RULA

Vibration Control System **RL-C21**

The Harmony of Solutions

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About RL-C21

RL-C21 is a state-of-the-art vibration control system for electro-dynamic shakers. The system is distinguished by simplicity, reliability and high safety standard.

RL-C21 vibration controller has a modular scalable architecture, which allows the user to get from 1 to 32 input channels. The configuration of RL-C21 system is flexible: it is determined by the user and can be modified at any time.

The most innovative techniques of digital signal processing are embedded in the system. The PC is not used in the control loop, all calculations and safety checks are run by a DSP directly in the controller. This feature provides the highest level of shaker protection.

RL-C21 enables running multishaker tests. The system successfully controls two- and three-axes shakers, as well as vibration shakers with up to 6 degrees of freedom.

Galvanic isolation of the input channels is an advantage of RL-C21, which sets it apart from the existing analogs and allows effectively protecting input chains from breaks.

Key Features

- Number of input channels: 1 – 32
- Number of output channels: 2 – 16
- Frequency range: 0.1 to 35000 Hz
- Sample rate: 1290 Hz-108 kHz
- Maximum number of systems stacked: 8
- Test types:
  - Sine test, Resonance Search and Tracking Dwell
  - Random test
  - Shock
  - SRS
  - TTH
  - Sine on Random, Random on Random, Sine and Random on Random, Sine on Sine
  - Transient Capture
  - Field data recording and replication
  - Fatigue test
- Operating temperature range: 5 – 50 °C
- Power consumption: < 50 VA
- Supply voltage: 110 – 245 V, 47 – 63 Hz
- Dimensions (L × W × H): 390 × 274 × 54 mm

RL-C21 Controller Parameters

Inputs

- Number of channels: 1 – 4
- Sensor types:
  - IEPE
  - Charge
  - TEDS
  - Displacement
  - Velocity
  - Force
- ADC resolution: 24 bit
- Noise floor: < 20 μV
- Voltage range: ±10 V
- Relative error of signal measurement: < 1%
- FRF non-linearity on the frequency of 1 kHz:
  - ±0.2 dB (in the range from 0.1 to 3 Hz),
  - ±0.1 dB (in the range from 3 to 35000 Hz).

Outputs

- Number of channels: 2
- DAC resolution: 24 bit
- Voltage range: ±10 V
- Noise floor: < 15 μV
- FRF non-linearity: < 1%

Auxiliary Logical Inputs and Outputs

- Number of inputs: 8
- Number of outputs: 8
- Maximum input voltage: 15 V
- Maximum output current: 0.1 A
- Number of auxiliary input functions: 12
- Number of auxiliary output functions: 7

Scalability

It is possible to stack up to 8 four-channel controllers providing up to 32 input channels and 16 output channels. The construction can be easily installed on the table or mounted in the rack. The modules are connected together with Ethernet cables.

Multishaker Test Support

RL-C21 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.

PC Communication

The controller is connected to PC with an Ethernet cable, which has many advantages over USB, PCI and LPT connections:

- Cable length up to 100 meters
- No installation of additional cards or special connectors required
- No drivers installation required

Windows Integration

TestUP software integrates into any Windows system, starting from Windows 7 and later. To start work, you are to install the program using the installation wizard and run the software.

Demo Version

You can easily download a free demo version of the software from our website. The software demonstrates all the capacities of our system without the actual RL-C21 controller.

Report Creation

TestUP software automatically produces ready-to-use, detailed reports at the end of a testing procedure. The user can select the information to be included in the report.

Shaker Compatibility

RL-C21 system works with any electrodynamic, servo-hydraulic and servo-electric shakers.

Pre-Start Check

The RL-C21 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-C21 system test duration is not limited. Any test can be paused and resumed later on 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, change the level, run a sine sweep from one frequency to another, hold frequency, etc. There is an option to form a cycle of commands, which is executed repeatedly a number of times.

LCD

The front panel of RL-C21 has an LCD that displays the information of test progress and the system status. This way the user is able to see all the information relevant to the current test directly on the controller.

Autonomous Mode

The RL-C21 system can run tests without a PC or laptop connected. The tests to be run are uploaded to the flash memory of the controller. User is able to see all the information relevant to the current test directly on the controller.

Safety System

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

Sine Test

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

Sine Test Parameters

- Frequency range: 0.1 to 35000 Hz
- Relative error of frequency setting: < 0.005%
- Number of control channels: 1 – 32
- Number of control outputs: 1
  (up to 8 for multishaker tests)
- Error of acceleration RMS maintenance: < 2%
- Dynamic range: > 120 dB
- System response time: 1 ms
- Operation modes:

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

Easy Test Set-Up

The test profile is presented 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. TestUP 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.

Sweep Rate Types

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

Test Duration

In the RL-C21 system test duration is not limited. Any test can be paused and resumed later on the user's command.

Control Channels

Control is based on 1 or more channels in the mode of weighted averaging or by the maximum value from the channels.

Features

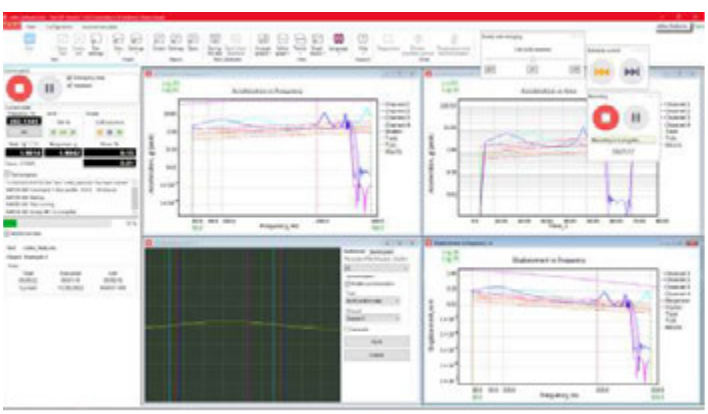
During the test, the user can:

- change the scheduled level;
- change sweep direction;
- set fixed frequency;
- pause the test and resume it later;
- display a number of parameters on the graphs.

Resonance Search and Tracking Dwell

RL-C21 determines resonant frequencies in the automated mode. After resonance search is done, the system can continue operating on one of the resonant frequencies for the preset time or until the user stops the test. Resonance tracking is possible in two modes:

- tracked dwell;
- fixed dwell.



Random Test

In case of random vibration the object under test is subject to true random signal with the preset PSD and either Gaussian or non-Gaussian non-Gaussian distribution. Random test provides a vibration impact, which is closer to the actual environment.

Random Test Parameters

- Frequency range: 0.1 to 35000 Hz
- Number of control channels: 1 – 32
- Number of control outputs: 1 (up to 8 for multishaker tests)
- Relative error of acceleration RMS measurement: < 1%
- Dynamic range: > 100 dB
- Number of spectrum lines: 800 to 52500
- Types of spectrum averaging: exponential, linear, CDOF

Easy Test Set-Up

The test profile is presented in the table form. Each table row is filled with either start and end frequency and PSD, or the start frequency, PSD and slope.

Control Channels

Control is based on 1 or more channels in the mode of weighted averaging or by the maximum value from the channels.

Kurtosis

RL-C21 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)

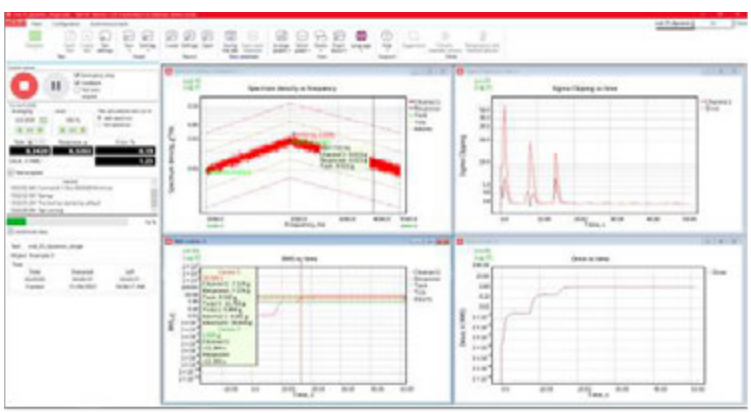
The option of using a constant number of degrees of freedom (CDOF) makes it possible to obtain an averaged value of the power spectral density in just a few seconds.

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.

Features

During the test, the user can:

- change the scheduled level;
- reset the spectral averaging;
- pause the test and resume it later;
- display a number of parameters on the graphs.



SRoR Tests

Besides Random Test, the RL-C21 controller enables running the following types of tests:

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

SRoR Test Parameters

- Frequency range: 0.1 to 35000 Hz
- Number of control channels: 1 – 32
- Number of control outputs: 1
- Relative error of acceleration RMS measurement: < 1%
- Dynamic range: > 100 dB
- Number of spectrum lines: 800 to 52500
- Types of spectrum averaging: exponential, linear, CDOF
- Number of superimposed tones: 1 to 12
- Number of superimposed random bands: 1 to 12

Easy Test Set-Up

The profile of the basic random vibration is presented in the table form. Each table row is filled with either start and end frequency and PSD, or start frequency, PSD and slope.

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

RL-C21 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)

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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.

Features

During the test, the user can:

- change the scheduled level;
- change sweep direction;
- set fixed frequency;
- pause the test and resume it later;
- display a number of parameters on the graphs.

Shock

RL-C21 supports all the classical pulse types. The shocks are run automatically with the preset interval or in the manual mode. To get the best accuracy, the system adjusts drive voltage before each shock.

Shock Test Parameters

- Shock amplitude maintenance error: < 5 %
- Shock duration maintenance error: < 5 %
- 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, rectangular, initial peak saw-tooth and terminal peak saw-tooth, full sine, half sine, haversine.

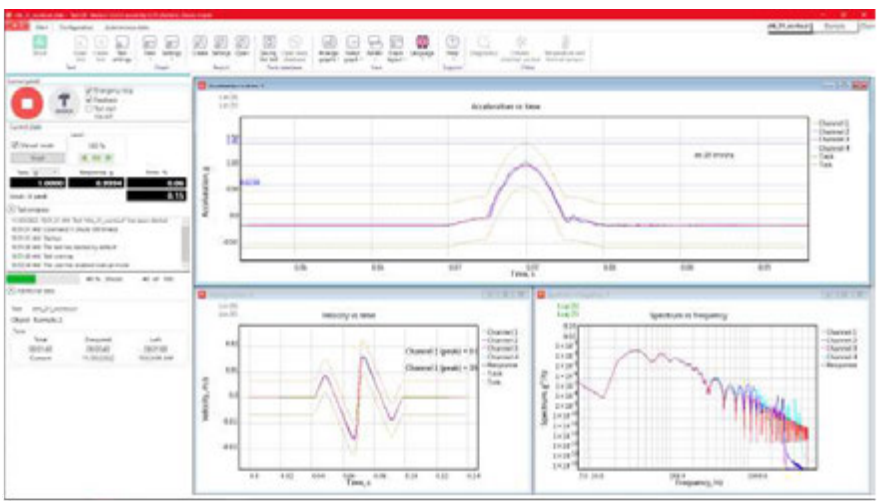
Easy Test Set-Up

After the user specifies the pulse type and other parameters, such as pulse amplitude and width, the system automatically calculates the most suitable parameters to optimize displacement and velocity requirements.

Features

During the test, the user can:

- change the scheduled level;
- switch from automatic to manual mode and vice versa;
- invert a shock;
- pause the test and resume it later;
- display a number of parameters on the graphs.



Shock Response Spectrum Test (SRS)

The SRS test provides the possibility to control the SRS of the device under test to match the required one. RL-C21 supports all the classical types of wavelets. The shocks are run automatically with the preset interval or in the manual mode. To get the best accuracy, the system adjusts drive voltage before each shock.

SRS Test Parameters

- 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

Easy Test Set-Up

To generate a waveform, the user has to specify only the type of wavelets, pulse amplitude and width. After the waveform and wavelets have been generated, the user can adjust any parameter of a wavelet or the waveform.

Features

During the test, the user can:

- change the scheduled level;
- switch from automatic to manual mode and vice versa;
- invert a shock;
- pause the test and resume it later;
- display a number of parameters on the graphs.

Transient Time History

Transient Time History (TTH) test provides the possibility to simulate seismic impact. RL-C21 supports all the most commonly used types of waveforms, such as sine and cosine waves, damped sine wave, teardrop, etc.

TTH Test Parameters

- Maximum pulse duration: 50 s.
- Shock types: enveloped sine, cosine, teardrop, random signal, etc.
- 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

Easy Test Set-up

The user can easily specify and synthesize the required waveform. SRS of the synthesized waveform and data from the channels are calculated automatically.

Features

During the test, the user can:

- change the scheduled level;
- switch from automatic to manual mode and vice versa;
- invert a shock;
- pause the test and resume it later;
- display a number of parameters on the graphs.

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.

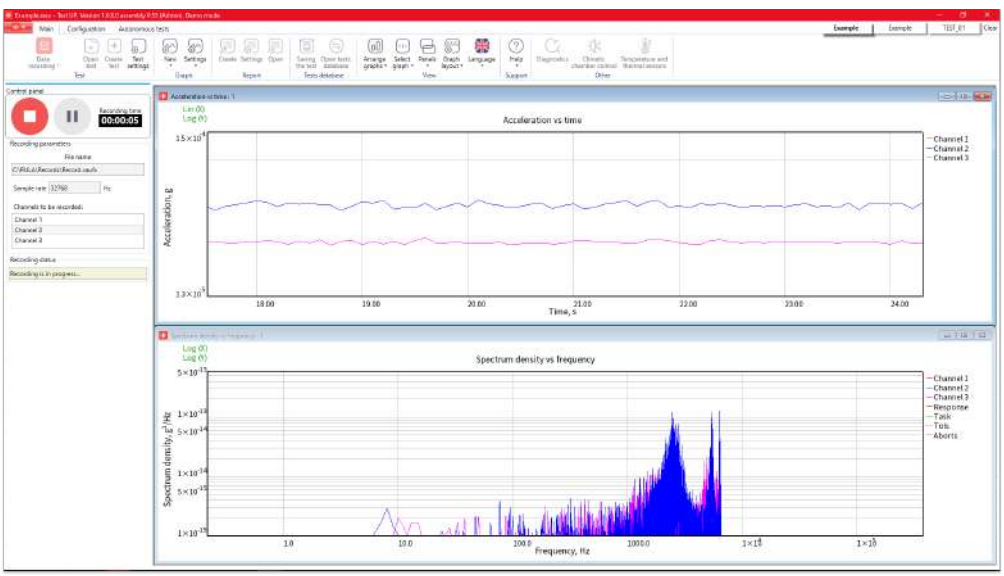
The recorded file may be used in the «Field Data Replication» test or analyzed in any specialized software.

Data Recording Parameters

- Frequency range: 0.1 to 35000 Hz

Recording Duration

The duration of data recording is only limited by the 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.

FDR Test Parameters

- Frequency range: 0.1 to 35000 Hz
- Relative error of acceleration RMS measurement: < 1 %
- Relative error of test duration: < 1 %
- Dynamic range: > 100 dB
- Number of spectrum lines: 800 to 52500

Supported File Formats

RL-C21 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.

Features

During the test, the user can:

- change the scheduled level;
- assess the quality of replication based on two types of error: pointwise and as per IEC standard;
- pause the test and resume it later;
- display a number of parameters on the graphs.

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.

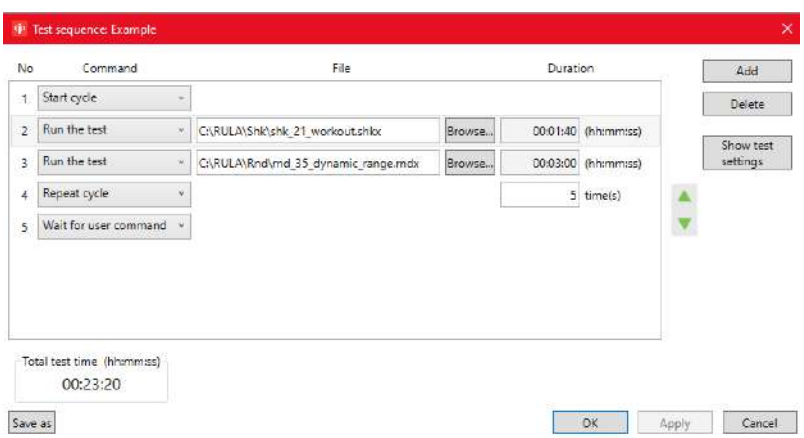
The system runs Sine test first, then automatically closes it, opens Shock test and starts it.

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.

Test Duration

In the RL-C21 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.



Multishaker Tests

RL-C21 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.

Supported test types are Sine, Random, Shock and FDR.

Multi-shaker Test Mode Parameters

- Number of control channels: 2 – 8.
- Number of control outputs: 2 – 8.
- Number of measuring channels: 1 – 30.
- Number of used shakers: 2 – 8.
- Frequency range: 0.1 to 35000 Hz.

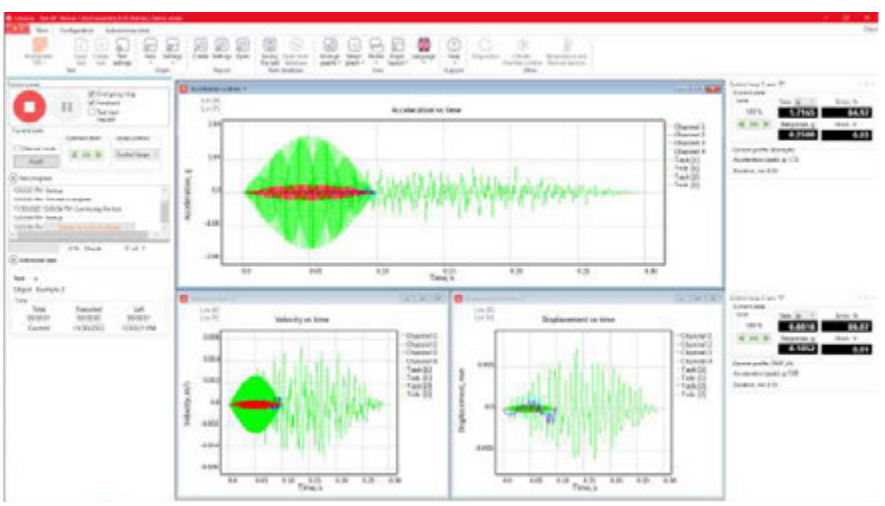
Easy Test Set-up

For each shaker in the vibration set the user specifies a control loop, which corresponds to an input and an output channel. The shaker may be placed along X, Y or Z axis.

Features

During the test, the user can:

- Change the scheduled level;
- Pause the test and resume it later.



Transient Capture

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

Transient Capture Parameters

- Frequency range: 0.1 to 35000 Hz
- Relative error of acceleration measurement: < 1 %
- 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

Easy Measurement Set-Up

The user can adjust all the parameters of data acquisition, such as trigger and filter characteristics.

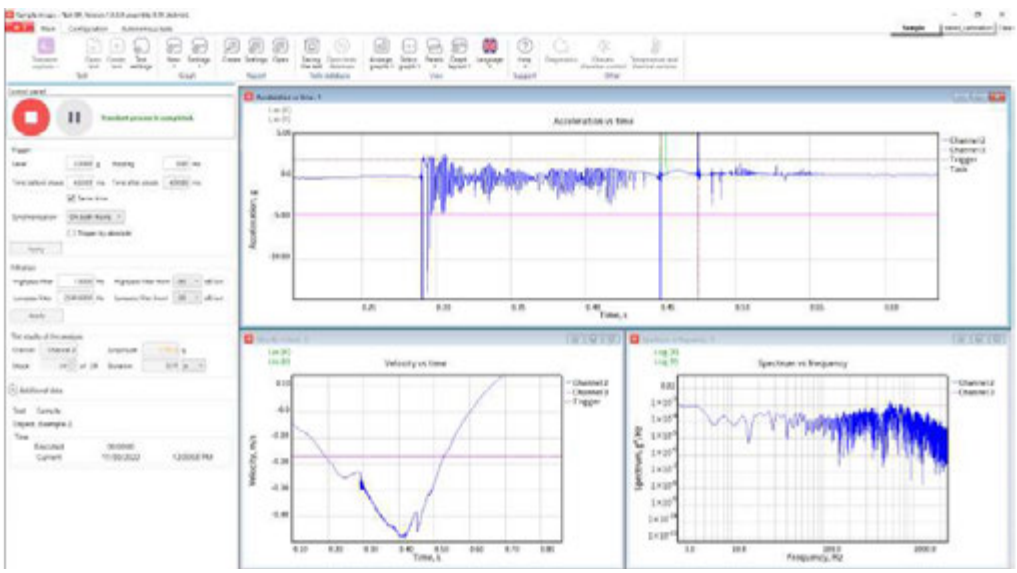
TestUP software provides the option to specify the reference pulse form. This form is to be shown on graphs in order to compare it with the detected pulse.

It is possible to change all the data acquisition parameters while the measurements are in progress.

Data Display Options

For each detected transient process, the system displays a waveform, spectrum and SRS.

The software displays the detected pulse duration, amplitude and other parameters on a special panel. After the acquisition is stopped, the user can view all the previously captured processes.



Fatigue Tests

RL-C21 provides the possibility to run specialized fatigue tests, intended to evaluate the durability of turbine and compressor blades.

This mode enables running Sine test with several sine tones simultaneously, searching resonances and tracking several frequencies at the same time.

Each sine tone is controlled independently to get the best possible accuracy.

Fatigue Test Parameters

- Frequency range: 0.1 to 35000 Hz
- Relative error of frequency setting: < 0.005%
- Number of sine tones run simultaneously: 1 – 8
- Number of resonance tracked simultaneously: 1 – 8
- Dynamic range: > 120 dB

Easy Test Set-Up

The test profile is presented 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. TestUP 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.

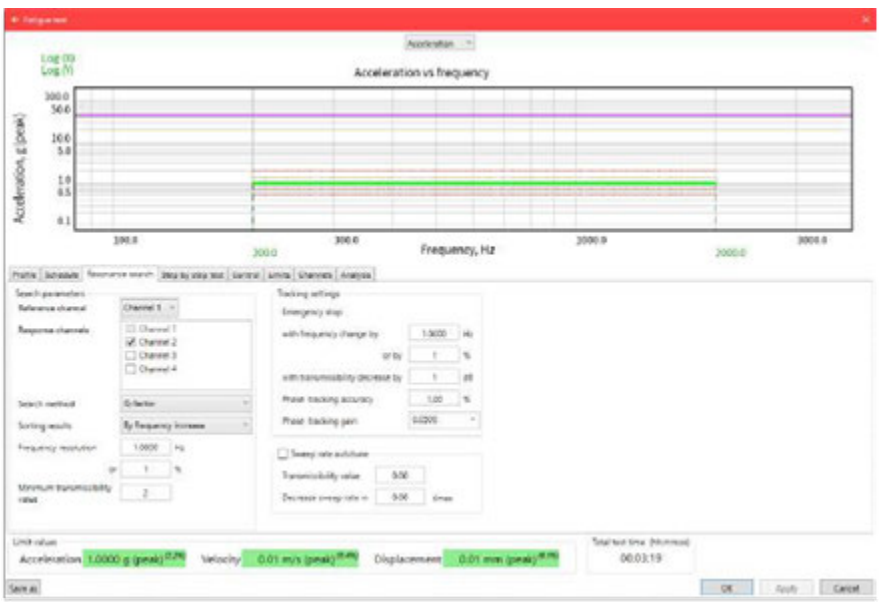
Sweep Rate Types

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

Independent Control

Each sine tone is controlled independently of the others and for each of them the user can create its own schedule.

While the test is in progress, the level of each sine tone can be manually adjusted.



Fatigue Damage Spectrum

Fatigue Damage Spectrum allows accelerating tests on real-live data based on the vibration fatigue.

FDS software calculated the damage spectrum by an algorithm based on the Palmgren-Miner rule and converts the calculated data to a Random test with the user-specified time.

Resonance Search and Tracking Dwell

RL-C21 determines resonant frequencies in the automated mode. After the resonance search is done, the system can continue operating on one of the resonant frequencies for the preset time or until the user stops the test. Resonance tracking is possible in two modes:

- tracked dwell;
- fixed dwell.

Several Resonances

RL-C21 can track several resonant frequencies simultaneously. For each resonance, the system provides independent control by amplitude and frequency.

Parameters

Calculation algorithm: Palmgrem-Miner rule based
Analysis frequencies: part-octave, 1/1 to 1/24
Profile Generation: PSD, with the user-defined test time

FDS software module provides:

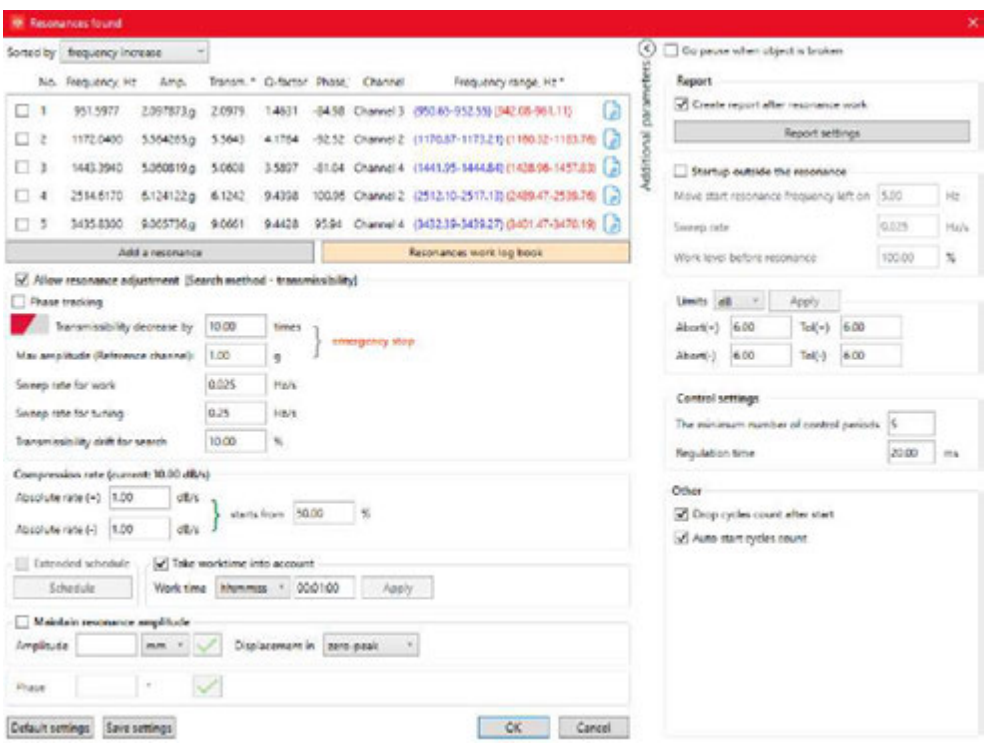
comprehensive test of product durability,
considerably reduced test time and expenses.

Control by Displacement

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

Expanded Safety System

In addition to the standard safety checks, Fatigue Tests check the shift of resonant frequency to ensure the object under test is not completely destroyed.



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