

RUSSIA PRODUCT CLASSIFIER CODE 422158

**TIME DOMAIN REFLECTOMETER
TDR-109**

USER MANUAL

4221-041-39189999-2011



ATTENTION!

Before using the device please carefully
read this User Manual

**This device intended for usage
by a qualified personnel only.**

This user manual contains instructions for operating the TDR-109 TIME DOMAIN REFLECTOMETER. The person operating TDR-109 must follow all safety precautions listed in this user manual in order to ensure the own safety and safety of the surrounding people in close proximity to the work area. Violation of these instructions can cause serious injury or death.

The device has open inputs.

When connecting the TDR-109, make sure that there is **NO voltage in the cable.**

Failure to comply with certain provisions of this manual may cause the device breakdown, without being a warranty claim.

The user manual for the TDR-109 data communication software you can find on the attached CD.

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Designations and Contractions

HVPG – high-voltage pulse generator

VF – velocity factor

HVL – High-voltage testing laboratory

PC – personal computer

UM – User Manual

SW – Software

GOVERNMENT STANDARD – GOST

Introduction

This UM is a document certifying guaranteed by the manufacturer the basic parameters and technical characteristics of the time domain reflectometer TDR-109 (hereinafter the TDR-109)

UM is intended for acquaintance with the TDR-109 device and the principle of operation and sets the operating rules, compliance with which maintains the device in constant readiness for action.

Persons with secondary technical education are admitted to work with the device, with experience in electrical appliances for general purposes.

1 Application Area

1.1 TDR-109 is designed for the following measurements on balanced and asymmetric cables with a wave resistance from 25 to 500 Ω :

- cable length measurement;
- measuring distances to wave impedance or damage impedance irregularities, using the pulse method;
- measuring the distance to the response from the burning arc, using the Arc-Reflection method - as part of the HVTL;
- measuring the distance to the breakdown point using the vibrational discharge method (wave) - as part of the HVTL;
- measurement of the velocity factor of the cable at a known length;
- determination of fault's nature;
- recording into internal storage and playback of at least 300 waveforms for subsequent processing in stationary conditions;
- Color TFT screen with a resolution of 640 x 480 pixels.

1.2 TDR-109 is a compact device designed to work in indoor and outdoor conditions.

TDR-109 meets climatic conditions Group 4 GOST 22261:

- operating temperature range from -20 to 40 °C;
- relative humidity 98%, at 25 °C;
- transportation and storage conditions from -50 to 50 °C

1.2.1 TDR-109 is stable and resistant to the sinusoidal vibration in frequency range from 10 Hz to 55 Hz. TDR-109 meets conditions Group 4 GOST 22261.

1.2.2 TDR-109 is powered by the built-in Li-Ion battery (7,2 \pm 0,7)V 6,6A. The design of the TDR-109 provides control of battery discharge and automatic device shut down in 2, 4, 8, 32 or 64 minutes of idle time.

1.3 TDR-109 does not emit toxic gases and audio noise.

Notes to Table 2-1:

- The amplitude (U1 or U2) can be selected in the "MENU" mode;
- the durations of the probe pulse for the amplitude (U1) on any subband can be selected from:
10 ns, 20 ns, 50 ns, 100 ns, 200 ns, 500 ns, 1 μ s, 2 μ s, 5 μ s, 10 μ s, 20 μ s, 50 μ s, 100 μ s;

2.5 Measurement relative error of the $V_F \pm 0,4\%$ in the range of V_F value from 1.000 to 3.000.

2.6 Receiver sensitivity when the signal exceeds the noise level by a factor of 2 on all subbands is not worse than 1 mV.

2.7 Asynchronous noise suppression - averaging 1 to 128.

2.8 Non-volatile memory capacity - reflectograms of at least 300, at least 500 velocity factors.

2.9 Measuring input impedance from 25 to 500 Ω .

2.10 Operation mode setup time less than 15 seconds.

2.11 Continuous running TDR-109 from the battery ACC1 at least 6 hours and depends on the battery status. Continuous running via AC adapter is not limited.

2.12 Maximum electric power consumed by the TDR-109 while charging the battery, not more than 45 W with AC adapter ES25E12-120.

2.13 Overall dimensions of the TDR-109 is not more than:

- length - 270 mm
- width - 246 mm
- height - 124 mm

2.14 Weight of TDR-109 with built-in battery no more than 2,5 kg

2.15 Reliability

2.15.1 MTBF - at least 6000 hours.

2.15.2 Service life - at least 5 years.

3 Delivery Contents

The set of TDR-109 includes:

- Time Domain Reflectometer TDR-109 tech. spec. 4221-041-39189999-2011 - 1 item
- AC Adapter ES25E12-120¹ - 1 item
- Connecting cable:
 - for connection to a cable cable (HB-A100²) - 1 item
 - to connect to a special connecting device (HB-B100³) - 5 items
- User Manual tech. spec. 4221-041-39189999-2011 - 1 item
- Accessories bag - 1 item
- Software CD - 1 item

Note: the AC Adapter has a certificate of conformity.

¹ Or similiar (12 V * 2,08 A)

² Or similiar

³ Or similiar

4 CONSTRUCTION AND OPERATING PRINCIPLE OF TDR-109

4.1 OPERATING PRINCIPLE

4.1.1 Pulse mode (TDR)

The instrument uses a Time Domain Reflectometry method (TDR), which is based on the phenomenon of a partial reflection of electromagnetic waves by the impedance irregularities in the cable. When applying the TDR method a rectangular probe pulse generated by the pulse generator is sent into the cable. Probe pulse propagating through the cable, completely or partly reflected from the fault area in the cable (impedance irregularities) and returns to the receiver input. Reflection waveform is observed on the screen and allows determining the type of the fault and the distance to it (see Table 4-1). The reflected pulses are returned to the device after a certain time from the moment of sending the probe pulse.

$$L = v \cdot \frac{t_d}{2} = c \cdot \frac{1}{PF} \cdot \frac{t_d}{2} = c \cdot \frac{VoP}{100} \cdot \frac{t_d}{2}$$

Knowing the speed of electromagnetic wave propagation along the cable, and the time delay of the reflected signal (measured by the device), we can calculate the distance to the impedance irregularity.

$$X = v \frac{t_d}{2} = \frac{C}{2 \cdot VF} \cdot t_d$$

X – Distance to the impedance irregularity, m;

v – Propagation speed of electromagnetic wave in the cable, m/μs;

t_d – Measured time delay of the reflected signal, μs;

c – Speed of light is equal to 299,8 m/μs;

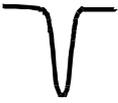
PF – Propagation Factor, c/v

VF – velocity factor;

Impedance irregularities are the result of violations manufacturing technology of cables as well as a consequence of mechanical and electrical hazards during the construction and operation of the cable cables. Any cable device (couple, split, joint, Pupin coil, etc.) causes irregularity of the cable impedance.

The impedance irregularities may be caused by any cable devices (couple, joint, Pupin coil, etc.) or faults (open, short, partial open, partial shot, wetting core of the cable, leaks to the ground, split pairs, etc.). TDR method allows fixing multiple irregularities both lumped and lengthy, depending on the ratio of their length and the minimal wavelength of the spectrum of the probe pulse.

Table 4-1 Waveforms of the typical irregularities

Waveform	Description
	Cable break
	Complex resistance is greater than the wave impedance of the cable
	DEAD SHORT
	Complex resistance is less than the wave impedance of the cable
	The breakdown of pairs or spurious coupling

Notes to Table 4-1:

The amplitudes of the pulses are given in the appropriate proportions at the same amplification.

As a probe pulse, a pulse of positive polarity with an amplitude of at least 10 V (or at least 45 V) is used (see Table 2-1). The duration of the probe pulse automatically changes with the scale of the measurement sub-range (see Table 4-2) and ranges from 10 ns to 100µs. This value can optionally be changed by the user.

The value of the shortening factor is individual for each type of cable. It is related to the type of cable sheath by the following formula:

$$VF \approx \sqrt{\varepsilon_0},$$

ε_0 – dielectric constant of cable sheath

The value of the VF can be determined experimentally from the known length of the cable.

Table 4-2 Scales of the measurement sub-ranges

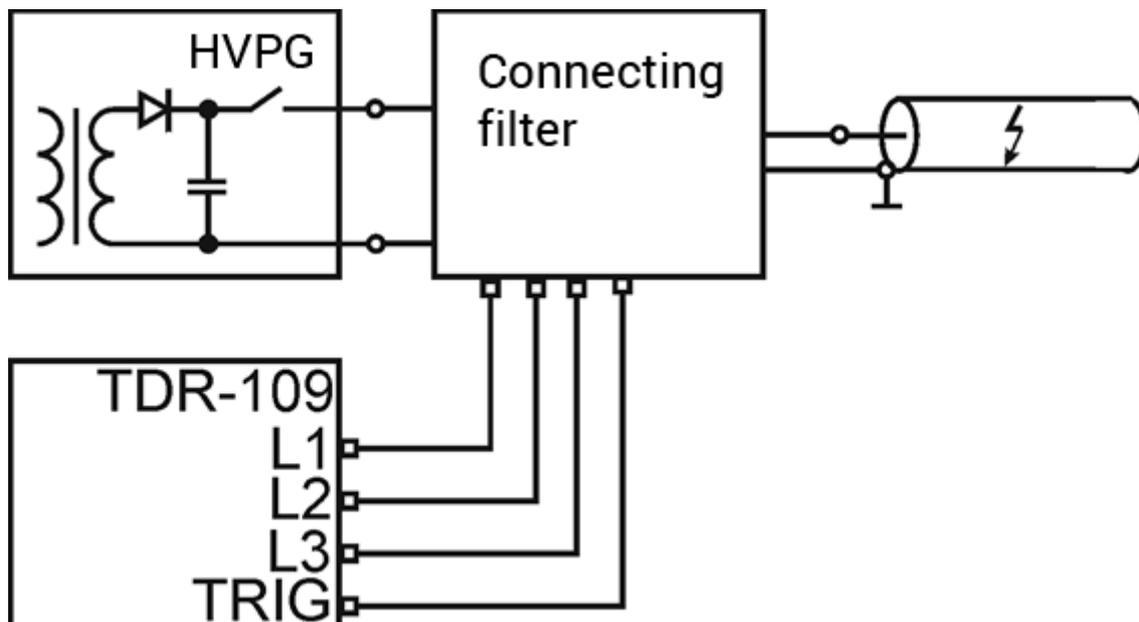
Sub-ranges, m	The default pulse width, ns	Sampling step, m PF=1.5 (VOP=66%)
0 – 62,5	10	0,125
0 – 125	10	0,250
0 – 250	20	0,500
0 – 500	50	1,000
0 – 1000	100	2,000
0 – 2000	200	4,000
0 – 4000	500	8,000
0 – 8000	1000	16,000
0 – 16000	2000	32,000
0 – 32000	5000	64,000
0 – 64000	10000	128,000
0 - 128000	20000	256,000

The error in determining the distance to the inhomogeneity can be determined by the discreteness of the indicator (500 discrepancies / scale) and the error in setting the VF. In addition, there are additional errors due to distortion of the shape of the reflected signal in the cables with frequency-dependent losses.

The measurement error can be also affected by the nature of the inhomogeneity, its magnitude, the presence of several breaks in the cable. The measurement error can be reduced by matching the device with the cable. In the TDR-109, the distance is determined automatically, corresponds to the position of the cursor on the screen.

4.1.2 Arc-Reflection mode (ARM)

Localization of high-resistance faults at the location of a defect is usually difficult when using a low-voltage pulse measurement method. One of the ways to localize such defects on power cables is the Arc-Reflection method (ARM).



Picture 4-1 Structural diagram of Arc-Reflection method implementation

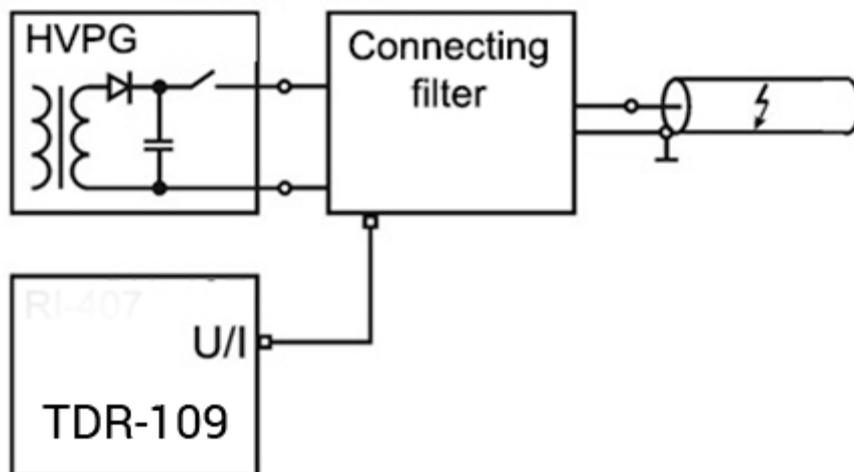
The implementation of the Arc-Reflection method is carried out using additional equipment: HVPG and a special connection device.

The essence of the Arc-Reflection method is that with the help of the HVPG, an arc is created at the point of cable damage, the low resistance of which reflects the probing pulse of the reflectometer.

Detection of cable faults by Arc-Reflection method is based on comparing the reflectograms of a faulty and nonfaulty cable. To obtain a reflectogram of a faulty cable, it is necessary to create a short-term breakdown (electric arc) at the fault location using the HVPG generator and the connecting device, while simultaneously performing the TDR-109 measurement. Due to its physical properties, the electric arc has a low resistance, so at the fault location on the reflectogram there will be a non-uniformity characteristic of a short circuit.

4.1.3 Oscillatory Discharge Methods (ODM)

Localization of the cable faults caused self-healing insulation breakdown is usually difficult when using low-voltage TDR method. One of the ways for localization such defects in power cables is an Oscillatory Discharge Methods (ODM): Impulse Current Method (ICE) and Decay travelling wave method (DECAY).



Picture 4.2 Diagram of the implementation of an Oscillatory Discharge method

The methods of oscillatory discharge (ICE, DECAY) are based on the measuring period of oscillatory processes occurring in the breakdown of the charged cable. The

method is implemented with the use of additional equipment: a high-voltage pulse generator and a special connection device.

The essence of the method is: HVPG raises voltage in the cable until the breakdown occurred. The defect causes a breakdown of the insulation at the site of the fault, causing a spark, which has low resistance and the oscillatory discharge in the cable occurs. Knowing the speed of electromagnetic wave propagation in the cable and the period of oscillation process, we can calculate the distance to the breakdown:

$$X = v \frac{t_{nn}}{2} = \frac{C}{2 \cdot VF} \cdot t_{nn}$$

X – distance to breakdown, m;

v – propagation velocity in the electromagnetic wave cable, m / μ s;

t_{nn} – half-cycle time, μ s;

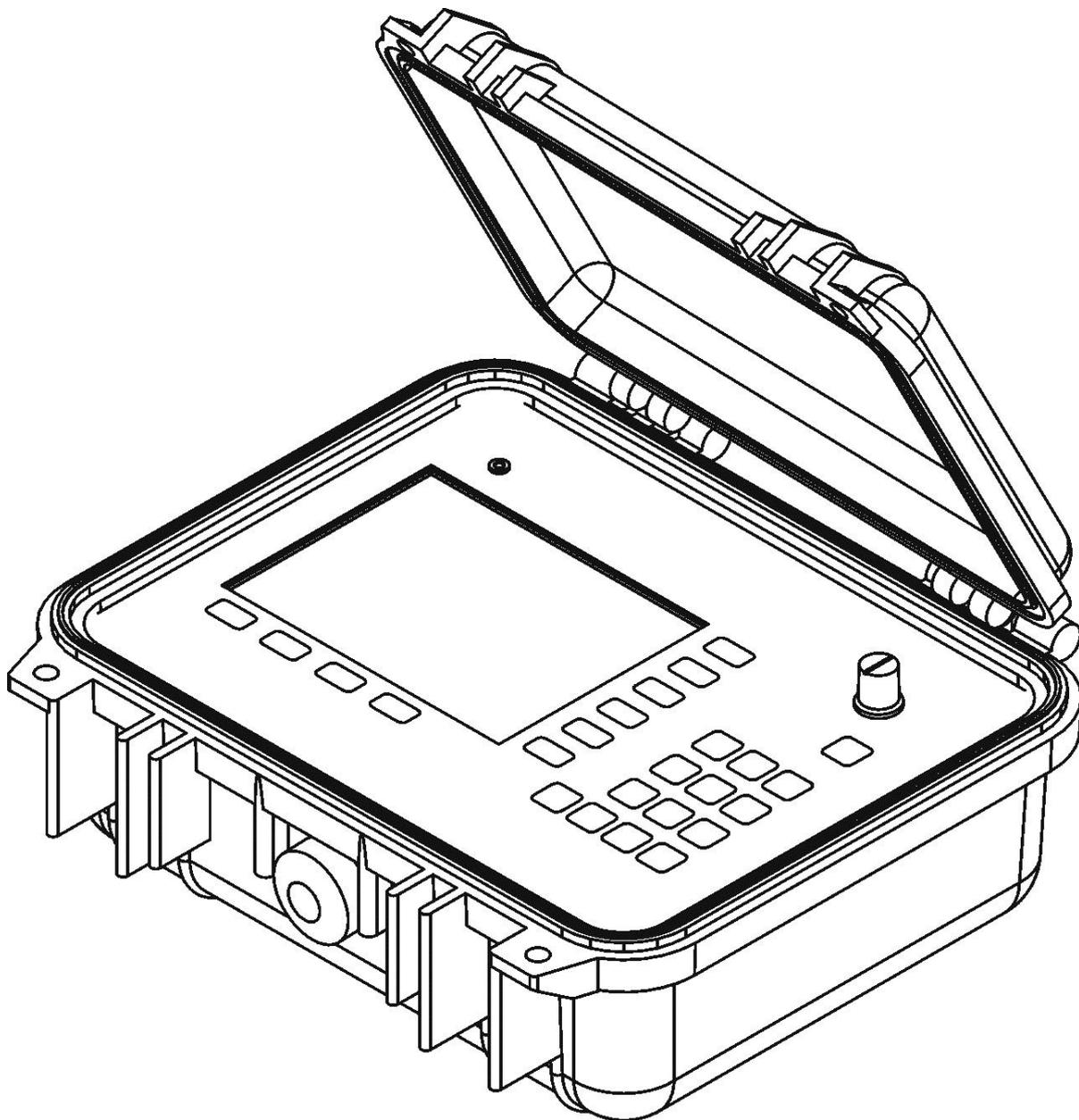
c – the speed of light equal to 300 m/ μ s;

VF – Velocity Factor.

To achieve the greatest accuracy, only the first half-cycle time is selected.

4.2 Exterior

The exterior of the device is shown in Picture 4-3.

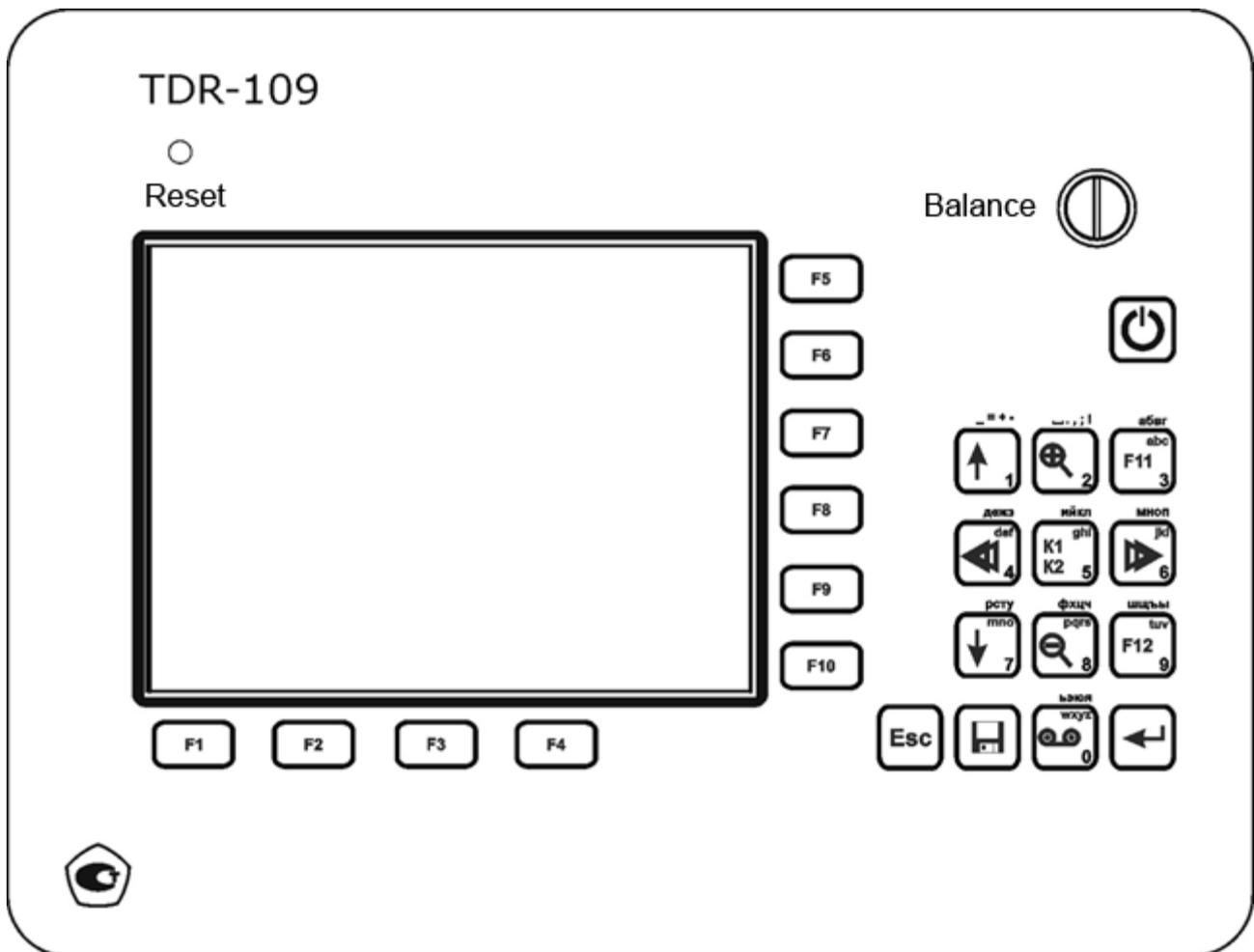


Picture 4.3 The exterior of TDR-109

4.3 Location and function of controls and displays

4.3.1 Front panel

The front panel of the device is shown in Picture 4-4. In the center of the front panel is a screen TFT 640x480 pixels. Also on the front panel are located: the "RESET" button, designed to force the device to turn off the power; handle "Balance", designed to align the measuring channel with the cable impedance; 24 - button keyboard, designed to control the instrument through the graphical interface displayed on the screen (Table 4-4).



Picture 4-4. Front panel

Table 4-3 (part 1 of 2)

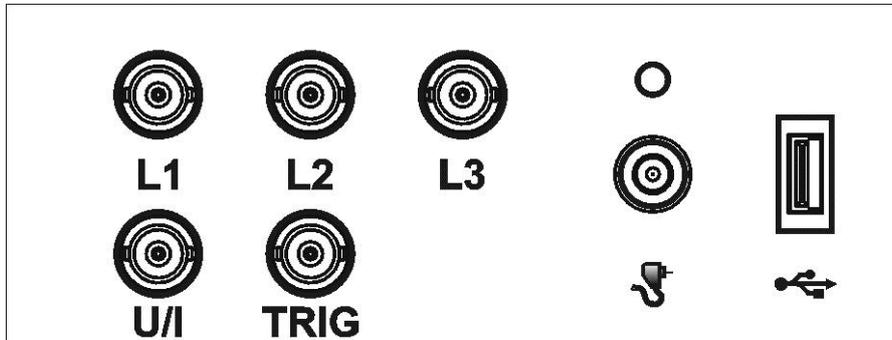
Button	Functions
	Turn ON/OFF the instrument
F1 - F10	Activate the Selector, located next to the button
	<ul style="list-style-type: none"> In the CHANNELS window – SHIFT UP of the selected waveform. In the PARAMS window – INCREASE the value of the active Selector: Scale, Pulse Width, Velocity Factor, Averaging, Gain, Offset Input Delay, Threshold. In the WAVEFORMS LIBRARY, CABLES LIBRARY and OPTIONS windows – NAVIGATE UP through the list. Inserts the character to the text (for example, when specifying the name of the waveform or cable in the LIBRARY): "Space", "=", "+", "-", "1"
	<ul style="list-style-type: none"> In the CHANNELS window and in the PARAMS window - adjustment of the waveforms HORIZONTAL SCALE (ZOOM IN) in the area of Active Cursor. Inserts the character to the text (for example, when specifying the name of the waveform or cable in the LIBRARY): "_", ".", ",", ";", "2".
	<p>Select fixed channel. The selector of the main channel changes color.</p> <p>Input characters:</p>
	<p>Move the active cursor to the left.</p> <p>Input characters:</p>
	<p>Select the active cursor. The active cursor is highlighted in yellow.</p> <p>Input characters:</p>
	<p>Move the active cursor to the right.</p> <p>Input characters:</p>
	<p>In the menu "Channels" - control the shift of the reflectogram of the selected channel down.</p> <p>In the "Parameters" menu - decrease the value of the parameters: Scale, Pulse, VF, Averaging, Gain, Offset, Input Delay, Threshold.</p> <p>Navigate down to the "Reflectograms Library" menu, "VF Library", "MENU".</p> <p>Input characters:</p>

Table 4-3 (part 2 of 2)

Button	Functions
	Turn off the Microplan mode in the active cursor position area, reduce (shrink) the section of the reflectogram into a specified number of times. Input characters:
	In the CHANNELS window and in the PARAMS window – toggles DIFFERENCE mode. Input characters:
	Saving the waveform of the selected channel.
	Cancel the action Delete text symbols
	Confirm the action

4.3.2 Rear panel

All connectors in the TDR-109 are located on the rear panel (Picture 4-5).



Picture 4-5 Rear panel

- L1, L2, L3 - to connect the device to the investigating cable;
- TRIG - to connect the synchronization cable (Arc-Reflection method);
- U / I - for connection to a voltage connecting device (oscillating discharge method) or current (wave method);
- Connector with indicator LED for connecting an external DC power supply 12 V, 2.08 A;
- USB-A connector for USB flash drive connection.

4.3.3 Display

The device is equipped with a TFT-display 5.7" with a resolution of 640x480 pixels. The display of the TDR-109 is intended for displaying measurement results, as well as for monitoring and setting the operating parameters of the instrument.

The instrument is controlled via the menu system. In all menus, the status bar at the top of the display shows the name of the current menu, the built-in battery's charge indicator, and the date and time. For each measurement method, additional information specific to each measurement method can be displayed in the status cable.

On the right and below, alongside the multifunction buttons "F1" - "F10" are working selectors, which display the applicable settings for each mode.

In the center of the screen there are graphs of the reflectograms and measuring cursors. The general view of the display differs for each mode of operation of the TDR-109.

4.4 PULSE mode (TDR)

The pulse mode in the TDR-109 device implements a low-voltage pulse method (TDR). Switching to the pulse mode is carried out by selecting the "Pulse" selector in the "MENU" menu by pressing the "F1" key. Exit the pulse mode by selecting the "MENU" selector by pressing the "F3" key.

Pulse mode has two menus: "CHANNELS" and "PARAMETERS".

4.4.1 CHANNELS in PULSE mode (TDR)

The transition to the "CHANNELS" menu is carried out immediately when switching to pulse mode, or when selecting the "CHANNELS" selector in the "PARAMETERS" menu.

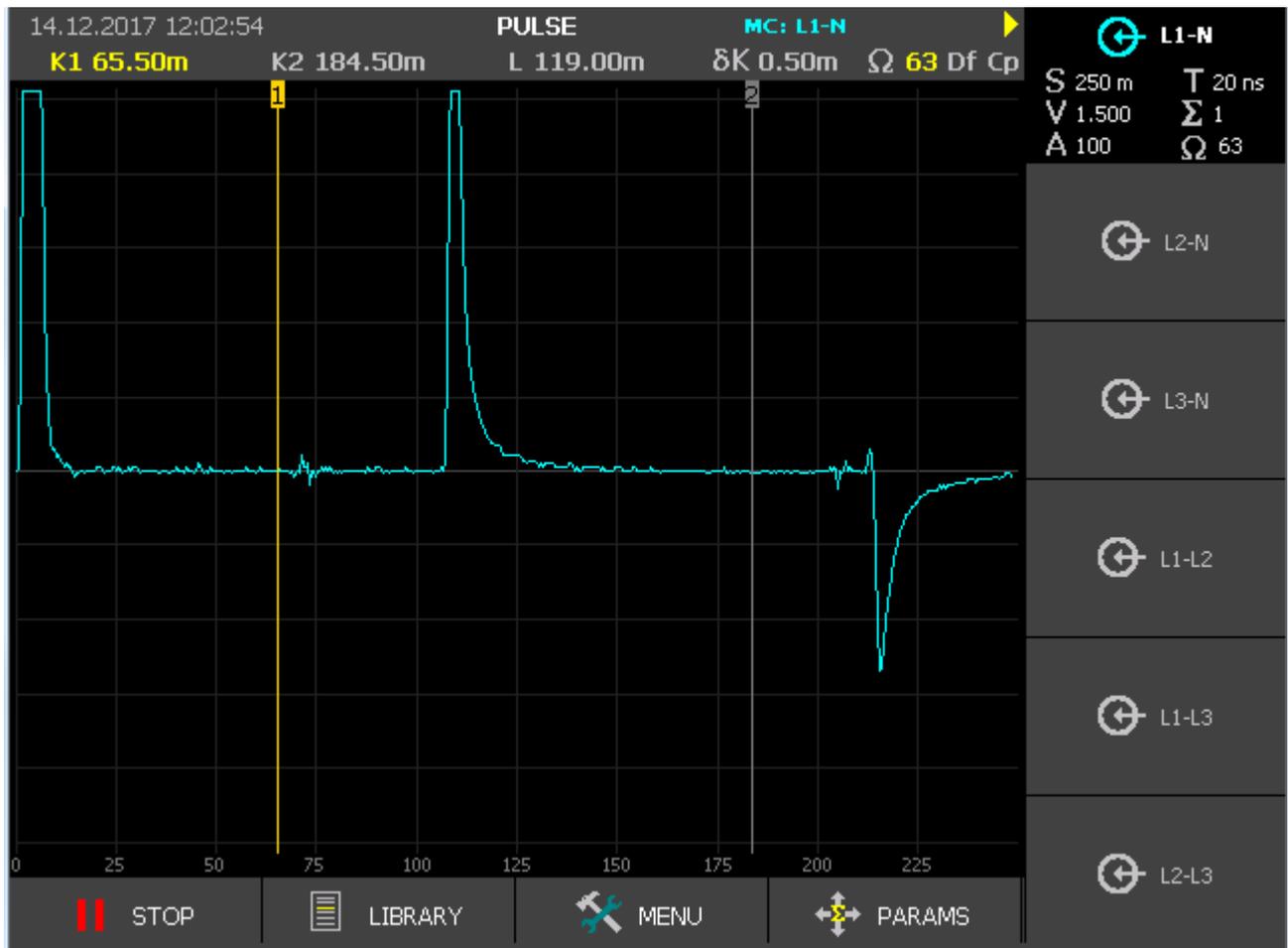
The "CHANNELS" menu in the PULSE mode is shown in Picture 4-6.

Working with the "CHANNELS" menu allows you to:

- Activate / deactivate the measuring channels and saved channels by successively pressing the buttons "F5" - "F10" next to the selectors of the corresponding channels, simultaneously displaying the following measuring channels connected to the inputs L1, L2, L3:

L1-N, L2-N, L3-N, L1-L2, L1-L3, L2-L3;

- measure the distance between sections of the reflectogram;
- study reflectograms in the "Comparison" and "Difference" modes;
- determine the nature of cable cable faults;
- identify the locations of non-permanent ("flickering") cable faults;



Picture 4-6 "CHANNELS" menu in PULSE mode

At the top of the menu, a status bar with the following parameters is displayed:

- date and time,
- battery charge indicator,
- The name of the mode is "PULSE",
- "MASTER CHANNEL" – MC: L1-N.

The following parameters are displayed under the status bar:

- cursor position K1 – 65.5 m from the origin,
- cursor position is K2 - 184.5 m from the origin,
- distance between the cursors L is 119.00 m,
- cursor step δK - 0.50 m,
- position of the matching knob - Ω 63,
- "DIFFERENCE" mode indicator - D,
- "CAPTURE" mode indicator - C.

In the center of the screen is a grid with graphs. The vertical cursors, denoted above by 1 and 2, are the measuring cursors - the first and second, respectively ("K1" and "K2"). The active cursor is highlighted in yellow.

Selectors of the multifunction buttons F1 - F10 control the following parameters:

- F1 - start ("START") and stop ("STOP") of the measurement,
- F2 - switch to the "LIBRARY" mode,
- F3 - go to the "MENU" mode,
- F4 - go to the "PARAMETERS" mode,
- F5 - activation / deactivation of the L1-N channel, or the memory channel,
- F6 - activation / deactivation of the L2-N channel, or the memory channel,
- F7 - activation / deactivation of the L3-N channel, or the memory channel,
- F8 - activation / deactivation of the L1-L2 channel, or the memory channel,
- F9 - activation / deactivation of the L1-L3 channel, or the memory channel,
- F10 - activation / deactivation of the L2-L3 channel, or the memory channel,

For each channel, the main parameters are displayed in the selector:

- S - Scale,
- T - Pulse Width,
- V - Velocity Factor (VF),
- Σ - Averaging,
- A - Gain,
- Ω - the position of the matching knob.

The measurement parameters can be set in the "PARAMETERS" menu.

Selectors next to the multifunction buttons F1 - F10 control the following parameters:

- F1 - start ("START") and stop ("STOP") of the measurement,
- F2 - switch to the "LIBRARY" mode,
- F3 - go to the "MENU" mode,
- F4 - go to the "PARAMETERS" mode,
- F5 - activation / deactivation of the L1-N channel, or the memory channel,

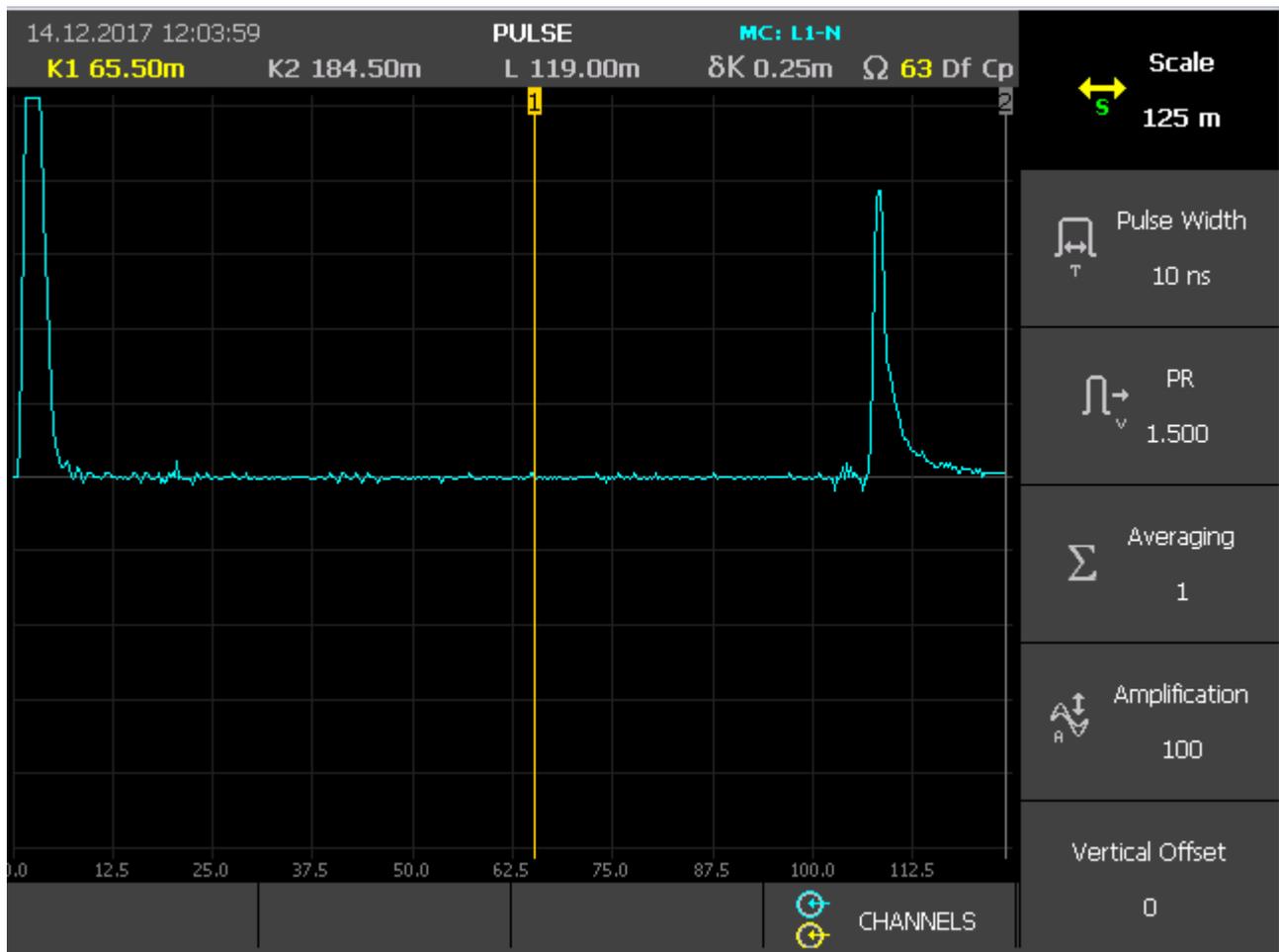
- F6 - activation / deactivation of the L2-N channel, or the memory channel,
- F7 - activation / deactivation of the L3-N channel, or the memory channel,
- F8 - activation / deactivation of the L1-L2 channel, or the memory channel,
- F9 - activation / deactivation of the L1-L3 channel, or the memory channel,
- F10 - activation / deactivation of the L2-L3 channel, or the memory channel,

For each channel, the main parameters are displayed in the selector:

- S - Scale,
- T - Pulse Width,
- V - Velocity Factor (VF),
- Σ - Averaging,
- A - Gain,
- Ω - the position of the matching knob

4.4.2 Menu "PARAMETERS" in PULSE mode (TDR)

Go to the "PARAMETERS" menu by selecting the "PARAMETERS" selector by pressing the F4 button in the "CHANNELS" menu. The menu "PARAMETERS" is shown in Picture 4-7. In the "PARAMETERS" menu, the measurement settings for the current "master channel" are set.



Picture 4-7. "PARAMETERS" in PULSE mode (TDR)

Selectors next to the multifunction buttons F1 - F10 control the following parameters:

- F1 - not used,
- F2 - not used,
- F3 - not used,
- F4 - switch to the "CHANNELS" mode,

- F5 - activate the change in the parameter "SCALE",
- F6 - activation of the change in the parameter "PULSE",
- F7 - activation of the change in the parameter "VF",
- F8 - activation of the change in the parameter " AVERAGING ",
- F9 - activate the change of the parameter "GAIN" (from 0 to 255 units),
- F10 - activation of the change in the parameter "VERTICAL OFFSET".

To change the activated parameters, use the  and  buttons. The changed parameter is automatically applied to the reflectogram of the master channel displayed in the grid of graphs.

Selectors next to the multifunction buttons F1 - F10 control the following parameters:

- F1 - not used,
- F2 - not used,
- F3 - not used,
- F4 - switch to the "CHANNELS" mode,
- F5 - activate the change in the parameter "SCALE",
- F6 - activation of the change in the parameter "PULSE",
- F7 - activation of the change in the parameter "VF",
- F8 - activation of the change in the parameter "AVERAGING",
- F9 - activate the change of the parameter "GAIN" (from 0 to 255 units),
- F10 - activation of the change in the parameter "VERTICAL OFFSET".

4.5 Arc-Reflection mode

The Arc-Reflection mode in the TDR-109 device implements an Arc-Reflection method of localizing high-resistance faults in the cables. The transition to the Arc-Reflection mode is carried out by selecting the "Pulse-Arc" selector in the "MENU" menu by pressing the "F2" key. To exit the Arc-Reflection mode select the "MENU" by pressing the "F3" key.

The Arc-Reflection mode has two menus: "CHANNELS" and "PARAMETERS".

4.5.1 Menu "CHANNELS" in Arc-Reflection mode (ARM)

The transition to the "CHANNELS" menu is carried out immediately when switching to Arc-Reflection mode, or when selecting the "CHANNELS" selector in the "PARAMETERS" menu. The "CHANNELS" menu in the Arc-Reflection mode is shown in Picture 4-8.

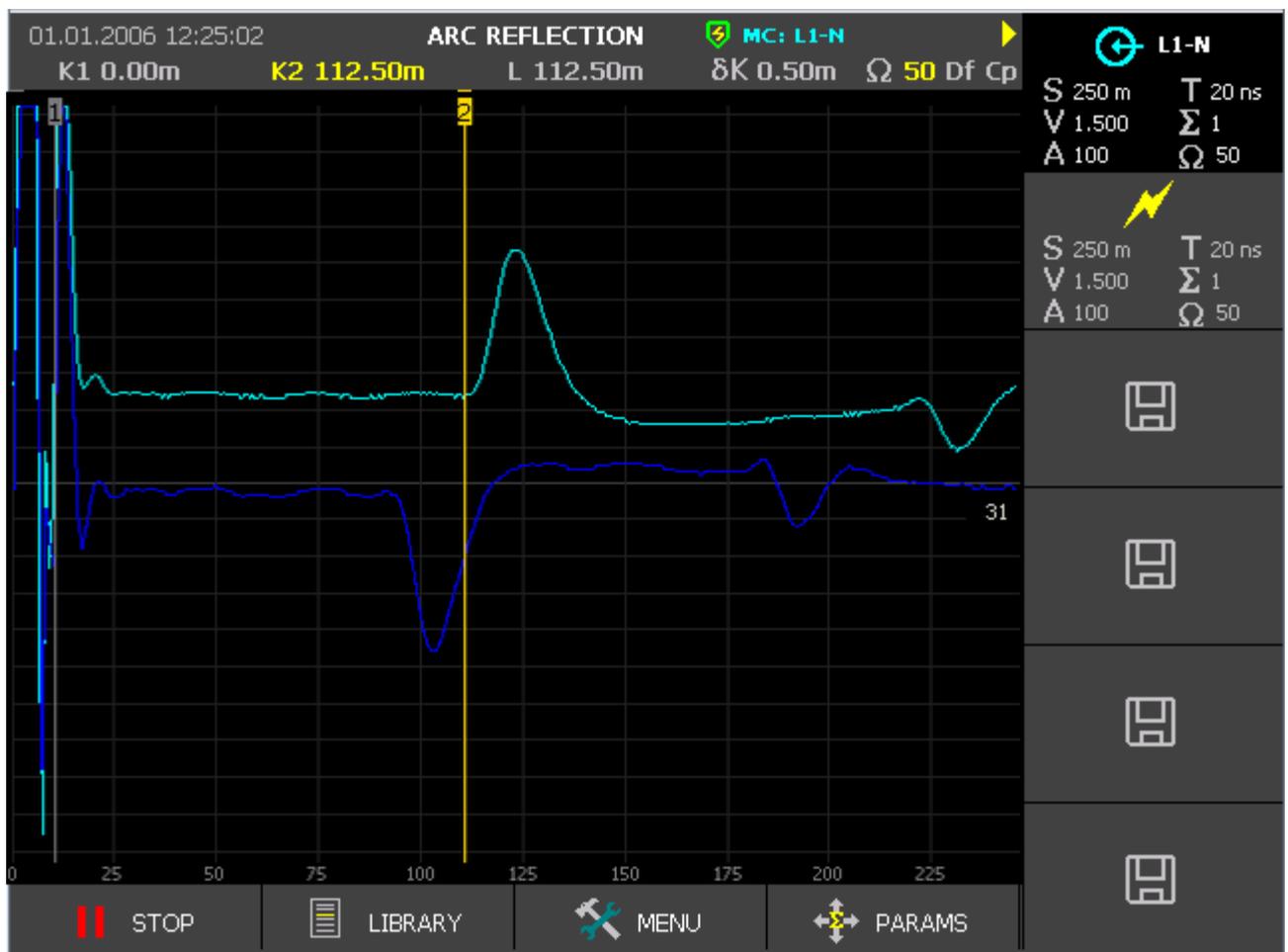
Working with the "CHANNELS" menu allows you to:

- Activate / deactivate the measuring channels and memory channels by successively pressing the "F5" button next to the channel selector, simultaneously displaying the following measuring channels connected to the inputs L1, L2, L3: L1-N, L2-N, L3-N, L1-L2, L1-L3, L2-L3;
- Measure the distance between sections of the reflectogram;
- Study reflectograms in the "Comparison" and "Difference" modes;
- Determine the nature of cable cable faults;
- Identify the locations of non-permanent ("flickering") faults.
- Measure the distance to the burning Arc.

At the top of the menu, a status bar with the following parameters is displayed:

- date and time,
- battery charge indicator,
- The name of the mode is "PULSE-ARC",
- indicator of the activated input protection card of the device inputs,
- "master channel" – MC L1-N.
- The following parameters are displayed under the status bar:
- cursor position K1 - 0 m from the origin,

- cursor position K2 - 112.50 m from the origin,
- distance between cursors L - 112.00 m,
- the cursor step is δK - 0.50 m,
- position of the matching knob - Ω 50 (matching for Arc-Reflection mode is set to constant),
- "Difference" mode indicator - P,
- "Capture" mode indicator - H.



Picture 4-8. "CHANNELS" menu in Arc-Reflection mode (ARM)

At the top of the menu, a status bar with the following parameters is displayed:

- date and time;
- battery charge indicator;
- The name of the mode is "ARC REFLECTION";
- indicator of the activated input protection of the device inputs;

- "master channel" – MC L1-N;

In the center of the screen is a grid with graphs. The vertical cursors, denoted above by 1 and 2, are the measuring cursors - the first and second, respectively ("K1" and "K2"). The active cursor is highlighted in yellow.

Selectors next to the multifunction buttons F1 - F10 control the following parameters:

- F1 - start ("START") and stop ("STOP") of the measurement,
- F2 - switch to the "LIBRARY" mode,
- F3 - go to the "MENU" mode,
- F4 - go to the "PARAMETERS" mode,
- F5 - selection of the measuring channel (the following channels are set as the master channel by cyclic pressing the button: L1-N, L2-N, L3-N, L1-L2, L1-L3, L2-L3)
- F6 - activation / deactivation of the channel with reflection from the arc,
- F7 - activation / deactivation of the memory channel,
- F8 - activation / deactivation of the memory channel,
- F9 - activation / deactivation of the memory channel,
- F10 - activation / deactivation of the memory channel,

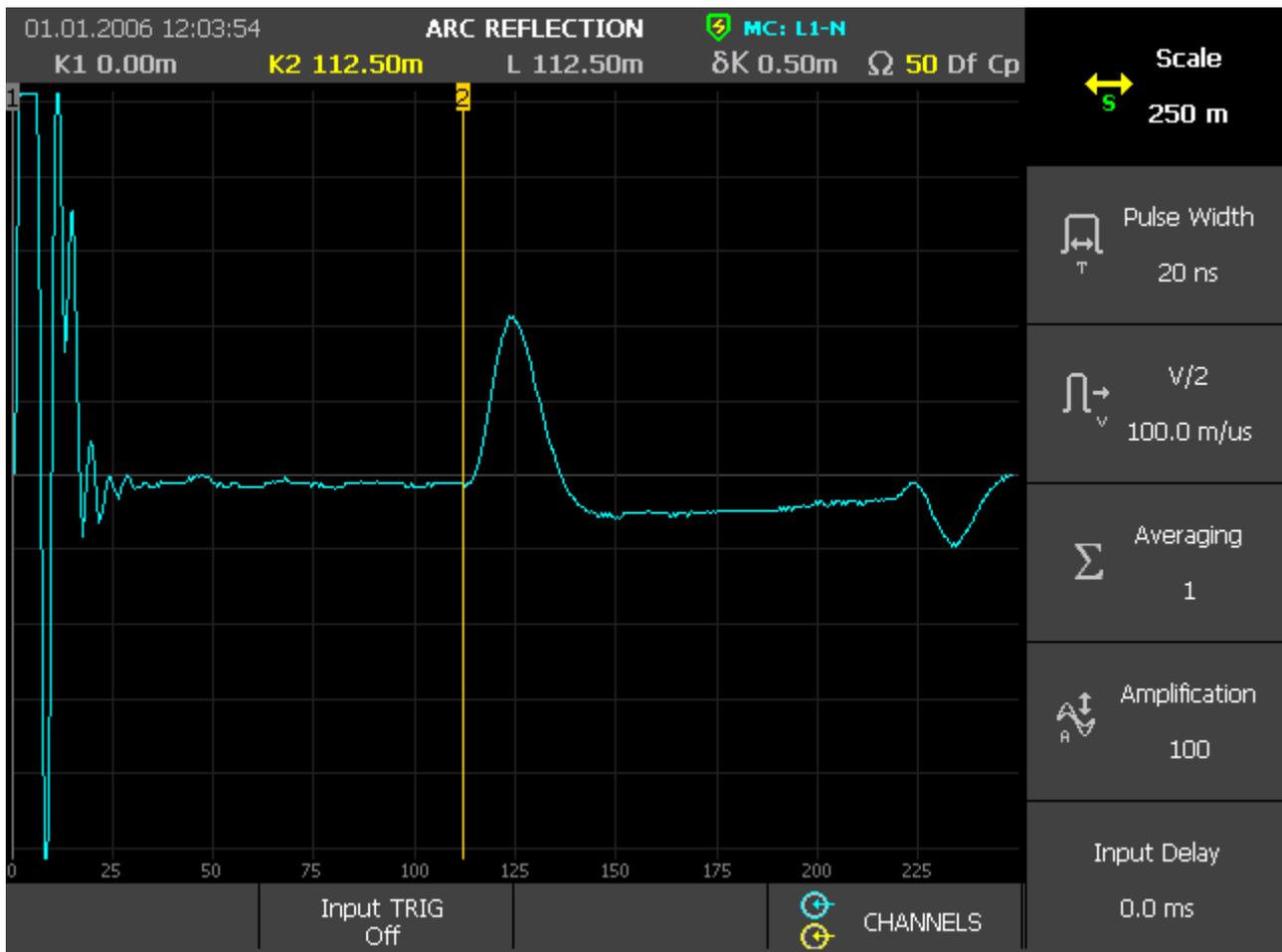
For each channel, the main parameters are displayed in the selector:

- S - Scale,
- T - Pulse Width,
- V – Velocity Factor (VF)
- Σ - Averaging,
- A - Gain,
- Ω - constant matching value - 50.

The measurement parameters can be adjusted via the menu "PARAMETERS".

4.5.2 "PARAMETERS" in Arc-Reflection mode (ARM)

To select the "PARAMETERS" menu press the F4 button in the "CHANNELS" menu. The menu "PARAMETERS" is shown in Picture 4-9. In the "PARAMETERS" menu, the measurement settings for the current "master channel" are set.



Picture 4-9. "PARAMETERS" menu in Arc-Reflection mode

Selectors next to the multifunction buttons F1 - F10 control the following parameters:

- F1 - not used,
- F2 - activation / deactivation of measurement synchronization at the input TRIG,
- F3 - not used,
- F4 - switch to the "CHANNELS" mode,
- F5 - activate the "Scale" parameter (the minimum setting is 250 m),
- F6 - activate the "Pulse Width" parameter,

- F7 - activate the «VF» parameter;
- F8 - activate the "Averaging" parameter (it is possible to set an additional parameter - "Auto", averaging the measurements for the entire arc burning time);
- F9 - activate the parameter "Gain" (from 0 to 255 units),
- F10 - activate the the parameter "Input delay" (time delay between the synchronization signal when measured by the in Arc-Reflection method from 0 to 50 ms, with step 0.2 ms).

To change the activated parameters, use the  and  buttons. The changed parameter is automatically applied to the reflectogram of the master channel displayed in the grid of graphs.

4.6 Wave mode (oscillatory discharge)

The wave mode in the device TDR-109 realizes the method of oscillatory discharge (wave) localization of the high resistance faults with help of HVPG. To implement the oscillatory discharge method in HVPG a voltage connecting device and a current connecting device is necessary. Wave mode TDR-109 allows you to work with both types of connecting devices. To enter wave mode select the "WAVE" selector in the "MENU" menu by pressing the "F3" key. Exit the wave mode by selecting the "MENU" selector by pressing the "F3". The wave mode has two menus: "CHANNELS" and "PARAMETERS".

4.6.1 The "CHANNELS" menu in WAVE mode

The transition to the "CHANNELS" menu is carried out immediately when switching to wave mode, or by selecting the "CHANNELS" selector in the "PARAMETERS" menu. The view of the "CHANNELS" menu in WAVE MODE is shown in Picture 4-10.



Picture 4-10. "CHANNELS" menu in WAVE MODE

Working with the "CHANNELS" menu allows you to measure the distance between the half-cycles of the oscillation process.

At the top of the menu, a status bar with the following parameters is displayed:

- date and time,
- battery charge indicator,
- The name of the mode - "WAVE",
- "MASTER CHANNEL" – MC: U/I.

The following parameters are displayed under the status bar:

- Cursor position K1 - 224.00 m from the origin,
- Cursor position K2 - 336.00 m from the origin,
- Distance between cursors L - 112.00 m,
- Cursor step is δK - 2.00 m,
- Position of the matching knob is Ω (the matching for the wave mode is set to constant),
- DIFFERENCE mode indicator - P,
- CAPTURE mode indicator - H.

In the center of the screen is a grid with graphs. The vertical cursors, denoted above by 1 and 2, are the measuring cursors - the first and second, respectively ("K1" and "K2"). The active cursor is highlighted in yellow.

Selectors next to the multifunction buttons F1 - F10 control the following parameters:

- F1 - start ("START") and stop ("STOP") of the measurement,
- F2 - switch to the "LIBRARY" mode,
- F3 - go to the "MENU" mode,
- F4 - go to the "PARAMETERS" mode,
- F5 - activation / deactivation of the U/I channel,
- F6 - activation / deactivation of the memory channel,
- F7 - activation / deactivation of the memory channel,
- F8 - activation / deactivation of the memory channel,
- F9 - activation / deactivation of the memory channel,
- F10 - activation / deactivation of the memory channel,

For the U / I channel, the main parameters are displayed in the selector:

- S - Scale,
- T - Pulse Width (deactivated),
- V – Velocity Factor (VF)
- Σ - Averaging (deactivated),
- A - Gain,
- Ω - constant matching value - 50.

The measurement parameters can be adjusted via the menu "PARAMETERS".

4.6.2 The "PARAMETERS" menu in WAVE mode

Go to the "PARAMETERS" menu by selecting the "PARAMETERS" selector by pressing the F4 button in the "CHANNELS" menu. The "PARAMETERS" menu is shown in Picture 4-11. In the "PARAMETERS" menu, the measurement settings for the U/I channel are set.



Picture 4-11. "PARAMETERS" menu in WAVE mode

Selectors next to the multifunction buttons F1 - F10 control the following parameters:

- F1 - not used,
- F2 - not used,
- F3 - not used,
- F4 - switch to the "CHANNELS" mode,
- F5 - activation the change of the parameter "Scale",

- F6 - activation the change of the parameter "Pulse Width" (deactivated),
- F7 - activation the change of the parameter "VF" (2.5),
- F8 - activation the change of parameter "Averaging" (deactivated),
- F9 - activation the change of the parameter "Gain" (from 0 to 255 units),
- F10 - activation the change of the "Threshold" parameter (the range for setting the measurement threshold is -60 to 60 V, 2 V step).

To change the activated parameters, use the  and  buttons. The changed parameter is applied after the measurement is restarted in the "CHANNELS" menu.

4.7 Calibration mode

The calibration mode is intended for verification operations of the TDR-109. The calibration mode uses the pulse measurement method, while the L1-N channel is fixed as the signal output, and the L2-N channel is fixed as the signal input. The control of the parameters of the calibration mode corresponds to the control of the parameters of the pulse mode.

Enter the calibration mode by pressing the "F4" button in front of the "CALIBRATION" selector in the "MENU" mode.

4.8 The “LIBRARY” menu

The "LIBRARY" menu is designed to work with non-volatile memory of the device and consists of two submenus: "LIBRARY OF REFLECTOGRAMS" and "LIBRARY VF".

4.8.1 "WAVEFORMS LIBRARY" submenu

Go to the LIBRARY menu by pressing the F1 button next to the selector in the LIBRARY menu.

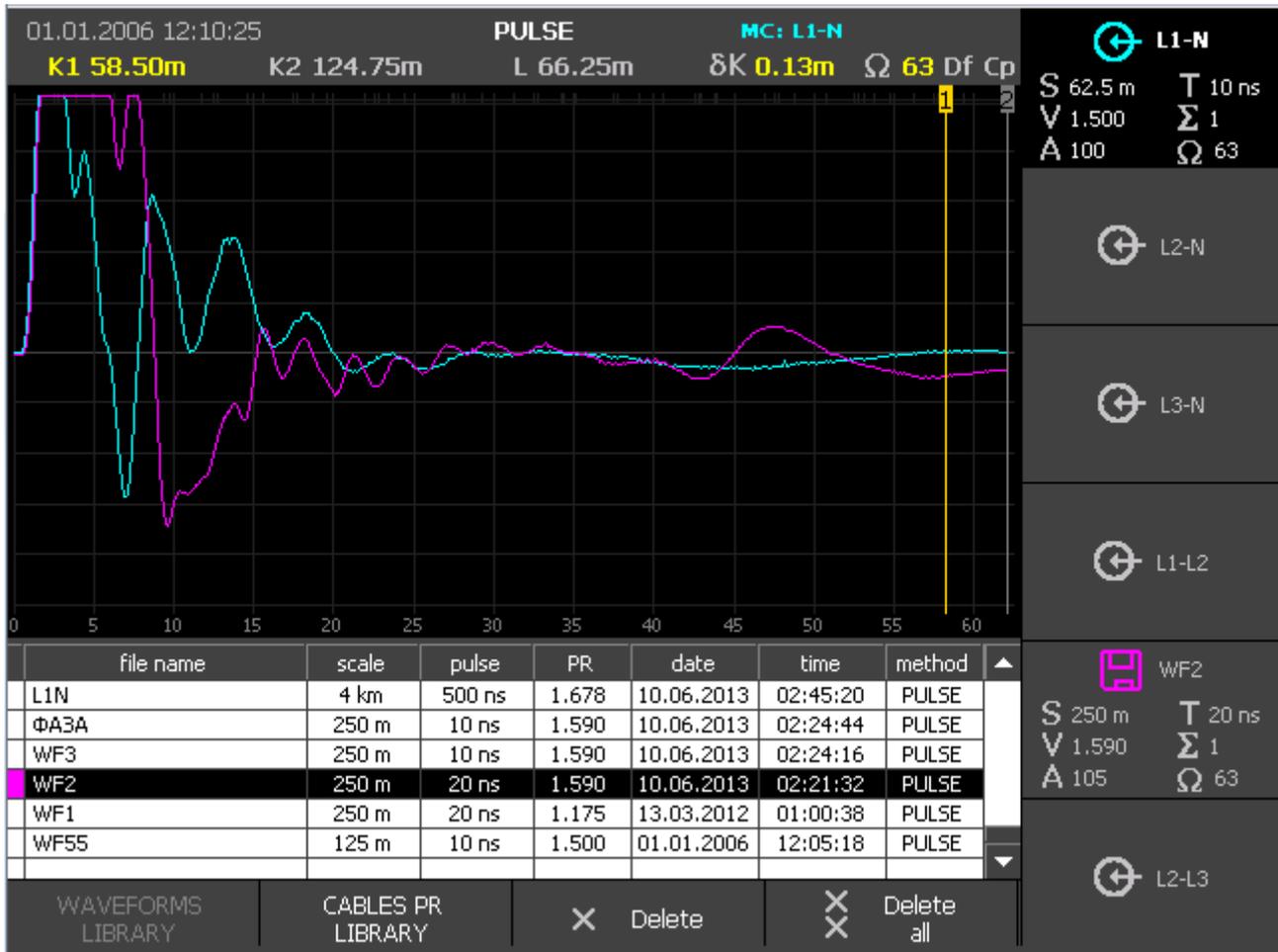
The “WAVEFORMS LIBRARY” menu allows you to view the list of waveforms stored in nonvolatile memory of the device, load them into memory channels (selectors) for subsequent comparison, and also to delete unnecessary waveforms from the library.

The general view of the " WAVEFORMS LIBRARY" menu is shown in Picture 4-12.

Directly under the grid of graphs is a waveforms library, presented in the form of a table.

The main columns of the table are:

- "FILE NAME" - the user's directly entered name of the saved reflectograms;
- "SCALE" - the measurement range on which the graph was observed;
- "PULSE" is the set duration of the probe pulse;
- "VF" - the established coefficient of velocity factor;
- "DATE" is the calendar date for saving the schedule; "time" is the time of its preservation, "method" is the method of measurement.



Picture 4-12. Waveforms Library

Selectors next to the multifunction buttons F1 - F10 control the following parameters:

- F1 - "Waveforms Library",
- F2 - go to "Cables Library" submenu,
- F3 - delete the selected waveforms - "Delete",
- F4 - delete all waveforms from the library - "Delete all",
- F5 - activation / deactivation of the L1-N channel, or the memory channel,
- F6 - activation / deactivation of the L2-N channel, or the memory channel,
- F7 - activation / deactivation of the L3-N channel, or the memory channel
- F8 - activation / deactivation of the L1-L2 channel, or the memory channel
- F9 - activation / deactivation of the L1-L3 channel, or the memory channel
- F10 - activation / deactivation of the L2-L3 channel, or the memory channel

- For each channel, the main parameters are displayed in the selector:
- S - Scale,
- T - Pulse Width,
- V - established Velocity Factor (VF)
- Σ - Averaging,
- A - Gain,
- Ω - the position of the matching knob.

To navigate through the library, use the buttons  and . To display the waveforms on the screen, select the desired one and activate it in the channel selector (with the "F5-F10" buttons).

4.8.2 "CABLES LIBRARY" submenu

You can go to the "CABLES LIBRARY" menu by pressing the "F2" button opposite the "CABLES LIBRARY" selector in the "LIBRARY" menu.

The menu is intended for viewing, editing and setting the value of the cable velocity factors of different brands. The general view of the "CABLES LIBRARY" menu is shown in Picture 4-14.

The central part of the display is a table of two columns: "cable type" and "value". The table lists the names of cables of different brands and the corresponding values of the VF.

01.01.2006 12:14:27		PULSE	MC: L1-N	
cable type		PR		
StYHS2Y PE 1 × 25 rm/10 Al 110 kV		2.154		Set
A2YHS2Y PE 1 × 300 rm/50 Al 110 kV		1.719		
A2YHS2Y PE 1 × 300 rm/50 Al 30 kV		1.729		
NHEKBA Paper-Oil 3 × 70 rm Al 30 kV		1.874		Add
NHEKEBA Paper-Oil 3 × 95 rm Al 30 kV		1.874		
NHKBA Paper-Oil 3 × 70 rm Al 30 kV		1.874		
A2YHSY PE 1 × 50 rm/16 Al 20 kV		1.764		
A2XHS2Y PE 1 × 120 rm/16 Al 20 kV		1.790		
A2YHSY PE 1 × 150 rm/25 Al 20 kV		1.732		
A2YHSY PE 1 × 185 rm Al 20 kV		1.723		
NHEKBA Paper-Oil 3 × 50 rm Al 20 kV		2.053		
NHEKBA Paper-Oil 3 × 120 rm Al 20 kV		2.039		
NKBA Paper-Oil 3 × 25 sm Al 10 kV		1.828		
NKBA Paper-Oil 3 × 35 sm Al 10 kV		1.806		
NKBA Paper-Oil 3 × 70 Al 10 kV		1.897		
NKY Paper-Oil 3 × 50 Al 10 kV		2.562		
NA2YSY PE 3 × 150/16 Al 10 kV		1.972		
NA2XS (F) 2Y VPE 3 × 150 rm/25 Al 10 kV		1.851		
NAKBA Paper-Oil 3 × 95 sm Al 10 kV		1.839		
NAKBA Paper-Oil 3 × 185 sm Al 10 kV		1.828		
NAKBA Paper-Oil 3 × 240 sm Al 10 kV		1.839		

WAVEFORMS LIBRARY
CABLES PR LIBRARY
X Delete
X Delete all

Picture 4-14. "CABLES LIBRARY" submenu

Selectors next to the multifunction buttons F1 - F10 control the following parameters:

- F1 - transition to the "WAVEFORMS LIBRARY" mode,
- F2 – «CABLES LIBRARY»,
- F3 - delete the selected cable type - "Delete",
- F4 - delete all cables type from the library - "Delete All",

-
- F5 - selector "Set" is intended for installation of the Velocity Factor as the operating value;
 - F6 - selector "Add" is intended to add a new Velocity Factor to the library.
 - F7 - not used.
 - F8 - not used.
 - F9 - not used.
 - F10 - not used.

4.9 "MENU" mode

The "MENU" mode in the TDR-109 is designed for:

- control of the basic settings of the device,
- selecting measurement modes,
- data exchange between the internal memory of the device and an external USB flash drive, see the information about the device.

14.12.2017 12:01:45		MENU		
Propagation parameter type	PR			Export Waveforms Library
Calendar	14.12.2017 12:01:45			
Automatic switch off	Off			Import Waveforms Library
Default file name	WF			
Interface language	English			Export Cables Library
Measurement repeat	Automatic			
Outgoing pulse amplitude	U1			Import Cables Library
				Reset settings to factory default
				About this device
Pulse	Arc Reflection	Wave	Calibration	

Picture 4-15. "MENU" mode

The transition to the "MENU" mode is performed when the device is turned on, or by pressing the "F3" button in front of the "MENU" selector in the "CHANNELS" menu of any of the measurement modes. The general view of the "MENU" mode is shown in Picture 4-15.

The central part of the display is a table of two columns: the left column is the name of the parameter, the right is the current value of the parameter. Use the and buttons to navigate through the menus. To control the setting, use the button .

Selectors next to the multifunction buttons F1 - F10 control the following parameters:

- F1 - switch to the "PULSE" mode,
- F2 - switch to the "ARC REFLECTION" mode,
- F3 - switch to the "WAVE" mode,
- F4 - switch to the "CALIBRATION" mode,
- F5 - selector "EXPORT WAVEFORMS LIBRARY" is designed to create a backup copy of the waveforms library on an external USB-Flash drive;
- F6 - selector button "IMPORT WAVEFORMS LIBRARY " is intended to restore the library of waveforms from a backup copy from an external USB-Flash drive;
- F7 - Selector "EXPORT CABLES LIBRARY" is designed to create a backup copy of the cables library on an external USB-Flash drive;
- F8 - Selector "IMPORT CABLES LIBRARY " is intended to restore the cableslibrary from a backup copy from an external USB-Flash drive;
- F9 - the "RESET SETTINGS" selector, which is used to return to the factory settings;
- F10 - the "About the device" selector is used to call information about device.

4.10 Display waveforms on the instrument display

In the central part of the display of each measurement mode, in the "PARAMETERS" and "CHANNELS" menu, a coordinate system is represented, the horizontal axis of which is a distance scale. The waveforms are shown by their own color. They can be vertically displaced relative to each other. The channels of the waveforms display are divided into "measuring channels" and "memory channels".

4.11 Master-channel

By "master channel" is meant one of the possible channels displayed on the screen of the device, which can not be deactivated. The "master channel" selection is made by successive pressing of the "F11" key in the "CHANNELS" menu, the "fixed channel" selector has black background (see Picture 4-3).

If the master channel is selected from the L1-N channel (L2-N, L3-N, L1-L2, L1-L3, L2-L3), the following functions are available when working with it:

- Save the reflectograms;
- Vertical offset of the reflectograms;
- Pointwise subtraction of other channels from it;

If the "master channel" is selected from the waveforms library, the following functions are available when working with it:

- Vertical offset of the reflectograms;
- Pointwise subtraction of other channels from it

5 Operation of the device

5.1 Safety precautions

Working with TDR-109 is allowed only for people who have read this User Manual.

TDR-109 does not operate with life-threatening voltages.

When operating the TDR-109 with the simultaneous charge of the battery through the charger, do not open the device body.

When working on different cable routes, personnel must comply with safety regulations for working on this type of cable route.

5.2 Preparation and operation procedures

5.2.1 Before operation, TDR-109 is inspected visually. In this case, special attention should be paid to the marking of the controls, the absence of visible damage

5.2.2 Before operation:

- The «Balance» knob is in the middle position;
- to the sockets "L1" ("L2", "L3") is connected the investigated cable,
- "TRIG" ("U/I") (if necessary) are connected to the jacks.

CAUTION: Before connecting to the cable, make sure that there is no voltage on the cable.

DO NOT: measure on live cables.

5.3 Switching the device on

To turn on the device, press and hold the button  within one second. The screen lights up, after 15 seconds the device loads the "MENU" mode and is ready to take measurements.

5.4 Setup of TDR-109

5.4.1 Setting the Propagation Parameter type

The device TDR-109 provides two options for displaying the speed of propagation of electromagnetic waves in the cable cable: PF and half speed ($V / 2$). To set the display of the propagation speed, you must:

- Enter the "MENU" mode;
- Using the buttons  and  select the "Propagation Parameter type" and press the button ;
- Select in the drop-down list of possible values using the buttons  and ;
- To confirm press the button .

5.4.2 Calendar settings

To set the calendar, you must:

- Enter the "MENU" mode;
- Using the buttons  and  select the cable "Calendar" and press the button .
- Using the buttons  and  select the parameter for editing (day, month, year, hour, minute, second);
- Using the buttons  and  increase or decrease the selected parameter;
- in confirmation press the button .

5.4.3 Setting the device's auto-off timer

TDR-109 provides the function of automatic power-off (with saving settings) in case of idle time (the buttons are not pressed). To set the device's auto-off, you must:

- Enter the "MENU" mode;
- Using the buttons  and  select the cable "Auto power off" and press the button .
- In the drop-down list of possible values using the buttons  and  select the desired value (off, 2 minutes, 4 minutes, 8 minutes, 32 minutes, 64 minutes);
- in confirmation press the button .

5.4.4 Set the default waveform file name

To change the name of the default name of the saving waveform file, you must:

- enter the "MENU" mode;
- using the buttons  and  select the cable "Default file name" and press the button .
- Press the "F1" button to select the characters sets;
- Press "F2" to select the input of symbols or numbers;
- to enter a symbol - logically press the desired button on the keyboard;
- to delete a character, press the button .
- to finish editing, press the button .

5.4.5 Setting Language Parameters

The device TDR-109 provides switching the language interface. To set the language parameters of the device you need:

- enter the "MENU" mode (4.9);
- using the buttons  and  select "Interface Language" and press the button .
- in the drop-down list of possible values using the buttons  and  select the desired language;
- press button  to confirm.

5.4.6 Reset settings

To return to the factory settings:

- enter the "MENU" mode;
- using the buttons  and  select "Reset settings" and press the button .
- pop-up window "Back to factory settings?" - in confirmation press the button .
- turn TDR-109 off and on again.

5.5 Connecting the device to the testing cable

CAUTION: Before connecting to the cable, make sure that there is no voltage on the cable.

DO NOT: measure on live cables.

To connect a device to a test cable, you must:

- connect the testing cable to the "L1" ("L2", "L3") connector, if necessary, using the supplied connection cable;
- connect the HVPG device to the "TRIG" ("U / I") connector, if necessary, using a connecting cable;
- Establish a method for connecting the testing cable

5.6 Setting the operating mode in the TDR-109

To set the operating mode of measurement, you must:

- enter the "MENU" mode;
- Select the operating mode (PULSE, ARC-REFLECTION, WAVE or Calibration) using the F1-F4 buttons.

5.7 Settings the measurements parameters in the TDR-109

5.7.1 Setting the method of connection of the measured cable

5.7.1.1 In the **PULSE** mode:

- enter the "PARAMETERS" menu;
- Activate / deactivate channels L1-N, L2-N, L3-N, L1-L2, L1-L3, L2-L3 using the buttons "F5-F10" respectively. In this case, the channel reflectogram of the corresponding color is displayed in the grid of graphs.

5.7.1.2 In **Arc-Reflection** mode:

- enter the "PARAMETERS" menu;
- to activate / deactivate channels L1-N, L2-N, L3-N, L1-L2, L1-L3, L2-L3 by cyclic pressing the "F5" button.

5.7.1.3 In the **WAVE** mode: the U / I channel is automatically set.

5.9.1.4 In the **Calibration** mode, the L1-N channel is the output, L2-N - the input is set automatically.

5.7.2 Setting the measurement subband

To set the measurement scale, you must:

- enter the "PARAMETERS" menu;
- press the "F6" button opposite the "Scale" selector;
- with the buttons  and  select a scale.

5.7.3 Setting the pulse width

To set the pulse width, you must:

- enter the "PARAMETERS" menu;
- Press the "F7" button opposite the "Pulse" selector;
- with the buttons  and  choose the Pulse Width from: 10 ns, 20 ns, 50 ns, 100 ns, 200 ns, 500 ns, 1 μ s, 2 μ s, 5 μ s, 10 μ s, 20 μ s, 50 μ s, 100 μ s.

5.7.4 Setting the VF (PF or V/2)

To set the VF, you must:

- enter the "PARAMETERS" menu;
- press the "F8" button opposite the "VF" selector;
- with the buttons  and  choose a numerical value;

5.7.5 Setting Averaging

To set the averaging parameter to suppress asynchronous noise, you must:

- enter the "PARAMETERS" menu;
- press the "F9" button opposite the "Averaging" selector;
- with the buttons  and  choose a numerical value;

5.7.6 Setting the Gain

To set the gain, you need:

- enter the "PARAMETERS" menu;
- press the "F10" button opposite the "Gain" selector, while the selector is activated by a certain color;
- with the buttons  and  choose a numerical value от 0 до 255.

5.7.7 Setting the reflectogram shift

To shift the reflectogram graph along the vertical, it is necessary:

- enter the "CHANNELS" menu;
- successively press the "F11" button to set the "master channel", which must be shifted vertically;
- with the buttons  and  move the master channel vertically.

In the pulse mode, an alternative method of setting the master channel shift is possible:

- enter the "PARAMETERS" menu;
- Press the "F10" button opposite the "Vertical Shift" selector,
- with the buttons  and  select a numeric value from -200 to +200.

5.7.8 Output impedance matching

5.7.8.1 In the pulse mode

To match the output impedance of the TDR-109 with the input resistance of the tested cable, it is necessary:

- enter the "CHANNELS" menu or the "PARAMETERS" menu;
- rotate the "BALANCE" knob for measurement channels, while the relative position of the "BALANCE" knob is displayed next to the " Ω " icon (from 0 to 63) in the information cable of the selected channel.

ATTENTION: the criterion of the best matching is the minimum value of the amplitude of multiple reflected signals.

5.7.8.2 In Arc-Reflection mode

In Arc-Reflection mode, the output impedance of the TDR-109 is automatically set according to the input impedance of the HVG connection device (Ω 50).

5.7.8.3 In the Wave mode

In the wave mode, the output resistance of the TDR-109 is automatically set according to the input resistance of the HVG connection device (Ω 50).

5.7.8.4 In the calibration mode

In the calibration mode, the output impedance of the TDR-109 is set in the same way as the setting in the pulse mode.

5.7.9 Setting the synchronization method in Arc-Reflection mode

In Arc-Reflection mode, the measurements can be synchronized either from the signal from the measuring input or from the signal at the TRIG input. To set the synchronization method, you must:

- enter the "PARAMETERS" menu;
- Press the "F2" button to activate the TRIG input synchronization ("TRIG input ON"), or to activate the synchronization via the measuring input of the master channel ("TRIG OFF").

5.7.10 Setting the time delay in Arc-Reflection mode

In Arc-Reflection mode, you can enter a delay between the synchronization signal and the start of the measurement. The delay allows you to select a more successful arc-burning time to obtain a high-quality response. To set the delay, you must:

- enter the "PARAMETERS" menu;
- Press the "F10" button to activate the "Input delay" selector,
- with the buttons  and  select a numeric value from 0 to 50 ms, step 0,2 ms.

5.7.11 Setting the threshold in Wave Mode

In wave mode, you can set the trigger threshold. Thus, when the threshold of the amplitude of the oscillation discharge process is reached, the TDR-109 starts the measurement. To set the threshold, you must:

- enter the "PARAMETERS" menu (4.6.2);
- Press the "F10" button to activate the "Threshold" selector,
- with the buttons  and  select a numeric value from -60 to 60 V, step 2 V.

5.7.12 Setting the measurement repeat

The TDR-109 allows measurements in the mode with repeated automatic restart or with manual one-shot starting of each measurement. To change this mode, you need:

- enter the "MENU" mode,
- with the buttons  and  select "Repeat measurements" and press the button ,
- with the buttons  and  Select "Automatic" or "Manual" and press the button .

5.7.13 Setting the probe pulse amplitude

The TDR-109 allows measurements with probe pulse amplitude of at least 10 V (U1) and at least 45 V (U2) (see Table 2-1). To set the amplitude of the probe pulse, it is necessary:

- enter the "MENU" mode,
- with the buttons  and  select "Pulse amplitude" and press the button ,
- with the buttons  and  select "U1" or "U2" and press the button .

5.7.14 Setting the "Zoom"

To zoom the reflectogram around an arbitrary point on the graph (Zoom mode), you need:

- enter the "CHANNELS" menu or the "PARAMETERS" menu;
- with the button  make the measuring cursor "K1" ("K2") active;
- with the buttons  and  select the desired point on the reflectogram chart;
- click on the button  for stretching a graph or a button  to narrow the schedule in Zoom mode;
- to control the step of the cursor δK at the top of the screen, at the same time, the maximum possible cursor pitch is 256 m, and the minimum step is 0.01 m.

5.7.15 Setting the Difference Mode

The device provides a special mode of point-by-point subtraction, designed to suppress synchronous interference and analysis of differences in reflectograms. To set the mode "Difference" you need:

- enter the "CHANNELS" menu;
- successively press the "F11" button to set the "master channel" from which the subtraction will be made;
- successively press the "F11" button to set the "master channel" from which the pointwise subtraction will be made;
- see the master channel reflectogram unchanged and the difference charts of the other channels;
- to exit the mode, press the "F12" button.

5.7.16 Setting the Capture Mode

The device has a special mode for fixing all changes in the reflectogram on the screen for an arbitrary time interval, designed to detect "flickering" defects, i.e. having an unstable in time character. To set the "Capture" mode, you must:

- establish the method of connection of the testing cable;
- enter the "CHANNELS" menu or the "PARAMETERS" menu;
- press the button .

-
- control the selection of the caption "C" at the top of the screen;
 - to exit the mode, you must press any button (except , ,  and ).

5.8 Measuring the distance to the fault (heterogeneity) of the cable

To measure the distance to the heterogeneity:

- set the required parameters of the device;
- connect the device to the testing cable;
- perform analysis of the reflectogram of the testing cable (Table 4-1)
- Use the  button to activate cursor "K1" or "K2";
- Use  and  buttons to set the cursor position at the beginning of heterogeneity area; (positive response - the testing cable is open at the far end, the negative response - the testing cable is closed at the far end);
- Determine the distance numeric value "K1" ("K2") at the top of the screen;

ATTENTION. For the correct interpretation of results, it is necessary to establish the velocity factor corresponding to the type of cable measured line.

ATTENTION. Connecting the measured line to the device with connecting cables, take into account their length when determining distance values.

ATTENTION. The most accurate cursor positioning in the heterogeneity response area is achieved in "Zoom" mode.

5.9 Measuring distance between heterogeneities of the cable line

To measure the distance between heterogeneities of the cable line:

- set the required parameters of the device;
- connect the device to the testing line;
- perform analysis of the reflectogram of the investigated line;
- Use the  button to activate cursor "K1";
- Use  and  buttons to set the cursor position at the beginning of the first heterogeneity front;
- Use the  button to activate cursor "K2";
- Use  and  buttons to set the cursor position at the beginning of the second heterogeneity front;
- Determine the distance numerical value next to "L =" in the upper part of the screen just above the grid.

5.10 Measuring the Velocity Factor knowing in advance the length of the cable

You can measure Velocity Factor value if you know in advance the length of some cable section (for ex. the entire length of the cable, distance to known joint etc.)

To measure velocity factor do following:

- set the required parameters of the device;
- connect the device to the testing line;
- perform analysis of the reflectogram of testing line;
- Use the  button to activate cursor "K1" or "K2";
- Use  and  buttons to set the first cursor to the front of reflected signal from the start of the section; (positive response - the investigated line is open at the far end, the negative response - the testing line is closed at the far end);
- Without moving the cursors adjust the Velocity Factor value, achieving equality distance $L=|K1-K2|$ to the known length of the measured cable section.

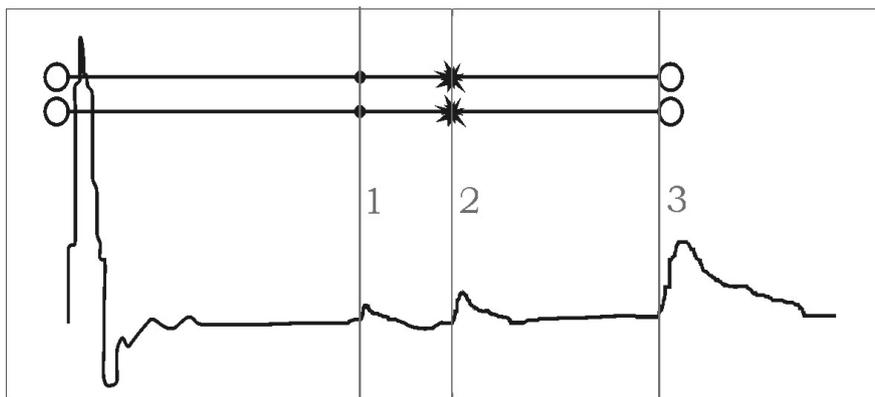
ATTENTION. Connecting the testing line to the device by connecting cables, take into account their length when determining distance values.

5.11 Analysis of the characteristic of the investigated cable

NOTE to Pictures 6-1 to 6-4: the testing cable is schematically shown, in the lower part - the reflectogram of this cable.

5.11.1 Determining the distances to the cable joints, breaks

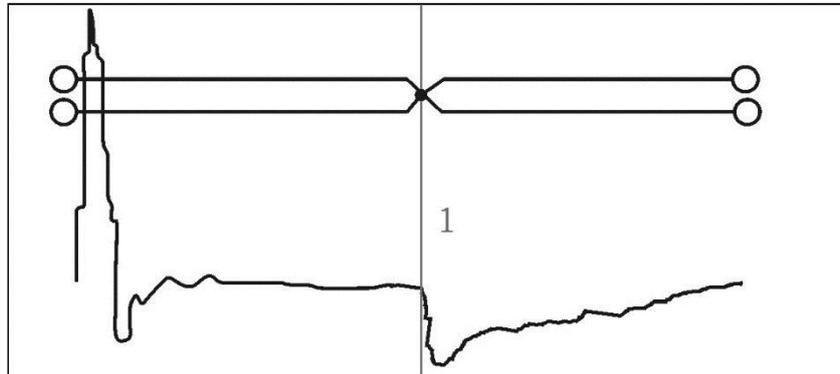
Reflection from the cable joint has a positive polarity. The quality of the cable joint can be estimated by the amplitude of the reflected signal. Instrument allows to distinguish several discrete heterogeneities. Cursor 1 is pointed to a positive polarity reflected pulse, indicating the presence of the joint in the cable cable. Cursor 2 is pointed to the reflection of another more distant joint. Second joint looks worse than first joint, because it has some bigger reflection. The cursor at position 3 points to the break (or the end of the cable).



Picture 6-1 Joints and break

5.11.2 Determining the distance to the short circuit between the conductors

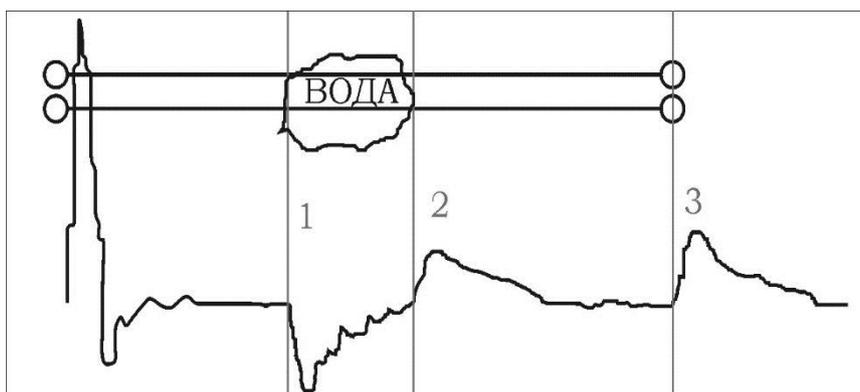
Reflection of heterogeneity typical of the cable cores short-circuit, expressed in the presence of negative polarity response. The cursor position 1 pointed to the reflected pulse of negative polarity, indicating the presence of a short circuit in the cable cable. The reflected pulse from the end of the cable cable is missing.



Picture 8.6 "Wet" section

5.11.3 Determining the distance to the "wet" section of the cable

The heterogeneity caused by cable branch in the cable is lengthy also. By type of waveform branch resembles "wet" cable. The difference is that the branch section is uniform. To determine the distance to the branch is necessary to point the cursor at the beginning of heterogeneity. If the length of the branch exceeds the remaining section of the cable, it is possible the complete disappearance of the reflected pulse from the end of the cable. The cursor position 1 is observed a reflected pulse and its form indicates whether the parallel branch in the cable and ends at cursor position 2.

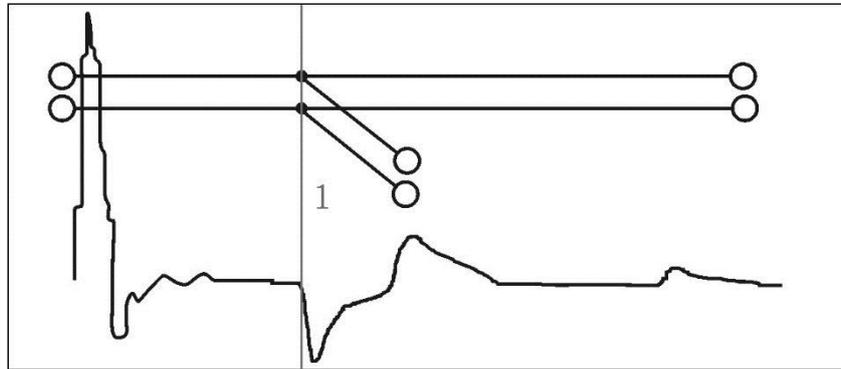


Picture 8.6 "Wet" section

5.11.4 Determining the distance to the cable branch

The heterogeneity caused by cable branch in the cable is lengthy also. By type of waveform branch resembles "wet" cable. The difference is that the branch section is uniform. To determine the distance to the branch is necessary to point the cursor at the beginning of heterogeneity. If the length of the branch exceeds the remaining section of

the cable, it is possible the complete disappearance of the reflected pulse from the end of the cable. The cursor position 1 is observed a reflected pulse and its form indicates whether the parallel branch in the cable.



Picture 8.7 Cable branch

5.12 Working with the Library

5.12.1 Working with Waveform Library

5.12.1.1 Saving waveform to the library:

To save waveform to the library:

- get the reflectogram with the required parameters in the "CHANNELS" menu;
- As a master channel select the channel with waveform you want to save;
- press ;
- press  and in the pop-up window: "Save the waveform of channel x?" press button  to confirm or "Esc" to cancel;
- The device automatically opens the window "WAVEFORMS LIBRARY";
- Specify a name for the waveform (or leave the default name)
- When the editing is finished, press the  button, TDR-109 automatically switches to the menu from which the save operation was performed.

ATTENTION. The device automatically saves the probing parameters used to get the waveform. The following settings are saved:

- measuring mode;
- measurement subrange;
- duration of the probe pulse;
- amplification of the input signal;
- matching output impedance;
- VF;
- averaging factor;
- date and time.

5.12.1.2 Loading waveform from the Waveform Library

The instrument lets you load and display up to 6 waveforms. It is possible to simultaneously work with the data coming from the measuring inputs. To load the waveform from the library to the memory channel:

- Open the window "WAVEFORMS LIBRARY"
- Use  and  buttons to select the appropriate waveform from the library;

- By pressing any of the buttons "F5" - "F10" in front of the selectors, output the reflectogram from memory to the screen, a selector is activated with a certain color, and in the grid of graphs, a reflectogram of the corresponding color is observed;
- To exit the "WAVEFORMS LIBRARY" menu, press the button , while the TDR-109 automatically switches to the menu from which you entered the "WAVEFORMS LIBRARY" menu.

ATTENTION: when the master channel is changed for all displayed graphs, the master channel parameters are set.

5.12.1.3 Delete waveform from the Waveform Library

To delete waveform from the library:

- Open the window "WAVEFORMS LIBRARY";
- Use  and  buttons to select the appropriate waveform from the library;
- Press "F3" opposite "Delete" selector;
- In the pop-up window: Delete the selected waveform from the memory? - Confirm the action by pressing the button ;
- To exit the "WAVEFORMS LIBRARY" menu, press the button , while the TDR-109 automatically switches to the menu from which you entered the "WAVEFORMS LIBRARY" menu.

5.12.1.4 Clear Waveform Library

To clear library:

- Open the window "WAVEFORMS LIBRARY";
- Press "F5" opposite "Delete all" selector;
- In the pop-up window: "Delete all waveforms from the memory?" - Confirm the action by pressing the button  or press "Esc" to cancel;
- To exit the "WAVEFORMS LIBRARY" menu, press the button , while the TDR-109 automatically switches to the menu from which you entered the "WAVEFORMS LIBRARY" menu.

5.12.1.5 Export waveform library to USB-Flash

To export waveform library to the USB-Flash:

- Open the window "MENU";

- Insert USB-Flash into the USB-port;
- Wait until the device identifies the USB-Flash (flashing USB-Flash LED);
- Press "F5" opposite "Export waveforms library";
- At the end of the copying window pops up: "Waveforms library successfully exported to a folder (the path to the folder)" - confirm the action by pressing the button .

5.12.1.6 Import waveform library from USB-Flash

To import waveform library from USB-Flash into the device internal storage:

- Open the window "MENU";
- Insert USB-Flash into the USB-port;
- Wait until the device identifies the USB-Flash (flashing USB-Flash LED);
- Press "F2" opposite "Import waveforms library";
- Use  and  buttons to select the folder;
- Press , a window pops up: "You're going to import the library to replace the current one. Do you want to export the current library?" – Press button , to backup current library into an external drive before replacing. Press  to proceed action without backup;
- After copying window pops-up: "WAVEFORMS LIBRARY successfully imported" - confirm the action by pressing the button .

5.12.2 Working with Cables Library

5.12.2.1 Applying Velocity Factor (VF) from the Cables Library

To apply Velocity Factor (VF) value from the library to the Master Channel:

- Enter the "CABLES VF LIBRARY" window (see 6.4.4);
- Use  and  buttons to select the appropriate cable value from the list;
- Press "F5" opposite "Set" selector;
- In the pop-up window "Set VF = ... ?" - confirm it by pressing , while the TDR-109 automatically switches to the menu from which you entered.

5.12.2.2 Adding Velocity Factor (VF) into the Cables Library

To add new VF value:

- Enter the "CABLES VF LIBRARY" window;
- Press "F6" opposite "Add" selector;
- Enter the name of the cable;
- press , "value" column is selected;
- Using  and  buttons set the velocity factor value;
- press , the new VF value is added to the table

5.12.2.3 Deleting Velocity Factor (VF) from the Cables Library

To delete VF value from the library:

- Enter the "CABLES PF LIBRARY" window;
- Use  and  buttons to select the appropriate VF value from the library;
- Press "F3" opposite "Delete" selector;
- In the pop-up window "Delete velocity factor value from the library?" - confirm it by pressing 

5.12.2.4 Clear Cables Library

To clear library do following:

- Enter the " CABLES VF LIBRARY " window;
- Press "F4" opposite "Delete all" selector;
- In the pop-up window "Delete all velocity factor values from the library?" - confirm it by pressing 

5.12.2.5 Export Cables Library to USB-Flash

To export Cables Library to USB-Flash:

- Open the window "MENU";
- Insert USB-Flash into the USB-port;
- Wait until the device identifies the USB-Flash (flashing USB-Flash LED);
- Press "F7" opposite "Export Cables Library" selector;

- At the end of the copying on the screen TDR-109 window pops up: "Cables Library successfully exported to a folder (the path to the folder)" - confirm the action by pressing the button .

5.12.2.6 Import Cables Library from USB-Flash

To import Cables Library from USB-Flash into the device internal storage:

- Open the window "MENU";
- Insert USB-Flash into the USB-port;
- wait until the device identifies the USB-Flash (flashing USB-Flash LED);
- press "F8" opposite "Import Cables Library " selector;
- Using  and  select folder;
- press , a window pops up: "You're going to import the library to replace the current one. Do you want to export the current library?" – Press button  to backup current library into an external drive before replacing. Press  to proceed action without backup;
- After copying window pops-up: "Cables Library successfully imported" - confirm the action by pressing the button .
- NOTE: Copying the velocity factor values is only possible if it was kept unchanged name and path to the folder, automatically assigned to it after the "EXPORT CABLES LIBRARY" operation.

5.13 Monitoring the battery status

Monitor the status of the internal battery TDR-109 using the icon in the upleft corner of the screen:

- symbol  means that the battery level is normal
- symbol  means you need to charge the battery.

5.14 Working with instrument using the power adapter

To operate the device from the charger, it is necessary to connect the 12 V, 2.08 A adapter to the power socket on the rear panel of the device, you can simultaneously use the device and charging the battery. If the battery charge is complete, "" is displayed in the upper left corner of the screen instead of the "" icon.

5.15 Switch Off TDR-109

To turn off the device, press and hold the button  for one second. The device has an automatic power off (when idle).

ATTENTION: When the device switched off all the settings and parameters of the measurement channels are saved. On next switch on the instrument automatically applies them.

6 Possible faults and solutions

If there are any faults in the device, it is necessary to apply to the manufacturer only.

If the TDR-109 software failure occurs, or the device cannot be disabled by the button , you must press the "reset" button with a long thin object (a straightened paper clip for example) to perform a forced device power off.

ATTENTION: When you turn off the instrument by "Reset" button the changes made to the parameters of measurements in the current session with the device are not saved.

7 Maintenance

7.1 TDR-109 does not require special maintenance. To eliminate body soilness use soapy water or alcohol. The use of aggressive chemicals (gasoline, acetone, paint thinner) is strictly prohibited.

7.2 TDR-109 has a built-in power supply maintenance-free battery voltage (7,2 ± 0,7) V 6,6 A/h. The batteries are sealed, maintenance-free for the entire service life.

At lower temperatures the battery capacity decreases (60% at -20 ° C). Prior to operation, check the battery status. Battery status can be assessed by the indicator in the upper left corner of the screen. The inspection results are approximate (as the status of the battery is strongly dependent on the ambient temperature), but allow to estimate the possible time of its battery life.

7.3 Charge the battery in the following sequence:

- connect the AC adapter to a 220 V 50 Hz;
- connect the AC adapter to the jack on the rear panel (picture 4-5);
- monitor the charging progress (6.15).

ATTENTION:

- charge the battery only by the supplied AC adapter;
- do not charge the battery at ambient temperatures below 0 ° C.

ATTENTION:

- the charging time of a fully discharged battery in the TDR-109 is no more than 8 hours.

8 Transportation and storage

- TDR-109, packed in containers, should be transported in closed vehicles of any type, at any distance, and stored under conditions established by a group of 4 to GOST 22261. When transporting by plane, TDR-109 should be placed in heated sealed compartments.
- The alignment and securing of cargo in vehicles should ensure a stable position of cargo during transportation.
- The shift of cargo during transportation is not permitted.

Railway cars, containers, and trucks used for the TDR-109 transportation, should not have traces of cement, coal, chemicals, etc.

9 Labels

TDR-109 has a labels containing:

- manufacturer's trademark;
- unit designation - TDR-109;
- approval sign of measuring instruments;
- serial number.

TDR-109 must have the symbols of the controls.

The labeling of TDR-109 shall be made in accordance with the design documentation.

10 Conservation and packaging

Time domain reflectometer TDR-109 technical specifications 4221-041-39189999-2011, serial number _____ is conserved in accordance with the requirements of the instruction on packaging and conservation.

Conservation data: « ____ » _____ 20__ year.

Term of conservation:

Conservation carried out by: (Signature)

Conserved device accepted by: (Signature)

L.S.

Packaging certificate

The time domain reflectometer TDR-109 technical specifications 4221-041-39189999-2011, serial number _____ is packed at the manufacturer according to the requirements of the packaging and conservation instruction.

Packaging date: « ____ » _____ 20__ year.

Packaging carried out by: (Signature)

Packaged device accepted by: (Signature)

L.S.

11 Warranty

The manufacturer guarantees the compliance of TDR-109 with the requirements of technical specifications 4221-041-39189999-2011 in condition that consumer keeps to the operating, transportation and storage conditions established in this User Manual.

The following causes of failure of the device are not warranty cases:

Connecting the device with an open input to the cable in the "Pulse" mode under high voltage or with an unsettled residual voltage;

Connection of the device to the high-voltage cable in the modes "Pulse-Arc" and "Wave" through faulty connecting devices of manufacturers of high-voltage stations, which results in high voltage (more than 200 V) reaching any inputs of the device. This situation is easily established by visual inspection and is characterized by "burnout" of parts and printed conductors on the board.

Connection to the charging input of the battery of any non-standard charger. Output voltage supply charger adapter for the range of 120-265V and the frequency of AC voltage over the range of 45-65 Hz.

The warranty period is 12 months from the date of TDR-109 in operation, but no more than 18 months from the date of manufacture

The warranty period of storage is set 6 months from the date of manufacture TDR-109.

The manufacturer undertakes to eliminate the identified defects free of charge or replace the failed parts of TDR-109 or the entire TDR-109 free of charge during the warranty period if it can not be corrected at the customer enterprise.

For warranty and post-warranty service, contact the manufacturer at: 196244, St. Petersburg, PO Box 28, AO ERSTED.