LIM-05
pulse fault locator user manual

Software version: 17.05

USER MANUAL

Ver. 17.12

CONTENTS:

1. Preinsulated district heating pipeline as a tested object

Production of preinsulated pipes with sensor wires ensures good reproducibility of the product both in terms of the physical properties of materials and reliable geometrical dimensions. This ensures that certain electrical properties are reproduced in all products. One of the electrical quantities characteristic to district heating pipelines is characteristic impedance, amounting to approximately 200 Ω. The impedance is measured between the carrier pipe and the copper sensor wire. It should be emphasised that impedance does not depend on the length and diameter of the district heating pipeline. However, it may change due to: local change of the distance between the copper wire and the steel pipe, appearance of moisture in polyurethane insulation, incorrect connection or a break in the detector line. These cases are regarded as faults that should be located and eliminated. Faults are located using a reflectometer. Measurement with this instrument requires generation of a very short electric pulse. It is transmitted between the copper wire and the steel pipe. Since the characteristic impedance of the measured circuit is constant, the electric pulse moves freely along the tested pipeline with speed almost equal to the speed of light propagation. If one of the indicated faults occur at some point of the preinsulated district heating pipeline, resulting in the abrupt change of characteristic impedance, the measurement pulse will be fully or partially reflected. The reflectometer measures the time from the sending of the electrical signal until its reflection returns. Then, using the entered value of measurement pulse speed and the measured time, it calculates the distance between the measurement station and the point of reflection, i.e. location of the fault.

The method of fault location in preinsulated district heating pipelines with a detector loop described above is implemented using the LIM-05 instrument.

2. General information about the LIM-05 instrument

The LIM-05 fault locator is a stationary instrument. It can be used to monitor four sections of the district heating pipeline with a pulse alarm system at the same time. The monitored section of the sensor wire should not be longer than 2500 m. The measurement result is presented on a graphical display in the form of an annotated chart. The result is created based on the difference between the previously recorded reference run and the chart depicting the current condition. Until a fault is detected, the chart is a straight line (axis x). Axis x is scaled in units of length [m]. The reference runs for each monitored section of the network are recorded automatically in the digital memory of the instrument shortly after the operator initiates the measurement procedure. During initial calibration of the instrument, the length of axis x on the chart is adjusted to be a precisely proportionate representation of the length of the monitored section of the district heating pipeline. Information about the fault, in turn, has the form of a representation of the reflected measurement pulse depicting its actual electrical shape. The location (above or under axis x) of the reflected pulse and its shape indicate the type of the fault (e.g. leak, electrical short circuit of the sensor wire with the steel pipe) and its intensity. The intensity/degree/size of the fault is represented by the amplitude (height) of the reflected pulse. The amplitude is measured in units of voltage [mV] and [V]. Axis y is scaled in these units by default. The distance from the beginning of axis x (x = 0) to the beginning (front) of the pulse is proportionate to the distance between the beginning of the district heating pipeline

and the location of the fault. The chart depicts the actual distance in [m]. Figures 1 and 2 depict the method of presentation of measurement information.
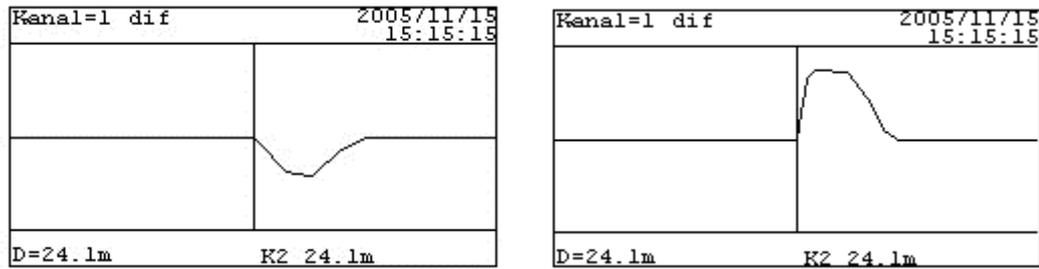
Fig. 1 Depiction of the reflected measurement pulse on the detector screen in case of a leak or short circuit of the sensor wire with the steel pipe (left chart) and breaking of the sensor wire (right chart)
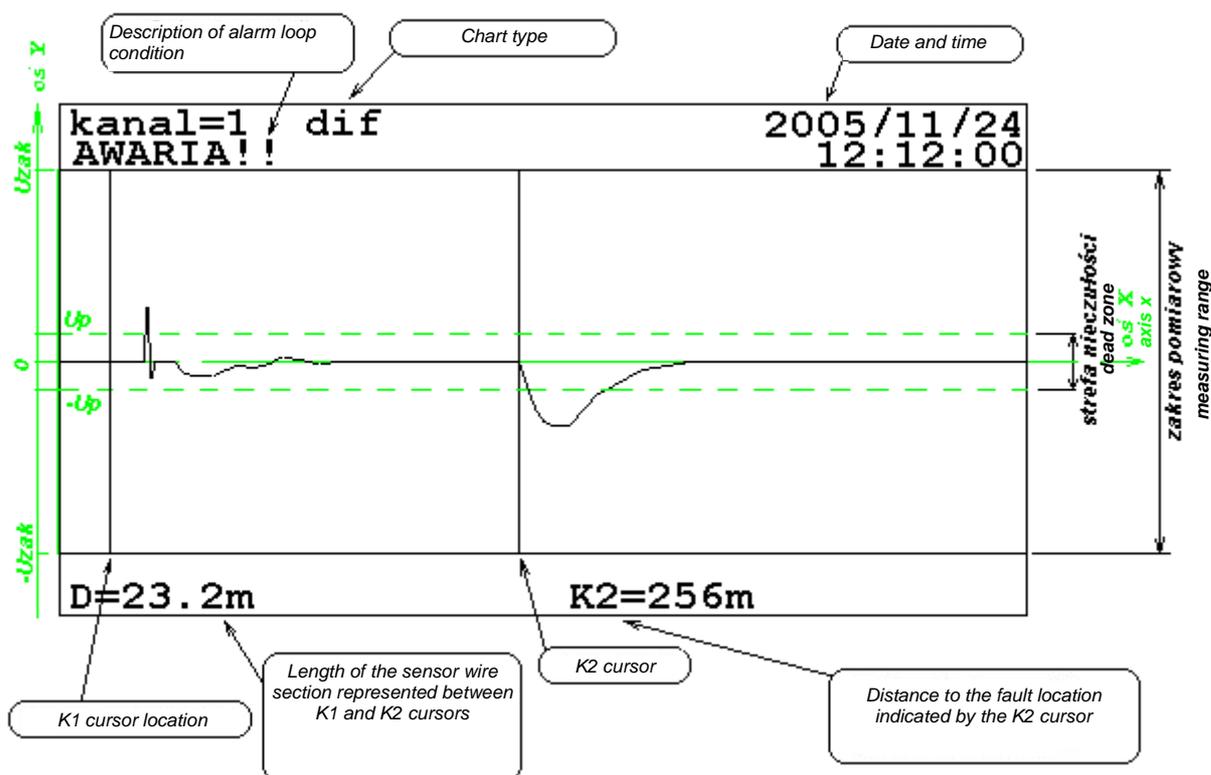
Fig. 2   The drawing depicts the method of presentation of measurement information, where:

Kanal=1 (Channel = 1) − number of the measurement channel (number of the monitored section of the district heating pipeline)

AWARIA (FAULT) − description of the status of the indicated district heating pipeline section

dif − differential chart created as the graphical difference between the current run and the reference run

2005/11/24; 12:12:00 − current date and time

K1 − K1 cursor at position x = 232.8 m

K2 − K2 cursor at position x = 256 m (actual distance between the reflectometer and location of the fault measured along the connection wire and sensor wire)

D = 23.2 m − distance between K1 and K2 cursors referred to the actual length of the section of the alarm wire between these cursors

x − default axis x

y − default axis y

-Up;+Up − voltage thresholds for initiation of automatic fault detection and indication (the dead area is 2Up)

-Uzak;+Uzak − voltage limits of the measuring range.

Figure 2 depicts the impact of the voltage threshold for fault identification (-Up and +Up voltage) on interpretation of measurement results. During automatic or manual image analysis, pulses with amplitudes within the ±Up range are not considered. The K2 cursor will omit such pulses.

Pulses with duration shorter than the duration of the measurement pulse will be omitted as well, even when their amplitude is higher than |Up|. This case will also be presented on the drawing.

3. Installation of the instrument at the measurement station

The LIM-05 locator is a stationary instrument supplied by a 230 V 50 Hz power source. The instrument can monitor four district heating pipeline sections. The number of measurement channels in use can be specified during programming of the measurement conditions for the instrument. There is no need to screw adapters, e.g. 66LV72, into the measurement ports that are not going to be used. The design of the instrument ensures that it is not sensitive to power outages. The recorded measurement procedure and measurement data are saved until the operating conditions return to normal.

3.1 Connection of the locator to the alarm system of the district heating pipeline

The locator is connected to the carrier pipe and copper sensor wire with a coaxial cable and the 67LV15 box. The box is fixed on a steel coupling welded to the carrier pipe. The coupling enables electrical contact of the measurement connector with the carrier pipe. The cable of the box should be connected to the sensor wire of the preinsulated pipe. The 67LV15 box should be connected with the LIM-05 fault locator using one of the indicated measurement cables with the following "electrical lengths": 5 m (67LV09), 10 m (67LV49), 15 m (67LV50), 20 m (67LV51), 25 m (67LV52). The second end of the sensor wire is connected to the 67LV15 box equipped with the 67LV23 port plug.
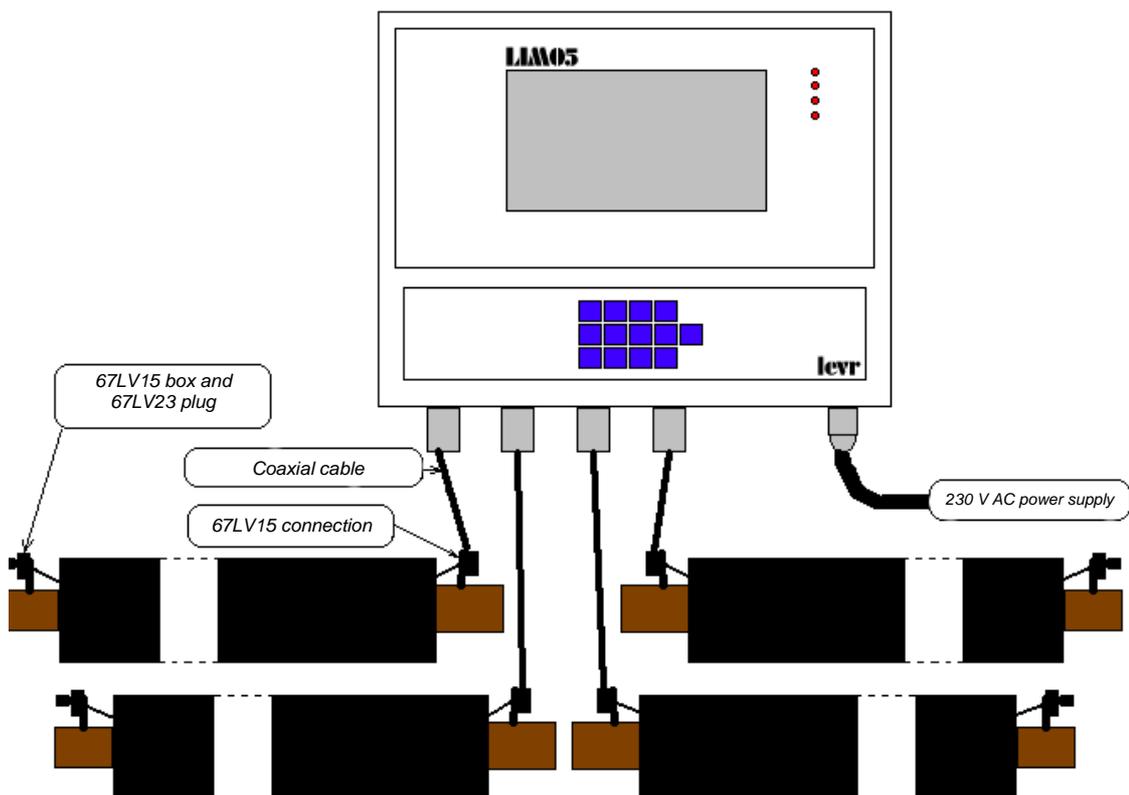

Fig. 3. Sample connection of the locator to the alarm system of the preinsulated district heating pipeline.

4. Keypad description

Figure 4 depicts the keypad of the LIM-05 locator.
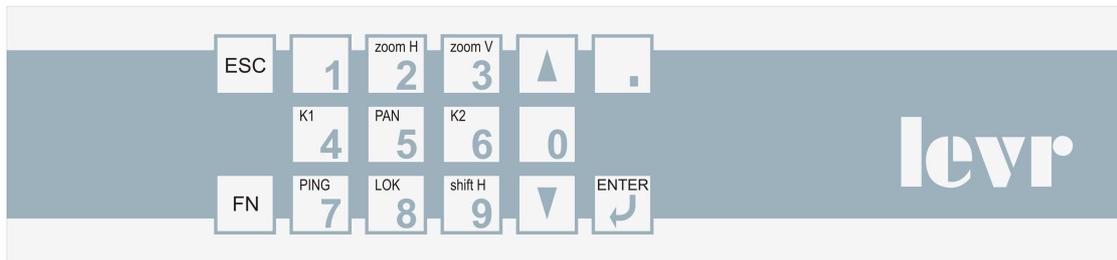
Fig. 4. Keypad

Most numeric keys have double function. The numeric function of these keys and the "." key is activated only when entering numerical data (selection of options and entries or entering data in the "*Kalibracja*" (Calibration) menu.

4.1 "1" key

Press the "4 K1" or "6 K2" key once to activate movement of the cursor – respectively, K1 or K2. The selected cursor will be moved by one step (10 units of length) whenever you press a key with the "▲" (right) or "▼" (left) symbol. If you hold the "1" button pressed when moving the selected cursor, the step will be ten times shorter (one unit of length)*. When you hold "▼" or "▲" buttons pressed for more than 1 s, in turn, the cursor will be moving in steps of 100 units for as long as the selected key remains pressed. The function of the "1" key is the overriding function for cursor movement modification.

)**The standard step of the cursor is 10 units of length. One unit of length is 0.23 VOP[m]. The VOP is a coefficient that expresses the ratio of the speed of propagation of the electrical pulse in the tested environment and the speed of light propagation in vacuum. For district heating pipelines with a copper sensor wire, this coefficient adopts values of the 0.91–0.93 range.*

4.2 "2 zoomH" key

Press the "2 zoomH" key once to initiate the function of widening or narrowing the chart along the x axis (length axis). To extend the chart, press the "▲" key; to narrow it – press the "▼" key. Use of this function is indicated by the "zoomH" text appearing in the bottom right part of the screen.

4.3 "3 zoomV" key

Press the "3 zoomV" key once to initiate the function of vertical increase or decrease of the run on the screen (along the y axis). Use "▲" and "▼" buttons to, respectively, increase or decrease the chart along the y axis (amplification adjustment). Use of this function is indicated by the appearance of the "zoomV" text in the bottom right of the display and specification of the amplification in mV/pixel.

4.4 "4 K1" key

Press the "4 K1" key once to activate movement of the K1 cursor. The cursor will be moved by one step (10 units of length) whenever you press a key with the "▲" (right) or "▼" (left) symbol. If you hold the "1" button pressed when moving the cursor, the step will be ten times shorter (one unit of length). When you hold "▼" or "▲" buttons pressed for more than 1 s, in turn, the cursor will be moving in steps of 100 units for as long as the selected key remains pressed. The function of the "1" key is the overriding function for cursor movement modification.

"K1" text will be displayed in the bottom right part of the screen after pressing the "4 K1" key.

4.5 "5 PAN" key

The screen of the instrument can display effects accompanying the movement of the measurement pulse along the entire length of the alarm wire in the form of a chart. The image can also be set to depict a chart of a selected fragment of the district heating pipeline. Press the "5 PAN" key to restore the chart representing the entire length of the monitored district heating pipeline. This will simultaneously restore the factory settings of K1, zoomV and shiftH functions. The K1 cursor will return to the beginning of the chart (x = 0). Amplification will be set to 10 mV/pixel. The chart (x axis) will be located in the centre of the screen (y = 0 mV).

4.6 "6 K2" key

Press the "6 K2" key once to activate movement of the K2 cursor. The cursor will be moved by one step (10 units of length) whenever you press a key with the "▲" (right) or "▼" (left) symbol. If you hold the "1" button pressed when moving the cursor, the step will be ten times shorter (one unit of length). When you hold "▼" or "▲" buttons pressed for more than 1 s, in turn, the cursor will be moving in steps of 100 units for as long as the selected key remains pressed. The function of the "1" key is the overriding function for cursor movement modification.

"K2" text will be displayed in the bottom right part of the screen after pressing the "6 K2" key.

4.7 "7 PING" key

Activating the "PING" function will force a measurement cycle in the selected measurement channel and display the measured run. Depending on the enabled option, this may be an input run depicting the current status of the monitored district heating pipeline or a differential run (in relation to the reference run).

4.8 "8 LOK" key

The differential run may contain information about the presence of one or many faults in the monitored section of the district heating pipeline. Activate the "LOK" function (press the "8" key) to set the K2 cursor in the place where the first fault is indicated on the chart. The screen will only depict a fragment of the differential run containing the image of the reflected measurement pulse at maximum zoom and the K2 cursor at the beginning of this image. Press the "8 LOK" key once more to find the next fault and display it as indicated above. In every case, the distance to the location of the fault will be displayed next to the K2 cursor. Press the "8 LOK" key after the last reflection of the measurement pulse (last fault location) is displayed to return to display of the differential run for the entire length of the monitored section of the district heating pipeline.

4.9 "9 shiftH" key

The "shiftH" function can be used to shift the chart along the default y axis. To do so, use "▲" (up) and "▼" (down) keys. When this function is activated, the "shiftH" text will be displayed in the bottom right corner of the screen, complete with the value of the shift in [mV].

4.10 "FN" key

Press the "FN" key to display the main menu of the locator on the screen.

4.11 "ENT" key

Use the "ENT" key to confirm your selection.

4.12 "ESC" key

Use the "ESC" key to leave your selection.

4.13 "•" key

Decimal sign key. Press it to cyclically change the displayed measurement channels with their recorded runs. It is also used to enter numerical values that require higher precision (e.g. tenths of a metre when entering the length of the alarm loop).

4.14 "▲ " and "▼ " keys

The role of the keys with the symbols indicated above depends on the selected function. Consequently, they are referred to as: right-left; up-down; increase-decrease.

5. Main menu

The main menu only appears on the screen after you press the "FN" key, and only when a chart is displayed. The options available in the main menu are specified below. The digits refer to symbols on the keys.

```
1 - Kanal (Channel)
2 - Start/Stop
3 - Kalibracja (Calibration) > [haslo] ([password])
4 – Historia (History)
5 – Przebieg roznicowy (Differential run)
6 - Przebieg wejściowy (Input run)
7 – Przebieg odniesienia (Reference run)
8 – Info
```

5.1 "Kanał" (Channel) option

This option can be used to display measurement information about one of the monitored sections of the district heating pipeline. To select the channel, enter the identification code of the channel (digits 1–4; see section 0). The same function is performed by the decimal sign ("·") key.

5.2 "Start/Stop" option

The LIM-05 instrument is designed for continuous operation. However, during its operation, the measurement process may be stopped for an unlimited period. This is done using the *Start/Stop* option. The setting is changed to the opposite setting whenever you press the "2" key. The *Start* setting activates cyclical measurements. This is continuously indicated by the ">AUTO<" description displayed in the bottom right corner of the screen. The *Stop* setting (measurement interruption) is not indicated on the screen.

5.3 "Kalibracja" (Calibration) screen

This option can only be used after you enter the password – a preset sequence of digits. The factory password is "123". You can use this password to enter the "*Kalibracja*" (Calibration) option and replace it with your own password. This option can be used to set the measurement conditions, e.g. value of the VOP coefficient, length of the alarm loop, etc.

5.4 "Historia" (History) option

You can use this option to view the first image of the measurement pulse reflected at the location of the fault that is recorded in the memory, read the distance to the location of the fault and the date and time of recording. Use "▲" and "▼" keys to navigate the memory resources in the "*Historia*" (History) option.

5.5 "Przebieg roznicowy" (Differential run) option

This option depicts the measurement information, which always has the form of an annotated chart. In this case, the chart is the graphical difference between two runs: *reference* run and *input* run. The run created and recorded after a short period of instrument operation at the measurement station is referred to as the *reference run*. Every measurement channel (monitored section of the district heating pipeline) has its own recorded reference run. The *input run*, in turn, contains information about the last measurement. The *differential run* is marked with a description reading: "dif". The description is visible in the first row of the text box at the top of the screen (see *Fig. 2*).

5.6 "Przebieg wejsciowy" (Input run) option

The measurement starts when an electrical pulse is generated and sent to the monitored alarm system of the district heating pipeline. Starting from this moment, the instrument records the time of return and shape of all returning pulses (echoes). These data are recorded in digital form in the input buffer of the locator. The described measurement process is repeated at preset intervals. The *Przebieg wejsciowy* (Input run) option enables presentation of the collected digital data in the form of a chart. These data refer to the last measurement. When the *input run* is displayed, the screen will display a description reading "input". The description is visible in the first row of the text box at the top of the screen.

5.7 "Przebieg odniesienia" (Reference run) option

Select this function to display the requested chart for the selected measurement channel. Every measurement channel (monitored section of the district heating pipeline) has its own recorded *reference run*. They are created and recorded during the initial period of locator operation at the measurement station. Display of the *reference run* is indicated by a description reading: "ref". The description is visible in the first row of the text box at the top of the screen. The date and time of registration will appear at the same time in the second row of the screen.

5.8 "Info" option

Select the *Info* option to display information with, for instance, the name of the monitored facility, symbol of the installed software version and cause for last reset of the processor.

6. Description of the *Kalibracja* (Calibration) option of the main menu

To enter this option from the main menu (FN), press the (3) key. You will be requested to enter the PIN code. The factory code is 123. You should create your own access code, which can be any number between 100 and 32000. After you correctly enter the PIN, you will be able to enter parameters and quantities that determine measurement conditions. The full list of available entries is included below. The digits refer to the symbols on the key used to initiate the requested entry.

```
1 - Długość pętli> (Loop length>)
2 – Napięcie progowe Up = (Voltage threshold Up =)
3 – Liczba kanałów = (Number of channels =)
4 – Przebieg odniesienia (Reference run)
5 – Czas martwy = (Dead time =)
6 - VOP =
7 - Parametry impulsu> (Pulse parameters>)
8 - Zakres pomiarowy Uzak= (Measuring range Uzak=)
9 – Wyświetlenie nastaw (Display settings)
0 - Kod PIN (PIN code)
```

6.1 "Długość pętli >" (Loop length>) entry

Contents of the discussed entry are presented below.

```
1 – Długośc pętli>
    1 – Między kursorami= (Between cursors=)
    2 – Zakres= (Range=)
    3 - Autokalibracja (Self-calibration)
        Ti=50ns▾▴   Ui=…mV▾▴
```

During measurements, the measuring range should be adjusted to the measured value. In the LIM-05 locator, the measuring range is determined so as to ensure that it most accurately corresponds to the length of the measured sensor wire. The x axis represents the measuring range and, at the same time, the length of the alarm wire. The beginning of the x axis has an assigned value x = 0 m, and the length at the end of the axis (end of the measuring range) should be equal to the length of the monitored sensor wire. The presented method of calibration of the x axis enables obtaining the highest possible measuring resolution. The calibration method also ensures that the image corresponds to reality. For instance, if a fault occurs near the end of the network, it will be represented near the end of the x axis and not, for instance, in the centre of the axis. Instrument calibration relating to determination of the length measuring range is done in two ways after entering the "Długość pętli>" (Loop length>) option. The names and description of each of these options are specified below.

METHOD 1

3 - Autokalibracja (Self-calibration)

Before initiating the procedure, make or break the end of the alarm system. For instance, remove the port plug from the box at the end of the sensor wire (breaking). Next, set the duration T_i and amplitude U_i of the measurement pulse. After you complete these actions, press the **(3)** key and wait (in older versions of the locator, this can take up to several minutes), until the instrument "locates" the end of the sensor wire on its own. Once the procedure is complete, the screen of the LIM-05 instrument will display the echo voltage function for the entire sensor wire. If necessary, adjust the position of the K2 cursor so that it is located at the beginning of the measurement pulse reflected from the end of the sensor wire. Next, eliminate the make/break at the end of the line, enter option *1-Między kursorami=* (1 – Between cursors =) in the *Kalibracja / Długość Pętli* (Calibration / Loop length) menu and enter the known, accurate length of the sensor wire.

If the LIM-05 instrument is unable to automatically "locate" the end of the wire for any reason, conduct the calibration described in section 0 of this manual.
METHOD 2
The specific procedure is described in section 8.1.

Note: A new reference run should be created and recorded after changing the physical length of the sensor wire. (See section <u>6.4</u> i <u>0</u>).

6.2 *"Napięcie progowe Up="* (Voltage threshold Up=) entry

Input signals whose voltage amplitude is within the ±Up range are not analysed. This limitation can be used to eliminate some of the low-amplitude interference appearing in the alarm system of the district heating pipeline. The ±Up voltage range can be set separately for each measurement channel.

6.3 *"Liczba kanałów="* (Number of channels =) entry

The instrument can monitor up to four sensor loops. The entered number (1–4) specifies the number of monitored sections of the district heating pipeline with the alarm system. (See section <u>0</u>). If the number of connected loops is smaller, they have to be connected to subsequent measurement ports of the instrument starting from the outermost left port (channel 1).

6.4 *"Przebieg odniesienia"* (Reference run) entry

Activating this function will force a specific measurement cycle in the selected measurement channel. The instrument will calculate the average value of measured results i, which will be recorded as the *reference run*. (See section <u>0</u>).

6.5 *"Czas martwy="* (Dead time=) entry

The automatic measurement cycle of the fault locator consists of measurements carried out for every section of the district heating pipeline. The measurements are carried out sequentially. Between the measurement cycles, there is a gap referred to as the dead time. The dead time can be adjusted in the range of 1–255 min. (See section <u>0</u>).

6.6 *"VOP="* entry

This entry enables setting the VOP coefficient for all measurement channels in use. It may be a fraction in the range of 0.3–1.0 or a value expressed as percentage from 30 to 100%. (See section <u>0</u>).
The factory setting is: VOP = 0.92. In practice, the coefficient is set as 0.84–0.93 for measurements of district heating pipelines.

6.7 *"Parametry impulsu>"* (Pulse parameters>) entry

The amplitude in [V] and duration in [ns] of the measurement pulse can be set for every measurement channel. Both of these values are selected depending on the length of the monitored district heating pipeline (length of the monitored sensor wire).
"**1-czas trwania =**" (**1 – duration =**) – duration of the measurement pulse is changed with keys marked with "▲" (increase) and "▼"(decrease) symbols. The changes are implemented in a stepwise fashion, at 12.5-ns intervals within a range of 12.5–75 ns.
"**2-amplituda impulsu =**" (**2 – pulse amplitude**) – the amplitude of the measurement pulse can be changed within a range of 2.3–7.8 V (4.8–14.6 V for amplitude of the voltage of the measurement pulse generator) using keys marked with "▲" (increase) and "▼"(decrease) symbols.

Note: The reference run should be created and recorded whenever the duration or amplitude of the measurement pulse are changed. (See section 6.4 i 0).

6.8 "Zakres pomiarowy Uzak=" (Measuring range Uzak=) entry

The range of voltage measured by the fault locator is ±2047 mV. If you enter 100 mV, the measuring range will be set to ±100 mV. Optimum setting: ± 500 mV. This setting can produce a clear image of the leak immediately after it occurs (after it is recorded) and in the initial stages of its development. The shape of the reflected pulse will be represented within the range of voltage thresholds determining the measuring range. Extending the voltage measuring range will affect duration of the measurement cycle.

Note: The reference run should be created and recorded whenever the measuring range is changed. (See section 6.4 i 0).

6.9 "Wyświetlenie nastaw" (Display settings) function

Use this function to display the list of entries of the *Kalibracja* (Calibration) function complete with all defined values of parameters and quantities.

6.10 "Kod PIN=" (PIN code=) entry

A PIN code will be needed to access the *Kalibracja* (Calibration) option. The *Kod PIN=* (PIN code=) entry is used to set and record the code. (See section 0).

7. Settings requiring a PC

Implementation of certain settings in the LIM-05 locator requires using a computer with suitable software, e.g. HyperTerminal. Both devices are connected with an RS232 transmission cable (three-wire crossover cable). The cable has to be terminated on both sides with female connectors. The RS232 port is located on the front panel of the locator. In order to ensure correct communication, the following transmission parameters should be set in the computer:

57600,8,N,2
- transmission rate = 57600 bps
- number of bits = 8
- no parity
- number of stop bits = 2.

After you finish entering the settings, press the ENTER key on the computer. The computer screen should display the following message:

LIM-05>

Absence of this message means that there is no communication between the computer and the locator. In such a situation, make sure that the devices are correctly connected and check the status of the selected COM port. You can enter the settings once the "**LIM-05>**" message appears.

7.1   Setting the time

In order to set the time in the locator, enter the following command on the screen of the terminal:
czas hh:mn:ss
where:
hh – hours
mn – minutes
ss – seconds.

Example: setting the time as 12 hours, 33 minutes and 30 seconds.
Type the following command on the computer screen: **czas 12:33:30**.
Press the ENTER key on the computer keyboard. The LCD of the locator should display the requested time.

7.2   Setting the date

In order to set the date, enter the following command on the terminal screen:
data rrrr/mm/dd
where:
rrrr – year
mm – month
dd – day.

Example: setting the date as 2006/10/11.
Type the following command on the computer screen: **data 2006/10/11**.
Press the ENTER key on the computer keyboard. The LCD of the locator should display the requested date.

7.3   Entering the locator name

The instrument is frequently made identifiable by being assigned the code, name or address of the measurement station. In order to check or change the existing name, enter the main menu (FN key) and access the "Info" option ("8" key). This will display the existing name. The name will be presented in the first line of the LCD.

To enter a new name, type the following command on the computer screen:

Nazwa =..name..

where:

..name.. – string of up to 20 alphanumeric characters (without Polish letters; you can use the "Backspace" key)

Example: entering the name of the locator by typing the address of the measurement station: ul. Poleczki 5

Type the following command on the computer screen: **Nazwa = Poleczki 5**

Press the ENTER key on the computer keyboard.

To verify if the name has been correctly entered, access the "Info" option in the main menu. If the entered name is longer than 20 characters, the name of the instrument will consist of the first 20 characters.

8. Procedure examples

Below, there are several examples with practical instructions on how to conduct some of the procedures discussed in this manual. All operations should be initiated only after the locator screen displays the run.

Calibration procedure: Kalibracja (Calibration) option; Długość pętli (Loop length) entry

Note: Locator calibration should be carried out 30 minutes after the device is turned on. This is the time necessary for the technical conditions inside the instrument to stabilise.   **!**

The following commands are described as separate instructions. Therefore, almost every one of them starts with entering the main menu **(FN)**, and ends with leaving by pressing the **ESC** key multiple times. In practice, for instance if several subsequent commands to be performed are included in the **Kalibracja** (Calibration) option, there is no need to leave this group after each command. Enter the commands one after the other and leave after you complete the last one. The same is true for leaving the main menu (**FN**). We believe that as you use the instrument, everything will become clear.

During calibration, it may turn out that the amplitude of the reflected measurement pulse is too small to correctly implement the command. In such a situation, use the *Kalibracja/Parametry impulsu>* (Calibration/Pulse parameters>) option to increase the amplitude of the measurement pulse. As a last resort, you can also increase the duration of the pulse.

We remind that the factory PIN code is 123.

1. Place the 67LV23 port plugs on the ends of the monitored alarm loops in 67LV15 boxes.
2. Disable automatic measurements.
   FN-> (2)

3. Set the number of monitored alarm systems.

```
FN-> (3) -> enter PIN -> (3) -> enter the number of
monitored alarm systems [1...4] -> ENT -> wait 2 s ->
ESC -> ESC
```
__NOTE:__ If the number of monitored alarm systems is lower than 4, connect them to subsequent measurement ports of the instrument starting from the outermost left port (channel 1).

4. Enter the number of the measurement channel to be calibrated.
```
FN -> (1) -> enter channel number [1...4] -> ENT
```

5. Enter the known VOP (see 0) or leave the factory-set value: VOP = 0.92.
```
FN-> (3) -> enter PIN -> (6) -> enter VOP in form of
percentage (30–100)or fraction (0.300–1.0] -> ENT ->
wait 2 s -> ESC -> ESC
```

6. Calculate the approximate length of the alarm loop:

1) Enter the length)* of the sensor wire greater by 20 to 30% from the actual length.
```
FN -> (3) -> enter PIN -> (1) -> (2) -> Enter length
->
-> ENT -> wait 2 s -> ESC -> ESC-> ESC
```
)* The as-built documentation should specify the precise length of the monitored alarm loop. However, sometimes this length is known only approximately. Whatever the case, it is recommended to first enter a length greater by 20–30%.

2) Create and record a reference run.
```
FN -> (3) -> enter PIN -> (4)
```
The screen will display the chart − straight line (x axis).

3) Simulate a break in the alarm system at the end of the district heating pipeline. To do so, remove the 67LV23 port plugs from the 67LV15 box. Perform a measurement by pressing the "7 PING" key. The chart will display an image of the reflected measurement pulse from the end of the district heating pipeline (location of the simulated fault).

The length of the section of the x axis visible on the chart does not reflect the actual length of the alarm wire. In section 3, increased length of the line was specified precisely in order to ensure that the image of the measurement pulse reflected at the end of the network "fits" in the chart. The length of the x axis on the chart should correspond to the actual length of the alarm wire in order to obtain maximum possible resolution of the screen of the monitored network. Also, if a fault occurs near the end of the network, it should be represented near the end of the chart (x axis) and not, for instance, in the centre of the chart in order to ensure that the image is fully consistent with the actual situation.

4) Set the K2 cursor at the beginning of the image of the reflected measurement pulse.
```
Press the "6 K2" key -> shift the K2 cursor with
"▲"(left) or „▼"(right) keys
```

8) Enter the actual length of the alarm wire, including the "electrical length" of the connection cable. If the actual length is unknown, enter the value displayed next to the K2 cursor. The instrument will automatically calculate the VOP for the actual length. It will be recorded in the memory. The factory value VOP = 0.92 or the value set by the operator will be used in the calculations (location) for the approximate length.
```
FN -> (3) -> enter PIN -> (1) -> (1) -> enter the
known length including the connection cable or copy
the approximate value specified next to the K2
cursor -> ENT -> wait 2 s -> ESC -> ESC -> ESC
```
The length measuring range will correspond to the length of the monitored sensor wire. This will provide the highest possible measuring resolution. The x axis simultaneously represents the measuring range and the length of the monitored sensor wire.

9) Place the 67LV23 port plug in the 67LV15 box at the end of the district heating pipeline.

10) Stop the measurements. Create and record a reference run.

```
FN -> 2 -> FN -> (3) -> enter PIN -> (4)
```

7. Repeat items 1) to 10) for every measurement channel in use. (See sections 6.3 and 0)

8. Set the dead time (interval between measurement cycles). Recommended time: 10 min.

```
FN -> (3) -> enter PIN -> (5) -> specify dead time:
1...255 min. -> ENT -> wait 2 s -> ESC -> ESC -> ESC
```

9. Activate automatic measurements.

```
FN -> (2)
```

Channel number entry

```
FN -> (1) -> enter channel number (digit from 1 to 4) ->
ENT
```

Initiate or stop automatic measurements

```
FN -> (2)
```

Initiation of automatic measurements is indicated by the >AUTO< description. It will appear in the bottom right corner of the screen. Stopping automatic measurements will cause the description to disappear. The setting is changed whenever you press the (2) key.

Creating and recording the reference run

```
FN -> (3) -> enter PIN -> ENT -> (4)
```

Enter the new length of the alarm loop

```
FN -> (3) -> enter PIN -> ENT -> (1) -> (2) -> enter new
length -> ENT -> (wait 2 s) -> ESC -> ESC
```

Create and record a reference run after this operation.

（**FN -> (3) -> enter PIN -> ENT ->(4)**）

Changing the number of monitored alarm systems

```
FN -> (3) -> enter PIN -> ENT -> (3) -> enter the number
of monitored channels [1...4] -> ENT -> (wait 2 s) -> ESC
-> ESC
```

Changing the VOP

```
FN-> (3) -> enter PIN -> EN -> (6) -> enter VOP in form of
percentage (30–100)or fraction (0.30–1.0) -> ENT -> (wait
2 s) -> ESC -> ESC
```

Changing the PIN

```
FN -> (3) -> enter PIN -> ENT -> (0) -> enter new PIN ->
ENT -> (wait 2 s) -> ESC -> ESC
```

Displaying the input run

```
FN -> (6)
```

Displaying the differential run

```
FN -> (5)
```

Changing the dead time

```
FN -> (3) -> enter PIN -> ENT -> (5) -> enter the dead
time: 1...255 min -> ENT -> (wait 2 s) -> ESC -> ESC
```

9. Description of the operating environment of the LIM-05 instrument

The instrument is designed for indoor operation. The instrument operates correctly within an ambient temperature range of +5°C to +50°C, and relative humidity should not exceed 80%. During storage of the instrument, the ambient temperature should be within the range of -40°C to +70°C. If the instrument was stored or transported at a temperature of less than +5°C, it should not be connected to power supply for at least 3 hours. After this time, the instrument should reach the operating temperature. The instrument cannot be used in dusty areas and in atmospheres containing explosive or corrosive gases.

The accuracy of measurements of parameters and quantities indicated in the technical specifications is reached after 30 minutes of instrument operation in suitable environmental conditions.

10. Maintenance of the LIM-05 instrument

A clean, dry cloth should be used to remove dust from the housing of the instrument. Other dirt should be removed with a cloth dampened with a 1% detergent solution. Greasy impurities can be removed with special products used to clean computer hardware. Transparent parts of the housing should be washed with soft cloths or with dedicated cloths for washing computer screens. Using spirit, petroleum naphtha or other solvents is not allowed. Such cleaning agents may cause surface damage to the housing of the instrument. After cleaning, the instrument should be wiped dry with a soft cloth. Care should be taken during cleaning to prevent large amounts of the cleaning liquids from getting inside the instrument.

11. Disposal of the LIM-05 instrument

In accordance with the Act of 29/7/2005 on waste electrical and electronic equipment (Journal of Laws, item 1495), the following symbol has been placed on the instrument:

This symbol means that it is prohibited to discard waste equipment together with any other waste. Users of equipment marked with this symbol are obliged to transfer it to dedicated companies that collect waste equipment. These obligations arise from Articles 35 and 36 of the above-mentioned act.

12. Technical specifications

Number of monitored alarm loops 4
Maximum length of the alarm wire .... 3518 m · VOP)[1]
Location measurement resolution .... ±0.23 m · VOP
Range of VOP values 0.300–1.000 (30–100%)
Location error.. ±1 m
Input impedance of the instrument .... 200 Ω
Indication of faults .... red LED (every channel)

Measurement pulse characteristics:
Duration .... 12.5 ns, 25 ns, 50 ns, 75 ns
Voltage amplitude (unloaded output) .... adjustable: 4.8–14.6 V

Method of measurement information display .... LCD screen, 128x240 pixels
Method of presentation of measurement results .... annotated chart
Method of instrument programming .... 16 numerical/function keys
Voltage measuring range .... ±2047 mV
Maximum measurement sensitivity .... 1 mV/pixel
Sensitivity threshold voltage range .... 1–1024 mV
Dead time range .... 1–255 min

Methods of communication with external devices:
Alarm output .... volt-free relay contacts (capacity 1 A/60 V)
Digital transmission RS232C
Radio transmission (optional) .... GSM transmission module

Supply voltage .... 230 V 50 Hz
Power drawn from the power supply network .... up to 6 VA

Operating temperature range .... 0 to +50°C
Relative humidity .... up to 80%
Housing protection rating .... IP54 (IP65 available upon request)
Electrical protection of measuring inputs .... 250 V (AC+DC)
Appliance class .... B
Dimensions .... 262 mm x 235 mm x 143 mm

)[1] − (VOP) *speed of propagation of the measurement pulse in the alarm wire in relation to the speed of light propagation in vacuum. This value is specified in percentage (from 0 to 100%) or in relative quantities (from 0.00 to 1.00).*