Faults detection and localization on power cables by reflectometry real-time monitoring

Soumaya **SALLEM**, Marc **OLIVAS**; WIN MS, (France), soumaya.sallem@win-ms.com, marc.olivas@win-ms.com
Pierre **WILLAMS**, Damien **JEANNEAU**; SICAME, (France), iot@sicamegroup.com

☐ **Young Researcher** (Proved full-time engineering and science university researchers and Ph.D.students under 35 YO)

ABSTRACT

This paper shows the relevance of integrating reflectometry sensors for live power network monitoring. The objective of this study is to propose a non-destructive real-time diagnosis technology for medium voltage (MV) and high voltage (HV) cables to ensure their security and the continuity of supply, while locating the beginning of weakness as soft faults and aging. With preventive maintenance we can also better understand the causes of failure, as deep investigation is more complicated when a fault has escalated, in order to reduce the consequences of failure on the distribution and improve the system reliability. To the best of authors' knowledge, this is the first time that the reflectometry technique is validated through XLPE cables tests using contactless inductive coupling for real-time soft faults detection and localization.

KEYWORDS

monitoring; diagnosis; reflectometry; high voltage cables; soft faults detection

INTRODUCTION

These High voltage cables suffer different stresses (thermal, electrical, mechanical, etc.) that can create soft faults which relatively impact the cable operation [1] [2]. These faults can evolve into hard faults, thus causing the system shutdown, and possibly some damages. Junctions represent the fragile part of the wire network that should be monitored primarily. We aim to be able to detect soft faults as soon as they appear and to be able to assess cable aging, an indicator of the cable health state, by placing reflectometry sensors which allow real-time monitoring of the high voltage cables installation.

Methods based on reflectometry are able to detect small impedance variations related to soft faults. Our technology allows also diagnosis signals to coexist with those of the system in operation without disturbing it [3].

In this context, several constraints were faced:

- Contactless coupling: injection of our reflectometry signals by inductive coupling to not disturb operation
- Monitoring: real time
- Environmental constraints: our sensors must be protected (EMC, high voltages, etc.)

Most of the publications that study faults in power cables focus on the faults of water treeing, it's a degradation of cable insulation due to a high level of moisture [4]. The phenomenon of water treeing is an anomaly that results from imperfections in the insulation: fracture lines appear and grow in the direction of the electric field, a phenomenon that worsens with the electric discharge [5].

A soft fault has generally a low amplitude signature on the reflectogram which depends not only on the variation of the characteristic impedance of the cable but also on its location and on the configuration of the test signal such as its bandwidth. Indeed, the increase of the maximum frequency of the test signal can improve the resolution of the soft defects signature. However, it increases, at the same time, the phenomena of attenuation and dispersion of the test signal, thus making the detection of these faults less reliable, and especially in the case of long cables like power distribution cables.

Soft faults need additional post-processing algorithm to be detected and characterized [6] [7] [8].

For branched networks, using a single sensor could not ensure the coverage of the entire network. This may be explained by the attenuation phenomenon due to the traveled distance and multiple junctions encountered. In addition, the multitude of branches in the network causes a fault location ambiguity. Distributed diagnostics where several reflectometers are placed at different ends of the network is required [9].

The objective of this collaborative work is to develop a connected sensor, based on MCTDR technology, able to be safely connected to MV and HV networks to ensure their monitoring. The project has several phases:

- The integration of the MCTDR technology for tests and multi-sensor trials;
- The validation and deployment of these sensors on electrical distribution networks to access the signature of each part of cables and offer monitoring of the health of these cables in order to anticipate failure;
- A parallel study on the signature of soft faults on XLPE cables with lab measurements and electromagnetic modeling.

The know-how for medium voltage coupler technologies makes it possible to connect MCTDR sensors to the live network.

The second part of this paper introduces power cables diagnosis and explains the advantages of using the MCTDR method. Third Section describes the test bench, results of laboratory measurements and electromagnetic modeling. Live monitoring is presented in the last section.

THE DIAGNOSIS METHOD

Reflectometry

Unlike reflectometry based method, other methods described in the literature are either destructive or they do not locate all type of fault in the cable accurately: Tan-Delta measurement and Partial Discharge method.

Reflectometry methods are used for cables diagnosis, it