Mutual Coupling of Rectangular DRA in a Four Element Circular Array

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Abstract— Mutual coupling of DRAs in a four element circular array is investigated. For several values of the array radius mutual coupling and return loss are computed and illustrated. The FDTD method with a UPML boundary condition is used for simulation.

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1. INTRODUCTION

Specific features of DRAs has made them suitable for a variety of applications specially MMW applications. DRAs have small size and low cost. They can be easily coupled to almost all types of transmission lines [1]. They can be integrated easily with MMIC circuits. In MMW applications conductor loss of metallic antennas become severe and the antenna efficiency decreases significantly, conversely the only loss for a DRA is that due to the imperfect material of the DRA which can be very small in practice [2]. Therefore DRAs have high radiation efficiency. In comparison to microstrip antennas, DRAs have wider impedance bandwidths. For a typical DRA with dielectric constant of 10 the impedance bandwidth of 10% can be achieved. Avoidance of surface waves is another attractive advantage of DRAs over microstrip antennas.

Single DRAs of different shapes has been studied, including rectangular, cylindrical, hemispherical, triangular, conical, etc. Among these different shapes cylindrical and rectangular are the most common and the rectangular has the advantage of having one more degree of freedom for design purposes.

There are a variety of feed configurations, which electromagnetic fields can be coupled to DRAs. Most common feed arrangements are microstrip aperture coupling, direct microstrip coupling, probe coupling and conformal strip coupling. Among these feed configurations, aperture coupling is more suitable for MMW applications. In aperture coupling configuration, since the DRA is placed on the ground plane of the microstrip feed, parasitic radiation from the microstrip line is avoided. Isolation of the feed network from the radiating element is another advantage of the aperture coupling method.

In many cases with a single element DRA, desired specifications can not be achieved. For example a high gain, directional pattern can not be synthesized with a single DRA of any shape. In these applications, a DRA array with appropriate element arrangement and feed configurations, can be used to provide desired specifications. In DRA arrays proximity of elements produces mutual coupling. Usually this mutual coupling is considered as an undesired phenomenon because it can alter the array characteristics. However with an exact knowledge of mutual coupling between different elements of an array, this undesired phenomenon may be optimally used to provide specific desired characteristics.

In this paper mutual coupling of different elements of a four element circular array of DRAs and its influence on return loss is computed and illustrated. For simulation, the FDTD method with a UPML boundary condition is applied.

Section 2 provides a brief introduction to the FDTD method including source modeling and the frequency domain parameter definitions. In Section 3 the single DRA dimensions and the simulated response with the FDTD is presented. Section 4 is main contribution of this paper. In this section mutual coupling between different elements of a four element circular array is investigated and simulated with the FDTD method. Section 5 concludes the work.