

Bandwidth enhancement by slotted ultra-wide band antenna

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ABSTRACT

This article submits a bandwidth enhancing technique using E-shape slot and 3 notches on the bottom corners of the patch for an antenna with micro strip line. The proposed small size antenna on 20 mm × 20 mm printed on substrate type (FR-4) is designed and confirmed through simulations. Reception apparatus parameters are moldered and introduced utilizing programming CST. The results show that at frequency 8 GHz the return loss value is -18.08 dB with VSWR 1.29; at frequency 10.04 GHz the return loss value is -45.9 dB with VSWR 1.03. The bandwidth of the proposed antenna is 3.1 GHz or about 34.33% at VSWR < 2, which can therefore be classified as UWB antenna.

Keywords: Ultra-wide band, slotted antenna, bandwidth enhancement.

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INTRODUCTION

The UWB system is named because this technique uses the entire radio spectrum, not a small one. As in other techniques in 2002 the FCC in United States issued the UWB range, which covers the 3.1 to 10.6 GHz frequencies. While in the European Union the UWB range is from 6 to 8 GHz. But in Russia it ranges between 2.85 to 10 GHz. When designing a UWB antenna, the main aim is to accomplish a wide data transfer capacity with high and low radiation productivity. Also, there are several factors to consider when choosing antenna topology for ultra-wide band design (UWB) including physical appearance, compatibility, radiation pattern, radiation efficiency, and bandwidth resistance. Microtrap patch antennas possess desirable attributes of low cost, lightweight, planar configuration, and ease of integration, therefore, they become popular for implementations in wireless communication systems (Alibakhshi-Kenari, 2018; Alibakhshi-Kenari et al. 2016a; Alibakhshi-Kenari et al., 2016b; Alibakhshi-Kenari et al., 2017) printed planar antennas features are that they can be manufactured using little cost printed circuit board techniques and they radiate energy with middling high gain in a direction vertical to the substrate (Alibakhshi-Kenari et al., 2016c), multiband antennas, which are designed using various existing modes including using: multimode monopoles

(Ammann, 2001), micro strip patches embedded with slots and metamaterial technologies (Alibakhshi-Kenari et al., 2017b; Chakrabarty et al., 2002; Surjati et al., 2016). In recent decades, to achieve various design goals a lot of tremendous research has been done. Using slot antennas (Alibakhshi-kenari et al., 2018a; Alibakhshi-Kenari et al., 2018c; Rahayu et al., 2010), a loop antenna, a spiral antenna (Alibakhshi-kenari et al., 2017a; Alibakhshi-Kenari et al., 2018b), various wideband antennas are designed. In Sadat et al. (2007), the antenna contains square ring slot and is fed by a one micro strip line with a thorn like tuning stub. While in Prombutr et al. (2009), using a modulate ground plane with diametrical edges, rectangular slot, and T-shape cut for the design of compact antennas which are presented as a bandwidth enhancing technique. In Beigi et al. (2016), the antenna contains two rectangular shaped slots in the ground plane and a butterfly shaped element frame and stepped patch with U-shaped slot. UWB antenna fed by micro strip transmission line with double notched features is presented in Boutejdar et al. (2015). In Valderas et al. (2006), UWB tucked Plate Monopole Antennas Based on TLM presented. While in Antonino-Daviu et al. (2003), planar monopole antennas with numerous feed points are suggested. In this article, using

a micro strip fed planar monopole. We suggested a technique to improve the bandwidth from various bandwidth enhancement systems. There are two procedures used for this proposed UWB antenna. The two systems are the utilization of slit and cutting notches at the base which can prompt a decent impedance bandwidth. The suggested antenna can work in UWB frequencies by selecting these parameters. The planar square monopole antenna is designed with a micro strip feed line (50Ω) on the FR4 substrate with relative permittivity = 4.3. To improve the bandwidth, we make a slot E-shaped with diagonal cuts at the bottom corners of the patch. The slot shape is composed deliberately by studying the current flow distributing. The discontinuity happened from cutting notches at the bottom corners of a rectangular patch has implemented the excitation of vertical current mode in the structure. On the patch The E slot gives return loss improvement at 10.04 GHz, in this manner, the slot wideband conduct because of the way that the current along the edges of the slot presented similar reverberation frequency, which, in conjunction with reverberation of the primary patch deliver a general broadband frequency reaction trademark. The reason of using the E slot is the bandwidth improvement because of a significant more vertical electrical current accomplished in the fix through the E slot bringing about

much customary appropriation of the magnetic current in the slot. The utilization of slot embedded on the micro strip patch appears as the best system used a coupled resonator approach in which the micro strip patch goes about as one of resonator and the slot as the second resonator close to its resonance for this situation the data transfer capacity expanding originates from the patch and E slot coupled together to form two resonances. The corresponding bandwidth is due to the state of the closed antenna to the feed point where the currents are stronger. The field supported by these currents to be mainly confined kept on the bottom piece of the rectangular antenna and the ground plane, this is because of a small part of wavelength of this edge to the ground plane, there-by, in this manner, this part acts as a matching elements. The study of the current stream on a planar monopole antenna reveals that it is for the most part gathered in the vertical and horizontal edges, as appeared in Figure 1, it is watched that the horizontal streams distribution is centered around the bottom edge of rectangular patch, furthermore, the horizontal component is likewise greater than the vertical on this piece of the antenna from Figure 1, which demonstrates that two types current distribution modes happened on patch radiator and feeding strip, for example, vertical current mode and horizontal current mode.

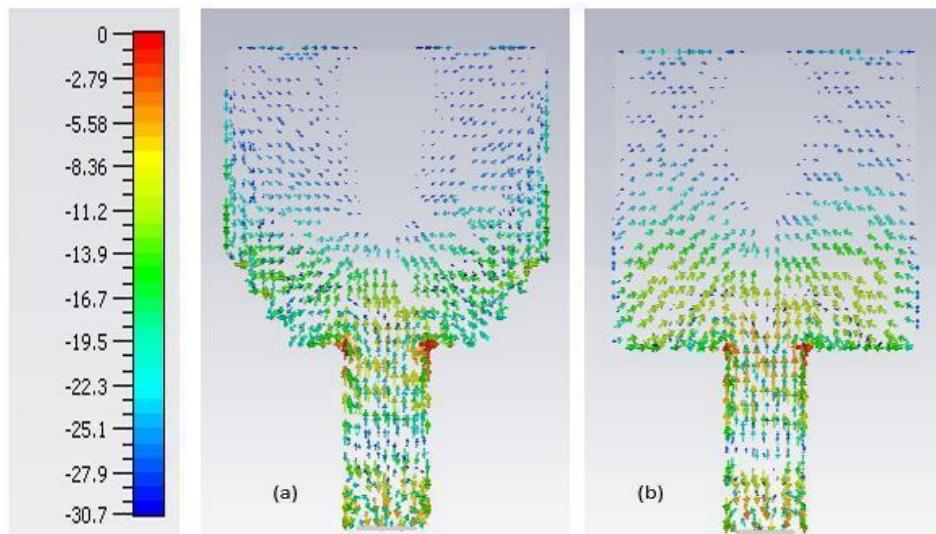


Figure 1. Simulated current distribution (a) rectangular with three notches at the bottom (b) rectangular.

ANTENNA DESIGN

The proposed antenna is composed on a substrate of sort FR4 with thickness = 1.4 mm and relative dielectric constant (ϵ_r) of 4.3. A rectangular patch designed on the frontal surface of the substrate with dimensions is given by:

$$W = \frac{c}{2f} \sqrt{\frac{2}{\epsilon_r + 1}} \quad (1)$$

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

Where,

$$\Delta L = 0.412 h \frac{(\epsilon_{ref} + 0.3)(\frac{w}{h} + 0.264)}{(\epsilon_{ref} + 0.258)(\frac{w}{h} + 0.8)}$$

$$L_{eff} = \frac{c}{2f\sqrt{\epsilon_{ref}}}$$

$$\epsilon_{ref} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{w} \right]^{-\frac{1}{2}}$$

$$f_r = \frac{C_0}{2\sqrt{\epsilon_r}} \quad (3)$$

From Figure 2, it is seen that the square micro strip antenna using slot E shape and three notches. The dimension of antenna is $W_{sub} = L_{sub} = 20$ mm and the measurements of slot of W_s , W_{s1} , W_{s2} , L_s , L_{s1} are 12, 2, 3, 7 and 2 mm, respectively. The micro strip line fed the radiator has 4 mm width (W_f) and length 7 mm (L_f). ground plane on the bottom layer of substrate has length $L_{gnd} = 10$ mm. There are three notches at the two lower corners of radiating patch have the same size of $W_1 = L_1 = 1$ mm. Figure 2: the return loss when the width of slot 2 mm.

When the width of slot equal to 2 mm, the return loss be -45.9 dB at frequency 10.04 GHz and the bandwidth of 3.1 GHz (10.58 - 7.48) GHz, is shown in Figure 3.

While when the width of slot be 1 mm, the return loss be -32.89 dB and the bandwidth of 2.8 GHz (10.4 - 7.6) GHz, is shown in Figure 4.

From the Figure 4, it is seen that the return loss is -14.3 dB, and bandwidth of 2.7 GHz (10.5 - 7.8) GHz.

From Figure 5, it is seen that the return loss is -14.3 dB and the bandwidth of 2.7 GHz (10.5 - 7.8) GHz.

From Figure 6, it is seen that the return loss is -15.8 dB and the bandwidth of 2.9 GHz (10.4 - 7.5) GHz.

From Figure 7, it is seen that the return loss is -19.3 dB and the bandwidth of 2.98 GHz (10.46 - 7.48) GHz.

From Figure 8, it is seen that the return loss is -27.8 dB and the bandwidth of 3.04 GHz (10.57 - 7.53) GHz.

RESULTS AND DISCUSSIONS

The overall results can be summarized into Table 1, 2 and 3. From the tables, it can be seen that the largest bandwidth of 3.1 GHz can be obtained when the proposed antenna has E slot on the patch and three notches on the bottom corners of the rectangular patch.

The height patterns for the antennas are mimicked at the H-plane ($\phi = 0^\circ$, yz -plane) and E-plane ($\phi = 90^\circ$, xy -plane). The radiation pattern gauged in a plane containing feed is called the E-plane pattern, while the pattern that is orthogonal to E-plane is called the H-plane

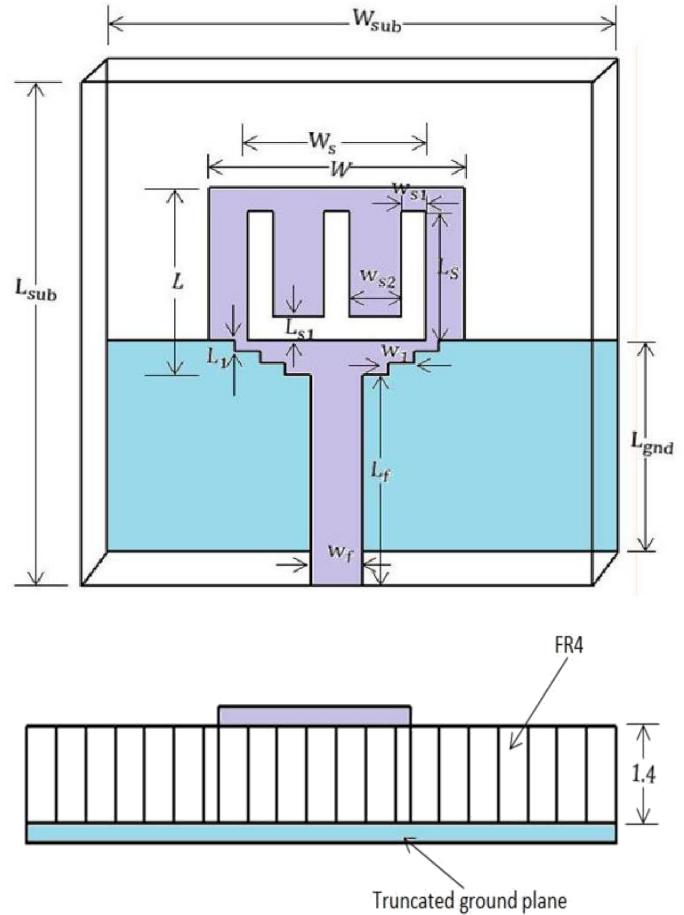


Figure 2. The geometry state of slot UWB antenna.

pattern. The simulated radiation patterns of the antenna are appeared in Figure 9 at frequencies 7.5, 8 and 10.04 GHz. The radiation patterns are almost omnidirectional. The radiation patterns taken are in frequencies 7.5, 8 and 10.04 GHz because the bandwidth is taken from this range of frequencies.

CONCLUSION

In this article, different bandwidth improvement techniques have been exhibited. The E slotted antenna has been designed and developed. Two bandwidth improvement techniques are embraced keeping in mind the end goal to deliver a little slotted UWB antenna. This proposed antenna utilizes three notches, and E slotted. Reception apparatus parameters are moldered and introduced utilizing programming CST. The results shown that at frequency 8 GHz the return loss value is -18.08 dB with VSWR 1.29; at frequency 10.04 GHz, the return loss value is -45.9 dB with VSWR 1.03; the bandwidth of the proposed antenna is 3.1 GHz or about 34.33% at VSWR < 2, which is classified as Ultra Wide Band antenna.

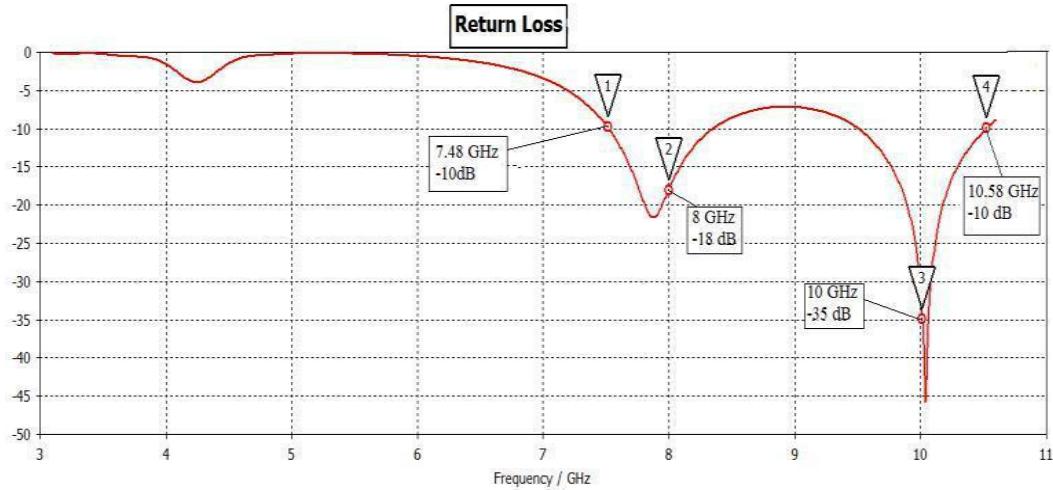


Figure 3. The return loss when the width of slot 2 mm.

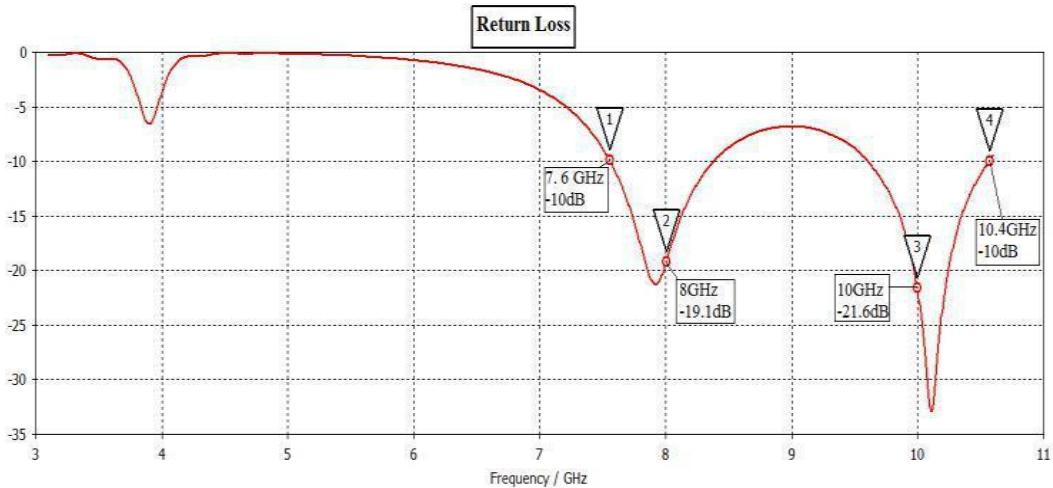


Figure 4. The return loss when the width of slot 1 mm.

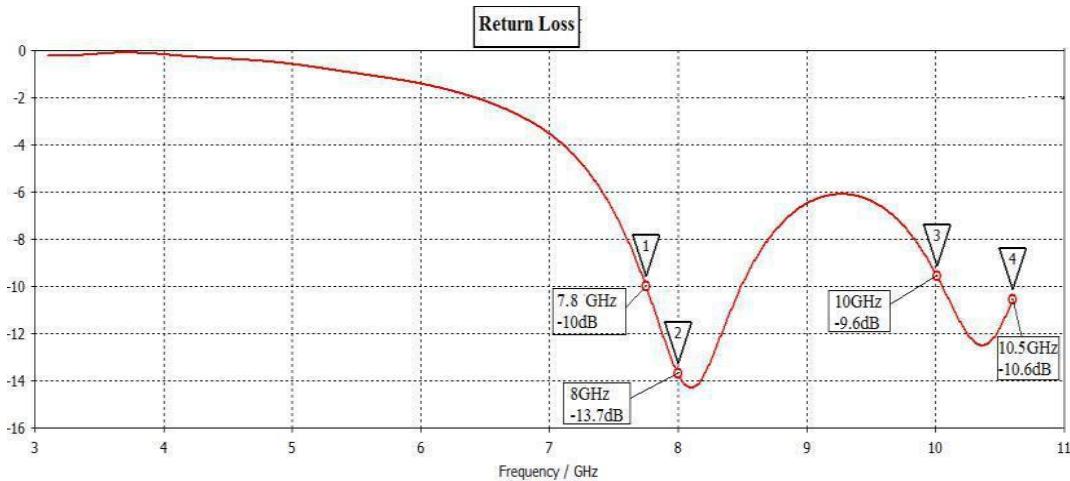


Figure 5. Return loss without E slot.

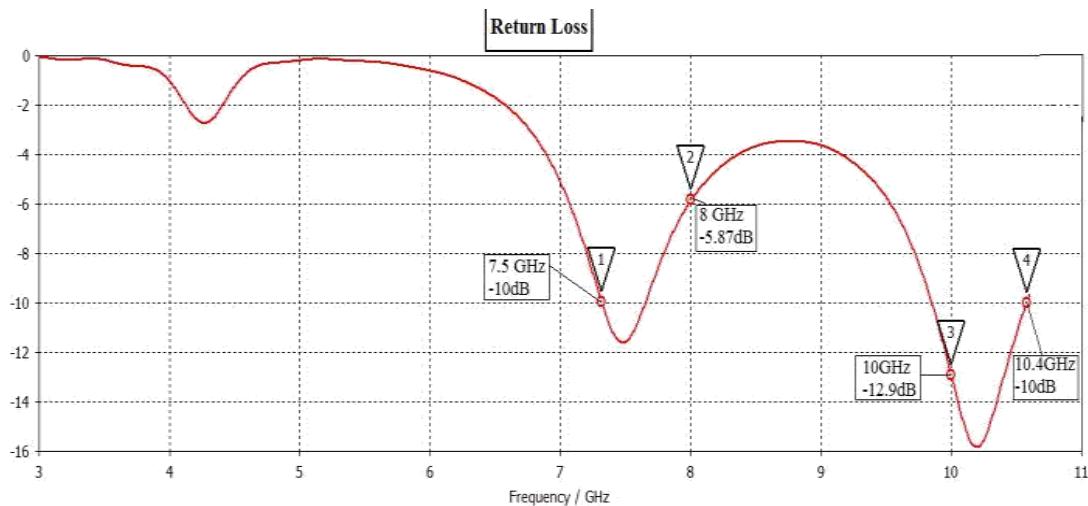


Figure 6. Return loss without notches.

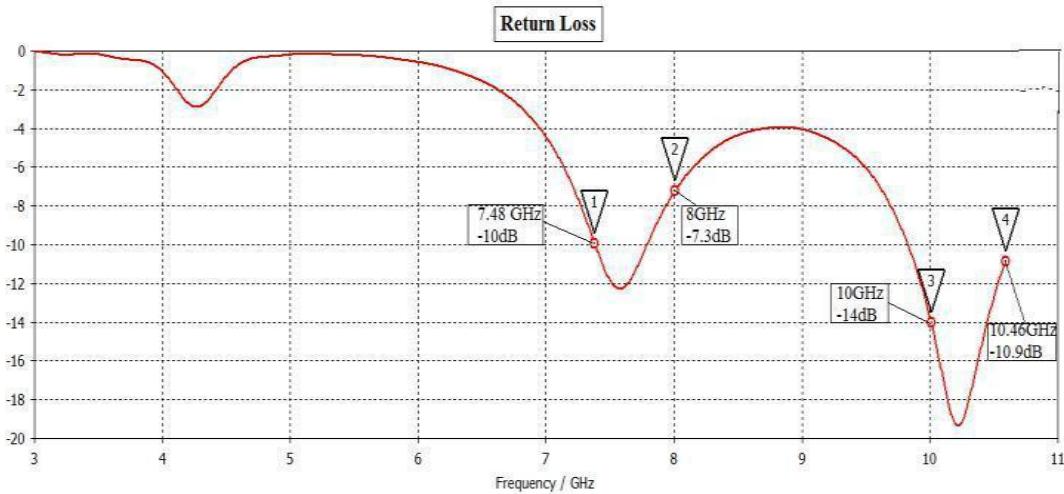


Figure 7. Return loss with one notch.

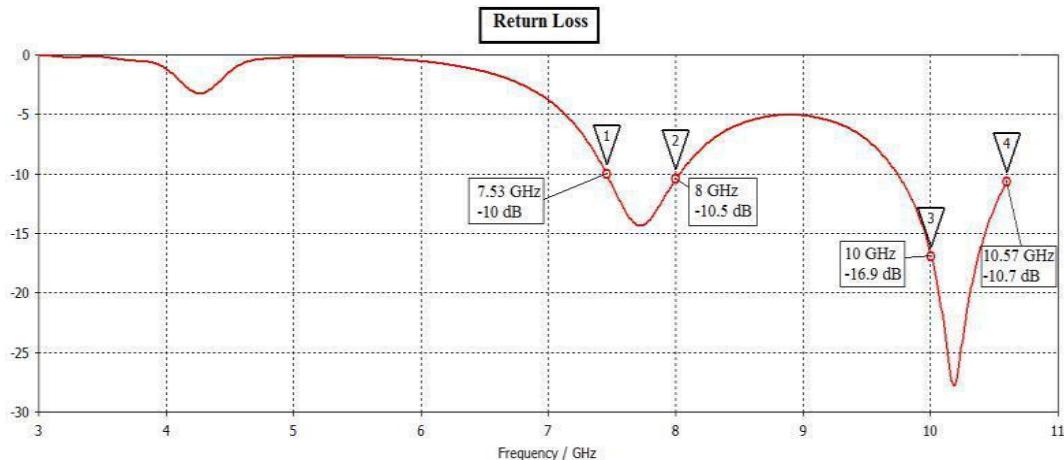


Figure 8. Return loss with two notches.

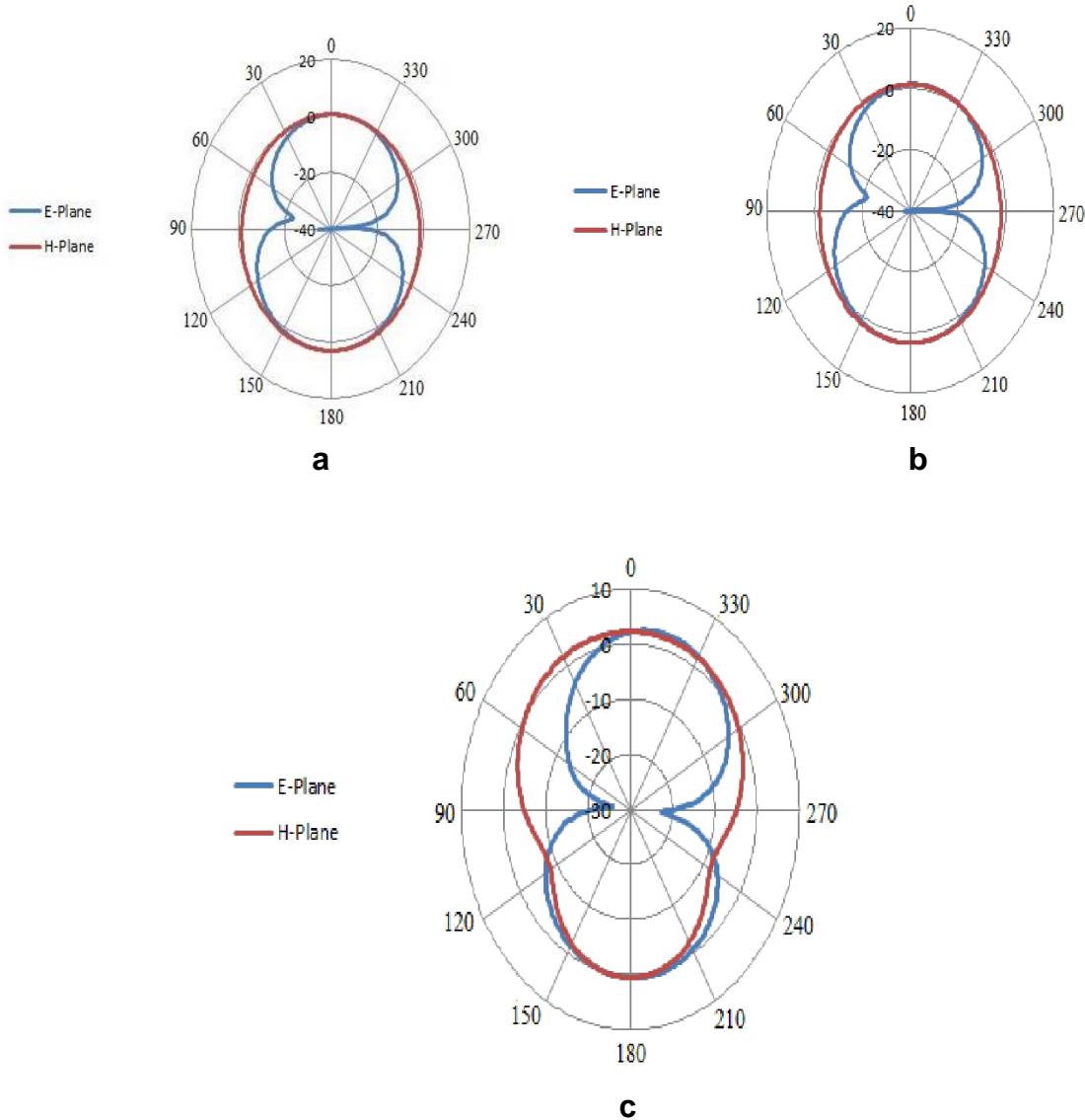


Figure 9. Simulated radiation pattern at (a) 7.5 GHz, (b) 8 GHz, (c) 10.04 GHz.

Table 1. Parameters of proposed antenna (units in mm).

L_{sub} : 20	W_{sub} : 20	L_{gnd} : 10	W_f : 4	L_f : 7
W : 16	L : 11	W_f : 1	L_f : 1	W_s : 12
W_{s1} : 12	W_{s2} : 3	L_s : 7	L_{s1} : 7	

Table 2. Simulation result of proposed antenna.

Condition	Parameter		
	Return loss (dB)	VSWR	Bandwidth (GHz)
Without three notches	-15.8	1.832	2.9
With one notch	-19.3	1.229	2.98
With two notches	-27.86	1.059	3.04
With three notches	-45.9	1.001	3.1

Table 3. Simulation result of effect e slot on proposed antenna.

Condition	Parameter		
	Return loss (dB)	VSWR	Bandwidth (GHz)
Without slot	-14.35	1.477	2.7
With slot	-45.9	1.001	3.1

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