THE APPLICATION
OF TECHNOLOGY

KEHUI

CABLE FAULT LOCATION

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The word Kehui, literally means the Application of Technology in the Chinese language. This phrase perfectly defines the company's commitment to technological innovation, which it achieves whilst striving for the highest levels of quality.

The company was founded in 1991 as a joint venture with a major US organisation, before becoming independent in 2005. It has utilised the best of Asian, European and American expertise to develop a selection of cable and transmission line fault locators, as well as equipment for the automation of electrical distribution systems and its range of switched reluctance motors.

Cable Fault Location

Cables are a fundamental part of the electrical power system, delivering electricity discretely, whilst improving the environment by displacing unsightly overhead lines. However, their invisibility comes at the cost of making it more difficult to locate and repair the faults that they may incur. A faulted cable brings the inconvenience of a loss of supply, but where the load is particularly important, this inconvenience becomes far more critical. Fault location is further complicated because most faults appear to be intermittent, due to their highly resistive nature, or environmental factors such as the presence of water, which is dispersed by the energy of the initial fault.

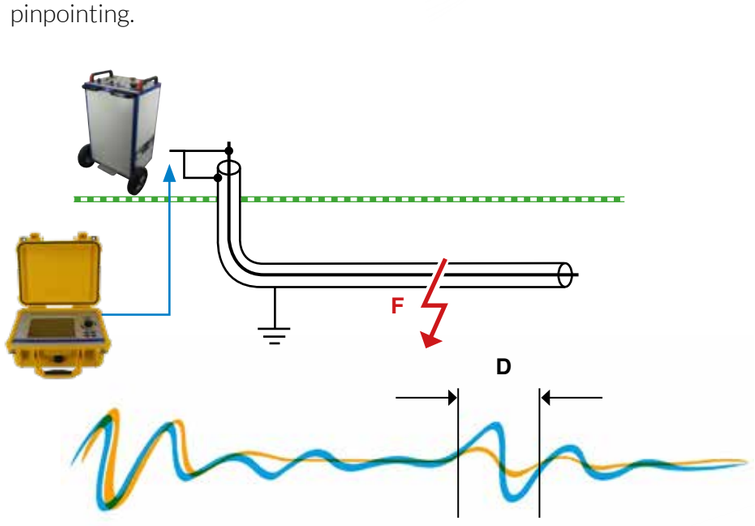
The primary objective of any cable fault location system is to provide quick, effective, accurate and safe fault location, thereby reducing system outages and "customer minutes lost". Furthermore, the deregulated industry has led to the imposition of financial penalties on power companies in the event of a power failure. As a result, there is a lot of pressure to quickly find the fault and Kehui addresses this need for swift fault location through its range of products.

Principle of MV Cable Fault Location

Fault Pre-location

As the fault (F) is unlikely to exhibit a low resistance, it is usually necessary to modify it to create a situation where it becomes suitable for pre-location techniques to be applied. This is carried out using a surge generator to inject energy in to the cable. This energy converts the fault such that it becomes low-resistance, allowing the use of Time Domain Reflectometry (TDR) to measure the distance to the fault.

TDR injects an impulse on to the cable and compares the reflection from the fault position before and during the arcing. The deviation of the signals (D) represents the distance to the fault position, based on time and a known pulse propagation velocity. This technique allows the approximate position of the fault to be determined. The exact location will then be identified through pinpointing.



Pinpointing

As with the pre-location, the Surge generator is used to break down the fault. In this case it applies regular impulses to the cable which can then be detected at the fault point; both audibly, through a ground microphone, and electromagnetically. The signals are picked up remotely through Bluetooth© on a tablet, where an APP identifies the precise fault location.

T-305E High Voltage Surge Generator

The T-305E high voltage surge generator, is used for locating high impedance and flashing faults on distribution cables. It works in conjunction with a cable fault locator for pre-locating the fault position and then with a pinpointer to find the precise fault location. It is applicable for different cable fault location techniques, such as the impulse current method (ICM) and the secondary/multiple impulse method (SIM/MIM).

The equipment consists of a capacitor bank, an in-built voltage transformer and a rectifier, switchable to achieve different capacitance and voltage levels. When the unit is switched off, its automatic and manual discharge facilities remove any residual capacitive charge. Additional Earth/Ground detection circuitry, blocks the operation of the unit if an effective Earth/Ground connection is not in place. These features, together with safety interlocking, ensure safe, reliable and easy-to-use operation. The T-305E also provides repetitive discharges to facilitate pinpointing, through the detection of the magnetic field and audio signals related to the fault discharging.

Features

- **Surge energy up to 1024J (2048J optional)**
- **Supports the following impulse methods:**
  - **Secondary Impulse method (SIM)**
  - **Multiple Impulse Method (MIM)**
  - **Impulse Current Method (ICM)**
- **Manual and automatic capacitor discharge**

Technical Data	
Mains Supply	220V ± 10% (110V through step-up transformer)
Mains Frequency	50/60Hz ± 20%
Maximum Power Consumption	1500W
Operating Modes	Single pulse, Cyclic pulse, DC
Surge Steps	1024J (option 2048J)
Surge Voltage	0 - 32kV; 0 - 16kV; 0 - 8 kV
DC Test (kV)/mA	0...32kV / 25mA Negative polarity
Rated Capacitance	2μF (0 -32kV), 8μF (0 - 16kV), 32μF (0 -8kV)
Pulse Ratio (Seconds)	4 - 30s
Mode Of Operation	DC / single impulse / multiple impulse
Discharge Period	4 – 15 s. Continuously adjustable
Testing Method	ICM, AIC, SIM/MIM
Dimensions	500 x 400 x 960mm
Weight	75kg
Operating Temperature	-10 - +50°C
Storage Temperature	-40 - +60°C
Operating Relative Humidity	5% – 90% relative humidity
Operating Atmospheric Pressure	86 – 106kPa

T-906 Automatic Power Cable Fault Locator

The T-906 is an easy to use, 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.

The T-906 can operate in four modes: Time Domain Reflectometry (TDR), Secondary/Multiple Impulse Method, (SIM/MIM), Decay Method and Impulse Current Method (ICM). Most power cable faults exhibit a high resistance, which requires the application of a high voltage surge to break it down for the purpose of pre-location. Of the four modes mentioned, ICM is the most cost-effective method of producing a flashover at the fault point using a standard surge generator. In the T-906, the ICM is augmented by an Automatic Impulse Current (AIC) method, in which waveform recognition techniques are applied to calculate the fault location automatically, without the need for the operator to manually interpret the waveforms. For flashover faults requiring a high breakdown voltage, the Decay Method can be applied in conjunction with a HV DC source. The cable is charged by the DC source until it breaks down, creating a transient voltage signal which is captured through a capacitive voltage divider and used for fault location analysis.

Features

- **Automatic recognition of impulse waveform and fault location**
- **Suitable for locating faults up to 64 km (40 miles)**
- **Lithium cell battery with up to 8 hours continuous operation**
- **Large LCD colour display**
- **Compact and lightweight**

Technical Data	
Measuring Range	64,000 m
Pulse Width	40ns - 3.56μs
Pulse Amplitude	30 V
Sample Rate	100MHz
Accuracy/Resolution	±1m
Screen	8.4" in touch, 640 x 480 dots, touch screen, colour LCD
Display Choice	Not defined
Storage	> 100 records
Connection	USB
Velocity	90 - 300 m/μs
Output Impedance	5 - 80 Ω
Weight	3 kg
Dimension	0.33 x 0.31 x 0.15 m
Menu styles	Guided Menu
Power source	Polymer Lithium-ion battery pack (5h life)
Battery charge input	100-265V AC (50/60Hz), 8h charging time
Temperature	-10°C to 50°C
Storage temperature	-20°C to 50°C
Fault Location Method	TDR, SIM, MIM, ICM, AIC and Decay Method
Language	English, French, German, Spanish
Ingress Protection	IP54

T-506 Smart Pinpointer for Power Cable Faults

The T-506 is used together with a high voltage surge generator, to pinpoint high resistance and flashover faults on power cables. It utilises an Application (App) running on an Android device, connected wirelessly to a hand-held sensor. The HV surge generator injects periodic high voltage surges down the cable which causes flashover at the fault point. The sensor detects magnetic and audio signals emanating from the faulted cable during this process. Although most Android tablets can be used, a pre-programmed, ruggedised device, with a hands-free neck strap, is available from Kehui. The Tablet has two modes; the Operator mode provides an intuitive indication of the position of the cable and the position of the fault relative to the user's position. The Waveform Analysis mode allows the user to diagnose the fault position from the magnetic field and audio waveforms. The Tablet also has a waveform recognition technique which recognises the audio signal from the flashover and rejects other spurious noise signals.

The equipment features waveform recognition to identify the "thumping" signal and differentiate it from other environmental noise. It does this through a "learning" process based on a large number of previously recorded signals using artificial intelligence. It is complemented by the use of noise-cancelling earphones to assist the user in hearing the sound of the discharge at the fault position.

Features

- **Display APP available for use on Android devices**
- **Option of pre-programmed, ruggedised hands-free Tablet**
- **Two level display with switchable Expert and intuitive Standard modes**
- **Intuitive display (right) indicates the user's position relative to the cable and the relative distance to the fault**
- **Hands-free Bluetooth connection from the receiver to the tablet PC**

Technical Data	
Sensor	
Dimensions	Diameter 23 cm (outer rim)
Height	17.5cm
Weight	Adjustable 54 cm – 77cm
Magnetic field frequency Range	160Hz – 50kHz
Audio Frequency range	100 – 1500Hz
Audio Filter stages	• No filter 100-1500Hz
	• Low pass filter 100 – 400Hz
	• Band pass filter 150 – 600Hz
	• High Pass filter 200 – 1500Hz
Protection Rating	IP65

Receiver; (Details of Kehui supplied Android tablet)	
Dimensions	21 x 13.5 x 2 cm
Weight	0.61kg
Display	7-inch, 128 x 80cm; resolution 1280 x 800
Gain	17.5cm
Operating time	Approximately 17 hours (3 hours charge time)
Weight	1.5kg
Protection Rating	IP68

T-1000 Cable Test Van

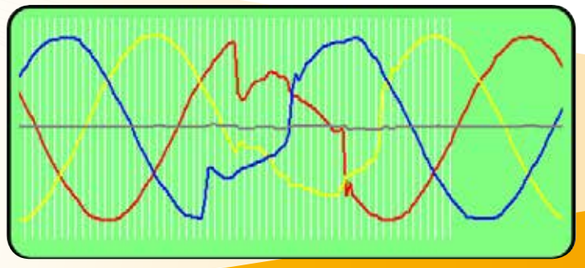
The T-1000 test van brings together Kehui's cable fault location solutions in a vehicle to provide ease of transportation, convenient connections to 50m cables housed on integral drums and a comfortable air-conditioned working environment. A back-up generator can be installed to provide a local power supply if required.

The van's industrial PC provides a large clear LCD display and runs analysis software to facilitate the fault location.

T-P23 Low Voltage Cable Fault Locator

The Kehui T-P23 has been designed for the location of all types of low voltage cable fault, without the need to disconnect the customers. If an intermittent fault is suspected on an LV cable, due to a blown fuse or customer complaints, the device is connected to the cable at the substation or at an intermediate location, such as a link box. It remains in place until a further event triggers it, at which time, it allows a local or remote operator to perform Time-Domain Reflectometry (TDR) testing on any combination of phases. A 3-channel transient recorder is included to record the 3-phase voltages of the faulty cable, so that the exact nature and behaviour of intermittent faults can be identified.

In addition to its use as a TDR, Travelling Wave Fault Location can be performed using two Kehui T-P23 units. The 3 phase voltage recordings from any 2, or more, Kehui T-P23 units can also be used for Fault Location using the Voltage Gradient method.



Features

- Locates all LV cable faults including transient and intermittent faults
- Measurement on live cables without disconnecting the customer
- Local Bluetooth® control from portable PC and Android phone or tablet
- Monitors all three phases simultaneously
- Remote control over the internet using integral GSM/GPRS modem
- Automatic remote notification of trigger and access to records
- Self-powered from the supervised cable, through the test leads

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