APPLICATION NOTE

Megger

Fault location on power cables

1. Introduction

Fault location on communication and power cables is a very specialized area of electrical technology. The performance of efficient fault location is very much dependent on good logistics and knowledge. Fast and reliable fault location is dependent on these factors if prelocation of a fault is to be done with high accuracy. The following pinpointing procedure, for the exact location of the fault location, can be done on a very short segment of the cable.

Cable testing, cable diagnosis and partial discharge measurements, will become of higher importance in the future. The condition based preventive maintenance of cable networks, will more and more replace the event-oriented maintenance of cable installations.

A good detailed knowledge of the construction of cable networks, cable types and their accessories, simplifies the evaluation of the measured results considerably. Many of these are processes are the essential grounds for correct decisions to be made. The types of cable faults and the required steps to do a cable fault location or a diagnosis are one of the most important details that the technician must be aware of.

2. Construction of power cables

A power cables purpose is to efficiently distribute electrical energy; distribution must be done with a high degree of reliability and safety over a very long period of time. Depending on the application, external environment and local factors such as ground water level, type of ground or voltage levels, different types of cables are used. Cables with impregnated insulation, such as PILC, were installed until the late 60’s and are still being installed in some areas. Today, these cables have been mostly replaced with PVC, EPR, PR or XLPE insulated cables. The developing characteristics of cables have caused cable faults and testing methods to change considerably.

The following chapters cannot cover all of the possible different constructions and varieties of cables and their different materials, but it will concentrate on the most important details. Many of the following details are not for the explanation of these said details, but more so to help understand and follow the used wording in our fault location guide.

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Basic cable construction

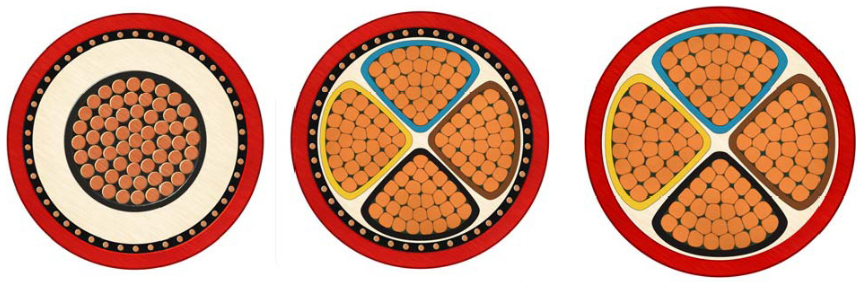

Fig. Single core Multi core shielded Multi core unshielded

2.1 Conductor

The purpose of the conductor is for current transmission and consists of soft electrolytic copper or pure aluminium. It can be round, sector shaped, single wire or multi stranded construction.

2.2. Insulation

The purpose of the insulation is for voltage resistivity and potential separation of conductors from each other and from the metallic outer jacket (Lead Sheath, Armour).

1 to 10 kV:	Mass impregnated paper (PILC)	Polyvinylchloride (PVC)
1 to 30 kV:	Mass impregnated paper (PILC)	Cross linked Polyethylene (XLPE)
		Ethylene Propylene Rubber (EPR)
From 60 kV:	Paper with Oil or Gas	Cross linked Polyethylene (XLPE)

Besides these typical materials, there are also different types of insulation in existence.

2.3. Semi conducting layers (at nominal voltages from 6 kV)

The purpose of semi-conducting layers is for the prevention of partial discharges (PD) and high electrical fields inside the cable. Semiconducting layers soften the electrical field that builds up around each single conductor strand; this process minimizes the risk of damage to cables by avoiding the discharge that can occur due to increased electrical fields.

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Other types of semi conducting layers are today being used for the outer insulating sheath / jacket. The purpose here is for example, to locate sheath faults on cables that are installed in ducts, where the return for the fault current through earth is non-existent.

2.4. Metallic sheath

The purpose of the metallic sheath is for protection and sealing from humidity, conduction of leakage or earth fault currents, potential equalisation, earth conductor and neutral concentric. For very important cables and for sub sea cables it can also provide strong mechanical protection.

2.5. Shield (at MV- and HV cables)

The purpose of the shield is for conduction of leakage, earth fault current and field control.

2.6. Armour

The purpose of the armour is for mechanical protection. It can consists of steel bands, flat wires, round wires etc. In some cases this armouring can consist of several different layers.

2.7. Plastic sheath

The purpose of the plastic sheath is for outer protection of the cable and it consists of PVC or PE

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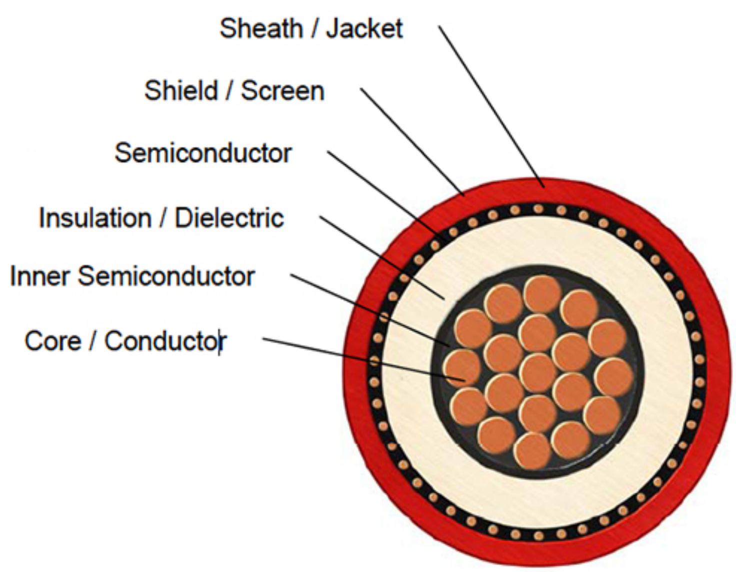
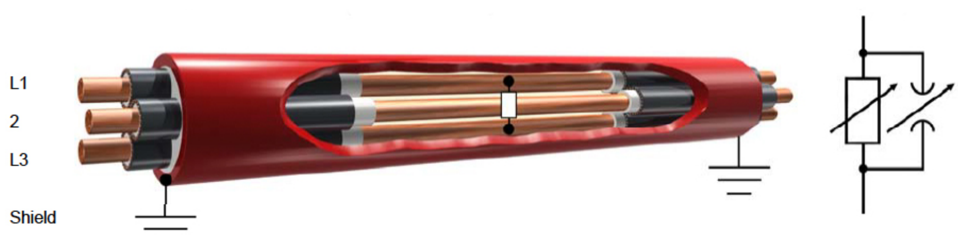


3. Cable faults

Depending on the type of cable fault, a suitable procedure must be selected. In the cable fault location the general differentiation is divided into the following fault types.

3.1. Fault Conductor - conductor (parallel Fault)

Connection between two or more conductors. The insulation resistance value of the fault can be between 0 Ohms (low resistivity) or several M Ohms (high resistivity).



3.2. Fault Conductor - shield (parallel Fault)

Connection between Conductor and shield or Conductor/Conductor and shield. The insulation resistance value of the fault can be between 0 Ohms (low resistivity) or

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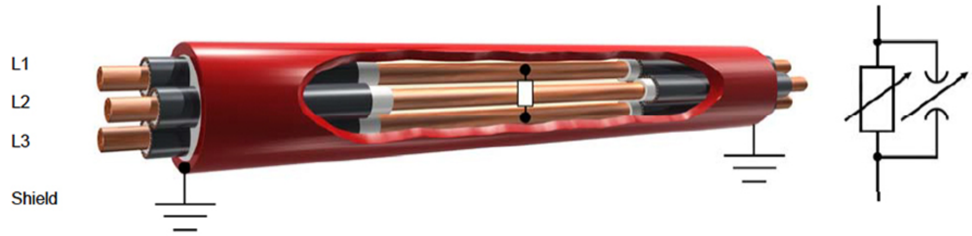
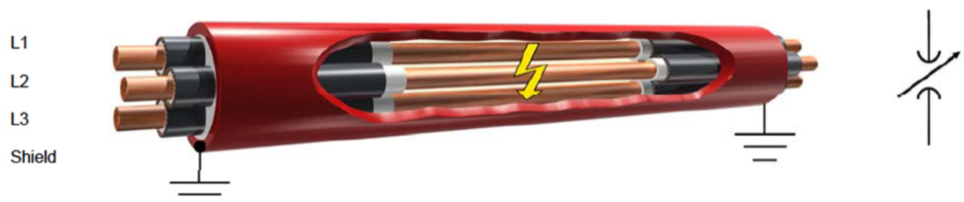
several M Ohms (high resistivity). Experience has shown, that most faults are in this category.



3.3. Flashing fault (parallel Fault)

Very high resistance fault. The cable can be charged. The flashover happens typically at some kV and is very often located in Joints. The cable acts comparable to an arc gap, where the distance between the electrodes determines the voltage. The insulation resistance of this fault is typically infinite up to the breakdown voltage.



3.4. Serial fault (Open, Interrupt)

Faults of this type can be very high resistive up to infinite (complete cut). Very often these types of faults are a combination of serial and parallel insulation resistances. The reason for this being a complete cut of the cable, or it is pulled out of the joint, which interrupts everything, but also permits flashovers in all possible variations.

If the conductor is partially burned off (Aluminium) we speak of longitudinal faults.

3.5. Earth faults, sheath faults

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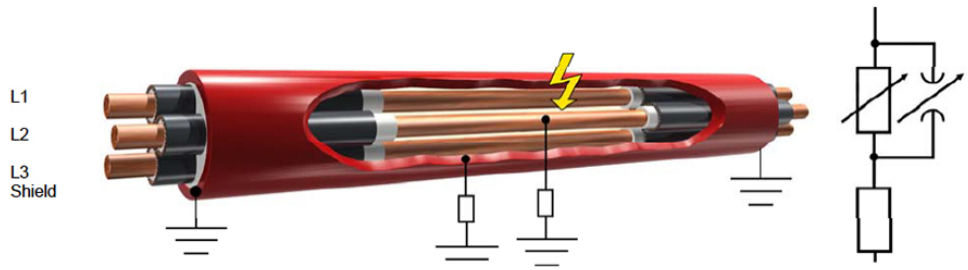
These include faults between the metallic shield and the surrounding soil in case of plastic insulated cables. Faults between the conductor and surrounding soil on LV and plastic insulated cables. Especially for these types of faults the highest precaution must be taken when using high voltage, this is of utmost importance, since the voltage discharges directly to earth. Resulting an increased potential danger to man and animal.



3.6. Humid / wet faults

On multi core cables, all conductors are often affected. The flashover does not always appear at the position where the water entered the cable. The fault resistance is in the range of several k Ohms. At the fault location, impedance changes do occur. Depending on the cable construction (e.g. longitudinal water sealing) these faults can be punctual or widespread throughout the cable. Humidity faults are the most difficult faults to locate. They have the tendency to change during the fault location procedure, sometimes in a very drastic manner and especially in joints. The fault can become highly resistive again after one or two discharges and then cannot be localised anymore. The water gets blown out of the joint and dries up.

Other forms of humidity faults are underwater faults. Here the water pressure prevents an effective ignition of the fault during the HV application. The location of these faults can be very difficult to pin-point.

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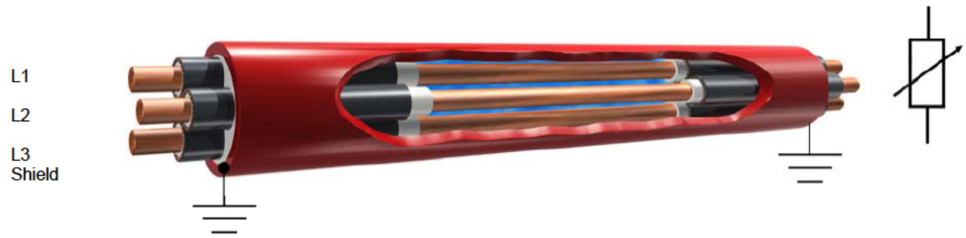

Comments

For fault resistance values there is a global differentiation between short circuit, resistive and high resistive faults. The detail of this information has a significant influence on the further procedures to be used during the fault location. These details are described in one of the coming articles.