CRYSTAL INSTRUMENTS

Spider-81 User's Manual

Spider-81 Vibration Control System

11/30/2010

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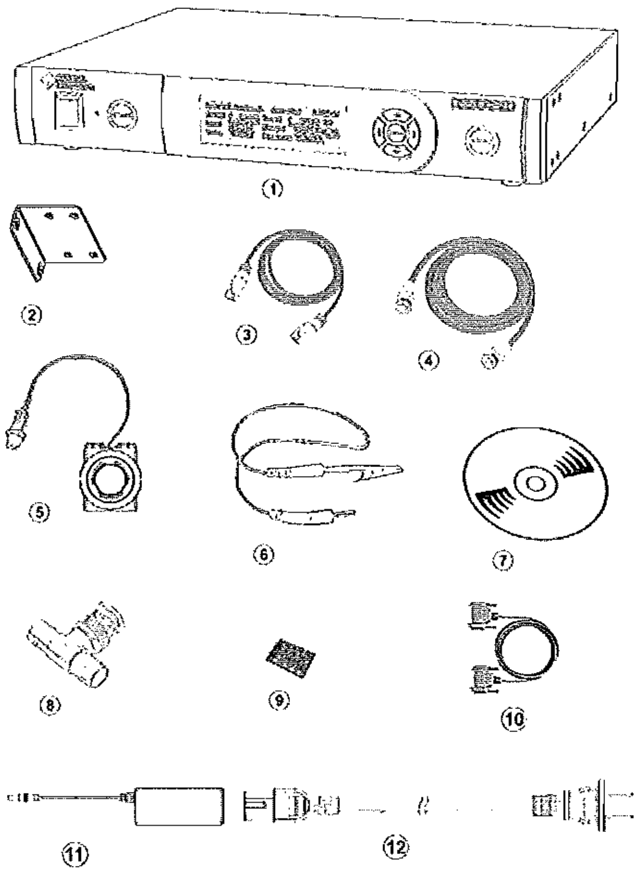
Quick Setup Guide

What's in the Box



	Description	Quantity
1	Spider-81 or Spider-81B shaker controller	1
2	Rack mount installation kit	2
3	Ethernet cable	1
4	BNC cable	1
5	External Abort button with 10 feet of cable	1
6	Cable for ground connection, 3 feet	1
7	CD with EDM software and documentation	1
8	BNC Tee connector	1
9	Digital I/O testing board	1
10	AC power adapter	1
11	Wall power cord	1

Table 1: Spider-81 Packing List

Important Safety Information

The Spider-81 Vibration Controller complies with:

EN 61326:1997+A1:1998+A2:2001

EN61000-3-2: 2000 & EN61000-3-3: 1995+A1:2001

Use the Spider-81 and its accessories only as specified in this User's Manual. Otherwise, the warranty protection provided by Crystal Instruments may be voided.

Condensation may form on the circuit boards when the device is moved from a cold environment to a warm one. In these situations, always wait until the device warms up to room temperature and is completely dry before turning it on. This acclimatization should take about 2 hours.

For the most accurate measurements a warm-up phase of 20 minutes is recommended.

The devices have been designed for use in clean and dry environments. It is not to be operated in 1) exceedingly dusty and/ or wet environments, 2) in environments where danger of explosion exists nor 3) in environments containing aggressive chemical agents.

Always lay cables in a manner to avoid tripping hazards.

A Warning identifies conditions and actions that pose hazard(s) to the user. A Caution identifies conditions and actions that may damage the Instrument.

To avoid electrical shock or fire:

1. The Spider-81 is a low voltage measurement instrument.
2. Do not apply input voltages above the rating of the instrument. Never apply a voltage that potentially exceeds ±40V.
3. Review the entire manual before use of the instrument and its accessories.
4. Do not operate the instrument around explosive gas or vapor.
5. Before use, inspect the instrument, BNC connectors and accessories for mechanical damage and replace when damaged. Look for cracks or missing plastic. Pay special attention to the insulation surrounding the connectors.
6. Remove the cables and accessories that are not in use.
7. Use the ground input only to ground the instrument. Do not apply any voltage.
8. Do not insert metal objects into connectors.
9. Use only the wall-mount power supply provided by Crystal Instruments.

AC Adapter Voltage Range

For external power source Spider-81 uses a wall-mount AC Adapter. The AC Power range is: 100Vac – 240Vac.

Maximum Measurement Input Voltage

Maximum Working Input Voltage: 20 V peak. Voltage ratings are given as "working voltage". They should be read as Vpeak for dynamic applications and as V dc for DC applications.

Maximum input range without damaging the hardware: 40Vpeak.

Installing the Engineering Data Management software (EDM)

To install EDM on your PC, insert the included CD-ROM into your drive. If the Welcome Screen does not automatically open you can run the Setup.exe file on the root level of the CD.

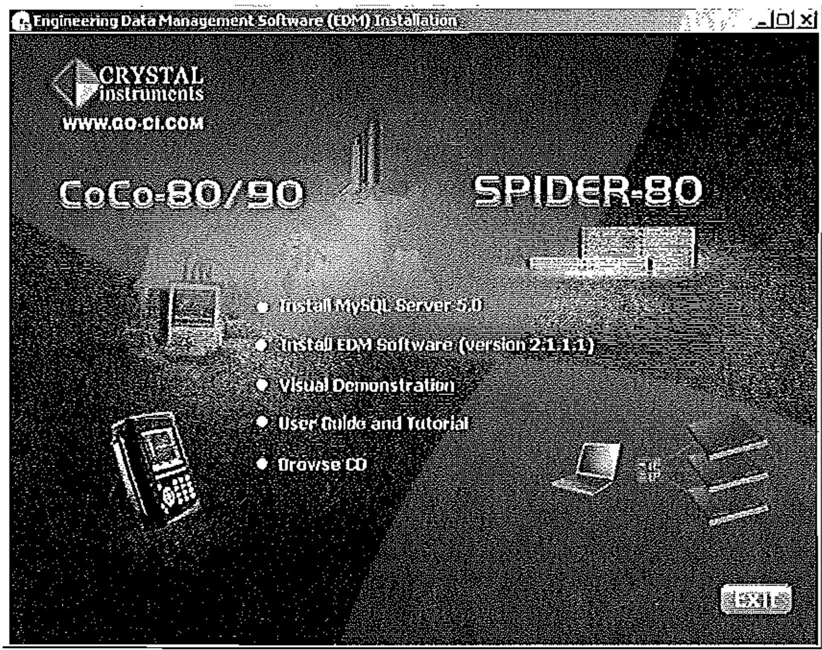


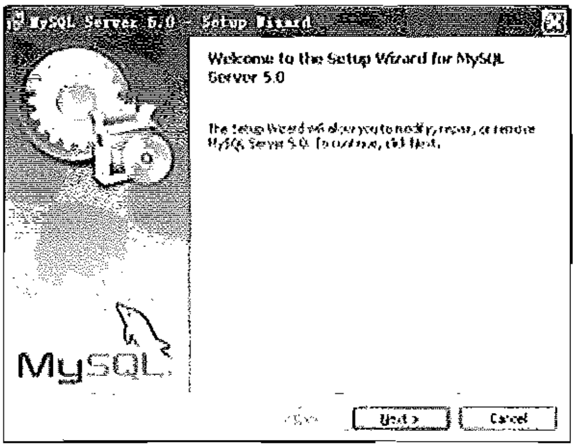
Figure 1: Welcome Screen for EDM Installation CD.

EDM requires the MySQL server version 5.0 or later. The CD includes version 5.0

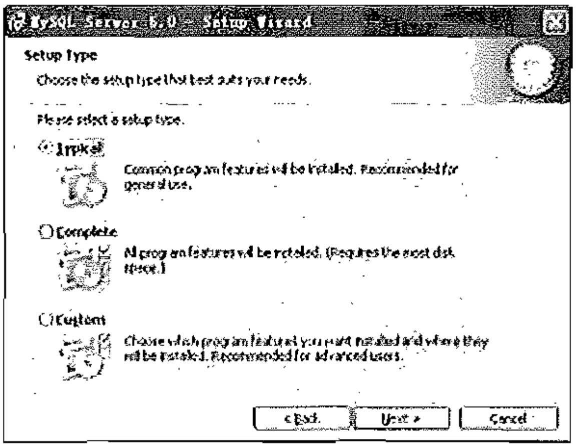
MySQL Server Installation

EDM requires the MySQL database server version 5.0. MySQL is a separate software package owned by Oracle Corporation and licensed under the open-source GNU General Public License. EDM uses the database to store test and measurement data.

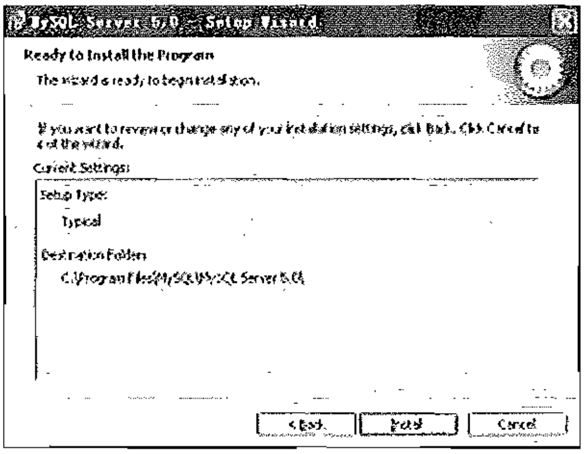
Click MySQL Server on the EDM Software Installation screen to begin installation. The MySQL Setup Wizard will start:



Click on **Next** button. You can then choose the destination folder or use the default folder. Then select **Typical.** It is not necessary to install all components of MySQL Server:



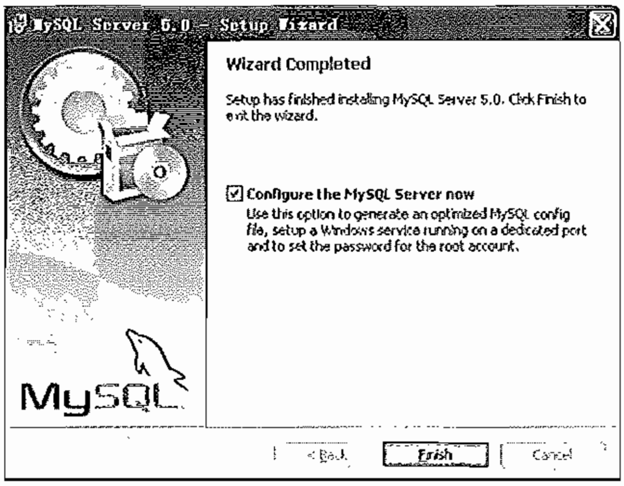
Click on **Next** button. Then Click on the **Install** button:



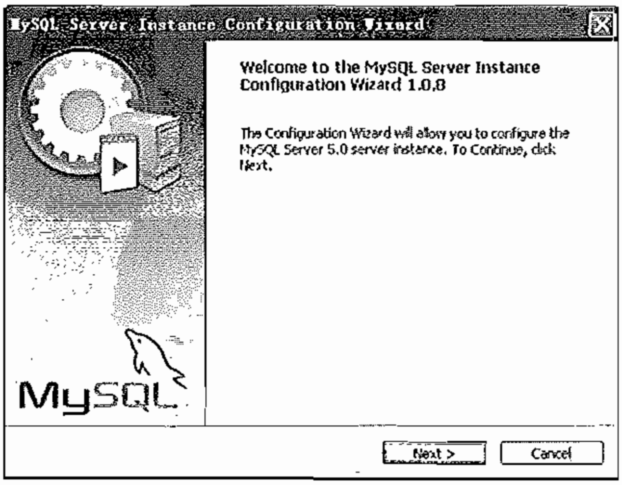
After the installation is complete, click on the **Next** button.

Click on the **Next** button again and the Setup Wizard will complete its initial operation.

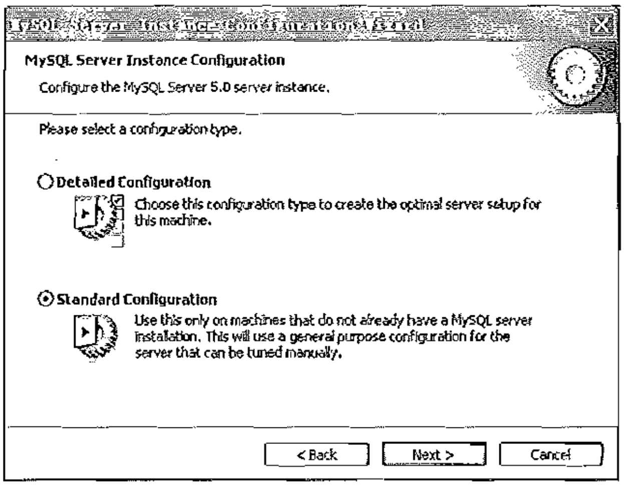
You are now ready to configure MySQL Server. Select the **Configure the MySQL Server Now**, and click the **Finish** button.



The Instance Configuration Wizard should open. If it does not, you have to open it manually. It is located at C:\Program Files\MySQL\MySQL Server 5.0\bin\MySQLInstanceConfig.exe



Click on the **Next** button. When the following screen appears, select **Standard Configuration**, click on the **Next** button.



To properly configure MySQL for use with EDM, the following configuration choices should be selected:

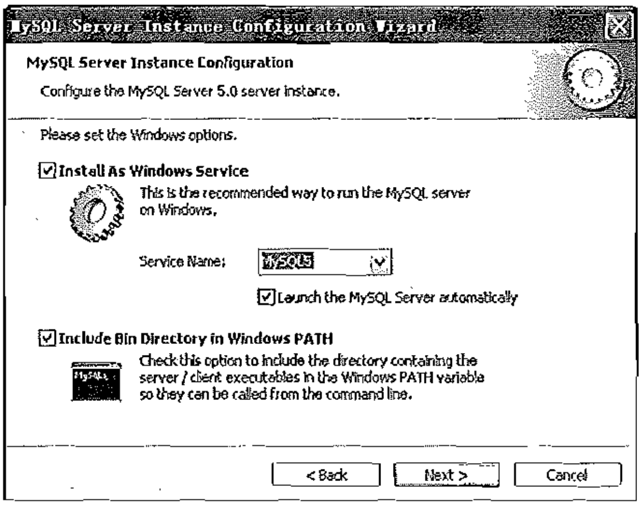
Select **Install As Windows Server**.

Enter a **Service Name**, or simply select **MySQL5**. The name you create must not have any spaces in it.

Check the **Include Bin Directory in Windows PATH**.

Select **Launch the MySQL Server automatically**.

> Caution: Be sure that all these selections have been made. EDM runs on MySQL and will not operate properly if these options have not been selected during MySQL installation.

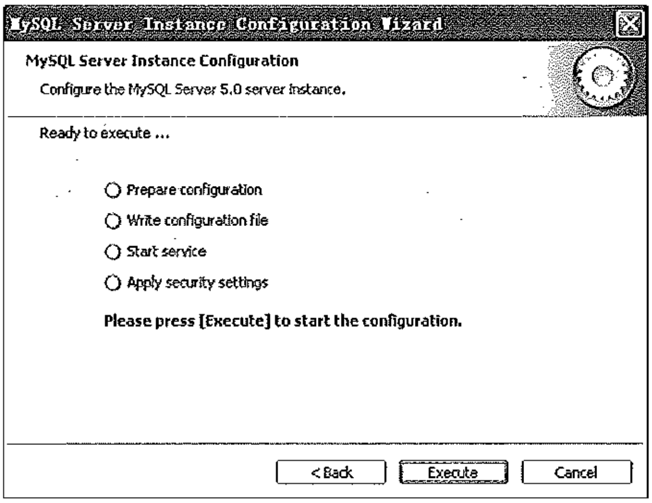


Next, choose a password for the database. If you want other computers to access the database on this computer, check **Enable root access from remote machines**.

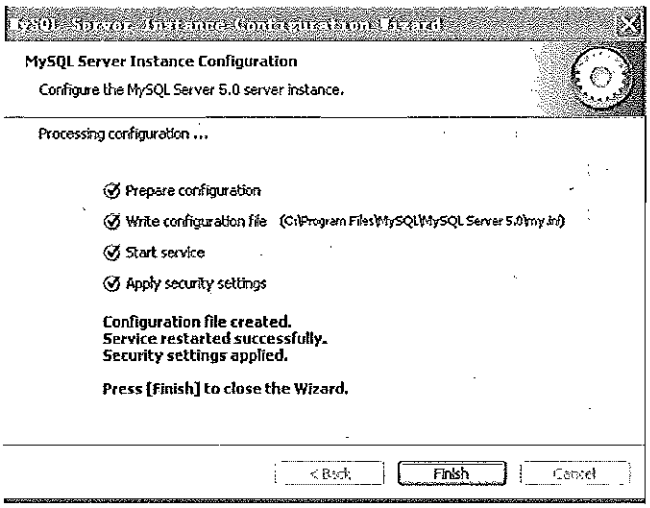
> Important! You should make a record of the password and keep it in a safe location. This password is required whenever you access the database.
>
> When EDM is launched, you will be required to enter EDM user account password. The EDM user account password setting is different to that of database setting.

Click on the **Next** button.

Click on the **Execute** button.



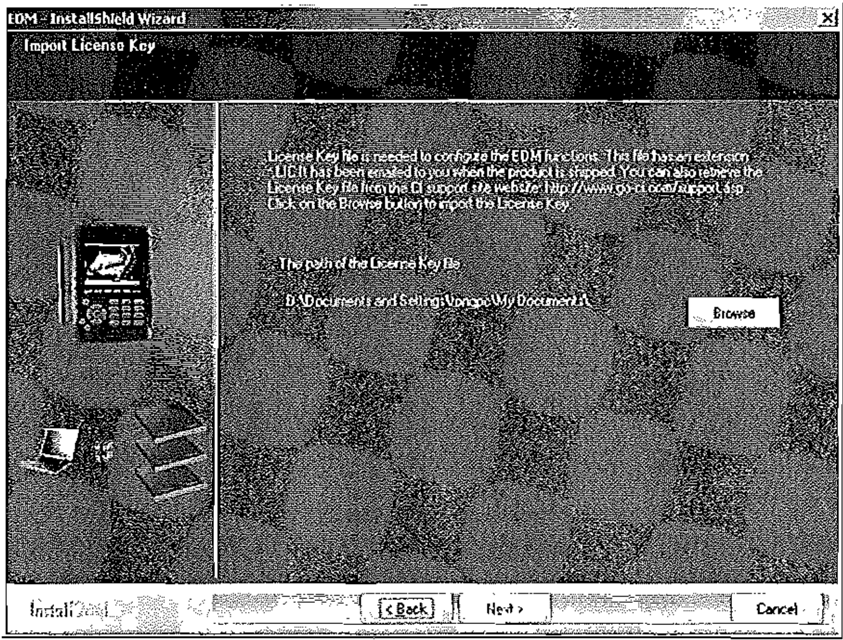
Click on the **Finish** button. The installation is now complete.



EDM Software Installation Wizard

Next, to install EDM, click on **Install EDM Software** on the Welcome Screen.

The EDM software uses Microsoft .NET resources. The .NET resource software is native in Windows Vista and Windows-7 but must be installed for Windows XP. .Net will automatically be installed if it is not detected on your system.



Where is My License Key?

There are two ways to obtain your EDM software License Key.

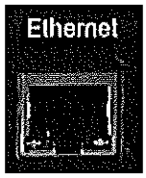
When you received your Spider from Crystal Instruments, you should have received an automated email message with shipping information, your EDM license key file, and your product serial number. The license key file is a file that contains the extension .LIC.

If you have not received the email message, or do not have your license key, you will need to obtain the license key file from the Crystal Instruments support web site: http://www.go-ci.com/support.asp. If you do not have a password, call Crystal Instruments tech support and they can send it to you (your login is the product serial number).

> It is a good idea to store the License Key, Serial Number of your instruments, and Password somewhere safe where you can always find it. You will need this information to log on to the CI Technical Support Site for assistance and

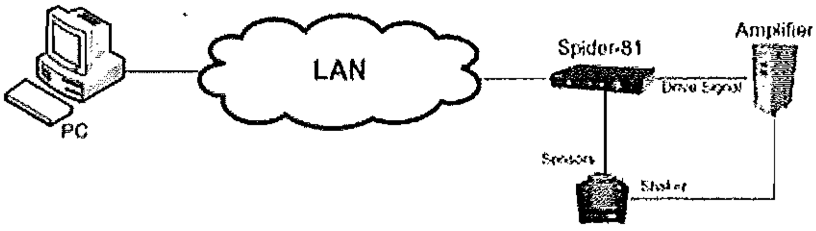
updates. If they are lost, please call CI Technical Support at (408) 986-8880.

Connecting Your PC to the Spider



You can connect your Spider through an Ethernet LAN or directly to your PC using an Ethernet crossover cable. There is a CAT-5 100Base-T jack on the rear of the instrument.

If your Spider system consists of more than one Spider module, you will need to connect the modules with a network switch or router. It is recommended that your system use a private LAN rather than sharing an office LAN.



Set Master or Slave Mode

The M/S switch on the back is used to control whether the Spider module is configured as Master or Slave. In a Spider-81 system includes other Spider-80 modules, only the Spider-81 can be configured as a Master, and every other unit is a Slave.

If you are using only one Spider module, the system will automatically configure it as a Master regardless of the switch position. If additional modules are added at a later date, it will be necessary to configure the first module as the Master and each of the additional modules as Slaves.

Connect the Power Adapter

Now connect the power adapter to the power jack on the rear of the Spider and to an AC power source. The power adapter is an AC to DC converter that accepts 100 VAC to 240 VAC and outputs 15 VDC. The total power consumption of a Spider module is less than 10 watts during full operation.

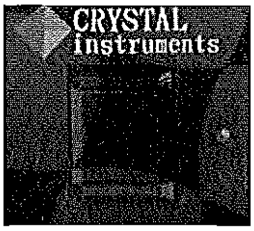
Connect the Drive and Measurement Inputs

OUT 1 is the drive channel. Connect it to the input side of shaker power amplifier.

CH1~8 are input channels. Connect these channels to the sensor outputs.

Turn Spider Power On

After the Ethernet cable and power adapter are connected to the Spider, it is OK to press the Power button on the front of the unit. The power LED will illuminate.



Warning: Never press this button to turn the power off while the controller is running. In case of emergency, press the Stop button on the front, or use the Abort contact switch that is connected to the back.

Set Spider IP Address

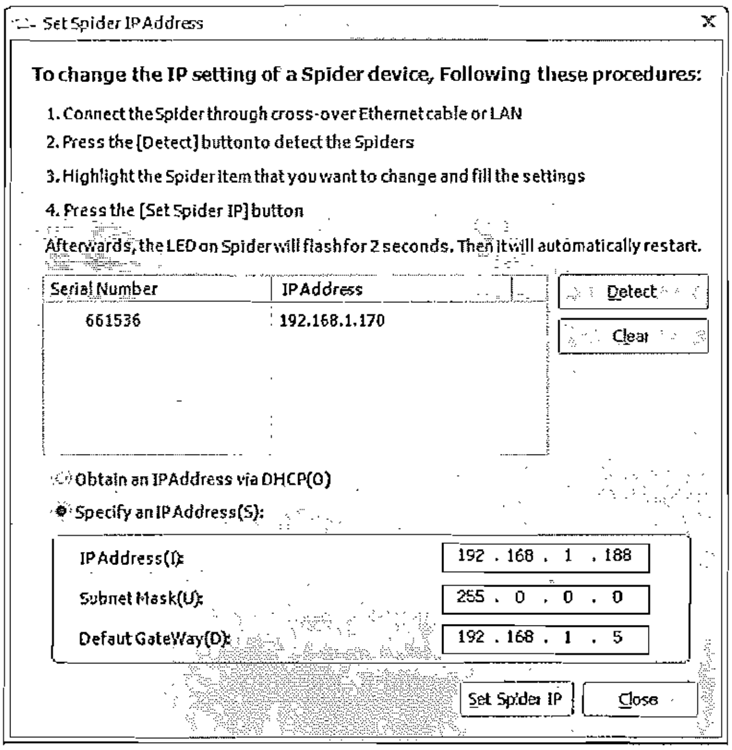
When each Spider is shipped, unless the user has requested otherwise, it is set by default to following IP address and subnet mask:

IP Address: 192.168.1.153

Subnet Mask: 255.255.255.0

If the user asks to set the IP address and subnet mask to match their computer settings, the production department will set them per user request.

To change the Spider IP settings, open the **Spider IP Address Setup** tool that was installed with EDM.



Each connected Spider module will be listed by serial number. To change settings, select a module, enter the desired IP address, subnet mask, and default gateway, and click **Set Spider IP.** You can also choose to have the IP settings automatically assigned via DHCP. The LED on the Spider will flash for a couple seconds, indicating that the new IP has been assigned. It is helpful to keep track of the IP addresses of each module and their physical location.

Resetting Spider to Factory Default IP Settings

To reset the Spider to the factory default IP address of 192.168.1.153:

- Turn the Spider power on
- Switch the Master/Slave button to the Slave position
- Press the Stop button for 4 seconds.

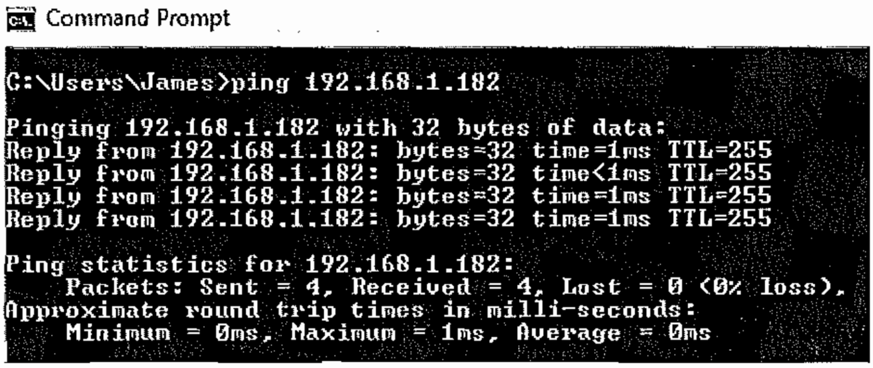
For Spider-81, it is recommended to use the front panel navigation buttons to set the IP address.

Computer Network Settings

The network settings on the PC must have a matching subnet mask in order to communicate with the Spider.

To verify the network connection, use the PING command in the Command Prompt window on the PC. In the windows Start Menu, select **Run,** type **ping 192.168.1.182,** and press enter. Replace 192.168.1.182 with the configured IP address of the spider.

If it is correctly configured, the **ping** command will receive responses from the Spider, as shown below.

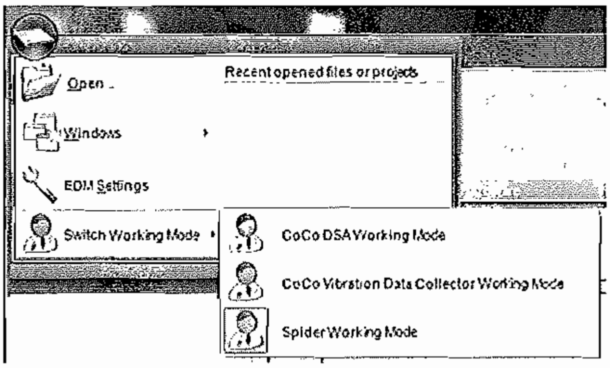


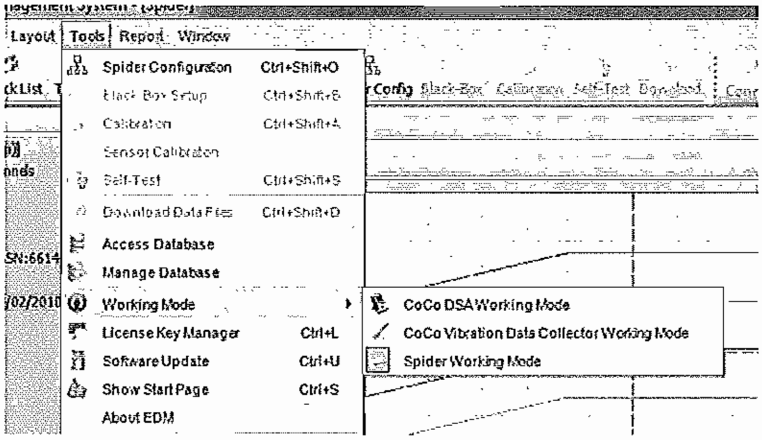
Running EDM

You are now ready to launch EDM. This section will explain the basics of configuring a system, running a test, and saving data.

Select Spider Real-Time Working Mode

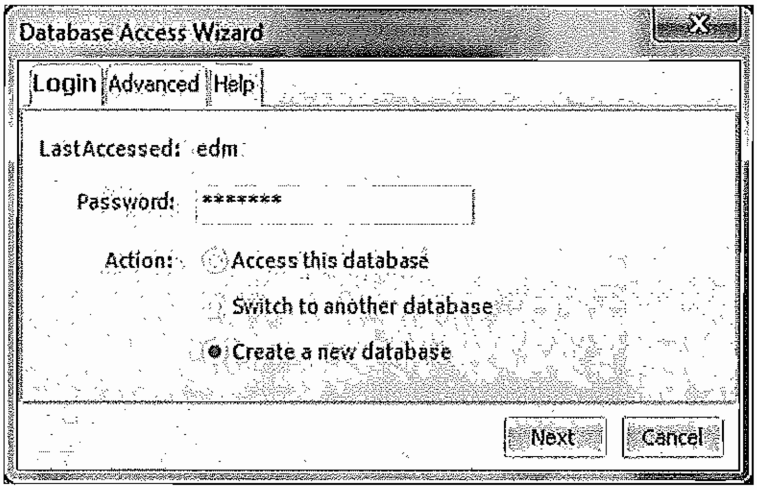
Make sure EDM is in Spider Working Mode. To change the working mode, use the Working Mode item either under the EDM menu in the upper left corner of the screen or under the Tools menu, depending on the current working mode.



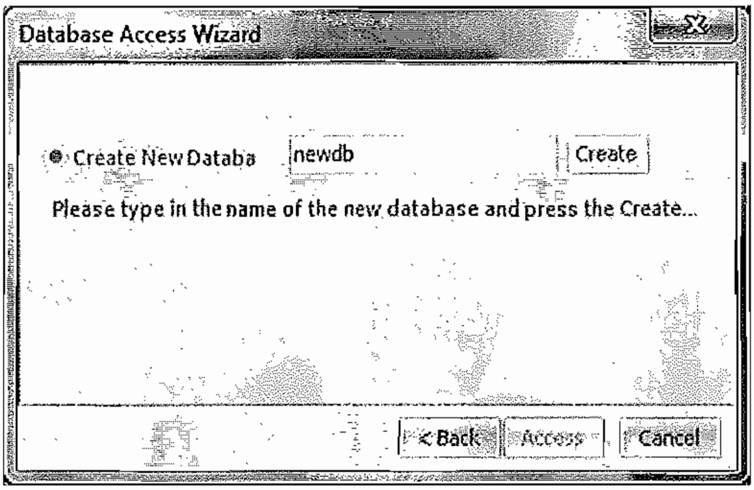


Connect to a Database

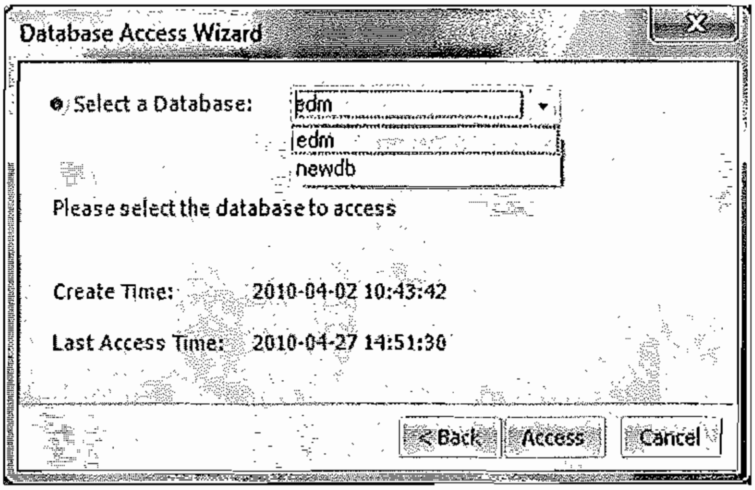
It is necessary to create a database to store and access test configuration data. When you first open EDM, the Database Access Wizard will be displayed. Select **Create a New Database** to create a new empty database. Click on the **Next** button, enter a new database name, and click the **Create** button. Then, click the **Access** button after the database has been created.



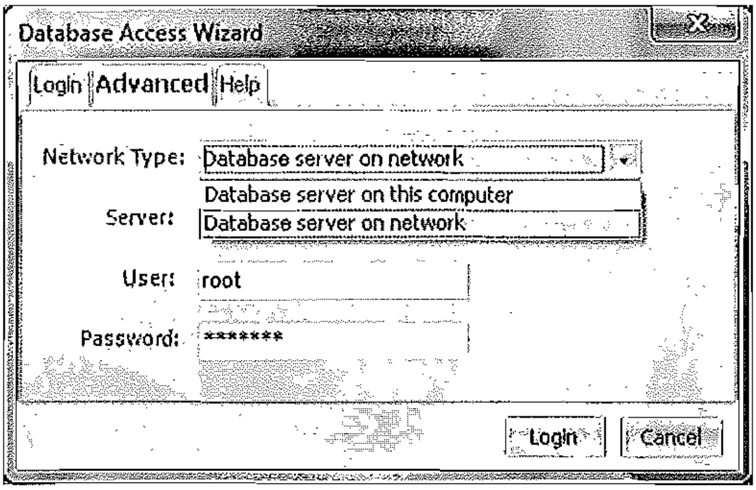
There are two password controls in the EDM software. One is the password that accesses the database server; the other is the password to login the EDM as a user account. The database password is used rarely. Please keep it in a secure place.



Alternatively, to choose an existing database, select **Switch to another database** and select the database to use in the next window.



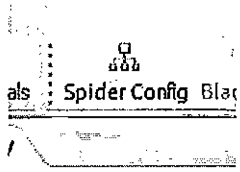
To connect to a database on a remote server, click on the Advanced tab and select **Database server on a network**. There, you can enter the server location, user name, port, and password.



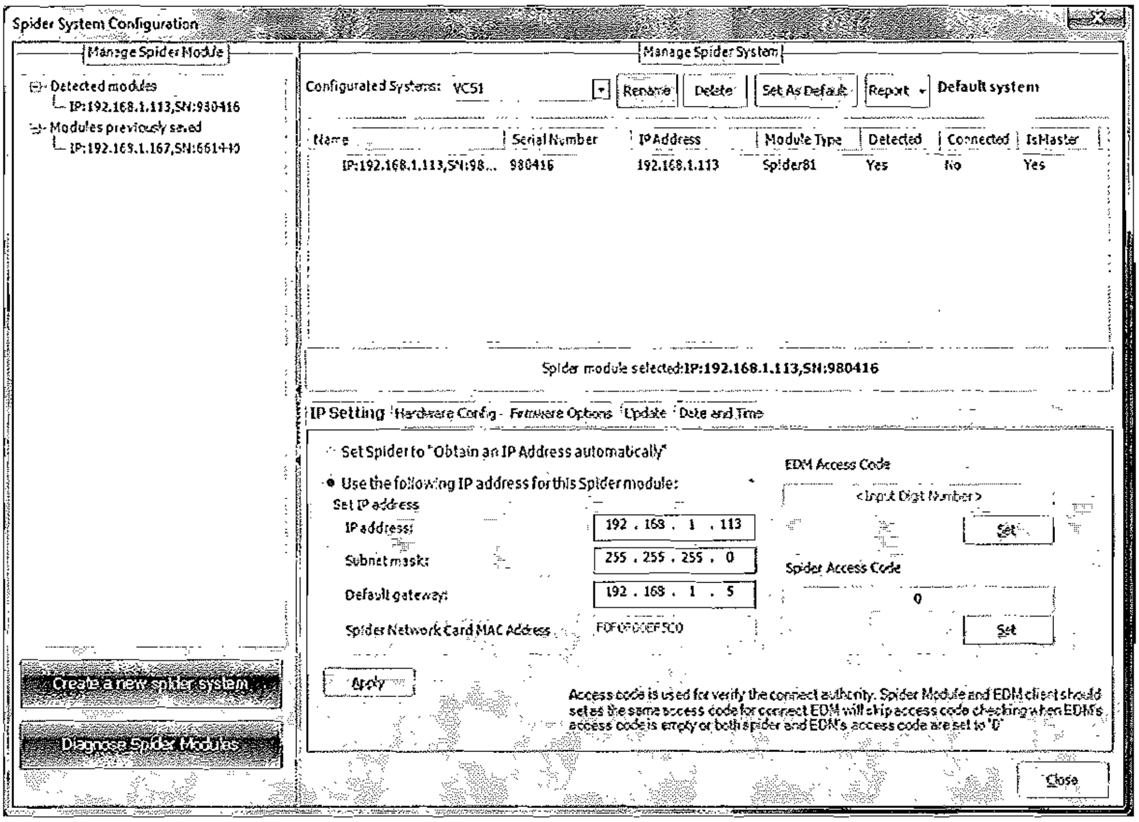
Configuring a Spider System

A Spider system can be configured from any combination of available Spider modules connected to the LAN. EDM can store multiple configurations and recall any one of them for a test.

When all the Spider modules have been connected to the LAN, bring up the Spider Configuration window by clicking on **Spider Config.**

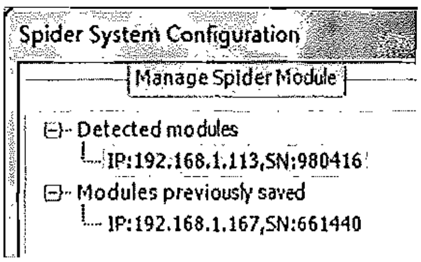


All detected Spider modules will be listed on the left side by their IP address and serial number, as well as previously used modules. The top right section shows the modules in the currently selected system, and below that are settings for the selected module. To create a new system, click the **Create a New Spider System** button on the bottom left, enter a name for the system, and select the module or modules to include.

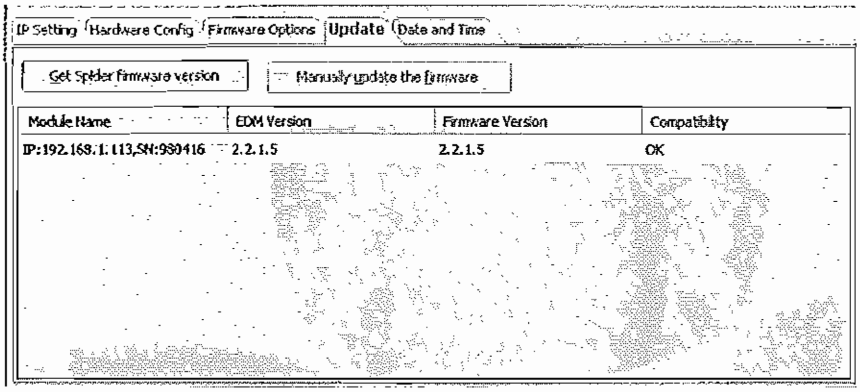


Updating Spider Firmware

All Spider modules should be kept up to date with the latest firmware to ensure the best operation. EDM will automatically detect and update the firmware on connected modules. The user can also choose to manually update the firmware on any Spider module. To do so, select the module from the list on the left under Detected Modules.

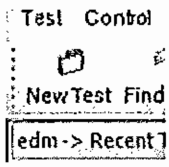


Then, click on the **Update** tab and press **Manually Update Firmware.**

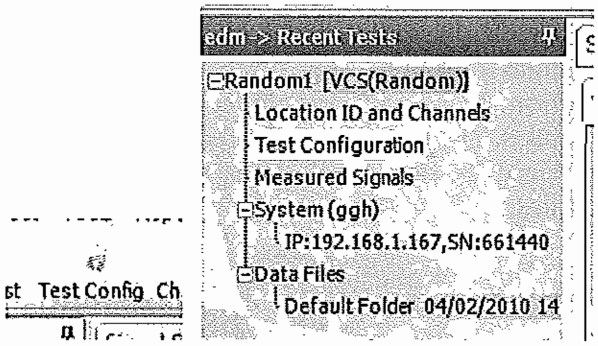


Creating a New Test

Once the Spider module has been connected and configured on the LAN, a test can be set up by clicking on **New Test**.

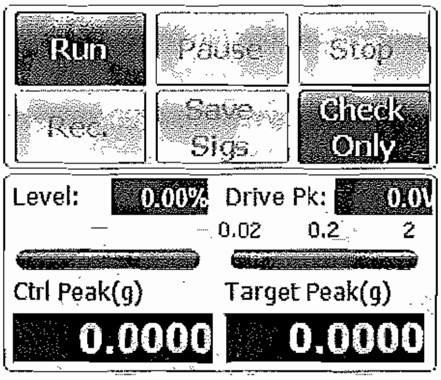


Click on **Test Config** (or double click the Test Configuration item) to access test configuration parameters.



The test configuration is a multiple-tab dialog box that allows the user to set up the analysis parameters, schedule, event-action rules and other settings. Some of these parameters can also be set directly on the control panel while the Spider is running.

The test can be controlled by the buttons on the control panel and on the Control toolbar.

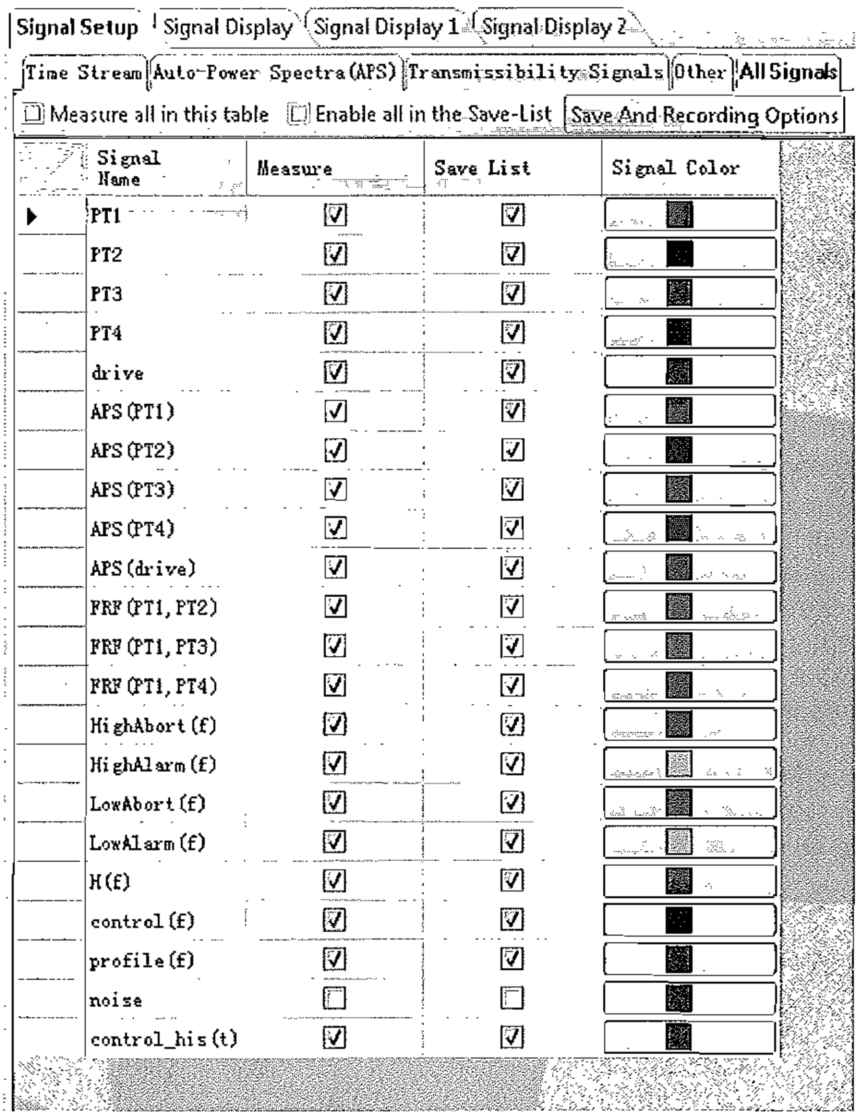


Saving Signals and Recording Time Streams

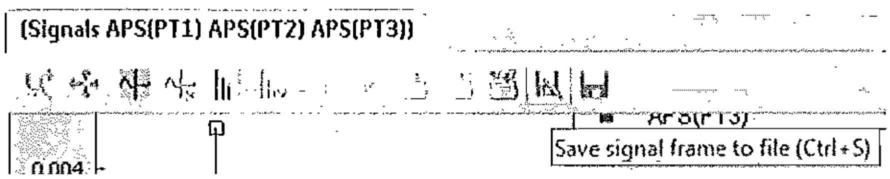
Different options are available to save measurement data. EDM uses the terms **Save** for block data and **Record** for time stream data. Blocks of data, which include time-domain and frequency domain blocks, can be manually saved by clicking the **Save Sigs** button or automatically captured based on a trigger setting. Time stream data can be recorded manually by pressing the **Rec./Stop** button or by using a run schedule. Data can be stored on the internal flash memory of the Spider or on a hard drive connected to the PC.

To select which signals to enable saving or recording, click on the Signal Setup tab. Under this tab, signals are organized according to their type, and each signal has an option to enable saving or recording.

The block signals checked in the Save List column can be automatically saved when the user presses the Save Sig button on the control panel, or when a Event-Action Rule generate a Save signal action.

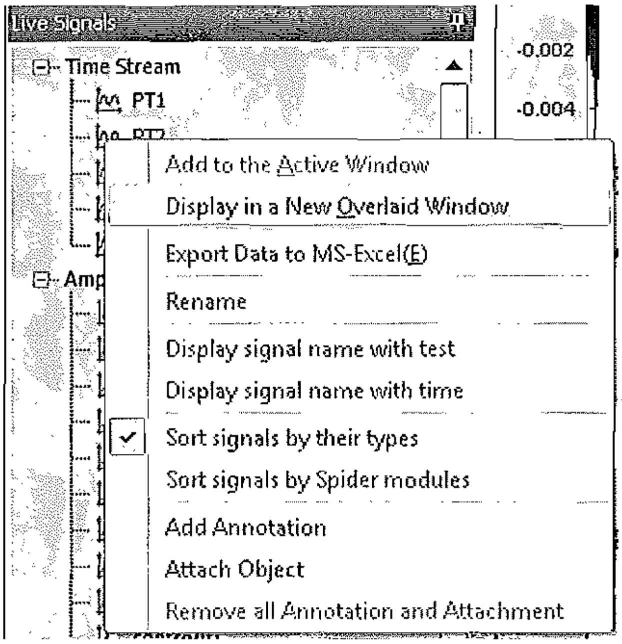


Currently displayed signals can also be saved by pressing F4 or clicking on the small disk icon on the top of the window.

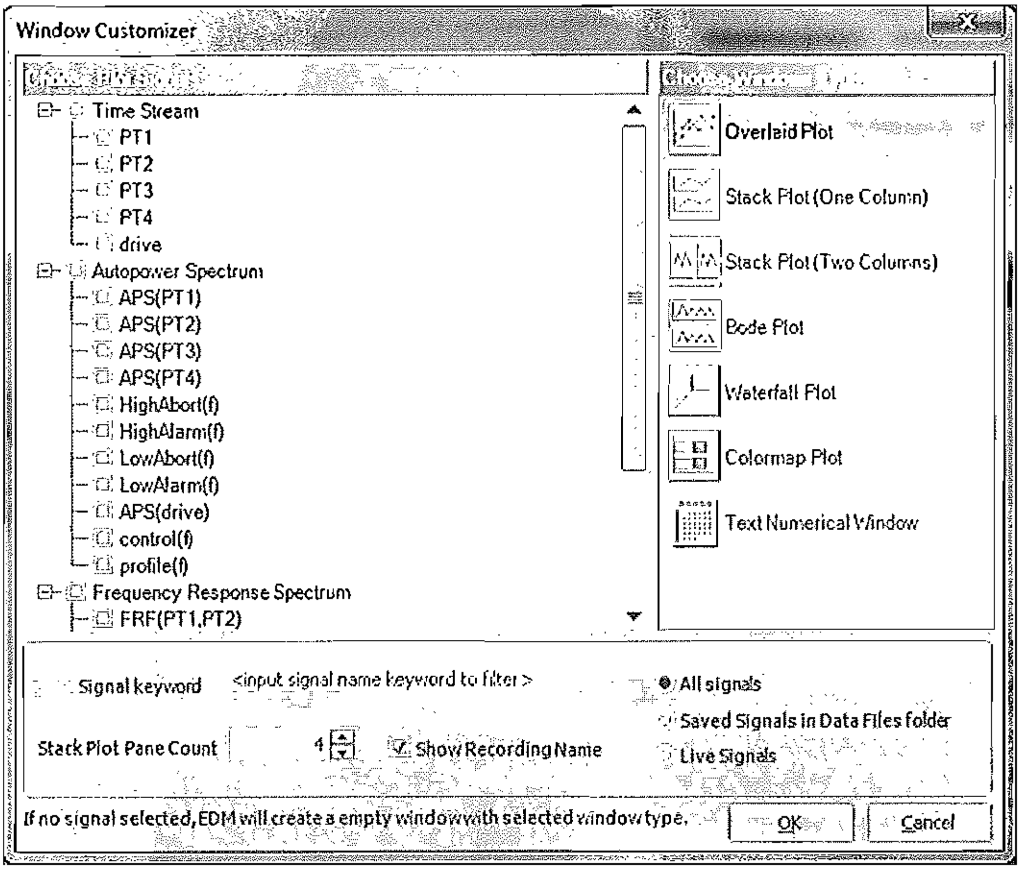


View Live Signals

On the left side in EDM there is a list of available Live Signals that can be displayed. To view one, right click on it and select Display in New Overlaid Window.

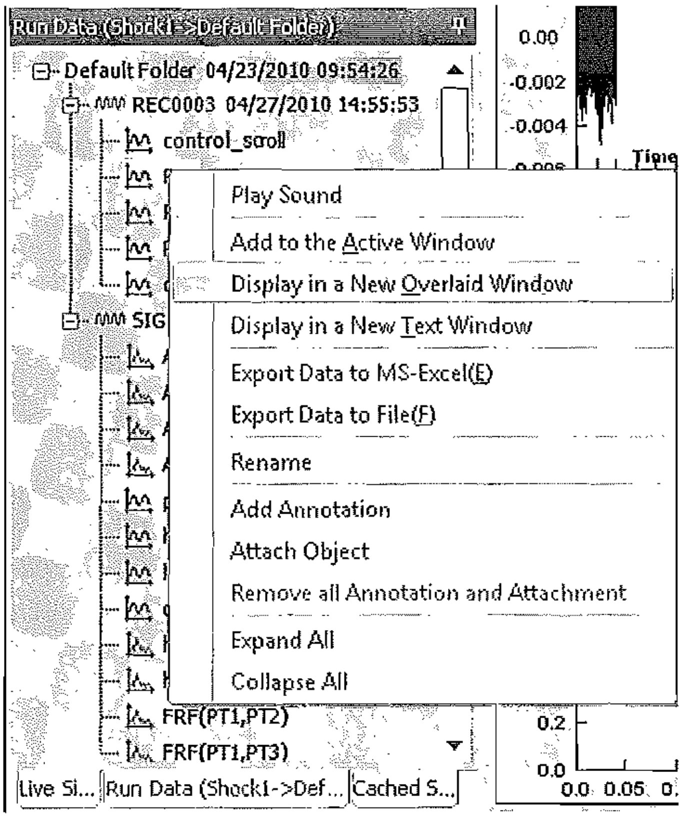


You can also select the **Customize** command under the **Display** menu. This brings up the Window Customizer dialog box where you can select which signals to display and the type of display window to use.

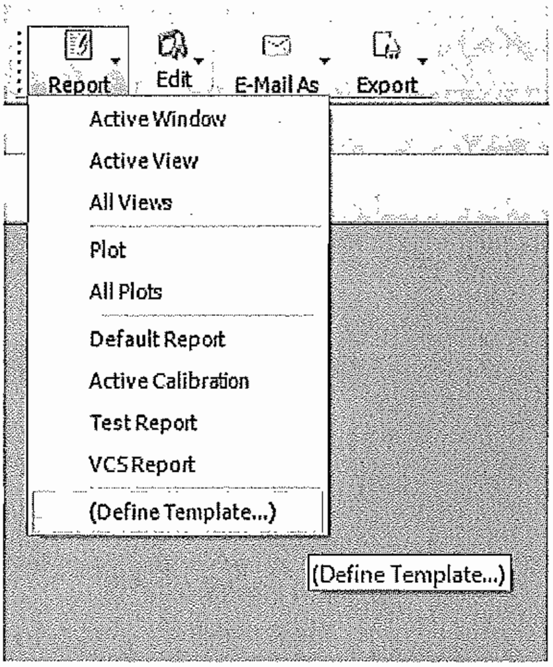

Window Customizer
Time Stream
PT1
PT2
PT3
PT4
drive
Autopower Spectrum
APS(PT1)
APS(PT2)
APS(PT3)
APS(PT4)
HighAbort(f)
HighAlarm(f)
LowAbort(f)
LowAlarm(f)
APS(drive)
control(f)
profile(f)
Frequency Response Spectrum
FRF(PT1,PT2)
Overlaid Plot
Stack Plot (One Column)
Stack Plot (Two Columns)
Bode Plot
Waterfall Plot
Colormap Plot
Text Numerical Window
Signal keyword
<input signal name keyword to filter>
All signals
Saved Signals in Data Files folder
Live Signals
Stack Plot Pane Count
4
Show Recording Name
If no signal selected, EDM will create a empty window with selected window type.
OK
Cancel

View Saved Data

Saved signals are shown under the Run Data tab on the left of the screen. Right click on any listed signal to display it.



Create a Report



Click on the **Define Template** command under Report to define a template. Then Click on any templates that were previously defined to generate the report.

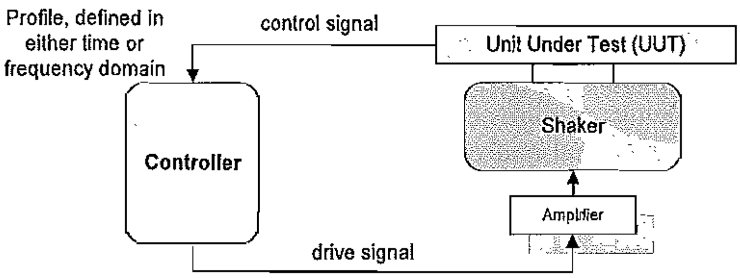
Overview of the Vibration Control System

The digital Vibration Control System (VCS) is a computer-based system that conducts closed-loop control of vibration shaker table systems. It generates an electronic signal for a shaker amplifier that provides the drive signal to a hydraulic or electrodynamic shaker. The vibration response on the UUT (Unit Under Test) is then fed back to the VCS controller from transducers that measure acceleration, velocity, or displacement. The controller adjusts the drive output such that this control signal conforms to specified characteristics in the time or frequency domain. There are many vibration control test types, including Sine, Random, Sine-On-Random, Random-on-Random, Classical Shock, Shock Response Spectrum, and Time Data Replication.

Most tests use a single axis shaker to excite the structure. Some sophisticated tests use multiple shakers. In the case when multiple exciters are used, the control procedure will involve MIMO (multiple-input/multiple-output) cross-channel calculations. The technique used in the multiple-exciter control is much more sophisticated than the single axis controller. Currently, EDM only supports single-axis control.

A control signal refers to one or more signals measured from sensors on the UUT. If the control signal deviates from the specified testing profile, adjustments are made to the drive signal so that the control signal will converge to this profile. The control system continuously, in real-time, corrects for the dynamics of the shaker and UUT to maintain a consistent response. Safety is enhanced when this control loop processing is done by a dedicated processor, independent of a personal computer system.

The block diagram below shows the process closed-loop control. Sensors such as accelerometers are used to measure the response of the UUT and provide the control signal.



A random controller will continuously output a wide band, random drive signal such that the control signal will have a power spectral density conforming to a given frequency profile.

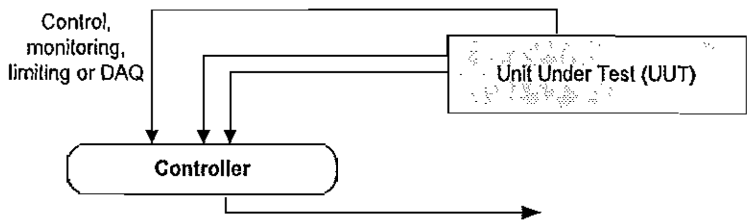
A sine controller will continuously output a sinusoidal signal with a varying frequency according to a pre-set schedule. The amplitude is adjusted such that the control signal maintains an RMS value given by a frequency profile.

Classical shock controllers define a profile in the time domain. The profile defines the shape and amplitude of a short time-duration pulse. Shock response spectrum, or SRS, control defines the pulse in the frequency domain. Road Simulation controller defines its profile as a long-duration time domain signal.

Sine-on-Random and Random-on-Random, also called mixed mode control, combine the random controller with another sine or random controller on top. This setup is considerably more complicated.

Most, if not all, of the controllers in the market have random and sine control functions. About half of them have classic shock control. Mixed mode, SRS, Transient History and Road Simulation are used in less common, specialized applications.

Even with one excitation source, there are reasons to use multiple sensors in different locations as inputs in the control loop. These measurement points can be used for several purposes, as shown below.



When multiple inputs are used for control, a control strategy is used to combine the signals, such as average, maximum, or minimum. For example, the average strategy takes a weighted average of all the control measurement channels.

A Brief History of Digital Vibration Controllers

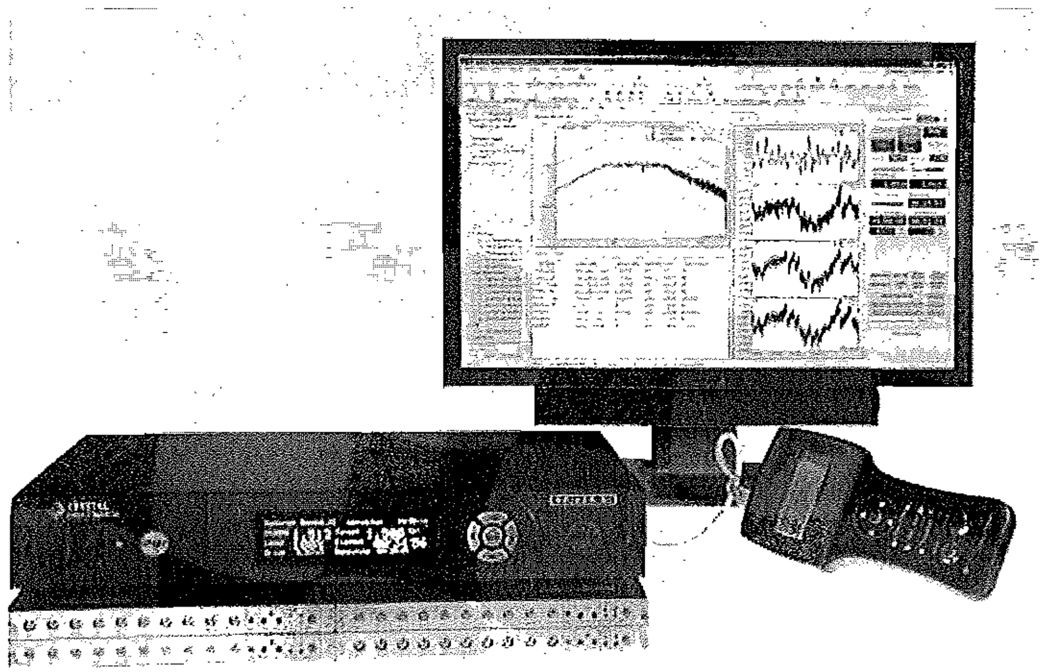
The earliest digital vibration control system was developed by a few HP engineers in 1970s. They tested many closed-loop control algorithms using the earliest and most successful signal analyzer, the HP5451. The HP5451 was built based on a HP2100 mini-computer with very limited memory and computational resources. In the early 70s, two inventors by the name of Edwin Sloane and Charles Heizman, working for a company named Time Data, were granted a patent for random vibration control. Time Data was later purchased by GenRad and became part of Spectral Dynamics.

In the early 90s, the IBM-PC gained popularity in industry. Many companies started to use the PC as the platform for data acquisition and dynamic signal analysis. Data Physics collaborated with the Lansmont Corporation, developed the first PC-based digital VCS controllers, the Lansmont TTVI controller and the DP540.

In 1996, Dactron Inc., founded by Joseph Driscoll (the Lansmont CEO) and Dr. James Zhuge, developed the next generation VCS. Dr. Zhuge believed that there existed technical shortcomings in the existing technology and he identified opportunities for improvement. The Dactron LASER series products turned out to be a great success. While the PC was still used, it was viewed as a peripheral of the system. In the new controller, the control loop did not go through the PC. With this strategy, a much faster loop-time could be achieved and many new algorithms were realized in the controller by taking advantage of floating point DSP architecture.

The LASER was the first VCS product that used multiple floating point DSP processors, 24-bit delta/sigma A/D converters, and USB for connection to the computer. The original application software was built on native Microsoft MFC. This architecture allowed the system to offer many more functions while still maintaining its ease-of-use. Thousands of Dactron's LASER controllers have been installed all over the world. In 2001 Dactron was acquired by LDS, the world largest ED shaker manufacturer at that time. Now LDS is part of B&K.

In 2010, Crystal Instruments released the Spider-81, the next generation of vibration control system. The Spider-81 takes the advantage of modern hardware and new software technology.



Spider-81 is the first network-based vibration control system that integrates the IEEE 1588 time synchronization technology. The base module can be configured with 4 or 8 input channels. Additional channels can be expanded to 1024 channels. It features very high reliability, high accuracy of measurement, high control performance and ease-of use. Spider-81 is equipped with a drive output channel, bright LCD, digital I/O interface, internal backup battery and on board RUN/Stop button. Spider-81 uses an Ethernet connection.

Spider-81 is viewed as the fourth generation of controller because it integrates time-synchronized Ethernet connectivity with embedded DSP technology. This strategy greatly increases the control performance, system reliability and failure protection of the controller. It also allows a large number of channels to be configured without sacrificing system performance. Because it is fully networked, a user can place the controller close to the shaker table and operate the controller either near the shaker or in a control room a few hundred meters away.

The architecture of the 4 VCS generations is summarized in the figure below.

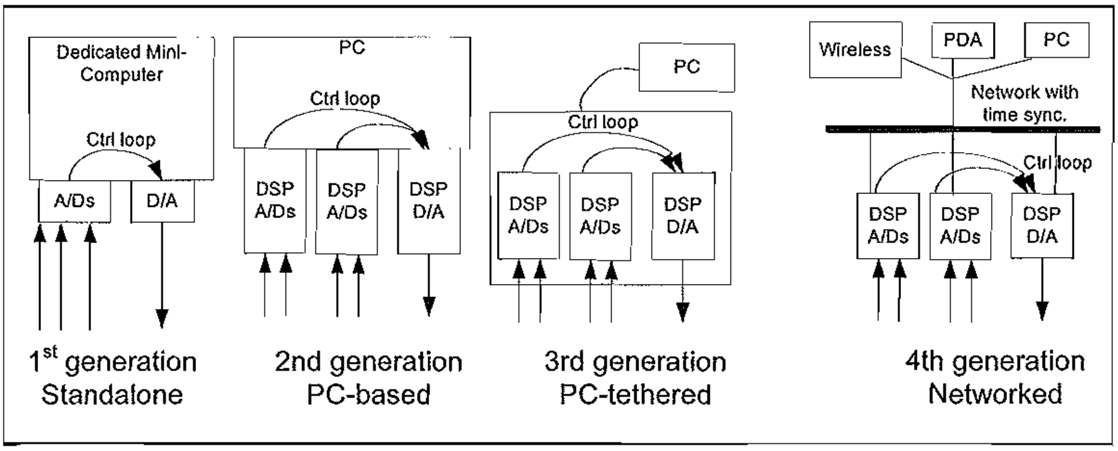


Figure 2 Architecture of four generations of VCS

Real-Time Performance

The 1st generation vibration controllers were not true real-time systems. Real-time means every single sample of the control signal is used for calculating the next sample of the drive signal. The CPUs of the early mini-computers had to skip input data frames when computing the system transfer function. The loop-time could be as long as many seconds.

The 2nd generation controllers were real-time systems. All the input samples were used to compute the drive signals, with the loop time as short as a fraction of second. Taking advantage of the PC, the user interface was greatly improved and the production cost reduced.

The 3rd generation of controllers can be considered "over-real-time". They have the capability of using the same input data for multiple tasks. For example, in the Dactron Random controller, multiple control loops can be running for different frequency bands simultaneously. In an extreme case of the Sine-on-Random controller, two random control kernels plus 12 sine control kernels can all run simultaneously. The control-loop time can be as short as a few milliseconds.

The 1st and 2nd generation controllers were trying to meet the requirements of the mechanical characteristics of the UUT. For some demanding applications, the control system may need 5 kHz real-time control bandwidth and up to 70 dB control dynamic range. The situation changed when the 3rd generation VCS was introduced. Thanks to the use of floating point processors and sigma-delta converters, the real-time bandwidth and the control dynamic range of the control system far exceeded the external mechanical requirements. From then on, improving the bandwidth and control dynamic range of a VCS cannot realize any real benefits to the customer. It became more or less a marketing pitch.

Spider-81 Hardware

Input Connections

The block diagram for the Spider inputs is shown in Figure 3. The input chain has a number of components that can be switched in or out of the signal path. There is a calibration circuit that is used for internal calibration (see the separate Spider Calibration Manual). There is also a charge amplifier and an IEPE power supply. The front-end amplifier can operate in single-end or differential mode. In Single-end mode, the shield input terminal is grounded, and the input voltage on the other terminal is referenced to this ground. In differential mode, the input terminals are "floating" and neither is referenced to ground (see Grounding). After this initial amplification stage, there is a high-pass filter for DC removal that can be switched on or off. Following that there is the final analog amplification stage, the Analog to Digital Converter, and the DSP processor.

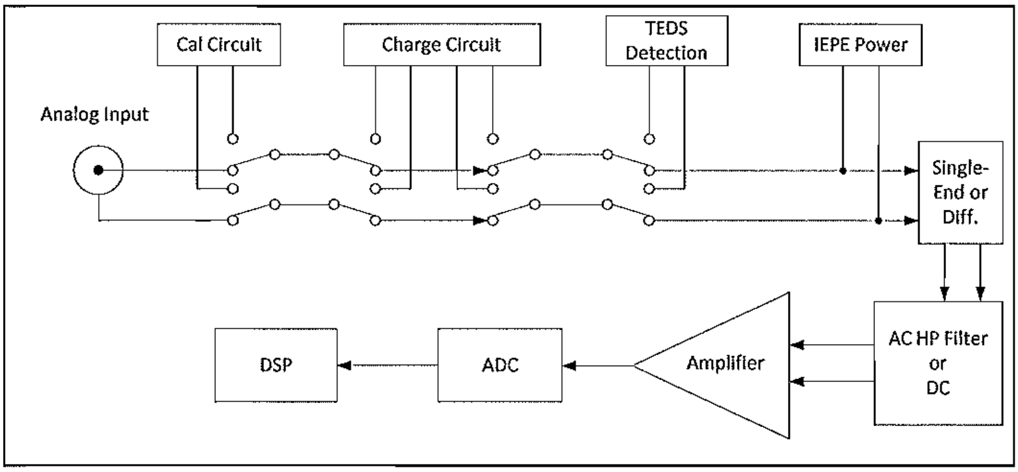


Figure 3. Input block diagram of Spider hardware

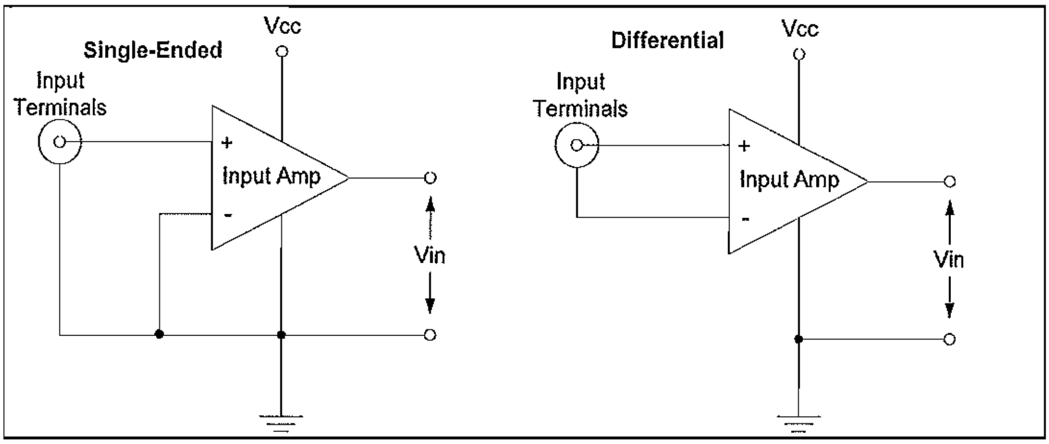


Figure 4. Single-Ended vs. Differential input

There are six modes that the inputs can operate in.

DC-Differential

In DC-Differential mode, neither of the input connections is referenced to the local ground. The input is taken as the potential difference between the two input terminals, and any potential in common with both terminals is canceled out. This Common Mode Voltage (CMV) will be rejected as long as the input gain stage isn't saturated by the overall input voltage level. Beware that very high CMV will cause clipping and may damage the input circuitry. Signals with a non-zero mean (DC component) can be measured in this mode.

DC-Single End

In single-ended mode, one of the input terminals is grounded and the input is taken as the potential of the other terminal with respect to the ground. Use this mode when the input needs to be grounded to reduce EMI noise or static buildup. Do not use this mode when the signal source is ground referenced or ground loop interference may result (see the Grounding section below). This mode also allows signals with a non-zero mean to be measured.

AC-Differential

AC-Differential is a differential input mode that applies a low frequency high-pass filter to the input. It rejects CMV and any DC components in the input signal. Use this when DC and low frequency AC voltage measurements aren't required or when a DC bias voltage is present. The analog high-pass filter of Spider has a cut-off frequency of -3dB at 0.3 Hz, and -0.1dB at 0.7 Hz for the IEPE input mode. Figure 5 shows the shape of the filter.

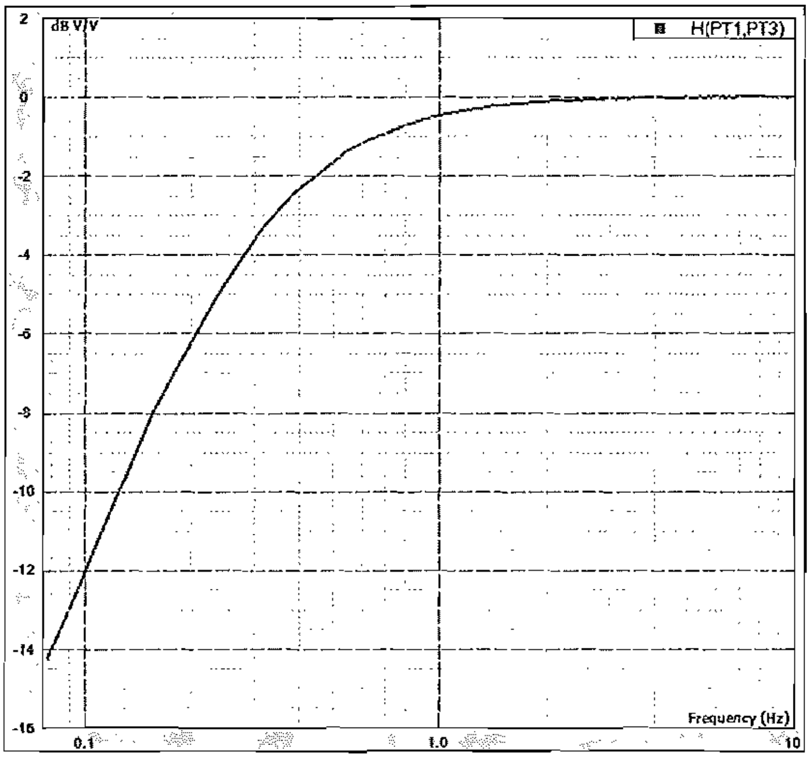


Figure 5: AC Input mode high-pass filter shape

AC-Single End

AC-Single End grounds one of the input terminals and applies a low frequency high-pass filter to block DC signals. Use this mode for non-ground referenced sources where measuring the DC or low-frequency components isn't required. It shares the same high-pass filter as that of AC-Differential.

IEPE (ICP)

All Crystal Instruments products support IEPE constant current output type input channels. IEPE, or **Integral Electronic PiezoElectric,** refers to a class of transducers that are packaged with built-in current amplifiers. These circuits are powered by a 4 mA constant current source at roughly 21 Volts.

IEPE accelerometers are available under several different brands including ICP® (PCB Piezotronics), Isotron® (Endevco), Delta-Tron® (B&K), and Piezotron® (Kistler).

IEPE sensors cannot measure DC or very low frequency signals. This is rarely a problem when measuring acceleration in dynamic tests. The IEPE input mode on the Spider has a built-in analog high-pass filter with a cutoff of -3dB at 0.3 Hz and -0.1dB at 0.7 Hz.

Charge Mode

Some sensors interface using a high-impedance charge output. Usually, these are high-sensitivity piezoelectric units that lack a built-in voltage mode amplifier (ie IEPE), allowing them to be used in high-temperature environments. The Spider-81 has a built-in charge mode amplifier that allows the system to read the output of these sensors.

The charge amplifier in the Spider converts the charge sensor output in picocoulumbs (pC) to millivolts, which is then input to the ADC. The sensitivity parameter in the software input settings sets the composite sensitivity from sensor output to engineering unit, so this process is transparent to the user. The analog high-pass filter of Spider has a cut-off of -3dB at 0.3 Hz and -0.1dB at 0.7 Hz.

There are two gain settings in the charge channel, one with full range of 10,000 pC and the other 49,000 pC. Similar to that of voltage input mode, the user should try to maximize the input range of charge signals while make sure no overload will happen.

Charge mode is only available to Spider-81. Spider-81B does not have charge mode.

TEDS

The IEEE P1451.4 "Standard for smart transducer interface for mixed mode sensors and actuators" describes a mixed-mode communication protocol based on existing analog connections. Mixed-mode means that both an analog and digital signal are sent over a single coaxial cable. IEEE P1451.4 also specifies Transducer Electronic Data Sheets (TEDS) where transducer-specific digital information such as transducer identification, sensitivity, location, calibration values, and other parameter data can be stored.

The Spider hardware can detect TEDS compliant sensors and read the digital data. The sensitivity and quantity parameters are then automatically copied to the Channel table. When the Detect TEDS button is clicked in the software, the hardware sends a digital polling signal to all channels and detects a response from any TEDS compliant sensors.

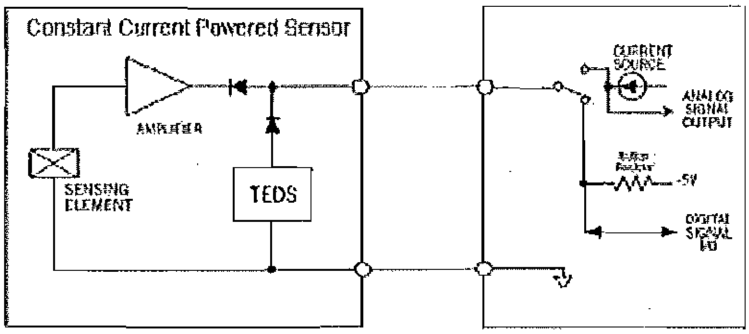


Figure 6. IEPE and TEDS circuitry

Matching Sensor Sensitivity to the Input Range

A special technique is used in CI products to achieve a very high dynamic range in the input channels. This patented technology uses two A/D converters for each input channel to achieve 130 to 150dB dynamic range. Refer to the *130dB Dynamic Range* CI whitepaper for more details.

With this technology, there is no need for multiple input range settings and measurements can be made over the entire range from a few micro-volts to 20 volts. However, signal outputs from sensors should be as large as possible without overloading the input channels to maximize the signal to noise ratio. Too large of an input will cause clipping and distortion.

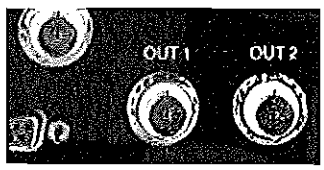
Do not exceed the input range stated in the specifications, usually ±20 V. For example, if you are doing a vibration measurement estimated to be 10 g RMS and the peak value of the test is assumed to go 5 times its RMS level, the sensitivity of the sensor should be smaller than 20V/50g-peak = 400 mV/g.

Choosing a sensor with very small sensitivity will cause the signals to be buried in noise. In the example above, if you choose a sensor with 4 mV/g, the useful signal will be 100 times lower. The effect of noise sources such as EMI and ground loops will be much greater.

For charge input, two ranges are 10,000pc and 49,000pc. For example, if the full charge range is 10,000 pC, you should choose a sensor that generates less than 10,000 pC with the expected peak excitation. But the signal should not be too small as to be buried in the noise.

Drive (Output) Connections

On the back of Spider-81, there are several output channels. The OUT 1 is always the default drive channel. Connect the OUT 1 to the input side of the power amplifier. The second output can be configured for various functions.



Second Output Setup

The second output mode is configured in the Test Configuration window.

The options for the second output are the shaker drive signal (same as first output), negative (or reverse) of shaker drive signal, control signal RMS level, RMS or peak level of any input channel, and COLA type 1 and 2. Not all options are available in some test modes.

RMS Value Monitoring
With this option, the output voltage will be proportional to the RMS value of the control signal or any of the other input channels. **Reverse sensitivity** is the proportionality constant, in units of **millivolts per engineering unit**.

COLA Type 1: Constant Amplitude Sine
This option is only applicable to the Swept Sine test mode. The output is a constant amplitude sine wave at the same frequency as the swept sine drive signal. The amplitude can be set to any value between 0 and 10 volts. When the test starts and stops, the COLA output will be ramped up to the specified amplitude and down to zero, respectively.

COLA Type 2: Voltage Proportion to Frequency
Also only applicable to swept sine mode, this option output a constant voltage proportional to the drive output frequency. There are settings for the start and stop frequency and voltage values. The output voltage is interpolated from these points based on the current swept sine output frequency (see figure below).

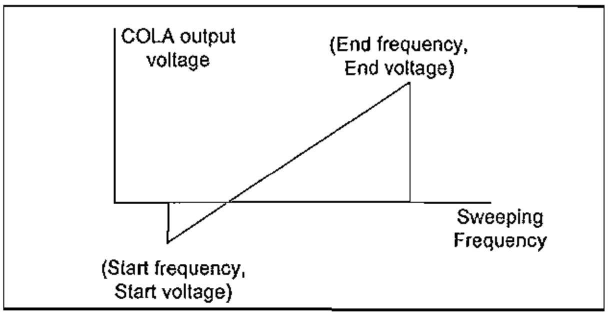
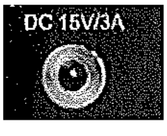


Figure 7 Cola Type 2 output voltage interpolation

Power Connection

The external power is provided through the wall-mount AC/DC adapter. The output of DC adapter, which is rated 15V/3A, should be connected to the DC connector of Spider-81 on the back.



Grounding

Improper grounding can cause ground loops that result in noise, inaccurate measurements, and output problems. Ground loops are caused by the use of multiple physically separate ground connection points. In a typical vibration test application, there are grounding points located at the PC, the controller, the shaker amplifier, and the sensors connected to the unit under test. Although these ground points are assumed to be at zero volts, different points may actually have a potential difference between them, both DC and AC. This is caused by outside current sources that cause a voltage drop through the ground system impedance and by induced voltage from stray magnetic fields. The further two ground points are from each other, the greater the possible potential difference between them.

This problem has been a major installation issue in old controller structures using a PC-plug-in card or USB connection. In such connections, the controller is physically located near the PC and is usually not close to the power amplifier or sensors. The ground potential differences between the controller, the PC, the amplifier, and the testing unit can vary significantly.

The USB bus has a ground lead that can carry ground-loop noise between connected devices. The output grounding problem is very difficult to solve in a USB-based controller because the grounds of the computer and controller are forced to be connected via the USB interface. Any potential difference between these grounds will be directly translated into drive voltage noise.

A controller connected via Ethernet, on the other hand, does not have this problem. The ground of Spider-80 is isolated from the other devices. When the output end (drive) is connected to the power amplifier, the common voltage can "float" to match the ground potential of the amplifier. Also, by removing the requirement that the controller be placed near the computer, the controller can be placed closer to the amplifier, which minimizes the ground potential difference.

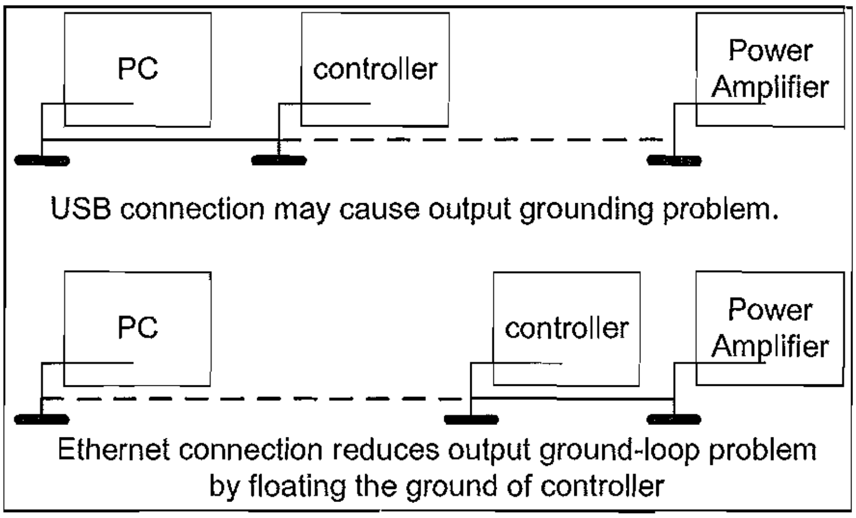
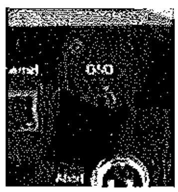


Figure 8. Illustration of grounding connections

On the back of Spider-81, there is a GND connection. This terminal connects to the internal ground of the electrical circuitry. It DOES



NOT connect to the enclosure, which may be grounded for safety but does not affect the noise issues discussed here.

Input Grounding

Input grounding problems are caused by AC and DC voltage differences between the ground of the controller and the grounds of sensors attached to the test unit. To diagnose input grounding problems, first connect the sensors to the input channels of Spider and set up the test parameters appropriately. Then, disconnect the drive cable and use the shaker diagnosis tool (or run the EDM in DSA mode) to observe the input signals. If there are unexpected AC signals at around 50Hz or 60Hz, then there is likely a ground noise problem.

To prevent input grounding problems, the sensors should be ground-isolated. Often, they are grounded to the metal chassis of the test unit which can be a significant source of noise. If sensor isolation is not possible, the input on the controller side should be isolated by using a differential input mode.

The IEPE and Charge mode inputs are always single-ended. When IEPE or charge sensors are used in an application where the sensors cannot be isolated, the ground of the spider needs to be connected to the sensor ground with a low impedance conduction path to bring both grounds to the same potential.

Output Grounding

Ground loops can cause problems in the output drive signal as well. They are manifest by a large AC excitation signal present at the amplifier when the controller is not outputting anything.

The shaker amplifier and the controller should be grounded at as close to the same point as possible, and the input to the amplifier should be a non-grounded differential input. If this is not possible, the controller and amplifier grounds should be connected by a low-impedance conduction path.

Digital I/O

Each Spider-81 has 8 isolated digital inputs and 8 digital outputs, corresponding to the pins on the Digital I/O connector. A digital input is detected when a low-high-low voltage change occurs, which triggers the event actions set in the Event Action Rules section of the Test Configuration window. Any device that can output square voltage pulses can communicate with the Spider/EDM system.

Pin Assignments

The DIO interface uses a DB-25 female connector.

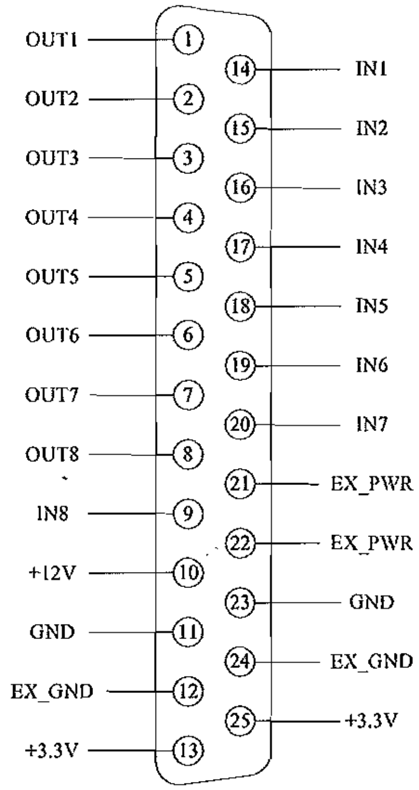


Figure 9: Pin Assignments of DIO Interface Connecter

Pin name	Pin number	Pin Description
OUT1 - OUT8	1, 2, 3, 4, 5, 6, 7, 8	8 output signal pins. Connect these pins to the input signal pins of the external device.
IN1 - IN8	8, 14, 15, 16, 17, 18, 19, 20	8 input signal pins. Connect output signals from the external device to these pins.
+3.3 V	13, 25	+3.3 V power supply from Spider-81.
+12 V	10	+12 V power supply from Spider-81.
GND	11, 23	The digital ground of Spider-81.
EX_GND	12, 24	The external ground for isolated external device.
EX_PWR	21, 22	The external power. Usually +12 V and its reference ground is EX_GND.

Table 2: DIO port pin description

The digital inputs are opto-isolated and take a 12 V signal. The voltage must be supplied by the output device. The circuit is shown in Figure 10. Input Circuit.

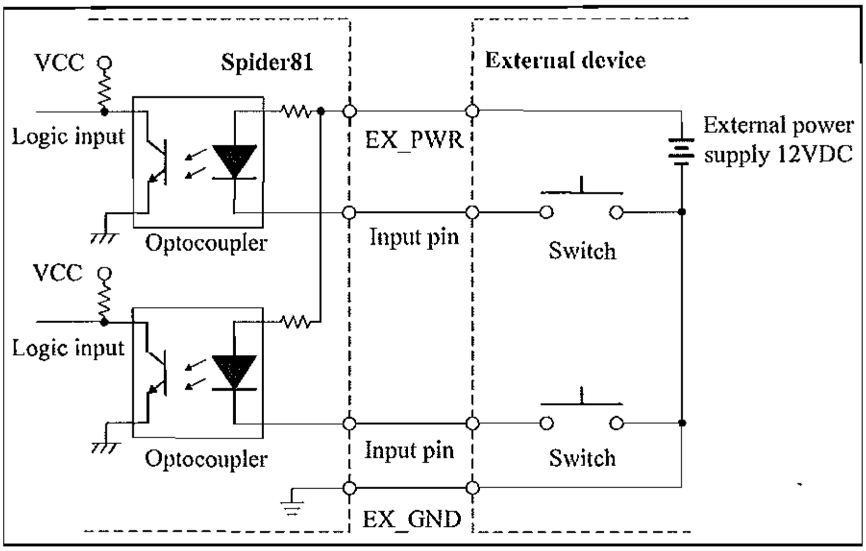


Figure 10. Input Circuit

Figure 11. shows an example of connecting a push-button switch to an input. When the switch is ON, the corresponding input bit is 0, and when the switch is OFF, the input bit is 1. Momentarily depressing the switch will trigger an input event in the channel. RL should not be greater than 6K ohm.

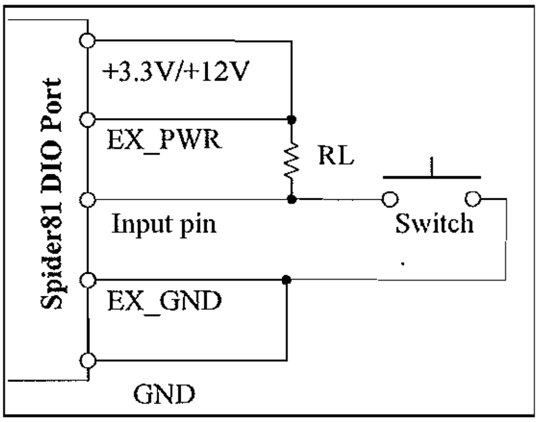


Figure 11. Switch connection to input

Output Circuit

The output channels can be connected to a current driven device such as a relay or LED. They are opto-isolated, open-collector outputs, but require an external voltage source.

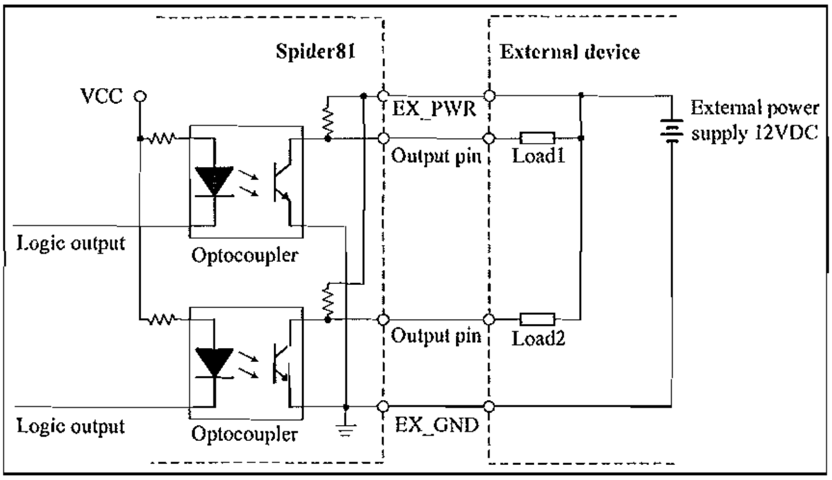


Figure 12. Output Circuit

The maximum rated output current per channel is 60 mA. The output section uses a low-saturated transistor for output so it can be connected to a TTL-level input. Figure 13. Output connection to LED shows an example of a connection to an external LED. The LED will illuminate when the output bit is 0.

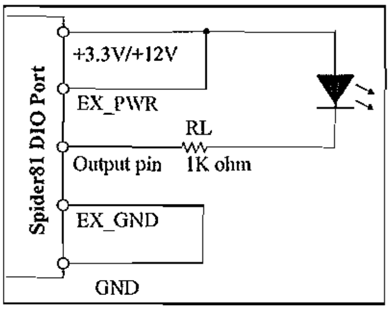
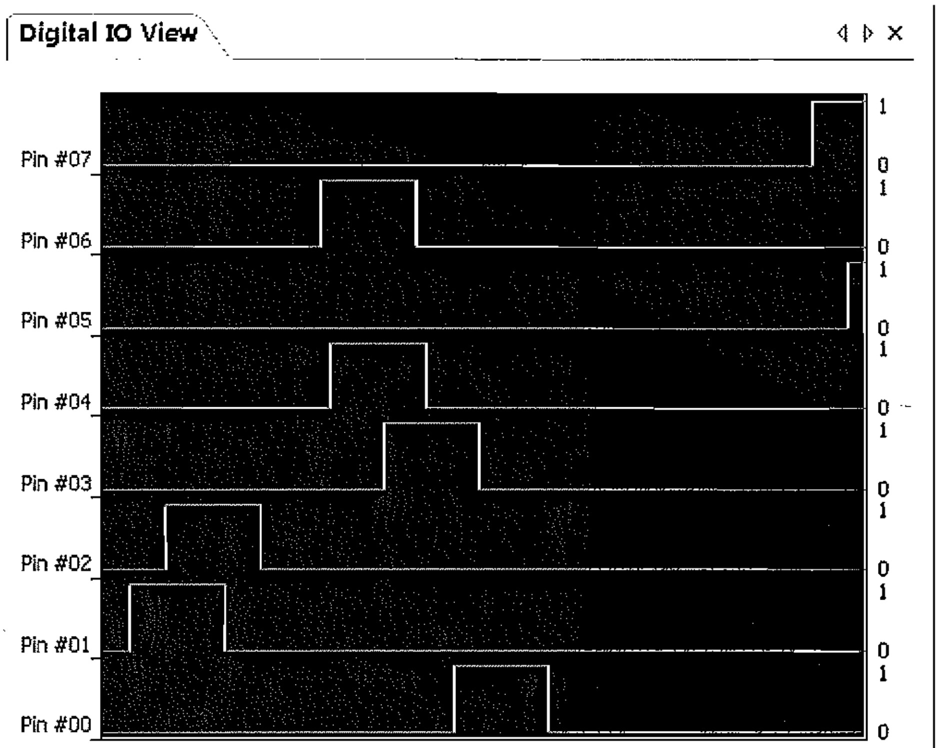


Figure 13. Output connection to LED

Programming DIO

A digital output is sent when a digital output action is triggered by an event in the Event Action Rules. The output signal can be set as a pulse or a step in the negative or positive direction (this setting is in the **Digital I/O Setup** tab of the Test Configuration window). Any device that can read such a voltage signal can then be controlled by the Spider.

The state of the digital inputs and outputs can be displayed with the Digital I/O View in the Signal Display tab in EDM. Right click in the window and select **Show Digital IO Window** to make it visible.



RS-485 UART Port

The Spider-81 provides RS-485 serial communication through a female DB-9 connector on the back of the unit. The pin assignments are shown below.

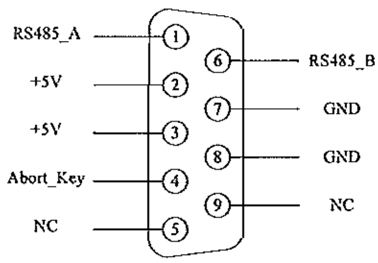


Figure 14. Pin assignments of RS-485 Interface Connector

Pin Name	Pin Numbers	Pin Description
RS485_A	1	Non-inverting Receiver Input and Non-inverting Driver Output
RS485_B	6	Inverting Receiver Input and Inverting Driver Output
+5 V	2,3	The power servicing RS485 bus.
GND	7,8	The digital ground servicing RS485 bus.
Abort_Key	4	Abort key. When connected, quickly ramp down the drive output
NC	5,9	No connect. They should not be connected to arbitrary signals.

Table 3. RS-485 port pin description

Monitoring Port

The Monitoring Port on the back of the Spider allows monitoring of all 8 input channels and 4 output channels through a female DB-25 connector. These connections output 50% of the input signal voltages and 100% of the output voltages with a range of ±10 V_{pk}. The pin assignments are shown below.

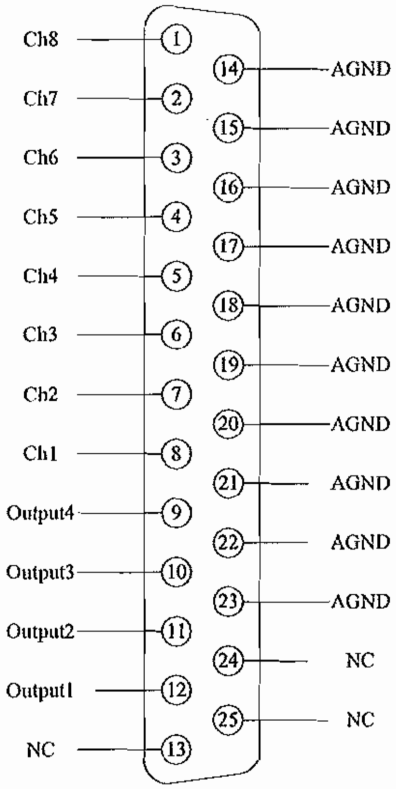


Figure 15. Pin Assignments of Monitoring Channel Interface Connector

For monitoring channels corresponding to charge inputs, the 10 V output range is normalized by the half range of the charge input. For example, if the full charge range of the input is set to 10000 pC, an input charge of 1000 pC will produce an output of 0.5 V in the monitoring channel.

If the sensor sensitivity is 10 pC/g, an acceleration input of 10 g will produce this 100 pC output.

Pin name	Pin number	Pin Description
Ch8 – Ch1	1, 2, 3, 4, 5, 6, 7, 8	Input channel monitoring pins. Outputs 50% of input voltages in any mode. Output Range: ±10 V_{pk}
Output4 – Output1	9, 10, 11, 12	Output channel monitoring pins. Duplicate of output channels. Output Range: ±10 V_{pk}
AGND	14, 15,16,17, 18,19,20,21,22,23	Analog ground of Spider-81
NC	13,24,25	Not connected. To prevent interference, do not connect to any signal source.

Table 4 Monitoring port pin description

Front Panel LCD Display

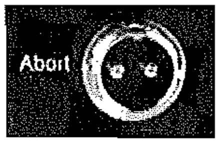
The LCD display shows test status and system info and the network IP settings. There are four pages, toggled by the left and right arrow keys on the front panel. Every page has the current system and Ethernet connection status on top. The status will show idle or the name of the current test. The welcome page says Crystal Instruments.

The system info screen shows the firmware version and the current IP address. In this page, pressing the up or down arrow key will display an arrow next to the IP address. Press enter to edit the address. When editing, the left and right keys select the digit to edit, and the up and down keys change the value. Press enter when done, and enter again to confirm.

The test status page shows the current control input RMS level, the target level, the current output drive voltage, and the elapsed and remaining time for the test.

The test list page shows all the tests that have been uploaded to the Spider in Black Box mode. Pressing the up or down arrow keys will select the current test.

Abort Contact Switch



The Abort connection on the back of the spider allows an external Abort switch to be connected. When the two terminals of the connection are shorted together, the Spider will immediately stop any output signal. This directly controls the output front end, so it will still work even if the DSP software or EDM becomes unresponsive.

The contacts must be shorted for at least 10 ms for the abort to be triggered. The response time for the controller is 10 ms.

The connector is a type GX16.

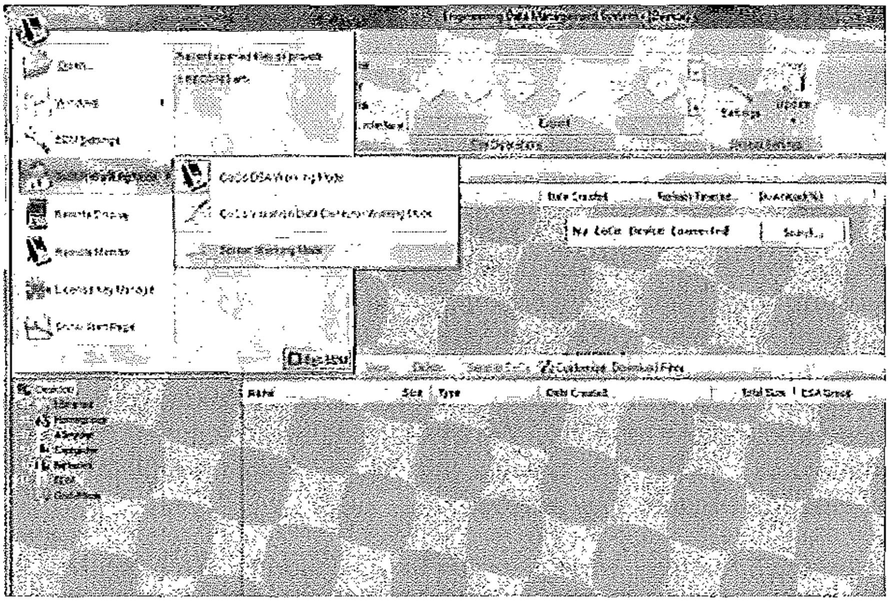
EDM User Interface

EDM, or Engineering Data Management, is the desktop software that works with all Crystal Instruments hardware.

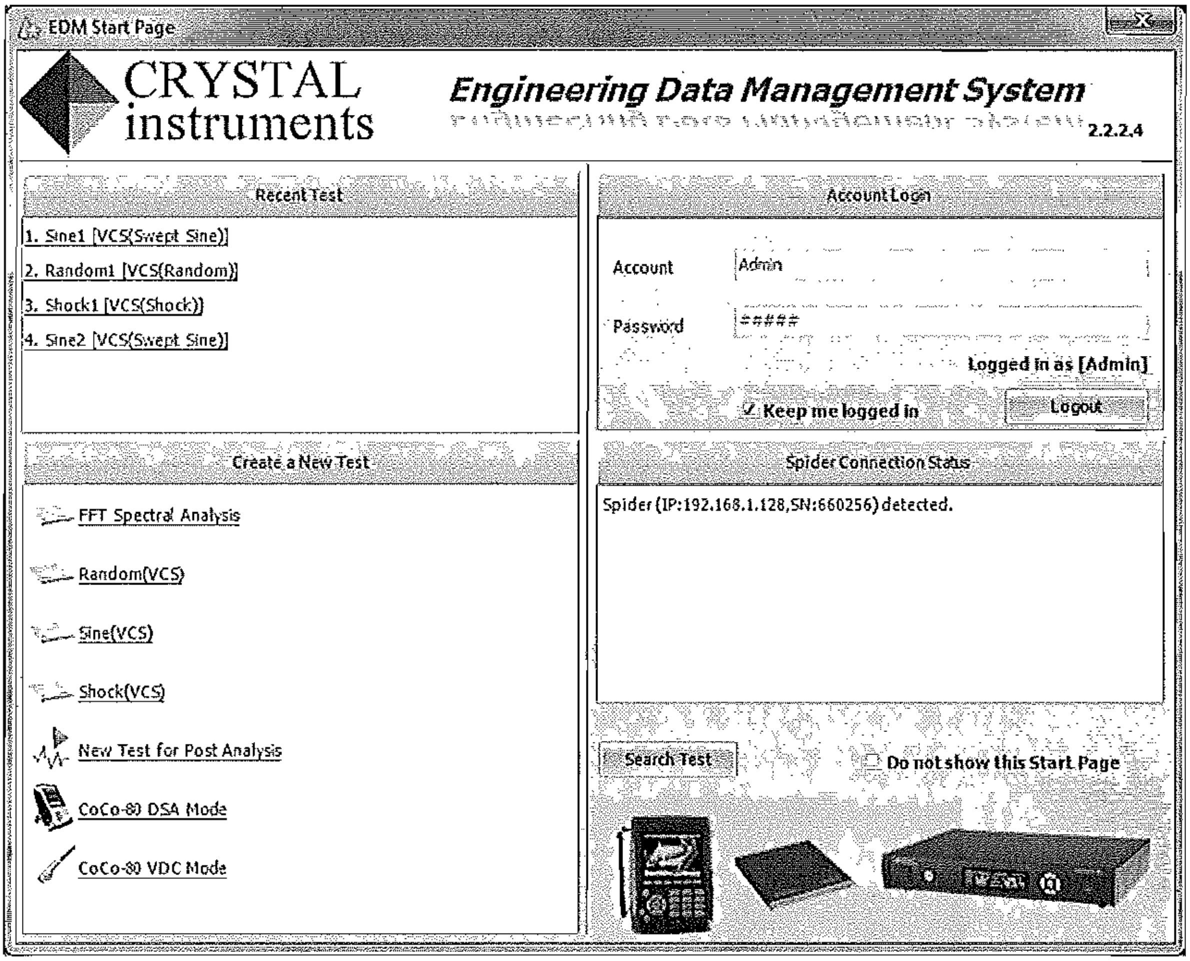
Working Modes

EDM has 3 working modes: CoCo Dynamic Signal Analyzer (DSA) mode, CoCo Vibration Data Collector (VDC) mode, and Spider real-time mode. The Spider real-time mode includes the Dynamic Signal Analyzer real-time operation and the Vibration Control System (VCS) operation.

To switch working modes, use the Switch Working Mode option under the Start menu in CoCo mode.



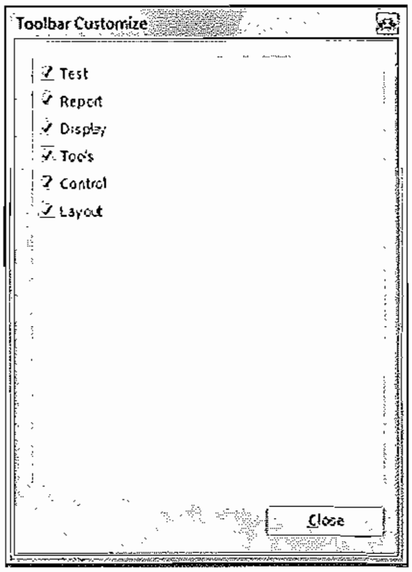
When EDM starts up in Spider working mode, it presents a Start Page from which a recent test can be opened, previous tests can be searched though, and new tests can be created. It is a convenient start point for most EDM operations.



This start page has four sections: Recent Tests, which allows quick access to recently used tests, Create a New Test, for creating a new test of the selected type or for switching working modes, Account Login to change the current user account, and Spider Connection Status which lists all detected spiders on the network. There is also a button to search through all tests in the database.

Unlike the EDM CoCo mode, which uses ribbons, Spider mode uses a traditional menu and toolbar interface. The toolbars allow quick access to the most common commands, while the menus provide a more complete catalog of EDM commands, organized by function.

There are 6 toolbars, corresponding to the 6 menus. To change which toolbars are displayed, select Toolbars under the Hide/Show button on the upper right corner. Toolbars can be rearranged by clicking and dragging their left edge to the desired location.

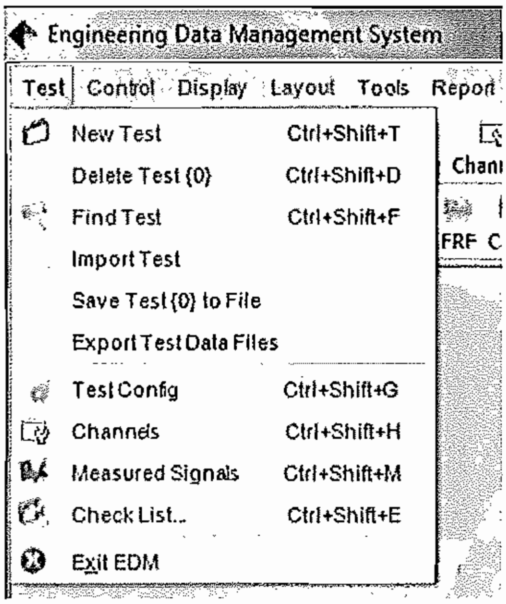


Menus in Spider Real-Time Mode

The 6 menus are Test, Control, Display, Layout, Tools, and Report.

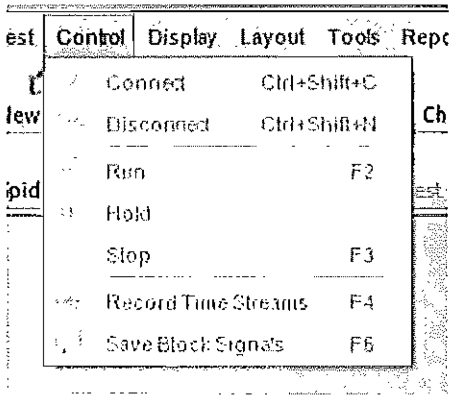
Test

This menu is for creating, opening, saving, and configuring tests. A **test** is a collection of configuration settings and acquired data. Each test operates in one mode, such as Random Control, Swept Sine Control, or Dynamic Signal Analysis. EDM uses a MySQL database to store the test data.



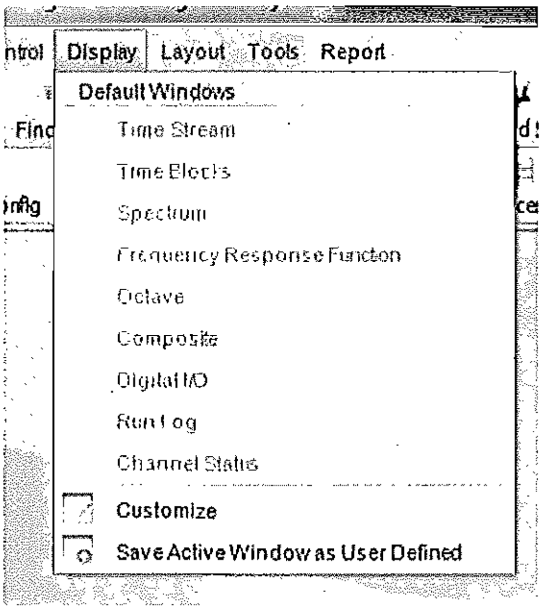
Control

Commands for controlling the test, such as run, hold, and stop, are found under the Control menu. These commands are duplicated on the control panel and the right side of the screen. There are also commands for recording time streams and saving block signals, which can be used even while a test is in Stop mode.



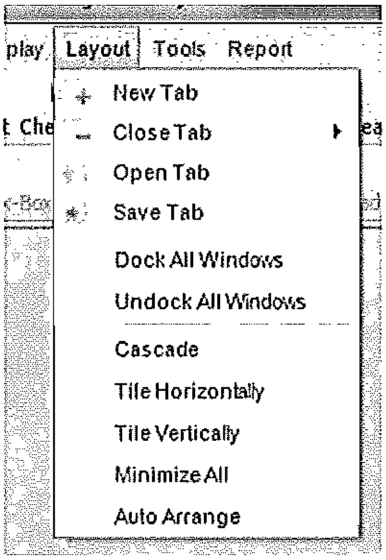
Display

The Display menu is used add display windows. **Display windows** are windows for displaying data under the Signal Display tab(s) in the main EDM window. This data can be from recorded files or real-time, in the time domain or frequency domain. EDM provides a set of default windows for displaying the standard data types such as time streams, blocks, and frequency spectra. Custom window templates, with user-defined combinations of displayed signals, can be defined using the **Save Active Window as User Defined** command. These custom templates will be listed in the bottom of this menu.



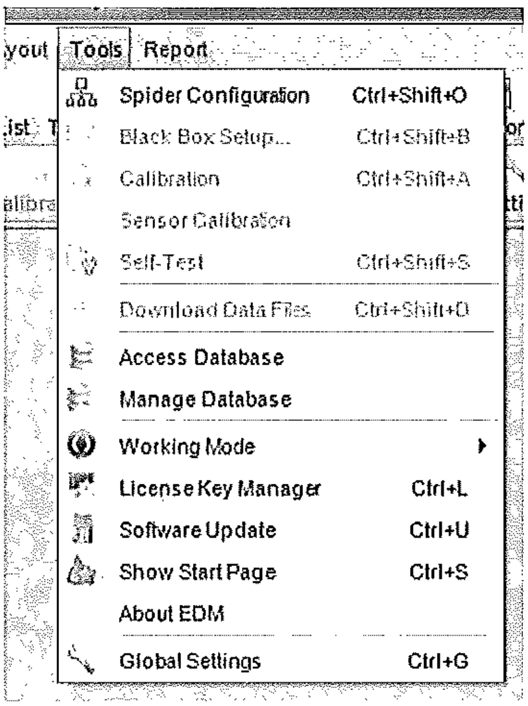
Layout

The Layout menu has commands for opening and closing signal display tabs. The tabs, with their current layout, can be saved and opened too. Each of these tabs contains one or more display windows, opened using the Display menu above. There are also commands for arranging the display windows in the current tab.



Tools

This menu has commands for general EDM functions. These include spider configuration and calibration, database functions, switching the EDM working mode, opening the license manager, and opening the Global Settings window.



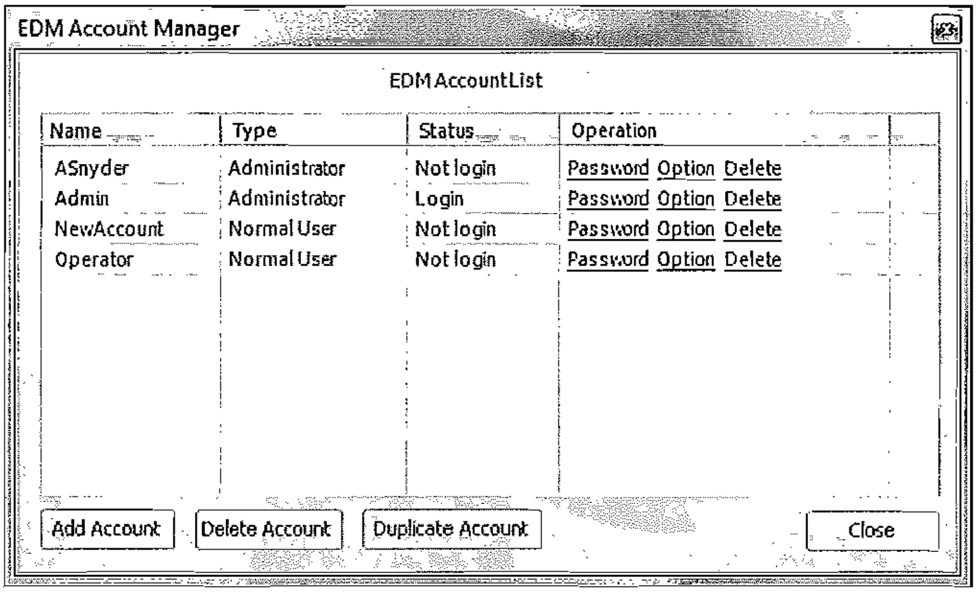
User Accounts

EDM has user management features that allow multiple user accounts to be created, each with different features enabled. This allows the user interface to be personalized for different users, and to control access to different levels of configuration. By default, there are two users defined: the *Admin* and the *Operator*. The admin has access to every feature and has the ability to edit the privileges of other users. The operator only has basic privileges available to operate, but not edit, a test.

When the EDM is initially installed, the accounts Admin and Operator have empty password.

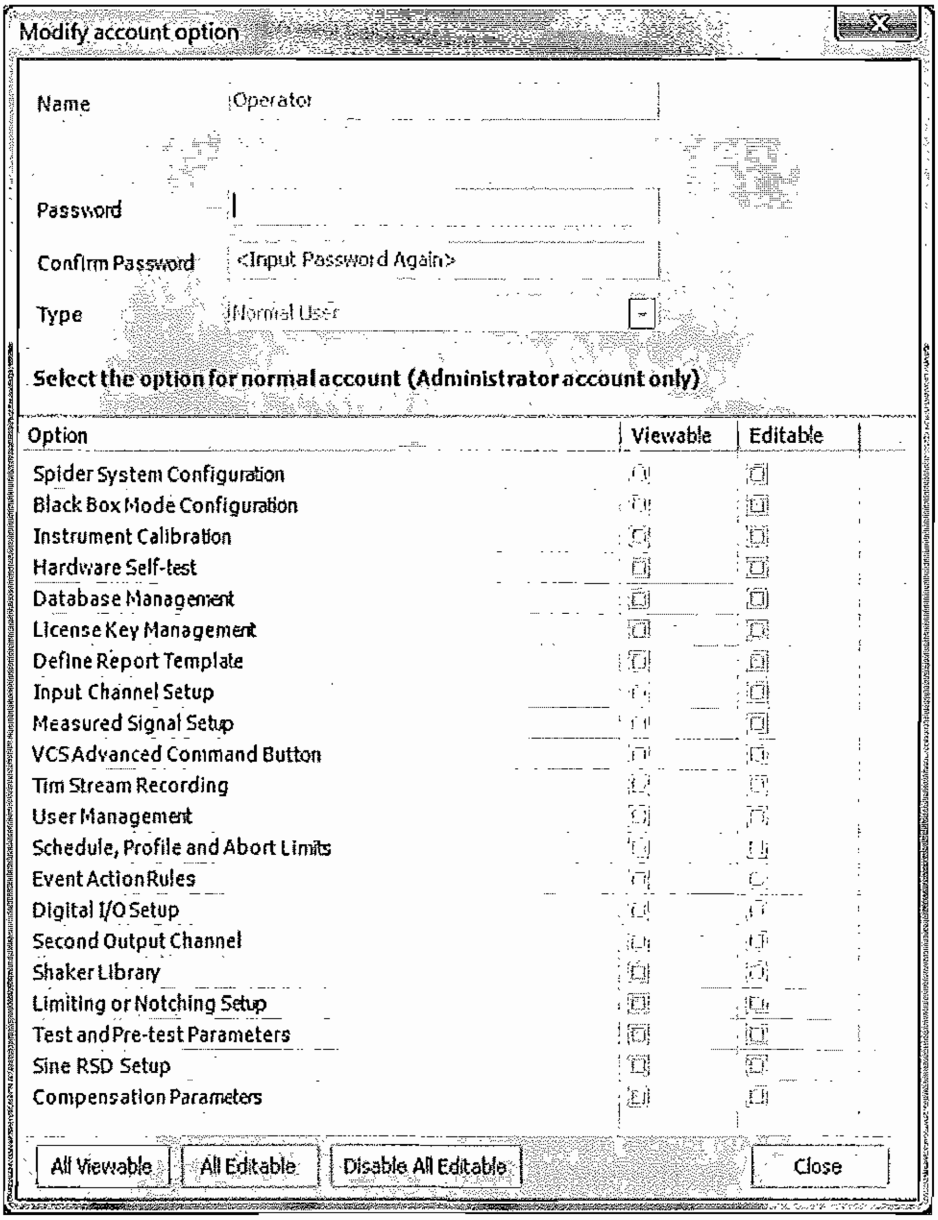
In the welcome screen when EDM first starts up, there is a section for logging in with a user name and password. Once a user is logged in, only the features enabled for that user account will be available. Accounts can be set as Administrator or Normal User accounts, and only Administrator accounts can change the user account settings.

To edit user accounts, you must be logged in under an administrator account. Selecting **Account Manage** in the **Tools** menu brings up a dialog window with a list of the defined users. On each row, there are links to change the password, change the account options, or delete the account. On the bottom of the window, there are buttons to add a new account, delete an account, and to duplicate the selected account.



Click on the **Option** link to edit an account. The Modify account option window that appears allows the password and account type to be changed, and has a list of user privileges. For each item in the privileges list, there is an **Editable** and

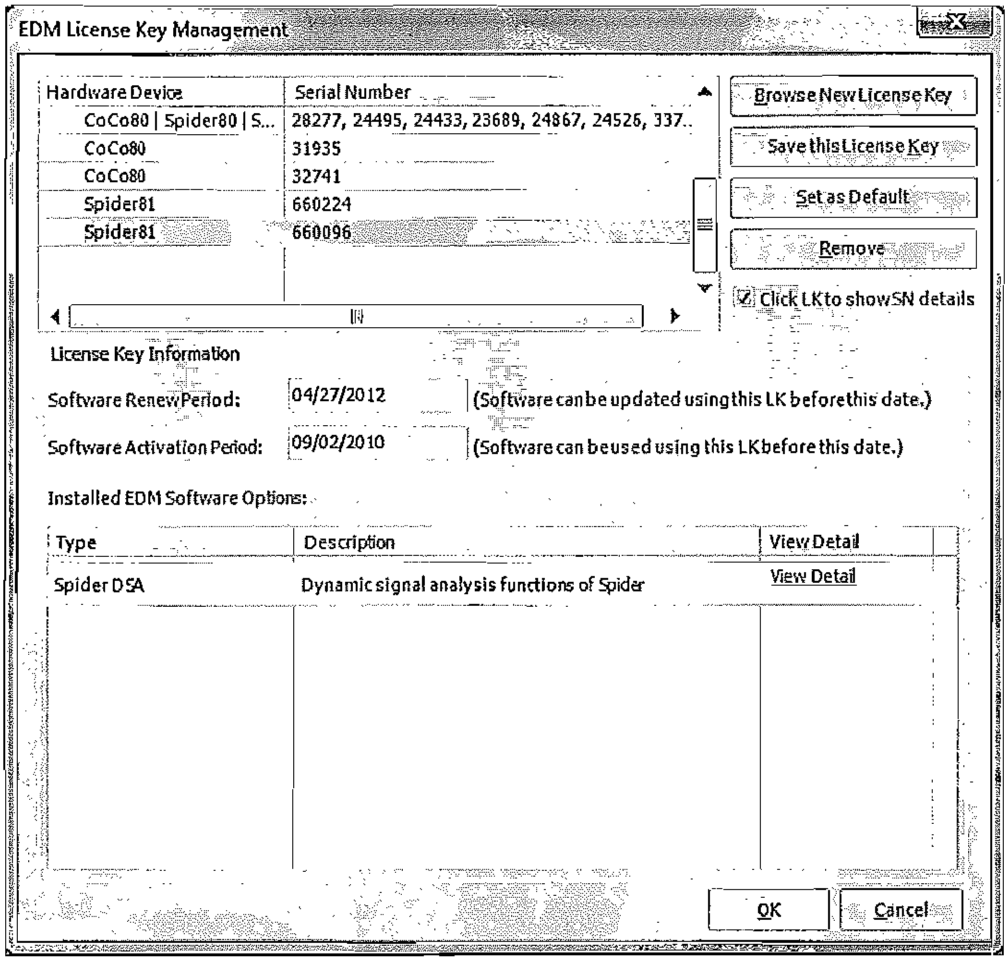
Viewable option. Disabling the Editable option prevents the user from modifying the settings for that item, and disabling the Viewable option prevents the user from seeing anything related to the item.



About License Keys and Evaluation Mode

EDM requires a license key file to run. This file verifies that the user has purchased the software features. A license key is linked to one or more hardware devices by serial number. If you try to connect to a device with a serial number not in the current license key, an error will be displayed.

Only one license key file is active at a time. To change the active key, open the **License Key Manager** under the **Tools** menu. The available license keys are listed at the top and information about the selected on is shown in the bottom. Double click a listing to activate it. EDM will have to be restarted for license key changes to take effect. If a license key isn't listed, but is present on your local computer, click **Browse New License Key** to find it.

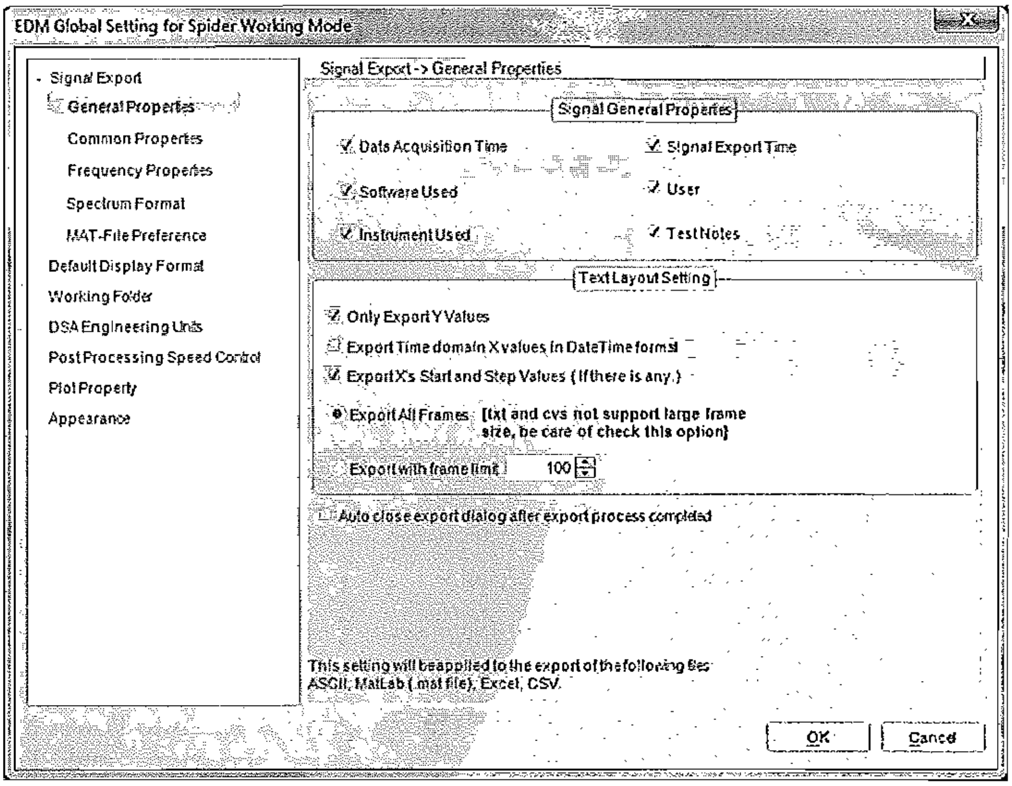


Test groups, such as Sine, Random, and Shock, are activated by the license key. There are two modes of each Test group, *a fully functional mode* and the evaluation mode. They are all controlled by the license key. If the fully functional mode of a test group is not activated, tests of its type can still be created in **evaluation mode.** In this mode, the test will only run for 30 seconds, signals cannot be recorded or saved, and reports cannot be generated. Every feature of the tests type is available, though. This allows you to configure and evaluate different test types. After creating such a test in evaluation mode, the test can be purchased from Crystal Instruments allowing it to run without limitations.

For details about how to activate the individual tests in the evaluation mode, please contact CI sales office or your local sales reps.

EDM Global Settings

The EDM Global Settings are settings that affect the entire EDM environment and interface. This is different than the Test Configuration options, which only affect the current test.



Signal Export includes four sub sections for signal export settings.

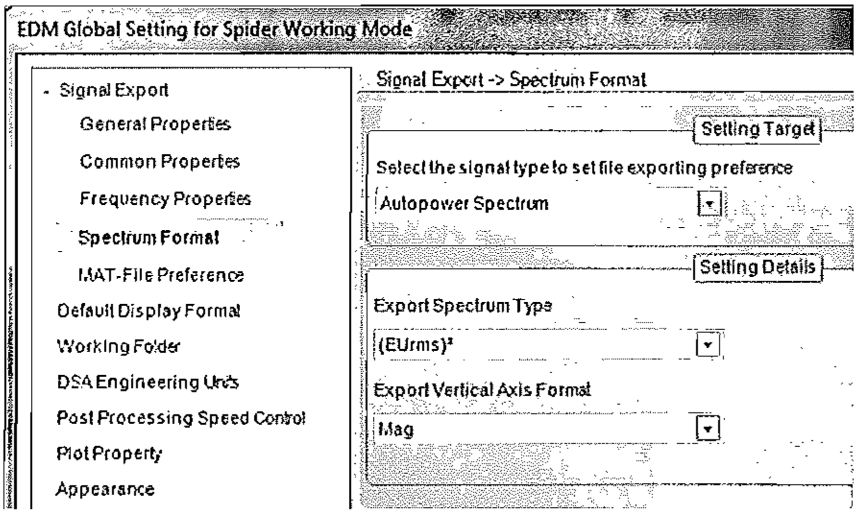
General Properties defines the signal attributes to be included in exported files including: spectrum format, window type, window correction mode, energy factor, amplitude factor, acquisition/calculation method, amplitude scaling, average mode, lin/exp averaging time constant, and number of averages. By default all of these attributes are exported with the data. These settings only apply to ASCII, Mat lab and Excel CSV data export formats. The other formats use a predefined list of attributes that cannot be modified.

Text export layout settings are also defined here. The options are to only export *Y* values and to export any *X* start and step values.

Common Properties defines additional signal attributes to be exported including signal name, sampling rate, block size, X unit, Y unit, and NVH signal type. These settings only apply to ASCII, MatLab and Excel CSV data export formats.

Frequency Properties defines additional signal attributes to be exported with frequency-domain signals including spectrum format, window type, window correction mode, energy factor, amplitude factor, acquisition/calculation method, amplitude scaling, average mode, lin/exp averaging time constant, and number of averages. These settings only apply to ASCII, MatLab and Excel CSV data export formats.

Spectrum Format defines the default spectrum format when Auto-Power Spectrum data is exported.



Setting Target selects the signal type that the Spectrum Type and Vertical Axis Format settings will affect. The signal types are Auto Power Spectrum, coherence, complex spectra, cross power spectrum, and Frequency Response Function.

Spectrum Type: $(EU)^2/Hz$, $(EU)^2s/Hz$, $(EU_{rms})^2$, EU_{peak}, EU_{rms}

Export Vertical Axis Format: magnitude (Mag) or decibels (dBMag)

MAT-File Preference defines attributes for the MatLab file export format.

Default Display Format defines the default display format of the frequency spectrum. These settings will be used when a new display window is created in EDM.

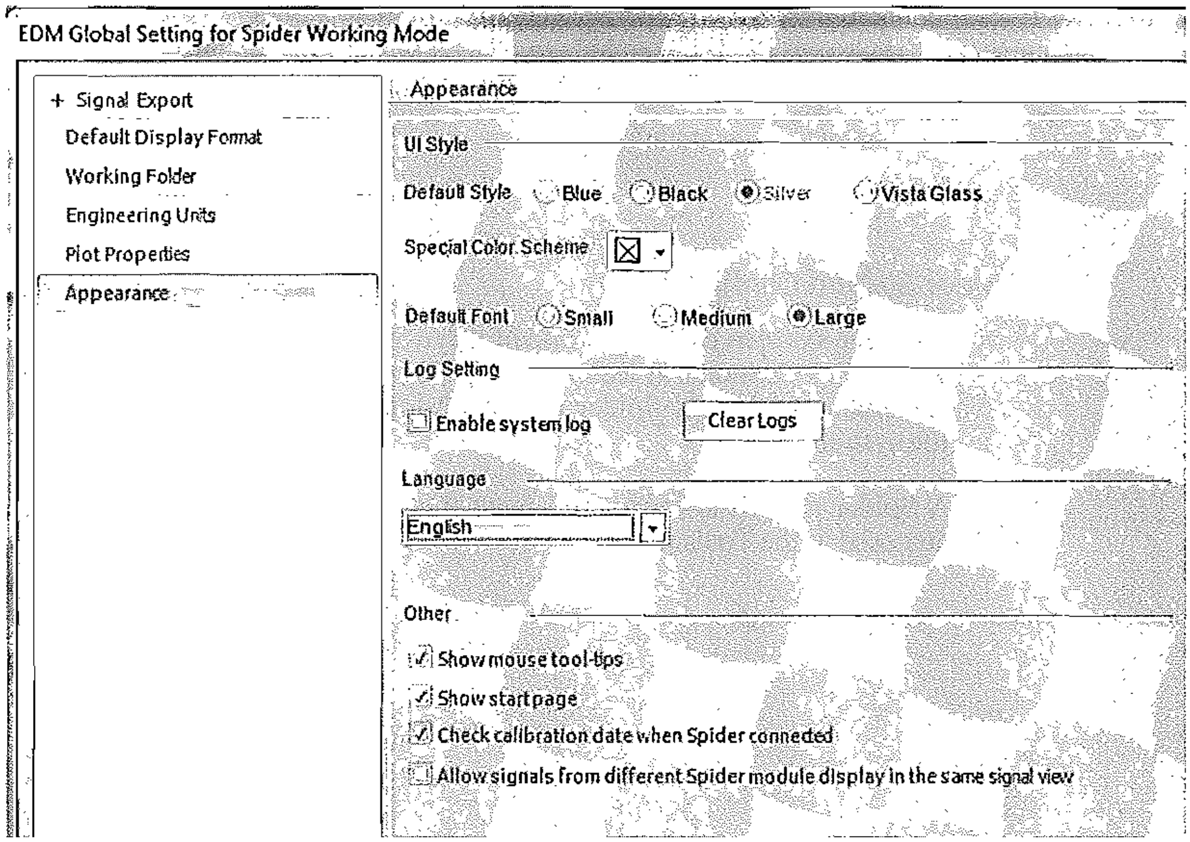
Working Folder sets the default working folders for program files and data storage.

DSA Engineering Units sets the engineering units used globally in EDM. The engineering unit display setting does not affect the actual values of the signals, only how they are displayed and labeled. This setting can be different than the setting on the devices from which the data was acquired. For example, an acceleration signal can be acquired in "g" on CoCo while displayed in "m/s^2" here.

Post-Processing Speed Control adjusts how much processing time is used for signal display when post-processing. More display detail means less processing resources available for the post processing data analysis. **Normal Speed** is the default setting that balances the data processing and signal display. **As Fast as Possible with complete signal display** prioritizes the display, and **As Fast as Possible with Little display** prioritizes the data processing.

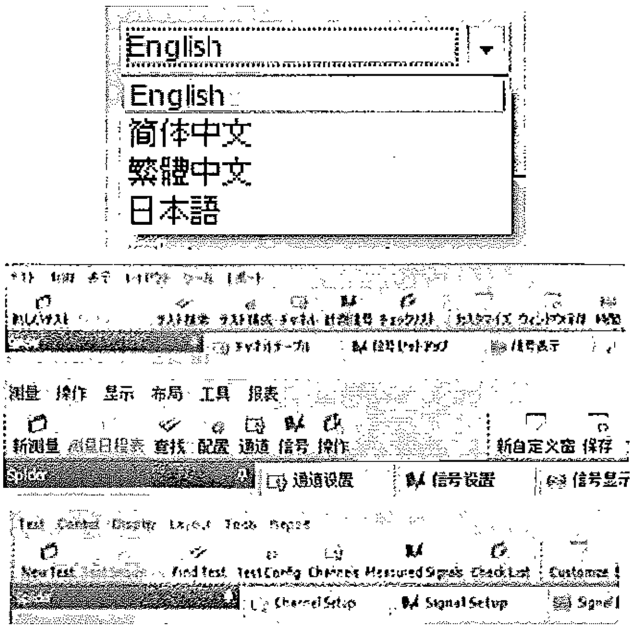
Plot Properties define how the time values, signal lines, numeric values, grids, and markers are displayed in the display windows where signals are plotted.

Appearance has options for the color scheme of the interface, for displaying the start window, and for enabling tool tips.



The Default Font size, *Small, Medium* and *Large* refer to the font size that we used in the signal plots and tables.

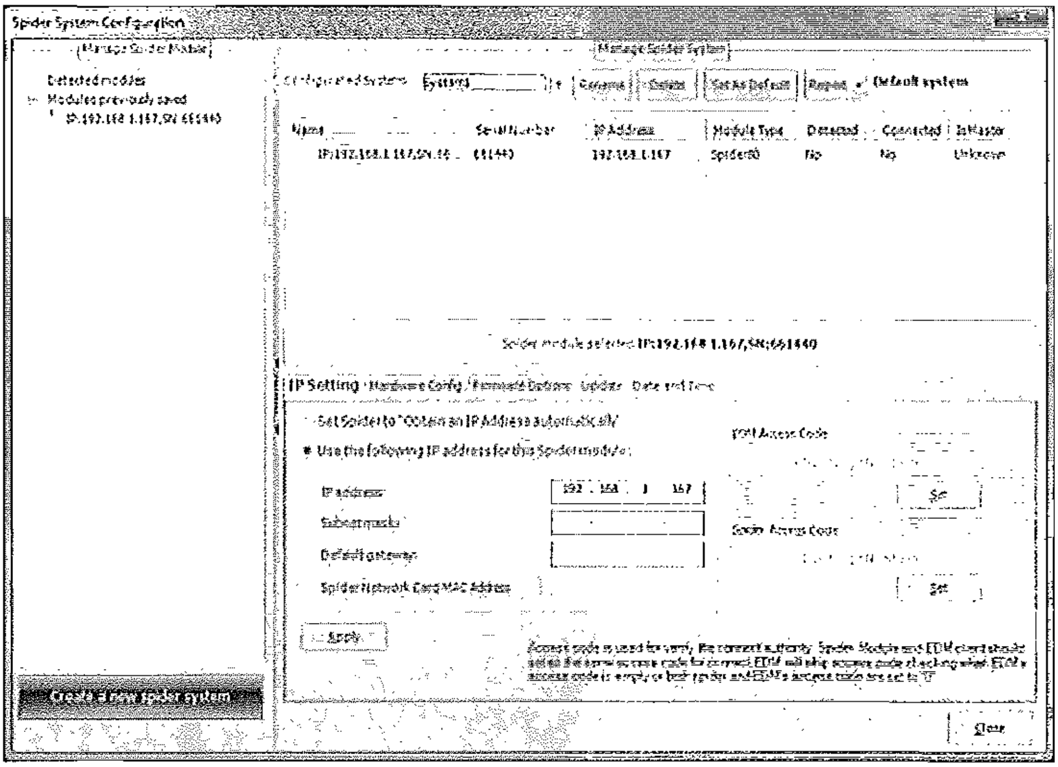
The language of the user interface can also be changed. EDM currently supports English, Japanese, Simplified Chinese and Traditional Chinese.



Spider System Configuration

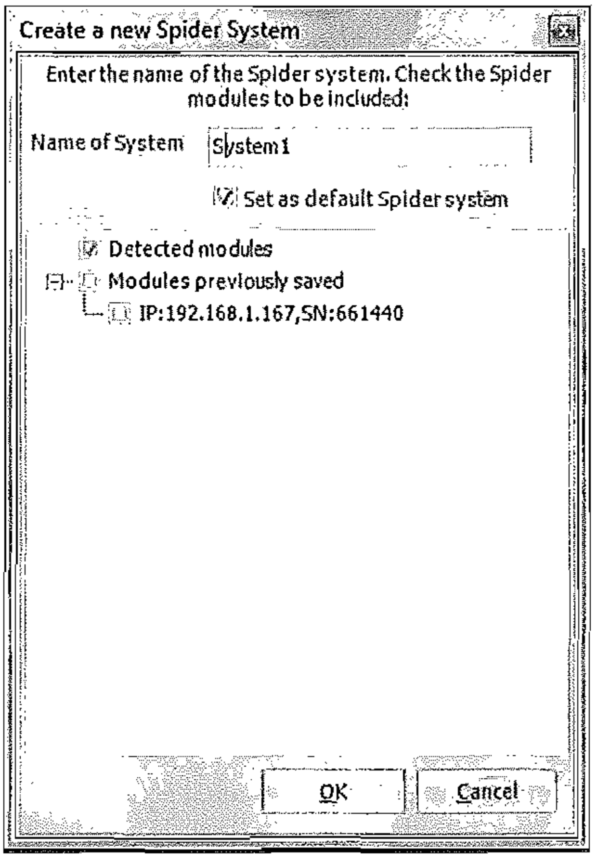
A Spider **system** consists of one or more Spider **modules** that operate together. To run in VCS mode, at least one of the Spider modules must be a Spider-81, but the others can be any Spider module. Additional modules add input channels to the system.

A Spider system is configured from the Spider System Configuration window, accessed in the Tools menu.

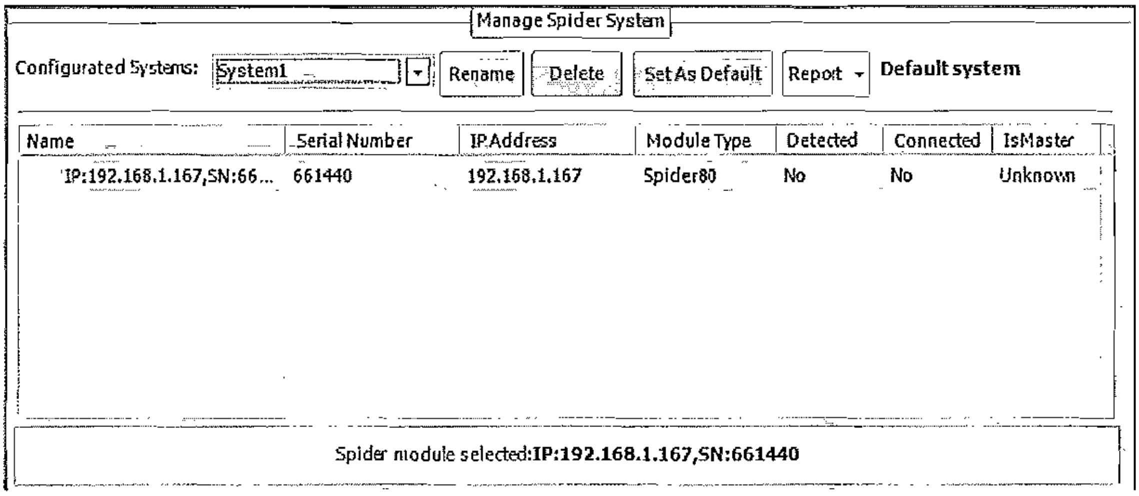


On the left side of the window, all detected Spider modules and previously used modules are listed. They are named by their IP address and serial number.

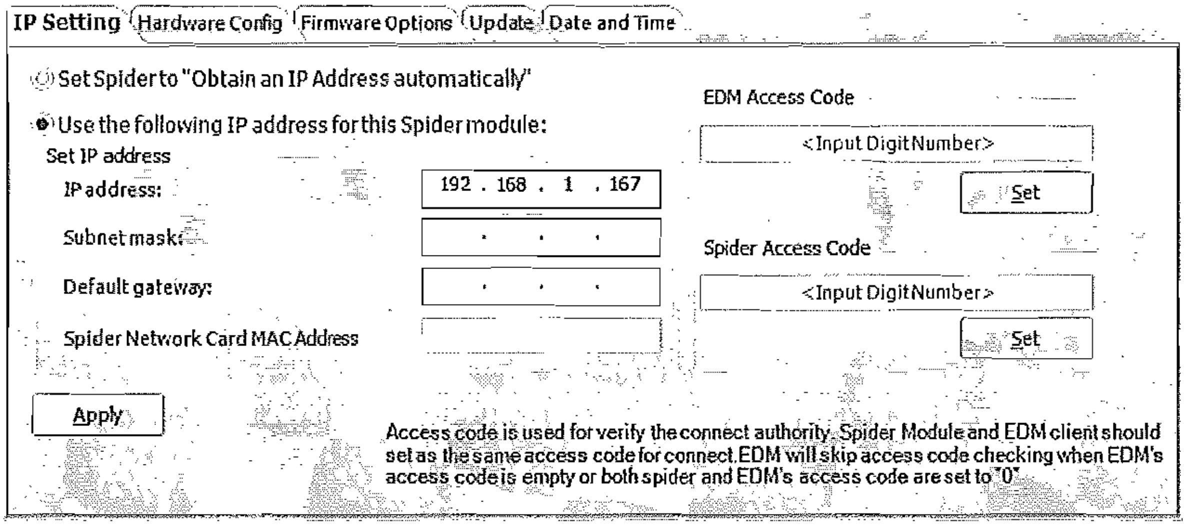
To setup a new system press the **Create a new spider system** button. In the window that appears, select the Spider module(s) to be included in the system, enter a name for it, and press OK. Selecting Set as default Spider system will make this the default system choice in all new tests.



The system will then show on the top pane of the window, with a list of the included modules. Use the Configured Systems drop-down menu to select other systems. The buttons along the top allow the selected system to be renamed, deleted, or set as default. There is also a button to generate a report with details about the system and associated Spider modules.

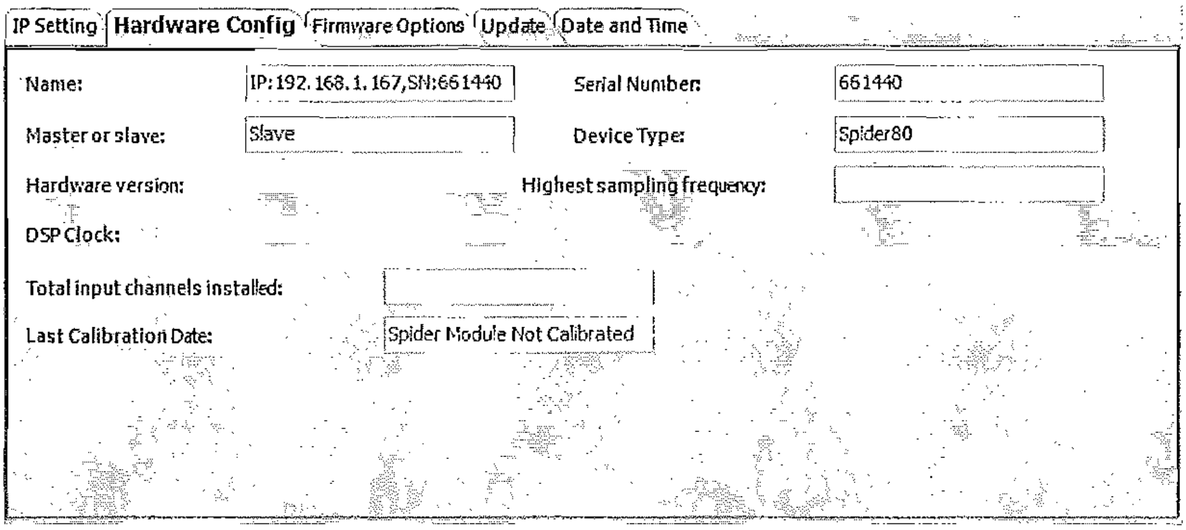


Settings for individual Spider modules are changed in the bottom part of the window. There are 5 tabs: IP Setting, Hardware Config, Firmware Options, Update, and Date and Time.

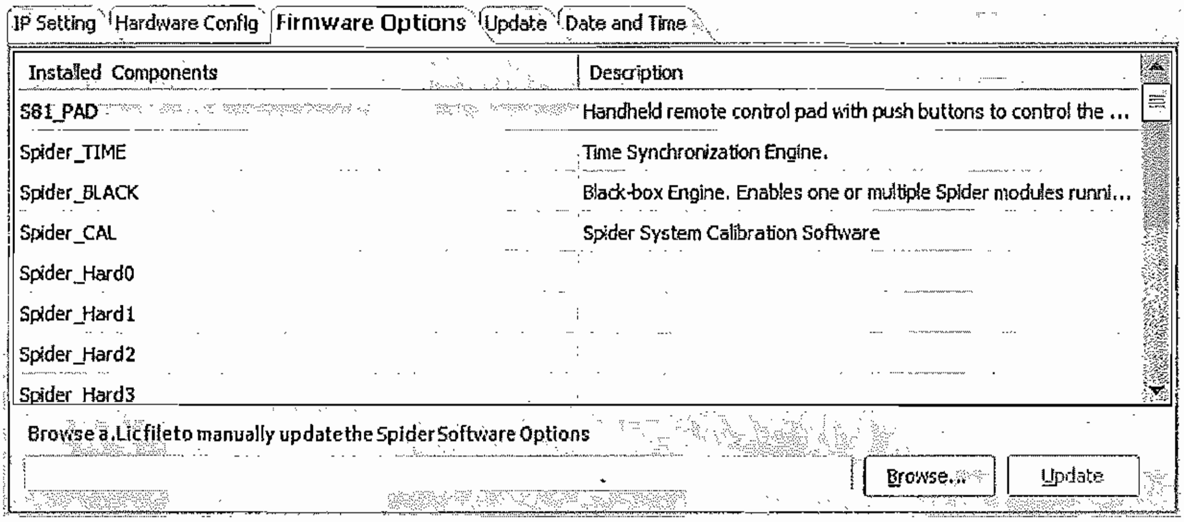


The IP Setting tab sets the IP configuration of the module. The Spider can use DHCP to obtain an IP address automatically, or use a manually configured IP address, subnet mask, and default gateway. These are set according to the configuration of the network the Spider is attached to.

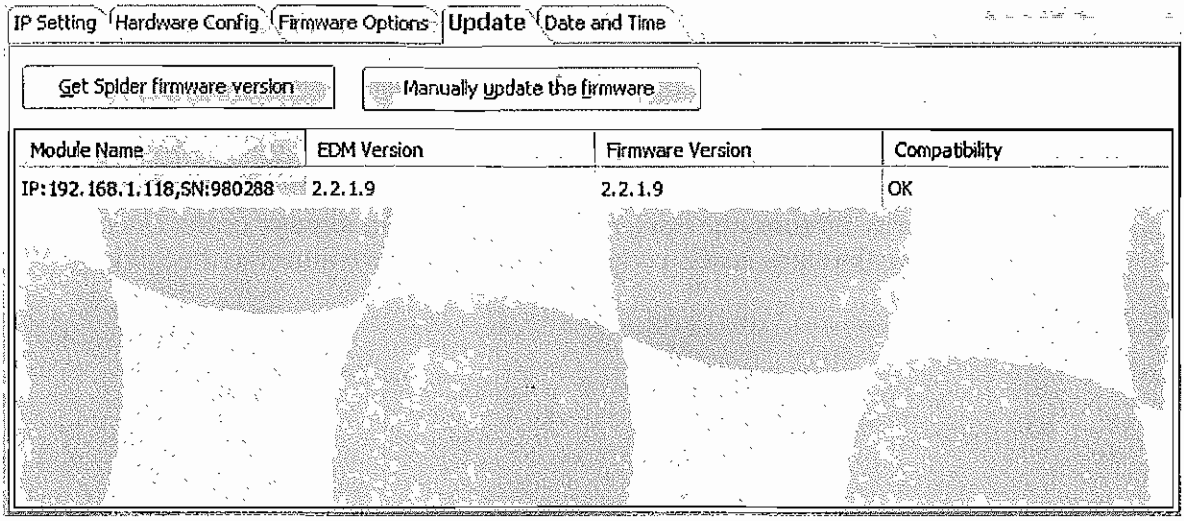
For security reasons, the Spider can be assigned an **access code**. Once set, EDM must have the same access code configured for it to connect to the Spider.



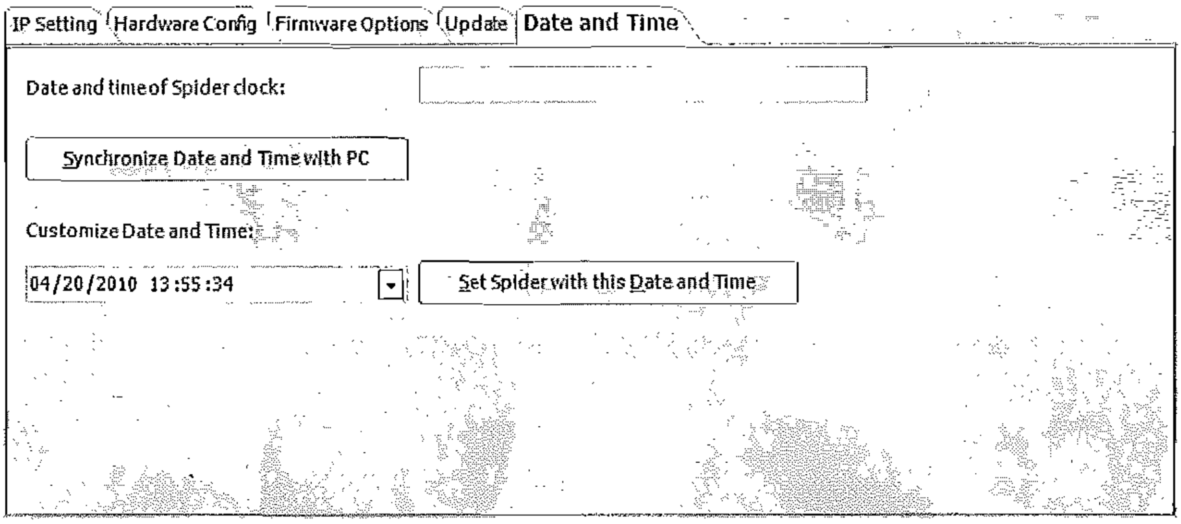
The Hardware Config tab shows hardware information about the module. These settings cannot be changed.



The Firmware Options tab shows software functions installed as firmware components. These components are installed by Crystal Instruments.



Firmware updates are managed through the Update tab. The list shows the firmware version of the Spider and the software version of EDM. If these versions are not the same, the Spider may not be able to connect to EDM. It is important to keep the Spider firmware up-to-date.



The Date and Time tab is used to change the internal clock setting in the Spider.

Input Channel Settings in EDM

The Spider uses the inputs to control the shaker drive output and to record and monitor the response of the Unit Under Test. Each Spider-81 unit has 8 inputs, and up to 128 Spiders can be connected together for a total of 1024 inputs. Sensors on the UUT act as transducers that convert physical quantities, such as force, acceleration, or displacement, to voltages which can then be detected by the Spider hardware. The software converts the measured voltages back in to physical units, such as newtons, meters per second squared, or centimeters, using a Sensitivity parameter as the proportionality constant.

The Spider uses each channel for control, monitoring, or limiting functions. Control channels are used directly in the vibration control feedback loop. The Spider VCS adjusts the drive output so that the control channel input has a frequency spectrum that conforms to the response profile.

More than one control channel can be used. One method for multiple channel control is combining them in a weighted average. The weights must be normalized to a unit sum to preserve the DC average of the control signals. Other methods are using the channel with the lowest response (minimum control) or the channel with the greatest response (maximum control).

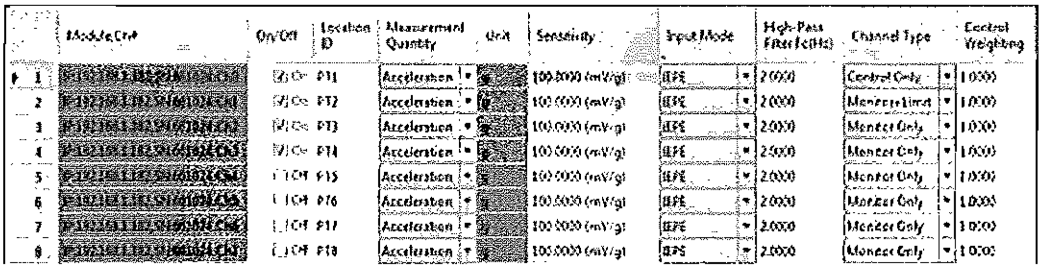
Limiting channels are used to enforce limit conditions on the test. The frequency response of these channels is monitored to ensure they do not exceed a limit profile defined in the frequency domain. They do not affect the output control except when a limit is exceeded.

Monitor channels are only used for viewing and recording data.

Each channel can be given a name under **Location ID** in the Input Channel Setup. This ID is shown with the channel everywhere it is displayed and with its saved time stream data. For other data processed from that time stream, EDM uses a consistent naming convention, where the data type is followed by the Location ID of the source in parenthesis. The data types are Block for block data, APS for Auto Power Spectral data and H for the Frequency Response Function. For example, the Auto Power Spectral data calculated from a channel with an ID "PT1" would be named as "APS(PT1)".

Input Channel Setup

The inputs are configured under the Channel Table tab in the test window. This tab can be opened by clicking on the **Channel Setup** item in the Recent Tests list.



	Module/Ch#	On/Off	Location ID	Measurement Quantity	Unit	Sensitivity	Input Mode	High-Pass Filter fc(Hz)	Channel Type	Control Weighting
1	[illegible]	On	PT1	Acceleration	[illegible]	100.0000 (mV/g)	IEPE	2.0000	Control Only	1.0000
2	[illegible]	On	PT2	Acceleration	[illegible]	100.0000 (mV/g)	IEPE	2.0000	Monitor+Limit	1.0000
3	[illegible]	On	PT3	Acceleration	[illegible]	100.0000 (mV/g)	IEPE	2.0000	Monitor Only	1.0000
4	[illegible]	On	PT4	Acceleration	[illegible]	100.0000 (mV/g)	IEPE	2.0000	Monitor Only	1.0000
5	[illegible]	Off	PT5	Acceleration	[illegible]	100.0000 (mV/g)	IEPE	2.0000	Monitor Only	1.0000
6	[illegible]	Off	PT6	Acceleration	[illegible]	100.0000 (mV/g)	IEPE	2.0000	Monitor Only	1.0000
7	[illegible]	Off	PT7	Acceleration	[illegible]	100.0000 (mV/g)	IEPE	2.0000	Monitor Only	1.0000
8	[illegible]	Off	PT8	Acceleration	[illegible]	100.0000 (mV/g)	IEPE	2.0000	Monitor Only	1.0000

On the top of the tab there are a series of buttons used to manage the channel settings. **Fill** allows the settings of one channel to be filled in to all the remaining channels (**Fill All**) or only to a range of channels (**Fill Range**). **Ex/Im** allows the current channel list to be saved to a file, or a previously saved list to be opened and applied. This allows the current settings to be saved and applied to future tests. **Unit** is a shortcut to the DSA Engineering Units section of the EDM Settings dialog, allowing the global engineering units to be set. The remainder of the tool bar is used for library synchronization (See "Using Libraries" below). The channel list shows a number of settings for each channel:

On/Off enables or disables the channel.

Location ID assigns a custom label used to identify the source in the signal display and other setup windows.

Measurement Quantity defines the physical unit that will be measured by the sensor connected to the channel.

Unit is the unit of measurement corresponding to the measurement quantity. This is a global setting found in Settings -> DSA Engineering Units (also accessed by the Unit button above the channel list).

Sensitivity sets the proportionality factor for the measurement (millivolts per engineering unit), given as a parameter of the sensor.

Input mode is the electrical interface mode of the sensor (see above).

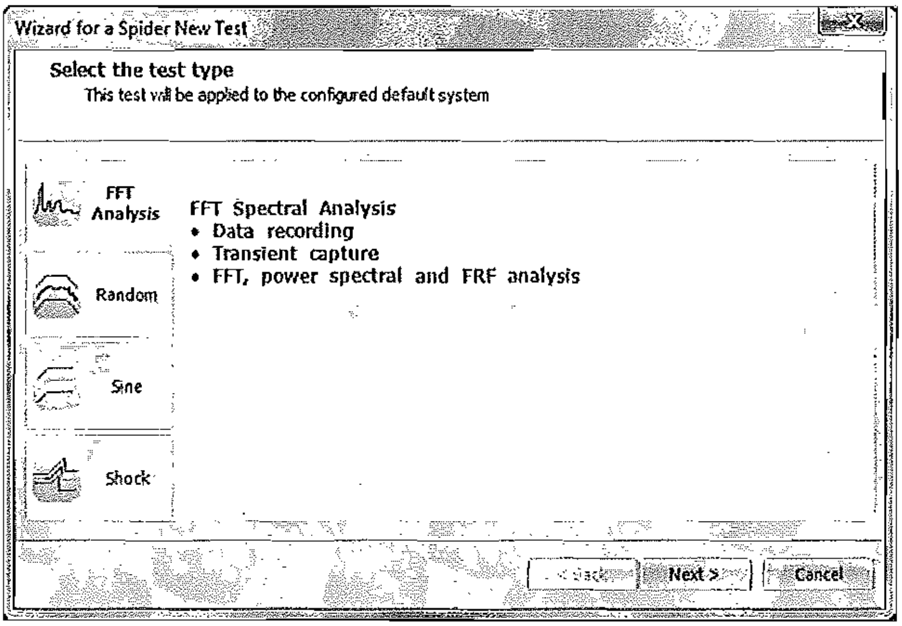
High-Pass Filter Fc (Hz) sets the digital high-pass filter frequency, used to block spurious low frequency and DC signals. To measure very low frequency or DC signals, set this value to zero and use DC-SE or DC-DI input mode.

Channel Type selects the function of the channel (control, limit, or monitoring only).

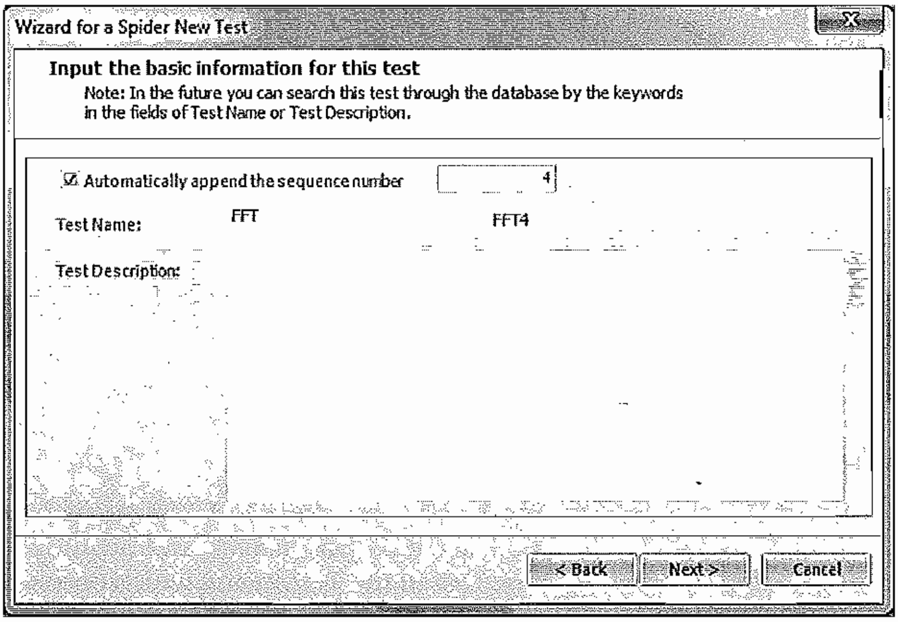
Control Weighting is used when more than one control channel is present for weighted averaging. See the description for the Control Strategy test parameter. The weighting factors are automatically normalized. For example, enter weighting factor 2.0 for channel 1, 1.0 for channel will be the same as entering factor 4.0 for channel 1 and 2.0 for channel 2.

Creating Tests

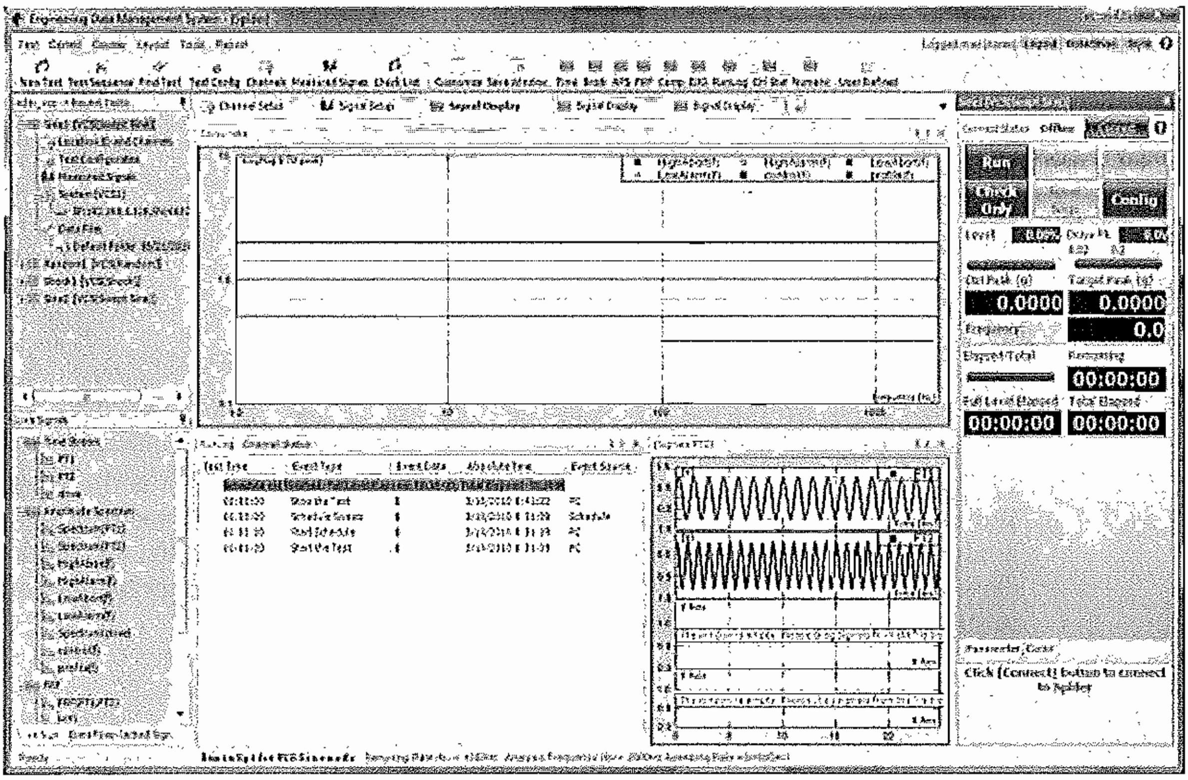
EDM runs in the context of a loaded test project. A test project consists of an input and output configuration, analysis parameters, and acquired data. A new test is created by selecting New Test in the Test menu, which opens the New Test Wizard.



In the first page, you select the type of test. FFT Spectral Analysis is the general Dynamic Signal Analyzer (DSA) mode, which is only passive data acquisition and analysis. The rest are Vibration Control System (VCS) modes, which are used for closed-loop control of a mechanical shaker. Each VCS mode is described in detail in subsequent chapters of this text.

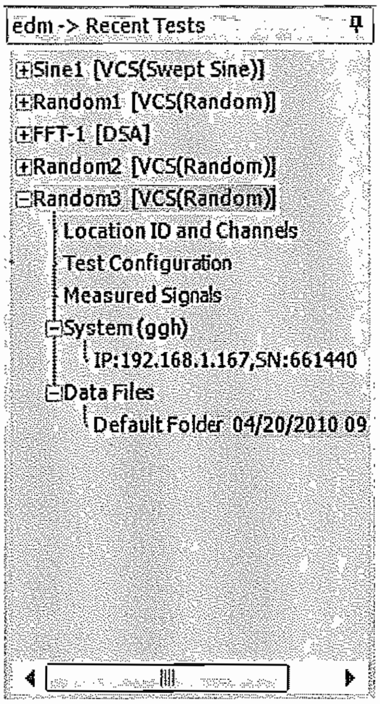


The next page allows you to name the test and write a description. For DSA mode test, there is a third page in the wizard where different analyses computations can be enabled or disabled, such as Auto Power Spectra and Frequency Response Functions. For VCS modes, press Finish to exit the wizard. You are then presented with the default display for a blank test.



This screen is divided into 5 parts. On the top is the menu and toolbar section. On the left side, there are two sections: the Recent Test list and the signal list. On the right is the test control and status window. In the middle, there are the Signal Display and Signal Setup tabs.

Recent Test List



On the upper left part of the screen, the Recent Tests list shows current and previous Spider tests. Each test is listed by its name and type (VCS or DSA). Each test entry is expandable to display items underneath related to the test.

Location ID and Channels opens the Channel Table tab where the input channels are configured. See Input Channel Setup.

Test Configuration opens a window where test configuration parameters are set. This is different for each test type and is described in the following chapters.

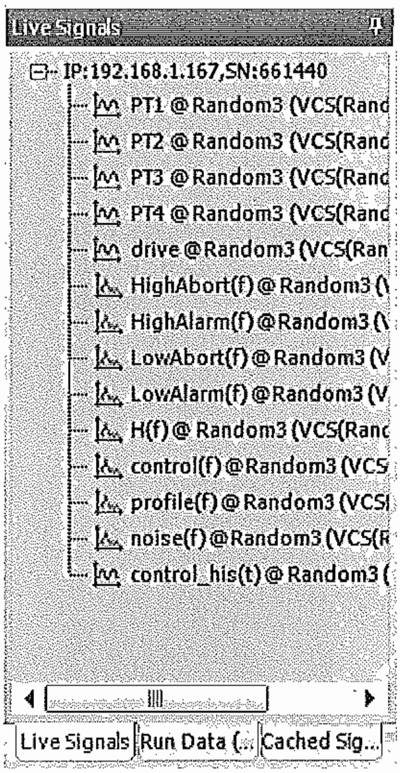
Measured Signals opens the Signal Display tab.

System lists the Spider modules associated with this test. The Spider system is set up with the Spider Config window, described under Spider System . The name of the system is displayed in parenthesis.

Data Files lists folders on the local disk where saved or recorded data will be stored. The data files are listed under **Run Data** below.

Signal List

Under the Recent Tests list is the Signal List, which shows live signals and saved data available for display.



Live Signals include all input channels that are part of the current Spider system and the output drive channel. Depending on the test type, there may be other signals such as the control profile and associated alarm and abort lines. The list is divided in categories for time streams, block signals, and frequency data from these sources. It can also be viewed according to spider module by right clicking on the list and selecting **Sort signals by Spider modules**.

Run Data are time streams and block data saved or recorded to disk. When block signals are saved by clicking the **Save Sigs** button, a data file will be created and shown here.

Cached Signals are signals cached by the keystroke Ctrl-K. These signals will remain as snapshots in the currently active display window. EDM stores the signals in memory but does not save them to disk.

Figure 16 shows two live signals being displayed along with previously cached versions of the same signals. The cached signals preserve a previous state of the display.

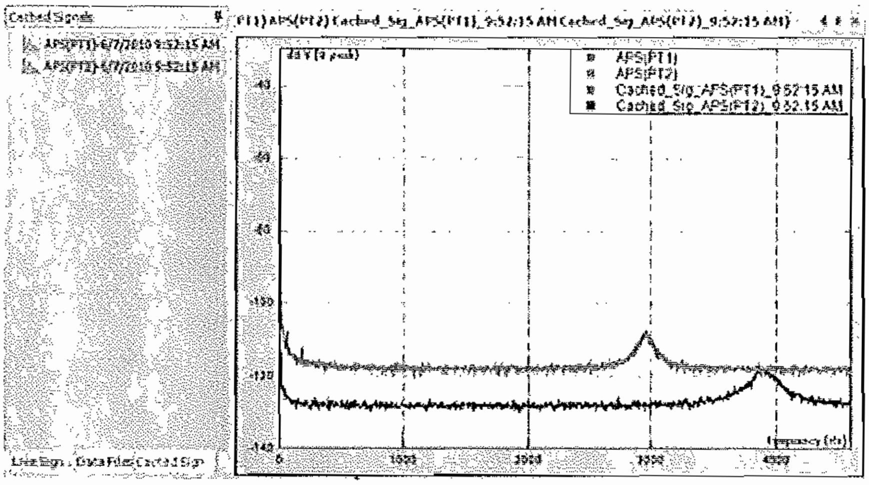
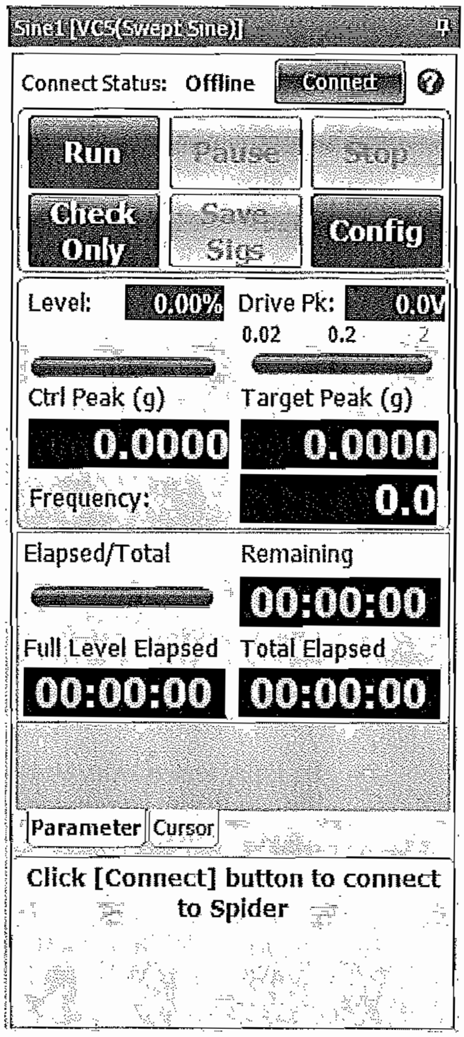


Figure 16: Cached Signals display

Control Panel



The Control Panel is used to control the test and display status information in real-time. The connection status of the spider hardware is shown on top, with a button to **Connect/Disconnect** (if no hardware is detected, this button will not be displayed). The control buttons – **Run**, **Hold**, **Stop**, **Save Sigs** – duplicate the items in the Control menu and on the Control toolbar. **Check Only** activates live viewing of signals from the Spider in EDM, but does not start a test. **Config** opens the Test Configuration window.

Below the control buttons, information on the state of the test is displayed. Depending on the test mode, this includes the output level (as a percent of the test profile) and peak voltage, the control input peak and RMS level, the target peak and RMS level, and the elapsed and remaining time.

Right-clicking in the control panel brings up options to display an expanded set of command buttons and test information. These commands are used to adjust the operation of the test such as changing the output level. These commands, along with all the display fields, will be described in the following chapters on the specific test modes.

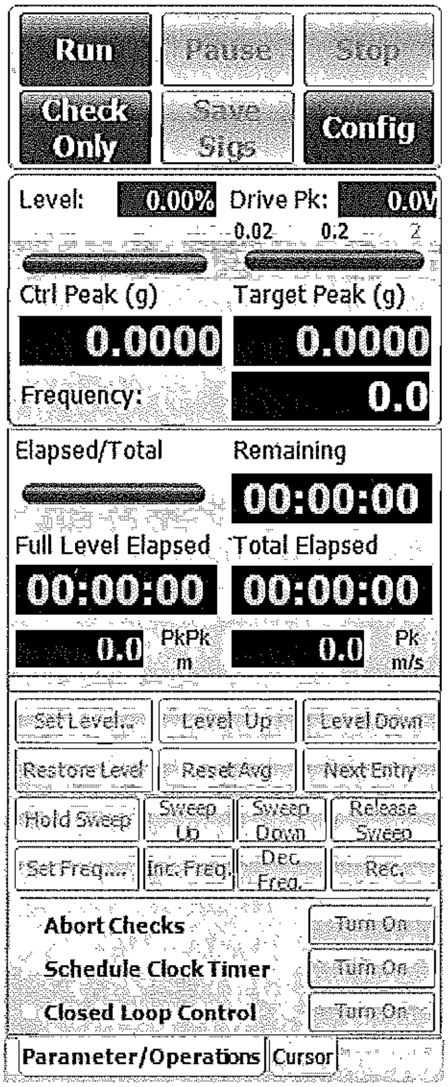


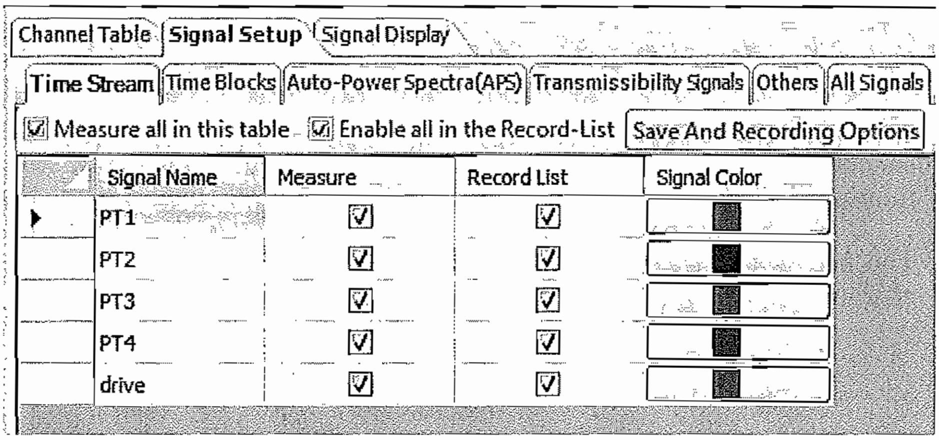
Figure 17: Expanded control panel

There are tabs on the bottom of the control panel for viewing different pages of information. The Cursor tab shows the abscissa and ordinate values for all displayed cursors and peak and harmonic markers.

In DSA test mode, there is an Input, Output, and Cursor tab. The Input tab sets the analysis parameters (block size, window type, overlap, and average) and trigger settings for the input channels. The Output tab controls the output function generator.

On the very bottom of the control panel the Spider system connection status is shown, along with any messages related to test events.

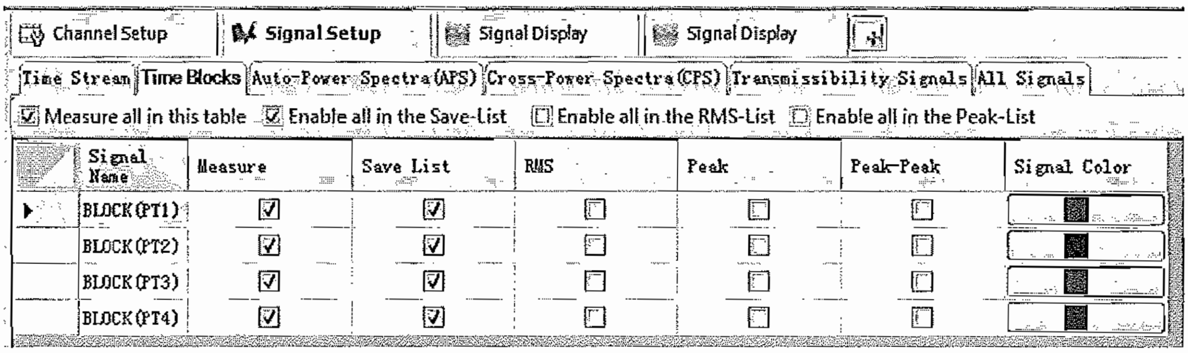
Signal Setup



The Signal Setup tab lists all signals with a **Measure** option. In addition, time stream signals have a **Record List** option and block signals have a **Save List** option. **Measure** enables the channel for display, **Record List** enables the channel for recording, and Save List enables the channel for block saving. Only time-stream signals can be recorded and only block signals can be recorded.

The signals are divided into type by the tabs on top. The **Time Stream** tab lists the native time stream signals. The other tabs list signals that are derived or computed from these native signals, and are organized in blocks rather than continuous streams. Deselecting **Measure** for these derived signals disables their computation and saves processor resources. When recording is activated, by the menu command or the **Rec.** button on the control panel, all signals with the **Record List** option enabled will be recorded to file. When the **Save Sigs** Button is pressed, all signals with the **Save List** option enabled will be saved to disk.

In the Time Blocks tab, the block signals have the additional options of RMS, Peak, and Peak-Peak display. Enabling these will create a signal that is the time history RMS, peak, or peak-peak value of every block (one point per block).

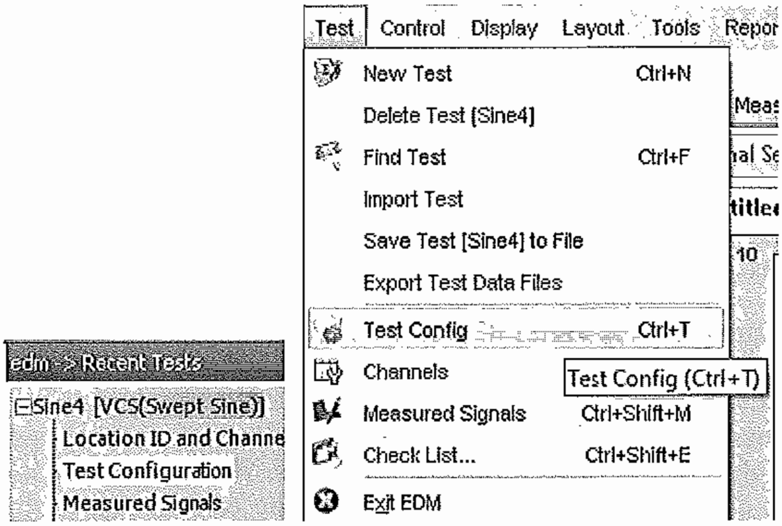


The color used to display the signals can also be changed here.

Test Configuration

The Test Configuration window is used to set test-specific software options and parameters. It is divided into a number of sections accessed by the list on the left. Many of these sections are specific to a particular test mode, and are described in the subsequent chapters on these modes. Other sections are for common functions shared by all test modes, and are described in their own sections of this manual. This window will be referenced many times throughout this text.

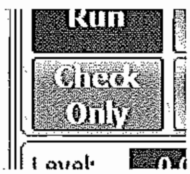
The access these settings, double click the Test Configuration item under the current test, or select the Test Config item under the Test menu.



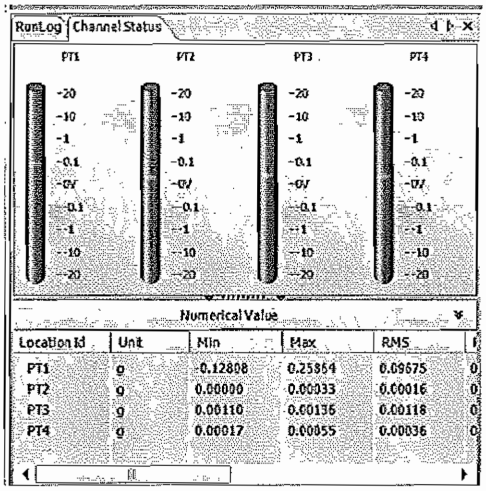
Test Profiles

Running a Test

Before starting a test, it is important to check that all connections are made correctly and all settings are correct. The Check Only button on the control panel will turn on the input channel displays, showing live readings from connected sensors without outputting a drive signal.

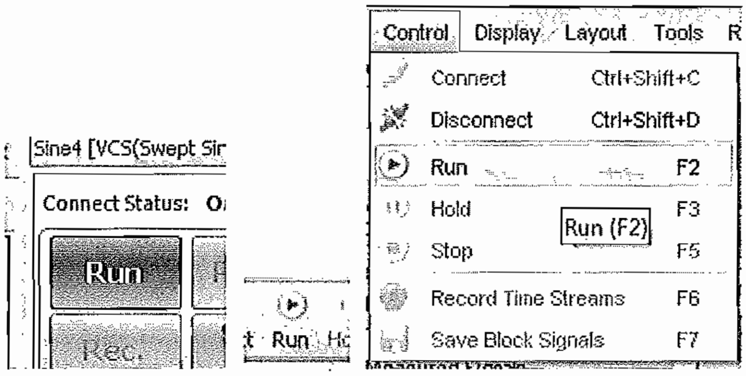


If accelerometers are used, a good check is to tap on the unit under test near where the accelerometers are mounted. The input should register a signal between 0.1 and 10 g's of acceleration. Anything significantly out of this range can indicate a problem with the connection or channel setup. The Input Channel Status also provides an overview of the current input levels.

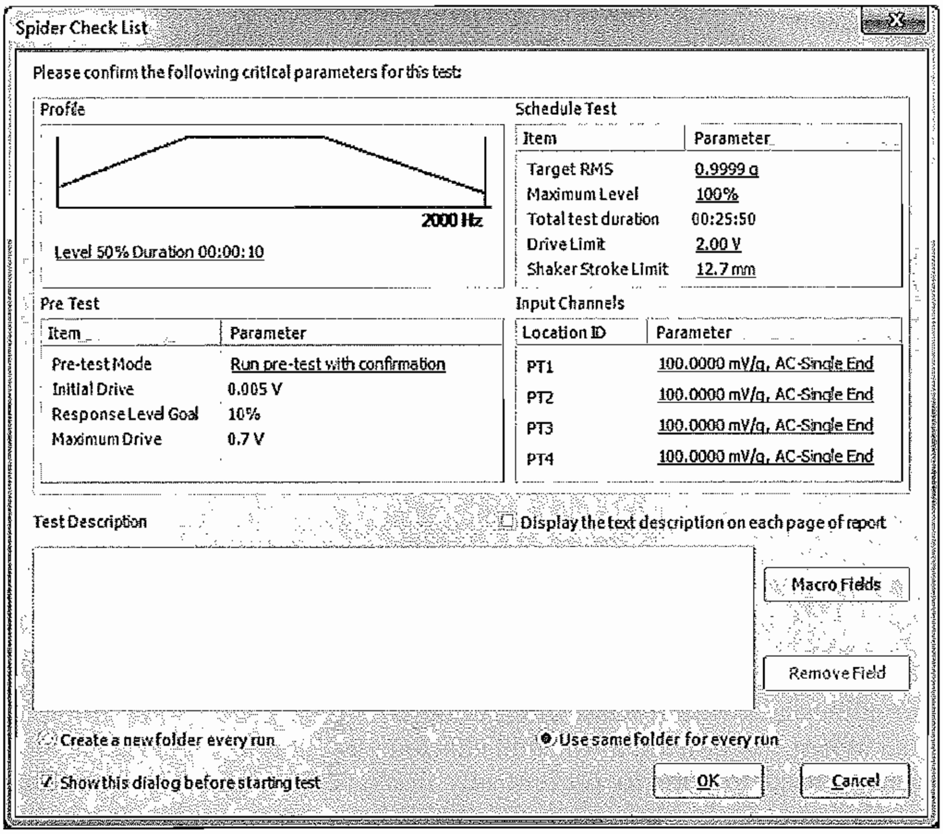


When the controller is connected to a shaker amplifier, it is important that the amplifier is always the last thing to be turned on and the first thing to be turned off. When configuring a test, and checking the inputs, it should be off or have the gain turned to zero to prevent any unexpected transients from damaging the equipment. Only after all connections have been double-checked should the amplifier gain be turned on.

Once ready, there are three ways to start a test: the Run button on the control panel, the Run button on the toolbar, and the Run command in the Control menu.



Then, EDM displays the Check List window, which summarizes the test configuration.



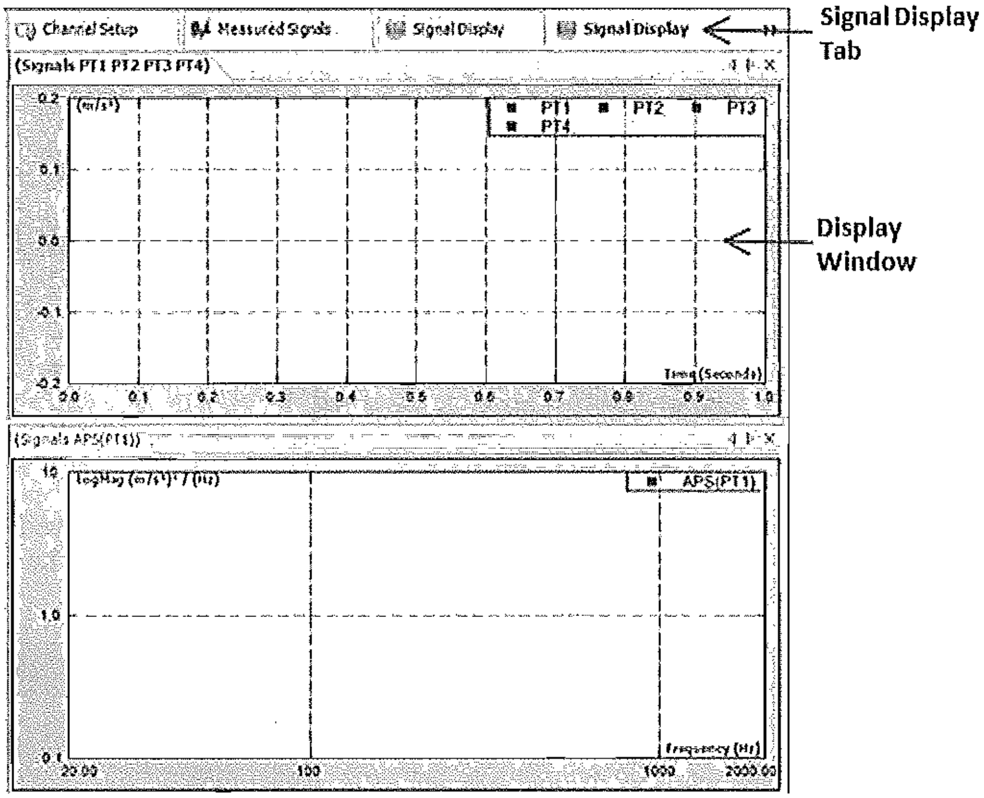
This window allows the user to confirm all the settings and make any last-minute changes. The window has sections for pre-test settings, test level and duration information, and input channel configuration. Most of these settings can be edited by clicking on the blue underlined text. There is also a section for adding custom report fields and a test description.

The text filled in the Test Description edit box can be searched when the user wants to find a specific test. The database management can quickly look through the tests with key words search.

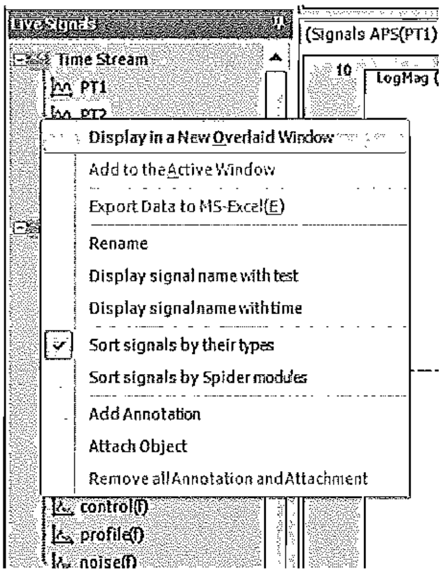
The test sequence is governed by a schedule and profile. The schedule can define different test stages, with a level and duration, that are based on the target profile. In Random and Sine modes, there is also a pre-test that runs before the schedule is executed. The pre-test checks the noise levels of the system and calculates an approximate frequency response function.

Viewing Signals

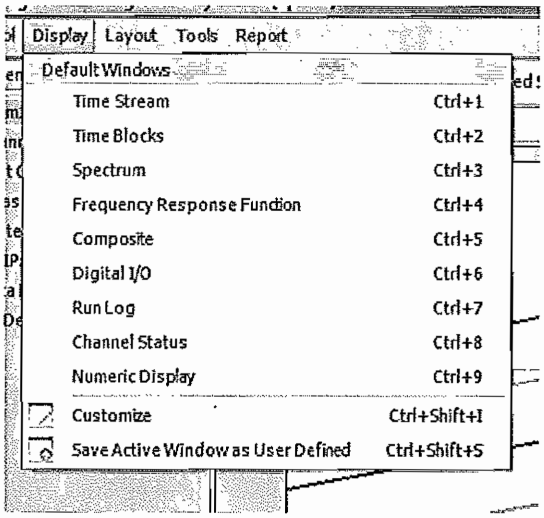
Signal data are displayed under **Signal Display** tabs. More than one of these tabs can be opened, but only one is active at a time. Each tab can have a custom title. Each Signal Display tab contains one or more **display windows**. These windows display data in various kinds of plots. These windows can be freely arranged inside the tabs or ordered using the commands under the Layout menu.



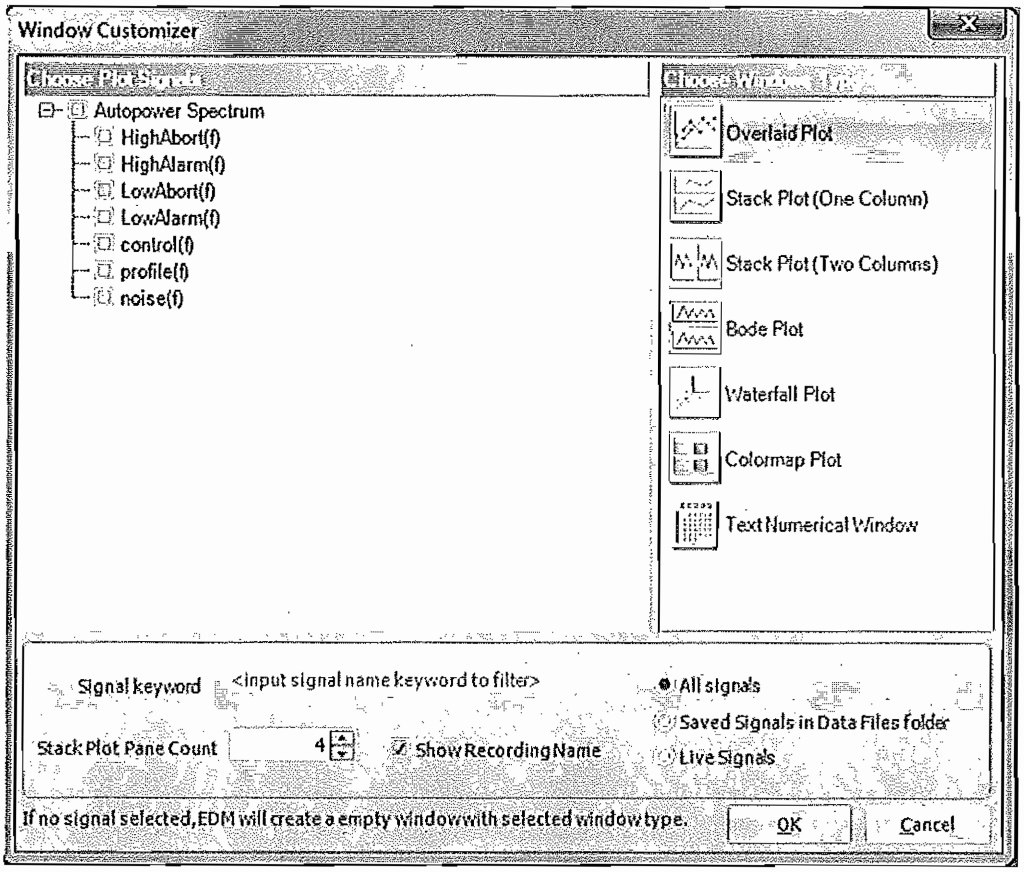
There are many ways to open a new display window. A signal can be directly viewed by right clicking on it and selecting Display in a New Overlaid Window.



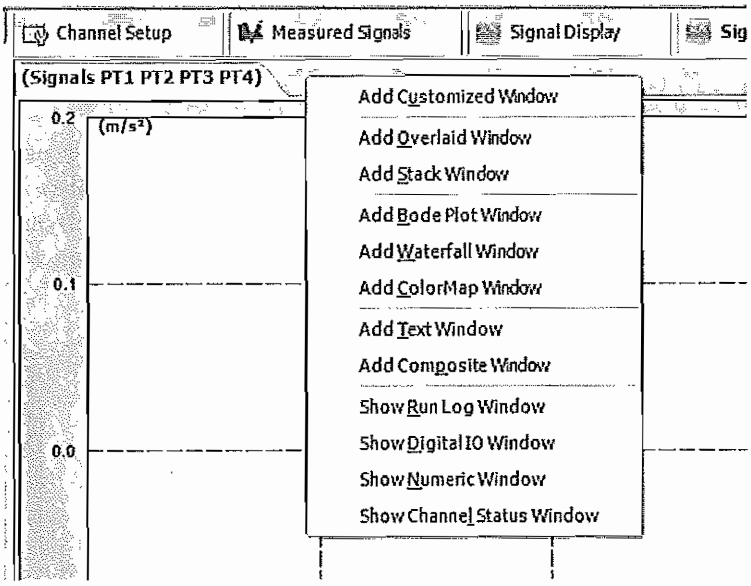
A blank window can be created from a window template by selecting the template under the Display menu.



When you select an item from the Display menu, a dialog is displayed allowing you to select the type of window and which signals to display. The available signals are listed on the left, and the plot types are shown on the right.



You can also create a new, empty window by right-clicking next to the display window tabs, and selecting the type of window.



There are 11 different types of windows here (depending on the current test type, only some of these may be available). **Add Customized Window** opens the window customizer dialog, shown above. The other types of windows are described here:

Overlaid Plot: plots multiple signals on the same axes within the same pane of window. Only signals of the same type, such as time stream, block, APS, FRF, etc., can be displayed in one overlaid plot.

Stack Plot (One Column): plots each signal in a separate plot, stacked vertically. All signals in a stacked plot must have the same x-axis quantities.

Stack Plot (Two Columns): plots each signal in a separate plot, arranged in two columns.

Bode Plot: plots the magnitude and phase of a signal in a stacked plot.

Waterfall Plot: shows a 3D display with time on one axis, frequency on another, and amplitude in the third.

Colormap Plot: plots frequency in the horizontal direction, time in the vertical direction, and uses color to represent magnitude.

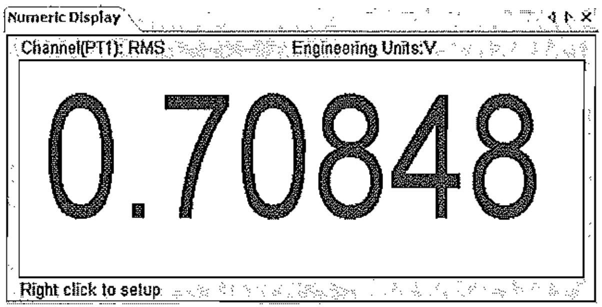
Text Window: displays numeric values of the signal in a table.

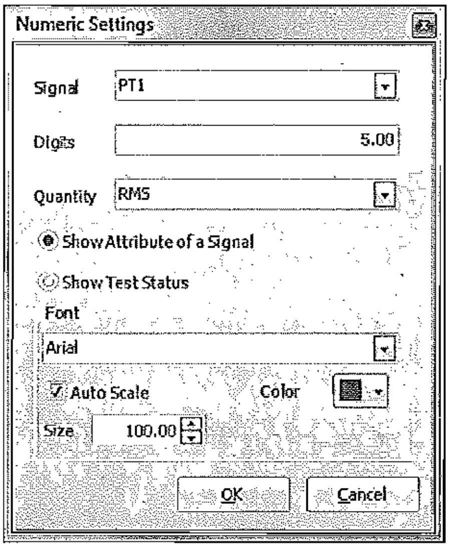
Composite Window: displays the test profile, control profile, and alarm and abort lines in an overlaid plot for vibration controller modes.

Run Log Window: shows a log of test events as they occur.

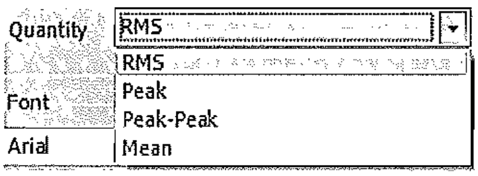
Digital IO Window: displays the current state of the digital inputs and outputs.

Numerical Window: shows the current RMS, peak, or peak-to-peak level of the signal as a large text numerical display. It can also display test status information, such as the current voltage level of the control signal, the current frequency of a Sine test, or time duration. The display can be changed by right clicking in the window and selecting Properties.

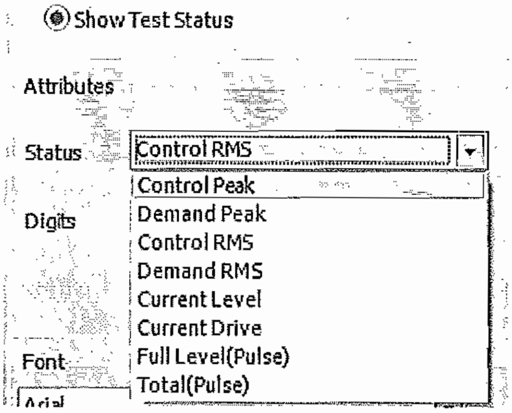




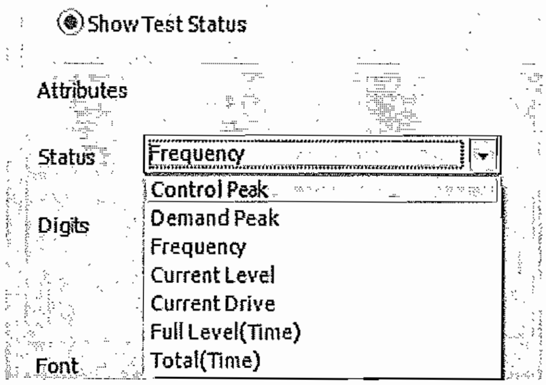
RMS, Peak, Peak-Peak, and Mean values can be shown for signal attributes.



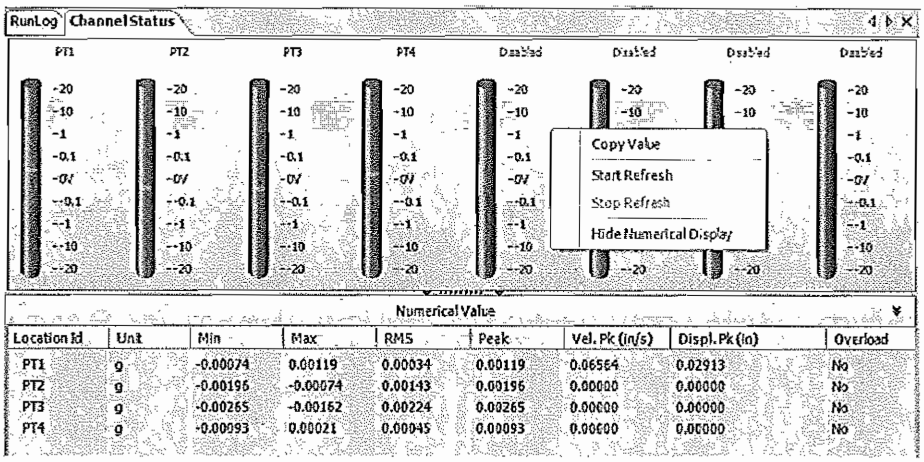
For Classic Shock, Transient, and SRS test the following status values can be shown:



For Sine test, the status values are:



Channel Status Window: shows the current state of each input channel. Has both bar graphs, which show the current overall voltage level, and numerical readings.



The bar graphs are in a logarithmic scale so that the presence of both low level and high level signals can be seen. The readings show the minimum, maximum, RMS, and Peak levels, in the units set in the channel setup table. If the units are in acceleration, then the signal is integrated to show the velocity peak and double integrated to show the displacement peak. The integration is done digitally and should only be taken as an estimation; the accuracy should not be relied on.

The Overload column shows when a channel is overloaded due to an input signal over the input maximum. When in the overloaded state, the readings from the channel should not be used.

The channel status information can be updated while a test is not running by right clicking in the window and selecting Start Refresh.

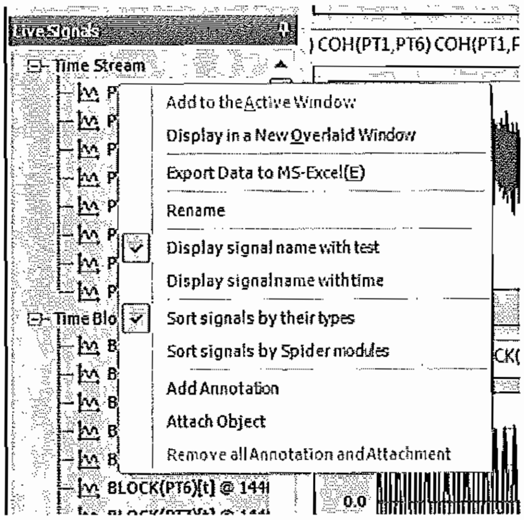
Once a window is created, with a type and combination of displayed signals, it can be saved as a custom window template. To save a current window layout, select the window and choose **Save Active Window as User Defined** under the Display menu. After saving, this template will be available under **User Defined Windows** in the Display menu.

Signals can also be added to existing windows. Dragging a signal from the signal list to a window will display it in the window. You can also right click on the signal and select **Add To the Active Window**. Note that the target window for the signal must be a valid option for the signal type.

Contextual Menus

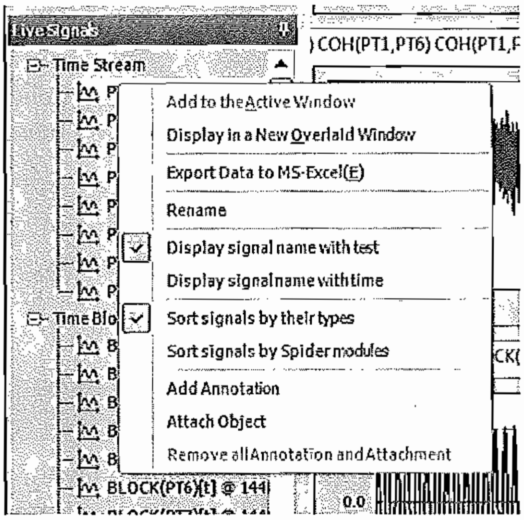
Right clicking in the various parts of the user interface in EDM will bring up a contextual menu where commands and options related to the area of the click are displayed.

Right clicking on a signal in the signal list brings up the following:



Add To the Active Window adds the selected signal to the currently selected Display Window. Note that only signals of the same type can be added to the same window; i.e. a time signal cannot be added to a window that already contains frequency data.

Display in a New Overlaid Window creates a new Display Window in the active View Tab and adds the selected signal.



Export Data to MS Excel exports the signal data to an Excel file.

Rename allows the display name of the signal to be changed.

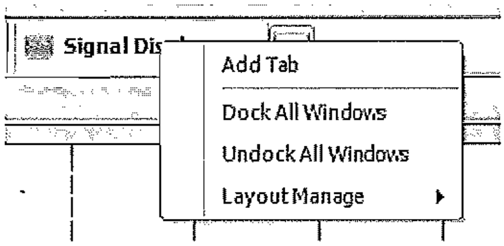
Display signal name with test adds the test name to the end of the signal names in the list.

Display signal name with time adds the creation time to the end of the signal names.

Sort signals by their types/by Spider modules changes the category display and sorting of the list.

Add Annotation/Attach Object allows text annotations or file objects to be referenced to the signal.

Right clicking on the Signal Display tab titles brings up a contextual menu with commands to manipulate the tabs:



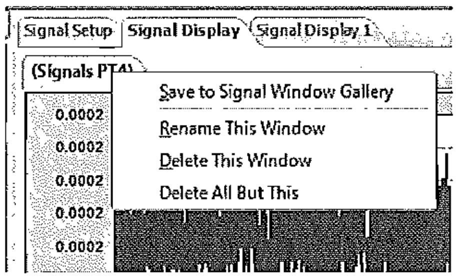
Add Tab adds a new empty Signal Display tab.

Dock all Windows docks all windows contained in the tab.

Undock All Windows turns all windows contained in the tab into floating windows.

Layout Manage has options for auto-arranging the windows contained in the tab. These commands are duplicated in the Layout menu.

The Window Popup Menu can be opened by right clicking on a window title tab. This gives you options to manipulate the windows being displayed.



Save to Signal Window Gallery saves the layout of the window as a custom template that can be recalled in future tests. The template includes the plot type, X and Y axes options, and the signals being displayed. It can be recalled under the Layout menu.

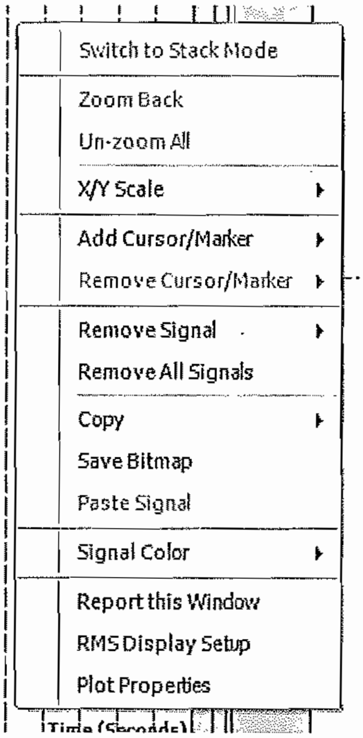
Rename This Window allows the title of the window to be changed.

Delete This Window removes the window from the view.

Delete All But This removes all other windows from the view.

You can rearrange the layout of the different windows by clicking on the title tab of any window and dragging it to a new location. While dragging, the Dock to Location icon will be displayed. Dragging the window on to one of the arrows docks it to that edge of the view. Dragging on to the center of the icon adds it as a tab behind the current window.

The Plot Popup Menu can be accessed by right clicking inside a window. This menu includes commands to change the contents and format of a plot. Many of these items can also be accessed on the toolbars.

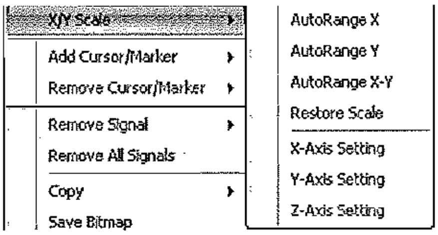


Switch to Stack Mode is available if there is more than one signal in the plot window. Stack mode will display each signal in separate plots, stacked vertically. If the window is already in Stack Mode, then **Switch to Overlaid Mode** will be displayed instead. Overlaid mode will show each signal in the same plot.

Zoom Back zooms out to the previous zoom ratio

Un-Zoom All zooms out to the full scale so the entire signal is visible

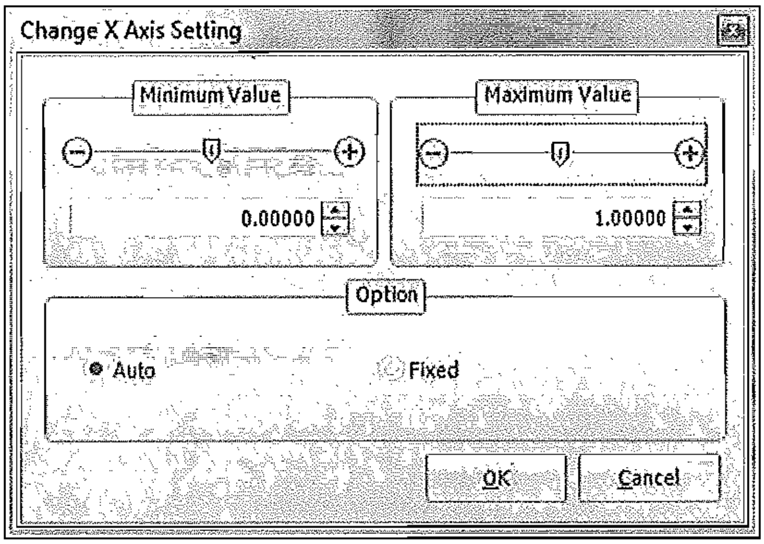
X/Y Scale has options for adjusting the scale of the X and Y axes.



Auto Range turns on automatic scaling for the axes

Restore Scale reverts to the previous axes display

Axis Setting opens this window, used to set a custom range:



This can also be opened directly by double-clicking on the axis label area.

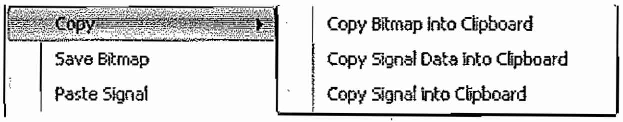
Add Cursor/Marker adds a vertical or horizontal cursor or peak and valley markers to the active window

Remove Cursor/Marker removes cursors or markers from the window

Remove Signal removes signals that are currently displayed from the active window

Remove All removes all displayed signals from the window

Copy copies either signal data or a bitmap image of the window in its current state onto the clipboard. **Copy Signal into Clipboard** allows the current signal to be copied and then pasted into another Display Window using the Paste Signal(s) item below



Save Bitmap allows the bitmap image of the window to be saved to a file

Paste Signal(s) pastes previously copied signals into the window

Horizontal Axis changes between linear and logarithmic display of the frequency axis for frequency-based signals.

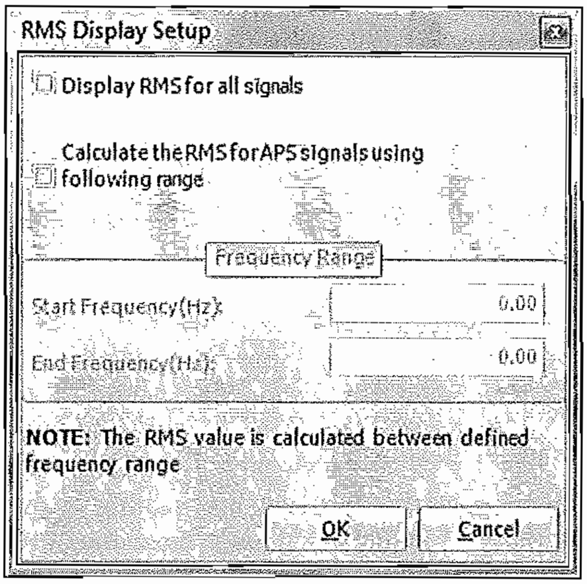
Vertical Axis changes the vertical axis to decibel (dB) or linear magnitude (Mag) scaling. This is only available for frequency-based signals.

Spectrum Type defines the units for spectrum signals as either power spectral density (EU^2/Hz), energy spectral density (EU^2s/Hz), squared units ($EUrms^2$), peak units (EUpeak), or RMS (EUrms). Again, this only applies to frequency based signals.

Signal Color defines the color scheme used for the signal plot.

Report this window generates a report from the window in MS Word format.

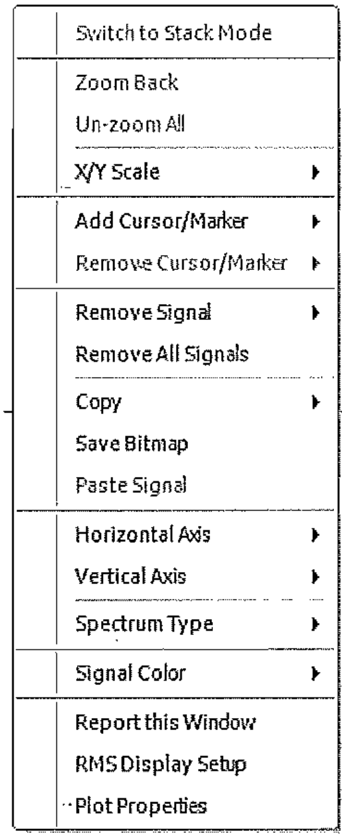
RMS Display Setup defines how RMS values are displayed on the plots. RMS values can be displayed for the overall signal on each plot or only for a specified frequency band.



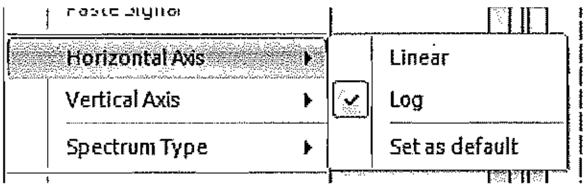
Plot Properties opens the Plot Properties section of the EDM Global Settings.

Frequency and Frequency Response Windows

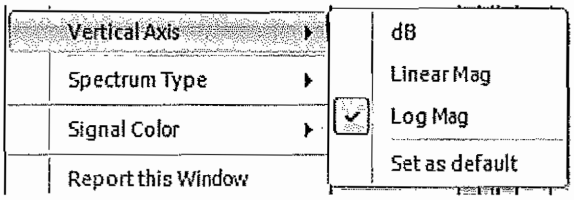
Windows that display data in the frequency domain have additional options to change how the spectrum is displayed. These options include the spectrum units and scaling for the X and Y axes. The contextual menu in Frequency plot windows has additional items for these settings.



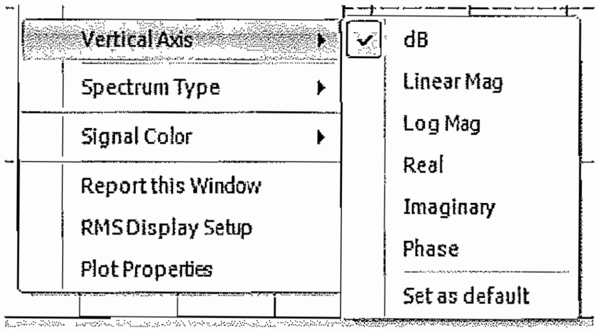
Horizontal Axis changes between linear and logarithmic scaling of the frequency axis.



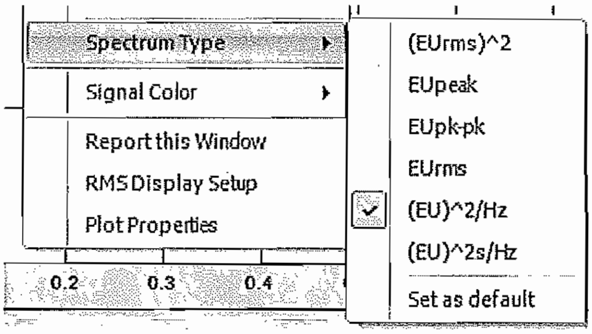
Vertical Axis changes the unit type and scaling of the vertical (ordinate) axis. For frequency plots of signals that only have magnitude values, such as auto power spectra, the options are dB units, linear magnitude, or logarithmic magnitude scaling.



Some frequency plots, such as linear FFT, cross-power spectra, and frequency response functions have complex ordinate values. Complex values have both real and imaginary parts, which can be converted to magnitude and phase. For these plots, there are additional options for displaying the real values, imaginary values, or phase (in degrees).



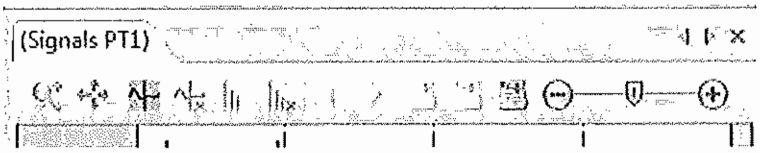
Spectrum Type defines the units for spectrum signals as either power spectral density (EU^2/Hz), energy spectral density (EU^2s/Hz), squared units ($EUrms^2$), peak units (EUpeak), or RMS (EUrms).



In all these settings, there is a default option that defines what is set for all new windows. This default can be changed by making the desired settings and selecting **Set as default**.

Display Window Toolbar

When a window is in focus, the Quick Access Toolbar will appear. All the commands shown in the Quick Access Toolbar can be accessed through the contextual menu as well, but the toolbar makes common commands accessible with one click. Hovering the mouse over a button will show that button's function. Some of these functions have been described above.



Zoom Back: zoom out to the previous zoom state

Auto Scale: automatically scale the X and Y axes

The Cursor and Marker icons control the display of cursors and markers on the current plot. See the next section.

Scroll Left/Previous Frame, Scroll Right/Next Frame: When a time stream is being displayed that is longer than what is currently visible, these buttons scroll through the time record. When a window is displaying a block signal with more than one data frame, these change which frame is displayed.

When a window is displaying a block signal, the right side of the toolbar shows the current and total frame count

When a time stream signal is being displayed, the **Global View** button is added on the right side. This view lets you control the time scale by clicking and dragging the arrows on the left and right sides of the gray bar that highlights the portion of the waveform that will be displayed in the main pane. This feature allows you to efficiently view long waveforms. The Global View can be hidden or revealed by clicking on the up or down arrow in the upper right corner of the view.

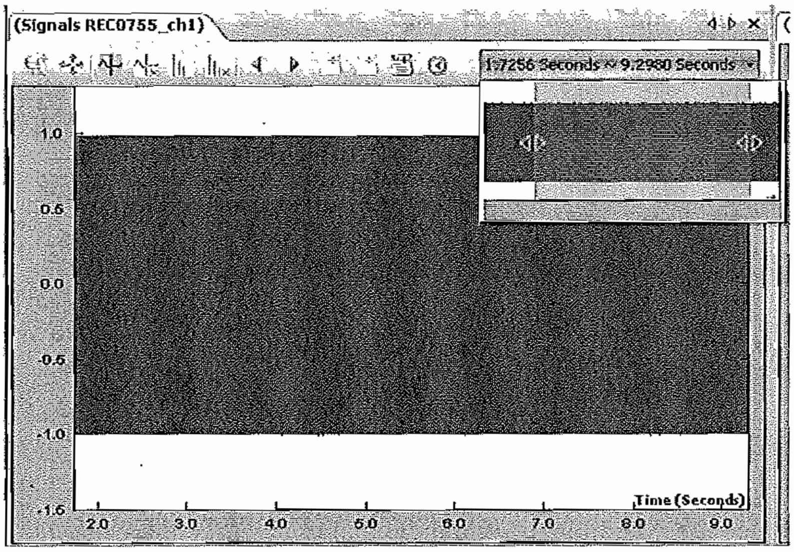


Figure 18. Global View for Time Waveforms.

Annotations: These buttons create a section, cursor, and text annotation on the current display. See the Annotations section below.

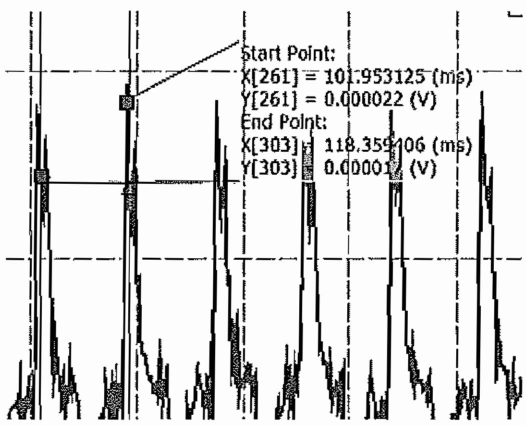
Absolute/Relative time: this toggles the displayed time values between relative time, where zero is the beginning of the time stream, and absolute time.

Time stream display duration: for live time-stream signals, this changes the total time duration that is visible.

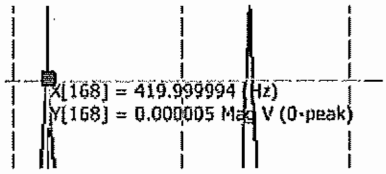
Annotations

Annotations are text notes that are attached to a display window. These notes can store signal attributes, cursor values, or user-entered text.

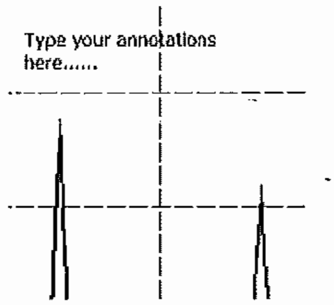
A section annotation displays signal values between two displayed cursors:



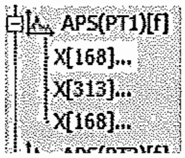
A cursor annotation displays the X and Y values of one cursor:



A user text annotation allows the user to enter any text.



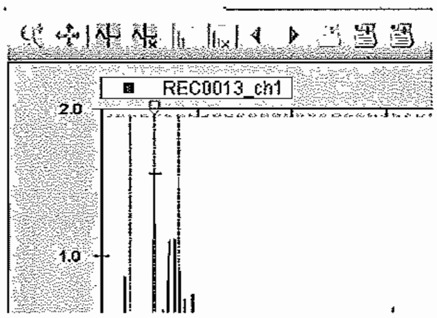
Annotations are also listed in the signal list.



Cursors and Markers

Cursors allow features of a waveform to be measured such as a peak value or the time between two events. Cursors are added by pressing the button on the toolbar or by pressing the space bar on the keyboard.

When any vertical cursor is enabled, pressing the up arrow will search for peak values in the vicinity of the cursor(s), and display those values.



A cursor can be moved by clicking and dragging it with the mouse. The arrow keys move all cursors together.

When a cursor is added to a window, the X and Y values are shown in the **Cursor** view on the right of the screen.

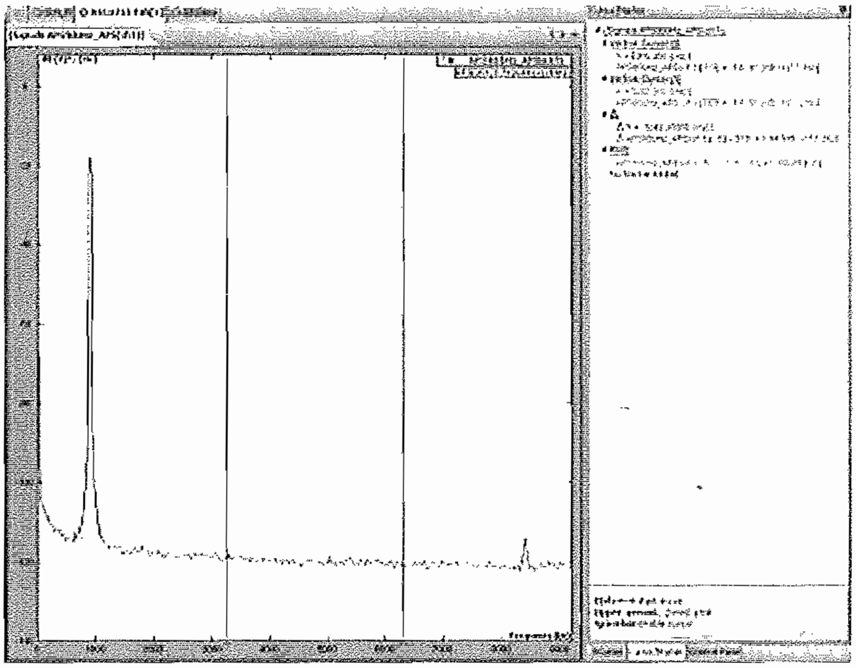
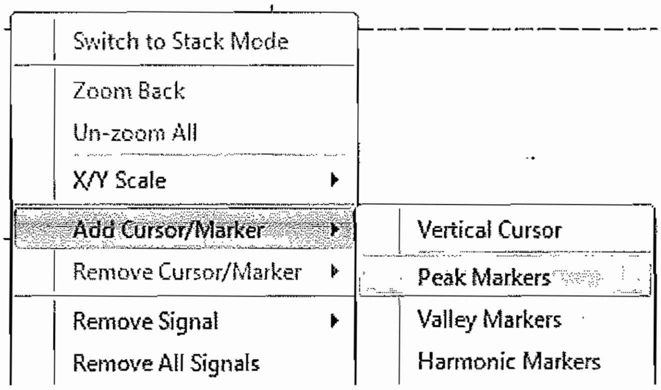
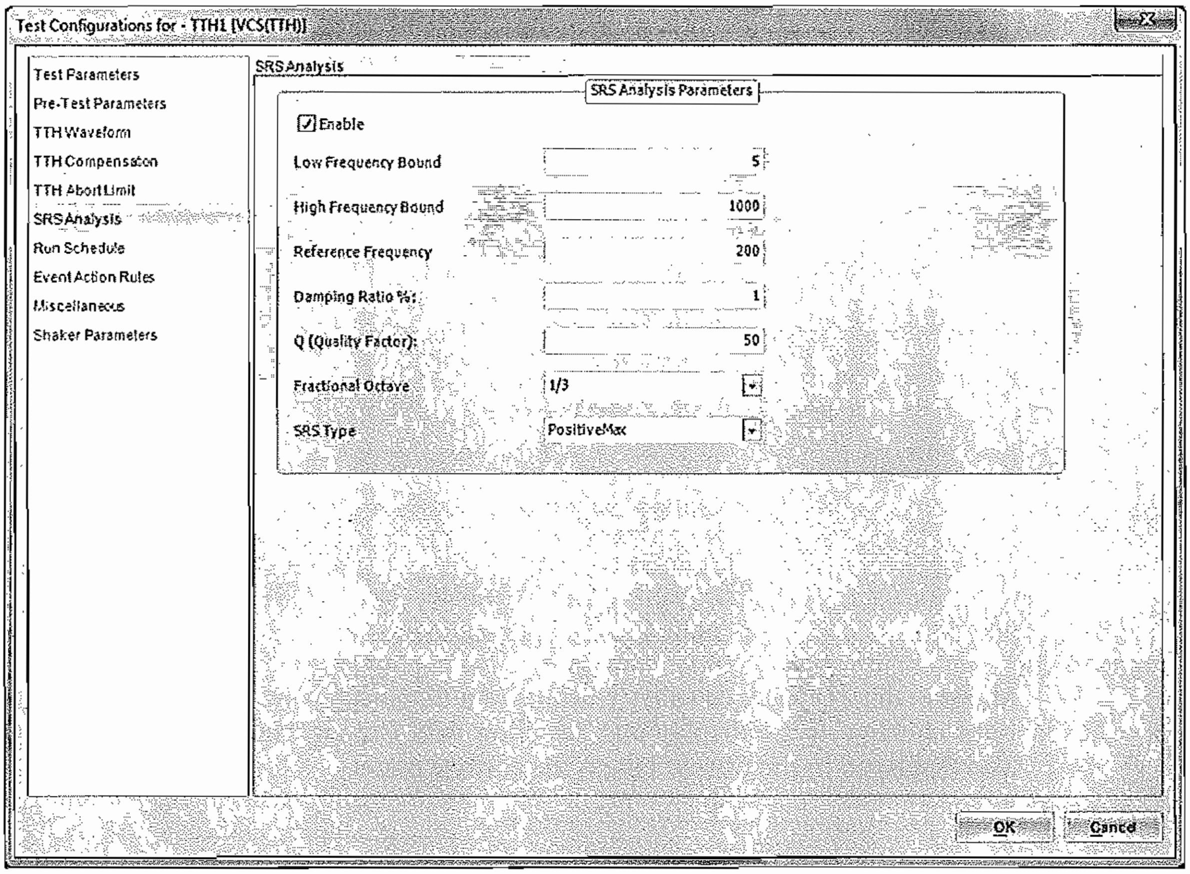


Figure 19. Pane with two vertical cursors

Markers display peak or valley features of a displayed waveform. Add markers by right clicking in the display and selecting Add Cursor/Marker. Marker data are also displayed in the Cursor tab on the control panel.



SRS Analysis

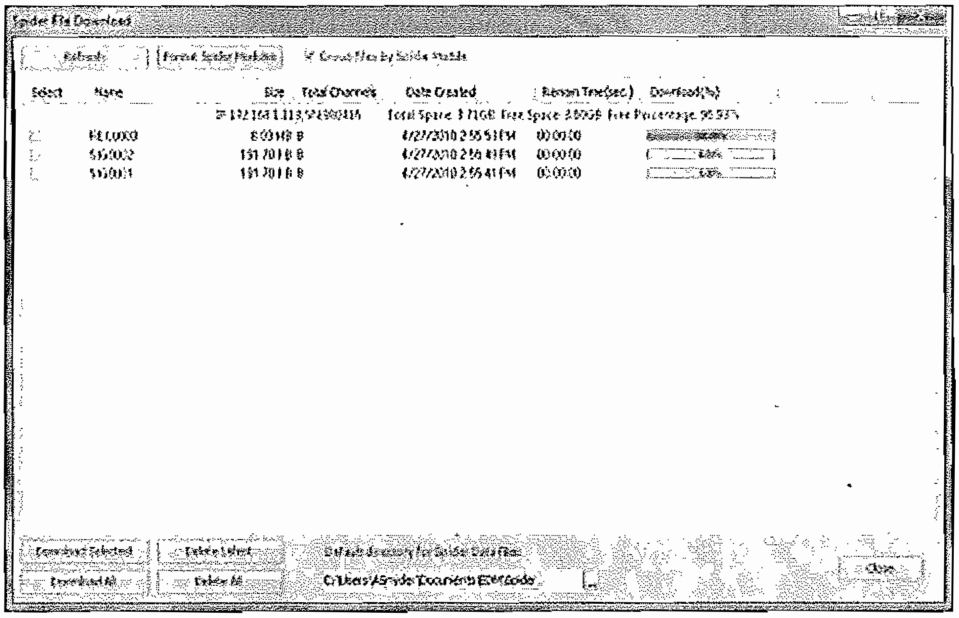


Saving and Recording Data

As previously described, there are two methods of data acquisition during a test: Saving and Recording. A save is activated by pressing the **Save Sigs** button on the toolbar, and saves block signal data to either the internal flash memory in the Spider or to the local disk (according to the Save/Recording Setup section of the Test Configuration window). Recording is activated by pressing **Rec.** button, and records time stream data to the internal flash memory.

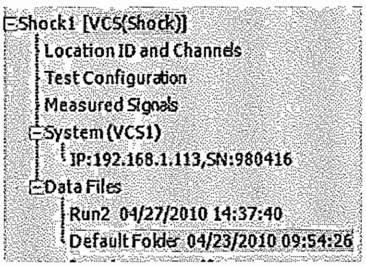
Under the Signal Setup tab, time stream signals have a Record List option and block signals have a Save List option. These options control which signals are included in a save or recording operation, respectively.

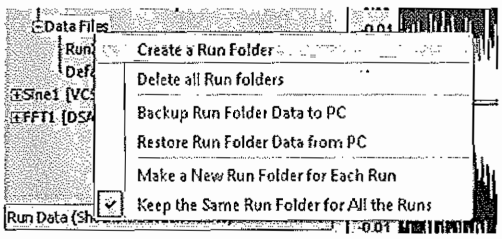
When recording or saving to the Spider's internal flash memory, the data files that are created are not visible in EDM until they are downloaded. To download files, select Download Data Files in the Tools menu.



In the window that appears, all data files associated with the current test will be shown. To download a file, click the checkbox next to the filename and select **Download Selected**. More than one file at a time can be selected to download, and all files can be downloaded at once by clicking **Download All.**

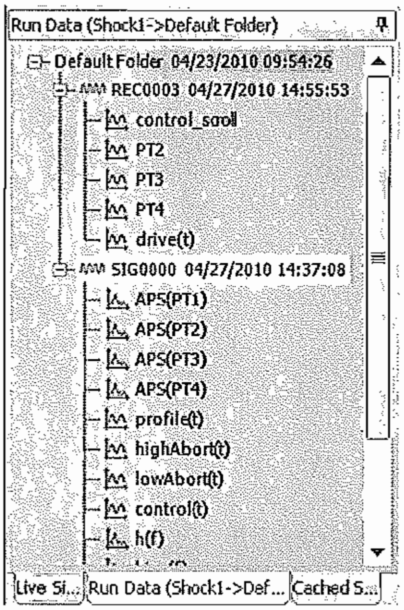
Downloaded files will be saved to the default run folder. This folder is listed under the Data Files section of the current test. Files saved directly to disk will also be saved here.





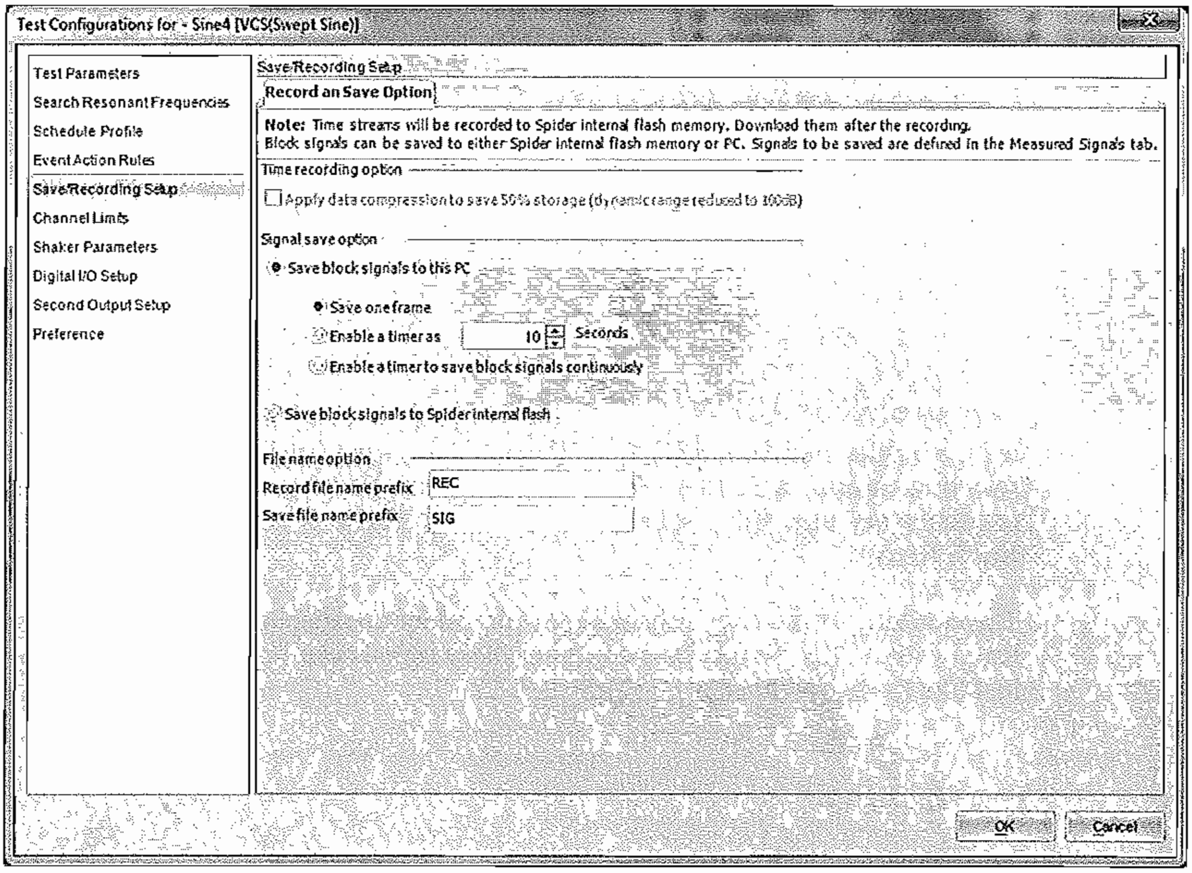
A new folder can be created by right clicking on the Data Files header and selecting **Create a Run Folder**. You can also choose to have a new run folder created every time the test is run by selecting **Make a New Run Folder for Each Run**.

The contents of the currently selected run folder are displayed below. Each file is listed with all the signals they contain. These signals can be displayed in windows just like the live signals.



Save/Recording Setup

There are options for the Save and Recording functions in the Test Configuration window.



The options include enabling data compression, the target location for saving block signals, and the data file name prefixes.

Data compression can be used on the recorded time streams, which saves the data at a lower resolution reducing storage requirements by up to 50%. Block signals can be saved to either the internal Spider flash memory or the local hard drive. Note that this only applies to saved block signals, and time streams are always recorded to the internal flash memory (they can be downloaded the PC later).

When the local PC is set as the target, there are different options for the Save operation. **Save one frame** is the conventional save action, which saves one block of all the signals on the save signal list immediately when the Save Sigs button is pressed. The next option is to save the blocks once every timer duration. This will occur repeatedly until the Save Sigs button is pressed again. The last option is to continuously save blocks for one entire timer duration.

Using Libraries

A number of settings, including the Channel Table, Reference Profile, Run Schedule, Event Action Rules, and Shaker Parameters allow the use of libraries. When linked to a library, the settings are saved to the library and are updated if any changes are made to it from within another test. For example, if the same shaker is used in multiple tests a library can be created for its shaker parameters. If one of these settings is changed, this change will be reflected in all the tests that are linked to that library.

To create a new library file based on the currents settings, click **Save To Library** and enter a name and (optionally) a description. When a name is assigned, it is set to public and other tests can refer to.

To make the library the default selection in all new tests, click **Save As Default**. In all future tests, the library name will show up in the Library Reference drop down menu. Selecting it in the list will link the current test to the library and replace the current settings with those of the library. To delete the library, press the red X next to the name. Click **Set To Private** to unlink the test from a library and use private settings instead.

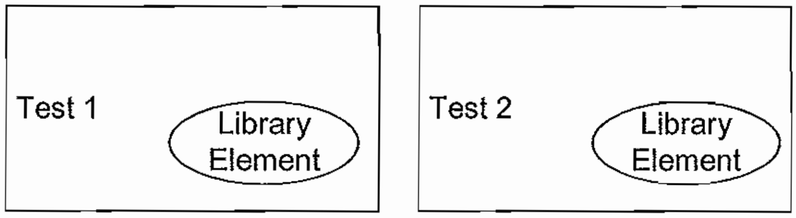


Figure 20 Set the Library Element as "Private"

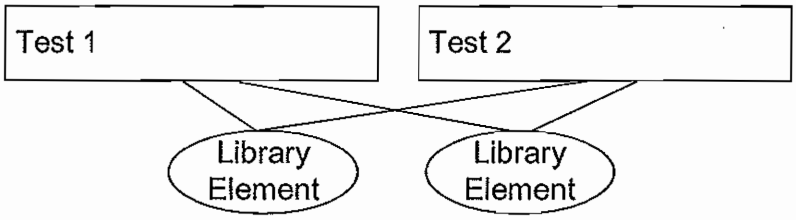


Figure 21 Set the Library Element as "Public"

Using libraries can save lot of setup time. For example, in a testing lab, each time when the sensors are calibrated, the sensitivity values will be changed. Without using a library, the user has to manually change the sensitivity values in all the tests. Using a library, they will only need to change the value in one location and let the all the tests reference to that channel library element.

Event-Action Rules

During the course of operation of a test, there are many events that can occur. These include certain response levels being reached, limits being exceeded, and user events such as pause or stop. The Spider system offers the most flexibility in controlling the operation of the system by making the response to these events completely customizable.

Event-Actions Rules define the response of the controller to these test events. Many actions are available as custom responses, such as sending an email to a mobile phone or shutting down the controller.

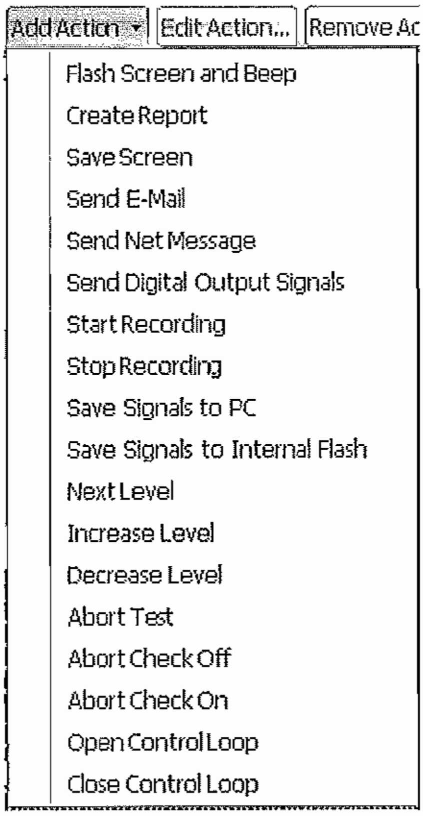
System Events

System generated events include user-stop, channel overload, output maximum, exceed high abort or alarm line, below low abort or alarm line, RMS high than alarm or abort, RMS lower than alarm or abort, any of digital input events.

Event	Test Mode	Description
Exceeds High Abort Line	VCS	Control channel over abort line in test profile
Exceeds High Alarm Line	VCS	Control channel over alarm line in test profile
Below Low Abort Line	VCS	Control channel below abort line in test profile
Below Low Alarm Line	VCS	Control channel below alarm line in test profile
RMS Higher than Abort	VCS	Overall control signal RMS higher than abort level
RMS Higher than Alarm	VCS	Overall control signal RMS higher than alarm level
RMS Lower than Abort	VCS	Overall control signal RMS lower than abort level
RMS Lower than Alarm	VCS	Overall control signal RMS lower than alarm level
User Pressed Stop	All	User pressed STOP button in EDM or on Spider unit
Any Channel Overloaded	All	Input level of any channel exceeded maximum input range
Output Reaches Maximum	VCS	Maximum output level, as specified in test parameters, has been reached
Control Channel Overloaded	VCS	Input level of control channel exceeded maximum input range
Control Channel Lost	VCS	Control channel signal lost
Receive Digital Input #xx	VCS	Received input event from digital input channel number xx
Just Triggered	DSA	Trigger event occurred, according to trigger settings
Output Reaches Maximum	DSA	Output voltage level has reached the maximum output range of the Spider

Actions

Flash screen, beep, create report, save screen, send emails, send Windows message to other program, set digital output signals, start recording, stop recording, save signals in the list, next level, increase level, decrease level, abort test, abort check-off, abort check-on, open control loop and close control loop.

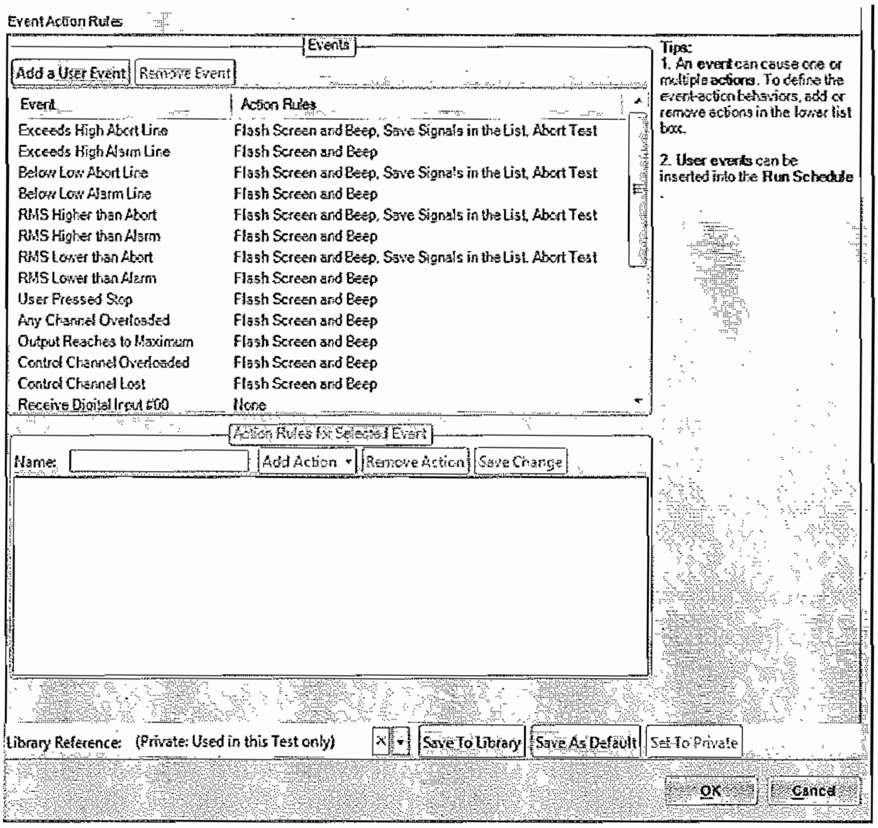


No more than 5 Actions can be inserted into the same event. The controller will prevent generating too many Actions within a very short time period.

User Defined Events

Aside from the events generated by the control system, the Spider allows the user to define their own events, and insert these events into a run schedule. These events then can then trigger user-defined actions.

Event Action Rules Setup

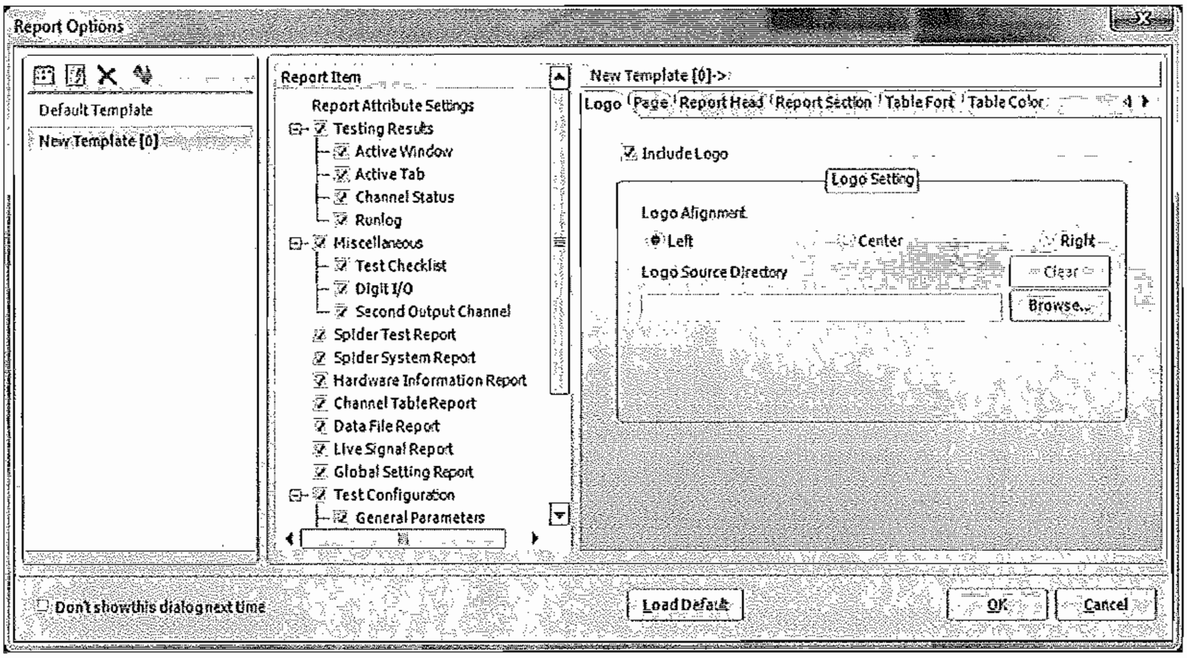


The Event-Action Rules tab in the Test Configuration window defines the actions that will occur in response to test events. User-defined events can also be created here with custom. The list box on top lists all the events and their actions. System events are blue and user defined events are green. When an event is selected here, its associated actions are listed below. Use the buttons on the top of the lower list to add or remove actions, to rename user events, and to save the changes.

Reports

EDM can generate customizable reports in Microsoft Word format that summarize the test setup and results (Microsoft Word 2003 or later is required to be installed for this feature). Reports are generated from templates, which define the formatting and what data is included.

To define a new template, select **(Define Template...)** in the **Report** menu.

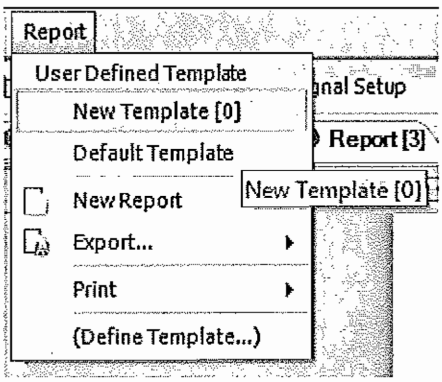


On the left column, all the defined templates are listed. The rest of the window shows the settings for the selected template.

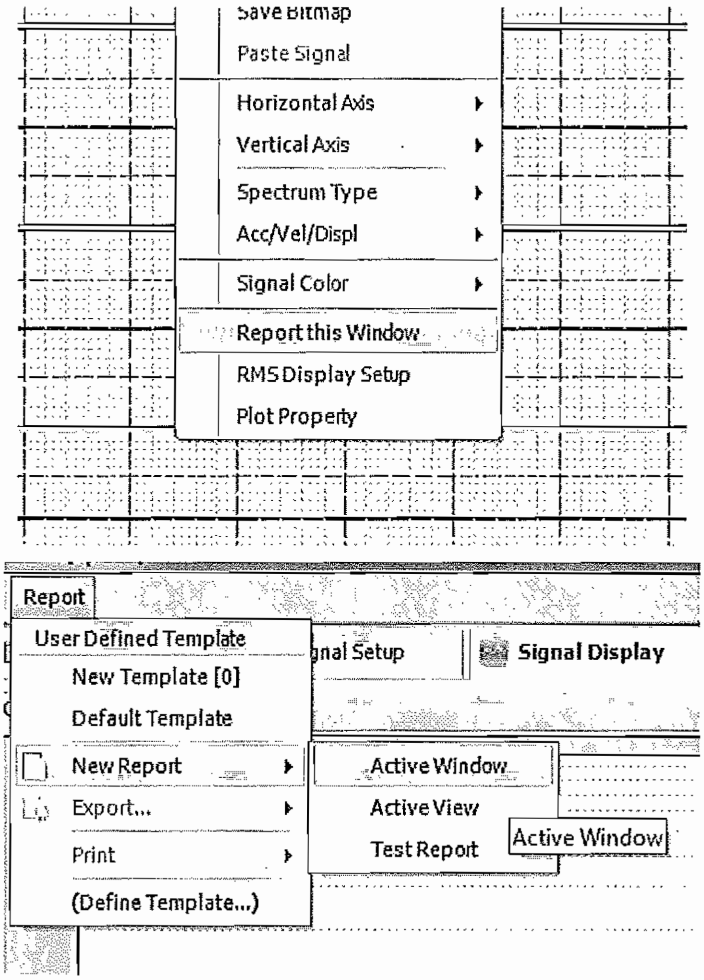
The middle column shows all the items that can be included in the template. Unchecking the box next to an item will exclude that section from the report. The **Active Window** item will include the currently selected display window in the top of the report. You can also create a report that only has the active window and none of the other sections, see below.

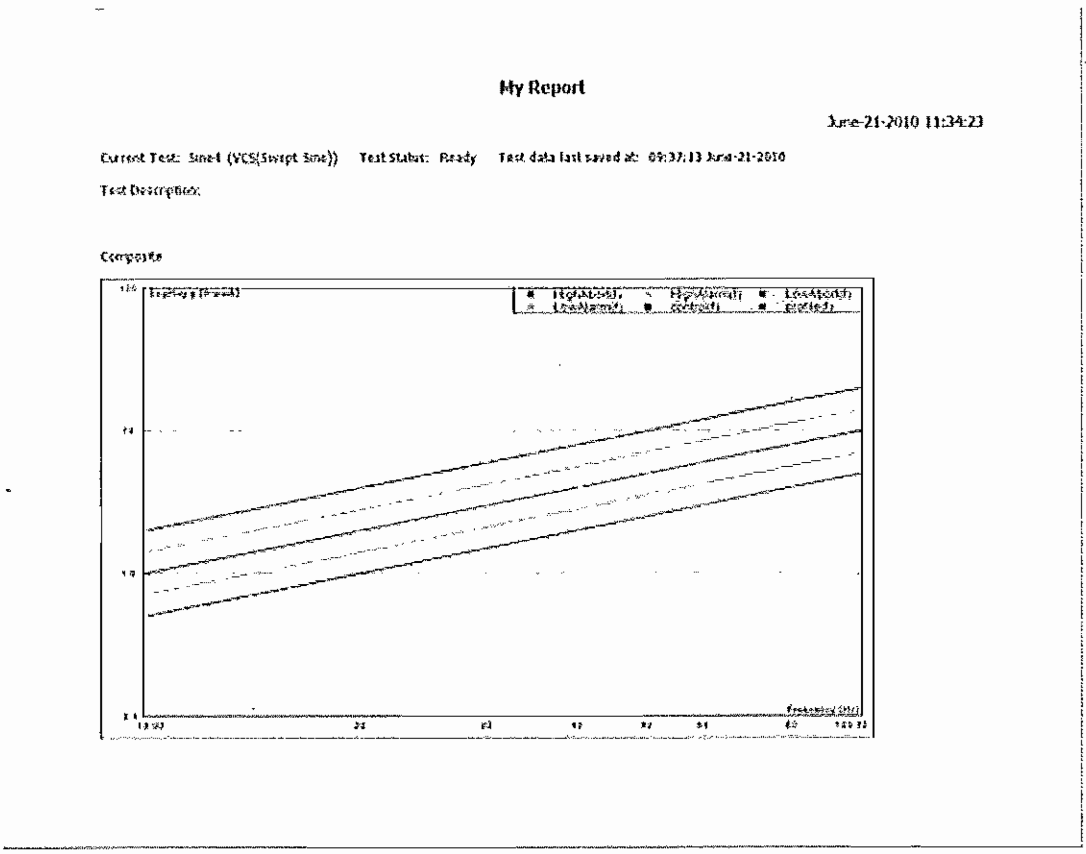
The right side of the window has 7 tabs for controlling the format of the report.

Once a template has been created, a report can be generated by selecting the template name from the Report menu.



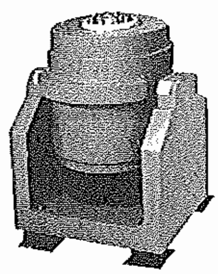
You can also generate a report that only includes one plot. To do this, configure a display window in EDM the way you would like. Annotations and cursors will be included in the report. Then, make sure that plot is selected, and right click in the plot area and select **Report This Window**. You can also select **New Report -> Active Window** from the **Report** menu. This will use the Default Template to control the formatting of the report.





Similarly, you can create a report that includes only the plots in the current view tab by selecting **New Report** -> **Active View**. Selecting **Test Report** will create a report with all the items enabled in the Default Template (it is the same as selecting **Default Template** in the **Report** menu.

Shaker Rating and Shaker Parameters



Shakers have limits in the maximum force, acceleration, and displacement they can output. The EDM software, in all tests, has checks to ensure these limits are not exceeded. The limits give the *capacity* of the shaker, and EDM calculates the *demand* of the current test setup. If the demand exceeds the capacity, the test cannot be run.

Force

For force ratings, shakers usually specify the maximum force for sine, shock, and random tests separately. The sine and shock ratings are given as peak units (in pounds or kilonewtons) and the random rating as RMS units. The random force rating assumes a certain spectrum shape (usually flat) over a given frequency range (usually 20 Hz to 2,000 Hz).

The above gives the force capacity. To calculate the force demand, the total mass of the shaker system must be known. It must include all of the moving masses involved in the actual test setup, including the shaker armature and payload. This mass value may be different for vertical axis testing and horizontal axis testing.

In EDM, the mass consists of two parts: a fixed amount present before the payload is applied, and the payload mass.

As the frequency range of the vibration test increases, it is safe to assume that some or all of the mass components included in the estimate do not actually behave as "masses". As the structure interacts with the shaker acceleration, some of the dynamic force may be absorbed by some mass elements. This effect, which must be taken into account as part of the overall force estimating process, decreases the calculated value of force.

Once the mass is known, the force demand is calculated based on Newton's second law, F=MA, where A is the acceleration demand of the current test.

Acceleration

Acceleration ratings for shakers may or may not be given separately for random, sine, and shock tests. The peak rating for a sine test is usually different than the peak rating of a shock test because a sine test requires continuous operation.

The acceleration demand is taken from the test specification. For sine vibration and shock test, the acceleration peak value is usually used. For random, the acceleration RMS value is used.

Displacement

Electrodynamic shaker armature displacement is limited by the axial length of the armature coil and the physical limitations of the armature suspension system. Since shakers have a limited operating displacement, it is most common to refer to displacement in peak to peak terms, also called *stroke* or *double amplitude displacement.*

Stroke is the most critical limiting parameter of the shaker.

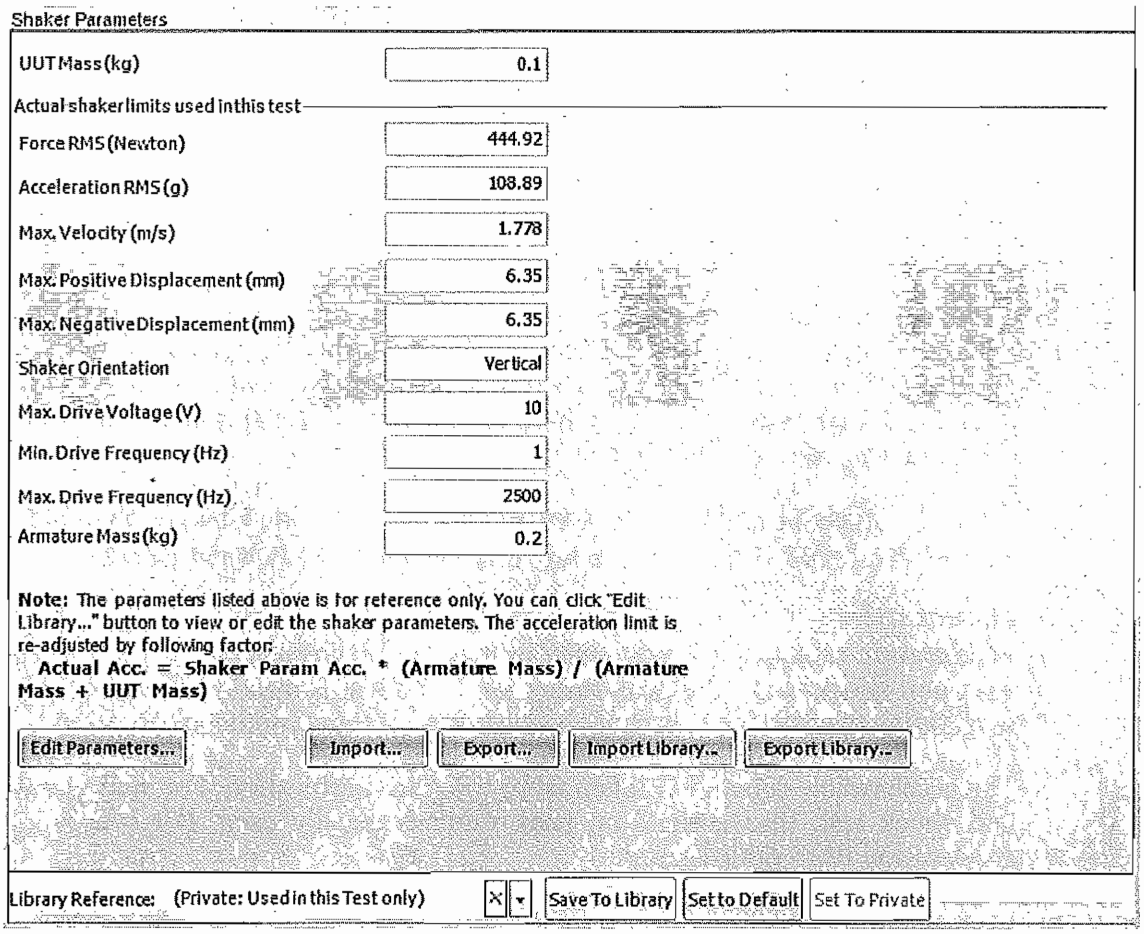
The displacement demand is calculated from the test profile.

Amplifier Input Voltage Limit

The power amplifier is not part of shaker; however in EDM, for safety, the maximum voltage range of the power amplifier is set as one of the shaker parameters.

Setting Shaker Parameters

Shaker parameters are set in the **Shaker Parameters** tab in the Test Configuration window. They should be set to the specifications of the shaker being used.

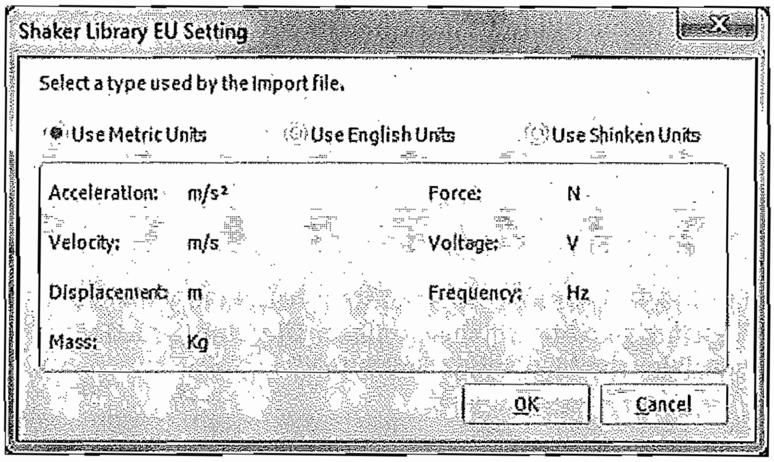


Click on *Edit Parameters...* to change the values. The shaker parameters can also be imported from a text file by clicking the *Import...* button. They can be exported to a text file for use in other tests by clicking the *Export...* button.

For sharing shaker parameters among multiple tests within the same database in EDM, use the **Library Reference**. Make the settings and click *Save To Library*. This library entry can then be accessed in all other tests.

A library can be imported from or exported to a comma delimited (CSV) text file. This file can contain the parameters for many different shaker models. This file may be, for example, provided by a shaker manufacturer for all their shaker models.

To import a library from a file, click on *Import Library...* Select the units that correspond to the units used in the file.



Then find the file from the Open dialog box. After importing, the models will be listed under the Library Reference menu.

Warning: The shaker parameter limits are not a guaranteed safety check. The acceleration, velocity and displacement limits of the shaker are checked against the measured control signals, not the actual acceleration, velocity, and displacement of the shaker. The force demand is calculated and not actually measured. The control signal may only approximately represent the shaker armature movement. When the UUT (Unit Under Test) has strong dynamic behavior, the control signal may not match armature movement at all.

This is a problem when the connection between the control accelerometer and the shaker armeture is overly flexible, causing the dynamic response at the control point to differ significantly from the dynamic response of the shaker. Figure 22 shows such an example.

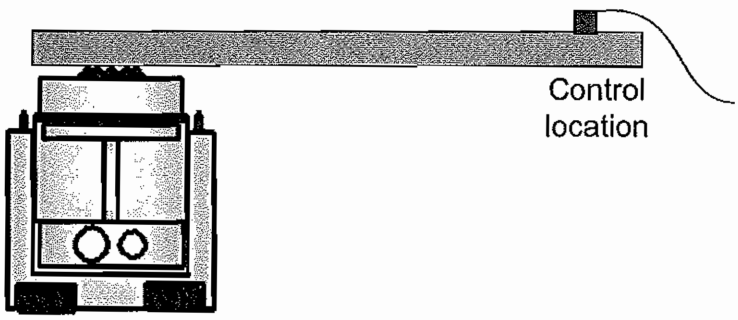


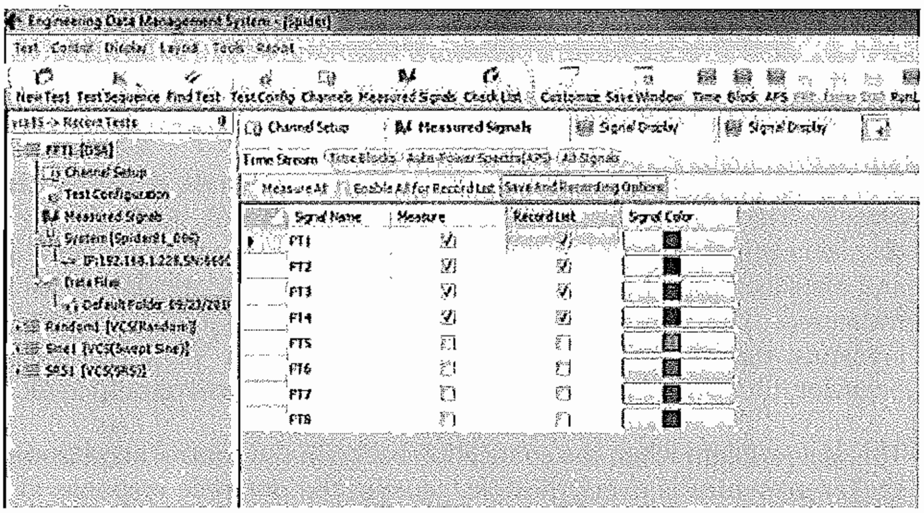
Figure 22 Example of an unstable control location

Black-Box Mode

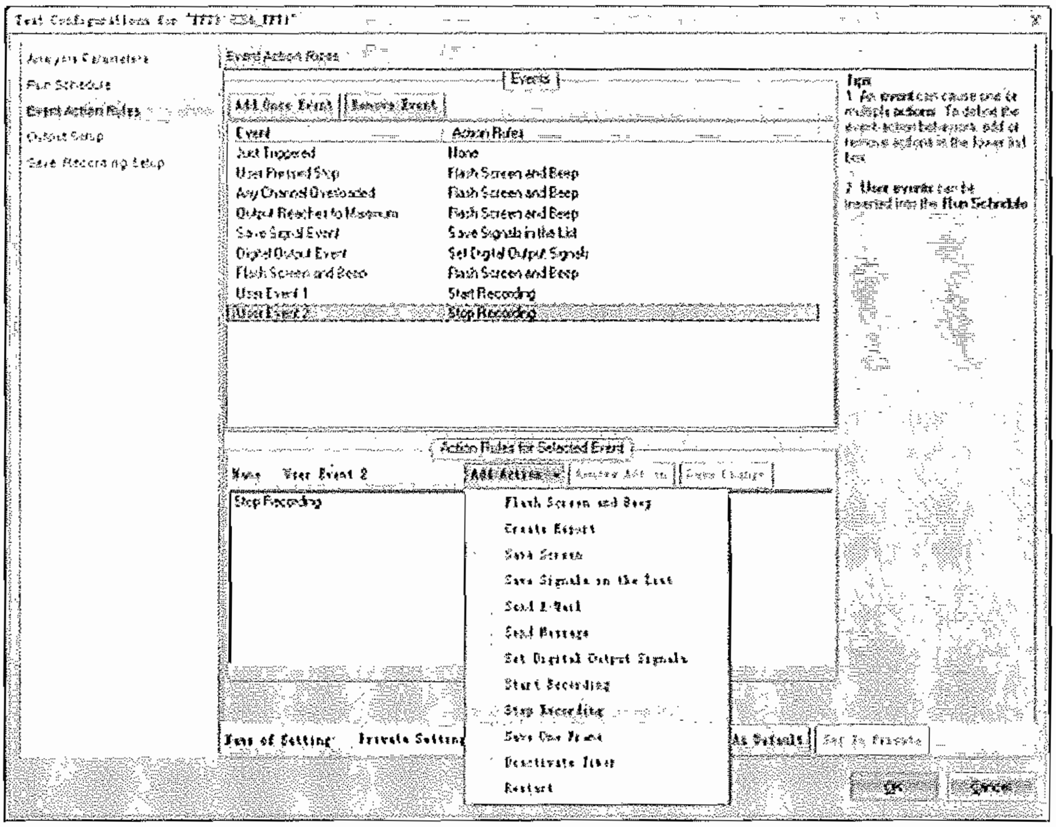
One of the unique features of the Spider platform is the Black Box Mode, which allows it to run autonomously without a computer connected. A computer is only used to configure the test, and to download data after the test is run.

Every time a test is run from a connected computer, all the test configuration data is uploaded to the Spider's internal memory. In normal operation, the computer remains connected while running to allow it to control the test and view the signals. However, all the signal processing is performed on board the Spider and not on the computer. Recorded data is stored on the internal memory in the Spider. This means the computer is not actually needed for the test, and Black Box mode takes advantage of this fact.

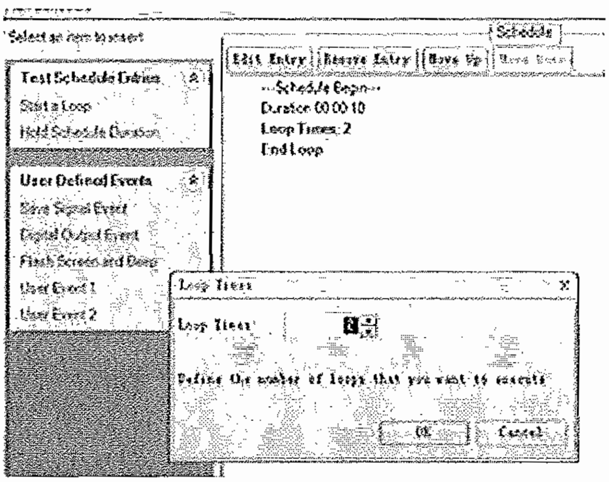
To run in Black Box mode, first set up a test, in any mode, on the computer. The test will run according to the items in the Run Schedule. Select signals to be recorded under the Measured Signals tab.



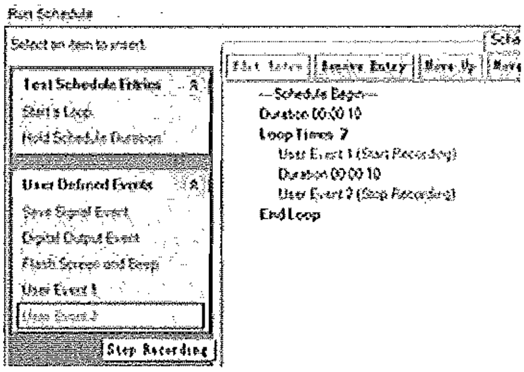
Under Event Action Rules in the Test Configuration window, create two user events: Start Recording Event and Stop Recording Event.



Set up the run schedule. Use a loop to have actions repeated a set number of times.

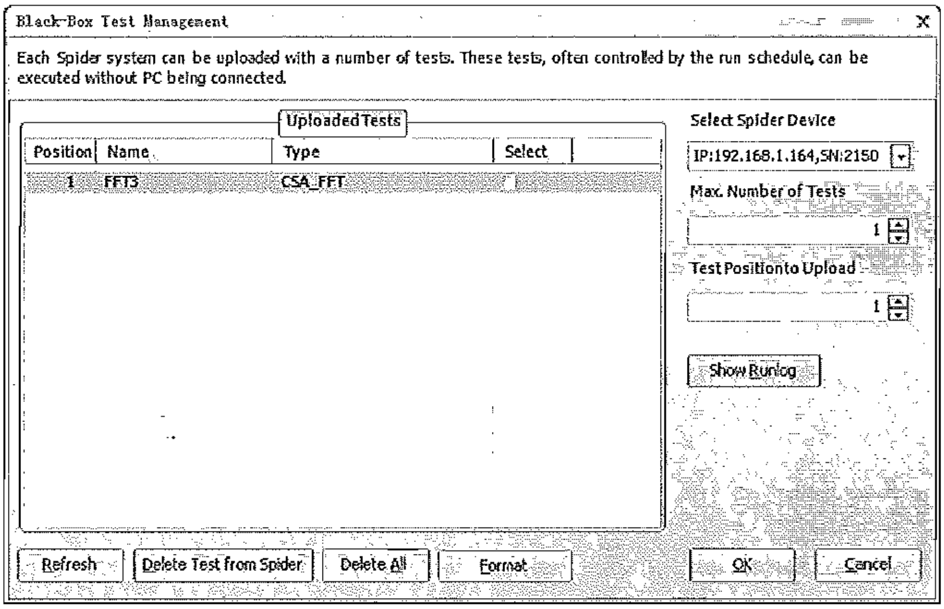


Insert the Start and Stop Recording events.



Then, connect to the Spider and run the test from the PC once. It is now loaded into the Spider's memory.

Select **Black Box Setup...** from the Tools menu and press Refresh button. The test will be listed under Uploaded Tests.



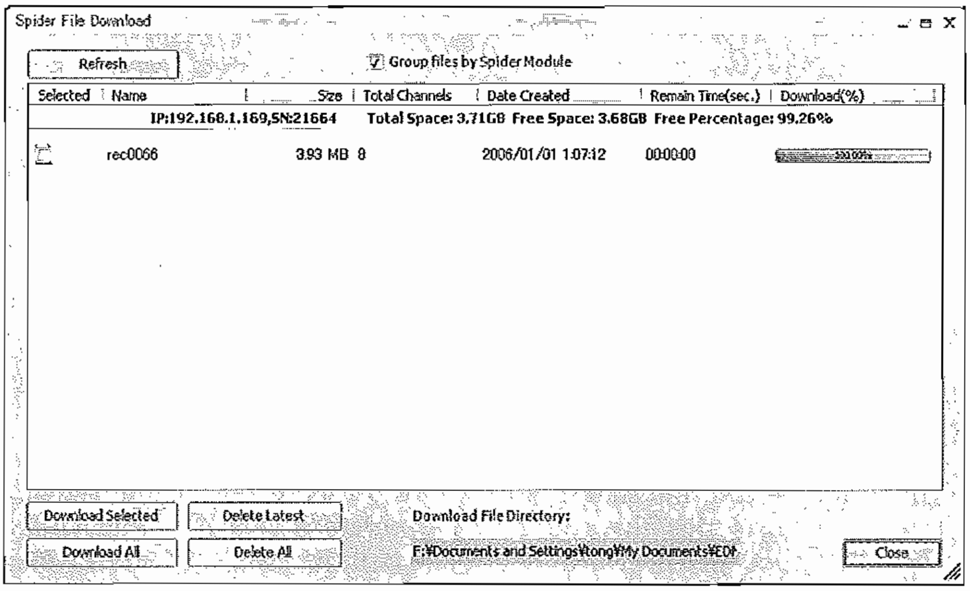
To upload more than one test, increase the *Max. Number of Tests.* Tests are always uploaded when run from a computer, whether Black Box mode is enabled or not. By default, the test in position 1 will be run. This can be changed from the front panel LCD display.

To select which test is run, press the right arrow key on the Spider's front panel until the Test List is shown. Then use the up and down arrow keys to select a test. When the Start button is pressed, the selected test will be run.

To start the test in Black Box mode, disconnect from the Spider and exit EDM. Press the **Start** button on the front panel of the Spider. Test status info will be shown on the front LCD panel, ant the MEM LED will illuminate when signals are being recorded.

Press the **Stop** button to stop the test.

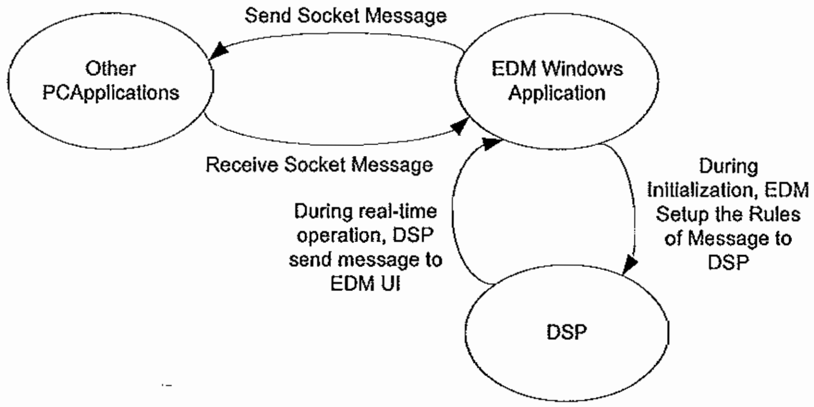
To download the recorded files, reconnect to the Spider in EDM, and choose **Download Data Files** from the Tools menu. Select the recorded files in the list and click on *Download Selected*.



The files will be downloaded to the current run folder. Click on the Data Files tab on the lower left part of the EDM to view the signals.

Using Socket Messages to Communicate with Other Applications

Socket messages are a convenient way for EDM to communicate with other Windows applications on the LAN.



The usage of socket messages in the EDM will be described in detail in a separate document.

Random Tests

In a random test, the shaker is driven by a wide band random signal. Feedback control adjusts this drive signal to generate a response that conforms to a specified **test profile**. The control algorithm calculates the inverse transfer function between the output drive and the input control channels, which is the composite of the amplifier, shaker, and UUT response. The product of the inverse transfer function and the response profile then gives the output drive spectrum. A phase randomizer and inverse FFT then generate the random drive output time stream.

The test profile is set under the Broadband Profile and Line Limits section of the Test Configuration window. The input channels used for control are set in the Input tab, accessed by clicking on **Location ID and Channels**. If more than one channel is selected as a control channel, the channels will be combined, in an average, maximum, or minimum strategy, to form the control signal. The FFT of this signal is the *control(f)* signal. The controller monitors the deviation of control(f) from the target profile and updates the output drive signal in real-time.

Safety Features

In Random mode, there are a number of safety features that help prevent damage to the shaker and related equipment. During a shake test, 5 different types of checks are performed and an event is triggered if any of the checks fail. The response actions to these events can be customized under the Event-Action Rules. The 5 checks are 1) the broadband profile line limits, 2) Maximum shaker drive voltage limiting, 3) Channel overload or loss detection, 4) RMS limits, and 5) Limit channels.

The test profile sets limits for the spectral lines of the control signal. If the control profile falls outside these limits, alarm or abort events will be triggered.

As another safety feature, Spider detects when input channels are overloaded or lost which can indicate a sensor fault or an accidental disconnect. Spider will abort the test if this occurs.

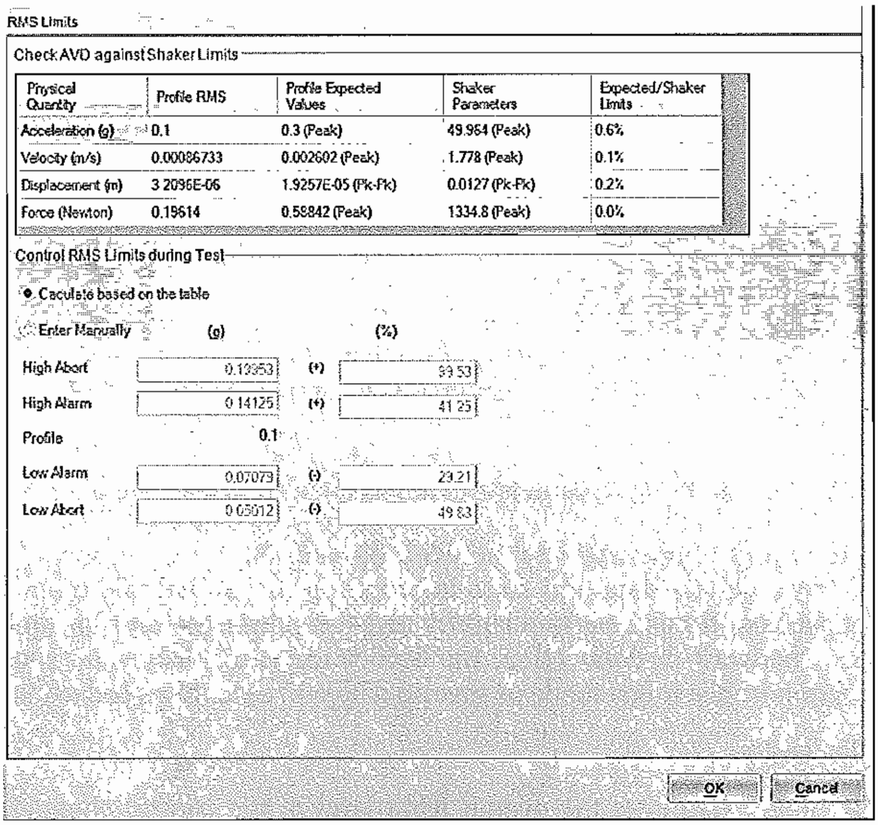
The Spider also detects when input channels are overloaded or lost which can indicate a sensor fault or an accidental disconnect. Spider will abort the test if this occurs.

RMS limits and limit channels are described in their own sections below.

In the event of an accidental network disconnection or power loss, the Spider is able to save test data and state information to non-volatile memory to protect against loss. It has a backup battery that can power the unit for up to 8 minutes. For a network disconnection, the Spider can either continue running the test program in Black Box mode or save all data and execute an orderly shutdown.

RMS Limits

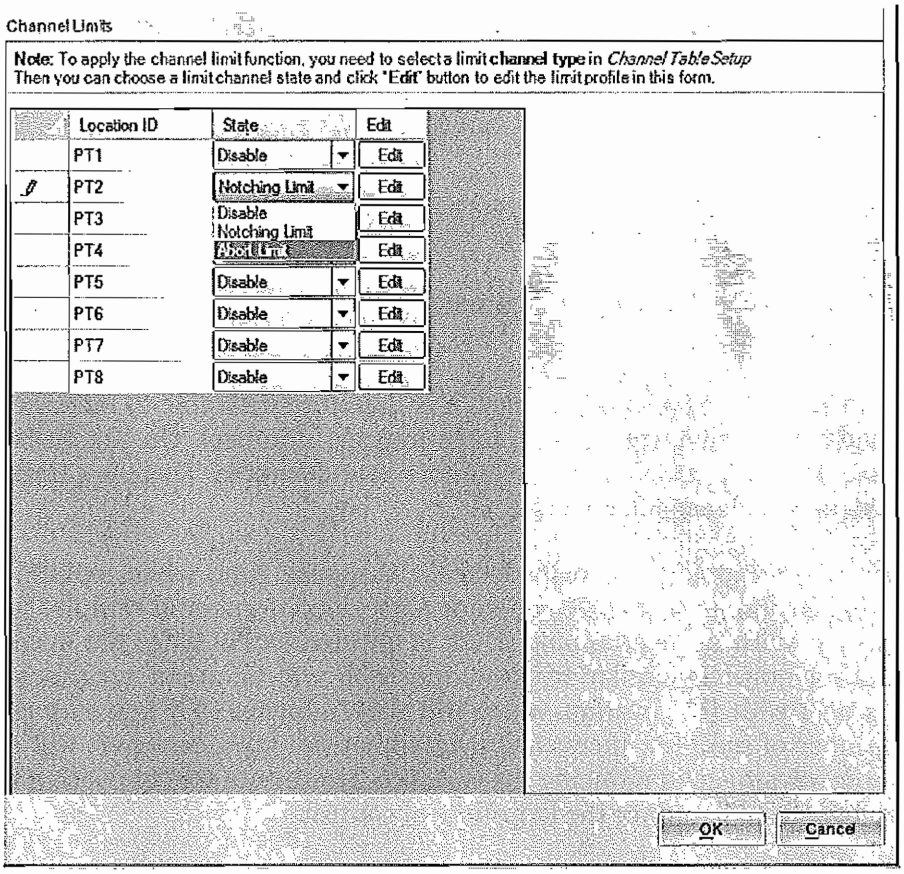
The Spider monitors the overall RMS level of the control channel (or for each channel if more than one control channel is used), and triggers an alarm or abort event if this level exceeds or drops below pre-defined limits. These limits are set under the RMS Limits section of the Test Configuration window.



The table at the top gives the expected RMS and peak values for the current broadband profile, the peak safety limits of the shaker, and the proportion of the profile values to the shaker limits as a percentage. This data comes from the given profile settings and the shaker parameters and cannot be changed here. Just like in setting the broadband profile, EDM has RMS limits for high- and low-alarm and high- and low- abort. These events trigger their associated actions defined in the Event Action Rules. The values are calculated automatically, but can be entered manually as an absolute magnitude or as a percent change relative to the profile RMS.

Limit Channels

Any input channels can be set as **limit channels.** These channels are given limiting spectral profiles (separate from the test profile), and if the spectrum of these channels exceed their profile and event is triggered. These limit channels can be set as either Aborting or Notching. Abort limit channels will abort the test when the response exceeds the limit. Notch limiting channels will lower the output until the response falls under the limit. These options are set under Input Channel Setup.



To enable a limiting channel, first set the channel type to Limit in the Channel Setup tab, and then select either **Notching Limit** or **Abort Limit** in the State column here. Click **Edit** to bring up the limit profile editor. Click **Insert** or **Append** to add lines to the profile.

Averaging and DOF

In Random mode, an estimate of the spectral values of the input control signal is generated by averaging the spectral transforms of multiple blocks. These blocks may be overlapped, where a specified proportion of samples are reused in subsequent blocks. A windowing function is applied to these blocks before they are transformed into the spectral domain by the FFT algorithm. A number of these blocks, set by the average number, are averaged together to create the spectral estimate. It is this estimate that the control algorithm uses in its calculation of the system transfer function.

Given a stationary system, it is desirable that this spectral estimate does not vary significantly from the true power spectral density of the underlying Gaussian process. Given an infinite average number, this estimate would indeed converge to the true PSD with zero variance. Unfortunately, such an average number would make the control loop time prohibitively large.

The spectral estimate varies along a chi-squared distribution with a Degrees-of-Freedom parameter given as a function of average number, block size, and window type. As the DOF increases, the variance of this distribution decreases. The relationship is:

$$DOF = 2\frac{E^2[P(f_n)]}{Var[P(f_n)]}$$

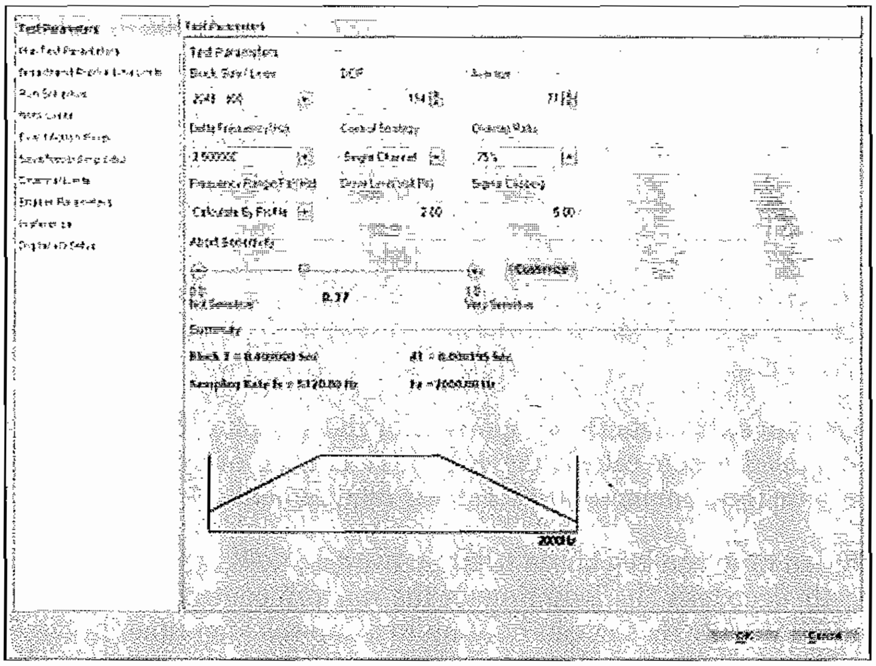
where $P(f_n)$ is the spectral estimate, E[] is the expected value, and Var[] is the variance.

On the basis of control accuracy, it is therefore desirable to increase the DOF as much as possible (by using a large average number). On the basis of response time, however, a large average number is undesirable. There is a tradeoff between accuracy and responsiveness.

Block overlapping can help decrease response time while maintaining a large DOF. Overlapping involves re-using a specified number of samples in subsequent blocks. With no overlapping, DOF is approximately twice the average number. With a non-rectangular window, the DOF will be about 1.3 times the average number with 50% overlap, which will allow a higher DOF value for the same total number of samples. Increasing overlap beyond 50%, however, will not yield any more advantage in reducing the variance. However a higher overlap ratio will still be beneficial to reduce the loop-time of control.

Test Parameters

In the Test Configuration window, the Test Parameters section has settings for the main analysis parameters, safety abort sensitivity, and control strategy of the random test.



Block Size/ Lines are the size of the time blocks, in number of samples, which the FFT algorithm transforms to the number of Lines in the frequency domain. Lines is the useful number of spectral lines. Increasing the block size increases the resolution of the frequency transform, and allows lower frequencies to be detected, but increases the calculation time and slows down response.

The ratio between Lines and Block Size is determined by the characteristics of A/D converter and anti-aliasing filter. In general, the ratio is about 0.46. It means that given an FFT transform size of 1024, the useful frequency lines is about 0.46 * 1024 = 471.

Average is the number of blocks that are averaged for the control spectrum. Increasing the average number will reduce the variance of the control spectrum.

DOF is the statistical Degrees of Freedom of the spectral averaging. It is a function of average number, data window and overlap ratio (see above).

Delta Frequency (Hz) is the spacing of the frequency lines in Hertz, and is a function of the block size and sample rate.

Control Strategy sets how the Spider system will use the input control channel(s). In Single Channel control, only one channel is used in the output feedback control.

Weighted Average control applies the weighting factor to every control input and then adds all the weighted signals together to produce the control signal. The factor for an input channel is equal to that input's weighting value squared, divided by the sum of the squares of the Weighting values for all the control inputs. If multiple control channels are enabled in the Input Channel Setup, Weighted Average is the default selection. The weighting factors are defined in the channel table.

Maximum control checks each spectral line, in all the control inputs, and produces a composite control spectrum based on the largest values at each spectral line.

Minimum control checks each spectral line, in all the control inputs, and produces a composite control spectrum based on the smallest values at each spectral line.

Overlap ratio sets the proportion of the samples in the time blocks that are overlapped when calculating the FFT. Higher overlap ratios result in faster response time but increase processing requirements.

Overlap ratio can be chosen from no overlap, 50%, 75% and 87.5%. Overlapping greatly decreases the loop time of the random controller. In older controllers, a 200 line/2000 Hz test can have up to a 100 ms loop time. In the CI controllers, the loop time can be reduced to 12.5 ms at the same line and frequency Range.

Frequency Range (Fa)(Hz) sets the maximum frequency resolved by the FFT transform by adjusting the sample rate. Selecting **Calculate By Profile** will set the sample rate based on the other settings especially the frequency range of profile.

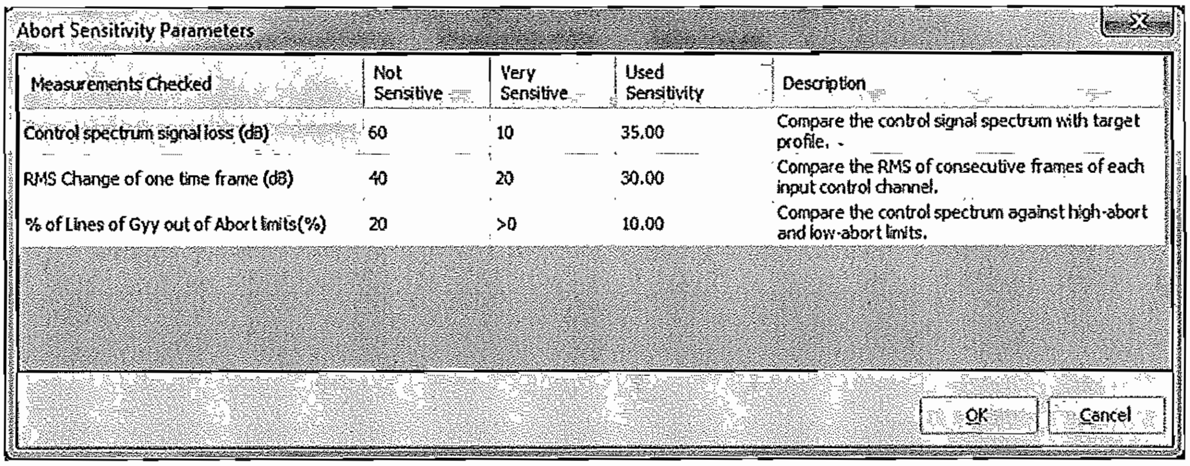
Given a profile, the frequency range can usually be calculated by the software. In some cases the user may want to truncate the frequency. Use any setting manually to truncate the frequency range.

Drive Limit (Volt Pk) limits the absolute maximum voltage output of the drive signal during the scheduled test. If the drive limit is reached but the control signal still could not reach to its target, the system will show a warning sign, Drive Maximized, on the control panel. For safety reason, output signal will not exceed the Drive Limit.

Sigma Clipping limits the peaks of the output voltage distribution. Any output level greater than this number times the variance of the output will be clipped. A special algorithm is developed to clip the output signal smoothly so no discontinuity will be output. Clipping produces non-linear effects that can significantly reduce the system's ability to control sharp resonances. This effect results from energy leaking across the test frequency range from the "square-wave" shape of the clipped peaks. The apparent noise floor will rise when a sigma clipping factor of 4 or less is used. In addition, signal energy out of the test bandwidth may be generated causing excitation of out-of-band resonances and poor control of resonances in the control frequency range under some conditions.

> Tips: People apply the Sigma Clipping in trying to maximize the shaker rating. If the vibration test is far below the maximum force rating of the shaker system, Sigma-Clipping should not be used.

The **Abort Sensitivity** slider is a quick way to adjust the safety abort parameters of the test. The values of these parameters can be adjusted by clicking the Customize button, which displays this window:


Abort Sensitivity Parameters

Measurements Checked	Not Sensitive	Very Sensitive	Used Sensitivity	Description
Control spectrum signal loss (dB)	60	10	35.00	Compare the control signal spectrum with target profile.
RMS Change of one time frame (dB)	40	20	30.00	Compare the RMS of consecutive frames of each input control channel.
% of Lines of Gyy out of Abort limits(%)	20	>0	10.00	Compare the control spectrum against high-abort and low-abort limits.

The slider adjusts these parameters between the Not Sensitive and Very Sensitive values. The **Control spectrum signal loss** is the maximum allowable difference, in dB, between the control signal peak and target profile, calculated before any averaging is done. The **RMS Change of one time frame** is the maximum allowable change in the RMS value of the control signal between successive time frames. The **% of Lines of Gyy out of Abort Limits** sets the maximum proportion of the response spectrum allowed to be outside of the test abort limits without causing an abort. Any exceedance of these values will immediately abort the test.

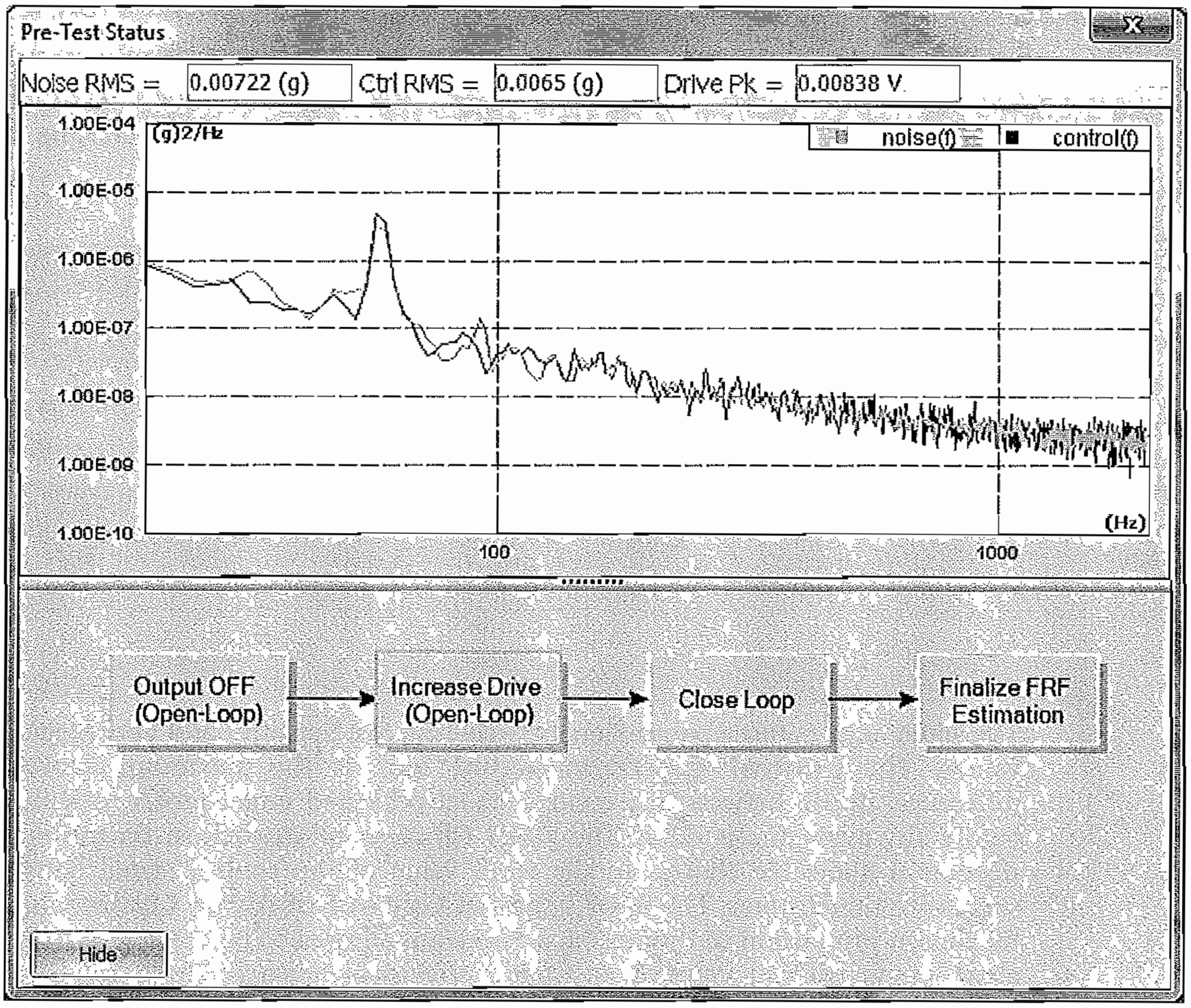
The software will interpolate the value between two ends and choose one proportional to the Abort Sensitivity slider position. The values in the Used Sensitivity column are calculated based on the current slider position interpolation.

Pre-Test

Before a shake test, EDM will run a pre-test to calculate an approximate Frequency Response Function (FRF) between the shaker output and the control sensor input. It consists of three stages:

1. A brief period with no drive output where the input channels are measured for the noise characteristics of the system
2. Outputting a small initial drive voltage

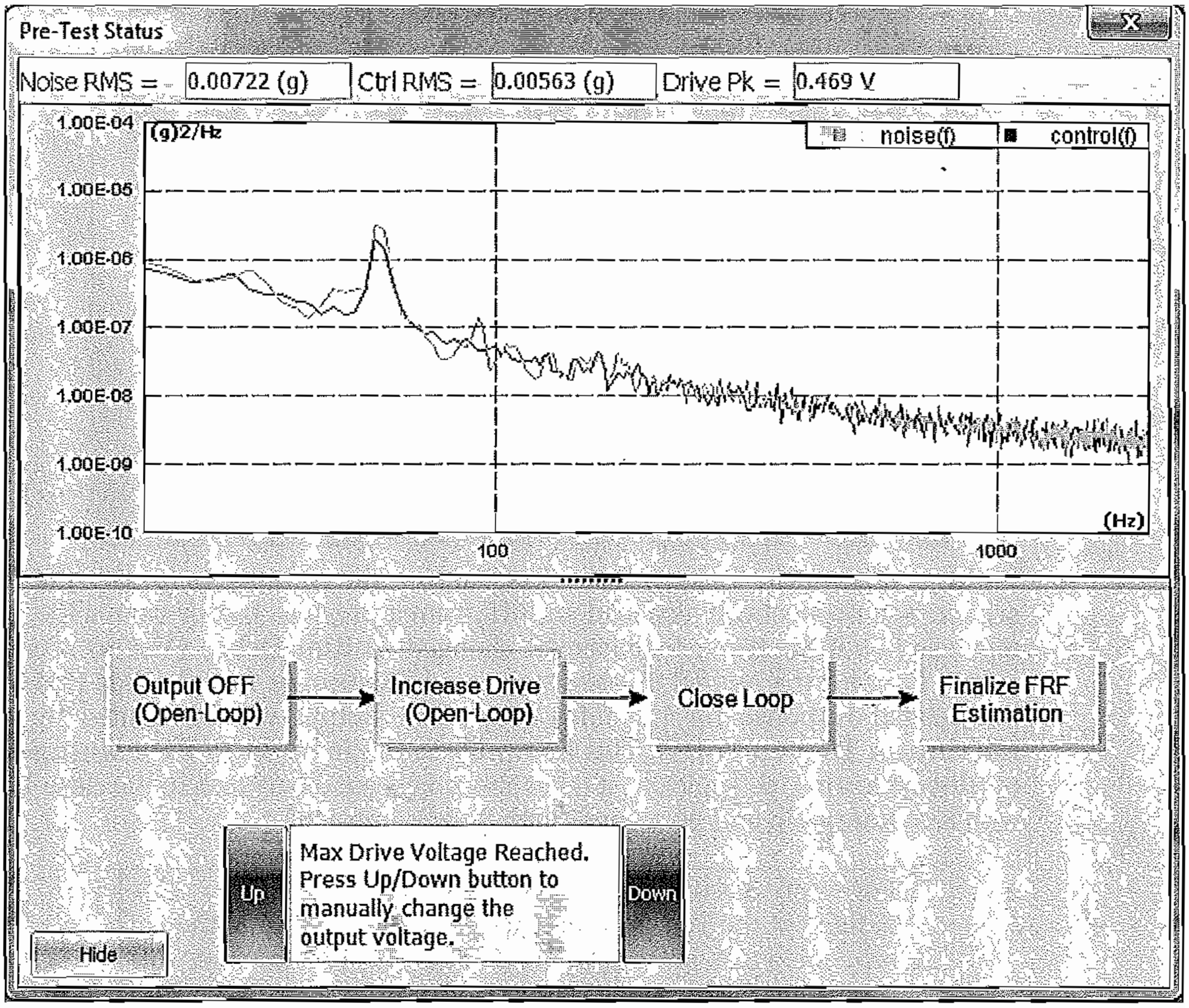
3. Ramping up the drive voltage until the measured response is at a small level in proportion to the target profile



This pre-test window shows the current state of the pretest and plots the noise and control signal spectrum. The grey noise signal is the noise floor of the system, found during the first step of the pre-test with no output on. At the top of the window, the RMS voltage level of the noise is shown, along with the current RMS voltage level of the input control signal and the RMS level of the output drive signal.

If, during step three, the maximum drive voltage is reached and the response has not reached a level that the controller can estimate the FRF (Frequency Response Function) at, an option is displayed to manually adjust the output voltage. This happens when the controller cannot detect the vibration signal in the control input that is higher than the noise. This can be caused by the following:

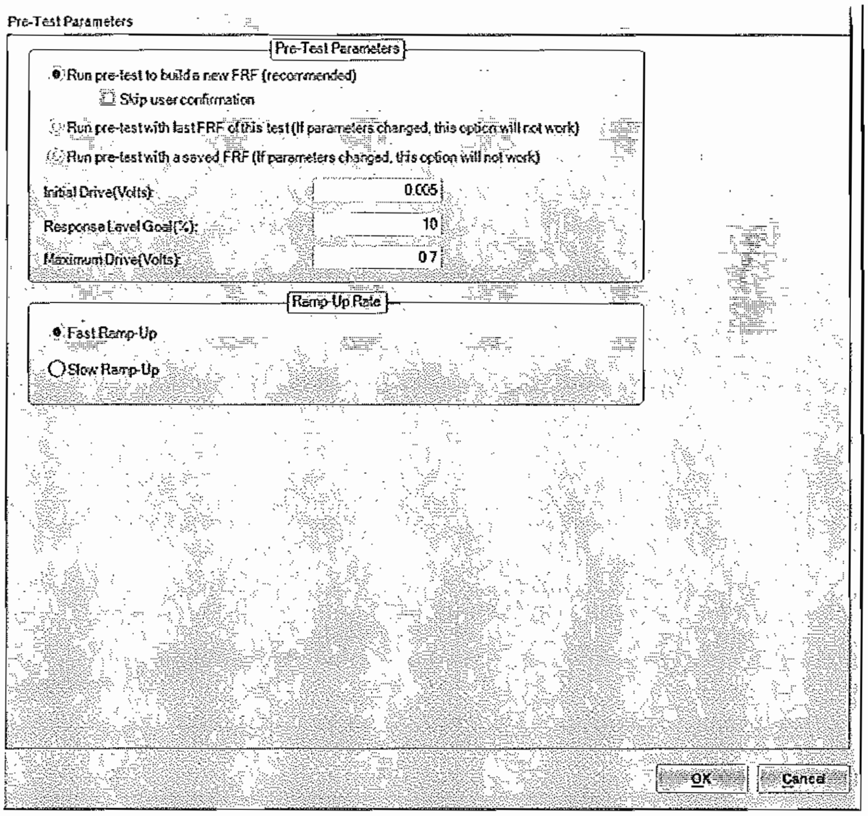
1. Drive cable is not connected properly
2. Amplifier is not turned on
3. Amplifier gain is set too small
4. Shaker table has a mechanical problem such that it does not move
5. Sensors are not mounted correctly
6. Sensors are bad and do not detect the signals
7. The sensors are not connected to the controller properly
8. The channel table of EDM is not set correctly. For example, with IEPE sensor, the IEPE mode must be turned on



When the controller detects the input vibration signal in the control signal, the drive signal will ramp up to a level that the controller determines the FRF can be estimated. It will then run at this level for a few seconds to estimate the FRF (this is the "Close Loop" step).

At the end of pre-test, the controller will estimate the peak drive voltage needed for the current test profile and compare it to the Maximum Drive setting. If the Maximum Drive setting in the Test Parameters is set too low, and error message will be generated

Pre-Test Parameters



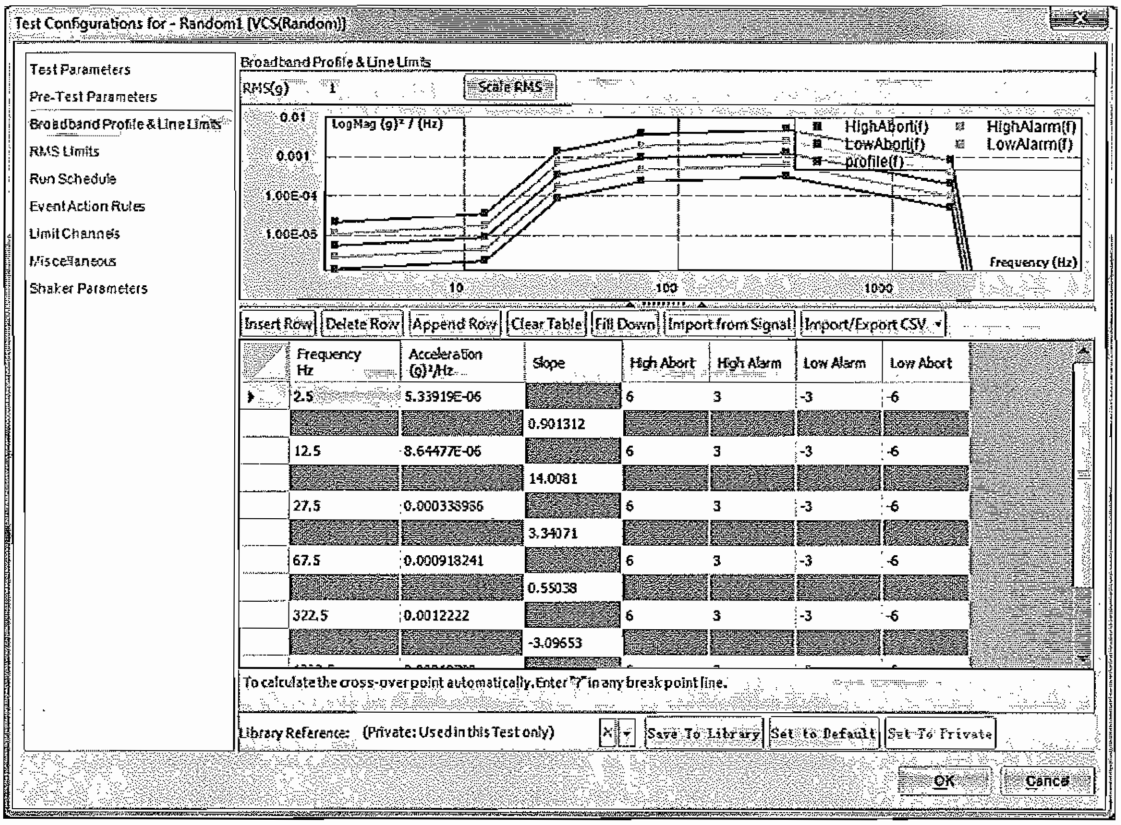
In this section of the Test configuration window, the parameters for this pre-test are set. The pre-test can also load an FRF from a previous test or from a file, but only use this if the test set-up has not changed. **Initial Drive (Volts)** sets the output level for the second pre-test stage, and **Response Level Goal (%)** sets the desired response for the third stage. The output will be limited by the **Maximum Drive (Volts).** This Ramp-Up Rate can be set to **Fast Ramp-Up** or **Slow Ramp-Up.** Typically, it takes about 15 seconds to reach to the close-loop with Fast Ramp-Up and 30 seconds with Slow Ramp-Up.

For safety reasons, there are two Drive Limits. One is defined in the Test Parameter tab that will be used in the scheduled test, and one defined in the Pre-Test tab that will be used in the pre-test process.

Test Profile

The test profile is defined in the **Broadband Profile Line Limits** section of the Test Configuration window. The window shows a graphical plot of the profile, in log magnitude versus log frequency axes. The profile is shown as a green line, high and low alarm lines are shown as yellow lines, and high and low abort lines are red lines. Below the graphical plot the profile points are shown in a table form.

The profile is defined as a set of breakpoints, with defined frequency and amplitude values, connected by straight lines.

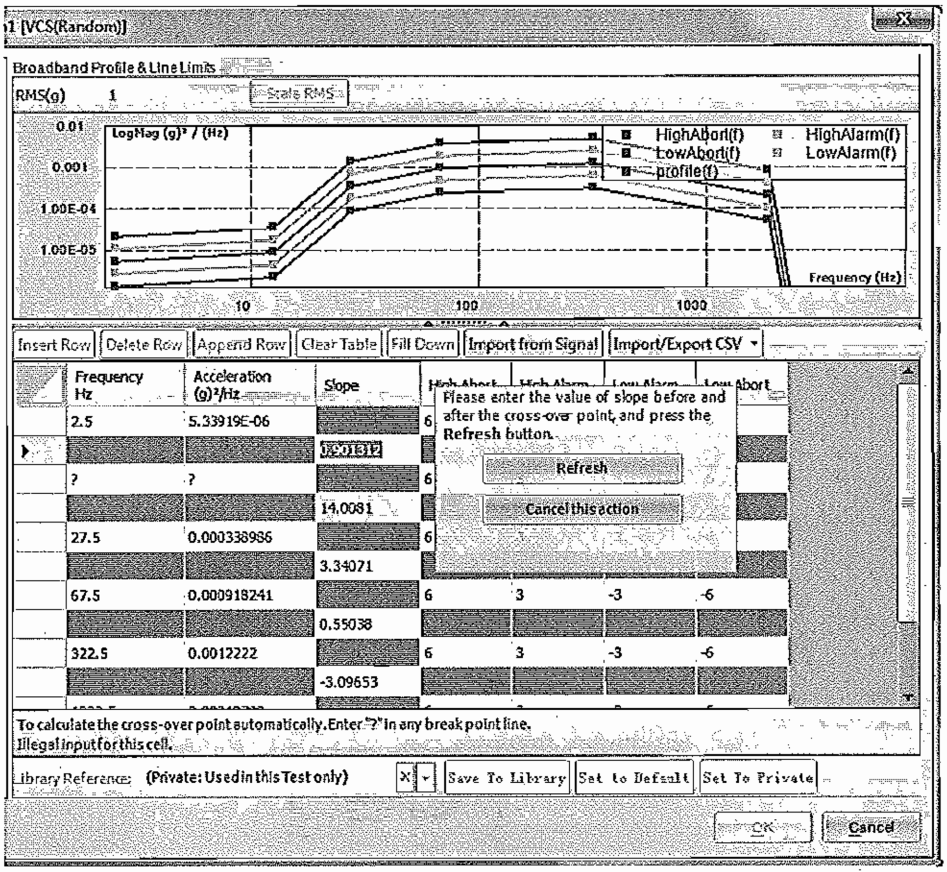


The breakpoints can be added, deleted, and manually dragged around the graph. Each point corresponds with a row on the table below which can be directly edited by entering frequency and magnitude values. The table also gives the slope of the lines between the points (in decibels per octave), and the alarm an abort levels in dB above and below the profile level. The overall RMS level of the profile is shown on the upper left. This overall level can be changed by clicking on **Scale RMS**, which scales the ordinate axis to reach the specified RMS level.

During the full test, if the response spectrum falls outside of the Alarm or Abort lines then an event will be triggered and cause the associated actions defined in the Event Action Rules to occur. The events will not be triggered until the proportion of the spectrum lines set by the Abort Sensitivity setting falls outside the limits (see above).

Crossover Breakpoint Calculation

In the profile editor, the intersection point of two lines with a specified slope can be automatically calculated. If a '?' is entered as a Frequency or Amplitude value, then the user will be prompted to enter the slope before and after that point. From these slope values and the adjacent breakpoint locations, EDM will calculate the Frequency and Amplitude values of the intersecting poi

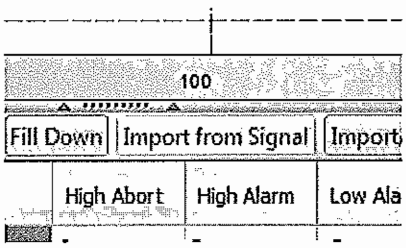


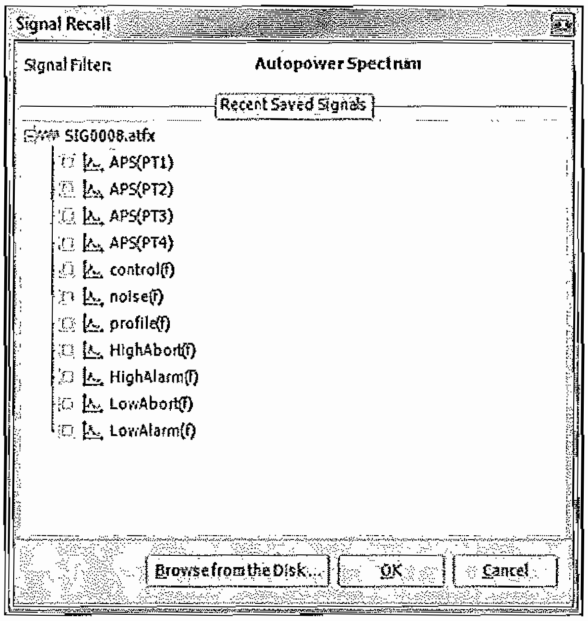
When this prompt is displayed, enter the slope values in the yellow fields and press the Refresh button. The question marks will be replaced with the calculated values.

Import Profile Function

The Random Profile can be imported from any saved signal file. The file formats supported include the ATFX format used by EDM, in addition to UFF, binary UFF, National Instruments TDM, MATLAB, and user-defined ASCII formats.

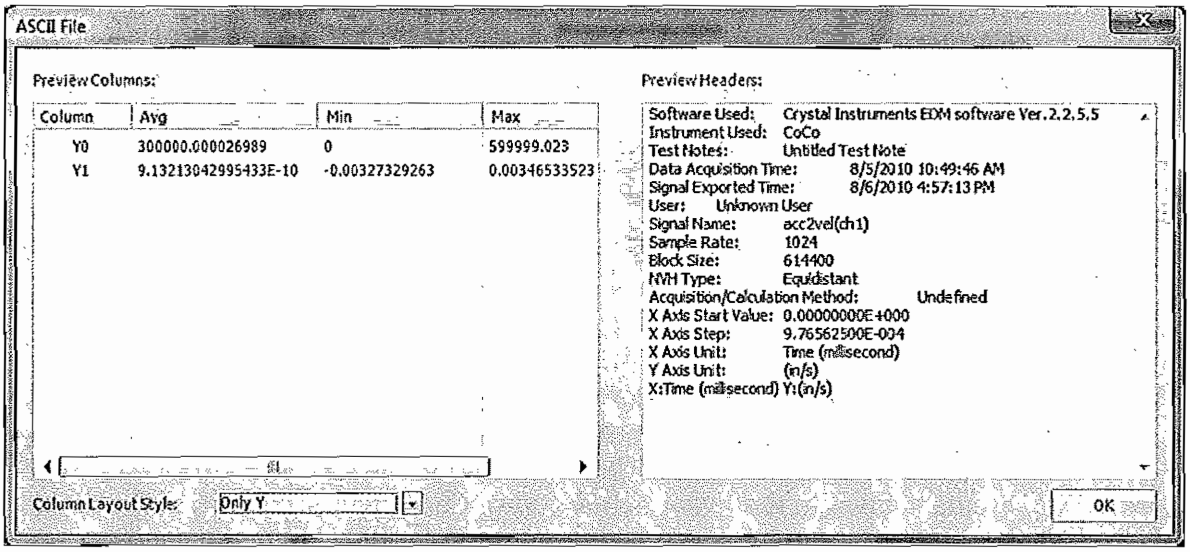
To import a signal, click the Import from Signal button. The Signal Recall window will be shown, with a list of recently saved spectrum signals in EDM.



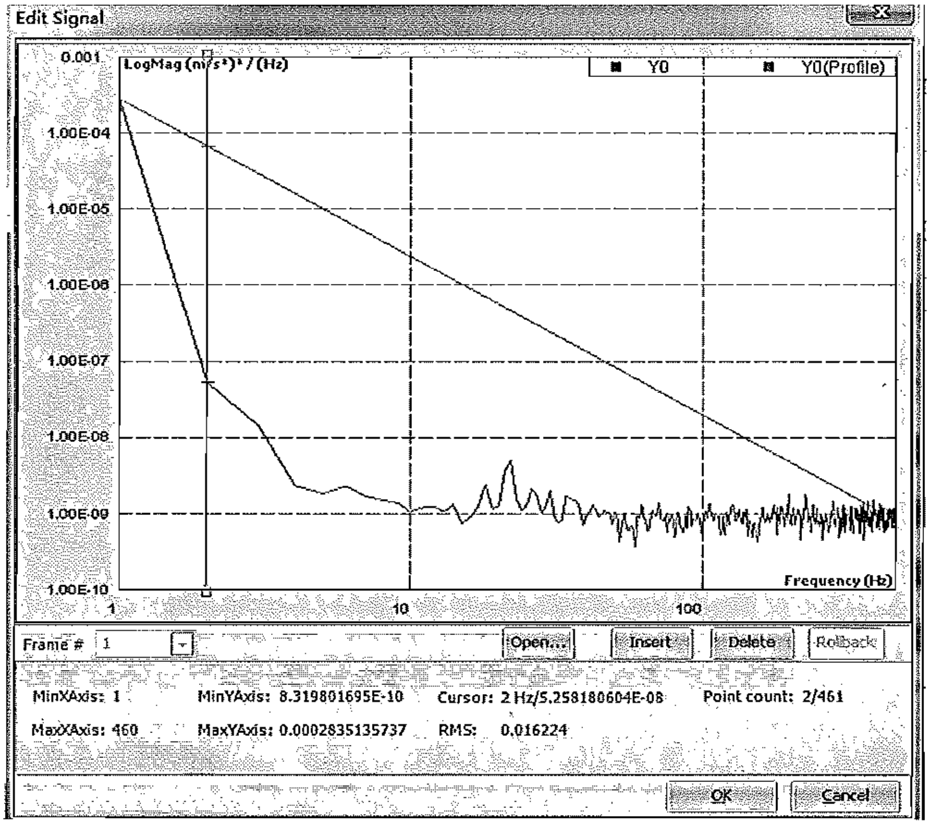


To use one of these recent signals, click the checkbox next to its name. Otherwise, click **Browse from the Disk...** to open a signal file.

When selecting ASCII files, the ASCII import window is shown. It shows the headers, and average, min, and max values for the data columns. The **Column Layout Style** sets whether the data columns contain X and Y value pairs, just Y values, or imaginary and real value pairs.



Once a file is imported and selected, press OK to open the Edit Signal window.

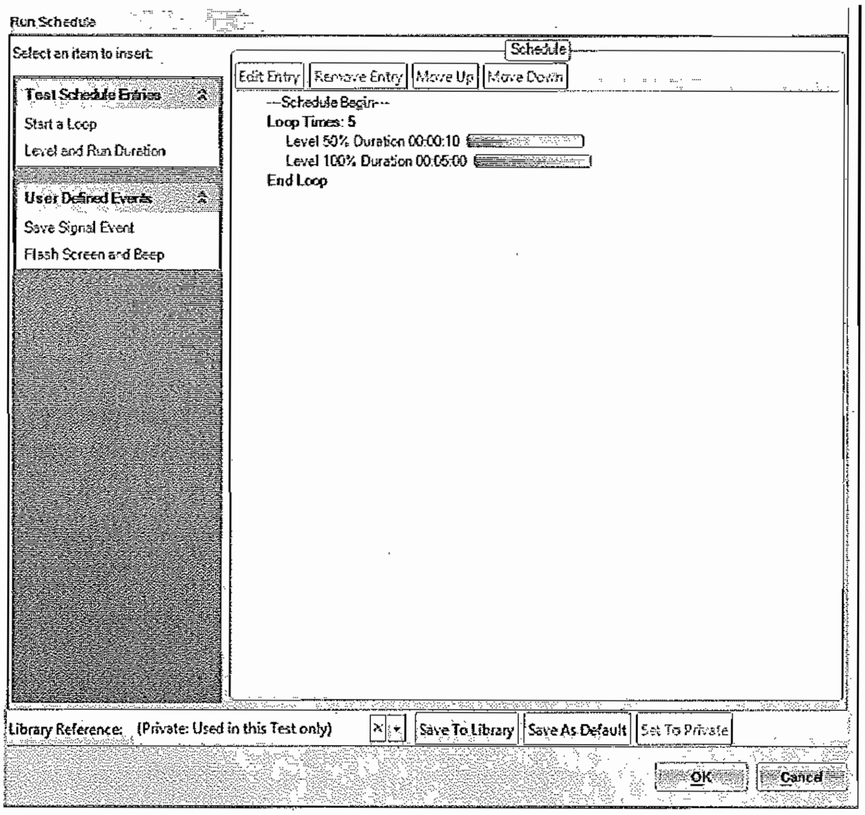


This window shows the imported signal in blue, and the profile in red. Points can be added to the profile from the imported signal by moving the cursor to the desired location and pressing Insert. Rollback will delete the last point added, and Delete will delete the point at the current cursor location. Once enough points have been added to match the profile with the signal, press OK and it will set the random profile.

If the imported signal has more than one frame, the current frame can be selected from the Frame # menu.

Run Schedule

The Run Schedule allows the test to be run automatically through a preset routine. This schedule can include loops and periods of running the test at a specified level and duration. The run schedule can also activate any user-defined events defined in the Event Action Rules. Click on event names in the list on the left to insert them into the schedule, and use the buttons on top to edit or remove them and to change their order. The schedule is activated when the test is started.



Measured Signals

The Live Signals tab on the lower left of the screen in EDM shows all the measured signals available for display. Listed here, for all test modes, are the native time streams of the input channels labeled by their location ID ("PT1", "PT2", "PT3"... by default), and the output drive time stream. The location ID of the channels can be changed under the Channel Table tab.

There are also signals derived from these time streams: block signals, labeled **Block**; auto power spectra signals, labeled **APS**; and the frequency response functions, labeled **FRF**; The labels are followed by the location ID of the original time stream signal in parenthesis (or, in the case of FRF, the location ID of the excitation channel followed by the ID of the response channel). These signals will only show in the live signal list if the measure option is enabled in the Signal Setup tab.

H(f) is the frequency response function between the drive output and the control input signal.

profile(f) is the frequency-domain test profile.

HighAlarm(f), **LowAlarm(f)**, **HighAbort(f)**, and **LowAbort(f)** are the limit lines of the profile.

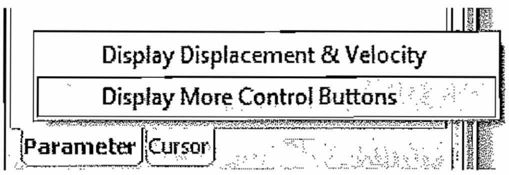
control(f) is the power spectrum of the control signal. If multiple control channels are used, the control(f) signal is either weighted-averaged spectra from all control channels, or the maximum spectrum, on per frequency bin base, among all the control spectra.

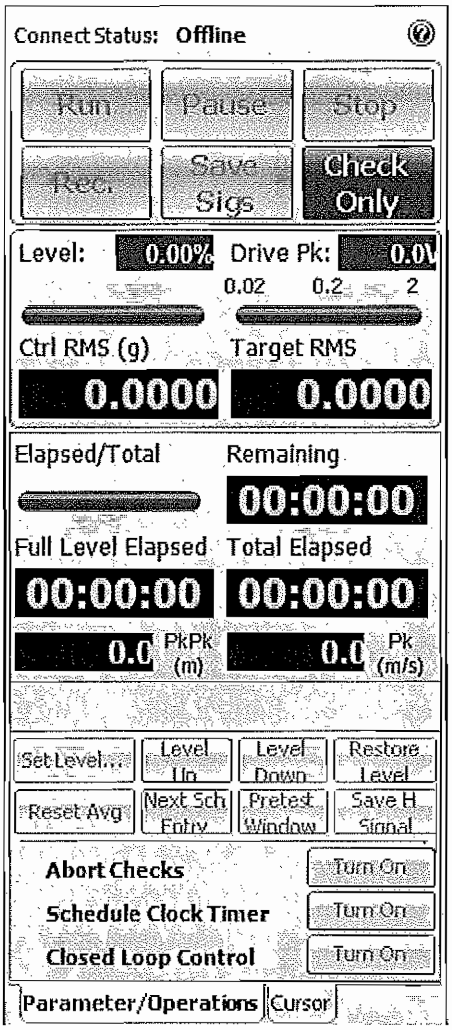
noise(f) is the power spectrum of the system noise, measured in the first part of the pre-test.

Control_his(t) is the RMS level history of the control signal.

Control Panel

The expanded control panel in Random mode has a number of commands to control the operation of the test. The control panel can be expanded by right clicking in the Parameters tab.





Test state information are displayed in the following fields:

Level is the current output level, as a percentage of the test profile. This is displayed graphically in the green bar below this field.

Drive Pk is the peak voltage of the output drive signal. This is shown graphically in the green bar below, as a proportion of the maximum drive voltage limit (set in Test Parameters).

Ctrl RMS is the RMS level of the input control signal. It is an overall rating of the control signal.

Target RMS is the target RMS level of the current test stage. This is a function of the test profile and the current test level percentage. The output is increased until the Ctrl RMS reaches the Target RMS.

Elapsed/Total is a green bar showing the elapsed time as a proportion to the total test duration, according to the run schedule.

Remaining is the remaining time of the test, according to the run schedule.

Full Level Elapsed is the time elapsed running at full (100%) output level.

Total Elapsed is the time elapsed since the test was started.

PkPk: This is the estimated peak-peak displacement of the control channel. If there are more than one control channel, only the peak-peak of the first control channel is displayed. The displacement signal is computed by double-integrating the acceleration signal. The accuracy of this computation may be very low if the signal contains significant amount of low frequency energy. Therefore this display is only used as a reference.

Pk: This is the estimated peak velocity of the control channel. If there are more than one control channel, only the velocity peak of the first control channel is displayed. The displacement signal is computed by integrating the acceleration signal. The accuracy of this computation may be very low if the signal contains significant amount of low frequency energy. Therefore this display is only used as a reference.

The following commands are available in the expanded toolbar:

Set Level...: change the current target output level to a specified value, as a percentage of the test profile

Level Up: increase the current output level by 5%

Level Down: decrease the current output level by 5%

Restore Level: restore the current output level to the level set by the current schedule entry

Reset Avg: reset all averages to zero

Next Sch Entry: end the current test stage and move to the next schedule entry

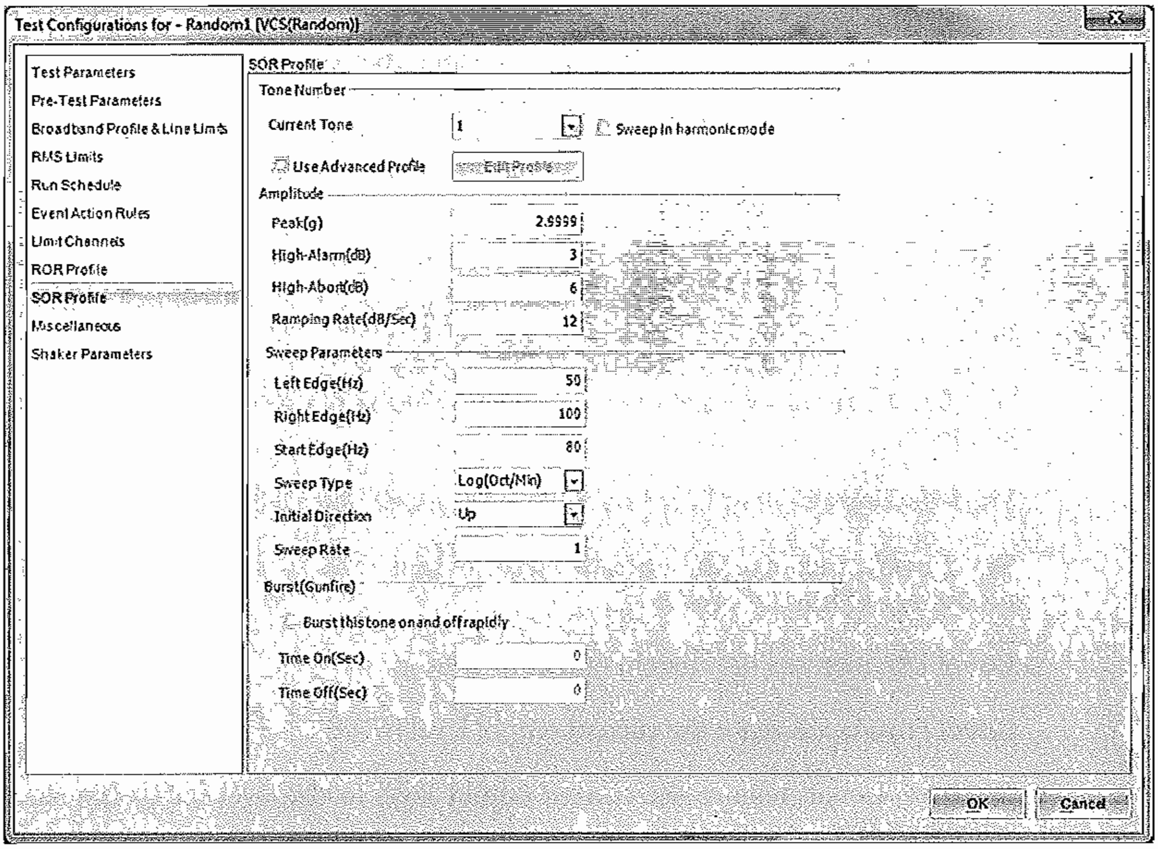
Pretest Window: open the pretest window

Save H Signal: save the H(f) signal, which is the frequency response function of the system

Sine on Random Tests

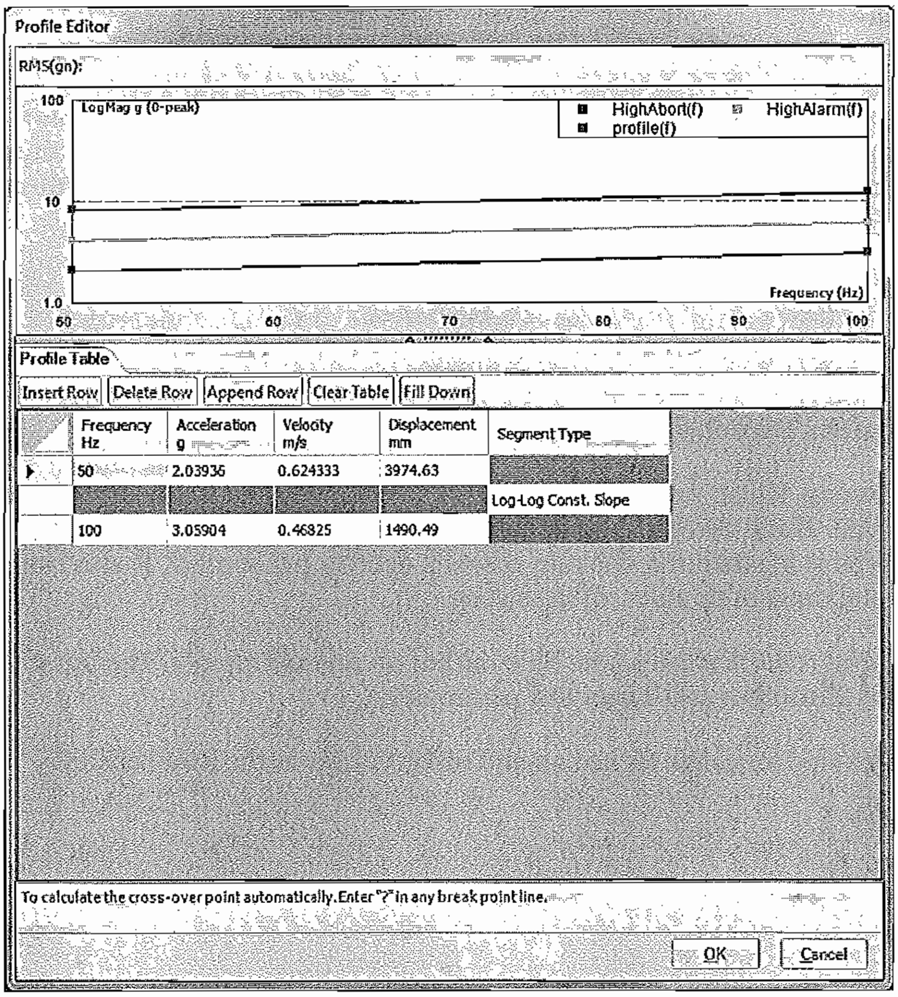
There are two types of composite random tests supported in EDM: Sine **on Random (SOR)** and **Random On Random (ROR)**. In each of these test types, an additional vibration profile is placed on top of the broadband random profile. In Sine On Random, this additional profile consists of sine waves that sweep through the profile frequency range. The random profile may represent a base excitation or noise level, and the sine waves strong single-frequency excitations. This mimics some real-world situations better than a random test by itself.

To set up an SOR test, go to the SOR Profile section of the Test Configuration Window.



Up to 12 sine tones can be placed on top of the random profile. The **Current Tone** menu selects the current sine tone that the settings are being applied to. **Sweep in harmonic mode** synchronizes the sweep rate of all the tones so that they sweep together.

Use Advanced Profile: select this to enable the advanced profile set by clicking on the *Edit Profile* button. The advanced profile can have multiple breakpoints to specify a more complex amplitude-vs-frequency profile. The profile editor is the same as the Swept Sine test profile editor.



Without the advanced profile enabled, the amplitude for the sine tone will be fixed for all frequencies. **Peak (g)** under the *Amplitude* section sets this amplitude.

High Alarm (dB): the level, in dB above the test profile, at which an alarm event will be triggered if exceeded by the input control signal.

High Abort (dB): the level, in dB above the test profile, at which an abort event will be triggered if exceeded by the input control signal.

Ramping Rate (dB/s): the maximum rate of change of the output amplitude of the sine tone in response to the input control signal.

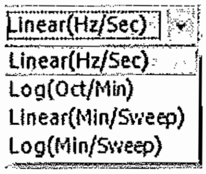
The *Sweep Parameters* section controls the sweep edge frequencies and rate. If *Sweep in harmonic mode* is enabled, the sweep rate will be the same for all the sine tones.

Left Edge (Hz): the lowest frequency of the sweep.

Right Edge (Hz): the highest frequency of the sweep.

Start Edge (Hz): the starting frequency for the sweep.

Sweep Type: changes between a linear and logarithmic sweep, and sets the units that the Sweep Rate is specified in. The sweep rate can be set as frequency change per time (Hz/sec or oct/min) or as total time of the sweep in minutes.

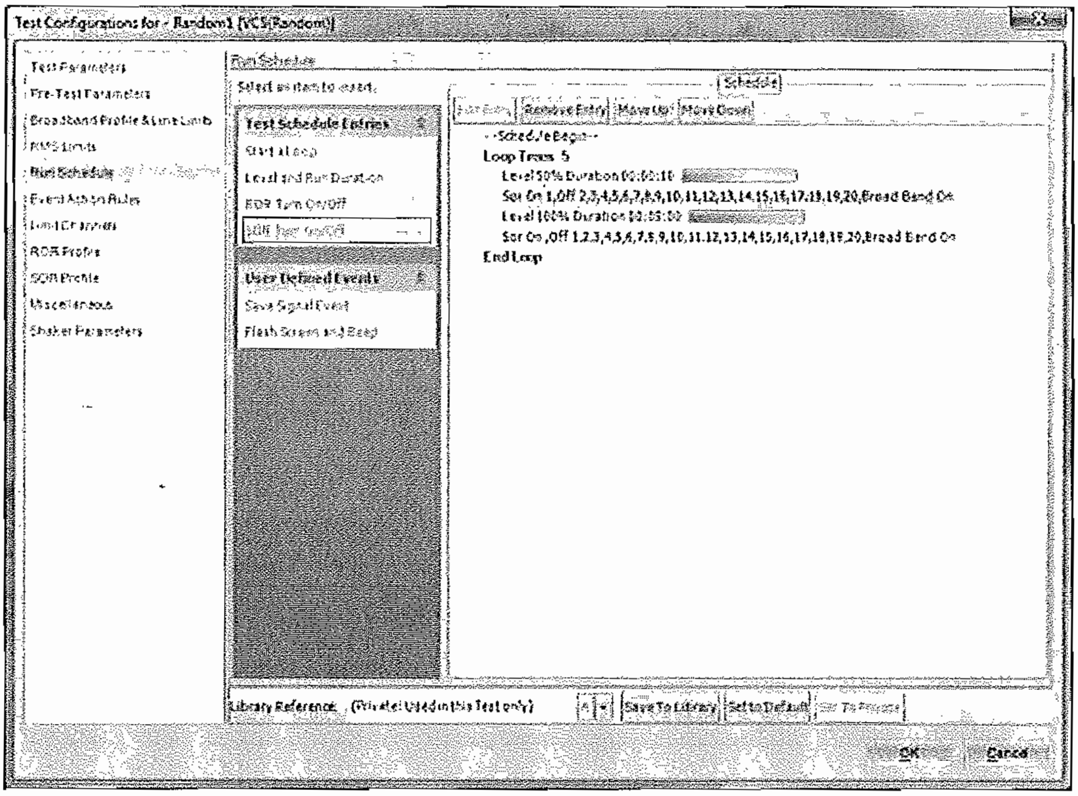


Initial Direction: Up or Down.

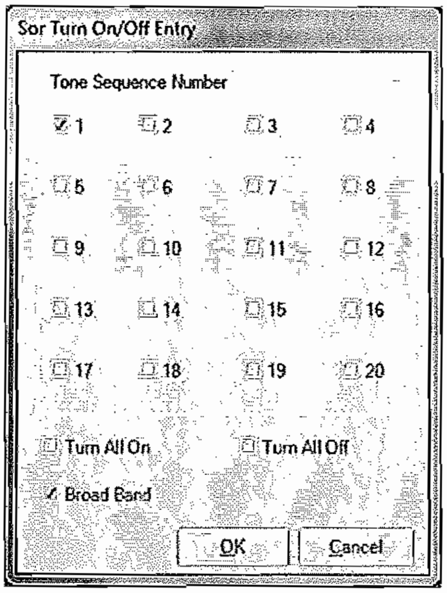
Sweep Rate: rate of the frequency sweep, specified in the units set under Sweep Type. If the Sweep Type is linear, the rate is set as Hz per second. If the Sweep Type is logarithmic, the rate is set as octaves per second. It also can be set as the total time, in minutes, of the sweep.

Burst (Gunfire) turns the Sine output on and off rapidly. The burst time is set by the **Time On** and **Time Off** parameters.

The sine tones are turned on and off by entries in the Run Schedule.

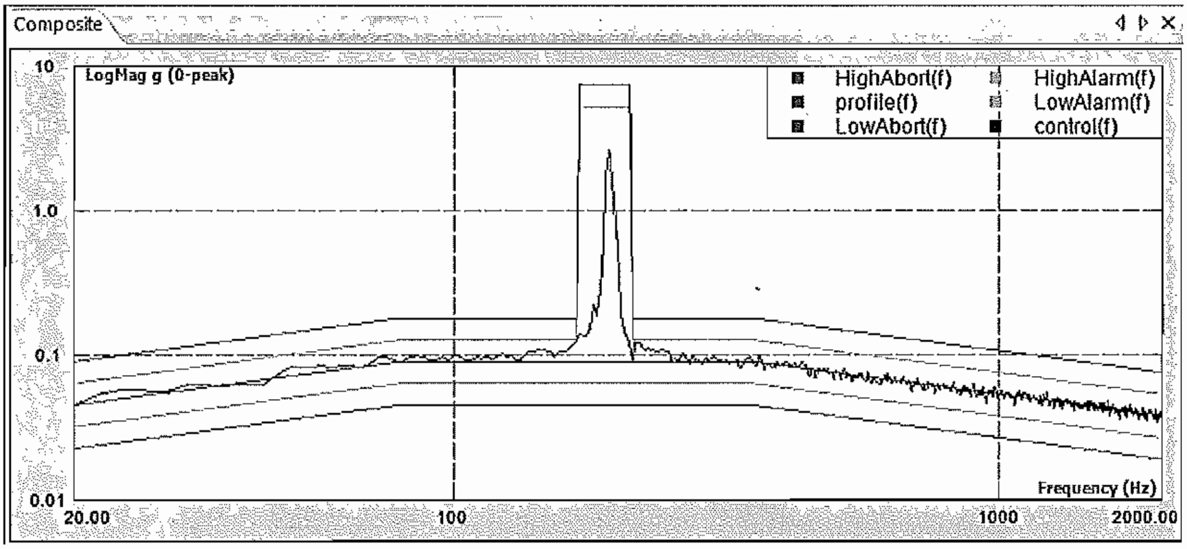


The **SOR Turn On/Off** item turns on or off some or all of the sine tones. Click on the entry to insert it into the schedule. In the window that comes up, select the numbers of the sine tones to enable. The Broadband item enables or disables the broadband random profile.



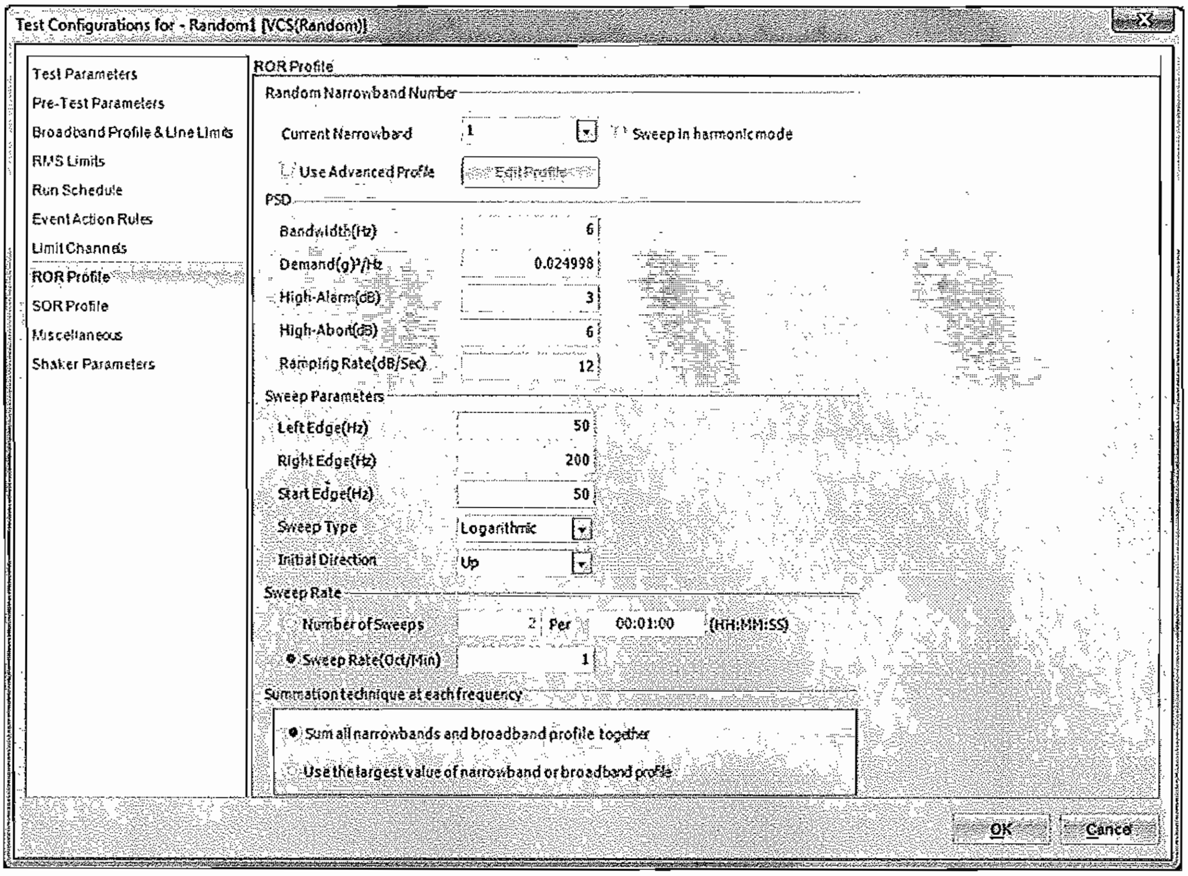
To disable the SOR tones, insert another SOR Turn On/Off item into the schedule with *Turn All Off* selected.

When SOR is running, the sine tone or tones will be shown superimposed on the broadband random profile.



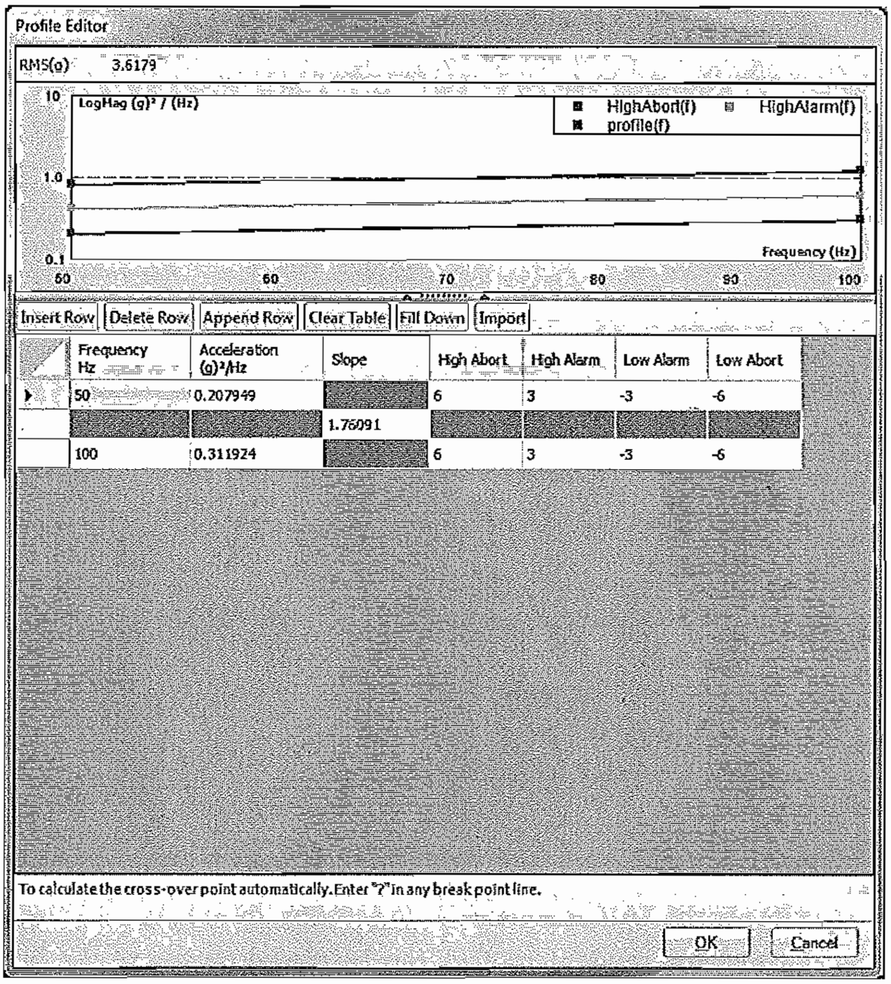
Random on Random Tests

A Random on Random test superposes one or more narrowband random profiles on top of the broadband random test profile. These narrowband profiles can be swept through a set frequency range. To set up an ROR test, go to the ROR Profile section of the Test Configuration Window.



Up to 12 narrowband random profiles can be placed on top of the broadband random profile. The **Current Narrowband** menu selects the current profile that the settings are being applied to. **Sweep in harmonic mode** synchronizes the sweep rate of all the profiles so that they sweep together.

Use Advanced Profile: select this to enable the advanced profile set by clicking on the *Edit Profile* button. The advanced profile can have multiple breakpoints to specify a more complex amplitude-vs-frequency profile. The profile editor is the same as the regular Random test profile editor.



Without the advanced profile enabled, the narrowband profile will be at a fixed demand level across a specified bandwidth.

Bandwidth (Hz): total bandwidth of the narrowband profile

Demand (g2/Hz): The level of the narrowband profile, in Power Spectral Density units.

High Alarm (dB): the level, in dB above the test profile, at which an alarm event will be triggered if exceeded by the input control signal.

High Abort (dB): the level, in dB above the test profile, at which an abort event will be triggered if exceeded by the input control signal.

Ramping Rate (dB/s): the maximum rate of the change of the narrowband profile amplitude in response to the input control signal.

The *Sweep Parameters* section controls the sweep of the center frequency of the narrowband profile. The bandwidth of the profile will remain constant. If *Sweep* *in harmonic mode* is enabled, the sweep rate will be the same for all the ROR profiles.

Left Edge (Hz): the lowest frequency of the sweep.

Right Edge (Hz): the highest frequency of the sweep.

Start Edge (Hz): the starting frequency for the sweep.

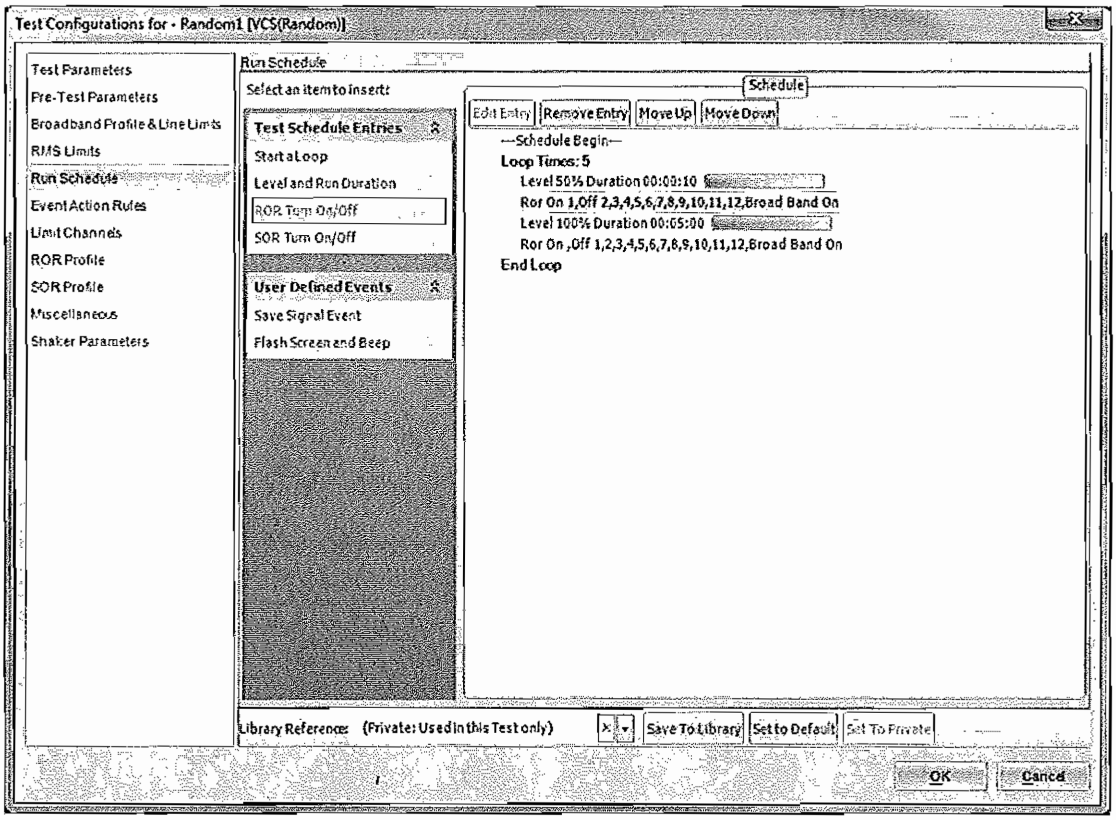
Sweep Type: changes between a linear and logarithmic sweep.

Initial Direction: Up or Down.

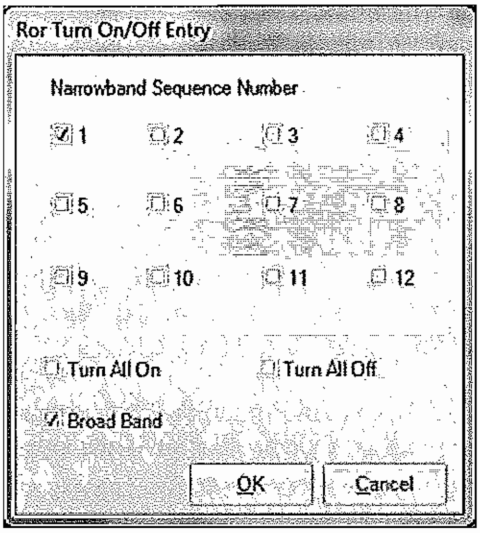
Sweep Rate: rate of the frequency sweep, specified as either the number of sweeps and the total time duration, or the rate as octaves per minute (logarithmic) or Hz per second (linear).

Summation technique: this specifies whether the narrowband profile is added to the broadband random test profile, or if the output is taken as the maximum between the two.

The ROR profiles are turned on and off by entries in the Run Schedule.

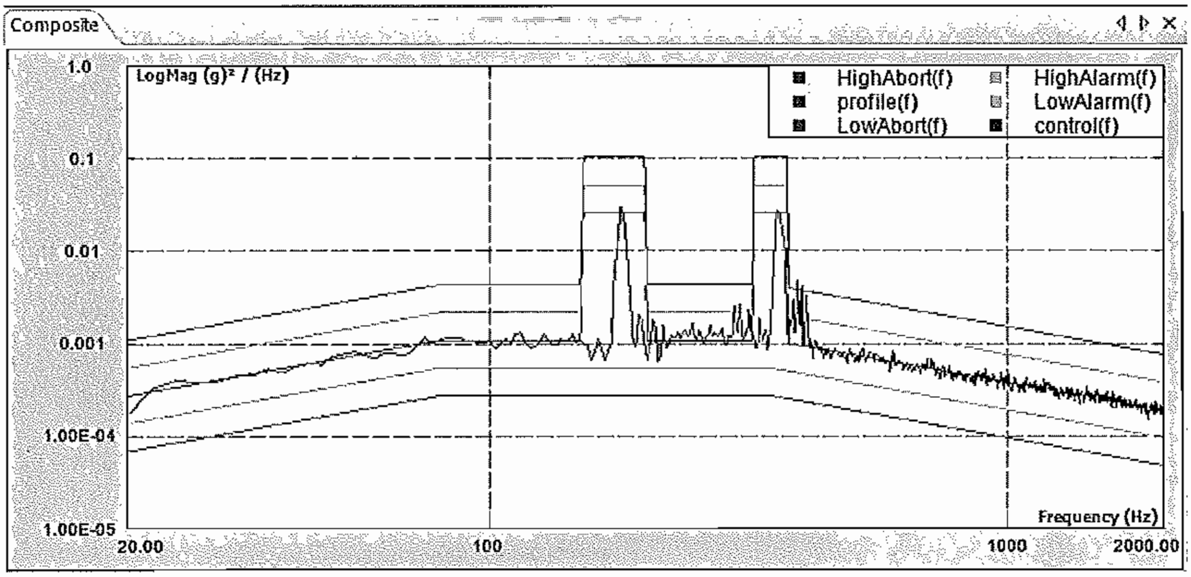


The **ROR Turn On/Off** item turns on or off some or all of the profiles. Click on the entry to insert it into the schedule. In the window that comes up, select the numbers of the profiles to enable. The Broadband item enables or disables the broadband random profile.



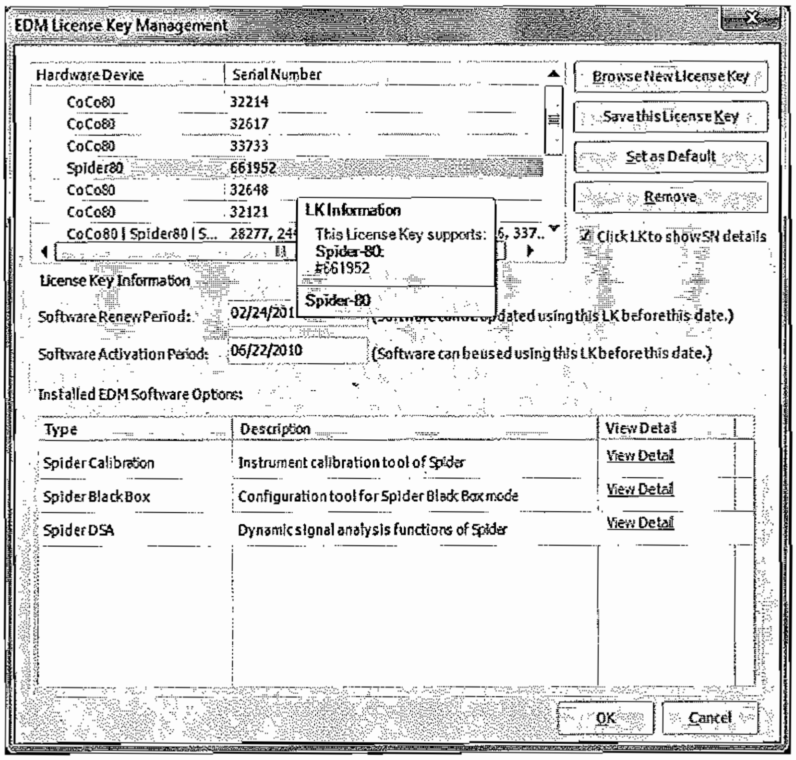
To disable all the ROR profiles, insert another ROR Turn On/Off item into the schedule with *Turn All Off* selected.

When ROR is running, the random narrowband profiles are shown superimposed on the broadband random profile.

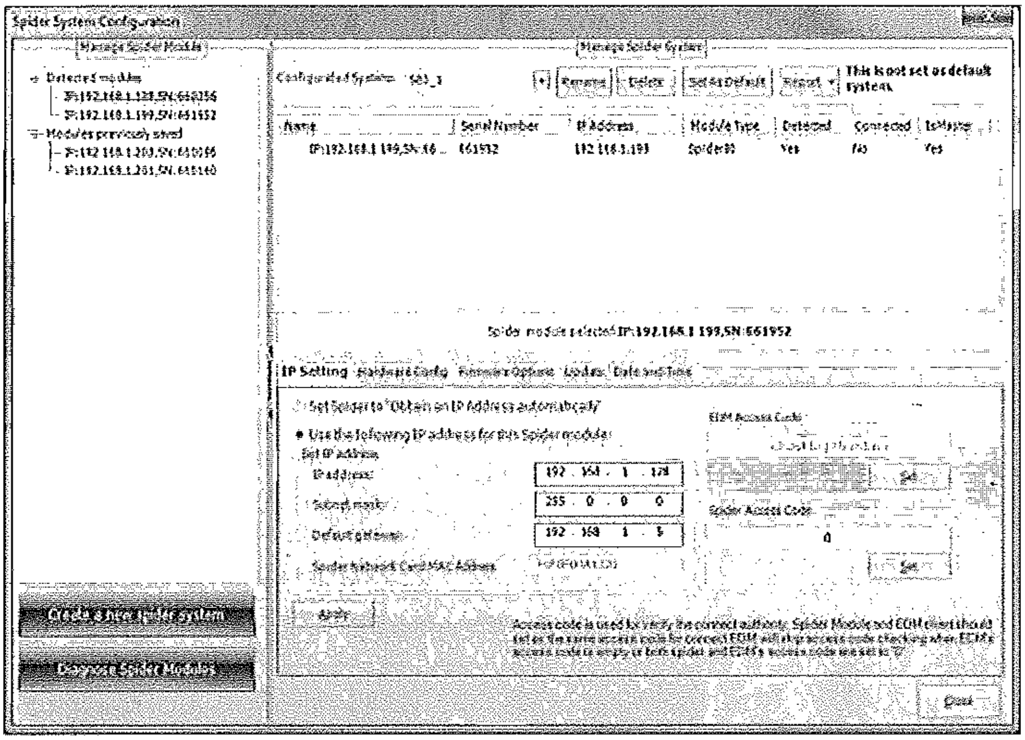


Typical Tests

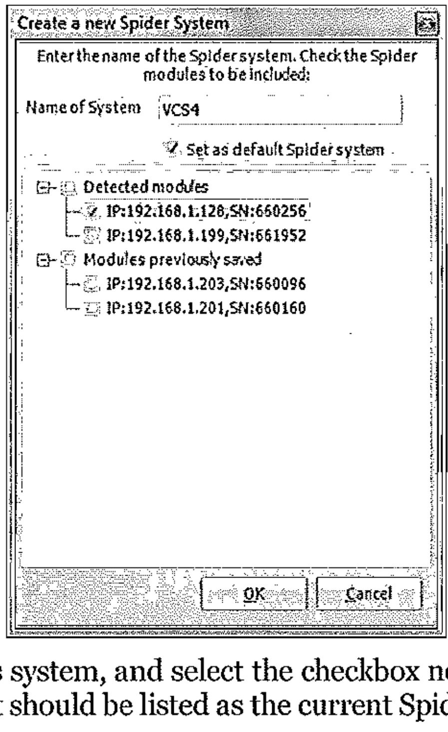
This section will walk through setting up and running a typical Random test. First, make sure EDM is running in Spider working mode, with a valid license key installed. Open **Tools -> License Key Manager,** and make sure that the serial number of the currently active license key matches the Spider hardware.



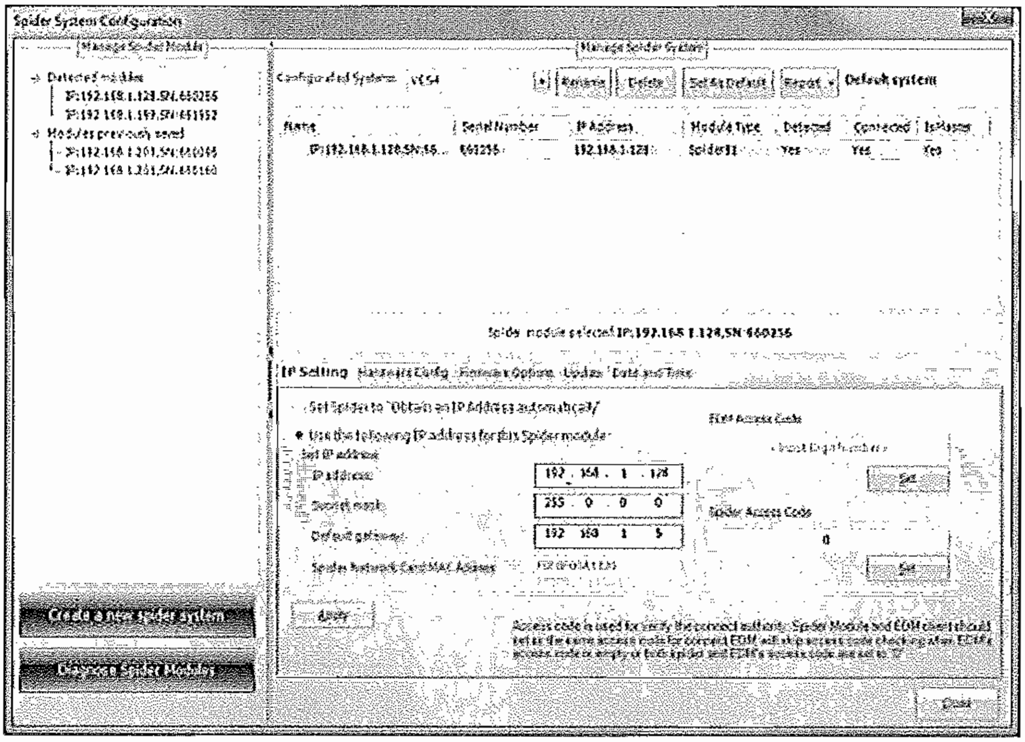
Plug the Spider-81 into the power cord and into the network, and turn it on. Then, configure a Spider system by opening **Tools -> Spider Configuration.**



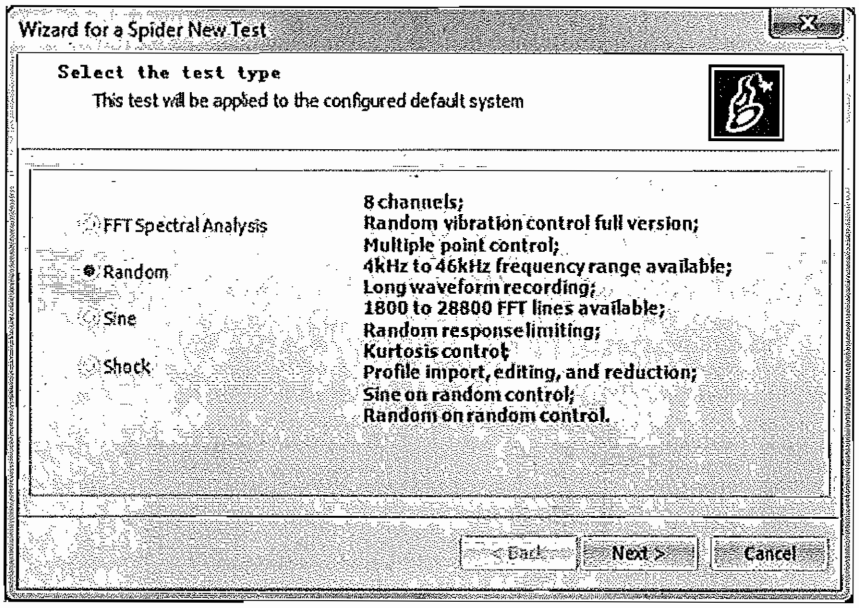
The Spider module should be listed under Detected Modules on the left in this window. Click **Create a new spider system.**



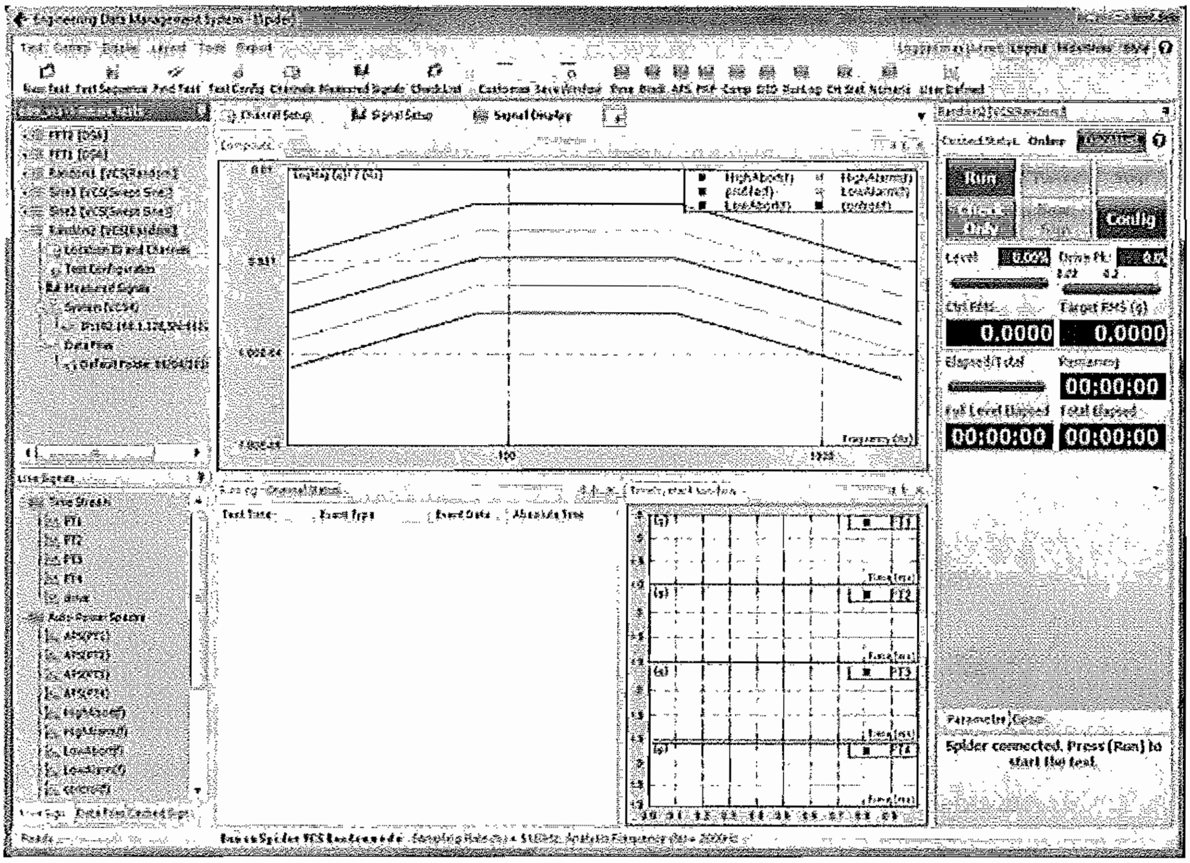
Enter a name for this system, and select the checkbox next to the Spider module. Press **OK**, and then it should be listed as the current Spider system.



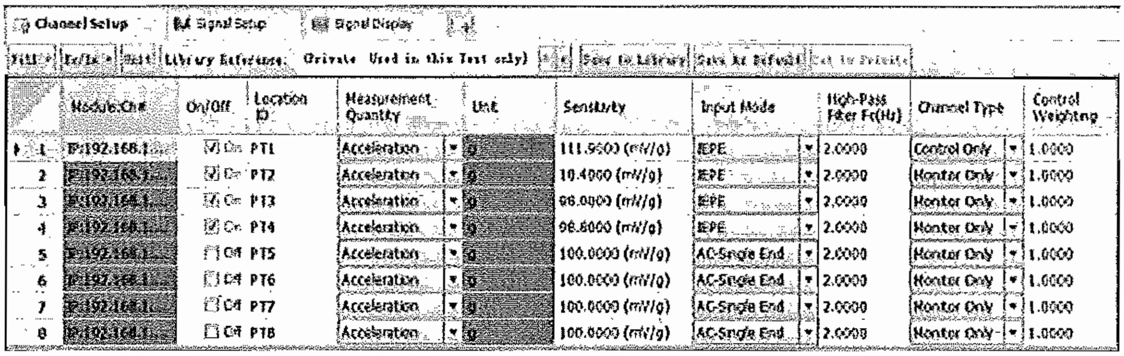
Close this window. Next, select **New Test** from the **Test** menu, and click Random.



Click **Next>**, assign a name to the test, and then click **Finish**. You will then be presented with the default EDM display for new tests.



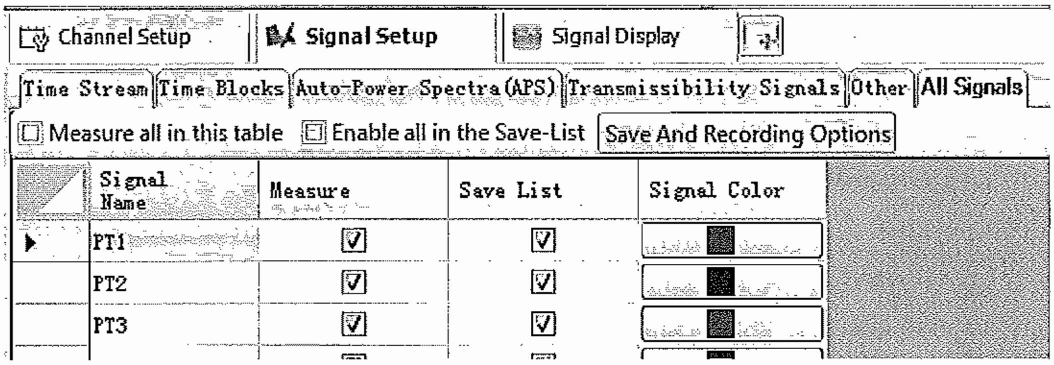
The next step is to configure the input channels. At this point, make all the connections from the sensors and shaker amplifier to the Spider. Then select the **Channel Setup** tab.



	Module:Ch	On/Off	Location ID	Measurement Quantity	Unit	Sensitivity	Input Mode	High-Pass Filter Fc(Hz)	Channel Type	Control Weighting
1	IP:192.168.1…	☑ On	PT1	Acceleration	g	111.9500 (mV/g)	IEPE	2.0000	Control Only	1.0000
2	IP:192.168.1…	☑ On	PT2	Acceleration	g	10.4000 (mV/g)	IEPE	2.0000	Monitor Only	1.0000
3	IP:192.168.1…	☑ On	PT3	Acceleration	g	96.0000 (mV/g)	IEPE	2.0000	Monitor Only	1.0000
4	IP:192.168.1…	☑ On	PT4	Acceleration	g	98.8000 (mV/g)	IEPE	2.0000	Monitor Only	1.0000
5	IP:192.168.1…	☐ Off	PT5	Acceleration	g	100.0000 (mV/g)	AC-Single End	2.0000	Monitor Only	1.0000
6	IP:192.168.1…	☐ Off	PT6	Acceleration	g	100.0000 (mV/g)	AC-Single End	2.0000	Monitor Only	1.0000
7	IP:192.168.1…	☐ Off	PT7	Acceleration	g	100.0000 (mV/g)	AC-Single End	2.0000	Monitor Only	1.0000
8	IP:192.168.1…	☐ Off	PT8	Acceleration	g	100.0000 (mV/g)	AC-Single End	2.0000	Monitor Only	1.0000

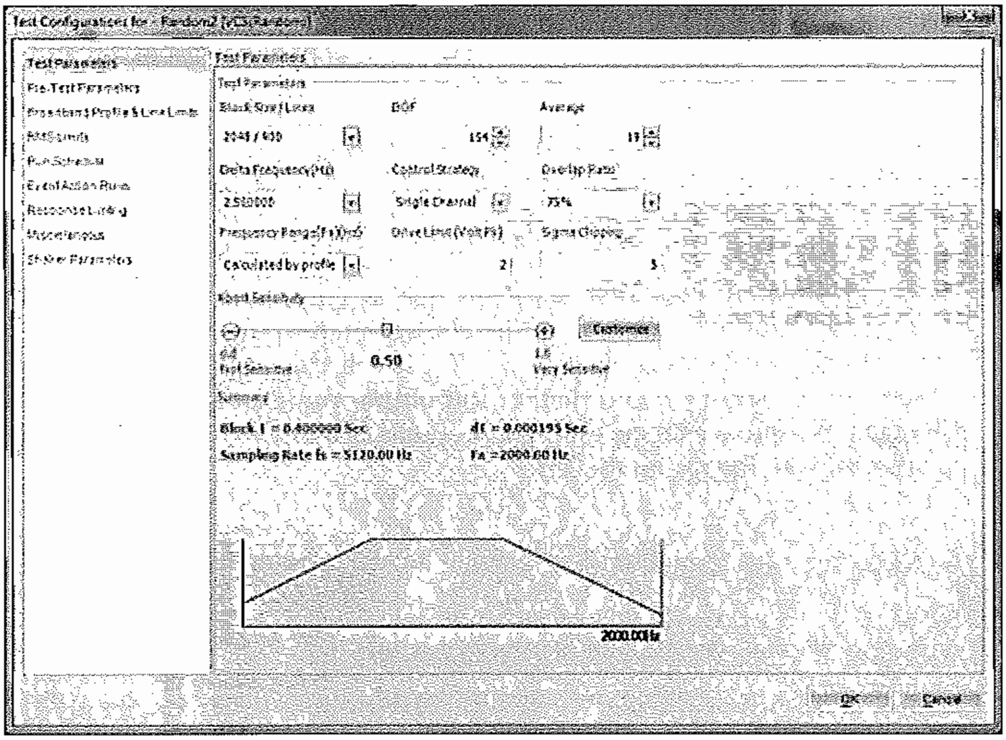
In this table, enable all the channels you will be using. For each channel, select the measurement unit, enter the sensor sensitivity, select the Input Mode, and set the high pass filter frequency if required. Under Channel Type, the channel that will be used for control should be selected as Control Only, and all the other channels should be selected as Monitor Only (unless you are using limit channels or multiple control channels).

Next, under the **Signal Setup** tab, enable the Measure option on all signals that you will be interested in viewing. For the signals that you are interested in saving or recording, enable the Save List option.



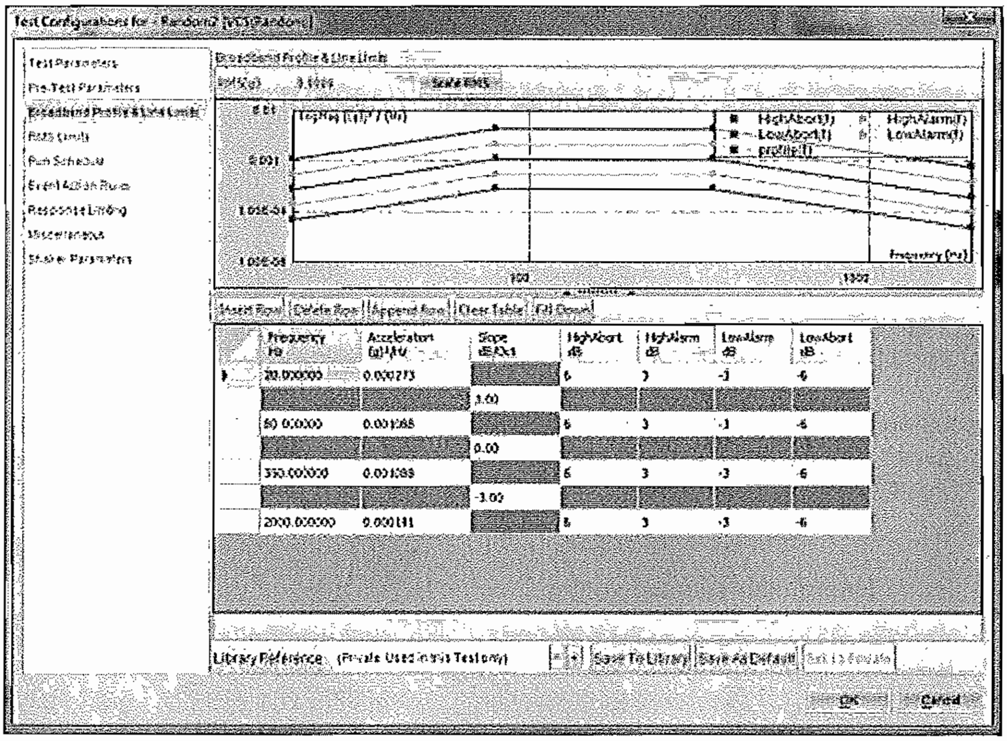
The next steps are to set the Test Configuration options, including the test profile and shaker parameters.

Open the **Test Configuration** window by selecting **Test Config** under the **Test** menu or by pressing the Config button on the control panel. The first page is the **Test Parameters** section.

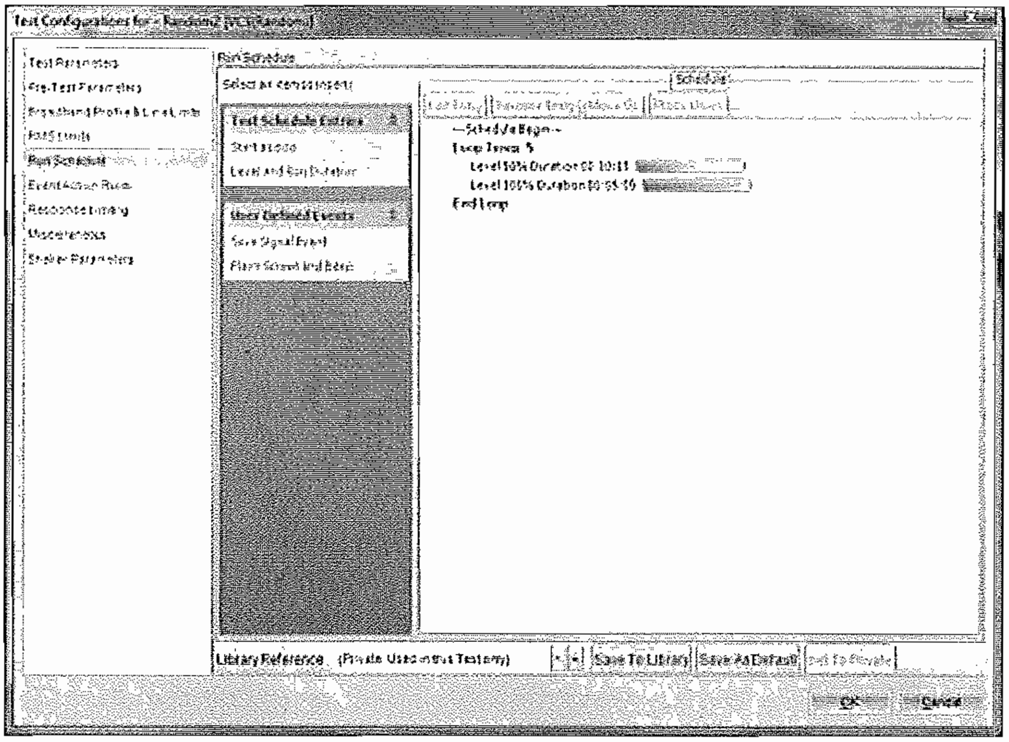


Set all the important analysis parameters here, such as block size and average number. The Drive Limit is the maximum voltage of the drive signal. Also, the Abort Sensitivity adjusts how sensitive the safety mechanisms are to triggering abort events while the test is running.

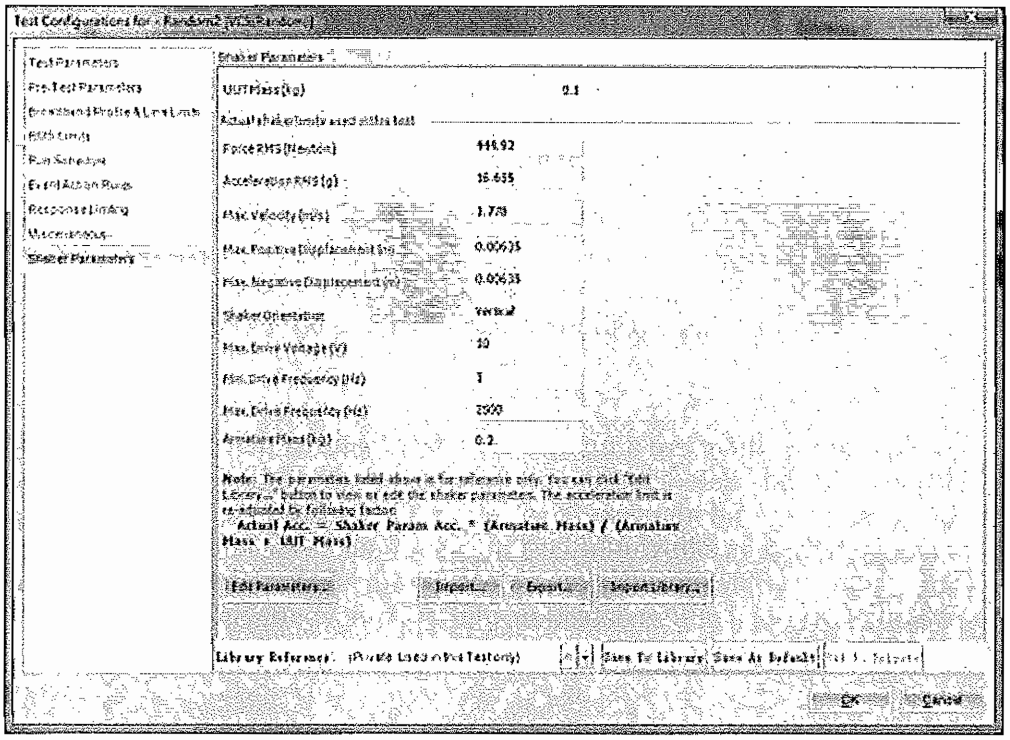
The test profile is set under **Broadband Profile and Line Limits**. Enter points in the breakpoint table to create the desired frequency profile. While running the test, the output drive signal will be adjusted such that the input control signal matches this profile. The overall RMS level of the entire profile can be adjusted by clicking Scale RMS.



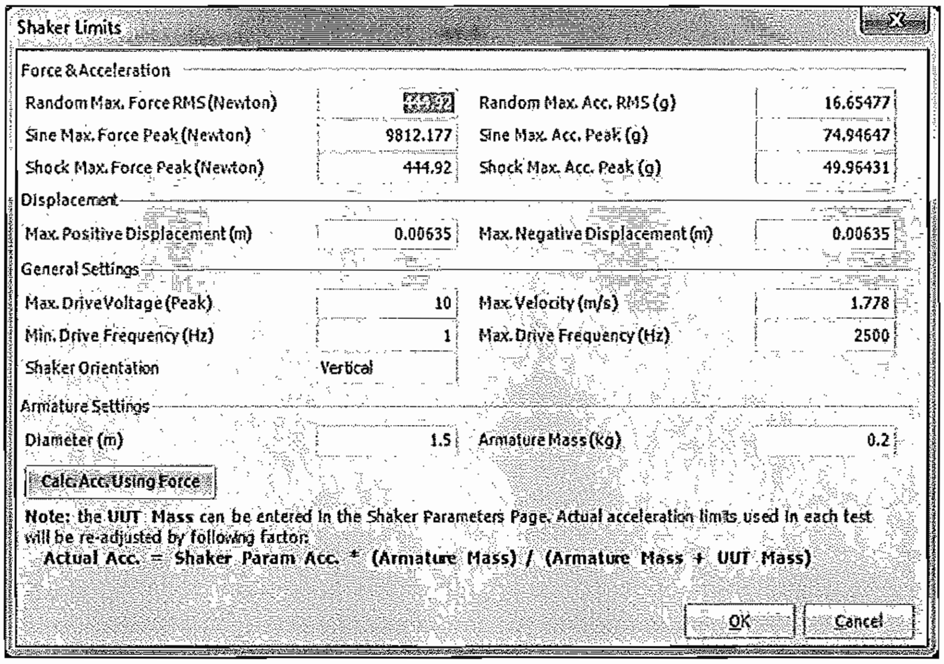
When the test is run, the test sequence is controlled by items in the **Run Schedule**. Select this section of the config window, and add items to the list to create the desired sequence. By default, the schedule consists of running the test at 50% for 10 seconds, and then at full output for 5 minutes. These time can be changed by double clicking on the items, and new entries can be added by clicking on the items in the list on the left.



The last important section in the Test Configuration window is the **Shaker Parameters.**



Click on **Edit Parameters...**, and enter the information from the shaker specifications. This is important for the safety of the shaker and testing unit.



Press **OK** to close the Test Configuration window, and then you should be ready to run the test.

Swept Sine Tests and Resonant Search and Dwell

Whereas a Random test generates many frequencies over the band of interest at once, a swept sine test generates only one frequency, and sweeps this frequency through a pre-set range. Feedback from the control signal is then used to adjust the output amplitude such that the response amplitude of the UUT matches a **test profile**. The test profile is a graph of amplitude (usually defined as Peak acceleration) versus frequency.

RSD, or Resonant Search and Dwell, is an extension of the Swept Sine test.

Safety Features

In sine mode, there are a number of safety features that help prevent damage to the shaker and related equipment. During a shake test, 5 different types of checks are performed and an event is triggered if any of these checks fail. The response actions to these events can be customized under Event-Action Rules. The 5 checks are 1) the profile line limits, 2) Maximum shaker drive voltage limiting, 3) Channel overload or loss detection, and 4) Limit channels.

The test profile has lower and upper limits for the control channel over the frequency range of the test. If the control signal falls outside these limits, alarm or abort events will be triggered.

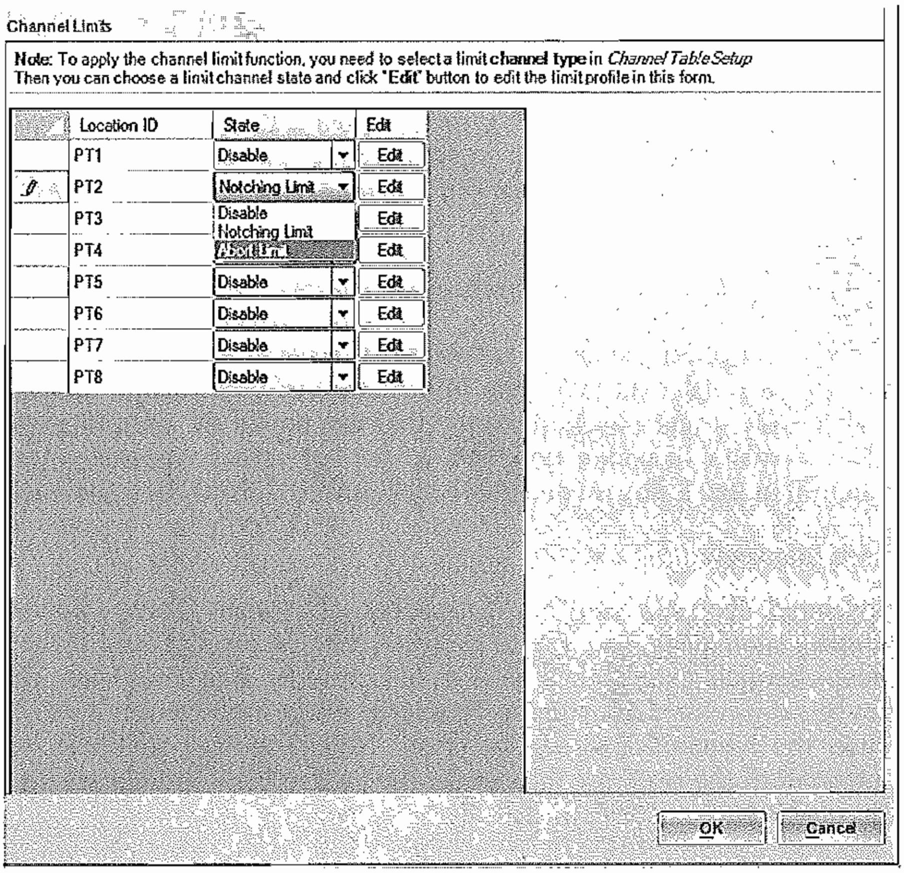
The Spider also detects when input channels are overloaded or lost which can indicate a sensor fault or an accidental disconnect. Spider will abort the test if this occurs.

Limit channels are described in the next section.

In the event of an accidental network disconnection or power loss, the Spider is able to save test data and state information to non-volatile memory to protect against loss. It has a backup battery that can power the unit for up to 8 minutes. For a network disconnection, the Spider can either continue running the test program in Black Box mode or save all data and execute an orderly shutdown.

Limit Channels

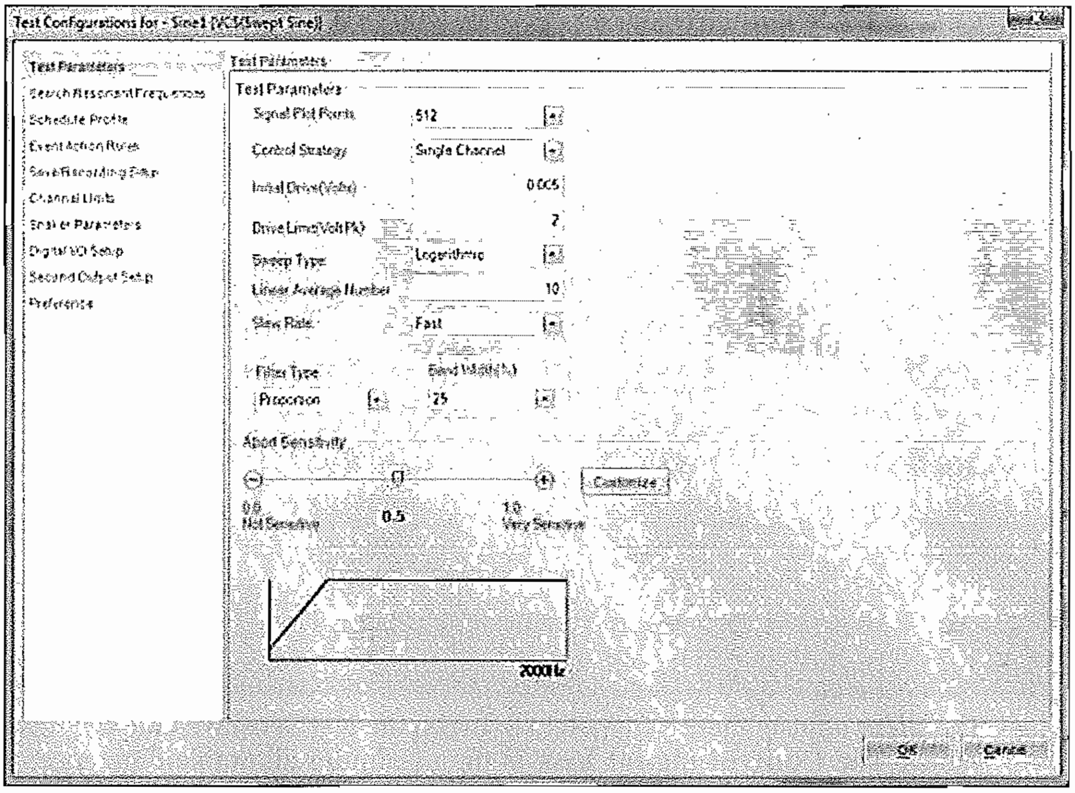
Any input channels can be set as **limit channels**. These channels are given limiting spectral profiles (separate from the test profile), and if the spectrum of these channels exceed their profile and event is triggered. These limit channels can be set as either Aborting or Notching. Abort limit channels will abort the test when the response exceeds the limit. Notch limiting channels will lower the output until the response falls under the limit. These options are set under Input Channel Setup.



To enable a limiting channel, first set the channel type to Limit in the Channel Setup tab, and then select either **Notching Limit** or **Abort Limit** in the State column here. Click **Edit** to bring up the limit profile editor. Click **Insert** or **Append** to add lines to the profile.

Test Parameters

When in Sine mode, this section of the Test Configuration window is used to configure settings related to the Sine mode analysis parameters and abort sensitivity.



Signal Plot Points is the number of frequency lines of resolution. The swept sine test mode does not use FFT for frequency analysis of the control signal, so this isn't the same as FFT lines or block size. It instead uses a tracking narrowband filter that follows the output drive frequency, and records the peak output level from the filter at this number of discrete points. The Signal Plot Points is not related to the resolution of sweeping frequency. If the Signal Plot Points is small, it only indicated that the controller keeps a smaller display buffer. The resolution of sweeping frequency can be as fine as 10^{-7}Hz.

Control Strategy sets how the Spider system will use the input control channel(s). In Single Channel control, only one channel is used in the output feedback control. In Weighted Average control, multiple control channels are combined using a weighted average to form a composite control signal. In Maximum control, the drive signal is adjusted such that the response in every control channel does not exceed the reference profile, and in Minimum control the drive signal is adjusted to that every control channel has a response equal to or greater than the profile.

Initial Drive (Volts) is the RMS voltage output for the initial test level.

Drive Limit (Volt Pk) limits the absolute maximum voltage output of the drive signal. If the drive limit is reached before the control signal reaches its target, the system will show a Drive Maximized warning. The output signal will not exceed the Drive Limit.

Slew Rate is the maximum rate that the output drive level can change. It can be set to fast, slow, or a customized value in dB/s.

The **Abort Sensitivity** slider is a quick way to adjust the safety abort threshold of the test. The values of these parameters can be adjusted by clicking the Customize button, which displays this window:

Abort Sensitivity Parameters

Measurements Checked	Not Sensitive	Very Sensitive	Used Sensitivity	Description
Control signal loss (dB)	60	10	12.60	Compare the control signal peak with target profile.
Peak Change of one time frame (dB)	40	20	10.80	Compare the Peak of consecutive frames of each input control channel.
Abort Latency(second)	0.3	0.05	0.06	The total number of seconds that the control signal may exceed the abort tolerances without a test shutdown.

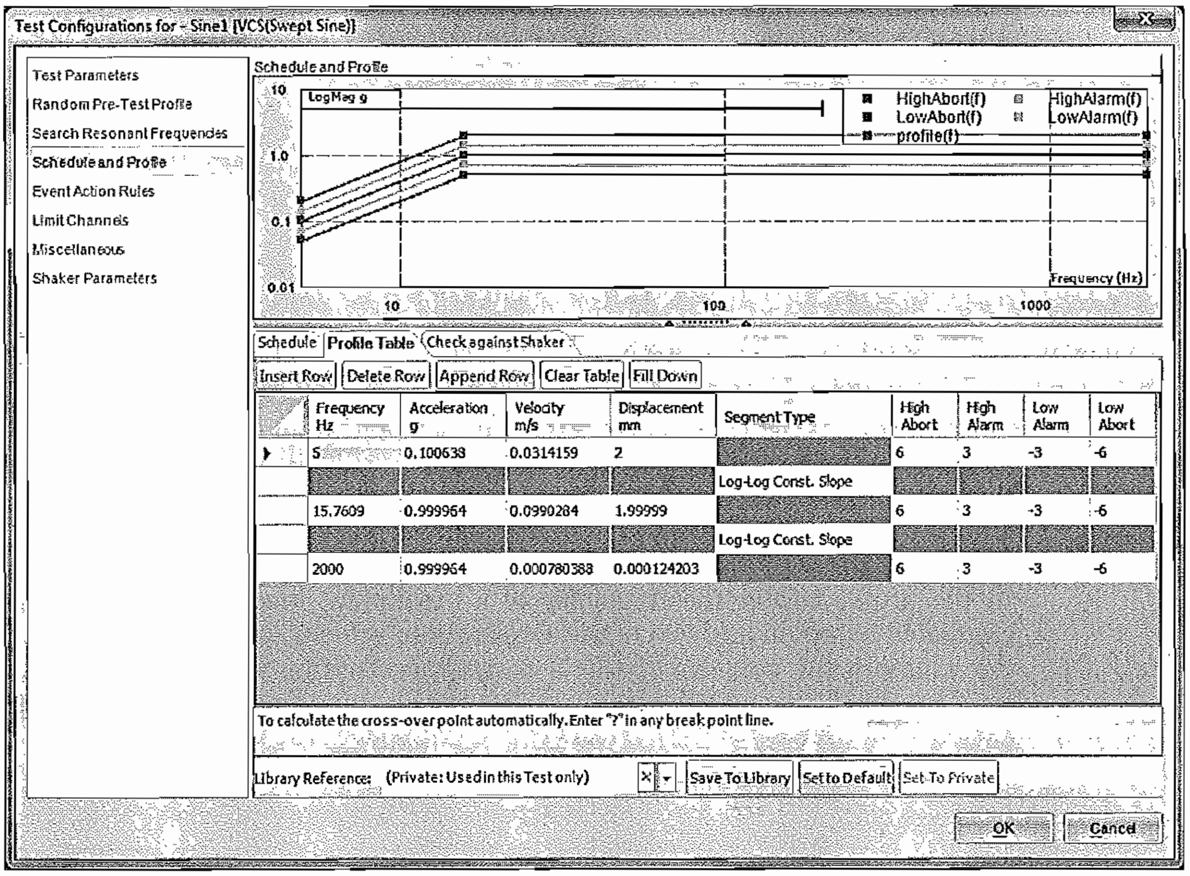
OK | Cancel

The slider adjusts these parameters between the Not Sensitive and Very Sensitive values. The **Control signal loss** is the maximum allowable difference, in dB, between the profile level and the control signal, calculated before any averaging is done. The **Peak Change of one time frame** is the maximum allowable change in the peak value between successive time frames of the input control signal. The **Abort Latency** is the maximum number of seconds the control signal may exceed the abort limit before an abort is triggered. Any exceedance of these values will abort the test. The software will interpolate the value between two ends and choose one proportional to the Abort Sensitivity slider position.

Test Profile and Schedule

In addition to the test profile, a Sine test is controlled by a run schedule. The schedule contains one or more entries that define test stages. A stage defines the output behavior and timing

The Schedule Profile window is where the test profile is defined. It is also where the schedule is set that controls the timing of the frequency sweep. There are three tabs: Schedule, which contains the run schedule; Profile Table, which defines the test profile; and Check against Shaker which shows the peak acceleration, velocity, displacement, and force of the profile and compares the values to the shaker limits.

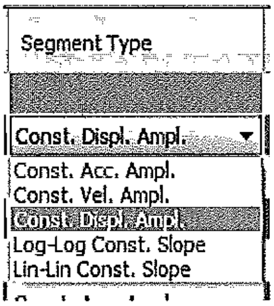


Frequency Hz	Acceleration g	Velocity m/s	Displacement mm	Segment Type	High Abort	High Alarm	Low Alarm	Low Abort
5	0.100638	0.0314159	2		6	3	-3	-6
				Log-Log Const. Slope				
15.7609	0.999964	0.0990284	1.99999		6	3	-3	-6
				Log-Log Const. Slope				
2000	0.999964	0.000780388	0.000124203		6	3	-3	-6

Profile

The graph on top shows the profile shape, along with four other lines: the Low- and High-Alarm Levels and the Low-High- Abort levels. The profile consists of breakpoints at a given frequency and magnitude connected by line segments. The breakpoints can be added, deleted, and manually dragged around the graph. Each point corresponds with a row on the table under the Profile Table tab. This table can be directly edited by entering frequency and magnitude values in the cells. The magnitudes are listed as acceleration, velocity, and displacement.

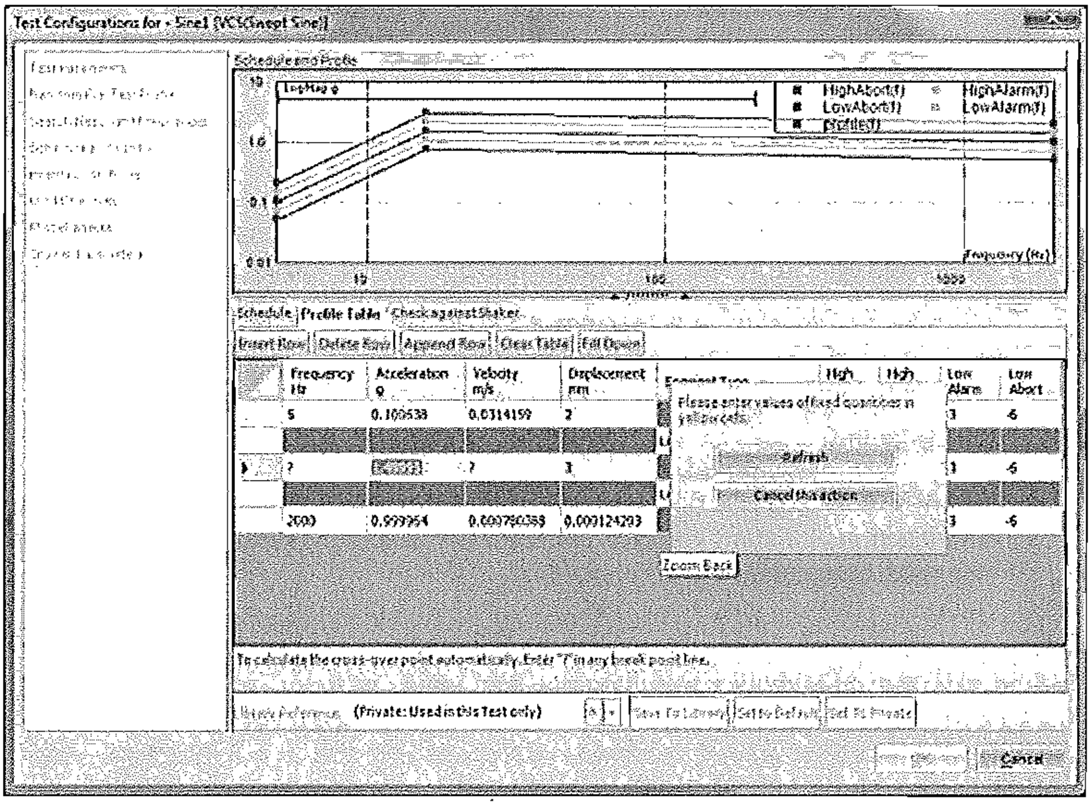
There are five types of segments that can connect the breakpoints: constant acceleration, constant velocity, constant displacement, constant log-log slope, and constant linear slope (in acceleration).



During the full test, if the response magnitude falls outside of the Alarm or Abort lines for longer than the **Abort Latency** value (see above), then an Alarm or Abort event will be triggered. The response to this event will depend on the settings in the Event-Action Rules.

Crossover Breakpoint Calculation

In the profile editor, the frequency of a breakpoint line can be automatically calculated based on any two of the acceleration, velocity, or displacement values. For example, the user can specify a desired acceleration and displacement level for a breakpoint and have EDM calculate the frequency and velocity. To do this, enter a '?' in the two fields that you want automatically calculated.



When this prompt is displayed, enter the desired values in the remaining two fields that are highlighted in yellow and press the Refresh button. The question marks will be replaced with the calculated values.

Example

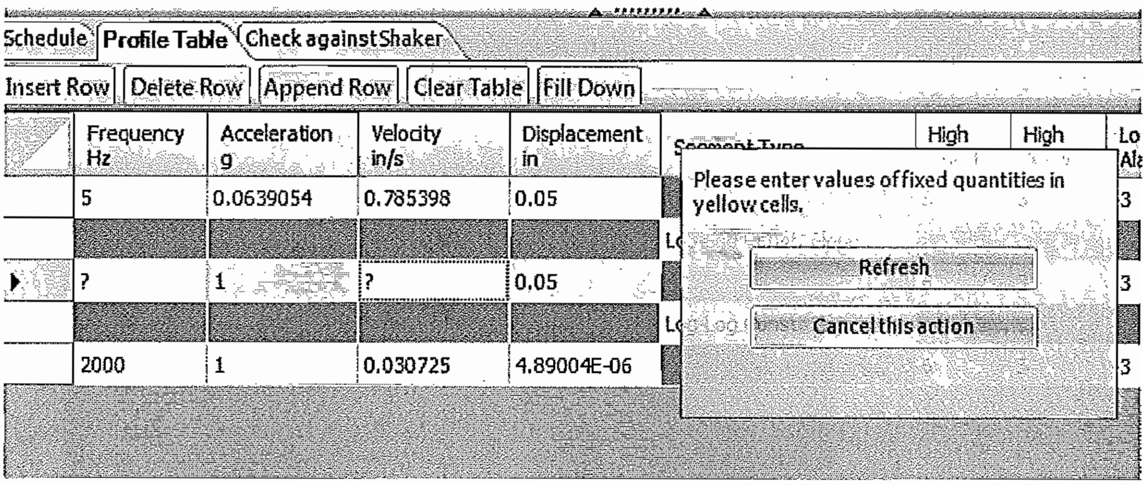
Assume you would like to calculate the cross over frequency at certain point which meets the following conditions:

1. From 5Hz and above, the displacement is 0.05 inch

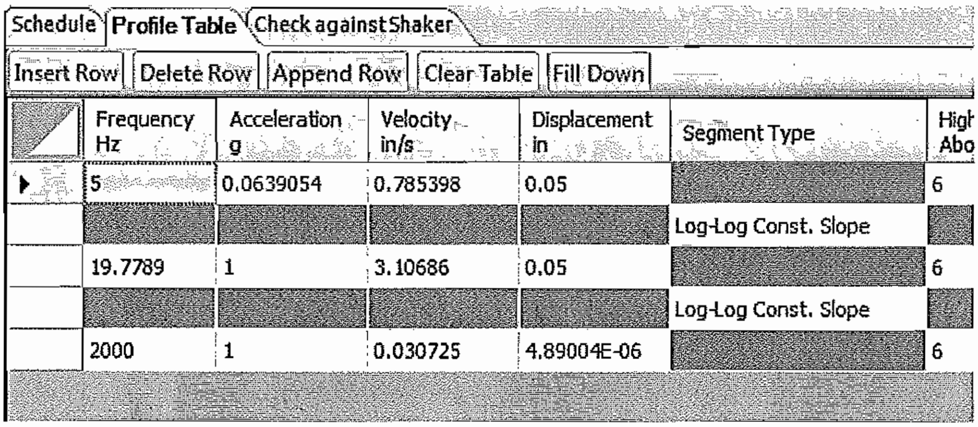
2. From 2000Hz and below, the acceleration is 1.0g

You have two unknowns: the frequency and the velocity.

First you create a breakpoint between 5Hz and 2000Hz. Secondly, you enter question mark at the frequency and velocity field, enter displacement 0.05 at 5Hz and the unknown field; enter the 1g acceleration into 2000Hz row and the unknown field.



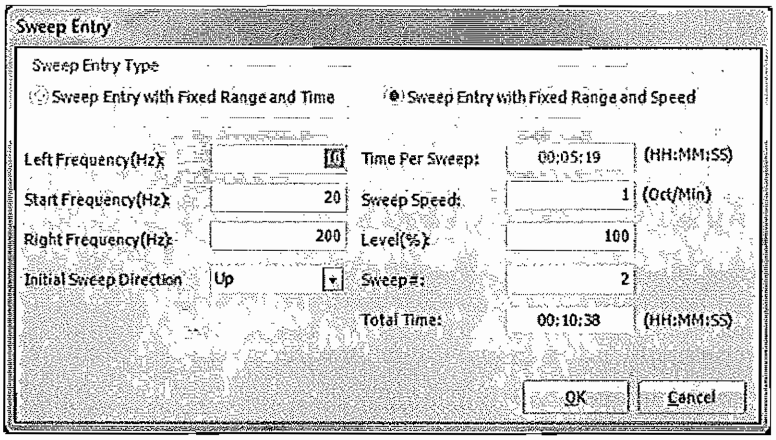
Press the Refresh button. The cross over point, 19.7789Hz, is then calculated.



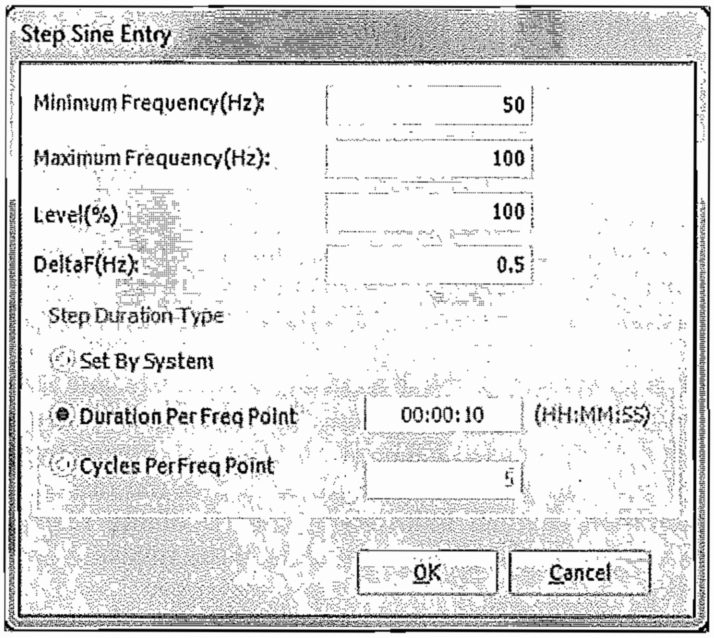
	Frequency Hz	Acceleration g	Velocity in/s	Displacement in	Segment Type	Higł Abo
▶	5	0.0639054	0.785398	0.05		6
					Log-Log Const. Slope	
	19.7789	1	3.10686	0.05		6
					Log-Log Const. Slope	
	2000	1	0.030725	4.89004E-06		6

Schedule

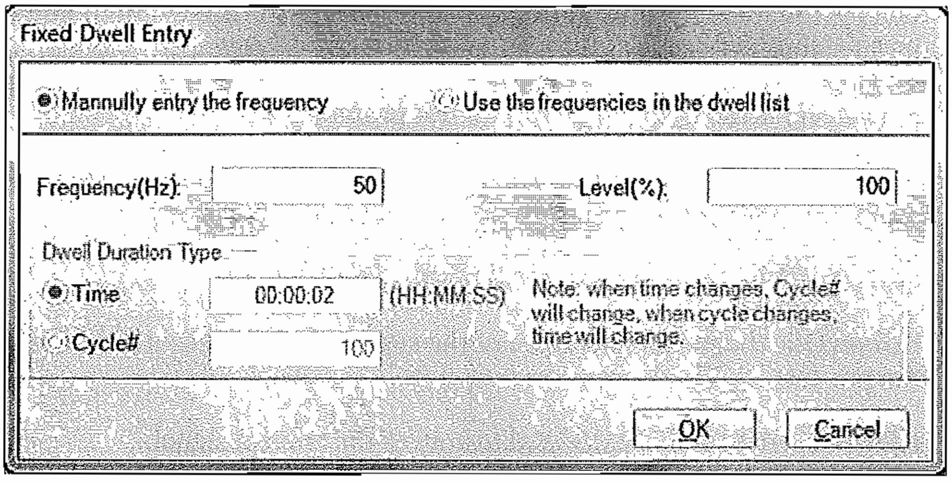
The Schedule sets the sequence of test stages that are activated when the test is run. A test stage is either a **sweep entry**, a **step sine entry**, a **fixed dwell entry**, or a **tracked dwell entry**.



The **sweep entry** sweeps the output between a low frequency and high frequency at a fixed rate or over a fixed period of time. The sweep rate can be logarithmic or linear, depending on the setting under Test Parameters. The **Level** sets the amplitude of the expected control signal, relative to the reference profile, and the **Sweep#** sets the number of times the sweep will be repeated.



A **step sine entry** steps the output from the low frequency to the high frequency at increments given by **DeltaF(Hz).** The duration at each step can be either set system-wide, given as a time period, or given as number of cycles.



A **fixed dwell entry** holds the output at a fixed frequency for a given duration. There is also an option to dwell at frequencies given in the **dwell list**, which is created in the Resonant Search and Dwell function (see **Error! Reference source not found.** below).

The run schedule can also activate any user-defined events defined in the Event Action Rules. Loops can be used to repeat a sequence of entries a set number of times.

Click on event names in the list on the left to insert them into the schedule, and use the buttons on top to edit or remove them and to change their order. The schedule is activated when the test is started (by the **Start** button on the control panel).

Measured Signals

The Live Signals tab on the lower left of the screen in EDM shows all the measured signals available for display. Listed here, for all test modes, are the native time streams of the input channels labeled by their location ID ("PT1", "PT2", "PT3", etc. by default), and the output drive time stream. The location ID of the channels can be changed under the Channel Table tab.

There are also signals derived from these time streams: block signals, labeled **Block**; auto power spectra signals, labeled **Spectrum**; and the frequency response functions, labeled **FRF**; The labels are followed by the location ID of the original time stream signal in parenthesis (or, in the case of FRF, the location ID of the excitation channel followed by the ID of the response channel). These signals will only show in the live signal list if the measure option is enabled in the Signal Setup tab.

Spectrum is the sine measurement value plotted across the frequency. Usually it is represented in acceleration peak value. The sine measurement is taken at the output of tracking filter.

H(f) is the frequency response function between the drive output and the control input signal.

profile(f) is the frequency-domain test profile.

HighAlarm(f), **LowAlarm(f)**, **HighAbort(f)**, and **LowAbort(f)** are the limit lines of the profile. These signals are in unit of EU-peak.

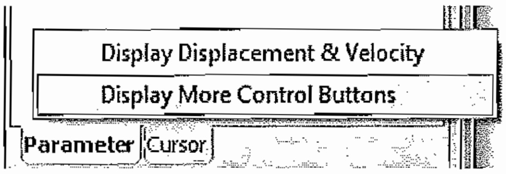
control(f) is the power spectrum of the control signal.

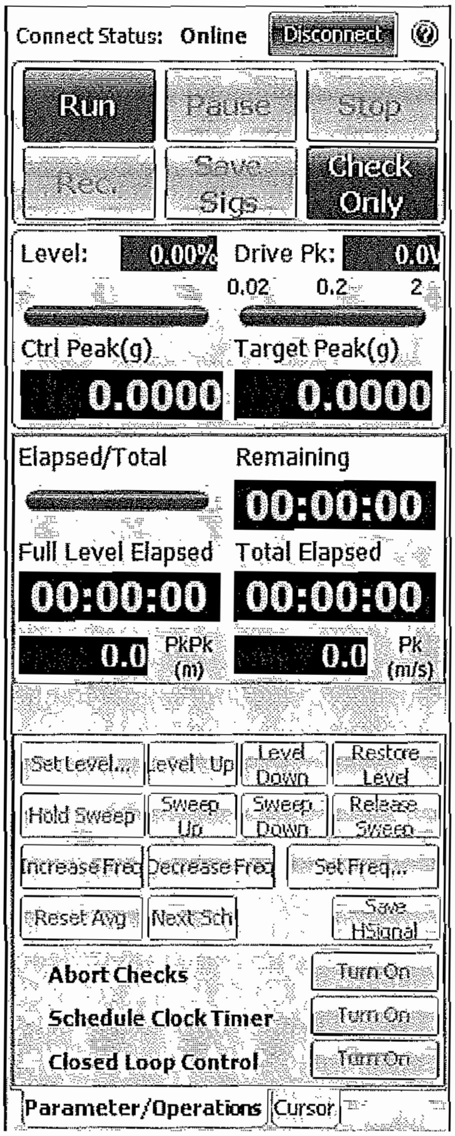
noise(f) is the power spectrum of the system noise, measured in the first part of the pre-test.

control_his() is the RMS level history of the control signal.

Control Panel

The expanded control panel in Random mode has a number of commands to control the operation of the test. The control panel can be expanded by right clicking in the Parameters tab.





Test state information are displayed in the following fields:

Level is the current output level, as a percentage of the test profile. This is displayed graphically in the green bar below this field.

Drive Pk is the peak voltage of the output drive signal. This is shown graphically in the green bar below, as a proportion of the maximum drive voltage limit (set in Test Parameters).

Ctrl RMS is the RMS level of the input control signal.

Target RMS is the target RMS level of the current test stage. This is a function of the test profile and the current test level percentage. The output is increased until the Ctrl RMS reaches the Target RMS.

Elapsed/Total is a green bar showing the elapsed time as a proportion to the total test duration, according to the run schedule.

Remaining is the remaining time of the test, according to the run schedule.

Full Level Elapsed is the time elapsed running at full (100%) output level.

Total Elapsed is the time elapsed since the test was started.

PkPk: This is the estimated peak-peak displacement of the control channel. If there are more than one control channel, only the peak-peak of the first control channel is displayed. The displacement signal is computed by double-integrating the acceleration signal. The accuracy of this computation may be very low if the signal contains significant amount of low frequency energy. Therefore this display is only used as a reference.

Pk: This is the estimated peak velocity of the control channel. If there are more than one control channel, only the velocity peak of the first control channel is displayed. The displacement signal is computed by integrating the acceleration signal. The accuracy of this computation may be very low if the signal contains significant amount of low frequency energy. Therefore this display is only used as a reference.

The following commands are available in the expanded toolbar:

Set Level...: change the current target output level to a specified value, as a percentage of the test profile

Level Up: increase the current output level by 5%

Level Down: decrease the current output level by 5%

Restore Level: restore the current output level to the level set by the current schedule entry

Hold Sweep: the sweep in progress at the current frequency

Sweep Up: begin sweeping in the direction of increasing frequency

Sweep Down: begin sweeping in the direction of decreasing frequency

Release Sweep: resume the sweep set by the current schedule entry

Increase Frequency: increase the current frequency and dwell there

Decrease Frequency: decrease the current frequency and dwell there

Set Freq...: dwell at a specified frequency

Reset Avg: reset all averages to zero

Next Sch Entry: end the current test stage and move to the next schedule entry

Pretest Window: open the pretest window

Save H Signal: save the H(f) signal, which is the frequency response function of the system

Resonant Search and Dwell Tests

In structural fatigue testing, sometimes it is desirable to shake a structure at its resonant frequencies for an extended period of time. The Sine test suite in EDM has functions that find and track these resonances. This section describes how such a test is implemented.

The peak displacement, velocity, and acceleration response of a system undergoing forced, steady-state vibration occur at slightly different forcing frequencies. A resonance frequency is defined as a frequency for which the response reaches a local maximum. These resonances are given as:

Displacement resonance frequency: $\omega_n(1-2\zeta^2)^{\frac{1}{2}}$

Velocity resonance frequency: ω_n

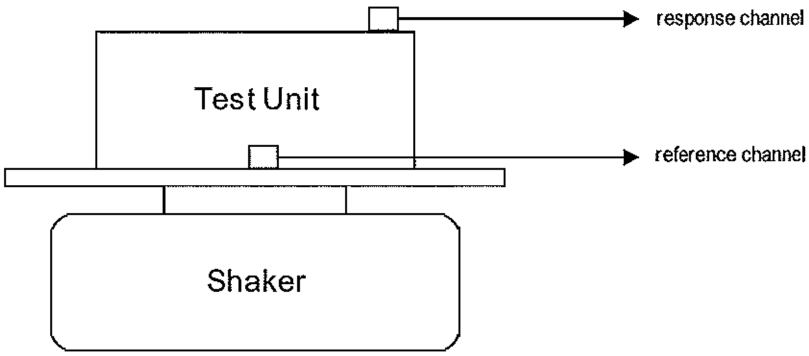
Acceleration resonance frequency: $\omega_n(1-2\zeta^2)^{\frac{1}{2}}$

For physical systems with small damping ratios, say $\zeta < 0.1$, the difference among the three resonance frequencies is negligible[1].

A direct method to find resonances is to measure the transfer function between the force excitation signal and the response signal of the structure (acceleration, velocity or displacement). Resonances will be seen as peaks on the transfer function curve. Unfortunately, this approach is unpractical in many shaker tests because the force measurement is not easy to obtain. Instead, transmissibility measurements are commonly used to find the resonances.

Acceleration transmissibility measurements are calculated from the response of two accelerometers, one on the shaker table and the other on the structure under test. Transmissibility is defined as the ratio of the response between two points.

[1] These explanations are drawn from the *Shock and Vibration Handbook* by Cyril Harris



Test Setup

There may be more than one response accelerometer, and transmissibility functions are calculated for each one. It is critical to select the right mount locations for these reference and response accelerometers. The wrong location may make it impossible to find some resonances. Also, if the response and reference channels are reversed, anti-resonances will appear as resonances.

The accelerometer for the reference channel should be mounted on the shaker table in a location that will accurately record the base movement. Each accelerometer for the response channels should be mounted on the structure in a location that has the greatest resonant vibration. This is based on the mode shapes of each of the resonances; accelerometers will not detect any response from resonant frequencies corresponding to modes that have a node at their location.

The resonance search works best with transmissibility signals that have clean, high-amplitude peaks.

In the CI control system, the transmissibility function is represented as:

Transmissibility y,x (f) = channel y / channel x

where y is the *response* channel and x is the *reference* channel.

Measuring Transmissibility Signals

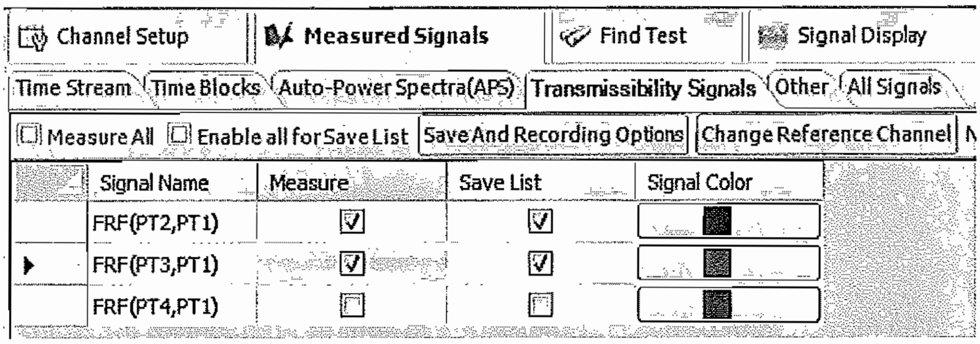
The first step is to measure one or more transmissibility signals that accurately characterize the resonances of the system. A transmissibility signal can come from any input-output test of the system, including random, swept sine, and shock excitations. An impact hammer test can even be used.

The test must cover the frequency range of interest. For swept sine test, this means the sweep must go from below the lowest frequency to above the highest frequency that is needed in the transmissibility function. For random tests, the profile must cover this range with enough energy to overcome the noise in the system.

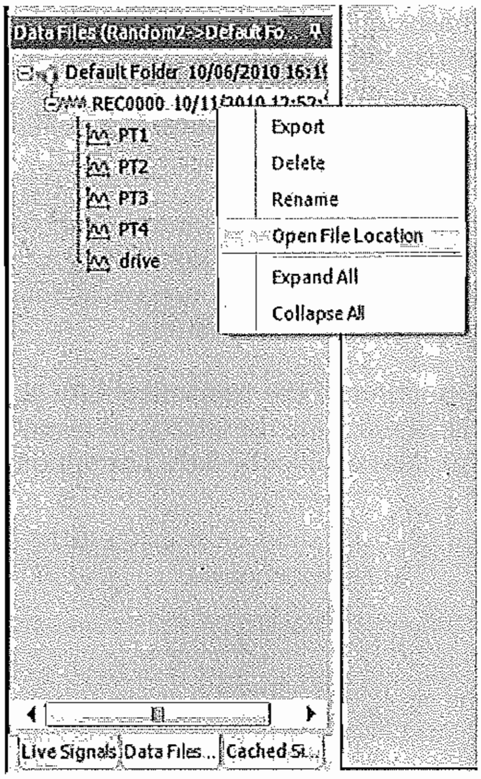
The excitation is measured at the source, which in shaker tests is where the shaker couples to the test structure. The best case would be measuring the actual force of the excitation; this would generate a true frequency response function. However, since force is more difficult to measure, the excitation is most often measured with an accelerometer.

The response is usually measured from one or more accelerometers mounted on the test structure. One response location can be adequate as long as none of the significant modes of the system has a node at that location. A node is a point where a mode has zero response amplitude.

To enable the calculation of the transmissibility signal in EDM, make sure the Measure option is enabled for the FRF(y, x) signal (y is response channel, x is excitation channel). Also enable the Save List option so the signal can be saved to a file.



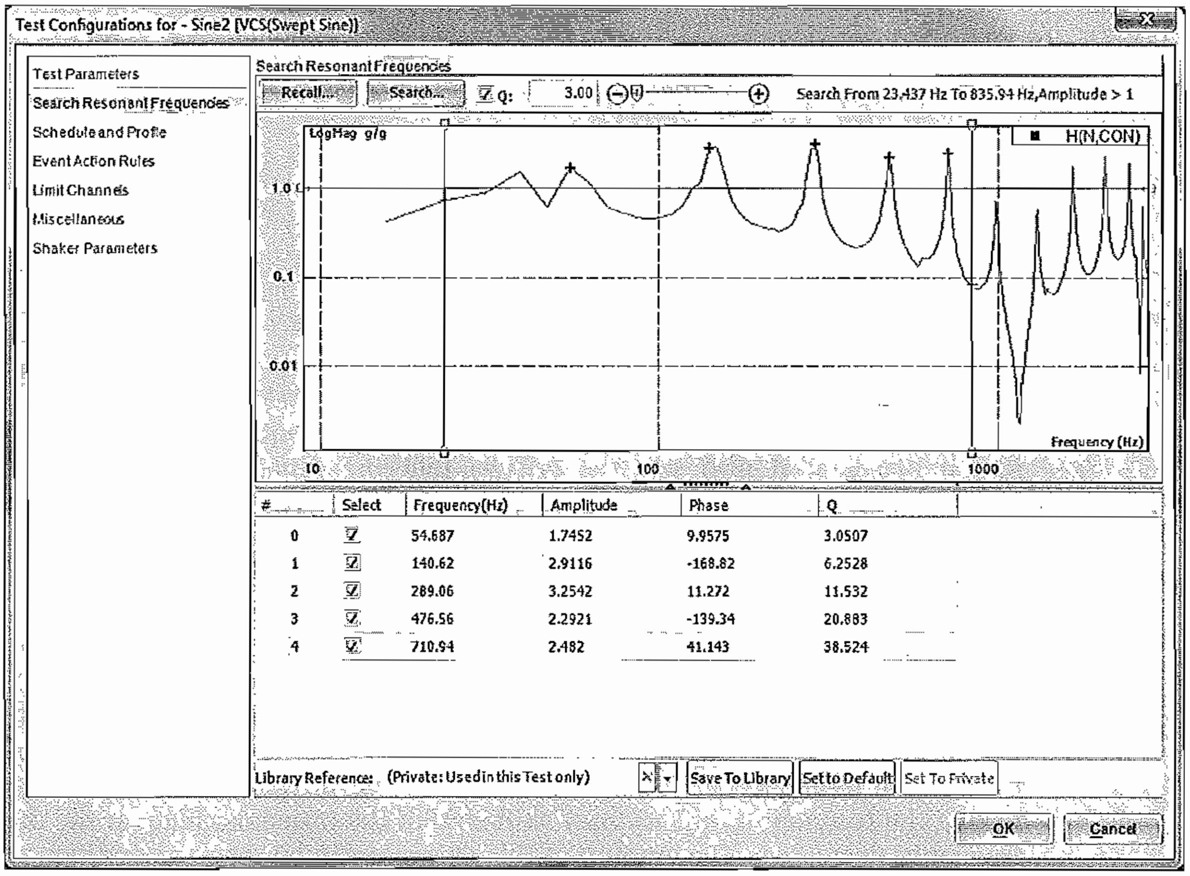
Once the test unit, sensors, and channels are all set up, run the test for a long enough period to acquire enough blocks for a stable average, or for the sine sweep to complete for swept sine tests. Then, press the **Save Sigs** button on the control panel and the FRF signals will be saved to disk. The saved files will show up under the Data Files tab on the lower left side of EDM. To locate the folder on disk, right click on the file and choose Open File Location.



The file can then be used for the Search Resonant Frequencies function.

Search Resonant Frequencies

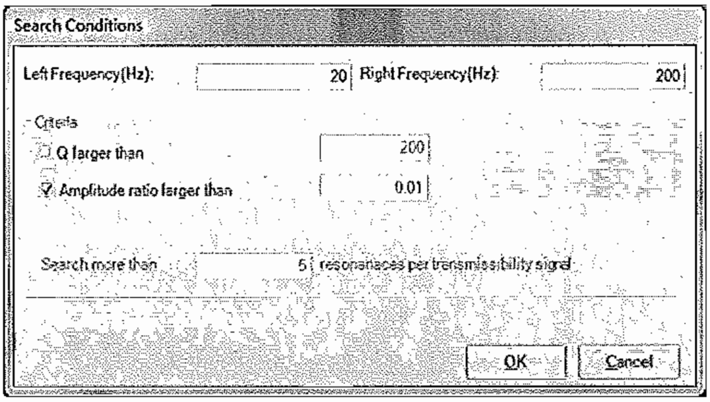
The resonance search function is implemented in the **Search Resonant Frequencies** section of the Test Configuration window. This function imports a transmissibility function saved in a data file and searches through a specified frequency range to find resonances. For each resonance, it calculates the resonant amplitude, phase, and Q value.



The signals displayed above are measured on a beam excited by an electrodynamic shaker. A dozen resonant frequencies are shown. The resonant search uses parameters such as the Q (Quality Factor) or amplitude ratio as criteria for detecting the resonant frequencies. Also, each detected resonant frequency can be manually edited after the search.

First, a signal must be recalled. Press the **Recall...** button and open any .atfx file that contains a transmissibility signal.

To set up the calculation press the **Setup...** button which brings up the Search Conditions window. The **Start...** button begins the RSD searching.

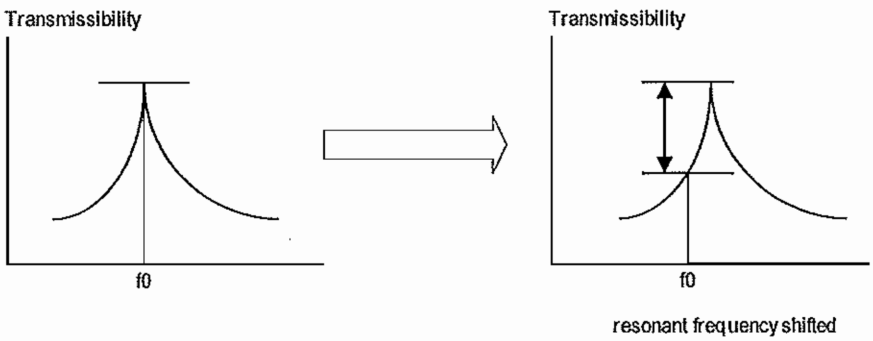


The Search Conditions window sets the low and high frequencies for the RSD to search between. It also sets the criteria that the function uses to detect a resonance, either as a minimum Q value or amplitude ratio.

After the resonance search, the detected frequencies are used in fixed-frequency dwell and tracked dwell tests.

Fixed-Frequency Dwell

Fixed-Frequency Dwell means the controller will output a frequency fixed at one of the frequencies detected in the search process. The dwell will continue until one or more pre-defined conditions are met. As a typical example, in fatigue testing the resonant frequency may shift so that the transmissibility at the dwell frequency decreases. The amount of this decrease can be set as a condition that terminates the dwell event.

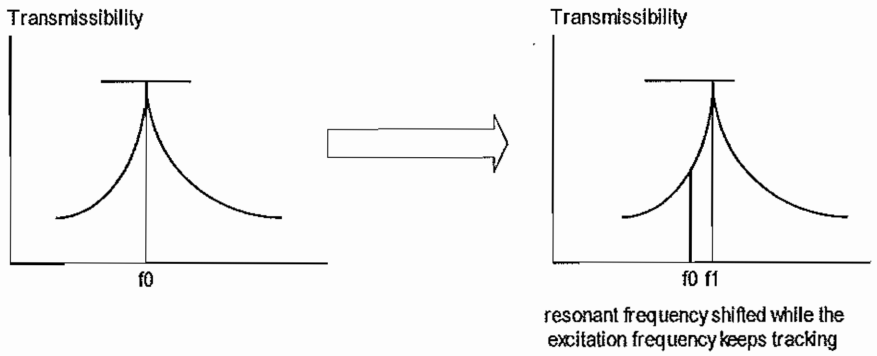


Frequency-Locked Dwell

Fixed-frequency dwell is done using the **fixed dwell** schedule entry, described above.

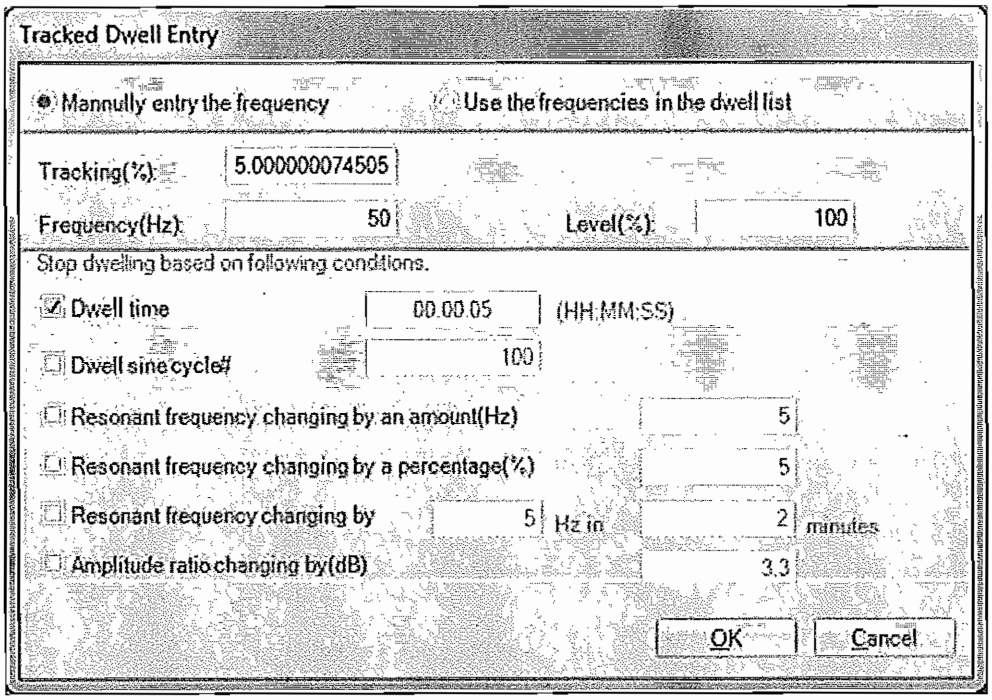
Resonance-Tracked Dwell

In tracked dwell, the controller monitors the resonance frequency and adjusts the drive frequency as this frequency changes. This change is caused by plastic deformation and fatigue damage in the test structure.



Resonance-Tracked Dwell (Automatic Frequency Adjustment)

A resonance-tracked dwell is done using the **tracked dwell** schedule entry. .



A **tracked dwell entry** adjusts the output frequency to track a resonance. Resonant frequencies may change during a test due to structural yielding and fatigue. The tracked dwell entry will compensate for this and shift the frequency to remain at resonance.

The frequency to dwell at can be entered manually, or the frequencies on the **dwell list** can be used (the dwell list is created in the RSD function). **Level(%)** is relative to the swept sine profile. **Tracking(%)** limits the maximum change in frequency as a percentage of the dwell frequency. For example, if the frequency is

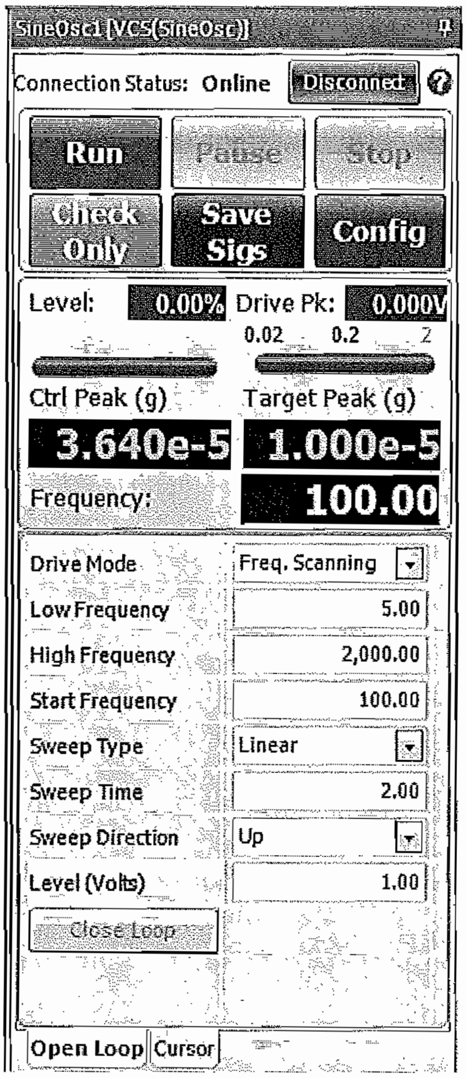
50 Hz and the tracking percentage is 5, then the tracked dwell will change the output frequency between 49 and 51 Hz to maximize the response.

The tracked dwell entry also has a number of abort conditions that can be set. When enabled, the tracked dwell will end when these conditions occur. The conditions are time, number of cycles, an absolute or relative change in the dwell frequency, a maximum rate of change of the dwell frequency (hz per minute), and change in amplitude (in dB) of the control signal.

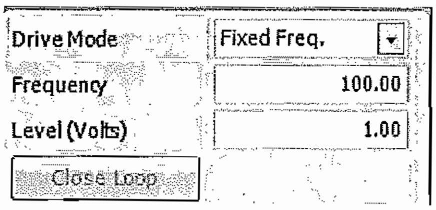
Sine Oscillator

The Sine Oscillator mode of the Swept Sine test allows the output sine wave to be manually controlled by the user. The controllable parameters include frequency, amplitude, and sweep rate, frequency limits, and direction. When being manually controlled, the sine output is not under closed-loop control as it is during a regular swept sine test. Closed-loop control can also be turned on to function as a simple sine controller.

The sweep parameters are set under the control panel. This replaces the run schedule that is used in the regular Sine mode.



The **Drive Mode** switches between Freq. Scanning mode, which outputs a sine sweep, and the Fixed Freq. mode, which outputs a fixed frequency.

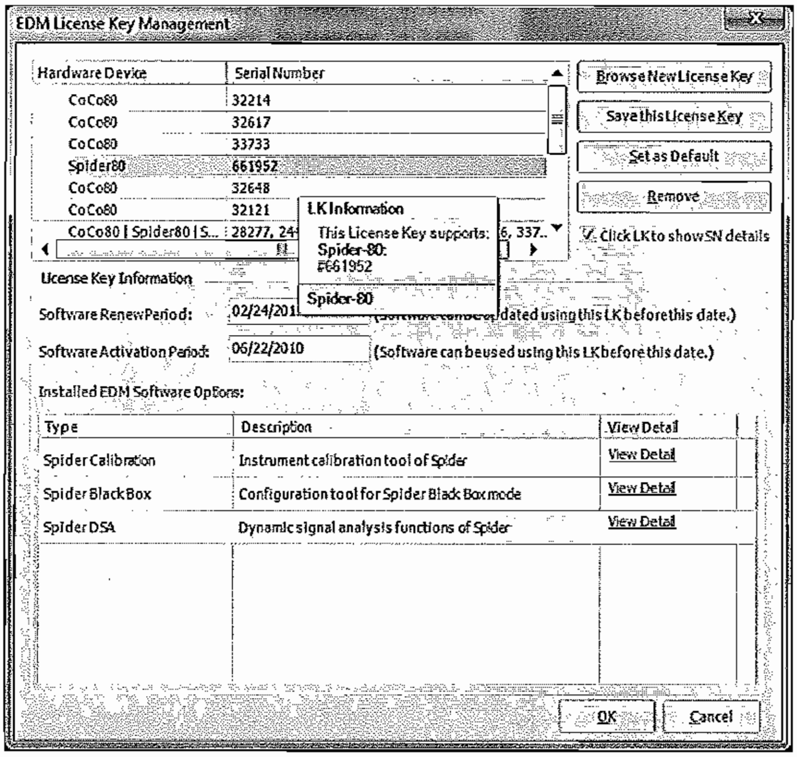


The **Close Loop** button turns on closed loop control. The output drive level will be adjusted so that the input control signal matches the profile. The profile is set under the Profile and Schedule section of the Test Configuration window, just like the normal Sine test.

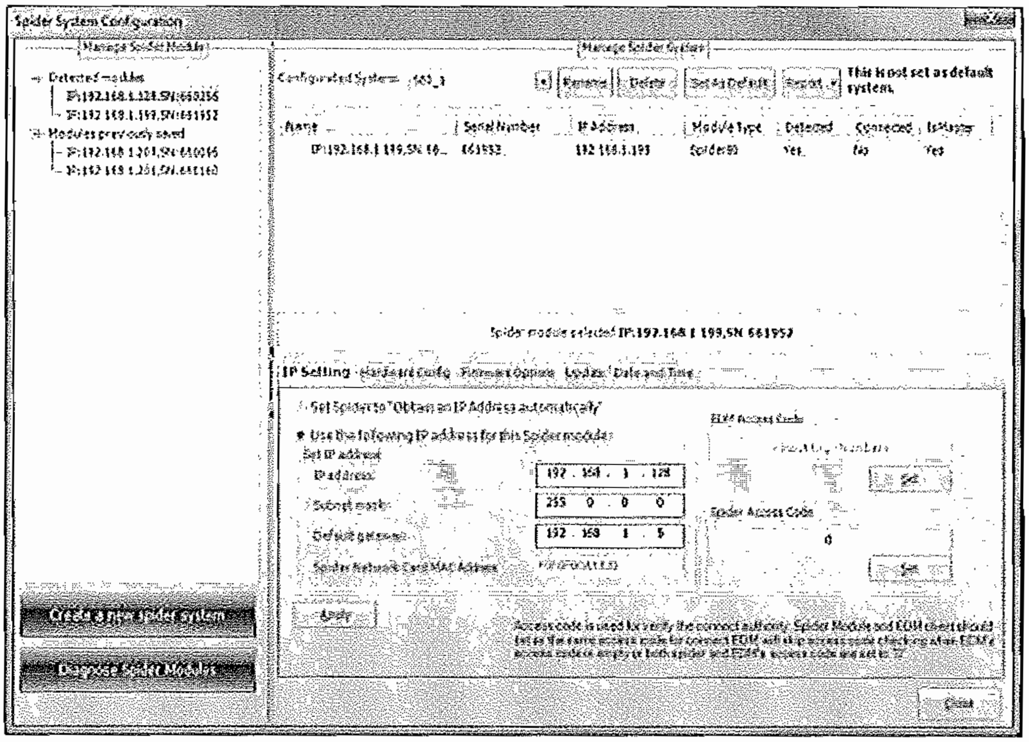
When in closed-loop control mode, pressing **Open Loop** will revert back to the manual control mode.

Typical Sine Test

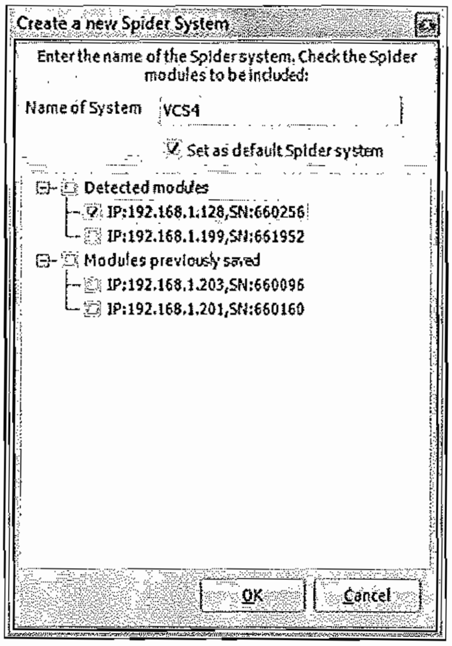
This section will walk through setting up and running a typical Sine test. First, make sure EDM is running in Spider working mode, with a valid license key installed. Open **Tools -> License Key Manager**, and make sure that the serial number of the currently active license key matches the Spider hardware.



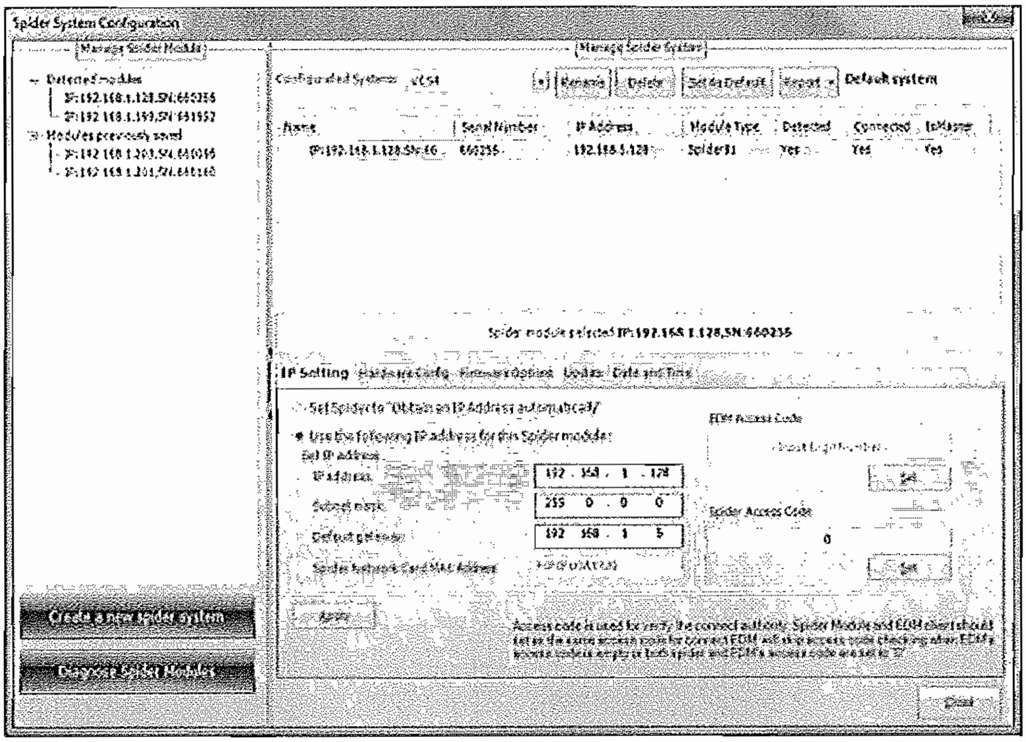
Plug the Spider-81 into the power cord and into the network, and turn it on. Then, configure a Spider system by opening **Tools -> Spider Configuration.**



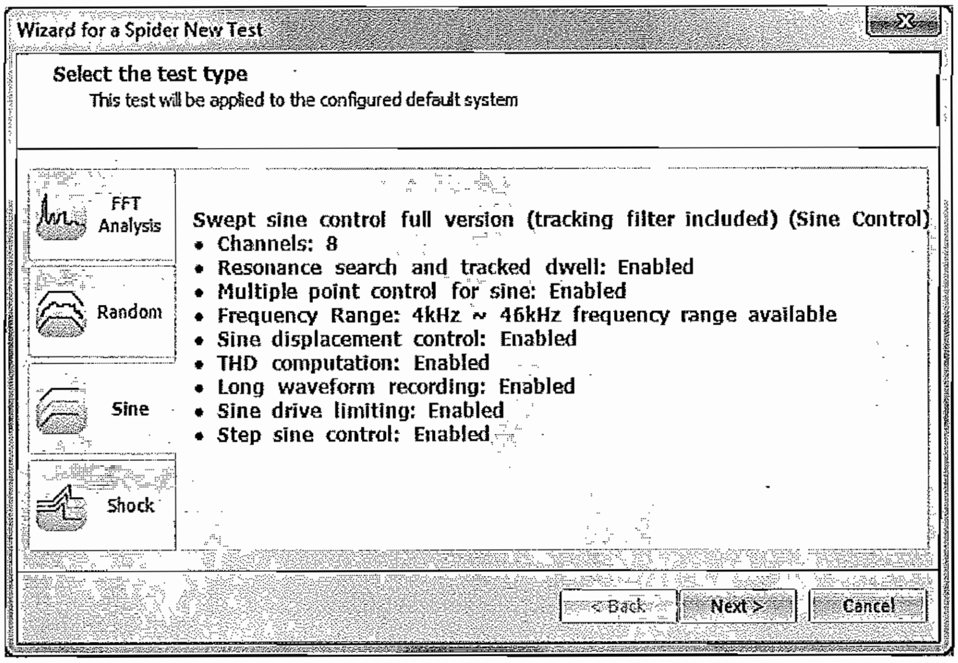
The Spider module should be listed under Detected Modules on the left in this window. Click **Create a new spider system.**



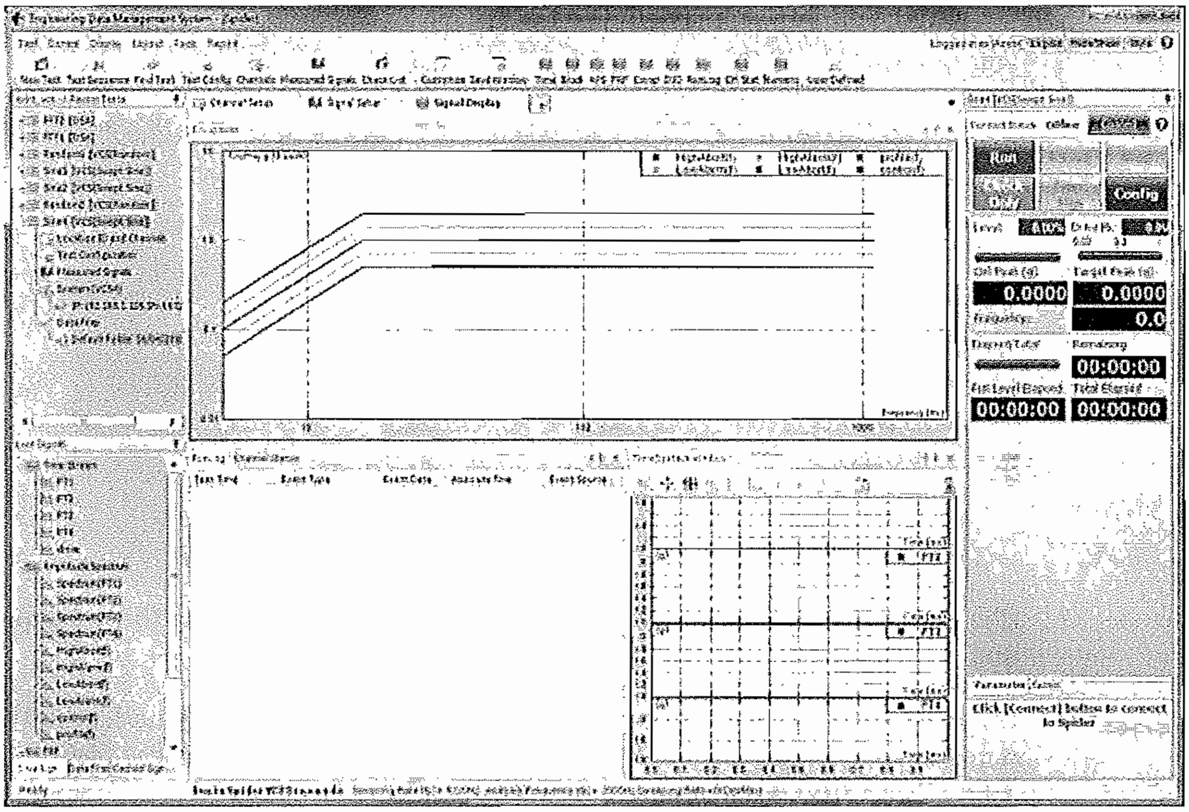
Enter a name for this system, and select the checkbox next to the Spider module. Press **OK**, and then it should be listed as the current Spider system.



Close this window. Next, select **New Test** from the **Test** menu, and click Sine.



Click **Next>**, assign a name to the test, and then click **Finish**. You will then be presented with the default EDM display for new tests.

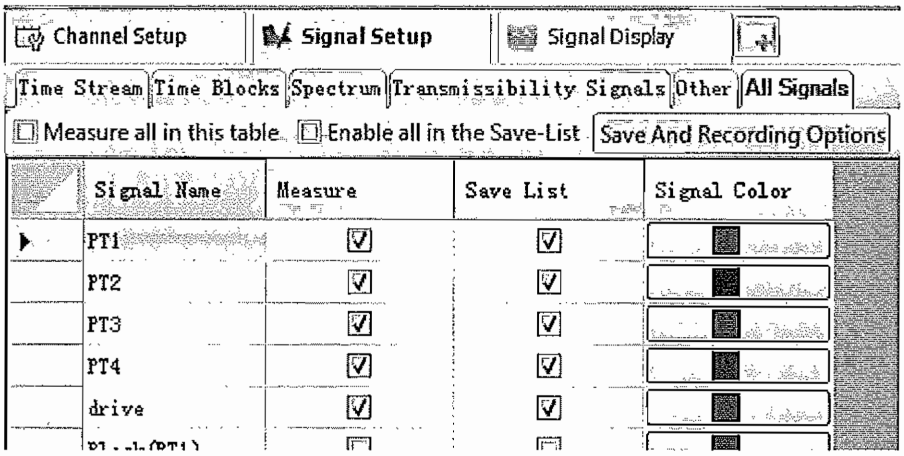


The next step is to configure the input channels. At this point, make all the connections from the sensors and shaker amplifier to the Spider. Then select the **Channel Setup** tab.

	Module:Ch#	On/Off	Location ID	Measurement Quantity	Unit	Sensitivity	Input Mode	High-Pass Filter Fc(Hz)	Channel Type	Control Weighting
1	IP:192.168.1...	On	PT1	Acceleration	g	111.9000 (mV/g)	IEPE	2.0000	Control Only	1.0000
2	IP:192.168.1...	On	PT2	Acceleration	g	10.4000 (mV/g)	IEPE	2.0000	Monitor Only	1.0000
3	IP:192.168.1...	On	PT3	Acceleration	g	98.0000 (mV/g)	IEPE	2.0000	Monitor Only	1.0000
4	IP:192.168.1...	On	PT4	Acceleration	g	98.8000 (mV/g)	IEPE	2.0000	Monitor Only	1.0000
5	IP:192.168.1...	Off	PT5	Acceleration	g	100.0000 (mV/g)	AC-Single End	2.0000	Monitor Only	1.0000
6	IP:192.168.1...	Off	PT6	Acceleration	g	100.0000 (mV/g)	AC-Single End	2.0000	Monitor Only	1.0000
7	IP:192.168.1...	Off	PT7	Acceleration	g	100.0000 (mV/g)	AC-Single End	2.0000	Monitor Only	1.0000
8	IP:192.168.1...	Off	PT8	Acceleration	g	100.0000 (mV/g)	AC-Single End	2.0000	Monitor Only	1.0000

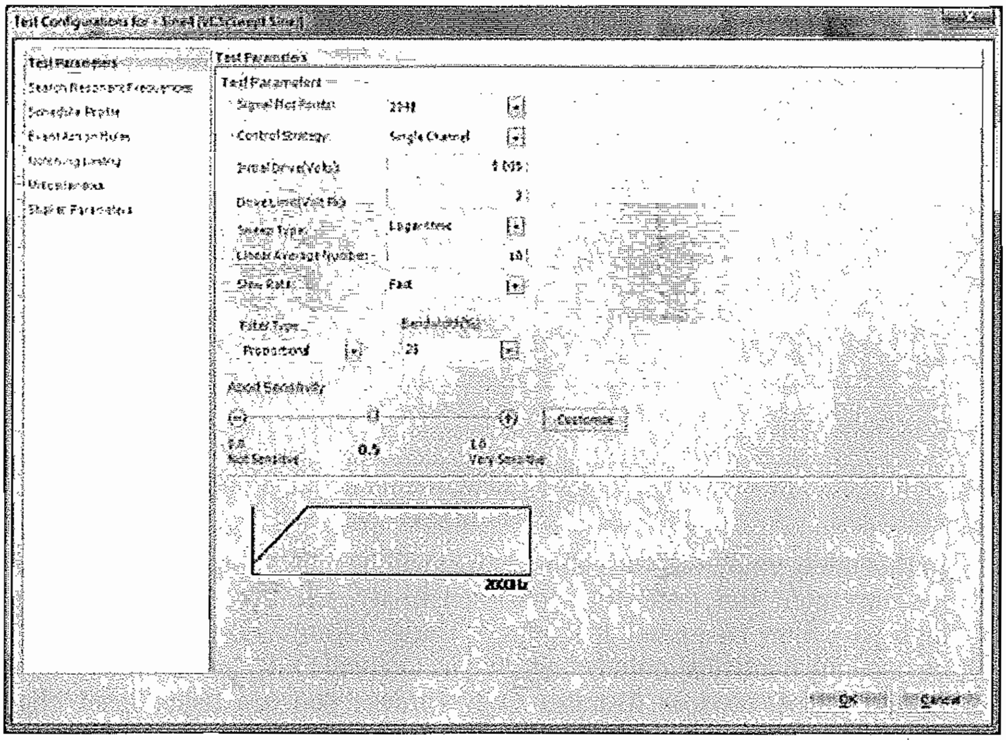
In this table, enable all the channels you will be using. For each channel, select the measurement unit, enter the sensor sensitivity, select the Input Mode, and set the high pass filter frequency if required. Under Channel Type, the channel that will be used for control should be selected as Control Only, and all the other channels should be selected as Monitor Only (unless you are using limit channels or multiple control channels).

Next, under the **Signal Setup** tab, enable the Measure option on all signals that you will be interested in viewing. For the signals that you are interested in saving or recording, enable the Save List option.



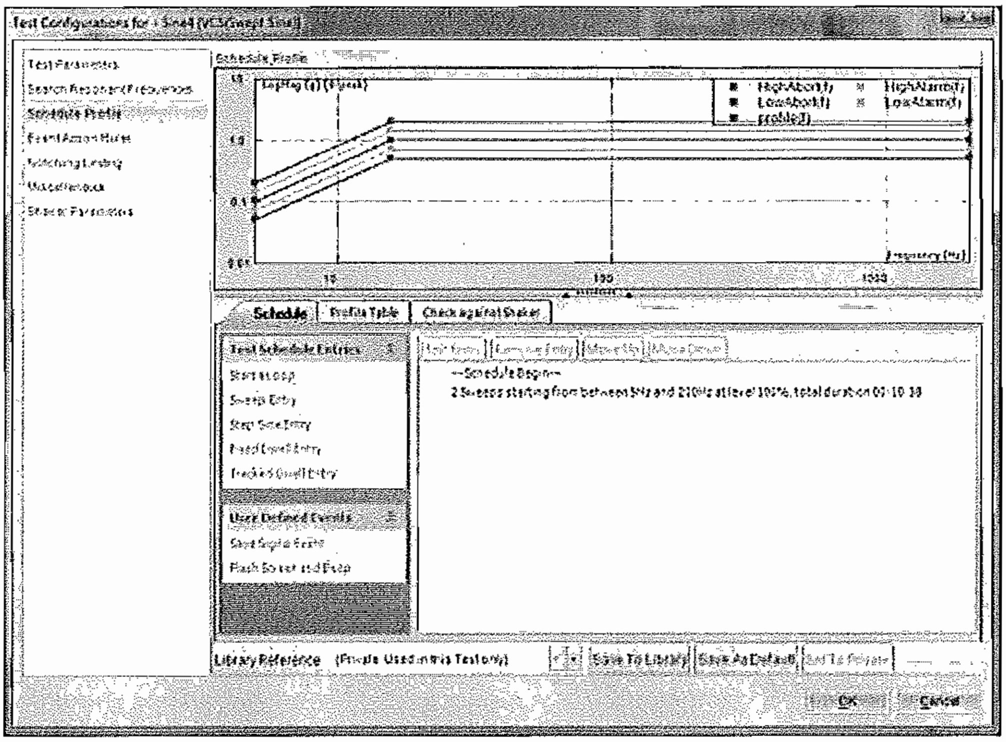
The next steps are to set the Test Configuration options, including the test profile and shaker parameters.

Open the **Test Configuration** window by selecting **Test Config** under the **Test** menu or by pressing the Config button on the control panel. The first page is the **Test Parameters** section.

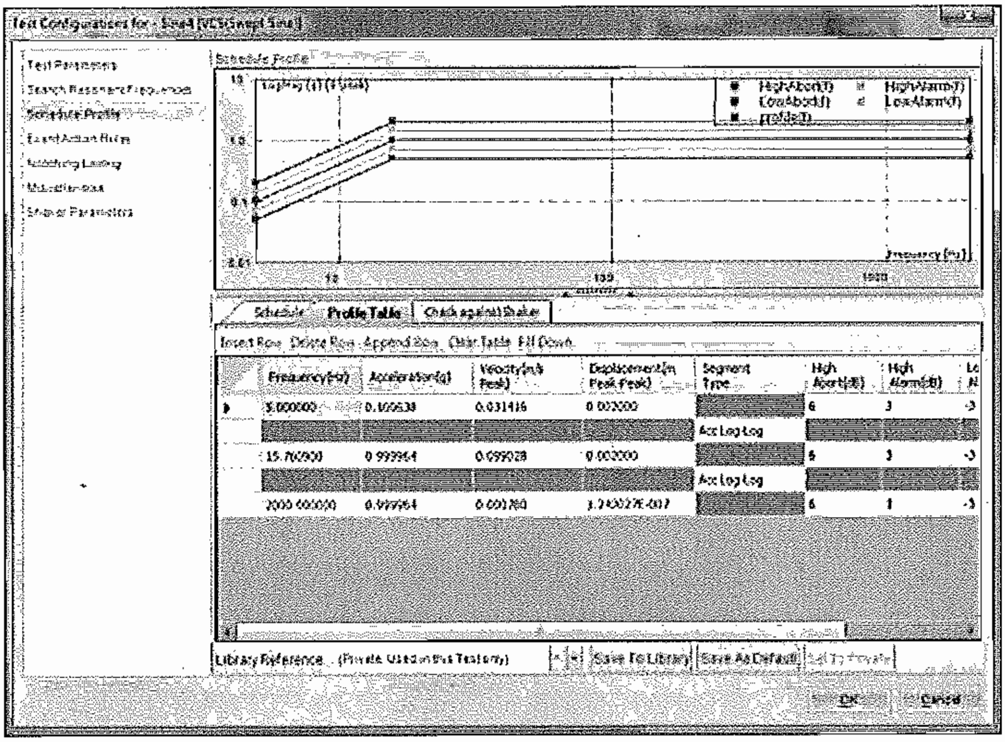


Set all the important analysis parameters here, such as signal plot points and average number. Also, set the sweep type (linear or logarithmic), and the tracking filter type and width. The Drive Limit is the maximum voltage of the drive signal. The Abort Sensitivity adjusts how sensitive the safety mechanisms are to triggering abort events while the test is running.

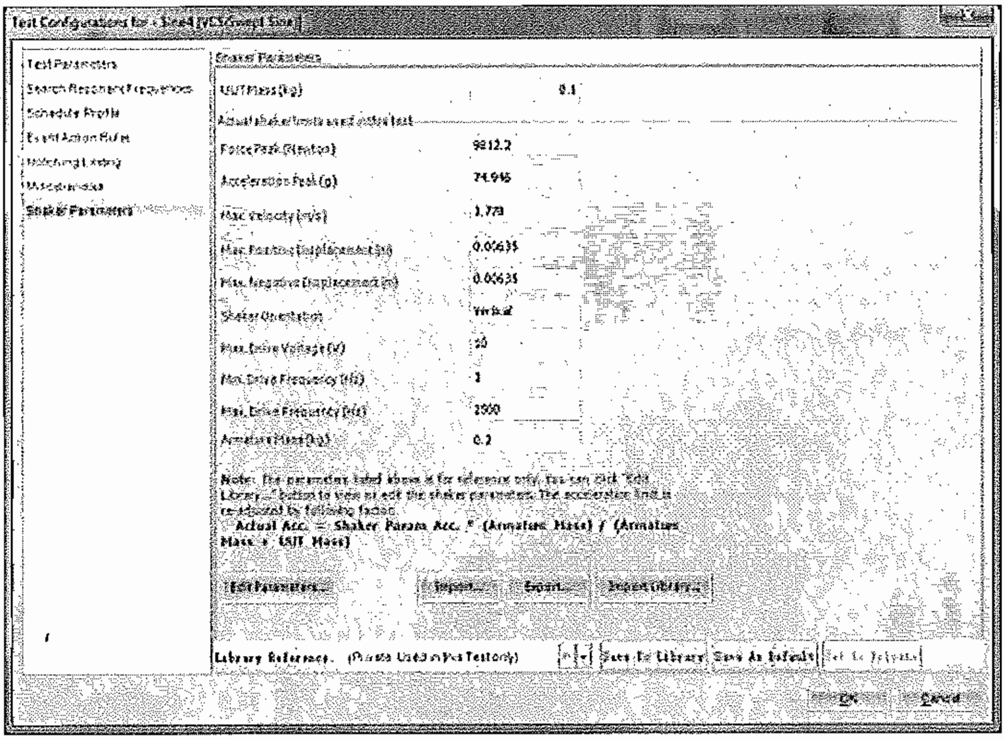
The test profile and run schedule is set under **Schedule Profile.** In the Schedule tab, edit or add entries to control the test sequence. By default, there is an entry for two sweeps between 5 and 200 Hz at 100% level. Double click this item to edit it, or click on the items on the list on the left to insert new entries.



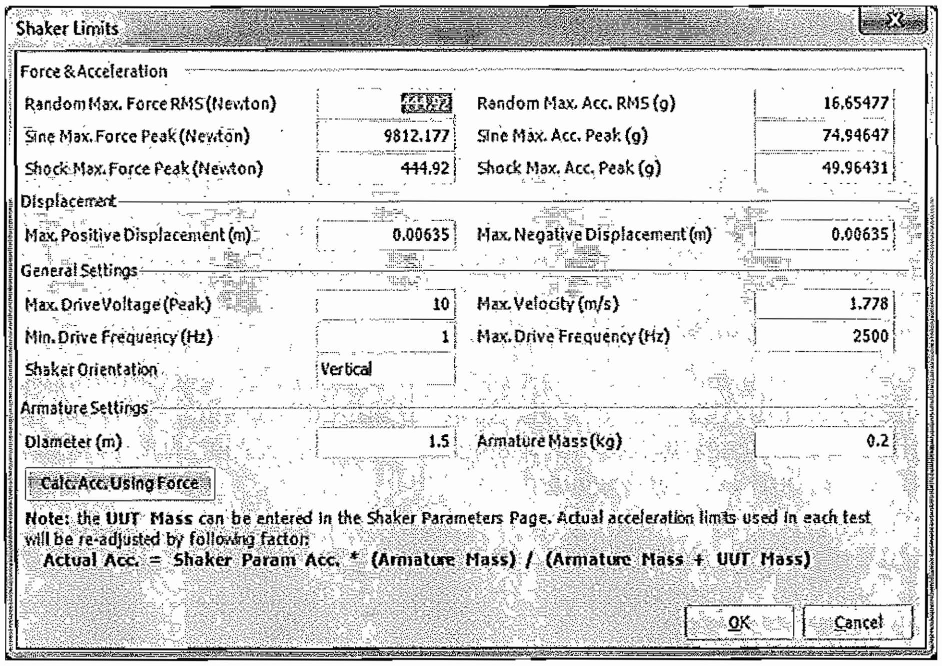
In the Profile Table tab, enter points in the breakpoint table to create the desired test profile. While running the test, the output drive signal will be adjusted such that the input control signal matches this profile as the output is swept through its frequency range.



The last important section in the Test Configuration window is the **Shaker Parameters.**



Click on **Edit Parameters...**, and enter the information from the shaker specifications. This is important for the safety of the shaker and testing unit.



Press **OK** to close the Test Configuration window, and then you should be ready to run the test.

Classic Shock Tests

A Shock test outputs a series of pulses to excite the structure under test. The response is measured at one or more locations on the structure and a spectral analysis is used to determine its resonance characteristics. This pulse response is an approximation to the impulse response function which has a Fourier transform equal to the frequency response function of the system.

The pulse shape can be half-sine, sawtooth, triangle, rectangle, trapezoid, or haver-sine. The pulse itself is always one-sided — its displacement is only in one direction. A series of these pulses would cause an unbounded armature excursion of the shaker in one direction, which is not physically possible. To keep the armature centered, each pulse must have a zero mean displacement. This is done by adding a compensating pre- and post-tail to the pulse.

Safety Features

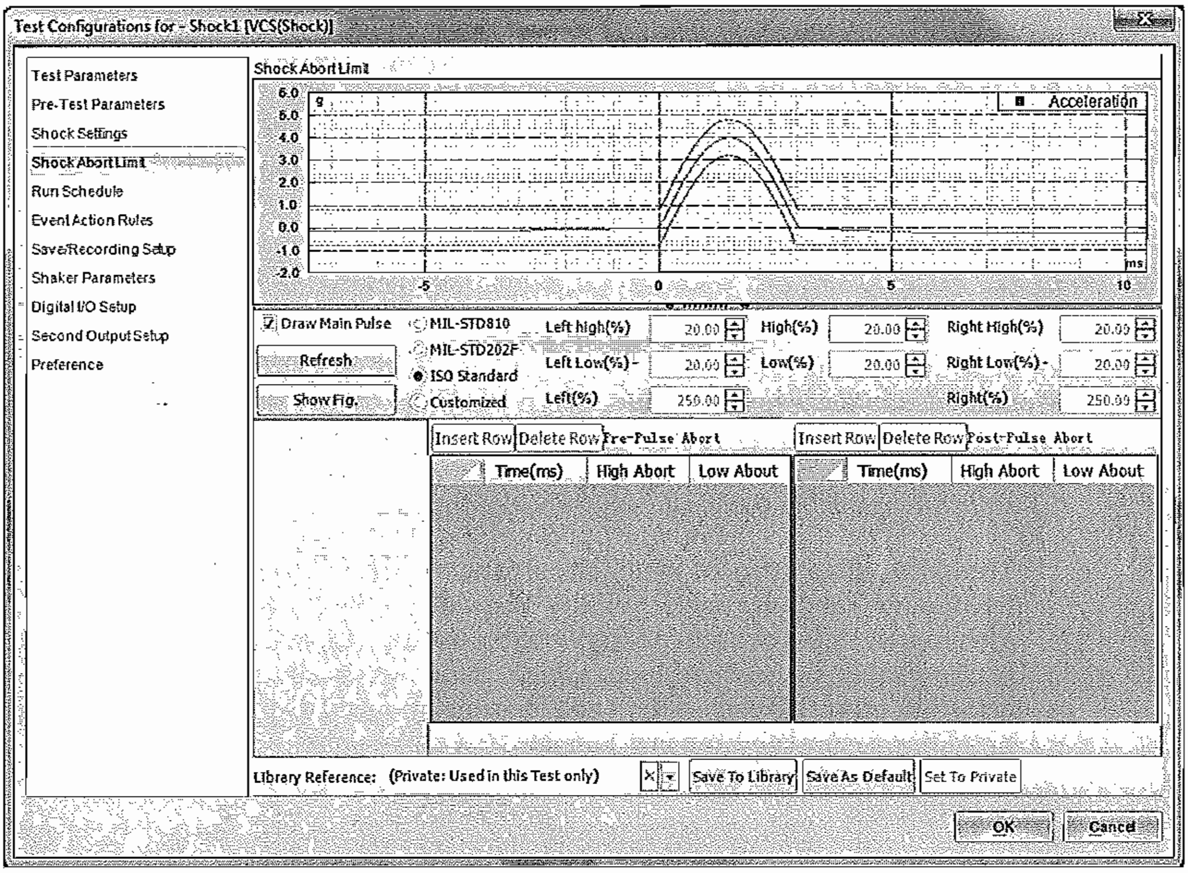
In sine mode, there are a number of safety features that help prevent damage to the shaker and related equipment. During a shake test, 5 different types of checks are performed and an event is triggered if any of these checks fail. The response actions to these events can be customized under Event-Action Rules. The 5 checks are 1) Maximum shaker drive voltage limiting, 2) Channel overload or loss detection, and 3) shock abort limits.

The Spider detects when input channels are overloaded or lost which can indicate a sensor fault or an accidental disconnect. Spider will abort the test if this occurs.

In the event of an accidental network disconnection or power loss, the Spider is able to save test data and state information to non-volatile memory to protect against loss. It has a backup battery that can power the unit for up to 8 minutes. For a network disconnection, the Spider can either continue running the test program in Black Box mode or save all data and execute an orderly shutdown.

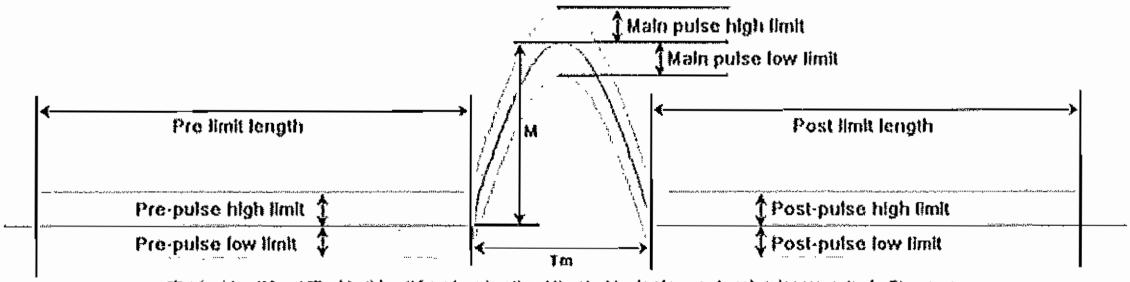
Shock Abort Limit

Shock abort limits are similar to the abort lines in the sine and random tests, but are defined in the time domain rather than the frequency domain. If the level of the control signal, within the vicinity of the pulse output, falls outside these limits then an abort event is triggered.



The top of the window shows the pulse acceleration shape as a green line with the beginning of the pulse at time zero. The abort limits are red lines (this is the same graph as shown in the Shock Settings section).

These limits can be set according to three standards: **Mil-Std 810**, **Mil-Std 202F**, and the ISO mechanical shock test standard. The text fields show the characteristics of the limits — high and low values as a percentage of the main pulse peak amplitude for the left tail, main pulse, and right tail; and the time length of the left and right tails as a percentage of pulse width. The figure below shows a graphic definition of these values (this figure can be shown by clicking the button **Show Fig.**).



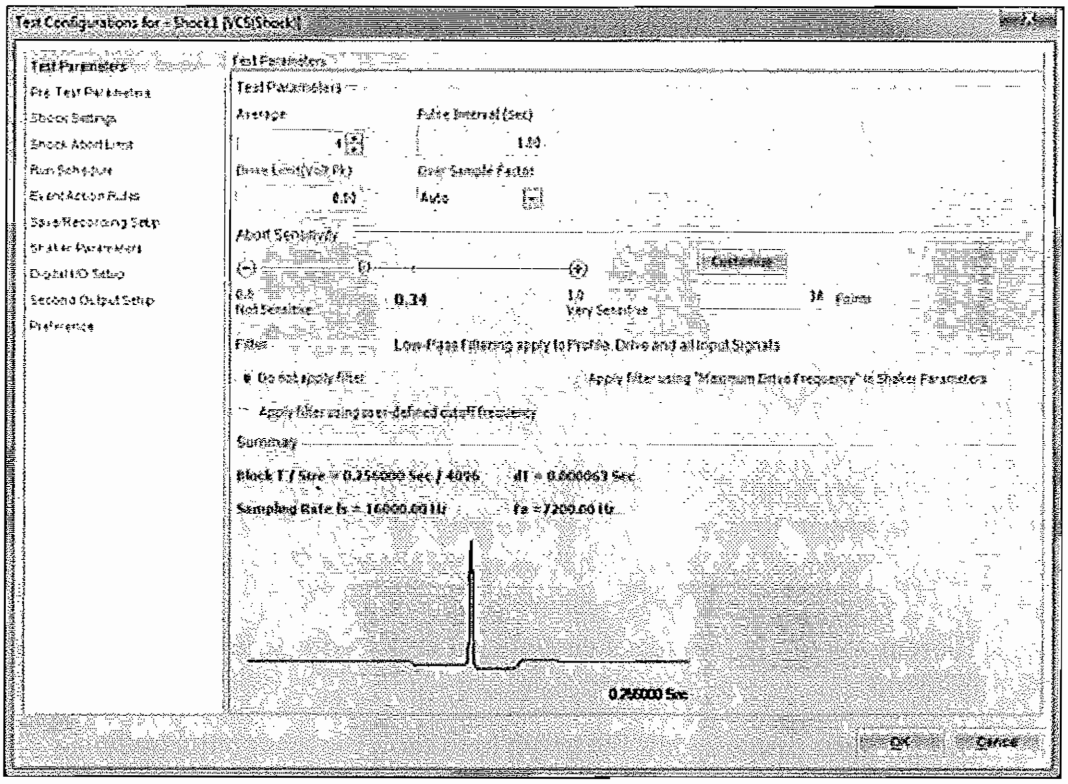
"Pre limit length" and "Post limit length" are time lengths of the abort limits of pre- and post- pulse respectively. They are in percentage of Tm (width of main pulse)
Others are in percentage of M (amplitude of main pulse)

There is also an option to set customized limits, with points entered on the table below.

Draw main pulse zooms the graph in to show the main pulse outline.

Test Parameters

The analysis parameters, pulse interval, output drive voltage limit, and abort sensitivity settings are set in the Test Configuration section of the Test Configuration window.



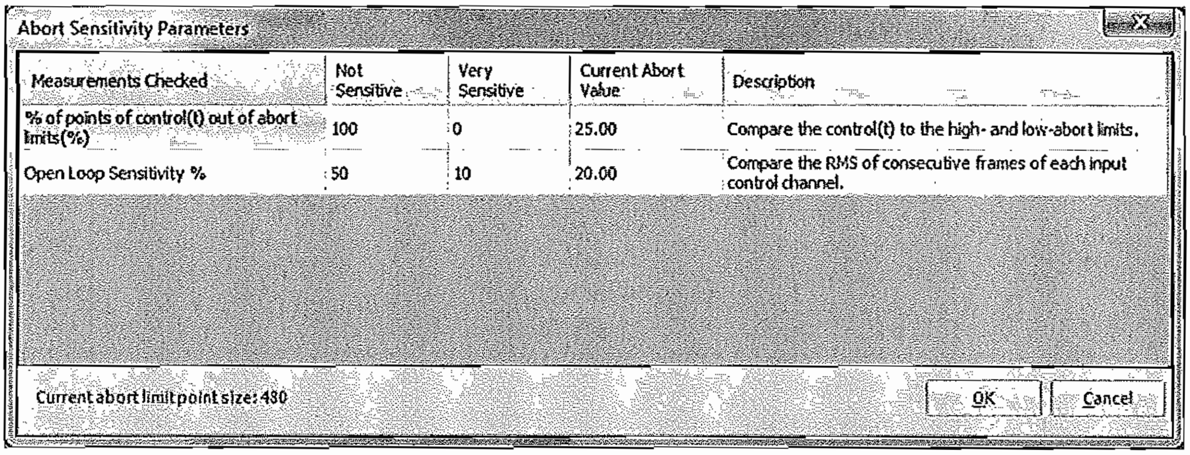
Average is the number of blocks that are averaged for the response profile. Higher averages will smooth out the response to any transient events.

Pulse Interval is the time period between successive pulses. The value should be large enough for the system's response to dampen out after a pulse.

Drive Limit (Volt Pk) limits the absolute maximum voltage output of the drive signal. If the drive limit is reached before the control signal reaches its target, the system will Drive Maximized warning. The output signal will not exceed the Drive Limit.

Over Sample factor is the factor by which the sampling rate is higher than the minimum required for the test profile. EDM automatically calculates the block size and sample rate required based on the frequency content of the pulse shape; this setting can force EDM to use an even higher rate. The block size will also be adjusted such that the total time length of the block remains the same.

The **Abort Sensitivity** slider is a quick way to adjust the safety abort threshold of the test. The values of these parameters can be adjusted by clicking the Customize button, which displays this window:



Abort Sensitivity Parameters

Measurements Checked	Not Sensitive	Very Sensitive	Current Abort Value	Description
% of points of control(t) out of abort limits(%)	100	0	25.00	Compare the control(t) to the high- and low-abort limits.
Open Loop Sensitivity %	50	10	20.00	Compare the RMS of consecutive frames of each input control channel.

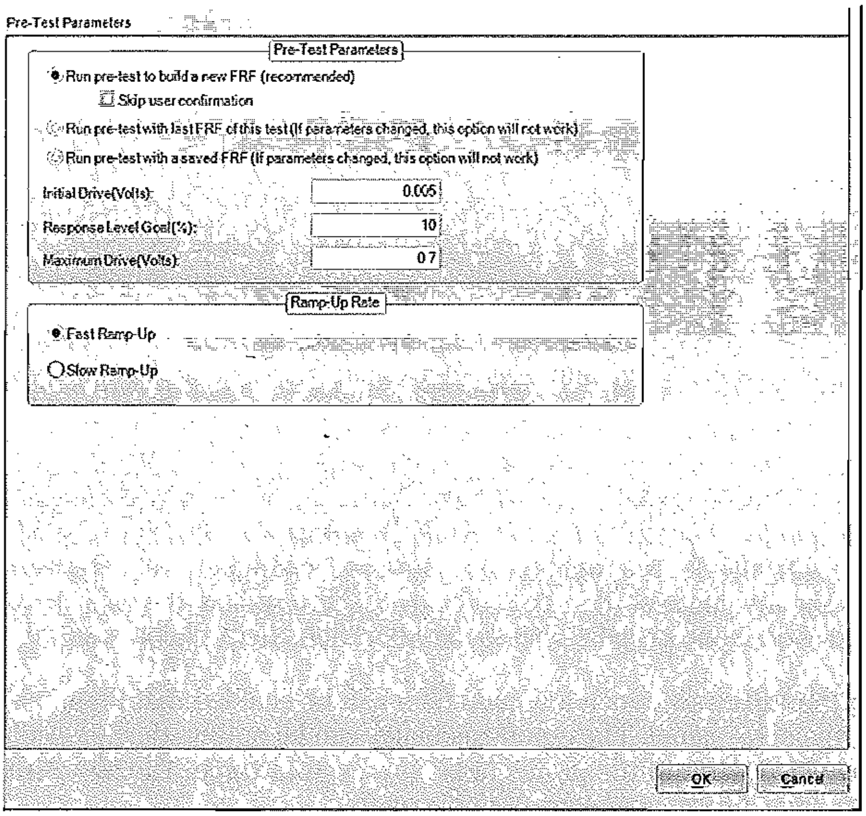
The slider adjusts these parameters between the Not Sensitive and Very Sensitive values. **% of points of control(t) out of abort limits** is the maximum number of samples of the control time signal, as a percentage of one block, allowed to be outside of the abort limits before an abort is triggered. **Open Loop Sensitivity** is the maximum allowable change in the RMS level between consecutive time blocks. The software will interpolate the value between two ends and choose one proportional to the Abort Sensitivity slider position.

In the **Filter** section, a low-pass filter can be enabled that limits high frequencies in the drive signal. The cutoff frequency can be automatically calculated based on the pulse shape of the profile or set to a custom value. The filter will be applied to the drive, profile, and control time signals.

Starting a Test

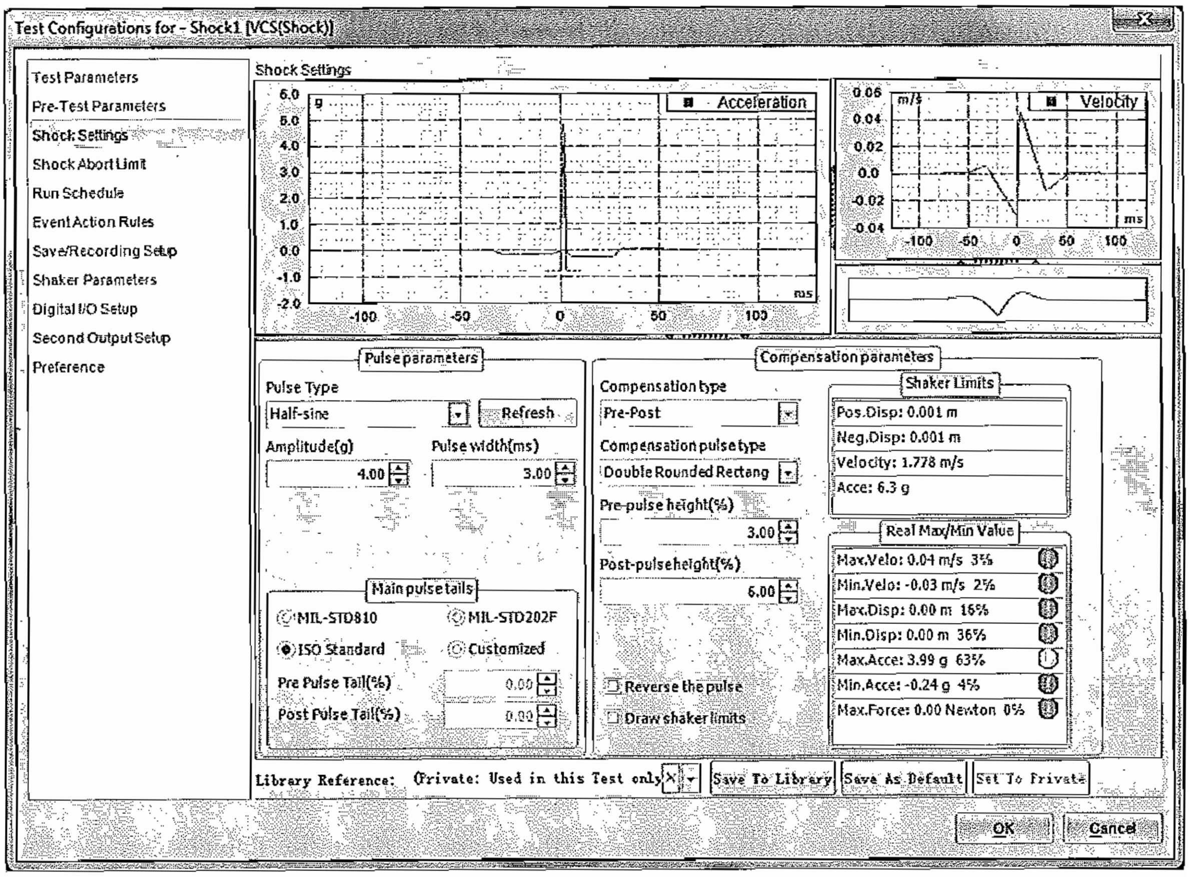
Just as in Random mode, EDM will run a pre-test to calculate an approximate Frequency Response Function (FRF) between the shaker output and the control sensor input. It consists of, first, measuring the noise of the system, then outputting a small pulse and increasing output until a small response of the structure is detected.

Pre-Test Parameters



Before a shake test, EDM will run a pre-test to build an approximate Frequency Response Function (FRF) between the shaker output and the control sensor input. It is the same pre-test that is run in the Random test mode. It will drive the shaker at the **Initial Drive (Volts)** level, and then ramp up until a response is generated at the level set by **Response Level Goal (%)**. The output will be limited by the **Maximum Drive (Volts)**. This Ramp-Up Rate can be set to **Fast Ramp-Up** or **Slow Ramp-Up**. The FRF can also be used from the last pre-test or can be loaded from a file. This can save time if running a test with the same setup as a previous test, but if anything has changed a new pre-test must be run to generate a new FRF.

Shock Settings



This is where the pulse shape and time characteristics are set. The window is divided into three sections: the top shows a plot of the pulse shape in acceleration, velocity, and displacement units. The bottom left has settings for the pulse parameters, and the right has settings for the compensation parameters.

The graphs on the top screen show the pulse shape as a green line. The pulse is set as an acceleration profile, and this shape is integrated to draw the velocity and displacement profiles. The acceleration graph also shows the abort limits as red lines above and below the pulse. These abort limits are set under the **Shock Abort Limit** settings, described in the next section. All the graphs can by zoomed by clicking and dragging a rectangle over the desired view area. To zoom out, right click in the graph and select **Zoom Back** to revert to the previous zoom level, or **Un-Zoom All** to zoom out completely.

Pulse Parameters

Pulse Type is the shape of the pulse. The options are **half-sine, terminal-peak sawtooth, initial-peak sawtooth, triangle, rectangle, trapezoid,** and **haver-sine.** The shapes have different frequency characteristics and are suitable for simulated different impulse conditions. Many testing standards specify the pulse shape to be used.

Amplitude sets the peak acceleration value of the pulse.

Pulse width sets the width of the pulse in milliseconds. Narrower pulses have greater high-frequency components.

Main pulse tails are the compensation tails described below. The time length of the pre- and post-tails can be set according to three standards: **Mil-Std 810**, **Mil-Std 202F**, and the ISO mechanical shock test standard. They can also be set to custom lengths as a percentage of the main pulse width.

Compensation Parameters
At the end of one pulse period, there must be zero residual displacement and velocity; otherwise it would become impossible to control the shaker. Because the main pulse is usually one-sided, **Compensation tails** must be added to counteract the one-directional acceleration. These are, essentially, additional secondary pulses at around 20% of the amplitude of the main pulse. While one compensation pulse could be used to give zero residual displacement, at least two must be used to give zero residual displacement and velocity.

Compensation type sets whether the tails are inserted before the main pulse (**pre-pulse only**), after the main pulse (**post-pulse only**), or both before and after (**pre-post**). Some testing situations require minimal disturbance before or after the test event, and having a compensation tail on only one side of the main pulse will aloow this. However, using compensation on both sides of the main pulse will maximize the available displacement ability of the shaker.

Compensation pulse type sets the shape of the tails. The choices are double rectangular, double rounded rectangular, and displacement optimum. Each of these shapes have different frequency characteristics. Displacement optimum maximizes the usable shaker displacement.

Pre-pulse height and **Post-pulse height** set the amplitude of the tails, as a percentage of the peak pulse amplitude.

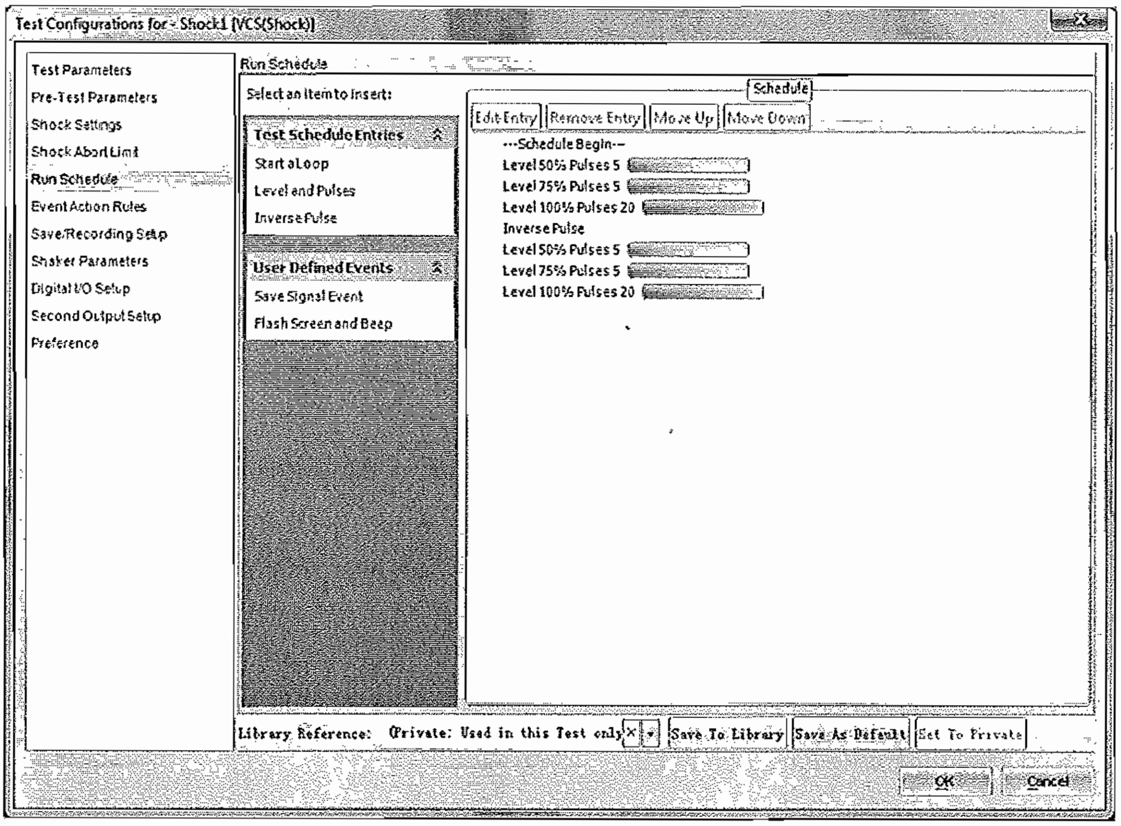
Reverse the pulse makes the peak of the main pulse negative.

Draw shaker limits draws red lines on the graphs at the top of the window that show the shaker acceleration, velocity, and displacement limits.

Shaker limits show the maximum allowable displacement (positive and negative), velocity, and acceleration values for the shaker set under the Shaker Parameters section. Below that, in the Real Max/Min Value table, the characteristics of the pulse are shown and compared with the shaker limits. Each row has an icon that is either green if the associated pulse characteristic is less than 50% of the shaker limit, yellow if if is great than 50%, and red if it is 100% or over the limit. Before starting a shock test, all these icons should be green or yellow.

Run Schedule

When a test is run, it executes the entries in the run schedule. These entries define test stages at certain levels and durations.



This schedule can also include loops to repeatedly execute a series of entries. When the test is running, pulses will be continually output at their set interval. There is also an entry to output inverse pulses. The run schedule can also activate any user-defined events defined in the Event Action Rules.

Click on event names in the list on the left to insert them into the schedule, and use the buttons on top to edit or remove them and to change their order. The schedule is activated when the test is started.

Measured Signals

The Live Signals tab on the lower left of the screen in EDM shows all the measured signals available for display. Listed here, for all test modes, are the native time streams of the input channels labeled by their location ID ("PT1", "PT2", "PT3"... by default), and the output drive time stream. The location ID of the channels can be changed under the Channel Table tab.

There are also signals derived from these time streams: block signals, labeled **Block**; auto power spectra signals, labeled **APS**; and the frequency response functions, labeled **FRF**; The labels are followed by the location ID of the original time stream signal in parenthesis (or, in the case of FRF, the location ID of the excitation channel followed by the ID of the response channel). These signals will only show in the live signal list if the measure option is enabled in the Signal Setup tab.

H(f) is the frequency response function between the drive output and the control input signal. **hinv(f)** is the frequency response function of the system when inverted pulses are output.

profile(t) is the time-domain test profile. **profile(f)** is this profile in the frequency domain.

HighAbort(t) and **LowAbort(t)** are the limit lines of the profile.

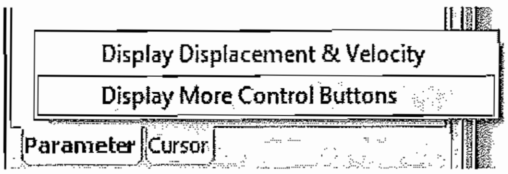
Control(t) is the control signal time stream. **control(f)** is the power spectrum of the control signal.

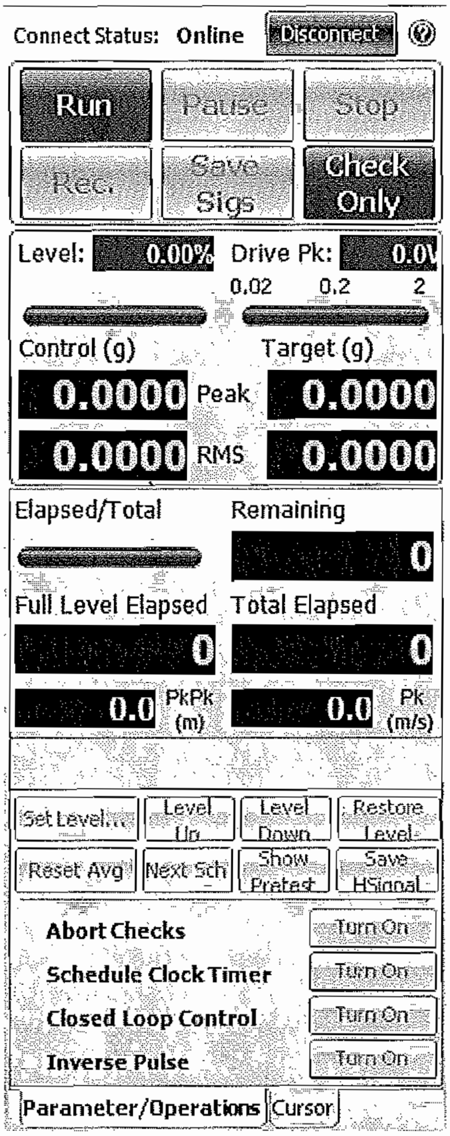
noise(f) is the power spectrum of the system noise, measured in the first part of the pre-test.

control_scroll is the RMS level history of the control signal.

Control Panel

The expanded control panel in Random mode has a number of commands to control the operation of the test. The control panel can be expanded by right clicking in the Parameters tab.





Test state information are displayed in the following fields:

Level is the current output level, as a percentage of the test profile. This is displayed graphically in the green bar below this field.

Drive Pk is the peak voltage of the output drive signal. This is shown graphically in the green bar below, as a proportion of the maximum drive voltage limit (set in Test Parameters).

Ctrl RMS is the RMS level of the input control signal.

Target RMS is the target RMS level of the current test stage. This is a function of the test profile and the current test level percentage. The output is increased until the Ctrl RMS reaches the Target RMS.

Elapsed/Total is a green bar showing the elapsed time as a proportion to the total test duration, according to the run schedule.

Remaining is the remaining time of the test, according to the run schedule.

Full Level Elapsed is the time elapsed running at full (100%) output level.

Total Elapsed is the time elapsed since the test was started.

PkPk: This is the estimated peak-peak displacement of the control channel. If there are more than one control channel, only the peak-peak of the first control channel is displayed. The displacement signal is computed by double-integrating the acceleration signal. The accuracy of this computation may be very low if the signal contains significant amount of low frequency energy. Therefore this display is only used as a reference.

Pk: This is the estimated peak velocity of the control channel. If there are more than one control channel, only the velocity peak of the first control channel is displayed. The displacement signal is computed by integrating the acceleration signal. The accuracy of this computation may be very low if the signal contains significant amount of low frequency energy. Therefore this display is only used as a reference.

The following commands are available in the expanded toolbar:

Set Level...: change the current target output level to a specified value, as a percentage of the test profile amplitude

Level Up: increase the current output level by 5%

Level Down: decrease the current output level by 5%

Restore Level: restore the current output level to the level set by the current schedule entry

Reset Avg: reset all averages to zero

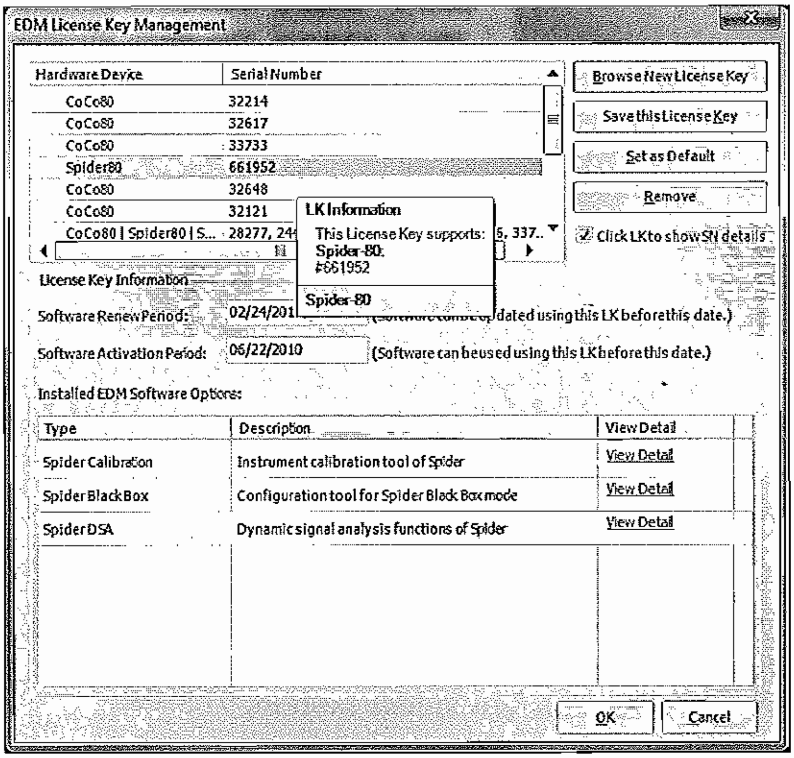
Next Sch Entry: end the current test stage and move to the next schedule entry

Pretest Window: open the pretest window

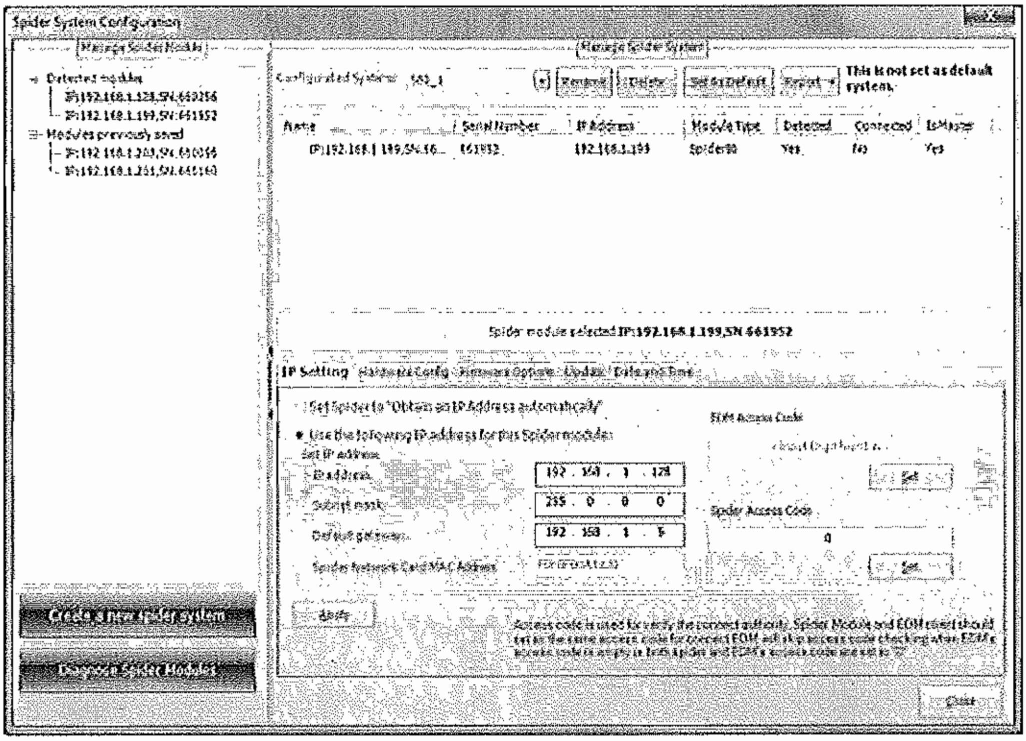
Save H Signal: save the H(f) signal, which is the frequency response function of the system

Typical Tests

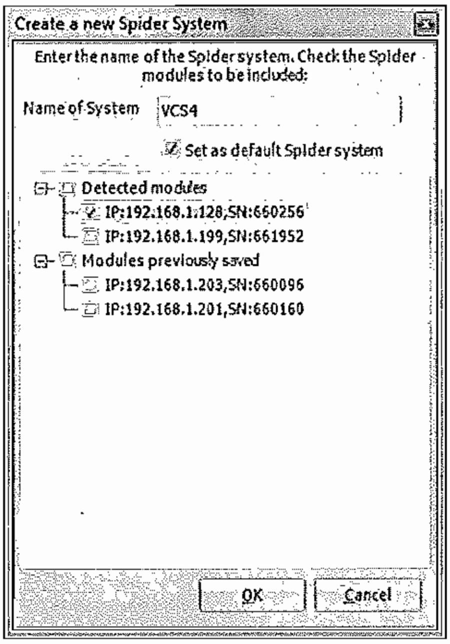
This section will walk through setting up and running a typical Shock test. First, make sure EDM is running in Spider working mode, with a valid license key installed. Open **Tools -> License Key Manager**, and make sure that the serial number of the currently active license key matches the Spider hardware.



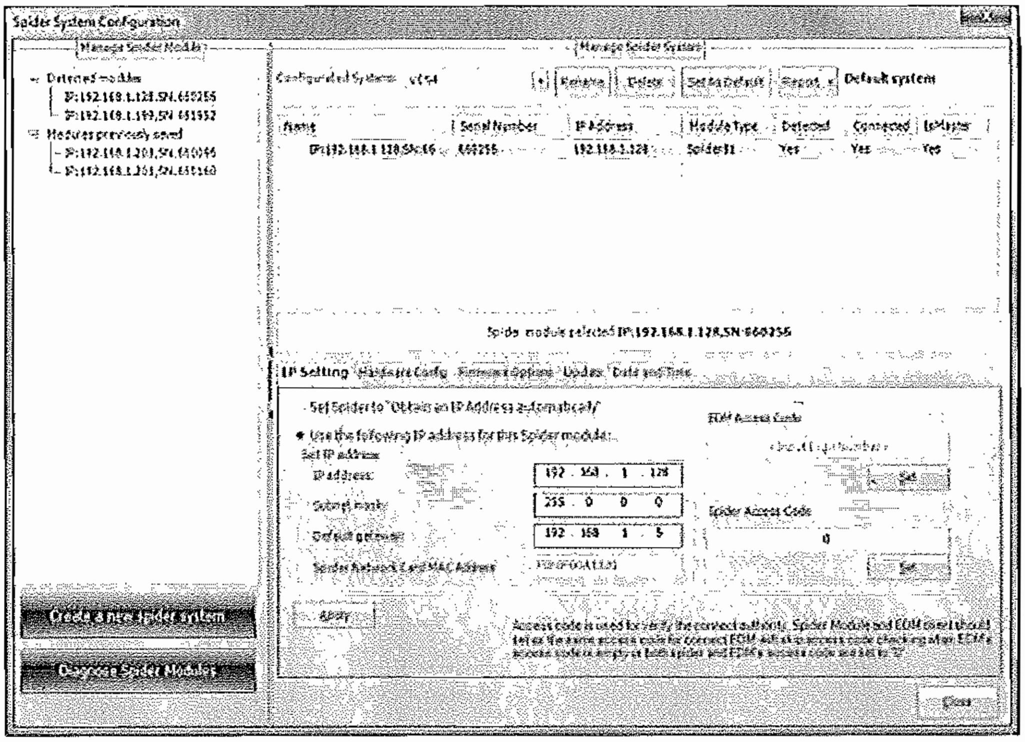
Plug the Spider-81 into the power cord and into the network, and turn it on. Then, configure a Spider system by opening **Tools -> Spider Configuration.**



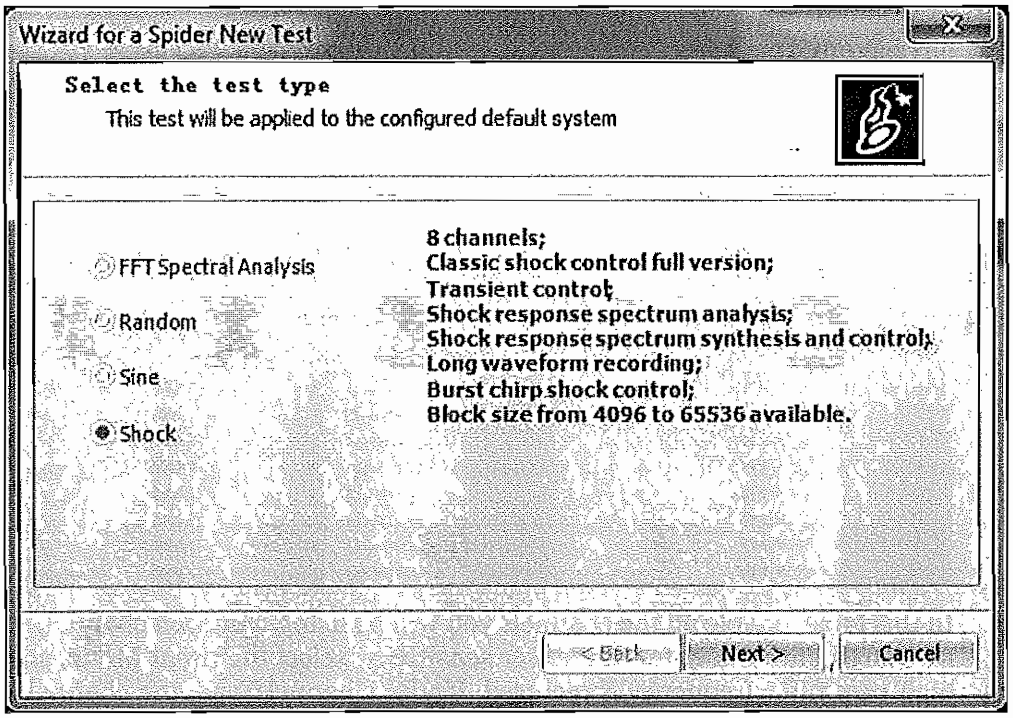
The Spider module should be listed under Detected Modules on the left in this window. Click **Create a new spider system.**

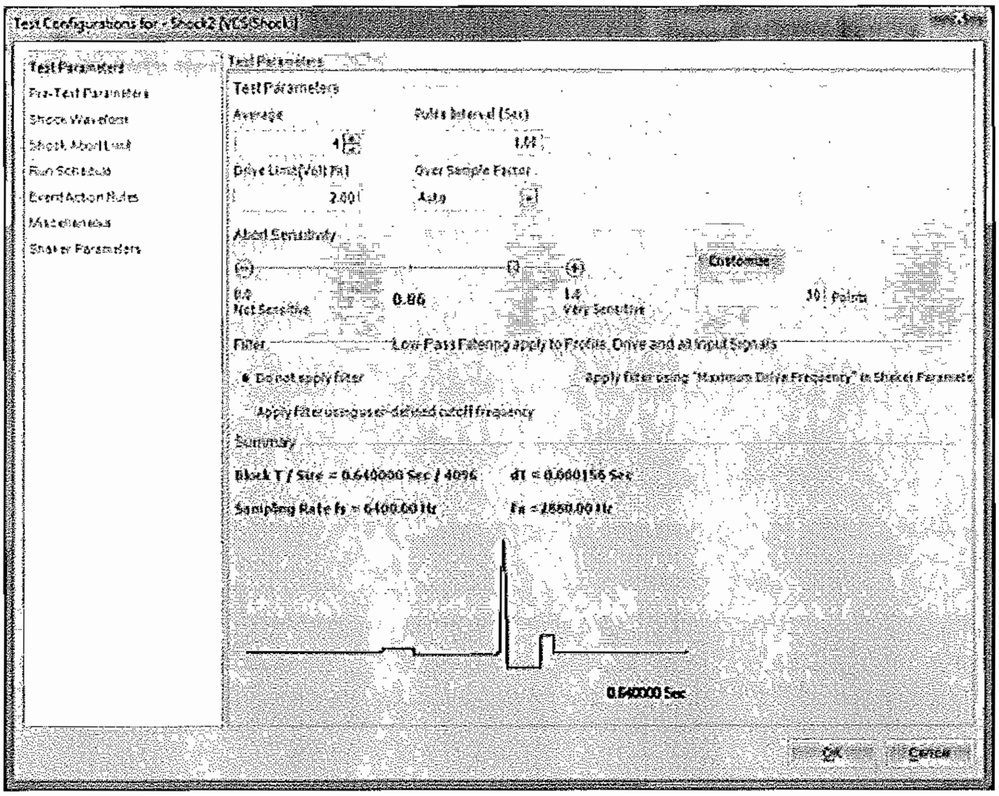


Enter a name for this system, and select the checkbox next to the Spider module. Press **OK**, and then it should be listed as the current Spider system.



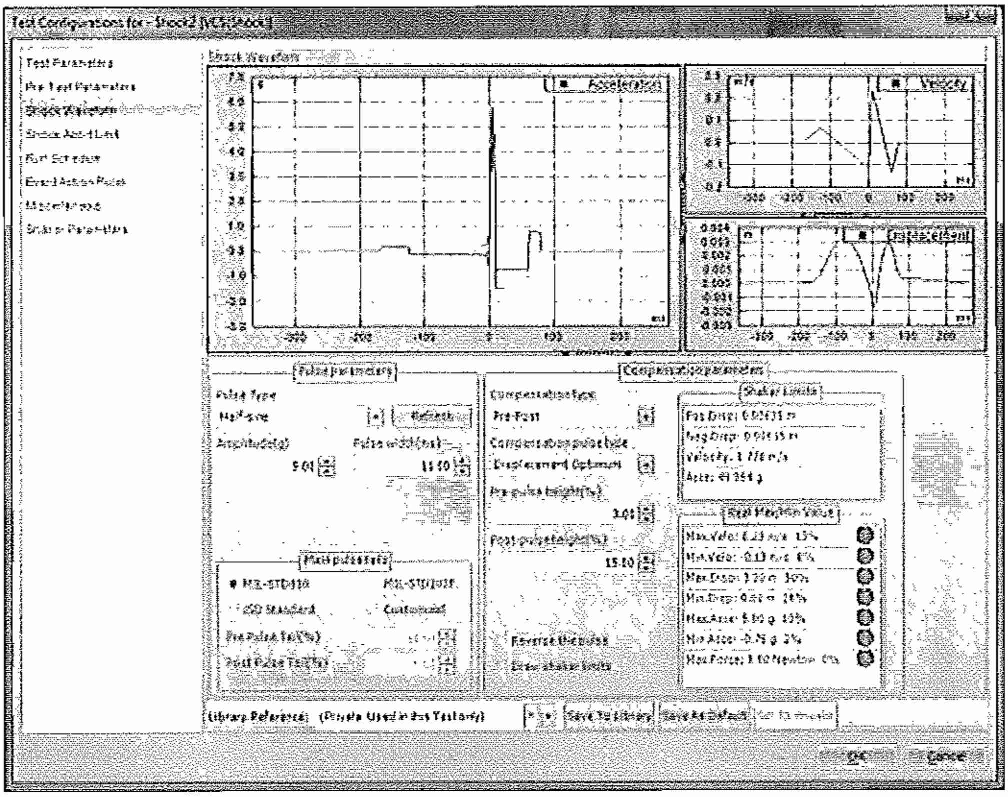
Close this window. Next, select **New Test** from the **Test** menu, and click Shock.



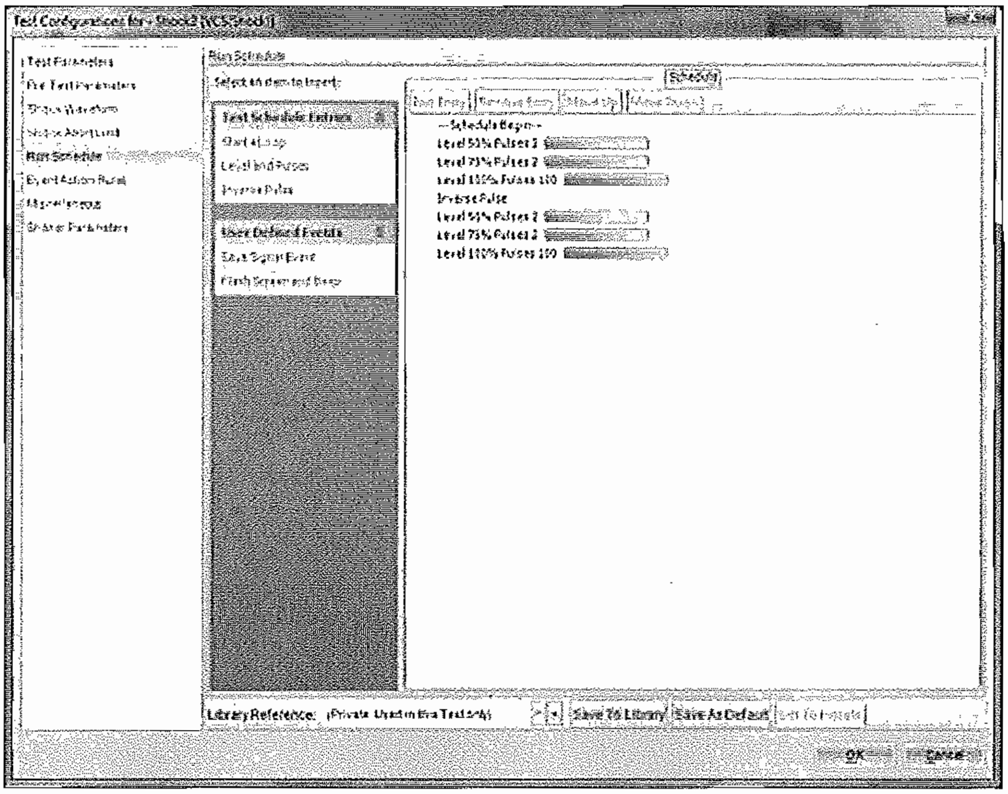


Set the average number, pulse interval, and output drive voltage limit here. The Abort Sensitivity adjusts how sensitive the safety mechanisms are to triggering abort events while the test is running.

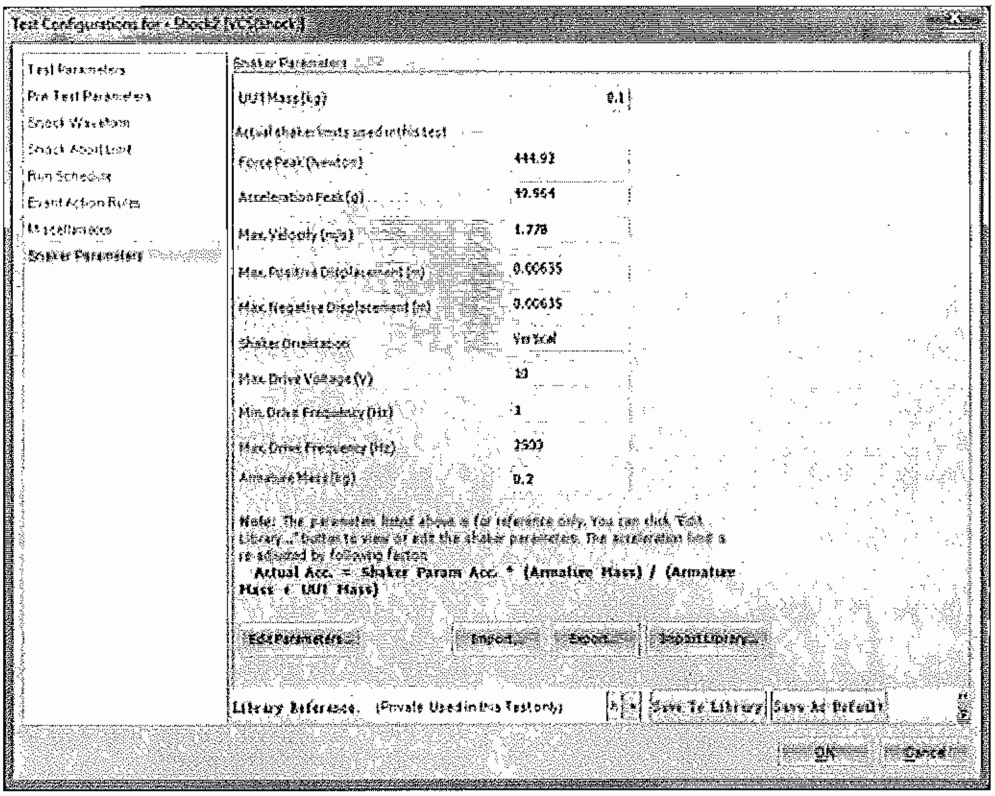
Select the Shock Waveform section to set the pulse shape. The important settings are the pulse type (have sine, trianglular, etc), the pulse amplitude, the pulse width in milliseconds, and the compensation type.



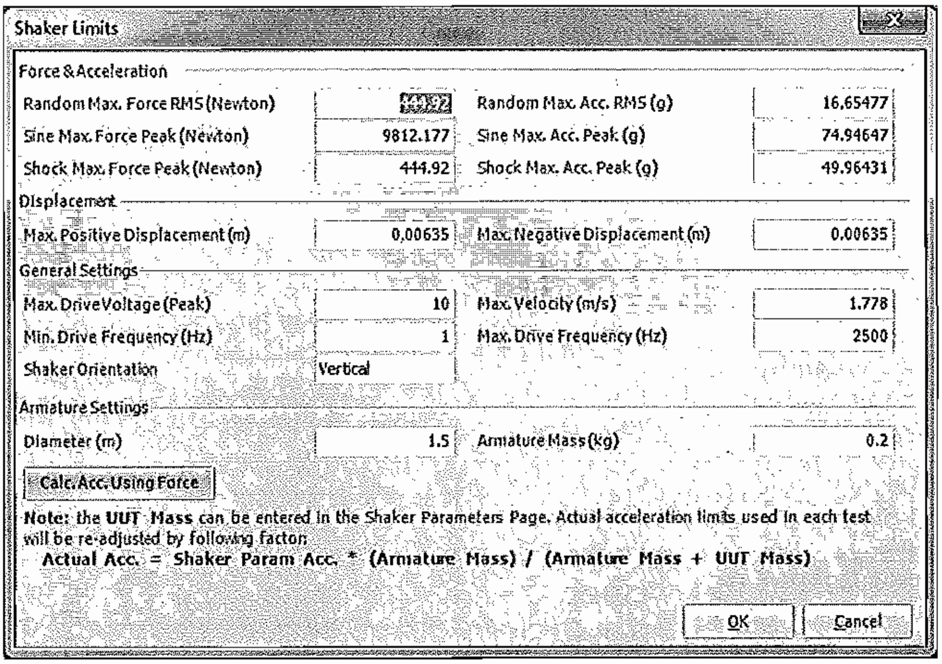
When the test is run, the test sequence is controlled by items in the **Run Schedule.** Select this section of the config window, and add items to the list to create the desired sequence. By default, the schedule consists of outputting 2 pulses at 50% level, 2 pulses at 75%, 100 pulses at 100%, and then inverting the pulse and repeating this. These can be changed by double clicking on the items, and new entries can be added by clicking on the items in the list on the left.



The last important section in the Test Configuration window is the **Shaker Parameters.**



Click on **Edit Parameters...**, and enter the information from the shaker specifications. This is important for the safety of the shaker and testing unit.



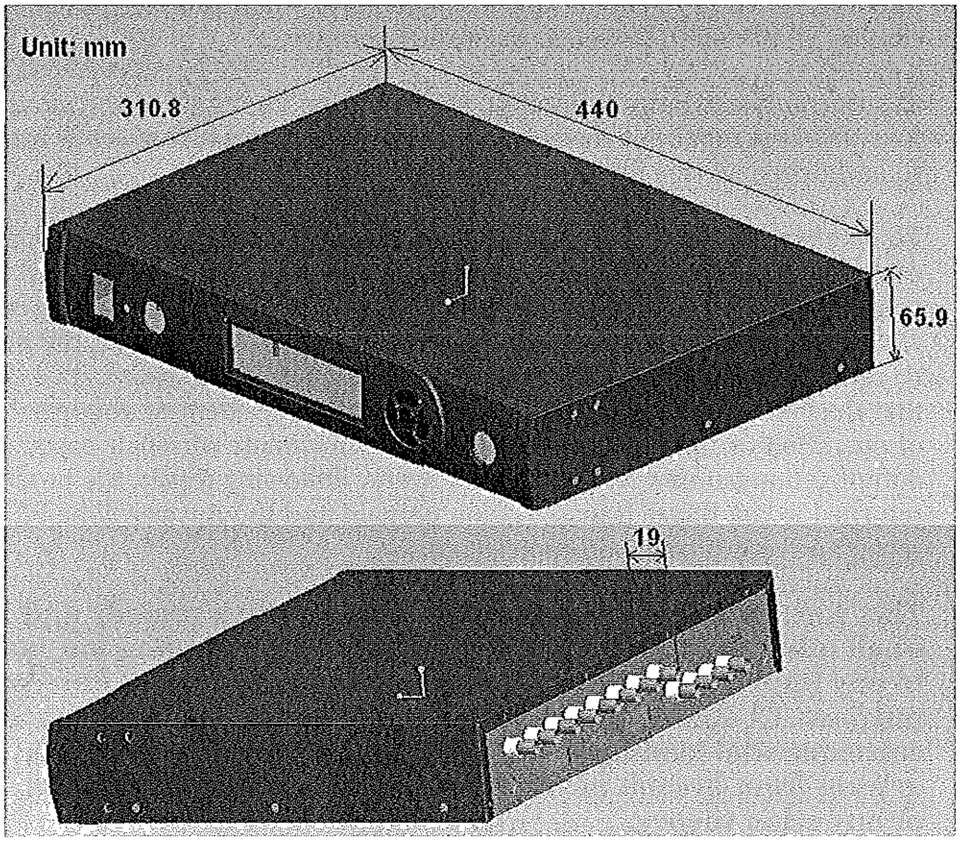
Press **OK** to close the Test Configuration window, and then you should be ready to run the test.

EDM Keyboard Shortcuts

Command	Keys	Description
Help	F1	Open a Help file
Run, Start	F2	Start the test or measurement
Pause, Hold	F3	Pause or hold the test
Continue	F4	Continue the test
Stop	F5	Stop the test
Record	F6	Record time stream
Save Sigs	F7	Save signals in the list
New Test	Ctrl-N	Create a new test
Find Test	Ctrl-F	Find test (open find test tab)
Copy image	Ctrl-C	Copy the image of active window to clipboard
Add Annotation	Ctrl-A	Add annotation to the active window if there is no cursor. Add annotation to the cursor location if there is a cursor.
Save Window Signal	Ctrl-S	Save signals in active window
Cache Signal	Ctrl-K	Cache signals in the active window. If there are many signals in the active window, cache all of them. The cached signals will be listed in the cached pane (at lower left corner).
Test Config	Ctrl-T	Configure current test
Global Setting	Ctrl-G	Global settings
New window	Ctrl-W	Open an overlaid new empty window
Auto/Fix-Y	Ctrl-Y	Toggle Auto scale and fix scale the Y axis of active window
Auto/Fix-X	Ctrl-X	Toggle Auto scale and fix scale the X axis of active window
Auto/Fix all	Ctrl-Q	Toggle Auto scale and fix scale for all windows
Open Plot Property	Ctrl-P	Open the dialog box of the plot property
Un-Zoom	Ctrl-Z	Zoom back to the previous scaling range for the active window
Tab	Tab	Change the active window to the next
Scroll plots(left,right)	left and right keys	Move the plot scales to the left or right for about 1/20 of the active window
Scroll plots(up,down)	Up and down keys	Move the plot scales to the top or bottom for about 1/20 of the active window
Cursor on/off	"Spacebar"	Enable or disable the cursor on the active window
Time Stream	Ctrl+1	
Time Blocks	Ctrl+2	
Spectrum	Ctrl+3	
Frequency Response Function	Ctrl+4	
Composite	Ctrl+5	
Digital I/O	Ctrl+6	
Channel Status	Ctrl+7	

Command	Keys	Description
Customize	Ctrl+Shift+I	
Save Active Window as...	Ctrl+Shift+s	
Connect	Ctrl+Shift+C	
Disconnect	Ctrl+Shift+D	

Spider-81 Dimensions



Limited Warranty & Limitation of Liability

Each CI product is warranted to be free from defects in material and workmanship under normal use and service. The warranty period is one year for the Spider hardware and its accessories. The warranty period begins on the date of shipment. Parts, product repairs and services are warranted for 90 days. This warranty extends only to the original buyer or end-user customer of a CI authorized reseller, and does not apply to fuses, disposable batteries or to any product which, in CI's opinion, has been misused, altered, neglected or damaged by accident or abnormal conditions of operation or handling. CI warrants that software will operate substantially in accordance with its functional specifications for one year and that it has been properly recorded on non defective media. CI does not warrant that software will be error free or operate without interruption.

CI authorized resellers shall extend this warranty on new and unused products to end user customers only but have no authority to extend a greater or different warranty on behalf of CI. Warranty support is available if the product is purchased through a CI authorized sales outlet or the Buyer has paid the applicable international price. CI reserves the right to invoice the Buyer for importation costs of repair/replacement parts when product purchased in one country is submitted for repair in another country.

CI's warranty obligation is limited, at CI's option, to refund of the purchase price, free of charge repair, or replacement of a defective product which is returned to a CI authorized service center within the warranty period.

To obtain warranty service, contact your nearest CI authorized service center or send the product, with a description of the difficulty, postage and insurance prepaid (FOB Destination), to the nearest CI authorized service center. CI assumes no risk for damage in transit. Following warranty repair, the product will be returned to Buyer, transportation prepaid (FOB Destination). If CI determines that the failure was caused by misuse, alteration, accident or abnormal condition of operation or handling, CI will provide an estimate of repair costs and obtain authorization before commencing the work. Following repair, the product will be returned to the Buyer transportation prepaid and the Buyer will be billed for the repair and return transportation charges.

This warranty is the buyer's sole and exclusive remedy and is in lieu of all other warranties, express or implied, including but not limited to any implied warranty of merchantability or fitness for a particular purpose. CI shall not be liable for any special, indirect, incidental or consequential damages or losses, including loss of data, whether arising from breach of warranty or based on contract, tort, reliance or any other theory.

Since some countries or states do not allow limitation of the term of an implied warranty, or exclusion or limitation of incidental or consequential damages, the limitations and exclusions of this warranty may not apply to every buyer. If any provision of this Warranty is held invalid or unenforceable by a court of competent jurisdiction, such holding will not affect the validity or enforceability of any other provision.