VOL. 17, NO. 2, JANUARY 2022 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

# TRIPLE BAND NOTCHED ULTRA COMPACT WIDEBAND MONOPOLE

Pradeep Vinaik Kodavanti[1,2], Jayasree PVY[2] and Prabhakara Rao Bhima[3]
[1]Department of ECE., JNTUK Kakinada, India
[2]Department of EECE., GITAM (Deemed to be University), Visakhapatnam, India
[3]School of Nano Technology, JNTUK Kakinada, India
E-Mail: pradeep.kodavanti@gmail.com

**ABSTRACT**

Wide band antenna design had consequently drawn more attention from academic to industries. So wide band antennas should be capable of operating over an ultra wide band and also cover high frequency bands. At the same time, small and compact antenna size is required to integrate it to communication systems. This work focuses on the design of an ultra compact rectangular monopole with corner feed. The size of the antenna is 22×20mm$^2$, fabricated on an FR4 substrate with 1.6mm thickness. An asymmetrical rectangular ground is introduced with a rectangular cut below the feed. The monopole works over a broad band beyond 7.5GHz. A reversed 'U' shaped opening on the rectangular patch presents a stop band (6.5-7.1GHz). With inverted 'L' shaped slot (L1) on the ground presents second notched band (11-11.69GHz). Another Inverted 'L' shaped slot (L2) is introduced on to the ground outcomes another notched band (13.16-13.93 GHz). The proposed antenna is simulated for VSWR, radiation pattern, total gain and current density.

**Keywords:** triple band, ultra compact, antenna, monopole.

## 1. INTRODUCTION

With the allocation of the range of frequencies 3.1-10.6 GHz, ultrawideband technology has become the most developing technologies for high datarate wireless communications. Compact Ultra Wide Band (UWB) antenna is the main subject in recent advancements of wireless communications, but with an increase in the number of applications there is a problem of electromagnetic interference in the spectrum of UWB antenna. To avoid electromagnetic interference in the spectrum of UWB, a band notched function is used. A notched band is realized by inserting a slot on to the UWB antenna. In this article a reversed 'U' shaped slot is inserted on to the rectangular patch to notch, 6.5-7.1GHz, inverted 'L' shaped slot (L1) on the ground plane introduces a second notch (11-11.69GHz) and inverted 'L' shaped slot (L2) on the other side of the ground plane presents a third notch (13.16-13.93 GHz).

Many investigators attempted to design various wide band antennas to expand the bandwidth. An UWB antenna whichextendsto20×20×1.6mm$^3$ is designed with various slots to operate between 2.39-18GHz [1]. Compact band notched antenna is fabricated with volume of 32× 28 × 1.6mm$^3$ operating between 2.08-12GHz. Three different types of slots were used in order to realize notched bands. The pattern of radiation is omnidirectional across the interested frequencies [2].

Printed aperture aerial consists of a circular patch, rectangular shaped ground with a circular opening on the rear side. The band stop function is achieved by using three quarter wavelength strips. This technique utilizes less space for obtaining band stop functions [3]. A compact, low cost circular patch antenna is designed using Split Ring Resonator and 'S' shaped slot in the feed. These are used to produce band stop characteristics [4].

Hexagonal shaped monopole antenna is designed with a partial circular ground with a square slit below the feed line shows an ultra wide band of 7.5GHz. A frequency stop band (5.1GHz - 5.57GHz) is achieved by presenting 'U' shaped slot [5]. Other techniques such as introducing spiral shaped slots, meandered ground stubs, bent and folded slots, nested semielliptical slots, energy band gap structures etc. are available in the open literature to introduce band stop features [6]-[12].

## 2. DESIGN OF RECTANGULAR MONOPOLE

In the design ground plane is asymmetrical with respect to the feed line, strip line feed is at one of the corners of the rectangular patch and a rectangular slit is introduced exactly below the feed. FR4 epoxy substrate with 1.6mm thickness, loss tangent=0.02 and $\varepsilon_r$=4.4 is used in the design. The design of the monopole is given in Figure-1 and its measurements are mentioned in Table-1.

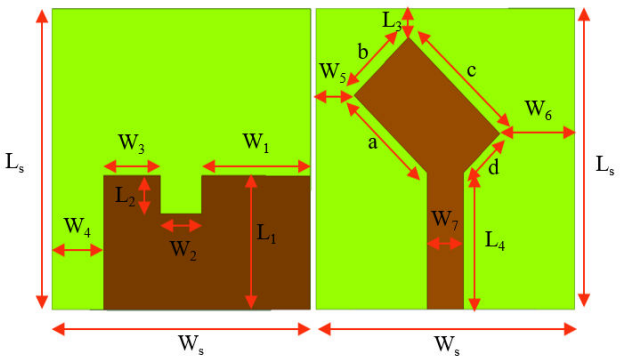



**Figure-1.** Rear and front view of proposed monopole.

**Table-1.** Dimensions of the rectangular monopole.

| S. No. | Parameters | Dimensions | S. No. | Parameters | Dimensions |
|---|---|---|---|---|---|
| 1 | $L_s$ | 22mm | 10 | $L_1$ | 9.8mm |
| 2 | $W_s$ | 20mm | 11 | $L_2$ | 2.8mm |
| 3 | $W_1$ | 8.4mm | 12 | $L_3$ | 2.08mm |
| 4 | $W_2$ | 3.2mm | 13 | $L_4$ | 10mm |
| 5 | $W_3$ | 4.4mm | 14 | a | 8mm |
| 6 | $W_4$ | 4mm | 15 | b | 6mm |
| 7 | $W_5$ | 2.92mm | 16 | c | 10mm |
| 8 | $W_6$ | 5.75mm | 17 | d | 4mm |
| 9 | $W_7$ | 2.8mm | | | |

## 3. RESULTS AND DISCUSSIONS

The rectangular monopole was simulated with HFSS 18.0 software. Simulated results reveal that the voltage standing wave ratio (VSWR) of rectangular monopole exhibits ultra wide band characteristics (4.87GHz to 18GHz) as given in Figure-2.

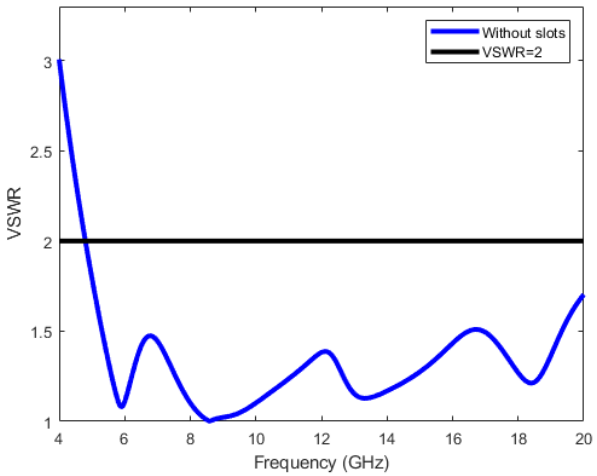
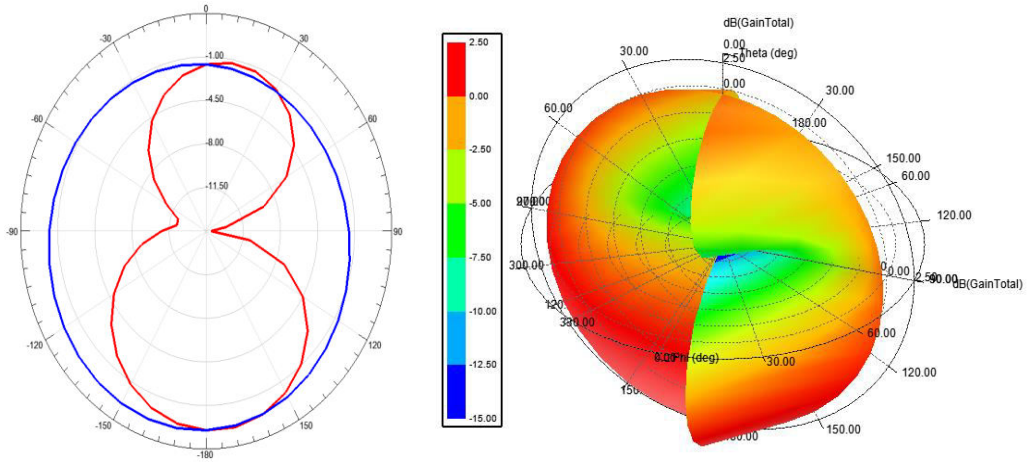
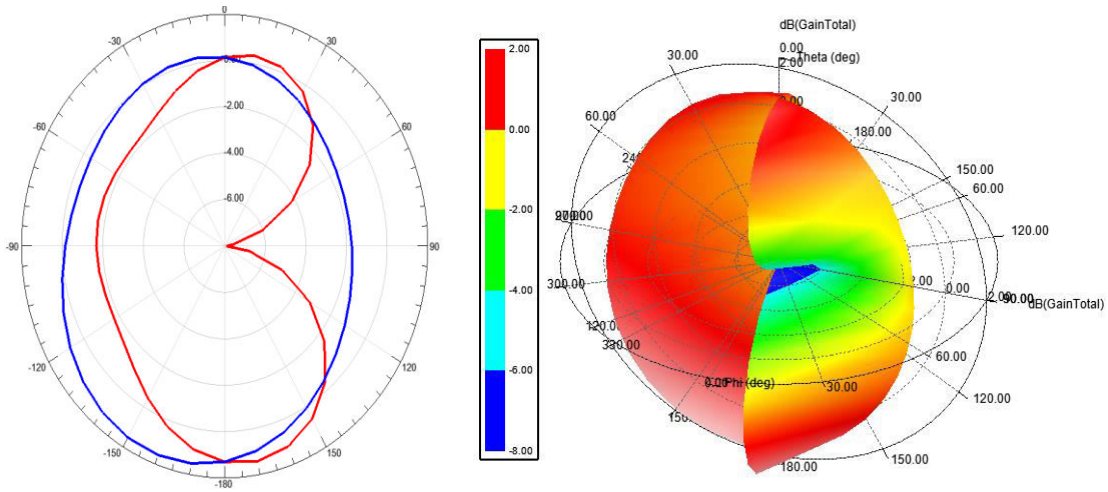



**Figure-2.** VSWR of the proposed antenna.

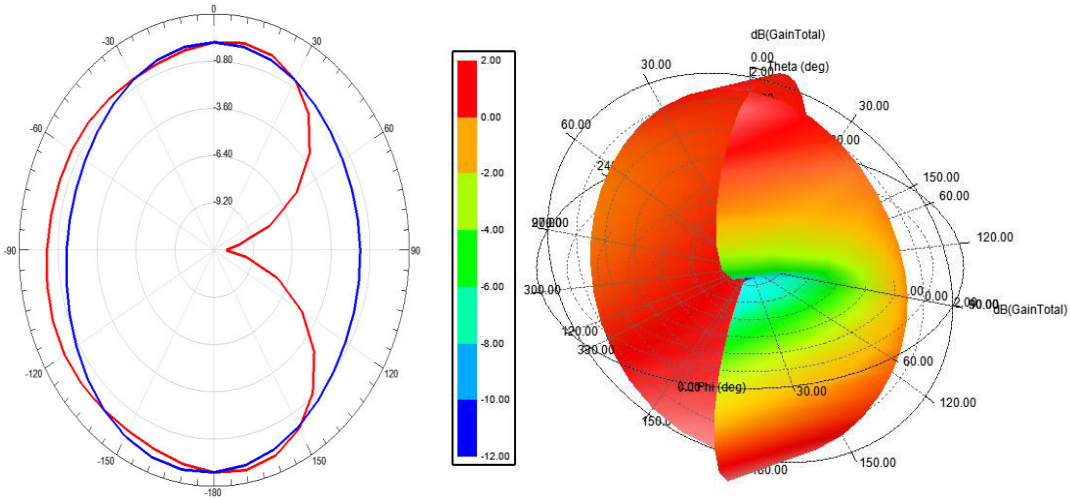
The pattern of radiation and total gain of rectangular monopole at 5GHz, 7GHz and 9GHz are presented in Figure-3.




at 5GHz




at 7GHz




at 9GHz

**Figure-3.** Simulated E-plane pattern (red), H-Plane (blue) pattern and Polar plots.

### 3.1 Reversed 'U' Shaped Slot on to the Patch

Reversed 'U' slot (x=1mm, y=4mm and z=6mm) introduced on the rectangular patch results in a notch band between 6.5GHz to 7.1GHz. The geometry of the slot on the patch is shown in Figure-4. The VSWR of rectangular monopole with slot is presented in Figure-5.

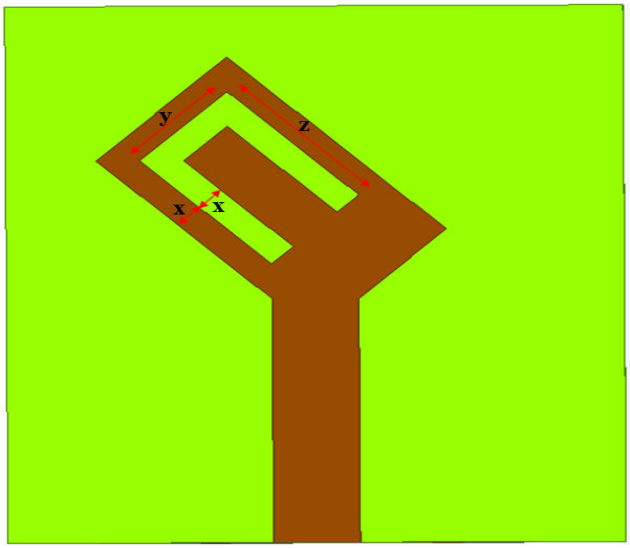



**Figure-4.** Geometry of slot introduced on the patch.

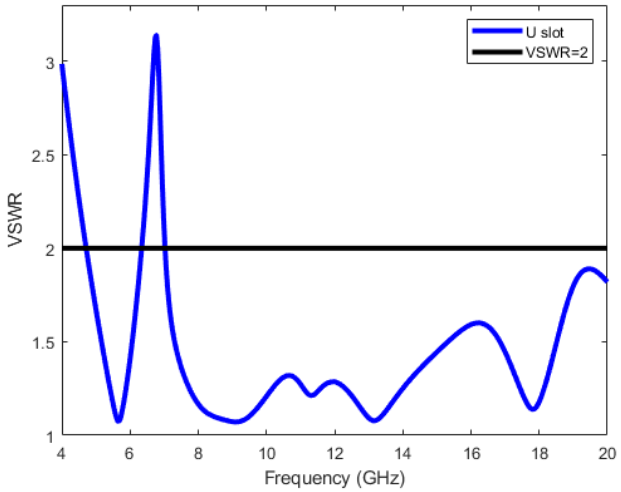



**Figure-5.** VSWR of rectangular monopole with inverted 'U' slot.

### 3.2 Reversed 'L' Shaped Slot on Ground Plane (L1)

Reversed 'L' shaped slot (L1) is introduced on to the ground plane (v=0.5mm, w=0.8mm, x=3mm, y=4mm and z=4.5mm) results in another notched band (11-11.69GHz).The geometry of the slot L1 is mentioned in Figure-6. The VSWR plot with respect to frequency is presented in Figure-7.

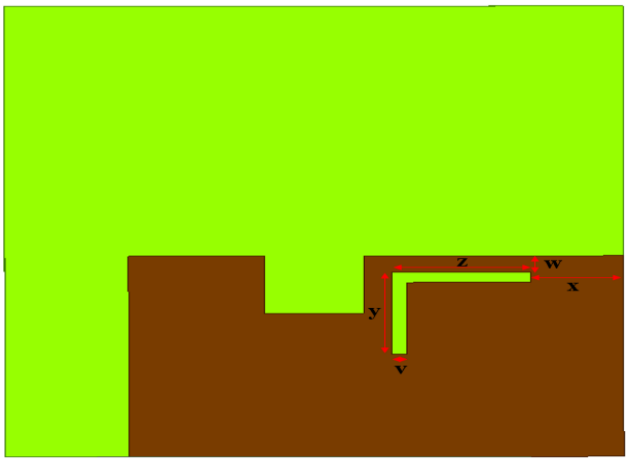



**Figure-6.** Geometry of 'L1' slot on the ground plane (rear view).

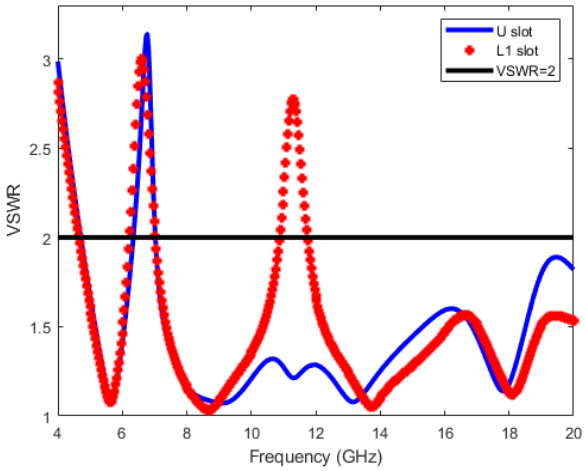



**Figure-7.** VSWR with reversed 'U' slot and 'L1' slot.

### 3.3 Reversed 'L' Shaped Slot on Ground Plane (L2)

Reversed 'L' shaped slot (L2) is introduced on to the ground plane (v=0.8mm, x=0.5mm, y=3mm and z=4mm) results in another notched band (13.16-13.93 GHz). The geometry of the slot L2 is mentioned in Figure-8. The VSWR plot with respect to frequency is presented in Figure-9.

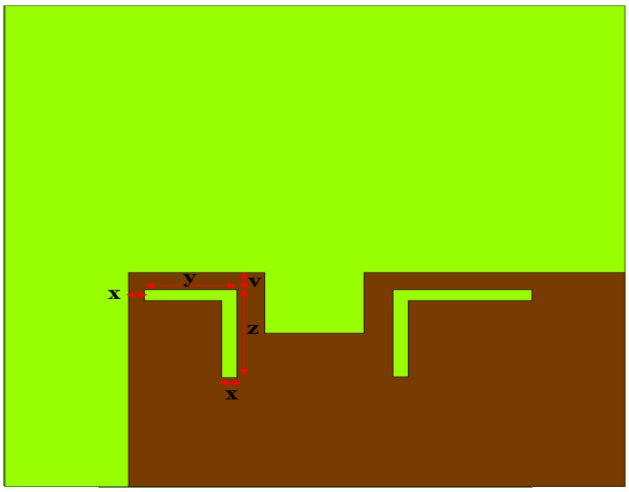



**Figure-8.** Geometry of 'L2' slot on the ground plane (rear view).

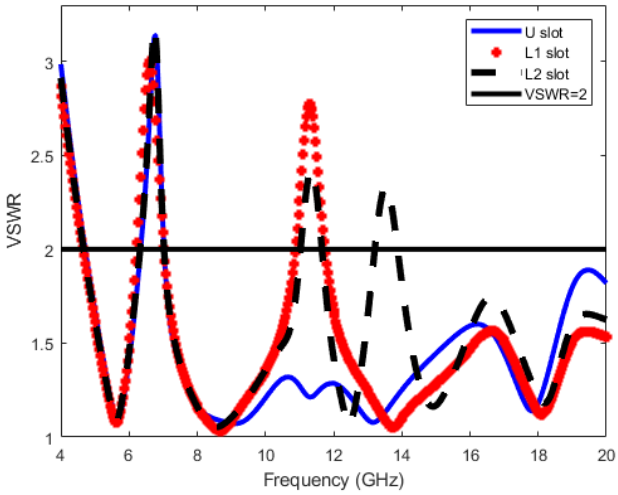



**Figure-9.** VSWR with inverted 'U', 'L1' and 'L2' slots.

### 3.4 Surface Current Distributions

Surface current distributions at each center frequencies of notched frequency bands 6.8 GHz, 11.35 GHz and 13.54 GHz are presented in Figure-10. The red colour in the surface current distribution characteristics indicate maximum current strength and blue colour designates minimum current strength. The surface current distribution plot indicates that the current distribution is maximum at the edges of the slots.

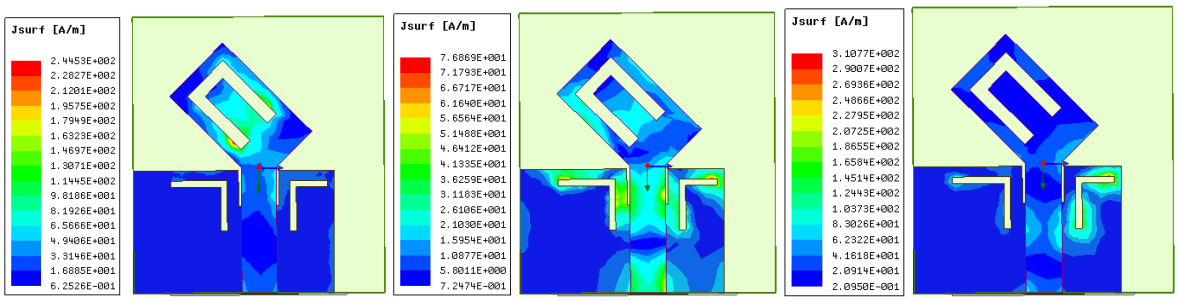



**Figure-10.** Current distribution at 6.8GHz, 11.35GHz and 13.54GHz.

## 4. CONCLUSIONS

A simple compact rectangular shaped antenna is designed for UWB applications (4.87GHz to 18GHz), which includes 5GHz WLAN, 5.8GHz ISM band, X band (8GHz to 12GHz) and Ku band (12GHz to 18GHz). A reversed 'U' slot on the patch results in a notch band (6.5 - 7.1GHz). Reversed 'L' shaped slot (L1) on the ground introduces a second notch(11-11.69GHz). Another reversed 'L' shaped slot (L2) on the other side of the ground plane presents a third notch (13.16-13.93 GHz). Each of the notch bands can be controlled individually. Hence it can be used as an UWB antenna with three band elimination features.

## REFERENCES

[1] Hamad E. K. I. and Mahmoud N. 2017. Compact Tri-Band Notched Characteristics UWB Antenna for WiMAX, WLAN and X-Band Applications. Advanced Electromagnetics, 6(2): 53-58. https://doi.org/10.7716/aem.v6i2.465

[2] S. Alotaibi and A. A. Alotaibi. 2020. Design of a Planar Tri-Band Notch UWB Antenna for X-Band, WLAN, and WiMAX. Eng. Technol. Appl. Sci. Res. 10(6): 6557-6562.

[3] F. Zhu *et al*. 2012. Asymmetric UWB aperture antenna with triple band-notched function. 2012 Loughborough Antennas & Propagation Conference (LAPC), pp. 1-4, doi: 10.1109/LAPC.2012.6403060.

[4] S. Agrawal, A. Yadav and R. P. Yadav. 2017. A compact triple band notched UWB antenna: SRR and feed miniaturization. 2017 International Conference

on Wireless Communications, Signal Processing and Networking (WiSPNET), pp. 929-933, doi: 10.1109/WiSPNET.2017.8299898.

[5] Pradeep Vinaik Kodavanti, Jayasree PVY and Prabhakara Rao Bhima. 2019. Irregular Hexagonal shaped antenna for UWB Applications. International Journal of Recent Technology and Engineering. 8(2).

[6] S. Jayant and G. Srivastava. 2020. Triple Band Notched UWB Antenna. 2020 6th International Conference on Signal Processing and Communication (ICSC), pp. 256-261, doi: 10.1109/ICSC48311.2020.9182765.

[7] Y. F. Weng, S. W. Cheung and T. I. Yuk. 2010. Triple band-notched UWB antenna using meandered ground stubs. 2010 Loughborough Antennas & Propagation Conference, pp. 341-344, doi: 10.1109/LAPC.2010.5666262.

[8] D. S. Rao and I. Govardhani. 2021. A Triple Band-Notched UWB Antenna for Microwave Imaging Applications. 2021 International Conference on Computer Communication and Informatics (ICCCI), pp. 1-6, doi: 10.1109/ICCCI50826.2021.9402436.

[9] X. Hu, W. Yang, S. Yu, R. Sun and W. Liao. 2015. Triple band-notched UWB antenna with tapered microstrip feed line and slot coupling for bandwidth enhancement. 2015 16th International Conference on Electronic Packaging Technology (ICEPT), pp. 879-883, doi: 10.1109/ICEPT.2015.7236720.

[10] Y. Li, Q. Liu, Y. Chen, C. Li, Z. Mo and F. Li. 2018. A compact triple wideband-notched UWB antenna. 2018 International Workshop on Antenna Technology (iWAT), pp. 1-4, doi: 10.1109/IWAT.2018.8379142.

[11] Ekta Thakur, Naveen Jaglan & Samir Dev Gupta. 2020 Design of compact triple band-notched UWB MIMO antenna with TVC-EBG structure, Journal of Electromagnetic Waves and Applications, 34: 11, 1601-1615, DOI: 10.1080/09205071.2020.1775136

[12] Naveen Jaglan, Binod Kanaujia, Samir Dev Gupta, and Shweta Srivastava. 2016. Triple Band Notched UWB Antenna Design Using Electromagnetic Band Gap Structures. Progress In Electromagnetics Research C. 66: 139-147.