



# T-906 Power Cable Fault Locator User Manual

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## 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. It can be operated as a basic time domain reflectometer (TDR) or using the Arc reflection/Secondary/Multiple Impulse Method (SIM/MIM), Impulse flashover or Decay Method.

T-906 is a complementary product to Kehui's High Voltage Surge Generators, Cable Fault Pinpointing Devices and Cable Fault Test Van and can also be used with appropriate equipment from other companies.

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 .....	5
2.	PRODUCT OVERVIEW.....	6
2.1	DESCRIPTION .....	6
2.2	PRODUCT CHARACTERISTICS.....	6
2.3	TECHNICAL SPECIFICATIONS .....	7
3.	WORKING PRINCIPLES .....	7
3.1	TIME DOMAIN REFLECTOMETER (TDR) METHOD .....	7
3.2	ARC REFLECTION OR SECONDARY/MULTIPLE IMPULSE METHOD (SIM/MIM) ..	9
3.3	IMPULSE CURRENT METHOD (ICM) .....	10
3.4	DECAY METHOD.....	14
4.	USING THE FAULT LOCATOR T-906.....	16
4.1	DEVICE LAYOUT .....	16
4.2	PREPARATION.....	18
4.3	BATTERY CONNECTION.....	19
5.	MENU OPERATING INSTRUCTIONS.....	20
5.1	T-906 SCREEN .....	20
5.2	<MODE> - OPERATING MODE .....	20
5.3	<RANGE> - OPERATING DISTANCE RANGE .....	21
5.4	<ADJUST> - OPERATING T-906 DURING TESTING .....	21
5.5	<WAVE> - OPERATING ON THE WAVEFORM .....	22
5.6	<FILE> - FILE MANAGEMENT .....	22
5.7	WAVEFORM STORAGE.....	22
5.8	WAVEFORM BROWSING .....	22
5.9	SAVE TO USB STICK.....	22
5.10	<SET> - SETTINGS .....	22
6.	USB COMMUNICATIONS .....	23
7.	POWER MANAGEMENT AND BATTERY CHARGING .....	24
7.1	POWER MANAGEMENT .....	24
7.2	BATTERY CHARGING .....	24
8.	CABLE TEST PROCEDURES.....	24
8.1	DIAGNOSTICS AND TESTING METHODS.....	24
8.2	TDR METHOD .....	25
8.3	ARC REFLECTION OR SECONDARY/MULTIPLE IMPULSE METHOD (SIM/MIM) ...	26
8.4	IMPULSE CURRENT METHOD (ICM) .....	29
8.5	DELAY TRIGGER.....	30
8.6	DECAY METHOD .....	31
9.	TRANSPORT AND STORAGE .....	32
9.1	TRANSPORT NOTE .....	32
9.2	STORAGE REQUIREMENTS.....	32
10.	TROUBLESHOOTING.....	33
11.	PACKING LIST – T-906 .....	34

# 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](mailto: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

- 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 and an overall view of the waveform, making comparison simple and intuitive
- The equipment goes into a power save 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 3MB 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.

## 2.3 Technical Specifications

Technical Parameters	Parameter Value
Fault Location Methods	TDR, SIM/MIM, ICM, DC Flashover, Impulse flashover and Decay
Resolution	$\pm 1\text{m}$
Sampling Rate	100MHz
Cable length	<64km
Blind spot	4m
Pulse width	40ns - 3.56 $\mu\text{s}$
Pulse amplitude	30V
Velocity	90 - 300 m/ $\mu\text{s}$
Communications	Via USB
Power source	Polymer lithium-ion battery pack, 7.4V nominal
Battery Duration	Up to 5 hours
Battery Charge	AC 100-240V at 50/60Hz, charging current 3A, 8 hours charging time
Screen	8.4" in touch, 640 x 480 dots, touch screen, colour LCD
Size	330mm x 305mm x 152mm
Weight	3kg
Working temperature	-10 to +40°C
Storage temperature	-20 to +50°C
Relative humidity	20 to 90% at 25°C
Atmospheric pressure	86 to 106kPa
Ingress protection	IP54 (lid closed)
Safety and EMC	EN 61326-1: 2013 (EN 55011: 2016+A1:2017) CE Marked
User interface languages	English, French, German, Spanish and Chinese

## 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, arc reflection (also known as 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

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. It can also be used to calibrate the cable length and to identify cable joints, T-joints and the end of the cable.

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

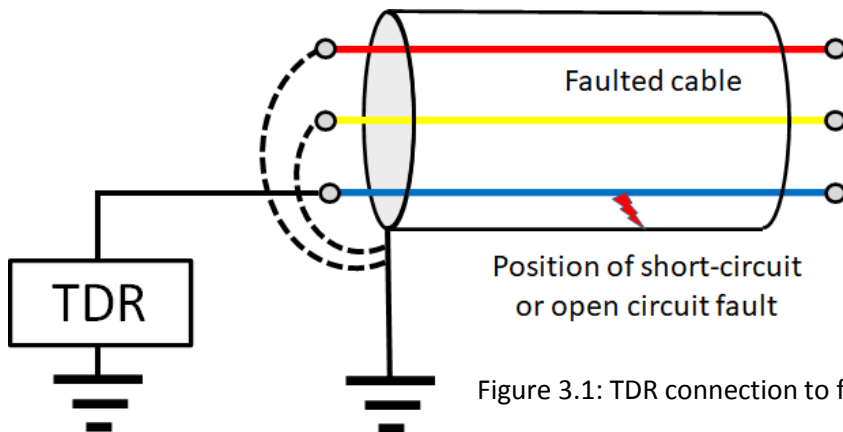


Figure 3.1: TDR connection to faulted cable

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. 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 the same polarity. A comparison of these scenarios is shown in Figure 3.2.

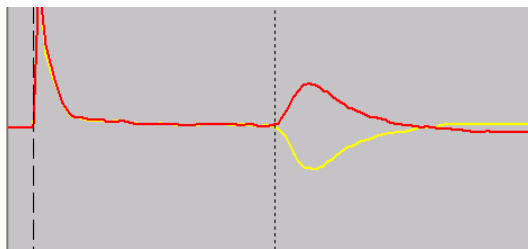


Figure 3.2: Comparison of TDR signals reflected from the far end of a healthy cable. The reflection from an open end is shown in red and from a short-circuited end is shown in yellow

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  $\Delta t$  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.



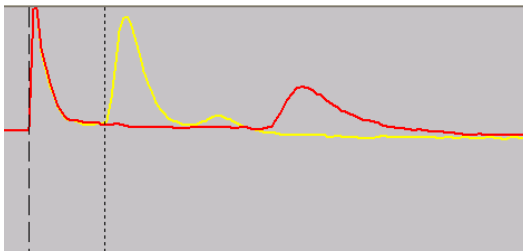


Figure 3.3: Comparison of TDR signals reflected from a faulted core with an open-circuit (yellow) and a healthy core of the same cable (red)

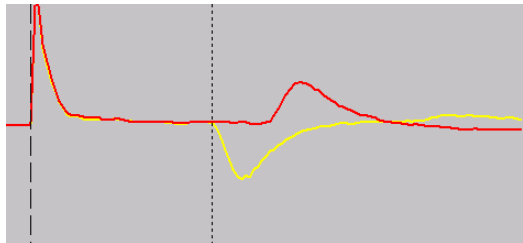


Figure 3.4: Comparison of TDR signals reflected from a faulted core with a short-circuit (yellow) and a healthy core of the same cable (red)

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.

### 3.2 Arc reflection or Secondary/Multiple Impulse Method (SIM/MIM)

This method requires a high voltage surge generator, such as the Kehui T-305E. The surge generator injects a high voltage, high energy pulse in to the cable to break down the fault, such that it becomes a temporary short circuit. The system is represented, in simplified form, in Figure 3.5 as a storage capacitor which discharges through a contactor. A filter is required with this method, which consists of a coupling capacitor, which protects the TDR unit from the high voltage surge, and an inductor which blocks the TDR pulse from travelling in to the surge generator, such that it is directed in to the cable. Most surge generators include this filter as an integral feature, although it can also be a separate discrete device.

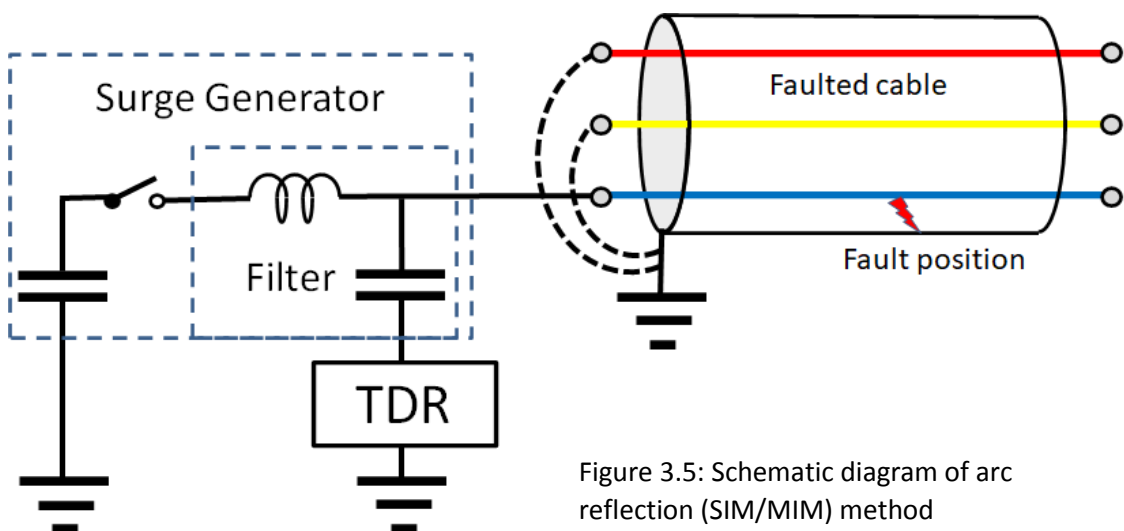


Figure 3.5: Schematic diagram of arc reflection (SIM/MIM) method

A TDR trace taken before or after, the surge is applied provides a reference signal (Figure 3.5). When the surge is applied and the fault is active, the TDR pulse is injected and its reflected impulse will have an opposite polarity to the reference. Comparing the two traces (Figure 3.6) allows the propagation time to the fault to be measured, allowing the distance to the fault to be determined.

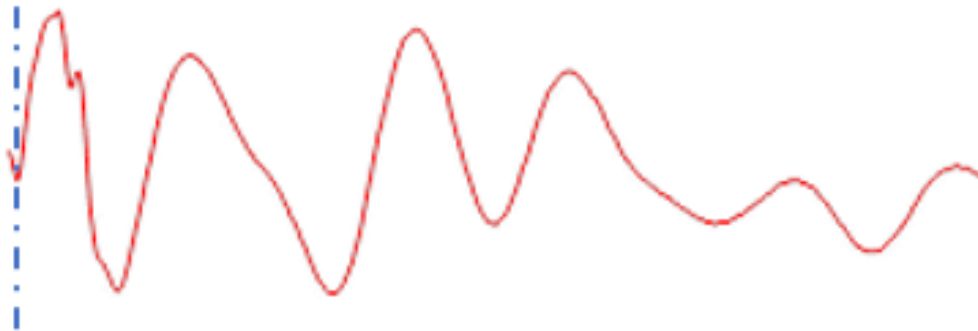


Figure 3.5 Arc reflection (SIM/MIM) trace on core prior to fault activation

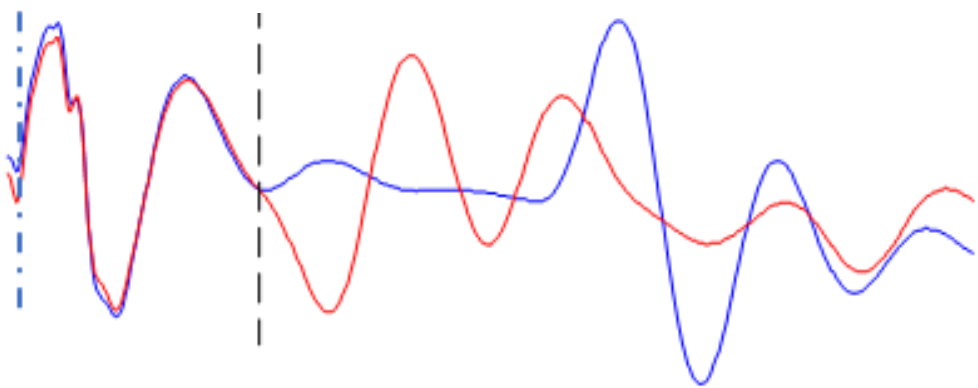


Figure 3.6 Comparison of traces, pre-fault and during fault activation

In Figure 3.6 the cursor has been moved to the point at which the traces diverge, this represents the fault position. The time represented by the cursor position is used to calculate the distance to the fault in the same way as with TDR.



The inclusion of the filter puts an inductive wave trap in series with the surge generator which may reduce its effectiveness in breaking down the fault.

### 3.3 Impulse Current Method (ICM)

ICM also requires the use of a surge generator, but the filter is not needed and will be switched out when this method is selected. A schematic diagram of the method can be seen in Figure 3.7, which shows that the full energy surge is injected in to the cable with no attenuation from the filter. This makes it more effective than the arc reflection method in breaking down the fault and, in most cases, eliminates any reason to use a fault burner to condition the fault.

The Impulse current equipment (ICE) functionality is usually incorporated in to the same device as the TDR used in Sections 3.1 and 3.2 (e.g., the Kehui T-906). The linear current coupler required to capture the signal from the fault, is often incorporated in to the surge generator (e.g., the Kehui T-305E). If this is not the case or the ICE does not have a compatible connection to the surge generator, an external current coupler can be used.

The linear current coupler is placed around the ground lead between the energy storage capacitor and the metallic shield of the cable. It picks up the magnetic field generated by the current in the earth lead to reproduce the current waveform.

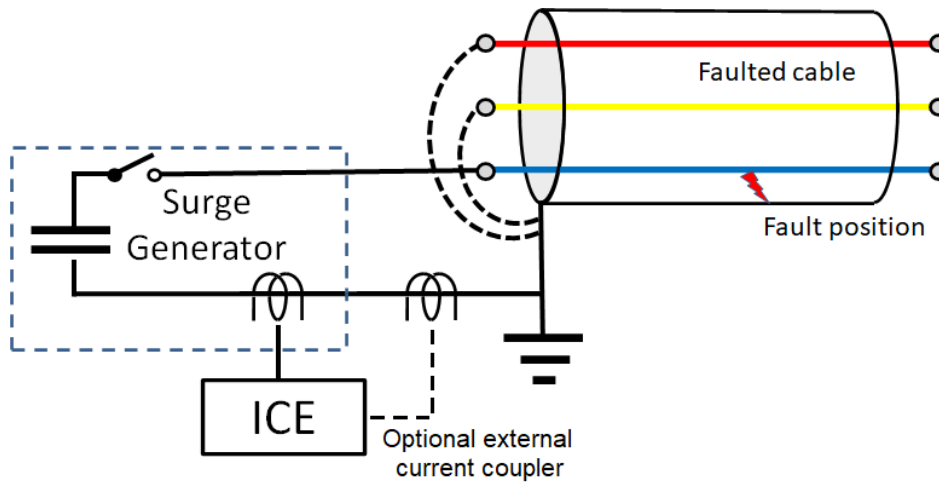


Figure 3.7 Set-up for Impulse Current Method

The fault in the cable is broken down by the high voltage, generating a current impulse which reflects multiple times between the Surge generator and the fault point. The waveform is captured at the current coupler and is analysed so the fault distance can be calculated.

The format of the waveforms detected by the impulse current method is illustrated in the following diagrams. The surge generator is represented in the top left and the cable runs from end A to end B with length  $L_{AB}$ .  $\ominus$  and  $\oplus$  refer to the pulse polarity.

Figure 3.8 shows a healthy cable to which is applied a positive surge, which can be seen at T1A. It is reflected off the far end of the cable with the opposite polarity (hence the wave is cancelled out at T1B) and it returns to end A at time T2A. The line length can be calculated from the time difference between T1A and T2A using the velocity of propagation divided by 2, as the time covers the propagation of the surge from one end of the line to the other and back again.

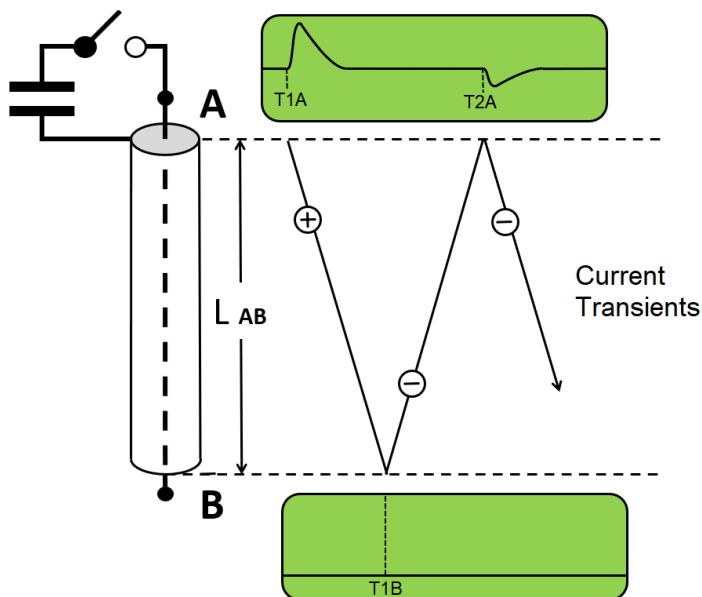


Figure 3.8: Impulse current method on a healthy cable

Figure 3.9 shows an open circuit fault. The surge no longer reaches the far end of the cable, but is reflected off the fault position with a negative orientation. The surge continues to reflect between the near end and the fault, changing its polarity each time it reaches the open circuit at the far end. The distance to the fault can again, be calculated from the time difference between T1A and T2A using the velocity of propagation divided by 2

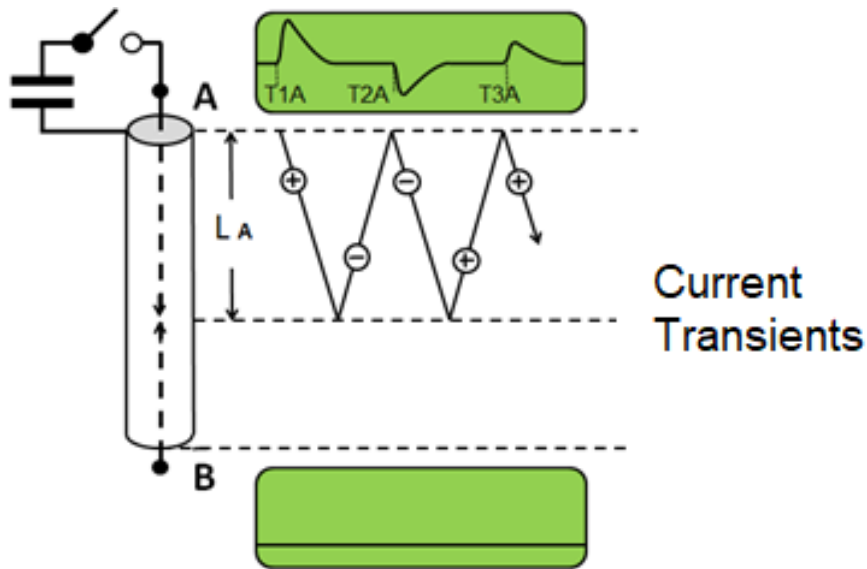


Figure 3.9: Impulse current method on an open circuit fault

Figure 3.10 shows a short circuit fault. In this case there is no change of polarity when the surge is reflected off the fault position

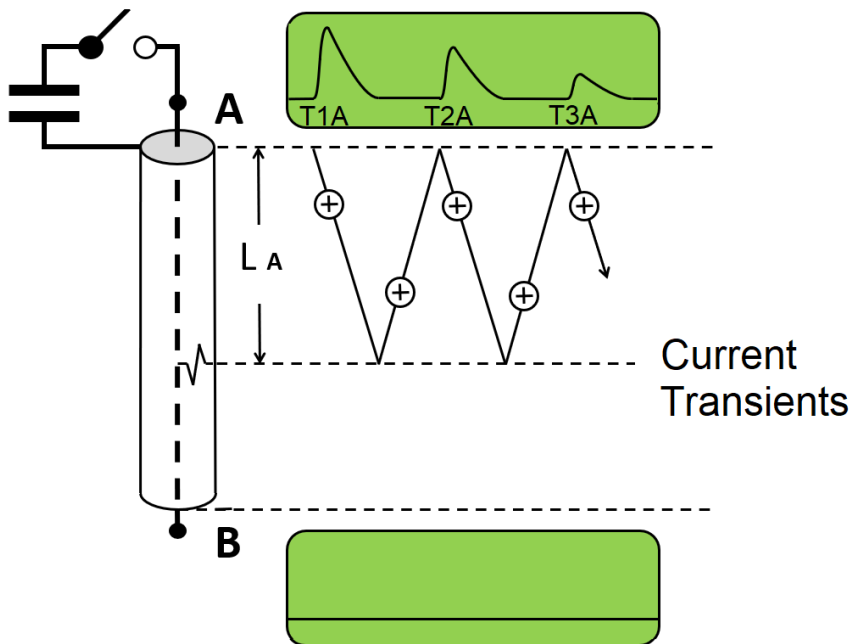


Figure 3.10: Impulse current method on a short circuit fault

Figure 3.11 shows a flashing fault. In this case the contactor of the surge generator is permanently closed and the surges originate at the fault point and travel in both directions. At the remote end they change polarity as they are reflected and are cancelled out. At the measured end, they will be seen as a succession of pulses with positive polarity.

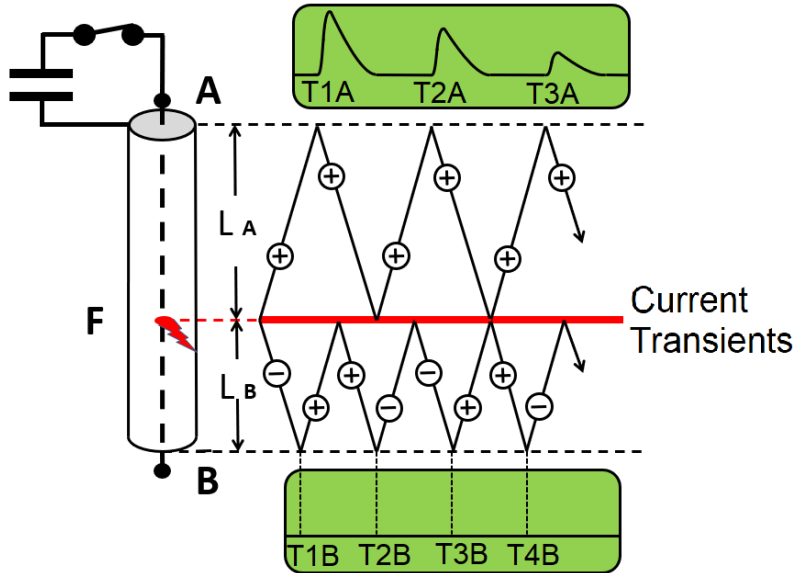


Figure 3.11: Impulse current method on a flashing fault

When the surge generator operates, it is normal for there to be a delay before the fault breaks down. During this period the surge will travel past the fault point to the far end of the line. When the fault breaks down, the resulting transients will behave in the same way as for the flashing fault in Figure 3.11. In this case the first pulse (T0A) should be discounted and the distance to fault calculated from the subsequent pulses (i.e., the time difference between T1A and T2A in Figure 3.12). T0A will initially reflect off the far end of the line and then off the other side of the fault, but the change in its polarity will cancel it out.

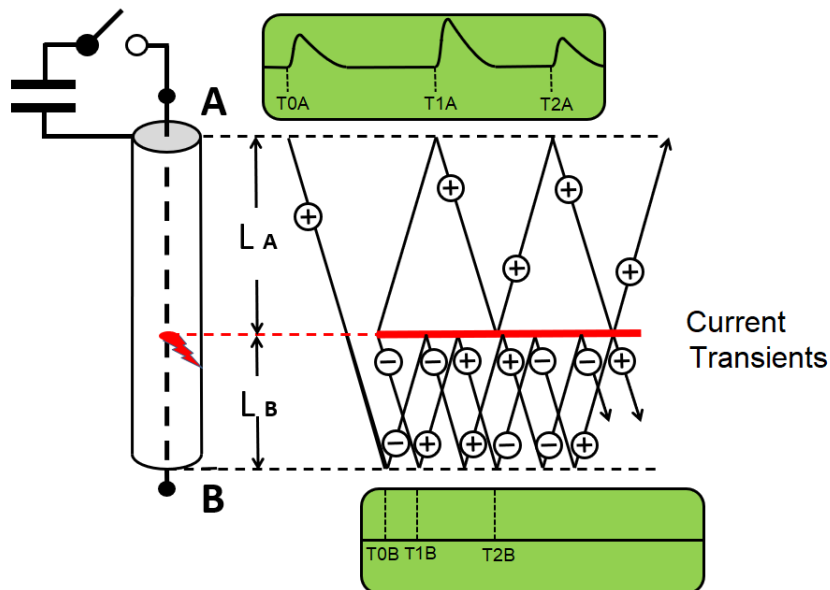


Figure 3.12: Impulse current method with a fault breakdown after a short ionisation time

If the ionisation time of the fault breakdown is longer, there may be sufficient time for the surge to reflect off the far end of the cable and return to the source before breakdown occurs. In this case the first two pulses should be discounted. As the pulse changes polarity at the far end, it is recorded as negative at the source and so can be readily identified (Figure 3.13). The initial surge will continue to reflect but all of the resulting pulses will be of negative polarity and can be ignored. The distance to the fault can be calculated from the time  $T_{1A}$  to  $T_{2A}$ .

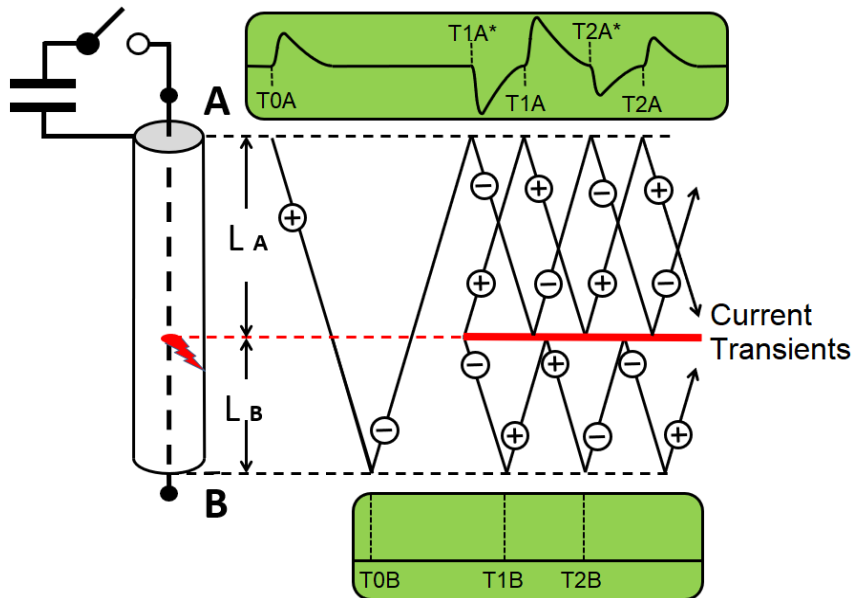


Figure 3.13: Impulse current method with a fault breakdown after a short ionisation time

T-906 has an artificial intelligence technique which can usually interpret the waveforms to provide the fault location results automatically, but if it is unable to do this, manual measurement can be made from the time between the appropriate pulses. This is normally measured by moving the cursors on the instrument.

### 3.4 Decay Method

The decay method uses either a DC or very low frequency (VLF) generator as the high voltage source. It needs to be used in conjunction with a capacitive voltage divider to supply the fault locator. It can be used as an alternative where the rating of the cable is too high to use a surge generator and a pressure test set has sufficient voltage to break down the fault.

The decay method's connection diagram is as shown in Figure 3.14. Its functionality may be incorporated into the same fault locator device as the TDR used in Sections 3.1 and 3.2 (e.g., the Kehui T-906).

If the available voltage is sufficient to break down the fault without using the surge facility, the DC supply can often be obtained from a surge generator with its contactor closed, the capacitor in the generator can be used as the capacitor divider (e.g., the Kehui T-305E).

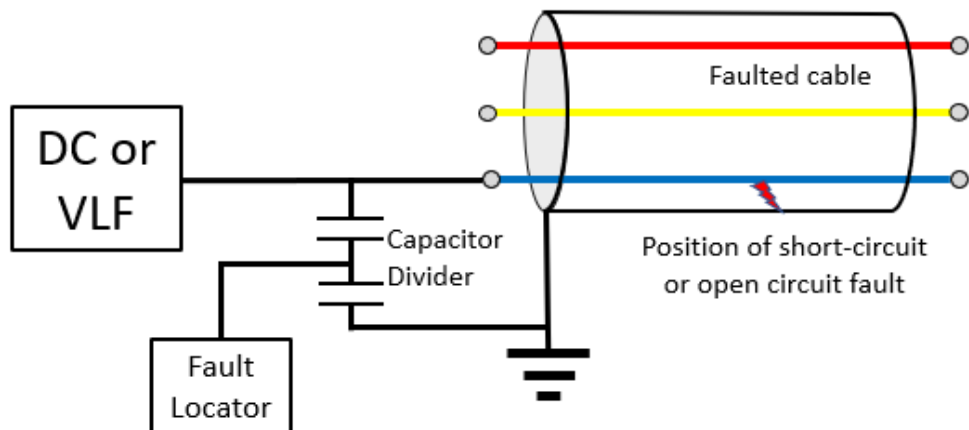


Figure 3.14 Set-up for the decay method

The DC or VLF signal is continuously applied to the cable until the fault breakdown voltage is reached. And the fault discharges. This breakdown will produce a voltage travelling wave, which reflects back and forth between the fault point and the HV source.

The distance to the fault can be calculated as before, using the time between two corresponding parts of subsequent peaks of the decaying waveform selected by the cursors on the instrument.

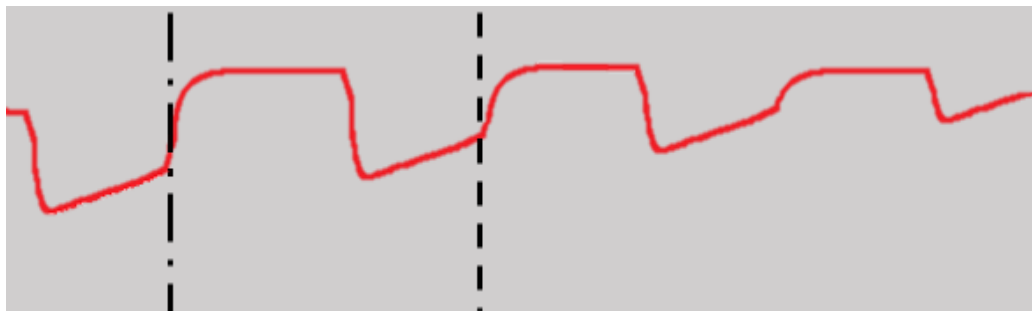


Figure 3.15 Decay method waveform

## 4. Using the fault locator T-906

### 4.1 Device layout

#### 4.1.1 Accessories

The T-906 has 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

- ① LCD display: 8.4-inch touch screen for waveform display.
- ② <On> <OFF> keys: Switch instrument's power supply.
- ③ <Test> key: Press once for manual test, press and hold for over 1s for automatic testing.
- ④ <Zero> key: Reposition the cursor to the starting point.
- ⑤ Cursor knob: Move the cursor left and right to determine the fault distance.
- ⑥ Trigger/Signal Lemo socket: Connection to the T-305E or other equipment.



### 4.1.3 T-906 Display

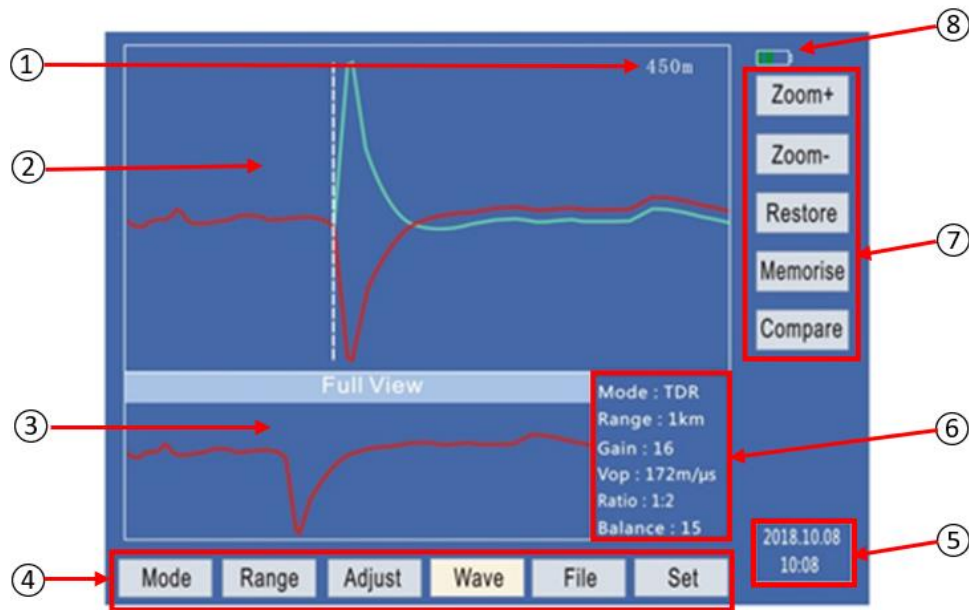


Figure 4.2 T-906 Display

- ① Distance to fault related to cursor position (Time x VOP)
- ② Analysis Area: Displays an enlarged section of the waveform plus cursor for analysis.
- ③ Thumbnail area: Displays the entire waveform.
- ④ Main Menu Area: Consists of the main menu selection.
- ⑤ Date and time
- ⑥ Test Information Area: Displays the parameter settings of the test mode selected.
- ⑦ Submenu Area: Consists of specific sub-menus according to the main menu selection.
- ⑧ Battery charge

### 4.1.4 Side panel composition

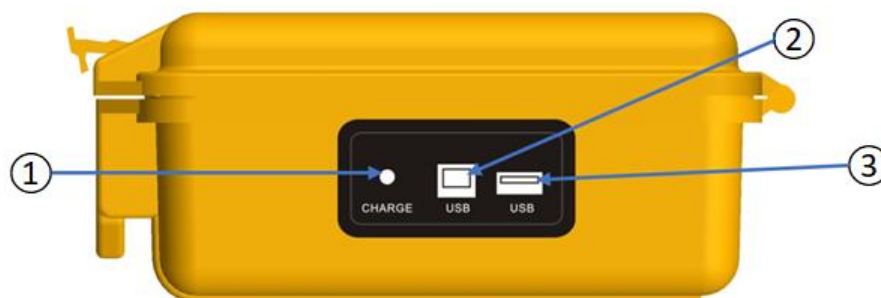


Figure 4.3 T-906 Side View

- ① Charge: For connection to the charger supplied.
- ② USB-B port: For a USB connection to a PC using the lead supplied
- ③ 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 with third-party surge generator, 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 appropriate power on or off button on the front panel (② 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.

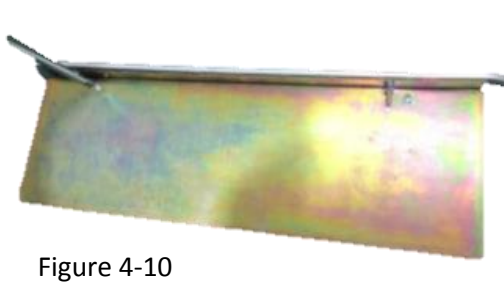


Figure 4-10

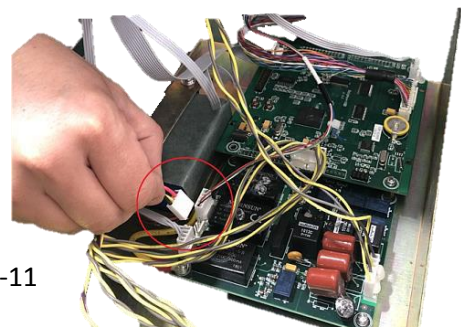


Figure 4-11

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 into the socket on the T-906 and ensure that it is working correctly by pressing the power on/off button on the front panel. 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

### 5.1 T-906 Screen

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.

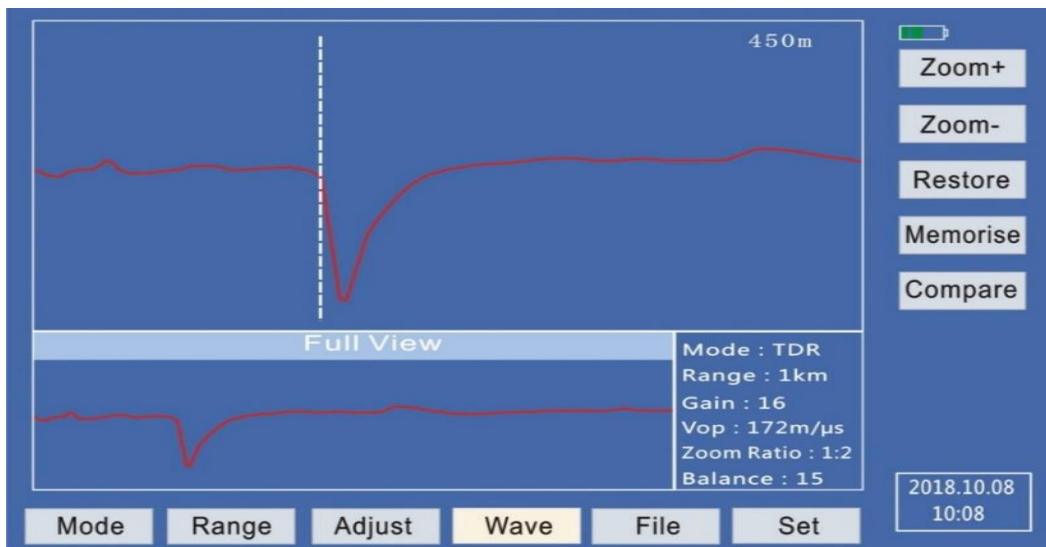


Figure 5-1: T-906 screen showing <wave> submenu.

### 5.2 <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.

### 5.3 <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.

### 5.4 <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.

#### 5.4.1 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.

#### 5.4.2 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.

#### 5.4.3 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

#### 5.4.4 Delay Adjustment

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

## 5.5 <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.

## 5.6 <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.

## 5.7 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, it has been saved. Do not power-off the unit during the process of saving or deleting.

## 5.8 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.

## 5.9 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.

## 5.10 <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).

### 5.10.1 Time setting

Pressing <Select> causes the date and time to be displayed (Figure 5.2) Press <Select> repeatedly to choose the value to be revised, then press TIME+ or TIME- to set the correct date and time.

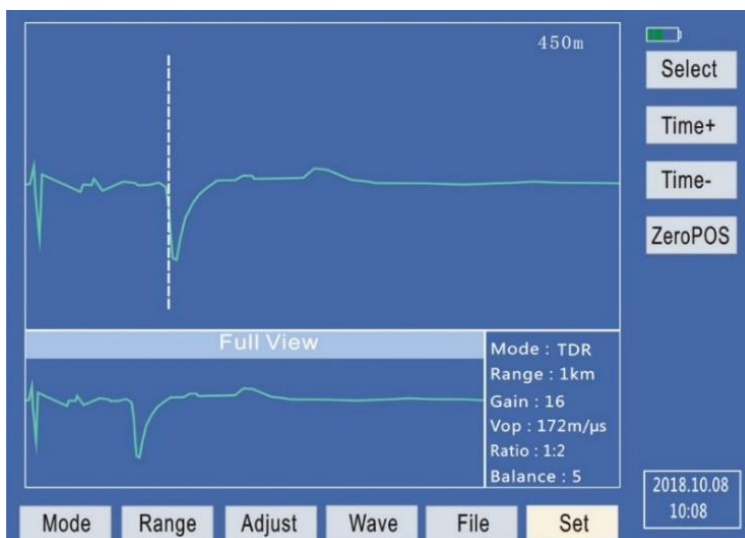


Figure 5.2: T-906 Time setting

### 5.10.2 Cursor movement

The Zero point of the cursor (Zero Cursor) is only valid under the arc reflection (SIM/MIM) mode, this sets the start point for the cursor. Under this mode, move the cursor to the start position by turning the rotary knob (Figure 4.1 item ⑤) 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.

## 6. 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](mailto: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 6.1.

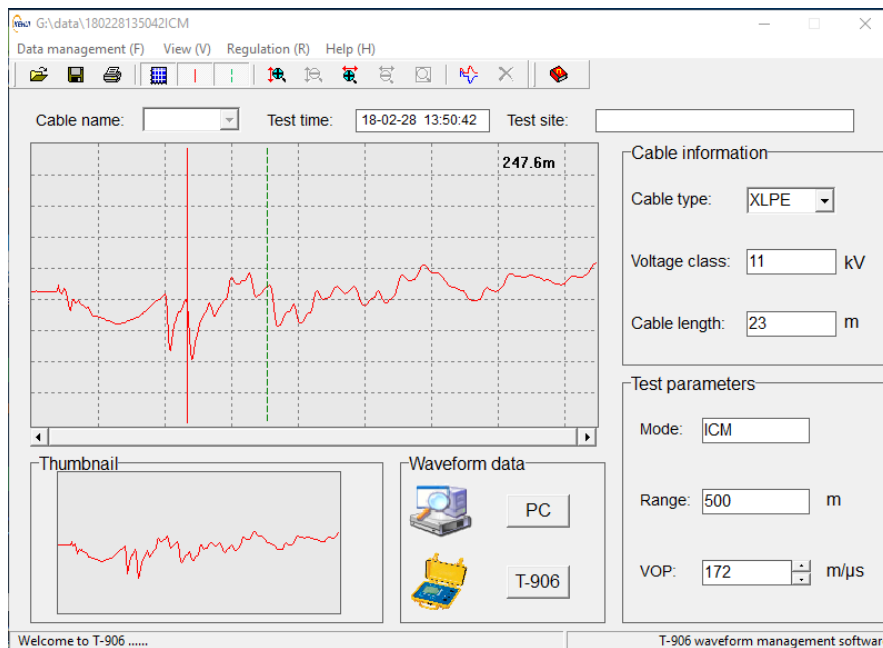


Figure 6.1 T-906

## 7. Power Management and Battery Charging

### 7.1 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.

### 7.2 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.

## 8. Cable Test Procedures

### 8.1 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. Next, the continuity should be checked 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.



## 8.2 TDR Method



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

Connect the test lead of the instrument to 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.

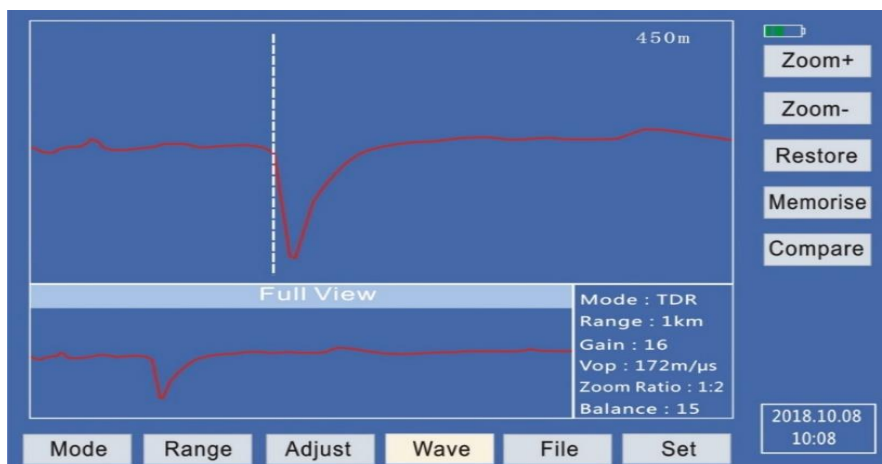
### 8.2.1 Automatic Testing

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.



Figure 8.1 Gain adjustment of the TDR method

The waveform can be zoomed in or out with respect to the dotted cursor to have a better view, as shown in Figure 8.2 Zoom adjustment of the TDR method



. The full view displays the entire waveform.

Figure 8.2 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.

### 8.2.2 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

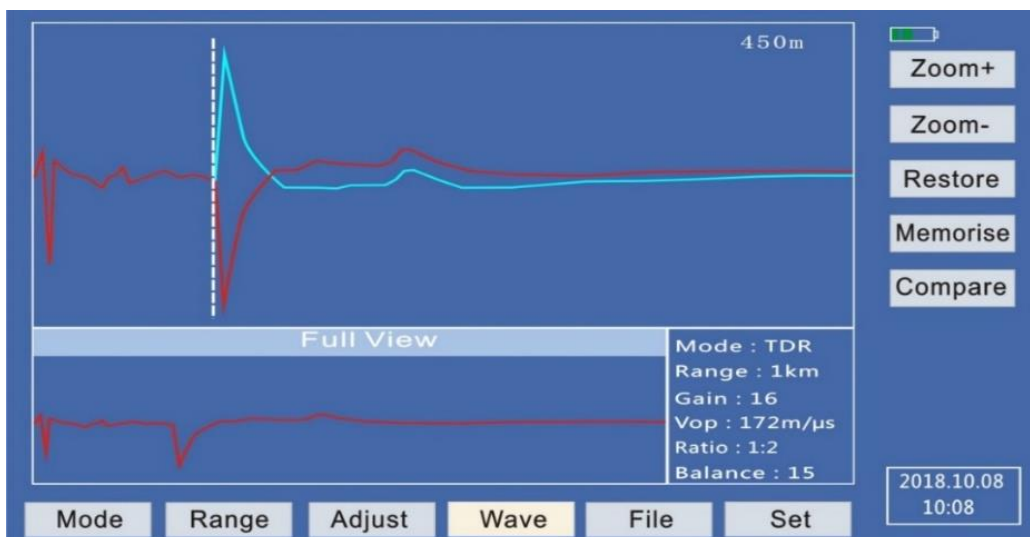


Figure 8.3 TDR waveform comparison

Figure 8.3 TDR waveform comparison

### 8.3 Arc reflection or Secondary/Multiple Impulse Method (SIM/MIM)

Before any testing is carried out, ensure that the cable is thoroughly discharged. Isolate it from other equipment and connect its metal protective sheath to ground.



This description assumes the use of the Kehui T-305E surge generator, although other devices can be used if a suitable trigger signal and input from the T-906 is available. The test should only be carried out after the user has thoroughly read the associated instruction manual.

**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.

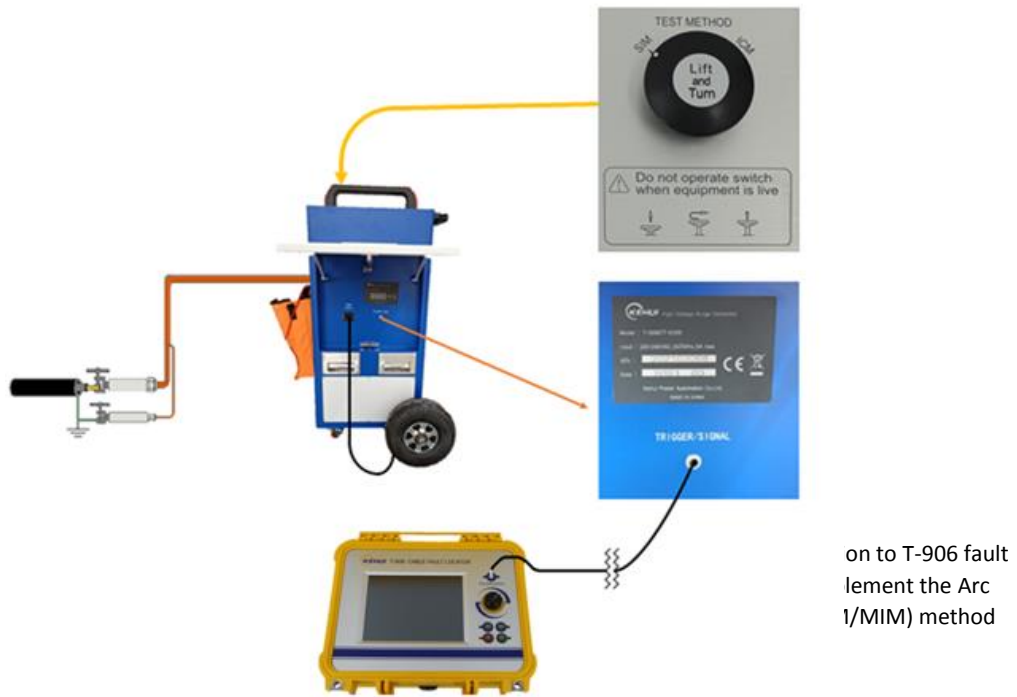


Figure 8.4 SIM/MIM set up with T-305E

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 8.4. 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 (Figure 8.5).

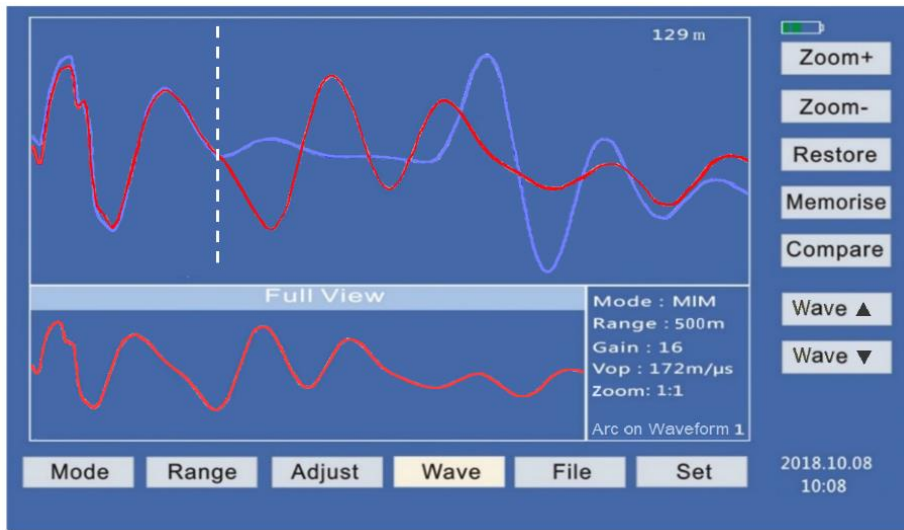
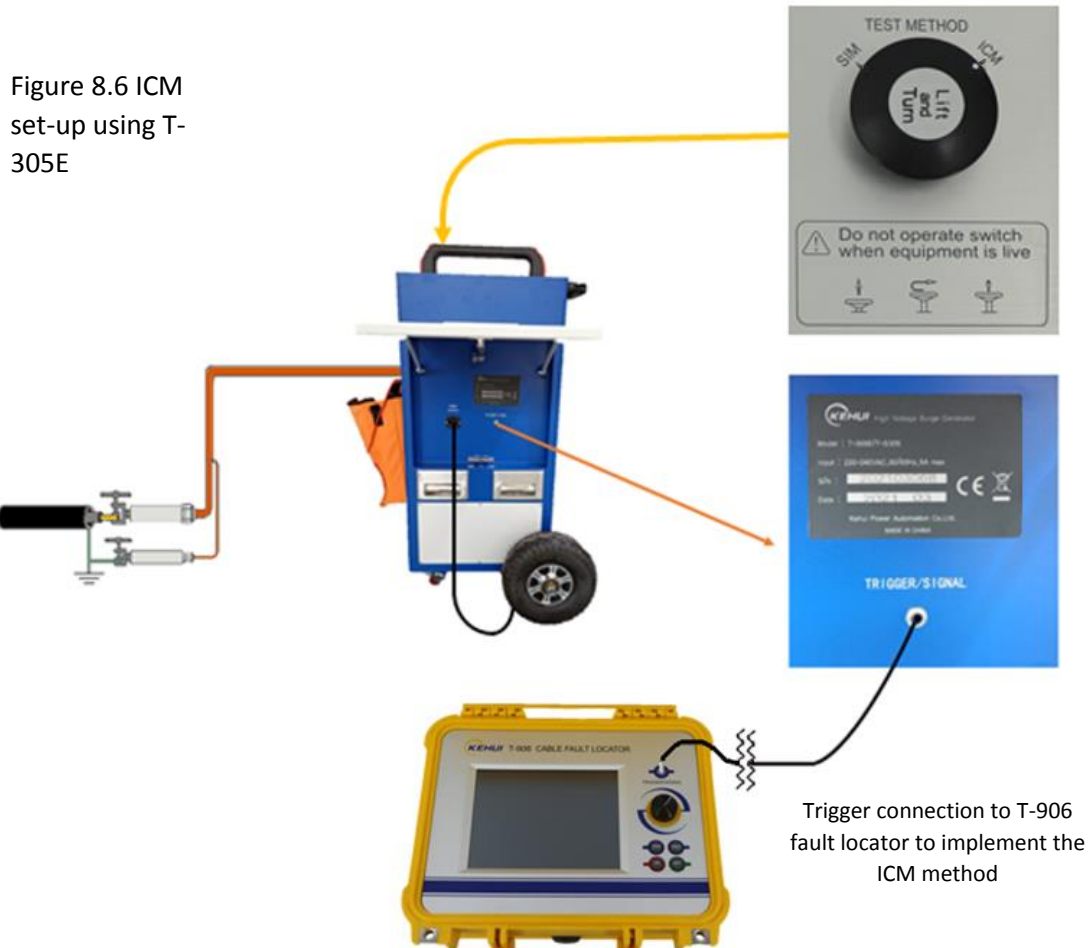


Figure 8.5 Multiple Impulse Method trace on the T-906 screen

The waveform can be compared with a waveform captured before the arc struck. Their relative position can be adjusted using the Wave▲ and Wave▼ keys until the initial portions of the two waveforms coincide and the point of deviation becomes clear. Using the cursor knob the white dotted cursor is moved to this point and the distance can be read from the top-right of the screen. Zooming the waveforms may help to get a more accurate measurement.

## 8.4 Impulse Current Method (ICM)

When used with the T-305E the connection for ICM mode is the same as for the SIM/MIM mode, but in this case the ICM setting is selected on the top of the T-305E (Figure 8.6).



As the T-906 is provided with an external 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 8.7 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.

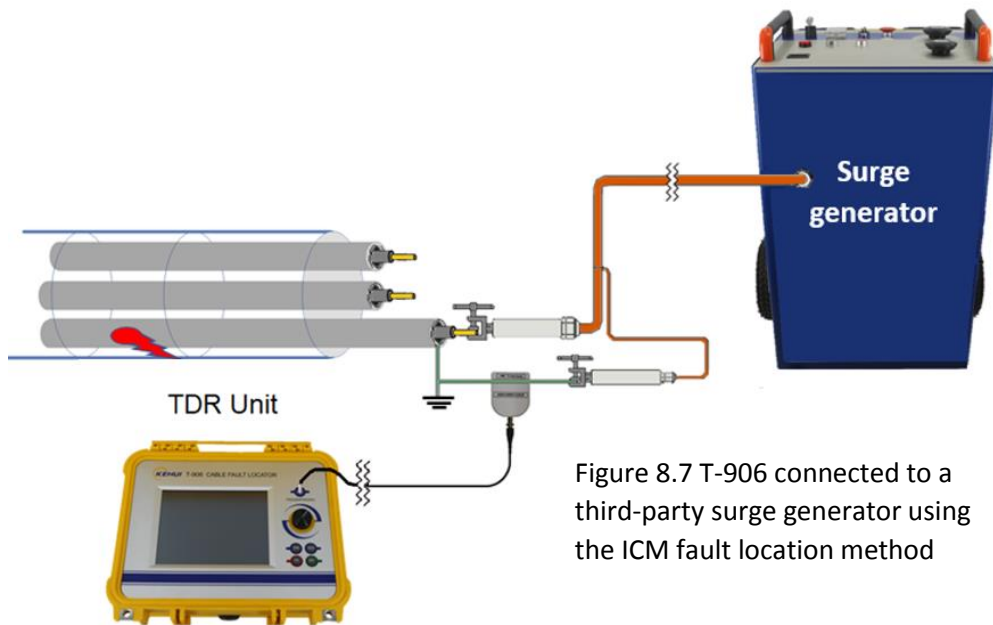


Figure 8.7 T-906 connected to a third-party surge generator using the ICM fault location method

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 trigger>.

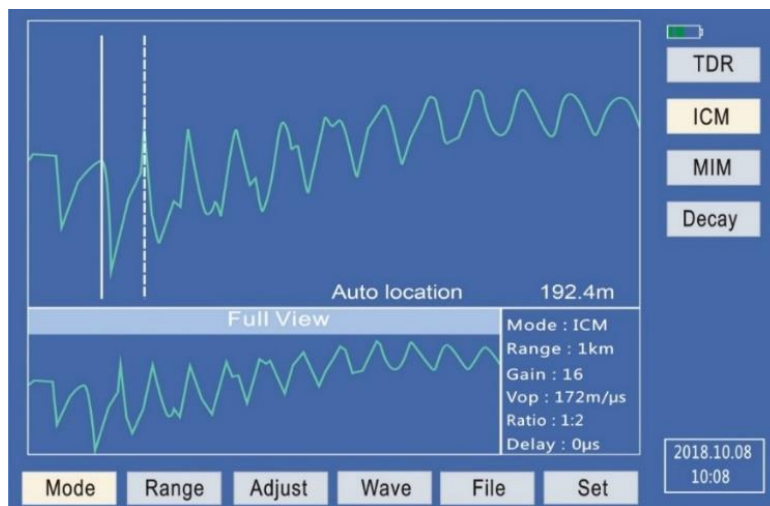


Figure 8.8 Automatic fault location for the ICM method

Discharge the surge generator, the T906 will automatically locate the fault distance and position the cursor at the fault position on the waveform (Figure 8.8). 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.

## 8.5 Delay Trigger

When the surge is applied, the normal burn-down duration of the fault will only be a few microseconds. However, sometimes, when the cable sheath is broken, the fault is associated with the ingress of moisture. In this situation, the discharge delay at the fault point can be hundreds of microseconds, or sometimes even milliseconds.

A typical cable fault locator starts to record the signal when the surge generator contactor closes, and the time recorded is limited by the instrument. If the discharge delay is prolonged, the instrument may already have completed recording when the fault point discharges.

As shown in Figure 9, the instrument record time is  $t_0$ . The fault burn-down time is at A, which exceeds the recording time  $t_0$ .

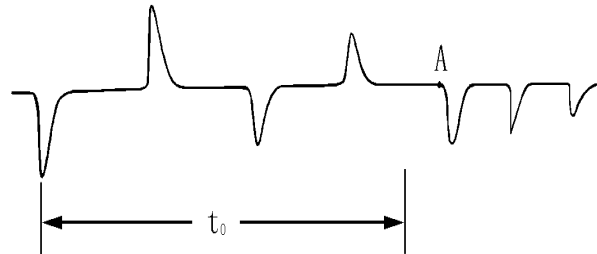


Figure 8.9 Long discharge delay

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

## 8.6 Decay Method

The decay method will normally use a VLF or DC supply which has sufficient capacity to breakdown the fault on the cable. It is necessary to have a suitably rated capacitor divider in order to connect the T-906 device.

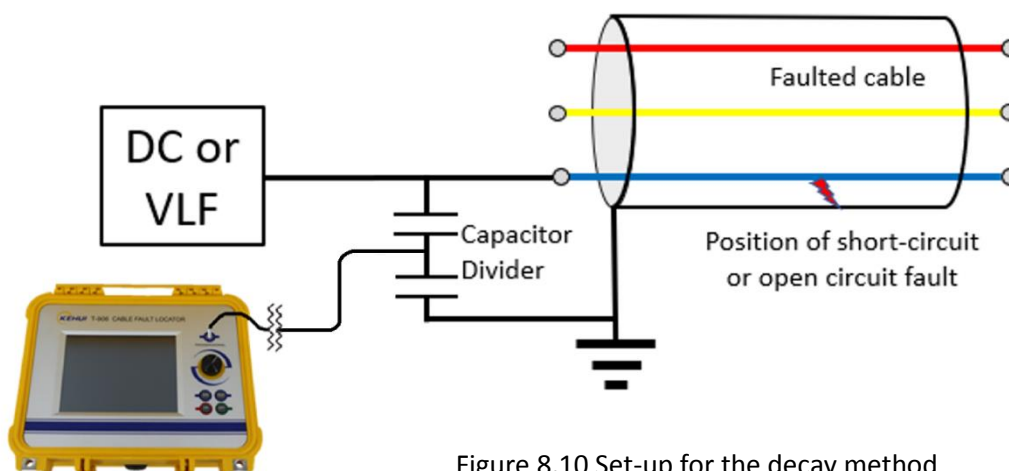


Figure 8.10 Set-up for the decay method

Connect a VLF or DC high voltage generator to the cable under test. Connect a capacitive voltage divider as shown in Figure 8.10. 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 trigger>. 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 8.11.

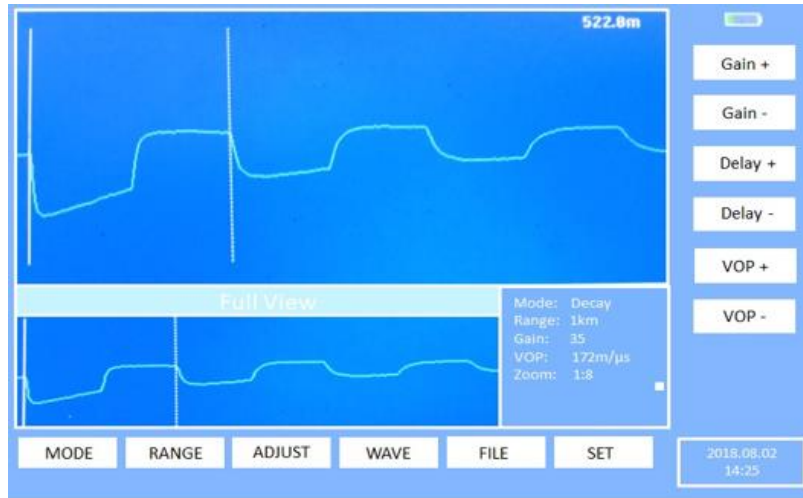


Figure 8.11 Decay method waveform showing the cursor at the reflection point

## 9. Transport and Storage

### 9.1 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.

### 9.2 Storage Requirements

The storage requirements are as follows:

- 1) Temperature range  $-40^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$
- 2) Relative humidity  $40^{\circ}\text{C}$  (20 to 90) %RH
- 3) Atmospheric pressure (86 to 106) kPa












## 10. 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.

<b>Fault</b>	<b>Possible Reason</b>	<b>Rectification</b>
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

## 11. Packing list – T-906

No.	Description		Quantity	Order Code
1	Power Cable Fault Locator		1	15.01.3032
2	Carrying Bag		1	07.06.2750
3	USB Communication Cable (USB-A to USB-B)		1	05.33.5233
4	Current Coupler (including BNC to Lemo plug connector)		1	15.01.3310
5	Coupler Cable (Lemo plug to Lemo plug)		1	05.38.9094
6	Testing Cable (Lemo plug)		1	05.38.9092
7	Charger		1	06.48.4778 05.35.8522
8	Manual and Certificate		1	
9	T-906 software		1	05.75.2360

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