A Concise Ultra Wideband Antenna with band incise function

Arpit Jain, Pallav Rawal
Department of Electronics and Communication Engineering, Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur, India
Email:arpitjain3105@gmail.com, pallav@skit.ac.in

Received 03.08.2022, received in revised form 05.10.2022, accepted 07.10.2022
DOI: ***10.47904/IJSKIT.12.2.2027.26-30***

***Abstract*— Ultra wide band (UWB) technology has been recognized as a possible technology for wireless networks applications because of its superb time-domain resolution permitting for meticulous location, trailing. UWB technology is indisputable for the localization of objects and others move quickly on a small-scale and complex environments and processes. During this paper we are going to chronicle an ultra-wideband antenna. Depiction of antenna on an FR-4 substrate with permittivity $\in r = 4.3$, height 1.6 mm, loss tangent = 0.025, width and length 24x28 mm^2. The antenna resonate at 4.73 GHz which work in the wideband from 3.1 to 10.6 GHz has VSWR is 1.06 and a gain of 1.8 and allow to frequency notch from 3GHz to 4GHz frequency band help in avoiding indoor interference of GPS(1.6GHz), Bluetooth and Wi-Fi (2.4GHz).**

***Keywords*—UWB, Wireless Communications, IoT.**

1. INTRODUCTION

Many trade observers claim UWB may prove a lot of prospering than Bluetooth as a result of it prevailing speed, is prudent, uses reduced power, and provides superior location discovery and device locomotive. Ultra-wideband (UWB) is also a interim wireless communication protocol—like Wi-Fi or Bluetooth—uses radio waves of short pulses over a spectrum of frequencies commencing from 3.1 to 10.5 GHz in various applications.

A new survey [1], by the top of 10 years, there'll be 50 billion such devices around us that may connect information by means of internet. Design for network with global wherever devices are connected to a true time information producing technologies appropriate for IoT devices [2], [3]. These devices options outrageous knowledge transmission, easy hardware configuration, low power consumption, small size, low interference, position radiation patterns and a linear section response [4]. The commercial use of the frequency band from 3.1 to 10.6 GHz set by the (FCC) [5]–[7]. UWB antennas have application on ground penetrating radars, e-Health applications, Wireless native space Networks (WLAN), military communication systems and short pulse radars for artificial intelligence [8]–[10].A slots cutting technique on ground is used to increase the frequency at high frequency to extend the information measure [9]. Likewise alternative commutation technology, UWB systems suffer from multipath attenuation. A multiple-input-multiple-output (MIMO) technology give multiplexing gain and variety gain to boost the capability and link quality. [11].

The existing wireless systems which are operating in the UWB band are 3.6 GHz IEEE 802.11y (WLAN), 4.9 GHz IEEE 802.11j (WLAN) and 5.9 GHz IEEE 802.11p (WLAN). The applications of UWB are necessary to prevent interface with these wireless systems. There are many designs has been proposed to minimize the interference by incorporating a notch-band in antenna design. Also several band-rejected UWB antennas are designed, like Planar Rectangular antenna [12]. The z- shaped ground plane is used to increase bandwidth [13]. These antennas can also be achieved by inserting a slot in ground plane or radiating patch [14]-[16]. The band-notch characteristics can be achieved by adding the parasitic element [17]. To achieve strong band rejection complex structures of designs can generate and control stop band properties. While in [18]–[20], authors presented some antenna designs for UWB applications. These all designs are having their own limitation regarding antenna structure and some of the antennas are too complex to design.

In this paper, we present the design of the proposed antenna that is fabricated on an FR-4 substrate with permittivity $\in r = 4.3$, height 1.6 mm, loss tangent = 0.025, width and length 24x28 mm^2. It is also notify that our proposed design is of low cost and easy to fabricate that makes it a favorable choice to install for UWB applications. The proposed antenna is ersatz and contrives to demonstrate the desired characteristics.

2. ANTENNA DESIGN

Starting Geometry of the antenna starts from a rectangular monopole-printed antenna. The antenna is fed by a micro strip transmission line with 50 Ω characteristic impedance. Design equations of antenna are shown below

$$l = \frac{c}{2fr\sqrt{\in reff}} ----(1)$$

$$\in reff = \left(\frac{\in r+1}{2}\right) + \left(\frac{\in r-1}{2}\right)\left[\frac{1}{\sqrt{1+12\frac{h}{w}}}\right]] \quad ---(2)$$

$$w = \frac{c}{2fr\sqrt{\frac{\in r+1}{2}}} -----(3)$$

Where f_r is the resonate frequency, c is the velocity of the light in a vacuum, $\in_r$ is the permittivity of the substrate, and h is the substrate thickness.

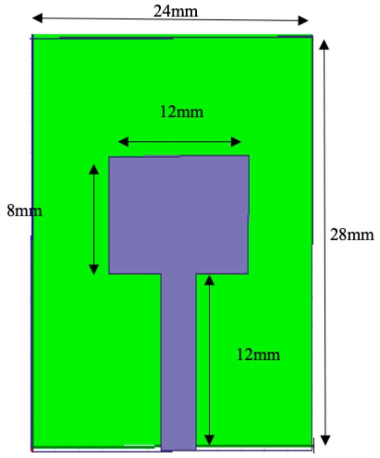

Figure 1: Antenna I

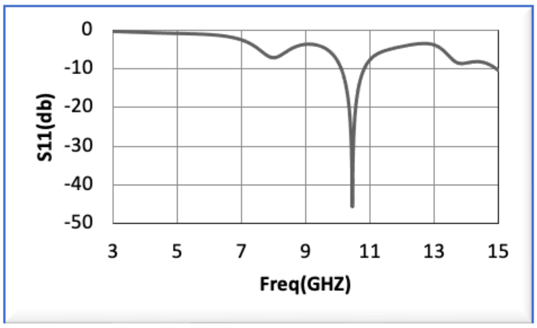

Figure 2: S_{11} v/s frequency graph of antenna I

Antenna I design on FR-4 substrate with permittivity ϵr = 4.3, height 1.6 mm, loss tangent = 0.025, width and length 24x28 mm^2 dimension of substrate, width and length 12x8mm^2 patch with feed line of 3x12mm^2 in dimensions was taken for its compact nature.

Micro strip Line Feeding is used to feed the patch. In such sort of technique conducting strips are connected straight to edge of micro strip patch. Advantage is feed being etched on same substrate having planar structure.

Antenna I result gives a resonating frequency at 10.5GHz occurred with bandwidth of 1 GHz.

As result in figure 2, antenna work at particular frequency with approximately 1GHz bandwidth which doesn't support the requirement of ultra-wide band antenna so we modify design with a slot in patch and observe its results.

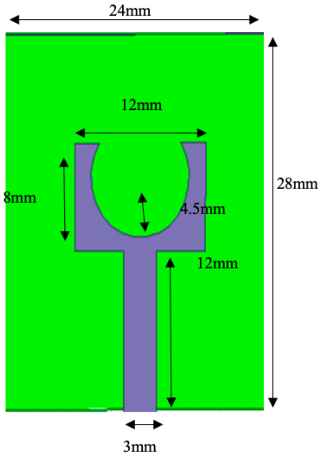

Figure 3: Antenna II

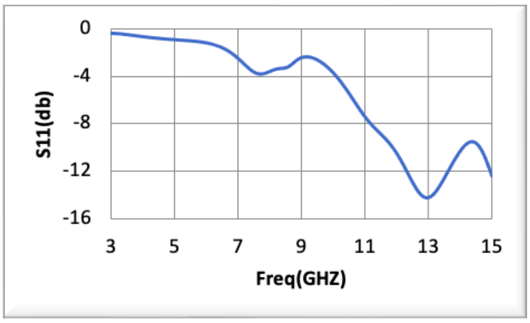

Figure 4: S_{11} v/s frequency graph of antenna II

The Antenna II has a U- shaped slot of 9mm diameter, centre at (12.5, 17.5) mm in a 12x8mm^2 patch dimensions.

Result of design second shows that a slight increase in bandwidth occurred at 3GHz. According to FCC for UWB antenna design we require full bandwidth from 3GHz to 12GHz. Such range is still to be achieved so we further modify structure of antenna with various design modification in patch and ground both.

The design of antenna III was simulated on FR-4 substrate with permittivity ϵr = 4.3, height 1.6 mm, loss tangent = 0.025, width and length 24x10 mm^2 has a U- shaped slot of 9mm diameter, centre at (12.5, 17.5) mm in a 12x8mm^2 patch with feed line of 3x12mm^2 and a 6x0.8mm^2 stab. The radiator and ground on either side of dielectric substrate, made of copper material with thickness 0.035 mm and conductivity = 5.96e7 S/m.

In this paper simple and compact antenna design has been proposed. To avoid interference the notch band frequency between 3.1 to 4.2 GHz. This is a modified antenna structure in which various things are included which not only make it ultra-wideband but also allow to frequency notch from 3GHz to 4GHz frequency band help in avoiding indoor interference of GPS(1.6GHz), PCS(1.9GHz), Bluetooth and Wi-Fi(2.4GHz).

Table 1: Size comparisons of proposed antenna design third with some other existing antenna.

Reference	Size(mm)	Freq.(GHz)	VSWR
[18]	33×37	2.3 – 12	1<range<2
[19]	36.5×35	3.1 – 10.6	1<range<2
[20]	65×65	2 – 10	1<range<2
This work	28×24	3.9 – 14.8	0.82

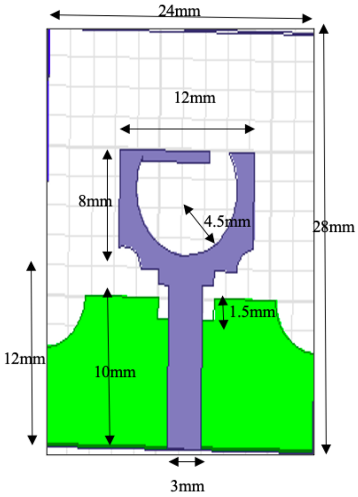

Figure 5: Antenna III

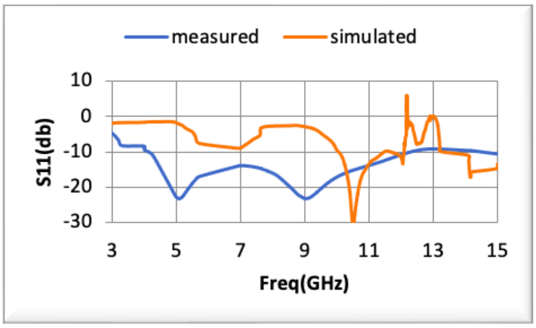

Figure 6: Measured and Simulated S parameter v/s frequency graph of design third.

This above antenna in figure 5 has an ultra-wideband antenna with a large bandwidth of approx.10 GHz in range starting from 3.9GHz to 14.8GHz.

The required ultra-wideband antenna was achieved as shown in figure 6 it works at a large bandwidth of approx.10 GHz in range starting from 3.9GHz to 14.8 GHz. In simulated and measured result of design third antenna differences occur due to fabrication errors and measured errors. But interference still exists so we further modify in ground structure to achieve the required result.

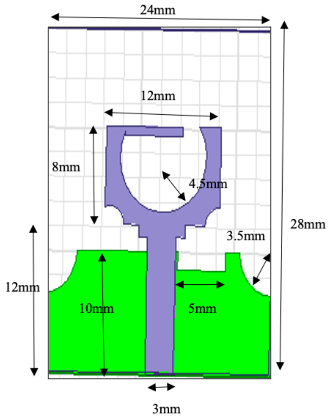

Figure 7: Antenna IV

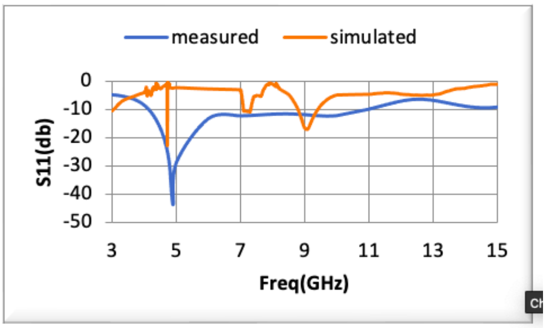

Figure 8: S_{11} v/s frequency graph of Antenna IV

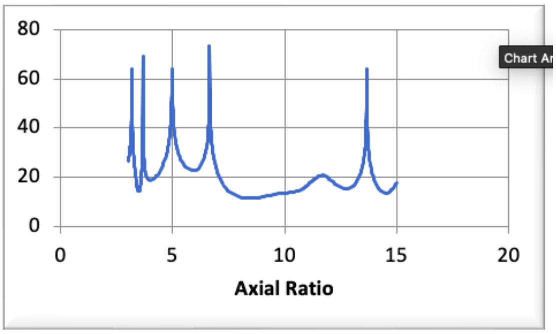

Figure 9: Axial ratio of Antenna IV

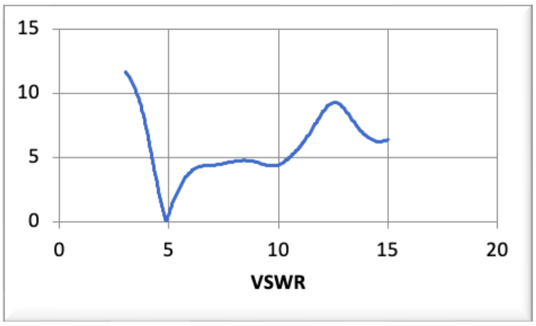

Figure 10: VSWR v/s Frequency graph of Antenna IV

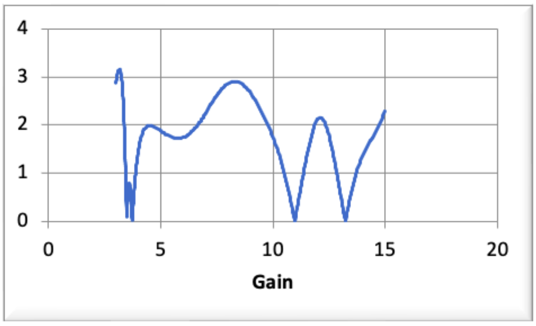

Figure 11: Gain v/s Frequency graph of Antenna IV

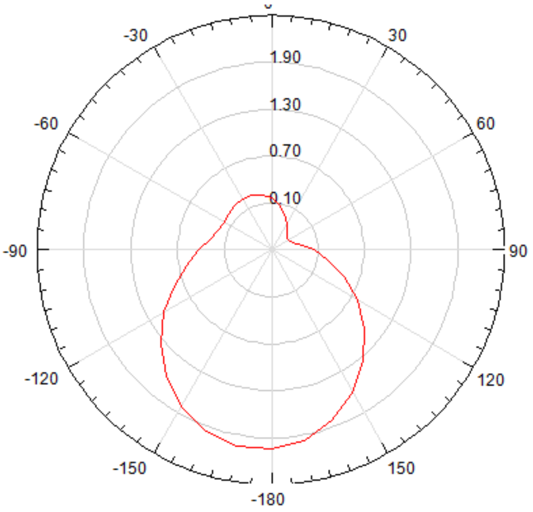

Figure 12: Radiation pattern at phi=0deg, freq=4.73GHz

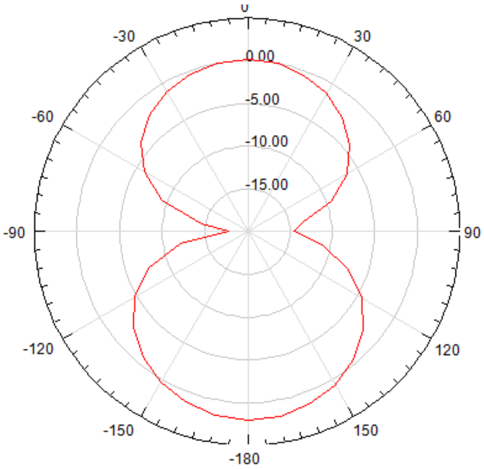

Figure 13: Radiation pattern at phi=90deg, freq=4.73GHz

Antenna IV works in approx.4 GHz to 8 GHz, the shift of rectangular slot of 5x1.5mm^2 in ground plane in right side of feed line. In simulated and measured result of antenna IV differences occur due to fabrication and measured error.

The antenna resonate at 4.73 GHz, a bandwidth from 4GHz to 8GHz make it ultra-wideband but also allow to Frequency notch from 3GHz to 4GHz frequency band help in avoiding indoor interference and in future could be used in IoT under 5G spectrum. Axial ratio graph above shows linear polarization at operating frequency of 5 GHz. voltage standing wave ratio (VSWR) is very good at operating frequency of 5 GHz.

3. CONCLUSIONS

In this paper, a structure of a microstrip patch antennas with partial ground for UWB communication systems suitable for IoT applications has been presented. The proposed UWB antenna covered the frequency range of 4 – 8 GHz in terms of return loss less than -10 dB. It also showed the VSWR less than 2 for the frequency range which is desirable in most of the wireless applications. Those features are mainly required in IoT supported devices. Ultra-wideband antenna provide high spatial awareness in wireless communication systems and doesn't required extra power and bandwidth. The proposed design is used in future IoT devices connectivity. It should be extended together with a lot of antenna components as per the future requirement.

REFERENCES

[1]. A. Grau, "How to Build a Safer Internet of Things: Todays IoT is full of security flaws. We must do better," IEEE Spectrum, March 2015 a-safer-internet-of-things .

[2]. A. Bekasiewicz and S. Koziel, "Compact UWB monopole antenna for internet of things applications," Electronics Letters, vol. 52, no. 7, pp.492-494, April 2016.

[3]. S. Moscato, L. Silvestri, N. Delmonte, M. Pasian, M. Bozzi and L. Perregrini, "SIW components for the Internet of Things: Novel topologies, materials, and manufacturing techniques," IEEE Topical Conference on Wireless Sensors and Sensor Networks (WiSNet), pp. 78-80, 2016.

[4]. L. C. Ping, C. K. Chakrabarty, R. A. Khan, "Enhanced Bandwidth of Impulse-Ultra Wideband (I-UWB) Slotted Rectangular Patch Antenna with Partial Ground Plane," International Journal of Electronics, Computer and Communications Technologies (IJECCT), vol 1, 2010.

[5]. N. H. M. Sobli and H. E. Abd-El-Raouf, "Design of a Compact Band-Notched Antenna for Ultra wideband Communication," Antennas and Propagation Society International Symposium, pp.5-11, 2008.

[6]. X. Shen, M. Guizani, R.C. Qiu and T. Le-Ngoc, "Ultra-Wideband Wireless Communication and Networks," John Wiley & Sons, England, 2006.

[7]. H. G. Schantz, G. Wolenec, and E. M. Myszka III, "Frequency notched UWB antennas," in Procceddings of IEEE Conferences Ultra Wideband System Technology, pp. 214-218, November 2003.

[8]. M. K. A. Rahim, M. N. A. Karim, T. Masri, and A. Asrokin, "Comparison between Straight and U shape of Ultra Wide Band Microstrip Antenna using Log Periodic Technique," in IEEE International Conference on Ultra-Wideband, pp. 696 - 699, 2007 .

[9]. M. A. Haq and M. A. Khan, "A Multiple Ring Slots Ultra Wide-Band Antenna (MRS-UWB) for Biomedical Applications," 17th IEEE International Multi-Topic Conference (INMIC), pp. 56-60, 2014.

[10]. G. Brzezina, Q. Ye, and L. Roy, "Development of a Practical Ultra-Wideband Antenna with Planar Circuit Integration Possibilities," in International Symposium of IEEE Antenna and Propagation Society, pp. 504-507, 2005.

[11]. L. Zheng and C. Tse, “Diversity and multiplexing: A fundamental tradeoff in multiple-antenna channels,” IEEE Trans. Inf. Theory, vol.49, pp. 1073–1096, May 2003.

[12]. K. George Thomas and M. Sreenivasan ,“ A simple ultrawideband planar rectangular printed antenna with band dispensation ,” IEEE Trans Antennas Propag, vol. 58, no. 1, January 2010.

[13]. M. Ojaroudi, Sh. Yazdanifard, N. Ojaroudi, and M. Naser-Moghaddasi, “Small Square Monopole Antenna With Enhanced Bandwidth by Using Inverted T-Shaped Slot and Conductor-BackedPlane,”IEEE Transactions on Antennas and Propagation,vol. 59, no.2, 670-674, February 2011

[14]. J. -B. Jiang, Z. -H. Yan, and C. Wang, “A novel compact UWB notchfilter antenna with a dual-y-shaped slot,” Progr. Electromagn. Res. Lett., vol. 14, pp. 165–170, 2010.

[15]. Y. F. Weng, W. J. Lu, S. W. Cheung, and T. I. Yuk, “UWB antenna with single or dual band-notched characteristic for WLAN band using meandered ground stubs,” in Proc. Loughborough Antennas and Propagation Conf. (LAPC), 2009, pp. 757–760.

[16]. S. Barbarino and F. Consoli, “UWB circular slot antenna provided with an inverted-L notch filter for the 5 GHzWLAN band,” Progr.Electromagn. Res., vol. 104, pp. 1–13, 2010

[17]. Raha Eshtiaghi, Javad Nourinia, and Changiz Ghobadi,"Electromagnetically Coupled Band-Notched Elliptical Monopole Antenna for UWB Applications,"IEEE Trans. Antennas Propag, Vol.58, pp.1397-1402, no.4, April2010

[18]. K. J. Singh and R. Mishra, "Design of A Circular Microstrip Patch Antenna with Single Band Notch Characteristic for UWB Applications," 2017 IEEE International WIE Conference on Electrical and Computer Engineering (WIECON-ECE), 2017

[19]. A. Q. Kamil and A. K. Jassim, "Design of Ultra wideband Antenna With Band-Notched for Wireless Communications," 2021 1st Babylon International Conference on Information Technology and Science (BICITS), 2021,

[20]. A. A. Kadam, A. A. Deshmukh, S. B. Deshmukh, A. Doshi and K. P. Ray, "Slit Loaded Circular Ultra Wideband Antenna for Band Notch Characteristics," 2019 National Conference on Communications (NCC), 2019,