A Near-Field Focused Phased-Array Antenna Design Using the Time-Reversal Concept for Weed Control Purpose

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***Abstract*—Near-field focus (NFF) antennas have been recently used in several applications for different purposes. In this work, the time-reversal (TR) concept is used to shape the phase distribution of the phased array elements for the NFF of the electromagnetic field strength. It is shown that the TR concept is equivalent to the known ray optic method for the NFF. A slotted waveguide phased array antenna operating at 5.8 GHz is designed to provide the maximum electric field strength at the near-field region of the phased array. It is shown that the application of the full-wave simulation allows for an antenna design that provide high strength of the electromagnetic field and sufficient steerability even at near-field conditions close to the phased array antenna.**

***Index Terms*—Phased-array antenna, near-field range, Slotted waveguide antenna, time-reversal**

I. Introduction

In farming production, weeds compete with crops for sunlight, space, nutrients, water, and CO_2 and can significantly impact crop products worldwide. Dense weed growth can make harvesting very difficult and reduce it significantly. Even though an estimated 3 billion kg of pesticides is currently applied worldwide, it is estimated that 37 % of global crop production is still lost. 13 % of this is due to insects, 12% to plant pathogens, and 12 % to weeds [1].

Controlling and demolition of the distribution of weeds in a crop field is vital to increase the production rate [2], [3]. Weed control by microwaves is an environmentally friendly method for replacing chemical or pesticide methods, which are no longer acceptable from an ecological point-of-view. One novel idea is to utilize a phased array antenna to concentrate the electromagnetic (EM) power at the area of the weed. In this regard, it's desired i) to achieve a high power density at the desired area and ii) to allow the focus of the microwave beam to be quickly and specifically targeted on the previously identified weed's location.

Delivering the maximum possible EM power at the expected area of the weed demands a near-field focused (NFF) phased array antenna. NFF antennas have been employed in various areas like industrial microwave applications, wireless power transfer, RFID applications, etc. The idea of the NFF is to contribute the phases of the array's elements in such a way as to have a focal point in the phased array's near-field region. To determine the phase distribution of the phased array antennas' elements for the NFF, a ray optic concept is proposed that correctly considers the phase difference between the far-field (FF) region and the near-field (NF) region. The idea comes from the point that in the NF region, the distance between two adjacent elements significantly affects the phase value and should be correctly considered. The details of the method are described in [4].

In this work, we use a time reversal (TR) concept to obtain the correct phase distribution of each element of the designed phased array antenna while performing in free space. The employed concept can be extended when an air-soil interface is located near a phased array antenna while the ray optic concept cannot. in Section II, the concept of the TR is addressed. Section III discusses the antenna design and configuration. Finally, the simulation results and discussion is provided in Section IV and Section V, respectively.

II. Near-Field Focused Theory

As mentioned earlier, despite the far filed region of an antenna, the phase difference in the near-field antenna cannot

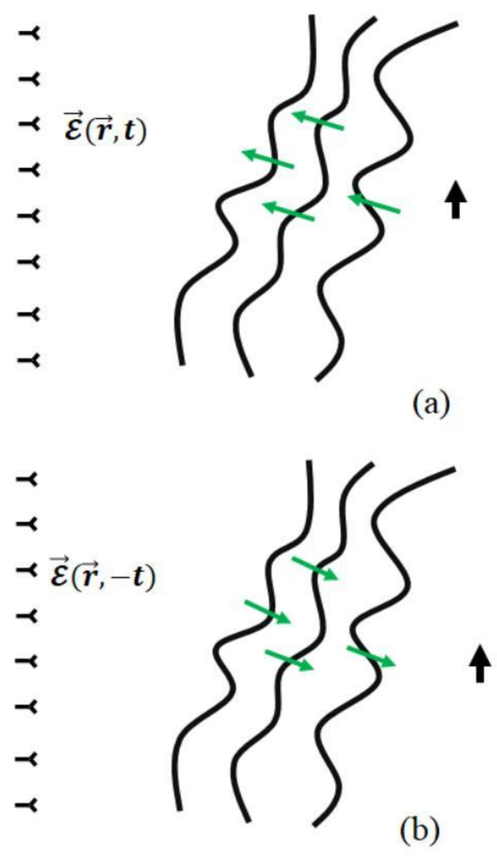

Fig. 1. (a) Radiation of EM fields using an infinitesimal dipole antenna, (b) Radiation of the time-reversed EM fields.