Cable fault location in power cables

Fault classification: Insulation and resistance measurement

شرکت اسپیداد

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1. Introduction

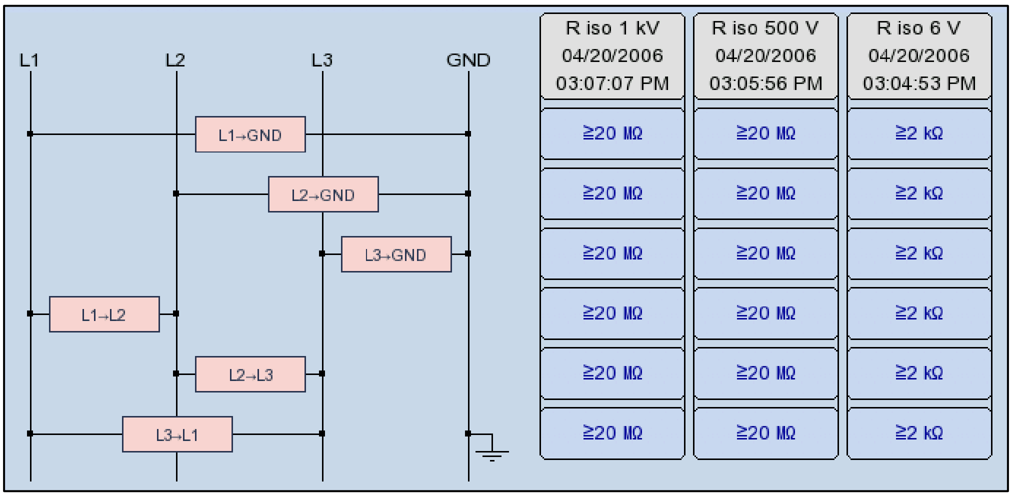
The first step in locating a cable fault – fault classification – should be very thorough. Exact cable plans, knowledge of the cable network as well as any civil engineering work can provide the first clues regarding the location of the fault and prevent any misinterpretation. The following insulation testing and resistance measurement can supply information about the characteristics of the fault.
After these measurements are performed a reflection measurement device (TDR) is connected in order to detect the cable length, sleeves or other changes in impedance. One should always compare conductors which are faulty with conductors which are not faulty. The more information gathered this way, the easier and more reliable the overall fault location process will be.

2. Insulation test

The insulation test shows the type of fault. To do this, the ohmic insulation resistance between the conductors and shield (phase – phase or phase – shield) is measured.

The results of the insulation test are important in deciding how to proceed further with the fault location process and can be classified as follows:

- No fault (no deviation between the resistance values)
- High resistive cable fault (kOhm, MOhm)
- Low resistive cable fault (contact between two conductors/screen)

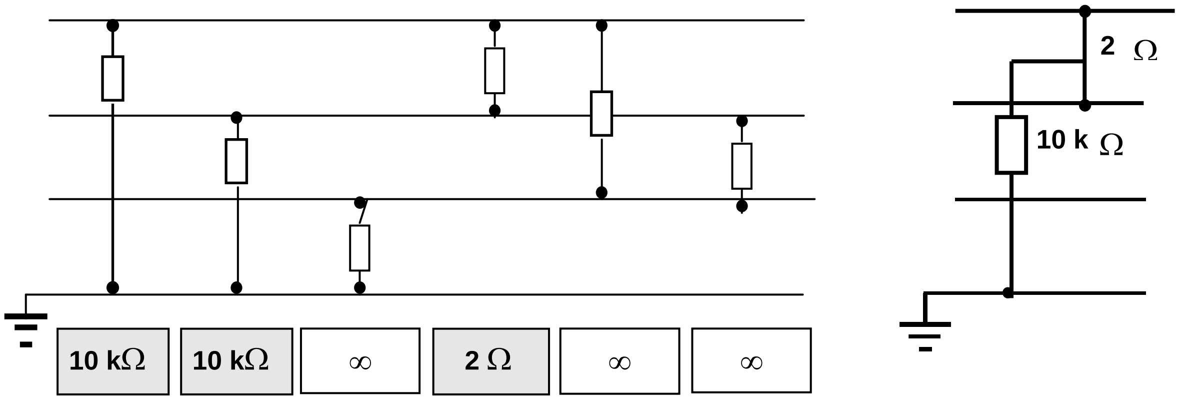


Normally, the insulation test can be performed directly from the cable test van. The maximum voltage is 1000 V. If higher voltages are required, individual apparatus must be used on site. Equipment with an analogue display has proven reliable in practice. For example, anomalies during the charging process can show up faults due to the presence of moisture. These tendencies can only be detected using pointer instruments.
With faults of very high resistance, direct current must be used to establish the level of breakdown voltage in the cable fault.

Equipment: Insulation testers 500 V, 1 kV, 2.5 kV, 5 kV,
integrated insulation testers up to 1 kV

3. Measuring the resistance of a fault

When choosing the pre-location method to be used, it is very important to have precise knowledge about the resistance of the fault and the position of the fault. The results of both measurements should be saved or noted. With multiple faults, the faults are often parallel. A drawing can help during evaluation.



In solely plastic low-voltage cable networks without shielding or armouring, it is recommended that the PEN be disconnected on all sides and a check then performed to see if there are any faults due to contact with the earth.

Equipment: Low-resistance ohmmeter, up to 10 ohm

4. Overview measurement with TDR

The following overview measurements should be carried out with a reflectometer (TDR):

- Comparative measurement – length measured according to length on cable plan, if necessary, correction of diffusion speed V/2
- Sleeve calibration
- Comparison of faulty and non-faulty wires
- Saving reflectograms for later comparison

Equipment: Teleflex MX (Centrix)
Teleflex T 30-E
Digiflex Com, Easyflex Com

Results of fault classification

Short circuit, 0 ohm
A short circuit is a direct, metal connection between conductors, i.e. these conductors have fused together or are touching one another. This results in all the acoustic pinpointing methods failing; due to the direct metal contact no breakdown noises can be produced. On the other hand, a short circuit can be very easily seen using classic reflection measurements. Nevertheless, an attempt should be made to send a shock of a higher resistance to this fault – with a high-power shock discharge generator – so that acoustic pinpointing can be undertaken.

Resistance fault greater than 0 ohm
Resistance faults do not allow the cable to be charged. However, these faults are visible when almost any of the pre-location or pinpointing methods based on high voltage are used.

Very high resistive faults
The resistance of these faults is so high that, in many cases, ignition using the normal voltage of a shock discharge generator can no longer take place. These faults are charged up to the flash-over voltage. The entire energy stored in the cable capacitance is discharged via the fault. DECAY and DECAY-Plus pre-location methods as well as acoustic pinpointing are possible.

Faults due to contact with earth
Pre-location using the bridge method and the voltage drop method

Which faults can be seen with the reflectometer (TDR)?

The following are visible

-All impedance changes below cable impedance
e.g.: parallel and series ohmic faults
-Sleeves
-Strong deflections
-Damaged areas and pressure points
-Incoming water
-Changes in cross-section
-Contact problems caused by corrosion

The following are not visible

-Faults of which the resistance is in a range many times the impedance of the cable. In theory, these faults are visible but the visible change is so small that it gets lost in the normal interference level or disappears due to the insulation.
With modern cables and correctly fitted sleeves, these changes in impedance can be so small that they can no longer be detected.
-Faults that normally do not exhibit any resistance (R=infinite). These faults (spark gaps) are ignited by applying an DC or VLF voltage. The voltage level depends on the defective insulation.
-Where a cable of unknown length has severed – a mix-up between cable end and severed point is possible. When there is doubt, short-circuiting at the far end can at once clearly confirm that there is such a fault present.

Depending on the type of fault, the visible reflections can be so small that they are inconspicuous and are therefore undetectable.

Remark: Further information can be found in the following article on reflection measurements