TDR Fingerprint on long Land and Submarine Power Cables

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ABSTRACT

TDR (time domain reflectometry) has proven to be a very useful tool for preventive maintenance as well as for fault location. This paper points out the limitations of TDR techniques for very long cables, and illustrates how, with professional expertise, good results can be achieved even with very long cables, despite high pulse attenuation and dispersion and low pass effect.

The paper highlights for the first time how accurate TDR distance measurements can be attained on very long cables despite the non-linear pulse propagation speed. This is particularly important in regards to the precise fault location on extra-long cables.

KEYWORDS

Time Domain Reflectometry, TDR Fingerprint, cable fault location, HVDC power cable, HVDC Interconnector, pulse propagation speed, joint location, cable testing

INTRODUCTION

TDR fingerprints after installation are recommended by a number of CIGRE technical brochures and IEEE guides. [1-8]. TDR fingerprints are also used for preventive and periodic maintenance testing and used as a reference during fault location activities. The TDR method is explained in many technical papers [1,9-11].

A TDR transmits a steep electrical pulse which then travels along the cable and is reflected on any cable impedance change. The time it takes for the pulse to travel back and forth is measured and converted into a cable distance, based on the impulse propagation speed along the cable. Reflections from cable ends and joints, geometric changes, low resistance and short circuit faults, as well as conductor or shield break faults, are detected.

What is meant by "TDR fingerprint"? TDR Fingerprint is defined as the measurement of the wave propagation characteristic of the cable. TDR fingerprints are recommended after cable installation and for periodic monitoring of high and extra-high voltage cables, the technology indicates all impedance characteristics and impedance-based irregularities. It is used to measure the length of the cable and to determine the propagation factor V/2, where V is the impulse propagation speed along the cable. In particular, it is also used to identify and measure the distance of cable joints. The test is recommended to be carried out on all phases (or on all cable poles, in case of HVDC cables) and the records should be obtained at both ends of the cable. [1,2,7]. The TDR records are used as a basic fingerprint and can later be directly compared with other maintenance and fault location tests. The traces or signatures are recorded, and the relevant parameters are stored. TDR has proven to be a very useful tool for preventive maintenance as well as for fault location.

The usual lengths of distribution power cables range up to 2 km, cable lengths of 10 km and more are rare. However, much longer cables are often installed in the high-voltage grid, the longest lengths up to some/several hundred kmsbeing reached by High Voltage Direct Current (HVDC) cables, see below.

Accurate TDR fingerprints on long cables are essential for the emergency preparedness strategy. CIGRE technical brochures [1-7], IEEE guides [8] and various standards strongly recommend recording TDR reference curves among the commissioning tests of long cables.

Fig.1: TDR test lead connection at dizzy height

However, the physical limitations of TDR technology quickly become evident with longer cables. Pulse attenuation, dispersion and low pass effect are of particular concern with long cables, reducing measurement sensitivity and accuracy, as well as the ability of capturing extreme cable lengths with TDR.

On the other hand, decentralised generation of electrical