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Design and Analysis of Circular Microstrip DGS Patch Antenna for Ku Band

Brajesh Kumar Gupta,Sumita Mishra, Ruchi Gupta
Department of Electronics & Communication Engineering,
Amity School of Engineering and Technology(ASET)
Amity University, Lucknow Campus, India

***Abstract* :In this paper a novel circular microstrip patch antenna is designed with defective ground structure (DGS) for Ku band. After analyzing the proposed design, HFSS simulator is used to create the required design. After successfully convergence of the proposed antenna its various parameters are obtained which includes gain, directivity, radiation pattern and S-parameter. Through simulation results it is concluded that the design is optimum and the results are within normal range.**

***Index Terms:*Circular microstrip, DGS, Ku band, Gain, Directivity, Radiation pattern, S-parameter.**

INTRODUCTION

Microstrip patch antenna is the most common type of antenna which has been studied extensively for last decades.A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. Some patch antennas do not use a dielectric substrate and instead made of a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth. Because such antennas have a very low profile, are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices.DGS refers to the defects present in the structure of the particular antenna; here in the proposed design we have used L-Shaped defects with respect to the ground plane. The defect in a ground structure is one of the unique techniques to reduce the bulkiness of the antenna. So the designing of antenna with the defective ground structure, the antenna size is reduced for a particular frequency as compared to the antenna size without the defect in the ground. DGS is realized by introducing a shape defected on a ground plane. Furthermore, the frequency used for the given design lies in the Ku band which ranges from 12 GHz to 18 GHz. The analyzed and optimized antenna parameter includes its gain, directivity, radiation pattern, S-parameter etc.

ANTENNA DESIGN METHODOLOGY

The proposed design uses rogers RT/duroid 5880(tm) material from syslibrary which has relative permittivity of 2.2 and permeability of 1. Dielectric loss tangent are found to be 0.0009 and the lambda G factor of 2. The infinite ground is created with the geometrical positions -0.5, -0.44, 0 and L x W as 1 x 0.9 cm with z-orientation as 0.032cm. The required design is shown below in figure-1.

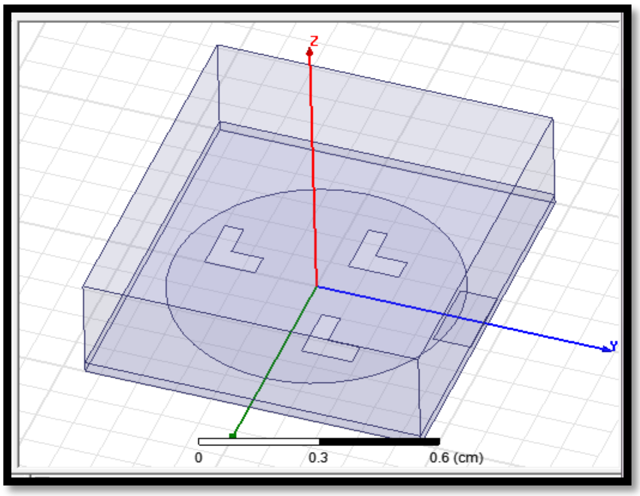

Figure-1 Proposed Microstrip Patch Antenna Design.

The air vacuum is created and the radiation boundaries are assigning to it. Furthermore, the sheet substrate includes circle with z-coordinate and radius 0.39cm and the defect is created on the ground plane as shown in figure-2.

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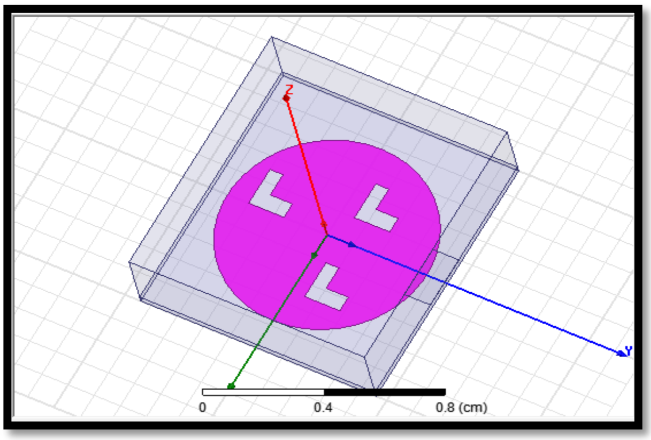

Figure-2 Antenna with DGS plane.

The system orientation is global for the proposed design and the radiation boundary is assign with proper specification as shown below in figure-3.

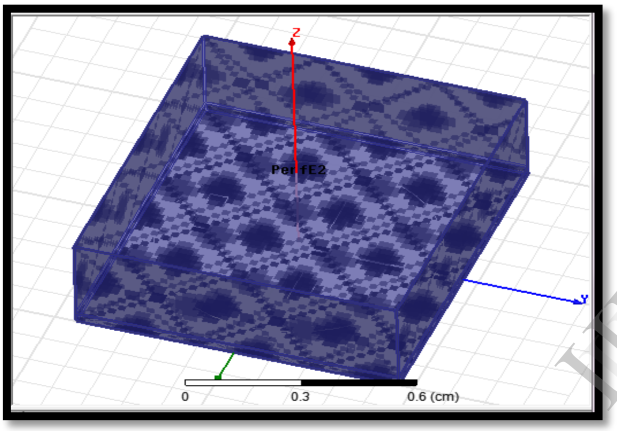

Figure-3 Antenna with radiation boundaries.

ANALYSIS &SIMULATION

For creating the simulation profile the radiation boundaries are assigned as air with perfect E and the excitation is assign as wave port. The analysis setup with solution frequency ranges between 12 GHz to 18 GHz. The chosen frequency for the present simulation is 12 GHz however it can be extended to 12 GHz to 18 GHz while simulating the design itself. In the simulation profile the adaptive solution with maximum number of passes is 20 and maximum delta is 0.02. The iterative solver is not enabled in the presented design. Furthermore refinement per pass is provided as 20%. The maximum delta with Z_0 is within 2% range. The interpolation is given with maximum solution of 250 and the error tolerance is below 0.5%. The sweep type is fast with linear count, the starting count is 1 GHz and the end count is 20 GHz with step size of 81; this completes the simulation profile for the given proposed antenna design.

The following figure-4 shows the convergence of the proposed antenna and it can be easily seen that the antenna is converged successfully.

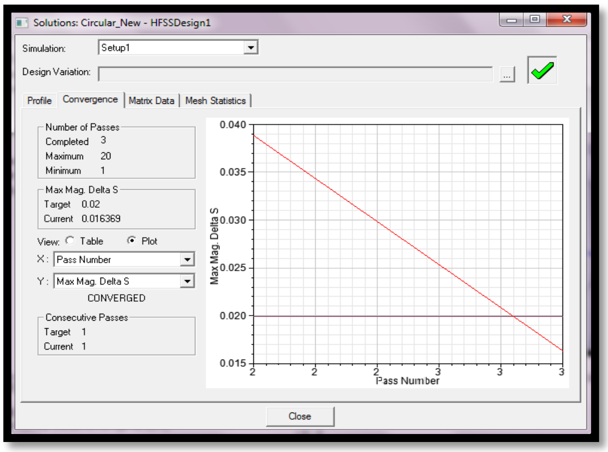

Figure-4 Antenna convergence.

Through simulation results antenna gain are found to be optimum and it is shown in figure-5,6, 7 and 8 with different geometrical conditions.

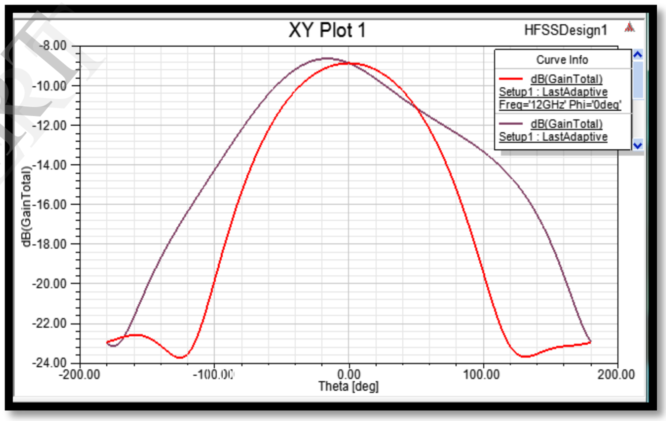

Figure-5 Antenna gain in far field.

The radiation pattern of the antenna gain is shown below in figure-6 as a rectangular polar plot.

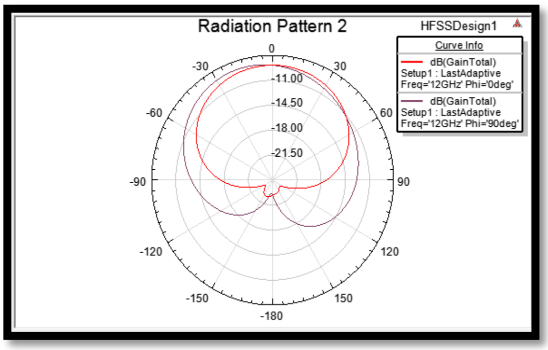

Figure-6 Antenna gain w.r.t rectangular plot.

The 3D-polar plot of the antenna gain is also shown in figure-7 & 8 below.

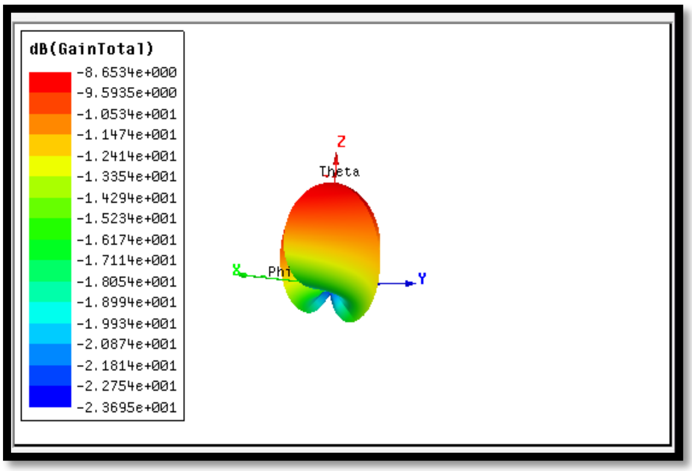

Figure-7 Antenna Gain w.r.t 3D polar plot-1.

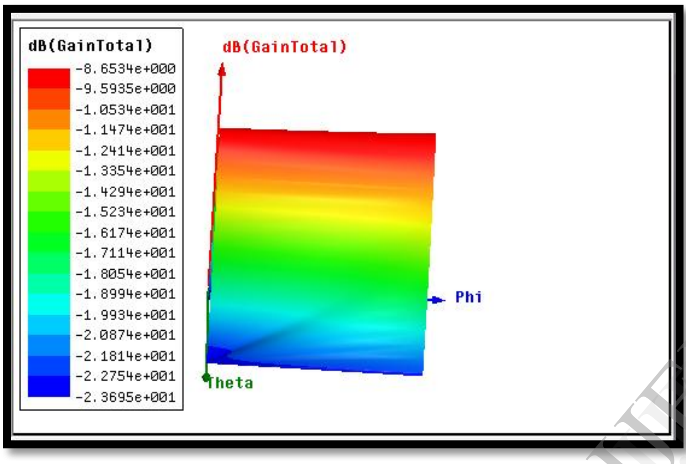

Figure-8 Antenna Gain w.r.t 3D polar plot-2.

The directivity of the proposed antenna is shown in figure-9 and 10 respectively.

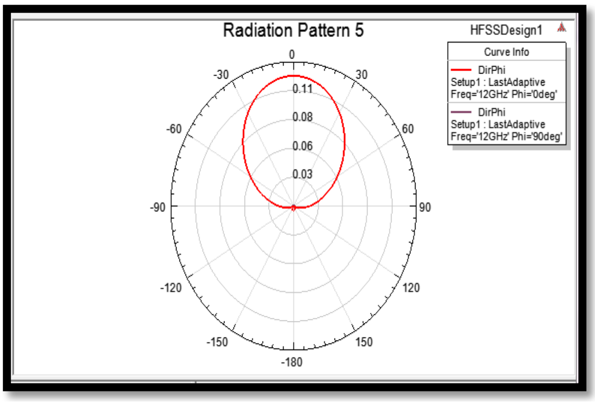

Figure-9 Antenna directivity.

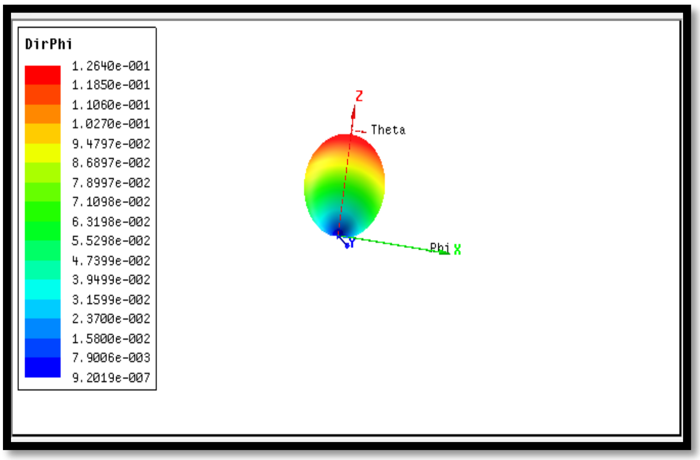

Figure-10 Directivity w.r.t 3D polar plot.

The S-parameters with sweep setup is shown in figure-11 and with adaptive pass is shown in figure-12; the smith chart for the presented antenna is shown in figure-13.

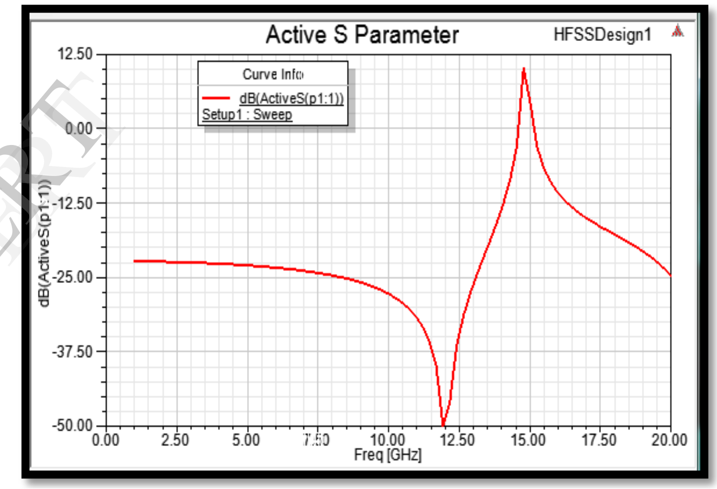

Figure-11 The S-parameter with sweep setup.

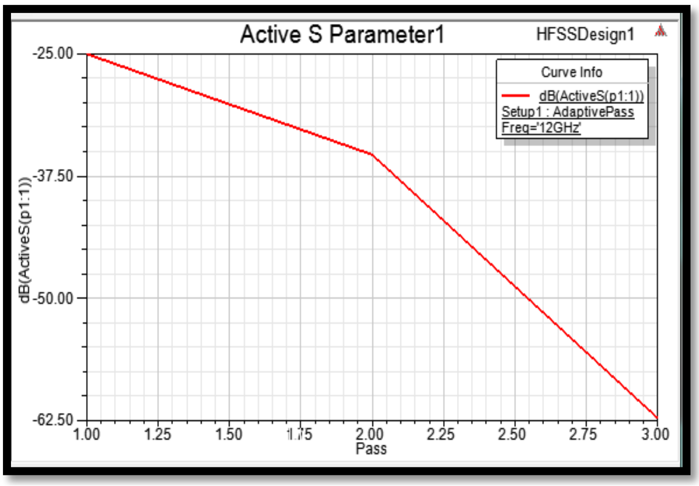

Figure-12 The S-parameter with sweep setup.

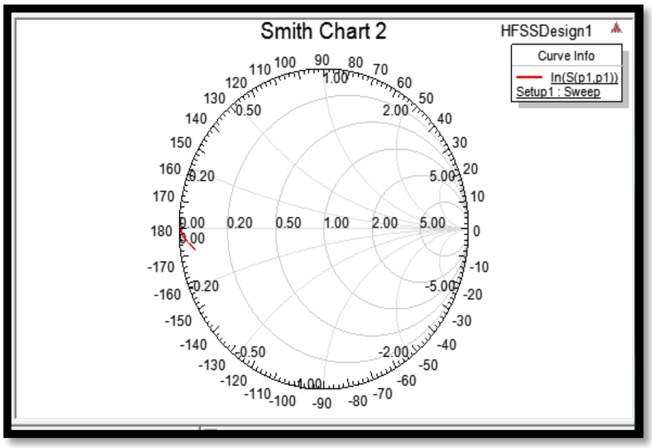

Figure-13The Smith Chart.

The other parameters like voltage standing wave ratio (VSWR) and rE are shown in the following figure-14 and 15.

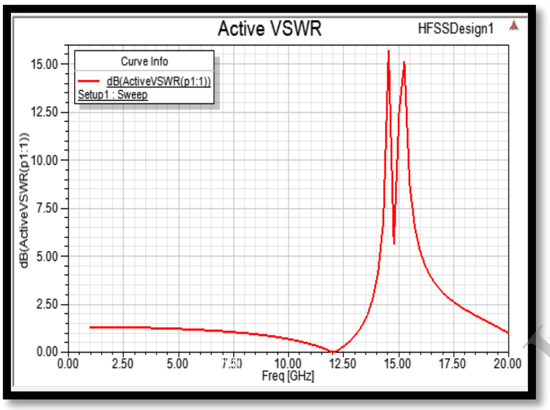

Figure-14 VSWR of the proposed antenna.

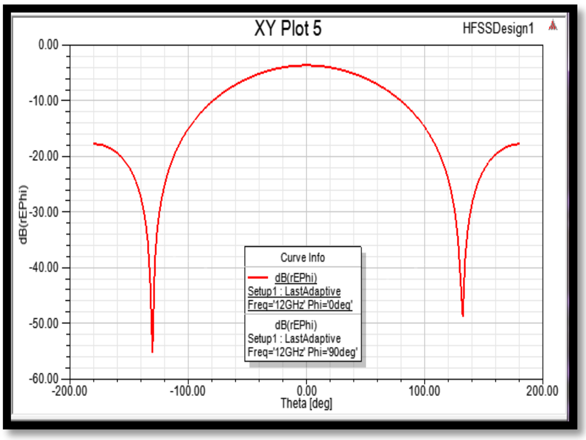

Figure-15rE(phi) of the antenna.

After analyzing the simulation the obtained results are tabulated as in the given table-1.

Table-1

Analyzed Parameters	**Obtained Results**
1. Gain	≈ 8 dB
2. Bandwidth	≈ 0.86%
3. Re (Impedance)	≈48.7
4. Directivity	Improved
5. Impedance Matching	Easy
6. Spurious Radiation	More (Increased)

CONCLUSION

The circular microstrip patch antenna with DGS plane is analyzed. The design for the same is created using HFSS simulator. The parameter of analysis includes antenna gain, directivity, radiation patter, VSWR etc. After careful observation it is concluded that the proposed antenna is within optimum range and the simulation results are nearly appropriate for the Ku (12 GHz to 18 GHz) band range of frequencies.

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