T-900 Power Cable Fault Locator

User Manual

Kehui International Ltd
2 Centrus, Mead Lane
Hertford, Hertfordshire
UK, SG13 7GX
Phone: (44) 1920 358990
Fax: (44) 1920 358990
Website: http://kehui.com

Legal Notices

This product complies with the design requirements for environmental protection and personal safety.

This product is a professional instrument specially designed for power cable faults. Please do not use it for any other purpose. The company assumes no responsibility or loss if it is used for other purposes.

The safety regulations in this user manual should be strictly adhered to.

The storage, use and disposal of the product should be in accordance with the product manual, relevant contracts or relevant laws and regulations.

As part of Kehui's continual product development this product is subject to design or technical changes without prior notice. When product improvement or technical changes occur, you can check the information through Kehui International Ltd. website http://www.kehui.com.

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Revision history:

Data version	Revision date	Revision reason	Person
1.0	2021.09.08	First edition	BilKib

Document reference: T-900_V1.0_UM_EN

Foreword

Thank you for purchasing the T-900 Power Cable Fault Locator (hereinafter referred to as T-900)

The T-900 is a hand-held fault locator for accurately locating open-circuit and low-impedance faults on metallic cables, using time-domain reflectometry (TDR). Comparison of TDR traces from the three phases of a faulty cable, can be used to identify differences between them, providing another useful aid to fault location.

The unit can also calculate the velocity of propagation (VOP) of a known length of cable or measure the length of cable on a drum, where the VOP is known.

Kehui constantly improves its products, and the individual instruments provided may differ from the instructions in this manual without prior notice. We are always at your service if you have any queries or should you require further information.

Table of Contents

1. Safety Instructions

Safety Note: This user manual is the commissioning and on-site operation guide for the T-900 Smart Cable Fault Pinpointer. All operators of the T-900 should read the contents of this manual in advance. The manufacturer of this product is not responsible for any loss caused by the operator's failure to comply with the operating procedures of this manual or for violation of the safe working practices of the operator.

Meaning of the manual symbols Important instructions concerning personal safety, operating procedures, technical safety, etc., are marked with the following symbols:

Symbol	Meaning
	Indicates a potential hazard that could result in serious or fatal injury
	Indicates a potential hazard which, if not avoided, may result in minor personal injury or property damage.
	Indicates that it contains important information and useful guidance for using this product. Failure to heed this information may result in the test not functioning properly.
	Indicates that this is a useful guideline based on field practice.

Use of accessories: Please be sure to use Kehui’s spare parts to ensure the safe and reliable use of this instrument. Using accessories made by other companies will make any warranty null and void.

Repair and maintenance: This instrument must be repaired and maintained by Kehui or an agent authorised by Kehui. If you have any questions concerning maintenance, cable fault detection, on-site test consultation, etc., please contact the company at info@kehui.com.

2. Product overview

The T-900 is an easy to use, compact hand-held instrument for accurately locating open-circuit and low-impedance faults on metallic cables, using time-domain reflectometry (TDR). Comparison of TDR traces from the three phases of a faulty cable, can be used to identify differences between them, providing another useful aid to fault location. It can also be used to calibrate the cable length and to identify cable joints, T-joints and the end of the cable.

The unit can also calculate the velocity of propagation (V_{OP}) of a known length of cable or measure the length of cable on a drum, where the V_{OP} is known.

Figure 2.1 T-900 hand-held TDR unit

2.1 Product characteristics

- Available in three versions with 8, 16 or 32km range
- Digital gain control
- Data transfer via USB flash memory for analysis on PC
- Automatic waveform identification eliminates dead zone
- Automatic impedance matching
- Large colour display with simple user interface
- 10 hours operation on one battery charge
- Resolution to 1m.

2.2 Technical Specifications

Technical Parameters	Parameter Value
Range	8km (16 and 32km are also available as options)
Accuracy	±0.5% of range
Resolution	Minimum resolution 1m
Pulse	±30v, 40ns-10us with automatic adjustment
Sampling rate	100MHz
Balance	25 - 300Ω automatically adjusted
Velocity of propagation	40-300m/μs
Dead zone	There is no dead zone
Power consumption	1W
Batteries	Lithium, 2 pcs of 18650 batteries in series
Charger	Input: AC110-240V, output: 8.4V
Battery life	10 hours
Dimensions	204 x 100 x 36 mm
Weight	0.38kg
Operating temperature	-15°C to +50°C
Ingress Protection	IP53
Working temperature	-10 to +50℃
Storage temperature	-20 to +70℃
Relative humidity	20 to 90% at 25℃
Atmospheric pressure	86 to 106kPa

3. Working Principles

The time domain reflectometer method (also known as the low voltage impulse method) is used to locate low impedance, short-circuit or open circuit faults on the power cable.

If a low voltage impulse is injected into one end of a cable of uniform impedance, it will travel to the far-end of the cable from where all, or part, of the signal will be reflected back to the source. However, if the impedance is not consistent due to a joint or a fault, then this will also result in a reflection, with a magnitude dependant on the impedance of the fault or discontinuity.

A schematic of the TDR method is shown in Figure 3.1.

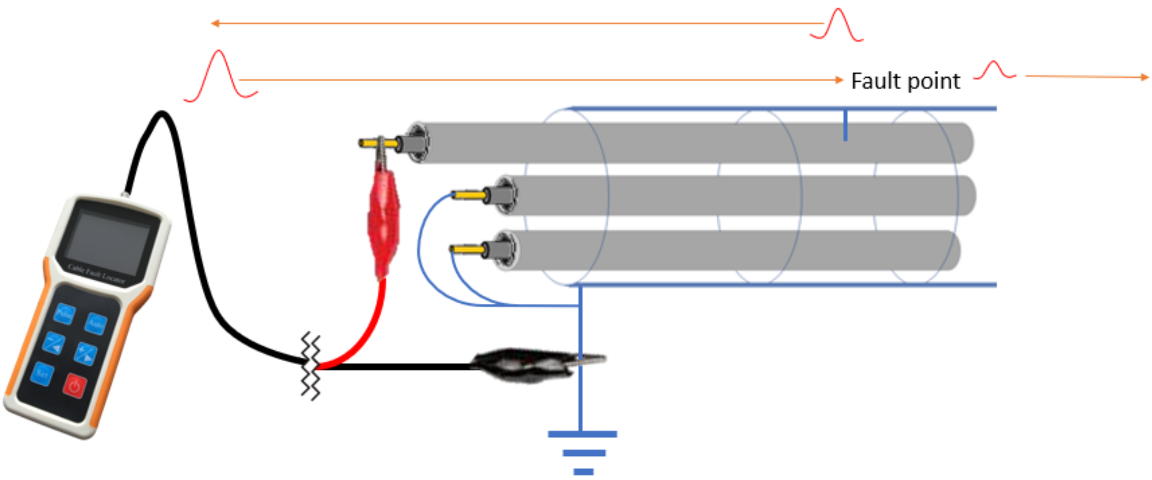


Figure 3.1: TDR connection to faulted cable

For an open circuit fault, the reflected wave will have a negative polarity and for short circuit and low impedance faults, the reflected wave will have a positive polarity. A comparison of these scenarios is shown in Figure 3.2. The reflection from an open end is shown in red and from a short-circuited end is shown in yellow.

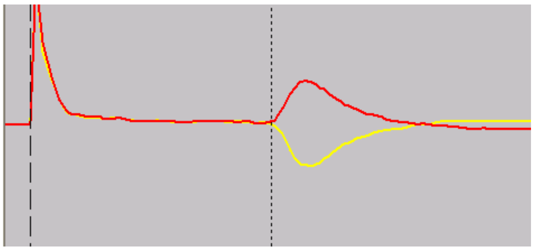


Figure 3.2: Comparison of TDR signals reflected from the far end of a healthy cable.

In Figure 3.1 the dashed line on the left represents the start of the cable where the TDR instrument is connected and the dotted line (moveable cursor) represents the time it takes for the pulse to reach the far end of the cable. As the propagation velocity of the pulse in the cable is known, the cable length can be calculated. It should be noted that the measured time is for the pulse to reach the end of the cable and return to the instrument, therefore the distance measurement must be divided by 2.

Hence if L_x is the length of the cable, v is the propagation velocity of the pulse and Δt is the time measure by the cursor, the line length can be expressed as:

$$L_x = \frac{v\Delta t}{2}$$

The reflection from a fault will occur in a similar way, with the magnitude and polarity of the reflection depending on the impedance of the fault. Comparing the reflection from a faulted core with either a previously measured trace from the core before the fault, or with a healthy core in the same cable, will produce traces like those shown in Figures 3.3 and 3.4.

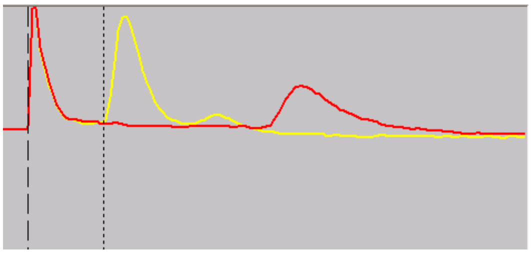


Figure 3.3: Comparison of TDR signals reflected from a faulted core with an open-circuit (yellow) and a healthy core of the same cable (red)

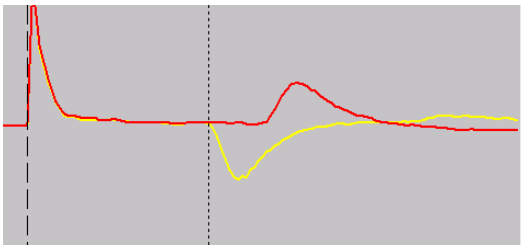


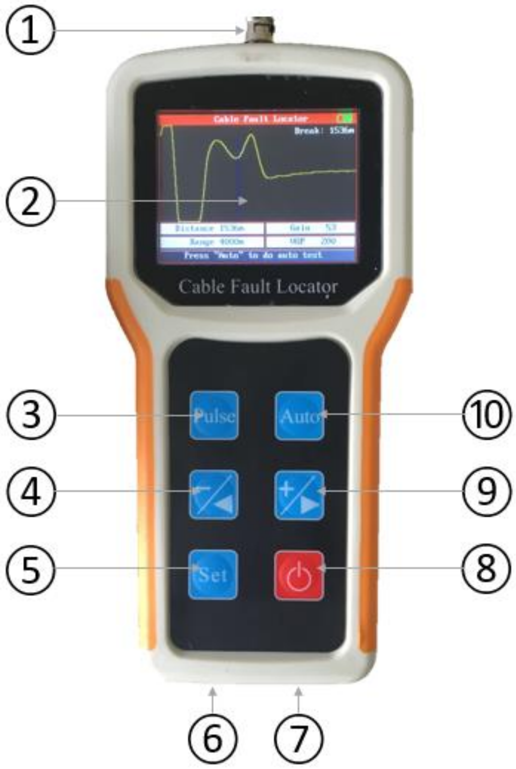
Figure 3.4: Comparison of TDR signals reflected from a faulted core with a short-circuit (yellow) and a healthy core of the same cable (red)

In Figures 3.3 and 3.4 the cursor can be moved to the point where the two traces deviate, which represents the position of the fault. The distance to the fault can be calculated using the same equation as before.

TDR is suitable for the pre-location of open and short circuits on the cable. However, for resistive or flashing faults, the TDR method is not applicable because the fault impedance is comparable to the insulation impedance of the cable, resulting in little or no reflection.

4. Using the fault locator T-900

4.1 T-900 hardware



① BNC port

② LCD display.

③ Pulse test.

④ Move cursor left and setting reduction.

⑤ Setting.

⑥ USB Memory port.

⑦ Charging port

⑧ On / off.

⑨ Move cursor right and setting increase.

⑩ Auto test.

Figure 4.1 T-900 hardware

4.2 Preparation

If testing is to be carried out on a power cable ensure that it is completely isolated from any electrical supply and ensure that it is thoroughly discharged. Failure to do this may result in electrocution.

4.2.1 Charging

Initially the unit has to be charged using the battery charger supplied; plug the charger into a suitable power outlet and insert its plug in to the socket on the T-900 marked “charger” Figure 4–3. In subsequent usage, the charge level is indicated by the green battery icon in the top-left of the display.

[**Warning**] The battery must be charged using the dedicated charger. Using other chargers that do not meet the exact parameters, may cause damage to the instrument.

4.2.2 Diagnostics

Before the test, the diagnostic tests should be performed on the cable to determine its insulation condition and the fault type, in order to choose the most appropriate testing method.

Measure should be made of the insulation resistance with a Mega-ohm meter, from the phase to ground and from phase to phase from one end of the cable. Next, the continuity should be checked by short circuiting all of the conductors at the remote end, this will determine whether there is an open conductor fault.

Depending on the result of these diagnostics, the faults can be categorised as follows ：

- Low resistance and short-circuit fault: If the phase-phase or phase-ground resistance is lower than 200Ω, the TDR Mode can be selected.
- Broken/Open conductor fault: If one core is broken or open-circuit, TDR mode can again be used.
- High resistance or flashing fault: These faults cannot be located using the T-900.

4.2.3 Turning on the T-900

The detector power can be turned on or off by pressing the power on / off button on the front panel (⑥ Figure 4.1). The power indicator on the display lights up when the T-900 is turned on.

4.2.4 Connections to the cable

Connect the cores which are not being tested to earth and attach the black crocodile clip on the test lead to the earth and the red clip to the core which is being tested (Figure 4.2).

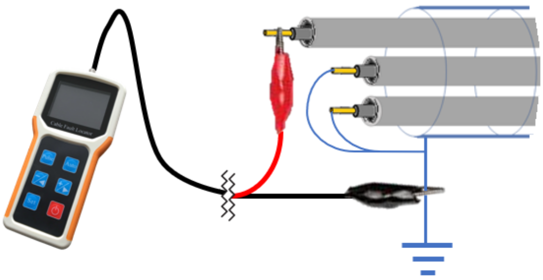


Figure 4.2 connections to the cable under test

4.3 Cable Test Procedures

If the velocity of propagation (VOP) is known this should be entered. Otherwise, the unit will use the default value of 200m/µs

4.4 Automatic Testing

Press the Auto button (⑧ Figure 4.1). The result of the test will be displayed on the instrument as shown in figure 4.2.

Note: The default setting wave velocity of propagation is 200m/µs, if a different value is required this can be changed using the procedure shown in section 4.5.1).

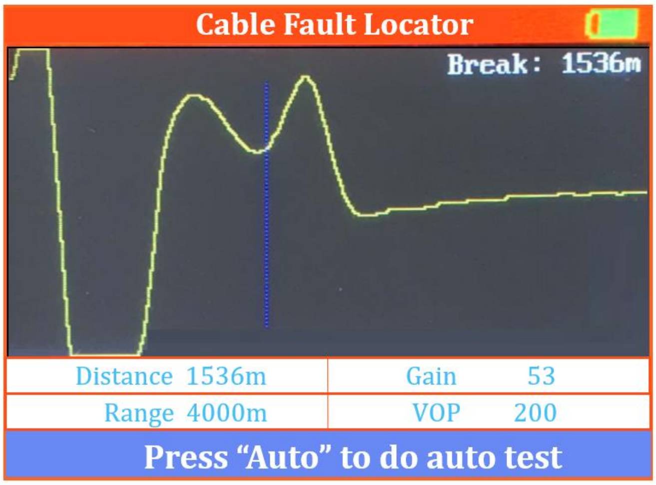


Figure 4.2 Auto test result

4.5 Manual Testing

If the fault cannot be detected automatically, the manual testing option should be tried. To set up the manual test the parameters should be adjusted. To do this pressing the "Set" button (④ figure 4.1) gives access to the various parameters.

4.5.1 Gain setting

Press "Set" repeatedly until Gain is highlighted on the screen menu (figure 4.3).

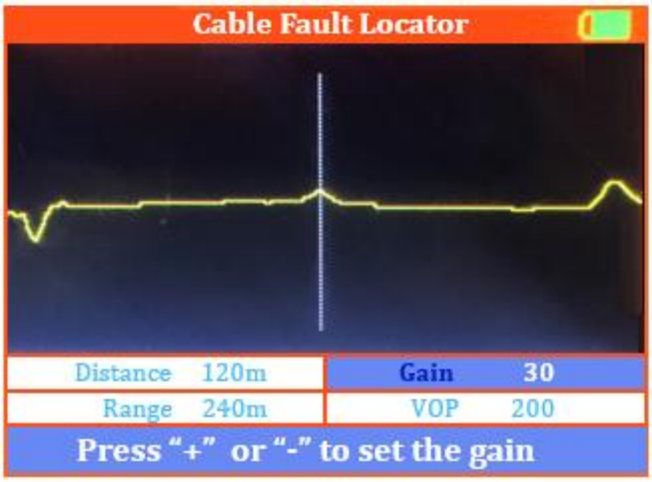


Figure 4.3 Display showing the gain adjustment selected

Pressing the “+” key (⑦ Figure 4.1) or “-“ key (③ Figure 4.1) will adjust the amplitude of the trace. Pressing the “Pulse” key (② Figure 4.1) will display the adjusted waveform (figure 4.4).

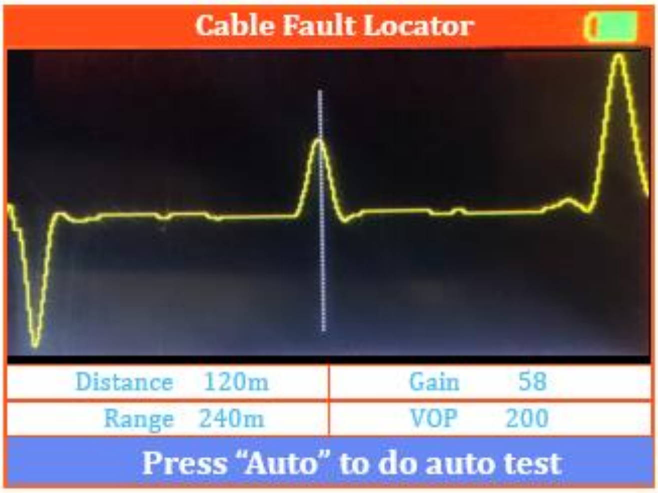


Figure 4.4 Display showing the waveform with increased gain

4.5.2 Range setting

The range determines the maximum testing distance of the instrument and should be selected such that it is longer than the actual length of the cable to be tested. It is preferable to have the range set such that it is only slightly longer than the cable length, as this will enhance the resolution and, hence, accuracy of the measurement.

Press “Set” repeatedly until “Range” is highlighted on the screen menu (figure 4.5).

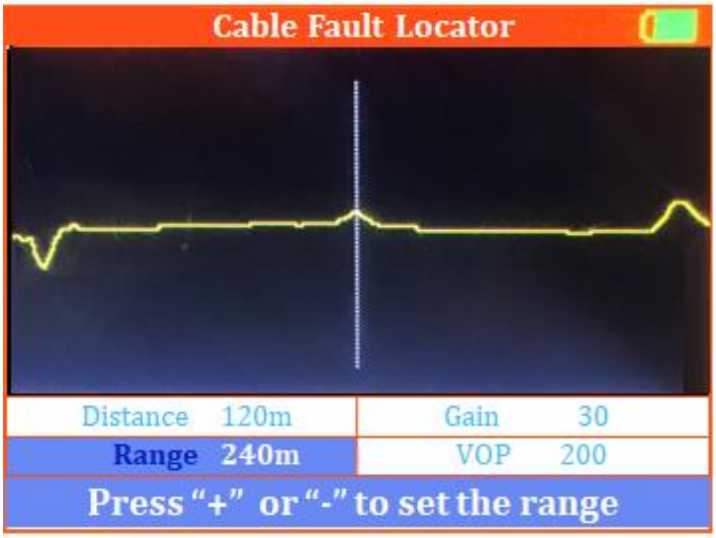


Figure 4.5 Display showing the range adjustment selected

Pressing the “+” key (⑦ Figure 4.1) or “-“ key (③ Figure 4.1) will adjust the range of the device.

4.5.3 Velocity of propagation (VOP) setting

The calculation of the distance to the fault is dependent on the value of the velocity of propagation. The device has a default value of 200m/µs which is an average value for underground cables. However, the VOP for cables varies depending on their construction, typical values are shown in table 4.1 below:

Cable Insulation Dielectric	Typical VOP (m/µs)
Oil paper	160
XLPE	170
PE	200
Rubber	220

Table 4.1 Typical VOP values for different sorts of cable

The VOP value can be entered by pressing “Set” repeatedly until “VOP” is highlighted on the screen menu (figure 4.3).

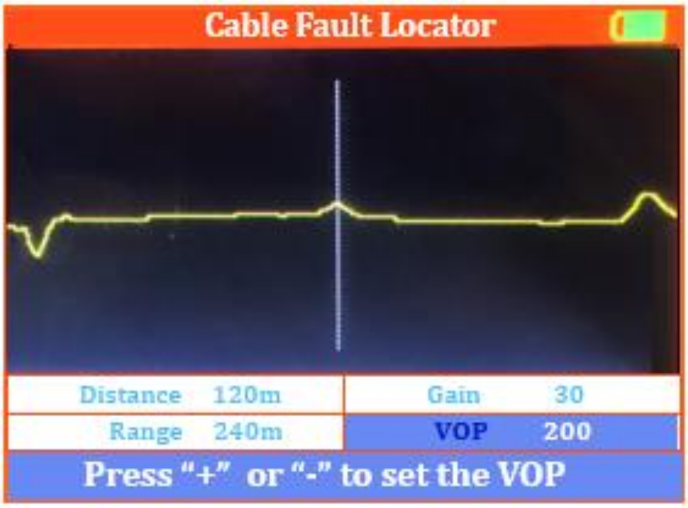


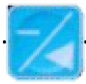
Figure 4.6 Display showing the VOP adjustment selected

Pressing the “+” key (⑦ Figure 4.1) or “-“ key (③ Figure 4.1) will adjust the range of the device.

4.6 Waveform comparison

An effective method of measuring the fault distance is to compare the waveforms of the faulty core and a healthy core.

To make the comparison, test the healthy core of the cable and save the waveform, by pressing “Set” repeatedly until it displays “Press “-” to memory, “+” to both” (figure 4.7).

Press the “-“ key .  ..to save the current waveform (figure 4.7).

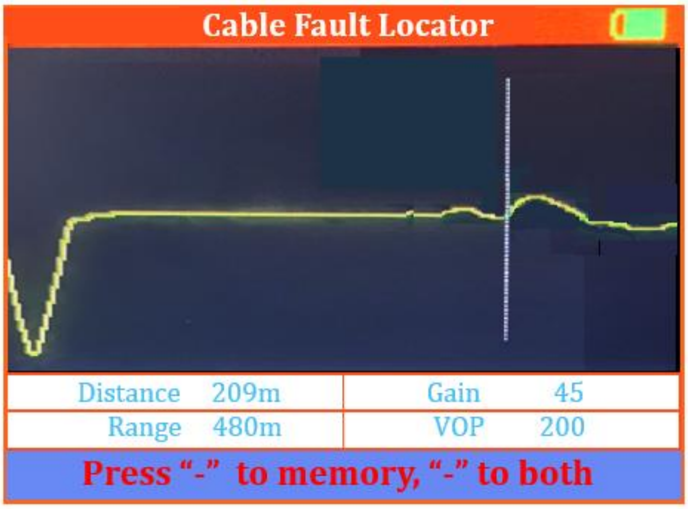
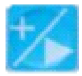


Figure 4.7 Saving a trace from a healthy phase

Now a test is done on the suspect core, a comparison is made by pressing the "+" key  in the memory mode, to recall the original waveform and superimpose it on the trace from the faulty core (figure 4.8).

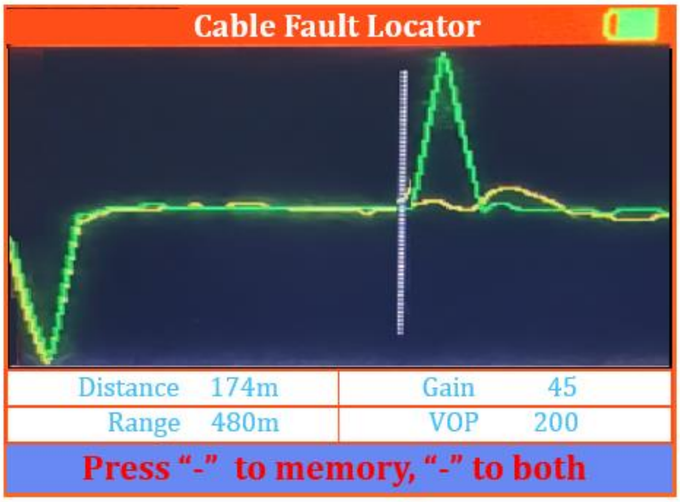


Figure 4.8 Waveform comparison

4.7 Waveform file saving

An external memory can be inserted in to the port on the bottom of the T-900 (figure 4.9)

Figure 4.9 External USB memory inserted in to T-900

Waveforms can be saved to an external memory, press “Set” repeatedly until “Press “-” to quit, “+” to save”. Quit will return the user to the normal testing mode and save will copy the waveform to an external USB memory (not provided) see figure 4.10.

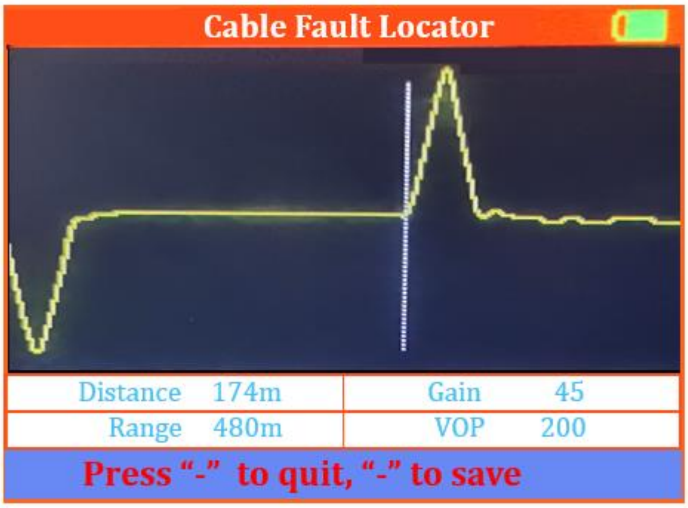


Figure 4.10 Saving a trace to an external memory

When the USB memory is transferred to a PC, then the TDR software provided, can be used to analyse it. The files are designated as .SWH (figure 4.11)

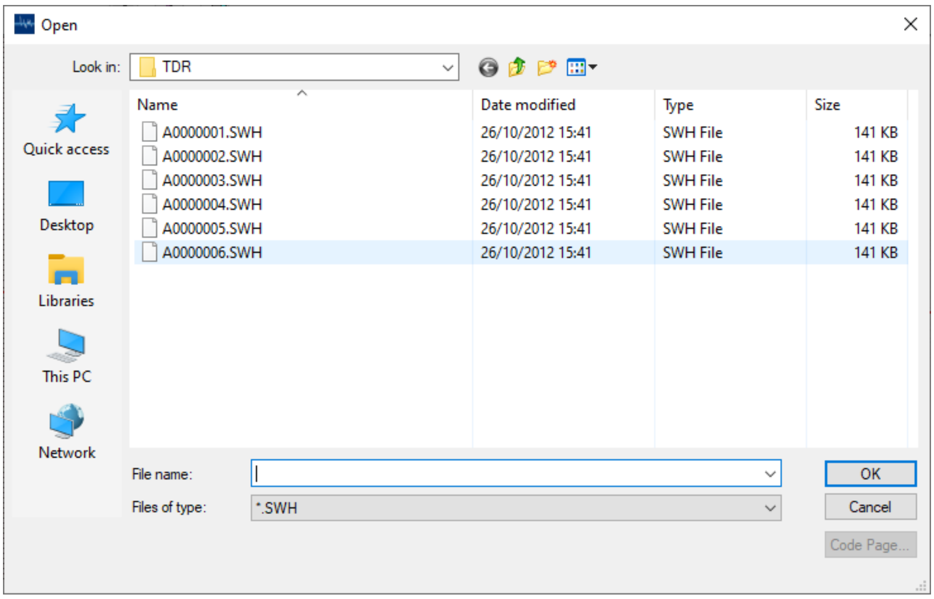


Figure 4.11 File directory

Opening the file in the TDR software allows the waveform to be examined and the distance to any discontinuities to be measured (figure 4.12).

Figure 4.12 PC TDR software

5. Transport and Storage

5.1 Transport Note

The instrument has undergone temperature, humidity, vibration and impact tests before shipment. However, it is still prudent to take care when transporting it and use the soft case provided. Observe the environmental conditions specified in the technical data sheet and avoid long term exposure to sunlight and humidity.

5.2 Storage Requirements

Where the instrument is not used on a regular basis, it should be stored indoors using the original packaging, and should not be exposed to the sun or rain. The room should be air-conditioned and should not be susceptible to corrosive gas. The instrument should not be subjected to severe mechanical vibration or shock and there must not be a strong electromagnetic field.

The storage requirements are as follows:

i. Temperature range -40ºC to +70ºC
ii. Relative humidity 40°C (20 to 90) %RH
iii. Atmospheric pressure (86 to 106) kPa

5.3 Unpacking and Inspection

Before unpacking for the first time, follow the steps below.

i. Take out the document bag containing the instructions and packing list.
ii. Check the packing list to ensure that the contents are complete and intact.
iii. Check that the serial number is consistent with the instrument and the factory number of the warranty card.

6. Packing list – T-900

No.	Description		Quantity
1	Power Cable Fault Locator		1
2	Carrying Bag		1
3	Testing Cable with BNC plug and crocodile clips		1
4	Charger		1
5	Manual and Certificate		1
6	T-900 software		1