Bell Shape Ultra Wide Band Patch Antenna with Integrated Band Notch Filiter

Nancy Sharma
M.Tech Student
Department of ECE
Panchkula Engineering College,
Mouli, Haryana, India

Manish Kansal
Assistant Professor
Department of ECE
Panchkula Engineering College,
Mouli, Haryana, India

Abstract — **Continuous increase in number of users with the fast development of wireless technology demands wide band width and high data rates equipments. To implement such high speed wide band applications, the Federal Communications Commission (FCC) announced an Ultra Wide Band (UWB) having a bandwidth of 7.5 GHz, i.e. from 3.1 GHz to 10.6 GHz. The shortcoming of such design was that the wide band results in interference with the existing 5.7 GHz ISM licensed free band communally used for WLAN application with UWB (3.1 to 10.6 GHz). This can be overcome using a band reject filter in cascade with the UWB antenna but results in bulky arrangement.**

The paper amid to design a novel Bell shaped UWB microstrip patch antenna with integrated band notch filter in ground element so that the antenna is compact enough to fit in any radio device, as the main components of wireless technology are embedded on a chip these days. The proposed UWB antenna will be designed and simulated using CST Microwave Studio on low cost easily available FR-4 substrate. The results will be stimulated for UWB i.e from 3.1 GHz to 10.6 GHz with sufficient radiation characteristics, band-width, gain and minimum return loss without any extra impedance matching device and will be able to filter WLAN frequency band. The proposed antenna structure can be used in WPAN, defense and high data rates applications.

Keywords— Band Notch Filiter, CST, Microstrip Patch Antenna, UWB.

I. INTRODUCTION

In February 14, 2002, the Federal Communications Commission (FCC) amended the Part 15 rules which govern unlicensed radio devices to include the operation of UWB devices. The FCC also allocated a bandwidth of 7.5 GHz, i.e. from 3.1 GHz to 10.6 GHz to UWB applications [1], by far the largest spectrum allocation for unlicensed use the FCC has ever granted. Ultra-wideband (UWB), a radio transmission technology which occupies an extremely wide bandwidth exceeding the minimum of 500MHz or at least 20% of the centre frequency [1], is a revolutionary approach for short-range high-bandwidth wireless communication. Differing from traditional narrow band radio systems (with a bandwidth usually less than 10% of the centre frequency) transmitting signals by modulating the amplitude, frequency or phase of the sinusoidal waveforms, UWB systems transmit information by generating radio energy at specific time instants in the form of very short pulses thus occupying very large bandwidth and enabling time modulation. Due to the transmission of non-successive and very short pulses, UWB radio propagation will provide an up to several hundred megabytes per second, very high data rate, and transmits the data difficult to track, its height to ensure the security of the data. For the same reason, UWB systems transmit power consumption is very low compared with traditional narrowband radio system. In addition, the short pulse generation revocation multipath fading, the reflected signals do not overlap the original. Because of these attractive features, UWB technology is widely used in many applications, such as indoor positioning, radar, medical imaging and target sensor data collection. One of the challenges for the implementation of UWB systems is the development of a suitable or optimal antenna. UWB antenna design a first important requirement is extremely wide impedance bandwidth. Next, the radio communication chamber, the radiation pattern is omni-directional characteristic requirement ultra wideband antenna, so that facilitate communication between the transmitter and receiver. Thus, the desired low directivity gain should be as uniform as possible for the different directions. Last but not least, because UWB technology is mainly used for indoor and / or table devices, ultra-wideband antenna size needs to be small enough so that they can be easily integrated into a variety of devices.

In the recent years various UWB antennas for high data rate applications has been reported [5]-[20]. However, there are still challengers in making this technology live up to its full potential. Some of the challenges of UWB antenna are discussed below.

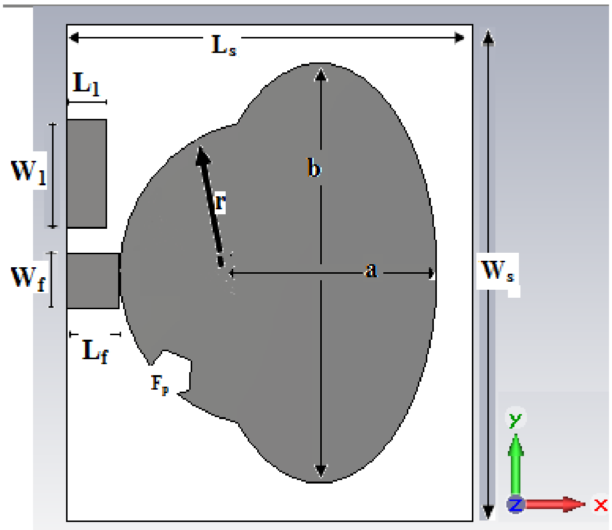
Among the classical broadband antenna configurations that are under consideration for use in UWB systems, a straight wire monopole is a simplest structure, but its bandwidth is only around 10%. A vivaldi antenna is a directional antenna [1] and hence unsuitable for indoor systems and portable devices. A biconical antenna has a big size which limits its application [2]. Log periodic and spiral antennas tend to be dispersive and super severe ringing effect, apart from big size [3]. There is a growing demand for small and low cost UWB antennas that can provide satisfactory performances in both frequency domain and time domain. The patch antenna has attracted considerable research interest due to its simple and compact structure. However, the patch antenna has limited bandwidth but it can be overcome by altering the patch dimension.

One of the limitations of UWB is interference between ISM 5.7 band for WLAN application and UWB application. So, the WLAN band has to be removed using band notch filters.

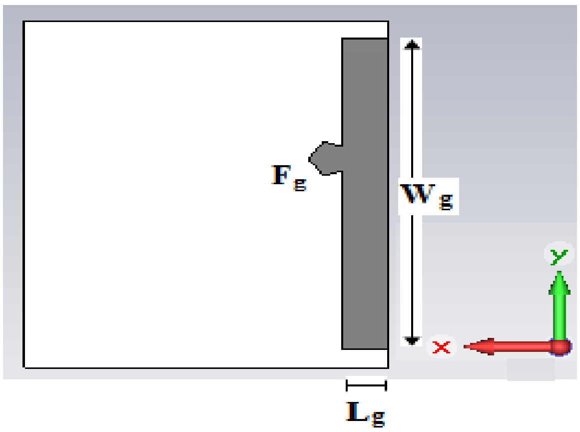
This proposed antenna design focuses on novel Bell shaped UWB patch antenna design and implementation of notch filter in ground element to eliminate WLAN frequency bands with sufficient radiation characteristics required for communication.
The paper is organized as follows. Section II discusses the novel proposed design, Section III discusses the results.

II. ANTENNA DESIGN

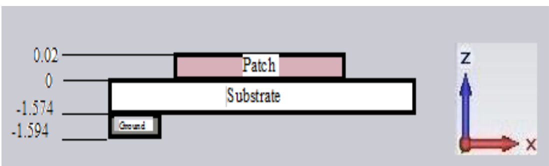
The proposed UWB antenna design consists of modified Bell shaped patch element with two pentagonal shaped element to act as a notch filter as shown in Fig. 1. The antenna is feed with a 50Ω line feed and is designed on a low cost FR4 (lossy) substrate which is 1.574 mm thick and having dielectric constant ϵr = 4.3. The dimensions of the optimized antenna are given in Table 1.



(a)



(b)



(c)

Figure1 (a), 1(b), 1(c): Front, back and bottom view of antenna design

Table 1: Parameter description of antenna design

Parameter	Description	Dimension (mm)
L_s	Length of substrate	32.4
W_s	Width of substrate	39
L_f	Length of feed	4.2
W_f	Width of feed	4.3
L_1	Length of slab 1	3.2
W_1	Width of slab 1	8.5
a	Patch element minor axis	20
b	Patch element major axis	28
r	Radius of circular patch	12
F_p	Area of pentagonal patch filter	12.5
L_g	Length of ground	4.2
W_g	Width of ground	35
F_g	Area of pentagonal ground filter	12.5

III. RESULT AND DISSCUSSION

The proposed antenna is designed first for UWB (3.1 to 10.6 GHz) to resonate at 3.1 GHz and ultra wide band characteristics are achieved using an extra patch slab to provide the constructive interference. One can vary the geometrical aspect of radiating patch which further culminates in deviation of current and hence the resonating frequency and other desired characteristics. Notch band filter is introduced to avoid interference from WLAN frequency band with the use of two pentagonal filter element at patch and ground as shown in fig 1.
The given antenna design consist of modified Bell shaped element with two pentagonal filter element in such a position that they provide proper isolation from license free WLAN band and is feed by a 50 Ω line feed. The proposed design is simulated for return loss, resonance frequency, impedance band-width, surface current, gain and radiation pattern. The return loss, radiation patterns, surface currents and smith chart is shown in Fig. 2, 3, 4 and 5 respectively.

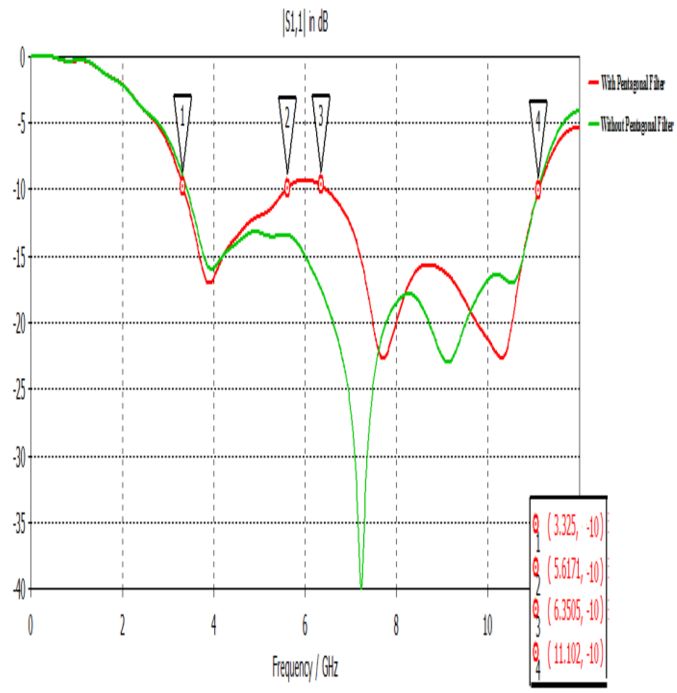


Figure 2: Return loss with and without band notch filter

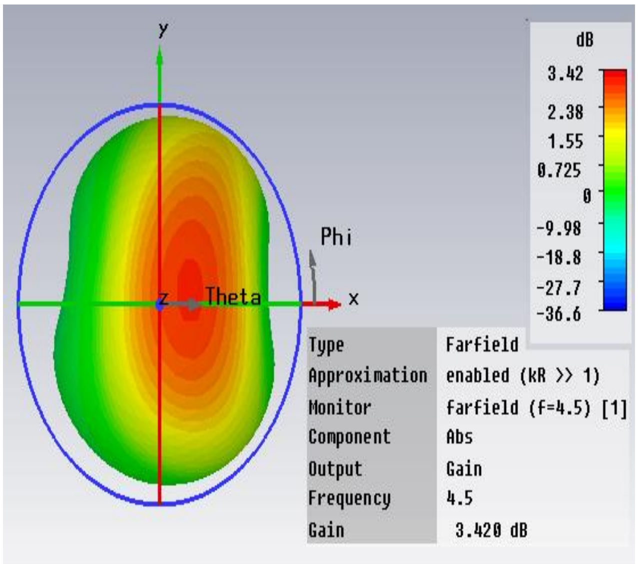


Figure 3: Radiation pattern and gain at 4.5 GHz

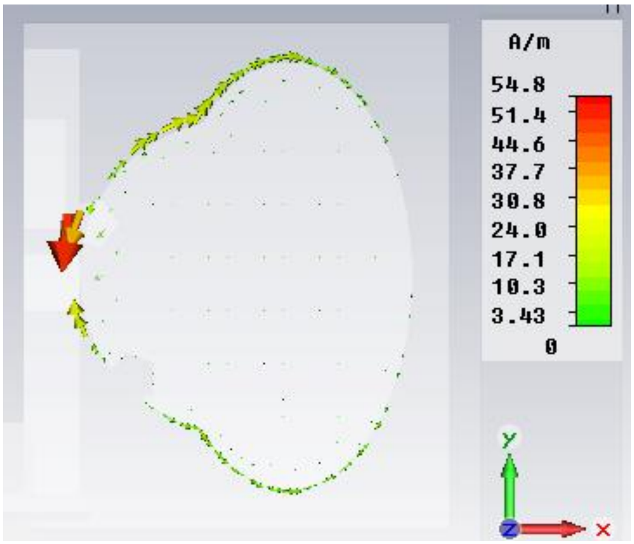


Figure 4: Surface current at 4.5 GHz

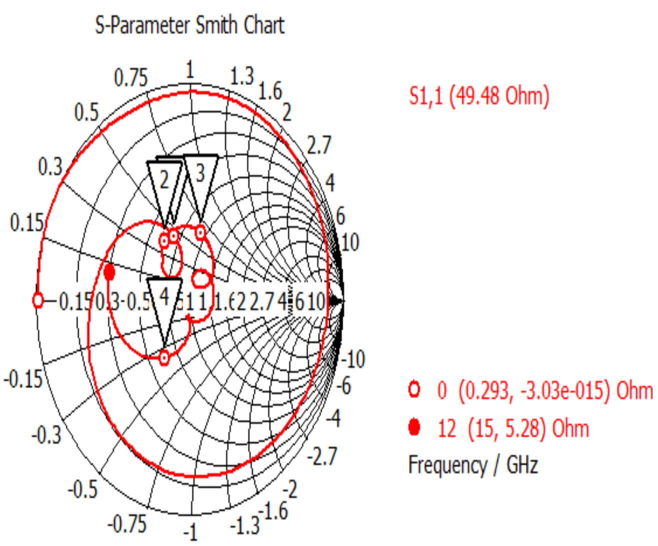


Figure 5: Smith Chart for designed antenna

The designed antenna had a bandwidth of 7.78 GHz i.e. from 3.325 GHz to 11.102 GHz with a return loss of -40 dB without pentagonal filters. On the other hand the antenna design with integrated pentagonal band notch filter covers two bands, one from 3.325 GHz to 5.617 GHz and second from 6.350 GHz to 11.102 GHz. Thus without the pentagonal filter the UWB is achieved and with integrated pentagonal filter the WLAN licensed free band is eliminated as shown in fig 2.

The radiation pattern at resonant frequency of 4.5 GHz i.e band 1 with a gain of 3.42 dB is shown in Fig 3. Surface current and smith chart in Fig 4, 5 represent the information regarding the current flowing through patch and input impedance respectively. The rest of the cases are simulated similarly and are summarized in Table 2.

Table 2: Summarized result for all cases

Filter	Band	Frequency Range (GHz)	BW (GHz)	BW %	Gain (dB)	Input Impedance (Ω)
With-out Filter	UWB	3.325-11.102	7.78	107.8	4.974	49.48
With Filter	Band 1	3.325-5.617	2.292	51.2	3.420	49.48
	Band 2	6.350-11.102	4.752	54.4	5.708	

IV. CONCLUSION

A novel Bell shaped UWB antenna with integrated pentagonal band notch filter had been presented. The antenna can operate on UWB (3.1 to 10.6 GHz) and provides proper isolation from WLAN licensed free band with sufficient radiation characteristics, band-width, gain and minimum return loss. The paper depicts the concept of UWB operations with the help line feed method. The design can be used for high data rates applications like WPAN, defense etc to solve the problem of interference of UWB with WLAN license free band on a single chip. The design is compact enough (32.4 × 39 × 1.62 mm) to fit in any wireless device and offer an input impedance of 49.48Ω (≈50Ω), thus does not requires any extra impedance matching device.

Future work includes comparison of measured and simulated result.

REFERENCES

[1] I. Linardou, C. Migliaccio, J. M. Laheurte, A. Papiernik, "Twin Vivaldi antenna fed by coplanar waveguide", *IEEE Electronics Letters*, 23rd October, 1997, vol.33,no. 22, pp. 1835-1837.

[2] Warren L. Stutzman and Gary A. Thiele, "Antenna Theory and Design", John Wiley & Sons, INC, 1998

[3] S. Licul, J. A. N. Noronha, W. A. Davis, D. G. Sweeney, C. R. Anderson and T. M. Bielawa, "A parametric study of time-domain characteristics of possible UWB antenna architectures", *IEEE 58th Vehicular Technology Conference*, VTC 2003-Fall, vol. 5, 6-9 October, 2003, pp. 3110-3114.

[4] H Singh, "Electromagnetics and Antennas" Katson Publication, 1st edition, 2013.

[5] G.A.Deschamps, "Microstrip Microwave Antennas", 3rd USAF Symposium on Antennas, 1953

[6] H.Gutton and G.Baissinot, "Flat Aerial for Ultra High Frequencies", French Patent No. 703 113, 1955

[7] I. J.Bahl and P.Bhartia, "Microstrip Antennas", Artech House, Dedham, MA, 1980

[8] D. H. Schaubert, D. M. Pozar, and A. Adrian, "Effect of Microstrip Antenna Substrate Thickness and Permittivity: Comparison of Theories

and Experiment", *IEEE Transactions on Antennas and Propagation*, Vol. AP-37, No. 6, pp. 677–682, June 1989

[9] Adam Narbudowicz, Xiulong Bao, Max Ammann, Hammam Shakhtour, Dirk Heberling, "Circularly Polarized Antenna With Steerable Dipole-Like Radiation Pattern", *IEEE Transactions on Antennas and Propagation, Vol. 62, No. 2,* February 2014

[10] Deepali K. Borakhade, S.B.Pokle, "Design Approach for Frequency Reconfigurable Vivaldi Antenna with Pentagoan Slot Resonator",*IEEE International Conference on Electronic Systems, Signal Processing and Computing Technologies,* 2014

[11] Lev Pazin, Yehuda Leviatan, "Reconfigurable Rotated-T Slot Antenna for Cognitive Radio Systems", *IEEE Transactions on Antennas and Propagation*, 2014.

[12] Syed Younus , A. N. Shivaram, "Probe Fed Patch Antenna Array Using Rohacell Dielectric Material Suma", *IEEE Transactions On Antennas and Wave Propagation* Volume 3 Issue 8, August 2014".

[13] C.L.Mak, K.M.Luk,, K.F.Lee, and Y.L.Chow, "Experimental Study of a Microstrip Patch Antenna with an L-Shaped Probe", *IEEE Transactions on Antennas and Wave Propagation,* 18 march 2014.

[14] Ms.Monika Nandal, Er.Sagar and Dr.Rajesh Goel "A New Approach to Optimal Design of T-shaped Tri-Band Fractal Microstrip Patch Antenna for Wireless System Applications", *IEEE Transactions On Antennas and Wave Propagation*, Volume 3, Issue 6, June 2014.

[15] Dheeraj Bhardwaj, Rakshit Jain, Vijay Sharma and Komal Sharma, "Broadband Gap-Coupled Assembly of Patches Forming Elliptical Microstrip Patch Antenna for C- Band Applications", *IEEE Transactions on Antennas and Wave Propagation*, Vol. 2, Issue 5, May 2014

[16] Rida El Messari, José Carlos Reyes Guerrero, Otman Mrabet, Abdellatif Medouri and Luis Antonio Mariscal Rico, "Broadband Circular microstrip patch antenna for WiMAX marine application", *IEEE Transactions on Antennas and Wave Propagation*, volume 44,feb 2014".

[17] Arvind Yadav, Kuldip Pahwa, "Microstrip Patch Antenna for Ultra Wideband Applications in S Band, C Band and X Band", *International Journal of Research in Information Technology (IJRIT)*, Volume 2, Issue 4, April 2014.

[18] Umang Upadhyay, Roshn , Priyanka Soni3, Rohit Gurja, "L-Shaped Microstrip Patch Antenna with C-Band Characteristic", *IEEE Transactions On Antennas and Wave Propagation* April, 2014".

[19] Eng Gee Lim, Zhao Wang, Chi-Un Lei, Yuanzhe Wang, K.L. Man, "Ultra Wideband Antennas – Past and Present", *IAENG International Journal of Computer Science*, August 2010.

[20] Sunita Rani, Devender Singh, Krishan Sherdia, "UWB Circular Microstrip Patch Antenna design simulation & its Analysis", *International Journal of Advanced Research in Computer and Communication Engineering* Vol. 3, Issue 7, July 2014.