Underground Cable Fault Detector Using Microprocessor

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Abstract- *Cable faults are damage to cables which affects the resistance in the cable. If allowed to persist, this can lead to a voltage breakdown. To locate a fault in the cable, the cable must first be tested for faults. This prototype uses the simple concept of OHMs law. The current would vary depending upon the length of fault of the cable. This prototype is assembled with a set of resistors representing cable length in Kilo meters and fault creation is made by a set of switches at every known Kilo meters (km's) to cross check the accuracy of the same. The fault occurring at what distance and which phase is displayed on a 16X2 LCD interfaced with the microcontroller. The program is burned into ROM of microcontroller. The power supply consists of a step down transformer 230/12V, which steps down the voltage to 12V AC. This is converted to DC using a Bridge rectifier. The ripples are removed using a capacitive filter and it is then regulated to +5V using a voltage regulator 7805 which is required for the operation of the microcontroller and other components.*

Keywords- cable; voltage break down; faults; prototype

I. INTRODUCTION

Power supply networks are growing continuously and their reliability is getting more important than ever. The complexity of the whole network comprises numerous components that can fail and interrupt the power supply for the end user. For most of the worldwide operated low voltage and medium voltage distribution lines underground cables have been used for many decades. During the last years, also high voltage lines have been developed to cables. To reduce the sensitivity of distribution networks to environmental influences underground high voltage cables are used more and more. They are not influenced by weather conditions, heavy rain, storm, snow and ice as well as pollution. Even the technology used in cable factories is improving steadily certain influences may cause cables to fail during operation or test. Cables have been in use for over 80years. The number of different designs as well as the variety of cable types and accessories used in a cable network is large. The ability to determine all kind of different faults with widely different fault characteristics is turning on the suitable measuring equipment as well as on the operator's skills. The right combination enables to reduce the expensive time that is running during a cable outage to a minimum.

II. CABLE TYPES

Cable types are basically defined as low-, medium- and high voltage cables. The most common designs of medium- and high voltage cables are shown below. According to the cable type, different requirements to cable testing, cable fault location as well as maintenance strategy are defined. Three-conductor cables have been in use in the lower voltage ranges. The tendency of the last years show the shifting to single-core systems as they are lower in price, lower in weight and cheaper in regards to repair costs. Furthermore oil impregnated or oil filled cables are used less and less, as the environmental sustainability can not be guaranteed. Especially in industrialized countries, these cable types have been replaced and are no more installed. On the other hand a high demand for maintenance of those cables is given as the installed oilinsulated networks do show up a lifetime of 50 years and more. Today mainly XLPE insulated cables are used. The improvement of the XLPE insulation material combined with the modern design of the cable enable to manufacture cables even for the extra high voltage level.

Figure 1. Single core, XLPE insulated medium voltage cables 6kV up to 36kV

All kind of low-, medium- and high voltage cables are delivered and stored on cable drums. The maximum available cable length is mainly specified by the diameter (1core ore 3-core cable) and the voltage level of the cable.

1. Cable Faults

A cable fault can be defined as any defect, inconsistency, weakness or nonhomogeneity that affects the performance of a cable. All faults in underground cables are different and the success of a cable fault location depends to a great extent on practical aspects and the experience of the operator. To accomplish this, it is necessary to have personnel trained to test the cables successfully and to reduce their malfunctions. The development of refined techniques in the field of high voltage testing and diagnosis, in addition to the variety of methods for locating power cable faults, makes it imperative that qualified and experienced engineers and service operators be employed. In addition, it is important for the trained personnel to be thoroughly familiar with the fundamentals of power cable design, operation and the maintenance.

III. WORKING

Power is stepped down by a step down transformer and the output is connected with 12v relay now ac is converted to dc power by full wave rectifier and the dc power is smoothen by the use of a power filter. Power is filtered and the supply is passed to timer and counter chip IC. We have used 6 led's mainly 3 green and 3 red.

These led's are connected to op amps, 3 pipe lines are used representing the three cables red yellow and blue and a switch is connected to trip the supply which symbolise short circuit When supply is given all the 3 red led glow one by one with the help of counter ic. The 3 green led keeps glowing until the power is interrupted. In case of short circuit in any cable there is interruption in power in the cable with fault this interruption is read by the op amp as a result the green led blows off and the led glows for the fault carrying cable and finally we find which cable is faulty.

1. EQUIPMENT USED

- Step down transformer
- Relay
- Full wave rectifier
- Timer and counter
- Diode & Resistor
- Led's & IC's
- Plastic pipe for UG cables
- Power filter
- SPST swi

III. CABLE FAULT LOCATION PROCEDURE

Cable fault location as such has to be considered as a procedure covering the following steps and not being only one single step.

- Fault Indication.
- Disconnecting and Earthing.
- Fault Analyses and Insulation Test.
- Cable Fault Pre-location.
- Cable Route Tracing.
- Precise Cable Fault Location (Pinpointing).
- Cable Identification.
- Fault Marking and Repair.
- Cable Testing and Diagnosis.
- Switch on Power.

Cable Fault Types

1. Fault between core-core and/or core - sheath:-

Low resistive faults ($R < 100 - 200\ \Omega$)

Open short circuit

High resistive faults ($R > 100 - 200\ \Omega$)

- Intermittent faults (breakdown or flash faults)
- Interruption (cable cuts)

2. Defects on the outer protective shield (PVC, PE):-

Cable sheath faults**-**

Most of the cable faults occur between cable core and sheath. Furthermore, very frequently blown up open joint connections or vaporized cable sections can cause the core to be interrupted..

V. CABLE FAULT PRE-LOCATION

Low voltage method

Impulse Reflection Method TDR for:

- Low resistive faults.
- Determination of the cable length.
- Localisation of cable interruptions.
- Detection of joints along the cable.

High voltage methods

Multiple Impulse Method SIM/MIM.

Impulse Current Method ICM.

Bridge method

- Low and high resistive cable faults. o Low and high resistive cable sheath faults. o Core to core faults in unshielded cables. o faults in pilot cables and signal lines o faults in unshielded cores to ground.

VI. CABLE ROUTE TRACING

Cable route tracing is applied to determine the exact route of the underground cable. Depending on the availability of cable laying maps, route tracing is of very high importance as prior step to cable fault pin-pointing. Route tracing can be performed either active or passive. At live cables the harmonics of the mains frequency can be heard as ‘mains hum’. However, all grounded conductors, water pipes and parallel running cables which are connected to the 50Hz mains system also have this ‘mains hum’. To avoid confusion, it is recommendable to disconnect the conductor and feed the cable with an audio frequency to perform an active cable route tracing.

1. Signal detection

Above the ground, the electromagnetic signal transmitted via the audio frequency generator can be measured along the cable trace. Depending on the pick-up coil direction, the signal can be coupled differently.

Maximum method

The detecting coil is horizontal to path of line. Maximum audio signal is directly above the line. The maximum method is used for cable routing as well for terrain examination.

Minimum method

The detecting coil is vertical to the path of the line. The minimum audio frequency signal is directly above line. The minimum method is used for depth determination measurement as well for exact cable tracing and pinpointing.

Depth Measurement according to the Minimum Method

For the depth determination with a simple surge coil, the characteristic of an isosceles triangle

- first determine the exact position of the cable.
- subsequently, the coil has to be rotated to 45°
- The minimum audio-frequency signal is heard at the depth “d” at a corresponding distance from the path of the cable. Instruments designed specifically for route tracing are operated with two integrated antenna covering the functions of minimum and maximum method as well as depth determination.

Terrain examination

Another application where the cable locating set can be applied is the so called terrain examination. The signal is injected into the soil via two earth spikes. In case there is any metallic conductor, the signal will return along the conductor. The electromagnetic signal along the conductor can be detected and the conductor can be found. To examine a particular area for existing cable/pipes system, the follow procedure is recommended:

- dividing the area into squares of approx. 25x25 m
- the audio frequency generator has to be set up in the centre of the cable run
- the ground rods need to be set into the ground to the left and right of the generator at approx. 12 to 15m
- the output power of the generator is kept low

If there is a metallic conductor within the set out area, it will propagate a magnetic field in its vicinity. The magnetic field has in most cases the shape of a single sided maximum; e.g. with a steep edge to the audio frequency waveform.

2. Selection of Audio Frequency

Every audio frequency generator is offering the possibility to select different signal output frequencies. The different characteristic of the frequencies is the induction effect. The induction of a signal into a neighbouring metal conductor is increasing with the frequency.

VII. CABLE FAULT PIN POINTING

Acoustic Fault Location

1. Acoustic Fault Location in direct buried cables

For pin-pointing of high resistive and intermittent faults in buried cables the acoustic method is used to pin-point the exact fault location. As signal source, a surge generator is used in repetitive pulsing mode. High energy pulses which are released by a surge generator (SSG) force a voltage pulse to travel along the cable. At the fault the flashover happens. This causes a high acoustic signal that is locally audible. Depending on the pulse energy, the intensity of the acoustic signal varies. These noises are detected on the ground surface by means of a ground microphone, receiver and headphone. The closer the distance from the fault to the microphone, the higher is the amplitude of flashover noise. At the fault position the highest level of flashover noise can be detected.

Figure 1.

The acoustic fault location set comprising the receiver UL30 and the ground microphone BM 30 offers the special feature of digital propagation time – distance measurement.

Firstly, the ground microphone is measuring the electromagnetic signal that can be recorded all along the cable where the HV impulse is travelling before finally flashing over at the faulty position. As this signal is available all along the cable trace towards the fault, it can further be used to make sure that the “cable trace” is followed. The maximum signal confirms to be directly above the cable.

Secondly the ground microphone will receive the flashover noise next to the fault on the ground surface as soon as the very close area around the fault is reached.

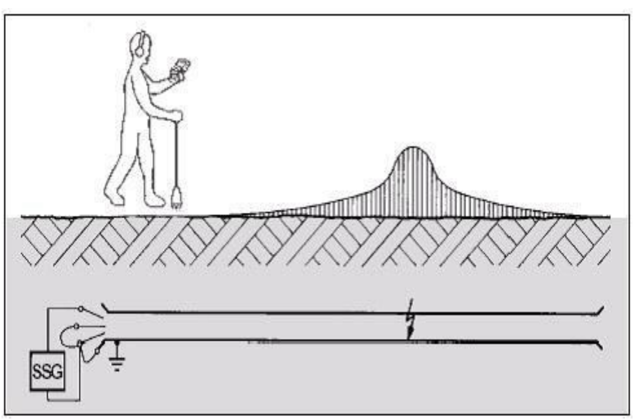

Figure 2. Schematic Connection And Shape Of Acoustic Signal – Acoustic Fault Location

VIII. CABLE IDENTIFICATION

Cable identification is the most critical and safety related sequence during all the procedure of cable fault location. The correct identification of a cable out of a bundle of cables, where most of them can be cables in service, has to be carried out not only carefully, but also by means of an instrument widely eliminating the possibility of human error or misinterpretation.

Additionally, it is highly recommended to use cable cutters according to EN 50340 and / or a cable shooting devices. The local safety and accident precaution instructions are always applicable, and mandatory. The BAUR cable identification system KSG 100 was designed to fulfil these most important safety aspects.

Principle of operation of the KSG 100

The transmitter of the KSG contains a capacitor that is charged and then discharged into the target cable. During this process the test sample must be connected in such a way that current can flow through it. The flexible coupler is used to couple the current pulse at the target cable. The direction of flow of the current pulse and its amplitude are indicated on the display of the receiver. The amplitude of the current pulse is dependent on the loop resistance. To be able to clearly determine the direction of current flow, the positive output is colour-coded red and the flexible coupler marked with an arrow. The current difference that is calibrated can be measured very accurately. As there are no relevant losses, the displayed current is nearly equivalent to the calibration signal.

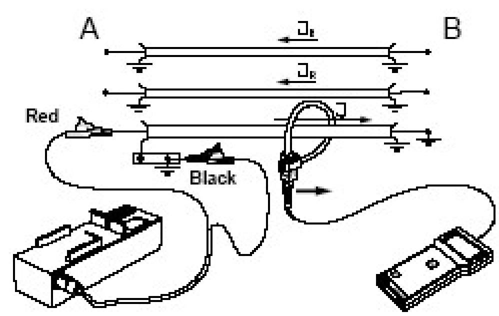

Figure 3. Pulse Signal Flow Scheme

Certain substation arrangements in combination with 3-core cables do not allow an access to the full diameter of the cable in the substation. The calibration as explained above can not be done similar. The Rogowski coil has to be connected around the core without the sheath involved. Therefore the calibration signal is not equal to the signal that is measured on the whole cable diameter on site. For these arrangements the KSG 100 is equipped with an Expert mode that enables to adjust the gain of the received signal. The indication of direction as well as the phase synchronisation is still corresponding to the calibration performed in the substation. Therefore, it is enabled to perform the safe cable identification even on very difficult arrangement. The application of cable identification in PILC cables may be influenced by the characteristic that the outer protective layer is conductive and therefore the cable sheath is also conductive to soil. If the signal return path is defined via the cable sheath, a certain amount of signal may be leaking and travelling via surrounding conductors. These so called vagabonding currents are then no more routed along a defined path. This effect is the reason, why on such arrangement not the full signal value may be available on site.

By using the KSG 100 in the Expert mode, also the effect of vagabonding currents can be considered. As long as possible, the forward and return path of the signal should be defined via the cable cores. Like this, the effect of vagabonding currents in PILC cables can be eliminated.

IX. CABLE FAULT LOCATION IN HIGH VOLTAGE CABLE

High voltage cables such as e.g. 115kV cables, 230kV cables or similar are mainly operated at high load. In case of a cable fault the flash over energy is very high.

XLPE cables:

In XLPE cables most often a big explosion is happening and the cable parts around the fault are burnt and/or vaporized completely. Also the other cores as well as neighbouring cables are very often damaged beside. Due to this reason cable fault location can be carried out easily with basic cable fault location equipment used for medium voltage cables. A fault location system based on a surge generator up to 32kV is mostly fully sufficient to pre-locate these cable faults. The comparison of TDR graphs of a healthy core in comparison with the faulty phase leads to precise cable fault pre-location graphs in low resistive fault conditions. Depending on the current load of the cable at the moment of flash over the conditions may also remain high resistive or intermittent. In general the 32kV surge generator combined with the SIM/MIM or ICM method can cover these fault conditions. If the fault condition shows solid grounded conditions the pin pointing may not be possible by means of the acoustic fault location method as no flash over can take place at a short circuit fault. In such a case the step voltage method is the only method to perform the cable fault pin pointing in 1-core cables.

Figure 4. Vaporized Core After Cable Fault, 132kv XLPE

In 3-core cables, which are used rarely, also the Twist Method can be used for pin pointing. PILC cables: High voltage PILC cables are more resistant to the flash over. In these cables the remaining fault condition may be an intermittent fault with a certain breakdown voltage possibly higher than 32kV. To pre-locate such faults the Decay method based on a HV DC or VLF instrument that is covering the breakdown voltage is required. Basically all these available HV instruments enable to be used in burn mode. Most of the fault conditions can be changed by application of the burn mode over a certain time.

During this fault burning the paper insulation is carbonizing and the break down voltage of the fault can be reduced.

Figure 5. Cable Fault In A 132kv PILC Cable

Finally for pin pointing a surge generator with a maximum output voltage of 32kV can be applied. Only very seldom it is required to use a surge generator with higher output voltage

X. CONCLUSION

Further this project can be enhanced by using capacitor in an AC circuits to measure the impedance which can even locate the open circuited cable, unlike the short circuited fault only using resistor in AC circuit as followed in the above proposed project.

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