# Time Reversal Focusing Property in Mismatched Media

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***Abstract*—**In this paper we report on an experiment in which we show that the focusing property of time reversal holds when the scattering medium in the time-reversed phase deviates moderately from the medium in the direct-time phase.

Keywords-time reversal; focusing electromagnetic fields; mismatched media;

## I. INTRODUCTION

Time reversal has been proven to be a powerful technique to focus electromagnetic waves in complex and heterogeneous media (e.g., [1]). The focusing process using TR consists of two steps: (i) a diverging signal originated by a source (and distorted by propagation in an inhomogeneous medium) is captured by receivers, and (ii) the captured time-domain signals are time-reversed and synchronously back-injected through the same medium. As a result, the back-propagated signals are refocused to the initial source point.

Note that in typical applications of TR, the back-propagation medium should be strictly identical to the direct time medium. However, this may not be the case in some applications such as medical care or aerial communication, where changes in the medium are inevitable. Also, when locating faults in power networks, since the location of the transverse branch representing the fault is unknown, multiple simulation runs are needed to locate the fault. Consequently, recent research work has been devoted to examine the TR refocusing property when there is a mismatch between the media considered in steps (i) and (ii) described above. Liu et al. [2] designed an experimental setup consisting of a number of movable dielectric rods and used it to experimentally study the focusing property of electromagnetic time reversal (EMTR) in a highly scattering environment and, in particular, when the medium changes in the forward and backward phases. The refocusing quality was examined in controlled mismatched media by precisely shifting the dielectric rod setup in the backward phase.

In this paper, we report on an experiment inspired by the work of Liu et al. [2] carried out in the EMC Laboratory of the Amir Kabir University of Technology to study the EMTR focusing property in a scattering medium in which moderate lumped changes are applied in the time-reversed phase.

## II. EXPERIMENT AND RESULTS

Two double-ridged horn antennas separated by a distance of 30 cm were used as emitting and receiving antennas. Twenty plexiglass dielectric rods (1-m long and 1-cm in diameter) were placed between the two antennas and they were fixed at their two extremities to two pieces of expanded polystyrene. The distance between every two adjacent rods was 6.5 cm. The antennas produce vertically-polarized electric fields. The measurements were obtained in the frequency domain (7-18 GHz) using a vector network analyzer (Rohde & Schwartz – ZVK).

Unlike previous studies, the type of mismatch we considered in this study corresponds to lumped changes. Namely, we assessed the TR focusing property when one or two of the rods were removed from the medium in the backward stage. For each considered configuration (matched and mismatched media), we measured the transfer functions using the VNA. The focusing property of the TR method was then evaluated using as an input a Gaussian pulse with a carrier frequency of 12.5 GHz.

It was found that, despite the mismatch between the direct-time and reverse-time phases, the method is able to focus the field back to its source.

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