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# Rectangular slot Microstrip Triband Antenna with Enhanced bandwidth

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***Abstract:*** *We demonstrated and presented triple band line feed microstrip patch antenna for wireless communication application. We introduced two rectangular slot on patch and one L-shape slot on ground plane of antenna, to enhance the bandwidth of mictrostrip antenna. The impedance bandwidth can be tuned by changing the ground plane geometry parameters (length and/or its width). The overall size of the antenna is 25mm×25mm×0.8mm including finite ground feeding mechanism. Adjusting the dimension of ground plane and patch, its enhanced bandwidth at primary and secondary resonance mode can increased sufficiently to achieve desired bandwidth of proposed antenna. Also rectangular slot on patch will produce third band and rectangular slot position of patch over ground plane have clear impact on third band of antenna. We demonstrated many antenna structures to study of these parameters on the resulting tri band response. In this paper, we designed tripple-band micro strip rectangle antenna with slot antenna using line-feed technique, it support the three wireless communication bands that is (1.4-3.2 GHz), (5.4-6.9 GHz) and (9.6-10.7GHz)*

***Keywords:*** *Microstrip Antenna, Finite Ground, and Monopole Antenna.*

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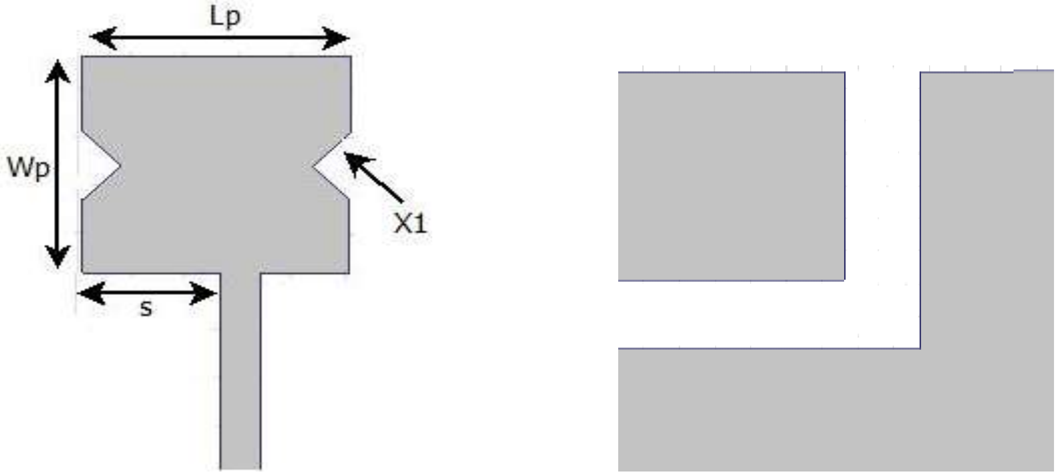
With rapid development of micro strip antenna it has been found that, Study of Micro Strip antenna with symmetrical Feed Line technique, Patch Antenna experimentally increase the Return Loss up to -33dB at frequency range 2.4 GHz to 2.5GHz and VSWR is less than 1.5 by using RT DUROID 5880[1]. With further study and optimization of dual band microstrip antenna [2] it has been found that the return loss for dual band Frequency at 2.4GHz is -43dB and at 3GHz is -27dB and acceptable VSWR. To get copact size and maintain performance of antenna for multiple band that is dual band, triple band antenna etc., various shapes of antenna was integrated [3]. It was presented in [4], introducing slot into patch that is L-Shape, experimentally increase bandwidth up to 13%. To enhance bandwidth further various shapes like L-shape, U-shape etc., slot was introduced and bandwidth up to 42% was increased [5,6]. In [7] and [8] the author's proposed bandwidth enhancement techniques that is by using photonic band gap structure and wideband stacked microstrip antennas respectively. By introducing stacked microstrip antenna band width and gain was enhanced. While Designing of symmetrical microstrip antenna, it has been found that microstrip antenna has narrow Bandwidth [9], Asymmetrical position of patch antenna on ground affect the performance of antenna that is to enhance bandwidth it was also found that asymmetrical position of slot on patch affects performance of antenna[10] that is asymmetrical L-shape, U-shape position of slot on patch affects the performance. In [10] designed asymmetrical slot of L-shaped on patch antenna for UWB application with acceptable return loss that is -10dB and peak gain 2.2 to 6.1 dBi for operating bandwidth 3.01-11.30 GHz frequencies.

In this paper we simulated and presented our design by using HFSS.13 simulator. In this paper a line feed patch with two rectangle slot microstrip antenna with two symmetrical triangular notch (Figure 1) is designed and simulated for the frequency range of 1-12 GHz. This antenna presents an extension to Triband Circularly Polarized Microstrip Antenna [10]. The proposed antenna has a gain of 1.8 dBi.

## I. Antenna Geometry

The results of proposed triple band microstrip patch antenna verified in HFSS Simulator with optimization. The initial antenna simulation setup is shown in Figure 2. Actual patch shape is shown in figure 1(a), it consists of two triangular notch on both side of patch and two opposite rectangular slot symmetrical to each other at the center of patch. Each end and placed within the patch [7]. The resulting antenna structure has the following parameters; the patch shape length Wp = 9 mm, and its width Lp =10 mm. The size of the ground plane has been found to be of Lg1 = 25mm and $Wg_1$ = 25mm. The height of substrate is h= 0.8 mm and dielectric constant εr = 4.4. A line feed is attached to the microstrip and has a length 8.37 and width 1.5mm. The length and width of four rectangle-slot that is S is 15mm and 1.5mm respectively. The two sides of the square patch are replaced with triangular notch, opposite notch are of same angle that is X1= $45^0$ [11].

Initially, we will conduct a simulation study on the structure of Figure 1(a) by adjusting the dimension of slot S that is position of feed line to patch. The resulting dimension of slot after simulation antenna structure is S= 14.35. Initially we put ground position for entire patch. As we reduce ground material, it is found that return loss is getting reduced from -10dB to -25dB. The ground substrate length on backside of patch is reduced and simulated for different dimension; it is observed that we get two band (1.4-3.2 GHz) and, (5.4-6.9 GHz) with sufficient return loss, the resulting return loss responses obtained by reducing ground plane, we obtain optimized return loss as presented in figure 3. Further we simulated to get third band, we introduced two rectangular slot on patch, we simulated for different dimension of rectangular slot on patch to get third band, dimension of rectangular slot for third band is 6mm×1mm, in this case it observed that we get first, second and third band with sufficient return loss, the resulting return loss presented in figure 4.




(a)Top view (Patch) (b) Ground (Ground)

**Figure 1:** Proposed Antenna Design

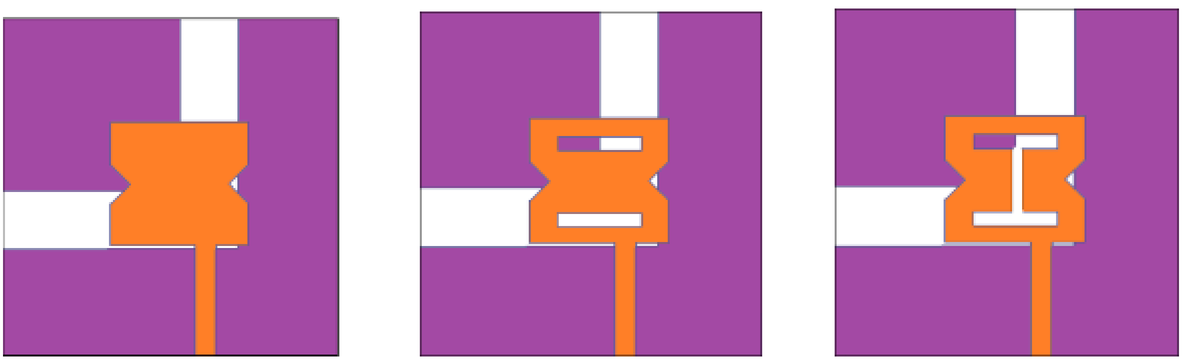
## II. Geometry Optimization And Discussions

In this section parametric study is conducted to optimize the proposed antenna. The key design parameters used for the optimization are number of triangle on patch and dimension of ground plane (length and width), and rectangular base dimensions. The detailed analysis of these parameters is investigated in the following paragraphs of this section.

## III. Effect Of Rectangular Slot

As showed in Figure 2, ground plane of the geometry is varied to see its effect on the performance of antenna. For this, patch antenna plane is changed to different shape. Initially, the patch is kept with without slot (type-1). After simulation it found that, three bands are available for type-1. We consistently changed the patch dimension as presented in Figure 2 i.e., type-2 and type-3, for this we obtained second, and third band.

As showed in Figure 2, rectangular slot on patch geometry is varied to see its effect on the performance of antenna. For this, ground plane is kept constant i.e. with inverted L-sape. The ground plane is located on the reverse side of the substrate in the shape of a rectangle, covering the entire back. Return loss characteristics of this study are presented in Figure 3.



a) Type 1 b) Type 2 c) Type 3

**Figure 2:** Variation in Patch antenna.

After optimizing the length, width of the ground is optimized. Figures 3 and 4 show return loss characteristics plots of this study. From these figures it may be noted that the quad bands can be obtained for $W_g$= 50mm, $L_{g1}$=47.7mm, and $L_{g2}$=12mm.The finalized dimensions obtained from these parametric studies are presented in Table 1.

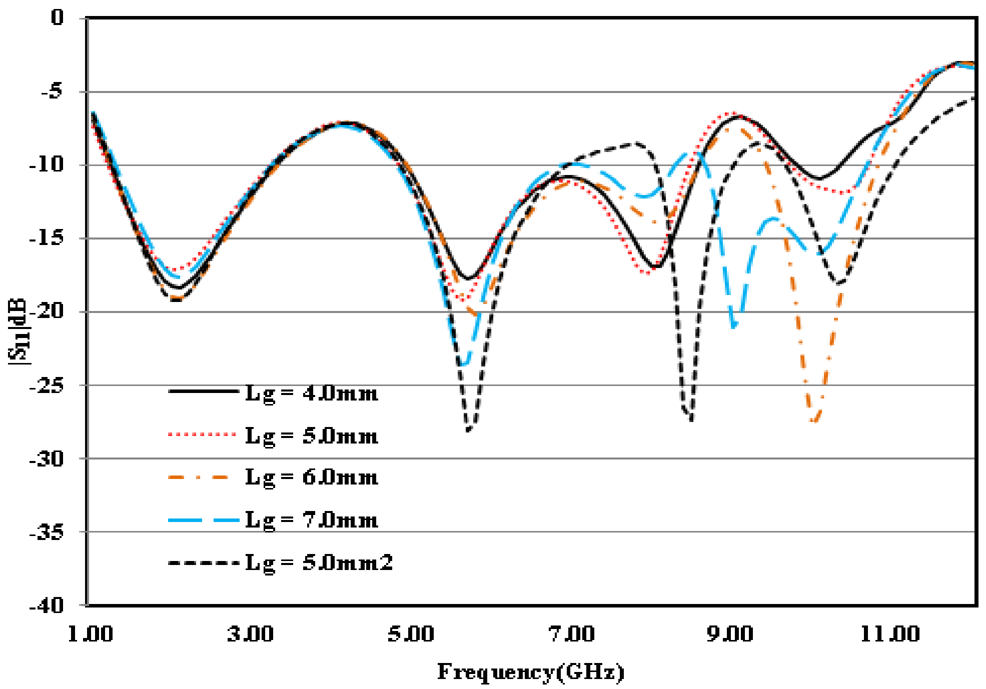



**Figure 3:** Return loss vs. frequency plot for variation length of ground ($L_g$).

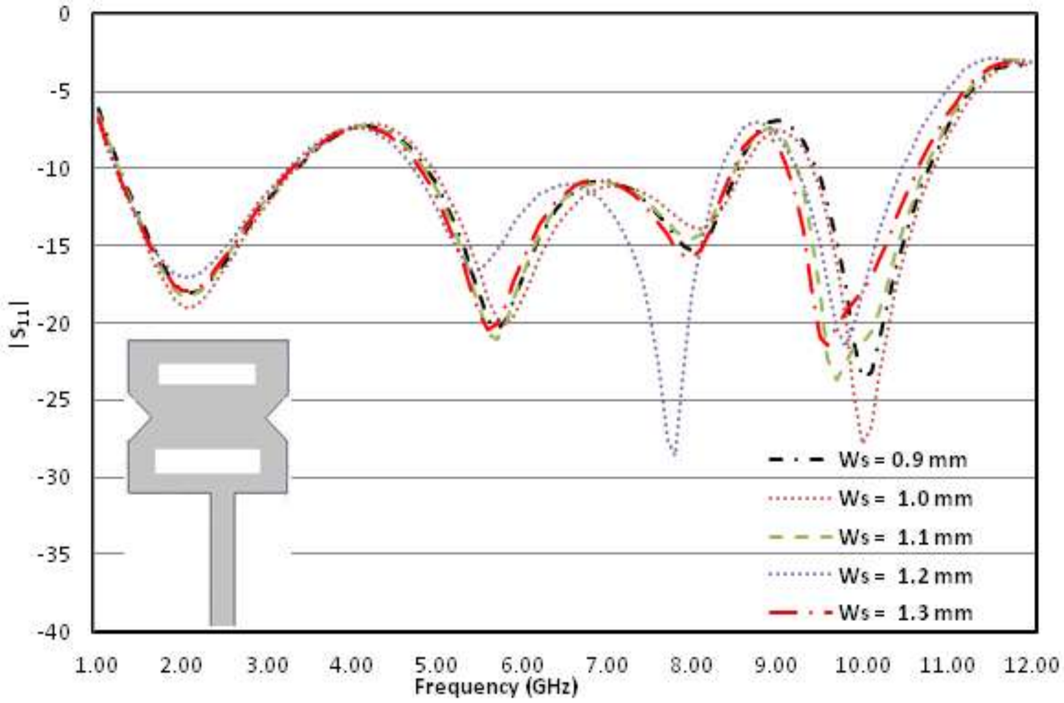



**Figure 4:** Return loss vs. frequency plot for variation in width of slot ($W_s$).

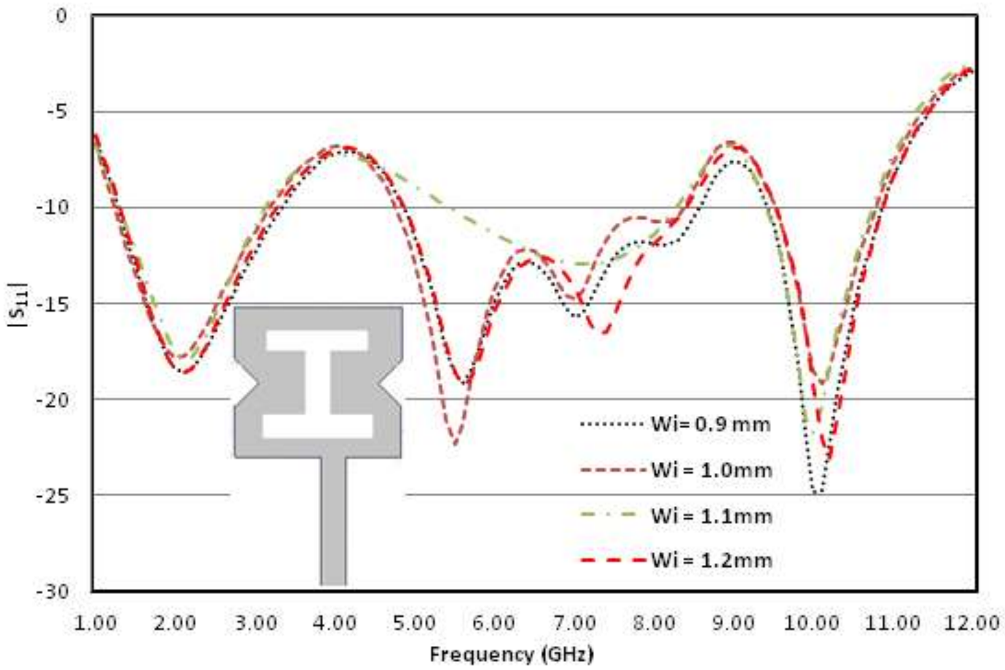



**Figure 5:** Return loss vs. frequency plot for variation in vertical slot on patch.

**Table 1:** Optimized dimensions of the proposed geometry.

| $L_f$ | $W_f$ | $L_t$ | $W_g$ | $L_{g2}$ | $L_{g1}$ | $W_p$ | $L_p$ | **Parameter** |
|---|---|---|---|---|---|---|---|---|
| 30 | 1.8 | 3 | 50 | 12 | 47.7 | 70 | 60 | **Unit(mm)** |

## IV. Effect Of Rectangular Base Dimensions

To study the effect of rectangular base dimensions on the antenna performance, its length values i.e., $L_g$ and $W_g$ arevaried. Initially, the length of upper rectangle($L_g$) is varied from 45 mm to 50 mm in steps of 1 mm keeping width of the rectangular base constant (50mm).The effects of variation of this study are presented in Figure 3. From Figure 3, it may be noted that the quad bands with return loss less than -10dB are (4.9 - 5.40GHz), (7.21-7.62 GHz), (8.6-9.62 GHz), and (9.95-11.02 GHz). Further we simulated for different width of ground plane by keeping length constant that is Lg1= 47.7mm. In this range having return loss less than -20dBm for all quad bands with lower cut-off frequency remains nearly constant whereas upper cut-off frequency varies slightly i.e., impedance bandwidth varies with respect to this parameter ($L_g$).

Results of the variation of the size of the ground plane, as Figure 2 implies that the triple band response increases for ground plane reduction by introducing slot into it.

However, tri-band responses are obtained with increased or decreased higher resonating bands. The effect of the width of ground has been demonstrated in Figure 2, and Figure 3.

From figure 2 and figure 3, it is observed that, we get minimum return loss that is -19dB, -20dB, and -27dB at 2.1GHz, 6.1GHz, and 9.9GHz respectively.

For larger values of the width of ground, the antenna offers a one-band resonant behavior, and the tri-band resonance occurs as the width is made smaller and approaches that of the reference antenna.

Figure (5)-(7) depicts the radiation pattern for tri band that is at 2.1GHz, 3.9GHz, and 9.9GHz frequency since return loss at this frequency is -20dB, -20dB and -27dB respectively.

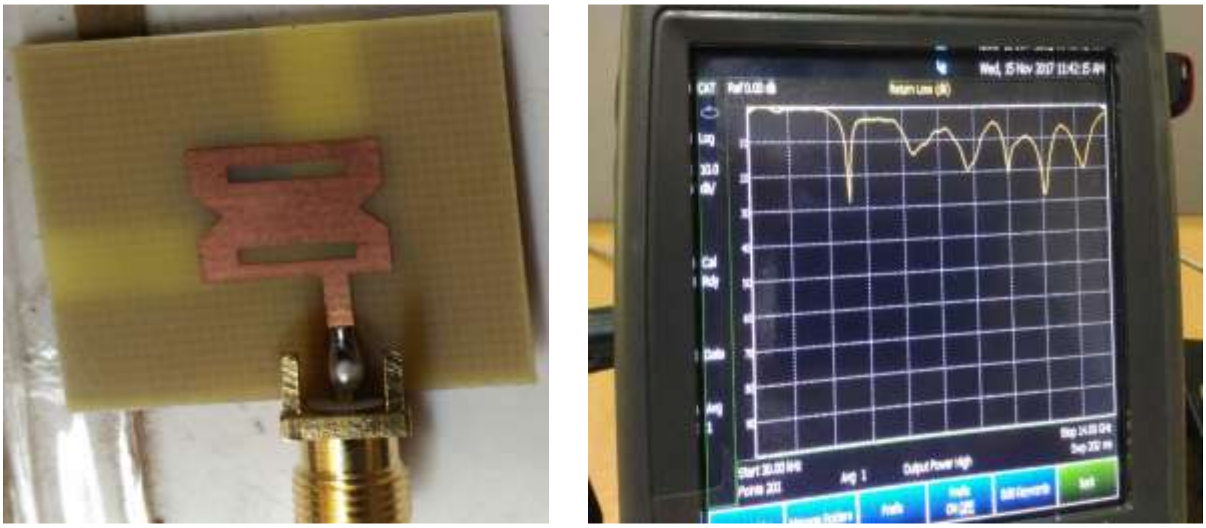
Figure(8) represents VSWR for all band, VSWR is less than 2 for all band that is good matching between feed line patch.

E-plane and H-plane radiation Pattern of proposed antenna is presented in Figures 6(a)-(d) at 5.0GHz, 6.0GHz, 7.4GHz and 9.9GHz respectively

## V. Experimental Results And Discussions

The geometry shown in Figure 1 with its optimized dimensions presented in Table 1was fabricated and tested. The substrate used for the fabrication is the FR4 glass epoxy with dielectric constant of 4.4, and thickness of 0.8mm. A photograph of the fabricated prototype is shown in Figure 6(a) and its $S_{11}$ measurement and VSWR measurement is shown in Figure 6(b) and Figure 6(c) The measured results fairly agree with the simulated values.

From Figure 6(b) it may be noted that the proposed antenna is having operating frequency range from 4GHz to 12 GHz with four operating bands located at (2.2-2.7GHz), (5.1-5.9GHz) and (9.0-9.7GHz). Radiation patterns of the geometry are presented at various frequencies in the band of operation (Figure 6) to demonstrate that the patterns are nearly stable across the bands of operations.



(a) Fabricated prototype (b) $S_{11}$ measurement

**Figure :6** Photographs of the fabricated antenna and its measurement setup.

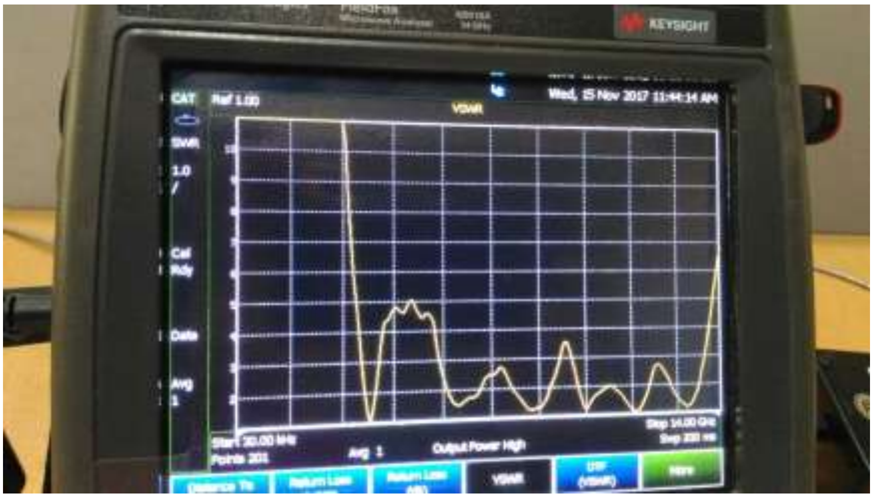


**Figure 6(c):** VSWR measurement

E-plane and H-plane radiation Pattern of proposed antenna is presented in Figures 6(a)-(d) at 2.4GHz, 6.1GHz and 10.0GHz respectively

## VI. **Conclusion**

The design optimization of a two slot patch antenna has been presented and discussed. It has been shown that, with correct selection of slot dimensions on patch and shape of ground plane, a tri band frequency response can be achieved. With this antenna, we get much improved bandwidth this design is obtained method, as a candidate for use tri band that is (1.4-3.2 GHz), (5.4-6.9 GHz) and (9.6-10.7GHz). The antenna has been modeled and its performance has been analyzed using a HFSS simulator. The proposed antenna has been found to possess a miniaturized size and a width making it suitable for compact size enhanced bandwidth tripple band applications. The simulated results of HFSS at 2.1 GHz is Return loss = -20dB, at 3.9GHz Return loss = -20 dB, and at 9.9 GHz Return loss = -27dB. VSWR at 2.41 GHz is 1.5, Gain = 1.8dBi at 2.1 GHz Efficiency= 90%.

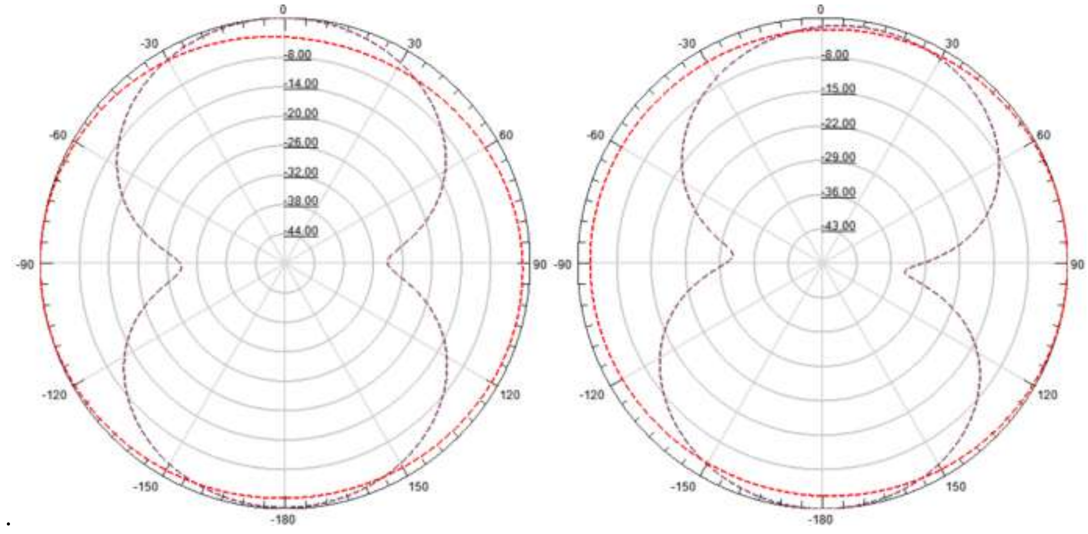



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**Fig. 5 E-Field and H-Field Radiation pattern at 2.4GHz**

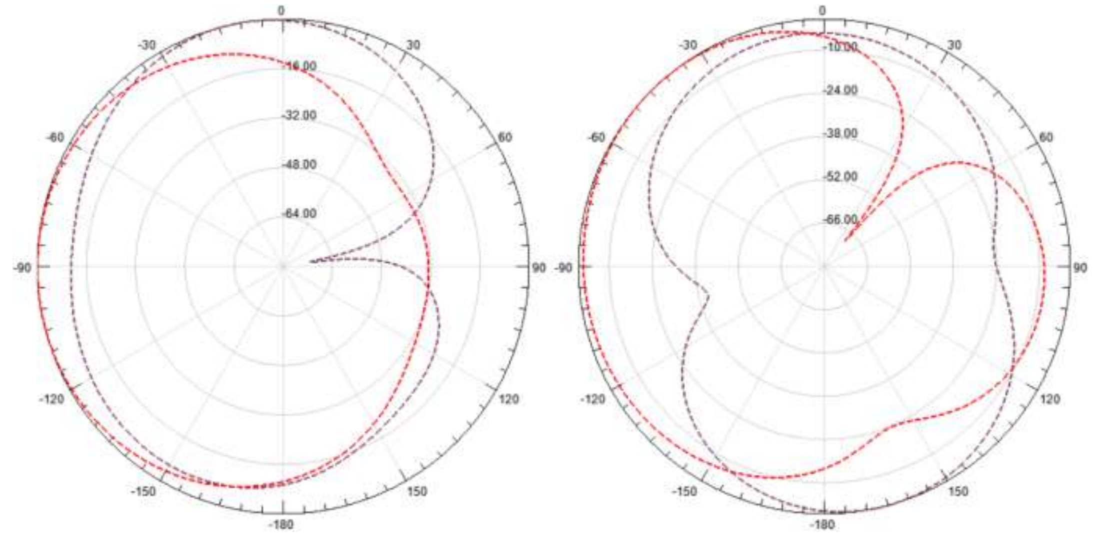


**Fig. 6 E-Field and H-Field Radiation pattern at 6.1 GHz**

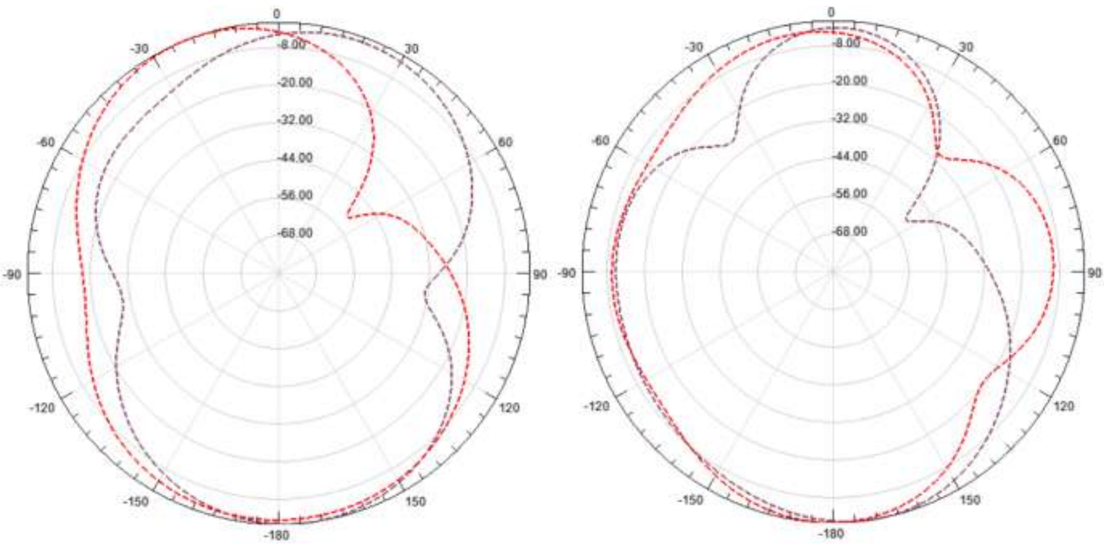


**Fig. 7 E-Field and H-Field Radiation pattern at 10 GHz**

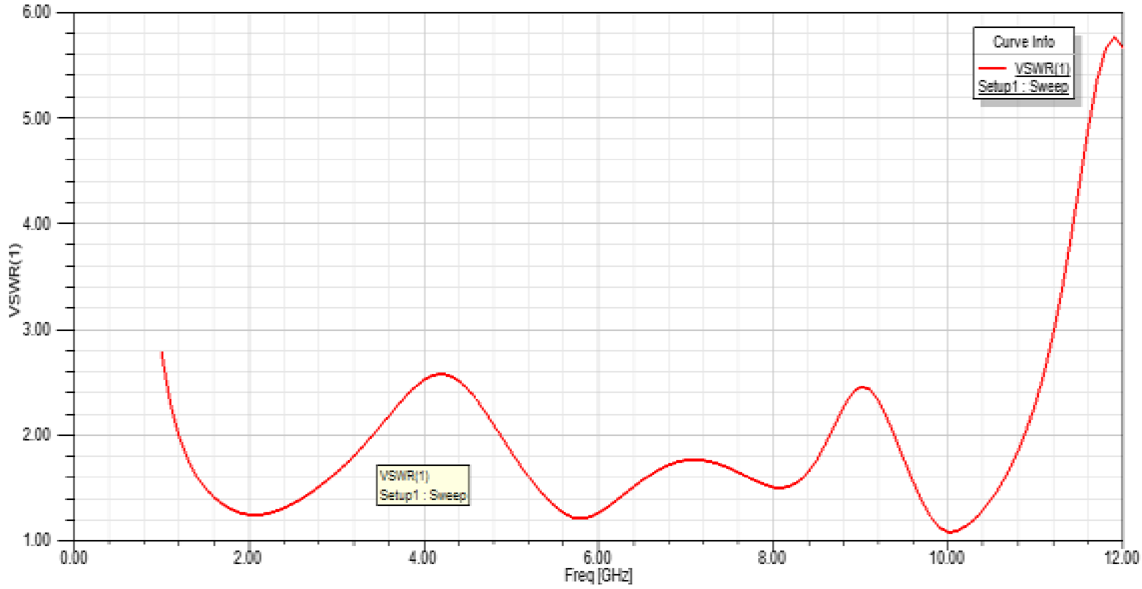


**Fig. 8 VSWR**

**Figure 6:** E-and H-plane radiation patterns at various frequencies throughout the band of operation.

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