T-906 Power Cable Fault Locator
User Manual

Kehui International Ltd
206 Mill Studio Business Centre
Crane Mead, Ware
Hertfordshire, UK, SG12 9PY
Phone: (44) 1920 444050
Fax: (44) 1920 468686
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.

Disclaimer: *Every effort has been made to make this material complete, accurate, and up-to-date. In addition, changes are periodically added to the information herein; these changes will be incorporated into new editions of the publication. Kehui International Ltd reserves the right to make improvements and/or changes to the product(s) and/or the program(s) described in this document without notice, and shall not be responsible for any damages, including but not limited to consequential damages, caused by reliance on the material presented, including but not limited to typographical errors.*

NOTE: Windows is a registered trademark of Microsoft.

Revision history:

Data version	Revision date	Revision reason	Person
1.0 Draft 001	2019.03.21	Major revisions. Decay method added	TonYip
1..0 Draft 002	2019.03.29	Reformatting, new template	DiaKib
1.0 Draft 003	2019.04.11	T-303A removed. Diagrams updated	TonYip
2.0	2019.04.11	Final edit and release	DiaKib
2.1	2019.07.18	Errors corrected	BilKib / DiaKib
2.2	2019.09.06	New Decay method diagram, minor typo change (delay to decay)	DiaKib
2.3	2020.01.24	Battery connection added	BilKib
2.4	2020.09.30	Changes in most sections including improved diagrams, pictures & some renumbering.	BilKib/DiaKib

Document reference: T-906_V2.4_UM_EN

Foreword

Thank you for purchasing the T-906 Power Cable Fault Locator (hereinafter referred to as T-906)

The T-906 is a high-performance portable fault locator for low, medium and high-voltage power cables. It can be applied for the pre-location of all kinds of faults, including open circuit, short circuit, low resistance, high-resistance and flashovers.

T-906 is a complementary product to Kehui's High Voltage Surge Generators, Cable Fault Pinpointing Devices and Cable Fault Test Van.

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.

Manual Objective

This user manual is the basic commissioning and on-site operation guide for the company's T-506. Users of the T-506 should read the entire contents of this manual in advance. If necessary, please contact us at info@kehui.com for further guidance.

This manual is mainly written for the first-line staff engaged in power cable fault repair, and can provide reference for the work of electrical technical engineers.

Manual Composition

This manual is mainly composed of two parts: the technical parameters of the product and the specific operation of the instrument.

Manual Agreement

This manual follows the following conventions:

1. All titles are in bold type.
2. If the title is followed by the words 'conditions', it means that the content required under the heading is required under certain conditions.

[**Note**] means that the reader should pay attention to those matters highlighted.

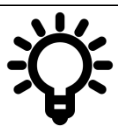
[**Warning**] means that it is vital that the reader pays particular attention to that topic, otherwise it could cause serious errors or compromise safety.

Table of Contents

1. Safety Instructions

Safety Note: This user manual is the basic commissioning and on-site operation guide for the T-906 Smart Cable Fault Pinpointer. All operators of the T-906 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

With the widespread use of power cables in power utilities, cable failures have correspondingly increased. A faulty cable causes interruption of supply to the consumers and increases "customer minutes lost". It is important for the faults to be located quickly, accurately and safely, to shorten the repair time of faults. T-906 power cable fault locator, together Kehui's high-voltage signal generators, provide sophisticated techniques for cable testing and fault location.

2.1 Description

The T-906 Power Cable Fault Locator uses modern microelectronics to produce a highly intelligent power cable fault location instrument. It has the advantages of simple and fast operation, high precision and strong noise immunity. It is a powerful tool for reducing labour and improving the efficiency of the maintenance crew in the electric power supply industry.

T-906 supports a number of working methods, including the time domain reflectometry (TDR) method, the secondary/multiple impulse method (SIM, MIM), an advanced impulse current method (ICM) and the decay method. The TDR injects a low voltage signal into the faulty cable and measures the pulse reflection from the fault. It is used to locate low resistance, short circuit and open circuit faults. The secondary/multiple impulse methods, using a HV generator and a signal coupler, are used to locate high impedance and flashover faults. The location is achieved by comparing two pulsed reflection waveforms, one during the fault ignition arc and the other during the arc extinguished state. The impulse current method, again with the cooperation of a high voltage signal generator, provides more efficient fault break-down and fault location. An artificial intelligence technique is used to automatically measure the fault distance, without the operator having to manually interpret the waveforms. The decay method is used to locate flashover faults requiring high breakdown voltage, using either a VLF (very Low frequency) or a DC high voltage generator.

2.2 Product characteristics

T-906 has the following characteristics:

- TDR, SIM/MIM, ICM and decay test methods to cater for all types of power cable faults.
- Automatic TDR method is complemented with an intuitive and user-friendly design.
- SIM/MIM testing provides easily recognisable waveforms, using a waveform comparative feature for high precision fault location.
- ICM is automated by an artificial intelligence waveform recognition technique.
- The equipment has an 8.4-inch resistive touch screen with a 16-bit true-color 640x480 LCD display. A rotary knob is included for cursor positioning and execution.
- User interface uses a picture-in-picture (PiP) display, simultaneously providing a detailed view and an overall view of the waveform, making waveform comparison simple, intuitive and more convenient.
- The equipment goes into a power safe mode after 2 minutes of no activity and switches off completely after another 8 minutes. It powers down automatically when the battery voltage is low to save the internal memory.
- Built-in 3M bytes of waveform storage memory.
- Communicates with the PC through a USB port for importing and exporting data. A dedicated PC management software is available.

- ➢ Smart battery charging to minimise charging time and to preserve battery life.
- ➢ Small size and light weight, easily portable.

2.3 Technical Specifications

- Basic fault location method: TDR, SIM/MIM, ICM, decay
- Highest resolution: 0.8m
- Highest sampling rate: 100MHz
- Longest cable length: 64km
- Blind spot: 4m
- Communications: USB
- Power source: Polymer lithium-ion battery pack, 7.4V nominal
- Battery duration: A fully-charged battery can last up to 5 hours
- Battery charge: AC 100-240V at 50/60Hz, charging current 3A, 8 hours charging time
- Size: 330mm x 305mm x 152mm
- Weight: 3kg
- Working temperature: -10 to +40℃
- Relative humidity at 25℃: (20 to 90)%RH
- Atmospheric pressure: 86 to 106kPa

3. Working Principles

The fault location methods of power cable can be broadly divided into four categories, based on the type of signal applied and the method of waveform acquisition. They are the TDR, secondary/multiple impulse method, impulse current method, and the decay method. The purpose and the working principles of these methods are explained below.

3. 1 Time Domain Reflectometer (TDR) method

3.1.1 Purpose

The time domain reflectometer method (also known as low voltage impulse method) is used to locate low impedance, short-circuit or open circuit faults of the power cable. It can also be used to calibrate the cable length and to identify cable joints, T-joints and the end of the cable.

3.1.2 Working principle

A low voltage impulse is injected into one end of the cable. The impulse travels down the cable until it reaches the fault position. The fault has an impedance of Z_f to earth which is different from the cable impedance Z_i. This will cause a reflection of the impulse.

The reflection coefficient p (the ratio of the reflected signal to the incident signal) is expressed by the following formula:

$$\rho = \frac{Reflected\ impulse}{Incident\ impulse} = \frac{Z_i - Z_f}{Z_i + Z_f}$$

From the formula it can be seen that the magnitude and the polarity of the reflected pulse depends on the values of Zi and Zf. For an open circuit fault, the reflected wave will have a negative polarity. For short circuit and low impedance faults, the reflected wave will have the same polarity. In both cases the reflection is significant and is clearly recognisable. These are illustrated in Figure 3-1.

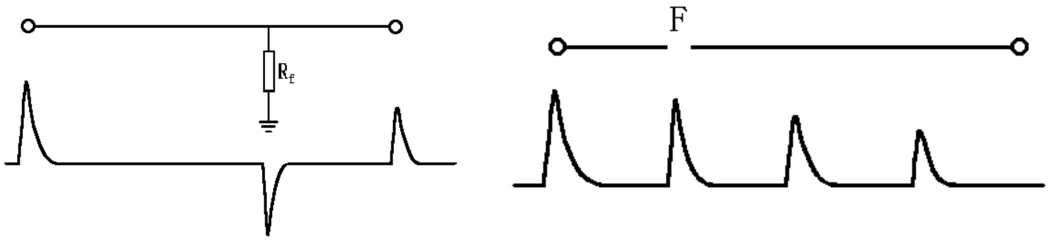


Figure 3-1 Reflected waves for short-circuit and open-circuit cable faults

Let the time duration between the incident impulse and the reflected impulse be Δt, and the fault distance be Lx. Also, let the wave propagation velocity be v. Since Δt is the time taken for the impulse to travel in a round-trip between the injection point and the fault, its relationship with Lx can be expressed by the following formula:

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

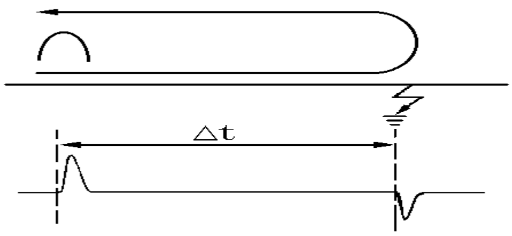


Figure 3-2 Round-trip time of reflected wave

3. 2 Secondary/Multiple Impulse Method (SIM/MIM)

3.2.1 Purpose

Secondary or Multiple impulse method (SIM/MIM) is used, in conjunction with the T-305E high voltage signal generator, to locate a power cable's high impedance and flashing faults. The faults can be single-phase to earth, multi-phase to earth and phase-to-phase faults. For SIM/MIM, the waveforms are simple and easily analysed.

3.2.2 Properties of a high voltage arc

When applying a sufficiently high DC voltage to a faulty cable, the resultant electric field causes the free electrons to move and create collisions. Their collisions with free neutrons create electrons and protons, which in turn will collide with other neutrons. This causes an avalanche condition, with insulation breakdown and the formation of conductive paths.

The fault point will have a temporary short circuit, when the voltage drops to almost zero and the current rapidly rises, resulting in a discharge arc. The impedance is very small, and can be regarded as a short-circuit or low impedance fault.

3.2.3 Working principle

For high impedance or flashing faults, the TDR method is not applicable. This is because the fault impedance is comparable to the insulation impedance of the cable, resulting in little or no reflection. The SIM/MIM works by applying a high DC voltage to the faulty cable until the fault breaks down, creating an arc. Low voltage impulse is injected into the cable under the arcing condition and the waveform is recorded. Since the arc can be considered as a short-circuit or low impedance fault, the reflected impulse will be significant and will have an opposite polarity as shown.

After the arc is extinguished, the fault goes back into the high impedance state. Injection of a low voltage pulse will cause a reflection from the end of the cable. By comparing the two waveforms and recognizing the difference, the fault distance can be identified.

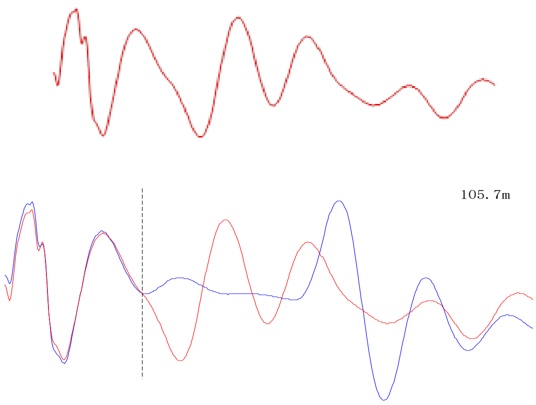


Figure 3-3 Single/Multiple Impulse Method

3. 3 Impulse Current Method

3.3.1 Purpose

In conjunction with a HV signal generator (for example Kehui's T-305E), the Impulse Current Method (ICM) can be used to locate single phase, multi-phase or interphase faults of a power cable. The fault is broken down by the high voltage, generating a current impulse which reflects multiple times between the T-305E and the fault point. The waveform is captured at the measuring point and is analysed. T-906 has an artificial intelligence technique which can interpret the waveforms to provide the fault location results automatically.

3.3.2 Working Principle

A high impedance and flashover fault of a cable has a large fault resistance (more than 10 times the cable's characteristic impedance). The low voltage pulse has no obvious reflection at the fault point (the reflection pulse amplitude is less than 5%), therefore the TDR method cannot be used.

As shown in Figure 3-, when the voltage applied to the cable has reached a certain value, the fault breaks down and is discharged. This results in an impulse current which moves towards the HV generator, moves back to the fault point by the capacitance reflection, then reflects back again. The impulse current is therefore reflected multiple times between the capacitor of the T-305E and the fault, which can be captured at the measuring point.

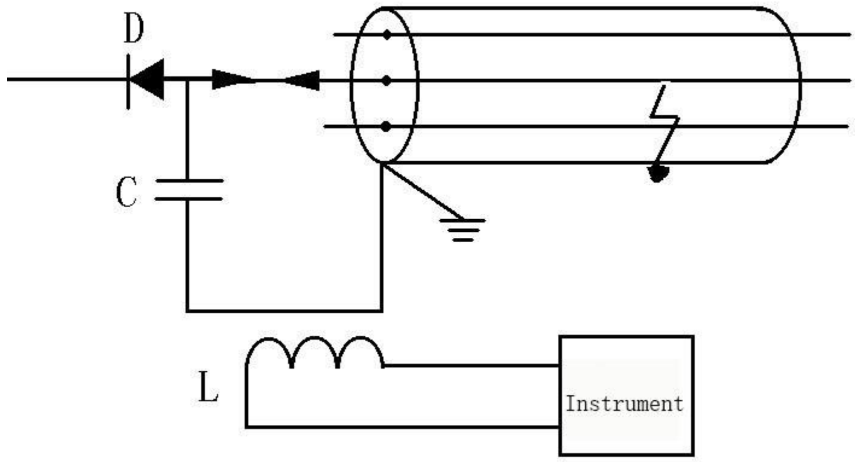


Figure 3-4 Set-up for Impulse Current Method

Impulse Current Method uses a linear current coupler to collect and record the current waveform generated by the breakdown. The linear current coupler L is placed next to the ground lead between the energy storage capacitor L and the metallic shield of the cable. It picks up the magnetic field generated by the current in the ground lead to reproduce the current waveform. Through analysis of the waveform to measure the round-trip time of the impulse, the fault distance can be calculated.

According to the different modes of high voltage signal applied to the cable, this method can be sub-divided into DC flashover method and impulse flashover method.

3.3.3 DC Flashover Method

DC flashover method is used when the fault impedance is very high. The HV test equipment is used to raise the DC voltage to a certain value until flashover occurs at the fault point. The connection is shown in Figure 3-, where T1 is a voltage regulator, T2 is a HV transformer, with a capacity between 0.5~1.0 KVA and output voltage between 30~60 kV, C is the energy storage capacitor of the HV generator and L is the linear current coupler. The resultant waveform is shown in Figure 3-.

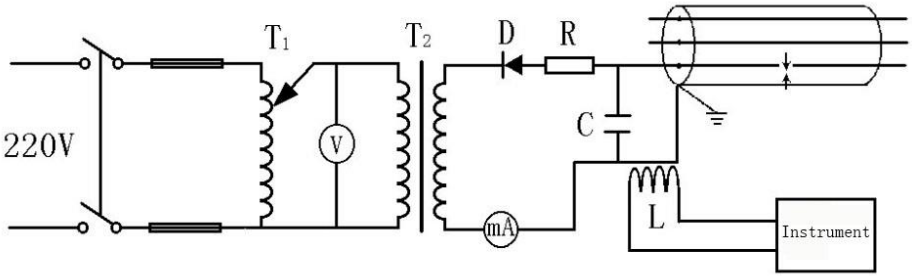


Figure 3-5 Set-up for DC flashover method

Figure 3-6 Waveform for DC flashover method

3.3.4 Impulse flashover method

When the fault impedance is not very high, due to the large earth leakage current, the voltage generated by the HV test equipment is applied mostly to its own internal resistance. The cable voltage is therefore small and is not sufficient to breakdown the fault. In this case, the impulse flashover method is used. The connection is very similar to the direct flashover method, except that a spherical gap G is inserted between the capacitor and the cable. When the voltage applied is sufficiently high, the spherical gap G breaks down, the capacitor C is then discharged to the cable. This process is equivalent to a sudden application of DC voltage to the cable which causes flashover of the fault. The typical waveforms are shown in
Figure 3-.

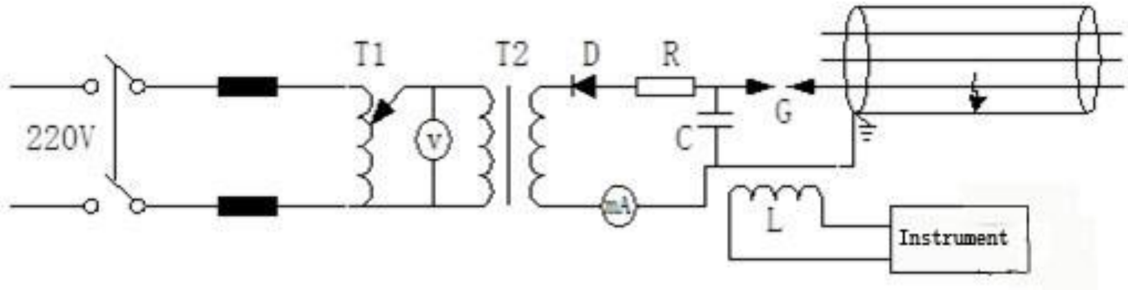


Figure 3-7 Impulse Flashover Method

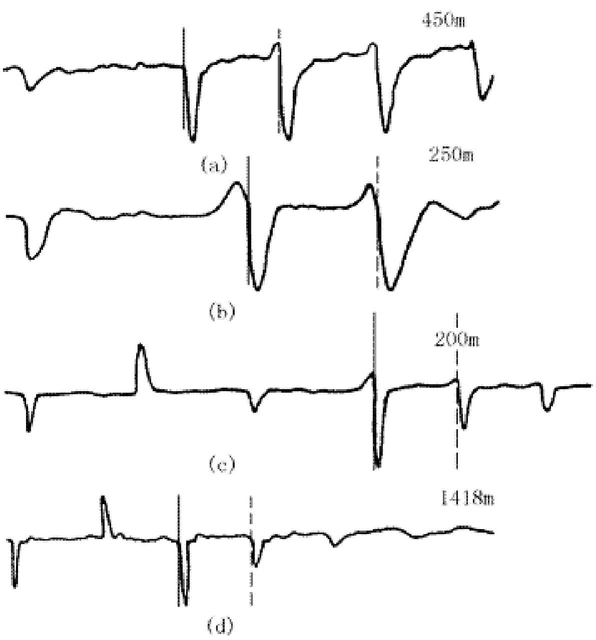


Figure 3-8 Waveforms for Impulse Flashover Method

3. 4 Decay Method

3.4.1 Purpose

The decay method is applicable where the fault breakdown voltage is higher than the rated voltage of the signal generator. In order to achieve the breakdown voltage of the cable fault, a DC or VLF is used as the high voltage source. It needs to be used in conjunction with a capacitive voltage divider, and is mainly for flashover faults.

3.4.2 Working Principle

The decay method's connection diagram is as shown in Figure 3-. A high voltage is continuously applied to the cable until the fault discharges. The energy is stored in the cable capacitor when the fault breakdown voltage is reached. The breakdown will produce a voltage travelling wave, which reflects back and forth between the fault point and the HV source.

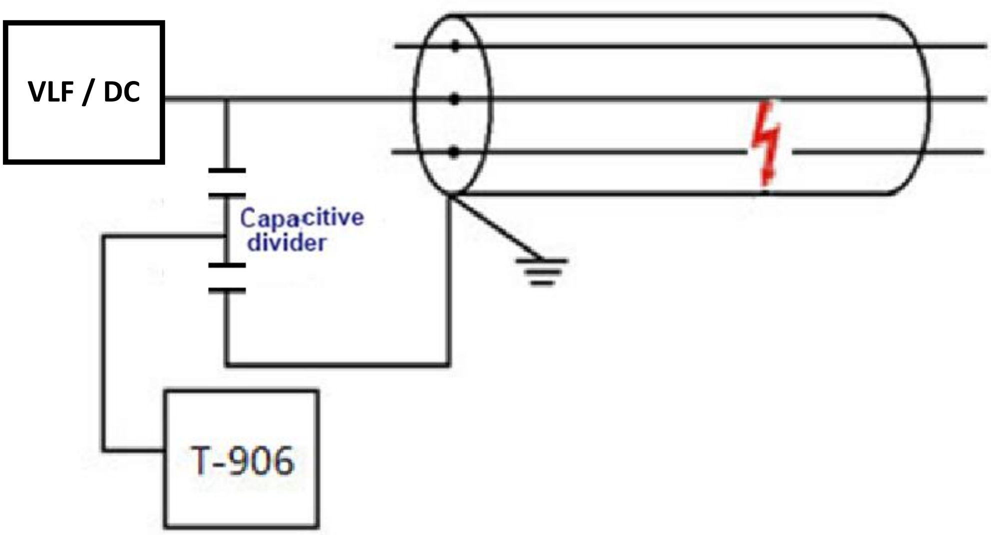


Figure 3-9 Set-up for the decay method

4. Using the fault locator T-906

4.1 Overall composition

4.1.1 Accessories

The T-906 consists of a number of accessories, detailed in the Packing list featured in Section 12.

4.1.2 Front panel composition

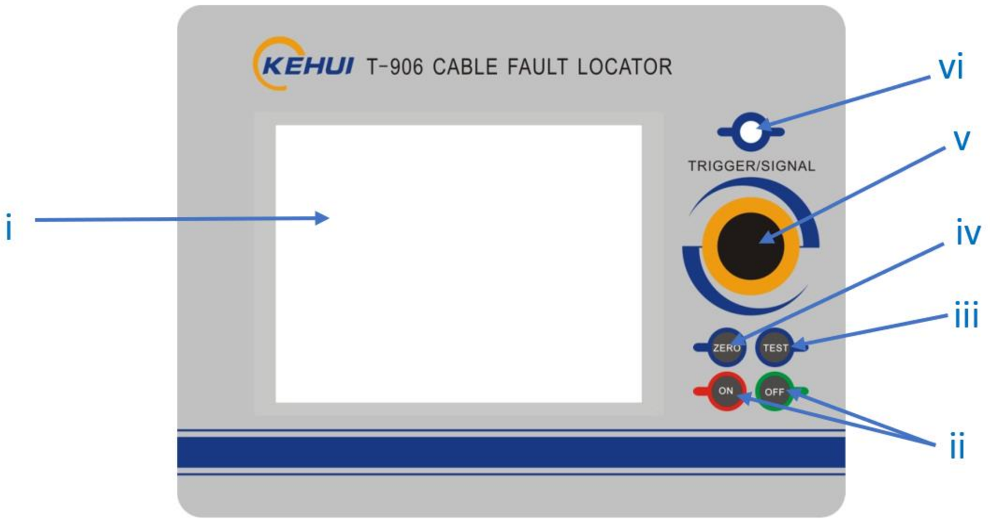


Figure 4-1 T-906 Front Panel

i. LCD display: 8.4 inch touch screen for waveform display.
ii. <On> <OFF> keys: Switch instrument's power supply.
iii. <Test> key: Press once for manual test, press and hold for over 1s for automatic testing.
iv. <Zero> key: Reposition the cursor to the starting point.
v. Cursor knob: Move the cursor left and right to determine the fault distance.
vi. Trigger/Signal Lemo socket: Connection to other equipment, using different leads depending on the test method.

4.1.3 LCD screen composition

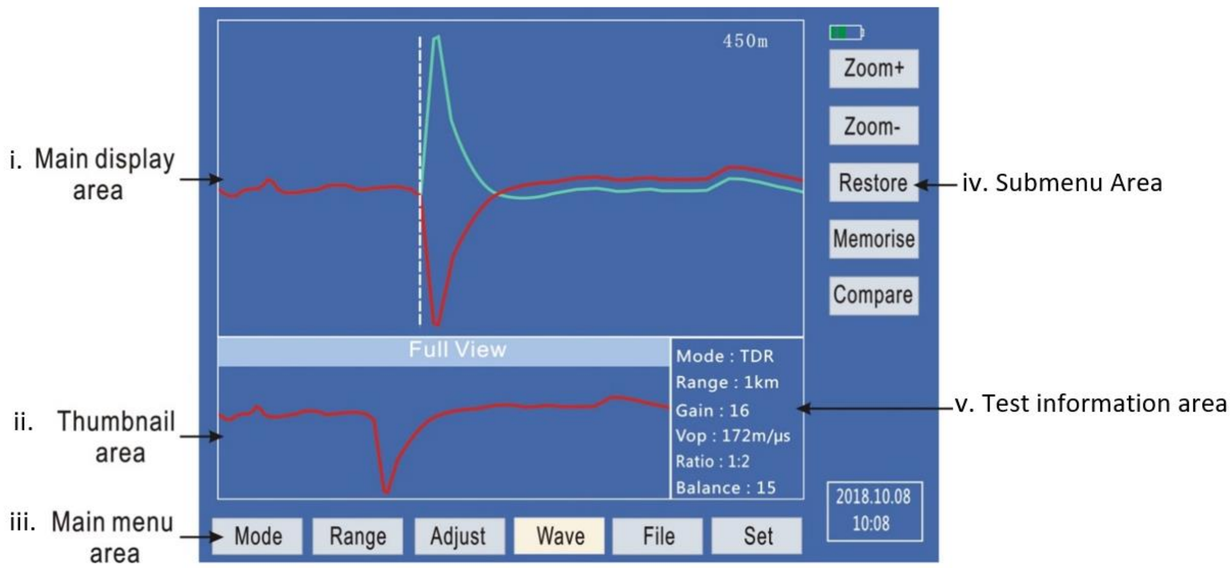


Figure 4-2 T-906 Display

i. analysis Area: Displays an enlarged section of the waveform plus cursor for analysis.

ii. Thumbnail area: Displays the entire waveform.

iii. Main Menu Area: Consists of the main menu selection.

iv. Submenu Area: Consists of specific sub-menus according to the main menu selection.

v. Test Information Area: Displays the parameter settings of the test mode selected.

4.1.4 Side panel composition

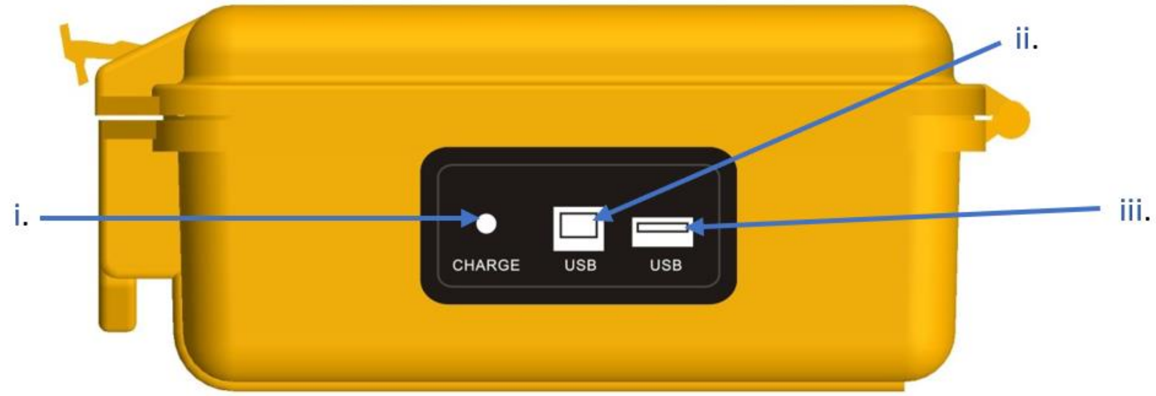


Figure 4-3 T-906 Side View

i. Charge: For connection to the charger supplied.

ii. USB-B port: For a USB connection to a PC using the lead supplied

iii. USB-A port: For inserting a memory stick for waveform extraction.

4.1.5 Functions of the test leads

The test leads feature Lemo plugs which will be inserted into the Lemo Trigger Signal socket on the T-906 front panel

a) Linear current coupler: For ICM testing, Figure 4-4

Figure 4-4

b) TDR test lead: For TDR testing Figure 4-5

Figure 4-5

c) Coupler test leads: For decay and SIM/MIM testing. The other end of the cable is plugged in to the trigger socket on the side of Kehui T-305E surge generator Figure 4-6

Figure 4-6

4.2 Preparation

The following steps should be taken to begin using the T-906;

4.2.1 Charging the T-906

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-906 marked "charger" Figure 4–3.

[**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 Turning on the T-906

The detector power can be turned on or off by pressing the power on/off button on the front panel (figure 4.1). The detector power indicator lights up when the detector is turned on.

If the unit does not turn on the first time it is used and it an attempt has been made to charge it, it is possible that the battery has been disconnected (see section 4.3)

4.3 Battery Connection

Due to airline regulations, the unit is often shipped with the battery disconnected. When the unit is first unpacked, plug the charger into a suitable power outlet and insert it in to the charger socket on the detector (section 2.7). Press the on/off button. If the unit's Power light does not illuminate, it is probable that the battery is disconnected. The following instruction should be followed if the battery is disconnected.

4.3.1 Opening the box

Disconnect the charger and open the box of the T-906 by removing the 4 screws on the bottom part of the box (Figure 4.7). Take care to put the screws in a safe place for re-assembly.

Figure 4-7

Figure 4-8

Figure 4-9

4.3.2 Removing the instrument

Take out the inside part as shown in figure 4.8, being very careful as there are some connection wires inside

Then remove the 2 screws marked above with the red circles in figure 4.9, this allows the complete metal box inside to be removed. This can be opened by removing the 4 screws on the metal box, (Figure 4.10). Again, keep the screws safe.

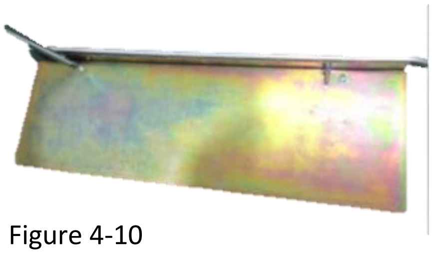


Figure 4-10

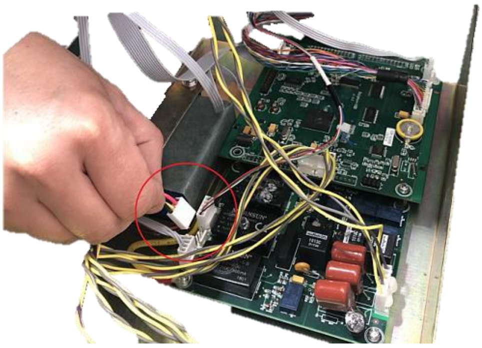


Figure 4-11

This will expose the inner part of the instrument, including the battery pack and the connection wire, please plug it back to the terminal as marked in Figure 4.11, above.

The board should now look as in Figure 4.12 below

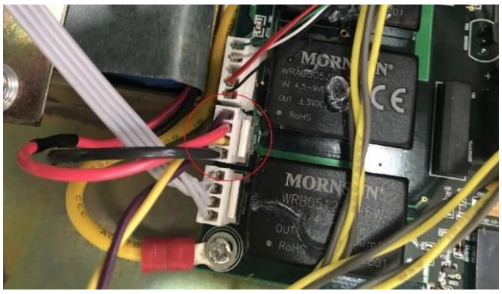


Figure 4-12

Plug the charger in to the socket on the T-906 and ensure that it is working correctly by pressing the power on/off button  on the front panel (figure 4.1). Take care not to touch any of the circuitry.

If it is working correctly reverse the disassembly instructions and put the device back together. Ensure that all of the screws are properly tightened.

The device can now be used.

5. Menu Operating Instructions

After the T-906 is switched on, the Kehui logo is seen and then the menu display appears. The display consists of the waveform analysis area, showing an enlarged section of the waveform, plus cursors for analysis purposes. There is also a thumbnail representation of the whole waveform (Full View), with waveform information displayed to the right of the thumbnail. This information includes the working mode, current range, gain, velocity of propagation, zoom and balance.

The main menu area at the bottom of the thumbnail consists of <Mode>, <Range>, <Adjust>, <Wave>, <File> and <Set> buttons, allowing the user to select various menu options. The right-hand side of the screen consists of a sub-menu which varies according to the main menu selected. The example shown in figure 5-1 corresponds to the <Wave> sub-menu for controlling the analysis waveform. Detailed functional explanations of the menu options are given in the following subsections.

Figure 5-1: T-906 screen showing <wave> submenu.

5.1 <Mode> - Operating Mode

The <Mode> is used to select the operating mode of the T-906. It consists of <TDR>, <ICM>, <MIM>, <Decay> in the sub-menu, corresponding to the 4 major cable fault location methods provided by the T-906. They are selected based on the fault type and the connection arrangement on site. The test information area shows the operating mode selected. The default operating mode after power-on is TDR.

5.2 <Range> - Operating distance range

Pressing <Range>, the sub-menu shows <500m>, <1km>, <2km>, <4km>, <8km>, <16km>, <32km>, <64km>. They are selected based on the length of the cable under test. The test information area shows the range selected; the default range is 500m.

5.3 <Adjust> - Operating T-906 during testing

Pressing the <Adjust> button, the sub-menu shows 6 buttons: <Gain+>, <Gain->, <Balance+>, <Balance->,<VOP+>, <VOP->. and <Delay+>, <Delay->

Note that Balance is used for TDR and MIM, Delay is used for ICM. VOP stands for Velocity of Propagation.

Depending on the mode of operation, pressing the <Test> button will have the following effect:

TDR: A TDR pulse will be generated. The waveform will be updated with the injected and the reflected pulses from the cable.

MIM, ICM, Decay: The screen shows <Ready for trigger>, the T-906 is now ready and is waiting for the HV generator to discharge. Under this condition, only the <Test> button and the <On/Off> buttons are effective. All other buttons are disabled. Pressing the <Test> button again will exit from this condition. After trigger, the new waveform will appear.

5. 3.1 Gain adjustment

Pressing <Gain+>, <Gain-> causes the Gain value in the test information area to change. Under TDR mode, the waveform will also change correspondingly.

5. 3.2 Balance adjustment

Under the TDR mode, pressing the <Balance+>, <Balance-> buttons will cause the <Balance: xxx> in the information area to change. The balance adjustment adjusts an internal balancing resistor network. The waveform on the screen will correspondingly change, and noise from internal relay operation which changes the resistor network can be heard.

5. 3.3 Velocity of Propagation (VOP) adjustment

Pressing the <VOP+>, <VOP-> buttons will cause the display <V=xxx> value to change, the calculated distance at the top right-hand corner of the screen will also change. The following table shows the typical VOP for different kind of cable.

Cable Insulation Dielectric	VOP (m/µs)
Oil paper	160
XLPE	170
PE	201
Rubber	220

5.3.4 Delay adjustment

Under ICM and decay method, pressing <Delay+>, <Delay-> will cause the <Delay xxx us> display to change.

5.4 <Wave> - Operating on the waveform

Pressing the <WAVE> button causes <ZOOM+>, <ZOOM->, <RESUME>, <SAVE> and <BOTH> buttons to be displayed in the sub-menu. <ZOOM+> and <, Zoom-> allow the waveform to zoom in and out, <RESUME> allows the waveform to revert to its original size, the ratio XX: 1 will change accordingly.

Pressing <SAVE>, saves the currently displayed waveform temporarily to the memory. Pressing <BOTH>, displays the current and saved waveforms for comparison.

5.5 <File> - File management

Pressing the <FILE> button causes <SAVE>, <PGUP>, <PGDN>, <SHOW>, <DEL>. (delete), and <save to USB disk> to be displayed in the sub-menu on the right.

5.6 Waveform Storage

Pressing <SAVE>, the screen will display <SAVE?>. Pressing <SAVE> again, the current waveform will be saved to the memory permanently.

Note: When saving the waveform, the <SAVE> button is highlighted. When it turns to grey, the saving process is finished. Do not power-off the unit during the process of saving or deleting.

5.7 Waveform browsing

<PGUP> and <PGDN> allows selection of saved waveforms for display. The <SHOW> button displays the highlighted one. Pressing <DE> will delete the highlighted waveform.

5.8 Save to USB stick

Plug in the USB disk and press <Save to USB Disk> to back-up the waveforms to the USB.

Note: It may take some time to save all the waveforms to the USB disk. Be patient until the button <Save to USB Disk> turns grey.

5.9 <Set> - Settings

Pressing the <Set> button causes <Select>, <Time+>, <Time->, <Zero> to be displayed in the sub menu on the right (n.b. Zero has no function in this version of the software).

5.9.1 Time setting

Pressing <Select> causes the date and time to be displayed, as shown in . Press <Select> repeatedly to choose the value to be revised, then press TIME+ or TIME- to set the correct date and time.

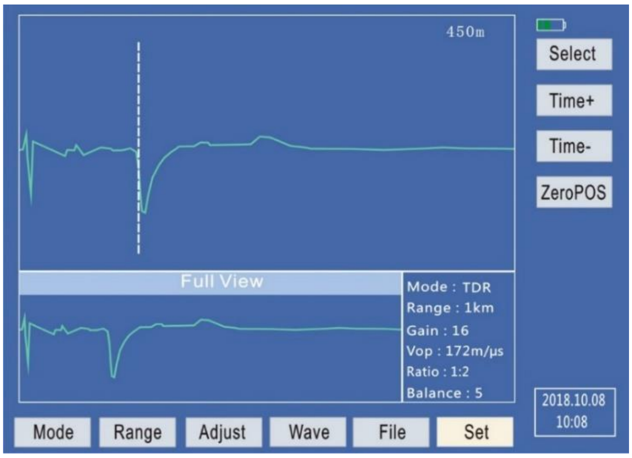


Figure 5-2: T-906 Time setting

6 Cursor Movement

The Zero point of the cursor (Zero Cursor) is only valid under MIM mode, this sets the start point for the cursor. Under the MIM mode, move the cursor to the start position by turning the rotary CURSOR knob on the panel which moves the “dotted line” cursor. When the selected position is reached, press the <Zero> button to fix the “solid line” cursor to that position. When this mode is exited and re-entered, the cursor will be placed at the start position automatically and is the reference for subsequent fault distance measurement. The “dotted line” cursor is moved to perform fault distance measurements.

7 USB Communications

T-906 can communicate with a PC through the USB port. The lead supplied is plugged into the USB-B port on the T-906 with the USB-A plug (the other end), plugged into a free socket on the PC running the T-906 software. The communication software is available from Kehui and will be delivered by email.

Notes:

- *The T-906 is regularly updated. Contact us on info@kehui.com to check if you have the latest version.*
- *When using the USB cable to connect the T-906 to a computer, press SET and TEST together to stop the T-906 software and avoid automatic shutdown. Re-boot the T-906 afterwards to resume its normal testing function.*
- *The T-906 will appear on the computer as a USB Drive. Its files can be accessed by clicking on the file icon.*
- *The resulting waveform is displayed as in figure 7.1.*

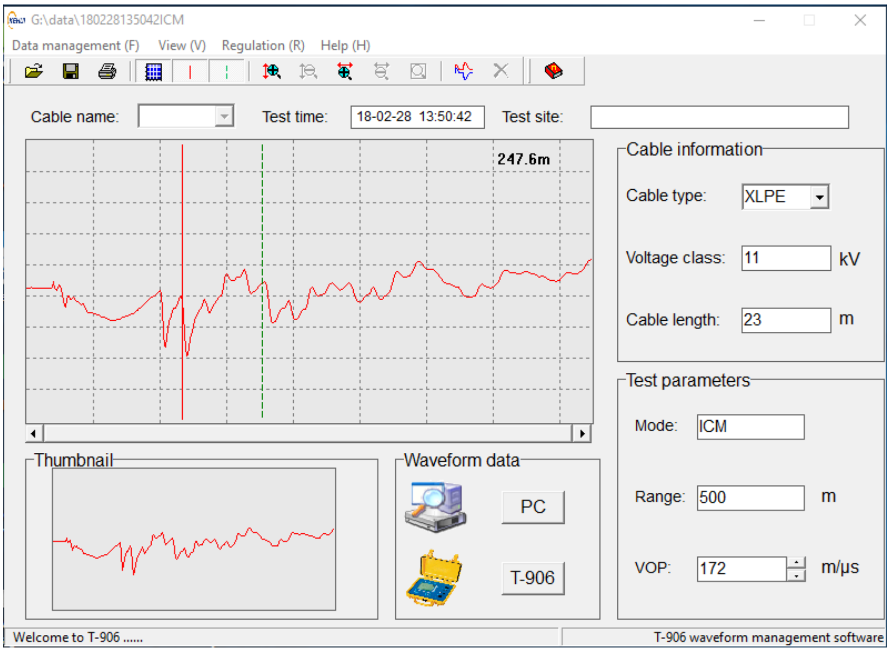


Figure 7.1 T-906

8 Power Management and Battery Charging

8.1. Power Management

i. Brightness auto adjust: When the LCD is on, it will automatically become dim if there is no operation within 30 seconds. This is to avoid power consumption.

ii. Battery capacity indicator: The solid bar indicates the capacity remained.

iii. Power off automatically: If there is no operation within 10 minutes, T-906 will power off automatically to save power.

iv. Power off when voltage is low: when the inner Li-ion battery voltage is lower than 7V, T-906 will power off automatically.

8.2 Battery Charging

The T-906 is powered by a rechargeable battery pack contained within the instrument.

When the battery supply has been depleted and the batteries need to be recharged, connect the external battery charger into the front panel charger socket. The front panel LED will turn to red to indicate the batteries are being charged. The indicator will be green when charging is completed.

Note:

- *Only use the battery and charger supplied by Kehui, or it will cause severe damage or even explosion if using a battery or charger from other manufacturers.*
- *Store the instrument free from high heat, humidity and dusty environments.*
- *If there is some damage to the power lead, do not use it, to avoid further damage and electric shock.*
- *In order to protect the battery, it is better to charge it as soon as the voltage is low.*

9 Cable Test Procedures

9.1 Diagnostics and testing methods

Before the test, the field engineer should perform diagnostic tests of the cable to determine its insulation condition and the fault type, in order to choose the most appropriate testing method.

The field engineer should measure the insulation resistance of the phase-ground and phase-phase from one end of the cable with a Mega-ohm meter. If the insulation resistance is too high, a continuity test should be carried out by shorting all of the conductors at the remote end, this will determine whether there is an open conductor fault.

According to the result of the 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: If the phase-phase or phase-ground resistance is high, ICM or MIM mode can be selected.

9.2 TDR Method

Before any testing is carried out, ensure that the cable is thoroughly discharged.

Connect one end of the test lead from the instrument to the core of the cable under test. Switch on the instrument, the default mode is TDR mode.

If the velocity of propagation (VOP) is known this should be entered. Otherwise, refer to the values in section 5.3.3.

9.2.1 Automatic Testing

Under TDR mode, by pressing TEST for more than 1 second, the instrument will adjust the RANGE, GAIN and BALANCE automatically, and place the cursor to the fault point. The fault distance will be displayed automatically on the LCD.

To check the result, go to the <Adjust> sub-menu and adjust the <Gain+>, <Gain->, "Balance+>, <Balance-> to obtain a desired waveform. The cursor should then be moved manually to coincide with the rising edge of the waveform

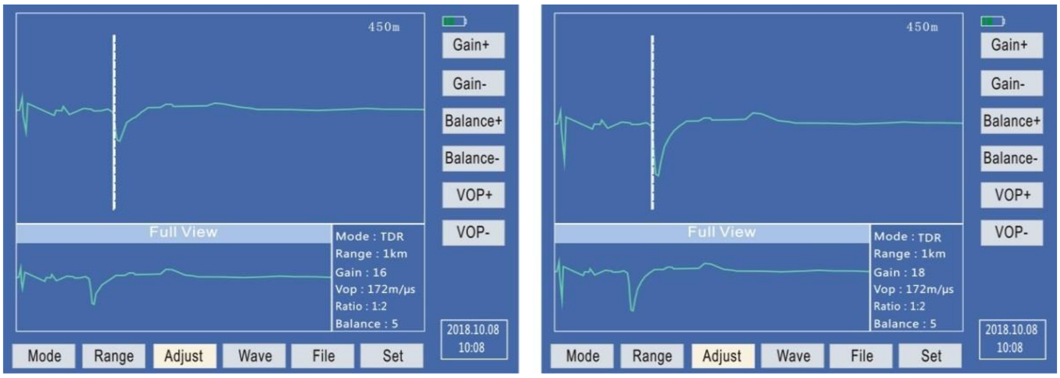


Figure 9-1 Gain adjustment of the TDR method

The waveform can be zoomed in or out with respect to the dotted curser to have a better view, as shown in Figure 9-2. The full view displays the entire waveform.

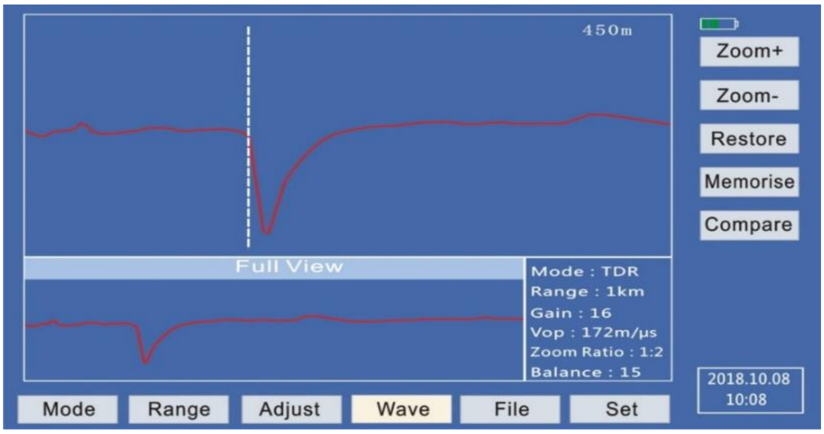


Figure 9-2 Zoom adjustment of the TDR method

If the automatic feature fails to identify a fault, adjust the waveform as above and carry out a manual check of the distance by moving the cursor until it coincides with the rising edge of the reflection.

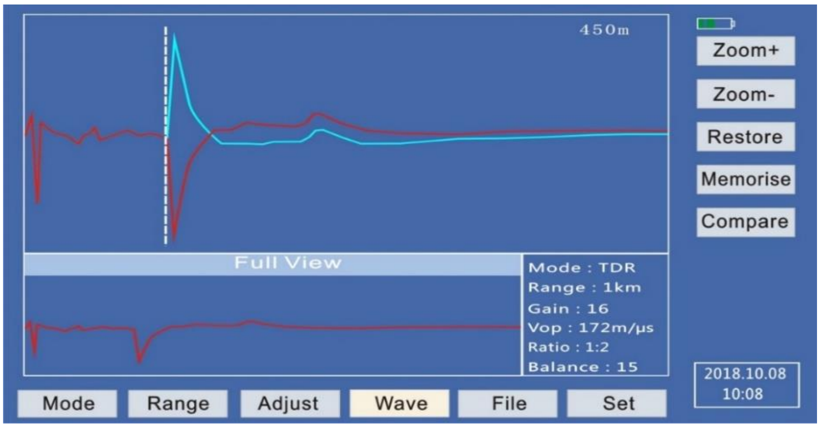
9.2.2 Waveform comparison

Under the same test mode, the fault distance can be measured by comparing the waveforms of the faulty core and a healthy core.

Test the healthy core of the cable, save the waveform, then test the faulty core and get the waveform, press <Compare> to display the two waveforms on the LCD. Move the cursor to the point where the waveforms deviate from each other, this will then be the faulty point.

If the correct length of a healthy cable is known, VOP of this kind of cable can be determined. Note that the longer the cable, the more accurate the VOP will be. Correctly place the cursors of the TDR on the output pulse and the reflected pulse from the end of the cable. Change the VOP setting until the “Distance Between Cursors” displays the known length. The VOP of the cable is now determined, as shown in Figure 9-3.

Figure 9-3 TDR Waveform Comparison



9.3 Secondary/Multiple Impulse Method (SIM/MIM)

9.3.1 Working with T-305E

The T-305E should only be used after the user has thoroughly read the associated instruction manual.

Ensure the faulty cable is fully discharged. Isolate it from other equipment and connect its metal protective sheath to ground.

Note: This ground connection is the working ground. This has the ground potential and acts as the reference during discharge.

Position the T-305E close to the cable and place the T-906 on the T-305E tray for ease of operation.

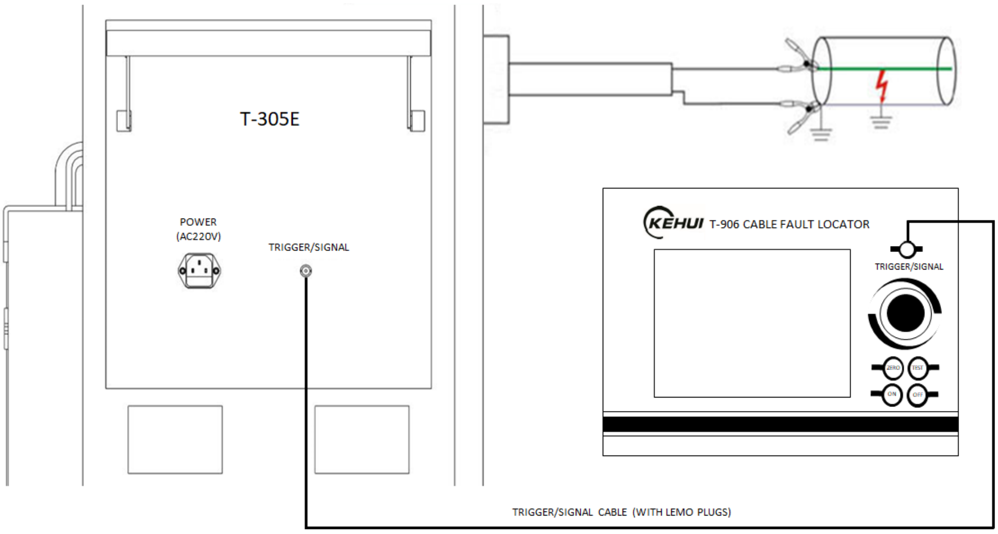


Figure 9-4 SIM/MIM set-up with T-305E

Connect the working ground, protective ground and the auxiliary ground. The protective ground and the auxiliary ground must be connected separately. Connect the T-305E Trigger/Signal connection with the T-906's Trigger/Signal connection using the lead with the two Lemo plugs supplied (Figure 4-6). The socket on the T-305E is beneath the tray as shown in figure 9.4. Switch on the T-305E, select <Pulse> mode, and select <SIM/MIM> test method. The cable under test is connected as shown (refer to the T-305E manual for instructions).

Turn on the T-906, set the work mode as MIM and press the <TEST> button, the instrument will display <Arm>. After discharge, the T-906 will automatically send the pulses, and will display the waveforms on the LCD. Move the cursor to the position where there is a sharp difference between the two waveforms, this allows the fault distance to be determined.

Figure 9-5 Multiple Impulse Method trace on the T-906 screen

9.4 Impulse Current Method (ICM)

9.4.1 Working with the surge generator

As the T-906 is equipped with a linear current coupler, it can be used with any suitable surge generator. The user should thoroughly read the associated instruction manual before using the chosen surge generator.

Ensure the faulty cable is fully discharged. Isolate it from other equipment and connect its metal protective sheath to ground.

Refer to Figure 9- for the connection of the surge generator. The linear current coupler required for ICM is provided with the T-906. Switch on the surge generator and select the pulse mode and the ICM test method.

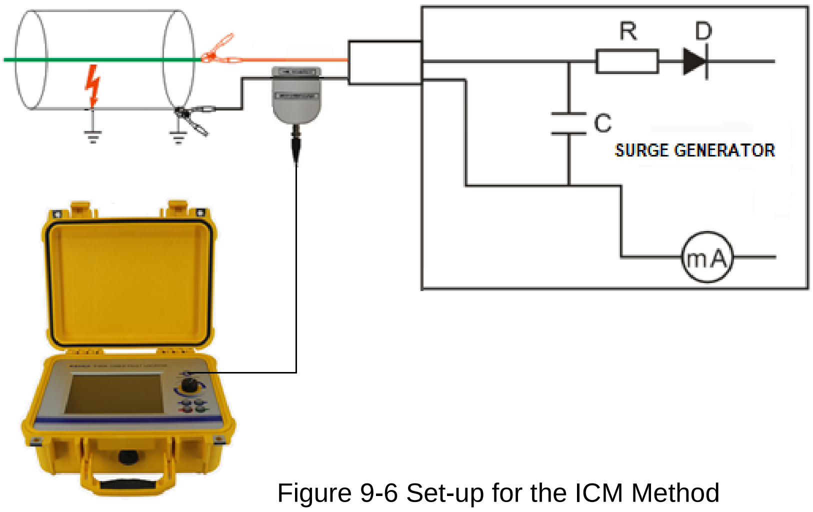


Figure 9-6 Set-up for the ICM Method

Switch on the T-906. In the <Mode> sub-menu, select <ICM>. In the <Adjust> sub-menu, adjust the appropriate Velocity of propagation (VOP) for the cable under test. In the <Range> sub-menu, select the appropriate length, typically 2 to 4 times the length of the cable. Press the <Test> button. T-906 displays <Waiting for rigger>.

Discharge the surge generator, the T906 will automatically locate the fault distance and position the curser at the fault position on the waveform. If the gain is not suitable, the display will indicate that the gain is too big or too small. Adjust the gain accordingly until a desirable waveform is displayed.

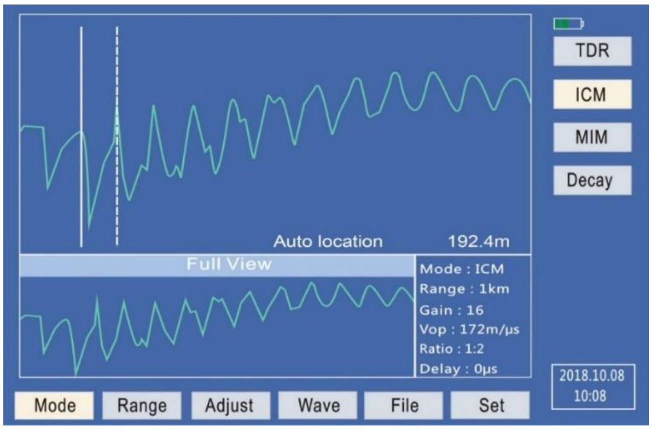


Figure 9-7 Automatic fault location for the ICM method

9.5 Decay Method

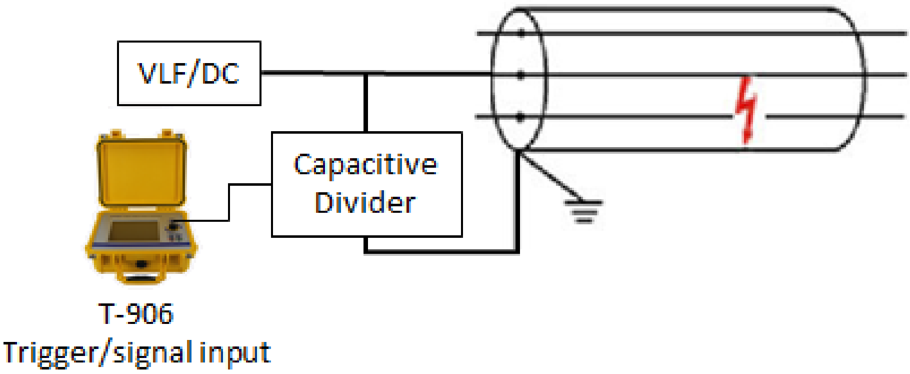


Figure 9-8 Set-up for the decay method

Connect a VLF or DC high voltage generator, such as the Kehui T-100C, to the cable under test. Connect a capacitive voltage divider as shown in the diagram. The divider steps down the voltage and feeds the signal to the T-906's trigger/signal input.

Switch on the T-906. In the <Mode> sub-menu, select <Decay>. In the <Adjust> sub-menu, adjust the appropriate Velocity of propagation (VOP) for the cable under test. In the <Range> sub-menu, select the appropriate length, typically 2 to 4 times the length of the cable. Press the <Test> button. T-906 displays <Waiting for rigger>. Use either a VLF or a DC high voltage generator to apply a high voltage to the cable. Sustain the high voltage until the fault breaks down. When it occurs, the T-906 will display a decayed waveform. Move the cursor to the reflection point to obtain fault location. If the gain is not suitable, the display will indicate that the gain is too big or too small. Adjust the gain accordingly until a desirable waveform is displayed.

The T-906 captures the voltage travelling wave signal through a capacitor voltage divider, see Figure 9-9.

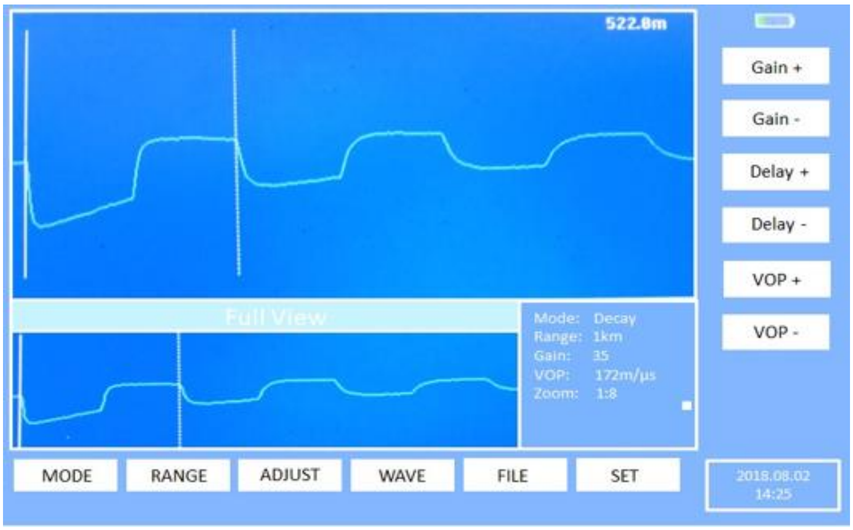


Figure 9-9 Decay method waveform showing the cursor at the reflection point

9.6 Delay Trigger

Some cable will get affected by moisture when the sheath is broken. Without healing in time, the discharge delay at the fault point can be hundreds of microseconds, sometimes even in milliseconds. However, the normal burn down delay is only a few microseconds.

A typical cable fault locator starts to record the signal when the gap is burned down, and the time recorded is limited by the instrument. If the discharge delay is prolonged, the instrument has already stopped recording when the fault point discharges.

As shown in Figure 9-5, the instrument record time is t0. The fault point burned down time is at A, which exceeds the recording time t_0.

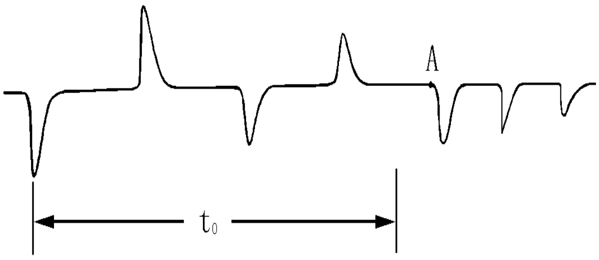


Figure 9-5 Long discharge delay

The Delay Triggering function of T-906 can solve this problem. It will initiate a time delay when the gap is discharged. After the pre-set time delay, the instrument will revert to record the waveform.

10. Transport and Storage

10.1 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 to avoid long term exposure to sun and humidity.

10.2 Storage Requirements

The storage requirements are as follows:

1) Temperature range -40ºC to +50ºC
2) Relative humidity 40°C (20 to 90) %RH
3) Atmospheric pressure (86 to 106) kPa

11. Troubleshooting

If problems are encountered which are not listed below, contact Kehui for repair or replacement. Do not perform service by yourself as this will void the warranty and may cause injury and/or further damage.

Fault	**Possible Reason**	**Rectification**
No display on the LCD when first turned on	Too low voltage for the inner battery	Charge the instrument
Instrument will not charge the first time it is used	Battery disconnected	Follow battery reconnection instructions
No display on the LCD when turned on	Too low voltage for the inner battery	Charge the instrument
The LCD display appears briefly but when first turned on but it powers off after only a few seconds	Voltage is too low for the inner battery	Charge the instrument
System halted	Interference	Reboot the instrument

12. Packing list – T-906

No.	Description		Quantity
1	Power Cable Fault Locator		1
2	Carrying Bag		1
3	USB Communication Cable (USB-A to USB-B)		1
4	Current Coupler (including BNC to Lemo plug connector)		1
5	Coupler Cable (Lemo plug to Lemo plug)		1
6	Testing Cable (Lemo plug)		1
7	Charger		1
8	Manual		1
9	T-906 software		1