RADAR Systems, Inc.

Prism2

Version 2.7x

User's Manual

Riga 2022

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1. Introduction

Our Company Radar Systems, Inc. is using 40 years of experience in this field; the studies in this field were launched by Aviation Subsurface Radiolocation Problem Laboratory (PLAPR) legally succeeded by Radar Systems, Inc.

A modern Ground Penetrating Radar (GPR or georadar) is quite a sophisticated radio engineering digital device. But it has become simpler in operation while applying of processor, FPGA and computer technologies, as compared with early models. The GPR user's skill actually means knowledges of how to use the software which description you are reading now. Take a look on software operation, and you'll find no difficulties in it.

The correct interpretation of GPR data is a result of the certain experience which you have already or which, hopefully, you'll acquire quite soon. The **Prism2** software will be your effective helper in your tasks and decisions.

First of all the **Prism2** Software Package is designed for proper use in a field as a component of **Zond**, **Python** and/or **xGPR** family of georadars. Second task of the software is to help while GPR data processing and its interpretation.

*Note: computer has to be equipped with **LAN 10/100 BaseT** or **Gigabit** device to operate the **Zond**, **Python** and/or **xGPR** family of georadars by Ethernet cable or with **WiFi** device for wireless communication.*

The Software tasks include:

1. Control of all GPR modes, and adjustment of its parameters for specific job conditions.
2. Receiving digital data from Georadar in a radiolocation sounding run, and recording them in data files on a computer hard disk.
3. Visualization of data being received (or received earlier) on a computer display in user's specified mode.
4. Digital processing of received data for extracting useful signals and suppressing noise, interference and non-informative signals.
5. Determination of various signal parameters, spectral computations, etc.
6. The results printout.

Software package is supplied on USB Flash card or online from the manufacturer web site (http://www.radsys.lv) as installation package (SETUP.EXE).

Package is compiled as a user's integrated medium, i.e. user starts PRISM2.EXE file only and deals only with this file. Any other auxiliary files are run automatically as a function of user's actions.

The application has a multi-window interface which is convenient for comparison of various profiles, e.g. before and after processing, single section covered using different antennas, etc.

2. Brief Description of Georadar

You will find a GPR simplified block diagram bellow, which allows to imagine the general idea of its operation principle, but does not describes its complexity.

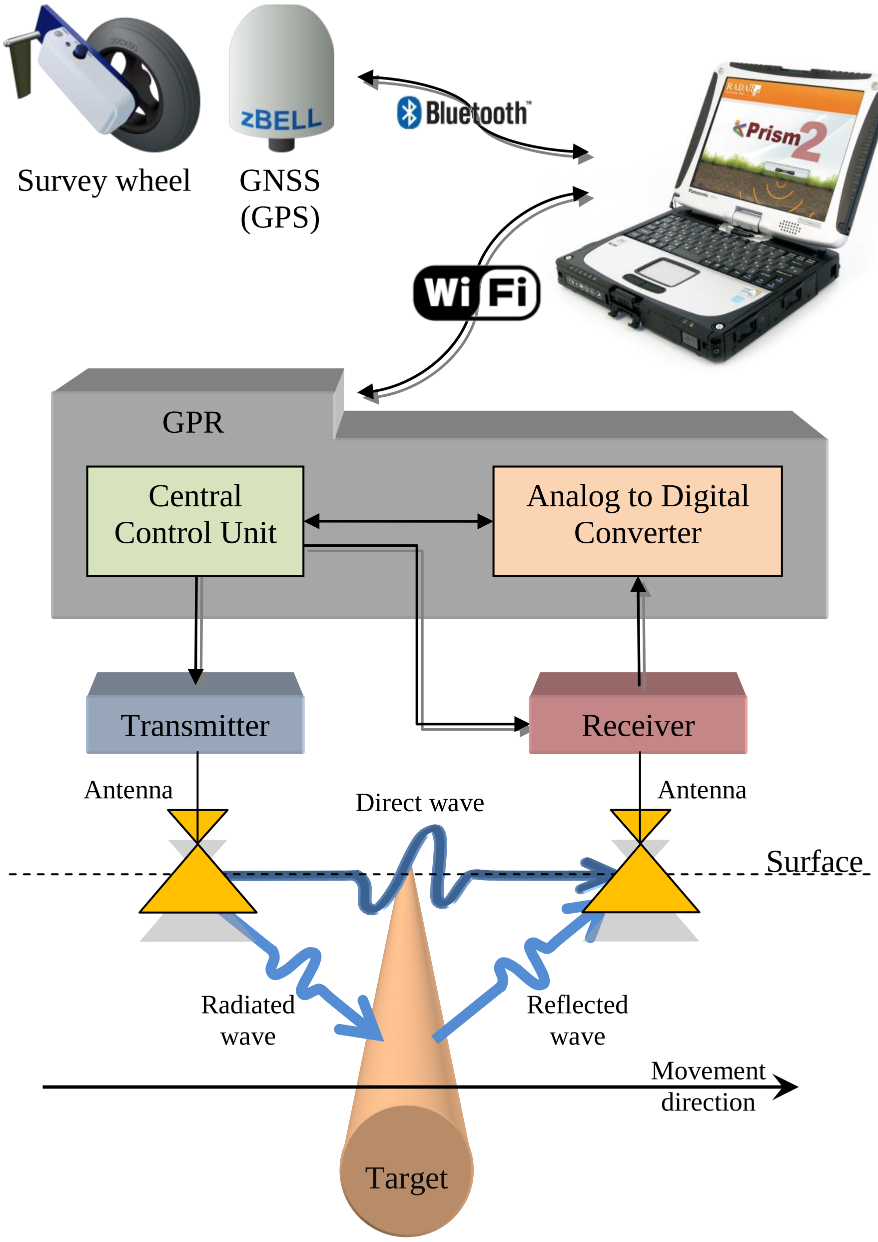


Fig. 2.1. Simplified block diagram of GPR

The transmitter excites the transmitting antenna with very short electrical pulses. The transmitting antenna radiates ultra-wideband one-and-half-period electromagnetic waves, its approximate shape is shown in Fig. 2.2.

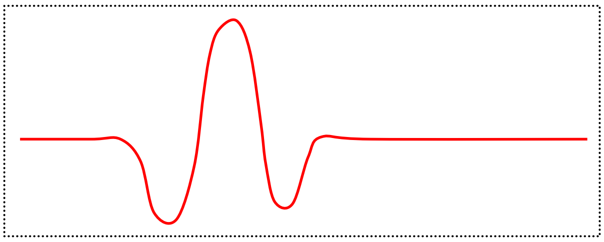


Fig. 2.2. The shape of the radiated electromagnetic wave

These electromagnetic waves propagate in the sounding medium, reflecting from the sections of the media and various objects (metals, cavities, layer boundaries with different parameters, etc.). The reflected signal is received and registered by the GPR receiver. But in addition to the reflected wave, there is also a direct wave that goes directly from the transmitting antenna to the receiving antenna along the shortest path. Therefore, the output of the receiver provides a signal, which is a sum of the transmitter pulse (as in Fig. 2.2.) and the reflected pulses following it.

Note: the time difference between the transmitter pulse and the reflected signals from the target surface determines the depth of the target in the medium.

Signals characteristics depend on the antenna, transmitter power (Tx), environmental conditions and receiver parameters (Rx) from the moment the transmitting antenna is excited until the reflected signal reception. All of these parameters affect the overall dynamic range of the entire system. There have been various methods for digitizing analog signals since the advent of digital technologies. One of the main methods used in pulsed georadars are the stroboscopic method and the Real Time Sampling method, or their symbiosis. Also, the structure of the GPR itself and of antenna systems used with it, or rather, the choice of an analog-to-digital converter (ADC), as the main element for converting an analog signal to digital, depends on the chosen method of digital conversion.

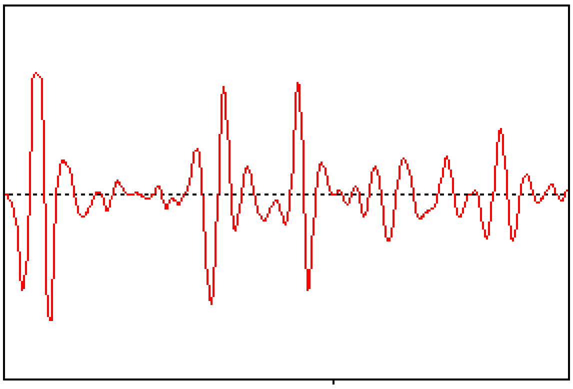


Fig. 2.3. Received signal example
The transmitter pulse is clearly visible on the left

The process shown in Fig. 2.3 is very fast and takes units or hundreds of nanoseconds and is technically difficult to process. One of the first solutions was the use of the stroboscopic method of signal digitizing (Fig. 2.4.), as in the “**Zond-12e**” and “**Python-3**” GPR families. The stroboscopic method is based on the thesis that the GPR and its antenna are in the same place for a relatively ultra-short millisecond time interval.

And accordingly, within these limits, the characteristics of the environment and equipment are not changing. So, if a wave with the same power is emitted by the transmitting GPR antenna, then all received signals on the receiving side will be the same. This means that it is possible to digitize not all samples of the received signal one after another at once, but separately each next sample on each received signal, increasing the delay with a constant nanosecond step. Thus, the GPR will receive 512 identical signals for 512 launches of the transmitter and take only one corresponding sample from each signal, and then build them all up into one trace, restoring the complete signal. At the same time, the georadar needs a transmitter with a trigger frequency of hundreds of kHz, a stroboscopic converter and a receiver with a sampling and storage device, the output of which will be fed to the ADC input with a trigger frequency of the transmitter.

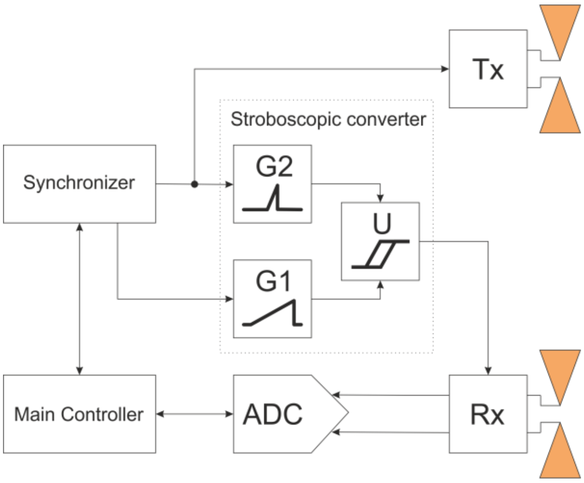


Fig. 2.4. Block diagram of the georadar of "**Zond-12e**" and "**Python-3**" GPR families based on the stroboscopic method

The limitation of this method is the frequency of transmitter triggering, which affects both the stroboscopic converter and the number of received traces per second, which is relatively small (at the level of tens or hundreds of traces per second). The problem also lies in expanding the dynamic range of the received data through increased stacking, because this approach requires a large number of traces and relatively fast operation of the ADC. Low-speed ADCs cannot be used in this case.

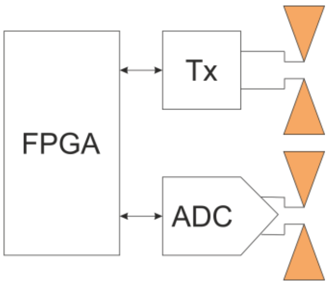


Fig. 2.5. Block diagram of a "**xGPR**" family based on the Real Time Sampling method

Thus, we have to use the Real Time Sampling method (see Fig. 2.5.) in combination with the stroboscopic approach, as in the case of the "**xGPR**" family. This method is based on high-speed ADCs with a clocking frequency from tens to hundreds MHz. There is no such direct dependence between the traces number and the transmitter clocking frequency in this method, unlike the stroboscopic one. The design of the transmitter itself remains the same, but one launch of the transmitter is enough to get a range of different samples amount from several ones to a complete trace, which significantly speeds up the operation of the entire system and increases the volume of the received data stream. The overall system clocking occurs at high frequencies (hundreds of MHz) - it allows the reducing of the time base step to tens of picoseconds. But on the other hand, while the time range per sample is decreasing, the number of transmitter launches per trace is increasing, because the speed of the ADC does not allow a true description of the analog signal. That's why the central processor uses the ADC in a mixed mode operation (i.e., in a pseudo-stroboscopic mode), where each transmitter triggering gives several samples on output, but not in a row, with an offset corresponding to the selected time range and the ADC clocking frequency. For example, if it is necessary to obtain a complete trace in 10 launches of the transmitter, then the first time the system receives 0, 10, 20-th, etc. sample, further the ADC clocking pulse phase is shifting by the corresponding value, and the system begins to receive the 1st, 11th, 21st, etc. sample on the second run. Thus, on the 10th run, the trace is completely formed. But, if we compare it with the classical stroboscopic method, this happen an order of magnitude faster. The traces overflow is better to convert to the high stacking (up to hundreds, thousands and tens of thousands times), that increases the bit resolution and dynamic range of the data, i.e. it increases the signal-to-noise ratio (one of the main advantages of this method).

This method significantly changes the general structure of the pulsed GPR. First of all, this is the refusing from the analog stroboscopic converter, because its functions are now performed by an ultra-fast field programmable gates array or FPGA. It also eliminated the need to use a receiver's electronics with a sample and hold device, since an original signal goes directly to the differential input of the ADC from the dipoles of the receiving antenna. But one of the main differences is the mandatory use of FPGA, instead of microcontrollers or processors. The main feature of FPGA is the parallel execution of operations, and not sequential, unlike in ARM or RISC processors. This gives the necessary speed for 64-bit operations with the "fast" ADCs, since the main task of the FPGA is to quickly receive data from the ADC, store them in memory, stack and transfer the final GPR traces to the logging device (computer). Such a range of tasks is beyond the power of even modern embedded multi-core processors. One of the main advantages of the whole system is the exact clocking of all processes under the control of the central logic, which eliminates the analog adjustment of parameters and their "floating" during operation.

Regardless of the GPR family architecture, it is controlled by a PC with the **"Prism2"** software, the description of which you are reading right now. While you are analyzing the GPR data, it should be borne in mind that the propagation velocity of electromagnetic waves in the sounding medium (if it is not an air) is not equal to the speed of light, but less than it by a factor of slowing down. The deceleration coefficient is equal to the square root of the medium dielectric constant; this factor is automatically taken into account in the **"Prism2"** software.

3. Terms Conventions

Some of the terms used in this manual are described below, as different literature has different interpretations of them.

- **Sample –** a single value containing the amplitude of the reflected signal at a certain point in time.
- **Trace** – a set of samples containing one-dimensional information about the reflected signals. Examples of traceses are shown in Fig.2.3 and 4.1.
- **Profile –** or a radargram, this is a set of traces that came to the receiving antenna in the time interval from the moment the sounding pulse was sent until the end of the time range sweep, preseted by the operator, containing two-dimensional information about the reflected signals received as a result some route passing. The profile can contain any number of traces. The horizontal axis of the profile is the X axis in meters. The vertical axis of the profile is the time axis Y with the zero at the moment of the sounding pulse radiation, where the end corresponding to the end of the trace recording (time range sweep). Examples of profiles in various output types are shown in Fig. 4.2 and 4.3. A profile (or some number of profiles) as a file (-s) is the final result of data acquisition. The next steps are data processing (if necessary), its interpretation and printing (if necessary).
- **Zero point** – the trace sample corresponding to the moment of the transmitter radiation maximum. It is the sample that used as a zero. It is a point where starts time counting of the reflected signal. As mentioned above, the transmitter pulse is one and a half period (i.e., three lobes) signal. This suggests that the zero point should be set to the middle of the transmitter pulse lobe (direct wave). The way to set the zero point is described in Section 11. Working with sounding data files on page 46. This is a very important parameter that must be taken into account while depth determination of the target in the sounded medium. Examples of the true zero point location are shown in Fig. 4.1, 4.2, 4.3, 11.3.
- **Wiggle plot** – is a method of the profile output, where traces are located vertically at constant distance from each other. The trace (or an average group of traces) drawing is made by a curved line, which is deviating from the trace axis line from side to side, depending on the amplitude of each sample in the trace. In this case, the positive half-waves of the signals are painted with the color corresponding to the maximum positive level of the selected color scale. The wiggle plot output examples are shown in Fig.4.2.
- **Line scan –** is a method of the profile output, where traces are located vertically, close to each other, and are drawn as vertical lines. The color at each point on the trace line depends on the amplitude of the corresponding trace sample according to the selected color scale. The line scan examples are shown in Fig. 4.3.
- **Coherent lineup (**in-phase axis**) –** it's a line of equal phases of identical signals on neighboring traces. For example, a line connecting the maximum of the wave reflected from the subsurface interface, a line connecting the maximum (minimums) of a diffraction wave from a pipeline, etc. The whole image of the research object is built on the profile by highlighting such lines. In the case of a subsurface interface, the in-phase axis practically repeats its shape and helps to rebuilt its shape exactly on a depth scale for the known permittivity or wave velocity.

- **Useful signals** – these are the reflected signals from the real subsurface targets Most often, these can be single reflections from target horizons and diffracted waves from target objects.
- **Not useful signals (interferences)** – these are signals that are not interest from the task point of view, but are present in the data, forming an interference pattern with useful signals and making it difficult to truly interpret. These include: hardware interferences, such as direct wave hiding the useful signals, multiple reflections from shallow boundaries, many diffracted waves from cracks, boulders, etc., reflected and diffracted waves propagating through the air (like wires, power lines, walls and corners of buildings, objects on the surface of the surface and above it).
- **Noise** – represents an irregular component of the data, where it is impossible to distinguish any in-phase axes. The reasons of the noise appearing are irregular electromagnetic processes in the GPR equipment itself and external electromagnetic fields of natural and artificial origin (for example, mobile communication signals). The value of signal-to-noise ratio determines the processing complexity and the overall efficiency of GPR researches in most cases.
- **Location marker** – it is a point on the ground, marked by a ground hammered peg, as well as the peg itself, a punched point or a point marked with permanent paint, a marker on any structures, a point for marking distances on the ground with a step of 100 m on railway lines or highways.
- **Mark** – it’s a feature of some profile trace, indicating some uniqueness of this trace and, consequently, a point of the profiling route. Marks are used to bind the profile to the terrain. User is able to add marks by pressing the button while passing any landmarks on the ground or pre-placed pickets. These marks will be displayed along with the profile, while its output. Marks examples you can see in Fig.4.3.

4. Radiolocation Data Display Examples

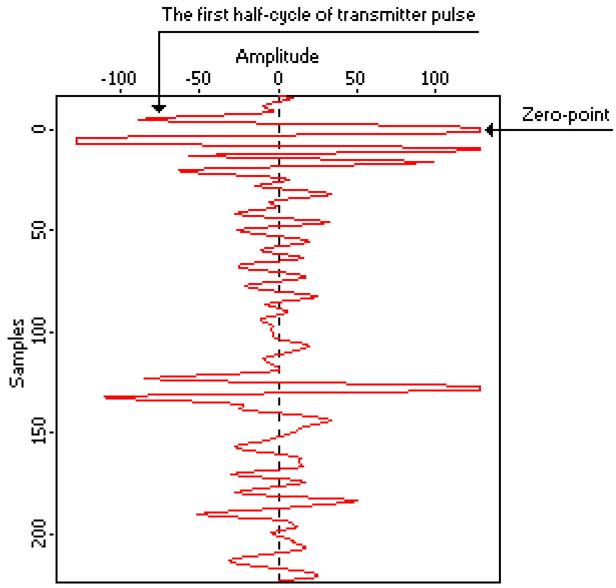


Fig. 4.1. Trace output

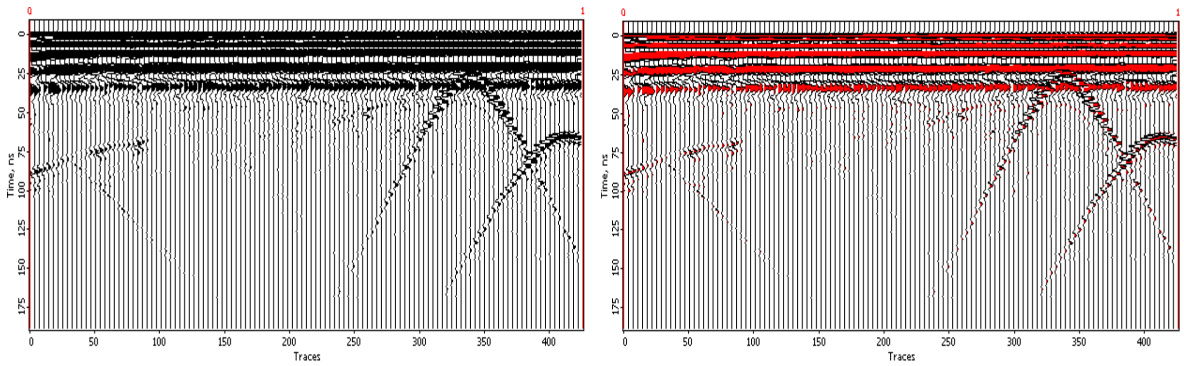


Fig. 4.2. Wiggle plot profile output (black-and-white and colored one).

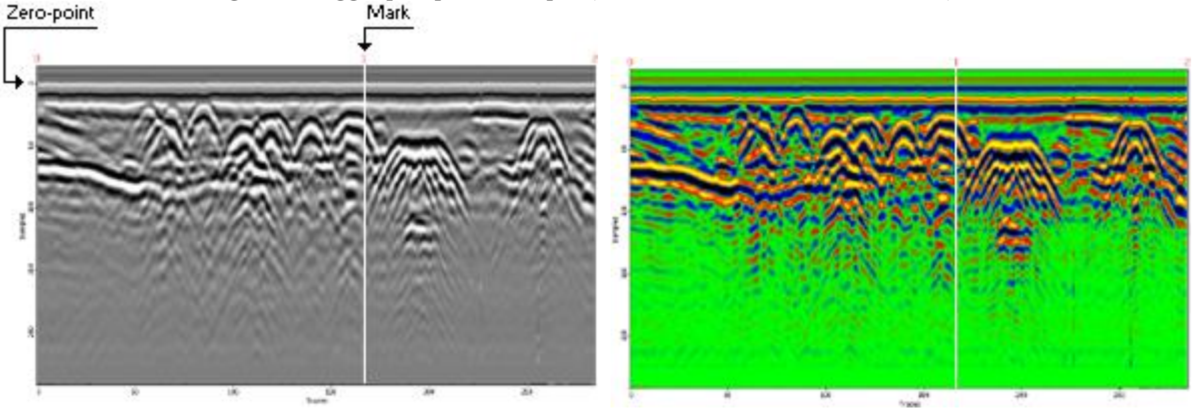


Fig.4.3 Line scan output (grayscale and colored one).

Note: The most informative output method is the ***line scan*** *in the* ***grayscale*** *palette (see Fig. 4.3, left side).*

5. Computer presets

5.1. Software installation

To install "**Prism2**" Package on the hard disk of the computer please follow the next steps:

- Plug the USB flash drive to the computer's USB port.
- Wait while drive automatically recognized by the Windows and adds it to the computer's drivers list as a virtual hard disk.
- Windows will prompt you to open the contents of the drive in Explorer, open Explorer and run the Setup program by its double-clicking.
- If autorun is disabled, then click the Start button on the tray and then Run (if your Windows does not have a the Run item in the Start menu, you is able to open the Run window by pressing Windows Key + R), type d:\setup in the Open line of the window Run, where d is the letter of the USB flash drive, and then click OK.
- Follow the installation instructions. The activation code is sticked on the USB flash drive envelope. You can also receive an activation code by email.
- Run the "**Prism2**" software.

5.2. Computer configuration for Ethernet cable connection with the GPR control unit

The "Zond-12e Advanced" GPR (from the serial number 0537) and "xGPR" family units are equipped by a built-in wireless router, that automatically configures the TCP / IP settings of user's PC (TCP/IP settings have to be set to "Obtain an IP address automatically"). For "**Zond-12e Single Channel**", "**Zond-12e Double Channel**" or earlier versions of "**Zond-12e Advanced**" GPR or if the user, for any reason, has changed the **Local Area Connection** settings, user has to configure manually PC settings for the connection with the GPR. To do so, please follow the next steps:

For **Windows XP:**

1. Click the **Start** button, point to **Settings** and then click **Control Panel**.
2. Double click the **Network connections** icon.
3. Double click your **Local Area Connection** icon and then click **Properties** button.
4. Select **Internet protocol [TCP/IP]** and click the **Properties** button.
5. For **GPRs manufactured after 2015** - click the **Obtain an IP address automatically** option and continue from the point **9.**
6. For **GPRs manufactured before 2015** - click the **Use the following IP address** option.
7. Click the **IP Address** box and enter **192.168.0.2** (if this address is occupied or is not accessible, you could use any address from 192.168.0.2 to 192.168.0.254, except occupied address 192.168.0.10. **Please, consult with your network administrator before changing IP addresses**).
8. Click the **Subnet mask** box and enter **255.255.255.0**.
9. Press OK button.
10. Press **Close** button.

For **Windows Vista / 7:**

1. Click the **Start** button, and then click on the **Control Panel**.
2. Chose the sub item **View network status and tasks**, of **Network and Internet** item.
3. Click the link **Change adapter settings** in the left part of **Network and Sharing Center**.
4. Select your **Local Area Connection** icon and click right mouse button on it. Select the item **Properties** of the pop-up menu.
5. Select **Internet Protocol Version 4 (TCP/IPv4)** and click the **Properties** button.
6. For **GPRs manufactured after 2015** - click the **Obtain an IP address automatically** option and continue from the point **10.**
7. For **GPRs manufactured before 2015** - click the **Use the following IP address** option.
8. Click the **IP Address** box and enter **192.168.0.2** (if this address is occupied or is not accessible, you could use any address from 192.168.0.2 to 192.168.0.254, except occupied address 192.168.0.10. **Please, consult with your network administrator before changing IP addresses**).
9. Click the **Subnet mask** box and enter **255.255.255.0**.
10. Press **OK** button.
11. Press **Close** button.
12. Close the **Network and Sharing Center** window

For **Windows 8 / 10 / 11**:

1. Right-click on bottom left corner (on your **Desktop**), and then press **Control Panel**.
2. Chose the sub item **View network status and tasks**, of **Network and Internet** item.
3. Click the link **Change adapter settings** in the left part of **Network and Sharing Center**.
4. Select your **Local Area Connection** icon and click right mouse button on it. Select the item **Properties** of the pop-up menu.
5. Select **Internet Protocol Version 4 (TCP/IPv4)** and click the **Properties** button.
6. For **GPRs manufactured after 2015** - click the **Obtain an IP address automatically** option and continue from the point **10.**
7. For **GPRs manufactured before 2015** - click the **Use the following IP address** option.
8. Click the **IP Address** box and enter **192.168.0.2** (if this address is occupied or is not accessible, you could use any address from 192.168.0.2 to 192.168.0.254, except occupied address 192.168.0.10. **Please, consult with your network administrator before changing IP addresses**).
9. Click the **Subnet mask** box and enter **255.255.255.0**.
10. Press the **OK** button.
11. Click the **Close** button.
12. Close the **Network and Sharing Center** window

If, for any reason, user doesn't need such IP address for his PC, he may change the IP address to the new one following procedures described above. But before PC IP address changing, user has to change Control Unit IP address. It is 192.168.0.10 as default. Please refer to Appendix A. Changing the Control Unit IP address (page 75) for how the default Control Unit IP address changes.

5.3. Computer configuration for wireless Wi-Fi connection with the GPR control unit

The "Zond-12e Advanced" GPR (from the serial number 0537), "Python-3" (from the serial number 0027) and "xGPR" family units are equipped by a built-in wireless router, that is able to automatically configure Wireless Network Connection settings on user's PC (TCP/IP settings have to be set to "Obtain an IP address automatically"). For earlier versions of "**Zond-12e Advanced**" and "**Python-3**" GPR or if the user, for any reason, has changed the **Local Area Connection** settings, user has to configure manually PC settings for the connection with the GPR. To do so, please follow the next steps:

For **Windows XP:**

1. Click the **Start** button, point to **Settings** and then click **Control Panel**.
2. Double click the **Network connections** icon.
3. Double click your wireless **Wi-Fi** connection icon and then click the **Properties** button
4. Select **Internet protocol [TCP/IP]** and click the **Properties** button.
5. For **GPRs manufactured after 2015** - click the **Obtain an IP address automatically** option and continue from the point **9.**
6. For **GPRs manufactured before 2015** - click the **Use the following IP address** option.
7. Click the **IP Address** box and enter **192.168.0.2** (if this address is occupied or is not accessible, you could use any address from 192.168.0.2 to 192.168.0.254, except occupied address 192.168.0.10. **Please, consult with your network administrator before changing IP addresses**).
8. Click the **Subnet mask** box and enter **255.255.255.0**.
9. Press OK button.
10. Press OK button.
11. Click the right button of mouse on your wireless **Wi-Fi** connection and then click **Connect** button.
12. Select **Zond-12e** or **Python** network and click the **Connect** button.
13. If you are using factory deffault Wi-Fi access point settings then follow to the next point, otherwise chose the secutity method for Wi-Fi connection end enter pass code if needed.
14. Press **OK** button.
15. Press **Close** button.

For **Windows Vista / Windows 7**:

1. Click the **Start** button, and then click on the **Control Panel**.
2. Chose the sub item **View network status and tasks**, of **Network and Internet** item.

3. Click the link **Change adapter settings** in the left part of **Network and Sharing Center**.
4. Select your wireless **Wi-Fi** connection icon and click right mouse button on it. Select the item **Properties** of the pop-up menu.
5. Select **Internet Protocol Version 4 (TCP/IPv4** and then click the **Properties** button.
6. For **GPRs manufactured after 2015** - click the **Obtain an IP address automatically** option and continue from the point **10.**
7. For **GPRs manufactured before 2015** - click the **Use the following IP address** option.
8. Click the **IP Address** box and enter **192.168.0.2** (if this address is occupied or is not accessible, you could use any address from 192.168.0.2 to 192.168.0.254, except occupied address 192.168.0.10. **Please, consult with your network administrator before changing IP addresses**).
9. Click the **Subnet mask** box and enter **255.255.255.0**.
10. Press **OK** button.
11. Press **Close** button.
12. Click the right button of mouse on your wireless **Wi-Fi** connection and then click the **Connect** button.
13. Select **Zond-12e** or **Python** network and click the **Connect** button (check the **Connect automatically** checkbox to connect to the network automatically in the feature).
14. If you are using factory default Wi-Fi access point settings then follow to the next point, otherwise chose the security method for Wi-Fi connection end enter pass code if needed.
15. Close the **Network and Sharing Center** window.

For **Windows 8 / 10 / 11**:

1. Right-click on bottom left corner (on your **Desktop**), and then press **Control Panel**.
2. Chose the sub item **View network status and tasks**, of **Network and Internet** item.
3. Click the link **Change adapter settings** in the left part of **Network and Sharing Center**.
4. Select your wireless **Wi-Fi** connection icon and click right mouse button on it. Select the item **Properties** of the pop-up menu.
5. Select **Internet Protocol Version 4 (TCP/IPv4** and then click the **Properties** button.
6. For **GPRs manufactured after 2015** - click the **Obtain an IP address automatically** option and continue from the point **10.**
7. For **GPRs manufactured before 2015** - click the **Use the following IP address** option.
8. Click the **IP Address** box and enter **192.168.0.2** (if this address is occupied or is not accessible, you could use any address from 192.168.0.2 to 192.168.0.254, except occupied address 192.168.0.10. **Please, consult with your network administrator before changing IP addresses**).
9. Click the **Subnet mask** box and enter **255.255.255.0**.
10. Press **OK** button.
11. Press **Close** button.

12. Click the right button of mouse on your wireless **Wi-Fi** connection and then click the **Connect** button.
13. Select **Zond-12e** or **Python** network and click the **Connect** button (check the **Connect automatically** checkbox to connect to the network automatically in the feature).
14. If you are using factory default Wi-Fi access point settings then follow to the next point, otherwise chose the security method for Wi-Fi connection end enter pass code if needed.
15. Close the **Network and Sharing Center** window.

*Note: If during connection **Set up network** dialog appears (or Windows asks the PIN code for the connection), please click the "**Connect to the network without setting it up**" link (like it shown on the figure below).*

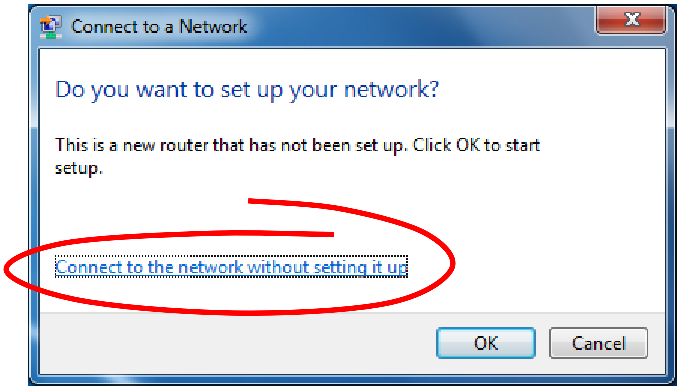


Fig.5.1. Wi-Fi network Set up dialog.

We recommend using Maximum Performance power option for the wireless Wi-Fi connections to avoid problems with weak Wi-Fi signal receiving under **Windows 8/10/11**. User has to configure manually those settings, to do so, please follow the next steps:

1. To open the **Control Panel:**
   - For **Windows Vista / 7** – Click the **Start** button, and then click on the **Control Panel**.
   - For **Windows 8 / 10 / 11** – Right-click on the bottom left corner (on your **Desktop**), and then select **Control Panel**.
2. Chose the item **Power Options.**
3. Follow the link **Change plan settings** (Fig. 5.2.)
4. Follow the link **Change advanced power settings**
5. Find and collapse item **Wireless Adapter Settings** and subitem **Power Saving Mode**
6. Chose value **Maximum Performance** for subitems **On battery** and **Plugged in**
7. Press the **OK** button.

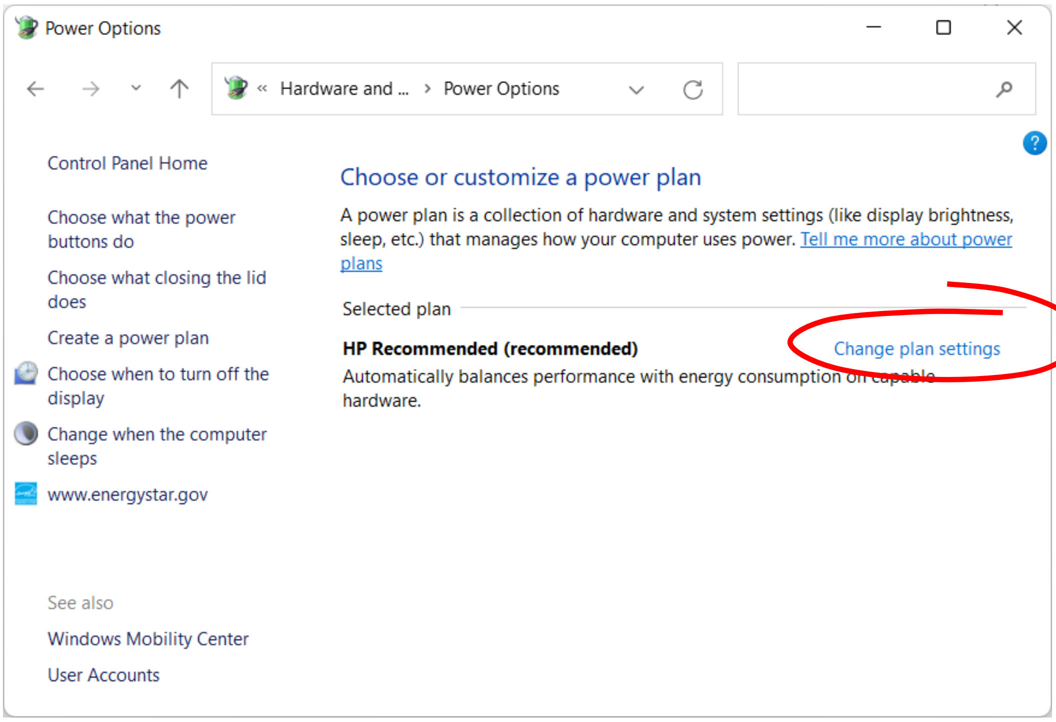


Fig.5.2. Power options dialog.

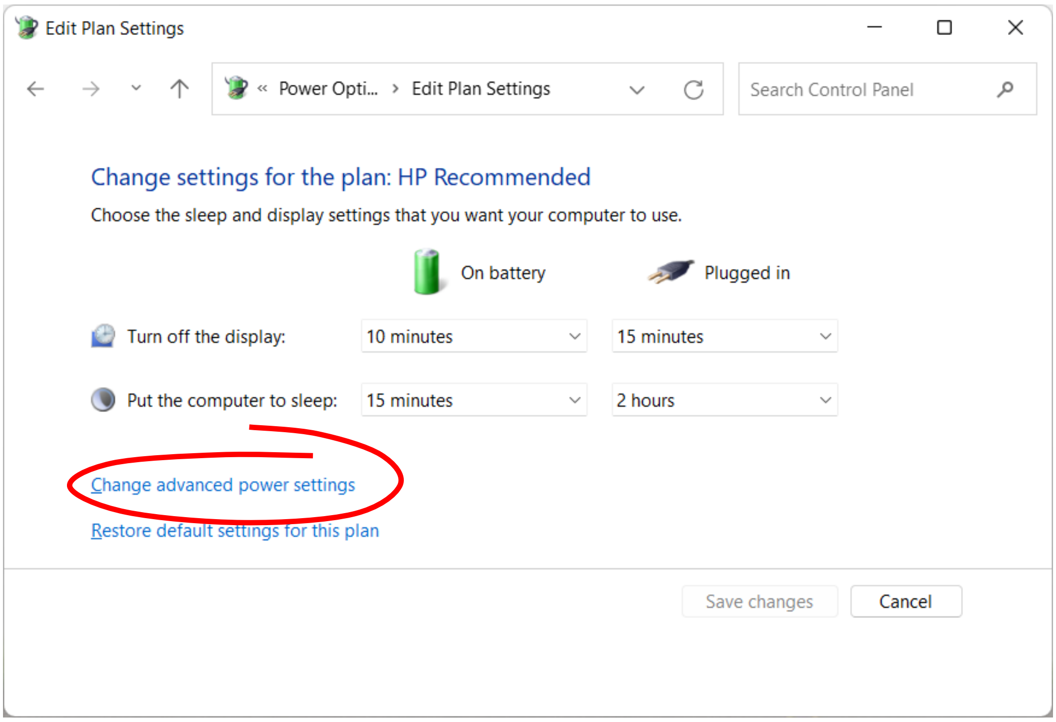


Fig.5.3. Edit power options dialog.

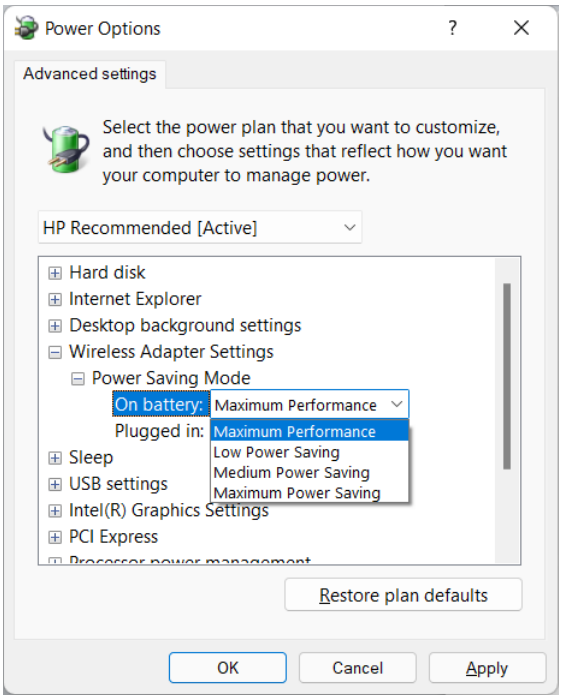


Fig.5.4. Power options advanced settings dialog.

Note 1: In some cases your portable device may have unsatisfactory connection even with power settings set to the maximum performance. In this case you should use external Wi-Fi USB adapter. We advise to use "NETGEAR N150 Wireless USB Micro Adapter" or newer.

Note 2: The "Zond-12e" (from the serial number 0537), "Python-3" (from the serial number 0027) and "xGPR" family units contain internal wireless router with complex operation system. You need to contact with our customer support before you try to change any of GPR's Wireless network settings! Please take a look on how to change router settings for earlier versions of GPRs in Appendix B. Wi-Fi Access Point (page 77).

Note 3: While connecting to your GPR via cable on some PCs, you will have to disconnect from any Wi-Fi networks, or even disable "Wireless Network Connection" on this PC completely.

6. First Run

You will see the brief menu with four items on **Prism2** start up:

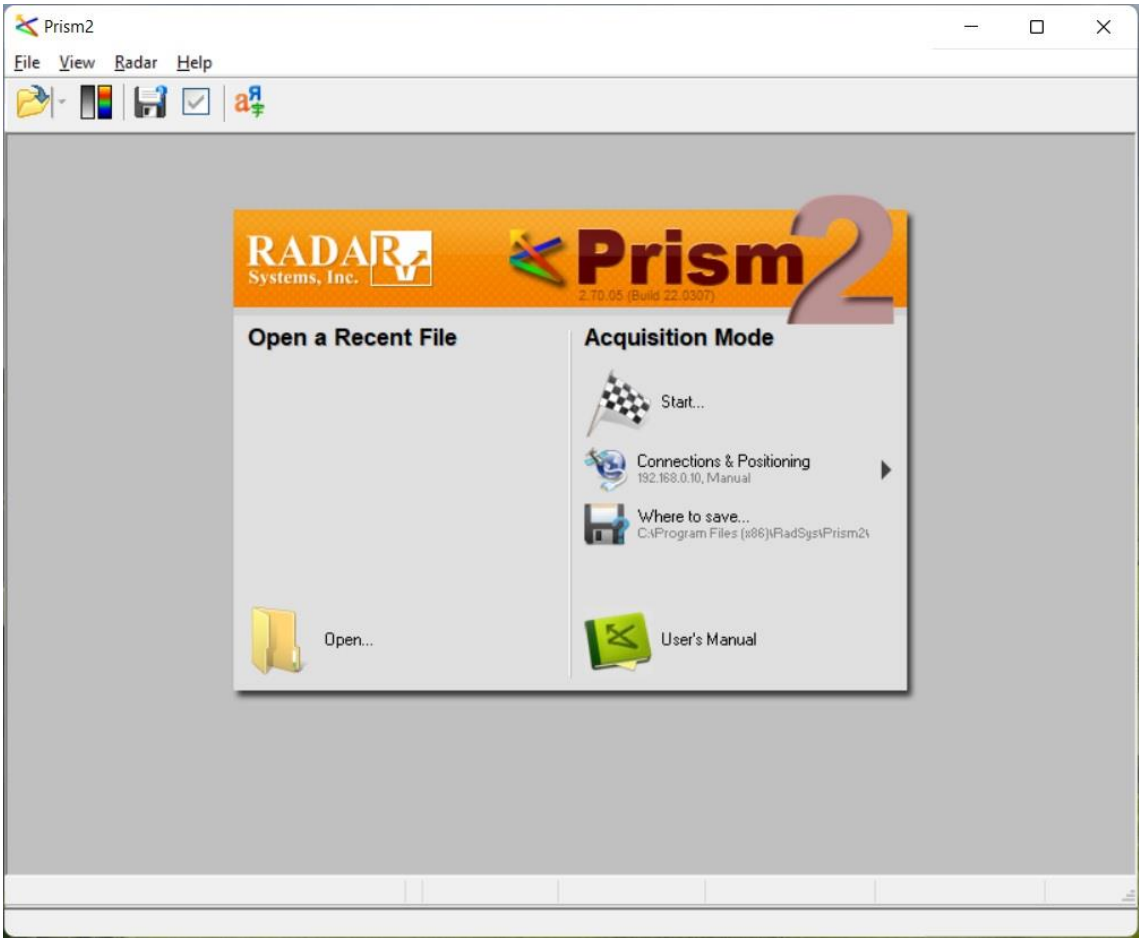


Fig. 6.1 "**Prism2**" brief menu.

The **Prism2** software default language is English. There are German, Russian, Greek, Korean and Chinese languages as well. If you wish to change it, to any mentioned language above, select menu **View/Languages** and press the button **Add language**. Find and select file ***.lng**, where * is the language name. You may set selected language as the default one by pressing **OK** button.

The next step is to enter the **Radar/Positioning** menu item or the **Connections & Positioning** brief menu item and select one from the four possible positioning methods for the current task. See the Positioning section below for more details.

In the Radar/Where to save menu item, you can specify the directory where your sounding data files will be automatically saved.

In principle, now the program is already ready to work with GPR and sounding data files, but in order for you to be ready for this, you should familiarize yourself with the purpose of the menu items, which is the subject of the next section.

7. Menu items

The full menu is displayed on the screen upon opening of the data file. The detailed description of each menu item is presented below.

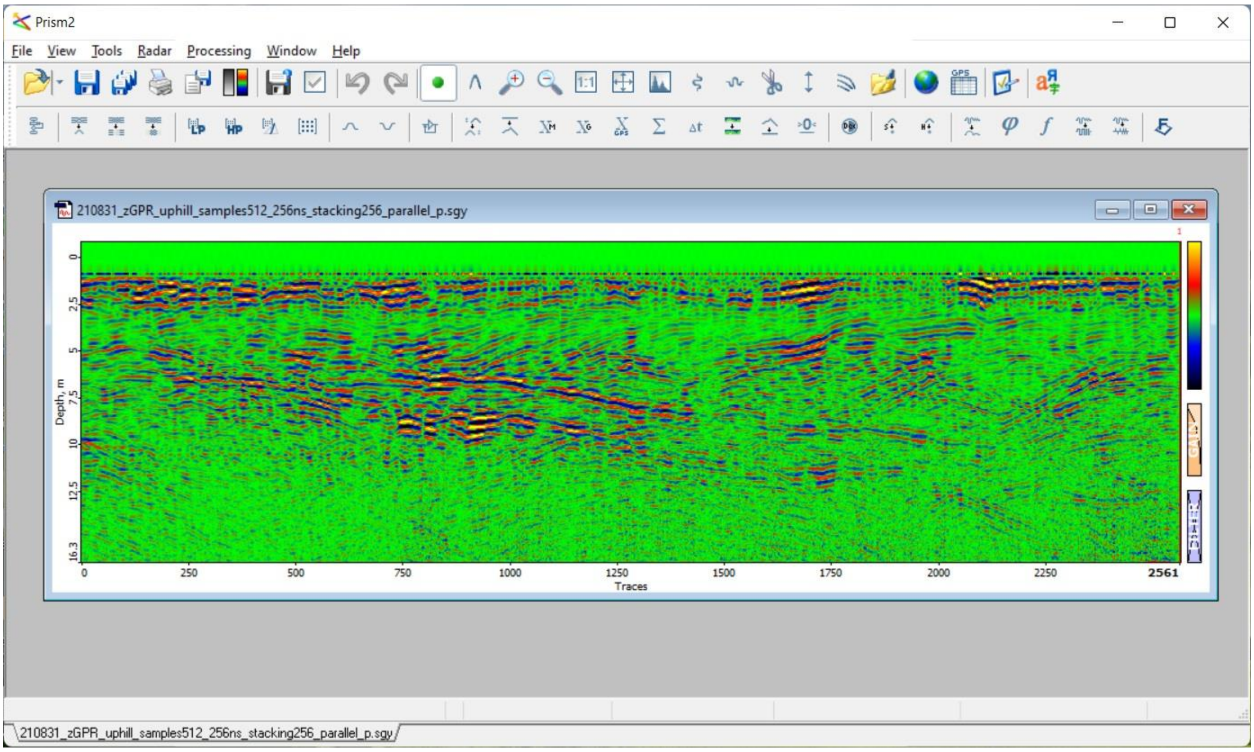


Fig. 7.1. Full Menu of "**Prism2**".

7.1. **File** – file handling operations and printout.

- **Open** – using this item you can select the required file and display it on the screen by typing its name in the File name line, or select the required file from the list and load it by clicking the Open button. If you need to open several files at once, first select them with the left mouse button. This item also provides some other standard features such as deleting, renaming, copying and creating folders and files.

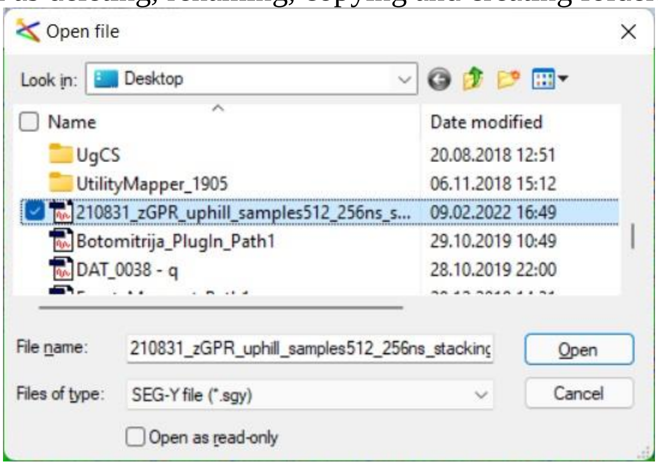


Fig.7.2. File Open dialog box.

- **Reopen** – quick way to open last opened 10 files by single click.
- **Save As** – save profile as a file on the hard drive.
- **Save All** – save all currently opened profiles in different files on the hard drive.
- **Close All** – close all currently opened profiles by a single click.
- **Add** – add stored before profile's data to the current profile.
- **Export –** export profile(-s) data in different ways:
  - **to Bitmap** – export of current profile window screenshot in the Bitmap (*.bmp) format.
  - **to JPEG** – export of current profile (button **Apply**) or of all opened profiles (button **Apply to all**) screenshot in the JPEG (*.jpg) format with the chosen JPEG compression quality.

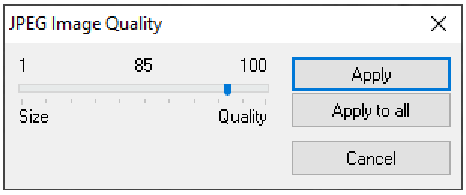


Fig.7.3. Export to JPEG dialog box.

  - **Marks to text file** – export of current profile marks (mark ID, trace No, distance) to the text ASCII file (*.txt) as a Tab separated table.
  - **Amplitudes to text file –** export of current profile data amplitude values to the text ASCII file (*.txt), as a Tab separated table, where each traces filled as a rows and samples as columns.
    - **Raw data** – raw data (not gained, not filtered) export.
    - **Processed data** – gained and filtered data export.
  - **Annotations to text file –** export of current profile annotations (File name, Annotation type, Trace No, Sample No, Distance, Time delay, Depth, Amplitude, mark, Latitude, Longitude, Altitude, Y Position, as a Tab separated table) to text ASCII file (*.txt), where multi vertexes annotations represents by segments.
    - **for active profile** – current profile annotations export.
    - **for all opened profiles** – all opened profiles annotations export.
  - **Coordinates to text file –** export of current profile (button **Apply**) or of all opened profiles (button **Apply to all**) coordinates (File name, Trace No, coordinates columns in correspondence to chosen **Coordinates System**, as a Tab separated table) to text ASCII file (*.txt), where output (export) file name could be chosen by pressing on **Browse** button.

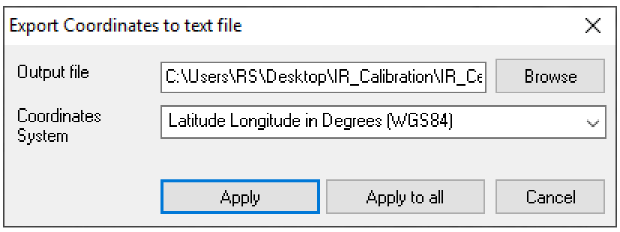


Fig.7.4. Coordinates export dialog box.

- **XYZC** – export of current profile (button **Apply**) or of all opened profiles (button **Apply to all**) data amplitude values as a Tab separated table with X, Y, Z and C columns (where X and Y corresponds to chosen **Coordinates System**, Z is a depth and C is an average amplitude value in cell with defined **Cell size** or amplitude value of each sample if **Each sample** option is chosen) to text ASCII file (*.txt), where output (export) file name could be chosen by pressing on **Browse** button (see Appendix C. on p. 79).

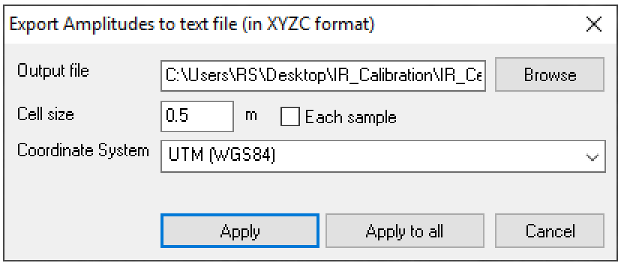


Fig.7.5. XYZC export dialog box.

- **Import –** different import options from existing stored before files:
  - **Gain Function** – gain function import from the stored profile.
  - **Zero point** – direct wave zero line point import from the stored profile.
  - **GPS coordinates in NMEA format** – GPS/GNSS coordinates import from the text file containing GGA strings in NMEA format.
- **Profiles combining** – opens **Profiles Combining Wizard** what helps to combine all selected profiles into single profile (see on p. 57).
- **Profiles splitting** – opens **Profiles Splitting Wizard** that helps to split selected profile(-s) to the several profiles (see on p. 58).
- **Profiles 3D aligning –** aligning of parallel profiles acquired for 3D imaging in third party software (see on p. 59).
- **Print** – Profile printout in one of the views supported by the software. The following items may be modified in the Print dialog box (Fig. 7.3):
  - **Printer** – Choice of the Printer that user can use for the printing out.
  - **Printing type** – **Scaled** or **Not scaled**. In case of scaled print, the vertical and horizontal scales shall be specified.
  - **Orientation** (
 Landscape or 
 Portrait) – When changing orientation of a page, the outline of the page and the layout of drawing therein are changed, respectively.
  - **Poster –** possibility to split printing output between specified number of pages per horizontal and vertical.
  - **Preview** – User can place the profile output area on the page. The yellow rectangle helps to change the output area size. The red rectangle shows the title area on the page.
  - **Size –** After clicking output's size modification area (small yellow rectangle on the right down of the output area) and holding left mouse button (the pointer will be replaced by the double arrow), moving the mouse will change output's size.
  - **Properties –** Standard dialog box for the printer settings.

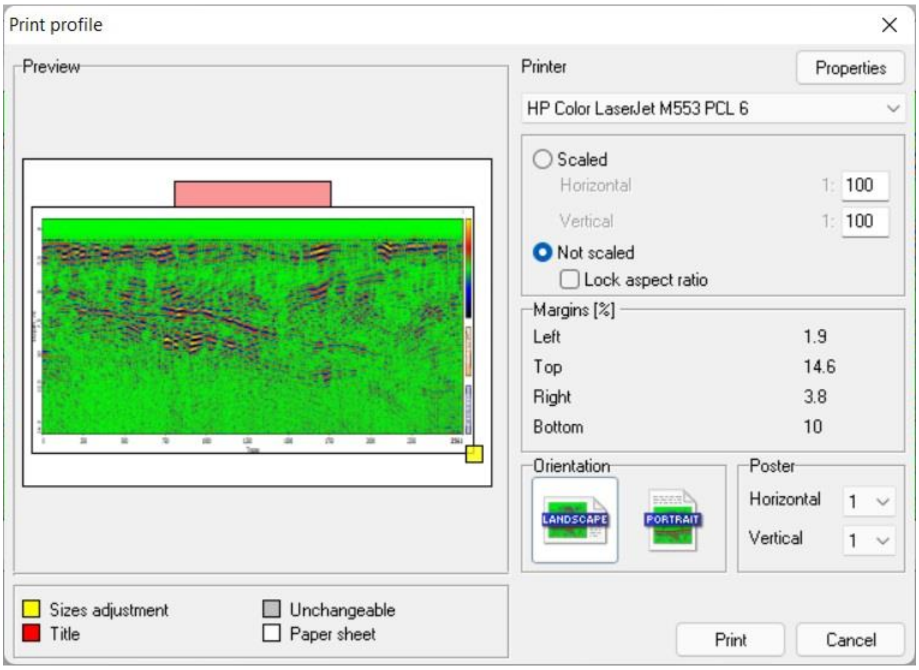


Fig. 7.6. Profile Print dialog box.

- **Print Setup** – printing properties.
- **Exit** – exit from the application. Most users may also use the standard application closing method by clicking the left mouse button on the  button at the upper right corner of application window or by simultaneous pressing **Alt+F4** buttons. You will have to answer relevant questions to confirm your exit if there are any unsaved files.

7.2. **View** – options determining the appearance features of the software.

- **Toolbars** – toolbars visibility settings:
  - **Show toolbar** – show / hide the Toolbar in the upper part of the application main window.
  - **Show processing toolbar** – show / hide the processings toolbar located in upper section of the main screen of the program.
  - **Windows tabs** – show / hide the profiles tabs for the quick profiles access in the lower part of the application main window.
  - **Show status bar** – show / hide the Status bar in the lower part of the application main window.
- **Large buttons** – toolbar buttons size enlarging.
- **Antialiasing** – enables / disables antialiasing while curves (wiggle trace, power curve etc.) rendering.
- **Languages** – choice of the interface's language. The software has different interface language files (*.lng): English, Russian, German, Chinese, Greek and Korean. You have to press button **Add language** to add the language file (*.lng), language files are located in the "**Prism2**" folder. If your language choice is correct you can press **OK** button to use chosen language as default for the next runs of the "**Prism2**" software. If you want to work with the interface in different language, don't hesitate to contact us at addresses listed in Appendix E. Attributes (see p. 86).

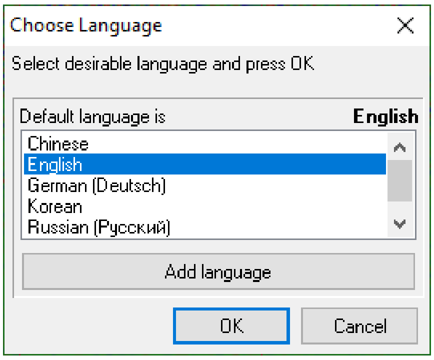


Fig.7.7. Language dialog box.

7.3. **Tools** – tools and options used for a profile handling and processing purposes. Take a look on the Section 11. Profile handling for more details (p. 44).

- **Color palette** – the choice and adjustment of a profile rendering colors Take a look on the Section 11. Profile handling for more details (see p. 55).
- **Gain function –** Gain function adjustment. Take a look on the Section 11. Profile handling for more details (see p. 45):
  - **Gain function** – gain function window activation. Take a look on the Section 11. Profile handling for more details (see p. 45):
  - **Enable Gain** – enable/disable gain of the current profile.
  - **Double Gain** – gain points values doubling (multiplication by 2).
  - **Build in the Gain Function** – replace the source (raw) trace data by the gained one in the current profile.
  - **Build in the Gain Function for All opened profiles** – replace the source (raw) trace data by the gained one in all opened profiles.
  - **Show trace in the gain function window** – Show/hide trace oscillogram in the gain function window.
- **Frequency filter** – digital frequency filtering of signals. If a **Customized High Pass Filter** was used during sounding, then the lower right column of the profile is active.
  - **Frequency filter –** filter parameters adjustment.
  - **Enable filtering** – enable/disable frequency filtering.
  - **Built in the Frequency filter** – replaces the initial profile data with the filtered ones in the active profile. Beware, this feature makes changes to the initial data.
  - **Built in the Frequency filter forr all opened profiles**) – replaces the initial profile data with the filtered ones in the all opened profiles. Beware, this feature makes changes to the initial data.
- **Mouse actions** – profile tools:
  - **Point info** – output of the following parameters for the clicked point: Trace number, Position, Sample, Time delay, Depth, Amplitude, as well as latitude, longitude and altitude (see p. 47). If there is a marker, its number is displayed in the bottom row.
    - **Hide point's info on mouse button release** – hides point information immediately when the mouse button is released.
  - **Hyperbola** – measuring local object depth and dielectric permittivity of surrounding medium by the hyperbola technique, with output of values for the following measured parameters: Position, Depth, Time delay, Permittivity,

Velocity. There is a shortcut **Stolt (F-K) method** for the migration processing using measured values (see p. 47).

- **Zoom in** – zooming in of the selected area (see p. 48).
- **Zoom out –** zooming out to the previous state**.**
- **Scaled output** – scaled output of the current profile with horizontal and vertical equal scaling factor.
- **Fit profile** – fitting of the whole profile in a window.
- **Average spectrum** – calculation of the average spectrum of the selected area (see p. 49):
  - **Average spectrum –** average spectrum calculation for the selected area.
  - **Normalization** – average spectrum amplitude scale normalization to 1 (only for **Times** scale).
  - **Raw data –** average spectrum calculation of raw data (before gaining).
  - **Processed data** – average spectrum calculation of processed data (after gaining).
  - **dB -** average spectrum calculation in dB.
  - **Times -** average spectrum calculation in times.
- **Trace inspection** – selected trace output (see p. 50):
  - **Trace inspection** – shows separate profile trace oscillogram.
  - **Show Wiggle trace** – show/hide chosen trace oscillogram curve.
  - **Show Power curve** – show/hide chosen trace power curve.
  - **Show Attenuation curve -** show/hide chosen trace attenuation curve.
- **Sample inspection –** outputs the amplitude of the traces on the specified sample along the visible profile (see p. 50).
- **Cut traces and samples** – deleting undesirable traces and samples from the profile (see p. 51).
- **Hodograph** – solving a problem of layer-by-layer ground thickness and permittivity determination using the common depth point method within a flat layer model (see Section 15 on p. 71).
- **Annotations –** profile annotations creation, editing and elimination (see p. 52).
- **Pulse delay adjustment –** profile time delay changing on the time axis.

- **Lines color –** choice of line color for markers and synthesized hyperbola.
- **Marks** – profile marks management tools:
  - **Insert** – Mark's insertion to the profile. There are several possibilities to insert marks to the profile: Single mark or Equi-distance multiply marks. Each mark has its strong connection to the trace and its index in the profile, what should be entered to insert mark to the certain position. If equi-distance option is chosen, user has to enter the Δ_x distance, what is used as the distance step between marks during its insertion. User can make insertion once by pressing on **OK** button, or continue insertion by pressing on **Apply** button. There is a possibility to insert mark by a single right click on the profile (pop-up menu **Marks / Insert**), where **Prism2** helps to get and place the trace index to the **Trace number** window.

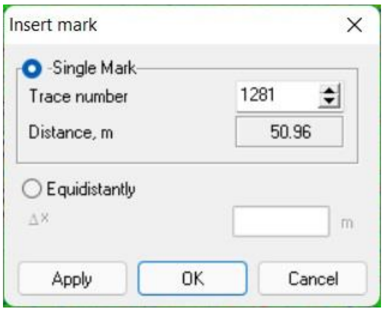


Fig. 7.10. Mark’s insertion dialog box.

- **Delete** – Mark’s deleting in the profile. User have to indicate the mark identification number and press **OK** or **Apply** button to delete this mark (if multiply marks have to be deleted, user should press **Apply** button). There is a possibility to delete mark by a single right click on the profile (pop-up menu **Marks / Delete**), where software helps to get and place the mark index to the **Mark number** window.

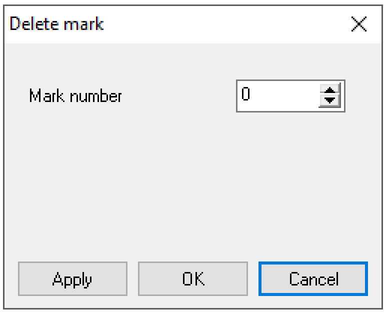


Fig. 7.11. Mark’s deleting dialog box.

- **Delete All** – All marks deleting of the current profile.

*Note: Mark’s identification number is used in a range from 0 to 255. Inserted mark’s number is applying automatically and is not sequential. It’s better to **Rebuild** marks at the end of its insertion or deleting process, to rearrange its indexes sequentially.*

- **Rebuild** – marks identification numbers rearranging.
- **Hide marks in All opened profiles** – disables mark’s lines drawing for all opened profiles.

The same pop-up menu can be promptly called by right-clicking in the marker numbers are in the profile window, and software will find the number of the nearest trace or the number of the nearest mark and put it to the corresponding fields.

- **Resample profile** – samples number changing of all traces in the current profile. User should apply it to the current profile only by pressing on **Apply** button, or to all opened profiles (**Apply to all** button).

Fig. 7.12. Mark's deleting dialog box.

Note: Profile resampling doesn't cut or add empty samples to the traces in the profile, it's rebuilding the traces and its data in correspondence to the new value! It's better to choose power of 2 values as a number of samples (like 128, 256, 512, 1024, etc.), due to some procedures used in the ***Prism2*** *software.*

- **Output parameters** – the active profile parameters, such as **Output range**, **Length of profile**, **Output view**, **Normalizing factor**, file description (**Text information**) and processing **history**. You can also switch on or off output of marks and annotations on the profile or leave annotations only as the final output result (see p. 56).
- **GPS Tracker** - survey path applying GPS positioning display (see p. 51).
- **GPS Coordinates Table** – display current profile's editable GPS coordinates table.
- **Rebuild profile distance in accordance to GPS coordinates** – profile distance rebuilding in accordance to the stored GPS coordinates:
  - **for active profile** – distance rebuilding of the current active profile.
  - **for all opened profiles** – distance rebuilding of all opened profiles.

Note: basic spherical ellipsoid with radius 6371032 m is used for the distance recalculation from the GPS coordinates.

- **Convert to UTM coordinates** – latitude / longitude coordinates conversion into UTM coordinates.
- **Undo** – Profile data changing rollback. Any manipulation with profile data cause **Undo / Redo** point creation, what helps to rollback or jump further to the previous or next stage of profile.

Note: All next Redo points are deleting automatically, if any manipulation applied on the profile after its rollback.

- **Redo** – returning back to the next stage of profile data changing.

7.4. **Radar** – GPR modes and parameters adjustment, sounding data acquisition.

- **Connection settings** – Control Unit IP address setup. The default IP address is **192.168.0.10.** You can read about Control Unit IP address changing in Appendix A on p. 75. How to configure the computer for communication with Zond-12e GPR you can find in Sections 5.1. (p. 10) and 5.2. (p. 12)

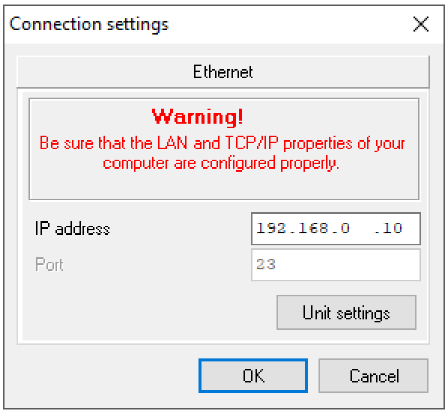


Fig. 7.13. Connection settings dialog box.

Note: Never change the IP address of the control unit without the need! The control unit IP address changing should be applied by a qualified user only, otherwise if user set the wrong IP address or lose it, then control unit becomes inaccessible, and its recovery faces with a number of inconveniences. This is especially sensitive for the ***Python*** *GPR, because the IP address resetting to the original one involves its housing opening and seal failure (its restoration is possible in professional environment only). An attempt to change the IP address of the control unit may result as a non-warranty repair by the manufacturer.*

- **Performance** for Zond-12e users – obsolete systems support s:
  - **Obsolete antennas protection** – GPR antennas older than 7 years, due to the obsolescence of internal components, lose the ability of fast and safe parameters switching in double channel mode, which may cause damage. To avoid this, this menu should be checked.
- **Performance** for Cobra GPR – connection performance choice:
  - **Autodetection** – automatic detection of connection interface for communication with Cobra GPR.
  - **Ethernet connection** – for communication with Cobra Wi-Fi GPR or Cobra CBD GPR.
  - **Bluetooth connection** – for communication with Cobra Plug-In GPR.
- **Positioning** – data acquisition’s positioning method choice (see Section 8. Positioning for details on p. 28).
- **Battery** – the GPR control unit (except the single-channel version) constantly measures the powering voltage level. It allows to display the battery voltage level, if user correctly selects the chemistry of the battery (lead-acid, nickel-cadmium, nickel-metal hydride or lithium-ion).
  - **Battery warnings** – enables/disables the low battery warning.
  - **Autodetect** – software requests GPR type and model on connection for the correct setting and mode applying. Additionally the built-in battery type detects.
- **Sounds** – sounds muting/unmuting for the data acquisition mode.
- **Where to save** – sounding data files storing directory choice.
- **When to save** – option that switches when the sounding data will be saved – during or after the acquisition. Software asks for the filename on the **Start** button pressing when **During acquisition is** chosen (this option is preferable to use for long profiles, it protects unsaved data losing in cases like power loss, insufficient RAM

space, critical system errors, etc). Otherwise, software asks for the filename on the **Save** button pressing when **After acquisition is** chosen.

- **Auto launch** – enables/disables the automatic Data Acquisition mode run on the application startup.
- **Tablet controls** – enables/disables touchable screen, touchpad and mouse in Data Acquisition mode.
- **Environment options –** data acquisition mode appearance adjustment:
  - **OFF computer on exit** – software prompts to shut down the PC on data acquisition mode leaving if this option is enabled.
  - **Show channel labels** – enables/disables semitransparent channel labels visibility on the foreground in double channel or circle data acquisition mode (Fig. 9.1b.).
  - **Vertical toolbar** – data acquisition mode controls orientation (vertical/horizontal).
- **Start** – runs the data acquisition mode (take a look on the Section 10. GPR Sounding for more details on page 42). The shortcut keys **Ctrl+A** is available also.

7.5. **Processing** – digital filtering of the profiles collected before. Processing goal is to extract the useful signals and elimination of noise, interferences and useless signals (take a look on the Section 13. Profiles post-processing for more details on page 61).

7.6. **Window** – profile windows positioning.

- **Tile vertical** – vertical windows positioning.
- **Tile horizontal** – horizontal windows positioning.
- **Tile smart** – windows positioning in consideration of the profiles' size.
- **Cascade –** cascaded windows positioning.

7.7. **Help** – information about the software.

- **User's Manual** – opens this manual.
- **Radar Systems, Inc. web page –** open Radar Systems, Inc. homepage.
- **Check for updates at startup** – enables/disables updates checking on software startup (PC should be connected to the Internet).
- **Check for updates** – run **Prism2 Updater** application and updates the software if update is available online (PC should be connected to the Internet).
- **Version History** – software versions history.
- **Prism2 Logging -** the software is able to log its internal actions and states in the text log file PrismLog.txt, which is located in the software root directory. This log may help to find and fix software bugs and errors.
- **Check Adiminstrator rights on startup –** software needs Administrator rights to work correctly with files and registers of the Windows operating system. Otherwise, the program may not work correctly. If the Administrator does not allow the user to obtain these rights, we advise you to disable this menu item in order to avoid displaying the corresponding message during program loading.
- **About –** information about the application and its developer (version, build number, building date).

8. Positioning

It is better to choose the positioning before data acquiring to correctly determine the location and/or geometric dimensions (traveled distance) of the acquiring GPR profile, because it will help while data processing and interpreting. The profile's traveled distance (its length) is used to locate targets relative to its starting point. There are many positioning methods, the main ones implemented in the Prism2 software and consisting of:

- **Manual** – manual way of positioning. User has to measure the traveled distance by some measuring device (tape measure, odometer, laser meter, etc.) for the manual method and then enter measured value manually while acquired data saving to the hard drive, or to the Output parameters menu item. parameters) (see below in section 11. Working with sounding data files on page 50).
- **Wheel** – survey wheel method of positioning. It is possible to use different types of measuring wheels (for example, our current measuring wheel has a diameter of 200 mm, a shock-proof cart wheel has the diameter of 250 mm, but a built-in 1500 MHz antenna wheel has the diameter of 80 mm). The wheel positioning can be selected in the main menu (see Fig. 8.1) or in the GPR Setup (take a look on Section 9. GPR tuning at the page 34). The GPR has a wheel interface and counts pulses got from the wheel encoder. Software has to know the wheel parameters to recalculate it to the traveled distance. A difference of a few mm in diameter can lead to meter errors while measuring the traveled distance. There are two possibilities to describe the wheel:
    - **Parametric** - the software allows adding (fig. 8.2), editing (fig. 8.3) or selecting previously added wheel. The main parameters of the wheel are diameter (in mm) and number of pulses per revolution, which you will find on the wheel.

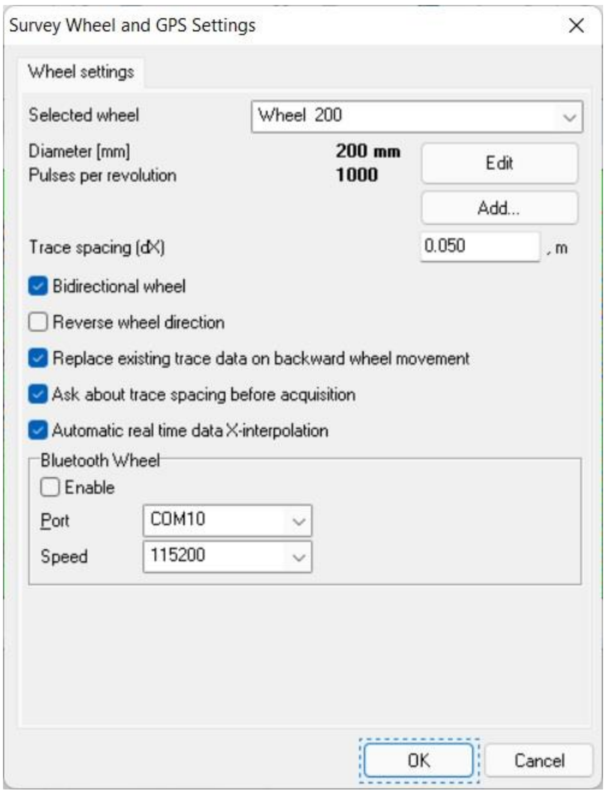


Fig.8.1. Survey wheel settings

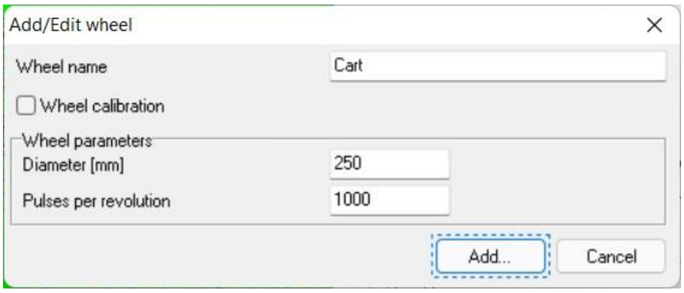


Fig.8.2. Survey wheel adding

Fig.8.3. Survey wheel editing

Note: The wheel's diameter is changing during lifetime, due to its use and worn out.

- **Calibrating** – the wheel can be calibrated (or recalibrated) by passing a precisely measured distance. In this case, user should select a calibration for an existing wheel, or add a new one and select a wheel calibration instead of its diameter and pulses per revolution. If selected wheel has a calibration possibility, the **Recalibration** button appears in the wheel settings window, press it and calibration window appears on the screen (Fig. 8.4). It is needed to establish a connection with the GPR and get an access to the wheel data, captured by the GPR for the wheel calibration. First of all, place the GPR antenna, with the connected wheel, at the starting point of the calibrating path. Setup all necessary settings of the GPR (take a look on the section 9. GPR tuning at the page 34) and turn it on. Press the **Start** button and move the antenna with a connected wheel for a precisely measured distance. Click the **Stop** button and enter the traveled distance. The software counts the number of pulses received from the wheel encoder to assign it to the entered distance. It will help to measure traveled distance precisely in the future. If necessary, you can check the calibration quality by pressing the **Check** button and passing the measuring distance again. These values should match with a correctly performed calibration.

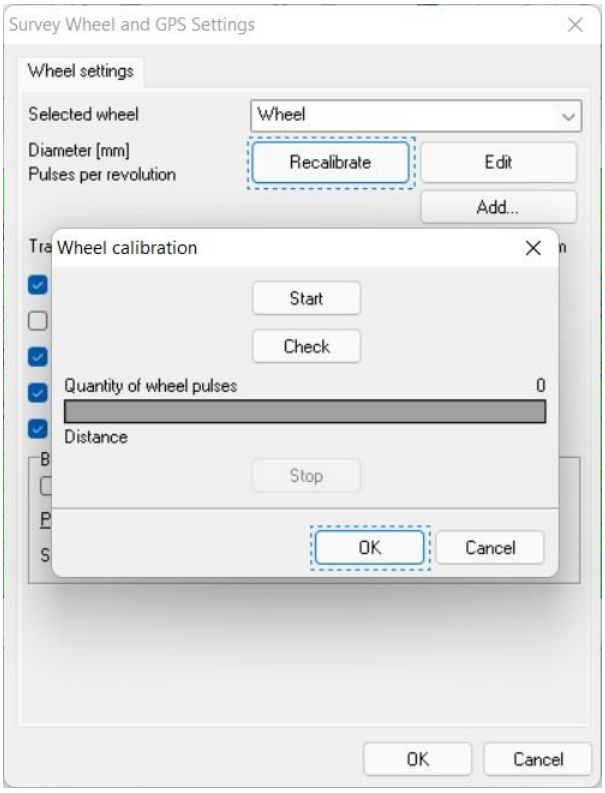


Fig.8.4. Survey wheel calibration

Software uses the captured wheel pulses to understand is wheel rotating or not. If wheel is not moving the traces are not adding to the acquiring profile. The calculated traveled distance is recording to the header of each acquiring profile trace.

- **Automatic real time data X-interpolation** – equidistant traces acquisition, when each trace has the preliminary defined trace spacing (dX) to each other.
- **Trace spacing [dX]** – is used to adjust the resolution along the profile. This value depends on the minimum size of the detected object, taking into account the fact that it is desirable to have 3-5 traces crossing the object. Those if the size of the object is 15 cm, then the dX should be 5 cm, but preferably 1 cm. But note, that too small dX leads to traces and the acquired profile increasing. The dX can be specified both in the wheel settings window and before the each start of data acquisition. This is controlled by the **Ask about trace spacing before acquisition** item.
- **Bidirectional wheel** – detection of toward/backward wheel direction.
- **Reverse wheel direction** – wheel direction changing while bidirectional wheel is used, i.e. backward movement becomes to forward movement and vice versa. This is may be used for different ways to move the GPR antenna (drag after the operator or push it in front of him), especially for a shock-proof cart.
- **Replace existing trace data on backward movement** – while the antenna moves forward, the profile is displayed on the screen from left to right, but if antenna moves back, then the profile also builds back, i.e. from right to left with a white vertical marker in front. If the antenna moves back along exactly the same path, then it looks like a white vertical marker moving back along the profile. This feature of the wheel is very useful for pinpointing of underground utilities; the vertical white marker aligns exactly with the top of the hyperbola

when moving backwards. When moving backwards, the profile data is either changed (overwritten) or only the position of the operator is noted. It is managerd by this parameter state.

- **Bluetooth wheel** – if it is not possible to physically connect a survey wheel, for example, for a **Python** GPR, or for a low-frequency unshielded antenna 150-75-38 MHz, it is possible to use a wireless Bluetooth wheel, like our **xWheel** (for more details, take a look on the Radar Systems, Inc. website – www.radsys.lv). User should to check the **Enable** item of the Bluetooth wheel parameter group, to use it. Any Bluetooth device must be connected using the operating system tools. User should check the assigned COM port number. This number has to be selected in the COM port list of the Bluetooth wheel.

- GPS - global positioning system or GNSS - global navigation satellite system (it combines signals from different satellite navigation systems as GPS [USA], GLONAS [Russia], GALILEO [European Union], BeiDou [China], NavIC/IRNSS [India] and QZSS [Japan]). Software supports GPS/GNSS receivers which outputs coordinates in NMEA 0183 format (version 1.5 and higher). The latitude and longitude are recorded in the header of each trace, which are used to calculate the current coordinate of the trace and the traveled distance. The GPS/GNSS settings for pairing with the GPR and its data presented in GPS settings window (Fig. 8.5).

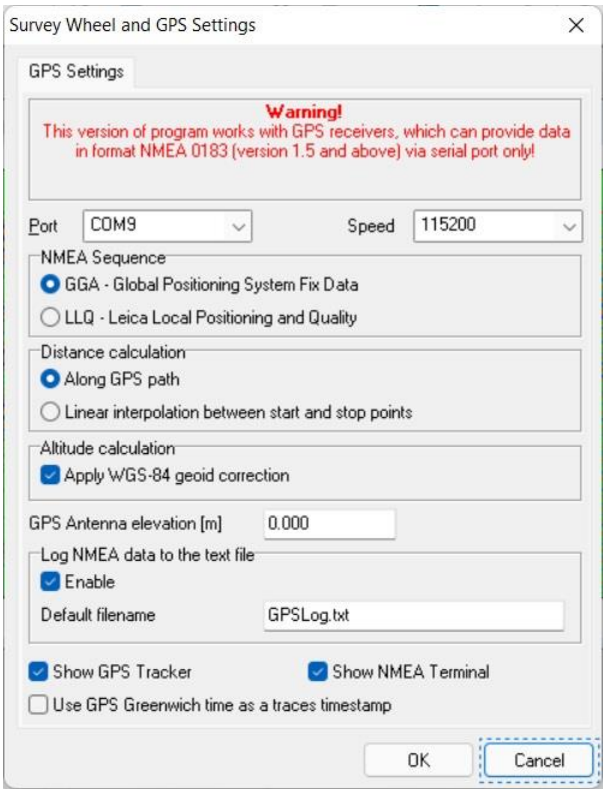


Fig.8.5. GPS/GNSS settings

- **Port** – GPS/GNSS receiver connection to PC is possible via a COM Port, including Bluetooth and USB interfaces, which presented as virtual COM ports. It is needed to specify the Speed of the serial connection, which indicated in the GPS/GNSS receiver user’s manual.

Note: The National Marine Electronics Association (NMEA) has developed a protocol to support compatibility between marine navigation equipment from different manufacturers. This NMEA protocol describes not only data received from GPS/GNSS receivers, but also measurements from sonars, radars, electronic compasses, barometers and other navigation devices used in the marine. The data exchange interface of most portable GPS/GNSS receivers is implemented in accordance with the NMEA specification. This data contains the complete navigation measurements of the GPS receiver - position, speed and time. All NMEA messages consist of a sequential set of data, delimited by commas. Each individual message is independent of the others and is fully "complete". The NMEA message includes a header, a set of data represented by ASCII characters, and a "checksum" field to verify the validity of the transmitted information. The header of standard NMEA messages starts from character '$' and contains additional 5 characters, which first two define the type of message, and the remaining three - its name. For example, all GPS NMEA messages are prefixed with "GP", GNSS with "GN", GLONAS with "GL", GALILEO with "GA", BeiDou with "GB", NavIC [IRNSS] with "GI" and QZSS with "GQ".

- **NMEA Sequence** – choice of the way where to capture coordinates. The NMEA protocol describes a large list of different messages, where we are interesting in **GGA - Global Positioning System Fix Data** (that contains Time, Coordinates and Positioning data, it provides coordinates in the form of latitude, longitude and altitude) as well as **LLQ - Leica Local Positioning and Quality** (that contains positioning in Mercator and its accuracy, it provides coordinates in the UTM coordinates reference system).
- **Distance calculation** during GPS positioning depends on the type and accuracy of the GPS/GNSS receiver. The error can reach meters or even tens of meters for the initial accuracy class, for a small number of satellites or without possibility to get a "clear sky". Therefore, the software is able to calculate the distance traveled either **Along the GPS path** - from coordinate to coordinate, or as **Linear interpolation between start and stop points**, i.e. the passed profile is considered to be absolutely straight from point A to point B, and the distance is calculating as the difference between the coordinates of the starting (A) and stopping (B) points.
- **Altitude calculation** – there are two ways to calculate the altitude above the sea level on the base of the received NMEA message, it is earth ellipsoid altitude or using WGS-84 geoid correction. If **Apply WGS-84 geoid correction** is disabled the altitude contains the earth ellipsoid altitude only, otherwise WGS-84 geoid correction is applying.
- **GPS antenna elevation [m]** under the ground surface. This value is deducting from the calculated altitude.
- **Log NMEA data to the text file -** this option allows to **Enable** recording of incoming NMEA data (any messages) to a text file (log). The software renames the log name according to the profile given name and restarts logging for the next profiling in data acquisition mode. If profile is not saved the specified **Default filename** is used for a log file**.**
- **Show GPS Tracker** – the passed path graphical output in accordance with the received coordinates.
- **Show NMEA Terminal** – show/hide the NMEA messages stream in a terminal pop-up window.

- **Use GPS Greenwich time as a trace timestamp** – each trace has a timestamp, it is able to replace by the GMT time received from the GPS/GNSS receiver, for example, for further synchronization with coordinates after its post-processing in the third party software.

*Note: It is better to use **X-interpolation / by GPS coordinates** processing for the data analizing and its interpretation (for more details, see page 73) for the GPS positioned profiles. It is important for velocity analysis of diffracted objects (the permittivity detection from the found hyperbolas), because the hyperbola may be distorted on non-equidistant profiles.*

- **Wheel + GPS** - combined Wheel and GPS positioning option, where the coordinates are recorded in the trace header, but the traveled distance is measured by the wheel, which is much more accurate than the distance measurements by the GPS / GNSS receiver.

*Note: GPS/GNSS accuracy corresponds to the receiver error, what is a chaotically fluctuating parameter from the negative to the positive value. It means, that if accuracy, for instance, is about 5 cm, then measured coordinates are spread around true point in radius of 5 cm and the maximum difference between measurements on the same point could be from -5 cm to +5cm, what turns to +10 cm in the distance measurements by **GPS positioning**. That's why it is better to use **Wheel+GPS positioning**, if possible.*

9. GPR tuning

It is necessary to correctly tune the GPR, before starting sounding. Please follow the next steps for it.

9.1. Connect all necessary GPR cables (Ethernet cable to PC with installed "**Prism2**" software, antenna cable(s), survey wheel, etc.). Set the GPR or antenna(s) to the working position.

Warning! Do not connect or disconnect cables while GPR is powered!

9.2. Power up PC and GPR. If you use wireless connection please make sure that PC is connected to the GPR wireless network (Zond-12e, Python, Cobra or xGPR) and run the "**Prism2**" software. Use menu **Radar/Start** or press keyboard shortcut **Ctrl+A**. if **Tablet Controls** are not enabled, then keyboard is possible to use only. It is better to use keys ←, →, **Enter** and **Space** for navigation between controls.

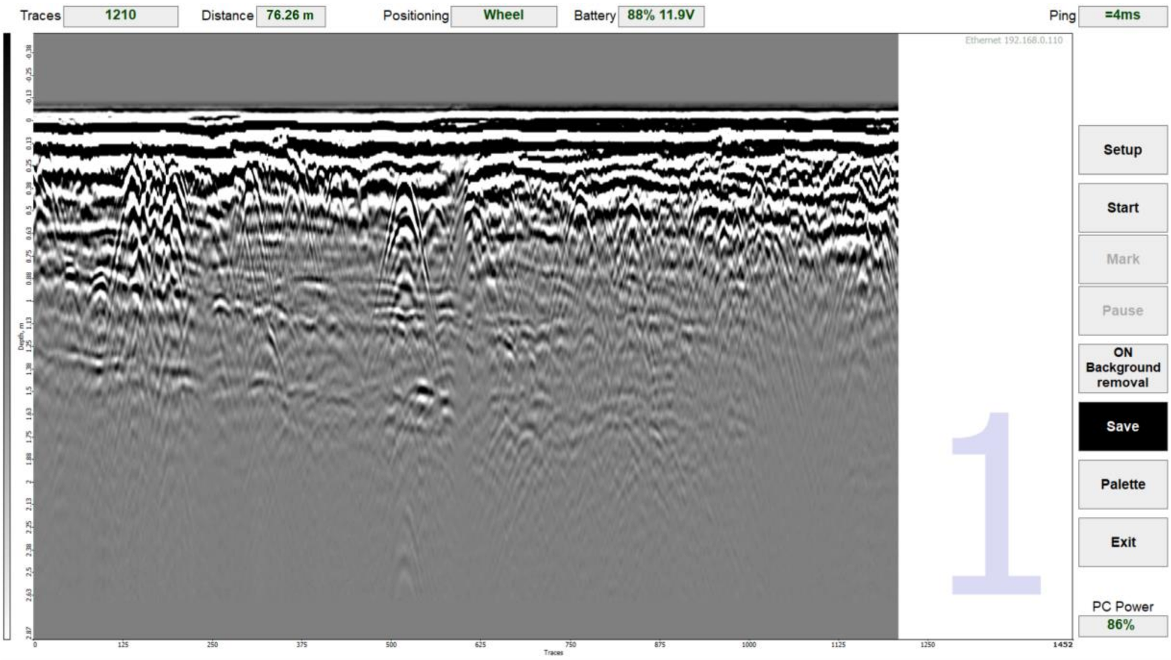


Fig. 9.1a. Data acquisition mode with vertical toolbar

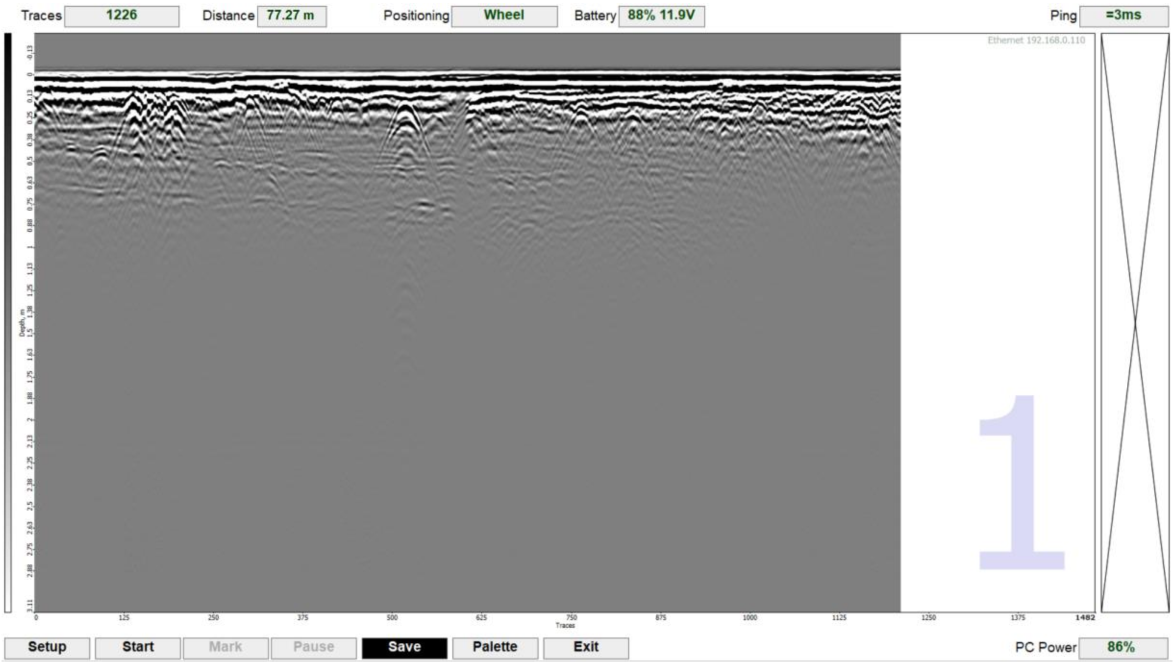


Fig. 9.1b. Data acquisition mode with horizontal toolbar

The data acquisition mode has black-and-white interface, it increases a contrast and image visibility on the direct sunlight. The controls consist of following items:

- **Setup** – GPR settings.
- **Start/Stop** data acquisition.
- **Mark** – mark insert to the current trace.
- **Pause/Continue** data acquisition.
- **ON/OFF Background removal** – enable/disable the real time filter, for the vertical toolbar interface.
- **Save** – profile saving as a file to the hard drive.
- **Palette** – choice of the profile color palette.
- **Exit** from the data acquisition mode.
- **Traces** – the amount of the acquired traces for the current profile.
- **Distance** – the traveled distance of the current profile.
- **Positioning** – selected positioning type.
- **Battery** – GPR battery level.
- **Ping** – the connection quality results on the base of the ICMP ping request, the measuring units are ms (as smaller as better). Usually the ping value has to be in a range from 1 to 25-50 ms. High ping values (>50 ms) indicates bad connection quality, that turns as delays and data losses while data acquisition. The ping timeout (---) more than 6 seconds from the data acquisition mode start, indicates a connection problem.
- **PC Power** – handheld PC battery level.

9.3. Select **Setup** button and press **Enter** or **Spacebar**. The GPR Settings interface depends on the connected GPR family type:

- Single channel **Zond-12e** GPR settings interface shown on Fig. 9.2a.
- Double channel **Zond-12e** and **Zond-12e Advanced** GPR settings interface shown on Fig. 9.2b.

- **Python-3** GPR settings interface shown on Fig. 9.2c.
- **xGPR** settings interface shown on Fig. 9.2d.

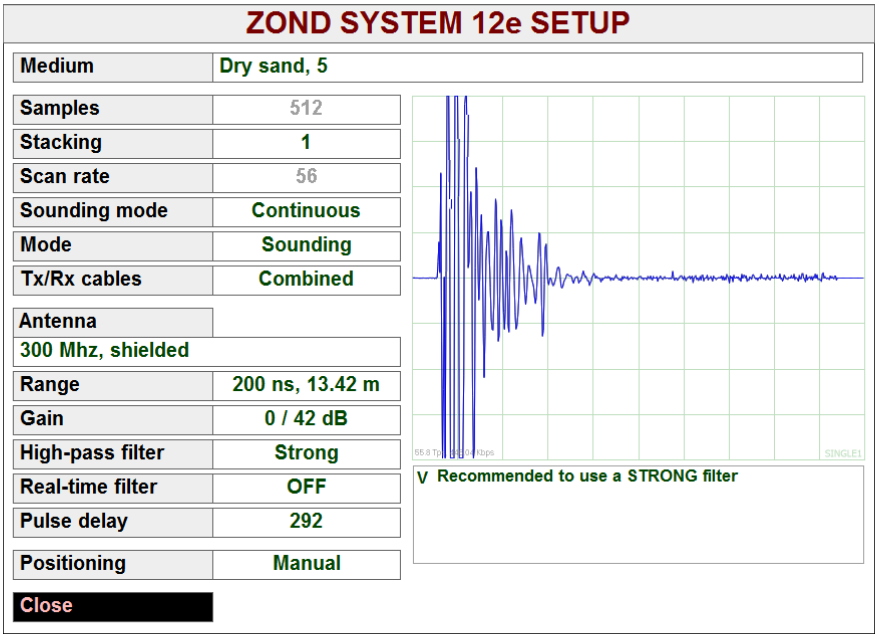


Fig. 9.1a. Single channel GPR settings.

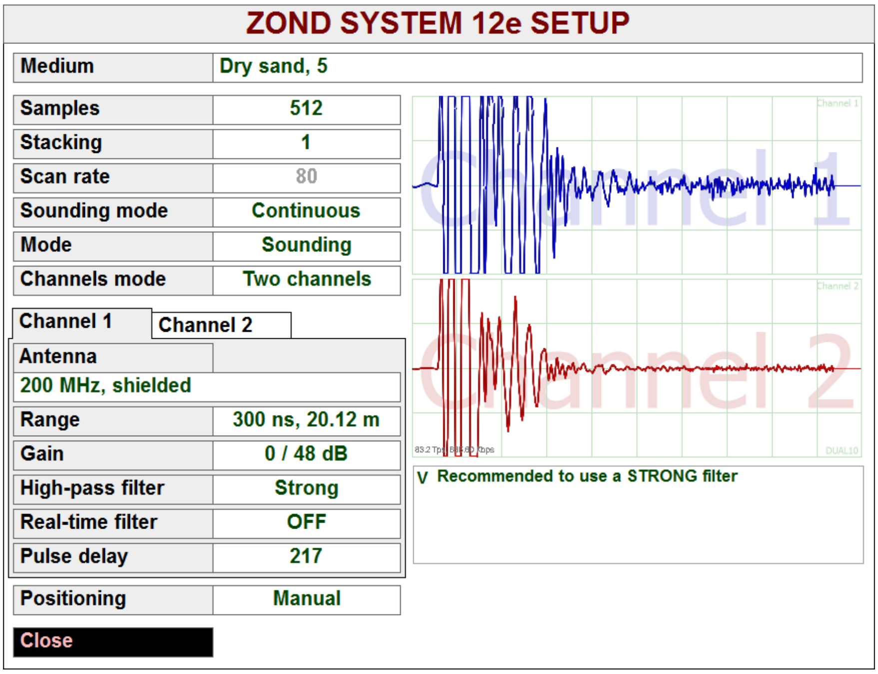


Fig. 9.1ba. Double channel GPR settings.

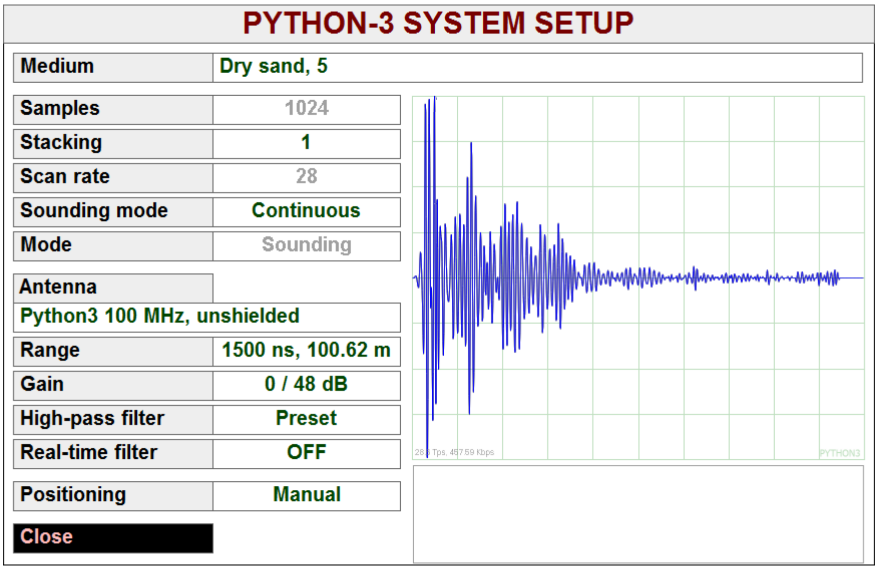


Fig. 9.1c. Python-3 GPR settings.

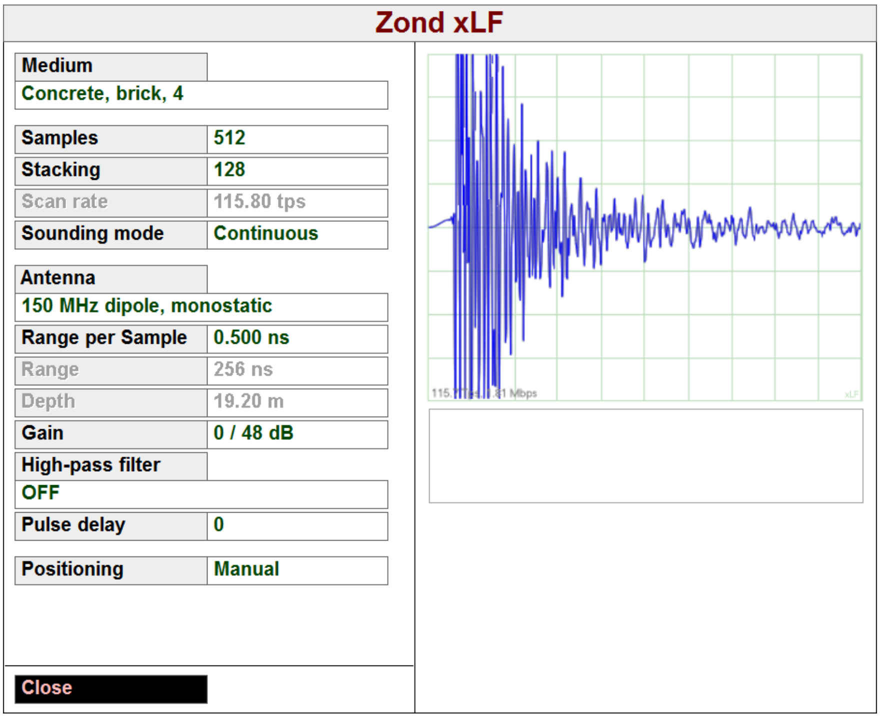


Fig. 9.1d. xGPR family settings.

There are a list of GPR settings on the left and an acquired trace oscillogram on the right. Additional information and recommendations are displayed below the oscillogram. Please note, the GPR antenna has to be in a working position, for example, at the beginning of the possible sounding path. Controls navigation is possible with the help of keys ↑ and ↓, selection – **Enter** or **Spacebar** or touchable (if such possibility is enabled). The grayed (disabled) items are for information only. The list of GPR settings contains:

- **Medium** – setting the medium that you intend to sound. Choose the closest medium from the list. Permittivity used for depth calculations is written after the name of a respective medium.

- **Samples** – samples number per trace:
  - There are 4 possible values for **Zond-12e Advanced** GPR: 128, 256, 512, 1024.
  - There is only one possible value for other **Zond-12e** GPR models: 512.
  - There is only one possible value for other **Python-3** GPR models: 1024.
  - There are 6 possible values for **xGPR** family: 256, 512, 1024, 2048, 4096, 8192.

Note: If samples rate reduces traces rate is increasing proportionally for ***Zond-12e Advanced*** *GPR. But traces rate doesn't depend on samples rate for xGPR family, it depends on stacking and time range per sample. User has to be very attentive to the information under the oscillogram window to avoid situation when number of samples is not enough for correct signal digitizing (at least 5 samples per signal period).*

- **Stacking** – number of the traces that are adding to each other and averaging in a row, the averaged trace is adding to a profile. The stacking helps to reduce high frequency noise, but increases the useful signal in a trace, that turns as deeper penetration. But please note that as higher stacking as lower traces rate. The high stacking decreases an operator speed to avoid information loss. Stacking is disabled if defined as 1, but a greater value enables it and is processing on software side for **Zond-12e** and **Python-3** GPR families. **xGPR** family is fundamentally different at this point. These GPRs are using a powerful FPGA processor and Real Time Sampling method to digitize the initial received signals, which increase the traces per second ratio of an order of magnitude. As the result, traces overflow is converting to stacking (hundreds and thousands of times), but without averaging – only summation, that enlarge the data sample length from the initial 16 bits to 32 bits. **xGPR** signal-to-noise ratio and its penetration depth are increasing compared to the previous GPR families.
- **Scan rate** or trace per second ratio, it is number of received traces per one second:
  - The maximum value is 240 traces per second for 128 samples per trace and stacking 1 in **Zond-12e Advanced** GPR.
  - The maximum value is 56 traces per second for stacking 1 in **Zond-12e Single-channel** GPR.
  - The maximum value is 80 traces per second for stacking 1 in **Zond-12e Double-channel** GPR.
  - The maximum value is 28 traces per second for stacking 1 in **Python-3** GPR.
  - The maximum value is 2500 traces per second for stacking 4 in **xGPR**, depends on the stacking and the selected time range per sample.
- **Sounding mode** – it has two options: **Continuous** or **Stepped**. The first one, most commonly used option, assumes that after data acquisition start, the GPR continuously perform sounding until **Stop** button (or **Esc** key) pressing. **Stepped** profiling is used in cases, when it is impossible to move the antenna continuously along the route or it is necessary to achieve the greatest sounding depth. This requires more time from the user for the sounding. Each individual trace adds to the profile on user key press (**Enter** – trace acquiring, **Spacebar** - trace acquiring and mark assignment). It is better to use increased stacking for this option. The **Stepped** option profiling technique uses the following way: place the antenna on an acquisition point (antenna is not moving while data acquisition!), collect a single (stacked) trace, place the antenna on the next point, collect the next trace, continue the data acquisition step-by-step equidistantly, along the profiling route and

perform sounding by pressing the corresponding key at each point. When finished, press **Esc** or the **Stop** button.

- **Mode** (for **Zond-12e** GPR family only) **-** it has three modes: **Sounding, Test** and **Calibration**. The first one is the sounding mode. The rest two modes are used to test the internal modules of the control unit without any connected antennas.
- **Tx/Rx cables** (for single channel **Zond-12e** GPR only) – it has two options: **Combined** or **Separated**, and indicates the state of connected antenna cable, is it contains both transmitting and receiving wires (**Combined**) or they are **Separated**. This parameter is always automatically defined as **Separated** and cannot be changed for 38-75-150 MHz dipole antenna. Other antennas have possibility to use it with different options.
- **Channels mode** (for **Zond-12e** Double channel or Advanced control units only) – there are four (**Zond-12e** Double channel) or six (**Zond-12e** Advanced) possible modes:
  - **Channel 1** – single channel mode for operation with single antenna connected to channel 1.
  - **Channel 2** – single channel mode for operation with single antenna connected to channel 2.
  - **Two channels** – double channel mode of operation with two antennas at the same time connected to channels 1 and 2 in parallel mode.
  - **Tx-1, Rx-2** – single channel mode when transmitting (Tx) antenna connected to channel 1 and receiving (Rx) antenna connected to channel 2. This mode is designed for Common Depth Point (CDP) operation and for 38-75-150 MHz dipole antenna.
  - **Tx-2, Rx-1** (for **Zond-12e** Advanced only) – single channel mode when Tx-antenna connected to channel 2 and Rx-antenna connected to channel 1.
  - **Circle mode** (for **Zond-12e** Advanced only) – modes are changing continuously in row: Channel 1; Channel 2; Tx-1, Rx-2; Tx-2, Rx-1.
- **Antenna** – the supported antennas list, user should choose the proper antenna used for sounding.
- The time range is one of the most important parameters and has to be chosen very carefully. There is a range of values. Please follow the software recommendations while time range tuning. If you set it too high, the following warning appears: **Warning! Too small sampling rate!** But if it is too small then software reports: **Sampling rate is some redundant**. Each time range has the calculated recalculated depth value (in meters) for the selected medium without attenuation. But in reality, the maximum sounding depth depend on the sounding signal attenuation in the medium. Each medium has its own attenuation level. Therefore, it is not recommended to set time range more than it is needed to solve your task. The principle of time range choice depends on the GPR type:
  - **Range** (for **Zond-12e** GPR family and **Python-3** GPR) – the time range is assigned for the whole trace and doesn't depend on its number of samples. The user can choose the **Customized** value and software automatically selects the closest satisfying time range and aligns it to **Customized** one.
  - **Range per sample** (for **xGPR** family) – the time range is assigned per sample in the trace, where, whole time range depends on the number of samples per trace. For example, if 0.5 ns is selected on 1024 samples, then the full trace time range will be 512 ns; and at 0.714 ns for 512 samples corresponds to 366 ns per trace,

the software calculates the time range per trace and outputs it to the Range field, the estimated penetration depth for the selected medium to the Depth field.

- **Gain** – it is digital gain (amplification) of the received traces. Due to the fact that the signal's strength is rapidly decreasing while it is propagating along the soil, the gain of the signal should be increased while the depth is increasing too. Therefore at the end of the trace the gain should be greater than in the beginning. You can set the gain function as a polyline connecting up to 10 vertexes, where each of them can be adjusted within 0-84 dB (for **Zond-12e** GPR family and **Python-3** GPR) or 0-168 dB (for **xGPR** family). Gain is used only for the GPR data output. The number of vertexes could be changed pressing keys from 2 to 9 in the **Digital gain function setup** window. Press 0 to get 10 vertexes. Vertex navigation is possible by the arrow keys ← and → and ↑ and ↓ to adjust the gain levels. The simplest useful gain function has 2 vertexes with values 0 dB at the beginning and 48 dB at the end. If such gain is not optimal it is possible to change it at any time in the post-processing (take a look on Section 11. Profile handling on page 44).

Note: The acquired GPR data are saved on the hard drive in the original shape (without gaining). Gaining is just a software tool and is used for data visualization purposes only.

- **High-pass filter** – cutoff frequency selection of the high-pass filter for received signals to attenuate low-frequency noises, which arises while antenna is crossing the rough terrain or due to antenna architecture. The following high-pass filters are available for different types of the GPR:
  - **Zond-12e** GPR family – there are different hardware filters states (**OFF**, **Weak**, **Strong** and **Super Strong**). Please follow the software recommendations. **Customized** filter is a digital software real-time bandpass filter and it disables hardware high-pass filter. Customized filter frequency band is modified in filter setup window that outputs the band curve and signal's spectrum in the real time. Frequency band is characterized by its vertexes (each vertex corresponds to filter cutoff frequency). To navigate between filter's vertexes use < and >, or tab keys. Changing vertexes' position (filter cutoff frequency) could be done by ← and → keys.

Note: It is recommended to use Customized High-Pass Filter if you are familiar with the spectrum analysis and the digital signal processing only. Otherwise it is better to use hardware filters on the base of software recommendations.

  - **Python-3** and **xGPR** family – there are two options to acquire data without high-pass filtering (option **OFF**) or using digital software **Preset** filter. Software automatically calculates cut-off frequencies for the **Preset** high-pass filter on the base of chosen antenna.
- **Real-time filter** (for **Zond-12e** GPR family and **Python-3** GPR) – real-time filter choise for background noises elimination. The constant background signals could be seen on the profile as a horizontal lines that do not change intensity and the time position. Such useless signals may hide the useful signals.

*Note: The acquired GPR data are saved on the hard drive in the original shape (not filtered) in case of **Customized** or **Real-time** filtering. Filtering (the same as a Gain function) is just a software tool and is used for data visualization purposes only.*

- **Pulse delay –** this option is used to adjust the sounding signal position. The initial delay values do not correspond to the optimal adjustment, as each antenna and the GPR unit has its own. The pulse delay has to be adjusted first time you are using antenna and cable on each needed time **Range**. It is possible to tune it automatically or manually. Press the ‘a’ or ‘A’ key to enter **Automatic** mode. Software automatically adjusts the pulse delay for selected **Antenna** and time **Range**. If you would like to adjust the pulse delay manually, please try to set the sounding signal to the desired position using ← and → keys for fine adjustment and the **Page Up**/**Page Down** keys for coarse adjustment. The optimal position of the sounding pulse (its first lobe) is the center of the first green oscillogram grid cell. Software stores **Pulse Delay** adjustment for each **Antenna** – **Range** combination, and there is no need to adjust it always.
- **Positioning** – the profile positioning choice. It duplicates **Radar / Positioning** main menu item. It is possible to choose positioning without data acquisition mode leaving. Each GPR family has its own list of possible positioning modes. There are additional settings for the Wheel positioning:
    - **Wheel name** – list of previously stored wheels, where each wheel name corresponds to its diameter and the number of pulses per revolution.
    - **Direction** - movement direction: forward or backward.

You will find the examples of successful and unsuccessful adjustments below, with relevant comments.

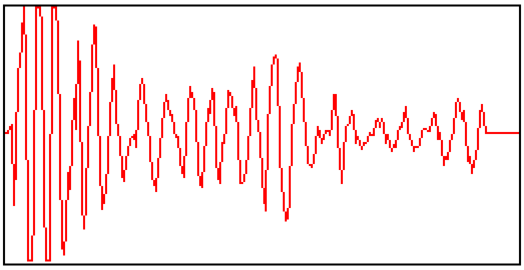


Fig. 9.3 Good tuning

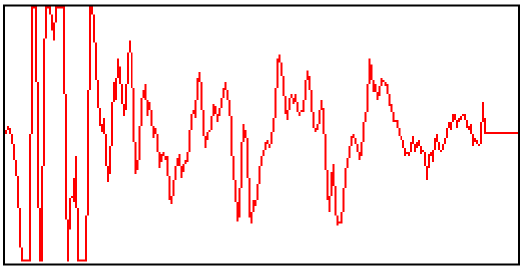


Fig. 9.6. Low-frequency interference present
High-pass filter should be applied

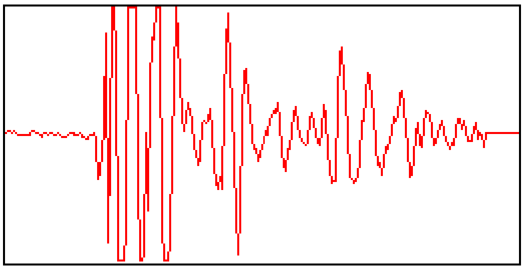


Fig. 9.7. Incorrect pulse delay
Pulse delay should be adjusted

10. GPR Sounding

Any field work starts at office, where it is better to check battery levels for GPR, PC and other necessary devices. Be sure that TCP/IP setting are adjusted properly to support communication with GPR (take a look on Section 5. Computer presets on page 10 for details). If you use any Bluetooth devices (GPS/GNSS receiver, Bluetooth wheel, etc.) please check it's pairing with PC and its COM ports numbers coinciding with indicated ones in **Prism2** software settings (menu **Radar/Positioning**). It is recommended to check also other initial GPR parameters from menu **Radar**. If you start a new field work it is suggested to create a separate directory on the hard drive for the data and indicate it in **Radar/Where to save** menu.

Filed work starts from the antenna(-s) placement, put it in a working position at the initial point of the survey line, Power up PC and GPR. If you use wireless connection please make sure that PC is connected to the GPR wireless network (Zond-12e, Python, Cobra or xGPR) and run "**Prism2**" software. Use menu **Radar/Start** or press keyboard shortcut **Ctrl+A**. if **Tablet Controls** are not enabled, then keyboard is possible to use only. It is better to use keys **←**, **→, Enter** and **Space** for navigation between controls.

Tune the GPR if needed and close the GPR settings windows. Make sure that the positioning mode is set correctly, the current positioning method is indicated at the top of the screen. There are controlling buttons at the bottom or right side of the screen in data acquisition mode (take a look on point 9.2 on page 34 for details). Initially there is access to five active buttons: **Setup**, **Start**, **Exit** and **Palette**. Using the **Palette** button to select the colors for the acquired data output. The **Start** button becomes active on start up.

Press **Start** button. If the **Radar/When to save/During the acquisition option** is enabled, the software asks to specify the filename for the future profile before sounding. if menu **Radar/Sounds** is checked user here **Let's go** sound and GPR sounding starts with the profile real time output on the screen. It is better to start moving the antenna at this moment.

There is additional information in the upper part of the screen. It is possible to read the current acquired traces number, traveled distance (except Manual positioning) and the GPR battery status. Software controls different parameters and if faces with something that needs user attention, it pops up the event. Events appear in the bottom part of profile. Each event has the color legend, take care about Red and Yellow ones.

The number and set of active buttons is changing right after data acquisition start: **Start** button changes to **Stop**, **Mark** and **Pause** buttons enabled, but **Setup** and **Exit** disabled. The **Mark** button becomes active. If user needs to insert a mark to the profile during the data acquiring, while passing location marker, just press the **Enter** or **Spacebar** at the moment when antenna and location marker centers coincide. Each marking is accompanied with a beep sound. Mark appears as a vertical line on the profile with its number at the top. First and last traces of the profile are marked automatically.

To stop data acquisition, press **Esc** or **Stop** button. User will hear the **Stopped** sound and acquisition stops. The buttons states are changing to initial one, where **Save** button becomes active.

There are different ways to handle the acquired data:

- It is possible to save it as a file to a hard drive. Software prompts to enter the traveled distance for the manual positioning, Y-offset, movement direction (forward or backward) and a filename. Software uses the default mask for the filenames "DAT_XXXX", where XXXX is incrementing id number. If it detects existing files in the store folder with such mask, it takes the maximum id and increments it to use as default filename for the new data file. The generated filename can be changed by the user. If file with indicated name exists in the folder, software prompts to overwrite it, append it or change the filename. If backward direction is chosen, the profile is mirrored "back to front" (take a look on processing **Reverse** on page 63, for details). If profiling passes in "zig-zag" way (toward, backward, toward…), then for each backward profile is better to indicate backward state and software rebuild all profiles in the same direction.

- If close the data acquisition mode with the acquired data on the screen, software replaces it as a separate profile window with name "Profile 1" in the main view for post-processing and prompt to save it on its close try.
- If acquired data is wrong or user doesn't need it, it can be restarted or canceled. Software controls the unsaved data and prompt user to save it or cancel.

If during the acquisition user needs to pause sounding (make a pause), press the **Pause** button and will hear the **Paused** sound signal. To continue - press **Continue** or **Mark** button.

Usually, the GPR field work is associated with the data acquisition only and there is no possibility for the post-processing, that's why software prompts to shut down PC on the exit from data acquisition mode.

11. Profile handling

When one ore more profiles have been created in the course of sounding, various operations may be made thereon, as described below.

Load a sounding data file, and have it displayed on the screen by using option **File/Open**. By default, the application will display data as a line scan profile (Fig. 10.1) in a separate window with standard Windows attributes in the right upper corner. The file name will be shown in the left-hand upper corner. The window may be drawn across the screen, and its size modified, using standard Windows means and ways. The number of profiles to be displayed in the screen shall be unlimited. By default, they will be arranged in a cascaded pattern; you may also choose their layout patterns at your discretion in option **Window** of the Main menu (see Subsection 7.6).

Fig. 11.1. Profile tabs.

Each opened profile has its associated named tab at the bottom of main window for the quick navigation between them. User can rearrange the tabs order using drag’n’drop technic.

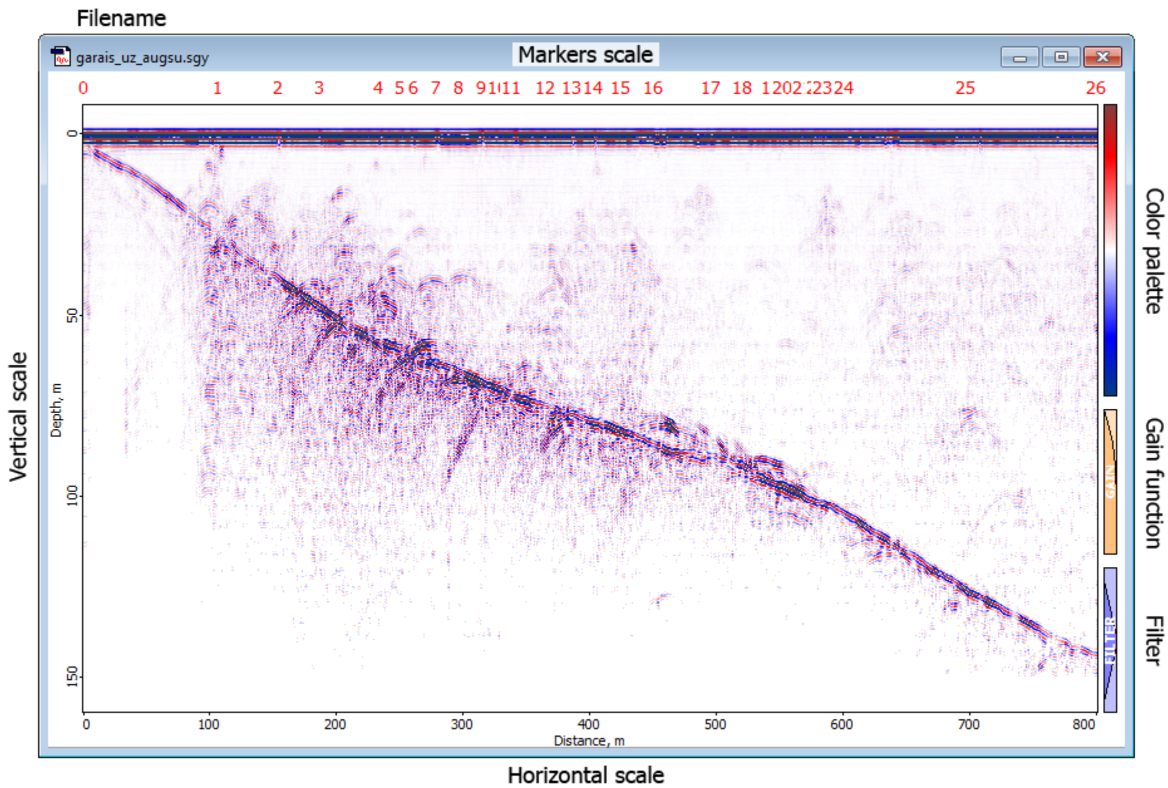


Fig. 11.2. Profile Output working window.

A radiolocation profile is provided with horizontal and vertical scales, vertical scale can be moved for zero point adjustment (see Subsection 3.4). To set a zero point, draw the cursor at the white field to the left of the profile (the cursor will take the form of a double arrow), now when you press and hold the left mouse button move your mouse up and down to move the scale so that the zero point coincides with the mid-point in the second line of the sounding signal, as shown in Figs. 4.2 and 4.3. To the right of the profile, there are three vertical columns used for quick tuning of the displayed profile. The upper column is intended to change the color palette of displaying the radiolocation profile; this column duplicates **Tools/Color palette** menu option and button (brief color palette changing menu appears when cursor holds under color palette column). Color palette modification is described below (see p. 55); we would like to recommend you to use black-and-white imaging, especially at the beginning.

The middle column is used to setup the signal's gain function. At first opening of the received sounding data, the gain function will be similar to one that was used at data acquisition. You are able to set any different gain function. To open **Gain function** window simply press on the middle vertical line **Gain** with your left mouse button.

Right after the first output of a newly created profile, gain function will have the same form as it was specified at data receiving. To change the gain function you should point mouse cursor on any vertex, so it will change its shape to arrowed crosshair under which is the value of gain in dB. Press and hold the vertex and move it left or right, so the gain will be correspondingly changed. The result of your actions will be immediately displayed on the profile.

If you need multi vertex gain function, you can add new vertexes (up to 10). For this purpose press the button and click on desired point on the Gain Function window and the new vertex will be created. To remove unwanted vertex you could use button or popup menu's item **Delete Vertex**. Mouse cursor will be changed to a crosshair. Now you can simply click on the vertex that you want to remove (gain function needs at least two extreme vertexes, which are not removable).

To import the desired gain function from a different data file press the button and choose data file by double click. You can also apply this gain function to the all currently opened profiles by pressing button .

If you need higher gaining (the common maximum gain is 84 dB), up to 168 dB, you could turn on **Double Gain** option, by pressing button or choose **Tools / Gain Function / Double Gain** menu item of Main menu.

There is a possibility to built-in gain function to the raw data of the profile by pressing button or choose **Tools / Gain Function / Built-in Gain Function** menu item of Main menu.

Warning: while gain function building-in the raw data of the profile are changing, and if you overwrite this file, your raw data lost.

By pressing (trace curve), (power curve) and (attenuation curve) buttons you can show/hide the mentioned curves in the **Gain Function's** window. Track bar located beneath the buttons can be used to regulate curve's transparency.

The lower column is used for the setup of the digital filter in the frequency domain. At the first opening filter's frequencies will be the same as they were setup at georadar adjustment dialog box. Lower column will be crossed if in sounding mode digital filter was not used. Double-clicking on the lower column will activate/deactivate digital filter, one click will open filter digital filter setup window.

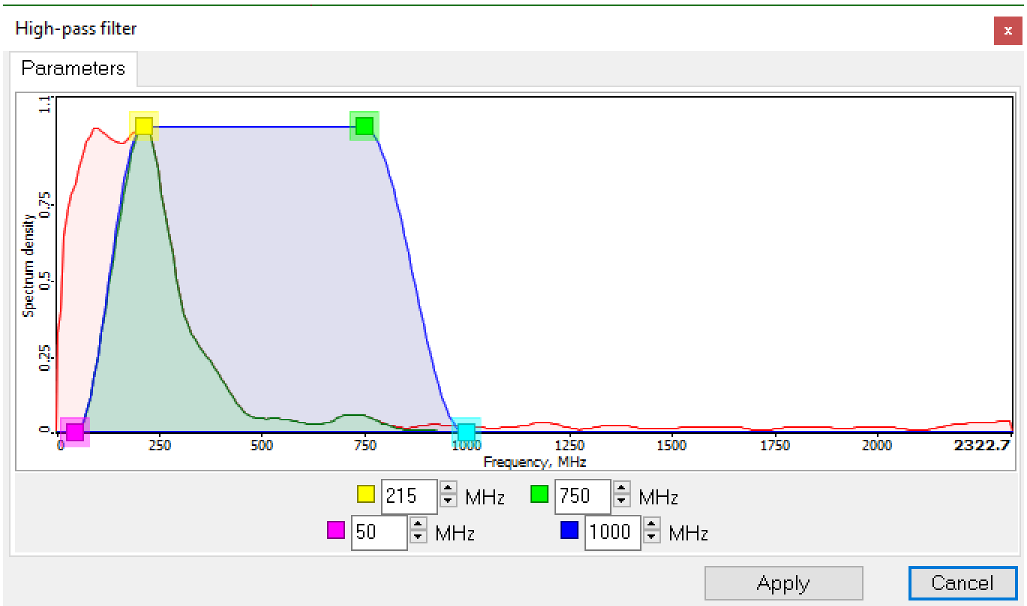


Fig. 11.3. Frequency filter dialog box.

Vertical and horizontal scale dimensions may be modified by pressing the right mouse button on the white field of a respective scale. If at data receiving mode manual positioning mode has been used, you should specify profile length in the **Set profile new length** drop-down menu option or at **Tools/ Output parameters** option in Main menu, which is also duplicated by the toolbar button. Vertical scale calculations in meters are calculated using permittivity that is set in the Georadar Adjustment dialog box. You can also change permittivity levels of a sounded medium after receiving data in the Main menu **Output parameters** option.

Important. Since there a distance between transmitting and receiving antennas (the antennas offset), the simple time-depth recalculation contains the error. This error depends on offset and measured depth ratio, because simple recalculation doesn't consider direct wave propagation time between transmitter and receiver. This error will be significant on small depths especially on the depths close to the distance between the antennas. Therefore there is **Processing/Moveout correction** program that excludes this error. You need to setup **Zero Point** correctly before using **Moveout correction**. To perform **Moveout correction** program enter correct distance between antennas. Georadar data already contains this distance for all "Zond-12e" antennas and will be setup by default, but you can still change it if it is required. We recommend applying this procedure every time no matter the depth you are working with.

You can display profile as a **Wiggle plot** (Fig. 4.2), setting this this mode in the Main menu **Output parameters** option (or toolbar button). Here you could also chose to display profile as a combined **Line scan + Wiggle plot** view.

Application tools used when working with sounding data files are described below, they are located in **Tools** option menu and duplicated as a toolbar buttons (Fig. 7.1.).

- **Point info** – parameter values output: Trace number, Position, Sample number, Time delay, Depth, specified profile's point Amplitude, Latitude, Longitude and Altitude as well as UTM Northing, Easting and Zone. If there is a mark its number will be displayed in the bottom line of the dialog box. After activating **Point info** option simply press anywhere on the profile where you need to know those parameters. Holding left mouse button pressed will display a **Point Info** window illustrated in Fig. 10.2. Some of the information (trace number or position, sample number or time delay or depth, latitude, longitude, altitude) is constantly displayed in the status bar located at the bottom of the main window while you move your cursor along the profile.

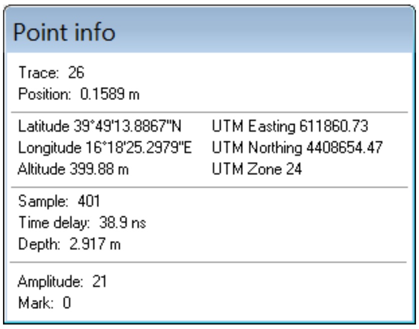


Fig. 11.4. Point Info output dialog box.

- **Hyperbola** – Local object's depth and medium's permittivity determination. When a profile intersects diffractive targets, such as pipes, cables, stones, archeological objects, areas of drastic soil properties variation, their signals on the radiolocation profiles have hyperbola shape; signal examples are shown in Figs. 4.2, 4.3, 10.3. When **Hyperbola** option tool is selected, pressing on the profile will draw hyperbolic line that goes from a theoretical local target in a theoretically homogeneous medium, and open an information window with this target and medium parameters. Your task is to match the theoretical hyperbola with the signal's hyperbola on the profile. First, align the vertices of the hyperbolas; for this purpose, bring the cursor to the signal's hyperbola vertex, and press the left mouse button. The hyperbola slope may be changed by pressing right mouse button: position the cursor on the signal's hyperbola branch, and press the right mouse button. For more accurate hyperbolas matching we recommend to use **Zoom in** on the Main menu (see below) and make several iterations. Matching hyperbolas example is shown in Fig. 11.3.

  Theoretical hyperbola's line color may be changed in **Tools / Lines color** drop-down menu.

  Always remember that parameters determination accuracy fully depends on a precociously configured profile length and zero point (**Tools / Output parameters**).

  After you finished working with hyperbola, press **Point info** button and the theoretical hyperbola will disappear.

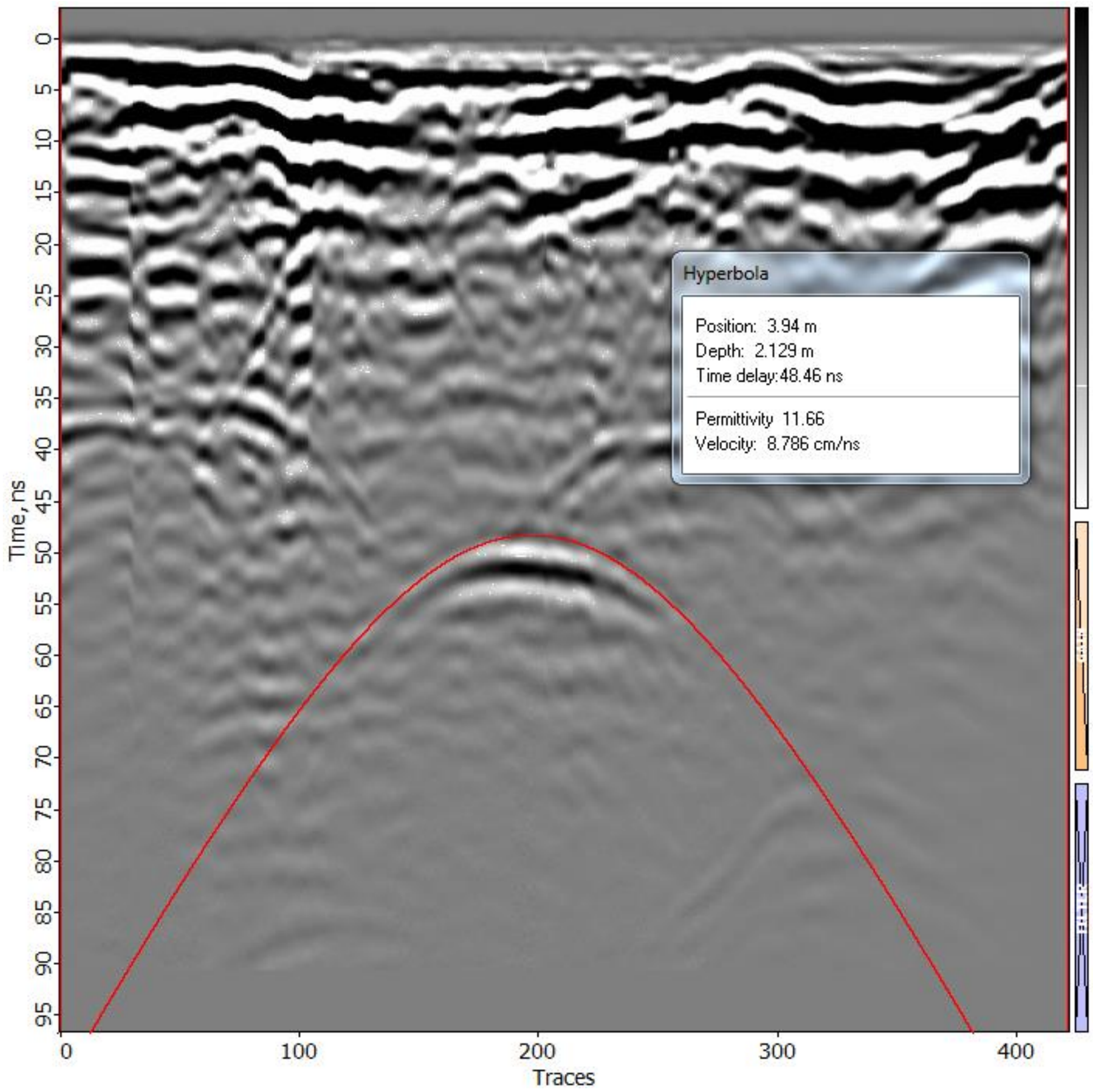


Fig. 11.5. Hyperbola technique used for measuring local target parameters.

- **Zoom in** – selected area magnification. To select magnification area, press and hold the left mouse button and select required zooming area. After releasing mouse button selected area will extend to a size of the window. You can also zoom in using your mouse wheel, simply scroll up the mouse wheel (while in **Zoom in** mode) and you will extend the area around the mouse cursor's position.
- **Zoom out** – Reverse action of **Zoom in**. You can also zoom out using your mouse wheel, simply scroll down the mouse wheel (while in **Zoom out** mode).

Note: you can always (no matter the instrument you are currently using) Zoom in or Zoom out by scrolling up or down the mouse wheel while holding Ctrl key on your keyboard!

- **Scaled output** – scaling output of the profile with horizontal and vertical equal scaling factor – one to one, depending on the selected dimensions of the vertical scale (samples to traces or depth to distance).

- **Fit profile** – Fits whole profile to the window size.
- **Average spectrum** – average spectrum calculation for the selected area on the profile.

Note: The power spectrum of a time series describes the distribution of power into frequency components composing that signal. According to Fourier analysis, any physical signal can be decomposed into a number of discrete frequencies, or a spectrum of frequencies over a continuous range. The statistical average of a certain signal or sort of signal (including noise) as analyzed in terms of its frequency content, is called its spectrum (https://en.wikipedia.org/wiki/Spectral_density).

Used for signal spectral characteristics and interference analysis when choosing bandwidth and suppression frequencies filters: Ormsby bandpass and Notch filter.

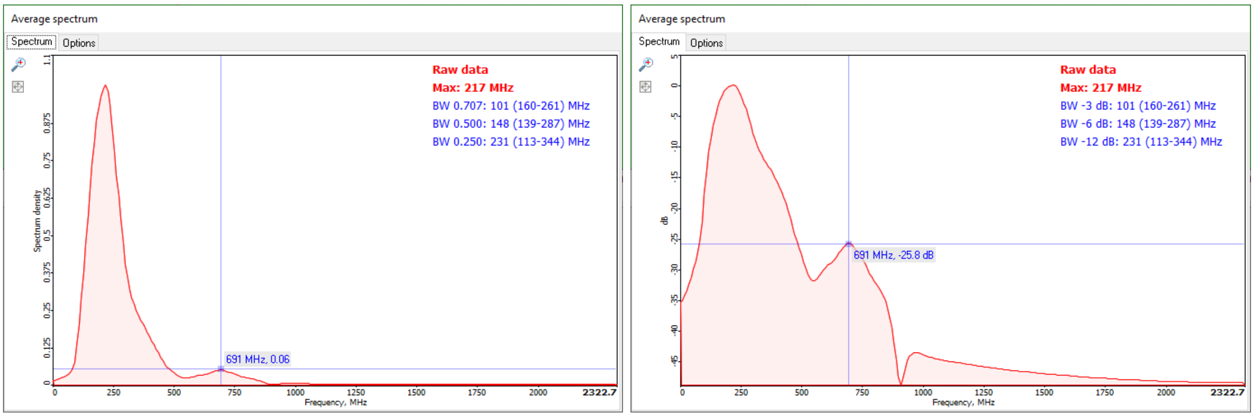


Fig.11.6. Spectrum Output dialog box in different amplitude scale units (in times/ in dB).

There are different options for Spectrum calculation and drawing on tab **Options** or **Tools/Mouse action/Average spectrum** menu item. User can choose the source of spectrum calculation (Raw or Processed data), scale units (times/dB) and color palette (spectrum, indication and background colors). To select the calculation area, press and hold left mouse button and select a rectangular area you need. After releasing mouse button **Average Spectrum** dialogue box will appear (Fig. 10.4). To get precise spectrum frequency and density values of a frequency axis point move the cursor to the required point and press the left mouse button. Two lines intersected at a given point will appear as well as the spectrum frequency and density values (Fig. 10.4). User could find a toolbox with **Zoom in** and **Fit** spectrum to window size tools on the left side of the window. There is an additional information output in the right top corner, what describes the maximum of spectrum function and calculated bandwidths on different levels: 0.707 (-3 dB), 0.5 (-6 dB) and 0.25 (-12 dB). Please note, that information output format depends on the size of spectrum window and part of spectrum which is zoomed in it. Scrollbar appears after zooming and could be used for scrolling of zoomed spectrum.

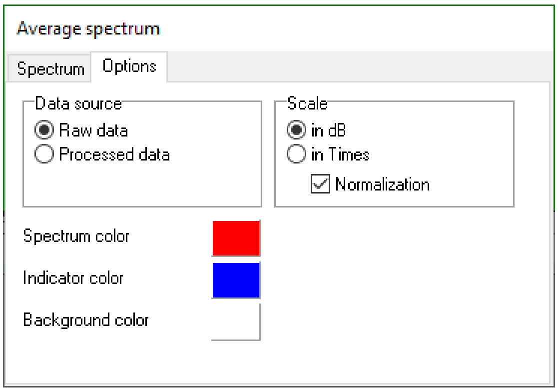


Fig. 11.7. Options tab of Spectrum Output dialog box.

-  **Trace inspection** – wave output of the trace signal in a separate window. Click the left mouse button at the desired place; vertical line with a crosshair will appear on the profile, indicating trace position. You can also navigate along the profile by pressing ← or → keys.

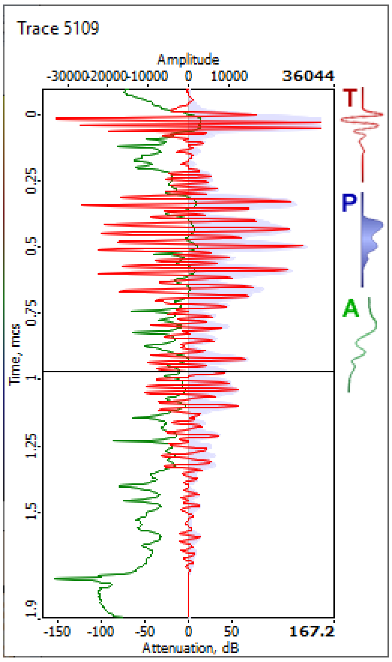
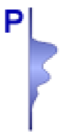
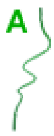


Fig. 11.8. Trace inspection window.

Buttons  (trace oscillogram curve),  (power curve) and  (attenuation curve) show/hide the corresponding curves. The vertical scale of the trace inspection window corresponds to the chosen profile vertical scale, if user changes the profile vertical scale while trace inspection window is visible, its vertical scale changes automatically. The top horizontal scale represents the amplitude of the trace signal in times, but the bottom one – attenuation in dB.

-  **Sample inspection** – samples amplitudes wave output along the visible part of profile, where the horizontal scale represents the amplitude of the trace signal in times and the horizontal scale of the sample inspection window corresponds to the chosen profile horizontal scale, if user changes the profile horizontal scale while sample inspection window is visible, its horizontal scale changes automatically. You can navigate along the vertical scale by pressing ↓ or ↑ keys, changing the desired sample number.

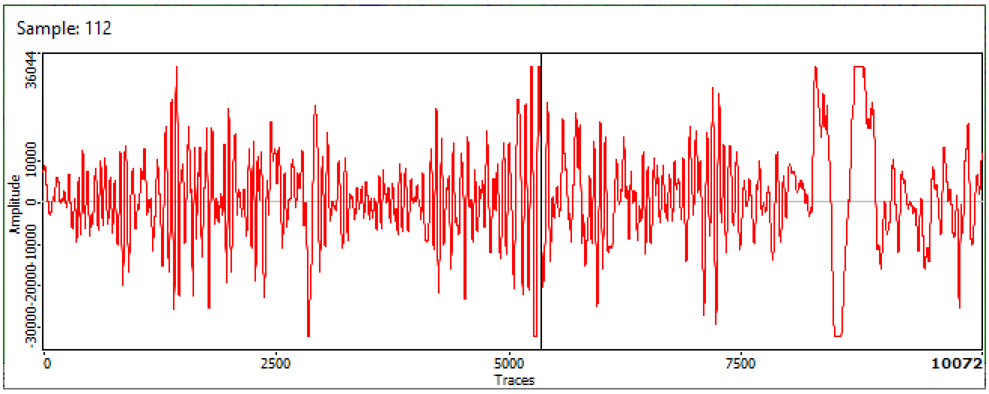


Fig. 11.9. Sample inspection window.

- **Hodograph** – layer-by-layer ground thickness values and permittivity calculation using the common depth point method within a flat layer model. See Section 14 for more details.
- **Cut** – traces and samples cutting out from the profile. Press and hold the left mouse button, then move your mouse horizontally to select undesirable traces, or move vertically for samples. Dialog window will appear, after the mouse button releasing, allowing you to correct initial and final trace or sample ranges for cutting out. Cutting could be applied to the current opened profile or to all opened profiles by pressing on a corresponding button - **Apply** or **Apply To All**.
- **Pulse delay adjustment** – profile time axis position adjustment. Moving the mouse while pressing and holding left mouse button will move time axis line to your desired position on vertical axis. Releasing left mouse button will move profile to the new position according to the new first lobe of the sounding signal.
- **GPS Tracker** – opens **GPS tracker window**, which displays profiles paths based on recorded coordinates of opened profiles. Blue and red rectangles indicate start and stop points. **GPS tracker** window has different visibility mode: as modal dialog box or always on top window, what controls pin button (always on top corresponds to pressed button). "Always on top" mode allows to track profiles traces on the **GPS tracker** window while the cursor is moving under the profile, green square indicates its position on the path. Profiles names which haven't coordinates are presents in "<…>" brackets.

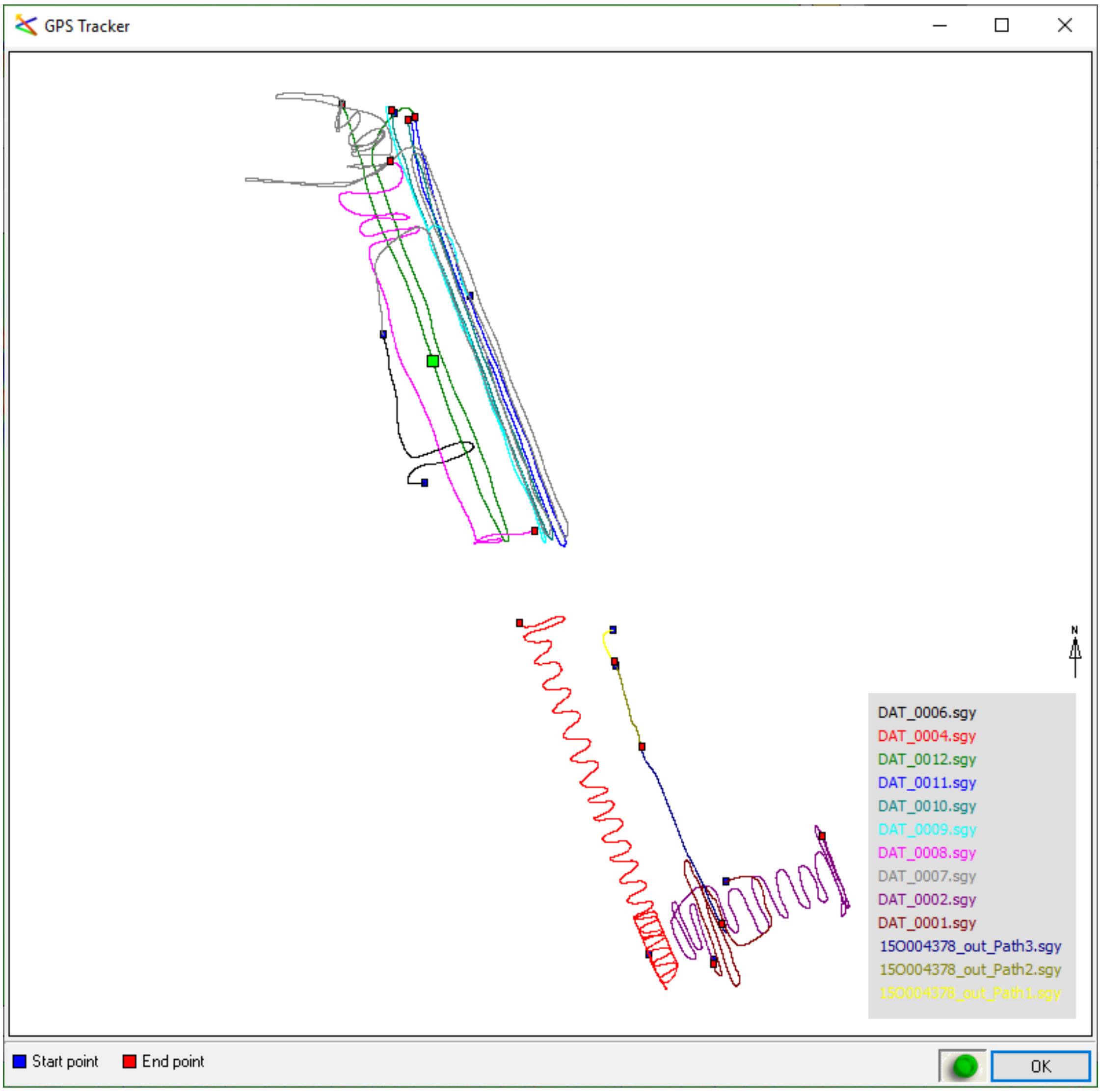


Fig. 11.10. GPS Tracker window.

- **Annotations** – creating, deleting and editing annotations on a profile. Software switches operation mode to the annotation mode, after this button pressing, and eight Annotation Toolbar comprising buttons will appear: **Pointer**, **Text**, **Lines, Area, Pipe, Picket, Edit picket** and **Close**. Annotations are saved in a separate file with **.ann** extension, under the same file name as the data file.
  - **Pointer** – allows working with annotation objects: moving text, moving line vertexes, deleting objects, and changing their properties. To move the objects or vertexes select them by pointing your cursor under the object, so they will change their color, press and hold left mouse button and move the cursor at the new place. If you select an item and press the right mouse button, it open a drop-down menu with appropriate list of options, like **Delete** or **Delete vertex** for an example.
  - **Text** – adds an annotation text. Press the left mouse button on the profile where you would like to add the text. Specify the text color (**FG**) by the left mouse click and background color (**BG**) by right mouse click from 16 provided colors in the

appeared dialog box (Fig. 10.5). Specify the font type (**Font**) and enter the text itself. Press **OK** or **Enter** to confirm**.**

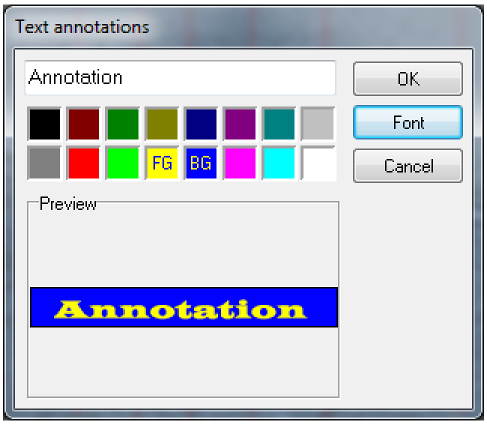


Fig. 11.11. Text Setting dialog box.

- **Lines** – draw a zigzag line or an arrow. You would specify its thickness, color and arrow type in the appearing dialog box (Fig. 10.6). To continue, press the **OK** button**.** You have to click by left mouse button each vertex point of expected zigzag line (if you would like to use an arrow, you need to click only two points – start and stop), when you are done, press right mouse button to confirm. If you wish to save created line as ASCII file, select it and press the right mouse button, in appeared dropdown menu select **Save as ASCII file** option. Enter file name and press save button. As default the program will offer the same filename as initial profile name with **.txt** extension.

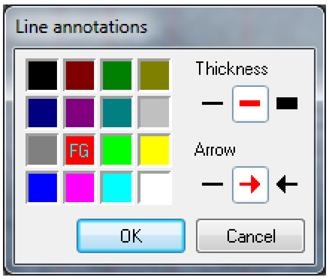


Fig. 11.12. Lines Settings dialog box.

- **Area**. Used to distinguish layers of the profile, with different geophysical mediums and characteristics, such as sand, sandy loam, peat, silt, water, etc., and to set respective permittivity for them. You should have to specify the area foreground color (FG) in the appearing dialogue box (Fig. 10.7.a) by clicking left mouse button on any of 16 colors listed, and enter the mean velocity for the area before selection of an area in the profile. Also you may select one of 52 available patterns (8x8 pixels each) for are painting in case if you need to fill selected area with a pattern. To do it press the button and select the pattern in the appearing right part (Fig. 10.7.b). Pattern colors shall be a function of the basic foreground color (FG) and selected background color (BG). If you don't need to use a pattern, simply press the button . Press OK button to continue. You have to click by left mouse button each vertex point of expected area on the, when you are done, press right mouse button and the last point will connect with the first one, completing the area and painting it with the pattern or the just a color you have chosen. There is no need to click all boundary points, while adjacent areas drawing. It is enough to set only three points on an existing boundary zigzag line, what contacts with the new expecting area (the fist point of boundary line, an any point in between and the last point of the boundary). Boundary zigzag line will be automatically constructed repeating the marked outline portion of an existing area after you place the third point, now you can finish drawing adjacent area with any additional points.

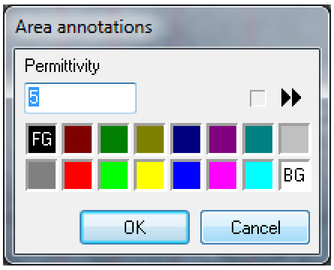


Fig. 11.13.a. Dialogue Box for Area Tuning.

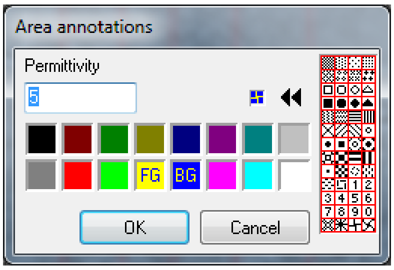


Fig. 11.13.b. Dialogue Box for Area Tuning with Pattern Selection.

- 

Pipe - is used for symbolic display of the cross-section of a pipe or a cable on the profile. After selecting this option press and hold left mouse button and then move the mouse as if you are selecting the area when you are done release mouse button, you will be asked to specify Pipe fill color, to confirm press OK button. To remove the pipe place the cursor on it, click the right mouse button and select option Delete.
- **Picket** – used to automatically select interfaces between media along the profile from the maxima of the reflected signals with an option to save the defined interface as an ASCII file. After selecting this option dialog window will appear letting you to select color and width of line depicting the interface. Confirm your choice by pressing the OK button, then place the pointer to the corresponding signal line of a ground interface and press the left mouse button. In appeared dialog box specify a profile section, within which interface selection will be made. Press OK button again and the line of your chosen color and width will be displayed coinciding with the signal line. If appeared line does not coincide with the signal correctly please use **Edit picket** option.
-  **Edit picket.** Editing should be always performed consequently from left to right along the profile. After **Edit picket** option has been selected, place your cursor at the place of the picket where the failure has occurred. Press and hold left mouse button and move it to the location where you think the interface should pass. Release the button to confirm. You can repeat this operation multiple times until you achieve a satisfactory result. If you wish to save picketing results as ASCII file, place cursor to the picket line, press right mouse button and select **Save as ASCII file** option in the pull down menu. Enter filename and press **Save** button. As default the program will offer the same filename as initial file name with **.txt** extension.
-  **Close** – exit from the annotations mode.

- Color palette – color palette editing. Any color from 24-bit palette is available in "**Prism2**". Color palette is used for data output in line scan mode (Fig. 10.1), as well for the positive half-wave output when the wiggle plot mode is used (Fig. 4.2). You may use up to ten basic colors and their relative levels for the color palette. You could open the palette window by pressing a respective Toolbar button or by selecting **Tools/Color palette** menu option, or by clicking a left mouse button on the color palette column located in the upper right corner of the profile window to change the color palette.

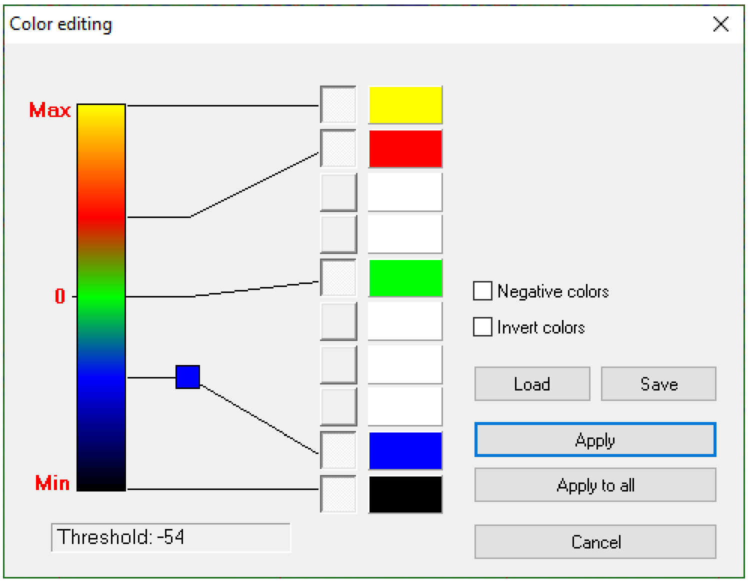


Fig. 11.14. Palette color editing dialog box.

Following actions could be applied in appeared Palette color editing dialog box (Fig. 10.8):

- Choose one of eight already created palettes. To do this, press **Load** button and select palette from existing ones provided in pop-up window. Press **OK** to confirm your choice.
- Modify existing palettes (add, delete or edit colors). Add or delete colors by pressing square buttons located to the right of the color palette. You may select the required color by clicking rectangle button located to the right of the square button. The pop-up dialog box will offer you to choose a color from the available basic colors, as well as an option to choose the half-tones in the Define Custom Colors dialog box. To change a level of color used in palette, point the cursor to the square button of appropriate color. The small color square will appear under the line connecting the color palette with the chosen color; the information window located below the color palette will display given color threshold level value, ranging from –127 to 127. Navigate the cursor in the small color square, press and hold left mouse button and start moving the square up and down, changing threshold level in correspondence with your choice.
- To save your created palette press **Save** button and chose which one of eight existing palettes you wish to overwrite with the new one.

- **GPS Coordinates Table** – current profile's editable list of coordinates as a table with the columns: trace number, coordinates, altitude (column quantity and input method of each column may differ for each coordinate system). Each table's row represents coordinates of one trace (**Trace** column will specify the number of each trace), so the sum of rows will be equal to number of all traces in the profile. If specific trace has no coordinates, the row will contain zeros. GPS Coordinates Table window comprises:

- **Deg** (Degrees Lat Long), **DegMin** (Degrees Minutes), **DegMinSec** (Degrees Minutes Seconds) and **UTM** (Universal Transverse Mercator) – allows choosing from varies coordinate systems.
- **Import** – allows to import ASCII text file (*.txt) with coordinates data into the GPS table. To import data with coordinate system differs from Degrees Minutes text file should have properly identified coordinate system in the beginning (it may have Deg, DegMin, DegMinSec or UTM). If text file hasn't coordinate system identification or it is identified with unsupported coordinate system, its data will be interpreted as Degrees Minutes.
- **Export –** export coordinate table's data into ASCII text file (*.txt) in accordance to selected coordinate system.
- Pressing **OK** button saves coordinates of each row to the coordinates of its corresponding trace number (it also saves UTM coordinates into each of the trace, even if it was not in there before opening **GPS Coordinates Table**).

-  **Output parameters –** all of the data file parameters output and its display type. Here you may input profile length information, change permittivity value, make textual information corrections, choose data displaying type (line scan profile or wiggle plot profile) and the data normalization way (entire screen or each trace). Here, you may also control profile's auxiliary components output, such as marks and annotations, by choosing **Show marks, Show annotations** and **Show only annotations** options.

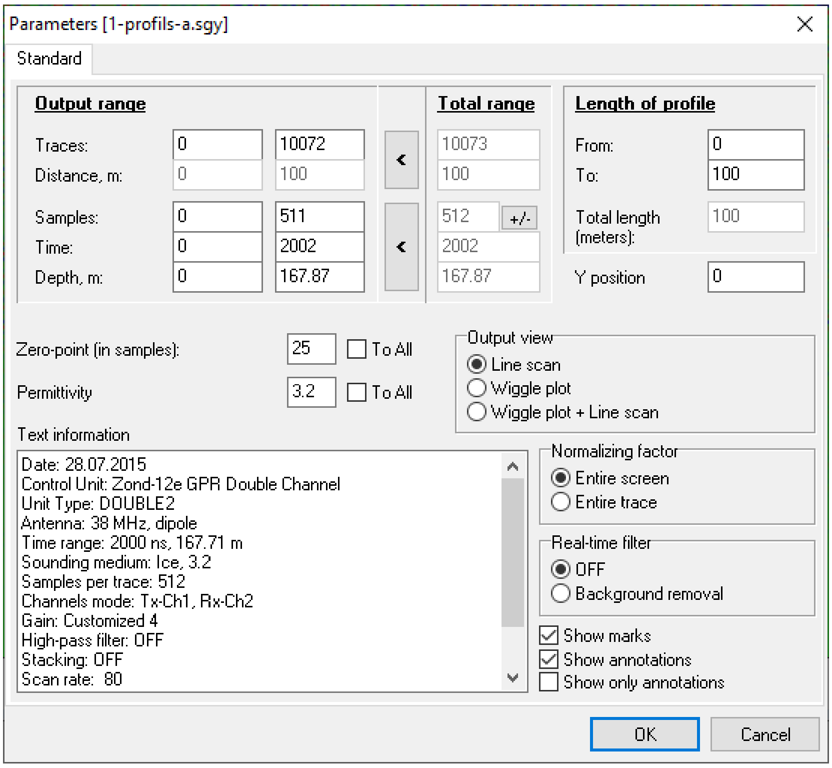


Fig. 11.15. Profile Parameters dialog box.

12. Multi-profiles operations

Several tasks of multi-profiles operations are extracted to the row of “wizards”, which can be found in menu **File**. Wizard in the "**Prism2**" Software, is the sequential row of functions and procedures with possibility to navigate from the first step to the final one using buttons **< Back** and **Next >**.

Note: Profiles added to any wizard have to have the same number of samples and equal time ranges.

12.1. Profiles combining wizard

There is a possibility to join several profiles to the single one using **Profiles Combining Wizard** (menu **File / Profiles Combining**). The wizard’s output is the single file stored on the hard drive.

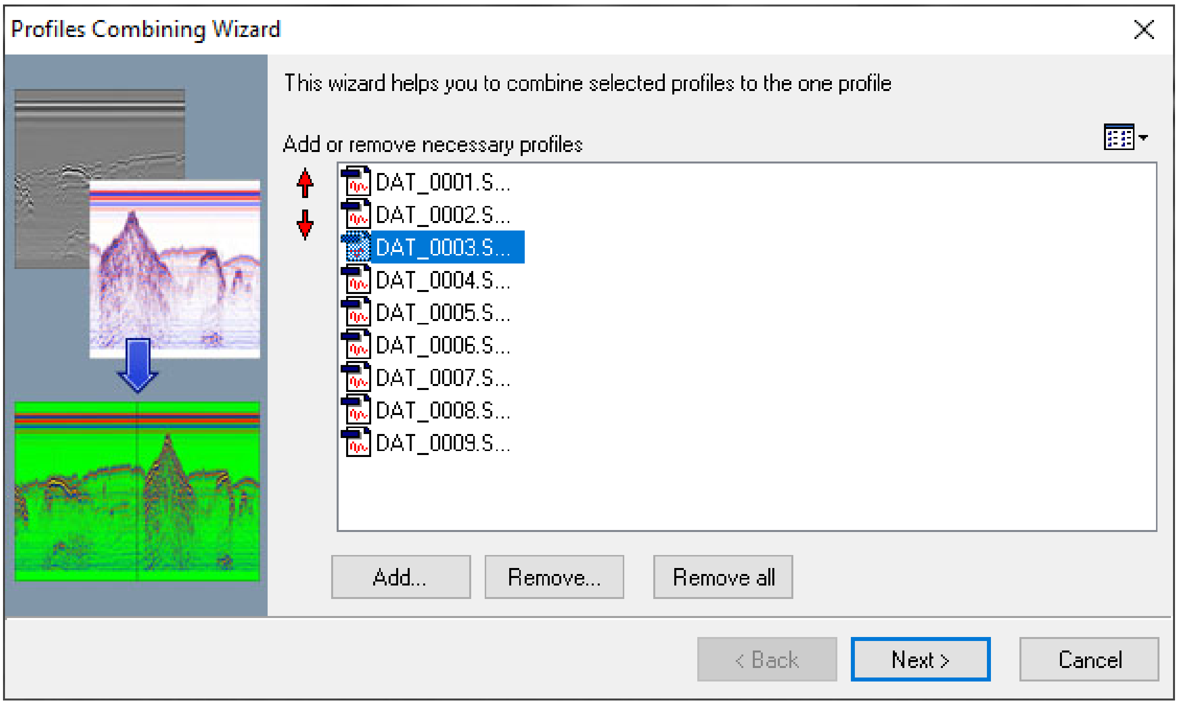


Fig.12.1. Profiles combining wizard dialog box on the 1st step.

User can add profiles from the hard drive pressing button **Add…** on the 1st step. Profiles could be added one-by-one or several profiles at once pressing **Ctrl / Shift** key in the open file dialog box. The joining order corresponds to the profiles order in the list, if you want to move up or down any profile in the order, select it and press correponding button: ↑ - to move up or ↓ - to move down. Any unnecessary profile could be removed pressing button **Remove…** If you need to clear the list – press button **Remove all**.

*Note: "**Prism2**" Softwareis is a 32-bit application and has limited amount of the operation memory (2 GB), provided by the operation software, what occupies opened profiles and its Undo/Redo points. Processing and operation speed depends on the size of* *the opened profile(-s) used for. Be careful, not to use profiles bigger than 100 MB size on the hard drive to prevent unpredicted hangs and crashes of the software.*

The result profile's file name and its location can be entered on the 2^{nd} step of the wizard. Windows **project name** and path contains the file name and its location on the hard drive (path can be chosen by button **Browse** pressing) of the resulting profile. If you want to store the result in a separate directory – check the box **Make folder**.

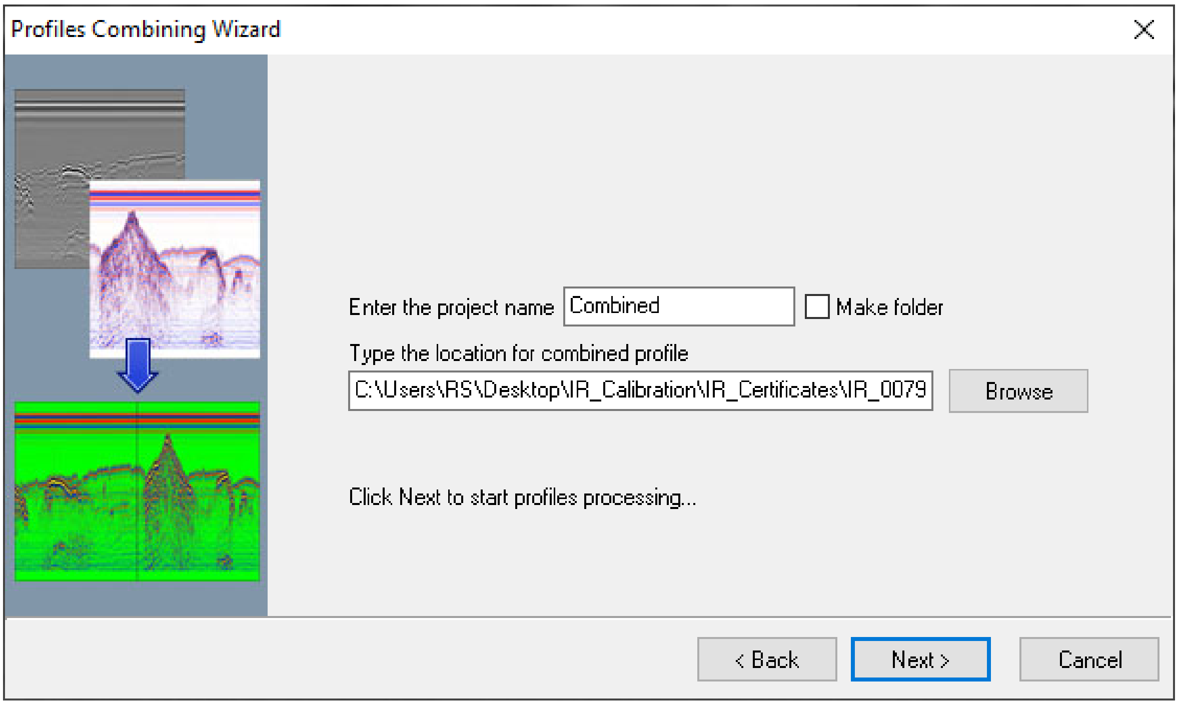


Fig.12.2. Profiles combining wizard dialog box on the 2^{nd} step.

The button **Next** > pressing starts the process of profiles combining, please wait while software process the selected profiles and enables the **Finish** button.

12.2. Profiles splitting wizard

Big profiles cause the "lazy" work of the software, to prevent user waiting, there is a possibility to split profile to the row of equal profiles, stored on the hard drive, using **Profiles Splitting Wizard** (menu **File / Profiles Splitting**).

The 1^{st} step of splitting wizard is equal to the combining wizard, where user has to add necessary profiles (see on previous p. 57). Splitting options are presented on the 2^{nd} step of the wizard.

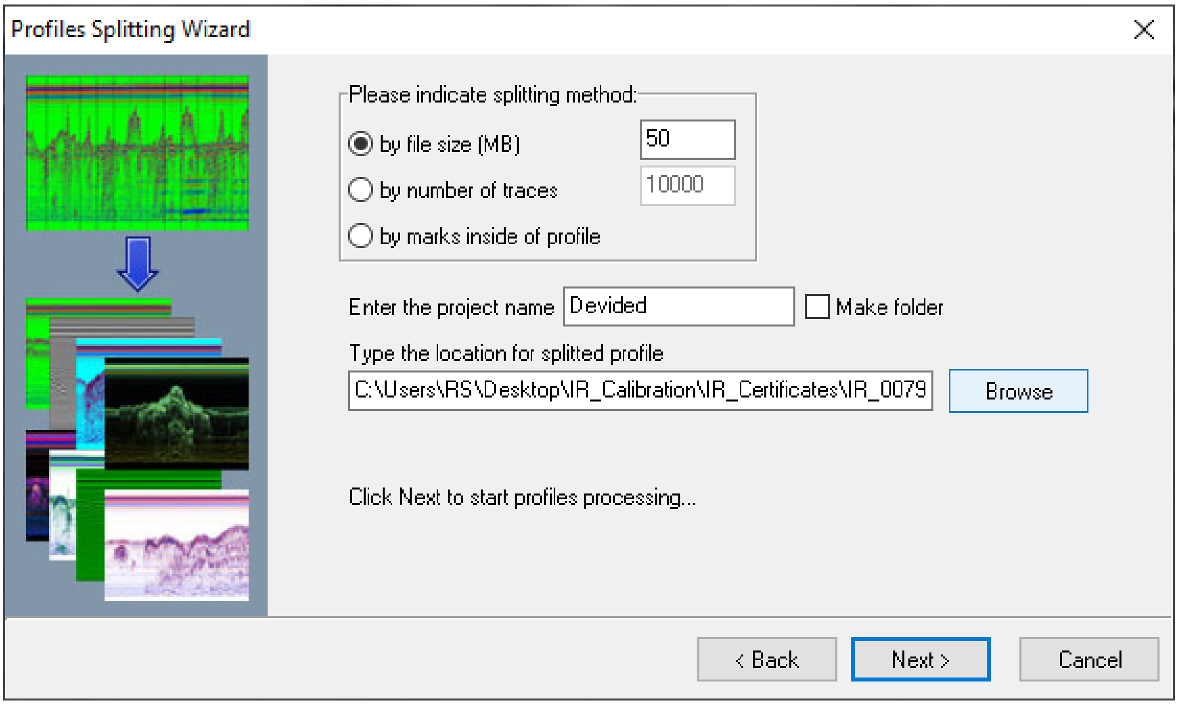


Fig.12.2. Profiles splitting wizard dialog box on the 2nd step.

Wizard provides different methods for the profiles splitting:

- **by file size (MB)** – initial profile(-s) is splitting in a row of files not bigger than the entered size on the hard drive in MB.
- **by number of traces** – initial profile(-s) is splitting in a row of profiles not longer than the entered number of traces.
- **by marks inside of profile** – initial profile(-s) is splitting in a row of profiles using the its marks (from mark to mark).

The resulting files names and location are managed in the same way like in the combining wizard (see on p. 57).

12.3. Profiles 3D alignment wizard

Profiles which are not equal in geometrical sizes (in traces and samples) hard to use in 3D Cube representation (see Appendix C. on p. 79). There is a way to equalize traces quantity in profiles using **Profiles 3D alignment wizard** (menu **File / Profiles 3D aligning**).

The 1st step of aligning wizard is equal to the combining and splitting wizards, where user has to add necessary profiles (see on p. 57). Aligning options are presented on the 2nd step of the wizard.

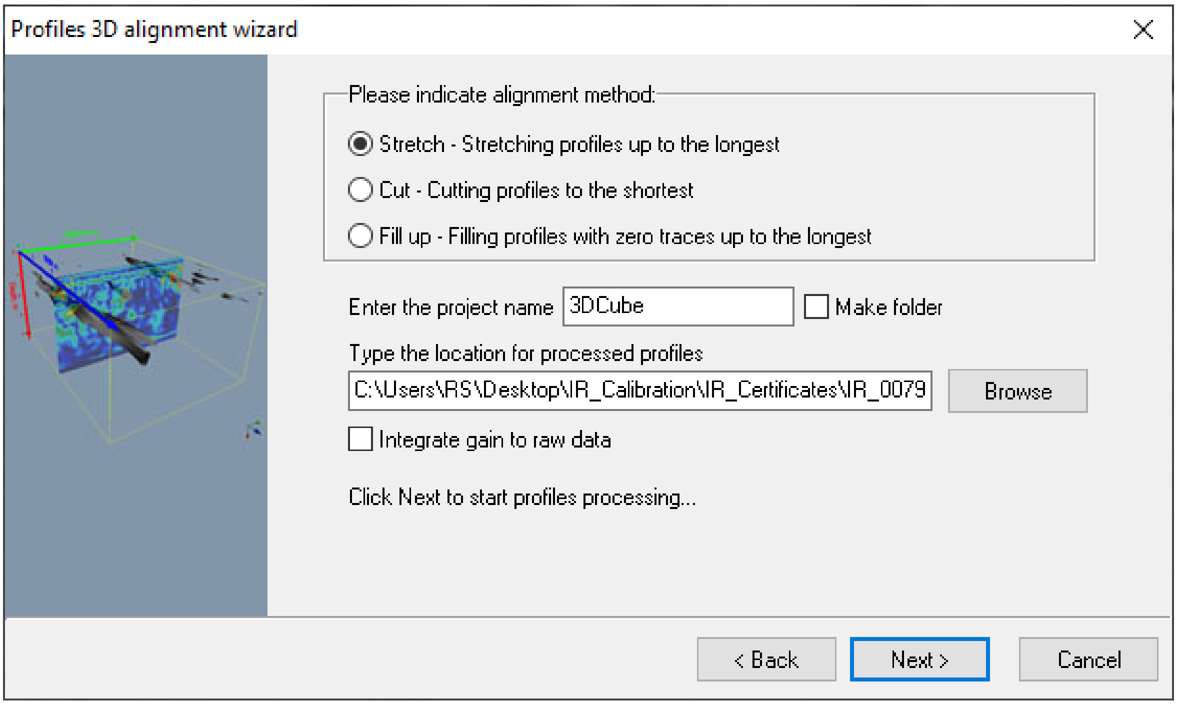


Fig.12.2. Profiles 3D alignment wizard dialog box on the 2nd step.

Wizard provides different methods for the profiles aligning (in traces):

- **Stretch** – initial profiles are stretching up to the longest one of the set.
- **Cut** – initial profiles are cutting to the shortest one of the set.
- **Fill up** – initial profiles are filling by zero traces (trace, where each sample equal to zero) up to the longest one of the set.

The resulting files names and location are managed in the same way like in the combining wizard (see on p. 57), just take in a account, that there is one more option **Integrate gain to raw data** – what replaces the raw data of the initial profiles by gained one, to keep data amplitudes in correspondence with applied gain.

13. Profiles post-processing

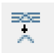
Processing task is to extract useful signals and suppress noise, interference and non-informative signals. Therefore, before processing, you need to define parameters that are different for the signals and interference. This may be amplitude, trajectory or spectral characteristics. The software contains all and any tools required for analysis of the said characteristics, such as **Trace inspection** and **Average spectrum**.

If your analysis shows that the signal and interference have path differences, use path processing procedures, i.e. **Horizontal LP-filter, Horizontal HP-filter, Migration, Flattening, Topography, X-interpolation, Reverse** or **Background removal**. In case of spectral differences, use filters: **Ormsby bandpass** or **Notch filter**. In case of amplitude differences, **Amplitude correction, Envelope** will be helpful. To draw up in depths scale profiles you will need **Moveout correction** and **Time-depth conversion**.

All available processing procedures are described below. The processing result is always displayed in the same window where initial file (before processing) has been displayed in "**Prism2**" Software. To save processed file use **File/Save** menu option. If you unsatisfied with processing results or if you would like to change procedure parameters, you can undo processing results selecting **Processing / Undo processing** or by pressing button . If you would like to redo data processing, select option **Processing/redo processing** or press button .

Each processing could be applied to the active profile or to all opened profiles by pressing on buttons **Apply** or **Apply To All** correspondingly.

Sometimes it is necessary to consequently apply several processing procedures to achieve the desired result. You can use **Processing flow** for this purpose, what could be used for multiple processing. Processing flow is described below, at the end of this section.

-  **Background removal** – the term speaks for itself. Under some sounding conditions, a signal happens to have "background" which may be seen on the profile as horizontal lines that do not change their intensity and time position and may mask the real reflected signals. In these cases, this procedure can ensure efficient background suppression. The algorithm is as follows: Summation and normalization are carried out to calculate the profile averaged trace which is then subtracted from each trace of the original profile. To avoid direct sounding signal removal, you can specify window height wherein background subtraction will be made.

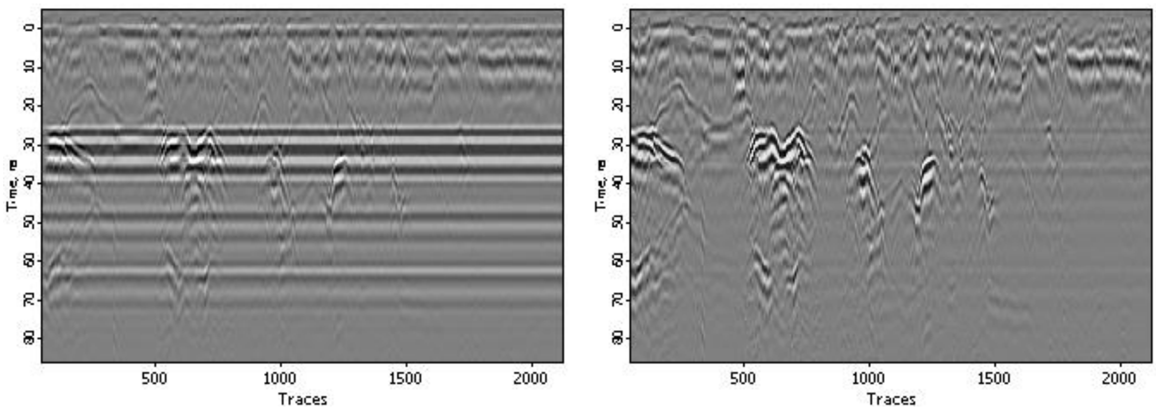


Fig.13.1. Example of path procedure effect. Left - original profile; right - result.

-  **Horizontal LP-filter** is a low-pass filter operating along the profile, in the antenna's moving direction. It is designed for the fast signal variable suppression and slow signal variable extraction (e.g. those from layer boundaries). The algorithm used here ensures that the averaged trace in a definite window shall replace the input profile trace which is positioned in the mid-window location. The resulting trace thus obtained shall be recorded in a relevant profile position. The window width shall be an input parameter for this procedure.

-  **Horizontal HP-filter** – high-pass filter acting along the profile in the antenna movement direction. Intended for profile extensive signals suppression and for rapidly varying signals extraction (e.g. from small-size objects, pipes, etc.). The algorithm used here operates so that the trace resulting from accumulation and normalization in a definite window is subtracted from the output profile trace whose position corresponds to the middle of the window. The trace thus obtained is recorded in a respective profile position. The window width is the input parameter for the procedure. If you don't wish the procedure to remove the direct sounding signal, specify the height of the window wherein subtraction will be made.
- **Ormsby bandpass –** a bandpass filter acting along a trace. Designed for low-frequency interference and signal's high-frequency components suppression. The algorithm used here comprises three steps: application of direct FFT (fast Fourier transform) for transition from the time domain into the frequency domain, of low-frequency and high-frequency trace spectrum components suppression, and application of reverse FFT for transition from the frequency domain into the time domain. Input parameters for this procedure include suppression/pass frequencies in the low-frequency and high-frequency regions of the frequency axis. The name of the filter is determined by cosine approximation between specified points of the frequency axis. Setting of cut off and pass by frequencies is made in the dialog box manually with their indication directly on averaged spectrum of file displayed by red line. Filter's frequency response is displayed by blue line and output signal spectrum – by the green colored line. Filter's desired frequency response setup is performed by moving filter's cut-off and bandwidth frequencies on the frequency axis with the mouse observing the shape of spectrum at the output of the filter. Setting the required cut-off and bandwidth frequencies may be done directly in the small boxes at the bottom of the dialog box. Desired spectrum part may be expanded for the more accurate cut-off and bandwidth setup using  and  buttons.

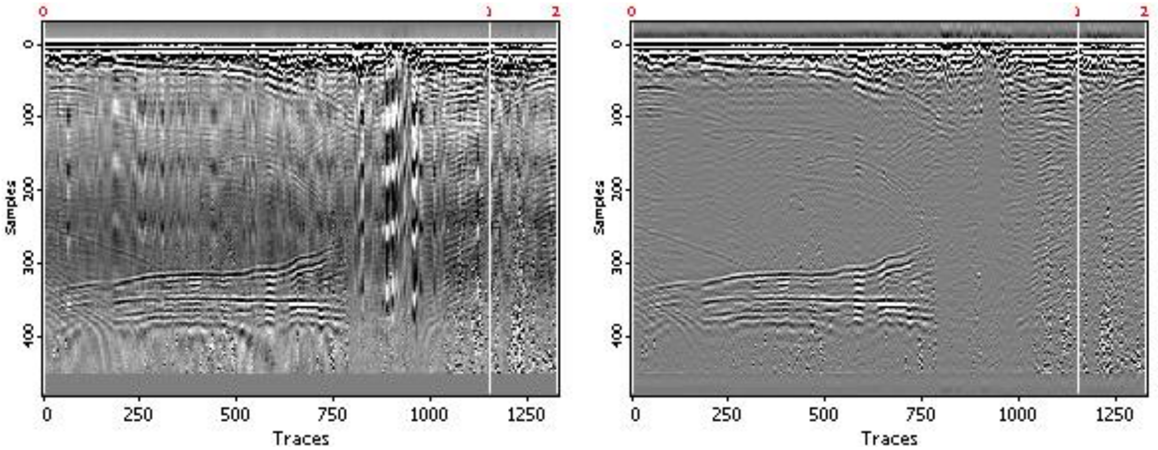


Fig. 13.2. Example of spectral procedure effect. Left - original profile; right - result.

- **Notch filter** - used to suppress narrowband interference against the broadband signal background in case of overlapping signal/interference spectra. The algorithm used here is inversed to the one used in bandpass filter algorithm.
- **AGC - Automatic gain control** – automatic signal gain within the width of the window in each separate trace. Used for leveling all signals in a trace. As a result, after processing, the profile is like one shown in Fig. 11.3.

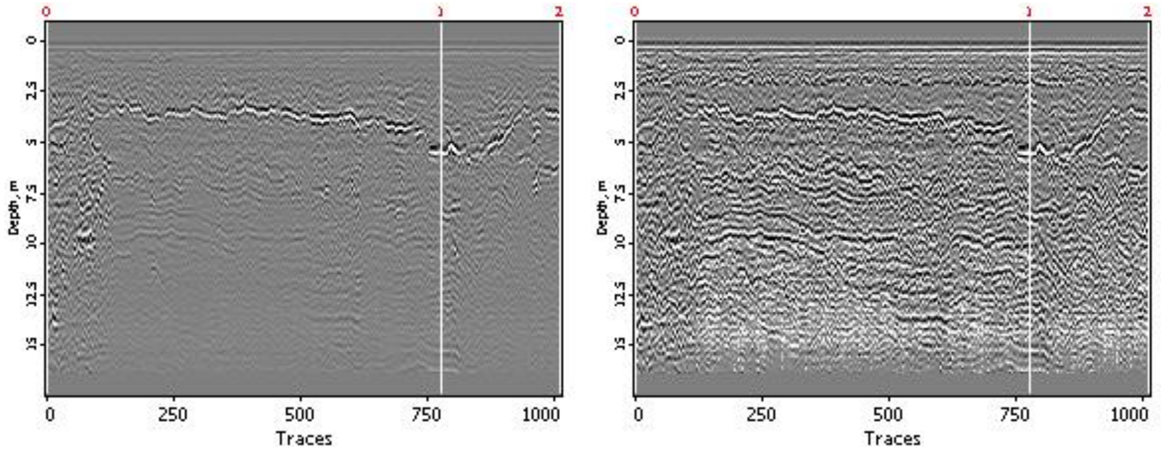


Fig. 13.3. Example of automatic gain control procedure effect.
Left - original profile; right - result.

- **Reverse** – a procedure used for back-to-front trace rearrangement, i.e. the first trace becomes the last one, the second trace becomes next to last, and so on. This may be useful when any area is sounded by tacks, i.e. the first profile is covered, and then the second is made with an offset and in the opposite direction and so on. For convenience of subsequent analysis and interpretation of sounding data, the procedure may be used before each even (or odd) profile.
- **Topography** is a procedure used to restructure a profile as a function of the sounding locality relief. Input parameters for this procedure shall be marked points elevations (in meters). To ensure proper procedure operation, marks shall have ascending numbering. In case of incorrect numbering or excessive marks or missing marks, they shall have to be properly arranged by using **Tools/Marks/Rebuild** menu option.

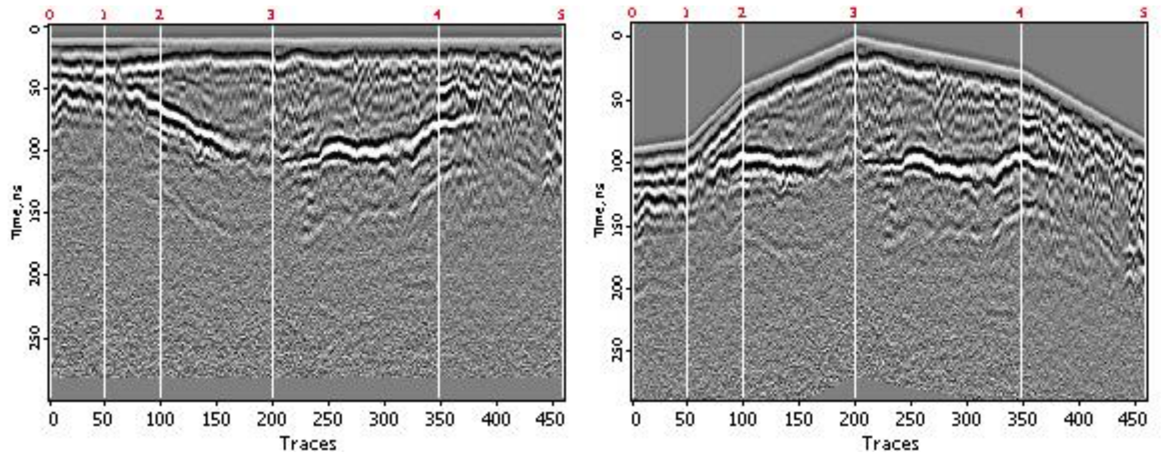


Fig. 13.4. Example of using the topography procedure.
Left-hand: initial profile; right-hand: resulting profile.

- **X-interpolation**. This procedure is purposed for movement judder along the profile effect removal and forming of the file with the constant specified interval between traces. There are two alternatives: **General** and **by Marks**. **By Marks** is used in cases of manual positioning when marks with known coordinates are located along the profile. **General** is used when the wheel or GPS is used for positioning.
- **Moveout correction** rebuilding profile to the pattern as it would be if signal radiated and received in a point located in the middle between antennas (for details see Chapter 10).
- **Stacking.** Setting a number of traces which will be added together in the average trace. Stacking contributes to suppression of noise and interference and to increase of the depth rating. However, it should be remembered that stacking decreases the trace amount and horizontal resolution. If the parameter is set to 1, no staking is performed.
- **Time-depth conversion** should be used for restructuring the initial time profile into a depth profile in compliance with the velocity areas as set in annotations. Profile portions for which no areas are set shall be restructured in compliance with the mean dielectric permeability specified in the profile parameters.

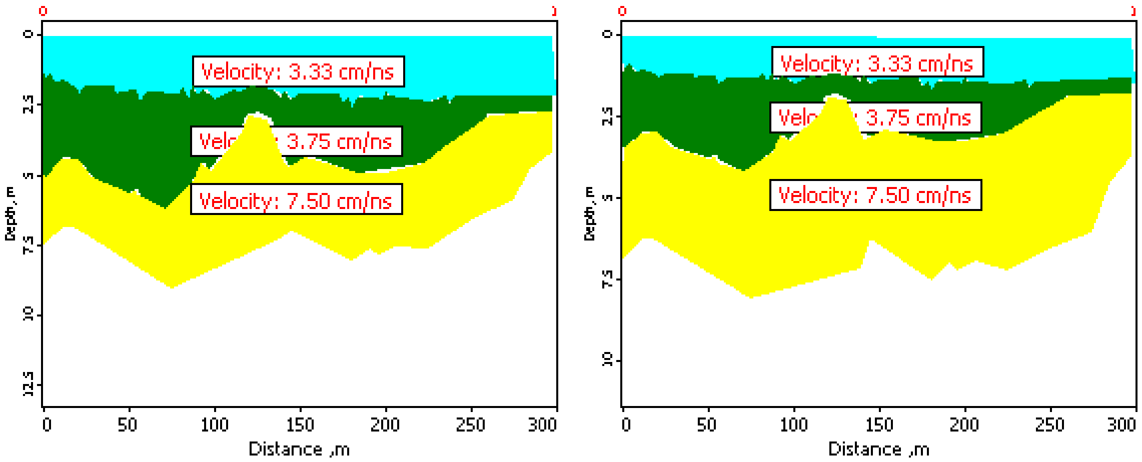


Fig. 13.5. Example of using the time-depth conversion procedure.
Left-hand: initial areas; right-hand: resulting areas.

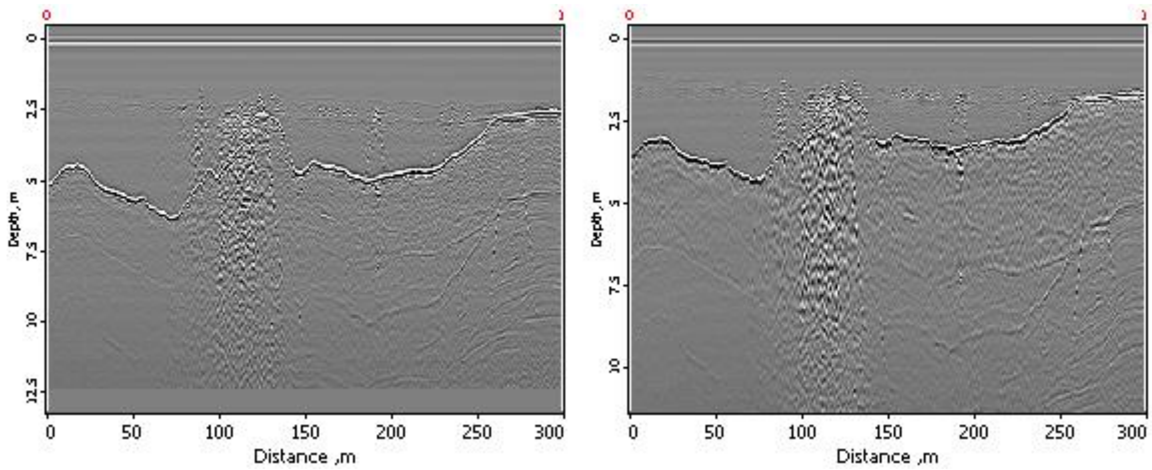


Fig. 13.6. Example of using the time-depth conversion procedure.
Left-hand: initial profile; right-hand: resulting profile.

- **Flattening** is intended for rebuilding initial profile into the profile with flat horizontal interface depicted by **Annotation/Lines** or **Annotation/Picket**.

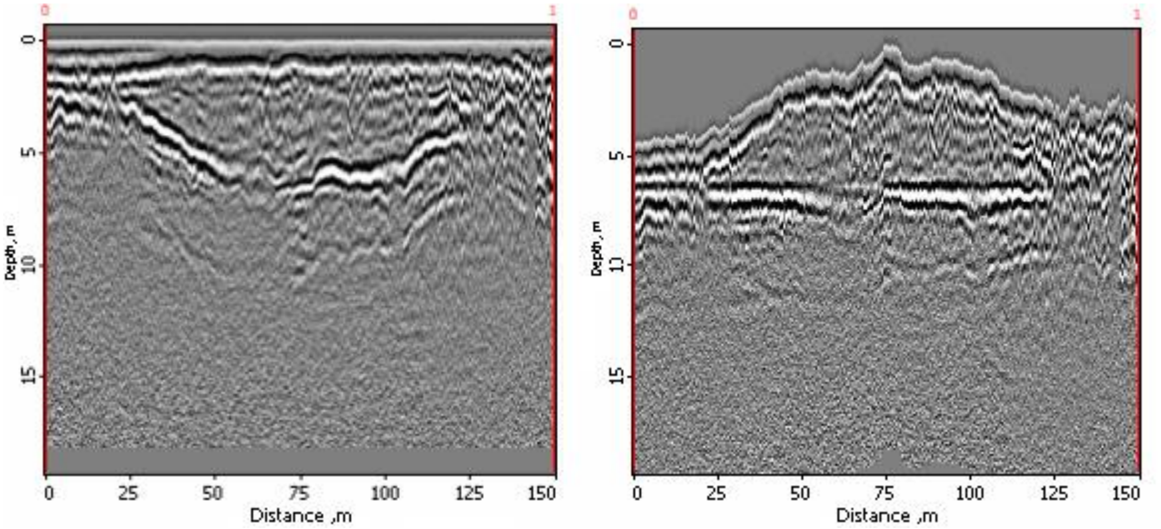


Fig. 13.7. Example of using the flattening procedure.
Left-hand: initial profile; right-hand: resulting profile.

- **Zeroline flattening** is used to flatten the direct surface wave in the whole profile, what could be used to decrease effect of transmitter electronic heating or antenna lifting changing.
- **Migration –** reconstruction of original shape of underground interface and local objects by its radiolocation profile. Very effective when having diffracting objects underground utilities, fixtures) on the profile. Software provide migration methods **Stolt (F-K) method** and **Hyperbolic summation** .

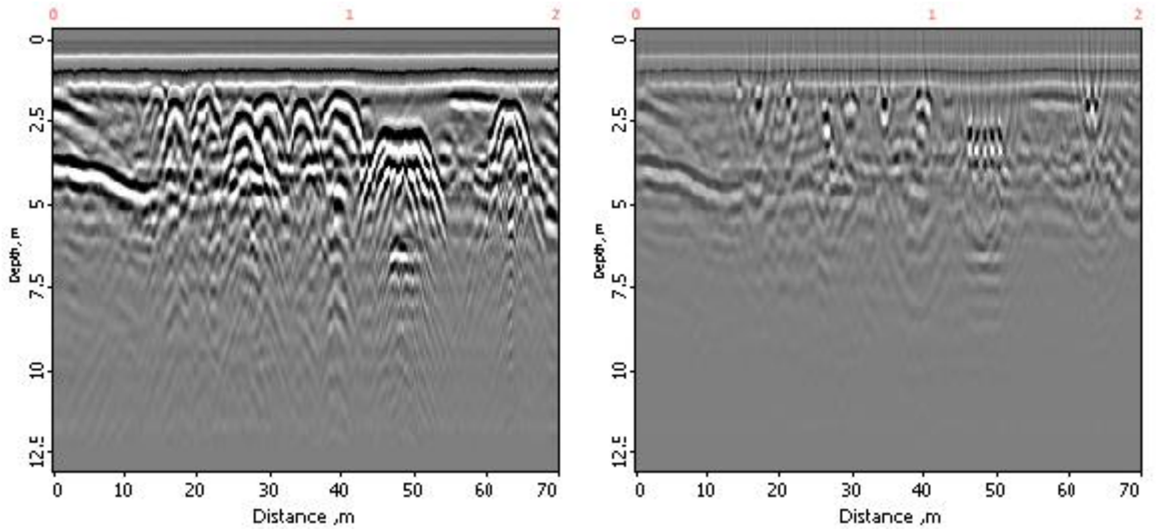


Fig. 13.8. Example of migration procedure using.
Left-hand: initial profile; right-hand: resulting profile.

- **Envelope** used to obtain signal envelope by Hilbert transform and works along the trace. The algorithm used here includes four stages: application of FHT (fast Hartley transform) for transition from the time to the frequency domain, Hilbert transform, inverse FHT for returning to the time domain, and root sum of squares computation of the trace initial and Hilbert transformed signals. No input parameters are used for this procedure.

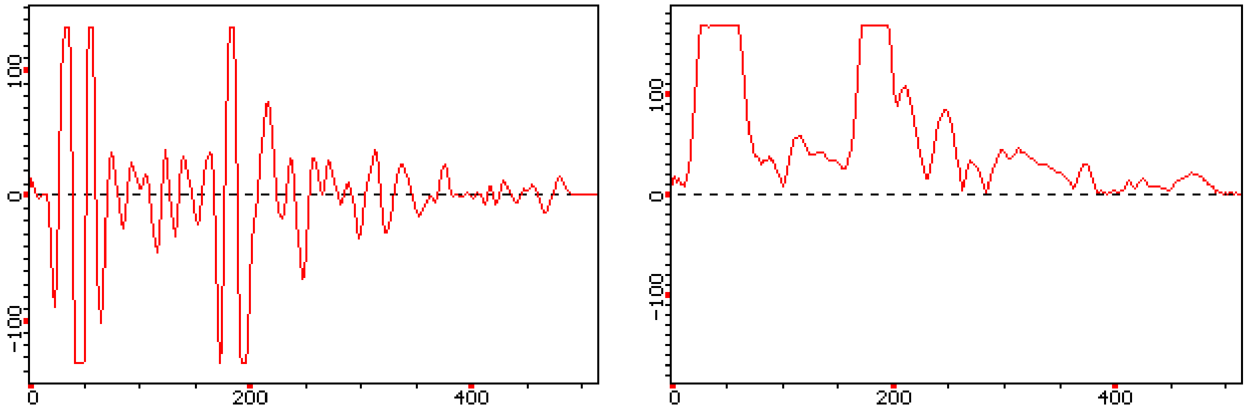


Fig. 13.9. Example of using the envelope selection procedure.
Left-hand: initial trace; right-hand: resulting trace.

- **Processing flow** - sequence of procedures creation for several data files processing under the same algorithm. When using the processing flow on the right in a dialog box in the **Processing List** tab entire list of available procedures is displayed, any of those procedures can be moved to the left side of the dialog box thus building a processing flow. Movement is performed by the mouse similar to the way it is done in Windows. Procedures execution sequence goes from top to bottom. Moving any procedure to the left will make it active, and allow you to change its parameters when selecting (left mouse click on the active procedure). To change all available parameters for selected procedure open the **Parameters** tab located to the left of the **Processing List** tab. Processing flow execution will start as soon as **Ok** button is pressed and the result will be displayed in the same initial profile window. **Do not press OK button until all of the processing procedures have been set!**
  The created processing flow with created parameters can be saved in the form of a separate file with *flw extension and repeatedly applied when processing any other data sets.
  Procedures removal from the flow is performed with the button and buttons ↑ and ↓ (in the upper left corner of the dialog window) used to move procedures and are similar to dragging.

14. Our Recommendations

In this section we want to provide some recommendations concerning the usage of our hardware and software. We are not claiming that our recommendations are the best for every situation, but still, if you have no experience with such equipment, we suggest you to read this section.

- In our opinion, black and white color scale is the most informative line scan profile displaying type (see Example in Fig. 4.3, left side). It would provide clear visibility of the weak signals.
- Always pay attention to the prompts and messages when you work with the software.
- Before you start, it is appropriate to make a separate directory for each particular GPR job (see section 7.4, menu **Radar \ Where to save**).
- Make file headers as informative as possible. You will find it quite helpful when interpreting and drafting of the report.

15. Radiolocation Sounding Data Format

"**Prism2**" software uses International Geophysical Data Format the by the Society of Exploration Geophysicists (SEG-Y).

15.1 SEG-Y Sounding Data Format

File begins from a 3200-byte EBCDIC descriptive reel header record which contains service information. Following EBCDIC there is a 400-byte binary reel header record containing service information about the data:

Offset from file beginning	Parameter length, Bytes	Parameter record format	Comments
3200	4	int	Job identification number
3204	4	int	Line number
3208	4	int	Reel number
3212	2	short int	Number of data traces per record
3214	2	short int	Number of auxiliary traces per record
3216	2	short int	Sample interval of this reel's data in **PICOseconds**
3220	2	short int	Number of samples per trace for this reel's data
3222	2	–	Unused
3224	2	short int	Data sample format code: 1 = 32-bit IBM floating point; 2 = 32-bit fixed-point (integer); 3 = 16-bit fixed-point (integer); 4 = 16-bit fixed-point with gain code (integer).
3226	2	short int	CDP fold (expected number of data traces per ensemble)
3228	26	–	Unused
3254	2	short int	Measuring system: 1 = meters; 2 = feet.
3256	344	–	Unused

Then there goes trace records, each contains a 240-byte binary trace header and trace data. Offset from the beginning of a file to the Kth trace record is 3600+K*(240+S*2), where S – number of samples in a trace, and K – trace number (counted from the zero trace and not from the first one). Trace data recorded sample by sample. No separators or symbols are used between samples. Each sample is represented as the data sample format code from binary reel header and takes (2 or 4)*N Bytes. Note, that samples and traces are numbered from zero and not from one. Trace header for each trace record is summarized in the Table below.

Offset from trace record beginning	Parameter length, Bytes	Parameter record format	Comments
0	4	int	Trace sequence number within line
4	4	–	Unused
8	4	int	Original field record number
12	4	int	Trace sequence number within original field record
16	4	–	Unused
20	4	int	CDP ensemble number
24	4	int	Trace sequence number within CDP ensemble
28	2	short int	Trace identification code: 1 = seismic data; 2 = dead; 3 = dummy; 4 = time break; 5 = uphole; 6 = sweep; 7 = timing; 8 = water break; 9 = optional use.
30	2	short int	Number of vertically summed traces yielding this trace
32	2	short int	Number of horizontally summed traces yielding this trace
34	2	short int	Data use: 1 = production; 2 = test.
36	4	–	Unused
40	4	float	Altitude (mean-sea-level)
44	4	float	Height of geoid above WGS84 ellipsoid
48	4	int	Backward/toward direction (if negative - backward)
52	4	float	Datum elevation at source in m (topography offset)
56	14	–	Unused
70	2	short int	Scalar for coordinates: + = multiplier; – = divisor.

72	4	float	X source coordinate (Longitude in 32-bit float accuracy for arc seconds)
76	4	float	Y source coordinate (Latitude in 32-bit float accuracy for arc seconds)
80	4	float	X receiver group coordinate
84	4	float	Y receiver group coordinate
88	2	short int	Coordinate units: 1 = length in meters or feets; 2 = arc seconds (DDMM.SSSS).
90	4	int	GPS signal quality
94	14	–	Unused
108	2	short int	Lag time between shot and recording start in **PICOseconds**
110	4	–	Unused
114	2	short int	Number of samples in this trace
116	2	short int	Sample interval of this reel's data in **PICOseconds**
118	42	–	Unused
160	2	short int	Hour of day (24 hour clock)
162	2	short int	Minute of hour
164	2	short int	Second of minute
166	2	short int	Time basis code (1 – Local, 2 - GMT)
182	8	double	Longitude in 64-bit double accuracy
190	8	double	Latitude in 64-bit double accuracy
214	2	short int	Time scalar. If positive, scalar is used as a multiplier. If negative – divisor.
236	2	short int	Marks indicator. If equal to 0x5555, trace is marked.
238	2	short int	Mark number.

16. Solving Problem of Layer-by-Layer Determination of Groung Thickness and Permittivity by CDP Technique in Flat Layer Model

Some General Information about the Technique

One of the main problems arising after a profile is taken relates to determination of electromagnetic wave propagation velocity in layers (or determination of layers permittivity).

Knowing the permittivity (or wave velocity) in the sounded medium layers is very important, since it is the permittivity value that defines layer thickness determination accuracy in data interpretation.

There are some more or less successful methods for estimating the wave propagation velocities. One of those methods suggests using a synthetic hyperbola superimposed on the path signal from a small-size target (menu option **Tools / Mouse action / Hyperbola**), or Main Menu  button. This method however, has its limitations:

1. You must have a profile with well discernible hyperbolic form signal and it is not always the case.
2. This method assumes sounded medium to be homogeneous, i.e. having constant electromagnetic wave velocity in any point thereof; in reality this is not always the rule, as the most media are layered.

One of the best known methods used for layer-by-layer velocities determination is **Common Depth Point** method (**CDP**) or **Common Mean Point** method (**CMP**). The idea of this method is as follows: over a selected point sounding is performed, with both antennas being equally spaced apart to opposite sides of the original position (see Fig. 14.1). Two separate antennas are used for transmitting and receiving signals, they are sounding in a step mode receiving the signal at each discrete distance value between the antennas. The path of reflected signal at such profile is known as hodograph. You are not obligated to use two similar antennas for obtaining hodograph. In Zond-12e equipment, for instance, it is possible to use a 500A antenna with a short cable for receiving (Rx), and a 300 MHz antenna with a long cable for transmitting (Tx).

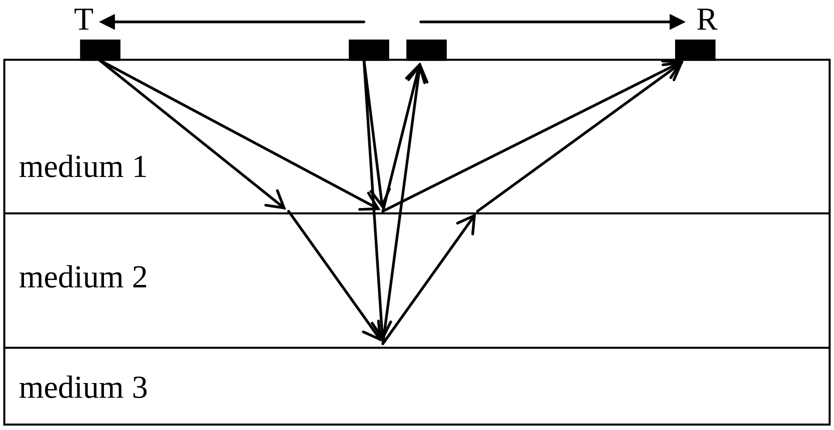


Fig. 16.1. Hodograph taking schematic. T - transmitting antenna; R - receiving antenna.

The following CDP acquisition guide could be used:

1. Each shielded antenna system contains one transmitting and one receiving antenna;

2. Here and below the antenna system called as unit, but the transmitting/receiving antenna of each unit is called Tx/Rx antenna;
3. The Tx antenna is placed in the back part of the unit (between main antenna and wheel connectors) and Rx antenna is placed in the front part of the unit (between main antenna connector and unit noose);
4. The Tx antenna of the first unit (immovable) and Rx antenna of the second unit (moveable) are used for CDP method;
5. Here and below the CDP result graph is called as Hodograph and looks like on Fig. 14.2;
6. The immovable unit direction is opposite to the Hodograph direction (unit noose backward, unit back ahead), but moveable unit direction coincides to Hodograph direction;
7. Hodograph starting point is the Tx antenna position of immovable unit;
8. Here and below the distance between the Tx antenna of immovable unit and the Rx antenna of moveable unit is called starting offset;
9. The stepped mode is used for the data acquisition in CDP method;
10. The moveable unit is shifting for a fixed step size (10-20 cm), one acquired trace = one step;
11. The total Hodograph distance has to be 2 times greater than measuring depth;
12. The Hodograph profile distance has to be entered to profiles settings as Length of profile, where “From” value is equal to starting offset and “To” value is distance between starting point (Tx antenna position of immovable unit) and the Rx antenna of moveable unit (or number of steps multiplied by step size plus starting offset).

When antennas are spaced apart, reflected signal amplitudes drop down considerably; therefore it is advisable to specify in **Output parameters** Menu / **Normalizing factor / Entire trace** option.

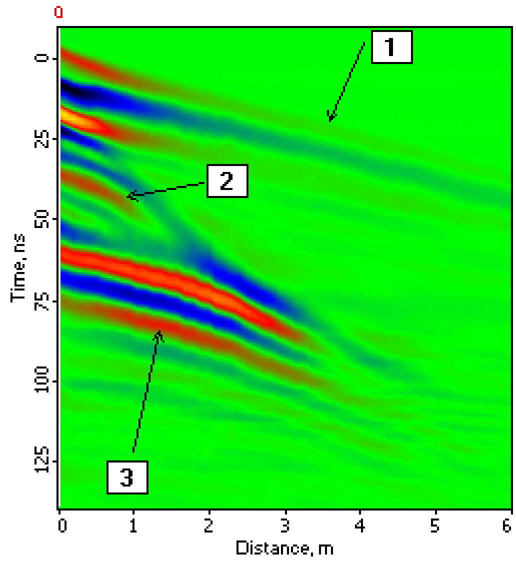


Fig. 16.2. Type profile shot using Common Depth Point technique.

Three signals are clearly visible on the provided profile, namely:

1. Air wave path signal. Always appears as an inclined straight line.
2. Signal path reflected from the first layer interface.

3. Signal path refracted at the first layer interface and reflected from the second layer interface.

Important! After you finished sounding and saved the file, be sure to enter the initial and final antenna spacing in **Output parameters**.

To calculate medium characteristics (wave velocity or permittivity) by hodographs of the received signals, activate **Hodograph** button in the **Main menu** or use **Tools/Mouse actions/Hodograph** menu option. It will open the Hodograph dialog box.

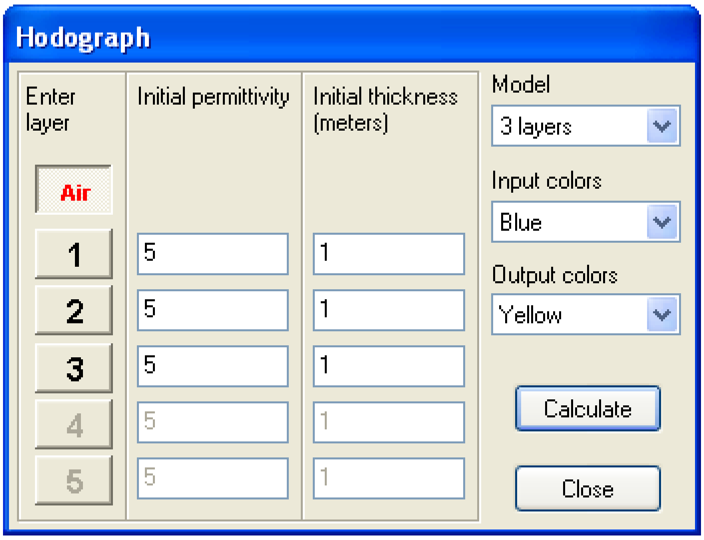


Fig. 16.2. Hodograph Taking dialog box

1. Using **Model** option in the dialog box, select the quantity of calculation model layers. This quantity depends on how many layer interfaces are visible in your profile; it may range from 1 to 5.
2. Using **Input colors** and **Output colors** options, determine input and output data line drawing colors. Colors should be chosen so as to be well visible on a profile. By the default red and blue colors are set, as they are clearly visible on the black-and-white image.
3. In the **Initial permittivity**, enter initial (estimated) permittivity values for the layers. By default, the value is set to 5, and for most cases is quite sufficient. You should adjust that value only when software is failed to find a solution.
4. In the **Initial thickness (meters)**, enter initial (estimated) layer thickness values in meters. <u>**Attention**! Layer thicknesses should be entered, not the depths!</u> By default, 1 m is set for all layers. This is quite sufficient for most cases. Adjustment shall be made only in cases where the software fails to find a solution.
5. Now, enter the air wave position which is fully determined by a single point, because the electromagnetic wave velocity in the air is known and remains constant (30 cm/ns). For this purpose, press button **Air** in section **Enter layer** of the dialog box. Move the cursor to the profile. It'll take the shape of crosshair which should be brought to the wave; click the left-hand key of the mouse. In this location, a cross will appear. For more accurate calculations, position the cross on the air wave at the large distances. The software will immediately ask you to enter **Offset (meters)**, i.e. the spacing between the antennas is in meters. Here, the entry field will be already filled by the software computed value on the basis of the profile length and the location where the cross is positioned. If it does not contradict with

the truth, press **OK**. Otherwise, you've made a mistake when entering the initial and final spacing between the antennas.

6. Enter the first layer interface. To do that, you have to activate button **1** in **Enter layer** section. Note, that interfaces are numbered from top to bottom. An interface is entered by the several points in series from left to right by moving the crosshair to the signal's path and press the left mouse button. Similarly to the air wave input case, following each click, the software will request to enter **Offset (meters)**. Then Press **OK** to confirm. As a result, a broken line will be drawn on the signal path. That should not confuse you – only nodal points are considered for in the computation.
7. Use the same procedure to enter the rest of interfaces (if any), activating sequentially buttons 2, 3, and so on in the **Enter layer** section and marking signal paths from respective interfaces. There could be any point number for the each interface.
8. Everything is ready for the calculation now. Press **Calculate** button. If the data is correct, the software calculates (this may take a few seconds) and outputs the result. Calculated signal paths will be drawn from computer model interfaces that minimize the discrepancy with real signal paths. Ideally, they should match exactly those paths that you have entered, whereas in reality they are sure to be somewhat different. In a separate information window, numerical calculation results will be displayed for each layer, namely: layer thickness in meters, electromagnetic wave velocity in cm/ns, permittivity, and mean root square value of approximation error (Error[MRS]). The smaller the last value the better the result. To exit the **Hodograph** menu option press the **Close** button.

Appendix A. Changing the Control Unit IP address

1. Turn ON Zond-12e Control Unit, computer configured according to p. 10 of present User's Manual, start up the Prism2 software.
2. Enter **Radar / Connection settings** Menu option. The Ethernet connection settings dialog box appears.

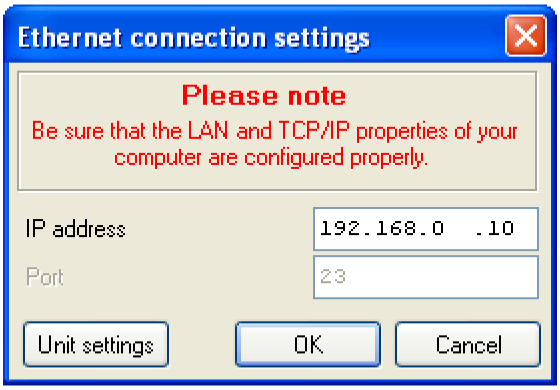


Fig. A1. Ethernet connection settings dialog box.

3. In IP address section will be Control Unit present IP address of. As default it is **192.168.0.10**
4. Click the **Unit settings** button. The Zond-12e Ethernet settings dialog box appears.

*Note: Please use the **Connection troubleshooter** if the error message appears.*

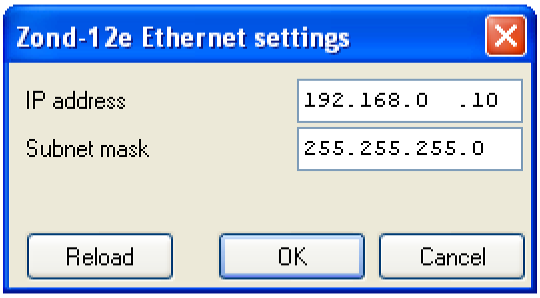


Fig. A2. Zond-12e connection settings dialog box.

5. Enter the new desirable Control Unit IP address in the **IP address** section.
6. Enter the new desirable Control Unit subnet mask in the **Subnet mask** section.
7. Press the OK button.

*Note: Please use the **Connection troubleshooter** if the error message appears.*

8. Press the OK button of Ethernet connection setting dialog box.

*Note: Please use the **Connection troubleshooter** if the error message appears.*

9. Configure new IP address of your computer compatible with the new IP address of Control Unit you set.

Resetting the default IP address of Control Unit

If you have forgotten or lost the Control Unit IP address, you can reset it to the default (**192.168.0.10**). To reset default IP address:

1. Configure your computer according to p. 10 of present User's Manual.
2. Turn ON the Control Unit, wait about 3 seconds and press the **RESET** button on the front panel of the Control Unit.

Connection troubleshooter

Error code **IP001.** "**The Control Unit with IP address … is unreachable!**"

	Possible reasons	What to do
1.	Entered IP address is not correct.	Reenter IP address and try again your action.
2.	Computer is not configured.	Configure your computer according to p. 10 of present User's Manual.
3.	Control Unit has unknown IP.	Reset default IP address (**192.168.0.10**) of the Control Unit according to p. 75 of present User's Manual
4.	Control Unit is switched off.	Switch on the Control Unit and try again your action.
5.	The Ethernet cable is unplugged.	Plug in Ethernet cable.
6.	The Ethernet cable is broken.	Use another Ethernet crossover cable.

Error code **IP002.** "**Error in writing into Flash Memory**"

	Possible reasons	What to do
1.	Connection timeout	Try again your action.
2.	Control Unit is failed.	Contact your dealer or producer for repair.

Appendix B. Wi-Fi Access Point

Older versions of “Zond-12e” (with serial numbers till 0537) and “Python-3” (with serial numbers till 0027) GPRs till 2015 has Wi-Fi Access Points for wireless connection. Wi-Fi security mode is disabled by factory default.

Note: It is not recommended to change Wi-Fi access point settings without the help of your local network administrator.

If you want to change the security mode of Wi-Fi access point, please use following steps:

1. Run any internet browser (all examples are based on Internet Explorer 10 here and below) and use Wi-Fi access point IP address as URL in address line.
2. Use „Zond12e” as a login name and „zond12e” as a password.
3. Press **Wireless** button on the WEB-page.
4. Chose menu item **Security.**
5. Chose **Security Mode** and enter all necessary information in corresponding fields.
6. Press **Apply** button.

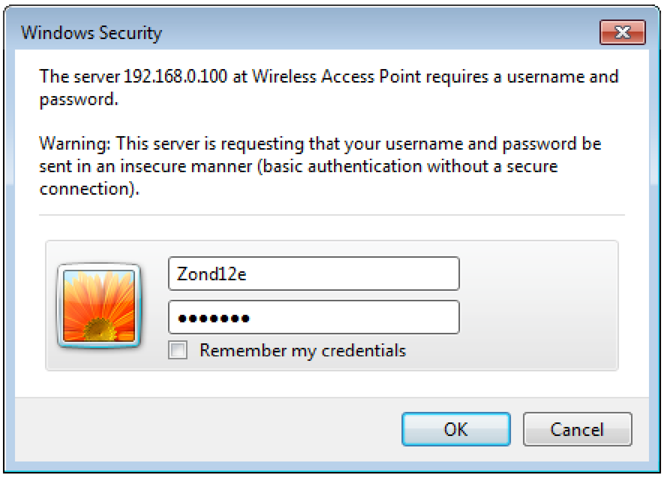


Fig.B1. Wi-Fi access point login dialog.

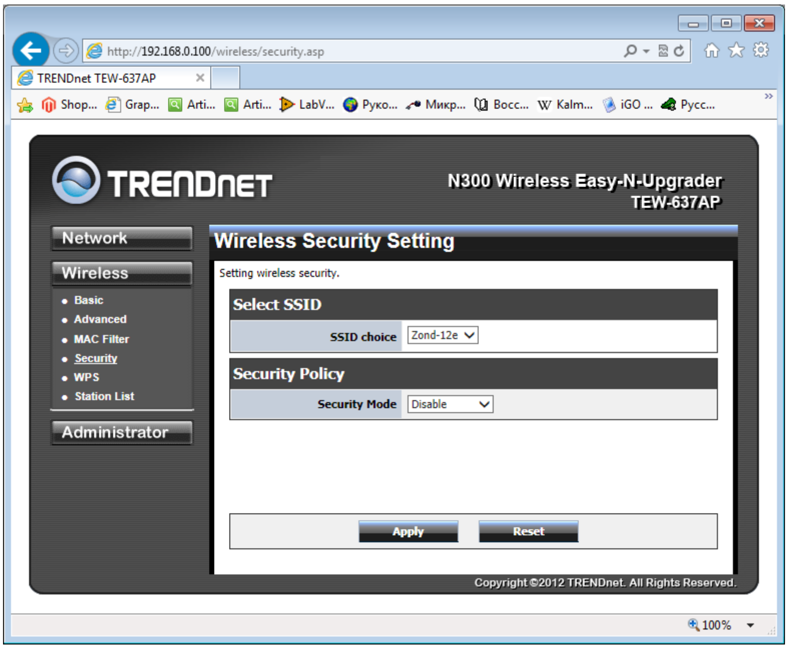


Fig.B2. Wi-Fi access point security settings WEB-page.

More detailed information about Wi-Fi access point settings you could find here: http://www.trendnet.com/asp/download_manager/inc_downloading.asp?iFile=17937

Starting from 2015 in "Zond-12e" (serial numbers from 0537) GPR contains internal network router that is able to automatically configure Local Area Connection settings on your (every version of Windows starting from Windows XP are configured to "Obtain an IP address automatically").

Appendix C. How to import Zond GPR data files from Prism to Voxler® 3D software

Voxler by Golden Software, Inc. (USA) (www.goldensoftware.com) is an easy to use software for a 3D visualization of the different data types.

1. First of all user have to be sure that GPR data files are stored as SEG-Y data files in Prism software (it is usually set up as default). If data files are saved in *.rdf format you have to run Prism software, open necessary GPR data files and Save As it as SEG-Y file *.sgy (menu "File -> Save As" or toolbar button ). All the 3D cube files have to be equalized in number of samples and traces. To equalize profiles do please follow the menu **File/Profiles 3D aligning**.
2. The Voxler window consists of three separate areas ("Network", "Properties" and visualization). You can choose the menu "File -> Import" or click right mouse button in the "Network" area and then choose the item "Import" from popup menu, to import GPR data files.

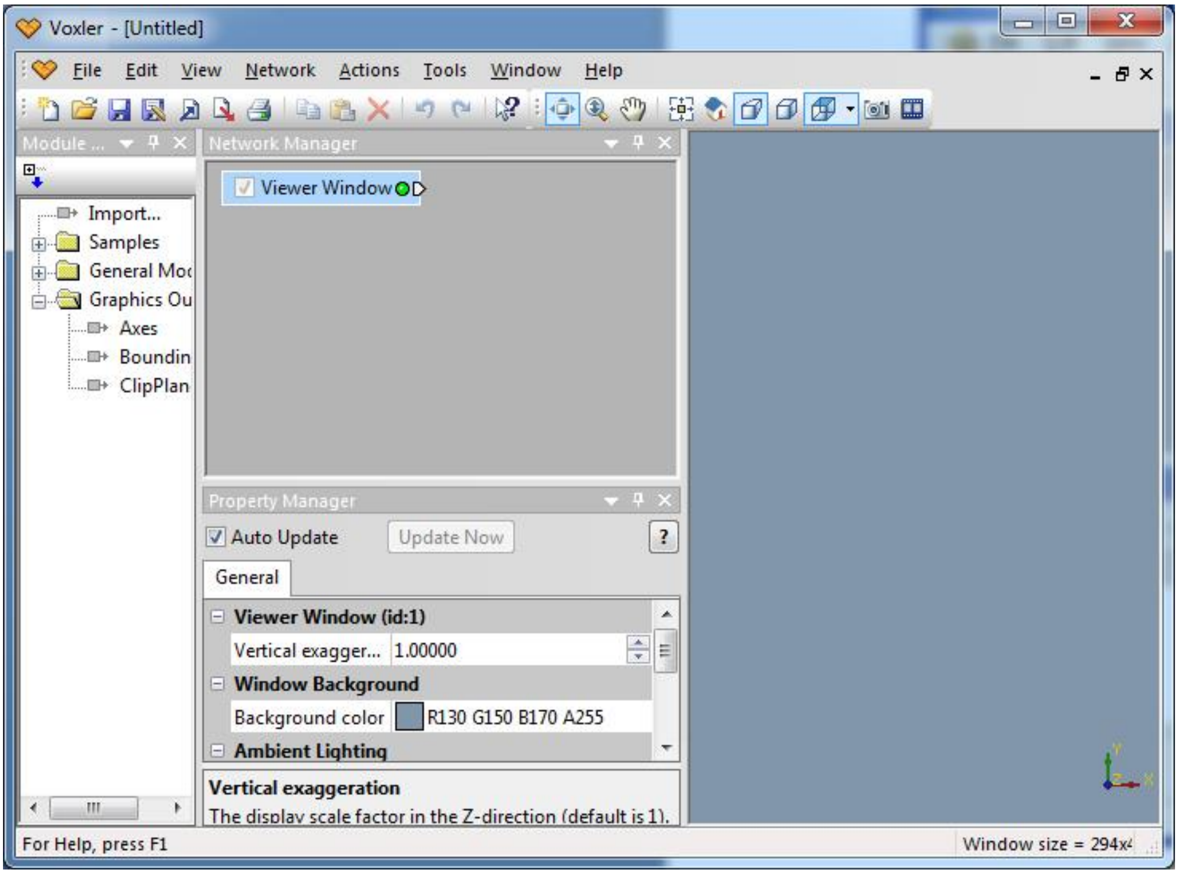


Fig. C1. Voxler software

3. Please select "SGY/SEGY SEG-Y Seismic Data Log (*.sgy, *.segy)" from the files type list in "Import" dialog and find the directory with necessary GPR data files (which are stored as SEG-Y files). You can import one or several separate GPR data files or import several profiles as an array (for a 3D cube). You have to mark necessary files by mouse frame (click the left mouse button on the clear area, hold

it and move mouse to mark files by frame) or with “Ctrl” and “Shift” keys help in the "Import” dialog.

4. You have to set SEGY Import Options as it shown on the picture bellow (Deviation from SEG-Y Specification: Litle-endian byte order, Data Type: Detect from Header, Import format: Import data as 2D Lattice.)

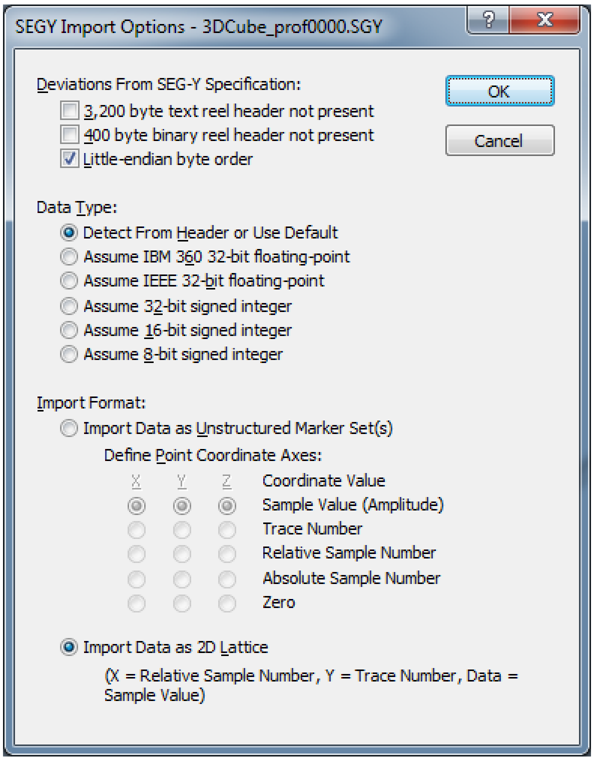
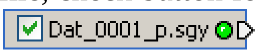


Fig. C2. SEGY Import Options

5. Voxler represents separate file or the array of files as a module (like a single small box with the name of first file, check button for enabling/disabling and small arrow on the right/left box side 

). If you marked some files like an array, but Voxler represents it in the different objects, and then imported profiles don’t match in samples and/or in traces (check it in the Prism software, and if necessary cut unmatched profiles).
6. You have to be sure, that all “Geometry Limits” of the imported data module are set properly (to see it just left-mouse click on the module and follow to the “Properties” area of Voxler window - "Geometry" tab). The X axis corresponds to the Samples/Time/Depth axis of the GPR data profile. The Y axis corresponds to the Traces/Distance axis of the GPR data profile. And the Z axis corresponds to the Width (profiles offset between each other) of 3D-cube for the files array. The Voxler calculates “Coordinate Limits” from imported files and gets it like samples quantity for X, traces quantities for Y, and 0 for Z. You could apply the calculated values and change only Z value (for the files array) by yourself, but the correct way is to apply all XYZ values in meters (Distance, Depth and Width). Distance and Depth you could get from Prism software.
7. You could visualize bounding box of your 3D-cube by adding new “Graphic Output” (click right mouse button on the imported data module in the “Network”

area and then choose the menu “Graphics Output -> BoundingBox” from the context menu.

8. Each imported data module may have a lot of branches (each “Graphic Output”, “Computational” or “General Module” represents like child-module of imported data module). You can brake, connect or disconnect these branches by drag-n-drop mouse action.
9. Please try to “play” with different graphic outputs to understand how it works and visualize the imported data. The best graphic output method of 3D-cube is “Isosurface” – it visualize all objects like a closed 3D-surfaces (for example – pipe could be visualized like tube). You have to change the “Isovalue” to apply the threshold value. You could also change the color output palette and other different settings.

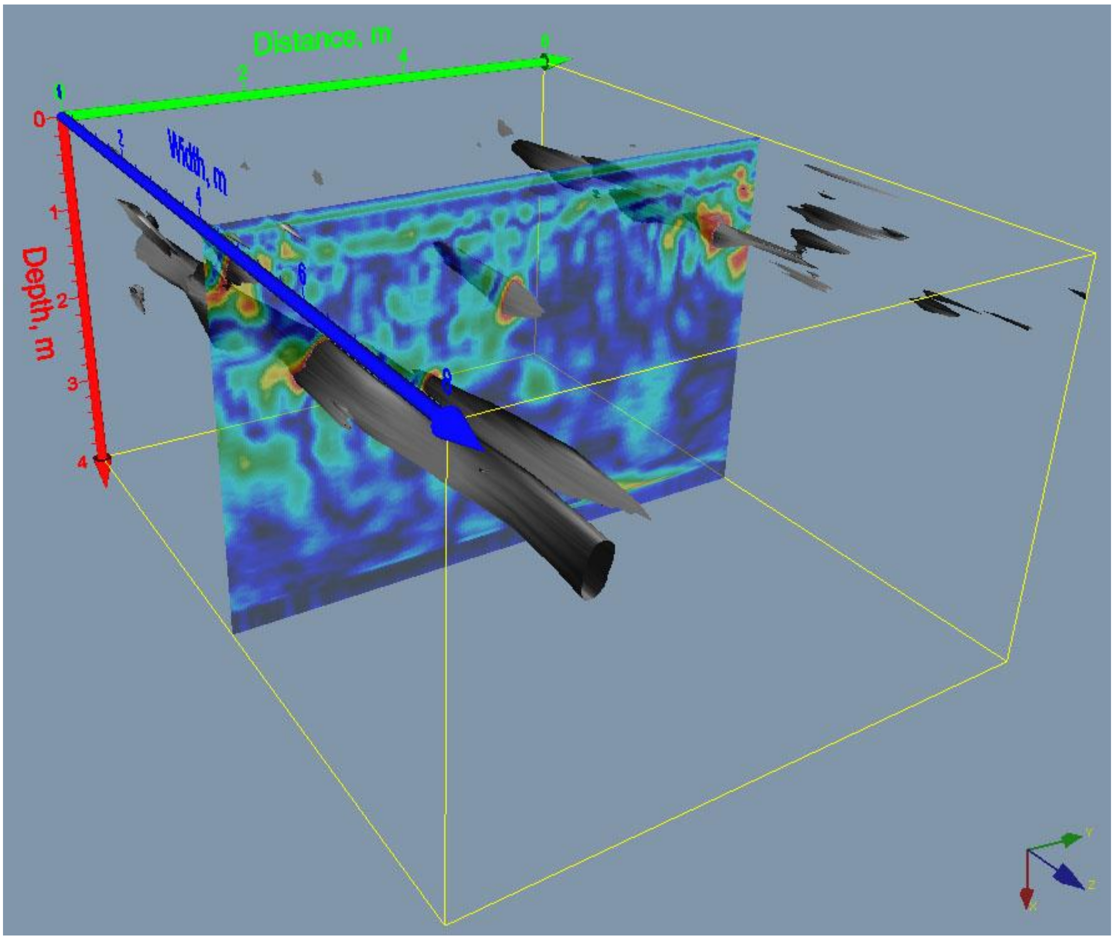


Fig C3. 3D-cube of underground pipes with the slice

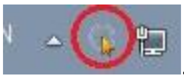
Appendix D. PrismClicker

Tool overview

PrismClicker is a small tool which allows the **Prism2** software (version 2.60.02 and above) to simulate mouse clicks for third party software. It is designed to simulate different mouse clicks on remote computer by pressing “Start”, “Stop”, “Pause”, “Resume” and “Mark” in **Prism2** acquisition mode.

PrismClicker is able to work via Serial Communication (by Bluetooth for example) or via TCP/IP communication protocol.

Starting the tool

It is strongly recommended to start **PrismClicker** as an Administrator (right click on PrismClicker.exe file and chose “Run as administrator”). Application starts minimized creating tray icon . User needs to configure it first, to be able to use it. There are two different configurations, the first one is the Connection Setup and the second one is the Click Setup. User has to run the **Prism2** software and setup the **Prism2** to work with **PrismClicker** before starting the Connection Setup.

Configuring the Prism2

Prism2 can work with both Serial and TCP/IP communications at the same time. User has to enable and configure any of those protocols that are needed for connection with the **PrismClicker** application.

Go to “Remote Marking” item of “Radar” menu

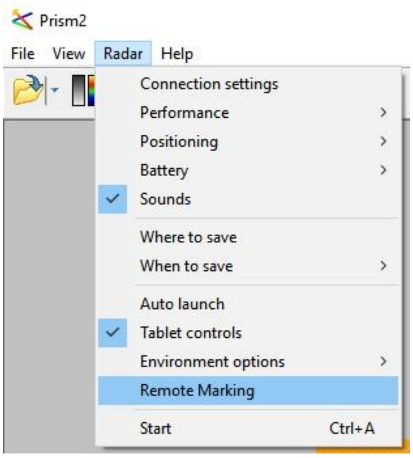


Fig.C1. **Prism2** Remote Marking menu

Enable and configure connection you are going to use in the Remote Marking dialog window:

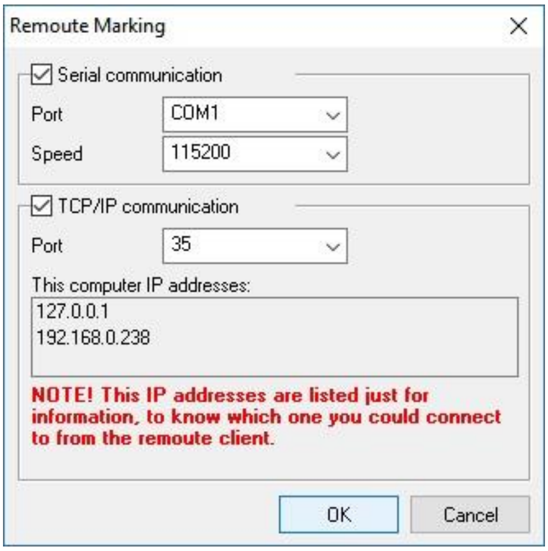


Fig.C2. **Prism2** Remoute Marking dialog window

Press “OK” button to save your configuration.

Configuring the connection

User could start to configure **PrismClicker**, after he has started and configured the **Prism2**. Right click on the **PrismClicker** tray icon and chose “Connection setup” of its menu:

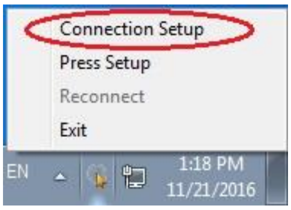


Fig.C3. **PrismClicker** tray menu

You have to choose the connection protocol (serial COM port communication or TCP/IP communication) with the host computer, which operating under the **Prism2** software. Configure communication protocol in “Connection Setup” window and press “OK”.

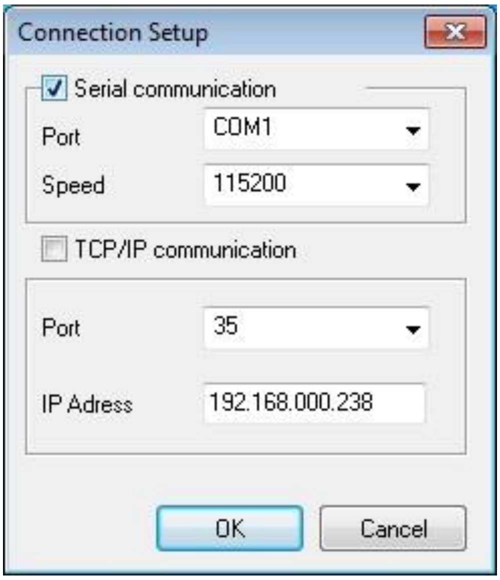


Fig.C4. **PrismClicker** connection setup dialog window

After you pressed “OK”, tool automatically try to connect and gives a warning if it fails.

Clicks Configuration

Click on the **PrismClicker** tray icon and chose “Press Setup” to configure the mouse clicks emulation. First of all user has to choose the triggering commands which manage the Mouse click emulation events in the “Press Setup” dialog window. To do it user is able to click on the checkbox corresponding to the command in “**Prism2** Commands” list. The “Set” button has to be pressed after choosing the commands. User is able to left click the necessary place of the third party software, what is needed to be simulated, after “Press Setup” dialog window closing. “Press Setup” dialog window will appear allowing to setup other commands.

Each **Prism2** command status is represented on the right part of the window. It is possible to pin multiple commands to one emulation click (simply select multiple checkboxes before you press “Set” button to apply it). It is not necessary to set all of the commands. There is a possibility to clear already checked commands (check corresponding checkboxes and press “Clear” button).

Fig.C4. **PrismClicker** Press Setup dialog window

Press “OK” to apply the Press Setup configuration.

How it works

Software is ready for using after all configurations. To start it working, you have to run the **Prism2** software on the host computer and **PrismClicker** on the remote one. Be sure that both computers are connected physically (by the serial, Ethernet or Wi-Fi communication) and go to the acquisition mode of the **Prism2** software. The GPR has to be turned on and reachable for the **Prism2** software. By the way, you is able to use the same GPR Wi-Fi network ("Zond", "Python", etc.), which is used for a host computer communication with the GPR, for communication between the host (operating **Prism2**) and remote (operating **PrismClicker**) computers (take a look on the part 5.2. for computers configuration of this manual for details, if you are going to use manual TCP/IP configuration, remember that IP addresses cannot be the same for different devices). **PrismClicker** automatically is trying to connect to the host computer at the start. If the connection is not established, application shows the error message with suggestion to reconnect it. If it happens, user has to click on the tray icon and press “Reconnect” button (if it fails to reconnect “Connection Setup” dialog window appears).

Press any setuped buttons in the **Prism2** software acquisition mode to take a look on the **PrismClicker** result. If everything is OK, **PrismClicker** emulates the left mouse clicks on the marked places: running/closing/pressing/checking any third party software or its components.

Appendix E. Attributes

We would be grateful if you could point us the shortcomings of the hardware and software, as well as suggestions for improving their parameters and consumer features.

We are always waiting your feedback with great pleasure.

If you found any difficulty using our equipment, do not hesitate to contact us or our representatives by phone, e-mail or mail.

We cherish sincere hopes that the equipment manufactured by our company will help you to achieve success in your business.

Radar Systems, Inc.
Darzauglu str. 1-105,
Riga, LV-1012,
Latvia.

Phone: **+371 67141041**
E-mail: **radsys@radsys.lv**
Web: **www.radsys.lv**