An Enhanced DORT Approach for Locating Multiple Soft-Faults in Complex Wire Networks

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The emergence of electrical employments geared the indispensable use of electrical cables which became the backbone structures that are widely utilized to distribute power and communication signals throughout nearly all modern systems. This increasing importance of wires made their reliable and safe operation a pivotal issue, especially that they are subject to unwanted modifications and breakdowns mainly distinguished as hard faults (open or short circuits) or soft faults, typically featured by minor alterations as insulation defects, that can lead to drastic consequences if not early rectified. It is worthy to note that our interest in soft faults shoved off from the studies that were conducted on cables and showed that 30% to 50% of detected wiring faults are considered to be soft faults which might be far dangerous than hard ones due to their detection difficulty.

The most widely used techniques are the reflectometry based methods whose aim is detect the presence of an impedance discontinuity by submitting a testing signal and monitoring the reflected one; they showed promising results when dealing with hard faults but failed when addressing to soft ones depicted by weak reflectivities. Moreover, these techniques started flopping with complex networks due to the appearance of junction related echoes that increased the complexity of analyzing the reflected signal.

Differential DORT, a method derived from the iterative Time Reversal (TR) process isolates and classifies different scattering centers without the need for iterations by utilizing the Time Reversal Operator given by $TRO = K^{*}K$ where K denotes the transfer matrix linking the injected signals to the received ones. The eigenspace structure of this TRO contains valuable information about the scattering centers in the medium where by propagating the corresponding eigenvector signals a focusing is obtained on the position of the desired scatterer. Recently, DORT was adopted from acoustics to guided wave propagation in transmission lines and succeeded in the single soft fault localization even with increased network complexity but showed an infeasibility in locating multiple faults. Besides, the standard DORT showed an inability of providing selective focusing on each of the faults separately within a network under test (NUT) where imaging the obtained results produced images containing the position of the two faults at the same time. In addition to that, infirmity aroused when dealing with weak soft faults, manifested by fault impedances starting from 5% and below of the characteristic impedance of the line, where results showed its failure of even detecting them. Moreover, complex NUTs turned to become an obstacle when dealing with multiple faults where ambiguity was obtained on the same soft faults' configurations when moving from a single cable to a single junction complex network with a significant deterioration when moving to double junction NUT. Within this context, our aim is to extend the application of the standard DORT to multiple fault localization which was crowned by an enhanced DORT version (EDORT) adopting the main principles followed by the standard DORT but with a complementary process. This process starts by locating the strongest fault present in a multiple faulty NUT by applying the standard DORT technique followed by the generation of a similar network as the tested one but with a arbitrarily chosen fault on the position of the detected fault. Consequently, the TRO of the new NUT will be computed whose eigenspace structure with that of the initial multiple faulty system will be used to generate focusing signals of the second strongest fault in the NUT. As a result, the same procedure is followed until all faults in a configuration are detected. The new EDORT technique showed a great eligibility and efficiency in locating multiple faults within different complexity NUTs and was able to overcome the constraints faced by the standard technique where experimental setups and measurements applied validated experimentally the new approach.