**Metamaterial Slot and S-Shaped Sot Loaded Band Notched Antenna for UWB Application**

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**ABSTRACT**

The ultra wideband (UWB) antenna inspired by loaded metamaterials with band notches is elucidated in this manuscript. The prototyped antenna is 20×16×1.6 mm3 in dimension and accomplishes a large bandwidth between 3.4 GHz and 10.8 GHz. By embedding a single RSRR metamaterial slot on the radiating patch & a slot of shape S on the microstrip feed line, the notching of desired band’s frequencies have been achieved. Worldwide Interoperability for Microwave Access (WiMAX) band (3.51-3.7 GHz), C-band applications (3.7-4.2 GHz), WLAN band (5.15-5.62 GHz), X-band satellite communication system (7-8 GHz), and uplink X-band (8.89-10.38 GHz) frequency rejection have all been achieved. By altering the measurements of the S-shaped slot and metamaterial inspired slot, the frequency of the rejected band can be changed. The proposed antenna has a high gain of 14.3 dB at frequency 7.73 GHz, and the radiation pattern of the projected antenna is observed over operating bands.

**Keywords**

Patch antenna, UWB, Metamaterial, Gain, band-stop characteristics, SRR.

# INTRODUCTION

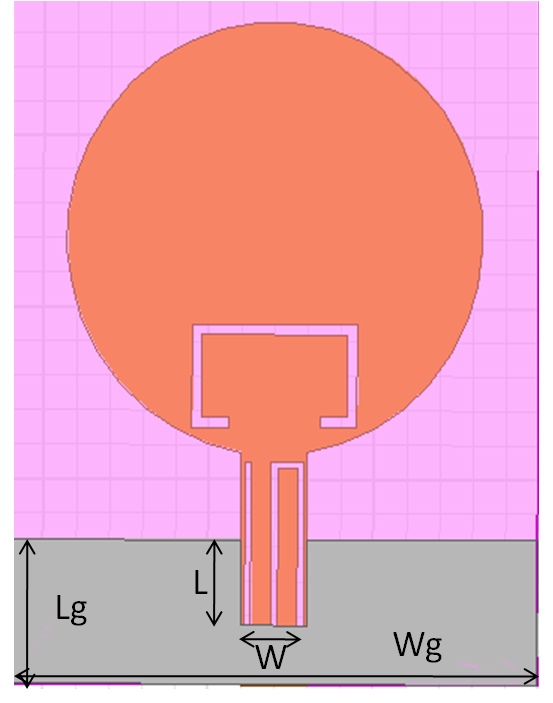
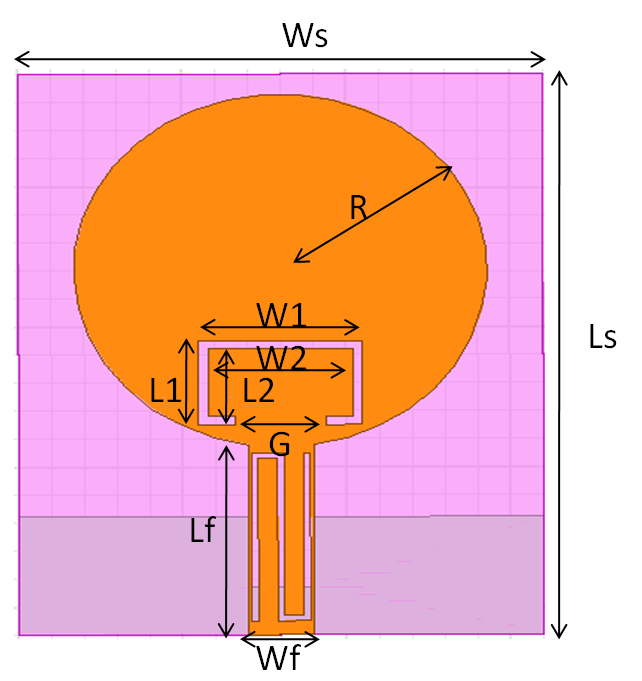
Due to its high data rate transmission, large data density, and low power operation, UWB communication systems are quickly becoming very attractive to a wide range of researchers from academia and industry. With an effective radiated power spectral density of -41.3 dBm/MHz, the Federal Communication Commission (FCC) declared the ultra wideband frequency range from 3.1 GHz to 10.60 GHz as an unlicensed band for commercial use [1]. Planar antenna is an excellent choice for UWB communication applications. While designing a UWB system, there are a number of obstacles to overcome because competing technologies like the WiMAX band (3.3-3.6 GHz), the C-band downlink (3.8-4.2 GHz), the WLAN IEEE 802.11a band (5.15-5.825 GHz), the downlink of the X-band satellite communication system (7.25-7.75 GHz), and the ITU X-band satellite communication (8.025-8.4 GHz) can interfere with the UWB system. For this reason, it's crucial to develop antennas with band-notched characteristics in order to avoid the intervention being discussed.

Various methods have been used over the last few years to create a single frequency rejection [2-5]. UWB antennas featuring several band notches have recently been reported [6–13]. Various designs use slots on the radiating patch and ground as well as three rectangular slots loaded with CPW-feed [6], electromagnetic band gap (EBG) [8], embedded parasitic elements in an open rectangular [9], and a coupled inverted U-ring strip in the radiating patch [10] to achieve dual notched bands. Along with creating triple notched bands [11], integrating band rejecting structures [12], and using asymmetrical slots [13], a quarter wavelength open ended slot and half wavelength slots on the radiating patch are also used. Split-ring resonators (SRR) can be used to create filters that have band notch at specific frequencies due to their extremely high quality factor. SRR may also be used as a slot-type structure to filter out unwanted frequencies [14–16].

This article suggests a small ultra-wideband (UWB) antenna that is loaded with a metamaterial structure that has band notch properties. WiMAX band, C-band downlink, WLAN, X-band downlink satellite communication, and ITU band satellite communication interference is reduced by using an SRR structure inspired by metamaterial (MTM) and a slot of S-outline on the microstrip feed line. The frequencies of stop-bands can be varied by altering the dimension of both MTM and S-shaped slots. The presented antenna is made of an economical FR4 Epoxy substrate. In order to achieve the band stop characteristics, the proposed design also makes use of an S-shaped slot and a single rectangular split ring resonator (RSRR) structure.

# Design of Antenna

The schematic of presented antenna having frequency rejection characteristics is illustrated in Figure 1.



**a) Front View b) Back View**

**c) S-shaped slot on microstrip feed line**

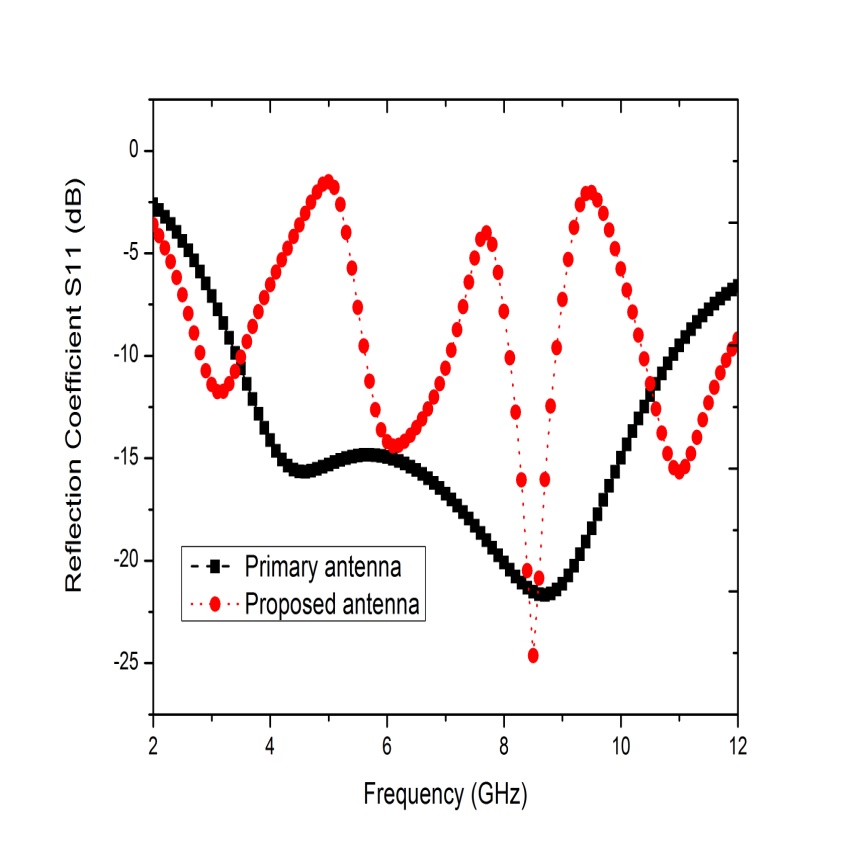
**Figure 1: Geometry of Presented antenna with band stop characteristics**

**Table 1: Measurement of UWB Antenna**

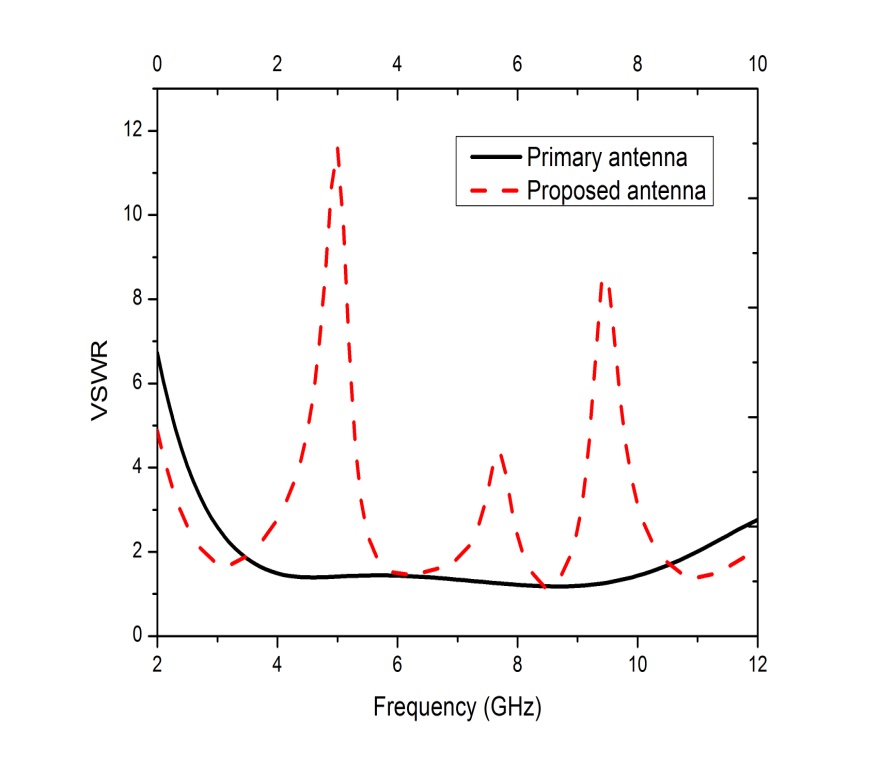
|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Ls** | **Ws** | **Lf** |
| **Unit** | 20 mm | 16 mm | 7 mm |
| **Parameters** | **Wf** | **R** | **L1** |
| **Unit** | 2 mm | 6.3 mm | 3 mm |
| **Parameters** | **W1** | **L2** | **W2** |
| **Unit** | 5 mm | 2.4 mm | 4.4 mm |
| **Parameters** | **L3** | **L4** | **L5** |
| **Unit** | 6 mm | 6 mm | 6 mm |
| **Parameters** | **W3** | **W4** | **G** |
| **Unit** | 0.6 mm | 0.6 mm | 2.8 mm |
| **Parameters** | **Lg** | **Wg** | **L** |
| **Unit** | 0.6 mm | 0.6 mm | 4.2 mm |
| **Parameters** | **W** |
| **Unit** | 16 mm |

Ansoft HFSS 15 is utilised to analyze the proposed antenna & the results of analyzed antenna are obtained. The prototyped antenna is constructed on a layer of FR-4 epoxy substrate material with a dielectric constant of 4.4 and a loss tangent of 0.02 and having dimensions of 20×16 mm2. To accomplish 50 ohm impedance matching, the width of feed-line is fixed at 2 mm and the antenna's height is 1.6 mm. Table1 provides specific information about the proposed antenna's dimensions.

Defining the location and dimensions of the introduced SRR metamaterial (MTM) is one of the key elements of a band-notched antenna design [17]. The slot is typically designed to have a length of about half the guided wavelength at the band's notch frequency [17]. The variation in reflection coefficient between the primary antenna and the suggested antenna with the metamaterial structure is shown in Figure 2. Figure 3 displays the variation in VSWR between the primary antenna and the suggested antenna. The frequency rejection for WiMAX band, C-band, WLAN band, and X-band satellite communication has been successfully achieved by embedding a single SSR slot of rectangular shape on radiating patch and a microstrip feed line with an S-shaped slot, as shown in figure 3.



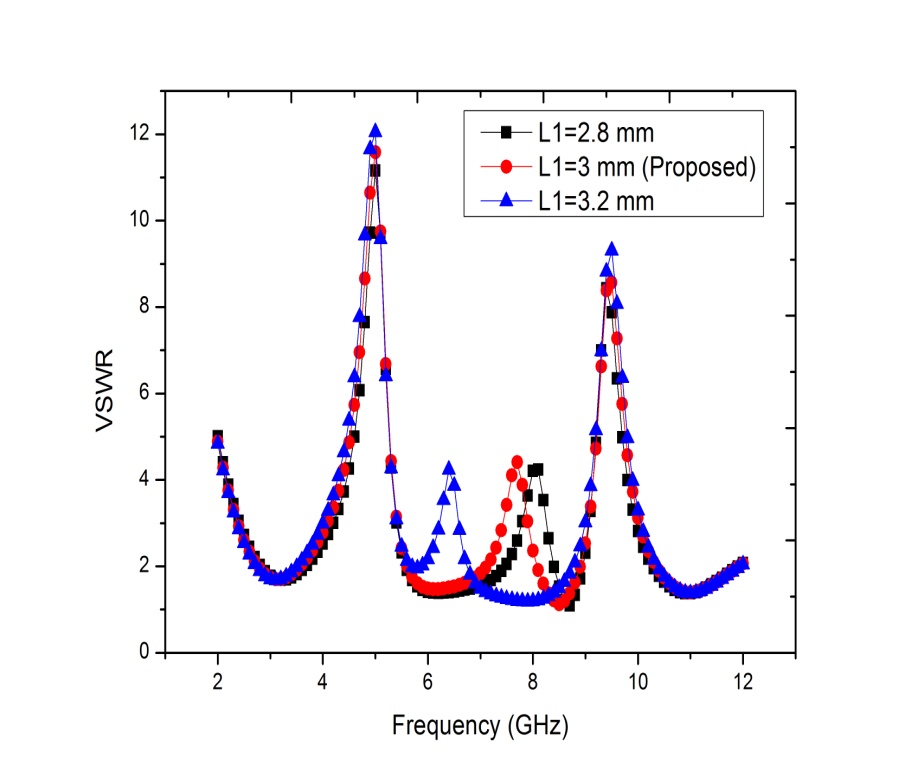
**Figure 2: Reflection co-efficient curve for conventional and proposed antenna**



**Figure 3: VSWR variation curve for primary and proposed antenna**

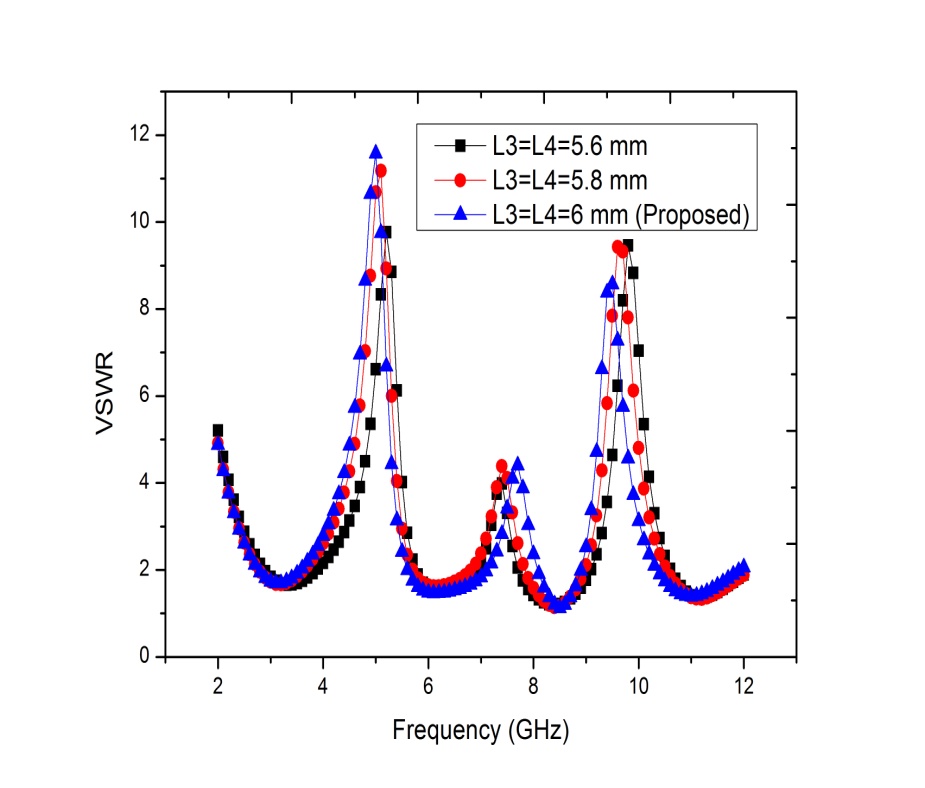
# Parametric Study of Proposed antenna

Using high frequency simulation software from Ansoft, the results of prototype antenna simulation are examined. The parametric investigation is being carried out to see how variations in the dimensions of the SRR metamaterial slot and the S-shaped slot affect the results. Antenna optimization is performed using these parametric analyses. The length (L1) of the SRR metamaterial slot was optimised as shown in Figure 4.

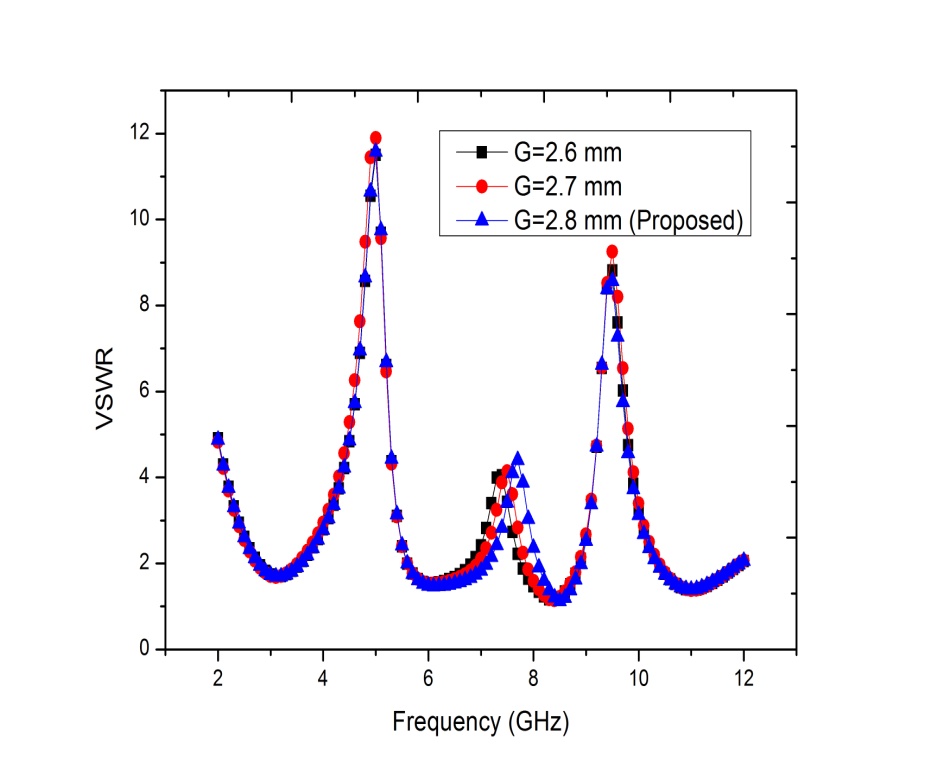


**Figure 4: VSWR curve for different dimensions of L1 of antenna**

Figure 4 shows that the frequency of the rejected band shifted from 8.1 GHz to 6.4 GHz as the length of the single rectangular split ring resonator (RSRR) metamaterial slot increased from 2.8 m to 3.2 mm.



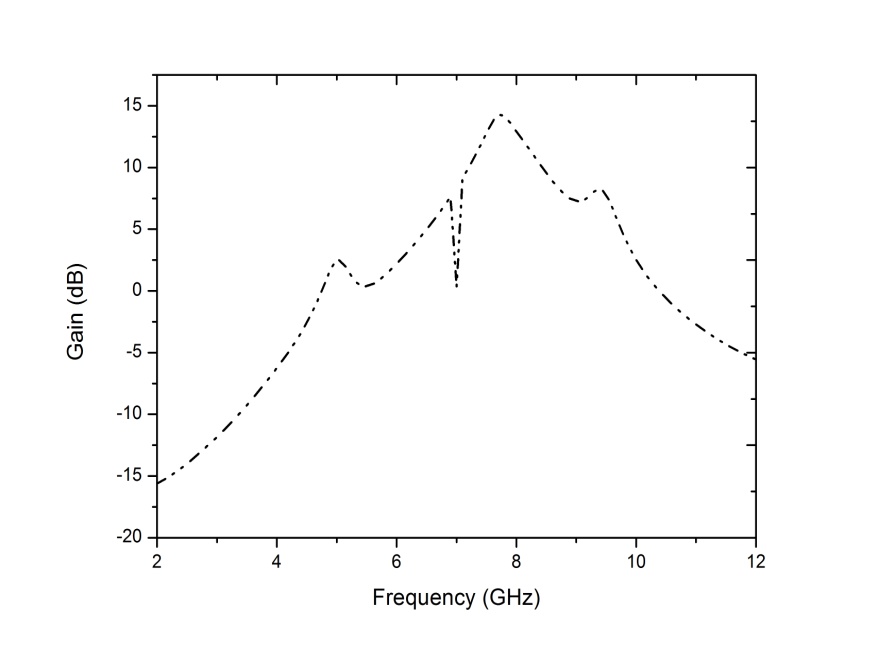
**Figure 5: VSWR curve for different dimensions of S-shaped slot of antenna**



**Figure 6: VSWR curve for different dimensions of G of antenna**

Figure 5 elucidates the variation of VSWR curve with different dimension of lengths (L3 & L4) and optimization of slot length has been done. The rejected band’s frequency reduces as the value of (L3 & L4) of the DMS slot increases, as shown in Fig. 5. The effective inductance and capacitance of the feed-line (microstrip line) enhance as a result of the defective microstrip structure (DMS). A lower rejected band results from an increase in effective inductance, which is caused by an increase in slot length.

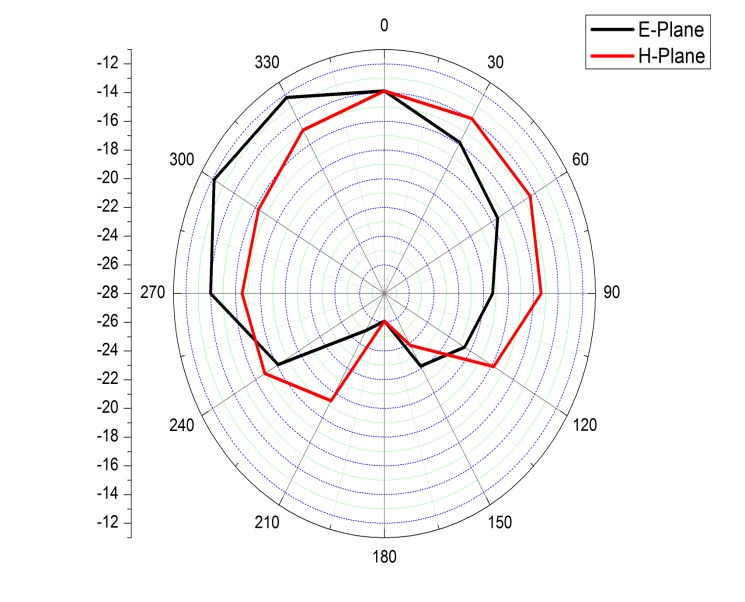
Fig.6 illustrates the variation in gap G VSWR consequences for a single rectangular SRR metamaterial slot on patch. Figure 6 shows that a single rectangular SRR is capable of producing notable band rejection characteristics. The effective inductance decreases along with the increase in gap size for the rectangular SRR inspired by metamaterials, leading to an upper resonance frequency.



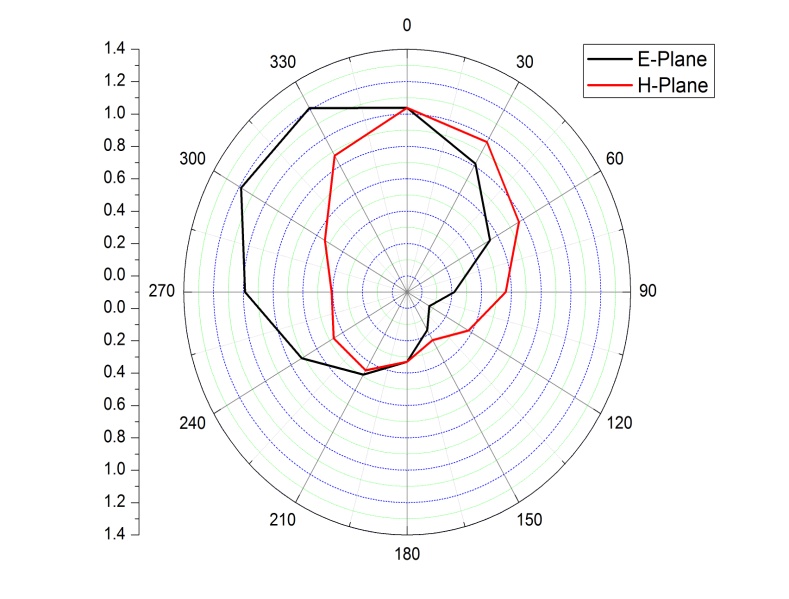
**Figure 7: Gain of Simulated Antenna**

Figure 7 shows the result of gain of simulated band rejected antenna versus the UWB frequency range (3-12 GHz). The outcome reveals a high gain of 14.3 dB with a low value at the rejected bands.

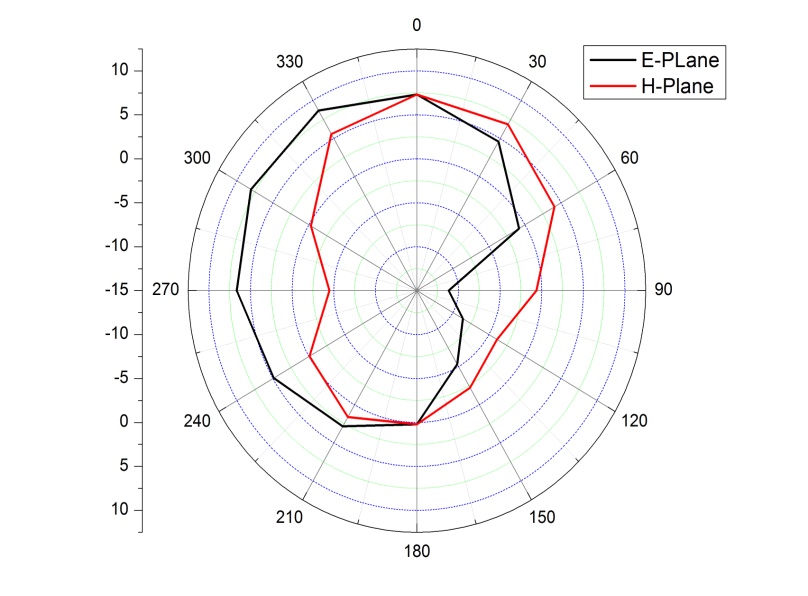
Figure 8 describes radiation patterns of the suggested antenna by simulation in both the E-Plane (phi=0o) and the H-Plane (phi=90o). The proposed UWB antenna exhibits a bi-directional radiation pattern in the E-Plane and an omni-directional radiation pattern in the H-Plane, as shown in figure 8.



1. **At 3.10 GHz**

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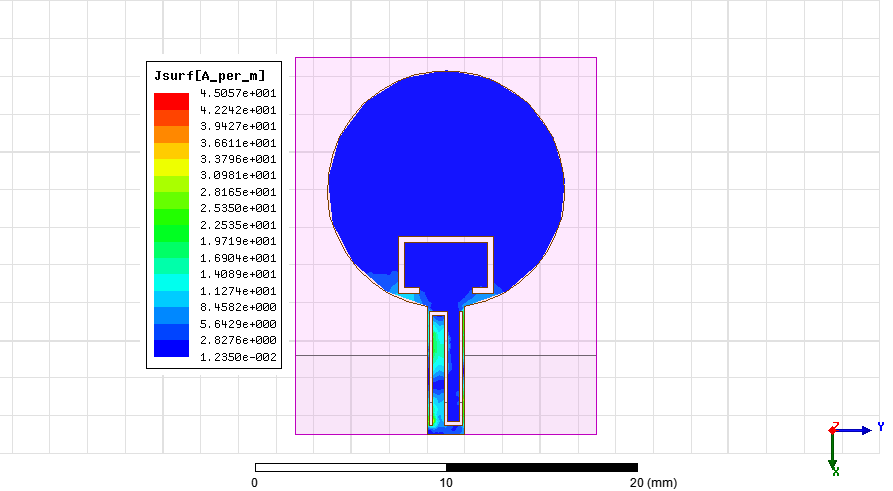
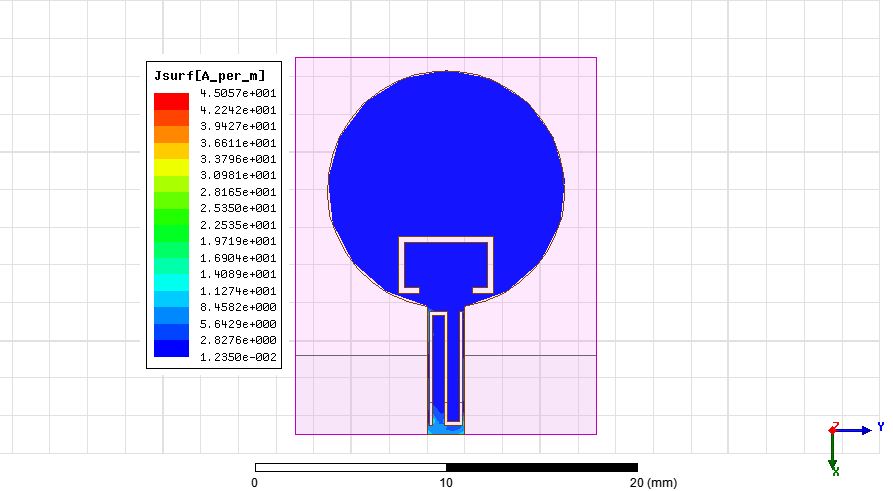
1. **6.10 GHz**

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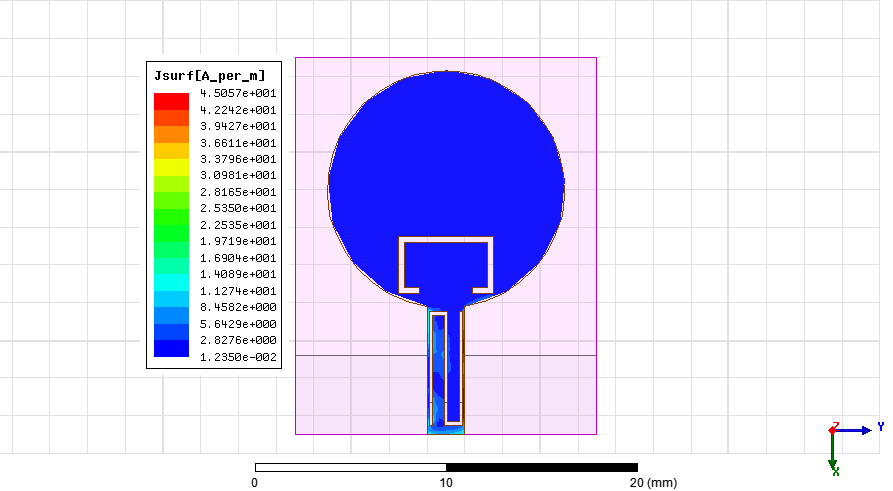
1. **8.50 GHz**

**Figure 8: Radiation pattern at different frequencies in E-Plane and H-Plane**

Figure 9 shows the simulated result of surface current distribution at various frequencies. Figure 9 shows that current is primarily distributed around the rectangular metamaterial slot for the split ring resonator (SRR) and slot of shape S for rejected bands.



**(a) At 5 GHz (b) At 7.7 GHz**

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**(c) 9.5 GHz**

**Fig 9: Surface Current distribution at different frequencies**

# CONCLUSION

This paper describes a miniaturized ultra-wideband UWB antenna with band-notched properties based on a split ring resonator (SRR) metamaterial slot and an S-shaped slot. Additional space is not required because they are introduced on the patch and the feeding line of the primitive antenna. By altering the introduced slots' dimensions, the notch frequencies can be easily controlled. A wide bandwidth of 3.4 GHz to 10.8 GHz is achieved by the design, and a high gain of 14.3 dB at 7.73 GHz is achieved. In the E-plane and the H-plane, the proposed structure achieves omni-directional and bi-directional radiation patterns over UWB frequency.

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