Vibration control system
ZET-02X

3TMC.441151.095 34

Operator’s manual

Thank you for choosing instruments manufactured by LLC “ETMS”!

Vibration control system ZET 02X is developed and manufactured by LLC “Electronic technologies and metrological systems”, located in Zelenograd, Moscow.

Vibration control system ZET 02X is intended for the control of various types of electrodynamic shakers.

The present Operator’s manual contains information concerning operation of the vibration control system ZET 02X. Due to the constant updating of the software, this user manual may slightly differ from the software version, that you are currently using. LLC “ETMS” reserves the right to introduce changes in the present Operator’s manual, as well as to withdraw it at any time without preliminary notification.

The present Operator’s manual contains links to the following documents:

IEC 60068-2-6 «Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)».

IEC 60068-2-64 «Environmental testing - Part 2-64: Tests - Test Fh: Vibration, broadband random and guidance».

IEC 60068-2-27 «Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock».

MIL-STD-810H «Environmental engineering considerations and laboratory tests».

It should be noted, that vibration testing performance requires certain experience in the course of its preparation and implementation. This issue should be considered both by the Customer and the Manufacturer.

Additional information concerning scope and use of the instruments manufactured by LLC “ETMS” in terms of vibration testing performance is available on our web-site in the section “Shaker control systems”.

Warranty agreement

LLC “ETMS” guarantees absence of the defects in the hardware part of the system for the period of ten (10) years from the date of system purchase upon condition of annual periodical verification of the instruments in the manufacturing facility of LLC “ETMS”.

LLC “ETMS” does not guarantee error-free operation of the shaker control system and is not responsible for the damage attributed to non-observation of the instructions specified in the present Operator’s manual (including wrong commutation of the equipment).

Introduction

Vibration control system ZET 02X (hereinafter referred to as **VCS ZET 02X**) is a hardware and software system used for generation of the signals applied to the input of the shaker amplifier in compliance with the set test profile. The system is also used for recording of the response from the transducers installed at the moving part of the system and at the specimen to be tested.

Depending on the configuration of **VCS ZET 02X** (see Table B.1), the controller can be used for operation of one or up to four shakers.

The scope of **VCS ZET 02X** includes:

- Multi-channel data acquisition system ZET 024, or ZET 028 (hereinafter referred to as **VCS controller**), depending on the configuration, the number of controllers varies from one up to four (see Table B.1);
- Software (software programs) **ZETLAB VIBRO** (to be installed on the PC with Windows OS);
- Primary transducers (accelerometers BC 110, BC 111, etc.).

Table B.0.1

Number of VCS measurement channels	*Number of VCS controllers*		*Number of control channels (signal generator channels)*
	ZET 024	*ZET 028*	
4	*1*	-	*1*
8	-	*1*	*1*
16	-	*2*	*2*
24	-	*3*	*3*
32		*4*	*4*
The maximal number of measurement channels can be increased up to 160, in the case if VCS is additionally equipped with FFT Spectrum analyzers of ZET 034, ZET 038 series.			

ZETLAB VIBRO software is a task-specific software complex by **ZETLAB**. The list of programs included into the scope of **ZETLAB VIBRO** software is specified in Table B.2.

Note! *The Manufacturer reserves the right to introduce changes and improvements, which do not deteriorate performance of VCS ZET 02X, without specifying them in the present Operator's manual. In the case of problems relating to the operation of VCS ZET 02X, please, contact us.*

LLC "ETMS" address: Russia, 124460, Moscow, Zelenograd,
street Konstruktora Lukina, house 14, building 12, room 423 **Telephone/fax**: (495) 739-39-19.
Web-site: www.zetlab.com **Technical support:** info@zetlab.ru

Table B.0.2

	Name of the program	Composition of ZETLAB Software program sets							
		DEMO	ANALIZ	VIBRO	NOIZE	TENZO	SEISMO	BASE	SENSOR
Signal analysis	Narrow-band spectrum	✓	✓	✓	✓	✓	✓	✓	✓
	Octave range spectrum	✓	✓	✓	✓		✓		
	Cross narrow-band spectrum	✓	✓	✓			✓		
	Cross-spectrum octave	✓	✓	✓	*		✓		
	Cross-correlation analysis	✓	✓	✓			✓		
	Non-linear distortion analysis	✓	✓	✓	✓	✓	✓		
	Synchronous accumulation	✓	✓	✓	✓	✓	✓		
	Modal analysis	✓	✓	✓	✓	✓	✓		
	Histogram		✓	✓		✓	✓		✓
	Super-resolution spectrum		✓	✓		✓	✓		✓
	STA\LTA detector		✓	✓		✓	✓		✓
	Wavelet analysis		✓	✓		✓	✓		✓
Measurement	AC voltmeter	✓	✓	✓	✓	✓	✓	✓	✓
	DC voltmeter	✓	✓	✓	✓	✓	✓	✓	✓
	Selective voltmeter	✓	✓	✓	✓	✓	✓	✓	✓
	Frequency meter	✓	✓	✓	✓	✓	✓	✓	✓
	Phase meter	✓	✓	✓	*	✓	✓	✓	✓
	Power meter	✓	✓	✓	✓	✓	✓	✓	✓
	Tachometer		✓	✓	✓	✓	✓		
	Torsiograph		✓	✓	✓	✓	✓		
	Encoder		✓	✓	✓	✓	✓		
	TR thermometer					✓			
	TC thermometer					✓			
	Strain-gauge meter					✓			
	Vibration meter	✓	✓	✓	✓		✓		
	Data recording from third-party instruments (Agilent, etc.)		option	option	option	option	option	option	
Display	Multi-channel oscilloscope	✓	✓	✓	✓	✓	✓	✓	✓
	XYZ-oscilloscope	✓	✓	✓	*	✓	✓	✓	✓
	XYZ-plotter	✓	✓	✓	*	✓	✓	✓	✓
	Results viewing	✓	✓	✓	✓	✓	✓	✓	✓
	Signals gallery	✓	✓	✓	✓	✓	✓	✓	✓
Generators	Signals generator		✓	✓		✓	✓	✓	option
	Synchronous generator		✓	✓		✓	✓	✓	option
	Shaker parameters editor	✓		✓					
	Feedback generator (Classical shock)	✓		✓					
	Feedback generator (Vibration shock)	✓		✓					
	Feedback generator (Sinusoidal vibration)	✓		✓					
	Feedback generator (Random vibration)	✓		✓					

Table 2 (continued)

		DEMO	ANALIZ	VIBRO	NOIZE	TENZO	SEISMO	BASE	SENSOR
Recording	Signals recording		✓	✓	✓	✓	✓	option	option
	Signals archive converter		✓	✓	✓	✓	✓	option	option
	Signal trends viewing	✓	✓	✓	✓	✓	✓	✓	✓
	Signal trends scanner	✓	✓	✓	✓	✓	✓	✓	✓
	Event trends viewing	✓	✓	✓	✓	✓	✓	✓	✓
	Signals reproduction		✓	✓	✓	✓	✓	option	option
	Multi-channel recorder		✓	✓	✓	✓	✓	option	option
Metrology	AFR measurement log. (AC)		✓	✓			✓		
	AFR - log. scale (with selection of external generator)		✓	✓			✓		
	AFR - log. scale (DC)		✓	✓			✓		
	AFR - log. scale (AC/DC)		✓	✓			✓		
	AFR - lin. scale (AC)		✓	✓			✓		
	AFR - lin. scale (DC)		✓	✓			✓		
	AFR - log. scale (Selective)		✓	✓			✓		
	Log. Ph.-freq. response		✓	✓			✓		
	Lin. Ph.-freq. response		✓	✓			✓		
	Log. Non-linear distortion factor		✓	✓			✓		
	Frequency response measurement in fixed frequency range (AC)		✓	✓			✓		
	Metrological self-check ZET7xxx		✓	✓			✓		
Automation	ZETView		option	✓	option	option	✓	option	option
	ZETView (exe)		✓	✓	option	option	✓	option	option
	Controller	✓	✓	✓		✓	✓	option	
	Arithmometer	✓	✓	✓	✓	✓	✓	✓	✓
	Adaptive filter 50 Hz	✓	✓	✓	✓	✓	✓	option	✓
	Signals filtration	✓	✓	✓	✓	✓	✓	option	✓
	Synchronization of instruments		*	*	*	*	✓	✓	
	Formula	✓	✓	✓		✓	✓	option	
	Switching unit control	✓	*	*	*	*	✓	✓	*
	Electrical circuits parameters control								
Network	Enable signals transmitter	✓	✓	✓	option	✓	✓	option	✓
	Connect to signals transmitter	✓	✓	✓	✓	✓	✓	✓	✓
	Connection of devices by Ethernet		✓	✓	✓	✓	✓	✓	*
	Connection of devices by Bluetooth	✓	*	*	*	*	*	✓	*
Service	ZETServer time	✓	✓	✓	✓	✓	✓	✓	✓
	Device manager	✓	✓	✓	✓	✓	✓	✓	✓
	Channels listening	✓	✓	✓	✓	✓	✓	✓	✓
	ZETLab error log	✓	✓	✓	✓	✓	✓	✓	✓

TABLE OF CONTENTS

Introduction ..... **I**

1 Common information concerning VCS ZET 02X **1-1**

1.1 General arrangement of VCS 1-3
1.2 Operational conditions of VCS 1-5
1.3 Information concerning ZETLAB VIBRO software 1-5
1.4 PC requirements 1-6

2 ZETLAB VIBRO: setting-up procedures **2-1**

2.1 Installing ZETLAB software to PC 2-1
2.2 Starting ZETLAB control panel 2-1
2.3 Help information 2-1
2.4 User directories configuration 2-2
2.5 Indicator “Status of the connected devices” 2-3
2.6 Closing ZETLAB software programs 2-5
2.7 Closing ZETLAB software control panel 2-5

3 Control and indication elements **3-1**

3.1 Cursor control in graphs 3-1
3.2 Scaling of numerical axes 3-1
3.3 Selection from the lists 3-2
3.4 Configuration of program windows display parameters 3-2
3.5 Using the keys «Start», «Stop» and «Recording» 3-5
3.6 Using signal level indicators 3-7
3.7 Adjustment of the color scheme used for displaying of the registered signal amplitude values 3-7
3.8 Transmission of graphical and numerical data to text editors 3-8

4 Connection of VCS controller to PC by Ethernet **4-1**

4.1 Connection sequence 4-1
4.2 Default parameters of VCS controller 4-1
4.3 Checking IP-address of the controller 4-2
4.4 Configuring IP-address of the PC 4-3
4.5 Configuring IP-address of the PC 4-5
4.6 Activation of VCS controller Ethernet channel 4-6

5 Working with ZETLAB VIBRO **5-1**

5.1 Shaker Parameters Program 5-2
5.2 Specimen Parameters program 5-5
5.3 ZET Device Manager Program 5-7
5.4 The Control Parameters program 5-11
5.5 The Sine Vibration Program 5-19
5.6 The Random Vibration program 5-41
5.7 The Shock program 5-62
5.8 User Defined Transient 5-76

6 Terms and definitions **6-92**

Appendix A. Shapes of the shock pulse accelerograms **6-99**

Appendix B. Common errors when operating ZETLAB VCS **6-101**

1 Common information concerning VCS ZET 02X

Before you start using *VCS ZET 02X*, it is necessary to:

- Study operational documentation to the VCS controller;
- Study operational documentation to the shaker, which is going to be controlled with VCS ZET 02X;
- Study operating principles of ZETLAB VIBRO software programs, and install ZETLAB software to the PC (section 2.1).

In order to start vibration testing, it is necessary to arrange the instruments in compliance with the applied scheme (Fig. *1.1*):

- Connect the VCS controller(s) to the PC via Ethernet (see section 4);
- Install the mounting fixture to the shaker and attach the specimen to be tested to it;
- Install the primary transducers (accelerometers) on the specimen in the areas, where it is necessary to control the vibration level in compliance with the requirements specified in «GOST ISO 5348-2002. Vibration and shock. Mechanical mounting of accelerometers»;
- Connect the primary transducers (accelerometers) to the inputs of the VCS controller, and connect the output of the VCS controller to the input of shaker amplifier;
- Configure parameters of ZETLAB VIBRO software (see section 5) in order to secure the vibration testing performance in compliance with the applicable requirements.
- Implement the test sequence and specify the relevant results in the test protocol.

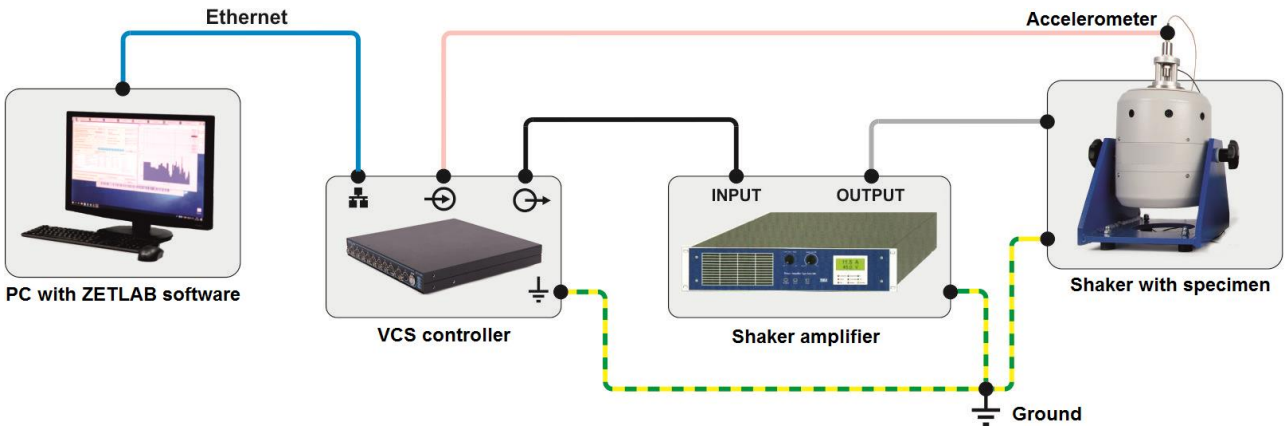


Fig. 1.1 Structural scheme of VCS ZET 02X

Since this scheme implies the use of shaker amplifier, it is necessary to provide grounding for all the components present in the scheme. The shaker and the amplifier are to be grounded in compliance with the relevant operational documentation. The grounding terminal of the VCS controller is located at the rear panel. All grounding wires are to be connected at a single physical point (as a

common point you can use the grounding terminal of the amplifier), which is to be connected to the grounding bus.

Grounding of the system components is necessary for securing protection of VCS controller from the cross-talk relating to the amplifier or the shaker. Besides, in many cases, proper grounding allows to reduce the interference from the power supply network (the harmonic signal at the frequency of 50 Hz).

Note: *In order to reduce electrical cross-talk, it is recommended to provide reliable electrical insulation between the primary transducers (accelerometers) and the table (head) of the shaker.*

For the purpose of emergency shut-down of vibration testing process, there is used “Stop” key located at the front panel of VCS controller. Upon activation of the “Stop” key, the system disconnects the output circuit of the VCS controller, and the shaker is switched off. In the case if VCS programs were not stopped automatically, it is necessary to close them in manual mode.

The rules of connecting the sensors (primary transducers) to the VCS controller are described in user manuals for transducers and relevant equipment.

1.1 General arrangement of VCS

Fig. 1.2 displays front panels of VCS controllers ZET 024 and ZET 028, and *Table **1.1*** describes functions of panel elements.

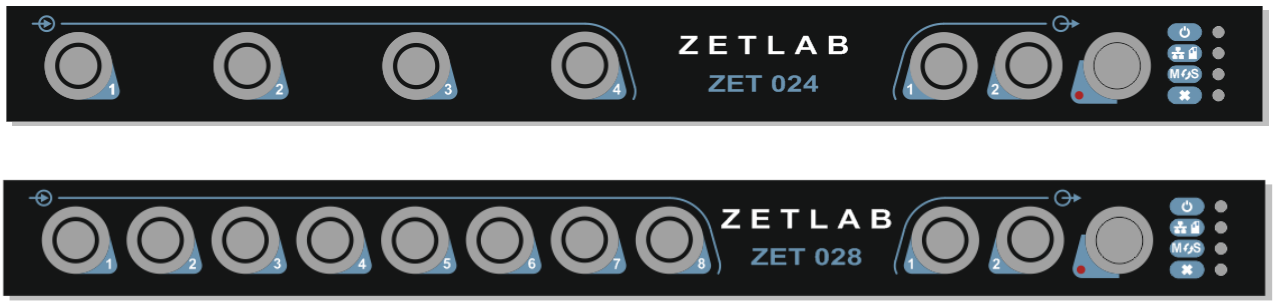


Fig. 1.2 Front panels of VCS controllers ZET 024 and ZET 028

Table 1.1 Functions of front panel control elements

Labelling	Function
(1…8)	Inputs of measurement channels with integrated indicators. Green LED – operation mode “Input by voltage” is enabled. Blue LED – operation mode “ICP input” is enabled.
(1, 2)	Generator outputs[1] with integrated operation indicators. Green LED – the generator is controlled from PC. Blue LED – standalone operation mode.
	Emergency shutdown of the vibration testing.
	Indicator of operational status of the controller (on/off). As the controller is on, the indicator flashes with green.
	Indicator of controller’s operation mode. When the controller is connected to the PC (stationary mode), the indicator flashes with green. If the controller is used for signals recording to SD-card without connection to PC (standalone mode), the indicator flashes with blue.
	Controller synchronization indicator. In the synchronization mode, the “Master” indicator flashes with green. In the synchronization mode, the “Slave” indicator flashes with blue.
	Error indicator. Indicator flashes with red if an error is detected, or input voltage level at the measurement channel is exceeded.

[1] Two generator outputs (mutually inverted).

Fig. 1.3 displays the rear panel of VCS controllers ZET 024 and ZET 028, and *Table 1.2* describes functions of the panel control elements.

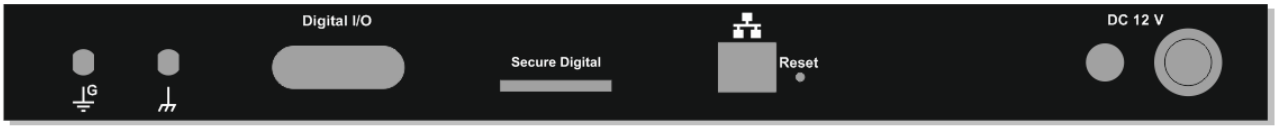


Fig. 1.3 Rear panel of VCS controllers ZET 024 and ZET 028

Table 1.2 Functions of rear panel control elements

Labelling	Function
Digital I/O	Digital input/output. Process connector.
Secure Digital	SD slot for recording signals and files with «*.log» extension in standalone mode. The system supports SD-cards of SD/SDHC format with volume up to 32 Gb.
	Port for connecting controller to the PC via Ethernet 10/100 interface.
Reset	«Reset» key of the Ethernet port address to the default parameters.
DC 12 V	Port for connecting 12 V power supply module. Key “Switching the controller on/off”.
	Grounding terminal of the controller.
	Grounding terminal of the controller generator.

1.2 Operational conditions of VCS

VCS controller can be placed on a table, or in the standard 19” frame with 19” support bracket (option).

Operational conditions:

- Ambient temperature: 5 - 40°C;
- Relative air humidity: up to 90 % at 25 °C;
- Atmospheric pressure (630– 800) mm Hg;
- Power supply network frequency (50 ± 0,5) Hz;
- AC power supply network voltage (220 ± 22) V.

1.3 Information concerning ZETLAB VIBRO software

ZETLAB VIBRO software contains a list of programs from ZETLAB software, covered by general license. The license for operation of ZETLAB VIBRO software is located in the firmware of VCS controller. Thus, as the controller is connected to the PC, all functions of ZETLAB VIBRO software become available to the user.

Description of ZETLAB software installation process, and the rules of using ZETLAB control panel are available in section 1 of the present manual.

1.4 PC requirements

For operation of *ZETLAB VIBRO* software, we recommend you to use the following minimal requirements to the PC configuration[2]:

- Two-core processor with processor speed more than 1,6 GHz;
- RAM – more than 4 Gb;
- Hard disk free space – more than 20 Gb;
- Video card with 3D-graphical acceleration, support of OpenGL, DirectX, memory – over 128 Mb;
- Minimal display resolution: 1600×900;
- Network interface 10/100 Mbps (RJ-45 port);
- USB 2.0 interface for installation of the programs;
- Mouse or any other pointing device (touch screen, track ball), TouchPad, graphic pad);
- Standard keyboard or any other input device (sensor screen, graphic pad).

ZETLAB VIBRO Software programs are intended for use on PC-s of IBM PC Intel® /Pentium®/Celeron®/ or other compatible configurations with localized or russified OS versions:

- Microsoft® Windows® 7 32 bit with SP1 update package;
- Microsoft® Windows® 7 64 bit with SP1 update package;
- Microsoft® Windows® 8 32 bit;
- Microsoft® Windows® 8 64 bit;
- Microsoft® Windows® 8.1 32 bit;
- Microsoft® Windows® 8.1 64 bit;
- Microsoft® Windows® 10 32 bit;
- Microsoft® Windows® 10 64 bit.

[2] These minimal PC requirements are recommended for operation with maximum 2 controller channels. For operation with a greater number of channels it is necessary to use PC with a higher capacity.

2 ZETLAB VIBRO: setting-up procedures

2.1 Installing ZETLAB software to PC

In order to install ZETLAB software, it is necessary to run installation file ZETLAB.msi (supplied on USB flash-drive) and follow further instructions to install ZETLAB Software to the directory C:\ZETLab.

2.2 Starting ZETLAB control panel

In order to start ZEETLAB panel, it is necessary to activate *ZETLAB* icon (Fig. *2.1*), located at the desktop.

Fig. 2.1 ZETLab icon image

At the top section of the screen there will appear *ZETLAB* panel (Fig. *2.2*).

Fig. 2.2 ZETLAB control panel

ZETLAB control panel allows to find the required programs by selecting a particular menu section of ZETLAB control panel and finding the required program in the drop-down list.

Images near the names of the programs allow to simplify the search of the required program.

2.3 Help information

During operation of ZETLAB software programs the user can get access to the help information, which has a tree-coded structure (Figure 2.3).

To get access to the help data for the program, which is currently used, click <F1> in the window of this program.

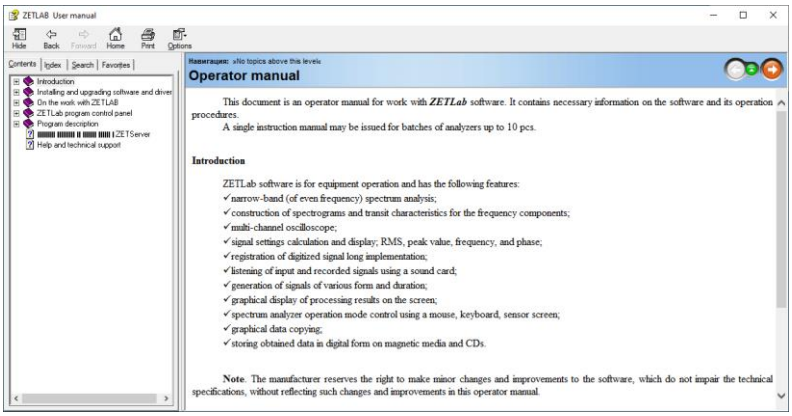


Fig. 2.3 Help information window

2.4 User directories configuration

ZETLAB software needs several directories on the PC for proper operation. Some directories are created by the software and cannot be changed, while the other can be configured by the user.

The directories containing signals, compressed signals, processing results and configuration files can be configured by the user.

To assign user directories, it is necessary to create them (in the case, if they do not exist), and then configure user path configuration for them.

To configure user path configuration, go to “ZETLAB control panel” (Fig. 2.2), click *ZETLAB* icon, and enable the panel “User path configuration” in the window “Main menu of the control panel” (Fig. 2.4).

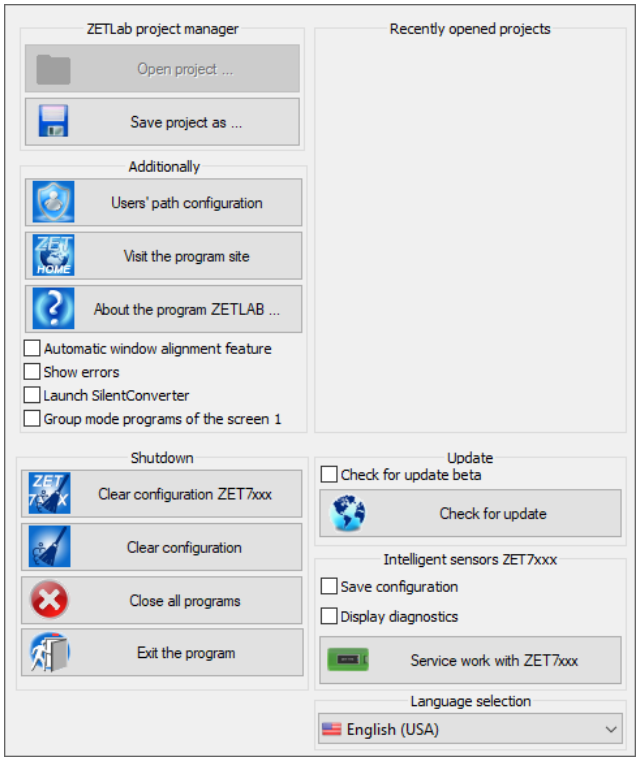


Fig. 2.4 Main menu of ZETLAB control panel

In the window “Adjusting configuration access” (Fig. 2.5), activate the panel «...» for each user directory, which corresponds to the data type to be stored in them (signals, compressed signals, processing results, configuration files). In the window “Choose directory” set the required configuration path, and click “Select folder”.

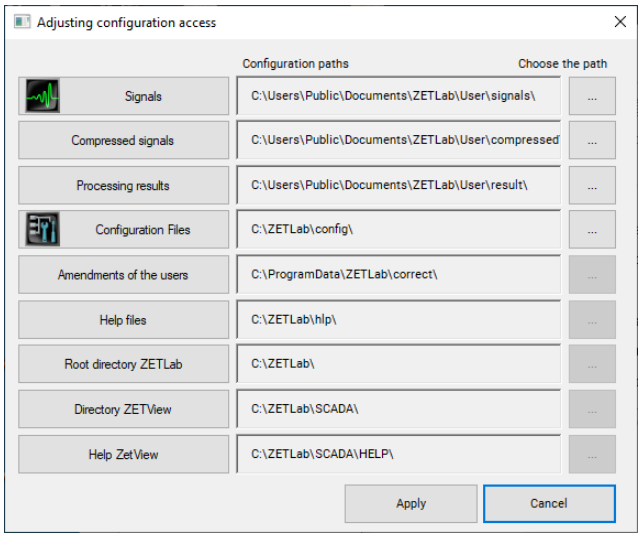


Fig. 2.5 Window «Adjusting configuration access»

2.5 Indicator "Status of the connected devices"

Indicator of the connected devices status is located in the right section of ZETLAB panel.

Depending on the results of constant diagnostics of the connected devices manufactured by LLC "ETMS", the indicator may have one of the three indication conditions:

- Normal mode;
- Warning;
- Error.

The *Normal mode* condition of the indicator is used in the case if the software does not detect any errors in operation of the hardware and parameters configuration of the software.

In the case, if the software detects minor errors in operation of one or several devices, or parameters configuration error, the system activates "*Warning*" indicator (or "*Error*" indicator in the case if a critical error is detected).

In order to obtain information concerning the reasons of the detected errors, activate the panel with the symbol of the connected devices parameters indicator. You will see a window containing description of the detected error type (Fig. *2.6*).

Note! *Before you continue using ZETLAB software, you should take measures aimed at elimination of the detected error's reason.*

To obtain additional information, right-click the menu panel (Fig. *2.7*) and click the line «Help».

In the help information window, (Fig. *2.8*), you will see information concerning the measures required for elimination of the detected error.

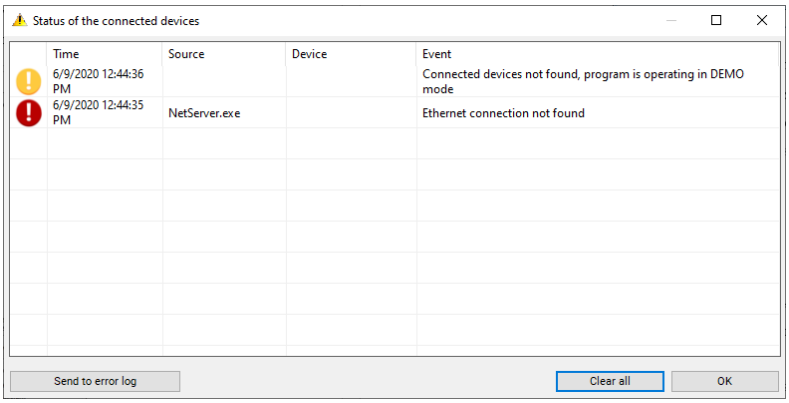


Fig. 2.6 Window «Status of the connected devices»

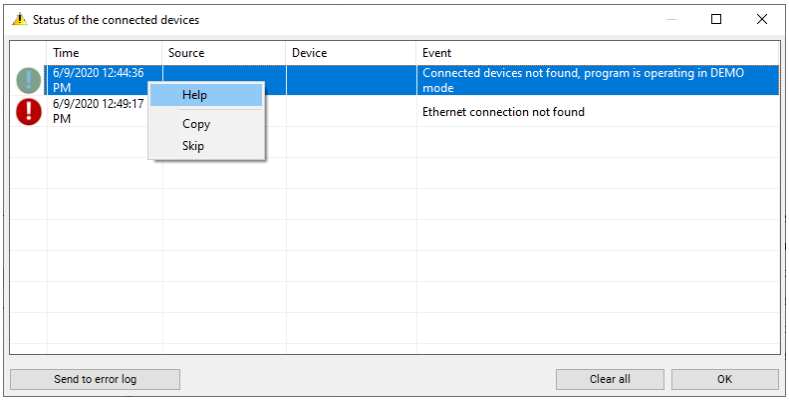


Fig. 2.7 Window «Status of the connected devices» with menu panel

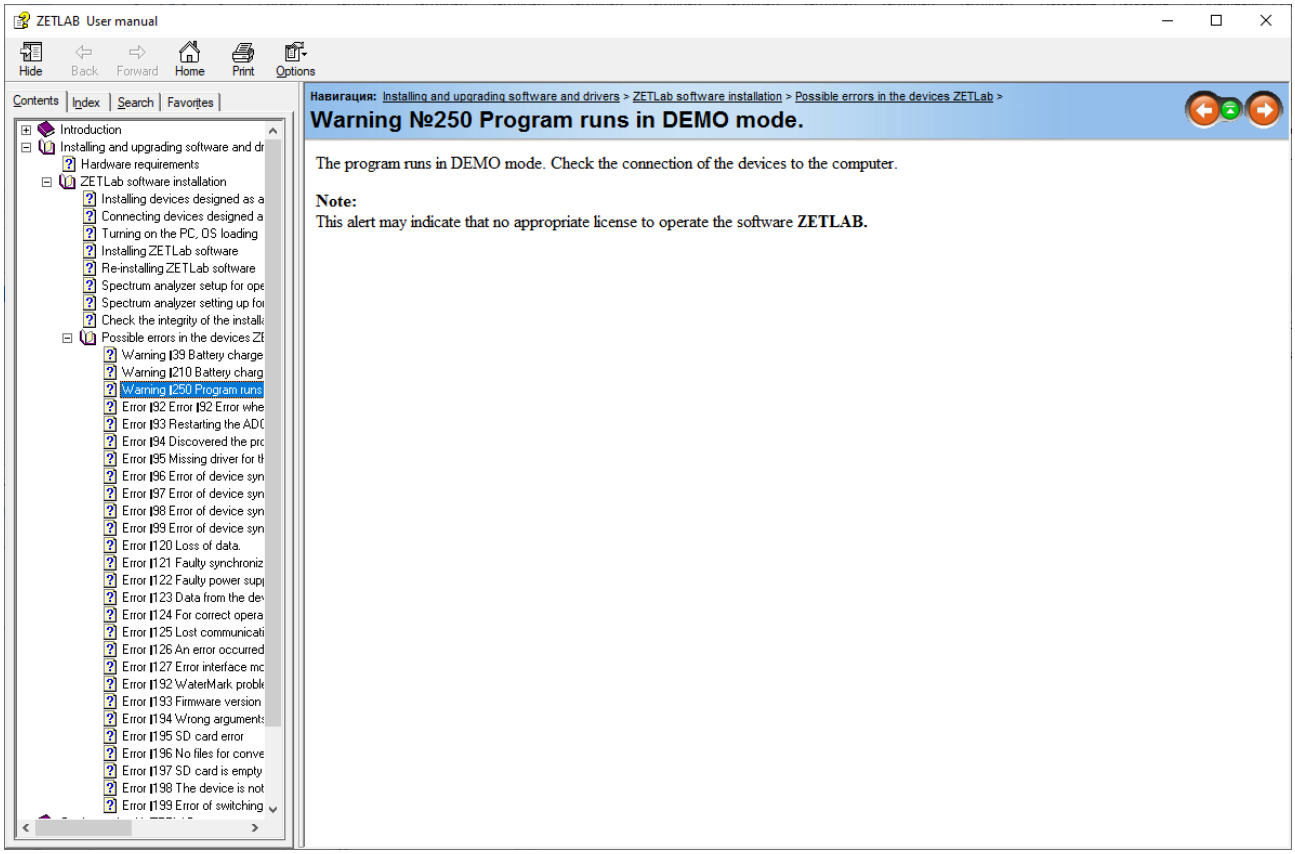


Fig. 2.8 Help information window

In the case, if the reason of the detected error was attributed to settings time or with connection of the devices, and this reason has already been eliminated, then, upon activation of the key “Clear all” in the window “Status of the connected devices” (Fig. 2.6), the indicator of the connected devices status will switch over to «*Normal mode» (*absence of errors). In the case, if the error reason has not been eliminated, the indicator of the connected devices status will display “Error” condition again.

2.6 Closing ZETLAB software programs

In order to close all programs, which have been started with the use of ZETLAB control panel, go to “*Main menu of the control panel*” (Fig. 2.4), and click the key “*Close all programs*”. *ZETLAB* panel will remain active.

2.7 Closing ZETLAB software control panel

In order to close ZETLAB control panel, go to “*Main menu of the control panel*” (Fig. 2.4) and click the key “*Exit the program*”. The system will close both *ZETLAB* control panel and all active *ZETLAB* programs.

3 Control and indication elements

3.1 Cursor control in graphs

Most of ZETLAB program windows that are used for displaying of graphs, have a cursor, which allows to display the values, calculated by the program, at a particular position of the cursor.

You can move the cursor in the program window using one of the following options:

- Place the cursor at a particular point of the graph, click and hold the left key until the cursor moves to the specified point;
- In active window of ZETLAB program (to activate the program window, left-click it) use the scroll key to achieve the desired frequency value;
- To move the cursor to the left in active window of ZETLAB program, click and hold <*A*>, to move the cursor to the right, click and hold <*D*>.

3.2 Scaling of numerical axes

You can scale the numerical axes using mouse.

To scale the numerical axes, place the mouse cursor to the scale axis of the graph. The cursor will change its appearance depending on its position on the numerical axis:

- For horizontal axes: ↔ , ⇥⇤ , ← , → ;
- For vertical axes: ↕ , ⇳ , ↑ , ↓ .

Symbols ↔ and ↕ stand for extension, and symbols ⇥⇤ and ⇳ - for compression of the graph scale by the corresponding axis. Symbols ← and → stand for moving to the left and to the right by the horizontal axis, and symbols ↑ , ↓ stand for moving up and down by the vertical axis.

As you select the required action for scaling by numerical axis and the cursor changes its appearance, you can scale the graph by using the left mouse key, or by using the scroll key.

For auto-scaling of the vertical axis in the registered range of values (which is displayed in horizontal axis of the graph), place the cursor at the crossing of the numerical axes, so that the cursor icon would change for ⤢ and left-click it.

3.3 Selection from the lists

The icon « » of ZETLAB programs allows the user to select the required parameter value from the list.

In order to select the required parameter from the list, place the cursor at the corresponding symbol. You will see a drop-down list with the available values. Place the cursor at the required value and left-click it. You can switch between the available values using the scroll key, or the keyboard keys <↑> and <↓>.

3.4 Configuration of program windows display parameters

Most of ZETLAB programs windows allow the user to change their display parameters. To change the window display parameters, place the cursor at the graph section of the program to be configured, and right-click it. You will see the Graph parameters window (Fig. *3.1*).

In the tab “Display parameters” (Fig. *3.1*) you can configure the line type and graph parameters. The graph can be displayed as a stepped line or as a broken line. This tab also allows to set the display parameters for each of the graphs (color, thickness, filling (color) of a particular graph area). As you set the required parameters, click “Apply” to save the changes.

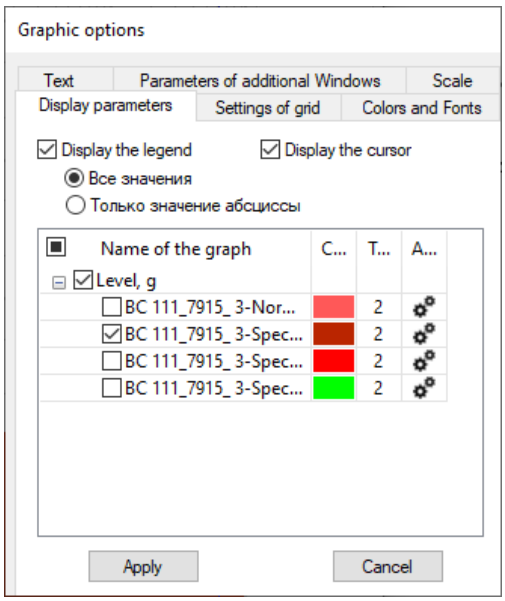


Fig. 3.1 The tab for configuration of graph display parameters

The tab “Settings of grid” (Fig. 3.2) allows to enable/ disable the displaying of horizontal and vertical labelling of axes and grid. In this tab, you can also set the visible area of graphs to be displayed: upper, bottom, left and right boundaries of the graph. As you set the required parameters, click “Apply” to save the changes.

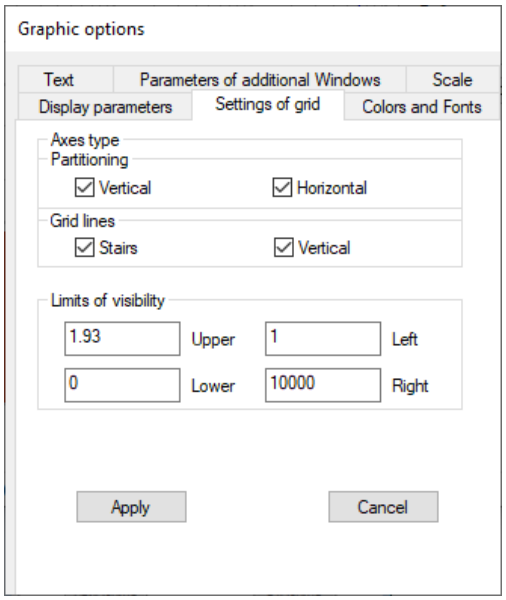


Fig. 3.2 The tab for configuration of graph grid parameters

The tab “Colors and fonts” (Fig. 3.3) allows to set the font size for numerical axes and the measured values. In this tab, you can also set the color of grid, cursor, background, axes marks, legend. As you set the required parameters, click “Apply” to save the changes.

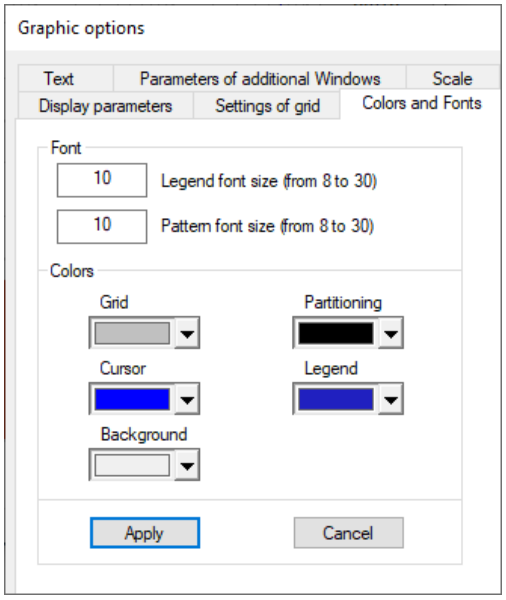


Fig. 3.3 The tab for configuration of color and fonts of the graph

The “Text” tab (Fig. 3.4) allows to add text to the graph (additional clarifying information) to be displayed as the graph is copied to text documents and reports. To add a text, click the checkbox “Show the text”, select the font and enter the text (in this example: “Transducer at the point 2”), then click “Apply” to save the changes.

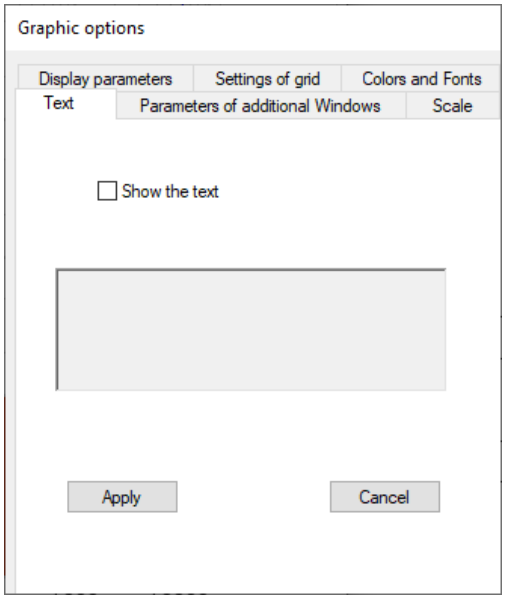


Fig. 3.4 The tab used for adding text to the graph

In this figure (Fig. 3.5) you can see a section of the program window «Narrow-band spectrum» with additional text information- «Transducer at the point 2».

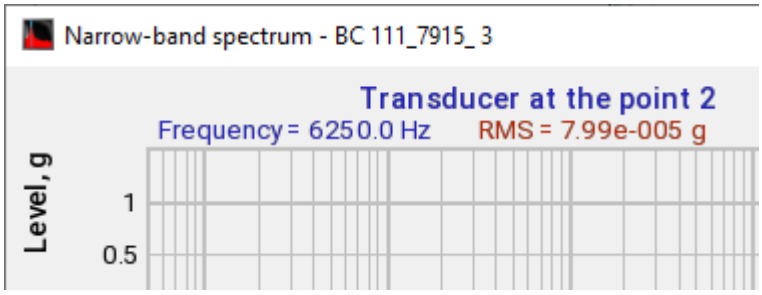


Fig. 3.5 Section of the program window with additional information

The «Scale» tab (Fig. 3.6) allows to select the type of vertical and horizontal axes representation. As you set the required parameters, click “Apply” to save the changes.

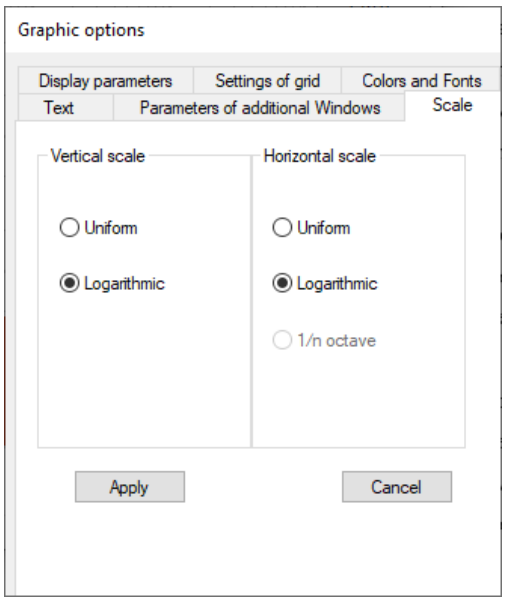


Fig. 3.6 The tab used for configuration of graph scale

To exit the Graph parameters without saving the changes, click “Cancel”, or click outside of the “Graph parameters” window.

Note: *selection of the representation type depends on the appearance of the displayed graph and can have limitations both for vertical and horizontal scale.*

3.5 Using the keys «Start», «Stop» and «Recording»

The “Start” key is used for displaying the graphical information in the program window in compliance with the calculation parameters. In the case, if the program has additional graph windows containing previously accumulated data, activation of the “Start” key clears this data, and data accumulation begins again.

The key “Stop” (pause) suspends displaying of graphical data in the program window and stops accumulation of data in additional graph windows relating to this program. To resume the data accumulation process, click “Start” key.

The “Recording” key allows to save the graphical information values to a text file with **.dtx* extension. Upon activation of the “Recording” key, there appears a standard dialog window allowing to set the name of the file and the file directory. The directory by default– C:\Users\Public\Documents\ZETLab\User\result. The structure of the text file is described in Table 3.1.

Table 3.1

Text file line number	**Corresponding information**
1	Name of the program window
2	Name of the measurement channel
3	Additional text (additional clarifying information set by the user – see section 3.4)
4	Program parameters configuration
5	Data of file recording
6	Time of file recording
7	Headings of columns and saved data
8	Measurement units of columns and saved data
9, etc.	Numerical values of the saved data, distributed by columns and represented in the floating point format, where the symbol «.» is used for separation of integer and fractional part

3.6 Using signal level indicators

Most of ZETLAB programs used for processing of the registered signals (by the selected measurement channel) have signal level indicators (Fig. *3.7*), displaying the current integral level of the signal.

Fig. 3.7 Indicator of signal integral level

Signal level indicator allows the user to evaluate the quality of selection, adjustment, and sensitivity of elements for a particular measurement channel, thus excluding signal processing in the case of overloading and signal failure in the selected measurement channel.

Two thirds of signal level indicator section display the signal level, which is below the maximal admissible value. The higher is the level, the more is indicator value. As the maximal admissible level is exceeded (without the presence of signal distortions), the indicator flashes with red. When overloading by the measurement channel will no longer be detected, the indicator will flash red until the user left-clicks it.

When there is no signal in the measurement channel, the field of the indicator will be completely filled with black color.

3.7 Adjustment of the color scheme used for displaying of the registered signal amplitude values

ZETLAB program windows used for displaying of the data in 2- or 3-dimensional format have indicators for adjustment of the color scheme of the registered values amplitude (Fig. *3.8*).

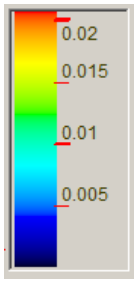


Fig. 3.8 Indicator of the color scheme adjustment

To switch over to the required color scheme and contrast level of the registered values, place the cursor to the right part of the indicator (Fig. *3.8*), the cursor will change its appearance (depending on its particular location): ↕ , ⇕ , ↑ , ↓ , ⤢ .

The symbol ↕ is used for extension of the color scheme, and the symbol ⇕ allows to compress it, symbol ↑ allows to go to the bottom part of the color scheme, symbol ↓ allows to go to

the top section of the color scheme, symbol ⤧ is used for auto-scaling.

As you select the required type of scaling, left-click the cursor symbol, or use the scroll key.

3.8 Transmission of graphical and numerical data to text editors

ZETLAB programs allow to copy numerical values, graphs, and to convert the displayed graphs into text sequence of numerical values, where the left column corresponds to graph values by horizontal axis, and the right column – to those by vertical axis.

In order to copy numerical value from ZETLAB program window, place the cursor into the window of the program used for recording of numerical values (e.g., “DC voltmeter”, “Encoder”, etc.), and left-click it. The data will be copied to the Clipboard. Place the cursor in the window of the text editor program (Microsoft Word, Excel, etc.), right-click it, and select the option “Paste”[3]. The numerical value registered by ZETLAB program will be copied to the document.

In order to copy a graph from ZETLAB program window, place the cursor on the relevant graph image in the program window (e.g., “narrow-band analysis”, “multi-channel oscilloscope”, etc.), and use the key combination<*Ctrl*> + <*C*>[4], after that the graph will be copied to the Clipboard. Place the cursor in the window of the text editor program (Microsoft Word, Excel, etc.), right-click it, and select the option “Paste”. The relevant graph will be copied to the document.

In order to convert the graph into a text sequence of numerical values, place the cursor on the graph displayed in the program window (e.g., “narrow-band analysis”, “multi-channel oscilloscope”, etc.), and press the key <*N*>[5]. The sequence of numerical values will be copied to the clipboard. Place the cursor in the window of the text editor program (Microsoft Word, Excel, etc.), right-click it, and select the option “Paste”. The numerical sequence, which corresponds to the displayed graph will be copied to the document.

In order to copy the graph values, which correspond to the particular position of the cursor, place the cursor to the required graph point in the program window (e.g., “narrow-band analysis”, “multi-channel oscilloscope”, etc.), and click the key <*T*>. The values will be copied to the clipboard. Place the cursor in the window of the text editor program (Microsoft Word, Excel, etc.), right-click it, and select the option “Paste”. The required values will be copied to the document. As you copy the values, which correspond to a particular position of the cursor, the program also copies additional information: name of the program, and name of the channel used for data recording.

[3] You can also use the combination <Ctrl>+<V>.
[4] You can also use the functions “**Copy graph**” or “**Copy image**” to copy the graph to the clipboard (in the case, if these functions are available)
[5] You can also copy the sequence of numerical values using the key “Copy data” (if this key is available)

4 Connection of VCS controller to PC by Ethernet

4.1 Connection sequence

During the first connection of the VCS controller to PC, it is necessary to configure Ethernet ports of the controller and PC, so that their network masks and IP-addresses would correspond to a single sub-network. In order to do that, you can configure IP-address of Ethernet port of the PC to the sub-network of the VCS controller port, or vice versa.

Note: *You can check IP-address of the VCS controller using the instructions specified in section 4.3*

In the case, if you need to configure the IP-address of Ethernet port of the PC to the sub-network of the VCS controller, follow the instructions specified in section 4.4.

In the case, if you need to configure the IP-address of VCS controller Ethernet port to the sub-network of the PC, follow the instructions specified in section 4.4 to re-configure the initial IP-address of the PC to the sub-network of the VCS controller, then follow the instructions specified in section 4.5 to re-configure the IP-address of VCS controller to the initial sub-network of the PC, then restore the value of the PC port IP-address to the initial one.

When the IP-addresses of Ethernet ports of PC and VCS controller are located in the same sub-network, activate Ethernet channel of the VCS controller. After that the VCS controller will be ready for use.

Note: *If you use several VCS controllers, it is necessary to use Ethernet switch to have the required number of Ethernet ports for connection. The connected ports of VCS controller and PC should belong to the same sub-network, and there should be no identical IP-addresses.*

4.2 Default parameters of VCS controller

By default, IP-address of the VCS controller is 192.168.0.100, network mask: 255.255.255.0.

Click and hold the “Reset” key at the rear panel of the VCS controller for more than 10 seconds to reset the IP-address of the controller to default value.

4.3 Checking IP-address of the controller

In order to check the IP-address of the VCS controller, it is not necessary that IP-addresses of Ethernet ports of VCS controller and PC should belong to the same sub-network.

To check the IP-address of VCS controller, go to ZETLAB panel – “Network programs” – “Connecting devices via Ethernet”. You will see the window of the program (Fig. *4.8*).

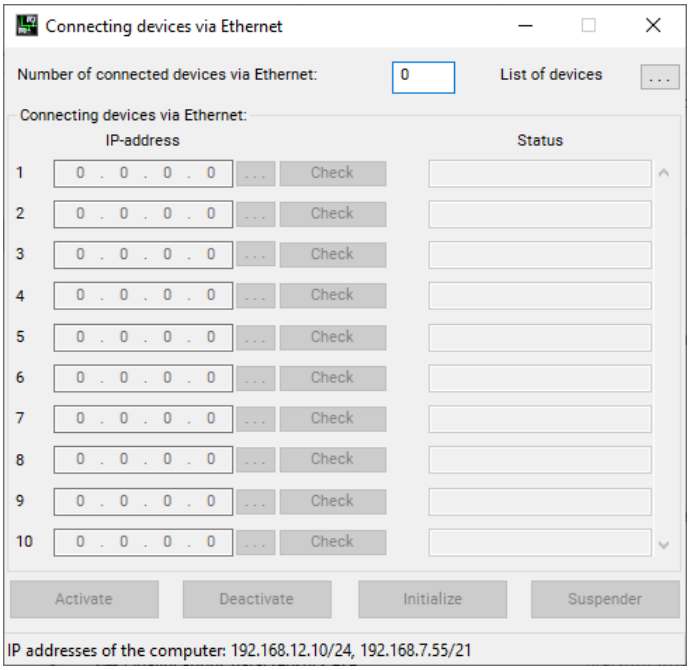


Fig. 4.1 « Connecting devices via Ethernet »

Click the key «...» (List of devices). In the window «List of available devices» (*Fig. 4.2*), you will see the IP-address of the VCS controller.

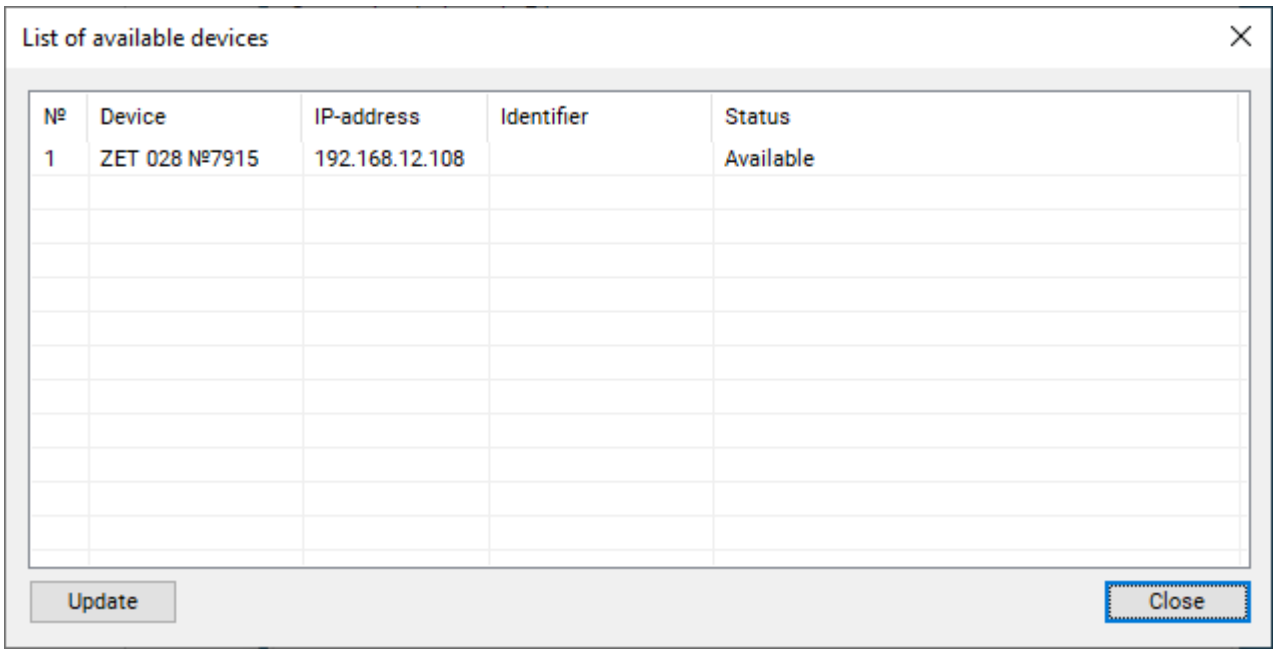


Fig. 4.2 «List of available devices»

4.4 Configuring IP-address of the PC

In order to configure the IP-address of the PC port, go to “Network connections” (Fig. *4.3*) and double-click the icon corresponding to the relevant Ethernet port. You will see the window “Ethernet Status” (Fig. *4.3*) of the selected port.

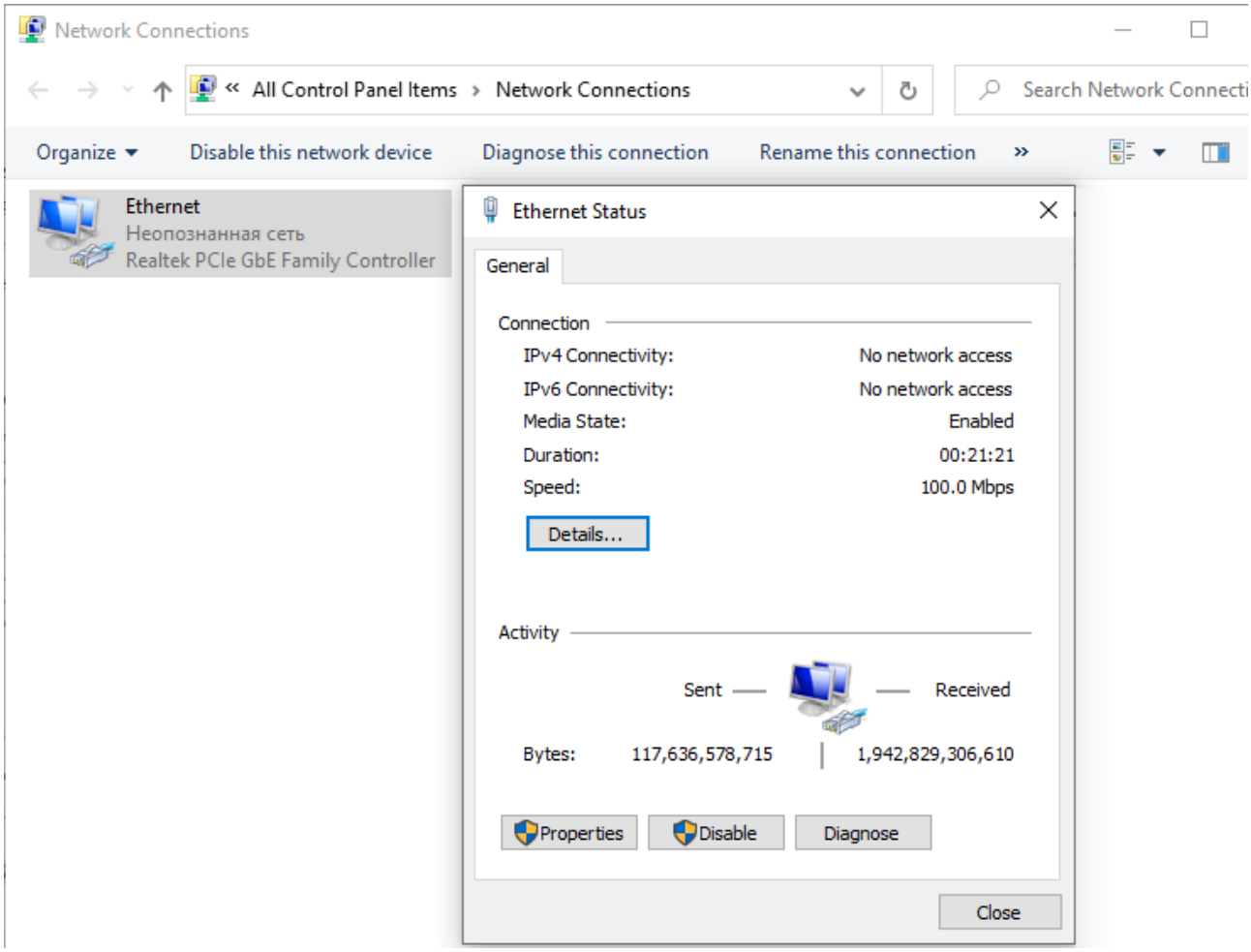


Fig. 4.3 «Status - Ethernet»

In the window « Ethernet Status » activate the panel *«Properties»*. In the window «Ethernet Properties» (Fig. *4.4*) select the line «IP version 4(TCP/IPv4)» (as it is shown in the figure) and click the panel «Properties».

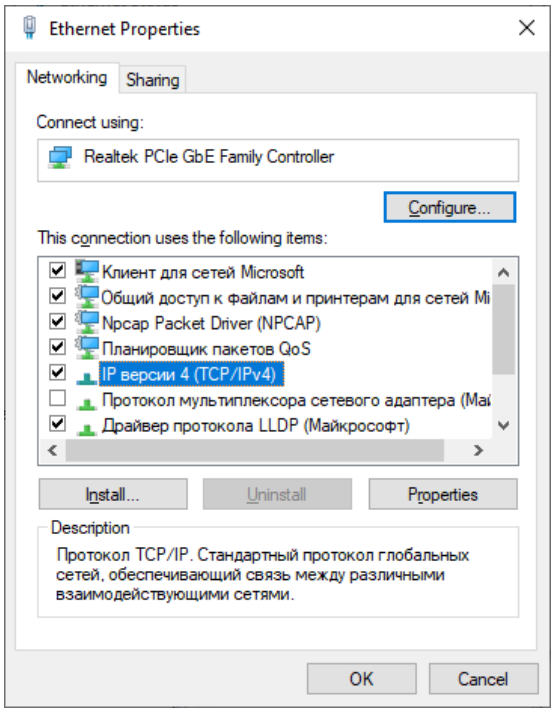


Fig. 4.4 «Properties»

In the window «IP version 4 (TCP/IPv4) Properties» assign IP-address and mask of Ethernet port of the PC.

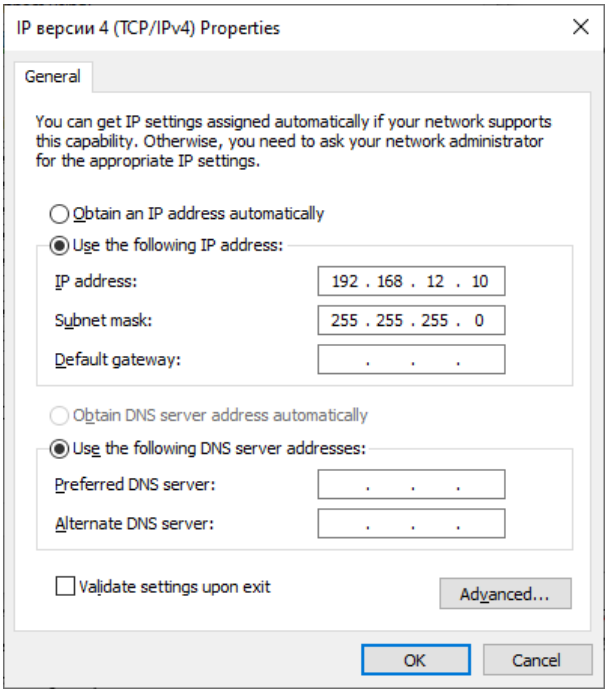


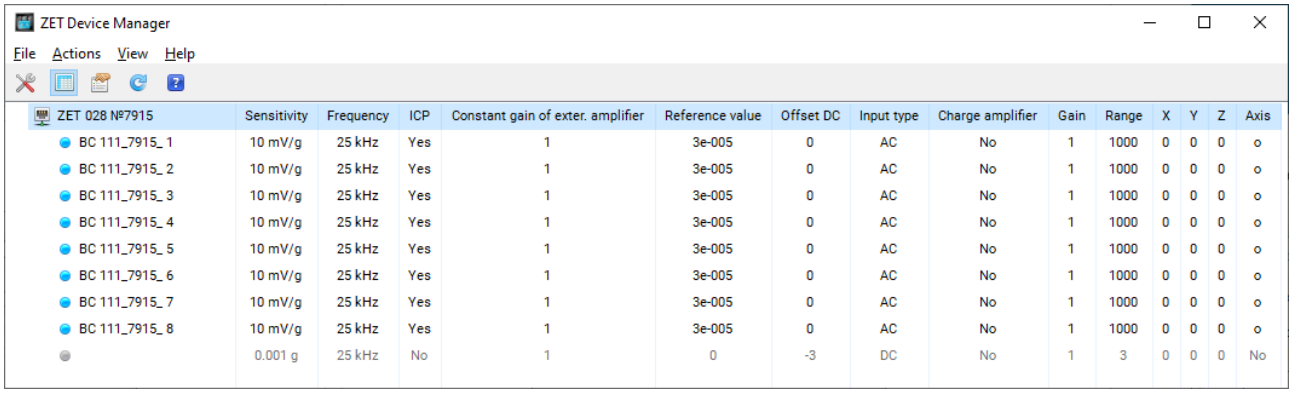
Figure 4.5 «Properties: IP version 4 (TCP/IPv4)»

Note: *by default, VCS controllers use the mask «255.255.255.0», that corresponds to the subnet of C-class (in this example, the IP-address is 192.168.12.xxx, where xxx stand for IP-addresses in the range from 1 up to 254 (in this example: 108 for controller port, and 10 for the PC port).*

4.5 Configuring IP-address of the PC

In order to configure IP-address of the VCS controller, enable Ethernet channel of the VCS controller following the instructions specified in section 4.6.

As the connection to the VCS controller is established, enable the program, “Device Manager” in the “Service” section of ZETLAB panel (*Fig. 4.6*)



ZET 028 №7915	Sensitivity	Frequency	ICP	Constant gain of exter. amplifier	Reference value	Offset DC	Input type	Charge amplifier	Gain	Range	X	Y	Z	Axis
BC 111_7915_1	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_2	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_3	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_4	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_5	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_6	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_7	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_8	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
	0.001 g	25 kHz	No	1	0	-3	DC	No	1	3	0	0	0	No

Fig. 4.6 «ZET Device Manager»

In the window of the program “ZET Device Manager” double-click the icon of the VCS controller. In the “Properties” window (*Fig. 4.7*) set the required IP-address and mask of VCS controller subnet (in this example: IP-address 192.168.12.108, mask 255.255.255.0).

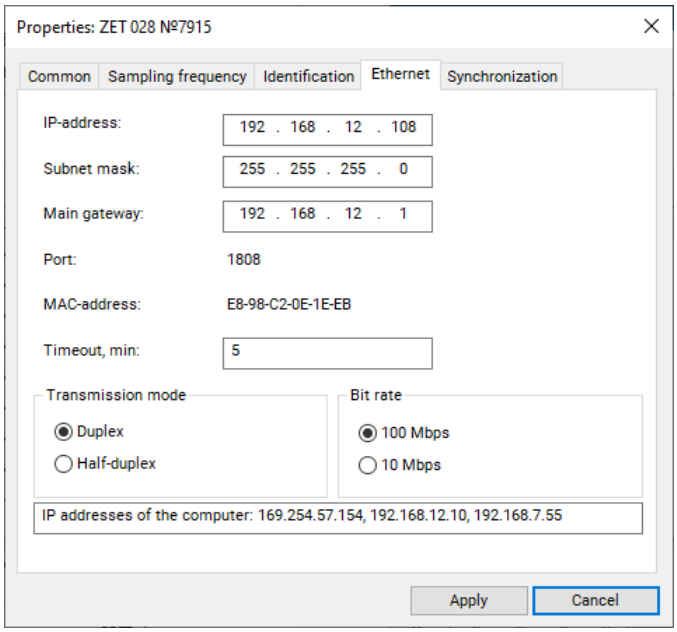


Fig. 4.7 «Ethernet» tab of the window «ZET properties»

Note! *As the IP-address of the controller is changed, its Ethernet channel will be disabled. For further activation, re-configure the IP-address of the PC following the instructions specified in section 4.4, so that it would correspond to the sub-net containing the IP-address of the VCS controller, then activate the Ethernet channel following the instructions specified in section 4.6*

4.6 Activation of VCS controller Ethernet channel

In order to activate Ethernet channel of VCS controller, make sure, that IP-addresses of VCS controller Ethernet ports and PC belong to the same sub-network. If necessary, follow the instructions specified in section 4.4 to re-configure IP-address of PC Ethernet port to VCS controller sub-network.

To enable Ethernet channel of VCS controller, go to “Network programs” of ZETLAB panel, and start the program “Connecting devices via Ethernet” (Fig. *4.8*).

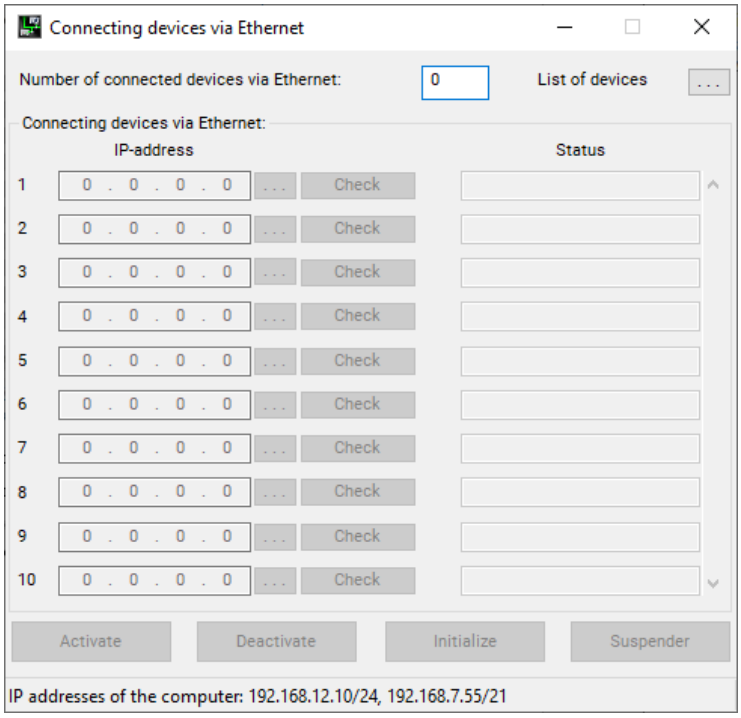


Fig. 4.8 «Connecting devices via Ethernet»

In the field “Number of connected devices via Ethernet” set the value equal to the number of VCS controllers used for vibration testing performance (in this example- «1»). As a result, you will be able to edit the first line of the IP-addresses list (*Fig. 4.9*).

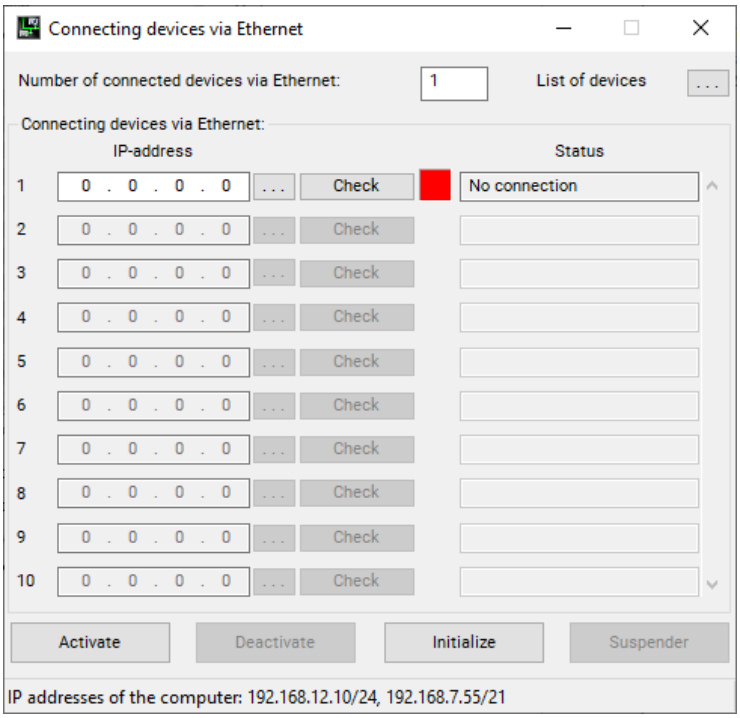


Fig. 4.9 «Connecting devices via Ethernet»

Enter the IP-address of the VCS controller to be activated (in this example - 192.168.12.108) (*Fig. 4.10*). If necessary, check the IP-address of VCS controller following the instructions specified in section 4.3.

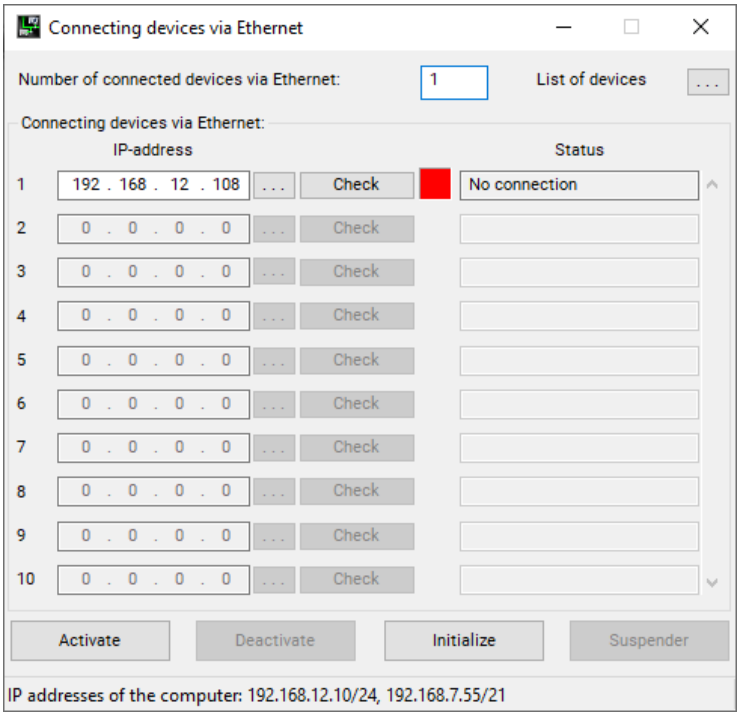


Fig. 4.10 «Connecting devices via Ethernet»

Click the key “Activate”. If the VCS controller is successfully connected to the PC, its status in the program “Connecting devices via Ethernet” will change for “Connected” (*Fig. 4.11*).

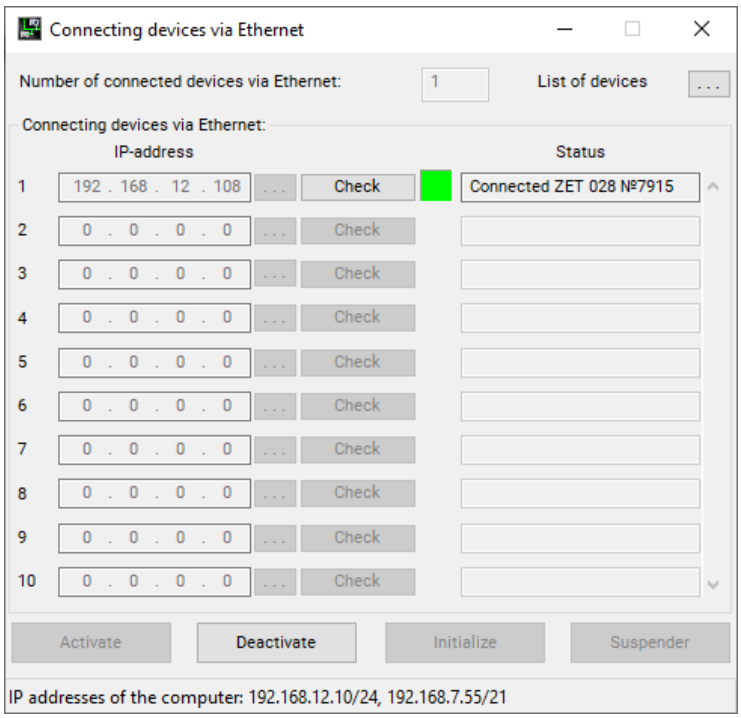


Fig. 4.11 «Connecting devices via Ethernet»

5 Working with ZETLAB VIBRO

To operate VCS programs in the *ZETLAB (Fig. 2.2)* control panel, activate VCS section, VCS panel window will open (*Fig. 5.1*).

Caution! *If you don't see VCS section in the ZETLAB control panel, it means that the appropriate license is not detected. Make sure that the VCS controller is connected to PC according to the instructions in section 4.*

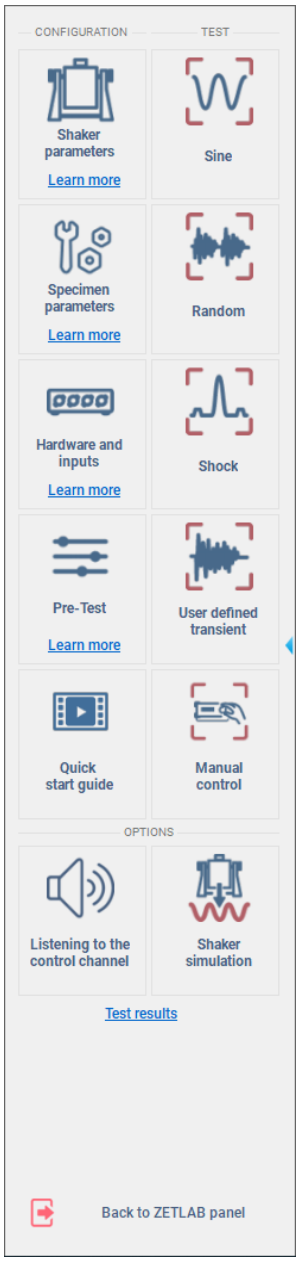


Fig. 5.1 VCS panel

Note*: When you open the VCS control panel, the ZETLAB control panel window will be minimized. If you need to go back to the ZETLAB main panel, press the Back to ZETLAB panel button on the VCS panel.*

5.1 Shaker Parameters Program

5.1.1 Program Purpose

The Shaker Parameters program is designed to set the *ZETLAB VIBRO* software parameter values corresponding to the parameters of the shaker being used in the following cases:

- After installing the *ZETLAB* software on your computer, or updates;
- When you start using another model of shaker;
- If you need to change the parameters of the shaker being used.

5.1.2 Program Operation Principles

To go to the Shaker Parameters program window, press the *Shaker Parameters* button on the VCS panel (Fig. 5.1). The Shaker Parameters window (*Fig.* 5.2) will appear on the screen.

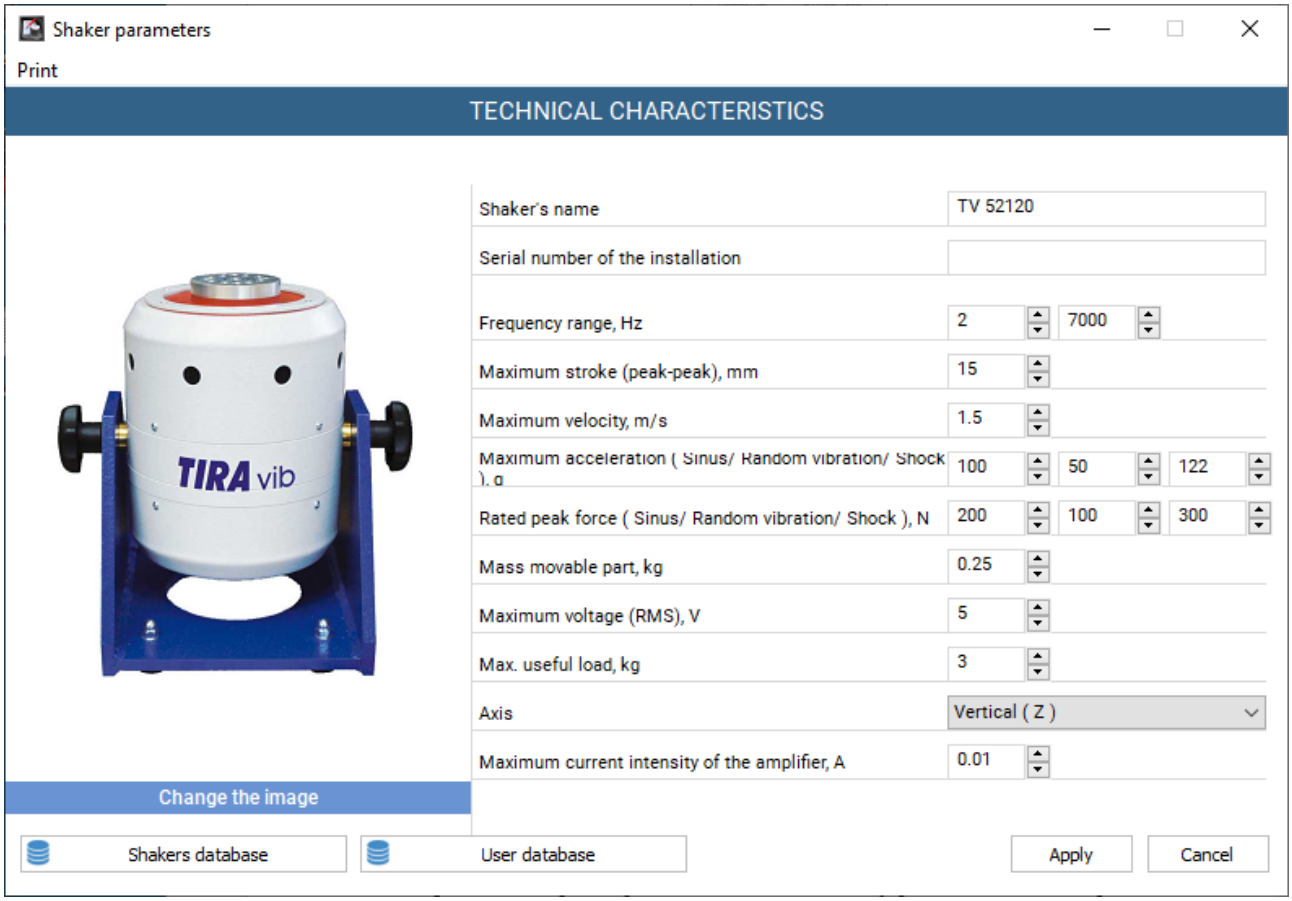


Fig. 5.2 Shaker Parameters window

If the software is installed for the first time, the program window will display the default parameters of the shaker.

To go to the shaker database and check whether the database contains the model identical to the model being used, press the *Shaker Database* button, the corresponding window will open (*Fig.* 5.3).

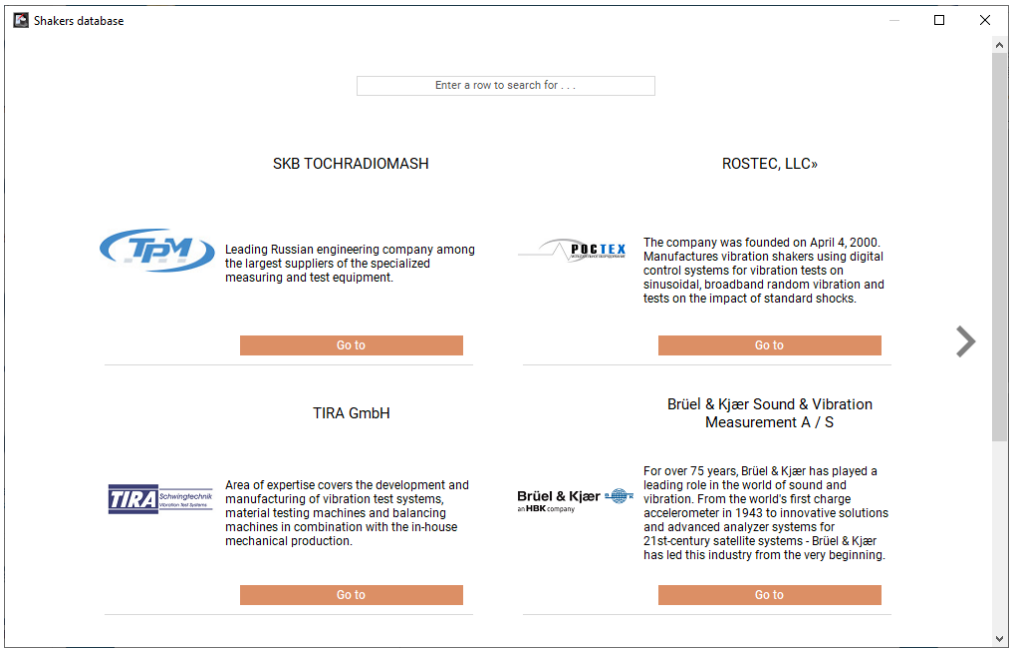


Fig. 5.3 Shaker Database window

In the opened Shaker Database window, shakers are grouped by manufacturer, where each manufacturer group contains a list of available shakers. To select, click the Go to button under the name of the corresponding manufacturer, and the window will display a list of available shakers. To search for a specific model of the shaker, use the Search field (*Fig. 5.4*).

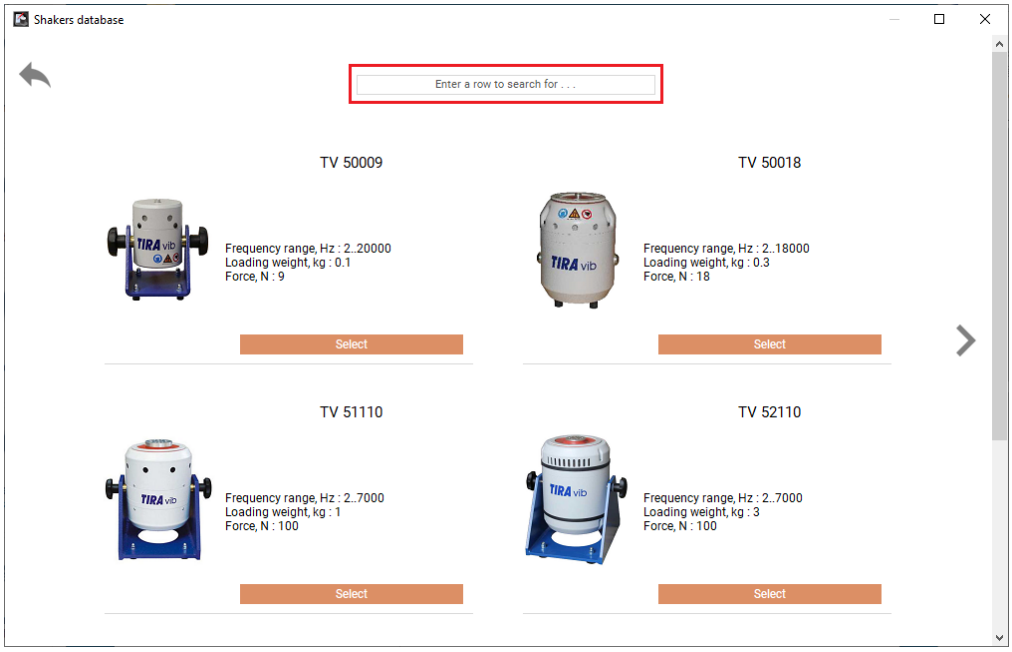


Fig. 5.4 Shaker Database window

After the required shaker is found in the Shaker Database window (*Fig. 5.4*), press the corresponding Select button, and the shaker parameters will be displayed in the Shaker Parameters window (Fig. *5.2*), then press the Apply button to use this type of shaker for the VCS operation.

If the required type of shaker is not found in the database, then in the Shaker Parameters window (Fig. 5.2), press the *User Database* button and the Add symbol in the opened window. The following options will appear:

- New;
- Add the existing;
- Add from database.

When you select New, you will be prompted to fill in the form of the Shaker Parameters window, and after filling in the form manually and pressing Save, this type of shaker will be saved in the user database. When you select Add the existing, the type of the shaker displayed in the Shaker Parameters window (Fig. 5.2) will be added to the user database. When you select Add from database, the Shaker Database window will open, and after selecting a type of the shaker from the database, it will be added to the user database.

In the user database, you can not only set required ranges and values for the used shakers, but also quickly select the type of shaker for testing (if VSC is periodically used to control various shakers).

Note: *For some types of shakers, the maximum permissible acceleration values and expulsive force for noise and shock may be unavailable. In this case, you can enter the manufacturer's values of the maximum acceleration and expulsive force parameters for sinusoidal vibration in the corresponding parameter fields.*

If necessary, press the *Change the image* button to add a photo of the shaker. The photo in the Shaker Parameters window provides an additional identification of the shaker in the user database.

Note: *The photo to be added in the shaker parameters window should be in any graphic format with 2/3 (width/height) aspect ratio and in any available directory.*

5.2 Specimen Parameters program

5.2.1 Program Purpose

The Specimen Parameters program is designed to set the *ZETLAB VIBRO* software parameter values consistent with the parameters of the specimen and tooling needed to fix the specimen on the shaker.

The Specimen Parameter program is used in the following cases:

- After installing the *ZETLAB* software on your computer, or updates;
- When changing the type of specimen subject to vibration tests;
- When changing the model of equipment used for fixing the specimen.

5.2.2 Program Operation Principles

To go to the Specimen Parameters window, press the *Specimen Parameters* button on the VCS panel. The monitor screen will display the Specimen Parameters window (Fig. *5.5*).

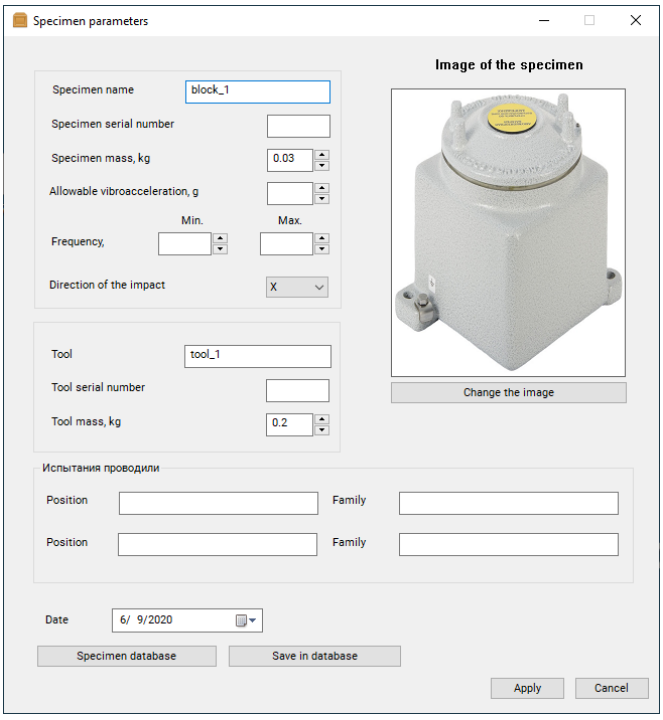


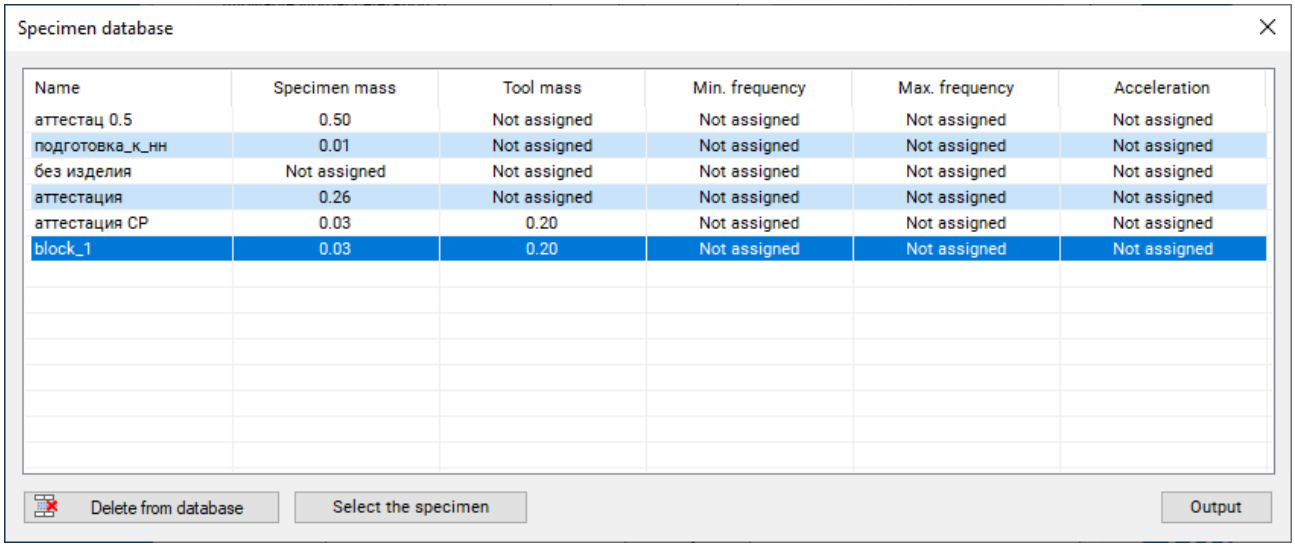
Fig. 5.5 Specimen Parameters window

In the parameter fields, enter the values corresponding to the weight of the specimen installed on the shaker and the weight of the tooling and, if necessary, the values limiting frequency and acceleration for testing this type of specimen. To apply the specified parameters (so that the *ZETLAB VIBRO* software applied the parameters displayed at the time of clicking on the Specimen Parameters window), press the *Apply* button, otherwise (to cancel the changes) press the *Cancel* button. The Specimen Parameters window will be closed in both cases.

Note: *If the specimen has no requirements for limiting exposure to the frequency range and vibration level, the Frequency and Allowable vibroacceleration fields can be empty. In this case, the limits applied to the shaker will be applied to the corresponding parameters.*

To add a specimen to the database, press the *Save in database* button. The specimen parameters will be saved in the database.

In the subsequent testing of specimens added to the database, select the desired type of specimen from the database window (Fig. *5.6*), and use the *Specimen Database* button in the Specimen Parameters window to go to it.



Name	Specimen mass	Tool mass	Min. frequency	Max. frequency	Acceleration
аттестац 0.5	0.50	Not assigned	Not assigned	Not assigned	Not assigned
подготовка_к_нн	0.01	Not assigned	Not assigned	Not assigned	Not assigned
без изделия	Not assigned	Not assigned	Not assigned	Not assigned	Not assigned
аттестация	0.26	Not assigned	Not assigned	Not assigned	Not assigned
аттестация СР	0.03	0.20	Not assigned	Not assigned	Not assigned
block_1	0.03	0.20	Not assigned	Not assigned	Not assigned

Fig. 5.6 Specimen Database window

Press the *Change the image* button to add a specimen photo to the Specimen Parameters window. The photo in the Specimen Parameters window provides an additional specimen identification in the database.

Note: *The specimen photo to be added in the specimen parameters window should be in any graphic format with 2/3 (width/height) aspect ratio and in any available directory.*

5.3 ZET Device Manager Program

5.3.1 Program Purpose

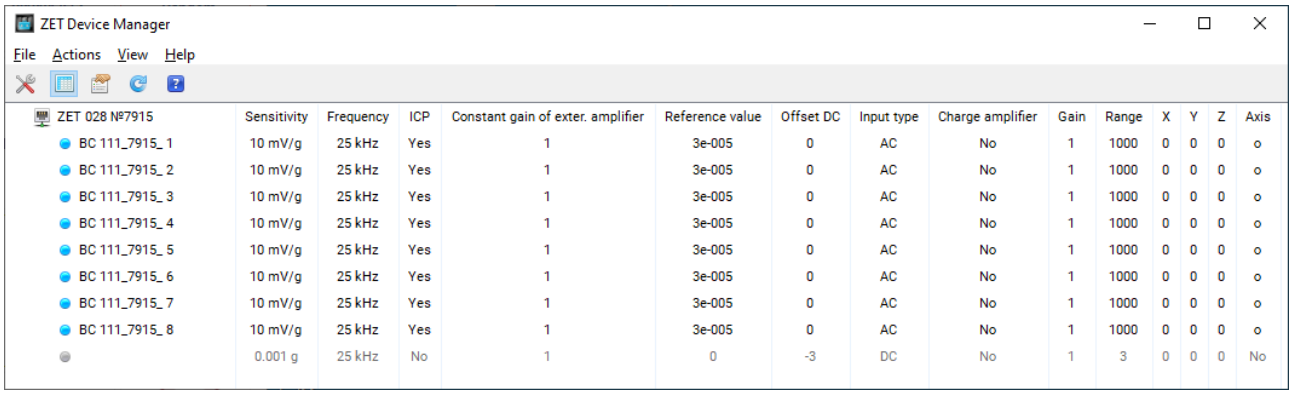
The ZET Device Manager program is designed to configure measuring channels according to the parameters of AC/DC converters (sensors) connected to the channels to be configured. The program displays IDs of devices connected to the computer, as well as lists of measurement channel IDs corresponding to these devices.

In the ZET Device Manager program, you can perform the following operations:

- Set the sample rate of the ADC controller (go to *Device ID/Properties/Sampling frequency*);
- Select a specific type of primary converter connected to the VCS controller's measuring channel from the list (go to *Measurement Channel ID/Properties /Name*);
- Set parameters of primary converters such as sensitivity, gain, range, unit of measurement (go to *Measurement Channel ID/Properties/field corresponding to the parameter being set*);
- Enable/disable the ICP power function for the sensors (go to *Measurement Channel ID/Properties/Use ICP field*);
- Enable/disable the high-pass filter function (go to *Measurement Channel ID/Properties/AC field*).

5.3.2 Program Operation Principles

To go to the ZET Device Manager window, press the *Hardware and inputs* button on the VCS panel. The ZET Device Manager window will appear on the monitor screen (*Figure 5.7*).



ZET 028 №7915	Sensitivity	Frequency	ICP	Constant gain of exter. amplifier	Reference value	Offset DC	Input type	Charge amplifier	Gain	Range	X	Y	Z	Axis
BC 111_7915_ 1	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_ 2	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_ 3	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_ 4	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_ 5	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_ 6	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_ 7	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
BC 111_7915_ 8	10 mV/g	25 kHz	Yes	1	3e-005	0	AC	No	1	1000	0	0	0	o
	0.001 g	25 kHz	No	1	0	-3	DC	No	1	3	0	0	0	No

Figure 5.7 ZET Device Manager Window

The selection of the controller's sampling rate depends on the objective of the vibration tests and type of the shaker used. To set the sampling rate of the controller, open the Properties menu by double-clicking left mouse button on the controller name. In the opened Properties window, go to the Sampling frequency tab (*Figure 5.8*) and select one of the available sample rate options in the ADC field:

- 5 kHz is used for low frequency testing;
- 25 kHz is a standard sampling rate value (used by default) suitable for most vibration tests;
- 50 kHz is used in most cases, when high-frequency testing is required.

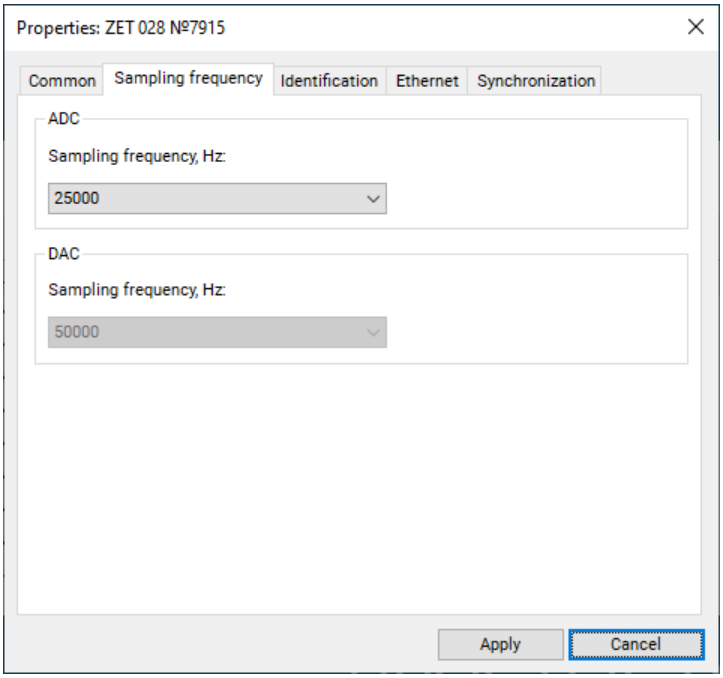


Figure 5.8 Sampling frequency tab of the Properties menu

To select a measurement channel to be configured, double-click left mouse button on the measurement channel name. In the Properties window, set the parameters of the measuring channel according to the datasheet for the primary converter and the current test conditions (Figure 5.9).

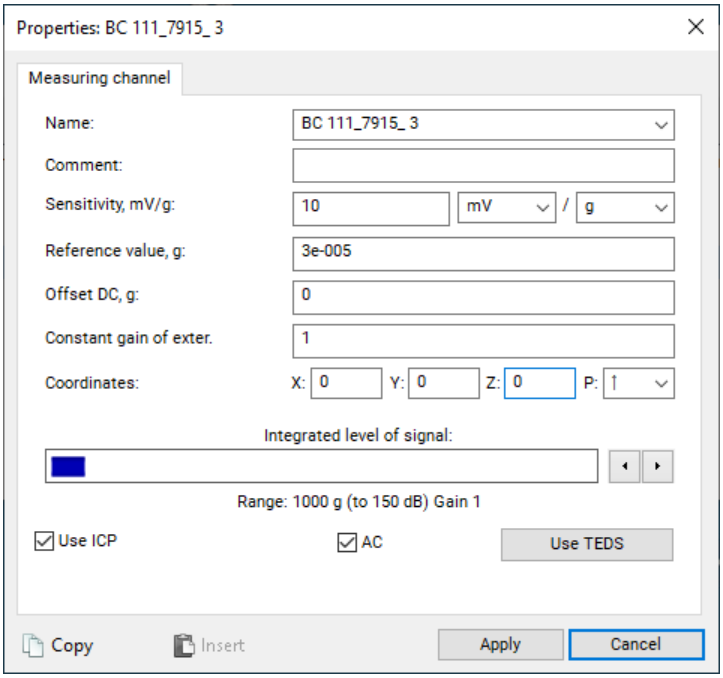


Figure 5.9 The Properties window of the measuring channel

In the *Name* field, enter the name of the connected sensor or select it from the drop-down list if its parameters were entered in the sensor database previously.

In the *Sensitivity* field, enter the sensor sensitivity value specified in the verification certificate of this sensor and the sensor's units, or select them from the drop-down list (all frequently used units are listed there).

Caution! *To perform vibration tests, you need measuring channels which are capable of recording vibration acceleration and set to "g" or "m/s^2" units.*

In the *Reference value* field, enter the value corresponding to the 0 dB level. For the units in the list, the reference value is set automatically according to GOST.

In the *Offset DC*, enter a constant value for the channel. Enter the offset only after you have set and saved the sensitivity.

In the *Coordinates* fields, enter the coordinates of the primary converter relative to the shaker table, vibration axis direction according to the vibration direction of the mobile part of the shaker.

The Integrated level of a signal scale shows the ratio of the current signal strength to the maximum possible value specified below in the Range line. The range value is calculated as the ratio of the maximum measured input voltage of the VCS controller to the sensor sensitivity. The maximum measured input voltage of the VCS controller is 10V. To reduce the measurement error of low-level

signals, the maximum measured input voltage (measuring range) of the VCS controller can be reduced by 10 or 100 times (respectively, up to 1V, 0.1V).

For the sensors requiring external ICP power, check the *Use ICP* option.

By activating the *AC* parameter, you apply a high-pass filter to the signal recorded in the measuring channel at the software level in all operation modes, in order to exclude the constant component from the signal.

Caution! *If you enable the AC parameter in one of the device channels, the signal phase will be shifted in this channel relative to other device channels, where this parameter is disabled, since a high-pass filter with 0.5 Hz cutoff frequency is used. In cases, where several measuring channels are involved, it is recommended to set the same AC parameter value for these channels.*

5.4 The Control Parameters program

5.4.1 Program Purpose

The primary converters (accelerometers) are installed on the specimen under test according to the test configuration and connected to the measuring channels of the VCS controller. You can assign a specific status (control, tracking, view) to each measuring channel of the VCS controller during vibration tests. In the Control Parameters program, a VCS operator can set which sensors are the most suitable for control, tracking, and view, before conducting the main tests. In the Control Parameters window, you can start the Pre-Test program, which is used to record the parameters required for the subsequent VCS operation. When the Pre-Test program is running (the test duration is 20 seconds), a low-intensity broadband test signal is supplied, while the shaker affects the specimen with sensors installed on it. The software is analyzing the signals returned by the measuring channels (from sensors) for compliance with the specified impact and provides recommendations for assigning the status for all available measuring channels of VCS.

Caution! *No vibration test will be available without a positive pre-test result. Most of the changes critical for VCS (made by the operator), after which a pre-test is needed, are controlled by software which prevents access to tests without the effective pre-test result. For those cases when the program does not control changes in the test conditions (changes in the sensor mounting locations, tooling for mounting the specimen or type of specimen), we strongly recommend that you conduct a pretest before starting the vibration tests, otherwise the specimen and the shaker may be exposed to overload during the tests.*

5.4.2 Program Operation Principles

To go to the Control Parameters window, press the *Pre-Test* button on the VCS panel. The monitor screen displays the Control Parameters program window (*Fig. 5.10*).

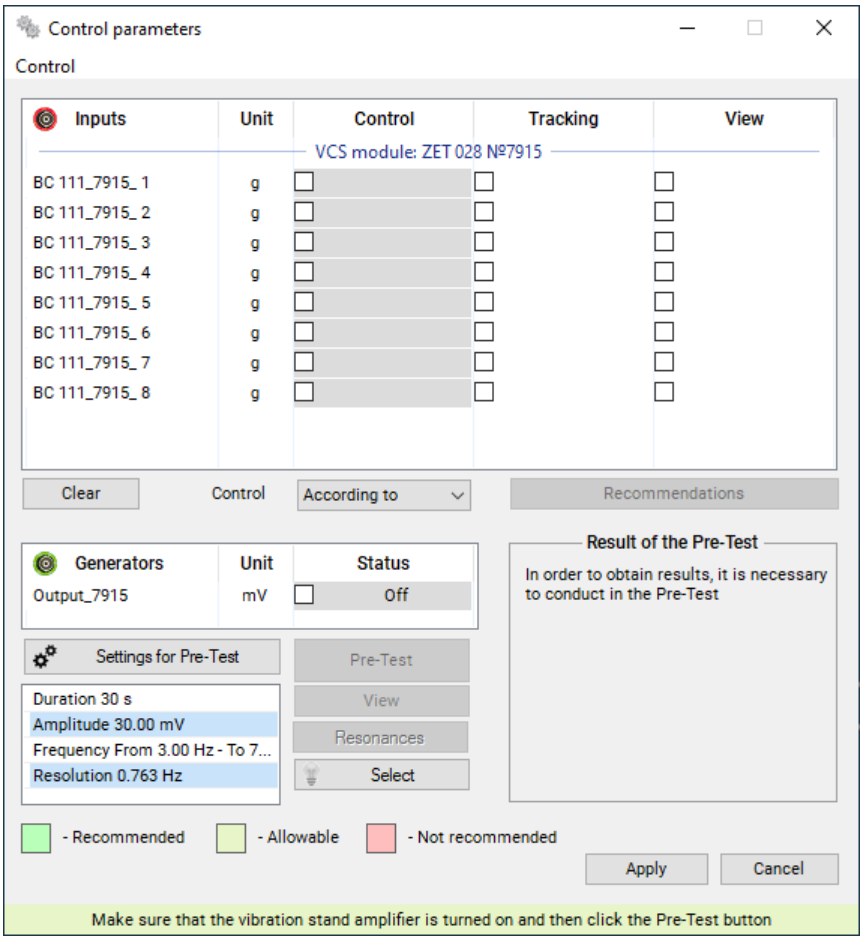


Fig. 5.10 Control Parameters window

Before the Pre-Test (if necessary), configure its parameters. To do this, in the Control Parameters window, press the *Settings for Pre-Test* button, and then the corresponding window will open (*Fig. 5.11*).

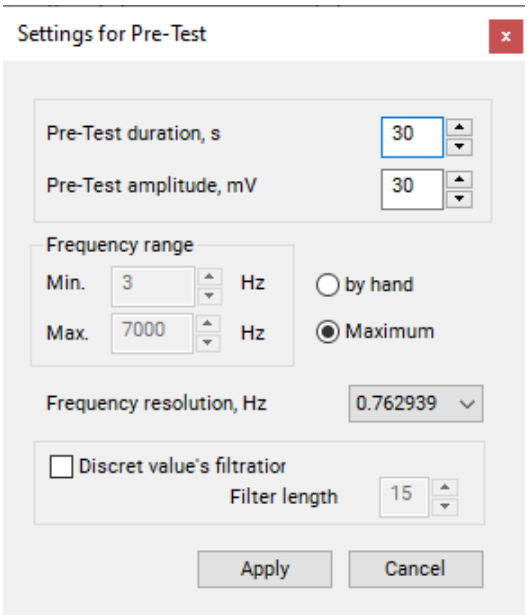


Fig. 5.11 Settings for Pre-Test window

Set the required values, then press the *Apply* button to save the changes.

The *Pre-Test Amplitude* parameter determines the level of pretest signal generation and can be set in the range from 10mV to 50mV.

Note: *The Pre-Test Amplitude parameter's upper threshold is 50 mV in order to limit the supply of high vibration levels to the shaker, including at the maximum position of the regulator on the shaker amplifier.*

Caution! *Do not set low values for the Pre-Pest Amplitude parameter, when the regulator on the shaker amplifier is below 50% of the maximum gain - in this case the pretest will not ensure the necessary level of parameter estimation for conducting vibration tests.*

Caution! *After the pretest, do not change the regulator position on the shaker amplifier, as this will affect the quality of the vibration tests. If you change the regulator position on the shaker amplifier, you'll have to perform the pretest again.*

The selection of the Frequency Range parameter values depends on the selected sampling rate of the controller. The lower the sampling rate, the lower frequency resolution value can be set.

Caution! *The lower set frequency range value, the more detailed the measurements you get. However, keep in mind that with decreasing frequency resolution, the computing load on the computer increases.*

To pass the pretest in the Control Parameters window, enable the channel of the generator that exciting impact by activating the corresponding cell (*Fig. 5.12*), otherwise the Pre-Test button will be unavailable.

Note: *The software makes it possible to perform vibration tests with up to four independent control channels, which requires an appropriate number of VCS controllers and shakers. In this case, in the Control Parameters window, activate the generators to be involved in the vibration tests and conduct a pre-test for each of them, and select a control channel for each of them (feedback channel) according to the pre-test results.*

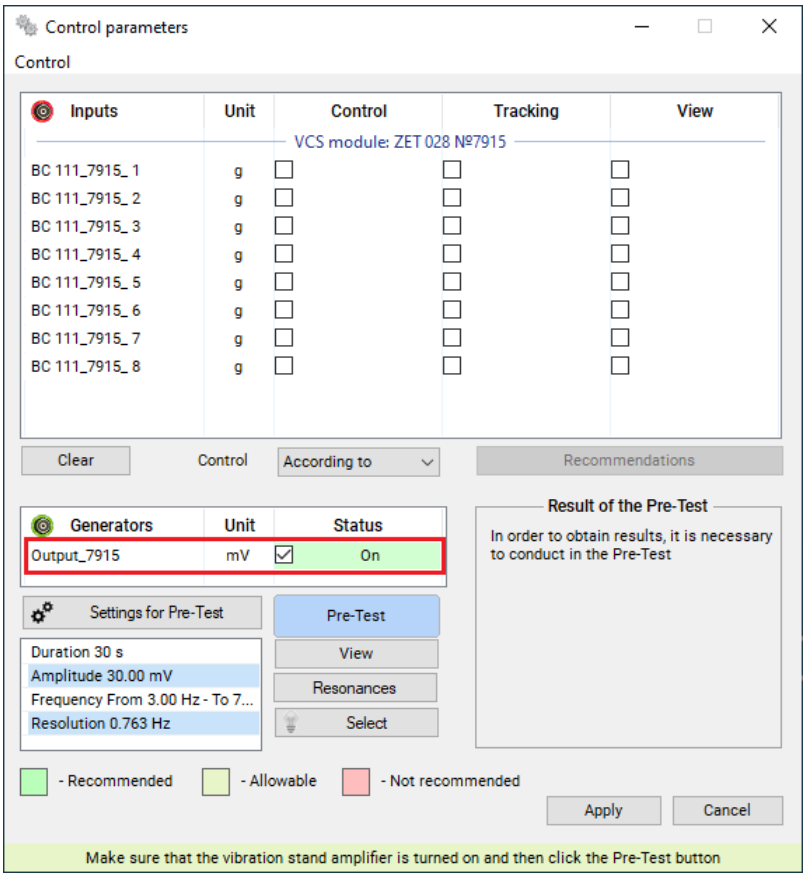


Fig. 5.12 The Control Parameters window

To start the pre-test, press the *Pre-Test* button in the Control Parameters window. In the Pre-Test window, you will see a process visualizing the analysis of whether the response of the measuring channels from sensors is consistent with the specified impact (*Fig. 5.13*).

Fig. 5.13 Pre-Test window with graphs for all measuring channels

The processing results will be displayed in the table in the lower-right corner of the Pre-Test program (*Fig. 5.14*).

	Input	Accel., g	Vel., mm/s	Disp., mm	Signal quality	Delay, ms	Variab., dB	Kurt.	Skew.	Noise, g	Ratio 50 / ...	Level
☐	Output_7915	32.9...										
☐	BC 111_7915_ 1	0.179	0.111	0.002	98.658 %	0.08	74.3	3.03	-0.00	0.007	6 %	
☐	BC 111_7915_ 2	0.715	0.387	0.003	99.222 %	0.10	79.3	3.04	0.00	0.005	14 %	
☑	BC 111_7915_ 3	1.284	0.759	0.028	99.990 %	0.04	35.8	3.04	-0.01	0.005	7 %	
☐	BC 111_7915_ 4	0.851	0.775	0.029	99.874 %	0.20	79.8	2.98	0.01	0.003	10 %	
☐	BC 111_7915_ 5	0.009	0.035	0.005	69.102 %	-3.98	79.5	3.11	-0.08	0.010	10 %	
☐	BC 111_7915_ 6	0.914	0.819	0.029	99.956 %	0.20	69.4	3.04	0.01	0.003	9 %	
☐	BC 111_7915_ 7	0.716	0.611	0.029	99.957 %	0.16	49.8	3.02	-0.00	0.003	14 %	
☐	BC 111_7915_ 8	0.010	0.037	0.005	69.457 %	-4.04	81.6	3.11	-0.09	0.010	10 %	

Fig. 5.14 Measured values of the pre-test results

For convenient viewing graphical information in the Pre-Test window, you can select the number of graphs to display. The figure (*Fig. 5.15*) shows an example of displaying graphical results for only one channels, for which only one channel selection field is activated in the table area (left column).

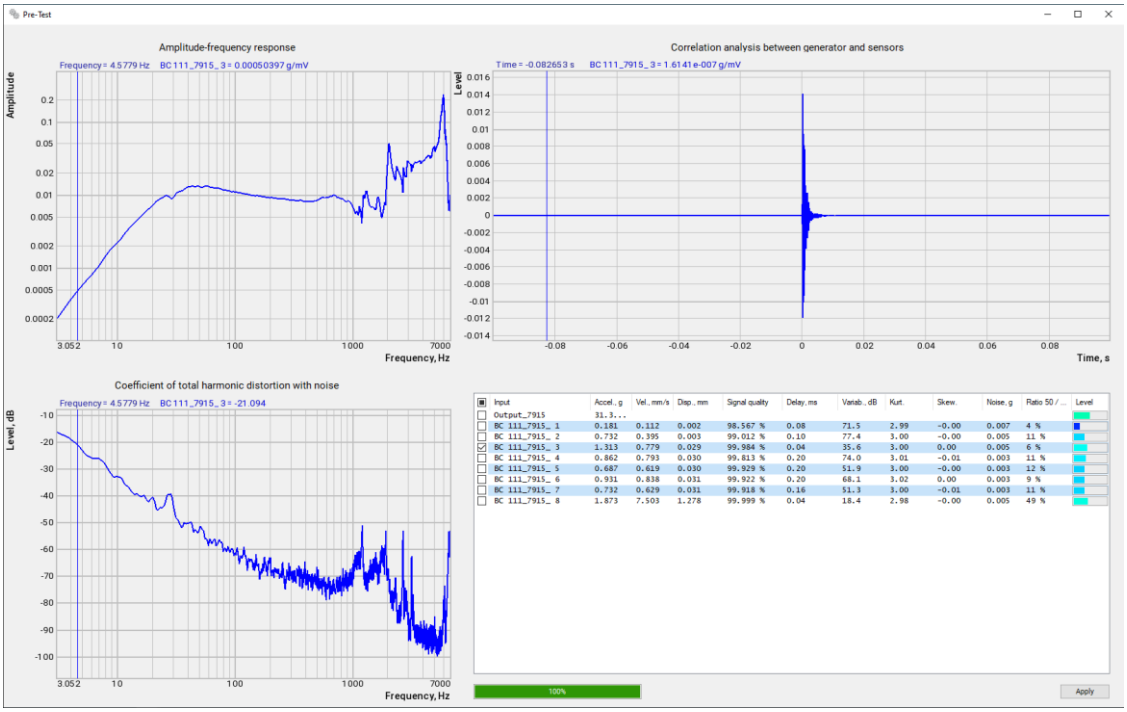


Fig. 5.15 The Pre-Test window with a single channel graph

To save the pre-test results (after the test is completed), you can press the *Apply* button. The pre-test results will be saved and the Pre-Test window will close.

If you save the pre-test results in the Control Parameters window, the measuring channel status selection cells will be colored to indicate the recommendation for assigning the status for each measuring channel: green - recommended, yellow – acceptable, red - not recommended (*Fig. 5.16*).

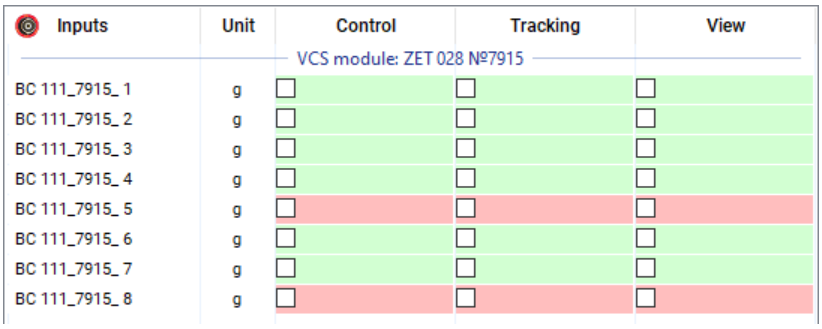


Fig. 5.16 Cells for selecting measuring channel status

To assign the status to the measuring channels (Control, Tracking, View), activate (check) the corresponding cells (*Fig. 5.17*).

The Control status means that the measuring channel is involved in the feedback and that the control system will response when the vibration test stops in case of exceeding the Limit thresholds in the profiles or the parameter values specified on the Control tabs of the profiles.

The Tracking status means that the control system will stop vibration tests if the parameters set on the Tracking tabs of the profiles are exceeded.

The View status means that the channel is monitored only without the control system's response to the values recorded in the channel.

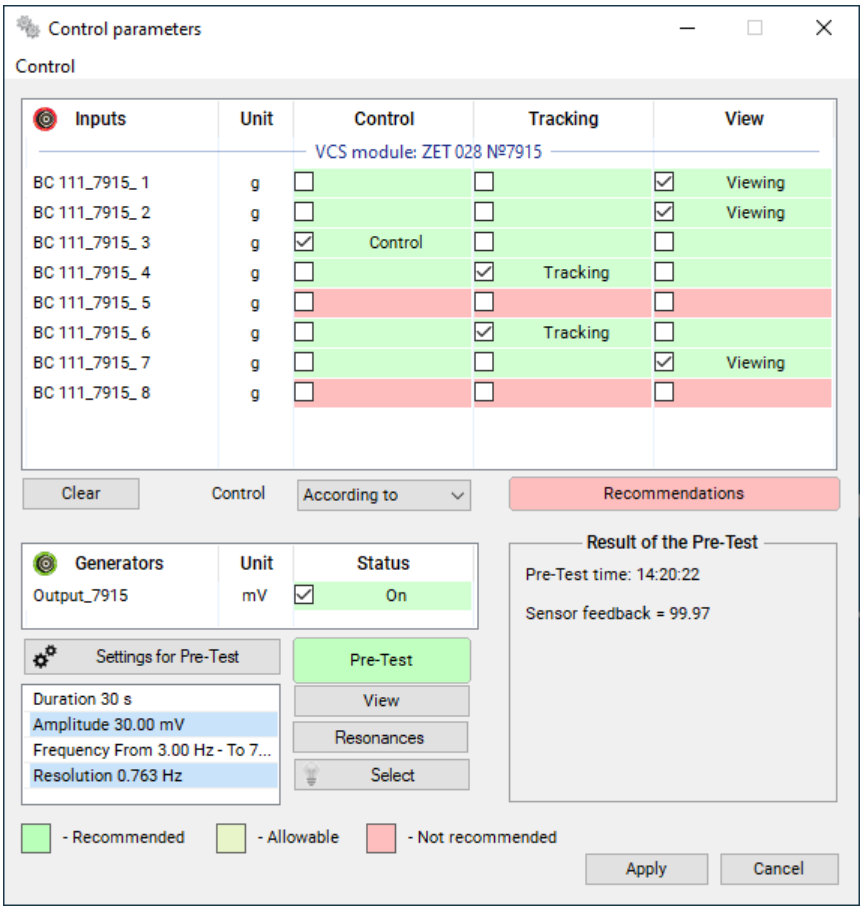


Fig. 5.17 Control Parameters window

Note! *If necessary, you can assign any status for measuring channels without taking into account the pretest recommendations.*

Caution! *The Control status is mandatory, since the signal recorded by it will be used for feedback during the tests.*

Caution! *You can select channels with the Control status only from the list of measurement channels corresponding to the VCS controller where the control channel is generated, while tracking and viewing channels can be selected from any measurement channels involved in the vibration tests.*

The Control Mode parameter defines an option for generating a feedback signal for measuring channels with the Control status:

- According to;
- By average;
- By maximum.

The "According to " control mode means that only one measuring channel is involved in generating the feedback signal. The "By average" or "By maximum" control mode means that two or more measuring channels are involved in generating the feedback signal, while VCS generates a feedback channel based on the principle of signal superposition by average values or maximum values recorded in the measuring channels.

Note! *When testing sinusoidal vibration, it is difficult to ensure the required level of specimen vibration in the "by one" mode if the sensor (with the Control status) records deep anti-resonances in the tested frequency range. For such cases, it is recommended to use the "by average" or "by maximum" control mode by assigning the Control status to sensors which are not consistent in antiresonances in the test frequency range.*

Caution! *In case of selecting "by average" or "by maximum" control mode, the channels selected for controlling will change their status to tracking, and a virtual channel formed by average or by maximum values becomes the controlling channel, respectively.*

To save the statuses assigned to the measuring channels in the program's Control Parameters window, press the *Apply* button.

Note! *In cases where it is only needed to change the statuses of the measuring channels, no repeated pre-test is required. Open the Control Parameters window, change the statuses of the measuring channels, and then press the Apply button to save the new status configuration.*

After passing the pretest, the VCS software will detect most configuration errors and element switching errors and output diagnostic results as recommendations for elimination.

You can view the diagnostic information after passing the pre-test. To do this, press the *Recommendations* button in the Control Parameters window. The opened Recommendations for Channels window will display the diagnostic results (*Fig. 5.18*). When you click on the symbol "ⓘ" in the line with the error, a help window will open with a detailed description of the error and recommendations for resolving it.

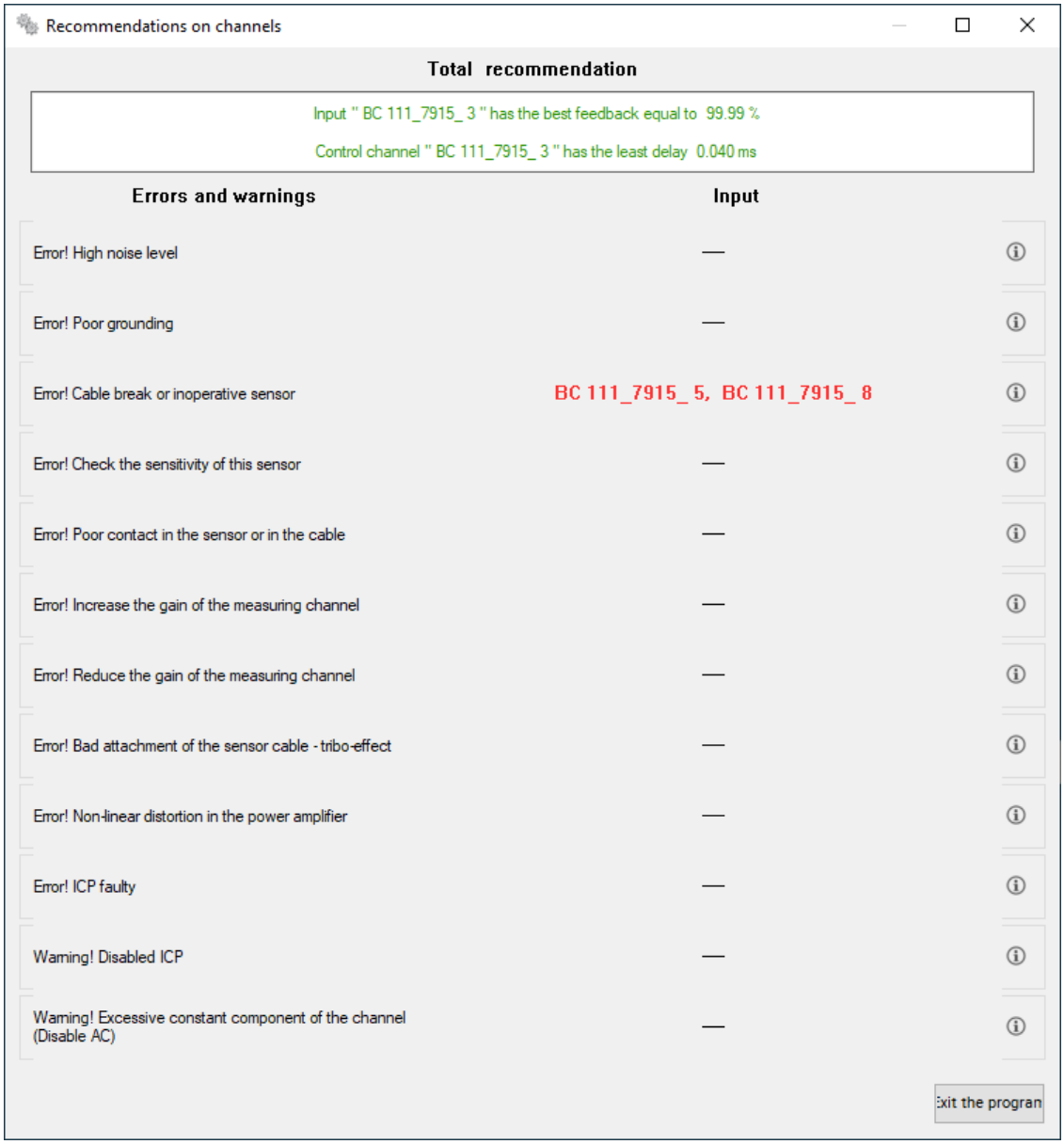


Fig. 5.18 Recommendations for Channels Window

5.5 The Sine Vibration Program

5.5.1 Program Purpose

To test specimens for vibration resistance at different frequencies and in different ranges, the Sine Vibration program is used.

5.5.2 Preparing for testing

When preparing to testing sine vibration, set the following parameters (if not set): shaker parameters, specimen parameters, channel parameters (see sections 5.1 to 5.3), and then start pre-test according to the section 5.4.

To go to the Sine Vibration program window, press the Sine button on the VCS Panel (Fig. *5.1*). The Sine Vibration program window (Fig. *5.19*) will appear on the monitor screen.

Caution! *The Sine button on the VCS panel will only be available if the program detects the pretest results.*

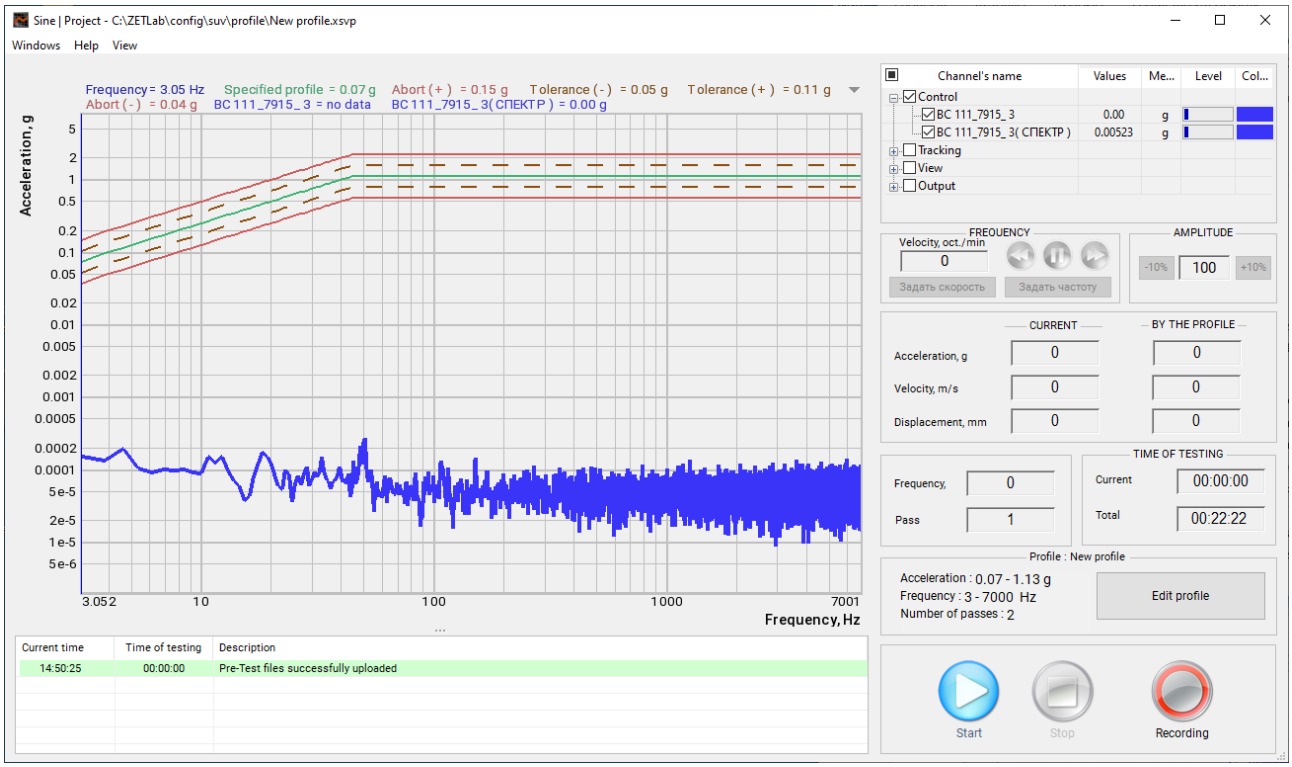


Fig. 5.19 Sine Vibration window

To set the test profile, press the *Edit Profile* button in the Sine Vibration program window. Edit profile – Harmonic Vibration window will open on the Profile tab (Fig. *5.20*).

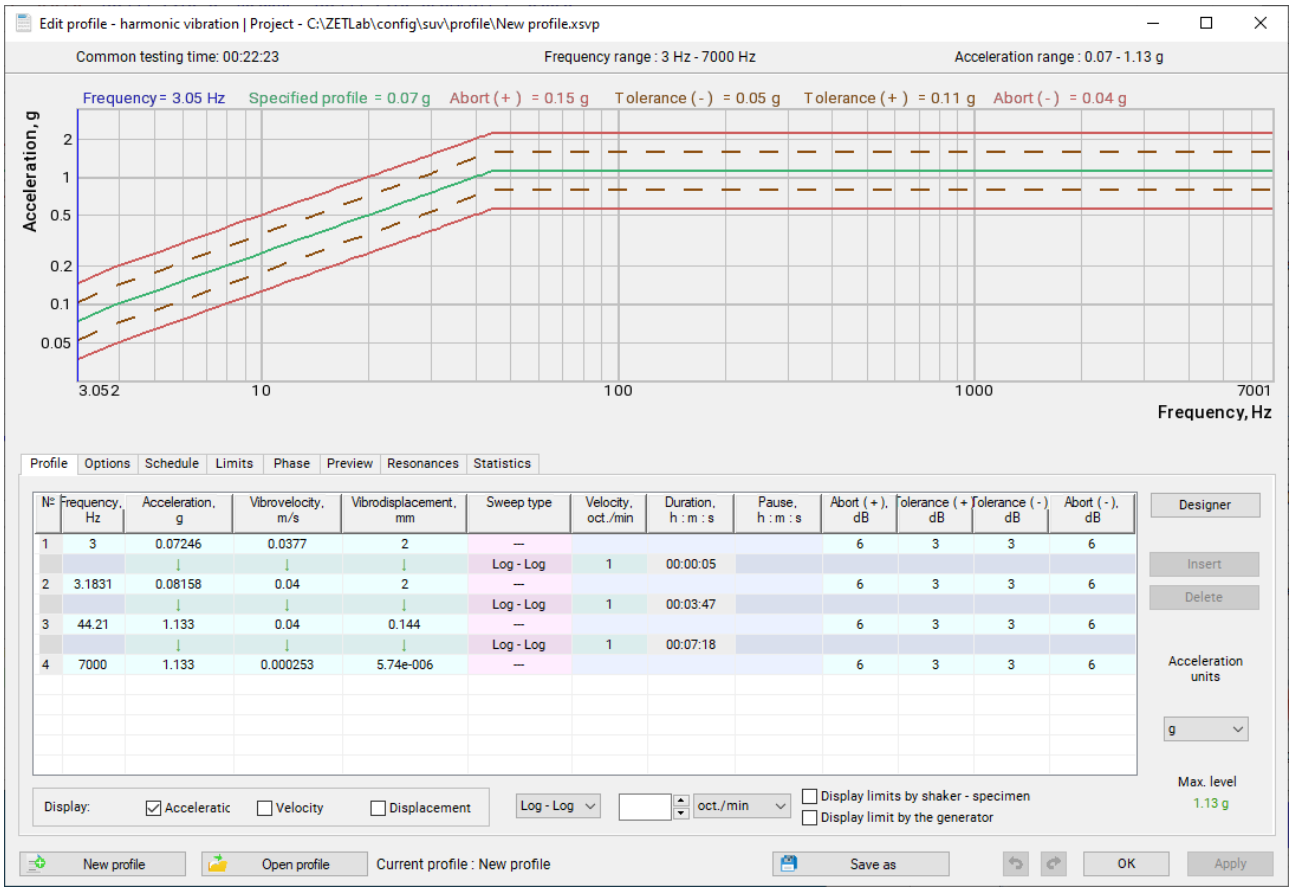


Fig. 5.20 Edit Profile window, Profile tab

Set the vibration test profile on the Profile tab. To add or delete new lines to/from the table, you can use the *Insert* or *Delete* buttons after specifying the required place (line) in the table with the mouse.

Another possible option to add and delete profile rows is as follow: using the mouse, point to the place to edit, click the right mouse button to open the context menu, change the number of rows (Fig. *5.21*) and select the necessary operation, such as insert, insert row above, insert row below, delete.

Note: *Not all operations from the context menu can be available at the same time, it depends on the place to be edited in the table.*

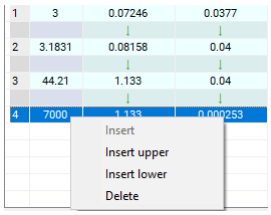


Fig. 5.21 Context menu for changing the number of rows

The vibration test profile consists of a set of segments defined by boundary points. The boundary points have serial numbers in the table and must be ranked by frequency. The boundary points

have four main parameters: Frequency, Acceleration, Vibrovelocity and Vibrodisplacement, and their values can be edited manually to set the required parameters of the test profile.

Note: *Activating the arrow symbol ↓ in the table field moves the value from the previous row to the next one, thus facilitating the profile editing process.*

Note: *Acceleration, Vibrovelocity and Vibrodisplacement are mutually dependent parameters, and when you enter one of them, the program automatically recalculates the others.*

Caution! *When editing the profile table, only the ascending sequence is allowed in the Frequency column. If violations are detected in the frequency value sequence, the software will report these violations by red highlighting the table fields.*

If you point the mouse to the Sweep Type field, in the context menu (Fig. 5.22) you can change the No sweep mode to Fix mode and Maintenance of resonance frequency mode. The sweep type can be selected individually for each boundary point.

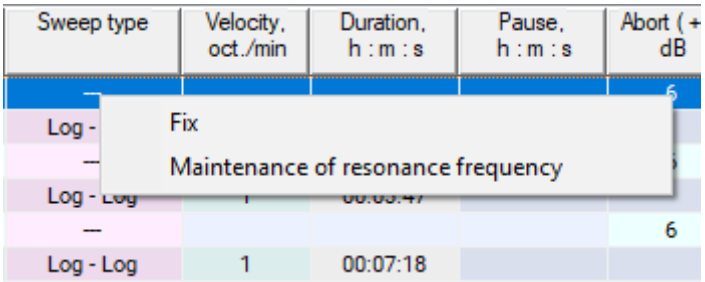


Fig. 5.22 Context menu for the sweep type

If the Fix mode is selected, set the time of fixing at the frequency specified for this boundary point in the Duration column.

If you select the Hold the Resonance Frequency mode, another column Phase will be added to the end of the table, where you must set the phase value corresponding to the resonance frequency for this boundary point (the value specified in the Frequency column).

Each boundary point also has 4 parameters defining the allowed range for the vibration tests Tolerance (+), Tolerance (-), Abort (+), and Abort (-). If the Tolerance (+) and Tolerance (-) parameter values are exceeded, a warning message will be sent to the user via the control channel. If the Abort (+) and Abort (-) parameter values are exceeded, the tests in the control channel will stop. The parameters set the tolerance of the integral acceleration level at each boundary point according to the profile. By default, the tolerances are set to ±3 dB and ±6 dB, respectively, but you can change them manually, if necessary.

The neighboring boundary points determine the profile segments. To edit parameters of the profile segment, the table contains the scan lines between the boundary points.

Each scan line in the table has three parameters: Sweep Type, Velocity, and Duration.

The Sweep Type parameter can be "logarithmic" or "linear".

The Duration parameter defines the time needed to pass the vibration tests through the scan between the boundary points.

The Velocity parameter determines the frequency change rate when passing through the scan between boundary points.

Note: *Duration and velocity are mutually dependent parameters and when you enter one of them, the program automatically recalculates the other one.*

Note: *For the linear scan type, the Velocity parameter is measured in Hertz per second; for the logarithmic scan - in octaves per minute.*

The Designer button opens the corresponding window (Fig. *5.23*) that allows to quickly create profiles with the necessary displacement, velocity, and acceleration.

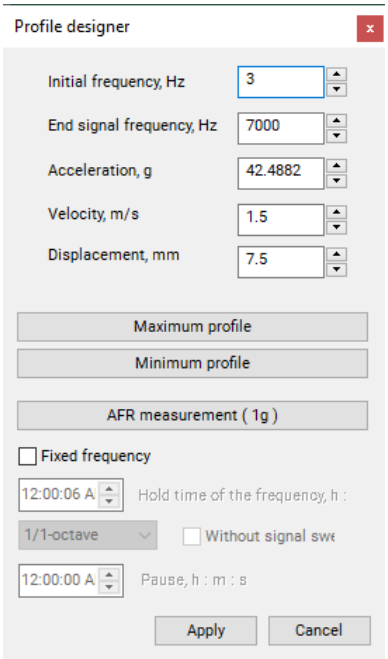


Fig. 5.23 Profile Designer window

The Maximum Profile button in the Profile Designer window allows you to automatically rebuild the profile to the maximum allowed values.

The Minimum Profile button in the Profile Designer window allows you to automatically rebuild the profile to the minimum allowed values.

When you select the Fixed Frequency parameter, you can automatically create a profile with fixed frequencies of the 1/3-octave or octave band by specifying the required frequency holding time in the corresponding field in the Profile Designer window.

In the Display section of the Edit Profile window, set a reference value for displaying the test profile graph. The profile graph can be represented as the dependence of the frequency on the acceleration, velocity or displacement; to do this, set the switch to the appropriate position. The graph of the acceleration test profile can be presented in either "g" or "m/s^2".

The profile's sweep type can be implemented in two ways: linear (Lin – Lin) and logarithmic (Log – Log). Also, you can set the test pass speed for the profile. For linear sweeping, the sweep speed is set in Hz/s, Hz/min or min/cycle. For logarithmic sweeping, the sweep speed is set in oct/min or min/cycle. If this function is enabled, the sweep speed will be the same for each test segment.

When you select the Display Limits by shaker - specimen parameter, the spectrum graph in the Sine Vibration window (Fig. *5.19*) will additionally display graphs of the maximum and minimum acceptable profile values (the range of acceptable profiles).

Note: *The graphs of maximum and minimum acceptable profile values are calculated according to the shaker and specimen parameters, as well as the pretest results.*

When you select the Display Limits by generator parameter, the spectrum graph in the Sine Vibration window (Fig. *5.19*) will additionally display graphs of the maximum and minimum allowable values (the range of acceptable values) of the generator level when generating the control signal.

Note: *The maximum value of the generator level is determined in the shaker parameters and cannot exceed 10V, the minimum value is determined by the pretest results.*

The Max. Level field in the Edit Profile window displays the maximum acceleration value in the profile.

The vibration test parameters can be set on the Options tab (Fig. *5.24*).

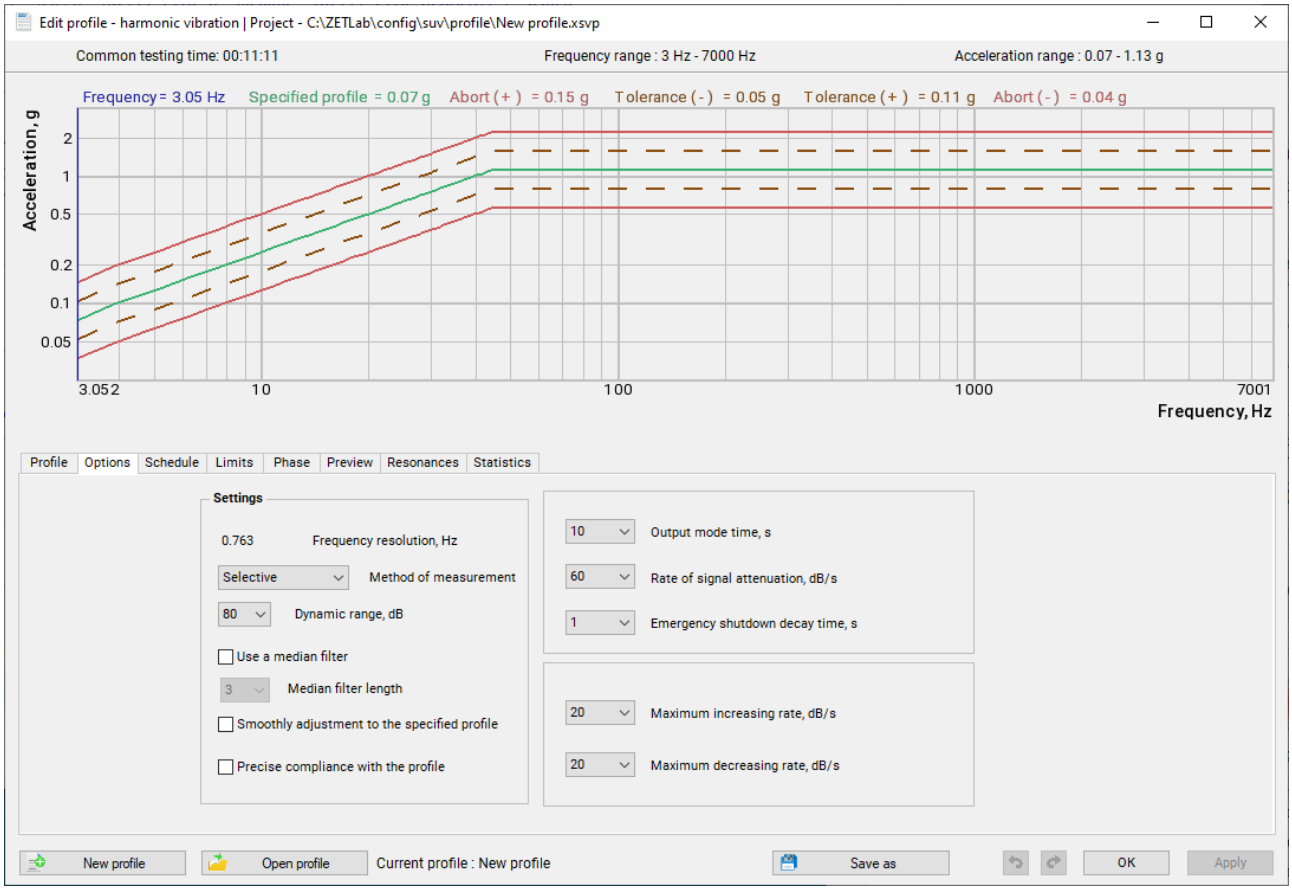


Fig. 5.24 Edit Profile window, Options tab

The Frequency Resolution parameter displays the value to be used by the program when performing the calculations. The frequency resolution value is changed when setting the pre-test parameters (see the section 5.4).

The Method of Measurement parameter sets the method for calculating the spectrum values, which can be Selective or Effective. When the Selective method of measurement is selected, the control channel records the values corresponding to response only at the generated vibration test frequency, if the Effective method is selected, in the entire band of the recorded signal.

The Dynamic Range parameter limits the difference between the maximum value and minimum value of the amplitude response.

The Use Median Filter parameter is used to "align" the amplitude response. The greater the value of the Median Filter Length parameter, the greater the alignment value.

When the Smoothly adjustment to the specified profile parameter is selected, the spectrum graph can return to the test profile when the transfer characteristic changes due to physical changes in the specimen under test or tooling.

When the Precise compliance with the profile parameter is activated, it will be forbidden to exceed the lower threshold of the specified profile for zones in the frequency range where antiresonances are detected in the feedback signal. If this parameter is deactivated, it simplifies the test process of the areas with antiresonances.

The Output mode time parameter defines the time for increasing the signal from zero level to the profile level.

The Rate of signal attenuation parameter determines the rate at which the signal will be reduced at the end of the test.

The Emergency shutdown decay time parameter defines the time when the signal will be reduced to zero when the program has detected the need for an emergency stop of testing.

Note: *The emergency stop attenuation time excludes the impact on the shaker and the specimen that occurs when the control signal instantly (abruptly) disconnects.*

The Maximum increasing rate and Maximum decreasing rate parameters determine the maximum rate of increasing and decreasing signal strength during the tests.

On the Schedule tab, you can set the time to enter test mode, as well as the number and direction of passes during the tests (*Fig. 5.25*).

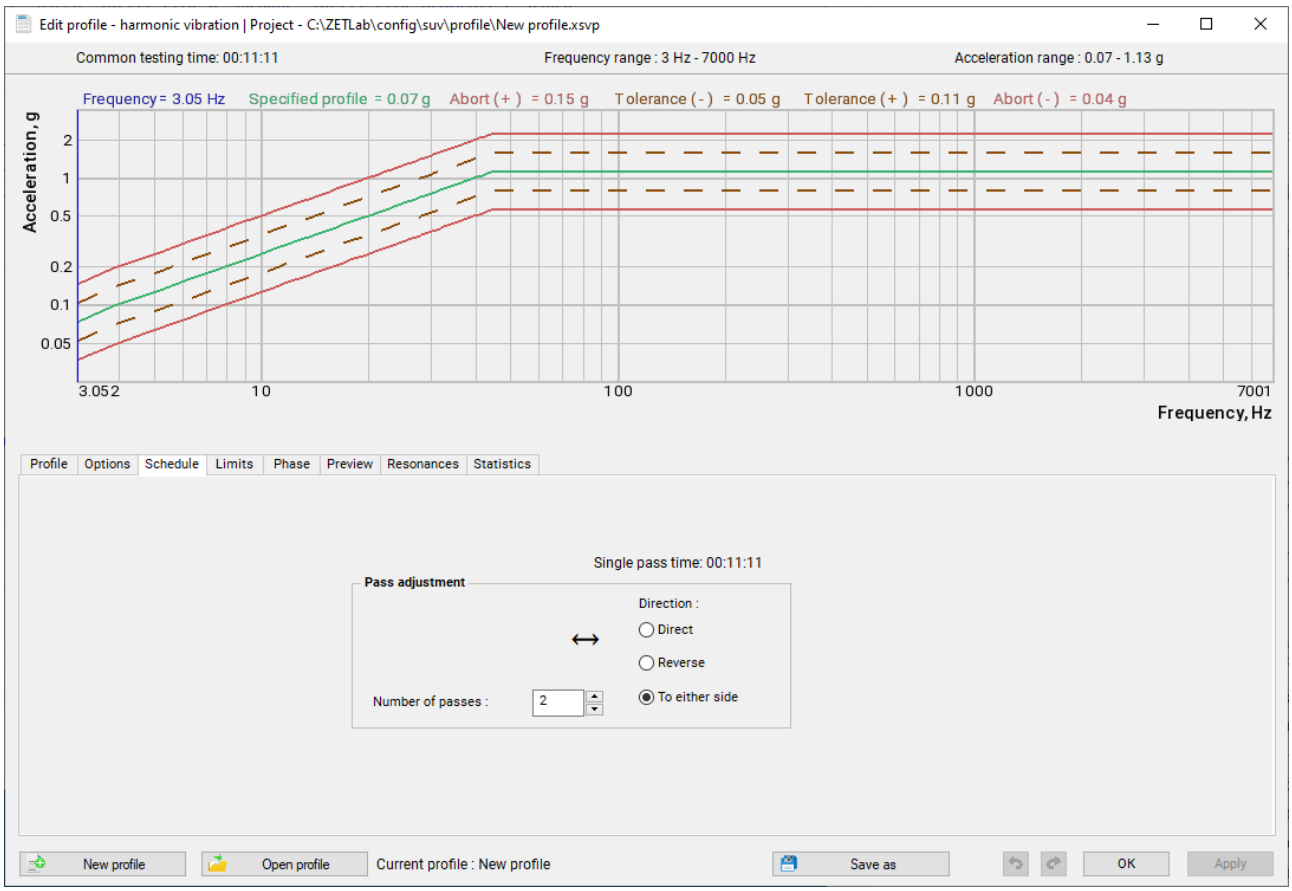


Fig. 5.25 Edit Profile window, Schedule tab

The Direction parameter determines how the vibration test cycles will be counted: Direct - from lesser frequency to greater frequency; Reverse - from greater frequency to lesser frequency; To either side - from low frequency to greater frequency and back.

The Number of Passes parameter determines the number of vibration test cycles.

On the Limits tab (*Fig. 5.26*), you can set the acceptable test limits for the control and tracking measurement channels. According to the parameters with enabled control, (during the tests) exceeding the set parameter values will be monitored, and if they are exceeded, the tests will stop immediately.

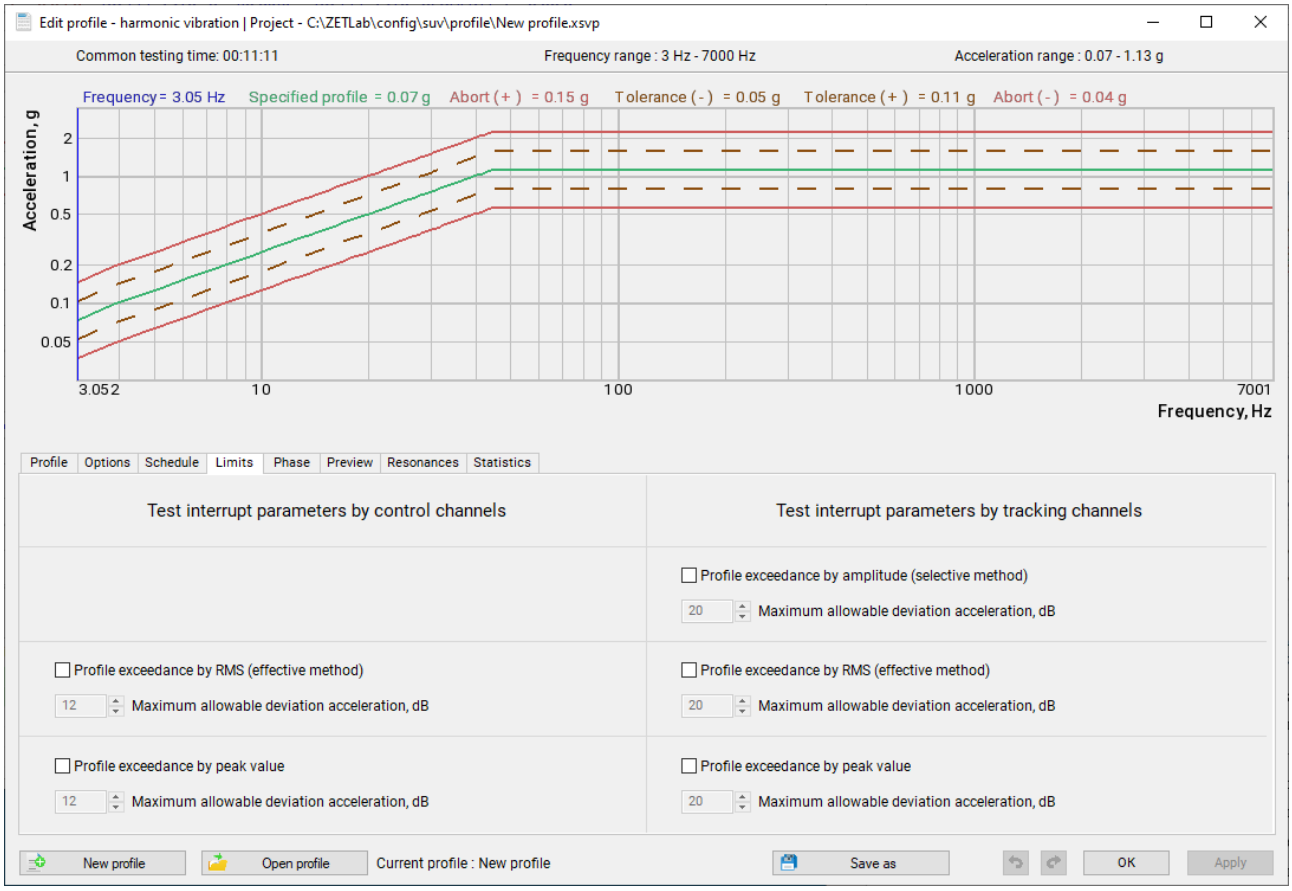


Fig. 5.26 Edit Profile window, Limits tab

To enable parameter control, activate (check the cell) the corresponding parameter, and to disable it, deactivate (uncheck the cell).

You can set limits for the following parameters:

- Profile exceedance by RMS;
- Profile exceedance by peak value;
- Profile exceedance by amplitude (only for tracking channels).

- On the Phase tab, you can set the operation mode for the VCS generators (*Fig. 5.27*).

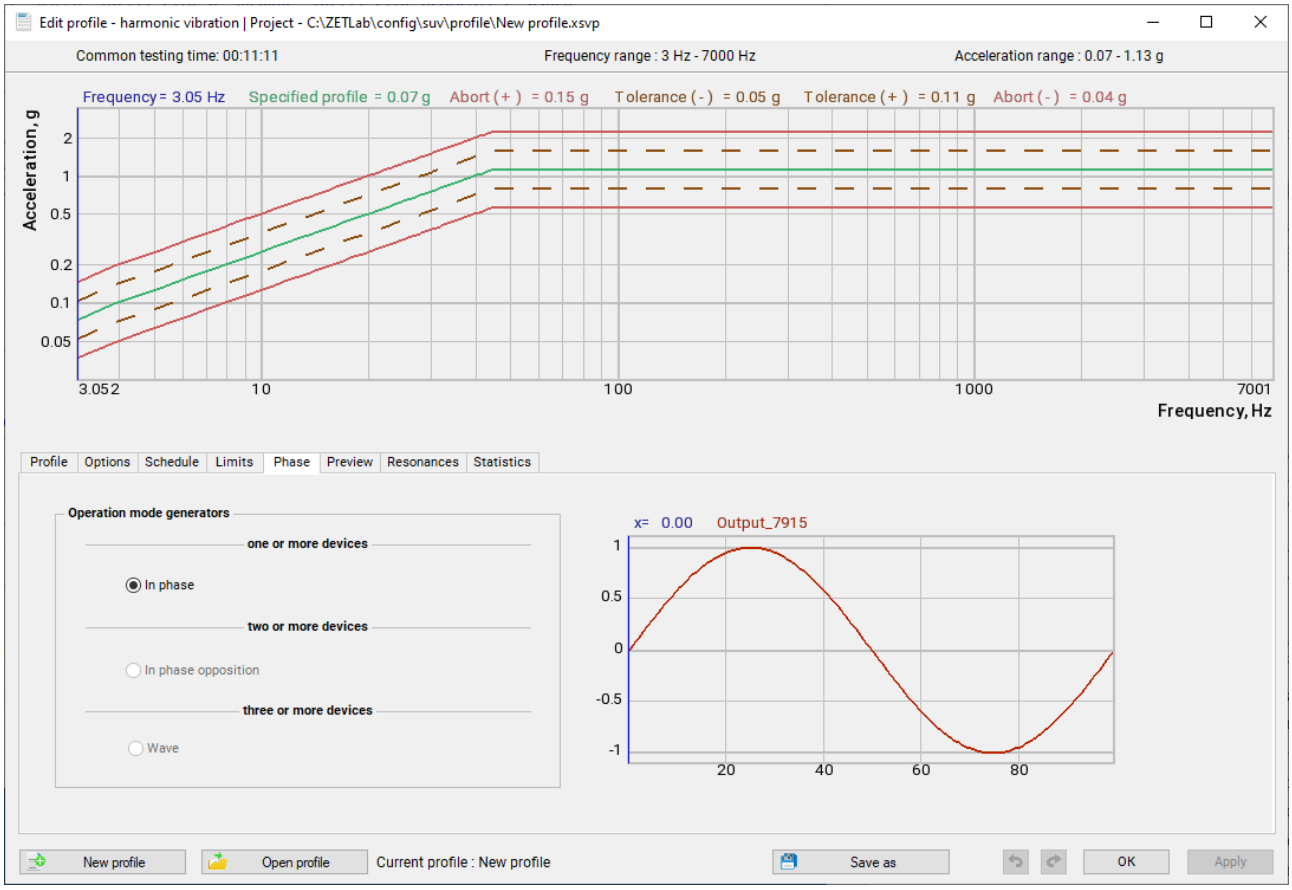


Fig. 5.27 Profile Configuration window, Phase tab

Whether it is possible to select the generator's operation mode on this tab depends on the number of simultaneously involved VCS controllers during the vibration tests:

- One VCS controller – In phase
- Two VCS controllers - In phase and In phase opposition
- Three VCS controllers - In phase and Wave.
- Four VCS controllers - In phase, In phase opposition and Wave.

Note: *In the Wave mode, the phase shifts between the controller control channels by 120° when three VCS controllers are involved and by 90° when four VCS controllers are involved.*

On the Preview tab, you can preview the vibration test graphs for a given profile obtained by calculation based on the pretest results (*Fig. 5.28*).

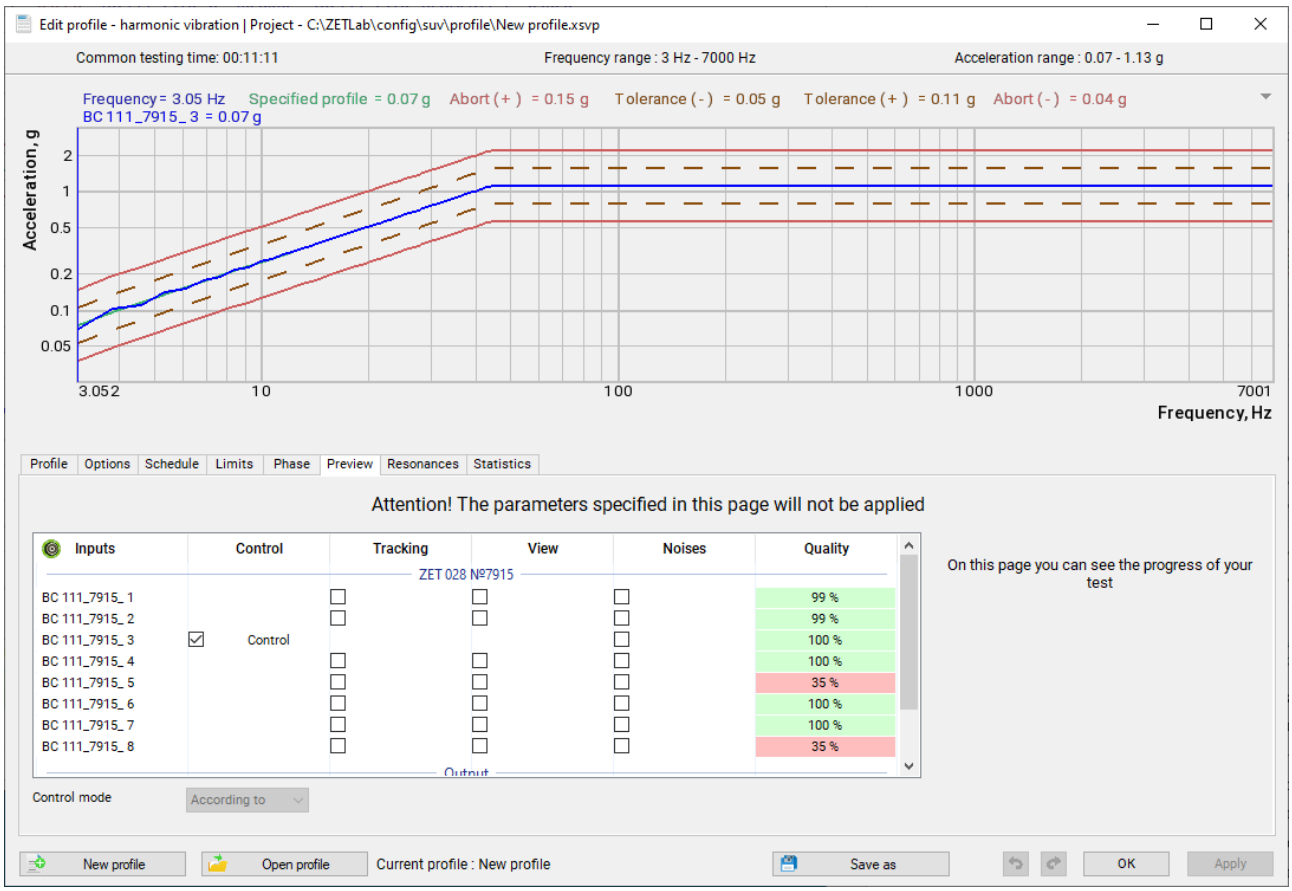


Fig. 5.28 Profile Settings window, Preview tab

The graphs are presented for all measuring channels of the VCS controller, and each measuring channels can be assigned any type of control (control, tracking, view, and also check the noise level of the channel). To display the desired vibration graph, check the corresponding table cell.

Note: *The graph information is for reference and intended to inform the VCS user of the expected results to be obtained in the vibration tests for a given profile.*

The Resonances tab contains statistical information based on the pretest results. On this tab, the operator to evaluate the presence of resonances and antiresonances on the amplitude response (*Fig. 5.29*).

Note: *If necessary (for more detailed consideration), scale the amplitude response on the frequency scale to the area of interest, and only resonances and antiresonances falling within the visualized graph area will be left in the table.*

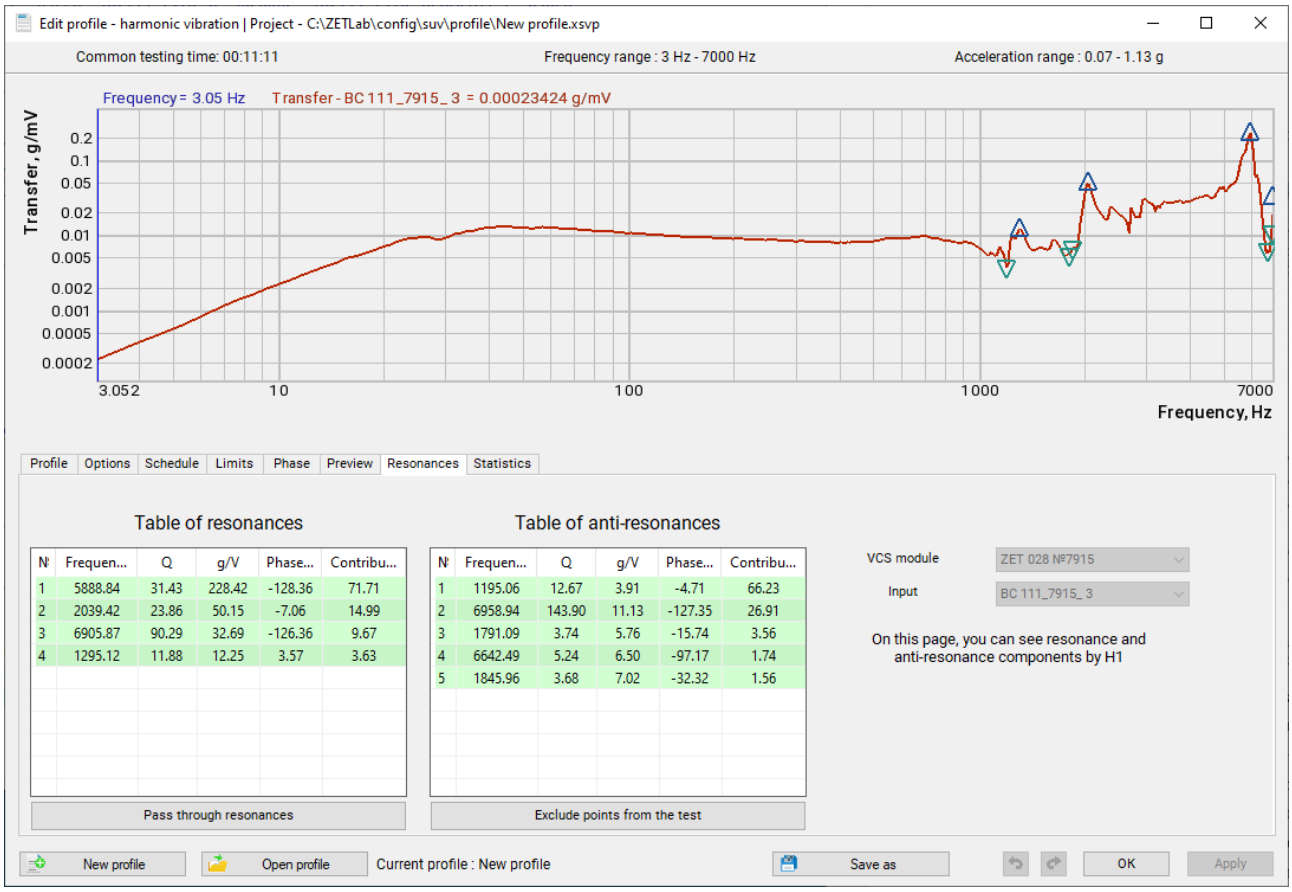


Fig. 5.29 Edit Profile window, Resonances tab

Using the Pass through Resonances button, you can build a profile with frequency holding at the resonances specified in the resonances table.

Note: *If necessary, you can manually edit the profile built automatically with frequency holding on resonances by excluding "excessive" boundary points.*

The Statistics tab contains statistical information based on the set values for the test profile parameters. It provides the user with a possibility to assess the load of the shaker during vibration tests (*Fig. 5.30*).

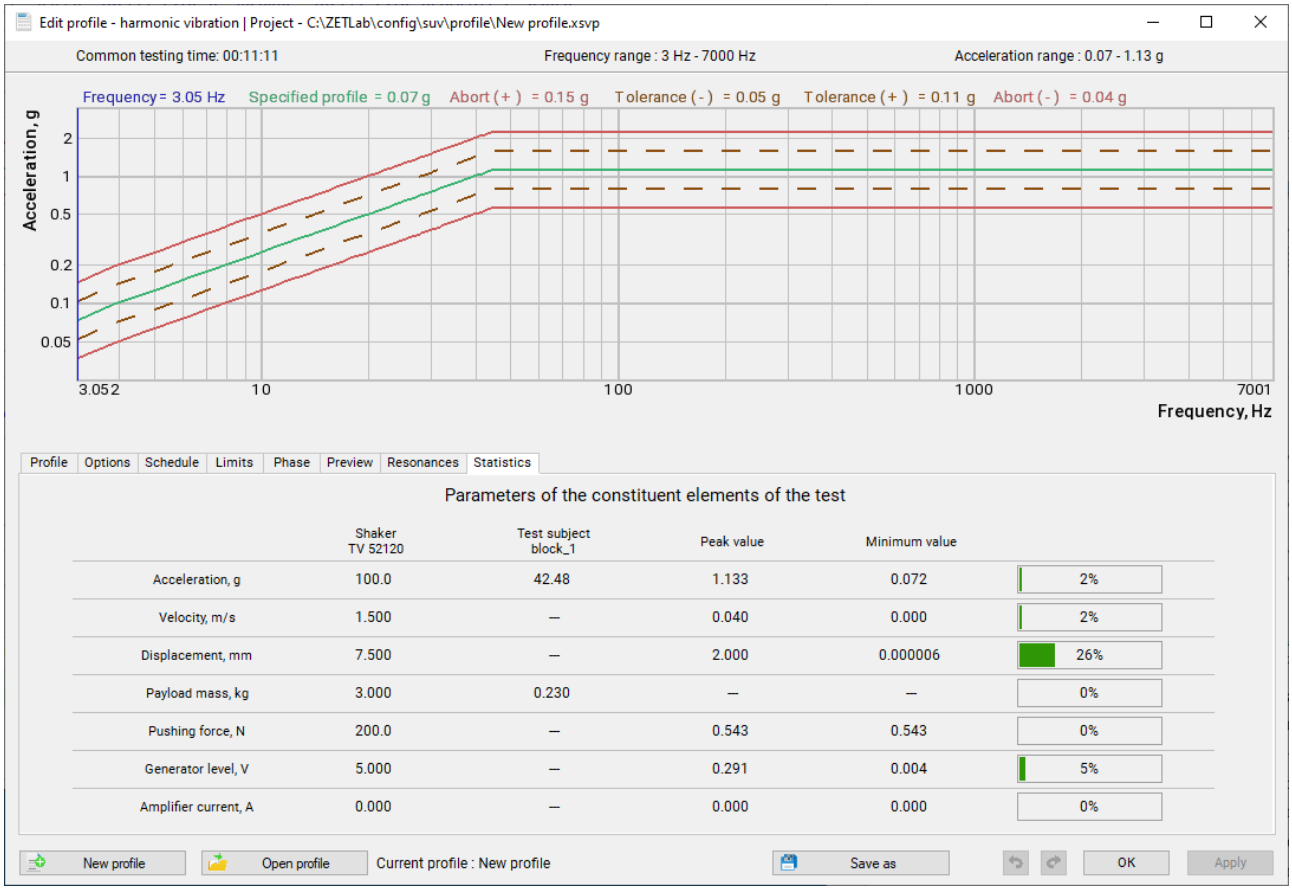


Fig. 5.30 Edit Profile window, Statistics tab

To save the settings in the Edit Profile program, press the Apply button.

Also, the user can save the current test profile as a file which can be downloaded from the Edit Profile window. To save the current test profile, select the Save as function in the Edit Profile window (Fig. 5.).

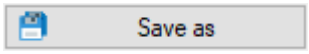


Fig. 5.31 Button for saving the test profile

In the opened window, set the name of the test profile and specify the path to save, and then press the Save button (Fig. 5.).

Note: *You can save the current profile with any tab open.*

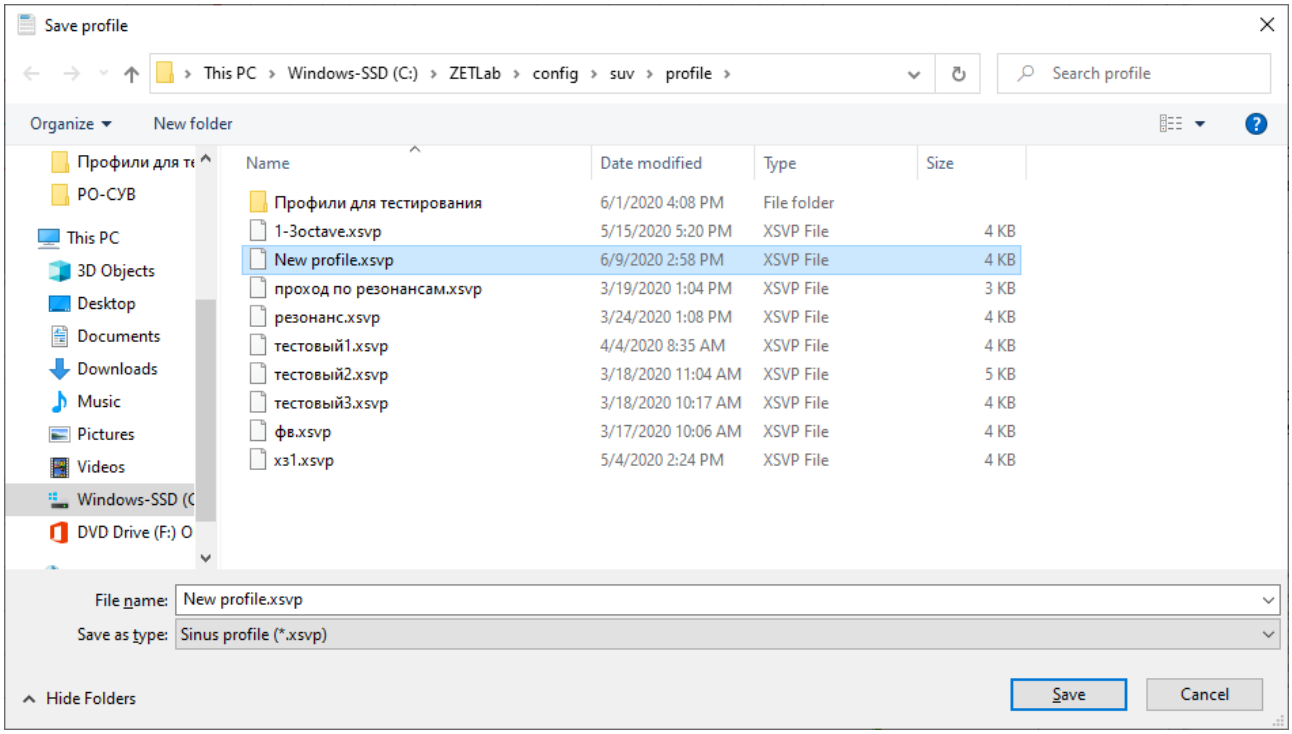


Fig. 5.32 Path to save the test profile

To download a previously saved test profile, select the Open Profile function. In the opened window, select the desired test profile file and press the *Open profile* button.

5.5.3 Testing

There is a coordinate grid with graphs in the center of the program window. During the vibration tests, it displays graphs of acceleration by frequency, minimum tolerance, and maximum tolerance.

The Manual Control field is used for changing the acceleration amplitude, sweep speed, and pass direction during the test. To display the Manual Control field, select it from the View menu of the Sine Vibration program.

The Integral Parameters field contains indicators of the current state of vibration tests (acceleration, velocity, displacement), as well as the test parameter values set in the test profile.

The Frequency and Time field contains the current frequency indicator and time counters. The Total Time counter shows the total duration of vibration tests. The Current Time counter shows the time elapsed from the start of the test.

The lower pane of the Sine Vibration program displays the event log, where important information of the program operation is saved. After starting the program, the event log displays information of the successful download of the pretest file (*Fig. 5.33*).

Current time	Time of testing	Description
15:53:42	00:00:00	Pre-Test files successfully uploaded

Fig. 5.33 Event log of the Sine Vibration program

Vibration tests are managed from a special menu in the lower-right corner of the program (*Fig. 5.34*).

Fig. 5.34 Control menu of the Sine Vibration program

To start the vibration tests, press the Start button. To stop testing at any time, press the Stop button. To pause testing, press the Pause button, and to resume testing, press the Start button.

Pressing the Recording button starts/stops recording electrical signals from all involved channels of the VCS controller. You can view the recorded signals in the View Results program from the ZETLab Panel Display menu (see ZETLAB software. Operator's manual).

After pressing the Start button, the test system will gradually enter the specified mode (*Fig. 5.35*).

Current time	Time of testing	Description
15:53:42	00:00:00	Pre-Test files successfully uploaded
15:55:50	00:00:00	Control module is running
15:55:53	00:00:00	Mode parameters stabilization . . .

Fig. 5.35 Event log of the Sine Vibration program

After the current acceleration RMS reaches 95% of the required acceleration, the program will start vibration tests and report it in the event log (*Fig. 5.36*).

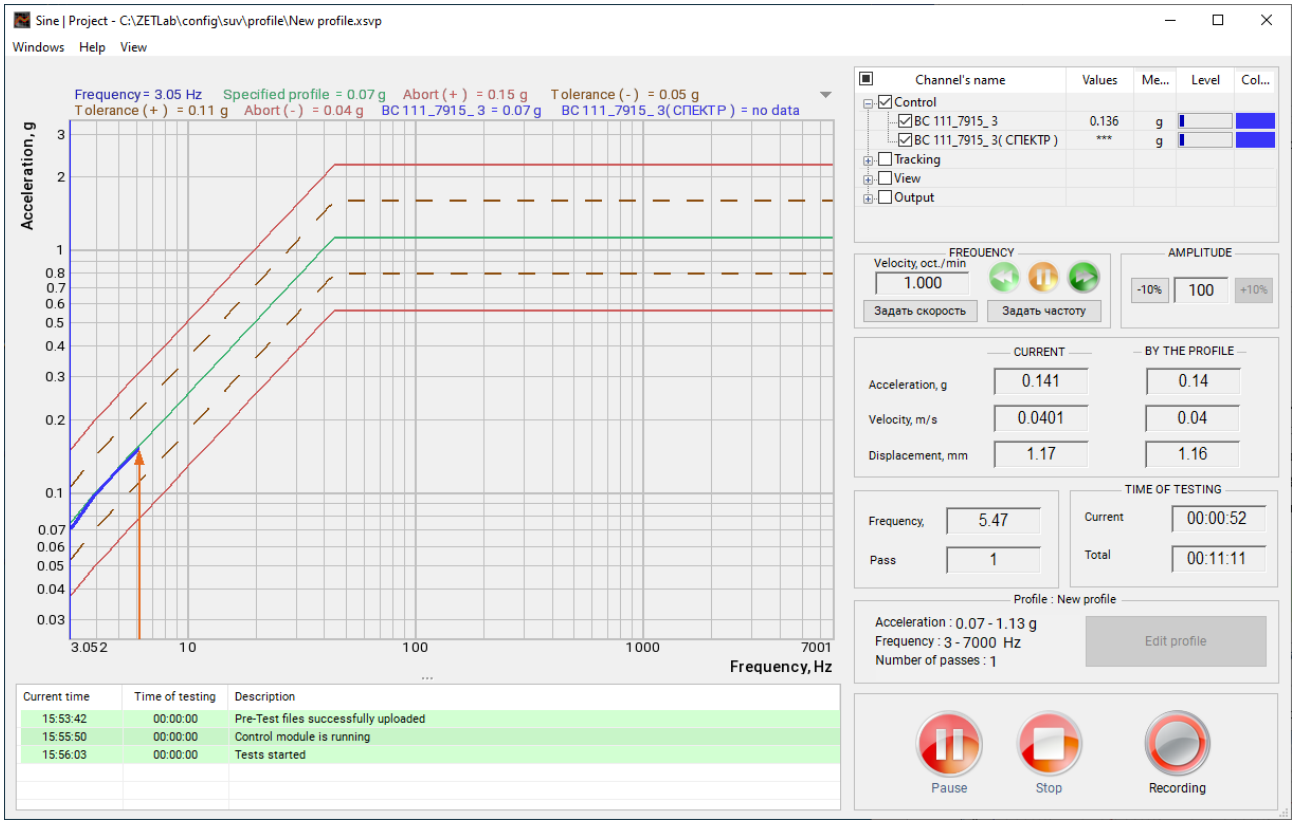


Fig. 5.36 Starting vibration tests

To display a measurement channel on the graph, select it from the list of channels in the right pane of the program window (*Fig. 5.37*). This list includes all measuring channels for which one of the test control types was selected in the Control Parameters program (Control, Tracking, View). The measurement channel line also displays information of the current acceleration and the integral load level for this channel.

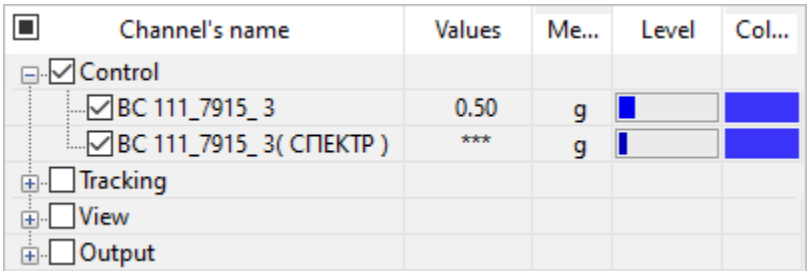


Fig. 5.37 Selecting a channel to display on the graph

If the Control status was assigned to multiple measuring channels in the Control Parameters program, then list of channels in the Sine Vibration program will contain an additional channel "Total (Medium)" or "Total (Max)", depending on the set parameters (*Fig. 5.38*).

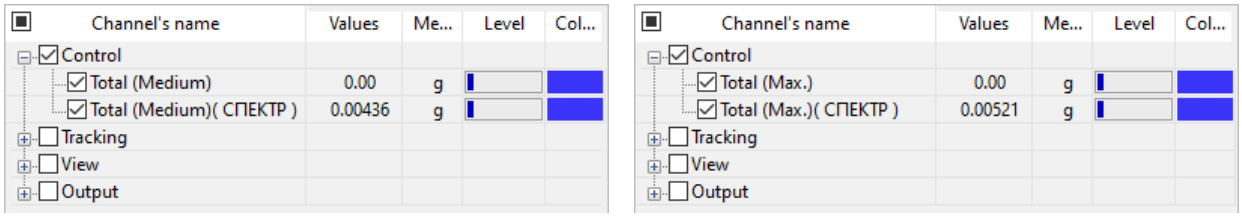


Fig. 5.38 Selecting a channel to display on the graph

Note! *If the control mode is selected based on the average value or maximum value, the channels selected with the Control status change their status to Tracking, and a virtual measuring channel formed according to the average value or maximum value respectively becomes a control channel.*

If the value of the control channel exceeds the set limits (exceeding the permissible limits, exceeding the maximum parameters of the shaker, etc.), the tests will stop. The message log will display information of the reasons for interrupting the test. To resume the vibration tests from the moment they stopped, press the Continue button (*Fig. 5.39*).

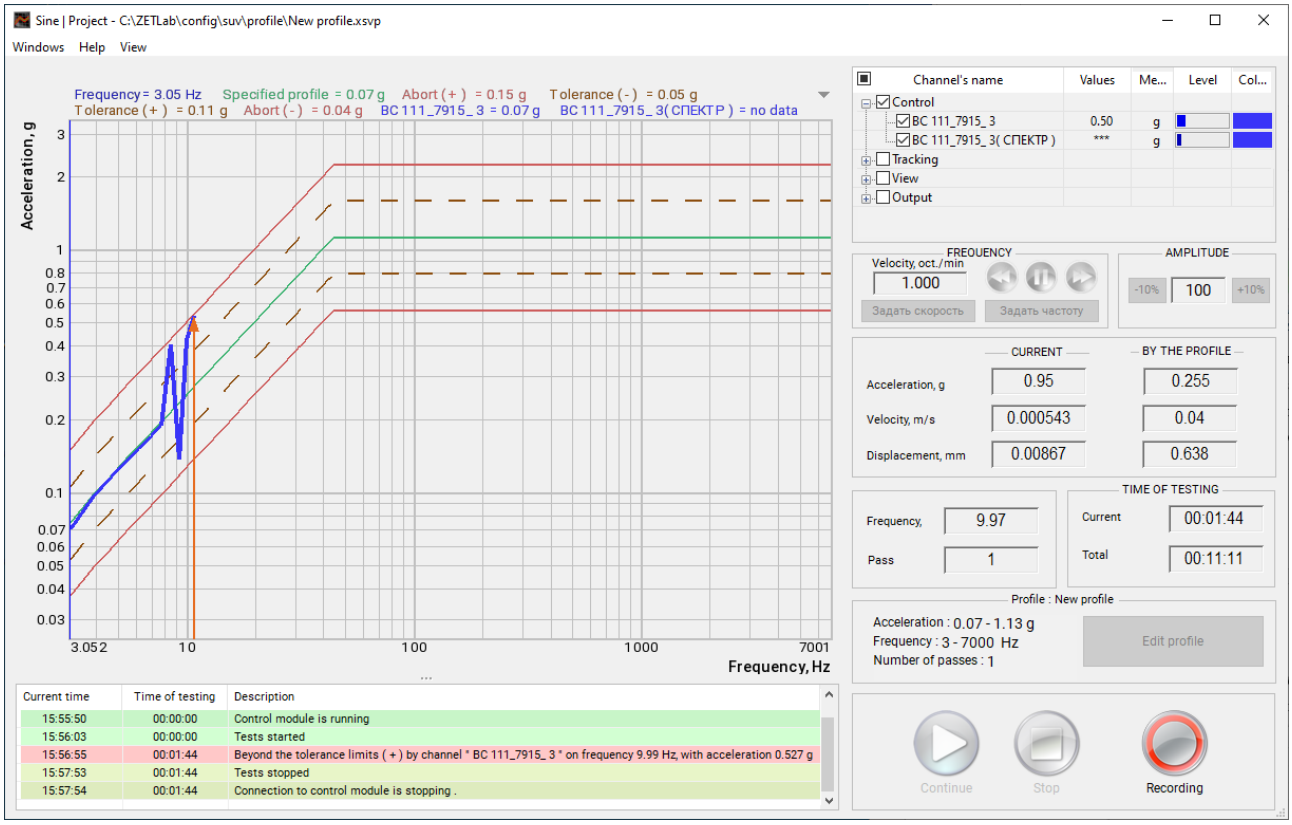


Fig. 5.39 The vibration test interruption

During the tests, it is possible to track changes in the condition of the specimen under test at the point (s) of the control channel setup in real time. To do this, start the Additional Graphs program (*Fig. 5.40*) from the Windows menu.

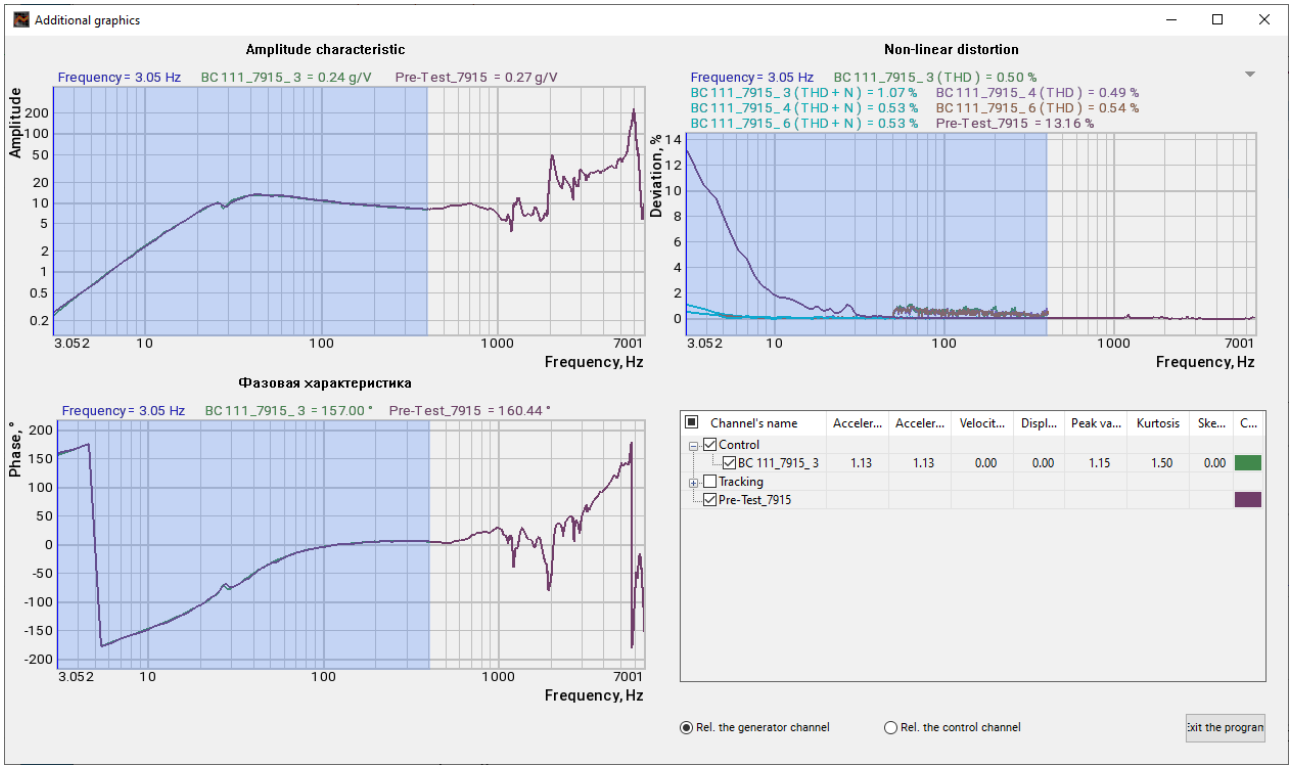


Fig. 5.40 The Additional Graphs program window

The graphs of the Additional Graphs program show deviations of the current spectrum parameter values of the selected channel from the spectrum parameter values of the control channel generated in the test profile after passing the pretest. The calculation can be performed relative to the control channel or the oscillator channel.

To display information of the temporary implementation of signal parameters, start the Results table program from the Windows menu of the Sine Vibration program. The opened Results table window (*Fig. 5.41*) will show information of the vibration test process in the past.

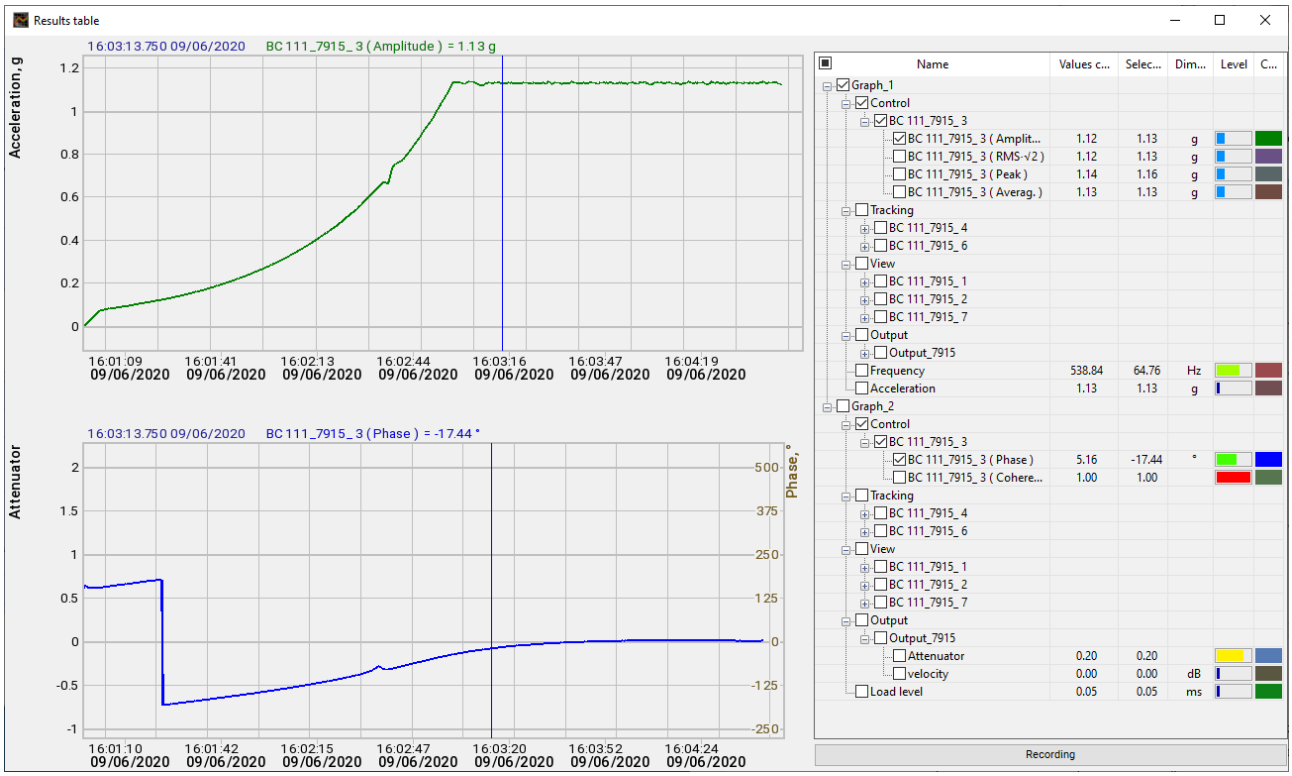


Fig. 5.41 The Results table program window

The upper-right corner lists the names of channels with available graphs. You can change the graph color by clicking on the colored rectangle. To save the recorder readings, press the Recording button. Only selected graphs available in the View Results program will be saved.

To display information of resonances and antiresonances, start the Resonance Analysis program from the Windows menu of the Sine Vibration program. The opened Resonance Analysis window (*Fig. 5.42*) will display information of the changed resonances and antiresonances parameters during the vibration tests.

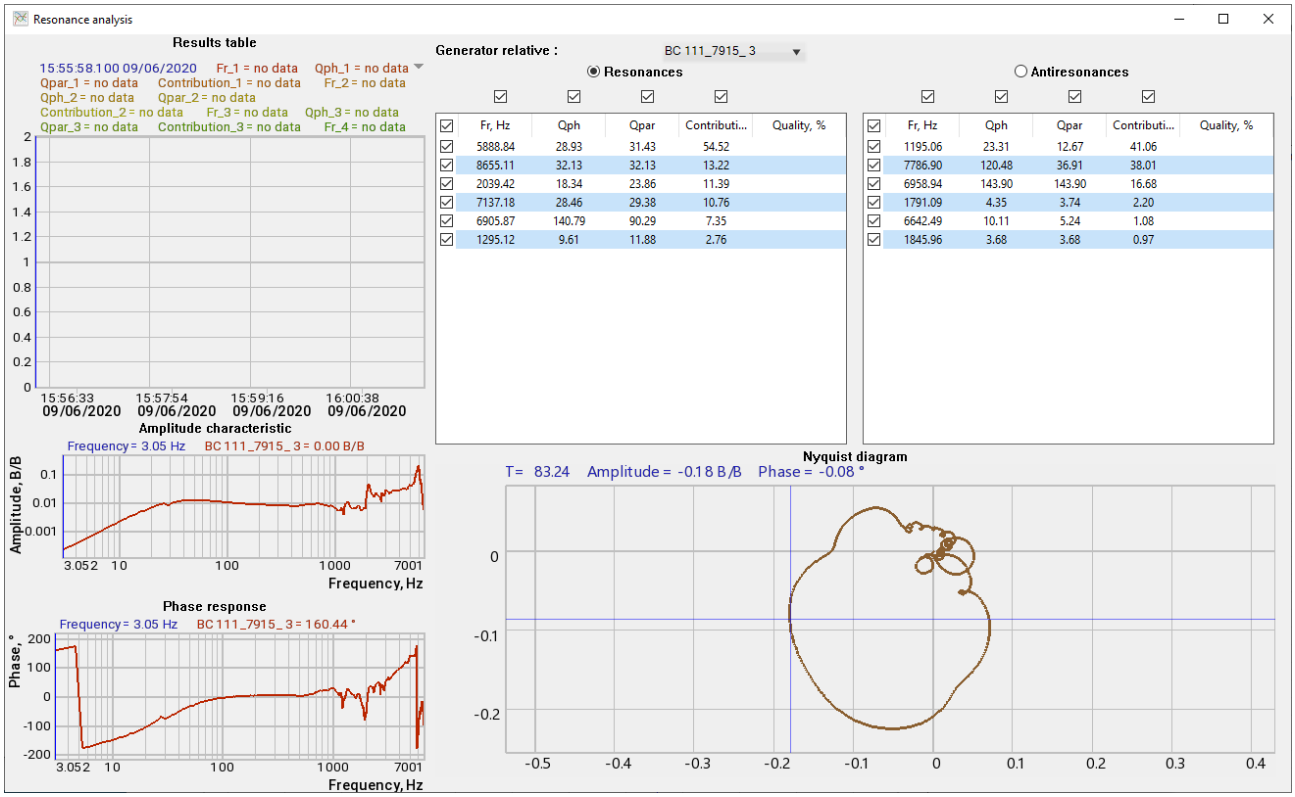


Fig. 5.42 Resonance Analysis Program View

To save the report, run the Report command from the Windows menu in the Sine Vibration program. In the opened window, you can specify the name of report file and path to save it, and then press the Save button. The report is also saved automatically after the vibration tests are completed.

To view the report files, press the Test Results button on the VCS panel. In the opened window, select the appropriate test type and go to the Test Results folder. You can view the report files using the View Results program. To do this, right-click on the file and select Open in ResultViewer (*Fig. 5.43*) from the context menu.

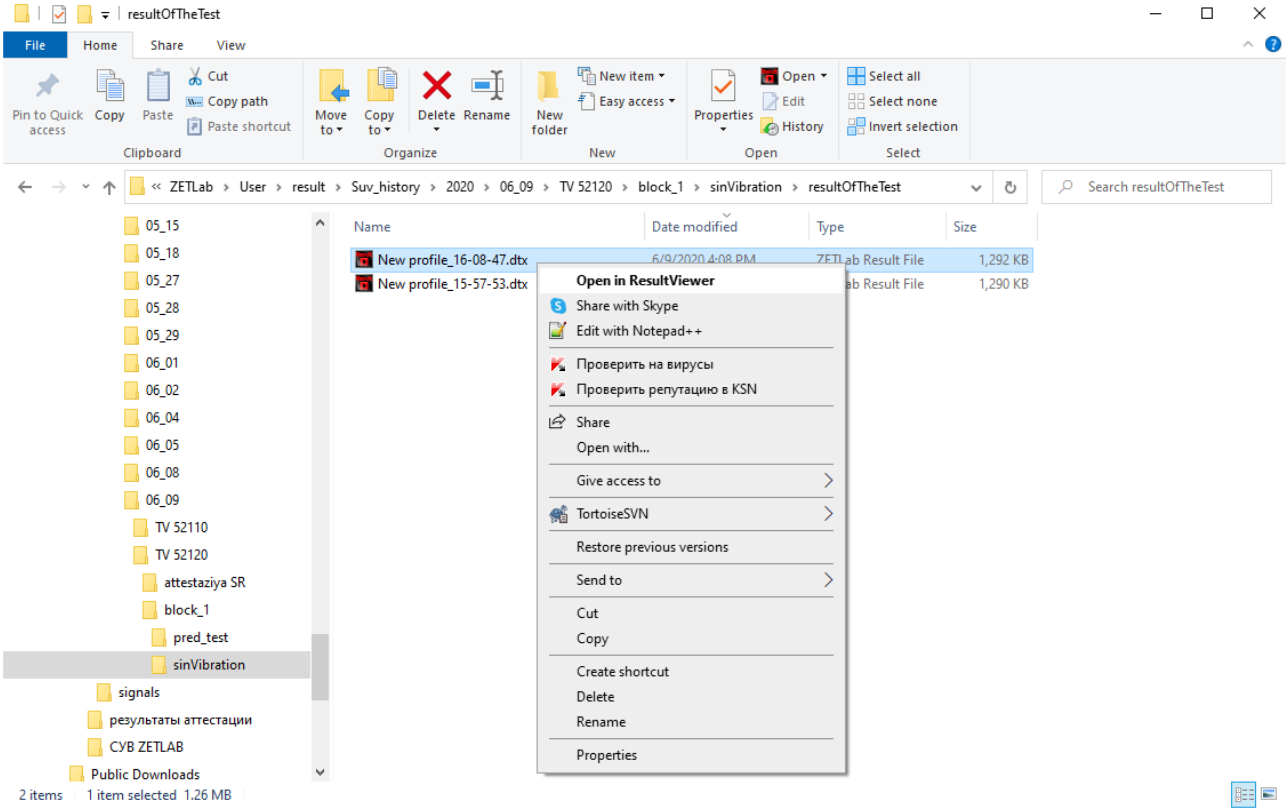


Fig. 5.43 Report Directory

In the View Results program, the Graph tab displays the graphical part of the report on the completed test (*Fig. 5.44*).

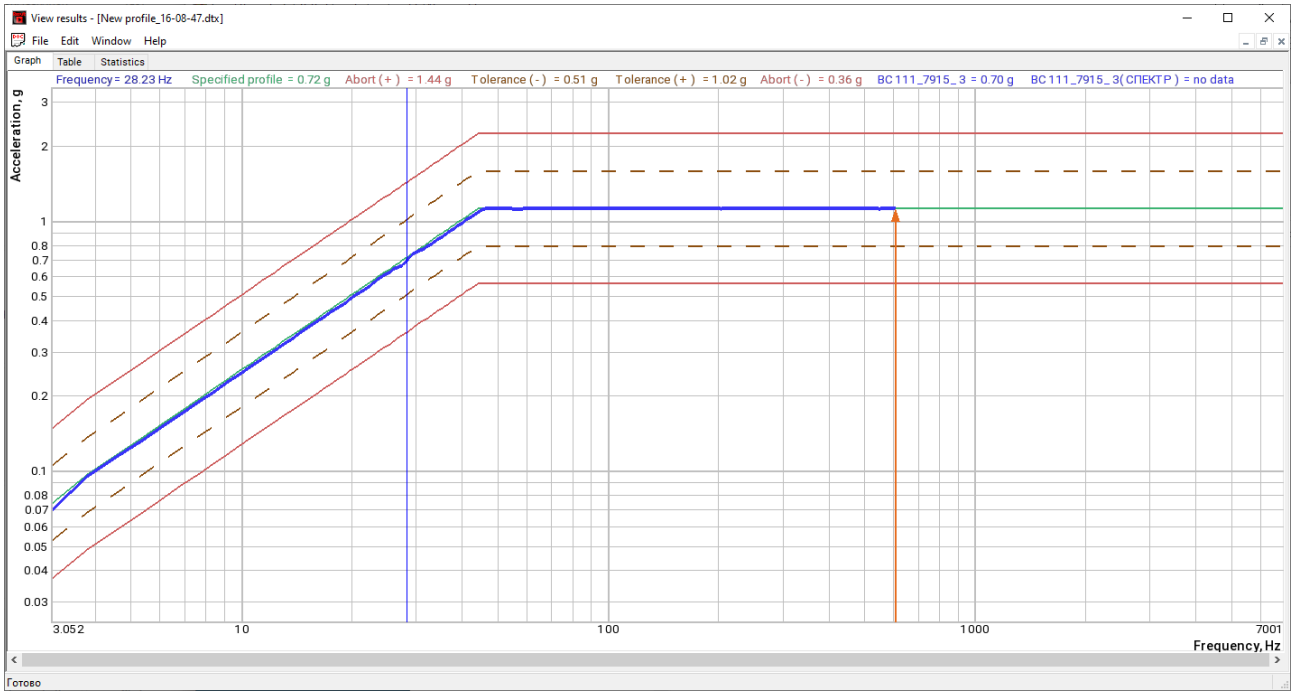
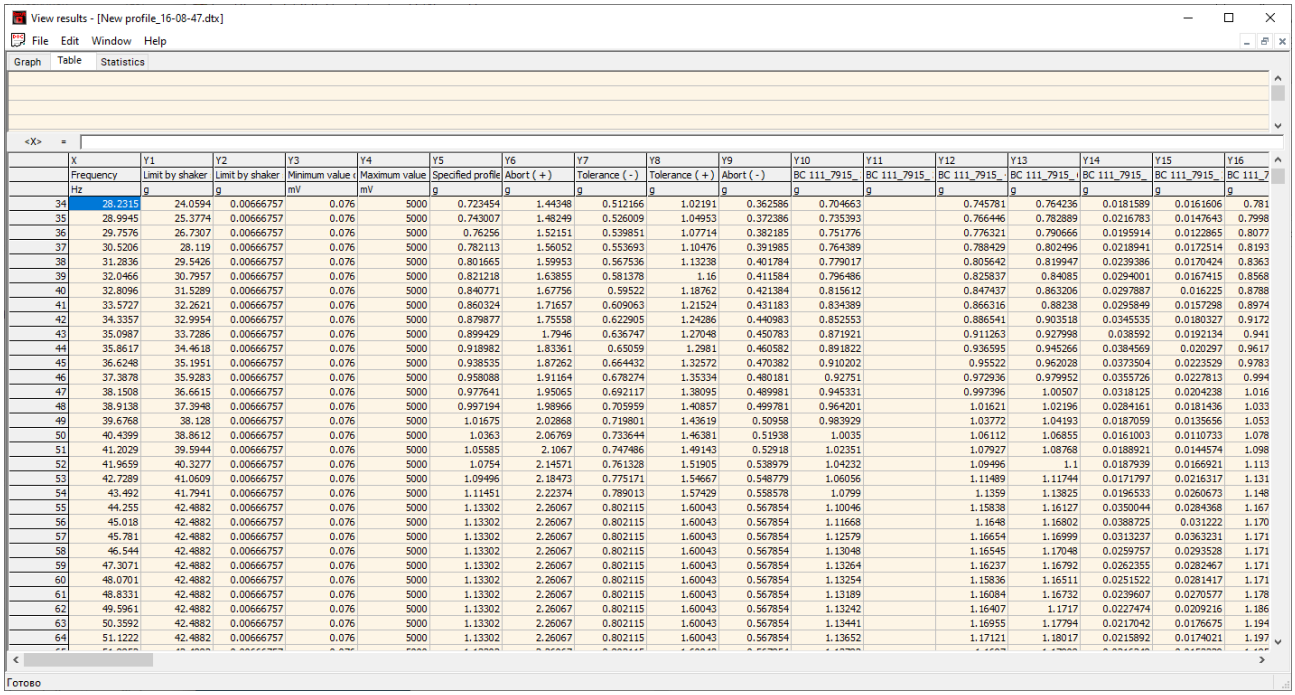


Fig. 5.44 Example of a vibration test report

To view the graph values in table form, go to the Table tab (*Fig. 5.45*).



	X	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16
	Frequency	Limit by shaker	Limit by shaker	Minimum value	Maximum value	Specified profile	Abort (+)	Tolerance (-)	Tolerance (+)	Abort (-)	BC 111_7915_	BC 111_7915_	BC 111_7915_	BC 111_7915_	BC 111_7915_	BC 111_7915_	BC 111_7
	Hz	g	g	mV	mV	g	g	g	g	g	g	g	g	g	g	g	g
34	28.2315	24.0594	0.00666757	0.076	5000	0.723454	1.44348	0.512166	1.02191	0.362586	0.704663		0.745781	0.764236	0.0181589	0.0161606	0.781
35	28.9945	25.3774	0.00666757	0.076	5000	0.743007	1.48249	0.526009	1.04953	0.372386	0.735393		0.766446	0.782889	0.0216783	0.0147643	0.7998
36	29.7576	26.7307	0.00666757	0.076	5000	0.76256	1.52151	0.539851	1.07714	0.382185	0.751776		0.776321	0.790666	0.0195914	0.0122865	0.8077
37	30.5206	28.119	0.00666757	0.076	5000	0.782113	1.56052	0.553693	1.10476	0.391985	0.764389		0.788429	0.802496	0.0218941	0.0172514	0.8193
38	31.2836	29.5426	0.00666757	0.076	5000	0.801665	1.59953	0.567536	1.13238	0.401784	0.779017		0.805642	0.819947	0.0239386	0.0170424	0.8363
39	32.0466	30.7957	0.00666757	0.076	5000	0.821218	1.63855	0.581378	1.16	0.411584	0.796486		0.825837	0.84085	0.0294001	0.0167415	0.8568
40	32.8096	31.5289	0.00666757	0.076	5000	0.840771	1.67756	0.59522	1.18762	0.421384	0.815612		0.847437	0.863206	0.0297887	0.016225	0.8788
41	33.5727	32.2621	0.00666757	0.076	5000	0.860324	1.71657	0.609063	1.21524	0.431183	0.834389		0.866316	0.88238	0.0295849	0.0157298	0.8974
42	34.3357	32.9954	0.00666757	0.076	5000	0.879877	1.75558	0.622905	1.24286	0.440983	0.852553		0.886541	0.903518	0.0345535	0.0180327	0.9172
43	35.0987	33.7286	0.00666757	0.076	5000	0.899429	1.7946	0.636747	1.27048	0.450783	0.871921		0.911263	0.927998	0.038592	0.0192134	0.941
44	35.8617	34.4618	0.00666757	0.076	5000	0.918982	1.83361	0.65059	1.2981	0.460582	0.891822		0.936595	0.945266	0.0384569	0.020297	0.9617
45	36.6248	35.1951	0.00666757	0.076	5000	0.938535	1.87262	0.664432	1.32572	0.470382	0.910202		0.95522	0.962028	0.0373504	0.0223529	0.9783
46	37.3878	35.9283	0.00666757	0.076	5000	0.958088	1.91164	0.678274	1.35334	0.480181	0.92751		0.972936	0.979952	0.0355726	0.0227813	0.994
47	38.1508	36.6615	0.00666757	0.076	5000	0.977641	1.95065	0.692117	1.38095	0.489981	0.945331		0.997396	1.00507	0.0318125	0.0204238	1.016
48	38.9138	37.3948	0.00666757	0.076	5000	0.997194	1.98966	0.705959	1.40857	0.499781	0.964201		1.01621	1.02196	0.0284161	0.0181436	1.033
49	39.6768	38.128	0.00666757	0.076	5000	1.01675	2.02868	0.719801	1.43619	0.50958	0.983929		1.03772	1.04193	0.0187059	0.0135656	1.053
50	40.4399	38.8612	0.00666757	0.076	5000	1.0363	2.06769	0.733644	1.46381	0.51938	1.0035		1.06112	1.06855	0.0161003	0.0110733	1.078
51	41.2029	39.5944	0.00666757	0.076	5000	1.05585	2.1067	0.747486	1.49143	0.52918	1.02351		1.07927	1.08768	0.0188921	0.0144574	1.098
52	41.9659	40.3277	0.00666757	0.076	5000	1.0754	2.14571	0.761328	1.51905	0.538979	1.04232		1.09496	1.1	0.0187939	0.0166921	1.113
53	42.7289	41.0609	0.00666757	0.076	5000	1.09496	2.18473	0.775171	1.54667	0.548779	1.06056		1.11489	1.11744	0.0171797	0.0216317	1.131
54	43.492	41.7941	0.00666757	0.076	5000	1.11451	2.22374	0.789013	1.57429	0.558578	1.0799		1.1359	1.13825	0.0196533	0.0260673	1.148
55	44.255	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.10046		1.15838	1.16127	0.0350044	0.0284368	1.167
56	45.018	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.11668		1.1648	1.16802	0.0388725	0.031222	1.170
57	45.781	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.12579		1.16654	1.16999	0.0313237	0.0363231	1.171
58	46.544	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.13048		1.16545	1.17048	0.0259757	0.0293528	1.171
59	47.3071	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.13264		1.16237	1.16792	0.0262355	0.0282467	1.171
60	48.0701	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.13254		1.15836	1.16511	0.0251522	0.0281417	1.171
61	48.8331	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.13189		1.16084	1.16732	0.0239607	0.0270577	1.178
62	49.5961	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.13242		1.16407	1.1717	0.0227474	0.0209216	1.186
63	50.3592	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.13441		1.16955	1.17794	0.0217042	0.0176675	1.194
64	51.1222	42.4882	0.00666757	0.076	5000	1.13302	2.26067	0.802115	1.60043	0.567854	1.13652		1.17121	1.18017	0.0215892	0.0174021	1.197

Fig. 5.45 Example of a vibration test report

5.6 The Random Vibration program

5.6.1 Program Purpose

To test specimens for vibration resistance in a wide frequency range, the Random Vibration program is used.

5.6.2 Preparing for testing

When preparing for vibration resistance tests in a wide frequency range, set the following parameters (if not set): shaker parameters, specimen parameters, channel parameters (see sections 5.1-5.3), and then perform a pre-test according to section 5.4.

To go to the Random Vibration program window, press the Random button on the VCS Panel (*Fig. 5.1*). The Random Vibration program window (*Fig. 5.46*) will appear on the monitor screen.

Caution! *The Random button on the VCS panel will only be available for activation if the program detects the pre-test results.*

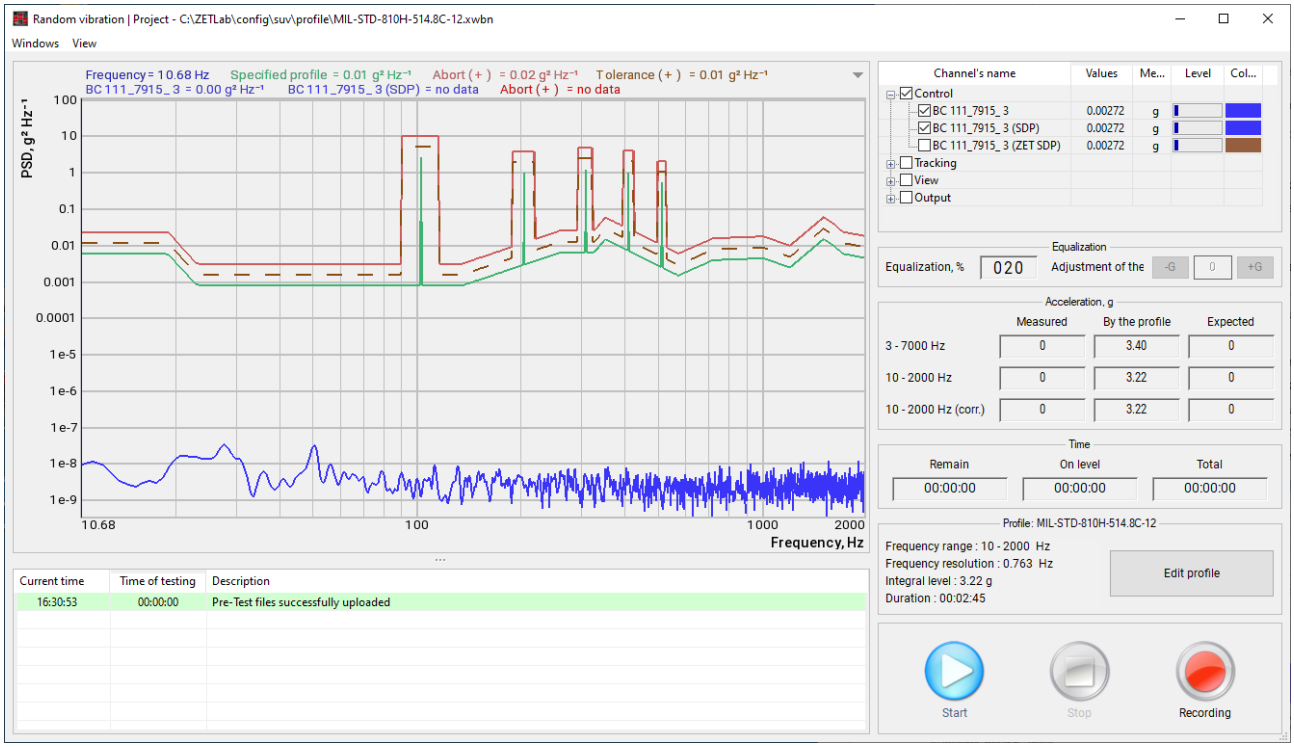


Fig. 5.46 Random Vibration program window

To set the test profile, press the Edit Profile button (*Fig. 5.47*) from the main window of the Random Vibration program.

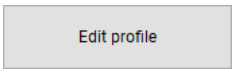


Fig. 5.47 Edit Profile button

The Edit profile – Random vibration window will open (*Fig. 5.48*).

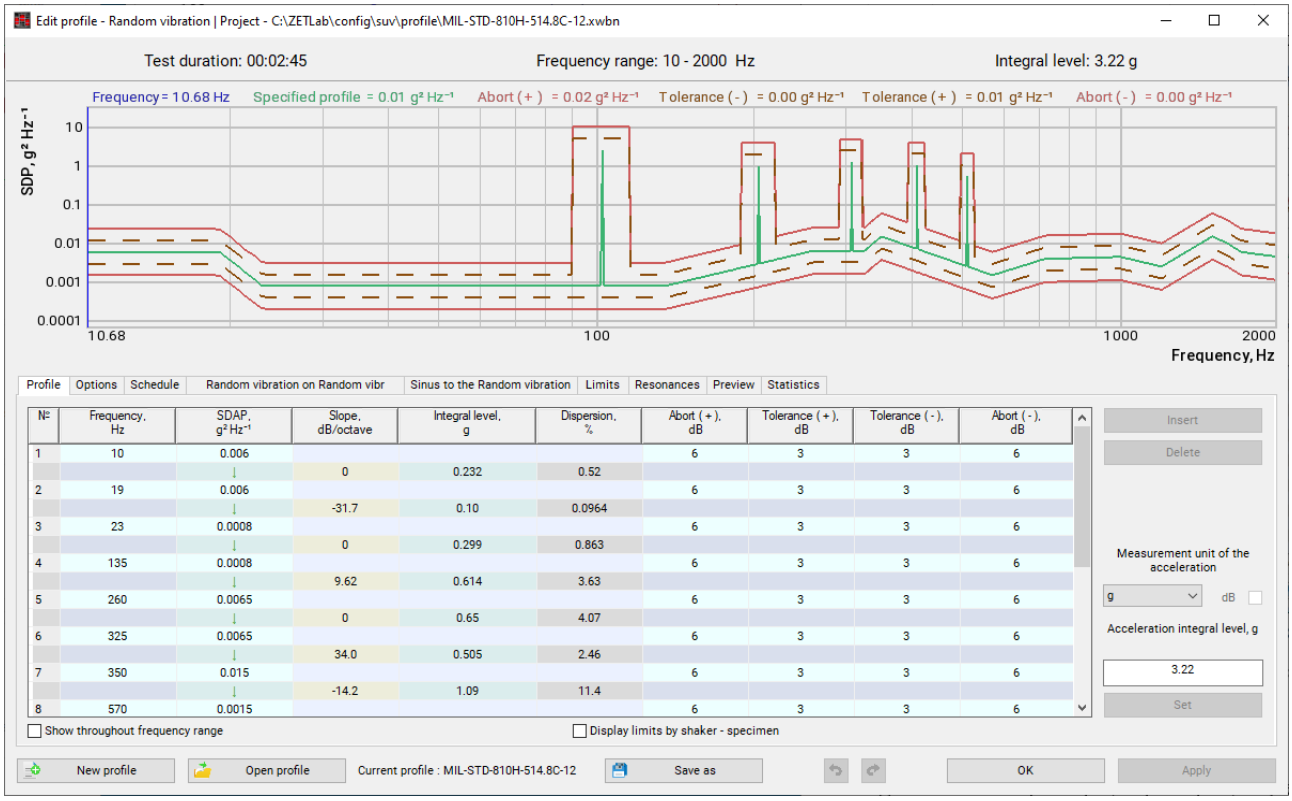


Fig. 5.48 Edit profile – Random vibration window, Profile tab

On the Profile tab, you can set the parameters of the Random Vibration test profile in the table. To add a row to the table, select the area in the table where you want to add the row and press the Insert button. In the new row, enter the parameters defining the inflection point. To delete a row, select it with a mouse click and press the Delete button. To start vibration tests, you need a profile consisting of at least two lines with different frequencies.

In addition, each reference point has 4 parameters defining the allowed range for vibration tests: Tolerance (+), Tolerance (-), Abort (+), Abort (-). If the Abort (+) and Abort (-) parameter values are exceeded, the tests in the control channel will stop. The parameters set the integral acceleration level tolerance at each test point according to the profile. By default, the tolerances are set to ±3dB and ±6dB, respectively, but you can edit them manually.

The Measurement unit of the acceleration parameter sets the acceleration unit to g or m/s^2 for the test profile graph.

To change the overall noise level in proportion, enter the required value in the Acceleration integral level field and press the Set button. The coefficients in the SDAP table will be automatically recalculated so that the total integral level becomes consistent with the specified number.

Activating the Show throughout frequency range parameter displays the entire frequency range set during the pretest on the spectrum graph.

When you select the Display Limits by shaker - specimen parameter, the spectrum graph in the Random Vibration window will additionally display graphs of the maximum and minimum acceptable profile values (range of the allowed profiles).

Note: *The graphs of maximum and minimum acceptable profile values are calculated according to the shaker and specimen parameters, as well as the pre-test results.*

A graph of the spectral density of acceleration power with tolerance graphs is displayed in the upper pane of the Edit profile – Random vibration program window.

The Options tab contains settings for calculating and displaying spectrum graphs (*Fig. 5.49*).

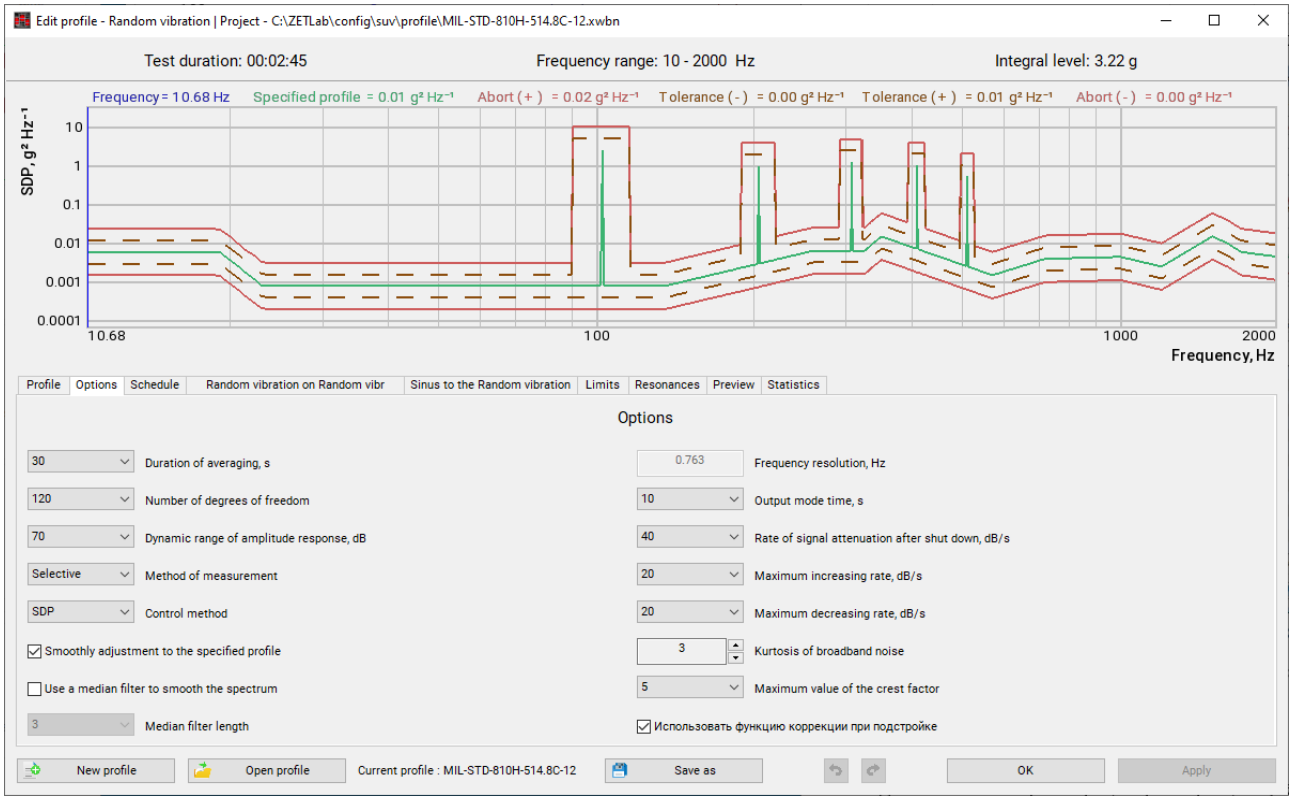


Fig. 5.49 Edit profile – Random vibration window, Options tab

The Duration of averaging parameter sets the interval duration of averaging values on the spectrum graph. In this way, the spectrum graph shows the averaged values for a set time period.

The Number of Degrees of Freedom parameter determines the time of data accumulation when calculating the spectrum, taking into account the specified frequency resolution. This parameter is the specimen of the accumulation time and frequency resolution. Thus, the lower the frequency resolution value, the greater the data accumulation time for the same number of degrees of freedom.

For the Dynamic Range of the amplitude response parameter, select a value that sets the difference between the maximum value and minimum value of the amplitude response.

The Method of measurement parameter sets the method for calculating SDP values. It can be Selective or Effective. With the Selective measurement method, the SDP values will be calculated according to the transfer characteristic H1 (when calculating SDP, only the response signal to the impact is taken into account). With the Efficient measurement method, the SDP values will be calculated according to the transfer characteristic Hv (when calculating SDP, the entire recorded signal is taken into account).

The Control Method parameter sets the method to control and display SDP of the registered signal. It can be SDP or ZET SDP. In the SDP control method, the spectral power of the recorded signal is used as the controlled quantity. The ZET SDP control method additionally includes digital

processing of the power spectral density for quick smoothing and clearing the noise on the power spectral density graph when averaging is insufficient, as well as reducing control errors.

When the Smoothly adjustment to the specified profile parameter is selected, the spectrum graph can return to the test profile when the transfer characteristic changes due to physical changes in the specimen under test or tooling.

The Use a median filter to smooth spectrum parameter is used to eliminate the generated pulses on the spectrum graph. The larger the Median filter length parameter value, the wider pulse can be taken.

The Frequency Resolution parameter displays the frequency resolution value set in the Control Parameter program.

The Output mode time parameter defines the time for increasing the signal from zero level to the profile level.

The Rate of signal attenuation after shut down parameter determines the speed at which the signal attenuates at the end of the test.

The Maximum increasing Rate and Maximum decreasing parameters determine the maximum rate of increasing and decreasing signal strength during the tests.

The Kurtosis of Broadband Noise parameter is used for individual configuration of the probability of distribution of noise emissions (pulses) for the generated wave shape. Increasing the kurtosis leads to a significant increase in high-power noise emissions (pulses).

The Maximum value of the crest Factor parameter limits the maximum allowed value of the signal's peak factor during the vibration tests.

The Schedule tab is used for setting the vibration test schedule: the number of vibration test stages, the time of each stage, equalization, and enabling / disabling the sine and noise adding function. (*Fig. 5.50*).

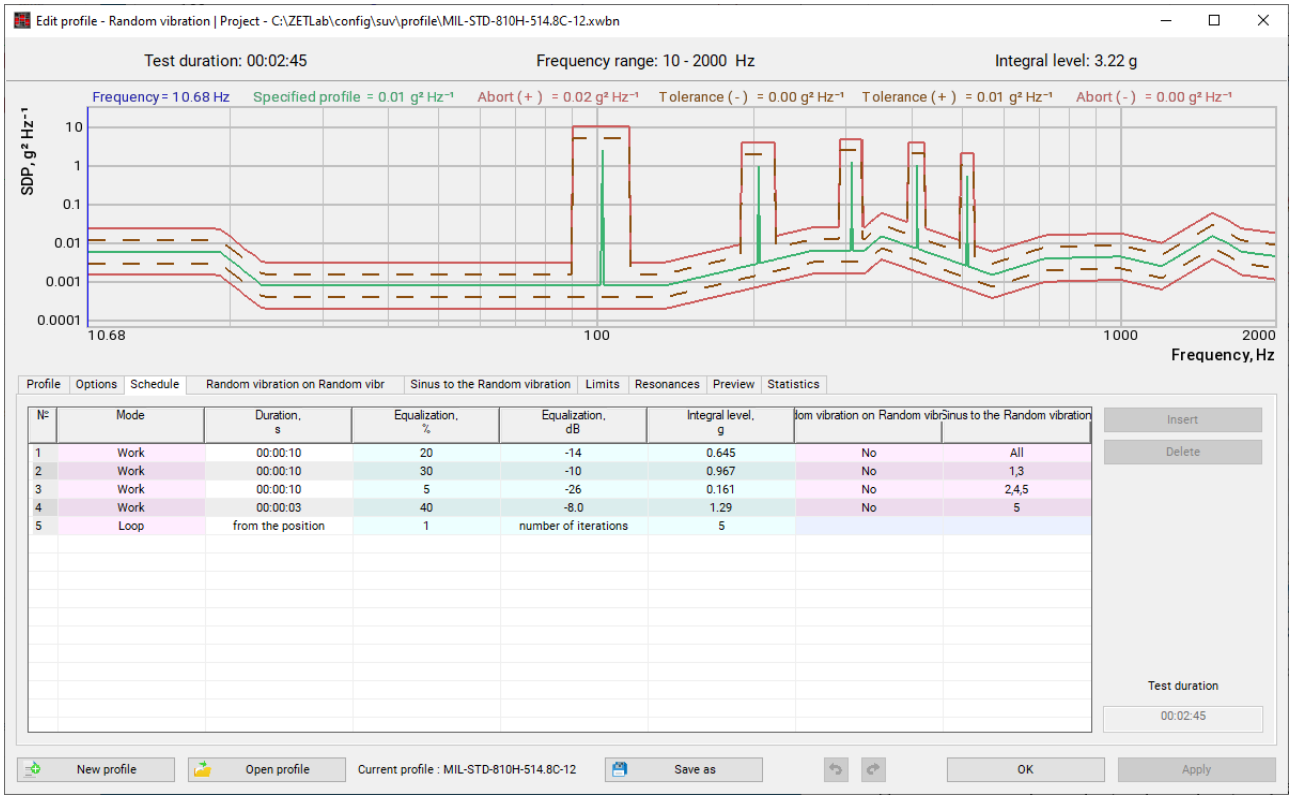


Fig. 5.50 Edit profile – Random vibration window, Schedule tab

The vibration test schedule is a data table. To add new rows to the table, press the Insert button. If vibration tests have multiple stages, add the appropriate number of rows to the table. The configuration is individual for each stage of the test.

The Mode parameter has several states:

- Work – in this mode, the program is performing tests according to the profile;
- Pause – in this mode, the program is pausing tests for a specified time;
- Loop – in this mode, the program is repeating operations from a specified position a specified number of times.

The Duration parameter is used to set the duration of the vibration test stages.

The Equalization (%), Equalization (dB) and Integral level (g) parameters are used to set the integral acceleration level ratio at the current test stage to the level determined by the test profile, and the values in one column automatically recalculate the values in other column.

The Random Vibration on Random Vibration and Sinus to the Random Vibration parameters are used for adding narrowband noise or sinusoidal vibrations to Random Vibration according to the settings on the respective tabs of the vibration test profile. To add segments with narrowband noise

or sinusoidal vibration overlaid on Random Vibration, left click on the corresponding cell and select the required segments (*Fig. 5.51*).

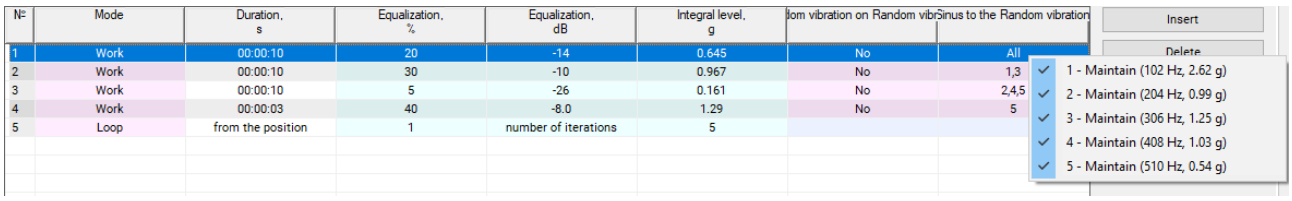
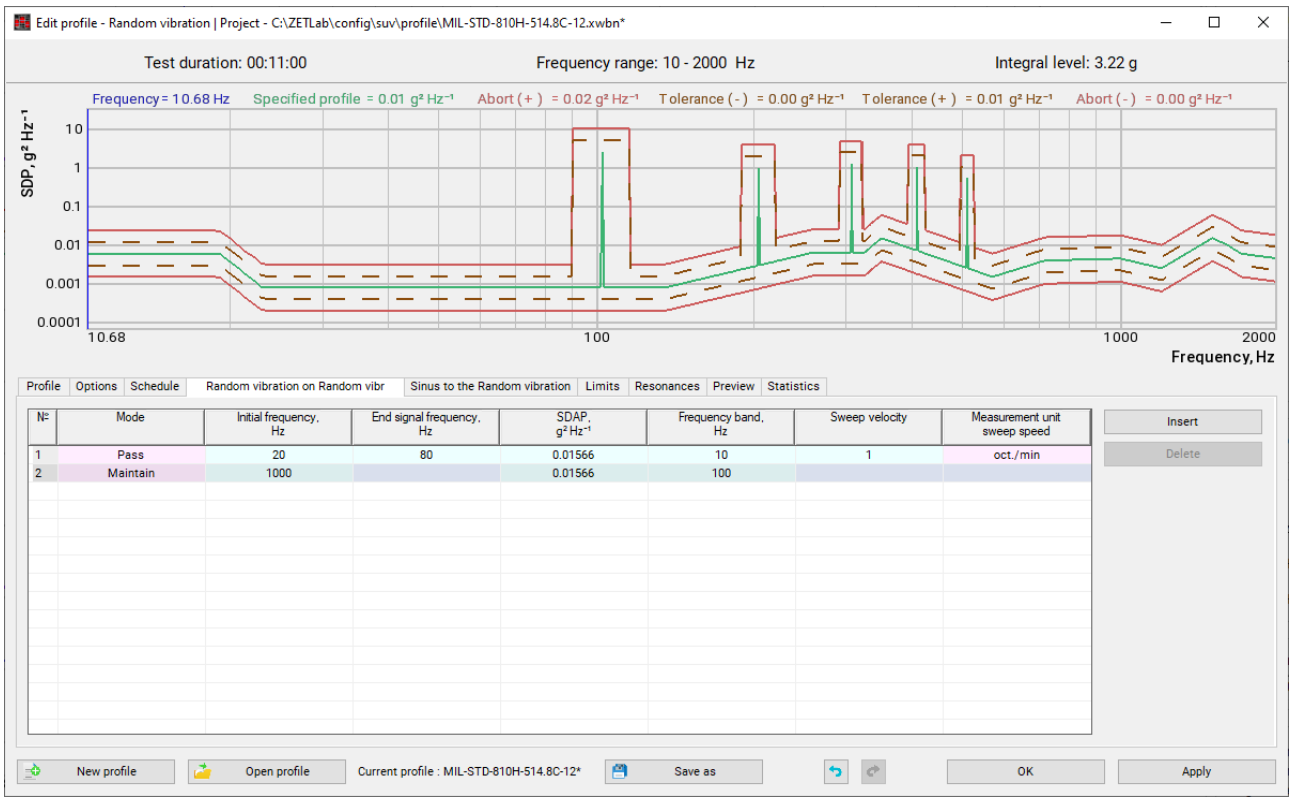


Fig. 5.51 Selecting segments for adding Sine to Random Vibration

In order to enable adding narrowband noise to Random Vibration (combined tests) when performing vibration tests, go to the Random Vibration on Random Vibration tab (*Fig. 5.52*).



№	Mode	Initial frequency, Hz	End signal frequency, Hz	SDAP, g² Hz⁻¹	Frequency band, Hz	Sweep velocity	Measurement unit sweep speed
1	Pass	20	80	0.01566	10	1	oct./min
2	Maintain	1000		0.01566	100		

Fig. 5.52 Edit profile – Random vibration window, Random Vibration on Random Vibration tab

The parameters of adding narrowband noise to Random Vibration are listed in a data table. To add new rows to the table, press the Insert button. If there are multiple segments, add the appropriate number of rows to the table. For each test segment, settings are made individually.

The narrowband noise adding to Random Vibration function has two modes:

- Pass mode – in this mode, narrowband noise with a set frequency band is moving from the initial frequency to the final frequency and back. In the table, set the values for the initial frequency and final frequency, frequency band, SDAP, and scan speed;
- Maintain mode – in this mode, narrowband noise is held in the specified frequency band. In the table, set the values for the initial frequency, frequency band, and SDAP.

To enable adding sinusoidal vibrations to Random Vibration (combined tests) when conducting vibration tests, go to the Sinus to the Random Vibration tab (*Fig. 5.53*).

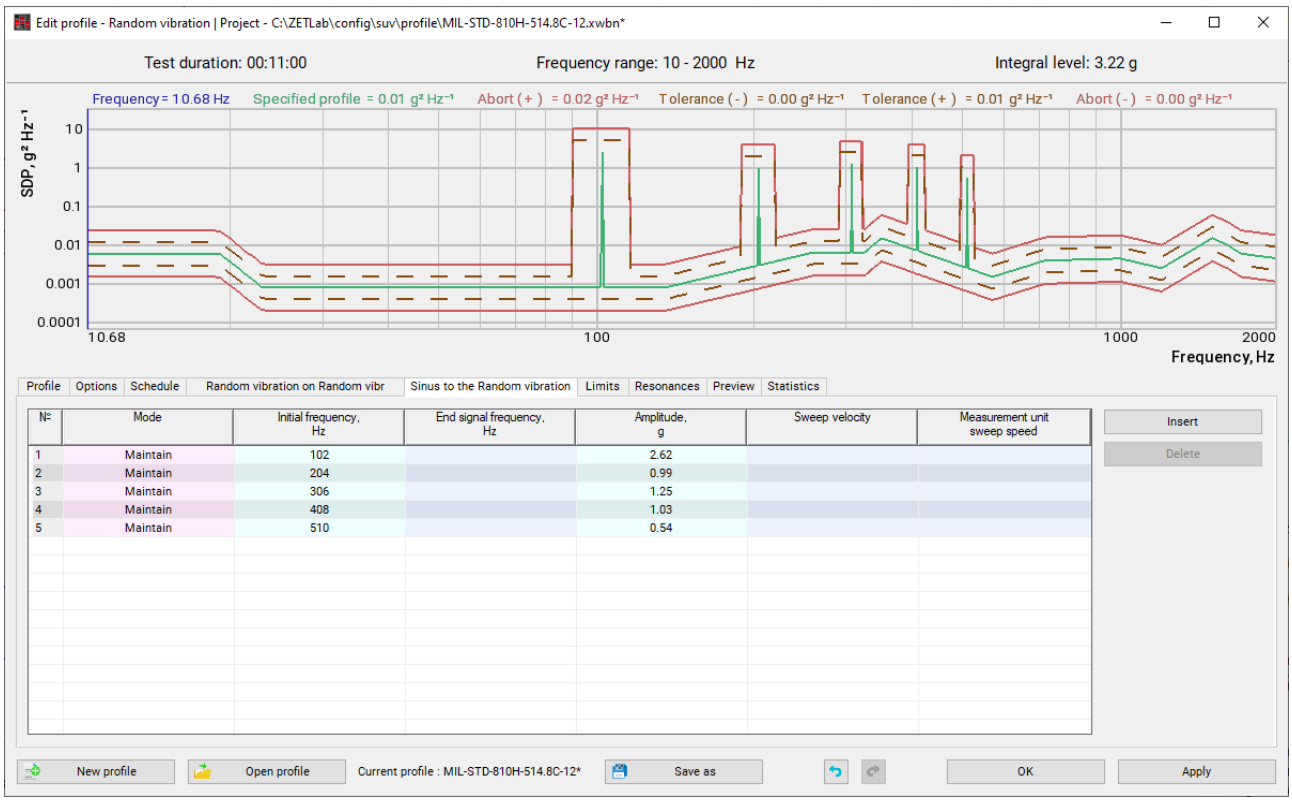


Fig. 5.53 Edit profile – Random vibration window, Sinus to the Random Vibration tab

The parameters of adding the sinusoidal vibration to Random Vibration are listed in a data table. To add new rows to the table, press the Insert button. If there are multiple segments, add the appropriate number of rows to the table. For each test segment, settings are made individually.

Adding sinusoidal vibration to Random Vibration has two modes:

- Pass mode – in this mode, sinusoidal vibration with a set amplitude is moving from the initial frequency to the final frequency and back. In the table, set the values for the initial frequency and final frequency, amplitude, and scan speed;
- Maintain mode – in this mode, sinusoidal vibrations are held at the specified frequency. In the table, set the values for the initial frequency and amplitude.

A graph SDPA power with added sine, as well as tolerance graphs are displayed in the upper pane of the Edit profile – Random vibration window.

On the Limits tab (*Fig. 5.54*), you can set the acceptable test limits for the control and tracking measurement channels. According to the parameters with enabled control, (during the tests) exceeding the set parameter values will be monitored, and if they are exceeded, the tests will stop immediately.

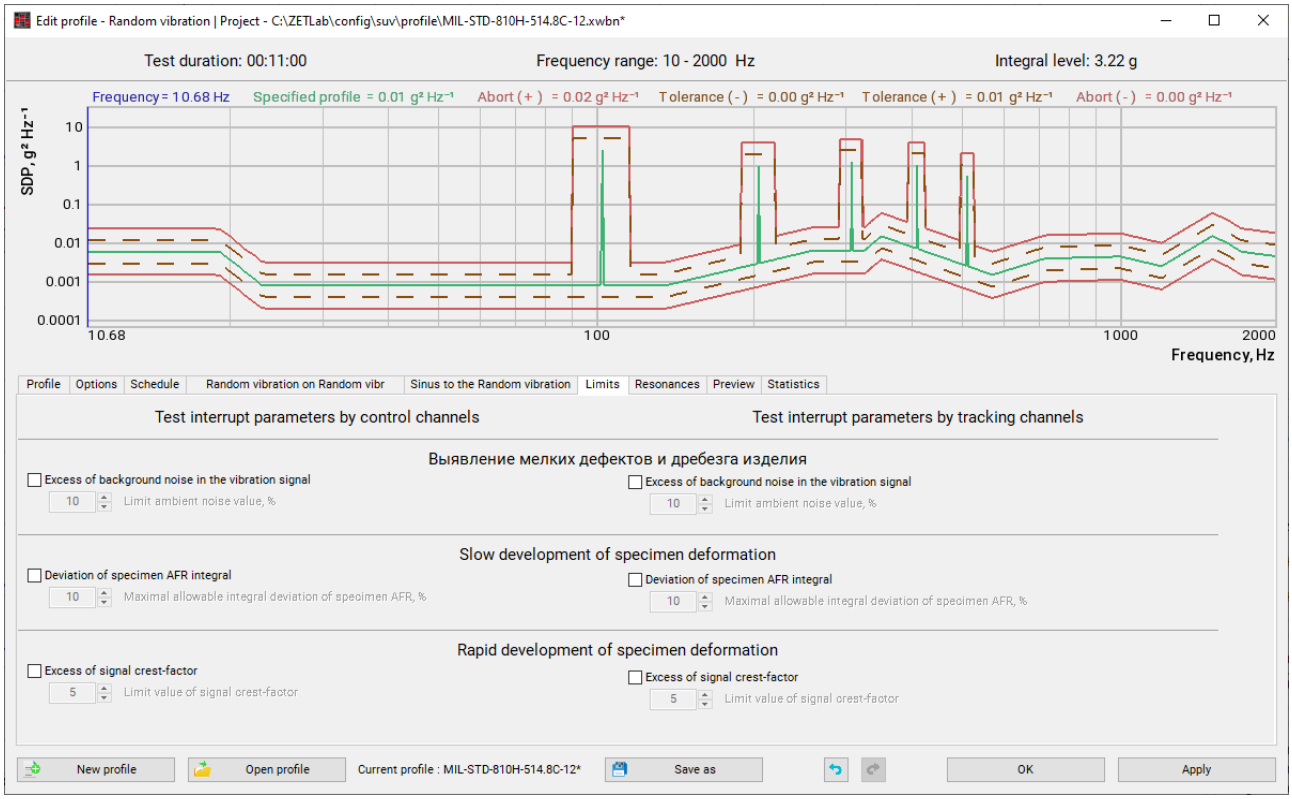


Fig. 5.54 Edit profile – Random vibration window, Limits tab

To enable parameter control, activate (check the cell) the corresponding parameter, and to disable it, deactivate (uncheck the cell).

You can set limits for the following parameters of the monitoring and tracking channels:

- Excess of background noise in the vibration signal;
- Deviation of specimen AFR integral;
- Excess of signal crest-factor.

The Resonances tab contains statistical information based on the pretest results. On this tab, you can evaluate the presence of resonances and antiresonances on the amplitude response (*Fig. 5.55*).

Note: *If necessary (for more detailed consideration), scale the amplitude response on the frequency scale to the area of interest, and only resonances and antiresonances falling within the visualized graph area will be left in the table.*

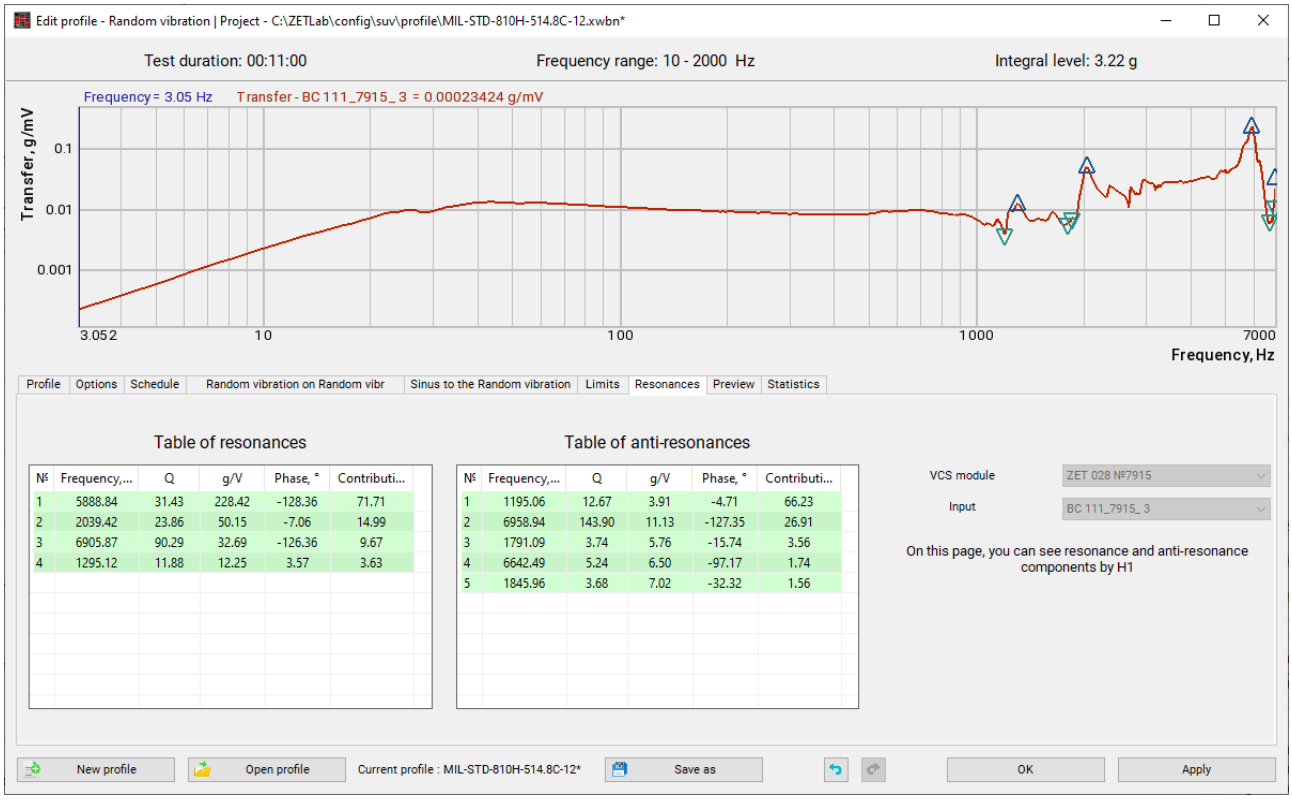


Fig. 5.55 Edit profile – Random vibration window, Resonances tab

On the Preview tab, you can preview the vibration test graphs for a given profile obtained by calculation based on the pre-test results (*Fig. 5.56*).

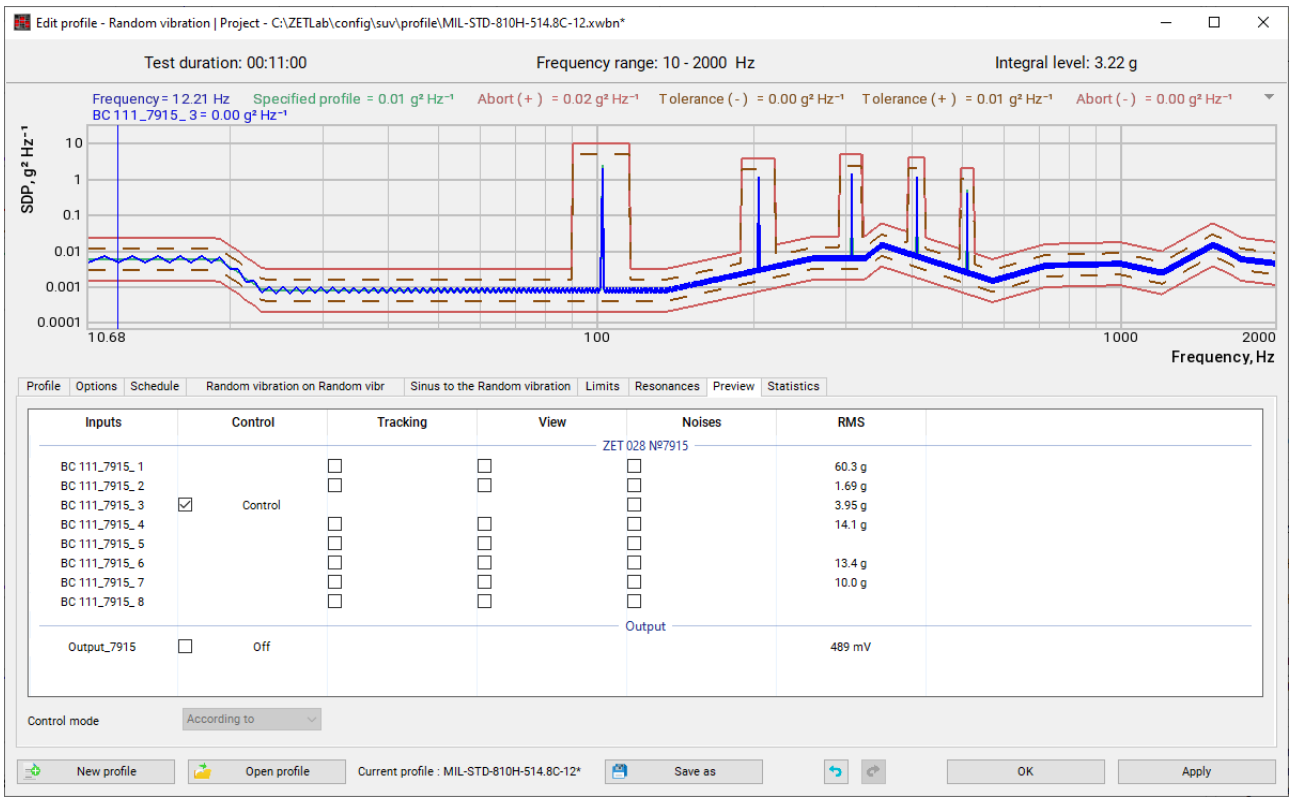


Fig. 5.56 Edit profile – Random vibration window, Preview tab

The graphs are presented for all measuring channels of the VCS controller, and each measuring channels can be assigned any type of control (control, tracking, view, and also check the noise level of the channel). To display the desired vibration graph, check the corresponding table cell.

Note: *The graph information is for reference and intended to inform the VCS user of the expected results to be obtained in the vibration tests for a given profile.*

The Statistics tab contains statistical information, so that the user can assess the load of the shaker during vibration tests (*Fig. 5.*).

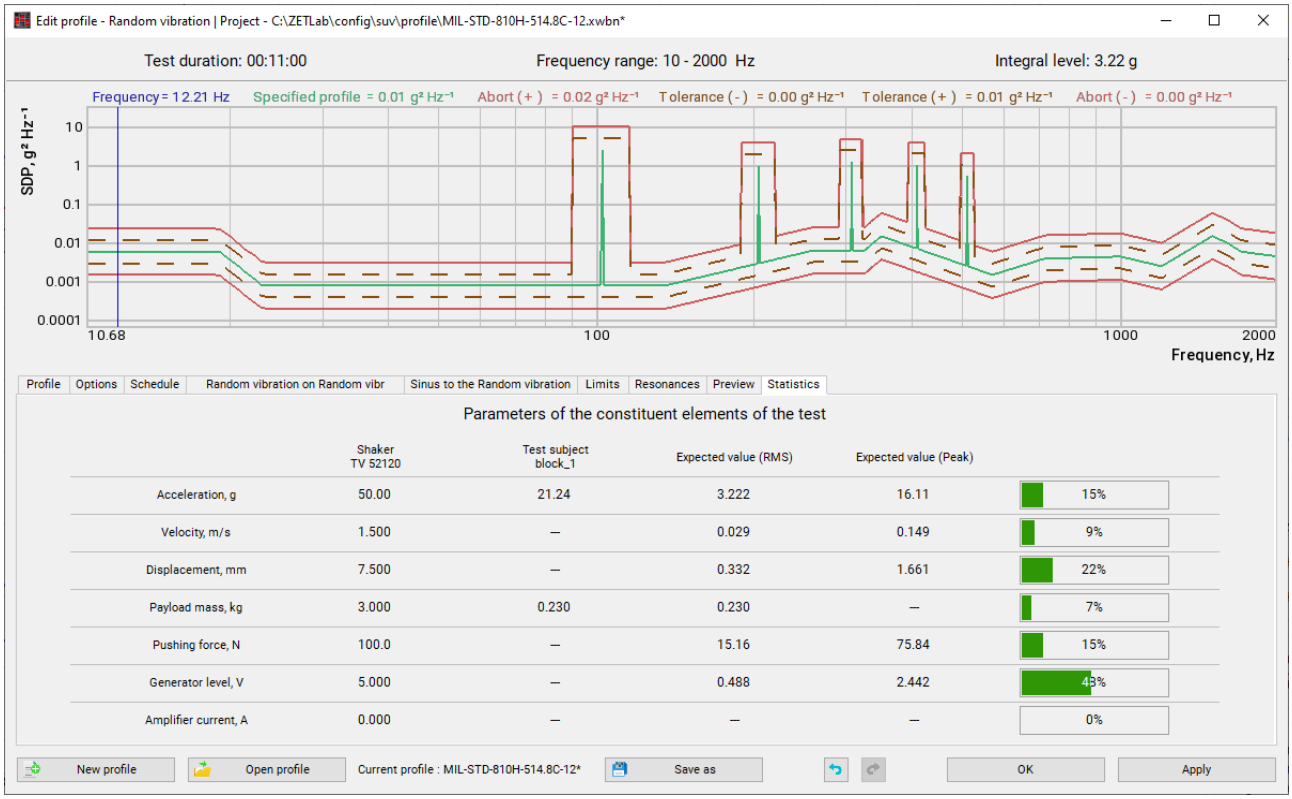


Fig. 5.57 Edit profile – Random vibration window, Statistics tab

Also, the user can save the current test profile as a file which can be downloaded from the Edit Profile window. To save the current test profile, select the Save as function in the Edit Profile window (*Fig. 5.*).

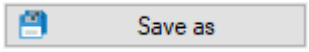


Fig. 5.58 Save as button to save your profile

In the opened window, set the name of the test profile and specify the path to save, and then press the Save button (*Fig. 5.*).

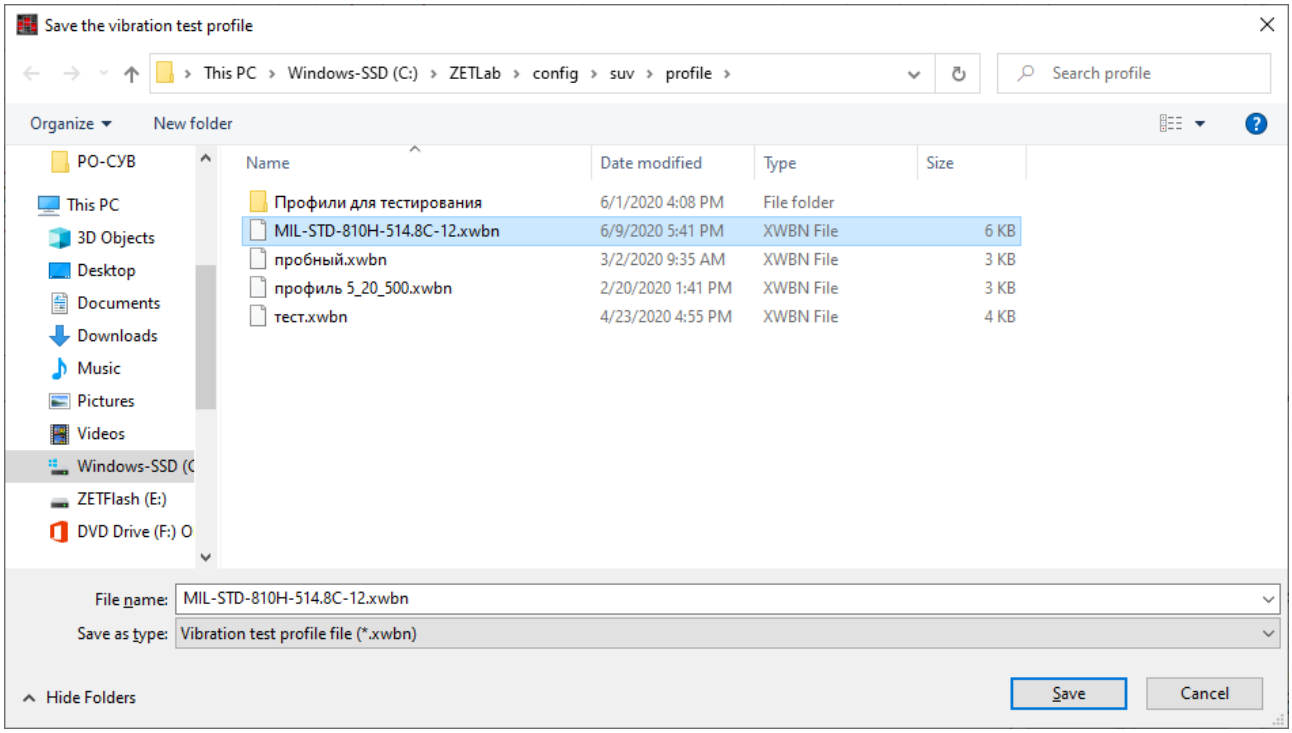


Fig. 5.59 Saving a profile

To download a previously saved test profile, select the Open Profile function. In the opened window, select the desired test profile file and press the Open button.

To apply the settings in the Edit Profile program, press the Apply button and then OK button.

5.6.3 Testing

The lower pane of the Random Vibration program displays the event log, where important information of the program operation is saved. After starting the program, the event log will display information of successful download of the pretest files (*Fig. 5.*).

Current time	Time of testing	Description
17:43:28	00:00:00	Pre-Test files successfully uploaded

Fig. 5.60 Event log

Vibration tests are managed from a special menu in the lower-right corner of the program (*Fig. 5.61*).

Fig. 5.61 Vibration test management menu

The *Start* button is used to start or resume vibration tests.

The *Stop* button is used to stop vibration tests at any time.

The *Pause* button is used to hold tests under conditions corresponding to the current test stage. That is, when you click the Pause button, the tests will continue, but the test time for the current stage will be suspended until you click the Start button again.

Pressing the Recording button starts/stops recording electrical signals from all involved channels of the VCS controller. You can view the recorded signals in the View Results program from the ZETLab Panel Display menu (see ZETLAB software. Operator's manual).

To start the vibration tests, press the Start button, and the program will gradually bring the test system to the specified mode (*Fig. 5.62*).

Current time	Time of testing	Description
18:00:50	00:00:00	Pre-Test files successfully uploaded
18:01:19	00:00:00	Is to run the control module
18:01:21	00:00:00	Control module is running
18:01:32	00:00:00	Mode parameters stabilization

Fig. 5.62 Event log

When the required acceleration RMS is reached, the program will start performing vibration tests and report it in the information field (*Fig. 5.63*).

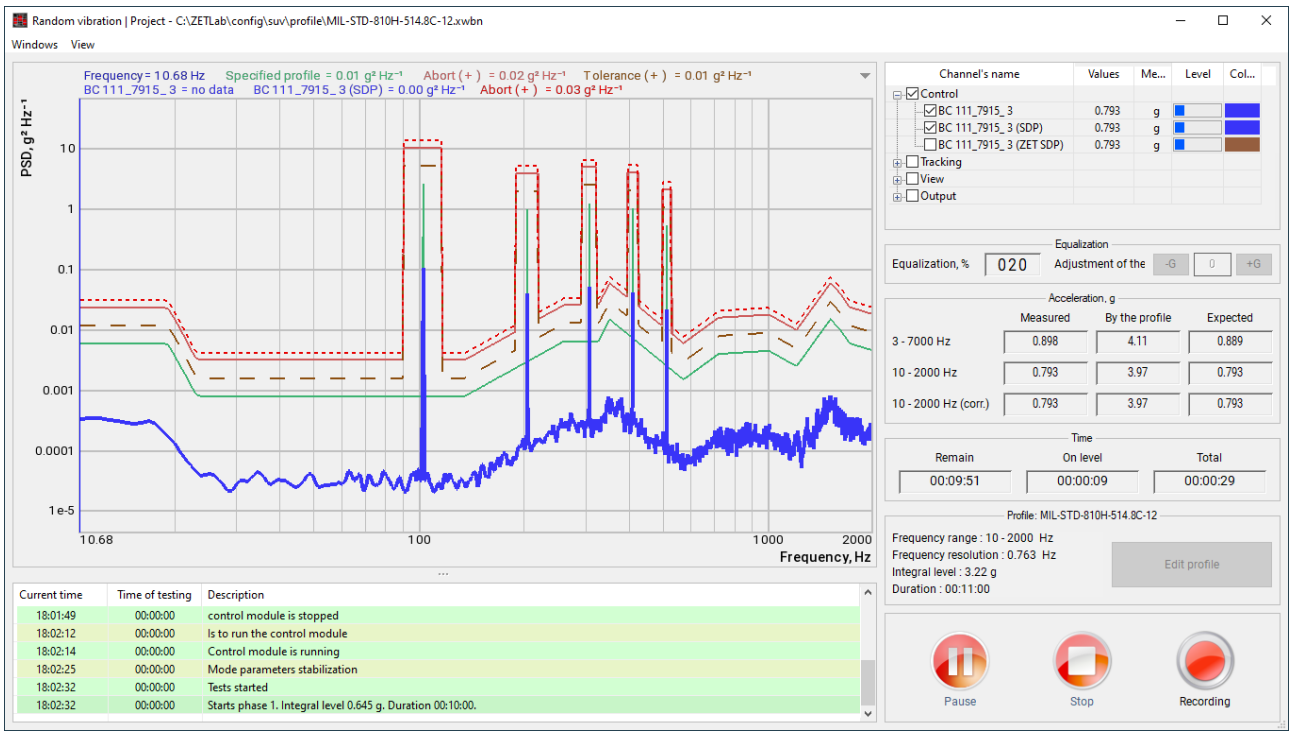


Fig. 5.63 Starting vibration tests

To display a measurement channel on the graph, select it from the list of channels in the right pane of the program window (*Fig. 5.64*). This list includes all measuring channels for which one of the test control types was selected in the Control Parameters program (Control, Tracking, View). The measurement channel line also displays information of the current acceleration and the integral load level for this channel.

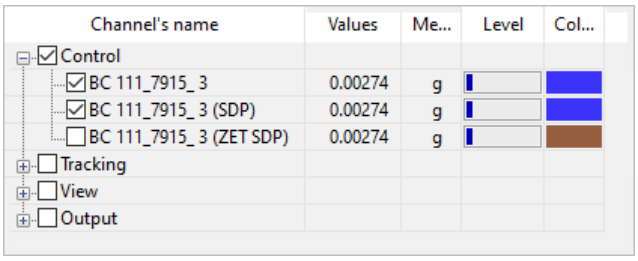


Fig. 5.64 Menu for selecting channels to display on the graph

If several measurement channels were defined as control channels in the Control Parameters program, list of channels in the Random Vibration program will display an additional channel Total (Medium) or Total (Max) depending on the set parameters (*Fig. 5.65*).

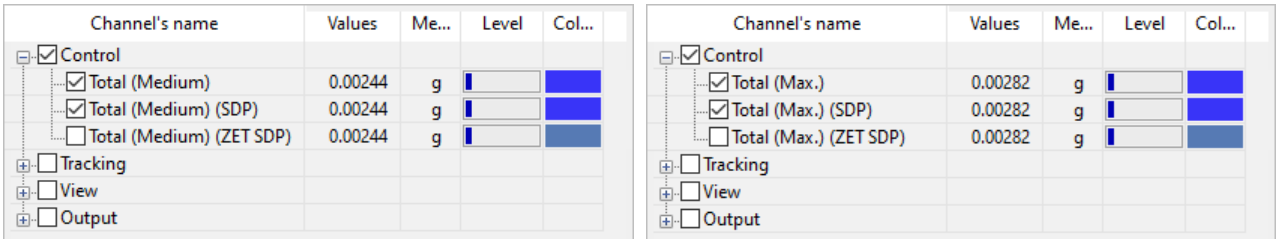


Fig. 5.65 Control channels "General (Medium)" and "General (Max)"

***Note!** In case of selecting a control mode by average value or by maximum value, the channels selected for control will change their status to tracking, and a virtual channel formed by average value or by maximum value becomes the control channel, respectively.*

If the value of the control channel exceeds the set limits (exceeding the permissible limits, exceeding the maximum parameters of the shaker, etc.), the tests will stop. The message log will display information of the reasons for interrupting the test. To resume the vibration tests from the moment they stopped, press the Continue button (*Fig. 5.66*).

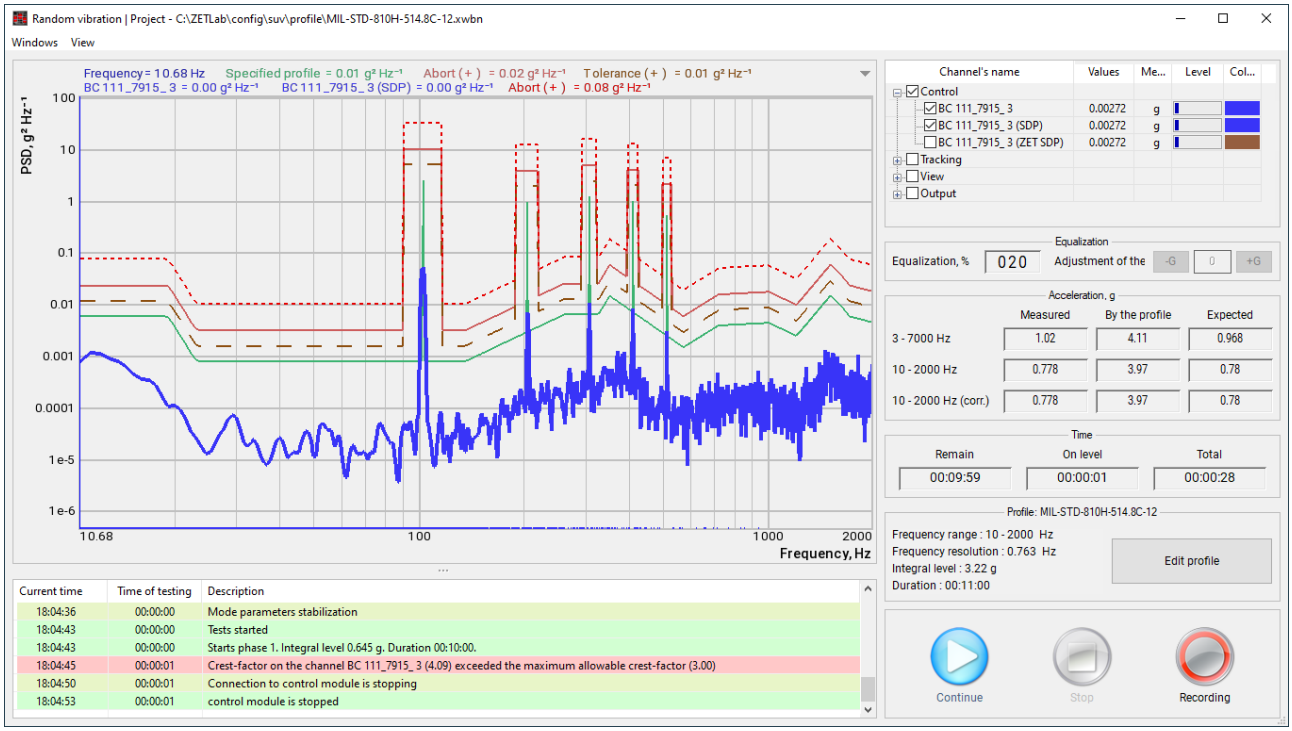


Fig. 5.66 Stopping vibration tests

During the tests, it is possible to track changes in the condition of the specimen under test at the point (s) of the control channel setup in real time. To do this, start the Additional Graphs program (*Fig. 5.67*) from the Windows menu.

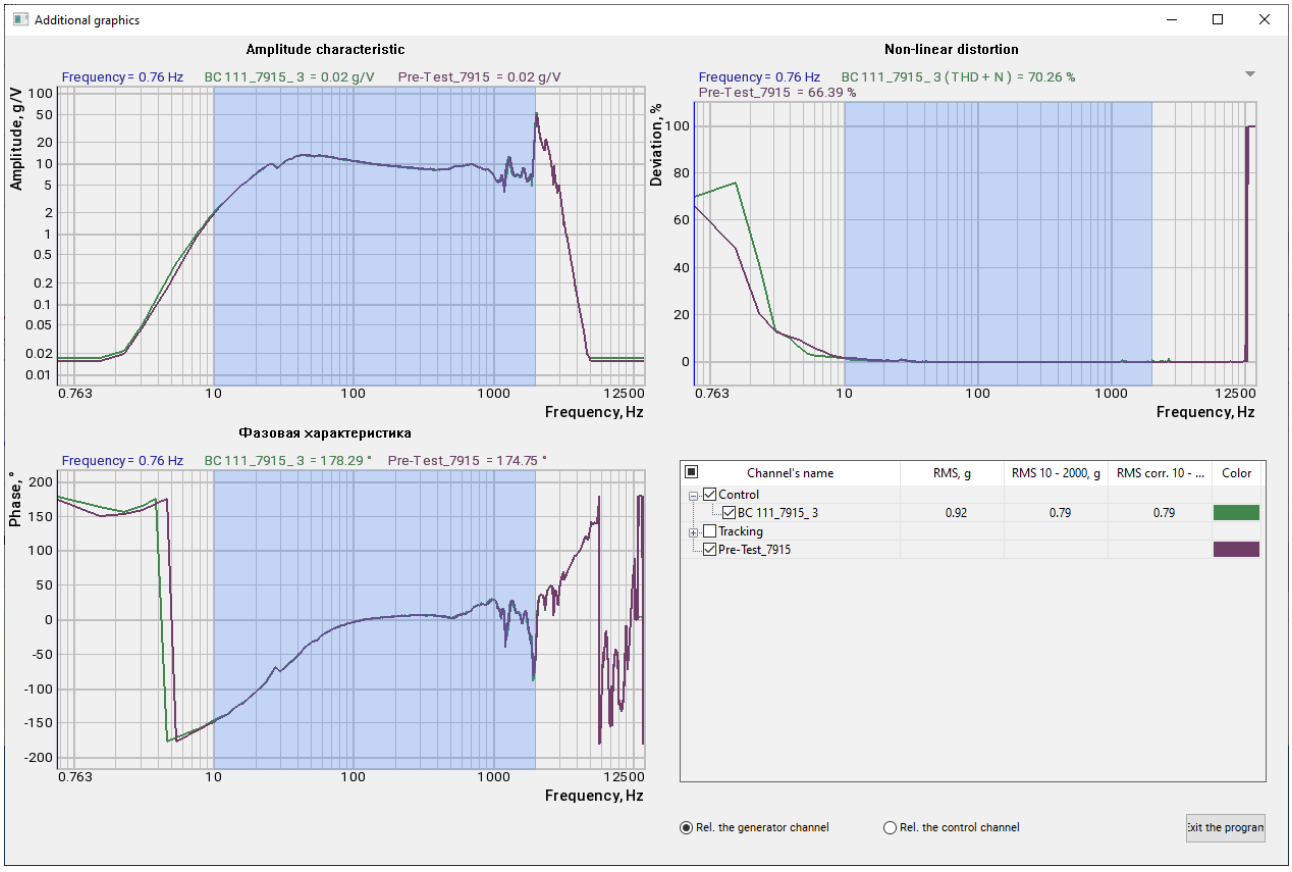


Fig. 5.67 Additional Graphs program window

The graphs of the Additional Graphs program show deviations of the current spectrum parameter values of the selected channel from the spectrum parameter values of the control channel generated in the test profile after passing the pretest.

To display information of the temporary implementation of signal parameters, start the Results table program from the Windows menu of the Random Vibration program. The opened Results table window (*Fig. 5.68*) will show information of the vibration test process in the past.

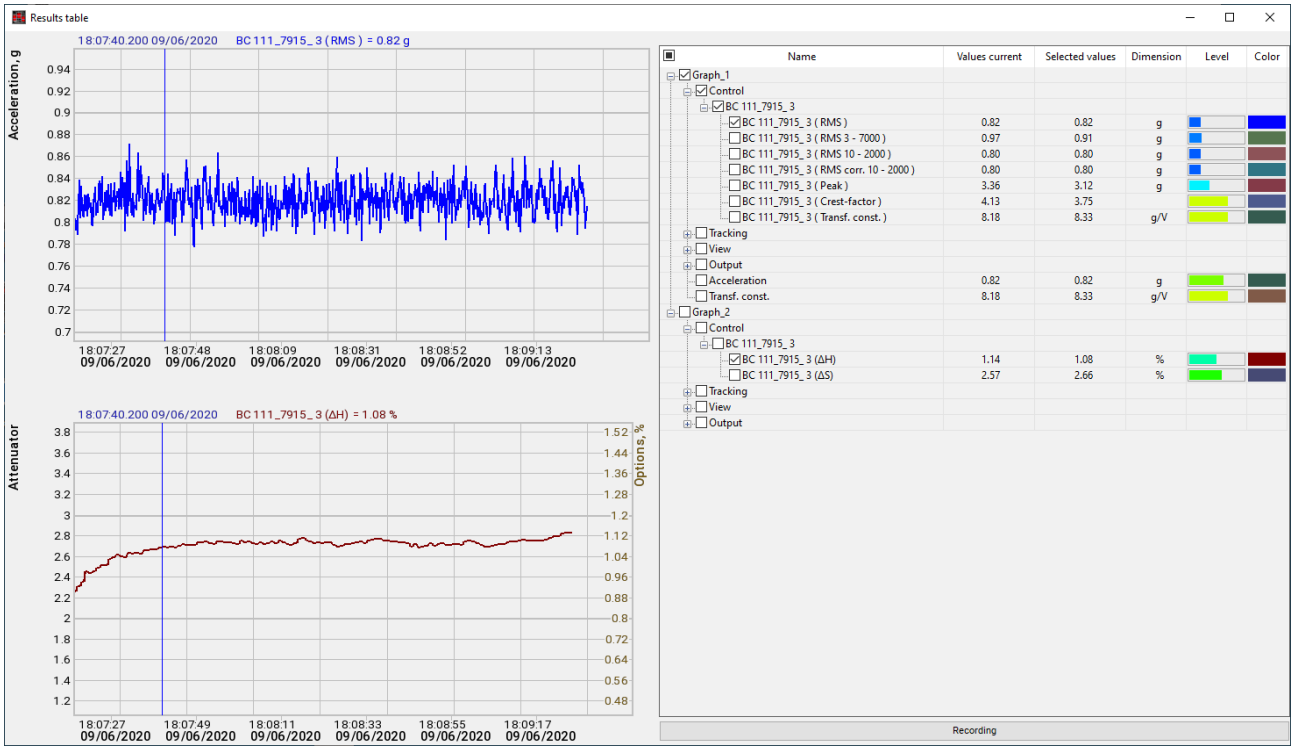


Fig. 5.68 Results table program window

The upper-right corner lists the names of channels with available graphs. You can change the graph color by clicking on the colored rectangle. To save the recorder readings, press the Recording button. Only selected graphs available in the View Results program will be saved.

To save the report, start the Report program from the Windows menu of the Random Vibration program. In the opened window, enter the name of report file and specify the path to save it, then press the Save button (*Fig. 5.69*).

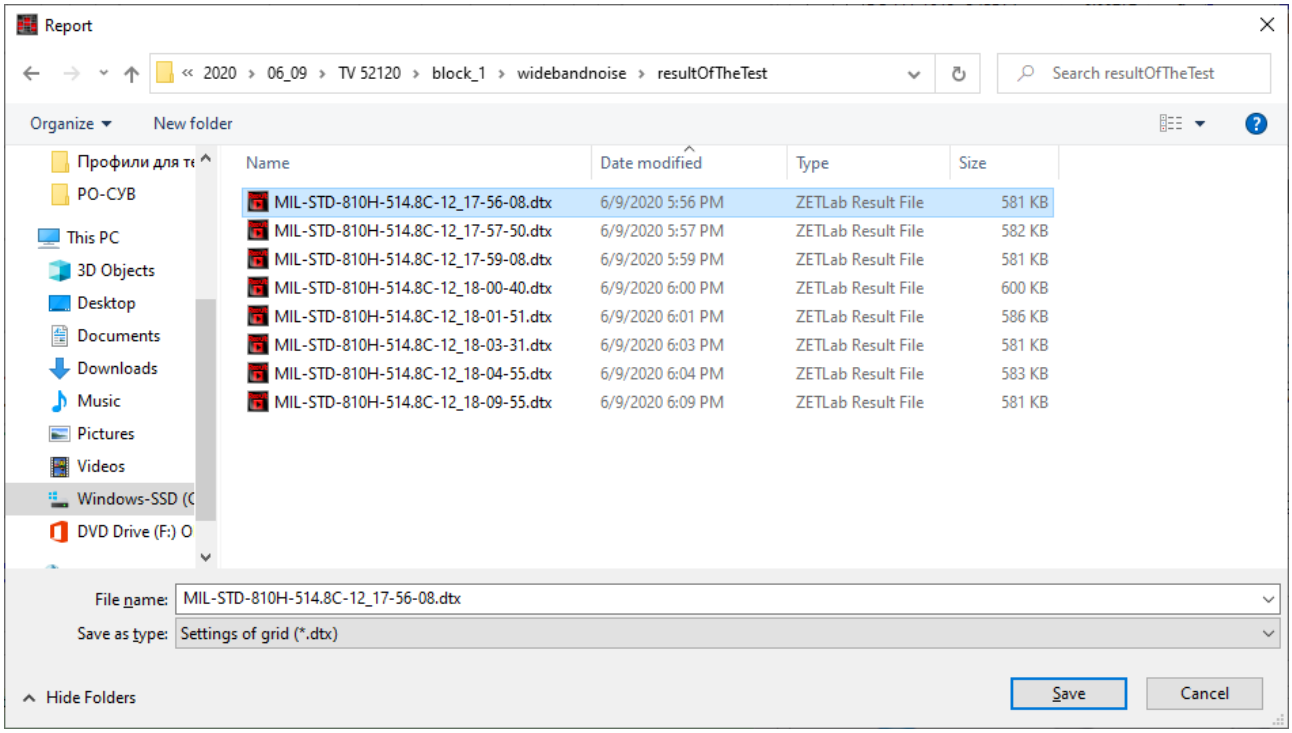


Fig. 5.69 Specifying the file name when saving the test results report

You can view the report file using the View Results program. To do this, right-click on the file and select Open in ResultViewer (*Fig. 5.70*) from the context menu.

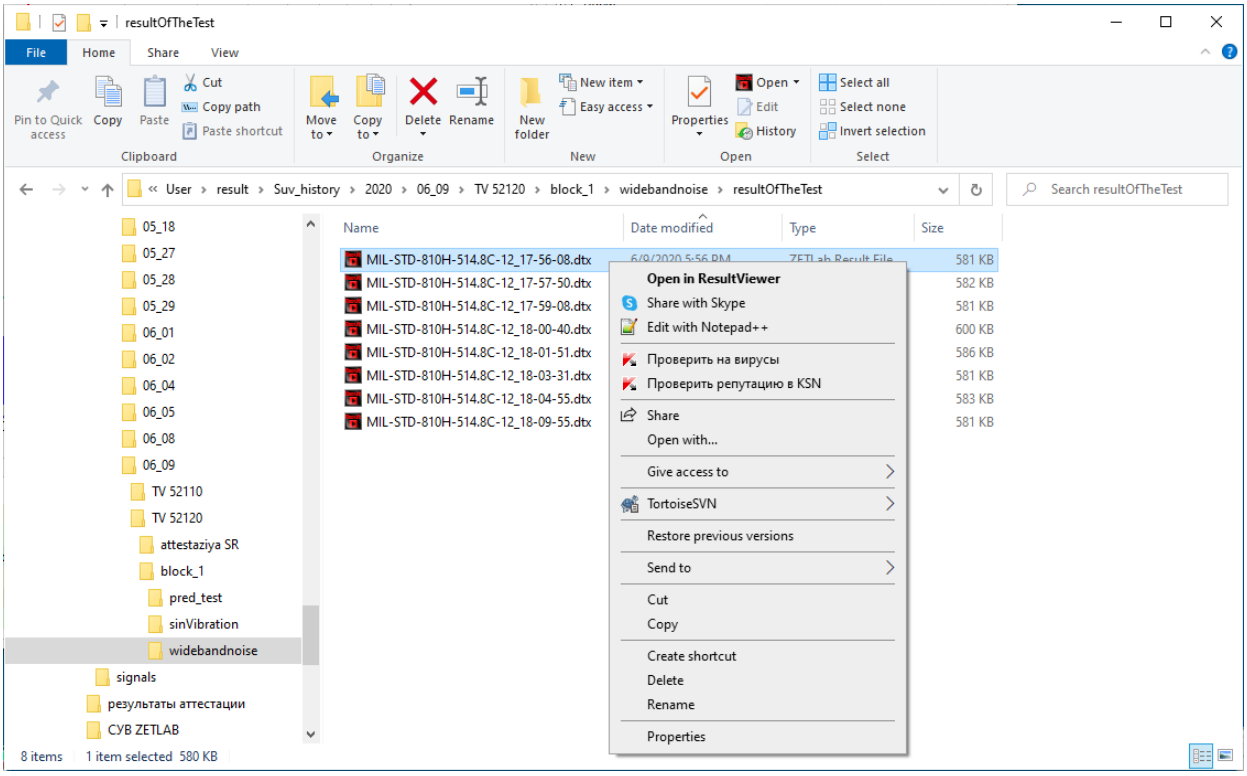


Fig. 5.70 Selecting a file from the test results directory

In the View Results program, the Graph tab displays the graphical part of the report on the completed test (*Fig. 5.71*).

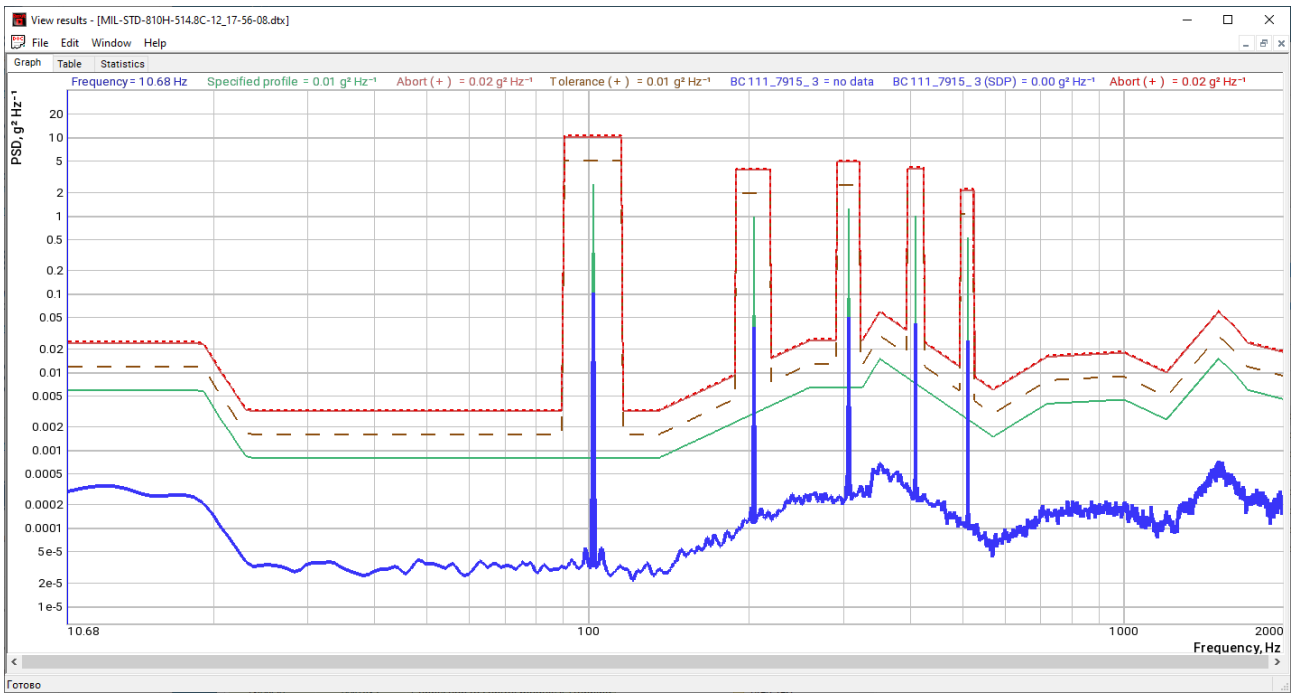
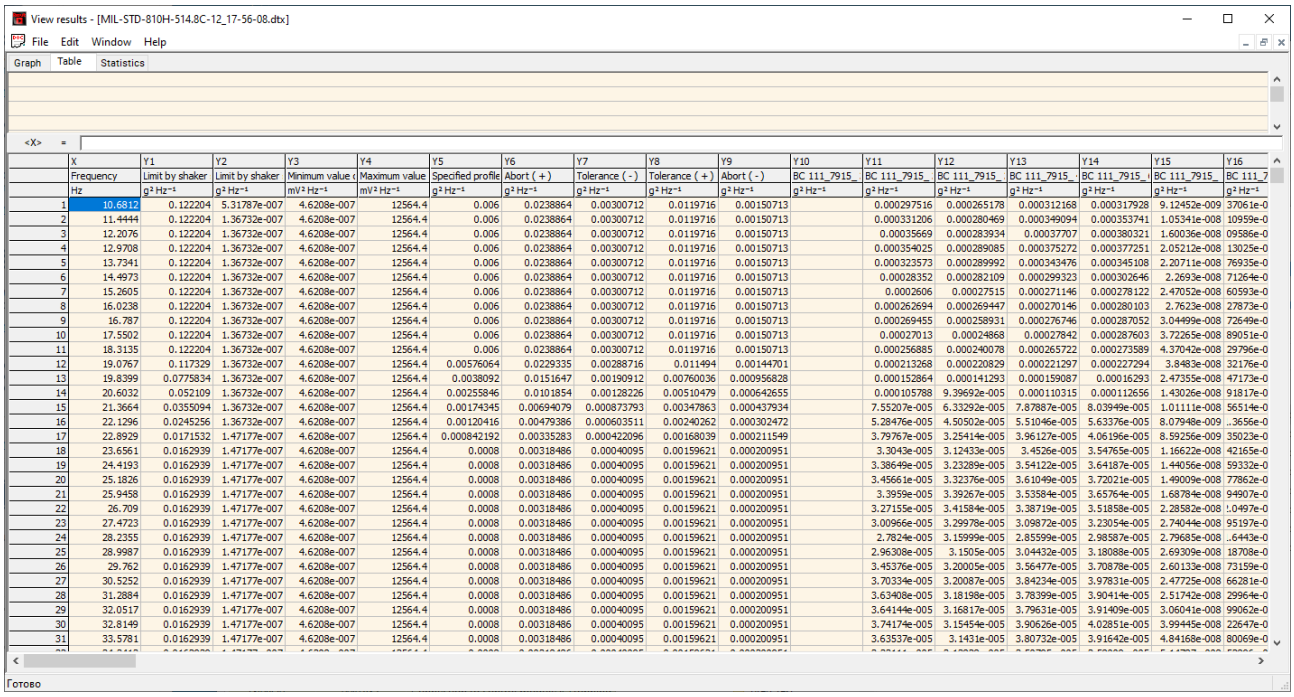


Fig. 5.71 Graph tab of the View Results window

To view the graph values in table form, go to the Table tab (*Fig. 5.72*).



	X	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16
	Frequency	Limit by shaker	Limit by shaker	Minimum value	Maximum value	Specified profile	Abort (+)	Tolerance (-)	Tolerance (+)	Abort (-)	BC 111_7915_	BC 111_7915_	BC 111_7915_	BC 111_7915_	BC 111_7915_	BC 111_7915_	BC 111_7
	Hz	g² Hz⁻¹	g² Hz⁻¹	mV² Hz⁻¹	mV² Hz⁻¹	g² Hz⁻¹	g² Hz⁻¹	g² Hz⁻¹	g² Hz⁻¹	g² Hz⁻¹	g² Hz⁻¹	g² Hz⁻¹	g² Hz⁻¹	g² Hz⁻¹	g² Hz⁻¹	g² Hz⁻¹	g² Hz⁻¹
1	10.6812	0.122204	5.31787e-007	4.6208e-007	12564.4	0.006	0.0238864	0.00300712	0.0119716	0.00150713		0.000297516	0.000265178	0.000312168	0.000317928	9.12452e-009	37061e-0
2	11.4444	0.122204	1.36732e-007	4.6208e-007	12564.4	0.006	0.0238864	0.00300712	0.0119716	0.00150713		0.000331206	0.000280469	0.000349094	0.000353741	1.05341e-008	10959e-0
3	12.2076	0.122204	1.36732e-007	4.6208e-007	12564.4	0.006	0.0238864	0.00300712	0.0119716	0.00150713		0.00035669	0.000283934	0.00037707	0.000380321	1.60036e-008	09586e-0
4	12.9708	0.122204	1.36732e-007	4.6208e-007	12564.4	0.006	0.0238864	0.00300712	0.0119716	0.00150713		0.000354025	0.000289085	0.000375272	0.000377251	2.05212e-008	13025e-0
5	13.7341	0.122204	1.36732e-007	4.6208e-007	12564.4	0.006	0.0238864	0.00300712	0.0119716	0.00150713		0.000323573	0.000289992	0.000343476	0.000345108	2.20711e-008	76935e-0
6	14.4973	0.122204	1.36732e-007	4.6208e-007	12564.4	0.006	0.0238864	0.00300712	0.0119716	0.00150713		0.00028352	0.000282109	0.000299323	0.000302646	2.2693e-008	71264e-0
7	15.2605	0.122204	1.36732e-007	4.6208e-007	12564.4	0.006	0.0238864	0.00300712	0.0119716	0.00150713		0.0002606	0.00027515	0.000271146	0.000278122	2.47052e-008	60593e-0
8	16.0238	0.122204	1.36732e-007	4.6208e-007	12564.4	0.006	0.0238864	0.00300712	0.0119716	0.00150713		0.000262694	0.000269447	0.000270146	0.000280103	2.7623e-008	27873e-0
9	16.787	0.122204	1.36732e-007	4.6208e-007	12564.4	0.006	0.0238864	0.00300712	0.0119716	0.00150713		0.000269455	0.000258931	0.000276746	0.000287052	3.04499e-008	72649e-0
10	17.5502	0.122204	1.36732e-007	4.6208e-007	12564.4	0.006	0.0238864	0.00300712	0.0119716	0.00150713		0.00027013	0.00024868	0.00027842	0.000287603	3.72265e-008	89051e-0
11	18.3135	0.122204	1.36732e-007	4.6208e-007	12564.4	0.006	0.0238864	0.00300712	0.0119716	0.00150713		0.000256885	0.000240078	0.000265722	0.000273589	4.37042e-008	29796e-0
12	19.0767	0.117329	1.36732e-007	4.6208e-007	12564.4	0.00576064	0.0229335	0.00288716	0.011494	0.00144701		0.000213268	0.000220829	0.000221297	0.000227294	3.8483e-008	32176e-0
13	19.8399	0.0775834	1.36732e-007	4.6208e-007	12564.4	0.0038092	0.0151647	0.00190912	0.00760036	0.000956828		0.000152864	0.000141293	0.000159087	0.00016293	2.47355e-008	47173e-0
14	20.6032	0.052109	1.36732e-007	4.6208e-007	12564.4	0.00255846	0.0101854	0.00128226	0.00510479	0.000642655		0.000105788	9.39692e-005	0.000110315	0.000112656	1.43026e-008	91817e-0
15	21.3664	0.0355094	1.36732e-007	4.6208e-007	12564.4	0.00174345	0.00694079	0.000873793	0.00347863	0.000437934		7.55207e-005	6.33292e-005	7.87887e-005	8.03949e-005	1.01111e-008	56514e-0
16	22.1296	0.0245256	1.36732e-007	4.6208e-007	12564.4	0.00120416	0.00479386	0.000603511	0.00240262	0.000302472		5.28476e-005	4.50502e-005	5.51046e-005	5.63376e-005	8.07948e-009	..3656e-0
17	22.8929	0.0171532	1.47177e-007	4.6208e-007	12564.4	0.000842192	0.00335283	0.000422096	0.00168039	0.000211549		3.79767e-005	3.25414e-005	3.96127e-005	4.06196e-005	8.59256e-009	35023e-0
18	23.6561	0.0162939	1.47177e-007	4.6208e-007	12564.4	0.0008	0.00318486	0.00040095	0.00159621	0.000200951		3.3043e-005	3.12433e-005	3.4526e-005	3.54765e-005	1.16622e-008	42165e-0
19	24.4193	0.0162939	1.47177e-007	4.6208e-007	12564.4	0.0008	0.00318486	0.00040095	0.00159621	0.000200951		3.38649e-005	3.23289e-005	3.54122e-005	3.64187e-005	1.44056e-008	59332e-0
20	25.1826	0.0162939	1.47177e-007	4.6208e-007	12564.4	0.0008	0.00318486	0.00040095	0.00159621	0.000200951		3.45661e-005	3.32376e-005	3.61049e-005	3.72021e-005	1.49009e-008	77862e-0
21	25.9458	0.0162939	1.47177e-007	4.6208e-007	12564.4	0.0008	0.00318486	0.00040095	0.00159621	0.000200951		3.3959e-005	3.39267e-005	3.53584e-005	3.65764e-005	1.68784e-008	94907e-0
22	26.709	0.0162939	1.47177e-007	4.6208e-007	12564.4	0.0008	0.00318486	0.00040095	0.00159621	0.000200951		3.27155e-005	3.41584e-005	3.38719e-005	3.51858e-005	2.28582e-008	.0497e-0
23	27.4723	0.0162939	1.47177e-007	4.6208e-007	12564.4	0.0008	0.00318486	0.00040095	0.00159621	0.000200951		3.00966e-005	3.29978e-005	3.09872e-005	3.23054e-005	2.74044e-008	95197e-0
24	28.2355	0.0162939	1.47177e-007	4.6208e-007	12564.4	0.0008	0.00318486	0.00040095	0.00159621	0.000200951		2.7824e-005	3.15999e-005	2.85599e-005	2.98587e-005	2.79685e-008	..6443e-0
25	28.9987	0.0162939	1.47177e-007	4.6208e-007	12564.4	0.0008	0.00318486	0.00040095	0.00159621	0.000200951		2.96308e-005	3.1505e-005	3.04432e-005	3.18088e-005	2.69309e-008	18708e-0
26	29.762	0.0162939	1.47177e-007	4.6208e-007	12564.4	0.0008	0.00318486	0.00040095	0.00159621	0.000200951		3.45376e-005	3.20005e-005	3.56477e-005	3.70878e-005	2.60133e-008	73159e-0
27	30.5252	0.0162939	1.47177e-007	4.6208e-007	12564.4	0.0008	0.00318486	0.00040095	0.00159621	0.000200951		3.70334e-005	3.20087e-005	3.84234e-005	3.97831e-005	2.47725e-008	66281e-0
28	31.2884	0.0162939	1.47177e-007	4.6208e-007	12564.4	0.0008	0.00318486	0.00040095	0.00159621	0.000200951		3.63408e-005	3.18198e-005	3.78399e-005	3.90414e-005	2.51742e-008	29964e-0
29	32.0517	0.0162939	1.47177e-007	4.6208e-007	12564.4	0.0008	0.00318486	0.00040095	0.00159621	0.000200951		3.64144e-005	3.16817e-005	3.79631e-005	3.91409e-005	3.06041e-008	99062e-0
30	32.8149	0.0162939	1.47177e-007	4.6208e-007	12564.4	0.0008	0.00318486	0.00040095	0.00159621	0.000200951		3.74174e-005	3.15454e-005	3.90626e-005	4.02851e-005	3.99445e-008	22647e-0
31	33.5781	0.0162939	1.47177e-007	4.6208e-007	12564.4	0.0008	0.00318486	0.00040095	0.00159621	0.000200951		3.63537e-005	3.1431e-005	3.80732e-005	3.91642e-005	4.84168e-008	80069e-0

Fig. 5.72 Table tab of the View Results window

5.7 The Shock program

5.7.1 Program Purpose

The program is used for classic shock test. The program can generate different wave shapes: sinusoidal, triangular, rectangular, serrated, and trapezoidal.

5.7.2 Preparing for testing

When preparing for classic shock tests, set the following parameters (if not set): shaker parameters, specimen parameters, channel parameters (see sections 5.1-5.3), and then perform a pretest according to the section 5.4.

To go to the Shock program window, press the Shock button on the VCS Panel (Fig. *5.1*). The Shock program window (*Fig. 5.73*) will appear on the monitor screen.

Caution! *The Shock button on the VCS panel will only be available if the program detects the pretest results.*

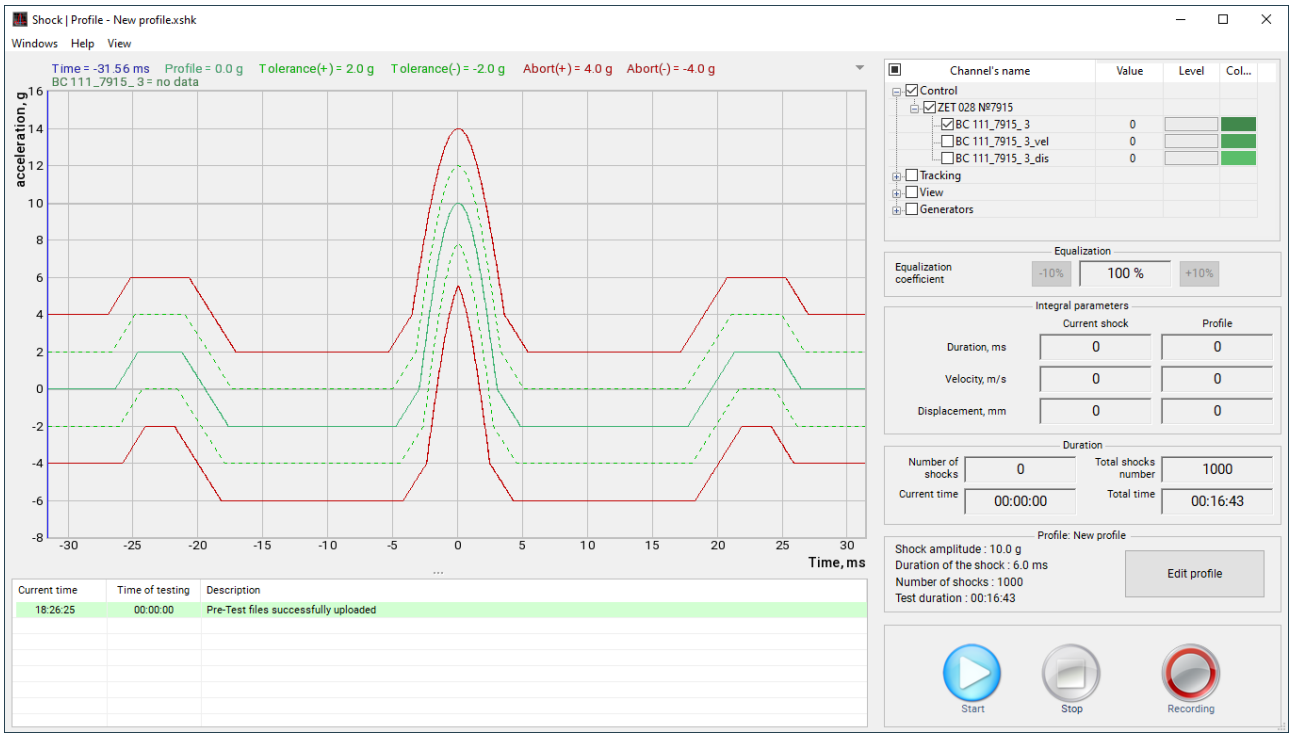


Fig. 5.73 The Shock window

To set the test profile, press the Edit Profile button (*Fig. 5.*) in The Shock program window.

The Profile Editor window will open with the active Options tab (*Fig. 5.*).

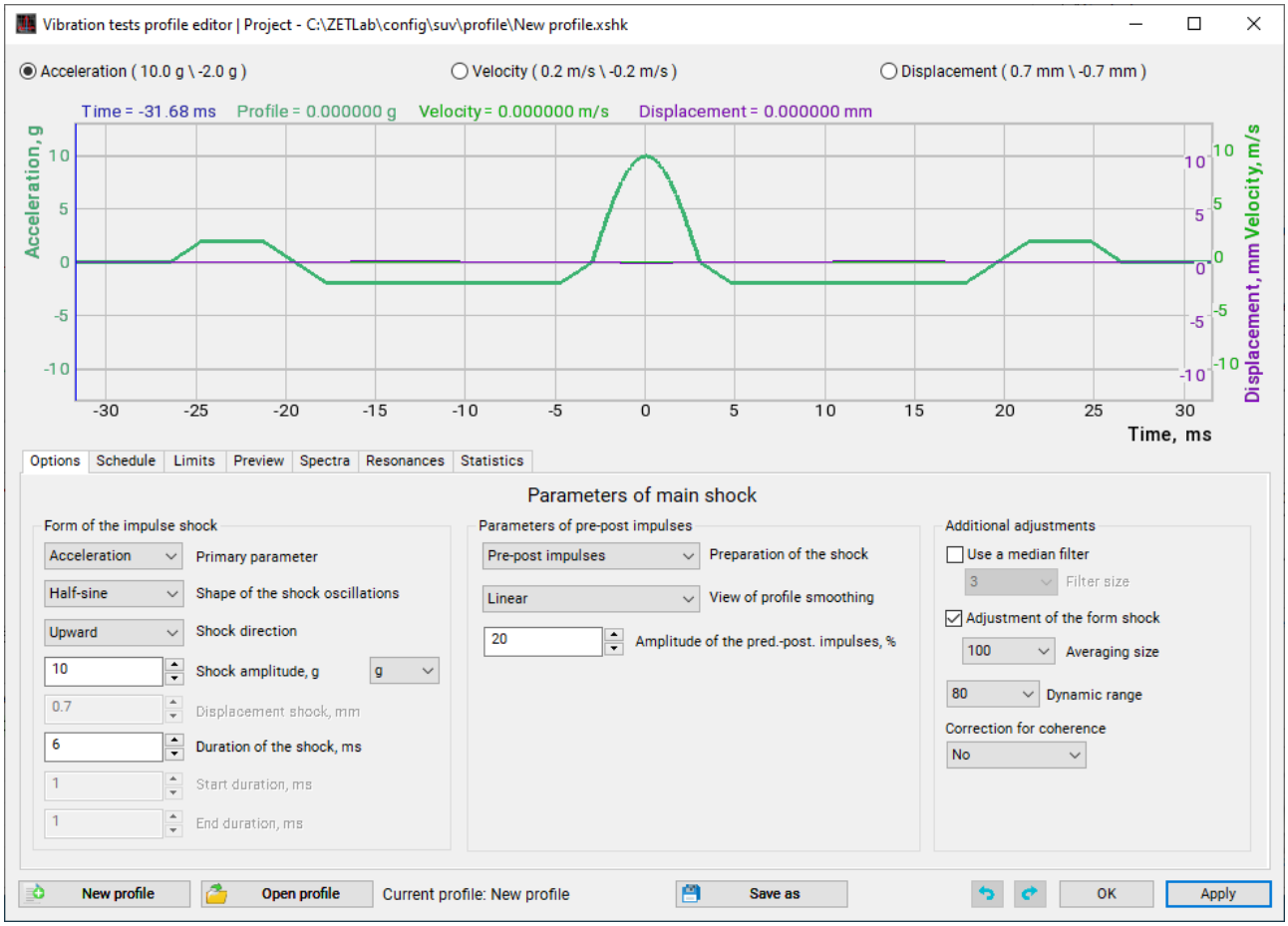


Fig. 5.74 Profile Editor window, Options tab

In the Options tab, you can set the primary parameter to produce the shock: acceleration or displacement.

If the Acceleration parameter is selected, specify the amplitude and duration of the produced shocks. If the Displacement parameter is selected, specify displacement and duration.

You can set the following as the Shock Shape:

- half-sine;
- triangle;
- rectangle;
- serrated (peak in the beginning);
- serrated (peak in the end);
- trapeze;
- haversine.

You can find an example of the shock pulse shapes in Appendix A. Shapes of the shock pulse accelerograms .

The Direction parameter is used to set shock direction - upward or down.

The Pre-post impulses parameter includes the pre-signals for balancing the velocity and displacement of the shaker. You can select the following as the pre and post pulses when producing a shock:

- No pre-post impulses;
- Post-impulses only;
- Pre-impulses only;
- Pre-post impulses.

You can select the following parameters for smoothing the displayed shock profile:

- Without smoothing;
- Linear;
- Hanna;
- Sinusoidal.

To accurately determine the required generator voltage when reproducing a shock pulse, set Amplitude of the pre-post impulse parameter. The Pre-post impulse value is set as a percentage of the value set for the Shock Amplitude parameter.

The Adjustment of the shock form parameter is used to adjust a shock shape in the test in case of differences between the registered shock shape and shock shape in the profile.

The Use a Median Filter parameter is used to "align" the amplitude response. The greater the value of the Filter Size parameter, the greater the alignment value.

The Dynamic Range parameter limits the difference between the maximum value and minimum value of the amplitude response.

To go to the Schedule tab (Fig. 5.), check the corresponding field in the Profile Editor window.

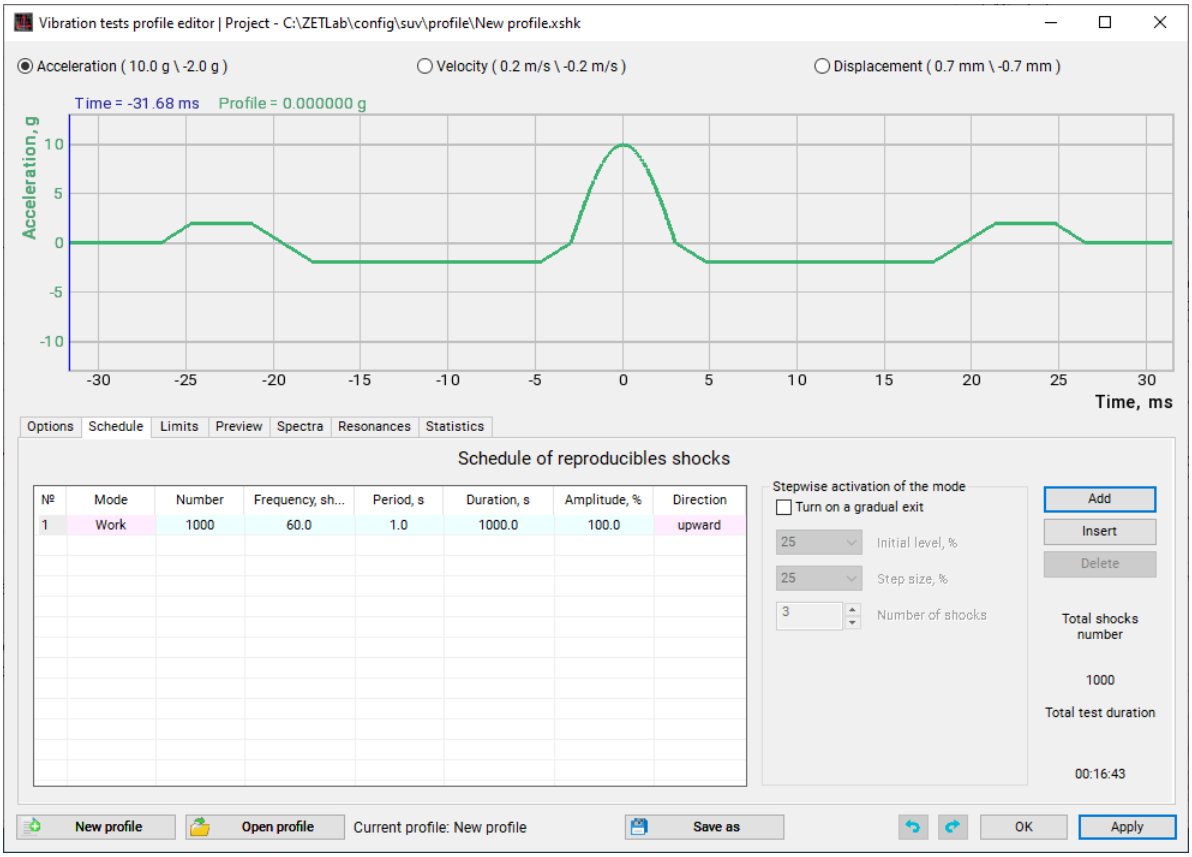


Fig. 5.75 Profile Editor window, Schedule tab

The vibration test schedule is a data table. To add new rows to the table, press the Insert button. If vibration tests have multiple stages, add the appropriate number of rows to the table. The configuration is individual for each stage of the test.

The Mode parameter has several states:

- Work – in this mode, the program is performing tests according to the profile;
- Pause – in this mode, the program is pausing tests for a specified time;
- Loop – in this mode, the program is repeating operations from a specified position a specified number of times.

The Number column is used to set the total number of shocks in the test.

The Frequency column is used to set the number of shocks per minute.

In the Period, sec column, you can set the period of shock.

The Duration, sec column is used to set the total time of the test.

The Amplitude (%) column is used to set the shock pulse amplitude as a percentage of the value set for the Shock Amplitude parameter.

The Stepwise activation of the mode parameter is used for gradual mode entry, where the shock level is evenly increasing at each step.

To go to the Limits tab (*Fig. 5.*), activate the corresponding field in the Profile Editor window.

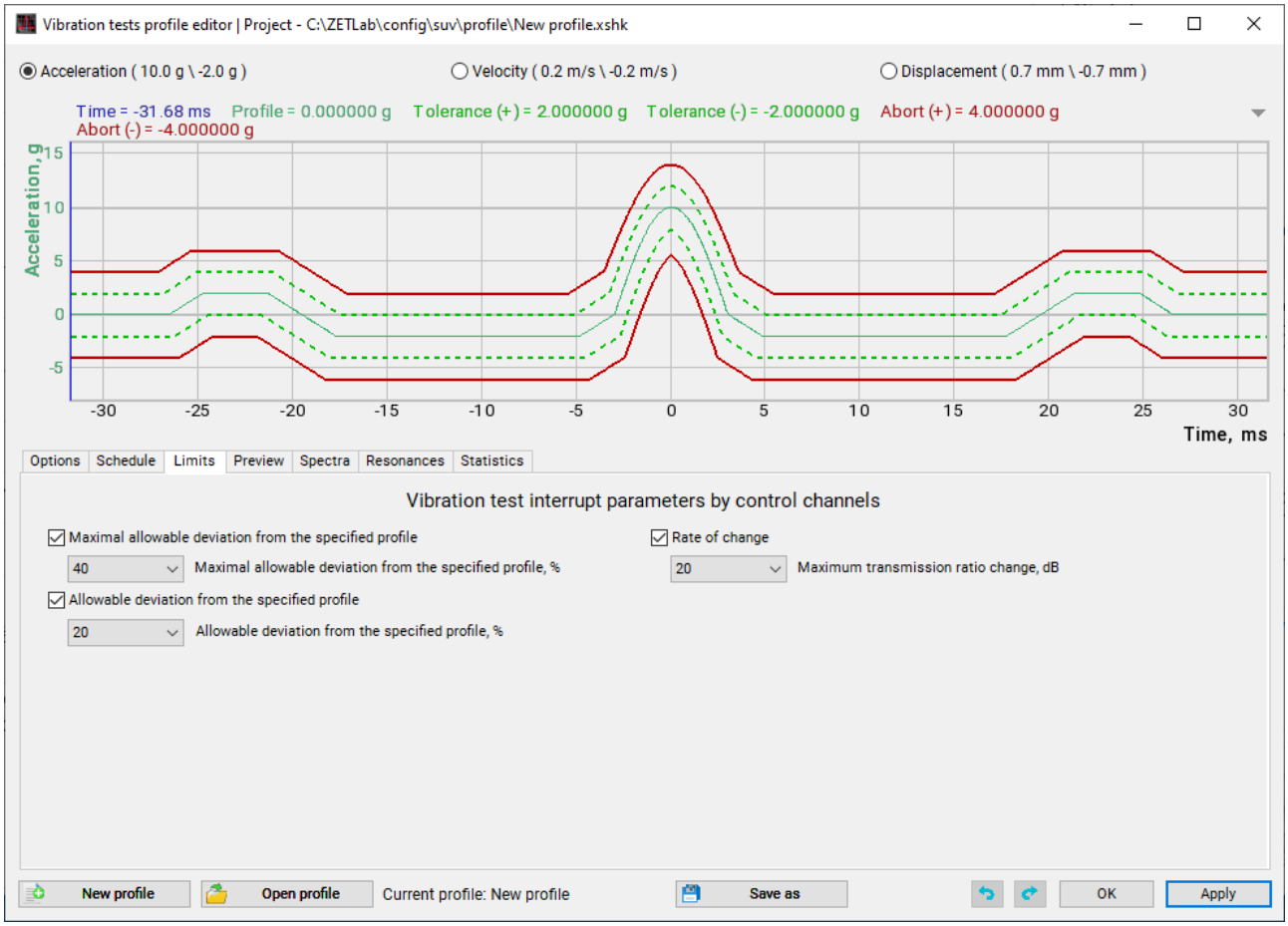


Fig. 5.76 The Profile Editor window, the Limits tab

On the Limits tab, you can set the test thresholds (in dB and %) for the control channel. According to the parameters with enabled control, (during the tests) exceeding the set parameter values will be monitored, and if they are exceeded, the tests will stop immediately.

To enable control by parameter, activate (check the cell) the corresponding parameter, and to disable it, deactivate it (uncheck the cell).

You can set limits for the following parameters of a control channel:

- Maximum allowable deviation from the specified profile;
- Allowable deviation from the specified profile;
- Rate of change.

To go to the Preview tab (*Fig. 5.*), activate the corresponding field in the Profile Editor window.

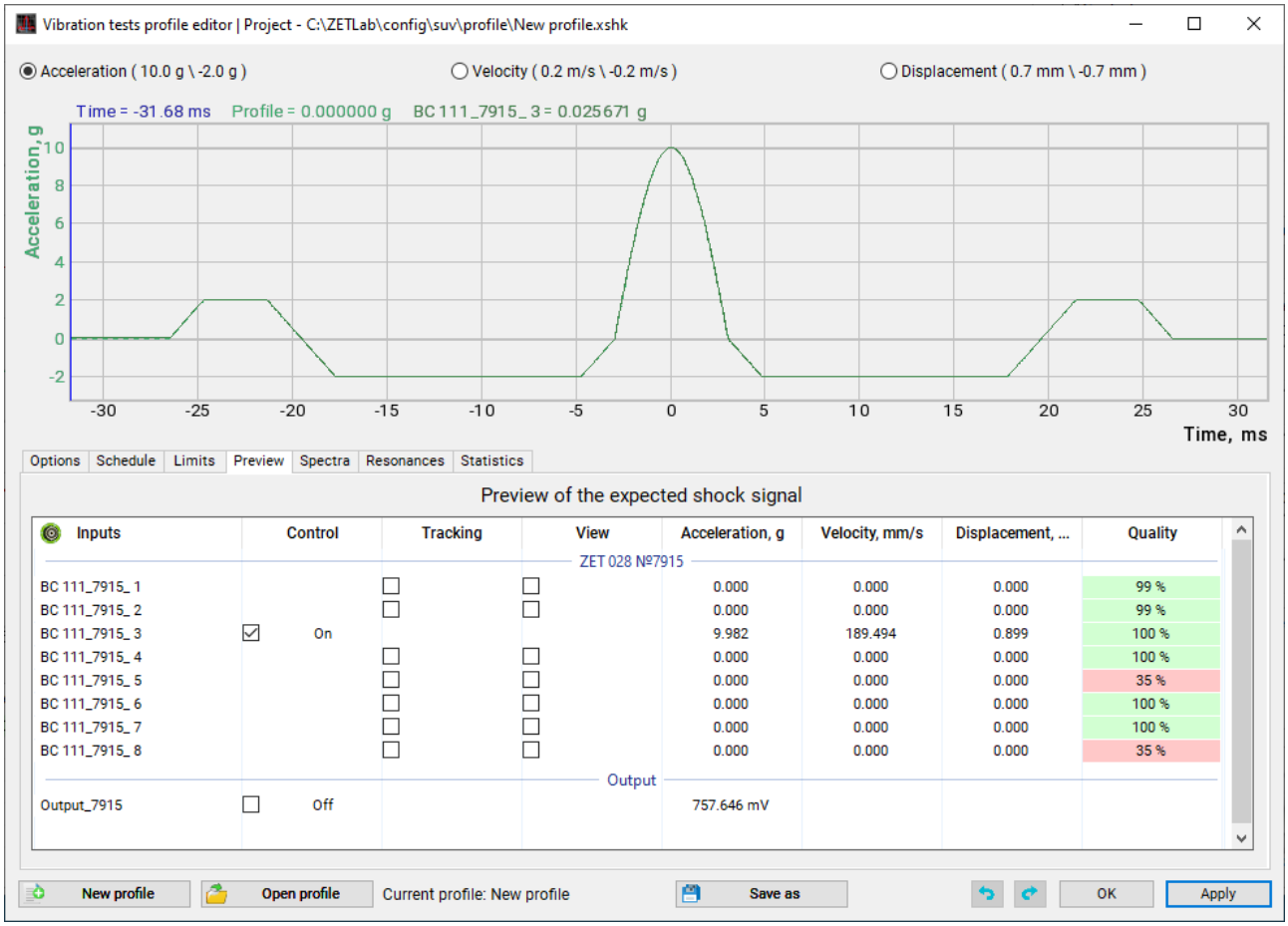


Fig. 5.77 Profile Editor window, Preview tab

On the Preview tab, you can preview the shock spectrum graphs for a given profile obtained by calculation based on the pretest results.

The graphs are presented for all measuring channels of the VCS controller selected at the test stage, and each measuring channel can be assigned any type of control (control, tracking, view, and also check the noise level of the channel). To display the desired vibration graph, check the corresponding table cell.

Note: *The graph information is for reference and intended to inform the VCS user of the expected results to be obtained in the vibration tests for a given profile.*

To go to the Spectra tab (*Fig. 5.*), activate the corresponding field in the Profile Editor window.

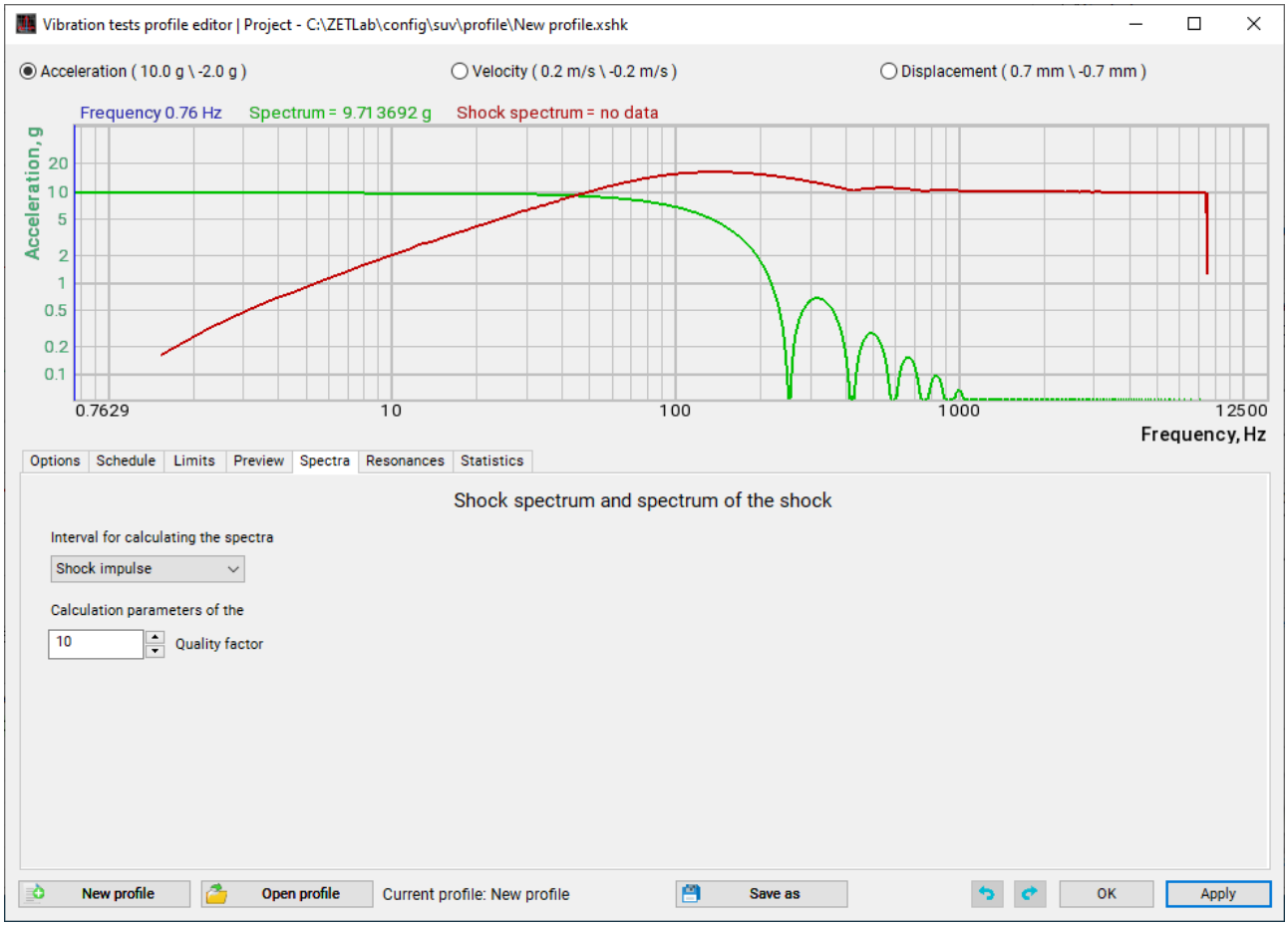


Fig. 5.78 Profile Editor window, Spectra tab

To go to the Resonances tab (*Fig. 5.*), activate the corresponding field in the Profile Editor window.

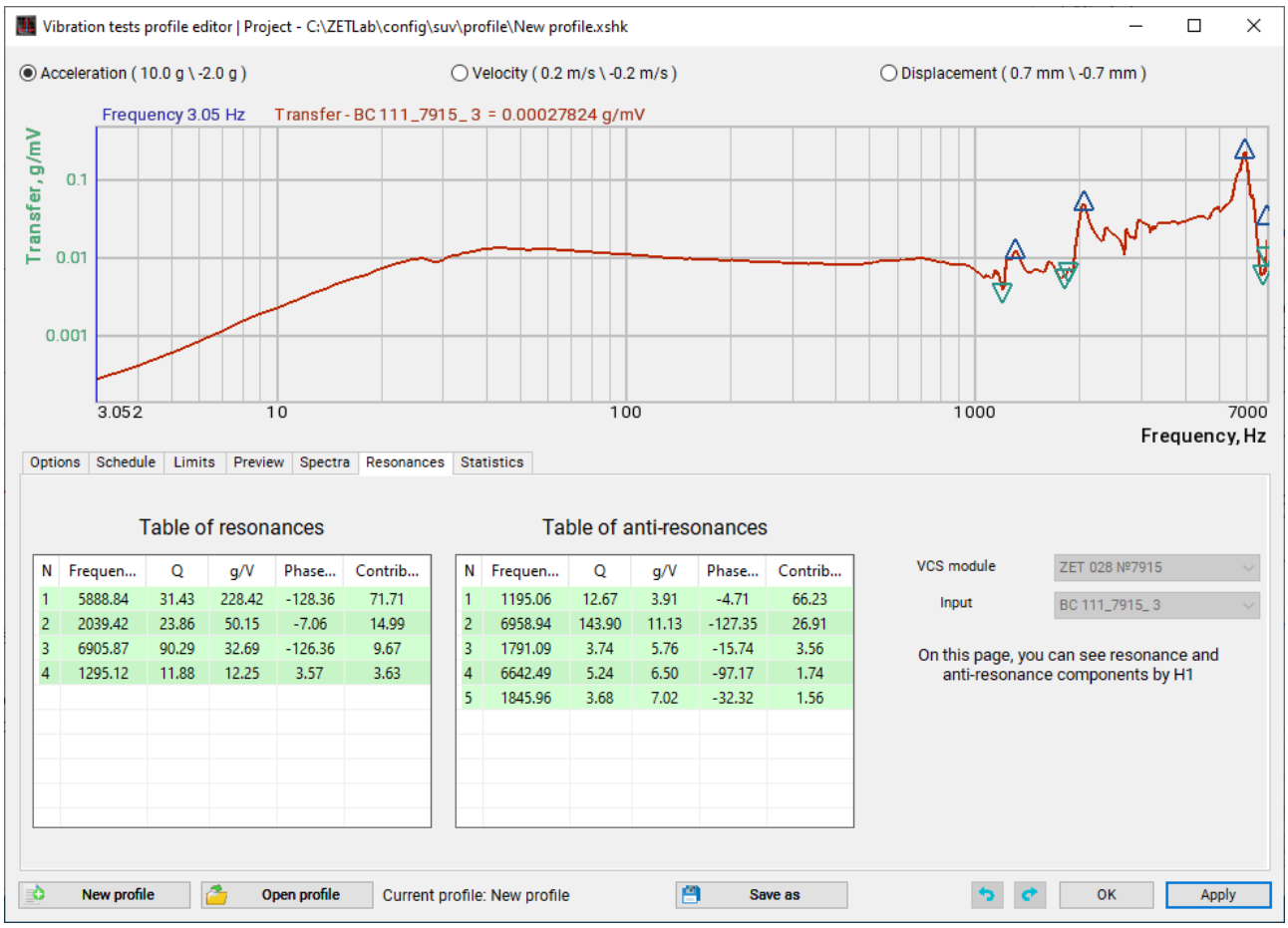


Fig. 5.79 Profile Editor window, Resonances tab

The Resonances tab contains statistical information based on the pretest results. On this tab, the operator can evaluate the presence of resonances and antiresonances in the amplitude response.

Note: *If necessary (for more detailed consideration), draw the amplitude response on the frequency scale closer to the area of interest, and only resonances and antiresonances falling within the visualized graph area will be left in the table.*

To go to the Statistics tab (*Fig. 5.*), activate the corresponding field in the Profile Editor window.

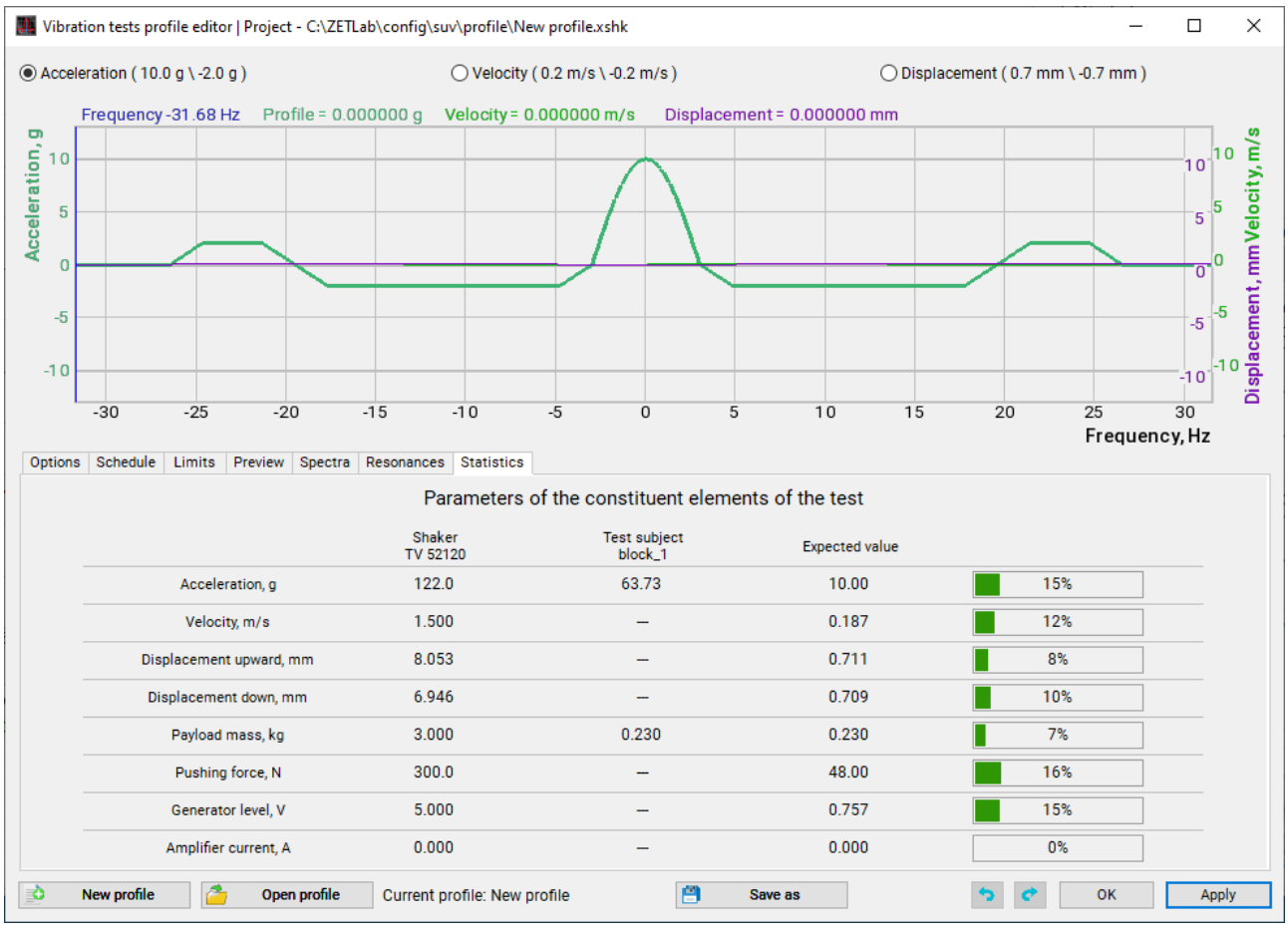


Fig. 5.80 Profile Editor window, Statistics tab

The Statistics tab contains statistical information based on the set values for the test profile parameters. It provides the user with a possibility to assess the workload of the shaker during vibration tests.

5.7.3 Testing

There is a coordinate grid with graphs in the center of the program window. During vibration tests, it displays acceleration graphs of the last recorded shock, the minimum tolerance, and the maximum tolerance.

The Integral Parameters field at top right contains indicators of the current state of vibration tests (acceleration, velocity, displacement), as well as the test parameter values set in the test profile.

The Duration field right down contains shock counters and time counters. The Total Time counter shows the total duration of vibration tests. The Current Time counter shows the time elapsed from the start of the test. The Number of Shocks counter shows the number of recorded shocks. The Total Shocks Number counter shows the required number of blows during the test. Vibration tests are automatically completed when the Number of Shocks counter reaches the Total Shocks Number value.

The lower pane of the Shock program shows the event log, where important information of the program operation is saved. After starting the program, the event log displays information of the successful download of the pretest file (*Fig. 5.*).

Current time	Time of testing	Description
18:26:25	00:00:00	Pre-Test files successfully uploaded

Fig. 5.81 Event log

Vibration tests are managed from a special menu in the lower-right corner of the program (*Fig. 5.*).

Fig. 5.82 Vibration test management menu

To start the vibration tests, press the Start button. To stop testing at any time, press the Stop button. To pause testing, press the Pause button, and to resume testing, press the Start button.

Pressing the Recording button starts/stops recording electrical signals from all involved channels of the VCS controller. You can view the recorded signals in the View Results program from the ZETLab Panel Display menu (see ZETLAB software. Operator's manual).

After clicking on the Start button, the program will start vibration tests and report it in the event log (*Fig. 5.83)*.

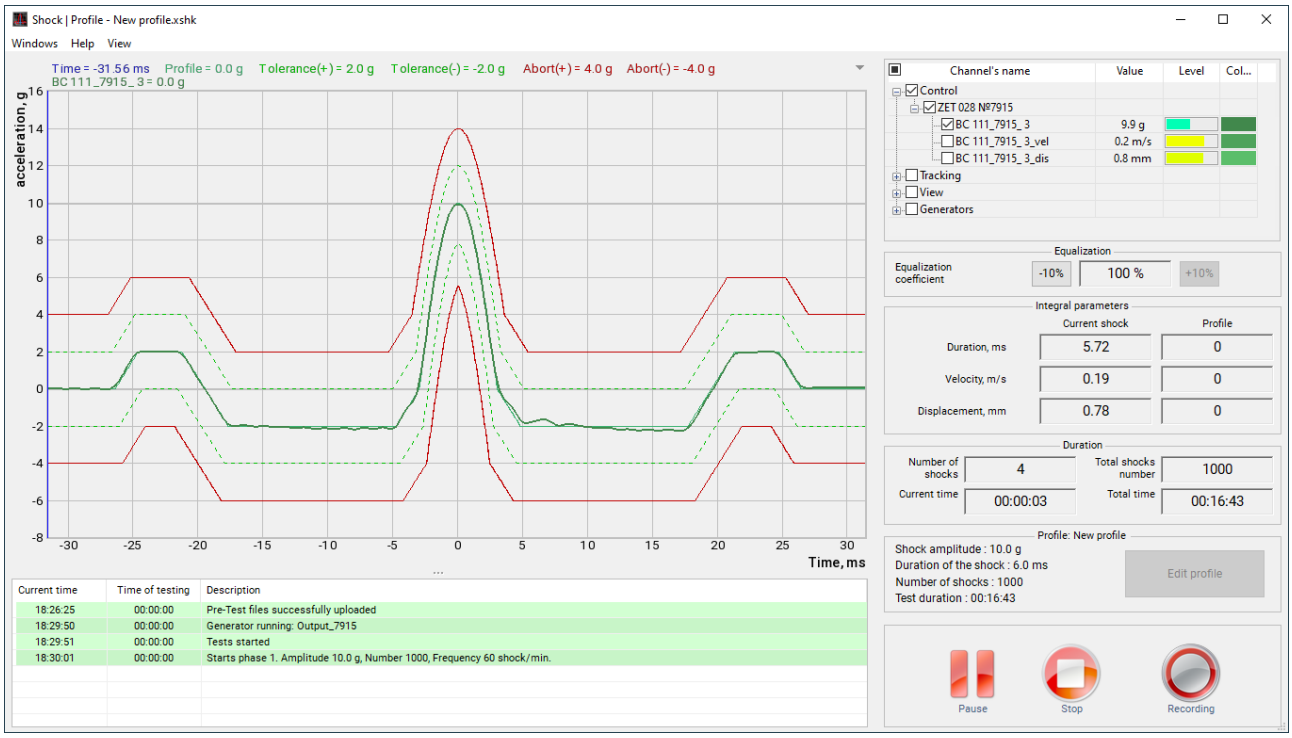


Fig. 5.83 Shock program window

To display a measurement channel on the graph, select it from the list of channels in the right pane of the program window (*Fig. 5.*). This list includes all measuring channels for which one of the test control types was selected in the Control Parameters program (Control, Tracking, View). The measurement channel line also displays information of the current acceleration and the integral load level for this channel.

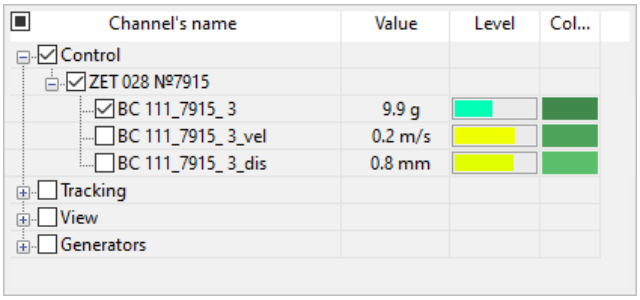


Fig. 5.84 Menu for selecting channels to display on the graph

During the tests, if the value of the control channel exceeds the thresholds set on the Limits tab, the event log will display information about exceeding the threshold, and the tests will be stopped (*Fig. 5.*).

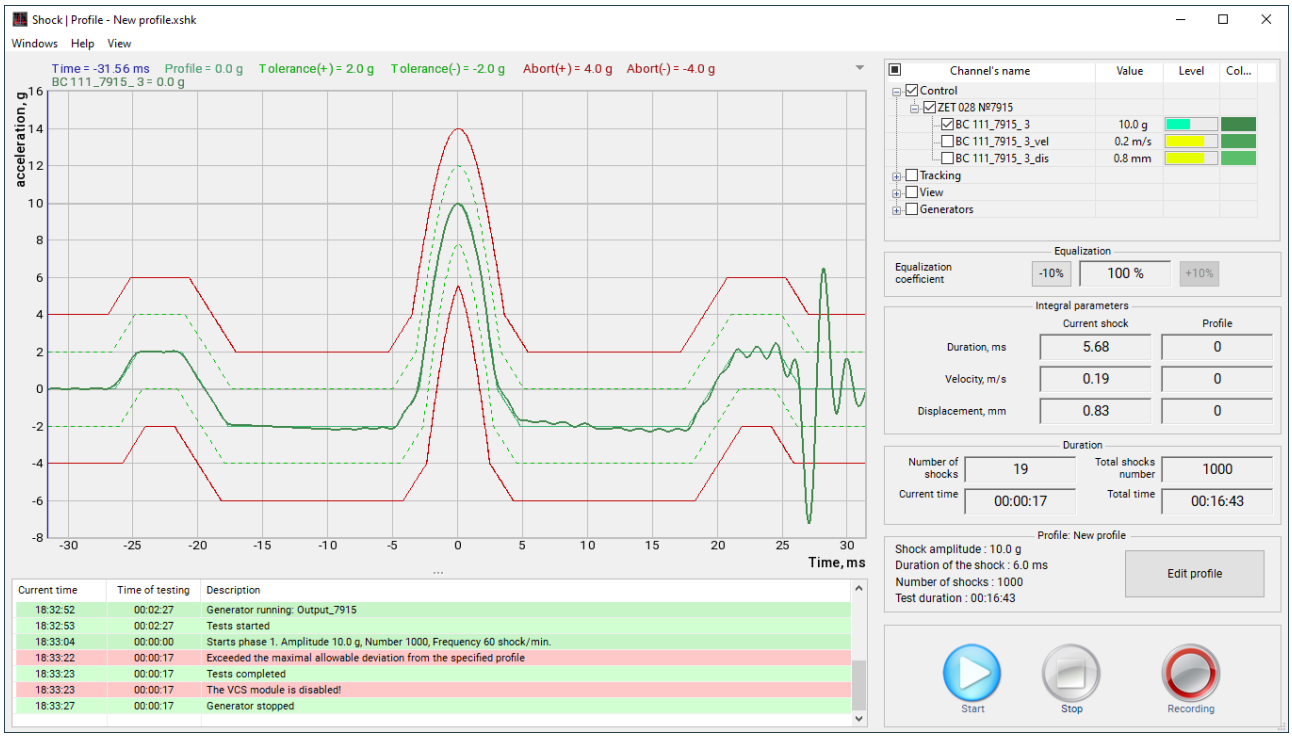


Fig. 5.85 Stopping vibration tests

During the tests, it is possible to track changes in the condition of the specimen under test at the point (s) of the control channel setup in real time. To do this, start the Additional Graphs program (*Fig. 5.40*) from the Windows menu.

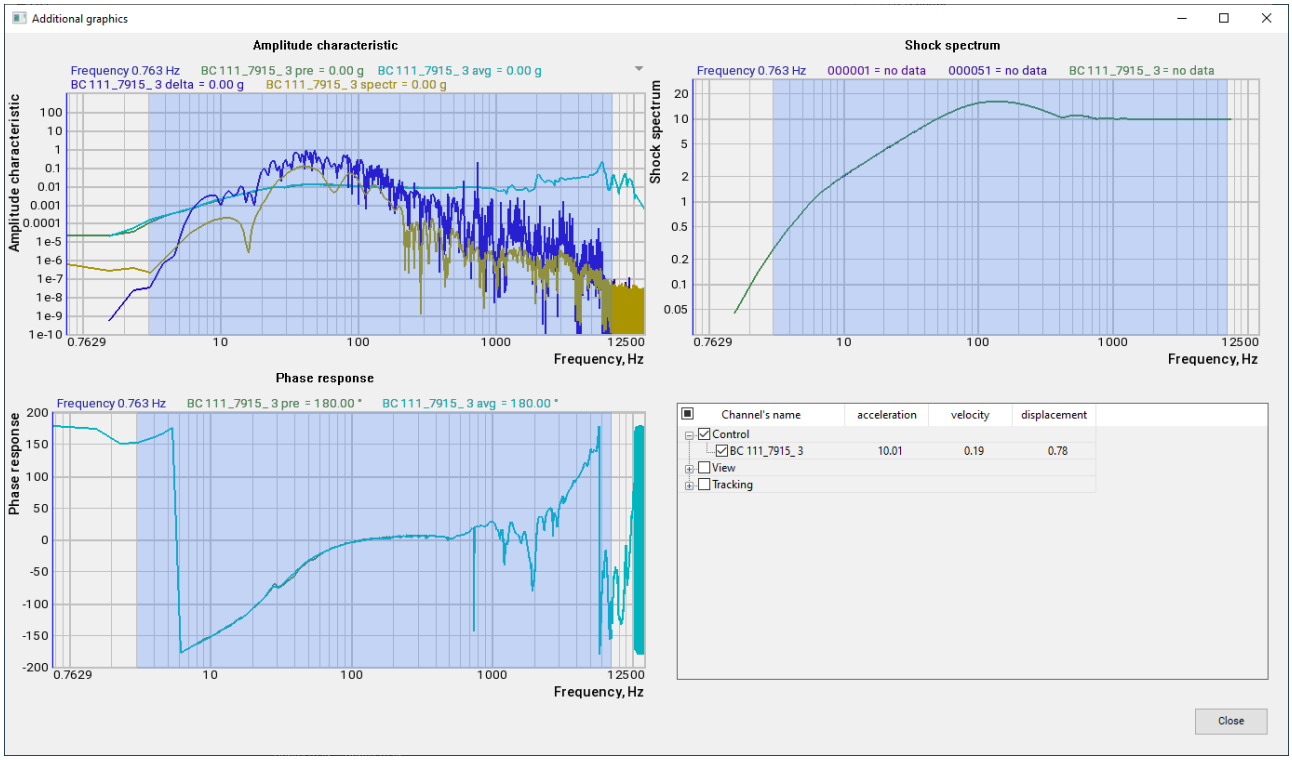


Fig. 5.86 Additional Graphs program window

The graphs of the Additional Graphs program show deviations of the current spectrum parameter values of the selected channel from the spectrum parameter values of the control channel generated in the test profile after passing the pre-test. The calculation can be performed relative to the control channel or the generator channel.

To display information of the temporary implementation of signal parameters, start the Results table program from the Windows menu of the Shock program. The opened Results table window (*Fig. 5.*) will show information of the vibration test process in the past.

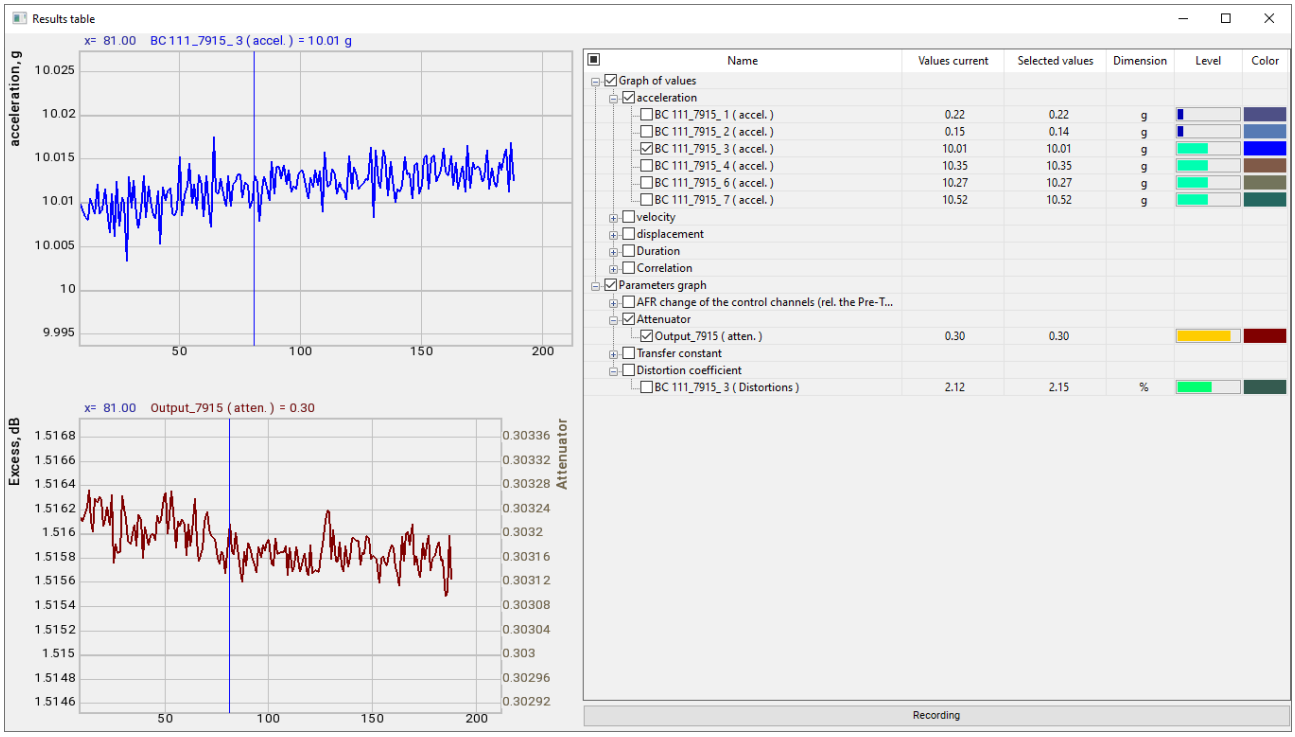


Fig. 5.87 The Results table program window

The upper-right corner lists the names of channels with available graphs. You can change the graph color by clicking on the colored rectangle. To save the recorder readings, press the Recording button. Only selected graphs available in the View Results program will be saved.

To save the report, start the Report program from the Windows menu of the Shock program. In the opened window, enter the name of report file and specify the path to save it, then press the Save button (*Fig. 5.88*).

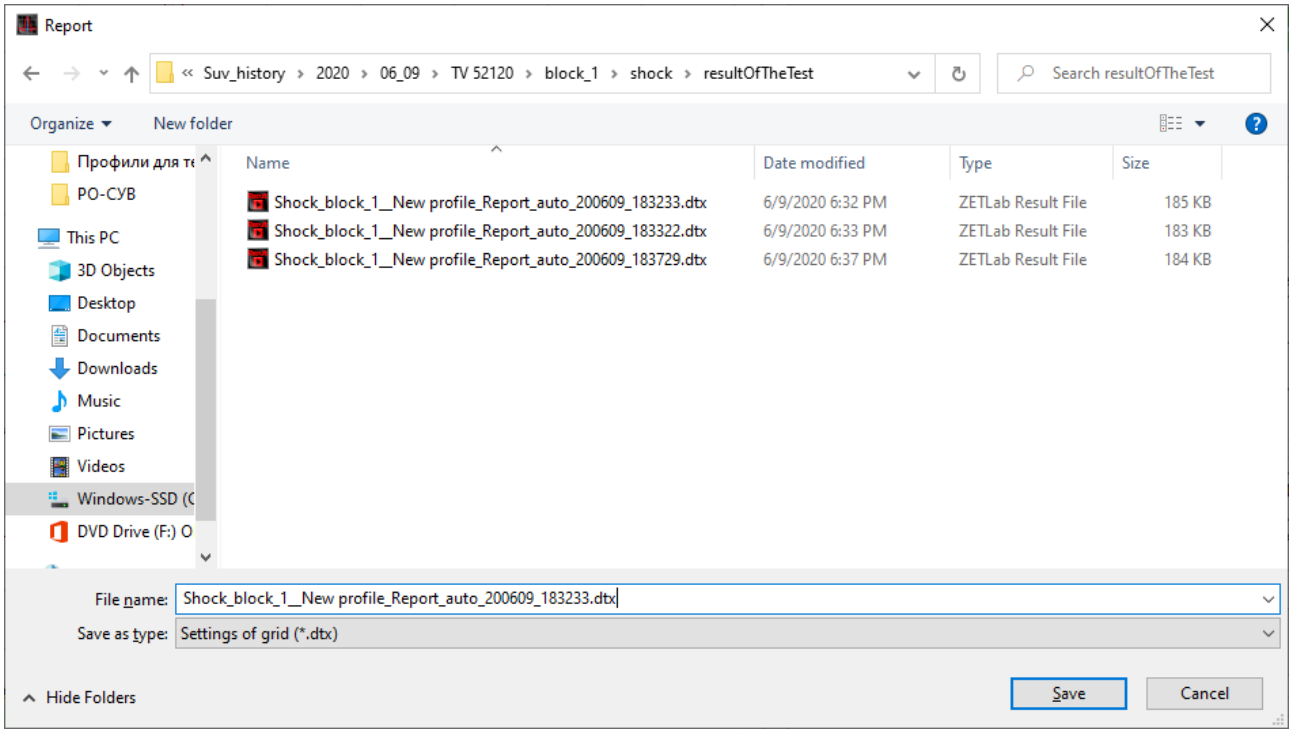


Fig. 5.88 Saving the vibration test report file

You can view the report file using the View Results program. To do this, right-click on the file and select Open in ResultViewer (*Fig. 5.*) from the context menu.

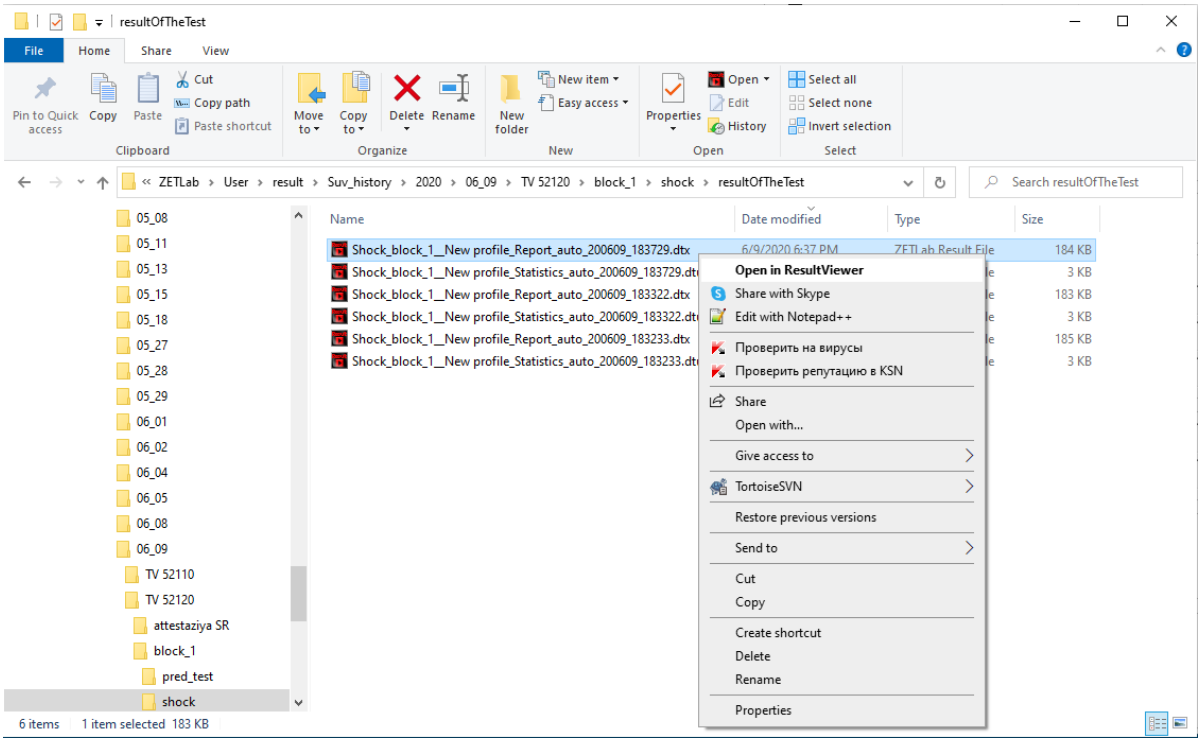


Fig. 5.89 Viewing the vibration test report file

5.8 User Defined Transient

5.8.1 Program purpose

The program is intended for single or multiple vibrational shock testing. In this program, you can generate a series of shocks with pre-set timing parameters filled with noise in a certain frequency band.

5.8.2 Preparation for testing

To prepare for vibrational shock testing, set the following parameters (if not set beforehand): shaker parameters, product parameters, channel parameters (see Sections 5.1 through 5.3), and perform a pre-test according to Section 5.4.

To switch to User Defined Transient program window, click the User Defined Transient button on the VCS (Vibration Control System) (*Figure 5.1*). The User Defined Transient program window will be displayed on the screen (*Figure 5.90*).

Attention! *The User Defined Transient button on the VCS Panel will be available only if the program detects pre-test results.*

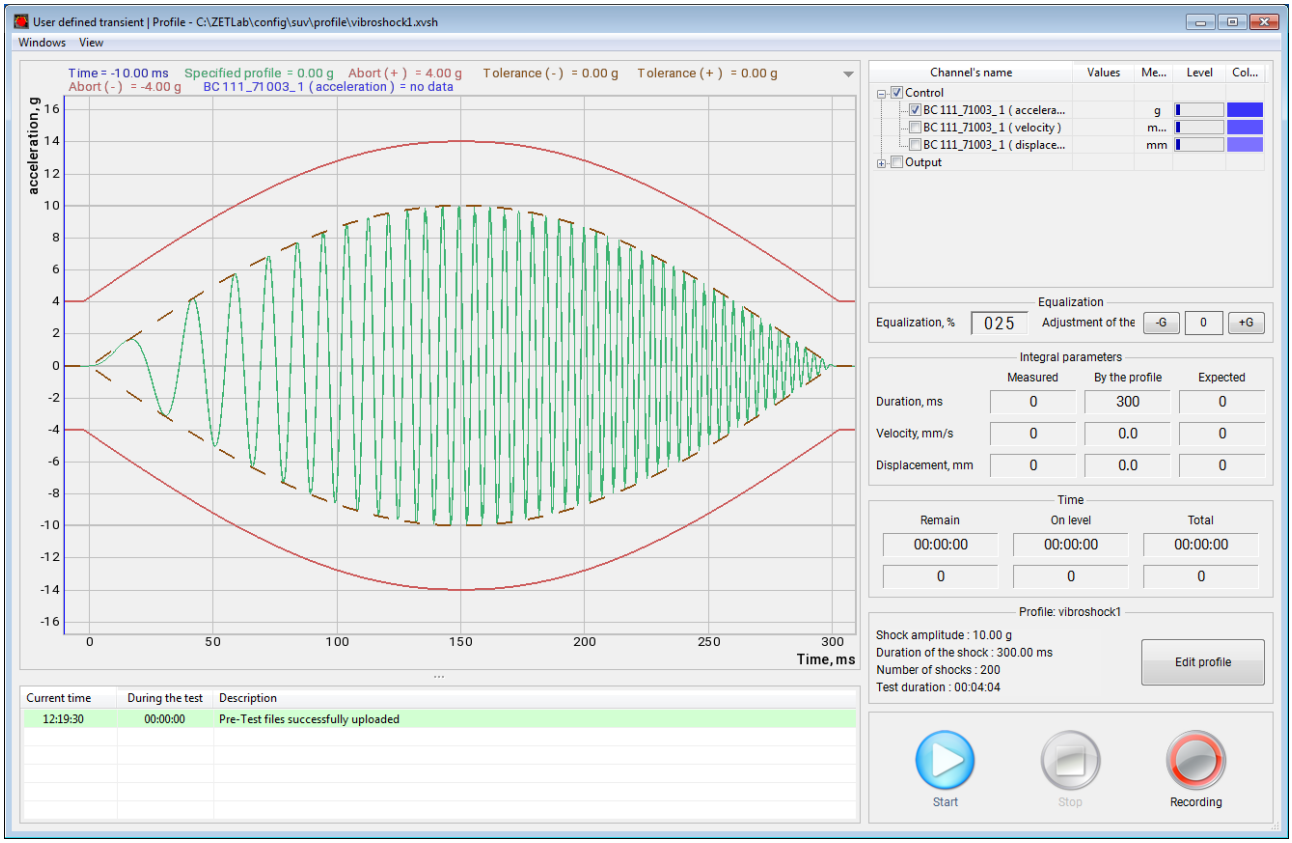


Figure 5.57 User Defined Transient window

To set a test profile, click the Edit Profile button (*Figure 5.90*) in the User Defined Transient window.

The Vibration tests profile editor window will open with the Envelope tab active (*Figure 5.91*).

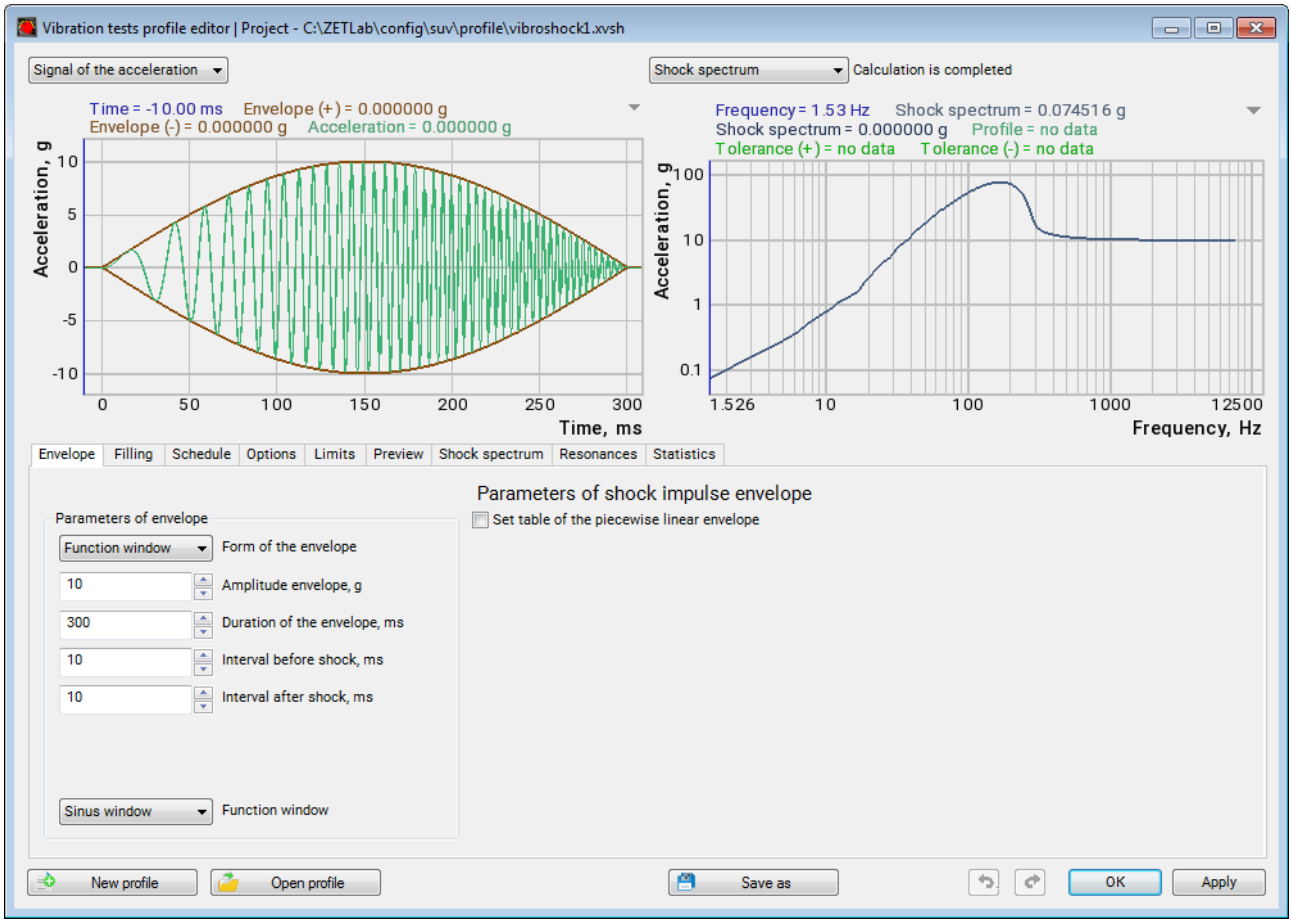


Figure 5.58 Profile Editor with Envelope tab

On the Envelope tab, you can set shock impulse envelope curve parameters.

The following Parameters of envelope Shape are available:

- Rectangular,
- Trapezoidal,
- Damping,
- Teardrop,
- Function window,
- Piecewise linear.

The Amplitude envelope parameter defines the maximum amplitude of the shock impulse envelope in “g” units.

The Duration of the envelope parameter defines the shock impulse amplitude duration, in msec.

The Interval before shock and Interval after shock parameters define intervals before and after the shock, respectively, in msec.

The Function Window parameters become active when the Window shape of the envelope is selected. For the Function Window, two options are available:

- Sinus window,
- Hann window.

When Set table of the piecewise linear envelope is selected, the corresponding table becomes available on the Envelope tab. To add new rows to the table, click the Add button.

To switch to the Filling tab (*Figure 5.92*), activate the relevant field in the Vibration Test Profile Editor.

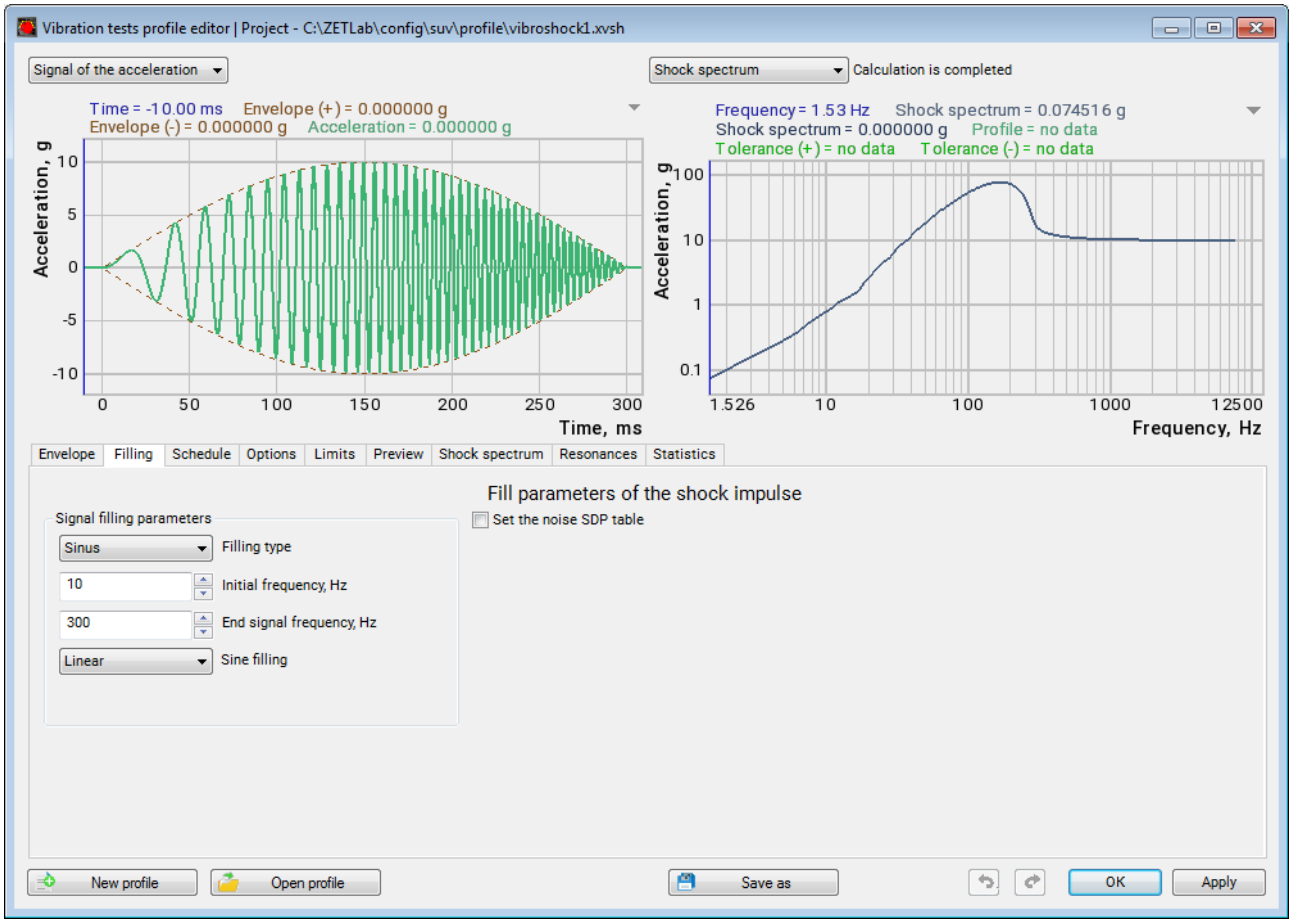


Figure 5.59 Profile Editor window, Filling tab

On the Filling tab, shock impulse spectral component parameters can be set.

The following shock impulse fill options are available for the Signal filling parameters:

- Sinus,
- Noise.

The Initial Frequency and End Signal Frequency parameters define the frequency band for the shock impulse fill.

For the Sinus fill, Linear and Logarithmic fill methods are available.

For the Noise fill, Uniform and Table fill methods are available. When Table method of shock impulse fill is selected, the relevant table Set the noise SDP table on the Filling tab becomes available for editing. To add new rows to the table, click the Add button.

To switch to the Schedule tab (*Figure 5.93*), activate the relevant field in the Vibration Test Profile Editor.

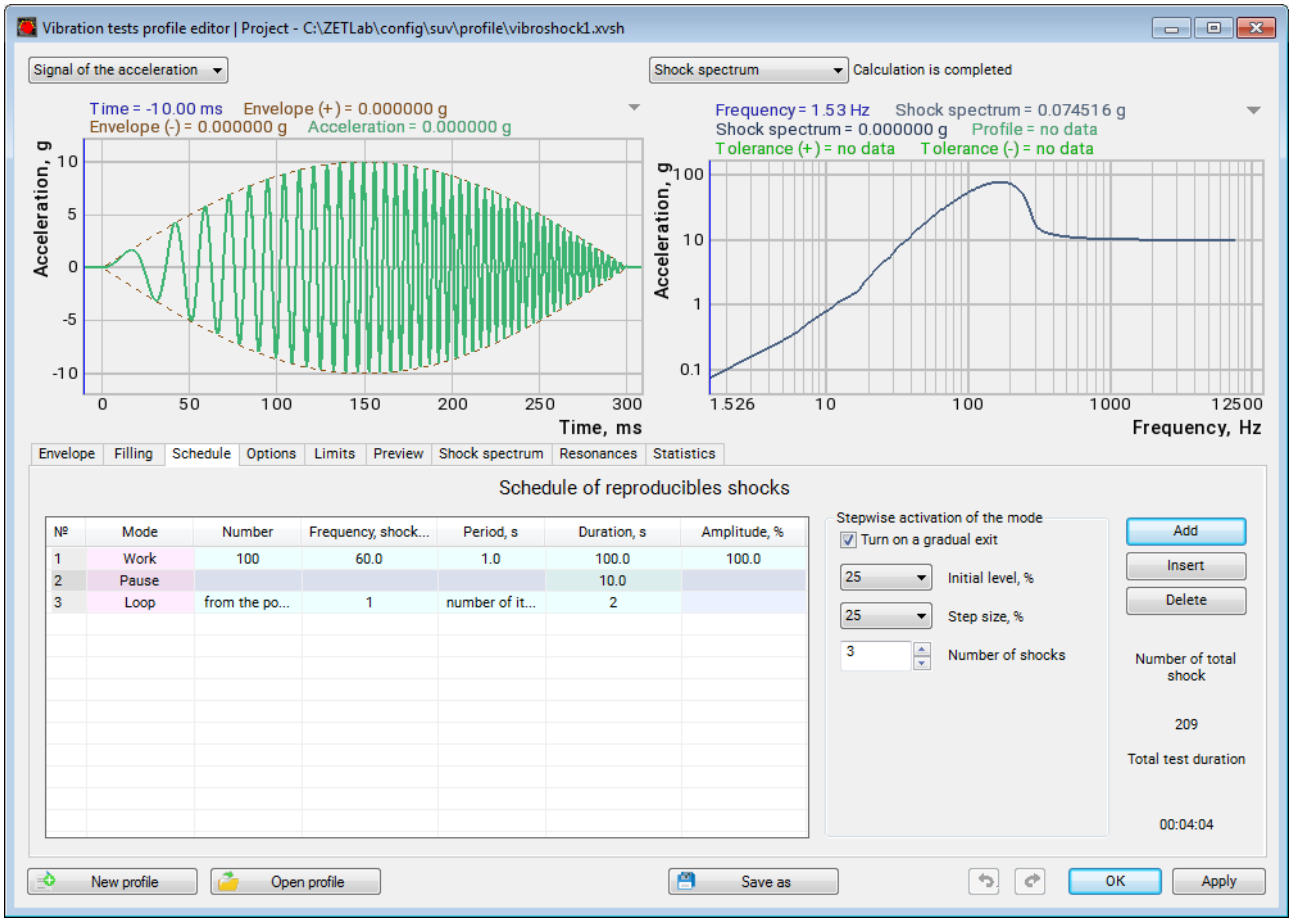


Figure 5.60 Profile Editor window, Schedule tab

On the Schedule tab, you can set a test schedule, including shock quantity, frequency, duration, period, and current shock amplitude to test-profile-defined amplitude ratio.

Vibration test schedule is a data table. To add new rows to the Schedule of reproducible shocks, click the Add button as many times as the number of test ranges to be added.

In the Number column, set the total number of shocks during the test.

In the Frequency/min. column, set the number of impulses per minute.

In the Duration (sec.) column, set the total duration of the test.

In the Amplitude (%) column, set the shock impulse amplitude, as a percentage of the value set for the Shock Amplitude parameter.

The Stepwise activation of the mode parameter defines a gradual process stabilization increasing evenly the repeatable shock level on each stage.

To switch to the Options tab (*Figure 5.94*), activate the relevant field in the Vibration Test Profile Editor.

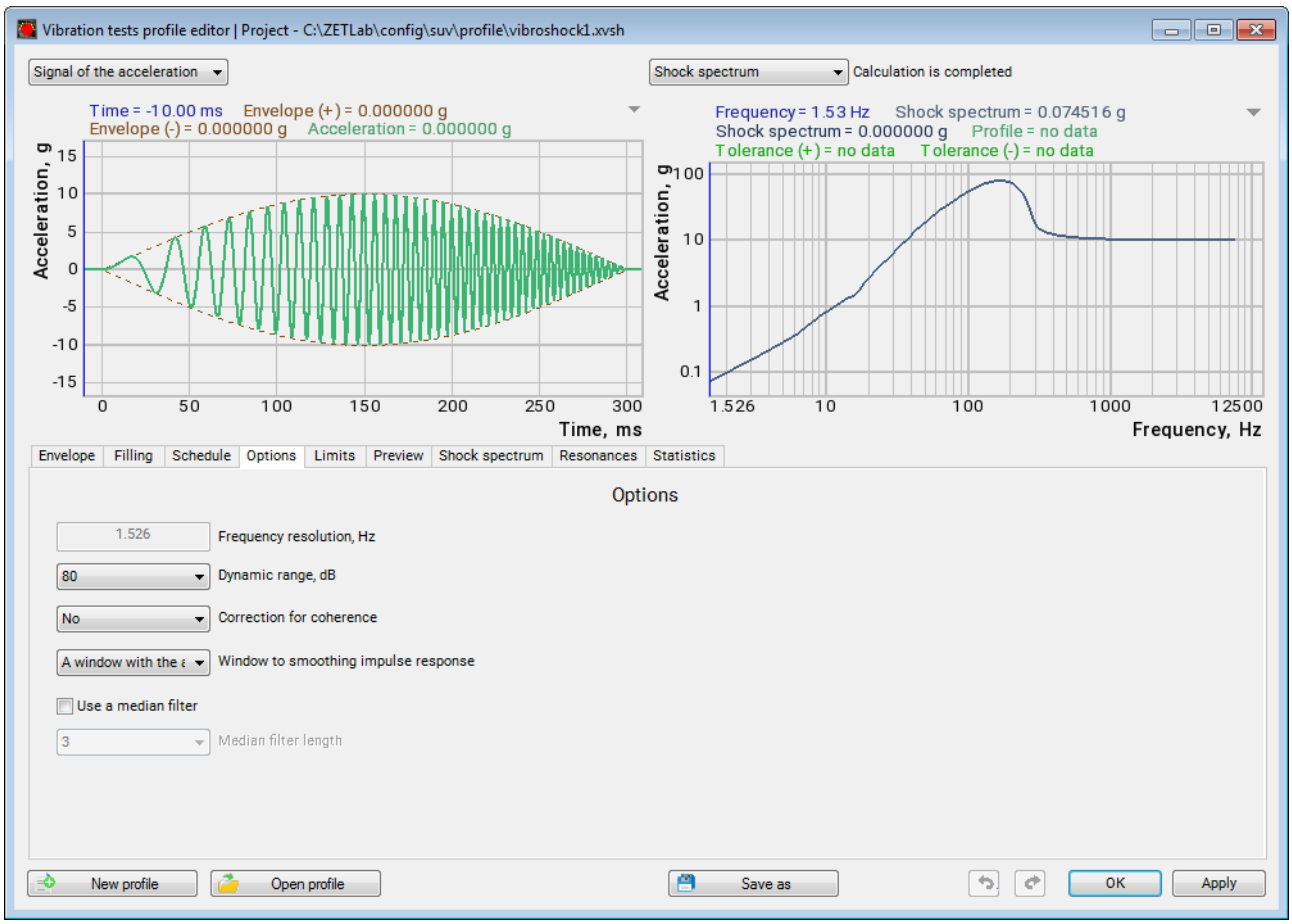


Figure 5.94 Profile Editor window, Options tab

To switch to the Limits tab (*Figure 5.95*), activate the relevant field in the Vibration Test Profile Editor.

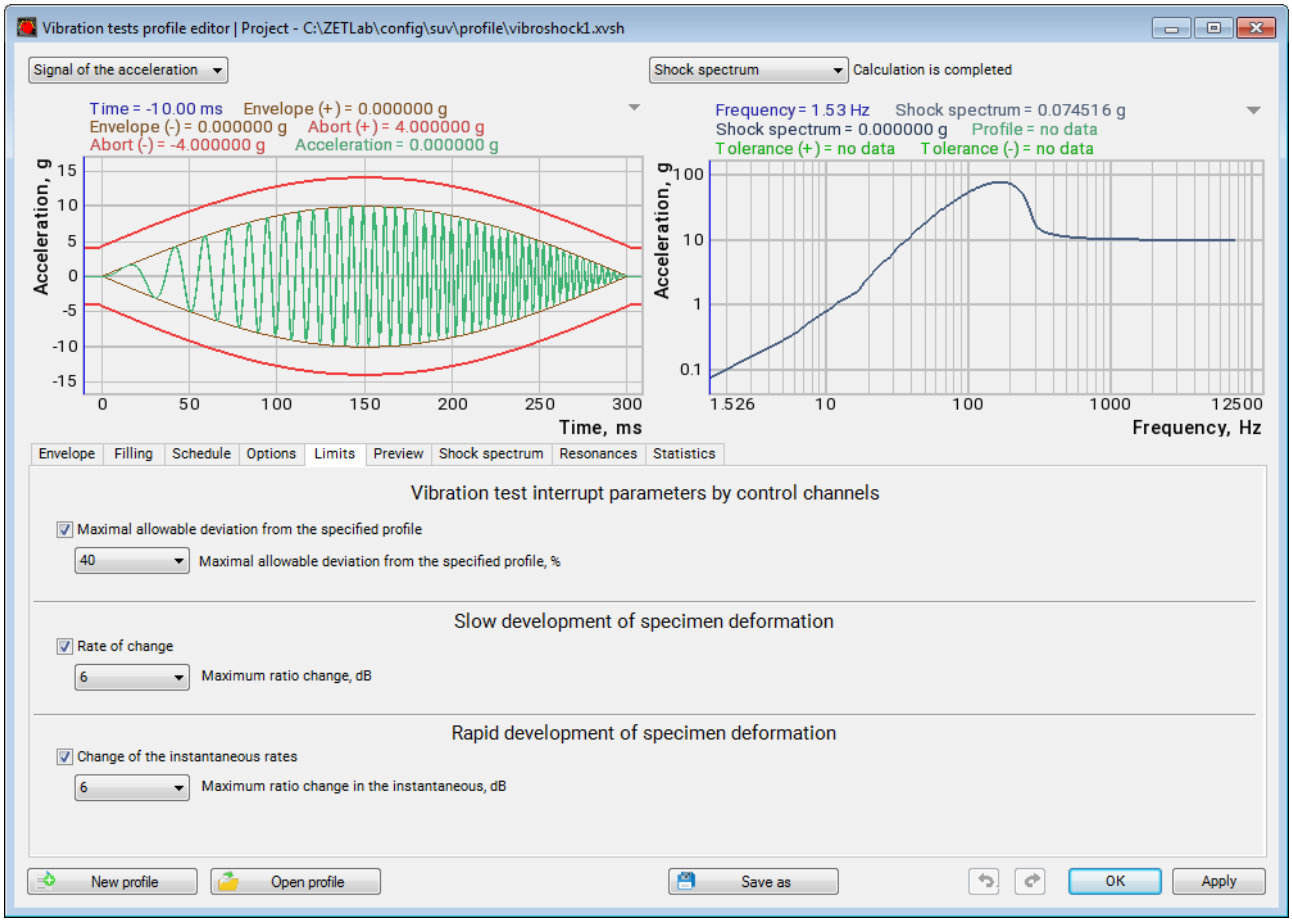


Figure 5.95 Profile Editor window, Limits tab

On the Limits tab, you can set the permissible test limits (as % of relevant measurement units) for the reference channel. The parameters with activated control (during the tests) will be monitored for exceeding the set limit values, and if so, testing shall be stopped immediately.

To activate parameter monitoring, set the relevant parameter flag, or clear the flag to deactivate monitoring.

In case of the reference channel, limits may be set for the following parameters:

- Maximal allowable deviation from the specified profile;
- Rate of change;
- Change of the instantaneous rates.

To switch to the Preview tab (*Figure 5.96*), activate the relevant field in the Vibration Test Profile Editor.

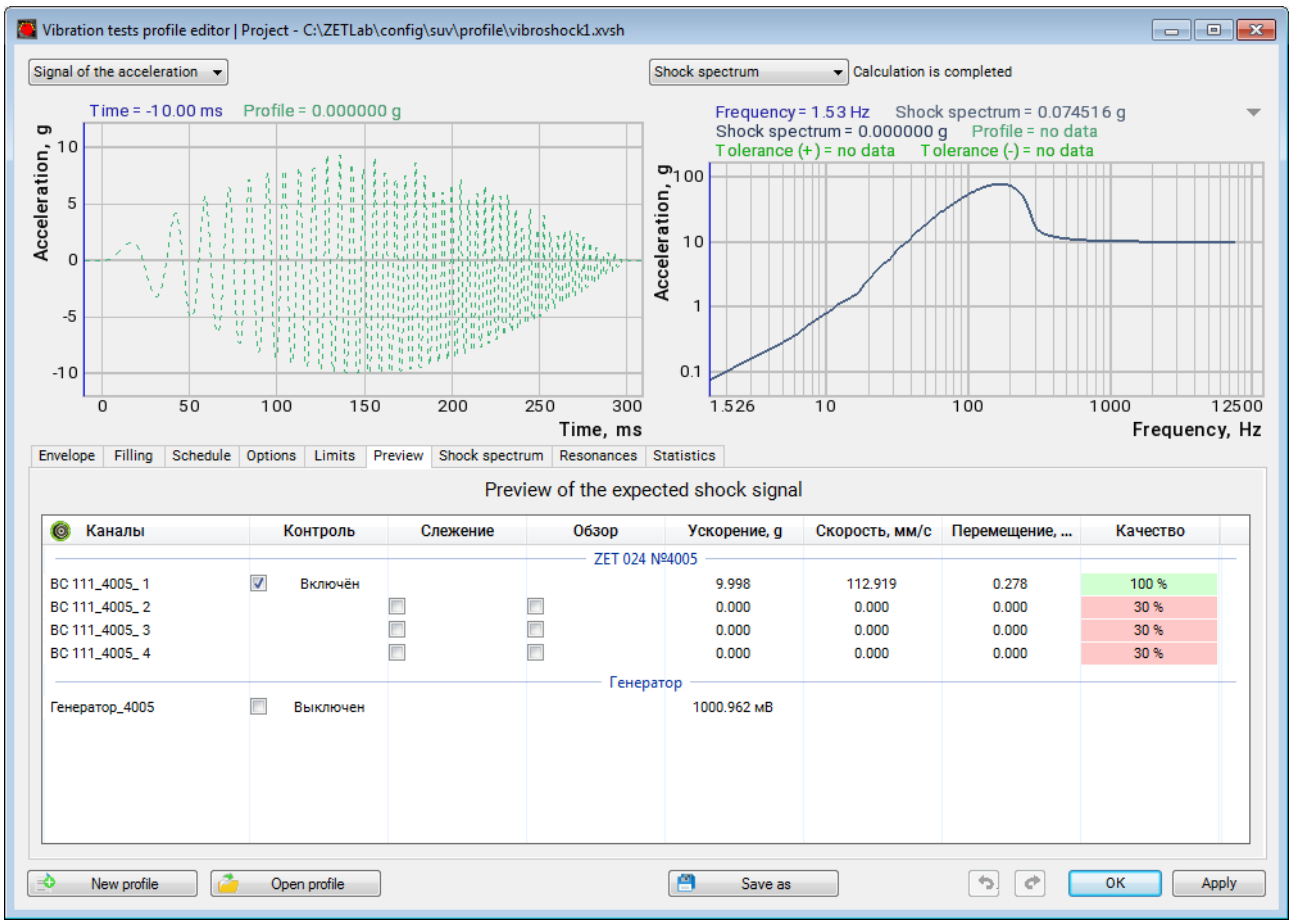


Figure 5.96 Profile Editor window, Preview tab

On the Preview tab, the set shock profile preliminary spectra built through calculations based on the pre-test data are displayed.

The spectra are provided for all the VCS controller measurement channels selected on the pre-test stage. For each measurement channel, you can set any control type (control, monitor, display) or check noise level in the channel. To display a required vibration spectrum, check the relevant cell in the table.

Note: *Information provided by the spectra is for information only; it is for providing the VCS operator with the expected results to be obtained in vibration tests using the set profile.*

To switch to the Shock Spectrum tab (*Figure 5.97*), activate the relevant field in the Vibration Test Profile Editor.

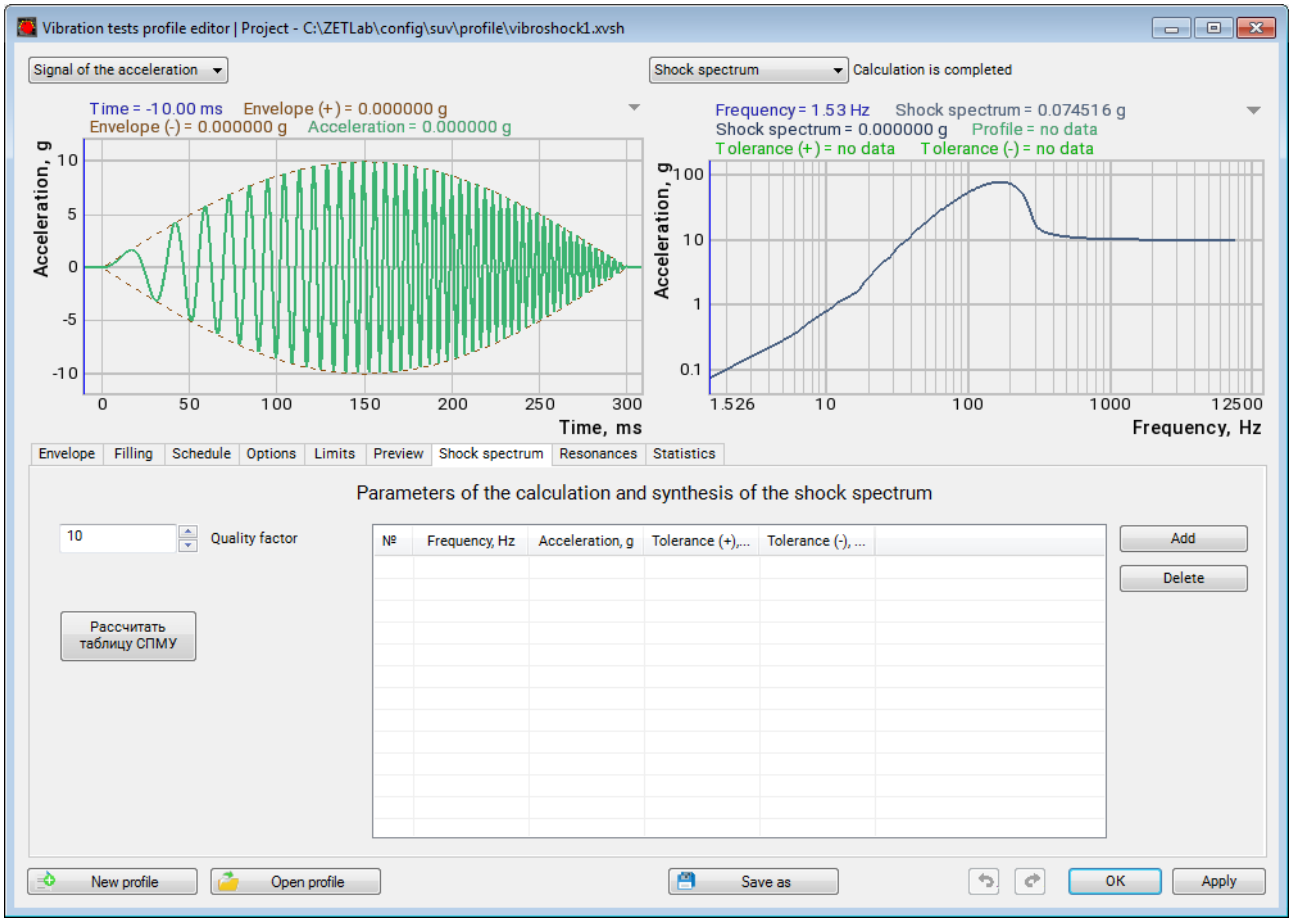


Figure 5.97 Profile Editor window, Shock Spectrum tab

Parameters for shock spectrum calculation are set on the Shock Spectrum tab.

To switch to the Resonances tab (*Figure 5.98*), activate the relevant field in the Vibration Test Profile Editor.

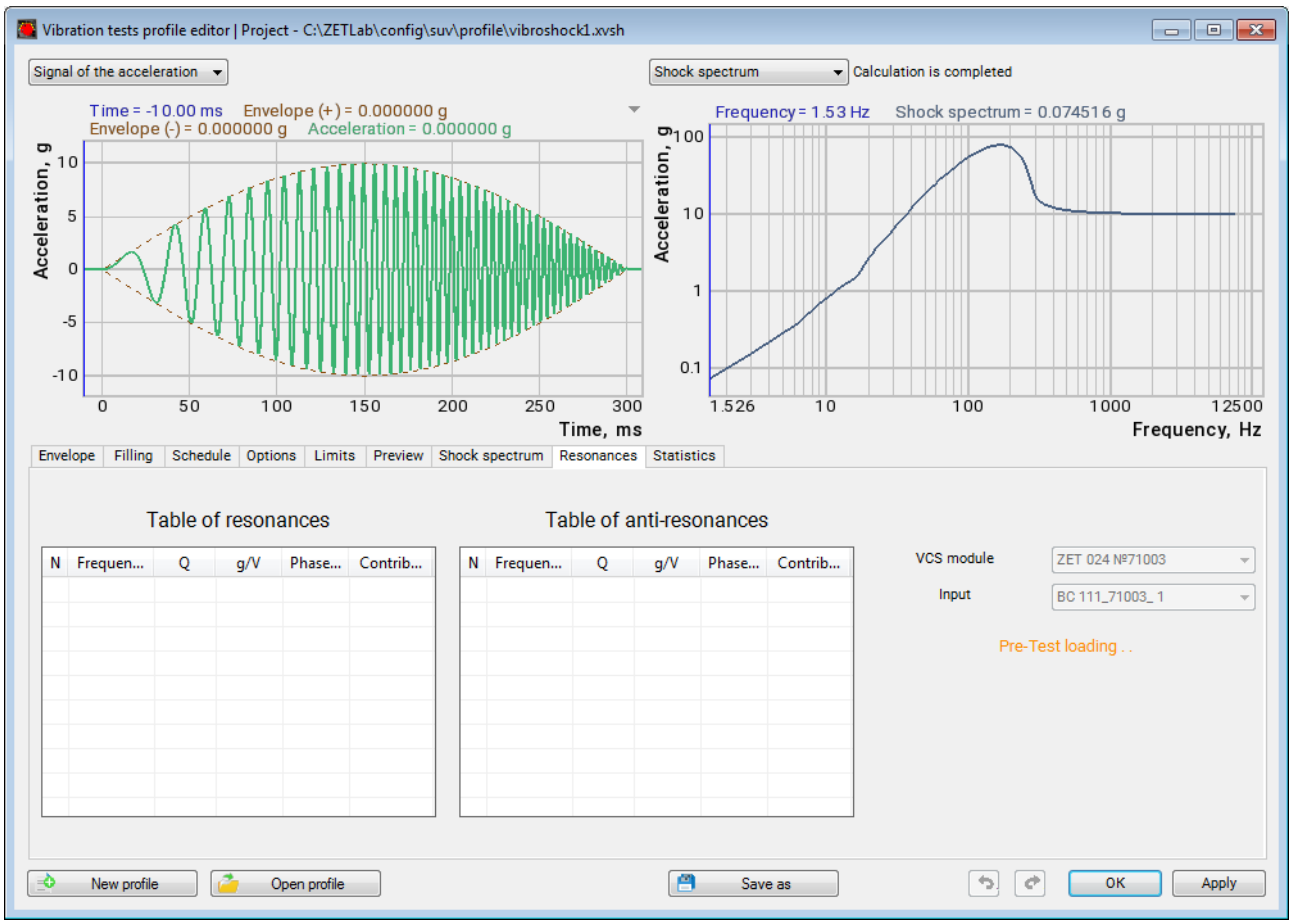


Figure 5.61 Profile Editor window, Resonances tab

The Resonances tab displays the statistical information calculated using the pre-test results. The tab allows the operator to estimate the presence of resonances and anti-resonances in the amplitude characteristic curve.

Note: *If required (for more detailed analysis), zoom in the amplitude characteristic curve on a frequency scale in the area of interest, and only those resonances and anti-resonances which fall inside the visualized section of the curve will remain in the table.*

To switch to the Statistics tab (*Figure 5.99*), activate the relevant field in the Vibration Test Profile Editor.

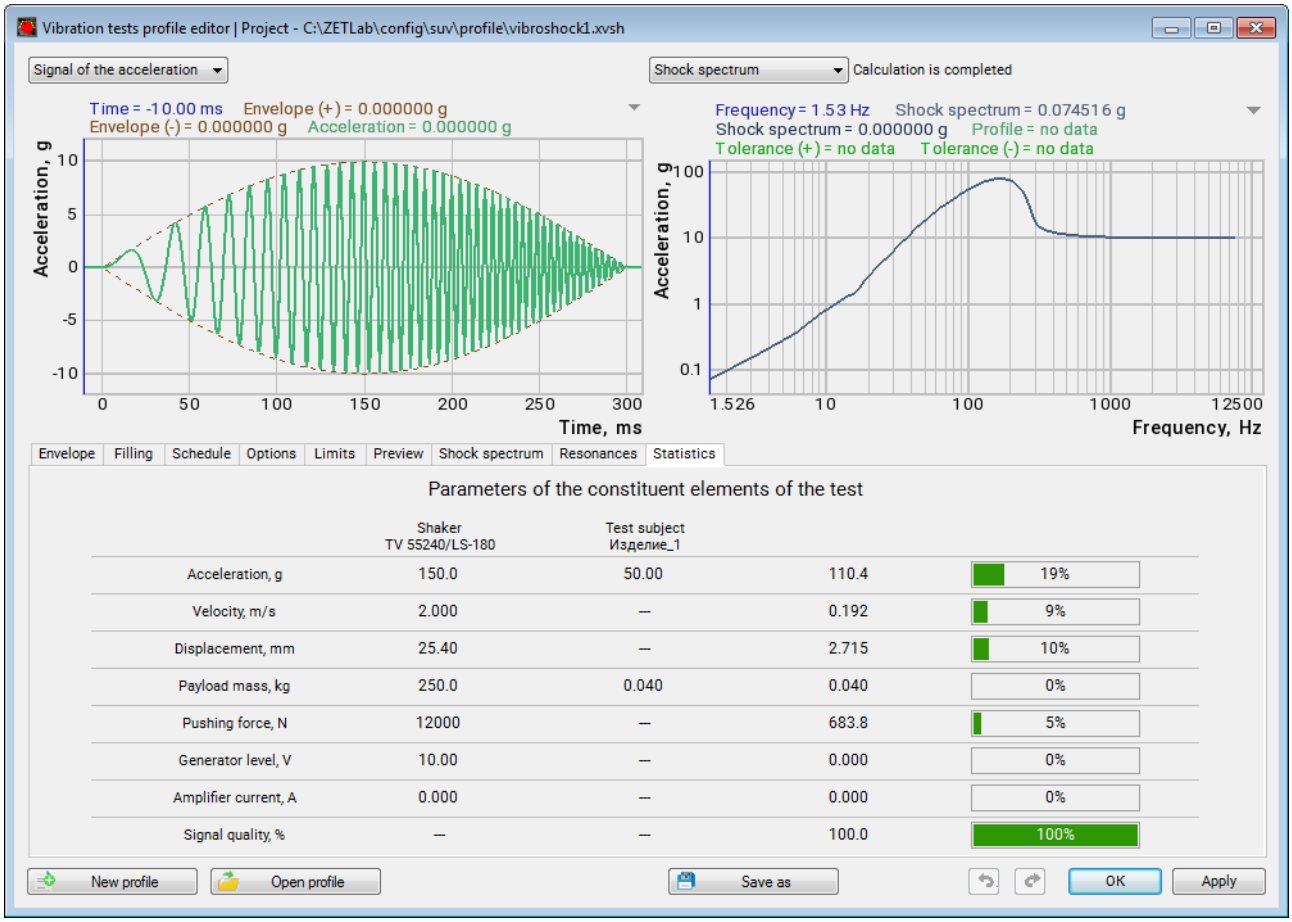


Figure 5.62 Profile Editor window, Statistics tab

The Statistics tab displays the statistical information calculated using the set values of the test profile parameters, giving the operator the possibility to estimate the shaker utilization during the vibration tests.

5.8.3 Testing

There is a coordinate grid in the center of the program window. During the vibration tests, it shows acceleration curves of the last registered shock, minimum and maximum tolerances.

Integral Indicators field in the right top corner contains the indicators of the current vibration test status (duration, speed, travel) and test parameter values set in the test profile.

Time field in the right bottom corner displays shock counters and timers. The Total counter displays the overall duration of the vibration test and the number of shocks. The Current counters display the time passed from the start of the test and the number of shocks registered. The Remaining counters display the time and number of shocks left. Vibration testing stops automatically when the Current counter reaches the value of the Total Shock Number parameter.

The event log in the lower part of the User Defined Transient window contains all information relevant to the program operation. After the program launch, the event log displays the information on successful loading of the pre-test file (*Figure 5.100*).

Current time	During the test	Description
12:19:30	00:00:00	Pre-Test files successfully uploaded
13:47:38	00:00:00	Profile updated

Figure 5.63 Event Log

Vibration tests are controlled from the dedicated menu in the right bottom area of the program window (*Figure 5.101*).

Figure 5.64 Vibration Test Control Menu

To start a vibration test, click the Start button. To stop a test at any moment, click the Stop button. To pause a test, click the Pause button, and the Start button to resume testing.

Click the Recording button to start/stop recording of electric signals from all the activated channels of the VCS controller. The recorded signals can be viewed in the Signal Gallery program from the Show ZETLAB Panel menu (refer to *ZETLAB Software. Operator manual*)

After clicking the Start button, the program will start vibration testing which will be reported in the event log (*Figure 5.102*).

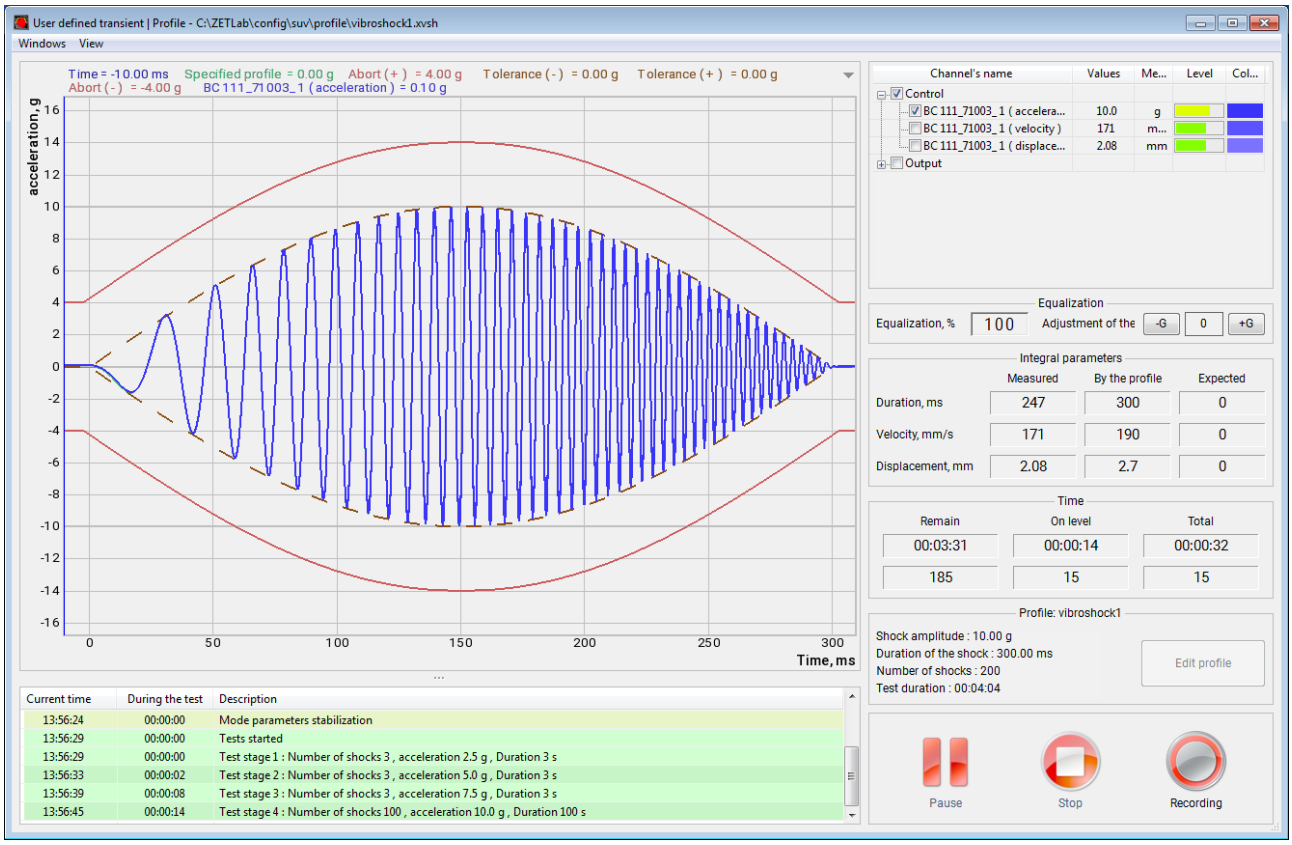


Figure 5.65 User Defined Transient window

To display a measurement channel curve, select it from the channel list in the right pane of the program window (*Figure 5.103*). This list includes all the measurement channels for which one of test control types (Control, Monitor, Display) has been selected in the Control Parameters program. The row with a measurement channel also shows information on the current acceleration and integral channel load.

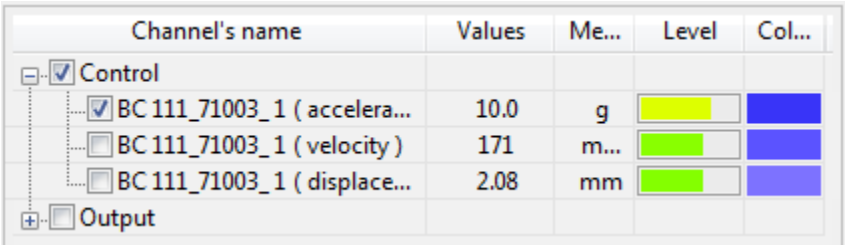


Figure 5.66 Menu for selecting channels to be displayed

During the test, if a value in the measurement channel exceeds the permissible limits set on the Control tab, it will be displayed in the event log, and the test will be stopped (*Figure 5.104*).

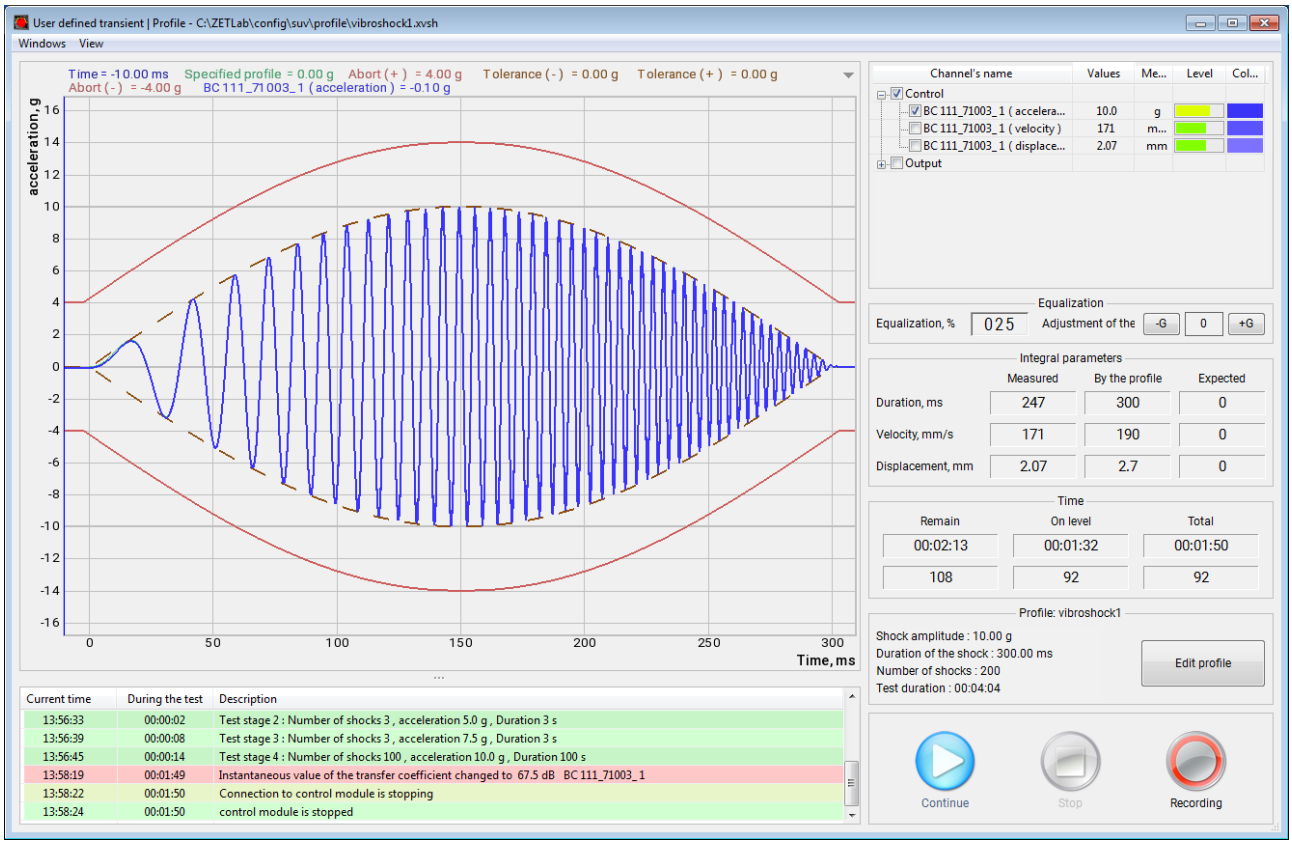


Figure 5.67 Vibration testing stop

During the tests, it is possible to track changes in the condition of the specimen under test at the point (s) of the control channel setup in real time. To do this, start the Additional Graphs program (*Figure 5.105*).

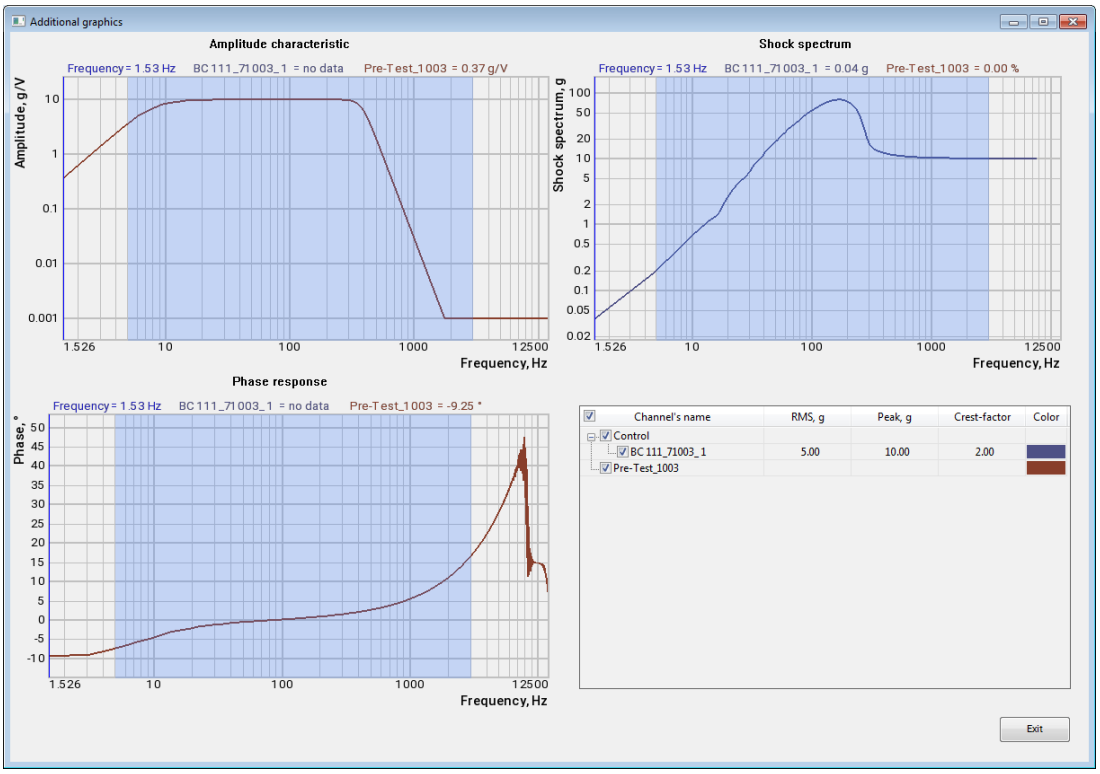


Figure 5.68 Additional Graphs program window

The charts of the Additional Graphs program display the deviations of the current spectrum values of a selected channel from the reference channel spectrum parameter values generated in the test profile after pre-test. The calculation may be performed using the reference channel or the oscillator channel.

To display information of the temporary implementation of signal parameters, start the Results table program from the Windows menu of the User Defined Transient program. The opened Results table window (*Figure 5.106*) will show information of the vibration test process in the past.

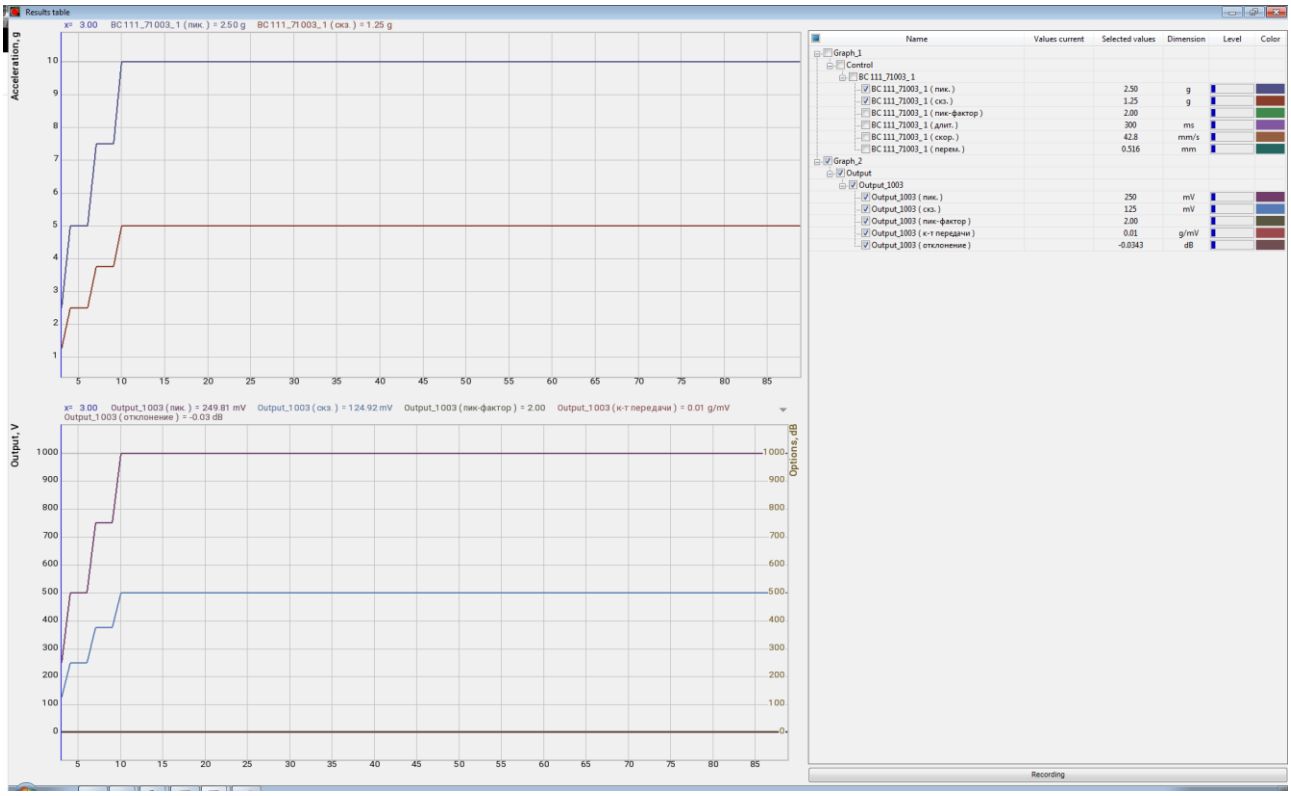


Figure 5.69 The Results table program window

The upper-right corner contains a list of the channels with available graphs. You can change the graph color by clicking on the colored rectangle. To save the recorder readings, click the Recording button. Only selected graphs available in the View Results program will be saved.

To save the report, run the Report command from the Windows menu in the User Defined Transient program. In the opened window, you can specify the name of report file and path to save it, and then click the Save button. The report is also saved automatically after the vibration tests are completed.

To view the report files, click the Test Results button on the VCS panel. In the opened window, select the appropriate test type and go to the Test Results folder. You can view the report files using the View Results program. To do this, right-click on the file and select Open in ResultViewer (*Figure 5.107*) from the context menu.

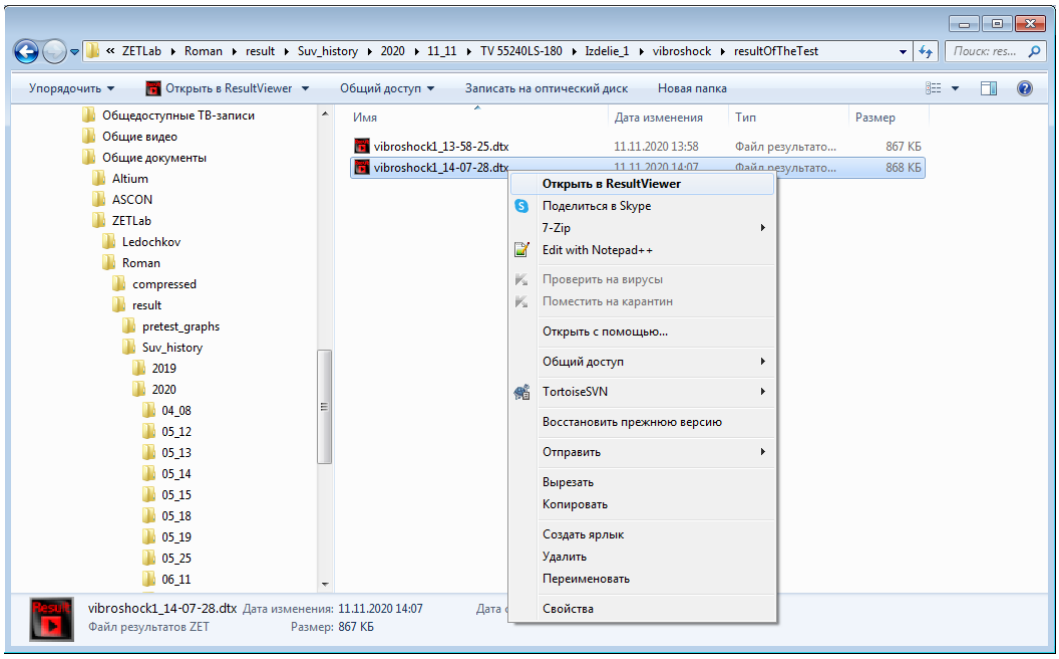


Figure 5.70 Report Directory

In the View Results program, the Graph tab displays the graphical part of the report on the completed test (*Figure 5.108*).

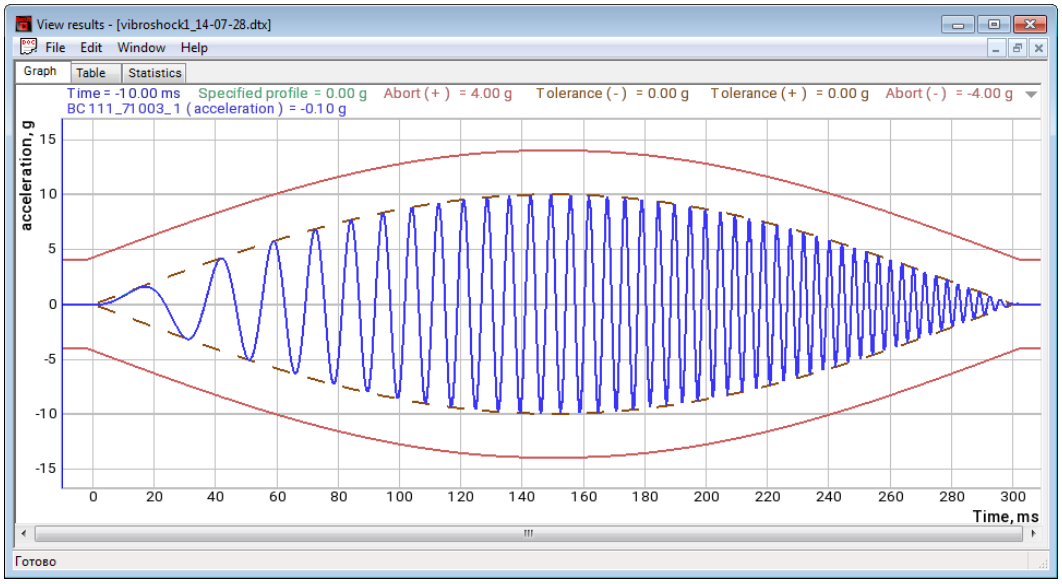


Figure 5.71 Example of a vibration test report

6 Terms and definitions

The main terms and definitions are listed in the table (Table 61).

Table 61

Accelerogram	Recording displacement, velocity, or acceleration as a time function
Accelerometer	Primary Converter (sensor) generating an electrical signal proportional to the registered acceleration
Amplitude	The largest (by module) instantaneous values determining the signal for the averaging period
Antiresonance	The frequency at which the response to the control signal (oscillator) is decreasing sharply (very small). Do not install sensors that will be assigned the Monitoring status (feedback channel) in areas of the test object with large anti-resonances. If there are high value antiresonances, you can use multipoint control (by selecting "by average" or "by maximum" control mode in the pre-test) for several sensors with Monitoring status whose antiresonances are inconsistent in frequency.
Vibration installation	The equipment including a shaker with a power amplifier
Imaginary reference point	A reference point to which a certain signal is assigned, produced by vibration signals from several verification points (with measuring channels in the Monitoring status) and used to control the test mode (multipoint control) so that to meet the test requirements
Reproducibility	The proximity of measurement results of the same dimension with the same value carried out by different methods, with different primary converters (sensors), by different operators, in different testing laboratories, at different times, the interval between which is significantly longer than the time of one measurement.
Averaging time	The time interval for sampling instantaneous signal from the recorded stream to the instantaneous value array for further processing of the array.
Boundary points	The points used for building vibration test profiles for sinusoidal vibration and broadband vibration
Effective vibration	Vibration characterized by signal from a sensor installed at the reference point.
Decibel (dB)	The unit of measurement of a physical quantity relative to the selected reference value, expressed as the logarithm lg (based on 10) of the ratio of the physical quantity value to the reference value. In the ZETLab vibration control system, the reference value is equal to one; therefore, for converting values in linear physical quantities "x" to dB, the formula is: dB = 20lg(x), and in the case of physical quantities with the power dimension "x2", the formula is: dB=10lg(x2)

Dynamic range of the measuring channel	It is defined as the ratio of the maximum level of recorded signals to the minimum recorded level. The theoretical limit for a 24-bit ADC is 140 dB, but the actual dynamic range is reduced due to interference and distortion in the system.
Dynamic range of the control signal	It is defined as the ratio of the maximum value of the signal generated on the control channel to its minimum value. For sinusoidal vibration mode, if the control signal changes from 1 mV to 10 V, the dynamic range is 10000 times = 80 dB. For broadband random vibration (BRV) mode, the maximum value and minimum value of the control signal are measured by the power spectral density. The dynamic range of the vibrating system in whole is determined not only by the dynamic range of the VCS's DAC controller, but in any particular test may be limited to other factors, such as noise level at the shaker table (recorded without control signal), a dynamic range of the vibratory installation, the maximum allowable vibration level in testing, etc.
Duration of the shock pulse	The time interval from the beginning to the end of the shock pulse which is a significant part of the accelerogram
Quality factor	This is a measure of resonance sharpness which is inversely proportional to the logarithmic decrement of attenuation. When testing specimens with high-quality resonances for sinusoidal effects, set high frequency resolution (a large number of frequency bands) and reduce the frequency scan speed
Units	You can connect sensors to the VCS controllers inputs to record various physical quantities, such as acceleration (m/s^2, mm/s^2, g), displacement (m, mm, micron), velocity (m/s, mm/s), therefore, to obtain valid results, for the measurement channels set units which correspond to the types of sensors being connected. *Note: Units of measurement for primary converters (accelerometers) are listed in their respective datasheets.*
Significant part of the accelerogram	For a classic shock: a part of the accelerogram between two points in time, when the signal reaches 10% of the peak value for the first time and when it falls below this level for the last time. For a vibration shock: a part of the accelerogram between two points in time, when the signal reaches 25% of the peak value for the first time and when it falls below this level for the last time
Measuring channel (monitoring/tracking/viewing)	The input channel (ADC channel) of the VCS controller with connected primary converter used for vibration tests. Measuring channels can be assigned the Monitoring, Tracking, and Viewing status during vibration testing. The Monitoring status determines that data from the measuring channel are used for generating a control signal, including an emergency stop of vibration tests upon exceeding the thresholds defined on the Profile tab of the test profile editor window.

	The tracking status indicates that measurement channel data are used to initiate an emergency stop of vibration tests when the thresholds defined on the Stop tab of the test profile editor window are exceeded. The Viewing status indicates that measurement channel data are not involved in the vibration tests control and are only used for visualization of the recorded signals.
Instrumental error	A set of errors introduced by both analog devices connected to the controller inputs and the VCS controller itself.
True spectral density of acceleration	The spectral density of acceleration affecting the specimen under test.
Feedback channel	The control system channel is used for: signal digitalization at the reference point, signal processing and conversion of the processed signal into analog format to feed to the power amplifier of the shaker.
Control channel	The VCS controller's oscillator channel used for generating the control signal.
Emergency stop button	The button located to the right on the front panel of the VCS controller and intended for emergency stop (STOP mode) of transmitting control signal to the shaker.
VCS controller	ZET 024 or ZET 028 model devices provide one output control channel (DAC) and, respectively, four or eight measurement channels (ADC).
Reference point	One of the verification points (with the measuring channel with Monitoring status), the signal from which is used to control the test mode (single-point control) in a way to meet the test requirements.
Correction	Procedure for minimizing the error in reproducing the acceleration spectral density
Maximum control voltage	Voltage threshold at the control channel (oscillator) output of the VCS controller
Instantaneous value of the signal	The signal amplitude value registered for a single ADC count.
Multipoint control	Control by signals averaged by analog method or other suitable mean, recorded by measuring channels from vibration sensors installed at several verification points.
Observed acceleration spectral density	Visualized acceleration spectral density on the VCS monitor, including instrumental error, random error, and offset.
Test Object	A specimen subjected to vibration tests.
Single-point control	Control by a signal recorded by the measuring channel from the vibration sensor installed at the reference point, to keep the specified vibration level at this point.
Cutoff of the drive signal	Limiting the maximum drive signal at the level determined by the peak factor value.

Primary converters	Sensors converting various physical quantities (acceleration, velocity, displacement, deformation, temperature, etc.) into an electrical signal proportional to the effect of the physical quantity.
Peak factor	The ratio of the peak value to RMS value of the signal.
Error in reproducing the acceleration spectral density	The difference between the specified acceleration spectral density and the acceleration spectral density of the control signal.
Transverse vibration	Vibration acting in a direction other than the specified direction (usually defined in two orthogonal axes in a plane perpendicular to the specified direction of movement. Please note that the transverse vibration must be measured close to the attachment points.
Preferred directions of vibration effect	Three mutually orthogonal directions chosen to ensure the maximum probability of damage to the test object in case of vibration exposure in these directions.
Verification point	The sensor installation points (with measuring channels with Tracking status) on the attachment device, vibration table or test object, located as close as possible to the attachment points of the test object (rigid connection) and used to monitor compliance with the test requirements.
Vibration test profile	Defines a profile required by the test conditions, which must be provided during vibration tests by generating a required signal through the control channel. For tests with broadband random vibration and sinusoidal vibration, the profile is determined in the frequency domain, and for tests in shock mode - in the time domain.
The frequency resolution	The width of the frequency increment interval in the acceleration spectral density view (in Hz)
Recording	Processing a set of readings (recorded in measuring channels at regular intervals) using the fast Fourier transform algorithm.
Control mode (by one, by average, by maximum)	There are three control modes used as a basis for generating control signal: in "by one" mode, the control signal is generated based on data recorded in a single control channel. In the "by average" mode, the control signal is generated based on the average values recorded in a group of channels selected for control. In the "by maximum" mode, the control signal is generated based on the maximum values recorded in a group of channels selected for control. The "by average" mode and "by maximum" mode refer to multipoint control.
STOP mode	In this mode, the emergency stop button on the right pane of the front panel of the VCS controller is pressed.
Resonance	The frequency at which the response to the control signal (oscillator) increases sharply (very high). When examining the specimen's fatigue characteristics, exposure to resonant frequencies is used.

Profile segment	A section of the vibration test profile bounded by adjacent frequency boundary points
Control signal	Output voltage of the control channel (oscillator) of the VCS controller used to excite the shaker
Signal attenuation rate	When stopping vibration tests, the control signal (oscillator) must attenuate smoothly, otherwise the test object may be subjected to shock. The control signal strength reduction can be selected from 20 dB/s to 60 dB/s
Random error	Error in estimating the acceleration spectral density that varies from one measurement to another and is caused by finit time of signal averaging and the finite filter bandwidth
High-frequency roll-off	A section of the acceleration spectral density at frequencies higher than the upper limit of the effective test frequency range
Low-frequency roll-off	A section of the acceleration spectral density at frequencies lower than the lower limit of the effective test frequency range
Acceleration spectral density	Frequency function defined as the threshold ratio of the average square of the acceleration signal value after it passes through a narrowband filter, whose geometric mean frequency is consistent with the specified frequency, to the filter bandwidth when the bandwidth tends to zero, and the averaging time tends to infinity.
The acceleration spectral density of the control signal	Acceleration spectral density of a signal measured at a reference point (real or imaginary)
Signal RMS	The square root of the sum of squares of instantaneous signal values recorded during averaging
Standard deviation	The characteristic of a random time signal that is consistent with the RMS value for a vibration signal
Static degree of freedom	A value that characterizes the properties of estimating the acceleration spectral density obtained by random samples with time averaging method, and depends on the frequency resolution and time of averaging.
Static accuracy	The ratio of true acceleration spectral density to the observed one
Response measurement point	Sensor installation points (with measuring channels with Viewing status) on the test object, the signals from which are not involved in the vibration test control, but used only for examining its frequency response.
Attachment point	A part of the test object which is in contact with the attachment device or vibration table in the place where it is usually attached during operation. If a device used during the operation of the test object is used for testing, the attachment point is determined on this device rather than on the test object.
Control by the maximum value	A method for determining the signal in multipoint control by selecting the maximum value of the controlled parameter for each frequency component at least in two verification points whose measuring channels are assigned the "Monitoring" status

Control by average value	Method for determining the signal for multipoint control by averaging each frequency component at least in two verification points whose measuring channels are assigned the "Monitoring" status.
Acceleration	A vector value determining the degree of speed change over time.
Acceleration of gravity	Acceleration of gravity is rounded to the closest integer, i.e. up to 10 m/s2.
Averaging (linear/exponential)	The time interval during which instantaneous signal values are sampled from the recorded data stream to the array for further array processing. It is used to improve statistical accuracy or suppress interferences. In case of linear averaging, each data element contributes the same amount to the average value. Linear averaging is usually used for limited time intervals, since for large time intervals, the last added values actually no longer affect the resulting averaged value. In case of exponential averaging, each last averaged value has a greater weight than those involved in the averaging earlier, so it can be used at infinite intervals. The average value will dynamically reflect the influence of the new recorded values involved in averaging, and the influence of the previous ones will decrease as they age. The degree of exponential averaging is determined by a weighting factor calculated as reciprocal value of the number of averaging.
Frequency	The number of vibrations or cycles per unit of time. Unit of measurement is Hz.
Sampling rate (sampling)	In relation to the measuring channels, it refers to the number of analog-to-digital conversions per second for each recorded measuring channel, in relation to the control signal, it refers to the number of digital-to-analog conversions per second when generating the control signal. The ZETLAB programs processing a digital signal require a data array from a set of recorded instantaneous values of the processed signal amplitude accumulated during averaging, and the frequency of recording instantaneous values is determined by the sampling rate. Thus, the higher the sampling rate, the larger the array becomes at the same averaging time. The accuracy of the measurement results is directly related to whether the averaging time and sampling rate are properly configured. The best measurement results are achieved when providing the required level of detail without unneccesary redundancy. For VCS with max. 48 channels, the sample rates are set to 25 kHz for measuring channels and 50 kHz for control channels. For VCS with 49 to 160 channels, the sample rate values are set to 2.5 kHz for measuring channels and 5 kHz for control channels.

Resonance frequency	The frequency value typical for an object susceptible to vibration, at which the following is recorded: increase in vibration amplitude of the object and the difference between the vibration effect phase and oscillation phase of the object equal to 90 degrees
Frequency range for testing	The range between the lower and upper limit in the frequency domain defined in the test profile.
Number of degrees of freedom	Indicates the number of independent variables used in calculating the average value. It is used in averaging for the broadband random vibration control. Each averaging adds two degrees of freedom. The more degrees of freedom, the more accurately the spectral power density of the broadband signal is calculated
The peak width at -3 dB	The bandwidth between two frequency response points located at 0.708 of its maximum value, assuming that the frequency response in this bandwidth describes a single resonance peak
Broadband random vibration (BRV)	The signal generated on the control channel (when testing BRV) is noise randomly distributed over a wide range in the frequency range
Stage of tests	A test program element occupying a line in the schedule table
Effective test frequency range	The range between the lower and upper limit in the frequency domain defined in the test profile. Remember that beyond the effective frequency range, there are also signal components due to lack of sharp drop in the acceleration spectral density curve at the profile boundaries.

Appendix A. Shapes of the shock pulse accelerograms

The ***Figure A1-Figure A5*** show the accelerogram shapes of waveforms being generated with specified parameters.

T (duration of shock, ms) refers to the duration of the signal of the corresponding waveform.

A (amplitude of blow, g) refers to peak value of vibration acceleration.

T1 (rise time, ms) refers to the time to reach the maximum value for the trapezoidal waveform.

T2 (decay time, ms) refers to the time when the signal drops to the minimum value, for trapezoidal and sawtooth pulses.

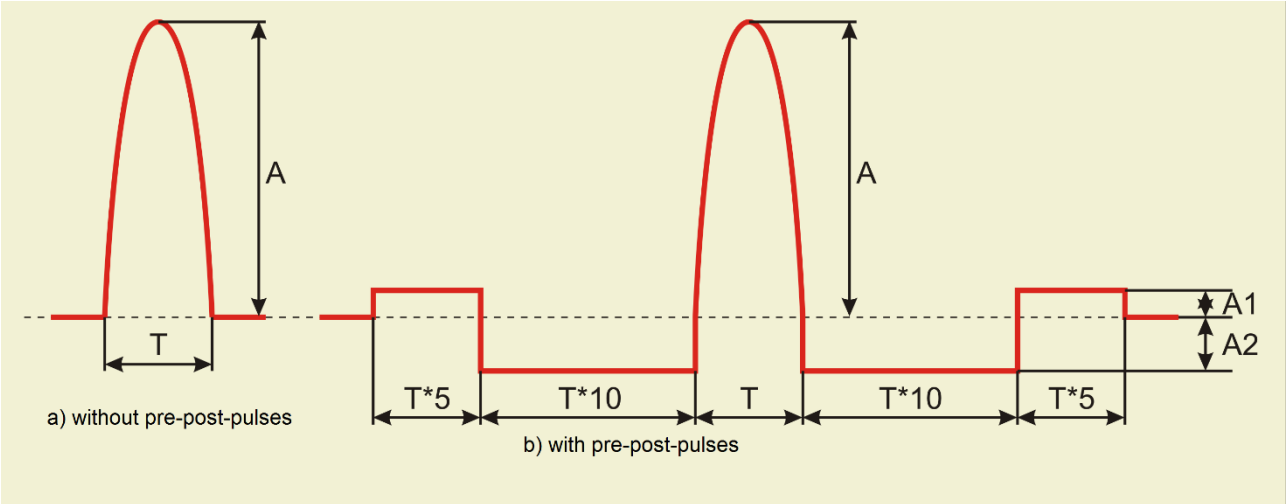


Figure A1 Sinusoidal waveform

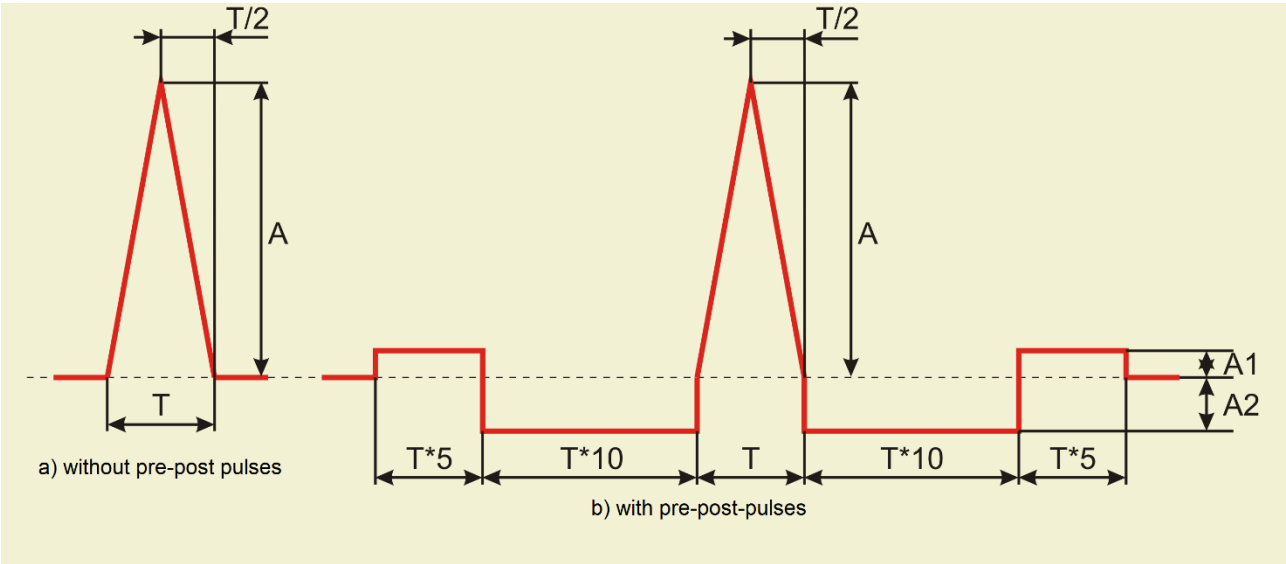


Figure A2 Triangular waveform

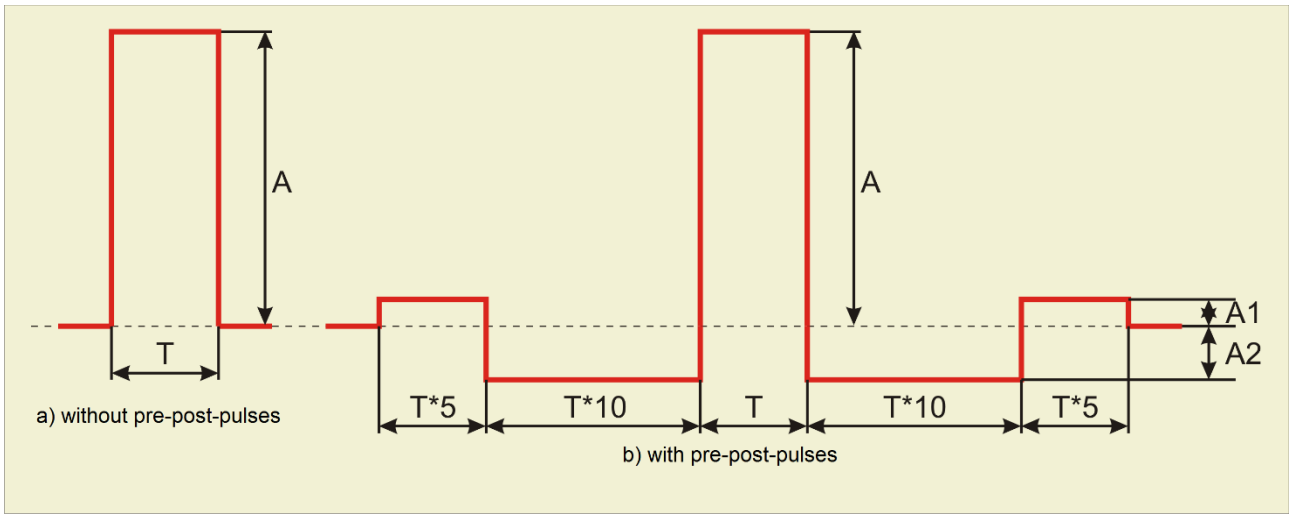


Figure A3 Rectangular waveform

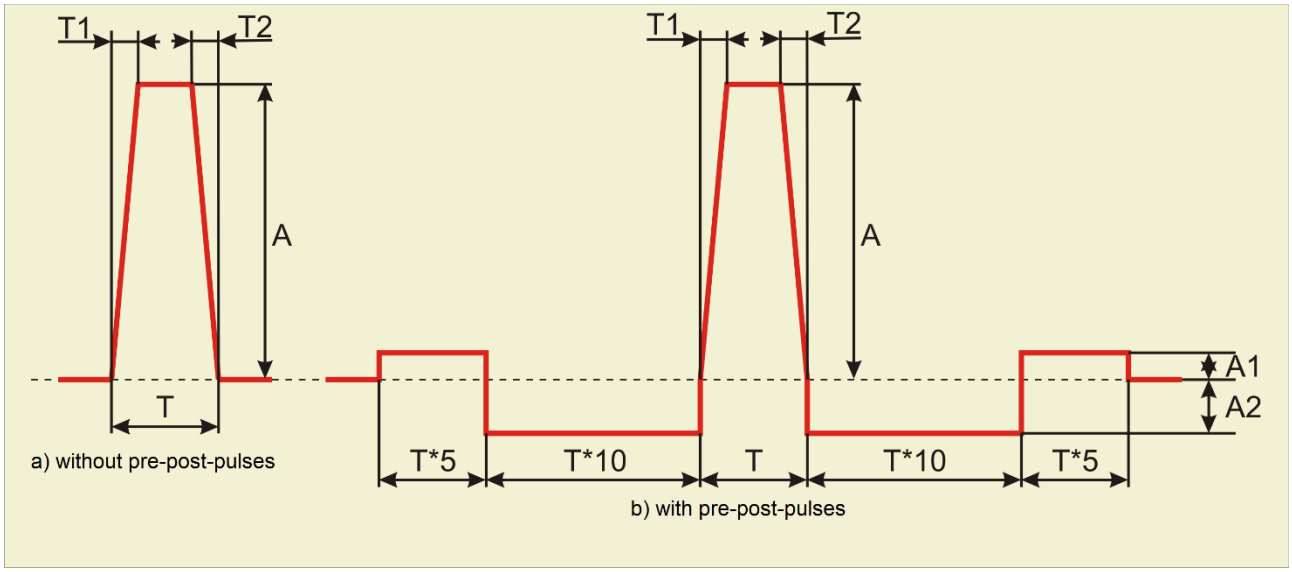


Figure A4 Trapezoidal waveform

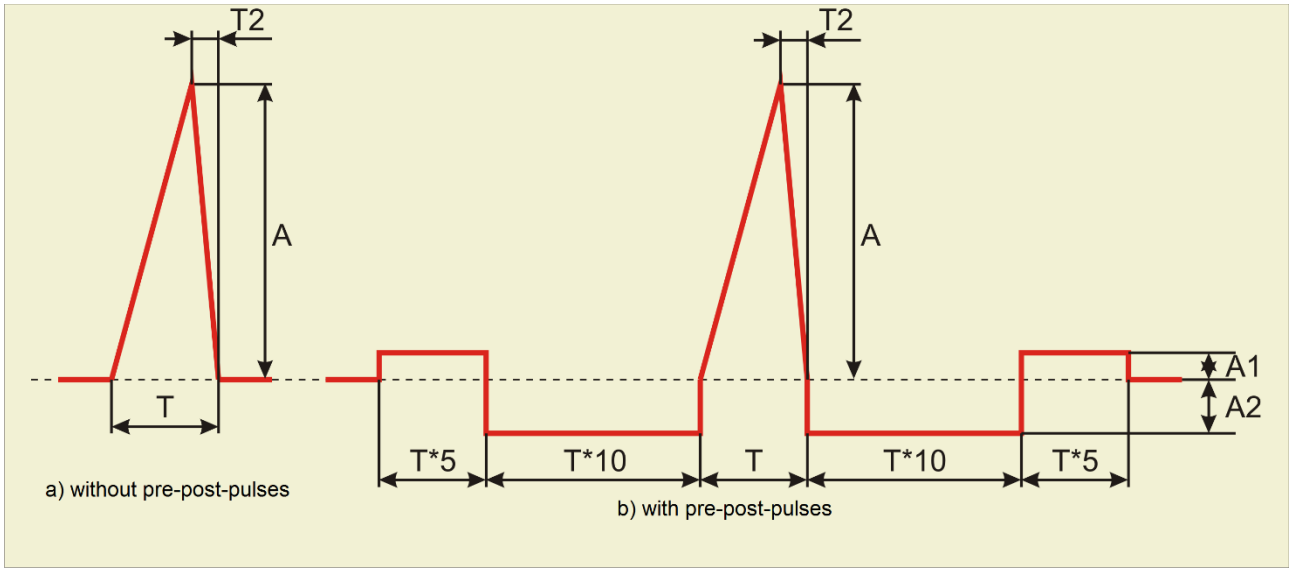


Figure A5 Sawtooth waveform

Appendix B. Common errors when operating ZETLAB VCS

1. Low pre-test quality due to poor contact of the control signal cable

Figure B.1 shows an example of a negative pre-test result obtained on a shaker with an extension table. The conclusion on the low pre-test quality is mainly based on the high harmonic distortion factor (close to 0 dB). The Signal Quality parameter (in the results table) also indicates the low results quality. Its value is below 90 % (highlighted in yellow or red).

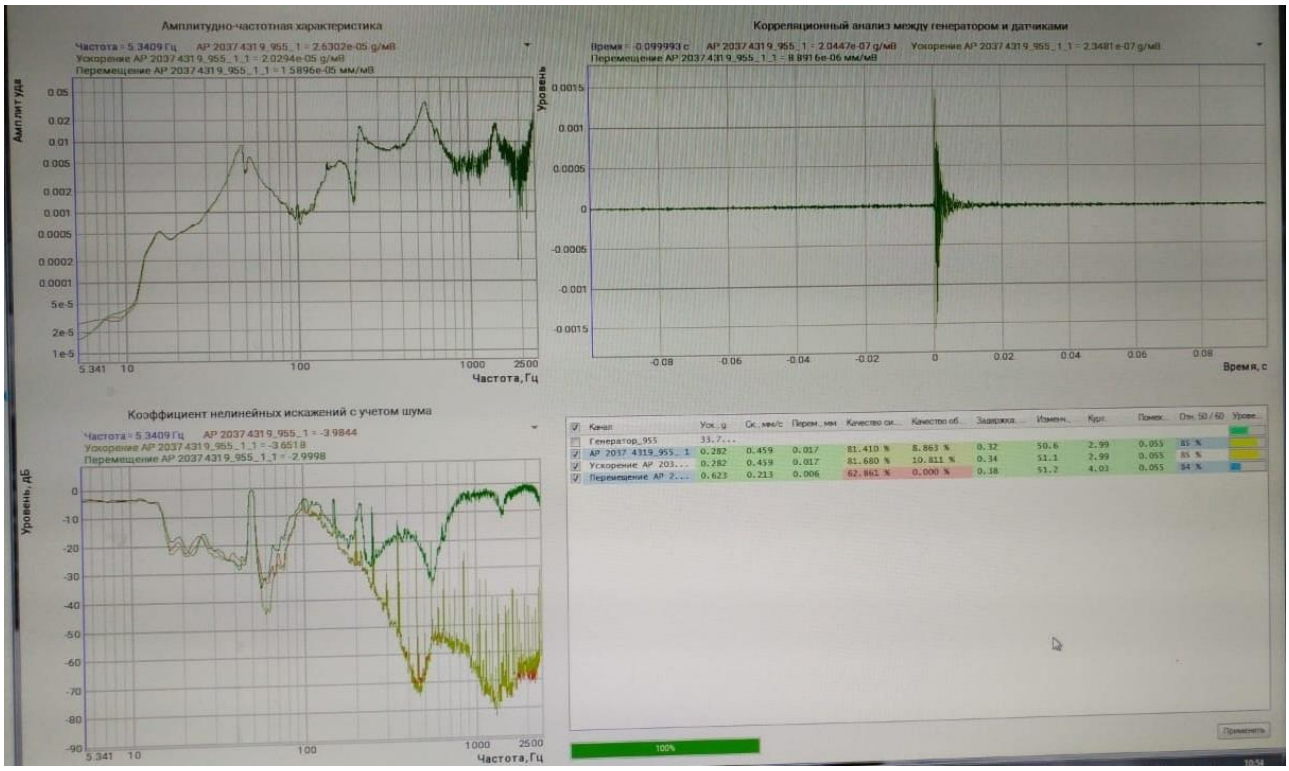


Figure B.6. Negative pre-test result

In this case, it is needed to identify and rectify the cause of the negative pre-test result before the commencement of testing. To do this, click the Recommendations button in the Pre-Test program window and in the appeared window check the suggested options of probable failures. Eliminate the cause, if relevant. If nothing of the suggested recommendations gives the result, try the options below, one by one:

- poor grounding,
- poor contact,
- damaged cable,
- failed sensor.

After fault handling, repeat the pre-test and make sure that the result is positive. *Figure B.1* shows an example of a positive pre-test result after handling a fault related to poor contact of the control cable.

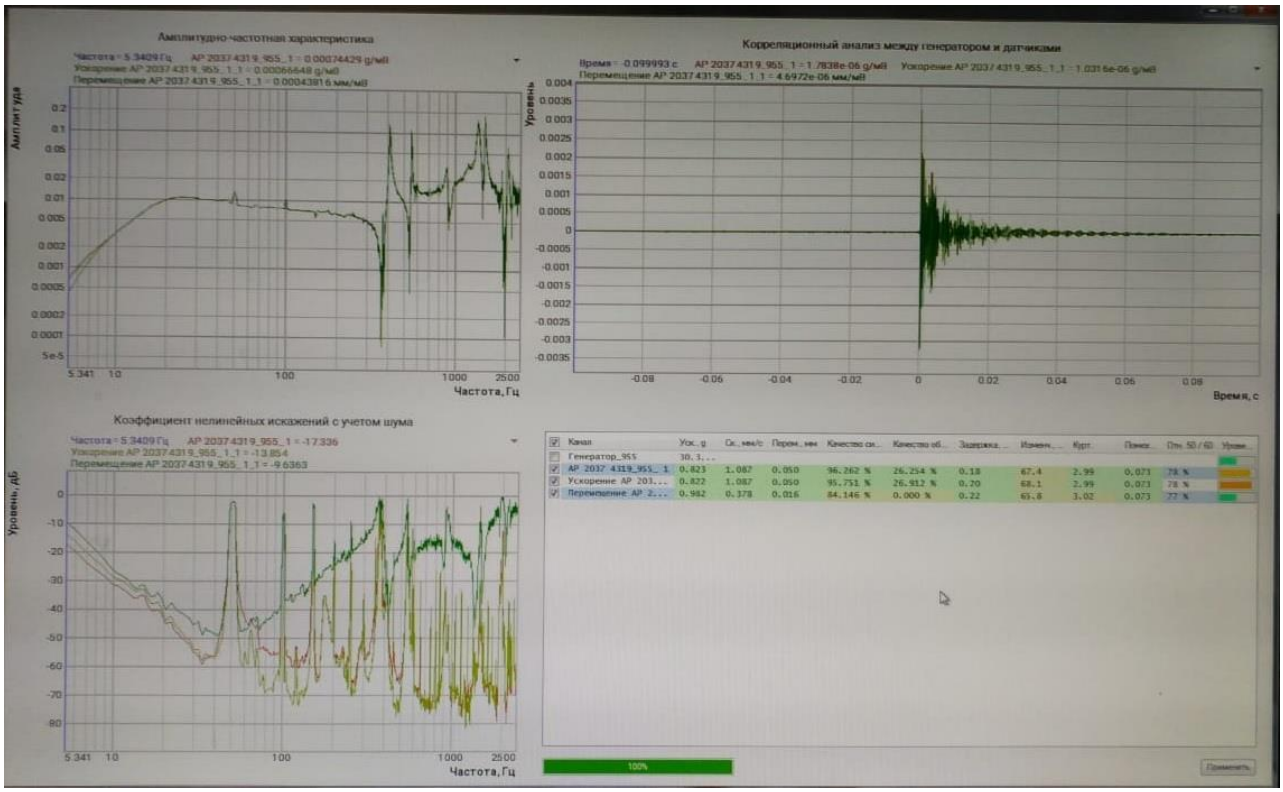


Figure B.7. Positive pre-test result

2. Poor pre-test quality due to poor grounding

Figure B.3 shows an example of low quality of a pre-test result obtained on an empty shaker (without an extension table). The conclusion on the low pre-test quality is mainly based on the high harmonic distortion factor in the low-frequency region (exceeding -20dB). The Signal Quality parameter (in the results table) also indicates low quality of the pre-test results for an empty shaker. Its value is below 98%. A positive result of pre-test (for an empty shaker) is at least 99% signal quality level.

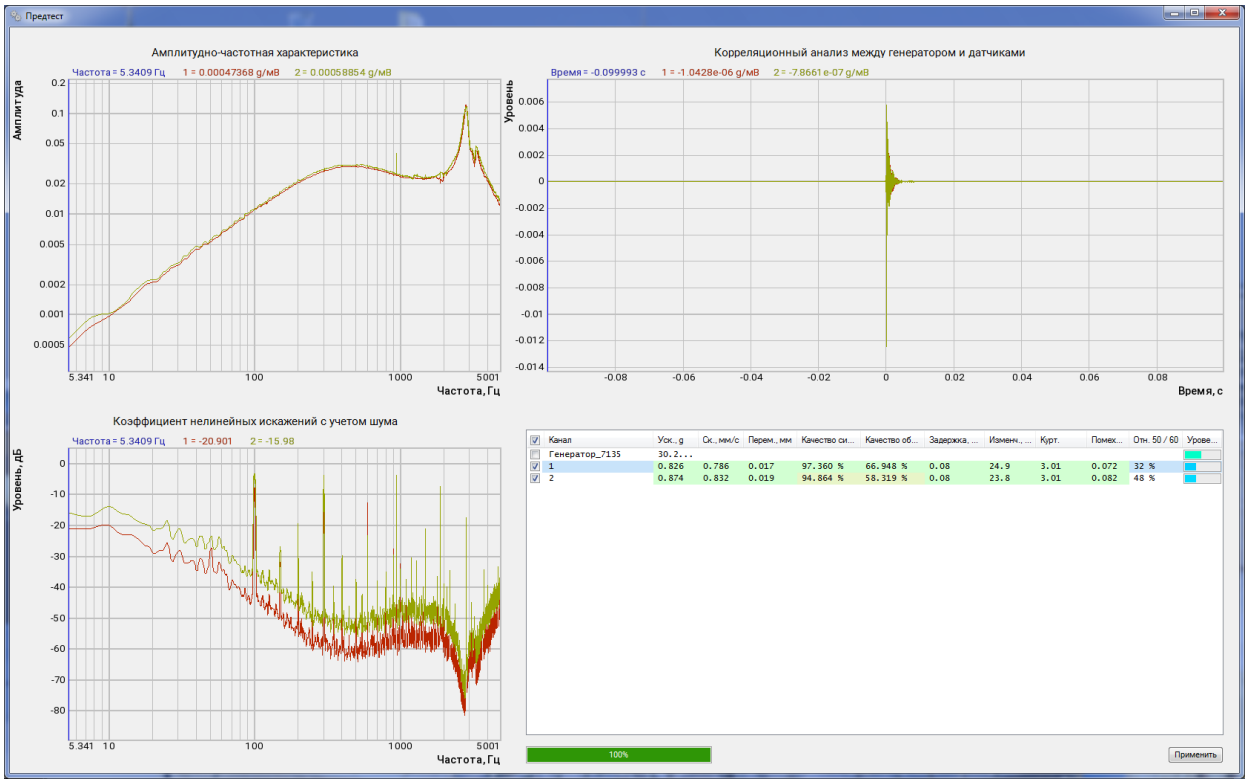


Figure B.8. Low pre-test result quality

After proper grounding, the pre-test was repeated. Its results are shown in *Figure B.4*. The figure shows that the harmonic distortion factor decreased significantly (below -30 dB) and the signal quality increased (above 99 %).

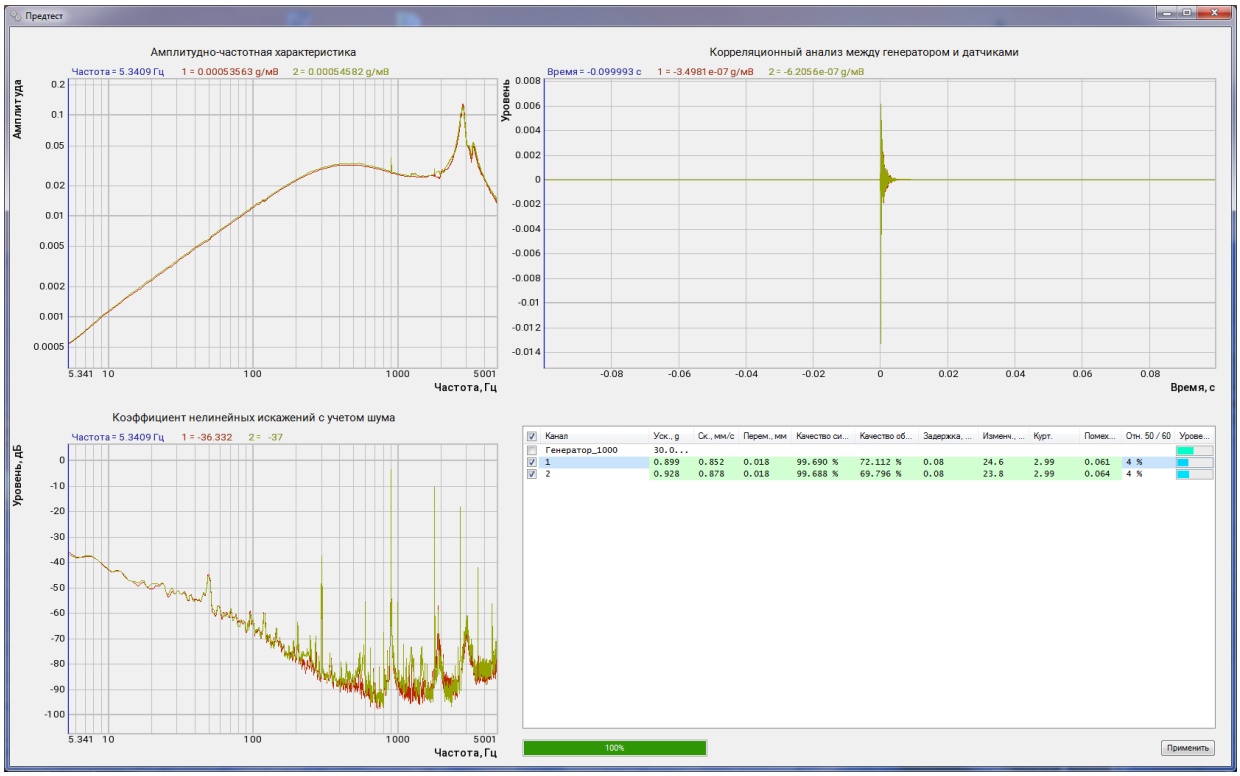


Figure B.9. High pre-test result quality

3. Influence of the shaker frame's horizontal position on the transverse vibration level

Figure B.5 shows harmonic distortion curve plotted at a small deviation of the shaker frame from the horizontal position (within 2 degrees), while *Figure B.6*, at the frame horizontal position. During the comparative tests, the shaker was loaded to 60 % of the maximum permissible load, and the effect level was 25 % of the maximum permissible level considering the installed weight.

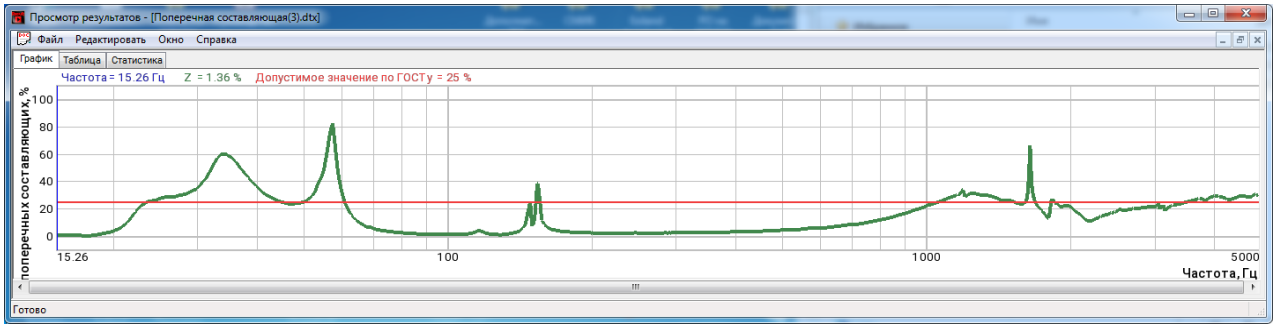


Figure B.10. Frame deviates from the horizontal position

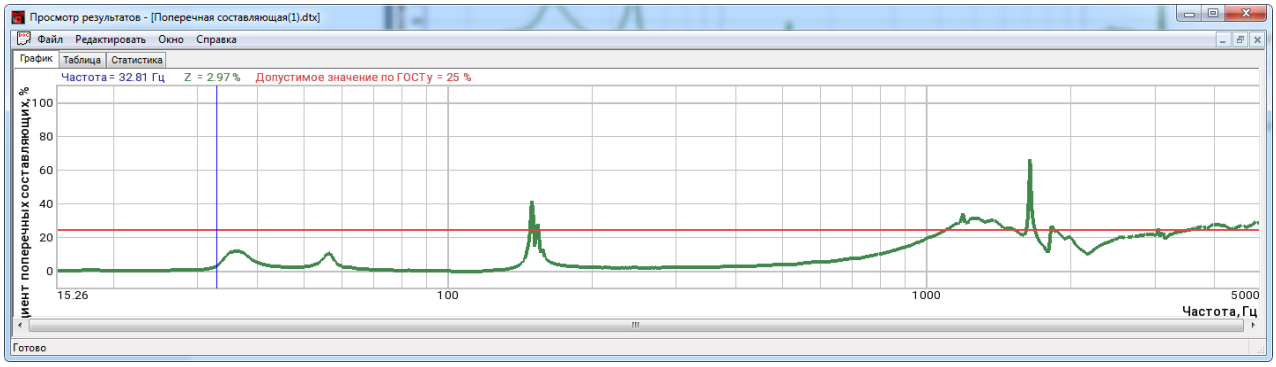


Figure B.11. Frame is in a horizontal position

The curves show that in the suspension member resonance region (20...50 Hz) even small deviations from the horizontal position may cause significant transverse vibrations on the shaker. This may be an obstacle both at the certification stage as well as during testing, especially when a significant effect level is set.