



# T-305E High Voltage Surge Generator User Manual Version 3.2

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>

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### Revision history:

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3.1	2019.05.01	New block diagram P8	DiaKib
3.2	2020.02.10	Clarified grounding and T-H200 operation	BilKib

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## Foreword

Thank you for purchasing the new product of Kehui - T-305E, the high voltage surge generator (hereinafter referred to as T-305E)

The T-305E is a high-performance high voltage surge generator with a maximum output voltage of 32kV and a maximum energy of 1024J. It is used for pre-location and pinpointing of high impedance and intermittent flashing faults of underground power cables.

The T-305E provides either DC or single-shot high voltage surge voltage signals to the faulty cable to break down the fault for pre-location purpose. It works in conjunction with Kehui's T-906, cable fault locator, to pre-locate cable faults. T-305E supports the Secondary/Multiple Impulse Methods (SIM/MIM) and the Impulse Current Method (ICM) for fault pre-location.

T-305E works in conjunction with the T-506 for cable fault pinpointing. It provides cyclic impulses to the faulty cable to periodically break down high impedance and flashing faults. A magnetic field and an acoustic signal are produced during this process. The signals are used by the T-506 to trace and to pinpoint the fault by the magnetic field and sound coincidence method.

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-305E. Users of the T-305E should read the entire contents of this manual in advance. If necessary, please contact us at [info@kehui.com](mailto: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 auxiliary 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.





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## 1. Safety Instructions

**Safety Note:** This user manual is the basic commissioning and on-site operation guide for the T-305E. All operators who will use the T-305E should read the entire 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 procedures 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 fatal or serious 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 will 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 such as maintenance, cable fault detection, on-site test consultation, etc., please contact [info@kehui.com](mailto:info@kehui.com)

## 2. Product Overview

### 2.1 Product features

The product has the following characteristics:

1. Three modes of operation: DC, pulse or periodic.
2. Different capacitor bank connection to provide different capacitance by a switch operation. The energy of the surge is directly proportional to the capacitance value.
3. Interlocking features prevent the equipment from HV operation if the ground is not securely connected.
4. Automatic discharge facility to remove the charges for the equipment and the cable's capacitance after test.

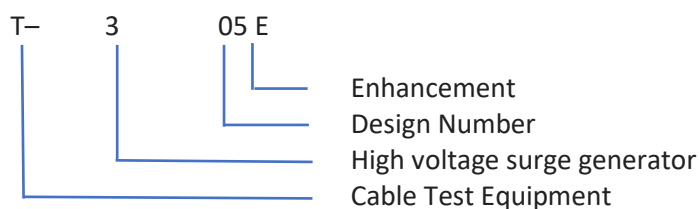
### 2.2 Main use and scope of application

T-305E is used, together with Kehui's power cable fault locator T-906 and pinpointer T-506, to pre-locate and to pinpoint underground power cable faults

The equipment consists of voltage conversion and rectification to produce high DC voltage for the test. Interlocking and safety features ensure safe and reliable operation of the equipment during test.

### 2.3 Product nomenclature

Product model naming method:



### 2.4 Environmental conditions

1. Working environment temperature: -10°C to 40°C
2. Working environment humidity: (20-90)% RH at 25 °C
3. Storage environment temperature: -10°C to 60°C
4. Atmospheric pressure: 86 to 016kPa

### 2.5 Standard Configuration

1. T-305E instrument
2. Cable for triggering and signalling
3. Earthing cables
4. A user manual.

Technical Parameters	Parameter Value
Output Voltage	0-32kV, 0-16kV, 0-8kV, Adjustable negative DC
Rated capacitance	2 $\mu$ f (when output voltage is from 0 to 32kV) 8 $\mu$ f (when output voltage is from 0 to 16kV) 32 $\mu$ f (when output voltage is from 0 to 8kV)
Impulse energy	1024J (32kV/2 $\mu$ f, 16kV/8 $\mu$ F, 8kV/32 $\mu$ F), 2048J Optional
Operating mode	DC / Pulse / Cyclic
Testing method	SIM(MIM) / ICM
Discharge period	4 - 15s adjustable continuously when in Cyclic mode
Discharge device	Built-in
Working voltage	220/240Vac $\pm$ 10%, frequency 50 $\pm$ 1Hz

### 3. Working principle

#### 3.1 Block Diagram

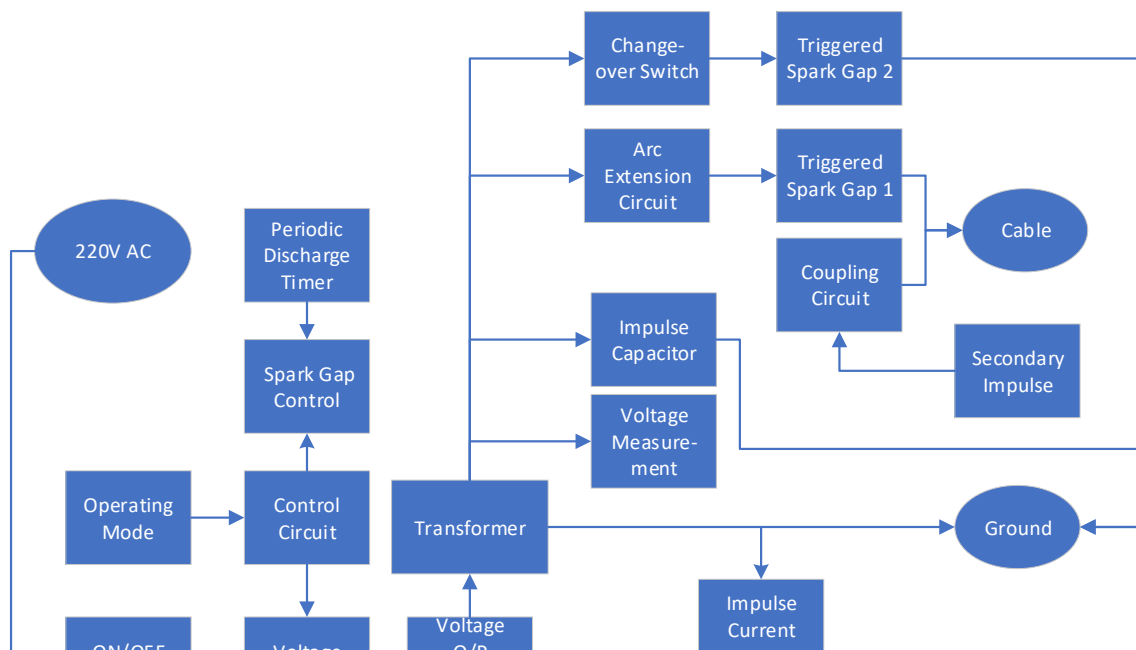


Figure 3.1 T-305 Block diagram

#### 3.2 Working principle

T-305E uses power electronics for high voltage step-up and rectification, producing compact design, with good overload and expansion capability.

Equipment has a special discharge feature. The discharge voltage is not limited by the spherical gap's distance. When a test initiates at any selected voltage level, the discharge facility will always operate and discharge into the faulty cable.



The equipment has an internal safety discharge feature. When the equipment is powered off, the selected capacitors and the cables will be connected to earth/ground through the safety facility. The residual capacitive charges will be released to ensure safety.

**Note: Hereafter all references to earth/earthing will revert to ground/grounding.**

## 4. Equipment Construction

### 4.1 Front Panel Description



Figure 4.1 T-305 Front panel

1. HV Voltmeter: It shows the high voltage value. The analogue meter allows the voltage fluctuations to be observed more directly during discharge.
2. Ammeter: It shows the leakage current during insulation testing.
3. Emergency Stop: In an emergency situation, pressing the button will cut-off the power supply and automatically discharge any residual charges.
4. Test method switch: To switch between two test methods: Impulse current method (ICM) and Secondary/Multiple impulse method (SIM/MIM).
5. Grounding alarm: Provides a red indication when the protective ground is not properly connected. The HV circuit will also be disabled.
6. Stop: Pressing this button will open the HV circuit. The red “start” indication will be off, the green “stop” indication will be on.

7. Start: Pressing this button will close the HV circuit. The internal discharge switch will operate. Red "start" indication will be on, green "stop" indication will be off.
8. Test Voltage Control – Has a zero voltage interlocking during power-up. Before power-up, the voltage must be adjusted to zero, otherwise the HV circuit cannot start.
9. Power switch: Before switching on the power supply, ensure the stop button is on.
10. Timer: between 4 – 15s for the cyclic discharge time.
11. Mode – Select DC/pulse/cyclic mode of operation.
12. Surge – Under pulse mode of operation, pressing this button will produce a single surge pulse to the cable under test.
13. Capacitor bank switch – Consists of 32kV/2 $\mu$ F, 16kV/8 $\mu$ F and 8kV/32 $\mu$ F capacitor banks, selectable for different cable types and different fault types.

## 4.2

### Rear Panel Description

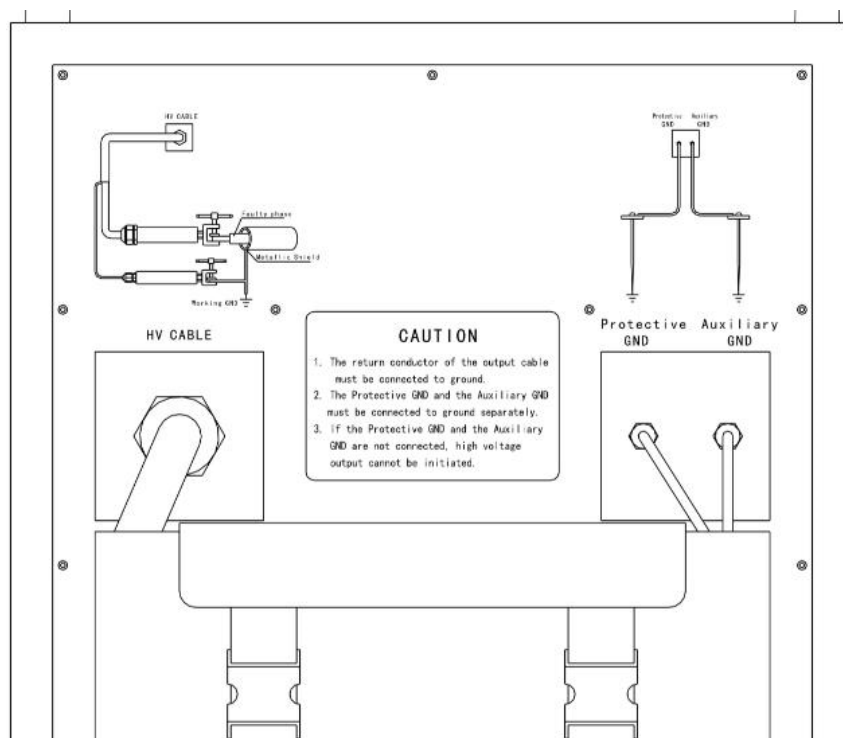


Figure 4.2 T-305 Back panel

The back panel of the instrument consists of the high voltage output cable, the protection grounding cable and auxiliary grounding cable.

1. High-voltage output cable: The core of the high-voltage cable is connected to the faulty cable, the transparent grounding wire is connected to the metallic protective sheath of the faulty cable. The metallic protective sheath must be grounded, which is called the working ground (**Working GND**).
2. Protection grounding cable: The protection grounding cable is connected to the ground using the grounding clamp. The protection ground (**Protection GND**) must be separated from the working ground. If separate grounding points are not available, the protection ground can also be connected to the substation earth bar but it must be as far away as possible from the point where the 'working ground' is connected.





3. Auxiliary grounding cable: The auxiliary grounding cable is connected to the ground using the grounding clamp. The auxiliary ground (**Auxiliary GND**) must be separate from the protection ground. If separate grounding points are not available, the auxiliary ground can also be connected to the substation earth bar but it must be as far away as possible from the point where the 'working ground' is connected. Additionally, it must not be clamped together with the auxiliary ground, but connected at a separate point on the substation earth bar.

**Note: The protection ground and the auxiliary ground must be grounded separately, otherwise the high voltage output cannot start.**

#### 4.3

#### Side Panel Description

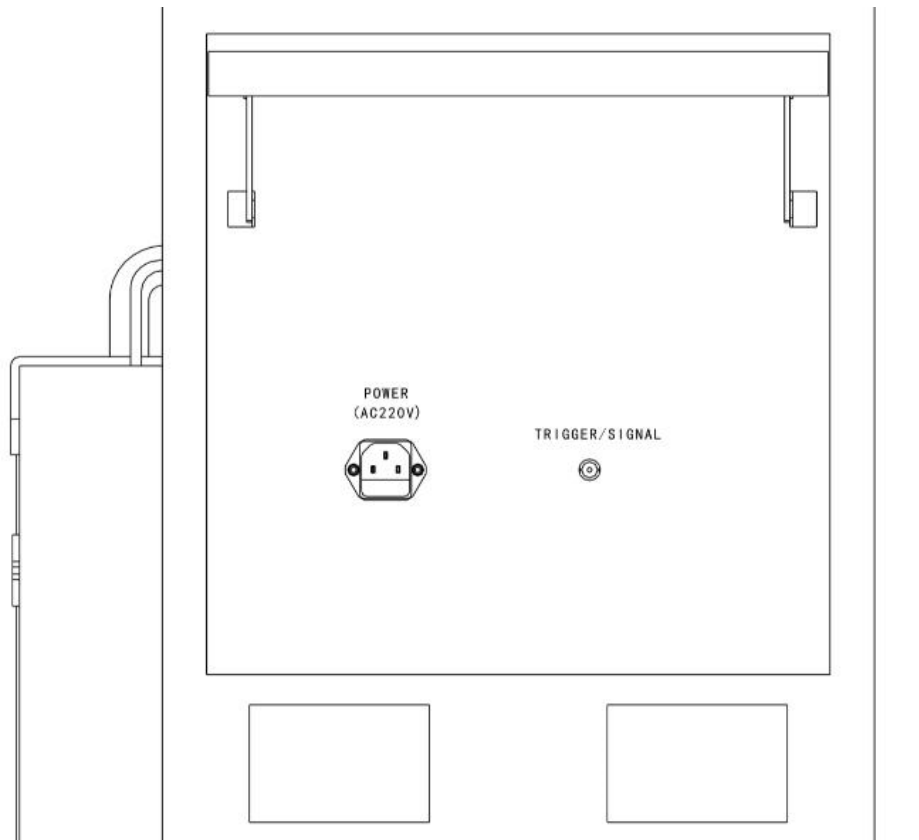


Figure 4.3 T-305 Side panel

The side panel consists of the power socket and the interface to T-906, the cable fault locator.

1. Power socket: Connect 220/240V AC input to provide power for the normal operation of the device.
2. Trigger/Signal port: For connection to the trigger/signal port of T-906. For the impulse current method, the output signal is the impulse current. For the secondary/multiple impulse method, the output signal is the secondary impulse, the input trigger is the Time Domain Reflectometry (TDR) pulse.

## 5.



## Getting started

Before operating the instrument, ensure that the cable under test is without power, fully discharged (see below) and totally isolated.

### 5.1

#### Using the discharge rod

The discharge rod equipped with T-305E is multi-sectional and retractable, and in the first section a discharge resistor is embedded. The discharge procedure consists of three stages: air ionization discharge, resistance discharge and direct grounding discharge.

1. Connect the discharge rod cable to the rod and attach it securely to a suitable grounding point using the crocodile clip.
2. Holding the handle of the rod, slowly let its metallic point approach the HV test item. During this process, a crackling discharge sounds can be heard. This is air ionization discharge.
3. When the reading of the KV voltmeter drops to less than 5kV, use the earth contact tip of the discharge rod to directly ground the item.
4. After the air ionization discharge becomes weak, the point of the rod can make contact with the HV test item directly. At this time, the item will be discharged through the discharge resistor inside the rod. The reading of the KV voltmeter will drop down.

### 5.2

#### Wiring connection

1. Preliminary work: disconnect the faulty cable with other devices and ground the metal sheath. This is the Working Ground, the zero-volt reference point during the discharge process.
2. Position the T-305E at about 2m away from the faulty cable, and put the cable fault locator T-906 on the tray at the side panel for easy operation.
3. Connect the testing cables according to the figure shown below:

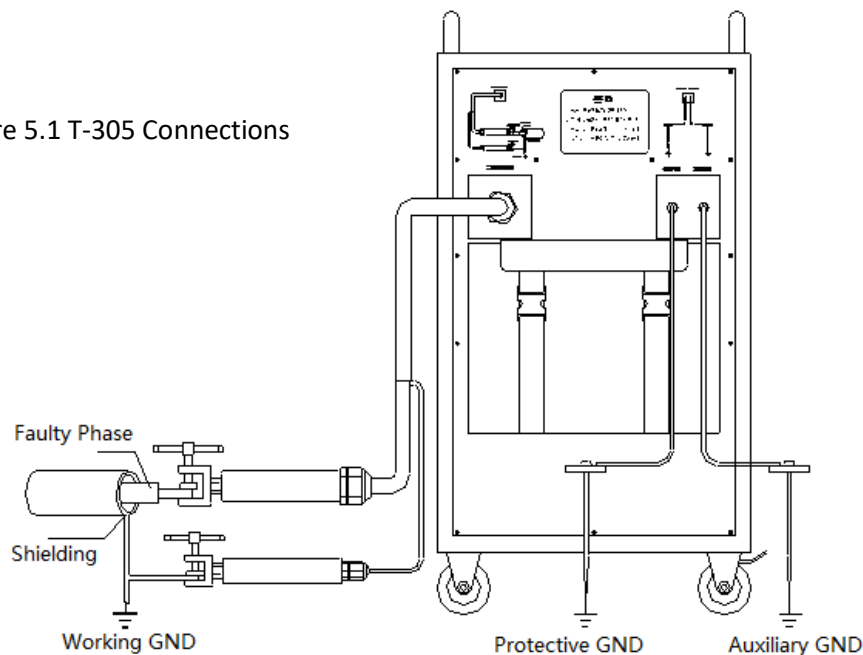


Figure 5.1 T-305 Connections

There are 5 cables that the operator can use, which are:

- a) High Voltage Test Cable - The red high voltage cable should be connected to the faulty core of the cable under test, the transparent cable should be connected to the metal sheath, and the metal sheath should be grounded (the Working GND).
- b) Protective GND Cable - This cable should be connected to a separate grounding point from the Working GND.
- c) Auxiliary GND Cable - Use a metal drill rod for grounding. Again this needs to be separated from the Protective GND.
- d) Power Cable - This is to connect to the 220/240V AC supply.
- e) TRIGGER/SIGNAL Cable – This is to connect to the TRIGGER/SIGNAL port of the cable fault locator T-906.



**Note:** *The Protective GND should be electrically separated from the Working GND (GND). This is to protect the shell of the instrument from the inducing voltage during high voltage discharge. This is also to protect the user from being injured in case of any T-305E current leakage.*



**Warning:** *Separate the Working GND with the Protective GND, they cannot be connected to one point. When it is discharging, the voltage of the working GND point will be raised to thousands of volts in a second. If the Protective GND is not separated from the Working GND, the high voltage may transmit through the protective earth lead onto the shell of the T-305E, causing damages to the instrument and injury to the user.*

4. Pull out the retractable discharging rod, put the screw at the end of the lead into the bolt and screw it tight, then clip the other end on the Working GND point. Leave the discharge rod at a reachable place beside the T-305E.
5. After examining all the cables for correct connections, the T-305E can then be powered on.

**Note:** *After removing the discharge rod, screw it securely.*

### 5.3

#### Fault Location



**Warning:**

- **Cable fault location must be performed by specially trained personnel. A minimum of two people should be present during the test to ensure safety.**
- **The operators must be AT LEAST 0.5 meters away from the HV connections during tests.**
- **DO NOT touch any metal part of the T-305E during discharging.**
- **Before each different mode switching, switch off and discharge the T-305E first.**

T-305E has three work modes for selection: DC, PULSE and CYCLIC, the operations are different for each work mode.

#### 5.3.1

##### DC mode

Under this mode, T-305E outputs continuously constant DC high voltage. The corresponding fault testing method is the DC Flashover method.

This method can only be used when the fault resistance is very high. If the fault resistance is low, most of the voltage drop is across T-305E's internal resistance. The voltage at the fault point will be too low to cause a break-down. In this case, the kV voltmeter cannot be raised and there is a significant buzzing sound from the instrument.

According to the statistics, approximately 20% of all kinds of cable faults can be tested using the DC Flashover methods account for, and most of the faults that happen in the preventive maintenance tests belong to this category. The waveform obtained by the DC Flashover method is simple and easy to interpret. However, the resistance of the fault point will decrease after several flashover discharges, such that the method cannot continue to be applied. Therefore, the use of the DC Flashover method must be used sparingly.

***Operational procedure:***

1. Turn the **MODE** to the **DC** position.
2. Power on, and the **POWER** indicator lights up.
3. Turn the voltage **ADJUST** knob to the zero position, otherwise the **START** will not work.
4. Press the **START** button. THE red **START** light is on, the green **STOP** light turns off. The sound of the HV protective device inside the instrument can be heard.
5. Turn the **ADJUST** knob slowly, the HV voltmeter will display the voltage applied onto the fault point. When the voltage is high enough, the fault point will be broken down, accompanied by the capacitor discharge. Repeat the charge and discharge process, the pointer of the kV meter swings back and forth periodically. Stop the voltage adjustment and start the fault location procedure.

When adjusting the voltage, if the HV voltmeter pointer goes up slowly or remains static, and there is a loud buzzing sound from the instrument, it indicates that the DC Flashover method is not suitable. The voltage **ADJUST** knob should be immediately returned to zero position. The Impulse Flashover method must be used.

### 5.3.2 PULSE mode

This mode is used to locate the range of faults with low resistance and high DC leakage current. The corresponding testing method is called the Impulse Flashover method.

The working process of the Impulse Flashover method is as follows: first charge the capacitor bank. When the voltage value goes up to a certain value, the discharge device will react to connect the capacitor to the fault cable to break-down the fault.

The Impulse Flashover method is suitable for most flashover faults.

***Operational procedure:***

1. Turn the **MODE** knob to the **PULSE** position.
2. Power on the T-305E, and the **POWER** indicator lamp lights up.
3. Turn the voltage **ADJUST** knob to the zero position, otherwise the **START** will not work.
4. Press the **START** button. The red **START** button will light up, while inside the instrument the reaction of the HV protective device can be heard.
5. Turn the **ADJUST** knob slowly, and stop it when the voltage rises to a certain value, press the **PULSE** button to ascertain whether the voltage is high enough to break-down the fault point. If the fault does not break-down, continue raising the voltage.
6. When the voltage reaches the break-down value, press the **PULSE** button to break-down the fault cable, and locate the fault by using the T-906 cable fault locator.

**Identification of whether the fault point is broken down:**

- a) Ascertain whether the T-906 is triggered or not. If the T-906 is triggered but the waveform is not satisfactory, the operator can increase the discharge voltage.*
- b) Judge by the swing range of the pointer of the kV meter. If the swing range is small, the fault point has not been broken down; if the swing range is large, the fault point has been broken down.*

### 5.3.3 CYCLIC (Cycling discharge) mode

This mode is used for pinpointing the fault position of the cable using the T-506 pinpointer. In this mode, the T-305E will discharge to the cable at a frequency determined by the TIME dial setting. It generates periodic magnetic and acoustic signals, which can be picked up by the T-506 pinpointer for precise location of the fault.

**Operational procedure:**

Perform the same procedure as the **PULSE** mode and increase the voltage until the fault point is broken down. Then turn the **MODE** switch to the position of **CYCLIC** position.

### 5.3.4 Impulse Current Method (ICM) Testing

The TRIGGER/SIGNAL port on the side panel is connected with the TRIGGER/SIGNAL Port of the T-906 using the Lemo cable supplied.

**Operational procedure:**

1. Turn the **MODE** knob to the **PULSE** position.
2. Turn the **TEST METHOD** to **ICM**.
3. Select a suitable capacitor bank. It is usual to choose 32kV/2 $\mu$ F initially.
4. Power on the T-305E, and the **POWER** indicator lamp lights up.
5. Turn the voltage **ADJUST** knob to the zero position, otherwise the **START** will not work.
6. Press the **START** button. The red **START** button will light, and the green **STOP** button will be off. Inside the instrument the reaction of the HV protective device can be heard.
7. Turn the **ADJUST** knob slowly, and stop it when the voltage rises to a certain value, press down the **PULSE** button to try whether the voltage is high enough to break-down the fault point. If the fault does not break down, continue increasing the voltage.
8. When the voltage reaches the break-down value, stop increasing the voltage and press down the **PULSE** button to break-down the fault cable, and locate the fault by using the T-906 cable fault locator.

### 5.3.5 Secondary/Multiple Impluse Method (SIM/MIM) Test

This is used for SIM mode testing. The **TRIGGER/SIGNAL** port on the side panel should be connected with the **TRIGGER/SIGNAL** port of the T-906 cable fault locator.

**Operational procedure:**

1. Turn the **MODE** knob to the **PULSE** position.
2. Turn the **TEST METHOD** to **SIM**.
3. Choose a suitable capacitor bank. It is usual to choose 32kV/2 $\mu$ F initially.
4. Power on the T-305E, and the **POWER** indicator lamp lights up.



5. Turn the voltage **ADJUST** knob to the zero position, otherwise the **START** does not work.
6. Press the **START** button. The red **START** button will light, the green **STOP** button will be off. Inside the instrument the reaction of the HV protective device can be heard.
7. Turn the voltage **ADJUST** knob slowly observing the voltmeter. When the voltage reaches the required value, press the **PULSE** button to break-down the fault. If the fault does not break-down, increase the voltage and repeat until the fault breaks down.
8. At this point, the fault can be located using the T-906 cable fault locator.

#### 5.4

#### DC Voltage Withstand Test

For power cables rated at 6kV or below, after the fault has been repaired, the T-305E can be used to perform a DC voltage withstand test.

##### **Cable Connection**

1. Preliminary work: Disconnect the faulty cable and ground the metal sheath.

**Note: This grounding is the Working Ground, the zero-volt reference point during the discharging process.**

2. Place the T-305E at a location about 2m away from the faulty cable, and put the T-906 on the tray of the side panel for easy operation.
3. Connect the cables according to the figure below.
4. Pull out the retractable discharging rod, put the screw at the end with the lead into the bolt and screw it tight. Clip the other end on the Working GND point. Leave the discharge rod at the reachable place beside the T-305E.
5. Examine all the cable connections to ensure correct connection, then the T-305E can be powered on.

##### **How to do the Test**

Because the remaining charge on the cable may be significant, it should be thoroughly discharged before the test. As a guide, it usually needs 5 minutes for the discharge process.

##### **Operational procedure:**

1. Turn the **MODE** knob to the position of **DC**.
2. Power on the T-305E, and the **POWER** indicator lamp lights up.
3. Turn the voltage **ADJUST** knob to the zero position, otherwise the **START** will not work.
4. Press down **START** button, and it lights up, while inside the instrument the reaction of the HV protective device can be heard.
5. Turn the **ADJUST** knob slowly, the voltage meter will show the voltage level applied to the cable. When the voltage reaches 75% of the tested voltage, the rate of rise should increase (roughly 2% per second) to avoid undue stress to the cable.



### Power off the T-305E

After the test is finished, we should first turn the **ADJUST** knob to zero to discharge the cable. The T-305E can then be powered down.



#### Warning:

*The power off procedure for DC Voltage Withstand Test is different from that for break-down test. There is no discharge loop for this test, the energy on the cable can only be discharged by the discharge rod. Therefore, the user MUST follow the right discharge procedure using the discharge rod.*

## 5.5

### Low Voltage Cable Break-down

Low voltage cable refers to cables below 400V.

The insulation for this type of cable is low. In order to protect the healthy part of the cable, the operator should be careful with the discharge voltage, it should not be over 5kV. If it is difficult to break-down the fault point, it is better to increase the capacitor value. Typically, 5kV with 10 $\mu$ F can normally break-down the cable.

The testing method and operation procedure is the same as testing the HV cable.

## 5.6

### Sheath Fault location using the Kehui T-H200

Note that the Kehui T-100C is the preferred power source for the T-H200, however it will also work with other suitable high voltage sources and can be powered from the Kehui T-305 surge generator, used in DC mode as explained above. Connections are shown below:



The Procedure for using the T-305 with T-H200 Sheath fault locator is similar to the DC mode, but reference should be made to the T-H200 manual for detail.

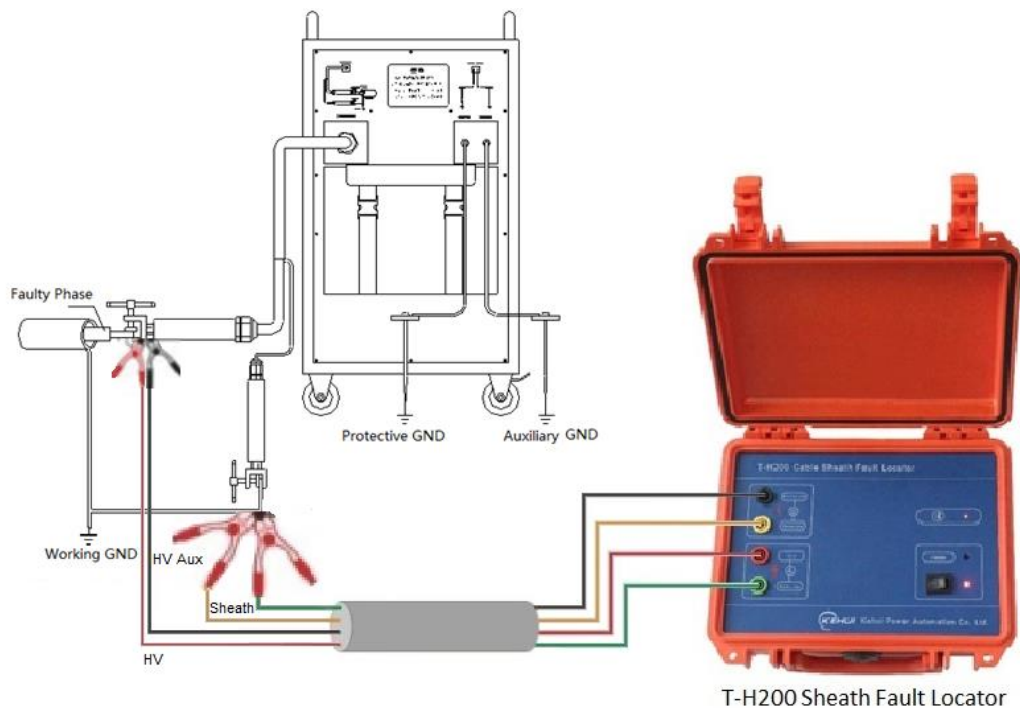


Figure 5.2 T-305 Connections to the T-H200

- 1) Slowly rotate the “HV adjust” knob to increase the output voltage, observing both the voltmeter and the ammeter. When the current reaches 50-100mA, stop raising the HV voltage.
- 2) On the tablet APP, select “cable length” and enter the exact length of the cable, the APP will calculate the “resistivity” automatically, and store the value for the next stage of operation.

## 5.7

### Shut Off Procedure

The T-305E has an internal high voltage discharge device, which will directly short circuit the cable, capacitor and ground terminals of the instrument when the power is off. If the power is shut off directly, without following the procedure below, the residual electric energy stored in the cable and the capacitor will discharge through this device. This will produce a loud discharge sound and may reduce the lifespan of the T-305E.

**Warning:** The T-305E MUST be shut down strictly according to the below procedures after the test is finished.

1. Turn the **ADJUST** knob to the zero position.
2. Press down the **PULSE** button to release the power stored in the capacitor.
3. Use the discharge rod in the right way to discharge the faulty cable, until the voltage is lower than 5kV (watch the kV pointer).
4. Press down the **STOP** button, the high voltage input will be cut off.
5. Power off the T-305E.
6. Further discharge the cable completely using the discharge rod.

**Note:**

*Only after all the HV parts have been fully discharged, the lead wires and test wires can be touched and removed. Remove the plug from the power socket first, and then remove the plug on the back panel of the T-305E.*












## 6. Maintenance and troubleshooting

When the following conditions happen, it is mostly likely caused by an incorrect operation. Please perform the following correct procedure.

- The power light is not on when the mains is connected.  
Reason: The power switch needs to be pressed to switch on the power. Check the power cable connection and press the power switch.
- Pressing the START button has no effect.  
Reason: The voltage ADJUST knob is not in zero position. Turn the ADJUST knob to zero position, then press the START button.
- When increasing the voltage ADJUST knob after the instrument has started, the voltmeter does not react.  
Reason: The T-305E is not properly grounded. Ensure that the working GND, the protective GND and the Auxiliary GND are grounded at different positions.
- When increasing the voltage, the voltmeter pointer is always at the lower voltage position, and there is big buzzing noise in the T-305E.  
Reason: The work mode is on DC position, and the fault is a low resistance fault. Adjust the work mode to PULSE position.

***This T-305E is a high voltage device, if the problems are other than the above, contact Kehui for repair or replacement (info@kehui.com). Do not try to fix it yourself, this may cause further damage or injury to the operator.***

## 7. Packing List - T-305E Packing list

No.	Materials	Picture	Quantity
1	High Voltage Surge Generator		1
2	Grounding pin		2
3	Power Cable		1
4	Discharge Rod		1
5	Discharge Rod Cable		1
6	Manual		1
7	Test certificate		1
8	QC Pass certificate		1
9	Adaptor		1