Microwave-range Imagery with an Ultrawideband Time Reversal-based RADAR

Lucio Bellomo #1, Sébastien Pioch #2, Marc Saillard #3

LSEET, UMR CNRS 6017

Université du Sud Toulon-Var, Bâtiment F, BP 20132, 83957 La Garde Cedex, France

1−3 {lucio.bellomo,marc.saillard,sebastien.pioch}@lseet.univ-tln.fr

Abstract— **This work presents a new RADAR prototype built for the purpose of imaging targets located in a cluttered environment. The system is capable of performing Phase Conjugation experiments in the ultrawideband [2-4] GHz. In addition, applying the D.O.R.T. method to the inter-element matrix allows us to selectively focus onto targets, hence reducing the clutter contribution. The system has been validated by phsyically backpropagating the focusing wave into the medium all over the frequency band and observing the expected focusing properties.**

I. INTRODUCTION

The concept of Time Reversal Mirror [1] has generated numerous studies in both Acoustics and Electromagnetism in the last decade. Many are the potential applications in non-destructive control, medical imaging, sub-marine acoustics, telecommunications and RADAR. The capacity of these mirrors to focus onto an object is very useful for imaging in random media as it permits to improve the signal-to-clutter ratio and to increase the robustness of the imaging algorithms. In [2] such properties have been demonstrated with synthetic data by including the response to the focusing wave in the solution of the non-linear inverse scattering problem. Our aim here is to build a prototype that allows us to get the data required by this inversion algorithm and to evaluate its performances.

In Electromagnetism, only a few experiments of Time Reversal (TR) have been performed. A first set [3] has been achieved directly in the time domain with a Digital Oscilloscope and an Arbitrary Waveform Generator (AWG). In a second kind of experiment [4], [5], the system works in the frequency domain with a Vector Network Analyzer (VNA). In the first approach the experimental backpropagation of the focusing wave is more easily performed thanks to the AWG, whereas in the second one the re-transmission is only done numerically and one ought to rather talk about Phase Conjugation over a given bandwidth and pulse synthesis. Yet the available bandwidths are smaller in the former case despite the recent progress of commercial AWG's.

Our prototype merges the advantages of both described solutions. It is made of a linear 8-antenna array, working in the frequency domain and capable of experimentally re-transmit the complex conjugate of the received signal within a bandwidth of 2 GHz at S-band. It also allows us to apply the D.O.R.T. (french acronym for Décomposition de l'Opérateur de Retournement Temporel) method [6], which is of particular interest to focus selectively onto a target. In case of multiple targets, it is in fact more powerful than Time Reversal, which has to be iterated and which restricts focusing to the brightest target.

We present here the prototype and the first experimental results conducted to validate it. They consist of an UWB Phase Conjugation experiment, equivalent after IFFT to Time Reversal, where an additional antenna is the source onto which we want to focalize the time-reversed wave, and of a D.O.R.T. experiment where a passive target is detected and illuminated. These results encourage us to explore the possiblity of using these methods for quantitave imaging of targets in cluttered configurations.

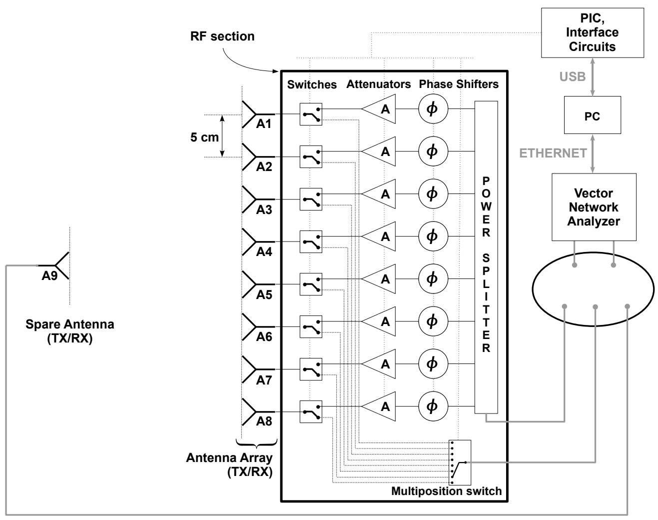

Fig. 1. Prototype architecture.

II. RADAR DESCRIPTION

The architecture of our RADAR (Fig. 1) is built around a 2-port VNA serving both as signal source and receiver. The RF front-end is made of a linear array of 8 UWB antennas (A1-A8) plus one more spare antenna (A9), working in a multistatic configuration. Antennas are antipodal symmetric Exponentially Tapered Slot Antennas (ETSA) [7]; they show a very good input impedance matching (SWR<2) in the [2-18] GHz frequency band and radiate a vertically-polarized (direction perpendicular to the plane of Fig. 1) electric field.