Comparison between Simple Patch Slotted Patch and Slotted Patch with DGS

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Abstract— In today life everybody wants highest profit at low cost. In the same way Antenna design having low cost and small size to be need. The slots are used here helps to increase the BW of an Antenna. The Antenna has multiband frequency operation. The comparison between simple rectangle patch, slotted patch and slotted patch with DGS are discussed on the bases of their return loss, VSWR, axial ratio, radiation pattern which are simulated on HFSS v13. The co-axial feed is used in all design. The RT/Duroid 5870 material with dielectric constant 2.33 is used for substrate.

Key words: Patch Antenna, Slots, DGS (Defective Ground Structur), Co-axial Feeding

I. INTRODUCTION

Micro strip antennas are used in a wide range of applications, but due to its narrow impedance bandwidth restriction occurs. Micro strip patch antenna is very well known form of printed antenna. Micro strip patch antennas are getting Popular in wireless application due to their small shape arrangement, simple geometry and low manufacture cost. It is a very important element in communications and radar applications since it provides a wide variety of designs, either planar or conformal. Micro strip antennas can be fed by a variety of techniques, besides its advantage of being compact and suitable for antenna array designs. The micro strip antenna generally consists of a radiating element (patch), an intermediate dielectric layer, and a ground plane [1]. Many antennas have been improved to face the rising demands of modern portable wireless communication device that is capable of integrating more than one communication standard into a single system .The slotted patch antenna has been design for dual band application on RT/Duroid 5870 material to cover Ku-K band application [5]. Recently the microstrip antenna is very useful due to its low cost, ease of installation and integration with feed networks, low profile and small size, but the micro strip patch antenna has one serious drawback of narrow bandwidth as it limits the useful frequency band. Several techniques have been used to enhance the bandwidth by interpolating surface modification into patch configuration. The most unique technique used to enhance the bandwidth and reduce the size of patch is to defect the ground.

A. Deign Consideration:-

The proposed structures of antennas is shown in Fig(1). The antenna is simulated on RT/Duroid 5870 having relative permittivity 2.33, dielectric loss tangent is 0.0012.the antenna's design frequency 5.8 GHz, thickness of substrate is 1.6mm. All these specification are used for all the design antennas. The antenna input fed by co-axial probe .The probe position can be inset for matching the patch impedance with the input impedance. The main advantage of probe is low radiation and ease of insetting.

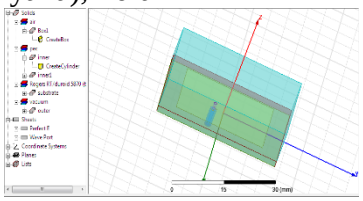

Fig a

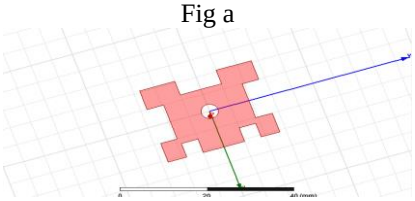

Fig b

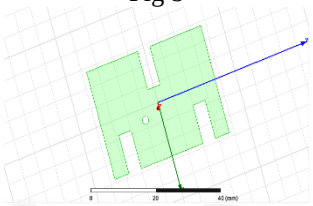

Fig c

Fig 1 (a), (b) and (c): Simulation of simple rectangular patch antenna (a), structure of slotted patch (b) and structure of DGS plane (c).

B. Design and Modelling

This section presents the design consideration of patch antenna. The equation for patch dimension are discussed as follows

$$W=\frac{vo}{2fr}\sqrt{\frac{2}{\varepsilon r+1}} \qquad (1)$$

$$\frac{\Delta L}{h}=0412*h\frac{\varepsilon reff+0.3(\frac{W}{h}+0.264)}{\varepsilon reff-0.258(\frac{W}{h}+0.8)} \qquad (2)$$

$$L_{eff}=L+2\Delta L_{eff} \qquad (3)$$

$$\varepsilon_{eff}=\frac{\varepsilon r+1}{2}+\frac{\varepsilon r-1}{2\sqrt{1+12h/w}} \qquad (4)$$

Where W is width of patch, L is length of patch, h is height of substrate, ε_r is dielectric constant of substrate. Due to fringing field ΔL is effective length of patch, ε_{reff} is effective dielectric constant.

C. Defective Ground Structure:

DGS is realized by etched periodic or non-periodic defect in the ground plane [4]. Defected Ground Structure changes shielded current distribution in the ground plane which depends upon shape and dimensions of the defect. The DGS structure generally controls the excitation and electromagnetic waves propagated through the substrate. It is very important that each different DGS produce different resonances and cut off frequencies that depends upon their geometry and size.

$$C=\frac{fc}{2Zo}\cdot\frac{1}{2\pi[fo2-fc2]} \quad (5)$$

$$L=1/4\pi^2 f_o^2 c \quad (6)$$

The DGS is examined as an equivalent circuit which consists of inductance and capacitance. The value of both L and C depends on the size and area of the defect which is to be cut in the ground plane. On varying the dimensions of defect the desired resonant frequency can be achieved.

II. RESULT AND DISCUSSION

A. Simple Rectangle Patch Antenna:

1) Return loss:

It is commonly expressed in negative dB's. The curve shows in Fig 2 the return loss of -23.3 dB,-21.4 dB at resonant frequency of 7 GHz and 8.7 GHz. The BW of the response is0.4GHz (8.9-8.5)

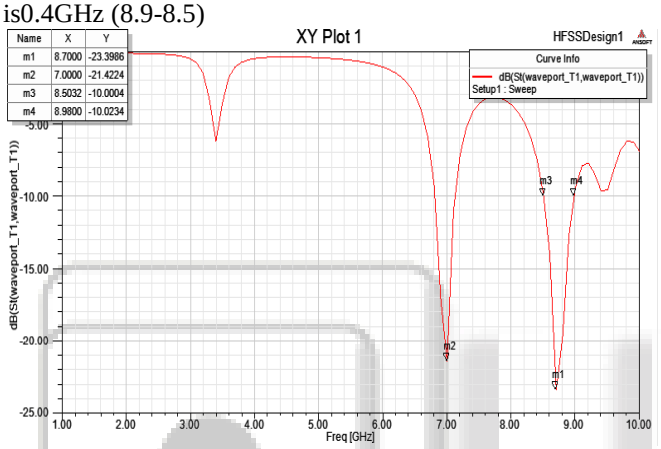

Fig. 2: Return Loss of Simple Rectangular Patch Antenna

2) VSWR

The VSWR is a measure of the impedance mismatch between the transmitter and antenna. The higher VSWR the greater is mismatch .The minimum VSWR which is corresponding to a perfect match is unity. The VSWR of antenna must be less than 2dB. The simulated result of VSWR of simple rectangular patch antenna in is shown in Fig 3 the values are 1.176 and 1.25 at frequency 8.7 and 7 GHz respectively.

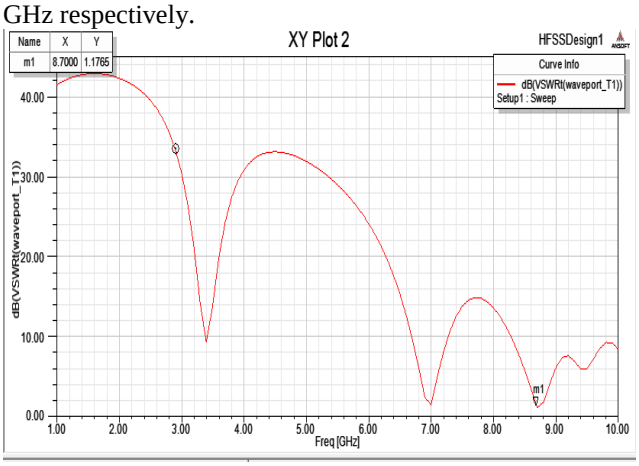

Fig. 3: VSWR of Simple Rectangular Patch Antenna

3) Gain:

The term of Antenna gain describe how much power is transmitted in direction of peak radiation to that of an isotropic source. The gain of proposed antenna is 2.08 dB as shown in Fig 4 and Fig 5.

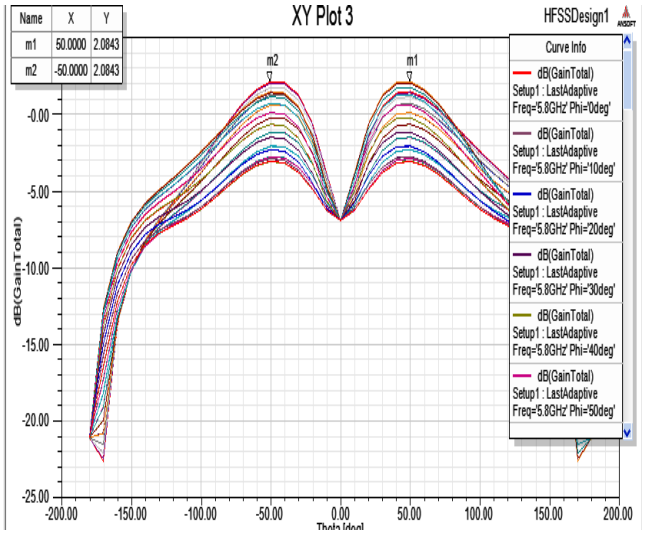

Fig. 4: Theta v/s Gain of Simple Rectangular Patch Antenna

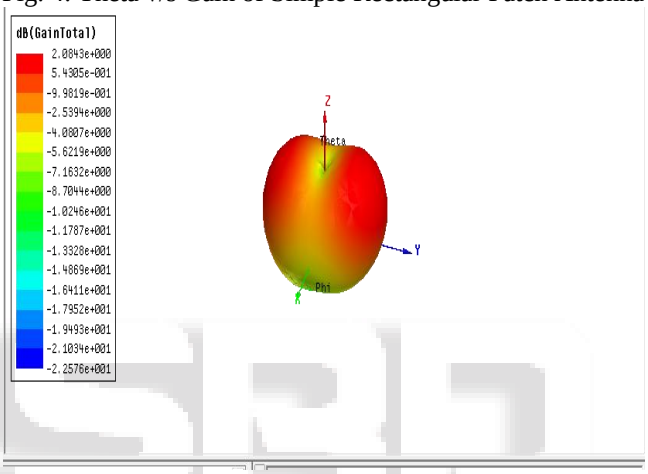

Fig. 5: Polar Plot of Simple Rectangular Patch Antenna

4) Radiation pattern:

Radiation pattern of an antenna is a plot of the far- field radiation properties of antenna as a function of spatial co-ordinates which are specified by elevation angle Θ and azimuthal angle Ø. It is the plot of power radiated from an antenna per unit solid angle which is nothing but the radiation intensity.

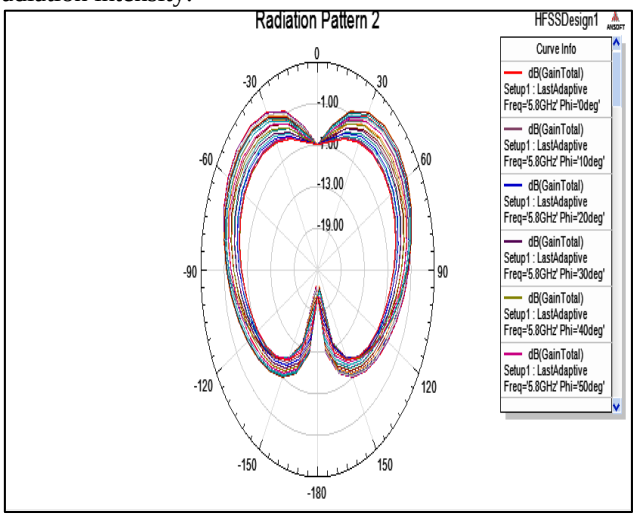

Fig. 6: Radiation Pattern of Simple Rectangular Patch Antenna

B. Slotted Rectangular Patch Antenna Result:

Due to numerous advantage of patch antenna and various technique to improve the performance of micro strip patch antenna slots are used to enhance the Bandwidth of proposed antenna .The dimension of patch can be reduce by increasing the slots and antenna get operate at multiple frequency

1) Return loss:

The return loss of slotted patch antenna gets decrease as compare to simple rectangular patch antenna. The return loss of antenna is -29.7dB at the resonant frequency of 8.6 GHz as shown in Fig 7.

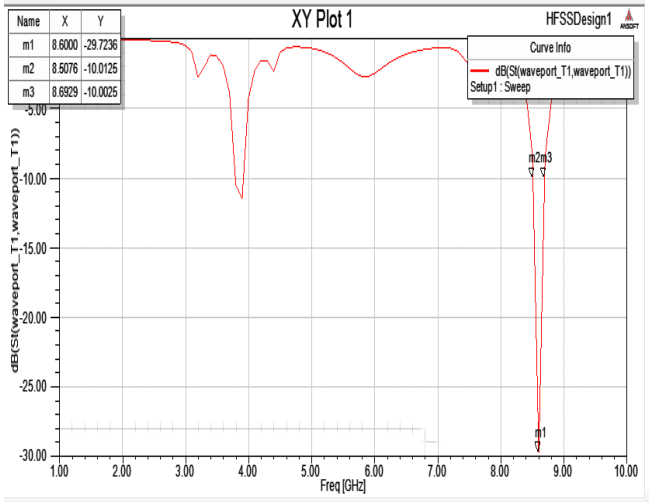

Fig. 7: Return Loss of Slotted Rectangular Patch Antenna

2) VSWR:

The value of VSWR is **0.56dB** at the frequency of 8.6 GHz as shown in Fig 8. The minimum VSWR which corresponding to a perfect match is unity

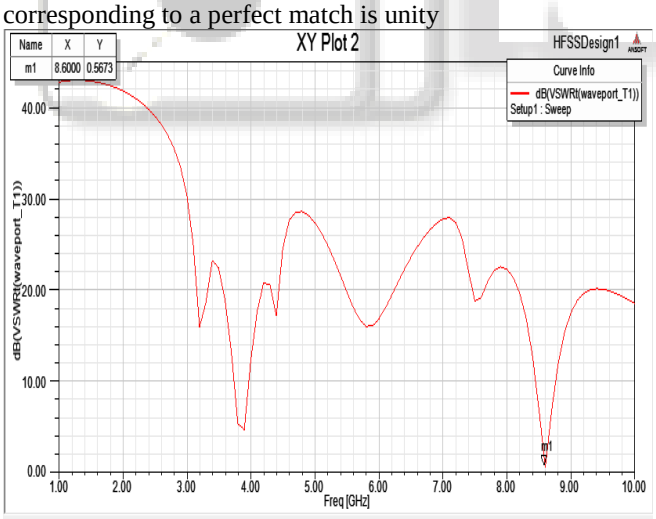

Fig. 8: VSWR of Slotted Rectangular Patch Antenna

3) Gain:

The gain of antenna is 3.23dB which is shown in Fig 9 and Fig 10.

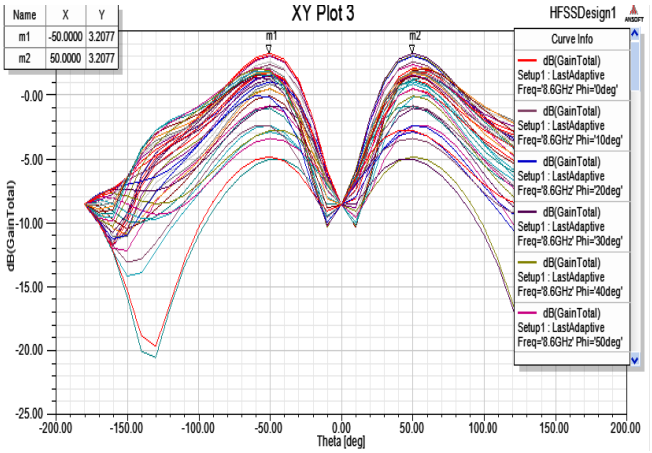

Fig. 9: Theta v/s Gain of Slotted Rectangular Patch Antenna

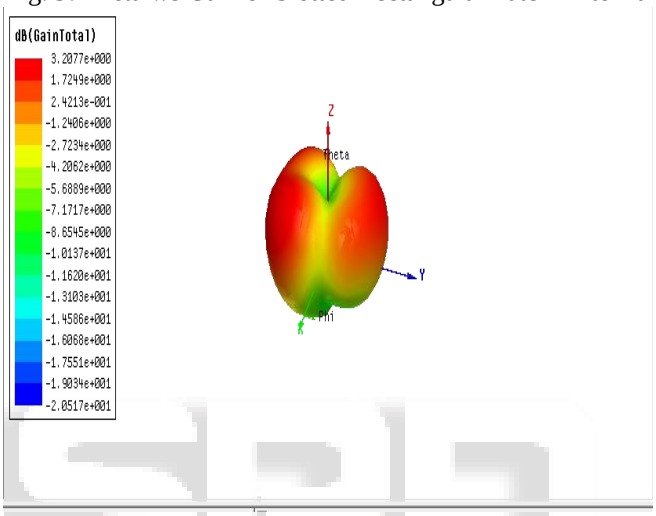

Fig. 10: Polar Plot of Slotted Rectangular Patch Antenna

4) Radiation Pattern:

The radiation pattern of Slotted Rectangular Patch Antenna is shown in Fig 11.

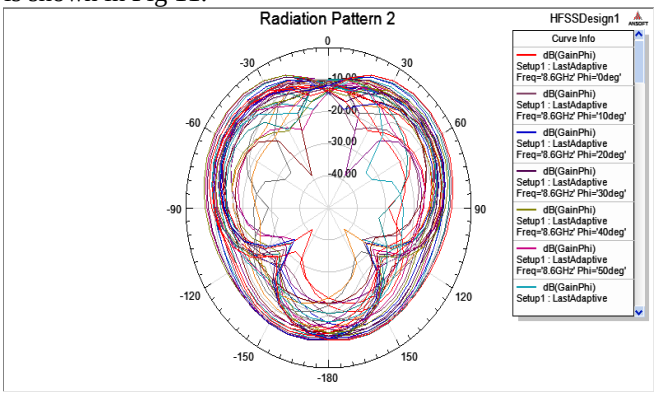

Fig. 11: Radiation Pattern of Slotted Rectangular Patch Antenna

C. Slotted Rectangular Patch Antenna with DGS:

DGS is realized by introducing a shape defected on a ground plane thus will disturb the shielded current distribution depending on the shape and dimension of the defect .The disturbance at the shielded current distribution will influence the input on the ground side, and the impedance and the current flow of the antenna. It can also control the excitation and electromagnetic waves propagating through the substrate layer. DGS is any defect etched in the ground plane of the micro strip can give rise to increasing the effective capacitance and inductance. DGS have the

characteristics of stop band slow wave effect and high impedance.

1) Return loss:

The proposed antenna used for multiband frequency operation. The value of return losses are -30dB and -23.5dB at resonance frequency of 10.2 GHz and 15.6 GHz respectively as shown in Fig 12. The bandwidth of proposed antenna is 1 GHz (9.7-10.7).

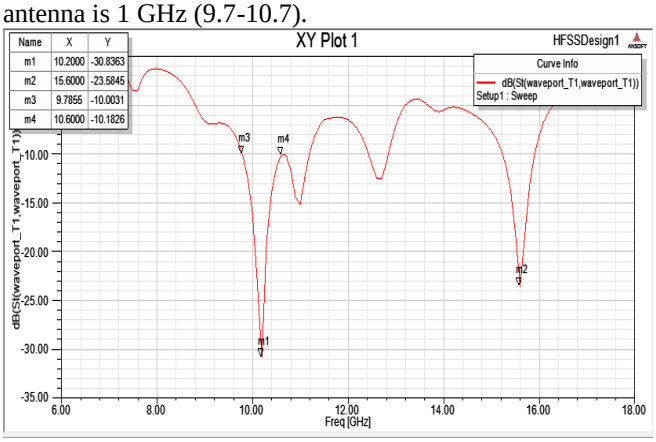

Fig. 12: Return Loss of Slotted Rectangular Patch Antenna with DGS

2) VSWR:

The VSWR of a patch antenna is less than -2dB accepted. The value of VSWR is **0.49dB** at the frequency of 10.2GHz which is less than 2dB which is shown in Fig 13

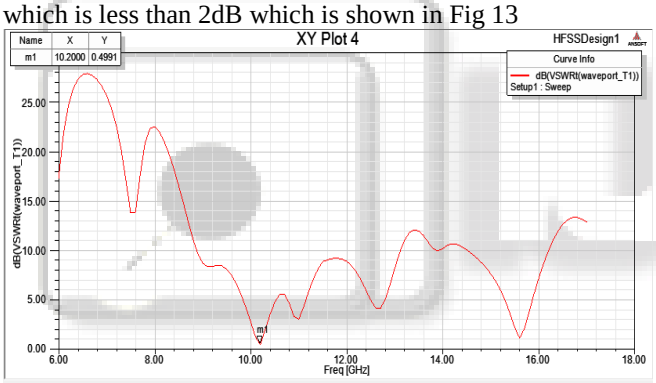

Fig. 13: VSWR of Slotted Rectangular Patch Antenna with DGS

3) Gain:

The term of antenna gain describe how much power is transmitted in direction of peak radiation to that of an isotropic source. The gain of antenna is 6.4dB as shown in Fig 14 and Fig 15.

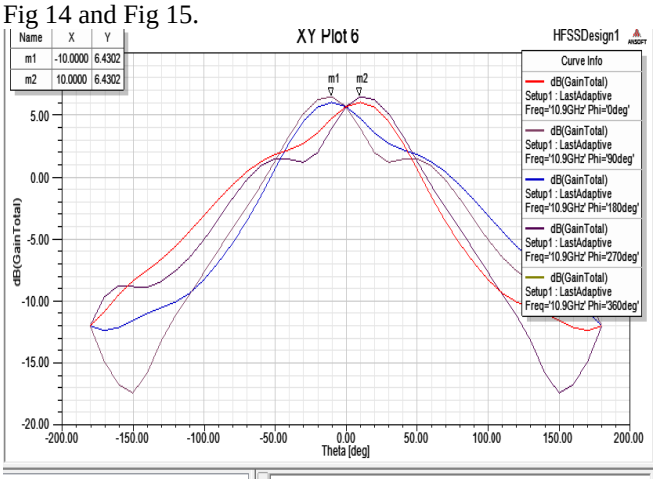

Fig. 14: Theta v/s Gain of Slotted Rectangular Patch Antenna with DGS

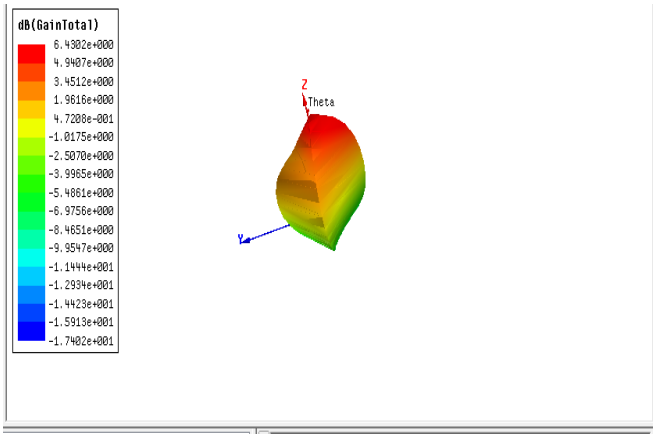

Fig 15: Polar Plot of Slotted Rectangular Patch Antenna with DGS

4) Radiation pattern:

Radiation pattern of an antenna is a plot of the far- field as shown in Fig 16.

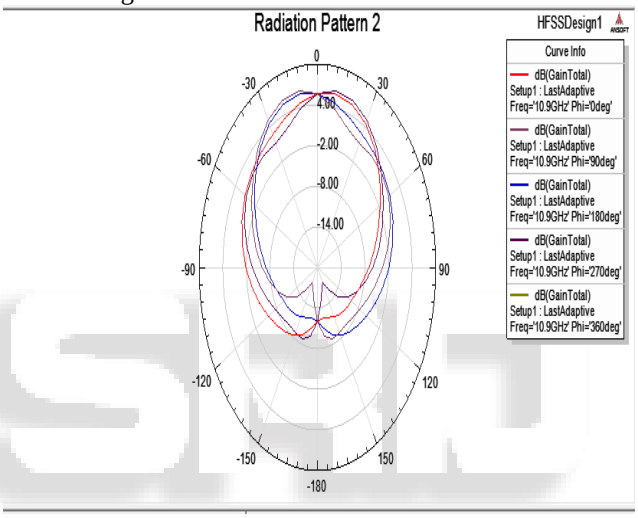

Fig 16: Radiation Pattern of Slotted Rectangular Patch Antenna with DGS

III. CONCLUSION AND DISCUSSION

In all design we use the co- axial feed. The plot of return loss shows that antenna can operate at multiband frequency. With the help of snapshots, an effort is made to provide a meticulous description of the simulation of those structures in HFSS. The comparison of results of simple rectangular patch antenna, slotted rectangular patch antenna and slotted rectangular patch antenna with defective ground structure (DGS) by using HFSS (High Frequency Structure Simulator) shown in Table 1.The various parameter of an antenna such as scattering parameter (return loss), voltage standing wave ratio (VSWR), gain and return loss is shown in Table 1.

Name of antenna	Return loss(dB)	VSWR(dB)	Gain (dB)
Simple rectangle patch	-23.5	1.1	2.08
Slotted patch antenna	-29.7	0.5	3.2
Slotted patch antenna with DGS	-30.8	0.49	6.43

Table 1

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