DESIGN AND ANALYSIS OF MICROSTRIP ANTENNA WITH SWASTIK AND SYMMETRIC L SHAPED SLOTS USING DGS FOR X BAND APPLICATIONS

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Abstract: A small printed microstrip antenna with swastik and symmetric L shaped slots using DGS for X - band applications ranging from 8 GHz to 11.5 GHz is suggested in this paper. The overall size of the antenna is 16mm× 12mm x 1.6mm simulated on FR4 substrate using HFSS. The suggested antenna consists of swastika and L shaped slots on front of the rectangular patch of size 8 mm x 10 mm. The bottom corners of size 1mm x 1mm are cut from the patch. On the rear side it is stepped ground with a slot of size 0.5 mm x 7 mm. The design parameters and the performance of the suggested antenna are analyzed by using HFSS.

IndexTerms – **DGS**, **swastik slot, L shaped slots, X band, HFSS**

I. INTRODUCTION

With the fast expansion of present Wireless Communication Technology, microstrip antennas are attracting many researchers [1]. Though printed Microstrip antennas are having advantages of simple geometry, ease of manufacture and little expensive, they suffer from drawbacks of narrow bandwidth and low gain [3]. X band is used in radar applications like single polarization, dual polarization, synthetic aperture radar and phased arrays and X band radar frequency sub-bands are used in civil, military, and government organizations for weather monitoring , air traffic control, maritime vessel traffic control, defense tracking and vehicle speed revealing for law enforcement. Many techniques are there in the literature to provide X band microstrip antennas which include bow tie antenna [3], using circular patch [4], using nine element quasi yagi antenna [5], using dielectric resonator [6], having two slots on the ground plane [7], using fractal patterned iris loaded cross dipole slot [8] and having two dielectric resonators coupled to an S-shaped slot [9], Single Band-Notched UWB Square Monopole Antenna with Double U-slot and Key Shaped Slot[11].

The aim of this paper is to suggest design and analysis of microstrip antenna with swastik and symmetric L shaped slots simulating with Ansoft High-Frequency Structure Simulator (HFSS) software [10], to cover applications of communication engineering ranging from 7 to 11.2 GHz in X band, radar applications from 8 to 12 GHz in X band, and to cover X band uplink frequency band from 7.9 to 8.4 GHz as assigned by the International Telecommunications Union (ITU). The microstrip antenna that is suggested is with miniaturized size and covering X band applications.

II. MODEL AND GEOMETRY OF THE PROPOSED ANTENNA

The schematic diagram of the suggested microstrip antenna is shown in Fig. 1. The antenna uses FR4 substrate of dielectric permittivity εr=4.4, and thickness h=1.6 mm having dimensions of 12x16x1.6 mm^3. A rectangular patch of dimensions 10x8 mm^2 is printed on one side and partial ground on other side. Two L slots with a swastik shaped slot are etched on the patch. Microstrip line feeding is used with dimensions of width 2 mm and length 7mm to achieve impedance matching. Dimensions of slots and ground were optimized at initial stage to get a wider bandwidth using HFSS software simulation.

A Defected Ground Structure (DGS) with stepped slots is printed on the bottom surface of the FR4 substrate. Length of the ground Lg is 3.5 mm and width is same as of the substrate (12mm). The slot in the ground has the dimensions Lgs = 0.5 mm and Wg1 = 7 mm. The structure is simulated in HFSS. All the dimensions are given in Table 1.

The type of feed is microstrip line feed as it is one of the easier methods to fabricate and can be considered as an extension of patch. The position of the strip is normally at the half of the width of patch in the direction of X axis.

The width and length of the patch are calculated at fr = 10GHz [2]. Initially the optimization is in the dimensions of slots, patch and partial ground to obtain better wide band characteristics. The optimized dimensions of the suggested antenna for front view and rear view are shown in Fig. 2.

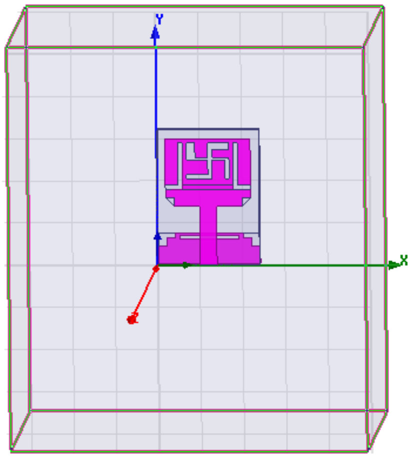
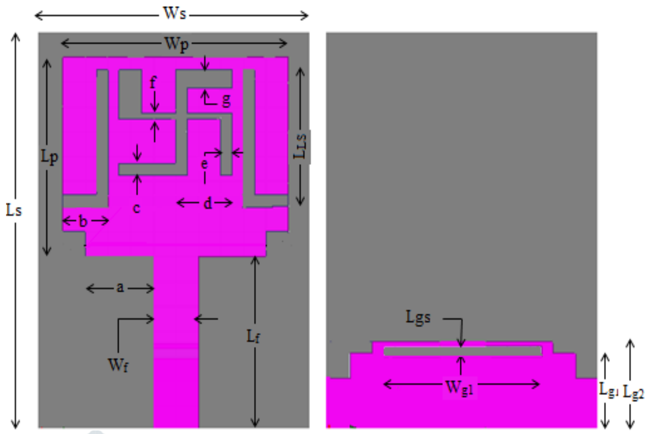


Figure.1. Schematic diagram of suggested antenna



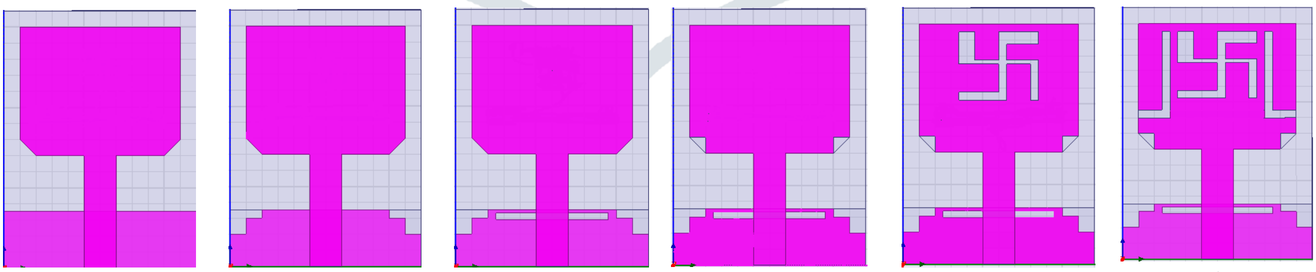
(a) (b)

Figure.2. Dimensions of suggested antenna
(a) Front view (b) Rear view

TABLE 1. Optimized dimensions of the proposed antenna

Parameter	Ws	Ls	Wp	L_{LS}	Lp	W_f
Value (mm)	12	18	10	5.5	8	2
Parameter	L_f	a	b	c	d	e
Value (mm)	7	3	2	0.5	2.5	0.5
Parameter	f	g	Lgs	W_{g1}	L_{g1}	L_{g2}
Value (mm)	0.25	0.75	0.5	7	3	3.5

Design evolution of the suggested antenna is shown in Fig. 3. With truncated corners at the bottom of the patch, without any steps on the ground and without any slot in the ground as shown in Fig. 3a, the operating frequency found to be 6.8 to 11.4 GHz without any frequency notching. When the steps are cut in the ground as shown in Fig. 3b, the lower operating frequency has come down by 300 MHz. With the introduction of the rectangular slot as shown in Fig. 3c, it is found that no major change in the parameters. With the bottom truncations changed to square cuts as shown in Fig. 3d, no major change in the parameters can be found. Further with the introduction of swastik slot on the radiating patch as shown in Fig. 3e, frequency notch from 9.1 to 9.6 GHz is observed. Finally to get a frequency range in the X band from 8 to 11.5 GHz, two L shaped slots are introduced as shown in Fig. 3f.



(a) (b) (c) (d) (e) (f)

Figure.3. Design evolution of suggested antenna

Variation of operating frequency and frequency notching parameters from Fig. 3a to Fig. 3f are summarized in the Table 2.

TABLE 2. Variation of frequency parameters with introduction of L and swastik shaped slots

Fig. 3	Operating Frequency Range (GHz)	Frequency Notching	Modification of Patch/Ground
(a)	6.8 – 11.4	No Frequency notching	Bottom corners of rectangle are cross cut and no steps in ground
(b)	6.5 – 11.5	No Frequency notching	Further steps are introduced in ground
(c)	6.7 – 11.5	No Frequency notching	Further rectangular slot is introduced
(d)	6.6 – 11.2	No Frequency notching	Further bottom corners of rectangle are square cut
(e)	6.6 – 11.5	Frequency Notch from 9.1 – 9.6 GHz	Further swastik slot is introduced
(f)	8 – 11.5	No Frequency notching	Further L shaped slots are introduced

III. RESULTS AND DISCUSSION

Fig. 4 shows the simulated reflection coefficient of this antenna according to the frequency. This result shows that the antenna has a bandwidth measured at -10dB ranges from 8 – 11.5 GHz for X- band applications.

Fig. 5 shows the simulated voltage standing wave ratio of the antenna according to the frequency. It is observed that the value of VSWR in the band is less than the value 2, which is sufficient to cover the band allocated by the FCC.

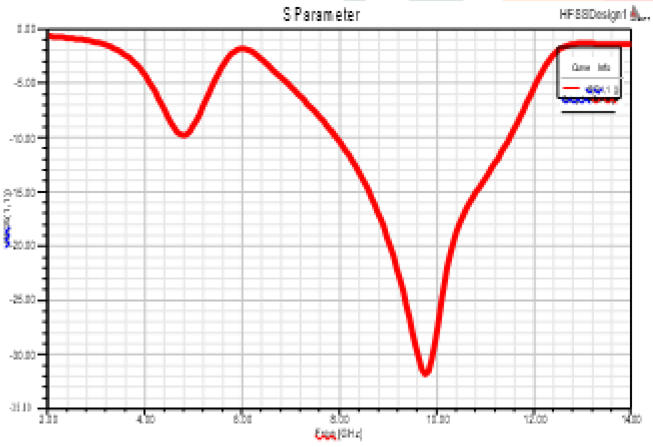


Figure.4. Simulated reflection coefficient S11 against frequency

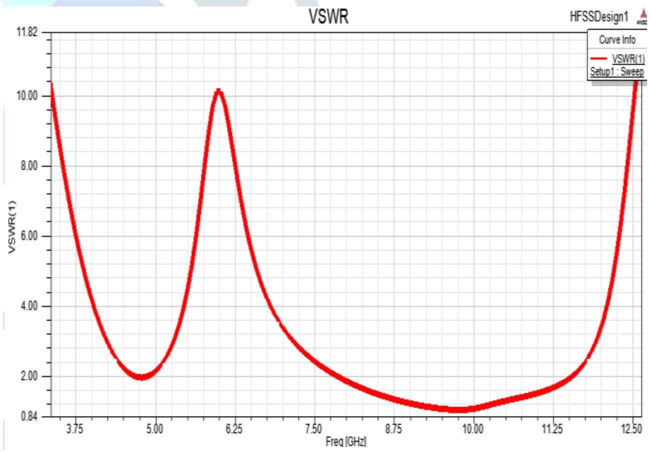


Figure.5. Simulated variation of VSWR

Fig.6 shows variation of reflection coefficient with the frequency for different values of "d". When the bottom two arms of the swastika are coming closer there is a difference in resonance values. Fig. 7 shows a graph between reflection coefficient Vs frequency for different values of L_{LS} (length of the L strips). As the length of both the strips is decreased, the lower operating frequency is getting shifted to higher side. Fig. 8 shows the variation of reflection coefficient with the frequency for different values of length of the slot present in the ground (Wg1). As the length of the slot is decreased, there is a change in the operating frequency range.

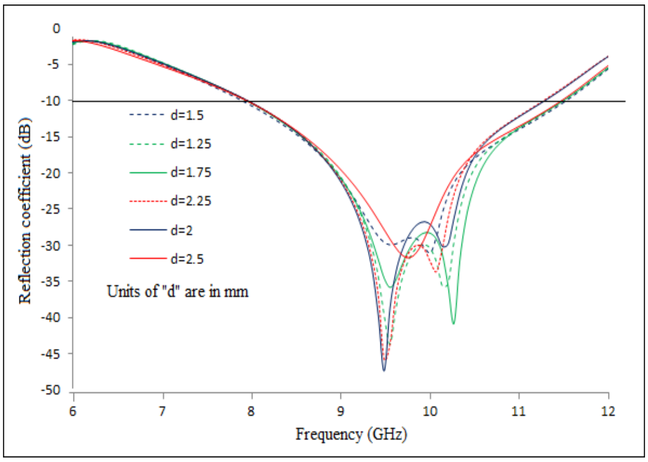


Figure.6. Simulated reflection coefficient S11 against frequency for different values of "d"

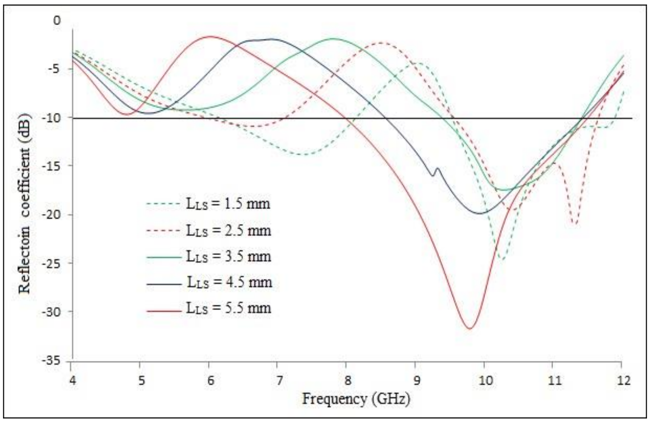


Figure.7. Simulated reflection coefficient S11 against frequency for different values of "L_{LS}"

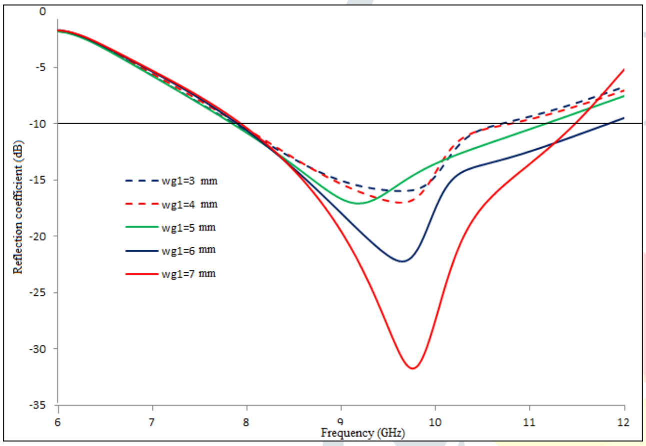


Figure.8. Simulated reflection coefficient S11 against frequency for different values of "Wg1"

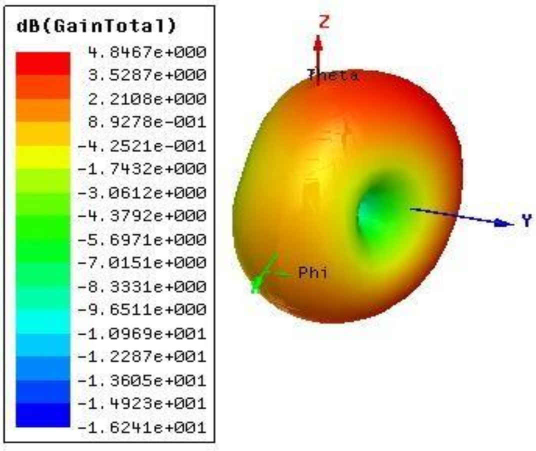


Figure.9. Simulated dB (Gain Total) at 10 GHz

The simulated dB (Gain Total) of the antenna is characterized by the variation of the radiation intensity at large distance in the different directions of space. The dB (Gain Total) at 10 GHz is shown in Fig. 9 as 4.84dB.

E-plane is the x-z plane (elevation plane) with some particular azimuth angle and the primary sweep will be theta. H-plane is the x-y plane (azimuth plane) with some particular elevation angle and the primary sweep will be Phi. Fig. 10 and Fig. 11 show the simulated two dimensional radiation patterns (E-plane, H-plane) of the antenna at 10 GHz. In the E-plane, the value of azimuth angle (Phi angle) φ of 0° and 90° with all theta values. In the H-plane, the value of elevation angle θ of 0° and 90° are taken into consideration.

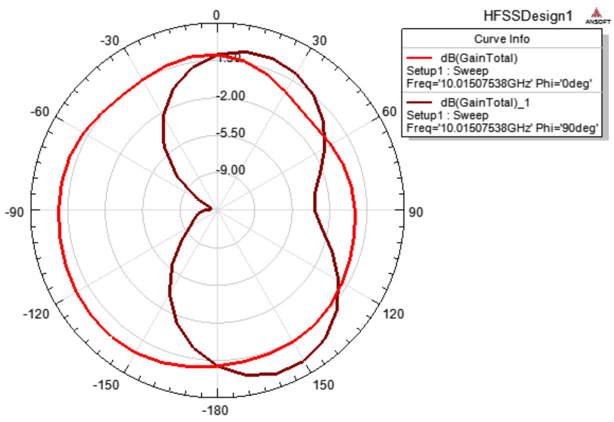


Figure.10. Simulated E- plane radiation patterns at 10 GHz

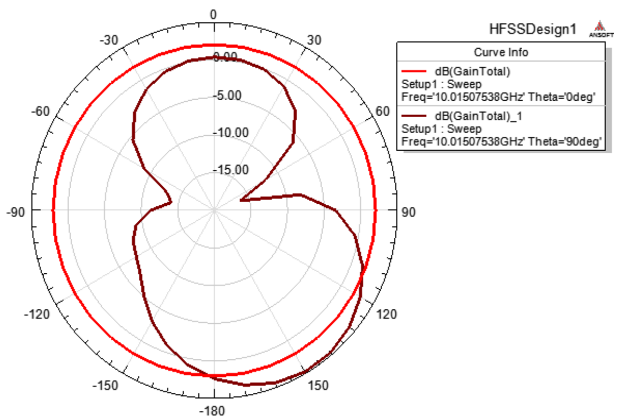


Figure.11. Simulated E- plane radiation patterns at 10 GHz

IV. CONCLUSION

In this paper, microstrip antenna with swastik and symmetric L shaped slots using DGS is proposed with the operating frequency range in X- band from 8 to 11.5 GHz below -10dB. The suggested antenna is simulated by using HFSS with good performance for the allocated X-band.

It is shown in this paper that, the parameters are changed with the combination of swastik and two L shaped slots and also with the stepped slotted ground. The radiation pattern of this antenna was analyzed. It has good stability over the entire frequency band required and that in the two principal planes E and H. The simulated gain is found to be a maximum of 4.84 dB at 10 GHz.

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