RULA

Vibration Control and Data Acquisition System **RL-C25**

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About RL-C25

RL-C25 is an advanced highly-accurate vibration control and data acquisition system designed for multichannel applications.

Scalable architecture of RL-C25 architecture allows the user to expand the system up to 512 channels in a synchronized data acquisition set.

RL-C25 comes with a full set of vibration and acoustic measurements and supports various sensor types.

Two advanced software packages – VisProbe SL and VisAnalyser – power the system to fulfill the vibration control and data acquisition functionality.

The modular principle of hardware configuration provides flexibility to suit different user demands.

Key Features

• Scalability

It is possible to stack a number of controllers to obtain up to 512 channels to provide synchronous acquisition, storage and analysis of data from different sensor types. The device can work as a desktop block or be mounted in the rack.

• Multishaker Test Support

RL-C25 system can control vibration shakers with up to 6 degrees of freedom. The system identification algorithm is based on computation of transfer-function matrix. This approach enables controlling vibration as well as rotation.

• Flexible Configuration

The hardware architecture of RL-C25 allows using different interchangeable measurement units, so the configuration of the system can be easily customized to user requirements. Each RL-C25 controller has 3 slots for adding analog input/output boards. There are 8 inputs on each analog input board and 4 outputs on each analog output board, and they can be combined in the controller in different combinations.

Configuration	Input channels	Output channels
Vibration control system	8	8
	16	4
Data acquisition system	24	0

Figure 1. Set of RL-C25

Technical Features

Maximum number of measuring channels	1 ÷ 512 (up to 24 channels in one controller)
Number of output control channels	0 ÷ 8
Sample rate, kHz	up to 265
Frequency range, Hz	DC 0.1 – 106000
Sensor types	IEPE, linear, charge, acoustic, displacement, velocity, force sensors
Input voltage range, V	±1 ±10
Charge range, pC	±1000 ±10000
DC measurement accuracy, V	$\pm(0.001 \cdot U_m + 0.001)$
AC measurement accuracy (RMS) on 100 Hz frequency, V	$\pm(0.001 \cdot U_m + 0.0001)$
Charge measurement accuracy (RMS) on 1000 Hz frequency, pC	$\pm(0.01 \cdot Q_m + 0.1)$
Relative error of frequency measuring/setting, %	0.005
THD measurement range, %	0.01 – 90
FRF non-linearity on the frequency of 1 kHz (voltage), dB • 0.1 – 60000 Hz • 60000 – 106000 Hz	 0.05 0.1
FRF non-linearity on the frequency of 1 kHz (charge), dB • 10 – 60000 Hz • 1 – 106000 Hz	 0.05 0.15
Output voltage range, V	±3 ±10
Dynamic range, dB	120
Number of digital inputs	8
Number of digital outputs	8
ADC/DAC resolution, bit	24
Supply voltage, V	180 ÷ 240 AC 12 ÷ 36 DC
Power consumption for one controller, VA	75
Dimensions, mm	428 × 370 × 47
Weight, kg	3.9

Connectors and Interfaces

- Input and output BNC-connectors.
- RS-232, RS-485, USB 2.0, CAN and HDMI.
- Auxiliary circuits for powering sensors and external devices (12 and 24 V, 50 mA).
- 1 Gb/s Ethernet to connect to PC.

Figure 2. RL-C25

Data Acquisition and Analysis

RL-C25 provides extensive capabilities of data acquisition and analysis using a powerful program complex VisAnalyser. Sources of signals for analysis can be different: data can come from DAQ-devices in real-time or from a recording. It is possible to analyze data acquired with RULA-devices or imported from other acquisition systems.

A free demo-version of the data acquisition software is accessible on the website of RULA Technologies.

Modular Software Configuration

The software comprises a number of options, which can be flexibly configured for a particular application. It is also possible to add more options when you are already working with the program.

Types of Data Analysis

- Viewing recorded signal waveform
- Spectrum analysis
- Statistic analysis
- Tacho-Analysis
- Signal integration and double-integration
- Calculating absolute value and sigma-clipping
- Arithmetic operations
- File editor
- Filtration with FIR or IIR filters
- Shock response spectrum
- Waterfall analysis
- Data recording
- Modal analysis.

Offline Analysis

Viewing Recordings

VisAnalyser enables the user to view files of virtually any length. Data cursors are lines parallel to Y-axis. The coordinate of intersection with X-axis and the value of the signal at the intersection point are shown on each of the cursors.

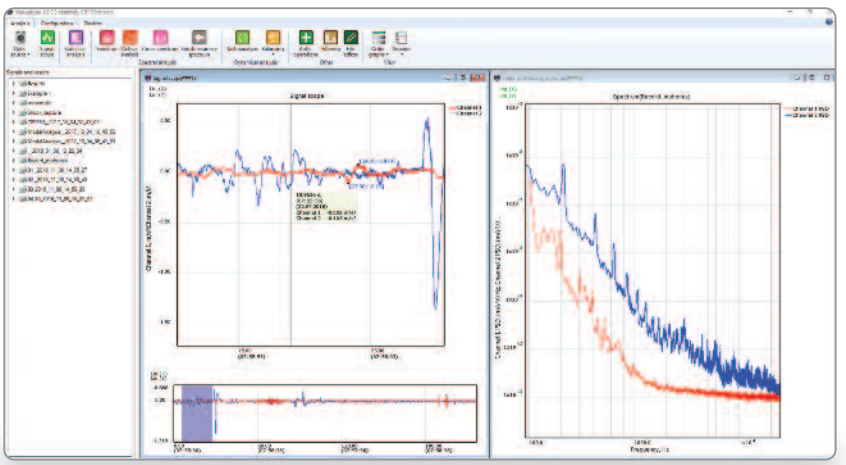


Figure 3. Viewing Recordings

Spectrum Analysis

The user can calculate signal PSD, and view spectra by RMS and amplitude.

For spectrum analysis, you can specify:

- Window length;
- Window function – Hann, Hamming, Blackman, Newtall, flat-top, Kaiser, Bohmann, Chebyshev;
- Averaging type – linear or exponential;
- Zero offset calculation and subtraction.

Octave Analysis

Using part-octave analysis, you can calculate octave spectrum with the pre-set octave part from 1/1 to 1/24 based on FFT calculation or IIR-filters.

The results of octave analysis can be used for vibration diagnostics of machines and mechanisms, calculating the characteristics of acoustic signal, noise level and vibration level.

Statistical Analysis

Statistical analysis option is used to obtain different integrated characteristics of the signal, e.g:

- RMS;
- Minimum value;
- Maximum value;
- Mean value;
- Median value;
- Cross-plot;
- Sigma-clipping value.

Besides, with statistical analysis the user can perform integration and double-integration of the signal – for example, analyze displacement of the object using the recording of its acceleration.

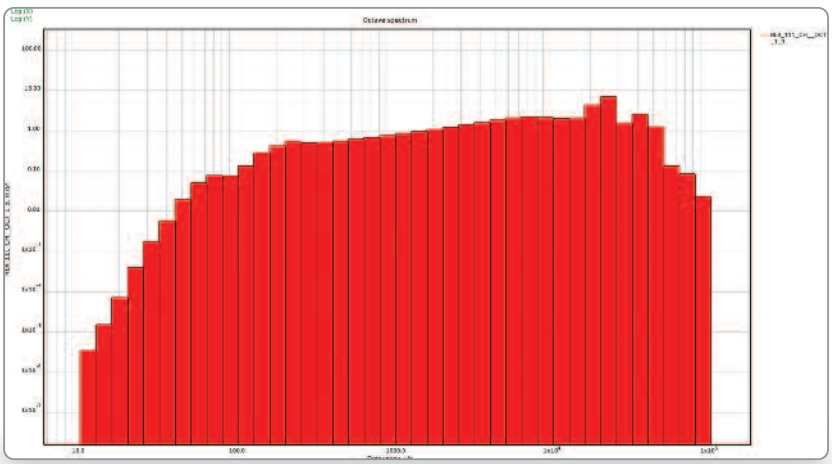


Figure 4. Octave Analysis.

Editing Files

In our post-processing software you can cut the relevant fragment from the data file and then save it as another file for subsequent analysis.

Arithmetic Operations

VisAnalyser supports different arithmetic operations on signals.

A signal can be added, divided or subtracted from a signal or a constant, or a logarithm can be taken. The arithmetic operations are specified in a line with a formula. The formula can then be saved as a template.

Signal Filtration

Filtering the signals with FIR and IIR filters eliminates the noise component from the signal. The result of filtration, as well as the result of other operations can subsequently become a source of signal for any type of analysis.

SRS Calculation

VisAnalyser is able to calculate shock response spectrum based on the file with recorded data. Shock response spectrum is defined as the response to a given acceleration acting at a set of mass-damper-spring oscillators, which are adjusted to the different resonance frequencies while their resonance gains (Q-factor) are equal.

Tacho-Analysis

With this type of analysis, the user can see the following parameters:

- rotation frequencies;
- phases of signals from accelerometers referenced to the signal from the tacho-sensor;
- unbalance vector.

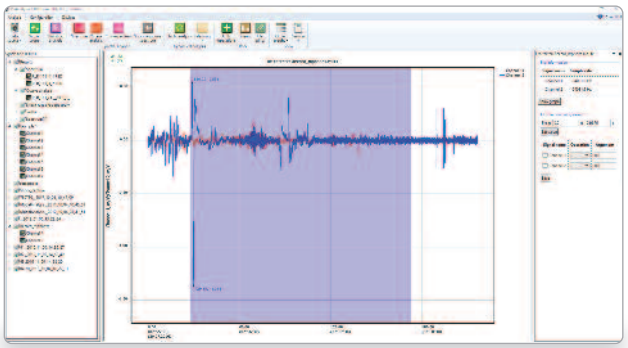


Figure 5. Editing Files

Figure 7. Signal Filtration

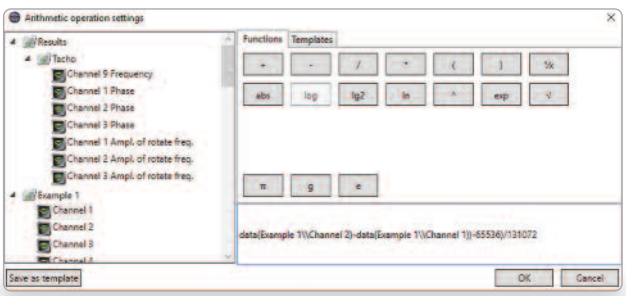


Figure 6. Arithmetic Operations

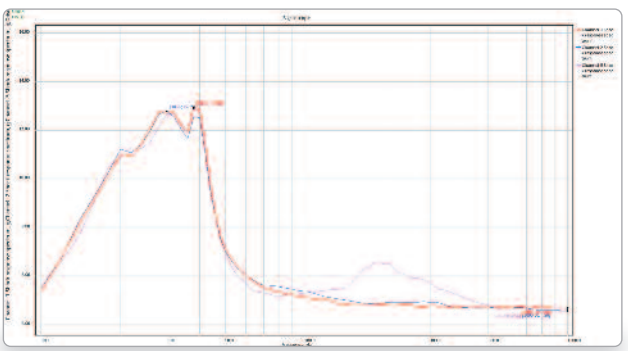


Figure 8. SRS Calculation

Online Analysis

Online analysis is the analysis of data acquired from analog channels of a data-acquisition system in real time. In case of RL-C25 it is possible to analyze data from up to 512 channels. The following types of analysis are available in this mode:

- Spectrum analysis;
- Part-octave analysis;
- Statistical analysis;
- FIR and IIR filters;
- Waterwall analysis.

Similarly to offline mode, the results of online analysis can be used as input signal for other types of analysis, for instance, RMS or spectrum calculation.

Textual Data Display

VisAnalyser can display the information in the text format – a useful option for controlling the main signal parameters. For example, for all the results of statistical analysis the program displays a special panel, which shows the value of the signal in real time in a large font.

Data Recording

Online analysis mode has the option of data recording. The maximum recording duration is only limited by the PC hard drive capacity. With this option, the user can acquire data to subsequently analyze them using any of the tools of VisAnalyser mathematical package.

Waterfall Analysis

Waterfall analysis is a three-dimensional spectrum analysis. The waterfall graph shows the dependence of the signal from frequency and time simultaneously. This type of analysis is used to study the spectrum structure of the signal in time.

Modal Analysis

Modal analysis is essential for finding resonance frequencies and waveforms of the object under test.

The software calculates the magnitude and phase frequency response to obtain resonance frequencies and waveforms, analyzing the reaction of the object under test to some impact. This impact can be different – a shock, a sine wave, random vibration, etc.

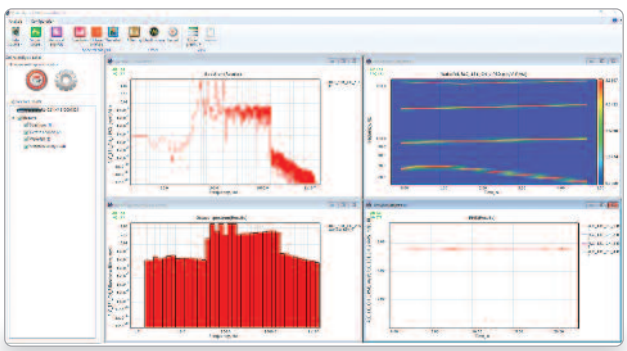


Figure 9. Online analysis

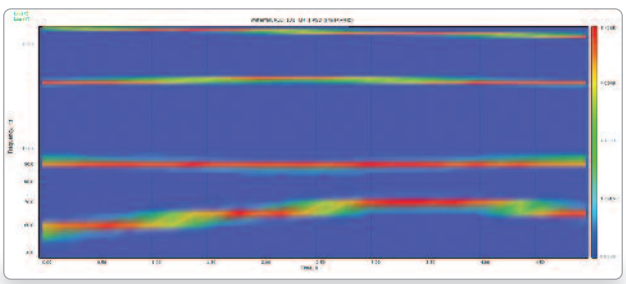


Figure 11. Waterfall Analysis

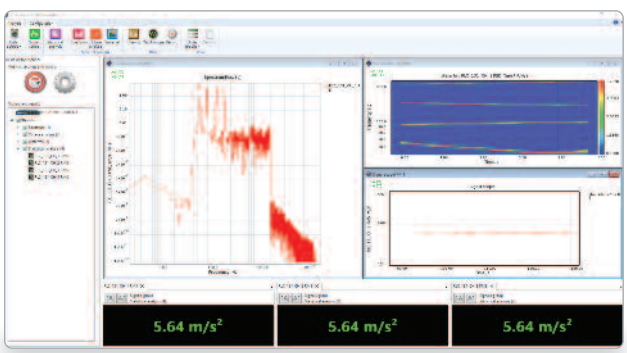


Figure 10. Textual Data Display

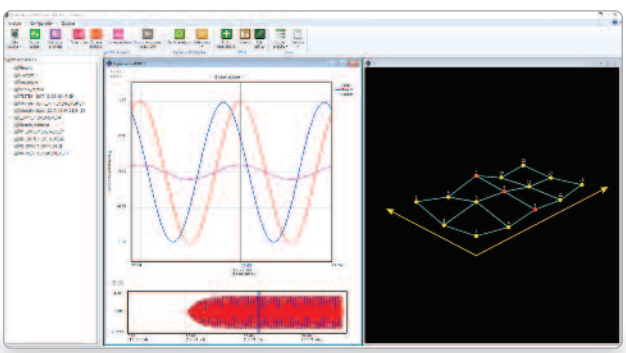


Figure 12. Modal Analysis

Vibration Control

As a vibration control systems RL-C25 provides outstanding accuracy of control, reliability and high safety standard. Vibration control system produced by RULA Technologies are used with a specialized software package for running vibration tests – VisProbe SL. The software supports all types of vibration tests: Sine, Random, Shock, SRoR, SRS, TTH, FDR, etc. Furthermore, the software enables running and controlling Multishaker tests.

Each software option in VisProbe SL can be activated independently of the others to meet the user's requirements.

Key Features:

- Shaker Compatibility

RL-C25 system works with any electrodynamic, servo-hydraulic and servo-electric shakers.

- Pre-Start Check

The RL-C25 system runs a pre-start check of the vibration set by providing sine vibration with the preset amplitude and frequency. This mode verifies the operation of the amplifier, controller, shaker and sensors. All the relevant information and graphs, such as spectrum scope and oscilloscope, are available to the user.

- Test Duration

In the RL-C25 system test duration is not limited. Any test can be paused and resumed later by the user's command. All the data, including test progress, frequency, test schedule, etc. will be saved.

- Test Schedule

Test schedule is specified in a sequence of commands, e.g.: run the preset number of shocks at the preset level, run a sine sweep from one frequency to another, hold frequency, create a cycle. Detailed test schedules maximize the automation of test procedures.

- Safety System

The system utilizes a great number of safety checks to protect the shaker and the object under test from being damaged. During the test the software monitors the shaker limits, maximum drive voltage, sensor connection status and other critical parameters.

- Easy Test Set-Up

The test profile is set in the table form. Each row corresponds to a segment of the test profile. Start and end amplitudes of a segment can be defined in the units of velocity, acceleration and displacement. VisProbe SL software provides an embedded sine point calculator to define the point of intersection for any combination of acceleration, velocity and displacement. The sweep time for any profile segment can be calculated automatically or preset by the user.

- Comprehensive Graphs

The graphic subsystem of VisProbe SL contains a convenient contextual menu, provides displaying several graphs in one window, autoscale option, unlimited number of user cursors, additional grid lines, textual notes.

Sine Test

Sine tests with fixed or swept frequency provides highly accurate multichannel control in real time. Resonance Search and Tracking option helps to determine FRF peaks of the object under test.

Modes:

- Swept frequency
- Fixed frequency
- Resonance search and tracking dwell.

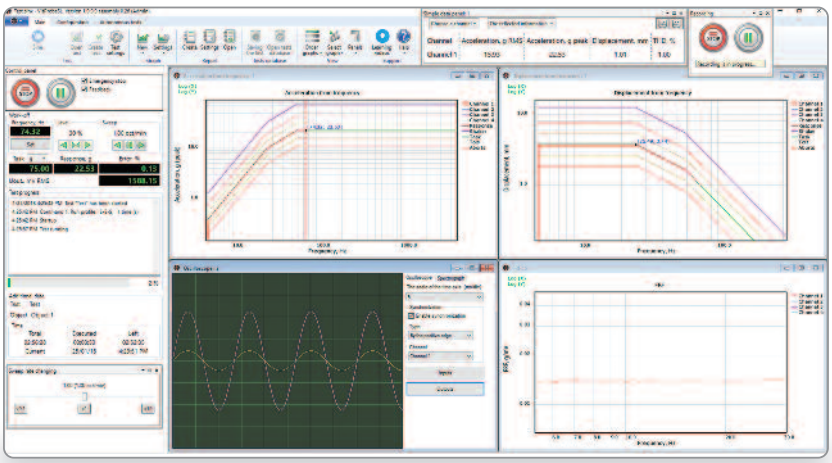
Sweep Rate

The user can specify linear (Hz/s, min/sweep, cycles) or logarithmic (Oct/min, dec/min, cycles) sweep rate for each profile segment.

Resonance Search and Tracking

RL-C25 determines resonance frequencies automatically. After resonance search is done, the system can continue operating on one of the resonances for the preset time or until the user stops the test. Resonance tracking is possible in two modes:

- tracked dwell;
- display of a number of parameters on the graphs.



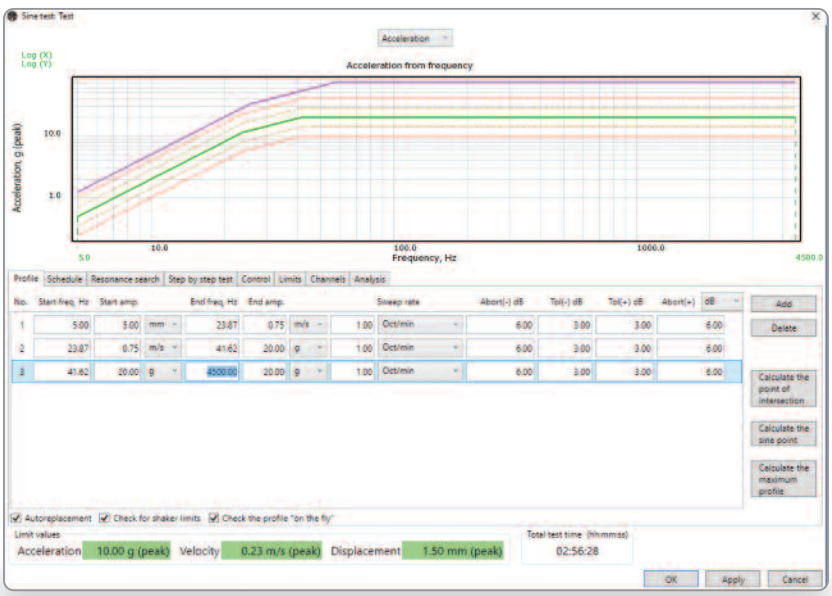


Figure 13. Sine Test

Advanced Sine Test

This test type allows using up to independent 8 sine tones simultaneously. Each sine tone has its own individual schedule. Besides, you can divide the frequency range of the profile into segments to have a sine tone run on each of them. Such a procedure helps to considerably decrease test time.

Advanced Sine Test Features

- Number of sine tones to run simultaneously: 1 – 8.
- Sine tone amplitude can be set in the units of acceleration, velocity and displacement.
- Each sine tone is controlled independently to get the best possible accuracy.
- Sweep rate for any profile segment can be calculated automatically or preset by the user.

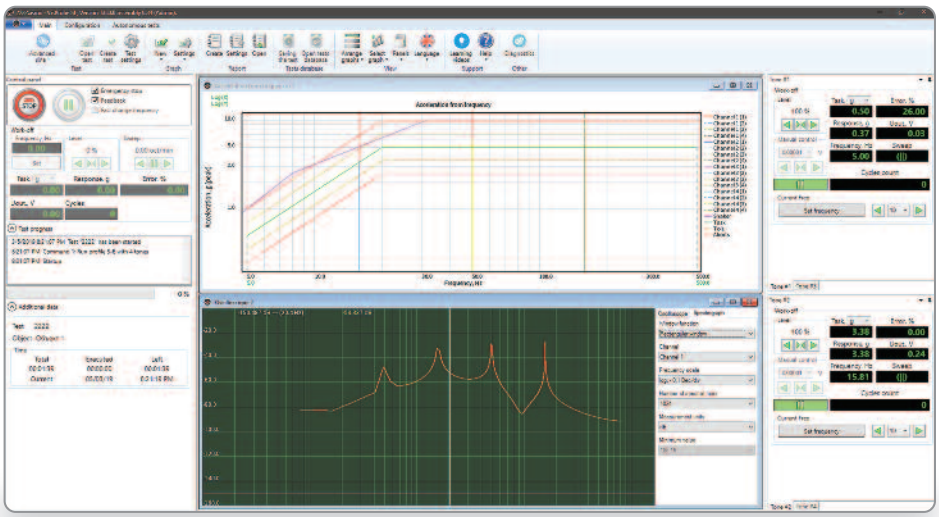


Figure 14. Advanced Sine Test

Random Test

In case of random vibration the object under test is subject to true random signal with specified PSD, and either Gaussian or non-Gaussian amplitude statistics.

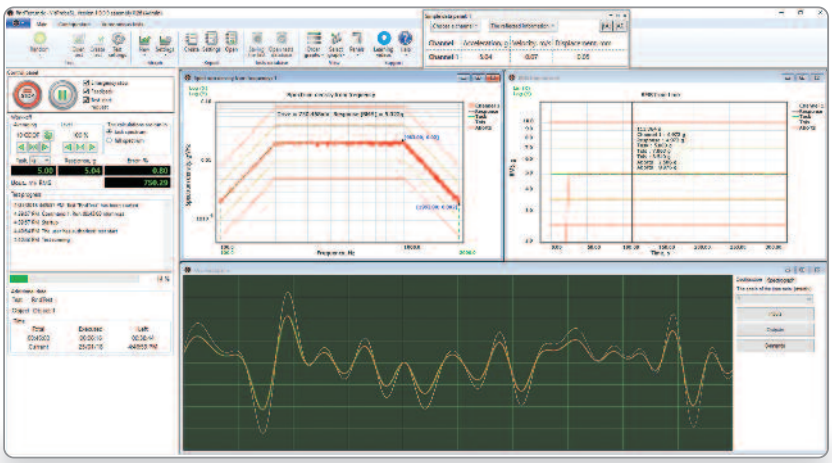
Kurtosis

RL-C25 supports tests with non-Gaussian random signals. Kurtosis control allows increasing the probability of peak acceleration values. Specifying the value of Kurtosis approximates the impact on the device under test to the actual operating conditions.

Constant Number of Degrees of Freedom (CDOF)

The option of using constant number of degrees of freedom (CDOF) makes it possible to obtain an averaged value of the power spectral density in just a few seconds.

The efficiency of this method of averaging is much higher than that of conventional methods, so the user can apply it to track resonances, evaluate the noise of the object under test and rigging more accurately.



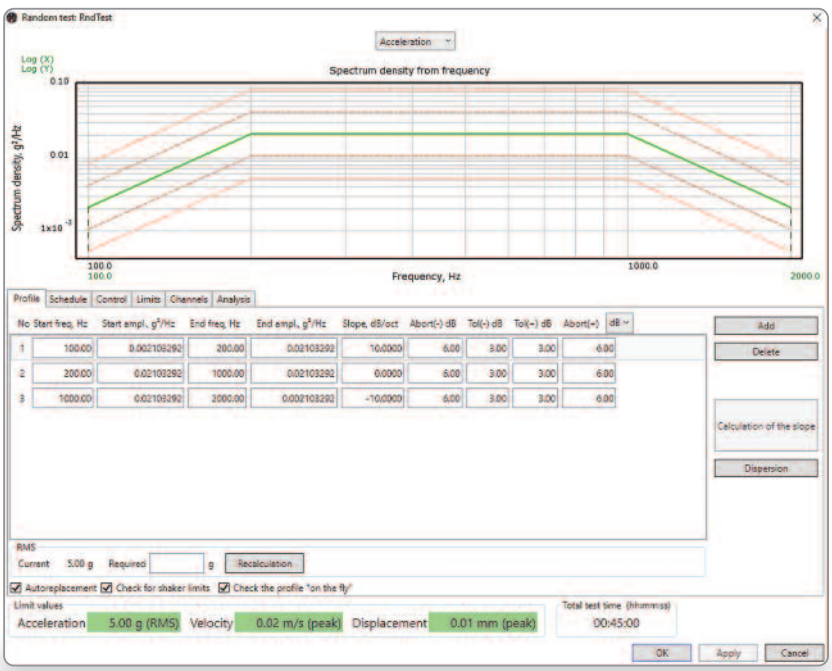


Figure 15. Random Test

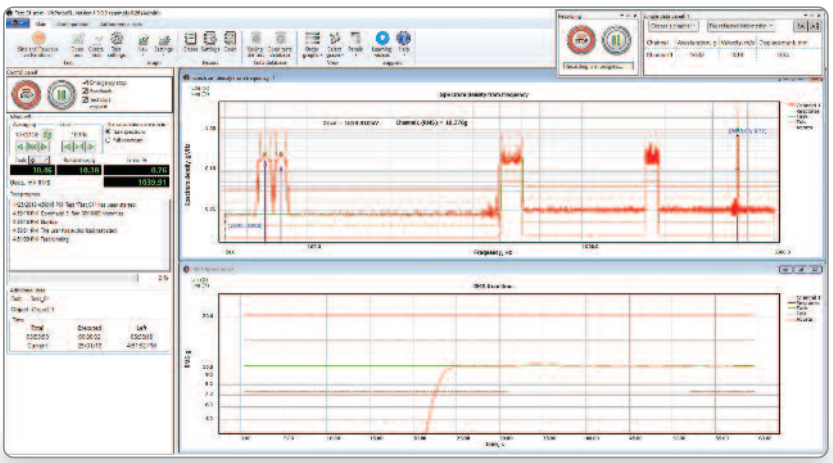
SRoR Tests

RL-C25 controller enables running the following types of tests:

- Sine on Random.
- Random on Random.
- Sine and Random on Random.
- Sine on Sine.

SRoR Test Features

- Number of superimposed sine tones: 1 to 12.
- Number of superimposed random bands: 1 to 12.
- For each superimposed sine tone or random band the user can specify sweep rate, start and end frequency and amplitudes.
- Sine tone amplitude can be set in the units of acceleration, velocity and displacement.
- Kurtosis settings.
- Spectrum averaging with Constant Number of Degrees of Freedom (CDOF).



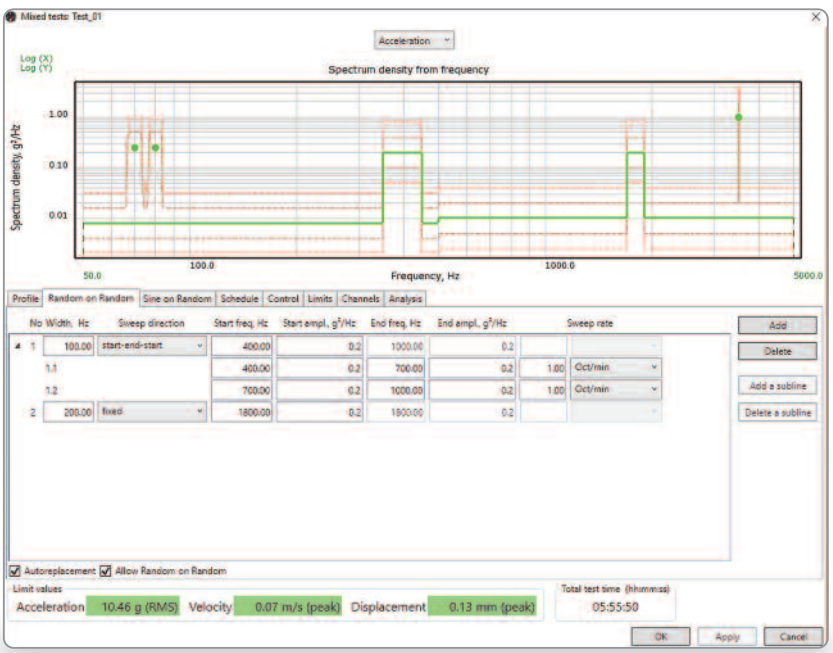


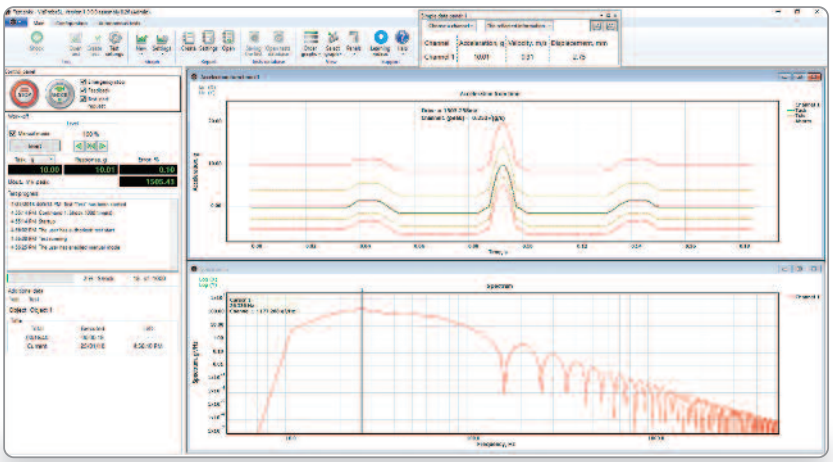
Figure 16. SRoR Tests

Shock Test

RL-C25 supports all the classical pulse types.

Shock Test Features

- Displacement requirements optimization
- Test modes:
  - «Automatic» – shocks are run with the preset interval. Interval duration is not limited
  - «Manual» – shocks are run only after the user presses the corresponding button
- Pulse types: triangle, trapeze, rectangle, initial peak saw-tooth and terminal peak saw-tooth, full sine, half sine, haversine



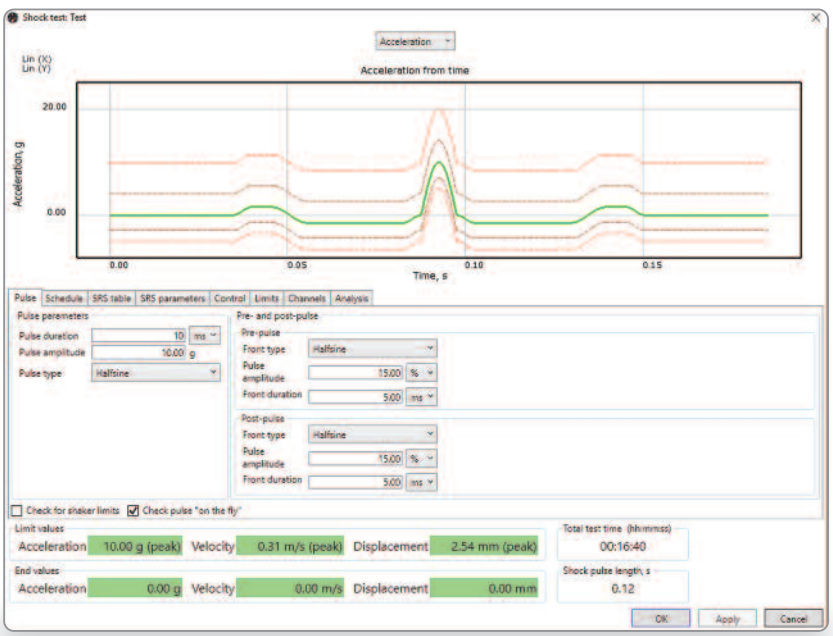


Figure 17. Shocks

Shock Response Spectrum Test (SRS Shock)

SRS test provides the possibility to control SRS of the device under test to match the required one. RL-C25 supports all the classical types of wavelets.

SRS Test Features

- Pulse duration: up to 10 s
- Types of wavelets:
  - WAVSYN
  - ZERD
  - Damped sine wave
- Frequency range: 0.1 to 35000 Hz.
- Test modes:
  - «Automatic» –shocks are run with the preset interval. The interval duration is not limited.
  - «Manual» – shocks are run only after the user presses the corresponding button

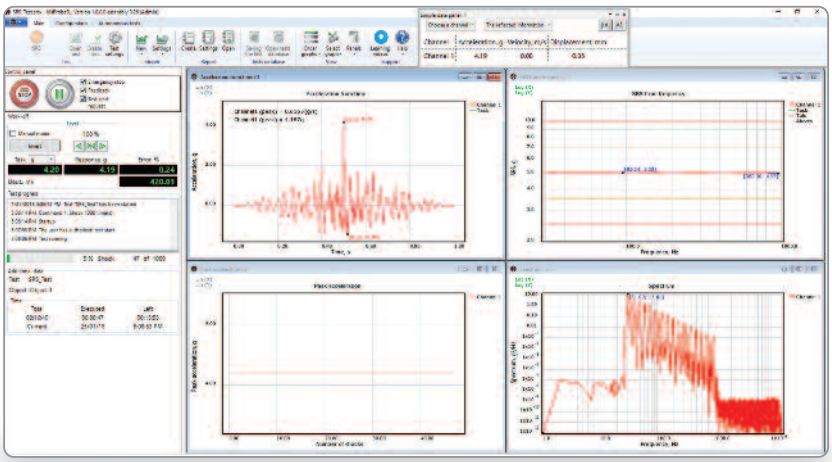


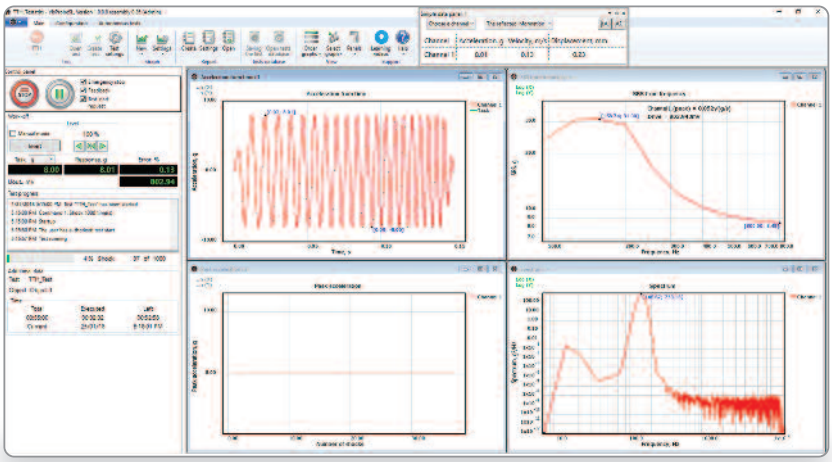
Figure 18. SRS Shock

Transient Time History

Transient Time History (TTH) test provides the possibility to simulate seismic impact.

TTH Test Features

- Maximum pulse duration: 50 s.
- Shock types: enveloped sine, cosine, teardrop, random signal, etc.
- Test modes:
  - «Automatic» – shocks are run with the preset interval. The interval duration is not limited
  - «Manual» – shocks are run only after the user presses the corresponding button



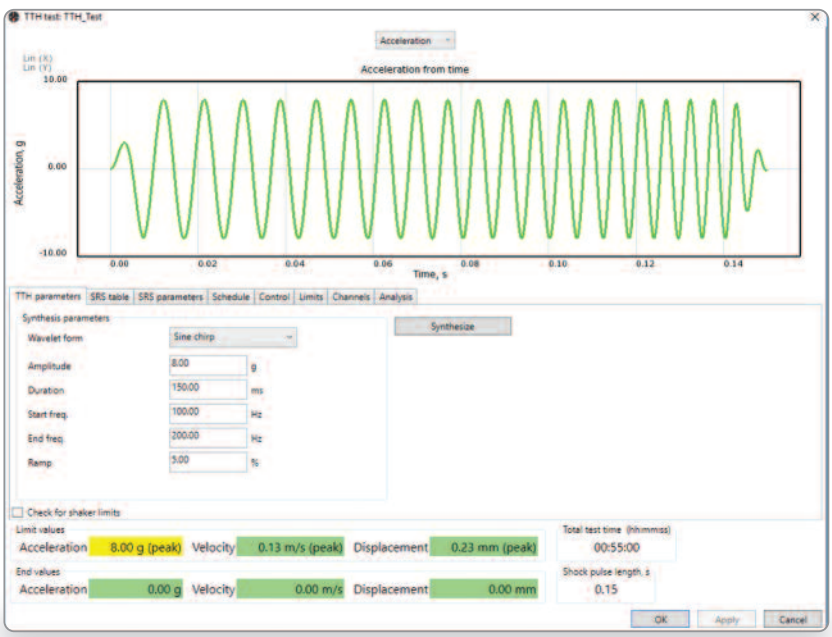


Figure 19. Transient Time History

Data Recording

The data from input channels are recorded into a file of a specialized open format. Sample rate of the recording can be changed, so that to achieve the optimal accuracy-to-file size ratio.

The recorded file may be used in the «Field Data Replication» test or analyzed in any specialized software.

The duration of data recording is only limited by hard drive capacity.

Field Data Replication

Field Data Replication test provides the possibility to reproduce the acquired field data on a shaker in the lab. This test gives the user highly accurate reproduction of the environment, avoiding imitations used in Sine, Random or SRoR tests.

Supported File Formats

RL-C25 supports importing data from sound files of .au, .wav and .uff formats and text files of .txt, .csv and .dat formats. While importing is in progress, the user can aggregate data from several channels into one by means of averaging.

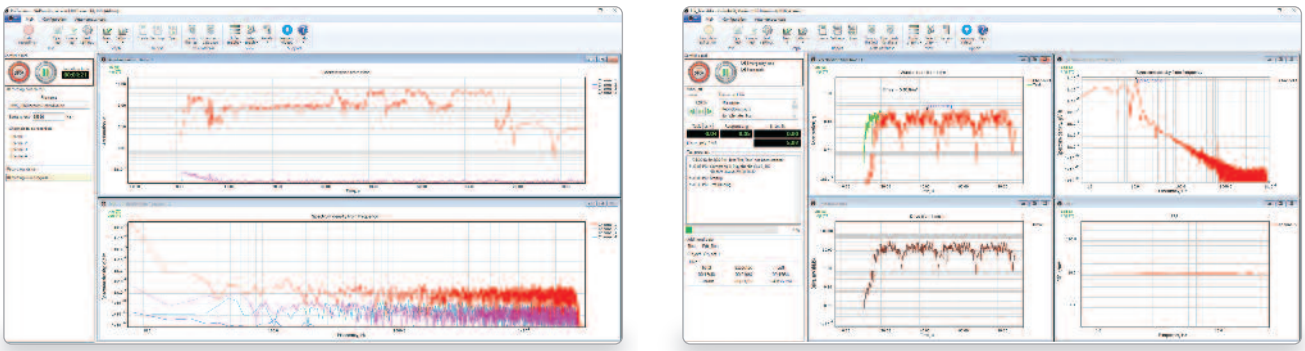


Figure 20. Data Recording

Figure 21. Field Data Replication

Sequences of Tests

This option provides the possibility to run a sequence of tests by pressing one button.

E.g. if the object under test is to be tested in Sine test first, and then in a series of shocks, all the user needs to do is to join these tests together into a sequence and start it. For example, the system runs Sine test first, then automatically closes it, opens Shock test and starts it.

Running tests in sequences does not differ from running them in the usual mode. All the windows and buttons are the same. The only difference is the sequence control panel located on the right side of the screen.

Test sequences save the user's time, when a series of tests is to be executed.

Multishaker Tests

RL-C25 system can control vibration shakers with up to 6 degrees of freedom. The system identification algorithm is based on computation of transfer-function matrix. This approach allows controlling vibration as well as rotation.

Multishaker Test Mode Features

- Supported test types are Sine, Random, Shock and FDR.
- Number of control channels: 2 – 8.
- Number of control outputs: 2 – 8.
- Number of measuring channels: 1 – 510.
- Number of shakers: 2 – 8.
- For each shaker in the vibration set the user specifies a control loop which corresponds to an input and output channel. The shaker may be placed along X, Y or Z axis.
- 2-axial and 3-axial phase control

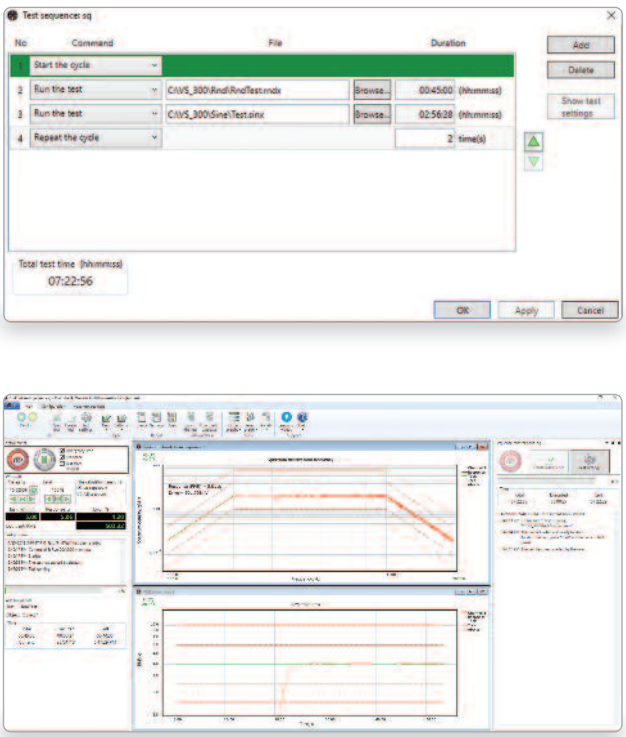


Figure 22. Sequences of Tests

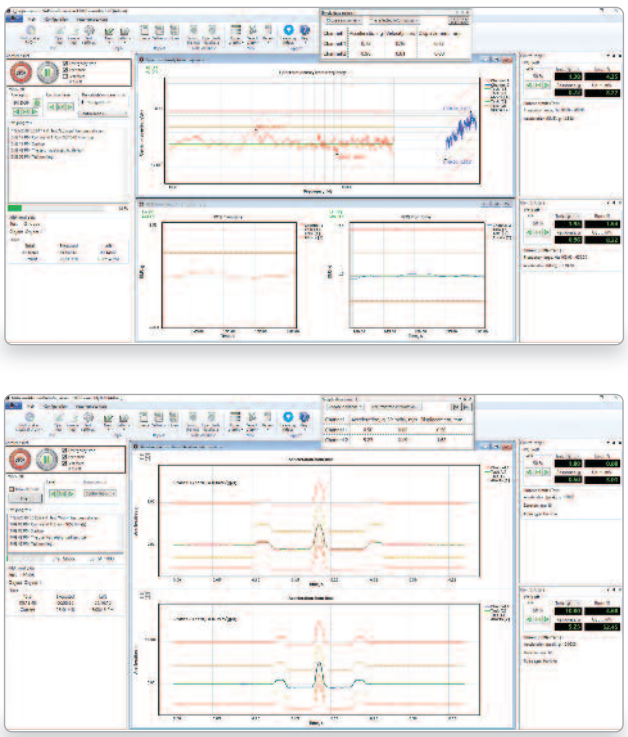


Figure 23. Multishaker Tests

Transient Capture

Transient Capture option provides the possibility to capture a transient waveform for post-processing.

Transient Capture Features

- Triggers: positive, negative, «by absolute value»
- Digital FIR filters
- Operation modes:
  - «Acquisition» – the program is continuously analyzing the data from the sensors and transient processes in them
  - «View» – viewing previously captured processes

- VisProbe SL software provides an option to specify the reference pulse form. This form is to be shown on graphs in order to compare it with the detected pulse.
- It is possible to change all the data acquisition parameters while the measurements are in progress.
- For each detected transient process, the system displays a waveform, spectrum and SRS.

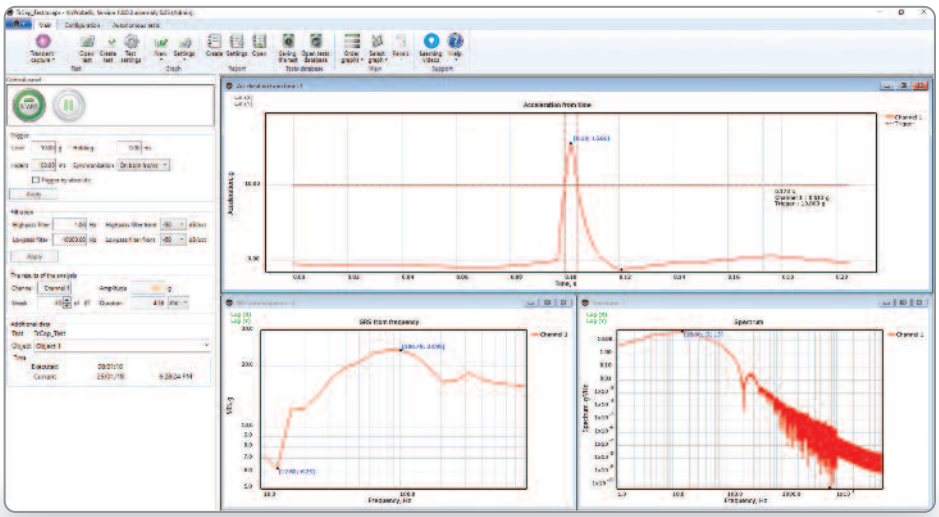


Figure 24. Transient Capture

Fatigue Tests

RL-C25 provides the possibility to run specialized fatigue tests, intended to evaluate durability of turbine and compressor blades.

This mode enables running Sine test, searching for resonances and tracking several frequencies at the same time.

Fatigue Test Features

- Each resonance is controlled independently to get the best possible accuracy
- Working with resonances using laser vibrometers and velocity sensors
- Automated resonance adjustment
- Number of resonance tracked simultaneously: 1 – 8

Resonance Search and Tracking

RL-C25 determines resonance frequencies in the automated mode. After the resonance search is done, the system can continue operating on several resonance frequencies for the preset time, until the user stops the test or until the object under test is destroyed. For each resonance, the system provides independent control by amplitude and frequency.

Control by Displacement and Velocity

It is possible to track a resonance frequency using displacement and velocity sensors, including laser vibrometers.

Expanded Safety System

In addition to the standard safety checks, Fatigue Test checks the shift of resonance frequency.

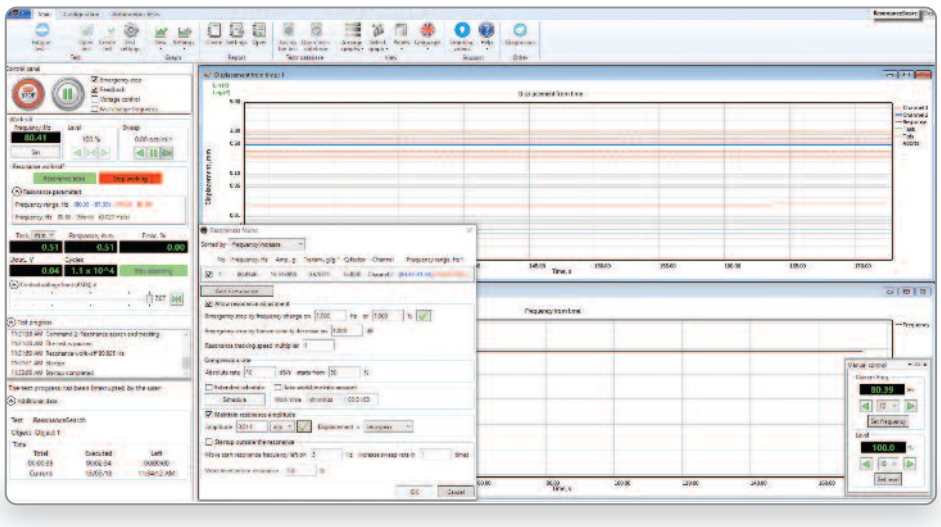


Figure 25. Fatigue Tests

About «RULA Technologies»

RULA Technologies is a fast-developing innovative manufacturer of vibration control and data acquisition systems.

A team of experienced engineers provides customized ready-to-use solutions for Automotive, Aerospace, Power&Energy and other spheres of industry. The advanced hardware features combined with the powerful user-friendly software make our systems the ultimate choice in the fields of vibration control and data acquisition.

RULA systems are distinguished by high level of accuracy, usability and reliable technical support.

RULA

Birzes 32-57, Riga, LV-1016, Latvia
Phone: +371 6610 2166
Support: support@rula-tech.com
Marketing: contact@rula-tech.com
www.rula-tech.com

«RULA Technologies», SIA
Birzes Iela 32-57, RIGA,
LV-1016 Latvia
Phone: +371 6610 2166
contact@rula-tech.com
www.rula-tech.com

«RULA Technologies», SIA
Birzes Iela 32-57, RIGA,
LV-1016 Latvia

Phone: +371 6610 2166
e-mail: contact@rula-tech.com
www.rula-tech.com