

# Time Reversal Applied to Fault Location: A Summary of Experimental Validations

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**Abstract**— Time reversal has been recently applied to the problem of fault location in power networks. In this paper we report on three experiments aimed at validating the use of time reversal to locate faults in power networks.

**Keywords**—time reversal; fault location; inhomogeneous medium; distribution network; transmission network;

## I. INTRODUCTION

Recently, Electromagnetic Time Reversal (EMTR) has been successfully applied to the problem of fault location in power grids [1].

The efficiency of the EMTR method to locate faults in power networks has been assessed through extensive numerical simulations [1] and also through experimental measurements obtained using reduced-scale laboratory experiments and full-scale distribution networks.

In this paper, we will present a summary of three experiments aiming at validating EMTR and assessing its performance as a means to locate faults in power networks.

## II. EXPERIMENTS AND RESULTS

### A. Reduced-Scale Experiment [2]

A reduced-scale experimental test was carried out in the EPFL laboratories using a network formed by standard RG-58 and RG-59 coaxial cables. The faults were generated at an arbitrary point of the cable network using a high-speed MOSFET. The fault-originated transients were measured by means of a 12-bit oscilloscope. The time-reversed transient waveforms were generated by using a 16-bit arbitrary waveform generator operating at the same sampling frequency adopted to record the fault-originated waveforms. For the reversed-time, the current at each guessed fault location as measured by using a current probe.

### B. Full-Scale Unenergized Distribution Line [3]

In November 2016, a field experiment was performed on an unenergized three-phase distribution line in Shanxi Province, China. The transmission-line system considered in the field experiment was a 677-m long, 10-kV double-circuit overhead power distribution line. To emulate a disturbance injection, a voltage pulse generator was

connected between one of the phases of the overhead line and the ground at a tower located 68 m away from the origin of the line. The disturbance-originated transients were recorded at the left line end by means of broadband current monitors. The measured transients were time reversed and back injected numerically into an EMTP-RV simulation model of the studied system.

### C. Full-Scale Distribution Network

In Summer 2017, a pilot test was performed on a distribution network operated by Groupe E electrical utilities in Western Switzerland. The tested network is a primary distribution feeder connecting two distribution substations located at Cressier and Kerzers, Switzerland. The network consists of an 11.9-km long double-circuit lines operating at 18/60 kV and multiple 18-kV three-phase laterals branching from the main feeder. The branched lines are either overhead lines, underground cables, or mixed, with lengths ranging from tens of meters to a few kilometers. The fault-originated electromagnetic transients were recorded in one substation using broadband voltage sensors. A 24-kV ABB<sup>TM</sup> medium voltage switchgear was used to initiate a phase-to-ground short-circuit at an arbitrary location along one of the laterals.

### D. Results

In all three experiments, the fault locations were found with excellent accuracy using the EMTR method.

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