Nonlinear Time Reversal in a Semi-Reverberant Complex Enclosure

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Abstract— Here we present nonlinear time reversal (NLTR) applied in a complex, semi-reverberant enclosure containing a passive nonlinear circuit. NLTR utilizes the nonlinear response generated at the nonlinear circuit due to an incident pulse. When this nonlinear response is extracted from the overall response, time-reversed and retransmitted into the enclosure, the signal will focus at the location of the nonlinear circuit. This technique provides a way to efficiently deliver short electromagnetic pulses at electronic devices without any prior measurement or knowledge about the environment.

Keywords – time reversal; nonlinear dynamics; HPEM; multipath; harmonic generation

I. Introduction

Time reversal (TR) techniques have shown to be effective in focusing short pulses in rich scattering, multipath environments [1]. In order to apply TR in such environments, the impulse (short pulse) response (IR) between the source antenna(s) and a target location is needed. When the IR is time-reversed and retransmitted into the environment, the waves experience the same multipath while the signal contains a reversed delay profile. This essentially "undoes" the multipath delays, coherently adding the pulses from the multipath components at the target to form a short pulse resembling the original impulse. Such temporal compression and spatial focusing may enable efficient delivery of high power RF pulses to a specific target location within a complex enclosure.

However, in many real-world applications we wish to focus a pulse at a location from which it is impractical or impossible to send an initial impulse. A recent demonstration has shown that an RF pulse can be focused at a target containing nonlinear circuit (i.e. electronic device) without actually sending an impulse from it [2]. That is, the nonlinear excitation due to an incident short pulse sent from a distance can be used as an initial "impulse". This technique, hereafter referred to as nonlinear time reversal (NLTR), therefore could be an efficient way to obtain the IR needed for TR focusing.

In this presentation, we apply NLTR in a semi-reverberant enclosure with open apertures containing a passive discrete nonlinear circuit. Unlike the previous demonstration, which consisted of a closed reverberant enclosure [2], the apparatus used in this experiment better represents a real-life structure. Furthermore, we evaluate the utility of this approach by comparing the peak power levels of the signal at the target location using NLTR waveforms vs. normal RF pulses.

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II. NLTR Experiment

In our experiment, a passive harmonic generator was used as a discrete nonlinear circuit inside an enclosure. The NLTR procedure is illustrated in Fig.1. Various RF frequencies were used to represent different electrical sizes of the enclosure.

We compare the peak power levels of the signals at the target location resulting from NLTR waveforms and normal RF pulses (i.e. short and long pulses). An example is shown in Fig. 2. The NLTR waveforms in general increases the peak power on the target indicating that this approach can be used to more efficiently deliver short pulses to a nonlinear target.

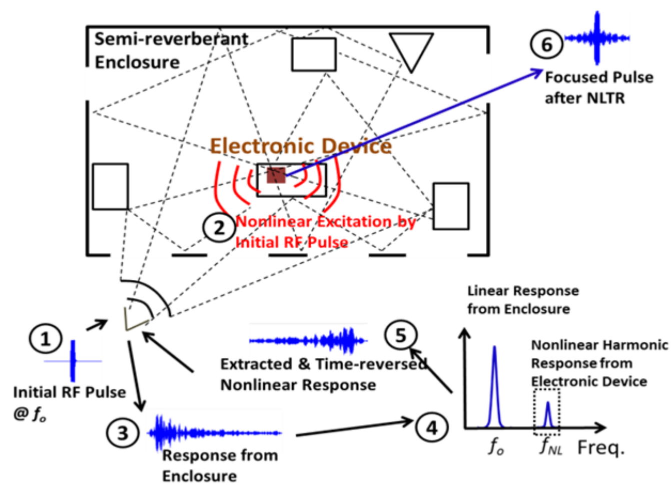

Fig. 1. NLTR experiment procedure

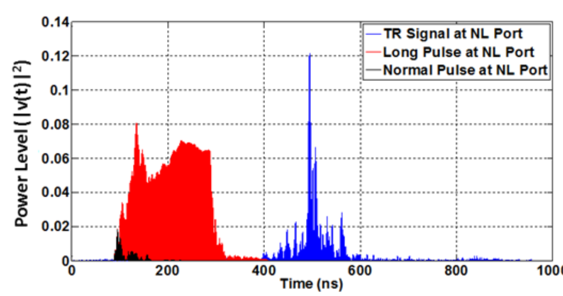

Fig. 2 Signal delivered at target location using NLTR waveform (blue), long CW-like RF pulse (red), and short RF pulse (black)

References

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