Accurate on-line fault location (full breakdowns) for MV cables with Smart Cable Guard

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ABSTRACT

For distribution network operators, a quick location of a MV cable fault, whether it is a full fault or a self-healing fault, will contribute to reduce the SAIDI and in case of a self-healing fault it will also reduce the SAIFI.

The quickest fault location is one that acts on-line. At this point a breakthrough is presented in this paper. Smart Cable Guard, an on-line monitoring device already known for being able to pinpoint partial discharges from weak spots, is now able to pinpoint faults as well. The fault location inaccuracy is 1 %.

It will be shown that this fault pinpointing is possible for any MV power cable type, independent of the network grounding and independent of the fact whether a fault is a permanent one or a self-healing one.

This paper will introduce the background and some first experiences. Smart Cable Guard has been developed with close support of the main Dutch network operators, together operating 100.000 km of MV distribution cable.

KEYWORDS

fault, breakdown, location, pinpoint, on-line, medium voltage power cable, PILC, XLPE, partial discharges, monitoring, degradation

INTRODUCTION

Smart Cable Guard (SCG) has proven to be a very effective monitoring instrument for on-line diagnosis of MV underground power cables by locating defects while the cable is in service. These defects are weak spots that generate partial discharges (PD's), but have not failed yet. This feature is called in this paper the SCG Defect Locator (SCG-DL).

Recently, a new feature was added to SCG, being an accurate on-line fault locator, called in this paper the SCG Fault Locator (SCG-FL). A fault is defined as a failure or breakdown, where the full cable system insulation is bridged by a short circuit. Such a short circuit does not always result in a detectable short circuit current. It will depend on the network grounding whether a short circuit current will become large enough to be detected by traditional protection equipment.

The above mentioned location (also called pinpointing) of weak spots and faults has an accuracy of 1% of the cable length, both for SCG-FL and SCG-DL.

Both features (SCG-FL and SCG-DL) help network operators to reduce their System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI).

Here are short introductions to the chapters that will be treated in this paper:

1. Basics of SCG: How does SCG work, why can it detect travelling waves from partial discharges or faults so accurate and how is the location of these travelling waves found with the low inaccuracy of 1 %.
2. SCG's fault locator (SCG-FL): In case of a fault, with SCG-FL the DNO immediately knows the exact fault location, speeding up the fault repair time. The first results on live cables will be treated. It will be shown that, based on its principles, SCG-FL performs well in any network, even in a network with an isolated neutral.
3. SCG's defect locator (SCG-DL): In case of a weak spot with PD's detected and located with SCG, the DNO can replace this weak spot before a fault happens. The principles of SCG-DL were extensively discussed in many papers in the past [for instance: 1, 2, 3] and only a short summary will be given in this paper.
4. Based on many years of experience with SCG-DL, this paper summarizes also the relation between the PD activity from a weak spot and the probability of a fault within a certain time interval, both for PILC and XLPE insulated cables. As far as it is known by the authors, this is unique information. A full paper on this subject is also presented at this Jicable 2015 conference.
5. A last part of this paper will summarize the network operation advantages of applying SCG, as seen by two different Dutch network operators.

BASICS OF SCG

For on-line PD monitoring, traditional PD detection devices use only one inductive sensor. Using only one sensor has the disadvantage that it is difficult or often even impossible to locate PD's and to distinguish PD's from noise.

SCG has two inductive sensors (for a general set-up, see Figure 1). These sensors can be placed for instance around the earth lead(s) at each cable end of the cable system being guarded (see Figure 2 for an example of a sensor placed at one cable end).

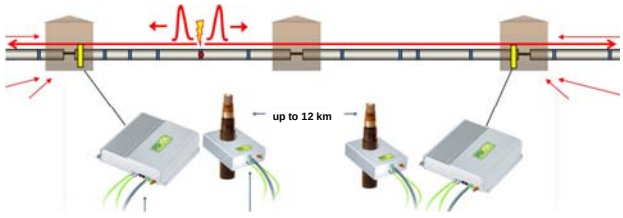

Fig. 1: Typical SCG set-up with left (location A) and right (location B) a sensor and a dedicated industrial computer with wireless or LAN internet connection.