Study of Different Configurations of Tapered-Slot Antenna Arrays for Detecting Buried Objects

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***Abstract*— In this paper, results of comparative study of several designs of tapered-slot antennas for subsurface applications are presented. To this end, influence of mutual arrangement of the antennas in bi-static configuration and placed in the antenna arrays has been studied using both simulations and experiments. Major attention is paid to the behaviour of the transmitting-receiving antenna pair near the ground surface. It was found that displacement of the antennas in the array by about a half of the antenna opening suppresses unwanted lateral coupling while the resistive loading strengthens the field radiated by the antenna into the medium. Antennas with the displacement of about 0.5 of the width of the opening exhibit weak coupling that can be fairly well subtracted. The tapered-slot antenna arrays had been fabricated and tested in a test site for the detection of low-contrasted objects like anti-personnel mines.**

I. Introduction

An ultra-wideband antenna normally operates at frequencies where the antenna length is close or larger of the wavelength λ and size of the antenna opening is near to λ/2. In the ground penetrating radar (GPR) applications, the antenna system design is a result of trade-off between sizes of typical subsurface objects, the lowest operating frequency governing penetration depth, gain of the antenna etc. That is why small wideband antennas are desirable for the detection of small buried objects. The tapered-slot antennas (TSA) belong to such class of antennas. They suit well also for the design of compact antenna arrays [1].

In this paper, we continue study of TSA with elliptical flare rate developed and fabricated earlier by authors [2]. Formerly, behaviour of a single antenna element from the viewpoint of internal unwanted reflections had been mostly studied. In the antennas in bi-static configuration and antenna arrays the radiated field is usually distorted due to the fact that single antenna elements cannot be considered as independent of each other. On the other hand, for detection of shallowly buried small targets the distance between the antennas should be as small as possible. That is why the knowledge of mutual coupling effects is important for the design of both separate elements and array geometry.

The coupling between array elements occurs due to three mechanisms, namely direct space coupling of the array elements, indirect coupling caused by nearby objects, and coupling through feed network such as open baluns. Some aspects of the impact of the antenna positions to each other and the location of antenna pairs in the array, we have already discussed in [3].

This work is devoted mostly to the study of the first mechanism by evaluation of the mutual influence of antennas placed in the proximity of the ground surface. To this end, three configurations of the transmitting and receiving antennas: without displacement of the antenna openings and shifted by $0.5L$ and $0.75L$, where L is the width of opening as shown in Fig. 1*a*-1*c*. Two antennas arrays designed with the antenna shift of $0.5L$ and $0.75L$ (Fig. 1*d*-*e*).

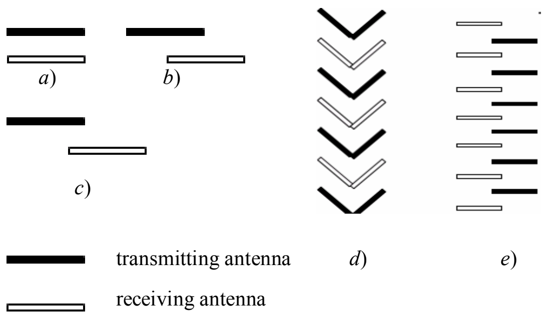

Fig. 1 Mutual arrangement of antennas in bi-static configuration: *a* – with zero shift; *b* – $0.5L$; *c* – $0.75L$; *d* – antenna array with the shift of $0.5L$; *e* – antenna array with the shift of $0.75L$

To estimate the influence of the antennas shift in the array, several models of the antenna pair in a bi-static configuration had been simulated using the CST Microwave Studio software.

II. Simulations

In the simulations, direct coupling of TSA in the bi-static configuration has been studied. TSA with the geometrical size of 230 to 120 mm using the FR-4 as a substrate have been placed in parallel at a fixed distance of 45 mm and shifted relatively by values of 0; $0.5L$; and $0.75L$ as shown in Fig. 1*a*-*c*. In Fig. 2, the electric field distribution in the form of the 2-D scalar plot of amplitude is shown for three antenna configurations, namely antennas in bi-static configuration