



CRYSTAL
INSTRUMENTS



Vibration Control System (VCS) Overview

Spider Hardware Platforms for Vibration Control

- **Spider-81:** premium controller model
- **Spider-81B:** economic version of Spider-81 (not expandable)
- **Spider-80X:** modular and scalable
- **Spider-80Xi:** compact, modular, scalable design up to 512 channels
- **Spider-80SG:** strain gage front-end to pair with vibration controllers
- **Spider-101:** temperature and humidity controller that integrates with any vibration controller

Spider Platform: Designed with Choices



Spider-81
Premium Vibration Controller



Spider-81B
Basic Vibration Controller



Spider-80Xi
Compact DAQ/DSA/VCS



Spider-80X
Modular DAQ/DSA/VCS

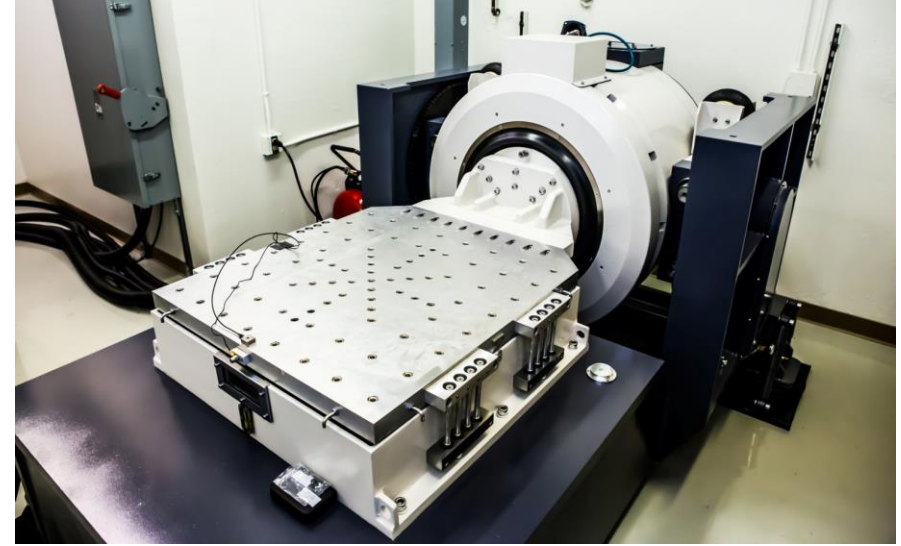


Spider-80SG
Modular DAQ/DSA/VCS



Spider-101
THV Chamber Controller

Spider Controllers Support a Wide Range of Shaker Systems



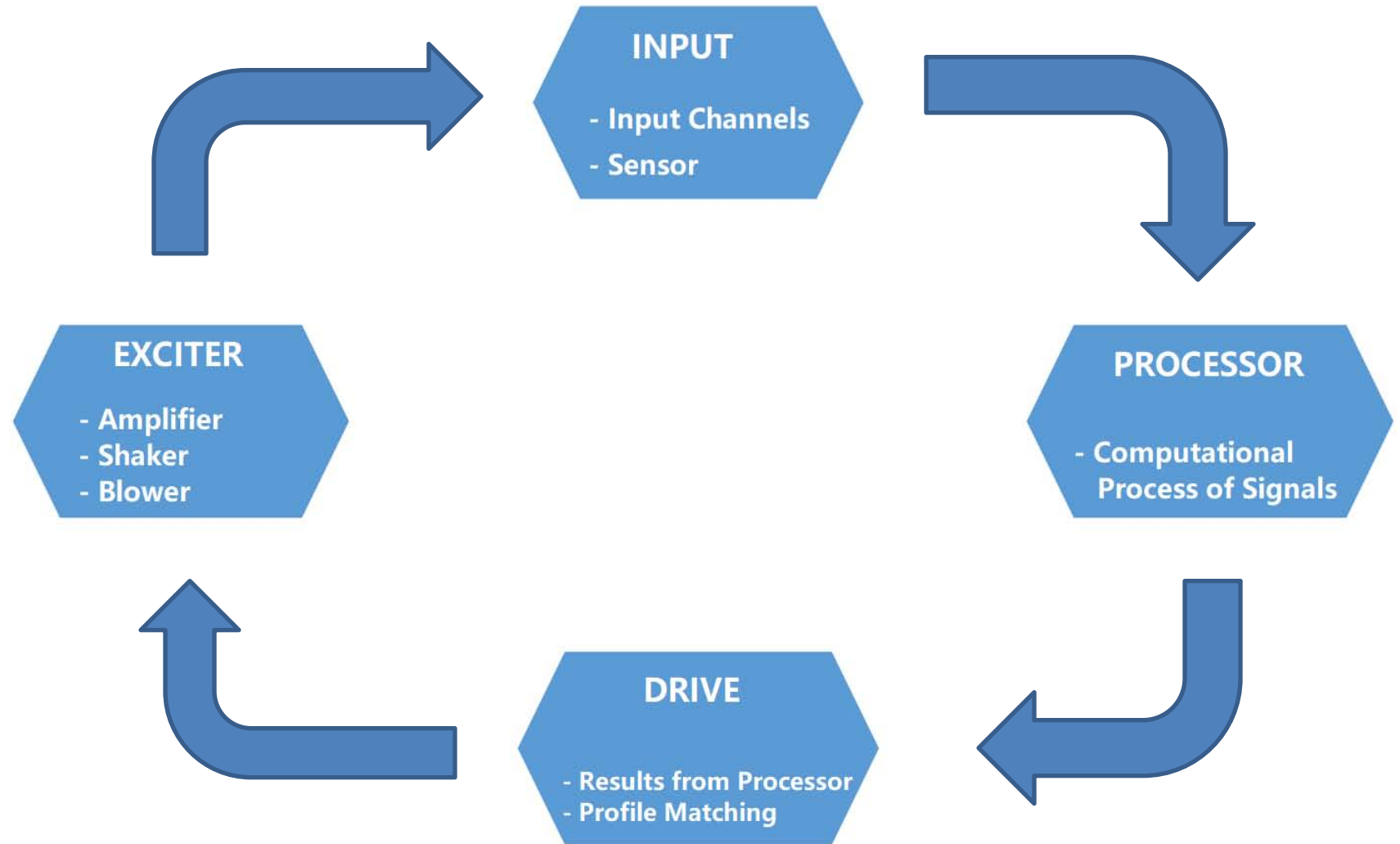


Single Axis Vibration Control Functions

- Random
 - Multi-Resolution Control
 - Kurtosis Control
 - Random on Random
 - Sine on Random
- MSC, Multi-Shaker Control
- Sine (Swept/Dwell)
 - Total Harmonic Distortion (THD)
 - Phase Track Dwell
 - Resonance Search and Tracked Dwell (RSTD)
 - Multi-Sine
 - Step Sine, Sine Oscillator
- Classic Shock
 - Transient Time History Control (TTH)
 - Shock Response Spectrum (SRS)
 - Earthquake testing
 - Time Waveform Replication (TWR)

EDM 8.1 | Key Elements in a Vibration Control System

- ▶ Input
 - Input Channels
 - Sensors
- ▶ Processor
 - Computational Process of Signal
- ▶ Drive
 - Results from processor
 - Profile matching
- ▶ Exciter
 - Amplifier
 - Shaker
 - Blower



Vibration Control | Hardware Overview

VCS Hardware | Platforms Overview

Spider-81



Spider-81B



Spider-80X



Spider-80Xi



Spider-80SG



<i>Input</i>	8-512	4	8 - 1024	8 - 1024	8 - 1024
<i>Output</i>	4	1	2	2	1
<i>Unique Features</i>	Flagship unit, expandable to 512 inputs. Supports MIMO	Smaller form factor of Spider-81. Lower price	Versatile for DSA mode. High Channel Count capability	High Channel Count with small form factor	Featuring Strain Gage Functionality

VCS Hardware | Hardware Self-Diagnose

Real-time checking capability to check the connection and reliability of hardware systems

- Precision signal source is used internally for validating the each channel
- DSP status check
- Memory check
- Flash memory check
- Ethernet connection check
- Storage check



Spider-81

Premium Vibration Test Controller



VCS Hardware | Spider-81 Input Channel

- 8 BNC input channels on each Spider module
- Support various input modes
 - AC-Single End
 - AC-Differential
 - DC-Single End
 - DC-Differential
 - Charge
 - IEPE (ICP®)



VCS Hardware | Spider-81 Input Main Specs

Voltage Mode Input Range: $\pm 20 V_{pk}$

Voltage Mode Input Impedance: 1 M Ω for differential; 500 k Ω for single-end

Input Protection Voltage: $\pm 220 V_{pk}$

A/D Resolution: proprietary dual 24-bit technology to achieve high dynamic range

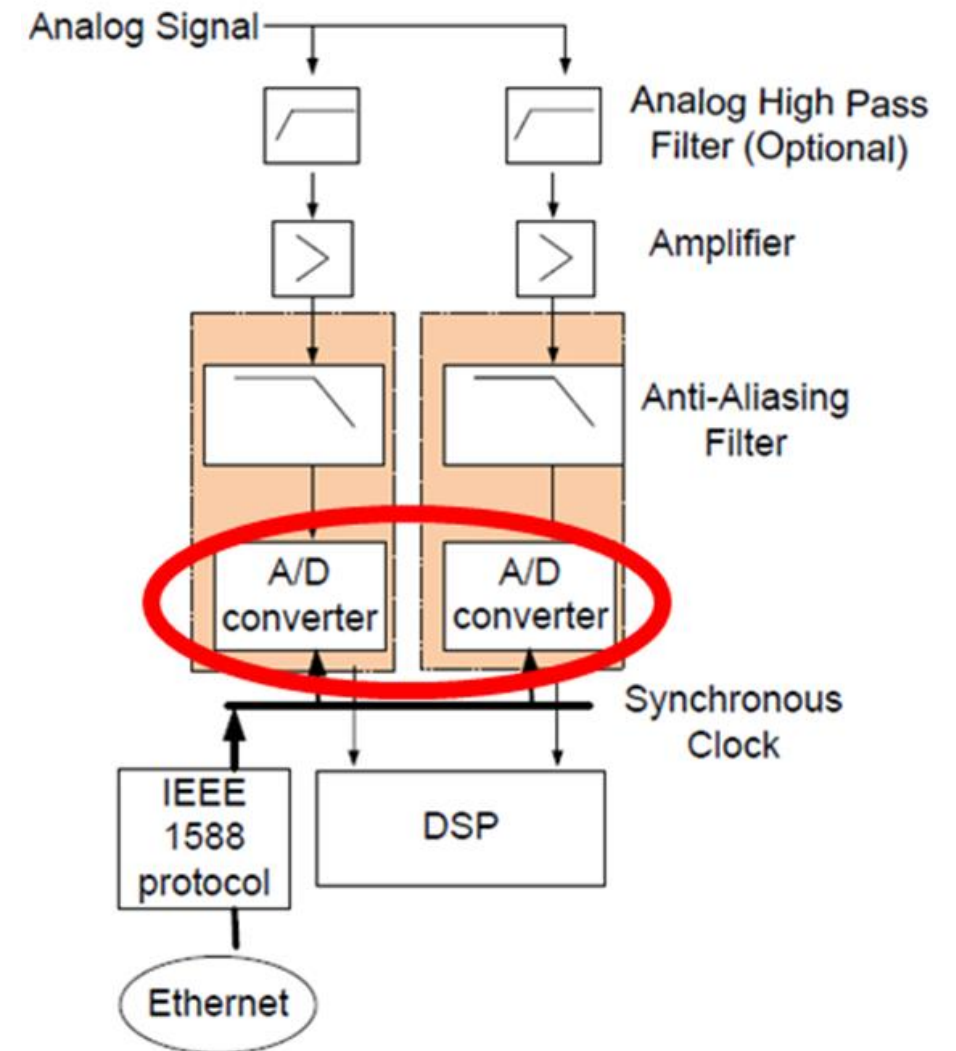
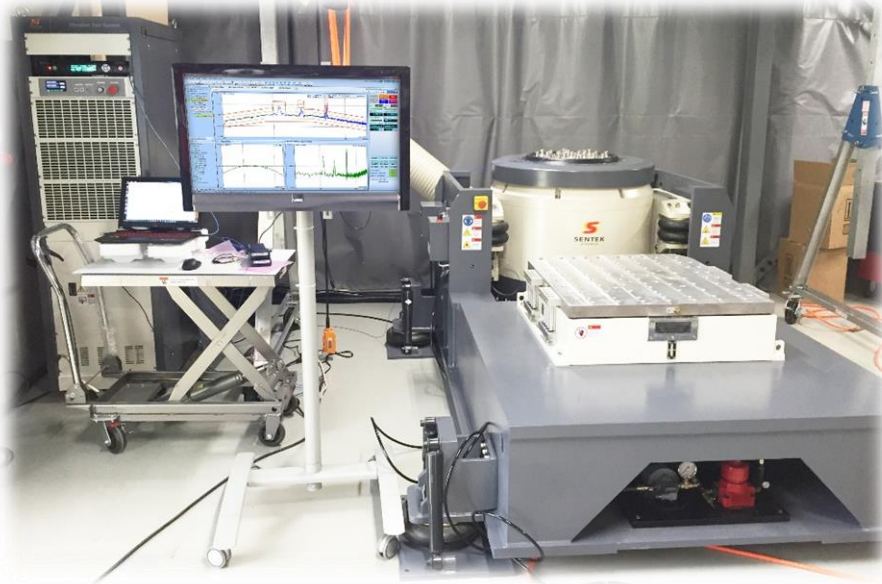
Digital Filter: User programmable digital high- and low-pass filters

Sampling Rate: 0.48 Hz to 102.4 Hz, 54 stages

Channel Phase Match: better than ± 1.0 degree, up to 20 kHz

VCS Hardware | Spider-81 Input Channel

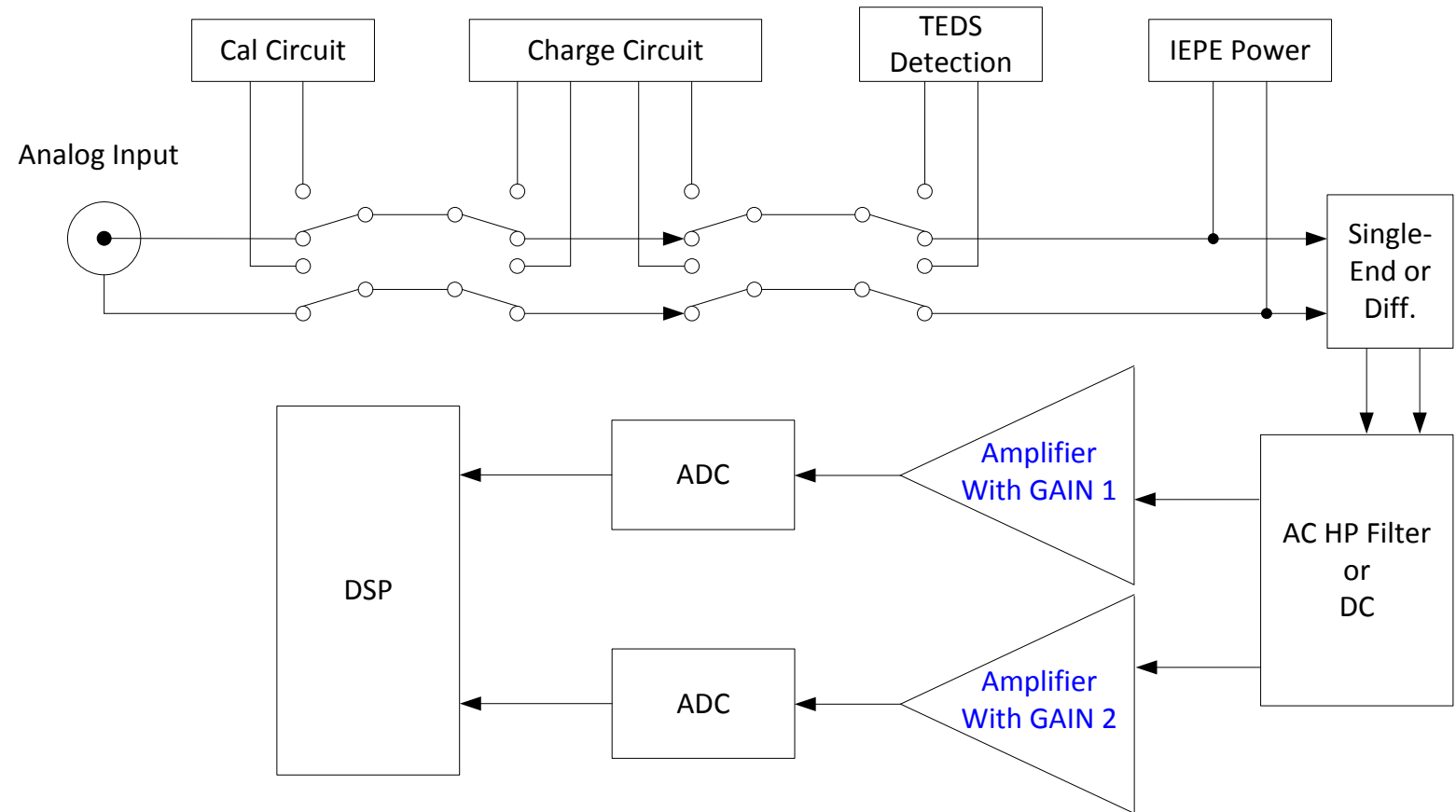
Crystal Instruments achieves its very high dynamic range (up to 160 dBFS) for all its measurement instruments by using a unique patented technology that uses two A/D converters in each measurement channel.



VCS Hardware | Spider-81 Input Channel

It is expensive to build the input channel with the dual A/D technology. The benefit received is that the user won't need to adjust the input range before the test.

Any measurement will be accurate from a few micro-volts up to 20V!



VCS Hardware | Spider-81 Input Channel

- Achieve 160 dBFS dynamic range by using patented dual A/D technology
- Super high dynamic range of inputs eliminated the needs of input range setting
- Crystal Instruments is the first company to adopt this technology. It has changed this industry.



US007302354B2

(12) **United States Patent**
Zhuge

(10) **Patent No.:** **US 7,302,354 B2**
(45) **Date of Patent:** **Nov. 27, 2007**

(54) **CROSS-PATH CALIBRATION FOR DATA ACQUISITION USING MULTIPLE DIGITIZING PATHS**

6,970,118 B2 11/2005 Regier 341/118
6,980,134 B2 12/2005 Ely et al. 341/20

OTHER PUBLICATIONS

Anderson, Ole Thorhauge et al., "New Technology Increases the Dynamic Ranges of Data Acquisition Systems Based on 24-bit Technology," *Sound and Vibration*, Apr. 2005, pp. 8-11.

* cited by examiner

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 49 days.

(21) Appl. No.: **11/392,198**

(22) Filed: **Mar. 28, 2006**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
G01D 18/00 (2006.01)

(52) **U.S. Cl.** **702/85; 341/120**

(58) **Field of Classification Search** **702/85; 341/120, 155, 163, 118, 128; 348/572**
See application file for complete search history.

(56) **References Cited**

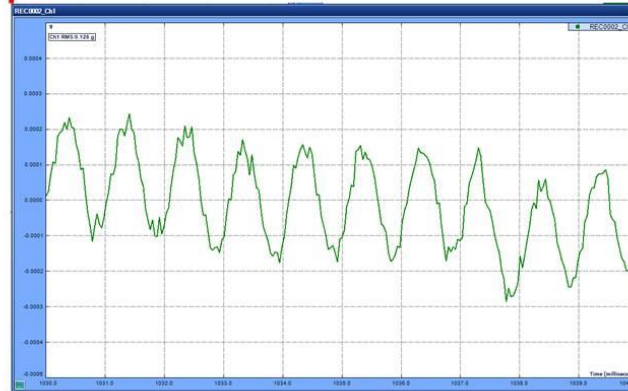
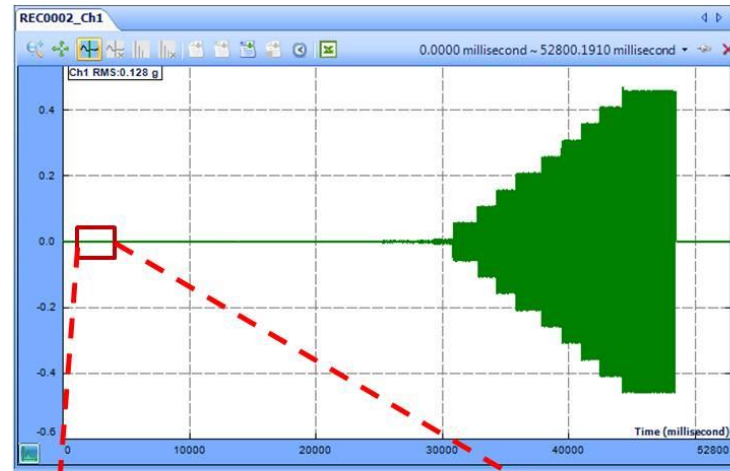
(57) **ABSTRACT**

The present invention utilizes multiple A/D (analog-to-digital) paths and cross-path calibration to provide accurate and reliable measurements for each input channel in a data acquisition system. When the system and method are applied, user and automated methods of selecting among a number of alternative input range settings can be reduced, or even eliminated. That is, there is a significant reduction or complete elimination of input range settings in a measurement system. For each measurement channel of interest, the input signal is directed to at least two paths, e.g., Path A and Path B. The first path measures the full range (e.g., +/-10 volts), while the second path includes a high-gain amplifier.

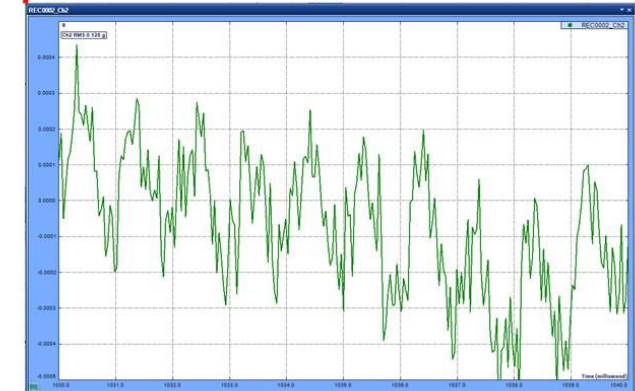
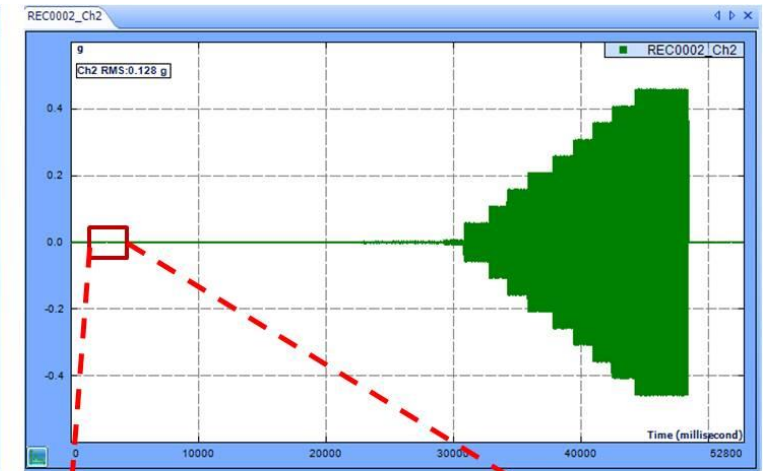
VCS Hardware | Spider-81 Input Channel

With Dual A/D, the signal measurement is clear even when it is very small.

On the right side, conventional methods without dual A/D are used, which is much noisier.



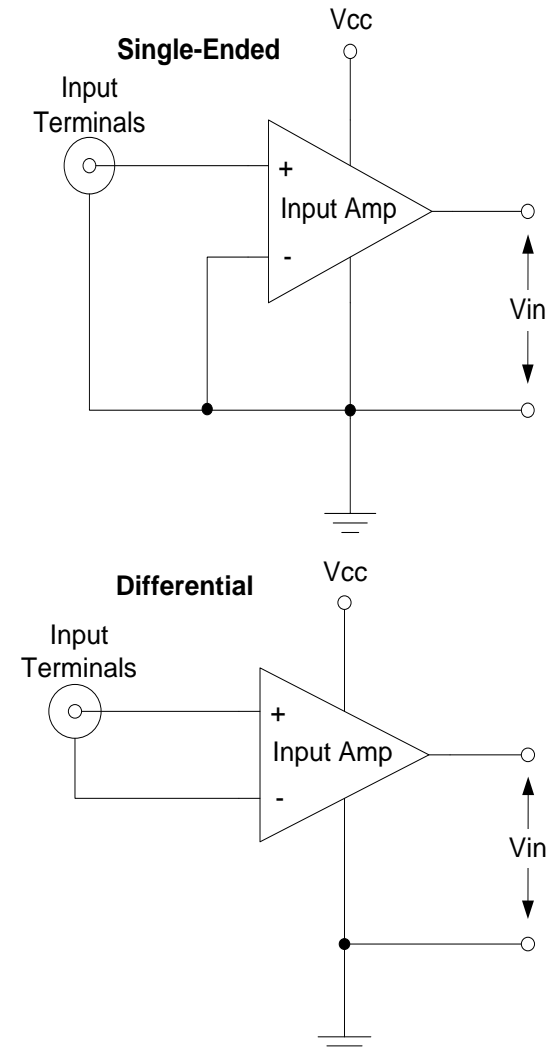
Digitally auto
Ranged Dual ADC



Full Range
Conventional ADC

VCS Hardware | Spider-81 Input Channel

- **DC-Differential:** neither of the input connections is referenced to the local ground.
- **DC-Single End:** one of the input terminals is grounded and the input is taken as the potential difference of the center terminal with respect to this ground.
- **AC-Differential:** a differential input mode that applies a low-frequency high-pass (DC-blocking) analog filter to the input.
- **AC-Single End:** grounds one of the input terminals and enables the DC-blocking analog filter.

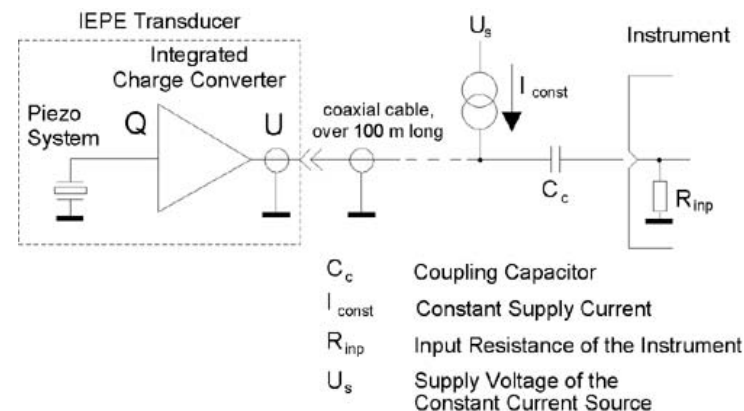


VCS Hardware | Spider-81 Input Channel

All Spider platforms support IEPE (Integral Electronic PiezoElectric) constant current output type input channels.

IEPE refers to a class of transducers that are packaged with built-in voltage amplifiers powered by a constant current.

These circuits are powered by a 4 mA constant current source at roughly 21 Volts.



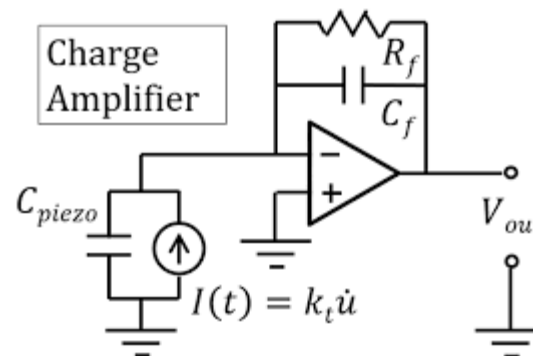
Input mode	
IEPE	▼
IEPE	▼
IEPE	▼
IEPE	▼
AC-Single End	▼
DC-Single End	▼
AC-Differential	▼
DC-Differential	▼

VCS Hardware | Spider-81/81B Input Channel

All versions of the Spider-81/81B are equipped with charge inputs internally.

The Spider-81 has a built-in charge amplifier that allows the system to read the output of these sensors.

Charge Input has 1,000 pC and 10,000 pC.



Input mode	
In-Line Charge Converter	▼
In-Line Charge Converter	▼
In-Line Charge Converter	▼
In-Line Charge Converter	▼
In-Line Charge Converter	▼
In-Line Charge Converter	▼
External Charge Amplifi	▼
External Charge Amplifi	▼

VCS Hardware | Spider-80X/80Xi Input Channel

Spider-80X has an optional internal charge amplifier (10,000 pC) or uses an external charge converter.

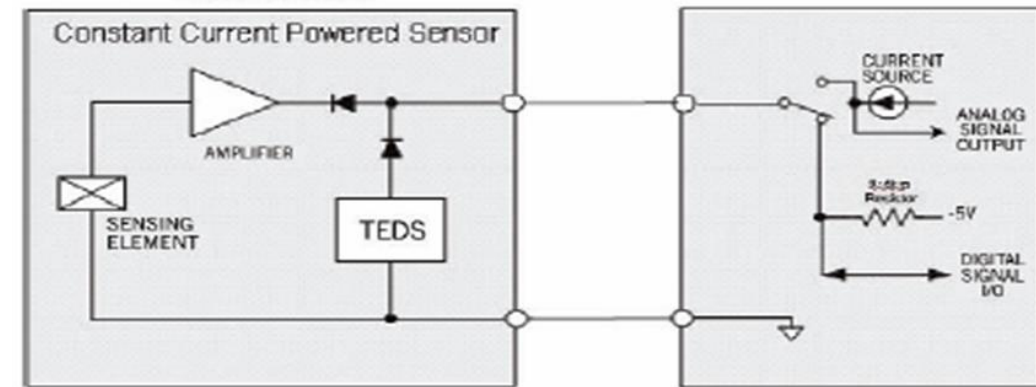
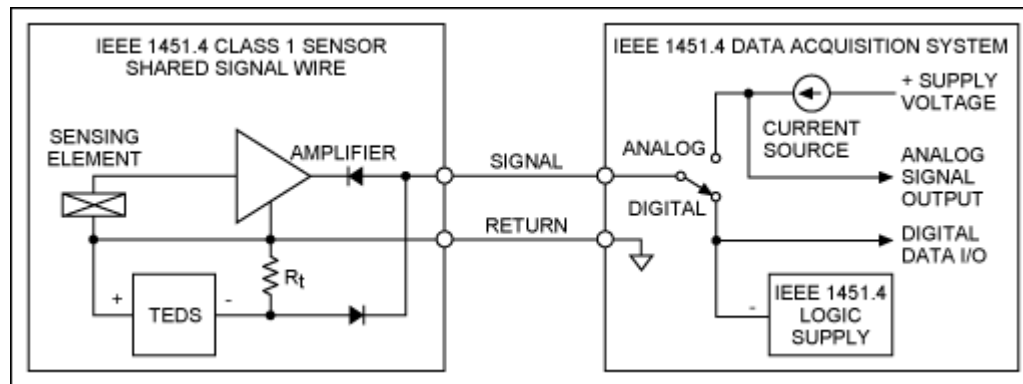
Crystal Instruments' 8-channel charge amplifier is compatible with any instruments requiring voltage input.



8-Channel External Charge Amplifier

VCS Hardware | Spider-81 Input Channel

Spider systems can use TEDS (IEEE 1451.4 compliant) to automatically import the measurement quantity and sensitivity of the connected sensors.



IEPE and TEDS Circuitry

VCS Hardware | Spider-81 Output Channel Specs

- **Output Channels:** 2 - 4 output channels
- **D/A Resolution:** 24-bit
- **Frequency Range:** up to 46 kHz, synchronized with input channels
- **Output Dynamic Range:** 100 dB
- **Maximum Output Current:** 250 mA
- **Output Range:** programmable ± 10 Volts



VCS Hardware | Spider-81 Isolated Digital I/O

- Provide connectivity to other hardware.
- Spider can send digital output when set event occurs.
- Spider can execute a command when receiving a digital input.

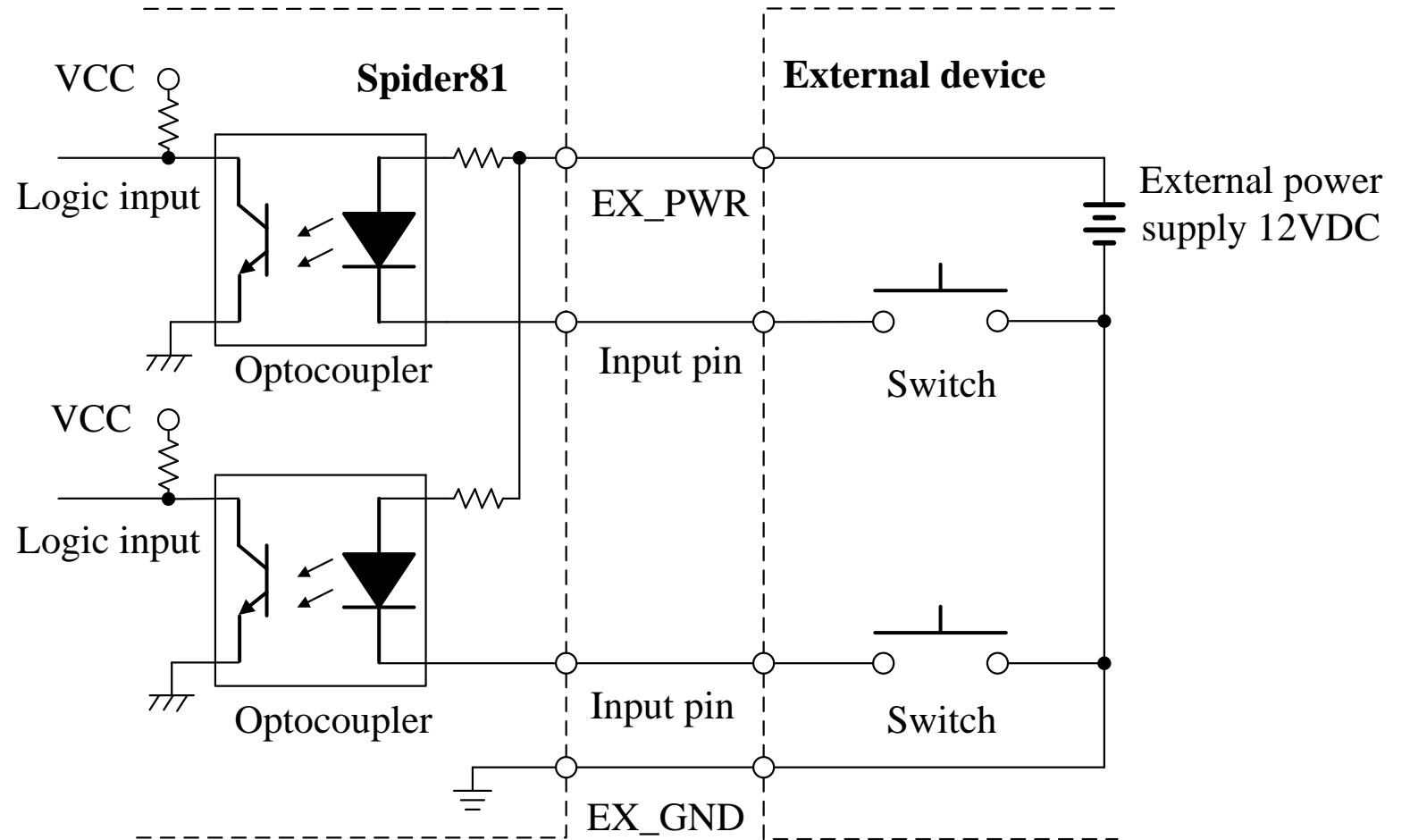


(Digital I/O interface is also available on Spider-81B/80X/80Xi/80SG)



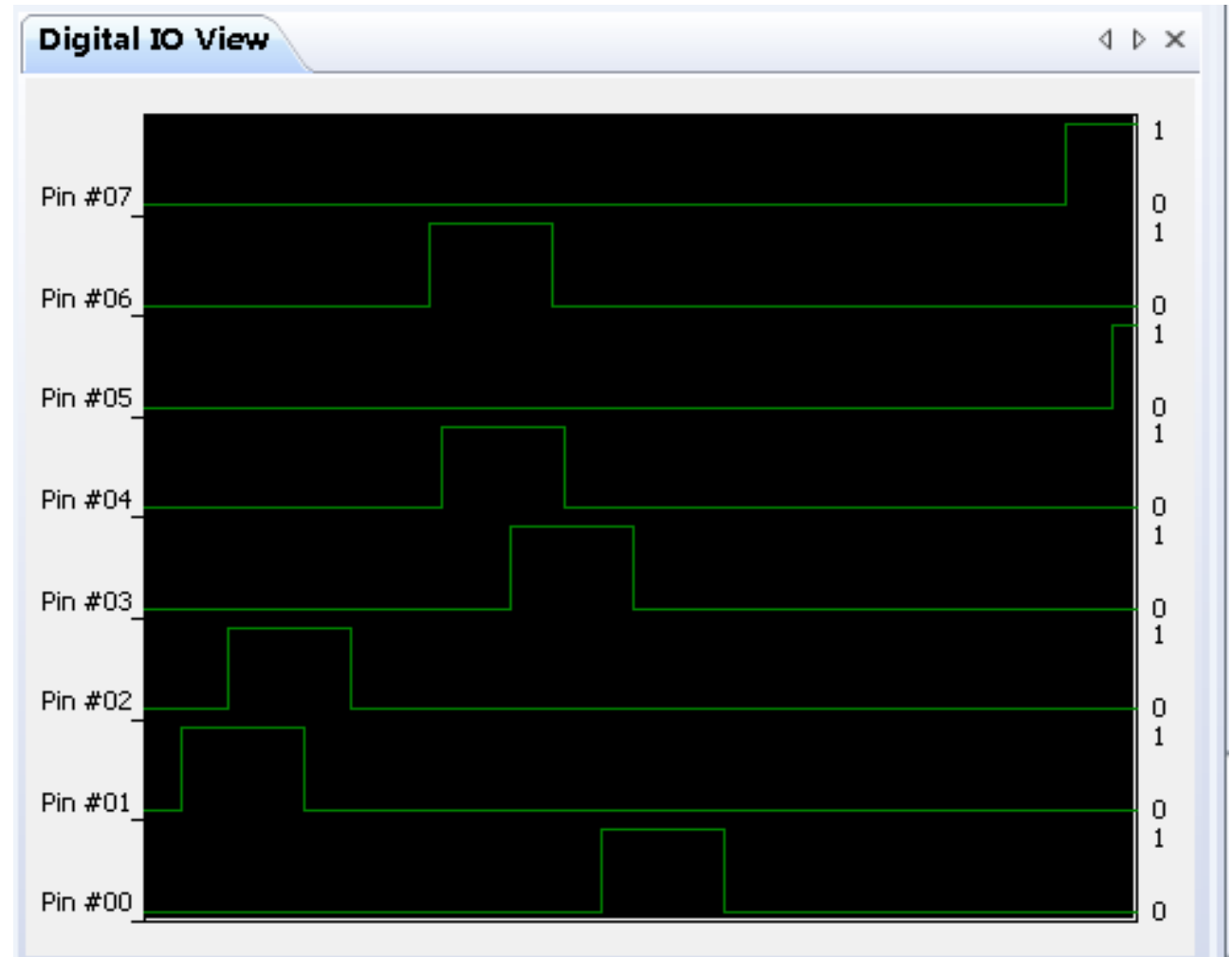
VCS Hardware | Spider-81 Isolated Digital I/O

- 8 digital inputs, 8 digital outputs
- Provide hardware interface to other equipment



VCS Hardware | Spider-81 Isolated Digital I/O

➤ Sample of Digital I/O View



Front panel display shows system status, network IP settings, and testing status in real-time.



VCS Hardware | Spider-81 Other Specs

Peripherals: 8 isolated DIO, LCD display with navigation buttons, RS-485, ground connection, abort contact switch, start and abort buttons

Dimensions & Weight : 440 x 66 x 330 mm (W x H x D), 4.2 kg

Power: Up to 18 watts during operation

Computer Connections: 100Base-T, RJ45 female connector supports connection to computer or network switch

Internal Memory: Flash memory for data storage is 4 GB per unit

Spider-81B

Economical Vibration Test Controller

Four inputs, one output, not expandable. Features same analog and control performance of Spider-81.



Spider-80X

High Channel Count Vibration Controller System

Modular, scalable, exchangeable.
Support up to 1024 input
channels, usable together with
strain measurement



High Channel Count Vibration Test Control (scale up to 512 inputs)

High Dynamic Range of Input (up to 160 dBFS)

Inputs: 8 BNC connectors per front-end, front-ends are networked to form up to 512 inputs, voltage or IEPE, single-ended or differential, AC or DC coupling, 24-bit A/D converters, optional charge amplifier, input range ± 20 volts, up to 102.4 kHz fs per channel

Outputs: 2 BNC connectors per front-end, 100 dB dynamic range, 24-bit A/D converters, ± 10 volts range

VCS Hardware | Spider-80X Specs

Channel Phase Match: Better than ± 1.0 degree up to 20 kHz among all channels

Dimensions & Weight : 238.8 x 215.7 x 20 mm, four Spider-80X vibration test controllers fit into one 1U-19 inch rack-mount slot; 1.3 kg per front-end

Power: Powered from external DC power

Computer Connections: 100 Base-T, RJ45 female connector supports connection to PC or network switch

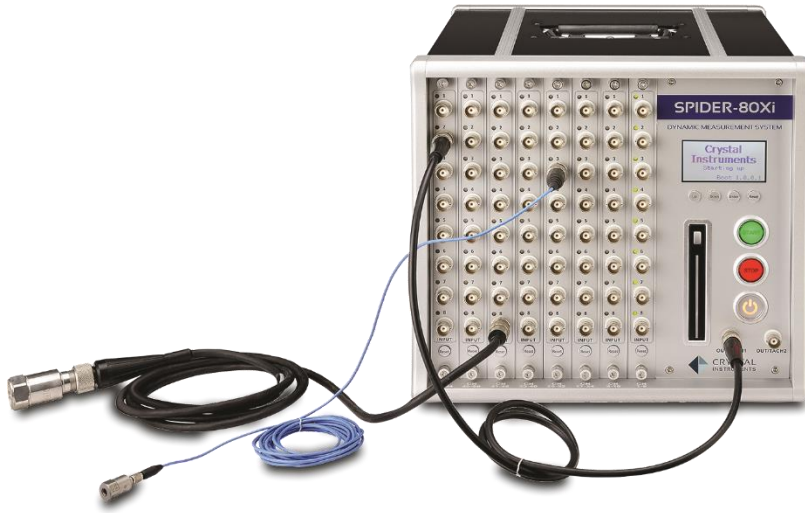
Internal Memory: Flash memory for data storage is 4 GB per unit

Operation Modes: Connected to computer or stand alone Black Box mode.

Spider-80Xi

A Compact Version of Spider-80X

Board level exchangeability, much lighter than the Spider-80X. Ideal for all three applications: vibration control, modal analysis and data acquisition



VCS Hardware | Spider-80Xi Main Features

- A compact version of the Spider-80X with an extremely lightweight form factor.
- Optimal design for field environment testing where portability is essential.
- High Precision Front-end Design, compatible with Spider-80SGi, the strain gage module
- Simple Network Connection, scales up to 512 inputs
- Black Box Mode

VCS Hardware | Spider-80X/80Xi Chassis

- 64-channel / 32-channel Chassis
 - 8/4 Spider-80Xi modules
 - 1 Spider-NAS
 - 1 Spider-HUB
 - Capable to connect to more chassis for a 1024-channel control system
- Integrated power design
- Removable SATA storage drive with RAID option (64 ch only)
 - Accessible from front panel



VCS Hardware | Spider High Channel Count System Major Advantages

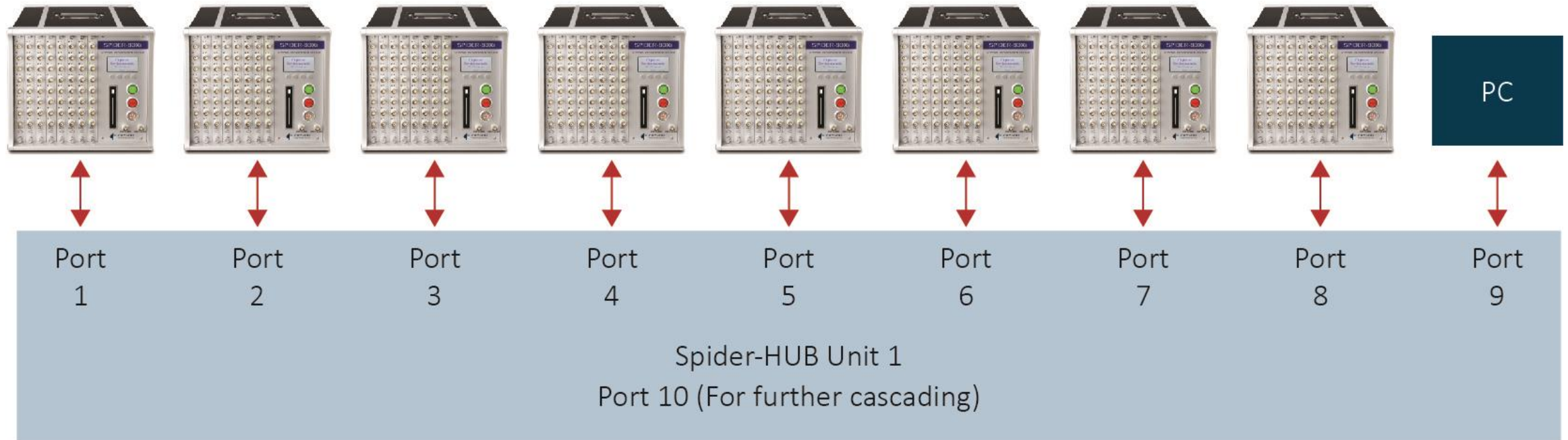
- Truly modular. This is the very first high-channel count system that can be configured at user level. Products from the competitors are configured by the manufacturer.
- User can configure or divide systems into multiple, or use each individual modules.
- High reliability: Network serial bus is more reliable than parallel bus (VME, PXI, VXI etc..).
- Vibration control, modal analysis, dynamic measurement and general data acquisition software functions are all supported.

VCS Hardware | Spider High Channel Count System Main Features

- Can scale up to up to 512-channels
- Three types of modules can combine to form a system according to the user's requirements
 - 8 channel Spider-81 (DSA and VCS)
 - 8 channel Spider-80X/80Xi (DSA and VCS)
 - 8 channel Spider-80SG (Strain Gage)
- Channel synchronized up to 50ns (1 degree at 20kHz)
- Dedicated recording for all input channels, disk is removable

VCS Hardware | Spider-80X/80Xi High Channel Count System

Spider-80Xi System (512 Channel Count)



VCS Hardware | Spider-HUB Industrial Network Switch

- High accuracy network switch
 - Synchronize Spiders to 50ns
 - Designed and produced by Crystal Instruments
- 10 Ethernet ports
 - IEEE 1588 (PTP)
 - Sync E
- Supports up to 8 Spider modules
 - Can be “daisy chained” to expand



Note: The Spider-HUB is installed inside of each Spider-80X and Spider-80Xi chassis. Users may not notice it.

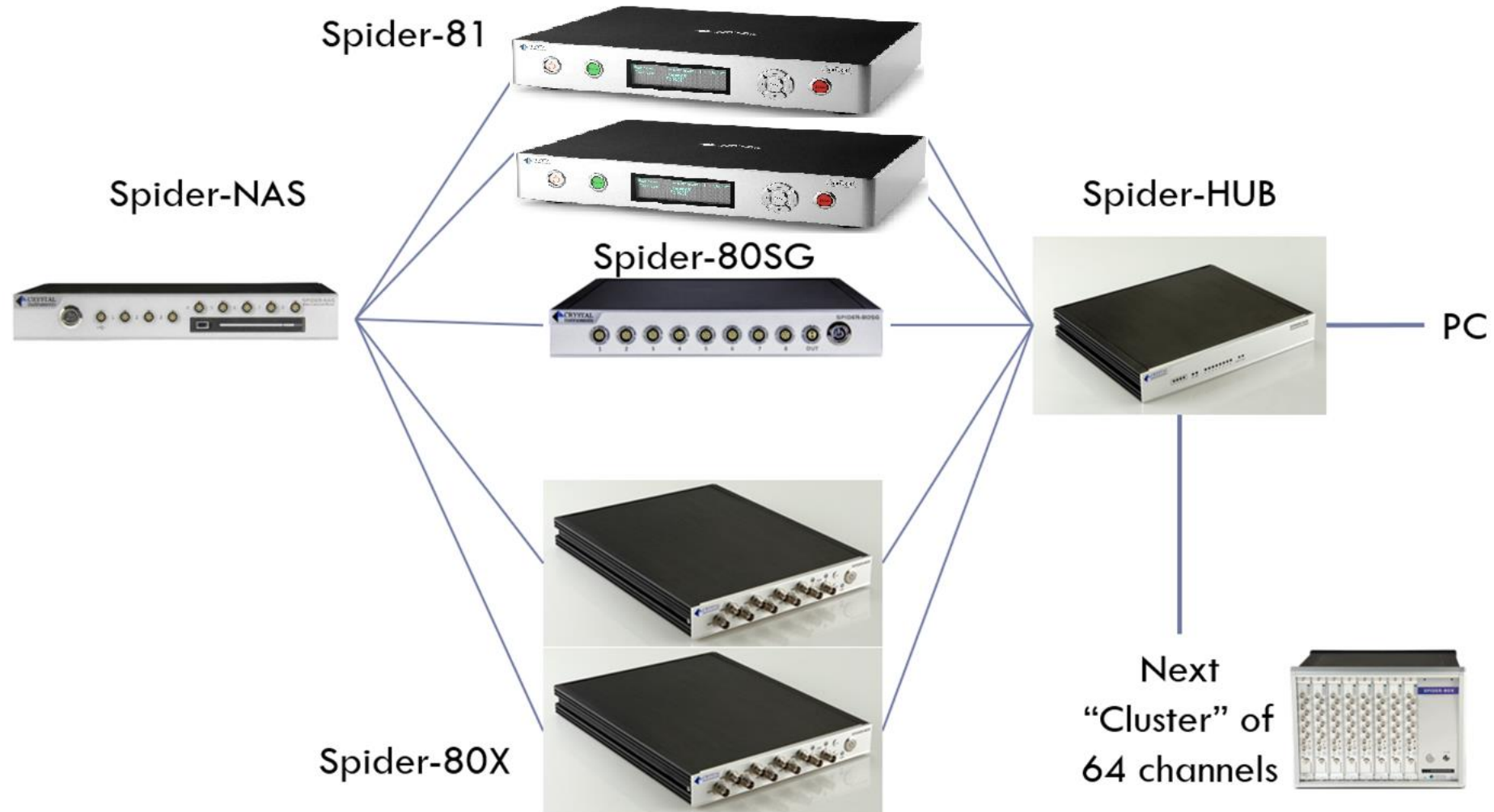
VCS Hardware | Spider-NAS Storage Device

- High-speed data storage device
 - Time stream recording at full speed
 - Direct physical connection to each Spider front-end.
- Removable SATA disk
- Support up to 8 Spider modules
 - 64 inputs sampled at 100 kHz can be throughput into Spider-NAS continuously



Note: Spider-NAS is installed inside of each Spider-80X and Spider-80Xi chassis. Users may not notice it.

VCS Hardware | High Channel Count System Hardware Configuration

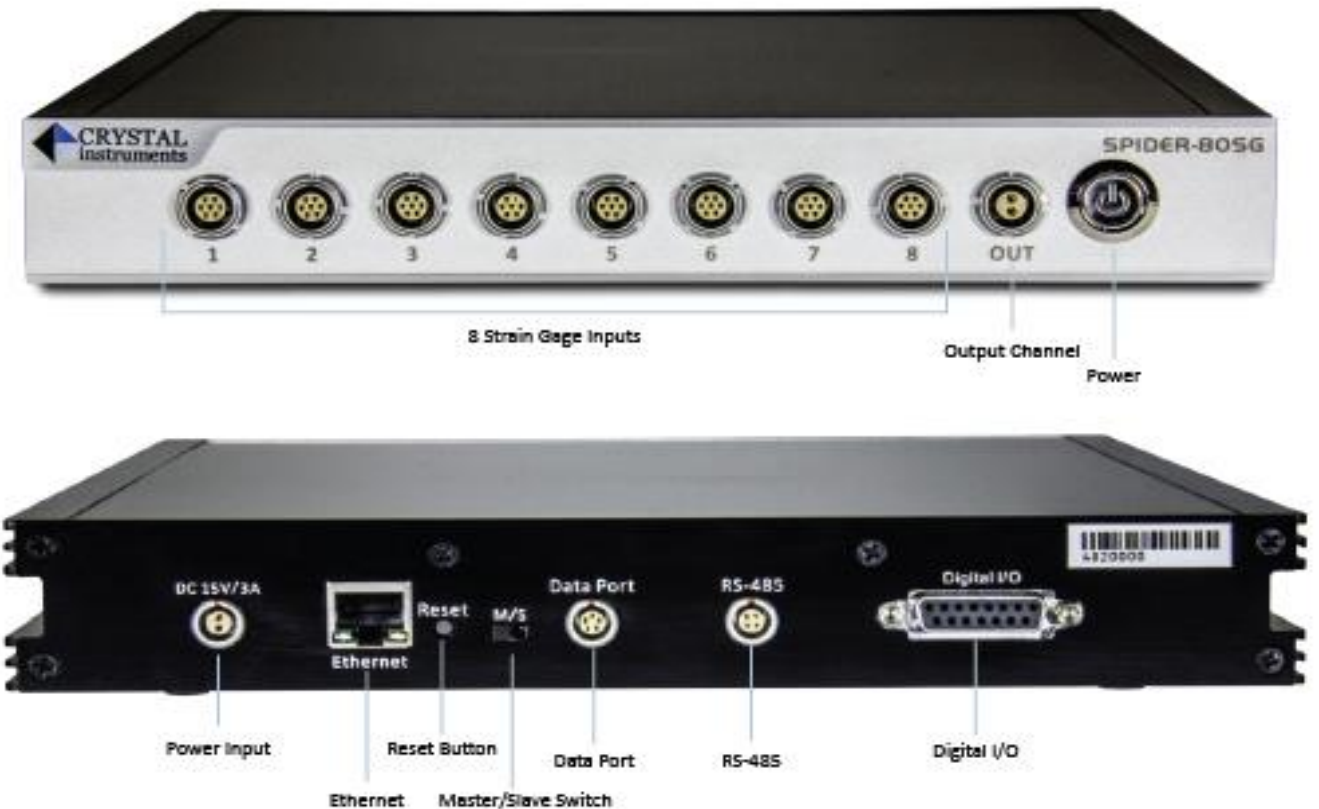


VCS Hardware | High Channel Count System Data Recording Reliability

- Acquire time and frequency data continuously at a rate of up to 102.4 kHz
- Acquire data from up to 512 channels
- Very large internal buffer ensures a high reliability of the data recording
- A special power design in the hardware recovers data in the event of power loss
- Data is stored in the chassis hard disk
- Data is easily accessed by a connected PC

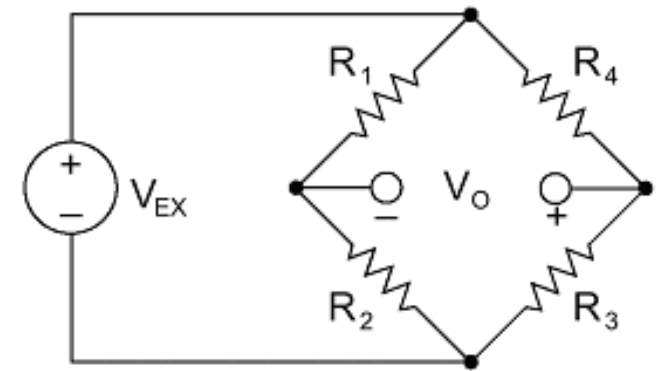
Spider-80SG: Strain Gage Measurement Modules

Fully integrated with any Spider
modules that measure vibration



VCS Hardware | Spider-80SG Main Features

- Support for full-bridge, half-bridge and quarter-bridge
- Fully integrated, simultaneous strain measurement with any VCS and DSA tests
- High channel count supports up to 512 input channels
- Customizable excitation within the range of -2.5V to +2.5V or -5V to +5V
- 24-bit ADCs with sampling rate up to 102.4 kHz
- +10V/50mA power supply to power the other sensors
- High precision 7-pin Lemo input channels
- Input channel adapter to eliminate the need for soldering
- User-friendly shunt calibration and offset-nulling
- Remote sensing function for distant measurement

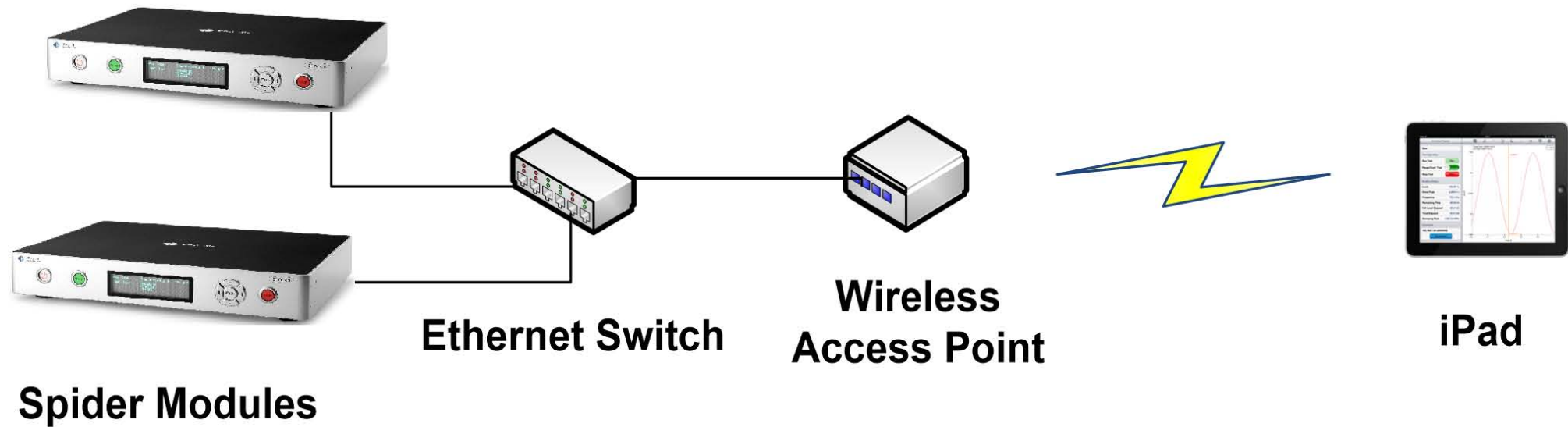


VCS Hardware | Hardware Network Connectivity

- Start and stop tests from the front panel
- Greater flexibility of Spider location
- Greatly reduces noise and electrical interference
- One PC can monitor multiple controllers
- Network connection doesn't affect the control reliability
- Connect wirelessly with optional wireless routers

VCS Hardware | Hardware Connectivity

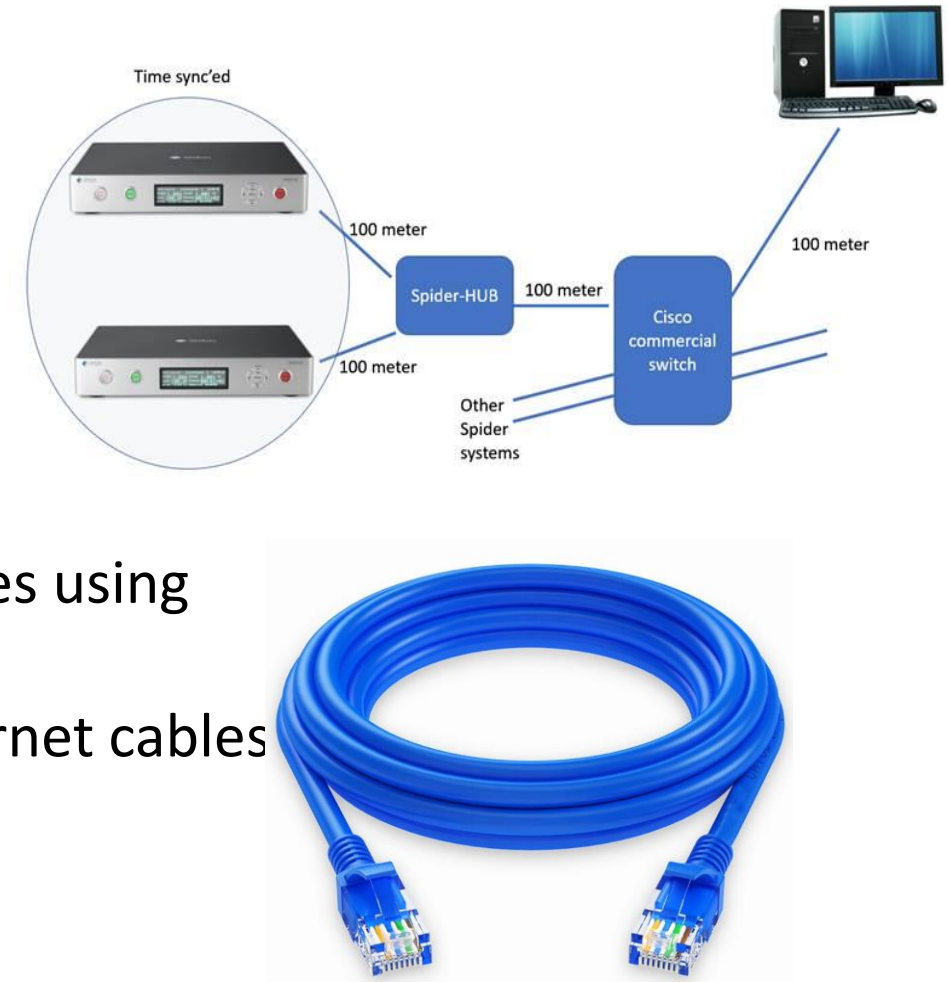
- Hardware devices are identified by IP address.
- Access codes can be applied additionally for strong security.



VCS Hardware | All Spider Hardware Connectivity

❑ Ethernet Connection Simplifies the Operation

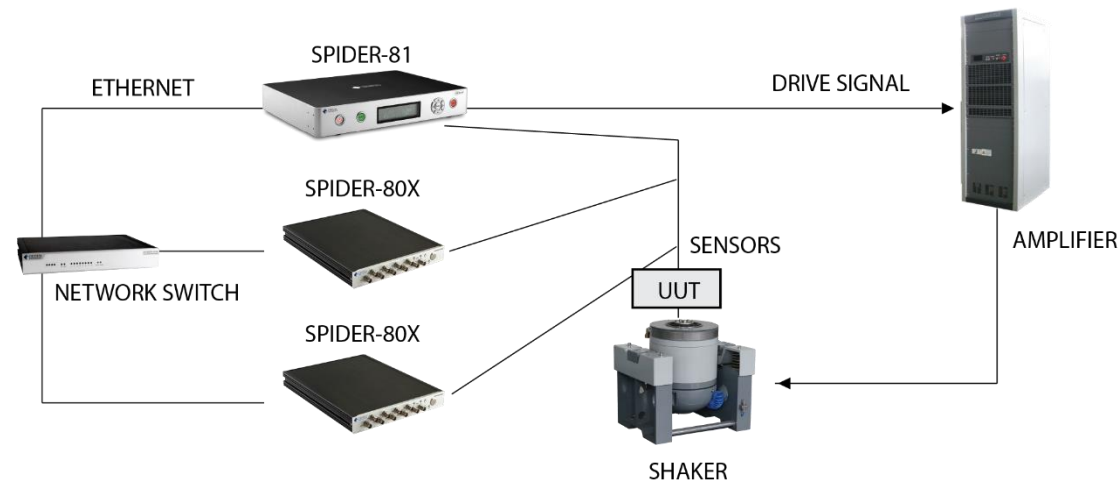
- Fast data transmission
- One PC can handle multiple Spider devices
- Device driver installation is not needed
- Standard security
- Uses TCP, IP, UDP standard protocols
- Can be integrated with other network devices using standard network socket messages
- Can be distributed over LAN with CAT6 Ethernet cables up to 100 meters



VCS Hardware | IEEE 1588 Time Synchronization

❑ All Spider platforms are equipped with IEEE 1588 Time Synchronization.

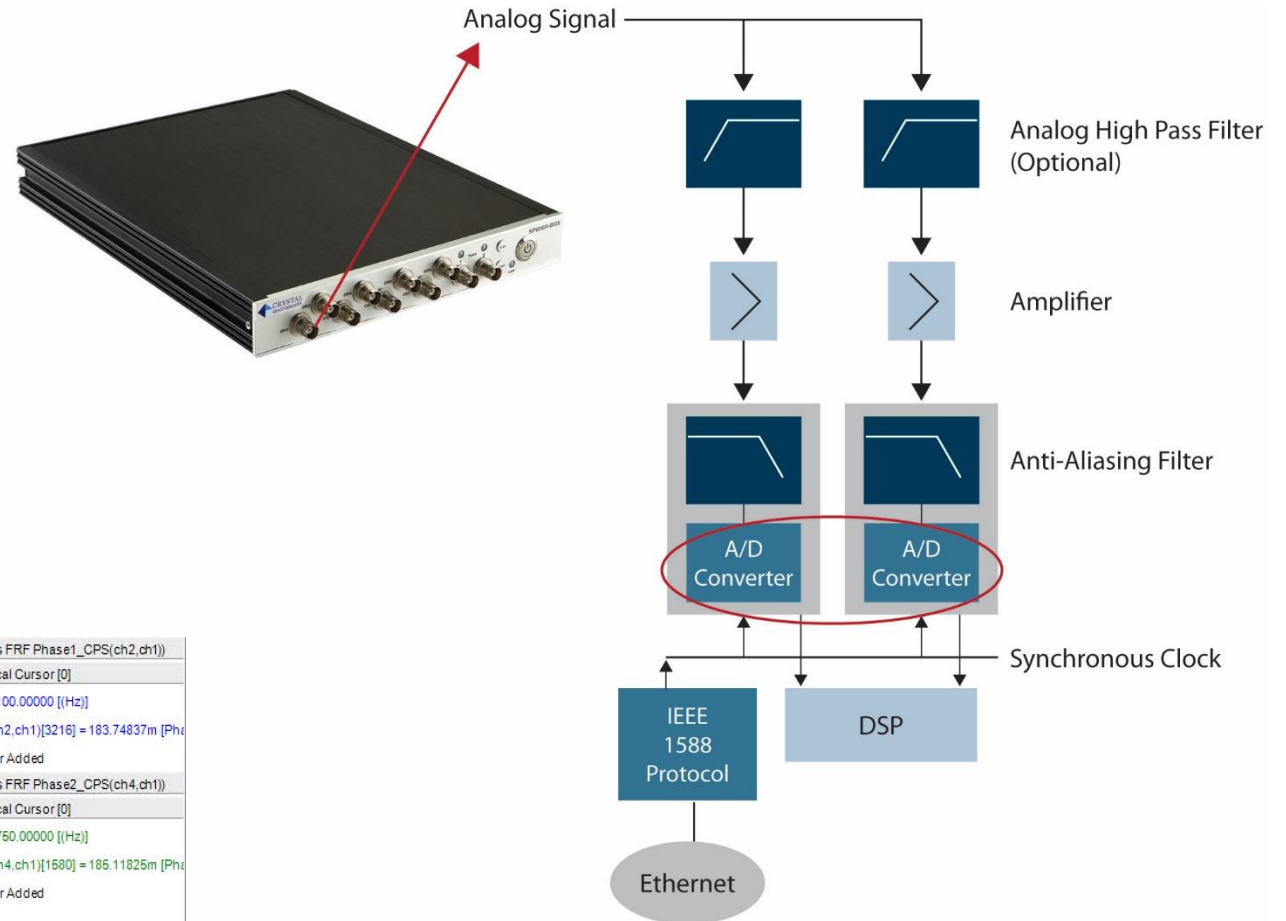
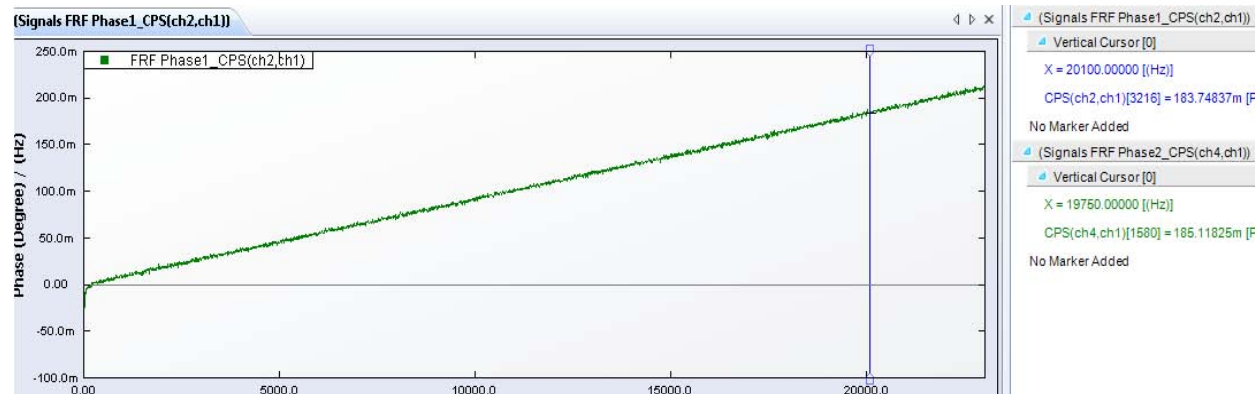
- Up to 50 ns accuracy
- ± 1 degree cross channel phase match up to 20 kHz
- Distributed components truly act as one integrated system



VCS Hardware | IEEE 1588 Time Synchronization

IEEE 1588 is a protocol designed to synchronize real-time clocks in the nodes of a distributed networked system.

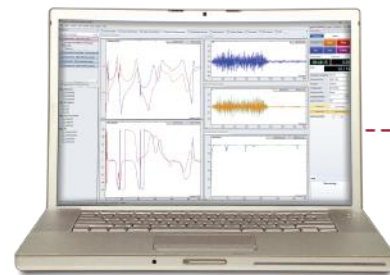
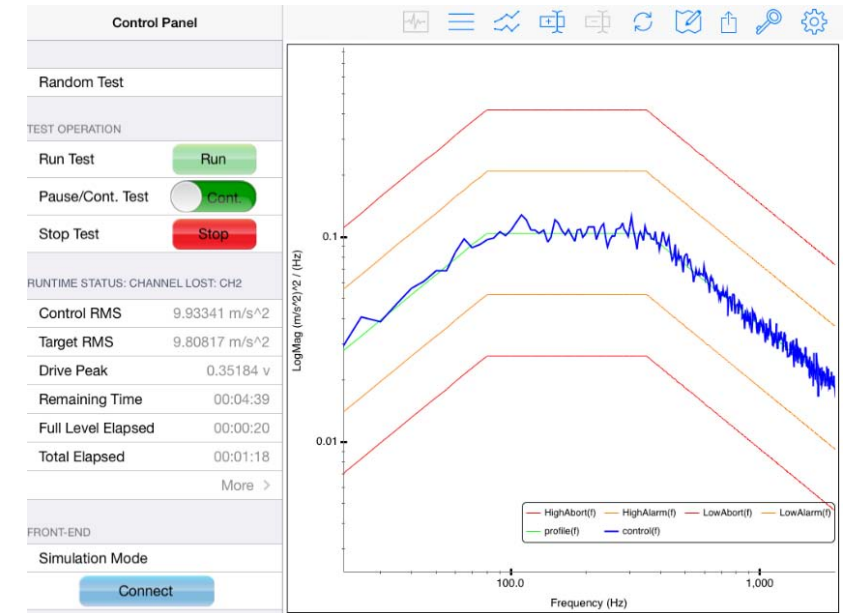
Crystal Instruments applies this technology in a unique way to synchronize the sampling of all A/D converters across multiple boards



VCS Hardware | Wireless Connection

Since all Spider platforms are network devices, they can be easily configured to support wireless connection.

- Control with PC or iPad
- Full EDM installation
- Connects to Spider through Wi-Fi



PC



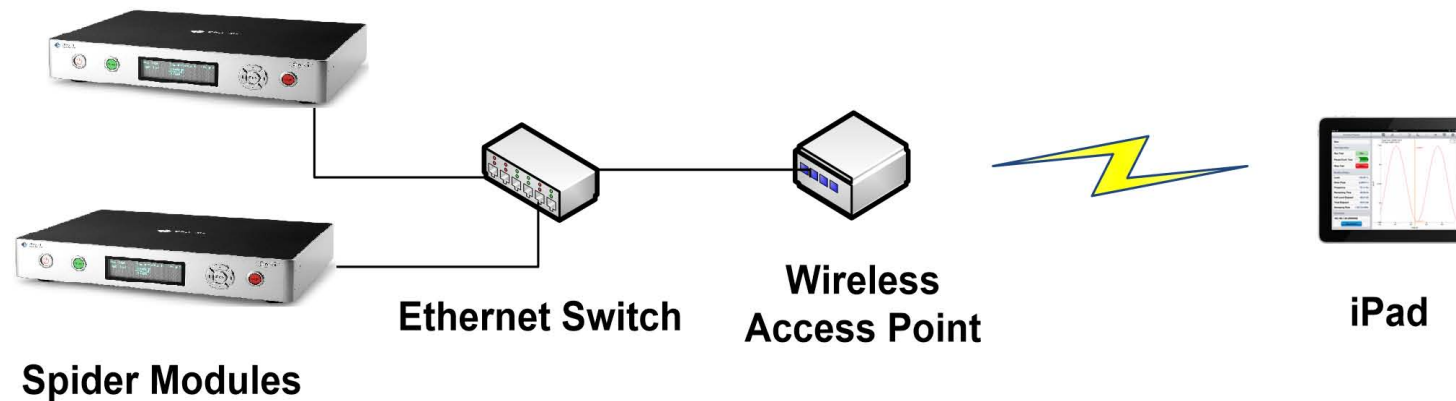
WiFi Router



Spider Front-end

VCS Hardware | Black Box Mode

- *All Spider platforms support Black Box mode.*
- *Black Box Mode* allows the spider to operate without a computer.
- A computer is used only to configure the test and download data.

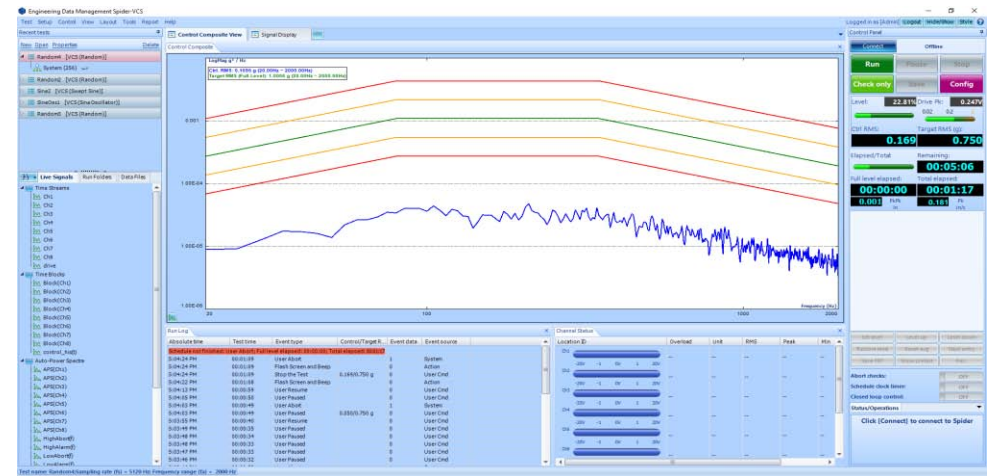
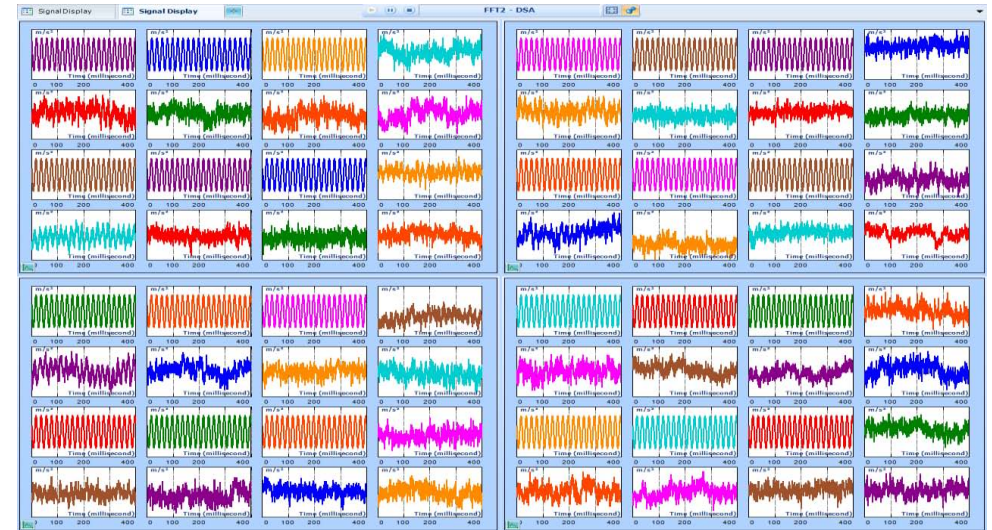


- **Hardware self-diagnostic process at the beginning of each test**
- **On-board real-time clock and flash memory storage**
- **Advanced safety routines**
 - Sensor failures detected in real time within milliseconds
- **All Spider hardware platforms passed strict environmental tests including:**
 - EMI, Temperature
 - Drop Shock
 - Sine and Random Vibration

Vibration Control | Software Overview

VCS Software | Introduction

- Customizable layout and display supporting multiple monitors.
- Template-based reports
- Graphical tools and wizards are added to make setup a snap
- Interface has been arranged to make it logical and more useful
- Event-Action Rules, Abort-Sensitivity, and other features simplify operation
- One central location for all parameter setup



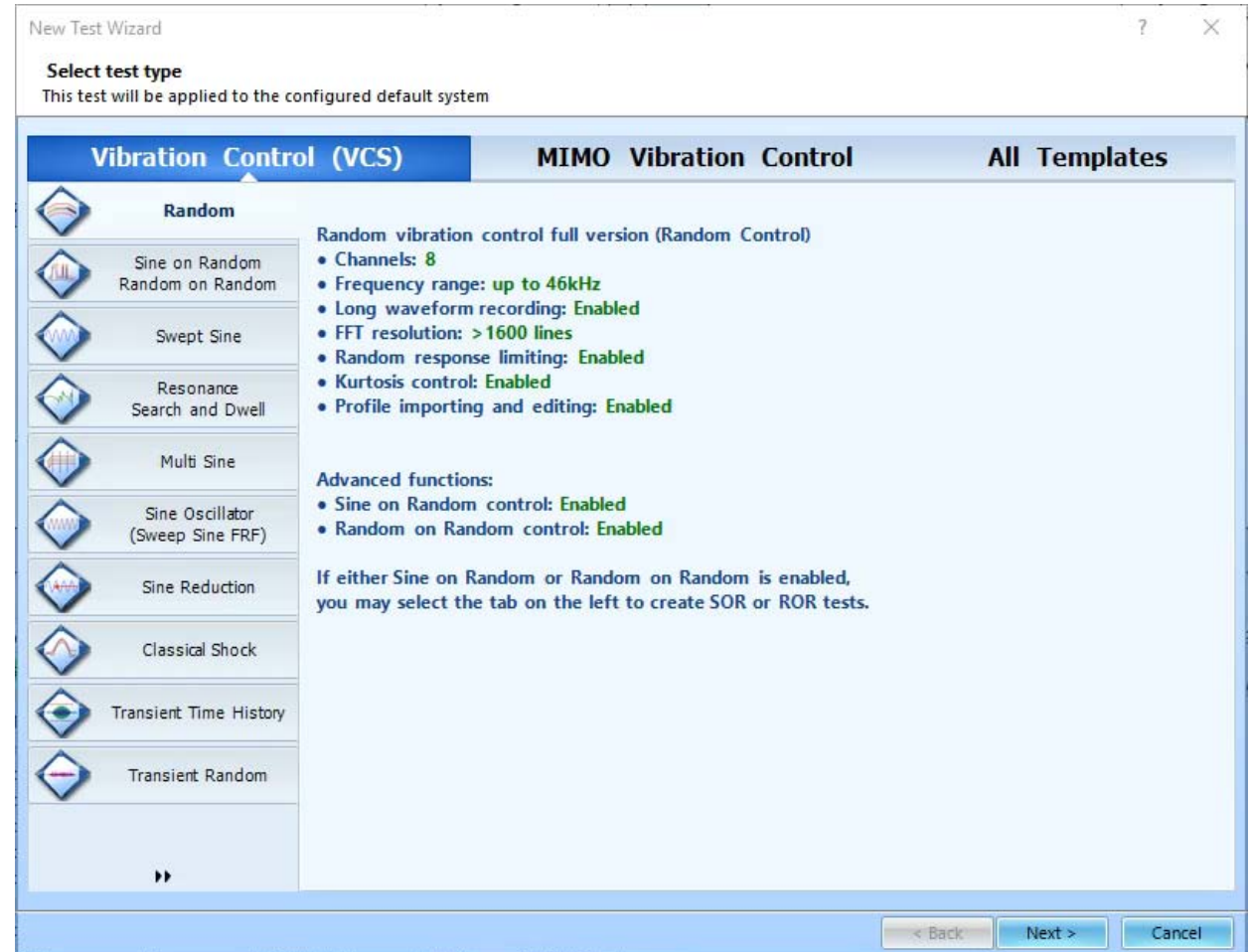
VCS Software | Safety Features

- Pre-test checks drive, sensor response
- Shaker safety limits
- RMS limits for control signal
- Output voltage limiting
- Open loop, sensor failure detection
- Use limit channels with customized limit profile
- Channel overload and sensor overload detection



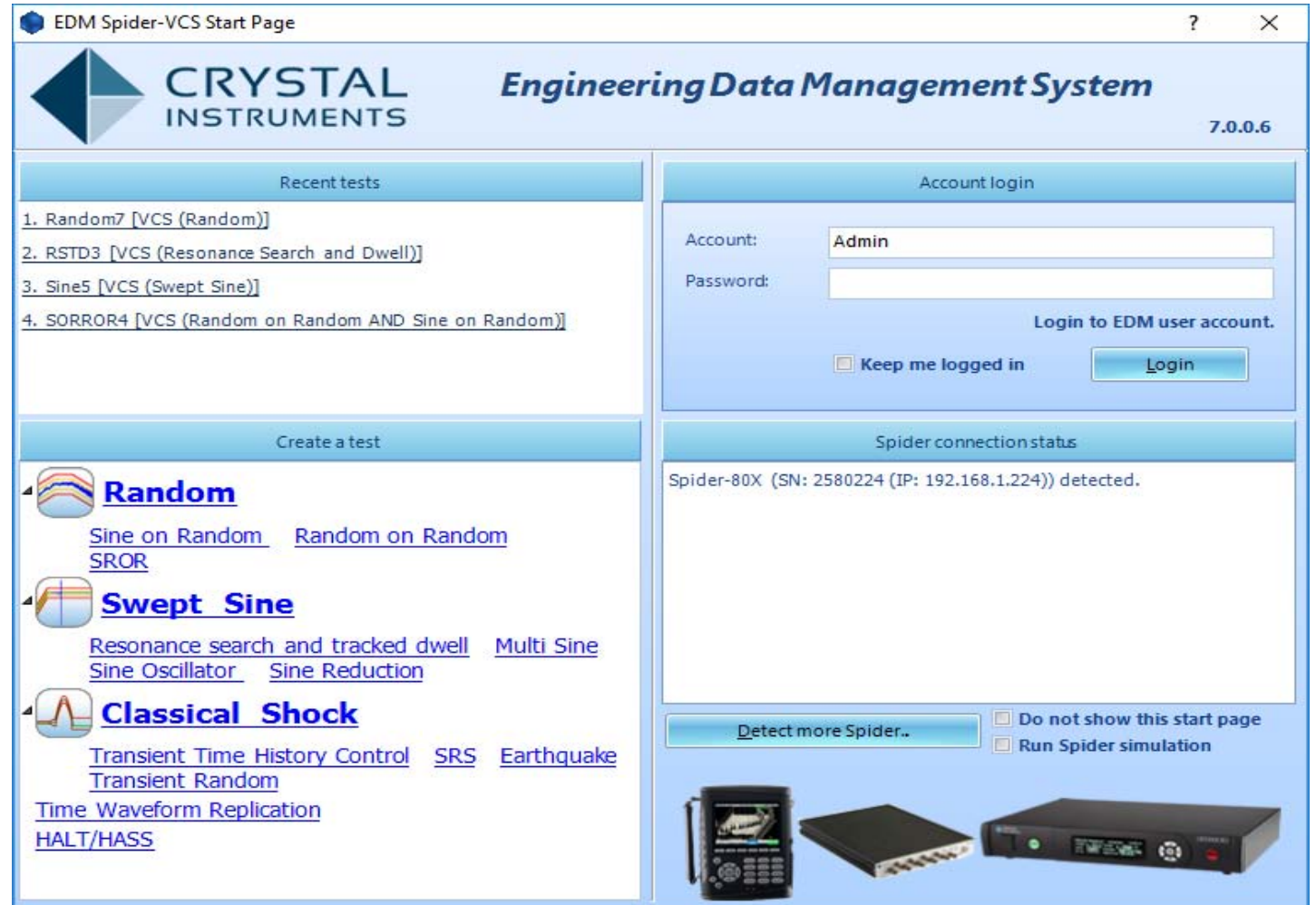
VCS Software | Overview of All Test Types in New Test Wizard

- Random
- SoR/RoR
- Swept Sine
- Resonance Search and Dwell
- Multi Sine
- Sine Oscillator
- Sine Reduction
- Classic Shock
- Transient Time History
- Transient Random
- Shock Response Spectrum Synthesis
- Earthquake
- Time Waveform Replication
- HALT/HASS



VCS Software | Start Page

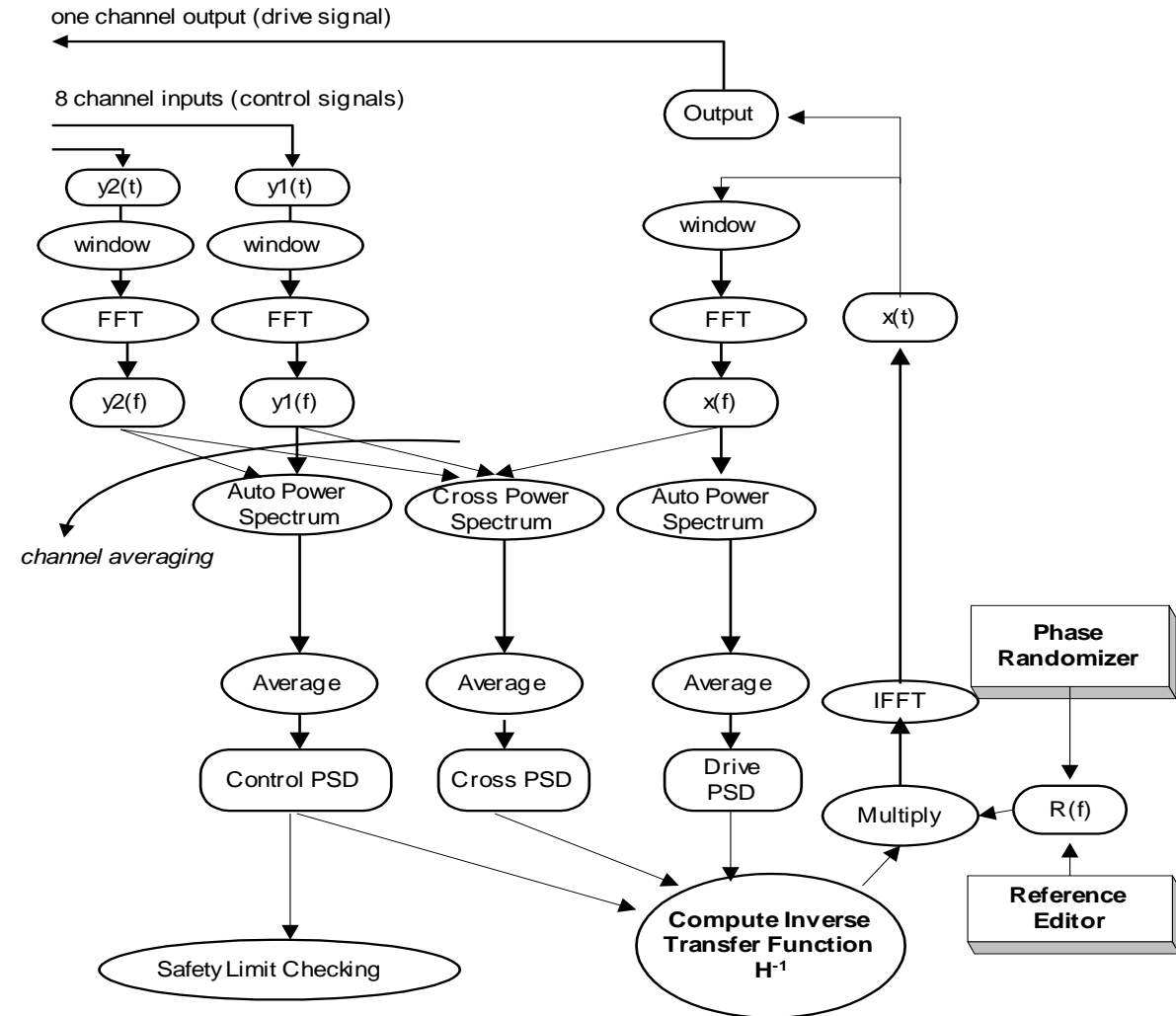
- Open a recent test
- Create a new test
- Log into an account
- View the list of Spiders



In a random test, the shaker is driven by a wide band random signal.

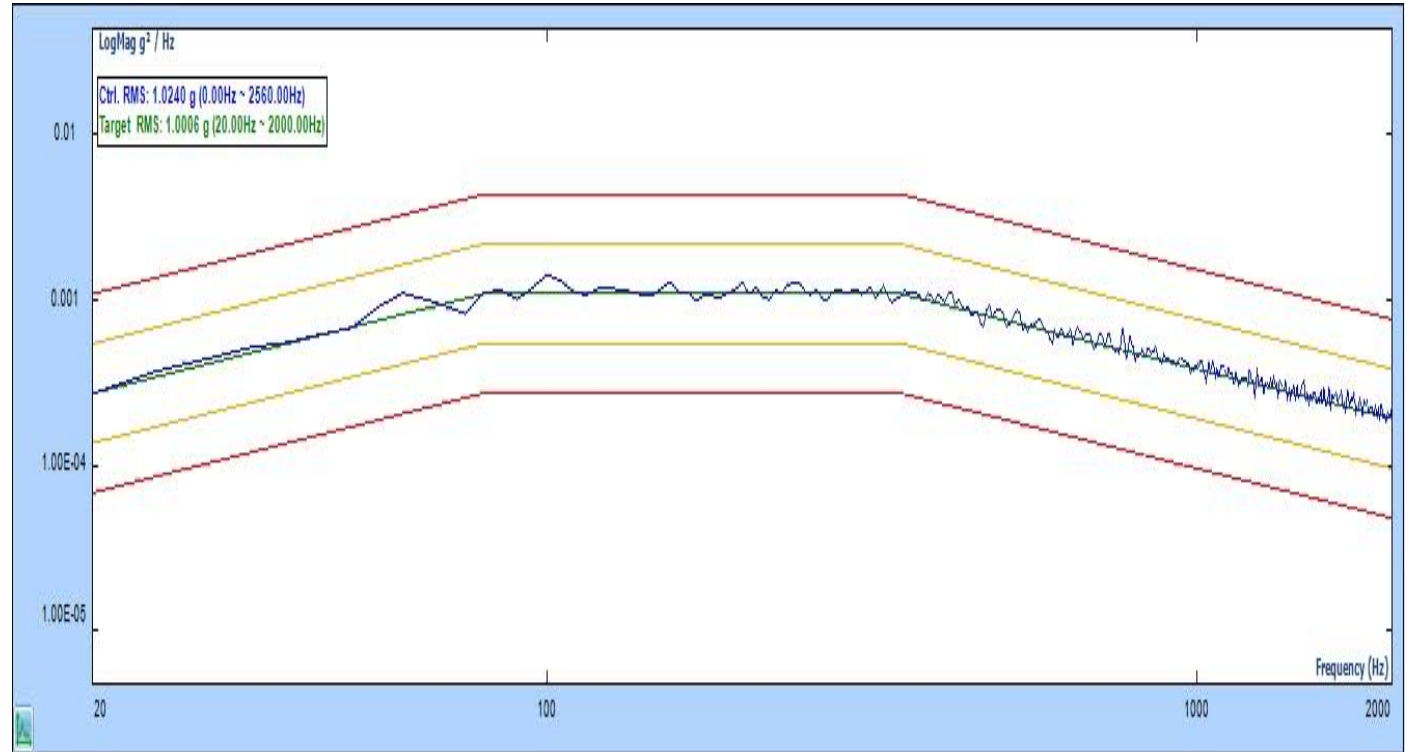
Feedback control adjusts this drive signal to generate a response that conforms to a specified test profile.

The control algorithm calculates the inverse transfer function between the output drive and the input control channels.



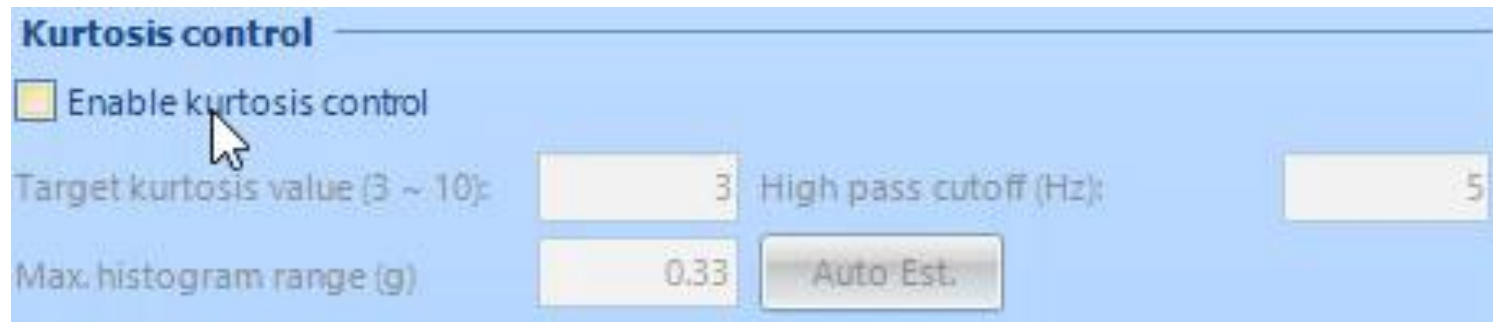
VCS Software | Random

- **Frequency Range:** up to 46 kHz
- **Spectral Resolution:** up to 25,600 lines
- **Loop Time:** 12.5 ms for 2000 Hz
- **Average Number:** 1 – 500 (2 – 1000 DOFs)
- **Overlap Ratio:** none, 50%, 75%, and 87.5%
- **Control Dynamic Range:** 90 dB
- **Control Accuracy:** ± 1 dB at 99% confidence with 200 DOF
- **Drive Sigma Clipping:** 3 – 10, or disabled
- **Level Ramp-up Rate:** Fast (20 dB/s), Slow (2 dB/s), Fastest (60 dB/s)
- **Kurtosis Control**
- **Non-Linear Control**
- **Non-Acceleration Control**
- **Multi-Resolution Control**
- **Fatigue Damage Spectrum**



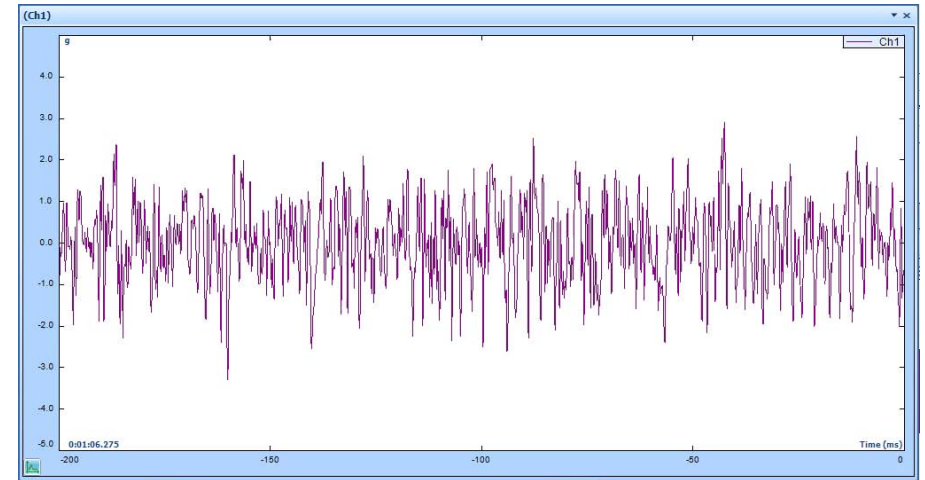
VCS Software | Kurtosis Control in Random

- A measure of the frequency of occurrences of large peaks in a waveform
- Allows the user to specify the target kurtosis of the random control signal, and the controller will adjust the amplitude distribution of the vibration to match the target
- Done with minimal effect on the frequency content and dynamic range.

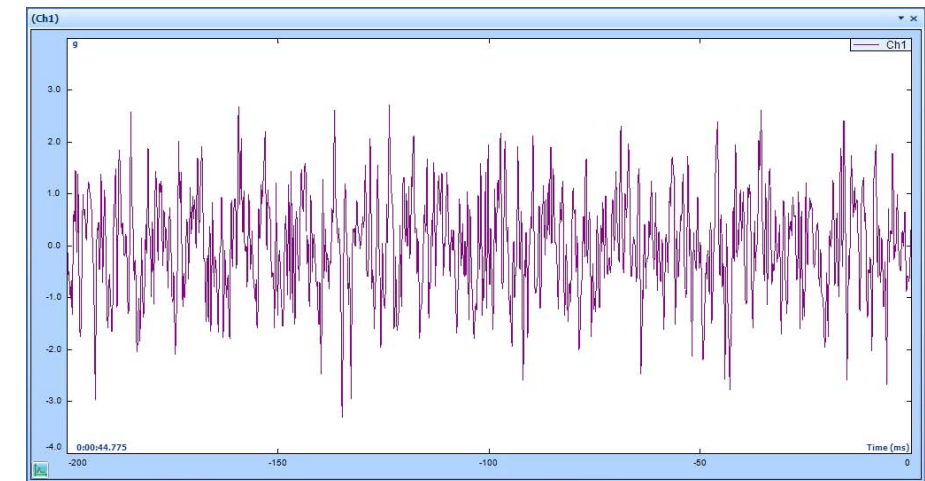


VCS Software | Kurtosis Control in Random

- Without kurtosis control, the output distribution of the random controller is Gaussian.
- Large peaks are relatively rare; the random waveform will be less than 4 times its RMS value 98% of the time.
- Kurtosis is a measure of "peakedness" and is related to the amplitude distribution. A random vibration with higher kurtosis will contain more "outlier" peaks in the extremes of the distribution.



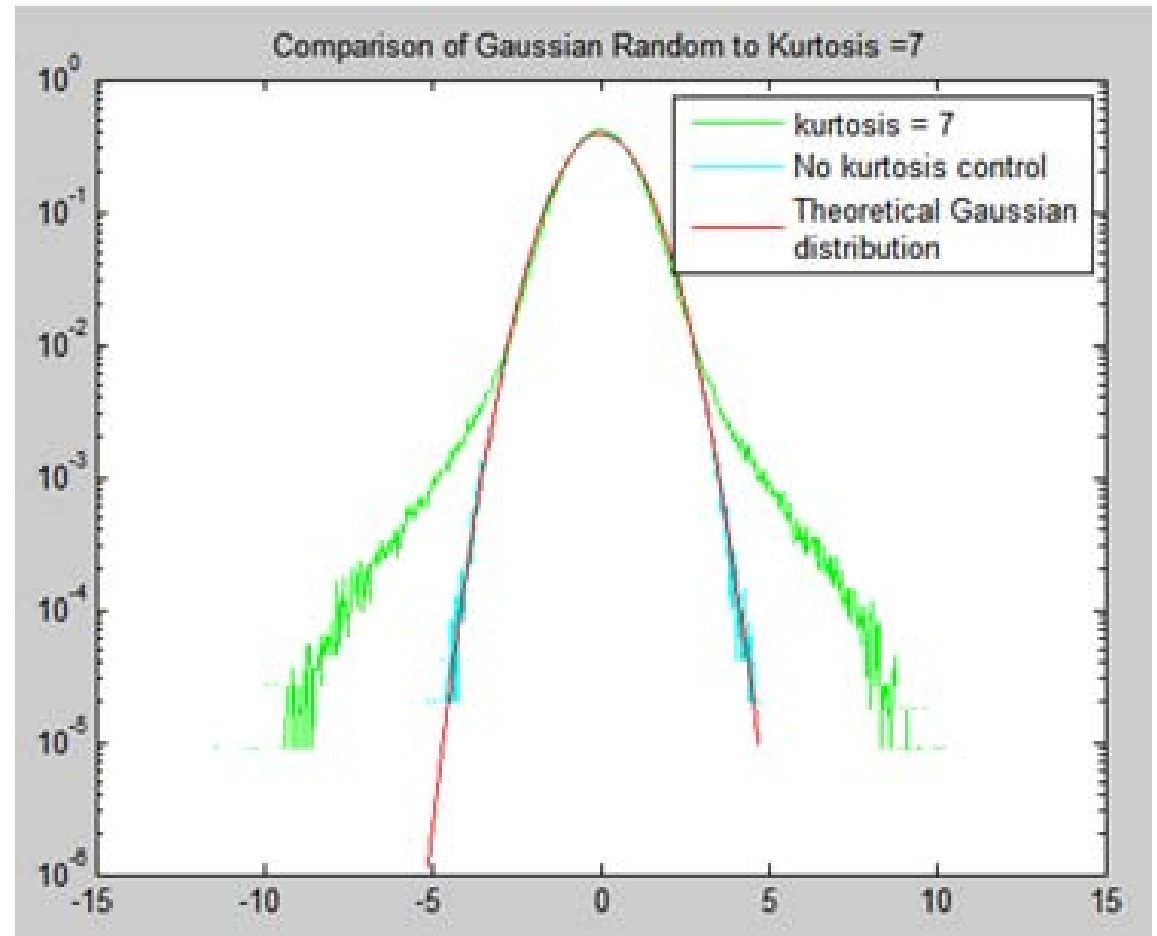
Gaussian random vibration waveform



Random vibration waveform with kurtosis = 7

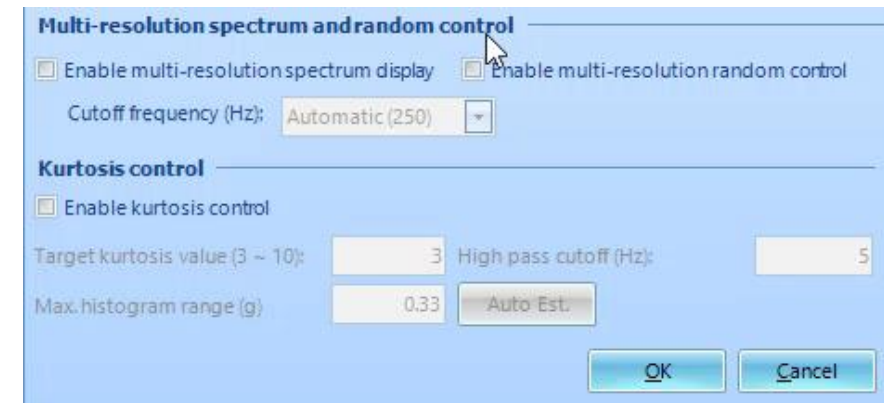
VCS Software | Kurtosis Control in Random

- This figure shows the difference in amplitude distributions of the tests.
- Amplitude distribution can be measured with histograms.
- It can be seen that the tails extend out much further with the higher Kurtosis.
- Since only the phase is changed, there is no effect on the frequency content of the vibration.



VCS Software | Multi-Resolution for Random

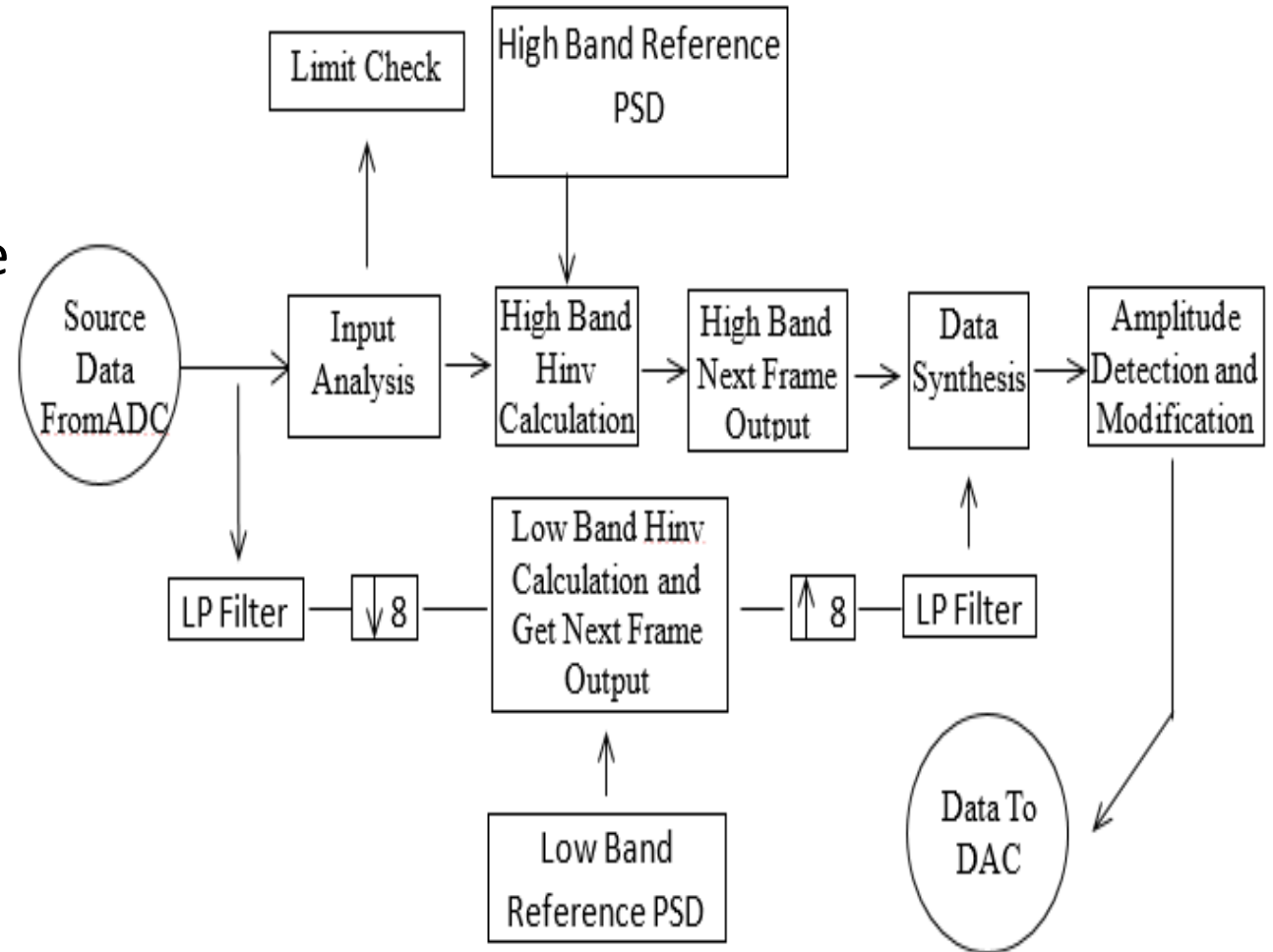
- Increase the control performance in the low-frequency range and maintain reasonable loop time
- Applies the selected resolution in the high-frequency range and 8 times of the resolution in the low-frequency range.
- Cutoff frequency calculated by the VCS software.
- A few adjacent frequencies can also be selected by the user to avoid system resonance or anti-resonance.
- When multi-resolution enabled, the frequency range is up to 8,000 Hz.



VCS Software | Multi-Resolution for Random

Two different control loops with different sampling rates are used.

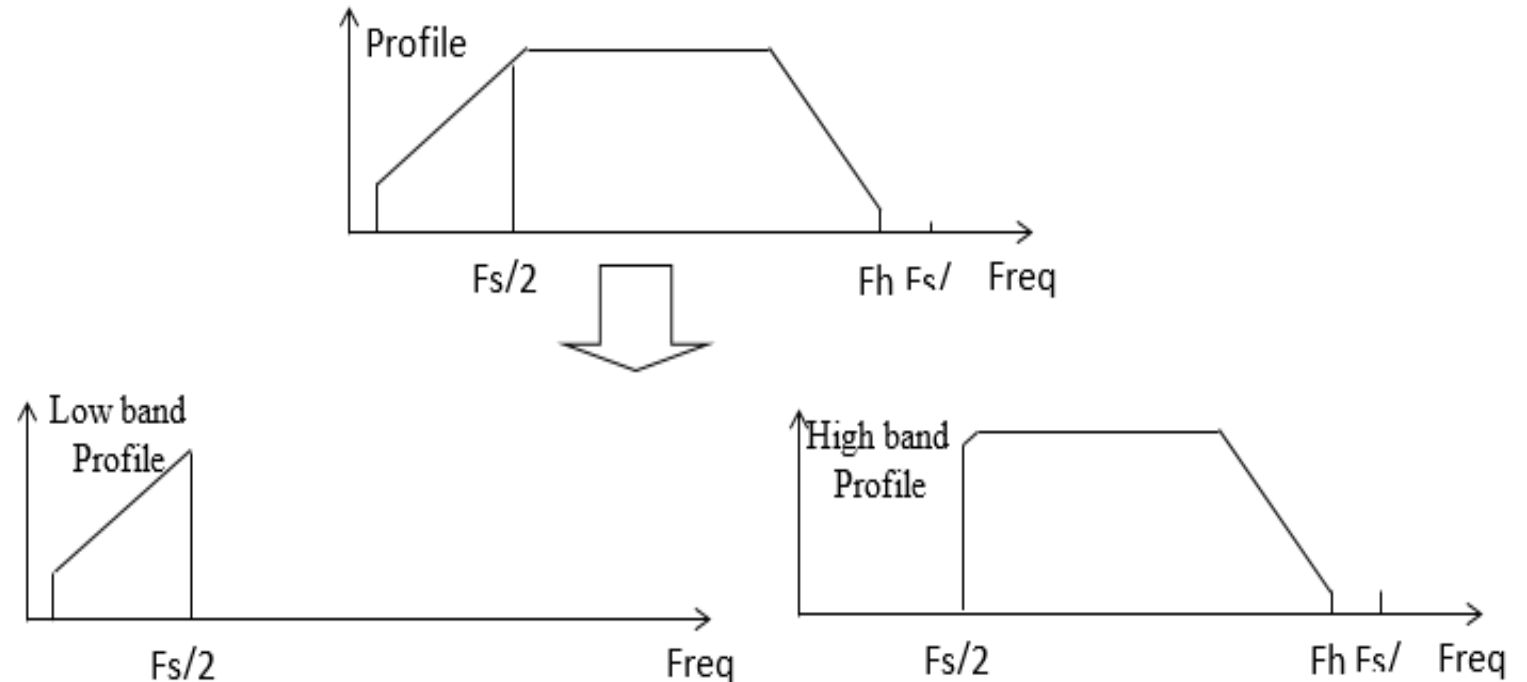
Suppose that the sampling rate in the control system is F_s , we divide the whole frequency range into two bands: $(0, F_s/20]$ and $(F_s/20, F_h)$. ΔF is the resolution in frequency band $(F_s/20, F_h)$, then we use $\Delta F/8$ as the resolution in $(0, F_s/20]$. Down sampling 8 is used in the algorithm.



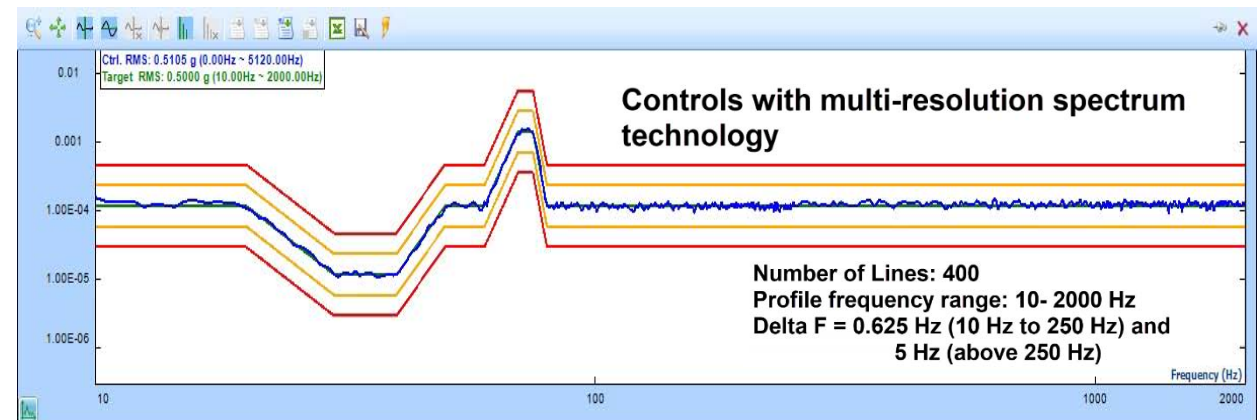
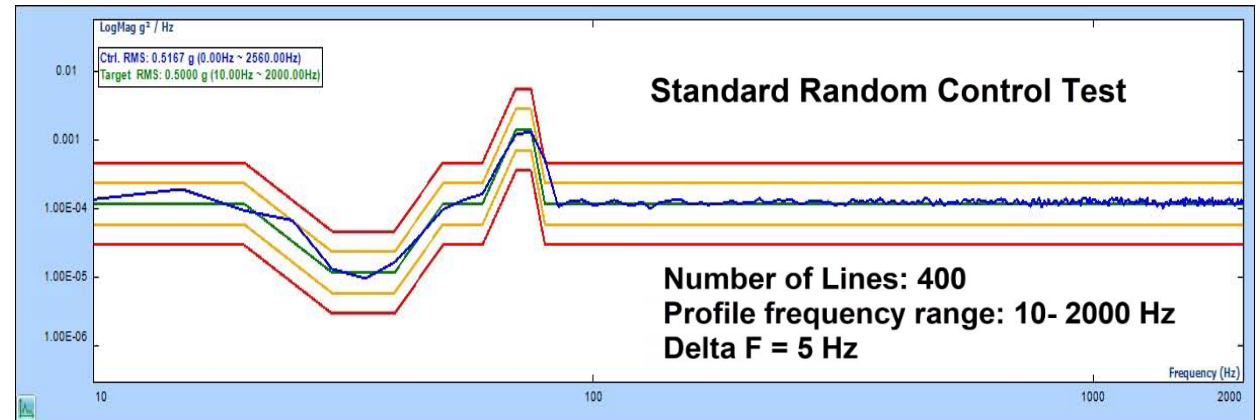
VCS Software | Multi-Resolution for Random

The user defined profile shall be decomposed into 2 bands in the initializing period, to get the low band reference profile.

The Spider will operate on these two profiles simultaneously.

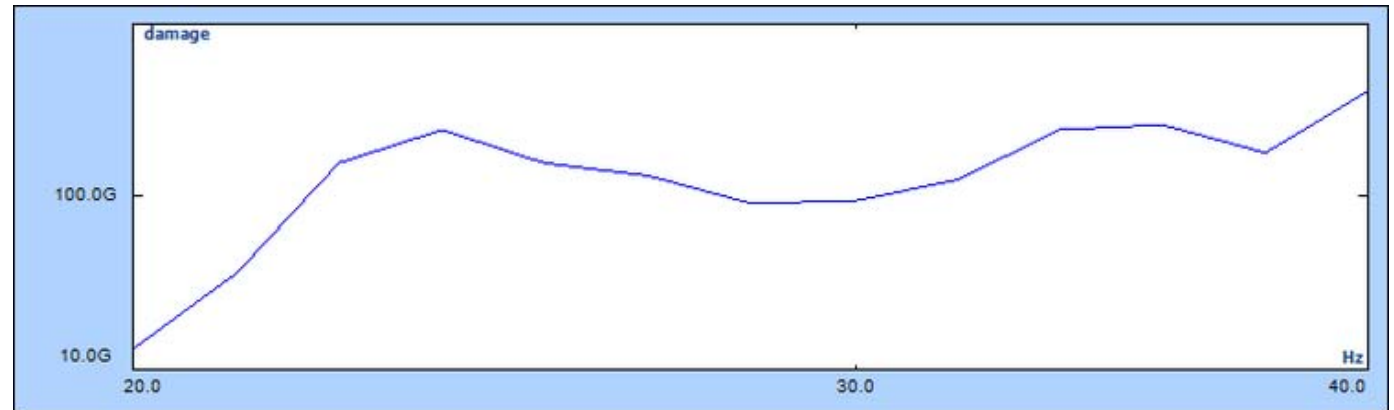


The multi-resolution control algorithm enhances higher resolution in the low frequency range to provide much higher control accuracy in that range



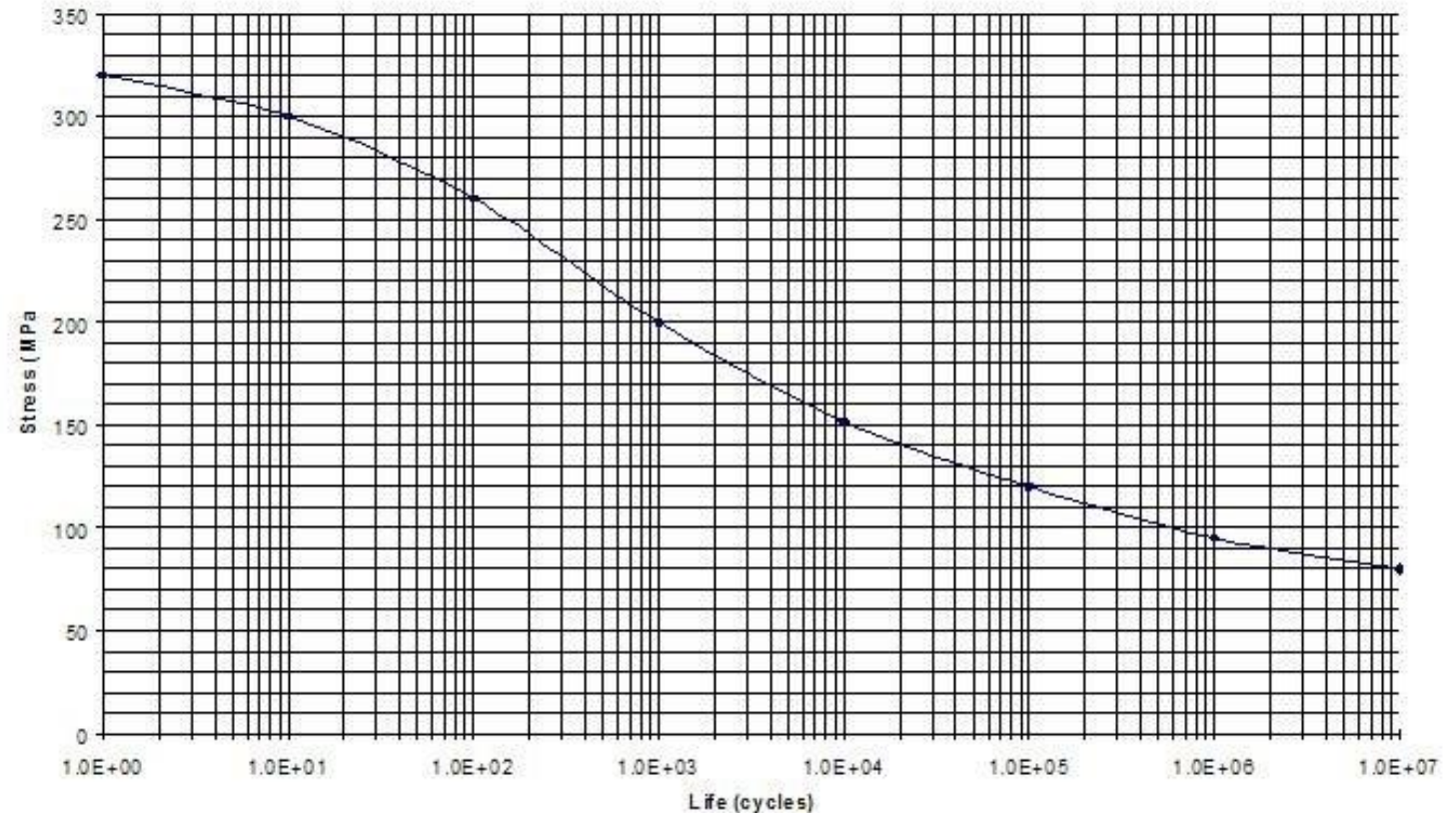
VCS Software | Fatigue Damage Spectrum (FDS) in Random

- Allows users to compare the potential damage caused by different Random and Swept Sine profiles
- Provides a way to reduce testing times by calculating the quickest path to destruction or damage
- Testing times are accelerated by focusing random or swept sine energy, depending on the FDS calculation, to where it will induce the most fatigue



VCS Software | Fatigue Damage Spectrum (FDS) in Random

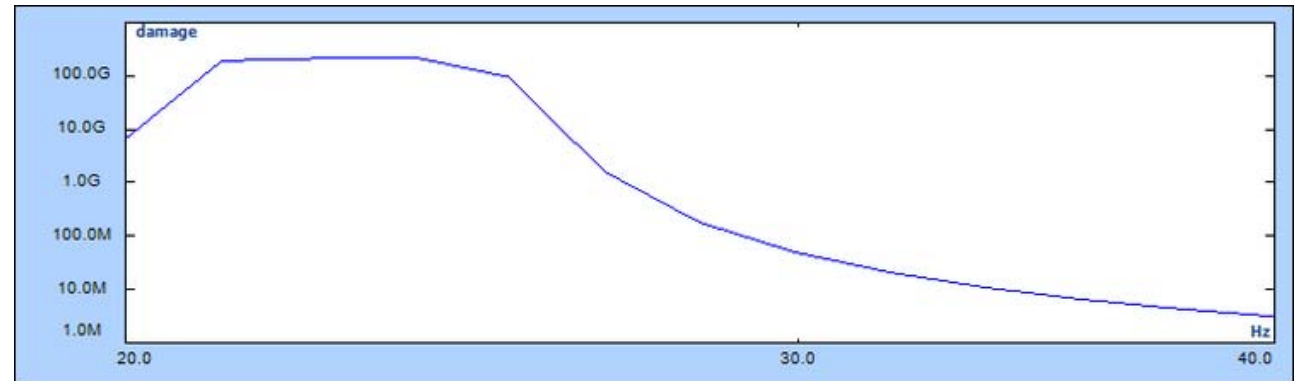
- FDS represents a spectrum with regard to the fatigue damage on an object. The FDS function makes use of the S-N curve to construct the spectrum.
- The S-N curve represents the stress applied to a material (S) versus the number of cycles of applied stress.



VCS Software | Fatigue Damage Spectrum (FDS) in Random

How to accelerate random vibration tests accurately:

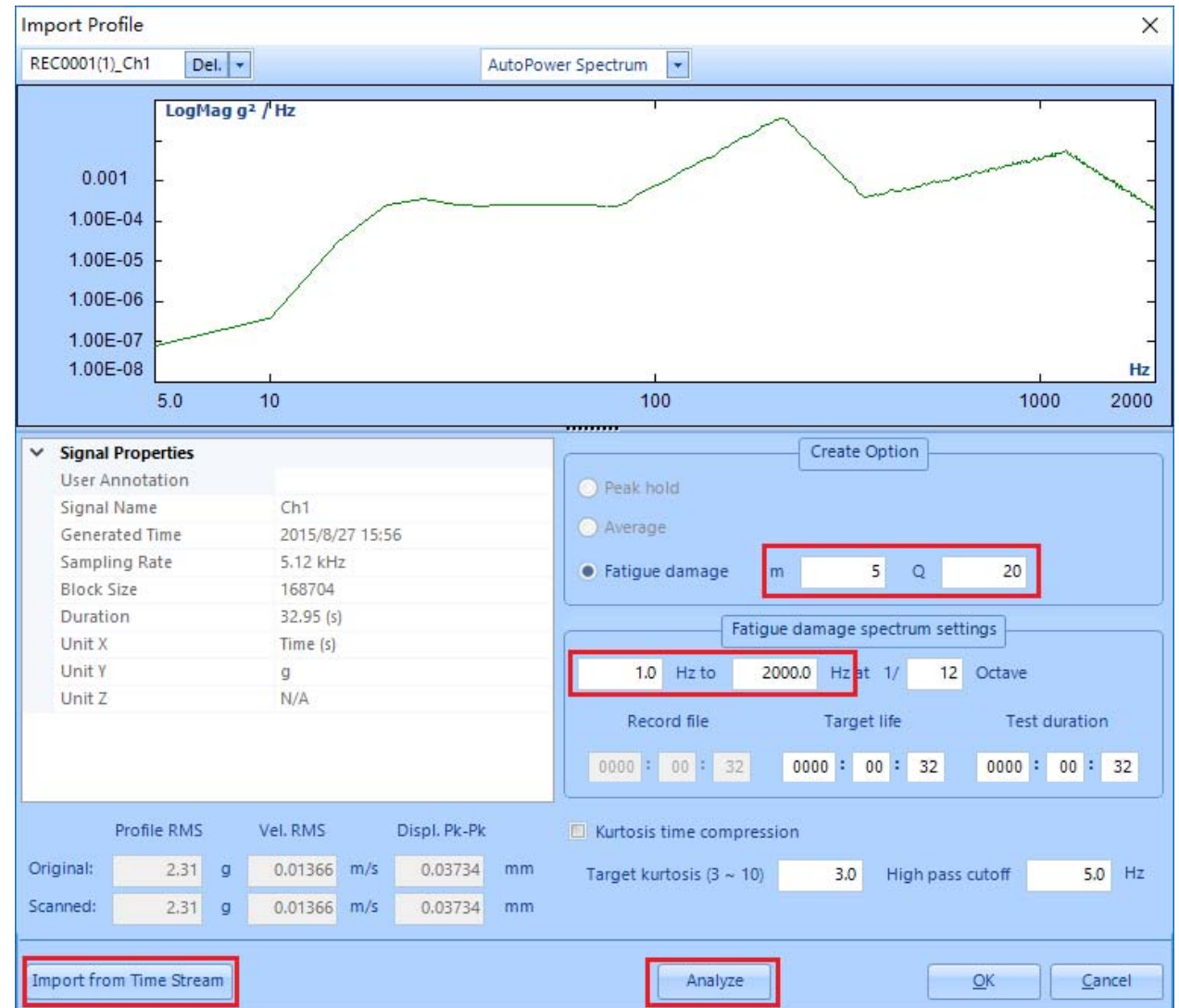
- Recorded file for end-use environment is required to be imported
- Fatigue damage spectrum (FDS) needs to be calculated, which is produced by plotting the individually calculated fatigue damage values for narrow frequency bands.
- Two methods to shorten the test duration:
 - 1. Increase the RMS level of test profile
 - 2. Increase the kurtosis value, which puts the large and damaging resonant peaks into the random test



VCS Software | Fatigue Damage Spectrum (FDS) in Random

Steps to import create a test profile to match end-use environment

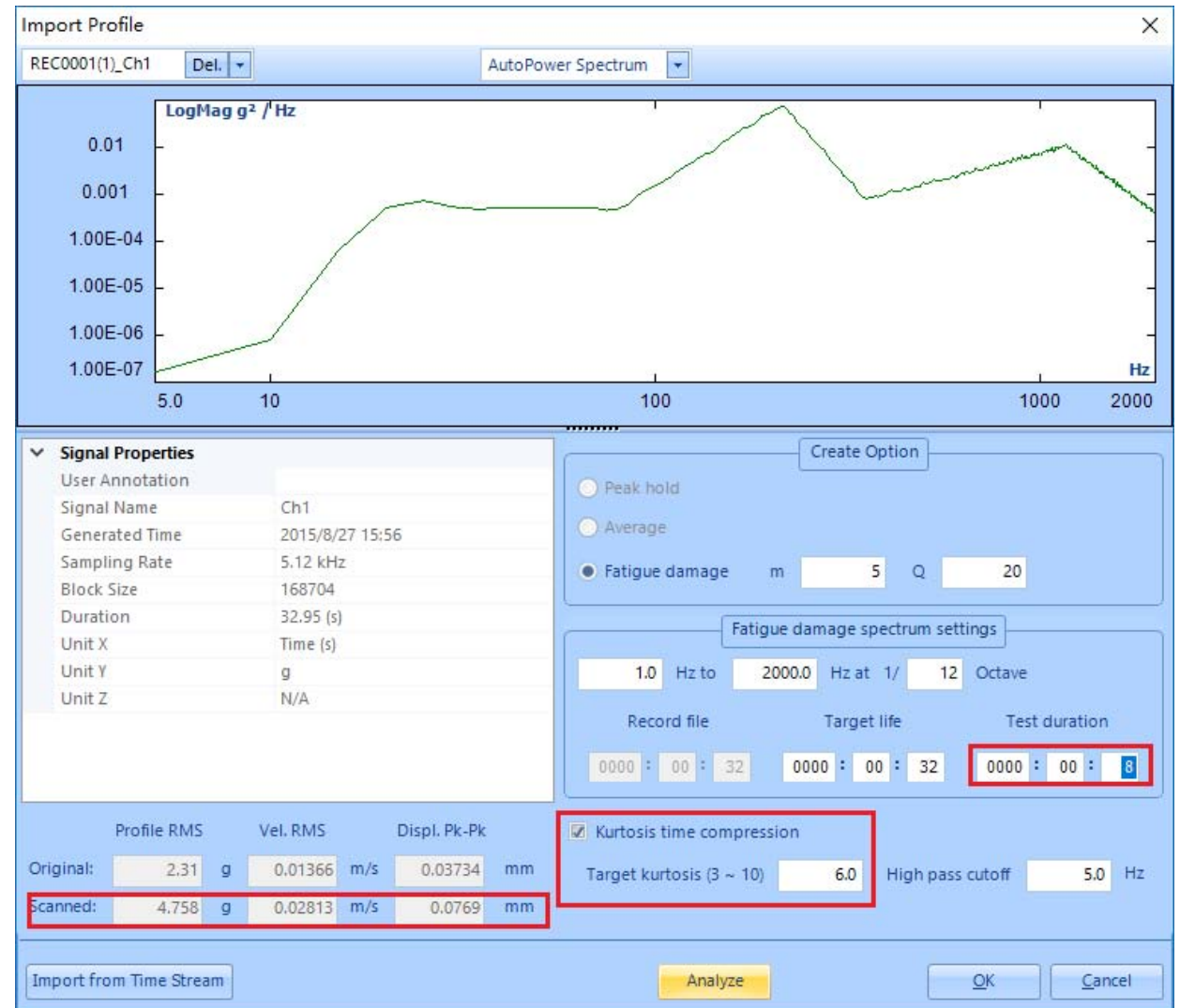
- Import a recording time stream
- Set m and Q values
- Set the frequency range of the test profile
- Test profile will be created by click “Analyze” button



VCS Software | Fatigue Damage Spectrum (FDS) in Random

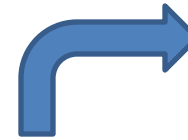
How to reduce test duration:

- Changed the test duration as you desired
- Checks “Kurtosis time compression” and changed target kurtosis value
- Click “Analyze” button and the new test profile will be created.
- The A.V.D RMS for the new test profile will be updated



VCS Software | Non-linear Control in Random

- Enables the advanced control algorithm that compensates for non-linear response in the test system.
- Significantly improve the control performance for vibration tests on mechanical shaker systems.
- Should be left enabled for all tests unless advised otherwise by a manufacturer's service representative.



Advanced Settings ? X

General

- ☐ Adjust High Alarm/Abort by level when it is less than 100% (0dB)
- ☐ Start notching when level is less than 100% (0dB)
- ☐ Reset average by level change
- ☐ Display Alarm/Abort with level
- ☐ Disable Control low limits while notching
- Abort ramp down rate (dB/s):
- Level change rate (dB/s):
- Adjust level step (%):

Performance optimization

- ☒ Non-Linear control
- ☐ Optimize displacement

Ramp-up rate

Slow ramp-up (about 2dB/s) Fast ramp-up (about 20dB/s) Fastest (about 60dB/s)

"Fastest" rate is not commonly used. Please make sure you're confident with the system's connections and there is no safety concerns.

Multi-resolution random control

- ☐ Enable multi-resolution random control
- Cutoff frequency (Hz):

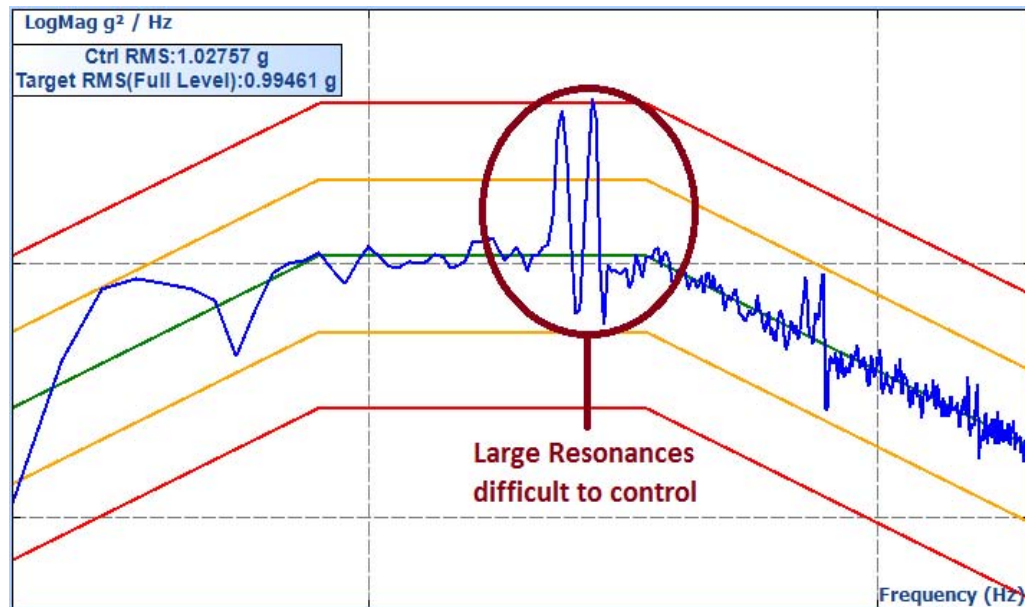
Kurtosis control

- ☐ Enable kurtosis control
- Target kurtosis value (3 ~ 10):
- High pass cutoff (Hz):
- Max. histogram range (g):

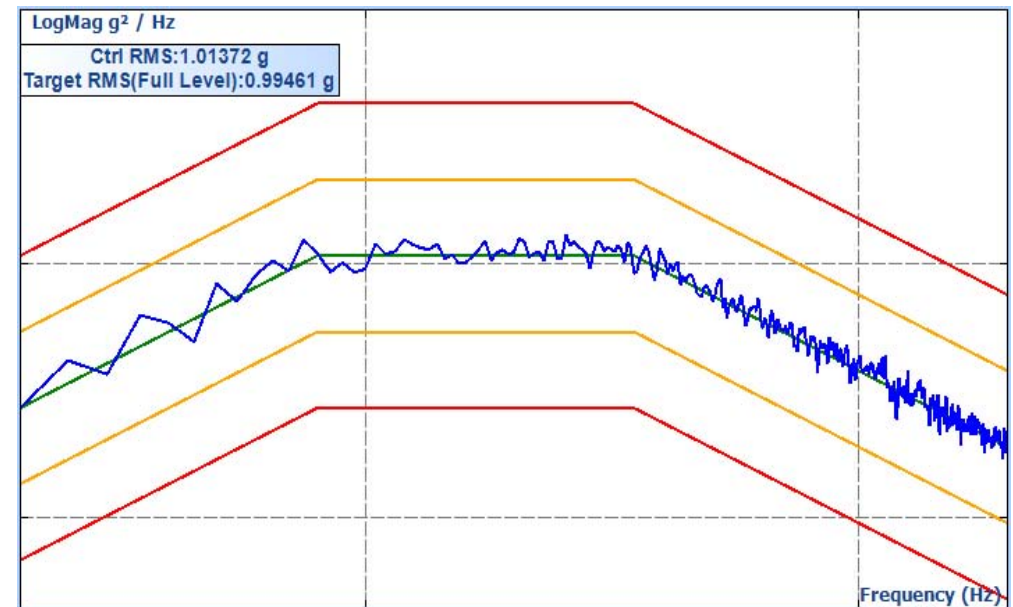
➤ Two typical cases in using the Non-Linear Control

- 1. A hydraulic driven shaker usually has very strong non-linear effect. The estimated transfer function does not completely represent the characteristics of the system. Enabling Non-Linear Control can increase the control accuracy so the control spectrum matches the profile better.
- 2. When UUT has sharp resonances, the data windows applied in the data acquisition process introduces the non-linear effect. To increase the control accuracy, turn on the Non-Linear Control option.

- Non-linear control can reduce the discrepancy caused by sharp resonances



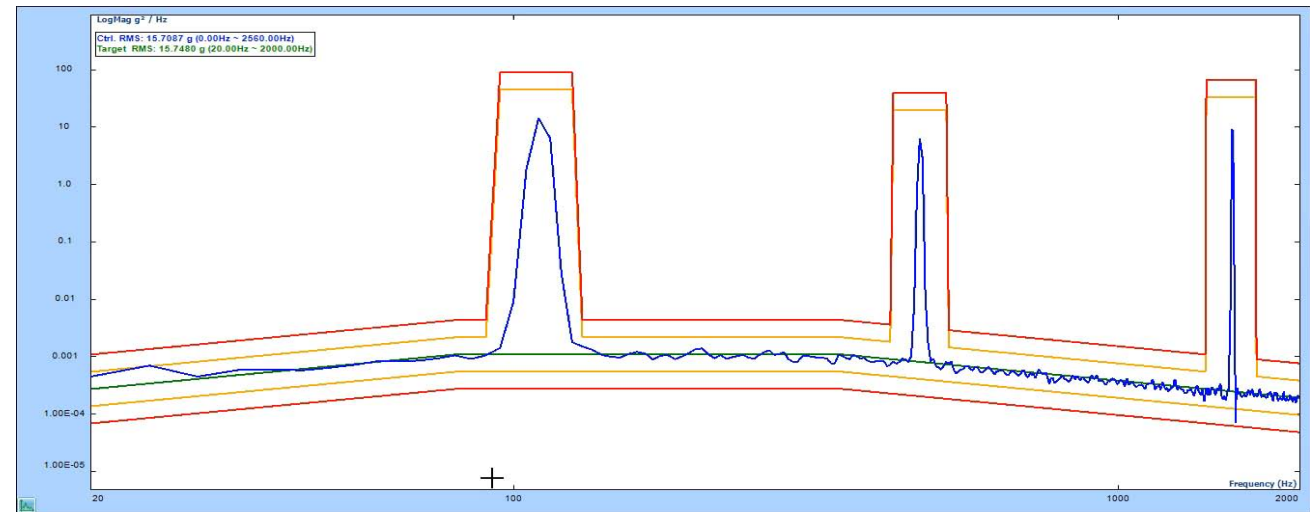
Without Non-Linear Control



With Non-Linear Control

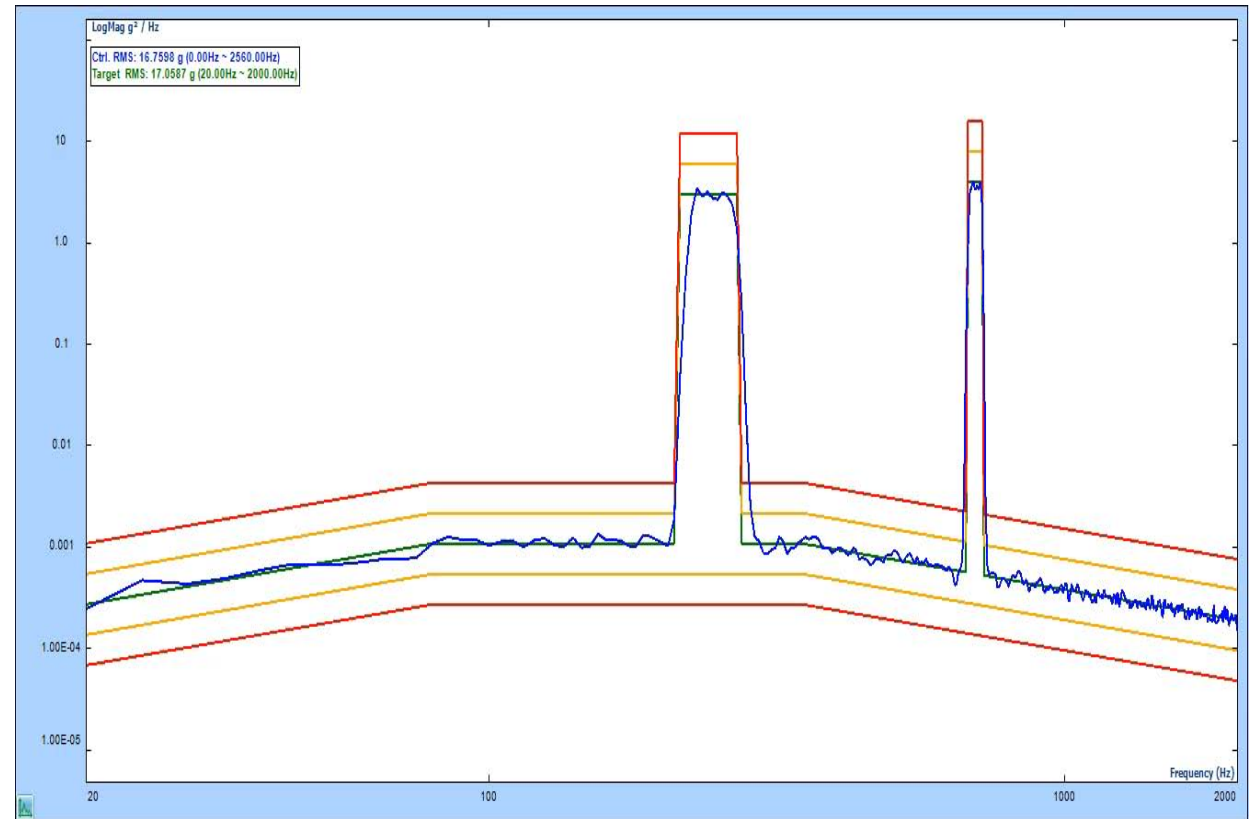
Sine on Random (SoR)

- Sweeping Mode: free sweeping mode where each sine tone has their own schedule and sweeping speed, and harmonic mode where the first tone controls the sweeping speed
- Number of Sine Tones: 1 - 12 in free-sweeping mode; 1 – 20 in harmonic mode, up to 32 when RoR is disabled.
- Operation Controls: Tone On and Tone Off controlled by run schedule, external events or user commands
- Supports up to 512 input channels.



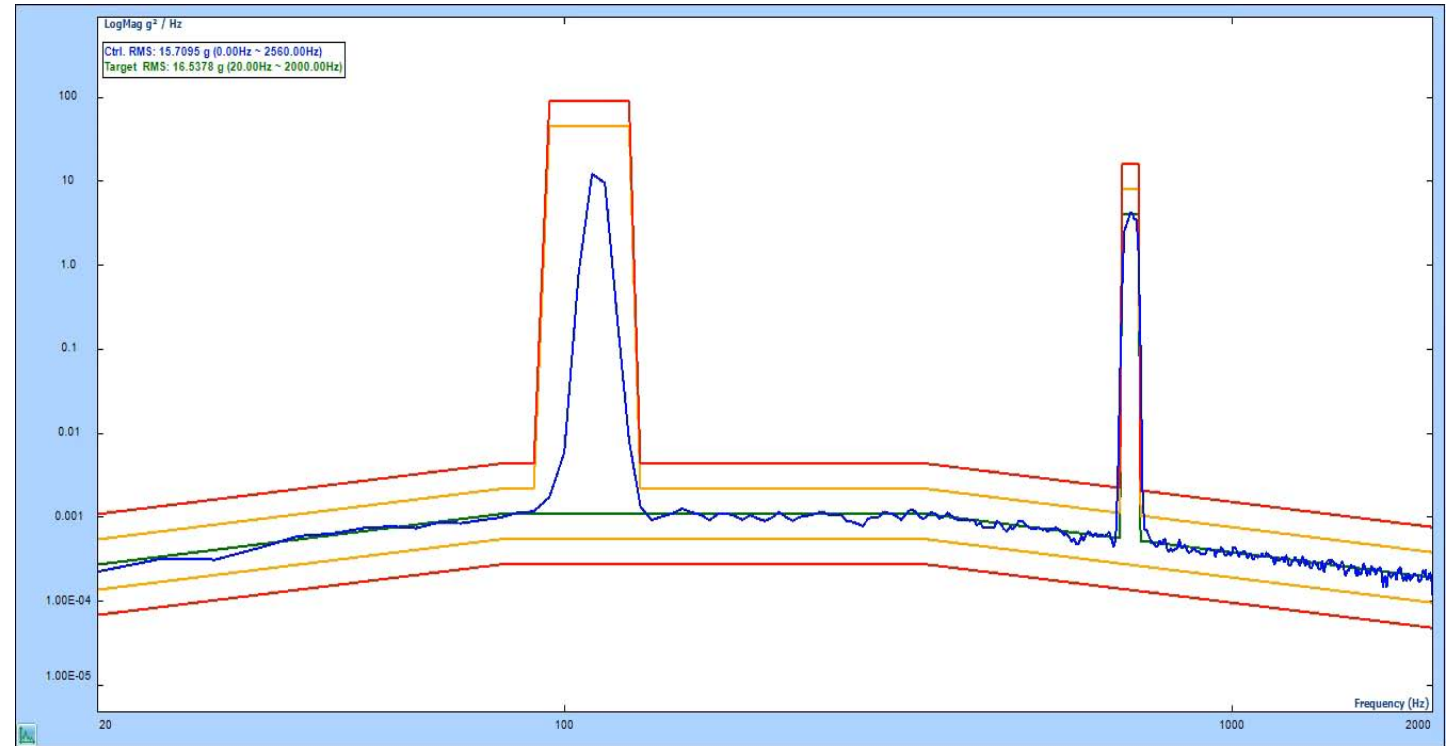
Random on Random (RoR)

- Sweeping Mode: free sweeping mode where each narrow random band has its own schedule and sweeping speed
- Number of Bands: 1 - 12, up to 32 when SoR is disabled.
- Operation Controls: Band On and Band Off controlled by run schedule, external events or user commands
- Supports up to 512 input channels.



Random on Random (RoR) Sine on Random (SoR) running together

Example: multiple
tones, advance tone
profile, scheduled tone

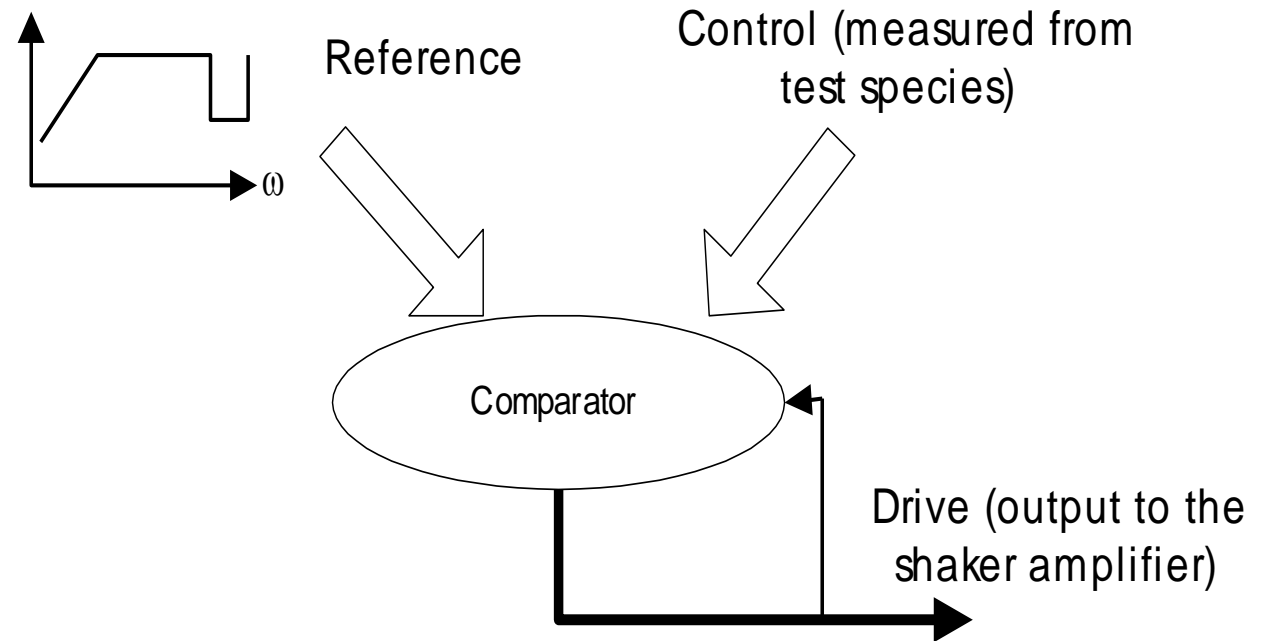


VCS Software | Swept Sine

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.



Sine Test Specs

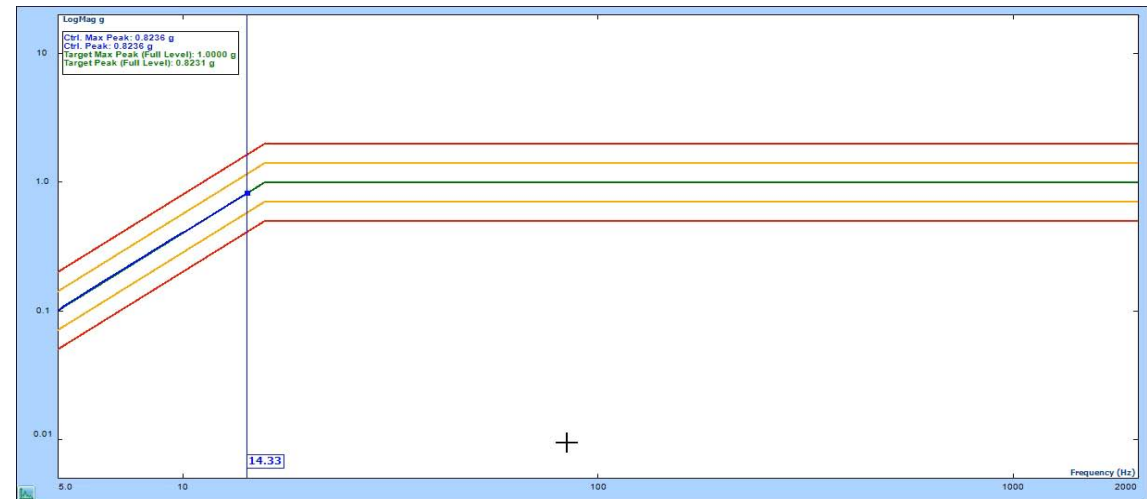
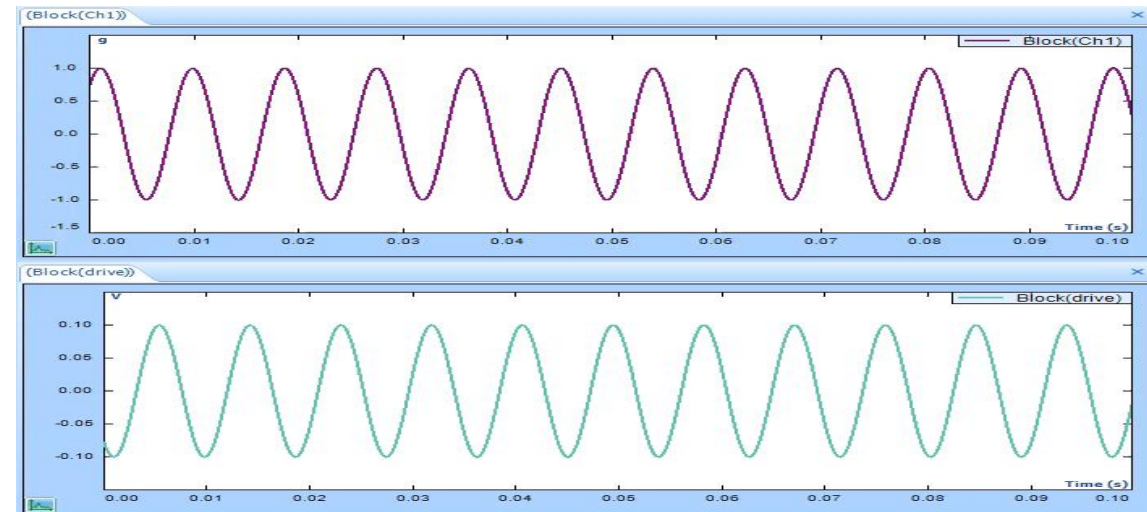
- **Frequency Range:** up to 46 kHz
- **Sweeping Speed:** Log (Oct/Min): 0.001 to 6000; Log (Dec/Min): 0.001 to 2000; Linear (Hz/Sec): 0.001 to 6000
- **Sweep Rate Increment:** Log (Oct/Min): 0.001 to 6; Log (Dec/Min): 0.001 to 2; Linear (Hz/Sec): 0.001 to 6
- **Sweep Speed Control:** Oct/Min, Hz/Sec, Dec/Min, Sweeps/Min, Sweep Time/Sweep, Cycles/Min
- **Level Change:** Customizable in both logarithmic and linear rate
- **Compression Rate:** Fast (60 dB/S), Slow (20 dB/S), and Customized (from 0.01 dB/S and up, pre-defined table)

Swept Sine Spec:

- **Ramp Rate:** Fast, Slow, Customized, Fastest
- **Spectrum Display Resolution:** 256 to 4,096
- **Loop Time:** 10 ms typical
- **Control Dynamic Range:** 100 dB typical
- **Measurement Strategy:** Filter, RMS, Mean, Peak (Multiple strategy allowed to each channel signal)
- **Tracking Filters:** Proportional: 7% – 100%; Fixed (Hz): 1 – 500 Hz
- **Control Accuracy:** ± 1 dB thru resonance with Q of 50 at 1 Oct/min
- **Frequency Resolution:** As fine as 0.000001 Hz

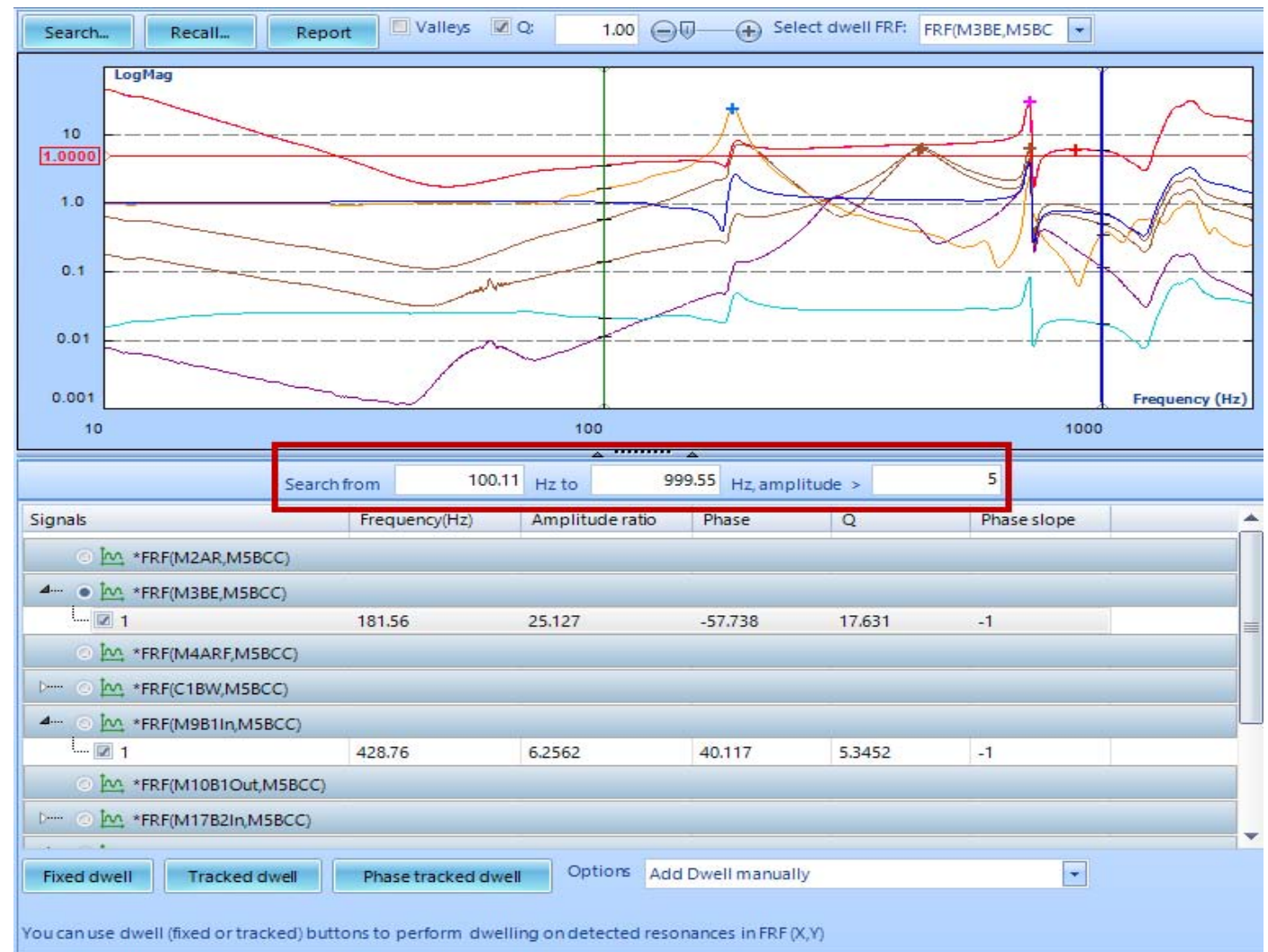
VCS Software | Swept Sine

- Tracking filter can be enabled to each individual input channels
- Log or Linear sweep at any rate
- Customizable control panels



VCS Software | Sine – RSTD: Resonance Search and Tracked Dwell

Determine the resonant frequency of a test object with a very high Q and dwell on the resonant frequency along with tracking the changes in the resonant frequency using the phase value.

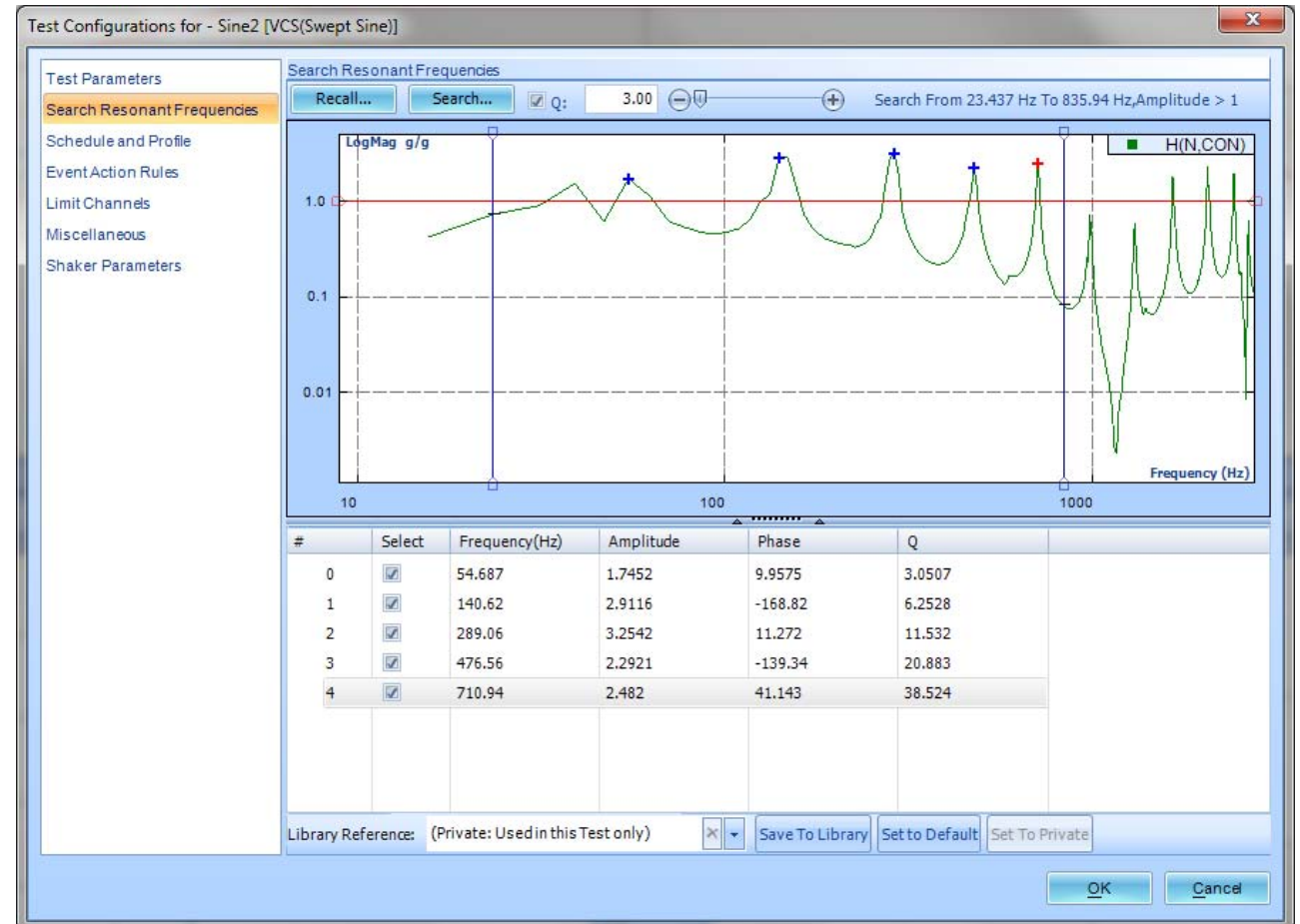
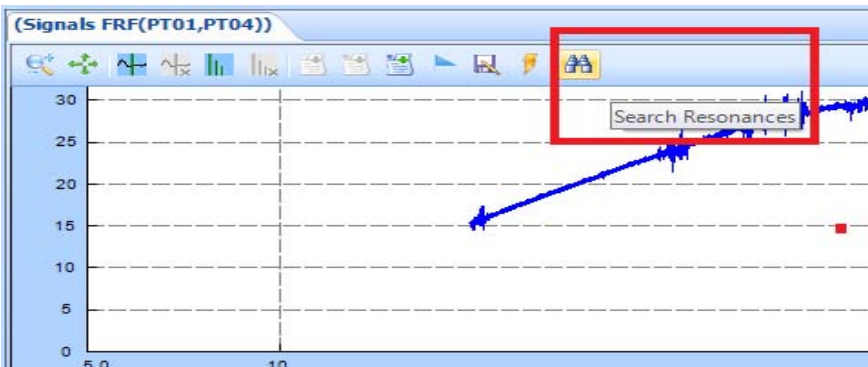


- In structural fatigue testing, sometimes it is desirable to shake a structure at its resonant frequencies for an extended period of time.
- A resonance frequency is defined as a frequency for which the response reaches a local maximum. These resonances are given as:
 - Displacement resonance frequency: $\omega_n(1 - 2\zeta^2)^{\frac{1}{2}}$
 - Velocity resonance frequency: ω_n
 - Acceleration resonance frequency: $\omega_n(1 - 2\zeta^2)^{\frac{1}{2}}$

VCS Software | Sine – RSTD: Resonance Search and Tracked Dwell

There are two general methods of finding resonance.

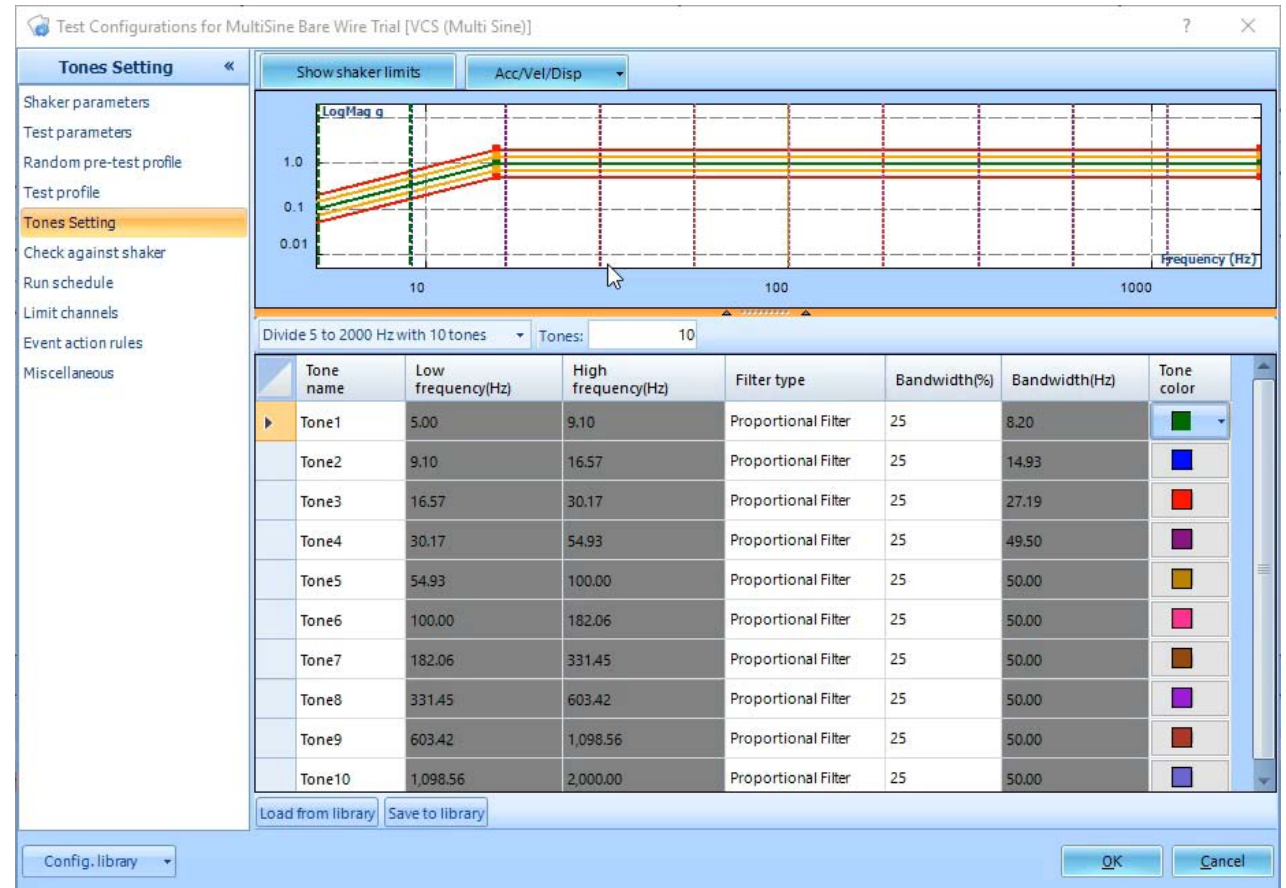
- **Method 1:** Using previously saved FRF
- **Method 2:** Using current measured FRF



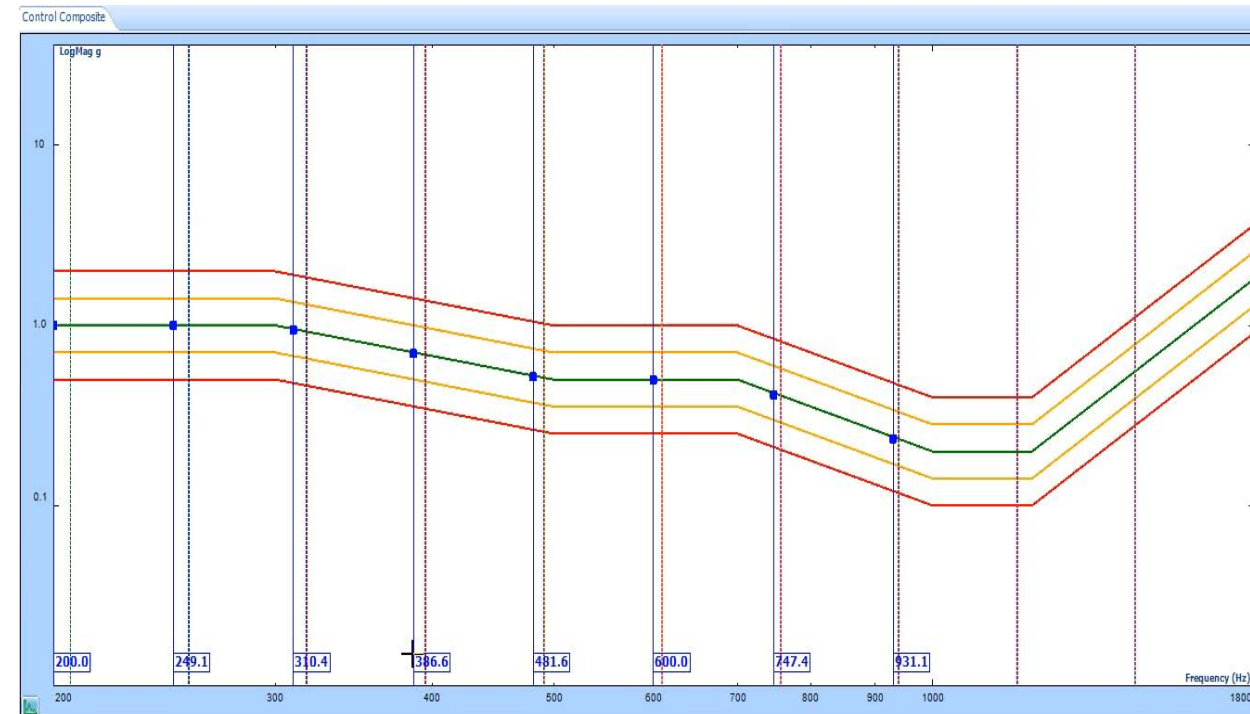
VCS Software | Multi-Sine

The Multi-Sine test allows simultaneous sweeping of multiple independent sine tones across the desired frequency range up to 5 kHz.

Compared to ordinary VCS swept sine, the multi-sine test greatly boosts testing efficiency for many long time sweep and dwell tests.



- **Number of Sine Tones:** up to 10 tones
- **Type of Sine Tone Interval:** even interval, user-defined interval, or Harmonic type
- **Operation Controls:** Tone On and Tone Off controlled by run schedule, or user commands
- **Number of Inputs:** Supports up to 512 input channels

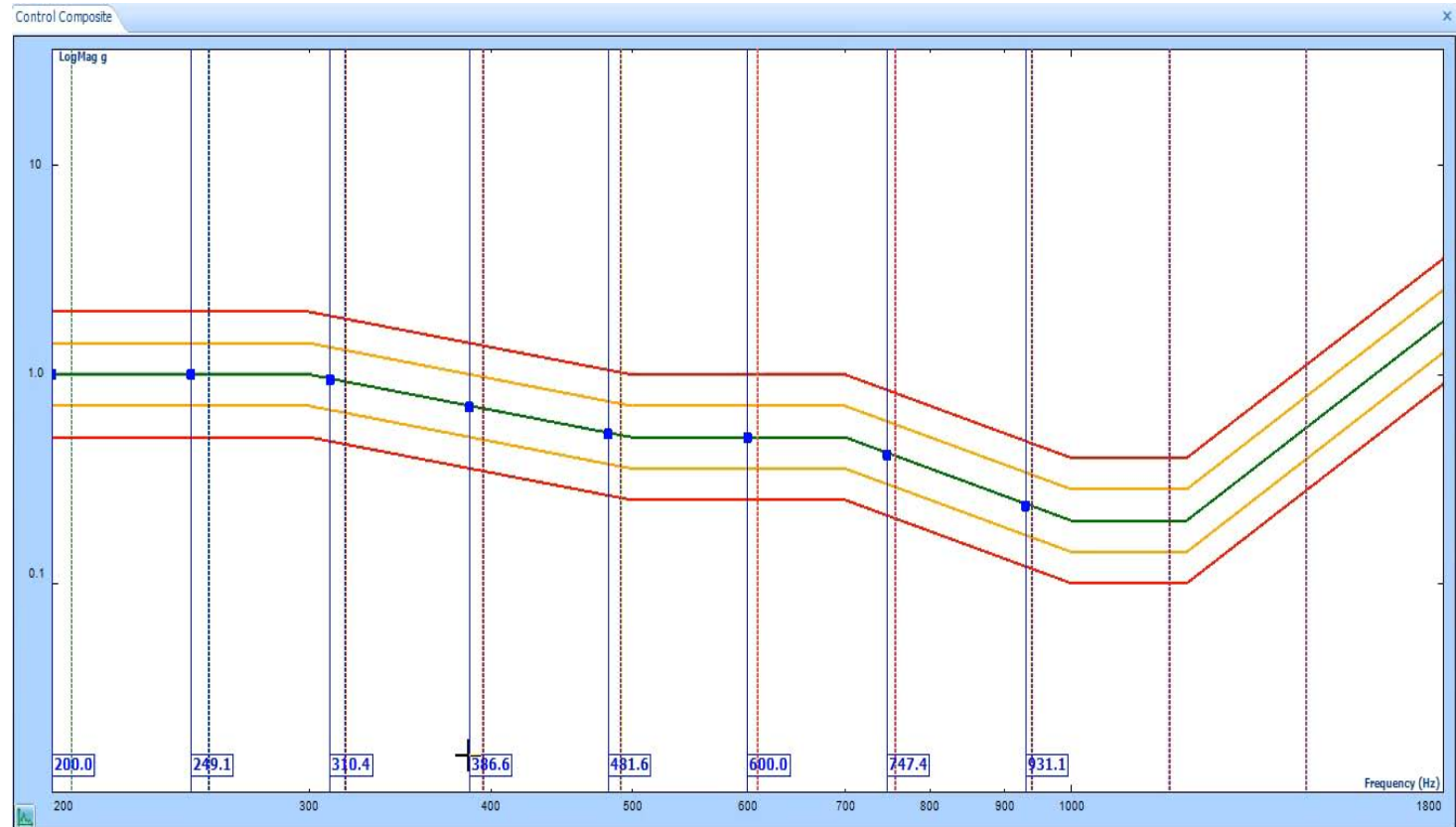


Multi-Sine Test Specs

- **Frequency Range:** up to 5,000 Hz.
- **Sweeping Speed:** Log (Oct/Min): 0.01 to 6000; Log (Dec/Min): 0.001 to 2000; Linear (Hz/Sec): 0.001 to 6000
- **Spectrum Display Resolution:** 256 to 4,096
- **Control Dynamic Range:** 90 dB typical
- **Tracking Filters:** Proportional bandwidth: 7%, 12%, 25%, 50%, 100%; Fixed bandwidth (Hz): is auto-calculated
- **Control Accuracy:** ± 1 dB at 99% confidence with 100 average number
- **Frequency Resolution:** as fine as 0.0001 Hz
- **Average Number:** 1 – 2000

Multi-Sine

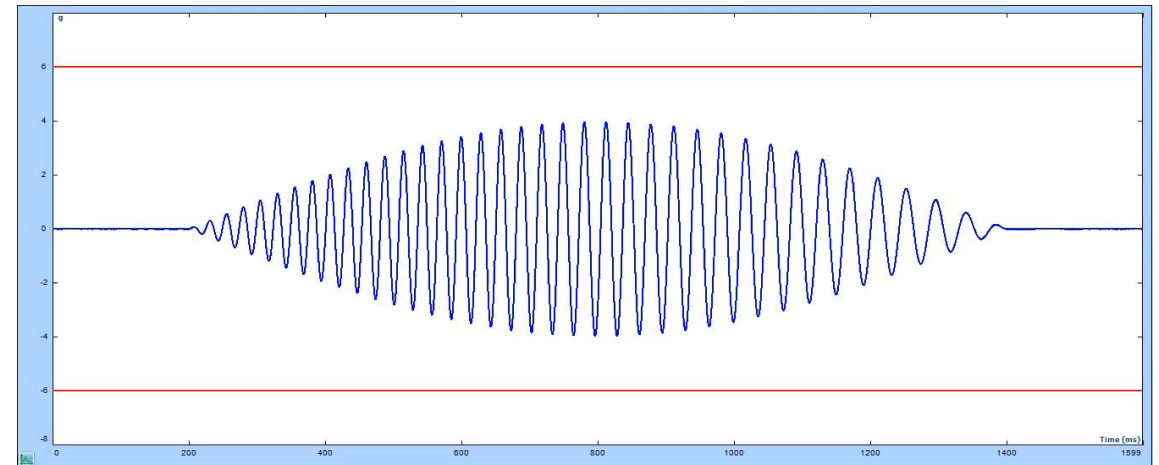
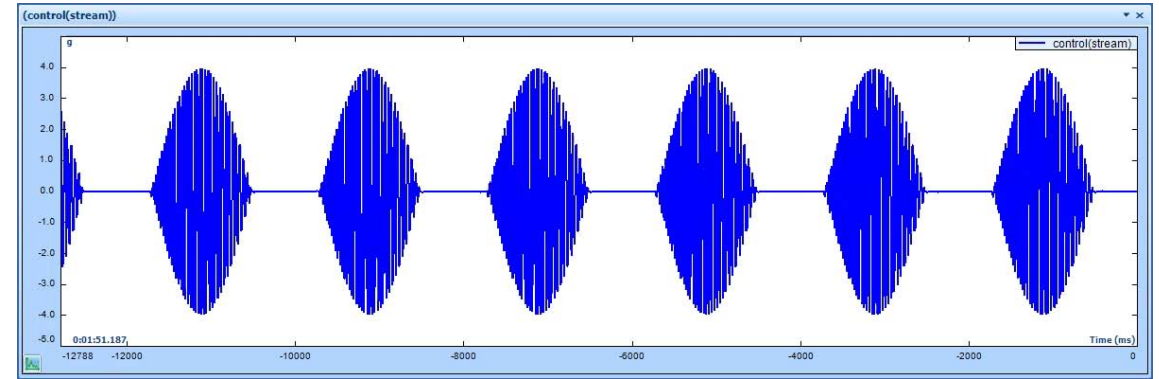
- Multiple Sine Tones
- Multiple Tracking Filters
- *Notching now available (EDM 8.1)*



VCS Software | Transient Time History (TTH)

Transient Time History (TTH)

- Using template based importing tools
- Time waveform in various formats are imported into EDM VCS
- Scaling, editing, digital resampling, high-pass, low-pass filtering, and compensation
- Compensation methods include
 - pre-pulse
 - post-pulse
 - DC removal
 - high-pass filters



Transient Time History (TTH)

Pre-stored profiles include

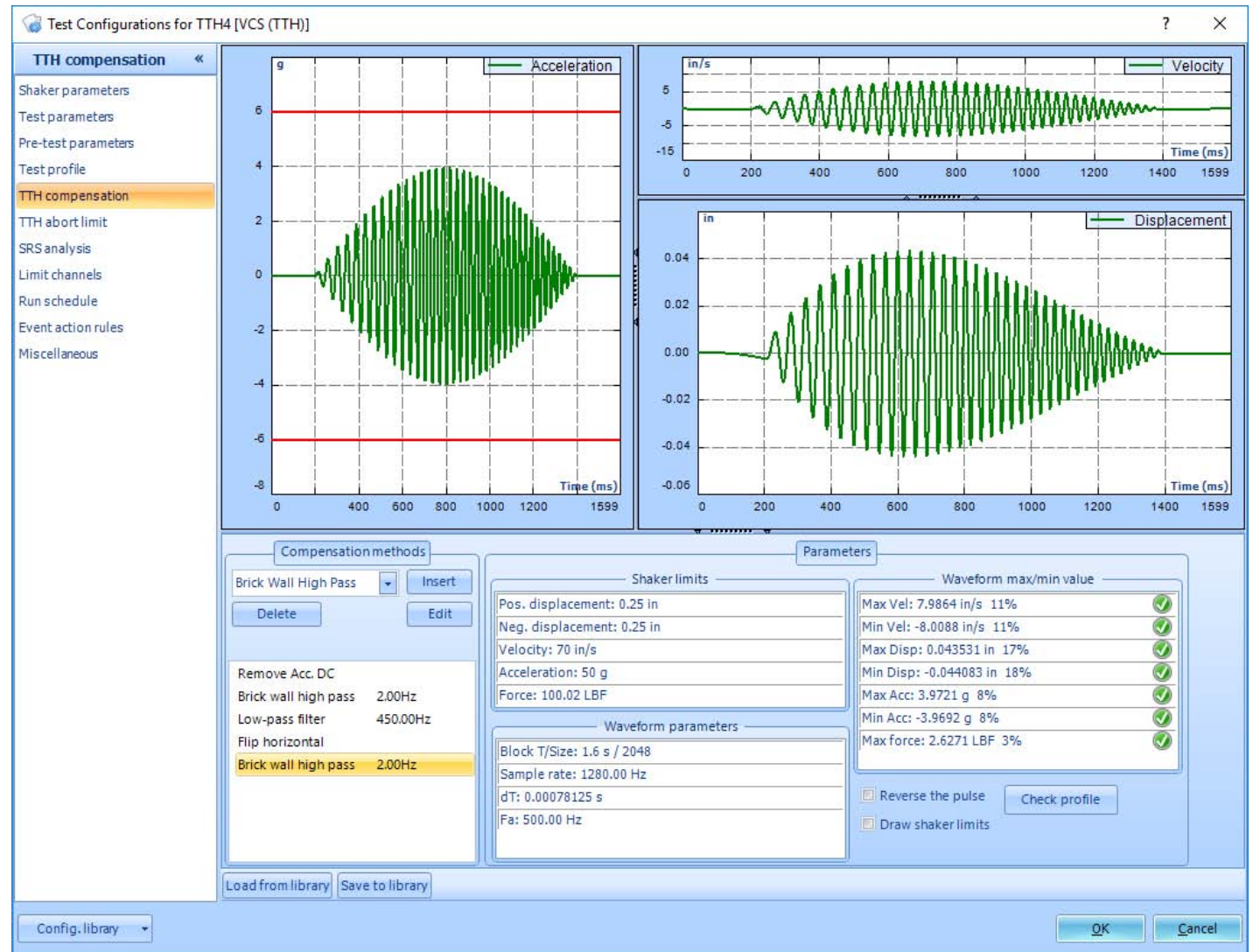
- Bellcore Z1 & Z2
- Bellcore Z3
- Bellcore Z4
- Sine
- Triangle
- Chirp
- Burst Chirp
- White Noise
- Sine Beat (multiple frequency)
- Door Slam (Ford).



VCS Software | Transient Time History (TTH)

Transient Time History (TTH)

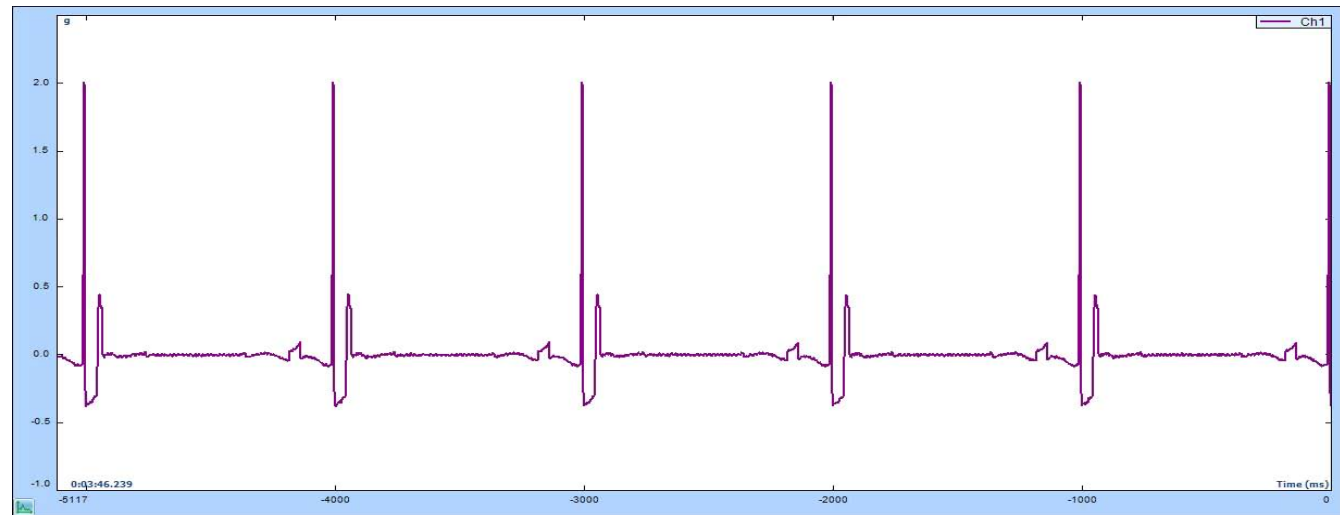
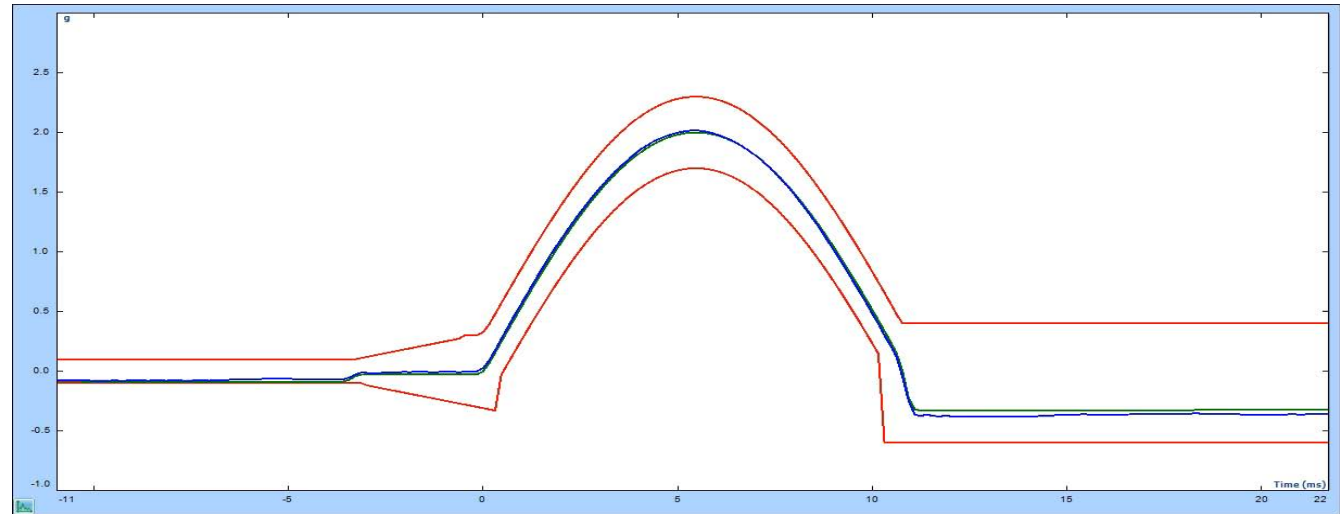
To adjust the displacement and fit into the shaker limit, select various compensation methods and parameters.



Classic Shock

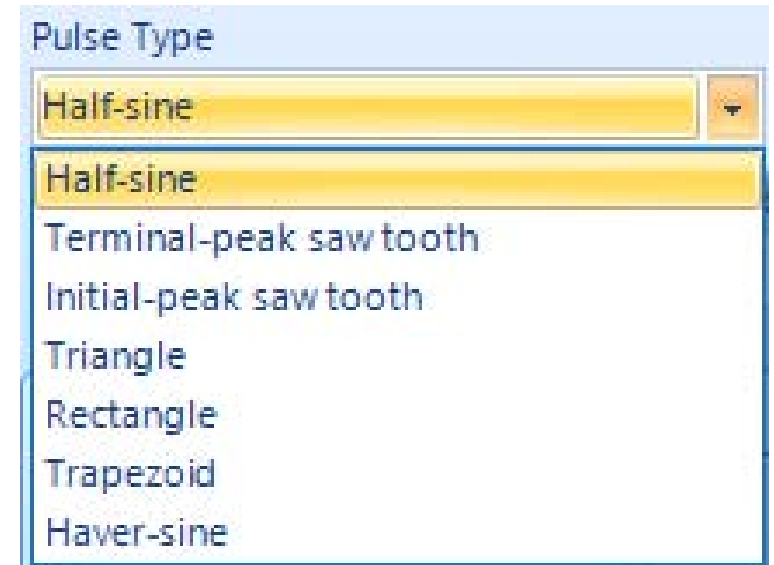
The Spider Classic Shock Vibration Control provides precise, real-time, multi-channel control and analysis for typical transient time domain signal. Up to 511 channels can be enabled for monitoring and time data recording.

Classical pulse types include half-sine, haversine, terminal-peak sawtooth, initial-peak sawtooth, triangle, rectangle, and trapezoid.



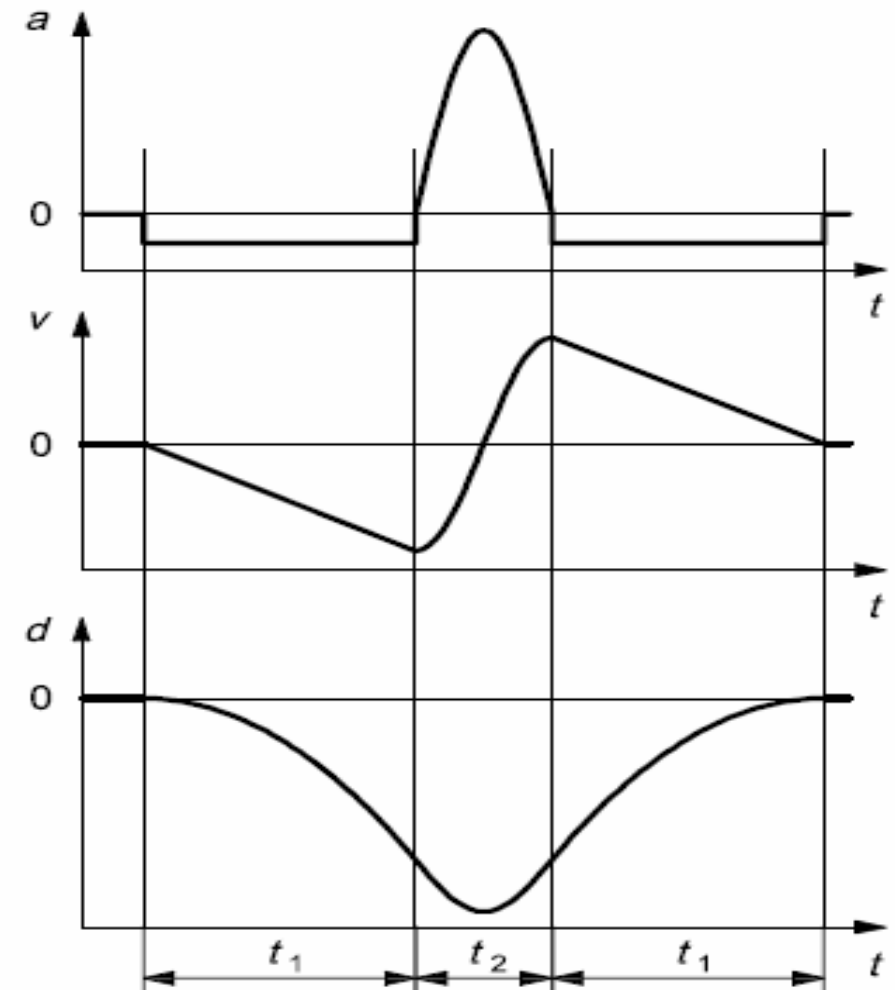
Classic Shock

- Precise, real-time, multi-channel control and analysis for transient time domain control.
- Up to 8 channels can be enabled for control, alarm checking, and time data recording on master module
- Up to 511 channels can be enabled for monitoring and time data recording
- Interval between pulses may be specified
- Optional low-pass filter and high-pass filter
- Pulse Width Definition and Measurement
- Display level and drive peak estimation of the next pulse
- Classical pulse types include (as shown on the right)

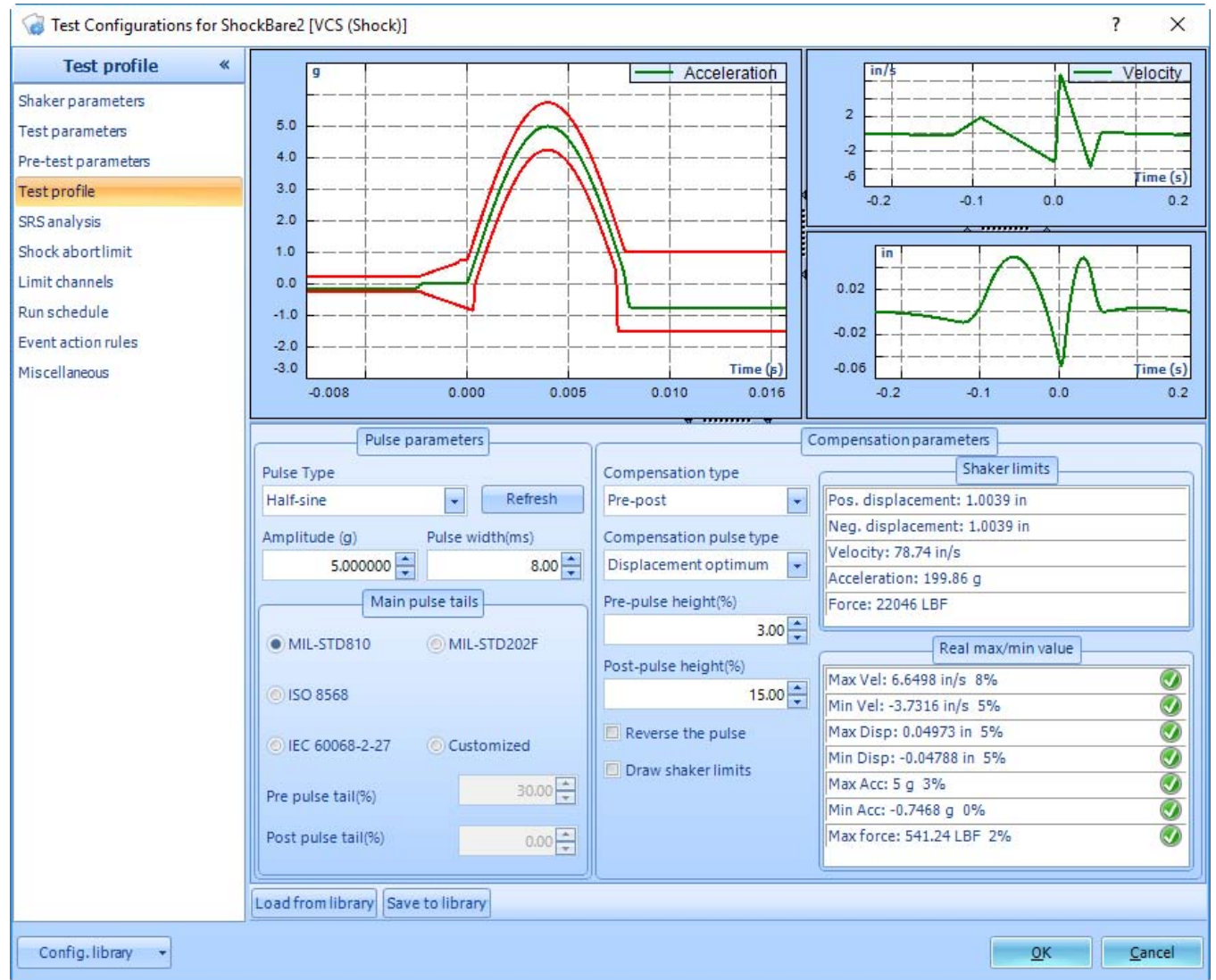


Classic Shock

- **Sampling Rate:** automatically calculated based on profile, or manually up to 102.4 kHz
- **Time Block Size:** 512 to 65,536 points
- **Average Number for Control:** 1 – 4
- **Test Start Method:** pretest runs with four excitation types: positive pulse, negative pulse, random with close-loop control, random with open loop

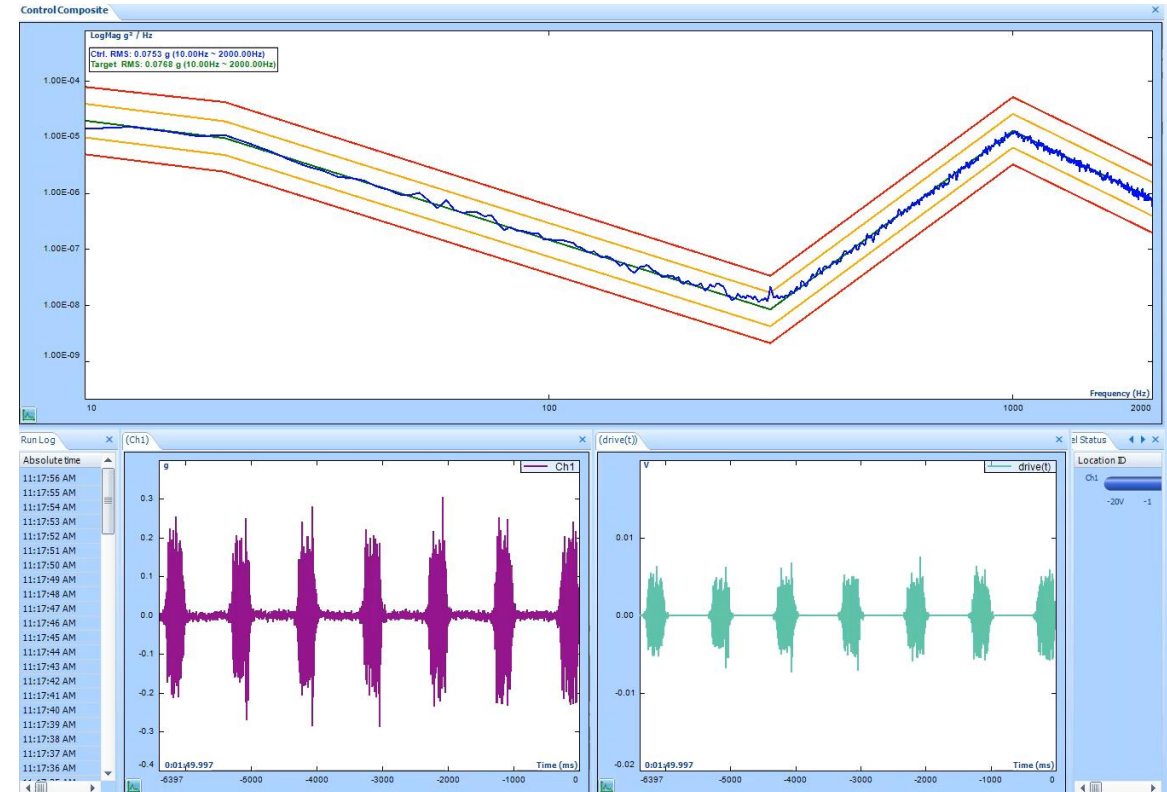


Classic Shock Test Profile and Parameters



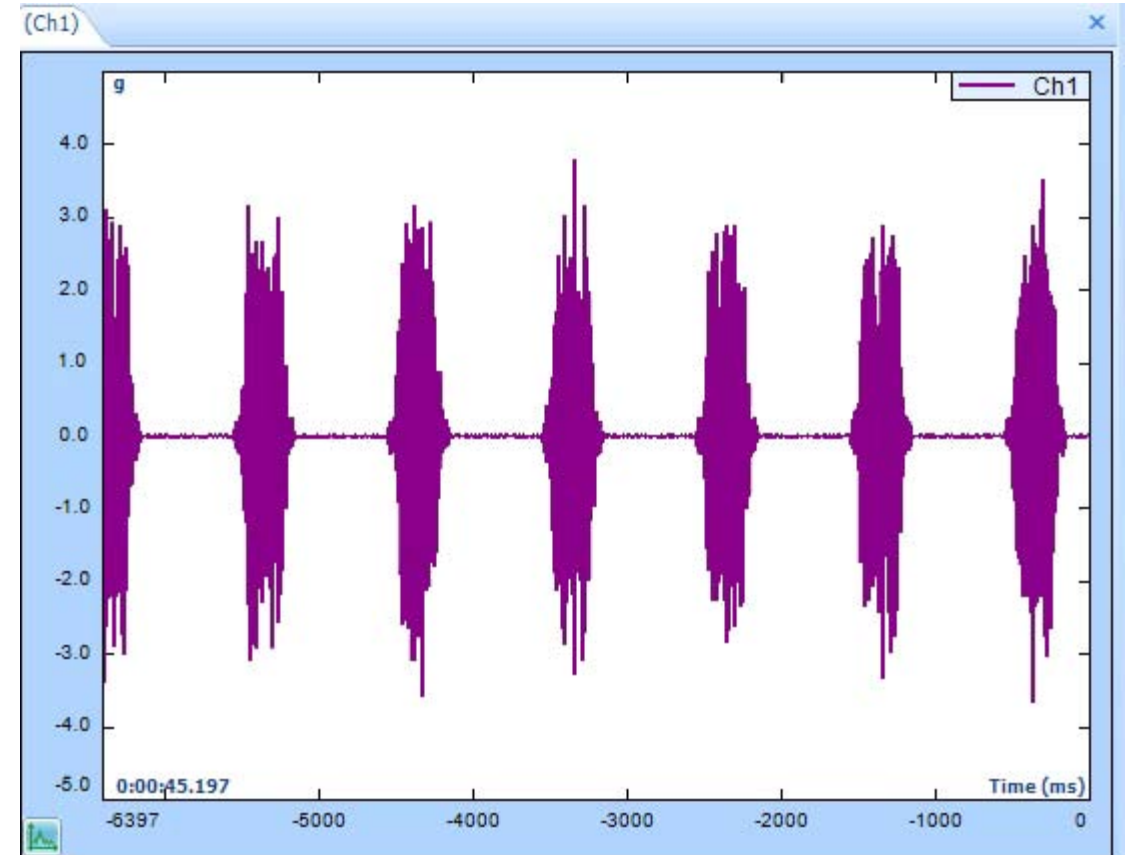
Transient Random

- Applies a chain of pulses with random nature to the shaker.
- Target profile power spectrum defined in the same way as Random control, with the addition of defining transient pulse interval
- Application includes simulation gunfire or road simulation

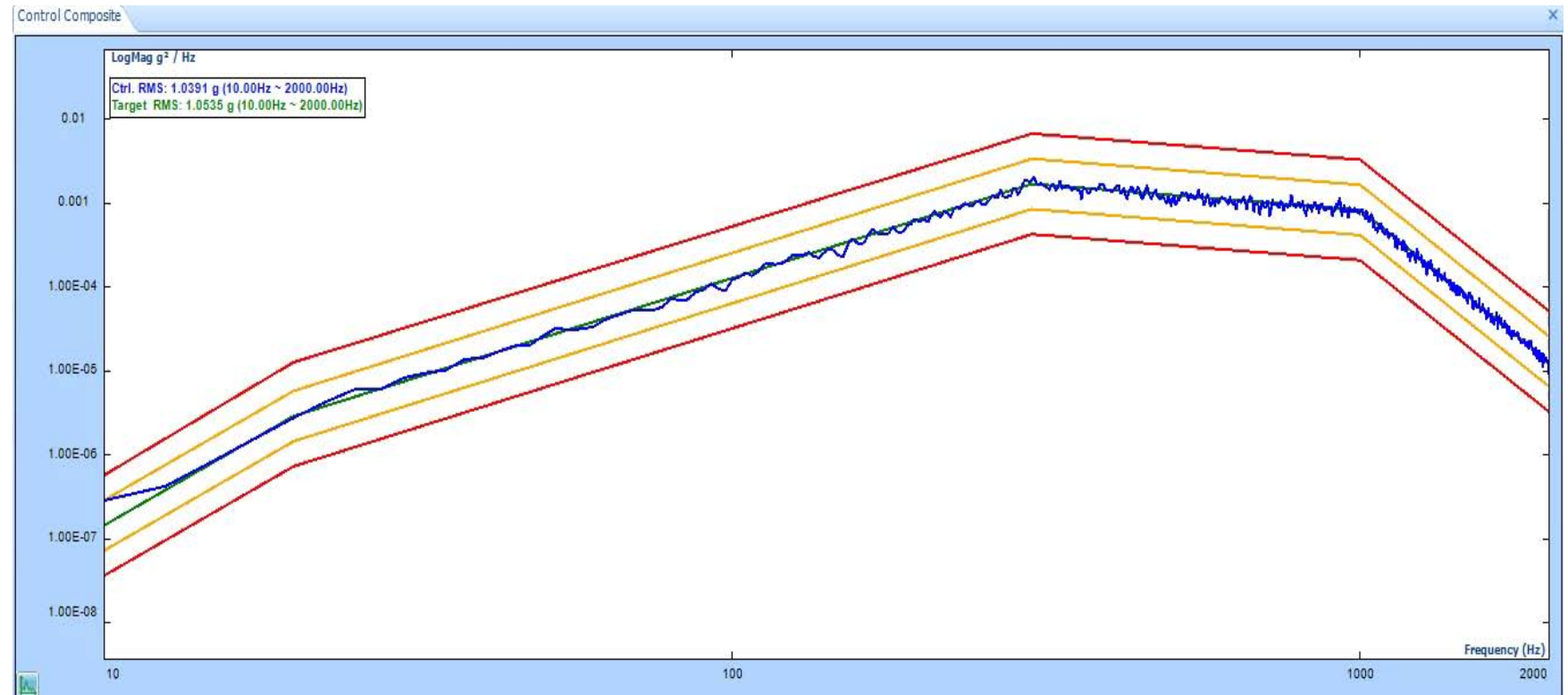


Transient Random Specs

- **Sampling Rate:** automatically calculated based on profile, or manually up to 102.4 kHz
- **Spectral Resolution:** 200, 400, 800, 1,600, 3,200, and 6,400.
- **Time Block Size:** 512 to 65,536 points
- **Average Number:** 1 – 500 (2 – 1000 DOFs)
- **Drive Sigma Clipping:** 3 – 10

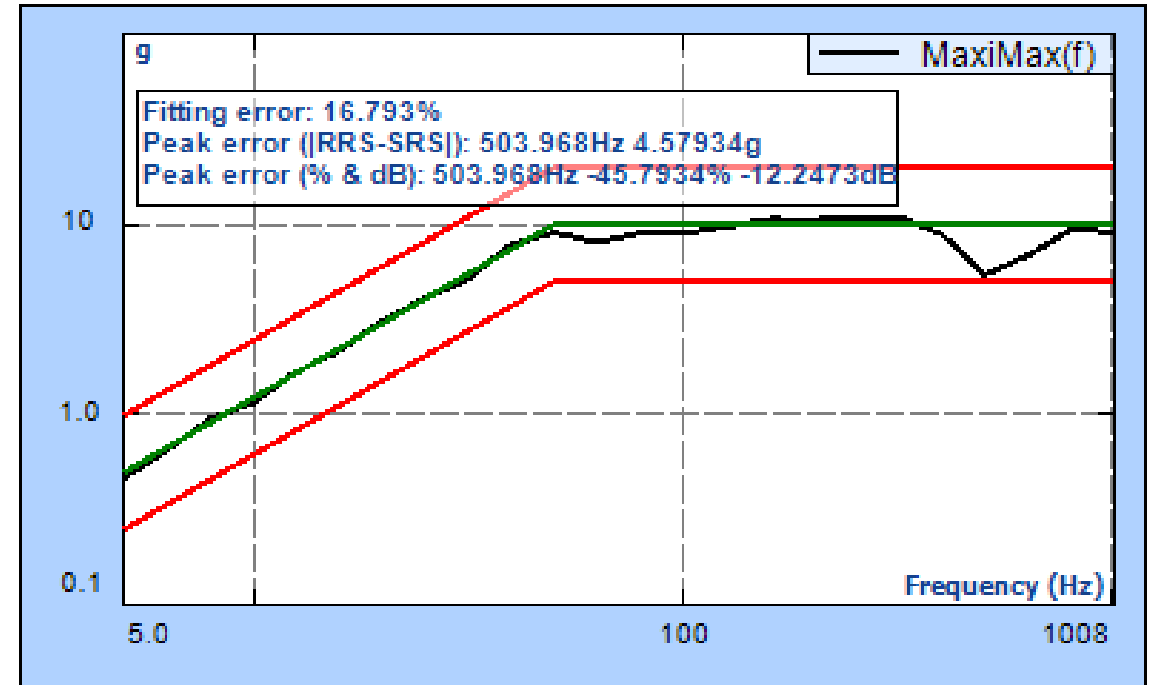


**Transient Random
displayed in the
frequency domain**

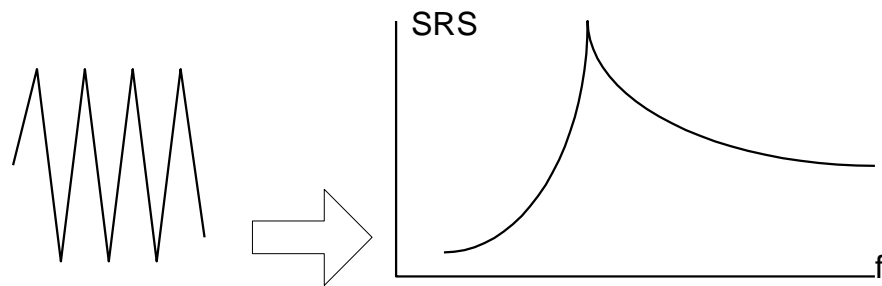


Shock Response Spectrum (SRS)

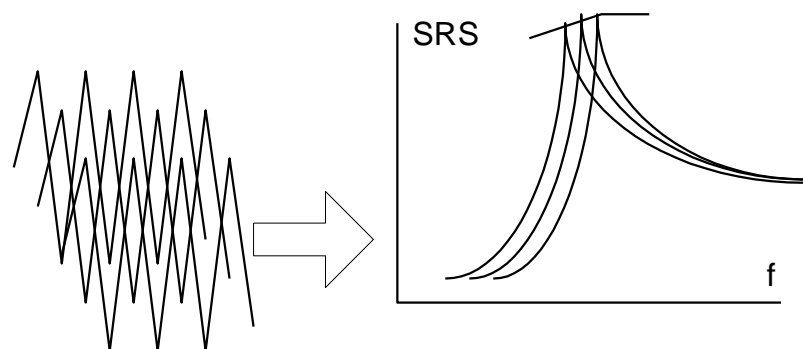
- Provides controls to meet a target Required Response Spectrum (RRS)
- Waveforms are automatically synthesized from a user-specified SRS reference profile using sine wavelets.
- The Transient Control option allows control of imported transient files
- High frequency waveforms, Alarm, and Abort tolerances may be applied to any active channel to provide an extra degree of safety for delicate test articles



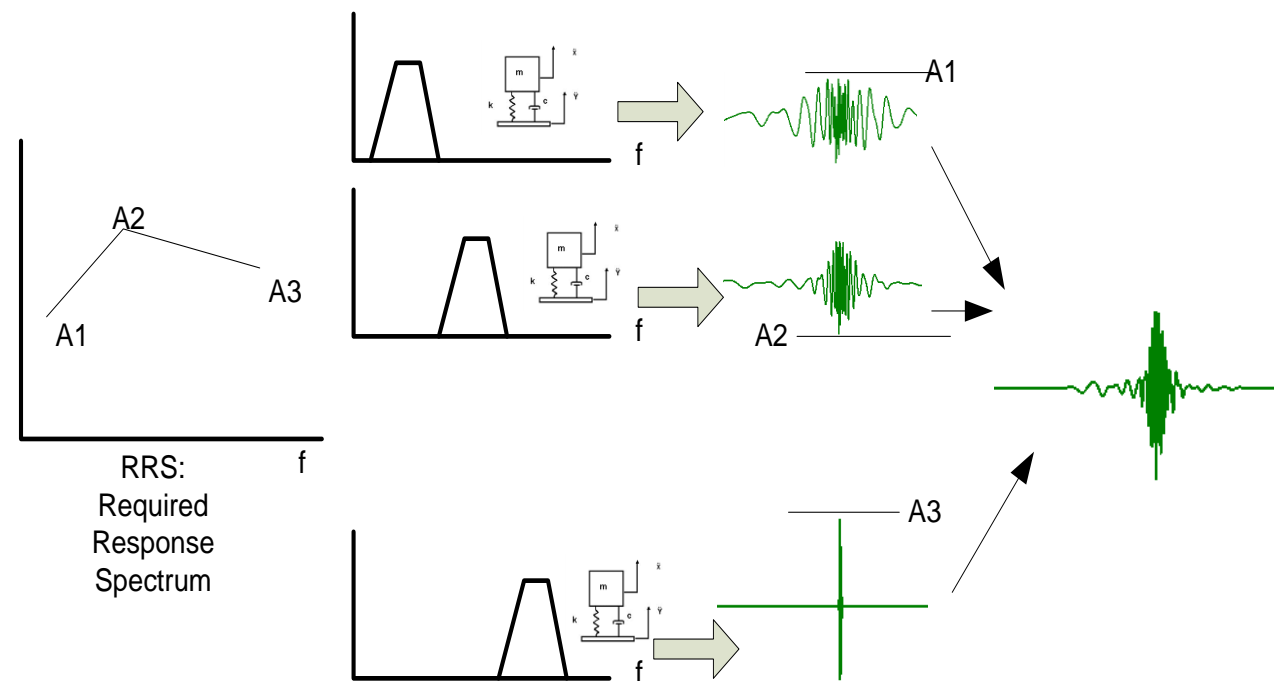
VCS Software | Shock Response Spectrum Synthesis



SRS of a Sine Wave



SRS of Multiple Sine Waves

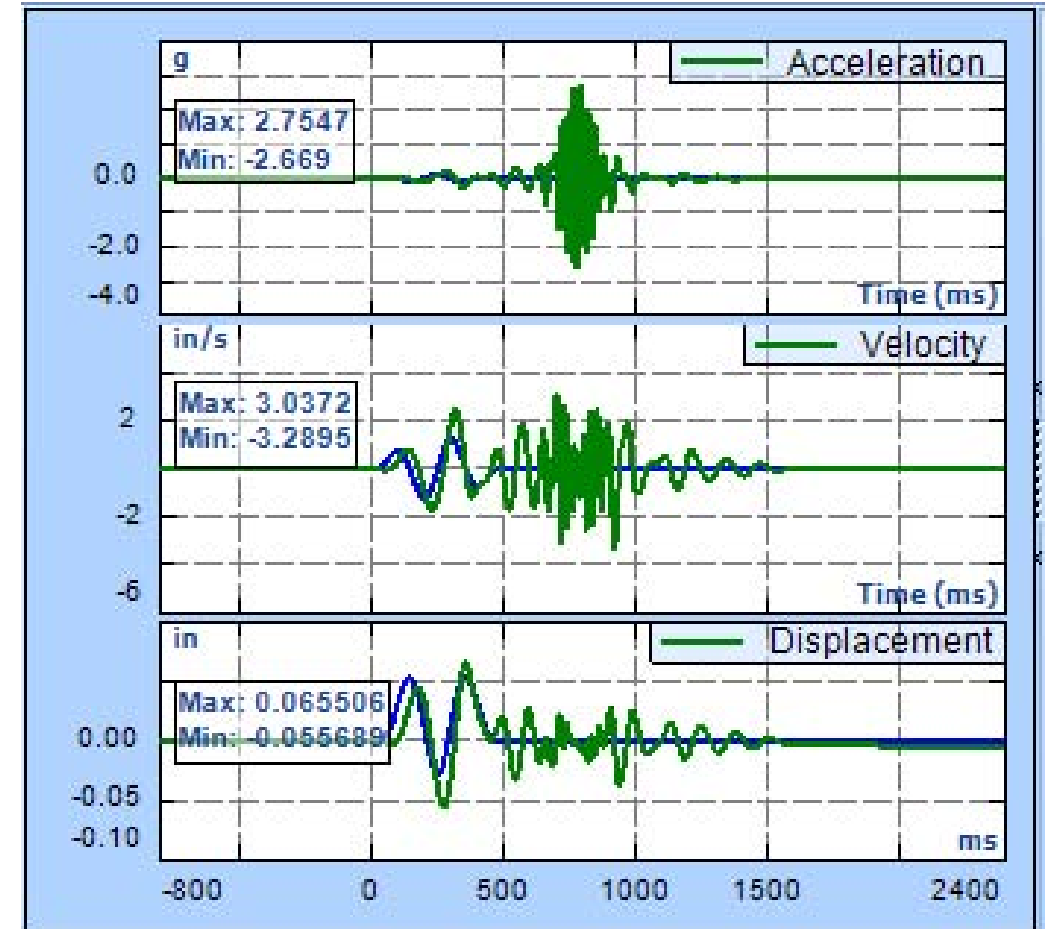


Synthesis Process

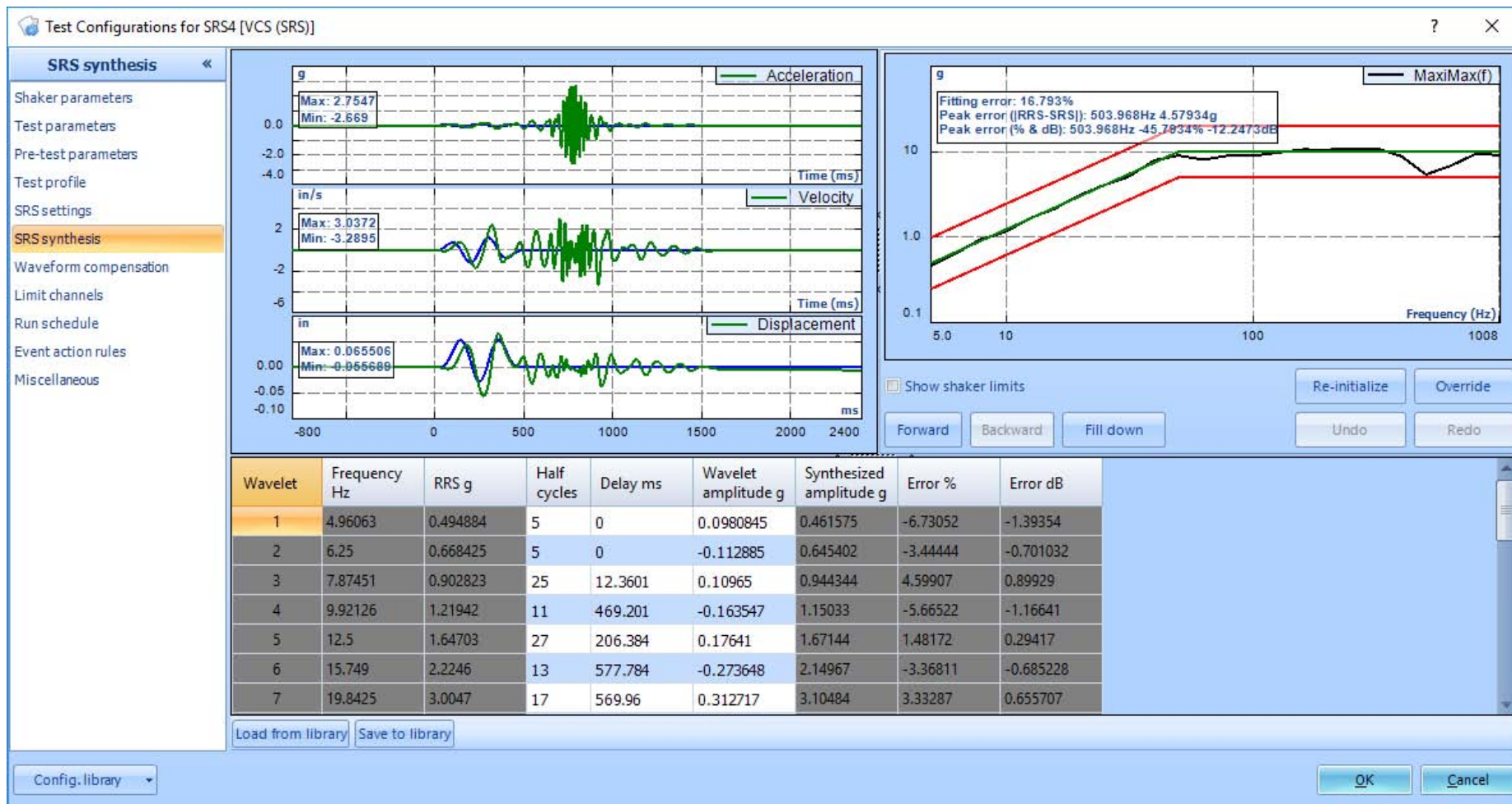
VCS Software | Shock Response Spectrum (SRS)

Process of Shock Response Spectrum Synthesis

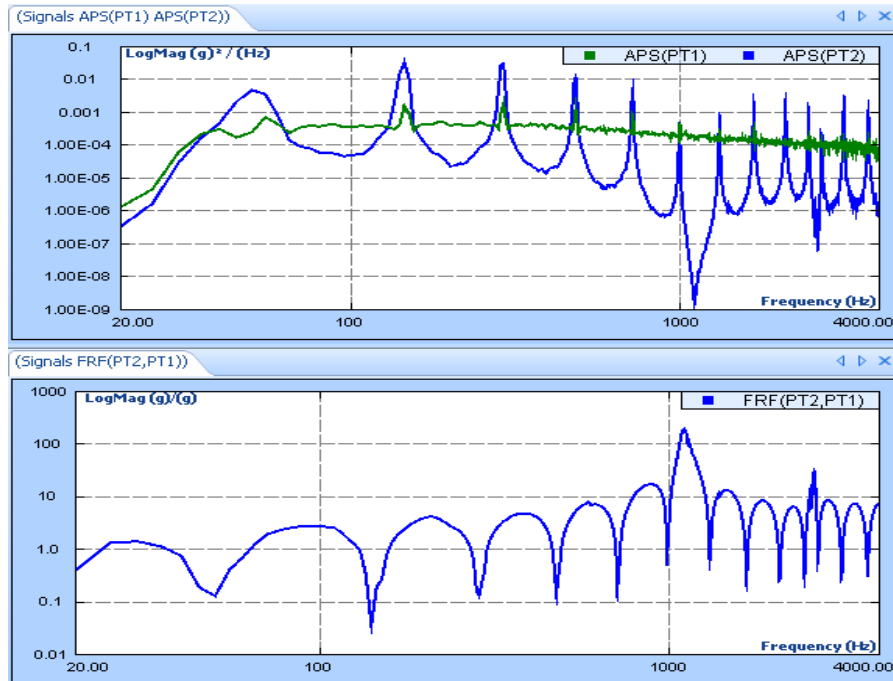
- **Waveform Synthesis Methods:** control time waveform is generated from multiple sine or damped sine or sine beat components
- **Damped Sine Parameters:** frequency, amplitude, critical damping factor, delay
- **Sine Beat Parameters:** frequency, amplitude, number of half sine cycles, delay
- **Component Generation:** auto or manually controlled
- **Synthesis Parameters:** waveform duration, max % of error, max number of iterations



Shock Response Spectrum (SRS) Synthesis Configuration



Shock Response Spectrum (SRS) Analysis



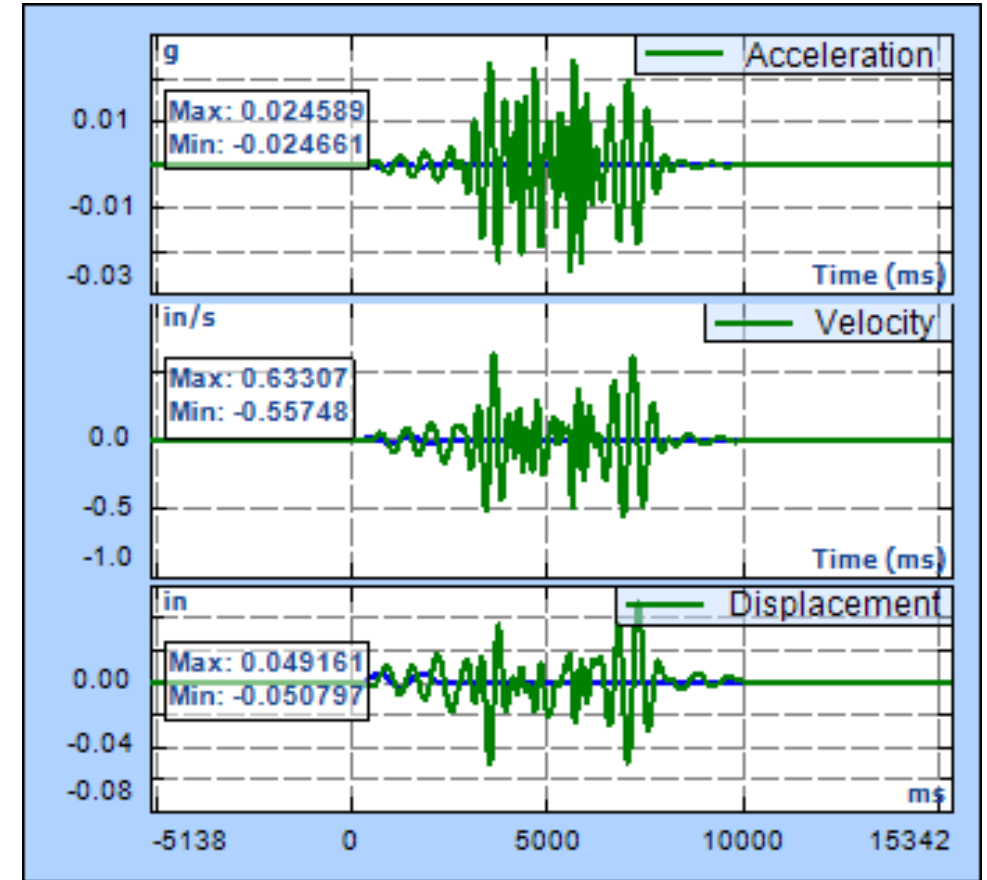
FFT, Power Spectrum, Transmissibility



SRS Analysis

Earthquake Testing

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

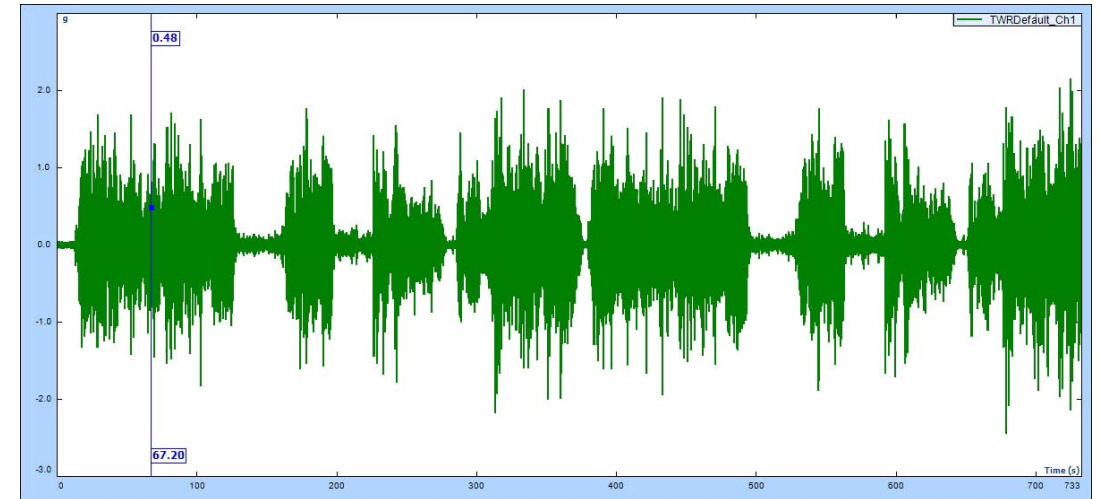
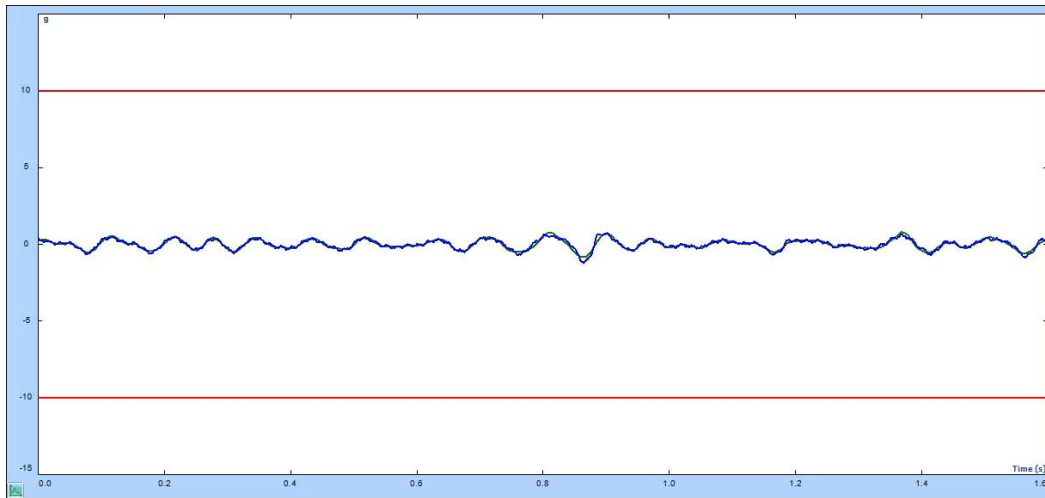


Earthquake Specs

- **Compliance:** IEEE 344-2013
- **Waveform Synthesis Methods:** multiple sine, damped sine, sine beat, uniform random, or shaped random
- **Component Generation:** auto or manually controlled
- **Random Wavelet Definition:** frequency, amplitude
- **Shaped Random Time Window:** user defined rising time, hold time and decay time
- **Component Generation:** auto or manually controlled
- **Synthesis Parameters:** waveform duration, max % of error, max number of iterations
- **Full Envelope:** configure test response spectrum to be greater than RRS in terms of dB

VCS Software | Time Waveform Replication (TWR)

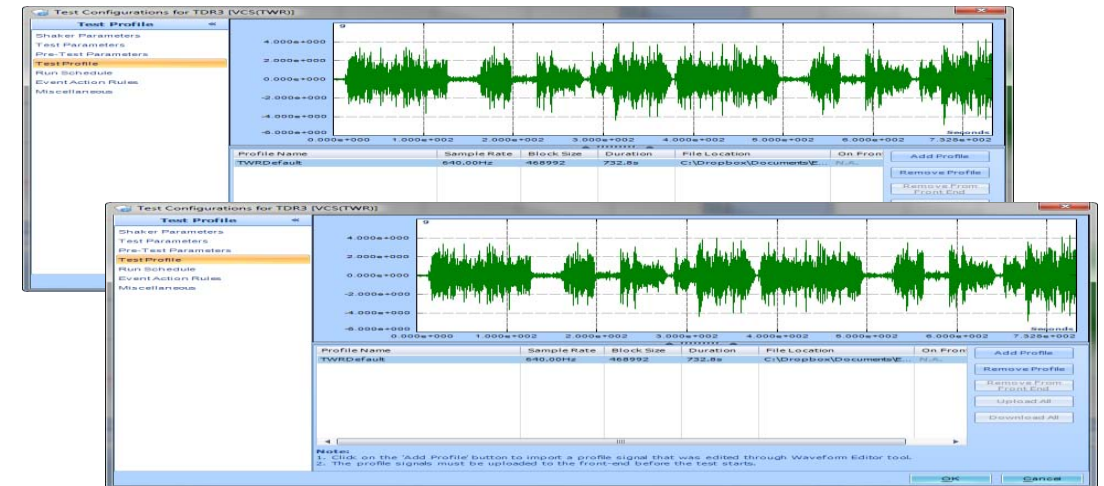
- TWR provides precise, real-time control for long waveform duplication up to 1 billion data points!
- Multiple long waveforms can be duplicated precisely on the shaker just as they were recorded
- Includes Waveform Editor (EDM-WE), a flexible importing and editing tools for long waveform signals
- Allows the recording of time stream data at the full sample rate on all input channels
- Up to 8 channels can be enabled for control and time data recording on master front-end
- Up to 511 channels can be enabled for monitoring and time data recording



VCS Software | Time Waveform Replication (TWR)

Time Waveform Replication (TWR)

- **Number of Waveform Profiles:** Infinite number of Waveform recordings
- **Maximum Number of Points:** all internal flash memory space is used for storing profile data (currently 3.7 GB), which corresponds to approximately 1 billion data points
- **Maximum Frequency Range:** up to 18 kHz
- **Maximum Sampling Rate of Data:** waveforms of any sampling rate up to 102.4kHz

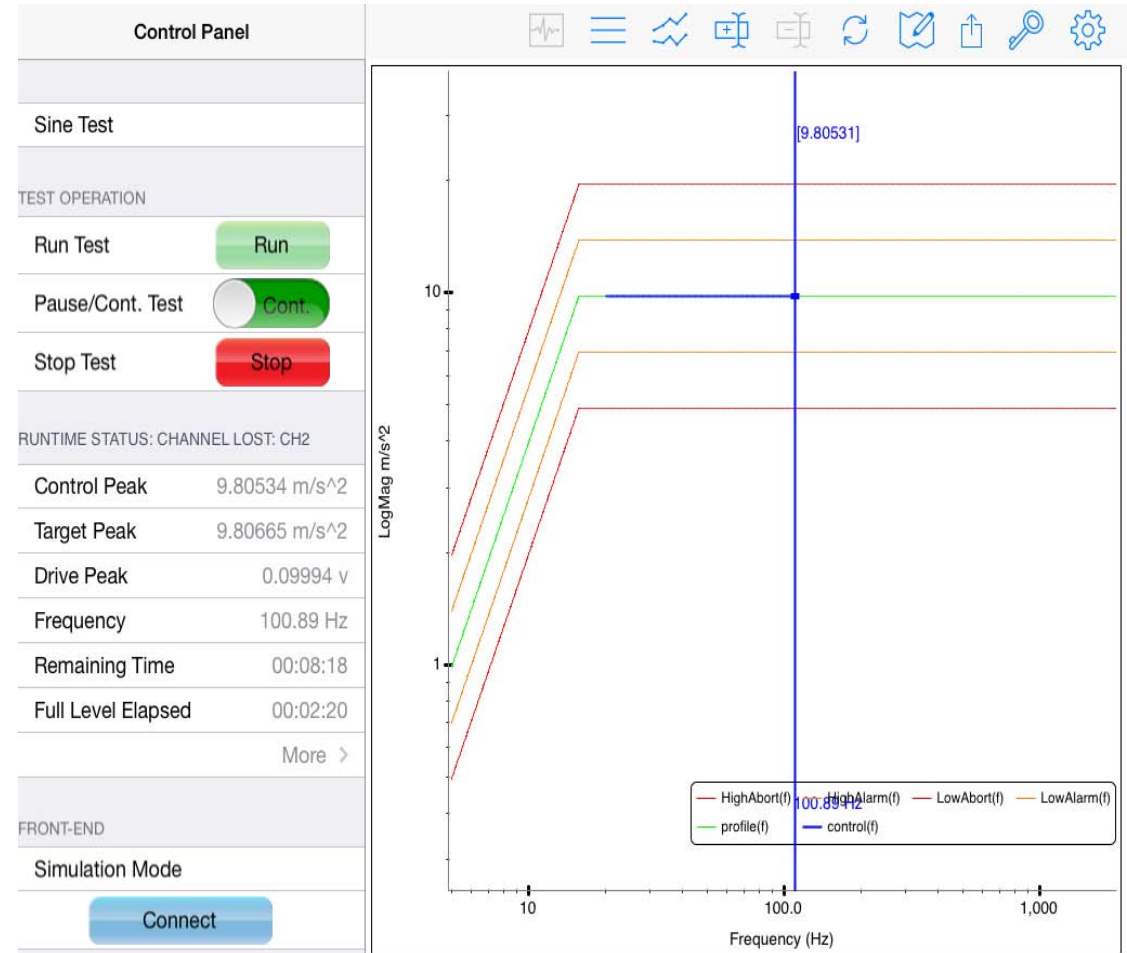


VCS Software | Time Waveform Replication (TWR) Spec

- **Sampling Rate:** up to 18 kHz
- **Maximum data points to replicate:** roughly 1 billion points
- **Display Time Block Size:** up to 4,096 points
- **Transfer Function Update Ratio:** transfer function is updated continuously in real-time depending on the transfer update ratio which can be entered by the user between 0 – 0.5.
- **Pretest:** a random close-loop pretest logic is built-in to generate an initial FRF value
- **Low Pass Filter:** applied to all input channels in real time

VCS Software | EDM App

- Allows the control and monitor of Spider system from iPad.
- All major parameters can be configured from the EDM App.



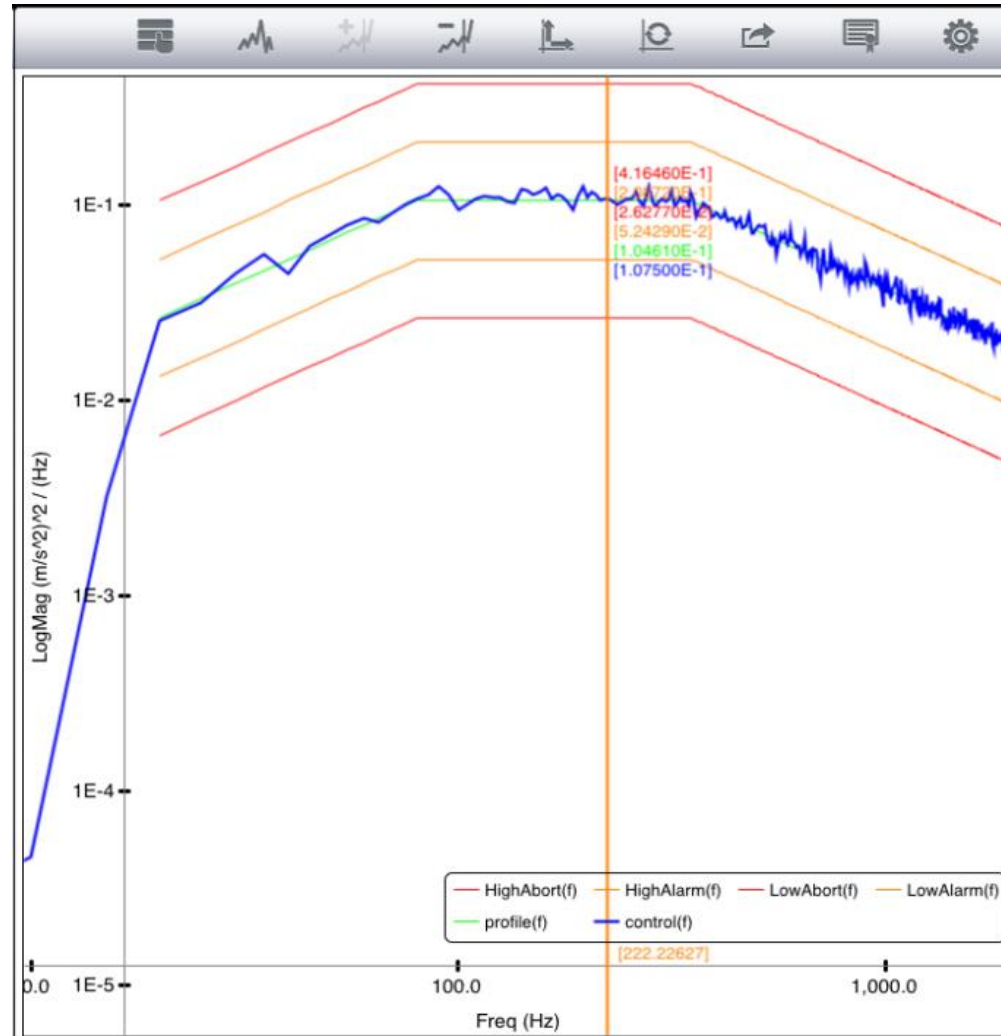
VCS Software | EDM App

- Up to 8 tests can be loaded onto the Spider hardware and accessed from the iPad.



VCS Software | EDM App

- The iPad provides basic control and status information.
- Test data can be viewed in real-time.
- Zoom and move the data plot.
- Use cursors to view data values.



Control Panel

Random

Test Operation

Run Test

Pause/Cont. Test

Stop Test

Runtime Status

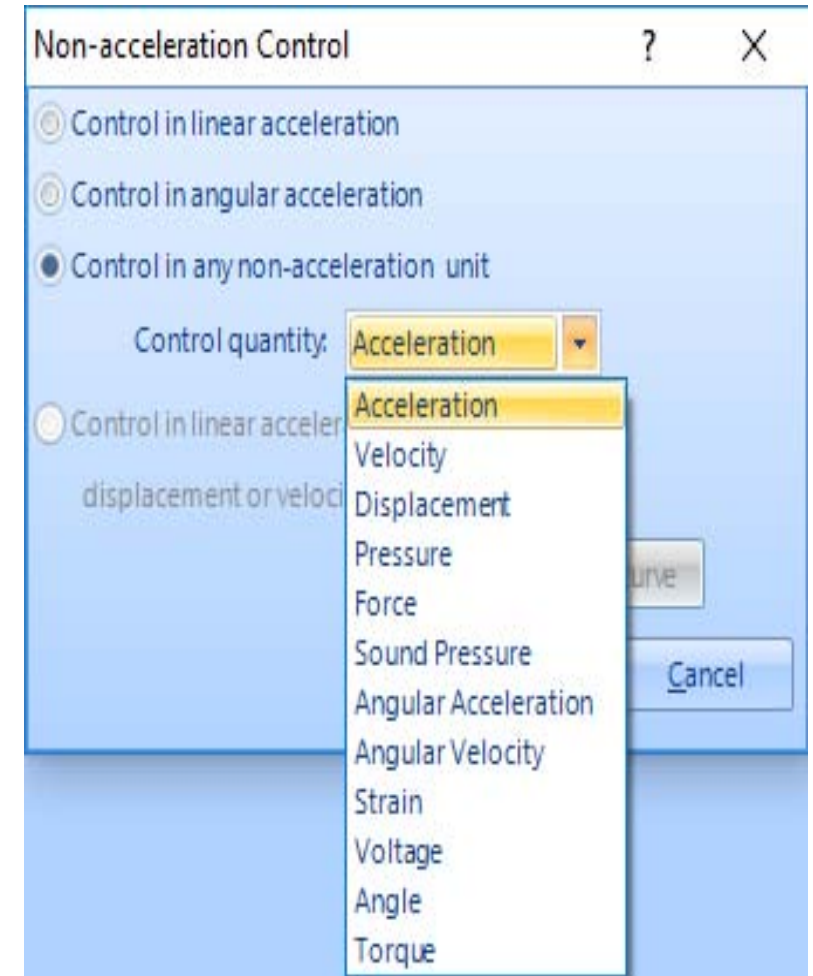
Level	100.00 %
Drive Peak	0.33857 v
Control RMS	9.90129 m/s ²
Target RMS	9.80817 m/s ²
Remaining Time	00:26:01
Full Level Elapsed	00:00:58
Total Elapsed	00:01:54

Front-End

192.168.1.58 (#994656)

VCS Software | Non-acceleration Control

- A non-acceleration measurement quantity can be applied to the control signal
- Choose from multiple quantities including force, sound, and voltage to control when appropriate sensors are used
- Angular acceleration can be controlled in Sine and Random tests

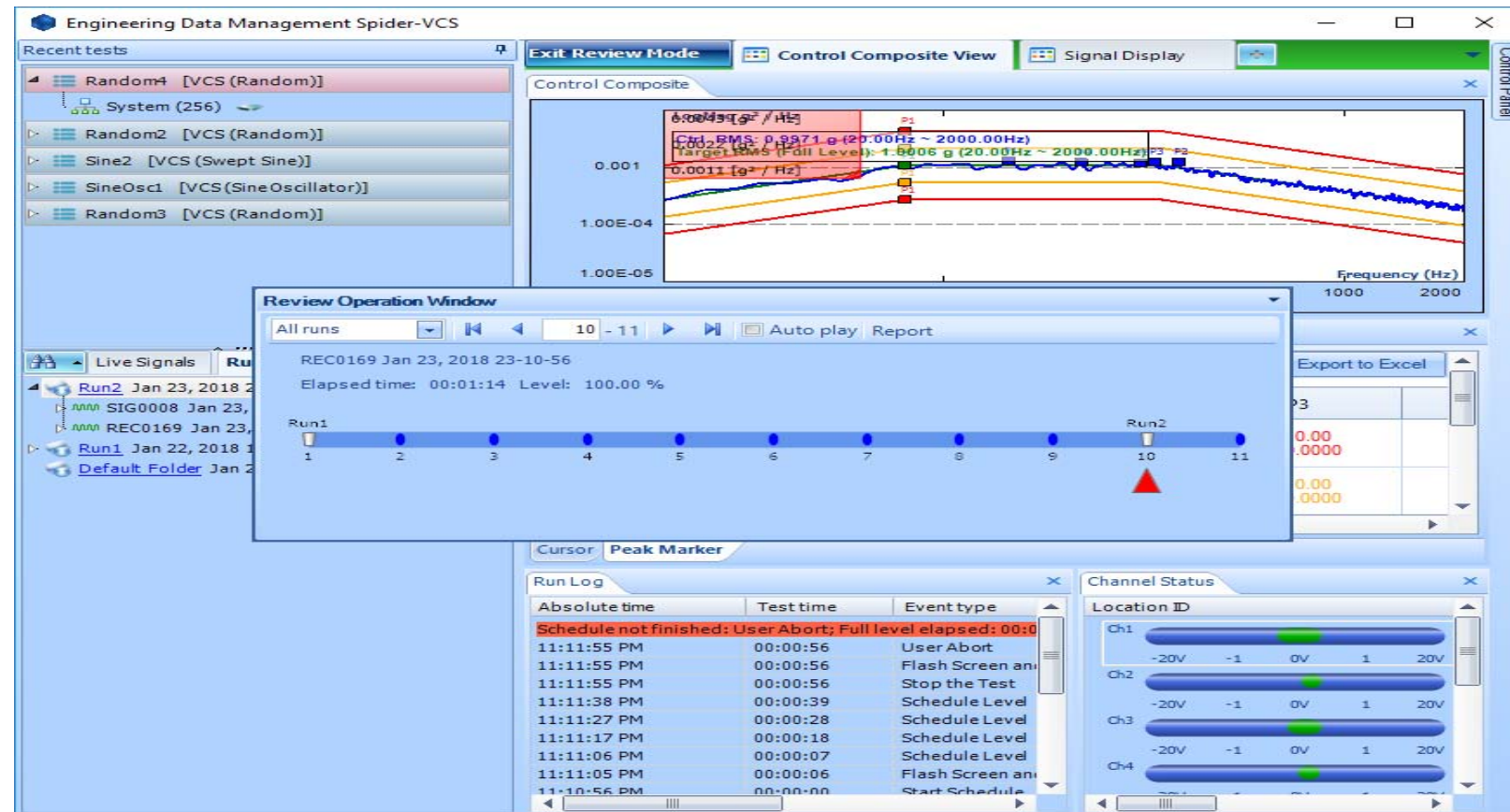


The controller is also capable of using mixed displacement, velocity and acceleration sensors to synthesize a control signal in the acceleration domain.

- **Random:** control in angular acceleration, control in any non-acceleration unit
- **Sine:** control in angular acceleration, control in any non-acceleration unit, control in linear acceleration while allowing displacement or velocity measurement
- **Shock/TTH:** control in any non-acceleration unit

VCS Software | Review Mode

Review mode is used to recall multiple saved signals in a user defined layout with one mouse click

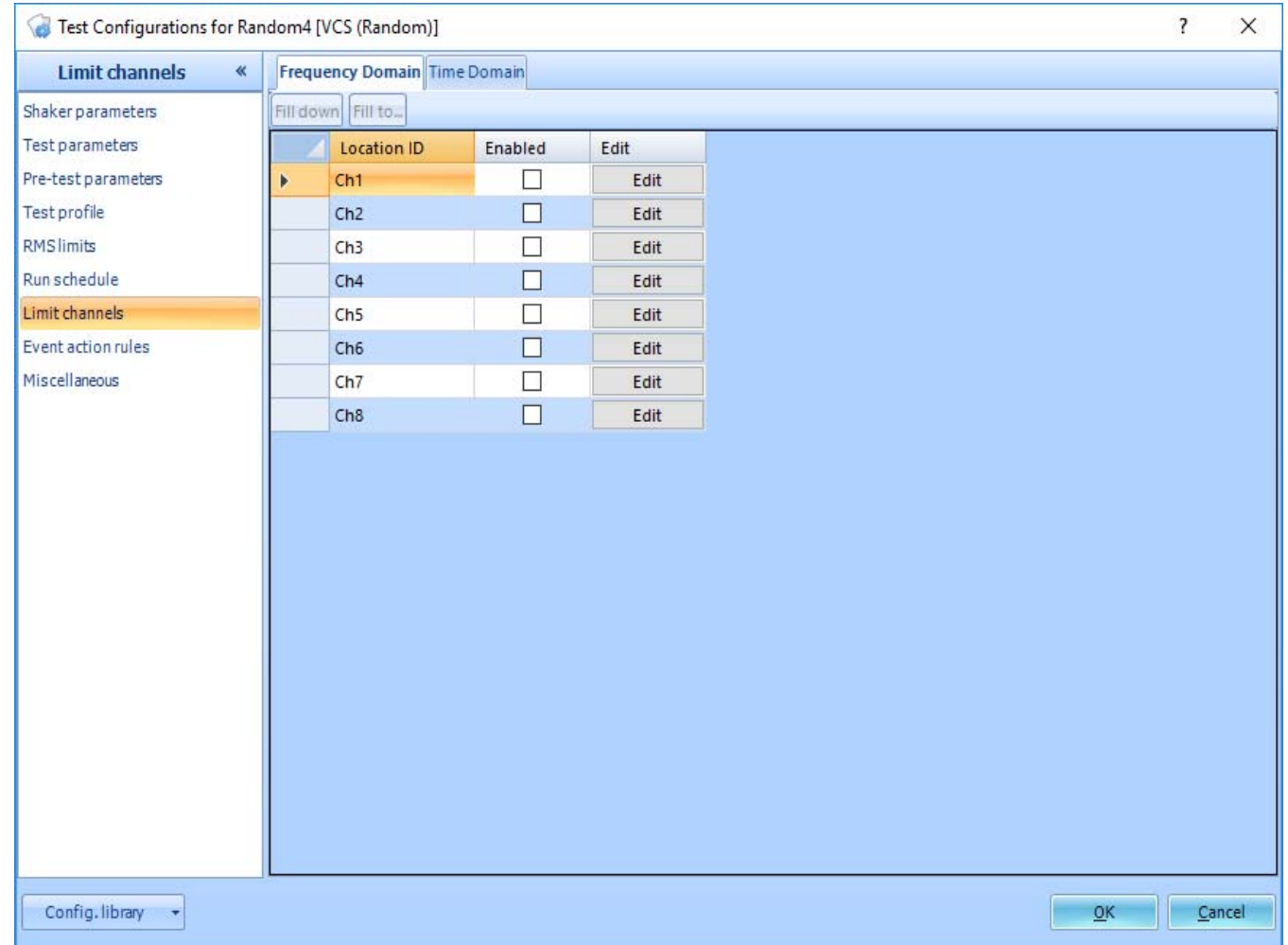


Here are a few examples of using Review Mode:

- In Shock, the user can save each pulse using the Save Signal setup. With Review Mode, the user can easily review each pulse together with other signals with one mouse click.
- In Random, signals can be saved every 2 minutes. Later, they can be auto-replayed one-by-one in the Review Mode.
- In Sine, signals of each sweep can be saved and then be reviewed and reported.

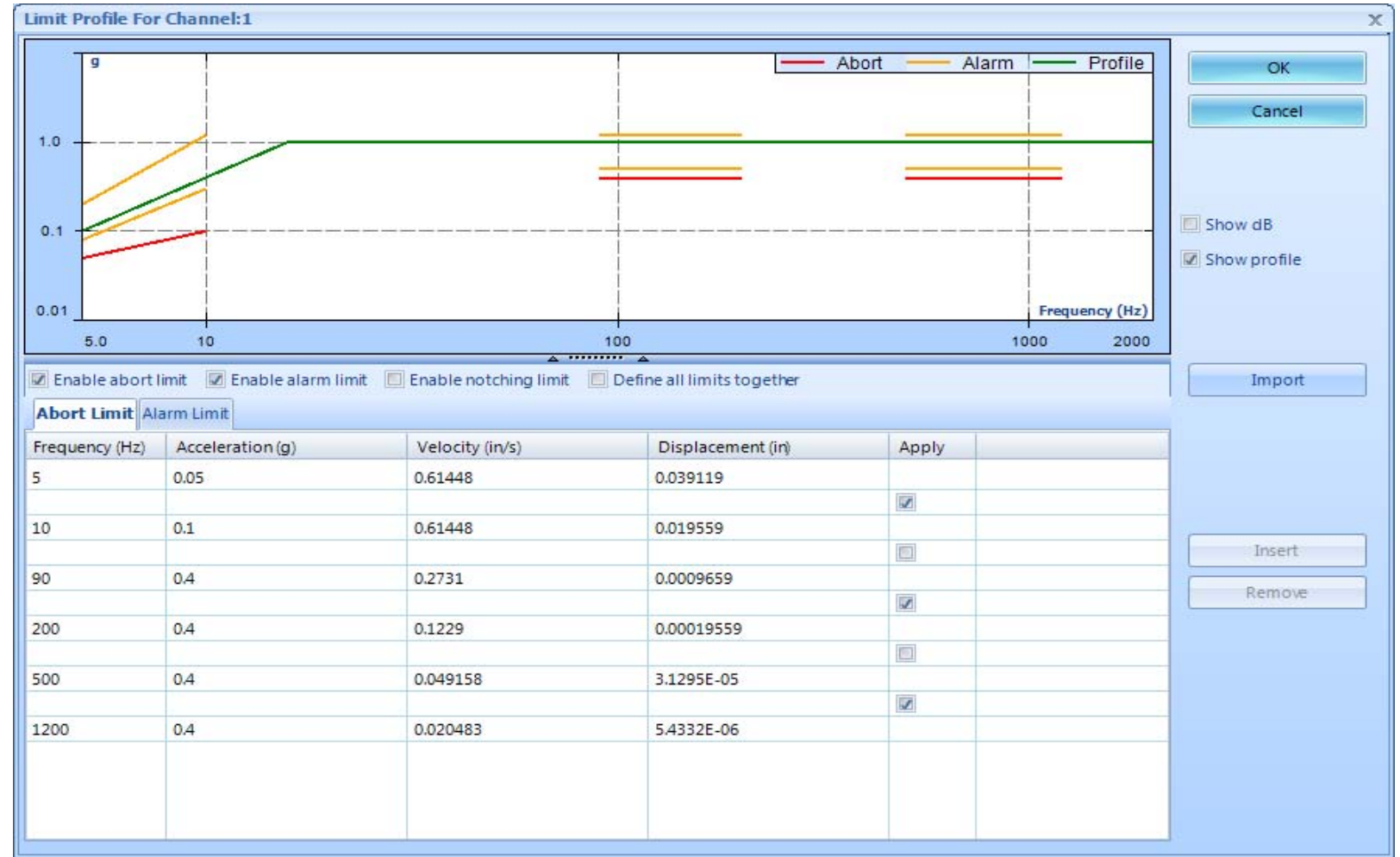
VCS Software | Limit Channel in Frequency Domain

- Any input channel can be set as a limit channel.
- These channels are given limiting spectral profiles, and if the spectrum of these channels exceeds their profile, an event is triggered.
- These limit channels can be set as Alarm, Abort, or Notch.



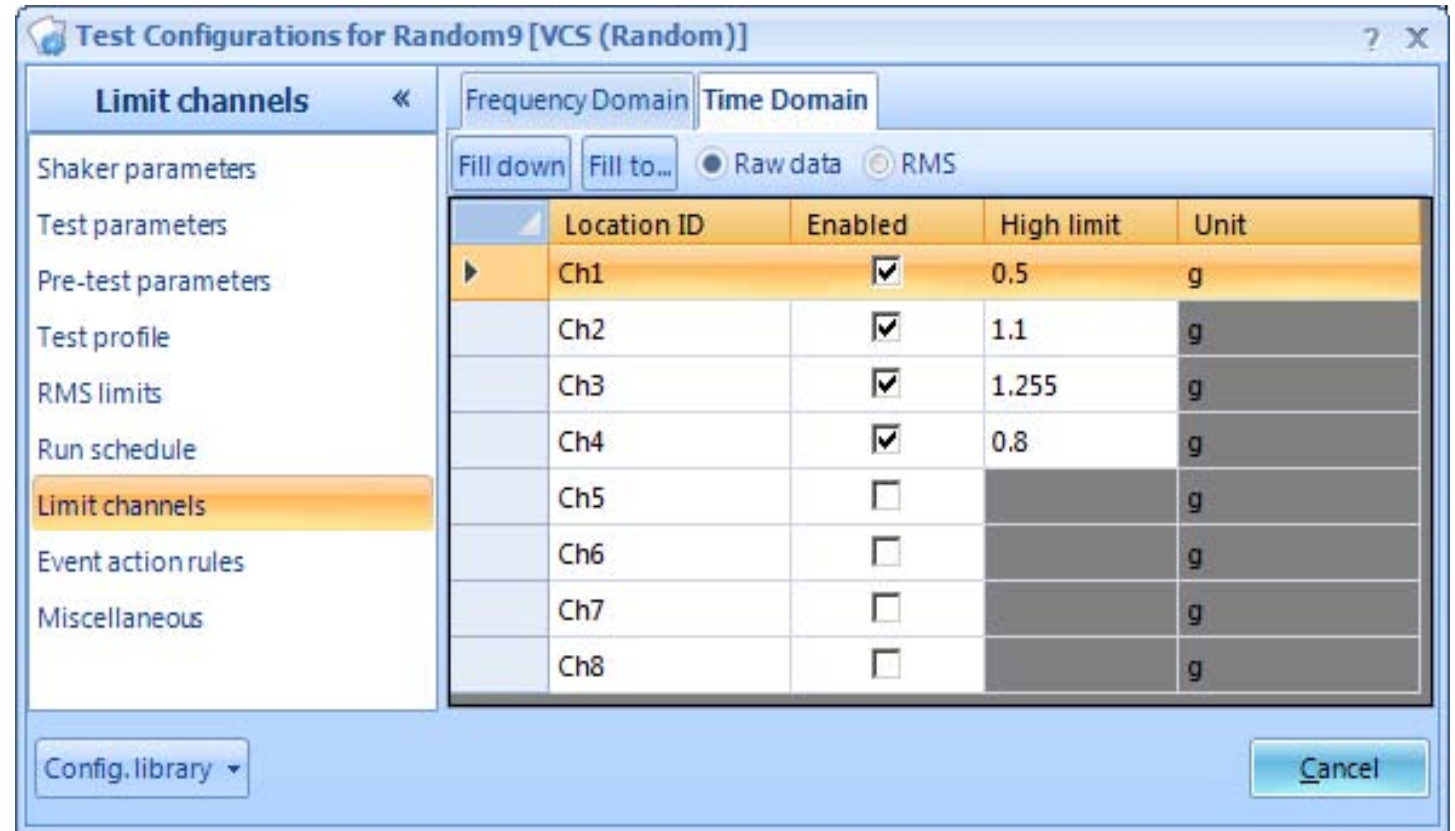
VCS Software | Limit Channel

➤ Edit the limit in VCS



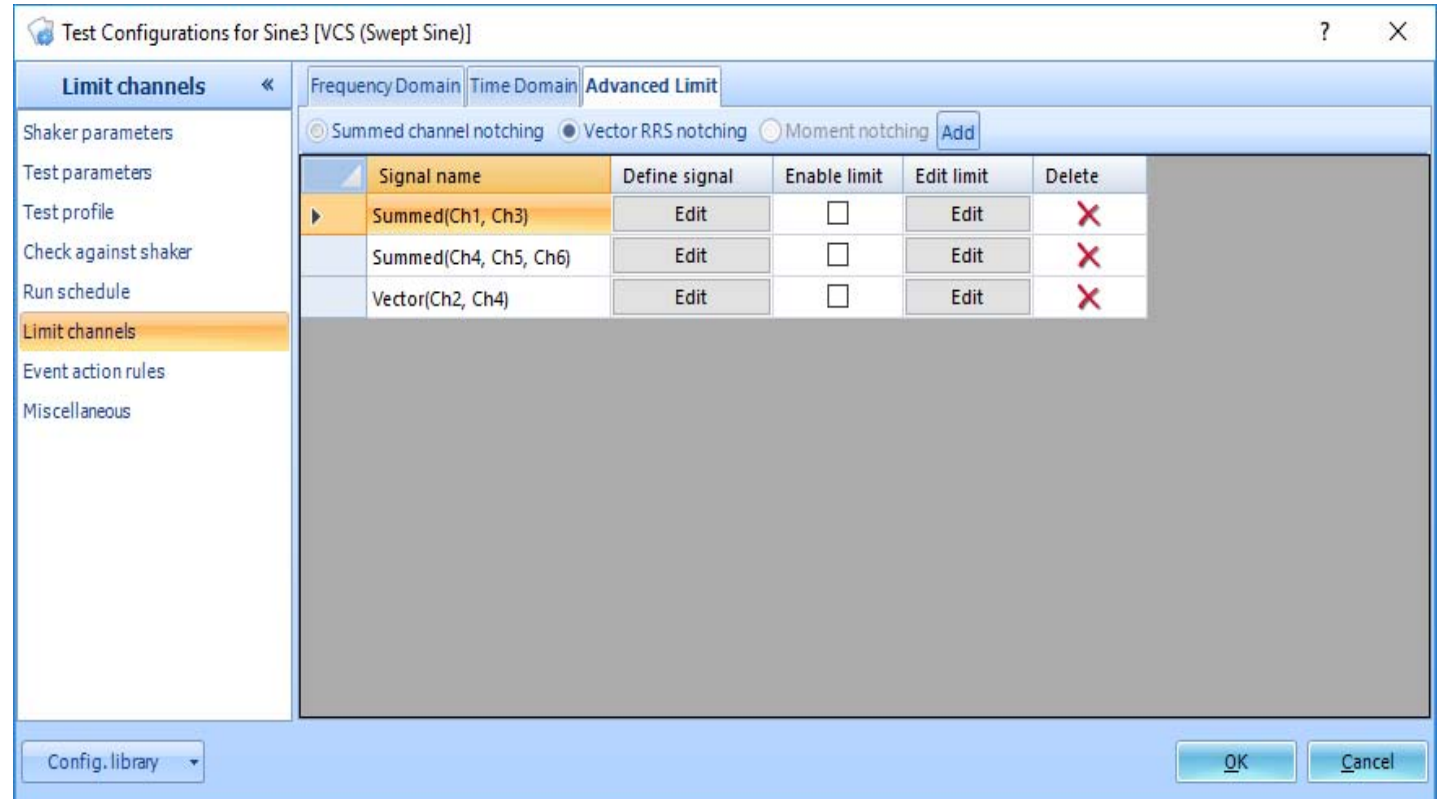
VCS Software | Limit Channel in Time Domain

- Limit check on time domain
- These channels are given high limit values, and if the time signal of these channels exceeds their limit, an event is triggered.
- The limit can be defined as raw data or RMS.



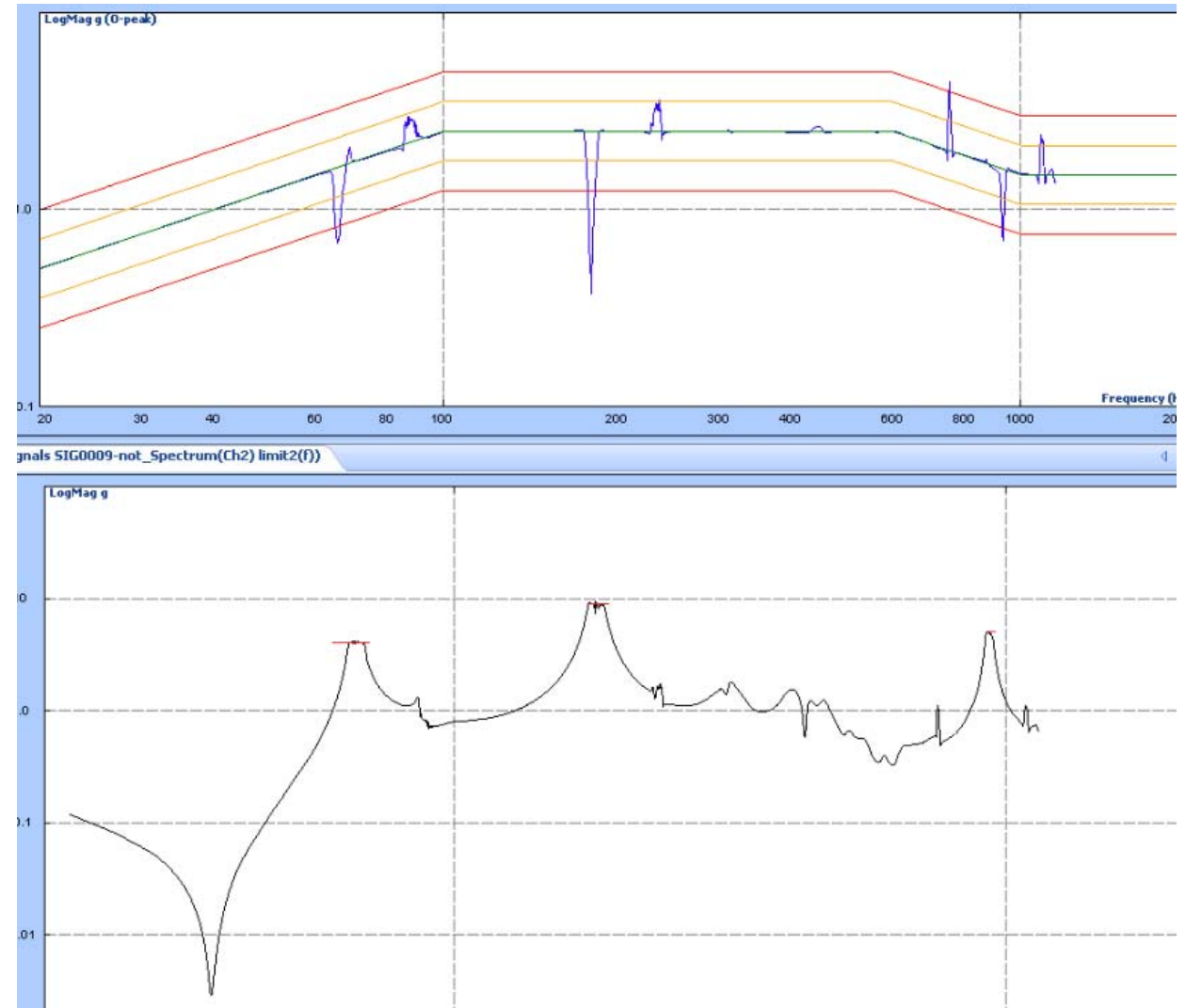
➤ Two advanced notching features

- Summed Channel Notching
- RSS Vector Notching



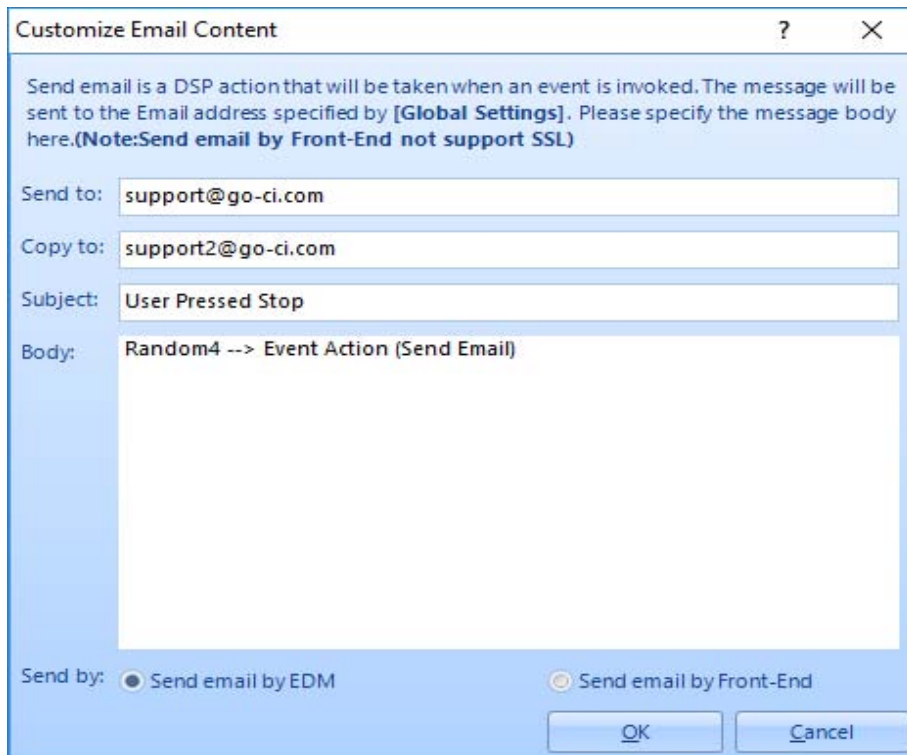
VCS Software | Notching

- Showing how the control signal and one of the APS signal will change after notching is applied.



VCS Software | Notification

VCS software can send email, socket messages, and/or digital output to any persons or external devices. This action can be triggered by the event action rules or digital input.



Customize Email Content

Send email is a DSP action that will be taken when an event is invoked. The message will be sent to the Email address specified by [Global Settings]. Please specify the message body here. (Note: Send email by Front-End not support SSL)

Send to: support@go-ci.com

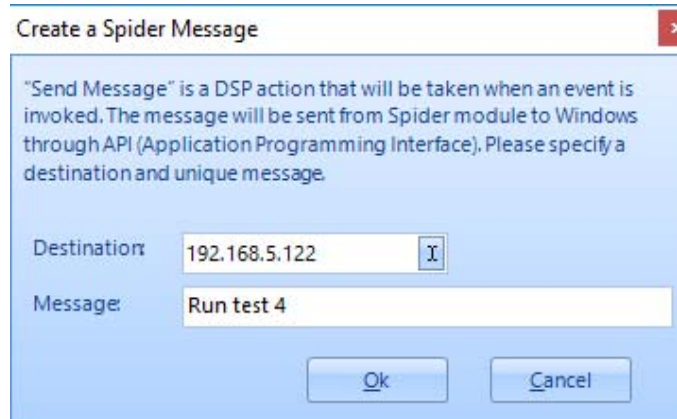
Copy to: support2@go-ci.com

Subject: User Pressed Stop

Body: Random4 --> Event Action (Send Email)

Send by: ☒ Send email by EDM ☐ Send email by Front-End

OK Cancel



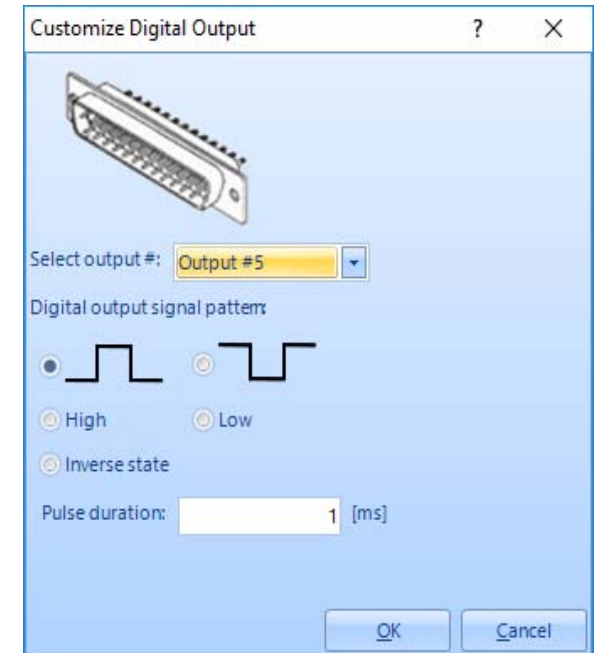
Create a Spider Message

"Send Message" is a DSP action that will be taken when an event is invoked. The message will be sent from Spider module to Windows through API (Application Programming Interface). Please specify a destination and unique message.

Destination: 192.168.5.122

Message: Run test 4

OK Cancel



Customize Digital Output

Select output #: Output #5

Digital output signal pattern

☒ High ☐ Low

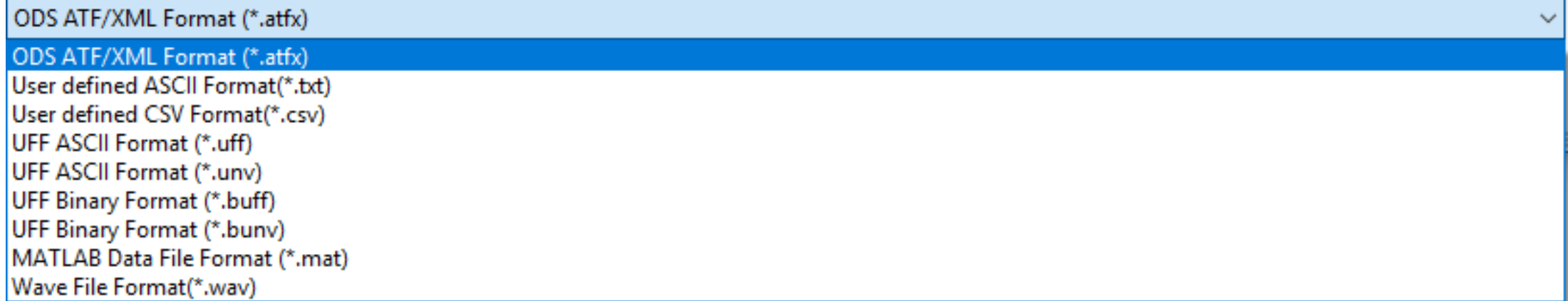
☐ Inverse state

Pulse duration: 1 [ms]

OK Cancel

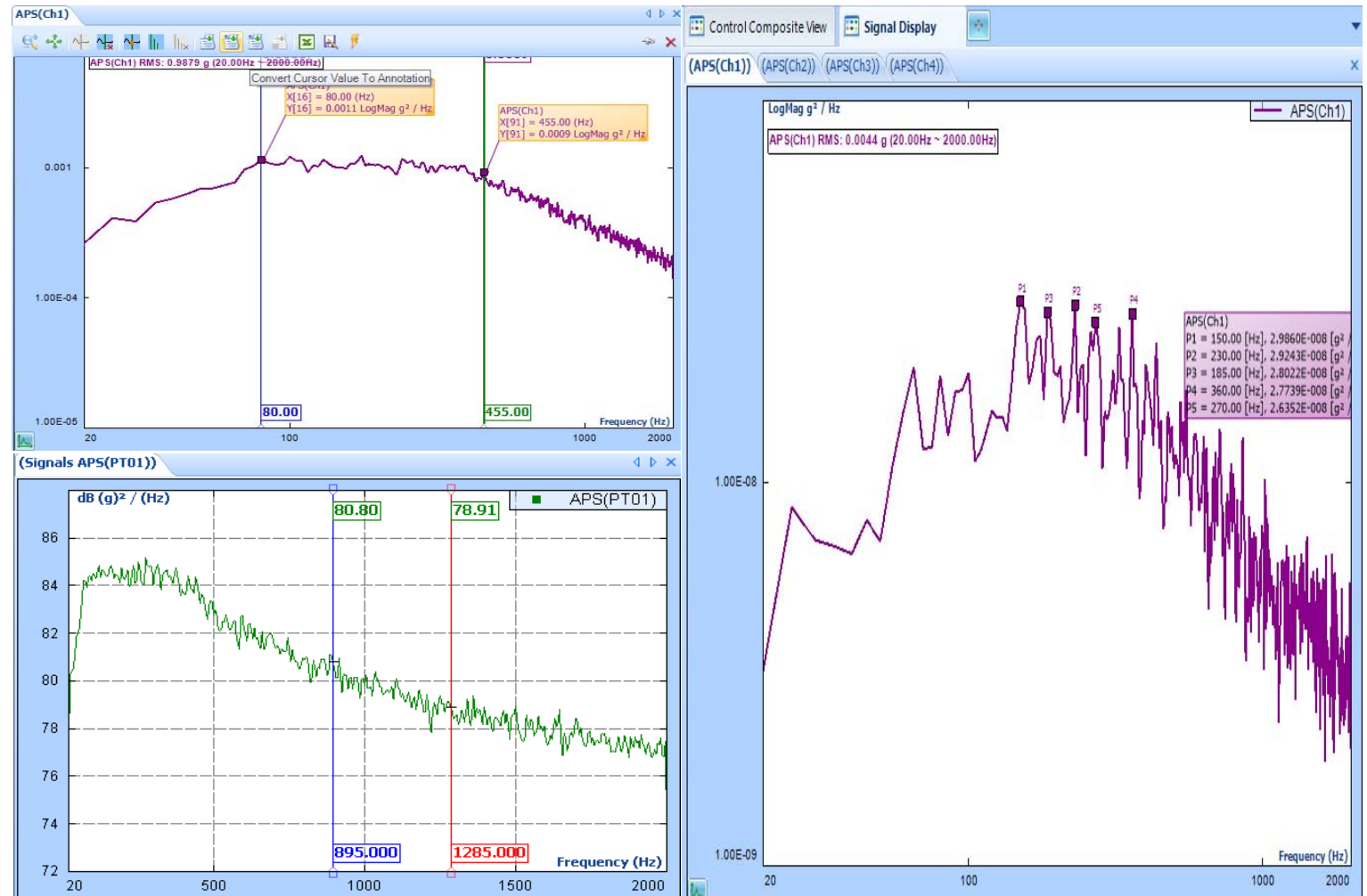
VCS Software | Import and Export Data Files

Support various file formats for both import and export



VCS Software | Cursors and Markers

- Cursors allow features of a waveform to be measured such as a peak value or the time between two events.
- Cursors can be converted to annotation.
- Markers display the peak or valley features of a waveform and can be displayed with signals



VCS Software | Cursors and Markers

The cursor and marker window display the cursor and marker values in a table.

Those values can be exported to Excel.



The screenshot shows the 'Cursor/Marker Window' in the VCS software. It features a table with 7 columns: 'Signal Name', 'P1', 'P2', 'P3', 'P4', 'P5', and 'Unit'. The table contains 6 rows of data for different signals. The first row, 'HighAbort(f)', is highlighted in blue. The second row, 'HighAlarm(f)', is highlighted in orange. The third row, 'profile(f)', is highlighted in green. The fourth row, 'LowAlarm(f)', is highlighted in orange. The fifth row, 'LowAbort(f)', is highlighted in red. The sixth row, 'control(f)', is highlighted in blue. The table also includes a 'Table Count = 1' indicator and buttons for 'Add Signals' and 'Export to Excel'.

Signal Name	P1	P2	P3	P4	P5	Unit
HighAbort(f)	X = 80.00 Y = 0.0043	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	Hz g ² / Hz
HighAlarm(f)	X = 80.00 Y = 0.0022	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	Hz g ² / Hz
profile(f)	X = 80.00 Y = 0.0011	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	Hz g ² / Hz
LowAlarm(f)	X = 80.00 Y = 0.0005	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	Hz g ² / Hz
LowAbort(f)	X = 80.00 Y = 0.0003	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	X = 0.00 Y = 0.0000	Hz g ² / Hz
control(f)	X = 190.00 Y = 0.0013	X = 130.00 Y = 0.0012	X = 320.00 Y = 0.0012	X = 155.00 Y = 0.0012	X = 200.00 Y = 0.0011	Hz g ² / Hz

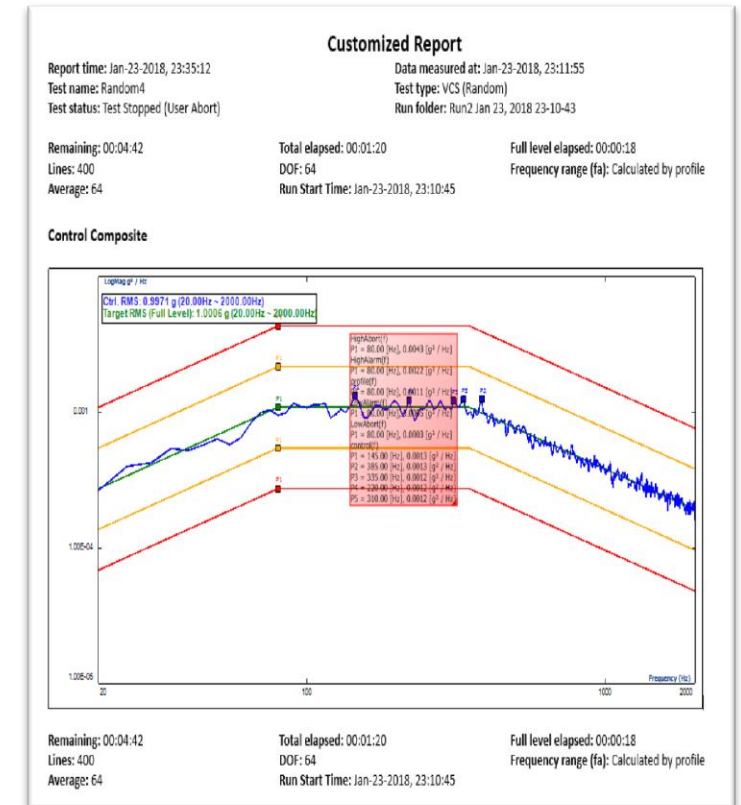
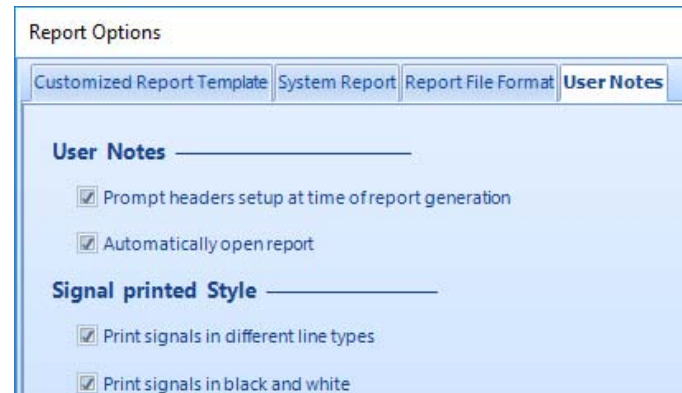
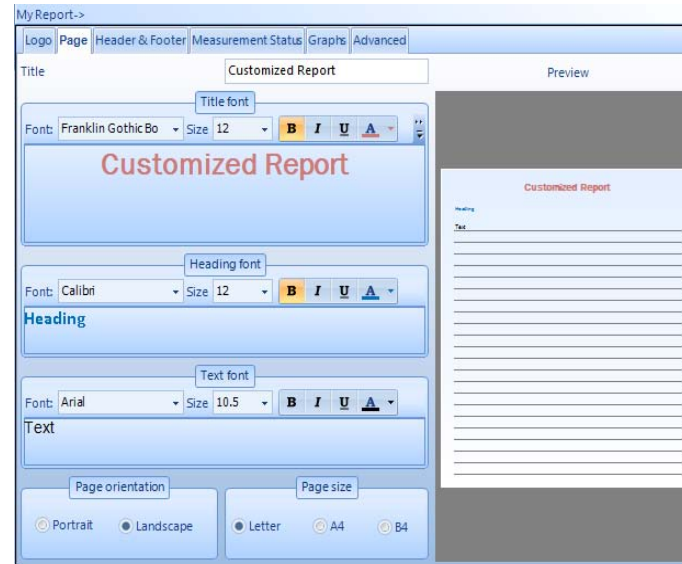
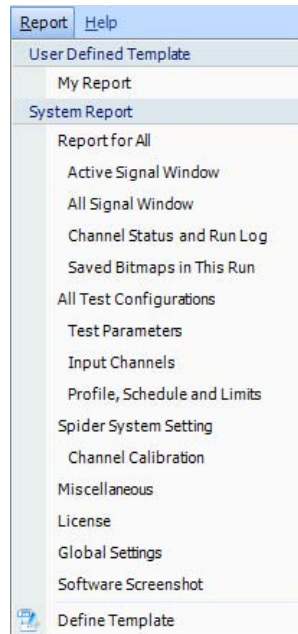
VCS Software | Report Function

➤ Formats

Available:

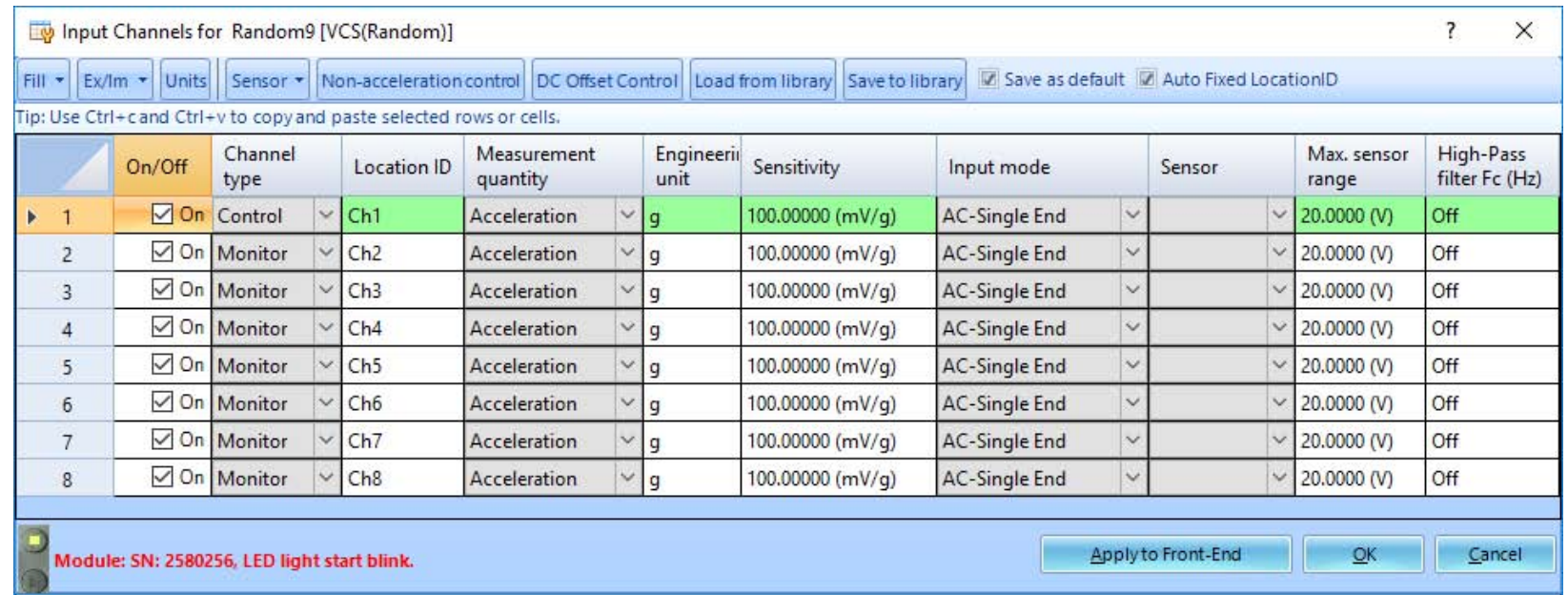
Open XML, MS Word (.doc, .docx), PDF

➤ Customizable Template: title, logo, fonts, page layout, position of test status, selected measurement status, and user note



VCS Software | Input Channel Table

- Input channel setup with customizable column selection.
- Engineering unit assigned to each channel
- Automatically extract the TEDS sensor information
- Filter setup for each channel
- Sensor library with optional sensor calibration notification



Input Channels for Random9 [VCS(Random)]

Fill ▾ Ex/Im ▾ Units ▾ Sensor ▾ Non-acceleration control DC Offset Control Load from library Save to library ☒ Save as default ☒ Auto Fixed LocationID

Tip: Use Ctrl+c and Ctrl+v to copy and paste selected rows or cells.

	On/Off	Channel type	Location ID	Measurement quantity	Engineering unit	Sensitivity	Input mode	Sensor	Max. sensor range	High-Pass filter Fc (Hz)
▶ 1	<input checked="" type="checkbox"/> On	Control ▾	Ch1	Acceleration ▾	g	100.00000 (mV/g)	AC-Single End ▾		20.0000 (V)	Off
2	<input checked="" type="checkbox"/> On	Monitor ▾	Ch2	Acceleration ▾	g	100.00000 (mV/g)	AC-Single End ▾		20.0000 (V)	Off
3	<input checked="" type="checkbox"/> On	Monitor ▾	Ch3	Acceleration ▾	g	100.00000 (mV/g)	AC-Single End ▾		20.0000 (V)	Off
4	<input checked="" type="checkbox"/> On	Monitor ▾	Ch4	Acceleration ▾	g	100.00000 (mV/g)	AC-Single End ▾		20.0000 (V)	Off
5	<input checked="" type="checkbox"/> On	Monitor ▾	Ch5	Acceleration ▾	g	100.00000 (mV/g)	AC-Single End ▾		20.0000 (V)	Off
6	<input checked="" type="checkbox"/> On	Monitor ▾	Ch6	Acceleration ▾	g	100.00000 (mV/g)	AC-Single End ▾		20.0000 (V)	Off
7	<input checked="" type="checkbox"/> On	Monitor ▾	Ch7	Acceleration ▾	g	100.00000 (mV/g)	AC-Single End ▾		20.0000 (V)	Off
8	<input checked="" type="checkbox"/> On	Monitor ▾	Ch8	Acceleration ▾	g	100.00000 (mV/g)	AC-Single End ▾		20.0000 (V)	Off

Module: SN: 2580256, LED light start blink.

Apply to Front-End OK Cancel

Shaker Parameters

- Parameters can be loaded and saved into library
- Shaker limit check against testing profiles

Test Configurations for [TTH] - Test [VCS (TTH)]

Shaker parameters

Shaker parameters
Test parameters
Pre-test parameters
Test profile
TTH compensation
TTH abort limit
SRS analysis
Limit channels
Run schedule
Event action rules
Miscellaneous

Shaker information

Manufacturer: Anonymous Shaker name: Default Shaker
Payload mass: 0,22046 LBS
Armature mass: 0,44092 LBS

Actual shaker limits used in this test

Force peak	100,02	LBF	✓
Acceleration peak	50	g	✓
Max. velocity	70	in/s	✓
Max. positive displacement	0,25	in	✓
Max. negative displacement	0,25	in	✓
Shaker orientation	Vertical		
Max. drive voltage peak	10	V	
Min. drive frequency	1	Hz	
Max. drive frequency	2500	Hz	

Note: The parameters listed above are for reference only. Click "Edit parameters" to view or edit shaker parameters.
The acceleration limit is adjusted by the following factor:
Actual Acc. = Min(Shaker param. Force / (Armature mass + Payload mass), Shaker param. Acc.)
Max. drive frequency should not be set too high, the recommended range within 10240 Hz.

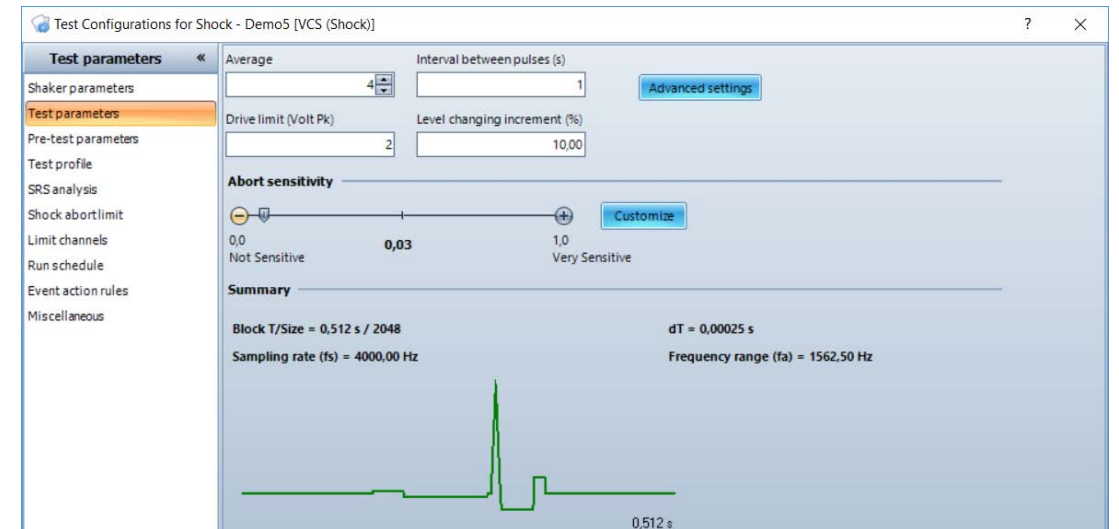
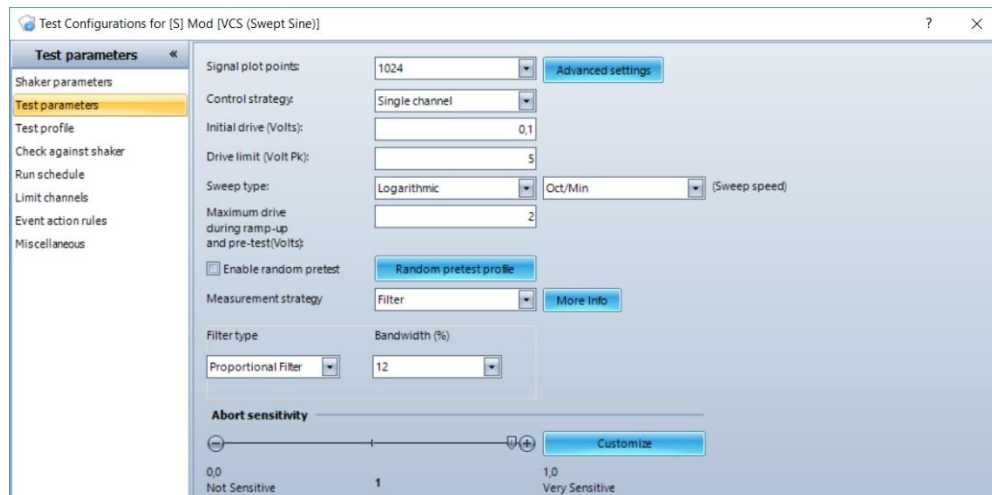
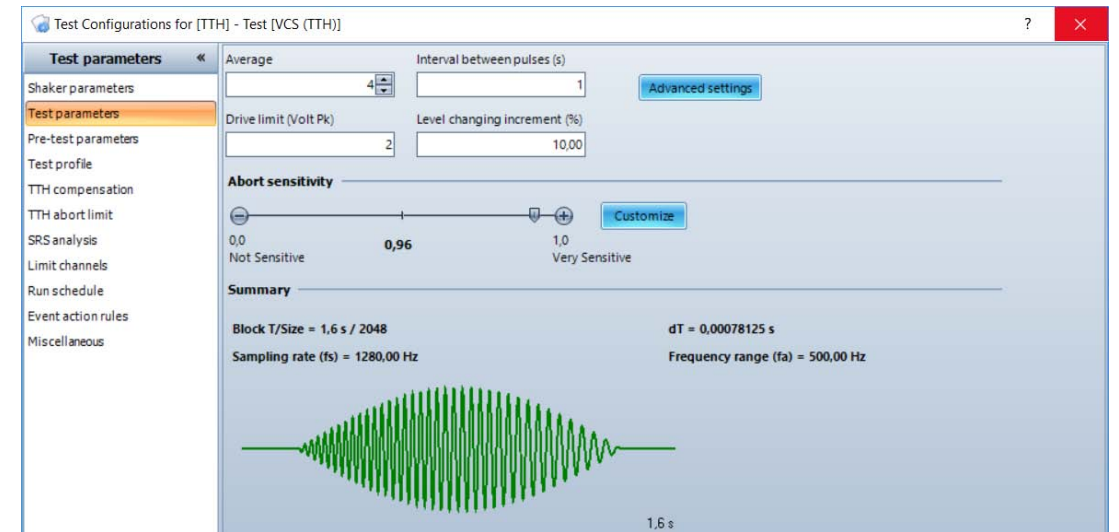
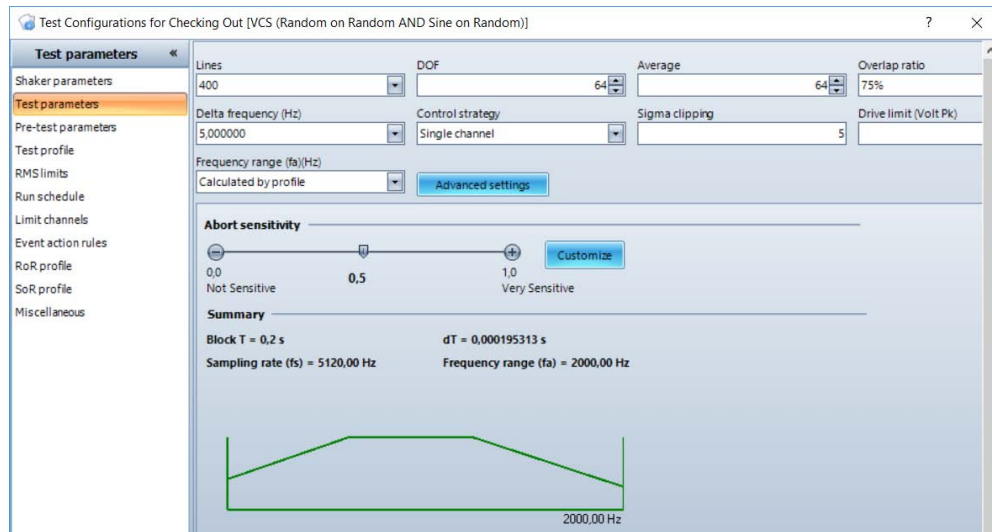
Edit parameters

Load from library Save to library Import manufacturer shaker list Export manufacturer shaker list

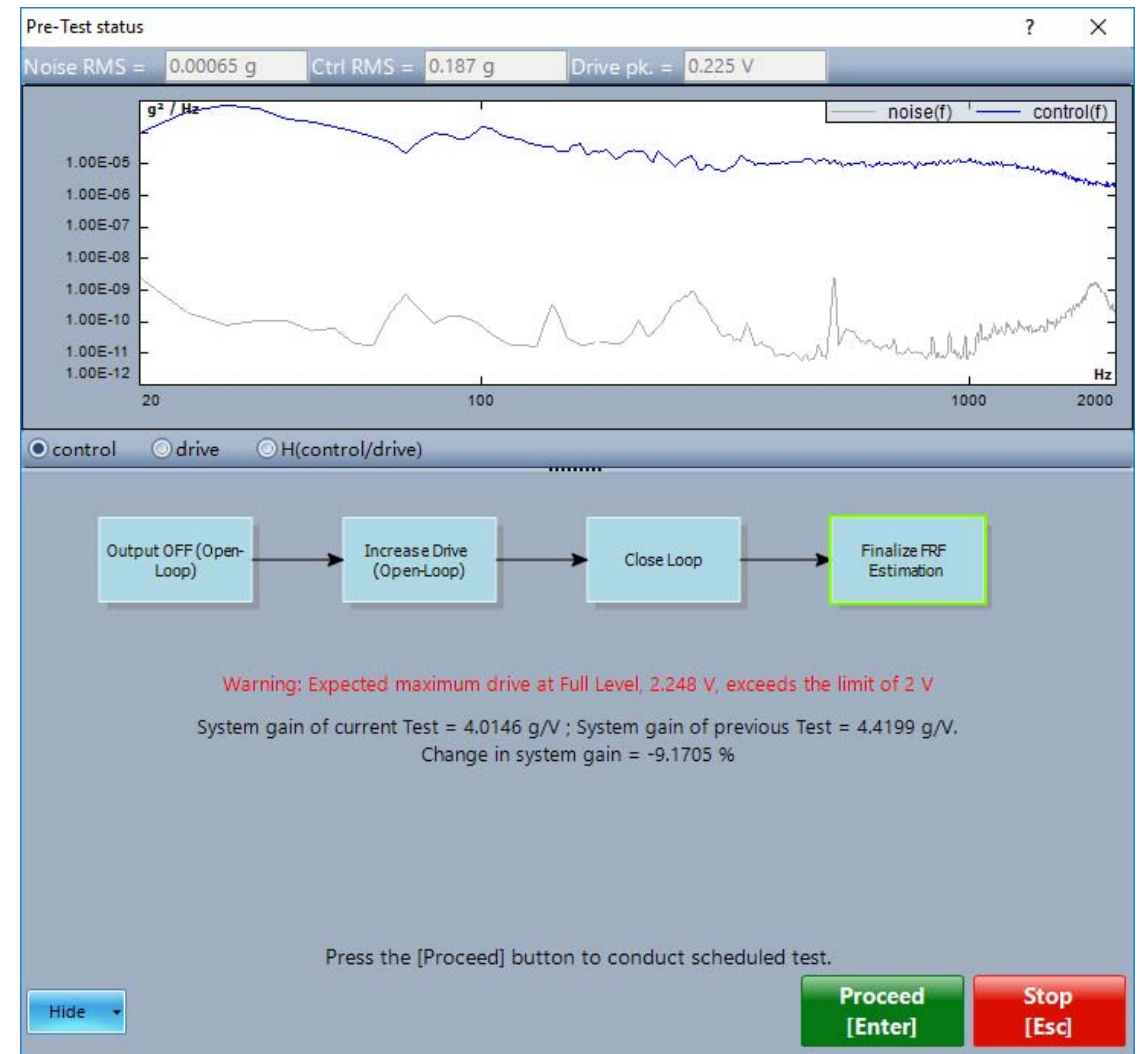
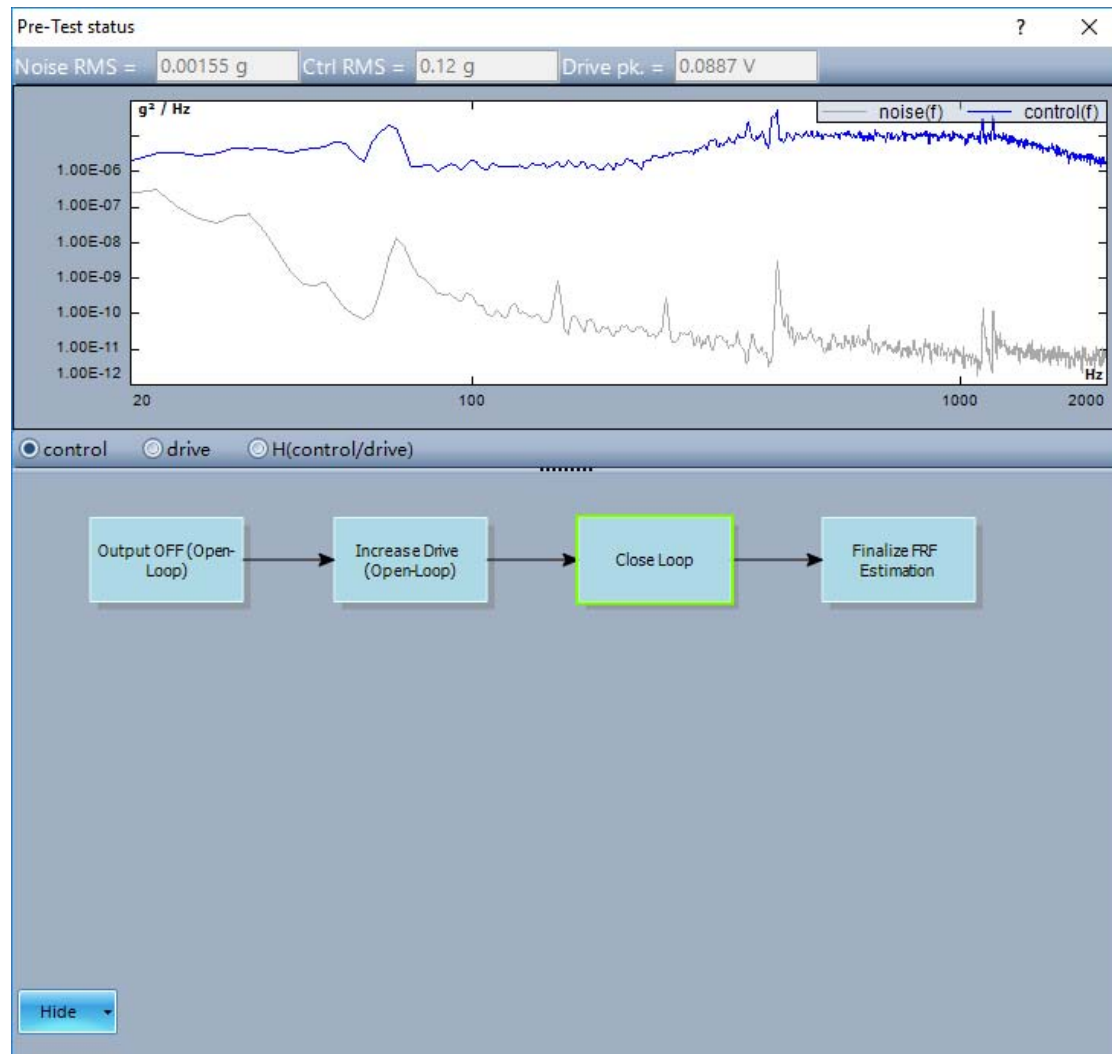
Config. library

OK Cancel

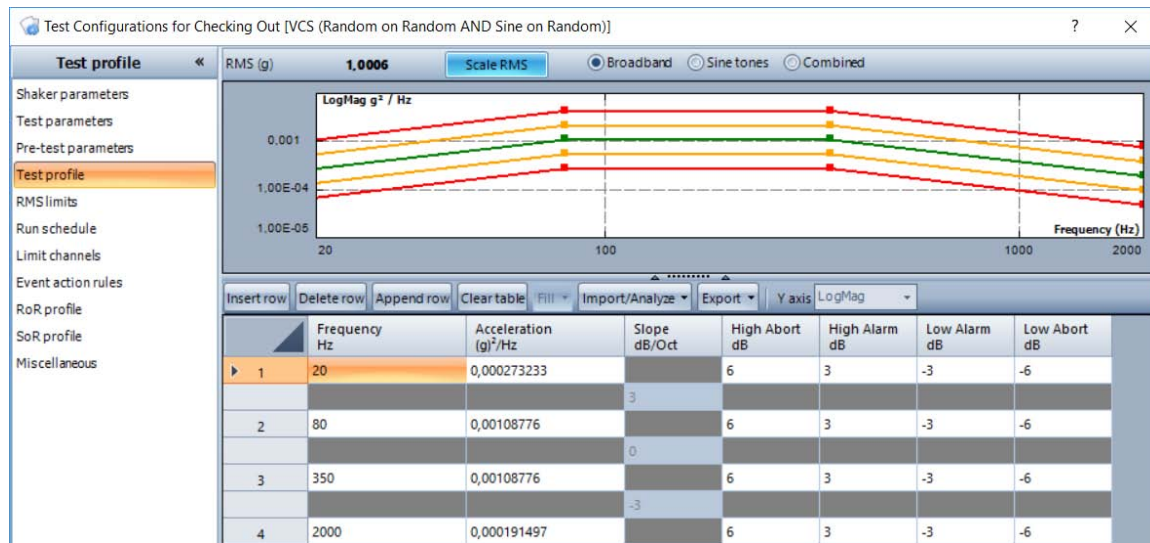
VCS Software | Test Parameters



VCS Software | Pre-Test

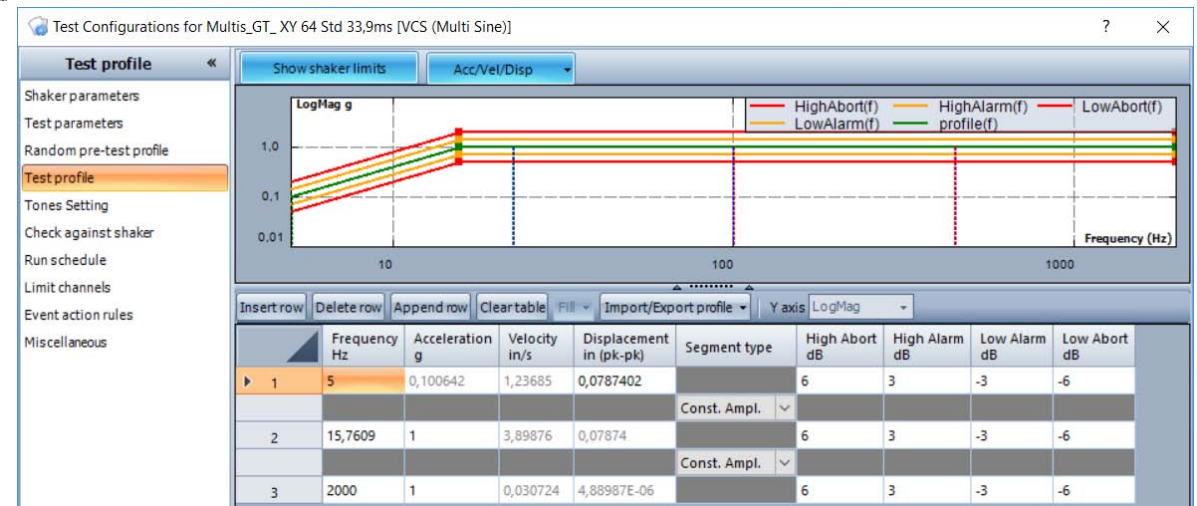


VCS Software | Test Profiles

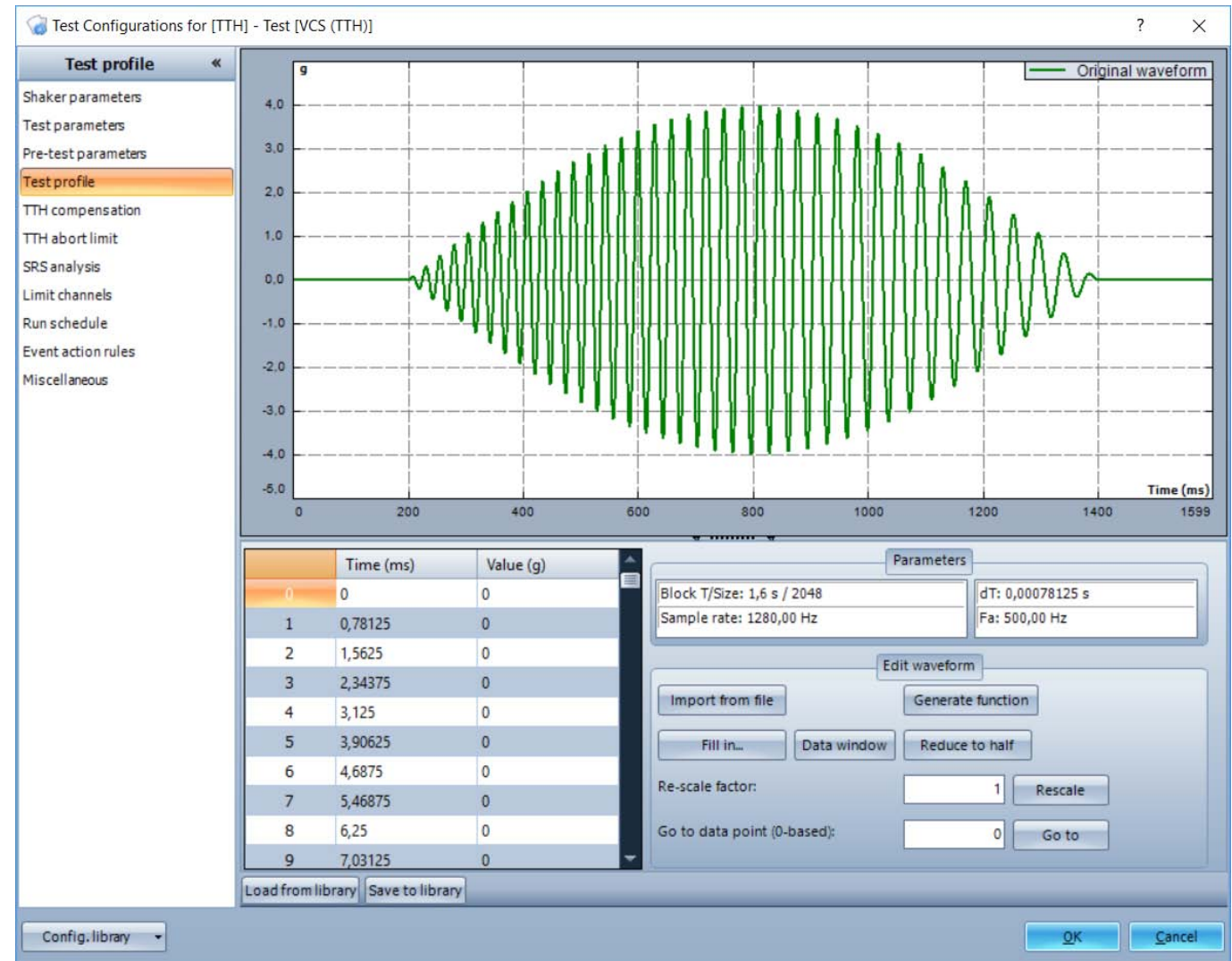


Random

Sine

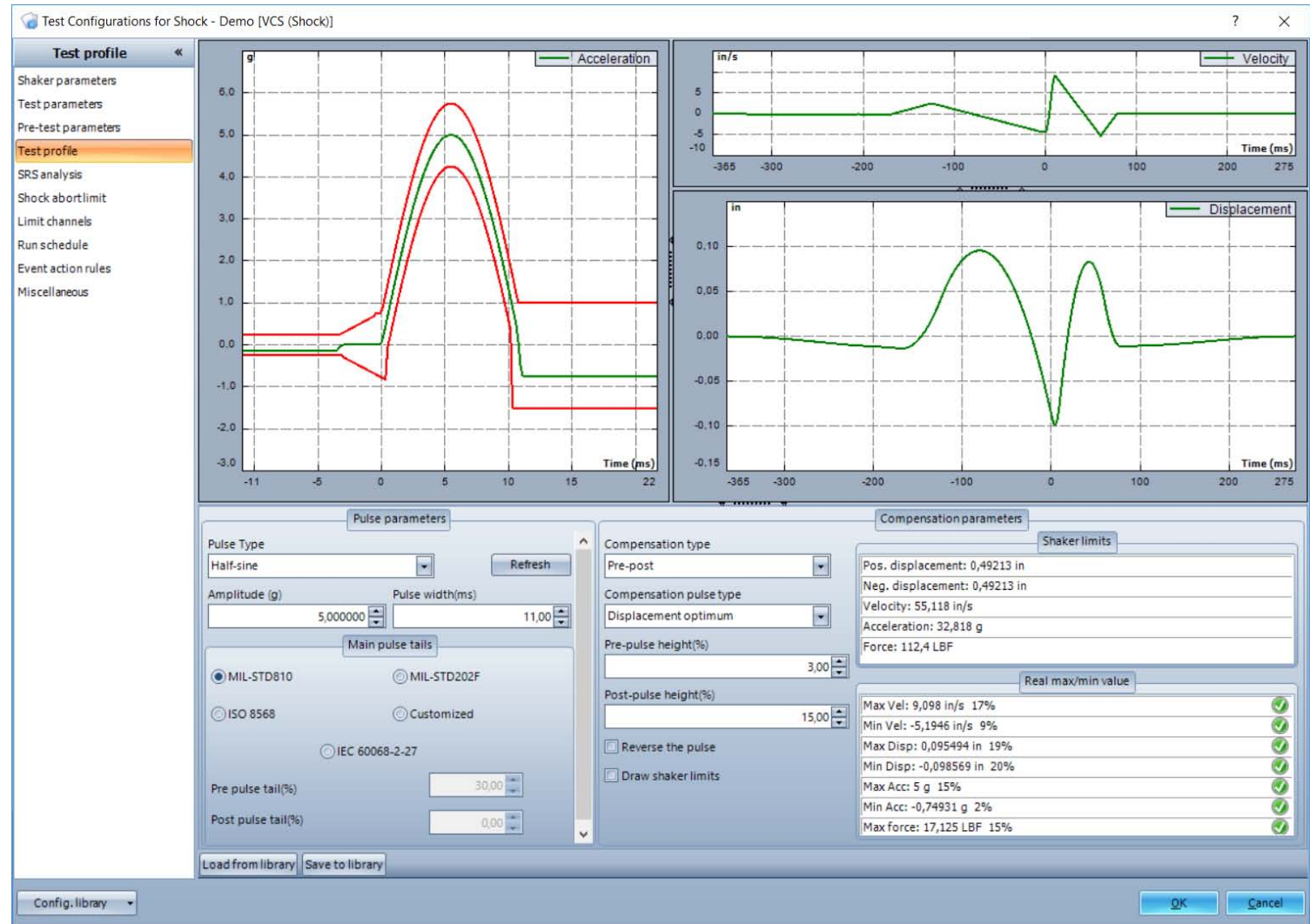


Target Profile setup for Transient Time History



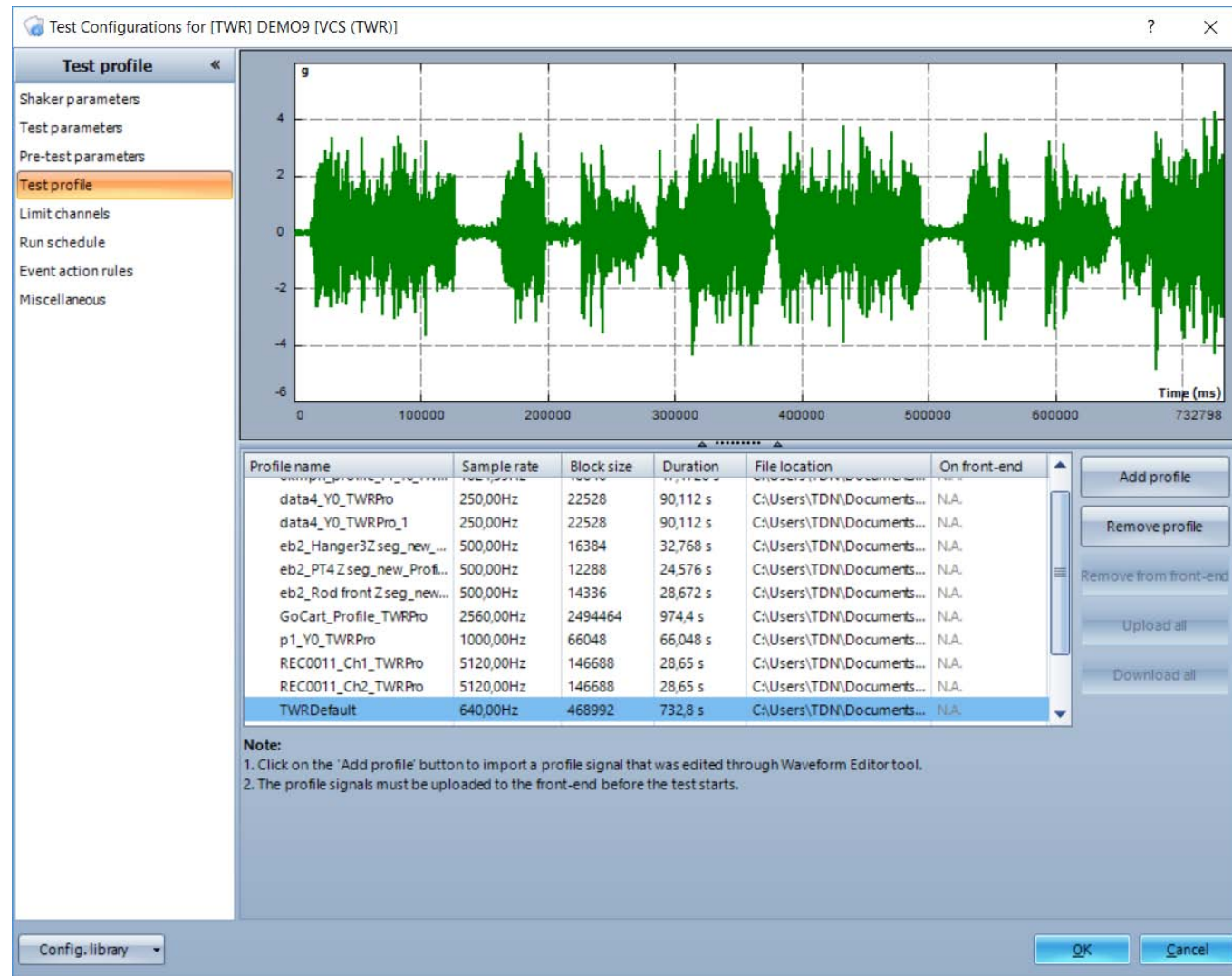
Testing Profile Setup for Classic Shock

- With many ways of displacement compensation
- Follow various testing standards

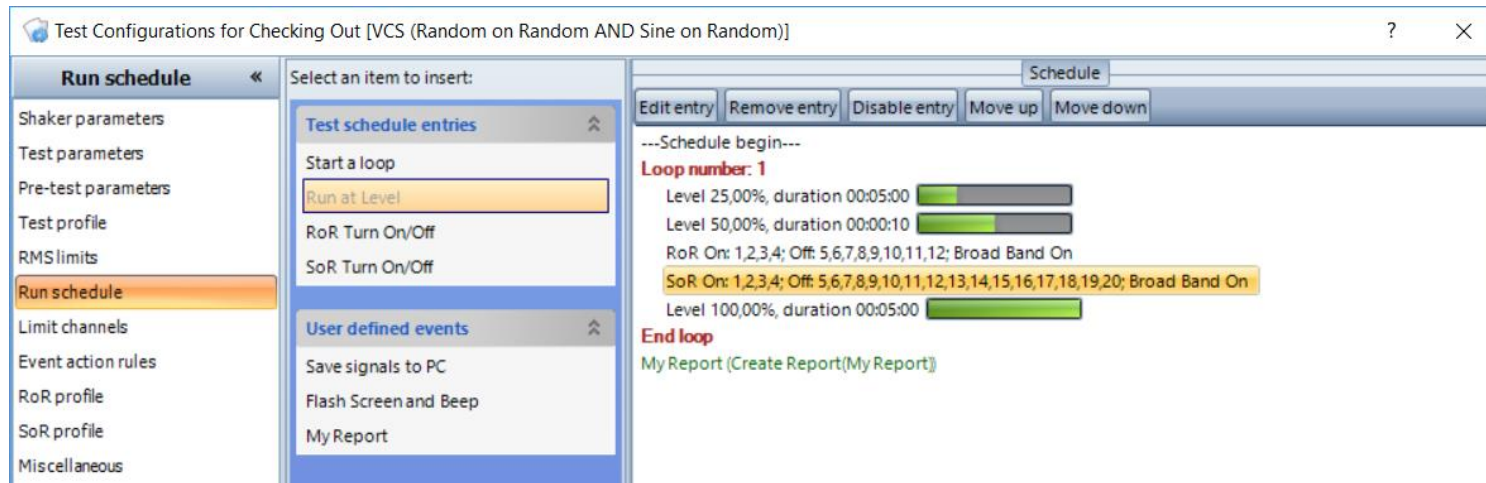


Profile Setup in Time Waveform Replication

- Testing profile setup used together with Waveform Editor tool
- Giga-words of size in profile length

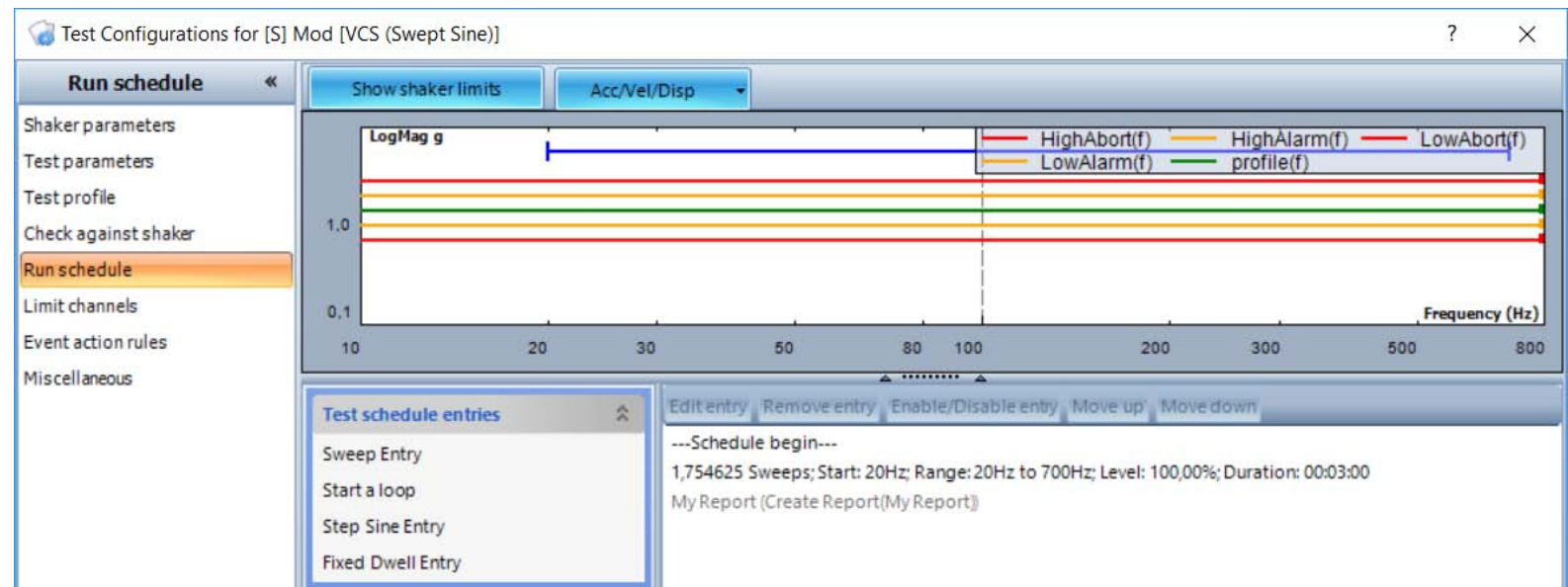


VCS Software | Run Schedule

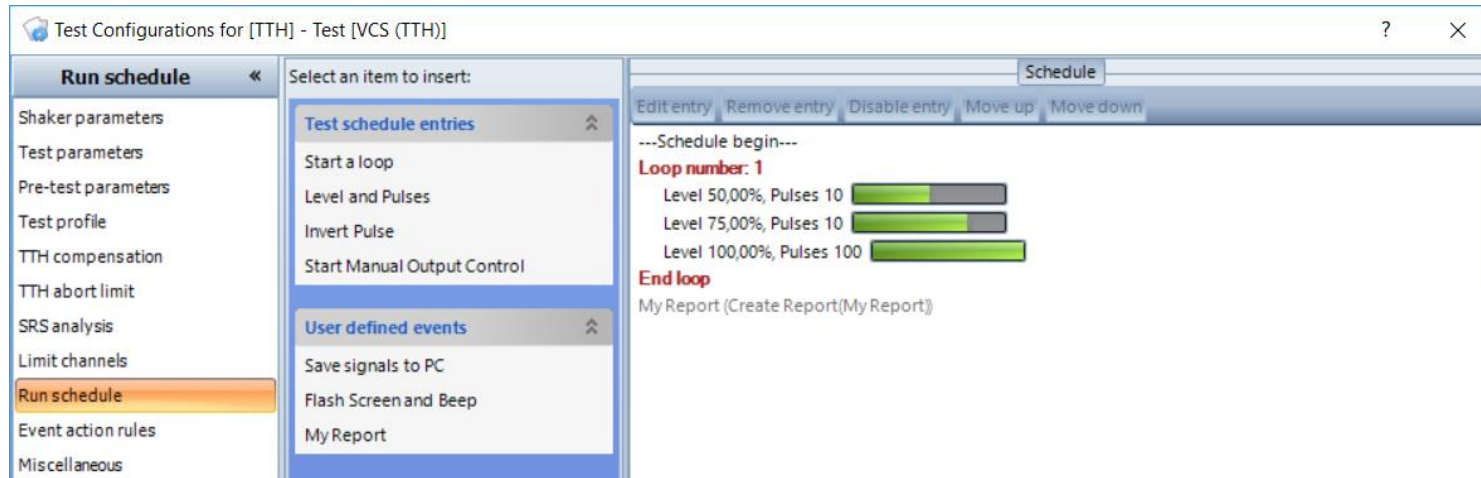


Random Run Schedule
(with RoR and SoR)

Sine Run Schedule

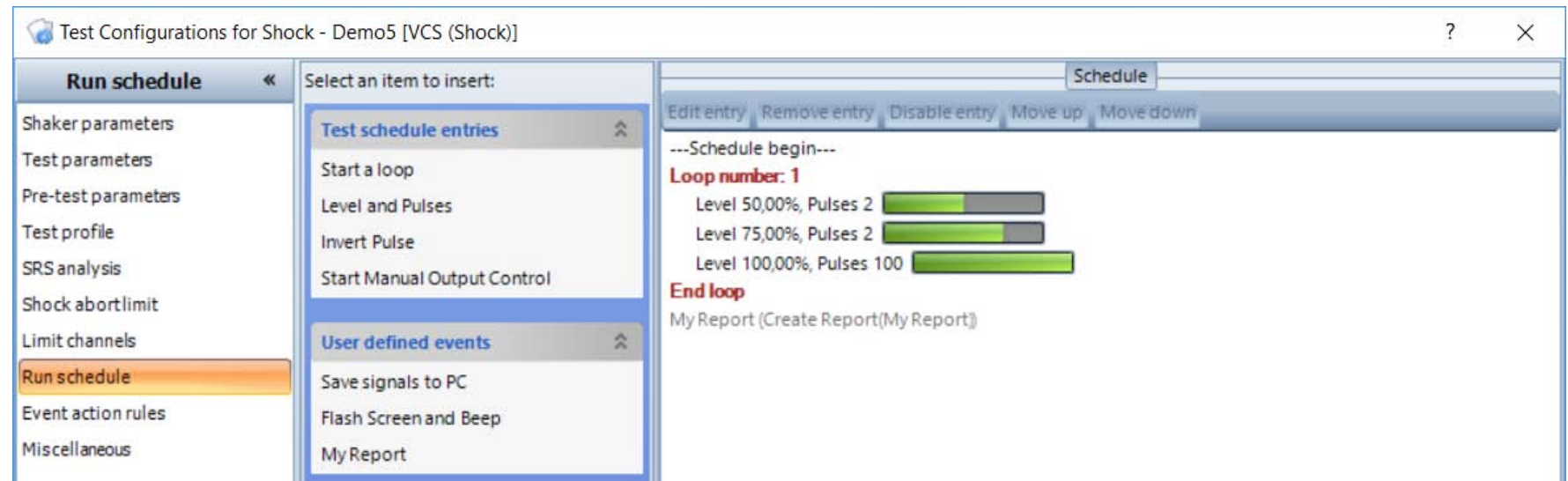


VCS Software | Run Schedule



TTH Run Schedule

Shock Run Schedule



TWR Run Schedule

The screenshot shows the 'Run schedule' window in the VCS Software. The window title is 'Test Configurations for [TWR] DEMO9 [VCS (TWR)]'. The left sidebar lists various configuration options: Shaker parameters, Test parameters, Pre-test parameters, Test profile, Limit channels, Run schedule (highlighted), Event action rules, and Miscellaneous. The main area is divided into two sections: 'Test schedule entries' and 'User defined events'. The 'Test schedule entries' section contains 'Start a loop' and 'Run Profile'. The 'User defined events' section contains 'My Report', 'Flash Screen and Beep' (highlighted), 'Save signals to PC', and 'Rec On'. The right pane shows the 'Schedule' tab with a list of test entries and their corresponding profiles. The first entry is 'eb2_Hanger3Z seg_new_Profile_TWRPro, Level 100, 00%, Repeats 1, Scale 0, 5', with a 'View profile' link. The second entry is 'eb2_PT4Z seg_new_Profile_TWRPro, Level 10, 00%, Repeats 1, Scale 1', also with a 'View profile' link. A green waveform visualization is shown for each profile. The total time of the profile is 32,768 s.

Test Configurations for [TWR] DEMO9 [VCS (TWR)]

Run schedule <<

Select an item to insert:

Test schedule entries <<

Start a loop

Run Profile

User defined events <<

My Report

Flash Screen and Beep

Save signals to PC

Rec On

Schedule

Edit entry Remove entry Move up Move down

---Schedule begin---

eb2_Hanger3Z seg_new_Profile_TWRPro,
Level 100,
00%,
Repeats 1,
Scale 0,
5

[View profile](#)

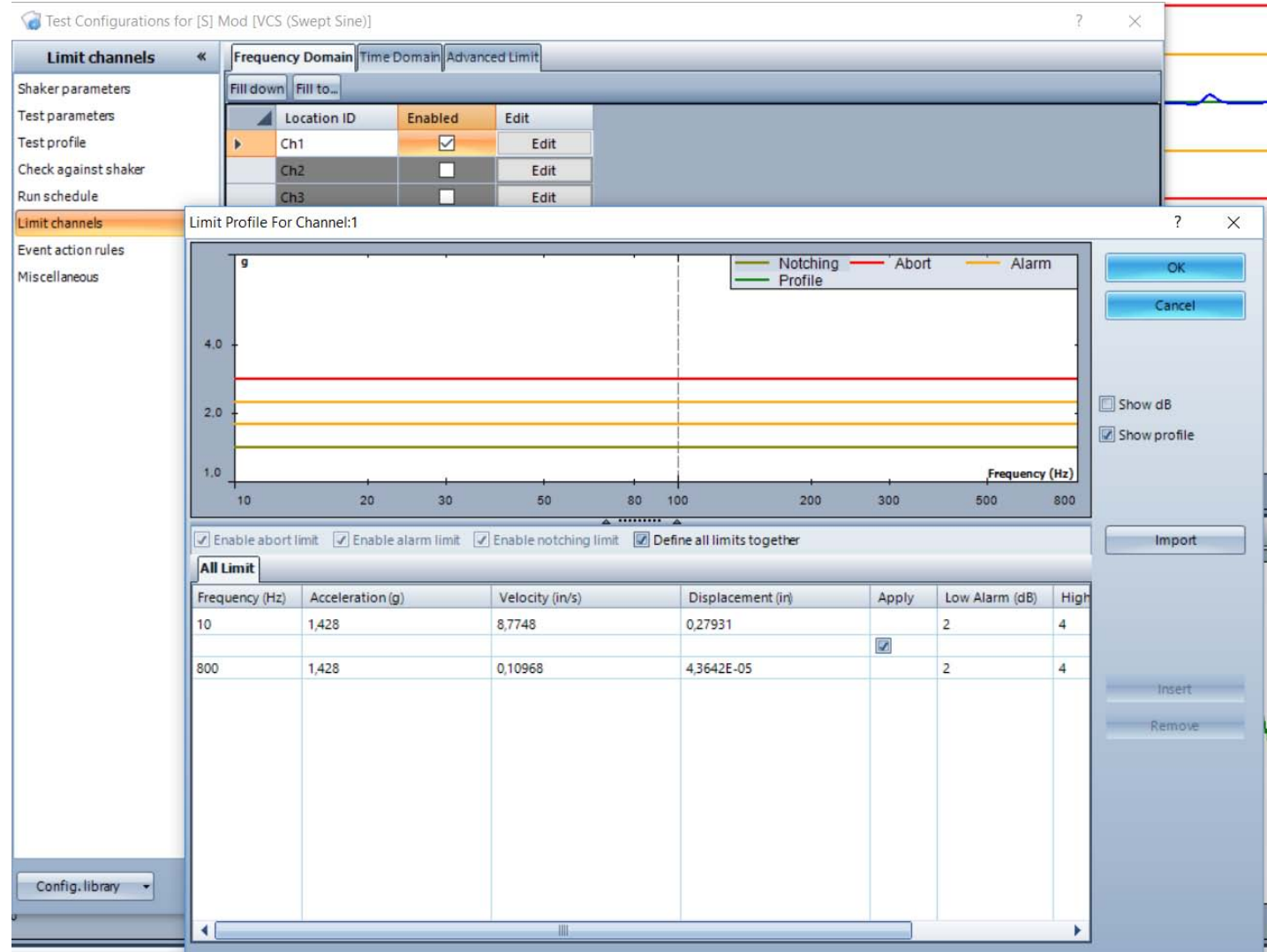
Total time of the profile: 32,768 s

eb2_PT4Z seg_new_Profile_TWRPro,
Level 10,
00%,
Repeats 1,
Scale 1

[View profile](#)

VCS Software | Limiting Setup

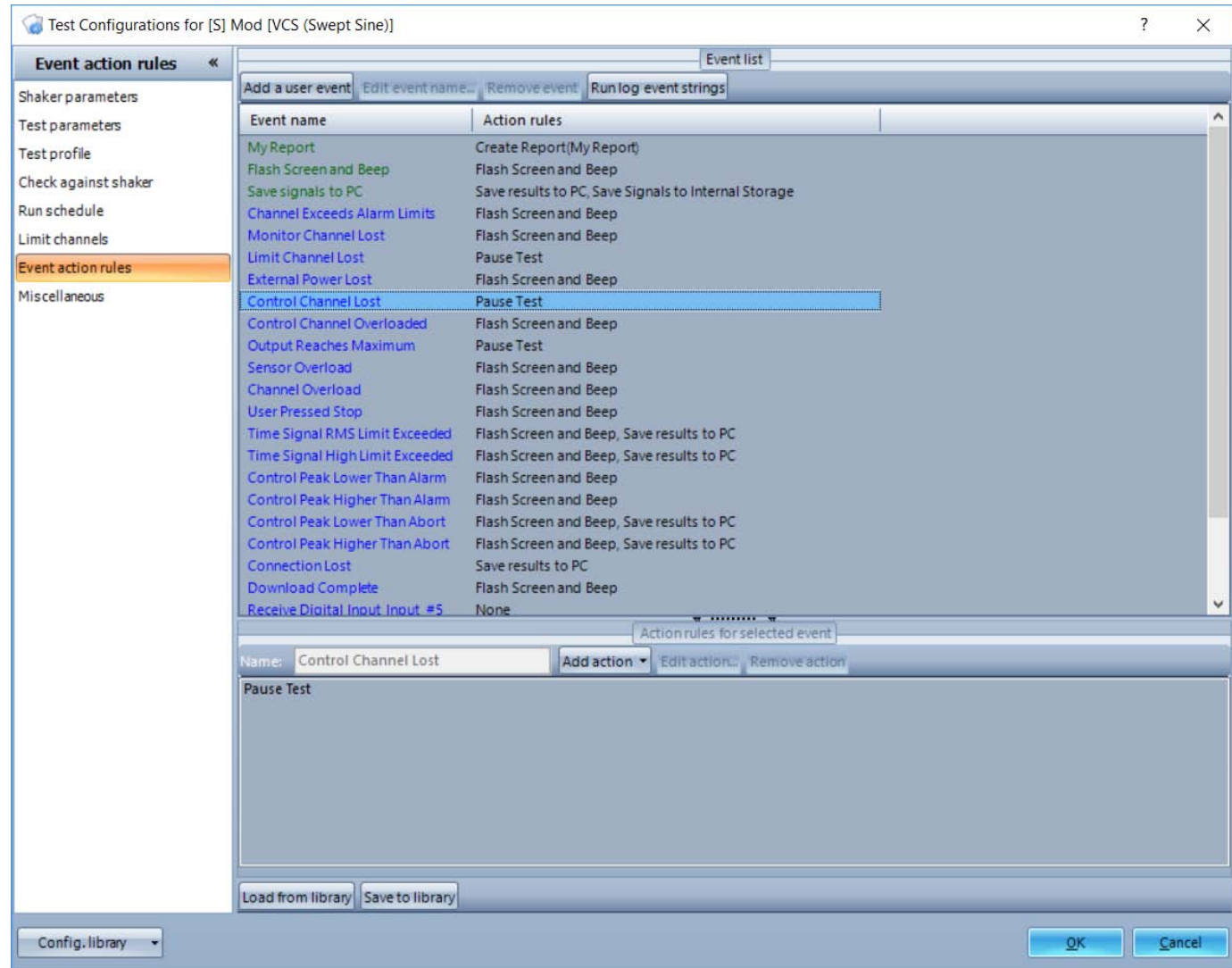
Apply customized limits to any individual channels. Limiting can be either in frequency domain or time domain



VCS Software | Event Action Rules

Test events such as alarms and digital inputs will trigger the user-assignable actions.

Actions Types: flash screen, beep, create report, save screen, send emails, send Windows message to other programs, 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 etc..



Sine: Data Saving Settings

Test Configurations for [S] Mod [VCS (Swept Sine)]

Miscellaneous « Record and Save Options Second Output Resolution of Time Block Time Stats Settings

Shaker parameters
Test parameters
Test profile
Check against shaker
Run schedule
Limit channels
Event action rules
Miscellaneous

Note: Time Streams are recorded to Spider internal storage and need to be downloaded before review.
Signals to be saved are defined in the measured signals tab.

Save results to PC under the following conditions

☐ When test starts
☐ When scheduled entry starts
☒ When test aborts
☐ When test pauses
☒ When test is finished
☐ Every 1 sweeps, starting from 1 sweep
☐ Every 100000 Cycles
☐ Sweep number 1,2,3-5
☐ All Sweeps
☐ Every 90 s

Following results will be saved

☒ Signals
☒ Composite window
☐ Active signal window
☐ All signal windows
☐ Software screenshot

☐ Auto convert frequency domain signal to Excel format
☐ Enter file name when manually save signals.
☐ Enter file name when manually record signals.

File name options

Record file name prefix REC Sequence number starts from: 343779826
Save file name prefix SIG Sequence number starts from: 69

Note: When there is already a file with the same name in the folder, keep both files(a number will be appended to the name of the latter file).

Config. library OK Cancel

Shock and TTH: Data Saving Settings

Test Configurations for Shock - Demo5 [VCS (Shock)]

Miscellaneous « Record and Save Options Second Output Time Stats Settings

Shaker parameters
Test parameters
Pre-test parameters
Test profile
SRS analysis
Shock abort limit
Limit channels
Run schedule
Event action rules
Miscellaneous

Note: Time Streams are recorded to Spider internal storage and need to be downloaded before review.
Signals to be saved are defined in the measured signals tab.

Save results to PC under the following conditions

☐ Pulse number 1,2,3-5
☐ At end of each level
☐ All pulses
☒ When test aborts
☐ When test pauses
☐ When control exceeds the limits
☒ When test is finished
☐ Every 90 s
☐ Every 1 pulses, starting from 1 pulse

Following results will be saved

☒ Signals
☒ Composite window
☐ Active signal window
☐ All signal windows
☐ Software screenshot

☐ Auto convert frequency domain signal to Excel format
☐ Enter file name when manually save signals.
☐ Enter file name when manually record signals.

File name options

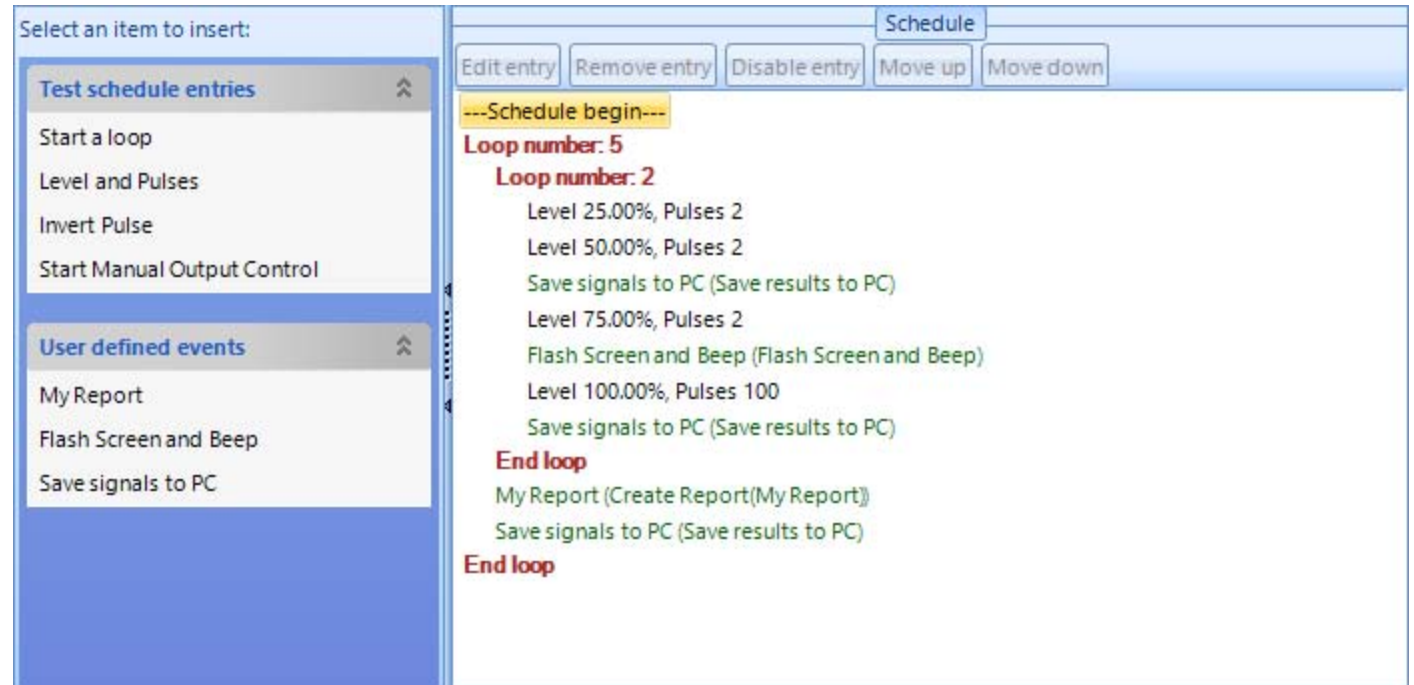
Record file name prefix REC Sequence number starts from: 3
Save file name prefix SIG Sequence number starts from: 1

Note: When there is already a file with the same name in the folder, keep both files(a number will be appended to the name of the latter file).

Config. library OK Cancel

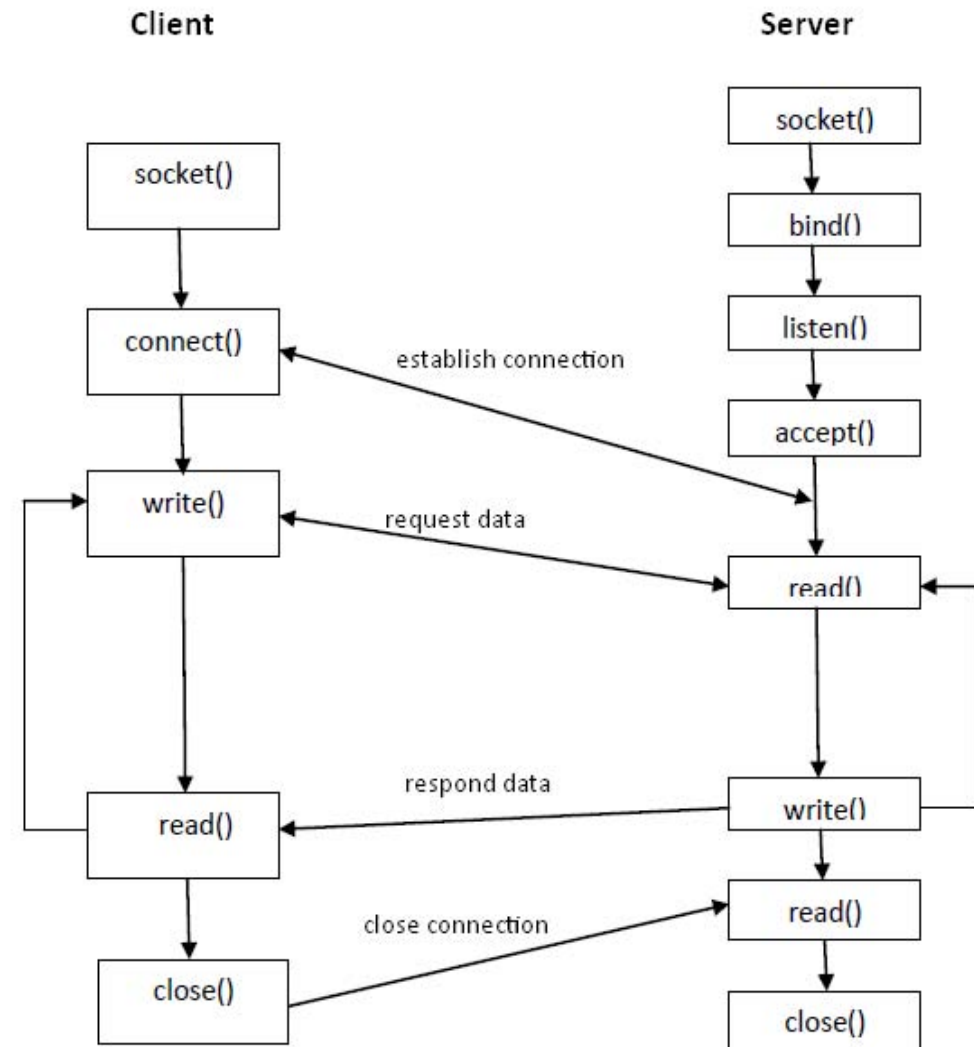
VCS Software | Run Schedule

- 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 schedule can also activate any user-defined events defined in the Event Action Rules.



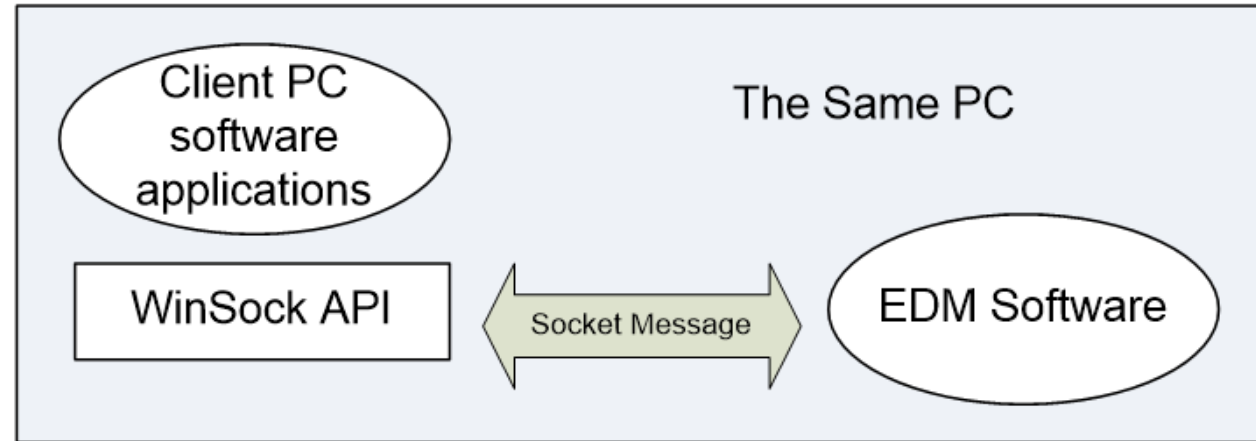
VCS Software | Socket Message

- Socket Messages are a means by which different processes on the same or different host computers can communicate with each other.
- This communication can be for data sharing, synchronization, test configuration or control, and can be between processes on the same computer or across a network.
- EDM Socket Messages are transmitted via either Ethernet port or serial port.



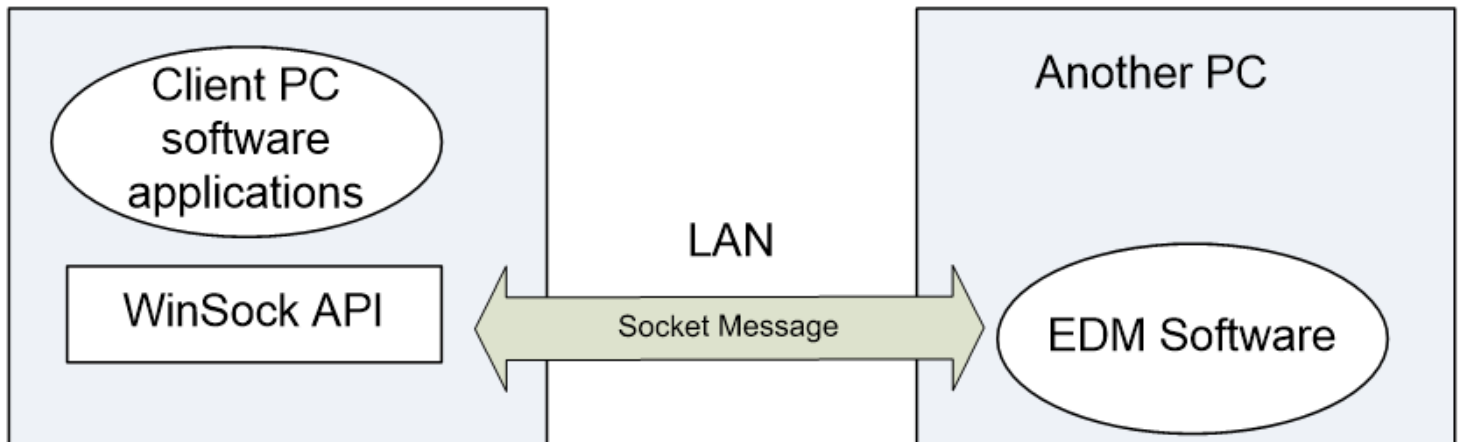
VCS Software | Socket Message

Communications on the same PC.



Communications on the different PC's.

Communication goes through LAN or RS-232

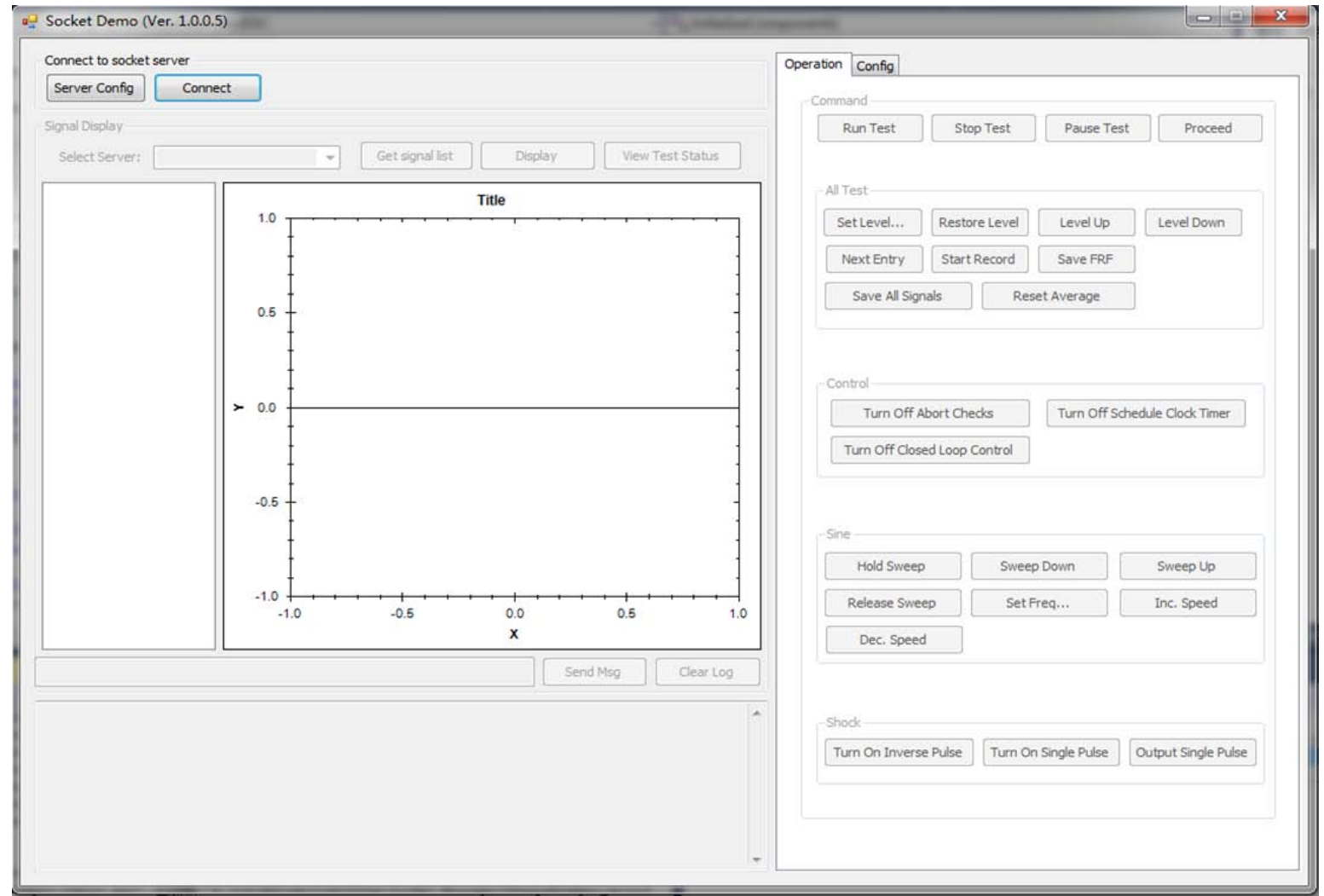


VCS Software | Socket Message User Interface

Socket client can be built as powerful as EDM-VCS.

CI offers over 50 socket commands to the users. And this number is still increasing.

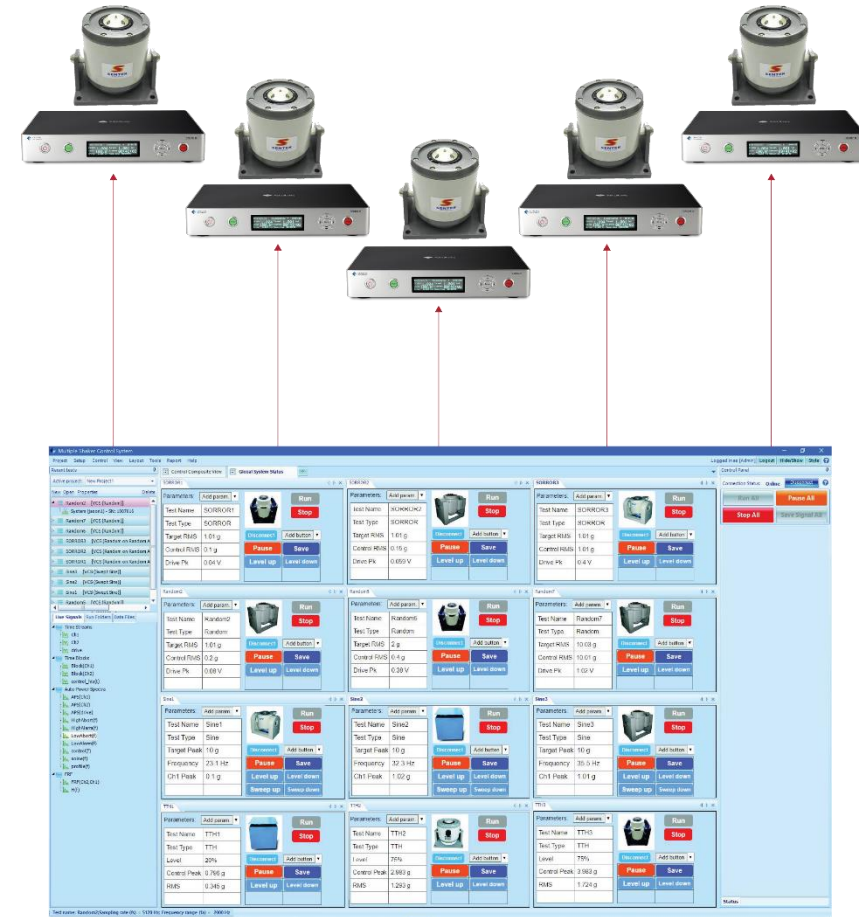
It supports both C++ and C#.



VCS Software | Multi-Shaker Control (MSC)

- MSC stands for Multi-Shaker Control, a function designed to control multiple shakers from one EDM instance
- Customizable push-buttons and displays for each shaker object
- Ideal for production testing

*Note: CI uses **MIMO Control** to describe the system that requires the control with time and phase correlation.*



VCS Software | Multi-Shaker Control (MSC)

- EDM feature to enable users to control and monitor multiple shaker tests from one PC station
- Single axis control; support up to 12 controllers
- Currently supports Sine, Random, SOR, ROR
- Common commands for all controllers
- Custom display/control panel for each test



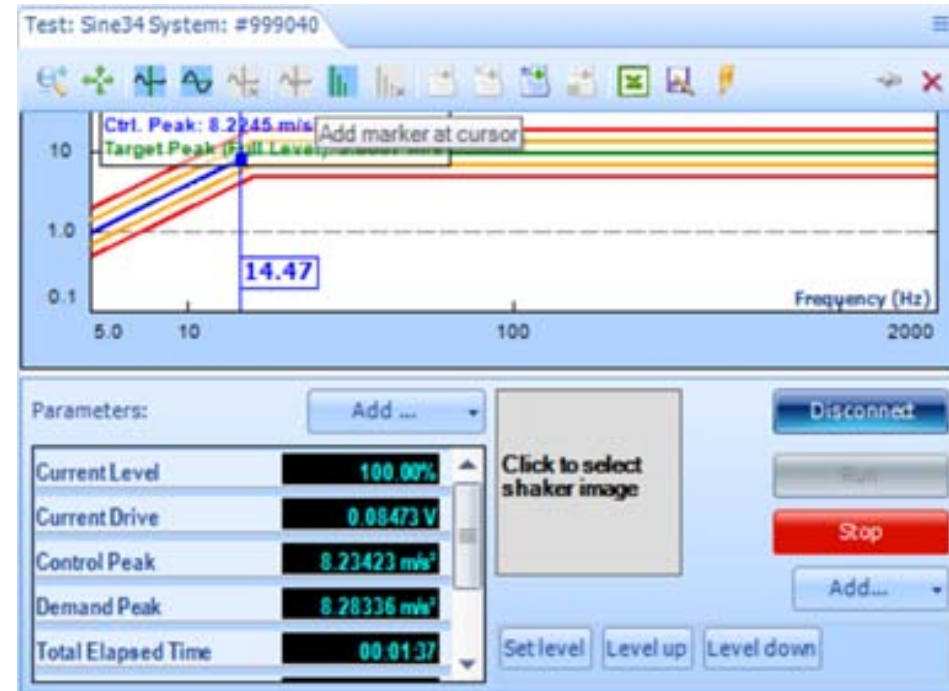
VCS Software | Multi-Shaker Control (MSC)

- Similar GUI to VCS
- Central control panel for all tests
- Manage multiple projects (each project contains multiple controllers)



VCS Software | Multi-Shaker Control (MSC)

- Composite view and/or status view
- Upload shaker image
- Add/delete control commands
- Add/ delete status parameters



VCS Software | Multi-Shaker Control (MSC)

- One-click start/stop for all controllers
- Independently control each test
- Individually adjust layout for each system
- Individually configure test profile for each system



MIMO Control uses a highly sophisticated algorithm to general multiple drives to meet the target of multiple profiles.

MIMO Testing Standards

- Mil-Std-810G Method 527
- IEST-RP-DTE022
- IEEE 344 Seismic Testing
- Transportation Time waveform Replication

MIMO Control Types

- MIMO Random
- MIMO Sine
- MIMO Classical Shock
- MIMO SRS
- MIMO Time Waveform Replication



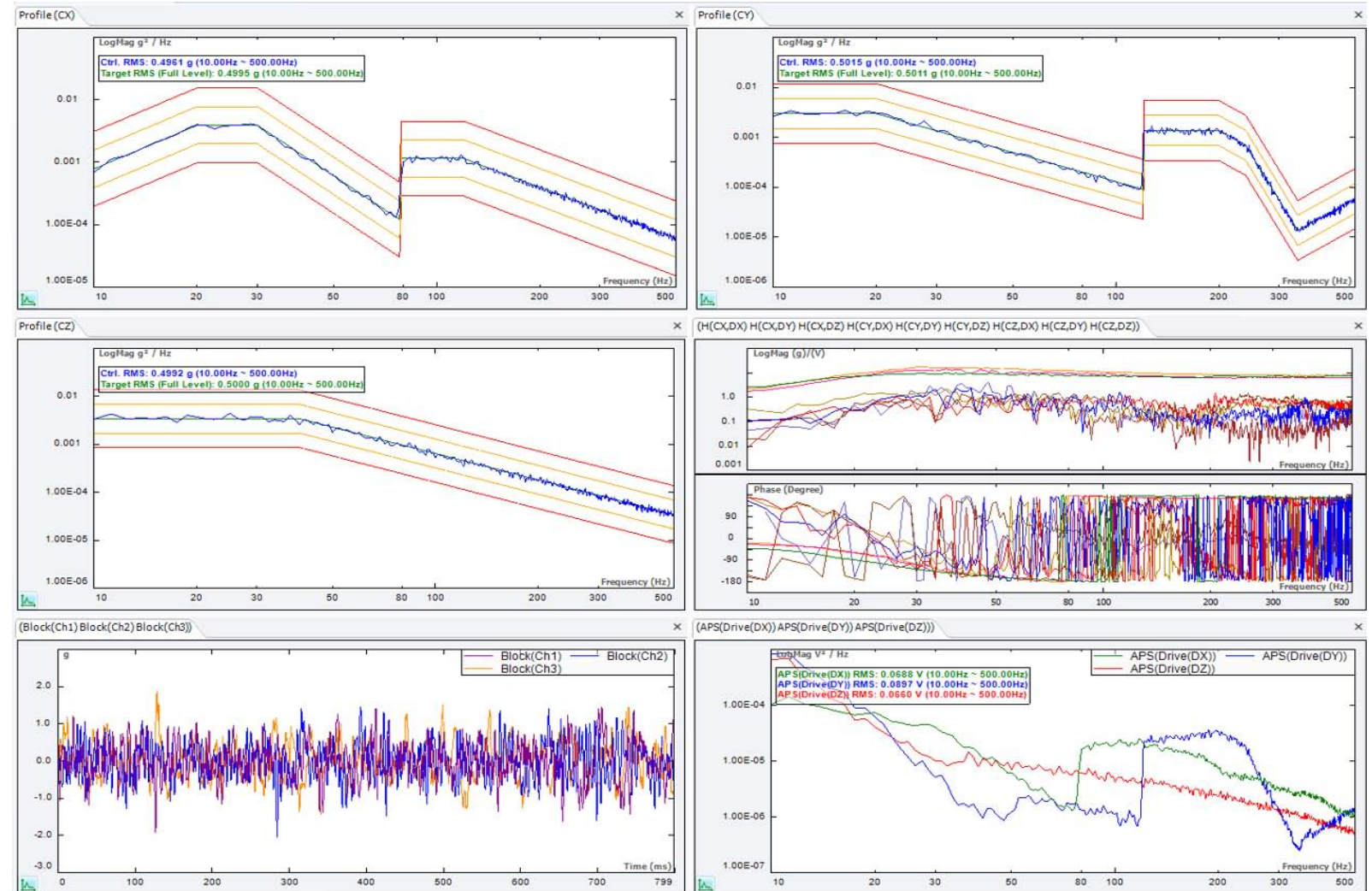
VCS Software | Dual-shaker Control, a Special case of MIMO Control

- Enables the system to output two random or sine drive signals simultaneously to control two shakers.
- The phase difference between each drive and control signal is calculated and taken into account during real-time operation.
- Apply to two shaker systems in push-pull or parallel configurations.



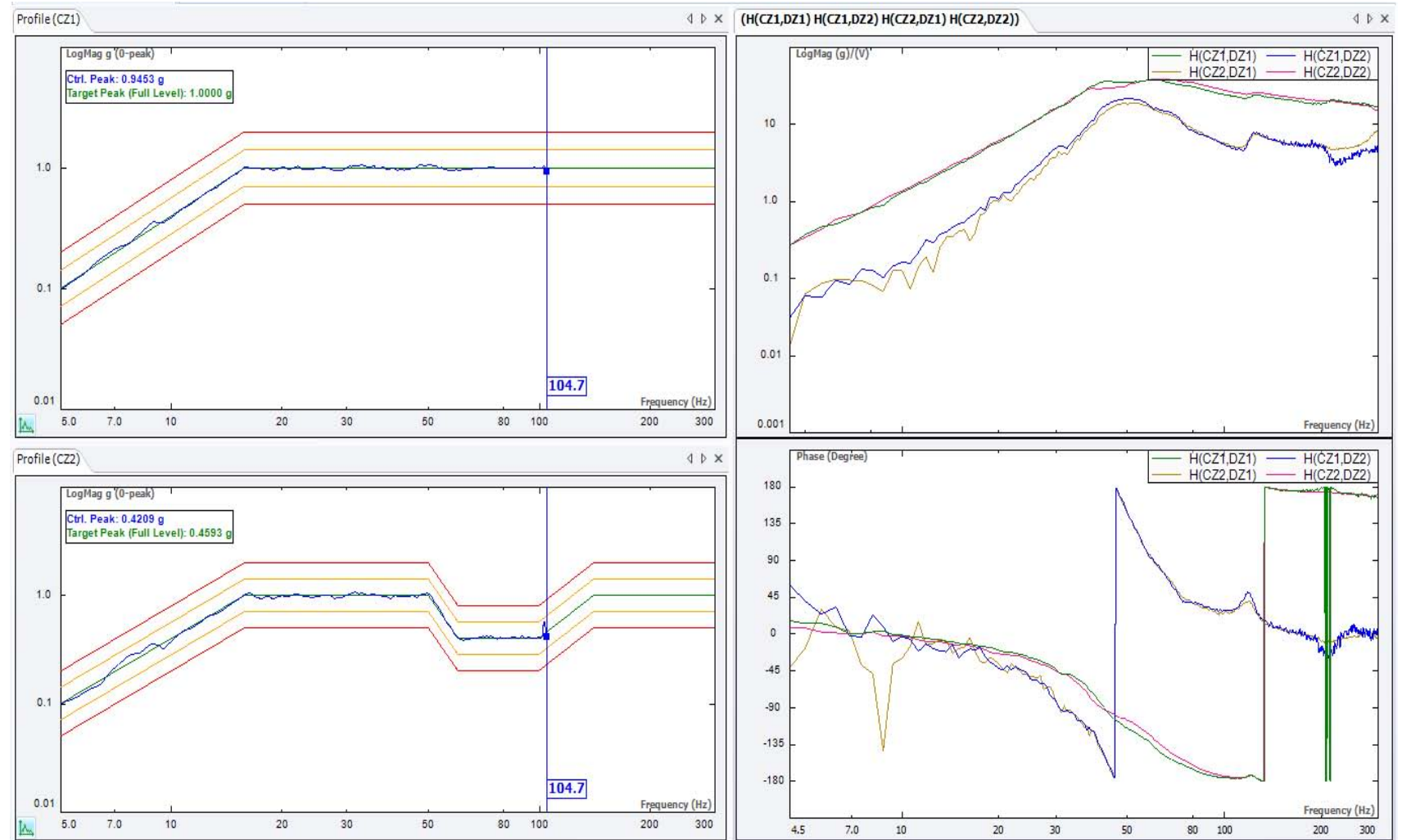
MIMO Random Control

MIMO Random supports up to 512 input channels, and up to 3 output channels (shakers). Besides the control channels, the rest input channels can be set up as monitoring and time data recording channels. The recording option records time stream data at the full sample rate on all input channels.



MIMO Sine Control

The MIMO Sine Control System provides precise, real-time, multi-channel control and analysis. MIMO Sine supports up to 512 input channels, and up to 3 output channels (shakers). Input channels can be enabled for control, monitoring, and time data recording channels.

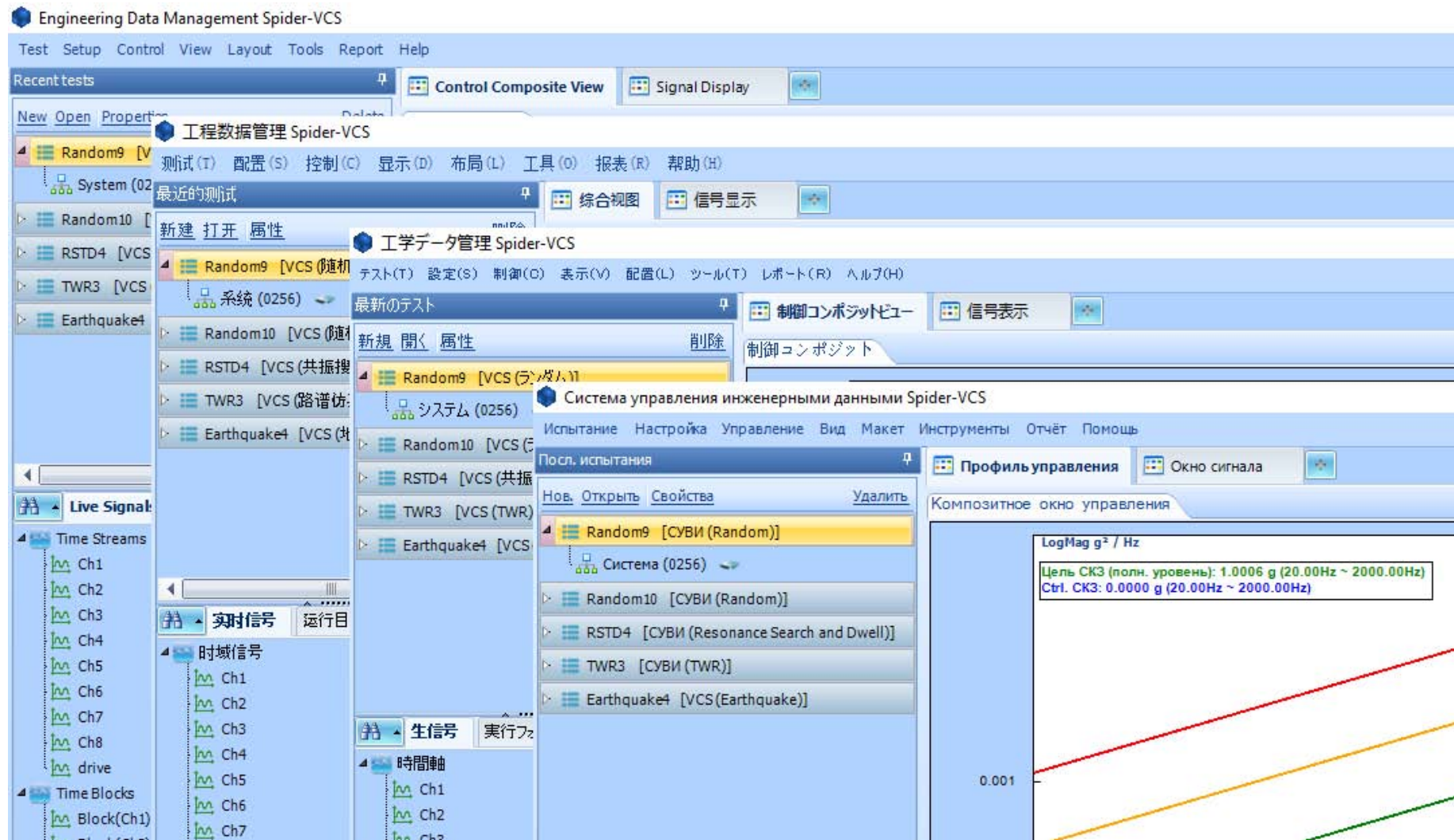


Multiple languages are supported (switch languages without reinstalling software.)

- English
- Chinese (simplified) - 简体中文
- Chinese (traditional) - 繁體中文
- Japanese - 日本語
- Russian - русский

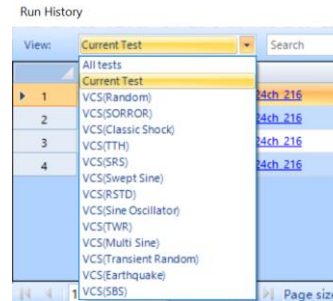


VCS Software | Multiple Languages



VCS Software | Run History

- Skim through Run History of the current test, selected test type, and all tests
- Keyword search by test name
- Sortable column titles
- Displays for test notes, description, run log and saved files



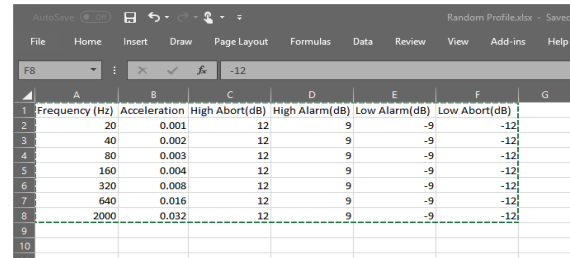
The screenshot shows the 'Run History' window with a table of runs. The table has columns: Date, Test, Run duration, Test type, End condition, User, Run folder, and File count. The selected run is highlighted in orange.

	Date	Test	Run duration	Test type	End condition	User	Run folder	File count
1	2019-08-15 17:12:09	Rand_24ch_216	00:14:25	VCS(Random)	User Abort	Admin		0
2	2019-08-15 16:46:17	Rand_24ch_216	00:04:23	VCS(Random)	User Abort	Admin	Run3 Aug 15, 2019 16:47-16	2
3	2019-08-15 16:45:34	Rand_24ch_216	00:00:21	VCS(Random)	User Abort	Admin		0
4	2019-08-15 16:42:42	Rand_24ch_216	00:01:59	VCS(Random)	User Abort	Admin		0

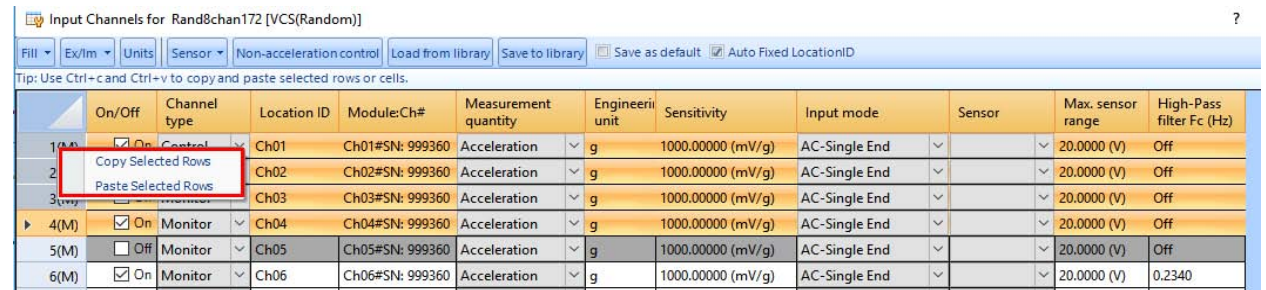
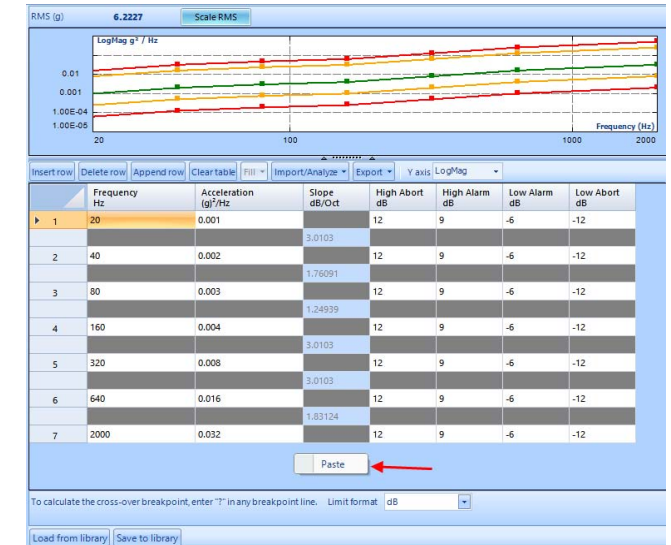
Below the table, there is a section for the selected run (Rand_24ch_216) with tabs for 'Run Log' and 'Saved Files'. The 'Run Log' tab is active, showing a detailed log of events including 'Schedule not finished: User Abort', 'Flash Screen and Beep', 'Stop the Test', 'Schedule Level', 'System Alarm', 'Start Schedule', 'Pretest Finished', 'Running in pre-test', and 'Measuring Noise'.

VCS Software | Copy and Paste

- Copy/paste breakpoint table from Excel into Random/Sine Profile
- Copy/paste settings between two different channels

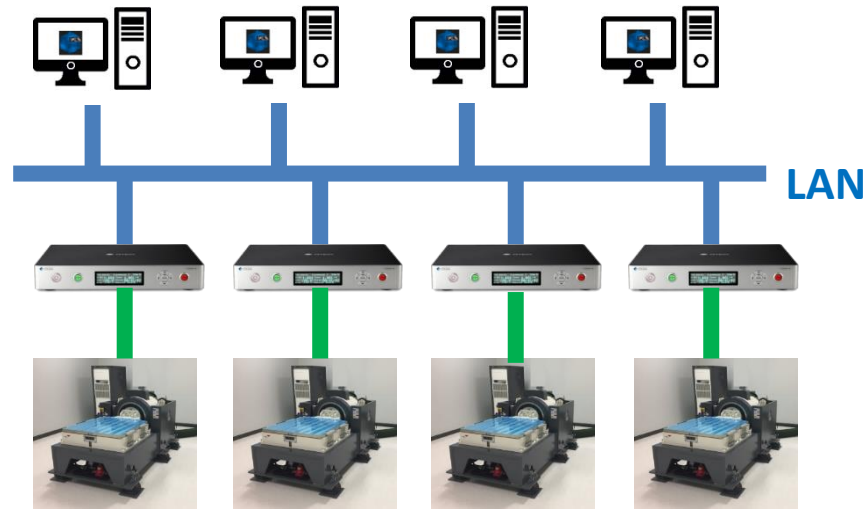


Frequency (Hz)	Acceleration	High Abort (dB)	High Alarm (dB)	Low Alarm (dB)	Low Abort (dB)
20	0.001	12	9	-9	-12
40	0.002	12	9	-9	-12
80	0.003	12	9	-9	-12
160	0.004	12	9	-9	-12
320	0.008	12	9	-9	-12
640	0.016	12	9	-9	-12
2000	0.032	12	9	-9	-12

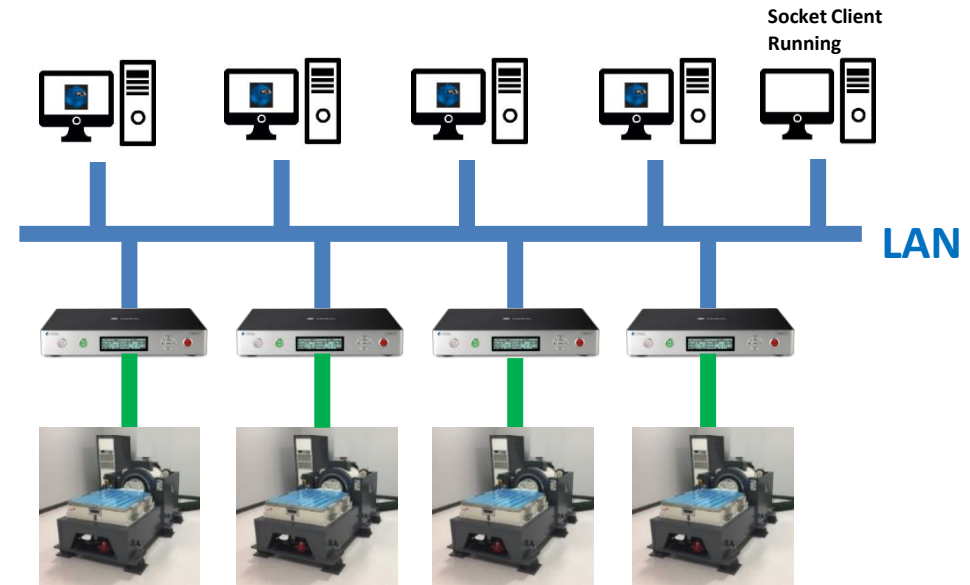


On/Off	Channel type	Location ID	Module:Ch#	Measurement quantity	Engineer unit	Sensitivity	Input mode	Sensor	Max. sensor range	High-Pass filter Fc (Hz)
1(M)	On Control	Ch01	Ch01#SN: 999360	Acceleration	g	1000.00000 (mV/g)	AC-Single End		20.0000 (V)	Off
2(M)	On Control	Ch02	Ch02#SN: 999360	Acceleration	g	1000.00000 (mV/g)	AC-Single End		20.0000 (V)	Off
3(M)	On Control	Ch03	Ch03#SN: 999360	Acceleration	g	1000.00000 (mV/g)	AC-Single End		20.0000 (V)	Off
4(M)	On Monitor	Ch04	Ch04#SN: 999360	Acceleration	g	1000.00000 (mV/g)	AC-Single End		20.0000 (V)	Off
5(M)	Off Monitor	Ch05	Ch05#SN: 999360	Acceleration	g	1000.00000 (mV/g)	AC-Single End		20.0000 (V)	Off
6(M)	On Monitor	Ch06	Ch06#SN: 999360	Acceleration	g	1000.00000 (mV/g)	AC-Single End		20.0000 (V)	0.2340

VCS Software | Multiple VCS Instances

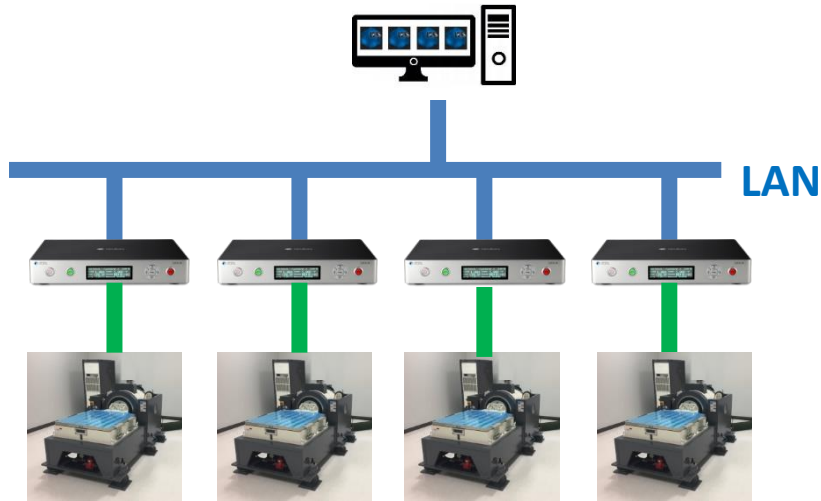


One instance per PC



One instance per PC, central control and monitoring on socket client

VCS Software | Multiple VCS Instances

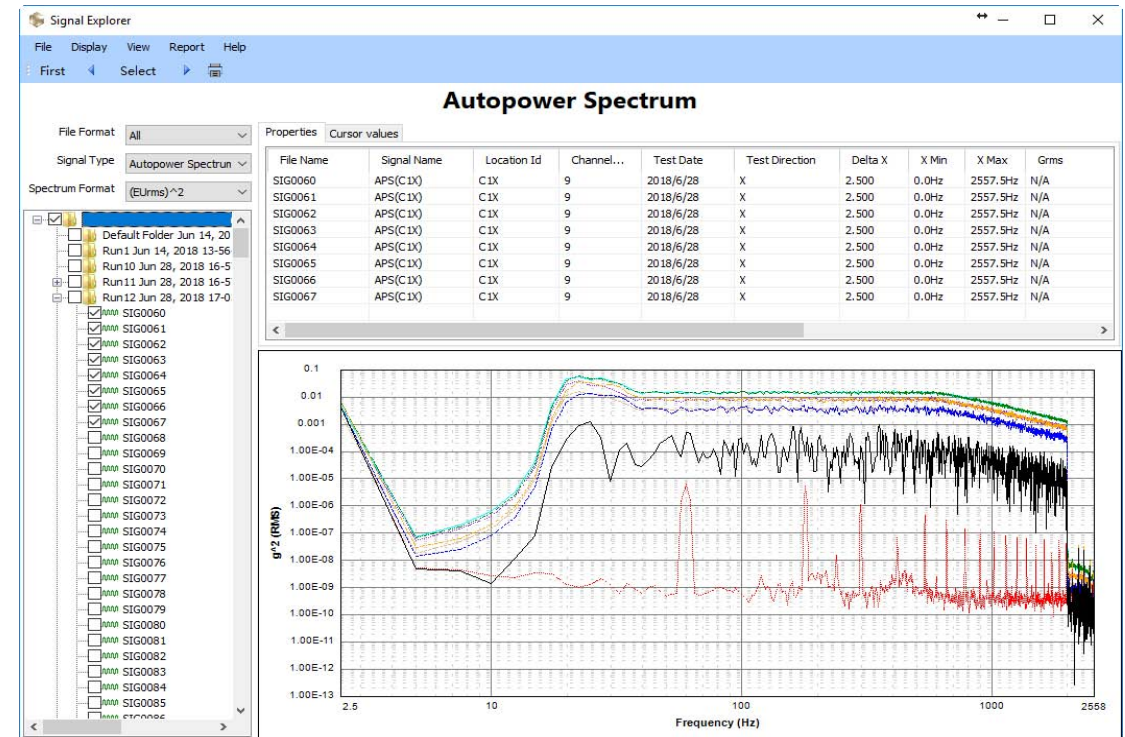


Multiple instances on one PC,
central control and monitoring



Signal Explorer | Portable tool

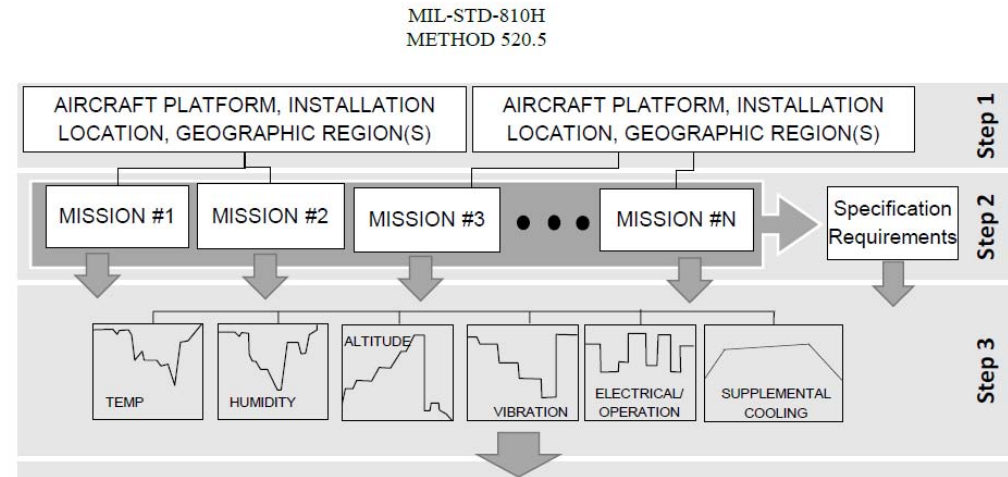
- Portable and lightweight: no installation required
- Tree structure for finding signal files quickly
- Compare the same signal for the same channel in multiple files (up to 8)
- Click once to switch to the next channel



Combined Environmental Testing

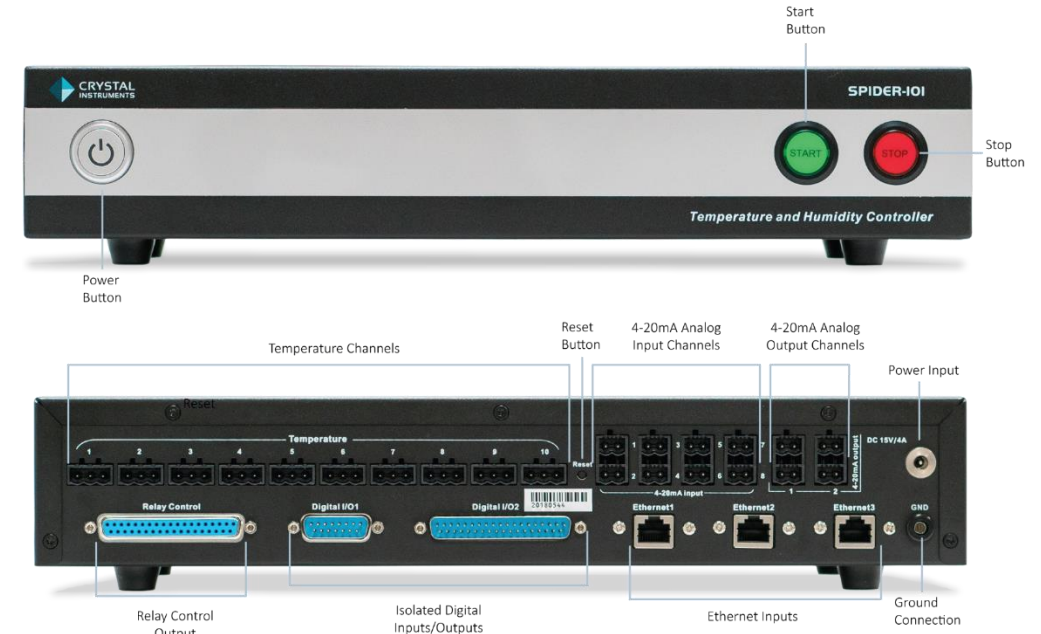
Industry trend: simultaneous control of multiple physical quantities

- Vibration
- Temperature
- Humidity
- Electrical power
- Altitude

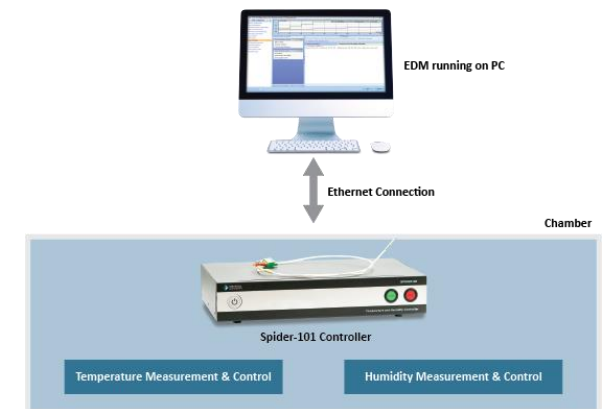
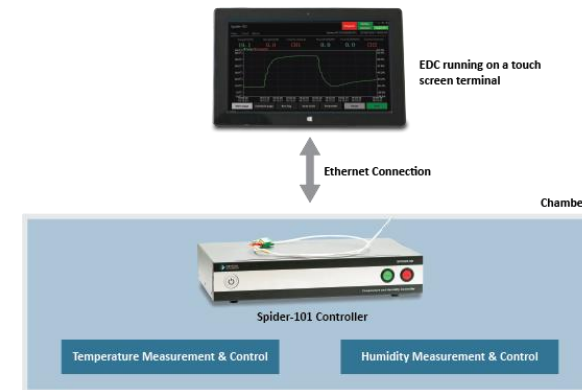
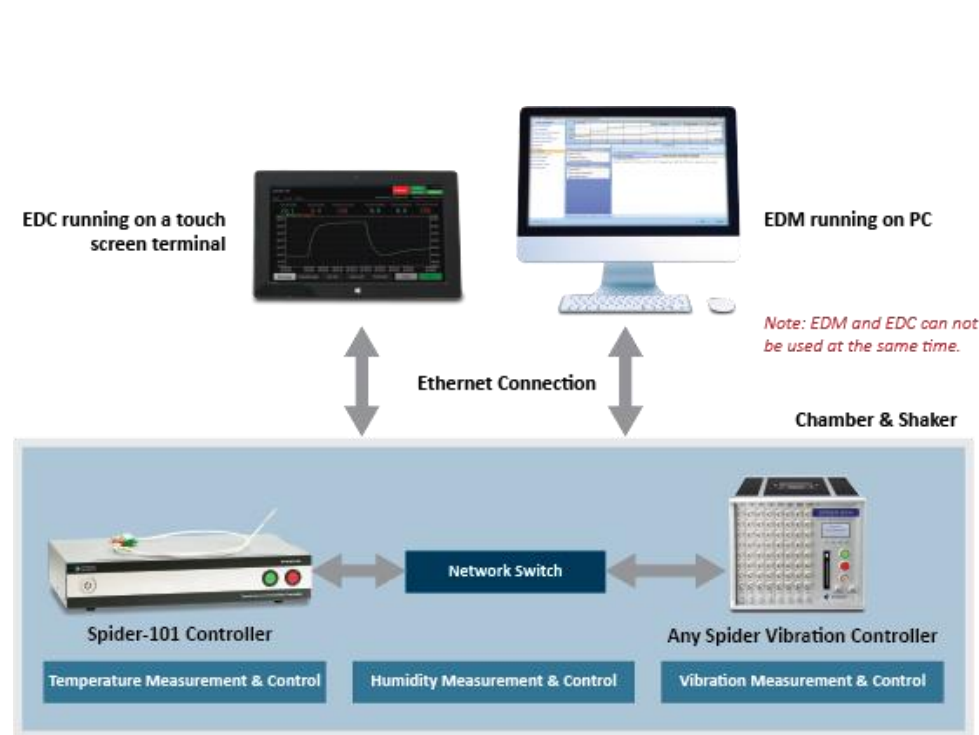


Combined Testing | Spider -101 Hardware

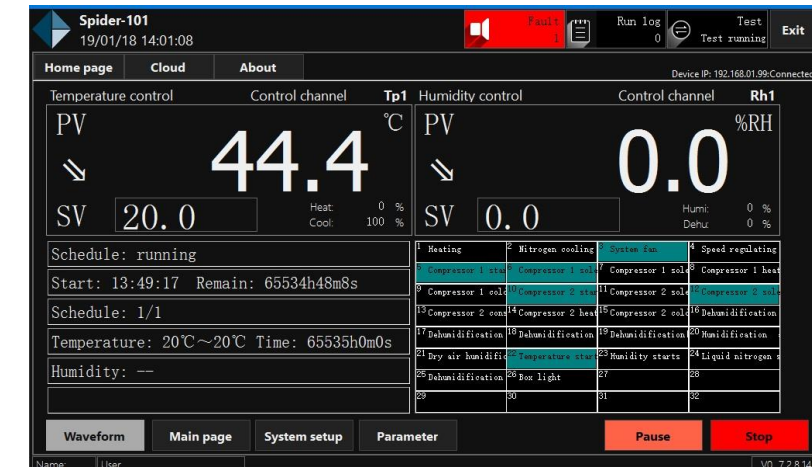
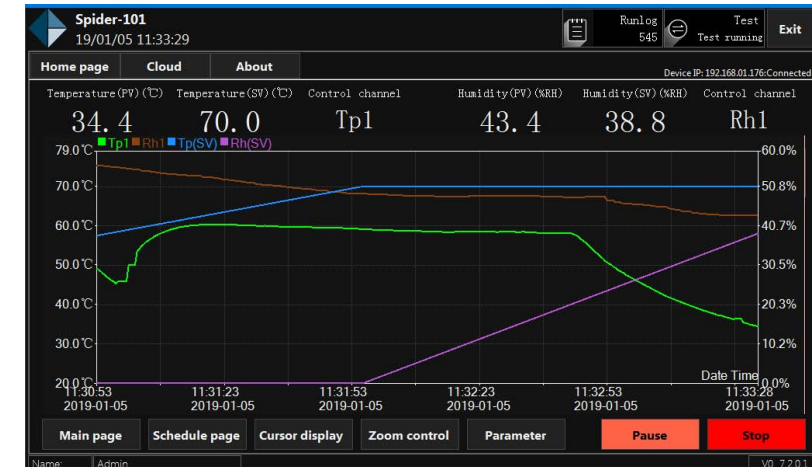
- A controller fully integrated with any shaker controller from Crystal Instruments for the application of **combined testing**.
 - One integrated setup
 - One clock and schedule
 - One user interface
 - One testing report
 - One vendor to provide the support
- Two software user interfaces:
 - EDC: Embedded Device Control, a touch screen user interface running on a Windows 10 tablet
 - EDM: PC software interface to control T, H and V



Combined Testing | Typical Configurations



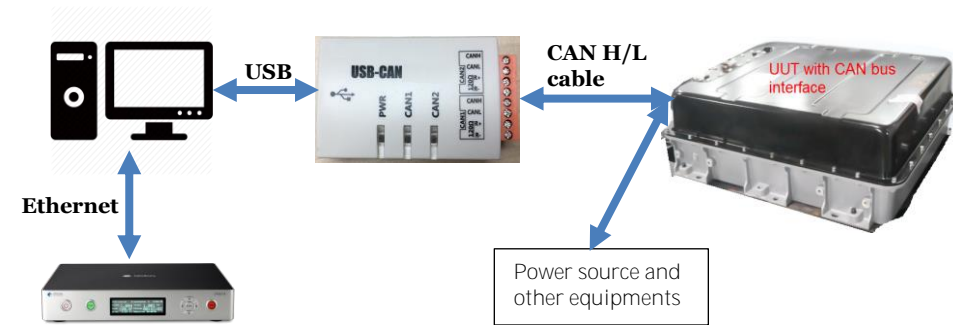
Combined Testing | EDM THV and EDC UI



- Growing market and investment in electric vehicles (EV)
- EV battery hazards and safety requirements
- Popular standards for vibration or environmental testing on EV batteries
 - SAE J2380 (2013): Vibration testing of EV batteries
 - ISO 12405-1 (2011): Test specs for Lithium-Ion battery packs and systems
 - SAE J2464 (2009): EV/HEV rechargeable energy storage system and abuse testing
 - UN 38.3: Transportation testing for Lithium cells and batteries

Battery Testing | Tested with integrated CAN bus support

- Integrate CAN bus settings in EDM
- View raw data and signals
- Set alarm/abort and color codes when exceeded
- Automatic system reactions to CAN bus messages



Complete Product Lines from Crystal Instruments



VCS: Vibration Control System



RCM: Remote Condition Monitoring



WE: Waveform Editor



FECT: Front-End Calibration Tool



M-Builder: Machine Builder



DSA: Dynamic Signal Analyzer mode



MSC: Multi-Shaker Control



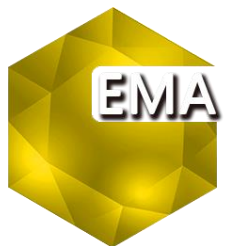
CoCo DSA: EDM for CoCo Dynamic Signal Analyzer mode



PA: Post Analyzer



VDS: Vibration Diagnostics System



EMA: Experimental Modal Analysis



IP Config: IP Configuration Tool



TRANSFER: Data Transfer Tool



CoCo VDC: EDM for CoCo VDC mode



THV: Temperature, Humidity, and Vibration Control System

The End

Thank you!



GERÄTE UND SYSTEME FÜR
FORSCHUNG • ENTWICKLUNG • VERSUCH • SERVICE

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