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DESIGN OF IMPROVED PERFORMANCE RECTANGULAR MICROSTRIP PATCH ANTENNA USING PEACOCK AND STAR SHAPED DGS

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Abstract- In this paper, two novel defected ground structures (DGS) are proposed to improve the return loss, compactness, gain and radiation efficiency of rectangular microstrip patch antenna. The performance of antenna is characterized by the shape, dimension & the location of DGS at specific position on ground plane. By incorporating a peacock shaped slot of optimum geometries at suitable location on the ground plane, return loss is enhanced from -23.89 dB to -43.79 dB, radiation efficiency is improved from 97.66% to 100% and compactness of 9.83% is obtained over the traditional antenna .Simulation results shows that the patch antenna with star shaped DGS can improve the impedance matching with better return loss of -35.053 dB from -23.89 dB and compactness of 9% is achieved. In the end comparison of both DGS shapes is carried out to choose one best optimize one. The proposed antennas are simulated and analyzed using Ansoft HFSS (version 11.1) software.

Keywords- *Rectangular microstrip patch antenna (RMPA), Defected ground structure (DGS).*

I. INTRODUCTION

Micro strip patch antennas [1] have been studied extensively over the past many years because of its low profile, light weight, low cost and easy fabrication. They are extremely compatible for embedded antennas in handheld wireless devices such as cellular phones, pagers etc. These low profile antennas are also useful in aircraft, satellites and missile applications, where size, weight, cost, ease of installation, and aerodynamic profile are strict constraints. But microstrip patch antenna [2] suffers from drawbacks like narrow bandwidth and low gain. While using Microstrip patch antenna the other problems which will occurs are high loss and surface waves in the substrate layer, as the losses will always occur in the radiation as the antenna is transmitting the signals. Due to the surface waves excitation losses occur that will cause decrease in the antenna efficiency, gain and the bandwidth because when surface waves occur, it can extract total available power for radiation to space wave.

So there have been inventions of new technology to overcome that entire drawback. One of the techniques is DEFECTED GROUND STRUCTURE.

In DGS, there is an introduction of a shape on a ground plane that will be etched on the ground thus will disturb the shielded current distribution depending on the shape and dimension of the defect. Due to this defect shielded current distribution will influence the input impedance and the current flow of the antenna. The excitation and electromagnetic waves propagation through the substrate layer can also be controlled by DGS [3-5]. Micro strip antenna with DGS [6-10] will provide higher operating bandwidth and improved return loss overcoming the limitation of conventional microstrip antenna. DGS can be integrated onto the ground plane of such antenna in order to improve its radiation, besides not requiring additional circuits for implementation.

DGS is basically used in microstrip antenna design for different applications such as antenna size reduction, return loss improvement, radiation efficiency, harmonic suppression etc. DGS are widely used in microwave devices to provide compactness and effectiveness. In this paper, a microstrip patch antenna with peacock and star shape defected ground structure is designed for C-BAND application. The paper has been organized into following sections. Section II provides the antenna design of the proposed rectangular patch with peacock and star shaped defect. Section III, section IV and section V provides the simulation results and discussion of the reference antenna and proposed antennas respectively. Section VI provides the comparison of proposed DGS antennas with reference antenna. Section VII provides the conclusion followed by references.

II. ANTENNA DESIGN

Reference antenna consists of a rectangular patch on upper surface and coaxial feed on lower surface as shown in fig 1. The Coaxial feed or probe feed is a very common technique used for feeding micro strip patch antennas. As seen from Figure 1, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.

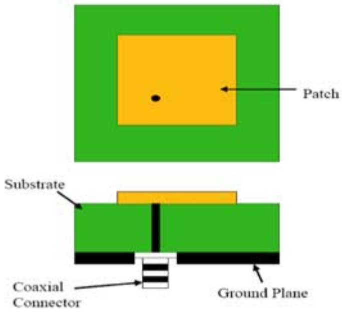

Fig 1: Probe fed Rectangular Micro strip Patch Antenna

The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation [1]. Rectangular patch is designed at the resonant frequency of 6.67GHz using the following equations and procedure.

Step 1: Calculation of Width (W)
For an efficient radiator, practical width that leads to good radiation efficiencies is calculated by transmission line model equation

$$W = \frac{c}{2f\sqrt{\frac{\varepsilon r+1}{2}}}$$

Step 2: Calculation of Effective Dielectric Coefficient (Ɛreff)
The effective dielectric constant is obtained by referring to equation

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

Step 3: Calculation of Effective Length (Leff)
The effective length is calculated using equation

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon reff}}$$

Step 4: Calculation of Length Extension (ΔL)
The value of ΔL can be obtained by using equation

$$\Delta L = 0.412h\left(\frac{(\varepsilon reff+0.3)\left(\frac{W}{h}+0.264\right)}{((\varepsilon reff-0.258)\left(\frac{W}{h}+0.8\right)}\right)$$

Step 5: Calculation of Actual Length of Patch (L)
The actual length of radiating patch is obtained by

$$L_{eff} = L + 2\Delta L$$

Step 6: Calculation of Ground Dimensions (Lg, Wg)

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. It has been shown by that similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, for this design, the ground plane dimensions would be given as:

$$L_g = 6h + L$$
$$W_g = 6h + W$$

After calculating length and width of rectangular microstrip patch, antenna is modelled and simulated using High Frequency Structure Simulator (HFSS) which uses FDTD method for simulation.

Rectangular shape is most commonly used configuration for the patch antenna because it is easy to analyse using both transmission line model and cavity model which are most accurate for thin substrates. The coaxial feed [6] used for excitation of an antenna is positioned such that it results in a good impedance matching. Fig 2 shows the top view of rectangular patch antenna.

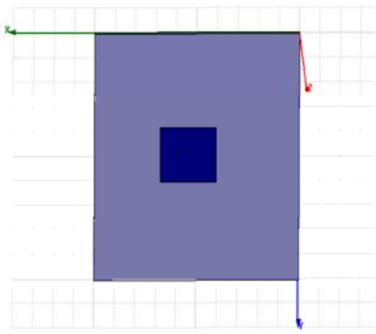

Fig 2: Top View of Proposed Antenna

A peacock shaped slot and star shaped slot as shown in Fig 3 and 4 are cut in ground plane of reference rectangular microstrip antenna to improve its characteristics. So the proposed antenna 1& 2 consists of a rectangular patch on the upper plane and etched peacock and star shaped DGS structures on the ground plane respectively. DGS acts as LC resonator circuit. Peacock & star shape defect etched in the ground plane of the microstrip can give rise to increase in the effective capacitance and inductances due to this reasons antenna characteristic are modified accordingly.

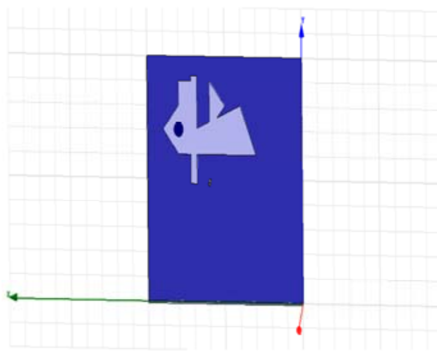

Fig 3: Peacock Shaped DGS Bottom View

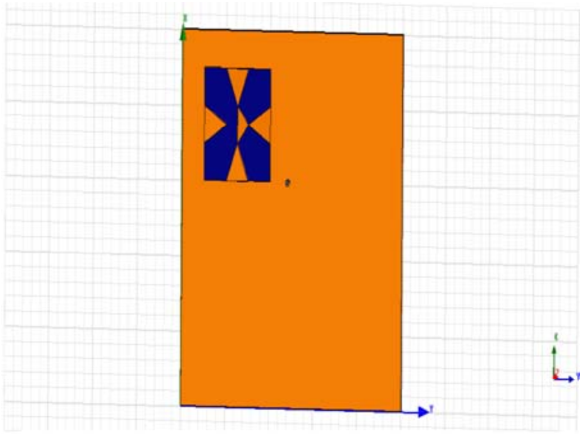

Fig 4:star shaped DGS Bottom View

III. RESULTS OF REFERENCE ANTENNA

The antenna performance of RMPA without DGS has been investigated. The simulation results of reference antenna are shown in Fig 5, Fig 6 and Fig 7.

RMPA resonates at frequency of 6.67GHz and the return loss of antenna is -23.89 dB as shown in Fig 5. Radiation pattern of reference antenna is shown in Fig 6. Antenna has maximum gain of 6.6283 dB in ϕ=0 direction. Fig 7 shows the radiation efficiency of reference antenna which has value of 97.66%.

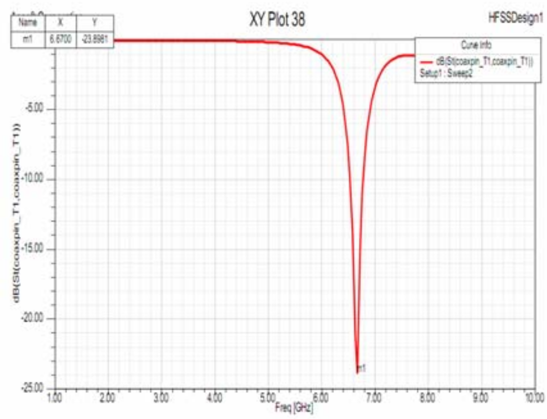

Fig 5: Return Loss of Reference Antenna

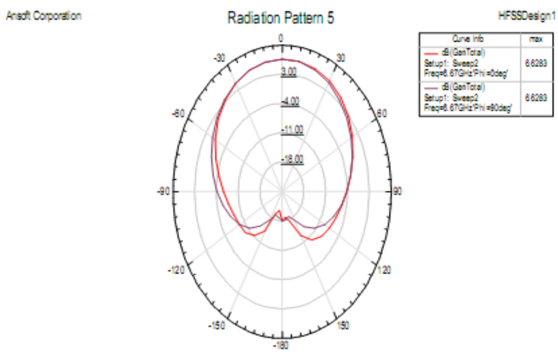

Fig 6: Radiation Pattern of Reference Antenna

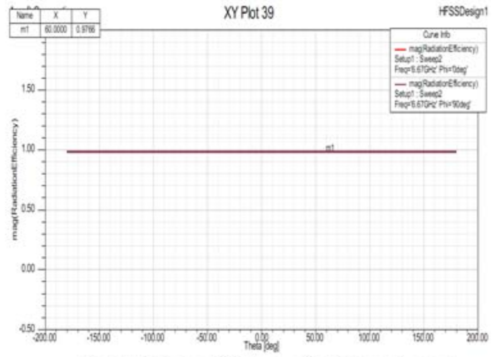

Fig 7: Radiation Efficiency of Reference Antenna

IV. RESULTS OF PROPOSED ANTENNA1 WITH PEACOCK SHAPE DGS ON GROUND PLANE

The simulated results of RMPA with PEACOCK SHAPE DGS is shown in Fig 8, Fig 9 and Fig 10.From Fig 8, we can see that by introducing DGS in reference antenna resonant frequency of antenna get shifted from 6.67GHz to 6.355GHz and antenna becomes compact by 9.83% .The enhanced return loss of antenna is -43.79dB as compared to -23.89dB of reference antenna.

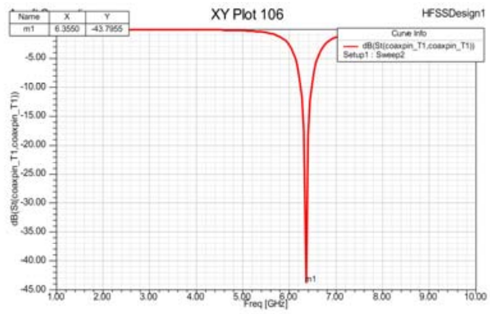

Fig 8: Return Loss of Proposed Antenna

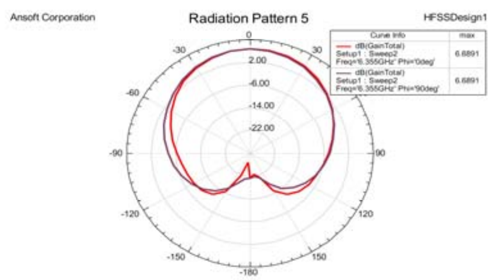

Fig 9: Radiation Pattern of Proposed Antenna

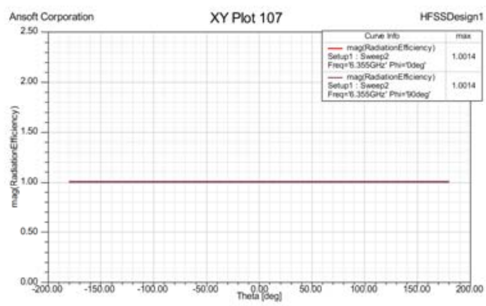

Fig 10: Radiation Efficiency of Proposed Antenna

Fig 9 and fig 10 shows the radiation pattern and radiation efficiency of DGS antenna respectively. The gain of DGS antenna is 6.689 dB and radiation efficiency has value of 100.14%.

V. RESULTS OF PROPOSED ANTENNA 2 WITH STAR SHAPE DGS ON GROUND PLANE

The simulated results of RMPA with STAR SHAPE DGS is shown in Fig 11, Fig 12 and Fig 13.From Fig 11, we can see that by introducing DGS in reference antenna resonant frequency of antenna get shifted from 6.67GHz to 6.4 GHz and antenna becomes compact by 9% .The enhanced return loss of antenna is -35.053dB as compared to -23.89dB of reference antenna.

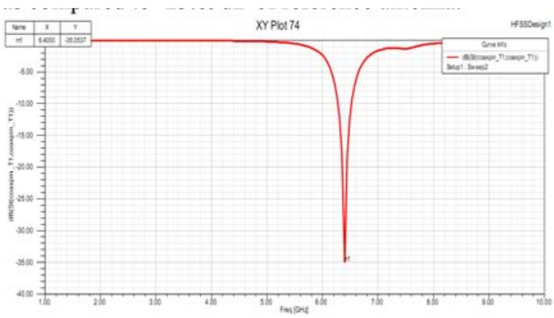

Fig 11: Return Loss of Proposed Antenna 2

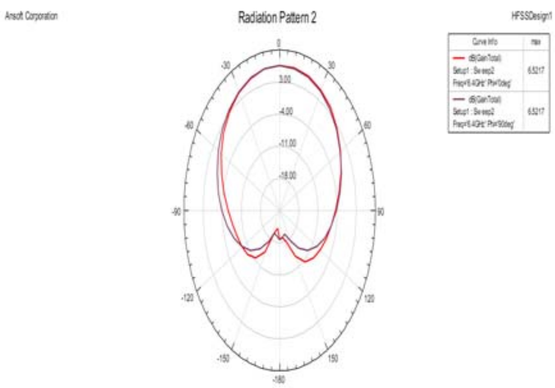

Fig 12: Radiation Pattern of Proposed Antenna 2

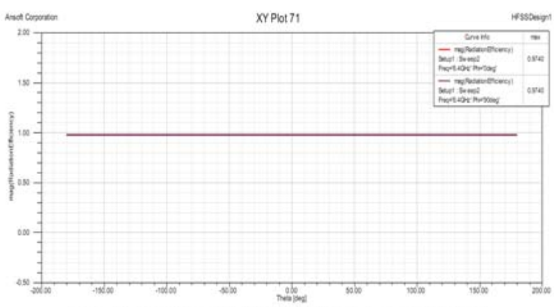

Fig 13: Radiation Efficiency of Proposed Antenna 2

Fig 12 and fig 13 shows the radiation pattern and radiation efficiency of DGS antenna respectively. The gain of DGS antenna is 6.5217 dB and radiation efficiency has value of 97.4%.

VI CAMPARISON OF PROPOSED ANTENNAS

In this section we compare both DGS shapes proposed antennas with reference antenna to analysed DGS antennas performance over reference.

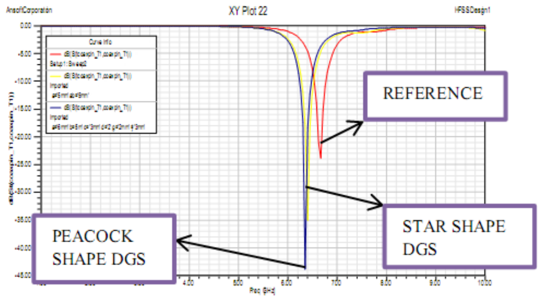

Fig 14 Comparison of Return Loss

Fig 14 shows the comparison of performance characteristics of conventional RMPA and proposed DGS antennas. By introducing DGS in reference antenna improvement in antenna characteristics is achieved.

TABLE 1: COMPARISION OF REFERENCE ANTENNA AND PROPOSED ANTENNA RESULTS

Antenna	Resonant frequency	Gain (dB)	Return loss (dB)	Radiation efficiency	compactness
Reference antenna	6.67GHz	6.628	-23.89	97.67%	-
Proposed antenna 1	6.355GHz	6.689	-43.79	100.14%	9.89%
Proposed antenna 2	6.4GHz	6.521	-35.05	97.4%	9%

From Table 1 we can easily compare both antennas with reference one. It is concluded from table that impedance matching is improved in both irregular shaped DGS in comparison with reference. Compactness is also achieved with both irregular shaped DGS as there is a shift in resonating frequency towards the lower side with respect to reference. But the peacock shape DGS provides better results as compared to star shapes DGS. Peacock shape DGS provide better impedance matching ,more compactness, good efficiency and more gain as compared to star shape DGS.

VII. CONCLUSION

New DGS peacock and star shapes for RMPA has been proposed in this work. The peacock shape DGS integrated antenna has improved impedance matching of reference antenna with better return loss of -43.7dB from -23.89 dB. Gain enhancement up to

.061 dB, radiation efficiency enhancement of 2.47% and compactness of 9.89% is achieved in proposed peacock shaped DGS antenna as compared to conventional antenna. Star shape DGS antenna also improves the return loss and provides compactness of 9%, but there is .10 dB degradation of gain as compared to reference antenna. Hence peacock shape is a better optimize choice for characteristics enhancement of reference antenna.

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