



# **Radiotechnical device for subsurface scanning (ground- penetrating radar, GPR)**

**«OKO-3»**

**Universal Basic Set**

**Technical Specification**

**User Manual**



**“Logic Systems” LLC  
Russia, Moscow Region  
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## TABLE OF CONTENTS

<b>1</b>	<b>TECHNICAL DESCRIPTION .....</b>	<b>5</b>
1.1	Application .....	5
1.2	Principal of operation.....	6
1.3	GPR Structure scheme .....	9
1.4	Universal Basic Set combination and application .....	10
1.5	Control Unit .....	11
1.6	Control Unit .....	12
1.7	Recharging Unit.....	13
1.8	Notebook Suspension.....	14
1.9	Shoulder-belt system .....	15
1.10	Optical converter .....	15
<b>2</b>	<b>USER MANUAL .....</b>	<b>16</b>
2.1	“OKO-3” Ground Penetrating Radar getting ready for operation .....	16
2.2	Universal Base Set get ready .....	16
2.3	Universal Base Set connection variants .....	18
2.4	GPR switching on .....	22
2.5	GPR “OKO-3” setting adjustment .....	23
2.6	Scanning modes .....	25
2.6.1	“On migration” .....	25
2.6.2	“Continuous” Mode .....	26
2.6.3	“Step-by-Step” Mode .....	26
2.7	Scan data record .....	26
2.8	Ground Penetrating Radar close down .....	28
2.9	Power Supply Unit BP-9/12 maintenance .....	28
	<b>APPENDIX 1 .....</b>	<b>30</b>
	<b>APPENDIX 2 .....</b>	<b>33</b>
	<b>APPENDIX 3 .....</b>	<b>34</b>
	<b>APPENDIX 4 .....</b>	<b>38</b>



## **General safety rules and certification**

In order to avoid accidents, as well as damages of the devices, the following safety engineering rules should be observed:

- While device operation do not direct antenna units to the people, during the device operation;
- During the device operation and transportation avoid strong impacts and mechanical damages;
- Only the staff who has passed training and acquainted with the operating instructions is allowed to work with the equipment;
- Only the qualified staff can perform device service maintenance;
- It is prohibited to sink the device or its' parts into water or other liquids (except ABDL "Triton");
- In order to prevent electrical shock injury, the device partial or complete disassembly is prohibited;
- Avoid to touch bare wire spots, do not touch exposed connections and components when charged with electricity;
- In order to prevent the device breakage, do not repair it by yourself.

The device radiation power level is not dangerous to humans' health, that is proved by Sanitary & Epidemiological Report № 50.99.04.431.П.008785.07.07 dated 03.07.2007

## **1 Technical Description**

### **1.1 Application**

Ground Penetrating Radar (further referred to as “GPR”) is a modern geophysics gadget, designed to different objects (non-metallic too) in various environment.

GPR is a portable radar system, it emits electrical waves not open space, but to specified studied environment. The studied environment may be soil (hence the most common name - GPR), water, buildings walls, etc. GPR is used for solving a wide range of geological, engineering, hydrogeological and search tasks:

#### **I. Territory geological structure study :**

- determining ground water level position;
- karst and slump structures mapping;
- survey of geological framework in conditions of frozen breeds, mapping of taliks.

#### **II. Exploratory search of water areas :**

- testing of depth and mud line of rivers and lakes;
- ice thickness detection;
- drowned objects finding;
- mapping of thickness of near-bottom deposits (silt, gyttja clay).

#### **III. Survey of airport runway, automobile roads and railways :**

- thickness and type of pavement sub grade blankets detection;
- determining the reinforcement type of hard pavement coat (frequency and depth of reinforcement);
- hard pavement coating defects detecting;
- survey of underlying subsoil with highlighting the deconsolidation zones of fracture, increased water content, etc.;
- search for underground pipelines.

#### **IV. Scanning of building structures :**

- determining the thickness of walls and floor construction;
- reinforcement type (frequency and depth of reinforcement) determining;
- electrical circuit wiring and pipes located along the building structures detection;
- building structures defects detection.

#### **V. Environment protection tasks :**

- oil contamination ground mapping;
- industrial and domestic solid garbage dump buried areas mapping.

#### **VI. Tasks in the area of archeology :**

- mapping of below ground foundations and old tombs, dead villages;
- detection of archaeological objects.

#### **VII. Tasks of security ministries :**

- explosives and projectiles detection within the walls, floors and other building structures;
- landmines detection including those frameless or in non-metallic body frames under highways and railways;
- detection of criminal ground disposals;
- search of alive people under heaps.

## 1.2 Principal of operation

The GPR operation is based on ability of radio waves to be reflected from medium boundaries with a different permittivity. A structure main parameter is dielectric capacity ( $\epsilon$ ) (see Appendix No.1).

The GPR transmitting antenna unit radiates electromagnetic pulses which have very small duration (units or nanoseconds) and rather a wide spectrum of radiation for getting a higher resolution capability. The choice of pulse duration is the result of a compromise between the required scanning depth and depth resolution requirements of the unit - the shorter the pulse, the less the scanning depth.

The electromagnetic pulse transmitted by a transmitting antenna unit into the tested environment reflects from any existing in this environment objects (both metallic and non-metallic) and heterogeneities whose dielectric permeability and conductivity differs from those of the environment itself. Such kinds of heterogeneities can be some cavities or interstices, boundary lines of different beds, the areas with different rates of humidity and so on.

As a result, the receiving antenna input gets a signal, which is a combination of transmitting antenna emitted signal and came directly to the receiving antenna (direct transmission signal or the direct wave), and signals reflected from various discontinuities surveyed environment objects.

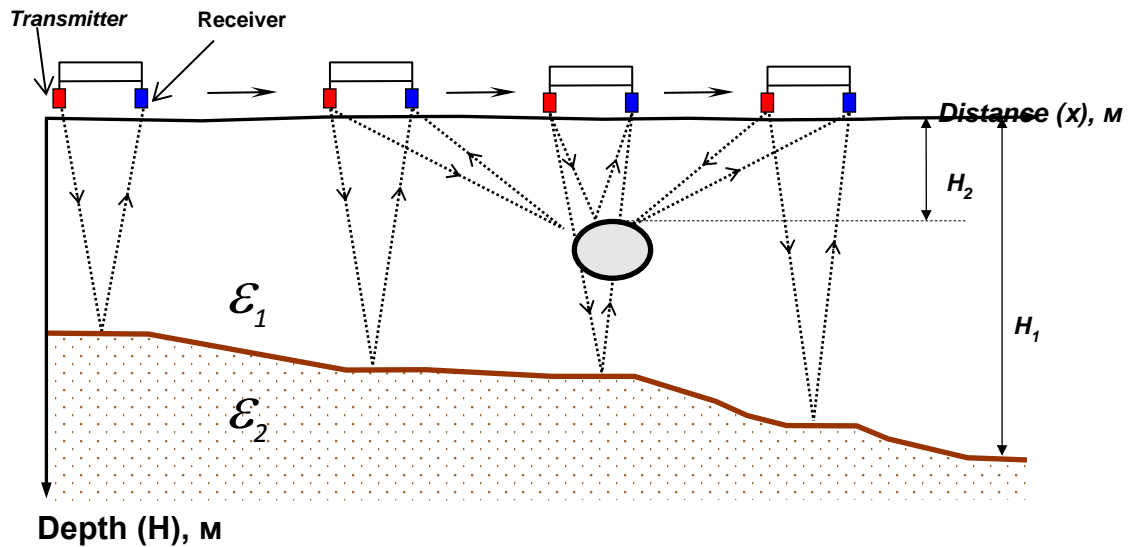
While moving GPR along the examined environment surface, a set of signals (a radarogram or a profile) is displayed in the monitor screen which helps to define the objects location, burial depth and length. (Pic. 1.1, Pic. 1.2).

Radarogram first reflection is direct wave. In most cases, direct wave is common for all profile scans (Pic. 1.3). It is determined by an antenna design and profile surface specific. Other radarogram waves are reflected from different layers or objects in soil (or other environment) waves.

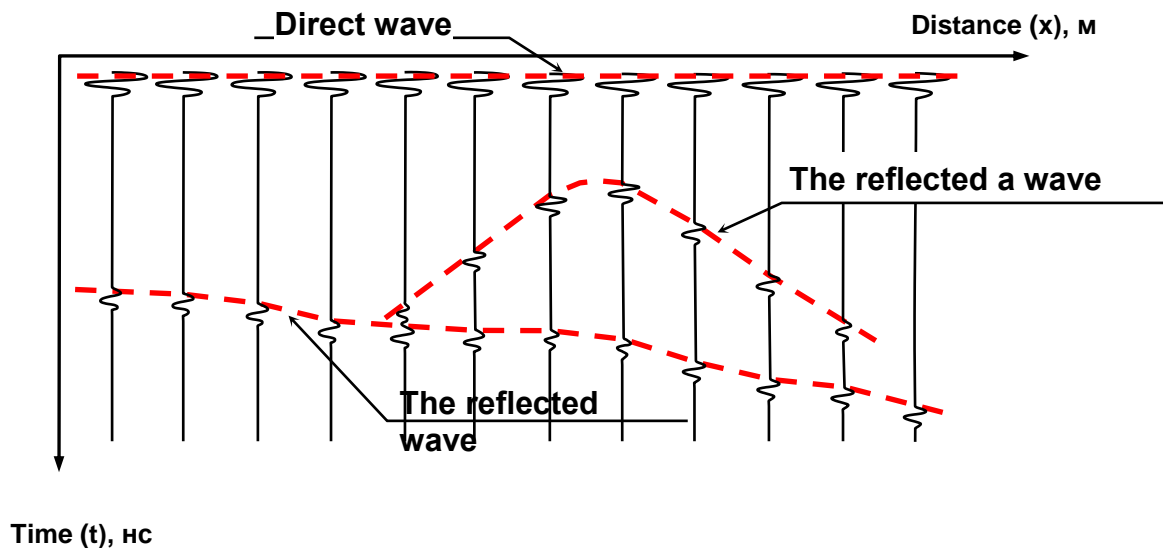
Due to the broad GPR reflected signals pattern from detected objects on radarogram are displayed not only directly at the point below the GPR, but also in some distance on both directions. The distance to the object on radarogram described as characteristic hyperbole, a makes so-called diffracted wave (Pic. 1.3). An object

from which came the reflected wave is at a point corresponding to the hyperbola top point.

From a practical point of view, the most important GPR characteristic is scan depth (probing depth) and resolution at depth.



Pic. 1.1 - GPR method operation scheme



Pic. 1.2 - Reflected from layers' borders and local objects wave creation

Resolution ability is the minimum distance at depth, under which two different objects can be distinguished. Resolution ability depends on sounding pulse duration

- the pulse duration is shorter than (respectively, central frequency higher), the resolution is higher.

The sounding depth depends on the GPR technical characteristics (emitting power, sensitivity, etc.) and detected structure electrical properties. The main affecting sounding depth characteristics is specific attenuation in the environment (structure). With specific attenuation increase, scan depth goes down.

Detected structures have wide variation in specific attenuation rate, which depends on electromagnetic wave signal central frequency, type detected environment (structure), its' salinity moisture saturation. Significant attenuation increase with central frequency increase is almost all natural and artificial structures main feature. Therefore GPR center frequency appointment is a compromise between the required depth sensing device and resolution.

Electromagnetic wave expansion speed in a structure depends on the structures' magnetic and dielectric penetration capability, however, most structures have magnetic penetration capability value close to one. Therefore, electromagnetic wave in a structure speed is:

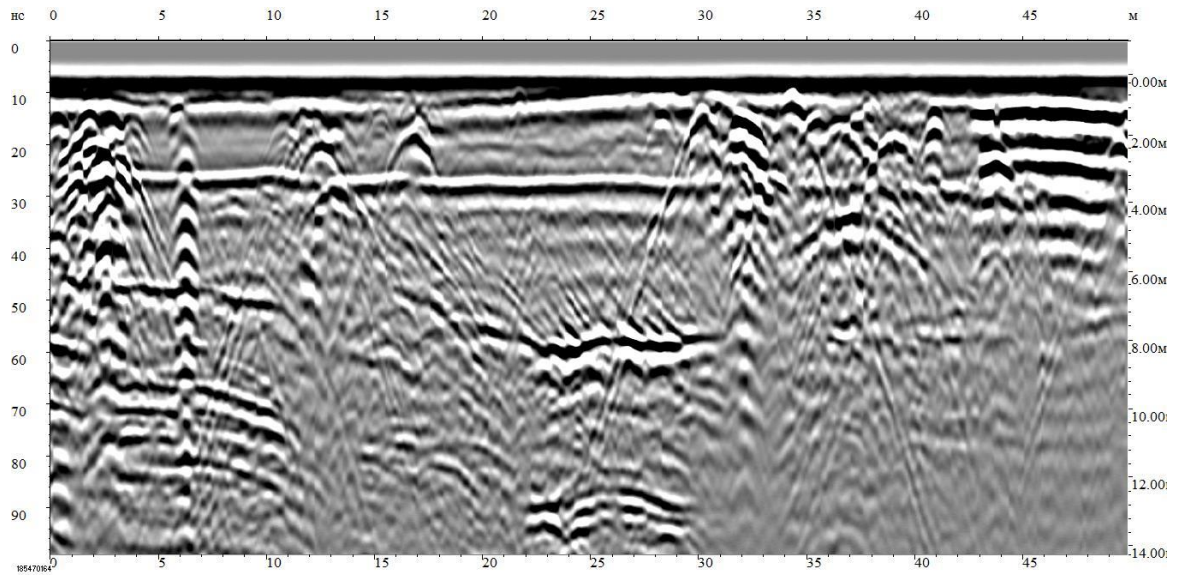
$$V = \frac{c}{\sqrt{\epsilon}} \quad (1)$$

where c - electromagnetic wave in vacuum expansion speed (light speed). It is common in geology radiolocation to measure the speed in cm / ns (centimeters per nanosecond in 1 ns = 10<sup>-9</sup>). Thus, the formula for calculating the rate is as follows:

$$V = \frac{30}{\sqrt{\epsilon}} \left( \frac{\text{cm}}{\text{ns}} \right) \quad (2)$$

Application Antenna Unit AB-250M radargram is given as an example (Pic. 1.3).





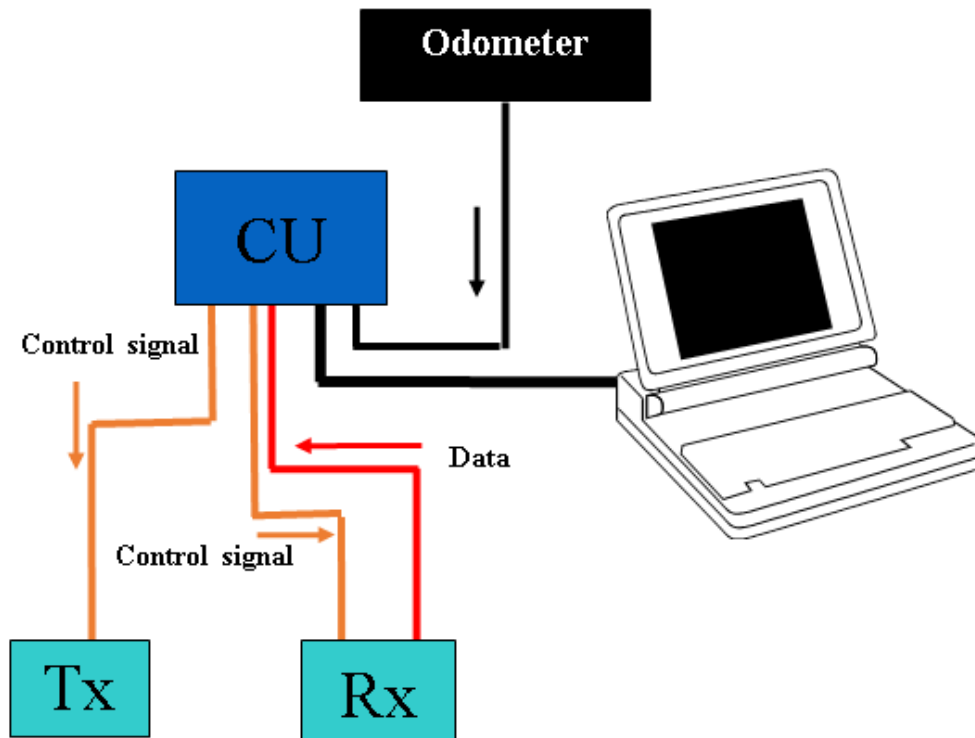
*Pic. 1.3 - Application Antenna Unit AB-250M radargram*

### 1.3 GPR Structure scheme

GPR OKO-3 consists of the following main components (Pic. 1.4):

1. Control Unit – transmitting and receiving antennas are synchronized in it, and received from antenna selected data shaped to scan sampling.
2. Data processing and visualization gadget – standard portable computer or specialized processing device.
3. Distance measure device is applied for collecting information about detected profile length. As usual that is odometer with wheel or bobbin with scaled rope. Also as a distance measure device GPS satellite receiver can be used.
4. Antenna Unit – transmitter and receiver are located here, and accordingly transmitting and receiving antennas. An antenna dimension are specified by sounding wave central frequency.





*Pic. 1.4 - GPR structural scheme*

#### 1.4 Universal Basic Set combination and application

The GPR Universal Basic Set "OKO-3" – is a set including devices, components and software worked out for GPR with antenna unit operation. GPR "OKO-3" uses three types basic sets: Universal Basic Set with Control Unit, Universal Basic Set with Two-Channel Control Unit, Universal Basic Set with Control and Processing Unit. The present technical description helps to understand universal basic set application, devices it consists of, variants of joining with GPR "OKO-3" antenna units, GeoScan32 software setting up features.

Universal Base Set application is to govern GPR operation via GeoScan-32 software.

The Universal Base Set includes (Pic. 1.5):

- One (or Two) channel Control Unit (CU);
- GeoScan-32 software basic version;
- notebook suspension – 1 pic.;
- power supply unit BP-9/12 – 1 pic.;
- recharging unit ZU-9 – 1 pic.;
- optic convertor (as an additional option);
- AB Cable;
- BP Cable;

- Ethernet Cable;
- Belt-Shoulder System;
- Spare Parts (Ethernet Cable – 1 pic., AB Cable – 1 pic., BP Cable – 1 pic.);
- Transportation Bag.



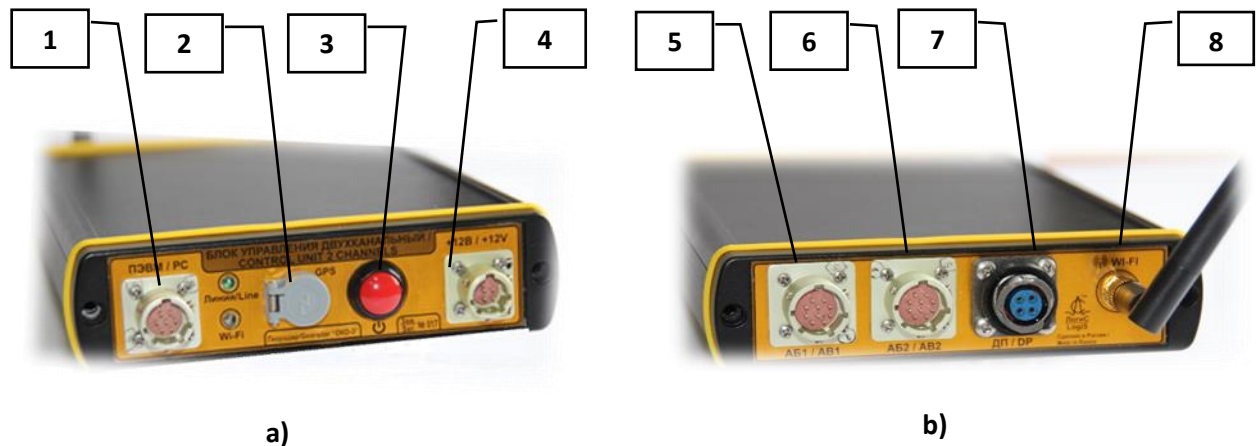
*Pic. 1.5 - The operator is ready to run on food detection using universal base set and antenna-monoblock*

## 1.5 Control Unit

The control unit (CU) is designed for control of all GPR operating modes. CU are manufactured in two types – one channel (one antenna unit can be connected) and two channel (possible to connect two antenna units). Pic. 1.6 – you can see two channels CU (one channel CU has only one plug for an antenna unit connection).

CU receives notebooks' orders via Ethernet interface or Wi-Fi channel, processes antenna units' current set-up and send it via RS-422 interface to antenna unit, sends to antenna commands for operational mode, receives data from the antenna unit, arrange secondary data processing, transfers the data after processing to via Ethernet interface to notebook.

CU has built-in voltage decoder, designed for laptop power supply, which provides an output voltage in the range of 15 ... 22V. The converter has 60Wt capacity.



*Pic. 1.6 - Two Channel CU a) front panel, b) back panel*

On the Pic. 1.6 by figures market :

- 1 – Ethernet Cable /joins CU and notebook, fixed on suspension/ connecting plug / connecting plug;
- 2 – GPS receiver /supplied as additional option/ connecting plug;
- 3 – CU power switch-on button;
- 4 – Power supply /BP/ cable connecting CU and power supply unit BP-9/12 plug;
- 5 – antenna unit connecting to CU plug /channel No.1/ plug;
- 6 – antenna unit connecting to CU plug /channel No.2/ plug;
- 7 – odometer cables' joining to CU plug;
- 8 – WiFi antenna connecting plug.

### 1.6 Control Unit

Control Unit (CU) consists of (Pic. 1.7) controlling device and accumulating battery. As accumulating battery is used Nickel-Metal-Hydrde battery.

Power supply unit BP-9/12 is applied for providing antenna units with electrical power, CU, notebook, control and processing unit.

### Specific features:

- The batteries are to serve not less than 500 cycles discharge / load;
- The battery low speed lose energy while storage allow to have the battery on stock without lose in technical capability to 6 months;
- There is light and sound indication for state of charge testing.

### Description of the light emitting diodes signals:

- The light indication is switched on for 1 second with the period up to 3-4.
- One time in 10 minutes period is given short sonic signal sounds and reminds that the power supply unit is on.
- Indication is flashing with the interval up to 3-4 seconds and an audible warning signal sounds - the battery is discharged.

During the exploitation process of nickel-metal-hydride accumulator batteries may have place so called “memory effect”, what may cause actual battery capacity reduction. To avoid that one should execute periodical “training” of the accumulators once within half a year, namely several cycles complete discharge and subsequent full charge. For full capacity restore may require 3-5 such discharge/charge cycles.



*Pic. 1.7 - Power Supply Unit BP-9/12*

## 1.7 Recharging Unit

Microcontroller automatic chargers (Pic. 1.8) with discharging function, are design for charge with electricity Power Supply Unit BP 9/12.

### Special properties :

- The charge process is controlled by « $\Delta U$  method» and by on time register;
- The testing phase before the start of the charge process allows to detect defective batteries;
- Polarity reversal protection;
- There is function for accumulating batteries discharge and restore;

- Upon the battery complete charge, the Recharging Unit comes to “trickle charge” (weak electricity supply) mode;
- The light emitting diodes which displays charge process stages.



*Pic. 1.8 - Recharging Unit ZU-9M*

### Light emitting diodes signal explanation:

- Yellow - battery is not connected
- Yellow - Initialization
- ORANGE - Quick charge
- GREEN / YELLOW - The final stage of charging
- Green – Charging
- ORANGE / GREEN - Error

## 1.8 Notebook Suspension

Notebook Suspension (Pic. 1.9) is a part of the universal basic set. It helps to fix a notebook and a control unit and hung them to relief belt pressure.



*Pic. 1.9 - Notebook Suspension*

## 1.9 Shoulder-belt system

It is used for proportional weight of all accessories (battery, notebook, etc.) spread over operator body (Pic. 1.10).



*Pic. 1.10 - Shoulder-belt system*

## 1.10 Optical converter

Optical converter (Pic. 1.11) is to convert optical signal into electrical signal. It is used in operation with optical antenna units: ABDL “Triton”, AB-90, AB-150. It is fastened to the magnet fixed on the handle-rod.



*Pic. 1.11 - Optical converter*



## 2 User Manual

### 2.1 “OKO-3” Ground Penetrating Radar getting ready for operation

The Universal Base Set is applied for running surveys by GPR “OKO-3” mounted on a vehicle, on foot or of fresh water.

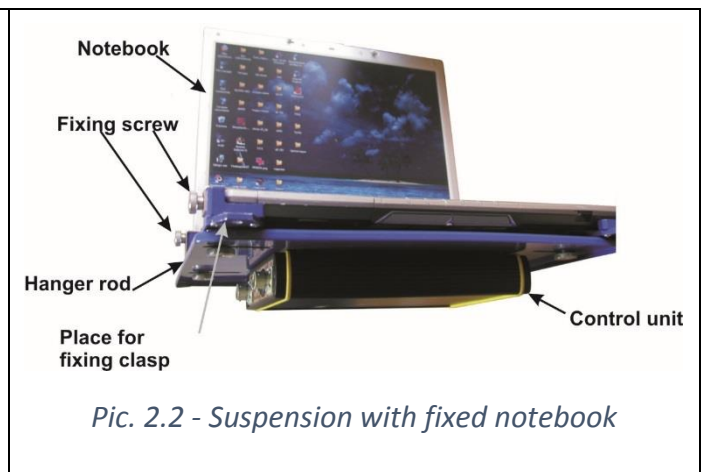
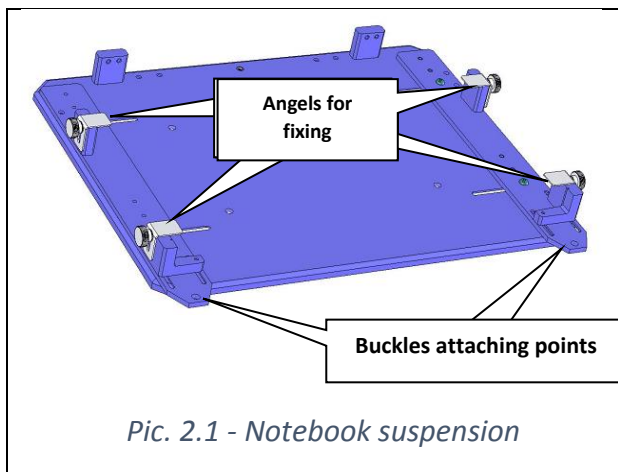
At the first method, CU, notebook and power supply unit are placed in vehicle cabin, antenna unit(s) is(are) fixed on special suspension, what joints to the vehicle (possible to run survey in two channel mode).

At the second method, operator using transportation rod or handle rod (depending on antenna type) pulls antenna unit over detected place surface (Pic. 1.5 - The operator is ready to run on food detection using universal base set and antenna-monoblock).

In fresh water survey CU, notebook are to be fixed on suspension, antenna unit and power supply unit are to be placed to (rubber) boat.

### 2.2 Universal Base Set get ready

Fix the notebook on suspension (Pic. 2.1). Before putting it, is necessary to unscrew the fixing angels, put the notebook on a carrier, and securely fix it with special angles. The carrier with the fixed notebook and control unit is given on Pic. 2.2.



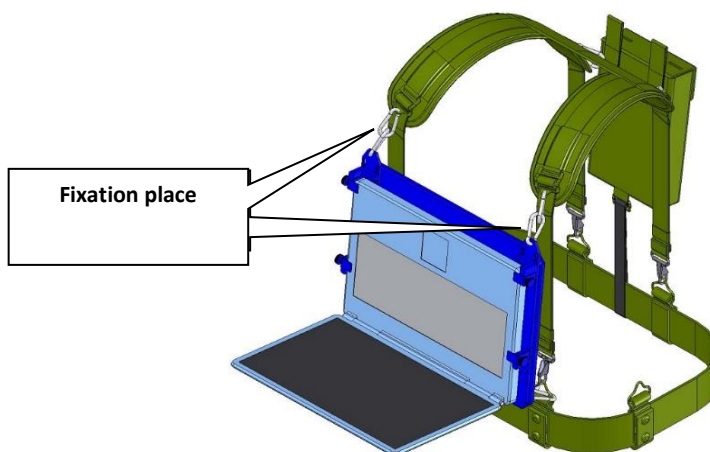
- Put charged power supply unit to shoulder-belt system's pocket (Pic. 2.3).





*Pic. 2.3 - Power Supply Unit BP-9/12 placement to shoulder-belt system*

- Fixed on suspension notebook stick by quick-link to shoulder-belt system as per shown on Pic. 2.4.



*Pic. 2.4 - Notebook, CU, power supply unit fixed on power-belt system*

- Connect notebook and control unit by Ethernet cable. One cable end is connected to “Ethernet / PC” CU’s plug, another end - to “Ethernet” notebook’s plug (Pic. 2.5).



*Pic. 2.5 - CU and notebook using Ethernet cable connection*

- Connect the plugs marked «+12 V» by power supply cable (BP cable) on the accumulators (power supply unit) and control unit.
- Turn on notebook and install “GeoScan32” software, installed from the disk, which is a part of a GPR basic set. Installation procedure and setting up software is explained in « GeoScan32 User’s Manual».
- Connect antenna unit. Depending on antenna unit type (monoblock, optic antenna), and the antenna to notebook data transmitting method (Ethernet cable or Wi-Fi channel), there are several basic set to antenna units connection schemes.

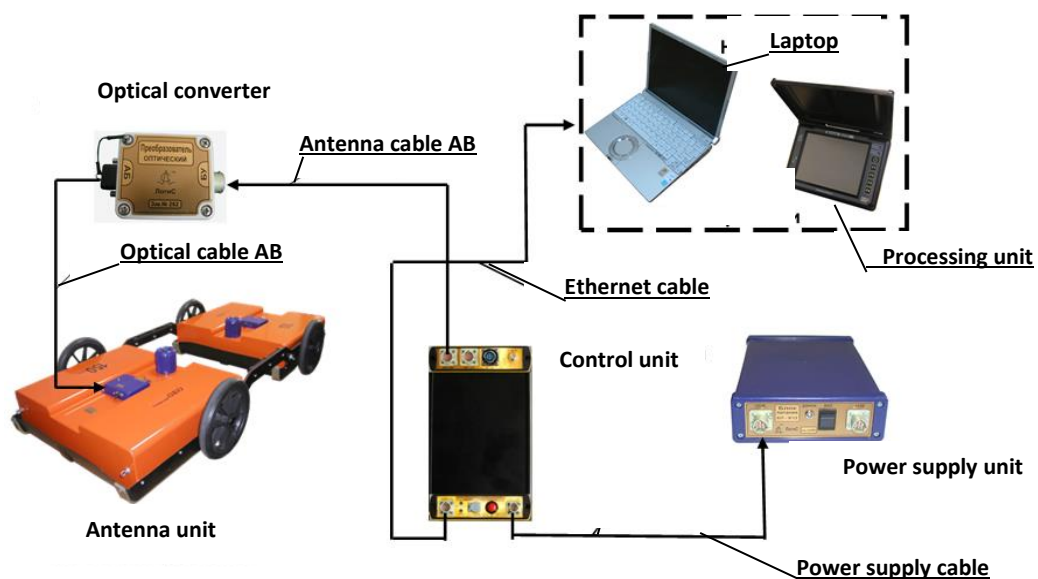
### 2.3 Universal Base Set connection variants

OKO-3 antenna units can be separated into categories – optic, where transmitting and receiving antennas are synchronized with each other via optic cable, and monoblock – where synchronization is arranged via electricity cable under one enclosure.

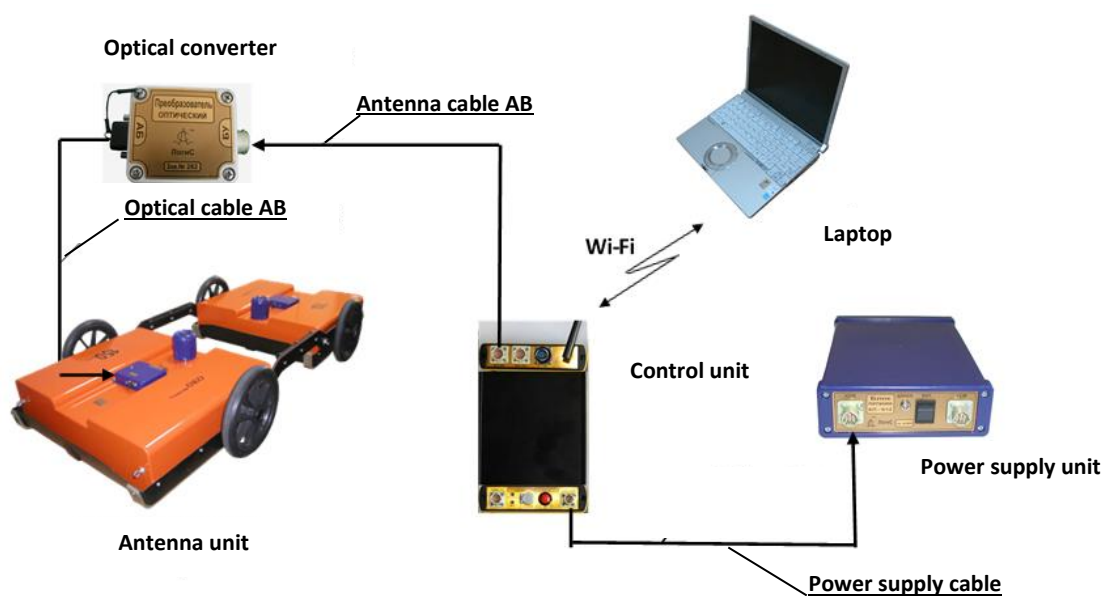
Antenna units with optical coupling: ABDL «Triton», AB-90, AB-150 are connected to the CU, the optical converter by AB optical cable joints to antenna unit, and to CU – via electrical AB cable.

Monoblock designed antenna units (including double frequency), namely, AB-1700M3, AB-1700P3, AB-1200M3, AB-1000P3, AB-2000P3, AB-400P3, AB-400M3, AB-700M3, AB-250M3, AB-250/700M3, AB-150M3, AB-150/400M3, connect to CU via electrical AB cable.

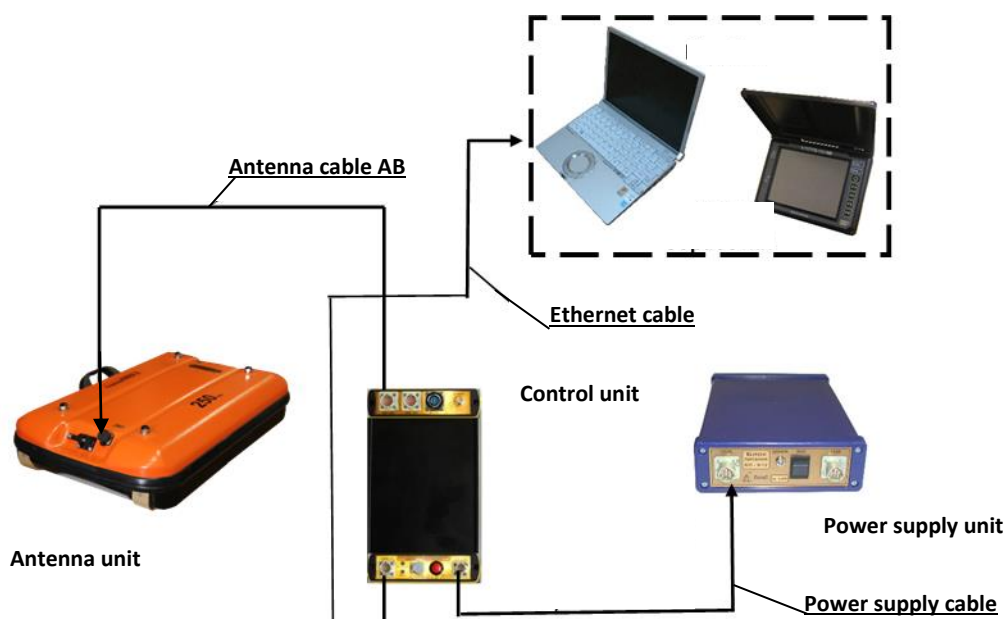
GPR Universal Base Set connection to antenna units with optical coupling (as ABDL “Triton”, AB-90, AB-150) and monoblocks functional scheme in Pic. 2.6-Pic. 2.9. Connection scheme also differs in method of transmission from CU to notebook. CU, GPR “OKO-2” and “OKO-3” Cables Compability Table is shown in Addendum No.2.



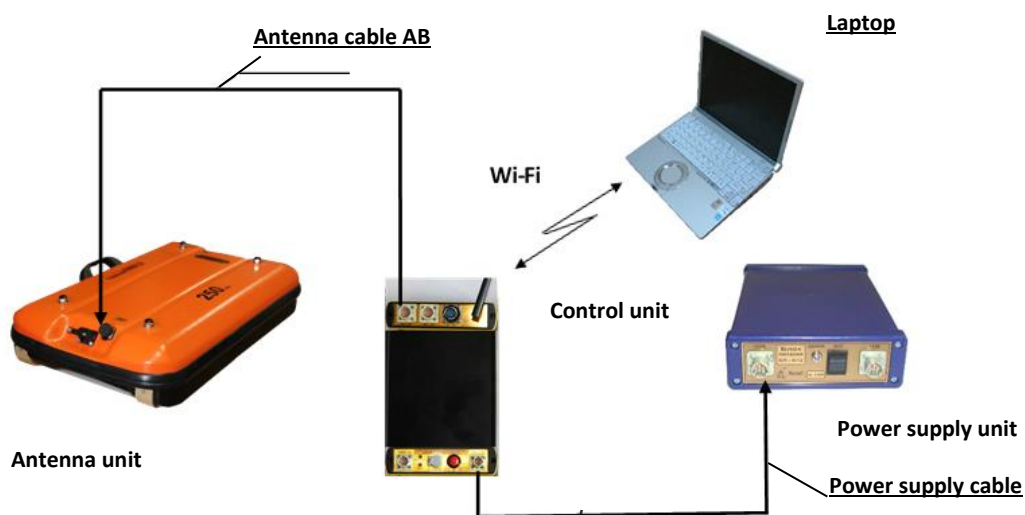
Pic. 2.6 - GPR Universal Base Set connection to antenna units with optical coupling (data transfer via Ethernet cable) scheme



Pic. 2.7 - GPR Universal Base Set connection to antenna units with optical coupling (via WiFi channel) scheme

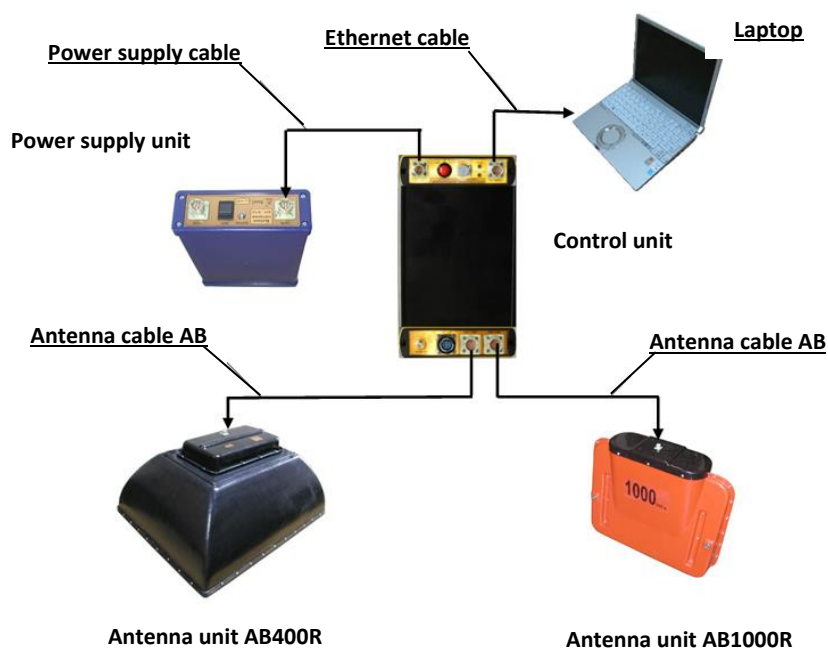


*Pic. 2.8 - GPR Universal Base Set connection to monoblock (data transfer via Ethernet cable) scheme*

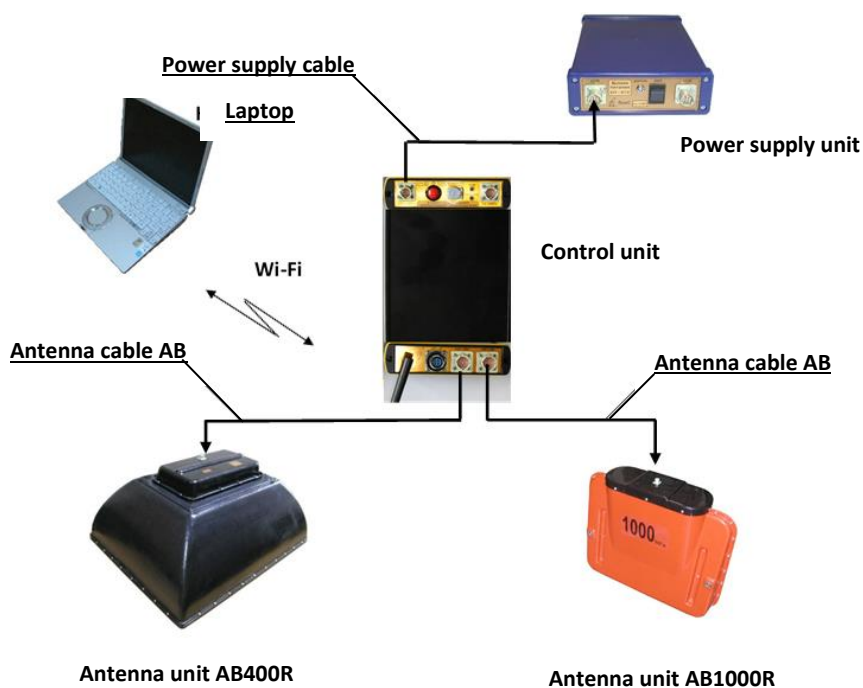


*Pic. 2.9 - GPR Universal Base Set connection to monoblock (data transfer via Wi-Fi channel) scheme*

GPR Universal Basic Set with two channels Control Unit connections are shown on Pic. 2.10–Pic. 2.11. Two Channels CU operation is ran with two standard antenna units, which also might be applied separately.




*Pic. 2.10 - GPR Universal Basic Set with two channels Control Unit connections (via Ethernet cable data transfer)*

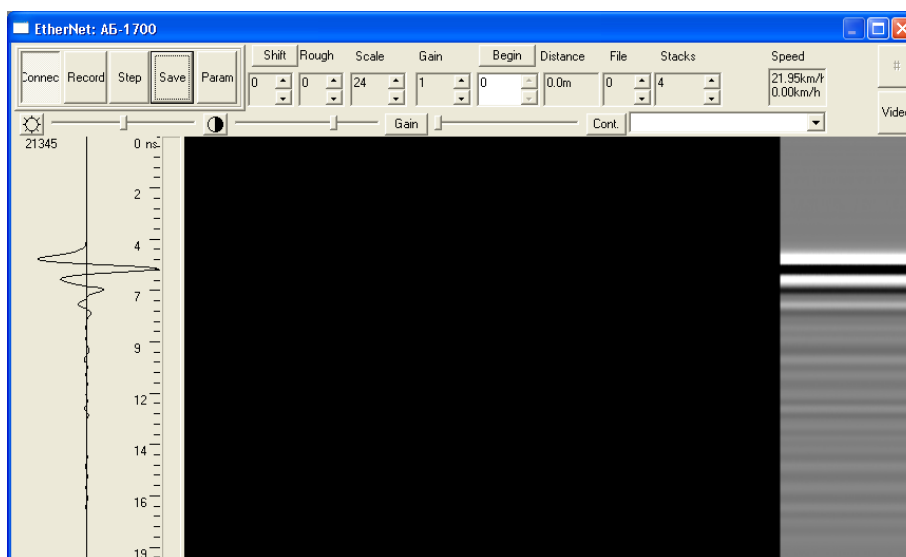


*Pic. 2.11 - GPR Universal Basic Set with two channels Control Unit connections (via WiFi channel data transfer)*

## 2.4 GPR switching on

Before turning on the GPR it is to be assembled completely (in conformity with description), and cables are to be connected according to Chapter 1.2 of the present – Operation Manual. GPR turning on is to be done by the following order :

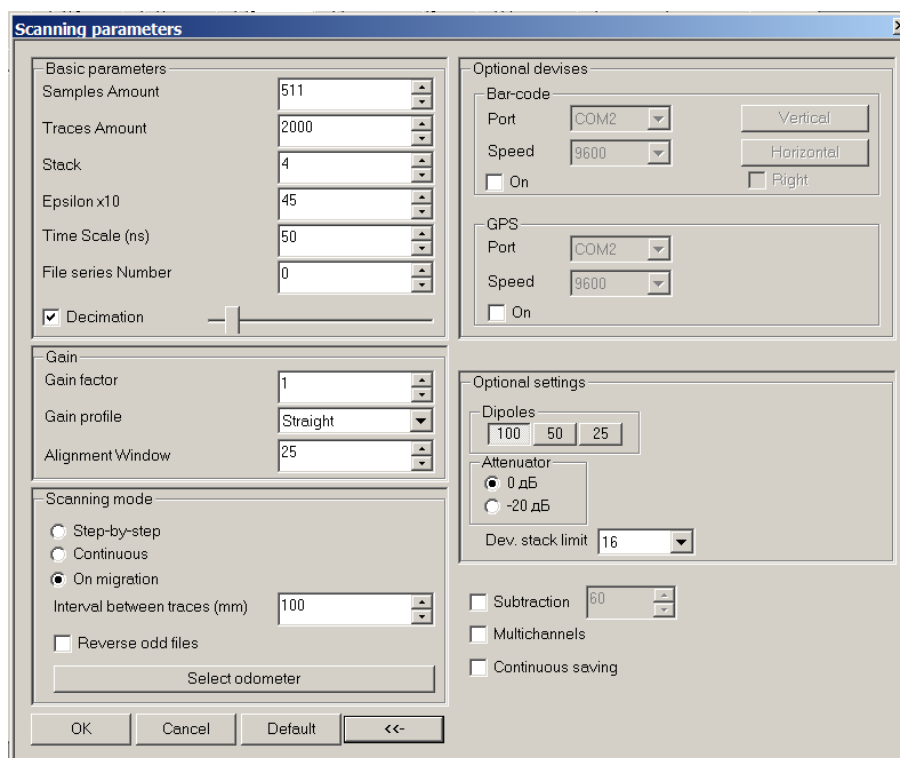
1. Switch on the power supply unit BP-9/12 by toggle switcher located on it's enclosure. In the normal condition of the accumulator battery, immediately after it's turning on, a short beep signal sounds and the LED starts to flash rarely.
2. Switch on control unit by pressing button to “ON” position. After turning on, two short beep signal sounds twice and green LED on the units' body.
3. In using antenna units equipped with optical coupling, switch on antenna unit power supply units type “BP-3,8/12”. In case batteries' energy power sufficient level, upon turning on a short beep signal sounds and the LED starts to blink. Antenna unit receiving module operation indicator starts to light. In case monoblock antenna is applied, power energy is sent from supply unit BP-3,8/12 upon CU is turned on.
4. In case odometer (or passed distance measure unit) is used with optical antenna units, odometer is to be switched on by button located on the device's enclosure. After turning on, LED starts to blink.
5. Switch on notebook and by mouse left button double press at GeoScan-32 software bar – initiate the software, the software bar is located on notebook Data Base DeskTop .
6. In the GeoScan-32 software main window start up scanning mode, by one of the ways :
  - chose “Scan” in files menu;
  - press together “Ctrl+S”;
  - in Tool Bar select “” and press the button.
7. After the mode is on, scan window is to be displayed on screen (Pic. 2.12). Ground Penetrating Radar is ready for scanning operation.



*Pic. 2.12 - GeoSca-32 software Scanning window*

## 2.5 GPR “OKO-3” setting adjustment

After GPR is switched on is very important configure scanning parameters correctly. Many of such parameters are displayed in “Scanning Setting up” window (Pic. 2.13), opened by “Param” (“Setting up”) bar in GeoScan-32 software scanning window or button “P” on keyboard. Some of the parameters are doubled at measuring module window. All introduced changes are saved in program exit.



*Pic. 2.13 - Measuring parameters*



Below is given each parameter brief description and explanation .

- **“Samples Amount”**

The parameter maximum value is 16 384 points. Depending to type antenna unit applied, to increase scan speed to 380 scan per sec (per one channel) it is necessary to state 512 points, points value to depth is 511 and less - scan speed will be similar to GPR OKO-2.

- **“Interval between traces, mm”**

This parameter stipulates the space between scan points along the profile. The step is counted only in “By steps” mode is switched on. Optimum space between each antenna unit scan points is to be set up depending on GPR detection required accuracy.

- **“Traces amount”**

При достижении заданного количества трасс запись автоматически прекращается / Parameter determines the maximum quantity of traces in the profile (in file). The parameter maximum value is defined by notebook Random Access memory capacity. It is recommended to use 1,5 times higher *ratio of profile length to scanning step* elation When the target traces number achieved, recording is automatically stopped.

- **“Stacks”**

The parameter to define number of secondary receipt of each trace for further it's summing. Increasing the parameter allows to define weak signals, increase actual scan depth and improve display quality, but same time it is recommended to reduce antenna unit pass speed while profile record.

Recommendations :

1-4 –Fast scan mode

8-32 –Main operational move - moderate tempo

more than 64 – use in “Step-by-step” mode and under conditions of weak signal heavy attenuation or strong interference.

- **“Epsilon x10”**

In recording the profile, the value of this parameter is set roughly (more accurately this parameter will be definid in operation). The Table with the main electric parameters of soils and rocks is shown in the Appendix 4.

- **“Time scale (ns)”**

Parameter which defines a time scale scanning profile to depth, it changes gradually (the first level is the lowest). “Time scale” parameter is selected depending to applied antenna unit type. While the first switch on the first “Time scale” stage is displayed in that window.

- **“File series number”**

It sets file series number, namely, all recorded files' names will include identified number in this field.

- **“Gain factor”**

The parameter value characterizes the gain factor by the end of receiving period and affects only data display (*it has no influence to recording data*).

## **2.6 Scanning modes**

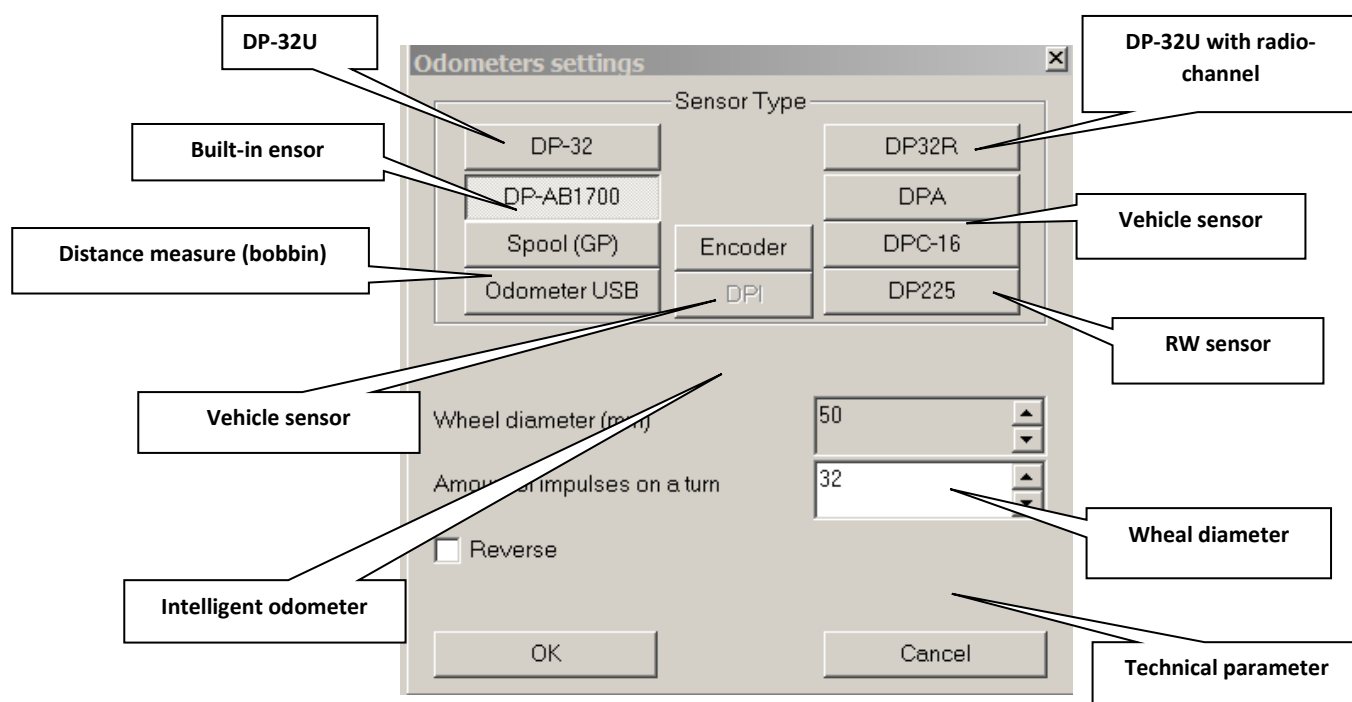
GPR OKO-3 has three scanning modes, which are to be chosen in GeoScan-32 software “Scanning Mode” window :

- “Migration” mode;
- “Continuous” mode;
- “Ste-by- step” mode.

### **2.6.1 “On migration”**

“On migration” mode is applied in work with odometer in order to reach better matching collected data to length (distance) surveyed profile. «Odometers settings» window is activated by pressing «Select odometer» key (Picture 25). Select proper odometer type in the window, at the same time the parameters change automatically (Pic. 2.14). In GPR OKO-3 are possible the following odometer connection variants :

- in operation with vehicle antenna units, which are fixed on a special suspension, “DPI”, “DPA-3m” odometers or endcoder join directly to control unit;
- in using antenna units operating in contact with detected object surface, “DP-32U”, “DPI” odometers are connected directly to special plug on the antenna body. In the case operation in dual-channel mode, “DPI” odometer can be connected to any antenna unit, “DP-32U” odometer can be used, but connected with the first channel;
- in the case GPS receiver be applied as a displacement sensor, it joints to CU, in "Settings sensing" menu should be marked «GPS» bar.



*Pic. 2.14 - Select odometer window*

### 2.6.2 “Continuous” Mode

Recording of the covered distance is not performed. The mode is used in operating the antenna unit ABDL “Triton” and while area, where odometer application is impossible.

In “Continuous” mode operation is possible to use odometer, data exchange between antenna unit and will be faster, in processing there will be possibility to see passed distance.

### 2.6.3 “Step-by-Step” Mode

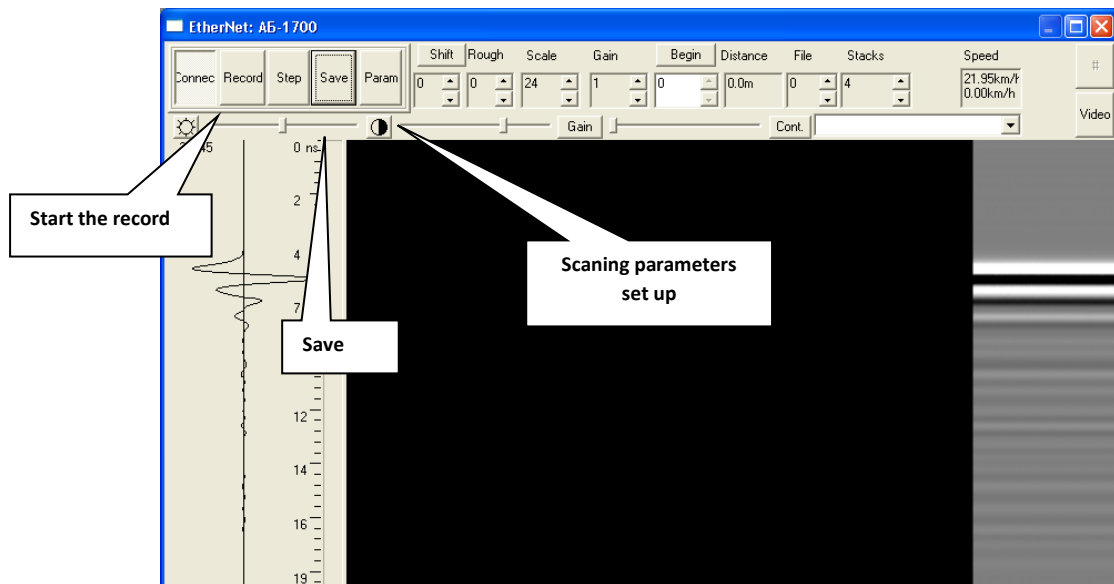
The “Step-by-Step” mode should be selected for scanning a profile with large stacks, if one trace processing requires much time, and it is not possible use odometer, or surveyed object has limited room for antenna to move.

Each new trace is recorder after pressing “Step” button on GeoScan-32 software tool bar (Picture 25).

## 2.7 Scan data record

After setting parameters and selecting “Scanning mode”, start the profile recording. Before starting to move antenna unit, should press “Profile” key (Pic. 2.15) in GeoScan-32 software scan module tool bar, then begin to move antenna unit. In

case operation under “On migration” mode, sounding is on only when the antenna is on move, and radargram drawing on the laptop screen is build synchronized with the antenna unit movement. In the case operation in "Continuous" mode, rendering on screen occurs continuously (on screen scan line moves independently the antenna unit movement) so to obtain undistorted radargram, antenna unit is to be moved with same speed the scan on GeoScan 32 software screen is of moved.



Pic. 2.15 - Scan mode window

In this case the data start to be recorded in the buffer (computer random access trore). In order to complete the data passage and to save the file, press the “Save” key, after that, chose the folder icon and assign the name of the saved file.

If press the “Save” key when “Record” key is not initiated, in other words GPR data is saved to buffer, profile extended “2 screens” length file is to be recorded.

While scan is on progress, possible by pressing “Ins” key put marks. The marks are displayed as black vertical lines, numeration sequentially starting from 1.

***\*The present Operational Manual does not give complete information about measurement parameters, to get more detailed information turn to GeoScan32 software User’s Manual.***

***\*\*In case problems in GPR operation appear, refer to Addendum 3.”Eliminating troubles by yourself”***

## 2.8 Ground Penetrating Radar close down

### To complete GPR operation follow the steps:

1. Quit the measurement module (press the “Escape” key and close the scanning mode window.
2. Switch off antenna unit’s power supply units (for optical antenna unit) and switch off odometer’s power supply.
3. Turn off computer and control unit. Light emitting diodes on the CU’s body stops blinking.
4. By toggle switcher (located on power supply unit BP-9/12 body) turn off the power supply unit. LED on its’ body stops blinking.
5. Unplug all cables, joining CU, power supply unit, notebook, antenna unit.
6. Disconnect odometer (passed distance measure unit) and antenna unit.
7. Disassemble the antenna units (as to AB-150, AB-90).
8. Put GPR assembling parts into travel bag.

## 2.9 Power Supply Unit BP-9/12 maintenance

### Power Supply Unit BP-9/12 charge order:

1. Connect Recharging Unit ZU-9 to electricity mains 220V 50Hz;
2. Turn on Power Supply Unit;
3. Connect Recharging Unit and Power Supply Unit;
4. Before the charge process, red LED blinks 2-3 seconds (test mode), then lights constantly. It takes less 10 hours for complete charge fully discharged battery;
5. After LED green light is on, switch off charger and power supply unit in inverse sequence.

“Effect of memory” might occur while nickel- metal-hydride accumulator batteries operation, that leads to the battery actual capacity.

In case the situation takes place and after long period the batteries were not in use, should be executed several discharge-charge cycles (for full capacity restore may require to 3 such cycles).

It is recommended to run discharge/charge only in case power supply unit complete loss capacity.

### Power supply units’ discharge order:

1. Connect a recharger and turn on power supply unit as per the way described above (charge order).
2. For discharge process begin push yellow button " PRESS " (ZU-9) on the power supply unit case (Pic. 2.16), keep pressed 2 seconds. “ZU-9”

blinks red LED , at the end of discharging phase the charger is automatically starts to charge the accumulator battery, and LED on the device case continuously lights red.

***It takes 6-8 hours to charge fully discharged battery***



*Pic. 2.16 - ZU-9 charge button*

**Warning !!!**

***If connection is done correctly, i.e. according with the “Sequence of charging power supply unit” described above, but the red LED is not lightning (flashing), than measure the tension on the power supply units. If the tension is close to null, than make several connections/disconnections charger to power supply unit, until the LED start lighting.***

***Such effect can be caused by the total discharge of power supply unit and at each new connection of ZU recharges the accumulator a little, and at the next connection it will have enough tension to start of normal charge.***

***In case if the lamp does not ligh, and there is the tension on power supply unit, turn to maintainer’s service.***

## Appendix 1

### The main types of soil and rock dielectric characteristics

The most important values characterizing the application potential of the georadiolocation method in different environments are electromagnetic waves in a structure (environment) specific attenuation ( $G$ , [dB/m]) and propagation velocity, which are defined by its electrical properties. The first parameter governs GPR penetration depth, knowledge of the second parameter is necessary for sound to depth reflected pulse till reflecting boundary temporary delay value recalculation.

The main electrical characteristics of the soil and the solid are given in Table “Main types of soil and rock dielectric characteristics”.

The propagation velocity of electromagnetic wave in the environment is equal to:

$$V = \frac{C}{\sqrt{\varepsilon}} = \frac{30}{\sqrt{\varepsilon}} [\text{cm}/\text{ns}] \quad (3);$$

$V$  - propagation velocity of electromagnetic wave in the environment;

$\varepsilon$  – relative electric permittivity of environment .

The specific decay coefficient  $G$  [dB/m] defines the signal decay value in passing 1 meter of the environment.

To illustrate the losses they are also given in times per 1 meter.

Losses in the environments with decay depend sufficient enough on humidity and level of mineralization (salinity).

The data by losses given in the table correspond approximately to a low level of mineralization. (less than 1 g/l).

With signal frequency increasing, the losses in the environment increase as well. For example, in black soil with 5% humidity and with frequency change from 250 MHz up to 1000 MHz the losses grow from 17 dB/m up to 30 dB/m.

Laboratory method of defining the solid or substance humidity :

$$\text{Влажность} = \frac{M - M_c}{M} \times 100\% \quad (4)$$

$M$  – the initial solid sample weight;

$M_c$  – dry solid sample weight.

It is better to use an electrical drier or oven for drying-up the sample.



### The main types of soil and rock dielectric characteristics

Type	Humidity %	$\epsilon$	Decay G[dB/m]	Decay (times/m)	Velocity [sm/ns]	Dealy of the reflected signal (ns/m)
Granular sand	0	3,2	0,05	1	17	12
	4	5	1,8	1,2	13	15
	8	7	3,5	1,5	11	18
	12	11	5,3	1,8	9	22
	16	15	6,5	2,1	8	26
Grey loam soil	0	3,2	0,1	1,01	17	12
	5	4,8	9,9	3,1	14	15
	10	7	15,5	6	11	18
	20	14,7	26	20	8	26
Chestnut loam soil	0	3,2	0,1	1,01	17	12
	5	4,0	3,2	1,4	15	13
	10	6,5	4,6	1,7	12	17
	20	10	10,8	3,5	10	21
Glaz	0	2,4	0,3	1,04	19	10
	4	5,4	23	14,1	13	16
	8	8	27	22,4	11	19
	12	12	40	100	9	23
	16	18,6	53	447	7	29
Congeaed sand		4,5	0,8	1,1	14	14
Dry snow		1,2-2,8	0,01	1	18-27	7-11
Wet snow		2-6			12-21	10-17
Fresh ice (- 10°C)		3,3	0,01-0,5	1-1,07	17	18
Field ice (- 15°C)	Salt content	8,1	20	10	10	20
	5	7,7	20,3	10	10	20
Field ice (- 25°C)	Salt content	6,7	7,8	2,5	12	17
	5	4,4	12,2	4,1	14	17
Humid basalt		8	5,6		11	18
Concrete (500 MHz)	0	3,7	4,5	1,7	16	13
	5	5,5	19,3	9,2	13	15
	10	7	84	16000	11	18
Fresh water		81	0,18	1,02	3,3	61
Sea water		81	330	3,6*1016	1,5	133

Type	Humidity %	$\varepsilon$	Decay G[dB/m]	Decay (times/m)	Velocity [sm/ns]	Dealy of the reflected signal (ns/m)
Congeaed loam soil	-	16	0,9	1,1	8	27
Chalkstone	0	8	0,5	1,06	11	19
	Humid	8	14	5	11	19
Dolomith		6,7	0,6	1,07	12	17
Чернозем (Юг Липецкой области)	0	3,7	7	2,2	16	13
	5	6,2	17	7,1	12	17
	10	10	27	22,4	9	22
	15	14	36	63	8	26
	20	22	60	1000	6	32
Mineral coal		4-6	1-5	1,1-1,8	15-12	13-17
Weat peat		62-69	3-10	1,4-3,2	4	50
Humid crouan		5	0,6		13	15

## Appendix 2

### GPR “OKO-2” and “OKO-3” control units, antenna units, cables compability

	<b>OKO-3 Control Unit</b>	<b>OKO-2 Control Unit</b>
OKO-3 Antenna Unit	One- and Two-channel connection (points to depth number - 16384 max., scan speed – 380 trace per sec. per 1 channel at 512 points to depth)	One-channel connection (points to depth number - 511 max., scan speed – 180 trace per sec. per 1 channel depending to antenna’s type)
OKO-2 Antenna Unit	One-channel connection (points to depth number - 511 max., scan speed – 180 trace per sec. per 1 channel)	One- or Two-channel connection (points to depth number - 511 max., scan speed – 180 trace per sec. per 1 channel)
Cables applied to OKO-3 Antenna Units	Applied in One-, Two-channel modes	Applied in One-, Two-channel modes
Cables applied to OKO-2 Antenna Units	Applied in One-channel modes (connection to channel 1)	Applied in One-, Two-channel modes
Ethernet Cable applied to OKO-3 GPR	Applied	Applied
Ethernet Cable applied to OKO-2 GPR	Not applied	Applied

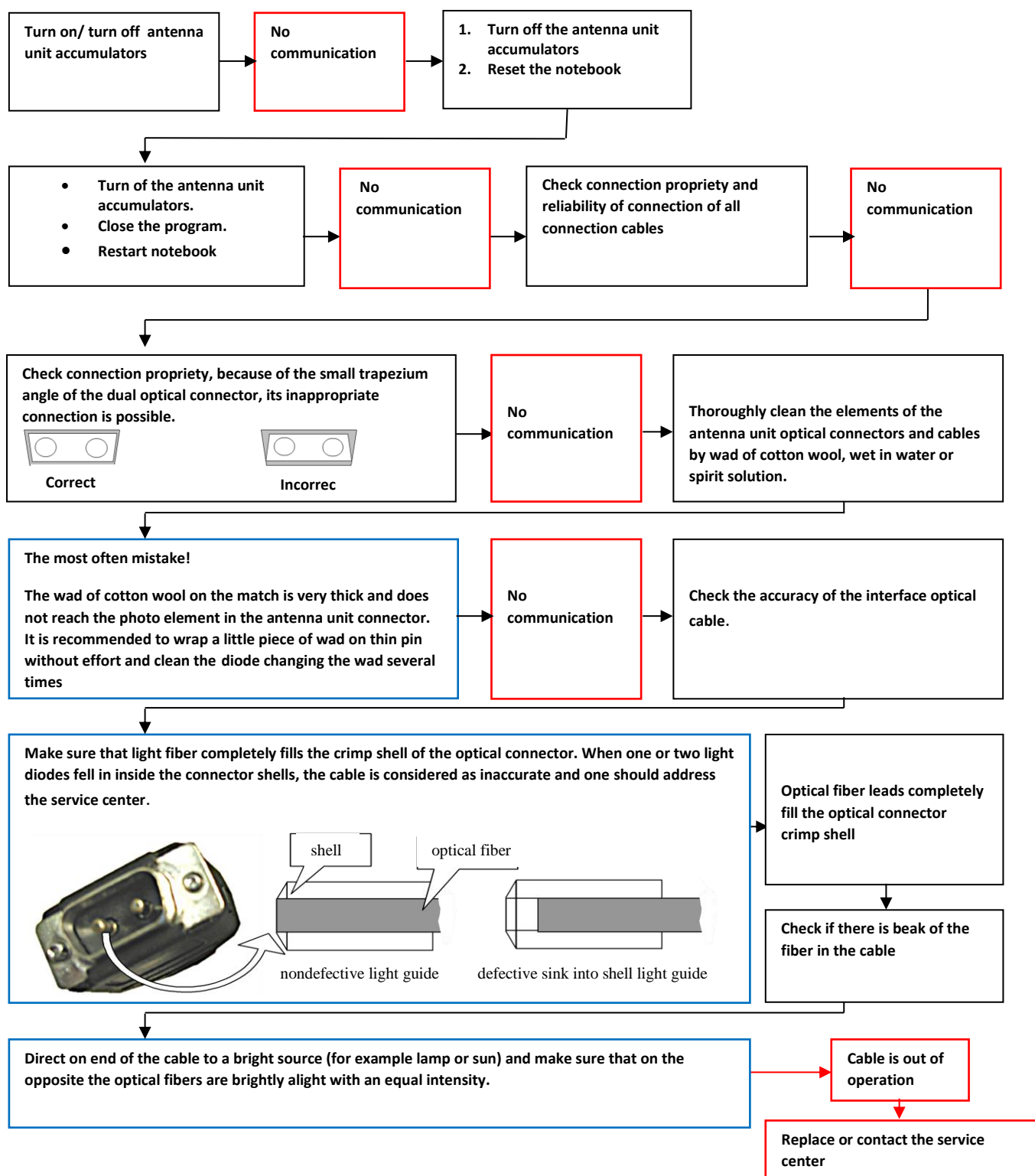
### **Appendix 3**

#### **GPR (georadar) self – troubleshooting**

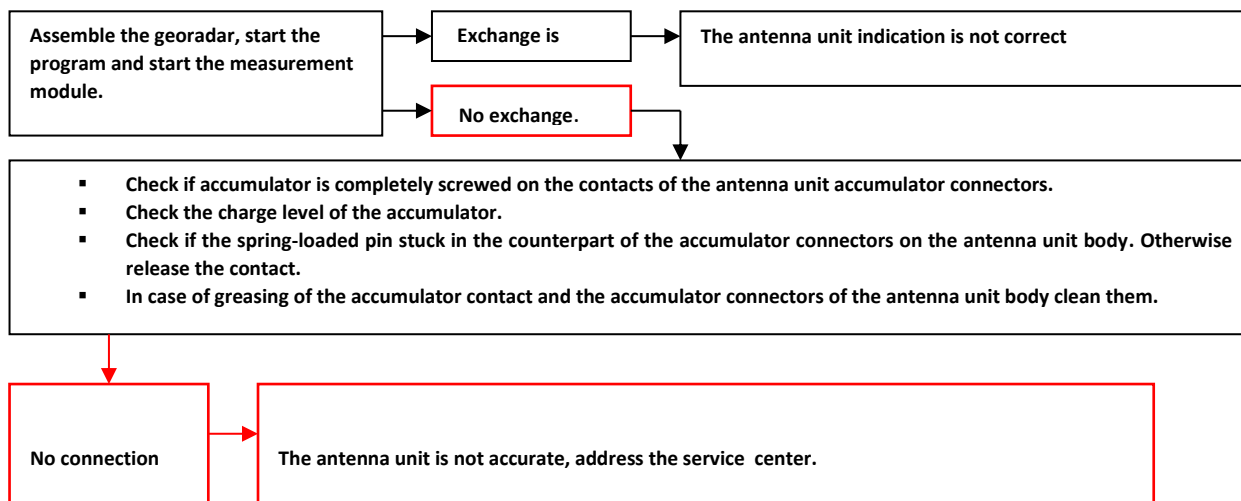
##### **Antenna unit and notebook data exchange is absent**

Troubleshooting: In mode of scanning window header is displayed «The device does not responds. Check the optocable or transfer the receiver power supply». The radarogram is not mapped.

First check that the georadar is completely assembled, all accumulators are charged, the control unit (CU) is on, the antenna unit and control unit indication works.

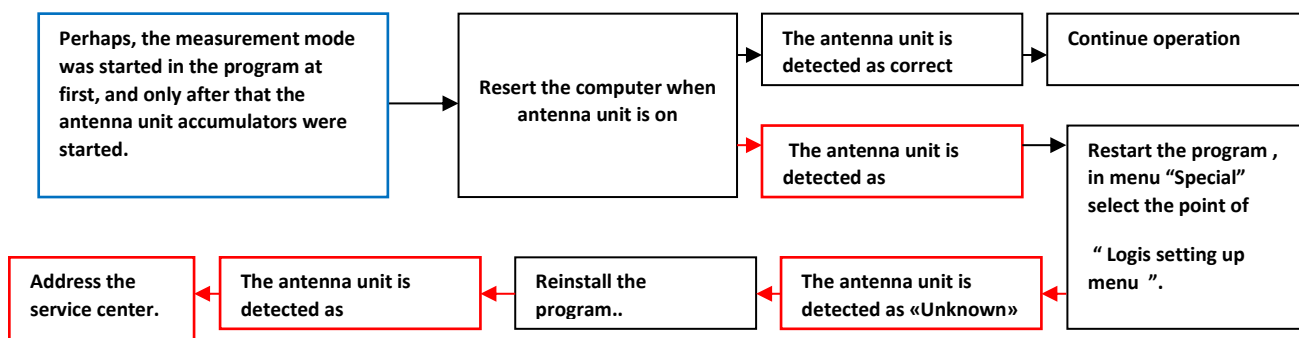


## Indication of the antenna unit operation is absent

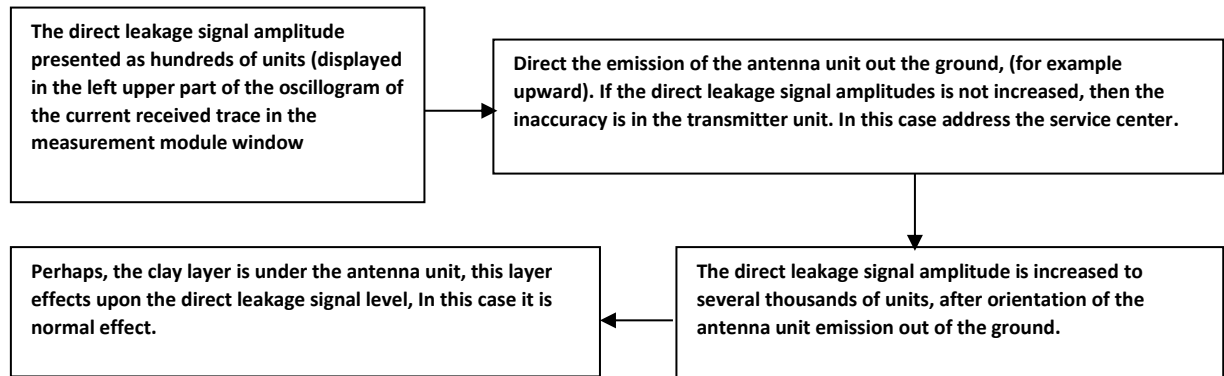


## The antenna unit is detected as “Unknown”.

Georadar is assembled, the date exchange is available, the antenna unit is identified as «Unknown».

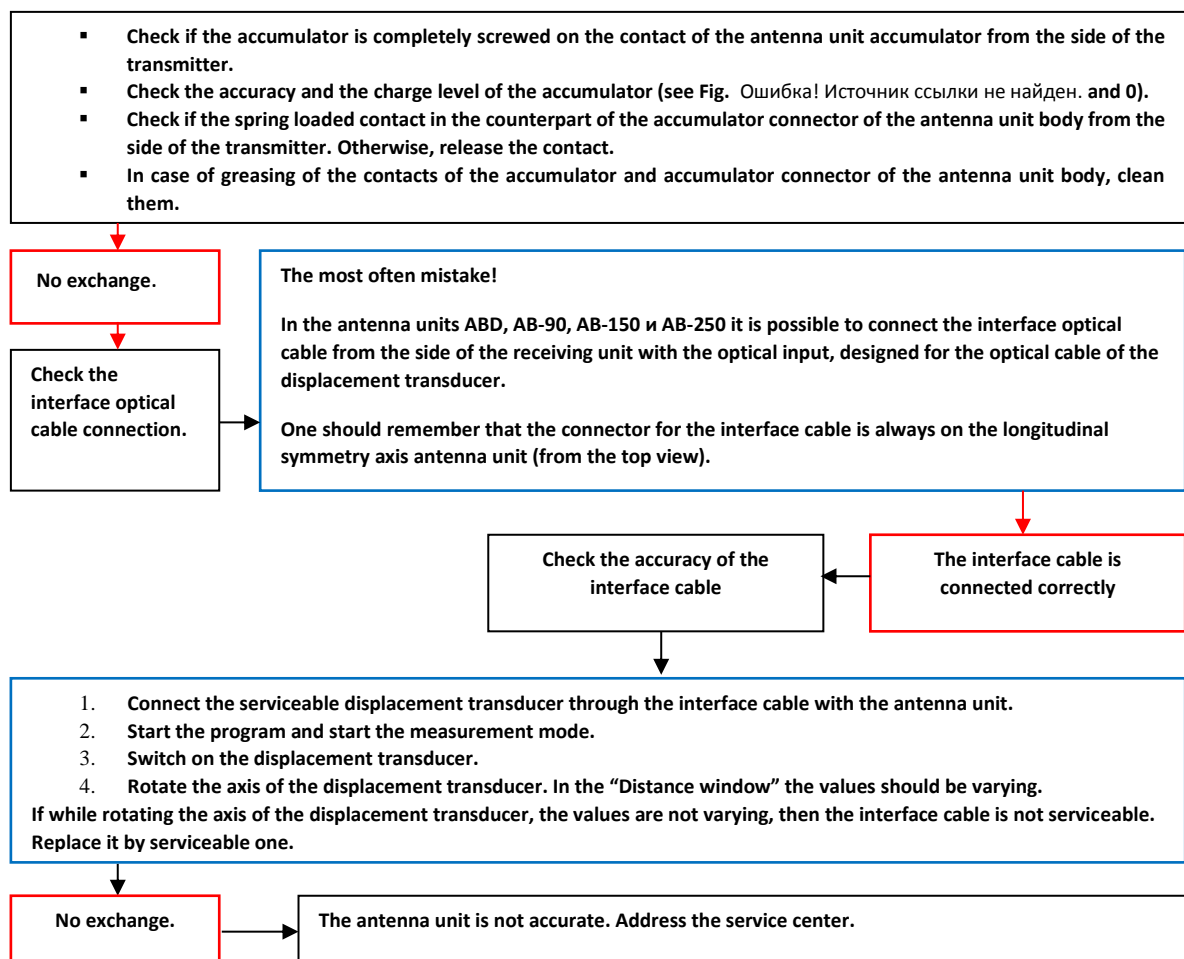


## Small direct leakage SIGNAL AMPLITUDE



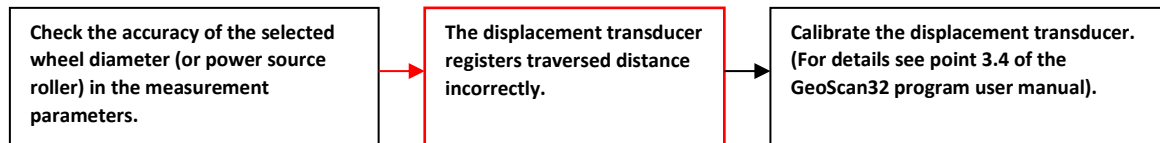
## Unwanted signal on the screen.

The data exchange is available, on the notebook display only noise signals, the indication of the transmitter operation is not working.

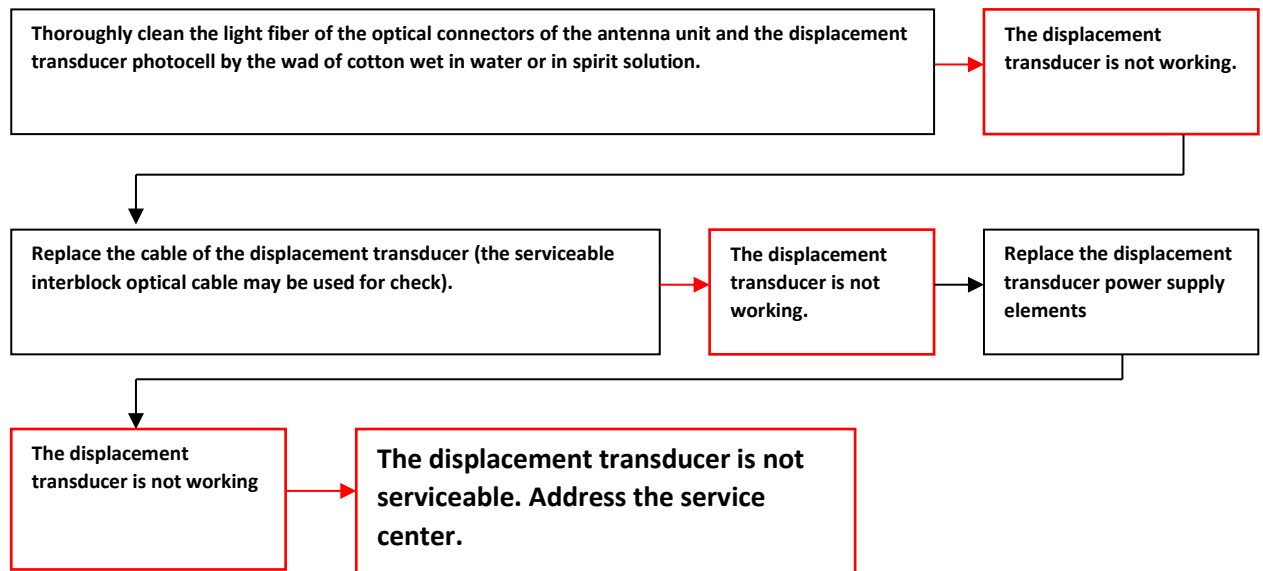




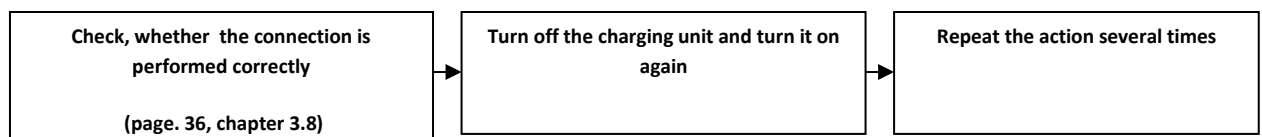
## The displacement transducer registers traversed distance is not correctly



## The displacement transducer is not working



## The charger does not charge the power supply



## Appendix 4

### Usage of color palette

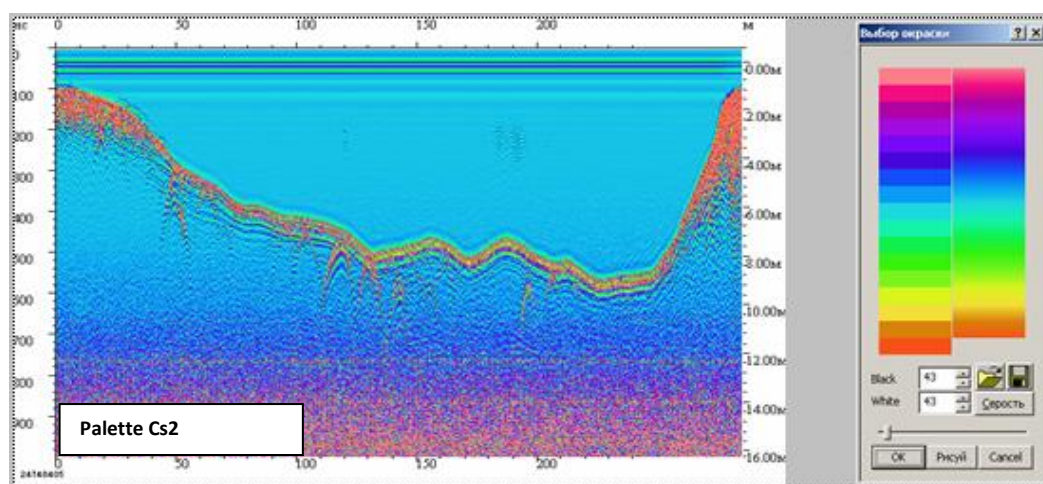
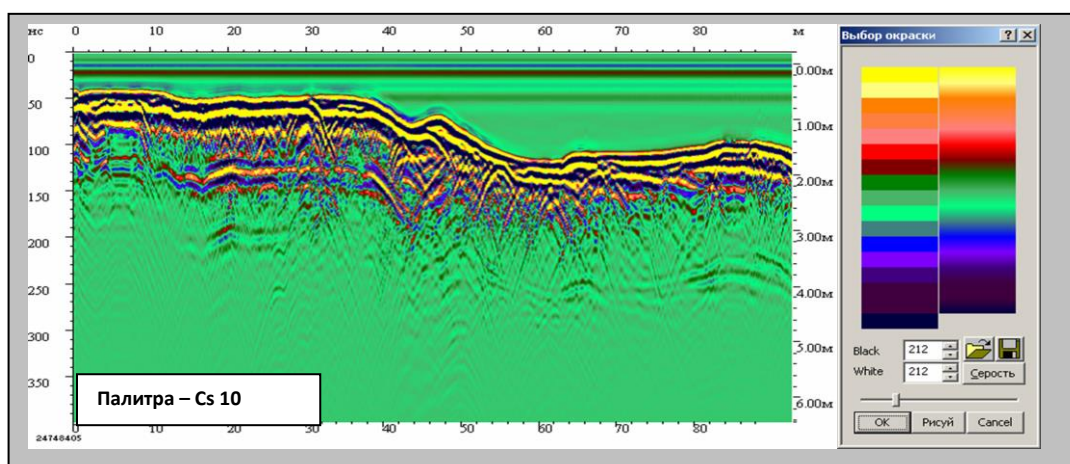
GeoScan32 software presents possibility in to use color palette instead of black and white in data processing.

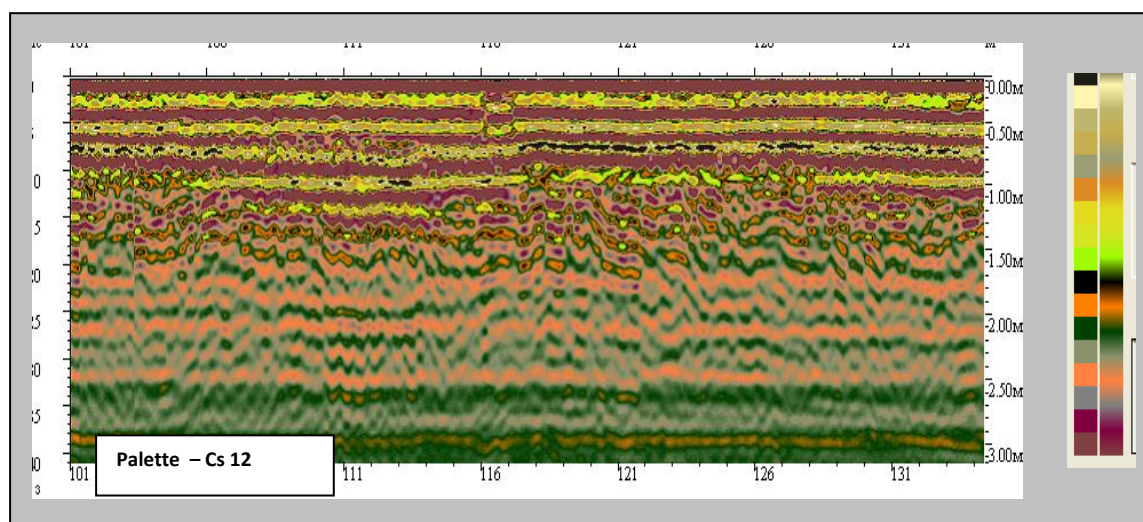
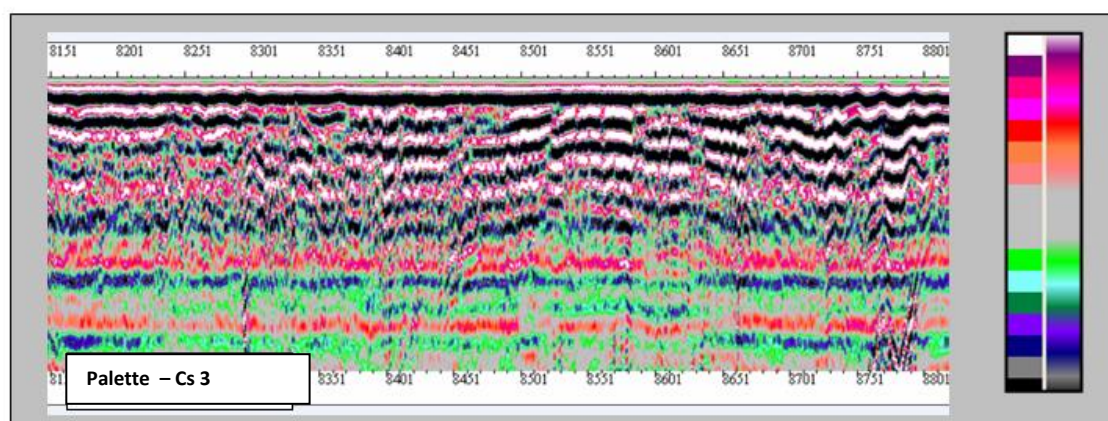
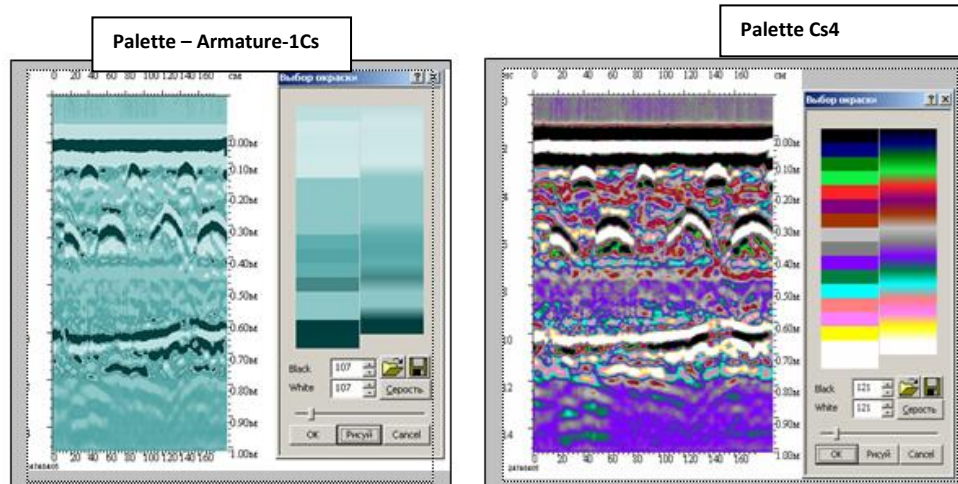
When the program are being installed, they are copied into the file: Program Files/GeoScan32, if the processing unit is operated on, the palette files can be found in Settings menu or you can copy them yourself from the computer.

Below given are the examples of the color palettes, included in the program set.

File Cs2 and Cs10 color palettes can be applied for painting radargrams collected while fresh water pools surface's survey, swamped solid.

The «Armature1-Cs» color palette can be applied for radiograms obtained in searching reinforcement in the brickwork and reinforced concrete slabs. Color palette Cs4 can be applied in deciding geological on underlining borders between the layers.





Cs3 and Cs12 color palette can be applied for on-line analysis the structure of the road beds or the objects of the railway subgrade formation before layer-by-layer processing of georadar scanning results.

*The palette usage not always improves visualization, in some cases the colored radiogram representation, can lead to arising not existing layers or to usefull data loss.*

*You can find the detailed information about the palette application in illustrated User's manual GeoScan32.*