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Hexagonal DRA with Complementary E-Shaped DGS for Mutual Coupling Reduction

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Abstract: A complementary E-shaped ground plane structure which can reduce mutual coupling between two hexagonal dielectric resonator antennas is proposed in this paper. The antennas are operating at resonant frequency 12.59 GHZ. Using ROGGERS substrate with Alumina (99.5%) lossy as DRA material, the proposed antenna is designed. The proposed design has improved its performance in parameters like bandwidth, VSWR and gain at resonant frequency and working frequency is in the range of 11-14 GHZ. It provides mutual coupling reduction up to 21.76 dB and return loss of -37.44 dB at a frequency of 12.59 GHZ. The proposed antenna is used in satellite communications and radar applications.

Keywords: Complementary E-shape; Defected ground structure; Mutual coupling; Dielectric resonator antenna; Voltage standing wave ratio; Band width

I. INTRODUCTION

The field of wireless communication has been undergoing a revolutionary change in the past decades. The main component required for wireless communication is antenna. In the last two decades, the investigation is carried on microstrip patch antenna and DRA. For enhancing the bandwidth and gain DRA is considered. DRA'S were first proposed in 1980's. DRA provides advantages of small size, light weight, low profile, high radiation efficiency and low cost. Though different shapes of DRA'S were investigated, but hexagonal DRA has high radiation efficiency and low return loss of greater than -30 dB [1,2].

MIMO antenna is used for improving the channel capacity. For MIMO system, DGS is one of the techniques to reduce mutual coupling between arrays of antennas. For an effective MIMO system mutual coupling between antennas should be low. DGS can be obtained by introducing a slot or defect on the ground plane. Thus the distribution of surface current depends on the shape and dimensions of the slot. It also controls the excitation and electromagnetic waves that propagate through the surface layer.

The bandwidth depends on the material permittivity. Higher permittivity results in size reduction and narrow bandwidth and lower permittivity broadens the bandwidth. DGS have been used in filters, coplanar wave guides, microwave amplifiers and suppressing the higher order harmonics.

This paper introduces a complementary E-shaped DGS for mutual coupling reductions and unwanted cross polarization. In this, the effects of DGS to the different DRA parameters are studied [3-5].

II. ANTENNA CONFIGURATION

The proposed design consists of array of antennas with hexagonal DRA and a complementary E-shaped defect etched on the ground plane. The antenna is excited with the side fed Micro strip feed.

The material and the dimensions are taken such that it operates in frequency 11-14 GHZ. The schematic diagram of proposed design is shown in Figure 1.

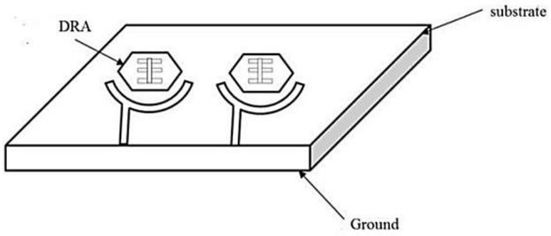

Figure 1: Schematic diagram of proposed design.

The dimensions proposed antenna as follows:

Design parametes	Dimensions	Materials used
Substrate	Ls×Ws×Hs 20×20×1.5 (mm^3)	Roggers RO3010 (lossy)
Ground	Lg×Wg×Hg 20×20×0.1 (mm^3)	Copper annealed
DRA (hexagonal)	Outer radius:10 Inner radius: 0	Alumina (99.5%) lossy
Feed (ring shaped)	Outer radius:13 Inner radius:11	Copper annealed
Side fed (microstrip line)	2×12×5 (mm^3) Lf×Wf×Hf	Copper

Alumina (Al2O3) 99.5% lossy with epsilon 9.9($\in_r$=9.9) and tan δ=0.0001 is used to design hexagonal DRA. ROGGERS RO3010 (lossy) with epsilon 10.2 ($\in_r$=10.2) and tan δ=0.0022 is used as substrate. Copper (annealed) is used for designing both ground plane and feed.

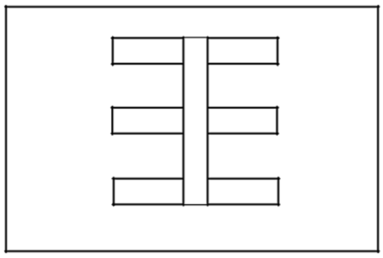

Figure 2: Schematic diagram of complementary E-shaped DGS.

DGS is used as a band pass filter and the resonant frequency for E-shaped DGS [6-8] (Figure 2) is given by equation (1):

$$f_r = \frac{V_o}{2Leff\sqrt{\in_{eff}}} \quad (1)$$

The resonant frequency of micro strip line is calculated by the following equation (2):

$$f_r = \frac{V_o}{2Leff}\sqrt{\frac{2}{\in_r sub+1}}$$

Return losses of -46.18 db. As the *coupling* between the two antennas is reduced and the antennas works more efficient as shown in Figure 3 [9,10].

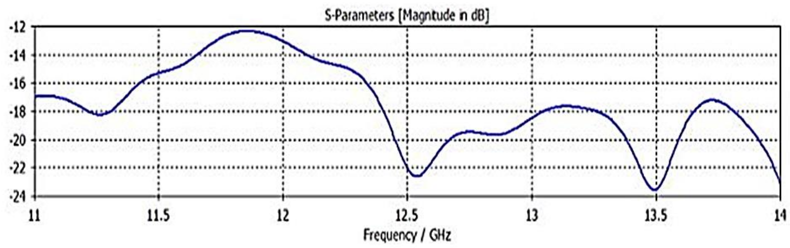

Figure 3: Mutual coupling plot (S_{12}).

Return losses of -46.18 db. As the coupling between the two antennas is reduced and the antennas works more efficient as shown in Figure 4.

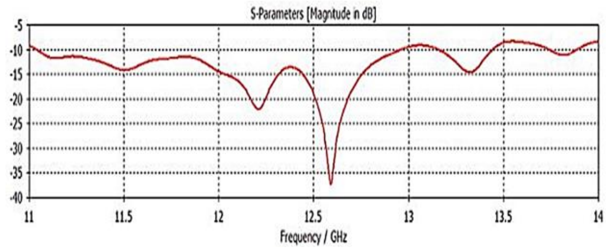

Figure 4: Return loss plot (S_{11}).

Thus the bandwidth is used for enhancing the gain. The bandwidth is calculated by using the formula:

$$\frac{f_h - f_l}{f_r} * 100$$

From the design the obtained Bandwidth will be 15.55%.

The voltage standing wave ratio (VSWR) is observed from result, shown in Figure 5.

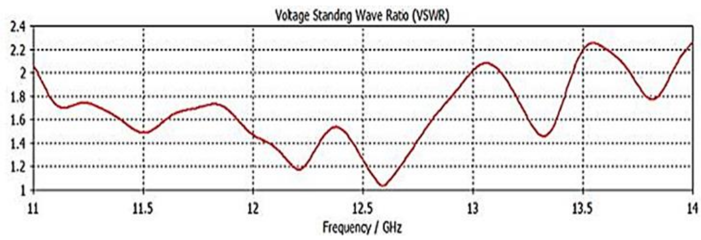

Figure 5: VSWR plot.

Antenna's Power gain is a key performance number which combines the antenna's directivity and electrical efficiency. The gain obtained is 9.99 as shown in the Figure 6.

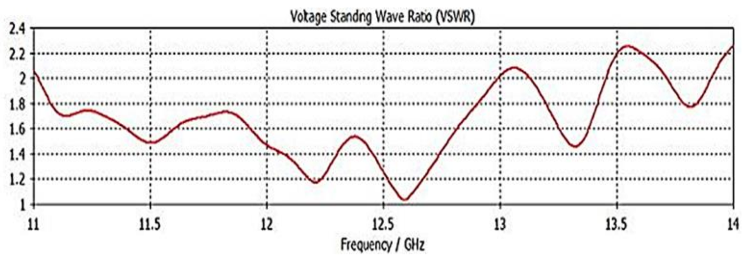

Figure 6: Gain plot.

A great way to improve wireless throughput is to move to a MIMO output. That means you have a radio capable of transmitting and receiving multiple data streams simultaneously. The Envelope correlation coefficient plot at resonant frequency is shown in Figure 7.

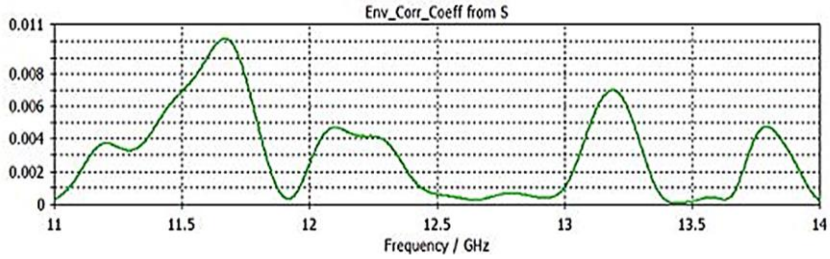

Figure 7: Envelope correlation coefficient plot.

III. CONCLUSION

Thus the mutual coupling reduction between two hexagonal DRA's is reduced by incorporating a complementary E-Shaped DGS etched on ground plane. Thus the obtained resonant frequency is used in satellite communication at Earth Station Antenna.

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