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Miniaturized Microstrip Patch Antenna with Defected Ground Structure for X band Applications

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Abstract: ***A dual band microstrip patch antenna with defected ground plane structure is proposed for x band applications particularly radar communication and SART. In order to increase the antenna parameters defected ground structure (DGS) is used. The designed antenna is compact in size with dimension 10×10×1.01mm³ with structure of defected ground. Multiple narrow slots are introduced in patch for getting two bands in X band region. The parameters of designed patch antenna such as return loss, VSWR and gain have been simulated using HFSS 13.0 simulator.***

Keywords: Microstrip patch antenna, DGS, X band, SART, Radar

1. Introduction

The X band ranges from 8 to 12GHz is specified by IEEE is used for radar applications. X band radar frequency sub bands are allocated for civil and military for weather forecasting, air traffic control and motor vehicle speed detection. Small and cheap antennas with high rotation speed are required for a very fair maximum range and better accuracy. So microstrip patch antennas are used as X band radar antennas since they are small in size, light weight, low cost, very high accuracy in manufacturing and easy to integrate with other circuits. But these types of antennas have some disadvantages such as narrow bandwidth and low gain. In order to overcome these structure of defected ground plane is introduced. DGS structure is realized by etching simple shape from the ground plane. DGS disturbs the distribution of current in the ground plane cause the defect in the ground. Due to this disturbance there will be some changes in transmission line paramteres such as capacitance and inductance.

In this paper a novel and miniaturized microstrip patch antenna with defected ground structure is designed for X band radar applications. The feeding of antenna is provided by an inset feed technique since it is easy to design and fabricate compared to other feeding technique.

The performance of the proposed antenna is optimized by introducing multiple slots on patch and DGS structure.

2. Antenna Design

The microstrip patch antenna with DGS parameters are calculated from the formulae given below.

1) Width of the patch:

$$W = \frac{c}{2 f_r \sqrt{\frac{(\varepsilon_r + 1)}{2}}} \qquad (1)$$

2) Effective dielectric constant:

$$\varepsilon_{reff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \qquad (2)$$

3) The actual length of the patch:

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

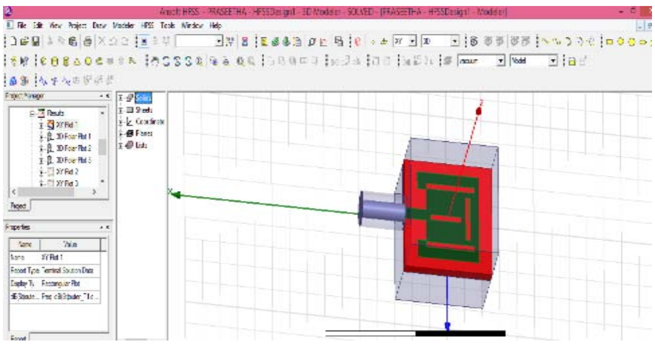
Where,

$$\Delta L = \frac{0.412h\,[\varepsilon_{eff} + 0.300]\left[\left(\frac{W}{h}\right) + 0.264\right]}{[\varepsilon_{eff} - 0.285]\left[\left(\frac{W}{h}\right) + 0.8\right]} \qquad (4)$$

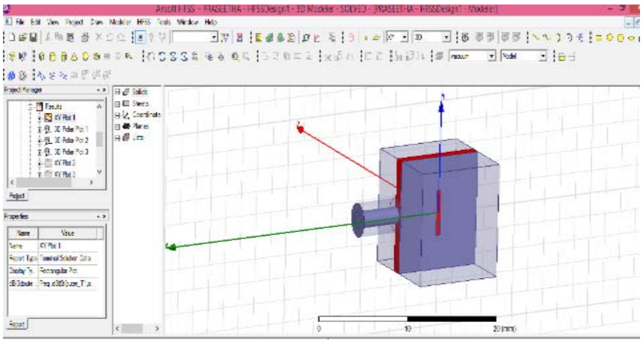
The proposed antenna structure is designed using FR4 substrate with 1.01mm thickness and dielectric constant 4.4 at resonant frequency 9.4GHz. After introducing narrow slots on patch the antenna is operated at dual frequency such as 9.4GHz and 11.6GHz both are in X band region.

3. Simulation Results

This designed antenna structure is simulated in HFSS 13.0 simulator software is given in fig.1.



a)



b)

Figure 1:a) The proposed antenna structure b) DGS structure on ground

After completing the simulation of the antenna structure, the results such as return loss, antenna gain and VSWR are figured given below.

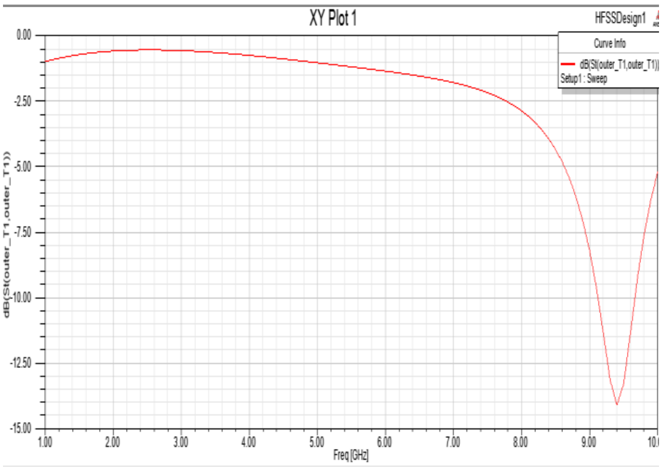


Figure 2: Return loss versus frequency

It is included that the return loss versus frequency of the antenna structure. This antenna structure gives return loss with -14.5dB at 9.4GHz. This parameter gives us the input-output relationship of an antenna system.

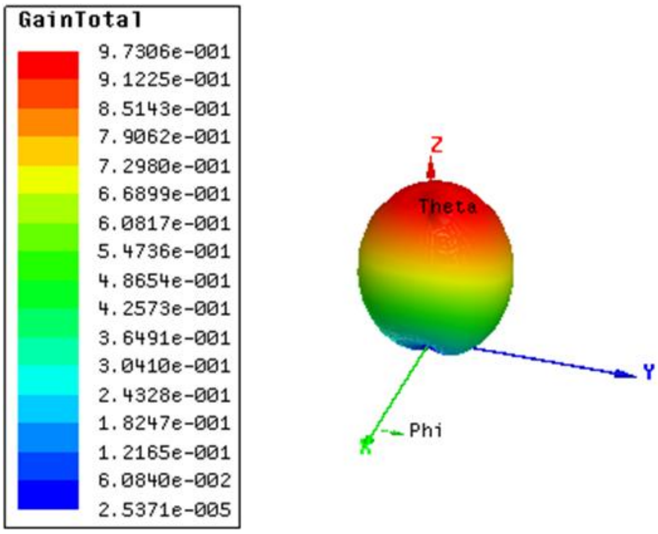


Figure 3: Antenna gain at resonant frequency 9.4GHz

It shows the 3D pattern with gain of 3.58dB for designed antenna structure at resonant frequency of 9.4GHz.

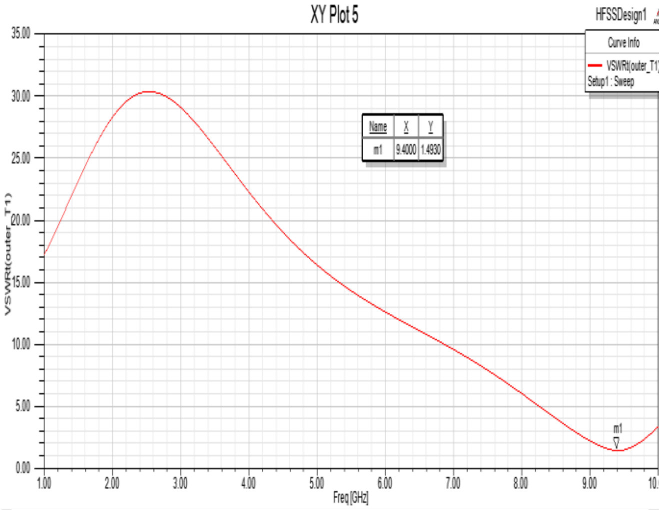


Figure 4: shows the VSWR of 1.4 for the designed antenna structure at 9.4GHz.

4. Conclusion

A miniaturized dual band microstrip patch antenna with DGS is designed and demonstrated using HFSS 13.0. The important antenna parameters at resonant frequency has been studied in this paper.The antenna proposed in this paper could be used in many applications. One area would be radar communications. The main issue in this area is weight and antenna lightness would be boon.The low profile antenna would allow for greater versatility in the antenna placement on radar. The antenna structure with DGS proposed in this paper is small in size low profile antenna that could be used in X band radar applications.

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