15th International Conference on
AEROSPACE SCIENCES & AVIATION TECHNOLOGY,
ASAT - 15 – May 28 - 30, 2013, Email: asat@mtc.edu.eg ,
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A Transceiver Array Antenna with Maximum Isolation using Defected Ground Structures

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Abstract: In this paper, a defected ground structure is employed in a transceiver array antenna to reduce coupling between the two antennas. The two arrays for transmitting antenna and receiving antennas are implemented on the same substrate with close separation. The coupling reduction principles for each transceiver MIMO antenna are explained. The MIMO antenna performance was examined using electromagnetic full wave. Results confirm that both coupling reduction reached better than15 dB with very close spacing; 2 mm spacing which is less than 0.05 λ0.

Introduction

High gain and compact antennas are needed for many communication and wireless applications. A good candidate for this purpose is to use MIMO antennas. Also, the need for high data transfer with small size has encourages the research for the use of the use of multiple input multiple output (MIMO) systems. The major problem that both of MIMO antennas suffer from is the mutual coupling. This problem arises between the elements of the same antenna and between the separate antennas in the MIMO antennas.

Several attempts have been conducted to reduce the mutual coupling effect between antenna elements in MIMO systems. Defected ground structures (DGSs) are implemented by etching slots of different shapes in the ground plane. This solution requires two layer fabrications which will increase the fabrication complexity and cost especially for close separation [1-7].

In this paper coupling reduction between a four elements MIMO antenna placed opposite to each other is accomplished. The proposed antenna is suggested as a wireless transceiver antenna. Mutual coupling reduction has been performed via the use of a DGS structures. The DGS structure was investigated individually for coupling reduction between two patch antennas oppose to each other The MIMO antenna performance and mutual coupling investigation has been checked using electromagnetic full wave analysis.

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Structure and Design Concept

The DGS structure can be implemented using different shapes in the ground plane for the sake of band stopping the surface wave between the TWO antennas.

The DGS structure is similar to a resonance LC network whose elements can be given as

$$C_p = \frac{5 f_c}{\pi\left(f_p^2 - f_c^2\right)}\,[pF] \quad (1)$$

$$L_p = \frac{250}{C_p\left(\pi f_p\right)^2}\,[nH] \quad (2)$$

where f_c is 3dB cut off frequency in GHz and f_p is the pole frequency. At the resonance, the DGS is a stopband and no field is excited the other side.

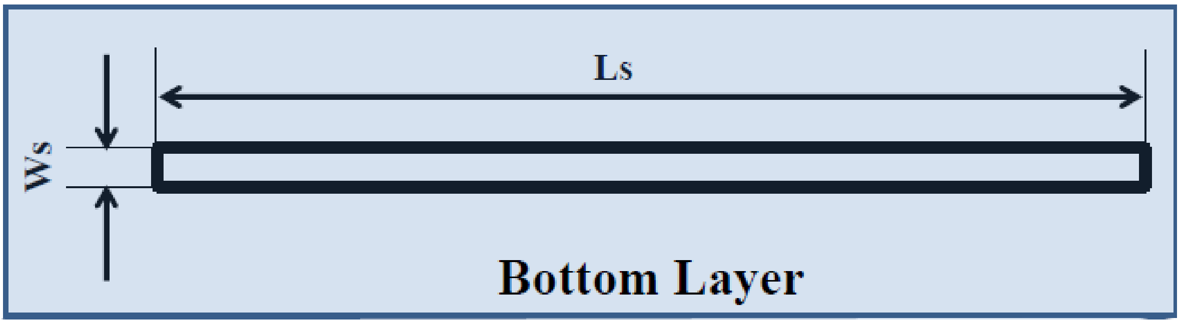

Figure (1) The configuration of the DGS structure in the ground layer

In our work, the employed DGS is a simple rectangular slot shown in Fig. 1. This was employed for the sake of compactness of the proposed transceiver antenna. The width (Ws) and length (Ls) of the DGS element was designed for adjusting the stop band at 5.8 GHz.

The structure of the four elements antenna employing the DGS structure is shown in Fig. 2. The separation between the two antennas is 2 mm, the DGS is inserted between the four elements in the ground plane. The desired four elements array was investigated. The antenna structure is shown in Fig. 2.

Results and Discussion

In this section we investigate the effect of the DGS of four element array antennas. The DGS was designed first on a single element MIMO antenna and then optimized using for the array antennas.

Also, the reflection coefficient at each antenna port was examined and also the mutual coupling between the two antennas. These results are shown in Fig. 3 and Fig. 4. From observing results in Fig. 3 and Fig. 4, we can conclude that the two antennas are operating at 5.8 GHz. This can be confirmed by reflection coefficient lower than -10 dB at the two cases. On the other hand, the mutual coupling has been reduced from almost -18 dB to almost -40 dB at the operating frequency 5.8 GHz. In other words, the coupling has been reduced by better than 20 dB.

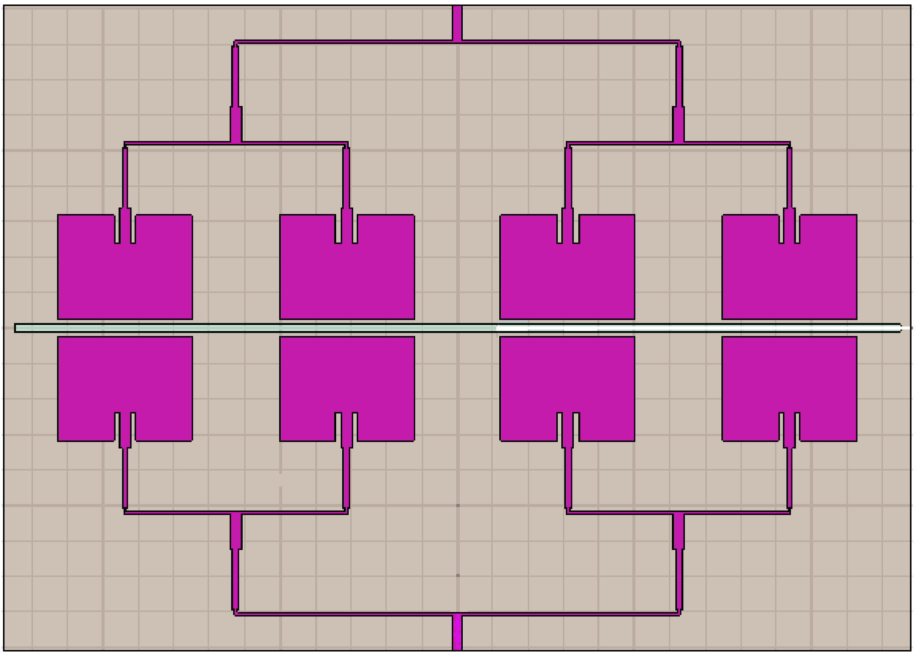

Figure (2) The four element array antenna employing a DGS in the bottom layer.

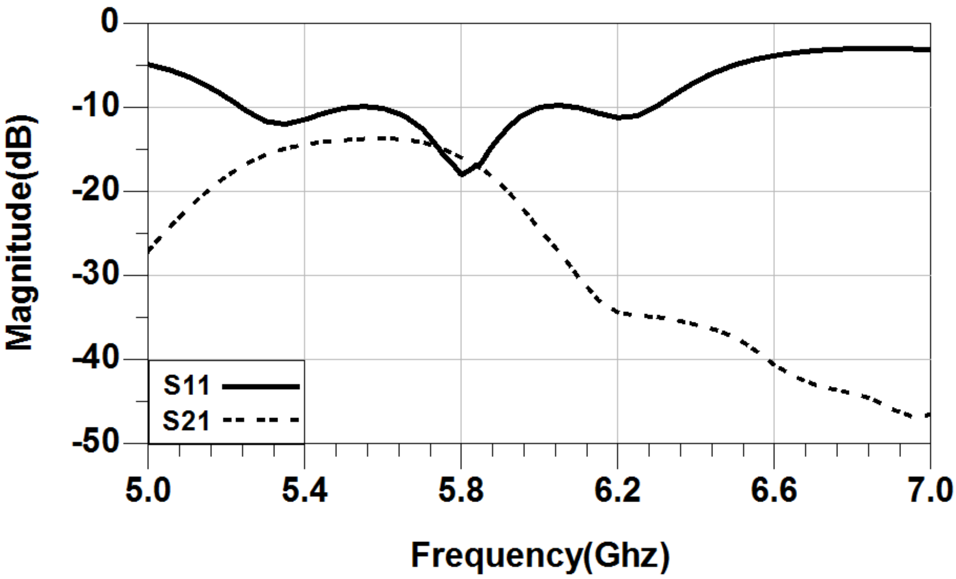

Figure (3) The scattering parameter magnitudes of the four elements array MIMO antenna without using a DGS

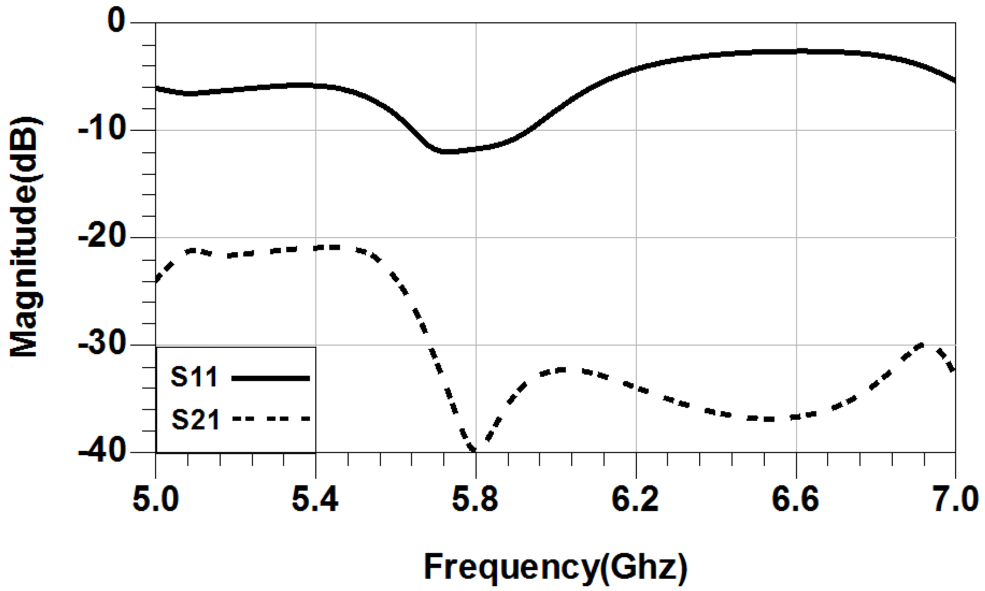

Figure (4) The scattering parameter magnitudes of the four elements array MIMO antenna using a DGS

For more confirmation about the coupling enhancements, the field profile on the whole substrate has been plotted in Fig. 5 and Fig. 6 for the two studied cases. The two figures illustrate the reduction of the field due to using the DGS structure.

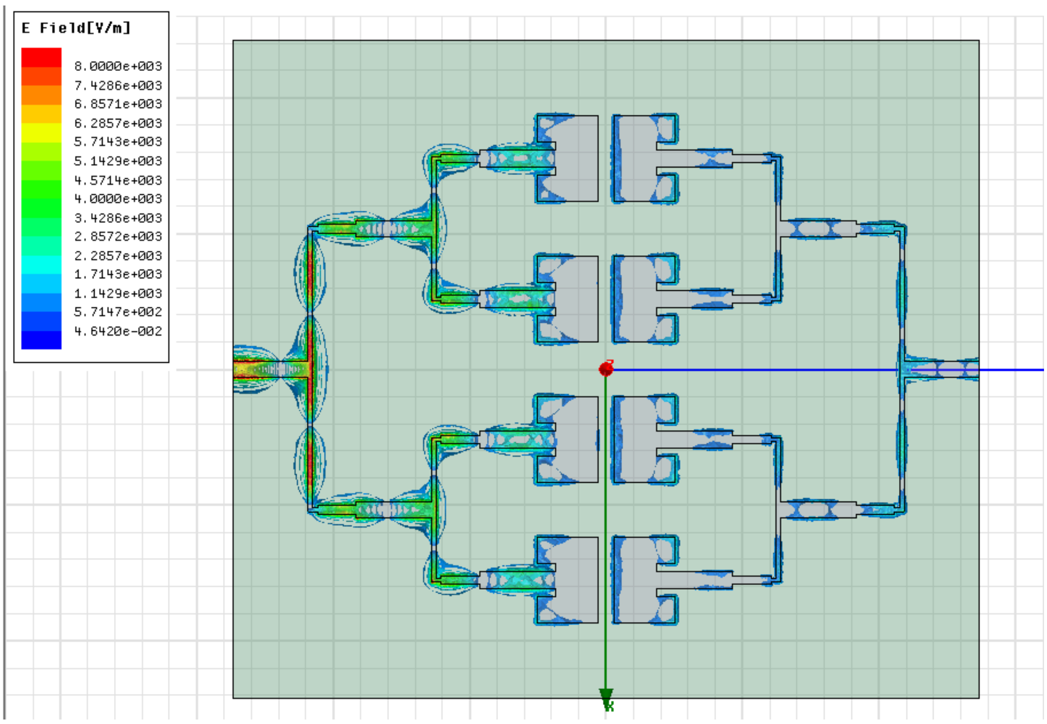

Figure (5) The field profile at the substrate top face in the case of without using DGS structure

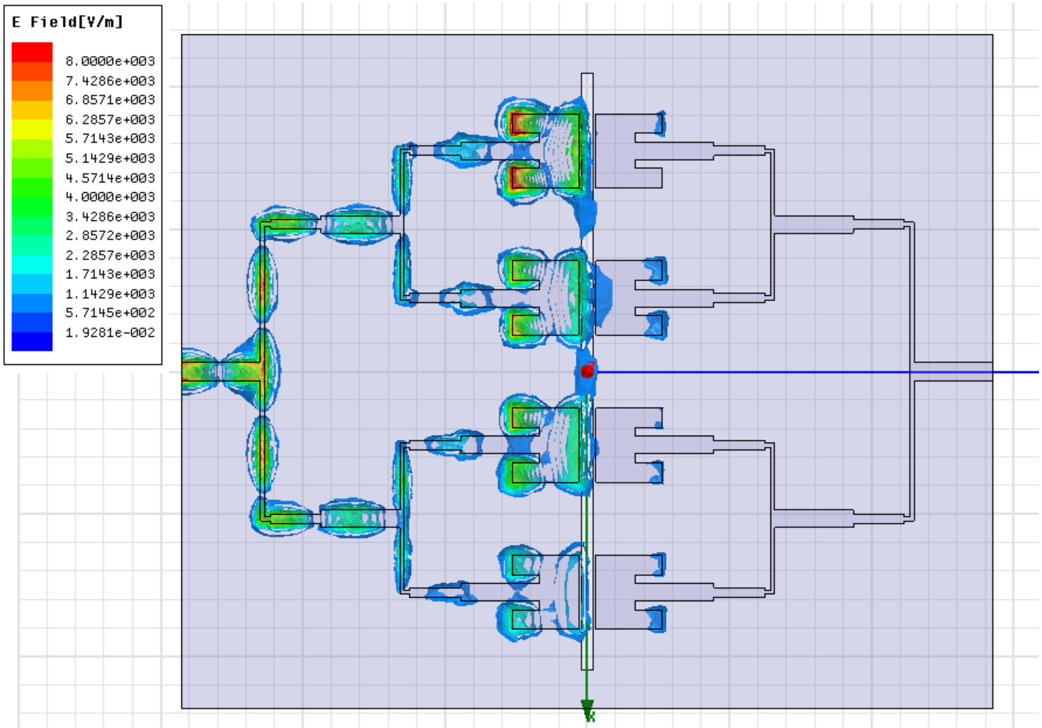

Figure (6) The field profile at the substrate top face in the case of with using DGS structure

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