Sonel®

USER MANUAL

CABLES AND UNDERGROUND INFRASTRUCTURE LOCATOR

LKZ-1500

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Locator LKZ-1500 is a modern, high quality measuring device, easy and safe to use. Reading and using of this manual will help to avoid errors in measurements and prevent possible problems when operating the machine. Due to a continuous development of the product and the implementation of the changes, in order to increase reliability and improve working conditions, there are slight differences between the product and the description of its construction in this user manual.

TABLE OF CONTENT

1 Safety

To ensure adequate service and correctness of the results obtained, the following recommendations must be observed:

- Please read this manual thoroughly before using the set, and follow the safety regulations and manufacturer's instructions.
- Any use of the kit other than those specified in this manual, may result in a damage to the device and will be a source of serious danger to the user.
- The LKZ-1500 kit can only be used by qualified persons with the required electrical work permit. Using the kit by unauthorized persons may damage the device and cause serious danger to the user.
- The use of this manual does not exclude the necessity of observing safety rules and other relevant fire-fighting regulations required for the performance of given kinds of work. It is essential to consult a person responsible for health and safety at work, before working with equipment in unsafe conditions, for example in dangerous atmosphere which may cause explosion or fire.
- It is unacceptable to use a tool that has been damaged and is totally or partially inoperable, e.g. with damaged cables or stored for long periods of time in poor conditions.
- Do not leave the transmitter connected to the object unattended.
- Do not disconnect the wires from the object while the transmitter is operating.
- Repairs may only be carried out by an authorized service center.

WARNING!
The set transmitter is designed for use on non-voltage objects. Connecting to a 230 V network may cause damage. The transmitter generates dangerous voltage up to 250 V. Please read this manual before turning on the transmitter.

WARNING:
Disconnecting the protective conductor is a serious life threat for executives and outsiders. Wherever possible, disconnect the mains voltage and the phase conductor (conductors) as soon as possible. Take special care when disconnecting the protective conductor or grounding of the neutral conductor from the system that must be live. Ensure that no outsiders are present in the danger area. Once the location is complete, it is essential to restore the protective earth conductor.

WARNING!
Due to the continuous development of the device software, the appearance of the displays for some functions may be slightly different than those shown in this manual.

2 Description of the system

The LKZ-1500 locator system consists of a LKO-1500 receiver and an LKN-1500 transmitter. The device allows to track a route of the underground objects like:

- Electrical wires and power cables,
- Control and telecommunication lines,
- Lightning protection and cathodic protection,
- water and sewage installations,
- heating systems and pre-insulated pipes,
- other metal objects that can conduct electricity.

3 Transmitter LKN-1500

Transmitters are designed for generating and transmitting signals in the line under study, and together with the LKO receiver, it allows to locate the track, determine the burial depth of object, as well as the location of insulation damage, e.g. cables or pipelines. Current output waveform for LKN-1500 is modified sine wave.

The transmitter can cooperate with any LKO receiver that has the same frequency. Transmitters are powered by integral maintenance-free sealed lead-acid accumulators. External 12 V 7 Ah DC source is allowed for use to provide the required power.

Supply voltage self-check system of transmitter indicates its reduction in the range from 11.0 to 10.5 V. Transmitters are switched off automatically in case of voltage drop below 10.5 V down to 10.0 V. The transmitter's accumulator charging mode is activated automatically when connecting power supply unit. Transmitter provide accumulator overcharge protection. The transmitter can operate in 3 signal generation modes:

a) continuous wave generation;
b) pulsing generation ⅔ (signal generation – 1 sec, pause – 0.5 sec);
c) pulsing generation ½ (signal generation – 0.5 sec, pause 0.5 sec).

3.1 Basic technical data

Tab. 1 Basic technical specifications of LKN-1500

No.	Parameter		Value	Notes
1.	Output signal frequency	single-frequency	273, 1024, 8928, 32768 (33 kHz)	± 2 [Hz]
		double-frequency (basic frequency)	1024 (↑↓), 8928 (φ)	
2.	Power output setting range, W		from 1 to 10	In steps 1, 2, 5 and 10 [W]
3.	Voltage output, max, V	without limitation	200	transmitter maximum voltage output is 130 V at a frequency of 32768 Hz;
		with limitations	30	
4.	Uncertainty of output voltage		± (5% m.v. + 5 numbers)	transmitter fault is not rated at frequencies of 8928 and 32768 Hz.
5.	Load conditioning range at maximum power output on frequencies, Ohm	273 and 1024 [Hz]	from 30 to 3000	
		8928 [Hz]	from 30 to 2000	
		double-frequency		
6.	Output current, no more than [A]		0,6	
7.	Current output indication error		± (5% m.v. + 3 numbers)	transmitter fault is not rated at frequencies of 8928 and 32768 Hz.
8.	DC power supply range, V		from 10,5 to 15,0	
9.	Power consumption if using 12 V external power supply, max., [W]		22	
10.	Continuous, Pulse operation mode at maximum power output in normal conditions on fully charged internal accumulator, hrs, minimum		6	In pulse mode at maximum output power

11.	Insulation strength between “Output” sockets and enclosure in normal conditions, alternate current at a frequency of 50 Hz, V	1500	Alternating current of frequency 50 [Hz]
12.	Insulation resistance between “Output” sockets and enclosure (voltage 2500 V) in normal conditions, minimum, MΩ	20	At the voltage 2500 [V]
13.	Overall dimensions, maximum, mm	275 x 250 x 180	
14.	Transmitter weight, maximum, kg	4,9	
Notes: m.v.– Measured value;			

3.2 Design and front panel of the Transmitter

Fig. 1 Design of the LKN-1500 transmitter

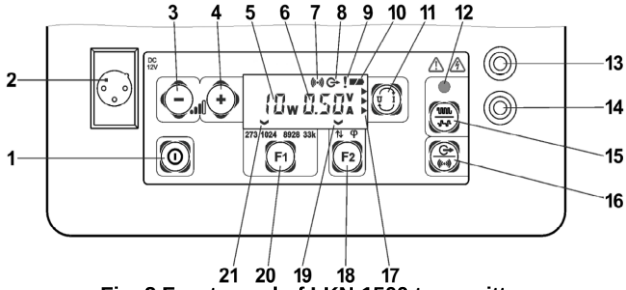

Fig. 2 Front panel of LKN-1500 transmitter

Tab. 2 Description of the front panel transmitter LKN-1500. Description of transmitter display

No.	Description
1.	Transmitter on / off button
2.	Power supply unit connector for integral accumulator charging or operation from a boost battery
3.	Power output decrease button
4.	Power output increase button
5.	Indication of power output
6.	Current output (A) or voltage (V) indicator
7.	The symbol of internal inductor's signal
8.	The symbol of signal passing through "Output" sockets
9.	External power source status indicator (symbol)
10.	Internal accumulator status indicator (symbol)
11.	Displayed parameter selection button: value of the output current [A] or voltage [V]
12.	Transmitter output signal condition
13.	Output" sockets for load connection
14.	Socket for connection of grounding probe
15.	Generation mode" button is used to set continuous wave or pulsing generation mode
16.	Option button for signal transmission: induction or direct galvanic connection
17.	Indication symbols of internal accumulator charging process
18.	Double-frequency signal type selection button
19.	Double-frequency selection indicators
20.	Signal frequency selection button
21.	Indicators of specified frequency rates

3.3 Operating principle of the transmitter LKN-1500

Operating principle of the transmitter is based on DC source energy conversion to AC signal. So, the transmitter microprocessor produces control pulses. Microprocessor also controls transmitter's conditioning by load to provide maximum power output. The transmitter operation and status information is presented on front panel display.

3.4 Safety measures

The transmitter shall be operated in compliance with electrical safety requirements by skilled personnel who learned this operation manual and have the required electrical safety access qualification level.

WARNING!
During operation voltage output level across “Output” sockets and connected circuits may reach 240 V. In operating condition avoid contact with conductive parts connected to the transmitter.

WARNING!
The transmitter shall be switched off during connection to and disconnection from the examined line or object.

WARNING!
Before operation check the status of “Output” sockets, the surface around them, and clean if needed. Do not use the transmitter and its component parts in the event of mechanical damage. During operation prevent moisture getting into the transmitter panel and/or power supply unit and use it in accordance with the instruction manual.

WARNING!
Do not expose to direct sunlight in summer season in order to avoid transmitter overheating.

3.5 Preparing the transmitter to work

Accumulator shall be charged when the transmitter is switched off for longer time. Following these guidelines will improve the battery life.

WARNING!
It is required minimum 8 hours to charge empty accumulator. Charging time period shall be increased to 12 hours to reach full capacity of accumulator.

WARNING!
For extended life time of accumulators you shall:
- charge accumulator at a temperature from +10 to +30ºC;
- limit the "depth" of discharging (do not allow to discharge completely);
- charge accumulator straight after discharge;

WARNING!
store the transmitter at a temperature from -15 to +30ºC and recharge accumulator once in 3 months.

To charge the battery, connect the power supply plug to the 12 V socket of the transmitter (see pos. 2 in Figure 2). Power supply unit shall be connected to 230 V mains. The battery charging process is shown as a scrolling icon
„▶” (See p. 17 in Fig. 2). When the battery is fully charged, the icons are continuous still and the display is periodically illuminated.

After charging is complete disconnect power supply unit from 230 V mains and then from the transmitter.

3.6 Rules and procedures for commencement of operation

The transmitter shall be maintained at operating temperature within two hours in case it was stored at a different temperature before.

Switching on and off the transmitter is done by pressing the on / off button marked with the symbol (see p. 1 on fig. 2). After switching on, the transmitter sets the minimum output power and frequency at 273 [Hz], but the output voltage level is not limited. Transmitter operating modes, internal battery status, or external power supply are indicated by the relevant indicators and are explained in Table 2 of this manual.

3.6.1 Signaling of the status and modes of operation of the transmitter

Indicator position in Figure 2	Indicator status	Transmitter status and operation mode
p. 8	Flashing light	The process of transmitter's load conditioning.
	Continuous light	Transmitter stabilized the power output with the load.
P. 15	Continuous green light	Continuous normal operation of the transmitter.
	Flashing green light	Pulse normal operation of the transmitter.
	Flashing red light at a frequency of 1Hz	Transmitter overheating. Signal is not generated and is resumed only when the transmitter is cooled down, but no sooner than in one minute
	Continuous glowing red	The transmitter "Output" sockets carry external voltage. The transmitter might have been connected into live circuit.
p. 10	Constant glowing	Internal battery voltage in normal.
	Flashing half of the battery symbol	Internal accumulator voltage level ranges from 11.0 to 10.5V which indicates deep discharge of accumulator battery.
	The battery symbol flashes	The internal battery voltage is below 10.5 V and after 1 minute the transmitter will be switched off (auto shutdown).
p. 9	No signal	Voltage of external power supply in normal range.
	Continuous glowing	The voltage of the external power supply is between 11.0 V and 10.5 V. The external battery is probably discharged.
	Pulsing flashing	Internal accumulator voltage level is below 10.5V and the transmitter will automatically shut off in 1 minute (automatic shut-off).
p. 17	Moving from top to bottom	Accumulator charges.
	Constant lighting of all three icons	Accumulator charged.

Tab.3 Status and operation mode light indication

3.6.2 Direct connection – galvanic mode

3.6.2.1 Connecting the transmitter to the object

WARNING!
Load connection to the transmitter output is allowed only when the transmitter is switched off.
The transmitter direct connection to the examined live line is prohibited. .

Socket shall be connected to ground pin driven into the ground at a distance of 5-10 m from the route of the object. To increase the survey current, ground pin shall be earthed at a maximum depth.

Connect the blue wire to the output socket of the transmitter, shown in figure 2 p.14 (⏚). The other end of the cable, using a blue crocodile, should be fastened to a pre-grounded grounding probe. Use the red wire to connect the output socket of the transmitter, marked in Figure 2 p.13, to the conductive part of the object (see fig. 3).

In the search for unearthed object, for example, gas pipeline or cable, it is preferable to earth the object at far end (see Figure 4) – it will provide maximum survey current. Otherwise, current will leak off the ground through isolation capacitance and its level will decrease. As a result it will reduce possible search range.

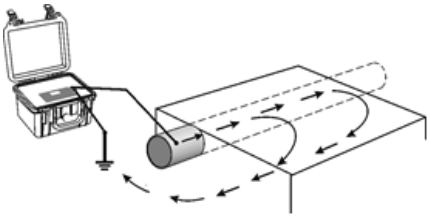

Fig. 3 Connection the transmitter to the metal pipeline.

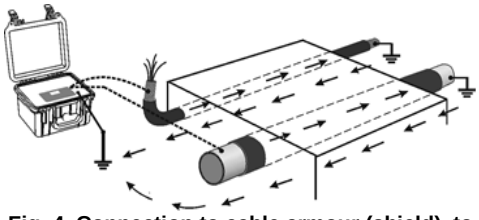

Fig. 4 Connection to cable armour (shield), to one of the cords in case of unshielded cable or to metal section of insulated pipeline.

There are other methods of transmitter connection to objects or cables depending on the purposes, for example, in case of insulation fault tracing. For more information see the section on Working with Frame A.

3.6.2.2 Signal frequency selection

Turn on the transmitter and set the desired output frequency, power, and operating mode . In addition, with the button (see p. 16 in Fig. 2), select the signal output from the transmitter's output sockets, and the symbol (p. 8 in Fig. 2) will appear on the display. Selection depends on particular search conditions, current task and requires acquisition of practical skills by an operator.

Signal frequency selection is made by pressing the button “F1” and is frequency-loop : 273 → 1024 → 8928 → 33k → 273, etc. (see position 1 in Fig 2).

Double frequency signal is made by the "f2" key with an indicator "↑↓" for double frequency 1024 [Hz] and "φ" for double frequency 8928 [Hz].

Low signal frequency in the wet ground allows for maximum search range and minimum signal routed to other communication lines or objects (“273”, “526” or “1024”). But at low frequencies the noise influence of power current and signals in adjacent lines is stronger.

High frequency (“8928”) in the dry ground allows for higher search range and lower power-supply disturbance. Higher frequency “33k” is recommended when searching for insulated cables and lines with far ends not connected to the ground. In this case, the survey current generated as a result of ground leakage through distributed isolation capacitance is higher. In addition, high frequency is preferable during wire-free connection of the transmitter to the objects or lines of communication.

However, it should be borne in mind that at high frequencies there is a stronger penetration of the signal from the transmitter to adjacent lines (objects), which may results in wrong search directions.

When the transmitter is operated in combination with LKO1500 receiver, at high density of communication lines, you can use current direction sensing function. The current flow from the transmitter (direct current) or to the transmitter (let-through adjacent line return current). In this regard, set the transmitter signal output at double frequency of 1024 [Hz] signaled "↑ ↓". Set operating frequency “1024” for the receiver. Setting the output power of the signal.

3.6.2.3 Signal power output settings

You should correlate the settable power, desired search time, power supply source parameters and estimated search range.

Increase or decrease power output by pressing the buttons  (pos.3 or pos.4 Fig.2.)
Indicator (pos. 5 Fig 2) shows power output value . Indicator on position 6 (pos. 6 Fig 2) shows voltage output (V) and output signal current value (A). Parameter can be selected by pressing the button  (pos.11 Fig.2).

If the desired current value cannot be obtained, check the grounding quality and / or change the signal frequency for the ground type. If the transmitter cannot provide the specified power, it is automatically limited to maximum possible value at the given load. In case of high load circuit resistance when minimum power cannot be generated (for example, open load), power level indicator shows: "-1". Also power output limitation may be resulted from insufficient accumulator capacity.

Generally load conditioning time does not exceed one minute. If conditioning is longer, check connections and ground quality, change power output or switch to continuous wave generation mode.

3.6.2.4 Transmitter operation mode selection

Continuous wave and pulsing generation modes are available for the transmitter. Continuous wave generation mode is recommended when determining position of communication lines, its depth and during insulation troubleshooting. Pulsing generation mode is recommended when searching for communication line under high noise conditions or at low signal received, as it's easier to determine your own signal by typical pause in this mode. Also the transmitter power consumption is reduced.

Generation modes from continuous to pulsing are switched by pressing the button  (pos. 15 in Figures 2) and displayed in time with output signal (the green diode is green) by indicator (pos.12 Fig.2).

3.6.2.5 Voltage output limitation

Mode of voltage output limitation to 30 V is activated for safety reasons during operations. For example, it is reasonable to limit voltage output level during cable cord selection in case of body contact with a cord.

To activate voltage output limitation, hold down the button  (pos. 15 in Fig,2) and press "-" (pos. 3 in Fig.2). On the display you will see indicator "V" flashing . In case the transmitter cannot provide preset power, it is automatically limited to maximum possible value at the given load.

To deactivate voltage output limitation, hold down the button  and press "+" (pos. 4 in Fig.2).

3.6.3 Non-contact survey current generation in communication line

If the transmitter cannot be directly connected to communication line in galvanic mode, for example, no access to conductive parts of communication lines or they carry voltage, the survey current can be generated in the examined lines from induction coil or by Sonel N-1 inductive clamps.

3.6.3.1 Internal transmitter inductor

The transmitter with coil produces alternating magnetic field in the ground that generates current in the line of communication. The higher is survey current, the lower is resistance of the closed circuit being a part of communication line. Earthing of communication line ends is the best decision as shown in Figure 5. If there are no earth conductors, the survey current level is lower as its strength is

determined by capacitive current through line insulation. The current level is being higher with a rise in frequency.
During operation in inductive mode transmitter shall be installed vertically along an axis of the examined communication line (Figure. 5).

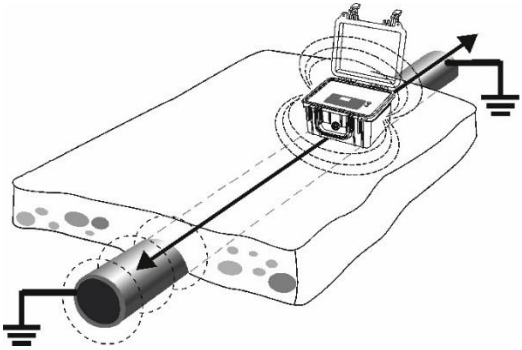

Fig. 5 Induction current excitation in the localized object

For operation from internal inductor press the button (pos. 16 Fig.2) , symbol (pos. 7 in Fig.2) will be displayed. Maximum outputs of internal inductor are at a frequency of 33 [kHz].

It should be noted that:

- the current level is substantially lower when it is generated in communication line by using transmitter rather than direct galvanic connection;
- transmitting signals are being routed to all adjacent current-conducting lines what may results in wrong search directions;
- the closer transmitter is located to communication line, the higher is the current level generated in communication line.

3.6.3.2 Inductive clamps

In case of access to communication line, for example, high voltage insulated live cable comes out, it is reasonable to use N-1 inductive clamps. Due to better magnetic interaction with line circuit, they provide higher survey current generation and eliminate sending signal to adjacent communication lines. Maximum diameter of communication line for N-1 is 52 mm.

WARNING!
Do not connect conductive clamps to live bare conductors.

Current resistance shall be as low as possible in order to provide maximum current in the examined communication line circuit. It should be noted that the higher is operating frequency, the higher is the level of the current generated in insulated and/or unearthed line when using clamps.
The clamps should be connected to the output sockets of the transmitter, while keeping the markings on the wires. The cable marked with the letter "E" with the grounding outlet of the transmitter ⏚ (p.14 fig.2) and the cable marked with the letter "H" with the load socket (p.13 fig.2). Grasp communication line with clamp (Fig. 6). On the transmitter panel press the "f1" key to set the frequency from available, i.e. 1024 [Hz], 8928 [Hz] or 33 [kHz].

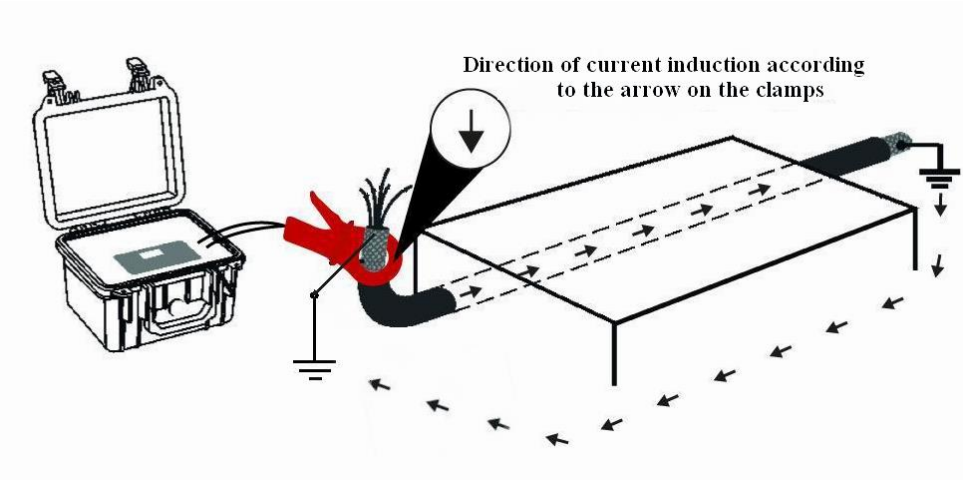

Fig. 6 Induction of excitation voltage in localized object with N-1 clamp

3.7 Potential failures and remedial procedure in LKN

No.	Type of failure	Possible cause	Remedial procedure
1.	Transmitter start failure or accidental shutdown	Discharging accumulator	Charge accumulator
		Accumulator failure	Replace accumulator at the authorized Sonel service.
2.	Accumulator fails to charge within a given period	Accumulator failure	Replace accumulator at the authorized Sonel service.
		Power supply unit failure	Check power supply unit

Tab.4 Potential failures .

4 Receiver LKO-1500

The LKO-1500 Receiver paired with the LKN-1500 transmitter is designed to locate and trace cable and pipe lines (hereinafter referred to as the “utilities”).
However, there is the possibility of self-operation of the receiver, without aid of the transmitter, i.e.:

- on the 50 [Hz] and 550 [Hz] frequencies it locates cable lines by detection induced signal of the industrial frequency current;
- on the 100 [Hz] and 300 [Hz] frequencies it locates utilities and finds areas of damaged insulation of pipes by detecting Electrochemical protection signals;
- on the 550 [Hz] and 1450 [Hz] frequencies it locates the areas of ground fault of overhead lines by detection current harmonics;
- in the “SB” (sound band) mode it locates utilities by re-radiated broadcasting and telephone signals within the frequency band from 48 Hz to 14 kHz.
- in the “Radio” modes it locates utilities by detecting induced broadcasting signals within the frequency band from 10 kHz to 36 kHz.

4.1 The main specifications

Table. 5 The main specifications

No	Parameter	Value	
1.	Rated values of operating frequencies (with Transmitter); sensitivity on the selected frequency	Frequency, [Hz]	Sensitivity, min, μA/m*
		273 491, 526 982, 1024 2000, 2048 8440, 8928, 9820 10000, 32768	500 300 150 50 25 5
2.	Rated values of operating frequencies (without Transmitter), Hz	50, 100, 300, 550 and 1450	
3.	Dynamic range of input signals, dB, min	102	
4.	Bandwidth for each operating frequency, max, Hz	at the level of minus 3 [dB]	at the level of minus 60 [dB]
		9	24
5.	Utility depth, m	from 0,10 to 6,00	
6.	Operating frequency current in the utility	from 10 mA to10,0 A	
7.	Admissible error of the depth of single extended utility line, max	±{[4+0,3h(h+1)]%+0,1 m},where h is a measured depth	
8.	Admissible error of location of a single line at the depth of 2 m, min	± 0,1	
9.	Operating frequency voltage at the SENSOR jack input	od 0,01 mV do 1,70 V	
10.	Sensitivity at the SENSOR jack input at the signal-noise ratio of 6 dB, mV, min	0,05	
11.	Limits of admissible main error of voltage measurement, max, % + dgt	± (3% v.m. + 3 digits)	
12.	Input resistance at the SENSOR jack input, MOhm	1	
13.	Overall dimensions, max, mm	700×300×140	
14.	Continuous operation under the normal conditions with full battery, min, h	5	
15.	Weight, max, kg	1,8	
*** Rated for the "Broad peak" method. The signal-noise ratio is 6 dB.**			

The Receiver provides signal gain adjustment with the step of 6 dB (each step provides doubled gain).

4.2 Power supply

The batteries may be replaced without breaking a seal. The Receiver provides signal gain adjustment with the step of 6 dB (each step provides doubled gain).
The Receiver is powered form a rechargeable Ni-Mh battery with the rated voltage of 6 V and capacity of 2000 mAh. The Receiver may be powered from the pack of five replacement batteries of the AA type put into the battery compartment. You may also use five AA-type batteries with the voltage of 1.2 V. Power supply voltage is from 7.5 V to 5.2 V.
The Receiver has a battery level indicator, and it goes off automatically to avoid excessive discharge when the battery is low. The Receiver is switched to a battery charging mode when the power supply unit is connected. The Receiver secures the battery against overcharge.

WARNING!

Before charging, make sure that a rechargeable battery is put into the battery compartment. If the battery case contains non-rechargeable batteries when charging, this may cause damage to the receiver.

WARNING!

The ambient temperature shall be from plus 10ºC to plus 30ºC when charging. Charging at other temperatures may reduce battery life.

If you want to charge the battery, connect a power supply unit plug (included in the delivery set) to the corresponding jack of the Receiver. Plug the power supply in. Full battery is shown with completely highlighted BATTERY bar graph indicator.
Charging time of an empty battery is from 6 to 8 hours. If the Receiver is out of use for a long time, recharge the batteries quarterly.

WARNING!

Charging of standard battery is with the current from 400 mA to 500 mA. When charging the batteries with other rated capacity, always check the temperature. If it rises quickly, stop charging.

4.3 Design and front panel of the receiver

Fig. 7 Design and identification of receiver sockets

No.	Description
1.	Battery charging socket
2.	Headphone jack - "Jack" 6.3 mm
3.	Battery compartment cover (battery)
4.	outlet for extra equipment (A-Frame)
5.	Receiver loudspeaker

You can attach the sun-protective cover. The cover is attached to the receiver handle with two "velcro" ribbons. The appearance of the sun visor receiver is shown in the figure below:

Fig. 8 Design with sun–protective cover

Fig. 9 Design and labeling of receiver buttons LKO-1500

Lp.	Functions description
1.	On/off button;
2.	Menu button - enters / exits the menu
3.	Display
4.	button for saving displayed parameters and GPS coordinates for further transmission to a PC;
5.	button for increase of the signal, allows movement through the menu options
6.	button for decrease of the signal, allows movement through the menu options
7.	button sets optimum signal gain in the TRACE or SENSOR channels (depending on actual control area). Measures the utility depth and intensity of current. Switches on/off the selected option in the MENU mode.
8.	button adjusts the sound volume

9.	button switches the available operating frequencies
10.	button selects available locating modes. Switches the control areas to change operating frequencies and amplify signal between the TRACE and SENSOR channels in the TRACE-SENSOR mode

4.4 Principles of operation

The Receiver locates utilities and cable faults by the induction method. Replacement sensors facilitate finding damaged insulation by the voltage caused by the current to the ground.

The alternating magnetic field induced by the utility and/or the voltage generated in the replacement sensors are transformed into a signal form. This signal is amplified and processed by the digital signal processor. Then the signal levels are displayed in a form of line bars and digital values in dB or Volts. The indication may be supported with the audible signal.

4.5 Proper use

Always observe safety rules when you work with live cables.
Do not apply voltage of more than 42 V to the open metal parts or jacks of the Receiver.
If the receiver is at a temperature different from the specified operating temperature, keep it at a working temperature of not less than 1 hour before use.
The receiver should be removed from the case and checked for proper covers, and mechanical damage on the receiver and power supply casing.

4.6 Selection and setting the main parameters via the Menu options

Press the button to enter or exit the settings (p.2 fig.9).The menu is navigated with the signal gain buttons (p.5 and Figure 6).The options may be selected and changed with the button. (p.7 fig. 9).

In the indication submenu :

- the “Trace” option (See Fig. 3c) is used to select the signal peak type (See Fig. 3d) and to switch on/off the peak or null indication;
- the “sensor” option is used to expand the scale 1:4 and to select signal level at the of the SENSOR jack input in dB or Volts (see Fig.12);
- „Compass line "- enables / disables compass function
- „the AUTO, H and I options – to switch on/off the continuous indication of utility depth (" H ") and the current flowing through the utility line (" I ");
- “Auto off” – time to automatic shutdown of the device. Available options: disabled – 10 min – 20 min – 30 min – 40 min – 50 min – 60 min – 70 min – 80 min – 90 min.

In the sound submenu (see Fig.11) you may select an auditory accompaniment of the indication:

- „as a single-frequency tone when the volume is proportional to the signal level
- „as a crack sound like in GM counter when the frequency of cracks is proportional to the signal level;
- as a direct audible signal from antenna on the frequencies of «Power» and «SB». This function provides operation by ear.
- "Natural" - for 50Hz and Ether (48 Hz to 14 kHz - marked with SB symbol), the signal grows along with the signal rise (this function provides operation by ear.).

In "Track" mode, the sound reproduces the "peak" signal level. When "Maximum scale" is turned off, sound reproduces the "minimum" scale signal level. In "TRACE SENSOR" mode, the sound reproduces the signal level at the input of the "SENSOR" socket.

In the "Frequency Set" submenu (fig.15) - set the frequency using the up or down arrow button (optional "f" or "speaker"). Adding or removing frequencies from the list is available by pressing (p.7 fig.9). Exit by pressing the menu button

In the "GPS" submenu (see Fig. 16) (see section 6);

- „GPS connection" - connection to a GPS module (Bluetooth);
  - „Switching on" - connection to Bluetooth;
  - „Searching a GPS Module "- shows currently available devices;
  - „Information" - registry status, current route, date, coordinates, ...;
- "PC connection" - connection to computer;
  - „Save track as…"
    - „New" – new object
    - „Continue in ... "Continue the track (select from among the available in the registry). Use the up / down arrows to select the register. Confirm with the button or delete by pressing the button .
    - „Autotracking" - to switch on / off automatic recording of track parameters at intervals of 1 sec. up to 60 sec.
    - "Distance" - from the last point or from the beginning.
    - "Time Zone" - time zones in the world. Set from -13 to 13.

In the "Language" submenu - select the language with the button (Fig.16).

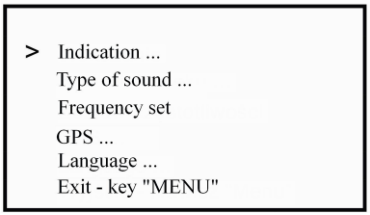

Fig. 10 Main menu

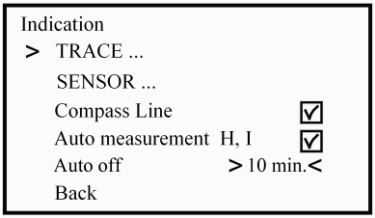

Fig. 11 Menu "Indication"

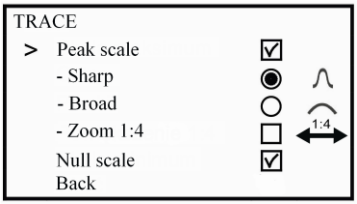

Fig. 12 Menu „Indication"/ „Track"

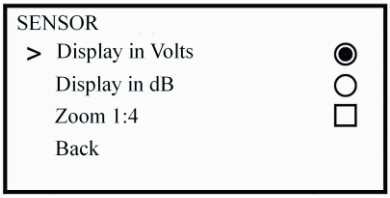

Fig. 13 Menu „Indication"/ „SENSOR"

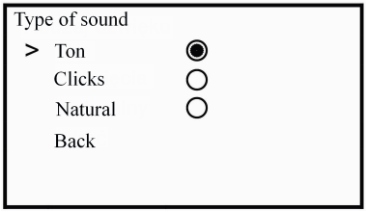

Fig. 14 Menu „Sound type"

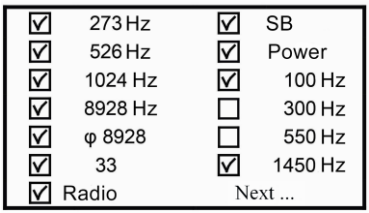

Fig. 15 Menu „Frequency set"

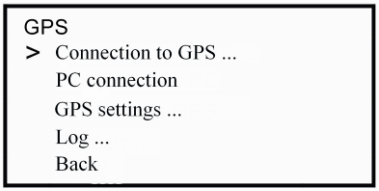

Fig. 16 Menu „GPS”

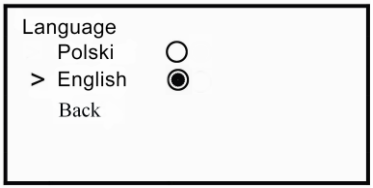

Fig. 17 Menu „Language”

4.7 Operating modes of the Receiver

The Receiver operates in two modes;

- TRACE – to locate the utility and detect its depth and operating frequency current flowing through it. The display of this mode is shown in Fig.18.
- „TRACE-SENSOR – to locate the utility insulation damage and detect the depth of damaged area; to detect the short-circuited areas or wire break and select the conductors in the multi-core cables. The display of this mode is shown in Figure 20.

Additionally with the COMPASS option switched on, the direction of the located cable relative to the Receiver will be displayed. The display of the TRACE mode with COMPASS feature is shown in Fig.19, in the TRACE-SENSOR mode – in Fig.21

To exit the TRACE mode and enter the TRACE-SENSOR mode (and vice versa), press the MODE key and hold it pressed for more than two seconds.

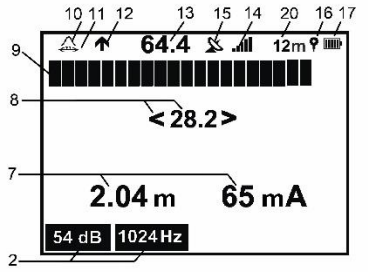

Fig. 18 Display in "Track" mode

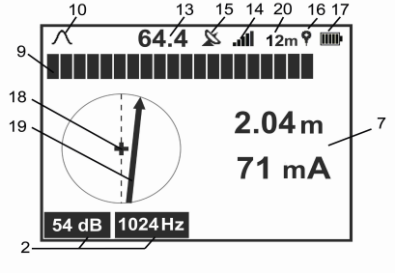

Fig. 19 Display with compass function

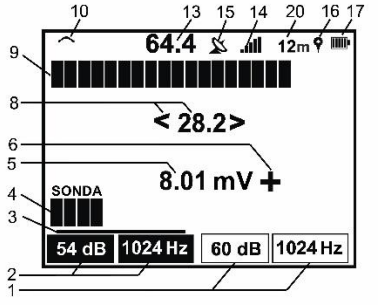

Fig. 20 Display in „Track-SENSOR” mode

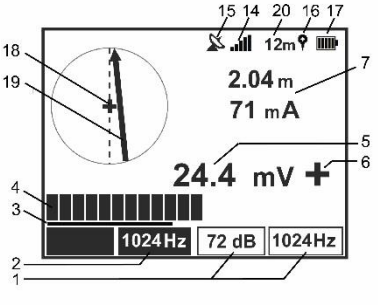

Fig. 21 Display with compass in „Track-SENSOR” mode

No.	Description
1.	gain and operating frequency of the SENSOR channel
2.	gain and operating frequency of the TRACE channel
3.	indicator of effective area for selected gain and/or operating frequency for the TRACE and SENSOR channels. To change the effective area, press the MODE key shortly
4.	the scale of the relative signal's level at the SENSOR jack input
5.	voltage at the SENSOR jack input – in Volts or dB
6.	relative polarity of the potential difference caused by the leakage currents at the SENSOR jack input (See Par. 5.2.1)
7.	indication of the utility depth and the intensity of current via the utility
8.	input signal from the magnetic antenna in dB and also a scale of input signal relative level (null scale) when searching by null method with the preset direction to the utility (See Par 4.8.2.3)
9.	relative strength of the input signal (peak bargraph). Locating is performed by the peak method (See Par. 4.8.2.1)
10.	indication of sharp peak («  ») or broad peak («  ») (See Par. 4.8.2.1)
11.	indication of scale extension «  »(See Par.4.8.2.1)
12.	direction of current: «  » – from Transmitter; «  » – to Transmitter (See Par.4.8.2.5)
13.	input signal from the lower magnetic antenna in dB. Locating is by the peak method (See Par.4.8.2.1)
14.	volume indicator
15.	GPS state, «  » or «  » (See Par.6.2)
16.	logging to the «» track, displayed at the moment of recording (See Par. 6.2);
17.	BATTERY state icon
18.	receiver axis
19.	utility position arrow
20.	Distance (see Par. 6.2.4)

WARNING!

The indicator of the input signal strength in dB (for locating by peak and null) turns red when the corresponding input channels are overloaded (See Pos. 13, Pos. 8 Fig 8).

4.8 Locating methods

4.8.1 Selection of operating frequency

Frequency selection shall be performed depending on operating conditions, targets and locating method. The operator shall have corresponding qualification and practical skills.
We recommend you to start location at low frequencies both by direct connection and induction methods. If the necessary signal strength fails to be reached, you may operate the device at higher frequencies.
Low-frequency location provides maximum range of search, especially in the wet soil, and it reduces interferences to other utilities. At the same time, the interferences of power signals and adjacent utilities are stronger at lower frequencies.

At higher frequencies, the range of search is greater in dry or frozen soil, and interferences of power signals and adjacent utilities are lower. Moreover, signal losses caused by insulated joints are much lower. At the same time, the Transmitter induces much noise to adjacent utilities, and this may result in false trails. You may locate the utilities and damaged insulation without Transmitter at the operating frequencies (main frequency or harmonic) – Frequency of the receiver 50 Hz so-called „Power or by electrochemical protection signal - receiver operating frequency 100 Hz, 300 Hz or by telephone and/or broadcasting signals – Receiver mode „SB" (called. Ether) or „RADIO". This method may cause false trails since the tracing of the utility may be complicated by branching, and direction of the target utility may not be detected by "own signal". The operator shall have corresponding qualification and practical skills for this method.

4.8.2 Peak, null and current direction modes

The Receiver contains four magnetic antennas. The Receiver shall be arranged vertically.

- The «broad peak» tracing - requires a lower horizontal antenna only
- During «sharp peak» tracing - two horizontal antennas operate
- one lower horizontal and one vertical antennas operate for tracing in the null mode
- COMPASS mode requires all 4 antennas of the Receiver.

4.8.2.1 Peak mode

The Receiver is equipped with sharp peak («») and broad peak («») functions, which facilitate high accuracy of tracing depending on the depth and density of utilities in the target zone.
Fig. 4.2.1 shows the relationship between the signal level and antenna displacement from the utility Figure 22.

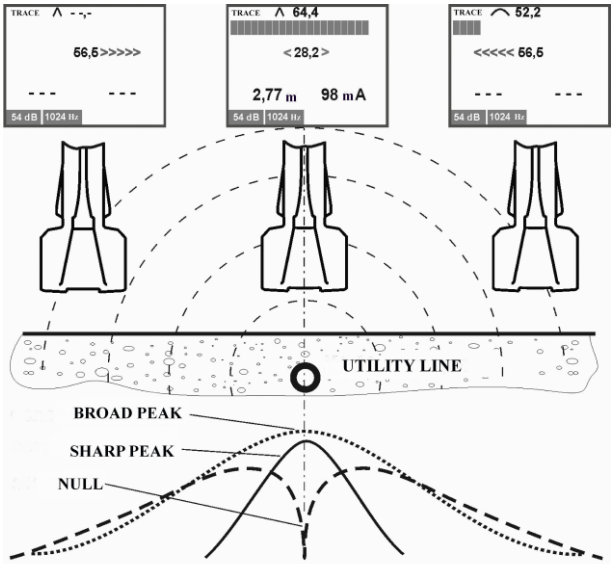

Fig. 22 The level of the responding signal depending on the Receiver displacement from the utility axis.

The «sharp peak» method provides high accuracy of the utility tracing since the signal peak near the line axis is on the abrupt area of the graph (see Fig. 22, left display). When the antenna is arranged right over the axis of the utility, the responding signal will be on its peak. The signal gain in this point shall be set so that ¾ of the scale were lighted; the sound volume shall be adjusted at the level, comfortable for the operator. The OK button (p.7 Fig.9) may be used to adjust the optimum gain of each specific signal automatically. The indicator bargraph will grow down when the Receiver moves away from the axis. Further displacement of the Receiver will result in disappearing of the linear scale. The „**--.-**" icon will appear instead of the signal level indication.

If the signal is weak or the depth of utility is sufficient, the indication on the Peak scale may be unstable or missing. In this case you shall use the «broad peak» method which demonstrates higher sensibility to weak signals.

The indicator scale readings do not depend directly on the location of the Receiver towards the utility at the «broad peak» method since the signal peak is within the broad area of the graph (see Fig.22, right display). However, this method provides maximum sensitivity of the Receiver.

As far as you move along the line, the Receiver gain and the sound volume shall be adjusted depending on the strength of the received signal. Along the route the signal strength may change depending on the cable core twists. The strength of signal may also drop considerably in the areas where the cables are laid under pipelines or near connecting sleeves, or in the areas where they are shielded with metal pipes.

4.8.2.2 Peak search with 1:4 scale

In some cases, the peak scale is not sufficient, e.g. when the pipeline branch of smaller diameter is traced deeply under the ground. At that, some portion of tracing current leaks through the branch, and the peak signal strength over the main pipeline drops slightly, and this may go unnoticed.

The "peak scale expansion 1:4" option reduces the scale divisions to increase its resolution. The "1:4" icon (Pos. 11 in Fig. 18) will be displayed, a yellow strip will appear under the peak scale to show the expansion bar graph relative to the normal (unexpanded) scale.

Using the gain up/down buttons  , place the end of the extended “peak” bar graph within the visible area of the display. The gain-up button is expands the scale. The gain-down button makes the scale shorter.

The optimum gain and scale for a specific signal intensity may be obtained by pressing the  button.
The option of the peak scale extension may be selected by scrolling the MENU options as follows: « Menu > Indication > Trace > Peak type > Zoom 1:4 (Fig.12).

4.8.2.3 The null method

The method of null provides precise tracing of single utilities. The null signal is within the abrupt area of the characteristic curve. The method of null provides precise tracing of a single utility line as the minimum signal is surrounded by 2 steep slopes, resulting in a strong signal change, with a slight deviation from the minimum. Figure 22 shows relationship between the null signal intensity and the displacement of the antenna away from the target utility. When the antenna is exactly over the axis of the utility, the signal will be on its minimum. When you move the antenna away from the utility, you will get the signal gain, and there will be more lighted segments of the bargraph towards the utility. Subsequent disposal of the antenna will result in smooth signal attenuation.
When you use the null method you should maintain the optimum gain level of the Receiver. If the gain is too low, the bargraph drift from the center will be minor or unnoticeable. If the gain is too high, the bargraph drift may be drastic. This may give the impression of chaotic operation of the Receiver.
When you move along the route of the utility, the signal may rise sharply. This means that the bending (or branching) of utility takes place. The indicator will show its direction.
When you locate the utilities surrounded with other lines and cables, use the method of sharp peak since the interferences of adjacent lines is too high during peak tracing.

4.8.2.4 Locating with “Compass line” option

The „Compass line mode” is used to facilitate location of single long-distance utility lines with bends and turns. This „Compass line ” shows the orientation of the located utility relative to the Receiver. This facilitates the user operation.
The „Compass option” is selected via Menu as follows: Menu > Indication > Compass Line (fig.11) then confirmation. 

The Compass arrow will show the direction of the utility (Fig.19 and 21, Pos.19). In the ”Trace” mode, the Receiver displays the peak scale and input signal strength; in the „Trace-SENSOR” mode, the Receiver displays the scale, strength and polarity of signal at the SENSOR input.
Locating with the COMPASS feature is shown in Fig.23

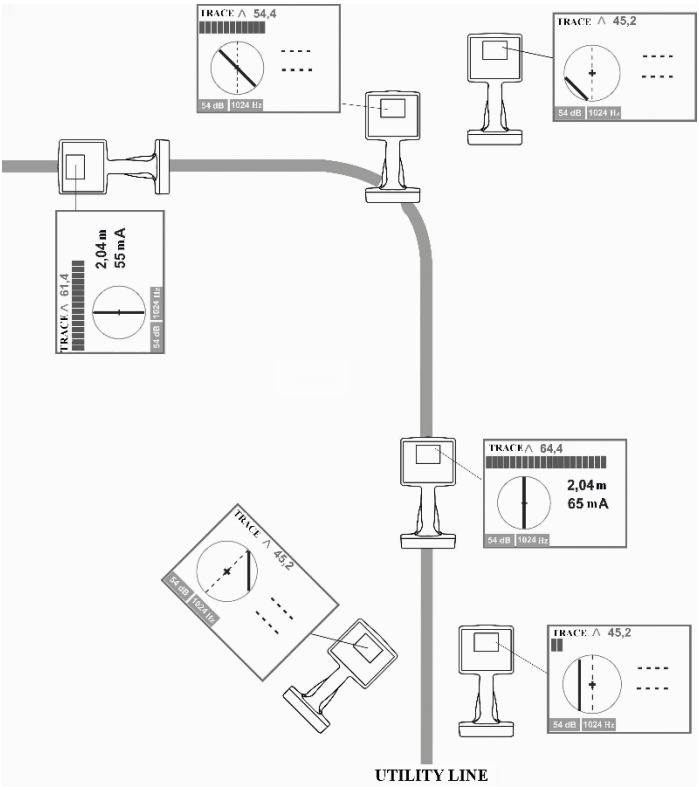

Fig. 23 Locating with "Compass line"

Moving along the target line, try to arrange the Receiver relative to the utility so that the Utility position arrow (Fig. 21 Pos. 19) turned to be aligned with the Receiver axis (Fig. 21 Pos. 18).

Warning!

The utility position arrow shall be used for visual presentation of utility location only. It shall not be used for precise localization of the target cable. If the signal is weak, the target line environment is crowded and noisy, use the peak method as specified in Par. 4.8.2.1

The utility position arrow may become fuzzy during location. This may occur when the Receiver is perpendicular to the path of the utility line or the Receiver and target utility are distant, or locating signal is too weak.

4.8.2.5 Locating by current direction

The method of current direction may be used to locate target line in the areas with high concentration of utilities. Select the mode of double-frequency signal of «1024 Hz» on the Transmitter, and set the operating Receiver's frequency at "1024 Hz". If the double-frequency signal strength is sufficient, the indication of current direction (Fig. 18, Pos. 12) will be active automatically.
If the "Compass line" feature is used, the current direction will be shown with the utility position arrow direction (pos. 19 Fig. 21).

The Transmitter shall be connected directly to the target line for this technique. The adjacent utilities shall be galvanically separated from the target line in the point of connection (see Figure 24).

The “direct current” will go via the target utility line from the Transmitter, and it will be displayed as the „↑” icon. The so-called “return current” will flow back to the Transmitter via the adjacent lines. This current is generated due to the distant galvanic or capacitance coupling with the target line, and It will be indicated as the “↓ “ icon.

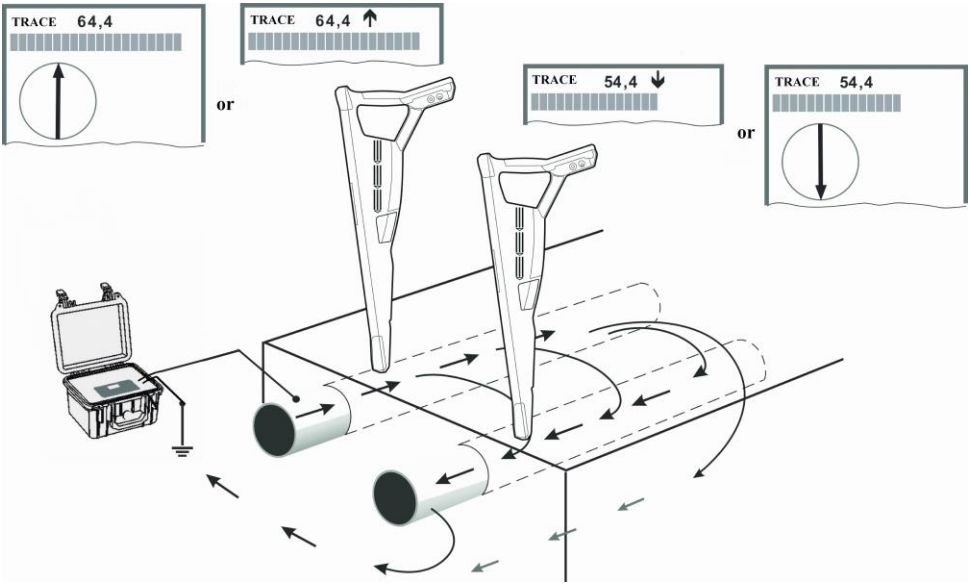

Fig. 24 The direction of current in the galvanically separated adjacent lines

In case the adjacent utility lines are galvanically coupled with the target line, all these lines will have the signals of equal direction (See Fig.25). Signal amplitudes of the adjacent lines may differ depending on the search current spreading.

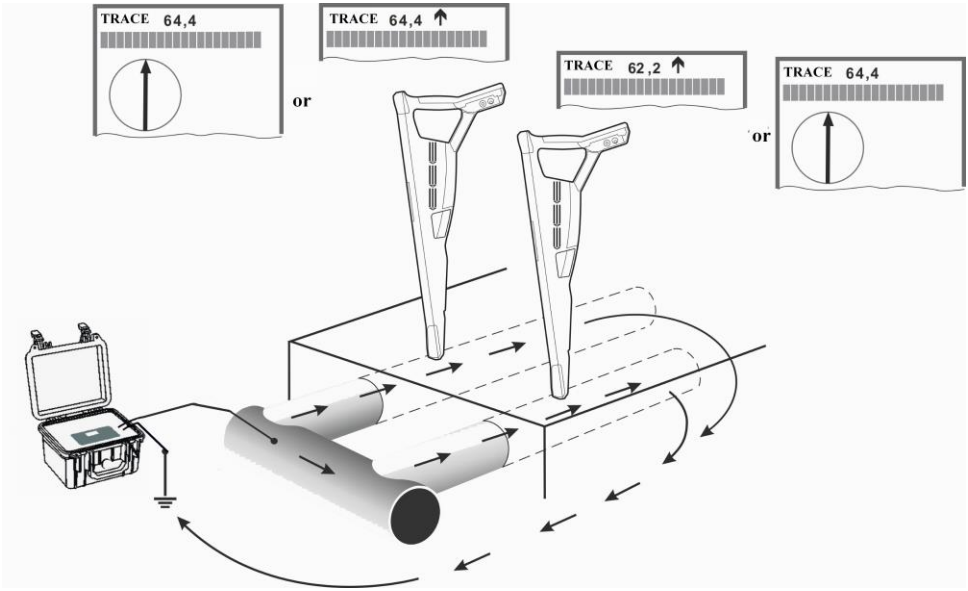

Fig. 25 The direction of current in the galvanically coupled adjacent lines

4.8.3 Depth and current intensity of the utilities

The utility line depth and current strength are not displayed on the “Radio” and “Eter” (SB) frequencies. The error of depth is not rated on the (Power) 50 Hz frequency.

Using the above techniques, keep the Receiver over the target utility axis, as shown in Fig. 26. The arrows on the Receiver body and antenna plain shall be perpendicular to the utility line axis.

Keep in mind that the errors of depth measurements may be caused by the magnetic field distortion produced by adjacent utilities or metal objects, bends or branches, or in high-noise areas. Always observe the rules of operation of the Receiver before operation to ensure against errors.

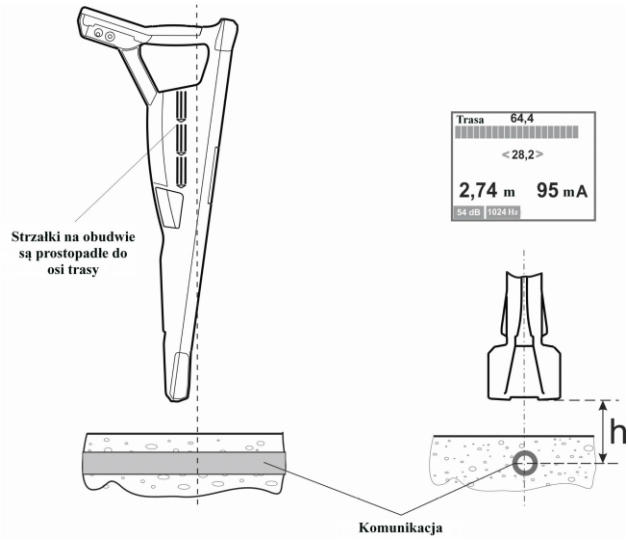

Fig. 26 Direct location of the utility depth

The Receiver displays the depth and current of target line by default. You may switch this function off (See Fig.11), and display these data by pressing the OK button.

Warning!
The depth is measured from the lower surface of the Receiver to the center of the utility line.

When the Receiver moves away from the utility axis the depth readings will increase as the distance to the utility increases. Thus, the most significant readout is the minimum value of the utility depth.
Perform two or three measurements of the depth in one point. The depth level shall be calculated as the average value of the obtained results.
To check the results of measurement you may perform the following: lift the Receiver 0.3 meters up and repeat measurements, making sure that you hold the Receiver evenly. The readings shall increase by the height of lifting. You may perform measurements at various frequencies.
The “LOW FIELD” or “----“ indication means that the obtained result are certainly wrong since the received signal is too weak or the Receiver is moved away from the target line or the utility field is distorted by the adjacent line currents. In this case, use ”the -6 dB method» (See Fig.27).

4.8.3.1 The indirect method of 6 dB

When the Receiver fails to measure the depth of the utility line or the depth shall be located on the passive frequencies, you may use the indirect method of „-6 dB”.

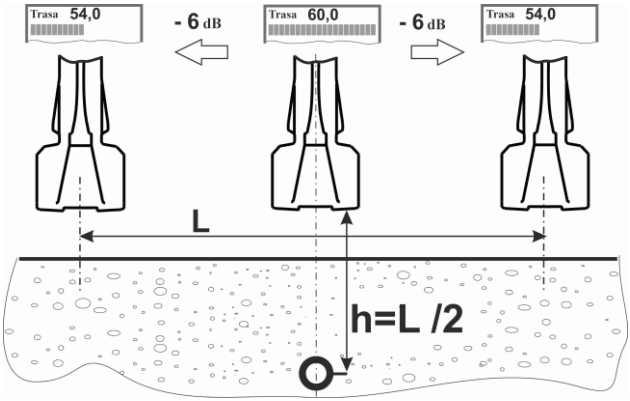

Fig. 27 Depth measurement by the -6dB method

Pinpoint the utility axis and store the readings of the input signal strength on the peak scale in dB. Moving to the left and to the right of the utility axis, find the positions in which the readings will be 6 dB less (this means that the signal strength is two times less). The distance between these two points will be equal to double distance from the Receiver to the utility line axis.

4.8.3.2 Locating by the utility current

When several utilities are running close together within the traced area, return signals from wrong lines may cause false retrieval. The problem sometimes occurs when the target line is deeper than the wrong line carrying the return signal, and the return signal from the wrong line is stronger than one from the target line. The current intensity does not depend on the utility depth, and maximum current will be detectable in the target line. The same level of current will be detected in the target line, and the target line will be identified easily.

When you use this technique, please be sure that the current strength in the target line is much higher, than in the adjacent utilities. To achieve this, connect the Transmitter directly to the target line (See Fig.3 or Fig.4), or use the current-control clamps

Moreover, the abrupt current change may represent branches or tie-in connections of the utilities (if they are made of current-conducting materials), since some current will leak thought the branches. The first Kirchhoff's law says that the total current inflowing in a junction is equal to the total outflowing current. You should note, however, that values of the current intensity near the branches will differ from the actual values. Accurate and true measurements may be performed within long-distance and uniform areas only.

4.9 Testing of ground plots

In order to avoid damage, the ground plots shall be tested to locate and trace the current-conducting utilities before excavating.

4.9.1 Passive locating without Transmitter

The territory may be located in response to re-radiated power, telephone, broadcasting signals or signals of electrochemical protection. Make tracing on the "Power", "100 Hz", "Radio" and "Eter" (SB) frequencies consecutively.

Set the Receiver gain so that a half of the "peak" bar graph is illuminated. Move in zigzags with the zigzag step of from 1 m to 5 m in one direction, and then – in perpendicular direction.

Increased signal strength on the “peak” scale shows the presence of the utility line. To validate a target line location, perform steps specified in Fig. 22 and 23. Find the direction of the located utility rotating the Receiver on vertical axis. The peak signal is generated when the Receiver plane is perpendicular to the utility line, the minimum one – when it is parallel.

4.9.2 Testing of ground plots with Transmitter LKN.

When the location on the passive frequencies is impossible because of the weak signal, and when you need more accurate location of the utility, you may perform tracing according to the Transmitter signals induced by the galvanic connection or Induced in line with Transmitting antenna

During the current search line excitation, you should take into account that:

- the high Transmitter power and small distance from the inductors to the Receiver cause strong direct connection, that will drown the utility signals;
- the strength of current induced in the utility line by means of the inductors will be much lower than that at the direct connection;
- the strength of current induced in the utility line by means of the inductors will be high at high operating frequencies of the Transmitter and close location of the inductor to the utility line;
- the utility current strength depends on the grounding on the ends of the utility line. If one of the ground contacts is missed, the location will be difficult, so the Transmitter shall be set on the maximum frequency to increase the currents via the capacity between the utility and ground.

The testing shall be made by splitting a studied territory into the areas with the size from 30x30 m to 100x100 m. Put the LKN Transmitter on the ground horizontally, in the center of the studied area (Fig. 28). Select inductive mode. Transmitter frequency will be set automatically on 33 kHz. Adjust the Transmitter power to achieve minimum direct connection between inductor and Receiver. In order to test the narrow regions, i.e. a trench, put the inductor apart from the tested area (at the distance from 15 m to 20 m).

Go along the perimeter of the area. Peak signal will be at the crossing of the area boundary with the utility lines.

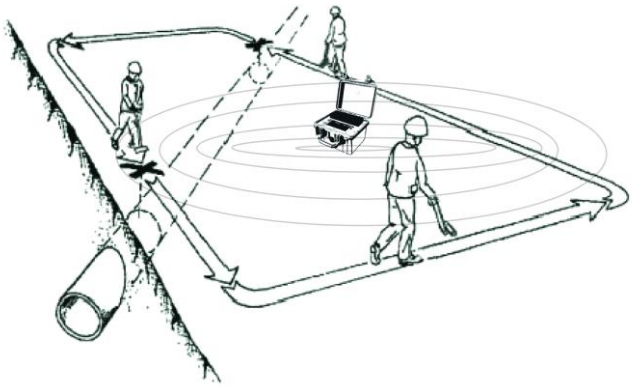

Fig. 28 Ground plot location with the Transmitter in inductive mode

5 Methods of locating damaged pipelines and utilities

The methods below are based on identification of relative distortions of signals within the damaged areas. Sometimes these distortions are unobservable so all the readings obtained during measurement shall be stored in the PC memory for further analysis (See Par. 6).

5.1 Fault finding with leakage current

This method should be used to locate broken insulation of pipelines or utilities with considerable leakage to ground. If a sudden drop of the current strength is revealed in the areas without tie-in connections and branches, this will mean that a considerable damage of the line insulation takes place. This method is true for high initial current (≥0,5 A) and considerable drop of current strength after the damaged area. We recommend you to make tracing on the frequencies of 273 Hz or 526 Hz.

5.2 Fault finding with insulation control sensors – DKI-E or A-frame

Contact sensors of insulation control called A-frame, and non-contact sensors DKI-E are used for location. Turn the Receiver into the “Trace-SENSOR” mode. The sensors shall be connected to the “SENSOR” jack (Pos. 4 in Fig. 7).
The broken areas are detected according to the strength of the signal from the sensors on the SENSOR scale and verification of the utility position control shall be performed with the “peak” and “null” methods (See Fig. 12). If the ”Compass” function is activated, locating will be performed by the position of the utility pointer relative to the Receiver (See Fig. 13). Always control the depth of the utility and the strength and direction of current to avoid false trials (the current direction shall be controlled when two-frequency signal of “1024 Hz” is set on the Transmitter).

To adjust the line scale of the signal strength from the insulation control sensors, set the pointer (Pos. 3 in Fig. 20 and 21) to the “SENSOR” position by pressing the “Mode” button. The gain may be selected with the gain up/down arrows. For the automatic gain selection use the OK button.

Warning!
Do not supply the voltage of more than 42 V to the „SENSOR” jack inputs.

5.2.1 Insulation fault finding by signal drop.

Both operators shall stand in trail over the axis of the target line (for the DKI-E sensor and A Frame) or both pins of the sensor shall be put into the soil for survey (Fig. 29).
The point of insulation failure may be defined by the signal peaks when one pin/operator is directly over the place of break. The signal drops to minimum when the point of insulation failure gets between the A Frame/ operators. When you get near to the area of failure , the distance between the frame A and the distance between the DKI-E probes need to be reduced.The signal null is between the bounds of insulation damage.When the long-distance insulation failure takes place, the signal peaks are located distantly from each other, on the bounds of failure. The signal null is between the bounds of insulation damage.
To make a precise tracing you may define the polarity of signal at the SENSOR input. For this, switch the mode of double-frequency signal of “1024 and 512 Hz” and set the operating frequency of the Receiver to the level of “1042” at the SENSOR input. The indication of current direction becomes active automatically, if the two-frequency signal strength is sufficient (Fig. 20, Pos. 6).

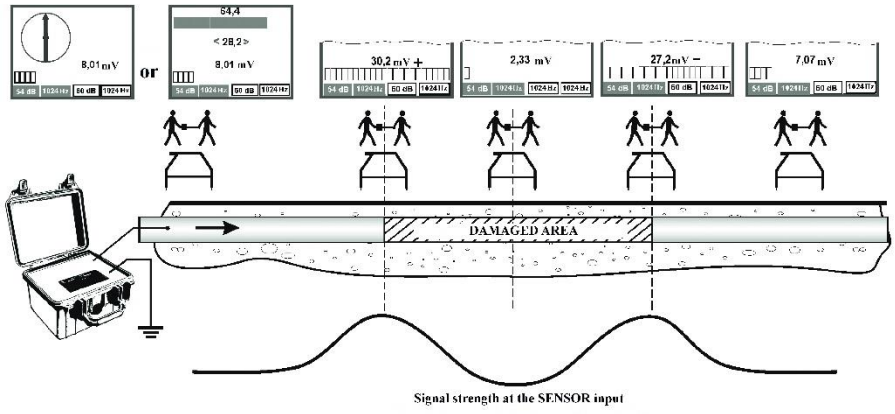

Fig. 29 Insulation fault finding by fall of signal

When the operator moves along the undamaged part of the utility, and then moves directly over the damaged area, the chaotic change (or missing) of polarity at the SENSOR input may occur because of weak signal (Fig 29). As far as the operator approaches the bound of the damaged area, and the signal increases, the polarity becomes stable (plus or minus sign, depending on direction of current inducement) When the operator passes the border of the damages area, the polarity will change (from "+" to "-" or vice versa). In case the insulation is damaged in one point only, the signal level over the damaged point will have a sharp null.

Keep in mind that the polarity inversion(sign on the display) without a specific signal fluctuation may not be considered as a sign of fault.

5.2.2 The search of the insulation failure by the signal rise

The technique of search is the same for A Frame and DKI-E.

One of the operators with the Receiver shall move along the target line with the certain step (for the DKI-E sensor) or one of the pins shall be embedded into the soil with a certain step for fault finding. The second pin or operator shall be away from the target line. The area of the insulation failure shall be determined by the signal peak (Fig. 30).

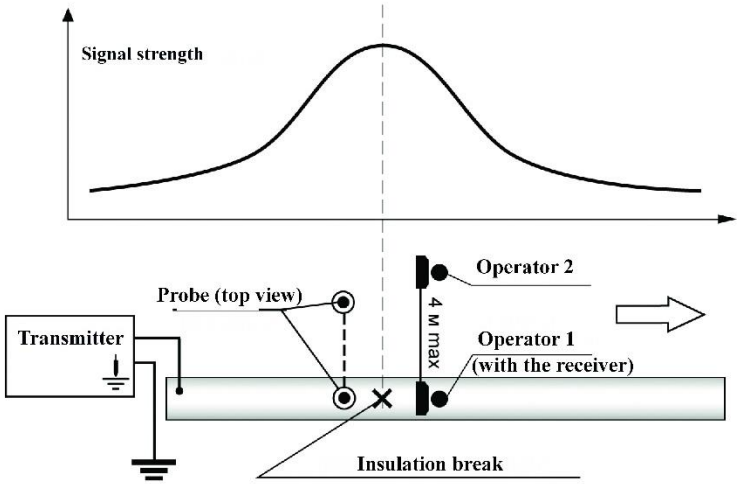

Fig. 30 Connection diagram and search of the insulation failure by the signal rise

Using the “A-frame” provides more accurate readings from measurement to measurement, since the fixed distance between the pins eliminates signal fluctuation error caused by different distances. Measurements with this sensor, however, require the pins to be embedded into the soil, that may be inconvenient in some cases. Keep the insulator surface of the A-frame clean. Soiling may cause signal drop or loss of sensitivity. When operation keep the insulator surface of the A-frame clean. Soiling may cause signal drop or loss of sensitivity.

DKI-E sensor accelerates tracing of single expanded utilities. The sensor operability does not depend on the type of soil or paving. The sensor, however, has lower sensitivity, particularly at low frequencies. Each operator holds a contact electrode of the sensor during operation. If tracing is performed close to the fault, the distance between the operators shall be reduced to clarify the position of cable failure.

5.2.3 Cable breakdown location

Keep in mind that the ferromagnetic shield over the cable conductor may reduce the detected signal strength so the search shall be made at maximum possible current.

5.2.3.1 Finding of short-circuited conductors

Fig. 31 shows the diagram of tracing the short-circuited cables. The Receiver LKO shall be brought along the target utility, and the signal strength shall be controlled on the peak scale. The signal strength may change before the shorted area depending to the cable lay pitch. The signal fluctuation stops behind the short-circuited area, and signal strength may drop (case 1) or rise (case 2).

In the first case, the dead short takes place, when only the cable conductors are shorted. In the second case, the cable conductors are shorted to each other and to the shield.

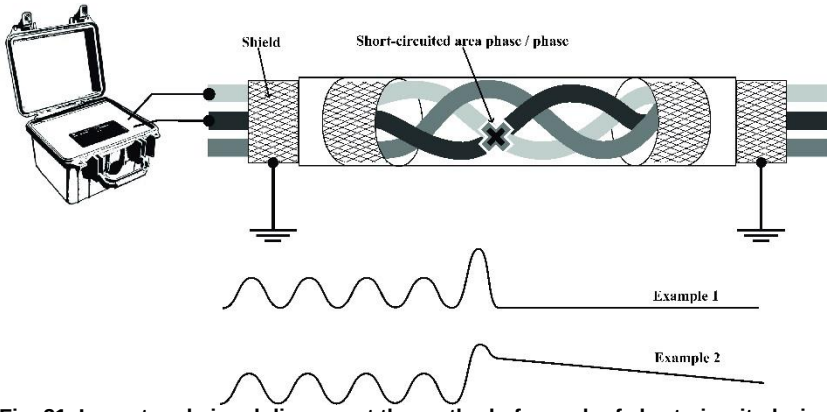

Fig. 31 Layout and signal diagram at the method of search of short-circuited wires

5.2.3.2 Location of shorted conductor-shield positions

The layout of location of conductor-shield shorted area is shown in Fig.32.

The signal strength may change before the shorted area depending to the cable lay pitch. The signal fluctuation behind the short-circuited area remains the same, and signal strength rise abruptly.

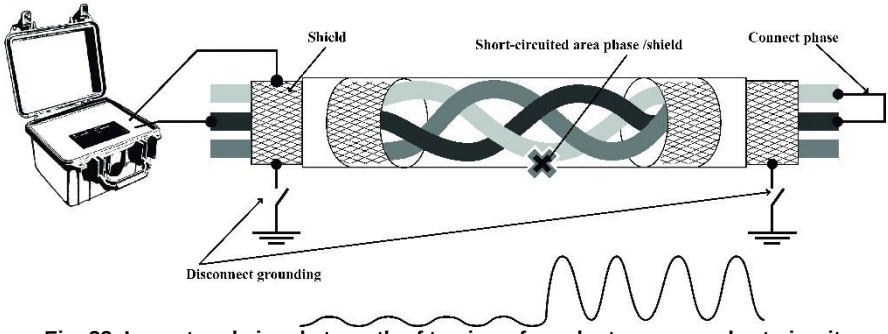

Fig. 32 Layout and signal strength of tracing of conductor- armor short-circuit

5.2.3.3 Tracing of damaged insulation and grounding area

Cable insulation failure relative to the ground with the resistance of hundreds Ohm may be located with insulation control sensors – A-frame/DKI-E. Connect the Transmitter in accordance with Fig. 33. The grounding wire shall be connected to the Transmitter jack with the "⏚ " marking. The methods of locating are generally the same as those described in Par. 5.2.1 and 5.2.2.

In case the cable insulation resistance relative to the ground does not allow the use of the insulation control, the method of phase tracing may be applied. The phase technique provides location of both low-resistance and high-resistance insulation failures with the leakage to ground of up the 0.5 MΩ.

The area of damaged insulation shall be determined initially with a reflection-coefficient meter for example: TDR-410. One operator only locates by this method, and no additional sensors are required.

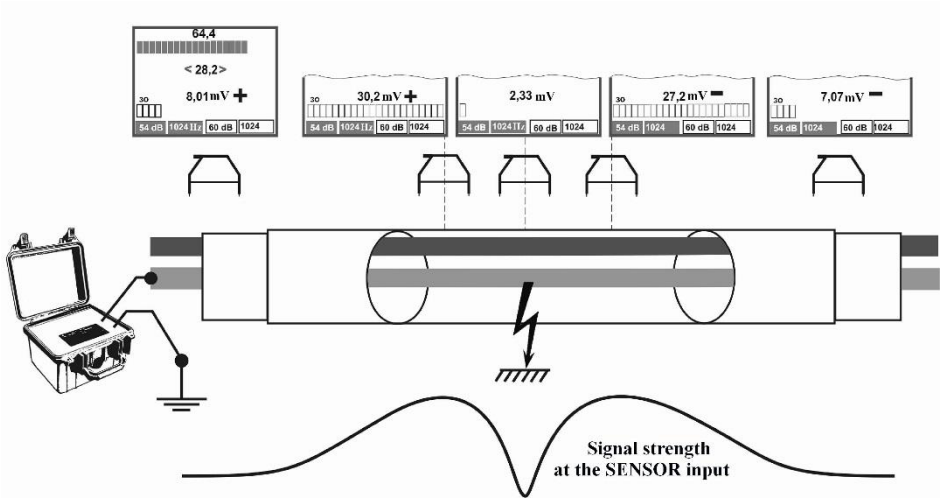

Fig. 33 Connecting diagram and signal strength for the method of insulation damage tracing with insulation control

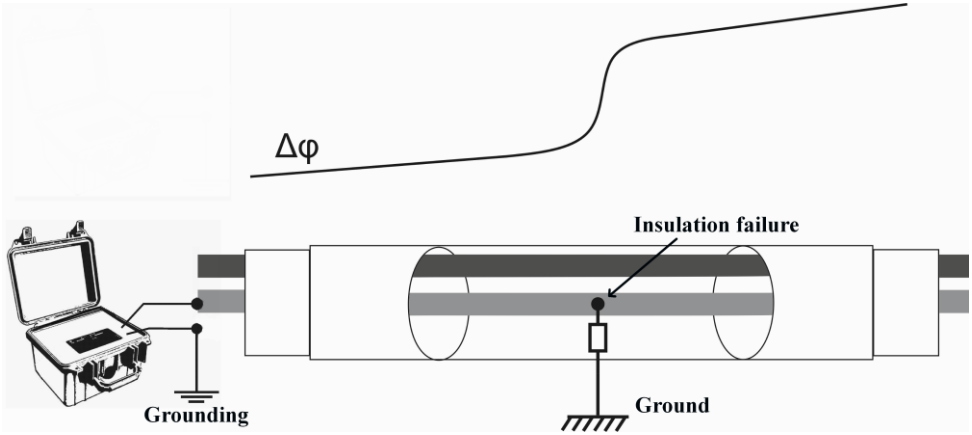

Fig. 34 Connecting diagram and phase shift at the phase method of cable insulation failure locating

Connect one lead of the Transmitter to a damaged conductor (See Fig.34). The opposite end shall be protected. The second lead of the Transmitter shall be grounded with a pin placed at the distance of no less than 5 m. from the cable. Preset the double frequency „**φ**". Select the "Trace" mode and frequency of the „**φ** 8928" on the Receiver. Stand directly over the utility line at the beginning of the tested plot. Make sure that you are not closer than 20 m to the point of connection of the Transmitter. Press the OK button on the Receiver to reset the phase indications. Move along the target line, directly over it, and control the position with the null scale; take phase readings carefully. The phase may change smoothly. The phase readings will rise abruptly by several scale units behind the area of

insulation failure. When you pass the area with damaged insulation, the phase readings will change smoothly.
The failures of this method are as follows:

- phase fluctuation within the areas of damaged insulation is less obvious than signal fluctuation by the insulation control sensor tracing method for example A-frame
- interferences from adjacent utilities.

6 Data storage, GPS navigation

The Receiver stores the measured data in the non-volatile memory, including position from external GPS module. Connection to the external GPS "Bluetooth" module is wireless.
The following parameters may be stored in the Receiver memory both with GPS coordinates and without them:

- strength of signals from magnetic antennas and at the SENSOR input (See 4.8.2):
- direction to utility line (See Par. 4.8.2.1);
- depth of utility and current flowing through it (See Par. 4.8.3);
- direction of tracing current (See Par. 4.8.2.5);
- relative polarity at the "SENSOR" input (See Par. 5.2);
- signal phase at the "Trace" input (See Par. 5.2.3.3);
- operating frequencies;
- local time and date at the moment of readings through GPS;
- target point coordinates obtained through the GPS.

Precise co-ordinate position depends on such factors as quantity of satellites within the direct visibility, satellite arrangement, reflected signals, if any, influence of ionosphere, satellites chronometer errors and technical characteristics of the GPS module.

WARNING!
The Receiver LKO has been tested with the GPS Bluetooth modules Holux M1000, Holux RCV3000. Sonel S.A. guarantees do not cover operation with the GPS

If you use GPS Bluetooth modules with enhanced make sure that the GPS Receiver puts the data out in the NMEA-0183 RMC and GGA formats with the data renewal rate of 1 second.

6.1 Adjustment of the Receiver to the GPS modules

The GPS module shall be placed very close to the Receiver, e.g. in the pocket of the sunscreen cover (Fig.8).

Before you start operation, match the Receiver with the GPS module. Select the "GPS" > "Connection to GPS" > "PIN code" options in the MENU. Set the PIN code of the GPS module.
These are more commonly used codes: "0000" or "1234". In you use other codes that consist of four randomly selected digits, enter the digits by pressing the gain up/down buttons. Then switch the GPS module on. Select the "GPS" >"Connection to GPS" > "Search of Connection to GPS". On completing the search, select the desirable GPS module from the list of available modules by pressing the gain up/down buttons. Confirm selected item by pressing the button. Connection to the selected GPS module will be performed through the "MENU"> "GPS" > "Connection to GPS" > "Switch on" options or automatically on selection of the track number (See Par. 6.2).

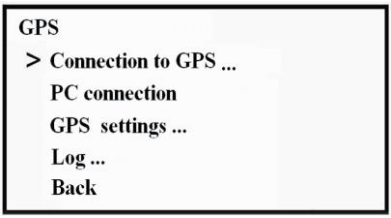

Fig. 35 GPS settings display

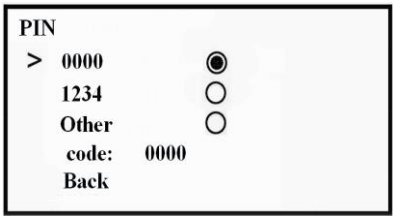

Fig. 36 GPS PIN settings display

Information on the status of access to GPS module is available with the „ ” or „ ” icons (Pos. 15 in Fig. 20).
The name and address of the GPS module, quantity of detected satellites and defined coordinates and time are available through the “MENU” > “GPS” > “Connection to GPS” > “Information” options.
Status of access to GPS module is displayed in the Receiver with symbols(p. 15 Fig.20).

Table 6. Status of access to GPS module

No.	Icon	Description
1.		No access to the GPS module
2.	yellow	Connection to the GPS module is establishing Wait for a minute
3.	yellow	Connection to the GPS module has been established GPS coordinates are missing (cold start of the GPS module, poor conditions of GPS signal processing)
4.	green	Connection to the GPS module has been established Coordinates under processing
5.	red	Lost connection to GPS module

The cold start period (e.g. first start after long-term idling of the GPS module) depends on the GPS model and quantity of available satellites, and it may last up to 20 minutes. At that, the “ “ icon will be shown in yellow. With the next start of the module establishing the connection to the satellites will not exceed a few seconds.

6.2 Track recording

Press the “ ” button after you switched the Receiver on. You will go to the following menu options: “MENU” > “GPS” > “GPS Settings” > “Save the track as…”. You shall decide if you create a new track or continue recording to the existing one. After that, the Receiver will establish communication with the GPS module

Obtained data may be recorded both by pressing the “ “ button and automatically at the preset intervals (auto tracking).

At the moment of recording, the “ “ icon will be displayed (See Pos. 16 in Fig.21). The icon will be green if the stored point has GPS coordinates; it will be red if the stored point has no coordinate possition.

Fig. 37 Track recording display

6.2.1 Recording with button

When you press the " " button, the information displayed at the moment of pressing will be stored in the selected track. In the "LKZ Terminal" program you may view the stored data. At that, the recorded point will be tagged with the " " in the "Tag" field.

To create specifically marked points in the track, e.g. to mark the areas of supposed insulation failure or utility branch, press the " " button and hold it pressed for 2 seconds. The audible signal will be heard continuously. When you view the stored data through the "LKZ Terminal" program you will see this point marked with „ !" in the "Tag" field.

6.2.2 Auto tracking

The Receiver stores the readings in the track with the present time intervals automatically. The auto tracking interval from 1 sec to 60 sec may be set in the menu as follows: "Menu" > "GPS" > "GPS Settings" > "Auto tracking". To initiate the auto tracking function press the " " button. Auto stop recording will be marked with " " symbol. This mode also allows to record specially marked points in the track, for this you should press and hold the " " button for 2 seconds (a long beep sound). In the records of the "LKZ terminal" program, this point in the column "Mark" will be marked as„ !".

The Receiver does not store the interval settings in the autonomous memory. They shall be set each time, if necessary, after the Receiver .

Fig. 38 Auto save selection display.

6.2.3 Log

The track list may be viewed through the "Menu" > "GPS" > "Log" > "Viewing» options.
The information on number, date, time of the first stored point and quantity of points in the track, if any, may be viewed for each track. Track selection may be done by the buttons of gain up/down. Track may be deleted with the "" button. With the " " button you may confirm the current track for data storage, exit from menu and start communication with the GPS module.

6.2.4 Distance

The receiver calculates and displays on the screen passed distance, basing on the obtained GPS coordinates from an external unit (p. 20 Fig. 19):

- as the distance of a straight run from the last point marked by pressing the button "" to the current location;
- as the sum of the altogether distances between the points registered by pressing "" from the very first and the distance between the last registered point and the current location. It allows display sprightly passed distances and also the distances consisting of broken lines. For this, each time you are changing direction, press the button "".

You can choose the proper option in the "Menu" > "GPS" > "GPS settings" > "Distance". The distance is not stored in the autonomous memory - it is set to zero at every turning on the receiver.

6.2.5 Transmission to PC

The Receiver may transmit data wirelessly to PC. The PC requirements shall be as follows: Windows (XP SP2/SP3, Vista, 7, 8,10), Bluetooth or external Bluetooth-USB adapter.

The PC shall be arranged within line-of-the-sight area, at the distance of no more than 8 meters from the Receiver. Data communication is facilitated by the operational system of the PC. Information is transmitted from the Receiver memory to the PC as files with tracks.

The special-purpose program "LKZ Terminal" is used to facilitate data processing. This program is designed to receive the tracks from the Receiver, save the tracks in the PC memory, edit the tracks, plot graphs for insulation condition analysis, etc. The program and its detailed description are available for downloading on the company's website www.sonel.pl:

In order to transmit data to the PC proceed as follows:

- start the "LKZ Terminal" program on the PC;
- select connection to the PC in the Receiver menu: "Menu" > "GPS" > "PC connection";
- select "Load track form Receiver" option from the menu of the LKZ Terminal" program to read the track from the Receiver. In the "Track selection" window choose the desired track from the track list and confirm with "OK". Wait until the track reading is complete.

With this program you may superimpose the tracks onto the maps of the "Yandex Maps" and "OpenStreetMap". In this case you shall have Internet connection. If the Internet access is via the proxy-server, you shall adjust the parameters through the "LKZ Terminal" program settings. In case of poor connection to the network, the map will not be displayed; the other functions will be available.

7 The possible faults and troubleshooting

The possible faults and remedies are listed in Table 7.

Table 7 Possible faults and remedies of LKO

No.	Fault	Possible cause	Remedies
1.	The Receiver fails to be switched-on or it is switched off spontaneously	Battery is defective or discharged	**Charge or replace batteries**
2.	When power supply is on the Receiver fails to respond to the Transmitter signal	No contact in antenna plug connector	Check and restore contacts
3.	The headphones fail to deliver sound whereas the sound is good through the internal speakers	Break in headphone circuit	Repair or replace headphones

8 Maintenance and running repairs

The service of LKZ-1500 Transmitter and Receiver is about following the rules of operation, storage, charging of batteries, routine check and troubleshooting recommended by Sonel S.A.

Repair and also replacement of the rechargeable battery or batteries, is allowed only at the manufacturer factory, or in special repair shops. Damage to the seals results in the loss of warranty for the device.

The case of the set, can be cleaned with a soft, damp cloth using generally available detergents. Do not use any solvents or cleaning agents that could scratch the housing (powders, pastes, etc.).

Cables can be cleaned with detergent water and then wiped dry.

9 Transportation and storage

Shipment of the Receiver shall be performed in a standard package by any type of vehicles. When the Device is delivered by plane, it shall be put into a heated hermetical compartment.
The Receiver shall be shipped and stored under the following conditions:

- ambient temperature: from minus 50ºC to +70ºC;
- relative humidity of 90 % max at the temperature of +30ºC;
- The impact of precipitation is not allowed.

Please note the following when storing the set:

- disconnect all wires from the transmitter,
- thoroughly clean the transmitter, receiver and all accessories, For extended periods of time, remove the batteries or accumulators from the receiver,
- To avoid full discharge of the battery in the transmitter, with long storage, it should be re-charged from time to time.

10 Dismantling and utilization

The Receiver utilization shall be performed by the customer in accordance with the rules and procedures adopted on the territory of the customer's country.

The device does not contain the ecologically hazardous elements. Keep in mind that:

- Waste electrical and electronic equipment should be collected selectively, i.e. not with other types of waste;
- Waste electronics should be disposed of at a collection point in accordance with the law on waste electrical and electronic equipment or in accordance with local law;
- Before disposing of equipment to a collection point, do not disassemble any part of this equipment yourself;
- Observe the local waste disposal regulations for used batteries and accumulators.

11Technical data

11.1 Transmitter LKN-1500

a) level of protection of transmitter case according to EN 60529.....IP 54 (IP53 For open casing)
b) transmitter power supply..... VRLA (AMG) lead-acid 12 V/7 Ah
c) overall dimensions.....275 x 250 x 180 mm
d) weight..... about. 4,9 kg
e) operating temperature .....-20...+55°C
f) storage temperature .....-50…+70°C
g) fiducial temperature .....+23 ± 2°C
h) relative humidity .....no more than 90 % at the temperature of +30 ºC
i) atmospheric pressure .....from 840 to 1067 hPa

Warning!
The transmitter can produce interferences which exceed its allowable values specified in EN 61326-1 and in the case of signaling on the mains power supply, it may cause interference to other equipment as it follows from its operating principle.

11.2 Receiver LKO-1500

a) level of protection of transmitter case according to IP54
b) receiver power supply..... nickel-metal hydride batteries Ni-Mh 6 V/2000 mAh
c) overall dimensions.....700 x 300 x 140 mm
d) weight..... about. 1,8 kg
e) operating temperature .....-20...+55°C
f) storage temperature .....-50...+70°C
g) atmospheric pressure .....from 600 to 1067 hPa
h) fiducial temperature .....+23 ± 2°C

Due to continual enhancement of transmitters, engineering changes improving their reliability and operation conditions, insignificant differences are possible between output products and design described in this manual instruction.

12 Equipment

12.1 Standard accessories

- LKN-1500 lines locator - Receiver **WMXXLKN1500**
- LKO-1500 lines locator - Receiver **WMXXLKO1500**
- test lead 5 m, blue, 1 kV (banana plugs) **WAPRZ005BUBB**
- test lead 5 m, red, 1 kV (banana plugs) **WAPRZ005REBB**
- crocodile clip, blue, 1 kV, 20 A **WAKROBU20K02**
- crocodile clip, red, 1 kV, 20 A **WAKRORE20K02**
- ground probe 23 cm **WASONG23**
- battery charger Z16 (transmitter) **WAZASZ16**
- battery charger Z17 (receiver) **WAZASZ17**
- bag L13 **WAFUTL13**
- sun-protecting cover LKO-1500 **WAPOZOSL4**
- accumulator NiMH 6V, 2Ah **WAAKU23**
- battery compartment **WAPOJ3**
- user manual

12.2 Optional accessories

It is possible to additionally purchase from the manufacturer and distributors the following elements, which are not included within the standard accessories:

- adapter – „A frame" **WAADALKZRA2**
- probe DKI **WASONDKI**
- adapter – module GPS RCV-3000 **WAADARCV300**
- N-1 transmitting clamps (Φ=52 mm) **WACEGN1BB**
- N-4 transmitting clamps (Φ=110 mm) **WACEGN4**
- N-5 transmitting clamps (Φ=125 mm) **WACEGN5**

13 Service

The manufacturer of the device provides all warranty and after-warranty repairs:

SONEL S.A.
Wokulskiego 11
58-100 Świdnica
Poland
tel. +48 74 858 38 60
fax +48 74 858 38 09
E-mail: export@sonel.pl
Web page: www.sonel.pl

14 Laboratory services

SONEL Testing and Calibration Laboratory has been accredited by the Polish Center for Accreditation (PCA) - certificate no. AP 173.

AP 173

Laboratory offers calibration for the following instruments that are used for measuring electrical and non-electrical parameters.

- **METERS FOR MEASUREMENTS OF ELECTRICAL PARAMETERS**
  - voltage meters,
  - current meters (including clamp meters),
  - resistance meters,
  - insulation resistance meters,
  - earth resistance and resistivity meters,
  - RCD meters,
  - short-circuit loop impedance meters,
  - power quality analyzers,
  - portable appliance testers (PAT),
  - power meters,
  - active and passive electric energy meters,
  - multimeters,
  - multifunction meters covering the functions of the above-mentioned instruments,
- **ELECTRICAL STANDARDS**
  - calibrators,
  - resistance standards,
- **METERS FOR MEASUREMENTS OF NON-ELECTRICAL PARAMETERS**
  - pyrometers,
  - thermal imagers,
  - luxmeters.

The Calibration Certificate is a document that presents a relation between the calibration standard of known accuracy and meter indications with associated measurement uncertainties. The calibration standards are normally traceable to the national standard held by the National Metrological Institute.

According to ILAC-G24 „Guidelines for determination of calibration intervals of measuring instruments", SONEL S.A. recommends periodical metrological inspection of the instruments it manufactures no less frequently than once every 12 months.

For new instruments provided with the Calibration Certificate or Validation Certificate at the factory, re-calibration should be performed within 12 months from the date of purchase, however, no later than 24 months from the date of purchase.

ATTENTION !
The person performing the measurements should be absolutely sure about the efficiency of the device being used. Measurements made with an inefficient meter can contribute to an incorrect assessment of the effectiveness of health protection and even human life.

NOTES

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