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MULTIBAND SLOTTED APERTURE ANTENNA WITH DEFECTED GROUND STRUCTURE FOR C AND X-BAND COMMUNICATION APPLICATIONS

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ABSTRACT

A series of simulations and investigations of slotted microstrip patch antennas with defected ground structure are presented in this work. The analysis includes the effects of varying the dimensions of the feed line, patch and the ground plane. All the investigated antennas are showing good bandwidth enhancement with microstrip feeding method. In this study, different shapes of slots, in U-shape and L-shape are taken in to the account. Among all the examined antennas, proposed slot microstrip patch antenna of dimensions 15X20X1.6 mm with additional slot apertures of U and L combination is providing excellent radiation characteristics at lower frequency band of communication systems.

Keywords: *Communication Systems, Defected Ground Structure (Dgs), Multiband Antenna, Slotted Aperture, Micro Strip Patch Antenna (Mspa).*

1. INTRODUCTION

The patch antenna is one of the excellent candidates for portable wireless devices nowadays, simply because of its low profile, light weight and low cost. However, the requirement of frequency bandwidth is becoming greater in present wireless communications systems. This contradicts the inherent narrow impedance bandwidth (BW) of patch antennas. Hence many researchers are focusing on the development of impedance bandwidth enhancement techniques for patch antennas. These techniques include the employment of a thick substrate (BW<10%) [1], parasitic patches either in stack or coplanar geometry (BW<20%) [2], U-shape slot patch (BW>30%) [3, 4], L-shape probe feeding method (BW>30%) [5, 6] and shorted trapezoidal microstrip patch coupled to a hook-shape probe
(BW~45%) [7].

Presently, wider bandwidth is required for the increasing demand of modern wireless communication system applications [8]. Generally each antenna performs its function at a single frequency, so different antennas require for different applications that will cause a restricted place and space problems [9]. Considerable research effort has done into the design of multiband antennas with narrow bandwidth. Now people are focusing towards the design and development of multiband antennas with wider bandwidths at their resonant frequencies with special techniques like defected ground structures and electromagnetic band gap structures [10-12].

A Microstrip line placed on DGS shows stop band(s) in its transmission characteristics. It is of interest to find out why. Both qualitative and quantitative analyses are essential to understand the working principle of DGS. A defect indeed changes the current distribution in ground plane of Microstrip line, giving rise to equivalent inductance and capacitance. Thus a DGS behaves like L-C resonator circuit coupled to the micro strip line. When an RF signal is transmitted through a DGS—integrated Microstrip line, strong coupling occurs between the line and DGS around the frequency where the DGS resonates. Obviously, it happens if the transmitted signal covers the resonant frequency of the DGS, and the most of the signal is stored in the equivalent parallel LC resonator. This indirectly indicates the band stop feature of a defect in a ground plane. The LC parameters are determined

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by the shape and size of the defect geometry [13-14].

This paper aims the design of such modern multiband antenna with considerable gain and high bandwidth by employing slots on the patch surface and defected ground structure on bottom side.

2. ANTENNA DIMENSION

Initially a basic microstrip patch antenna on FR4 substrate was designed with defected ground structure as shown in the Figure 1(a). To increase the electrical length of the antenna and to reduce the resonant frequency, an U-slot model is constructed as shown in Figure 1(b). Figure 1(c) consists of double U-slot aperture antenna model with modification in iteration 2. Finally proposed model of U and L-slot combination with defected ground structure is designed to operate the antenna at lower frequency band also as shown in Figure 1(d). The dimensions of the final proposed model are as follows. Length of the patch Lp=10mm, Width of the patch Wp=7.5mm, Substrate material used=FR4 Epoxy with dielectric constant 4.4, Substrate height H=1.6mm, Length of the ground plane Lg=15mm, Width of the ground plane Wg=5mm, Length of the feed line Lf=7.2mm, Width of the feed line Wf=2mm. Figure 2 shows the proposed slotted aperture antenna with dimensions.

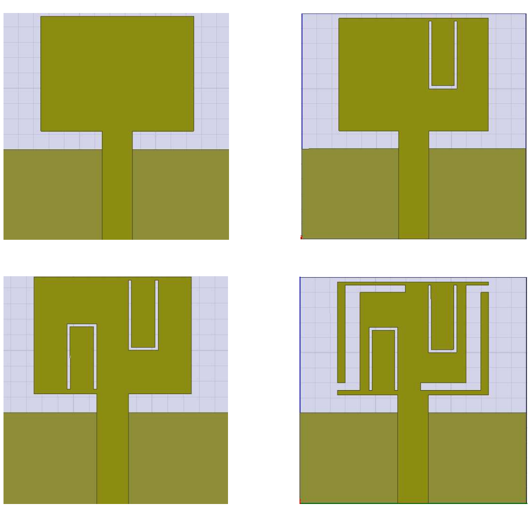

Figure 1 : Slotted MSP Antenna, (a) Iteration 1, (b) Iteration 2, (c) Iteration 3, (d) Iteration 4

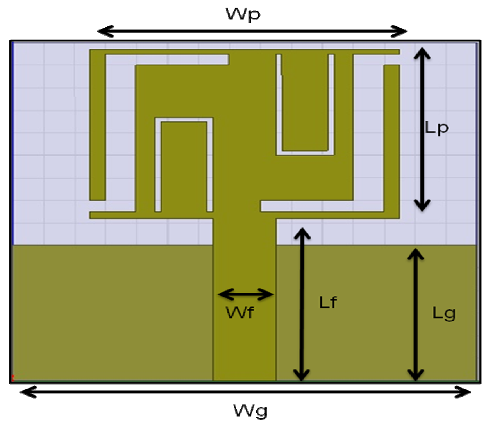

Figure 2 : Proposed Slotted Aperture Antenna

3. RESULTS AND DISCUSSION

Figure 3 shows the return loss curve for the designed models. Return loss is the measure of reflected energy from a transmitted signal which is commonly expressed in decibels (dB). Larger the value, lesser is the energy reflected. It is been observed that iteration 1-3 are working in the x-band with high bandwidth, but iteration 4 is showing operational characteristics at lower band also. Generally most of the portable communication systems work in the range of S and C-bands. Here we can observe the proposed model resonance at C and X-band with considerable bandwidth.

The input impedance of an antenna is the ratio of the voltage V and current I at the port of the antenna when the antenna is isolated in free space, that means without the presence of other antennas or scattering structures. Thus, this is sometimes referred to as the isolated input impedance. Since voltage and current are not practical quantities at radio frequencies (RFs), the input impedance is usually determined from the reflection coefficient and the characteristic impedance of the transmission line connected to the port of the antenna. Figure 4 shows the impedance plot with change in frequency. In the operating band of C and X, we can observe the impedance values are nearer to 50 ohms.

To optimize the dimensions of the antenna before fabrication, a parametric analysis is done for better understanding of the antenna behavior. Figure 5 to 10 shows the parametric analysis results of the proposed slotted aperture defected ground structured antenna with change in the length of the patch, width of the patch, length of ground plane,

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Figure 3 : Frequency Vs Return Loss Curve For Different Iterations

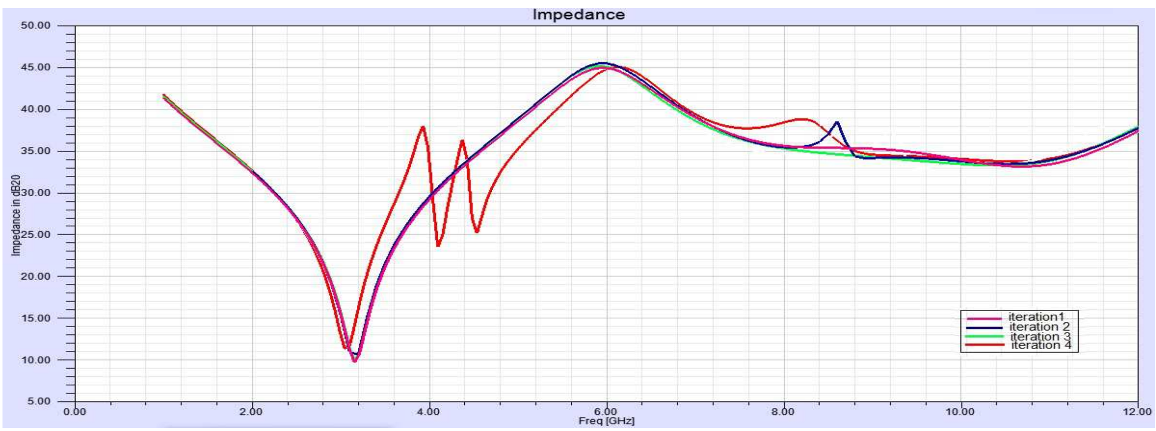

Figure 4 : Frequency Vs Impedance Of Different Iterations

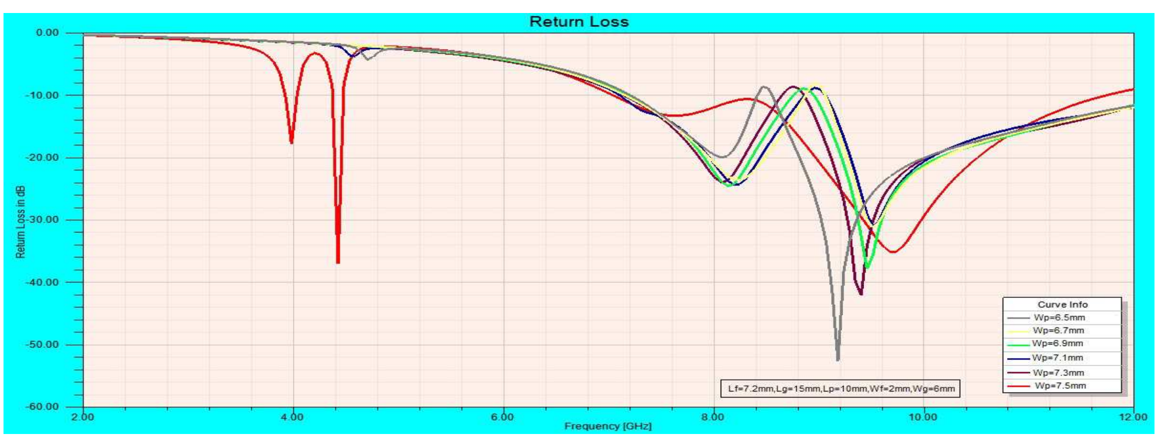

Figure 5 : Parametric Analysis With Change In Wp

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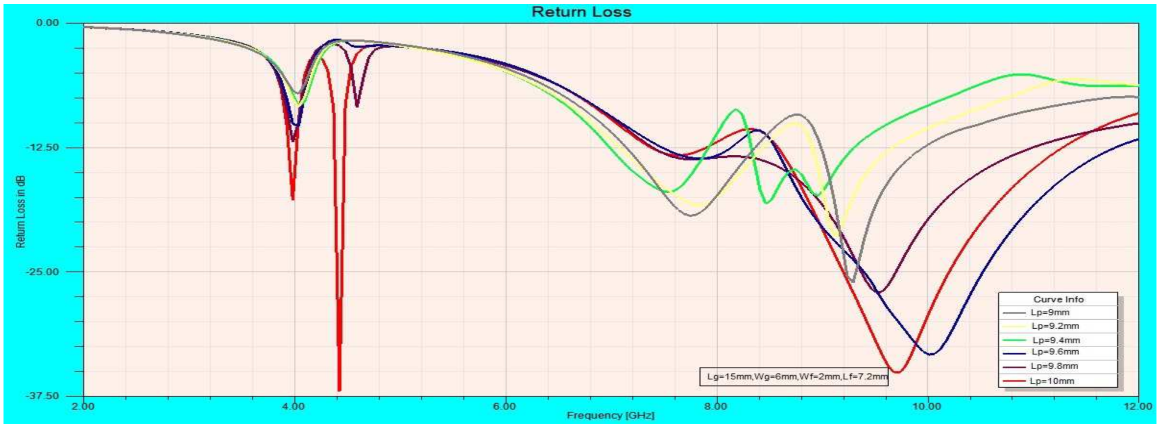

Figure 6 : Parametric Analysis With Change In Lp

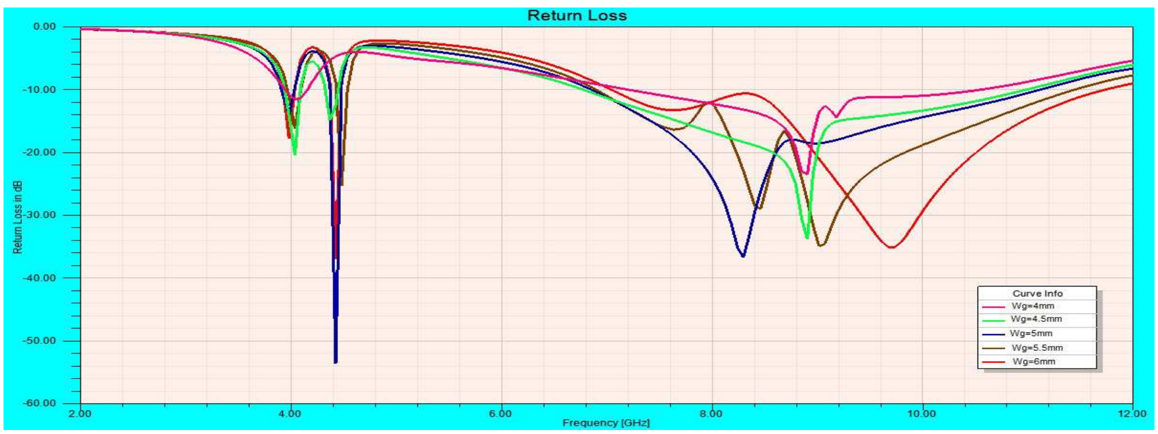

Figure 7 : Parametric Analysis With Change In Wg

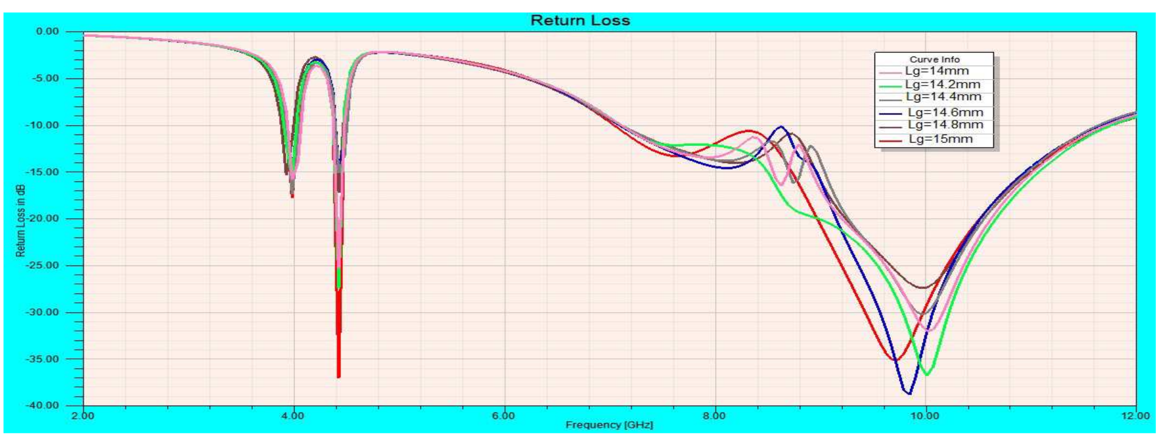

Figure 8 : Parametric Analysis With Change In Lg

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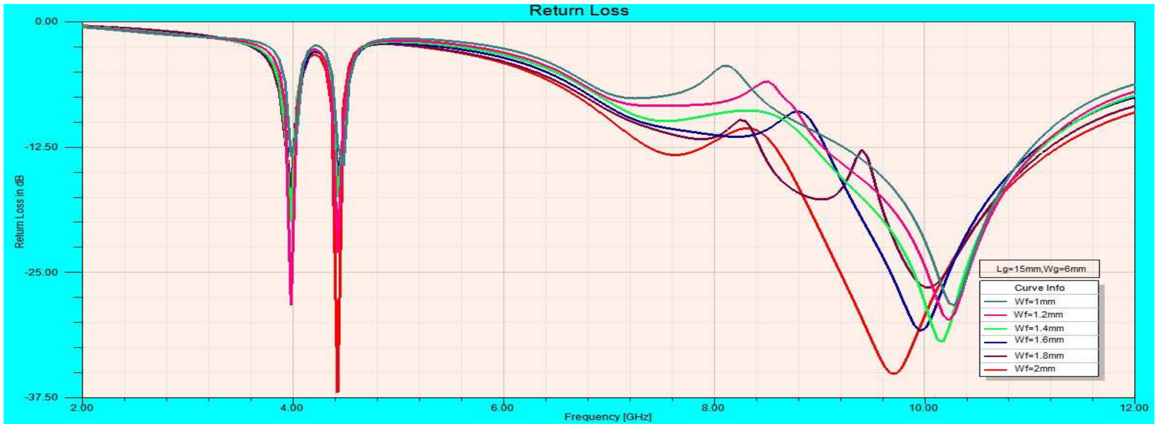

Figure 9 : Parametric Analysis With Change In Wf

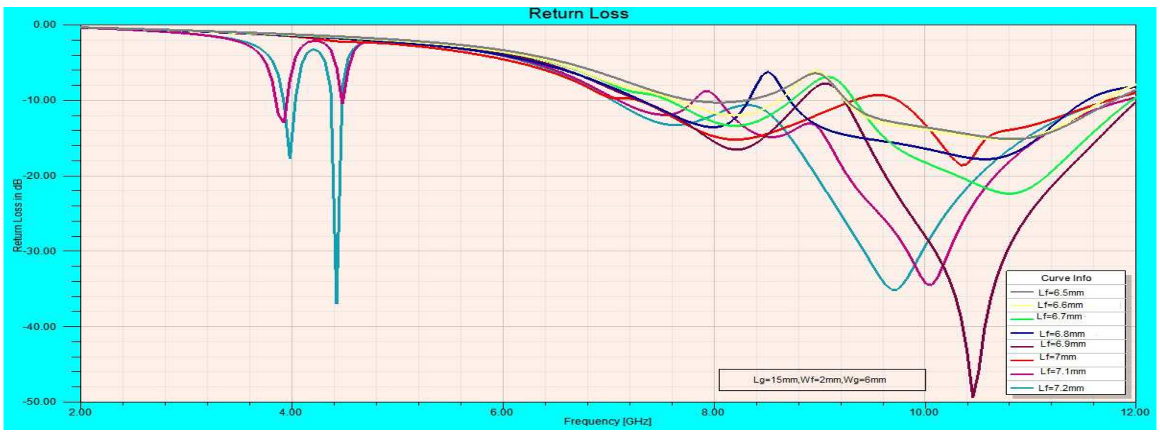

Figure 10 : Parametric Analysis With Change In Lf

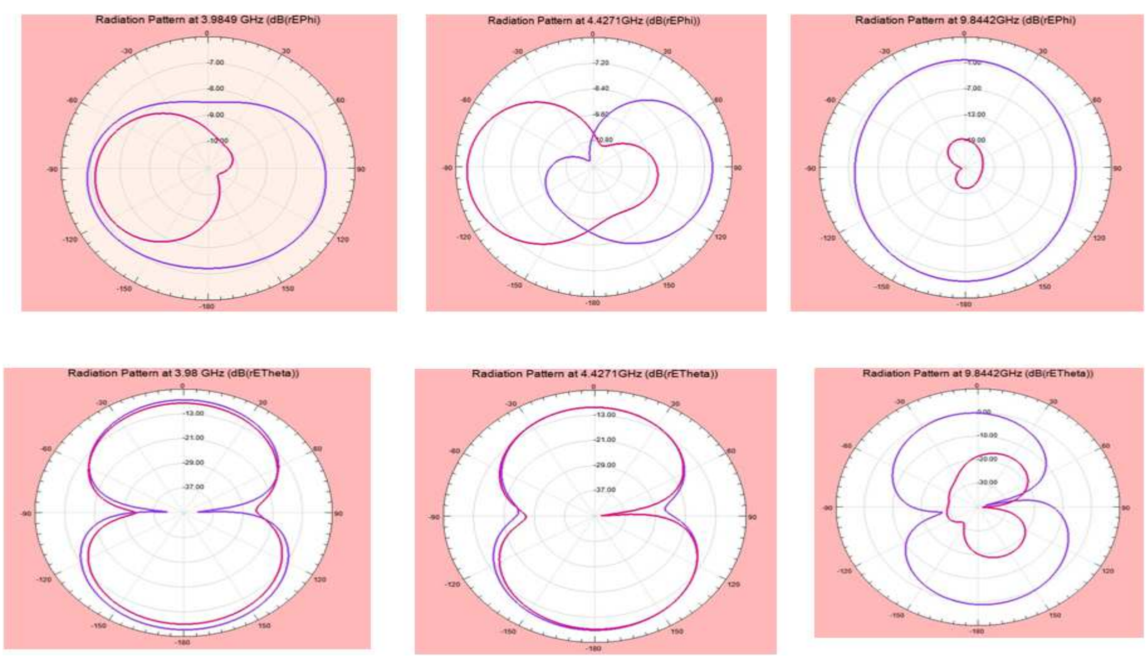

Figure 11 : Radiation Pattern Of Proposed Model In E And H-Plane

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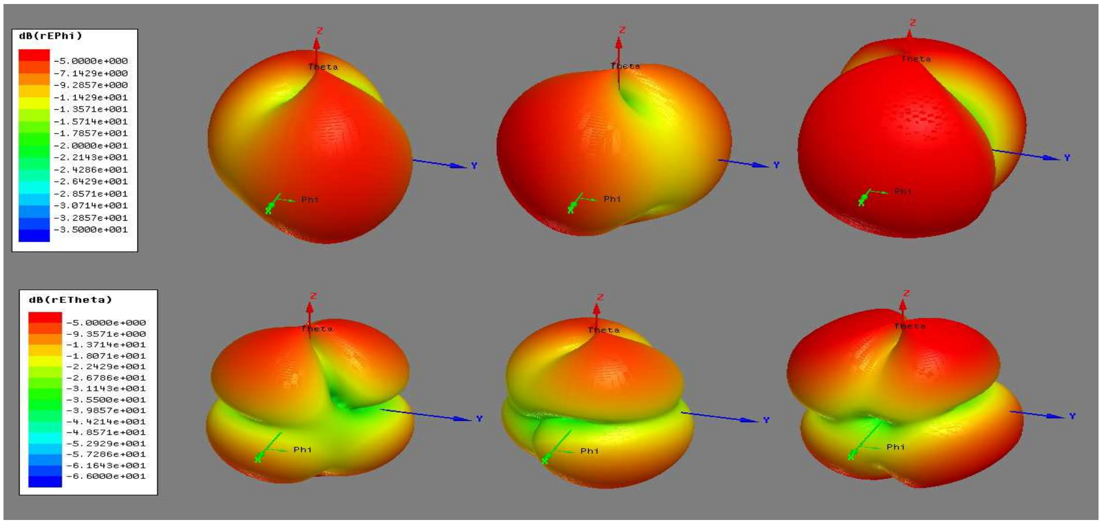

Figure 12 : Three Dimensional View Of Radiation Pattern Of The Proposed Model In E And H-Plane

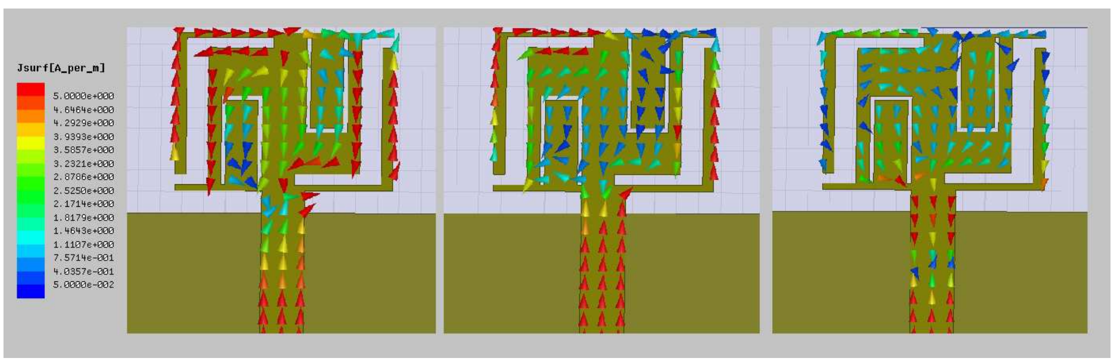

Figure 13 : Surface Current Distribution Of The Proposed Antenna At 3.9, 4.4 And 9.8 Ghz

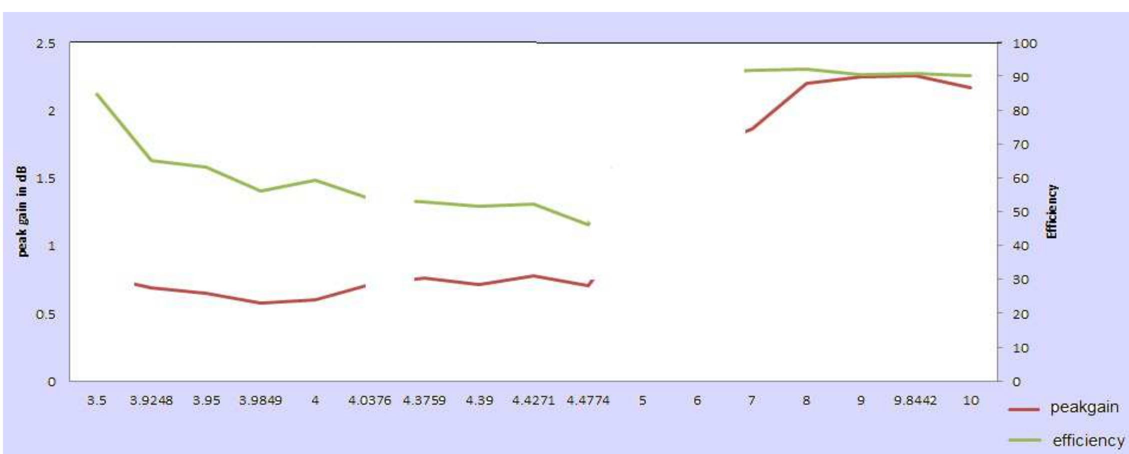

Figure 14 : Frequency Vs Gain And Efficiency Of The Proposed Antenna

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Table 1 : Antenna Parameters

Iteration	Resonant Frequency	Return Loss in dB	Bandwidth in GHz	Impedance Bandwidth %	Gain in dB	Peak Directivity	Efficiency %
1	10	-39.86	4.59	45.6	2.22	2.43	91.2
2	9.8	-41.8	4.53	45.75	2.24	2.45	91.3
3	9.5	-38.9	4.37	45.7	1.85	2.38	77.8
4	3.9, 4.4, 9.8	-17.8, -36.9, -35	0.2, 0.2, 4.69	2.8, 2.2, 47.6	1.25, 1.02, 2.49	1.02, 1.49, 2.48	90.9

width of ground plane, feed line length and feed line width. The parametric analysis helped us to realize the working condition of the antenna at different dimensions.

The radiation pattern is a mathematical function or graphical representation of the radiation properties of the antenna as a function of space coordinates. In the most common case, antenna radiation patterns are determined in the far-field region. This region is where the angular field distribution is essentially independent of the distance from a specified point in the antenna region. Typically, the far-field region is identified by those distances greater than $2D^2 / \lambda$, D being the maximum overall dimension of the antenna and λ the free-space wavelength. In the far-field region of any antenna the radiated field takes a particularly simple form. Figure 11 shows the radiation characteristics of the antenna at its resonant frequencies in E-plane and H-plane. At lower frequencies antenna is showing directive radiation pattern and at higher frequency omnidirectional radiation pattern in H-plane. In the E-plane antenna is showing dipole like radiation as shown in Figure 11. The corresponding three dimensional radiation patterns in E and H-plane is shown in Figure 12. The 3D plots giving the better visual appearance of the radiation characteristics of the proposed antenna model at resonant frequencies compared with polar plots in Figure 11.

The surface current distribution of the antenna is shown in Figure 13. At lower frequency slotted curve edges are participating in the radiation and at higher frequency the intensity is low at edges. The currents meeting on the feed line at higher frequency will cancel each other, resulting no radiation from the antenna by feed line. At both lower resonant frequencies the radiation is due to the feed line. The slotted portion is giving rise to the new path to the current movement on the surface of the patch, which intern increasing the electrical length of the antenna and decreasing the resonant frequency to lower side.

Figure 14 shows the gain and efficiency plot for the proposed antenna model. it sis been observed that at lower frequency the gain and efficiency is little bit low, but at high frequency a considerable gain and high efficiency can be observed. Table 1 gives the complete characteristics of the proposed antenna model. One of the key important factor impedance bandwidth of the antenna is having almost average value of 45% in all the iterations.

4. CONCLUSION

Multiband slotted aperture microstrip patch antenna with defected ground structure is presented in this paper. By placing U and L-shaped slots with defected ground structure, the proposed antenna is resonating at lower frequency band also with acceptable gain. The proposed antenna is compact in size with 15X20X1.6 mm dimension and resonating at C and X-bands. The current antenna is showing bandwidth more than 4.6 GHz at x-band and gain more than 2.49 dB with efficiency more than 90%. Impedance bandwidth of more than 45% with considerable directivity is making this antenna suitable for communication applications.

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