CRYSTAL INSTRUMENTS

DYNAMIC TEST & MEASUREMENT SOLUTIONS

WWW.CRYSTALINSTRUMENTS.COM

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"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 & CEO of Crystal Instruments

Technology & Innovation Drives Our Success

In 1993, only two years after I arrived the USA, I read about a new technology that was just introduced into the consumer industry. A small start-up company, m-Wave, 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 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.

With the support of my wife, I quit my job and started to develop a measurement system. My partner and I 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. 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.

In 2004, I left Bruel & Kjær/LDS and reactivated Crystal Instruments. The CoCo-80 was a great success as the first product of Crystal Instruments. With two different working modes, one device performs simple route data collection or advanced real-time processing. It speaks to its user in familiar terms which he understands in both cases.

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 2006, 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 & CEO

Timeline of Achievements

www.crystalinstruments.com/about-crystal-instruments

2007: CoCo-80
Dynamic Signal Analyzer
Vibration Data Collector

2011: Spider-81
Fourth-Generation
Vibration Controller

2013: Spider-80X
Scalable Vibration Controller

2015: Spider-20
Handheld Dynamic
Signal Analyzer

2016: CoCo-80X
Touchscreen Dynamic
Signal Analyzer &
Vibration Data Collector

2017: EDM Modal
Complete Modal Testing &
Analysis Sotftware Suite

2018: EDM MIMO VCS &
Spider-80M Controller
Multiple-Input Multiple-Output
Vibration Control

- 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 certication, reaffirming our dedication to high quality products.
- 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.
- 2015: Spider-20, the first wireless dynamic signal analyzer and data recorder is released. It is battery-powered and palm-sized.
- 2016: CoCo-80X, the LCD touchscreen dynamic signal analyzer, is released following the success of the original CoCo-80.
- 2016: Spider-80Xi, a compact and lightweight high channel count system is released
- 2017: Introduced EDM Modal, a suite of tools for modal test and analysis
- 2018: EDM MIMO VCS Control, software for Multiple-Input Multiple-Output Control
- 2018: Spider-80M Controller is released, based on the Spider-80Xi architecture and is dedicated to MIMO VCS control and MIMO structural testing applications.

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.

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

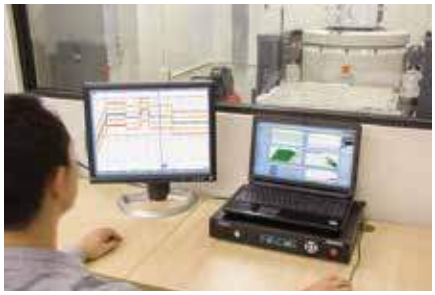
Producing first-rate engineers is a daunting responsibility. More and more, experimental skill and experience with technologically advanced instrumentation is demanded by industry. Today's engineer needs to be both analytically competent and experimentally capable. Leading universities have broadened 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.

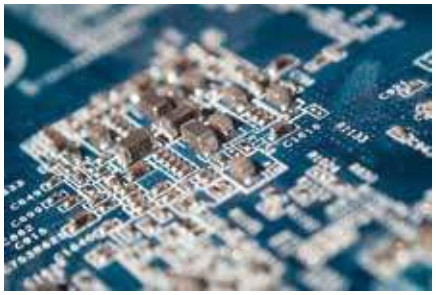
Data Acquisition and Analysis

- 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

Spider-81 Premium Vibration Controller

Spider-81B Basic Vibration Controller

Spider-81

The Spider-81 is the flagship model of Crystal Instruments vibration controllers. This 4th generation hardware is highly modular, distributed and scalable. Each Spider-81 has 8 analog input and 4 analog output channels. Eight digital I/O pairs are provided for custom applications. A bright front panel LCD displays the system status and test information. Users can instantly view real-time status information such as control RMS or sweeping frequency on the LCD panel.

The Spider-81 not only uses Ethernet for data communication, it goes further by employing IEEE 1588v2 time-synchronized Ethernet connectivity. This technology allows (up to 100 meters in distance) remote input modules to be connected solely by Ethernet (with no dedicated “sync” cable required), while still provides sampling and triggering synchronization within an accuracy of 50 ns. The Spider-HUB industrial Ethernet switch can 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 at least 250 GB of solid-state disk (SSD) storage in a removable SATA cartridge. One Spider-NAS records streamed time waveforms for up to eight Spider front-ends at the same speed of 102.4 kHz per channel.

Spider-81B Economical Vibration Controller

The Spider-81B front-end is a smaller, simplified system providing everything needed to run Sine, Random or Shock tests, measuring the control, and up to 3 monitor signals. This basic system offers a very comprehensive facility with the same control quality, safety assurance, measurement precision, expandability and human interface that distinguishes all Crystal Instruments controllers.

Shown here are the Spider-80XA35, the Spider-HUB, the Spider-NAS, and 9 Spider-80X front-ends.

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

The Spider-80Xi is a compact, lightweight, high channel count data acquisition system intended for portable field use.

The Spider-80M is dedicated to MIMO control and MIMO structural testing applications.

Spider-80X

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

Spider-80Xi

The Spider-80Xi is a platform that can host various front-end cards. Featuring a 64-channel chassis weighing less than 10.5 kg, the Spider-80Xi can be carried in one hand and is optimal for field environmental testing where portability is essential.

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

Spider-80Xi platforms can host various front-ends including voltage, IEPE, strain, temperature or charge mode. Multiple Spider-80Xi chassis can combine to create a system with up to 512 channels, all simultaneously sampled and synchronized in excellent phase match between all channels, either on the same front-end or across front-ends, or even across multiple chassis.

Spider-80M

The Spider-80M platform is based on the efficient Spider-80Xi architecture and is dedicated to MIMO VCS control and MIMO structural testing applications. Each Spider-80M chassis features 8 outputs capable of carrying out 6-degree of freedom MIMO testing. One Spider-80M chassis and multiple Spider-80Xi chassis can chain together to form a very large system with up to 504 input channels.

Hardware Platform	Spider-81	Spider-81B	Spider-80X	Spider-80Xi	Spider-80M
Application	VCS, DSA*	VCS, DSA*	VCS, DSA, EMA*	VCS, DSA, EMA*	MIMO VCS, MIMO FRF*
Number of Front-ends Per Chassis	1	1	1	8	7
Number of Inputs Per Front-end	8	4	8	8	8
Max Number of Inputs Per Chassis	8	4	8	64	56
Max Number of Inputs Per System	1024	4	1024	1024	1016
Number of Outputs Per System	4	1	2	2	8
Input Mode	Charge TEDS IEPE Voltage	Charge TEDS IEPE Voltage	Charge (optional) TEDS IEPE Voltage	Charge TEDS IEPE Voltage Strain gage MEMS RTD Thermocouple	Charge TEDS IEPE Voltage Strain gage MEMS RTD Thermocouple
Digital I/O	8 in/out, isolated	4 in/out, isolated	4 in/out, isolated	4 in/out, isolated	4 in/out, isolated
Front Panel LCD	Yes	No	No	Yes	Yes
Front Panel Start/Stop button	Yes	Yes	Yes	Yes	Yes
High Speed Data Port	Yes	No	Yes	Yes	Yes
Notes	Flagship product for VCS line. Input protection up to 250V. Equipped with Stop/Start button.	Economical solution	Modular at box level.	Modular at board level. Input Mode depends on front-end type. See the following table.	Modular at board level. Input Mode depends on front-end type. See the following table.

** VCS = Vibration Control System*
** DSA = Dynamic Signal Analyzer*
** EMA = Experimental Modal Analysis*
** MIMO VCS = Multi-input Multi-output Vibration Control System*
** MIMO FRF = Multi-input Multi-output FRF analysis in EMA*

The Front-ends of the Spider-80Xi and Spider-80M Platform			
Front-end Types	**Spider-80Xi**	**Spider-80SGi**	**Spider-80Ti**
Max Sampling Rate	102.4 kHz	102.4 kHz	2 kHz
Number of Inputs Per Front-end	8	8	16
Connector Type	BNC	LEMO	3-pin screwed terminal
Input Type	IEPE Voltage TEDS	Voltage Strain gage Strain gage-based sensors MEMS DC-based sensors	3-wire RTD K type thermocouple
Input Coupling	AC Differential DC Differential AC Single-ended DC Single-ended	AC Differential DC Differential	-------
Sensor Excitation	4.2 mA at 21 V for IEPE	2.5V, 5V, 10V	-------
Strain Gage Type	-------	Quarter Bridge Type I, II Half Bridge Type I, II Full Bridge Type I, II Excitation voltage: ±2.5, ±5	
Max Input Range	±20Vpk	±10V	-------
Input Protection Voltage	±220V	±40V	-------
Analog to Digital Converter Per Channel	Dual 24-bit ADC	24-bit ADC	-------
Cross Talk	< -100 dB	< -130 dB	-------
Amplitude Accuracy	±0.1% at 1kHz 1V	±0.1%	-------
Phase Match	< 1° up to 20kHz	< 1° up to 20kHz	-------

Combined Environmental Testing

www.crystalinstruments.com/temperature-humidity-environmental-controller

Temperature and Humidity Chamber with a shaker system

The industry trend demands environmental testing conducted in fully integrated environments. Various physical parameters, including vibration (acceleration, velocity and displacement), temperature, humidity, pressure, torque, and electrical signals such as those from CAN bus should be monitored and controlled by one system. Crystal Instruments made dedicated efforts to achieve this goal.

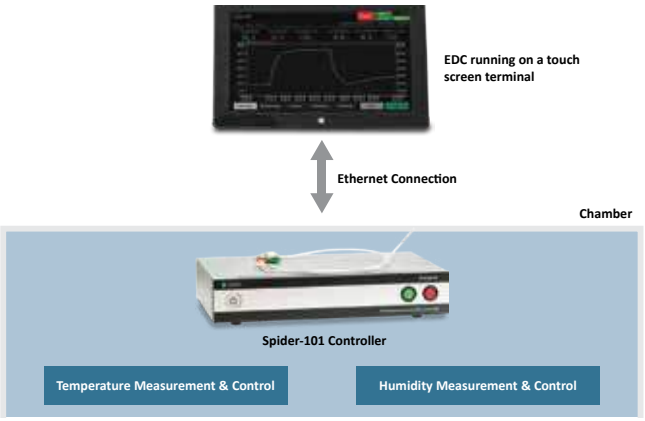
Using the Ethernet network and PTP time synchronization technology, all Spider hardware devices connected to the LAN can be accessed and configured as one integrated system.

The Spider-101 is specifically designed to perform tests subjecting the DUT to simultaneous temperature cycling and variable humidity. The Spider-101 controls both temperature and humidity in a chamber system, which includes external heating/cooling and humidification/dehumidification systems.

The Spider-101 Temperature/Humidity Controller

When vibration control is required along with temperature and humidity control, users can access the parameter and schedule setup between all combined physical quantities from one fully integrated user interface. Users can execute vibration tests such as Random, Sine, Shock, SoR, RoR, and other types together with various cycle settings of temperature and humidity.

- One integrated setup
- One clock and schedule
- One user interface
- One testing report
- One vendor to provide technical support

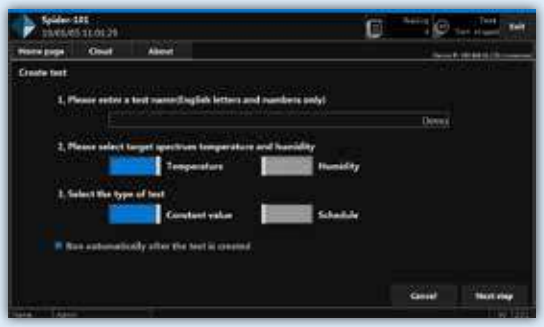


Software Designed for Combined Environmental Testing

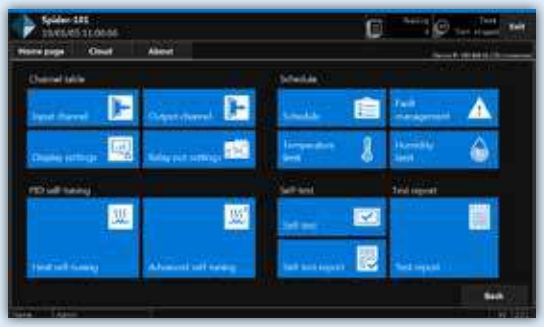
EDC (Embedded Device Controller) and **EDM THV** are two software modules specifically designed for the Spider-101 to perform Temperature/Humidity (TH) or Temperature, Humidity, and Vibration (THV) control tests.

EDC is a lightweight Windows application with an interface designed for touchscreen use. It runs smoothly on both Intel-based and ARM-based Windows 10 tablets, which can serve as wireless touchscreen terminals that users can mount to the testing chamber. In addition, there is a wide selection of Windows tablets offered in the market that fulfill various requirements (such as the IP6X tablet). The Spider-101 controller runs on EDC software to conduct TH testing (without vibration) in independent climate chambers. Users can configure a test, operate a test, review test logs and review signals from the EDC interface.

Test status page of EDC on a wireless, touchscreen terminal.

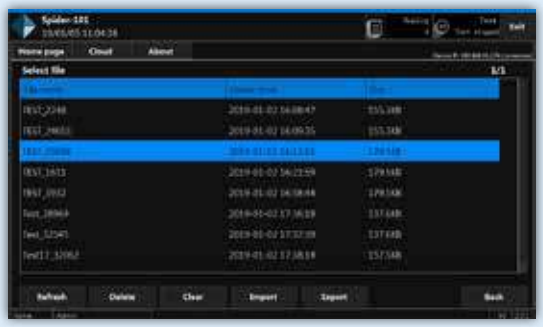


Create test page of EDC on a wireless, touchscreen terminal.



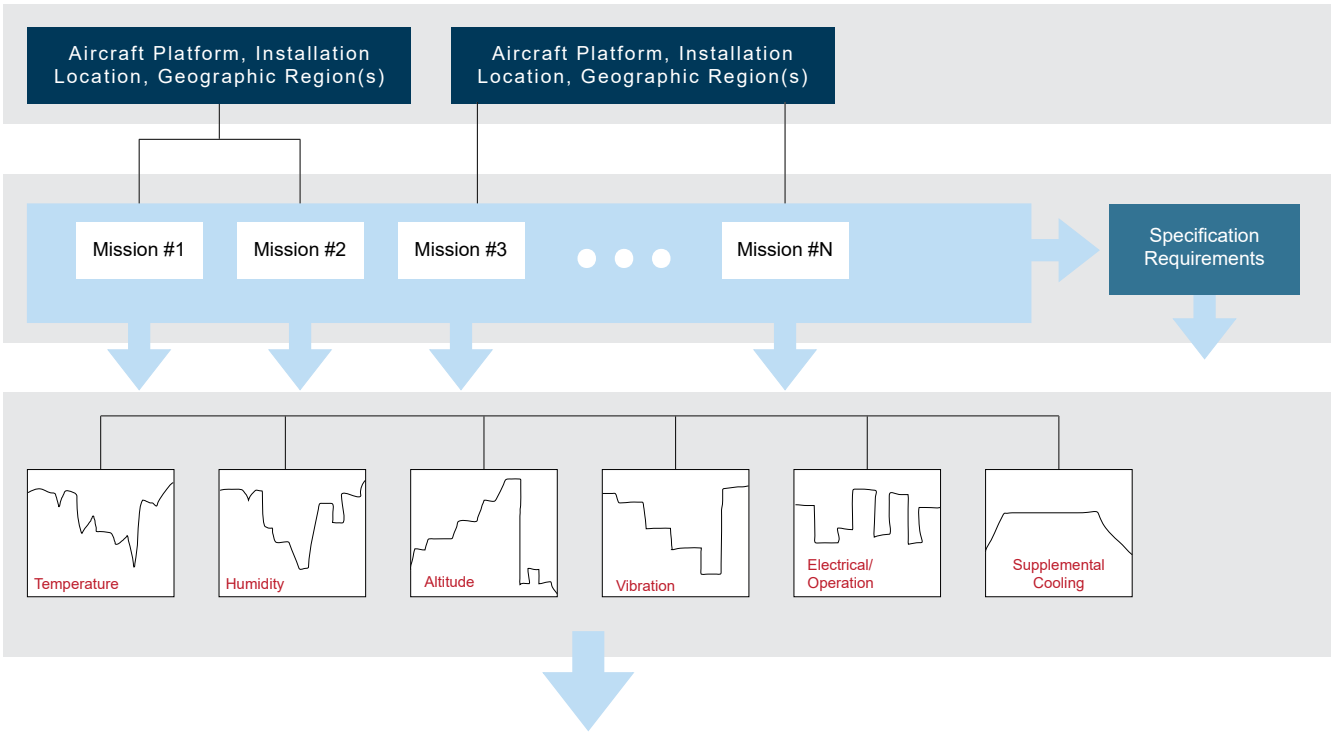
Parameter page of EDC on a wireless, touchscreen terminal.

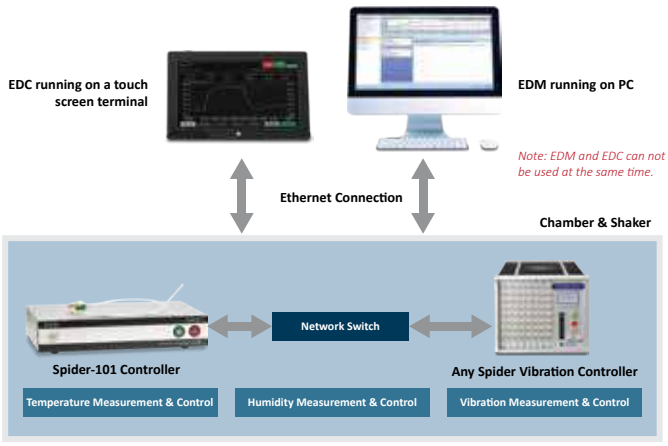
Run log page of EDC on a wireless, touchscreen terminal.



Signal file page of EDC on a wireless, touchscreen terminal.

MIL-STD-810H
Method 520.5





EDM THV is the THV control software application included in EDM (a PC-based software developed by Crystal Instruments). Use EDM THV with Spider-101 when vibration control is required along with temperature and humidity control. EDM THV is a premium and full-featured software product as well as EDM VCS (Vibration Control System) and EDM DSA (Dynamic Signal Analyzer).

EDC and EDM THV can be used together to provide great flexibility and portability to the test operation.

Battery Testing of Electric Vehicles

www.crystalinstruments.com/battery-testing-for-electric-vehicles

Standards for Battery Testing of Electric Vehicles	
IEC 62133	Safety Requirements for Portable Sealed Secondary Cells & Batteries made from them
SAE J2464	Electric Vehicle Battery Abuse Testing
UL 2054	Testing & Certification for Battery Packs
UL 2202	Standard for Safety Electric Vehicle (EV) Charging System Equipment
UL 2231-2	Standard for Safety Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems
UN 38.3	Transport of dangerous goods
ISO 12405-1	Lithium-ion traction battery packs & systems
SAE J2380	Durability testing of single batteries
GMW16390	General Motors manufacturer standard

The global demand for electric vehicles has increased the need for battery testing. Batteries must be tested to withstand the harsh conditions resulting from shipping and everyday usage to ensure their safe operation. Environmental hazards can range from extreme temperatures to repeated shocks and vibrations resulting from transportation.

Testing the batteries includes a combination of electrical, vibration and environmental tests. Performing these tests simultaneously would better simulate the conditions electric vehicles typically operate in to ensure safety for the drivers.

The Spider platform of products provides one integrated software interface to perform combined vibration and environmental tests while monitoring CAN bus information through one system.

Users can add CAN bus to their Spider system to monitor received data and display data through EDM software. EDM monitors the real-time battery information received from CAN bus and applies a threshold. When the threshold is exceeded, EDM will stop the test or execute pre-defined actions (e.g. send email to the operator or DIO message) to automate safety reactions that were pre-determined by the tester.

The combination of features in addition to the flexibility in using multiple Spider products together not only accurately mimics the environment of electric vehicles, but also provides battery condition monitoring and automatic reactions to ensure the testing safety and frees the tester from continuous monitoring. The overall and integrated solution makes the Spider system the best choice for performing battery tests.

Crystal Instruments offers the following battery testing solutions:

- **Complete Vibration Testing** (Software, hardware, USA-based product support)
- **Combined Environmental Testing** (Temperature/Humidity/Vibration)
- **Testing with CAN bus integration** (Automatic and customizable safety reactions)
- **Data Acquisition Solutions** (Handheld, Tabletop, to High Channel)

Strain Gage Measurement

www.crystalinstruments.com/spider80sg-general-data-acquisition-with-strain-gage

The Spider-80SG Strain Gage Measurement System

The Spider-80SG Strain Gage Module

The Spider-80SG/SGi is a front-end in the Spider-80X/Xi hardware family platform. It is a high precision, general purpose data acquisition device featuring strain gage functionality. This device can be used in a variety of physical and measurement tests.

The Spider-80SG can acquire data from a strain gage or a wide range of sensors. With the help of precision excitation voltage, the Spider-80SG/SGi can support strain gage based sensors, MEMS sensors, and DC sensors (to name a few) thus expanding the scope of the Spider-80Xi hardware platform to support the synchronized acquisition of a wide range of measurement quantities including Force, Torque, Pressure, Acceleration, Velocity and Displacement. It can be used for strain measurement and many other types of sensors that requires external power. EDM-DSA and VCS software fully supports the Spider-80SG front-end in all its testing operations.

In addition to the features shared with the Spider-80Xi hardware platform, the Spider-80SG/SGi offers the following capabilities.

High Channel Count

Named for their networkable ability, the Spider hardware platforms (including the Spider-80X/Xi and the Spider-80SG/SGi) share the flexibility of scaling up in channel count and functionality. The Spider-80SG/SGi can combine with any Spider-80Xi device to create a high channel count system with up to 512 channels.

Spider-80SG

Highlighted Features:

- 8 Strain Gage/General Purpose Inputs Per Front-end
- 24-bit ADC Channel
- Supports Multiple Measurement Quantities
- Supports Quarter Bridge, Half Bridge and Full Bridge and Rosette Strain gage Configurations
- Supports a Variety of Strain Gages based sensors, Load Cells, Pressure Transducers, Torque Sensors, MEMS Accelerometers. Displacement Sensors, Velocity Transducers and Geophones
- User Configurable Synchronized Sampling Rate
- Remote sensing: Measures strain accurately from up to 1000 ft cable length with up to 10 KHz frequency.
- Precision Excitation Voltage of ±2.5V and ±5V
- Power Supply Voltage of 2.5V, 5V and 10V for Sensor Excitation
- Shunt Calibration
- Offset Nulling for any measurement quantity
- Multiple Trigger Modes
- Compact, Portable Design
- Scale up to 512 channels using multiple front-ends
- User selectable sampling rate for each front-end in a high channel count system
- DC Drift: less than 1.5 µV/V in 48 hours

Dual Modes of Excitation

The Spider-80SG is equipped with dual excitation modes. There is an option for Precision Excitation Voltage of ± 2.5V or ± 5V that can be used to excite a strain gage or a strain gage based sensor and to accurately measure the minute change in resistance. It is also equipped with a user configurable DC power supply of 2.5V, 5V and 10V which can be used as an excitation voltage for a wide variety of sensors.

Strain Measurement

The Spider-80SG/SGi supports Quarter Bridge, Half Bridge and Full Bridge configurations for each input channel. It also supports measuring strain through Rosette configurations by combining the user selected channels in the desired configuration.

Remote Sensing

The Spider-80SG has been tested to work on strain gages up to 1000 ft away from the analyzer using the remote sensing feature. Using an 18AWG 5 conductor cable to measure the excitation voltage using remote sensing and changes in output voltage, the error was measured to be less than 1.5% for signal frequencies up to 10 KHz.

Measurements Quantities and Sensor Types

The Spider-80SG/SGi's user-selectable precision excitation voltage feature enables it to interact with a wide range of sensors, allowing the synchronized acquisition of a wide range of measurement quantities.

Supported Sensor Types: MEMS based Sensors, Strain gage based sensors, Precision Excitation DC Sensors.

Supported Measurement Quantities: Force, Pressure, Torque, Acceleration, Displacement, Velocity, Sound Pressure.

Spider-HUB Industrial Ethernet Switch

Spider-NAS Storage Device

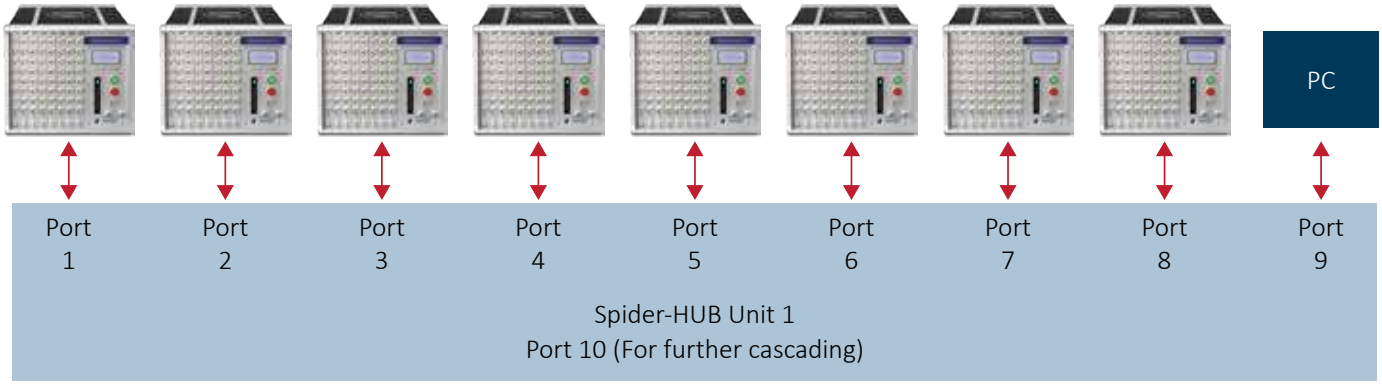
Spider systems use superior Ethernet and time synchronization technology developed by Crystal Instruments which allows modular expansion to support up to 512 input channels. When a system is running with multiple front-ends totaling to hundreds of input channels, all data is simultaneously acquired and is accurately phase matched. The phase match accuracy can be less than 1 degree within the normal testing frequency range. By providing such high phase match, the frequency response function of cross channel measurement can be used for analyzing the characteristics of the UUT (unit under test), such as modal shape and damping ratio.

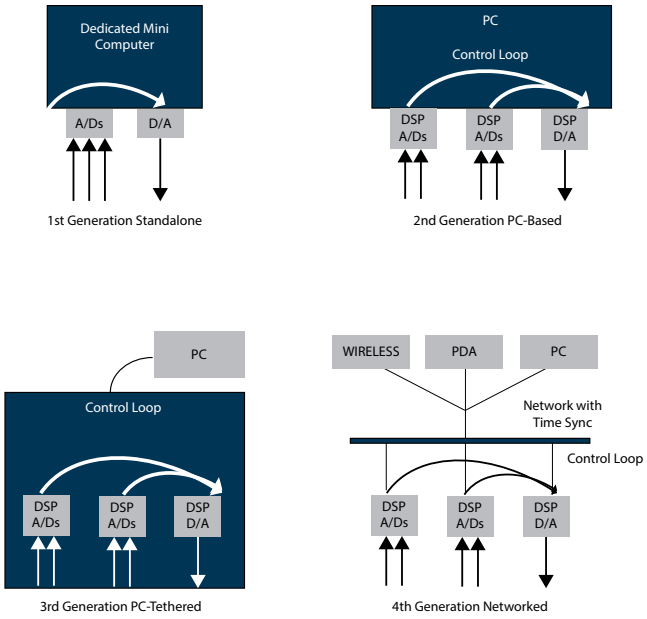
In a Swept Sine test that runs hundreds of input channels, the tracking filter and notching can be applied to any of input channels. In a Random control test, the monitoring channel, limiting, or Sine-On-Random can all be simultaneously applied to all input channels. In TTH or Shock, all data captured among all channels will be acquired simultaneously. CI's Spider system is the only product in the world that fully integrates the DSA and VCS functions to operate with up to 512 channels.

Data recording on Spider systems can be realized via either of two approaches: (1) record the time-stream data into the flash memory on each of Spider front-end or (2) record the time-stream data into an external storage device such as the Spider-NAS.

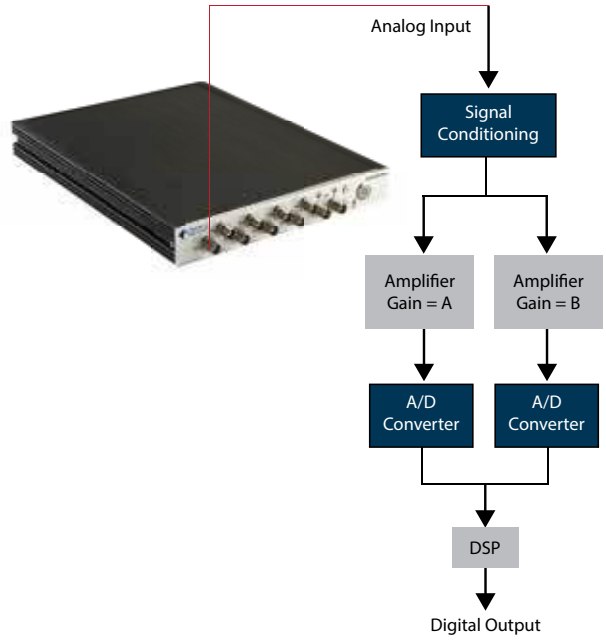
The Spider-NAS can store simultaneous data from all (64 maximum) attached dynamic measurement channels at a sample rate as high as 102.4 kHz, or as low as a few samples per second. If a system has more than 64 channels, every 64 channels will require one Spider-NAS.

Spider-80Xi System (512 Channel Count)





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



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 flash memory. Increased storage space is possible with the addition of a 250 GB external unit.

Shaker Compatibility

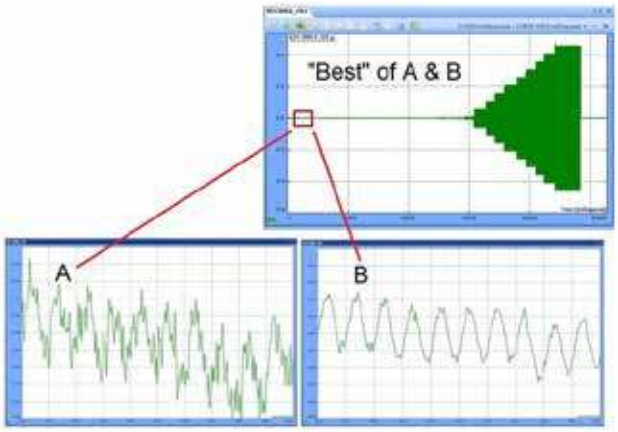
Spider controllers work with any electrodynamic, servo-hydraulic, or servo-electric shaker with all ranges of force ratings, from tiny desktop to multi-ton water cooled systems. Frequency range can be from sub 1 Hz to 40 kHz.

Designed for High Precision and Accuracy

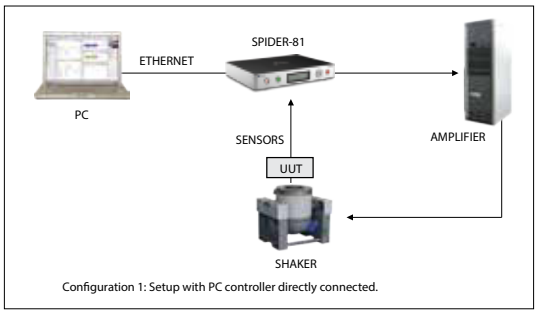
The Spider analog input channels provide extremely high precision measurements. Each channel has single-ended or differential AC or DC input coupling. It can also provide IEPE (ICPTM) input mode (AC coupling with a 4 mA constant current from a 24 VDC source) for use with industry-standard accelerometers 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.

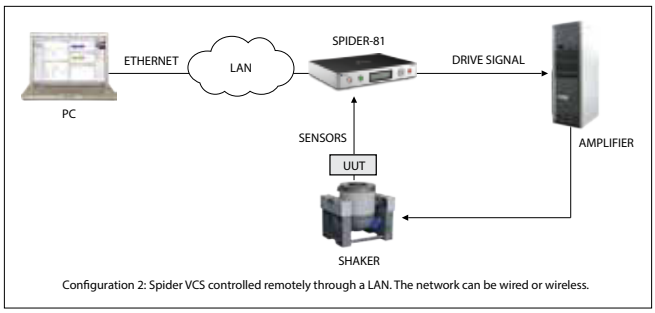
Using our patented parallel dual analog-to-digital converter (ADC) design (U.S. Patent number 7,302,354), each measurement channel provides an unprecedented dynamic range of 160 dBFS (v7.7 and later) and can detect signals as small as 600 nV and as large as 20 V. This design eliminates the need for the input range or gain settings found on traditional controllers.



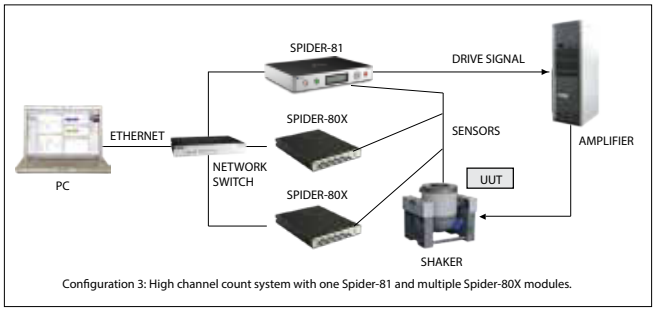
DSP knows how to pick the data from either A or B path, and "stitch" them together.



Configuration 1: Setup with PC controller directly connected.



Configuration 2: Spider VCS controlled remotely through a LAN. The network can be wired or wireless.



Configuration 3: High channel count system with one Spider-81 and multiple Spider-80X modules.

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.

On-Board LCD Display

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

Designed for High Reliability

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

Designed for High 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.

Designed for High Scalability and Expandability

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

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 VCS software suites support Spider hardware systems with as few as two input channels to systems with up to 512 input channels and multiple drive output capabilities. Software solutions for vibration control includes Sine, Resonance Search Track & Dwell (RSTD), Oscillator, Random, Sine-on-Ransom (SoR), Random-on-Random (RoR), Swept Random-on-Random (SRoR), Classical Shock, Transient, Seismic, Shock Response Spectrum (SRS) Synthesis, Time Waveform Replication, multi-shaker control and a range of MIMO control functions. The VCS software is fully integrated into the combined test environment which includes controls to temperature, humidity, pressure, strain, torque and other quantities.

The same Spider hardware running VCS 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 a comprehensive suite of modal testing and analysis.

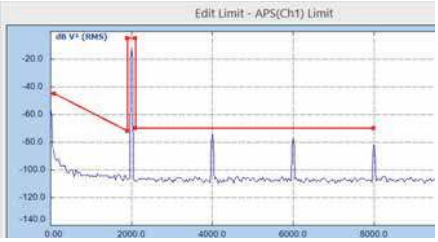
Multi-Language Support

Crystal Instruments' EDM fully supports software interfaces in English, Japanese, Simplified Chinese, Traditional Chinese or Russian. The selected language can be changed without re-installing the software.

Easy Network Configuration

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

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

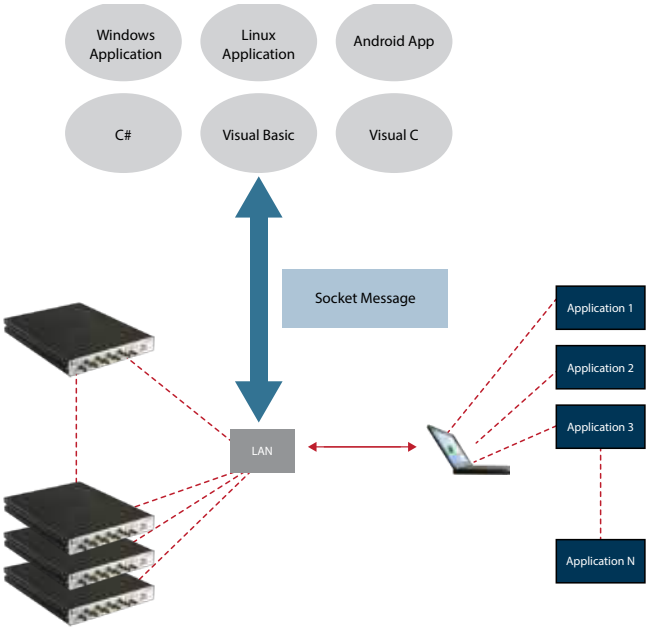
Multi-Tab and Multi-Screen Support
To support the high channel count system that may display up to hundreds of signals, the software is designed to support multiple tabs and multiple screens. The highly flexible online display capabilities are expandable, making monitoring high-channel count systems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

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

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

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

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



Connectivity to Other Software, Hardware and You

Various approaches have been developed to establish the connectivity between the EDM software and other applications, such as climate chamber software or an amplifier controller. Socket messages, a common language that runs on nearly all operating systems and hardware platforms, is used to send and receive messages between EDM and other software. A digital input/output hardware interface is also provided on every Crystal Instruments product, which enables interfacing to other hardware devices. Test status reports can be sent via email or SMS text message to your mobile phone, enabling you to decide whether to return to work or not within minutes of the test stopping.

Continuous Time Data Recording

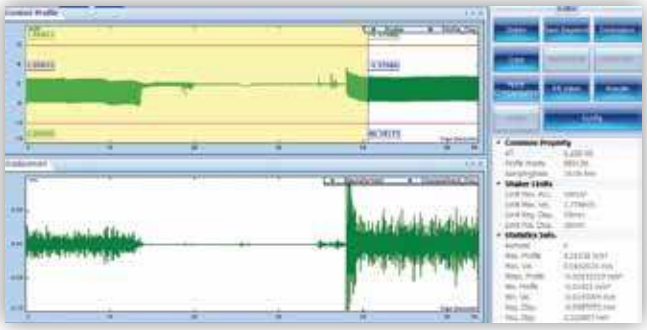
The Spider platform is capable of recording the data of 512 control/monitor input channels sampled at up to 102.4 kHz. The storage can be either internal flash memory or a dedicated solid-state drive. The reliability of the software for such real-time data transfer has been fully validated. Continuous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

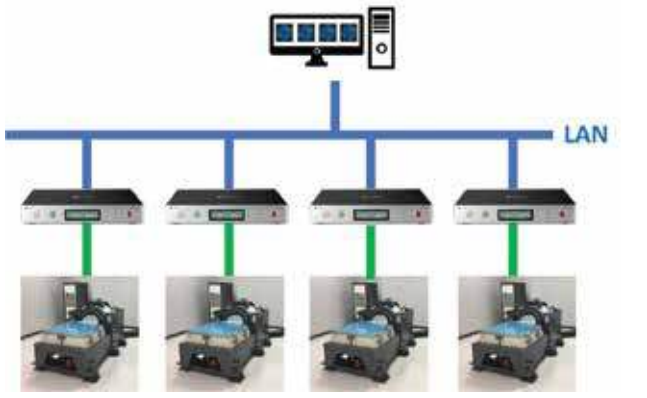
Database Technology

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.

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 started.

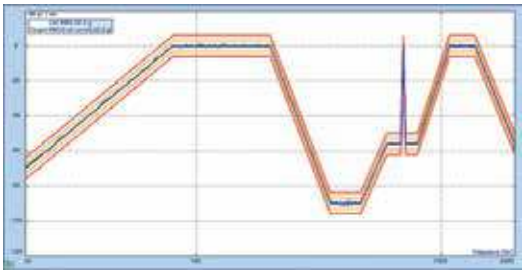
Flexible Math Function
EDM software provides flexible math functions to perform block arithmetic on signals using +, -, *, / or other arithmetic operations. Math functions can be applied in both time and frequency domains.

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

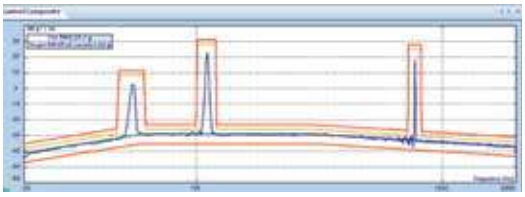
Remote Operation Communication Using Socket Messages
Communicate with and control Spider systems remotely with Window socket messages. Socket messages also allow communication with other hardware, such as temperature chambers. With the Socket Message protocol, Crystal Instruments' controller can be accessed from LabView, Matlab or other customized software running on Linux, MacOS, or Windows operating systems. Please refer to the Socket Message Specifications for further details.

Shaker Parameters
Shaker parameters are saved to the library and used repeatedly in different tests. The library can be imported from or exported to a Microsoft Excel spreadsheet.

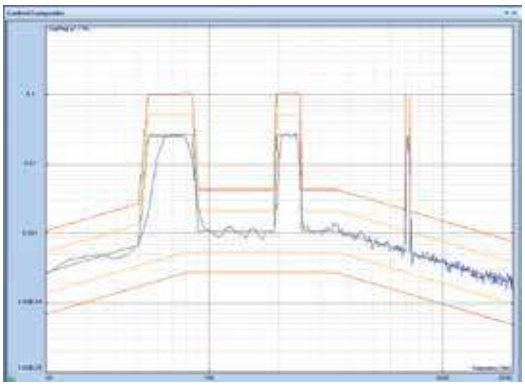
Multiple VCS Instances
Launch multiple EDM VCS instances on one computer. Each instance of full-featured VCS software connects to one controller that drives one shaker. Each instance runs the vibration control test individually. All instances may run different test types or the same test type. The operator performs the tests and monitors the test status from the same computer, where all reports and signals from multiple instances are saved to for better management.



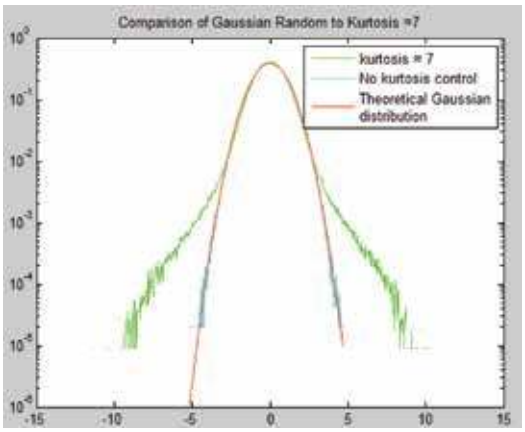
Random Vibration Control
Random Vibration Control provides precise multi-channel control in real time. The device under test is subjected to true random noise with a precisely shaped spectrum with either Gaussian or non-Gaussian amplitude statistics.



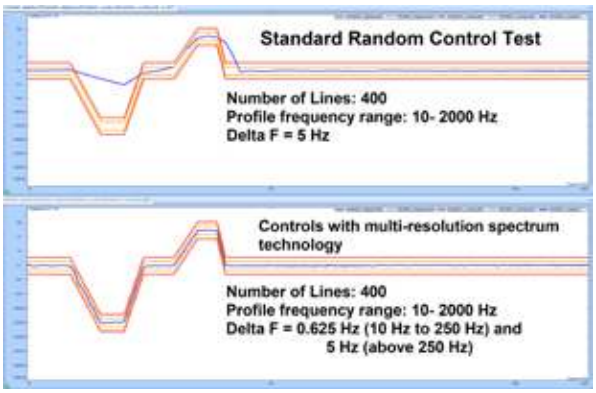
Sine on Random Control
Up to 12 independently sweeping controlled sine tones may be added to the broadband random signal. Each sine tone has its own sweeping schedule and range. Tones can be turned on and off manually or by a predefined schedule.



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

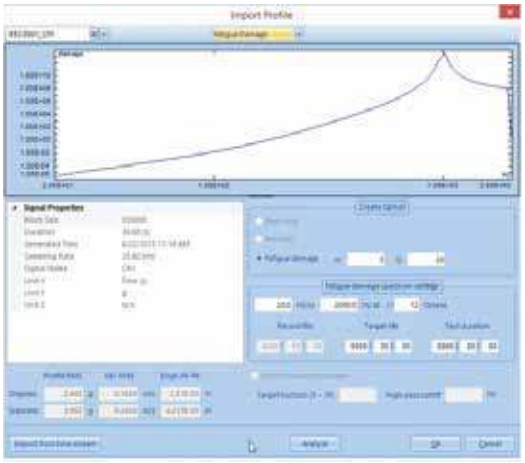


Kurtosis Control & Drive Clipping
Kurtosis control can provide a more damaging non-Gaussian random control time history. A unique patent pending technology can generate a non-Gaussian control time history while precisely maintaining its spectrum shape.



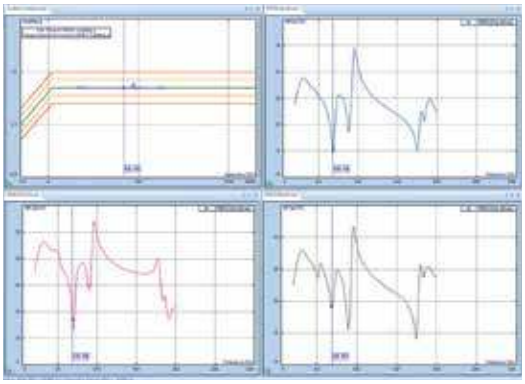
Multi-Resolution Control

The Multi-Resolution function applies the selected resolution in the high-frequency range and 8 times of the resolution in the low-frequency range. It perfectly fulfils the requirements of many Random profiles having details in the low frequency range and up to 2 kHz. Adequate loop time, spectrum refresh rate, and storage are maintained without using high resolution (large block size) that is not needed in the high frequency.



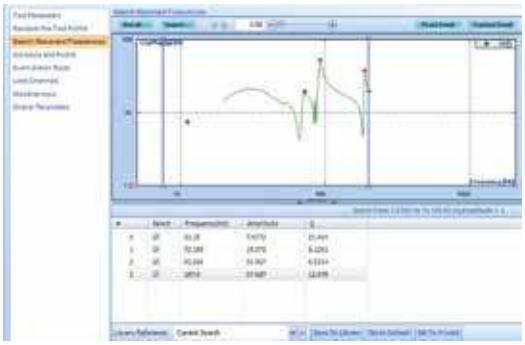
Fatigue Damage Spectrum

Fatigue Damage Spectrum (FDS) allows users to compare the potential damage caused by different Random and swept Sine profiles. In a similar fashion to Multi-Sine Control, FDS provides a way to reduce testing times by calculating the quickest path to destruction or damage.

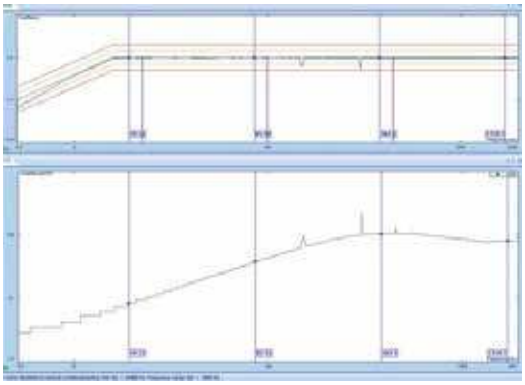


Swept Sine Control

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.

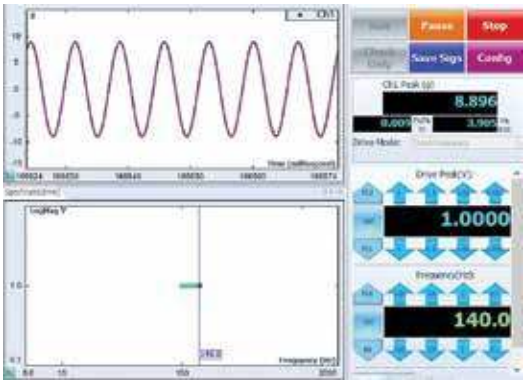


Resonance Search and Tracked Dwell (RSTD) Control
The resonance search function determines resonant frequencies from the peaks of a transmissibility signal. Dwell type (Fixed dwell, Tracked dwell, Phase tracked dwell) may be specified manually (with a list of resonance frequencies) or automatically executed after a resonance search is done.



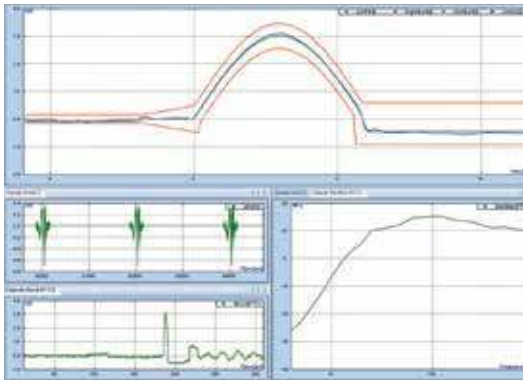
Multi-Sine Control
Multi-Sine control enables multiple sine tones sweeping simultaneously and ensures that multiple resonant frequencies of the structure can be excited. With multiple sine tone excitation, the required time duration of sine testing can be reduced significantly.

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



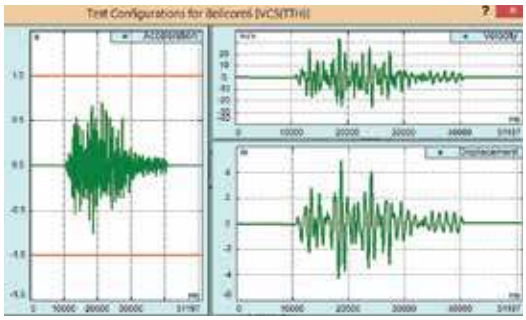
Sine Oscillator

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 aug- mented manual control functions.



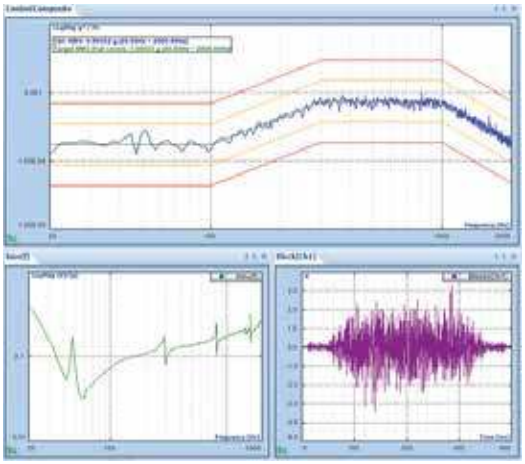
Classical Shock Control

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. Applicable Test Standards include MIL-STD-810F, MIL-STD-202F, ISO 9568 and IEC 60068 (plus user-defined specifications).



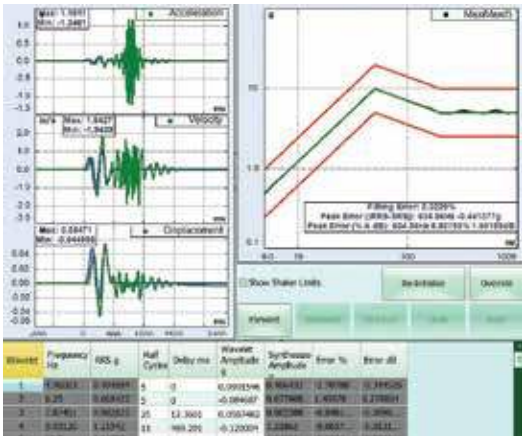
Transient Time History Control (TTH)

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 dupli- cated on a particular shaker.



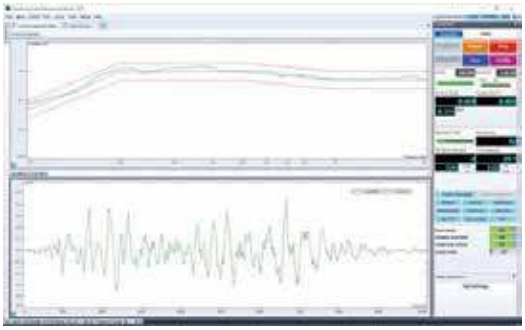
Transient Random Control

Transient Random control applies a chain of pulses with random nature to the shaker. The target profile power spectrum is defined in a same way as Random control, with the addition of defining transient pulse interval. Applications includes gunfire simulation or road simulation.



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.



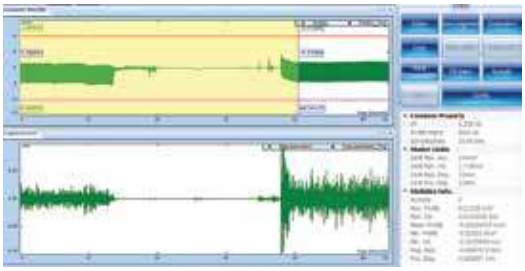
Earthquake Testing Control

The earthquake testing control package provides controls to meet a target a Required Response Spectrum (RRS).

Waveforms are automatically synthesized from a user-specified SRS reference profile using random type of wavelets, uniform or shaped. Alarm and Abort tolerances may be applied to any active channel to provide an extra degree of safety for delicate test articles.

Time Waveform Replication

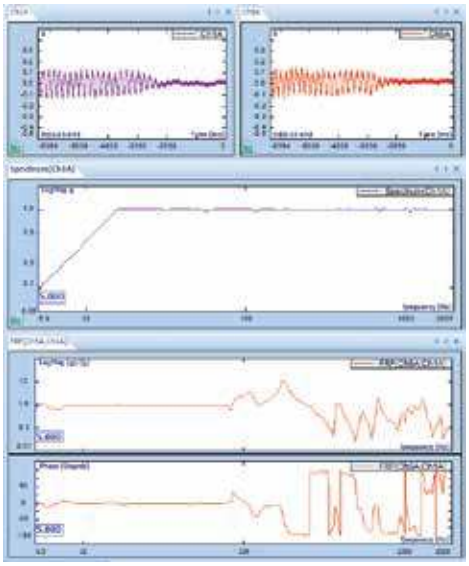
Time Waveform Replication (TWR) provides precise, real-time, multi-channel control for long duration waveform duplication. TWR includes the Waveform Editor, a flexible importing and editing tools for long waveform signals. The Recording option records time stream data at the full sample rate on all input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



Waveform Editor

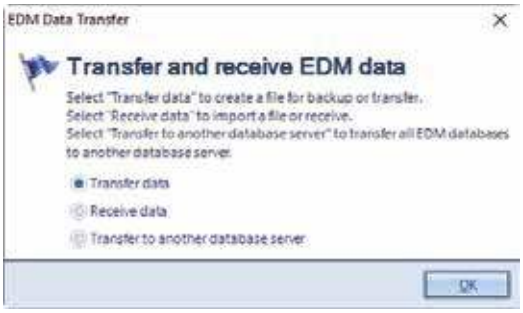
Profile Definition: Any existing signal is treated as a profile and is imported and defined as a control.

Profile Editing: Waveforms with any sampling rates are digitally resampled, 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



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 system while an independent vibration controller controls the shaker. The sine reduction application calculates the same time and frequency functions as the controller, but using its own input signals. This function requires a COLA signal from the vibration controller system for instantaneous frequency, phase detection, and spectrum analysis.



Data Transfer Tool

The Data Transfer Tool is installed with EDM. It transfers all EDM databases (including tests, parameters, and saved files) from a local computer to another over LAN or storage media (e.g. flash drive, DVD, …). In addition, databases can be transferred between SQL server instances. The transfer and receive process can also be treated as a backup and recovery process. The step-by-step wizard guides the user through the whole process.

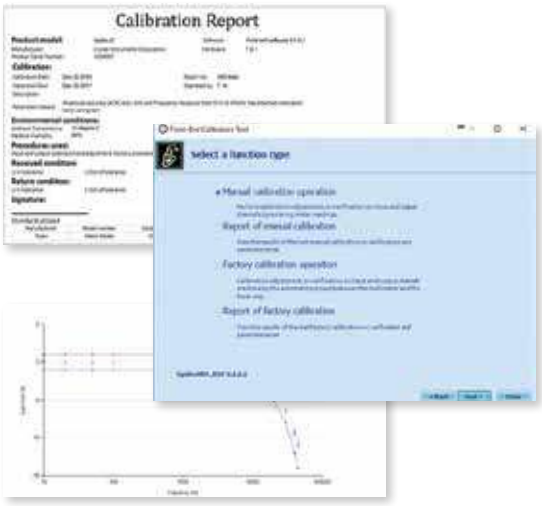
Sensor Calibration

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

Versatile Report Functions

The EDM software generates test reports from pre-defined templates. Users can customize the logo, margins, orientation of the paper, font formats, and contents of the test reports. The reports can export as OpenXML, PDF, or Microsoft Word file types for convenient usage. A word processing program does not need to be installed in order to create reports. With ActiveX reporting, signal displays in the report can be rescaled, analyzed, and zoomed.

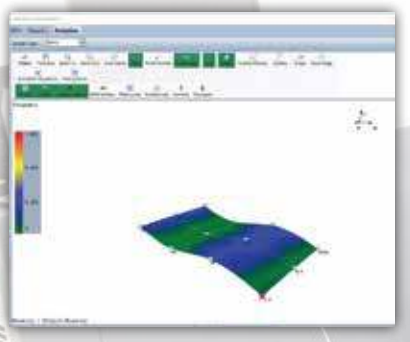
- Users can select from various templates for creating reports
- Plot reports can be generated by simply right-clicking the mouse
- Company logos can be inserted into the template header or footer
- Reports can export as WORD, OpenXML or PDF format
- “Active Report” allows the user to ZOOM in and out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

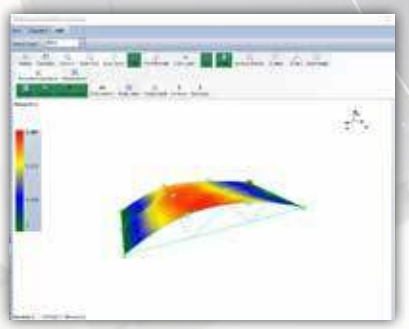


Front-End Calibration Tool (FECT)

All products are calibrated at the factory prior to shipping and should be recalibrated annually by a factory authorized calibration service. The optional calibration tool existing before EDM 6.1 release is replaced by FECT, which provides a basic adjustment and is operable by the user or a calibration specialist. Reports can be generated from EDM or FECT.

For a more comprehensive calibration report, which provides as found and as left data measured at different frequencies, contact Crystal Instruments or an authorized calibration service provider for more information.





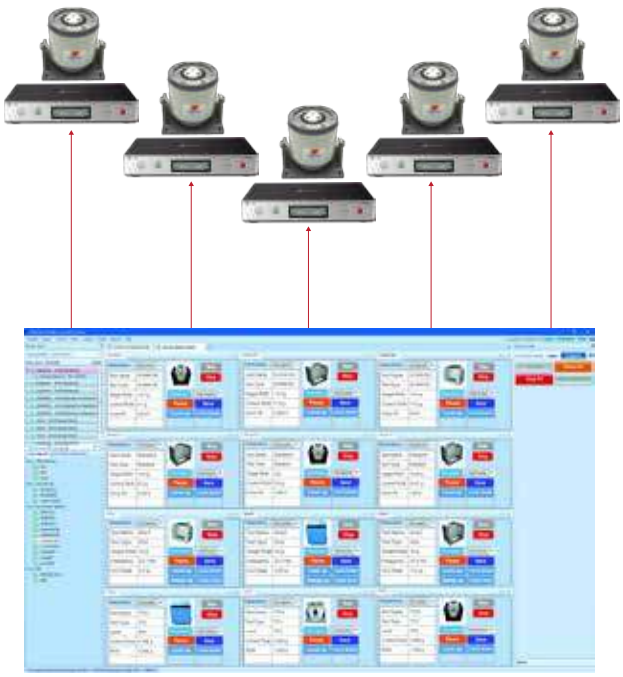
Vibration Visualization

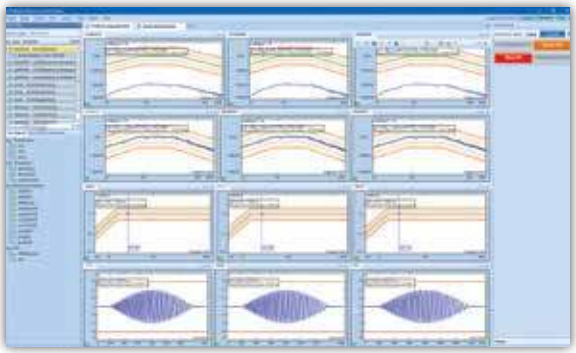
The EDM Vibration Visualization feature is available in **all test types of EDM VCS software**. This option provides fast and efficient structural model generation and full 3D visualization of the online vibration pattern on the structure under test. There are three tabs to cover the geometry model editing, input channel DOF mapping, and operational deformation shape animation.

The first tab (**Editor**) is designed to help users create the geometric models for viewing the operational deflection shapes of the test structure. The second tab (**Channels**) allows the user to assign the corresponding DOF information to each enabled input channel. The third tab (**Animation**) displays the deformation animation of the operational deflection shapes of the structure under test. **Block** and **RMS** data from the input channels can be used for the vibration visualization of the operational deflection shapes.

Multi-Shaker Control from One Application

www.crystalinstruments.com/multiple-shaker-control-software





The multi-shaker control function is specifically designed for production applications, where the operator wants to observe and command multiple shaker tests from one PC station. The operator can manage the entire testing configuration from one EDM instance at their workstation – this includes observing the testing status, viewing individual signals from different shaker systems, and sending commands to each controller.

Spider systems are not limited by bandwidth in their number of controllers – the ethernet connectivity of Spider systems allows for any number of connections. For practical reasons we limit the number of controllers that EDM can access to 12.

Customizable Status Display

The status display for each individual shaker controller can be customized. For example, you can display the Peak value for a Sine controller and the RMS value for Random. These can be displayed on one screen.

Customizable Individual Command Panel

Commands for each controller are customized. Some panels can have Start/Stop/Pause, and other panels can show Sweep Up/Down.

Run Different Type of Tests

Different types of tests can be mixed and loaded into this application together. Random, Sine, TTH or Shock can run in the same test duration.

Common Commands

Several common commands have been implemented – these commands can be applied to all controllers at once. All the tests can be started or stopped by pressing one button.

Robust Tolerant Design

Robust software design allows for tests to run without being interrupted by the failure of other tests. If one test failed for any reason, the other tests will continue, until the operator wants to stop them.

Multiple-Input Multiple-Output (MIMO) Vibration Control System

www.crystalinstruments.com/mimo-vibration-control-overview

MIMO Vibration Control Overview

MIMO Testing has gained a huge momentum in the past decade with the development of multiple shaker table systems, the availability of Multiple-Input Multiple-Output (MIMO) controllers, and the readiness of the standards (e.g., Mil STD 810G method 527 and IEST DTE 022 working group recommendation,).

In the real world, structural vibrations are excited from sources in all directions. To simulate a real-world vibration environment, testing must be performed simultaneously in multiple directions. MIMO testing with simultaneous multiple direction excitation reduces the overall testing time and eliminates the time needed to change the fixing of the DUT to the table and to change shaker orientations (e.g., from vertical to horizontal).

The multi-shaker system ranges from Multiple Exciter Single Axis (MESA), to Multiple Exciter Multiple Axis (MEMA), with 2 to 6 shakers involved, for single axis, three axis translational shaker table, 6 DOF Multi Axis Shaker Table (MAST) table, etc.

Multi-Exciter Single-Axis (MESA) is a type of application in which multiple exciters providing dynamic input to the test item along a single axis. For cases in which the two exciters are driven to a common specification with respect to both phase and amplitude, the output may be described basically in one axis of excitation.

Three axis shaker tables are available for Multiple-Exciter Multiple-Axis (MEMA) test arrangements. Many testing applications require testing the DUT in simultaneously all three directions. With a three- axis shaker table system, the overall testing time is reduced by two-thirds over single-axis testing along each axis.

The automotive industry has been running tests on their vehicles for decades using four poster testing systems. Nowadays, with the availability of sophisticated MIMO control, testing with four posters is raised to a whole new level. Users can accurately reproduce time waveforms recorded from the testing tracks or real road conditions inside the lab.

The vibration environment is incomplete without rotation. The MEMA Type 6 DOF Shaker Tables are available for these types of testing. The arrangement of shakers among all three axes allows the row, pitch, and yaw to be achieved along with the three-dimensional translation motions from the table.

MIMO Vibration Control Software

MIMO Vibration Control has always been a challenge for testing engineers. With Spider MIMO Control software, it is now possible to perform accurate and precise MIMO testing using multiple shakers to reproduce real-world complex vibration environments. Spider MIMO Control software covers the complete range of multi-shaker test requirements.

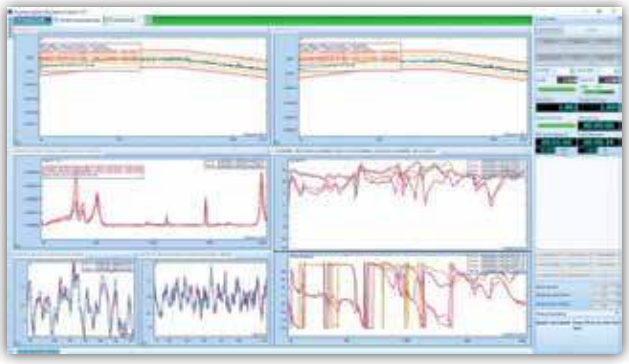
The Spider MIMO Control System uses multiple shakers and multiple control channels with defined profiles. The MIMO Control process is expanded into a Matrix fashion compared to the Scalar fashion of single shaker control.

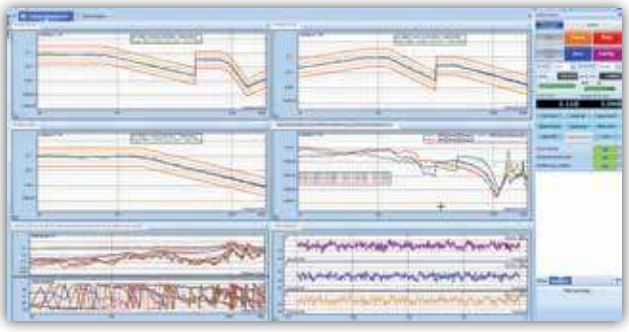
For a multiple shaker system with the number of drive X equals to m, and the number of Control Y equal to n, it will follow the system equation,

$$\{Y\}_{nx1} = [H]_{nxm} \{x\}_{mx1}$$

The $[H]_{nxm}$ is the system transfer function matrix, which is typically evaluated during the pretest stage. {Y} is the linear spectrum vector of the responses (controls), and {X} is the linear spectrum vector of the drives.

MIMO Random Control, like MIMO Sine Control, can control the phase between shakers and between axes. By maintaining a multi-dimensional system matrix, the Spider system is always capable of determining the contribution from each shaker to the overall response and properly differentiating for each shaker so that proper, accurate, and safe control is assured.





MIMO Random Control

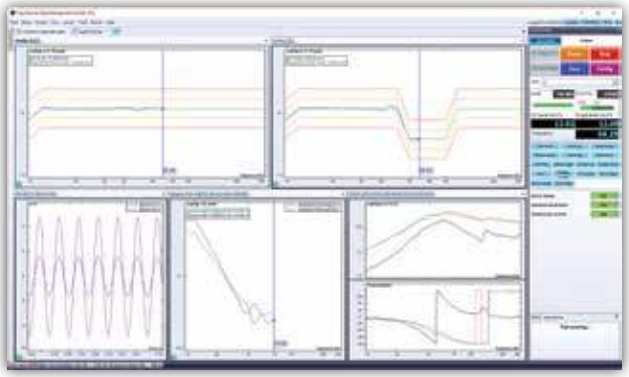
MIMO random control is one of the more commonly used multiple shaker control methods, which provides precise control in real time. The device under test is subjected to true random noise with a precisely shaped spectrum with Gaussian amplitude statistics.

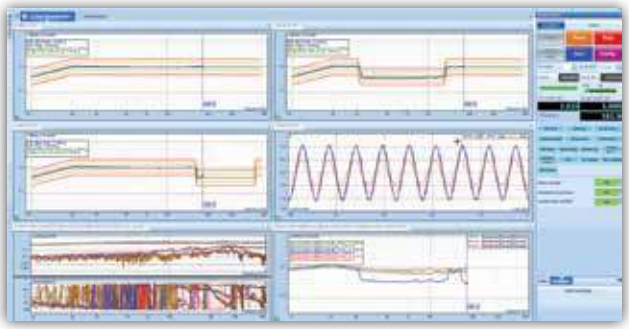
For MIMO random control, multiple random profiles are defined for each control channel. The relationship among these controls can be defined and controlled, or not. This results in different MIMO Random control modes: Magnitude only control, Mag and Phase control, and Advanced control.

Depending on the test requirements, users can update or keep a system FRF matrix the same for the duration of a test. Users also have the option to turn on non-linear control at any time to correct an error.

The first MIMO Random control screenshot illustrates an identical profile with coupled (in phase) control on a dual shaker setup.

The second screenshot is a MIMO Random test that ran on a three-axis shaker table. Three different profiles are assigned to three control channels along each axis. The control is uncoupled so that the phase relationship between any axis control is defined or controlled.



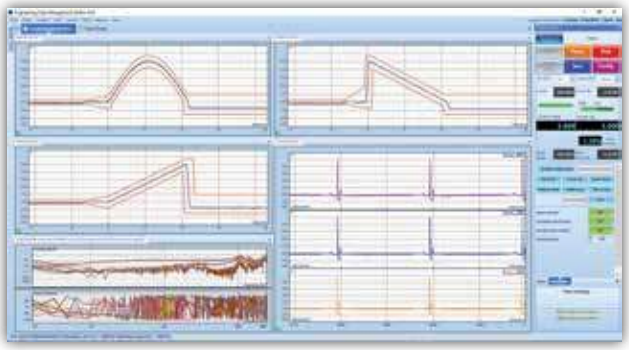


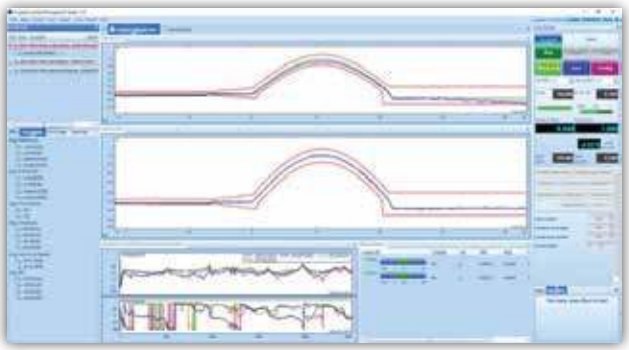
MIMO Sine Control

MIMO Sine control is another commonly used multiple shaker control method that provides precise control in real time. It controls multiple sine waves with a control dynamic range of up to 100 dB. With MIMO Sine control, the linear spectrum profiles of Mag, or Mag/Phase are defined and assigned to multiple control channels. With the sweep rate defined, the sine waveform in the time domain is determined.

Random signals are applied during the pretest to identify the system FRF matrix. During the control, the closed loop control will correct the errors from all control channels. Tracking filters are more often used to control channels as well as measurement channels to calculate the sine signal amplitude and phase.

The screenshots to the left illustrate tests with dual shaker and 3-axis shaker tables respectively.





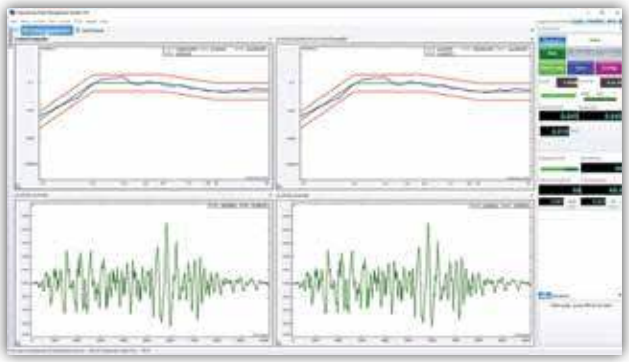
MIMO Classical Shock Control

EDM MIMO Classical Shock Control tests are used to measure the reliability and durability of the object under test. It is a multiple shaker system control method that provides precise, real-time, multi-channel analysis of classical shock waveforms in the time domain. The MIMO Shock control process is essentially a time-domain waveform replication process that uses an FFT based algorithm to correct the test system dynamics.

A MIMO shock test outputs a series of pulses to test the structure. The responses are measured at multiple locations on the structure and spectral analysis is used to determine its frequency characteristics. The Fourier transform of the impulse response is the Frequency Response Function (FRF) of the system.

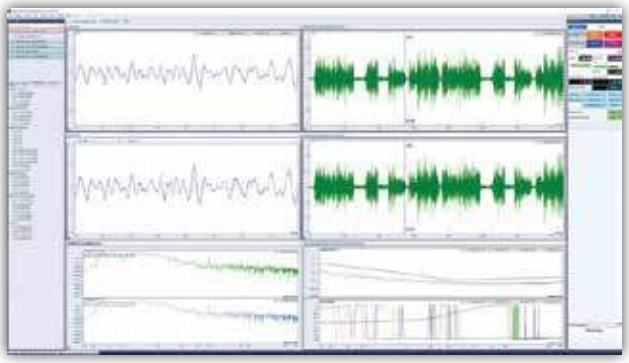
A dual shaker test is carried out and shown in the following screenshot, with the same shock profile defined.

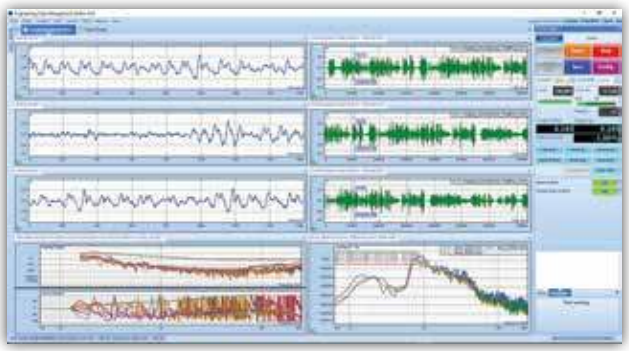
On the 3-axis shaker table, three different types of classical shock waveforms are defined, as shown in following screenshot.



MIMO Shock Response Spectrum (SRS) Control

The MIMO Shock Response Spectrum (SRS) control package provides controls of multiple shakers to meet multiple target Required Response Spectrum (RRS). Time waveforms are automatically synthesized from a user-specified SRS reference profile using different types of wavelets. Sine beats and damped sine are commonly used types of wavelets. Each control channel is assigned with one RRS and to the synthesized time waveform accordingly. Users can apply high frequency waveforms and alarm and abort tolerances to any active channel to provide an extra degree of safety for delicate test articles.





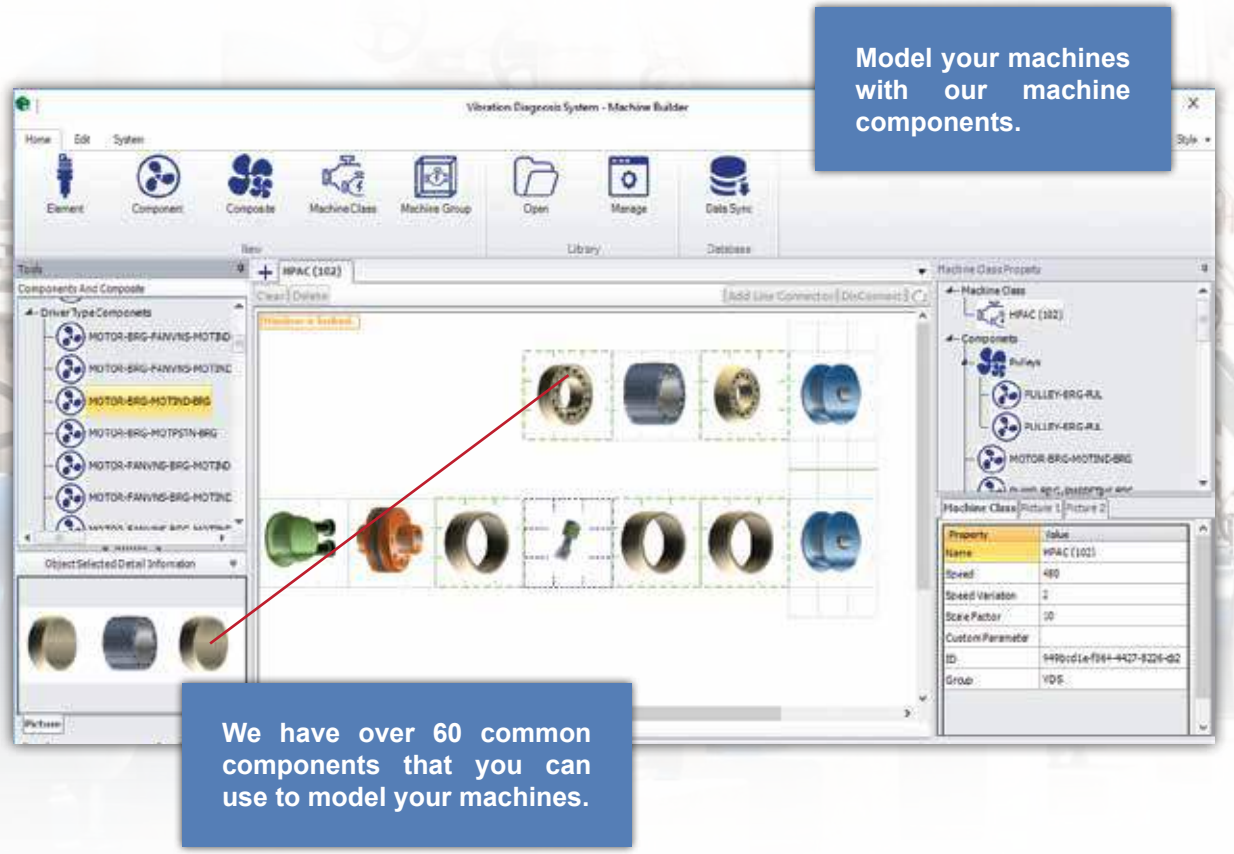
MIMO TWR Control

MIMO Time Waveform Replication (TWR) is very popular method to use when field recorded data needs to be reproduced on a multiple shaker table in the lab. With MIMO TWR control, a time waveform profile containing multiple channels of data can be imported, pre-processed (such as bandpass filtered, etc.), and selected as the control profile.

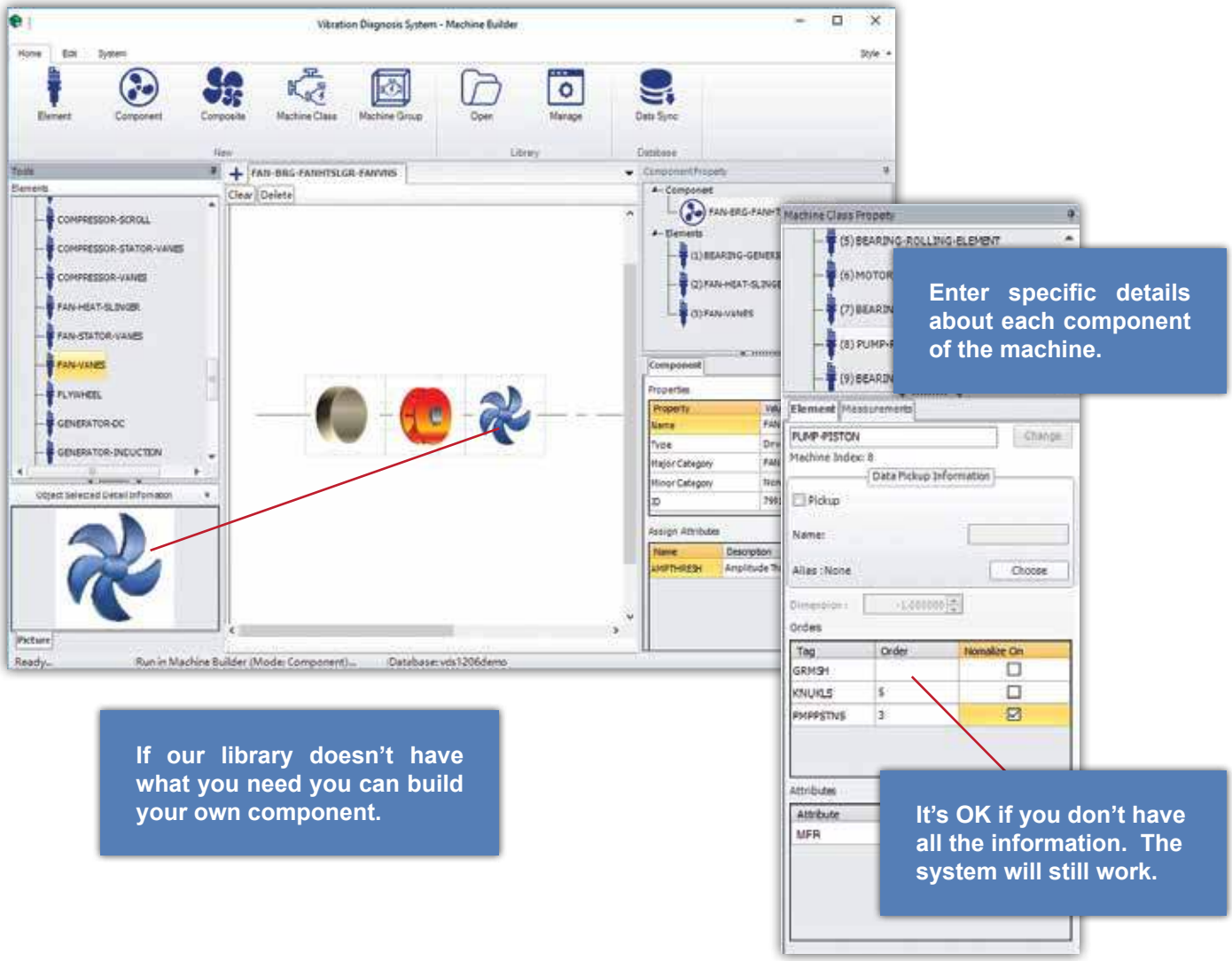
Each channel of time waveform in the profile is of the same sample rate and length. The MIMO TWR control is carried out based on block by block of data. Users can select from two control algorithms. One algorithm keeps the system FRF matrix measured from the pretest stage while updating the drive to correct the error from one block to the next. The other control algorithm updates the system FRF Matrix online as the test is operating.

A dual shaker test result is shown in the screenshot to the left, with the same profile defined for both control channels.

On the 3-axis shaker table, three different waveforms are defined, as shown in the screenshot to the left.

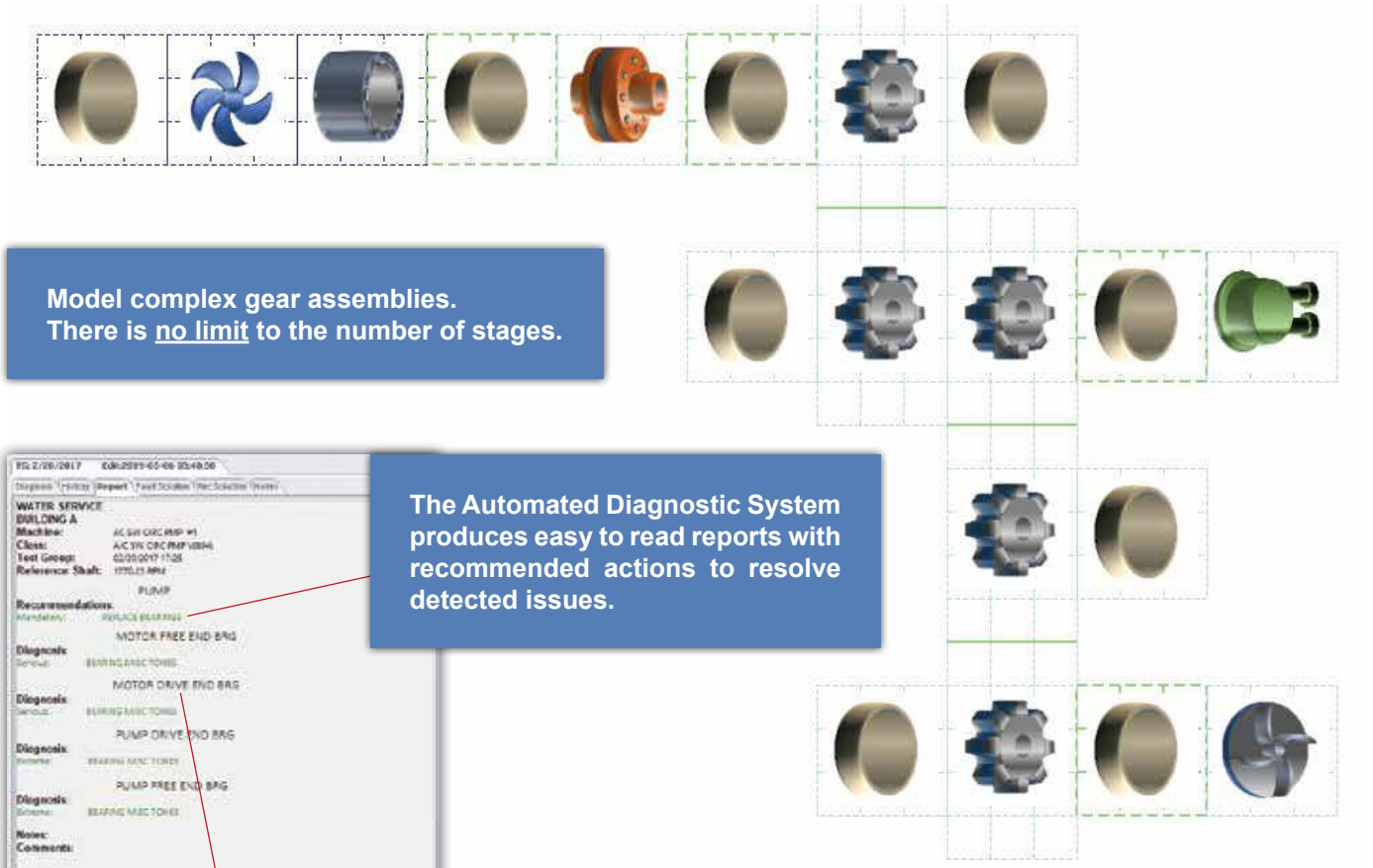


The Vibration Diagnostic System (VDS) is a vibration data management system designed specifically for the machinery Predictive Maintenance (PdM) community. It harnesses the graphic display capabilities of Crystal Instruments EDM Software for the work of machinery vibration analysts. It allows the user to quickly get to the data for a machine of interest and display that data in the familiar Tri-axial or Single Axis view. It lets users quickly compare to other data from the same machine, quickly navigate back into the historical data of the machine, and quickly compare the data to that of other machines in the database. The software supports the construction of Average (a.k.a. baseline) data for a class of machines and allows easy comparison to that data as well. When users interact with the data they will have access to a full suite of cursors designed specifically for PdM analysis.



In addition to great graphics, Crystal Instruments has developed an extensible machine modeling system specifically for vibration analysis. It allows users to model machines based on the elements of the machine that can contribute to the vibration energy of the whole. Model bearings, rotors such as motor bars, couplings such as flexible and fluid couplings, account for slip in things like fluid couplings, model gears and pulley systems, and model turbines by accounting for each stage. It's wide open, users can create new elements to use in their system.

Not all users may want to do all that, and for those users we're including a comprehensive library of machine components such as AC and Induction Motors, Couplings, Gears, Pulleys, Pumps, and other components. With our single and double gear shafts, users will be able to model many kinds of gear boxes with an unlimited number of stages. This ability alone lets you model your machines to view and use to keep track of vibration pickup locations, record the forcing frequencies of each part of the system, and attach attributes such as manufacturer and other part information.



Model complex gear assemblies.
There is no limit to the number of stages.

The Automated Diagnostic System produces easy to read reports with recommended actions to resolve detected issues.

The Automated Diagnostic System shows the detected machinery faults.

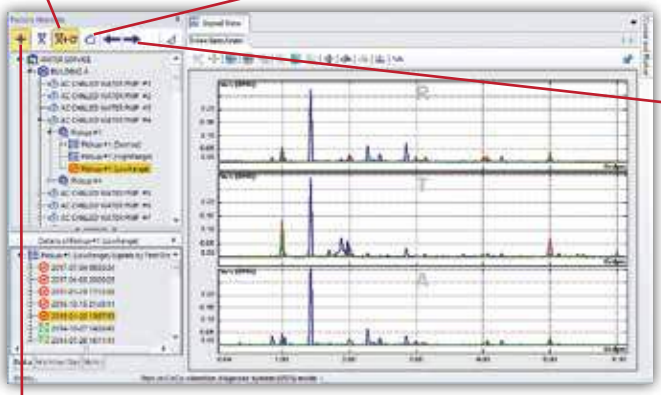
The Machinery Modeling system provides the structure for our narrow band automated diagnostic system. VDS provides the following features in support of an automated diagnosis system:

- The Machine Modeling System, which allows us to model machine components and to know the relative rotational speeds of all the shafts of the system.
- A method to organize Machine Class Average (baseline) data for each designated pickup location.
- Associate a physical machine with a Machine Class.
- A diagnostic rule processing system based on a forward chaining, probabilistic, inference engine.
- A method to define machinery faults.
- A method to define recommended actions based on recognized faults.
- Provide functions to support basic vibration analysis that takes care of all the mundane details such as extracting dominant peaks from each data set, matching the extracted peaks to forcing frequencies defined by the Machine model, comparing individual datasets with the appropriate Average data and returning the difference in amplitude between the two.

In essence, VDS takes care of all the math and accounting to let the rule writer focus on applying their knowledge of machine condition analysis.

Overlay baseline data.

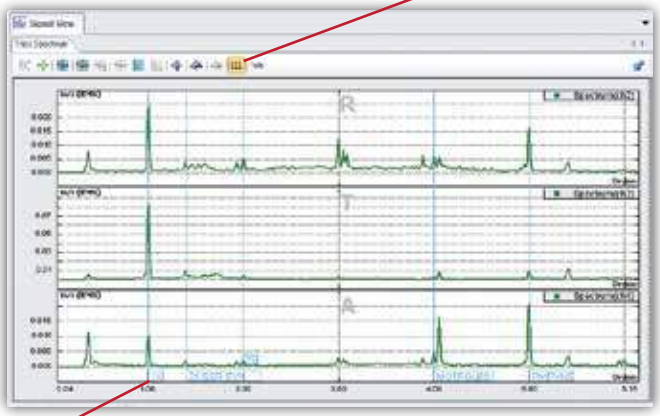
Easily cycle through the machine's data.



Navigate back through previous data.

Turn Forcing Order markers on and off.

Overlay data from the same Machine or other Machines.



Forcing order marker values are from the Machine Class setup. Users can customize which ones are displayed.

We know that most analysts don't have the time or desire to write their own rules for identifying machinery faults so we hired an expert to write a comprehensive set of rules for all of the machine components in our component library. When you model your machines with our component library you will get the benefit of **Artificial Intelligence (AI)** that will find many common machine problems.

Because our inference engine is based on a well-known open source scripting language called Lua, those that do want to build their own rule base or add to our rules will be able to do so. Using our low level, documented API, and open source tools, anyone could attempt to build or add to a knowledge base. But so as not to disappoint, keep in mind that this is not for the faint of heart, it can be a challenging task. Entities that may want to do this include:

- Predicative Maintenance organizations that specialize in a certain kind of machine and have years of detailed knowledge about these machines, could encode their knowledge with rules, thus extending our system to meet their needs.
- University Engineering departments may want to work with our system to teach and experiment with machine vibration analysis.

CoCo-80X Handheld System

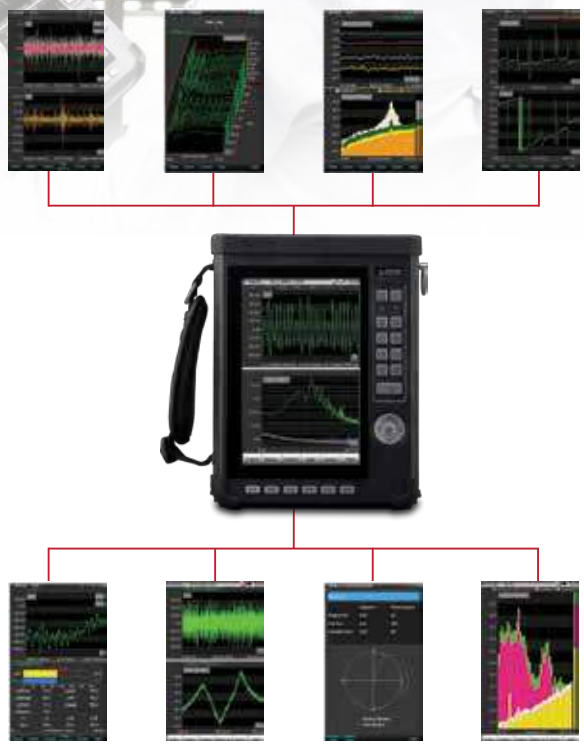
www.crystalinstruments.com/coco80x-dynamic-signal-analyzer

CoCo-80X

Highlighted Features:

- 2-8 inputs with IEPE
- Full speed recording
- Battery powered (portable)
- **CAN bus**, USB, HDMI, **GPS**, Audio, and Wi-Fi*
- Patented dual-AD technology
- Large touchscreen with vivid color display
- 150 dBFS input dynamic range
- SD card for mass data storage
- 20 volt input range
- Hard keys for quick access
- 102.4 kHz sampling

**Non Wi-Fi & Non GPS Options Available*

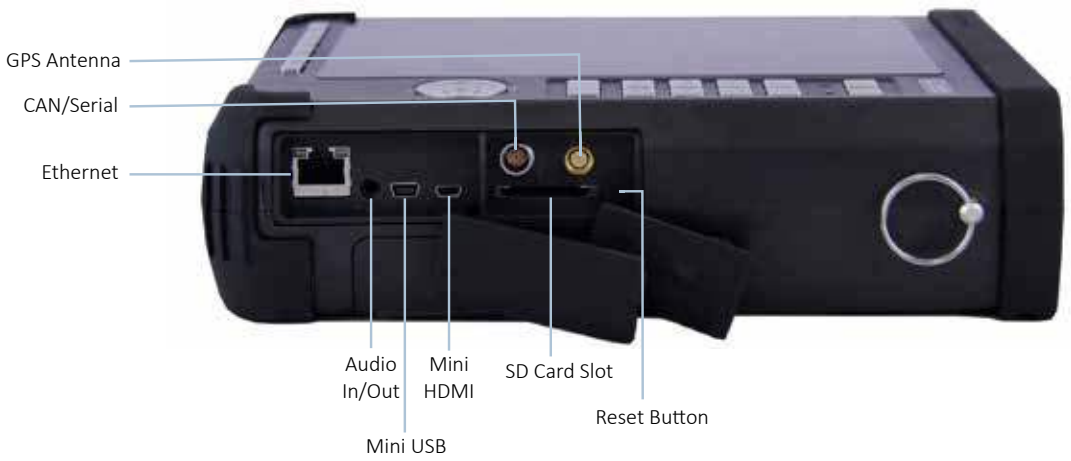


CoCo-80X Dynamic Signal Analyzer

The CoCo-80X is a rugged, lightweight, battery-powered handheld system with unparalleled performance and accuracy. Combined with hard keys, the multi-point functionality touchscreen is designed for an intuitive user interface that provides a wide variety of analysis functions.

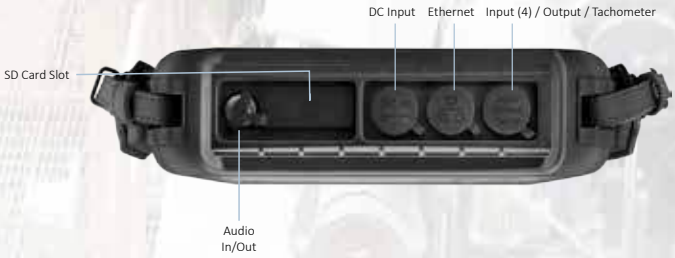
The CoCo-80X is equipped with 8 software-enabled channels. Measured time histories can be recorded in 32-bit single precision floating point format and all subsequent signal processing is performed using floating-point arithmetic. 54 sample rates from 0.48 Hz to 102.4 kHz are provided with better than 150 dB of alias-free data.

CoCo-80X Hardware Diagram



CoCo-70X Vibration Analyzer

The CoCo-70X is Crystal Instruments' latest handheld vibration analyzer, featuring an improved user interface and redesigned chassis. The CoCo-70X is a four-channel vibration analyzer with an IP-67 rating, designed specifically for the machinery Predictive Maintenance (PdM) community. The CoCo-70X offers powerful processing capabilities and an intuitive user-interface, providing users with an easy-to-use data collection experience. The newly designed chassis is lighter and more ruggedized, making the CoCo-70X a perfect device for route-based measurements.

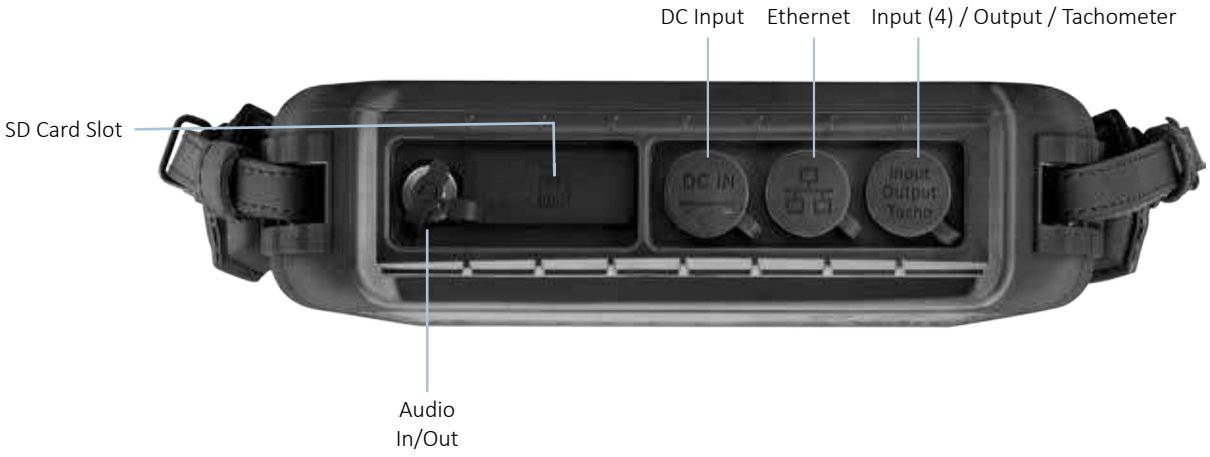


CoCo-70X

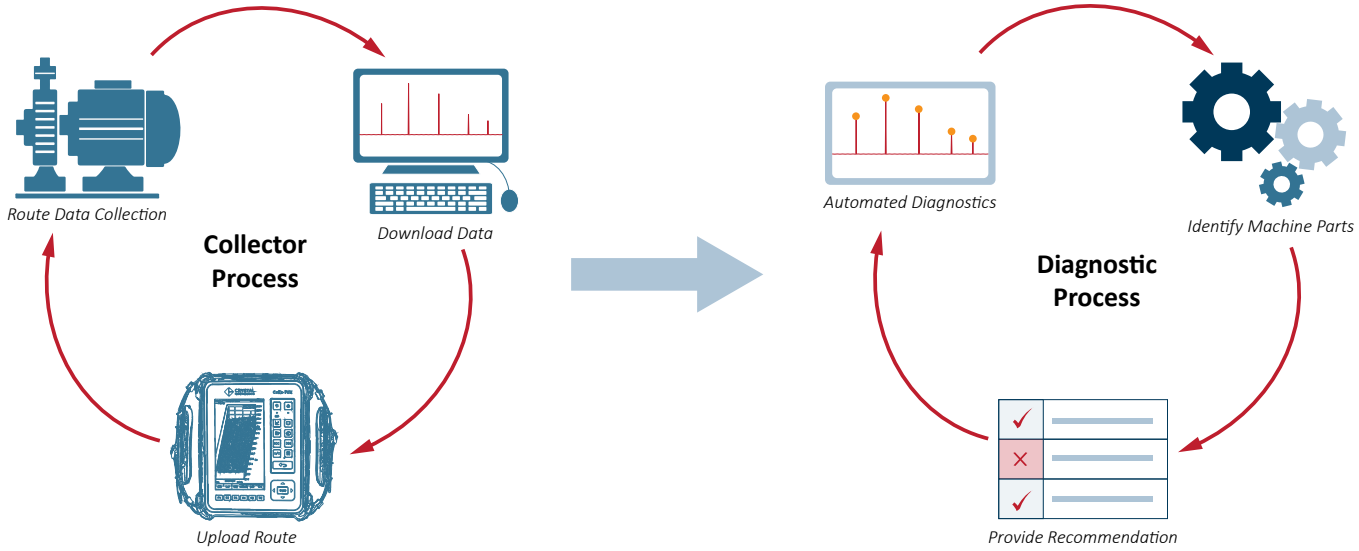
Specifications:

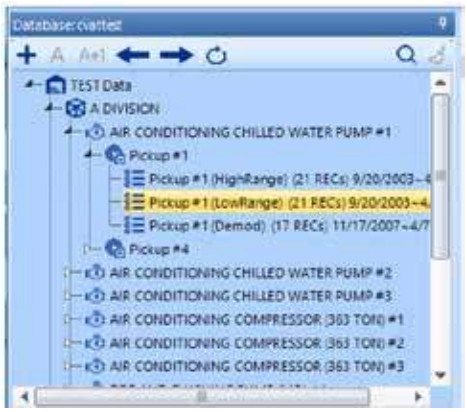
- 4 Inputs with IEPE plus tach
- Sampling rates up to 102.4 kHz
- 150 dBFs dynamic range
- Audio via headphones
- SD Card for mass data storage
- Waterproof IP-67 rating
- Data recording & real-time measurement

CoCo-70X Hardware Diagram

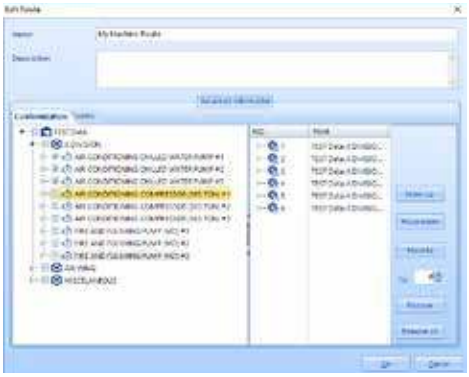


Improving Machinery Health
with Crystal Instruments'
Vibration Diagnostic System (VDS)





Data structure is Factory, Space, Machine, Pickup



VDS supports maintaining one or more machine routes

Database
Data structure is Factory, Space, Machine, Pickup. We added "Space" to the data hierarchy to give more control over how you group your machines.

All data is stored in a a MS SQL Server database. The database may be accessed locally or served on a network to allow multiuser access. Access to the database as well as program features can be managed with individual usernames and passwords. Each user is assigned an access level that can be customized for the tasks that individual needs to perform with the system.

Routes
VDS supports maintaining one or more machine routes. Routes can be thought of as a to-do list that is loaded onto a CoCo-70X.

Once uploaded to a data collector the user can use it to gather data for some or all of the machines in the route. The data is then downloaded to VDS for storage in the database. Before the data is placed into the database each set of machine data is grouped together and assigned a Test Group and the user is given an opportunity to check that the data has been grouped properly. The Test Group ensures that the data for this data collection cycle will always be identifiable. No need to check data timestamps to ensure the data you are analyzing is all from the same collection period.

CoCo-90X

www.crystalinstruments.com/coco-90x-dynamic-signal-analyzer

CoCo-90X Specifications

Input Channels: 16 inputs with IEPE LEMO connnectors. One 24-bit A/D converter per unit.

Input Modes: Single-ended

Coupling: AC- or DC-coupling

Ports: 100 Base-T Ethernet, Wi-Fi, GPS, Mini-USB, SD Card, Audio Input and Output, CAN bus

7” Touchscreen LCD Display

Max Sampling Rate: 102.4 kHz

16 Channel Configuration of CoCo-90X

Spider-20 Handheld Wireless Dynamic Signal Analyzer

www.crystalinstruments.com/wireless-analysis-anywhere

Handheld Field Testing Solution

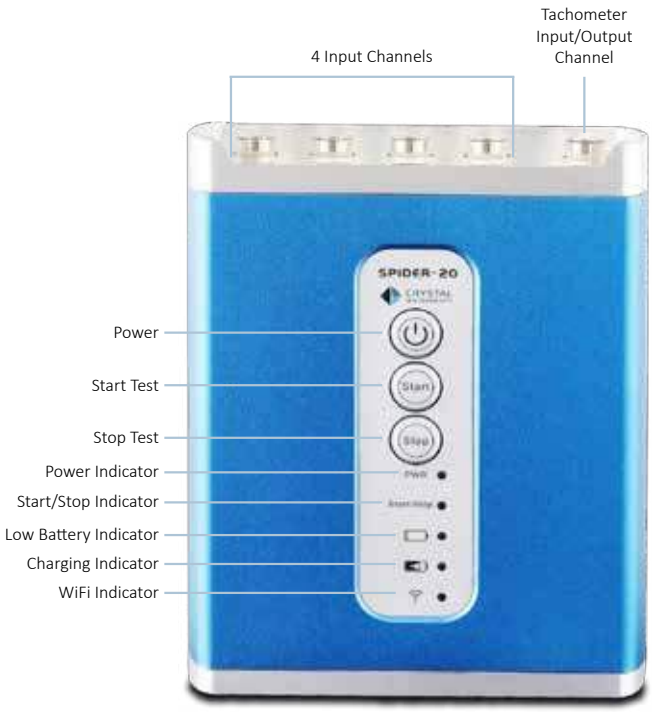
Spider-20 is a compact yet powerful dynamic signal analyzer and digital data recorder. It provides four 24-bit precise high-fidelity input channels, and a unique software-selectable tachometer-input/signal-source output channel (all using conventional BNC connectors). Each input is individually programmable to accept AC or DC voltage or output from an IEPE (ICP) sensor with built-in electronics.

Spider-20 is a diminutive 5.3 x 4.3 x 1 inch tool weighing only 18 ounces. It has only three push-button controls and five LED status indicators. This little powerhouse can run over 6 hours on its internal rechargeable battery which can be replaced in field with a backup battery. It can also record data on its built-in 4GB flash memory at the simple push of a button.

Spider-20 communicates with the world through its built-in Wi-Fi interface. Use your iPad to setup and view or record time histories as well as perform spectrum analysis or measure Frequency Response and Coherence functions. Link the Spider-20 to your laptop or tablet running Windows and enjoy the full repertoire of functionality provided by our EDM (Engineering Data Management) software including 1/nth Octave acoustic functions, Order Tracking for rotating machinery, Shock Response Spectra for drop testing, or Digital Filtering for special purpose analysis.

A secondary version, Spider-20E, replaces Wi-Fi with a wired Ethernet connection. The Spider-20E has the same form factor as the standard wireless version.

Transfer measured data to truly massive storage space using the EDM Cloud server. EDM can be used to program your Spider-20 to perform a custom measurement or measurement sequence at the touch of its START button, making it an unintimidating and user-friendly tool. No computer, tablet or phone is required; just use your thumb and your Spider-20 operating in Black Box mode. Use our flexible Automated Schedule and Limiting software to turn this Spider into an intelligent unattended monitor capable of responding to data conditions or networked instructions, notifying you of significant conditions via e-mail.



SPIDER-20 & SPIDER-20E

Features:

- Weighs only 18 ounces
- Built-in Wi-Fi (Spider-20)
- Built-in Ethernet (Spider-20E)
- 4 GB Flash Memory
- 4 Input Channels
- 1 Tachometer Channel
- PC Independent
- iPad Compatible
- 6 Hour Battery Life

Spider-20 Industry & Product Applications

Machinery Diagnosis

Four inputs and a tachometer channel are the perfect size for many machinery monitoring tasks. Simultaneously measure two perpendicular proximity probes or horizontal and vertical bearing cap accelerations at both ends of a machine. Record this along with a 1/rev tachometer during startups and shutdowns to plot waterfalls and Campbell diagrams identifying resonances, critical speeds and unusual forcing functions. Use the same signal inputs to balance the machine. Place accelerometers on either side of a coupling to aid alignment.

Machine/Process Monitoring

Load a custom monitoring program employing our Automated Schedule and Limiting software and leave your Spider-20 to monitor speed and four dynamic inputs. Upon detecting an alarm-level limit (in the time or frequency domain), it can send you an email reporting the finding and make an immediate recording for more detailed analysis. For longer stays, leave the accessory AC power unit plugged in. This allows Spider-20 to draw power (6 Watts, maximum) from any 100 to 240 VAC (50/60 Hz) power line. Alternatively, you can provide a battery backup of 15 VDC (±10%) for more remote applications.

Octave Analysis & Sound Level Meter

www.crystalinstruments.com/acoustics-measurement

Acoustic Measurements with the Spider Series

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

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

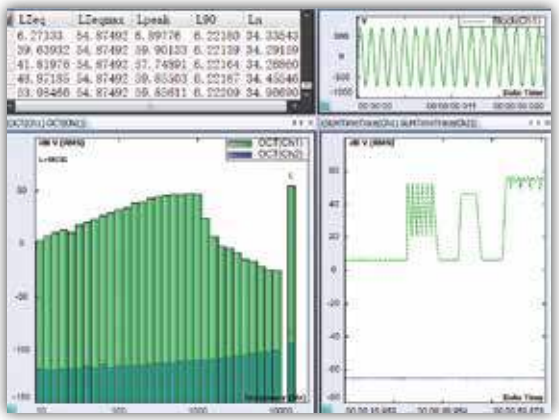
Onboard IEPE (ICP®) transducer power capability allows for direct connection to pre-polarized microphones when used with an ICP microphone preamplifier. Traditional condenser microphones are also easily accommodated by connecting the direct voltage signal from the microphone power supply into an input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

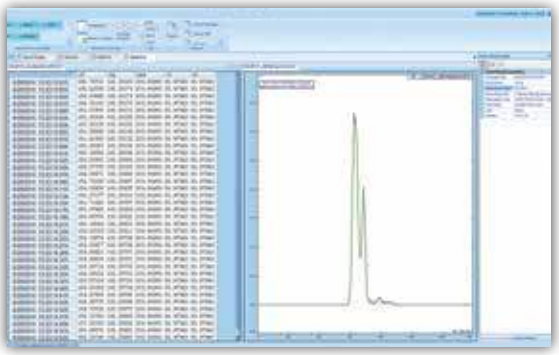
Real-time Octave Analysis

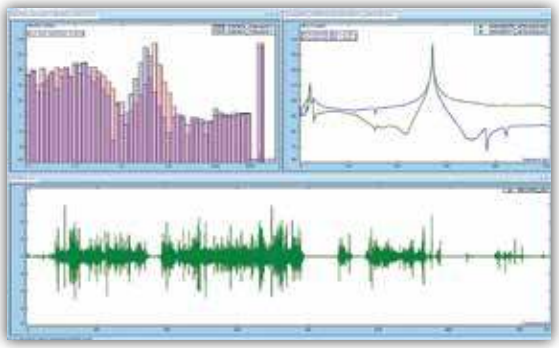
The acoustic data acquisition software option for Spider hardware includes real-time octave filters, sound level meters, and microphone calibration functions. These three operations allow users to perform many acoustic measurement operations.

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

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







Acoustic Measurement: Sound Level Meter

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

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

Built-in Microphone Calibration

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

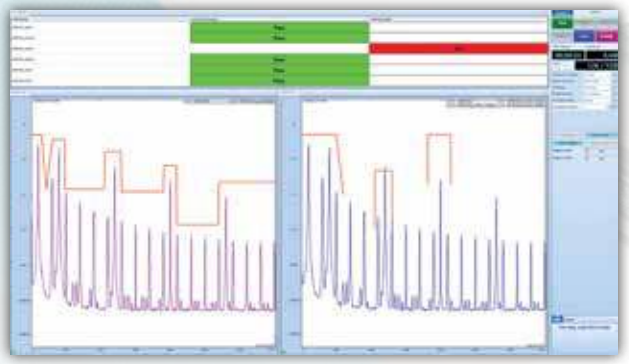
Simultaneous Recording and Octave Analysis

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

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

Automated Production Testing

www.crystalinstruments.com/automated-production-testing



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 and Spider-80Xi systems are complete multi-channel analyzers and controllers with IEEE 1588 Precision Time Protocol (PTP) Ethernet communication. The Spider systems can be programmed to accomplish multiple complex measurement tasks using a workstation or PC running Engineering Data Management (EDM) software. 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.

The PC can (optionally) be disconnected and tests run in "Black Box" mode without an attached computer.

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.

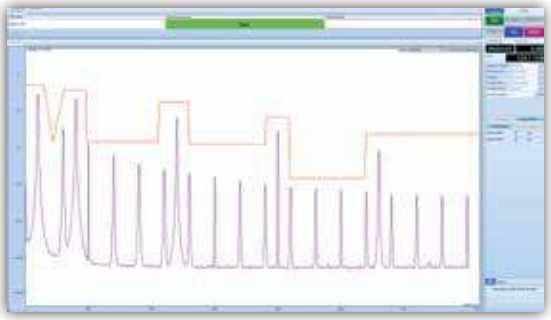
Step 3:
User will receive an alarm email

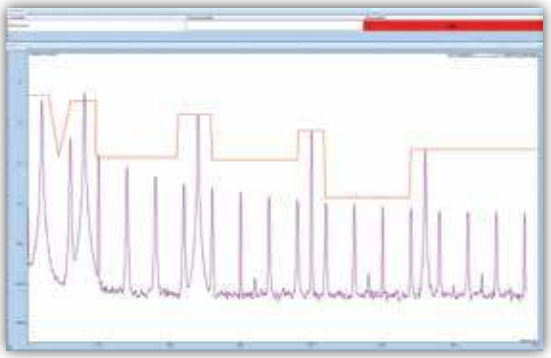
EDM or EDM Cloud Email Service

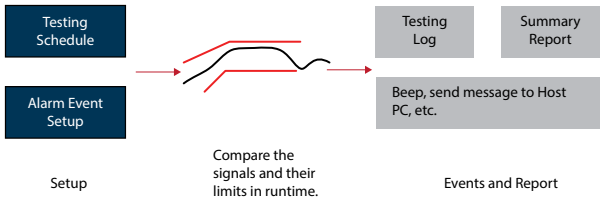
Black Box mode provides the ability to run Spiders without an attached computer. Control of the Spider may be accompanied through an Apple iPad tablet using the EDM App for iPad. The Spider API, when used along with Black Box mode, is the gateway to integration with LabView, Mat-lab and other scripting 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.

Limit Configuration
Alarm limits could be defined independently and multiple limits could be defined to each channel and 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.

Customize Actions for Specific Events
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).







An illustration of the automatic testing process.

Auto Failure Detection

Defining the limits on either time or spectral data enables the Spider system to compare the input signal with the defined Pass/Fail tolerances and instantaneously display the status on the EDM. This feature is particularly useful during Burn-in tests. 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 platform of products. The Spider provides a stimulating programmable function generator using the output channel and data is collected from the input channels which is then compared with the tolerances to detect the failed products.

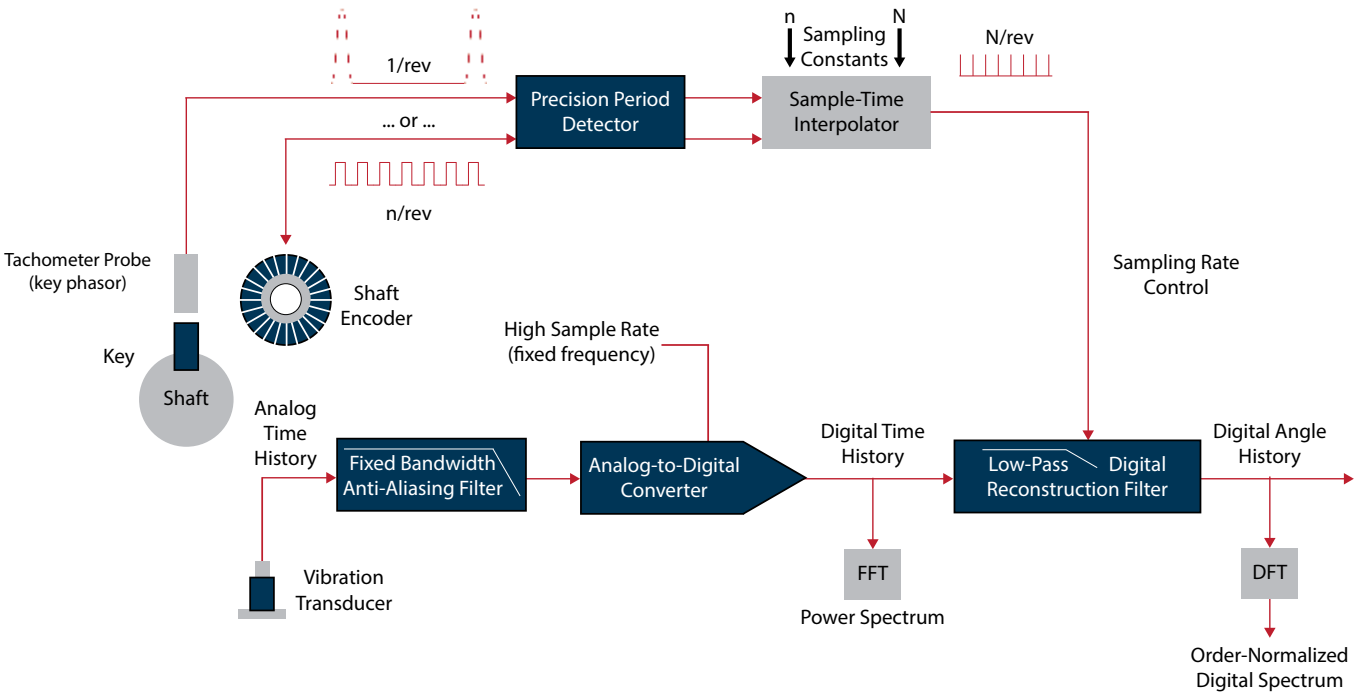
However, burn-in tests are not the only type of automated production tests performed with sound and vibration instrumentation. Product validation and verification are also an important part of production line testing. Such tests range from validating incoming components to verifying a finished product 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.

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.

Scalability

Scalability is a one of the benefits of automation and this is why the Spider-80X/Xi is designed as a networked device. With an Ethernet connection on the Spider-80X/Xi, multiple front-ends are connected to test tens if not hundreds of products simultaneously.



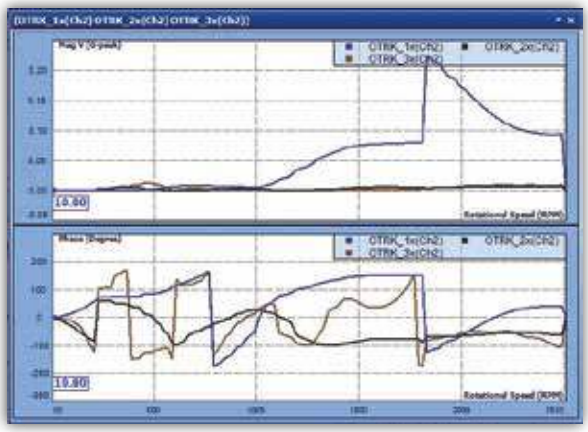
Providing Real-Time Order Tracking

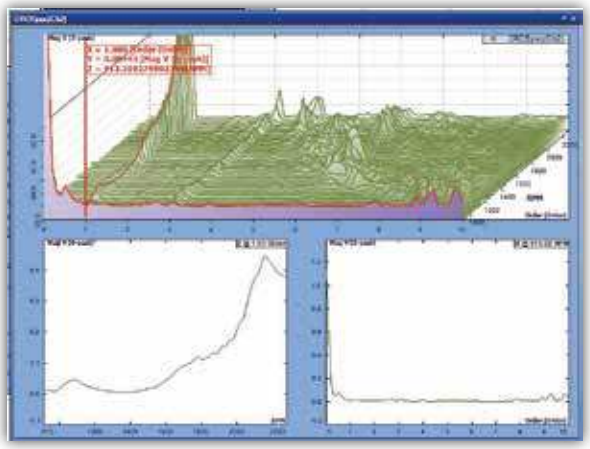
The high channel count Spider systems provide a wide range of real-time order tracking capability to understand the noise and vibration induced within rotating and reciprocating machines Fixed and variable speed machines are accommodated as are both structural vibration and condition monitoring diagnostics.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

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

Advanced Digital Processing

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





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

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

Real-Time Order Tracks and Order Spectra

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

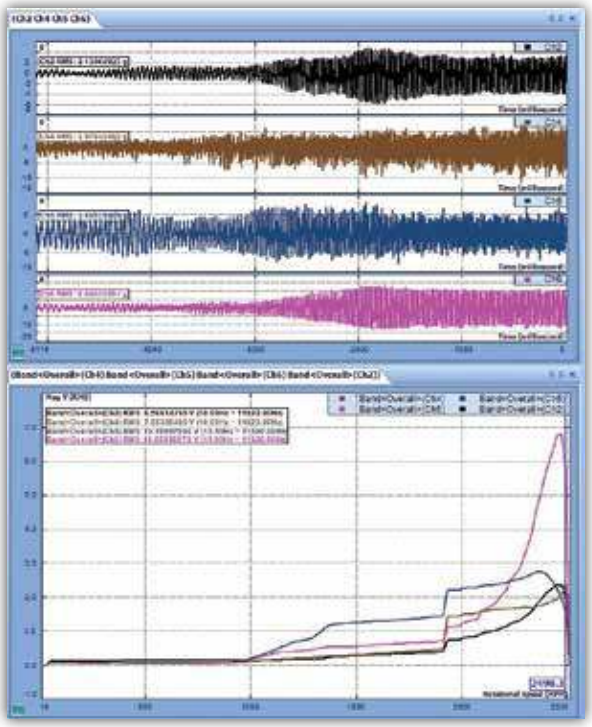
The RPM range can be from 10 to 10,000. The acquisition modes include: Free Run, Run Up, Run Down, Run Up and Down, Run Down and Up order tracks can be scaled with linear peak, linear RMS, or power scaling.

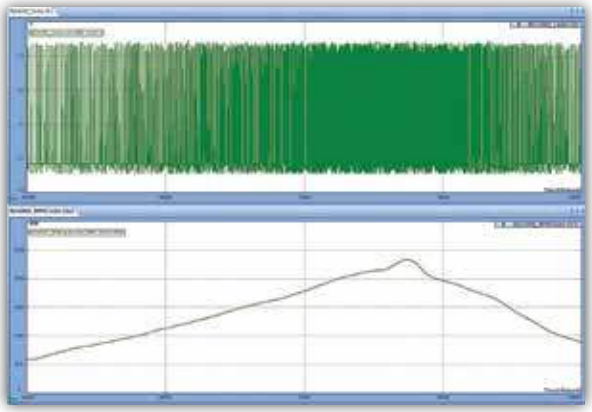
Constant Band Frequency Spectra

Constant band frequency spectrum displays the auto power spectrum of the selected fixed band of frequencies and is computed using FFT analysis within the fixed band of interest. 3D plots using time or RPM as the reference are available along with 3D extractions of desired orders of interest. The available spectrum amplitude units includes EU_{pk}, EU_{rms}, EU^2_{rms}, EU^2/Hz, and $EU^2 \cdot s/Hz$

Order Tracks with Phase

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





Tachometer Processing

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

Orbit Analysis

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

Display Flexibility

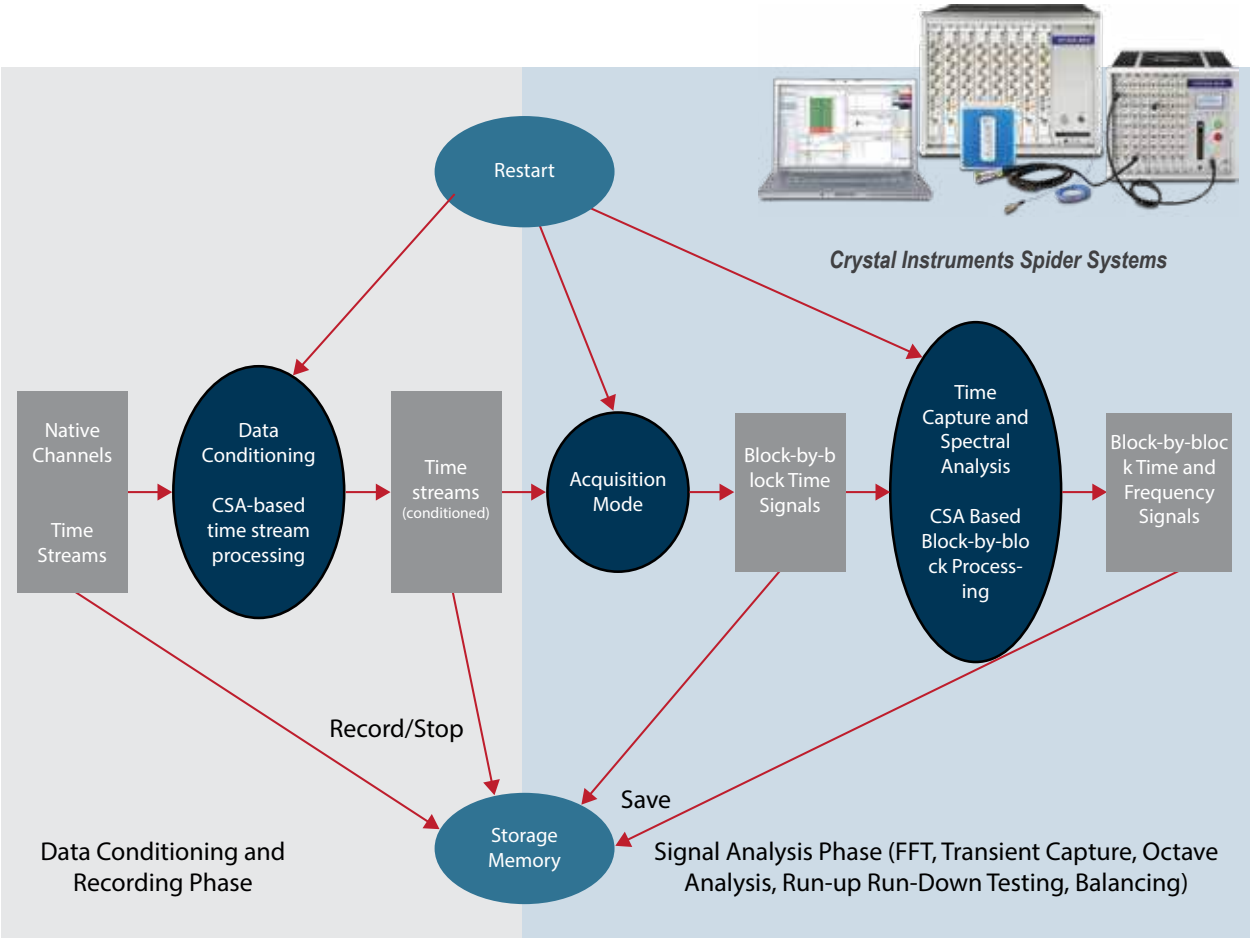
Measurements can be viewed in real time as the data is being acquired and analyzed. On line displays include the time histories, orbit plots, order spectra, order tracks, waterfalls, spectrograms, and contour plots. Users can also view the instantaneous RPM as a function of time.

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

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

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

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



Introduction

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

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

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

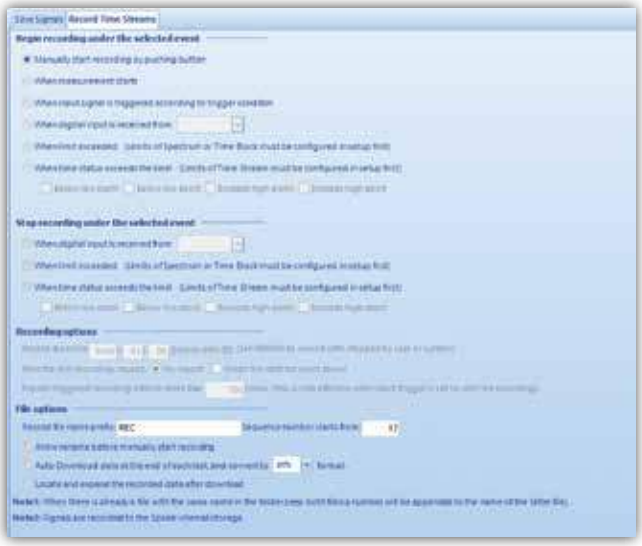
While being recorded, the measured values can be graphically displayed as y/t or y/x diagrams, as bar charts, as waterfalls, FFT, PSD, tachometer speed, or numerical statistics displays with a simple mouse-click. EDM software allows users to design an individual graphical visualization for each desired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

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

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

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 204.8 kHz sampling rate retained with 32-bit floating point format (per IEEE 754-2008) • Aggregate speed is greater than 26 MB/second
Typical Storage Duration for a 250 GB Disk	• 4 channel at 1 kHz/ch sampling rate: 4660 hours • 8 channel at 5 kHz/ch sampling rate: 466 hours • 8 channel at 102.4 kHz/ch sampling rate: 23 hours • 64 channel at 102.4 kHz/ch sampling rate: 3 hours
Management	• Wake-on LAN, Keyboard Power-on, Timer Power-on • System power management, AC power failure recovery • Watch Dog Timer

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



High Channel Count Solution Using Spider Front-ends

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

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

Remote Operation on Recorded Data

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

EDM Modal: Complete Modal Testing & Analysis Software

www.crystalinstruments.com/edm-modal-testing-and-analysis-software

Overview

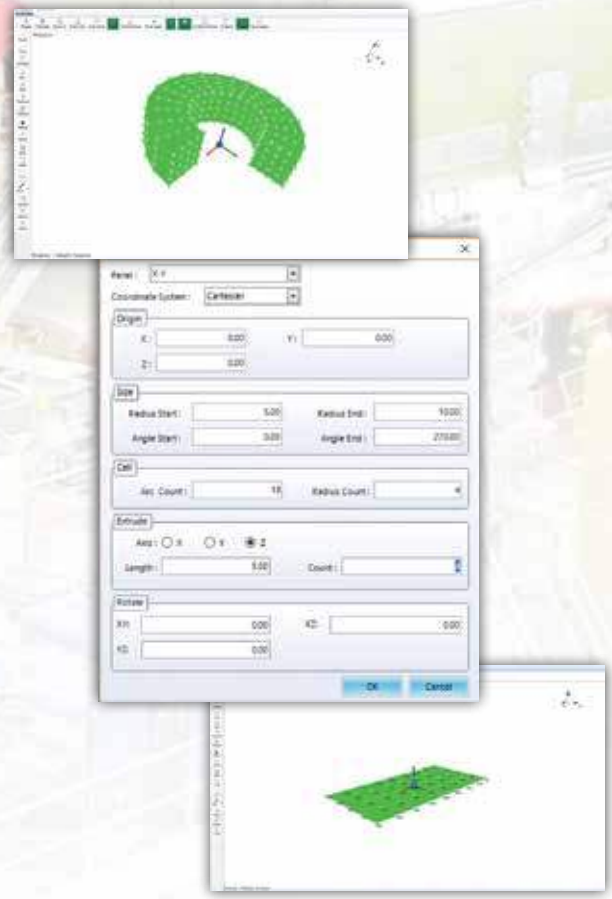
EDM Modal is a complete Testing and Analysis suite for Experimental Modal Analysis (EMA). With its intuitive controls and powerful features, EDM Modal is the ultimate tool for modal analysis applications. An intuitive interface allows users to manage highly complicated tests that can involve hundreds of measurement points and multiple excitations. This interface also allows for simple tests to be conducted quickly and with little effort.

The Geometry Editor handles all types of structure modeling and supports all types of coordinate systems. Using the concept of 'components', parts of a complicated structure can be built simply and then integrated into the geometric model. Inside the Input Channel Setup window, the measurement points and their corresponding directions can be defined. Once the test is started, the measurements will proceed through all the test points, as defined by the Degree of Freedom (DOF) information for each measurement point.

To acquire the FRF signals, there are several methods per excitation arrangement. Included methods are hammer impact testing or modal shaker(s) testing. When using a modal shaker, the drive signal can be random or sine. Under certain circumstances, the excitation is not available or difficult to measure. Operational Modal Analysis takes use of the ambient excitation or machinery operating status.

EDM Modal employs several curve fitting methods for modal parameter identification. The Least-Squares Complex Exponential (LSCE) method is implemented for the pole (natural frequency and damping factor) identification of single-reference Frequency Response Function (FRF) cases. For multiple-reference (Multiple Input/ Multiple Output or MIMO) testing cases, the corresponding Poly-Reference Time Domain (PTD) method can be used, closely-coupled modes can be isolated. The Poly-X provides efficient and neat fitting results based on the p-LSCF algorithm. The Poly-Reference Frequency Domain method (PFD) is used For mode shape calculation.

The animation tool is a powerful visualization facility that simulates the mode shapes of the device under test, allowing users to study and understand large amounts of data through a 3-dimensional animated display. The animation module can apply color contours to the surfaces of the geometry model to help visualize deflections in a 3-dimensional space. Using the same geometry model, Operational Deflection Shapes (ODS) can be displayed using measured time or spectrum operating responses. Correlation analysis bridges the EMA and FEA results.

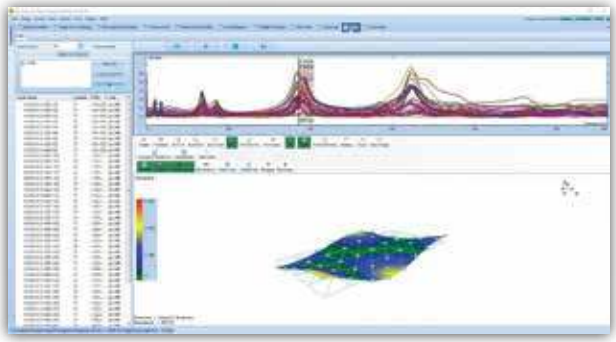


Geometry

EDM Modal Geometry is the primary EDM Modal software module and is required for every EDM Modal system. This option provides fast and efficient structural model generation and full 3D visualization of test and analysis results.

The base elements (points, lines, and surfaces) can be added/deleted graphically, or through typed Model Editor entry. Components can be specified for each part of the structure. Each component can have its own origin, as well as its directions and Euler angles. The basic component library includes: line, plane, cube, cylinder, sphere and Circle. Any of these can be added to the geometry model by specifying origin, direction, dimensions, and the number of cells of the component.

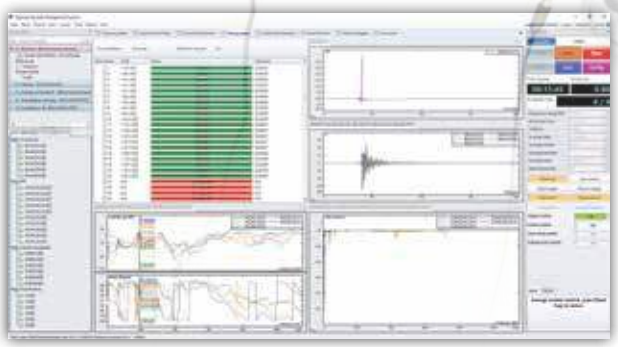
The geometry model can be saved and later recalled by other tests. Also, the model can be cleared when the user wants to start over with a new geometry model for the structure under current test. Several types of format from 3rd party applications are supported for geometry model import. The Universal File Format (UFF) format of point and line models is widely used, and may be imported to EDM Modal Geometry.



Operational Deflection Shape

EDM Modal Operational Deflection Shape (ODS) is a feature that allows users to better visualize the deformation of the structure under test. Time domain data and spectrum data can be animated using the animation feature of the geometry model. It is an integrated feature with the Geometry and works for all types of EDM Modal testing.

The database structure of EDM makes it very easy to navigate and select data. The selected data set can be animated using the geometry model. The vibration pattern, either in time domain, or frequency domain, can be saved to .avi video files, too.



Hammer Impact Testing

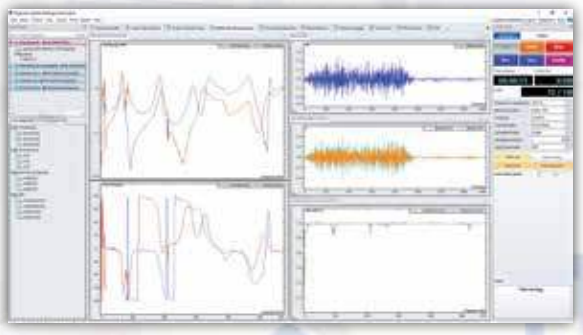
EDM Modal Hammer Impact Testing provides the necessary features for a single-operator experimental modal test. The Hammer Impact GUI features an intuitive step-by-step process, allowing a user to easily go through the setup and then the testing.

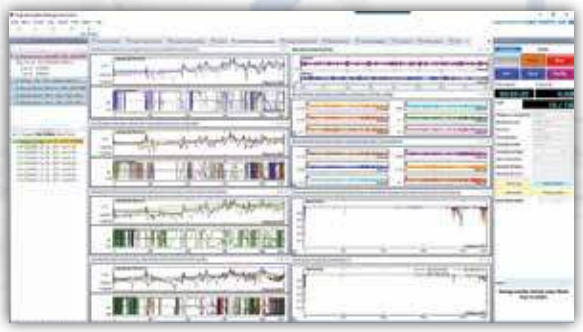
The testing process has been designed to help users quickly define acquisition parameters, so that more time can be spent on analysis. Users can define trigger behavior through the Trigger Setup; a Trigger-Preview window allows control over the trigger level and pre-trigger delay. For users that may need to review their measurements after each acquired frame, the 'Manual-Arm' trigger mode can be used. When this trigger mode is selected, acquired signals will be displayed for review and will prompt the user to accept/reject the signal. The auto-arm mode simply auto-accepts acquired measurements and automatically re-arms the trigger, helping to speed up the whole test process.

Driving Point Selection will help users decide where to place the fixed excitation or response reference. The process is to survey several candidate driving points and measure their FRFs – this allows user to choose the best available DOF for the driving point. The FRF at the trial driving-point which best excites most of modes can be selected as the driving-point. EDM simplifies the data management for this important pre-test survey.

When taking measurements, the status of the DOFs are indicated in a Table window. The status of every measurement point is available from this table, which is updated as the test progresses. The Trigger Preview window is optimized for viewing experiences – featuring a resizable window and adjustable font size. With this added flexibility of the trigger window, EDM Modal supports users with various display types- users can be far removed from their display and still be able to take measurements.

One common problem associated with hammer testing is the "double hit". EDM Modal Hammer Impact software can automatically detect a double hit and give the user the choice to automatically or manually reject the double strike.



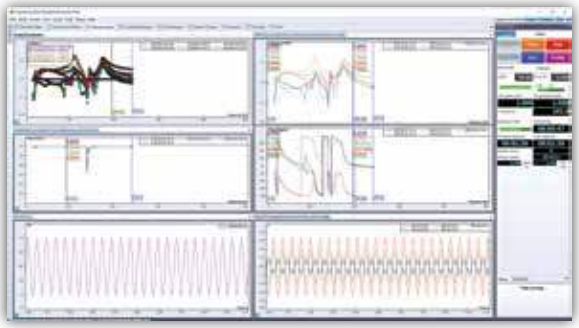


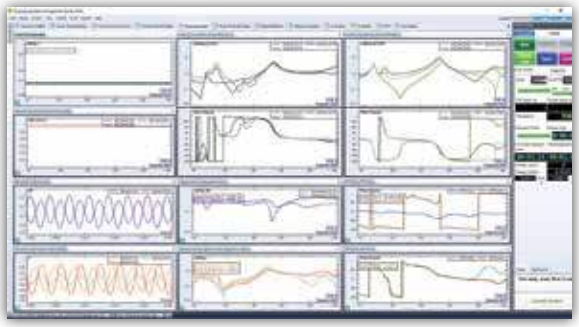
SIMO/MIMO FRF Testing

EDM Modal MIMO FRF Testing includes a dedicated test setup and operation process flow using single or multiple simultaneous shakers to acquire FRF signals. Using a large channel count data acquisition system (i.e., Spider- 80X or Spider-80Xi), this shaker excitation method provides much higher efficiency and accuracy for the FRF measurements while minimizing local stresses on the test article.

When using multiple shaker random excitation applications, the shaker-driving Source signals are guaranteed to be uncorrelated with one another. The Source Output type supports pure random (white noise), burst random, chirp/burst chirp, pseudo random, and periodic random. For periodic random types (pseudo random and periodic random), the delay block and cyclic block numbers can be set so that the structure exhibits steady-state response, allowing precise window-free analysis.

Multiple shaker excitation is useful to separate and clearly identify repeated roots and frequency-proximate modes. With more than one reference shaker, multiple columns of the Frequency Response Matrix can be measured simultaneously. Combined with the poly reference curve fitting algorithm, the modal participation factor will help to isolate the repeated and highly coupled modes.

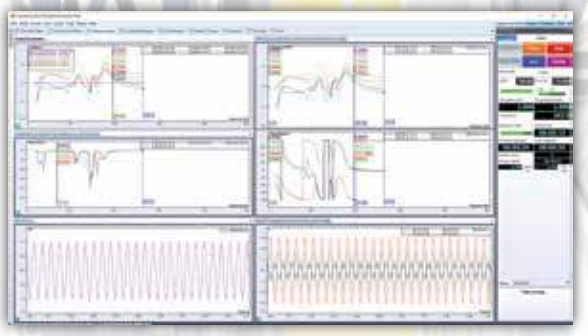




SIMO/MIMO Stepped Sine Testing

EDM Modal SIMO/MIMO Stepped Sine Testing includes a dedicated test setup and operation process flow using single or multiple shakers outputting sine wave(s) to acquire FRF signals. The Source Output type is Stepped sine tones. The step mode can be linear or logarithmic. The FRF signals of each measurement DOFs with respect to defined reference channels will be constructed. The output drive level can be defined to operate the test in an open loop, or the response of a control channels can be specified to operate the test in a closed loop.

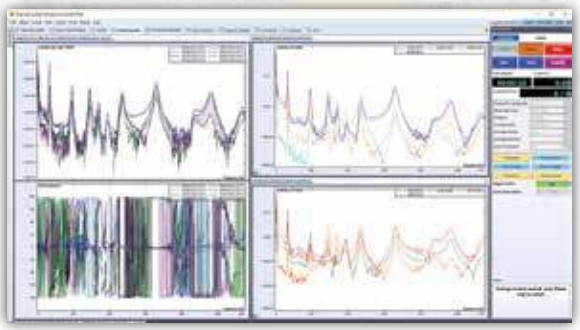
For MIMO Stepped Sine test, multiple sweep is required with different set of initial phases from each output, or the controlled targets.



SIMO Swept Sine Testing

EDM Modal SIMO Swept Sine Testing includes a dedicated test setup and operation process flow using a single shaker outputting a sine wave to acquire FRF signals. The source output type is swept sine. The sweep mode can be linear or logarithmic. The FRF signals of each measurement DOFs with respect to defined reference excitation DOF will be constructed.

The output drive level can be defined to run the test under no control strategy, or the response of a control channel can be specified to run the test in a closed loop.

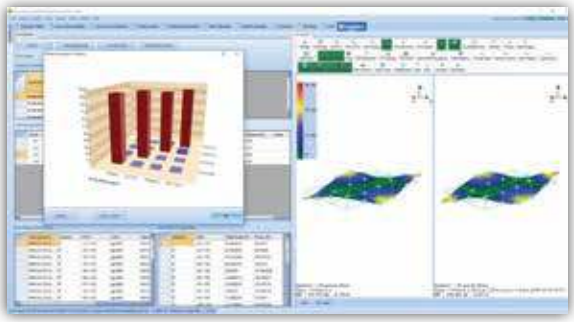


Operational Modal Testing

EDM Modal Operational Modal Testing (OMA Testing) includes a dedicated test setup and operation process flow using ambient vibration data. Using a large channel count data acquisition system (e.g., Spider- 80X or Spider-80Xi), the excitation method provides a much higher efficiency and accuracy for FRF measurements while minimizing local stresses on the test article.

Typical modal analysis methods and procedures are based on forced excitation tests carried out in the laboratory. Frequency Response Functions (FRFs) are measured as input to modal parameter identification. However, the real loading conditions to which a structure is subjected often differs considerably from those used in a laboratory testing. In many cases, (i.e., excitation of off-shore platforms or traffic/wind excitation of a bridge,) forced excitation tests are very difficult, if not impossible to conduct; at least when using standard testing equipment. In such cases, operational vibration data is often the only resource available.

Operational modal testing is designed to measure and process ambient vibration response data, which will be ready for parameter identification. The resulting cross power spectrum vector(s) can be further smoothed by using the de-convolution method.

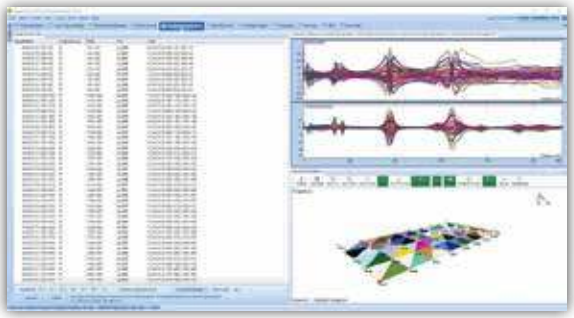


Correlation Analysis

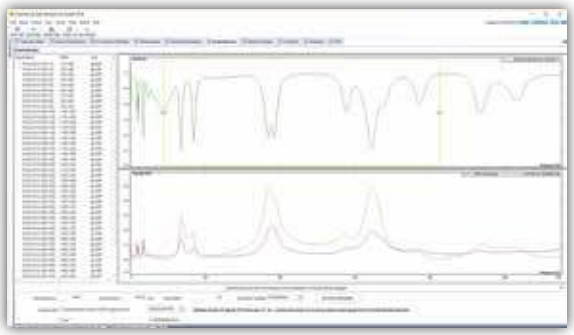
EDM Modal Correlation Analysis allows the user to correlate two modal models. The modal models can be EMA model, and/or FEA model. Comparing the experimental data with that acquired through finite element analysis helps in validating the test results. The geometry model and mode shape data from the FEA software or another set of mode shape data from EMA can be imported. A modal mapping procedure is executed to match the EMA and FEA models. After this matching procedure, the new mode shape information from FEA is interpolated and the FEA modal parameters are displayed alongside with EMA results. Finally, to observe the correlation between the results from two methods, a Cross-MAC matrix is calculated and shown.

Modal Analysis

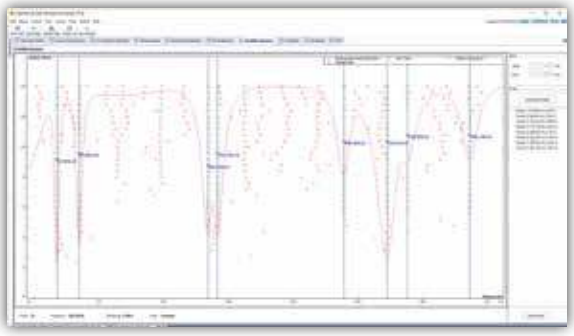
EDM Modal Standard Modal Analysis provides the user with a complete arsenal of tools, from FRF data selection and parameter identification to results validation and mode shape animation. Upon completion of the Modal testing, the set of FRF data is made available for the next step: Modal Analysis. Users can also add/replace individual FRF signals. The complete set of FRF test signals can be exported, or imported from other sources. These operations are managed by the 'Modal Data Selection'. The FRF signals are organized for a rapid comprehensive review, one by one, or multiply in one graph window.



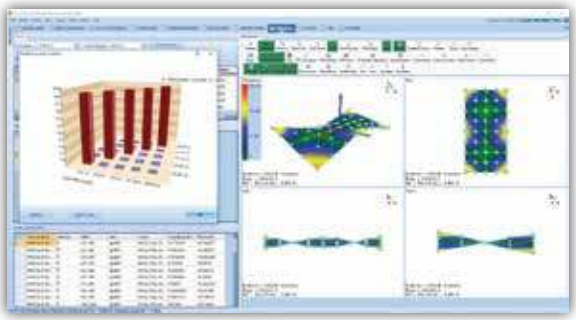
With one click, the Modal Parameter Identification process can be started. With the help of a Mode Indicator Function (MIF), the natural frequencies can be labeled. The Multivariate, Complex, Real, and Imaginary Sum MIFs are available. MIF indicators aide identifying repeated roots (repeated poles) and closely-space distinct roots.

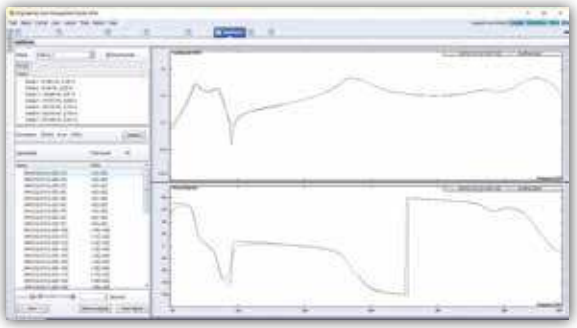


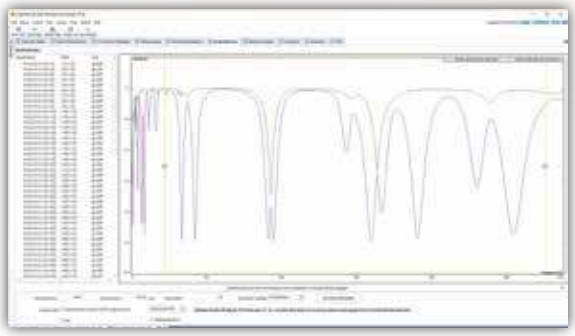
A Stability Diagram is employed with modal parameter identification. With the Standard Modal Analysis option, the proven Least Square Complex Exponential (LSCE) fitter is implemented for pole identification. The physical poles sought are stable (as opposed to 'computational poles' sometimes produced by the LSCE) and can be selected from the Stability Diagram for the next step mode shape calculation, using the Least Square Frequency Domain (LSFD) algorithm.

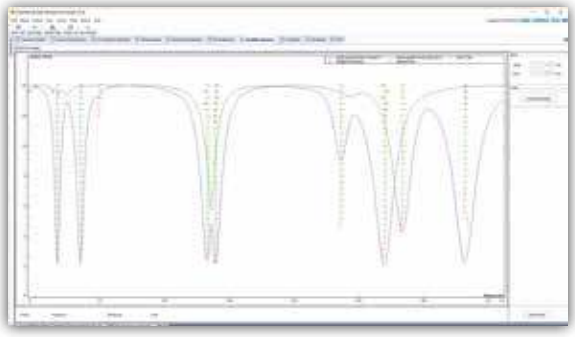


The resulting mode shape table are saved and used for mode shape animation. Modal Assurance Criterion (MAC) function and FRF synthesis are also available. These provide means for modal parameter validation.









EDM Modal Advance Modal Analysis includes all the features of Standard Modal Analysis. On top, it provides the Poly-reference modal analysis algorithm to curve fit the FRF matrix from the MIMO FRF testing results. The time domain curve fitting algorithm for the pole identification is Poly reference time domain method (PTD), which is sophisticated and proven.

The selection of the curve fitting method, PTD or LSCE, is automatic based on the type of FRF signal set selected, whether it is single reference or multi reference.

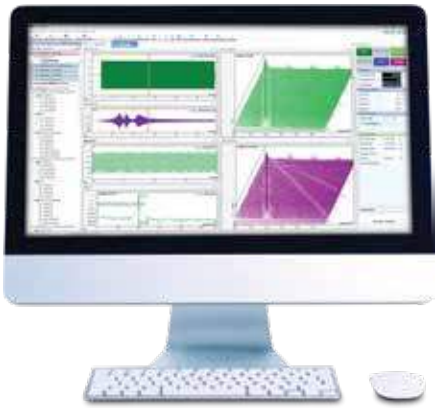
EDM Modal Premium Modal Analysis includes all the features of Standard and Advanced Modal Analysis. On top, it provides the Poly-X, which is poly reference Least Square Complex Frequency domain (p-LSCF) modal analysis algorithm to curve fit the FRF matrix from the MIMO FRF testing results. This frequency domain modal parameter estimator is more efficient and neat on the stability diagram.

The selection of the curve fitting method, Time Domain or Poly-X, is available from the EDM Modal software. It applies to either single reference or poly reference FRF data sets.

Function	**Standard Modal Analysis**	**Advanced Modal Analysis**	**Premium Modal Analysis**
Modal Data Selection	√	√	√
Band selection, MIF functions	√	√	√
Stability Diagram	√	√	√
Animation, MAC, FRF Synthesis	√	√	√
LSCE (single reference time domain)	√	√	√
PTD (Poly-reference time domain)		√	√
Poly-X (Poly-reference frequency domain)			√

EDM Post Analyzer Software

www.crystalinstruments.com/edm-post-analyzer-software



Crystal Instruments EDM PA

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

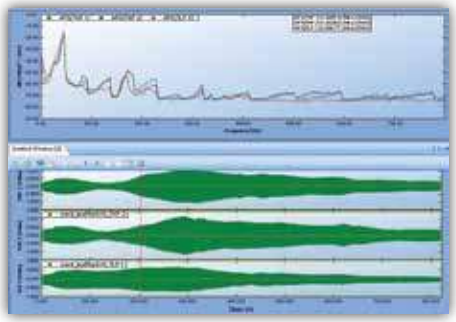
Recording first and analyzing second makes great sense to first-responding problem solvers. Simply recording does not require all of the tactical measurement decisions be made before data is taken. Often a new problem requires some “get acquainted” measurements to really define the difficulty and its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

To offer a complete package of both real-time analysis and post processing, Crystal Instruments developed three separate but related software modules: Post Analyzer, Waveform Editor, and File Converter. Post Analyzer (PA) contains many powerful post processing tools with batch processing capability. Post Analyzer is an independent Windows application that analyzes recorded data files on a computer using various algorithms. Most of the algorithms implemented in PA are identical to those used in the real-time DSP of the Spider hardware. The user should expect the same or very similar calculation results using PA to those computed in the hardware in real-time. This document describes the PA functions.

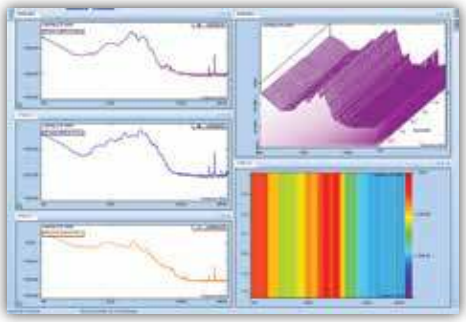
Waveform Editor is an independent Windows application that allows the user to cut, edit or merge the time waveforms. File Converter is an independent Windows application that converts files in various data formats to standard ATFX format.

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

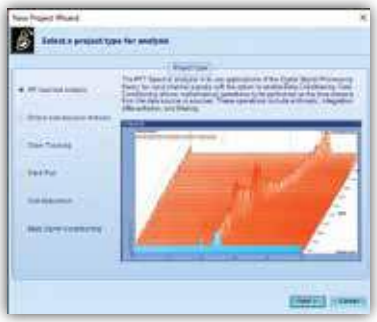
Engineering Data Management (EDM) is a complete suite of turn-key solutions for both real-time processing and post analysis. Shown in the next page are typical screen shots of EDM PA functions, in the following order: Post Processing, PA Spectra, and PA Projects.



Post Processing



PA Spectra

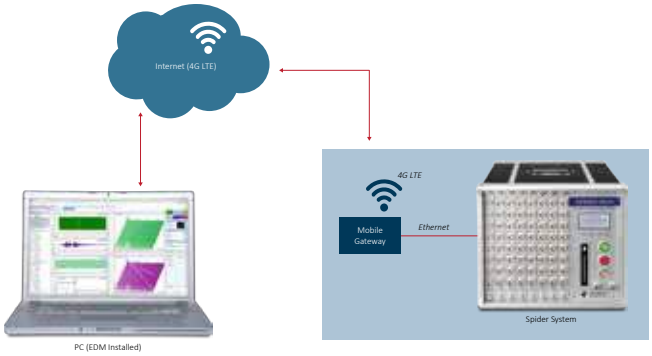


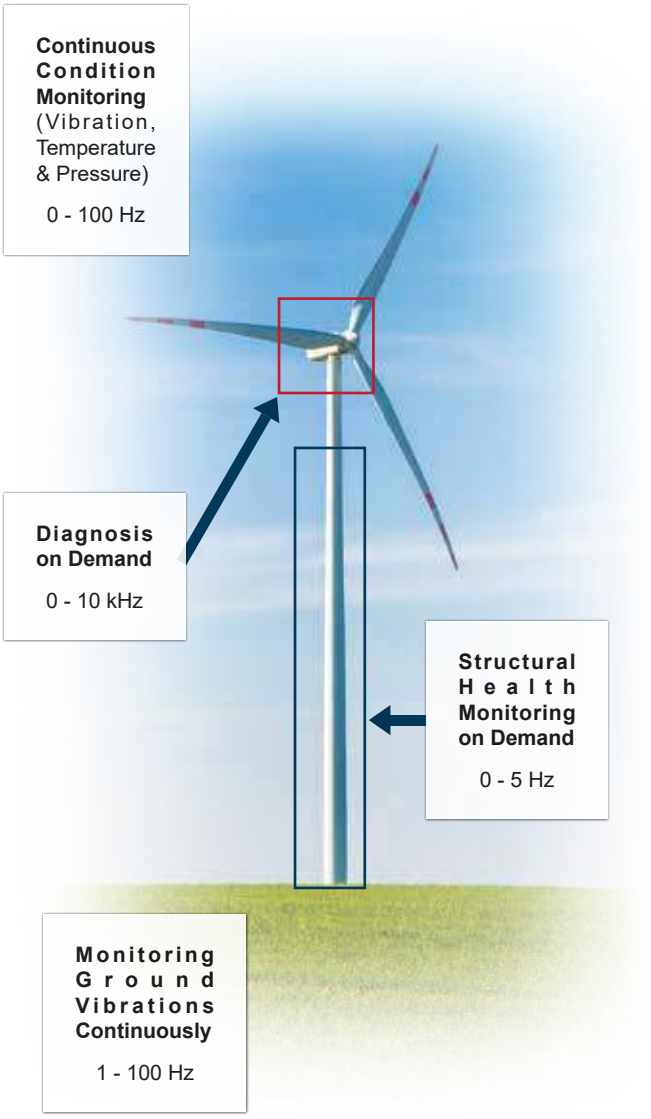
PA Projects

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

Remote Condition Monitoring

www.crystalinstruments.com/remote-condition-monitoring-software





Hardware and Software Solutions

Sometimes a test conducted at a proving ground in Michigan needs to be controlled by engineer in California or a wind turbine in Germany requires observation by designers in Japan or vibrations on an orbiting space station need to be remotely evaluated. That's when remote condition monitoring is the tool of choice. A Crystal Instruments Spider system remotely deployed can be wirelessly linked to a PC in an office which is running EDM-RCM (Remote Condition Monitoring Software).

EDM-RCM provides a convenient interface to setup multiple single and high channel count systems and simultaneously monitor all the systems together.

Monitoring Using Cellular Networks

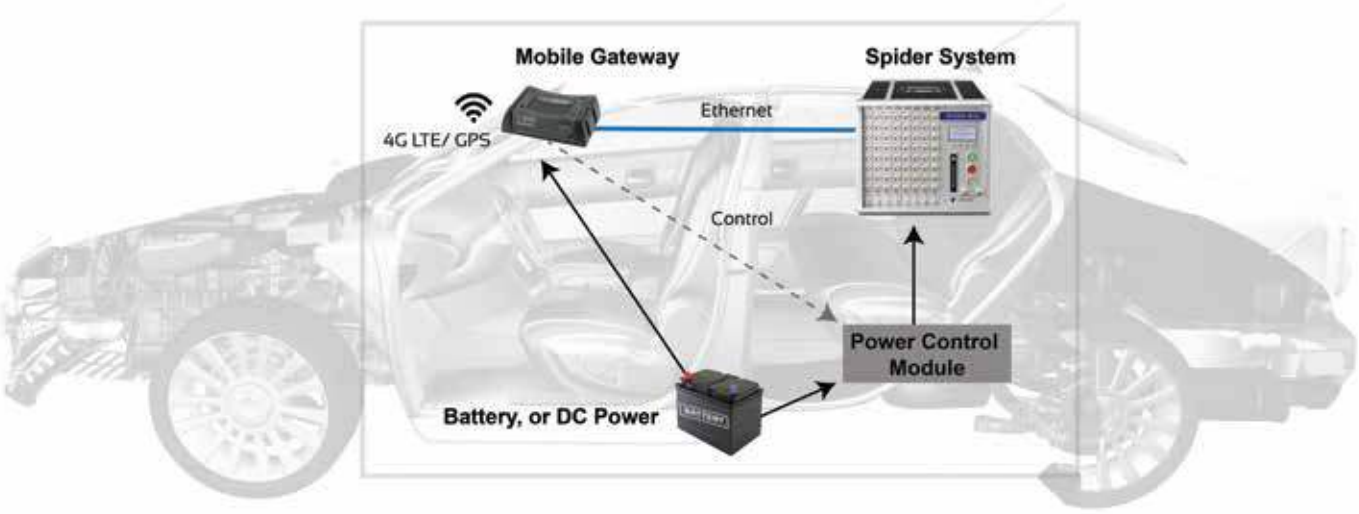
Wireless service providers have expanded rapidly to support world wide connectivity.

In the United States, cellular carriers such as Verizon, AT&T and Sprint have covered the most populated areas of the country with 4G LTE technology and the transmission bandwidth can easily reach to 10 to 20Mb/s. Other developed countries have wireless networks that reach and surpass that of the United States' and even developing countries are rapidly expanding wireless internet connectivity.

This means that a Spider system placed in a moving car can be remotely monitored and controlled by a PC with an internet connection running EDM-RCM software. The Mobile Gateway modem makes the remote in-vehicle operation of Spider system possible. Crystal Instruments has developed several competitive features that help its line of Spiders succeed at wireless remote condition monitoring.

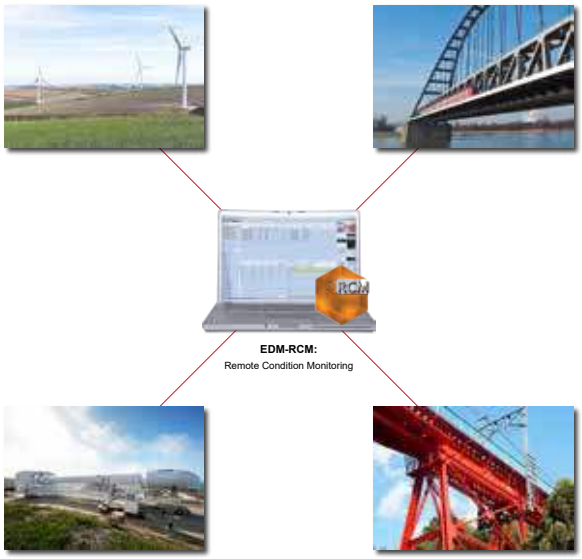
Using the powerful "Black-Box" mode feature of the Spider, the PC merely acts as a terminal to view the status. If the connection fails or slows due to limitations in the transmission, such as the wireless connection becoming bad, neither the data acquisition nor the monitoring functions on the Spider system will be interrupted.

The design function resilience of the Spider system assures that no external failures will compromise its smooth operation.



Remote Condition Monitoring Features

- Simultaneouly monitor status of multiple Spider systems
- Simulanously download data from all Spider systems
- View generated alarms across all Spiders
- Low Power Consumption
- 160 dbFS Dynamic Range
- “Black Box” Mode (No PC Required)
- Reliable in All Circumstances



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

Monitoring Over LAN

Using the capabilities of the Spider’s Black Box mode together with the ability of EDM-RCM to efficiently monitor multiple Spider systems simultaneously, the Spider systems could be deployed in a plant or a factory where continuous monitoring of several machines are needed.

Each Spider front-end is configurable to continuously monitor the input channels and can be set to save data or generate specific events when certain user defined limits on time or spectral data is exceeded. The generated alarms are then passed to the EDM-RCM software for the user to diagnose.

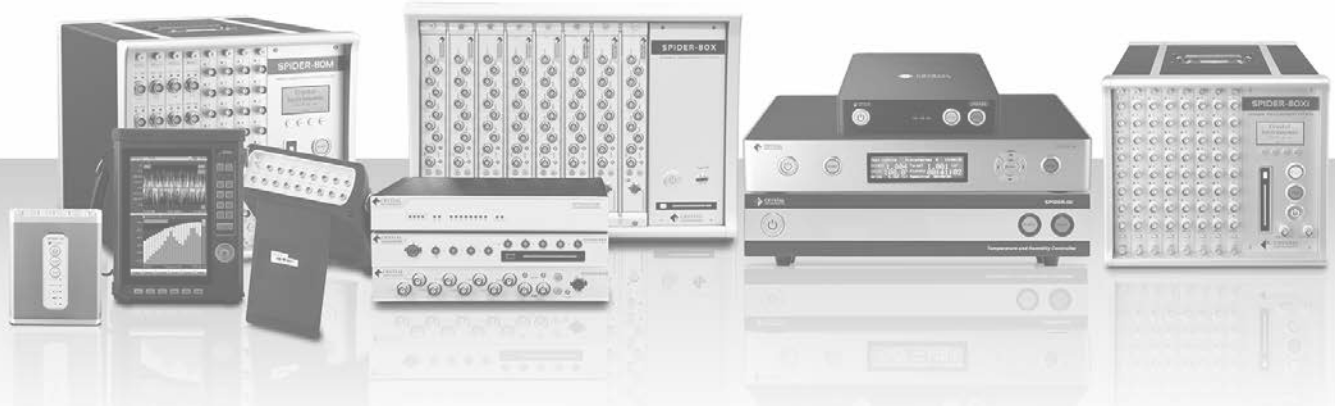
Remotely Manage Power to a Spider System

The active power consumption of one eight channel Spider front-end is less than 10 watts. It is feasible to use battery power, or solar assisted power source to power the units.

In the events where the Spiders need to save power when data acquisition is not needed, users can put the system into power saving mode using an intelligent power control module developed by Crystal Instruments. The power module uses Ethernet messages which can transmit to the Spider using a local network or through the internet. The power module can also be used to remotely power recycle the Spider.

Comprehensive Technology Service Agreement

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

Services offered are:

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

Annual Hardware Calibration

Crystal Instruments DMS is certified by ISO:9001. Hardware calibrations are also performed at the customer's site upon request. Customers with a Premier Technology Service Agreement will receive standard annual hardware calibration services at no additional cost (a $1500 value).

Annual Software Upgrades

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

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

Temporary Replacement Units

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

Live Product Support

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

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

Hardware Repair Services

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

Data Recovery Services

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

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

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