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Research Article

Designing and Analyzing the Defected Ground Triple-Band Microstrip Patch Antenna

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Abstract

This paper presents a triple-band microstrip patch antenna with defect in the ground plane. Defected ground structure perturbs the current distribution of ground plane and causes the antenna to resonate at three distinct resonating frequencies of 6.3GHZ, 8.5GHZ, 9.3GHZ, with fractional bandwidth 200MHZ and 1.2GHZ respectively. Antenna has an appropriate gain of 8.0698dB at resonating frequency of 9.3GHZ. The proposed antenna also has good radiation characteristics and VSWR below 2 over the operating bands. The antenna is simulated using Ansoft HFSS software. Taconic RF-35(tm) material is used for substrate with height 3mm. the designed antenna is found to be appropriate in C and X-band applications.

Keywords: *DGS; Microstrip antenna; Triple-band; Taconic RF-35(tm); HFSS*

1. Introduction

In the field of antenna engineering, microstrip patch antennas now find extremely prominent applications for transmitting and receiving electromagnetic waves. Because these antennas are low profile, they have the ability to integrate with printed and active devices (Keith *et al*, 1981; Herscovici, 1998; Orban *et al*, 2009; Silver, 2009). Nowadays the utility of microstrip antennas are not only bounded for single band operations but also scaled for triple band operations. Microstrip antennas have a considerable problem of narrow bandwidth and low gain. This problem can be reduced to some extent by defected ground structure. The effective inductance and capacitance can be increased by any defect which is etched off in the ground plane of the microstrip patch antenna. Till now, a lot of DGSs have been introduced and because of its varied applicability in microwave circuit designing, it has become one of the most popular areas of research (Weng *et al*, 2008). (Gurpreet *et al*, 2013) compared the performance of a G-shaped DGS with that of a simple microstrip patch antenna. Various parameters were considered and the results brought-in comparatively much improved performance in the proposed antenna with DGS. Besides, miniaturized microstrip patch antennas with DGS have also been proposed for wireless communication applications (Sakshi *et al*, 2012). The proposed antenna gave triple band with 2 separate impedance bandwidths for WLAN and the WIMAX bands. L-shaped DGS where-in staircase slots in ground and U-shaped slots on the substrate with CPW feeding mechanism have been used. Several other triple band antennas have been introduced such as presented by (Sami *et al*, 2013). They proposed a tri-band rectangular patch antenna that has been fabricated for WLAN and WIMAX applications. Tri-band was successfully achieved by appropriate loading using shorting elements and slots in a rectangular patch antenna. Experimental and simulated antenna results showed a good impedance matching ie; 5.8% at 2.4GHZ, 3.7% at 3.5GHZ and 1.57% at 5.7GHZ.

Similarly, (Kaur *et al*, 2014) proposed a microstrip patch antenna with the aid of microstrip feeding technique. A tri-band has been achieved with first band having mid-frequency 5.5GHZ and bandwidth 66MHZ useful for WIMAX applications. And the other two bands were 6.3GHZ and bandwidth 190MHZ, 6.8GHZ and bandwidth 102MHZ respectively which were proper for STM Link1 wireless application. Results were simulated using CST MWS 2010.

Also, an E-shaped rectangular patch antenna (Ramesh *et al*, 2013) that is able to operate on a triple-band 2.4GHZ, 4.6GHZ and 5.5GHZ has been introduced. Triple-band is obtained here by regulating the width between the two parallel slots in the rectangular patch. Dimensions were modified using CST MWS EM Simulator for maximum efficiency.

In this paper, design aspects of a microstrip patch antenna with defected ground structure for triple frequency operation are discussed. The designed

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antenna is simulated with the aid of HFSS simulator and analyzed for its desired performance.

2. Antenna Structure

The structure of the proposed antenna is shown in fig.1 and fig.2. Various parameters considered are indicated in Table-1.

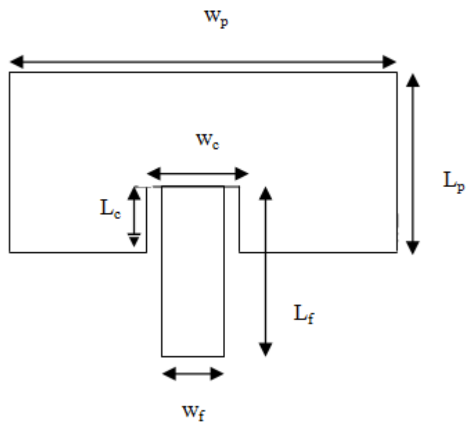


Figure 1 Geometry of the proposed antenna

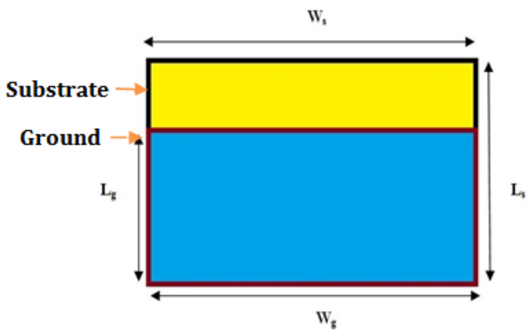


Figure 2 Proposed antenna with defected ground structure (upside down view)

Table1 Dimensions of the proposed defected ground antenna

Specifications	Dimensions(in mm)
substrate (L_s*W_s*h_s)	47*50*3
Ground(L_g*W_g)	35*50
Patch(L_p*W_p*h_p)	20*20*3
Feed(L_f*W_f*h_f)	15.5*3.588*3
Cut-out rectangle(L_c*W_c*h_c)	8*8*3

3. Results and Discussion

Taconic RF-35(tm) material has been used for substrate with height 3mm. The performance analyses has been carried out considering microstrip patch antenna with and without defected ground structure for the antenna parameters; return loss, VSWR, gain, surface current distribution, radiation pattern and directivity. In the figures given below, red color indicates graph for setup1 antenna with DGS and green color indicates setup2 graph for antenna without DGS.

A. Return Loss (S_{11})

The proposed antenna shows better return loss characteristics that is -17.8941dB, -30.2288dB and -33.8102dB at resonance frequency of 6.3GHz, 8.5GHz and 9.3GHz respectively. Improved return loss results could be made possible by using DGS technique as compared to antenna without DGS as shown in figure below. Increasing negative value of return loss implies good impedance matching w.r.t the reference impedance of 50ohms. Return loss can be further improved by using different feeding techniques.

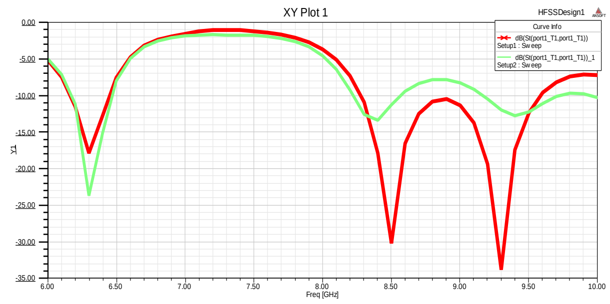


Figure 3 Return Loss Vs frequency of designed antenna

B. VSWR

The VSWR graph of proposed antenna shows the VSWR value is 1.2921, 1.0636 and 1.0416 at frequencies 6.3GHz, 8.5GHz and 9.3GHz respectively for antenna with DGS. VSWR values imply the impedance matching between the source and the feed is good, which is an essential requirement for the proper working of the antenna. VSWR value below 2 is successfully achieved for good antenna performance.

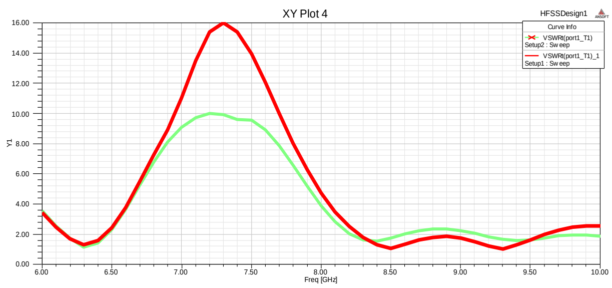


Figure 4 Measured VSWR values at distinct frequency points

C. Gain

Antenna gain tells how much of the power is radiated in a given direction. The designed antenna has a good gain of 8.0698dB at a resonance frequency of 9.3GHz as is understood by the red line graph, which means the antenna is more efficient at this frequency, while a low gain of 0.0396dB at 6.3GHZ and 0.7886dBat resonance frequency of 8.5GHz is realized. In contrast the antenna without defected ground structure as is visible from the green line, gives a good gain of 6dB at 9.3GHz and relatively lower values at 6.3GHz and 8.5GHz respectively.

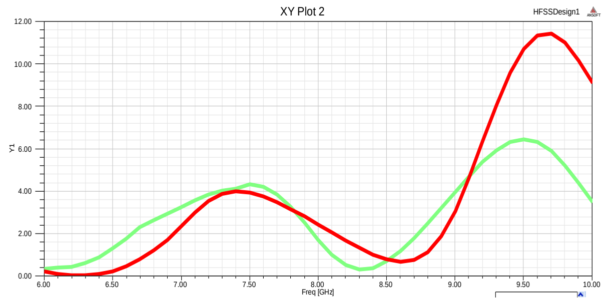
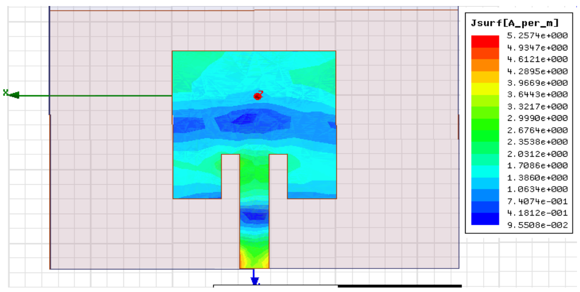


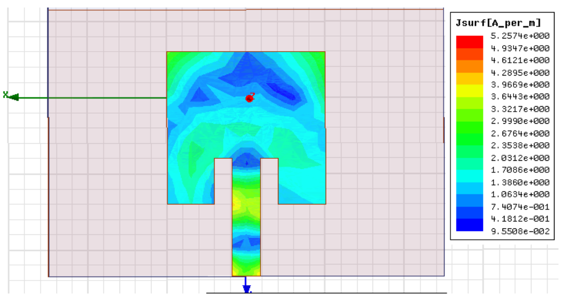
Figure 5 Gain Vs frequency of designed antenna

D. Surface Current Distribution

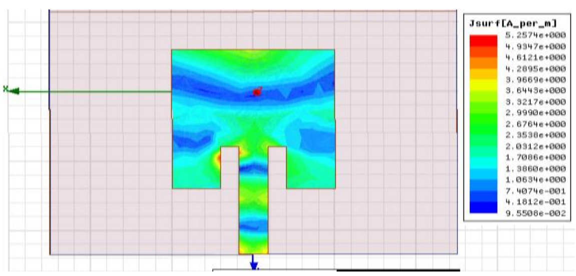
Figure.6 shows the surface current distribution in the designed rectangular patch antenna at the obtained resonance frequencies.



(a)



(b)



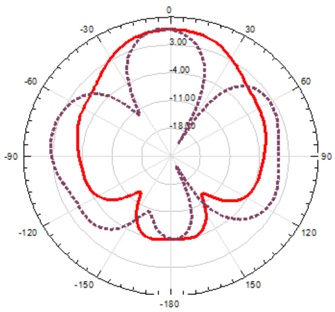
(c)

Figure 6 Current distribution at (a)6.3 GHZ, (b)8.5GHZ, (c)9.3GHZ

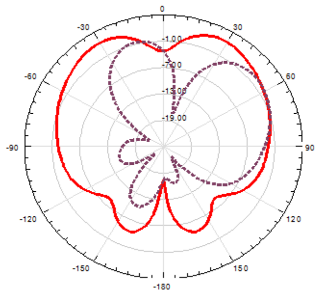
As can be seen from the figure.6(a), (b) and (c), the current is found to concentrate near the edges of the inset fed and patch and not the entire patch, which hence shows that the current flow is good. The current distribution can be changed by changing the dimensions of ground plane.

E. Radiation Pattern

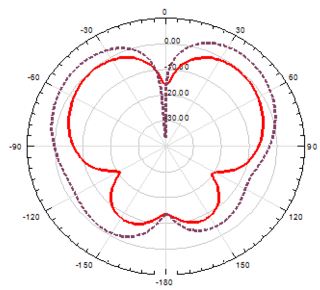
The 2D radiation patterns for the elevation and azimuthal plane respectively of the proposed antenna is given in fig.7. Radiation pattern is the graphical representation of the radiation properties of the antenna as a function of space. Radiation pattern describes how the energy is radiated out into the space by the antenna or how it is received. For the resonant frequencies 9.3GHZ and 6.3GHZ, the radiation pattern is bidirectional in the azimuthal plane and nearly omnidirectional in the elevation plane. Similarly, at 8.5GHZ, radiation pattern is omnidirectional in the azimuthal plane and bidirectional with 3 side lobes representing relatively weaker radiation in the elevation plane.



(a)



(b)



(c)

Figure 7 Radiation Patterns of designed antenna at (a) 9.3GHZ, (b)8.5GHZ, (c)6.3GHZ

F. Directivity

The directivity plot given below shows the maximum amount of radiation intensity that is equal to 9.5621 is achieved at resonant frequency of 9.7GHz. While a directivity value of 6.9982 at 9.3GHz, 0.9860 at 8.5GHz 0.0359 at 6.3GHz has been obtained.

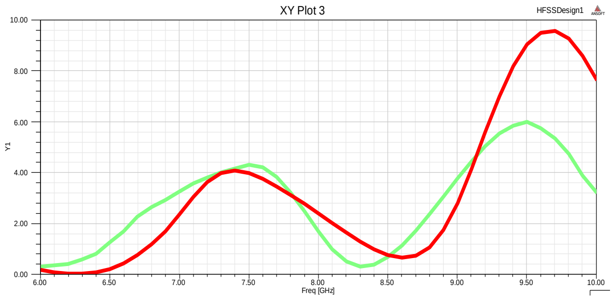


Figure 8 Directivity Vs frequency of designed antenna

Conclusion

The proposed defected ground triple band microstrip patch antenna shows that by optimizing ground plane, antenna is able to resonate at 3 frequencies ie; 6GHZ, 8.5GHZ and 9.3GHZ. The designed antenna is appropriate for C and X-band applications. The obtained VSWR is below 2 and radiation characteristics are also appropriate. Gain, return loss, surface current distribution and directivity parameters have also been discussed in this work. The multiband behavior of antenna can be procured by simply loading the slots and notches in the ground plane and on the patch. Different feeding techniques can also be used for increasing the efficiency of antenna. Modifying the dimensions of ground plane or patch or using different substrate material for designing the antenna.

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