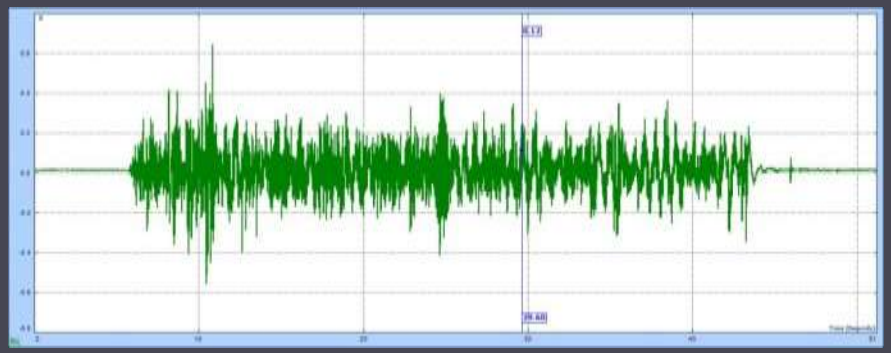


New Time Waveform Control Features

(TTH, TWR, and SRS Synthesis)

What is Time Waveform Control?

- Reproduction of Time Waveforms
  - Time domain transients
  - Recorded data
  - Imported data
- Synthesis of Shock Response Spectra (SRS)
- Applications
  - Seismic
  - Road simulation
  - Bellcore testing

CRYSTAL instruments

Implementation in EDM

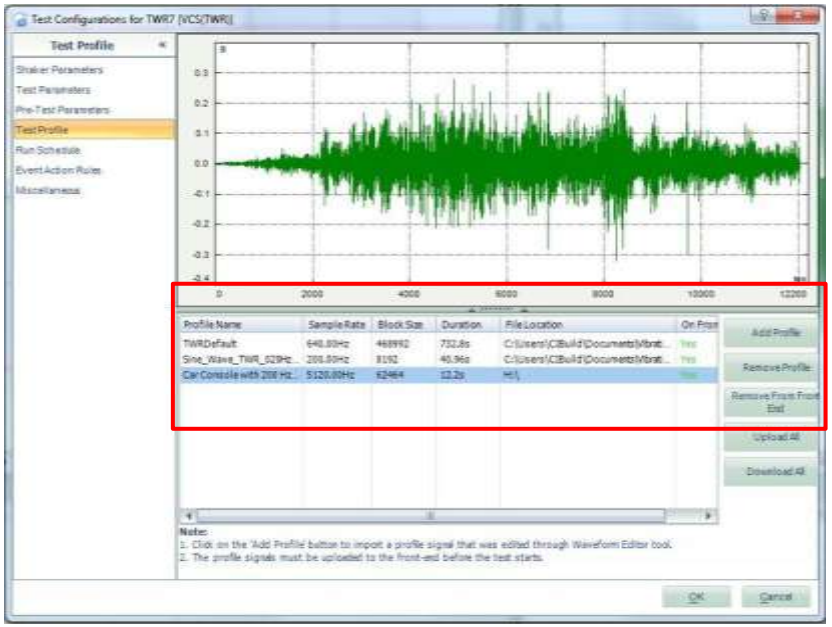
- Transient Time History (TTH) Control
  - Short duration transient waveforms
- Time Waveform Replication (TWR)
  - Arbitrarily long waveforms
- SRS Synthesis Control
  - Waveform from Required Response Spectrum (RRS)

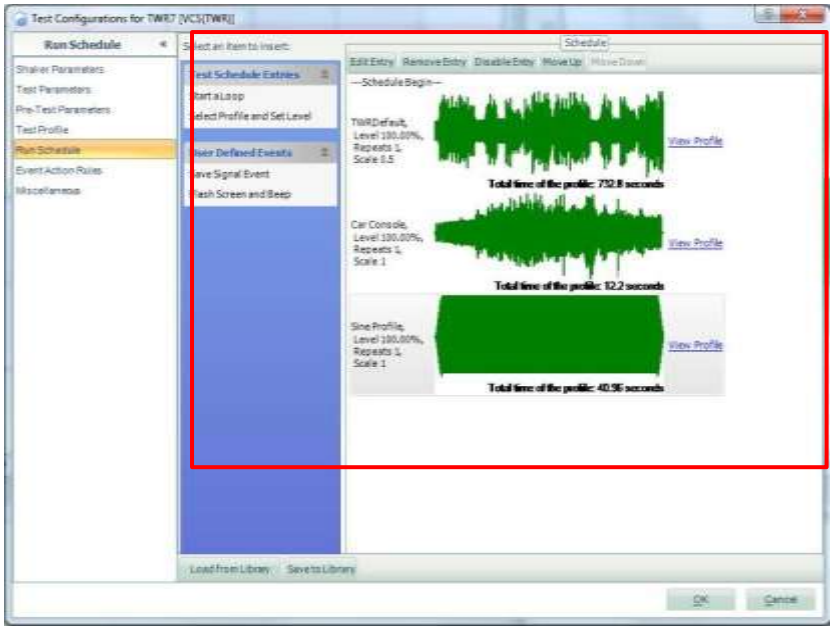
TWR – What's New

- Multiple profiles in Schedule
- Multi-point Control
- Long Waveform Recording
- Now Includes EDM Waveform Editor – Import and Edit Waveforms of different file types

TWR - Multiple profiles in Schedule

- Any number of profiles can be added in 4GB hardware memory space and played back in schedule

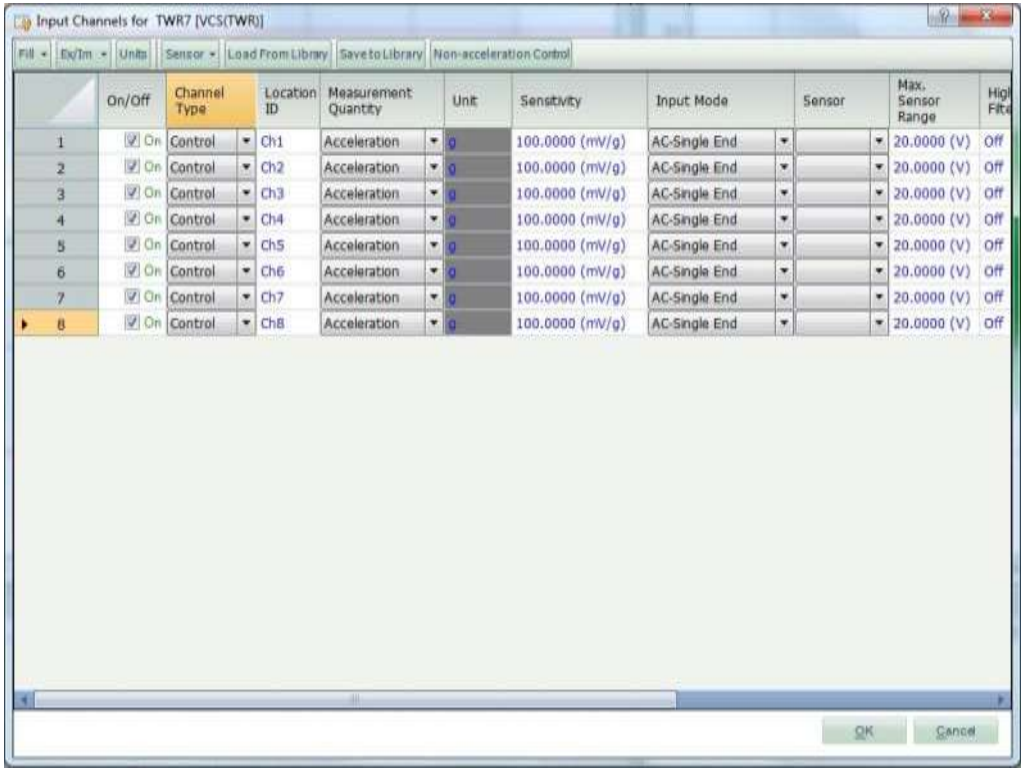




CRYSTAL instruments

TWR – Multi Point Control

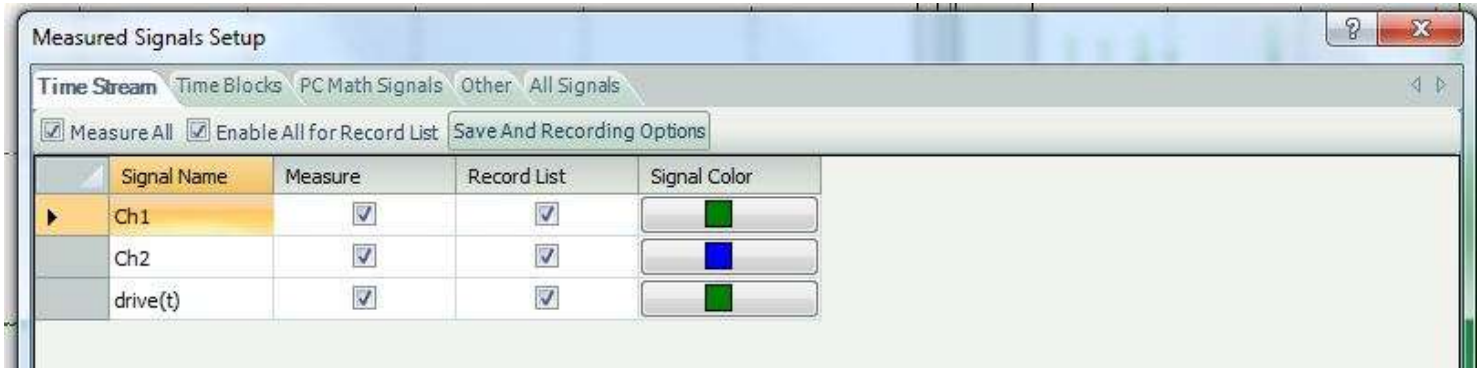
- Up to 8 control channels on the master module can be enabled.



CRYSTAL instruments

TWR – Long Waveform Recording

- Introduced recording of Time Stream Data
- Recording can be done to the limit of the Hardware's internal flash which is 4GB.



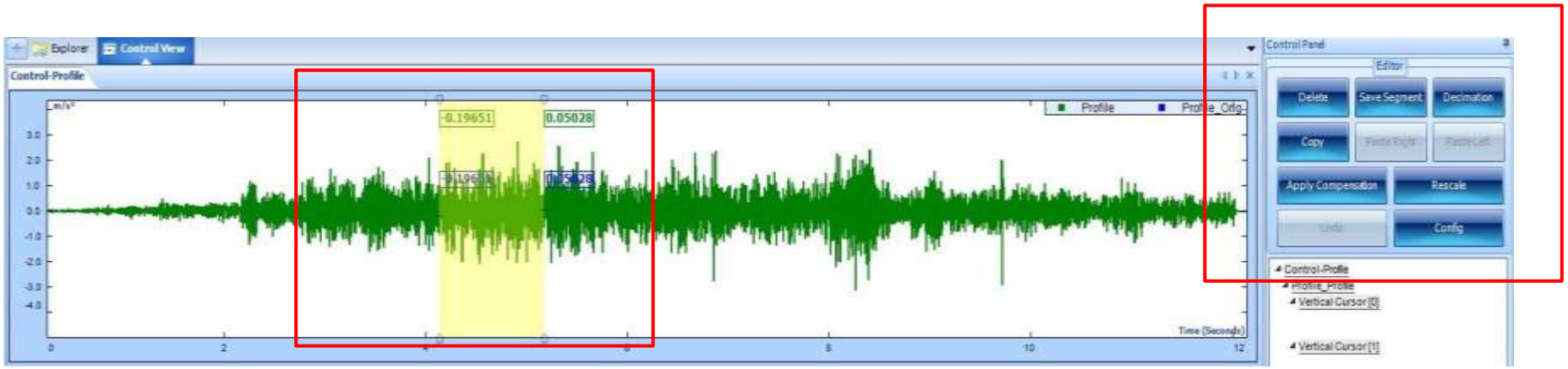
TWR: Importing and Editing Data

- Any pre-recorded time stream data
- Flexible file import
- Edit waveforms with the Time Waveform Editor

CRYSTAL instruments

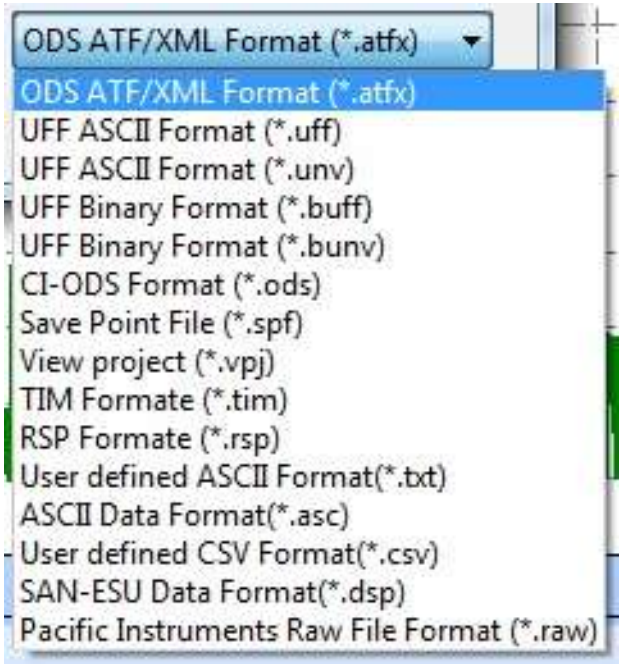
TWR: Importing and Editing Data

- Re-sampling, Decimation, Re-scaling, Selecting parts of Waveform can all be done using Waveform Editor

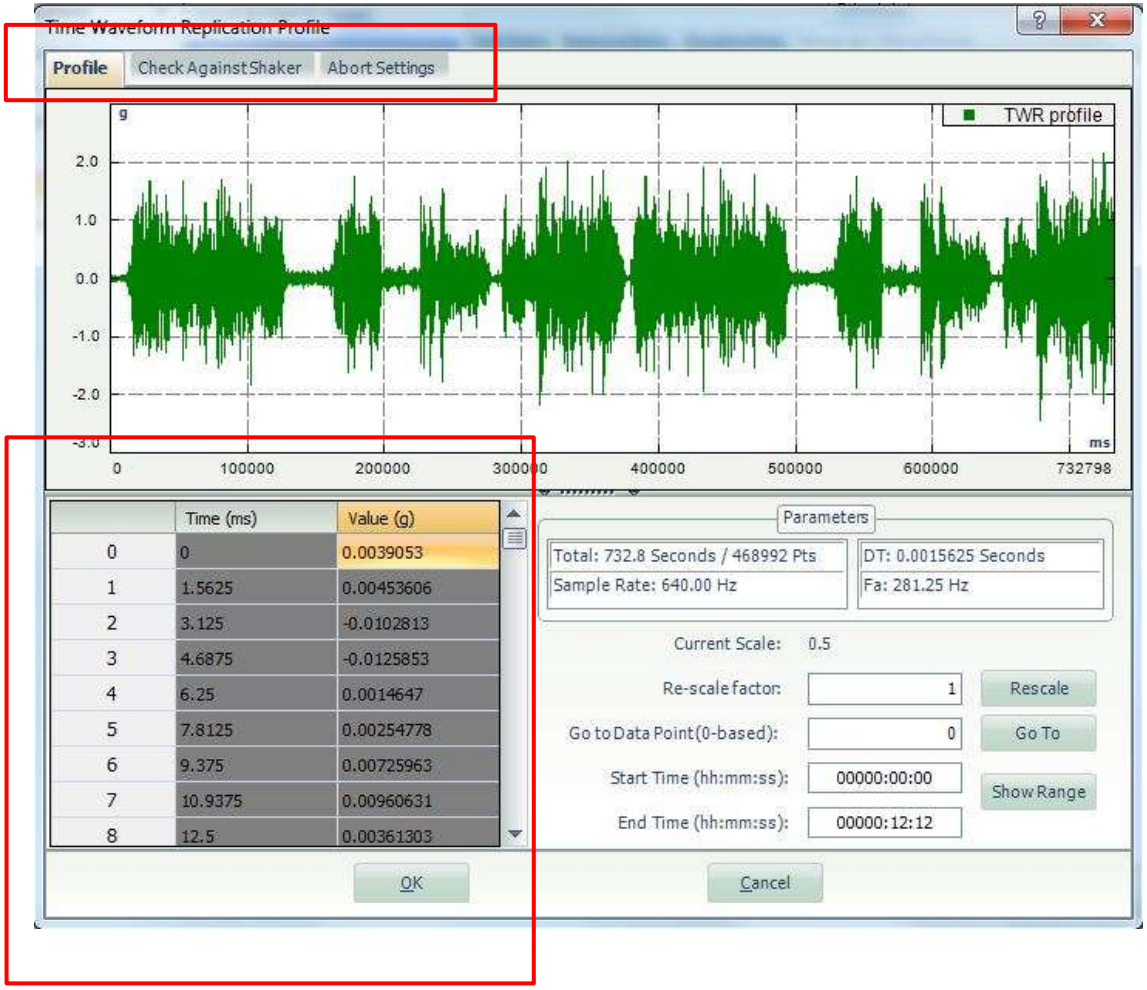


TWR: Importing and Editing Data

- Waveform Editor supports the import of multiple file types:

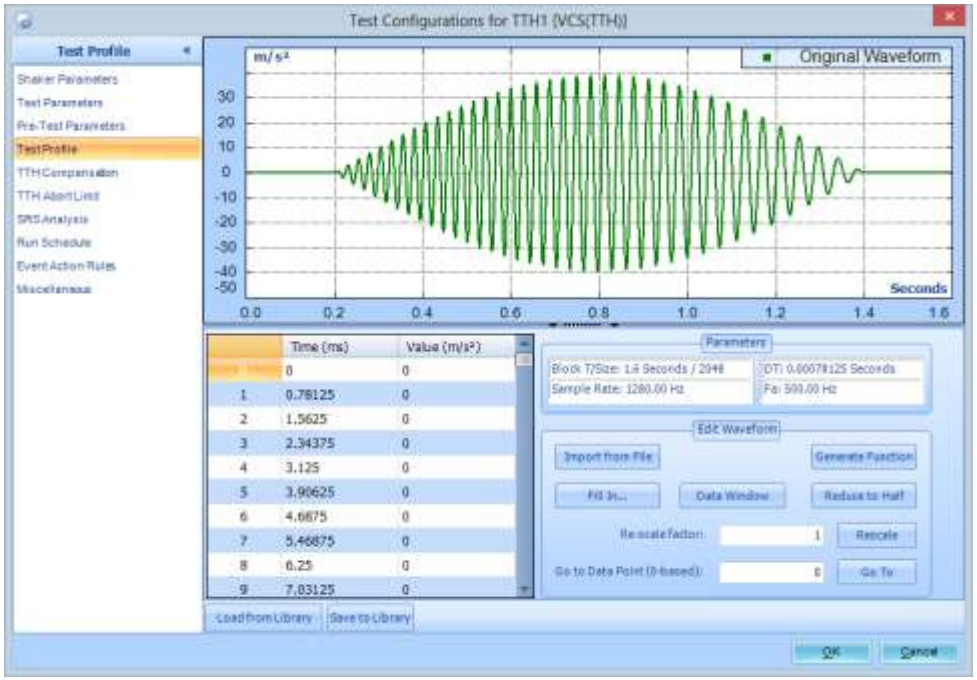


TWR: Profile Editing and Setting Shaker and Abort Limits



Transient Time History (TTH)

- Supports very large block size: up to 64k
- Building blocks: sine, triangle, & white noise
- Apply windows



TTH: What's New

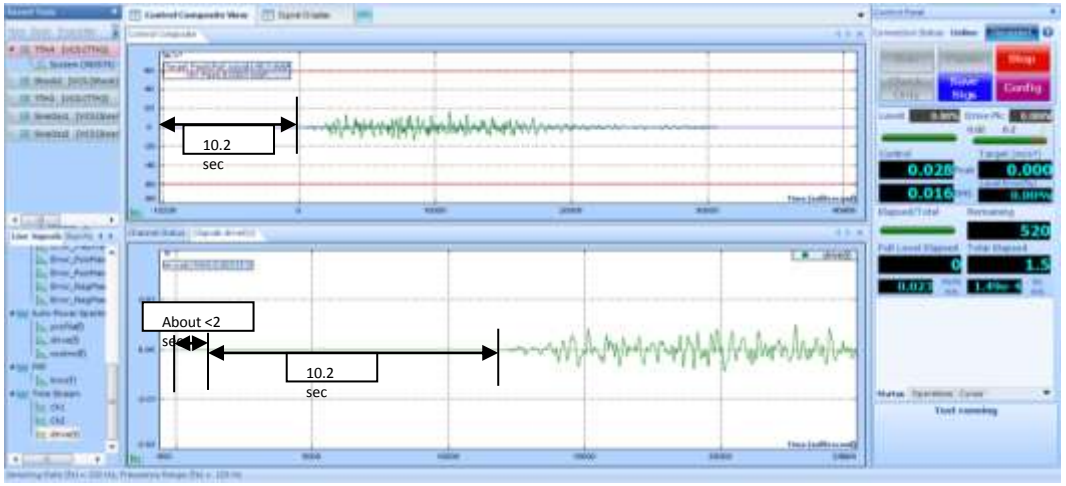
- 64K Block Size is now supported with up to 4 channels.
- Significant improvements in Pre-test
- Improved Noise measurement

64k Block Size

- Up to 4 control channels on Master module
- Up to 32 Monitor channels across 8 modules

Improved Pre-test and Noise Measurements

- Pre-test now takes up to 40% less time for profiles with long duration
- Noise measurement frame is reduced to under 5 seconds for Profile of any time length

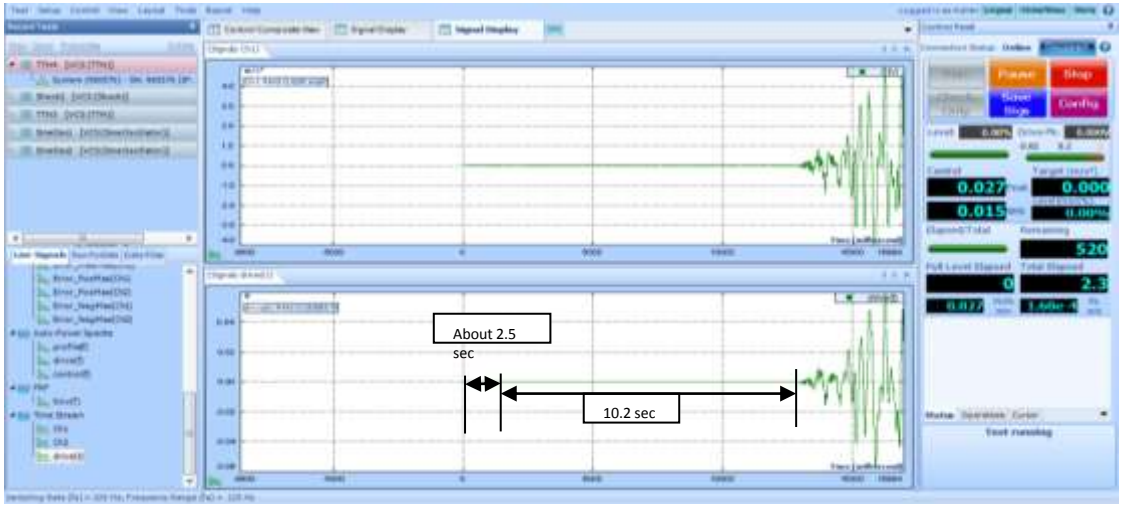


Under 2 seconds Noise frame for a frame of 50 seconds.

CRYSTAL instruments

Improved Pre-test and Noise Measurements (continued)

- Preserves the advantages of having noise measurement and takes extremely small amount of time
- Test with Saved FRF starts off immediately – ideal for Earthquake simulators

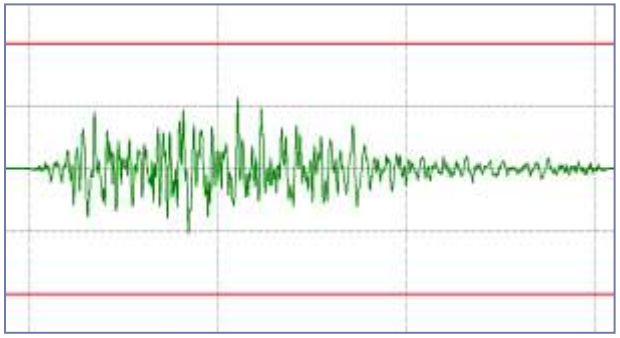


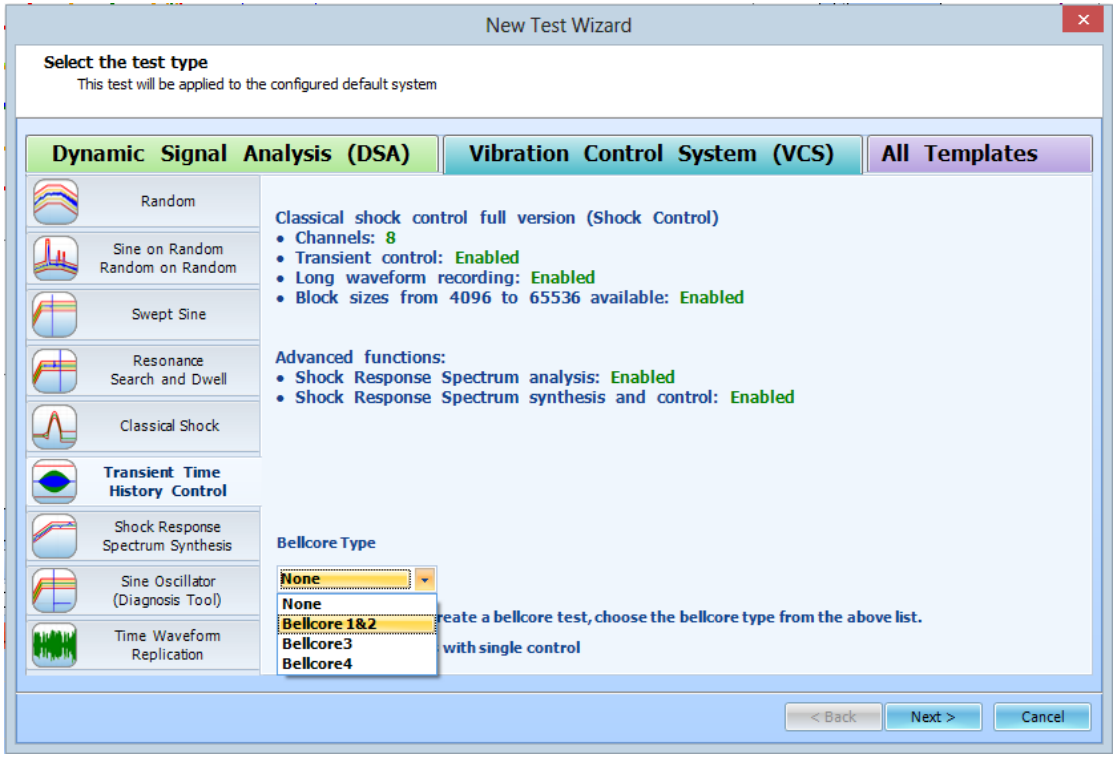
Test (of any duration) with Saved FRF starts within 3 seconds and still measures the noise floor

CRYSTAL instruments

TTH: Bellcore

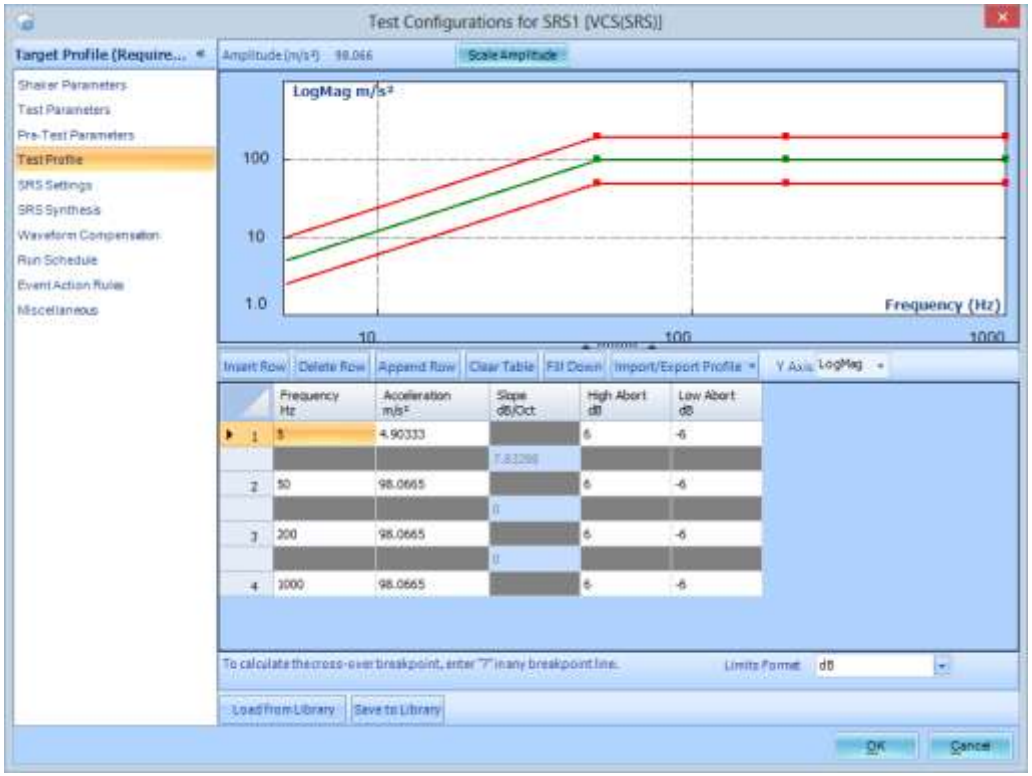
- Bellcore standard waveforms built-in





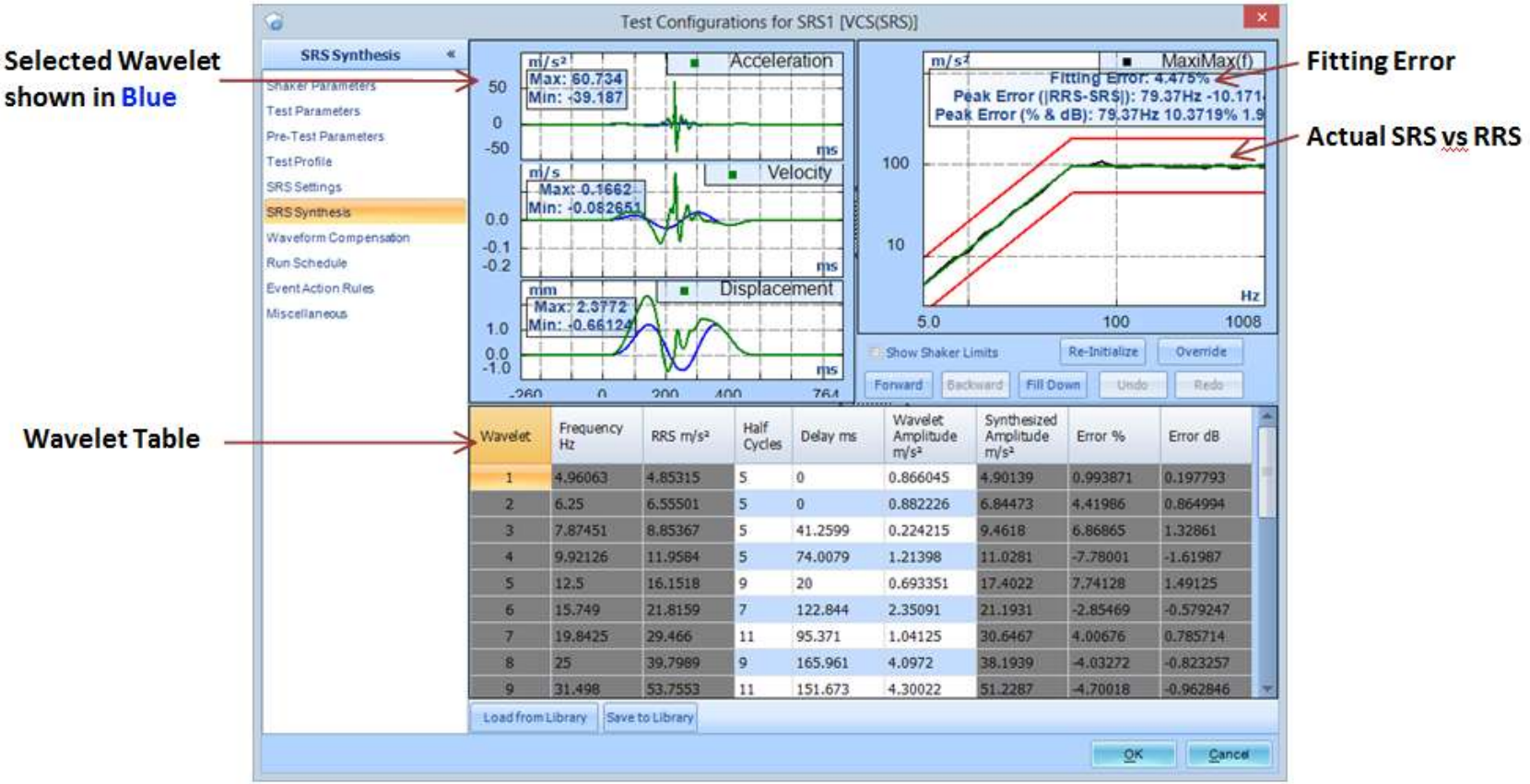
SRS Synthesis

- Test Profile is Shock Response Spectrum
- Called Required Response Spectrum (RRS)



SRS Synthesis

- Waveform generated from Sine Wavelets

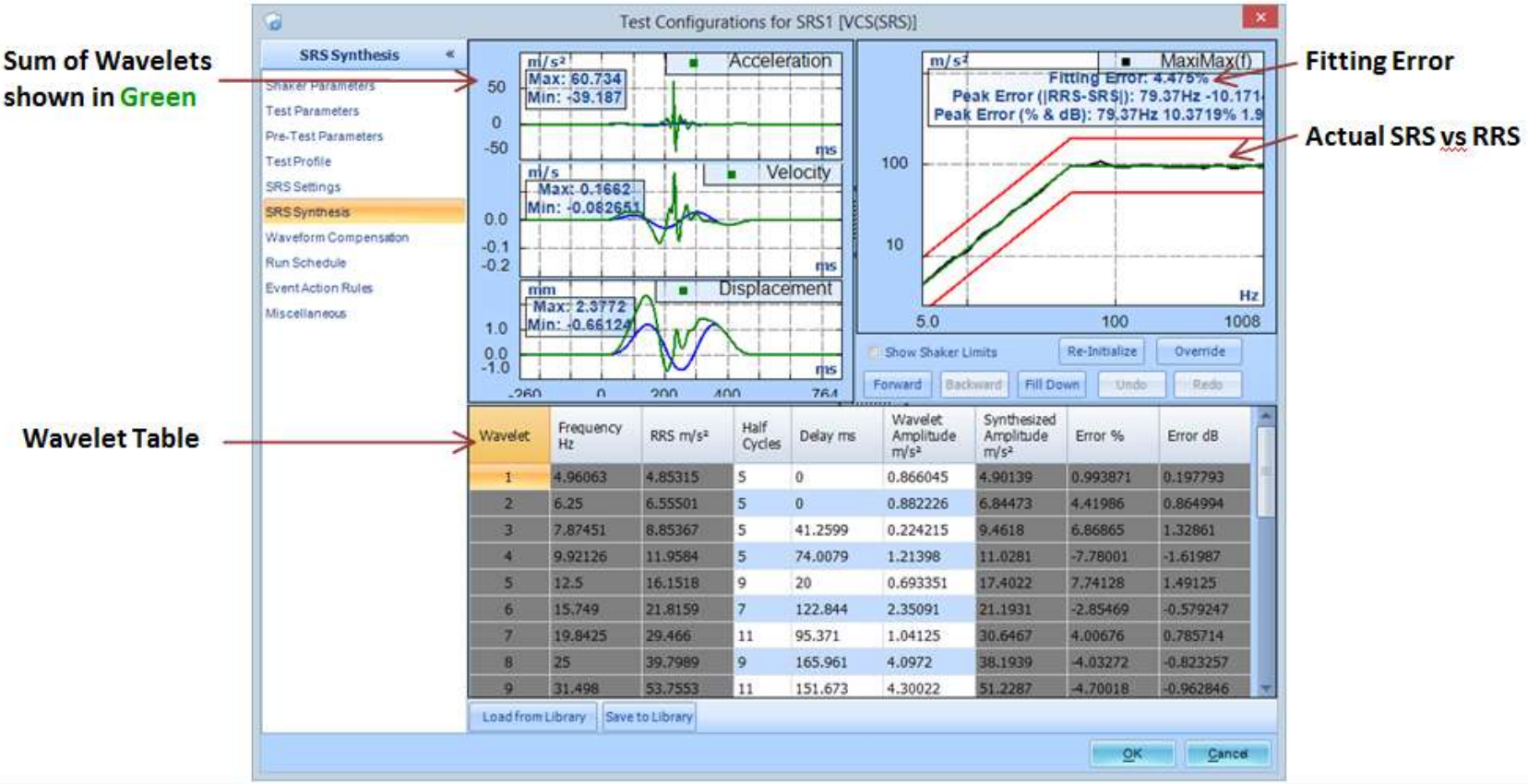


Wavelet	Frequency Hz	RRS m/s²	Half Cycles	Delay ms	Wavelet Amplitude m/s²	Synthesized Amplitude m/s²	Error %	Error dB
1	4.96063	4.85315	5	0	0.866045	4.90139	0.993871	0.197793
2	6.25	6.55501	5	0	0.882226	6.84473	4.41986	0.864994
3	7.87451	8.85367	5	41.2599	0.224215	9.4618	6.86865	1.32861
4	9.92126	11.9584	5	74.0079	1.21398	11.0281	-7.78001	-1.61987
5	12.5	16.1518	9	20	0.693351	17.4022	7.74128	1.49125
6	15.749	21.8159	7	122.844	2.35091	21.1931	-2.85469	-0.579247
7	19.8425	29.466	11	95.371	1.04125	30.6467	4.00676	0.785714
8	25	39.7989	9	165.961	4.0972	38.1939	-4.03272	-0.823257
9	31.498	53.7553	11	151.673	4.30022	51.2287	-4.70018	-0.962846

CRYSTAL instruments

SRS Synthesis

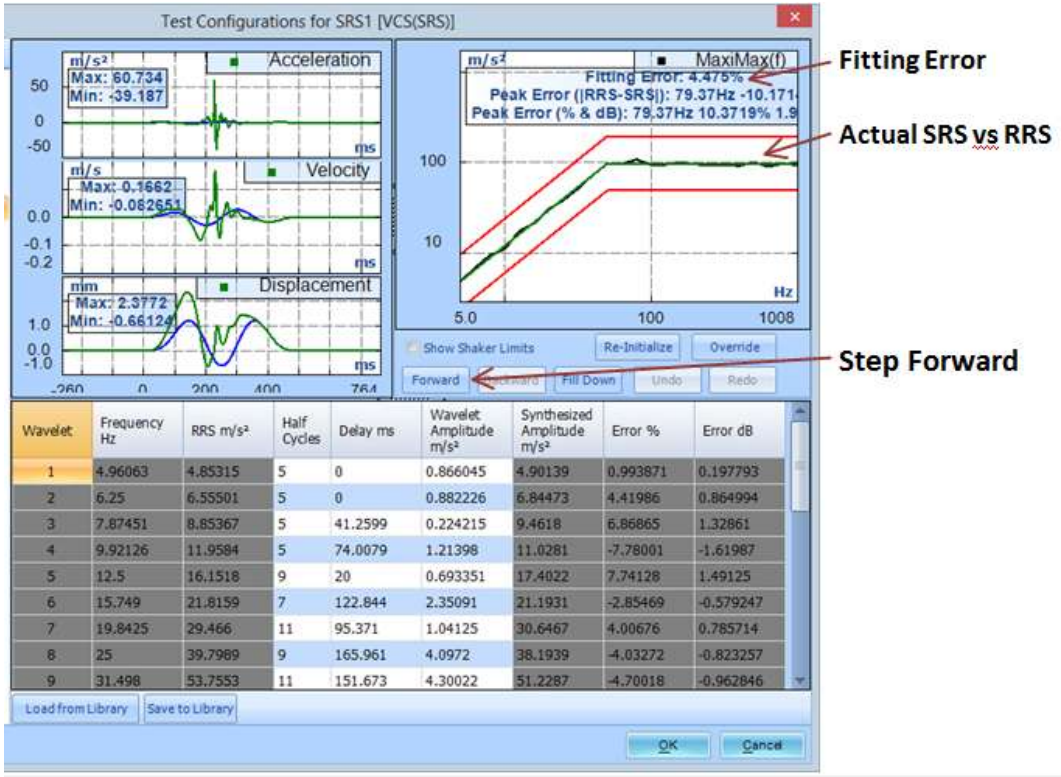
- Sum of wavelets produces transient waveform



Wavelet	Frequency Hz	RRS m/s²	Half Cycles	Delay ms	Wavelet Amplitude m/s²	Synthesized Amplitude m/s²	Error %	Error dB
1	4.96063	4.85315	5	0	0.866045	4.90139	0.993871	0.197793
2	6.25	6.55501	5	0	0.882226	6.84473	4.41986	0.864994
3	7.87451	8.85367	5	41.2599	0.224215	9.4618	6.86865	1.32861
4	9.92126	11.9584	5	74.0079	1.21398	11.0281	-7.78001	-1.61987
5	12.5	16.1518	9	20	0.693351	17.4022	7.74128	1.49125
6	15.749	21.8159	7	122.844	2.35091	21.1931	-2.85469	-0.579247
7	19.8425	29.466	11	95.371	1.04125	30.6467	4.00676	0.785714
8	25	39.7989	9	165.961	4.0972	38.1939	-4.03272	-0.823257
9	31.498	53.7553	11	151.673	4.30022	51.2287	-4.70018	-0.962846

SRS Synthesis

- Iterative process
- Wavelet parameters adjusted so that SRS converges on RRS
- Step Forward until Fitting Error minimized

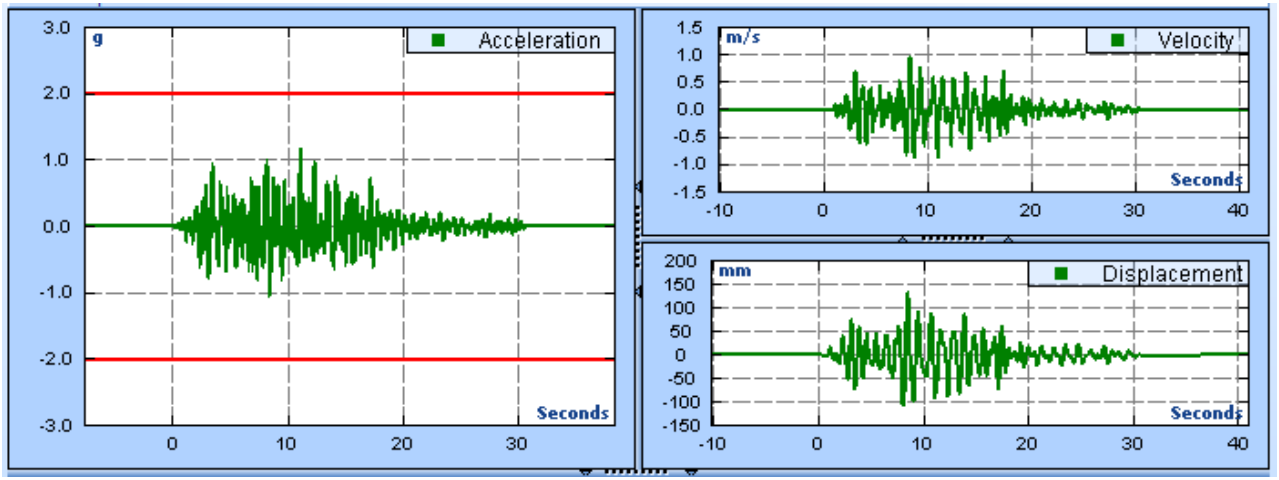


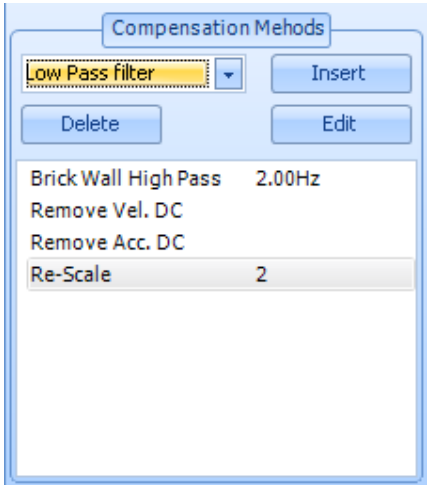
Wavelet	Frequency Hz	RRS m/s²	Half Cycles	Delay ms	Wavelet Amplitude m/s²	Synthesized Amplitude m/s²	Error %	Error dB
1	4.96063	4.85315	5	0	0.866045	4.90139	0.993871	0.197793
2	6.25	6.55501	5	0	0.882226	6.84473	4.41986	0.864994
3	7.87451	8.85367	5	41.2599	0.224215	9.4618	6.86865	1.32861
4	9.92126	11.9584	5	74.0079	1.21398	11.0281	-7.78001	-1.61987
5	12.5	16.1518	9	20	0.693351	17.4022	7.74128	1.49125
6	15.749	21.8159	7	122.844	2.35091	21.1931	-2.85469	-0.579247
7	19.8425	29.466	11	95.371	1.04125	30.6467	4.00676	0.785714
8	25	39.7989	9	165.961	4.0972	38.1939	-4.03272	-0.823257
9	31.498	53.7553	11	151.673	4.30022	51.2287	-4.70018	-0.962846

CRYSTAL instruments

Waveform Compensation

- Remove DC
- Residual velocity, displacement to zero
- High-pass filter
- Brick-wall high-pass
- Low-pass filter

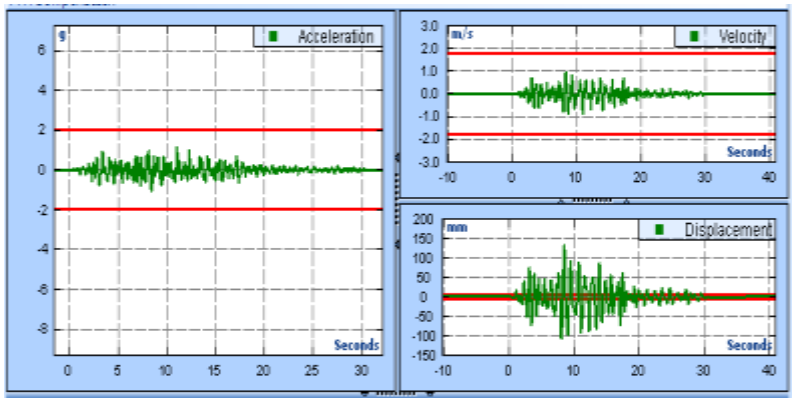


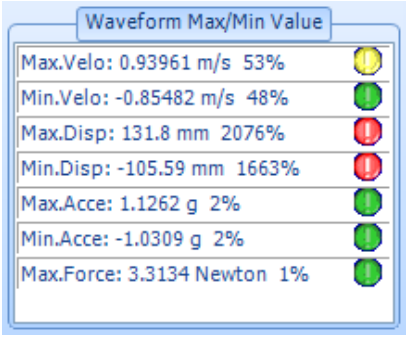


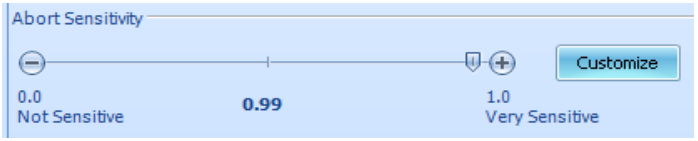
CRYSTAL instruments

Safety Limits

- Profile validation
  - Shaker limits
  - Acceleration, velocity, displacement
- Abort Checks
  - RMS changes, control signal loss
  - Abort Sensitivity setting makes adjustment easy
- Hardware Abort Buttons



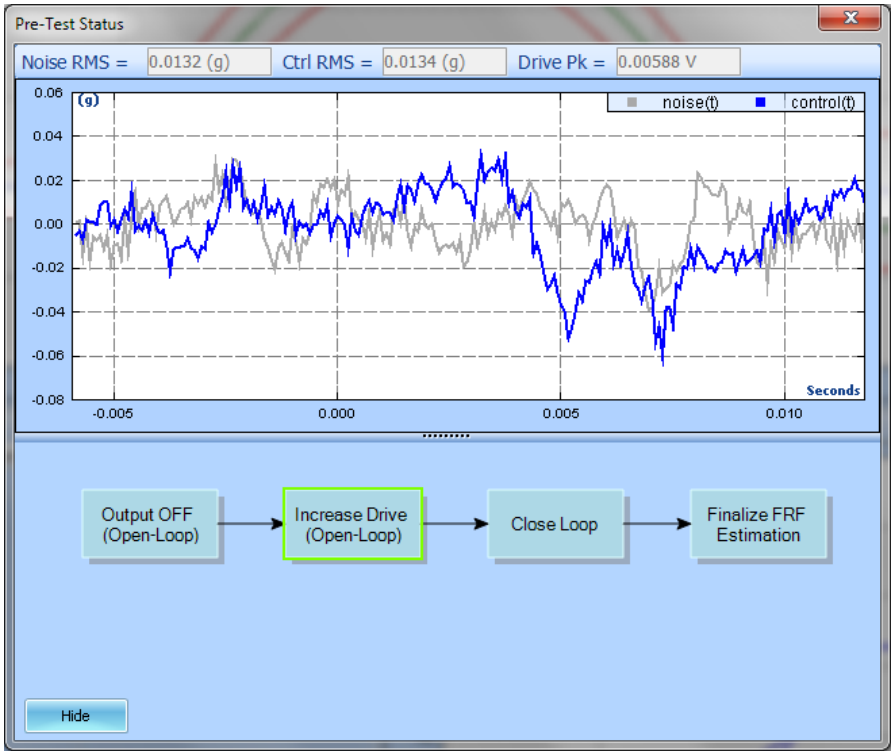




CRYSTAL instruments

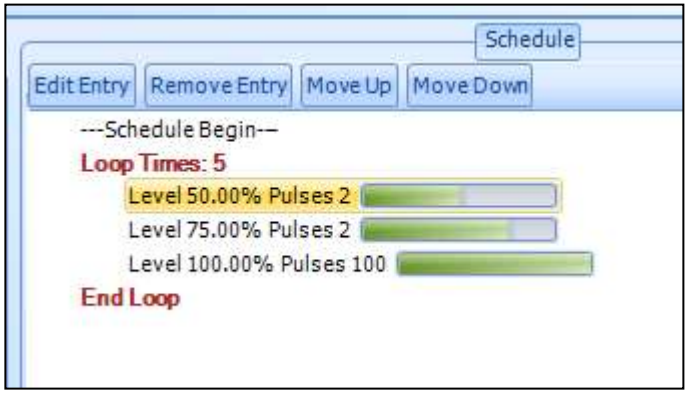
Transfer Function Calculation

- Pre-test
  - Random noise or time waveform
  - Calculates FRF
  - Can be skipped with saved FRF
- Continuous updating

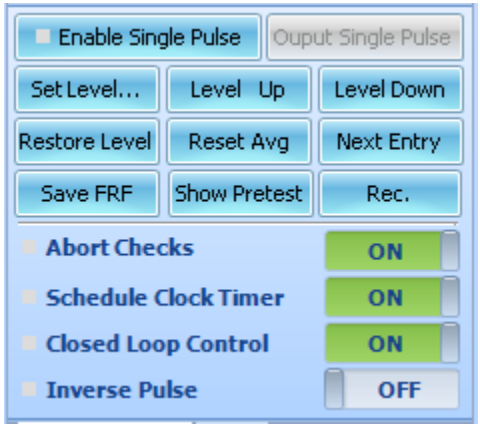


Automatic and Manual Run Control

- Run Schedule

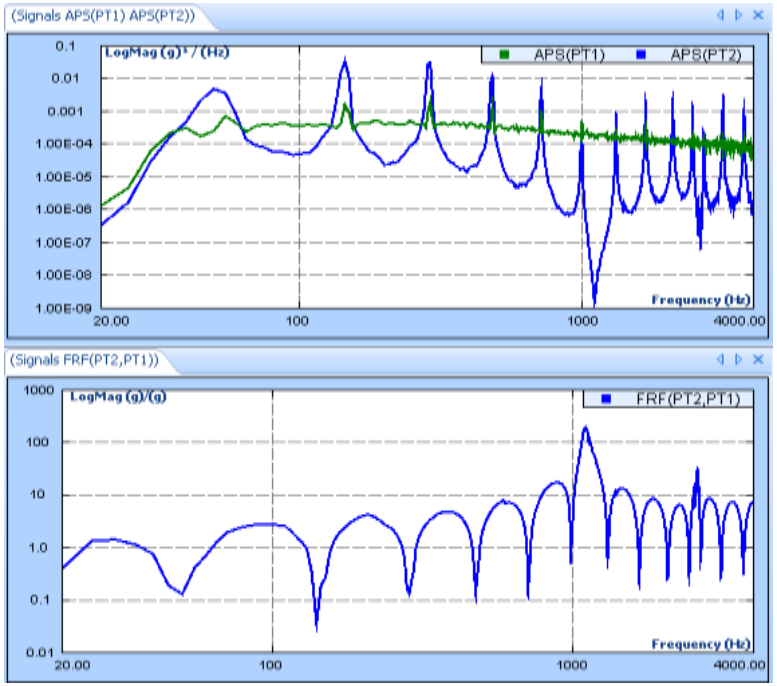


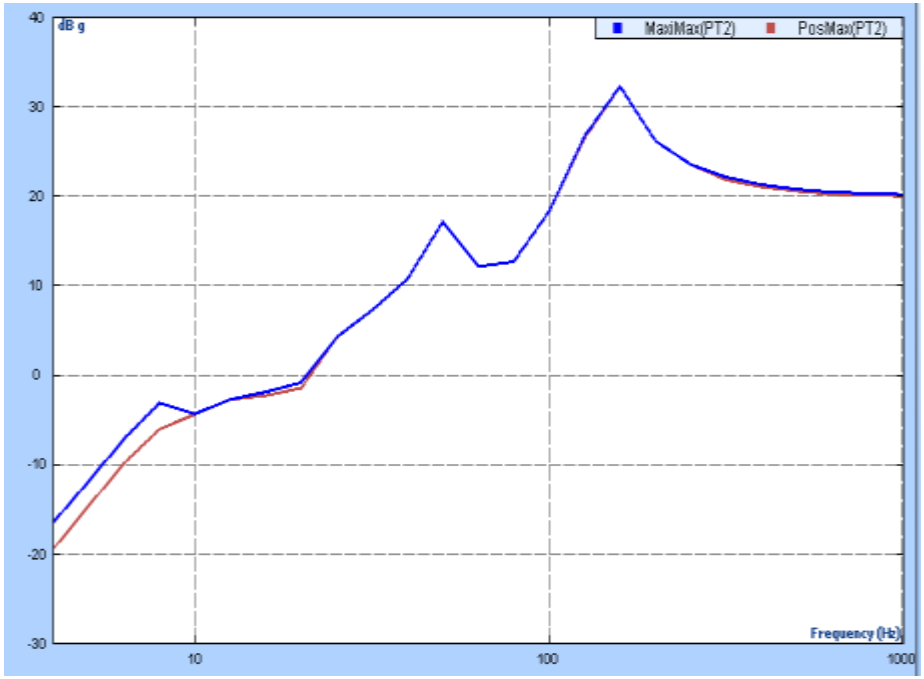
- Full Manual Control



Analysis Tools

- FFT, Power Spectrum, Transmissibility
- SRS Analysis

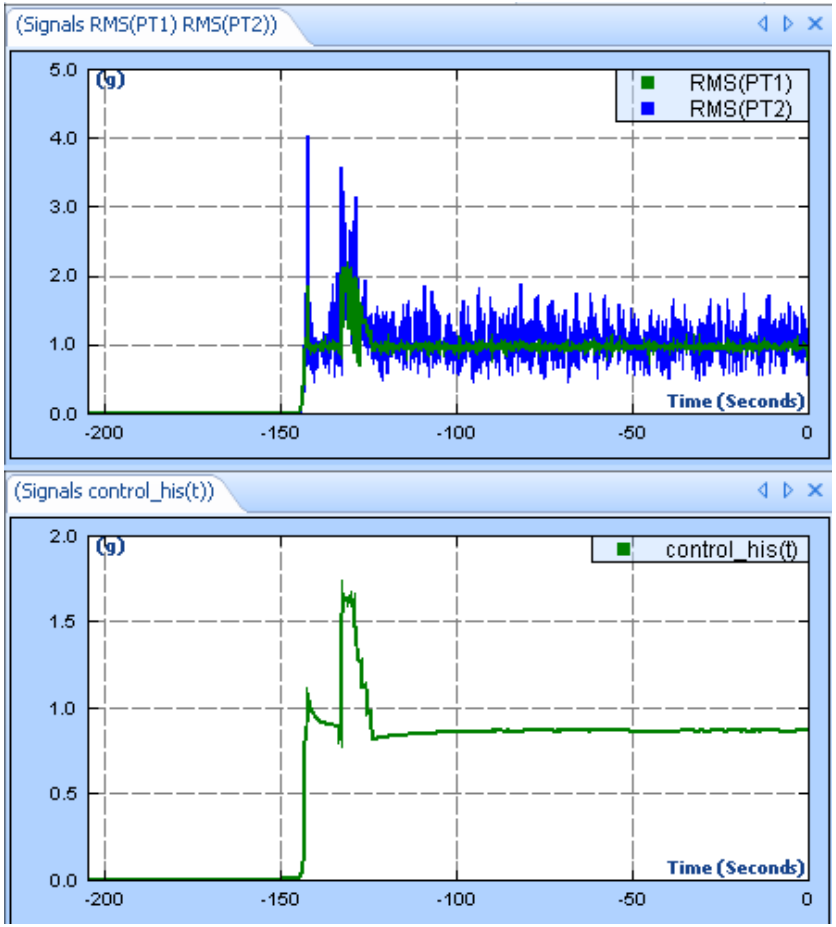




CRYSTAL instruments

Special Displays

- Time block history: RMS, Peak, Peak-peak
- Control History



CRYSTAL instruments