



# DGS Based Microstrip Patch Antenna for UWB System

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**ABSTRACT:** This paper proposes a compact microstrip patch antenna with defected ground structure. It's a trend in wireless application now a days. First, a primary patch antenna with resonant frequency of 4.6GHz is designed with FR4 substrate. To increase the bandwidth and efficiency, the DGS has been incorporated to these antennas. It is observed that the primary antenna with final modified ground plane shows a better performance. Simulation is carried out using HFSS software and the simulated results are in good agreement.

**KEYWORDS:** Defected Ground Structure (DGS), Ultra-Wide Band (UWB), Microstrip patch antenna (MPAs).

## I.INTRODUCTION

The new generation of wireless systems demands effective and reliable antennas, these antennas include parabolic reflectors, patch antennas, slot antennas and folded dipole antennas [1]. Microstrip patch antennas (MPAs) have many attractive features such as low profile, lightweight, ease of manufacture, conformability to curved surfaces, low production cost. These attractive features have recently increased MPAs popularity and applications and simulated greater research effort to understand and improve their performance [2]. Most of the proposed designs for patch antennas suffer from narrow bandwidths, to overcome this we use UWB antennas with the release of the 3.1-10.6GHz band [3] [4].

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 generally made of conducting material and can take any possible shapes.

In this paper, both circular and pentagonal antennas are designed by using relevant equations. The DGS is introduced to analyze the impact on bandwidth and efficiency.

## II MICROSTRIP UWB ANTENNA WITH DGS

These antennas can be easily molded to any desired structure and easily linked to any host surface because of their conformal structures of low-profile planar configuration. Production of these antennas also so simple and easy, and the major advantage of MPA of low cost.

Most of the proposed designs for patch antennas suffer from narrow bandwidths, and a number of techniques have been proposed and investigated to render them suitable for UWB communication applications by enhancing their bandwidth. Presently, there are many simulation tools to design using HFSS (High Frequency Structural Simulator). HFSS is a software tool provided by ANSOFT Corporation. It solves the structure by FEM (Finite Element Method) method.

The defect in a ground is one of the unique techniques to reduce the antenna with the defected 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 plan thus will disturb the shielded current distribution depending on the shape and dimension of the defect.



A simple block diagram is shown in fig:1 represents a methodology steps of antenna verification.

Fig-1: Block Diagram of Antenna design

### A. CIRCULAR MICROSTRIP PATCH ANTENNA

A circular microstrip patch antenna with a wide bandwidth is proposed by using defected ground structure (DGS). The design plan was done in four steps. In first step, a conventional antenna (circular patch antenna with ground plane below the substrate) was designed. By using resonant frequency and dielectric constant we find radius of patch.

$$f_r = \frac{1.8411c}{2\pi r \sqrt{\epsilon_r}} \dots \dots \dots (1)$$

We give line feeding to the patch to match impedance in both edges we use 50 Ω and 100 Ω feedline.

$$W = \frac{7.48h}{e^{\frac{z_0 \epsilon_r + 1.41}{87}} - 1.25t} \dots \dots \dots (2)$$

The width of feed line can be calculated by using this equation. The length of feed line for 100 Ω can be selected as per design and the 50 Ω length is approximately equal to λ/4 unite the all feedlines at the end.

We design the antenna for resonating frequency 4.6GHz and substrate material epoxy FR\_4 with the dielectric constant 4.4 and thickness of the substrate is 1.6mm.

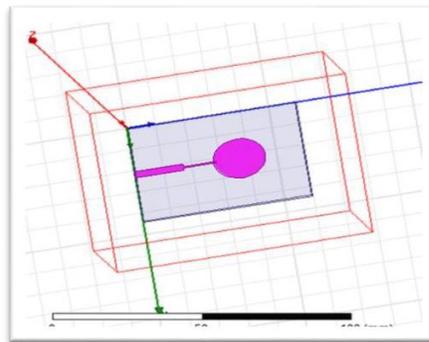
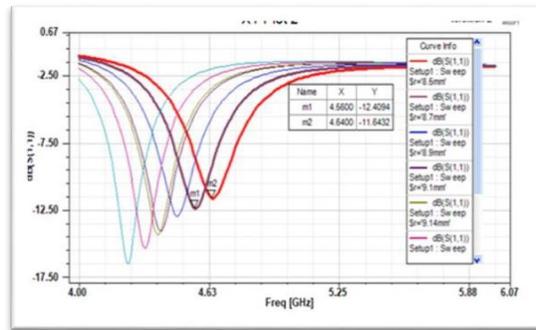


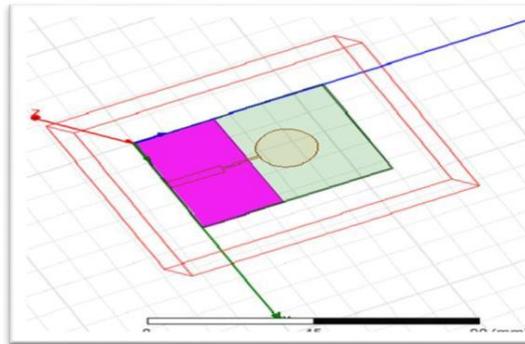
Fig-2: Basic antenna design

To obtain the solution frequency we use optimetric parameter. In this we give radius of patch as a variable parameter with difference slots. We obtain the return loss for each slot of radius. This return loss for various radius parameter is represented in fig 3.



**Fig-3: Return loss for optimetric parameter**

In next step we make finetune to get exact radius at frequency 4.6GHz. To increase the bandwidth of an antenna we modified the ground plane. We reduce the ground size to half of its original to increase the bandwidth and this technique is called truncated DGS. The design is modified as shown in Fig 4 and has a large bandwidth.



**Fig-4: DGS based antenna design**

This is the final antenna design, we obtain the results using HFSS software.

**A. Pentagonal Microstrip Patch Antenna**

The antenna consists of a pentagon radiating patch with suitable dimensions on the upper side of a dielectric substrate and a rectangular ground plane. DGS is introduced to analyze the impact on efficiency and gain.

This includes two steps of design; the first step is designing basic antenna. A pentagon patch antenna occupies less space compared to circular patch antenna. The designing of microstrip antenna requires resonant frequency ( $f_0$ ), dielectric material and height of substrate ( $h$ ).

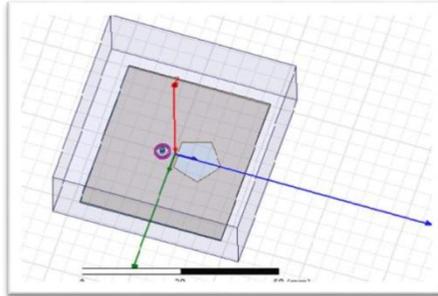
Width and length of substrate is calculated by using given equation (3)

$$\omega = \omega\gamma + 6h \tag{3}$$

The width of patch can be calculated using equation (4)

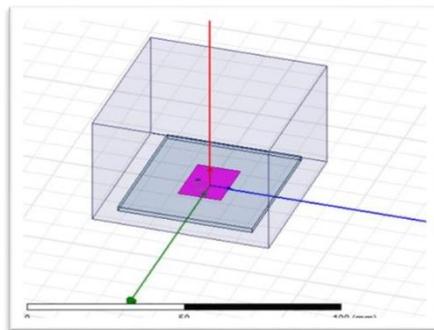
$$W_p = \frac{c}{2f\gamma} \sqrt{\frac{2}{\epsilon_r + 1}} \tag{4}$$

The proposed pentagon patch antenna is shown in fig 5 below.



**Fig-5: Basic antenna design**

For the designed antenna we get exactly solution frequency 4.6GHz and this designed antenna has less efficiency, to overcome this we use rectangular shape DGS. This increases the efficiency up to 83.9%, the coaxial probe feed helps to increase the efficiency and decrease the size of the antenna.

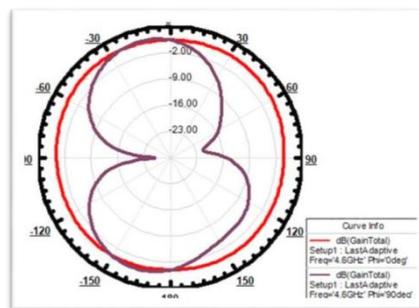


**Fig :6 Rectangular DGS antenna**

### III. RESULTS

#### A. *CMPA RESULTS*

The far field radiation patterns of final structure in the E-plane ( $\phi=0^\circ$ ) and the H-plane ( $90^\circ$ ) were measured at frequency (4.6GHz), results and clarification are shown in Fig 7 below.



**Fig-7: 2D radiation pattern of CMPA**

The plotted 3D radiation pattern follow the conventions in the antenna society. The pattern is a popular plot with larger gain further away from the origin and in red colour, and the smaller gain closer to the origin and in red colour shows high gain.

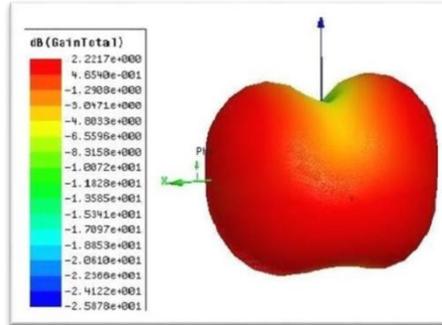


Fig-8: 3D radiation pattern of CMPA

A measure of the loss of power in the signal reflected by a transmission line to a load, is usually expressed in decibels(dB) as the logarithmic ratio of relative magnitudes of input power and reflected power. The proposed antenna exhibits the return loss of -24.25dB as maximum and -12.26 dB for solution frequency with DGS at 4.6GHz. Fig 9 shows the plot of return loss v/s frequency of CMPA with DGS.

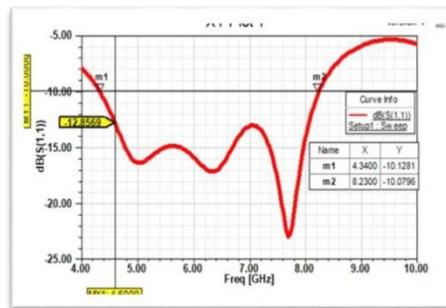


Fig-9: Return loss of antenna

VSWR of CMPA without DGS is 1.8 and is reduced to 1.5 with DGS. Fig 10 is a plot of VSWR with DGS.

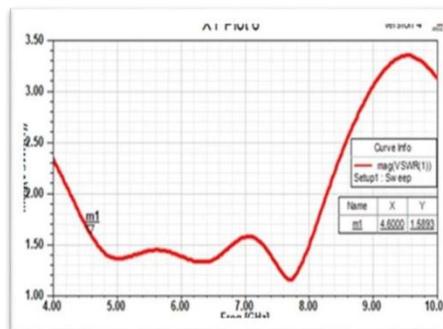


Fig-10: VSWR

### B.PMPA RESULTS

Considering design parameters of pentagonal microstrip patch antenna [PMPA] and operating frequency as 4.6 GHz, following simulation results are obtained. The far field radiation patterns of the final structure in the E-plane ( $\phi = 0^\circ$ ) and the H-plane ( $\phi = 90^\circ$ ) were measured at solution frequency. Fig 11 represents the 2D plot of PMPA.

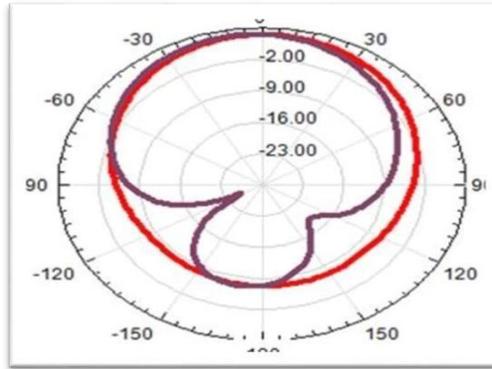


Fig-11:2D radiation pattern of PMPA

The plotted 3D radiation patterns say that in red colour it as high gain and transmit range is also in that region. Fig 12 represents the 3D plot of PMPA with DGS.

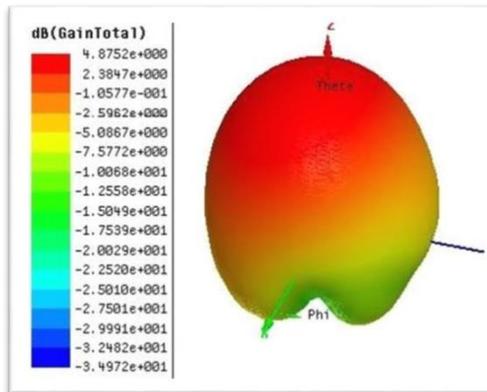


Fig-12: 3D radiation pattern of PMPA

The proposed antenna exhibits the return loss of - 11.56dB with DGS and - 17.53dB without DGS at 4.6GHz. Fig 13 shows the plot of return loss v/s frequency of PMPA with DGS.

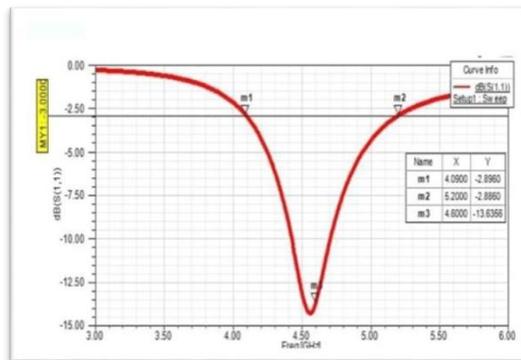


Fig-13: Return loss of Antenna

The range of values for VSWR is from 1 to  $\infty$ . A VSWR value under 2 is considered suitable for most antenna applications. The antenna can be described as having a good match of PMPA without DGS is 1.912 and is reduced to 1.32 with DGS. Fig 14 shows the plot of VSWR v/s frequency of PMPA with DGS.

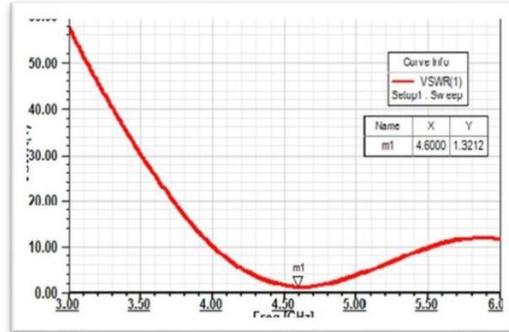


Fig-14: VSWR v/s frequency

### Comparison of Antenna with and without DGS

Defected ground structure (DGS), increases the performance of the system by deliberately altering the ground plane metal of micro strip circuit. DGS is analyzed by intentionally etching off a normal shape (slot or defect) in the ground surface plane which is called as “defect or fault”.

#### A. CIRCULAR MICROSTRIP PATCH ANTENNA

Parameter	Without DGS	With DGS
Efficiency	32.5%	83.99%
VSWR	1.912	1.32
Return loss	-11.56	-17.53
bandwidth	220MHz	1.1GHz

Table :- 1 Performance of CMPA with and without DGS

#### B. PENTAGONAL MICROSTRIP PATCH ANTENNA

Parameter	Without DGS	With DGS
Efficiency	32.5%	83.99%
VSWR	1.912	1.32
Return loss	-11.56	-17.53
bandwidth	220MHz	1.1GHz

Table :-2 Performance of PMPA with and without DGS

### IV. CONCLUSION

The proposed circular and pentagonal microstrip patch antenna has been designed and simulated before and after using the DGS technique, then a comparative study between them has been presented. We have successfully improved the bandwidth and also reduced the return loss; the improvement is clearly demonstrated through the

simulation results obtained using HFSS software.

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