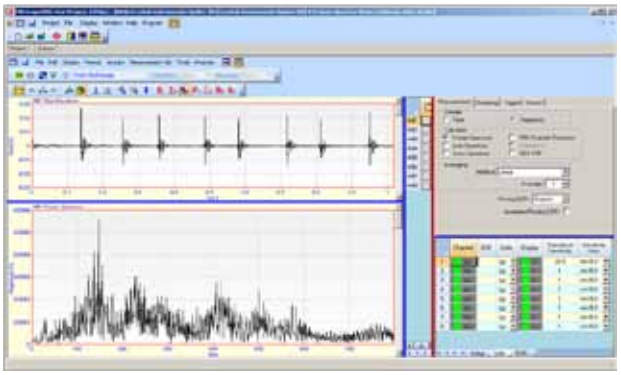
The Spider API defines a set of system commands based on character strings. This implementation is widely compatible with various connection tools such as APIs, scripts, socket messages and handheld devices, facilitating future technical support.

The Spider API assists users in developing their own industry-specific custom applications. Crystal Instruments offers advanced hardware and API, allowing users to focus on building their own user interface. While the Spider system is running, the user can access the signal data in real-time using the API. The signals include both time and frequency domain data. The user can also initiate long time history recording. After the test, the time recording can be downloaded to a PC using API function calls.

The Spider Windows API was developed using Microsoft Visual Studio technologies as well as Python. It provides a high level, user-friendly interface for the most common development tools within the Windows environment, such as Microsoft Visual C++/C#/Basic. As long as the programming languages support the call to a dynamic-linked library (DLL) or Python, users can utilize Spider API to develop their own applications. DLL provides users with easy function calls to send commands to the Spider hardware to set up the front-end, control the acquisition of data, check the status of the processor, and access DSP processed time and frequency data.

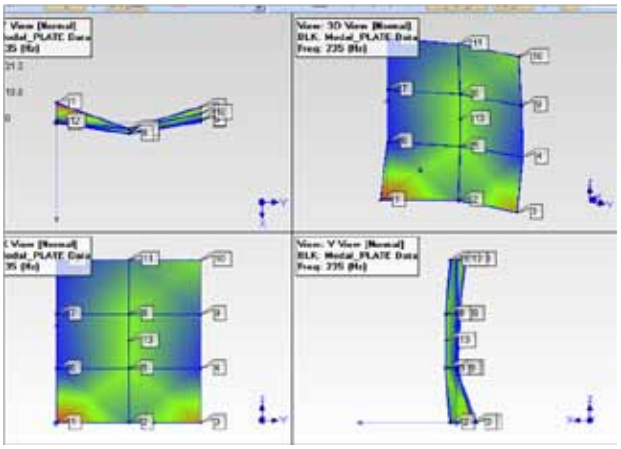


Windows API Sample for acquiring data using Spiders



MEScope SAMPLES FOR
DATA ACQUISITION & MODAL TESTING

Using API, the Spiders can be directly accessed and managed by MEScope from Vibrant Technology. Modal testing and modal analysis can be done using the hardware acquisition system from Crystal Instruments and the software from Vibrant.



DATA FILE IMPORT AND EXPORT

Crystal Instruments software uses a standard ATFX ODS data file as its default format. This format is supported by hundreds of vendors including National Instruments, LMS, Head Acoustics, Bruel &Kjaer, etc. Crystal Instruments software also provides support for the import and export of common formats, including: ASCII, WAV, UFF, UNV, BUFF, BUNV, TXT, CSV, ODS and SPF.

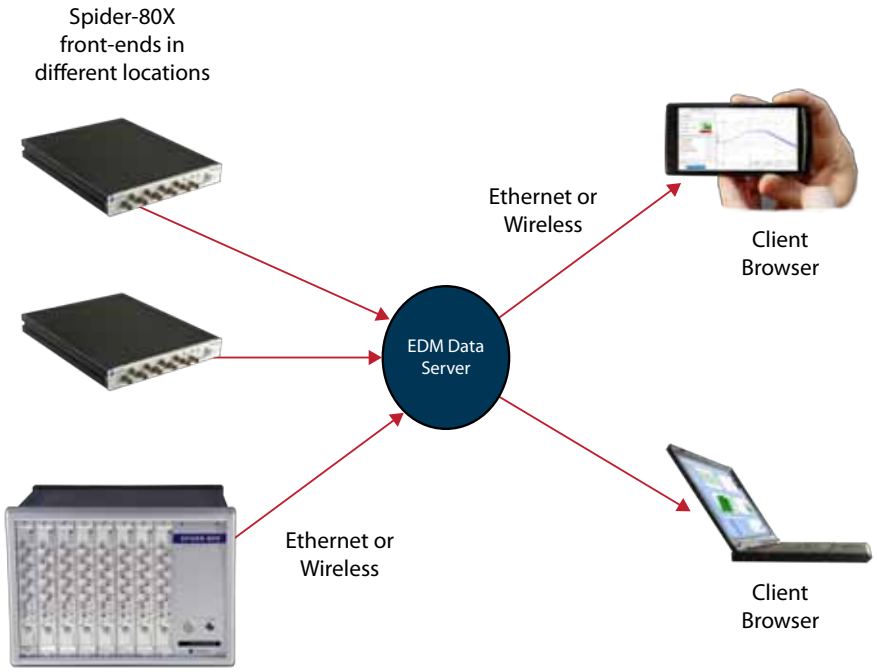


Figure 1: Crystal Instruments Spider-80X monitors and experts joined by a Local Area Network (LAN).

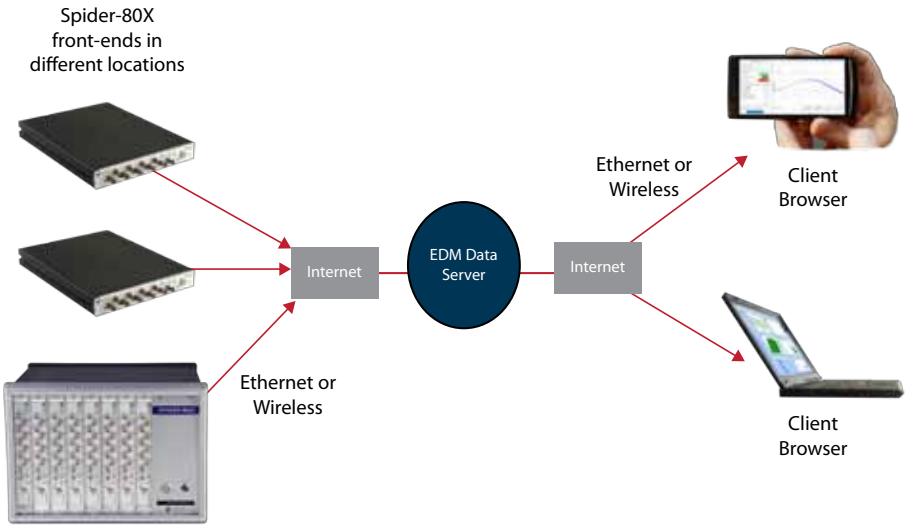


Figure 2: Crystal Instruments Spider-80X and skilled people joined by the Internet.

CLOUD BASED REMOTE MONITORING SOLUTIONS

Sometimes the machinery stretches from Taipei to Tuscaloosa. Or all the interesting action takes place in a tiny room 200' off the ground. That's when EDM Cloud is the tool of choice. With EDM Cloud, the test and the test engineer can be literally oceans apart. Any of the usual EDM tests can be incorporated into a test suite, fully developed in the comfort of the office, then sent to the Spider front-ends far away. Check measurements against a variety of criteria; tests run locally, on the Spiders. Results are available across the world, in real-time.

EDM Cloud is server-based software designed to take vibration and other measurements remotely using Spider front-ends. Applications include machine conditioning monitoring, wind turbine vibration and status monitoring, bridge and railway vibration monitoring, tunnel sound monitoring and more. By opening a web browser on a tablet PC, iPad, PC or a smart phone, the user can access real time or historical data instantly.

Login anywhere in the world to view live signal reports via EDM Cloud by Crystal Instruments.

At most facilities, this is made possible by an Ethernet “backbone” linking all of the manufacturing units into a plant-wide LAN as shown in figure 1. At each manufacturing unit, permanently installed monitoring transducers are wired to monitors at a sheltered proximate central point (typically a local control room). In turn, each monitor is connected to the Ethernet LAN. This allows the data to be viewed and analyzed anywhere the LAN has a port. An Engineering Data Management (EDM) program running on the LAN’s server manages data transfers to any computer on the network running the appropriate browser-based viewing/control software. Add an Internet modem to the LAN to provide a remote communication path to any internet-connected computer in the world.

At facilities lacking a plant-wide Ethernet backbone, the Internet may be used as a substitute path as shown in figure 2. Any combination of broad-band telephone, cable or wireless connection to the internet is fair game. A cellular modem connected to a monitor provides a true stand-alone measurement subsystem. While line power is almost always available within a manufacturing plant, it may not be for other applications. Monitoring bridges, wind-powered generators, road profiles, flutter or airport noise may call for a battery-powered installation, perhaps one with solar (or other) backup. For this reason, the monitoring hardware should be fully capable of running (at full performance) from low voltage DC as well as domestic, overseas and aircraft AC line power.

EDM software supports three levels of operator privilege.. Super-Admins control the privileges of other users, and have all the rights of the lower level users. Admins set up tests: they map out the system and decide what measurements will be needed, then set the limits that define events. They also have all the rights of users. Users monitor signals, but are unable to change the test. Each user has complete control over which signals to examine and which events will generate an alert for that user.

Users can check on installations from anywhere in the world. Both the event log and real-time signals are available online.

CUSTOMIZE MESSAGE STRINGS

When a certain event happens, such as the spectrum of measurement point 1 of bearing 2 exceeding the limit, the event report string can be customized to tell the user exactly what the problem is: “Warning: Measurement point 1 of bearing 2 exceeded limit”. These special strings are logged in the Spider hardware as well as on the Cloud server. The user can view these events or receive them through emails or IM (instant messages).

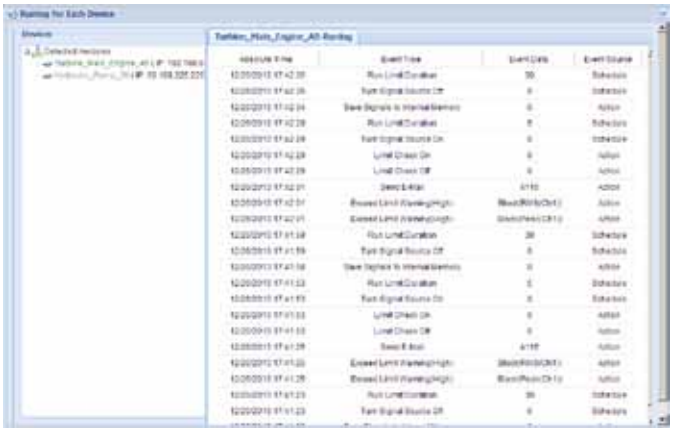
ONLINE ANYWHERE, ANYTIME

Since EDM Cloud is web-based, users can check on installations from anywhere in the world. Both the event log and the real-time signals are available online. Check the time domain signal, flip to spectrum, move through the device map to see every aspect of machine operation. At the same time, other users can be viewing other signals, concentrating on other indications of machine performance. EDM Cloud is the most flexible, customizable test suite available.

SET UP EVENT ACTION RULES

Events are anything that prompts a response from the system. If monitored signals go outside specified limits, (one kind of event), EDM Cloud offers a full suite of responses. Often, the first response will be to report the problem. Other responses might include visual signals, direct commands to other instruments, even shutdown of the system under test.

Any user can request email notification of events. One user might only care if the bearings in units 9 and 10 begin to wear, while another needs to know if the sound level in the level 2 control room a hundred miles away increases too much. Each user sets up a personalized list of events that can trigger corresponding alerts.



View runlog events from any location

Users can receive emails that contain keywords that are preset by the users, for example, "limits exceeded".

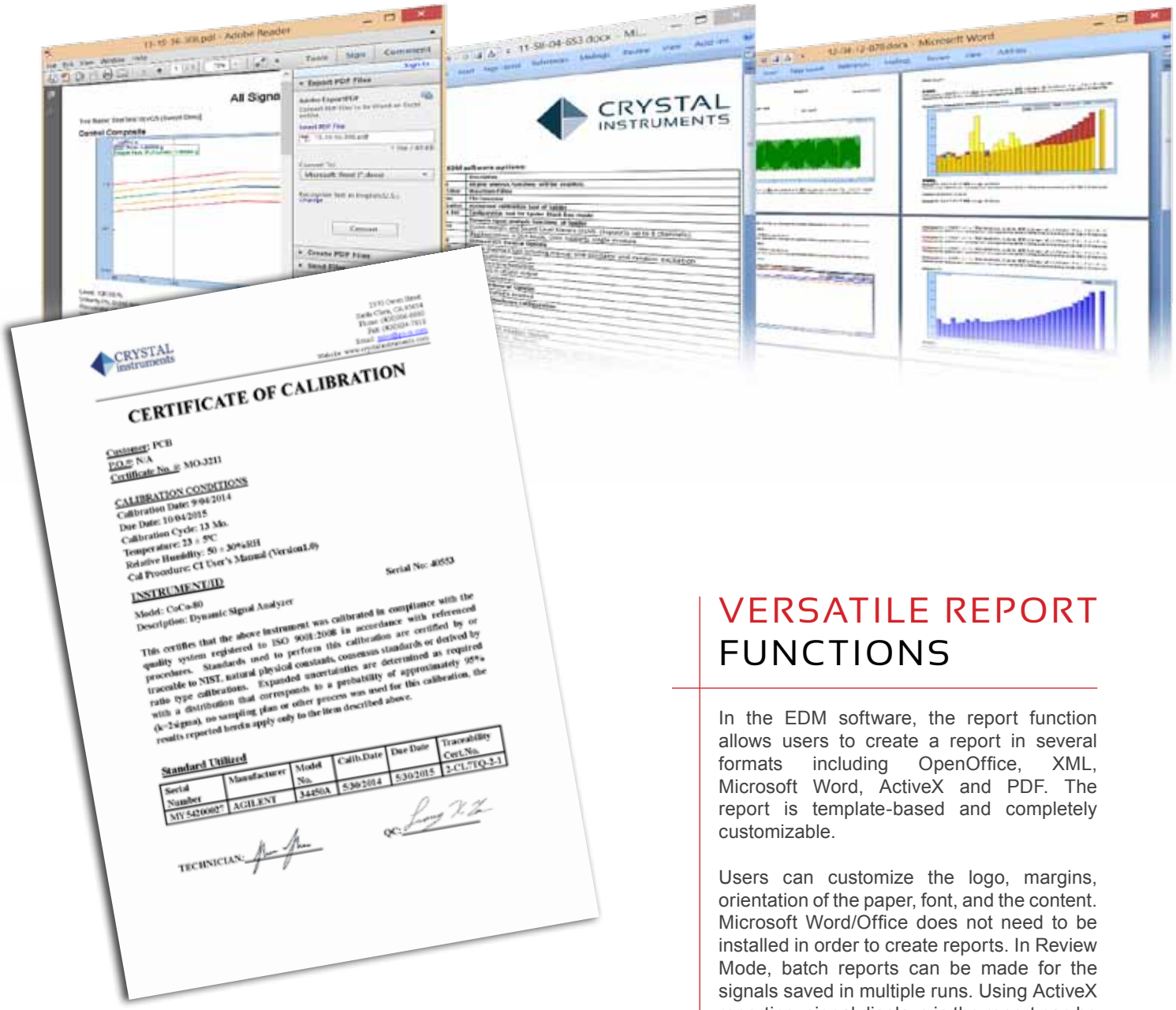
FULLY CONFIGURABLE TESTS

Tests are initially set up and uploaded to the Spider hardware from a PC runing EDM software. Measured signals might include:

- Vibration
  - Time records (realtime blocks, or long time waveform format)
  - RMS or Peak level
  - Harmonics
  - Power spectra
  - Frequency Response Functions (Magnitude and Phase)
- Sound level
- Ancillary measurements such as temperature, humidity, strain, voltage.

Alarm limits can be set for vibration and sound measurements. Up to 64 limit lines per measurement. Up to 64 breakpoints per limit line. Draw the lines with a mouse or stylus or enter in a breakpoint table – tests are completely customizable. At any time, Admins can change test parameters and adjust limits.

The Spider DSP provides powerful and flexible processing functions. FFT, long wave recording, trigger, digital filters, octave and sound level meter measurement, to name a few. These processing functions can be triggered by events or operate on a fixed time schedule. Using the Spiders' unique patented dual A/D technology, high dynamic range data acquisition is possible with superb accuracy for both large and small signals. This is crucial for monitoring processes since the user often has no prior knowledge about the signal levels before critical events occur.



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

Product support is provided in-house by highly trained engineers.

Crystal Instruments Application Engineers also travel to customer sites to provide training.

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 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.

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).

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.

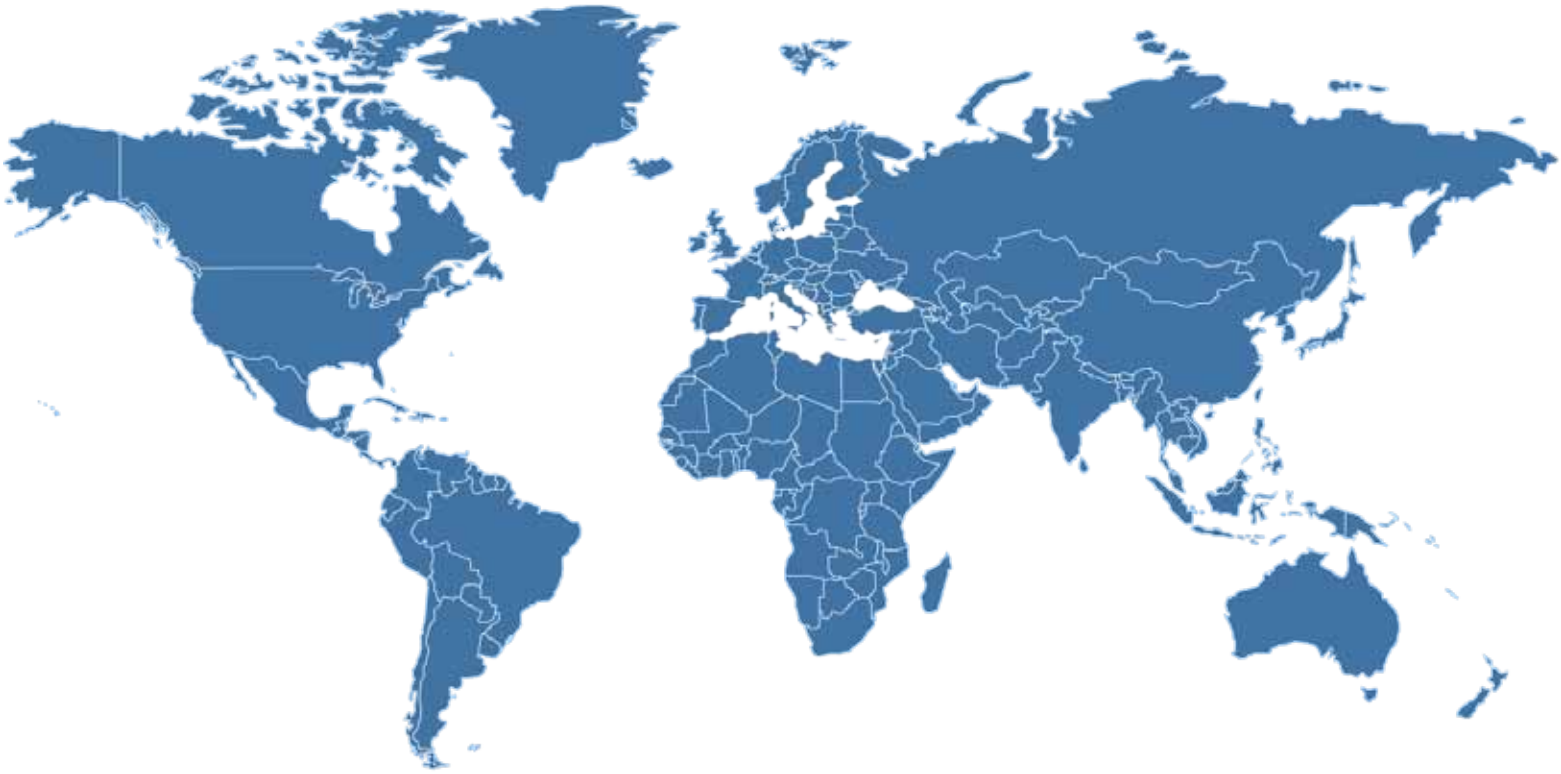
HARDWARE REPAIR SERVICES

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.

Full product support is provided with replacement units, hardware repair services, software upgrades, and more.



To find a distributor near you, please visit our website:

CRYSTAL INSTRUMENTS
2370 OWEN STREET
SANTA CLARA, CA 95054 (USA)

PHONE: +1-408-986-8880
FAX: +1-408-834-7818

EMAIL: SALES@GO-CI.COM
WWW.CRYSTALINSTRUMENTS.COM