Indian Journal of Pure & Applied Physics
Vol. 64, November 2026, pp. 1173-1180
DOI: 10.56042/ijpap.v64i11.29122

# A Slot-Loaded Tuning-Fork-Shaped UWB Antenna with Dual-Band Notch Using EBG Structure

Rama Krishna Chokkakula[a,c], Moses Nesasudha[a] & Doondi Kumar Janapala[b*]

[a]Division of Electronics and Communication Engineering, Karunya Institute of Technology and Sciences, Coimbatore, Tamilnadu 641 114, India

[b]Department of Electronics and Communication Engineering, Vishnu Institute of Technology, Bhimavaram, Andhra Pradesh 534 202, India

[c]Department of Electronics and Communication Engineering, Smt B Seetha Polytechnic College, Bhimavaram, Andhra Pradesh 534 202, India

*Received: 26th February 2026; accepted: 29th September 2026*

In this paper, a planar Ultra-wide-band (UWB) antenna is designed with dual-band notch characteristics to suppress interreference from WLAN and X-band applications. The antenna utilized a tuning fork shaped patch with a squared slot loaded at centre. The UWB antenna operational band covered from 2.1 GHz to 12.81 GHz. An inverted U-shape and T shaped are positioned together to form the unit cells. Initially the proposed unit cell is etched as slot on the partial ground plane, this helped in notching the band above 10.59 GHz. Now another unit cell is added to the ground plane as stub to achieve the dual-band notch to filter 4.03 GHz to 7 GHz and 8.32 GHz to 9.58 GHz. The proposed UWB antenna with dual-band notch operates at 3.126 GHz, 7.558 GHz & 10.337 GHz. The simulated and measured $S_{11}$ and radiation pattern curves are in good agreements. The designed antenna is suitable candidate for UWB applications requiring the WLAN and X-band interreference suppression.

**Keywords:** UWB, Notch bands, WLAN, X-band, Slot, Stub

## 1 Introduction

Over the years several UWB antennas have been developed to serve various application requiring the wideband coverage for larger data transfer. These UWB antennas cover 3.1 GHz-10.6 GHz as per the Federal Communications Commission (FCC). Designing antennas with wide band coverage involves varying the radiating element and ground plane to achieve the better band width ratio. There are several narrow band applications such as WiMAX, WLAN and X-band within the UWB coverage, which may cause interreference. The interference challenges can be mitigated by introducing notch characteristics into the UWB antenna design. With the notch characteristics the UWB antennas can filter the selected bands that may interfere with UWB operation[1-5].

Different techniques have been introduced to notch single to multi bands with lower to higher band rejections. The methods to achieve the notch characteristics mainly involve incorporating the slots and stubs into the design. These slots or stubs can be added to either radiating patch or the ground based on antenna design and the application requirement. In recent years several structures like metamaterials (MTM), frequency selective surface (FSS), artificial magnetic conductors (AMC), split ring resonators (SRR), and parasitic elements are being used to achieve notch characteristics. An open-ended L-shaped slot is introduced to a planar monopole antenna with asymmetric coplanar strip (ACS) feed[6], the slot helped in achieving the band notch at 5.2 GHz and additionally produced 2.4 GHz passband. Similarly, an arc-shaped slot is etched on radiating patch[7], to achieve WLAN band notch characteristics at 5.5 GHz. In[8] a FSS unit cell made of square shaped EBG structure is used to filter the 3.7 GHz to 4.2 GHz band from circular UWB antenna which covered 2.9 GHz to 14 GHz. A CSRR is loaded as slot on radiating patch for WLAN notch to filter 4.95 GHz to 5.35 GHz[9]. Here another layer of FSS array at back side of the antenna is used to enhance the gain. Another UWB antenna is developed with a different SRR etched on the patch to reject WLAN band with center frequency at 5.2 GHz[10]. Here the UWB MIMO antenna isolation is improved by using a ground stub.

*Corresponding author: E-mail: doondi.j@vishnu.edu.in

In[11], EBG Structure is used to achieve the triple bad notch at 3.3 GHz, 5.72 GHz and 8.32 GHz rejecting the WiMAX, WLAN and X-band satellite uplink to develop a two-element UWB MIMO antenna. An UWB antenna is developed with dual-band notch to suppress interference from sub-6 GHz 5G applications and satellite uplink by using an EBG Structure near strip feed and another slot with inverted π-shape is etched on ground plane[12].

The notch bands can be achieved by varying the ground plane, by involving the slots, stubs and defective ground structures (DGS). In[13], a DGS along with slots used to achieve the dual-band notch at 3.1 GHz to 4 GHz and 5 GHz to 5.9 GHz. A combination of methods is also used to achieve the required number of notch characteristics to filter single to multi band interference. In[14], structures like EBG, SRR and step impedance resonator (SIR) are used together to achieve quintuple band rejection. Here two elliptical shaped SRRs are etched on the circular patch to create gaps between the satellite downlink in C-band and WLAN band in lower region. An EBG structure is used to achieve another dual-band notch characteristic to reject INSAT and WLAN band upper region. Now an SIR is positioned near the feed line on other side of the EBG structure cell to filter a single band covering the ITU. Similarly, Triangular shaped fractals are used inside a circular ring patch to achieve triple notch characteristics to filter WiMAX, WLAN and X-band applications[15]. A combination of ω and c shaped slots are used to notch WiMAX, & WLAN applications[16]. Three different shaped slots like arc, rectangular and split ring are used to reject the X - band along with WiMAX and WLAN[17]. Four different sized spiral lossy resonators are used to achieve quad notch to reject WiMAX, L & U - WLAN and C- bands[18]. An E - shaped resonator is used along with meander and U - shaped slots to generate a triple notch UWB antenna. Here the individual notch bands can be controlled by varying the parameters of the slots and resonator[19].

The UWB antennas with proper filtering can reduce the interference from the existing models and allow the specific applications to be carried with in the UWB as multi band applications. In current work, the antenna suppressed a wider band from 4.03 GHz to 7 GHz to suppress the Wi-Fi/WLAN at (5.15 GHz - 5.825 GHz), C-band uplink (5.925 GHz - 6.425 GHz), and 5G mid band n79 (4.4 GHz – 5 GHz) applications. While allowing the lower region of the UWB covering from 2.1 GHz to 4 GHz (S-band). By allowing the S band it can serve the major applications at 2.4 GHz and n78 bands of 5G applications and major portion of the n77 band is also covered within this band. The second notch from 8.32 GHz to 9.58 GHz is introduced to suppress the X-band satellite and radar interference.

## 2 Methods and Materials

### 2.1 Fork-Shaped Dual-Band Notch UWB Antenna

The proposed dual-band notch UWB antenna is presented in Fig. 1. Where the radiating element is designed based on tuning fork shape with a square shaped open slot at center. The antenna is fed by microstrip model as shown in Fig. 1 (a). A partial ground with open slot is used in this design illustrated in Fig. 1 (c). For achieving the notch characteristics, a metamaterial inspired EBG structure is used as slot and stub. The EBG structure is formed using inverted

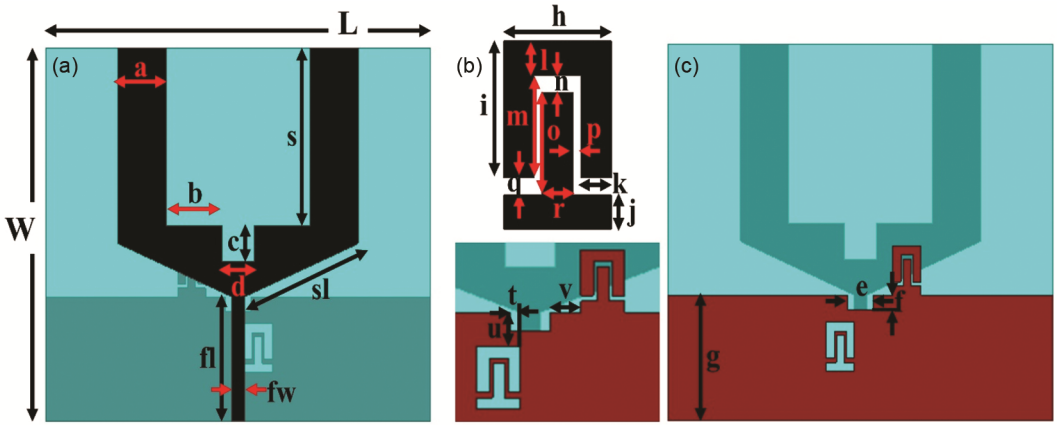


Fig. 1 — Design of the proposed dual-band notch UWB antenna (a) Top view (b) EBG structure with its positioning details; and (c) Bottom view

U and T shaped stubs together as shown in Fig. 1 (b). The geometrical dimensions are listed in Table 1.

The antenna is fabricated using FR4 substrate with thickness 0.8 mm and dielectric constant 4.4. The overall dimensions of the antenna is maintained as 48 mm × 42 mm. when viewed from top view the EBG structure slot is made on ground plane at right side of the feed line and as stub it is added at left side of the strip feed. The antenna without introducing EBG structure produces UWB respnse. The tuning for shaped antenna $S_{11}$ vs Frequency comparison without side vertical strips and with side vertical strips is compared in Fig. 2.

In the above Fig. 2, it can be seen that without the vertical strips the antenna UWB coverage is not maintained. When the vertical strip lines are extended, the antenna covered the operational band from 2.1 GHz to 12.81 GHz below -10 dB level maintaining a bandwidth of 10.71 GHz. Here the initial UWB antenna covered beyond the 3.1 GHz to 10.6 GHz. The final antenna with EBG structure as slot and stub on ground plan allowed additional operational from UWB (2.32 GHz to 3.1 GHz) to be used for S-band applications. The additional band from 10.6 GHz onwards is notched.

Table 1 — The dual-band notch UWB antenna design parameters in (mm)

| Parameters | Value | Parameters | Value |
|---|---|---|---|
| W | 42 | m | 3 |
| L | 48 | n | 0.5 |
| a | 6 | o | 3 |
| b | 7 | p | 0.2465 |
| c | 4 | q | 0.5 |
| d | 4 | r | 1 |
| e | 3.2 | sl | 15.4616 |
| f | 1.6 | fl | 14 |
| g | 14 | fw | 1.5 |
| h | 3.493 | s | 20 |
| i | 4 | t | 0.8465 |
| j | 1 | u | 3 |
| k | 1 | v | 2.4535 |
| l | 1 | | |

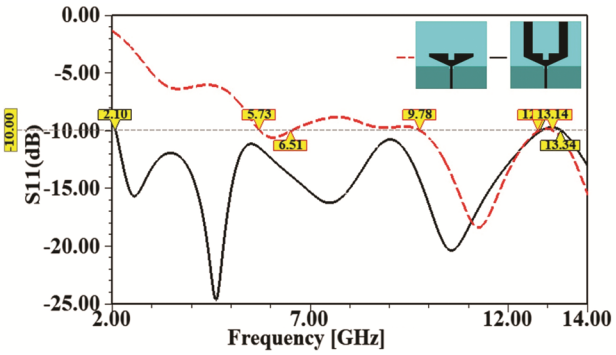


Fig. 2 — $S_{11}$ vs Frequency comparison of the tuning fork shaped UWB antenna

## 3 Results and Discussion

A novel metamaterial inspired EBG structure is designed by placing the inverted U and T shaped stubs together. One-unit cell is etched as a slot on the ground plane while the other unit cell of same size is added to the ground plane as a stub. The $S_{11}$ vs Frequency comparison between the proposed UWB antenna and with EBG slot on the ground plane is presented in Fig. 3. Similarly, the comparison is presented when the EBG structure is used as stub in Fig. 4. The proposed dual-band notch characteristics when both slot and stub are used together with the UWB response compared in Fig. 5.

From the Figs. 3 to 5, the effect of EBG structure on the antenna performance is summarized in the Table 2.

When the EBG structure is used as slot it helped in notching the band after the UWB higher frequency 10.59 GHz. In Fig. 4, the EBG unit cell is added as a stub it helped in achieving a wider stop band along

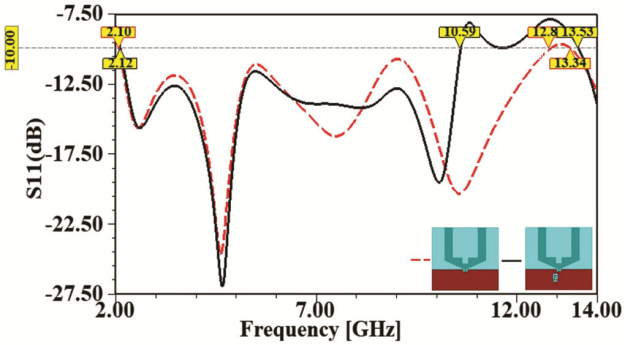


Fig. 3 — $S_{11}$ vs Frequency comparison of UWB antenna with EBG structure as slot

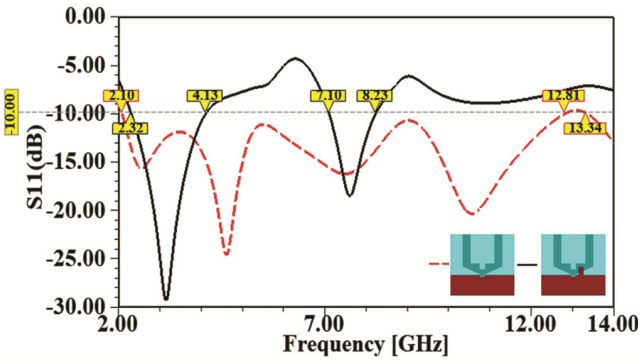


Fig. 4 — $S_{11}$ vs Frequency comparison of UWB antenna with EBG structure as stub

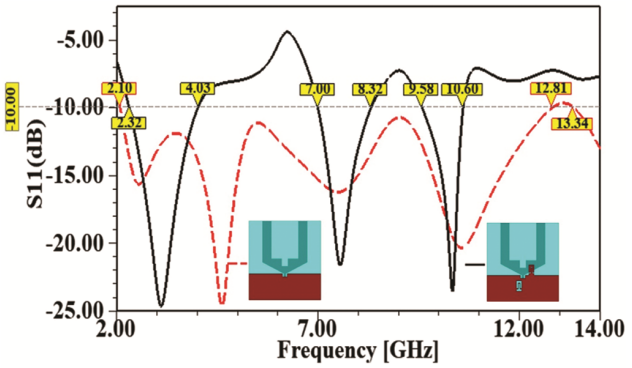


Fig. 5 — $S_{11}$ vs Frequency comparison of UWB antenna with EBG structure as slot & stub together

Table 2 — The Effect of EBG Structure on Operational & Rejected Bands

| Method | Operational/Pass band (GHz) | Rejected/Stop bands (GHz) |
|---|---|---|
| EBG structure as a slot a on ground plane | 2.1 - 10.59 | None within UWB |
| EBG structure as a Stub on ground plane | 2.1 - 4.13<br>7.1 - 8.23 | 4.13 - 7.1<br>8.23 to remaining |
| EBG structure as a Slot & Stub on ground plane | 2.32 - 4.03<br>7 - 8.32<br>9.58 - 10.6 | 4.03 – 7<br>8.32 - 9.58 |

with another notch band (4.13 GHz -7.1 GHz & 8.23 GHz on wards), Now the EBG slot and stub introduced together and from Fig. 5 it can be seen that along with S-band they helped in creating two more pass bands. one at 7 GHz - 8.32 GHz for serving applications like satellite uplink (7.25 GHz - 7.75 GHz) & space research with deep space communications (7.9 GHz - 8.4 GHz). Another pass band at 9.58 GHz -10.6 GHz to serve the upper X-band radar applications. It also restricted the second notch to 8.32 GHz - 9.58 GHz to suppress the interference from lower X-band satellite and radar applications.

### 3.1 Parametric Analysis of Selected EBG Dimensions

The positioning of the EBG structure as a slot (dimensions t & u) & stub (dimension v) are kept constant while varying the dimensions h, j, i & o. The effect on pass bands and stop bands due to the variation of these dimensions is presented in Figs. 6-8.

From the Figs. 6-8 the pass band and stop band details are listed in Tables 3-5 respectively.

The current work presents an UWB antenna with dual notch bands, here any operational bands beyond the UWB range are not required. From Fig. 6 and Table 3 data one can observe that, for the h = 4.493 mm and 5.493 mm variations antenna

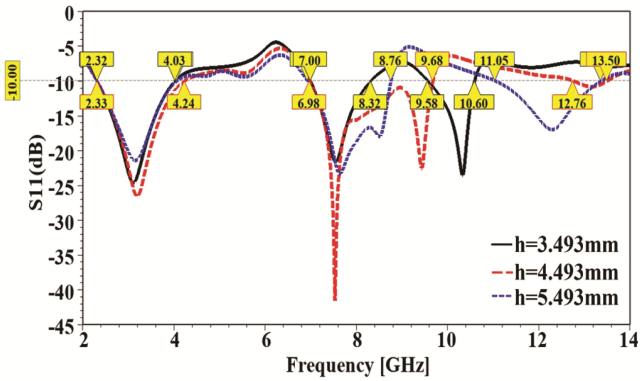


Fig. 6 — Effect of parameter h on $S_{11}$ vs Frequency curve

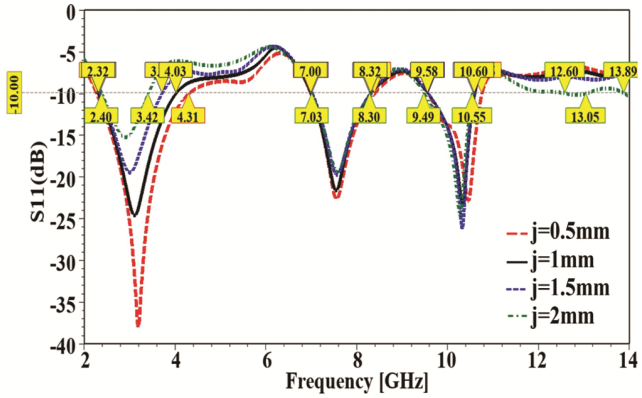


Fig. 7 — Effect of parameter j on $S_{11}$ vs Frequency curve

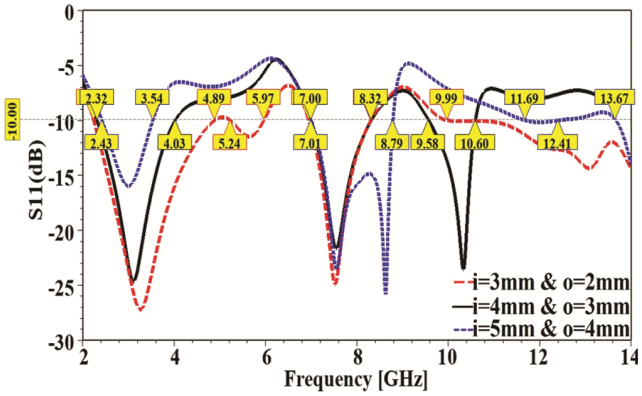


Fig. 8 — Effect of parameters i & o on $S_{11}$ vs Frequency curve

exhibited two pass bands within the UWB range. With three notch bands. Whereas for h = 3.493 mm, antenna exhibited triple band operation with dual notch bands.

From Fig. 7 and Table 4 data it can be observed that, the second pass and notch bands showed less or no change for all the variations of j. The first pass band and stop bands showed significant changes when j is varied and the third pass band also showed some variation but significantly less compared to the first pass band. For j = 0.5 mm the impedance matching is

Table 3 — Operational & Rejected Bands for h Variation

| Variation (mm) | Operational/Pass bands (GHz) | Rejected/Stop bands (GHz) |
|---|---|---|
| h = 3.493 | 2.32 - 4.03<br>7 - 8.32<br>9.58 - 10.6 | 4.03 – 7<br>8.32 - 9.58 |
| h = 4.493 | 2.33 - 4.24<br>6.98 - 9.68<br>12.76 - 13.5 | 4.24 - 6.98<br>9.68 - 12.76<br>13.5 - remaining |
| h = 5.493 | 2.32 - 4.07<br>6.93 - 8.76<br>11.05 - 13.36 | 4.07 - 6.93<br>8.76 - 11.05<br>13.36 - remaining |

Table 4 — Operational & Rejected Bands for j Variation

| Variation (mm) | Operational/Pass bands (GHz) | Rejected/Stop bands (GHz) |
|---|---|---|
| j = 0.5 | 2.28 - 4.31<br>6.99 - 8.4<br>9.57 - 10.76 | 4.31 - 6.99<br>8.4 - 9.57<br>10.76 - remaining |
| j = 1 | 2.32 - 4.03<br>7 - 8.32<br>9.58 - 10.6 | 4.03 – 7<br>8.32 - 9.58 |
| j = 1.5 | 2.35 - 3.72<br>7.03 - 8.3<br>9.58 - 10.58 | 3.72 - 7.03<br>8.3 - 9.58<br>10.58 - remaining |
| j = 2 | 2.4 - 3.42<br>7.03 - 8.3<br>9.49 - 10.55<br>12.6 - 13.05<br>13.89 - remaining | 3.42 - 7.03<br>8.3 - 9.49<br>10.55 - 12.6<br>13.05 - 13.89 |

Table 5 — Operational & Rejected Bands for i & o Variation

| Variation (mm) | Operational/Pass bands (GHz) | Rejected/Stop bands (GHz) |
|---|---|---|
| i = 3 & o = 2 | 2.25 - 4.89<br>5.24 - 5.97<br>6.95 - 8.31<br>9.99 - remaining | 4.89 - 5.24<br>5.97 - 6.95<br>8.31 - 9.99 |
| i = 4 & o = 3 | 2.32 - 4.03<br>7 - 8.32<br>9.58 - 10.6 | 4.03 – 7<br>8.32 - 9.58 |
| i = 5 & o = 4 | 2.43 - 3.54<br>7.01 - 8.79<br>11.69 - 12.41<br>13.67 - remaining | 3.54 - 7.01<br>8.79 - 11.69<br>12.41 - 13.67 |

better in the first pass band compared to other j variations but the third pass band covered beyond UWB range. For the remaining j variations 1 mm, 1.5 mm & 2 mm, the third pass band operated within the UWB range, but the third pass band operated up to 10.6 GHz as per the required UWB range for j = 1 mm variation only.

Now the data from Fig. 8 and Table 5 indicate that, the i & o variation exhibited similar response like h variation. Only i = 4 mm & o = 3 mm variation it exhibited triple operational bands and two rejected bands within the UWB range and for the remaining variations only two pass bands and triple rejected bands are observed.

### 3.2 Surface Current Distribution Curves and 3D Radiation Patterns

The proposed dual-band notch UWB antenna operates at three resonant frequencies including 3.126 GHz, 7.558 GHz and 10.337 GHz. The surface current distribution and the 3D radiation patterns are presented at these three frequencies in Figs. 9 & 10. In Fig. 9 (a) it can be observed that, the maximum surface current distribution at 3.126 GHz is around 83 A/m and the distribution is more at strip feed and medium distribution observed throughout the antenna except the edges of the vertical strips. Compared to the lower frequency resonance the current distribution is higher in Fig. 9 (b) & (c) around 145 A/m and 143 A/m respectively. The surface current distribution is lesser at the left vertical strip lines for both the higher operating frequencies. Overall, the surface current is mostly distributed along the feed line and radiating edges. As the frequency increased additional current concentration are observed and they formed in a non-uniform manner. The surface current redistribution based on frequency change contributes to the change in radiation patterns at these resonant frequencies. Similarly, from Fig. 10 data the maximum gain at 3.126 GHz is 2.7 dB. which is lower compared to the two remaining resonant frequencies. At 7.558 GHz & 10.337 GHz the maximum gain is maintained as 4.2 dB and 3.55 dB respectively.

### 3.3 Experimental validation and Comparison with Previous Works

The proposed dual-band notch UWB antenna fabricated prototype and its radiation pattern measuring setup is shown in Fig. 11. The simulated and measured comparison for the reflection coefficient and the radiation patterns at the three resonant frequencies are presented in Figs. 12 & 13.

From Figs. 12 it can be seen that the simulated and measured reflection coefficients are in good agreement for the most of the pass and rejected bands. Similarly, in Figure 13, the measured co-radiation patterns are in good agreement with the simulated analysis. As the frequency increased the co-polarization patterns became more directional with additional lobes and nulls. It shows the implemented antenna exhibited frequency depended electromagnetic behavior. The designed dual-band

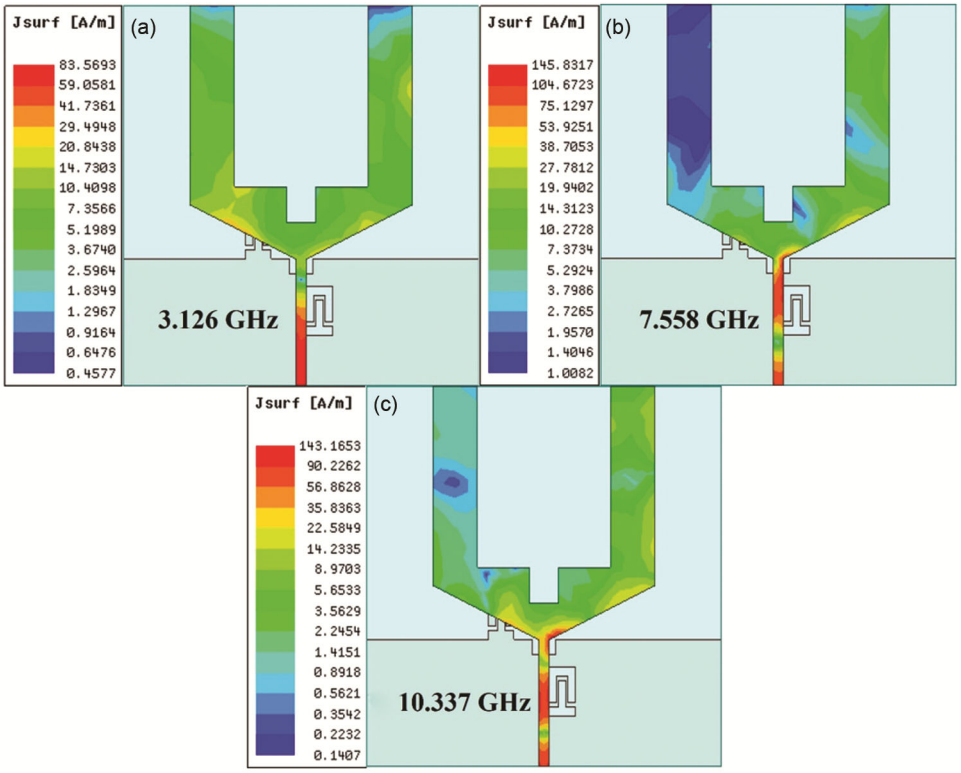


Fig. 9 — Surface current distribution: (a) 3.126 GHz (b) 7.558 GHz; and (c) 10.337 GHz

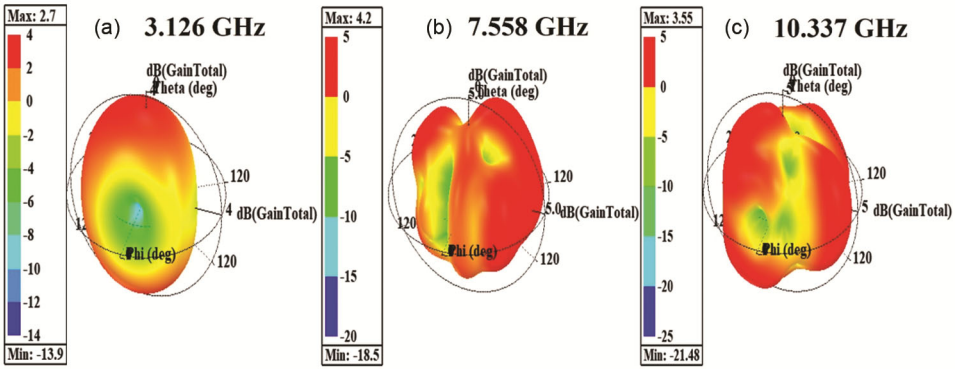


Fig. 10 — 3D radiation patterns: (a) 3.126 GHz (b) 7.558 GHz; and & (c) 10.337 GHz

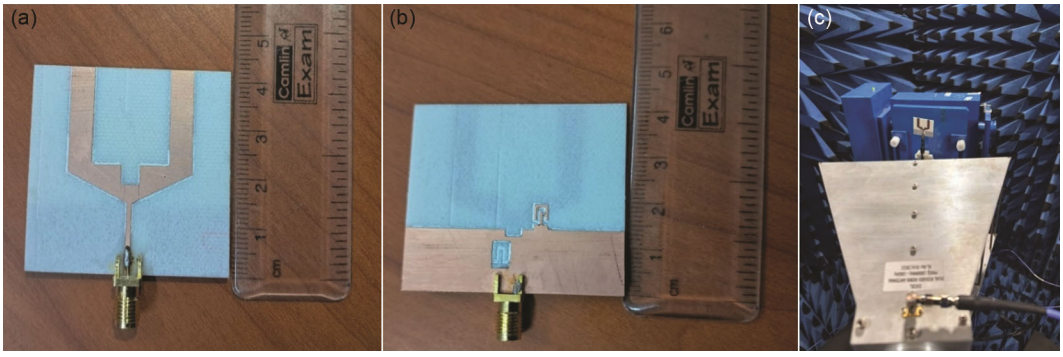


Fig. 11 — (a) Top view (b) Bottom view; and (c) Radiation patterns measuring setup

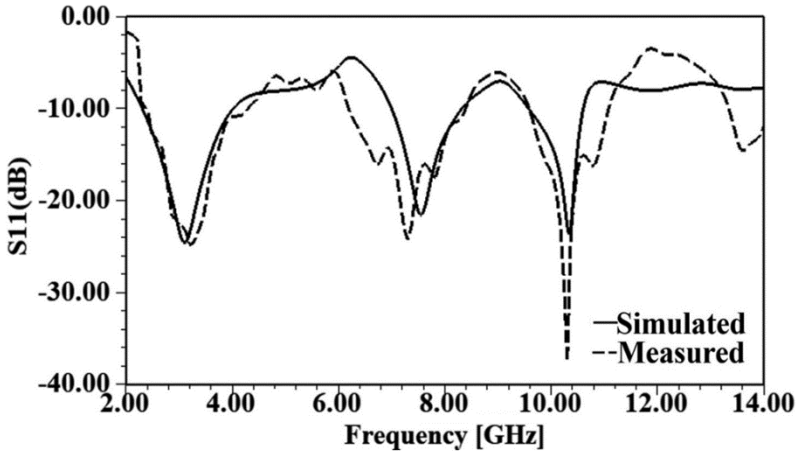


Fig. 12 — Simulated and measured reflection coefficient comparison

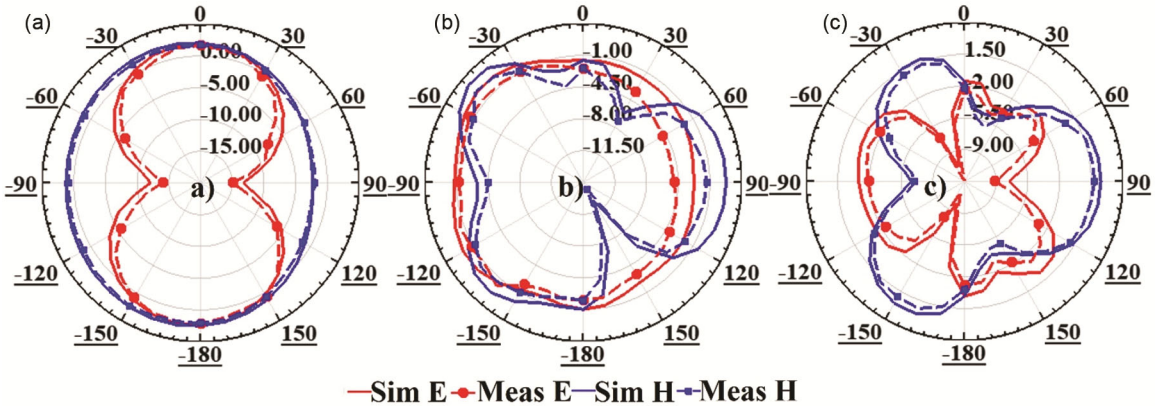


Fig. 13 — Simulated and measured radiation pattern comparisons (a) 3.126 GHz, (b) 7.558 GHz & (c) 10.337 GHz

Table 6 — The dual-band notch UWB antenna performance comparison with previous works

| Ref | Size (mm) and mm$^3$ | Operating band UWB (GHz) | Methode | Rejected bands (GHz) | Gain (dBi) | Substrate material |
|---|---|---|---|---|---|---|
| [16] | 40 × 37 × 1.6 (2368) | 2.5 - 11.5 | ω and inverted C shaped slots with rectangular stub | 3.3 - 3.8 (WiMAX)<br>5.15 - 5.825 (WLAN) | 2 - 5 | FR4 |
| [17] | 27 × 27 × 1.6 (1166.4) | 2.12 - 14.0 | Arc-shaped and split ring slots | 3.16 - 3.76 (Wi-MAX)<br>5.26 - 5.87 (WLAN)<br>7.30 - 7.68 (X-band satellite communication) | 3.65 - 8.19 | FR4 |
| [18] | 50 × 40 × 1.6 (3200) | 2 - 12.5 | Spiral lossy resonator slots | 3.24 - 3.56 (WiMAX)<br>4.76 - 5.34 (L-WLAN)<br>5.58 - 5.91 (U-WLAN)<br>7.37 - 7.71 (C-Band) | - | RO4003C |
| [19] | 33 × 34 × 1.6 (1795.2) | 1.4 - 11.3 | Meandered & U-shaped slots | 1.8 - 2.3 (AWS1-AWS2)<br>3.2 - 3.8 (WiMAX)<br>5.6 - 6.1 (IEEE 802.11) | 3.6 - 4.6 | FR4 |
| This Work | 48 × 42 × 0.8 (1612) | 2.1 - 12.81 | EBG structure as slot and stub | 4.03 – 7 (Wi-Fi, WLAN)<br>8.32 - 9.58 (X-Band) | 2.7 – 4.2 | FR4 |

notch UWB antenna performance is compared with previous works having dual to multi band notch characteristics to prove its suitability for the UWB applications with interference suppression. The designed antenna size is compact compared to the previous works listed in the Table 6.

## 4 Conclusion

A dual-band notch band UWB antenna is designed and presented to operate with triple band applications. Three resonant frequencies occurred at 3.126 GHz, 7.558 GHz & 10.337 GHz serving applications like S-band, satellite uplink & space research with deep space communications and upper X-band radar applications. The antenna achieved two notch bands, where the first one is wider stop band to filter Wi-Fi, WLAN (4.03 GHz-7 GHz) & the second one is to notch the X-Band (8.32 GHz-9.58 GHz). The antenna maintained maximum gain around 2.7 dB, 4.2 dB and 3.55 dB respectively at the three operating frequencies. The simulated and measured analysis for the reflection coefficient and the radiation patterns showed good agreement. The antenna is good candidate to operate with wider stop band to suppress interference from several sub-7 GHz applications like WiMAX, WLAN, 5G n79 bands. The second notch helped to suppress interreference from upper X-band satellite and radar applications.

## References


1 Ling, X, In *InTech eBooks*, 7 (2012) 127.
2 Emadian S R & Nojavan M F, *IntechOpen*, 6 (2024) 1.
3 Matta L, Sharma B & Sharma M, *Wireless Netw*, 30 (2024) 1339.
4 Shome P P, Khan T & Laskar R H, *Int J RF and Microwave Computer-Aided Eng*, 29 (2) (2018) e21518.
5 Abbas A, Awan W A, Hussain N, Choi D, Lee S & Kim N, *Heliyon*, 11 (2) (2025) e41922.
6 Koohestani M, Azadi-Tinat N & Skrivervik A K, *IEEE Access*, 11 (2023) 7540.
7 Kaur K, Kumar A & Sharma N, *Mater Today Proceed*, (2023) 1.
8 Mukherjee S, Roy A, Mukherjee A, Kundu S, Sarkar P P & Bhunia S, *AEU - Int J Electron Comm*, 178 (2024) 155276.
9 Kumar A, De A & Jain R K, *Wireless Pers Commun*, 133 (2023) 507.
10 Saleem S, Kumari S, Mirdha V, *et al.*, *Sādhanā*, 49 (26) (2024) 1.
11 Kapure V R & Rathod S S, *Sādhanā*, 48 (7) (2023) 1.
12 Bantupalli P, Gimmadi S & Shaik A S, *J Inst Eng India Ser B*, 106 (2025) 103.
13 Zayani Z, Jam S, *Iran J Sci Technol Trans Electr Eng*, 47 (2023) 327.
14 Arora S, Sharma S, Anand R, *et al*., *Analog Integr Circ Sig Process*, 123 (2025) 4.
15 Orugu R & Moses N, *Int J Numeric Model Electron Netw Device Fields*, 34 (1) (2020) 1.
16 Pandey G K, Singh H S, Bharti P K, *et al.*, *Wireless Pers Commun*, 89 (2016) 79.
17 Kaur K, Kumar A & Sharma N, *Analog Integr Circ Sig Process*, 114 (2023) 143.
18 Parthiban N & Ismail M M, *Progress Electromagn Res C*, 124 (2022) 11.
19 Iqbal A, Smida A, Mallat N K, Islam M T & Kim S, *Sensors*, 19 (6) (2019) 1411.