MUTUAL COUPLING REDUCTION IN MIMO WIRELESS COMMUNICATION SYSTEM USING S-SHAPED PERIODIC DGS

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Abstract : The designed antenna is placed on a material called FR-4(flame retardant) whose dielectric constant ε_r equals to 4.4 and the size of the substrate is 50mm×68mm. This antenna is simulated; a return loss of -15 dB and a gain of 8dB are obtained. The antenna can be used for Wireless Local Area Network application. The S-shaped DGS units are etched away from ground plane between microstrip antenna elements to reduce mutual coupling between antenna elements which operates at a frequency of 5.2GHz. Addition of slit wall in the ground plane that acts as an filter sandwiched between microstrip antenna elements to diminish mutual coupling. This method has achieved a mutual coupling reduction of -20 dB at resonant frequency.

***IndexTerms* - Periodic DGS, Microstrip patch, Mutual Coupling, Coaxial Feed.**

I. INTRODUCTION

In modern communications systems nowadays we use MIMO technology. The critical factor in multiple antenna systems is due to the presence of strong electromagnetic coupling between the antenna elements causing signal interference problem affecting the overall systems performance. One of the most significant issues to be considered in designing a MIMO system is reduction of mutual coupling between the radiating elements. The mutual coupling reduction in turn increases the overall system performance, by achieving an higher gain and improved efficiency.

The Periodic Defected Ground Structure (PDGS) is inserted between the two radiated elements to reduce the coupling due to the conduction current passing between these two elements. Another antenna design also used S-shaped slits at 2.57GHz\ resonating frequency where interference is high [2]. The other methods include Planar- Electromagnetic Band Gap (P-EBG) structures, Wave Guided Metamaterials (WG-MTM), Split Ring Resonators (SRR) and Slotted Meander Line Resonators (SMLR) are designed for WiMAX applications [3].

The proposed system of patch antenna is designed with coaxial feed. This feed method has low spurious radiation and is easy to fabricate. In another work there is dumb-bell shaped slits in the using closely packed PIFA and 17.43dB the mutual coupling reduction [1].

II.MICROSTRIP PATCH ANTENNA

A Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The patch is normally made of conducting material such as copper or gold and can take any likely outline. On the top of the dielectric substrate feed lines and the radiating patch are photo etched.

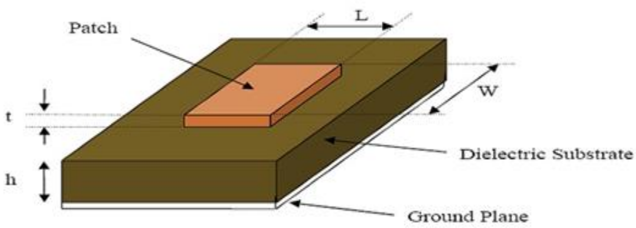


Fig 1 Microstrip Patch Antenna

The radiation in a Microstrip patch antennas is predominantly because of the fringing fields between the edge of the patch and ground plane. The performance of an antenna depends upon two prime factors – thickness of the dielectric substrate and lower value of dielectric constant. With the above two factors into consideration while designing the antenna we can able to accomplish good efficiency, larger bandwidth and better radiation. Nevertheless, the antenna is said to be larger in size with the above said configuration. To design a compact sized antenna, the dielectric constant of the substrate material must be of higher value that results in a narrower bandwidth and poor efficiency.

III.ANTENNA DESIGN

The antenna dimensions are calculated using the following formulas [4] [5].

1. The width of the microstrip patch antenna is given by

$$W = \frac{c}{2f_o\sqrt{\frac{\varepsilon_r+1}{2}}}$$

2. The effective dielectric constant is

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\frac{h}{w}\right]^{\frac{-1}{2}}$$

3. The length of extension of the patch is

$$\Delta l = 0.412h\left[\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)}\right.$$

4. The effective length of the patch is

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}}$$

5. The finite Length of the patch is given by

$$L = L_{eff} - 2\Delta l$$

6. The ground plane dimensions are

$$W_{g=}6h + W$$

$$L_{g=}6h + L$$

Some of the essential parameters for the purpose of antenna design are calculated. The proposed antenna uses FR-4 as substrate with dielectric constant of 4.4 with the thickness of 1mm. The width of the patch is 13.4mm and the length is 9.8mm. In similar way the ground plane has the dimensions of 68mm and 50mm as width and length respectively.

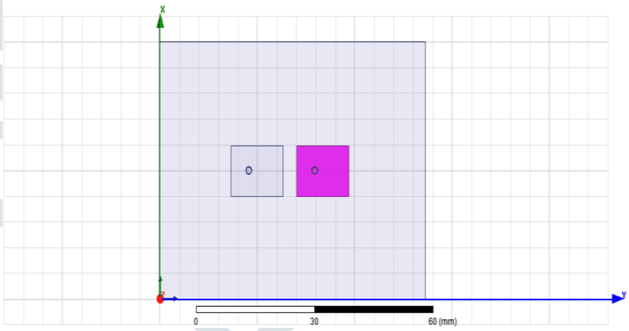


Fig 2 Antenna designed with coaxial feed

In this basic design S-shaped DGS units are etched from the ground plane to reducing the mutual coupling of the antenna. The Fig 3 shows the S-shaped slits in the ground plane view that are placed at a periodic interval as per the calculated values.

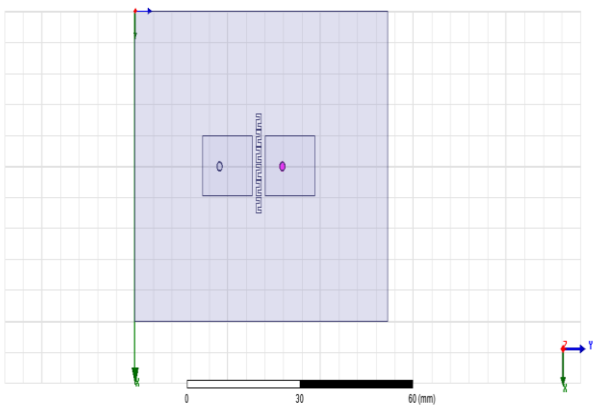
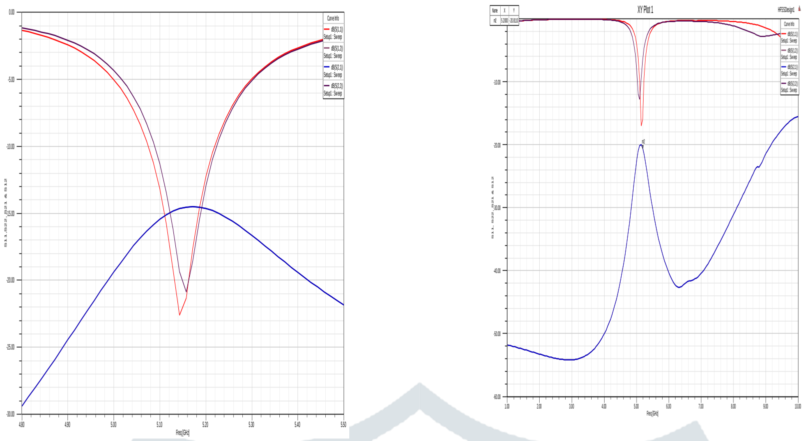


Fig 3 Ground Plane View with S-slits

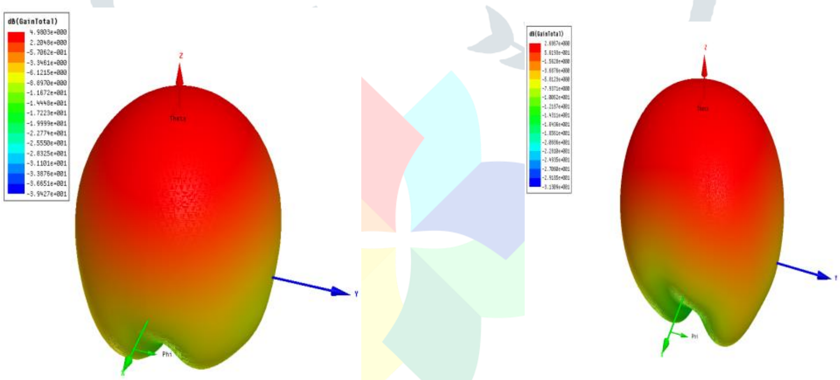
Ansys high frequency structure simulator (HFSS) is used to calculate mutual coupling reduction performance of PDGS. Return loss and mutual coupling of antenna elements with and without the S-Slit are shown in Fig 4. It is clearly shown that the working frequency of microstrip antenna is 5.2GHz.



(a) (b)

Fig 4 Comparison of S-parameters (a) Without S-Slit (b) With S-Slit

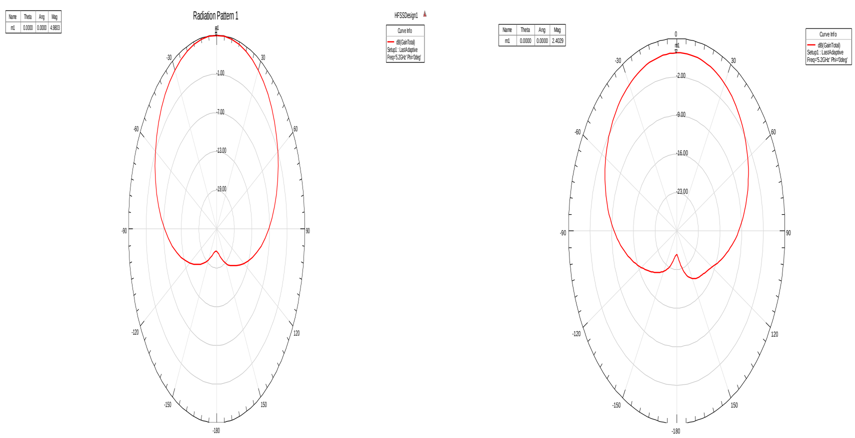
The antenna radiation in the E-Plane and H-Plane is depicted in Fig 5.When comparing the performance of the antenna without and with S-slit, there is constant improvement in antnna gain. By using the proposed PDGS the efficiency of the antenna is improved and these are the effects of reduction of mutual coupling in the antenna.



(a) (b)

Fig 5 3D radiation pattern in E-Plane and H-Plane (a) without S-Slit (b) with S-Slit

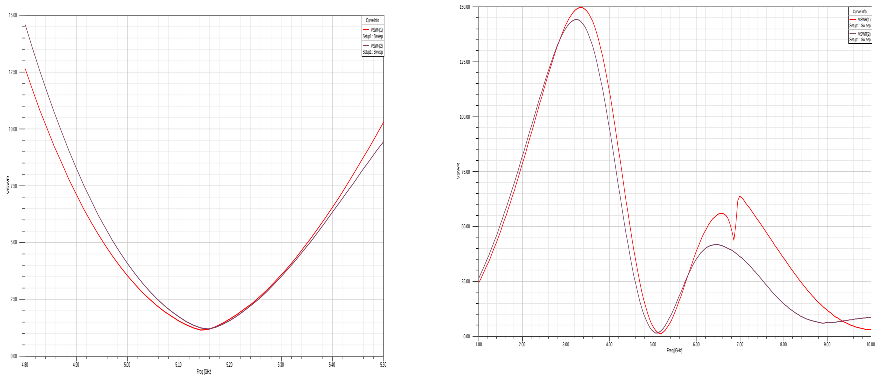
The gain of the antenna is also increased when we observed in the 2D plot and is more symmetrical. The proposed has obtained a gain of 8dB with S-Slit. A better sphere is obtained when the DGS units are introduced in the ground plane.



(a) (b)

Fig 6 2D radiation pattern (a) Without S-Slit (b) With S-Slit

The Voltage Standing Wave Ratio (VSWR) of the Patch antenna is shown in Fig 7. The antenna with S-Slit has VSWR of 1.332 (VSWR <2 or about -10 dB return loss). VSWR must be low to avoid impedance mismatch in the source and load. An antenna with good VSWR value will have a better gain.

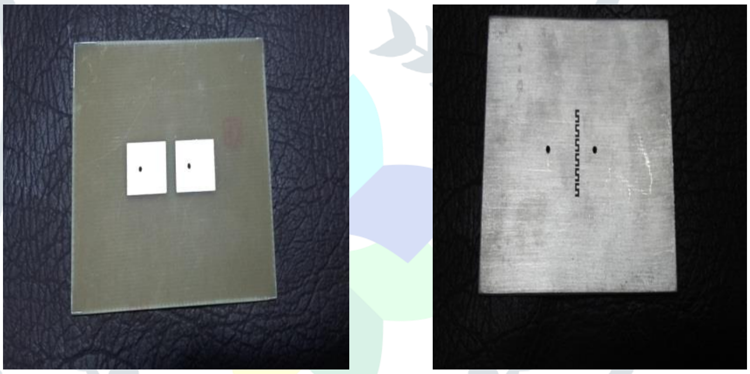


(a) (b)

Fig 7 VSWR Without S-Slit (b) With S-Slit

IV.FABRICATION

The above designed antenna using the software is fabricated manually along with the S-shape slits in ground, using FR-4 material in substrate and it is tested using network analyzer. The results obtained during simulation in software are matched with the tested results of fabricated antenna. This antenna shows good return loss and coupling loss during testing. The below Fig 8 shows the top view and bottom view of fabricated antenna.



(a) (b)

Fig 6 Fabricated Antenna (a) Top View (b) Bottom View

The top view is the substrate in FR-4 material and two patches in the antenna. The bottom shows the S-slits between the patch in the ground plane. In between each patch a coaxial feed is connected using a connector to test the antenna radiation. The fig 9 shows the testing results of the antenna.

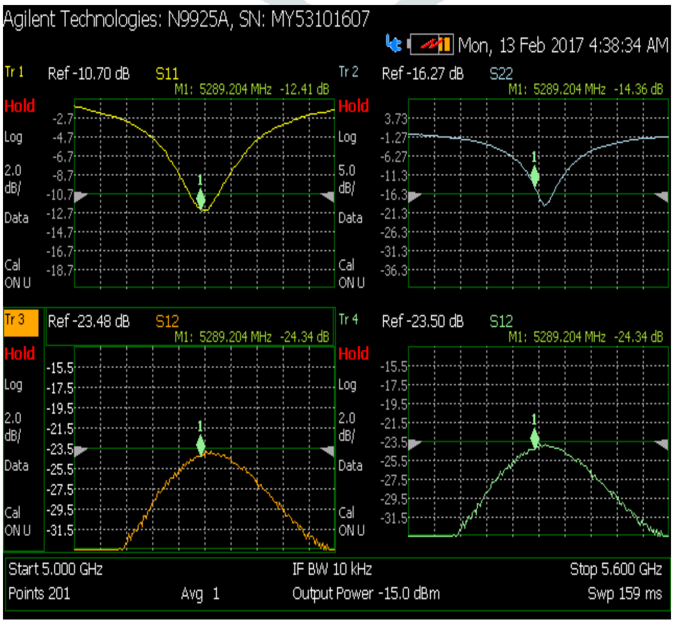


Fig 9 Return Loss and Coupling Loss

In the above figure S11 and S22 are the return loss components and S12 and S21 are the coupling loss of antenna.

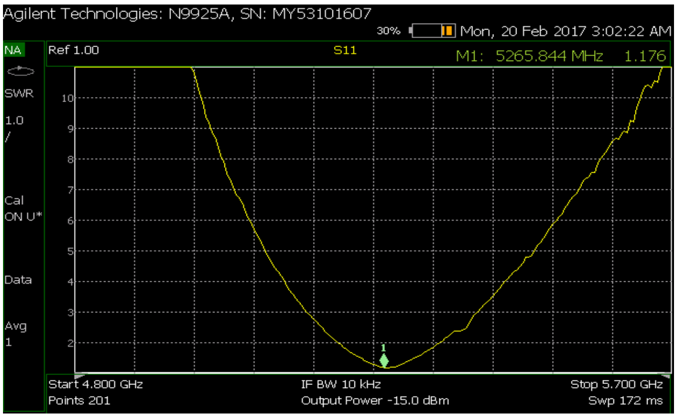


Fig 10 VSWR

The Fig 10 shows the VSWR of the antenna. It shows that the antenna has 1.176 as VSWR which reduced the standing waves and the impedance mismatch.

V.CONCLUSION

The Microstrip Patch antenna design is simulated using Ansys HFSS. Designs are made using FR4 substrate having relative permittivity 4.4 and height of 1mm which is a low cost material and easily available. Microstrip feed line of 50ohms is used. Measurement of all the antennas is done using vector network analyzer. The reduction of mutual coupling in the designed microstrip patch antenna is about 20dB and a gain of 8dB has been successfully achieved. There is significant improvement in achieving mutual coupling reduction when measured with S slit.

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