Information

Cable Fault Prelocation with

ICEplus

Mess- und Ortungstechnik
Measuring and Locating Techniques

Elektrizitätsnetze
Power networks

Kommunikationsnetze
Communication networks

Rohrleitungsnetze
Water networks

Leitungsortung
Line Location

Innovative Fault Location System for Low Voltage Cable Systems
With New ICEplus Prelocation System

Introduction

The deregulation of the energy market has led to important organisational changes of the electric power suppliers. They try to reduce costs in every field using a lot of imaginativeness, without considerably impairing the availability and the reliability of the cable systems. These criteria are increasingly included in the discussion about the fees for the use of the cable system.
Within the measures of cost reduction, and above all the merging of network operators, the existing equipment for cable testing and fault location were generally decentralized and new investments in cable test vehicles considerably reduced.
Therefore, you nowadays find in many cable systems very distant locations of cable test vehicles, which consequently lead to considerably longer access or waiting times for action in the case of cable failure.
In the case of failure in medium voltage networks, the respective switching measures generally guarantee further supply, and longer waiting times only increase the risk of subsequent failures.
However, in low voltage cable networks, outage time essentially depend on the promptness of the fault location, and longer waiting times for one of the very distant cable test vehicles becoming apparent are a big problem.

Not only the claims for compensation of the customers in the case of power outage or of the electric power suppliers because of the impossibility to transmit the power are at stake, but also the image of the suppliers.

With the new fault location system SPG 5-1000, known test methods with state-of-the-art operating philosophy are used. The often complicated prelocation of cable faults in branched low voltage networks becomes a real measuring pleasure with the new prelocation system ICEplus.

The Technical Problem of Fault Location in Branched Cable Networks

For reasons of costs reduction, a decreasing number of cable distribution boxes has been integrated into low voltage cable networks, and the number of houses connected to a power cable is sometimes 15 houses and more. Unfortunately, it is still not possible to get around the big problem of accessing the house connections in order to remove the fuses, because hazardous DC and surge voltages have to be used for the location of high-impedance cable faults.
A real metrological problem for the prelocation of faults on cables with many tee-branches consists in the high attenuation of TDR pulses (Time Domain Reflectometer) and the complexity of the reflection patterns due to the impedance leaps at the joints and tee-branches. (Figure 1)

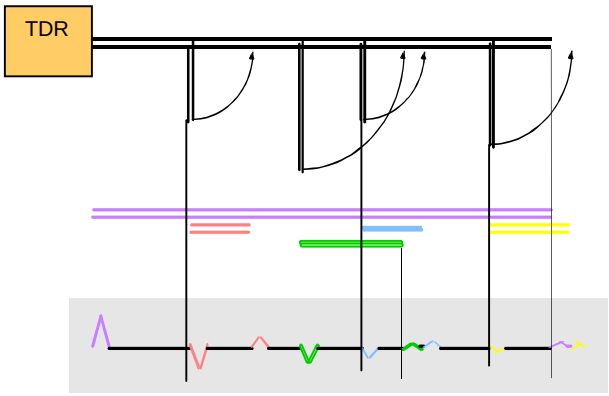

Figure 1 schematic diagram of the attenuation and complexity of reflection measurements (TDR)

Often, faults behind the third or fourth tee-joint are no longer recognizable due to these effects. In the case of faults in branch sleeves, the situation is even more difficult, because they cause themselves a strong self-reflection. Even the arc reflection measurement (ARM) known for many years is affected by these limitations in the same way.
Thus even experienced fault locators nowadays often have to locate the fault by measurements from different ends of the

branched cable. Possibly, the measured section is even isolated by cutting the cable. That means, a time- and cost-intensive and often nerve-racking matter - not only for the nerves of the locating staff, but also of the affected customer.

The Solution – ICEplus

The aim was to develop a solid, reliable and easy to operate test method independent from the a.m. impedance and attenuation problems.
Since the beginning of cable fault location, the so-called impul current method (ICE) is known, where the transient current signal of a shock discharge is recorded upon the ignition of a cable fault. This method can be applied very successfully to medium voltage cables without branches.
However, regarding cables with tee-joints, the evaluation is very complicated or even impossible as is the case with the reflection measurement due to the impedance changes of the branches.
The test signal produced upon a fault breakdown not only contains the known current impulses, but there is an oscillating current (carrier wave), superimposed by the transient current impulses (figure 2), the oscillation frequency of which results from the parameters of the set-up of the measuring instruments.

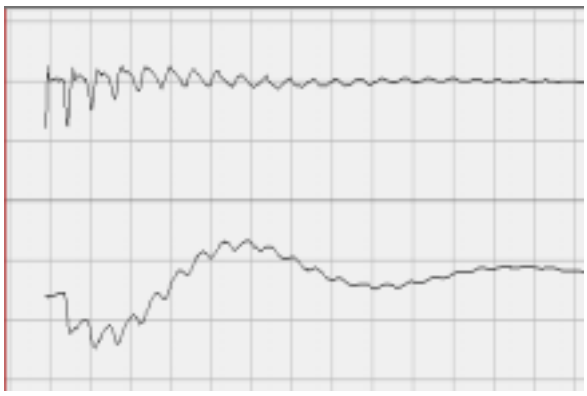

Figure 2 Transient current coupling and total current with carrier wave

The known capacity of the surge capacitor of the SPG 5-1000 and the inductance per unit length of the defective cable up to the fault are the dominant parameters influencing the oscillation frequency of the carrier wave (Figure 3).

The capacity of the defective cable can be neglected compared with the surge capacitor, and the inherent inductance of the measurement equipment and the connecting cable are known and will be considered in the evaluation accordingly.

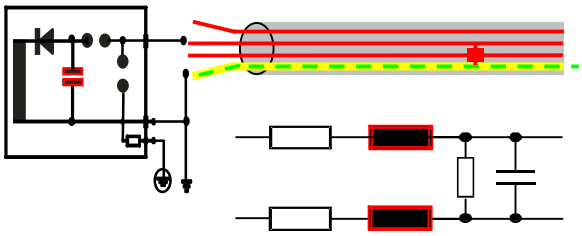

Figure 3 Surge capacity and cable inductivity, the dominant components of the oscillation circuit

Based on the determination of the oscillation frequency of the carrier wave, the inductivity of the oscillation circuit can be calculated

$$L = \frac{1}{\omega_o{}^2 C}$$

using the know oscillation formula

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$

The important know-how of the ICEplus method consists in the reliable determination of the oscillation frequency or period, which is the actual measured variable.
The evaluation of the test signals with a strong attenuation of the carrier wave, up to the evaluation of aperiodic half-waves or signal values highly noise-infested by the intermittent arc is done via a digital signal processor (DSP) and a multistage approximation software as well as various evaluation algorithms.
With the measured radian frequency ω and the calculated oscillation circuit quality Q, the inductivity up to the fault position L_F can be calculated.

$$L_F = \frac{1}{\omega^2 C_S (1 + 1/4Q^2)}$$

From the inductivity value L_F thus determined, the fault distance is calculated via the kilometric inductance per unit length L_k of the cable, which depends on the conductor cross-section and the geometric position of the conductors.

In order to get a good database for the calculation of the fault distance, comprehensive field tests were carried out for the determination of the typical inductivity values of the different cable types and conductor layouts.
By means of a simple set-up of the measuring instruments with known cable length, even the parameters of „exotic“ cable types, which are presently not included in the equipment file, can in the future be determined.

With this patented ICEplus method, even inexperienced users can carry out the prelocation of cable faults without any problems.

For the pinpoint location of cable faults, the standard test methods as described under the following sub-section are available.

Fault Locating Made Easy

The operating concept of the entire measurement equipment is based on our philosophy.

The instrument is self-explaining and the user can operate the device without having to study many pages of the manual beforehand.
Owing to the ¼ VGA display of the device, there is enough space for the graphic display of the status, information and operation instructions, as well as the measurement parameters.
The operation via a rotary selector with ENTER function enables easy navigation within the menu and a quick setting of the parameters.

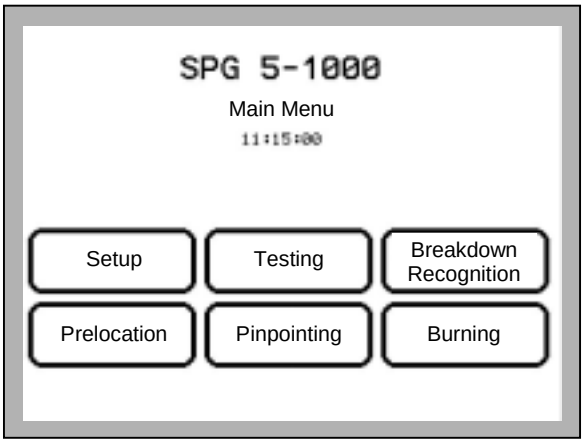

Figure 4 Main menu for the selection of the measuring functions

For quick orientation of the user as to which fault pattern is present, the test function displays both the leakage current and the insulation resistance values.
Another helpful function is the “breakdown recognition“. Here, the breakdown voltage of the fault is automatically determined in order to set the most effective surge voltage amplitude for the prelocation and pin-point function. This assures that the cable is not energized with unnecessarily high surge voltage and the risk of secondary damage is reduced.

While running the ICEplus prelocation function, the user follows the input instructions on the display, which mainly consist in the input of the conductor cross-section, the cable layout and the conductor position, of the connected cable. The user is always offered a list to choose from or a graph of the cable data (e.g. 4-conductor cable or three-conductor cable with sheath; other connection to adjacent conductor or opposite conductors).

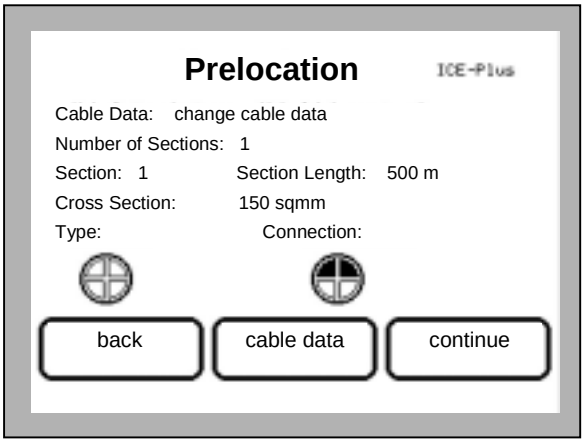

Figure 5 Input mask for prelocation with ICEplus

Should the cable section be composed of different types of cable, an input by sections is also possible.
The correct indication of the conductor cross-section and the connection layout are the precondition for an exact calculation of the distance of the cable fault. Should the fault be located in a tee-branch, e.g. within the house connection cable, there will be a shift of the prelocation result due to the change of cross-section not taken into account. However, this is within the range of inaccuracies produced anyhow by the transfer of the distance to the field.

If the measured fault distance indicates that the position of the fault is in a tee-branch and that this tee-branch has a length of more than 20 m, a supplementary measurement from the end of the relevant tee-branch would be useful.

With ICEplus, the fault distance is indicated in meters so that an interpretation of complicated reflection diagrams is not necessary !

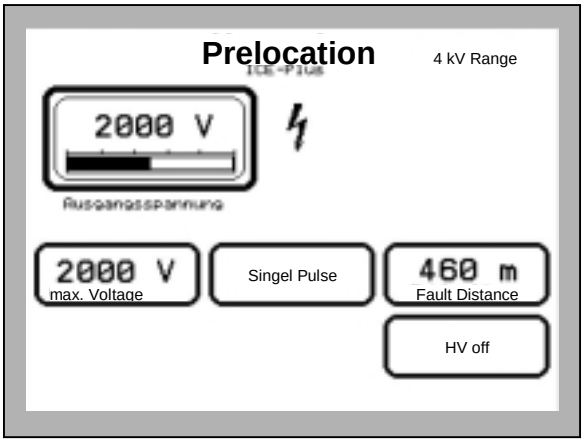

Figure 6 Representation of the result with ICEplus

For the pinpoint location of cable faults, the SPG 5-1000 has the DC step voltage method and the acoustic method available.
The step voltage method uses a pulsed, adjustable DC current, while the surge capacitor is not connected.
For the acoustic location, the voltage levels of 2 or 4 kV with 1000 Ws surge energy each are available. This enables an efficient location of the acoustic field of cable faults even under conditions with loud ambient noises.

In summary, the performance features of the SPG 5-1000 system:

- Self-explaining, menu-driven operation
- Single knob operation
- DC tests up to 5 kV
- Insulation resistance in MOhm
- Automatic breakdown recognition
- Prelocation with ICEplus
- Burndown function
- Pinpoint location with DC step voltage
- Pinpoint location with SWG function (max. 1000 J at 0 ... 2 kV and 0 ... 4 kV)

With the SPG 5-1000, the electric power utilities have a comprehensive and easy to operate portable fault location system available. This enables quick fault location and failure elimination in low voltage cable systems independently from cable test vehicles.
The prelocation system ICEplus brought about a real innovation in the cable fault location process.

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