An alternative approach about fault location on HVAC and HVDC cables during commissioning and operation

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ABSTRACT

This paper discusses with an alternative method for monitoring of long and very long HVAC and HVDC cable systems concerning the detection and localization of fatal breakdown errors during routine and commissioning tests as well as under service conditions. The principle based on the Time Domain Reflectometry (TDR) is compared with the classic method of TDR fault location.

The basic concept is described and explained with theoretical and experimental results. Whereas the theoretical considerations are made by a detailed simulation of the measuring network including HV cable. The practical experiments were performed on MV and HV cable samples under both AC and DC stresses.

The presented technology is implementable for land and submarine cables. Special attention is paid to the measurement technique and to the applicable evaluation by software algorithm. The proposed online fault location requires well-adapted measurement hardware, which keeps its performance under testing and service conditions even when a powerful breakdown occurs. The hardware mainly consists of a HV divider and a transient recorder. The operation of the measuring system should be completely invisible and long-term reliable until the cable system fails. Therefore the same HV measuring device is used as it is installed for the HV measurement during cable tests or under service of the cable system. For the latter case the measuring system could also be used for other quality and diagnostic measurements.

KEYWORDS

Cable testing, breakdown localization, cable monitoring, time domain reflectometry, TDR, transient recorder, signal propagation

INTRODUCTION

In the last years the number of newly installed HV cable systems has been largely increased. This was necessary to fulfill the rising demands of the public power networks. On the one hand it is more and more difficult to find the space for new routes of overhead lines. On the other hand the technique of HVDC transmission systems becomes much more importance. Often such systems contain HV cables. An important example is the connection of offshore wind farms to onshore power grids, where the export cables are long HVAC or very long HVDC submarine cables. Most of these cables are not or only with expense and difficulties accessible after laying and commissioning (with exception of cables laid in cable tunnels). A simple visual check after a failure is impossible. The well-known fault location method TDR tends to their limits in such cases.

The aim is to provide an online tool and device for fast diagnostic and especially fault location in case of breakdown.

For testing such cables and cable systems in factory and on site a number of standards and recommendations should be considered (e.g. [1], [2], and [3]).

CONCEPT OF MEASURING METHOD

The here described TDR method differs from the known classic one. While the classic TDR is applied after the fault event, the new method continuously monitors the cable system and evaluates the signals generated by the breakdown itself. That means the measuring system must be connected and in operation during the complete test or the service life of the cable. Only in case of test with a separate HV source repeated measurements can be done. The applied testing voltage can be increased up to a certain voltage level to enforce the breakdown again.

A comparison of the two TDR measurement methods shows *Table 1*.

	Classical TDR	Online breakdown TDR
Application	**After** the fault event, offline	**During** the fault event, online
Artificial impulse application	**Yes** for reflection measurement	**No** Signals from the break down itself
Reflections from the far end or failure site	**Dependent** on the kind of fault	**None** complete breakdown at failure site
Cable length	**some 10 km** state of the art (more depends on fault type)	**> 100 km** expected length (to be verified)

Table 1: Comparison of fault location methods

An advantage of the online method is the absence of reflections from the far end. The breakdown causes a very low impedance at its location and the signals are reflected from here. A simplified circuit for online measurements is shown in *Fig. 1*.