

Ultra Wide Band Antenna with Band Rejection Configurability for Wireless Applications

¹M.Nirmala, ²K.Ratnavathi, ³S.Riyaz Basha, ⁴V Sai sandeep, ⁵B.Suresh

¹Assistant Professor, Department of ECE, ANITS, Visakhapatnam, India

^{2,3,4,5} UG Student, Department of ECE, ANITS, Visakhapatnam, India

ABSTRACT: The design of Ultra Wide band antenna is suitable for short range with high data speed in wireless applications within the frequency band from (3.1-10.6GHz). Ultra-Wide band applications can coexist with other narrow band communications standards that occupy the same spectrum. Military X band (7.25-7.745GHz), WLAN (5.15-5.725GHz) technology have played a major role where electromagnetic interference occur with ultra-wide band applications. While designing an antenna, improvement in the antenna characteristics is a major demand of the wireless industry that is growing rapidly. Microstrip antennas are used in extensive range of applications such as wireless and biomedical diagnosis. A microstrip antenna quite has a lot of advantages over the other antennas due to their light weight, robustness, low cost of production and low profile nature. In this proposed project work, the simple rectangular patch antenna with line feed is used. To avoid the interference with existed narrow band military X band and WLAN applications, the UWB antenna with band notch characteristics is required. A notch band is created in UWB antenna which provides non resonance to the military X band, WLAN. Band rejection can be done by inserting diodes to slots and its switching conditions. The antenna size can be reduced which achieves the miniaturization of antenna size, material cost and helpful in portability that can be used in wide range of applications. ANSYS HFSS is used to analyze and design this antenna.

KEYWORDS: Band notch, Interference, ultra wide band.

I.INTRODUCTION

Due to the enormous deployment of wireless communication systems, the frequency spectrum allocation has witnessed a noticeable congestion in the last few decades. This serious issue has restricted the response to the incredible customers' demand for new forms of high-performance communication systems. Cognitive radio (CR) [1] systems were invented to mitigate the limitations of the frequency spectrum allocation. As identified by the Federal Communication Commission (FCC) [2], about 70% of the allocated spectrum is idle for a remarkable amount of time. CR systems recruit the idle frequency, which is specified for a licensed user (primary user), for another unlicensed user (secondary user). In other words, the secondary user can communicate via the primary user's channel as long as the primary user is in its idle mode. CR systems are divided into interweave and underlay systems. The former category of CR systems uses an ultrawide-band (UWB) antenna to sense the presence of the idle channels and another reconfigurable antenna [3] for communication purposes. On the other hand, the underlay CR systems, which represent the main scope of this work, utilize a single UWB antenna with reconfigurable band notches [4] to cancel the communication via the licensed channels during the active modes of the primary users. The underlay CR systems transmit a reduced amount of power along the UWB frequency band (3.1–10.6 GHz) [5] to minimize the interference with the already existing applications. Some applications do not accept any amount of interference, so the UWB antenna of the underlay systems should have the capability of band notch generation to completely eliminate the interference with these critical applications. Like the conventional frequency reconfiguration [6], the reconfiguration of the antenna band notch may be accomplished with the aid of radio frequency (RF) switches such as PIN diodes [7], MEMS switches, and photoconductive switches. In addition, the band notch center frequency can be tuned by attaching a varactor diode to the designed antenna. For planar monopole UWB antennas [8], reconfigurable band notches can be presented in many ways such as controlling the length of a slot etched on the ground plane, modifying the length of parasitic elements, or reshaping split ring resonators. However, the band notch reconfiguration of wide-slot UWB antennas [9] may be achieved by controlling the length of slots etched on the antenna tuning stubs, attaching a variable



length parasitic element [10] to the radiating stub, or modifying the length of parasitic elements attached to the tuning stub [11]. A compact wide-slot UWB antenna with two sharp and reconfigurable band notches for underlay CR communications is proposed in this paper. The shapes of the slot and the tuning stub of the proposed antenna are modified so that the antenna operating bandwidth covers the entire UWB frequency spectrum (3.1–10.6 GHz). The two band notches are generated by presenting two parasitic elements within the antenna slot. The first band notch is generated by inserting a pair of quarter wavelength parasitic elements to the ground plane to reject the radiation of the 5GHz WLAN (5.15–5.725 GHz). A pair of half wavelength parasitic elements is engraved on the ground plane side of the antenna along the circumference of the antenna tuning stub to avoid the interference with the down link of the military X-band satellite communications (7.25–7.745 GHz). Each band notch is switched ON and OFF by a pair of PIN diodes. The measurements agree well with the simulated results and both verify the sharpness and successful reconfiguration of the two band notches.

II.ANTENNA DESIGN CONFIGURATION

This section explains the design evolution of the proposed dual band antenna with slots and DGS. A basic square patch antenna has been initially designed having dimensions 40mm x 29.04mm x 1.6mm as shown. A 50Ω microstrip feed line is used. The following Equations are used to design the proposed antenna.

The width of the patch (W)

$$W = \frac{c}{2f_0 \sqrt{\epsilon}} \dots \dots \dots (1)$$

Where,

C is velocity of light

f0 is Resonant Frequency

εr is Relative Dielectric Constant

Effective dielectric constant εeff is

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \sqrt{1 + 12} \dots \dots \dots (2)$$

h is height of the substrate

Effective length Leff is

$$L_{eff} = \frac{c}{2f_0 \sqrt{\epsilon}} \dots \dots \dots (3)$$

Length Extension ΔL is

$$\Delta L = 0.412h \frac{(\epsilon_{eff} + 0.3) \left(\frac{W}{h} + 0.264\right)}{(\epsilon_{eff} - 0.258) \left(\frac{W}{h} + 0.813\right)} \dots \dots \dots (4)$$

Actual length of patch L is

$$L = L_{eff} - 2\Delta L \dots \dots \dots (5)$$

The planar wide-slot UWB antenna consists of feed line, radiating wide slot etched on the ground plane, and tuning stub to enhance the coupling between the feed line and the antenna radiating slot. The structure and the dimensions of the proposed wide-slot UWB antenna attached to a 50-Ω microstrip feed line. The dielectric substrate of the proposed antenna is Rogers RT5880 whose dielectric constant and loss tangent are 2.2 and 4 × 10⁻⁴, respectively. The overall dimensions of the antenna are 28 × 26 × 0.8mm. The antenna layouts are shown in Figure 1 and Figure 2. Diode d1 modifies the length of the quarter wavelength parasitic elements that are responsible for generating the band notch that cancels out the radiation of the 5-GHz WLAN applications. The parameter d2 determines the length of the half wavelength parasitic elements that are presented to provide a band notch to reject the radiation of the downlink of the military X-band satellite radiation. It is clear from that the two half wavelength parasitic elements meet each other at their top vertices to form one full wavelength parasitic element.

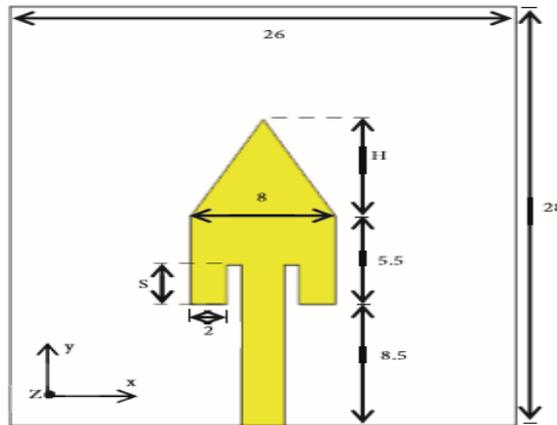


Figure 1: Front view of UWB antenna

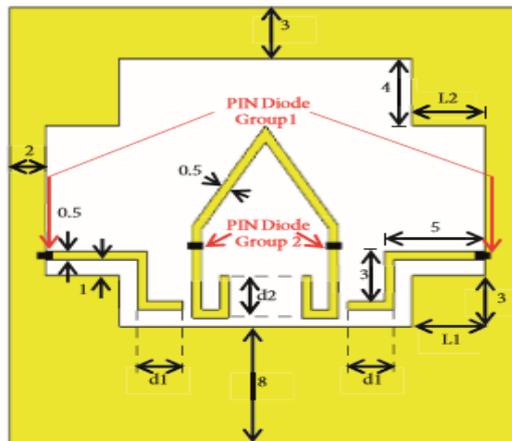


Figure 2: Back view of UWB antenna

The SMP1320 series of plastic packaged, surface mountable PIN diodes is designed for use in high volume switch applications from 10 MHz to more than 10 GHz. The low current performance of these diodes (0.9Ω maximum at 10 mA and 2Ω typical at 1 mA) makes the SMP1320 series particularly suited to battery operated circuits. The equivalent circuit of the pin diode is shown in figure 3 in both ON and OFF conditions.

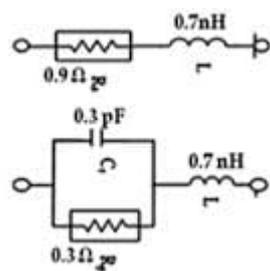


Figure 3: PIN diode ON/OFF conditions

The presence and the absence of the band notches are determined by the ON and OFF states of the two groups of PIN diodes, respectively. Group 1 is attached to the quarter wavelength parasitic elements, whereas Group 2 is inserted to the half wavelength parasitic elements. All PIN diodes used in this antenna are SMP1320-079LF whose reverse biasing capacitor is ($C_r = 0.3 \text{ pF}$), and forward resistance value is ($R_f = 0.9 \Omega$ at 10 mA)[3]. When the diodes are in OFF condition, the designed antenna resonates in the UWB range (3.1GHz-10.3GHz). If the diodes are in ON condition the antenna shows the band rejection characteristics in two bands. The lower band ranges from 5GHz to 5.8GHz with centre frequency of 5.3GHz and the higher band range from 6.2GHz to 7.1GHz with centre frequency of 6.3GHz. For

the simulation results, the Ansys High Frequency Structure Simulator (HFSS), 3D full-wave finite element method (FEM) method based electromagnetic software is used.

III.RESULTS AND DISCUSSION

Initially simulation is done for UWB antenna when the diodes are in OFF condition. The simulation result is showing acceptable reflection coefficient level in UWB band (3.1GHz-10.6GHz). The reflection coefficient S11 of UWB antenna is shown in Figure 4. The measured operating band is observed from 3.1GHz-10.3GHz.

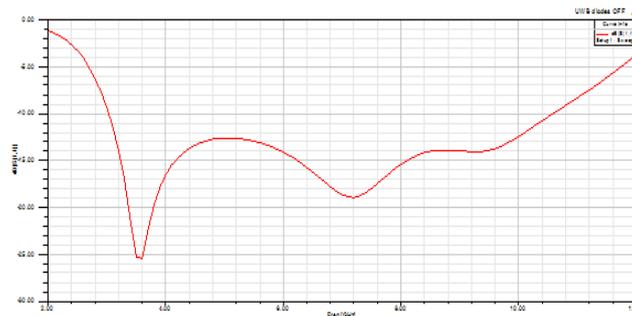


Figure.4. Reflection Coefficient S11 (dB) of UWB antenna when diodes are in OFF condition.

The simulation result of UWB antenna with band rejection capability is shown in figure 5. If the diodes are in ON condition the antenna shows the band rejection characteristics in two bands. The lower band ranges from 5GHz to 5.8GHz with centre frequency of 5.3GHz and the higher band range from 6.2GHz to 7.1GHz with centre frequency of 6.3GHz.

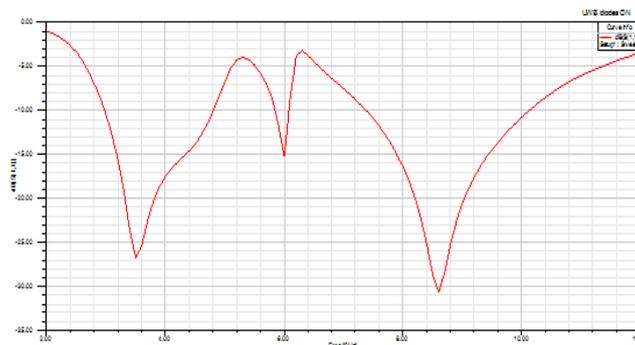


Figure.4. Reflection Coefficient S11 (dB) of UWB antenna when diodes are in ON condition (Band Rejection).

IV.CONCLUSION

Ultra-Wide band antenna is designed with in the frequency band from (3.1-10.6GHZ). Military X band (6.1-7.3GHZ), WLAN (4.8-5.725GHZ) technology have played a major role where electromagnetic interference occurs with ultra-wide band applications. Due to the changes in current distribution and radiation pattern the antenna does not resonate at Military X band and WLAN frequency band. By inserting diodes to slots and its switching conditions the band is rejected. Observed the improvement in each stage, the return loss is below -10 dB for the design within the frequency band of 3.1-10.6GHz and the return loss is above -10 dB for the rejected band of 5-5.8GHz and 6.2-7.1GHz.

REFERENCES

- [1] A Novel Printed UWB Slot Antenna With Reconfigurable Band-Notch Characteristics Nasrin Tasouji, Javad Nourinia, Member, IEEE, Changiz Ghobadi, and Farzad Tofigh, Student Member, IEEE
- [2] A. Valizade, Ch. Ghobadi, J. Nourinia, and M. Ojaroudi. "A Novel Design of Reconfigurable Slot Antenna With Switchable Band Notch and Multiresonance Functions forUWBApplications",IEEE Antennas and wireless propagation letters,VOL.12,2013 Page(s): 1166 - 1169, October 2012

- [3] Nasrin Tasouji, Javad Nourinia, Member, IEEE, Changiz Ghobadi, and Farzad Tofigh, "A Novel Printed UWB Slot Antenna With Reconfigurable Band-Notch Characteristics". IEEE Antennas and wireless propagation letter IEEE. Page(s): 922 - 925, July 2013
- [4] Bahareh Badamchi¹, Javad Nourinia¹, Changiz Ghobadi¹, Arash Valizade Shahmirzadi "Design of compact reconfigurable ultra-wideband slot antenna with switchable single/dual band notch functions." IET Microw. Antennas Propag. Page(s): 541 - 548. June 2014
- [5] Chao-Ming Luo, Jing-Song Hong, Muhammad Amin, and Lei Zhong School of Physical Electronics, "Compact UWB Antenna with Triple Notched Bands Reconfigurable" .Electronics letters. June 2016
- [6] Anudeepa S. Kholapure¹ and R.G. Karandikar². , "Antenna with reconfigurable triple band notched characteristics for cognitive radio." ICTACT Journal on communication technology ,2016
- [7] K. V. Ajetroa A. P. Dhande, "Phi Shape UWB Antenna with Band Notch Characteristics.", Engineering, Technology & Applied Science Research Vol. 8, No. 4, 2018
- [8] Saeed Ur Rahman | Qunsheng Cao | Yi Wang | Habib Ullah. , "Design of wideband antenna with band notch characteristics based on single notching element" , Int Journal RF Microwave Computer Aided Eng, October 2018.
- [9] Venkateswarlu Gujjala, M.Nirmala, Brm.Krishna, N.Deepika Rani, "Design of Ultra-Wideband Antenna with Dual Notch Characteristics at WiMAX/WLAN Bands" IEEE International Conference on Intelligent Systems and Green Technology (ICISGT), DOI: 10.1109/ICISGT44072.2019.00021, February 2020.
- [10] M.Nirmala, N.Nitish, R.Maheswari B.Santhosh Naidu , "Dual Band Microstrip Antenna for Improved Gain and Reduced Return Loss with Rectangular Slots and DGS" International Journal of Emerging Technologies and Innovative Research (JETIR) ISSN: 2349-5162, Volume 5, Issue 12, PP 549-553, December 2018.
- [11] Ramesh Raja Babu P., Nirmala M. (2016) Design and Analysis of Single Feed Dual Band Stacked Patch Antenna for GPS Applications. In: Satapathy S., Rao N., Kumar S., Raj C., Rao V., Sarma G. (eds) Microelectronics, Electromagnetics and Telecommunications. Lecture Notes in Electrical Engineering, vol 372. Springer, New Delhi.