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Design and Analysis of Different Shapes for Unit-Cell Reflectarray Antenna

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Abstract

This paper presents an analysis and design of unit cell reflectarray antenna using different shapes of radiating elements: square patch, rectangular slot, triangular slot, square loop and Minkowski element are employed in separate unit-cell design operating in X -Band (8-12 GHz) at the center frequency of 10 GHz. In order to investigate the scattering characteristics of the unit cell studied, commercially available computer models of CST Microwave Studio is used, based on the method of finite integration technique, and using the approach of Floquet (Infinite periodic approach). The analyses of reflection coefficient and reflection phase curves for each resonant element are presented, and Figure of Merit has been defined for the comparison of reflection phase curves obtained by simulation. It has been demonstrated that among the resonant elements square loop acquires higher static phase range of 203°, and the maximum reflection loss of 7.11dB.

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Keywords: Reflectarray; Reflection phase; Phased array; Floquet approach; Figure of Merit.

1. Introduction

Reflectarray technology is a hybrid of conventional reflector and phased array technologies[1.2]. Constituent elements of the reflectarray antenna (RA) that are set into a regular lattice mimic the function of phased array radiating elements and the free space acts as the transmission medium between the elements and the signal source

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(feed). Adjustment of the geometrical features of constituent elements of RA is utilized to realize desired aperture field distribution [3]. Contrary to conventional microstrip phased arrays that employ printed transmission lines and henceforth suffer from excessive loss at higher frequencies [4], reflectarray use the free space medium to transmit the electrical signal from the feed to the elements and thus avoid degradation in the gain performance as a result of loss in the feeding system [5].

Advances in Wireless Technologies and Telecommunication require the deployment of low cost, light weight, high gain and easy to install microstrip antennas reflect arrays is largely diffused in many application fields, such as remote sensing and satellite communications. With the new emerging technologies, advanced features are required in terms of broadband, dual polarization, and beam-scanning operations [6.7]. This antenna suffers from one major shortcoming, its limited bandwidth. Two factors control reflectarray bandwidth; resonant element and path from the feed phase center to each element, and several methods exist for BW improvement, the simplest uses of Variable Substrate thicknesses [8].

This paper is devoted to design of different shapes of unit cell reflectarray in X-Band (8 GHz-10GHz) thus all results of reflection loss and reflection phase are reported using CST Microwave Studio.

Nomenclature

RA	Reflectarray antenna
B W	Bandwidth
FoM	Figure of Merit
FEM	Finite Element Method

1.1. Principle of reflectarray

A printed reflectarray consists of a planar array of printed radiating elements that incorporates a certain phase shift to produce a collimated or a shaped beam when it is illuminated by a feed Fig.1. The operating principle can be explained by considering the reflect array in transmitting mode with a horn antenna located in a centered or offset position, and assuming that the reflect array elements are in the far field region of the horn. In this case, the electromagnetic field incident on each reflectarray element at a certain angle can be locally considered as a plane wave with a phase proportional to the distance from the phase center of the feed horn to each element, as corresponds to spherical wave propagation. In order to convert the spherical wave radiated by the horn into a focused beam, the field must be reflected from each element with an appropriate phase shift. This phase shift is adjusted independently for each element to produce a progressive phase distribution of the reflected field on the planar surface that generates a pencil beam in a given direction.

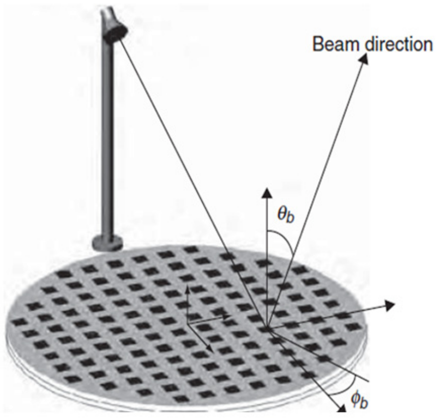

Fig. 1. Typical geometry of a printed reflectarray antenna.