INTERUNIS-IT

A-Line

User manual

2026

WARNING! Changes may have been made to the software that are not reflected in this manual.

The settings shown in the figures are used as examples. Real values should be chosen based on specific conditions.

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Chapter 1. Short description

Many years of experience of INTERUNIS-IT in the field of non-destructive testing has made it possible to create a family of **A-Line** digital hardware and software systems designed for multichannel registration and measurement of parameters of acoustic emission electrical signals in order to evaluate the technical condition of hazardous production facilities during non-destructive testing.

This manual applies to software of acoustic emission measuring systems **A-Line PCI**, **A-Line DDM**, **A-Line DS** (hereinafter referred to as **A-Line** complexes), which are multichannel measuring automated complexes for receiving and processing information from the testing object in the process of acoustic emission testing. The phenomenon of acoustic emission (AE) consists in the emission of acoustic waves by an object under the influence of a loading or under the influence of other factors. Information is received from a variety of acoustic emission sensors, which receive acoustic waves propagating in the testing object and convert them into an AE electrical signal, which is then amplified by a built-in or external preamplifier, converted to digital form and processed in order to detect developing defects, their localization and determination of the degree of danger.

The **A-Line** complexes include one or more computer-based data acquisition and processing units, external devices connected to them and the **A-Line** software common for all complexes of the family. The **A-Line** software provides extensive control over data acquisition, processing and presentation of measurement results, both in real time and in post-processing mode. In addition to the main program, INTERUNIS-IT also created the program **A-Line OSC**, which allows for more detailed processing of waveforms, and the program **A-Line Stat**, designed for statistical processing of acoustic emission data.

> ✍ Recording of waveforms is carried out by the main program **A-Line**, and subsequent processing can be performed both by the main program **A-Line** and additional programs **A-Line OSC** and **A-Line Stat**.

Also, the **«A-Line»** software package can be used to process data recorded by the universal non-destructive testing device **«UNISCOPE»** in the acoustic emission mode.

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Section 1

Installing software and setting up the connection

Chapter 2. Installing the software

✻ Chapter *“Installing the software”* is entirely devoted to installing the A-Line software package.

✎ Coordinates for contacting INTERUNIS-IT are given in the chapter *“Manufacturer information”*.

When talking on the phone, ask the secretary to switch to the Software Development and Maintenance department, when forwarding a fax or sending an e-mail, make a note "To support".

The A-Line complex is supplied complete with software that runs on the Windows operating system. The software is designed to control the AE equipment, receive and analyze acoustic emission data. In the absence of AE equipment, the installed software allows processing of recorded AE data.

2.1. Downloading software from the site

To download a software package for the A-Line AE complexes from the INTERUNIS-IT website, use the link https://interunis-it.ru/en/info/downloads

Select and download the required version of the software (32- or 64-bit).

2.2. Installing the software

Run the downloaded installation software with administrator rights. The sequence of installation steps is shown in Fig. 2.1 – Fig. 2.10.

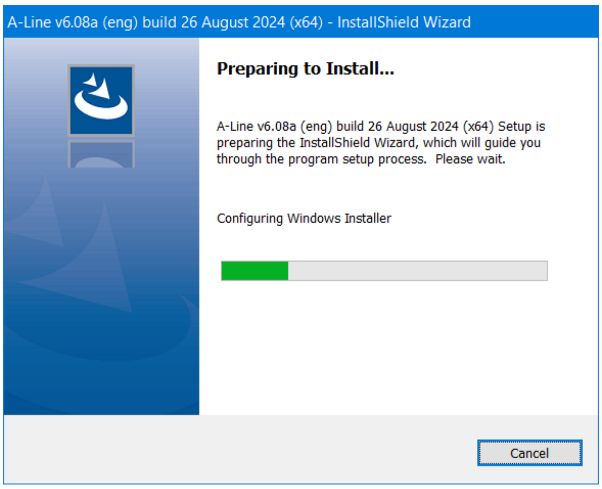

Fig. 2.1. Preparing to install

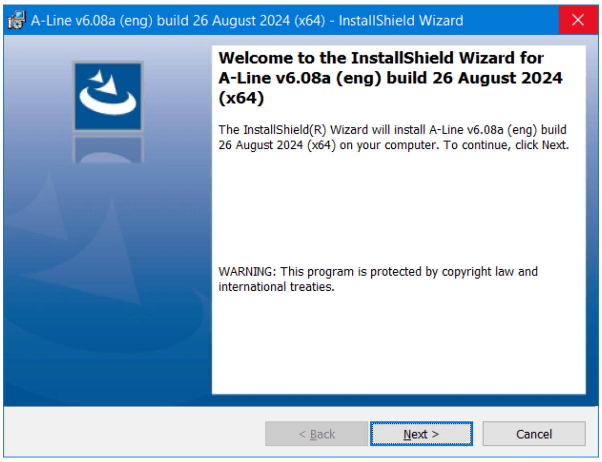

Fig. 2.2. Welcome message

Read carefully the recommendations on installing programs and working with the A-Line complex in the corresponding dialog.

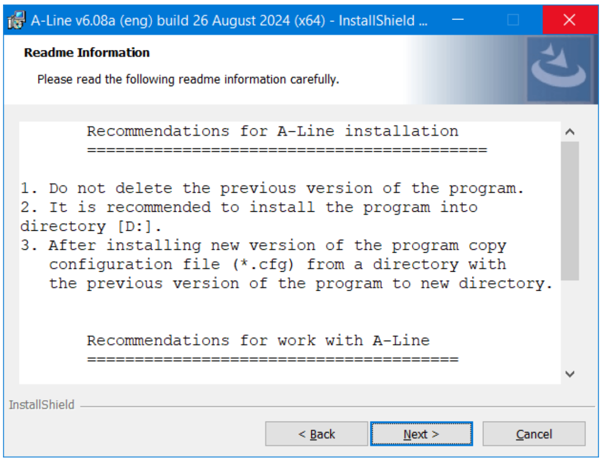

Fig. 2.3. Recommendations

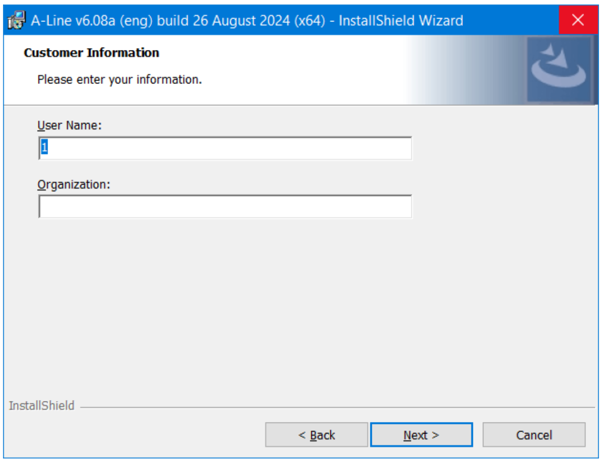

Fig. 2.4. Acquisition of customer information

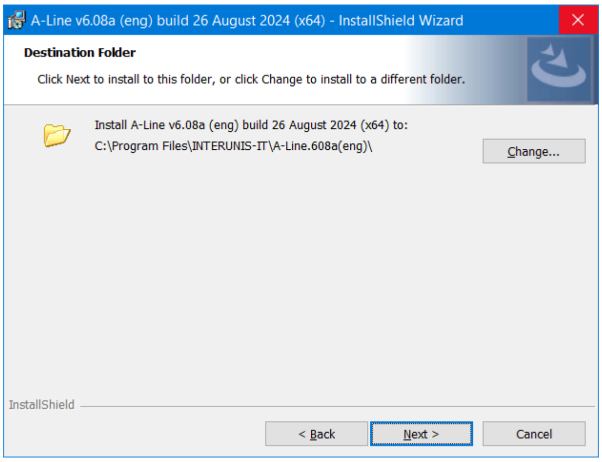

Fig. 2.5. Selecting destination folder for installation

If there is already another version of the software on the computer, it is allowed to install the new version in a separate folder. In this case, different versions do not conflict with each other.

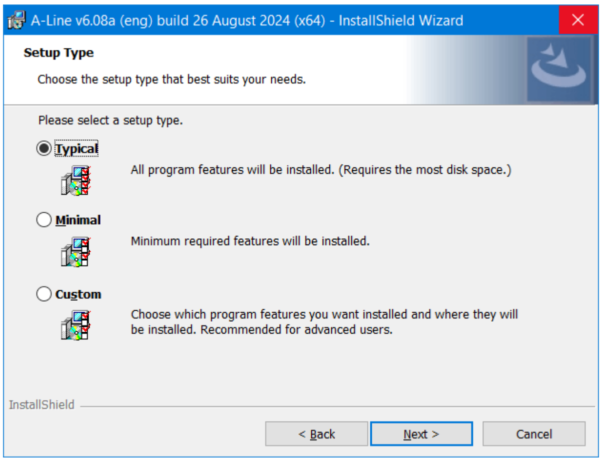

Fig. 2.6. Selecting the setup type

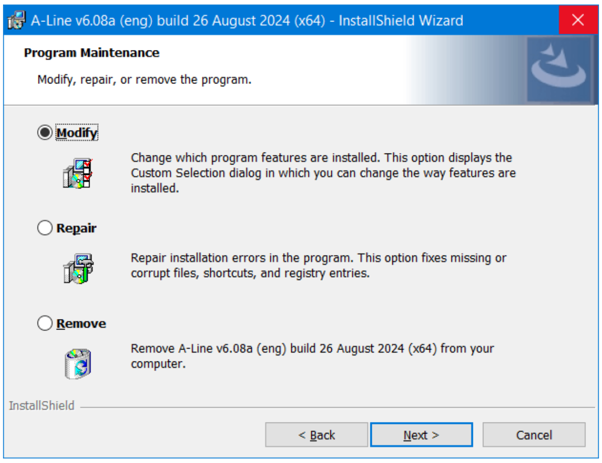

Fig. 2.7. Program maintenance

If the computer already has software that matches the version number of the software being installed, then instead of the dialogs shown in Fig.2.3 – Fig.2.6, the program maintenance dialog appears (Fig.2.7).

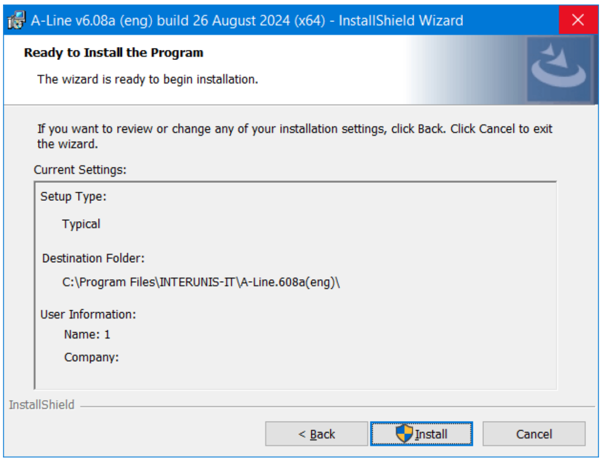

Fig. 2.8. Viewing installation settings

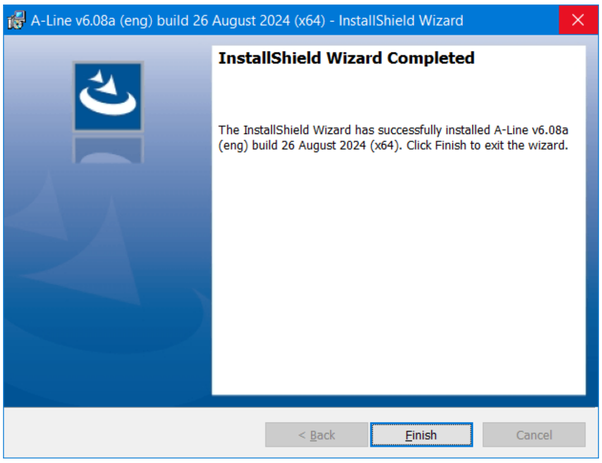

Fig. 2.9. The software package installation is complete

In the final dialog, confirm the reboot or refuse it. If at least one similar installation has been performed before, then the reboot can be skipped. If the installation is performed for the first time, then the reboot is necessary.

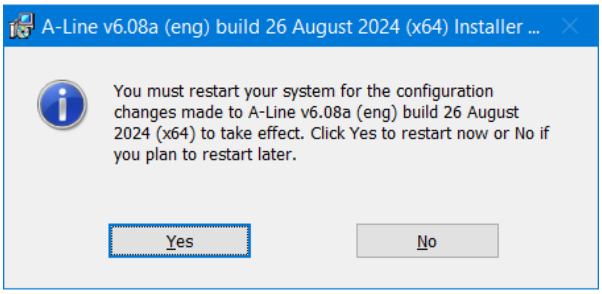

Fig. 2.10. Dialog to choose whether to reboot or not

Additionally, it is recommended to select the file "A-Line.exe" in the folder with the installed program (Fig.2.5) in the subfolder "A-Line", right-click, select "Properties", section "Compatibility", activate the switch "Run this program as administrator", click **OK**.

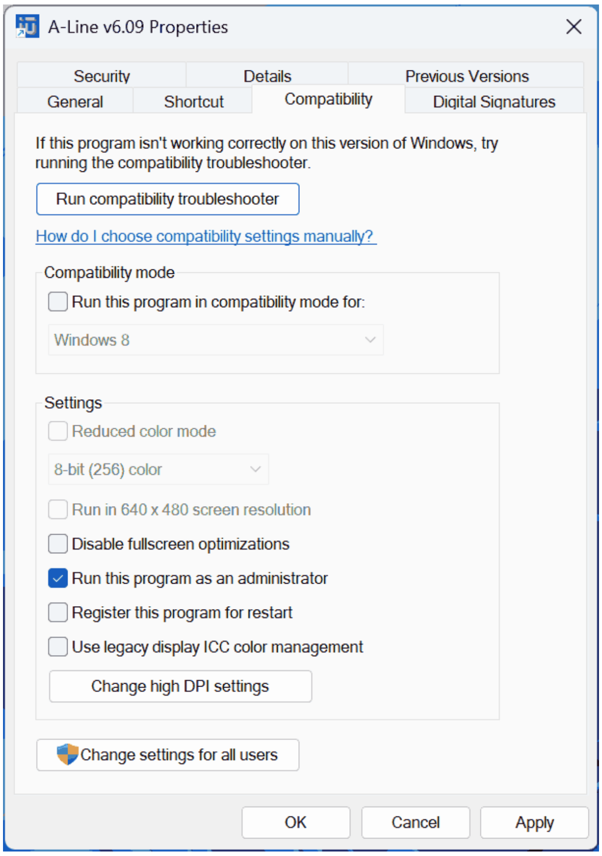

Fig. 2.11. A-Line.exe application compatibility settings

Additionally, the following settings can be made.

For ease of use, you can create 2 shortcuts for the file "A-Line.exe" on the Desktop, rename one of the shortcuts to "A-Line Post", in its properties in the "Object" line add **/p** after the full path to the "A-Line.exe" software in quotation marks, click **OK**. Using such a shortcut allows you to run a second copy of the software during AE data acquisition to analyze previously recorded AE data without conflict between the copies (see the section *“Command line arguments”* on page 39).

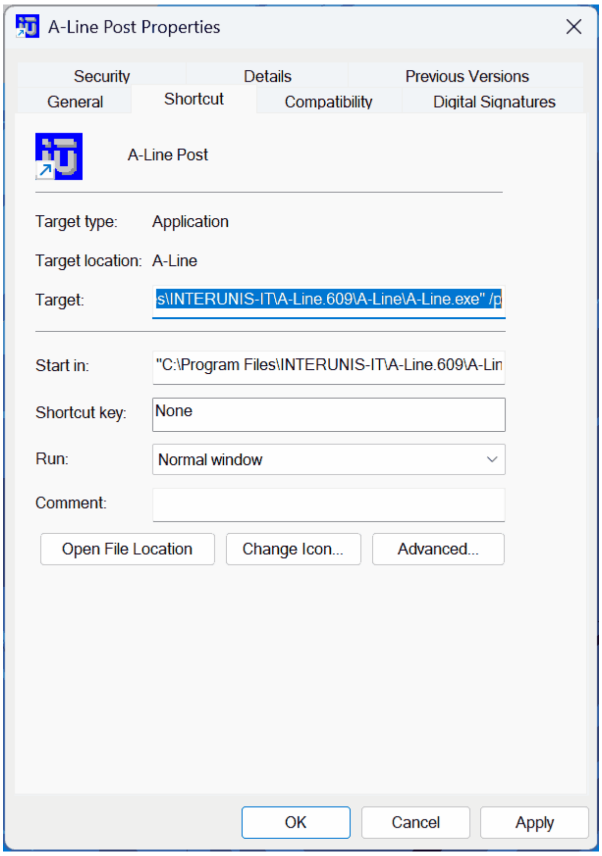

Fig. 2.12. Setting up "A-Line Post" shortcut

In the folder with the installed A-Line software package (Fig. 2.5) in the "AE Workbench" subfolder there is an installation software of the trial version of the AE Workbench package, consisting of the AE Correlation Expert, AE Post Expert, AE Converter Expert software. This software package can be installed separately. A description of this software package is given on the website http://www.aetest.ru

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Chapter 3. Configuring the Ethernet-box type system

✻ Chapter *"Configuring the Ethernet-box type system"* is entirely devoted to setting up the network connection.

3.1. Short description

The INTERUNIS-IT company offers A-Line systems in various designs, including "Ethernet-Box". Below is a view of these systems (without laptop).

Fig. 3.1. External view of the A-Line system in the "Ethernet-Box" design

The system consists of a data acquisition and processing units of Ethernet-Box type, a set of connecting cables, preamplifiers or modules and AE sensors. The Ethernet Box is controlled using another personal computer (PC) or laptop. It is recommended to use a wired connection to organize a network connection.

If the A-Line complex includes one Ethernet Box (Ethernet Box XL), the following steps must be taken:

◇ connect the control personal computer (laptop) to the Ethernet Box with a reverse patch cord;
◇ connect the Ethernet Box power cord;
◇ turn on the Ethernet Box;
◇ turn on the control personal computer (laptop).

If the A-Line complex includes several Ethernet Boxes, the following steps must be taken:

◇ connect the Ethernet Boxes to each other with a synchronization cable (cables);
◇ connect each Ethernet Box with patch cord to network hub;
◇ connect the control personal computer (laptop) to network hub with patch cord;
◇ connect power supply unit of the network hub;

- ◇ connect power cord of each Ethernet Box;
- ◇ turn on each Ethernet Box;
- ◇ turn on the control personal computer (laptop).

3.2. Configuring network equipment

For correct identification of the connected Ethernet Box by the control personal computer (laptop), it is necessary to configure the network equipment.

> ⚠ It is recommended to coordinate changes in computer settings for a local network with the network administrator.

To configure network connections, you need to open the "Local Area Connection – properties" dialog: **Start – Control Panel – Network and Internet – Network and Sharing Center – Change adapter settings**.

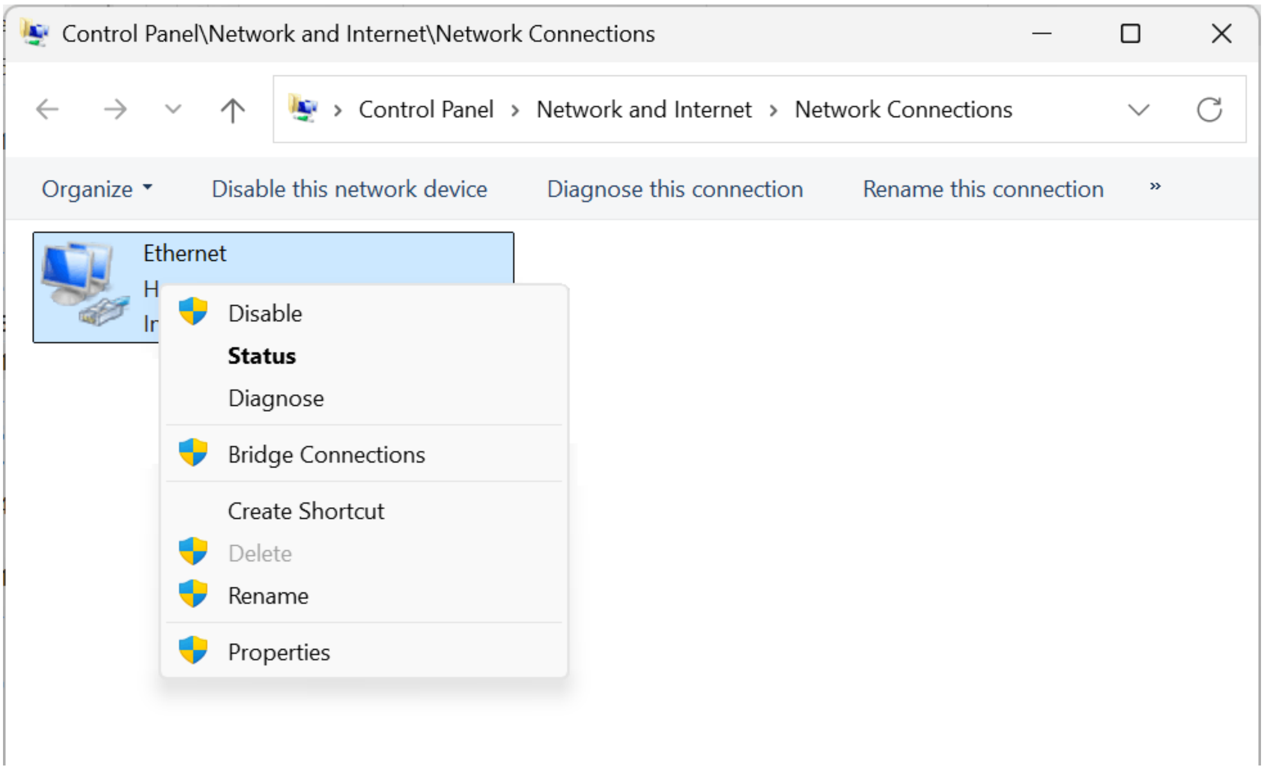

Fig. 3.2. Starting the network settings dialog

> ⚠ It is technically possible to use a Wi-Fi network connection (login of the following type: ALineEBox_XY_ZB, depending on the serial number of the block, password: ALineEBox). When performing AE testing, it is recommended to use a wired connection, which is more reliable.

Then go to the properties of the Internet protocol TCP/IP. If the computer is planned to be connected only to the Ethernet box, then the following fields must be filled in:

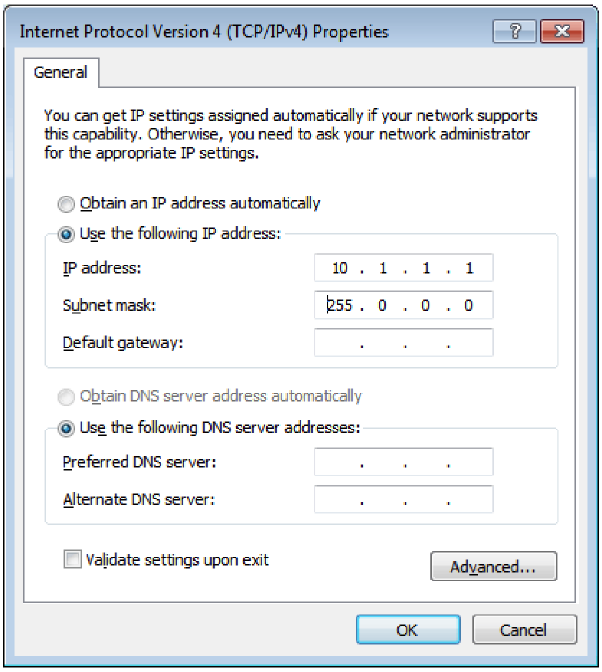

Fig. 3.3. Configuring TCP/IP for Ethernet box connection only

If you plan to use the computer also on the local network to connect with other computers, you should contact the network administrator with a request to provide a fixed address (if the computer is configured to automatically receive an address in the local network), and also add the IP address and mask to the existing settings:

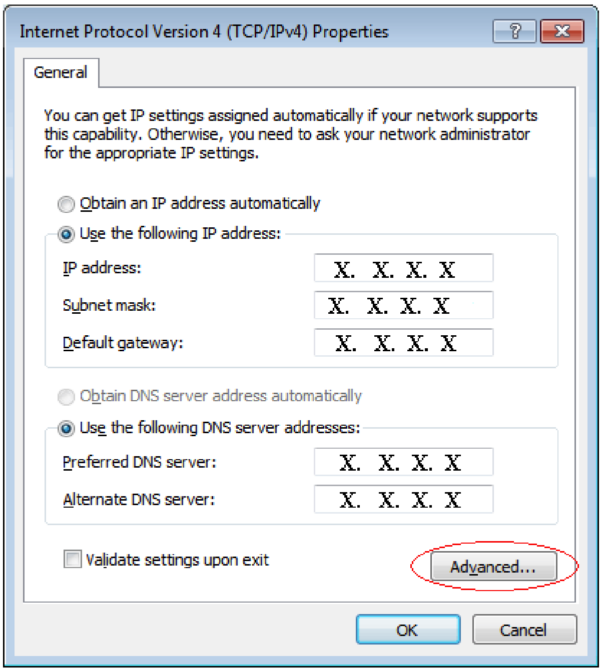

Fig. 3.4. Configuring TCP/IP to connect the Ethernet box to the local network

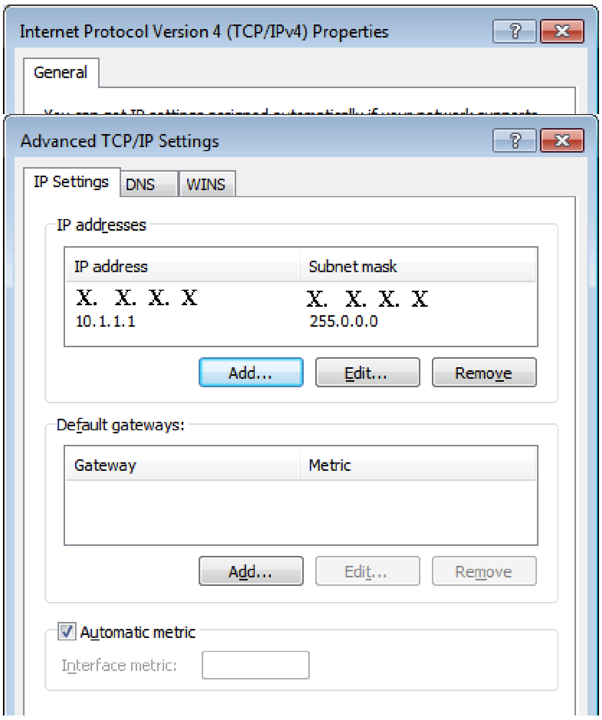

Fig. 3.5. Configuring advanced TCP/IP settings

⚠ Changing the computer settings for working on a local network is recommended to consult with the network administrator.

3.3. Checking connection with Ethernet box

After the basic settings have been checked, it is necessary to check the connection between the computer and the Ethernet box. First you need to ping the address 10.100.XY.ZB (Ethernet box address indicated in the passport or on the case).

The Ethernet box network address corresponds to the serial number of the device.

The serial number is XYZ-MM or XYZ-NN-MM. Using the first group of digits (XYZ), you can get the network address of the Ethernet box - 10.100.XY.ZB, where B for systems with a single Ethernet box is 1, and for multi-box systems - the sequence number of the Ethernet box.

To run the ping program, call the command prompt:

- use the key combination <Ctrl + R> and the command **cmd**;
- or select in the **Start** menu subsection **Command prompt** in the **Service (Standard)**.

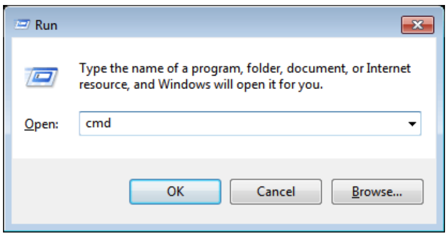

Fig. 3.6. Starting the command prompt via the console

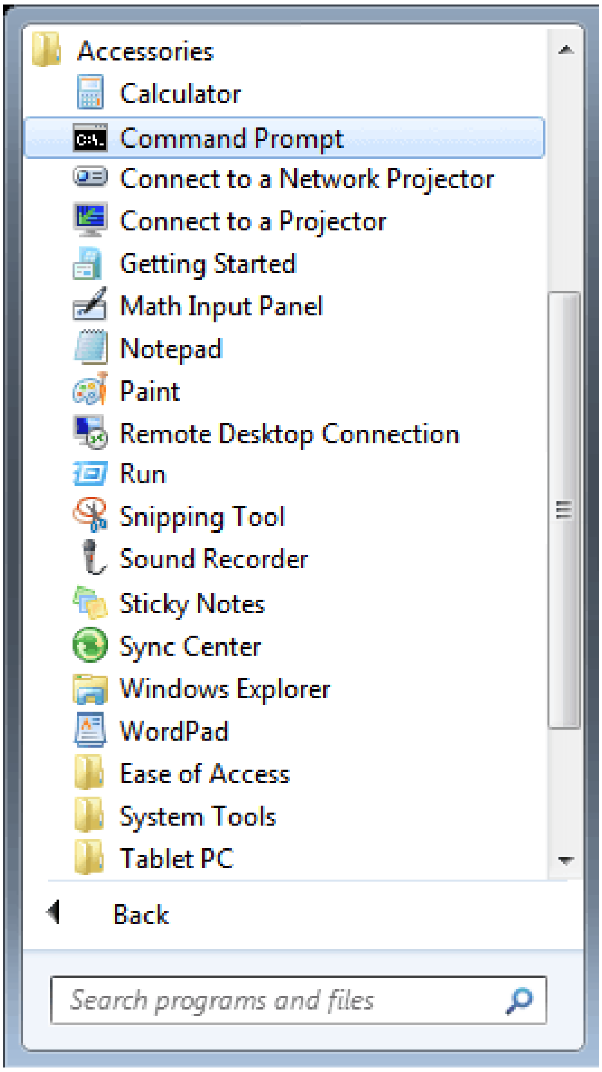

Fig. 3.7. Starting the command prompt via the **Start menu**

Enter in the command prompt:

> ✱ ping 10.100.XY.ZB
> (instead of the address 10.100.XY.ZB, specify the address of the Ethernet Box being checked)

This will result in four packets being sent.

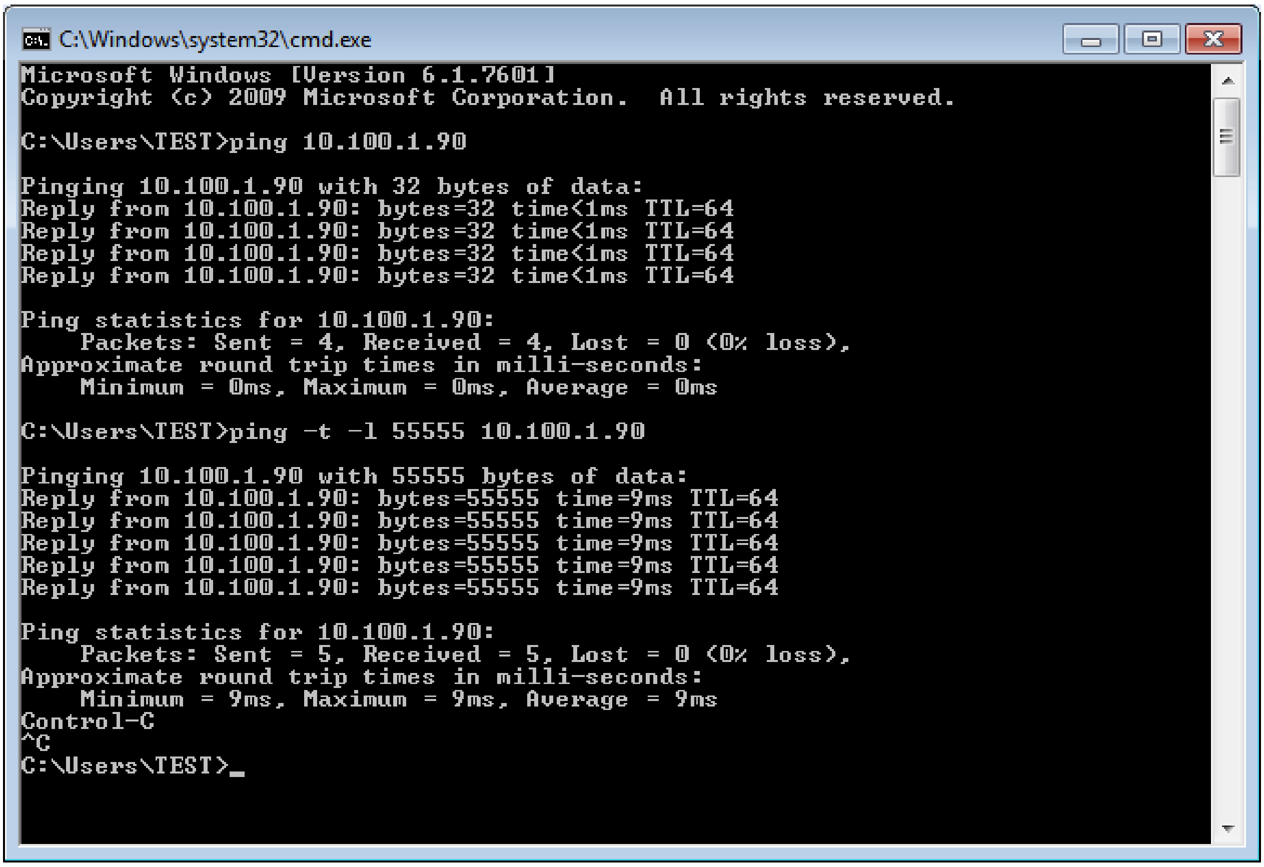

Fig. 3.8. Checking the connection with the Ethernet box

To send more continuous packets, enter:

> ping –t –l 55555 10.100.XY.ZB
>
> (instead of the address 10.100.XY.ZB, specify the address of the Ethernet Box being checked)

Interrupting the reception and transmission of packets is done by pressing the "Ctrl-C" key combination.

If the connection between the computer and the Ethernet box using a patch cord is normal, then the following keyword is expected: "*lost = 0 <0% loss>*".

If there are errors, check the settings of the network equipment (see chapter *“Configuring network equipment”* on page 19), test with a different network cable.

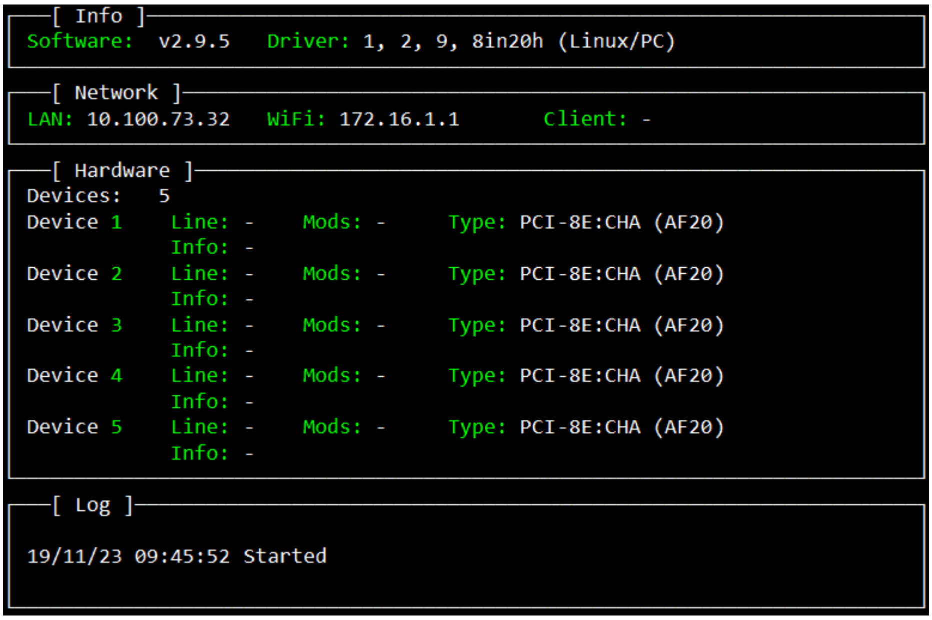

Fig. 3.9. Checking the connection with the Ethernet Box

If the cause of the connection errors cannot be identified, turn off the Ethernet Box, connect it directly to the monitor, turn on the Ethernet Box and wait for it to boot. Contact the manufacturer and report the contents of the monitor screen.

3.4. Setting A-Line network parameters

To set the IP address of the device (or several devices combined into one by connecting them to a common network to increase the number of measurement channels with the possibility of their synchronization), use the main menu command **Options – Settings**. As a result, the dialog box **General settings** appears, in which you should select the page **Network connections**.

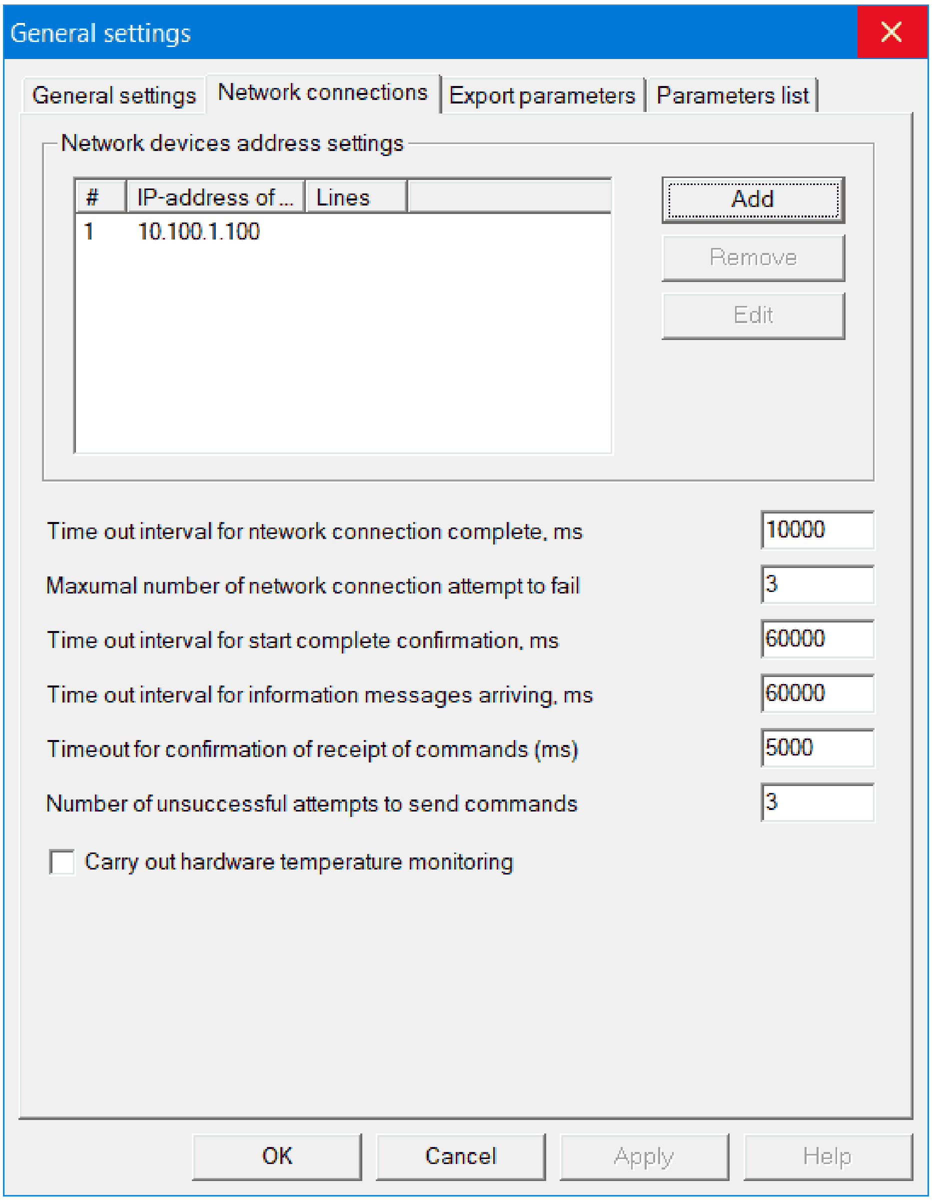

Fig. 3.10. Dialog box **General settings**, page **Network connections**

On this page, in the group **Network devices address settings**, there is a list of IP addresses and control buttons applicable only for AE complexes with an data acquisition and processing units of Ethernet-Box type.

◇ The dialog box contains a list of IP addresses.

◇ The following commands are available for working with a list of IP addresses:

- To add a new IP address, click the **Add** button, after which the **Enter IP-address** dialog box appears.

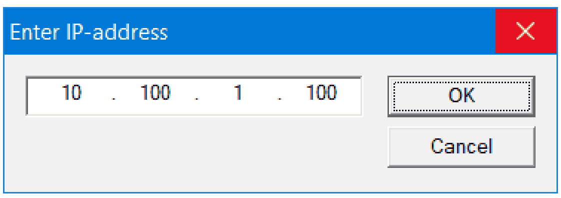

Fig. 3.11. Dialog box **Enter IP-address**

Enter the IP-address of the device specified in the passport of the complex, and press the button **OK**, to cancel the entered data — the button **Cancel**;

- To edit an IP address, select it in the dialog box using the standard line selection procedure, either with the mouse or using the appropriate keyboard shortcut, and press the **Edit** button. After that, the dialog box **Enter IP-address** will appear, in which you can edit in the input field IP addresses.

  You can also edit the IP address as follows: highlight the desired IP address in the dialog box, then move the mouse cursor to the selected line and double-click the left mouse button. After that, the dialog box **Enter IP-address** will appear, in which you can edit IP addresses.
- To remove an IP-address, select it in the dialog box and click the **Remove** button.
- Note that only one IP-address can be added or changed when working with a list of IP-addresses. To remove, you can select one or more IP-addresses from the list using the standard line selection procedure and use the **Remove** button.

◇ Enter the appropriate timeouts in the input fields:

- Start completion confirmation — in the input field **Time out for start complete reply, ms**.
- Information message arrival — in the input field **Time out for information messages complete reply, ms**.

◇ To monitor the internal temperature of the data acquisition and processing unit and enter data into the log file of the complex operation, activate the switch **Carry out hardware temperature monitoring**.

After setting the required parameters, press the button **OK**, to cancel — the button **Cancel**.

3.5. Starting A-Line session

After the system has been correctly configured, it is necessary to conduct a test run. Apply power to the Ethernet Box. After 20…30 seconds (after loading the internal software of the Ethernet Box), launch the A-Line software. Launching A-Line, like any other software for **Windows**, is done either by double-clicking the mouse button on the icon located on the **Desktop**, or by selecting the required command in the **Start** menu.

✍ By default, the command to start the program A-Line is set to **Start – Programs – "A-Line"**.

After a short delay (5…10 s), the main program window appears.

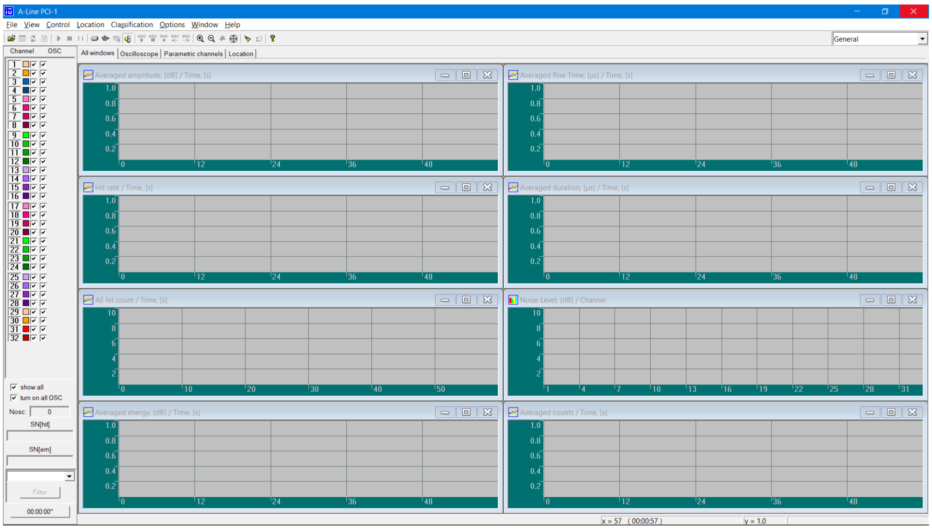

Fig. 3.12. The main window of the A-Line complex

Also, the program icon appears in the Windows system tray. Clicking on it will call up the console with information about the progress of the complex loading.

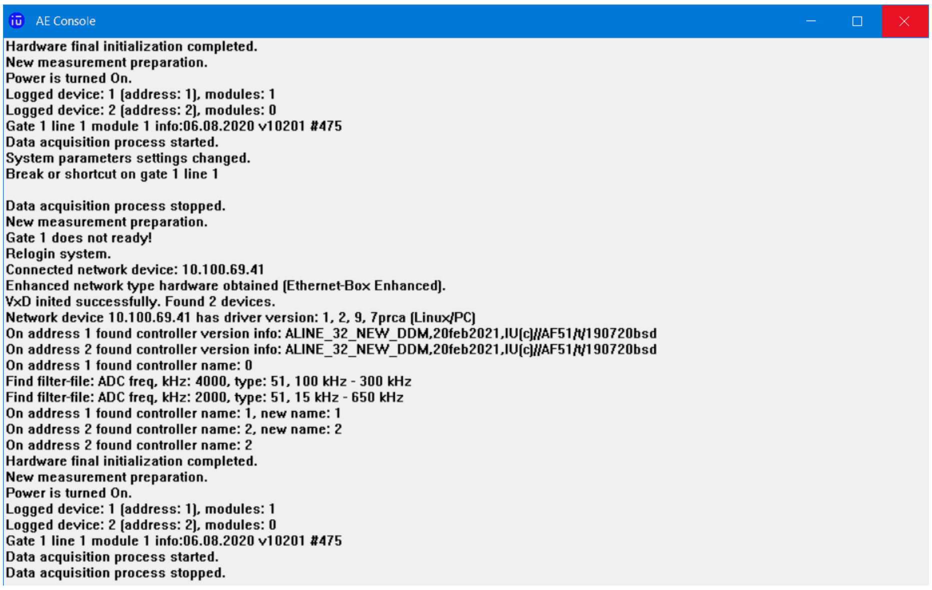

Fig. 3.13. Console

In some types of complex, before the main window appears, a window appears briefly showing the process of initializing the hardware.

If the main configuration file is not found at the beginning of the program loading, the complex informs about it.

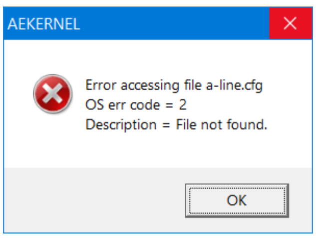

Fig. 3.14. Error message

After that, the complex continues to work with the default values of the parameters. This usually allows you to continue working. However, after downloading the complex, it is recommended to check the correctness of the set values and save the configuration file.

Depending on hardware availability, the following download options are available.

◇ *There is a hardware part.*

In some complexes, the loading process is accompanied by the appearance of a window in which the hardware initialization process is displayed. After the loading process is completed, the window automatically disappears, the main program window appears, and the complex will work in the **online** mode.

- Complexes of A-Line PCI and A-Line DS types.

Fig. 3.15. The window for initializing the hardware of the complex of A-Line PCI and A-Line DS types

- Complex A-Line DDM.

  When starting complexes of this type, the main window immediately appears. Features of working in the **online** mode with complexes of the A-Line DDM type are in the part of the beginning of a new measurement, which is described in the section *"Preparing for a new measurement"* on page 47.

◇ *Hardware missing or driver not installed.*

- Hardware missing.

  In this case, the program reports that the hardware is not initialized and the complex will offer to continue working in the **offline** mode.

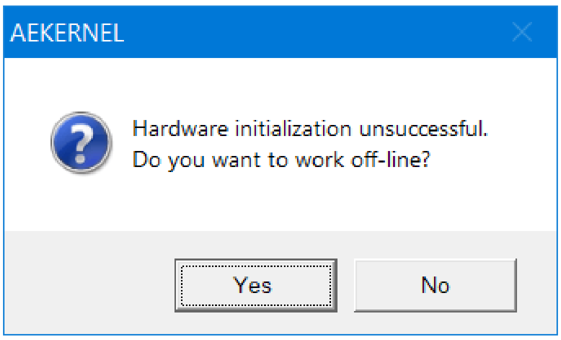

Fig. 3.16. Selecting the operating mode

  To select the operating mode **offline**, press the **Yes** button, to complete the work, use the **No** button.

- Driver not installed.

When the hardware is connected, you may receive a message similar to the one that appears when the hardware is not connected. This indicates that the driver is not installed, and therefore there is no interaction between the program and the hardware.

- Unable to communicate with network device.

In this case, the program reports that the connection with the network device has not been established, and the complex will offer to restore the connection. If such a message appears, it is recommended to check the correctness of the patch cord connection and the correctness of the Ethernet Box IP address in the program settings, read the messages about the progress of the complex loading in the console or refer to the chapter *“Checking connection with Ethernet box”* to search for and troubleshoot problems.

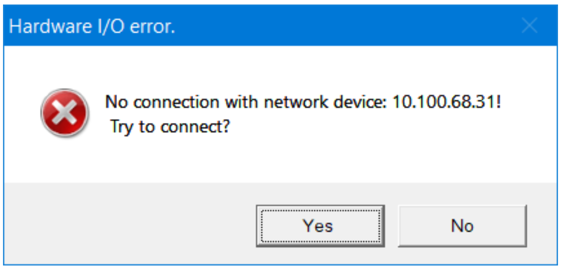

Fig. 3.17. No connection with network device

To reconnect to the network device, press the **Yes** button, otherwise use the **No** button.

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Section 2

A-Line software

Chapter 4. A-Line features

Working with the A-Line complex consists of two main stages - data acquisition and processing. At the first stage, after starting the complex and setting the necessary parameters, the data are received and saved. These operations are discussed in more detail in the chapters *“Configuring complex settings”* and *“Working with the complex”*.

At the second stage, the received data is processed, followed by printing the results or saving them to disk. The chapter *“Data processing”* is devoted to this procedure. The main operations in data processing are filtering (selecting part of the data according to some condition) and location (determining the coordinates of AE sources).

The program can carry out its work not only in the presence of hardware, but also in its absence. Working with the hardware connected is called the **online** mode, in which both data acquisition and post-processing are carried out. The mode of operation in which the hardware is disabled is called the **offline** mode. In this case, only post-processing of data is possible.

4.1. Data acquisition

◇ During data acquisition, the following is done:
- setting the complex parameters;
- complex diagnostics and channel calibration;
- complex control during data acquisition (complex start, stop, pause);
- graphical and textual representation of the received data in real time;
- classification of detected AE sources according to the degree of danger.

◇ During the measurement, it is possible to locate defects:
- using simple location types (linear, planar);
- using special types of location (spherical, cylindrical, conical vessels, tank bottoms and walls, volumetric location).

4.2. Post-processing

◇ The program provides ample opportunities for post-processing:
- reading data from files, their graphical and textual representation;
- create new graphs of dependences of any parameters on each other and histograms of the distribution of the number of events for any of the parameters;
- printing the results;
- location of AE sources according to data from files;
- classification of detected AE sources according to the degree of danger.

◇ Filtering AE data by various criteria, including:
- according to AE parameters (time, channel number, amplitude, energy, AE impulse rise time, AE impulse duration, number of threshold exceedings in AE impulse, frequency);
- according to location results (coordinates, location amplitude);

- by complex conditions (by formula, by clustering results, by region).

◇ Working with data files:

- storage and subsequent processing of data obtained as a result of filtering;
- export data to TXT or CSV formats, including AE data, data from parametric inputs and waveforms;
- concatenating data contained in several files;
- creating a project (a set of data files, waveform files and other related files corresponding to one measurement).

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Chapter 5. Program overview

✻ In the *“Program overview”* chapter, the program interface is described, a summary of all commands of the main menu, tool bar, and default hotkeys are listed.

5.1. Measured and programmed channel parameters

The A-Line complex is a multi-channel AE impulse acquisition complex, each channel of which operates independently of the others. The complex allows you to receive AE impulses and measure their parameters.

Each AE impulse received by the complex is characterized by a set of measured parameters. The correct selection of AE impulses against the background noise is affected by a set of user-configurable channel parameters.

In addition to the measured and adjustable parameters, the program uses calculated parameters of AE impulses, which are some ratios of the measured parameters.

◇ The *measured parameters* of AE impulses include:

- Amplitude — maximum value of AE impulse amplitude;
- Energy — AE impulse energy value;
- Time — AE impulse start time (time of first crossing the threshold);
- Rise time — time interval between AE impulse start time and the moment at which the impulse amplitude reaches its maximum value;
- Duration — the time interval between the start and end (the moment when the signal goes below the threshold level) of the AE impulse;
- Frequency — average frequency, calculated as the number of zero-voltage level crossings (in one direction) within an AE impulse, divided by the duration (only for PCI-1E and DDM-2 systems);
- Counts — emission counts (number of crossings of the threshold level within the AE impulse).

◇ In addition to these values, the list of measured parameters includes the so-called flags:

- ADC overload flag — **Flag A**;
- flag of impulse termination by maximum duration — **Flag D**;
- waveform presence flag — if there is an waveform for this impulse.

◇ *Settings* are:

- main amplifier gain;
- voltage threshold — a fixed or adjustable voltage applied to the input of the equipment, above which the AE impulse is detected, received and/or processed, and below which detection is not performed, receiving and/or processing is not performed (in the complexes A-Line this value is adjustable);
- hit definition time — time after the measured signal drops below the threshold level, during which the impulse may continue;

- dead time — time after the end of the AE impulse, during which the channel cannot receive other AE impulses;
- maximal duration — maximal duration of the AE impulse.

◇ *Computed parameters* include:

- **Counts/Duration** — average frequency, calculated as the ratio of emission counts to the duration of AE impulse (except for PCI-1E and DDM-2 systems);
- Amplitude RMS is calculated as the AE impulse root mean square voltage over the recording interval;
- The parameter characterizing the proximity of the AE impulse shape to the pulsed one (**Amax/Arms**) is calculated as the ratio of the maximum value of the AE impulse amplitude to its RMS amplitude;
- **MARSE** of AE impulse — parameter calculated as measured area under the rectified signal envelope;
- **Ampl./Counts** — parameter calculated for AE impulses as the ratio of amplitude to the number of emission counts in the AE impulse.
- **Ln(Ampl.,[ADC bits])/Counts** of AE impulse — parameter calculated for AE impulses as the ratio of the natural logarithm of amplitude (in ADC bits) to the emission counts in AE impulse.

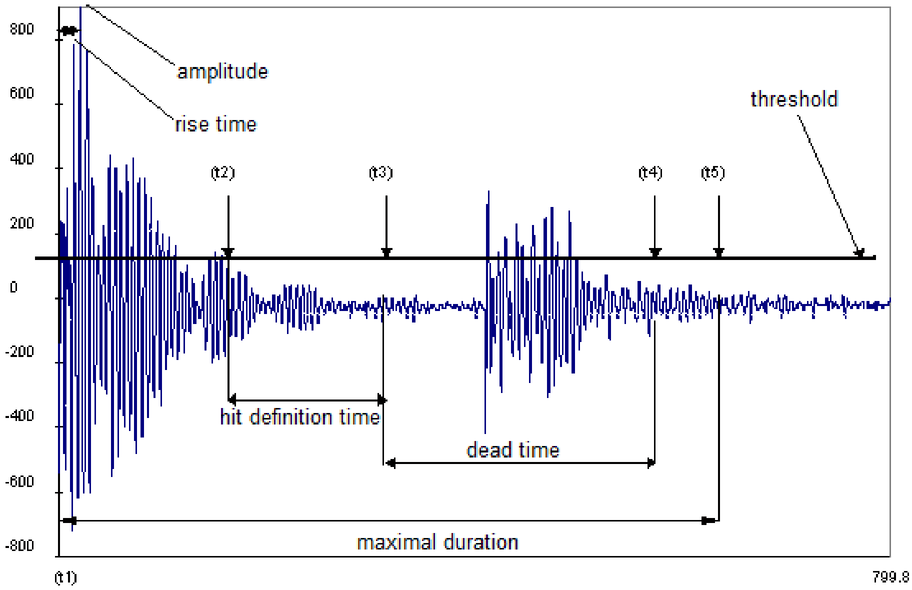


Fig. 5.1. Waveform of a real AE impulse

The figure above shows the waveform of a real AE impulse. The voltages are plotted along the vertical axis (for convenience, the scale is calibrated in ADC bits), the time is plotted along the horizontal axis.

5.2. Starting a session

The relevant procedures are described in the chapter *“Starting A-Line session”* on page 26.

5.3. Stopping A-Line complex

There are several ways to stop an A-Line session:

- ✧ selection in the main menu of the command **File – Exit**;
- ✧ pressing the key combination **<Alt + F4>**;
- ✧ double click on the system menu button.

After performing any of these actions, a window will appear asking you to finish the job.

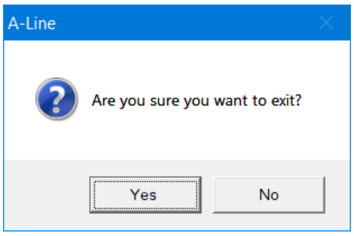


Fig. 5.2. Request to stop work

To confirm your exit from the complex, press the **Yes** button. If you don't need to leave or the exit was chosen by chance, then use the **No** button. In the latter case, work with the complex will continue.

If you try to shut down during a data acquisition, you will be warned that it is not possible to shut down during a data acquisition.

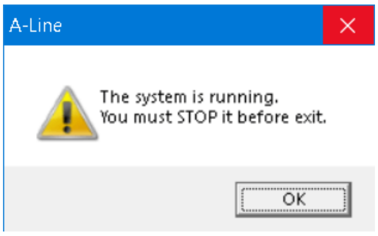


Fig. 5.3. Request to stop the complex

Next, you need to press the **OK** button and, if you need to exit the program, you should stop the data acquisition, as described in the section *“Complex management during data acquisition”* on page 50, and repeat the exit procedure.

Changes can be made to the program configuration during operation. Then, before closing the main program window, a window appears asking you to save the changed configuration.

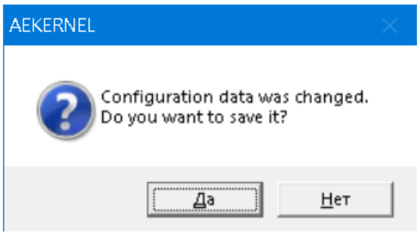


Fig. 5.4. Request to save configuration

If the modified configuration is not required in the future, then you should click the **No** button and the configuration will not be saved. Otherwise, you should use the **Yes** button. If the main configuration file (or another one selected by the user) exists, the complex will ask for confirmation to overwrite this file.

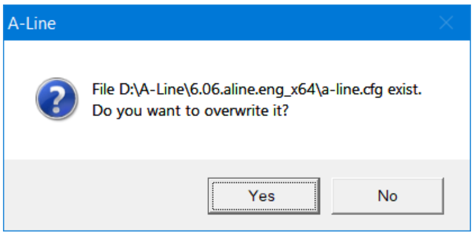


Fig. 5.5. Configuration file overwrite confirmation

When you click on the **Yes** button, the settings will be saved in the main configuration file. Otherwise, the complex will prompt you to select a file name in which the configuration will be saved. To do this, a standard dialog box **Save as** will be displayed, in which you must specify a new name for the configuration file.

Note that the prompt to save the configuration file appears if this is selected in the settings. You can enable the request to save the configuration file in the **General settings** dialog box, as described in the *"Setting the general parameters of the complex"* on page 114 section.

5.4. Windows for displaying the resulting information (WDRI)

There are various windows for displaying measurement results in the program. More details on the presentation of results and working with windows are described in the chapter *"Working with windows"* on page 121. The titles and descriptions of the main windows available in the program for displaying the results are listed below.

- ✧ **Averaged amplitude [dB]/ Time [s]** — average value of the AE impulse amplitudes for each channel during the averaging period.
- ✧ **Max. amplitude [dB]/ Time [s]** — maximal value of the AE impulse amplitudes for each channel during the averaging period.
- ✧ **Max. counts / Max. amplitude [dB]** — dependence of the maximum emission counts value on the maximal amplitude value for each channel during the averaging period.
- ✧ **AE activity / Time [s]** — number of AE impulses for each channel in 1 s.
- ✧ **AE hit count / Time [s]** — total number of impulses for each channel depending on the time from the start of data acquisition.
- ✧ **AE hit count / Channel** — a histogram of the total number of impulses for each channel from the start of the complex to the current time.
- ✧ **AE ring-down counts / Time [s]** — total emission count for each channel from the start of data acquisition.
- ✧ **AE ring-down counts / Channel** — a histogram of the total emission count for each channel from the start of the complex to the current time.
- ✧ **Count rate / Time [s]** — number of emission counts in all AE impulses for each channel in 1 s.
- ✧ **Averaged energy [dB] / Time [s]** — average value of AE impulse energy for each channel during the averaging period.
- ✧ **Energy run-on[dB] / Time [s]** — the sum of the average values of impulse energy for each channel from the start of the complex to the current time.
- ✧ **Averaged rise time [µs] / Time [s]** — average rise time of AE impulses for each channel during the averaging period.

- ✧ **Averaged duration [µs] / Time [s]** — average value of AE impulse duration for each channel during the averaging period.
- ✧ **Total average amplitude [dB] / Time [s]** — the sum of the average values of the amplitude in decibels of the AE impulses for all channels during the averaging period.
- ✧ **Total AE activity / Time (s)** — sum of AE hit count rates for all channels.
- ✧ **Total number of AE impulses / Time [s]** — sum of AE hit count values for all channels.
- ✧ **Noise level [dB] / Channel** — histograms of noise level distribution, threshold value and minimum noise level by channels.
- ✧ **Noise level [dB] / Time [s]** — maximum value of noise amplitude for each channel during the averaging period.
- ✧ **Averaged counts / Time [s]** — average value of the emission counts per AE impulse for each channel during the averaging period.
- ✧ **Controller parameter / Time [s]** — service, diagnostic parameters of the complex.
- ✧ **Level of PPS transmitter signal / Time [s]** — shows the signal level of the PPS transmitter (only for complexes with a radio channel).
- ✧ **Level of PPS signal receiver signal / Time [s]** — shows the signal level of the PPS receiver (only for complexes with a radio channel).
- ✧ **Intensity of PPS data reception / Time [s]** — shows the intensity of PPS data reception (only for complexes with a radio channel).
- ✧ **Error rates of PPS / Time [s]** — shows the intensity of PPS reception errors (only for complexes with a radio channel).
- ✧ **Battery life of PPS / Time [s]** — shows the battery charge of the PPS (only for complexes with a radio channel).
- ✧ **ASL [dB] / Time [s]** — average rectified value of the noise amplitude for each channel during the averaging period (only for data recorded by the A-Line DDM-2 system or UNISCOPE).
- ✧ **RMS [µV] / Time [s]** — RMS value of the amplitude of the continuously recorded signal for each channel during the averaging period (only for data acquired by the A-Line DDM-2 system).
- ✧ **Parameter N / Time [s]** — values of arbitrary parameters (pressure, temperature, current, voltage, etc.) received from parametric inputs.
- ✧ **Waveform [ADC scale] / Time [µs]** — AE impulse digital waveform for the selected channel.
- ✧ **Spectral power [µV/MHz] / Frequency [kHz]** — the frequency spectrum of the current waveform.
- ✧ **Threshold [dB] / Time [s]** — graph of the threshold value for each channel.
- ✧ **Gain [dB] / Time [s]** — graph of the gain values for each channel.
- ✧ **Loc. amplitude [dB] / Size [mm]** — distribution of the average or maximal or individual location amplitude values by coordinates.
- ✧ **Location / Size [mm]** — coordinates of the located events.
- ✧ **Ampliture attenuation histogram N / Attenuation [dB/m]** — Attenuation distribution histograms.
- ✧ **Velocity measurement histograms N / Velocity [m/s]** — Velocity distribution histograms.

Note that the program has the ability to build other graphs. This operation is described in more detail in *“Window manager”* on page 137.

5.5. Types of files used

- *Data files* contain information about the measured parameters of all received AE impulses, noise packets and data received from parametric inputs.

  Files of this type have the extension **.ALD**.
- *Waveform files* contain waveforms.

  Files of this type have the extension **.OSC**.
- *Configuration files* contain the settings of complex (channel settings, location of windows for displaying the resulting information (hereinafter referred to as WDRI), other settings). Files of this type have the extension **.CFG**.
- *Location settings files* contain information about location groups. Files of this type have the extension **.LFG**.
- *Velocity measurement settings files* contain information for velocity measurements. Files of this type have the extension **.VFG**.
- *Filter settings files* contain data filtering settings. Files of this type have the extension **.FLT**.
- *Alarm settings files* contain alarm settings.

  Files of this type have the extension **.ALR**.
- *Location criterion files* contain the parameters of the location area lists and have the extension **.CRG**.
- *Project files* combine various types of files (AE data, waveforms, location, velocity measurements, load lines, settings) related to the testing object. Files of this type have the extension **.ALP**.
- *Imported graphics files* contain images that are overlaid on the WDRI. A-Line can handle the following formats: vector graphics files with **.WMF** or **.EMF** extension, as well as raster graphics files with the **.PNG**, **.JPG**, or **.BMP** extension.
- *Additional line description files* contain descriptions of load lines that are superimposed on the WDRI. *Files with attenuation curve data* contain parameters of the attenuation curve used for the most accurate evaluation of location amplitudes. *Files for generating a location scheme* contain coordinates of AE sensors. Files of this types have the **.CSV** extension (spreadsheet format, UTF-16 encoding) or the **.TXT** extension (text format). For additional line description files, it is also allowed to use the extension **.NAG**.
- *Exported files* in **.CSV** (UTF-16 encoding) or **.TXT** format contain the results of conversion (respectively, into spreadsheet or text form) of files with data or waveforms, graphs, selected lines in text view windows.
- *Sound files* are used to sound alarms. Files of this type have the extension **.WAV**. To create sound files, use sound editors (for example, the standard Windows program *Sound Recorder*, the editor *Sound Forge*, etc.).
- *Digital filter files* provide the ability to filter the input signal. Files of this type have the **.ALNF** extension and are used in **A-Line PCI, A-Line DS and A-Line DDM-2** complexes.

> ⚠ It is not recommended to change the contents of the directory with digital filter files, because this may result in the inability to use some filters.

5.6. Command line arguments

To improve the convenience of work and to implement batch data processing, command line arguments are provided to start the A-Line with additional parameters or in special modes. The software with additional arguments is started using the command line, a bat-file or a customized shortcut.

Table 5.1.

Command line arguments	Performs an action
/p	Starting the software in post-processing mode. Recommended for use during data acquisition to run an additional copy of the program for the purpose of analyzing previously recorded files, as well as on computers to which the A-Line complex is not connected
*.ald *.osc *.alp *.cfg *.lfg *.vfg*.nag	Starting the software and opening files of the specified types
*.flt in.ald out.ald *.flt in.ald in.osc out.ald out.osc	Starting the software in command line mode, reading source files (in.*), filtering based on *.flt, saving filtered files (out.*) and closing the software
/e *.ald *.txt /e *.ald *.csv /e *.osc *.txt /e *.osc *.csv	Starting the software in command line mode, exporting from a data file or waveform file to a TXT or CSV file, closing the software
/l	Specifies the directory from which files specified on the command line will be read from now on if their names are specified without a path. Also, the specified directory is recorded to the Windows Registry as the default for reading the corresponding file types
/s	Specifies the directory into which files specified on the command line will be recorded from now on if their names are specified without a path
/f	Specifies the directory in which *.alnf files are saved for those system types that support overloadable digital frequency filters read from files. If this argument is not activated, the default subdirectory /FILTERS of the main software directory is used

5.7. Main menu

File menu

This menu contains all the operations related to working with files. It includes the following commands:

Table 5.2.

Command	Action
Open	Opens (loads) a data file
Filter current file	Filters and views the data of the current file
Show Header	Shows information about an open file
Open OSC wave	Opens (loads) the waveform file
Show OSC Header	Shows information about an open waveform file
Create project	Creates a project from the selected files and saves it in the selected subdirectory
Open project	Opens the project file
Close project	Closes the project
Printer setup	Configures printer settings
Print	Prints data
Filter and review	Filters and views the selected data file
Recovery and sort	Recovers and sorts the contents of the data file
Concatenation	Concatenates data from files
Export ALD Data	Converts data files to TXT or CSV formats
Export OSC data	Convert waveform files to TXT or CSV format
Create Config	Creates configuration files
Open Config	Loads the settings file
Save Config	Saves the current settings of the complex to file
Exit	Exits the program

View menu

Menu commands **View** allow you to customize the workspace of the program for the most convenient presentation of the results.

Table 5.3.

Command	Action
Toolbar	Toggles the toolbar on and off
View Bar	Toggles the view bar on and off.
Page Bar	Toggles the page bar on and off
File read Bar	Controls the process of reading data files
Calibration bar	Toggles the calibration bar on and off
Status Bar	Toggles the status bar on and off
Project Workspace	Shows a list of files in the current project
Sync. View	Shows the parameters of received AE impulses in text form during data acquisition (online mode)
Time markers	Toggles time markers on and off

Command	Action
Radio channel panel	Toggles the PPS work indicator on and off
Zoom in	Zoom in the graph
Zoom out	Zoom out the graph
Zoom Back	Returns to the original scale of the graph
Sync. Scrolling	Synchronously moves the time axis in time-dependent windows
X Axis	Toggles the X-axis on and off in the active window
Y Axis	Toggles the Y axis on and off in the active window
Z Axis	Toggles the Z axis on and off in the active 3D window

Control menu

Menu commands **Control** provide control of the complex during data acquisition. All commands of this menu, except for **New Measurement**, are available only in the **online** mode.

Table 5.4.

Command	Action
Start	Startes the complex
Stop	Stops the complex
Pause	Temporarily stops the complex, resumes its work after a temporary stop
Noise events	Enables and disables the mode of receiving noise packets
Sound	Enables and disables alarm sounds
AutoThreshold	Enables and disables the automatic threshold mode for all channels
Radio tuning	Selecting the mode of operation of PPS
OSC Start	Startes the oscilloscope
OSC Stop	Stops the oscilloscope
OSC Record	Enables the waveform recording mode
New Measurement	Prepares for a new measurement
Relogin	Relogins modules
Marker	Sets the markers

Location menu

The commands in the menu **Location** allow you to set the location parameters.

Table 5.5.

Command	Action
New location	Creates new location group schemes
Open location	Opens previously saved location group schemes
Edit current location	Corrects the parameters of the current location group schemes
Close current location	Closes current location group schemes
Clear Locations	Clears all location windows from location results
Restore Locations	Restores the contents of all location windows
New velocity	Measures the propagation velocity of the AE impulse in the testing object
Open velocity	Opens a file containing a scheme of the installation of sensors for measuring the velocity
Edit current velocity	Corrects the current scheme of sensor installation to measure the velocity of propagation of the AE impulse
Close current velocity	Closes the velocity measurement window
New Calibration	Sets the channel calibration parameters
Open Calibration	Opens the calibration settings file
Edit current calibration	Changes the calibration settings
Close current calibration	Closes the calibration window

Classification menu

Menu commands **Classification** allow you to classify AE sources according to the degree of danger.

Table 5.6.

Command	Action
Amplitude criterion	Applies amplitude criterion
Locally-dynamic criterion	Applies locally-dynamic criterion
S-H diagram	Builds an S-H diagram
Statistic criterion	Applies a statistical test
Criterion GB/T 18182-2012	Applies GB/T 18182-2012 criterion
Criterion JB/T 10764-2007	Applies JB/T 10764-2007 criterion

Options menu

Menu commands **Options** allow you to configure the settings of the complex.

Table 5.7.

Command	Action
Channel parameters	Sets gains, thresholds, auto threshold and displaying colors for each channel.
OSC parameters	Sets the oscilloscope parameters.
Time definition	Defines the timings for each channel.
Calibrators parameters	Sets autocalibration parameters.
Parameters inputs	Sets up parametric inputs.
Hardware	Sets up hardware profiles.
Controller settings	Configures the system for displaying service diagnostic information
Current window	Sets up the active window.
Hot Key settings…	Sets up the hotkeys.
Settings…	Sets the general parameters of the complex.

Window menu

Menu commands **Window** provide work with windows.

Table 5.8.

Command	Action
Page Manager	Controls the display pages of program windows
Alarm Manager	Controls the system alarms
Window Manager	Controls the system display window
Additional lines	Creates an additional line
Restore all	Restores all working windows and arranges them in a certain order
Cascade	Arranges working windows one after another with a shift
Tile	Arranges working windows without overlap
Arrange Icons	Organizes working windows minimized to icons
WDRI names	Quickly activates the corresponding window
All windows	Allows you to activate any window

Help menu

Menu commands **Help** allow you to get help when working with the complex.

Table 5.9.

Command	Action
About	Displays brief information about the program

5.8. Toolbar

Toolbar consists of buttons with icons. Each button is associated with some operation, duplicating, in most cases, any command of the main menu.

Fig. 5.6. **Toolbar**

Table 5.10.

Button	Duplicates a menu or performs an action
	**File – Open**
	**File – Filter current file**
	**Control – Relogin**
	**Control – New Measurement**
	**Control – Start**
	**Control – Stop**
	**Control – Pause** Pressing the button again resumes data acquisition
	**Options – Channels parameters**
	**Options – OSC parameters**
	**Control – Autothreshold**
	**Control – Sound**
	**Control – OSC Start**
	**Control – OSC Stop**
	**Control – OSC Record**
	**Previous OSC wave**
	**Next OSC wave**
	**View – Zoom in**
	**View – Zoom out**
	**Draw region / polygon**

Button	Duplicates a menu or performs an action
	**Shift visible area**
	**Location – Clear Locations** Clearing all windows of correlation dependencies, histograms and locations
	**Location – Restore Locations** Restoring all windows of correlation dependencies, histograms and locations
	**Help – About**

5.9. View bar

View bar, located on the left, is intended for the convenience of working with the complex. A detailed description of working with **View bar** is given in the section *“Using the View bar”* on page 52.

5.10. Status bar

Status bar displays brief tips when working with the menu and **Tool bar**, and also indicates the position of the cursor (coordinates X and Y) within the active window and, for some windows, additional information.

Fig. 5.7. **Status bar**

5.11. Hotkeys

To increase the convenience of work, the program provides "hot keys" (combinations of various keys). Each key combination allows you to quickly call any command of the main menu.

Table 5.11.

Hotkey	Duplicates a menu or performs an action
<Alt + N>	**File – Create project**
<Ctrl + O>	**File – Open**
<Alt + O>	**File – Open project**
<Ctrl + P>	**File – Print**
<Alt + F4>	**File – Exit**
<Ctrl + F5>	**Control – Start**
<Ctrl + F6>	**Control – Stop**
<Ctrl + F7>	**Control – Pause**
<Ctrl + Shift + F5>	**Control – OSC Start**
<Ctrl + Shift + F6>	**Control – OSC Stop**

Hotkey	Duplicates a menu or performs an action
<Ctrl + R>	**Control – OSC Record**
<Ctrl + N>	**Control – New measurement**
<Ctrl + L>	**Control – Relogin**
<Ctrl + M>	**Control – Marker**

Note that the above "hot keys" are installed in the program by default. If desired, the user can change the proposed and add new combinations. Setting up hotkeys is described in *“Setting up hotkeys”* on page 120.

✶ ✶ ✶

Chapter 6. Working with the complex

✻ Chapter *"Working with the complex"* is devoted to preparing for a new measurement and managing the complex during data acquisition.

6.1. Preparing for a new measurement

Before starting data acquisition, you must set the parameters for the new measurement. To do this, select the main menu command **Control – New Measurement**, or press the button on **Toolbar**, after which the dialog box **Measurement details** appears.

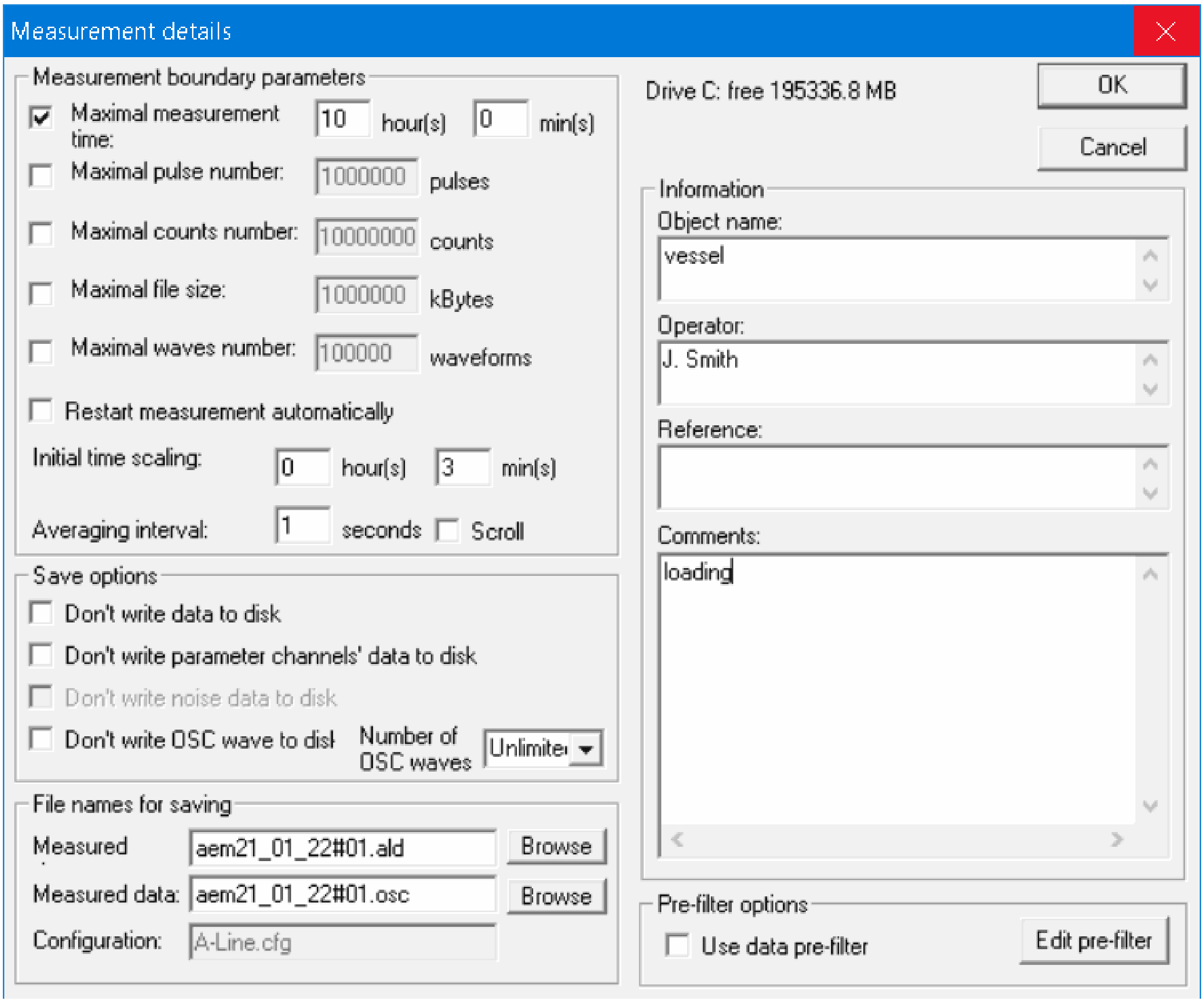


Fig. 6.1. Dialog box **Measurement details**

This dialog box sets the parameters that determine the upcoming measurement.

◇ In the **Time measurement parameters** group, you must enter the time measurement parameters and select one or more criteria for stopping the complex. If one criterion is activated, the complex will stop after reaching the maximum value set for this criterion. When using several (or all) criteria at the same time, the complex will complete data acquisition after reaching the maximum value for any of the selected parameters. The received data will be written to a file, and the complex will either automatically restart and continue receiving data, or stop. This will be determined by the activation of the appropriate commands.

- The maximal measurement time is indicated in the **hour(s)** and **min(s)** input fields located in the line **Maximal measurement time**. The time interval is specified in hours and minutes. After the specified time has elapsed, data acquisition will be terminated.
- The maximal number of impulses is set in the input field **pulses**, which is located in the line **Maximal pulse number**. Upon reaching the specified number of impulses in total for all channels, data acquisition will be terminated.
- The maximal number of emission counts is set in the input field **counts**, which is located in the line **Maximal counts number**. Upon reaching the specified number of emission counts in total for all channels, data acquisition will be terminated.
- The maximal file size is set in the input field **kBytes**, which is located in the line **Maximal file size**. When the specified file size is reached, data acquisition will be terminated.
- The maximal number of waveforms is set in the input field **waveforms**, which is located in the line **Maximal waves number**. Upon reaching the specified maximum number of waveforms in total for all channels, data acquisition will be terminated.
- To automatically restart the complex, activate the switch **Restart measurement automatically**. After that, the complex will be restarted every time after one of the selected stop criteria is met. In this case, the complex can be stopped using the main menu command **Control – Stop**, or the button on **Toolbar**, or hotkey combinations **<Ctrl + F6>**.

  If the switch is not activated, data acquisition will end when the maximal value for one of the selected stop parameters is reached.
- The initial time scaling interval for displaying results, set in the WDRI, is indicated in the input fields **hour(s)** and **min(s)**, located in the line **Initial time scaling**. The time interval is specified in hours and minutes.
- The averaging interval of the received data, expressed in seconds, is indicated in the input field **Averaging Interval**.

◇ In the group **Saving options**, set the parameters of saving data.

- The program provides the ability not to save received data on disk by setting the switch **Don't write data to disk**.
- If there is no need to save data from parametric inputs, set the switch **Don't write parameter channels' data to disk**.
- To exclude the recording of noise packets, set the switch **Don't write noise data to disk**.
- The program also provides the ability not to save received waveforms by setting the switch **Don't write OSC wave to disk**.
- The number of waveforms written to disk should be entered in the field **Number of OSC waves**.

◇ In the **File names for saving** group, specify the names of the files in which the data will be saved.

- The name of the file in which the data will be saved can either be entered manually in the input field **Measured data**, or selected using the standard dialog box for working with files by clicking button **Browse**.

- The name of the file in which the waveforms of the received AE impulses will be saved can either be entered manually in the input field **OSC wave**, or selected using the standard dialog box for working with files by clicking **Browse**.
- The name of the configuration file is specified in the field **Configuration**.

◇ In the **Pre-filter options** group, you can set the pre-filter options.

- To enable the pre-filtering mode, set the switch **Use data pre-filter**.
- Pre-filtering parameters can be set by clicking the **Edit pre-filter** button. After that, the window **Filter settings** opens. It is described in more detail in the section *"Data filtering"* on page 73.

◇ In the **Information** group, you can set comments to the data. All of them are purely informative and serve only for the convenience of data identification during further processing, without affecting the measurements.

- The name of the object is indicated in the input field **Object name**.
- The operator name is set in the input field **Operator**.
- The reference to the regulatory and technical documentation used to carry out the testing can be entered in the input field **Reference**.
- Comments are set in the input field **Comments**.

After entering all the parameters, you must click the **OK** button in the **Measurement details** dialog box. After that, the complex is ready for data acquisition. To cancel the set parameters, use the button **Cancel**.

⚠ If there is no data receiving, then using the command **New Measurement** only prepares the complex for data acquisition. Registration of AE impulses starts only from the moment of execution of the command **Control – Start**. Further description of the control of the work of the complex is set out below in the section *"Complex management during data acquisition"*.

The command **New Measurement** is also available during data acquisition. Its use at this moment results in the end of the current measurement and the immediate start of a new measurement with the same parameters. In this case, data is written to new files without calling the corresponding dialog. New file names are auto-numbered based on the file names used during the previous (interrupted) measurement.

Features of the start of the A-Line DDM complex

As in all complexes, when working with A-Line DDM, before starting data acquisition, select the main menu command **Control – New Measurement**. After that, the dialog box **Measurement details** appears, in which the necessary parameters are set. The peculiarity of A-Line DDM is that after setting the parameters in the **New Measurement** dialog box and pressing the **OK** button, the complex is not immediately ready to a new measurement, but a power supply to the line is required. At the same time, a corresponding request appears on the screen.

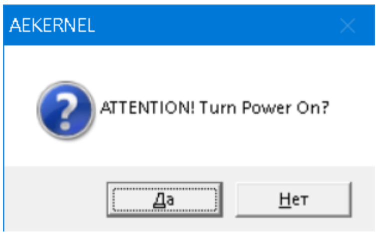


Fig. 6.2. Request for turn power on

After selecting the **Yes** button, power is applied and the modules are subsequently detected. After a few seconds, a list of detected modules appears on **View bar**.

If a break is detected while checking the lines for service, a message appears indicating the number of the line that is not ready for service.

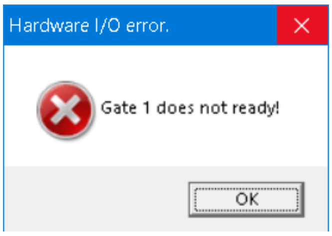


Fig. 6.3. Notice about a line break before starting work

After eliminating the break in the line, you must repeat the entire start procedure, starting with setting the parameters of the new measurement.

Note that if there are enough collected lines to receive data, then the complex may work in the presence of breaks in other lines. In this case, power will be supplied only to the assembled lines. Modules found in these lines will participate in data acquisition regardless of the readiness of other lines.

During the data acquisition, the complex may stop due to a line break. In this case, a message appears about a break indicating the line number and about the termination of the measurement:

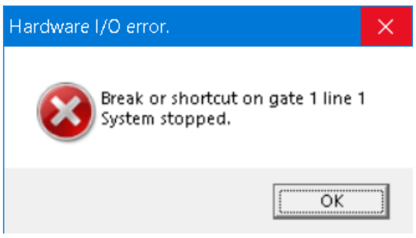


Fig. 6.4. Message about line break during data acquisition

To continue data acquisition, it is necessary to eliminate the cause of the break and repeat the start procedure from the beginning.

6.2. Complex management during data acquisition

To start data acquisition, select **Control – Start** in the main menu, or press the ▶ to **Toolbar**, or use the hotkey combination **<Ctrl + F5>**. From this moment, the countdown of the measurement time and the registration of AE impulses begin.

During data acquisition, it is possible to temporarily suspend the complex without stopping the countdown of the total measurement time. To do this, use the command **Control – Pause** in the main menu, or the button on **Toolbar**, or a combination of hot keys **<Ctrl + F7>**. To continue the operation of the complex, use any of the above methods again, after which the complex will continue to receive inpulses.

To stop data acquisition, use the command **Control – Stop** of the main menu, or the button on **Toolbar**, or a combination of hot keys **<Ctrl + F6>**. The end of the measurement also occurs when at least one of the selected criteria for stopping the complex is met:

- after the maximum measurement time has elapsed;
- upon reaching the specified number of impulses or the number of emissions, in total for all channels;
- on reaching the specified file size or number of waveforms, total for all channels.

The listed criteria are set when preparing a measurement in the dialog box **Measurement details**, described in the section *“Preparing for a new measurement”* on page 47. When one of the criteria is met, the complex reports the end of data acquisition.

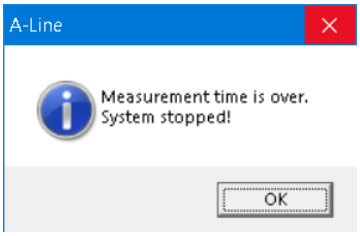


Fig. 6.5. Message about the end of data collection

In complexes of the A-Line DDM type, it is possible to stop during the data acquisition due to a line break, which is reported to the user.

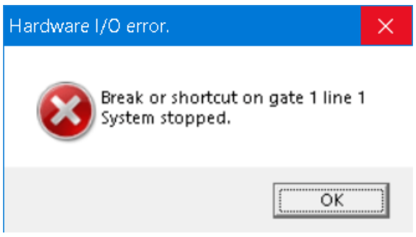


Fig. 6.6. Message about line break during data capture

To continue data acquisition, it is necessary to eliminate the cause of the break and repeat the start procedure from the beginning.

Oscilloscope control

During data acquisition, it is possible to turn the oscilloscope channel on and off at any time, except for the **Pause** mode.

To start the oscilloscope, you can use the main menu command **Control – OSC start**, or the button to **Toolbar**. This option is not available if none of the **OSC** pages of the dialog box **Channels parameters** is set to **On** (see *“Configuring oscilloscope channels”* on page 107).

To stop the oscilloscope, use the main menu command **Control – OSC stop**, or the button to **Toolbar**.

To save the received waveforms, press the  button on the **Toolbar**, or use the command main menu **Control – OSC record**. If this button is not pressed, the waveforms are only displayed on the screen. It should be noted that saving waveforms is not possible if the option **Don't write OSC wave to disk** was set when setting the measurement parameters in the dialog box **Measurement details**, described in the section *“Preparing for a new measurement”* on page 47, or in the case when on the page **OSC** of the dialog box **Channels parameters** none of the **Save** switches is activated (see section *“Configuring oscilloscope channels”* on page 107). In addition, after saving the number of waveforms specified when entering the measurement parameters, the ability to save them is also lost.

6.3. Using the View bar

For convenience, the program provides **View bar**.

Fig. 6.7. **Viewbar**

◇ For each channel you can use it to:
  - turn the channel on and off by pressing the button with the channel number;
  - quickly determine the channel number by the color of the chart;
  - switch on and off the displaying of graphs corresponding to this channel by activating and deselecting the switches in the column next to the colored square corresponding to the channel's displaying color;
  - select a channel whose data is displayed in the oscilloscope window by turning on the appropriate switch in the **OSC** column;
  - to facilitate the identification of the position of the module in the system at the test object, turn on the blinking of the built-in LED of any module at the operator's choice. To do this, right-click on the colored box indicating the displaying color of this module. Blinking is available independently for each module at any time after power is applied to the line, except for the data acquisition period (for DDM-2 type systems);
  - using the pop-up context hint to determine the physical number of the module (for DDM type systems).

◇ To quickly enable all channels, activate the switch **show all**. To quickly turn off all channels, reset this switch.

◇ To quickly turn on the waveforms from all channels, activate the **turn on all OSC** switch. To turn off waveforms from all channels, clear this switch.

◇ To enable the display of graphs of results for channels included in the corresponding location group, enable the corresponding switch in the group **Loc. groups**.

◇ The number of accumulated waveforms in the data acquisition mode is indicated in the **Nosc** field. In post-processing mode, this field indicates the number of the displayed waveforms.

◇ The number of received impulses is specified in the **SN[hit]** field. In acquisition mode, this field displays the current number of impulses since the acquisition began. In post-processing mode, this field indicates the total number of impulses contained in the file.

◇ The emission counts is indicated in the **SN[em]** field. In acquisition mode, this field displays the current total emission count in all impulses received since the acquisition began. In post-processing mode, this field indicates the total emission count in all impulses contained in the file.

◇ To call the **Location filter dialog** box for the selected location group, click the **Filter** button.

◇ The time elapsed since the start of data acquisition is indicated on the bottom button **Viewbar**.

6.4. Alarm manager

For the convenience of the user, the program provides the ability to create sound messages called alarms. Each alarm is characterized by a sound file and a set of conditions under which this sound file is played.

To call the alarm management dialog, select the command **Window – Alarm Manager** in the main menu, after which the dialog box **Alarm Manager**.

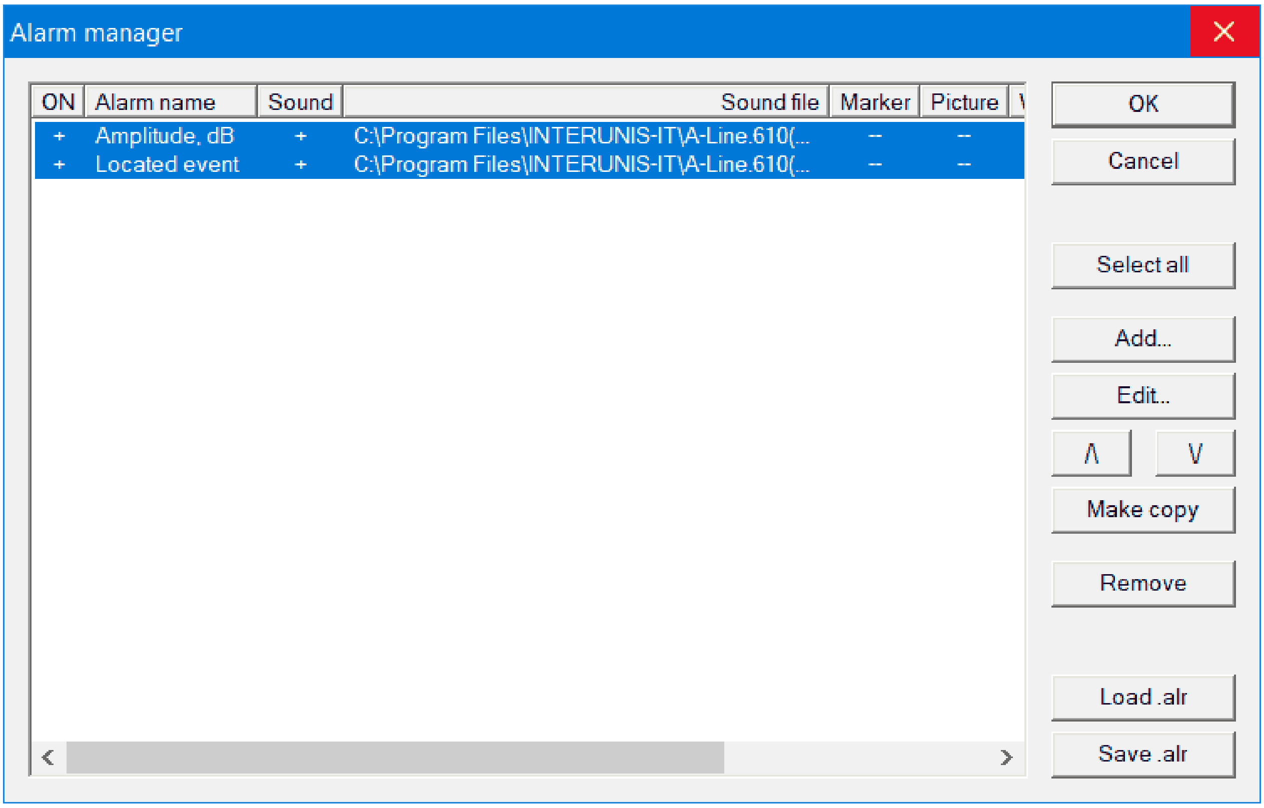


Fig. 6.8. Dialog box **Alarm manager**

This window contains a list of alarms and commands for managing alarms.

◇ The dialog box contains a list of alarms. For each alarm, its parameters are indicated: activation, alarm name, sound file name, and others.

◇ The following commands are available for working with the list of alarms and changing their parameters:

- To add a new alarm, click the **Add** button, after which a dialog box appears **Alarm parameters settings**, in which you should set the parameters for the appearance of a new alarm, as described in the section *“Alarm settings”* on page 54;
- to change the alarm settings, select it in the list and use the **Edit** button, and then in the dialog box that opens **Alarm parameters setting** make the necessary adjustments;
- to move in the list of alarms, use the "/\" buttons to move up one line, or use the "\/" buttons to move to one line down;
- to copy an alarm, select it in the dialog box and click the button **Copy**;
- to remove an alarm, select it in the dialog box and click the **Remove** button.

◇ Note that only one alarm can be added or modified when working with the alarm list. For moving, copying and deleting, one or more alarms can be selected from the list using the standard line selection procedure, either with the mouse or using the appropriate keyboard shortcut:

- To select the entire list, use the **Select all** button.

◇ To load and save alarm files, use the corresponding buttons:

- activate the button **Load .alr** and select the necessary alarm file (extension *.alr);
- activate the button **Save .alr** and in the opened dialog box **Save as** specify the path and enter the file name, where the alarm (or list of alarms) will be saved.

After creating and configuring alarms, press the **OK** button, to cancel press the **Cancel** button.

✍ Alarm set parameters are stored in a common configuration file.

Alarm settings

Audio message parameters are set in the **Alarm manager** dialog box, which is called from the **Alarm manager** dialog box.

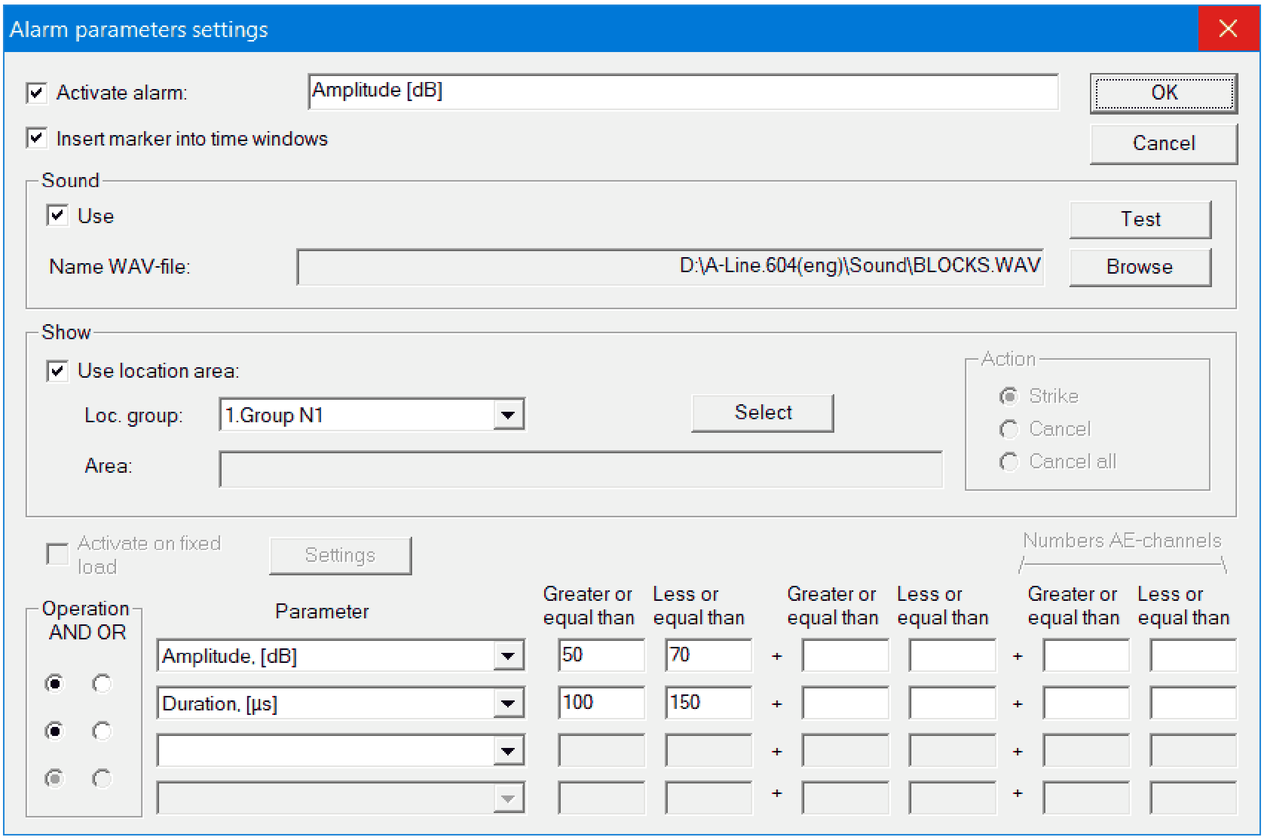


Fig. 6.9. Dialog box **Alarm parameters settings**

In this dialog box, set the parameters of the audio message:

◇ Turn on the switch **Activate alarm…** and enter its name in the input field.

◇ To automatically set the marker in all time-dependent windows, activate the switch **Insert marker into time windows**.

◇ In the **Sound** group, select the sound *.wav file corresponding to the activated alarm:

- check **Use**;
- click the **Browse** button and select the desired sound file to be played at the appropriate moment (sound playback occurs only in data acquisition mode);
- To test the selected sound file, use the button **Test**.

Several sound files are located in the **A-Line** program directory in the **Sound** subdirectory.

◇ The program has the ability to create an audio message at the selected location area in case the specified number of located AE events is exceeded. To do this, in the **Show** group, set the parameters of the location area corresponding to a certain number of located AE events:

- activate the switch **Use location lot**;
- select the appropriate location group in the list **Loc. group**;
- To define a location area containing the area of interest, press the button **Select**, after that, the name of the selected location area will appear in the input field **Area** and the switches in the **Action** group will become available;
- To work with the region of interest, one of the radio buttons should be activated in the **Action** group:
  - to highlight the area of interest, use the radio button **Strike**;
  - if necessary, remove the illumination of the area under study, activate the radio button **Cancel**;

◦ To turn off all highlighted areas, use the radio button **Cancel all**.

Note that the switches **Strike** and **Cancel** are available for any type of location, except for a location of type "Picture". The switch **Cancel all** is only available for "Picture" location type.

◇ Set the criteria for the sound signal to appear:

- select the parameter to which the complex will react with the sound signal, select **Parameter**;
- specify the lower and upper limits of the sound signal triggering ranges in the input fields **Greater or equal than** and **Less or equal than**, respectively.

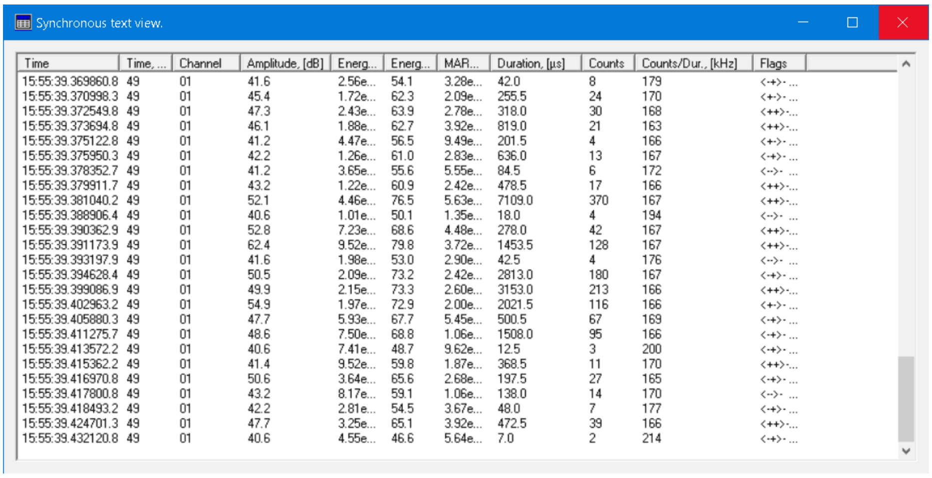
For each parameter, you can set up to three ranges for the sound signal and four conditions combined with logical "AND" or "OR".

To save the sound signal settings, press the **OK** button, otherwise —the **Cancel** button.

6.5. Synchronous text view

Online mode

When receiving AE impulses (**online** mode) in the program, it is possible to view their parameters in text form. To do this, select the main menu command **View – Sync.View**. After that, the **Synchronous text view** window appears.



Time	Time, ...	Channel	Amplitude, [dB]	Energ...	Energ...	MAR...	Duration, [µs]	Counts	Counts/Dur., [kHz]	Flags
15:55:39.369860.8	49	01	41.6	2.56e...	54.1	3.28e...	42.0	8	179	<-+>- ...
15:55:39.370998.3	49	01	45.4	1.72e...	62.3	2.09e...	255.5	24	170	<+->- ...
15:55:39.372549.8	49	01	47.3	2.43e...	63.9	2.78e...	318.0	30	168	<++>-...
15:55:39.373694.8	49	01	46.1	1.88e...	62.7	3.92e...	819.0	21	163	<++>-...
15:55:39.375122.8	49	01	41.2	4.47e...	56.5	9.49e...	201.5	4	166	<+->- ...
15:55:39.375950.3	49	01	42.2	1.26e...	61.0	2.83e...	636.0	13	167	<-+>- ...
15:55:39.378352.7	49	01	41.2	3.65e...	55.6	5.55e...	84.5	6	172	<-->- ...
15:55:39.379911.7	49	01	43.2	1.22e...	60.9	2.42e...	478.5	17	166	<++>-...
15:55:39.381040.2	49	01	52.1	4.46e...	76.5	5.63e...	7109.0	370	167	<++>-...
15:55:39.388906.4	49	01	40.6	1.01e...	50.1	1.35e...	18.0	4	194	<-->- ...
15:55:39.390362.9	49	01	52.8	7.23e...	68.6	4.48e...	278.0	42	167	<++>-...
15:55:39.391173.9	49	01	62.4	9.52e...	79.8	3.72e...	1453.5	128	167	<++>-...
15:55:39.393197.9	49	01	41.6	1.98e...	53.0	2.90e...	42.5	4	176	<-->- ...
15:55:39.394628.4	49	01	50.5	2.09e...	73.2	2.42e...	2813.0	180	167	<-+>- ...
15:55:39.399086.9	49	01	49.9	2.15e...	73.3	2.60e...	3153.0	213	166	<++>-...
15:55:39.402963.2	49	01	54.9	1.97e...	72.9	2.00e...	2021.5	116	166	<+->- ...
15:55:39.405880.3	49	01	47.7	5.93e...	67.7	5.45e...	500.5	67	169	<-+>- ...
15:55:39.411275.7	49	01	48.6	7.50e...	68.8	1.06e...	1508.0	95	166	<-+>- ...
15:55:39.413572.2	49	01	40.6	7.41e...	48.7	9.62e...	12.5	3	200	<-+>- ...
15:55:39.415362.2	49	01	41.4	9.52e...	59.8	1.87e...	368.5	11	170	<++>-...
15:55:39.416970.8	49	01	50.6	3.64e...	65.6	2.68e...	197.5	27	165	<-+>- ...
15:55:39.417800.8	49	01	43.2	8.17e...	59.1	1.06e...	138.0	14	170	<-->- ...
15:55:39.418493.2	49	01	42.2	2.81e...	54.5	3.67e...	48.0	7	177	<-+>- ...
15:55:39.424701.3	49	01	47.7	3.25e...	65.1	3.92e...	472.5	39	166	<++>-...
15:55:39.432120.8	49	01	40.6	4.55e...	46.6	5.64e...	7.0	2	214	<-+>- ...

Fig. 6.10. **Synchronous text view** window

In the window that opens, real AE data will be displayed, disordered in terms of the time of receiving of AE impulses. The viewing page will display the parameters of the latest impulses received by the complex. The number of impulses presented is determined by the page size of the text view, which can be changed at the user's request.

To set the text view page size, use the main menu command **Options – Settings**. In the opened dialog box **General** (described in the section *"Setting the general parameters of the complex"* on page 114), in the input field **Size of the filter and text window page** in the group **Constants** enter the size of the text view page. The value 1000 is considered optimal for the operation of the complex.

During the data acquisition, after each averaging interval, the information in the view page window is updated, which makes it difficult to carefully analyze the incoming data. For a closer look at the received AE impulses, you can temporarily suspend data acquisition using the **Pause** button, and then use the scroll bar in the synchronous text view window.

Offline mode

The program provides for the possibility of synchronous viewing of the parameters of received AE impulses in the post-processing mode. This feature is available for location windows and correlation windows. Please note that this function is not available for the WDRI windows and histograms.

To perform synchronous viewing in location windows, you need to:

- select main menu command **View – Sync.View**;
- enlarge, for greater convenience, the window of interest;
- move the cursor to the point of interest;
- press the right mouse button.

The selected point will be framed by an inverse color rectangle for clarity. After that, a context menu appears, in which you need to select the command **Show impulses**.

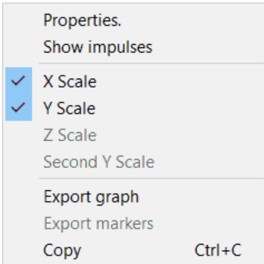


Fig. 6.11. Context menu for location window

Then, the parameters of all AE impulses that generated location events within the selected coordinates will appear in the synchronous text view window. In the case of a linear location, events are highlighted in the entire corresponding column. Each new showing will be highlighted in the synchronous text view window.

To display a set of AE impulses in the synchronous view window, either left-click to select the required area of AE impulses with a rectangle, or use the button (region/polygon) set the required area by points. Then press the right mouse button and select the command **Impulse charecteristic** in the context menu that appears, after which the parameters of all AE impulses of the selected area will appear in the synchronous view window.

The program provides the ability to quickly access the waveform corresponding to the impulse shown in the synchronous text view window, which has an waveform presence flag. To do this, double-click on the line corresponding to the impulse.

In the windows of correlation dependences, the procedure for synchronous viewing of the parameters of AE impulses with the selected display coordinate is also available. Note that this procedure is not available for histograms.

The program provides the ability to transfer selected lines to other Windows applications using the clipboard. To copy the selected lines, right-click, select TXT or CSV format. To copy in text format, you can also press the key combination **<Ctrl + C>**.

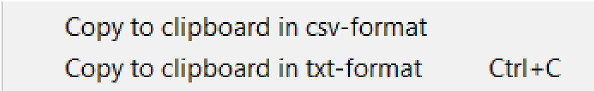


Fig. 6.12. Selecting a clipboard format

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Chapter 7. Data files

✻ Chapter *“Data files”* covers basic data file handling.

7.1. Working with files

Opening a data file

To load previously saved data, select the command **File – Open** in the main menu, either press the button on **Toolbar**, or use the key combination **<Ctrl - O>**. In the opened standard dialog box **Open file** select the required file and press the **Open** button. This opens the **File header** dialog box, which is described in the section *“File header”* on page 60. Note that in this window you can change the file opening mode, including activation the **File reading panel**. To continue loading the data file, press the **OK** button, to cancel the data loading press the **Cancel** button.

File reading panel

To change the playback speed of the recorded data, you can activate **File reading panel** by turning on the switch **Show result diagrams only** in the **File header** dialog as described in *“Controls”* on page 63.

Fig. 7.1. **File reading panel**

Using the buttons on this panel, you can control the process of reading files.

- To increase the speed of reading a file, use the button (**Speed up**).

  You can change the playback speed from 1 (real-time playback) to 500 (playback is 500 times faster). The playback speed is displayed in the current time-dependent window at the bottom of the **View panel** in square brackets.

- To decrease the file reading speed, use the button (**Slow down**).
- To stop reading the file, use the (**Cancel**) button. This stops reading the file and the panel disappears.

  You can also cancel reading a file using the main menu command **View – File reading panel** by deselecting the switch **File read Bar**. After that, calling the file reading panel from the main menu is not available.

- To temporarily stop the file reading process, use the button (**Pause**).

To remove **File reading panel** when temporarily stopped, select the main menu command **View – File read Bar**. To restore **File reading panel**, select the same main menu command again.

- To continue reading the file, click the button C (**Continue**).

When the file reading is finished, **File reading panel** disappears. The main menu command **View – File Reading Panel** is also disabled.

Saving data file

The program implements automatic saving of received data, which occurs once a minute, after the end of data acquisition and when the pause mode is turned on. The name of the file in which the data is saved is specified when setting the measurement parameters.

Opening a waveform file

Opening waveform files is similar to opening data files, with the following exceptions:

- to open waveform files use **File – Open OSC wave**;
- instead of the **File header** window, the **OSC wave file header** window appears, similar to the **File header**, but containing additional information regarding the waveforms.

The **OSC wave file header** window is described in *“Header of the waveform file”* on page 64.

Saving a waveform file

The program implements automatic saving of waveforms, similar to saving a data file.

7.2. File header

The **File header** dialog box appears when opening a data file (the procedure is described on page 59), when opening a file for filtering (the operation is described on page 74). In addition, this window can be opened when the data file is loaded using the main menu command **File – Show Header**.

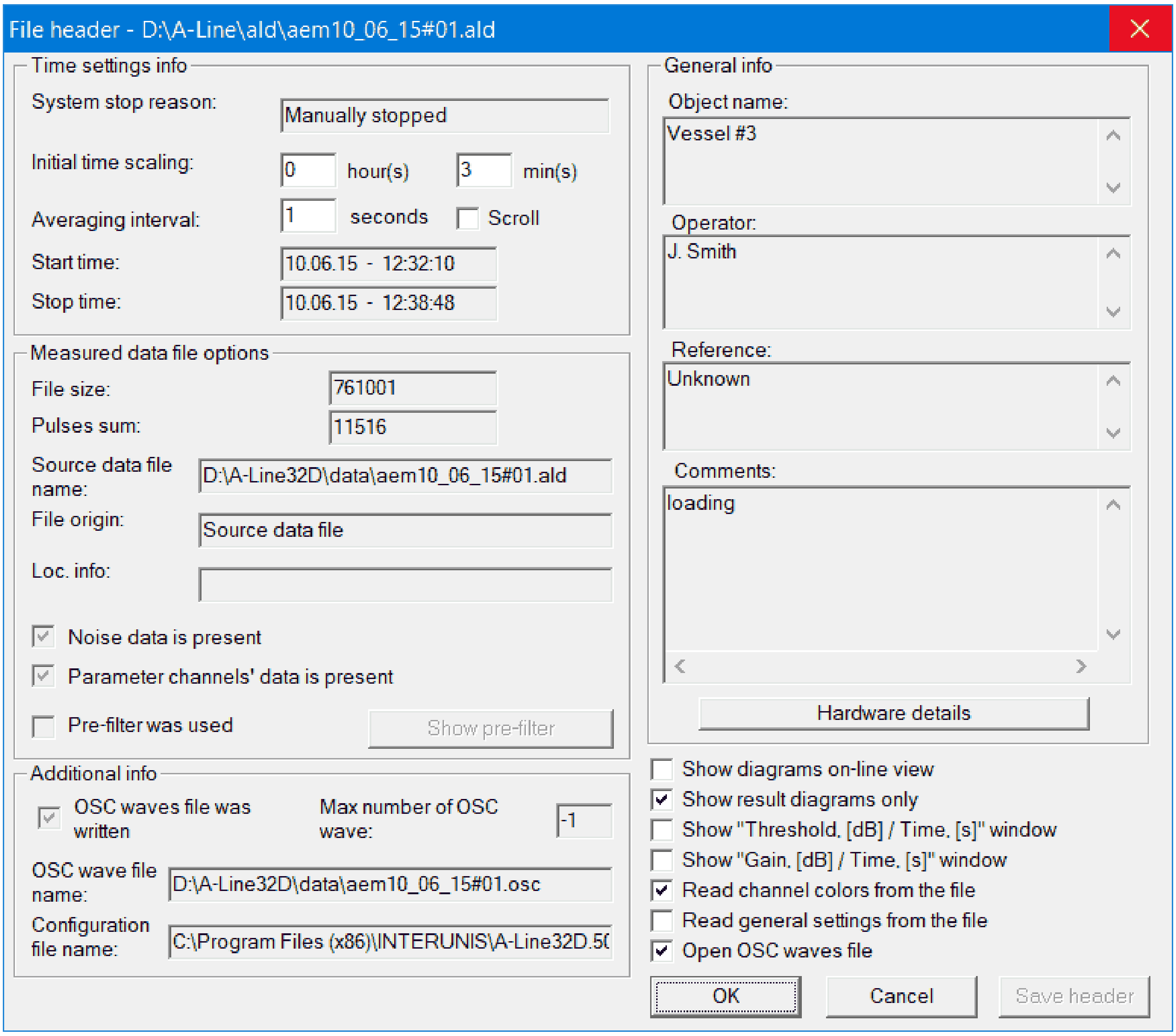


Fig. 7.2. **File header** window

The **File header** window contains controls and information about the data file.

Data file information

Most of the information presented in the **File header** dialog box comes from the data file. It is divided into four groups.

◇ The **Time settings info** group contains information about the time parameters of the measurement and the reason for stopping the complex:

- reason for stopping the complex — in the field **System stop reason**;
- initial time scale size —in the **Initial time scaling** fields;
- averaging time — in the field **Averaging interval**;
- measurement start time —in the field **Start time**;
- measurement end time —in the field **Stop time**.

◇ The group **Measured data file options** contains information about the data file:

- file size — in the field **File size**;
- number of impulses contained in the file —in the field **Pulses sum**;
- source data file name — in the field **Source data file name**;

- data source type —in the field **File origin**:
  - **Source data file** for the data file obtained as a result of the measurement;
  - **Filtered data file** for a data file obtained as a result of filtering;
  - **Location filtered data** for a data file obtained after filtering as a result of location.
- file name and location group number in the field **Loc.info**;
- whether noise data was recorded — flag **Noise data is present**;
- whether data was recorded from parametric inputs — flag **Parameter channels' data is present**;
- whether a pre-filter was used — flag **Pre-filter was used**.

Pre-filter settings can be viewed by clicking **Show pre-filter**.

◇ The **Additional info** group contains information about accompanying waveform and configuration files:

- whether the waveform file was written — flag **OSC waves file was written**;
- the maximal number of waveforms is in the field **Max number of OSC wave**;
- waveform file name in the field **OSC wave file name**;
- configuration file name in the field **Configuration file name**.

◇ In the group **General info** there are comments to the data file:

- object name is in the field **Object name**;
- operator name is in the field **Operator**;
- reference to the regulatory and technical documentation used to carry out the testing is in the field **Reference**;
- comments are in the field **Comments**;
- information about the hardware-software version of the complex on which this file was recorded. Press the **Hardware details** button, after which the **Hardware details** dialog box opens.

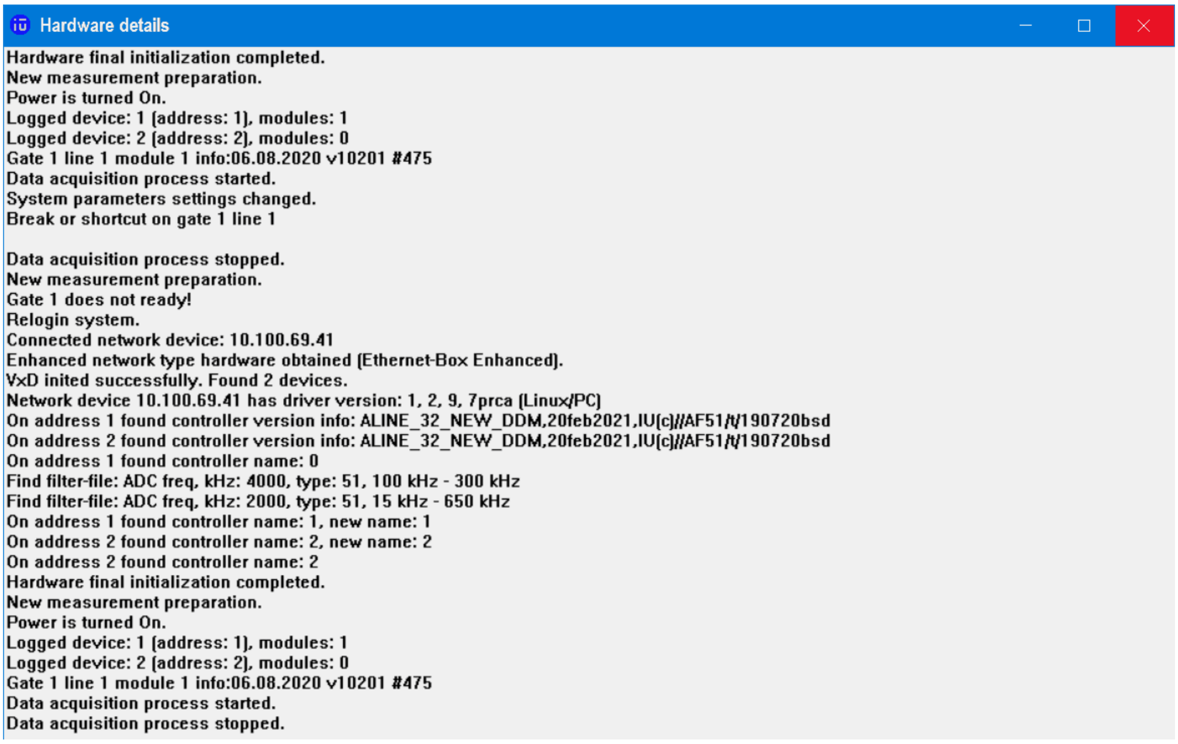


Fig. 7.3. Window **Hardware details**

The field of the dialog box that opens contains information about the hardware and software version of the complex.

Controls

In the dialog box **File header**, in addition to information about the data file, there is a group of switches that allows you to change the process of loading data, their presentation, and the values of custom parameters.

◇ Use the following options when opening a data file for easy loading and viewing.

- In the **Averaging interval** input field, you can change the averaging time, which is 1 s by default. With a large amount of data, it is recommended to increase this value, as this speeds up the loading process. To analyze dynamic processes, you can use an averaging time value less than 1 s.
- In the **Initial time scaling** input field, you can also change the default initial time scale size.
- For the convenience of viewing time-dependent graphs, you should activate the switch **Scroll time**. It enables the visualization of a time scroll bar on all time charts. The width of the time-dependent window will correspond to the value set in the input field **Initial time scalling**.
- Activation of the switch **Show diagrams on-line view** makes it possible to build WDRI graphs based on average parameters obtained from the hardware of the complex during data acquisition and written to the original file. Otherwise, the WDRI graphs are built on the basis of the parameters of the AE impulses contained in the file (for example, filtered).
- To observe the process of data acquisition and gradual plotting (WDRI, locations and others), disactivate the switch **Show result diagrams only**. In this case, when loading a file, **File reading panel** will appear, with which you can control the file reading process. Working with **File reading panel** is described in *“File reading panel”* on page 59.

When the switch is activated, graphs corresponding to the full data set in the file are immediately plotted, loading time is reduced.

◇ The program provides the ability to create additional windows while opening a data file.

- To create plots of threshold and gain vs. time, set the switches **Show 'Threshold, dB/time, s' window** and **Show 'Gain, dB/time, s' window**.
- To call the appropriate file OSC (if it was recorded during data acquisition) use the switch **Open OSC waves file**.

◇ The program provides the ability to use various settings of the complex parameters when loading a file.

- It is allowed to use the color of the channels from the opened data file. To do this, activate the switch **Read channel colors from the file**. Otherwise, colors from the current configuration file will be used.
- It is possible to use the general settings of the complex saved in the opened data file by setting the switch **Read general settings from the file**.

◇ When executing the command **File – Show header** and calling this window from the window **Filter and preview** fields in the group **General info** become editable. To save the changes, click the button **Save header**.

7.3. Header of the waveform file

The **OSC wave file header** dialog box appears when opening a waveform file (the procedure is described on page 60). In addition, this window can be opened when the waveform file is loaded using the main menu command **File – Show OSC Header**.

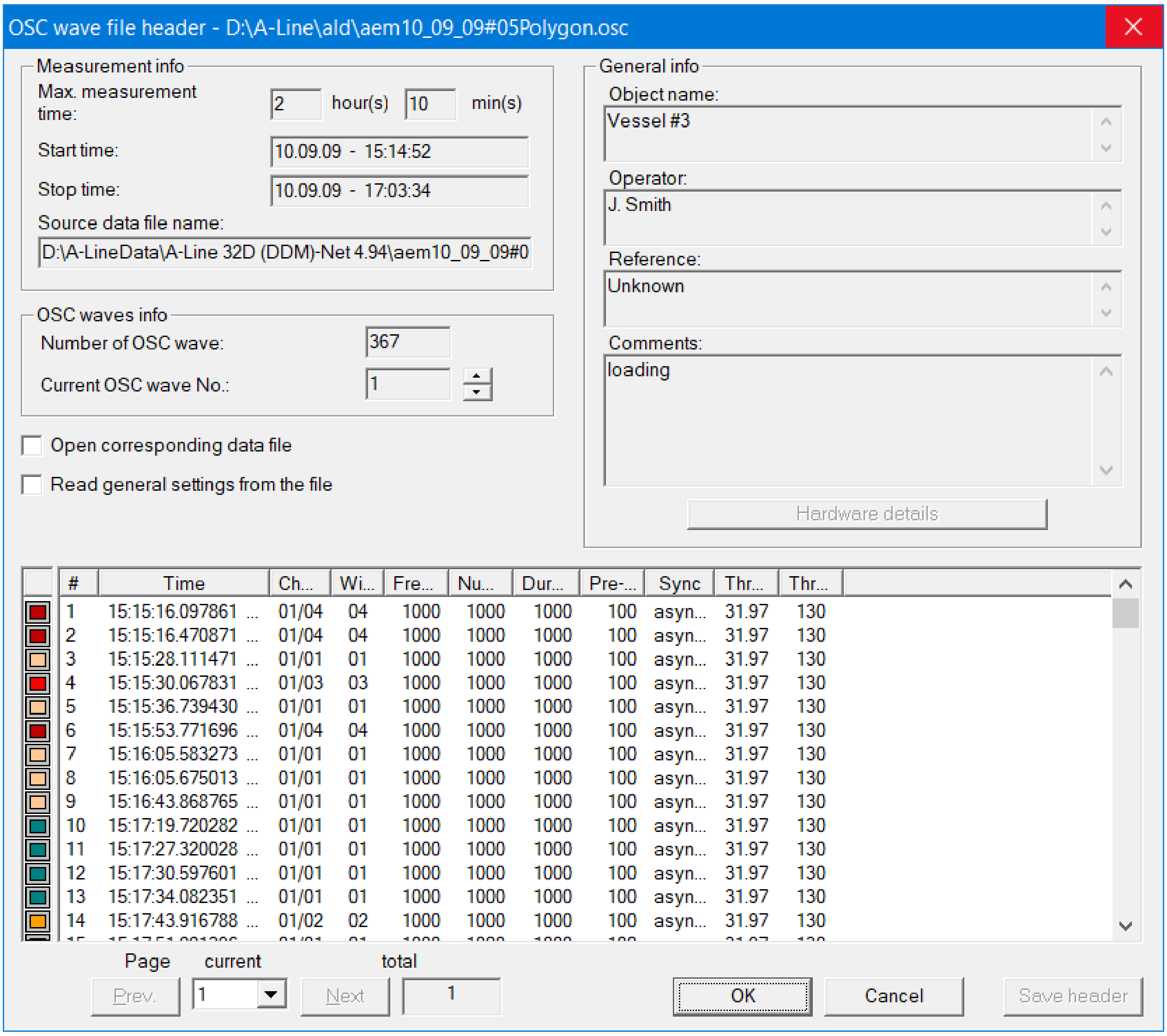


Fig. 7.4. **OSC wave file header** window

In the **OSC wave file header** window, information about the waveform file is contained in the following groups:

◇ The group **Measurement info** contains information about the time parameters of the measurement:
  - maximal measurement duration in **Max measurement time** fields;
  - measurement start time in the **Start time** field;
  - measurement stop time in the **Stop time** field;
  - the name of the data file obtained as a result of the measurement in the **Source data file name** field. If the data was not saved, then the message **Data was not recorded** appears in this field.

◇ The group **OSC waves info** contains information about the number of waveforms in the file:
  - number of real number of received waveforms in the field **Number of OSC wave**;
  - number of the current waveform spinner **Current OSC wave No**.

The selected current waveform is displayed in the WDRI **Digital Oscilloscope**. In this case, autoscaling of the waveform window along the Y axis is performed either according to the full scale of the ADC, or according to the maximum of the current waveform (dialog box **Axis**).

Calculation and display of the frequency spectrum of the current waveform is carried out in the data acquisition mode and is displayed in the WDRI **Spectral power [μV/MHz] / Frequency [kHz]**.

◇ When opening an OSC file the program has the ability to use various settings of the complex parameters:
  - It is possible to open a file at the same time OSC and data file. To do this, activate the switch **Open corresponding data file**.
  - A procedure is available for reading the general parameters of the complex saved in the opened OSC file of waveforms. To do this, set the switch **Read general settings from the file**. Otherwise, the general settings will be read from the current configuration file.

◇ The group **General info** contains comments on the waveform file:
  - object name is in the field **Object name**;
  - operator name is in the field **Operator**;
  - reference to the regulatory and technical documentation used to carry out the testing is in the field **Reference**;
  - comments are in the field **Comments**.
  - Information about the hardware and software version of the complex on which this OSC file was written — click the button **Hardware details**. After that, the dialog box **Hardware details** similar to Figure 5.3 opens.

◇ In the lower part of the **OSC wave file header** window, the following information about all received waveforms is displayed:
  - waveform displaying color - column of colored squares. If the entire large square is filled, it means that the color of the channel is assigned individually for this channel. If only the small square inside the large square is filled, this means that the color assigned to the oscilloscope channel matches the color selected for the acquisition channel;
  - waveform number in the **№** column;
  - waveform arrival time (absolute, with high accuracy) and waveform arrival time relative to the start of measurement with an accuracy of 1 s in the **Time** column. The arrival time of the waveform (absolute, with high accuracy) is used to calculate the velocity of the acoustic wave from the waveform;
  - number of the channel from which the waveform was received in the **Channel** column;
  - the number of the window to which the output of the waveform channel is assigned is in the **Window** column;
  - sampling rate of the oscilloscope channel in the **Sampling rate, kHz** column;
  - the number of points in the oscilloscope frame in the **Number points** column;
  - oscilloscope frame duration in the **Duration, μs** column;
  - oscilloscope operating modes in the **Pre-triggering**, **Sync** columns (oscilloscope operating modes are described in detail in the section *“Configuring oscilloscope channels”* on page 107);
  - threshold value in dB in the **Threshold, dB** column;
  - the value of the threshold in ADC bits in the **Threshold, ADC bits** column.

Information about the received waveforms is presented in the viewer window and displayed in parts. The total number of pages is indicated in the field **total**. To view the next page, press the **Next** button, and to return to the previous page, press the **Prev** button. Each transition is accompanied by the appearance of a window reflecting the loading process. To open a file on an arbitrary page, use the list **current**. The number of data lines displayed on one page is set in the dialog box **General settings**.

When you execute the **File – Show OSC Header** command, the fields in the **General info** group become available for editing. To save changes to the header, click the **Save header** button.

You can close this window with the **OK** button. When opening a waveform file, pressing the **OK** button continues loading the data file, the **Cancel** button allows you to cancel the download.

7.4. Data files concatenation

When conducting various tests, it is often necessary to concatenate data contained in several files. The program provides the possibility of separate merging of data files (extension **.ALD**), waveform files (extension **.OSC**), as well as data files containing links to files **.OSC**. An unlimited number of files can be merged.

> ⚠ Concatenation of files whose start time differs by no more than 48 hours is allowed.
>
> The time intervals of the signal records in the concatenated files should not overlap in time. Otherwise, the program gives a message indicating the names of files that are not suitable for merging.

To concatenate data, select the **File – Concatenation** command from the main menu. After that, the **Concatenation settings** dialog box appears.

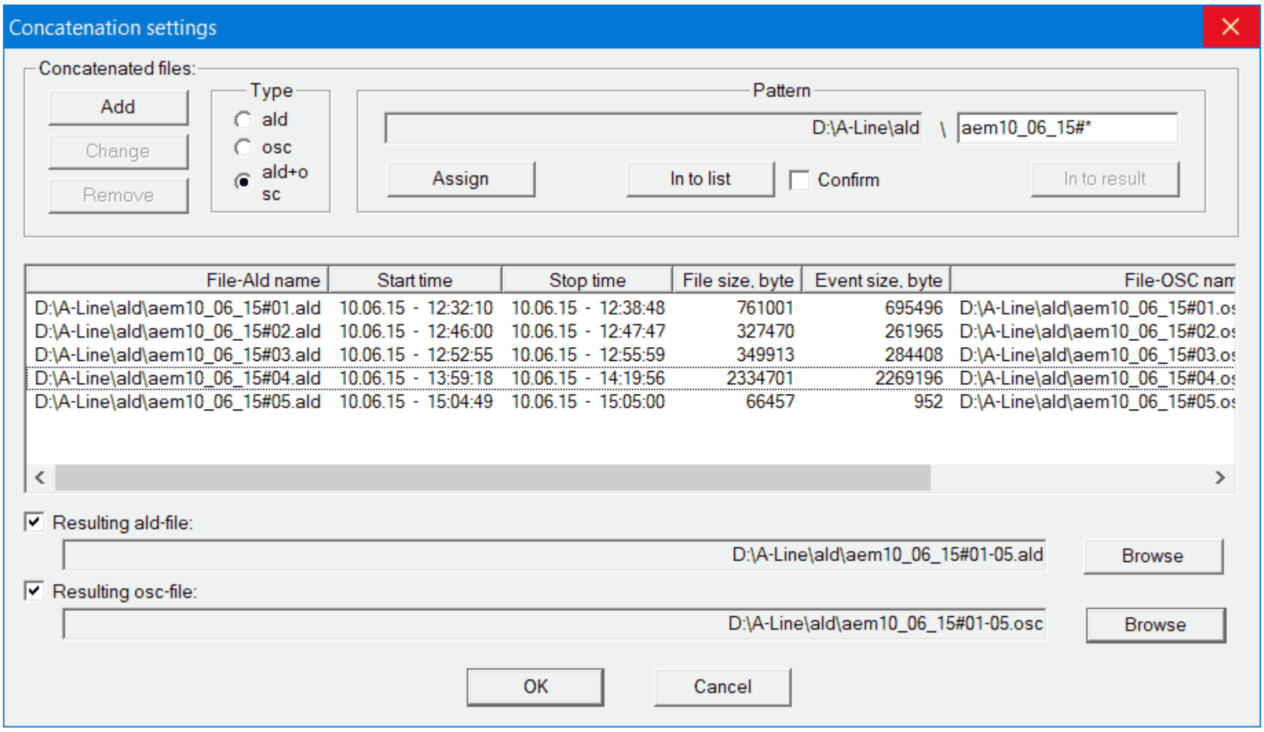


Fig. 7.5. Dialog box **Concatenation settings**

◇ To perform concatenation, in the dialog box that opens, select the type of files to be merged.

- To merge data files, click the switch **"Resulting ald file"** , which will automatically turn on the radio button **"ald"** in the **Type** subgroup and enable the **Add** button in the group **Concatenated files**.
- To merge waveform files, click the switch **"Resulting osc file"** , which will automatically turn on the radio button **"osc"** in the **Type** subgroup and make the button available **Add** in the group **Concatenated files**.
- To combine data files containing file links **.OSC** , activate both switches — **"Resulting ald file"** and **"Resulting osc file"** , which will automatically enable any radio button in the subgroup **Type** (by default, the program selects the radio button **"ald"**). When choosing radio buttons **"ald"** or **"ald+osc"** the **Add** button becomes available in the **Concatenated files** group. When the switch **"osc"** is activated, **Add** button becomes unavailable.

⚠ Concatenation of files like this is allowed:

✧ only data files with extension **.ALD** ;

✧ only waveform files with extension **.OSC** ;

✧ only data files containing links to files **.OSC** ; as a result, two new files are created, one of which contains only the merged data files (extension **.ALD**), and the second only merged waveform files (extension **.OSC**);

✧ data files containing links to files **.OSC** , with data files.

It is not allowed to merge data files containing links to files **.OSC** , with waveform files.

◇ After selecting the type of files to merge in the dialog box, specify the names of the files to merge.

- Files are added to the merge list by pressing the button **Add** and arbitrary selection of the necessary files in the standard dialog box **File open**. In this case, each added file is automatically placed in a certain sequence in the list. **File name** indicating the end and start time of the measurement, depending on the time of impulse registration.
- To merge and select a large number of files with similar names, the program has the ability to specify files through a pattern, using the characters "**?**" or "*", as described later in the section *“Using a pattern”*.

◇ To modify the list of merged files, the program provides the following options:

- To remove the selected file, click the **Remove** button.
- To replace the selected file, click the **Change** button.

The listed operations become available after selecting one of the files in the merge list. The delete and replace operations are performed on the selected file.

◇ To set the name of the resulting file, click the **Browse** button. Next, in the standard dialog box **Save as** specify the name of the file where the merged data will be saved.

After specifying the file names, click the **OK** button. The status bar shows the process of merging files.

Using a pattern

To merge and select a large number of files with similar names (for example, files of the same experiment recorded at different times), the program provides the ability to select files using a pattern, using the symbols "**?**" or " *".

The character "**?**" replaces any one character in the file name, the character "*" replaces any number of characters in the file name. For example, the pattern Data**?**1 corresponds to the files Data01, Data11, DataB1, etc. The pattern Data***** corresponds to the files Data, Data1, Data123, DataCB, etc.

◇ To set a pattern in the concatenation window, use the **Assign** button in the **Pattern** group. In the opened standard dialog box **Open file** select the source file to create the pattern. Note that the selected pattern, if desired, can be edited.

◇ To fill in the list, click the button **In to list**. The **File name** list will contain file names that match the pattern and do not overlap in time. Otherwise, a message will appear indicating the names of files not to be merged.

◇ To confirm the inclusion of a file in the merge list, activate the **Confirm** switch, and then click the **In to list** button. After that, each time a dialog box **Confirm addition of file** will appear, in which you should select either the button **Yes** — when a file is included in the merge list, or — the **No** button. When you select the **Cancel** command, the program stops considering the subsequent list of files. Previously selected files remain in the list.

◇ Once you have selected files to merge using a pattern, you can specify the name of the resulting file. To do this, use any of the following methods:

- Press the button **In to result**. The field **Resulting files** will contain the name of the resulting file suggested by the program. It will be made up of the name of the selected pattern, including the different parts for each merged file.
- Select one or more files in the list **File name**. Then press the **In to result** button. The field **Resulting files** will contain the name of the resulting file. It will be made up of the name of the selected pattern, including the different parts of the selected files.

> ✱ In most cases, the pattern replaces the number after "**#**" with "*". For example, if you specify …#0* (…#1*, …#2*) in the template, then the program will select only files from …#00 (…#10, …#20) to …#09 (…#19, …#29..), respectively.

7.5. Data file recovery

The program implements the ability to sort data, as well as recover files damaged as a result of hard disk failures, errors when writing them to other media, and unauthorized shutdown of the computer.

◇ To sort data or find errors in a file, do the following:

- use the main menu command **File – Recovery and sort**;
- in the dialog box **Open** that opens, select the file whose data you want to sort or check for corruption; then a window will appear showing the process of checking the file;

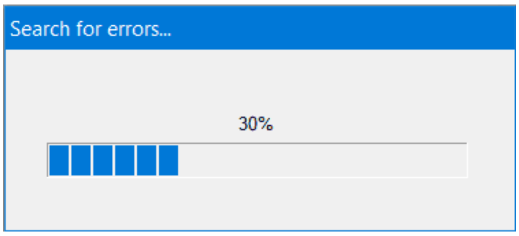


Fig. 7.6. **Search errors**

- After the file check is finished, a second window appears with a message about the result:

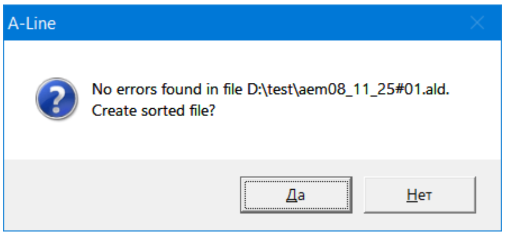


Fig. 7.7. **No errors found**

or

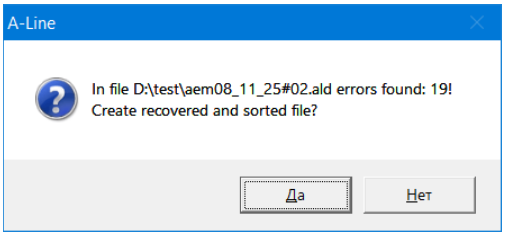


Fig. 7.8. **Errors found**

◇ To save a sorted (or recovered) copy of the original file, click the **Ok** button. The data is sorted by the time of arrival of the impulse, and in case of coincidence of arrival times, by channel number.

◇ Clicking the **No** button will not save the sorted or corrected copy of the file.

7.6. Project

For the convenience of working with files, the program provides for the creation of a project that combines various types of files (data files, waveforms, locations, measurements of velocity, load, settings) related to the testing object.

Creating a project

To create a project, use the main menu command **File – Create project**. After that, the dialog box **New project settings** appears.

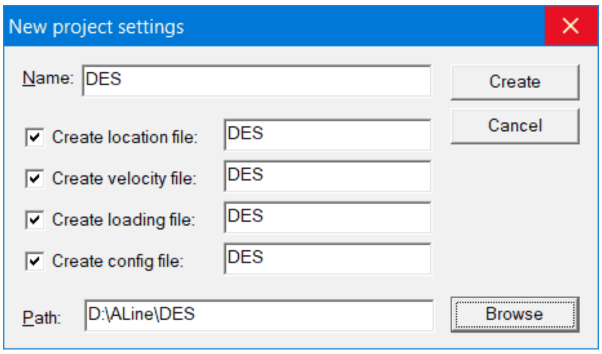


Fig. 7.9. **New project settings** window

This dialog box defines the settings for the new project.

◇ In the input field **Name** enter the name of the project. After that, it will be automatically assigned to all files included in the project.

◇ In the input field **Path** specify the name of the directory where the project will be located. To select a directory, you can use the **Browse** button. In the dialog box that opens **Select directory name** specify the path where the project will be placed.

◇ Select the file types to be included in the project:

- to include location configuration files, set the switch **Create location file**;
- to include files of velocity measurement parameters in the project, set the switch **Create velocity file**;
- to include files with additional line description, set the switch **Create loading file**;
- to include configuration files, set the switch **Create config file**.

To create a project, click the **Create** button, after which the project window appears. To cancel the entered settings press the button **Cancel**.

Project window

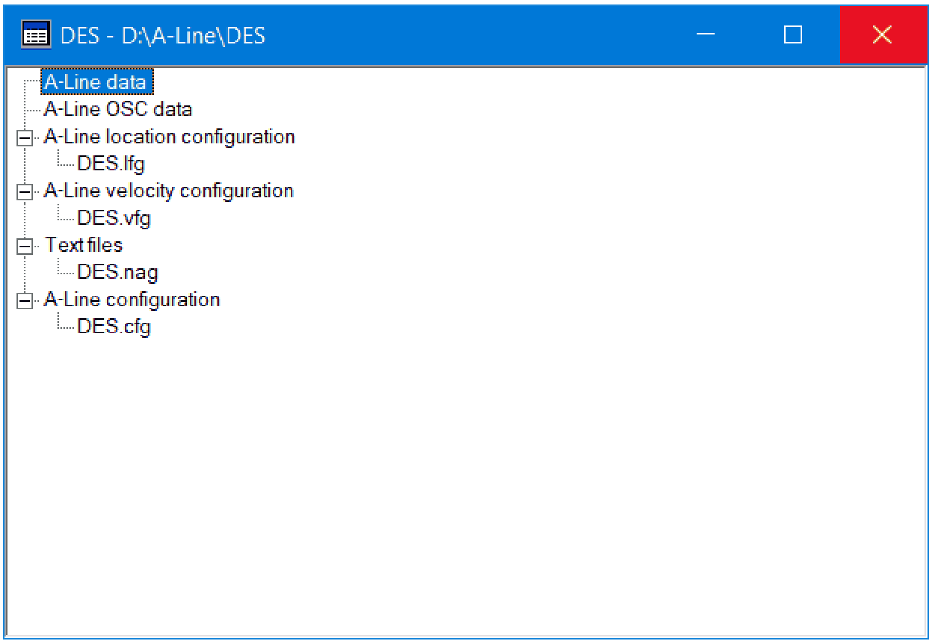


Fig. 7.10. Project window

The project window lists all the files in the project. To set parameters or change them, move the cursor to the file name and double-click the left mouse button. After that, a corresponding dialog box appears, in which you can either enter new parameters or change existing ones.

Also, you can use the right mouse button instead of the left. A single click on the right mouse button leads to the appearance of a context menu.

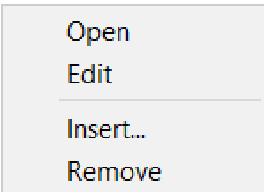


Fig. 7.11. Context menu for project files

Table 7.1.

Command	Action
Open	Opens the corresponding file
Edit	Opens a settings window for changing the parameters of the corresponding file type
Insert	Adds a new file to the project
Remove	Removes the selected file from the project

Project window control

To open a previously created project, use the main menu command **File – Open project**. After that, the project window appears, which can remain open during the data acquisition. This allows you to make the necessary changes during the measurement.

To temporarily close the project window, use the main menu command **View – Project Workspace**. To restore it, select the main menu command **View – Project Workspace** again.

If you need to completely close the project window, use the main menu command **File – Close project**.

✶ ✶ ✶

Chapter 8. Data processing

✻ Chapter *“Data processing”* contains information about post-processing data: printing, filtering, classification.

8.1. Data filtering

Filter options

The program allows filtering data by the following AE impulse parameters:

- serial number of the impulse in the file — **Number**;
- time of arrival of the impulse relative to the beginning of the measurement — **Time, [s]**;
- channel number — **Channel**;
- impulse amplitude (expressed in ADC bits, in dB and μV) — **Amplitude, [ADC]**, **Amplitude, [dB]** and **Amplitude [μV]**;
- RMS impulse amplitude — **Amplitude RMS, [μV]**;
- impulse energy (expressed in (ADC bits)^2, μV^2*μs, decibels and μV*μs) — **Energy**, **Energy [μV^2*μs]**, **Energy [dB]**, **MARSE [μV*μs]**;
- impulse duration — **Duration, [μs]**;
- impulse rise rime — **Rise time, [μs]**;
- emission counts in an impulse — **Counts**;
- average impulse frequency — **Frequency, [kHz]** (for DDM-2 and PCI-1E systems) or **Counts/Duration, [kHz]** (except for DDM-2 and PCI-1E systems);
- the ratio of the maximal impulse amplitude to the RMS amplitude — **Amax/Arms**;
- the ratio of the impulse amplitude to the emission counts — **Amplitude [μV]/Counts**;
- the logarithm of the ratio of the impulse amplitude and the number of emission counts — **ln(Amplitude [ADC]/Counts)**.

In addition to filtering by parameters, you can filter by additional features:

- ADC amplitude overload flag — **Flag A**;
- flag of signal termination by maximal duration — **Flag D**;
- waveform presence flag — if there is an waveform for a given impulse, the flag field displays the serial number of this waveform in the corresponding osc-file.

After performing the filtering procedure by location, it becomes possible to filter by a number of additional parameters:

- location coordinates — **Loc. X, [mm]**, **Loc. Y, [mm]** and **Loc. Z, [mm]**;
- location amplitude — **Loc. Amplitude, [dB]**;
- Differences in arrival times of AE burst impulses — **TAD [μs]**;

- on the basis of the fact that the impulses are simultaneously located in different location groups — **Loc.******;
- clustering results — **Locations per cluster** (this is a filtering of such location events, the number of which in a cluster for planar types of location or in a column for linear location is within the specified range).

In addition to filtering data by AE impulse parameters, the program also provides more complex filtering algorithms:

- filtering by a formula that reflects some functional dependence (linear, logarithmic, etc.) of the two parameters of each AE impulse;
- synchronous interference filtering;
- filtering AE pulses packs;
- filtering AE impulses following ones exceeding the maximal duration;
- additional actions;
- filter by area.

Filter and preview window

To view data in text form, select the command **File – Filter and review** in the main menu. Next, in the standard dialog box **Open file**, select the file whose data you want to view or filter, and click the button **Open**. Then, the **File header** dialog box opens. When you select the **OK** button in this window, a window appears on the screen that shows the process of loading the file. When you select the **Cancel** button, the download process does not occur.

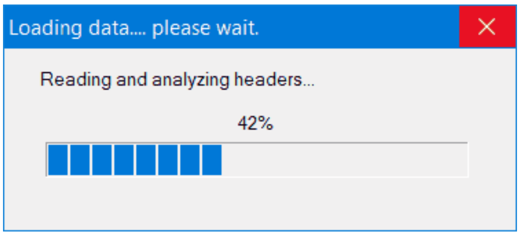
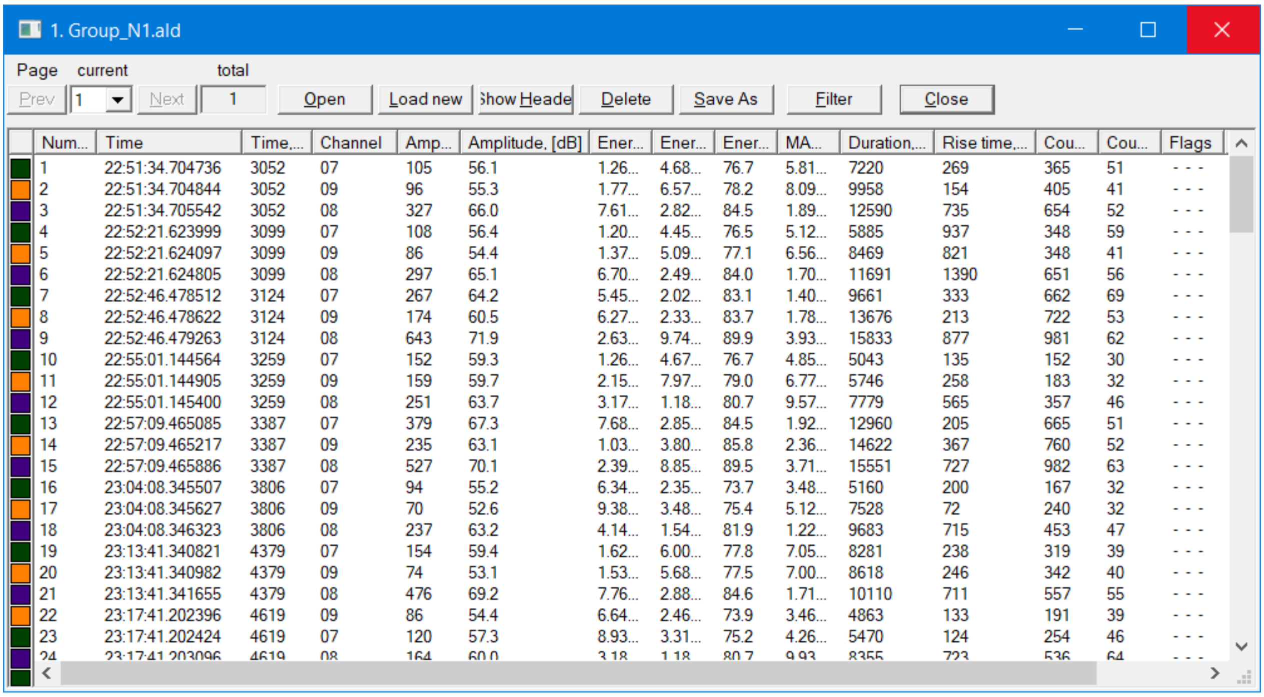


Fig. 8.1. File loading process

After the download is completed, a file viewing window appears, which presents the data contained in the file in text form. To view and filter the current file, use the main menu command **File – Filter current file**. After that, a preview window also appears.

Each line in the preview window corresponds to one AE impulse. The title of the window displays the file name. Channel numbers, for clarity, are duplicated by color indication.

Setting up the list of parameters displayed in the AE table is described in detail in the section *“Setting parameters list page”* on page 119.



Num...	Time	Time,...	Channel	Amp...	Amplitude, [dB]	Ener...	Ener...	Ener...	MA...	Duration,...	Rise time,...	Cou...	Cou...	Flags
1	22:51:34.704736	3052	07	105	56.1	1.26...	4.68...	76.7	5.81...	7220	269	365	51	- - -
2	22:51:34.704844	3052	09	96	55.3	1.77...	6.57...	78.2	8.09...	9958	154	405	41	- - -
3	22:51:34.705542	3052	08	327	66.0	7.61...	2.82...	84.5	1.89...	12590	735	654	52	- - -
4	22:52:21.623999	3099	07	108	56.4	1.20...	4.45...	76.5	5.12...	5885	937	348	59	- - -
5	22:52:21.624097	3099	09	86	54.4	1.37...	5.09...	77.1	6.56...	8469	821	348	41	- - -
6	22:52:21.624805	3099	08	297	65.1	6.70...	2.49...	84.0	1.70...	11691	1390	651	56	- - -
7	22:52:46.478512	3124	07	267	64.2	5.45...	2.02...	83.1	1.40...	9661	333	662	69	- - -
8	22:52:46.478622	3124	09	174	60.5	6.27...	2.33...	83.7	1.78...	13676	213	722	53	- - -
9	22:52:46.479263	3124	08	643	71.9	2.63...	9.74...	89.9	3.93...	15833	877	981	62	- - -
10	22:55:01.144564	3259	07	152	59.3	1.26...	4.67...	76.7	4.85...	5043	135	152	30	- - -
11	22:55:01.144905	3259	09	159	59.7	2.15...	7.97...	79.0	6.77...	5746	258	183	32	- - -
12	22:55:01.145400	3259	08	251	63.7	3.17...	1.18...	80.7	9.57...	7779	565	357	46	- - -
13	22:57:09.465085	3387	07	379	67.3	7.68...	2.85...	84.5	1.92...	12960	205	665	51	- - -
14	22:57:09.465217	3387	09	235	63.1	1.03...	3.80...	85.8	2.36...	14622	367	760	52	- - -
15	22:57:09.465886	3387	08	527	70.1	2.39...	8.85...	89.5	3.71...	15551	727	982	63	- - -
16	23:04:08.345507	3806	07	94	55.2	6.34...	2.35...	73.7	3.48...	5160	200	167	32	- - -
17	23:04:08.345627	3806	09	70	52.6	9.38...	3.48...	75.4	5.12...	7528	72	240	32	- - -
18	23:04:08.346323	3806	08	237	63.2	4.14...	1.54...	81.9	1.22...	9683	715	453	47	- - -
19	23:13:41.340821	4379	07	154	59.4	1.62...	6.00...	77.8	7.05...	8281	238	319	39	- - -
20	23:13:41.340982	4379	09	74	53.1	1.53...	5.68...	77.5	7.00...	8618	246	342	40	- - -
21	23:13:41.341655	4379	08	476	69.2	7.76...	2.88...	84.6	1.71...	10110	711	557	55	- - -
22	23:17:41.202396	4619	09	86	54.4	6.64...	2.46...	73.9	3.46...	4863	133	191	39	- - -
23	23:17:41.202424	4619	07	120	57.3	8.93...	3.31...	75.2	4.26...	5470	124	254	46	- - -
24	23:17:41.203096	4619	08	164	60.0	3.18	1.18	80.7	9.93	8355	723	536	64	- - -

Fig. 8.2. Filter and preview window

Data in the file view window in text form is displayed in parts. The total number of pages in the file is shown in the **total** field. To view the next part of the data, press the **Next** button, and to return to the previous part, press the **Prev** button. Each transition is accompanied by the appearance of a window showing the loading process. To open a file on an arbitrary page, use the list **current**. The number of data lines displayed on one page can be changed by specifying the required number in the **General settings** dialog box.

◇ To sort data by any parameter within one page, click on the button with the name of this parameter in the header of the list of impulses. The sort order of data (ascending or descending) can be changed by repeated clicking this button. You can use the mouse to change the width and order of the columns.

◇ To load the data file being viewed into the graphical windows of the program, use the button **Open**. At the same time, the window for viewing the file in text form remains open.

◇ The program provides the ability to quickly access an waveform corresponding to an impulse that has an waveform presence flag. To do this, double-click on the line corresponding to the impulse.

◇ You can see the file header by clicking the **Show Header** button. After that, the **File header** window appears, described in the section *"Opening a data file"* on page 59.

◇ The program provides the ability to load a new data file for viewing and filtering without closing the viewing window. To do this, press the button **Load new**, in the standard dialog box **Open file**, select the desired file and press the button **Open**. After that, in the dialog box **File header** — press the button **OK**.

◇ Data can be filtered in two ways: using the software filtering function and manually removing impulses.

- To perform filtering using the program, click the **Filter** button in the browser window. For more details on setting filtering conditions, see the *"Filtering"* section below.

- To delete impulses manually, select the required impulses and press the **Delete** button. To select multiple lines, you can use the mouse and cursor keys in combination with the **<Ctrl>** and **<Shift>** keys. If you want to save the data file with the changes made, then click the button **Save as** and in the standard dialog box **Save file** specify the name of the file where the data will be saved.

◇ The program provides the ability to transfer selected lines to other Windows applications using the clipboard. To copy the selected lines, right-click, select TXT or CSV format. To copy in text format, you can also press the key combination **<Ctrl + C>**.

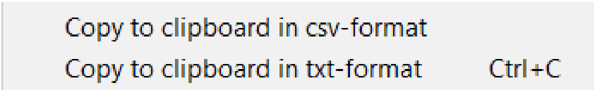


Fig. 8.3. Selecting a clipboard format

You can close the window for viewing a file in text view by clicking **Close** in this window.

Filtering

To perform filtering, click the **Filter** button in the vieving window, after which the **Filter settings** dialog box appears.

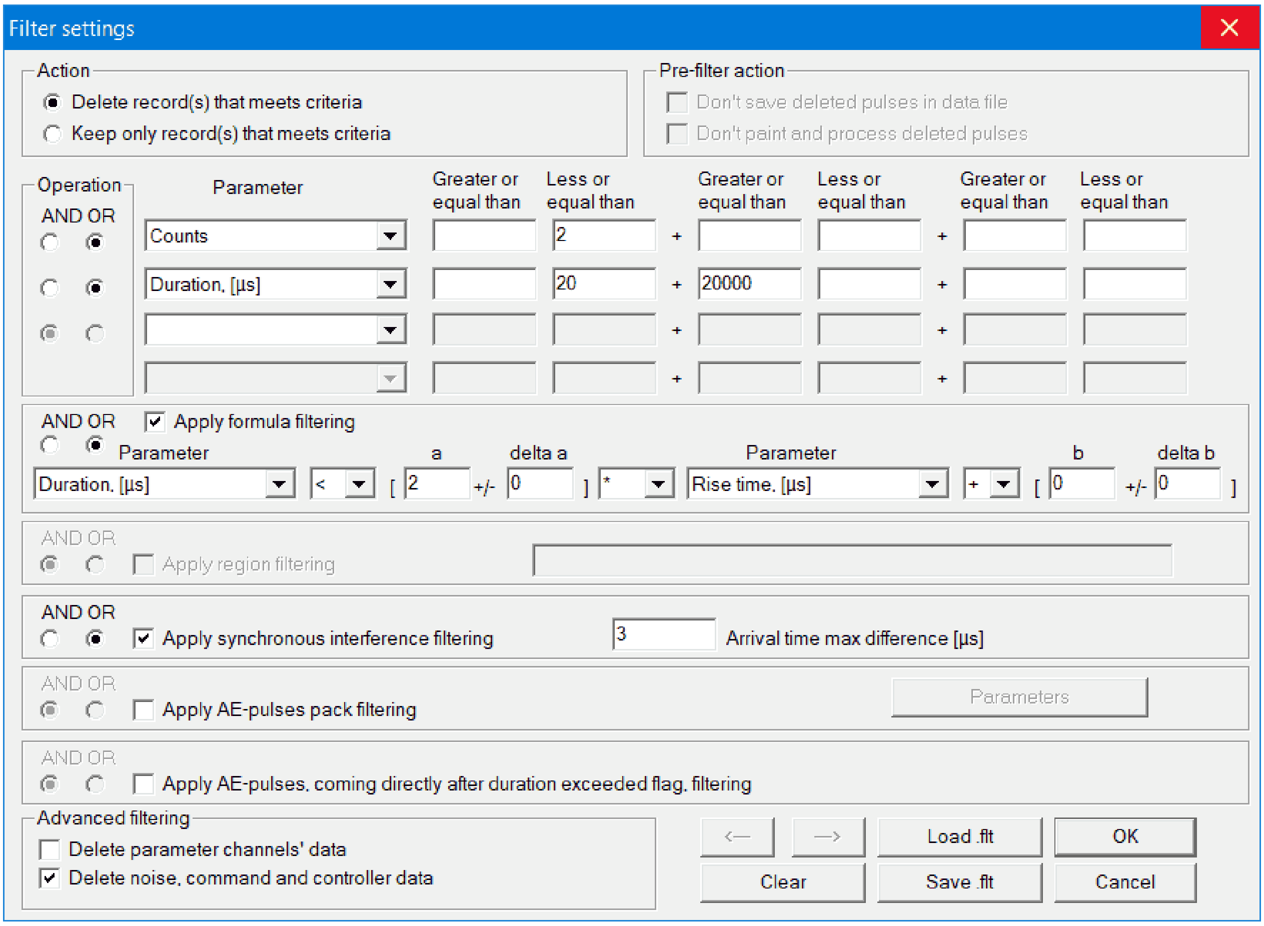


Fig. 8.4. Dialog box **Filter settings**

In this dialog box, you must specify filtering settings.

◇ Set filter criteria.

- Select the parameter to filter by in the list **Parameter**.

- Specify the upper and lower limits of the filtered parameter ranges in the input fields **Greater or equal than** and **Lower or equal than**.

Up to three filtering ranges can be set for each parameter.

Simultaneous filtering is allowed by several criteria (from one to four), combined by logical conditions "**AND**" or "**OR**".

◇ In the **Action** group, select an action to perform on impulses that meet the given criteria below.

- To delete data, select the radio button **Delete record(s) that meets criteria**.
- To save data, select the radio button **Keep only record(s) that meets criteria**.

◇ Set additional filtering options, if necessary.

After all the necessary filtering settings have been selected, click the **OK** button. In the dialog box **Save file**, you should confirm the default file name suggested by the program to save the filtered data, or correct it if necessary. After that, a window will appear showing the filtering process.

At the end of filtering, the program offers to replace the data in the view window with data from the file obtained as a result of filtering.

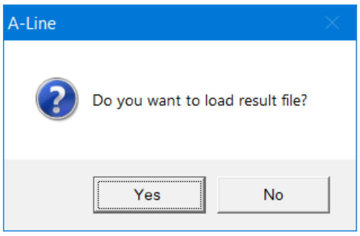


Fig. 8.5. Data replacement request

If you click the **Yes** button, the data will be updated. If data updating is not required, then select the button **No**.

If you need to continue the process of filtering data by other parameters, click the **Filter** button again. In the opened dialog box **Filter settings**, set new (or call previously used) filtering settings and execute it.

The program provides the ability to save and load 20 set and applied filtering conditions while the program is running. After completing at least one filtering process in the dialog box **Filter settings**, the button [<----] becomes available. It allows you to return to the previous filtering settings. After the filtering process has been carried out several times, the [---->] button also becomes available, allowing you to call the next, in relation to the considered, filtering settings. To change previously set filtering criteria, click the **Clear** button, and then enter new criteria.

To save the current filtering settings to a file, click the **Save .flt** button. In the dialog box **Save** that appears, specify the name of the file in the **.FLT** format, in which the filtering settings will be saved.

To load filtering settings from a file in the **.FLT** format, click the **Load .flt** button. In the dialog box that appears **Open** select the desired file.

> The program implements batch filtering of data from the command line. If you specify the name and path of the **.FLT** filter file, as well as the names of the input and output data files (and the output file of waveforms if joint filtering is performed) on the command line when starting the program, the program will be started in a special command line mode, the main window will not be displayed, while the specified data filtering will be automatically performed, the results will be saved in the output files, and the program will exit. By specifying the required number of filterings in the executable ***.BAT** file using the set of command lines described above, you can significantly speed up the processing of a large data array, since the most lengthy operations will be performed without the direct participation of the operator.

Filtering by formula

The program provides the ability to filter the file using any functional dependence (linear, logarithmic, etc.) of the two parameters of each AE impulse.

In general, the formula for the relationship between two parameters of AE impulses is as follows:

Parameter1 {Ratio} (a±delta a) × Function(Parameter2) + (b±delta b),

where:

- Parameter1 and Parameter2 — AE impulse parameters;
- Ratio — order relation (*equal to*, *greater than*, *less than*, *greater than or equal to*, *less than or equal to*);
- a±delta a and b±delta b coefficients;
- Function — function (×, /, lg, ln, exp) defining dependency.

To perform filtering by formula, select the **Apply formula filtering** switch in the **Filter Settings** dialog box, select the logical condition "**AND**" or "**OR**" and set the formula, which reflects the dependence of two parameters of AE impulses in the group of filtering parameters according to the formula.

When specifying a formula, you should:

- select AE impulse parameters in the lists **Parameter**;
- select the order relation in the corresponding list;
- select the type of function in the corresponding list;
- enter coefficient values in input fields **a**, **b**, **delta a**, **delta b**.

Filtering by region

The program provides the ability to filter by a region/polygon (a region is an area that is limited not only by straight line segments, but also by arbitrary curves). This type of filtering is applicable only for correlation windows (creation of correlation windows is described in *“Window manager”* on page 137).

Before filtering by region in the correlation window, you must graphically select the region by doing the following:

- activate the correlation window (if it is not already active);
- click ("Draw polygon/region") button on **Toolbar**;

- ✧ draw a polyline, fixing its vertices by pressing the left mouse button, or draw an arbitrary line by moving the mouse with the left button pressed;
- ✧ close the region by placing the last point of the polyline in the vicinity of the first point, or by clicking the right mouse button in an arbitrary place (the first point is automatically connected to the last one).

After graphical selection of the region, it is necessary to call the dialog box **Filter settings**, set the radio button **Apply region filtering** and select the logical condition "**AND**" or "**OR**".

Synchronous interference filtering

To remove/keep synchronous interference, set the switch **Apply synchronous interference filtering** in the dialog box **Filter settings**, select the logical condition "**AND**" or "**OR**" and in the input field **Arrival time max difference, [μs]** enter the maximal difference in arrival times.

Note that usually synchronous interference for a linear type of location is displayed on the location graphs in the form of columns located in the middle between the sensors. For a planar type of location, it is displayed either as a point located in the center of a circle passing through 3 AE sensors (if interference is received by three sensors), or as a line perpendicular to a side of the triangle (if interference is received by only two sensors). After filtering, these columns/dots/lines disappear. Moreover, unlike similar filtering in the location filter, this interference is distinguished by the difference in arrival times on all channels at once, regardless of location groups.

AE pack filtering

The program has the ability to filter packs of AE impulses. A pack of AE impulses is a sequence of impulses (at least two) received by different channels in such a way that the difference in arrival time of the chronologically first and last impulse of the sequence (called the duration of the pack) does not exceed a certain specified time interval. To filter AE impulse packs, set the switch **Apply AE-pulses pack filtering** in the dialog box **Filter settings**, select the logical condition "**AND**" or "**OR**" and set the parameters of the AE pack. To do this, click the button **Parameters**. After that, the **Parameters of AE pulses pack** dialog box will open.

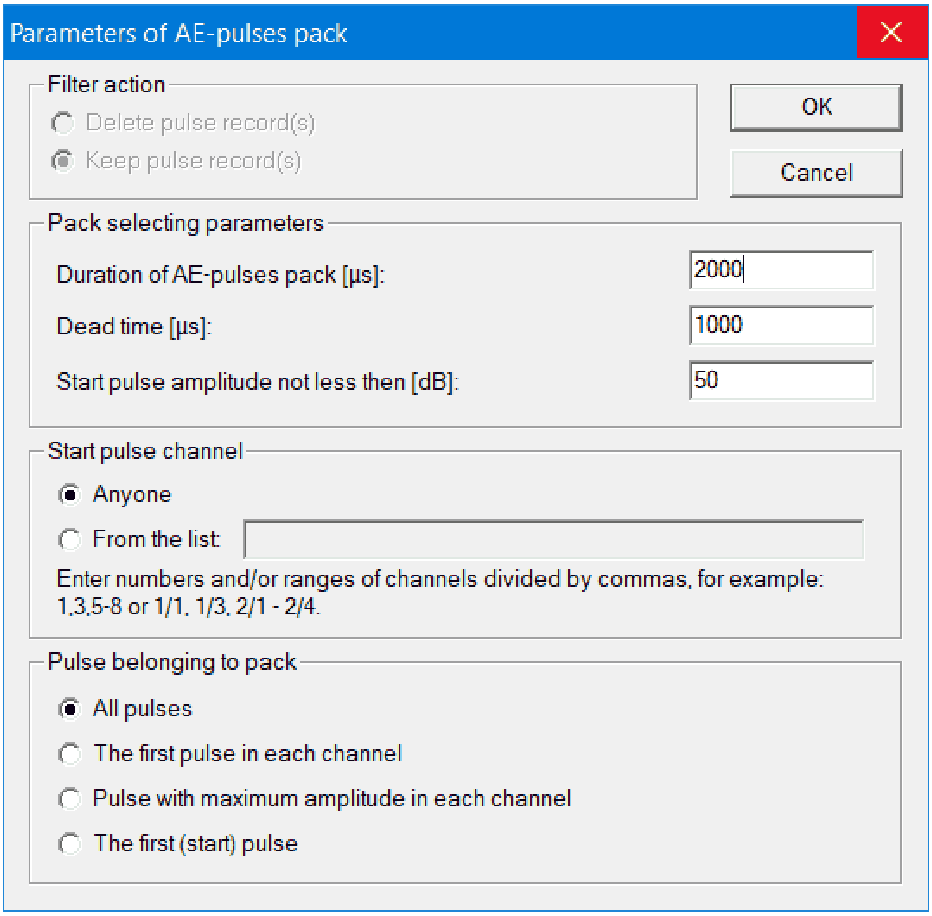


Fig. 8.6. Dialog box **Parameters of AE-pulses pack**

In this dialog box, set the parameters of the AE pack.

◇ The group **Filter action** displays the action on impulses set in the dialog box **Filter settings**.

- To delete AE impulses related to a pack, activate the **Delete pulse record(s)** switch.
- To save AE impulses related to a pack, use the switch **Keep pulse record(s)**.

◇ In the **Pack selecting parameters** group, set the time parameters of the AE impulses pack.

- Enter the duration of the AE impulses pack in the input field **Duration of AE pulses pack [µs]**.
- Specify the dead time value in the input field **Dead time [µs]** (dead time is counted from the end of the pack).
- Set the amplitude of the first AE impulse in the input field **Start pulse amplitude not less than [dB]**.

◇ In the **Start pulse channel** group, select the channel for the first impulse in the pack.

- When using any channel, activate the radio button **Anyone**.
- To use a specific channel, activate the radio button **From the list**. When activating the latter, you must enter the number and / or ranges of channels in the corresponding input field.

◇ In the **Pulse belonging to pack** group, set the criterion for impulses that form a pack of AE impulses.

- If all AE impulses are included in the pack, then use the radio button **All events**.
- If the pack is formed from the first AE impulses for each channel, then activate the radio button **The first pulse in each channel**.

- If a pack is formed from AE impulses with maximal amplitude in each channel, then use the radio button **Pulse with maximum amplitude in each channel**.
- When filtering a pack of AE impulses, it is possible to leave only the first (starting) AE impulse of the pack. To do this, use the radio button **The first (start) pulse**. The remaining impulses of the pack and the impulses that do not belong to the packs will be deleted from the file.

After setting the parameters, click the **OK** button. To cancel the changes made, click the button **Cancel**.

This dialog box can also be called from the dialog box **Advanced location options**, in which the switch **Apply AE signals location pack filtering** should be activated, and then use the now available button **Parameters**. The dialog box **Parameters of AE pulses pack** that opens is shown in the figure.

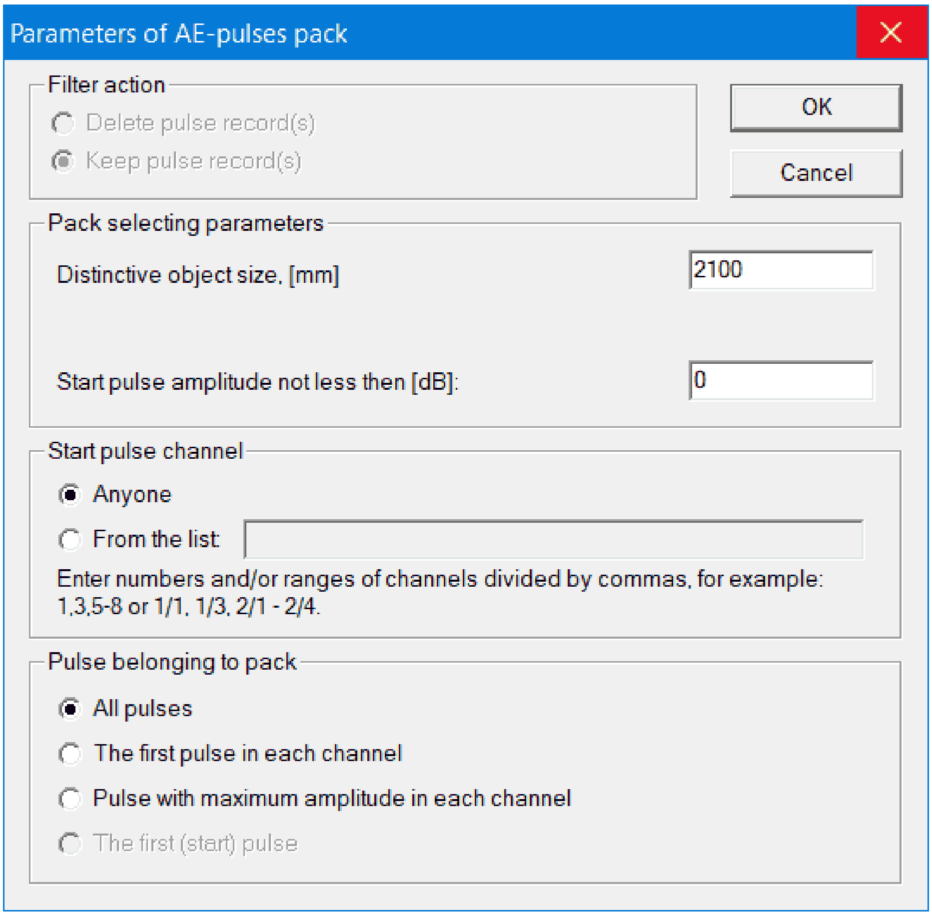


Fig. 8.7. Dialog box **Parameters of AE-pulses pack**

This window is the same as the dialog box called from the window **Filter settings**, except for the group **Pack selecting parameters**. In this group, in the input field **Distinctive object size, [mm]**, by default, the value of the size of the testing object, calculated by the program, will be shown. The data for calculation is taken from the dialog box **Location group settings**. To change the object size, it is enough to change the current value directly in the input field itself. Use either the **OK** button to confirm the entered parameters, or the **Cancel** button to cancel the entered changes.

Additional filtering options

In the **Advanced filtering** group in the **Filter settings** dialog box, you can set additional filtering options.

- ✧ To delete data from parametric inputs contained in a data file, set the **Delete parameter channels' data** switch.
- ✧ To delete noise data, set the switch **Delete noise, command and controller data**.

If this window is called to set pre-filtering parameters, then the **Pre-filter action** group becomes available.

- ◇ In order to prohibit saving AE impulses that have not passed pre-filtering, it is necessary to set the switch **Don't save deleted impulses in data file**. Impulses not saved to a file will also not be displayed on the graphs and will not participate in the location.
- ◇ In order not to display deleted AE impulses on the graphs and exclude them from the number of impulses participating in the location, set the switch **Don't plot and process deleted impulses**. If this option is selected, AE impulses that have not passed pre-filtering will be written to a file.

8.2. Classification

Program A-Line allows you to classify AE sources according to the class of danger.

According to the Russian Safety Guidelines "Methodological Recommendations for Conducting Acoustic Emission Testing" (Rules for the organization and conduct of acoustic emission control of vessels, apparatus, boilers and process pipelines), identified and identified AE sources are divided into four classes:

- ✧ class I source - passive source;
- ✧ class II source - active source;
- ✧ class III source - critically active source;
- ✧ class IV source - catastrophically active source.

According to EN 14584:2005 (norms of the European Economic Community), identified AE sources are divided into three classes:

- ✧ class I source;
- ✧ class II source;
- ✧ class III source.

The program allows you to use various criteria for separating sources into classes:

- ✧ *amplitude criterion*;
- ✧ *locally-dynamic criterion*;
- ✧ *S-H diagram*;
- ✧ *statistic criterion*;
- ✧ *GB/T 18182-2012 criterion "Non-destructive testing — Acoustic emission testing — Metallic pressure equipment"*;
- ✧ *JB/T 10764-2007 criterion "Non-destructive testing — Acoustic emission testing — Detection of corrosion at atmospheric and low-pressure metallic storage tank floors"*.

Amplitude criterion

✱ **Location-amplitude criterion (Russian Safety Guidelines "Methodological Recommendations for Conducting Acoustic Emission Testing")**

- *Class I source* — $N_{A<A_{critical}} < N2$ and $N_{A>A_{critical}} = 0$
- *Class II source* — $N_{A<A_{critical}} \geq N2$, but $N_{A>A_{critical}} = 0$
- *Class III source* — $0 < N_{A>A_{critical}} < N1$
- *Class IV source* — $N_{A>A_{critical}} \geq N1$

where A is the location amplitude of the AE source;

$A_{critical}$ is critical value of the location amplitude (set by the operator);

N1 is critical value for the number of high-amplitude impulses (set by the operator);

N2 is critical value for the number of low-amplitude impulses (set by the operator);

$N_{A>A_{critical}}$ is number of registered events with location amplitude greater than the critical value;

$N_{A<A_{critical}}$ is the number of registered events with a location amplitude less than the critical value.

✱ **Amplitude criterion (EN 14584:2005)**

- *Class I source* — $N_{A>A2} < N2$ and $N_{A>A1} < N1$
- *Class II source* — $N_{A>A2} \geq N2$ but $N_{A>A1} < N1$
- *Class III source* — $N_{A>A1} \geq N1$

where A1 is the first critical value of the location amplitude (set by the operator);

A2 is second critical value of the location amplitude (set by the operator);

N1 is first critical value for the number of events (set by the operator);

N2 is second critical value for the number of events (set by the operator);

$N_{A>A1}$ is number of registered events with location amplitude greater than the first critical value;

$N_{A>A2}$ is number of registered events with location amplitude greater than the second critical value.

When using the amplitude criterion to identify the class of danger of an AE source, the location window must first be opened. Then select the main menu command **Classification – Amplitude criterion**. After that, the dialog box **Amplitude criterion setup** opens with the location-amplitude criterion variant (Russian Safety Guidelines "Methodological Recommendations for Conducting Acoustic Emission Testing") selected by default in the group **Criterion variant**.

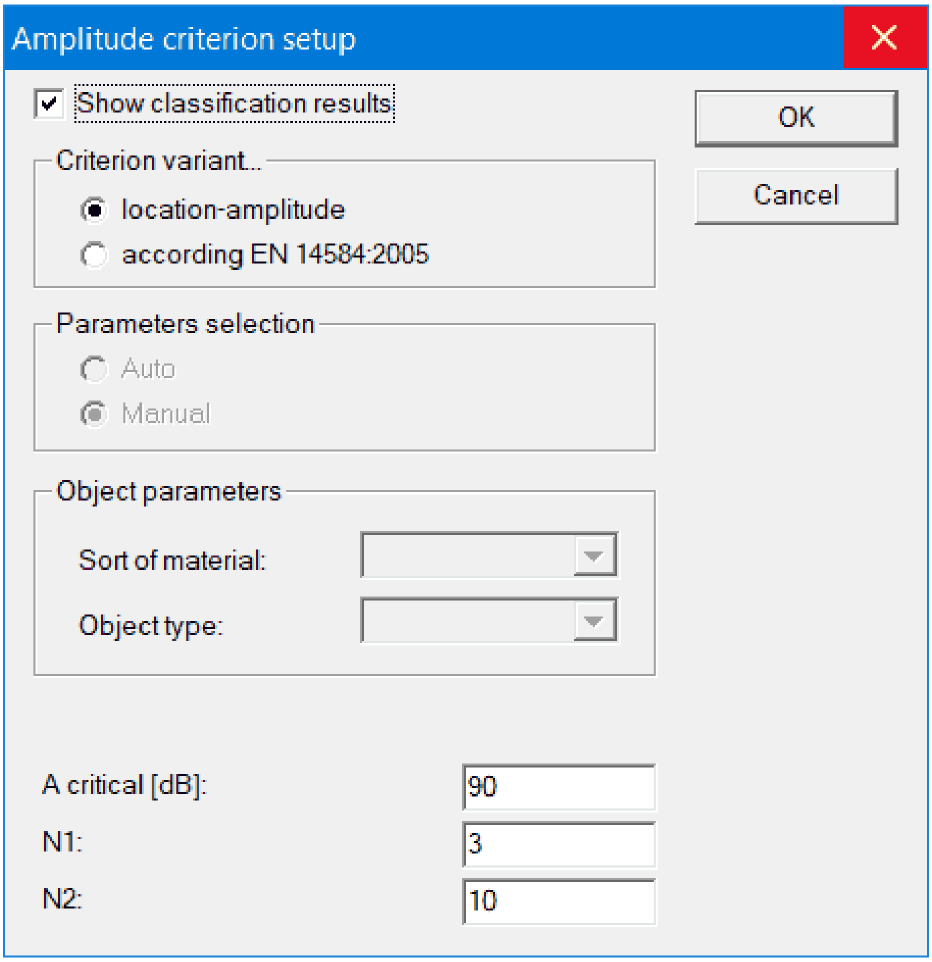


Fig. 8.8. Dialog box **Amplitude criterion setup**

When selecting the European amplitude criterion **according to EN 14584:2005** in the **Criterion variant** group, the **Amplitude criterion setup** dialog box looks different.

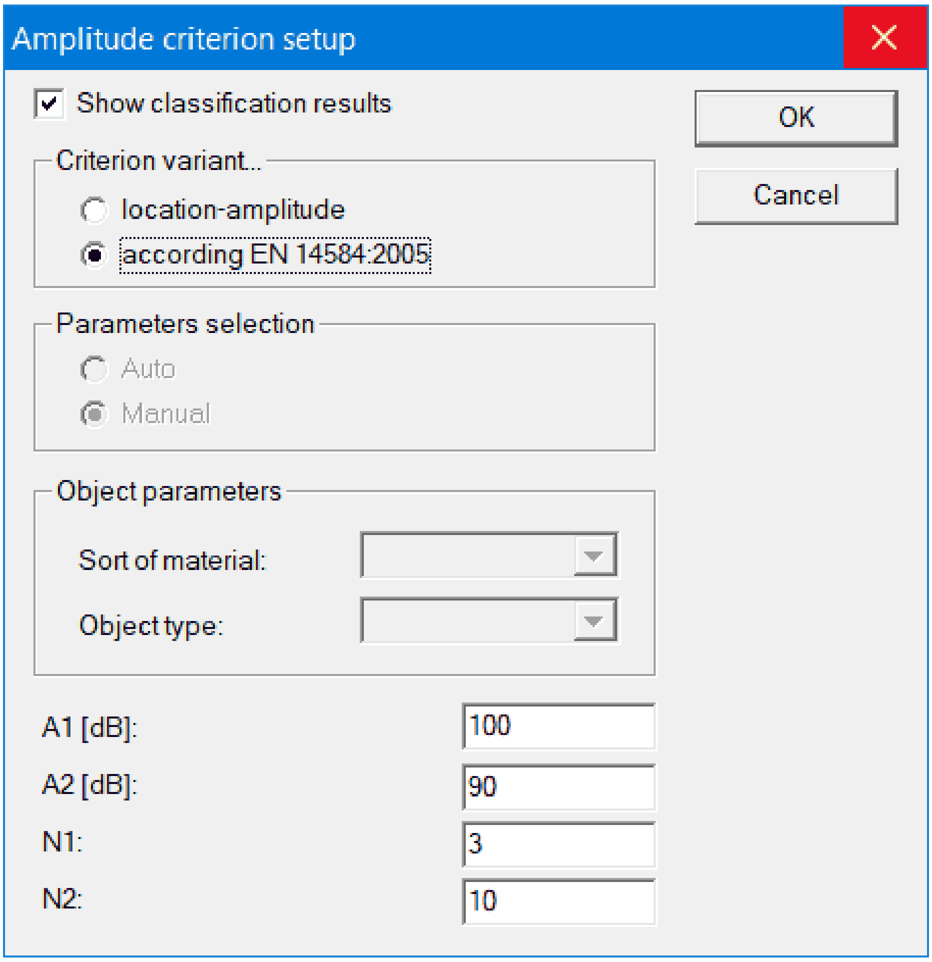


Fig. 8.9. Dialog box **Amplitude criterion setup**

In this dialog box, set the parameters necessary to determine the class of danger of the AE source.

◇ To display the classification results of AE sources in the location window, activate the switch **Show classification results**.

◇ To select an AE source hazard criterion, in the **Criterion variant** group, select the required criterion using the corresponding switch:
  - switch **location-amplitude** when selecting location-amplitude criterion (Russian Safety Guidelines "Methodological Recommendations for Conducting Acoustic Emission Testing");
  - switch **according to EN 14584:2005** when European amplitude criterion is selected, according to EN 14584:2005.

◇ When choosing a location-amplitude variant of the criterion (Russian Safety Guidelines "Methodological Recommendations for Conducting Acoustic Emission Testing") in the group **Criterion variant** in the input fields **A critical, dB**, **N1** and **N2** enter the appropriate values, or use the ones set in the program.

◇ When choosing a European amplitude criterion in the group **Criterion variant** in the input fields **A1[dB]**, **A2[dB]**, **N1** and **N2** enter the appropriate values, or use the ones set in the program, taken from the European document EN 14584:2005.

After setting the parameters, press the **OK** button, to cancel the selected parameters press the **Cancel** button. The classification results will be displayed in the location window.

Locally-dynamic criterion

* The locally-dynamic criterion characterizes the process of development of defects over time depending on the loading parameter, i.e.

$N \simeq \alpha\, p(t)^n$

where N is the number of registered impulses;

p is a load parameter;

n is the power (exponent).

In this case, the class of danger of the AE source, according to the Russian Safety Guidelines "Methodological Recommendations for Conducting Acoustic Emission Testing", is classified as follows:

- ✧ $0 < n < 1$ is a class I source;
- ✧ $n \simeq 1$ is a class II source;
- ✧ $1 < n < 6$ is a class III source;
- ✧ $n \geq 6$ is a class IV source.

When using the locally-dynamic criterion to identify the class of danger of an AE source, the data file must first be opened. Then you should open the loading file (to do this, use the main menu command **Window – Additional lines**. After that, you can use the locally-dynamic criterion by selecting the main menu command **Classification – Locally-dynamic criterion**.

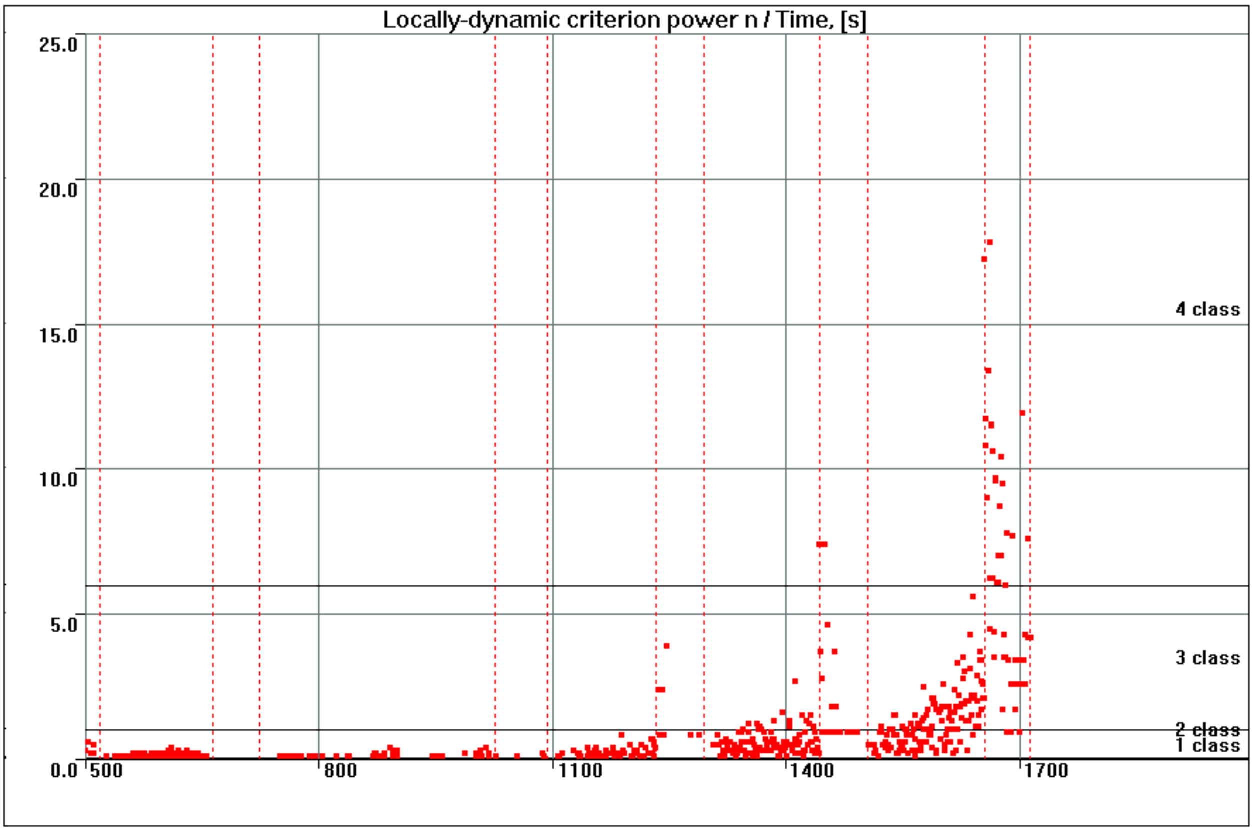


Fig. 8.10. Window **Locally-dynamic xriterion power**

Then the **Locally-dynamic criterion power n/Time, [s]** window opens, in which the **X** represents time, along the **Y** axis (left) — the power (exponent) of the locally-dynamic criterion, along the **Y** axis (right) — the parameter values loading. Classification of defects will be in the right part of the window.

S-H diagram

> * The description and application of this criterion is given in Russian Safety Guidelines "Methodological Recommendations for Conducting Acoustic Emission Testing".

When using the S-H diagram to determine the class of danger of an AE source, you must first open the data file. Then use the main menu command **Classification – S-H diagram**. After that, the dialog box **File header** reopens to read the data file.

When the data is loaded, the **S-H diagram** window appears, which displays the points corresponding to the various channels. Depending on their position, the hazard class of the AE source is classified according to Russian Safety Guidelines "Methodological Recommendations for Conducting Acoustic Emission Testing".

Statistic criterion

> * The statistical criterion allows obtaining information about the nature of the source (leak, crack) that caused the AE, and identifying the moment of transition from one stage of deformation to another using statistical methods. The method is based on the registration of relative changes in the statistical characteristics of the distribution of AE impulse parameters (amplitude, energy, duration, etc.).

To use a statistical criterion, select the main menu command **Classification – Statistic criterion**. After that, the dialog box **Statistic criterion setup** opens.

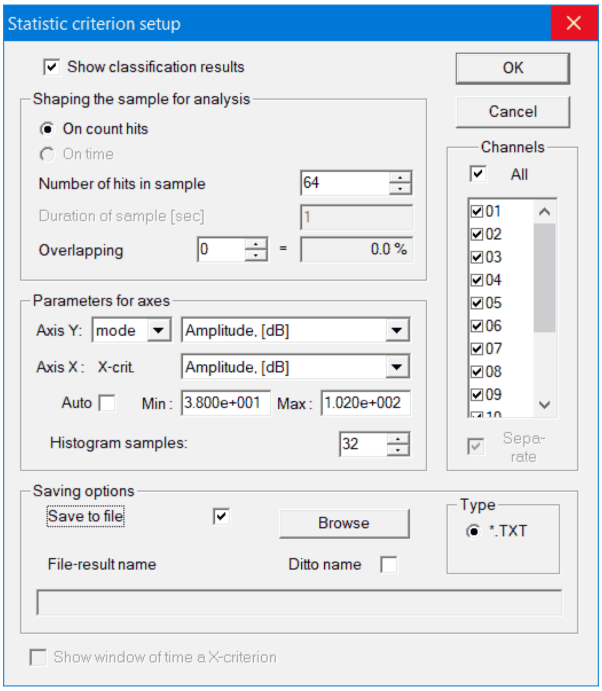


Fig. 8.11. Dialog box **Statistic criterion setup**

In this dialog box, set the parameters necessary to determine the type of AE source.

◇ To display the results of classification of AE sources in the location window, activate the switch **Show classification results**.

◇ In the **Shaping the sample for analysis** group, set the parameter (**On count hits** or **On time**), which will be used for sampling, and set its characteristics.
  - To form a sample by the number of impulses, activate the radio button **On count hits**, by time — use the radio button **On time**.
  - Set the number of impulses in the sample with **Number of hits in sample**.
  - Specify the value of the time interval in the field **Duration of sample [sec]**.
  - Enter the amount of impulse overlap in the sample using the **Overlapping** spinner.

◇ In the **Parameters for the axes** group, select the method that will be used when calculating the parameter distribution statistics to obtain diagnostic diagrams.
  - In the lists for the Y axis, select the calculation method (max, mode, mean) —list **Axis Y** and a parameter.
  - In the list for the X axis, select an option.
  - Set the range of values for the selected parameters in the corresponding **Min** and **Max** fields, or activate the **Auto** switch for automatic selection parameter values.
  - Set the number of histogram intervals with **Histogram samples**.

◇ In the **Channels** group, specify the channels through which statistical data processing will be carried out.
  - To select all channels, use the **All** switch.

◇ In the **Saving options** group, specify the method for saving the data obtained as a result of applying the statistical criterion.
  - To save the received data in a file, activate the switch **Save to file**.
  - Enter the new name of the resulting file in the input field **File-result name**.
  - Specify the directory where the resulting file will be located. To do this, use the button **Browse**.
  - To keep the same file name, use the **Ditto name** switch. After that, the full path of the source file will appear in the input field **File-result name**.

After setting the parameters, press the **OK** button, to cancel the selected parameters press the **Cancel** button. The results of applying the statistical criterion will be displayed in the location window.

GB/T 18182-2012 criterion

Based on the GB/T 18182-2012 standard "Non-destructive testing — Acoustic emission testing — Metallic pressure equipment", the criterion allows for the assessment of the class of danger based on the activity level (Q) and intensity level (N) of the source.

When using this criterion, the location window must first be open.

Then select the main menu command **Classification – Criterion GB/T 18182-2012**. After this, the **GB/T 18182-2012 criterion setup** dialog box opens. In this dialog box, set the parameters necessary to determine the class of danger of the AE source.

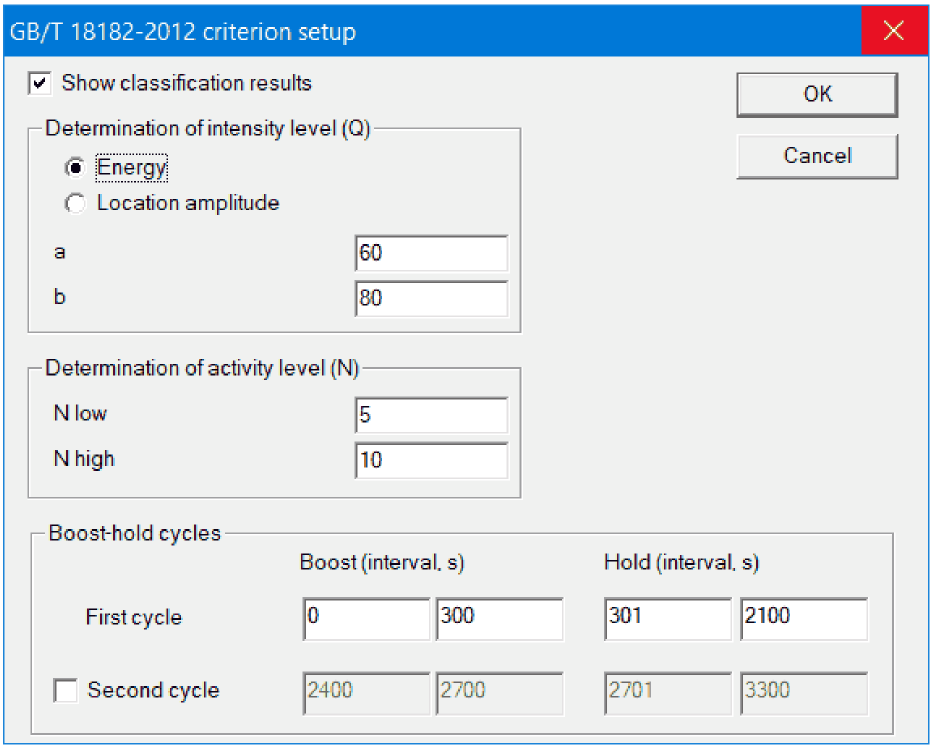


Fig. 8.12. Dialog box **GB/T 18182-2012 criterion setup**

In the **Determination of intensity level (Q)** group, select the option of the energy parameter to be used: **Energy** or **Location amplitude**, enter the corresponding values of the classification parameters **a** and **b**, or use the default values.

In the **Determination of activity level (N)** group, enter the corresponding values of the classification parameters **N low** and **N highr**, or use the default values.

In the **Boost-hold cycles** group, in the **First cycle** line, in the **Boost (interval, s)** section, enter the start and end time of the boost, in the **Hold (interval, s)** section enter the start and end time of the hold. If necessary, activate the switch in the line **Second cycle** and enter the corresponding values of the time intervals.

After setting the parameters, use either the **OK** button to confirm the entered parameters, or the **Cancel** button to cancel the entered changes. The classification results will be displayed in the location window.

The table shows the default classification parameter values recommended by the GB/T 18182-2012 standard when using location amplitude.

Table 8.1.

Parameter	Recommended value
a	60 dB
b	80 dB

JB/T 10764-2023 criterion

Based on the JB/T 10764-2023 standard "Non-destructive testing — Acoustic emission testing — Detection of corrosion at atmospheric and low-pressure metallic storage tank floors", the criterion allows for assessing the class of danger by analyzing either the number of AE events located in a given area per hour, or the number of AE impulses received per hour for each individual channel.

To use the JB/T 10764-2023 criterion, select the **Classification – Criterion JB/T 10764-2023** main menu command. This opens the **JB/T 10764-2023 criterion setup** dialog box. In this dialog box, set the parameters necessary to determine the class of danger of the AE source. In the **Classification by** group, you should select the criterion option: **E parameter (location)** or **H parameter (zone location)**.

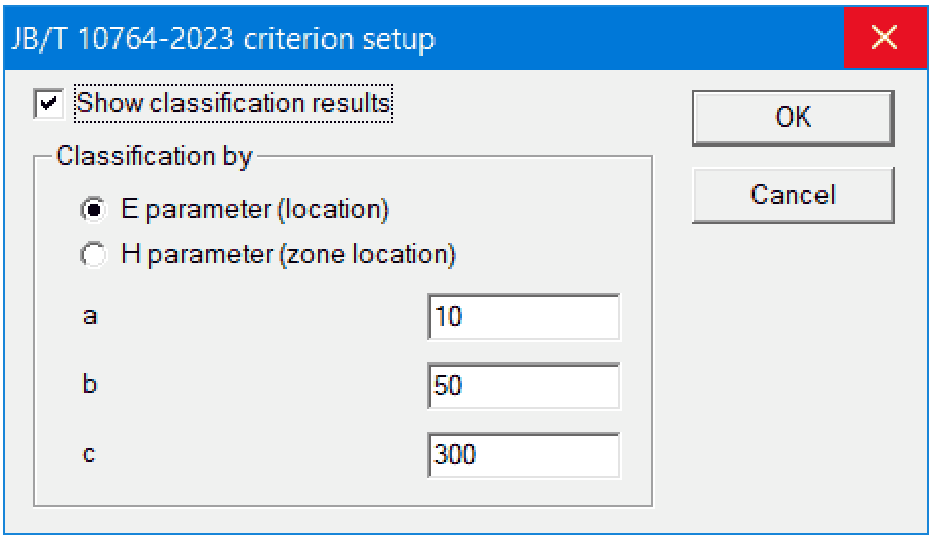


Fig. 8.13. Dialog box **JB/T 10764-2023 criterion setup** when using E parameter

Table 8.2.

Class of danger	E (the number of AE events located in a given area per hour)
I	E≤a
II	a<E≤b
III	b<E≤c
IV	E>c

When using the **E parameter (location)** option, the location window must first be open. Enter the corresponding values for the **a**, **b**, **c** parameters, or use the default values. The relationship between the parameter values and the assigned class of danger is given in the table. After setting the parameters, use either the **OK** button to confirm the entered parameters, or the **Cancel** button to cancel the entered changes. The classification results will be displayed in the location window.

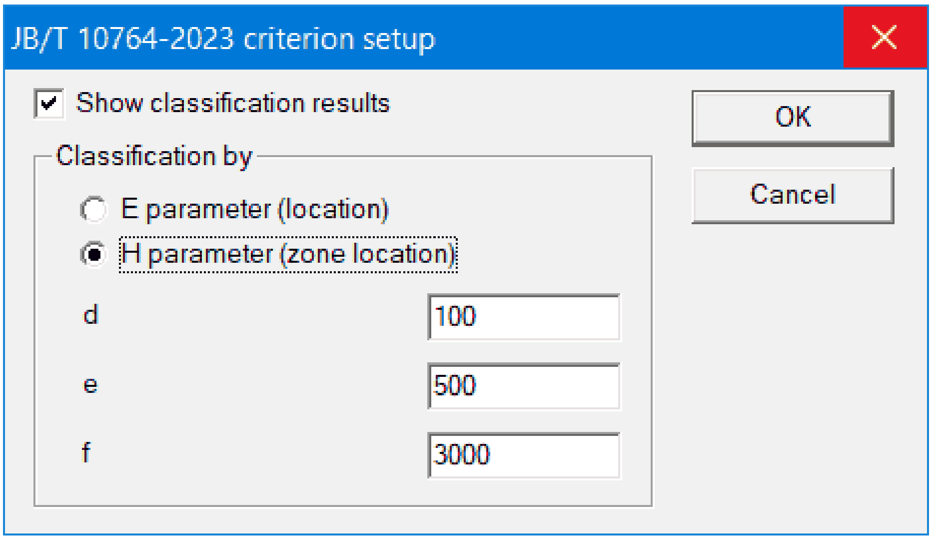


Fig. 8.14. Dialog box **JB/T 10764-2023 criterion setup** when using H parameter

Table 8.3.

Class of danger	H (the number of AE impulses received per hour for each individual channel)
I	H≤d
II	d<H≤e
III	e<H≤f
IV	H>f

When selecting the **H parameter (zone location)** option, enter the corresponding values of the **d**, **e**, **f** parameters, or use the default values. The relationship between the parameter values and the assigned class of danger is given in the table. After setting the parameters, use either the **OK** button to confirm the entered parameters, or the **Cancel** button to cancel the entered changes. The classification results will be displayed on the **AE hit count/Channel)** window.

The table shows the default values of the classification parameters recommended by the JB/T 10764-2023 standard.

Table 8.4.

Parameter	Recommended Value
a	10
b	50
c	300
d	100
e	500
f	3000

8.3. Print

To print data, use the main menu command **File – Print**. After that, the **Print setup dialog** dialog box appears.

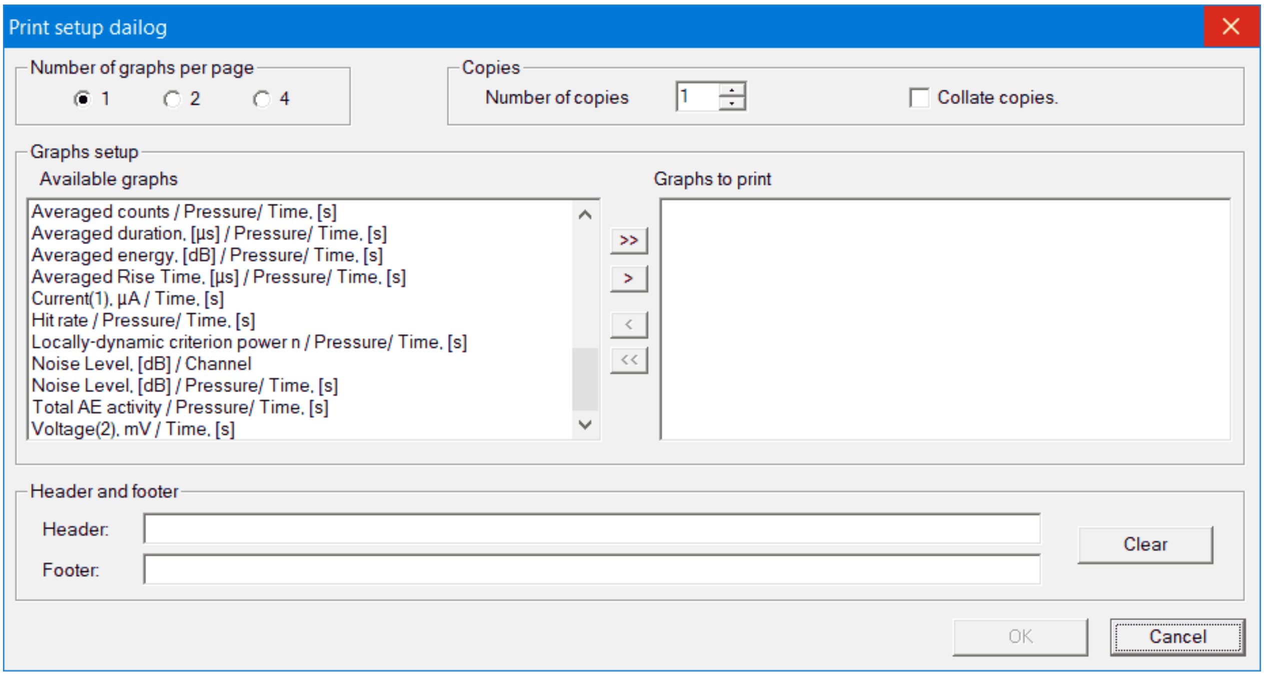


Fig. 8.15. **Print setup dialog** box

This dialog box allows you to set print options.

◇ The number of graphs placed on one sheet can be selected using the radio buttons **1**, **2** and **4** in the group **Number of graphs per page** for one, two and four graphs, respectively.

◇ The number of copies is set using the **Number of copies** spinner in the **Copies** group. The program allows you to receive from one to ninety-nine copies.

◇ Collating printouts into copies is set by turning on the switch **Collate copies** in the group **Copies**.

◇ In the group **Header and footer** in the input fields **Header** and **Footer** enter the header and footer respectively. Using the button **Clear** removes headers and footers.

◇ You can select graphs for printing in the list **Available graphs**. There are several ways to do this.

- double-click on the name of the desired graph;
- mark the desired graph with a single click of the mouse button and press the button >;
- To print all graphs, use the button >>;
- Removing a graph from the list of printed ones is carried out in the same way, i.e. by buttons < and << respectively, as well as by double clicking in the list **Graphs to print**.

To start printing, press the **OK** button, to cancel the selected settings — the **Cancel** button.

Printer setup

The printer is configured by selecting the main menu command **File – Printer setup**.

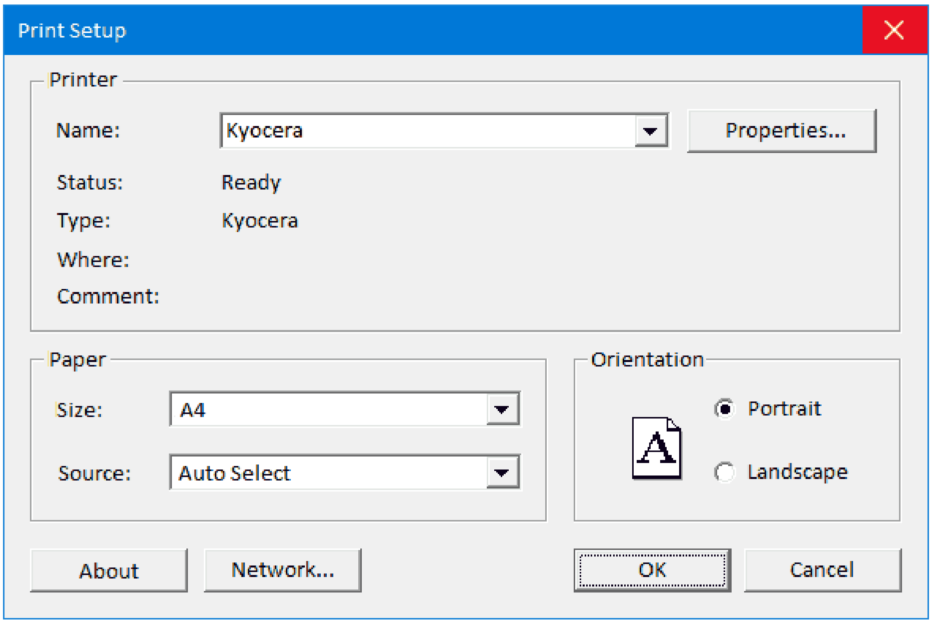


Fig. 8.16. Dialog box **Printer setup**

Next, in the dialog box **Printer setup** that appears choose:

- printer type in the group **Printer**;
- paper size in the group **Paper**;
- paper orientation in the group **Orientation**;
- other printer-specific options;
- for setting up a network printer click the **Network** button, after that the dialog box **Connect to a printer** will open, in which you should specify the network settings printer.

Getting a screenshot

In some cases, you may need to get and possibly edit the screenshot in another application.

To do this, proceed as follows:

- activate the WDRI whose image you want to receive;
- configure the required window settings (colors, scale, grid, sizes);
- press the key combination **<Alt - Print Screen>**;
- go to a graphics editor (or another program);
- run the command **Edit – Paste**.

8.4. Data export

Program **A-Line** allows you to convert (export) your data files and waveforms to TXT and CSV formats that can be used when working with other programs.

Exporting data files

Data files are exported as follows.

- In the main menu, select the command **File – Export ALD Data**.
- In the appeared dialog box **Open file** select the data file and press the button **Open**.
- In the next dialog box **Save file** choose the type (TXT or CSV) and the name of the file in which the exported data will be written, and click the button **Save**.

An indicator appears on the screen, showing the data export process:

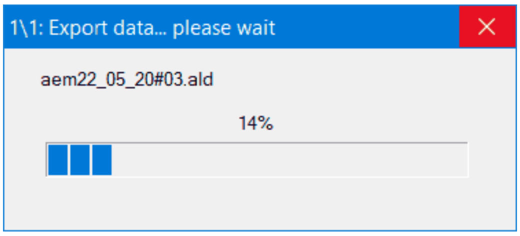


Fig. 8.17. Data export process

This window will disappear when the export is complete. The export time depends on the amount of data in the file, so this process may take a long time on large files.

Data export settings are detailed in *“Settings of the export parameters”* on page 117.

Exporting waveform files

Exporting waveform files is similar to exporting data files.

◇ In the main menu, select the command **File – Export OSC Data**.

◇ In the dialog box **Open** select the waveform file and press the button **Open**.

◇ The **Select type for export files** dialog box opens.

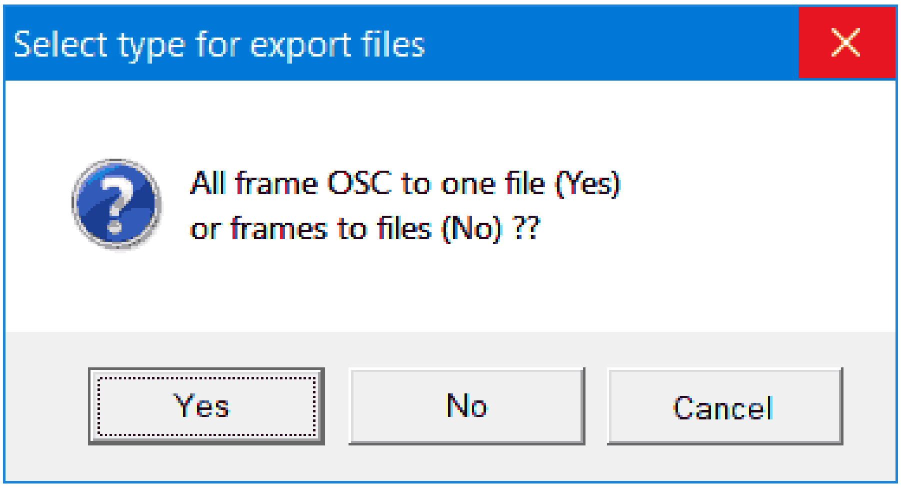


Fig. 8.18. Dialog box **Select type for export files**

In this window, set the type of the resulting file(s) of waveforms.

- regular format (all waveforms are in one file) — button **Yes**;
- format, when each waveform is written to a separate file, and that's all they are saved in the same directory — button **No**;
- to cancel — button **Cancel**.

◇ In the next dialog box **Save file** choose the type (TXT or CSV) and the name of the file into which the exported waveforms will be saved and click the button **Save**.

An indicator appears on the screen showing the progress of waveform export. When the export is completed, this window disappears. The export time depends on the number of waveforms in the file, so if there are many waveforms, the export process may take a long time.

✶ ✶ ✶

Chapter 9. Configuring complex settings

*Chapter *“Configuring complex settings”* is devoted to setting up complex parameters.

9.1. Saving and loading configuration files

To open a configuration file, select **File – Open Config** from the main menu. After that, the **Open file** dialog box appears, in which you should select the configuration file and click the **Open** button.

To save the configuration file, use the main menu command **File – Save Config**. If the file with the specified name already exists, the complex asks about overwriting the file. By pressing the **Yes** button, the settings will be saved in the specified file. When you select the **No** button, the complex will display the **Save file** dialog box, in which you must specify a new file name and click the **Save**. If there is no file with the specified name, it is written, otherwise, the complex requires confirmation of overwriting the selected file.

It is possible to save new measurement settings (such as time measurement parameters, saving parameters, pre-filter settings, general information) and post-processing window settings in a configuration file. To save these settings, use the main menu command **File – Save Config**, to call the saved settings use **File – Open Config**.

9.2. Creating a channel configuration

For systems type DDM-1, DDM-2, PCI-N, PCI-8 and PCI-8E the program implements a configuration generator for any number of channels and their distribution over the lines. This makes it possible to create the required system configuration without connecting the required number of modules or on a computer not equipped with A-Line hardware, as well as saving it in a file with the extension **.CFG** for further use in data acquisition or processing mode.

To create a channel configuration, select **File – Create config** from the main menu. After that, the dialog box **Create system configuration, P.1** appears.

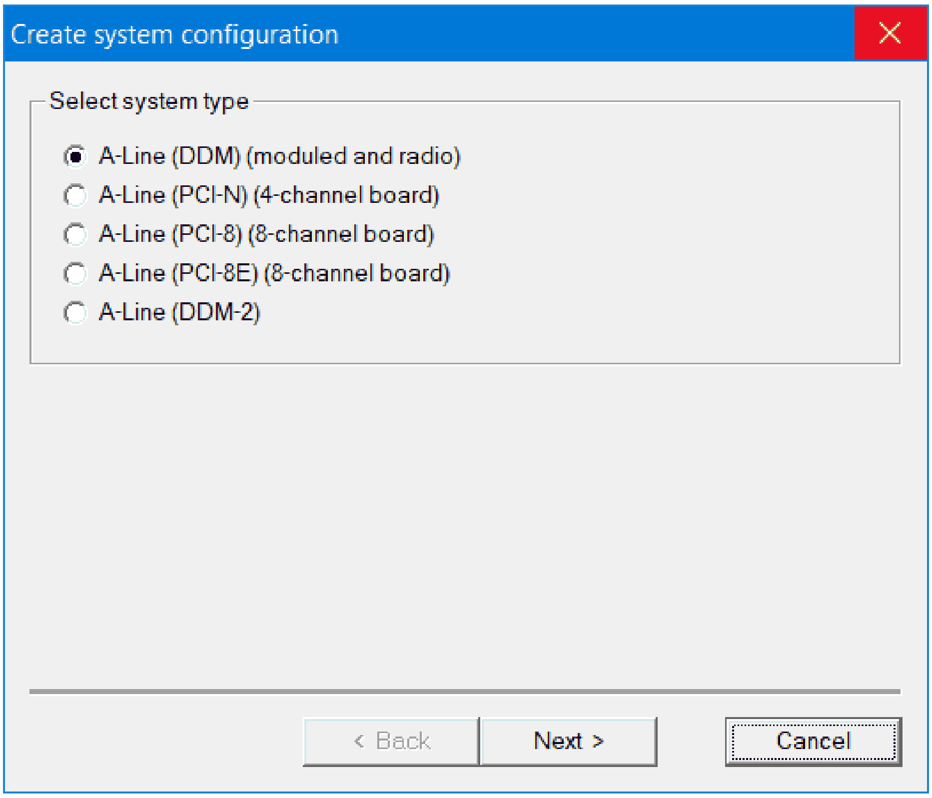


Fig. 9.1. Dialog box **Create system configuration, P.1**

In the dialog box that opens, in the group **Select system type**, activate the switch, appropriate for the desired system type. Then press the button **Next** to go to **P.2** dialog box **Create system configuration**.

On **P.2** set the required amount lines (DDM-1) / boards (PCI-N, PCI-8, PCI-8E) and modules (DDM-1, DDM-2) / channels (PCI-N, PCI-8, PCI-8E) for the selected type systems. Working with **P.2** dialog box **Create system configuration, P.2** for DDM-1 and DDM-2 type systems, see in the section *“Creating a configuration file for A-Line DDM-1 and DDM-2 systems”* on page 96, for PCI-N, PCI-8 and PCI-8E systems, see in the section *“Creating a configuration file for A-Line PCI-N, PCI-8, and PCI-8E systems”* on page 98. After setting the parameters on **P.2**, press the **Finish** button, then a dialog box will appear **Configure hardware profiles**, which is described in the section *“Configuring hardware profiles”* on page 99.

Creating a configuration file for A-Line DDM-1 and DDM-2 systems

After opening the dialog box **Create system configuration, P.1**, selecting the radio button **A-Line (DDM-1) (moduled and radio)** or radio button **A-Line (DDM-2)** and pressing the button **Next** will open the **P.2** dialog box **Create system configuration, P.2**.

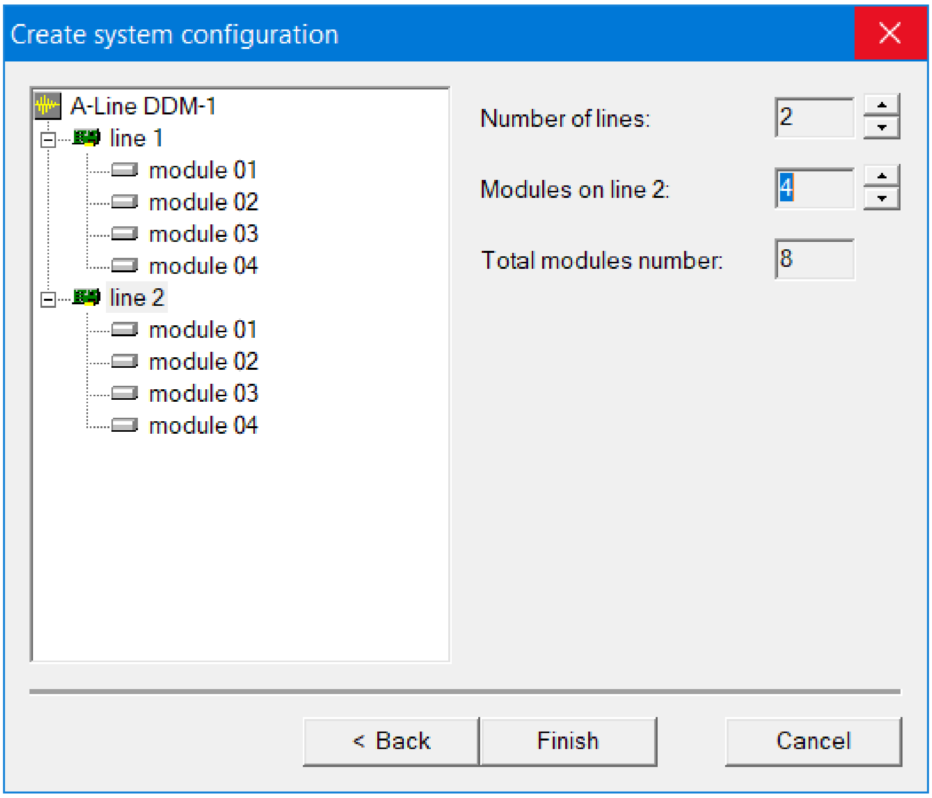


Fig. 9.2. Dialog box **Create system configuration (DDM), P.2** for DDM-1 type systems, **P.2**

For systems of the DDM-1 type, on the **P.2** that opens, specify the required number of lines in the system and the number of modules on each of them. The program provides the ability to enter parameters in a different sequence:

◇ Setting parameters on **P.2** (the first way is to randomly select a line from the list, for which the number of modules is set):
  - set the required number of lines - spinner **Number of lines**;
  - in the list of given lines, move the cursor to the desired line and mark it with a single click of the left mouse button;
  - set the number of modules on the selected line - spinner **Modules on line N**;
  - for any next line selected from the list, repeat the procedure for entering the required number of modules;
  - total number of modules on all lines is displayed in the **Total modules number** field.

◇ Setting parameters on **P.2** (the second way is sequential selection of the line with simultaneous setting of the number of modules on each of them):
  - when switching to **P.2**, line 1 is set and activated by default;
  - set the number of modules on line 1 - spinner **Modules on line N**;
  - activate the next line (line 2) - enter the number 2 with **Number of lines**, then move the cursor to the number of this line in the list of given lines (line 2) and mark it with a single click of the left mouse button;
  - set the number of modules on the next line (line 2) - to do this, enter the number of modules with the **Modules on line N**;
  - continue the procedure of sequential input of lines (line 3, line 4, etc.) while simultaneously setting the required number of modules on each of them;
  - total number of modules on all lines is displayed in the field **Total modules number**.

For systems of the DDM-2 type, on the **P.2** that opens, specify the required number of modules on each of the lines:

◇ in the list of given lines, move the cursor to the desired line and mark it with a single click of the left mouse button;

◇ set the number of modules on the selected line - spinner **Modules on line N**;

◇ for any next line selected from the list, repeat the procedure for entering the required number of modules;

◇ total number of modules on all lines is displayed in the **Total modules number** field.

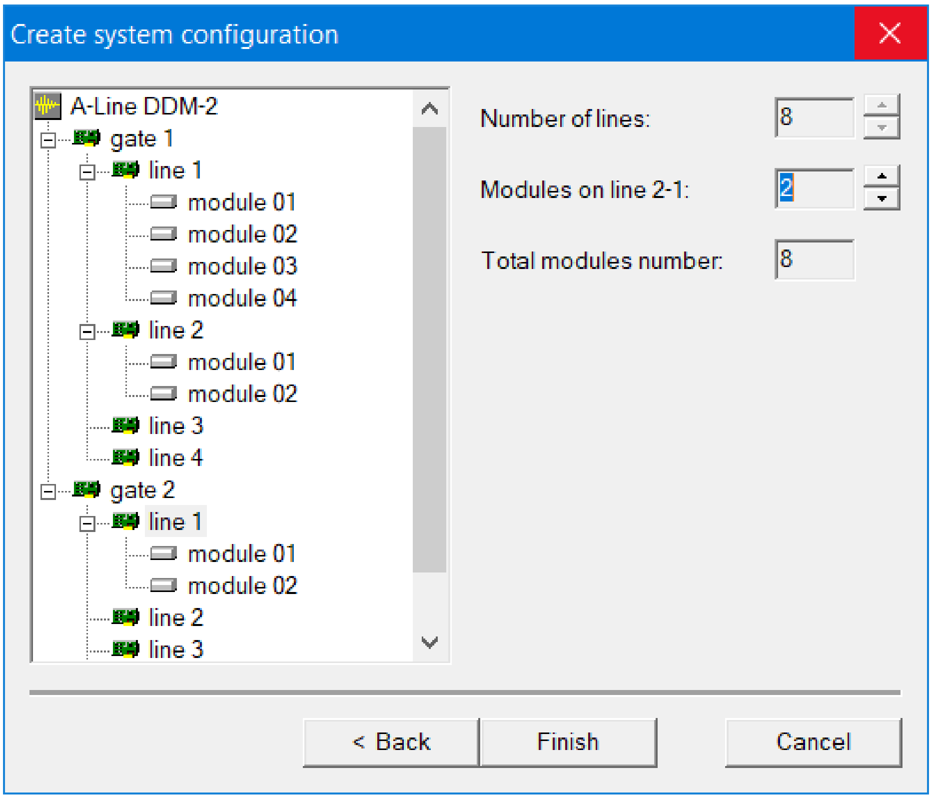


Fig. 9.3. Dialog window **Create system configuration (DDM), P.2** for DDM-2 type systems, **P.2**

After setting the parameters (the number of lines and the number of modules on each of them) press the **Finish** button, to return to **P.1** press button **Back**, to exit the dialog box without saving the entered parameters press button **Cancel**. Using the **Finish** button will open the **Configure hardware profiles** dialog box, which is described in the section *“Configuring hardware profiles”* on page 99.

Creating a configuration file for A-Line PCI-N, PCI-8, and PCI-8E systems

After opening the **P.1** dialog box **Create system configuration**, selecting any of the **A-Line (PCI-N) (4-channel board)**, **A-Line (PCI-8) (8-channel board)**, **A-Line (PCI-8E) (8-channel board)** and pressing the button **Next** will open **P.2** of the dialog box **Create system configuration** for the selected system.

The **Create system configuration** window will appear, opened on **P.2**:

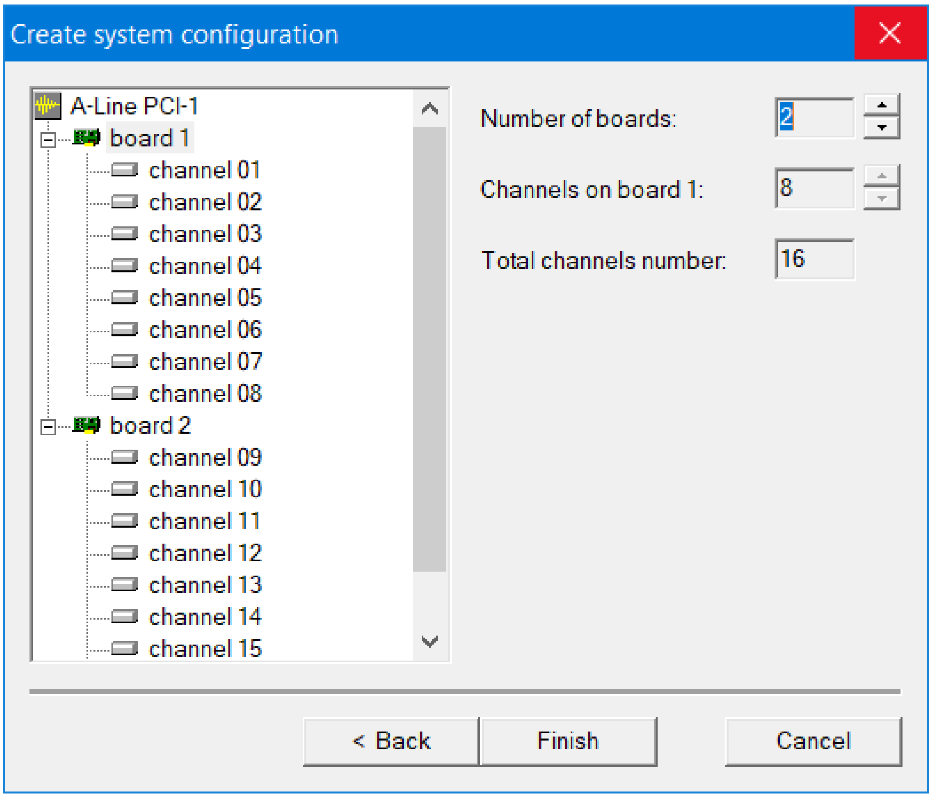


Fig. 9.4. Dialog box **Create system configuration (PCI-N), P.2**

On the opened **P.2** for this type systems, you should specify only the required number of boards in the system. The number of channels on each board is fixed and set automatically. For systems of type **A-Line (PCI-N)** it is equal to four, for systems of type **A-Line (PCI-8)** and **A-Line (PCI-8E)** to eight.

◇ set the required number of boards - spinner **Number of boards**;

◇ the number of channels on each board is fixed and is set automatically, depending on the type of system - spinner **Channels on board**;

◇ total number of channels on all lines is displayed in the **Total channels number** field.

After setting the parameters (number of boards), press the button **Finish**, to return to **P.1** press the button **Back**, to exit the dialog box without saving the entered parameters press the button **Cancel**. Using the **Finish** button will open the **Configure hardware profiles** dialog box, which is described in the section *"Configuring hardware profiles"* on page 99.

After setting the parameters, press the button **Finish**, to return to **P.1** press the button **Back**, to exit the dialog box without saving the entered parameters press the button **Cancel**. Using the **Finish** button will open the **Configure hardware profiles** dialog box, which is described in the section *"Configuring hardware profiles"* on page 99.

Configuring hardware profiles

The program provides the ability to use several quick-switching hardware settings (hardware profiles). For creating new profiles, as well as changing and deleting previously created ones, use the dialog box called by **Configure hardware profiles** or main menu command **Options – Profiles settings**, or by clicking **Finish** in the dialog box **Create system configuration**, which is described in the section *"Creating a channel configuration"* on page 95. After running one of these commands the dialog box **Configure hardware profiles** appears.

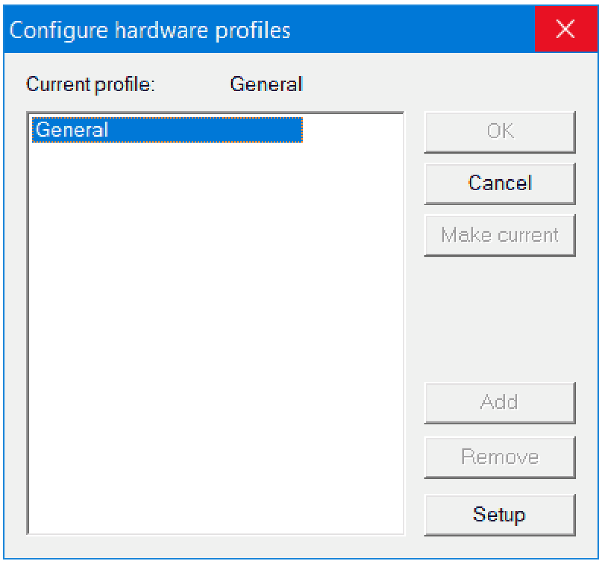


Fig. 9.5. Dialog box **Configure hardware profiles**

The dialog box that opens contains a list of hardware profiles and commands for managing profiles.

◇ The dialog field contains a list of hardware profiles containing at least one active current configuration profile. The total number of profiles is unlimited.

◇ The following commands are available for working with hardware profiles and changing their parameters:

- To add a new profile, select the name of the desired profile in the list and activate it with the left mouse button, then click the **Add** button, then in the dialog box **Configure hardware profiles** an active line will appear with the name of a new profile assigned by the program by default with the possibility of replacing it with any other;
- to work with any profile from the list, first make it current by selecting the line containing the name of the desired profile with the left mouse button and pressing the button **Make current**;
- to change the parameters of any profile from the list, first make it current (use the left mouse button and the **Make current** button), then use the **Setup** button, then in the dialog box **Channel settings** that opens, the work with which is described in the section *"Configuring main settings"* on page 102, make the necessary changes to the parameters and click the **OK** button, or the **Cancel** button to return to the **Configure hardware profiles**;
- To remove a profile from the list, select it in the field of the dialog box and click the button **Remove**;

◇ Note that when working with a list of profiles, only one profile can be added, modified or deleted using the standard line selection procedure, either with the mouse or using the appropriate keyboard shortcut.

After creating and configuring hardware profiles, press the **OK** button, to cancel press the **Cancel** button.

9.3. Channel settings

General information

The following commands are available in the main menu to configure channel settings:

- ✧ **Options – Channels parameters**;
- ✧ **Options – OSC parameters**;
- ✧ **Options – Time definitions**;
- ✧ **Options – Calibrator parameters**;
- ✧ **Options – Parameters settings**.

Commands **Options – Channels parameters** and **Options – OSC parameters** are also duplicated by the buttons of the toolbar. After selecting one of these commands, a dialog box **Channels parameters** appears opened on the corresponding page **Main settings**, **Oscilloscope**, **Time definitions**, **Calibrator**, or **Parametric inputs**.

The **Channels parameters** dialog box is multifunctional. It is for channel selection and setting the main parameters and time definitions for receiving AE impulses (pages **Main settings** and **Time definitions**, respectively), parameters of oscilloscope channels (page **Oscilloscope**), calibrators (page **Calibrator**) and parametric inputs (page **Parametric inputs**).

The settings on each page are presented in the view window as rows with the corresponding line and channel number. If the window that opens contains a scroll bar, this means that not all the settings fit in its visible part, and, if necessary, you should use the scroll bar to select the necessary settings.

Working with settings begins with the selection of a line (block or individual lines). To do this, move the mouse pointer to the desired line and click the mouse button. When selecting a block, use the **Shift** key and, holding it down, select the first and last rows of settings in the block, as described above. To highlight individual lines, use the **Ctrl** key and the mouse cursor, which each time should be brought to the desired line, and then click the left mouse button.

After selecting a row, the channel settings will be shown in the corresponding elements of the dialog box. When selecting a settings block or individual lines, the parameter values will also be shown in the window elements if their values are the same for all channels. Otherwise, the parameter value will be missing. Note that not always after selecting a line (block or individual lines) and displaying the parameter values in the window elements, the window elements themselves will not be activated (available for settings correction).

Performing settings correction on the dialog box page is not available in file read mode, except for some options related to the displaying of results (for example, choosing a channel color). This procedure is available only in data acquisition preparation mode and in data acquisition mode after line power is applied. Power is supplied after the first call to the dialog **Measurement details** (command **Control – New measurement**) upon confirmation by the operator commands "**Turn Power On**".

After applying power to the line and selecting settings (line, block or individual lines), all the elements of the dialog box (lists, input fields, spinners) located at the bottom will be available, and parameter adjustment will become possible. To do this, set the required value of any parameter in the corresponding element of the dialog box, after which it will be assigned to all the same parameters in the selected lines.

Using spinners to change the settings in the selected row leads to an increase/decrease in their values within the specified limits. Changing the settings in the block (in the highlighted lines) with different parameter values when using the spinner occurs as follows: the increase is performed from the minimal value of the parameter in the block (in the highlighted lines), and the decrease is performed from the maximal value.

When making adjustments in the input fields, it is possible to restore the original value of the parameter if the settings are entered incorrectly. To do this, clear the input field (keys **<Del>** or **<Backspace>**), after which the initial value of this parameter for the selected settings will appear in the data view window. If, after entering a new parameter value, the mouse cursor was moved to any other element of the dialog box, then it is either assigned to the corresponding parameters in the selected data (if the value of the entered parameter is valid), or the **Input error** window appears (if the allowable range of values).

To simultaneously set parameters for all channels, use the **Select all** button on each page. Then set the parameter values that you want to assign to all channels.

To switch to other pages of the dialog box, move the mouse cursor to the corresponding tab and press the left mouse button (or use the key combination **<Ctrl + Tab>**). Your choice of channel(s) will be saved when you navigate to other pages.

After setting the parameters on all pages, click the **OK** button. To cancel — the **Cancel** button. Note that the **Cancel** button cancels changes on all pages.

Configuring main settings

To configure the main settings, select the main menu command **Options – Channels parameters** or click the  button to **Toolbar**. After that, the **Channel settings** dialog box appears, opened on the **Main settings** page.

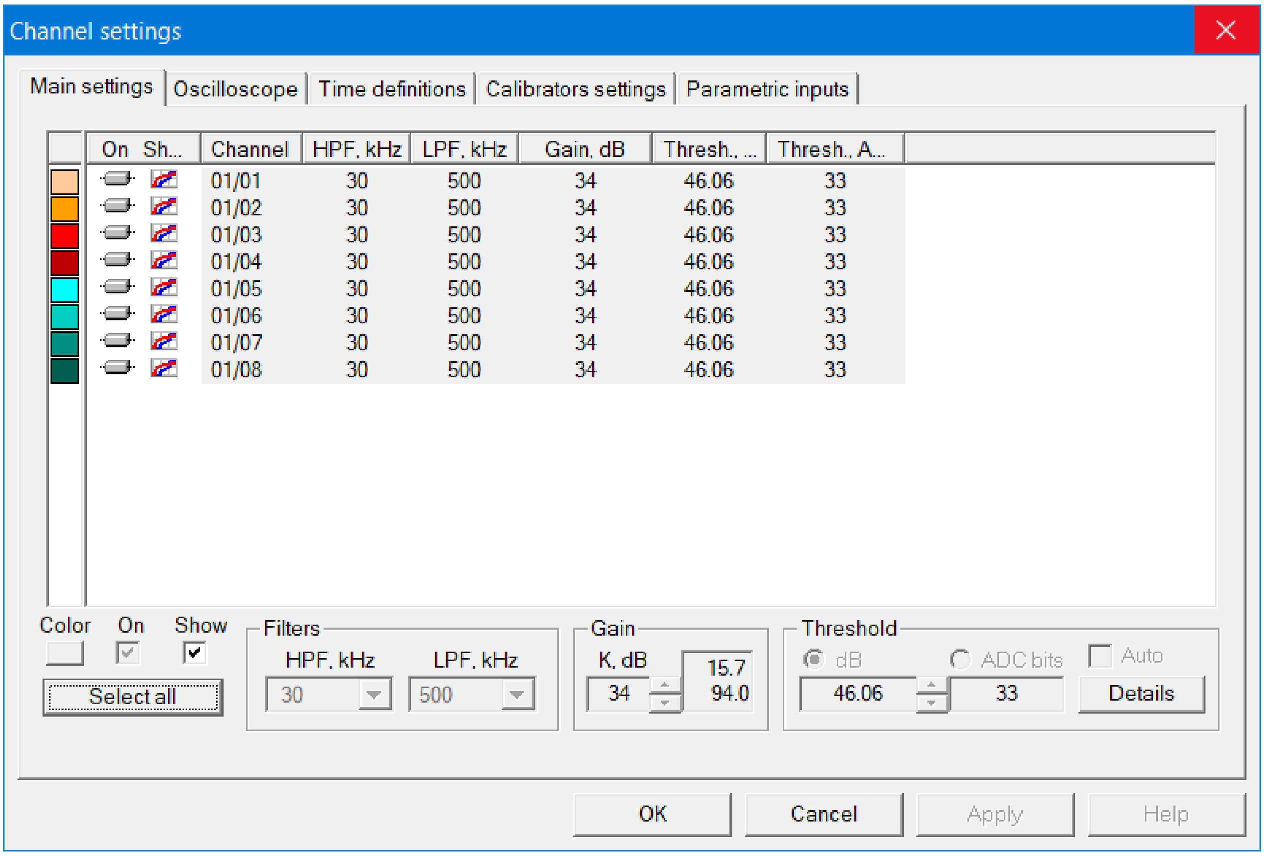


Fig. 9.6. Dialog window **Channels settings**, page **Main settings** for the complex of type "A-Line DDM-1"

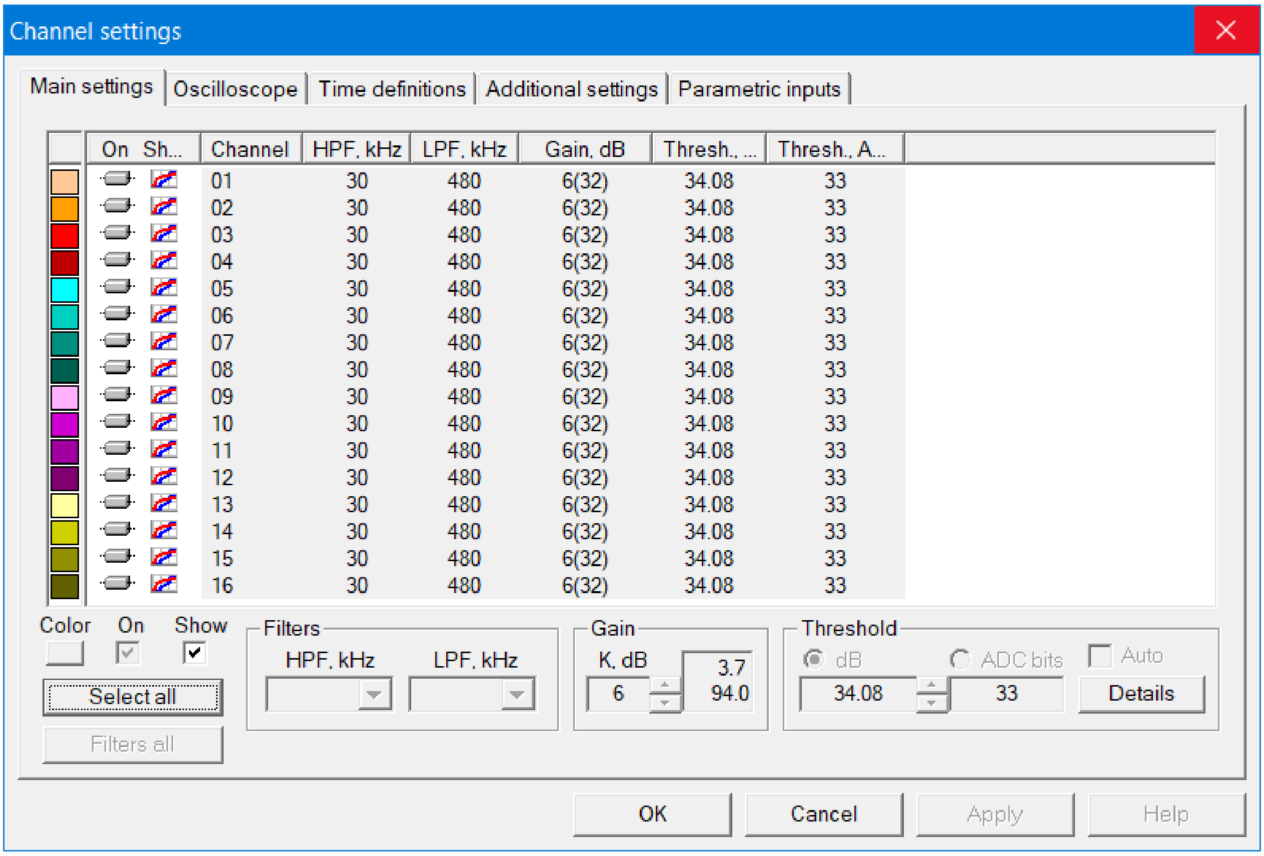


Fig. 9.7. Dialog window **Channels settings**, page **Main settings** for complexes of types "A-Line PCI" and "A-Line DS"

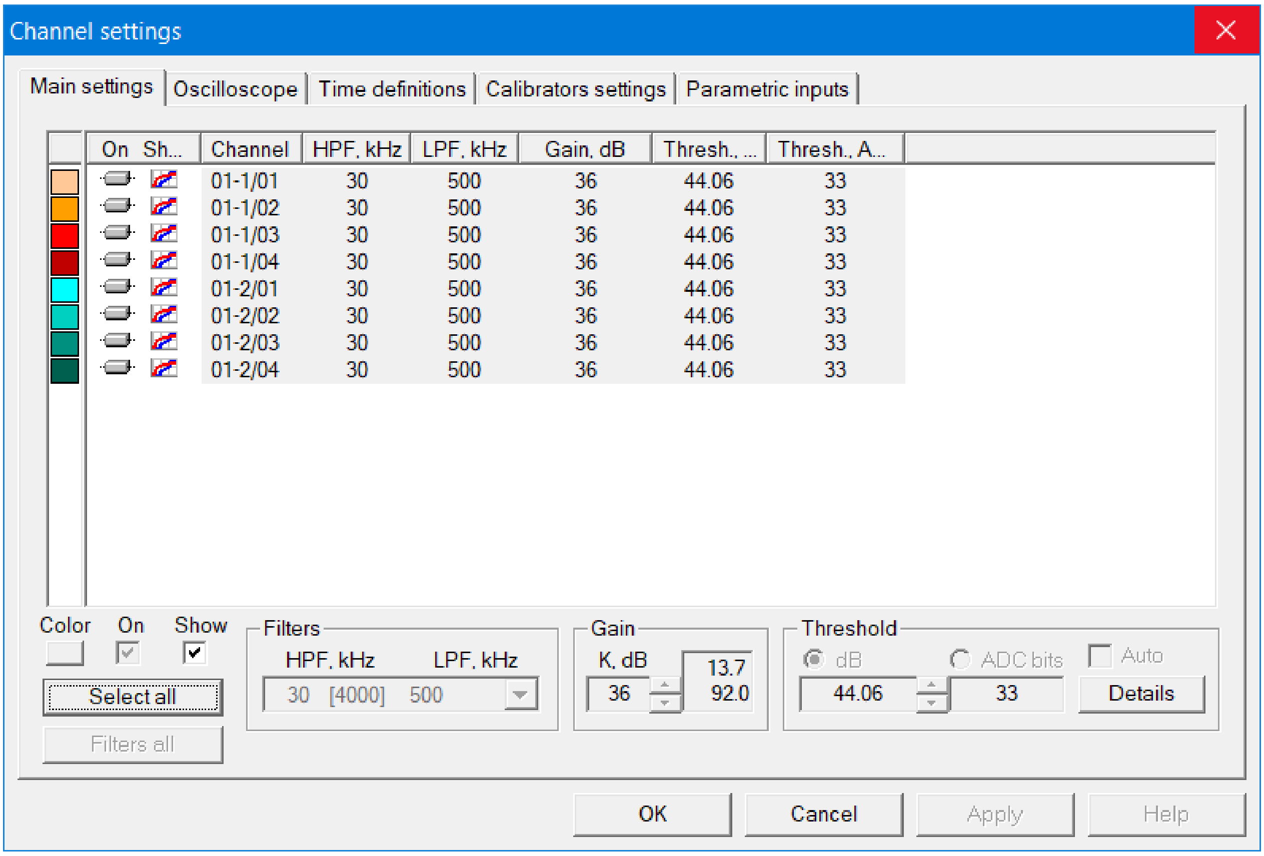


Fig. 9.8. Dialog window **Channels settings**, page **Main settings** for complexes of type "A-Line DDM-2"

On this page, set the main settings of the channels.

◇ Turn channels on/off and displaying data from these channels with switches **On** and **Show**, respectively.

◇ Select the frequencies of the high pass filter (HPF) and the low pass filter (LPF) in the respective lists **HPF, kHz** and **LPF, kHz** in the group **Filters**.

◇ The possibility of common loading of external digital filters for all channels is implemented. To do this, press the **Filters all** button and open the **Filters loading manager** dialog box, in which you should select the desired external filters for immediate loading. It is recommended to carry out this procedure during the process of initial system setup before the start of data acquisition in order to use all loaded filters in the future without restrictions and avoid wasting time on loading them.

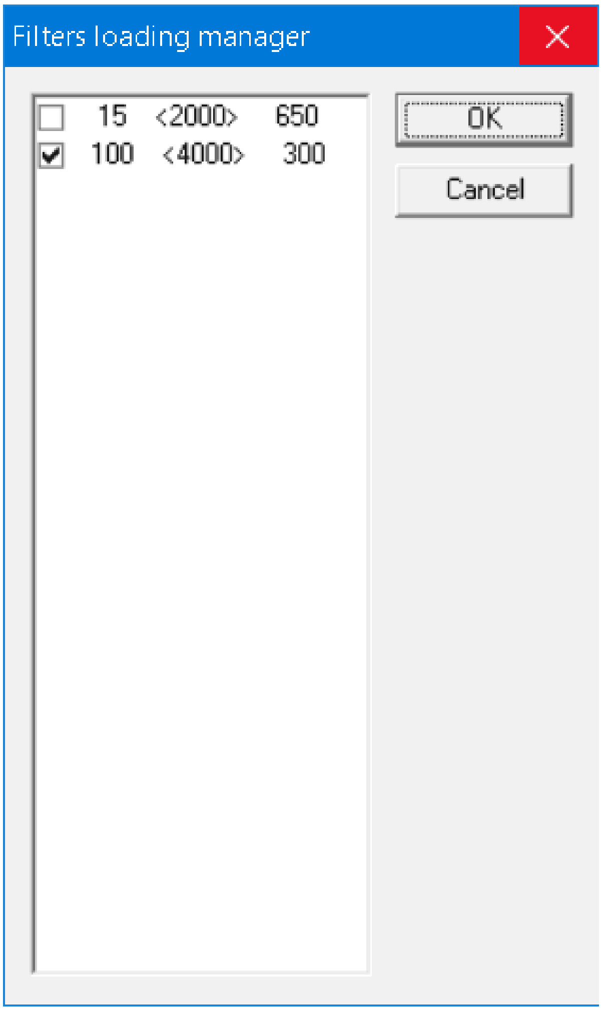


Fig. 9.9. Dialog box **Filters loading manager**

When choosing frequencies for **HPF** and **LPF** it is necessary to take into account that the frequency value for **LPF** should be at least twice the frequency value for **HPF**. If this condition is not met, the program itself changes the frequency values.

The filters are divided into those loaded into the module's memory (they are displayed in the list with square brackets around the sampling rate), and external, written in alnf files (they are displayed in the list with triangular brackets around sample rate), see *“Types of files used”* on page 38. Loading one or more external filters into modules is available only in the mode when no data is received. After loading into the internal memory of the modules, such filters begin to be displayed with square brackets around the sampling rate, they can be further used without restrictions until the power in the line is turned off.

◇ The gain values are displayed in the **Gain** group.

The right part of the **Gain** group displays the amplitude value in decibels corresponding to 1 ADC unit, as well as the ADC overload.

For "A-Line DDM-1" type complexes, the gain values can be changed using the **K, dB** spinner.

Changing the gain values also changes the threshold values. This follows from the formula linking these quantities:

Threshold (dB) = 20 lg (Threshold(ADC bits)*D/Reference) - Gain (dB),

where

D — parameter characterizing the ADC of the module;

Reference — base value of the scale for converting received AE impulse values to dB. The value of this parameter is set in the dialog box **General settings** (main menu command **Options – Settings…**).

At the same time, if the switch **dB** is activated in the **Threshold** group, then the complex will try to select such an ADC bit value to keep the threshold value in dB as constant as possible.

When the switch **ADC bits** is activated, the threshold value in ADC bits. The ADC remains unchanged, and the threshold values in dB change after the corresponding recalculation by the program.

◇ Set the discrimination threshold with the spinner in the group **Threshold**.

When the switch **dB** is activated, the change in the threshold value will be displayed by two values — fractional and integer (the integer value is indicated in brackets). Such a presentation of the change in the threshold value in dB is associated with the operation of the program, which will select the threshold values in ADC bits so that the sampling step is approximately equal to 1 dB (this value is indicated in brackets). The fractional value shows the value that is closest to the value in brackets available. When the switch **ADC bits** is activated, the sampling step is equal to 1 ADC bit.

◇ The program provides the ability to automatically set the threshold value. To set the auto threshold mode, activate the **Auto** switch in the **Threshold** group. This switch is only available in **online** mode. After that, the threshold value selected by the program will be automatically assigned to all channels. Setting the auto threshold value is described below.

To select the autothreshold mode, you can also use the main menu command **Control – AutoThreshold**, or the button on **Toolbar**.

◇ To change the color for displaying received data by channels, use the button **Color**.

The color is chosen using the standard dialog box **Color**.

After setting the parameters, click the **OK** button. From this moment on, the set values take effect. To cancel setting parameters, click the **Cancel** button. To apply new settings without leaving the **Channels settings** dialog box, there is a button **Apply**.

To set the auto threshold value, click the **Detailes** button in the **Threshold** group. After that, the **Auto threshold parameters settings** dialog box appears.

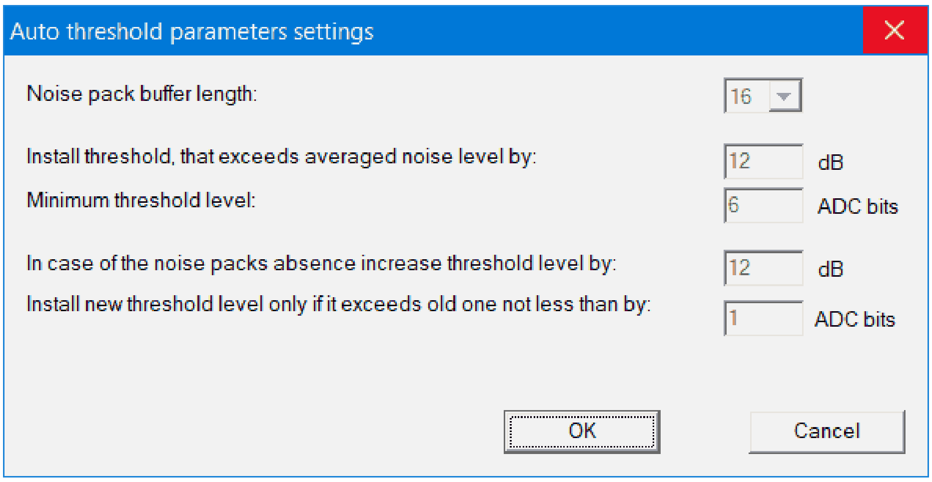


Fig. 9.10. Auto threshold parameters setting

In this dialog box, set the parameters for calculating the auto threshold value.

✧ Select the length of the noise pack averaging buffer from the list **Noise pack buffer length**.

✧ Set the threshold value exceeding of the average noise level in the field **Install threshold, that exceedes averaged noise level by … (dB)**.

✧ Enter the minimum threshold level in the field **Minimum threshold level (ADC bits)**.

✧ Set the value of threshold increase per second in the absence of noise bursts in the **In case of the noise packs absence increase threshold level by… (dB)** field.

✧ Enter the minimal difference between the new threshold and the previous one in the **Install new threshold level only if it exceeds old one not less than by… (ADC bits)**. If during the calculation the value of the new threshold differs from the previous one by a value less than the specified one, the threshold is not changed.

After setting the parameters, click the **OK** button. To cancel the changes made in the **Auto threshold parameters settings** dialog box, click the **Cancel** button.

We recommend using the default settings in the program.

Configuring oscilloscope channels

To configure the parameters of waveforms (oscilloscope channels), select the main menu command **Options – OSC parameters** or the icon . After that, the dialog box **Channels parameters** opens on the page **Oscilloscope**.

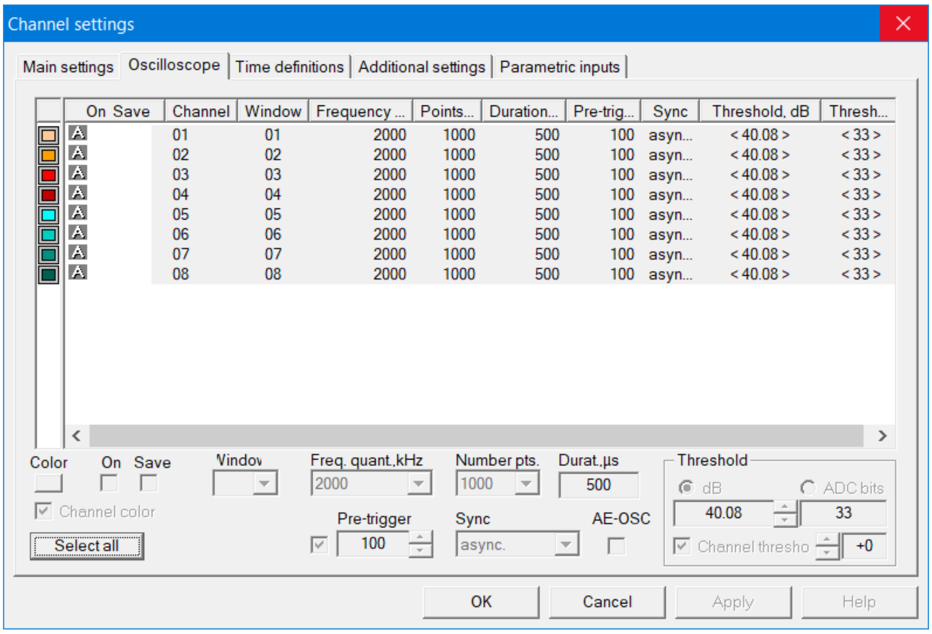


Fig. 9.11. Dialog box **Channels parameters**, page **Oscilloscope**

On this page, set the parameters of the oscilloscope channels.

◇ To turn the oscilloscope channel on and off, use the switch **On**

◇ To save waveforms from the oscilloscope channel, activate the switch **Save**

◇ Select the number of the window in which the waveforms from the oscilloscope channel will be displayed in the **Window** list.

◇ Select the sampling rate in kHz from the list **Sampling rate, kHz**.

◇ Specify the number of points in the waveform in the list **Points number**.

◇ The duration of the waveform is calculated by the program and its value is displayed in the field **Duration, µs**.

Formula for calculating waveform duration:

Duration (µs) = (Points number/Sampling rate (kHz)) × 1000

◇ The number of points in the waveform containing the AE impulse history before the first threshold crossing (see the section *"Main parameters"* on page 210), is set with the **Pretriggering**.

◇ The oscilloscope threshold is set in the **Threshold** group.

- Set the oscilloscope threshold value with the spinner in the **Threshold** group, similarly to how it is described for the page **Main settings** on page 107.
- If the threshold value of the oscilloscope channel must match the threshold value of the corresponding AE data channel or be a fixed number of decibels higher than any chosen channel threshold, then activate the switch **Channel threshold** in **Threshold** group and, if necessary, set the difference between the thresholds. In this case, the threshold values in the columns **Threshold, dB** and **Threshold, ADC bits** in the view field will be presented in brackets. In addition, the threshold for receiving such waveforms in dB will be displayed as XX.XX(Y), where XX.XX is the set individual threshold, Y is an additive constant.

◇ To change the color of displaying received data on oscilloscope channels, use the button **Color**. The color is chosen using the standard dialog box **Color**.

◇ To display oscilloscope channel data in the same color as data from the corresponding AE data channel, activate the **Channel color** switch. After its activation, it is impossible to change the color of the selected oscilloscope channel on the **Oscilloscope** page using the **Color** button. If you need to change the color, you should return to the page **Main settings** and select the desired color using the button **Color**, or reset the switch **Channel color** on the page **Oscilloscope**.

Configuring time definitions

To configure the time definitions of the channels, select the main menu command **Options – Time definitions**. After that, the dialog box **Channel settings** opens on the page **Time definitions**.

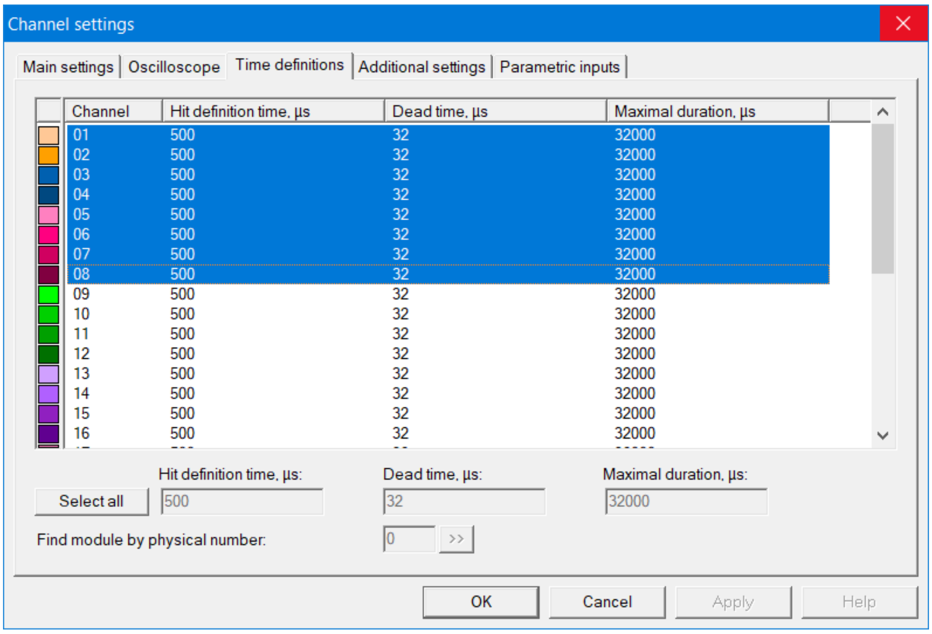


Fig. 9.12. Dialog box **Channel settings**, page **Time definition**

On this page, set the time definitions of the channels.

✧ Set the value of the HDT (hit definition time) parameter in the input field **Hit definition time (µs)**.

✧ Enter the value of the dead time parameter in the input field **Dead time (µs)**.

✧ Set the value of the maximal duration parameter in the input field **Maximal duration (µs)**.

✧ For DDM type systems, it is possible to search for a device in the complex by its physical number. To search for a device in the input field **Find module by physical number**, enter the number of the device (before the hyphen, without the # sign) and click the search button **>>**. The device address will be displayed in the text line to the right of the search button. Device search is available only after power is applied to the line.

Configuring calibrators

The page **Calibrator** is available only for complexes "A-Line DDM-1" and "A-Line DDM-2" types.

To configure the parameters of the calibrators, select the main menu command **Options – Calibrators parameters**. After that, the dialog box **Channels parameters** appears, opened on the page **Calibrators settings**.

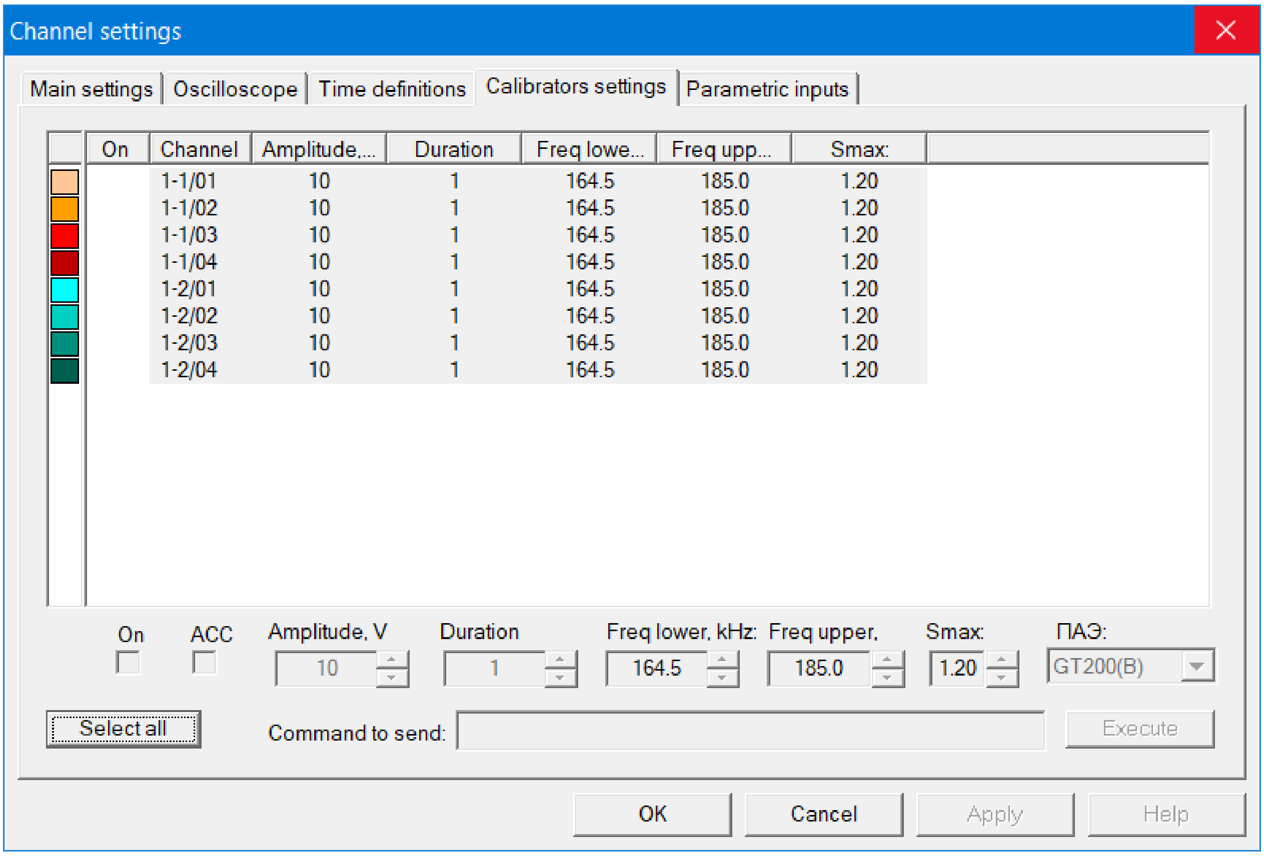


Fig. 9.13. Dialog box **Channel settings**, page **Calibrators settings** (for A-Line DDM-1 and A-Line DDM-2)

On this page, set the parameters of the calibrators.

- To turn calibrators on and off, use the switch **On**
- To turn autocalibration on and off, use the **ACC** switch (currently only available for A-Line DDM-2 complexes).
- Set the amplitude of the impulses emitted by the calibrator with the **Amplitude, V**.
- Set the ACC impulse duration with **Duration** (currently available only for A-Line DDM-2 complexes).
- The upper and lower limits of the analyzed frequency range for the ACC, if necessary, adjust the spinners **Freq. lower (kHz)** and **Freq. upper (kHz)** (currently only available for A-Line DDM-2 complexes).
- If necessary, adjust the AE sensor installation quality criterion with the **Smax** spinner (currently available only for A-Line DDM-2» type complexes).
- In the field **AE sensor type** select from the list the type of AE sensor installed on this channel (currently available only for complexes "A-Line DDM-2" type). This will set the **Freq. lower (kHz)**, **Freq. upper (kHz)** and **Smax** values to the default values for this type sensor.

> ⚠ When the calibrator is turned on, the receiving of impulses by the corresponding AE data channel is disabled.
>
> In the ald-file, the moment of applying a regular calibration impulse (not ACC) corresponds to a impulse record with zero duration, rise time, amplitude, energy, and emission counts.

> When the **ACC** switch is on, the corresponding channel A-Line DDM-2" starts both sending and receiving impulses from the calibrator.
>
> For details on configuring the calibrator parameters for the automatic channel calibration mode, see the section *“Automatic channel calibration (ACC)”* on page 186.

To simultaneously set parameters that are the same for all channels, use the button **Select all**.

Additional settings

To configure additional settings, select the main menu command **Options – Channels parameters** or press the button on **Toolbar**. After that it appears dialog box **Channel settings**, in which you need to select the tab **Additional settings**.

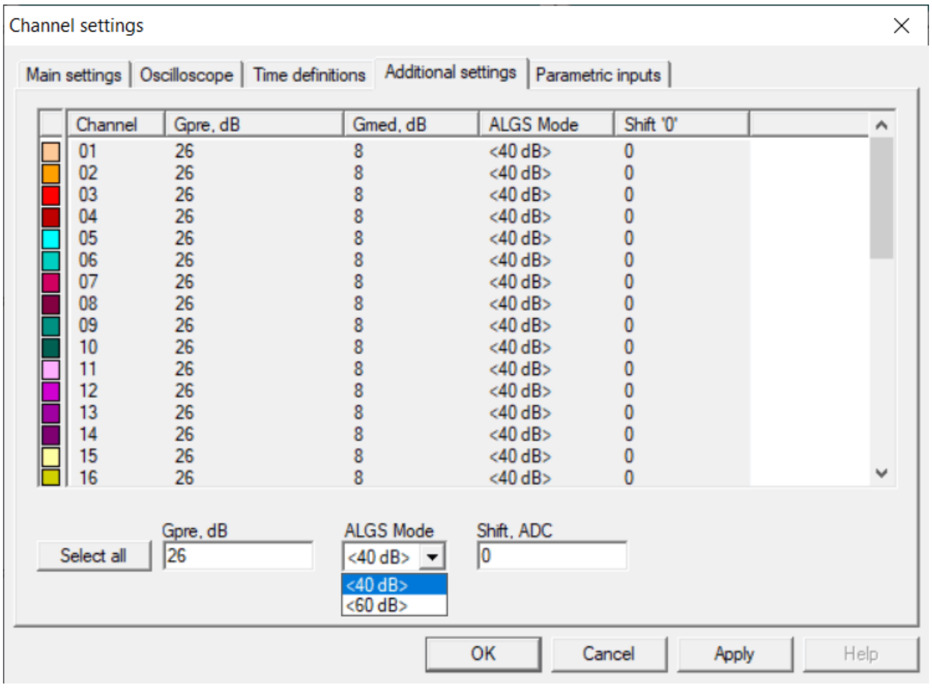


Fig. 9.14. Dialog box **Channel settings**, page **Additional settings** (for A-Line PCI type systems)

This page sets the preamplification value and zero offset parameters.

- ✧ Enter the preamplification value in the field **Gpre, dB**.
- ✧ Specify the shift value in the input field **Shift "0"**.

For "A-Line PCI" Ex systems that include a preamplifier and an intrinsically safe barrier in the analog signal transmission path, in the field for the preamplification value **Gpre, dB** you should enter not the gain coefficient of the preamplifier (default 20 dB), but its sum with the barrier gain (default 6 dB).

For "A-Line PCI" systems with the gain switch, an additional selection is made in the **ALGS Mode** input field. The corresponding intermediate gain value is calculated by the program, and its value is displayed in the **Gmed, dB** field.

In the absence of a gain switch, the **ALGS Mode** input field is not available for editing, the table displays the value **Gmed, dB** = 0.

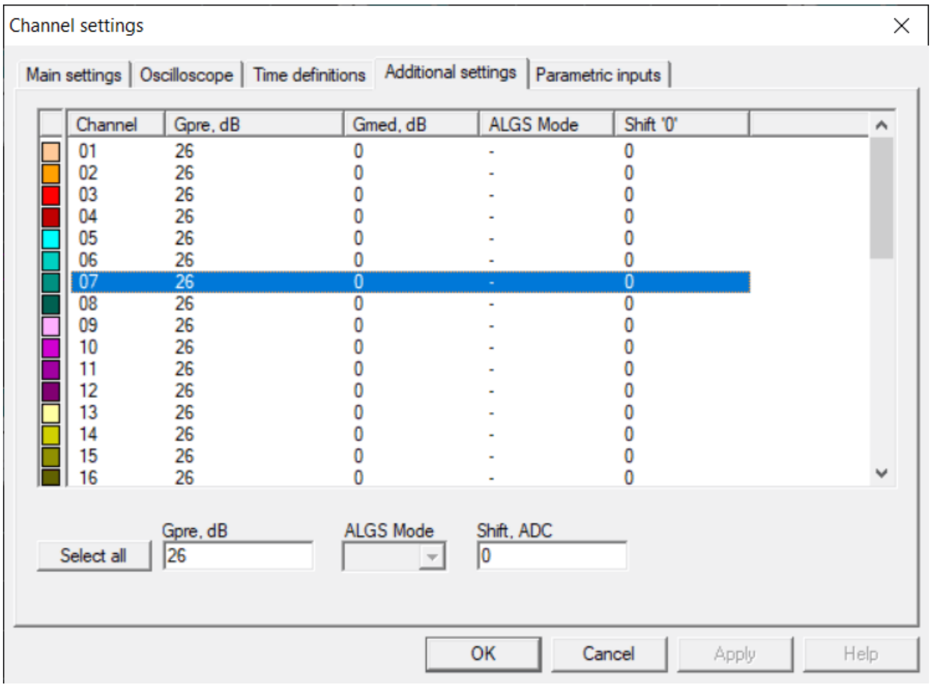


Fig. 9.15. Dialog window **Parameters channels**, page **Shift** (for A-Line PCI systems without gain switch)

To simultaneously set parameters that are the same for all channels, use the button **Select all**.

Note that the page **Additional settings** is available only for complexes "A-Line PCI" and "A-Line DS" types.

Configuring parametric inputs

To configure parametric inputs, select the command **Options – Parameters settings** in the main menu. After that, the dialog box **Channel settings** opens on the page **Parametric inputs**.

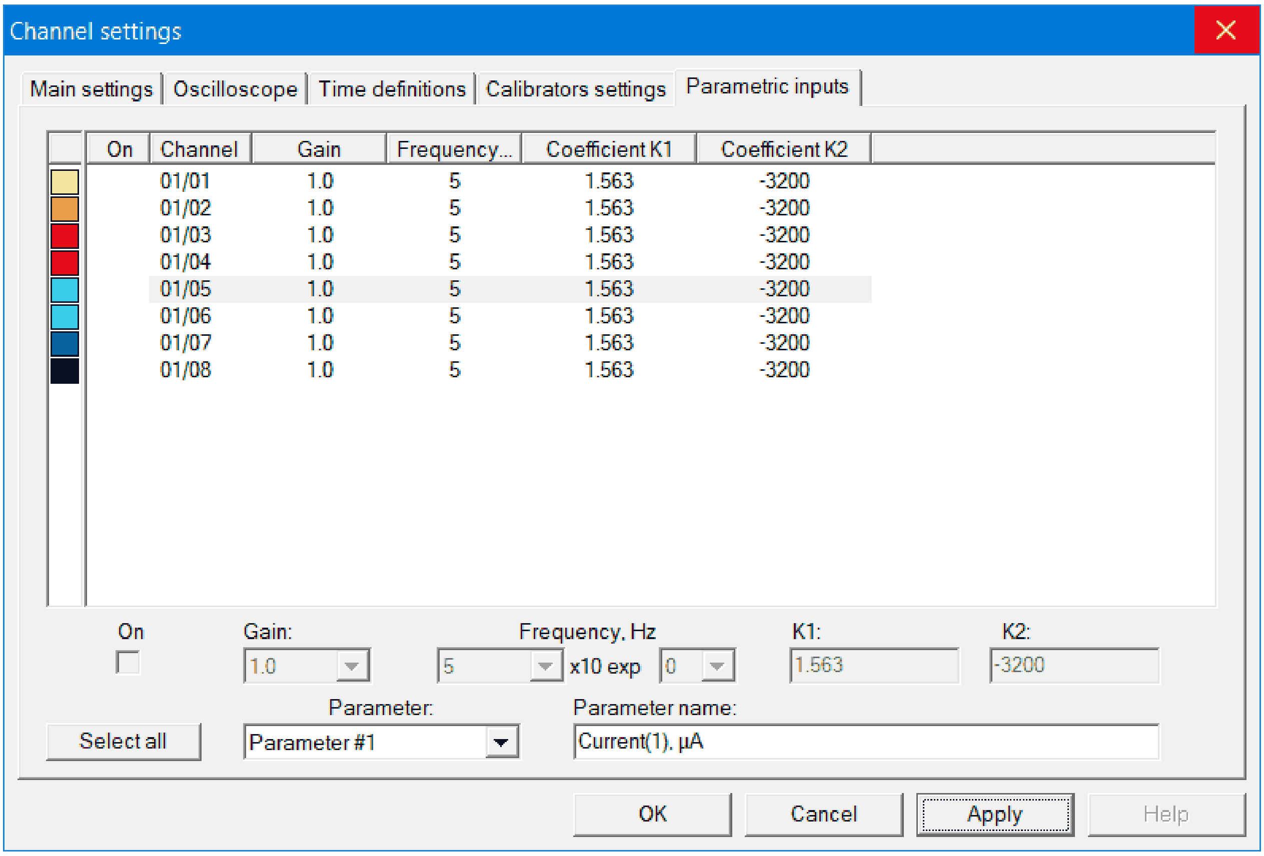


Fig. 9.16. Dialog box **Channel settings**, page **Parametric inputs**

On this page, you can configure parametric inputs.

- To enable/disable parametric inputs, use the switch **On**.
- Set the value of the sampling rate of parametric inputs, which is determined by the formula $f = N*10^m$, in the lists **Frequency, Hz**. To do this, select the desired base N (N=5, 10, 31) in the left list and the exponent m (m= 0, 1, 2) of the number 10 in the right list **Frequency, Hz** to calculate the sampling rate of the selected parametric input.
- Set the K1 and K2 coefficients in the input fields **K1** and **K2**.

  The value of the parameter in real units is set using the dimensional coefficients K1 and K2 by the following formula:

  Parameter (real units) = K1 × Parameter (ADC bits) + K2

It is recommended to determine the values of the coefficients of the parametric channel as follows.

In the **Options - Settings - General settings** section, the switch **Parameter coefficients auto set** is set to the inactive position.

The procedure is performed after connecting the external measuring equipment to the parametric input, before the start of the main loading.

The values K1=1, K2=0 are set. In this case, the values of the signal at the parametric input will be displayed in ADC units on the program screen.

When the pressure/loading value is low, its actual value **P1** is recorded (in MPa, kPa, atm or other units), as well as the corresponding value of the signal **A1** in ADC units on the program screen.

At a high pressure/loading value (close to the operating or pre-test pressure), its actual value **P2** (in MPa, kPa, atm or other units) is recorded, as well as the corresponding value of the **A2** signal in ADC units on the program screen.

From the system of equations

P1 = K1 × A1 + K2

P2 = K1 × A2 + K2

it follows:

K1 = (P2 - P1) / (A2 - A1)

K2 = P1 - K1 × A1

When setting the values K1, K2 obtained in this way, the signal values at the parametric input will be displayed on the program screen in the appropriate units (MPa, kPa, atm, etc.)

- Clicking the **Save K1 and K2** button will resave the open data file with the modified coefficients. To plot parametric data based on the new coefficients, open the file again.
- The choice and name of the parameter are set in the list **Parameter** and in the input field **Name**, respectively. Note that the list **Parameter** and the input field **Parameter name** are available immediately after opening the page **Parametric inputs**. These parameters are common to the entire complex.

To simultaneously set parameters that are the same for all channels, use the button **Select all**.

9.4. Setting the general parameters of the complex

Setting the general parameters of the complex is carried out in the dialog box **General settings**. The window is multifunctional, and all configurable general parameters are divided into four groups. Each group of parameters is set on the corresponding page:

- general settings of the complex — on the page **General**;
- configuring the network addresses of devices combined into a single complex — on the page **Network connections**;

- ✧ setting export options **.ALD** file into text or spreadsheet format on the page **Export parameters**;
- ✧ selection of parameters for their presentation in text form in the filtering and synchronous text view windows — on the page **Parameters list**.

Setting options on the page General

Setting the general parameters of the complex is carried out by selecting the main menu command **Options – Settings**. As a result, the **General settings** dialog box appears, opened on the page **General**.

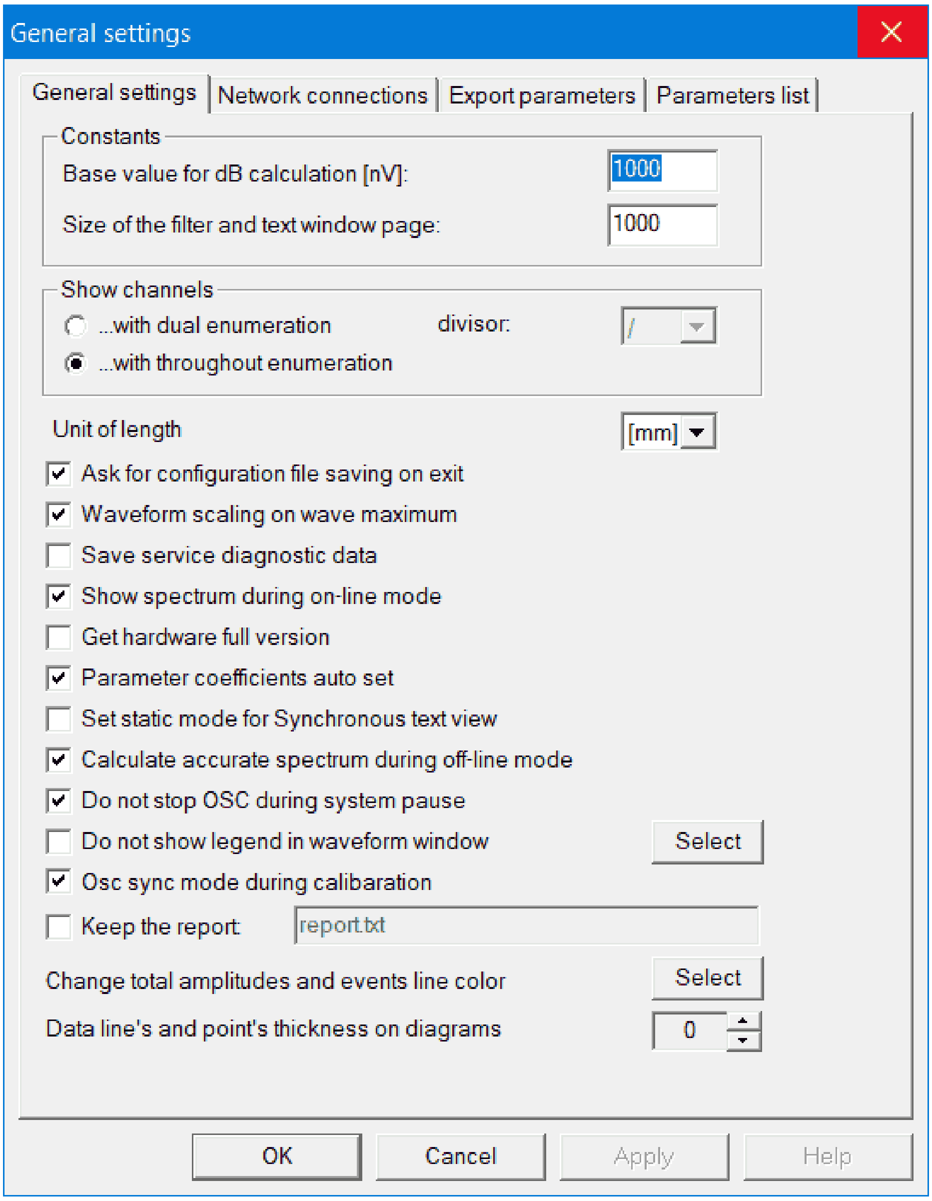


Fig. 9.17. Dialog window **General settings**, page **General**

On this page, the options are divided into three groups, and also presented as a series of switches.

◇ In the group **Constants** constants for the whole complex are set:

- The base value of the scale for converting the obtained values of AE impulse amplitudes to dB is in the input field **Base value for dB calculation, [nV]** (recommended value 1000 nV).

- Number of lines on the text view page is in the input field **Size of the filter and text window page** (recommended value 1000).

◇ The group **Show channels** contains information about the choice of channel enumeration:

- Using double enumeration (recommended for "A-Line DDM" type complexes) —**…with dual enumeration** radio button. (When using double enumeration in the complexes "A-Line DDM-1", "A-Line PCI", "A-Line DS" types, the first digit indicates the number of the line/board, the second the number of the module/channel on this. For the "A-Line DDM-2" complex, the first digit indicates the input number, the second - number of the line on this input, and the third - number of the module on this line).
- Selecting a separator (**/, \, -, --**) when using double channel enumeration is in the list **divisor**.
- Using end-to-end enumeration (recommended for complexes "A-Line PCI" and "A-Line DS" types) to display channels — **… with throughout enumeration**.
- Selecting a separator for mirror channels in location is in the **divisor for mirror channels in location** list. Available only when location files are open.

◇ In the **Unit of lenght** list, select a common unit of measurement for all coordinates, distances and other geometric parameters.

The program also provides the following features:

✧ Save configuration file on exit — switch **Ask for configuration file saving on exit**.

✧ Scaling an waveform (on the Y scale) by its maximal value — switch **Waveform scaling on wave maximum**. Otherwise, autoscaling will be carried out according to the full scale of the ADC.

✧ Save service diagnostic data in a data file — switch **Save service diagnostic data**;

✧ Show spectrum during on-line mode — switch **Show spectrum during on-line mode**.

✧ Output to console and protocol file of firmware version of full hardware of DDM-2 type complex, and not only modules (service mode) — switch **Get hardware full version**.

✧ Default setting of coefficients of parametric inputs — switch **Parameter coefficients auto set**.

✧ Output in window of **Synchronous text view** only one line for each channel per second and presentation of statistics of differences of individual parameters of different channels (service mode, useful when checking the complex) — switch **Set static mode for Synchronous text view**.

✧ Calculate accurate spectrum in post-processing mode — switch **Calculate accurate spectrum during off-line mode**.

When this switch is activated, the actually captured frame of the waveform is lengthened by filling the buffer with points with zero amplitude, and such a refined spectrum is calculated.

✧ Continue operation of the oscilloscope in measurement pause mode — switch **Do not stop OSC during system pause**.

✧ Remove legend from oscilloscope window — switch **Do not show legend in waveform window**.

✧ Setting the font of the text legend in the oscilloscope display windows — button **Select** opposite the option **Do not show legend in waveform window**;

After clicking this button, a standard dialog box **Font** will open, in which you should select all the desired text input options, except for the color. The displaying color of the text legend will be determined inverse to the display color of the AE channel. Selected options apply to all displaying waveforms windows immediately after pressing the **OK** button of the font settings dialog box and are saved in the configuration file.

- ✧ Synchronous start of oscilloscope on all channels at the moment of emission of calibration pulse on one of them — switch **Osc sync mode during calibration**.
- ✧ Keep the report (text file) - switch **Keep the report**;

  When you enable this check box, enter the desired log file name in the input field. Messages are recorded in the protocol in text form about the main actions of the operator and the characteristics of the system. The name of the log file is saved in the configuration file, and records of the current session of the system are added to the end of the log.
- ✧ The color of the line on the graphs of total (summary) parameters is selected using the standard dialog box **Color**. To open it, use the button **Select**.
- ✧ The thickness of information lines on graphs and the size of points in various windows are set with the **Data line's and points' thickness and digital's on diagrams** (0 corresponds to minimal possible line thickness and point size, set by default).

After setting the required parameters, press the button **OK**, to cancel press the button **Cancel**.

Setting network connections page

The relevant procedures are described in the chapter *“Setting A-Line network parameters” on page 24*.

Settings of the export parameters

The program implements the ability to jointly export to one text text or spreadsheet file the full contents of the system data file (AE impulse parameters, readings of parametric inputs, noise measurement data, service data and operator commands). In the resulting text (spreadsheet) file, information of various types will be presented in separate lines in accordance with the order in which they are received from the hardware. To configure data export, use the main menu command **Options – Settings**. As a result, the **General settings** dialog box appears, in which you should select the page **Export parameters** and mark the desired export fields for each type of information. The set export options are saved in the configuration file.

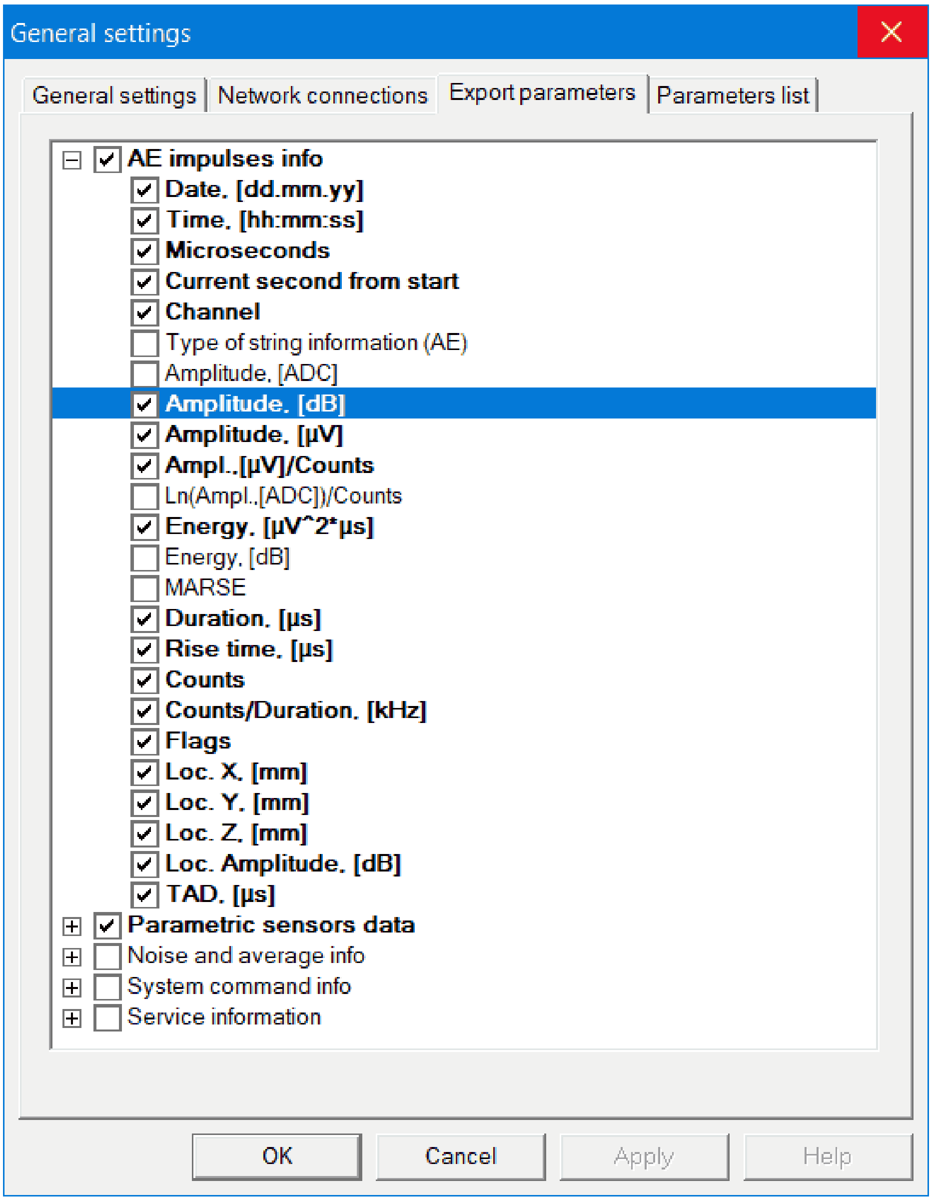


Fig. 9.18. Dialog box **General settings**, page **Export parameters**

On this page, select the desired type of information and then the corresponding data to export in the tree view:

◇ AE impulses info — activate the switch **AE impulses info**:
  - open the activated list and select the options for export.

◇ Readings of parametric inputs — activate the switch **Parametric sensors data**:
  - open the activated list and select the options for export.

◇ Information about noise and averaged data — activate the switch **Noise and average info**:
  - open the activated list and select the options for export.

◇ Information about system commands — activate the switch **System command info**:
  - open the corresponding activated list and select the options for export.

◇ Service information — activate the switch **Service information**:
  - open the activated list and select the options for export.

After setting the required parameters, press the button **OK**, to cancel press the button **Cancel**.

Setting parameters list page

The program has the ability to use an individual desired set of characteristics in the filtering and synchronous viewing windows. To do this, use the main menu command **Options – Settings**. In the appeared dialog box **General settings** select the page **Parameters list**.

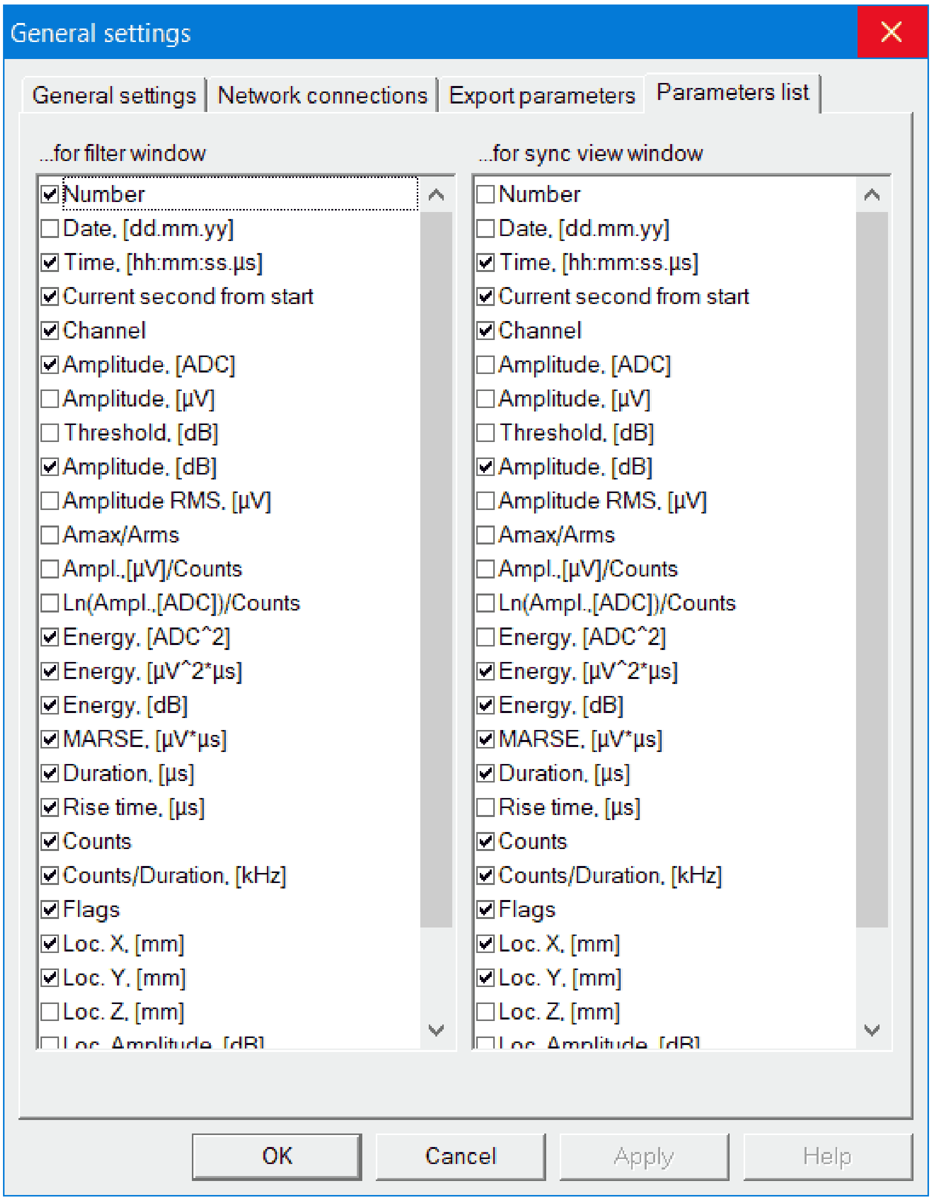


Fig. 9.19. Dialog box **General settings**, page **Parameters list**

On this page, in two fields, there are lists of possible options for each view window, from which you should select the desired ones by activating the corresponding switch:

- in the field **...for filter window** there is a list of possible options for viewing in the filter and preview window;
- in the field **...for sync view window** there is a list of possible options for the synchronous view window.

After setting the required parameters, press the button **OK**, to cancel press the button **Cancel**.

9.5. Setting up hotkeys

To configure the hotkey system, use the main menu command **Options – HotKey Settings**. After that, the **HotKey settings** dialog box appears.

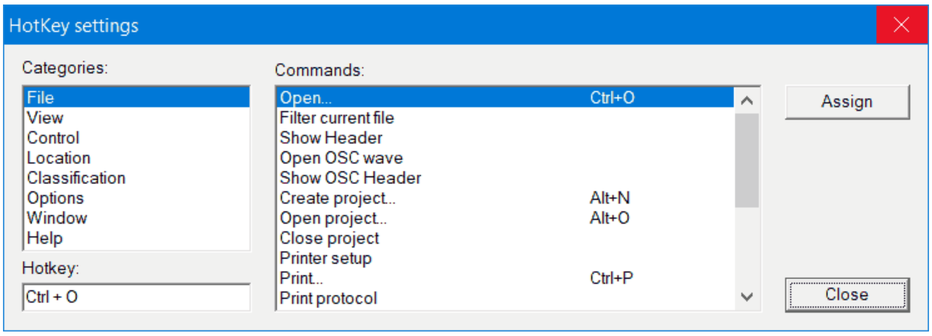


Fig. 9.20. Dialog box **HotKey settings**

In this dialog box, set the hotkey settings.

- In the **Categories** list, select the main menu command. After that, all submenus of the selected command will appear in the **Commands** list.
- In the **Commands** list, select the required submenu.
- Enter the designation in the input field **HotKey** using the keys **<Ctrl>**, **<Alt>** or **<Shift>**.
- Press the button **Assign**.

  After that, in the **Commands** list, the corresponding combination of hot keys appears opposite the selected command.

To cancel the set hotkey combination or replace it with another, repeat the above procedure again. At the same time, enter the command **No** or any other key combination in the input field.

After finishing setting up hotkeys, close the dialog box using the **Close** button.

✶ ✶ ✶

Chapter 10. Working with windows

✻ In the *“Working with windows”* chapter, work with program windows, their features, as well as customizing the data presentation are considered.

10.1. Introduction

The A-Line complex allows you to monitor the process of data acquisition and carry out various presentations of the received data. All results obtained are displayed in the corresponding windows. The program has the following options for presenting the received data:

- as lines or dots;
- in the form of histograms;
- in the form of waveforms;
- in various location windows;
- other views.

Each window has a working area and axes. The results are directly presented in the workspace. With the help of the axes, you can determine the coordinates and limit the area under consideration. It is also possible to create and overlay an additional line on the graphs.

10.2. Line view windows

The most common representation of results is as lines or dots. The view is selected from the **Graph Setup** dialog box, as described in *“Setting up the WDRI workspace”* on page 134.

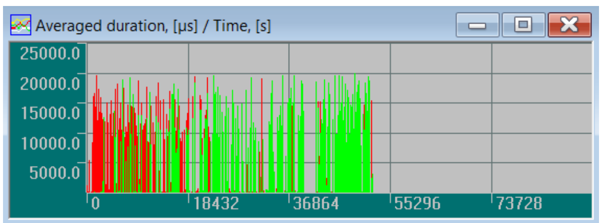


Fig. 10.1. Representing results as lines

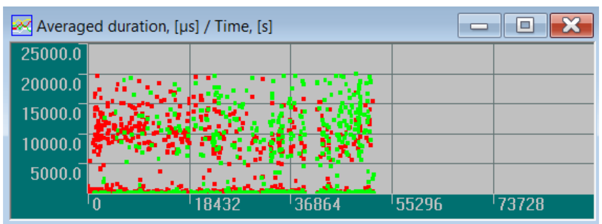


Fig. 10.2. Representing results as points

There are a number of windows with simultaneous channel-by-channel presentation of results. In this case, the window displays several graphs, each of which has the color of the corresponding channel. There is also a part of the dependencies, which is represented by one graph.

For the convenience of viewing and moving the viewing area along the time axis, the program provides a scrolling function. This feature is only available for time-dependent windows. This feature is discussed in more detail in the section *“Scrolling”* on page 133.

10.3. Histograms

The program uses various types of histograms to display some data. The height of the histogram column corresponds to the value of the displayed parameter.

Usually histograms are the result of the accumulation (total count) of AE impulses or emission counts on specified channels.

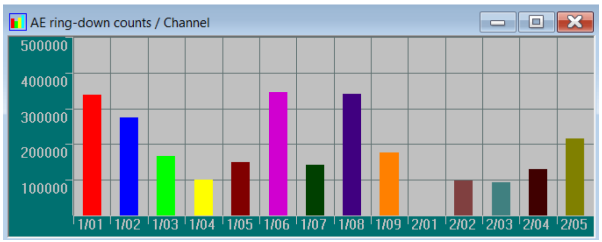


Fig. 10.3. AE ring-down counts by channel

In addition, the program has histograms that are used to represent the noise level.

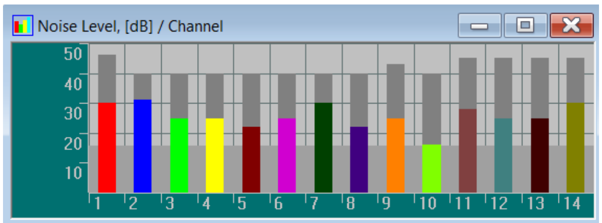


Fig. 10.4. Histogram of noise level by channels

This columns displays three characteristics:

- ✧ The gray high column shows the current value of the threshold level set for the channel;
- ✧ grey wide column shows the minimal possible signal level (1 ADC bit);
- ✧ colored column shows the current value of the noise level for the channel.

In addition to standard histograms such as **AE ring-down counts** by channel and **Noise level** by channels, the program allows you to create other distribution windows in which the results will be presented in the form of histograms. The procedure is described in detail in *“Window manager”* on page 137.

10.4. Waveforms

The program has the ability to display waveforms of AE impulses (oscillograms). Waveforms are the result of continuous signal recording for a certain time interval on the selected channel.

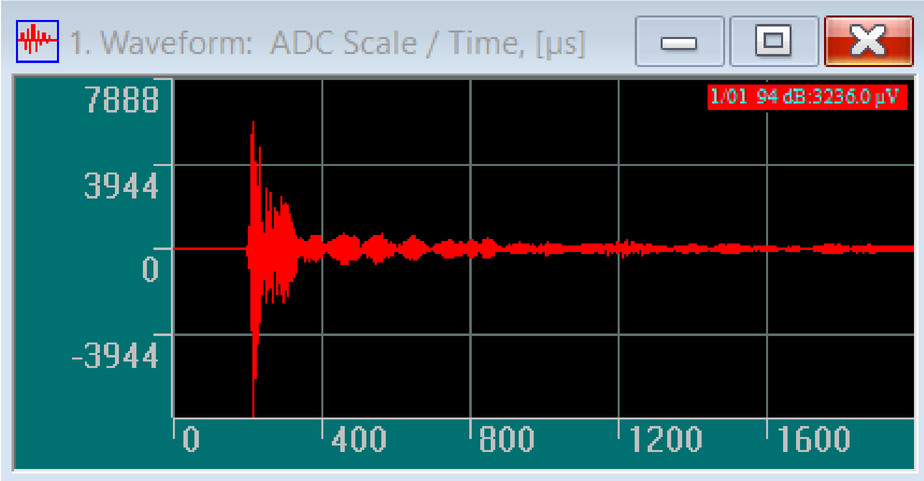


Fig. 10.5. Example waveform

It is possible to simultaneously display several waveforms obtained from different channels in one window. The color of each displayed waveform will match the selected channel color.

In addition to the waveform, the registration window displays the legend and the threshold level. The legend contains:

✧ channel number;

✧ maximal value of AE impulse amplitude in **dB**;

✧ RMS value of the AE impulse amplitude.

In addition to changing the threshold value in the **Channel settings** dialog box on the **Oscilloscope** page (see section on page 114) it is possible to change the threshold value of the oscilloscope for one channel directly in the registration window. To do this, move the cursor to the threshold line and set it to the desired value. If you need to change the threshold value of the oscilloscope for another channel, then go to the corresponding window for this oscilloscope channel. Note that when changing the oscilloscope threshold value in the **Threshold** group of the dialog box **Channel settings** the switch **Channel threshold** is activated, then the newly set oscilloscope threshold value will be exactly the same for the threshold of the corresponding channel.

Spectral power

The program has the ability to calculate the spectral power of the AE impulse based on the received waveforms. For this, mathematical processing of waveforms using the Fourier transform is provided.

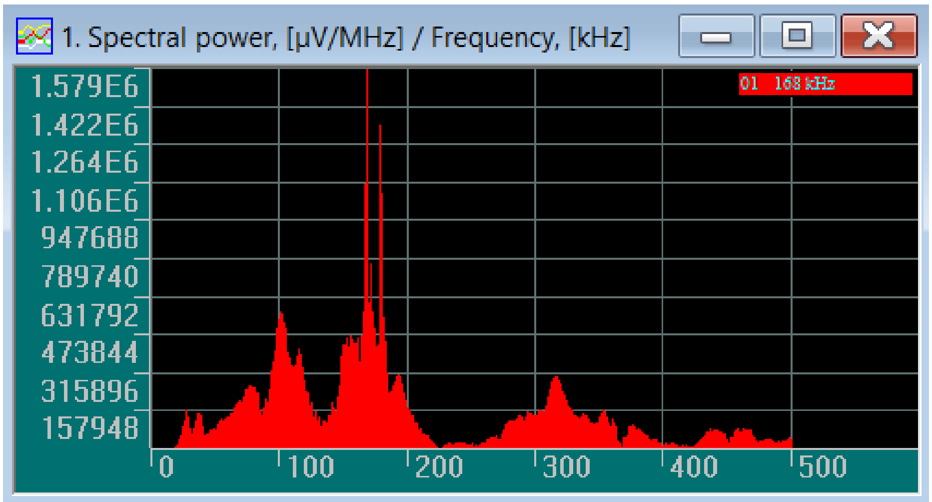


Fig. 10.6. An example of the spectral power obtained from the waveform

In addition to the spectrum, a legend is displayed in the registration window. The legend contains:

- channel number;
- main mode in spectrum;
- In ACC mode, the legend contains additional information, see *"Automatic channel calibration (ACC)"* on page 186.

Calculation of the spectral power of a AE impulse is possible if the spectral power display mode is activated in the channel settings. In this case, an additional window appears in which the spectral power of the AE impulse will be presented. Otherwise, only waveforms of the received impulses are displayed. This mode of operation is described in more detail in on page 114.

10.5. Location windows

The program uses the following location windows to present different types of location results:

- linear location window;
- plane location windows;
- cylinder location windows (for cylindrical vessels);
- sphere location windows (for vessels of a spherical shape);
- cone location windows (for conical vessels);
- windows for locating the bottom and wall of the vertical steel tank;
- 3D location windows;
- Zonary location window.

The program also has the ability to create special windows that will display additional information about the location:

- windows for accumulation of located AE impulses;
- location amplitude window.

Linear location window

In the evaluation of possible defects in extended objects, a linear type of location is used. This is described in detail in the section *“Linear location”* on page 155. The location results will be displayed in the linear location window.

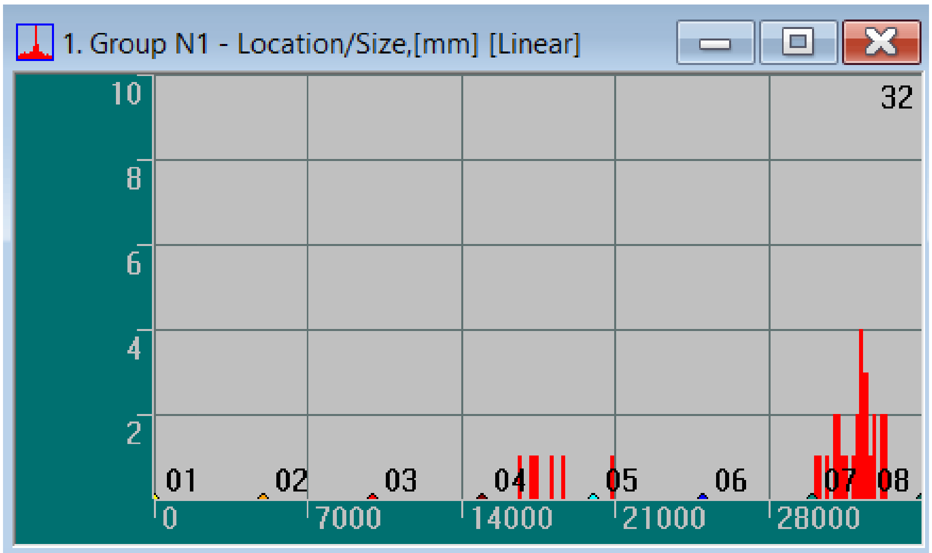


Fig. 10.7. Linear location window

The presence of columns in the location window indicates the possible presence of AE sources in the given interval. The height of the columns shows the number of accumulated events from the sources. The greater the height of the column, the greater the probability of finding an AE source in the considered interval. The width of the location interval is obtained based on the length of the object and the number of intervals, which are set in the dialog box **Linear scheme settings** *“Configuring the sensor scheme”* on page 155.

In the linear location window, in addition to the accumulated events from the AE source, sensors are also shown in the form of circles of the corresponding color in the lower part of the graph. Using the cursor, you can determine the coordinate of any sensor and then make qualitative estimates about the location of a possible AE source.

Planar location window

To analyze possible defects in flat structures, as a rule, a planar type of location is used. This is described in detail in the section *“Planar location”* on page 157. The results of these studies will be presented in the planar location window.

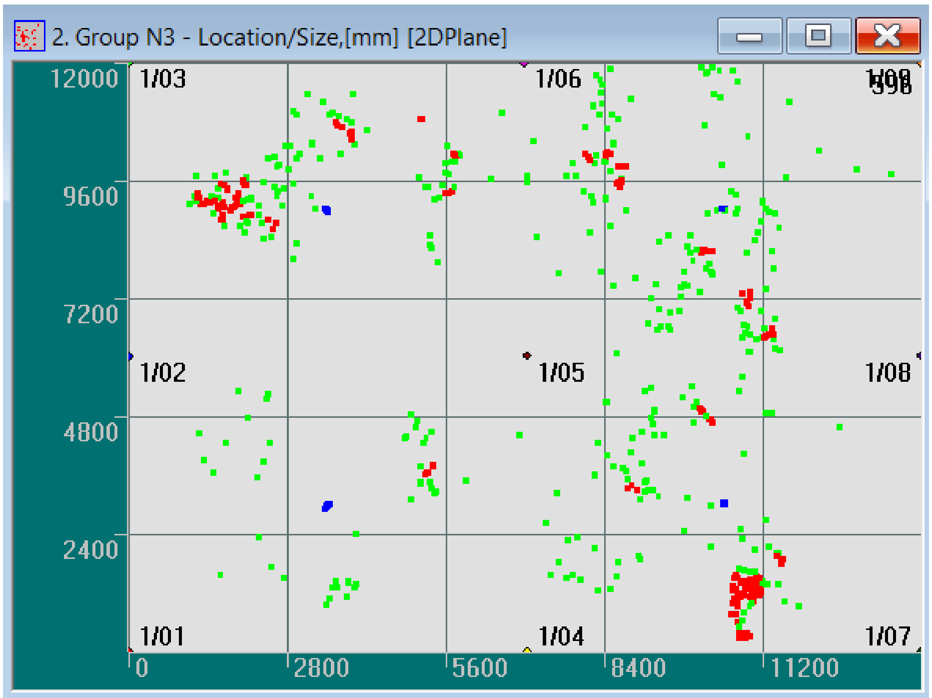


Fig. 10.8. Plane location window

A cluster of dots of a certain color will be shown in the location window in the area of a possible AE source. Using the color designations of the clustering window, one can estimate the intensity of the possible AE source. As a rule, color designations are set in such a way that a darker color corresponds to more intense AE source events. Based on the obtained location graph, which also includes sensors, it is possible to make qualitative estimates about the location of a possible AE source. The coordinates of areas of increased intensity and sensors, indicated by colored circles, are determined using the cursor.

> ✱ To display the geometry of an object (dimensions, external welds, etc.) when using planar location, it is convenient to use the option of creating and overlaying an additional line, described in the section *“Setting imported graphics”* on page 142.

Different representations of a planar location

Studies at various objects have shown that when locating and identifying possible AE sources, an important role is played by taking into account the geometric features of testing objects. In this regard, some location models were proposed that allowed these features to be taken into account. The following types of locations have been developed:

- location of cylindrical vessels;
- location of spherical vessels;
- location of conical vessels;
- location of the bottom and wall of the vertical steel tank.

At the basis of these models, when calculating the coordinates of AE sources, planar location was used.

When testing cylindrical vessels, cylinder location is used. This location type is detailed in the section *“Location of the cylindrical vessels”*on page 158. The location results will be displayed in the cylinder location window.

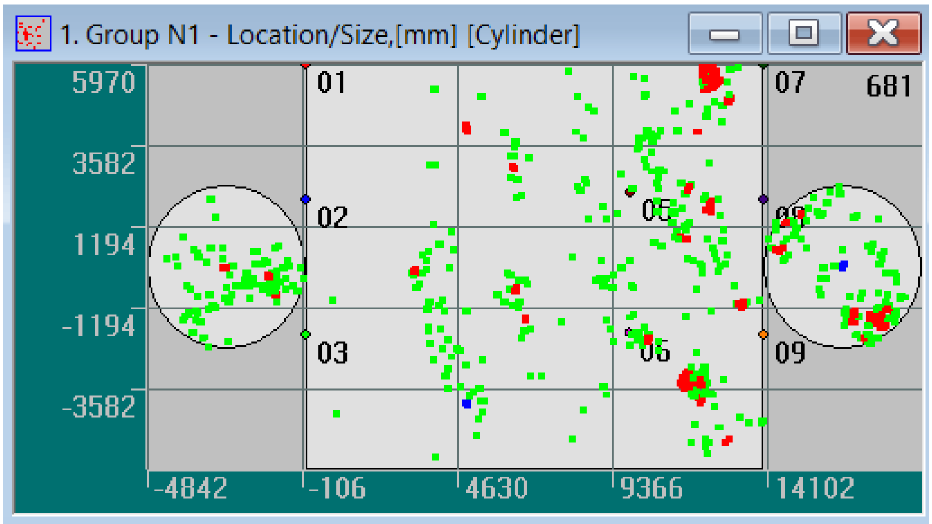


Fig. 10.9. Cylindrical vessel location window

In addition to the located sources and sensors, the location window shows a net (projection) of the testing object. It consists of a shell, represented by a rectangle, and bases in the form of ellipses. Bases will be shown on the installation if they are included in the location scheme.

When conducting location studies of spherical vessels, you should use the location of the sphere. This type of location is described in detail in *“Location of the spherical vessels”* on page 160.

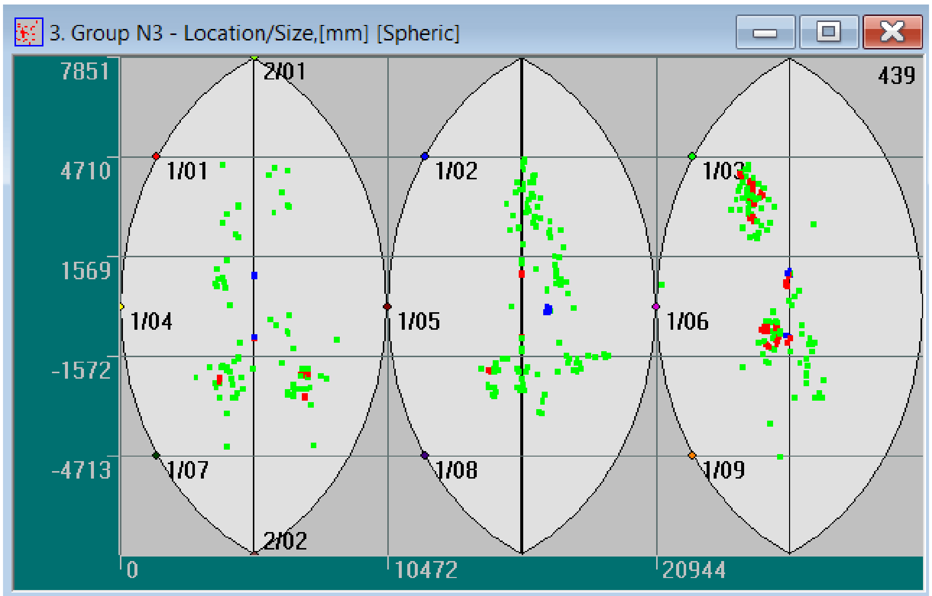


Fig. 10.10. Spherical vessel location window (sector type)

The location results will be displayed in the sphere location window. Depending on the selected representation method, the net of the testing object may look like "orange slices" (sector type) or a rectangles (cubic type).

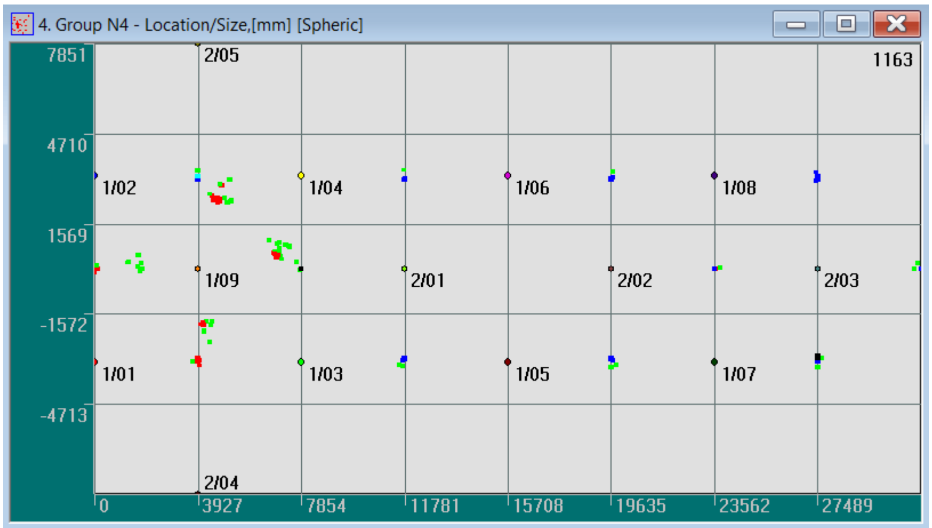


Fig. 10.11. Spherical vessel location window (cubic type)

When testing vessels (or parts of vessels) of a conical shape, the location of the cone is used. This type of location is described in detail in the section *"Location of the conical vessels"* on page 162. The location results will be displayed in the location window of the cone.

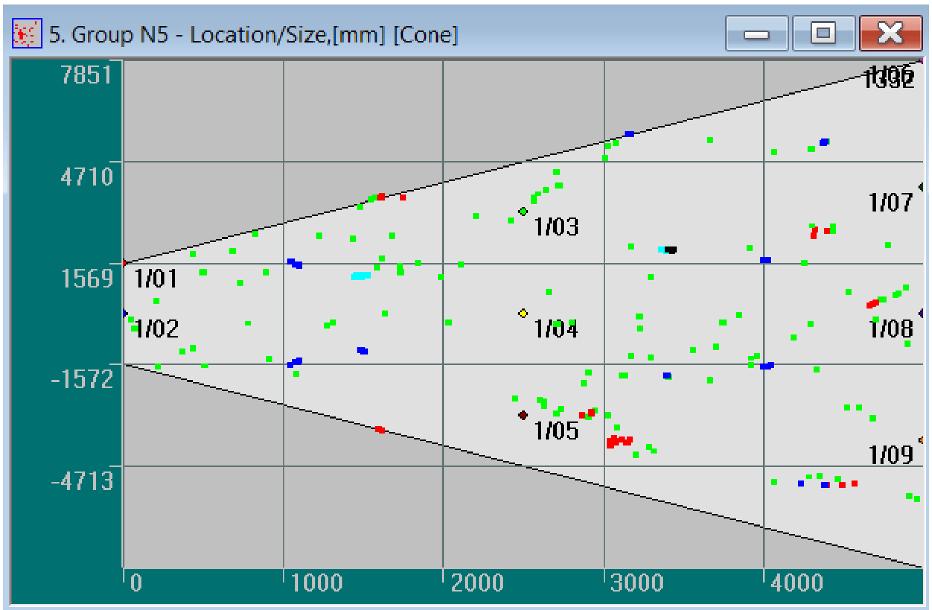


Fig. 10.12. Conical vessel location window

In addition to the located sources and sensors, the location window shows a net of the testing object. It has the shape of a trapezoid (horizontal or vertical, depending on the position of the object). For testing the bases of a conical vessel, use the location of the bottom.

When testing objects whose radius of the region of interest is much larger than the height and does not have access to bottom, the location of the bottom is used. This location type is detailed in the section *"Bottom location"* on page 164. The location results will be displayed in the bottom location window.

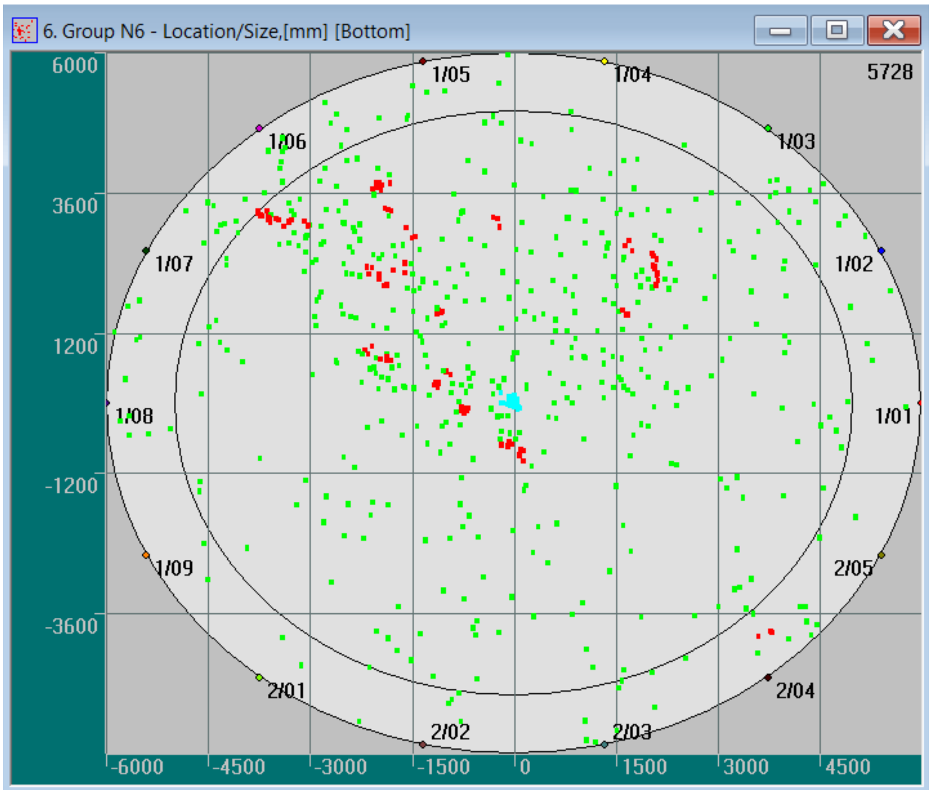


Fig. 10.13. Bottom location window

Also, the location window shows a net of the testing object. It consists of a shell, shown in the form of a ring, and the bottom shown in the form of an inner circle. The width of the ring indicates the maximal height at which the sensors can be installed.

3D location window

In the testing of three-dimensional filled objects, 3D location is used. This type of location is described in detail in the section *"Three-dimensional location"* on page 167. Location results will be presented in 3D location windows, depending on the shape of the testing object.

To display the results of locating cylindrical, spherical or conical vessels, there is a corresponding window with a three-dimensional model of the object. Note that in this case, the possible AE sources obtained as a result of location will be located on the surface of the object.

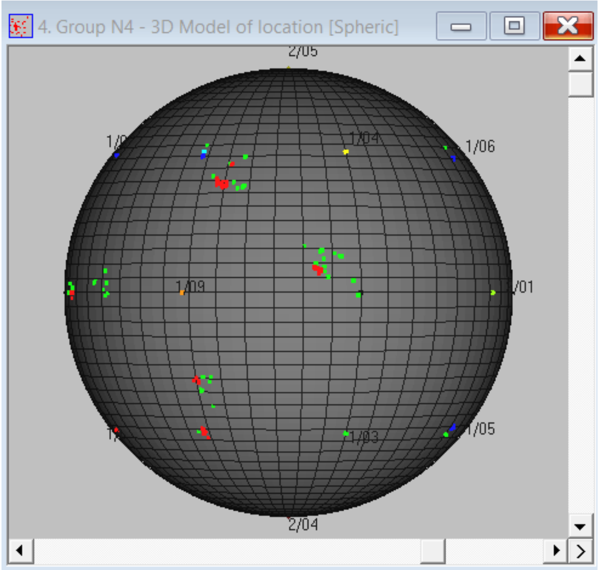


Fig. 10.14. 3D model of the location of a spherical vessel

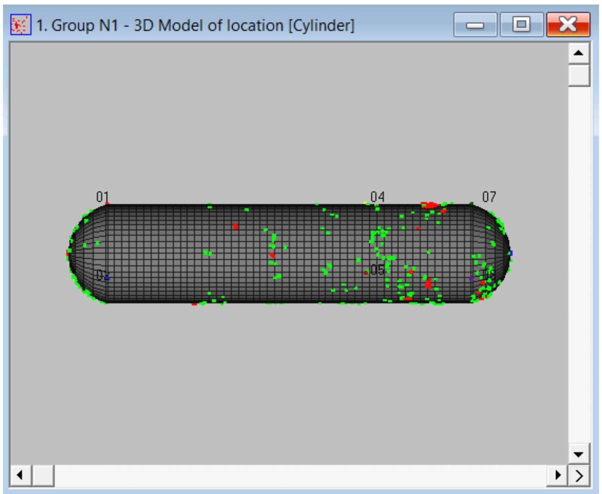


Fig. 10.15. 3D model of the location of a cylindrical vessel

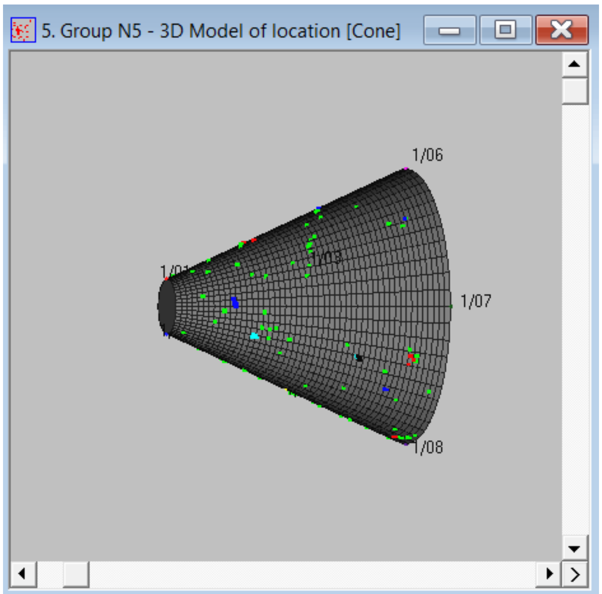


Fig. 10.16. 3D model of the location of a conical vessel

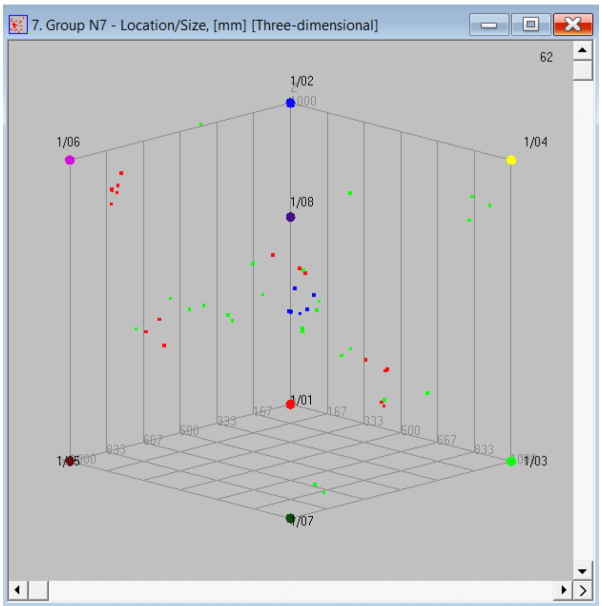


Fig. 10.17. 3D location window

Managing the 3D location model window

The 3D location model window is intended for observing 3D location models of cylindrical and spherical vessels, as well as filled 3D objects. When working with an image of three-dimensional objects with a given sensor arrangement, various functions are provided in the 3D location window.

- ✧ To rotate the vessel around the horizontal axis, use the vertical scroll bar.
- ✧ To rotate the vessel around the vertical axis, use the horizontal scroll bar.
- ✧ To animate (simultaneous rotate of the vessel around both axes passing through the center of the vessel), press the > button.
- ✧ To stop rotation, depress the > button.

10.6. Additional windows

The program provides the ability to create additional windows: correlation windows and histogram windows. This procedure is described in *“Window manager”* on page 137.

In additional windows, as well as in normal ones, you can turn on and off the display of individual channels. This procedure is described in *“Using the View bar”* on page 52.

To clear additional windows from the results, you can use the  button on **Toolbar**. To restore graphs in additional windows, use the button  on **Toolbar**.

Correlation (dependence) windows

In the correlation windows (windows of mutual dependencies of parameters), the corresponding values of these parameters are plotted along the X and Y axes. The results are displayed in the main area of the window as a set of colored dots. The color of the dots corresponds to the color of the channel. The presence of a point indicates that among all the data contained in the file, there are those whose parameters correspond to the coordinates of the point.

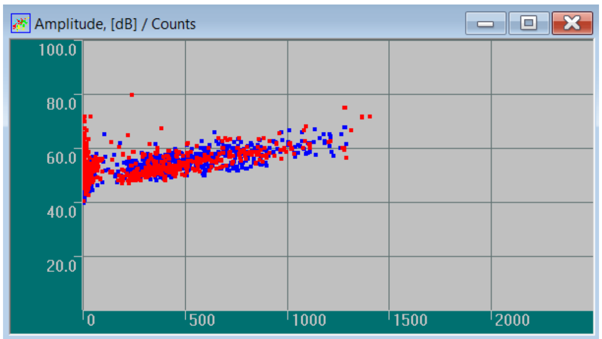


Fig. 10.18. Graph **Amplitude, (dB)/Counts**

Histograms (distribution windows)

In addition to plotting "any from any", the program has the ability to create histograms (distribution windows). The newly obtained distributions will be presented in the corresponding windows in the form of histograms. The distribution windows along the vertical axis indicate the number of AE impulses within the specified range of the selected parameter. The value of the parameter is plotted along the horizontal axis with the splitting step specified in the dialog box **Window Manager**.

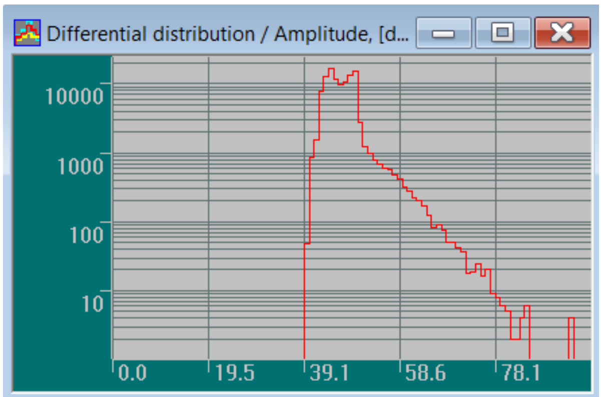


Fig. 10.19. Window **Differential distribution/Amplitude, [dB] (Total)**

10.7. Graph control

Zoom

For the convenience of reviewing the results obtained, the program has the functions **Zoom in** and **Zoom out**. To use this function, activate any data window. Then, using the left mouse button, select the area that needs to be examined in more detail, and use the main menu command **View – Zoom in**, or the button on **Toolbar**, which duplicates this command.

The program also allows another sequence of actions to zoom in on the graph. You can first use the main menu command **View – Zoom in**, or the button , and after to select the required area in the active window.

To return the graph to its original state, use the main menu command **View – Zoom out**, or the button that duplicates this command. Note that in this case, the ranges of the **X** and **Y** axes in the active window return to the state **Auto**.

The program has the ability to zoom in only on one of the axes. To do this, use the left mouse button to select the area. Then hold down either the **<Ctrl>** key (to zoom in on the **X** axis only) or the **<Shift>** key (to zoom in only on the axis **Y**) and at the same time use the main menu command **View – Zoom in** (or the button). After that, the graph is enlarged along one of the selected axes. When selecting the **View – Zoom out** command (or the button), the graph returns to its original range.

Scrolling

For the convenience of viewing time-dependent windows and moving the viewing area along the time axis, the program provides a scrolling function. To enable it, activate the switch **Scroll axis** and set the interval for viewing the time-dependent window in seconds in the dialog box **Axis Setup Dialog** described on page 136.

After that, a scroll bar appears at the bottom of the window with the selected width of the viewing area. Using the scroll bar, it is convenient to move the viewing area in the entire range. At the same time, its width remains unchanged, but the view window changes each time.

To simultaneously view data in all time-dependent windows, the program provides the synchronous scrolling function described below.

Synchronous scrolling

To simultaneously view and move the area of visibility along the time axis in all time-dependent windows, the program provides a synchronous scrolling mode for real-time windows and post-processing windows. To activate this mode, use the main menu command **View – Sync. Scrolling**. After that, moving the position of the scroller in one of the windows will lead to the simultaneous movement of the view areas for all windows that have the scroll mode enabled.

To apply scrolling to all time-dependent windows, use the **Apply to all** button in the **Range** group of the dialog window **Axis Setup Dialog**. If scrolling does not need to be applied to all windows with a time dependence, then it should be activated only in the required windows. If the need for synchronous scrolling in time-dependent windows disappears, then you should use the main menu command **View – Sync. Scrolling** again. After that, the scrolling function will be performed separately for each time-dependent window.

10.8. WDRI context menus

The context menu is called by pressing the right mouse button in the corresponding part of the window:

- ✧ in the graph display area;
- ✧ in the zones of the abscissa (X) or ordinate (Y) axes.

The context menu for the graph display area is shown in the figure:

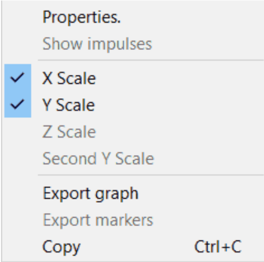


Fig. 10.20. Context menu for graph display area

Table 10.1.

Command	Action
Properties	Set window options
Show impulses	Invokes the synchronous view window with the parameters of the selected impulses
X Scale	Turns the X axis on and off
Y Scale	Turns the Y axis on and off
Z Scale	Turns the Z axis on and off
Second Y Scale	Turns the optional Y-axis on and off
Export graph	Converts the contents of the graphs to TXT or CSV formats
Export markers	Converts the contents of the markers to TXT or CSV formats
Copy <Ctrl + C>	Copies the selected graph to the Windows clipboard as a graphic

The context menus for the X, Y axis zones and the second Y scale are the same for all axes.

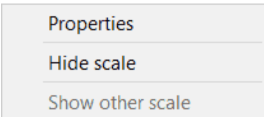


Fig. 10.21. Context menu for axes zone

Table 10.2.

Command	Action
Hide scale	Turns off the corresponding axis
Properties	Sets the axis parameters
Show other scale	Turns on another axis (in case the last one is disabled)

10.9. Setting up the WDRI workspace

To configure the workspace of windows, select the main menu command **Options – Current window** or right-click in the main field of the WDRI. Then, in the context menu that appears, select the command **Properties**. After that, the **Graph Setup** dialog box appears.

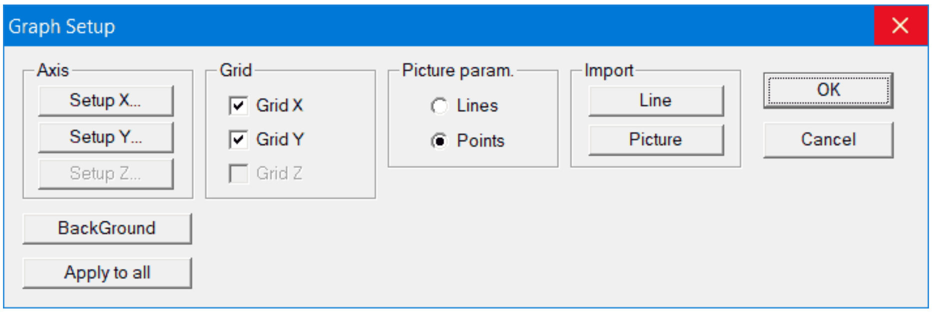


Fig. 10.22. Dialog box **Graph Setup**

This dialog box sets the window options:

- To set up the coordinate axes X and Y, press the buttons **Setup X** and **Setup Y**, respectively, in the group **Axis**. Axis configuration is described below in *"Setting the coordinate axes"* on page 136.
- To display the scale grid along the X and Y axes, turn on the switches **Grid X** and **Grid Y** in group **Grid**.
- To display line graphs, set the **Lines** radio button in the **Picture param.** group. To display graphs with points, set the **Points** radio button in the same group. Note that some windows have a single view type.
- To change the parameters of an additional line, click the **Line** button in the **Import** group. Setting up an additional line is described in the section *"Setting up an additional line"* on page 141.
- To change the parameters of imported graphics, click the **Picture** button in the **Import** group. Customizing imported graphics is described in *"Setting imported graphics"* on page 142.
- To change the background color of the selected WDRI, click the **Background** button in the **Color** group. The color is chosen using the standard **Color** dialog box. The selected background color can be set immediately in all windows by clicking the button **Apply to all**.

Features of location windows

Additional options appear in the **Graph Setup** dialog box for location windows.

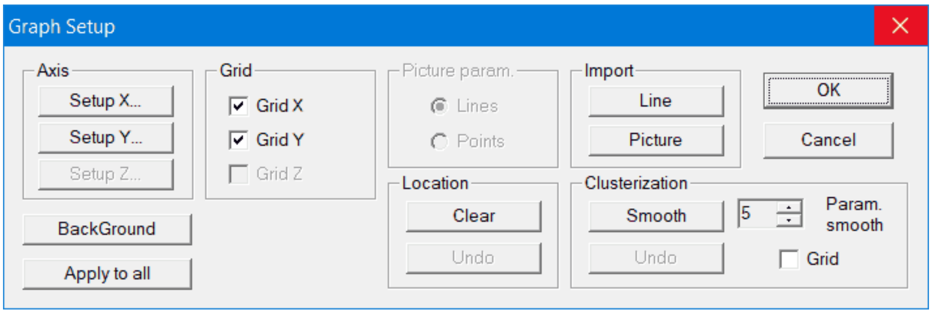


Fig. 10.23. Dialog box **Graph Setup**

- To clear the location window from the location results, click the **Clear** button in the **Location** group, to restore the location results click **Undo**.

  Note that local cleaning is possible both during data collection and during post-processing.
- To perform cluster smoothing in the windows **Location/Coordinate, mm** and **Location ampl., dB/Coordinate, mm** for linear and planar types of location, use the **Param. smooth** to set the number of clusters for smoothing and press the button **Smooth**. To return to the location picture, use the **Undo** button in the **Clusterization** group.

The smoothing procedure makes it possible to filter out location events randomly scattered over the location field and merge zones with a large number of events. To do this, use the color palette of the number of clustering events. Note that the smoothing procedure is not available when receiving data.

✧ To show the clustering grid in the windows of planar location types, turn on the **Grid** switch in the **Clusterization** group.

After changing the required settings, click the **OK** button. To cancel the changes made, click the button **Cancel**.

10.10. Setting the coordinate axes

To set up the X and Y coordinate axes, press the button **Setup X** or **Setup Y**, respectively, in dialog box **Graph Setup**, or right-click in the axes field. In the context menu that opens, select the command **Properties**. After that, the **Axis Setup Dialog** box appears.

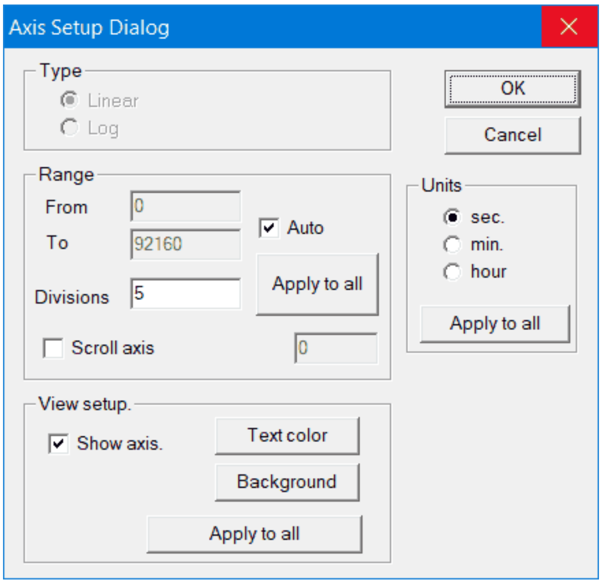


Fig. 10.24. **Axis Setup Dialog** box

In this dialog box, set up the settings for the coordinate axes.

◇ In the group **Type**.

- To select a linear type of scale along the Y axis, use the radio button **Linear**.
- To select a logarithmic scale type along the Y axis, activate the radio button **Log**.

Note that this group is not available for those WDRI where the results are already presented in the decibel scale, which is a variation of the logarithmic scale.

◇ In the group **Range**.

- For the selected axis, set the initial and final values of the parameter in the **From** and **To** input fields, respectively. To automatically select the range, use the switch **Auto**.
- Specify the number of divisions on the axis in the considered range in the input field **Divisions**.
- For the convenience of showing and moving the viewing area along the time axis, use the scrolling function by activating the switch **Scroll axis** and setting the interval for viewing the time-dependent window in seconds in the input field **s**.

  This switch is only available for the time axis (X scale). See on page 133.

- The **Apply to all** button is available for all time axes. Clicking this button allows you to set the specified values of the time range and apply scrolling in all windows that present the dependence of parameters on time.

◇ In the group **View Setup**:

- To change the background color of the axis, click the **Background** button. Select a color using the standard dialog **Color**.
- To change the color of parameter values, press the button **Text color**. Select a color using the standard dialog **Color**.
- The selected axis background color and the color of parameter values can be set at once in all WDRI by clicking the button **Apply to all**.
- To display the coordinate axis, turn on the **Show axis** switch. To remove the coordinate axis, this switch must be reset.

◇ In the group **Units** for some types of axes, you can change the way the parameter value is displayed.

- For time axes using radio buttons **sec**, **min**, **hour** select the unit of time used for displaying.
- For the Y-axis in the oscilloscope window using the radio buttons **ADC**, **μV**, **dB** select the amplitude unit.
- For the Y-axis in the oscilloscope window, it is possible to display the signal threshold level set for each channel. To do this, activate the switch **Show threshold**. To remove the graph of threshold values, this switch must be reset.
- For the Y-axis in the oscilloscope window, it is possible to display a marker that sets labels for each channel. To do this, activate the switch **Marker**. To remove the labels, this switch must be reset.
- Normalization procedure is available for histograms in post-processing mode. To do this, activate the **Axis Setup Dialog** dialog box (for the Y axis) and set the **Normalization** switch in it. The normalization results can be used for further comparative analysis of the form of distribution for each channel.

After setting the parameters, click the **OK** button. To cancel the changes made, click the button **Cancel**.

10.11. Window manager

In addition to the standard WDRI, the program allows you to create the following additional windows:

✧ an unlimited number of correlation windows showing the dependence of any parameter on any other;

✧ unlimited number of histogram windows displaying the distribution of any parameter;

✧ up to 50 registration windows of waveforms and spectra.

To create windows, select the main menu command **Window – Windows Manager**. After that, the **Windows manager** dialog box appears.

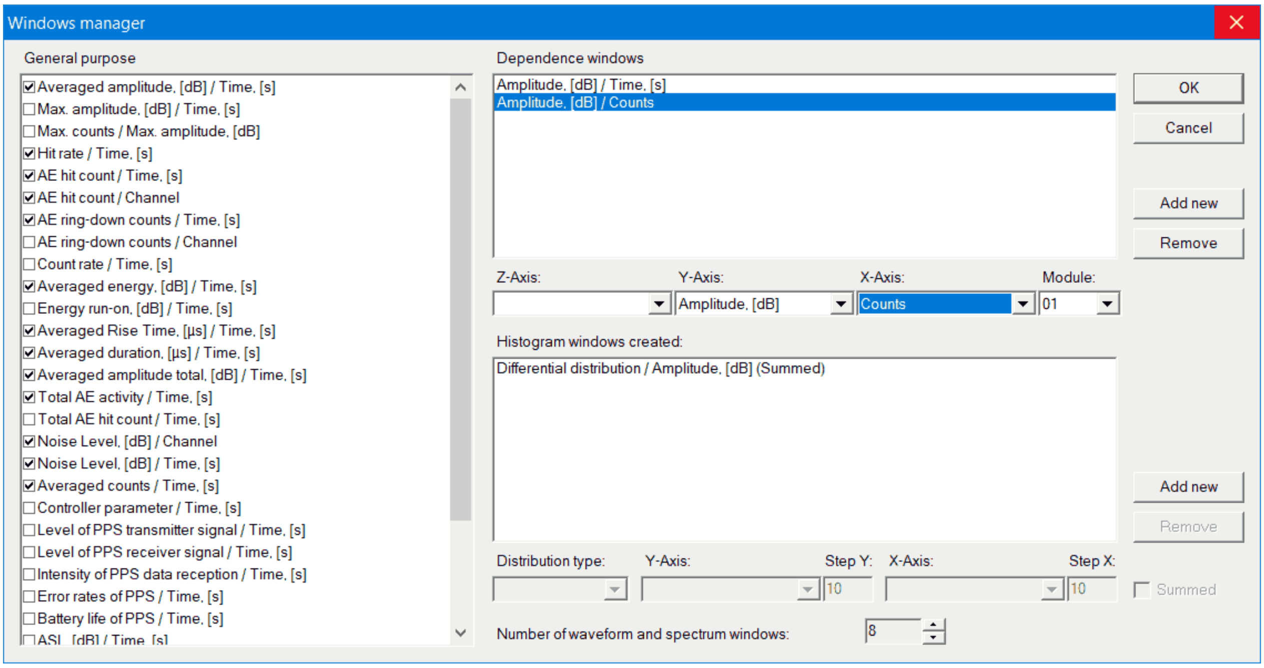


Fig. 10.25. Dialog box **Windows manager**

In this dialog box, select the main windows and set the options for additional windows:

◇ To create/delete an WDRI, activate/deactivate the corresponding switch in the **General purpose** list.

◇ To create an "any-on-any" correlation window, do the following:

- use the button **Add** in the group **Dependence windows**;
- in lists that have become available, in groups **Z-Axis**, **Y-Axis** and **X-Axis** select the required parameters (when setting parametric data (voltage, current), select the channel number in the list **Module**);

  setting a non-empty parameter along the Z axis allows you to build correlation dependencies for three parameters simultaneously. Such dependencies are displayed using OpenGL 3D graphics windows;

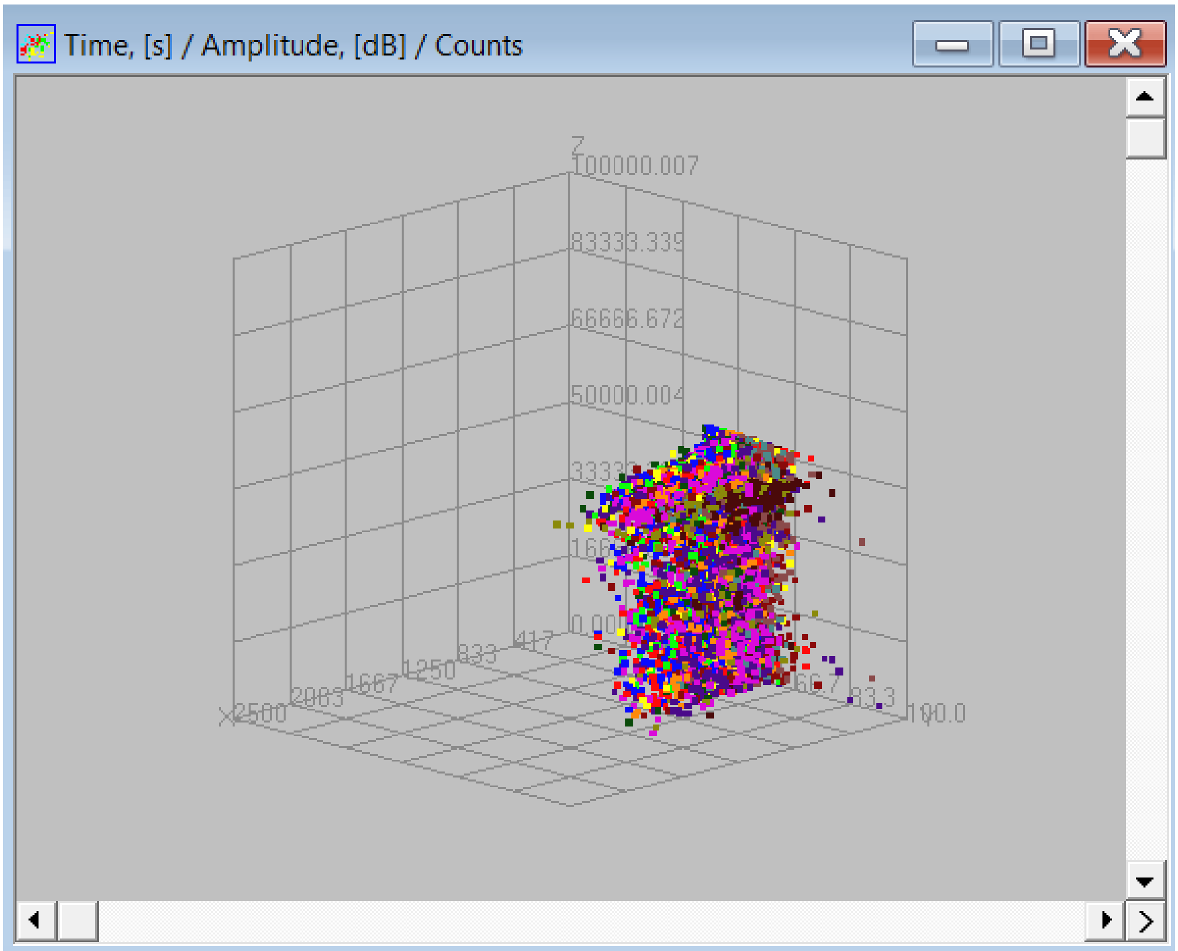


Fig. 10.26. **Correlation 3D-window**

- to remove created windows from the **Dependence windows** list, use the **Remove** button.

◇ To create a distribution window, do the following:

- use the button **Add new** in the group **Histogram windows created**;
- in lists that have become available, in groups **Distribution type**, **Y-Axis**, **X-Axis** select the required parameters, and in the input field in the **Step** group, specify the split interval value;
- to get the total distribution for all channels, activate the switch **Summed**;
- to delete the created histogram windows from the list **Histogram windows created** use the **Remove** button;

◇ Set the number of waveform and spectrum windows using the **Number of waveform and spectrum windows** spinner (the number of windows can vary from 0 to 49).

After setting the parameters for new windows, click the **OK** button, after which new windows will be created. To cancel the changes made, click the button **Cancel**.

⚠ In the case of a large data stream or a large file being processed, you should avoid opening an unreasonably large number of additional windows, especially for systems with older computing hardware.

10.12. Page manager

The program provides the ability to arrange WDRI on several pages and perform actions with them (delete, add, rename). The number of pages is unlimited. To call the page management dialog for displaying program windows, select the command **Window – Page Manager** in the main menu, after which the dialog box **Page Manager** appears.

In the right list of windows available for placement on display pages, the line with the window name in square brackets indicates the names of the pages on which the specified window is currently located. If there is no information in square brackets after the window name, then the specified window is not located on any of the display pages. In addition, for windows of the "Waveform" and "Spectral power" types, before the list of display pages in square brackets, the list of AE channels is similarly displayed, the waveforms and spectra of which are displayed in the specified window. If such a list is empty, it means that the settings are made in such a way that no information will be displayed in this window.

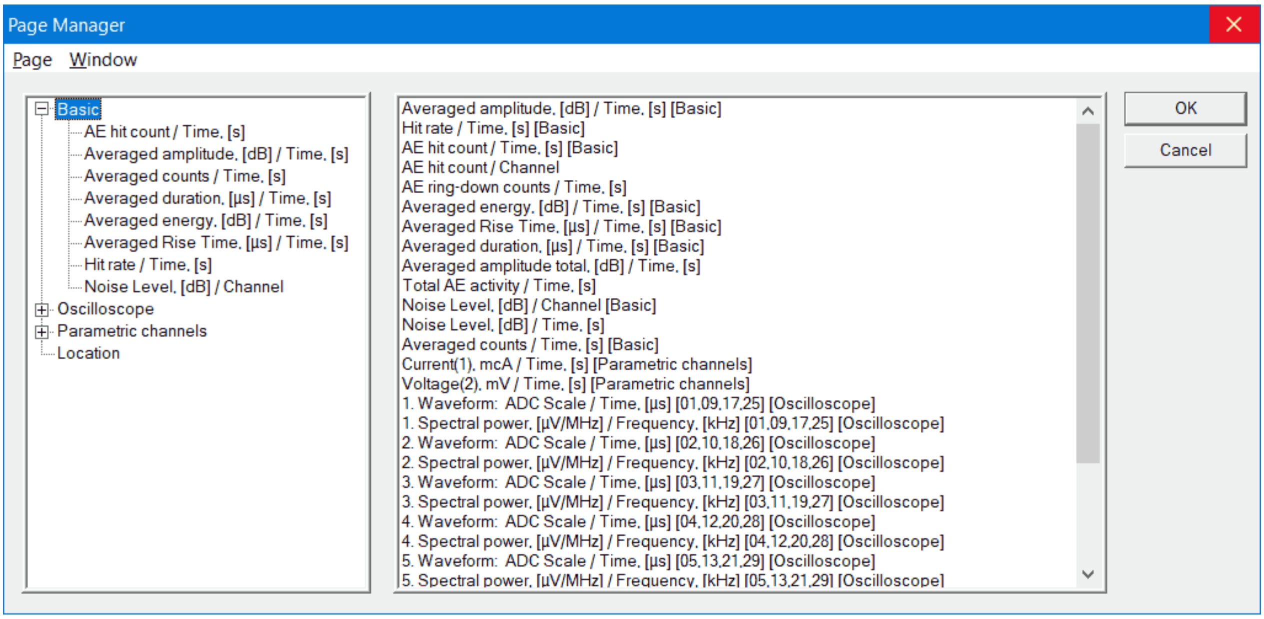


Fig. 10.27. Dialog box **Page Manager**

In this window, when working with pages, the following options are available:

- ✧ Create a new page — menu command **Page – Add new**, then enter a new page name and press the **OK** button.
- ✧ Remove page — select the page name in the list of pages (using the mouse or the **<Shift>** key), then use the menu command **Page – Remove**.
- ✧ Rename page — select the name of the page in the list of pages (using the mouse or the **<Shift>** key), then use the menu command **Page – Rename** and enter a new page name.
- ✧ Remove all windows from the selected page — highlight the page name in the list of pages (using the mouse or the **<Shift>** key), then use the menu command **Page – Clear**.
- ✧ Adding all WDRI from the right list to the selected page — select the page name in the page list (using the mouse or the **<Shift>** key), and then use the menu command **Page – Refill**.
- ✧ Adding one or more WDRI to the selected page — highlight the page name in the list of pages (using the mouse or the **<Shift>** key), select the WDRI in the right window list; then use the menu command **Window – Add to page**.

You can also add an WDRI to a selected page using the mouse. To do this, move the mouse cursor and double-click on the name of the required WDRI in the right field of the dialog box. Note that the program does not allow adding two identical windows to one page.

✧ Removing the WDRI from the selected page — highlight the page name in the list of pages (using the mouse or the **<Shift>** key), select the WDRI in the left list of the window; then use the menu command **Window – Remove from page**.

You can also remove the WDRI from the selected page using the mouse. To do this, move the mouse cursor and double-click with the left button on the name of the required WDRI in the left field of the dialog box.

After creating the necessary pages filled with the corresponding WDRI, use the **OK** button, otherwise use the **Cancel** button.

10.13. Additional lines and graphics overlay

Setting up an additional line

To set up an additional line, click the **Line** button in the **Import** group of the **Graph Setup** dialog box. After that, the **Import line from a file or parameter** dialog box appears.

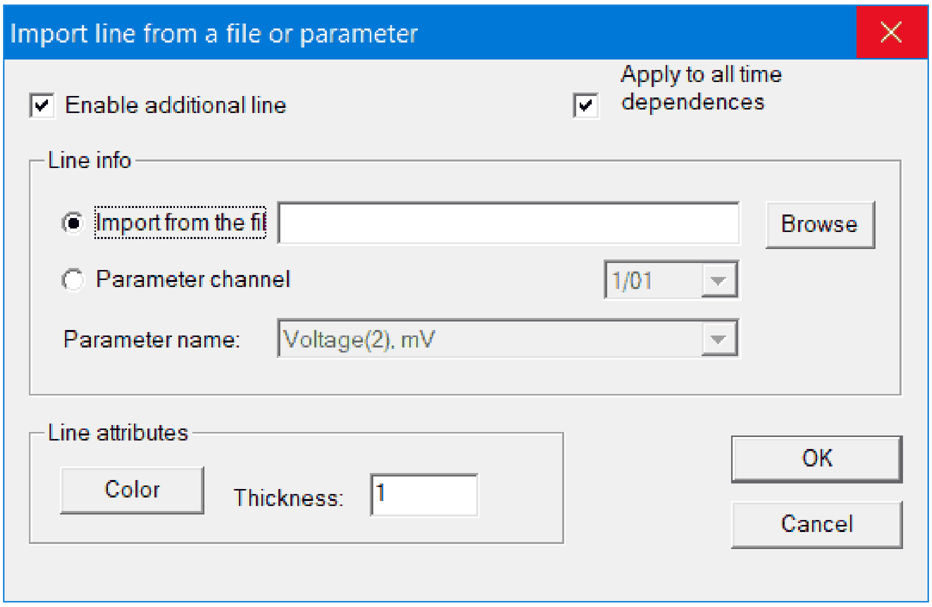


Fig. 10.28. Dialog box **Import line from a file or parameter**

In this dialog box, set the settings for the additional line:

◇ To overlay an additional line, activate the switch **Enable additional line**.

◇ In the **Line info** group, select the data source for the additional line.

- To use data from a file, enable the radio button **Import from the file**. Then specify the file name in the input field or click the **Browse** button and select the desired file using the standard dialog box **Open file**.

  When overlaying a line from a file, you can specify its name by entering a string in the load file that begins with the character "**!**" followed by the name of the parameter.

- To use data from parametric inputs, turn on the radio button **Parameter channel** and select the input number from the corresponding list. The name of the given parametric input will be used as the name of the parameter.

Note that when superimposing a line from a parametric input on any time-dependent WDRI, the name of this parameter will be displayed in the title of this window as follows: **"Y axis name"/"Y2 axis name"/"Name X-axis"**.

◇ In the **Line attributes** group, set the line display parameters.

- To change the line color, press the **Color** button. After that, select the required color using the standard dialog **Color**.
- Specify the line thickness in the input field **Thickness**.

◇ If, when creating an additional line in the WDRI, in which time is selected along the X axis, turn on the switch **Apply to all time dependences**, then the settings of the additional lines will be applied to all time-dependent windows.

After setting the desired parameters, click the **OK** button. To cancel the changes made, click the button **Cancel**.

Setting imported graphics

To configure the imported graphics, click the **Picture** button in the **Import** group of the **Graph Setup** dialog box. After that, the **Import picture setting** dialog box appears.

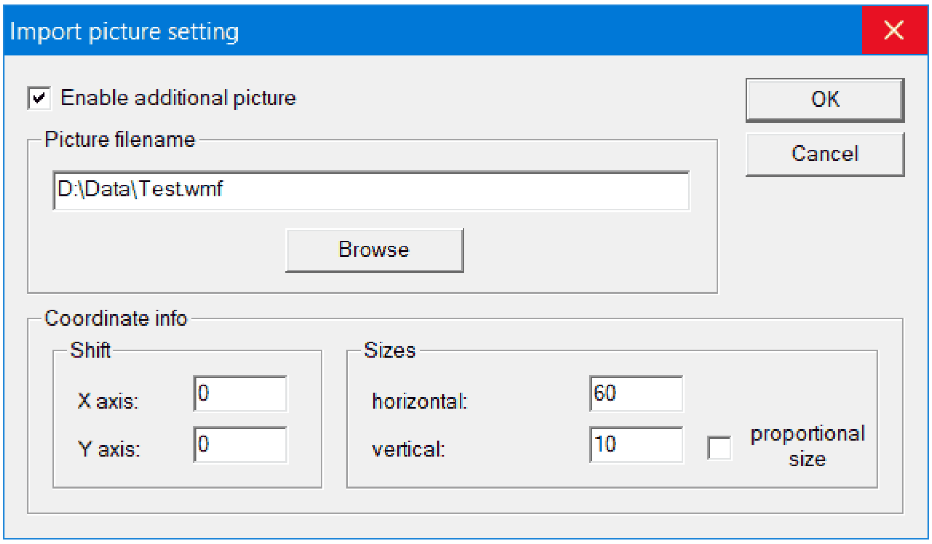


Fig. 10.29. Dialog box **Import picture setting**

In this dialog box, set the settings for imported graphics:

◇ To overlay imported graphics, activate the switch **Enable additional picture**.

◇ In the group **Picture filename** in the input field enter the file name or click the **Browse** button and select the desired file using the standard dialog box **Open file**.

◇ In the **Coordinate info** group, set the displaying options for imported graphics.

- In the group **Shift** in the input fields **X axis** and **Y axis** enter the coordinates of the point where you want to place the graphic image.
- In the group **Sizes** in the input fields **horizontal** and **Vertical** specify the dimensions of the image.
- To automatically select the vertical size with a fixed horizontal size, proportional to the size in the source graphic file, turn on the switch **proportional size**.

After setting the desired parameters, click the **OK** button. To cancel the changes made, click the button **Cancel**.

Creating a load line

To create and superimpose a load line on all time-dependent windows, except for parametric ones, select the command **Window – Additional lines** in the main menu. After that, the **Additional lines** dialog box appears.

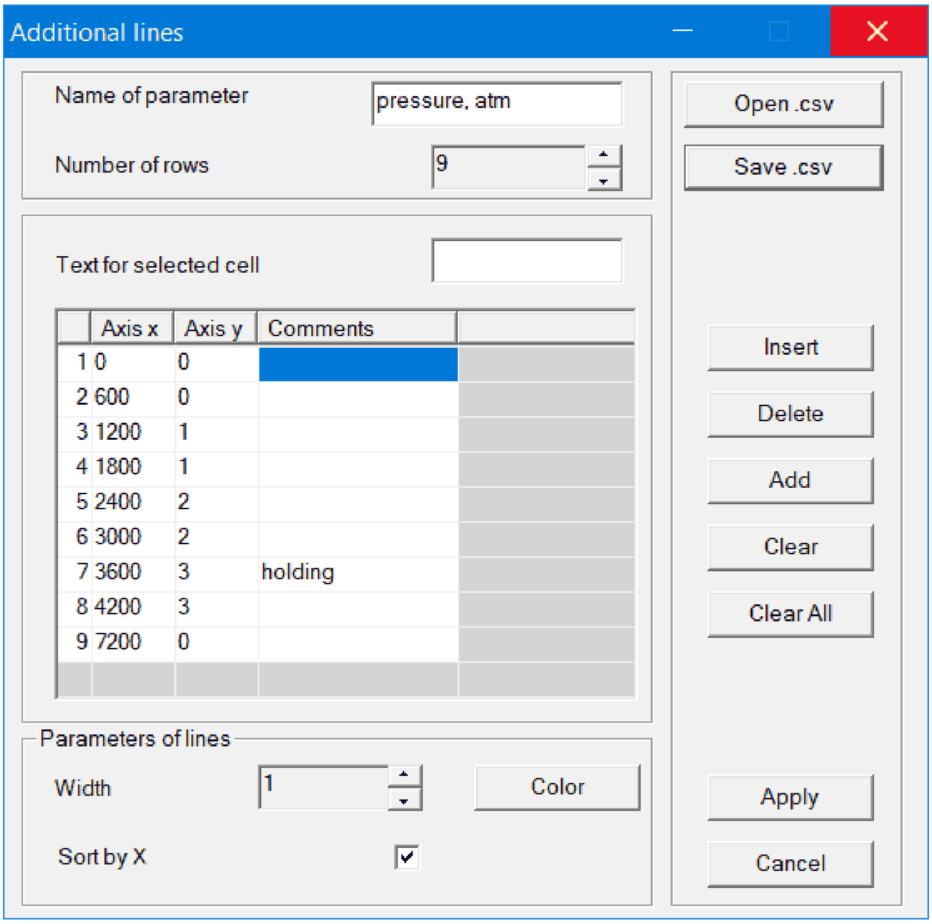


Fig. 10.30. Dialog box **Additional lines**

In this window, when creating an additional line, the following options are available:

◇ Specifying a table of any size for data entry.
- Set the number of rows for data entry using the rotary **Number of rows**.
- To insert an additional line before the selected line, use the button **Insert**.
- To delete the selected data (the entire line/lines are deleted), use the button **Delete**.
- To add a line at the end of the table, use the button **Add**.

◇ Enter additional line values.
- Enter the values of the load line along the X and Y axes, as well as the necessary comments in the appropriate cells of the table.

  To enter data, move the mouse cursor to the corresponding cell, activate it and enter the parameter value in the input field **Text for sellected cell**.
- To delete data from the selected cell(s), use the **Clear** button.
- To remove all data from the table and corresponding graphs, use the button **Clear All**.

◇ Setting the parameters of the additional line.
- Enter parameter name (pressure, temperature, etc.) in the input field **Name of parameter**.

- Specify the thickness of the overlay line using the **Width** spinner in the **Parameters of lines** group.
- Select the color of the line using the standard **Color** dialog box, after pressing the **Color** button.
- To sort points by time, activate the switch **Sort by X**.

◇ To load an additional line from a text file, use the button **Open .csv**. Next, in the standard **Open file** dialog box, select the required file.

◇ To save the entered data, click the **Save .csv** button. Then, in the standard dialog box **Save as**, specify the name and type (TXT or NAG for text format, CSV for spreadsheet format) of file in which the load line parameters will be saved.

After setting the parameters, click the **Apply** button. The load line will be displayed on all graphs depending on time. When you click the **Close** button, all entered data will remain in the dialog box.

Recommendations for creating a welded seam map

To create a welded seam map and overlay it on the location window, do the following:

✧ open the location file, select the desired location window and "stretch" it to fit the screen;

✧ copy the screen image to the clipboard (button **Print Screen**);

✧ invoke some vector graphics editor (for example, *CorelDraw* or *Visio*);

✧ create a new drawing in a graphics editor;

✧ insert the image of the location window into it (command **Edit – Paste**);

✧ draw a rectangle along the border of the WDRI (without a field of axes) and a seam map on the location object;

✧ delete the location window image (activate the location window image and press the **<Del>** button), after which a rectangle should remain in which the welded seam map will be drawn;

✧ export this drawing as **Windows metafile** (files with **.wmf** extension) or **Enhanced Metafile** (files with **.emf** extension);

✧ return to the "A-Line" program in the location window and overlay the file with the image of the seam map obtained in the graphics editor (command **Options – Current window**).

✶ ✶ ✶

Chapter 11. Location

✻ Chapter *“Location”* is all about the location.

11.1. Introduction

To conduct the location of AE sources, the program provides a special location function. Depending on the object, the following types of locations can be used:

- linear location;
- plane location;
- cylinder location;
- cone location;
- sphere location;
- bottom location;
- 3D location;
- zonary location;
- vertical steel tank wall location.

It should be noted that different types of location can be used simultaneously.

11.2. Measurement of AE wave velocity and sensor distance

Measurement of the AE wave velocity

To correctly locate a defect, it is necessary to know the effective propagation velocity of AE waves in the testing object. The program provides automatic measurement of this velocity. To do this, select the main menu command **Location – New Velocity**. After that, the **Velocity/ distance measurement scheme** dialog box opens.

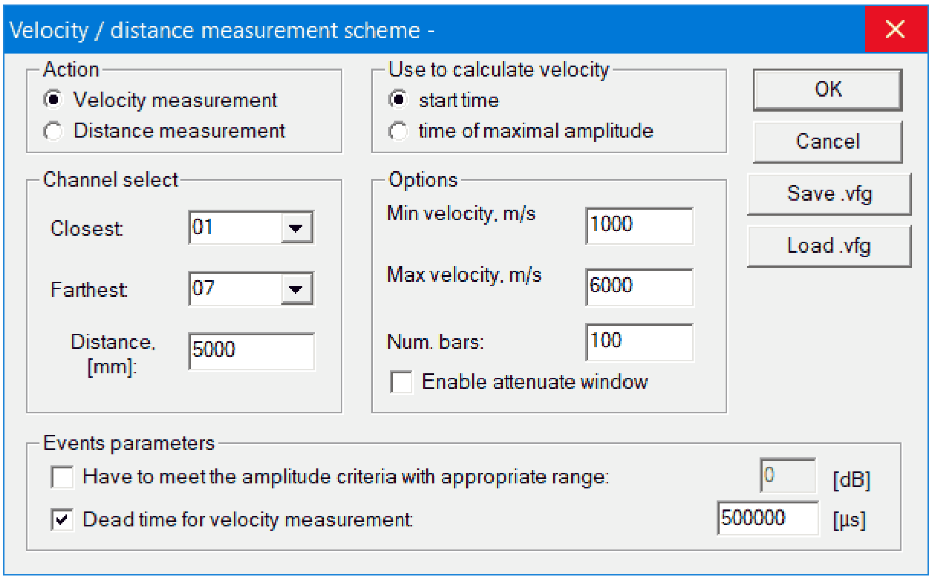


Fig. 11.1. Dialog box **Velocity/distance measurement scheme**

In this dialog box, activate the radio button **Velocity measurement** in the group **Action**. Then set the parameters required for automatic velocity measurement.

◇ In the group **Channel select**:

- select numbers of sensors involved in measuring the velocity from the lists **Closest** (for the closest sensor to the AE simulator) and **Farthest** (for remote sensor);
- specify distance between sensors in the input field **Distance, [mm]**.

◇ In the group **Options**:

- enter the range of permissible velocities in the input fields **Min velocity, m/s** and **Max velocity, m/s**;
- specify the number of bars on the histogram of measured velocities in the input field **Num bars**;
- Enable the **Create attenuate window** switch to create a window for evaluating the attenuation factor.

◇ In the group **Use to calculate velocity** select the calculation method:

- by the time of the first signal crossing the threshold level — activate the radio button **start time**
- by the time of reaching the maximal amplitude of the signal — activate the radio button **time of maximal amplitude**.

The radio button **start time** is set by default in the program.

◇ In the group **Events parameters**, if necessary, additional criteria are set for automatic selection of pairs of impulses selected for velocity and attenuation calculations.

- *Amplitude criteria*.

  To apply this criterion, in which the amplitude of the signal (in dB) arriving at the closest sensor must not be less than the signal amplitude at the farthest sensor, turn on the switch **Have to meet the amplitude criteria with appropriate range** and enter the allowable impulse amplitude residual in dB. The traditional operation of the criterion corresponds to the value of the residual dA = 0. When setting the dA > 0 value, impulses will be rejected if the impulse amplitude at the farthest sensor exceeds the corresponding value at the clothest sensor by a value greater than dA (the criterion condition will be softer). In the case of dA < 0, impulses will be rejected, in which the impulse amplitude at the farthest sensor is less than the corresponding value at the closest sensor by a value less than dA (the criterion condition will be more stringent).

- *Dead time criterion*.

  To apply this criterion, which will not analyze AE impulses received earlier than the interval of the set dead time expires after the arrival of the previous test impulse accepted for analysis, turn on the switch **Dead time for velocity measurement**. Then enter the dead time value in the input field **[μs]**.

To create a window for measurement the velocity of propagation of AE waves, press the button **OK**, after which the window **Velocity Measurement Histogram N/Velocity (m/s)**. To cancel, select the button **Cancel**.

> ✍ After creating the velocity measurement window, you should conduct an experiment with simulating AE impulses.

Measurement the distance between sensors

To measure the distance between the sensors, it is necessary to repeat the procedure for calling the **Velocity/distance measurement scheme** dialog box. Then, in the dialog box that opens, activate the radio button **Distance measurement** in the group **Action** and set the parameters for measurement the distance between the sensors. Note that most of the parameters will be the same as when measuring the velocity.

◇ In the group **Channel select**:

- numbers of sensors involved in measuring the distance between sensors are selected in the same way as when measuring the velocity;
- specify the effective velocity in the input field **Velocity, m/s**.

◇ In the group **Options**:

- Enter the range of allowable distances in the input fields **Min distance, [mm]** and **Max distance, [mm]**;
- specify the number of bars on the distance distribution histogram in the input field **Num bars**.

◇ In the group **Use to calculate velocity/distance**, the calculation method is selected in the same way as when measuring the velocity.

◇ In the **Events parameters** group, additional criteria are selected in the same way as when measuring the velocity.

To create a window for measuring the distance between sensors, press the **OK** button, after which the window **Distance Measurement Mistogram N/Distance (mm)** will be created. To cancel, select the button **Cancel**.

> ✍ After creating the distance measurement window, you should conduct an experiment with simulating AE impulses.

Actions with the sensor scheme

If the parameters entered in the dialog box **Velocity/distance measurement scheme** are required in the future, they can be saved by clicking the **Save .vfg** button. Then a standard dialog box **Save as** will appear, where you must specify the name of the file with the **.vfg** extension, in which the settings will be saved, and click the **Save**.

To load velocity/distance measurement settings files, use the **Load .vfg** button and select the required file in the dialog box **Open**.

If you need to re-measure velocity with a previously saved sensor scheme, use the main menu command **Location – Open velocity**. Next, in the standard **Open file** dialog box, select the file containing the required scheme and click the **Open** button.

To correct the sensor scheme, select the main menu command **Location – Edit current velocity**. Then, in the opened **Velocity/distance measurement scheme** dialog box, change the required parameters.

You can close the velocity measurement window by selecting **Location – Close current velocity** command in the main menu.

11.3. Location groups settings

To set up location groups, select **Location – New location** command in the main menu. Then the **Location scheme settings** dialog box appears.

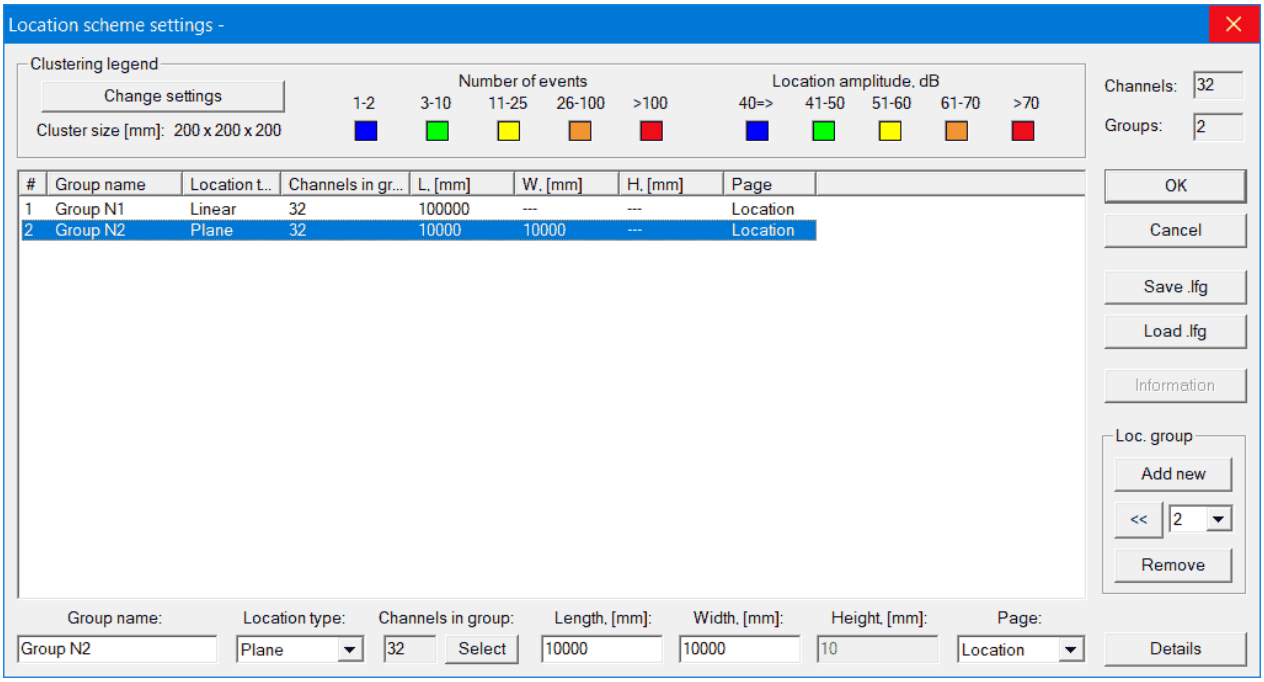


Fig. 11.2. Dialog box **Location scheme settings**

This dialog box sets the parameters of location groups and contains commands for managing them.

- ◇ The dialog box contains a list of location groups. For each group, its parameters are indicated: number, group name, location type, number of channels used, size of the location area (length, diameter, height, depending on the type of location), displaying page.
- ◇ There are controls for viewing and changing the parameters of the selected location group in the list.

- Enter the name of the group in the input field **Group name**.
- Select the type of location from the list **Location type**. The following location types are available:
  - **Linear**;
  - **Plane**;
  - **Cylinder**;
  - **Sphere**;
  - **Bottom**;
  - **3Dim**;
  - **Zonary**;
  - **Picture**;
  - **Cone**;
  - **RVS-wall**.
- Select numbers of sensors included in this group, and the shape of the location zone, triangular or quadrangular (for all types of planar location) by pressing the button **Select**. The choice of sensors included in the location group and the shape of the location area are described below in the sections on different types of location. After the selection is completed, control will return to the **Location scheme settings** dialog box. The number of sensors included in this group will be indicated in the field **Channels in group**, to the left of the button **Select**.
- Enter the location area size in the input fields **Length, [mm]**; **Width, [mm]**; **Height, [mm]**; **Diameter, [mm]**; **Perimeter, [mm]**. Features of the geometry of different types of locations are described in the sections on the corresponding types of locations.
- Select the page for displaying the location group in the **Page** list, which contains all the pages available in the current configuration.
- Set up the sensor installation by pressing the button **Details**. Further, depending on the selected location scheme, one of the dialog boxes for setting the location scheme parameters opens. Working with these windows is described in the section *“Configuring the sensor installation”* on page 150. Features of setting the scheme parameters for different types of locations are described in the sections on the corresponding types of locations.

◇ The following commands are available for working with the list of location groups:

- To create a new location group, click the **Add new** button in the **Loc. group** group, after which the list will show the number 1 (location group number), and in the field of the dialog box, a string with the default parameters of the new group.
- To copy a location group, select it in the dialog box and click the << button, or select the group number in the list and click the button <<.
- To remove a location group, select it in the dialog box and use the **Remove** button.
- To load location files, click the button **Load .lfg** and in the opened dialog box **Open file** select required location file (*.lfg extension).
- To save a location group (or a list of location groups), select it in the location field, activate the button **Save .lfg**, then in the dialog box that opens **Save as** specify the path and name of the file where the location group (or list of location groups) will be saved.

◇ The total number of available location groups, which may change during the setup process, is shown in the **Groups** field, the number of available channels is shown in the **Channels** field.

◇ In the group **Clustering legend** there is a color palette used to display the number of located events and the location amplitude on the testing area of the surface, divided into conditional rectangles of a given size, or volume divided into conditional parallelepipeds of a given size. To change the clustering settings, click the **Change settings** button in this group. This operation is described in more detail in the section *“Clustering”* on page 183.

Next, click the **OK** button in the **Location scheme settings** window. After that, a check is made for the correspondence between the cluster sizes and the corresponding sizes of the location groups. For linear, planar and volumetric types of location, the correspondence of lengths, widths and heights is direct. For the vessel, sphere and bottom, the conformity check is carried out according to the net (projection). If the number of clusters per corresponding location group size is less than five, then a request is made to ignore this situation. When you select the **No** button, the **Clusterization settings** dialog box appears, in which you need to change the cluster size. After that, new location windows are created for each location group. When you select the **Yes** button, new location windows for each location group are created immediately, with any correspondence between the cluster size and the size of the location group.

To cancel the changes made in the **Location scheme settings** dialog box, click the **Cancel** button.

Additional features

After setting all the parameters of the location groups, you can click the **Save** button to save the entered parameters. This opens a standard dialog box **Save as**, where you must specify the name of the file in which the settings of the location groups will be saved and click the button **Save**.

If the settings of location groups have been previously saved, they can be loaded using the main menu command **Location – Open location**, or by pressing the button **Load Loc Cfg**. After that, in the standard **Open file** dialog box, select the required file and click the **Open** button. Then the window **Location scheme settings** will appear, showing the settings contained in the file. In case of an incorrectly selected file, press the button **Cancel**, to accept the proposed scheme press the button **OK**.

To make changes to the current settings of location groups, use the main menu command **Location – Edit current location**. After that, in the dialog box **Location scheme settings**, you can make the necessary changes to the parameters of the location groups, add new or delete existing location groups.

To clear location windows from location results, you can use the main menu command **Location – Clear Locations**, or use the button to **Toolbar**. To restore location windows, use the main menu command **Location—Restore Locations**, or press the button on **Toolbar**. Also, the procedure for cleaning and restoring location windows is possible through the context menu **Properties**.

11.4. Configuring the sensor installation

Setting up the sensor installation scheme consists in setting the coordinates of the sensors used in the location, setting the parameters and forming the location zones.

◇ Setting up the sensor installation scheme starts with specifying the coordinates of the sensors in the corresponding dialog boxes for setting the location schemes. Sensor coordinates can be specified either relative to reference points, such as the origin, or relative to the position of other sensors. This operation is described in more detail in the section *“Setting sensor coordinates”* .

◇ In the **Optional constants** group, set additional options.

- Velocity of propagation, enter in the input field **Velocity [m/sec]**.
- Specify the sensor image size on the graphs in the input field **Image diameter**.
- For linear location, in the **Number of columns** list, select the method for setting the size and number of columns (number of columns, width as a percentage of the length of the plot shown on the diagram, width as a percentage average distance between AE sensors or width in mm).
- For planar location schemes, in the input field **Local region** specify the size of the location area around the sensors. When you exit the dialog boxes for setting the parameters of the location scheme, a check is made for the sufficiency of the "local region". AE sources found outside this zone are filtered out.
- For a zone location scheme, set the number of AE impulses in a pack using the **Minimum number of events in pack** spinner. Note that the minimum number of impulses in a pack is two.

◇ For all planar location types (plane location, vessel location, sphere location, bottom location, vertical steel tank wall location) in the group **Location zones** the button **Edit Zones**, which allows you to distribute sensors by zones. It should be noted that the program can automatically divide the area into triangular or quadrangular zones according to the coordinates of the sensors specified in advance. In this case, the zones are formed from sensors with different numbers in such a way that they intersect each other and are non-degenerate (i.e., the area of a triangle or quadrilateral is non-zero). This operation is described in more detail below in the section *“Distribution of sensors by zones”* on page 153.

◇ To use additional location options, click the **Advanced** button. After that, the dialog box **Advanced location options** will open. Working with this window is described in the section *“Advanced location options”* on page 172.

◇ To filter by location, click the **Filter** button. After that, the dialog box **Location filter dialog** will open, in which you need to set the filtering parameters. Working with this window is described in the section *“Filtering by location”* on page 176.

After setting the sensor installation scheme, press the **OK** button, after which control will return to the **Location scheme settings** dialog box.

11.5. Setting sensor coordinates

In the previous section, it was noted that coordinates can be set either relative to reference points or relative to other sensors. The following reference points are available for different location types:

✧ for linear location: origin, left side, right side;

✧ for planar location: origin, LeftBotCorn, LeftTopCorn, RightTopCorn, RightBotCorn;

✧ for locating cylindrical vessels: origin;

✧ for locating a spherical vessels: no;

✧ for bottom location: bottom, 3 hours;
✧ for 3D location: none;
✧ for zone location: no coordinates are set;
✧ to locate the vertical steel tank wall: origin.

Start setting up the sensor installation by specifying the coordinates of the sensors. The positions of reference points are discussed in the corresponding sections of the location.

◇ To set the coordinates of sensors, perform the following actions in the group **Manual setup** (or in the group **Three-Dimentional details setup dialog** in case of 3D location):
  - select the sensor number in the list **Channels**;
  - select the origin of the sensor position (relative to the origin of coordinates, or relative to another sensor) in the list **Relatively**;
  - set the sensor offset relative to the selected origin in the input fields **Shift along X[mm]**, **Shift along Y[mm]** and **Shift along Z[mm]**;
  - click **Apply**.

  It should be noted that in the group **Coordinates** in the fields **X[mm]**, **Y[mm]** will indicate the absolute value of the coordinates, relative to the origin. Also note that not all location types use both coordinates (for example, only one coordinate is used for linear location).

◇ You can set the coordinates of the sensors using the mouse.

  In addition to directly entering sensor coordinates using the keyboard, you can also set sensor coordinates using the mouse. To do this, click the mouse button on the sensor image and, holding it, move the sensor image to the desired position. A similar operation must be repeated for each sensor. In this case, the channel number and sensor coordinate are displayed in the **Coordinates** group, as well as in the **Manual Setup** group.

  Note that in the case of 3D location, it is not possible to set the coordinates of the sensors using the mouse. With zone location, the coordinates of the sensors are not set at all.

The program also provides the ability to automate the process of setting coordinates.

◇ To form a location scheme in the case of linear location (as well as for other types of location), it is convenient to use the following method for specifying sensor coordinates:
  - in the **Manual setup** group, activate the switch **Auto**;
  - in the **Channels** list, select the channel number **1/01**;
  - in the list **Relatively** select **Origin**;
  - in the input field **Shift along X[mm]** (if necessary, also set the offset value in the input fields **Shift along Y[mm]** and **Shift along Z[mm]**) set the amount of offset along the X axis for the position **1/01** of the sensor;
  - click **Apply**;
  - in the list **Channels** and **Relatively** select the following channels (**1/02** and **1/01**, respectively);
  - set the position of the **1/02** sensor relative to **1/01**;
  - click the button **Apply**.

    In the lists **Channels** and **Relatively**, the channel numbers are automatically incremented.

  Set the coordinates of the remaining sensors in the same way.

◇ When generating a location scheme for any type of location, you can import the coordinates of the AE sensors from a text file or a spreadsheet file:

- in the group **Manual setup** click the button **Import**;
- in the **Open file** dialog box that opens select a text file (extension *.txt) or a spreadsheet file (extension *.txt);
- in the **Manual setup** group, click the **Apply** button.

◇ To correct the distance between sensors in an already generated scheme, do the following:

- in the lists **Channels** and **Relatively** select the required channel numbers;
- after that, in the field **Shift along X[mm]** (or **Shift along Y[mm]** and **Shift along Z[mm]**) the required value will appear.

◇ To shift the origin, press the **Shift** button in the **Coordinates** group. After that, the dialog box **Coordinate origin shift** appears.

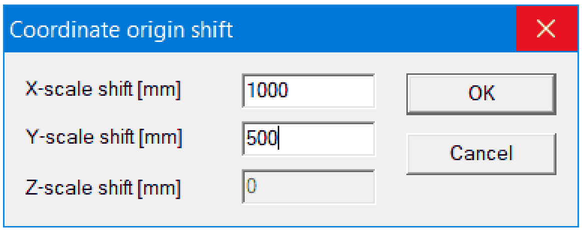


Fig. 11.3. Dialog box **Coordinate origin shift**

Shifting the origin of coordinates is possible for all types of location, except for the location of the bottom, volumetric and zone locations.

Set the shift value in the input field **X-scale shift, mm** (if necessary, also set the corresponding shifts in the input fields **Y-scale shift, mm** and **Z-scale shift, mm**).

To set the shift, press the **OK** button. To cancel the changes, press the button **Cancel**.

11.6. Distribution of sensors by zones

To distribute sensors by location zones in the dialog boxes for setting parameters of planar location schemes, click the button **Edit Zones**. After that, it becomes possible to change the distribution of sensors by zones.

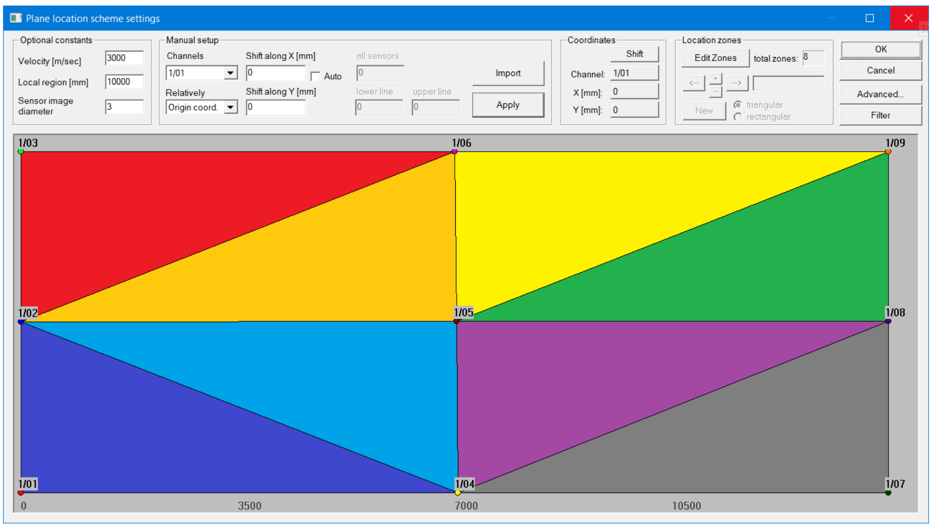


Fig. 11.4. Dialog box **Plane location scheme settings** in the mode of setting location zones

◇ To select a zone, use the buttons <- and -> in the group **Location zones**. The selected zone is outlined in white.

◇ To add a zone, click the + button in the **Location zones** group.

After pressing the + button, the **Adding or deleting location zones** dialog box appears.

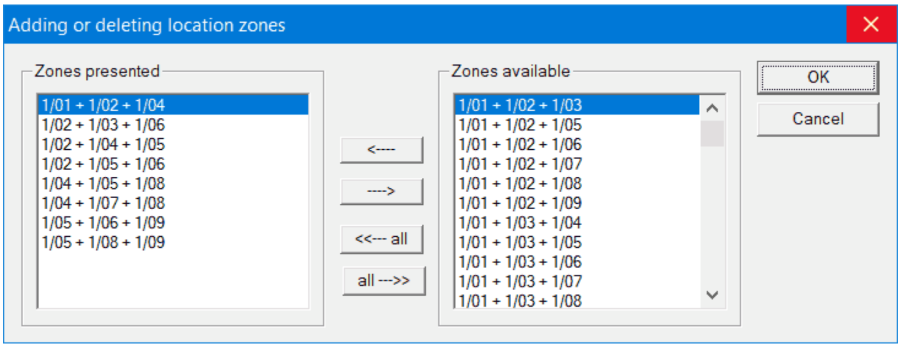


Fig. 11.5. Dialog box **Adding or deleting location zones**

In this dialog box, you can add or remove location zones formed by triples or quadruples of AE sensors. The list **Zones presented** lists existing zones, while the list **Zones available** shows zones that can be added. To move a zone from one list to another, you have the following options:

- double-click on the required zone in the corresponding list;
- mark the required zone with a single click of the mouse button and press the button <---- or ---->;
- To simultaneously create or delete all existing and valid zones, click the <<-- all or all -->> button.

After completing the setting of location zones in the **Adding or deleting location zones** dialog box, click the **OK** button. To cancel the changes press the button **Cancel**.

◇ To delete the selected zone, click the -- button in the **Location zones** group.

◇ Changes to the configuration of the selected zone can be made either arbitrarily with the mouse, or automatically when changing the type of location antenna (triangular or quadrangular).

- To freely change the zone setting using the mouse, do the following: turn off the button **Edit Zones**; move the cursor to the top of the zone and, holding it, move the cursor to the new top and only then depress the mouse button; then press the buttons **Edit Zones** and **New** in the group **Location zones**. After that, a new division of the location scheme into zones will occur, taking into account the selected type of antenna.
- When changing the type of antenna by switches **Triangular** and **Quadragonal** re-zoning is done automatically.

After all zones are correctly set, press the **OK** key. Then the mode of dialog boxes for setting the parameters of planar schemes of location returns to the mode of specifying the coordinates of the sensors.

11.7. Linear location

When using the linear type of location, the testing area is characterized by one size (length). This type of location is used, as a rule, when testing extended objects (when one of the dimensions is much larger than the others), such as pipelines, beams, structural elements of cranes, bridges, etc.

Including sensors in a location group

To include sensors in a location group, press the **Select** button in the **Location scheme settings** dialog box. After that, the **Including or excluding sensors from group** dialog box appears.

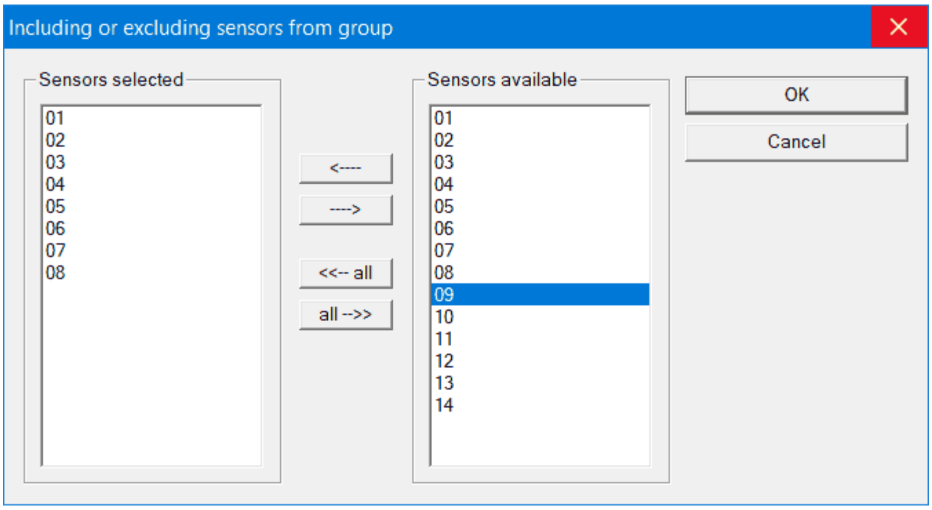


Fig. 11.6. Dialog box **Including or excluding sensors from group**

In this dialog box, you can add or reduce the number of sensors included in the location group.

◇ The following options are available for including a sensor in a group:
  - double-click on the required sensor number in the list **Sensors available**;
  - mark the desired channel number with a single click of the mouse button and click the button `<----`;
  - you can use the mouse in combination with the **<Ctrl>** and **<Shift>** keys to select multiple channel numbers.

◇ To remove a sensor from a group, perform the same actions in the **Sensors selected** list using the `---->` button.

◇ To simultaneously include or remove all available sensors in a group, click the button `<<-- all` or `all -->>`.

After completing the channel selection, press the **OK** button, to cancel the selection, use the **Cancel** button. To select sensors for other types of location, the **Select channels** dialog box is used, similar to the **Including or Excluding Sensors from group** dialog box.

Configuring the sensor scheme

To configure the sensor installation scheme, click the **Details** button in the **Location scheme settings** dialog box. After that, the **Linear scheme settings** dialog box appears.

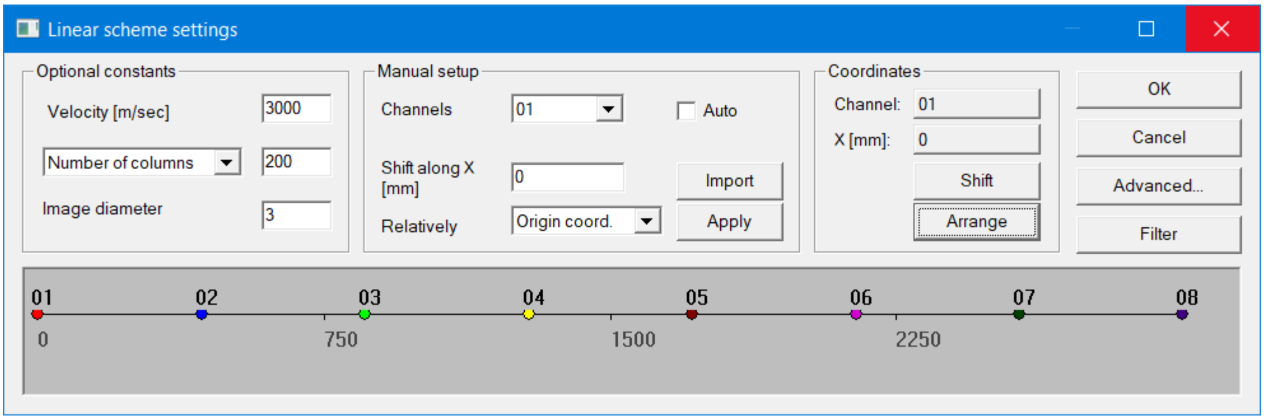


Fig. 11.7. Dialog box **Linear scheme settings**

This dialog box is described in *"Configuring the sensor installation"* on page 150. Of the features of this type of location, it should be noted the presence of only one coordinate and the absence of location zones. The anchor reference for linear location are **Origin**, **Left side** and **Right side**. If no coordinate shift is applied, then the position of the reference point **Origin** is the same as the position of the point **Left side**. Otherwise, there are three independent points.

In the case of a linear location, in the group **Optional constants** there is a choice of how to set the size and number of columns representing the results of the location:

◇ select **Number of columns** submenu from the list and specify the number of columns in the input field;

◇ select the submenu **Width in %** from the list and set the column width in % of the total length in the input field;

◇ select the submenu **Width in % [n-m]** from the list and set the column width in % of the average length between the AE sensors installed on the object in the input field;

◇ Select the **Width in (mm)** submenu from the list and specify the column width in units of measurement (in mm) in the input field.

The possibility of automatic uniform and automatic non-uniform installation of sensors is provided.

◇ Uniform automatic installation of sensors.

If all sensors are located at the left end of the testing object (i.e., they have coordinate 0), then pressing the **Arrange** button will cause them to be uniformly spaced along the entire length of the testing object with increasing number sensor from left to right.

◇ Non-uniform automatic installation of sensors.

If at least one of the sensors is shifted relative to the origin, then pressing the **Arrange** button will lead to the following non-uniform arrangement of the sensors:

- sensor with the smallest number is placed on the left edge of the object, the smallest coordinate along the X axis;
- the sensor with the highest number is placed on the right edge of the object;
- The remaining AE sensors are automatically placed alternately at each step in the middle of the longest available segment between two adjacent AE sensors.

11.8. Planar location

When using the planar type of location, the testing area is characterized by two dimensions (length and width). This type of location is applicable for monitoring flat (sheet) structures, individual sections of adjacent structures.

Including sensors in a location group

To include sensors in a location group, press the **Select** button in the **Location scheme settings** dialog box. After that, as in the case of linear location, the **Select channel** dialog box appears. Working with this dialog box is described on page 155. It is also possible to use location zones of various shapes. To do this, in the group **Antenna type**, you should activate either the radio button **Triangular** for triangular zones; or radio button **Rectangular** for quadrangular zones.

Setting the sensor scheme

To configure the sensor installation scheme, click the **Details** button in the **Location scheme settings** dialog box. After that, the **Plane location scheme settings** dialog box appears.

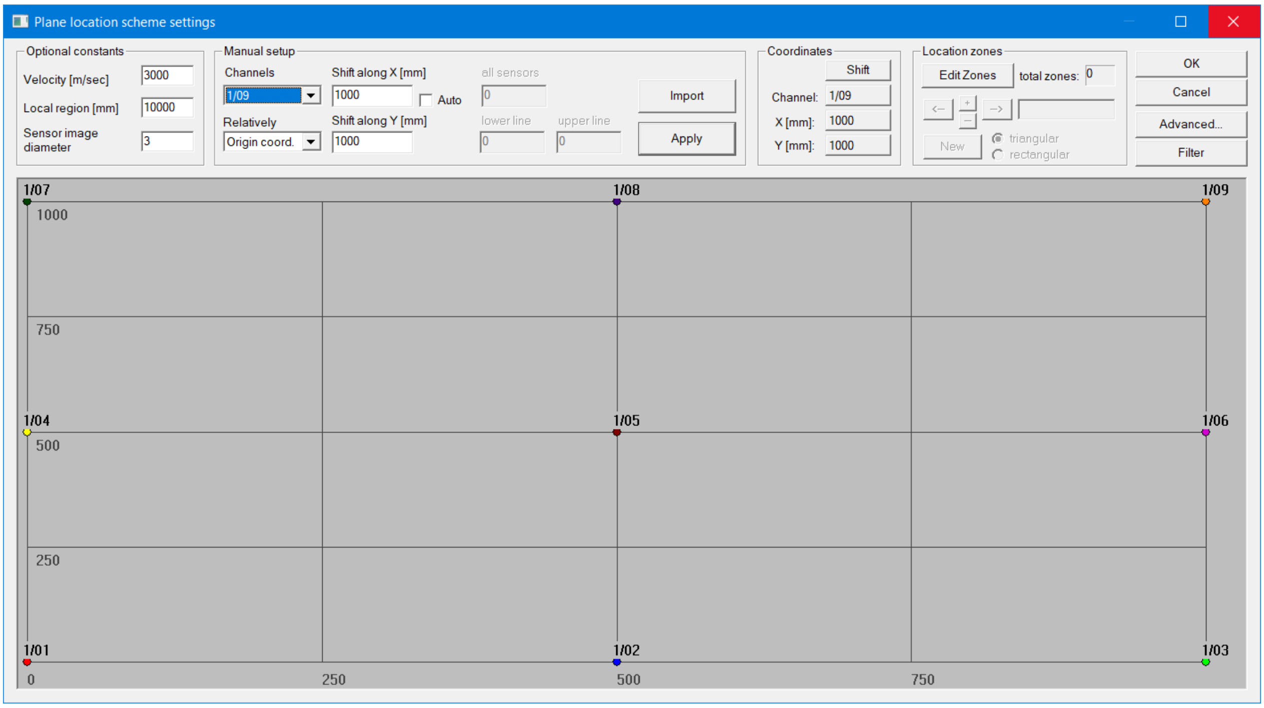


Fig. 11.8. Dialog box **Plane location scheme settings**

This dialog box is described in *"Configuring the sensor installation"* on page 150. For this type of location, reference points are **Origin**, **LeftBotCorn**, **LeftTopCorn**, **RightTopCorn**, **RightBotCorn**. By analogy with linear location, the position of the **Origin** point can be changed. If there is no shift, its position is the same as the **LeftBotCorn**.

11.9. Location of the cylindrical vessels

When using the location of cylindrical vessels, the testing area is characterized by two dimensions (length and radius of the bottom). This type of location is used for testing cylindrical vessels.

Including sensors in a location group

To include sensors in a location group, press the **Select** button in the **Location scheme settings** dialog box. After that, the **Select channels for 3D scheme** dialog box appears.

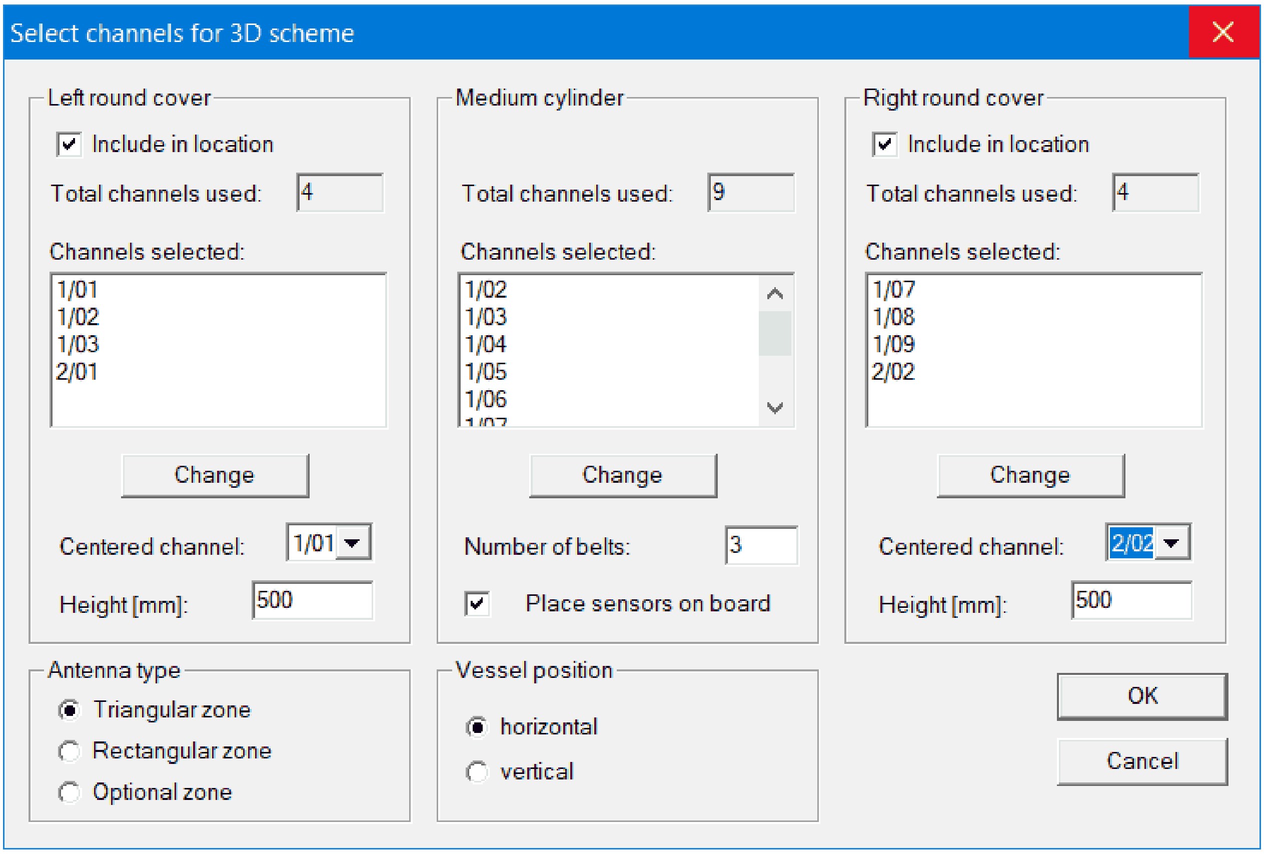


Fig. 11.9. Dialog box **Select channels for 3D scheme**

In this dialog box, you can set the distribution of sensors over the areas of the vessel:

- ✧ in the center of the window on the shell;
- ✧ on the right and left sides on the bottoms.
- ◇ To include the right and/or left bottoms in the location, you must set the **Include in location** switches in the corresponding part of the window. After that, the definition of the parameters of this part becomes available.
- ◇ To select the sensors involved in locating the shells and bottoms, press the **Change** button in the corresponding group. After that, the dialog box **Select channels** appears, the operation of which is described on page 155. After closing the window **Select channels** in the fields **Total channels used** the number of selected channels is indicated, and in the lists **Channels selected** these channels are listed.
- ◇ In the **Medium cylinder** group, set the parameters for placing sensors on the shell.

- The number of location belts (the number of rows of sensors on the object) is indicated in the input field **Number of belts**.
- The location belt installation method is selected using the switch **Place sensors on border**. When the switch is set, the outer zones of the location are placed on the border of the shell and bottoms. Otherwise, the location belts are placed evenly along the shell.

◇ In the groups **Left round cover** and **Right round cover** you should set the sensor installation parameters on the bottoms.

- The number of the sensor installed in the center of the bottom is selected from the list **Centered channel**.
- Height of the bottom (if it is not flat) is set in the input field **Thikness [mm]**.

◇ To select a location antenna, use the corresponding switch in the **Zone type** group.

- Triangular antennas are selected using the **triangular** radio button.
- Quadrangular antennas are selected using the **rectangular** radio button.
- Antennas of arbitrary shape are selected using the switch **optional**. In this case, there will be no geometric representation of the zones, an image of a rotating object will appear, for which it will be necessary to apply the fuzzy location method with an arbitrary arrangement of sensors.

◇ To set the position of the vessel, use the corresponding radio button in the group **Vessel position**:

- radio button **horizontal** when the vessel is placed horizontally;
- radio button **vertical** when the vessel is placed vertically.

After setting all the parameters, you must press the **OK** button. To cancel the changes press the button **Cancel**.

Configuring the sensor scheme

To configure the sensor installation scheme, click the **Details** button in the **Location scheme settings** dialog box. After that, the dialog box **Cylinder volume details setup dialog** appears.

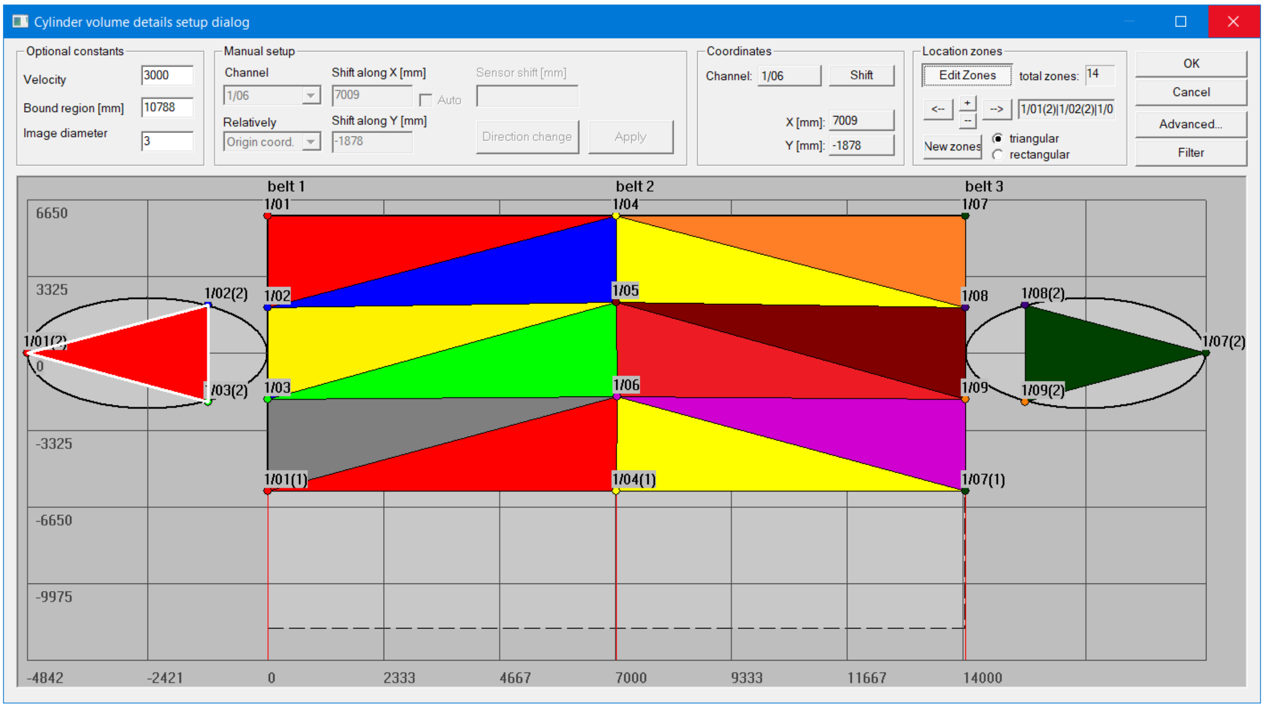


Fig. 11.10. Dialog box **Cylinder volume details setup dialog**

This dialog box is described in *“Configuring the sensor installation”*on page 150. For this type of location, the reference point is the **Origin**. If no coordinate shift is applied, then the **Origin** point is at the point where **Bottom 1** touches the left edge of **shell**, as shown.

11.10. Location of the spherical vessels

When using this type of location, the region of interest is specified by one parameter (the radius of the sphere). This type of location is used for testing spherical vessels.

Including sensors in a location group

To include sensors in a location group, press the **Select** button in the **Location scheme settings** dialog box. After that, the **Select channels for sphere location scheme** dialog box appears.

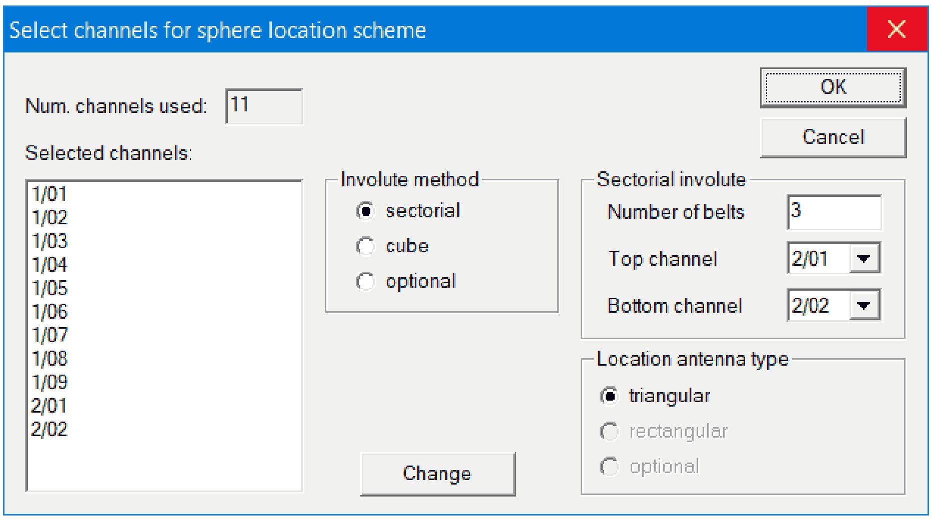


Fig. 11.11. Dialog box **Select channels for sphere location scheme**

In this dialog box, you can set the scheme of sensors installation over surface of the sphere.

◇ To select the sensors involved in the location, press the button **Change**. Then the dialog box **Select channels** appears, similar to the dialog box **Including or excluding Sensors from group**, work with which is described on page 155. After closing the window **Select channels** in the field **Num channels used** the number of selected channels is indicated, and in the list **Selected channels** these channels are listed.

◇ After selecting the channels, you must specify the method for locating the sphere. To do this, in the **Involute method** group, activate the corresponding radio button.

- When using the sectorial method of locating the sphere use the **sectorial** radio button.
- In the case of a cubic way of locating a sphere use **cube** radio button.

  Note that when choosing a cubic type of sphere location, by default, the sensors are placed first along the vertices of the cube inscribed in the sphere, then along the centers of faces and edges. This arrangement of sensors involves the use of at least eight sensors. The coordinates of the sensors and the output of the location results are given in the coordinate system "Longitude (X)" -"Latitude (Y)".
- For an arbitrary way of locating the sphere use the radio button **optional**.

◇ When you select the sector method for locating the sphere, the **Sectorial involute** group becomes available. It should specify additional parameters.

- The number of location belts (the number of rows of sensors on the object) is set in the input field **Number of belts**.
- The number of the top sensor is selected from the list **Top channel**.
- The number of the sensor placed at the bottom is selected from the list **Bottom channel**.

◇ To select a location antenna, activate the corresponding switch in the group **Location antenna type**.

- Triangular antennas are selected using the radio button **triangular**.

  This type of location antenna is available with sector and cube methods of locating the sphere.
- Antennas of a quadrangular shape are selected using the radio button **rectangular**.

  This type of location antenna is available with a cubic sphere locating method.
- Antennas of arbitrary shape are selected using the radio button **optional**. In this case, there will be no geometric image of the zones, an image of a rotating object will appear, for which it is necessary to apply the fuzzy location method with an arbitrary arrangement of sensors.

  This type of locating antenna is available with an arbitrary method of locating the sphere.

After setting all the parameters, you must press the **OK** button. To cancel the changes press the button **Cancel**.

Setting the sensor scheme

To configure the sensor installation scheme, click the **Details** button in the **Location scheme settings** dialog box. After that, the dialog box **3D-Sphere details setup dialog**.

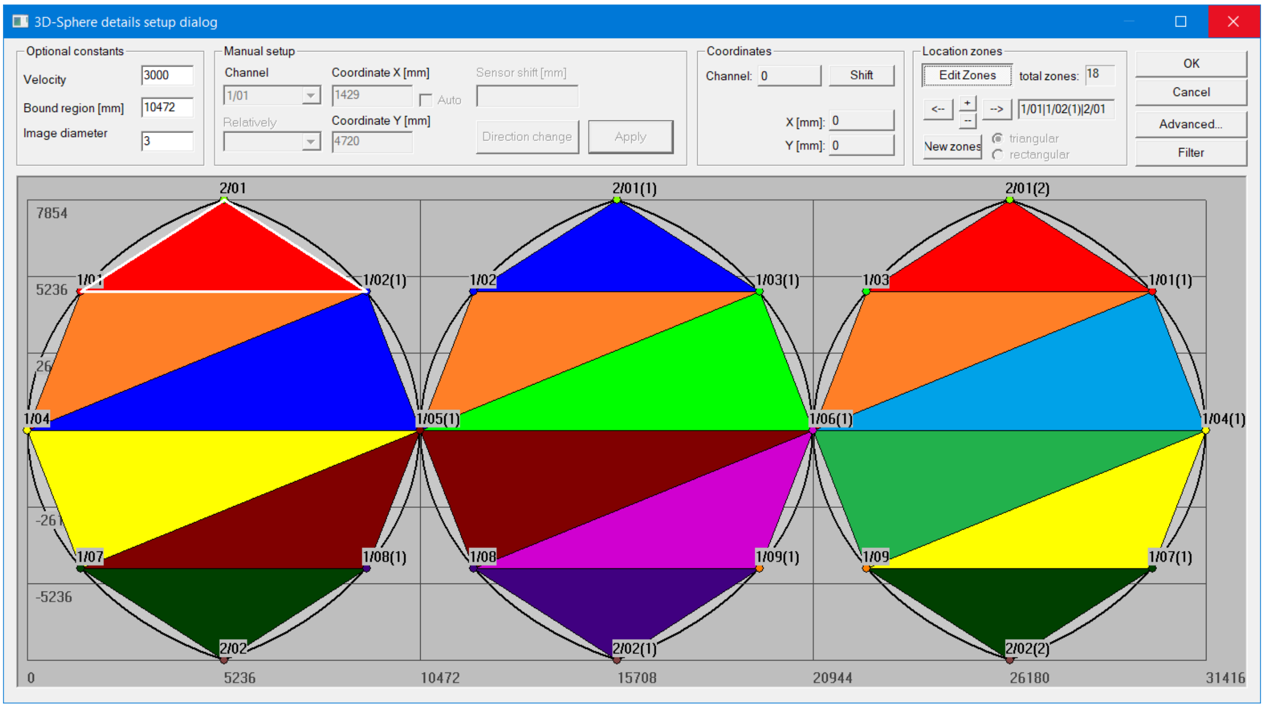


Fig. 11.12. Dialog box **3D-Sphere details setup dialog**

This dialog box is described in *“Configuring the sensor installation”* on page 150. Of the features of this type of location, it should be noted that with the sectorial method of locating the sphere, it is possible to manually change only one coordinate (the second coordinate is calculated automatically), as well as a different graphical representation of the sphere (depending on the choice of the net method).

11.11. Location of the conical vessels

When using the location of the cone, the testing area is characterized by three dimensions (length and two base radii). This type of location is used for testing conical vessels.

Including sensors in a location group

To include sensors in a location group, press the **Select** button in the **Location scheme settings** dialog box. After that, the **Channel selection for location scheme of conical vessel** dialog box appears.

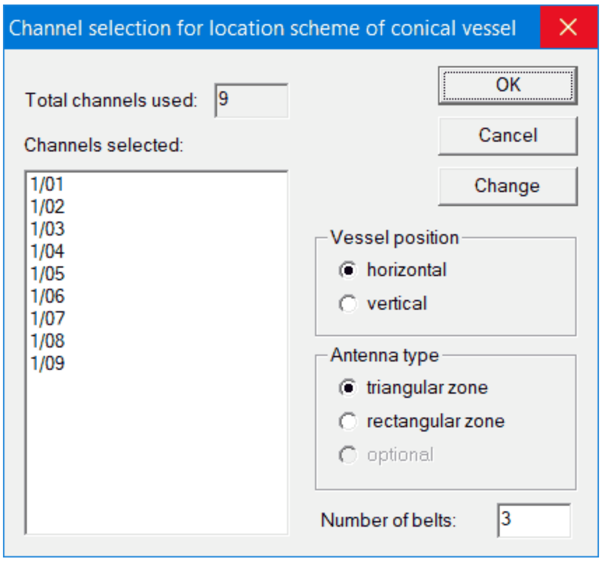


Fig. 11.13. Dialog box **Channel selection for location scheme of conical vessel**

In this dialog box, set the scheme of sensors installation over the sections of the cone.

◇ To select the sensors involved in locating a conical vessel, press the **Change** button. After that, the dialog box **Channel selection for location scheme of conical vessel** appears, similar to the dialog box **Including or excluding eensors from group**, which is described on page 155. After closing the window **Channel selection for location scheme of conical vessel** in the fields **Total channels used** the number of selected channels is indicated, and the lists **Channels selected** shows these channels.

◇ To select a location antenna, activate the corresponding switch in the **Antenna type** group.

- Triangular antennas are selected using the **triangular zone** radio button.
- Quadrangular antennas are selected using the **rectangular zone** radio button.

◇ To set the position of the vessel, activate the corresponding radio button in the group **Vessel position**:

- radio button **horizontal** when the vessel is placed horizontally.
- radio button **vertical** when the vessel is placed vertically.

After setting all the parameters, you must press the **OK** button. To cancel the changes press the button **Cancel**.

Setting the sensor scheme

To configure the sensor installation scheme, click the **Details** button in the **Location scheme settings** dialog box. After that, the dialog box **Cone volume details setup dialog** appears.

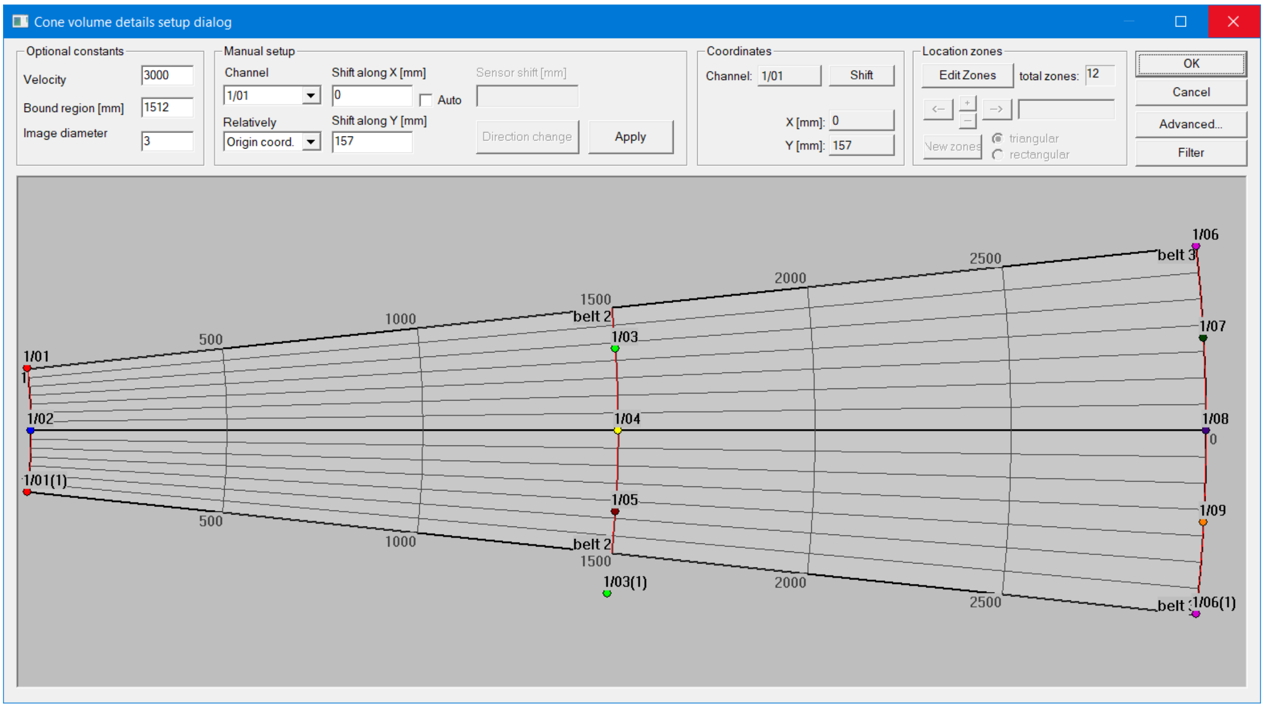


Fig. 11.14. Dialog box **Cone volume details setup dialog**

This dialog box is described in *“Configuring the sensor installation”*on page 150. For this type of location, the reference point is the **Origin**. If no coordinate shift is applied, then the point **Origin** is located at the point of intersection of the boundary of the left base and the generatrix of the cone.

11.12. Bottom location

When using the bottom location, the testing area is characterized by two dimensions: the bottom diameter and the depth value (height). This type of location is used for testing the bottoms of tanks, including buried ones (inaccessible for placing sensors).

Including sensors in a location group

To set up the sensor installation scheme, press the **Select** button in the **Location scheme settings** dialog box. After that, the dialog box **Select channels for bottom location scheme** appears.

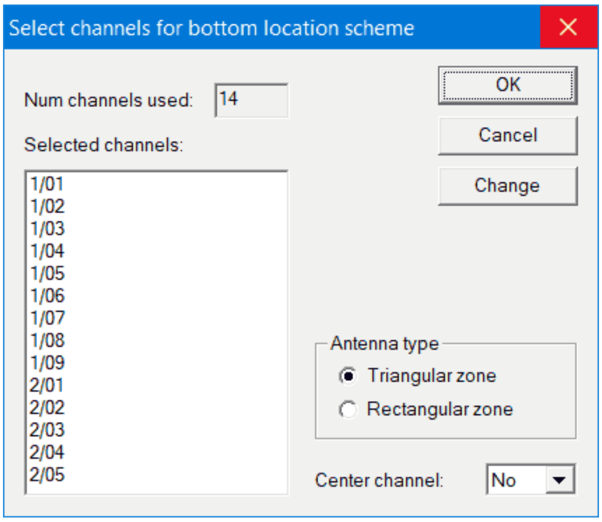


Fig. 11.15. Dialog box **Select channels for bottom location scheme**

In this dialog box, you can set the distribution of sensors over the sections of the bottom.

To select the sensors used in the location, press the button **Change**. After that, the dialog box **Select channels for bottom location scheme** appears, similar to the dialog box **Including or excluding Sensors from group**, which is described on page 155. After closing the window **Select channels for bottom location scheme** in the field **Num channels used** the number of selected channels is indicated, and in the list **Selected channels** these channels are shown.

Then, in the **Center channel** list, specify the number of the sensor, if any, located in the center (in the thickness of the medium). If there is no such sensor, select **No**.

To select the location zone shape in the **Antenna type** group, choose either the radio button **Triangular zone** for triangular zones forms; or radio button **Rectangular zone** for quadrangular zones.

After setting all the parameters, you must press the **OK** button. To cancel the changes press the button **Cancel**.

Setting the sensor scheme

To configure the sensor installation scheme, click the **Details** button in the **Location scheme settings** dialog box. After that, the **Bottom details setup dialog** dialog box appears.

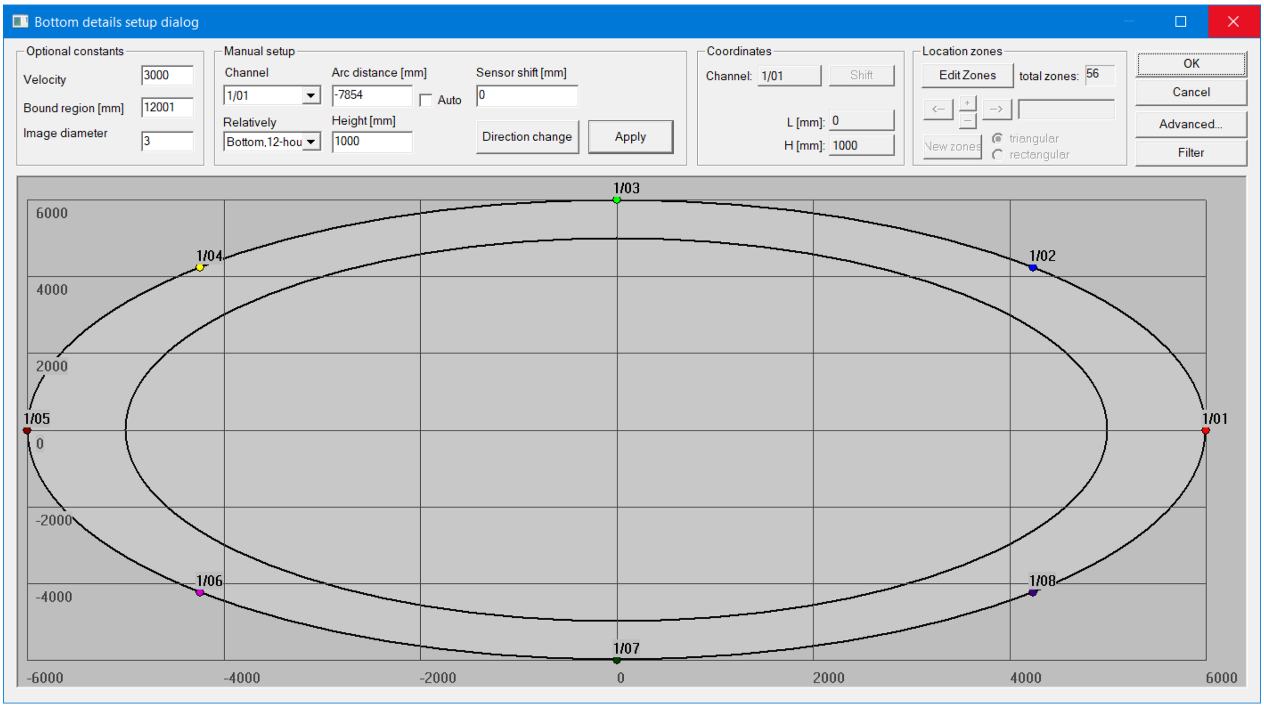


Fig. 11.16. Dialog window **Bottom details setup dialog**

This dialog box is described in *"Configuring the sensor installation"* on page 150. Of the features of this type of location, the following should be noted:

- ✧ When locating the bottom in the dialog box **Bottom details setup dialog** instead of the X and Y coordinates enter the length of the arc (input field **Arc distance**) and sensor installation height (input field **Height**). The arc distance is the distance along the arc of the circumference of the bottom, counted from the extreme right position (in which the 1st sensor is installed by default) counterclockwise.
- ✧ Relationship of X and Y coordinates with arc distance and height is determined by the formulas:

  $X = R \cos(L/2\pi R)$ and $Y = R \sin(L/2\pi R)$, where

  R is bottom radius, L is arc length counted from the extreme right position counterclockwise to the location of the selected sensor.

  For this type of location, the reference point is the **Bottom, 3 o'clock** point, which coincides with the position of the **1/01** sensor in the figure, or the **Bottom, 12 o'clock point** which matches the position of the **1/03** sensor in the figure.
- ✧ To shift all AE sensors by a specified length along the perimeter, enter the offset value in the field **Sensor shift** and press the button **Apply**.
- ✧ To change the direction of sensor numbering (clockwise/counterclockwise), use the button **Direction change**.

Setting location zones

To set up location zones, press the **Edit Zones** button in the **Bottom details setup dialog** box. Working with this dialog box is described in the section *"Distribution of sensors by zones"* on page 153. The peculiarity of this type of location is the following.

To select the number of location zones, press the **New zones** button in the **Bottom details setup dialog** dialog box. After that, the **New location zone parameters** dialog box appears.

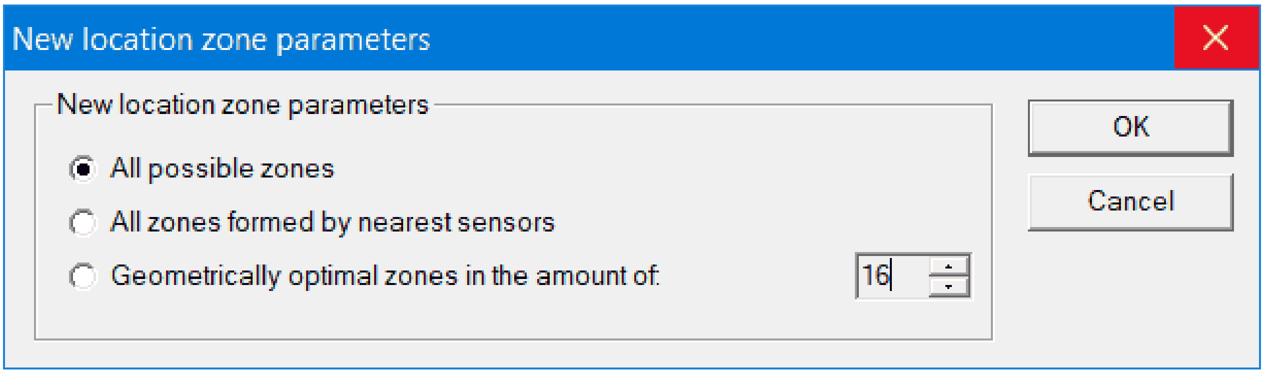


Fig. 11.17. Dialog box **New location zone parameters**

- ✧ When **All possible zones** is selected, all possible zones of the location are formed.
- ✧ When you select **All zones formed by nearest sensors**, all location zones are formed, consisting of neighboring 3 AE sensors (or 4 AE sensors - in the case of quadrangular zones).
- ✧ When you select **Geometrically optimal zones in the amount of:**, a user-specified number of location zones is generated, the shape of which is as close as possible to an equilateral triangle or square. The degree of proximity is given by the number of zones. If you set the minimal possible number of zones N=number of AE sensors / 3 (or N=number of AE sensors / 4 for quadrangular zones), then only zones that are close to equilateral and such that each channel enters only one zone will be formed. If you increase the number of zones, then the most suitable zones in terms of geometry will be added, while one AE sensor can already be included in several zones.

11.13. Three-dimensional location

When using a three-dimensional (volumetric) location type, the area of interest is characterized by three dimensions (length, width and height). This type of location is used for 3D filled objects (for example, bridge supports).

Including sensors in a location group

To include sensors in a location group, press the **Select** button in the **Location scheme settings** dialog box. After that, the dialog box **Select channels** appears, similar to the dialog box **Including or excluding sensors from group**, which is described on page 155.

Note that at least five sensors must be used to conduct volumetric location.

After setting all the parameters, you must press the **OK** button. To cancel the changes pressthe button **Cancel**.

Setting sensor scheme

To configure the sensor installation scheme, click the **Details** button in the **Location Scheme Settings** dialog box. After that, the **Three-Dimentional details setup dialog** dialog box appears.

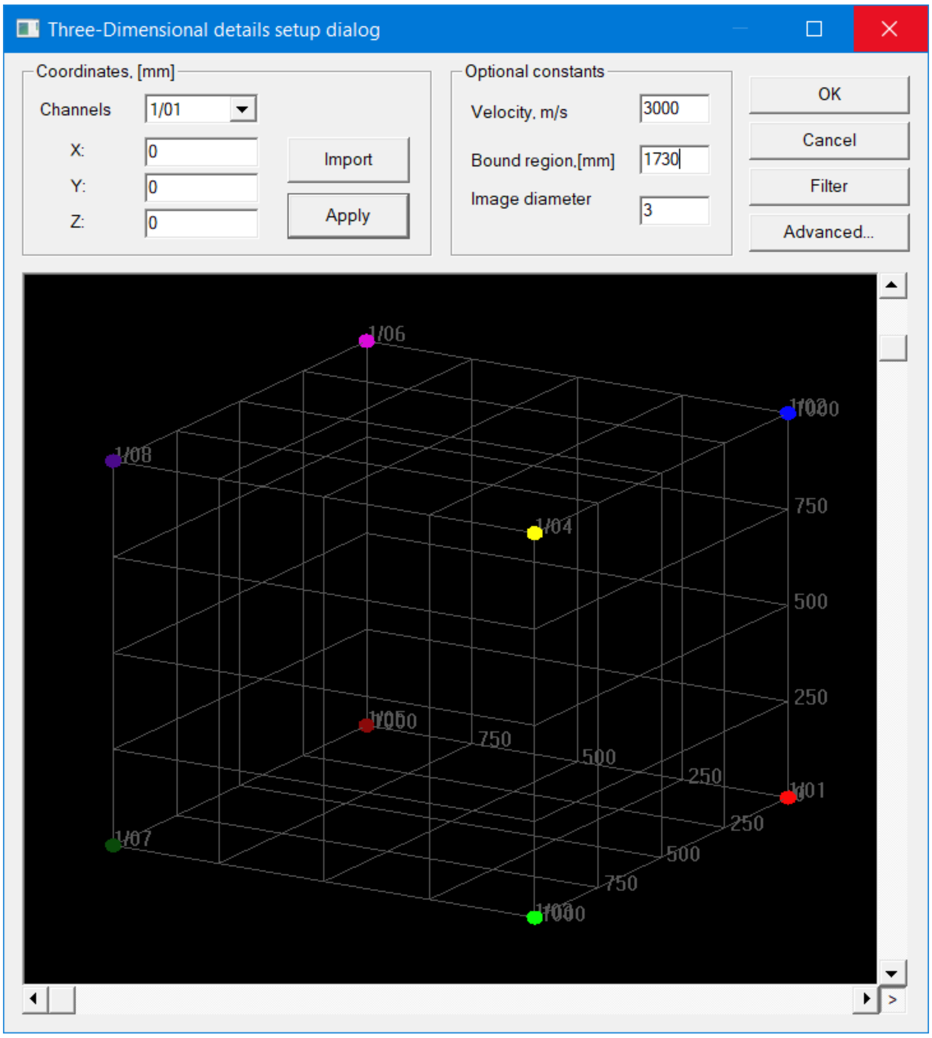


Fig. 11.18. Dialog box **Three-Dimentional details setup dialog**

Working with this dialog box is described in *“Configuring the sensor installation”* on page 150.

Of the features of this type of location, the following points should be noted:

- presence of three coordinates;
- no location zones.

The presence of three coordinates in this location model causes a three-dimensional rotating image to be obtained in this dialog box. In this case, there is no possibility of setting coordinates from the window using the "mouse". When working with a 3D image, the following actions are possible:

- to stop the rotation of the model, click the < button located in the lower right corner of the dialog box;
- use the horizontal scrollbar to rotate the model around the horizontal axis;
- use the vertical scroll bar to rotate the model around the vertical axis.

11.14. Zonal location

Zonal location is used mainly for the testing of vessels:

✧ in especially difficult cases, when there is no good access to the testing area of the object;
✧ when it is difficult to choose the value of the effective velocity of propagation of AE waves;
✧ when the use of other location types is impractical (for example, due to insufficient number of available AE channels).

In such cases, zonal location enables an express analysis to detect the presence of AE sources without measuring their coordinates. With its help, you can only estimate between which sensors the source is located.

Including sensors in a location group

To include sensors in a location group, press the **Select** button in the **Location scheme settings** dialog box. After that, the dialog box **Select channels** appears, similar to the dialog box **Including or excluding sensors from group**, work with which is described on page 155.

After completing the channel selection, press the **OK** button, to cancel the selection, use the **Cancel** button.

Zonal scheme settings

To set up a zonal location scheme, click the **Details** button in the **Location scheme settings** dialog box. After that, the **Zonary details setup dialog** box appears.

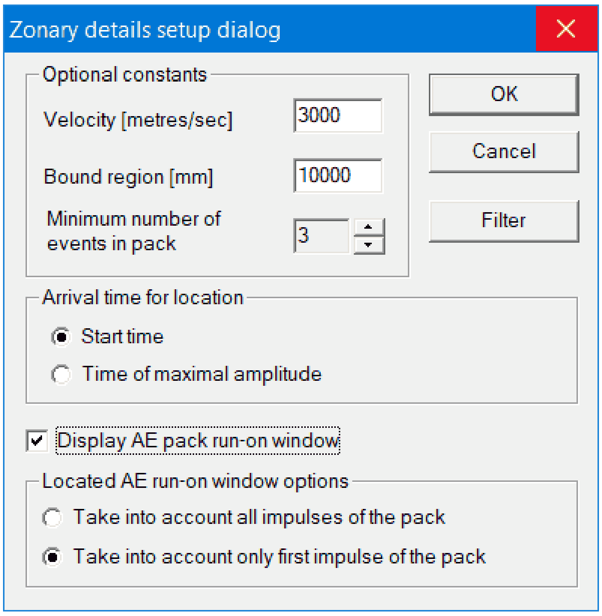


Fig. 11.19. Dialog box **Zonary details setup dialog**

Working with this dialog box is described in *"Configuring the sensor installation"* on page 150.

From the features of this type of location, it should be noted the absence of coordinates and location zones, as well as the presence in the **Zonary details setup dialog** dialog box of an additional group **Arrival time for location** and switch **Display AE pack run-on window**.

◇ In the group **Arrival time for location** select the location mode:
  - by AE impulse start time using **Start time** radio button;
  - by time of maximal amplitude using **Time of maximal amplitude** radio button.

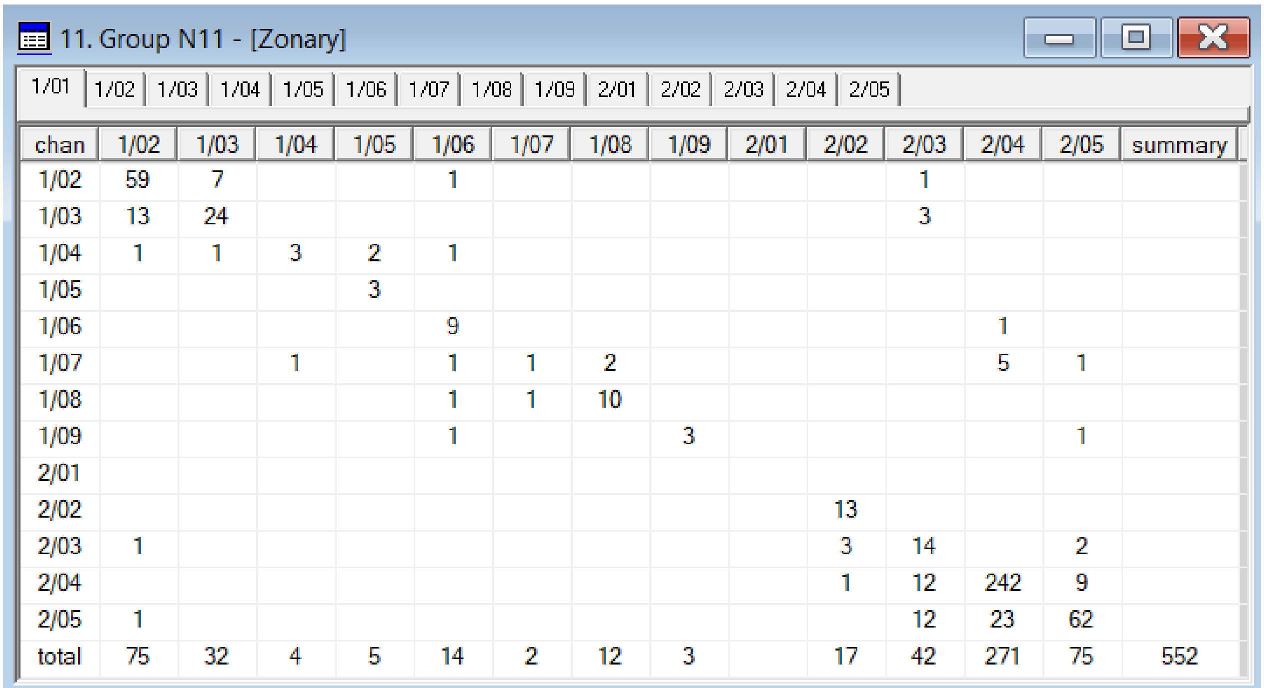
◇ To monitor the dynamics of accumulation of packs in a zone location (similar to the window for accumulation of located events), turn on the switch **Display AE-pack run-on window**:

- use the **Take into account all impulses of the pack** radio button to display statistics on all impulses in a pack in the window;
- use the **Take into account only the first impulse of the pack** radio button to display in the statistics accumulation window only for the first impulses of a pack.

After setting all the parameters, you must press the **OK** button. To cancel the changes press the button **Cancel**.

Presentation of result

The results of zonal location will be presented in the window in tabular form. The sum of the cells of the corresponding column is contained in the line **total**, and the total number in cells on the selected page is contained in the field **summary**.



chan	1/02	1/03	1/04	1/05	1/06	1/07	1/08	1/09	2/01	2/02	2/03	2/04	2/05	summary
1/02	59	7			1						1			
1/03	13	24									3			
1/04	1	1	3	2	1									
1/05				3										
1/06					9							1		
1/07			1		1	1	2					5	1	
1/08					1	1	10							
1/09					1			3					1	
2/01														
2/02										13				
2/03	1									3	14		2	
2/04										1	12	242	9	
2/05	1										12	23	62	
total	75	32	4	5	14	2	12	3		17	42	271	75	552

Fig. 11.20. **Zonary location window**

The result of this type of location is the selection of groups of impulses (packs) that arrived sequentially at several different sensors (at least two) with a total arrival interval of no more than a specified value (the value of this interval is set in the **Zonary details setup dialog** box locations by defining bound region and velocity).

In the window for displaying the results of the zonal location, the table shows the numbers indicating the number of selected packs, selected by the first three (two) sensors of the pack. The sensors receiving pack impulses are specified as follows: the first sensor is selected in the top line and sets the page of the table; the second sensor is selected from the columns of the table; the third sensor is from the rows of the table. The column with the largest number of selected packs, against the background of the others, indicates the possibility of a source located between the three selected sensors.

Note that a possible source will be located closer to the sensor, the number of which corresponds to the page number of the table. In the case of a packs consisting of two impulses, the row and column numbers are the same.

In the data file filtered by the results of the zone location, the parameter "**Pack №**" appears (by analogy with the source coordinates for other types of location), which combines the AE impulses included in one pack, its common serial number.

11.15. Vertical steel tank wall location

When using the vertical steel tank wall location, the testing area is characterized by two dimensions (perimeter and height). This type of location is used for testing the walls of vertical steel tanks.

Including sensors in a location group

To include sensors in a location group, press the **Select** button in the **Location scheme settings** dialog box. After that, as in the case of linear location, the **Including or Excluding sensors from group** dialog box appears. Working with this dialog box is described on page 155. It is also possible to use location zones of various shapes. To do this, in the group **Antenna type**, you should activate either the radio button **Triangular** for triangular zones; or radio button **Rectangular** for quadrangular zones.

Setting the sensor scheme

To configure the sensor installation scheme, click the **Details** button in the **Location scheme settings** dialog box. After that, the **Plane location scheme settings** dialog box appears.

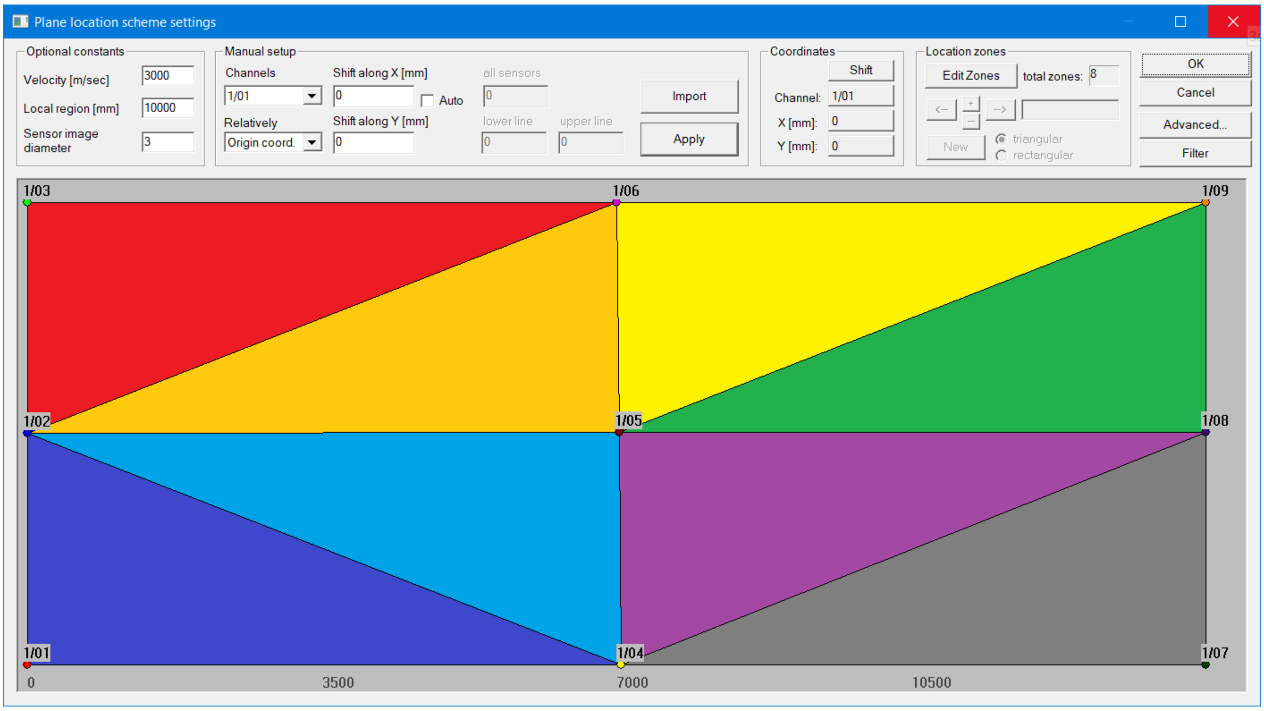


Fig. 11.21. Dialog box **Plane location scheme settings**

This dialog box is described in *“Configuring the sensor installation”*on page 150. For this location type, reference points are **Origin**, **LeftBotCorn**. By analogy with linear location, the position of the **Origin** point can be changed. If there is no shift, its position is the same as the **LeftBotCorn**.

In the **Plane location scheme settings** dialog box, in the case of the vertical steel tank wall location, the following options are additionally available:

✧ Displacement of all AE sensors by a given value along the X axis.

To do this, in the **Shift along X[mm]** group, specify the shift value in the field **all sensors** and click the button **Apply**.

✧ Shift the sensors of the lower/upper row by a given value along the Y axis.

To do this, in the group **Shift along Y[mm]** specify the offset value in the field **lower line**/**upper line** and click **Apply**.

11.16. Advanced location options

To set advanced location options, click the **Advanced** button in the dialog boxes for setting location scheme parameters. After that, the dialog box **Advanced location options** appears.

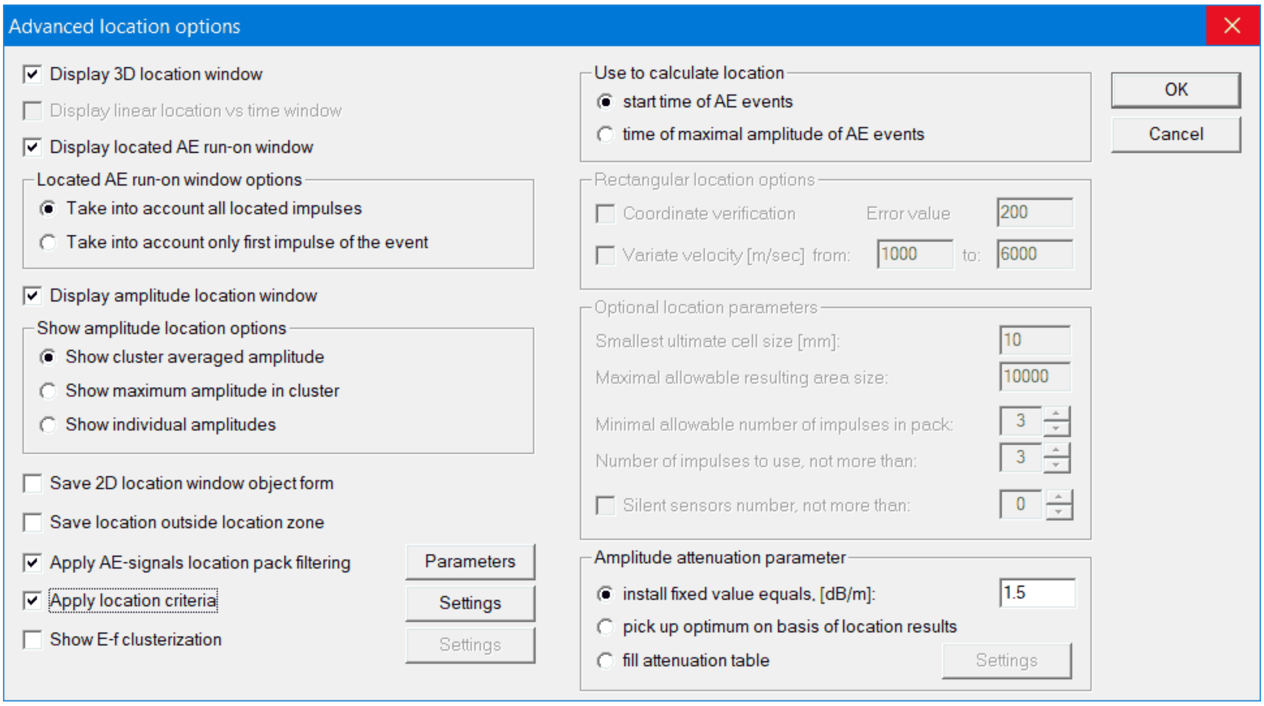


Fig. 11.22. Dialog box **Advanced location options**

◇ To observe 3D location models of cylindrical, spherical and conical vessels, activate the switch **Display 3D location window**.

◇ To view the X-coordinate of the located impulses as a function of time when using a linear location group, activate the **Display linear location vs time window** switch. On the correlation diagram, which will be displayed both in post-processing and in real time modes, all located events will be shown as separate points, and the abscissa of each point corresponds to the registration time of the earliest impulse of the location pair, and the ordinate corresponds to the calculated X coordinate of the located event.

◇ To create a window for accumulation of located AE impulses, use the switch **Display located AE run-on window**.

- use the **Take into account all located impulses** radio button to display statistics for all located impulses in the window for accumulation of located AE impulses;
- use the **Take into account only first impulse of the event** radio button to display statistics for the first impulses of located events only in the window for accumulation of located AE impulses.

◇ Turn on the switch **Display amplitude location window** to create a location amplitude window. Then, in the **Show amplitude location options** group that has become available, set the radio button corresponding to the selected action:

- use **Show cluster averaged amplitude** radio button to display the cluster average amplitude in the location amplitude window ;
- activate **Show maximum amplitude in cluster** radio button to display the maximum amplitude in the cluster in the location amplitude window;
- if **Show individual amplitudes** radio button is activated in the location amplitude window, each location event (indication) is displayed in an individual color, depending on the own value of its location amplitude.

◇ In order to display the results of two-dimensional location types (planar, cylinder, sphere, bottom, cone, vertical steel tank wall) in the windows where the coordinate axes are automatically scaled, preserving the shape of the objects with any change in the size of the window, set the switch **Save 2D location window object form**.

◇ To select the method of further processing of location points that are not inside the triangular or quadrangular location zone that formed them, use the switch **Save location outside location zone** (off by default):

- when the switch is off, location points that are not inside the location zone that formed them are displayed only if they are not inside any other location zone;
- when the switch is on, location points are displayed regardless of which location zone they are into.

◇ To use AE pack filtering, activate the **Apply AE-signals location pack filtering** switch. Then use the now available button **Parameters** and set the filtering parameters in the opened dialog box **Parameters of AE-pulses pack**. Working with this dialog box is described in detail in *“AE pack filtering”* on page 79.

◇ To use the location criteria, activate the switch **Apply location criteria**. Then use the **Settings** button that has become available and set the parameters of the sites to which the location criterion will be applied in the **Location areas list** dialog box that opens. Working with this dialog box is described in detail in the section *“Location areas”* on page 178.

◇ To select a method for calculating location coordinates, activate the corresponding radio button in the group **Use to calculate location**:

- to calculate the coordinates on the base of the difference in the time of arrival of the AE impulse at the sensors, set the radio button **start time of AE impulses**;
- to calculate the coordinates on the base of the difference in times of reaching the maximal amplitude of the AE impulse, use the radio button **time of maximal amplitude of AE impulses**.

These radio buttons are available for all types of locations, except zonal.

◇ To check the validity of the obtained values of the source coordinates, use the quadrangular zone type in the corresponding channel selection dialog. Then, in the now available group **Rectangular location options**:

- activate the switch **Coordinate verification**;
- enter the value of the allowable error in the input field **Error value [mm]**.

Note that this check can be carried out based on the capabilities of the algorithm for calculating location coordinates using four sensors. The accuracy of the obtained values is determined using the relation (“truth criterion”):

$| X^2 + Y^2 - V^2 T^2 | \leq \varepsilon^2$,

where:

X and Y are source coordinates; V — velocity; T — propagation time; ε — set value of error (discrepancy).

If the “truth criterion” is not met at the velocity V_0 specified in the location, it is allowed to select it within the specified limits to ensure possible equality with the selected accuracy ε. For this:

✧ activate the switch **Variate velocity [m/s]**;

✧ specify the allowable velocity range in the input fields **from** and **to**, including the value of the initial velocity V_0.

◇ In the **Amplitude attenuation parameter** group, select the method for setting the attenuation parameter:

- use **install fixed value equals, [dB/m]** radio button to set the attenuation parameter to a fixed value and enter the value of the attenuation parameter in the corresponding input field;
- activate **pick up optimum on basis of location results** radio button to select the optimal attenuation parameter value from the received location results;
- set the radio button to **fill attenuation table** to enter the attenuation curve as a table and click the button **Settings** that has become available. After that, the **Attenuation** dialog box appears.

  To work with this dialog box, see *“Setting the attenuation curve parameters using a table”* on page 174.

After setting all the parameters, click the **OK** button. To cancel the changes press the **Cancel** button. Note that the volume location window and the location amplitude window will be created along with the other location windows.

> ⚠ It is not recommended to use the displaying windows of 3D location models open during data acquisition due to the significant consumption of computer resources for displaying them.

Setting the attenuation curve parameters using a table

To set the parameters of the attenuation curve using the table, activate switch **fill attenuation table** in the group **Amplitude attenuation parameter** of the dialog box **Advanced location options** and click the **Settings** button. After that, the dialog box **Attenuation** will appear with a table for setting the parameters of the attenuation curve (distance - in meters, amplitude - in dB), a coordinate area for displaying the curve and commands for managing data.

◇ To work with the attenuation curve parameter table, the following commands are available in the dialog box:

- To enter data into the parameter table, press the button **Add**, after that a line with zero values (0.00) will appear in both columns.

  Move the mouse pointer to the editable cell with a value and double-click the left button, after that it becomes possible to enter data in the selected cell. Then move the mouse pointer to another cell in the same row, use the left mouse button, double-clicking, and enter the data. To enter data in a new line, move the mouse cursor to the table field and click once with the left mouse button. Then press the button **Add** and repeat the data entry procedure.

Entering data into the parameter table can be done differently: press the required number of times on the **Add** button, after which two columns with zero values will appear, and then enter the attenuation curve parameters as described above. Simultaneously with data input, the program builds a attenuation curve in the coordinate axes.

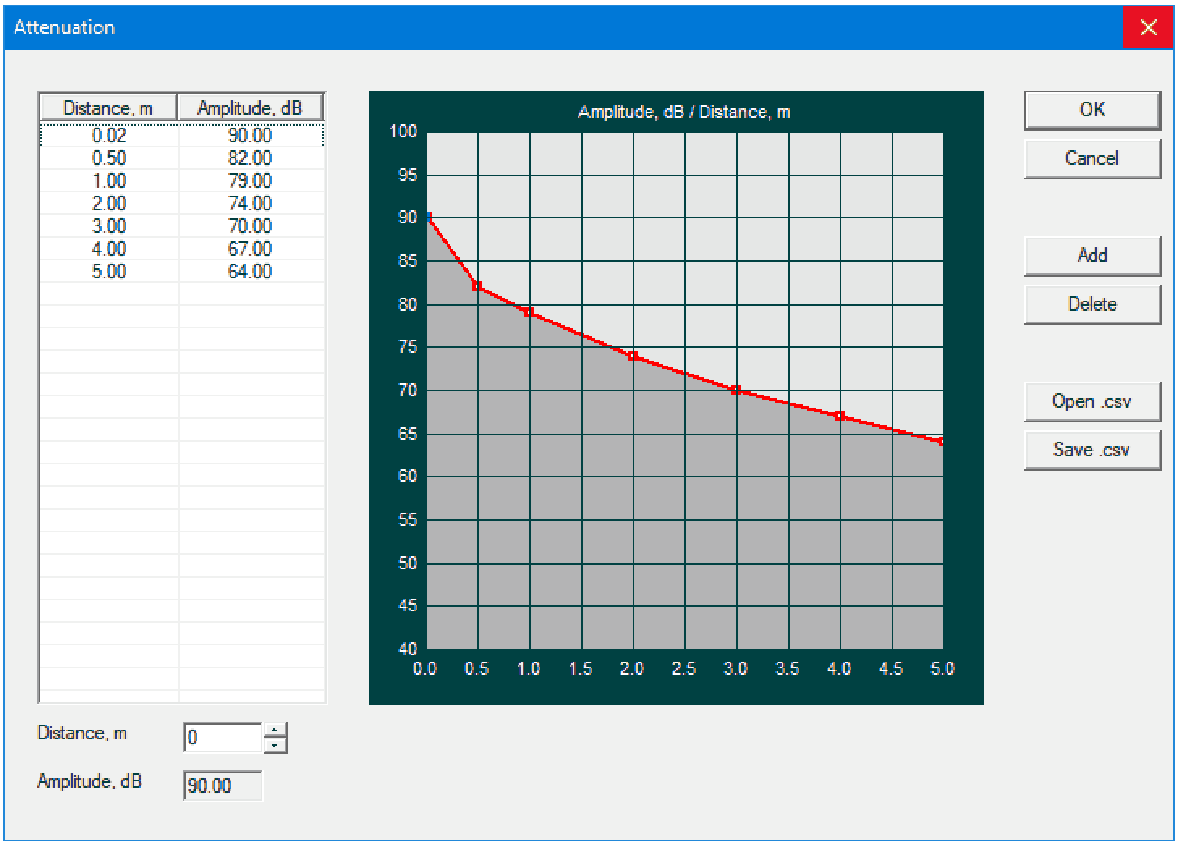


Fig. 11.23. Dialog box **Attenuation** (attenuation curve)

- To view the coordinates of the attenuation curve, use the **Distance, m** spinner.

  The amplitude value corresponding to the selected distance value is shown in the field **Amplitude, dB**. On the attenuation curve, the current position of the coordinates is displayed as a dot of a different color, which moves along the curve when the coordinate changes in the field **Distance, m**.
- To delete data, select the corresponding row(s) in the table and use the **Delete** button.
- To load files with attenuation curve parameter data, click the **Open .csv** button.

  In the dialog box **Open file**, select the required attenuation curve file (*.txt extension).
- To save the attenuation curve parameters to a file, use the **Save .csv** button. In the dialog box **Save as** that opens specify the path, enter the name of the file in which the attenuation curve data will be saved, select file type (TXT or CSV) and click the button **Save**.

- To save the current set of attenuation curve parameters, press the **OK** button, to cancel all changes, use the **Cancel** button. The dialog box **Attenuation** will be closed.

11.17. Filtering by location

To select located events and perform filtering, press the **Filter** button in the dialog boxes for setting the location scheme parameters. After that, box **Location filter dialog** box will appear. In the dialog box that opens, set options for the filtering by location.

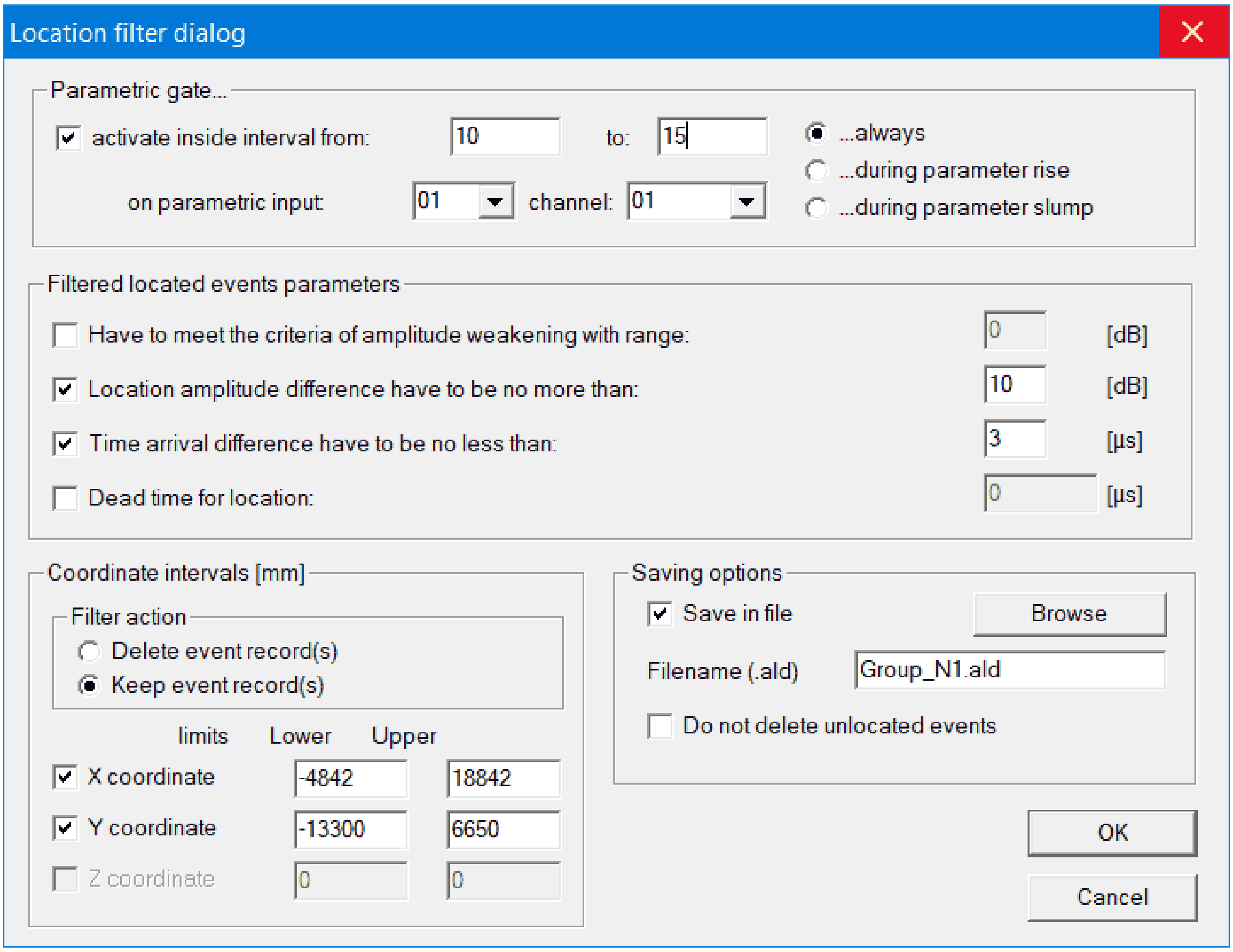


Fig. 11.24. **Location filter dialog** box

◇ To conduct a joint analysis of the temporal behavior of the selected parametric input and the flow of AE impulses, set the necessary parameters in the group **Parametric gate**:

- turn on the switch **activate inside interval**, after which all parameters in the group become available;
- set the range of values of the registered parameter in the input fields **from** and **to**;
- activate the radio button of the desired direction of change of the selected parameter: **…always**, **…during parameter rise** or **…during parameter slump**, at which the location of AE impulses will be allowed.
- select in the list **on parametric input** the number of the parametric input that will receive the corresponding measured data (for example, current, voltage, pressure, temperature, etc.);

- indicate the number in the list **channel** devices (modules in case of complexes of "A-Line DDM" type; boards for complexes of "A-Line PCI" type), where data from the selected parametric input will be recorded;

◇ In the **Filtered located events parameters** group, select, if necessary, the criterion/criteria for automatic rejection of located events using the corresponding switch.

- *Amplitude attenuation criterion*.

  This criterion is met by events in which the amplitude of the AE impulse that arrived at the near AE sensor is not less than the amplitude of the AE impulse at the far AE sensor. To apply this criterion, turn on the switch **Have to meet the amplitude criterium with appropriate range** and specify the value of the allowable residual in the input field **[dB]**.

- *Criterion for discrepancy between location amplitudes*.

  This criterion is met by events in which the difference in the values of the location amplitudes at the location of the defect for AE impulses that make up a location pair (for linear location) or a triple (for planar types of location), recalculated by the program, taking into account the attenuation parameter and the distance from the defect to sensors does not exceed the specified value. To apply this criterion, turn on the switch **Location amplitude difference have to be no more than** and specify the difference in the location amplitudes in the input field **[dB]**.

- *Criterion for difference in AE impulse arrival times*.

  This criterion is met by events in which the difference in the arrival times of the AE impulse at the AE sensor, which make up a location pair (for linear location) or a triple (for planar types of location), is not less than a given value. To apply this criterion, turn on the switch **Time arrival difference have to be no less than** and specify the difference in arrival times in the input field **[μs]**.

- *Dead time criteria for a location*.

  According to this criterion, an event will be located only if the arrival times of all AE impulses that make up its location pair (for linear location) or triple (for planar location types) differ from the arrival times of the AE impulse on the same channel that participated in the previous located event by at least the value of the specified dead time. To apply this criterion, turn on the switch **Dead time for location** and specify the amount of dead time in the input field **[μs]**.

◇ In the **Coordinate intervals** group, specify the coordinates of the area where the AE source can be located.

- Set the switch **X-coordinate**, (and the switch **Y-coordinate** for planar location scheme; and switch **Z-coordinate** for 3D location scheme).
- Enter the appropriate coordinates in the **Lower limit** and **Upper limit** fields.

If the switch **X-coordinate** and the switch **Y-coordinate**, or both switches are disabled, then the entire range of coordinates is allowed.

◇ In the group **Filter action**, set the radio button corresponding to the required action on events:

- to exclude events that fall into the selected zone, set the radio button **Delete event record(s)**;

- To exclude events that do not fall into the selected zone, set the radio button **Keep event record(s)**.

◇ To save the filtering results, activate the switch **Save in file** in the group **Saving options**. Then set the filename in the input field **File name .ald**, or click the **Browse** button and select the desired file using the standard dialog box **Open file**. To save all events in the file, not just the located ones, activate the switch **Do not delete unlocated events**.

After setting all the parameters, you must press the **OK** button. To cancel press the button **Cancel**.

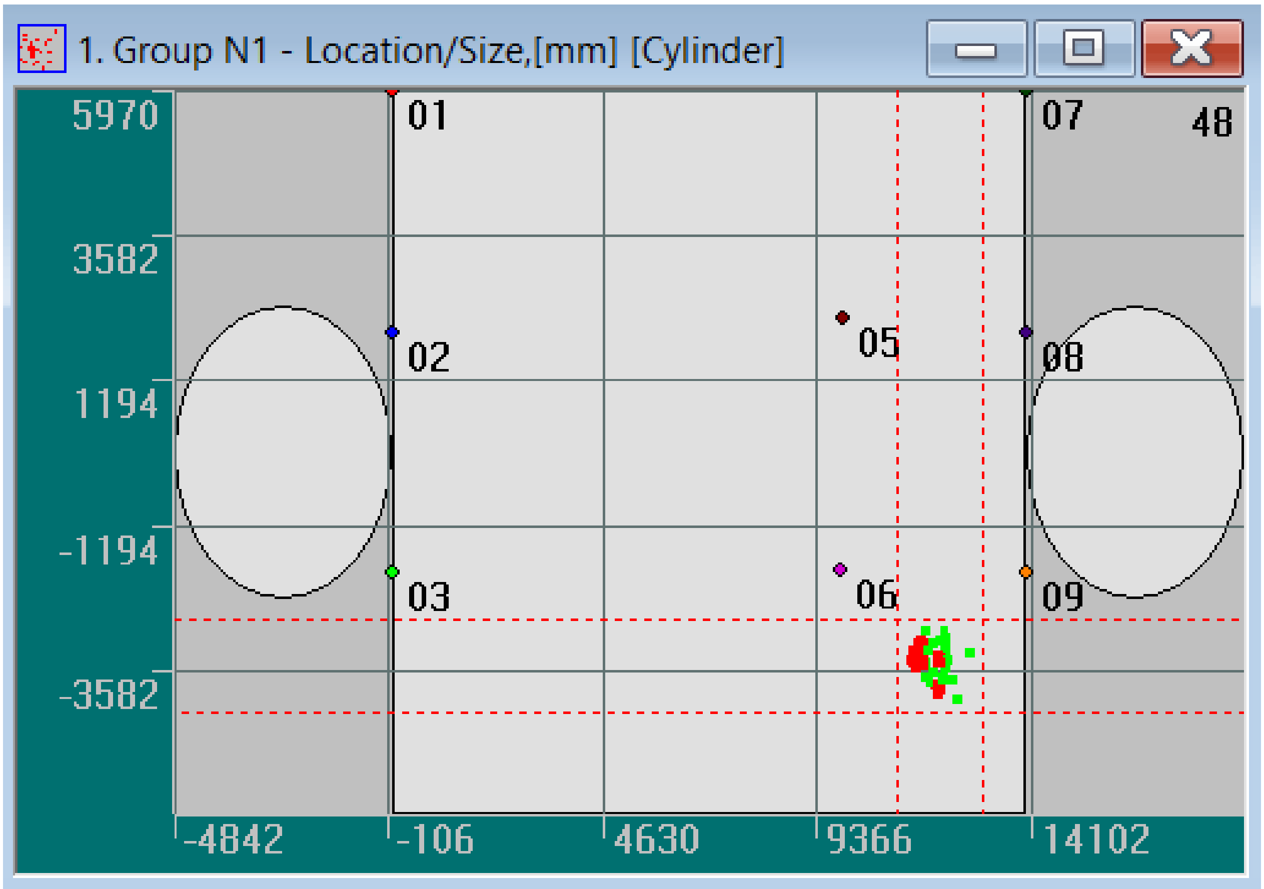


Fig. 11.25. Location window when specifying in the group **Coordinate intervals** the coordinates of the area where the AE source can be located

If the group **Coordinate intervals** contains the coordinates of the area where the AE source can be located, marker lines will additionally appear on the location scheme, displaying the boundaries of the filtering area by coordinates (except volumetric location).

11.18. Location areas

The program proposes an original method for automated analysis and presentation of location results. It is the use of a location criterion for each location group. This is convenient when testing complex objects, when the image of a real object can be presented in a location of the type **Picture** with a "dangerous area" (location area) highlighted. A location area is an area on an object within which the obtained location results are considered to belong to the same source. The location area of the testing object is approximated by a rectangle, the coordinates of which are set in the dialog box **Location area parameters** in the group **Visualization of area** (*"Setting up the location area"*on page 180). In locations of this type, "dangerous areas" will have a solid shading, and not presented as a set of points, as in locations of other types.

When using the location criterion for the selected location group, activate the switch **Apply location criteria** and click the **Settings** button in the dialog box **Advanced location options**.

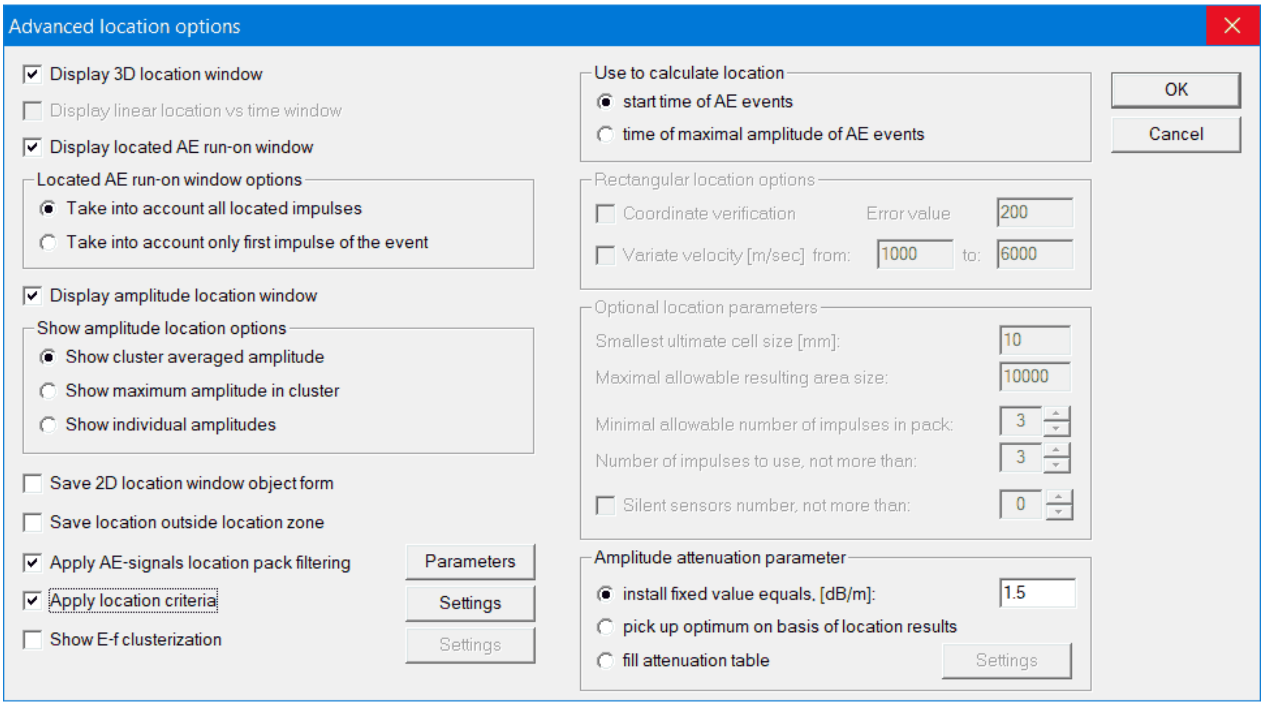


Fig. 11.26. Dialog box **Advanced location options**

After that, the dialog box **Location areas list** will open, in which you should configure the location criterion for the selected location type.

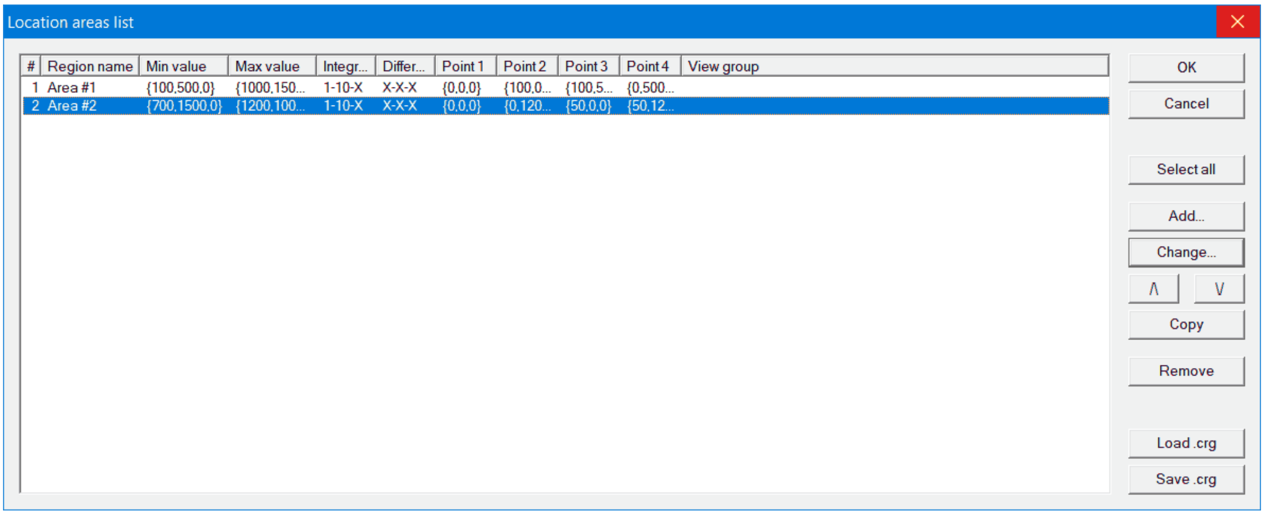


Fig. 11.27. Dialog box **Location areas list**

This window contains a list of location areas and commands for managing location areas.

◇ The list of location areas is presented in the dialog box. For each location area, its parameters are indicated: number, region name, minimum and maximum coordinates of the selected area, parameters of the integral (according to the accumulation of events) hazard criterion, parameters of the differential (according to the rate of accumulation of events) hazard criterion, coordinates of visualization of the selected area on a real object in the location window for location type "Picture".

◇ The following commands are available for working with the list of location areas and changing their parameters:

- to add a new location area, click the **Add** button, after that the **Location area parameters** dialog box appears, in which you should set the parameters of the new location area, as described in the section *“Setting up the location area”* on page 180;
- to change the parameters of a location area, select it in the list and use the **Change** button, and then in the dialog box that opens **Location area parameters** make the necessary adjustments;
- to move in the list of locations, use the "/\" buttons to move up one line or the "\/" button to move down one line;
- to copy a location area, select it in the dialog box and press the button **Copy**;
- to remove a location area, select it in the dialog box and click the **Remove** button.

◇ Note that when working with the list of location areas, you can add or change only one location area. For moving, copying and deleting, you can select one or more locations from the list using the standard line selection procedure, either with the mouse or using the appropriate keyboard shortcut.

- To select the entire list, use the **Select all** button.

◇ To load and save location criterion files, use the appropriate buttons:

- activate the button **Load .crg** and select the required file of the location criterion (extension *.crg);
- click the button **Save .crg** and in the opened dialog box **Save as** specify the path and file name in where the parameters of the location area (or set of location areas) will be saved.

After creating and configuring location areas, press the **OK** button, to cancel press the **Cancel** button.

> ✍ Parameters of a location area (a set of location areas) are saved in the location file or in the location criterion file.

Setting up the location area

To configure the location area parameters, open the **Location area parameters** dialog box using the **Add** button in the dialog box **Location areas list** as described in *“Location areas”* on page 178.

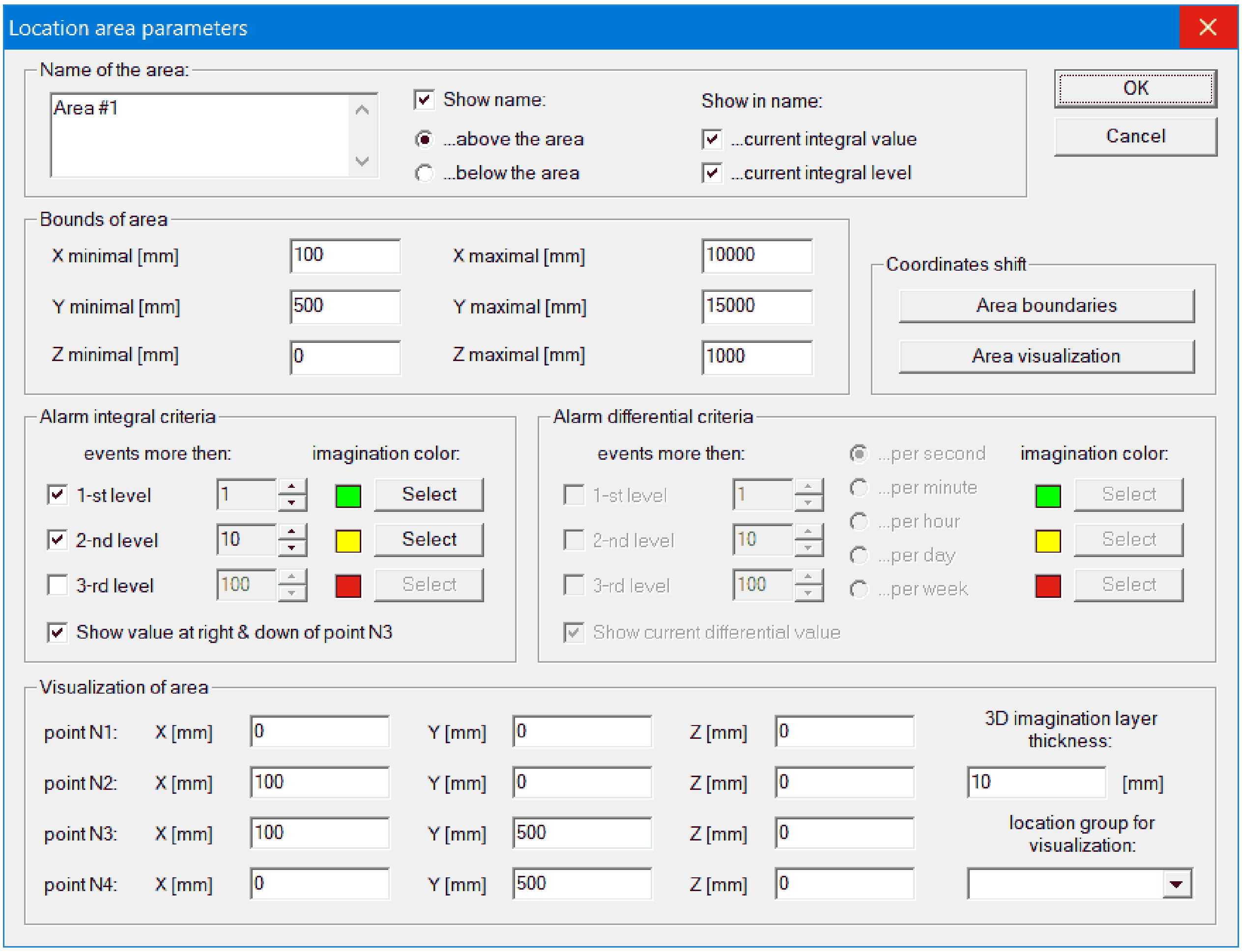


Fig. 11.28. Dialog box **Location area parameters**

After that, the **Location area parameters** dialog box will open, in which you should make the necessary settings.

In this window, set the parameters of the location area, possible values of the integral hazard criterion (according to the accumulation of events), displaying colors and the visualization parameters.

◇ In the **Name of the area** group, enter the name of the area and set its displaying parameters.

- In the input field, enter the name of the area, which can be multi-line.
- To display the name of the area, activate the switch **Show name** and select the desired option for the position of the name:
  - above the image of the area: radio button **…above the area**;
  - under the image of the area: radio button **…below the area**.

◇ To display the value of the current accumulation of events or the value of the current threshold in the plot name, set the corresponding switch in the subgroup **Show in name**:

- to display the value of the current accumulation of events — switch **…current integral value**;
- to display the value of the current threshold — switch **…current integral level**;
- to simultaneously display the values of the current accumulation of events and the current value of the threshold, activate both switches.

◇ In the **Bounds of area** group, set the boundaries of the location area:

- Enter the minimal values of the boundaries of the plot along the X, Y and Z axes in the corresponding input fields: **X minimal (mm)**, **Y minimal (mm)** and **Z minimal (mm)**;
- Enter the maximal values of the boundaries of the plot along the X, Y and Z axes in the corresponding input fields — **X maximal (mm)**, **Y maximal (mm)** and **Z maximal (mm)**.

◇ In the **Coordinates shift** group, set the shift value for the coordinates of the area boundaries and the shift value for the coordinates of the area visualisation.

- To set the shift of the coordinates of the boundaries of the plot, click the button **Area boundaries**.

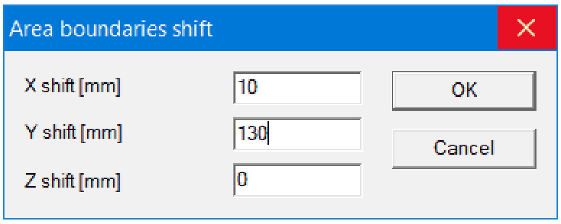


Fig. 11.29. Dialog box **Area boundaries shift**

In the dialog box **Area boundaries shift**, set the coordinate shift along the X, Y and Z axes in the corresponding input fields:

  ◦ shift along X-axis: in the input field **X shift[mm]**;
  ◦ shift along Y-axis: in the input field **Y shift[mm]**;
  ◦ shift along Z-axis: in the input field **Z shift[mm]**.

After setting all the parameters, press the button **OK**, to cancel press the button **Cancel**.

- To shift the coordinates of visualization of the location area, click the shift button **Area visualization**.

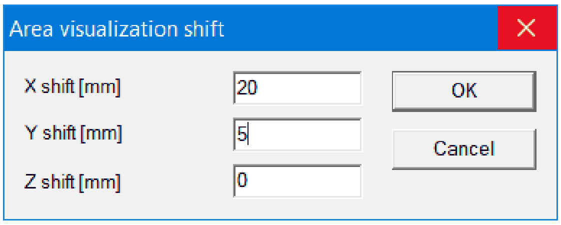


Fig. 11.30. Dialog box **Area visualization shift**

In the opened **Area visualization shift** dialog box, set the coordinate shift along the X, Y and Z axes in the corresponding input fields:

  ◦ shift along X-axis: in the input field **X shift[mm]**;
  ◦ shift along Y-axis: in the input field **Y shift[mm]**;
  ◦ shift along Z-axis: in the input field **Z shift[mm]**.

After setting all the parameters, press the button **OK**, to cancel press the button **Cancel**.

◇ In the **Alarm integral criteria** group, set the parameters of the hazard criteria by the accumulation of the number of events (integral hazard criterion).

- Note that only one or part of the criteria can be specified. The inclusion of a criterion of a higher level is possible only when the criterion of the previous level is activated.
- For each of the Levels 1, 2, and 3 criteria, set the following parameters:
  ◦ To use the criterion of a certain level, activate the appropriate switch **1-st level**, **2-nd level** and **3-rd level**;

  - ◦ set the number of events corresponding to the selected level of the danger criterion for the accumulation of events, using the **events more than** spinner;
  - ◦ To change the display color of accumulated events corresponding to the selected severity level, click the **Select** button, then select a color using the standard **Color** dialog box.
- To display accumulated events to the right and below point 3, activate the switch **Display value at right and down point N3**.

◇ In the **Visualization area** group, set the parameters for visualization the area:

- in the line **point №1** enter the coordinates of the point №1 in the input fields **X (mm)**, **Y (mm)** and **Z (mm)**;
- in the lines **point №2**, **point №3** and **point №4** enter, respectively, coordinates of points №2, №3 and №4 in the fields **X (mm)**, **Y (mm)** and **Z (mm)**;
- in the input field **3D imagination layer thickness** set the layer thickness for 3D visualization;
- in the **location group for visualization** list, select the location group to visualize the area.

After creating and configuring location areas, press the **OK** button, to cancel press the **Cancel** button.

11.19. Clustering

The program provides the ability to visualize the number of located events and the location amplitude. To do this, press the button **Change settings** in the group **Clustering legend** in the dialog box **Location scheme settings**. After that, the **Clusterization settings** dialog box appears.

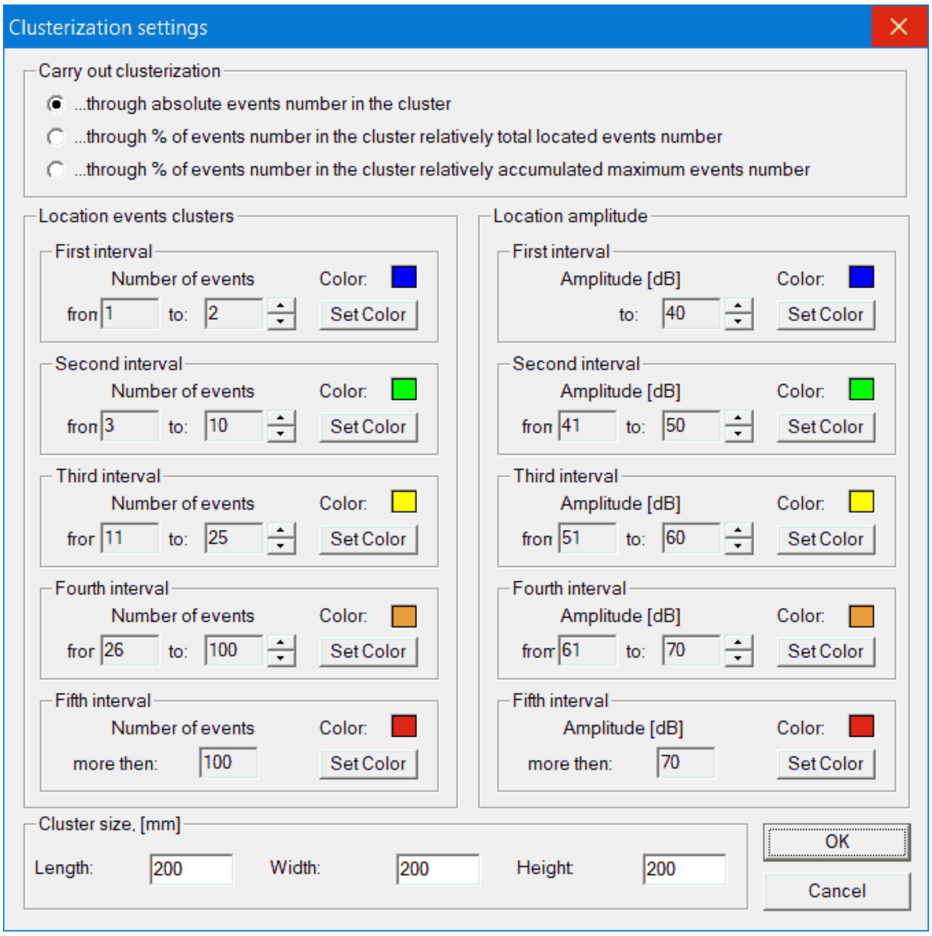


Fig. 11.31. Dialog box **Clusterization settings**

In the dialog box that opens, set the clustering parameters.

◇ In the **Carry out clusterization** group, select the criterion by which you will cluster:

- to perform clustering of located AE sources by the absolute number of events in this cluster, activate the radio button **…through absolute events number in the cluster**;
- to carry out clustering of located AE sources by the percentage of the number of events that are into a given cluster relative to the total number of located events, use the switch **…through % of events number in the cluster relatively total located events number**;
- to carry out clustering of located AE sources by the percentage of the number of events that are into a given cluster, relative to the weight of the maximum accumulated cluster of located events, use the switch **…through % of events number in the cluster relatively accumulated maximum events number**.

◇ In the group **Location events clusters** using the spinners **Number of events:** set the ranges for the number of received events for each interval. In addition, in this group, you can select a displaying color for each interval. The color is set by pressing the button **Set Color** in the corresponding subgroup and selecting the color in the standard dialog box **Color**.

◇ Similarly, in the group **Location amplitude clusters**, determine the intervals of location amplitudes and select the corresponding colors.

◇ In the group **Cluster size, [mm]** in the input fields **Length**, **Width** and **Height** set the size of the cluster.

After setting the clustering parameters, click the **OK** button. The control will return to the **Location scheme settings** dialog box. In the group **Clustering legend** the selected colors will be shown corresponding to different ranges of the number of registered events and location amplitude. The selected cluster size will also be indicated there.

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Chapter 12. Calibration procedure

✻ Chapter *“Calibration procedure”* is entirely devoted to the calibration procedure.

12.1. Automatic channel calibration (ACC)

Automatic channel calibration (ACC) is currently only available for A-Line DDM-2 systems.

To configure the automatic channel calibration parameters, select the main menu command **Options – Calibrators parameters**. After that, the dialog box **Channel settings** appears, opened on the page **Calibrator settings** (Figure 9.13). The procedure for setting up calibrators is described in *“Configuring calibrators”* on page 109.

In ACC mode, it is recommended to use:

◇ duration value of 1;

◇ values **Freq. lower (kHz)**, **Freq. upper (kHz)** and **Smax**, set by by default for the specified AE sensor type;

◇ in the section **Main settings**: filters 30-500 kHz, gain 36 dB, threshold 80 dB;

◇ in **Oscilloscope** section: sample rate 1000 kHz, number of points 4000.

If AE sensors are used for which there are no preset values for the coefficients **Freq. lower (kHz)** and **Freq. upper (kHz)**, it is recommended to use the following algorithm:

◇ for an airborne AE sensors, the main mode in the spectrum is determined (see section *“Spectral power”* on page 123);

◇ AE sensor is installed on the testing object;

◇ trial values of coefficients **Freq. lower (kHz)** and **Freq. upper (kHz)** are set, which differ from the frequency of the main mode by 5-10 kHz;

◇ if the value of Smax displayed on the power spectra window does not exceed 1.5, new trial values of the coefficients **Freq. lower (kHz)** and **Freq. upper (kHz)**, differing from the fundamental mode frequency by 5-10 kHz;

◇ if the value of Smax displayed on the power spectra window exceeds 1.5, the current values of **Freq. lower (kHz)** and **Freq. upper (kHz)** are used for ACC AE sensor of this type further.

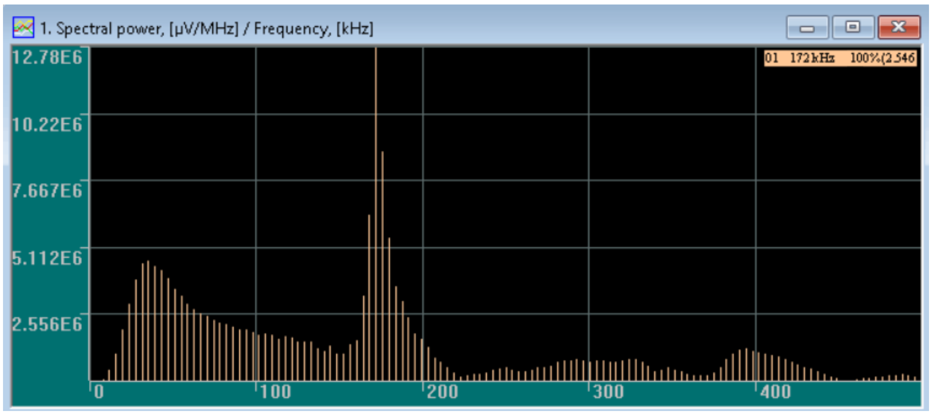

Fig. 12.1. An example of the power spectra in automatic channel calibration mode

When ACC is started, the legend of the power spectra window (see sect. *“Spectral power”* on page 123) shows the percentage of the quality of the AE sensor installation (the second parameter from the right) and the value of Smax (the first parameter on the right).

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Section 3

A-Line OSC software

Chapter 13. Features of A-Line OSC

The program **A-Line OSC** is intended for system processing of waveforms.

In typical cases of testing objects with a wall thickness of 3 to 50 mm, Lamb waves propagate at typical frequencies of AE equipment from 30 to 500 kHz, the main feature of which is the presence of dispersion - a strong dependence of the propagation velocity on the wall thickness of the object and frequency.

A spectrogram is well suited for processing such signals - a special signal transformation that gives an idea of the distribution of its energy both in time and in frequency. The spectrogram of the AE impulse that passed through the testing object in the form of a combination of Lamb waves represents dispersion curves with a characteristic shape. If they are detected, the AE operator can be sure that he is dealing with a useful signal of burst acoustic emission. In addition, in some cases, it is possible to determine the distance between the AE impulse source and the AE sensor from the signal received by one AE sensor.

Thus, the use of spectrograms makes it possible to reveal the dispersion curves of Lamb waves, which makes it possible to understand the nature of AE signals at a deeper level and distinguish them from noise.

Different actions are possible in the program.

◇ Working with waveforms, their spectral power and spectrograms:
  - detailed analysis of waveforms;
  - signal filtering;
  - getting the frequency spectrum;
  - combining and averaging spectra;
  - combining and averaging spectrograms;
  - obtaining spectrograms based on various transformations (continuous wavelet, Choi-Williams distribution, Wigner);
  - convert waveforms to audio files.

◇ Performing various calculations of special parameters on waveforms, their frequency spectra and spectrograms:
  - energy calculation;
  - calculation of the correlation value from waveforms and spectra;
  - plotting a graph of Lamb wave group velocities and superimposing dispersion curves on spectrograms with the ability to determine the distance to the signal source;
  - outline;
  - noise filtering in signal waveforms.

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Chapter 14. Program overview

14.1. Result display windows

All results in the program are presented in the result display windows. Simultaneously, you can process waveforms from one or two files. Waveforms of each file have their own set of windows, logically grouped into panels. Below is their description:

- ✧ **Shared Digital Oscilloscope: [ADC] / Time, [μs]** is a digital AE waveform presented in the corresponding panel.
- ✧ **Spectral power, [μV/MHz] / Frequency, [kHz]** is the frequency spectrum in μV/MHz of the current waveform displayed in the corresponding panel.
- ✧ **Spectrogram: Frequency, [kHz] / Time, [μs]** is frequency-time dependence of the energy density of the current waveform, presented in the corresponding panel.

The program also has additional windows:

- ✧ **Correlation / Time, [μs]** is correlation function calculated for two OSC frames presented in two panels.
- ✧ **Correlation of interval / Time, [μs]** is correlation function for the selected interval of the waveform presented in the first panel, relative to the similar interval of the waveform presented in the second panel.

14.2. Main menu

File menu

The **File** menu contains all the operations related to working with files. It includes the following commands:

Table 14.1.

Command	Action
Open OSC-1	Opens (loads) the waveform file into the first panel.
Show Header OSC-1	Shows information about an open waveform file in the first panel.
Spectrum and Spectrogram-1	Opens the saved spectrum file in the first panel. Saves the current frame of the frequency spectrum in the first panel.
Export-1	Converts the signal, frequency spectrum and spectrogram of the first panel to text format.
Close-1	Closes all open files in the first panel.
Open OSC-2	Opens (loads) the waveform file into the second panel.
Show Header OSC-2	Shows information about an open waveform file in the second panel.
Spectrum and Spectrogram-2	Opens the saved spectrum file in the second panel. Saves the current frame of the frequency spectrum in the second panel.

Command	Action
Export-2	Converts the signal, frequency spectrum and spectrogram of the second panel into text format.
Close-2	Closes all open files in the second panel.
Printer setup	Configure printer settings.
Print	Prints data.
Average	Merges and averages the selected spectrum files (FFT files).
Convert	Convert waveform files to WAV files (standard sound files in Windows).
Exit	Shuts the program down.

View menu

Menu commands **View** allow you to customize the working field of the program for the most convenient presentation of the results.

Table 14.2.

Command	Action
Toolbar	Toggles the toolbar on and off.
View Bar	Toggles the view panel on and off.
Status Bar	Turns the status bar on and off.
Spectrogram settings	Sets the parameters of the spectrogram.
OSC-1 Outline	Turns on the OSC-1 outline mode.
Clean OSC-1 Outline	Turns on the OSC-1 outline cleaning mode.
OSC-2 Outline	Turns on the OSC-2 outline mode.
Clean OSC-2 Outline	Turns on the OSC-2 outline cleaning mode.
Dispersion curves	Turns on the mode for displaying Lamb wave dispersion curves.
Zoom in	Zoom in the image.
Zoom out	Zoom out the image.
X Axis	Displays and hides the X axis in the active window.
Y Axis	Displays and hides the Y axis in the active window.

Window menu

Menu commands **Window** provide work with windows.

Table 14.3.

Command	Action
Cascade	Arranges working windows one after another with a shift.
Tile	Arranges working windows without overlap.
Arrange Icons	Organizes working windows minimized to icons.
Parameters	Sets the main parameters of the program.

Help menu

Menu commands **Help** allow you to get help when working with the program.

Table 14.4.

Command	Action
About	Displays brief information about the program.

14.3. Toolbar

Toolbar (Fig. 14.1) consists of buttons that show pictograms. Each button has an associated operation that, in most cases, duplicates any command from the main menu.

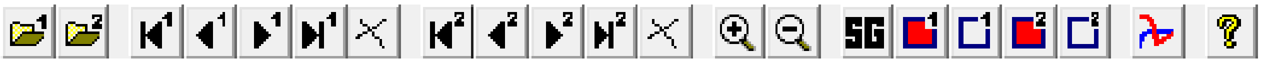
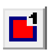
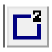


Fig. 14.1. **Toolbar**

Table 14.5.

Button	Duplicates a menu or performs an action
	**File – Open OSC-1**
	**File – Open OSC-2**
	**First frame OSC-1**
	**Previous frame OSC-1**
	**Next frame OSC-1**
	**Last frame OSC-1**
	**Hides frame OSC-1**
	**First frame OSC-2**
	**Previous frame OSC-2**
	**Next frame OSC-2**
	**Last frame OSC-2**
	**Hide frame OSC-2**
	**View – Zoom in**
	**View – Zoom out**
	**View – Spectrogram setting**
	**View – OSC-1 Outline**
	**View – Clean OSC-1 Outline**
	**View – OSC-2 Outline**

Button	Duplicates a menu or performs an action
	**View – Clean OSC-2 Outline**
	**View – Dispersion curves**
	**Help – About**

14.4. View bar

For convenience, the program provides **Viewbar** (Fig. 14.2), located on the left. It has two groups of waveforms, OSC-1 and OSC-2, which use the same set of controls.

Fig. 14.2. **Viewbar**

◇ For the first and second waveforms (in groups OSC-1 or OSC-2, respectively), the view bar contains the following controls and visualizations:

- input or display field **Frame** to enter or display the waveform frame number;
- field **Channel**, displaying the number of the channel on which the recording was made;
- field **Pre-trig**, displaying the number of points in the waveform frame recorded before the first signal intersection with the threshold level;
- a field that displays the measurement date in the *DD:MM:YY* format, the start time of the current waveform frame, counted from the moment the measurement started, in seconds, and the time of the first signal intersection of the current waveform frame with the threshold level in the format *HH:MM:SS.μs* (with an accuracy of 1 μs) or *HH:MM:SS.μs.NS* (with an accuracy of 0.1 μs), in depending on the type of system.

◇ Navigation buttons are provided to view different frames of the first and second waveforms (in OSC-1 or OSC-2 groups, respectively):

- to return to the first frame — button |<;
- to return to the previous frame — button <-;
- to move to the next frame — button ->;
- to view the last frame — button >|.

◇ To work with the spectra of the first and second waveforms (in groups OSC-1 or OSC-2, respectively), the following controls are available:

- list **Win** to select the overlay window (Hanna window or normal spectrum calculation without window overlay when *none* line is selected);
- list **SG** to select the method of calculating the spectrogram:
  - none - do not calculate spectrogram;
  - Wavelet - continuous wavelet transform based on Morlet wavelet;
  - Choi-Williams - time-frequency distribution of Choi-Williams;
  - Wigner - Wigner time-frequency transform.

- switch **log** to turn on and off the logarithmic scale for displaying energy density in a spectrum or spectrogram;
- switch **full win** to calculate the spectrum of the full waveform if it is set or calculate the spectrum of a part of the waveform if it is reset;
- input fields with spinners for specifying the beginning and end of the waveform fragment, the spectrum of which will be calculated when the **full win** switch is reset.

◇ In addition to separate processing of each waveform, the program allows joint processing of two waveforms by calculating the correlation function. To set the parameters for calculating the correlation function, the following options are available in the group **Correlation**:

- calculate the normalized correlation function in the entire recorded time interval by activating the switch **Full**;
- calculate the correlation function for a part of the waveform by activating the switch **Interval** and setting the required range using the spinners or blue markers on the waveform that determine the beginning and end of the waveform fragment;
- observe correlation coefficient of signals at zero offset in **R sign.**;
- observe the correlation coefficient of the two presented spectra in the field **R spec**.

14.5. Status bar

Status bar (fig. 14.3) displays brief tips when working with menu and **Tool bar** (Fig. 14.1), as well as the position of the cursor (X and Y coordinates) within the active window and additional information for some windows.

A progress indicator is shown while the spectrograms are being calculated. For spectrograms, **Status bar** shows the ratio of the coefficient of the spectrogram corresponding to the position of the mouse to the maximum value of the coefficients on the spectrogram. When displaying dispersion curves in the spectrogram window, **Status bar** additionally displays the value of the arrival rate of the signal components corresponding to the time determined by the position of the mouse in the field of the oscilloscope or spectrogram window.

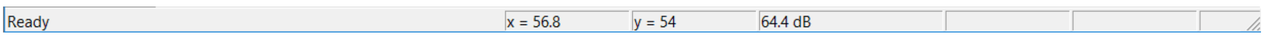


Fig. 14.3. **Status bar**

Chapter 15. Working with windows

15.1. Introduction

In the **A-Line OSC** program, the following ways of presenting the results of processing waveforms are implemented:

- in the form of waveforms;
- in the form of spectral power;
- in the form of spectrograms;
- as a correlation function of two OSC frames.

Processing results are displayed in the corresponding windows, each of which contains the working field and axes. The results are presented directly in the working field, using the axes, you can determine the coordinates and set the boundaries of the area under consideration.

15.2. Waveforms

The program has the ability to display waveforms from one or two files. Waveforms are displayed in the **Shared Digital Oscilloscope: [ADC] / Time, [µs]** window (Fig. 15.1) and represent the result of continuous recording of the signal for a certain interval of time on the selected channel.

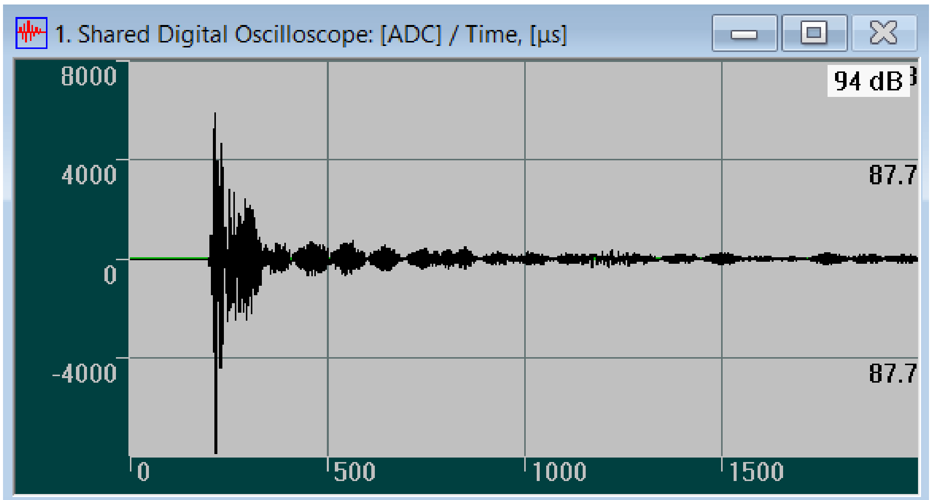


Fig. 15.1. AE waveform

In the **Shared Digital Oscilloscope: [ADC] / Time, [µs]**, in addition to the waveform, the following are displayed:

- legend in the upper right corner containing the maximum value of the AE impulse amplitude in **dB**;
- a horizontal line representing the threshold value;
- AE impulse envelope;

✧ vertical red markers, with which you can set the required range for calculating spectra and spectrograms;

✧ vertical blue markers with which you can set the required range for calculating the correlation function.

Waveforms are controlled using **View bar** (Fig. 14.2), where each waveform is represented by the same set of controls in the corresponding group.

15.3. Spectral power

Based on the received waveforms, the program has the ability to calculate the spectrum of the AE impulse using the Fourier transform.

The calculated spectral power is displayed as histograms in the windows **Spectral power, [μV/MHz] / Frequency, [kHz]** (Fig. 15.2), where the AE impulse frequencies in kHz are plotted along the horizontal axis, and the energy densities in μV/MHz are plotted along the vertical axis.

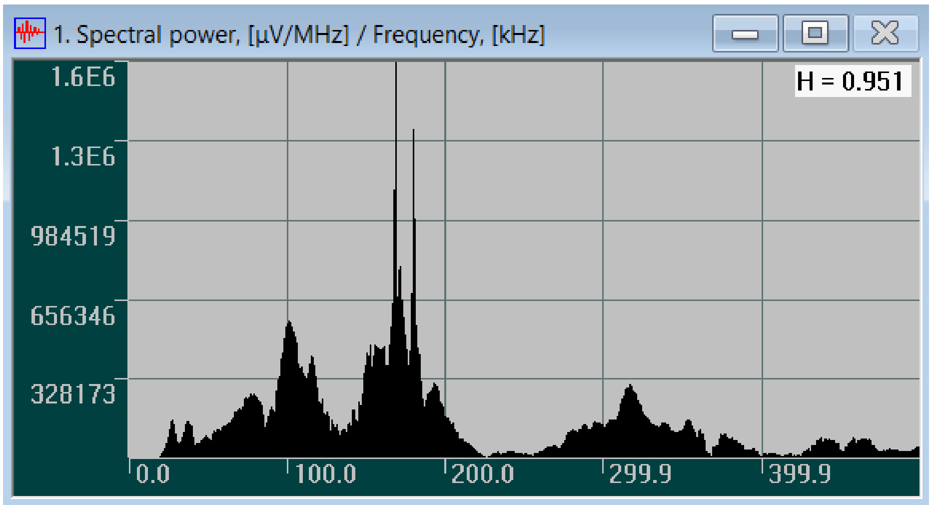


Fig. 15.2. AE impulse spectral power

In addition to the spectrum, the registration window in the upper right corner displays a legend containing the entropy value of the visible part of the AE impulse.

15.4. Spectrograms

Based on the received waveforms, it is possible to calculate spectrograms. For this, the program provides mathematical processing of waveforms using the Wigner transform and others. The results of spectrogram calculation are displayed in the **Spectrogram: Frequency, [kHz] / Time, [μs]** windows (Fig. 15.3).

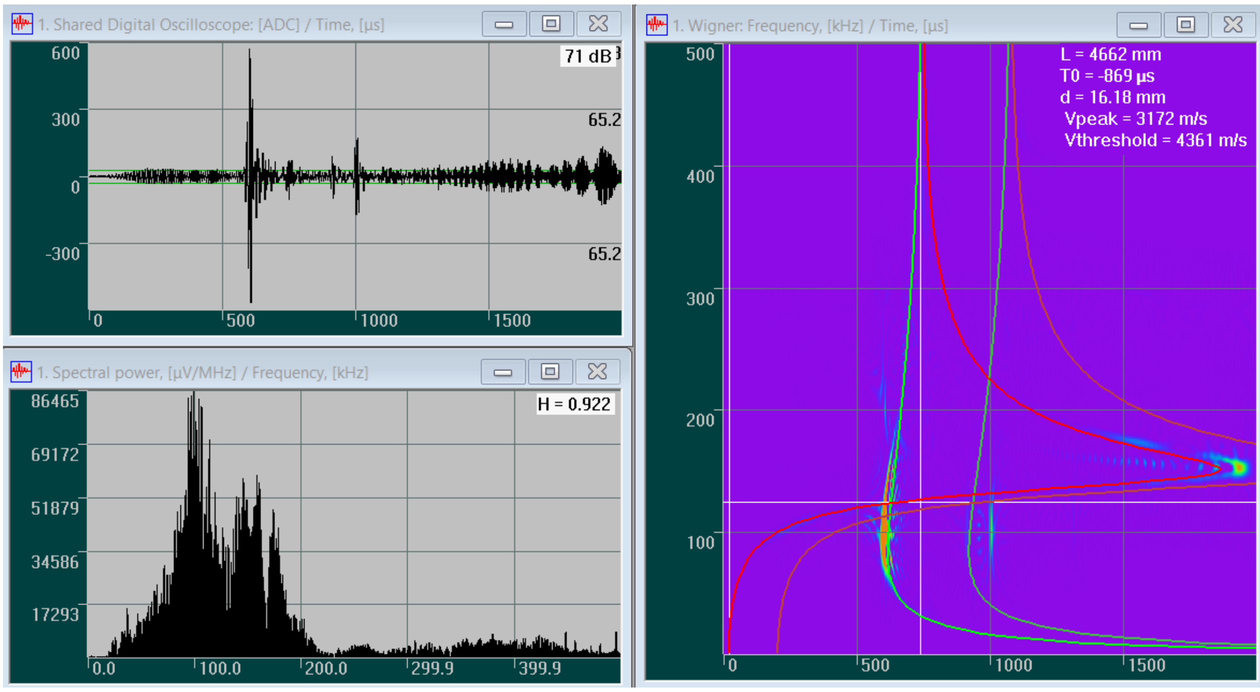


Fig. 15.3. Waveform, spectrum and spectrograms of the AE impulse

The spectrogram shows the distribution of signal energy simultaneously in the time (horizontal) and frequency (vertical) domains by changing the color hue from purple, through blue, green and yellow, to red. Areas with the lowest density values are shown in purple, areas with the highest density values in red. It is also possible to display in black and white, when black corresponds to the highest energy density, and white to the lowest.

In addition to the spectrogram, the window displays:

- ✧ Dispersion curves V(F) calculated in the **Dependence of the Lamb group speed V, [m/s] from frequency F, [kHz]** menu (Fig. 15.4) and converted by the formula $t(f)=T_0+\frac{L}{V(F)}$, where T_0 is impulse emission time, L is distance from AE sensor to AE source;
- ✧ Vertical markers used to match dispersion curves with peaks on spectrograms.

In the upper right corner of the spectrogram are displayed:

- ✧ in the absence of dispersion curves:
  - ◦ spectrogram frequency resolution;
  - ◦ maximum modulo value of the coefficients on the spectrogram (only for wavelet spectrograms);
- ✧ in the presence of dispersion curves:
  - ◦ calculated distance (**L = … mm**) from AE sensor to AE source;
  - ◦ calculated signal emission time (**T0 = … µs**) by the AE source relative to the moment of the beginning of the waveform;
  - ◦ wall thickness of the testing object (**d = … mm**);
  - ◦ velocity corresponding to the moment of maximum signal amplitude (**Vpeak = … m/s**);
  - ◦ velocity at which threshold crossing was registered (**Vthreshold = … m/s**).

If there is insufficient allocated RAM when working in the 32-bit version of the program with spectrograms based on the Choi-Williams and Wigner transforms, it is recommended to run the program with /3GB /PAE command line arguments or to use the 64-bit version.

Dispersion curves

To calculate dispersion curves, select the main menu command **View – Dispersion curves**. After that, the **Dependence of the Lamb group speed V, [m/s] from frequency F, [kHz]** dialog box appears (Fig. 15.4).

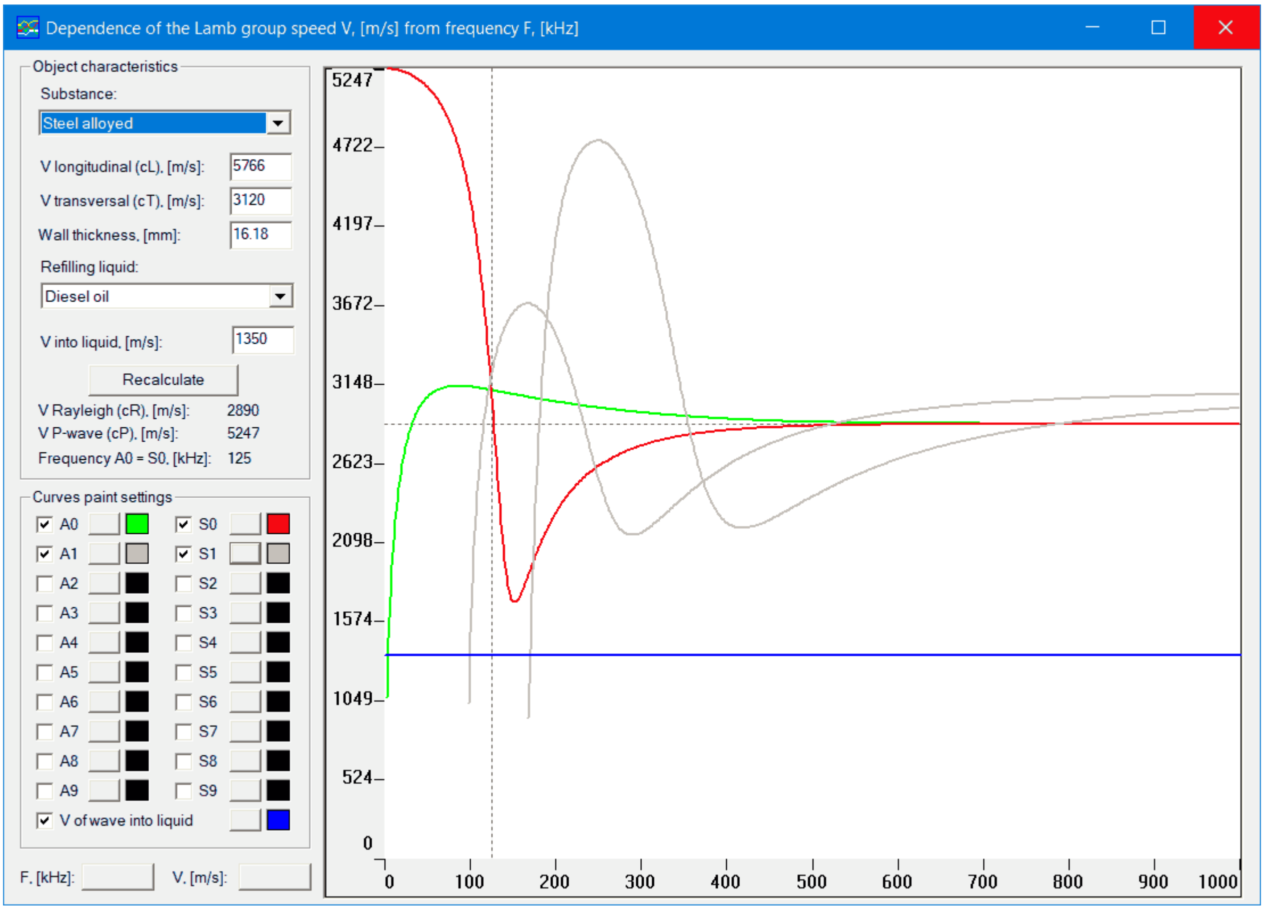


Fig. 15.4. Dialog box with dispersion curves

To calculate group velocities and construct dispersion curves, in the window **Dependence of the Lamb group speed V, [m/s] from frequency F, [kHz]**, some parameters should be set.

◇ In the group **Object characteristics**:

- name of the studied material in the list **Substance**;
- value of the wall thickness of the test object in the input field **Wall thickness, [mm]**;

- if necessary, the name of the filling liquid in the list **Refilling liquid**.

> After selecting the material, reference speed values appear in the input fields **V longitudinal (cL), [m/s]** and **V transversal (cT), [m/s]**). To change these values, it is necessary to enter new speed values in the corresponding input fields, while the **Substance** field becomes empty.
>
> After selecting the filling liquid, the input field **V into liquid, [m/s]** automatically displays the value of the velocity of sound in the selected liquid. The value of the velocity of sound in a liquid can be changed by entering a new velocity value in the input field, while the field **Refilling liquid** becomes empty.

◇ In the group **Curves paint settings**:

- activate the mode numbers necessary for the calculation (A0 … A9, S0 … S9) using the appropriate switches;
- select the displaying color for each dispersion curve using the standard **Color** dialog box (fig. 15.5) by clicking the corresponding button to the right of the fashion number;
- activate the switch **V of wave into liquid** to display the velocity of a longitudinal wave in a liquid and select the display color using the standard dialog box **Color** by clicking the corresponding button on the right from switch **V of wave into liquid**.

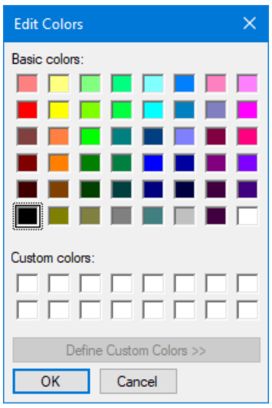


Fig. 15.5. Standard dialog box **Color**

In the main field of the window will be presented:

✧ calculated dispersion curves;

✧ Rayleigh wave speed versus frequency (dotted line);

✧ the value of the velocity of a longitudinal wave in a liquid (horizontal solid line).

To determine the velocity values at the frequency and mode of interest, move the cursor to a point on the corresponding curve with a given frequency value displayed in the **F, [kHz]** field, and read the result presented in the **V, [m/s]**.

15.5. Correlation

When processing two waveforms together, the program has the ability to calculate the total and interval correlation.

When calculating the full correlation function, the standard algorithm for calculating the correlation of two signals taken over the entire time interval is used. To calculate this function, it is necessary to activate the switch **Full** on **Viewbar** in the group **Correlation** (Fig. 14.2). The calculation results will be displayed as histograms in the window **Correlation / Time, [µs]** (Fig. 15.6).

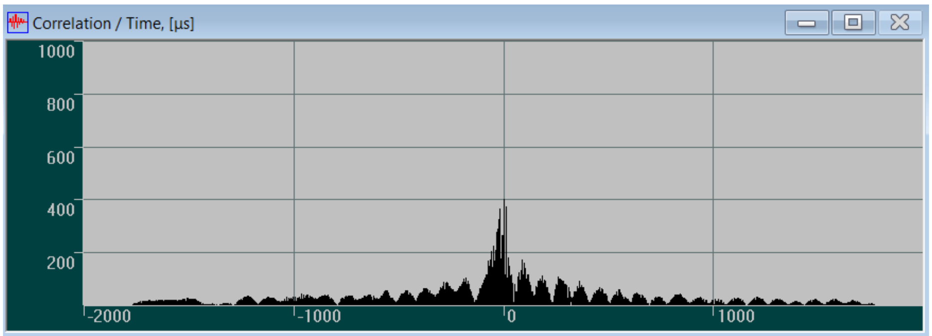


Fig. 15.6. Full AE Signal Correlation Function

When calculating the interval correlation function, turn on the **Interval** switch in the **Correlation** group. After that, blue vertical markers appear in the **OSC-1** window in the **OSC-1** group. Using these markers, you can select the required time interval in the oscilloscope spectrum and calculate the correlation function using a simplified algorithm. In this case, the correlation function is the result of calculating the correlation dependence of two signals OSC-1 and OSC-2, taken with different offsets. The calculation results will be displayed in the window **Correlation of interval / Time, [µs]** as histograms (Fig. 15.7).

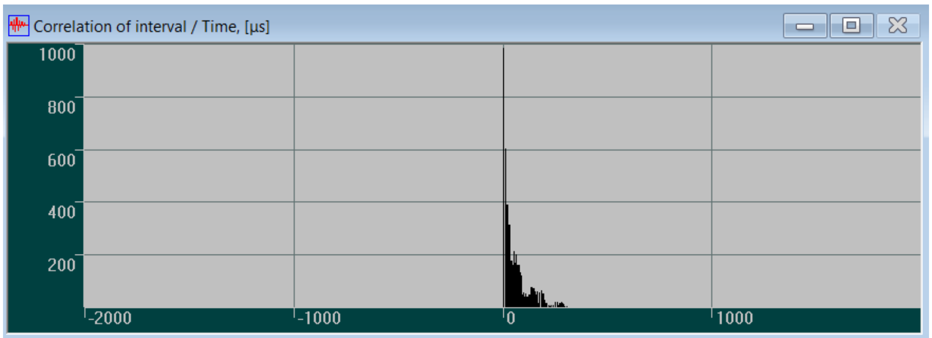


Fig. 15.7. Interval AE impulse correlation function

15.6. Window context menus

The context menu is called by pressing the right mouse button in the corresponding part of the window:

✧ in the plot display area;

✧ in the zones of the X or Y axes.

The context menu for the plot display area is shown in Fig. 15.8.

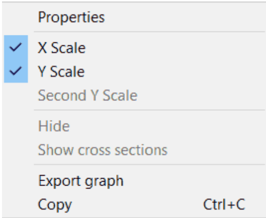


Fig. 15.8. Context menu for the plot display area

The actions performed when different menu items are selected are shown in the table 15.1.

Table 15.1.

Command	Action
Properties	Set window options.
X Scale	Displays and hides the X axis.
Y Scale	Shows and hides the Y axis.
Second Y Scale	Turns the optional Y axis on and off.
Hide	Hides the AE impulse waveform (for waveform windows only).
Show sections	Shows sections of spectrograms (when t = const, F = const).
Export	Converts the contents of the graphs to text format.
Copy	Copies the contents of the graphs to the Windows clipboard in a printable format.

The context menus for the X and Y axis zones are the same for both axes (Fig. 15.9).

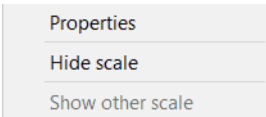


Fig. 15.9. Context menu for axes zone

The actions performed when different menu items are selected are shown in the table 15.2.

Table 15.2.

Command	Action
Properties	Sets the axis parameters.
Hide scale	Turns off the corresponding axis.
Show other scale	Enables another axis (in case that axis has been blanked out).

15.7. Setting the working field of the window

To set the working field of a window, hover over its main field and press the right mouse button, then in the context menu that appears (Fig. 15.9) select the command **Properties**. After that, the **Graph Setup** dialog box appears (Fig. 15.10).

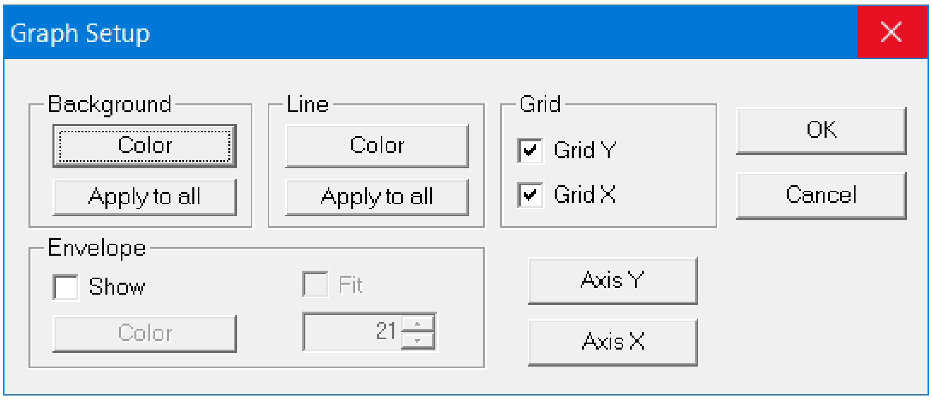


Fig. 15.10. Dialog box **Graph Setup**

The following window options can be set and configured in the dialog box:

- ✧ Change the background color of the selected window using the **Color** button in the **Background** group. The choice of color is made in the standard dialog box **Color** (Fig. 15.5). When you click the button **Apply to all** the selected background color is set immediately in all windows.
- ✧ Change the line color using the **Color** button in the **Line** group. The choice of color is made in the standard dialog box **Color** (Fig. 15.5). When you click the button **Apply to all** the selected line color is set immediately in all windows.
- ✧ Displaying the scale grid along the X and Y axes using the switches **Grid X** and **Grid Y** in the group **Grid**.
- ✧ Calculation and display of the envelope line using the **Show** switch in the **Envelope** group. If it is necessary to smooth the envelope, set the switch **Smooth** and use the spinner to specify the number of points over which smoothing should be performed. Changing the color of the envelope line is done by pressing the **Color** button in the same group. The choice of color is made in the standard dialog box **Color** (Fig. 15.5). The **Envelope** group is only available for the waveform window.
- ✧ Setting up the X and Y coordinate axes after pressing the **Axis X** and **Axis Y** respectively. Axes configuration is described further in the chapter 10.10 *"Setting the coordinate axes"*.

There is no group **Envelope** for the spectral window and the spectrogram window in the **Window settings** dialog box. Also, the commands of the **Background** and **Line** groups are not available for the spectrogram window.

15.8. Setting the coordinate axes

The coordinate axes are set up in the **Axis Setup Dialog** dialog box (Fig. 15.11), appearing either after selecting the command **Properties** in the context menu for the axes zone (Fig. 15.9), or after pressing the **Axis X** or **Axis Y** buttons in the **Graph Setup** dialog box windows (Fig. 15.10).

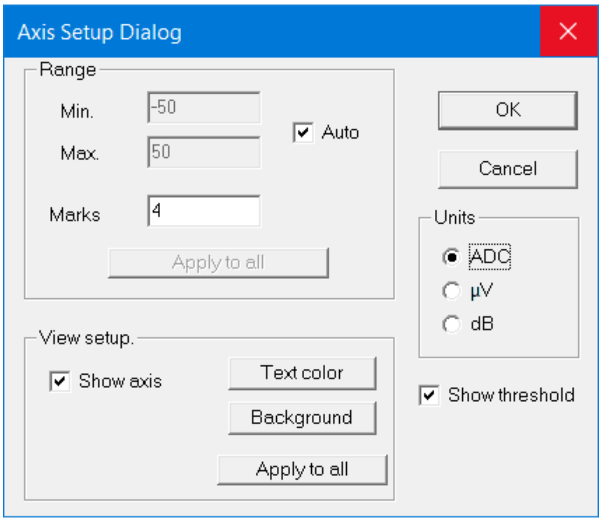


Fig. 15.11. Dialog box **Axis Setup Dialog**

The following options are available to the user for configuration:

◇ In the group **Range**:
- start and end values of the parameter for the selected axis in the input fields **Min** and **Max**, respectively, or automatic range selection in case of switch setting **Auto**;
- number of divisions on the axis in the considered range in the input field **Marks**;
- set time range preset values for all time axes in all windows using the button **Apply to all**.

◇ In the group **View Setup**:
- changing the color of parameter values using the button **Text color**. The choice of color is made in the standard dialog box **Color** (Fig. 15.5);
- change the background color of the axis using the button **Background**. The choice of color is made in the standard dialog box **Color** (Fig. 15.5);
- setting the selected axis background color and parameter value color in all windows at once when clicking the button **Apply to all**.

◇ In the **Units** group (only for the waveform window), one of the radio buttons is selected:
- ADC;
- µV;
- dB.

◇ To display the threshold level in the waveform window, enable the **Show threshold** switch (only for the waveform window).

Exit the **Axis Setup Dialog** dialog box with saving the entered values by clicking **OK**, without saving by clicking **Cancel**.

✶ ✶ ✶

Chapter 16. Working with waveforms

16.1. Working with files

Opening a waveform file

To load previously saved waveform files, select the command **File – Open OSC-1 (OSC-2)** in the main menu, or press the button (or) on **Toolbar**, or use the key combination **<Ctrl - O>** (only for opening waveforms from the first file). In the standard dialog box **Open file** that opens, select the required file and press the **Open** button. After that, the **OSC file header** dialog box opens (Fig. 16.1), which is described later in chapter 16.2. When opening waveforms from the second file, keep in mind that the parameters of the waveforms (sampling rate, number of points, etc.) of both files must be the same, otherwise the program will display an error message.

Closing waveform file

To close the waveform file, use the main menu command **File – Close-1** or **File – Close-2**. After executing this command, the waveform file is closed and the view bar is cleared.

16.2. Header of the waveform file

Dialog box **OSC file header** (Fig. 16.1) appears when opening a waveform file (the procedure is described above). In addition, this window can be opened when an waveform file is loaded using the main menu command **File – Show Header OSC-1** or **File – Show Header OSC-2**.

Window **OSC file header** contains information about the waveform file.

◇ The group **Measurement parameters** contains information about the time parameters of the measurement:
  - maximum measurement time —in the fields **Max measurement time**;
  - measurement start time —in the field **Start time**;
  - measurement stop time —in the field **Stop time**;
  - name of **.ALD** data file obtained as a result of measurement is in the field **Source data file name**, if the data is not saved, then the message **Data was not recorded** appears in this field.

◇ The group **OSC waves info** contains information about the number of waveforms in the file:
  - Number of actually captured waveforms is in the field **Number of OSC wave**;
  - current waveform number is in the input field with **Current OSC wave No**.

The selected current waveform is displayed in the window **Shared Digital Oscilloscope**. In this case, autoscaling of the oscilloscope window along the Y axis is performed either according to the full scale of the ADC, or according to the maximum of the current waveform (dialog box **Axis Setup Dialog**). The calculated frequency spectrum of the current waveform is displayed in the **Spectral power, [μV/MHz] / Frequency, [kHz]** window, the spectrogram is displayed in the **Spectrogram: Frequency, [kHz] / Time, [μs]** window.

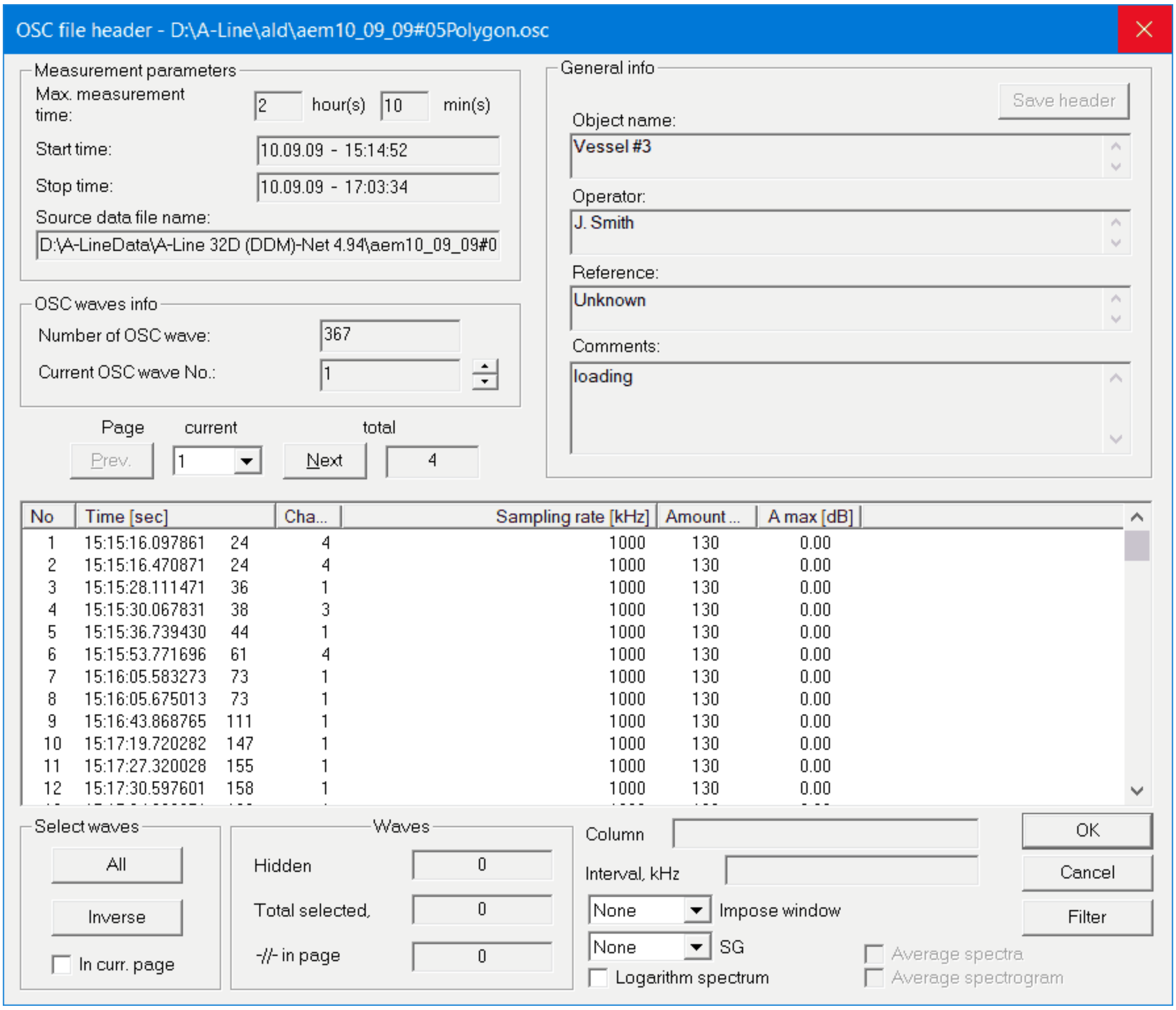


Fig. 16.1. Window **OSC file header**

◇ The group **General info** contains comments on the waveform file:

- object name is in the field **Object name**;
- operator name is in the field **Operator**;
- reference to the regulatory and technical documentation used to carry out the testing is in the field **Reference**;
- comments are in the field **Comments**.

Saving the entered information in the group is done by pressing the button **Save header**.

◇ All information about the received waveforms is presented in the frame list and displayed in parts. The total number of pages is indicated in the field **total**. The number of lines of data displayed on one page is set in the **Pages size** field in the **Adjusting the main parameters** dialog box (see chapter 17.1).

To view the next page, click **Next**, to return to the previous page click the button **Prev**. Each transition is accompanied by the appearance of a window reflecting the loading process. To open a file on an arbitrary page, use the list **current**.

◇ In the middle part of the **OSC file header** window, the OSC frame list contains the following information about all recorded waveforms:

- number of the recorded waveform is in the **No** column;

- waveform arrival time is in column **Time [sec]**;
- channel number is in the **Channel** column;
- maximum amplitude is in column **A max [dB]**;
- other parameters (sampling rate, number of points, duration, synchronization type, threshold, etc.) are in the appropriate columns.

All columns in the OSC frames field, except for the number column **No**, can be disabled or shown at the user's request. To do this, you need to activate or deactivate the corresponding parameters in the **Adjusting the main parameters** window (Fig. 17.1) in the **List of the viewing parameters**.

When you click on a column heading, the waveforms in the OSC frame field are sorted by the parameter corresponding to that column. In addition, the order of waveforms during navigation is carried out according to sorting in the list of signals in the window **OSC file header**.

◇ For the convenience of working with data in the list of OSC frames, information about the names of the columns and the size of the spectral ranges is presented in the corresponding fields:

- To obtain information about the names of columns in the list of OSC frames, move the mouse cursor to any number in any column and click on it with the left mouse button, after which the **Column** field will display its name.
- To obtain information about the value of the spectral interval, move the cursor to the corresponding value of energy or frequency and click on it with the left mouse button, after which the name of the column will appear in the field **Column** indicating the number of the spectral interval, and in the field **Interval, [kHz]** the corresponding spectral range will be indicated. The value of this range can be set in the window **Adjusting the main parameters**.

◇ The **Select waves** group contains tools for selecting waveform frames for subsequent operations on them:

- Button **All** to select all frames to work with.
- Button **Inverse** to invert previously selected frames (frames are selected using **<Ctrl>** or **<Shift>** and the left mouse button) - previously selected frames in the frames list will become unselected, and the rest of the frames contained in the file will be selected. When you press the **Inverse** button again, the complex will return to its original state.
- Switch **In curr. page** to perform **All** and **Inverse** operations on OSC frames on the current page. If the switch is cleared, these operations will be performed on all frames in the selected file.

◇ When selecting frames, the **Waves** group contains fields for displaying the number of selected and hidden frames of waveforms:

- field **Total selected** to display the total number of selected OSC frames on all pages;
- field **-//- in page** to display the number of OSC frames selected on the current page;
- field **Hidden** to display the number of hidden OSC frames.

◇ The program also provides other possibilities when working with frames, the implementation of which is carried out through the commands of the dialog box **OSC file header**:

- carrying out averaging with the choice of weight windows when choosing a window in the list **Impose window**;

- displaying the spectrogram in the viewer window when selecting the type of spectrogram in the list **SG**;
- carrying out automatic threshold wavelet filtering by pressing the button **Filter**;
- Displaying the frequency spectrum on a logarithmic scale using the switch **Logarithm spectrum**.

◇ After selecting OSC frames (there must be two or more), the following operations become available:

- performing the operation of averaging the spectrum using the switch **Average spectra**;
- Performing the spectrogram averaging operation using the switch **Average spectrogram**.

After setting all the necessary parameters to exit the **OSC file header** window, press the **OK** button, to exit without saving the parameters press button **Cancel**.

OSC frame field context menu

The context menu of the OSC frame field (Fig. 16.2) is called by right-clicking in the frame field.

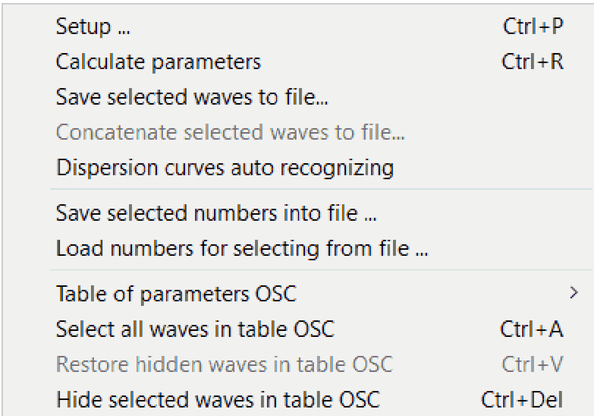


Fig. 16.2. Context menu for OSC frame field

The actions performed when different menu items are selected are shown in the table 16.1.

Table 16.1.

Command	Action
Setup	Sets viewing parameters, sets spectral frequency intervals.
Calculate parameters	Calculates the parameters activated when calling the command **Setup**.
Save selected waves to file	Saves selected OSC frames in a separate *.osc file.
Concatenate selected waves to file	Merges the selected OSC frames into a separate *.osc file.
Dispersion curves auto recognizing	Startes the procedure for automatic recognition of dispersion curves.
Save selected numbers into file	Saves only the numbers of selected OSC frames in a separate text file as a single column.
Load numbers for selecting from file…	Loads selected frame numbers from a text file.

Command	Action
Table of parameters OSC	Invokes the corresponding submenu.
Select all waves in table OSC	Selects all frames either in the entire file or on the activated page.
Restore hidden waves in table OSC	Restores all hidden frames.
Hide selected waves in table OSC	Hides selected frames either in the entire file or on the activated page.

The **Table of parameters OSC** command contains a submenu (Fig. 16.3), which is called by moving the cursor over it mice. The actions performed when selecting the various submenu items are shown in the table 16.2.

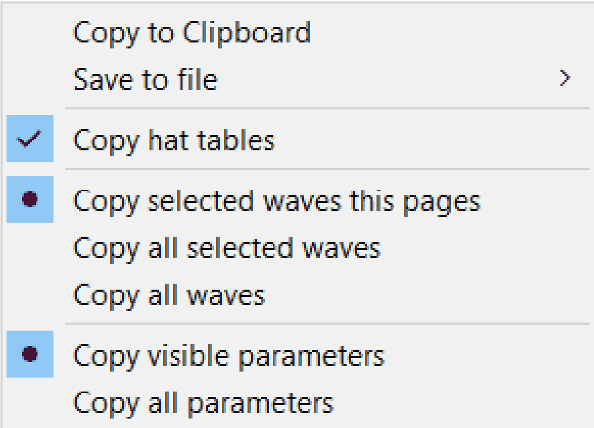


Fig. 16.3. Context menu for the command **Table of parameters OSC**

Table 16.2.

Command	Action
Copy to Clipboard	Saves OSC frame parameters to the clipboard.
Save to file	Saves OSC frame parameters in files of various formats (the corresponding submenu is called).
Copy hat tables	Turns on the mode of copying the header of the OSC frame parameters table.
Copy selected waves this page	Enables the mode of copying selected OSC frames only on the current page.
Copy all selected waves	Turns on the mode of copying all selected OSC frames in this file.
Copy all waves	Enables copying of all OSC frames.
Copy visible parameters	Enables the mode of copying only visible parameters presented in the parameters table.
Copy all parameters	Turns on the copy mode of all activated and presented in the table parameters.

When the **Save to file** submenu command is activated, the submenu appears as shown in Fig. 16.4.

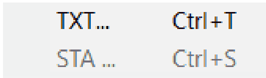


Fig. 16.4. Context menu for **Save to file** command

Table 16.3.

Command	Action
TXT…	Saves data in text format.

To execute commands **Copy all selected waves** etc., **Copy visible parameters** etc. you should move the mouse cursor to the required command, press the left mouse button, and then call this context menu again. The dot will be next to the selected command. After that, you should select a command to copy to the clipboard or to a file.

When executing the command **Copy to Clipboard** or **Save to file**, depending on the selected mode, different amount of data is stored or copied. When the command **Copy selected waves this pages** is selected, only the selected waveform files on this page are copied, when the command **Copy all selected waves** is activated, selected frames of waveforms from the entire file are copied, when executing the command **Copy all waves** all the frames contained in the file are copied.

When you select the **Copy visible parameters** command, only the data that is currently visible in the view table gets into the file or clipboard. When selecting the mode **Copy all parameters**, all parameter values activated in the dialog box **Adjusting the main parameters** are copied (Fig. 17.1), even if these columns are currently hidden in the view table.

Batch mode for calculating tables of parameters OSC

A batch mode is provided for automating the calculation of tables of parameters OSC and saving them to a text files. In this case, the A-Line OSC software is launched with the following keys:

/p *.osc

The software is launched with additional keys from the command line or from a bat-file. The result of the software operation in this mode is the creation of text files with tables of parameters OSC of the specified osc-files. The name of the created txt-file coincides with the name of the original osc-file. The calculation parameters of the normal software mode are used.

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Chapter 17. Configuring program settings

17.1. Main parameters

To configure the main parameters of the complex, select the main menu command **Window – Parameters**. After that, the dialog box **Adjusting the main parameters** appears (Fig. 17.1).

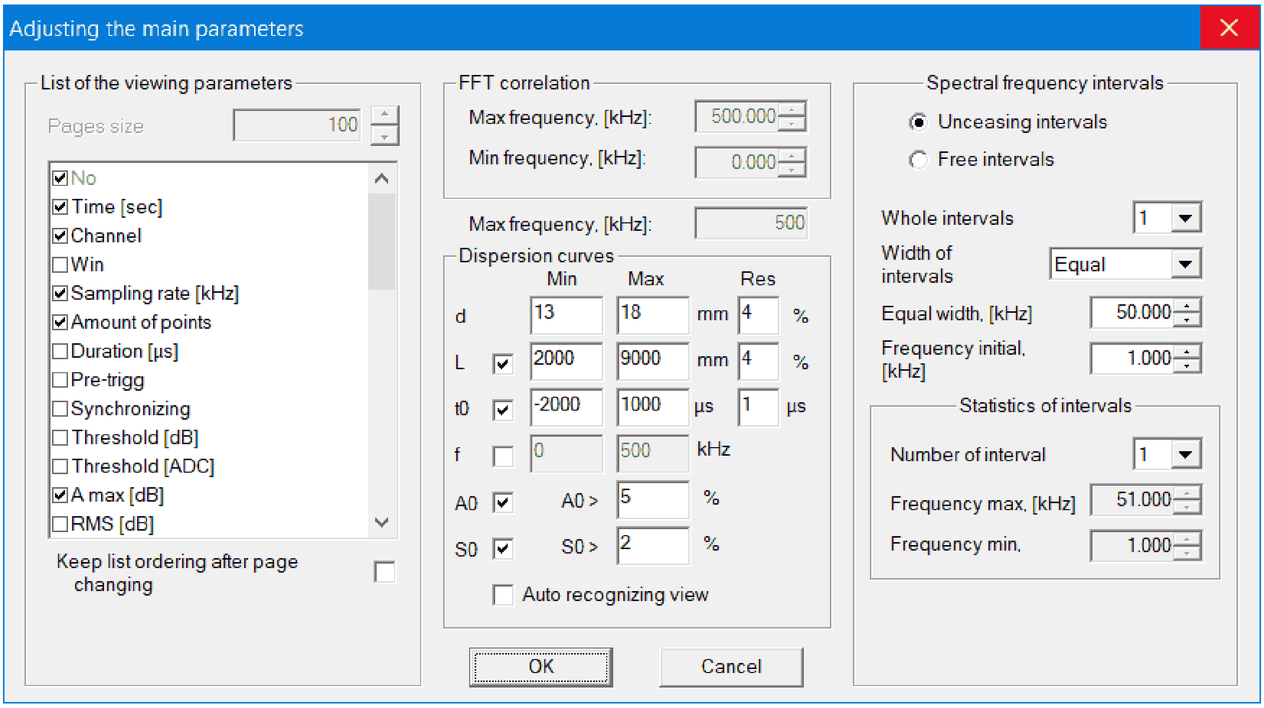

Fig. 17.1. Dialog box **Adjusting the main parameters**

The options are grouped in this dialog box.

◇ In the group **List of the viewing parameters**:

- spinner **Pages size** is designed to select the page size for displaying data (recommended value is 1000);
- The window below shows the full list of available options that the user can enable or disable:
  - **No** is waveform number in the file;
  - **Time [sec]** is time of the first crossing of the threshold level by the signal (arrival time value); time in seconds from the start of data acquisition in the selected file to registration (second time value);
  - **Channel** is number of the channel through which registration takes place;
  - **Win** is number of the oscilloscope window for displaying this channel in the main program **A-Line**;
  - **Sampling rate [kHz]** is sampling rate of the oscilloscope channel;
  - **Amount of points** is number of points on the waveform;
  - **Duration [µs]** is duration of the oscilloscope signal, depends on the number of points and signal frequency;

- **Pre-trigg** is the number of points in the oscilloscope frame containing the AE impulse prehistory before the first threshold crossing (see section *“Configuring oscilloscope channels”* on page 107);
- **Synchronizing** is selection of the oscilloscope signal registration mode (for **A-Line DDM** complexes, only asynchronous mode is available; for other complexes, the following four types of synchronization: asynchronous, MASTER, SLAVE, MASTER/SLAVE);
- **Threshold [dB]** is oscilloscope threshold value set in dB;
- **Threshold [ADC]** is oscilloscope threshold value set in ADC bits;
- **A max [dB]** is maximum absolute signal value of the current OSC frame;
- **RMS [dB]** is RMS value of the amplitude of the oscilloscope signal;
- **A max/RMS** is ratio of the maximum amplitude to the RMS value of the amplitude of the oscilloscope signal;
- **Energy [dB]** is the energy of the oscilloscope signal;
- **ASL [dB]** is average absolute value of the oscilloscope signal amplitude;
- **ZeroLevelIntersect, all/toMax** is the ratio of the number of zero crossings of the oscilloscope signal in the entire signal to the number of zero crossings by it until the maximum value is reached;
- **Theta [kHz]** is power of the exponent approximating the signal;
- **<Theta> [kHz]** is refined power of the exponent approximating the oscillating functions;
- **Error** is approximation error;
- **Thickness [mm]** is thickness of the testing object in mm, determined by automatic superposition of dispersion curves;
- **Distance [mm]** is distance in mm from the AE source to the AE sensor determined by automatic superposition of dispersion curves;
- **Multiplier of signal** is division value of one ADC bit in μV;
- **Max SI** is the maximum value of energy density in a given spectral range (SI);
- **Mean SI** is mean value of energy density in the spectral interval;
- **Max/Mean SI** is the ratio of the maximal spectral power on a given SI to its average value on a given SI;
- **Energy [%] SI** is energy contribution of a given spectral interval in relation to the total energy of the entire signal in %;
- **Max frequency [kHz] SI** is frequency characterizing the maximal spectral power in a given spectral interval;
- **Entropy SI** is entropy value for a given spectral interval.

- Switch **Keep list ordering after page changing** is designed to preserve the sequence of viewing parameters when changing pages.

All parameters, except for **No** (OSC frame number), can be enabled or disabled at any time. The **No** parameter is always enabled. All other values of the activated parameters are also presented in the OSC frame view field in the corresponding columns.

◇ In the **FFT correlation** group, the values of the frequency range boundaries are set for calculating the spectral correlation value:

- maximum frequency in the selected frequency range, according to which the correlation coefficient is calculated - spinner **Max. frequency, [kHz]**;
- minimum frequency in the selected frequency range, according to which the correlation coefficient is calculated - spinner **Min. frequency, [kHz]**.

◇ The **Max. frequency, [kHz]** input field is used to set the display value of the frequency range in the windows.

◇ In the group **Spectral frequency intervals** set the parameters of the spectral intervals:

- switch **Unceasing intervals** activates sequential consideration of the entire spectral interval under study, when one interval follows another without gaps;
- switch **Free intervals** allows the selection of arbitrary spectral intervals when gaps or overlapping intervals are possible;
- in the list **Whole intervals** the number of intervals is set (the maximum possible number of intervals is seven);
- list **Width of intervals** is intended for setting the size of the spectral interval (the following options are available — Octave, 1/2 Oct., 1/3 Oct., 1/4 Oct., 1 /8 Oct., Equal, Free);
- spinner **Equal width, [kHz]** becomes available when the option **Equal** is activated in the list **Width of intervals** and is intended for choosing the width of the spectral interval;
- spinner **Frequency initial, [kHz]** is designed to select the initial frequency, from which the widths of the spectral intervals are counted;
- subgroup **Statistics of intervals** contains data on the boundary values of the frequencies of all specified spectral intervals:
    - The spectral interval required for consideration can be selected in the list **Number of interval**;
    - The value of the maximum frequency of the selected frequency interval is shown in the field **Frequency max, [kHz]**;
    - The value of the minimum frequency of the selected frequency interval is shown in the field **Frequency min, [kHz]**.

If **Free intervals** option is selected for the width of the spectral interval, the frequency limit values are set by the spinners **Frequency max, [kHz]** and **Frequency min, [kHz]** respectively. For other options, the frequency values are calculated automatically based on other specified parameters.

◇ In the **Dispersion curves** group, set the parameters for automatic batch recognition of dispersion curves on the spectrogram:

- In the line **d** in the input fields **Min.** and **Max.** indicate the minimum and maximum possible wall thickness of the test object in mm, in this case, the calculation will be carried out with the step specified in the input field **Res** in %.
- In the **L** line, the switched on switch allows taking into account the distance from the AE source to the AE sensor in the calculations. In the input fields **Min.** and **Max.** indicate the minimum and maximum possible distance in mm, while the calculation will be carried out with the step specified in the input field **Res** in %.
- In the **t0** line, the enabled switch allows you to take into account in the calculations the time of signal emission by the AE source relative to the moment of the beginning of the waveform. In the input fields **Min.** and **Max.** indicate the minimum and maximum possible time in μs, while the calculation will be carried out with the step specified in the input field **Res** also in μs.

- In the **f** line, the switched on switch allows you to set the limits of the frequency range in kHz in the fields **Min.** and **Max.**.
- The **A0** switch allows you to set the threshold for switching a point into the A0 mode, specified in the **A0** field in % of the maximum.
- The **S0** switch allows you to set the threshold for switching a point into the S0 mode, specified in the **S0** field in % of the maximum.
- To display the result of the dispersion curve recognition operation on the spectrogram, set the **Auto recognizing view** switch.

After setting all the necessary parameters, to exit the window **Adjusting the main parameters**, press the button **OK**, to exit without saving press the button **Cancel**.

It is important to note that when you select the **Window – Parameters** command, in the **Adjusting the main parameters** dialog box (Fig. 17.1) group **Spectral frequency intervals** is not available. When this dialog box is called from the OSC frame view field (command **Settings…**), the group **FFT correlation** is not available.

17.2. Spectrogram settings

General parameters of spectrograms

To configure the parameters for calculating and visualizing spectrograms, select the main menu command **View – Spectrogram settings**, or use the button in the toolbar. After that, the dialog panel **Spectrogram settings** (Fig. 17.2) opened on the page **Common**.

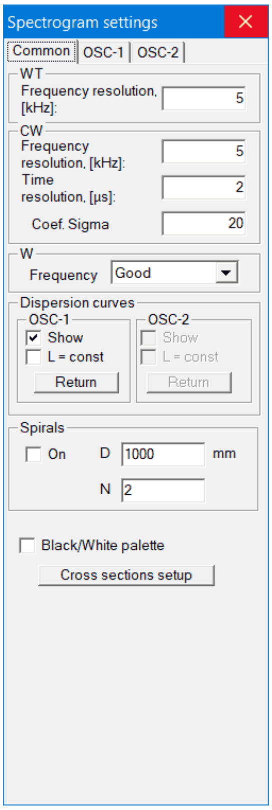

Fig. 17.2. Dialog box **Spectrogram settings**, tab **Common**

This tab defines the parameters common to the OSC-1 and OSC-2 panels used to calculate spectrograms. The general parameters are divided into appropriate groups, depending on the chosen calculation method (wavelet transform based on the Morlet wavelet, Choi-Williams time-frequency distribution, Wigner transform).

◇ The **WT** group provides the following controls for setting wavelet transform parameters:
  - Input field **Frequency resolution, [kHz]** to set the frequency resolution value.

◇ The following values are set for the Choi-Williams transformation in the group **CW**:
  - The value of the frequency resolution value in the input field **Frequency resolution, [kHz]**.
  - The value of the time resolution value in the input field **Time resolution, [μs]**.
  - The value of the image contrast ratio in the input field **Coef. Sigma**. A higher Sigma value corresponds to a better resolution.

◇ For the Wigner transform, the **W** group contains the list **Frequency**, which is used to select the quality of the calculation detail for this time-frequency transform.

◇ To work with dispersion curves, the group **Dispersion curves** contains the following controls (subgroup **OSC-1** or **OSC-2** respectively):
  - switch **Show** to superimpose dispersion curves on the corresponding spectrogram;
  - switch **L = const** to keep the value of the distance from the AE sensor to the AE source constant when manually moving the curves along the spectrogram;
  - button **Return** to return to the initial values of the distance from the AE sensor to the AE source and the emission time;
  - in subgroup **Spirals**:
    - switch **On** to take into account the cylindrical shape of the testing object;
    - field **D** to enter the diameter of the test object in mm;
    - field **N** for entering the maximum number of turns of the spiral along which the acoustic wave passes on the way from the AE source to the AE sensor.

◇ Clicking the **Cross sections setup** button opens the spectrogram sections setup dialog box (Fig. 17.3). A detailed description of cross section setup is provided later in the chapter *“Setting sections”*.

◇ To display spectrograms in black and white, there is a switch **Black/White pallette**.

After setting the necessary parameters, you can left-click in the spectrogram display field, or activate any other page (**OSC-1**, **OSC-2**) of the dialog panel, or move the cursor to any other input field on this page, after which the program will perform the corresponding calculations.

Setting sections

The program provides the possibility of constructing sections of spectrograms. Depending on which parameter is fixed: time (**t = constant**) or frequency (**F = constant**), the section will be shown on spectrum, or on an waveform, respectively. The view of the section will depend on the type of spectrogram and the value of the selected parameter (time or frequency).

To set up cross sections, press the button **Cross sections setup** in the dialog box **Spectrogram settings** on the tab **Common** (Fig. 17.2). After that, the **Cross sections setup** dialog box opens (Fig. 17.3), in which the parameters of the sections are set.

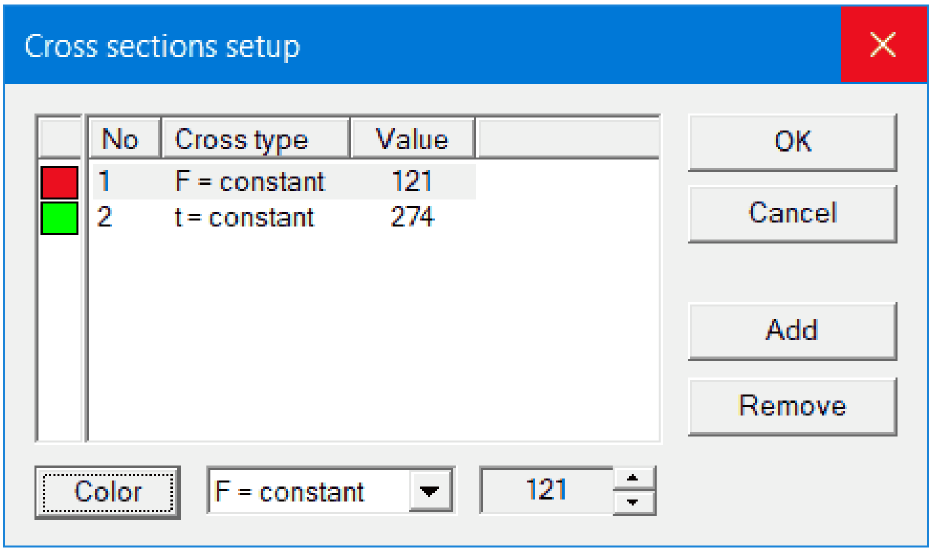

Fig. 17.3. Dialog box **Cross sections setup**

◇ To enter section parameters, press the **Add** button, then move the mouse cursor to the line that appears and activate it using the left mouse button. After that, you can enter the parameters of the sections:

- Color selection is made in the standard **Color** dialog box (Fig. 15.5) after pressing the button **Color**;
- section type selection is made in the list **t=constant** or **F=constant**;
- The value of the selected parameter, time or frequency, is set using the spinner.

◇ After setting the parameters of the section, press the button **OK**, to cancel the set parameters, press the button **Cancel**, to delete the entered parameters, press the button **Remove**.

◇ To view the obtained sections, move the mouse cursor to the field of the corresponding window, press the right mouse button and call the context menu, in which select the command **Show cross sections**. This command is available only if the section settings are set in the **Cross sections setup** dialog box.

After that, the corresponding sections will be shown on the waveform and spectrum (Fig. 17.4).

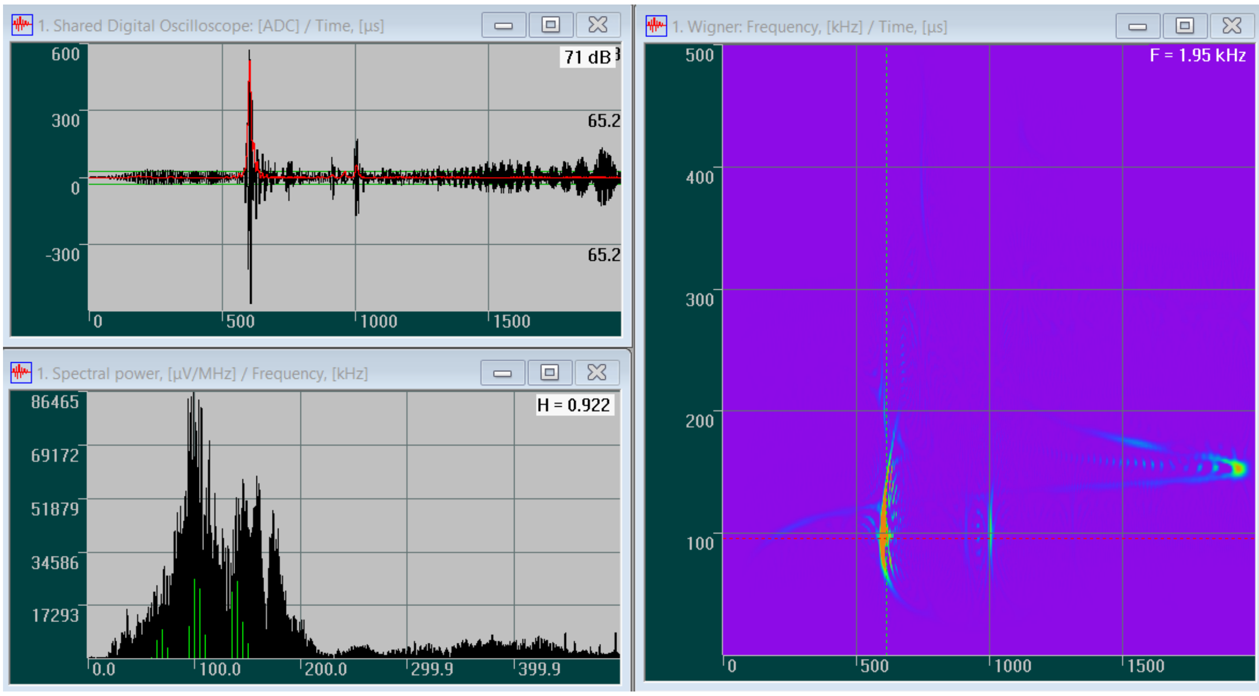

Fig. 17.4. Spectrogram cross sections

To simultaneously view all specified sections (**t = constant, F = constant**), you must activate the command **Show cross sections** for each window on the view panel.

Spectrogram settings for OSC-1 and OSC-2 view bars

For each view bar, in addition to the general parameters (frequency resolution, time resolution) that are the same for the spectrograms of the **OSC-1** and **OSC-2** panels, there are parameters, the values of which may differ. The values of these parameters are set for each spectrogram on the **OSC-1** and **OSC-2** pages, respectively.

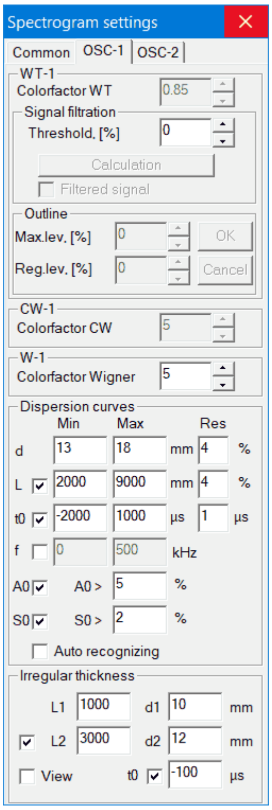

Fig. 17.5. Dialog box **Spectrogram settings**

◇ For wavelet spectrograms in the **WT-1** group (page **OSC-1**) or in the **WT-2** group (page **OSC-2**) set the following parameters:

- Factor for displaying energy density in a certain color using the **Colorfactor WT** spinner (minimum value of energy density is displayed in purple (white) color, maximum value is in red (black). Increasing the value of this parameter improves the visibility of weak components on the wavelet spectrogram).
- Filtration threshold value, below which all function values are reset, using the **Threshold, [%]** spinner in the **Signal filtration** subgroup.
- To carry out the filtration process, press the button **Calculation** in the subgroup **Signal filtration**.
- To view the filtering results, set the switch **Filtered signal** in the **Signal filtration** subgroup.

◇ To highlight any point of the area on the selected wavelet spectrogram, in which the energy density exceeds the user-specified level, in the subgroup **Outline** of the group **WT-1** (page **OSC-1**) or in the group **WT-2** (page **OSC-2**) you need to set the following parameters:

- The value of the threshold for searching for local maxima in percent using the spinner **Max. lev. [%]**.
- The value of the threshold for searching for the region of the local maximum in percent using the spinner **Reg. level [%]**.

For a more detailed description of the contouring procedure, see *“Outline”*.

◇ For spectrograms obtained using the Choi-Williams transform, in the **CW-1** group (page **OSC-1**) or in the **CW-2** group (page **OSC-2**) set the following parameter:

- Factor for displaying energy density in a certain color using the **Colorfactor CW** spinner (minimum value of energy density is displayed in purple (white) color, maximum value is red (black)).

◇ For spectrograms obtained using the Wigner transform, in the **W-1** group (page **OSC-1**) or in the **W-2** group (page **OSC-2**) set the following parameter:

- Factor for displaying energy density in a certain color using the **Colorfactor Wigner** spinner (the minimum value of energy density is displayed in purple (white) color, the maximum value is displayed in red (black)).

◇ To configure the recognition of dispersion curves on the spectrogram of the displayed waveform, in the **Dispersion curves** group, set the following parameters:

- In the line **d** in the input fields **Min.** and **Max.** enter the minimum and maximum wall thickness of the testing object in mm. In this case, the calculation will be carried out with the step specified in the input field **Res** in %.
- In the **L** line, the switched on switch allows taking into account the distance from the AE source to the AE sensor in the calculations. In the input fields **Min.** and **Max.** indicate the minimum and maximum distance in mm, while the calculation will be carried out with the step specified in the input field **Res** in %.
- In the **t0** line, the switched on switch allows taking into account in the calculations the time of the AE impulse emission by the source relative to the moment of the beginning of the waveform. In the input fields **Min.** and **Max.** indicate the minimum and maximum time in μs, while the calculation will be carried out with the step specified in the input field **Res** also in μs.
- In the **f** line, the switched on switch allows you to set the limits of the frequency range in kHz in the fields **Min.** and **Max.**.
- The **A0** switch allows you to set the threshold for switching a point into the A0 mode, specified in the **A0** field in % of the maximum.
- The **S0** switch allows you to set the threshold for switching a point into the S0 mode, specified in the **S0** field in % of the maximum.
- To display the result of the dispersion curve recognition operation on the spectrogram, set the **Auto recognizing** switch.

◇ To take into account the non-uniform thickness of the testing object when constructing dispersion curves, the following parameters are set in the **Irregular thickness** group:

- In the field **L1** indicate the length of the first section of the testing object, the thickness of which corresponds to the value specified in the field **d1**.
- In the field **L2** indicate the length of the second section of the testing object, the thickness of which corresponds to the value specified in the field **d2**. These values are taken into account when setting the switch on this line. If the switch is cleared, the fields **L2** and **d2** become inactive and the thickness of the testing object is assumed to be uniform.
- The set switch **t0** makes it possible to take into account the value of the time of emission of the AE impulse by the source relative to the moment of the beginning of the waveform, which is indicated in the adjacent input field.
- The set switch **View** displays the calculated dispersion curves on the spectrogram taking into account the irregular thickness of the testing object.

Outline

The program provides for the procedure for selecting a region in the vicinity of any point on the wavelet spectrogram, in which the value of the energy density exceeds the level specified by the user. This is called the outline procedure, which is carried out in two stages.

At the first stage, only those local maxima are calculated, the values of which are defined, set by the user, as a percentage of the value of the main maximum. Other wavelet maxima, whose values are less than the specified value, will not be taken into account in further calculations.

◇ To carry out the first stage of the calculation in the subgroup **Contouring** you need:

- select the **Wavelet** value in the view panel (Fig. 14.2) in the calculation method display field spectrograms **SG**;
- select the main menu command **View – Spectrogram settings** or use the button on **Toolbars** to set the parameters of the contouring procedure.

After that, the **Spectrogram settings** dialog box appears, which should be opened on the **OSC-1** tab or on the **OSC-2** tab (Fig. 17.5).

Then in the subgroup **Outline** you need to set:

- value of the search threshold for local maxima in percent in the field **Max. lev. [%]**;
- Region threshold value in percentage in **Reg. lev. [%]**.

To start the outlining process, press the button **OK** in the subgroup **Outline** or the button ( ) on **Toolbars**.

The outline process begins. After performing the calculation, the button ( ) on the **Toolbar** will be drowned, and the field **Max. lev. [%]**, in which the value of the threshold of local maxima is set, will become unavailable.

> ✱ Setting the search threshold for local maxima to 10% means that only those local maxima of the energy density level on the spectrogram will be found, the value of which is at least 10% of the main maximum; when setting the value to 0%, all local maxima will be found, including the main maximum.
>
> Setting the area threshold value to 50% means that only those areas of the local maximum, the value of which is at least 50% of the value of this local maximum, will be colored on the wavelet spectrogram.

At the second stage, the region is selected in the vicinity of the point selected by the user on the wavelet spectrogram, in which the value of the energy density exceeds the level specified by the user.

◇ To carry out the second stage of the calculation, move the mouse cursor to the point relative to which the calculation will be performed and press the left mouse button, while the status bar will display the current values of the coordinates of the selected point.

After that, the region of the local maximum is highlighted (colored in orange) in the field of the wavelet graph, and the calculated energy value in dB and in percentage at this point appears in the status bar. The upper right corner shows the maximum value of the wavelet energy and frequency resolution.

◇ To clear the wavelet window, press the **Cancel** button in the **Outline** subgroup or the button ( ) on **Toolbars**. After that, the initial image of the wavelet spectrogram appears and it becomes available to change the parameter of the area threshold value in percent in the field **Reg. lev., %**. To change the value of the search threshold for local maxima in percent in the field **Max. lev., %**, press the button **OK** in the subgroup **Outline** and enter a new threshold value for local maxima.

◇ To complete the operation of the **Outline** algorithm, you must once again press the **OK** button in the **Outline** subgroup or the button ( ).

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Section 4

A-Line Stat software

Chapter 18. Brief Description of A-Line Stat software

The **A-Line Stat** software is an add-in program of AE data analysis. It is designed for automatic clustering of acoustic emission data. A specific feature of this program is the possibility to work both with impulses and with waveforms.

The initial data for **A-Line Stat** are as follows:

✧ acoustic emission impulse file (.*ald* format);

✧ waveform file (.*osc* format).

The results of work are:

✧ automatic structuring of data;

✧ data assignment to clusters corresponding to different acoustic events.

The program concept is based on the fact that AE signals generated by the same source of acoustic emission must have a similar shape. Such similarity can be explained by the similar way of origination of acoustic emission waves, and by the same acoustic path of wave propagation. Thus, the principle of data analysis implemented in the **A-Line Stat** Stat software is formulated as follows: AE signals being similar in shape and spectrum can be radiated with a high degree of probability from the same acoustic emission source, and, alternatively, the signals having significantly different shapes and spectrums are radiated from different AE sources or can appear due to noises.

The basis of the algorithm is the clustering analysis of data that allows for making an uncontrollable classification of data is the basis for the algorithm. The data being similar to each other in a number of preliminary selected attributes are assigned to the same cluster.

In the **A-Line Stat** software, AE signals are the subject of clustering, and as the measure of similarity the cross-correlation coefficient of AE signals is used.

Basic stages of work with program:

◇ Clustering of waveforms based on the shape and spectrum similarity. Extraction of the “waveforms clusters”:
  - separation of waveforms recorded by diferrent channels;
  - clustering of waveforms by the form and spectrum similarity;

◇ extraction of “packs” of AE impulses recorded from one AE event;

◇ clustering of “packs” of impulses based on the results of preliminary clustering of waveforms. Obtaining of “clusters of AE sources”;

◇ determination of characteristics of each cluster.

The initial data of the program are time-ordered AE impulses and AE waveforms. Each figure designates an acoustic emission impulse (Fig. 18.1, where figures of different shapes designate impulses recorded by different channels).

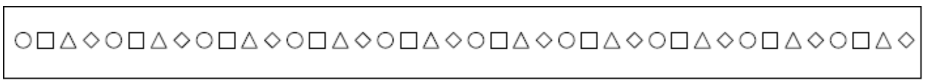

Fig. 18.1.

At stage 1, the impulses and waveforms are grouped according by different channels (Fig. 18.2). Next, the waveforms are clustered (Fig. 18.3, where the figure color designates the cluster number).

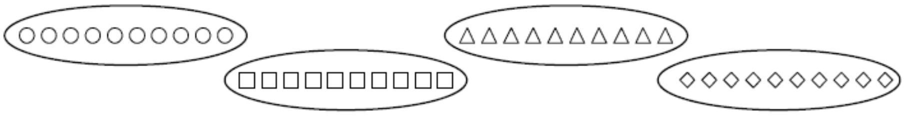

Fig. 18.2.

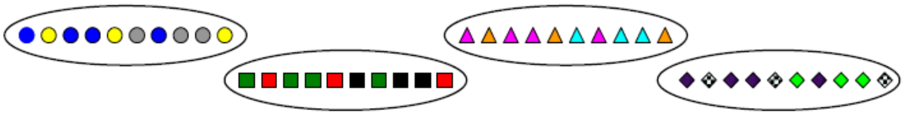

Fig. 18.3.

As a result of calculations, at the end of the first stage we obtain a sequence of “colored” AE impulses (Fig. 18.4, wherein the shape designates the channel number, and the color designates the cluster number).

Fig. 18.4.

Stage 2 is extraction of “packs” of AE impulses recorded from one AE event. The packs are extracted by means of a pop-up window of the specified characteristic length (Fig. 18.5, 18.6).

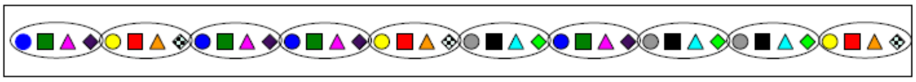

Fig. 18.5.

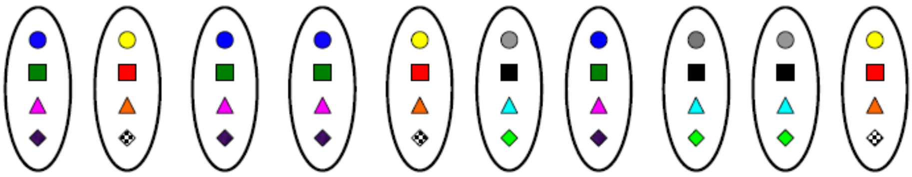

Fig. 18.6.

Stage 3 is clustering of “packs” of impulses and formation of classes of AE events. It should be noted, that in some “packs” the shape of AE impulses appears to be identical, as evidenced by identical “colors” of the impulses recorded by the same channel. Such “packs” are combined into “clusters of AE sources” (Fig. 18.7).

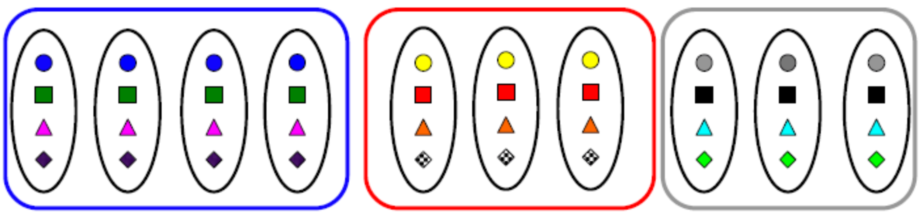

Fig. 18.7.

At stage 4, the calculation of attributes, typical for each “AE sources cluster” is performed:

✧ numbers of three channels with the maximum amplitude of signals {$chan\_A_1$, $chan\_A_2$, $chan\_A_3$};

✧ average values of amplitude for channels {av_A_1, av_A_2, av_A_3};

✧ numbers of three channels with the minimum time-of-arrival of signals {$chan\_T_1$, $chan\_T_2$, $chan\_T_3$}.

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Chapter 19. Program interface

Software contains three tabs: **OSC clustering**, **Pack clustering** and **Pack features**, on which the user can perform statistical data processing.

◇ On the **OSC clustering** tab (Fig. 19.1), calculation of the correlation matrix for OSC-file (*.osc*) (see section 20.1) and calculation of the signal clustering by the specified "Parameters" (see section 20.2) are performed.

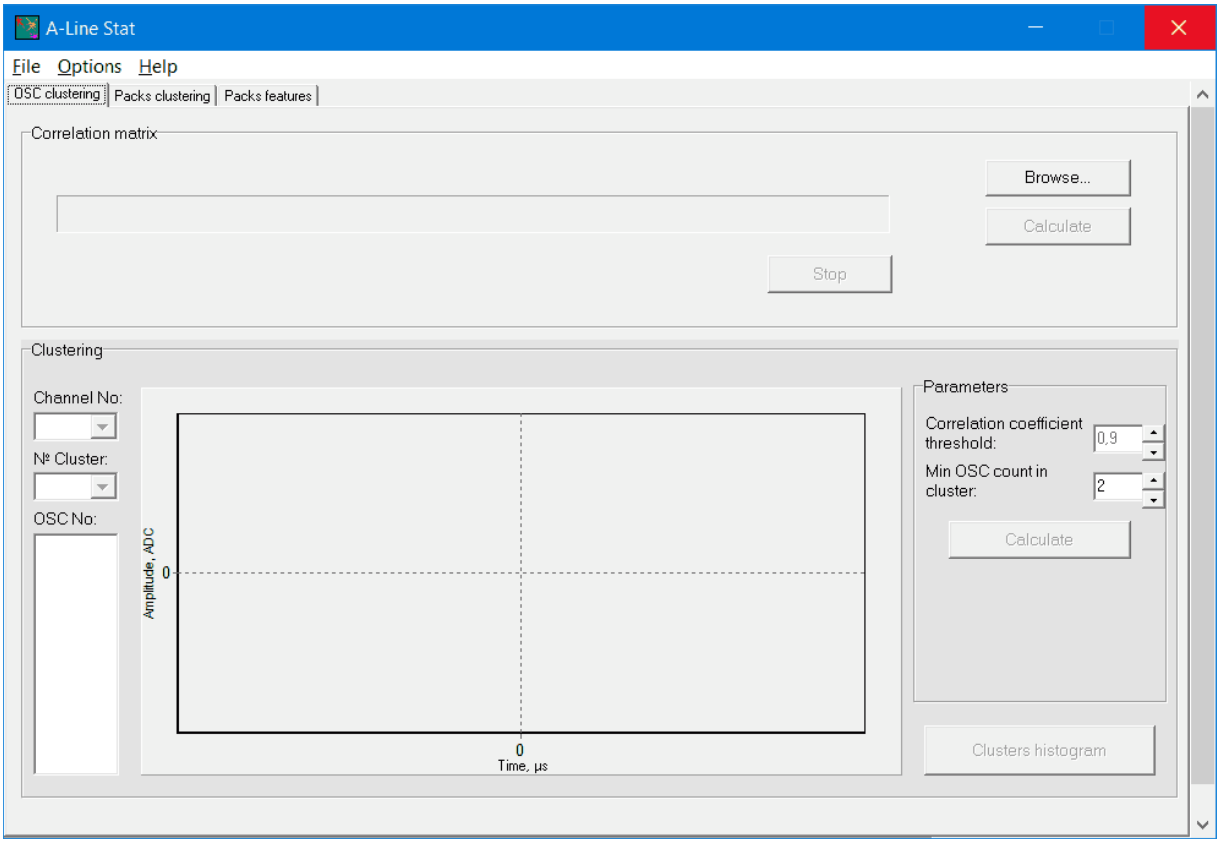

Fig. 19.1. **OSC clustering** tab

In the **Correlation matrix** group, the user has the following controls:

- button **Browse** is selection of OSC-file (**.osc*), the file of incomplete correlation matrix (**.ecor*) or the file of complete correlation matrix (**.cor*);
- button **Calculate** is calculation of the correlation matrix;
- button **Stop** is interruption of the complete correlation matrix calculation with saving the calculated data to the incomplete correlation matrix file (**.ecor*).

The **Clustering** group provides the user with the following controls and visualizations:

- list **Channel No** to select the required channel number;
- list **№ Cluster** to select the desired cluster number;
- field **OSC No** to display waveform numbers in the selected cluster of the selected channel;
- in the group **Parameters**:

- ◦ field **Correlation coefficient threshold** to set the measure of cluster similarity for each channel;
- ◦ field **Min OSC count in cluster** to set the minimum number of waveforms that form a cluster;
- ◦ button **Calculate**, after pressing which the signal clustering is calculated;
- button **Cluster histogram**, after clicking which opens the review of signals assignment to the clusters for each channel.

◇ On the **Packs clustering** tab (Fig. 19.2), data is clustered by class (see 20.3).

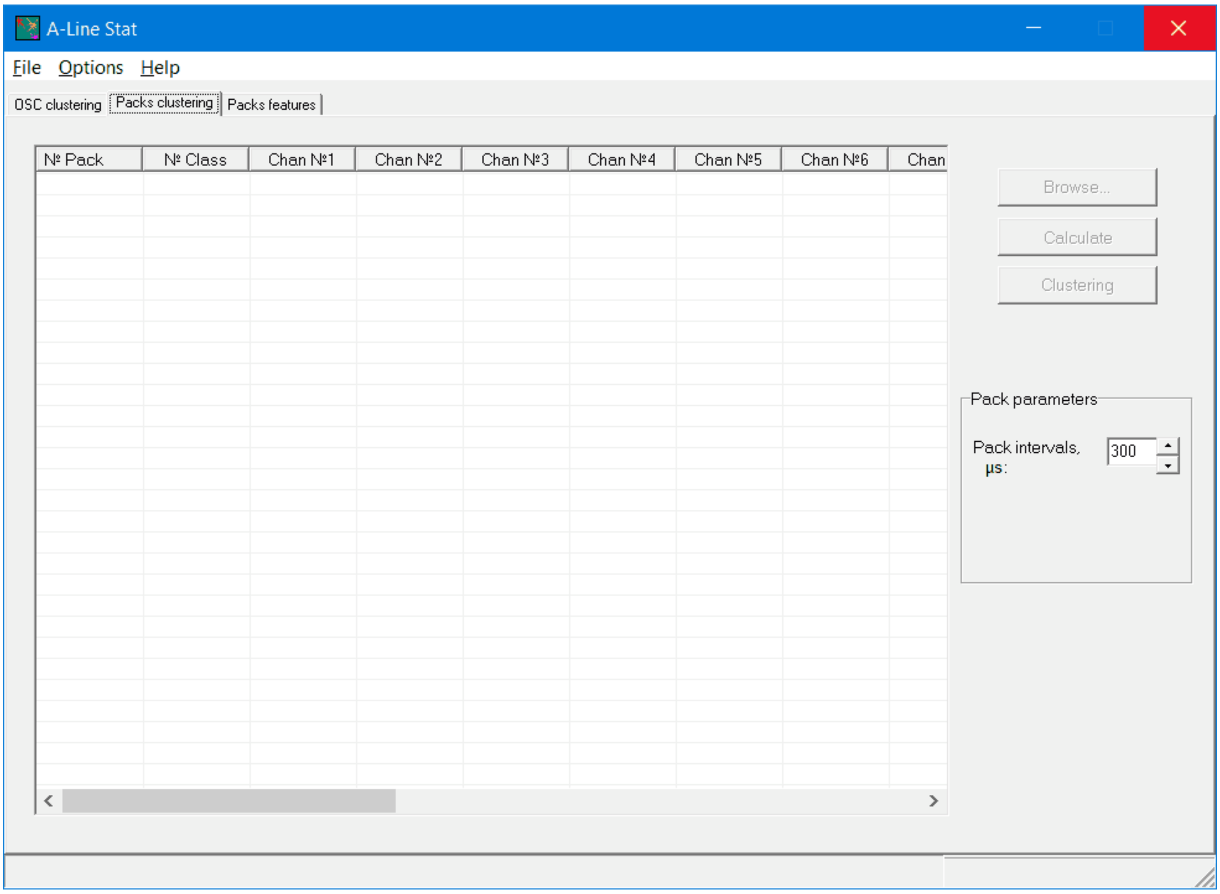

Fig. 19.2. **Packs clustering** tab

◇ The tab provides the user with the following controls:

- **Browse** button to select the data file (**.ald*) corresponding to the OSC-file (**.osc*) in the **OSC clustering** tab;
- button **Calculate** for assignment of the clusters to channels and packs;
- button **Clustering** for assignment of the data to classes;
- in the group **Pack parameters**:
  - ◦ input field **Pack interval, µs** to specify the the length of AE impulses pack in µs.

◇ On the **Pack features** tab (Fig. 19.3), the basic parameters of signals are calculated (the number of channel with the maximum signal amplitude, the average value of amplitude, the number of channel with the minimum time-of-arrival of signal) (see section 20.4).

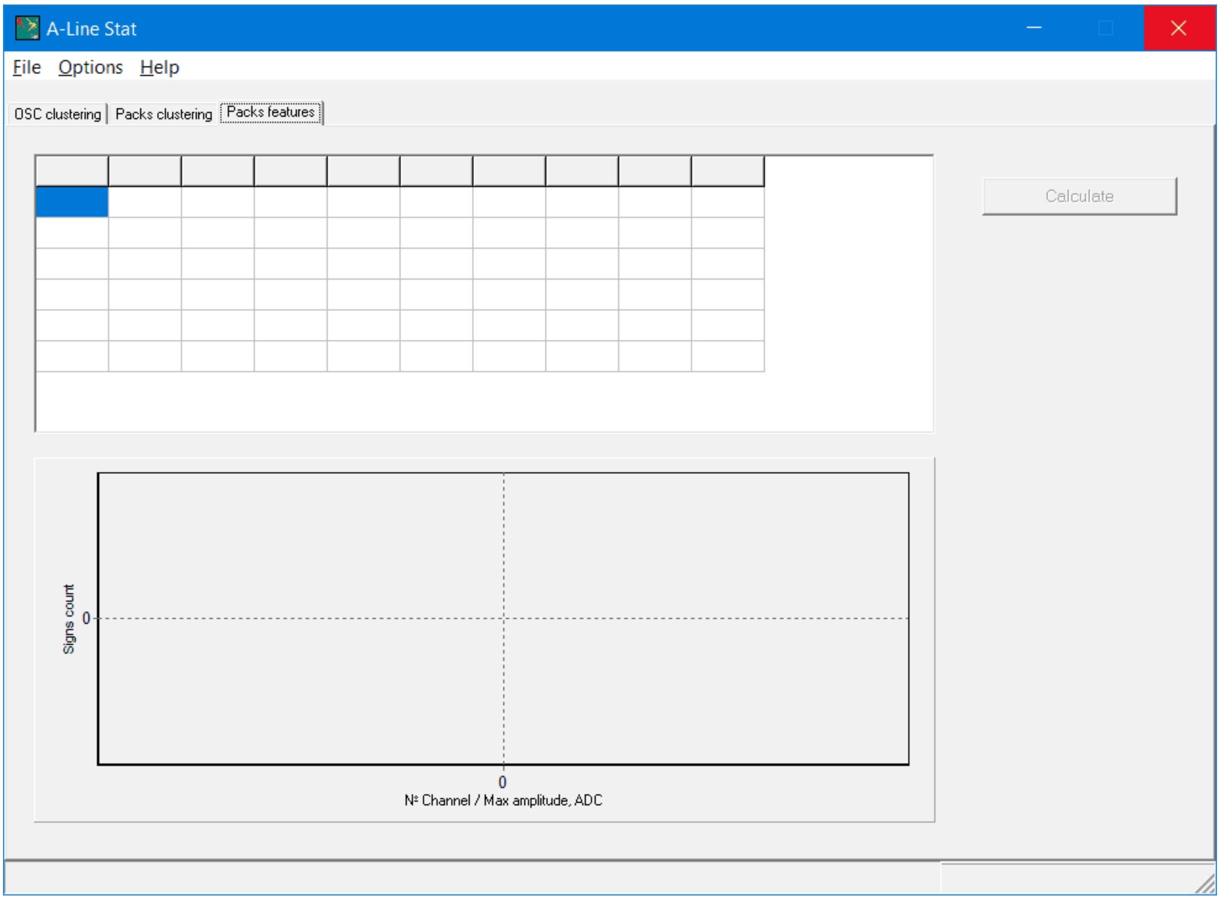

Fig. 19.3. **Pack features** tab

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Chapter 20. Working with the program

20.1. Calculation of the correlation matrix for OSC-file (*.osc)

The correlation matrix is calculated on the **OSC clustering** tab. To open an OSC file (*.osc*), it is necessary to click the **Browse** button, and a dialog box of file opening appears. In the **File type** list, select *Osc file (*.osc)* and point the required file (Fig. 20.1). Click on the **Calculate** button. The progress bar shows the execution of calculation and displays the volume of executed calculation as % (Fig. 20.2).

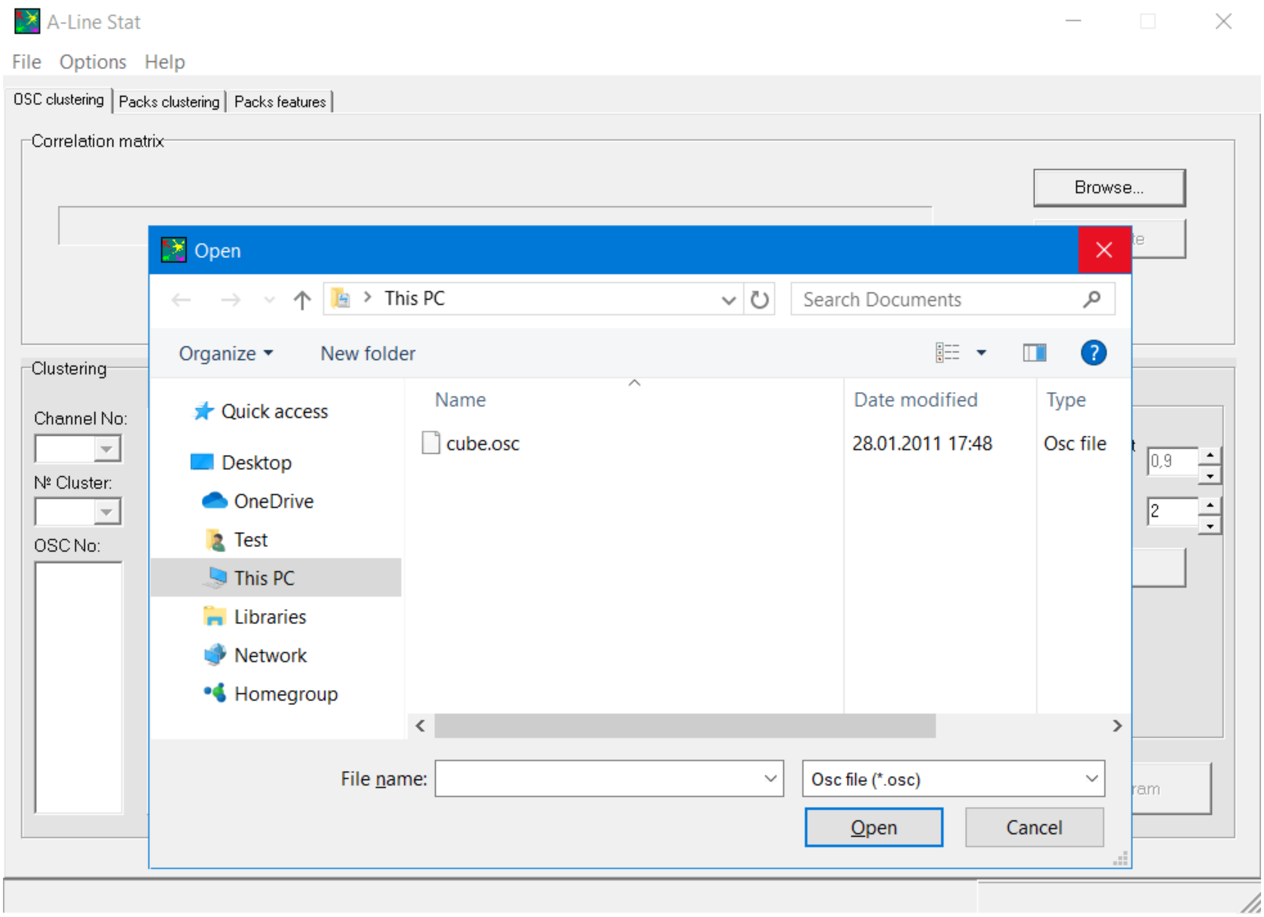

Fig. 20.1. Opening **.osc* file

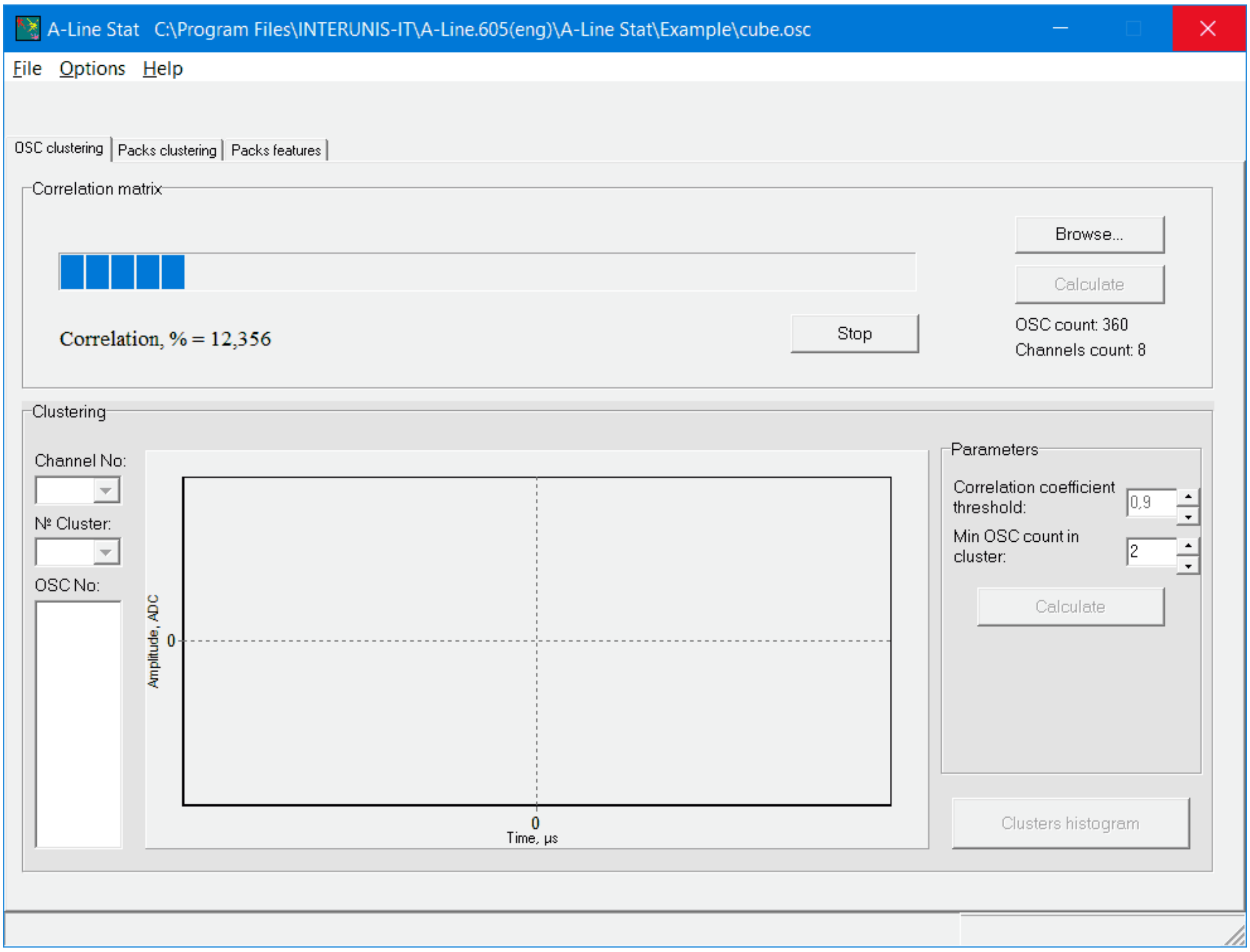

Fig. 20.2. Calculation of signal correlation matrix

If OSC-file contains many waveforms, the correlation matrix calculation process may last too long, and one computer session will be insufficient to bring it to a close. Therefore, the possibility exists of calculating the correlation matrix not at once, but in parts. When the calculation is activated, the **Stop** button becomes accessible, and after clicking it the dialog box of saving the incomplete correlation matrix file (**.ecor*) appears (Fig. 20.3). It is necessary to point the file name and click the **Save** Then, the possibility exists either to continue the correlation matrix calculation through clicking the **Calculate** button or to finish the work with software.

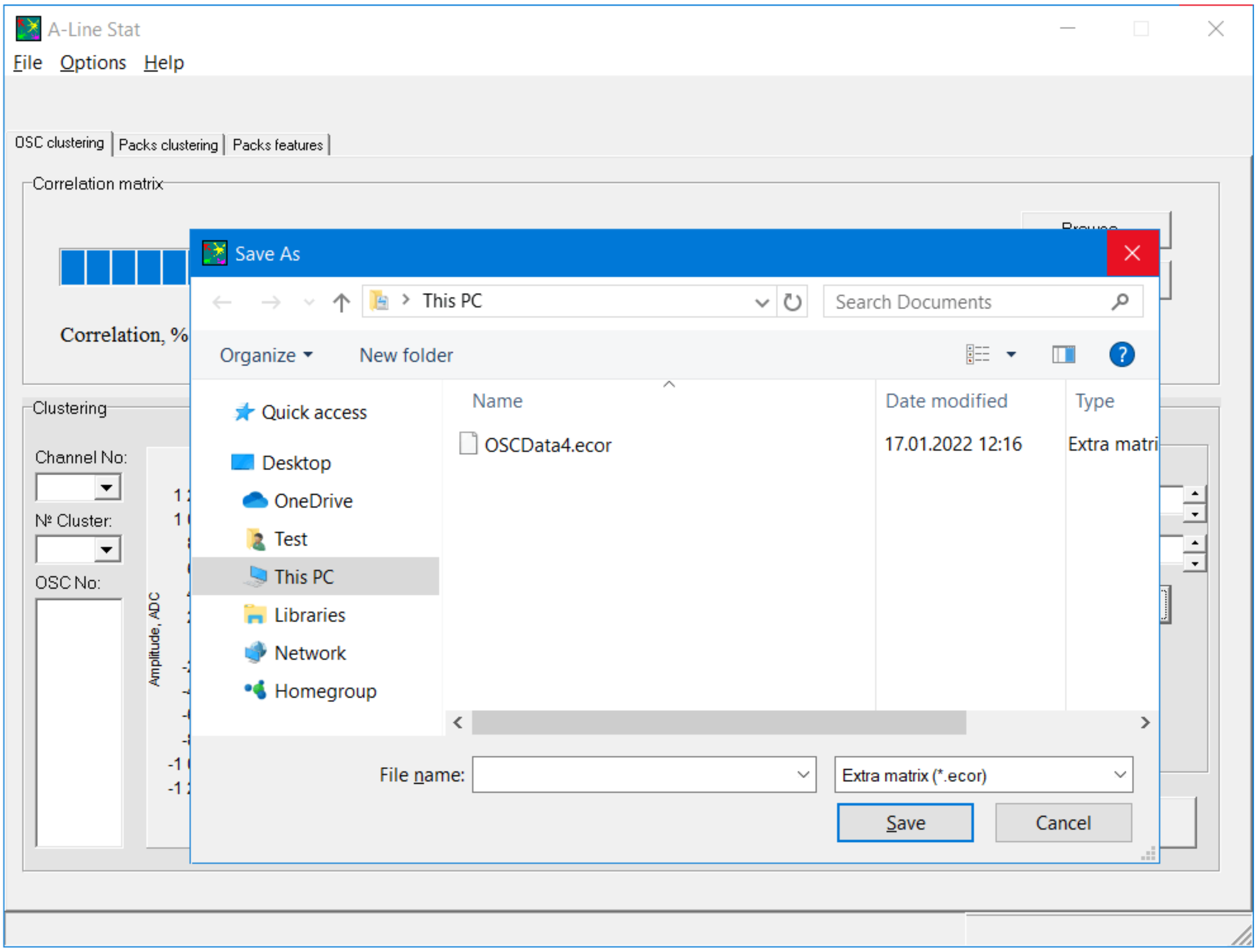

Fig. 20.3. Saving of INCOMPLETE correlation matrix file *.*ecor*

If the incomplete correlation matrix file (**.ecor*), already exists, by clicking the **Browse** button in the **File type** list it is necessary to select *Extra matrix (*.ecor)* and open the required file (Fig. 20.4). The dialog window appears wherein it is necessary to point the OSC-file for which the incomplete correlation matrix (**.ecor*) has been calculated. Click the **Open**, button, and then for starting the calculation click the button **Calculate**.

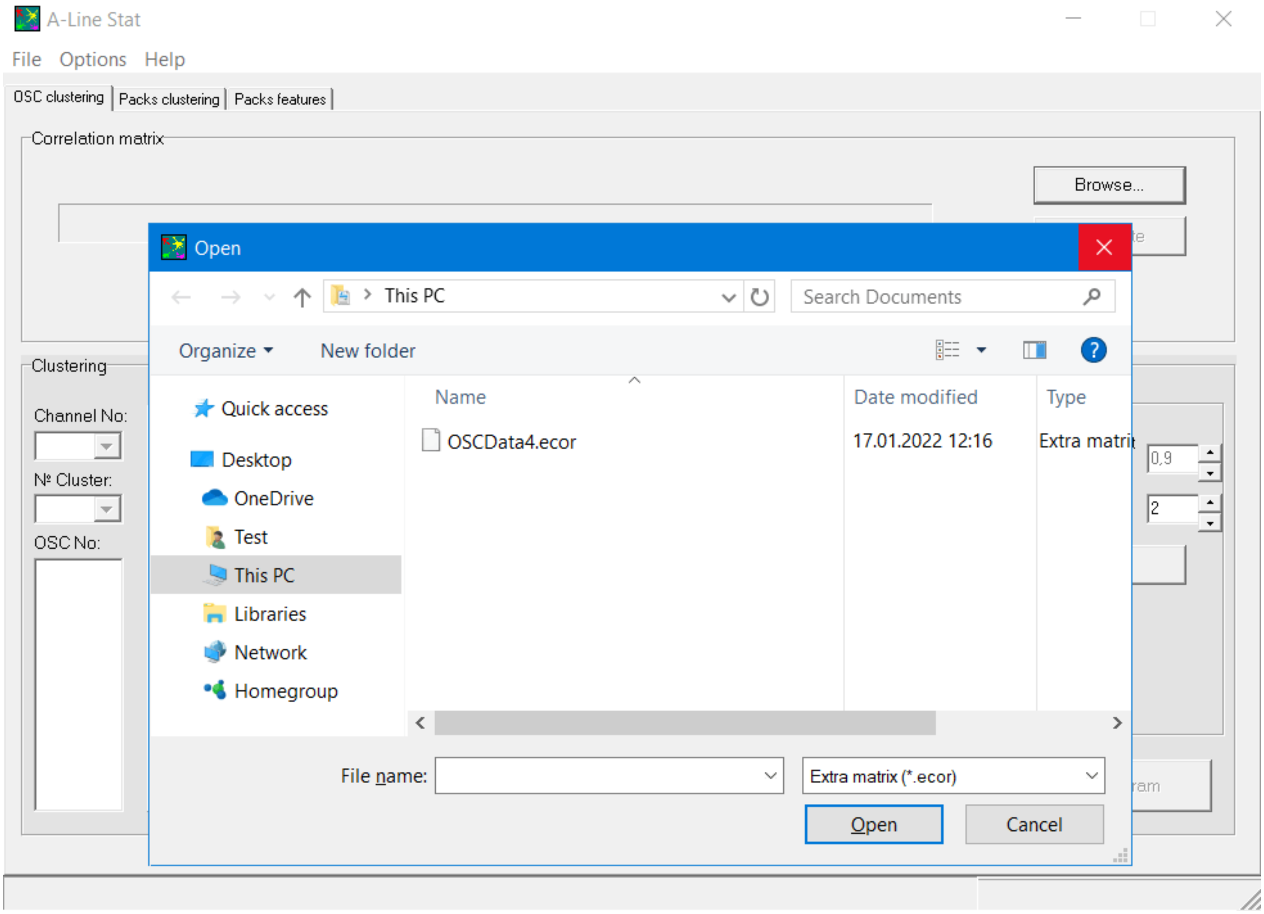

Fig. 20.4. Opening of INCOMPLETE correlation matrix file **.ecor*

After comprehensive calculation of the correlation matrix, the dialog window of saving of the complete correlation matrix file (**.cor*) appears automatically. It is necessary to point the file name and to click the **Save** button (Fig. 20.5).

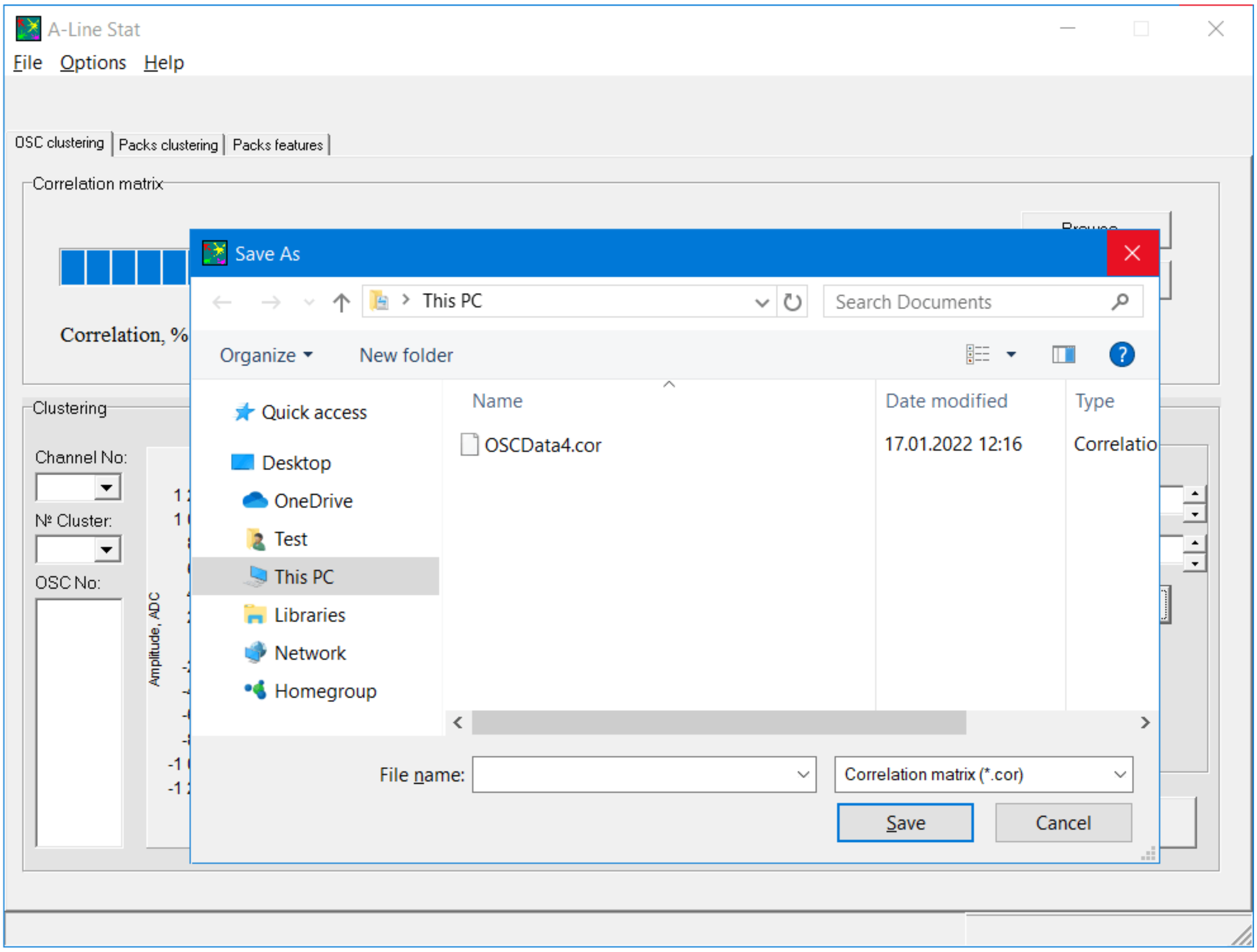

Fig. 20.5. Saving of COMPLETE correlation matrix file *.cor*

If the complete correlation matrix file (*.cor*), already exists, by clicking the **Browse** button in the **File type** list it is necessary to select *Correlation matrix (*.cor)* and open the required file (Fig. 20.6). The dialog window appears wherein it is necessary to point the OSC-file for which the complete correlation matrix (*.cor*) has been calculated. Click the **Open** button, and then the signal clustering calculation can be launched.

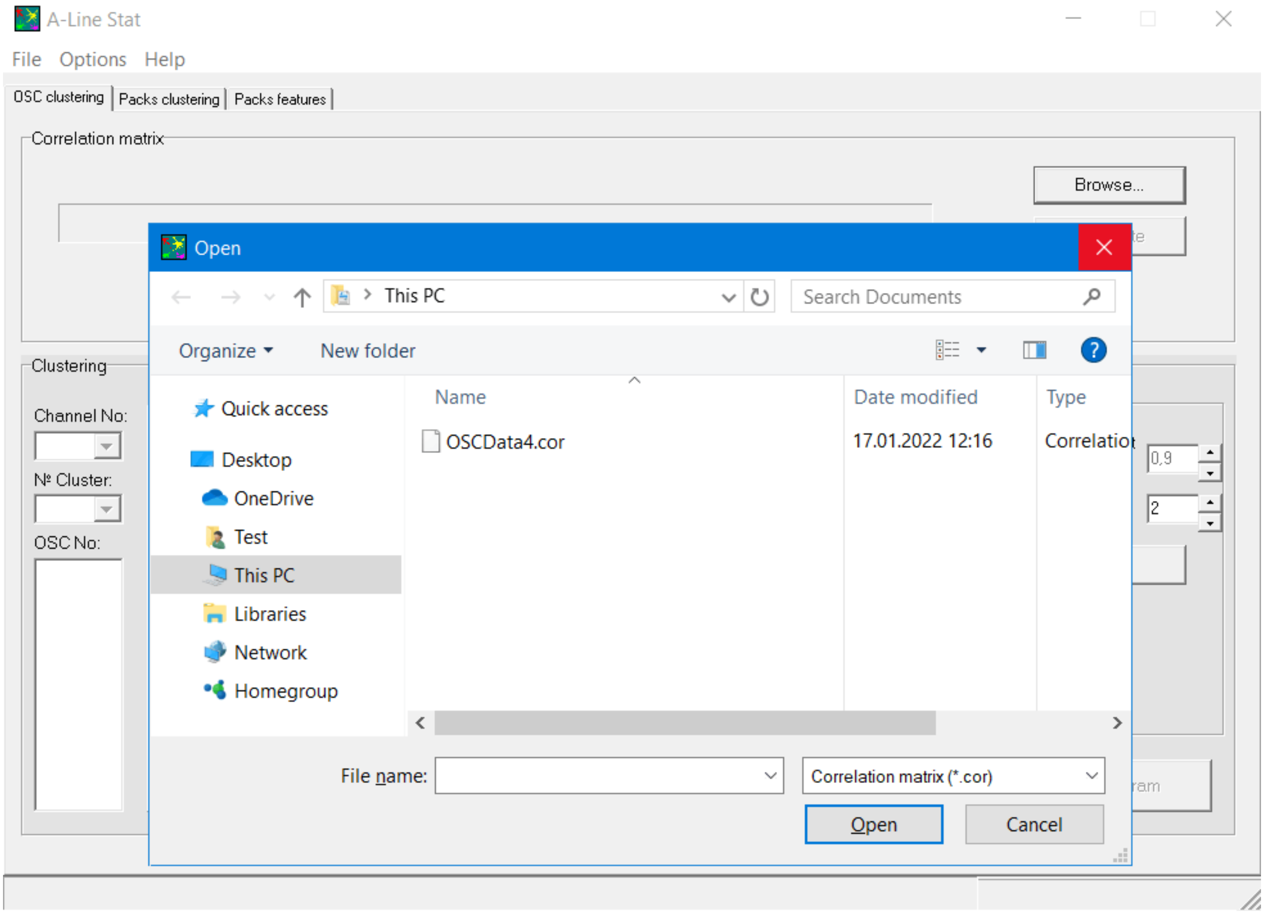

Fig. 20.6. Opening of COMPLETE correlation matrix file *.cor*

20.2. Calculation of signal clustering

Signal clustering is calculated on the **OSC clustering** tab. Before the calculation, it is necessary to specify the correlation threshold, namely, the measure of similarity for clusters of each channel, and the minimum quantity of waveforms in the cluster in the **Parameters** group. Having specified these required parameters, the **Calculate** button should be clicked (Fig. 20.7).

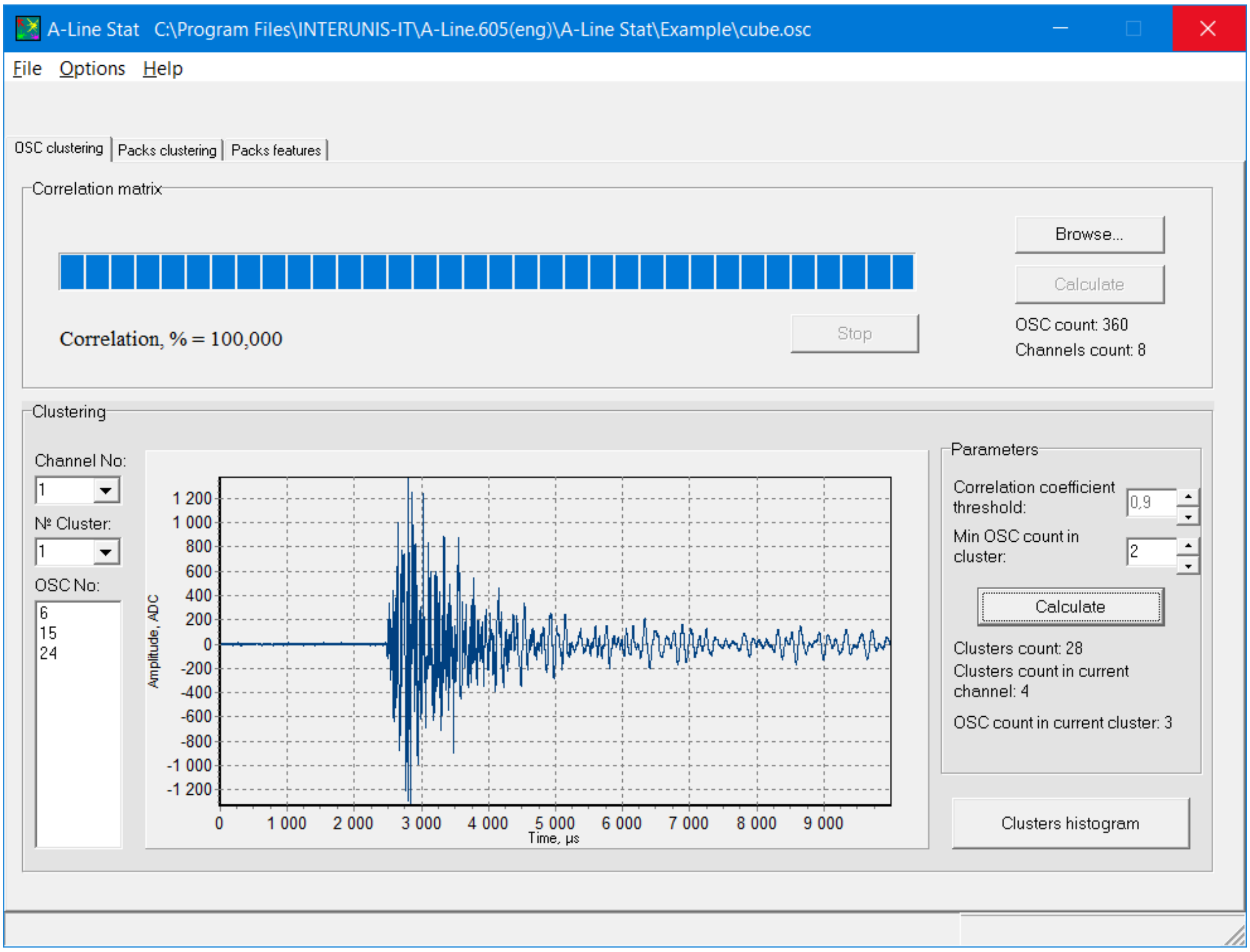

Fig. 20.7. Calculation of signal clustering

The graph displays the waveform whose number is selected in the **OSC No** field. By default, the waveform whose number is the very first in the **OSC No** field is displayed (Fig. 20.7).

To find out how many waveforms are contained in each cluster for a specific channel number, you must click on the **Cluster histogram** button and view the distribution of waveforms by clusters for the selected channel (Fig. 20.8).

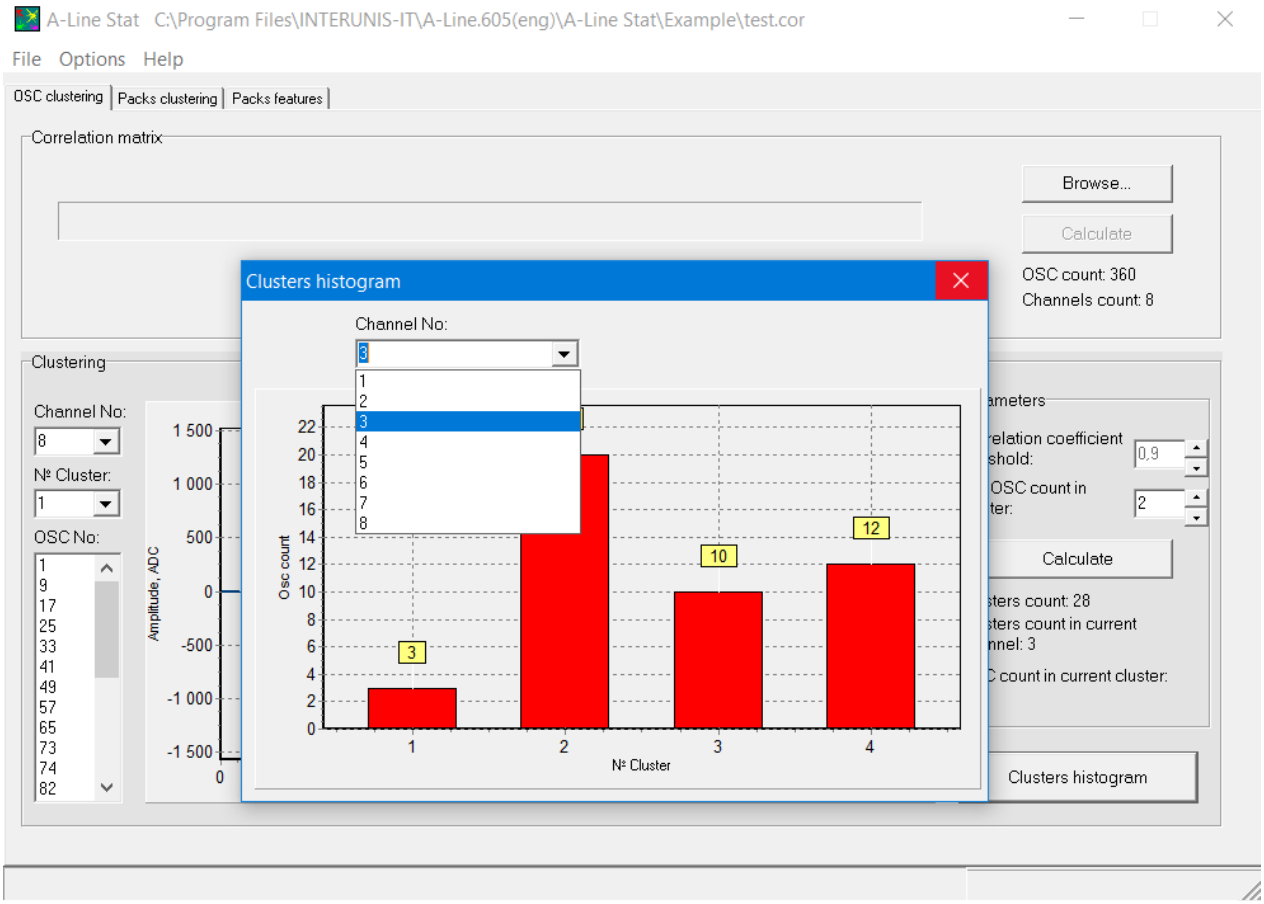

Fig. 20.8. Clusters histogram

In the **Channel No** drop-down list, you can select the desired channel number, and in the **№ Cluster** drop-down list, the cluster number for the selected channel. The **OSC No** field displays the waveform numbers for the selected cluster and channel (Fig. 20.9, Fig. 20.10).

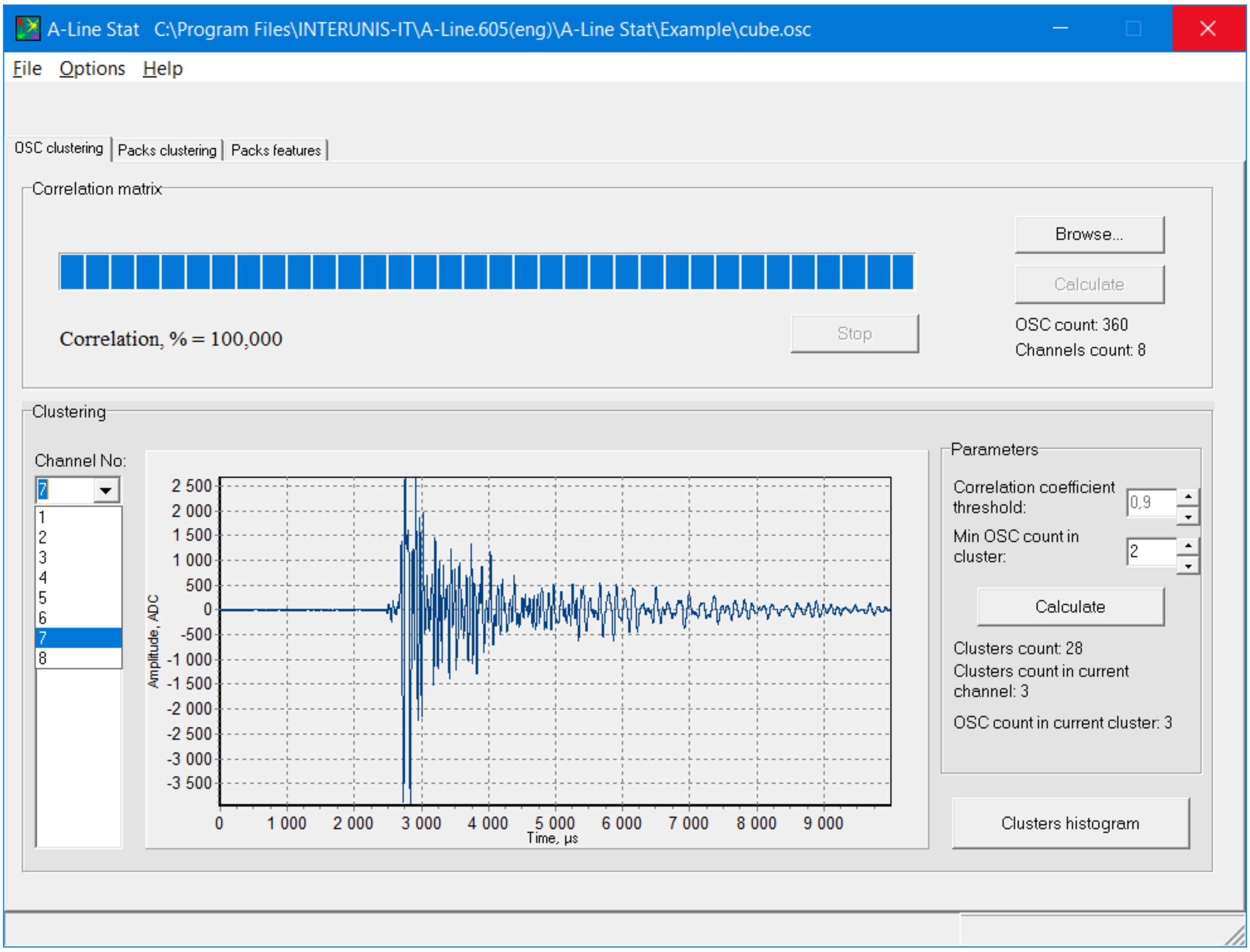

Fig. 20.9. Each channel clusters

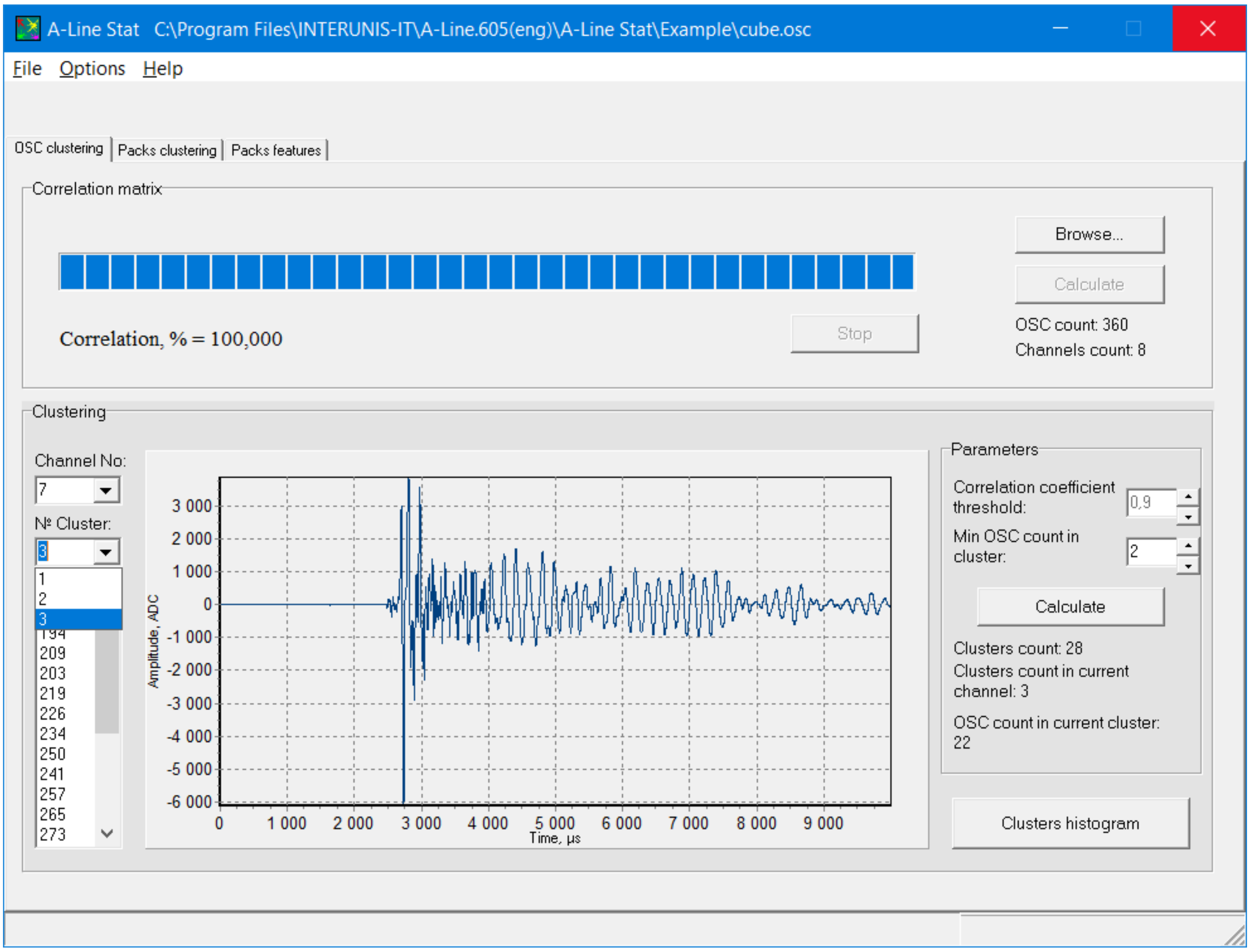

Fig. 20.10. Each cluster signals

20.3. Pack clustering

Pack clustering is performed on the **Pack clustering** tab. Click the **Browse** button and select the data file (*.ald*) corresponding to the OSC-file used in the previous tab (Fig. 20.11). In the **Pack parameters** group, group specify the required length of the impulse pack in μs.

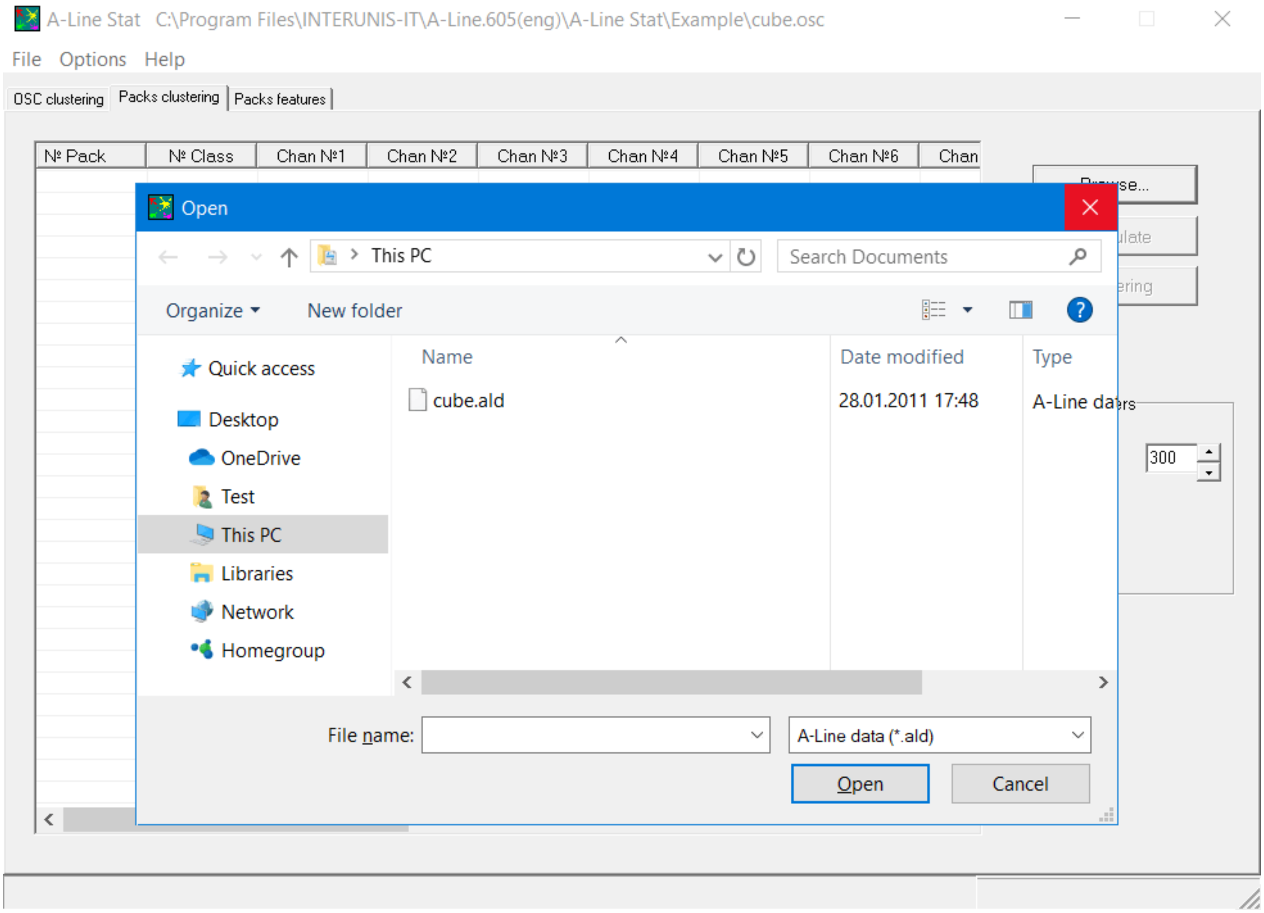

Fig. 20.11. Opening of data file **.ald*

Then, click the **Calculate** button, and clusters' assignment to channels (lines), and packs (columns) will take place (Fig. 20.12).

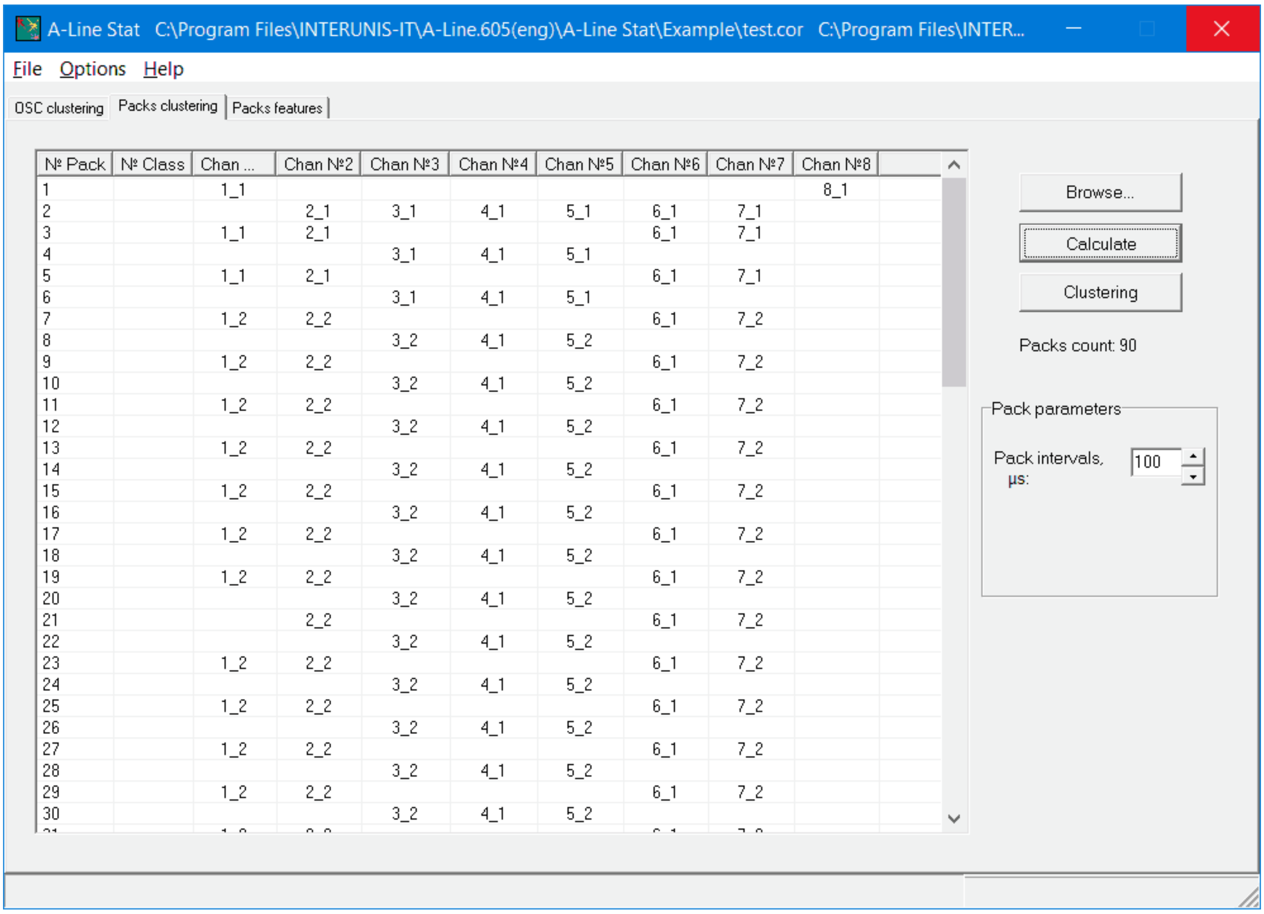

Fig. 20.12. Calculation of table of clusters assignment to channels and packs

The following types of designations are accepted in the table:

- "3_OSC" - the first digit means the channel number, "OSC" means, that the waveform exists, but it is contained in none of clusters for the given channel in the given pack;
- "3_1" - the first digit means channel No., the second figure means, that the waveform is contained in cluster No.1 for the given channel in the given pack.

By clicking the **Clustering** button, data will be assigned to classes (fig. 20.13).

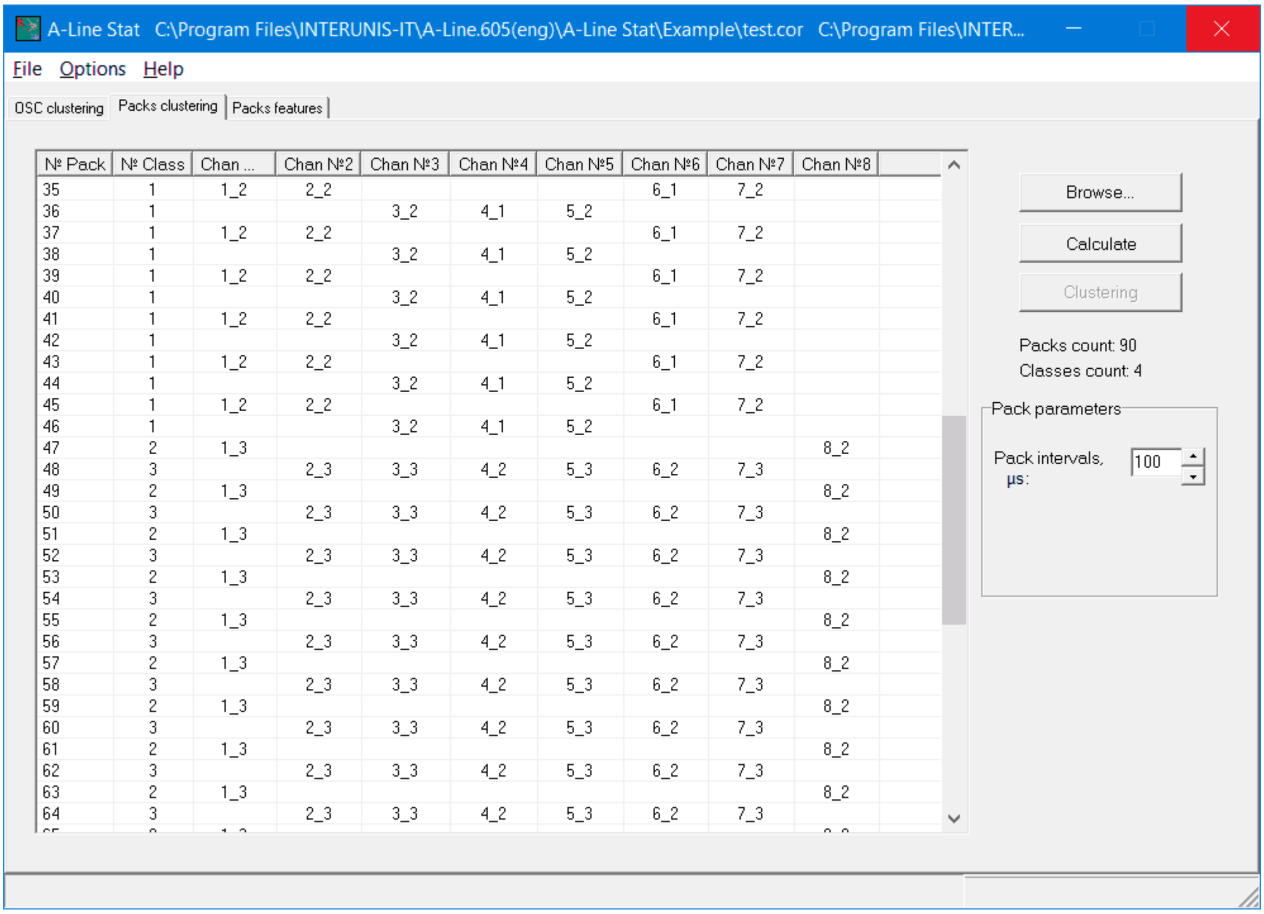

Fig. 20.13. Data clustering calculation

20.4. AE impulses analysis

To calculate the parameters of impulses on the **Pack features** tab, click the button **Calculate**. The basic parameters of impulses for each class will be calculated and summarized in the table (the class number is indicated in the first column): the number of channel with the maximum amplitude, the number of channel with the second-by-significance amplitude, the number of channel with the third-bysignificance amplitude, the average value of amplitude, the second-by-significance average value of amplitude, the third-by-significance average value of amplitude, the number of channel with the minimum time-of-arrival of impulse, the number of channel with the second-by-significance minimum time-of-arrival of impulse, the number of channel with the third-by-significance minimum time-of-arrival of impulse (Fig. 20.14).

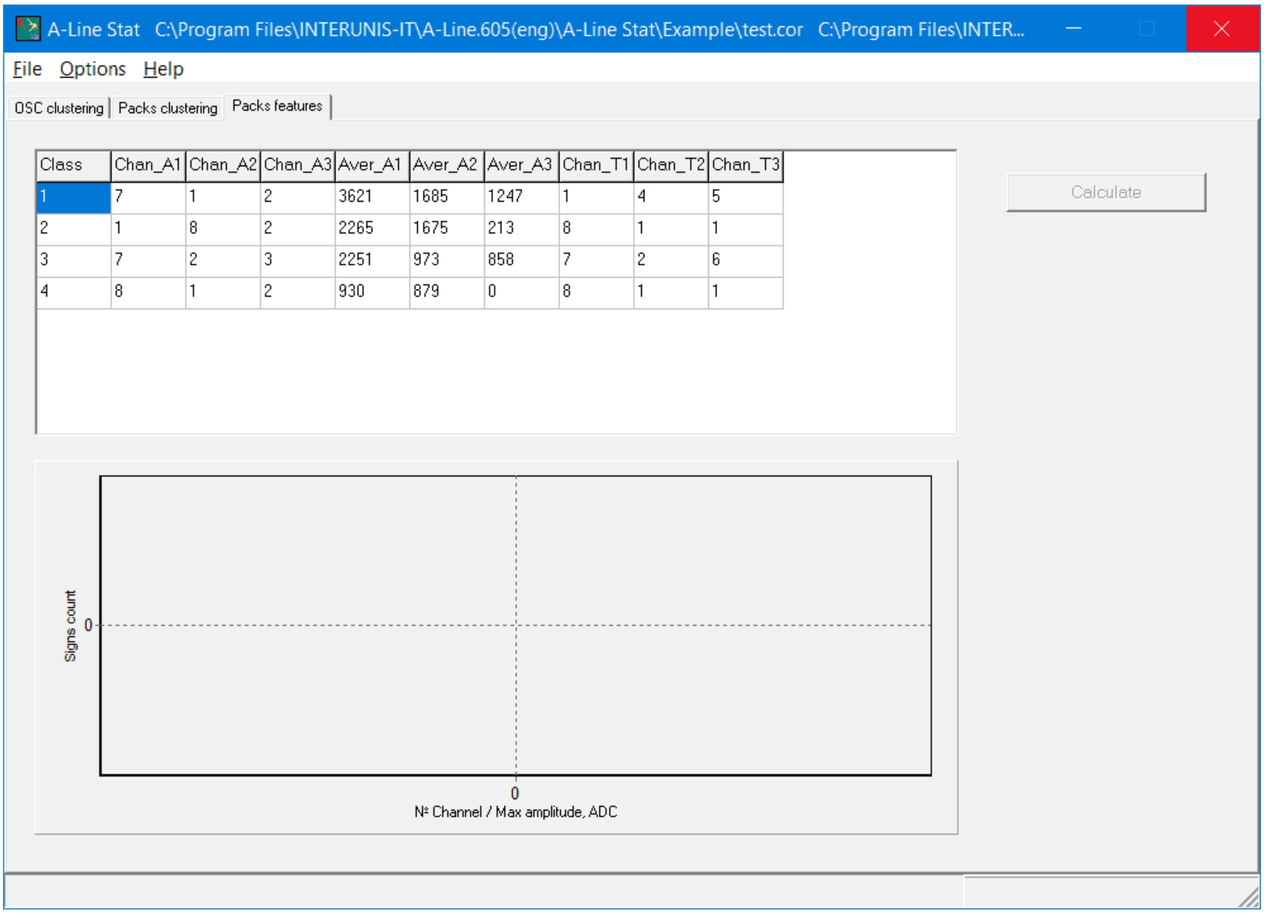

Fig. 20.14. Calculation of basic parameters of signals

A histogram is placed under the data table. By clicking each cell of the table, the histogram displays the statistics, namely, the assignment of parameters to packs (for each class): the channel number or the average value of amplitude is plotted along the X-axis (depends on which of parameters is viewed), while the quantity of such parameters (attributes) is plotted along the Y-axis (Fig. 20.15).

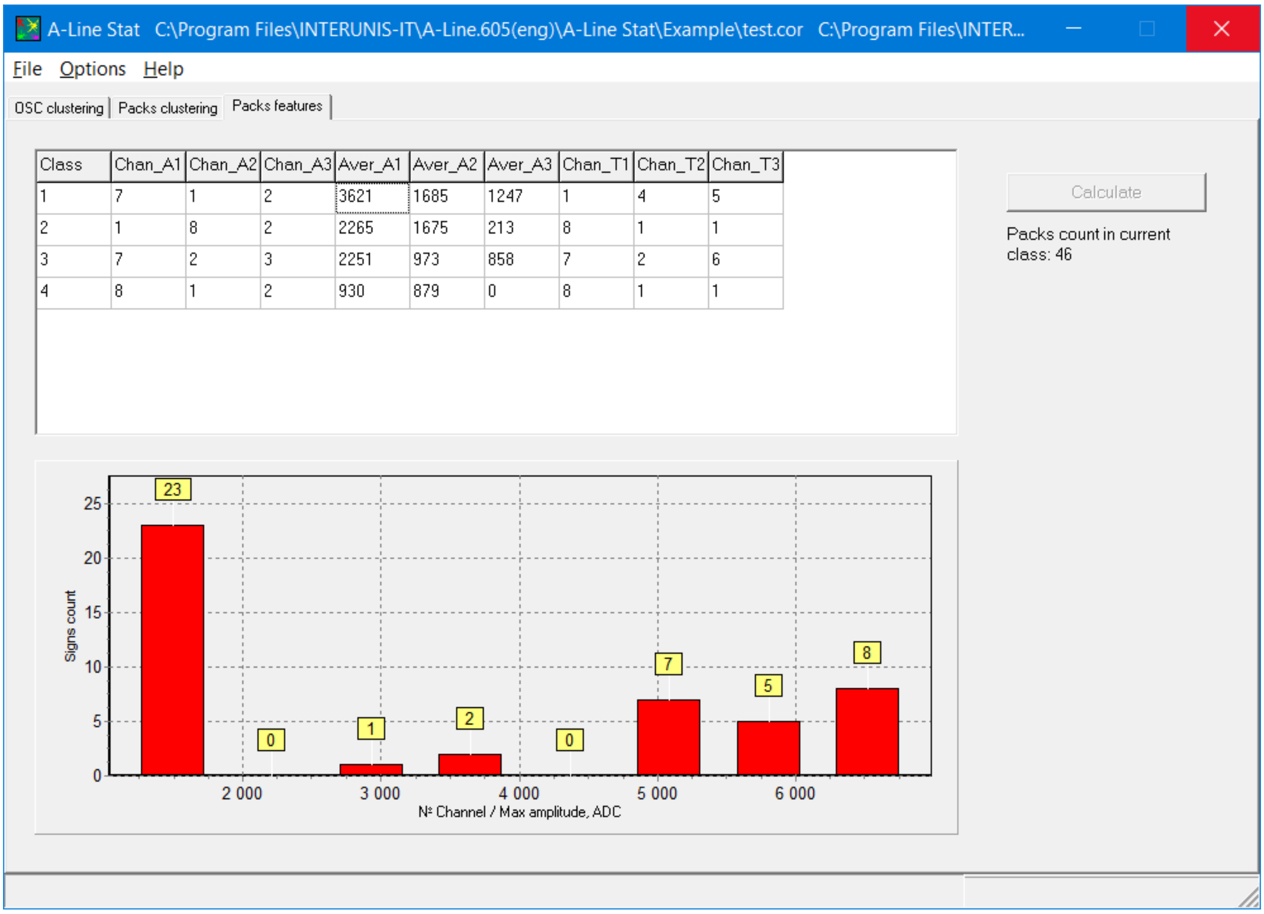

Fig. 20.15. Displaying specific parameters of signals

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Chapter 21. An example of using the program

To determine acoustic characteristics of concrete, the following experiment was conducted. On a concrete cube face (the face length is 1m) AE waves were alternately emitted by AE sensors GT-205 and sensorP 3-60 (Fig. 21.1). It turns out, that two AE sources with different characteristics are placed in the immediate vicinity from one another, or one AE source is placed that changes its characteristics with time.

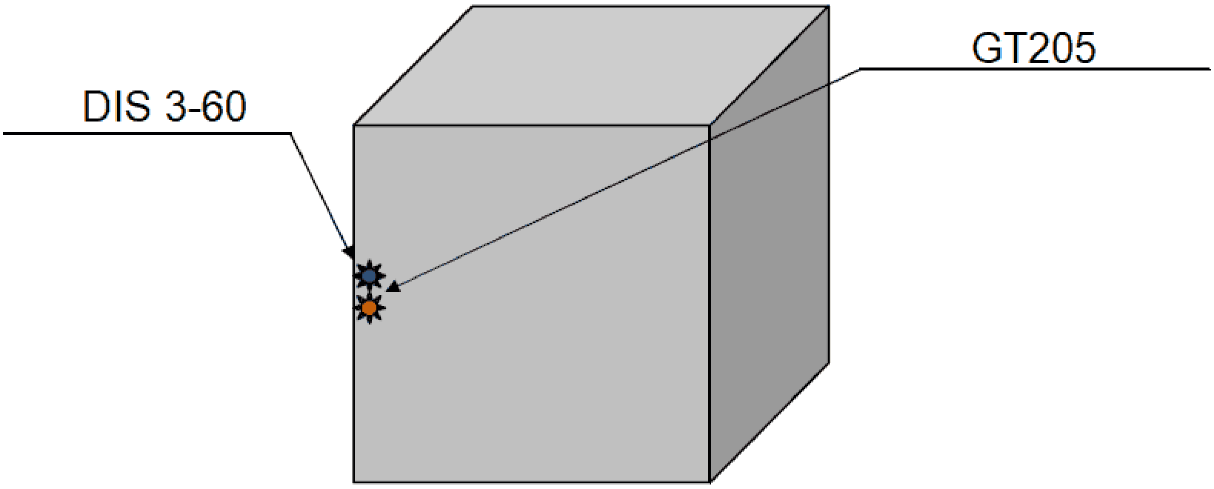


Fig. 21.1. Experiment scheme

Fig. 21.2 shows the result of volume location. As would be expected, all the emitted impulses were located in one area. Having used the location, we defined the acoustic emission position, but we could not detect, that the located impulses had different characteristics.

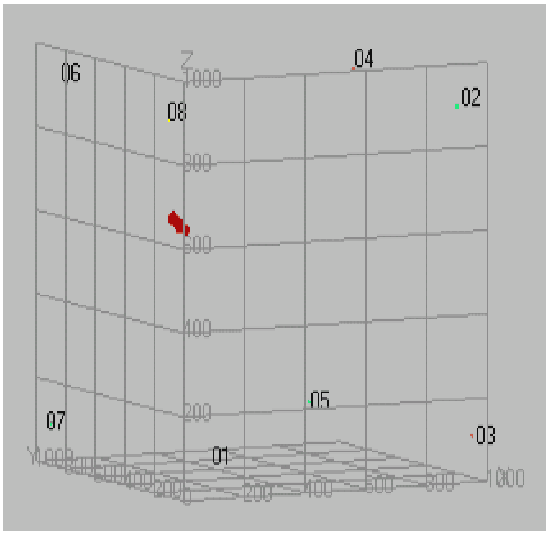


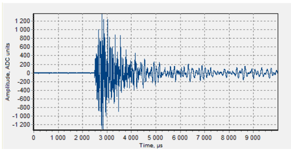
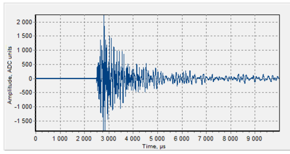
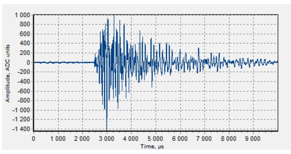
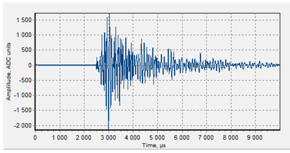
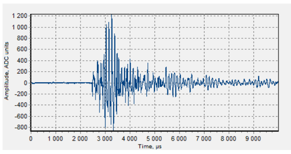
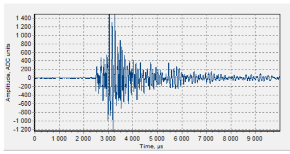
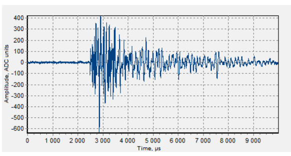
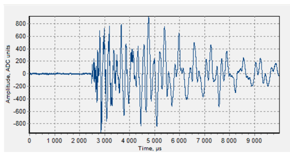
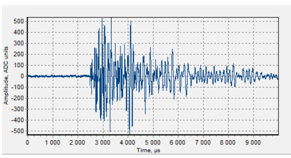
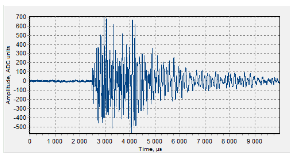
Fig. 21.2. Result of volume location

To perform the data analysis, the waveform file (cube.osc) and the impulse file (cube.ald) were created in **A-Line Stat**, program which are attached to this description.

The waveform file contains 380 waveforms recorded by eight measuring channels. After calculation of correlation and clustering factors, waveforms having the similar shape are combined in clusters. In our case two clusters are formed for each channel; the waveforms obtained during emission by GT 205 fall within one cluster, while the waveforms obtained during emission by sensorP 3-60 fall within another cluster.

Results of clustering are shown in Table 21.1. The waveforms of characteristic shape are represented in table cells for each cluster. The table lines correspond to the different measuring channels. Each cluster contains 22-23 waveforms similar in shape. The high-frequency signals are recorded during emission by GT 205, while the low-frequency ones during emission by sensorP 3-60.

Table 21.1.

Channel 1	
 Fig. 21.3. cluster 1_1 (22 waveforms)	 Fig. 21.4. cluster 1_2 (22 waveforms)
Channel 2	
 Fig. 21.5. cluster 2_1 (23 waveforms)	 Fig. 21.6. cluster 2_2 (22 waveforms)
Channel 3	
 Fig. 21.7. Cluster 3_1 (23 waveforms)	 Fig. 21.8. cluster 3_2 (22 waveforms)
Channel 4	
 Fig. 21.9. cluster 4_1 (23 waveforms)	 Fig. 21.10. cluster 4_2 (23 waveforms)
Channel 5	
 Fig. 21.11. cluster 5_1 (23 waveforms)	 Fig. 21.12. cluster 5_2 (23 waveforms)

Channel 6

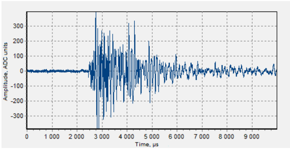


Fig. 21.13. cluster 6_1 (23 waveforms)

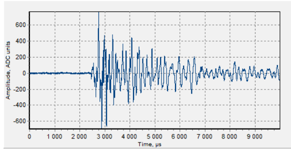


Fig. 21.14. cluster 6_2 (23 waveforms)

Channel 7

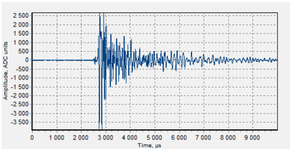


Fig. 21.15. cluster 7_1 (23 waveforms)

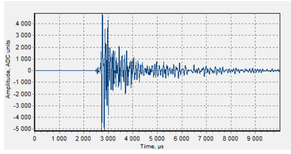


Fig. 21.16. cluster 7_2 (23 waveforms)

Channel 8

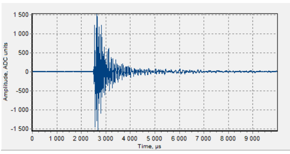


Fig. 21.17. cluster 8_1 (23 waveforms)

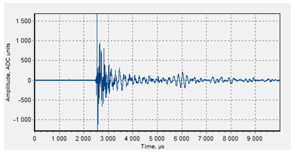


Fig. 21.18. cluster 8_2 (23 waveforms)

Fig. 21.19 shows the second tab of the **A-Line Stat** interface window. The table lines correspond to the impulses packs, while the columns correspond to the different measuring channels. The table cells include the numbers of clusters for each waveform.

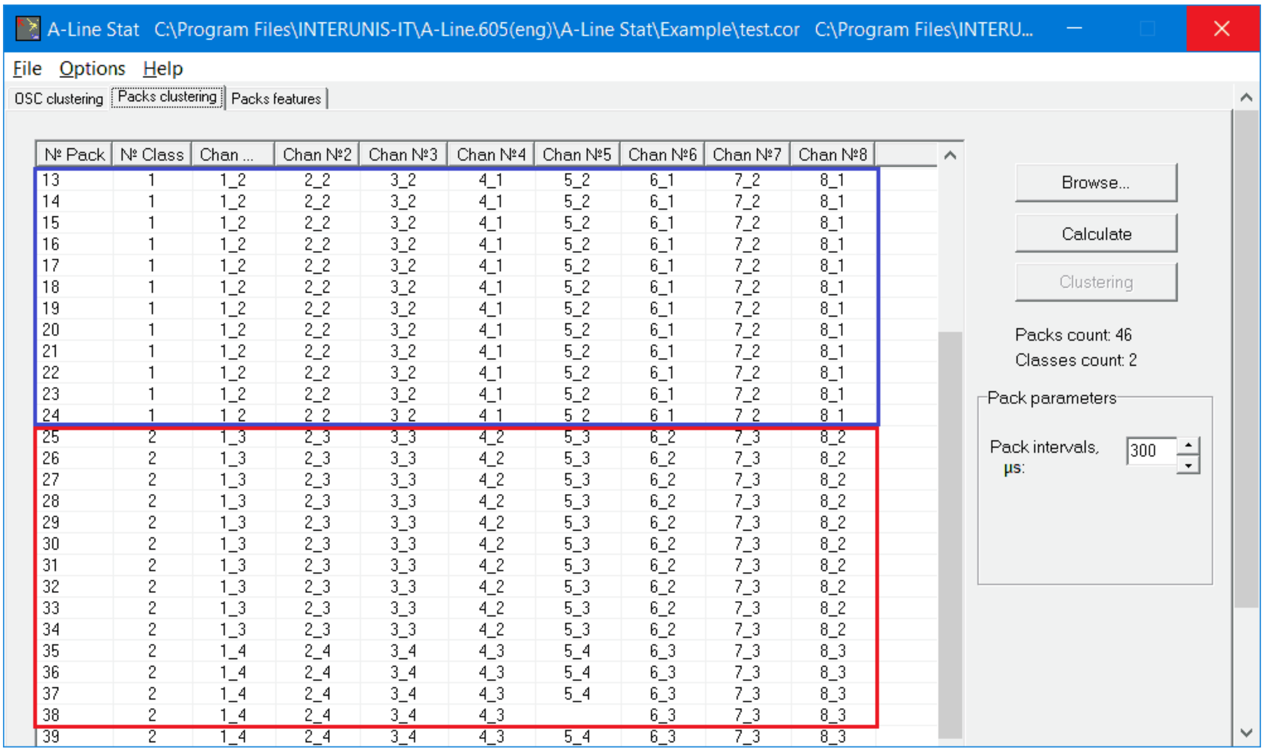


Fig. 21.19. Result of AE impulse clustering

For explanation below the table top line marked with an ellipse is illustrated.

Table 21.2.

Pack No.	Class No.	Chan. No.1	Chan. No.2	Chan. No.3	Chan. No.4	Chan. No.5	Chan. No.6	Chan. No.7	Chan. No.8
13	1	1_1	2_1	3_1	4_1	5_1	6_1	7_1	8_1

This line belongs to the pack with the sequence number 13 indicated in the first column. In the second column figure “1” means a result of the given pack clustering, it is assigned to Class 1. The following eight columns (from third to tenth) correspond to eight measuring channels that contain the result of waveforms clustering for each measuring channel. The numbering of clusters is non-continuous, the clusters are numbered for each channel separately. The following cluster designation is accepted: the first figure designates the channel number, while the second one designates the number of cluster for the given channel.

In this example the waveforms recorded for each of channels are assigned to two clusters. The waveforms recorded for the channel 1 form the clusters 1_1 and 1_2; for the channel 2 – the clusters 2_1 and 2_2, and for the channel 3 – the clusters 3_1 and 3_2, etc.… The waveforms included into the pack No. 13 are assigned to the clusters (1_1, 2_1, 3_1, 4_1, 5_1, 6_1, 7_1, and 8_1).

If consider the table as a whole, it can be seen that the waveforms included into the packs with the numbers 13-24 at the top of the table are assigned to the clusters (1_1, 2_1, 3_1, …, 8_1), while the packs 25-40 at the bottom of the table are assigned to the clusters (1_2, 2_2, 3_2, …, 8_2).

This means that the packs of the first group (13-24) are formed by the waveforms of the same shape, and the packs of the second group (25-40) are formed by the waveforms of the same shape, other than 13-24. Thus, we obtain two clusters of the packs that characterize different sources of acoustic emission. In the frame of the given example, the packs from the group 1 (marked blue in Fig. 21.19) are obtained during simulation of AE waves by GT-205, while the packs from the group 2 (marked red in Fig. 21.19 – during emission by sensorP 3-60. Thus, from one location area two “clusters of AE sources” have been extracted.

The third tab contains the attributes peculiar to either of the two obtained clusters (Fig. 21.20). The attributes “chan_T1”, “chan_T2”, and “chan_T3” representing the numbers of three channels with the minimum time-of-arrival of signals define the location area wherein the AE source having formed the cluster is placed. In this case AE sensors No. 1, 6, 7, 8 are mounted at corners of one face of the concrete cube.

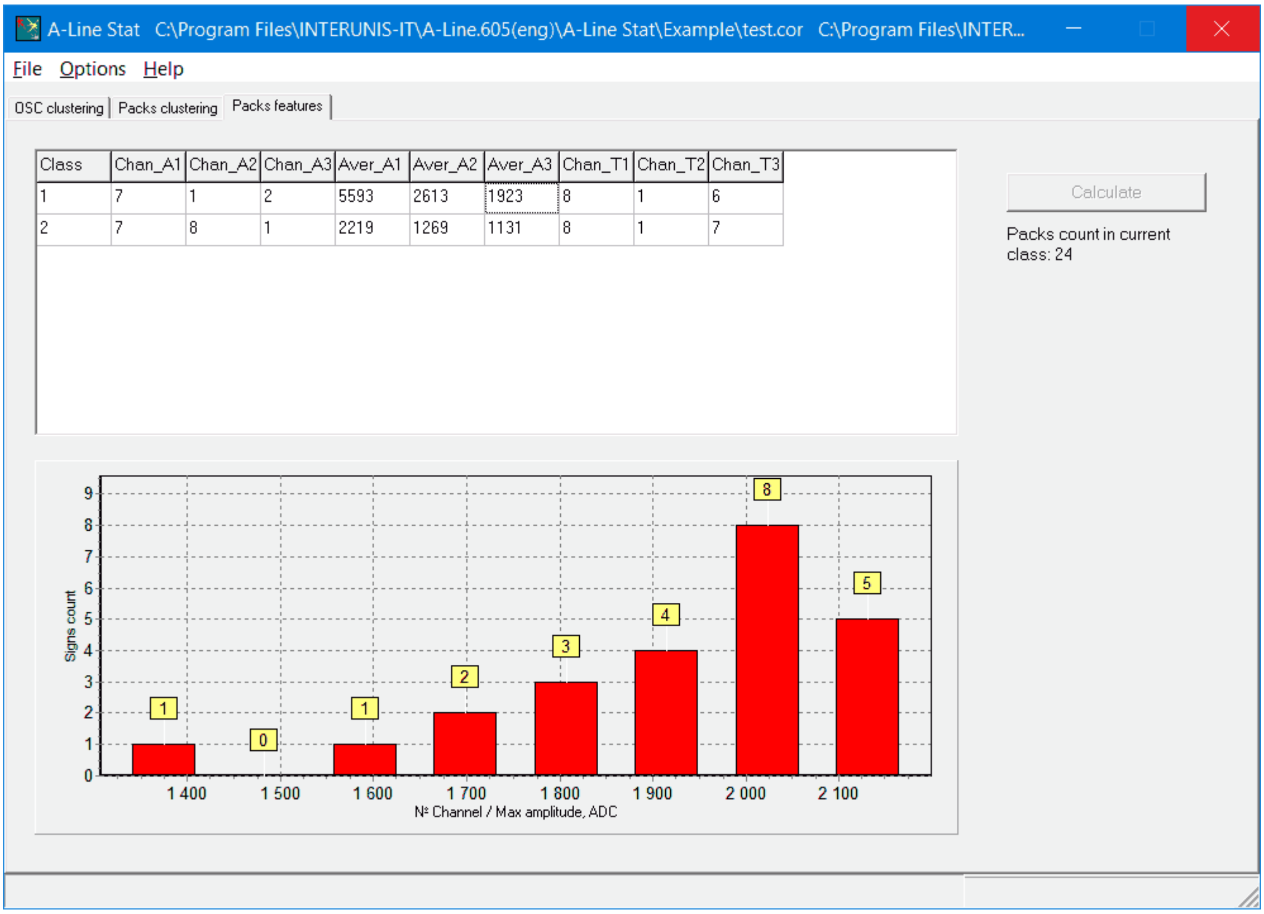


Fig. 21.20. Characteristics of AE source classes

The amplitude attributes **aver_A1**, **aver_A2** and **aver_A3** representing the average values of three maximum amplitudes make it possible to judge the AE source power.

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Section 5

Publication lists

Chapter 22. Publications by company employees

*	Chapter *“Publications by company employees”* contains a list of 121 publications in English in which company employees contributed.

2025:

Barat V.A., Marchenkov A.Yu., Poroykov A.Yu., Lepsheev E.A., Pankina A.A., Lavrik N.V. Study of acoustic emission under cyclic loading of dissimilar welded joints of 12kh18n10t and grade 20 steel. Edelweiss Applied Science and Technology. 2025. Vol. 9, No. 10. P. 223-230. DOI: 10.55214/2576-8484.v9i10.10385. https://learning-gate.com/index.php/2576-8484/article/view/10385/3374 (full text). eLibrary ID: 86878109

Elizarov S.V. The progress of acoustic emission testing technology in Russia. World Conference on Acoustic Emission (WCAE-2025), Kunming, China. October 14-17, 2025

Elizarov S.V., Barat V. AE application for the air leakage control onboard of spaceship. World Conference on Acoustic Emission (WCAE-2025), Kunming, China. October 14-17, 2025

Barat V.A., Marchenkov A., Ushanov S., Lavrik N., Elizarov S., Lepsheev E. Detection of intergranular corrosion of austenitic steels by acoustic emission method. World Conference on Acoustic Emission (WCAE-2025), Kunming, China. October 14-17, 2025

Ushanov S.V., Barat V., Elizarov S., Lepsheev E. Intelligent data analysis in structural health monitoring systems a case study of a dragline excavator. World Conference on Acoustic Emission (WCAE-2025), Kunming, China. October 14-17, 2025

Barat V.A., Marchenkov A.Yu., Ushanov S.V., Lepsheev E.A., Sviridov G.B., Lavrik N.V., Elizarov S.V. Identification of Diffusion Interlayers of Dissimilar Welds of Steel 20 and Steel 12Kh18N10T under Static Tension by Acoustic Emission Method. Russian Journal of Nondestructive Testing. 2025. Vol. 61, No. 1. P. 11-22. DOI: 10.1134/S1061830924602587. https://link.springer.com/article/10.1134/S1061830924602587 eLibrary ID: 80669940

2024:

Barat V., Marchenkov A., Bardakov V., Arzumanyan D., Ushanov S., Karpova M., Lepsheev E., Elizarov S. Detection of Diffusion Interlayers in Dissimilar Welded Joints in Processing Pipelines by Acoustic Emission Method. Applied Sciences (Switzerland). 2024. Vol. 14, No. 22. P. 10546. DOI: 10.3390/app142210546. https://www.mdpi.com/2076-3417/14/22/10546 (full text). eLibrary ID: 79148054

Barat V.A., Ushanov S.V., Lepsheev E.A., Sviridov G.V., Lavrik N.V. Identification of diffusion interlayers of dissimilar welds under static tension by acoustic emission method. Edelweiss Applied Science and Technology. 2024. Vol. 8. No. 6. P. 1554-1565. DOI: 10.55214/25768484.v8i6.2273 (full text). https://learning-gate.com/index.php/2576-8484/article/view/2273 (full text). eLibrary ID: 74663953

2023:

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