A survey on frequency notching techniques used in UWB antennas

Anju A Chandran

***Abstract*— A detailed study on the frequency notched characteristics of UWB antennas based on the interference effect of nearby frequencies on the UWB antenna systems. Distinct antenna designs to reject interference from fixed frequency bands such as WLAN, WiMAX, DSRC, and HIPERLAN are considered and explained here.**

***Key Words*—UWB, HIPERLAN, WLAN, WiMAX, DSRC**

1) INTRODUCTION

According to federal communication commission (FCC) rules, from 2002 onwards the 3.1 - 10.6 GHz band is allocated to the ultra wideband (UWB) applications [1]. UWB technology has several advantages like very wide bandwidth of 7.5 GHZ (from 3.1 to 10.6 GHz) compared to many other existing wireless communication standards [4] and low cost, simple RF circuitry, high data rates and low average radiated power [2][3].

UWB applications can coexist with other narrowband communication standards that occupy the same spectrum due to the limitation of power level. But this will causes a severe interference between the UWB systems and narrow band systems. There are some narrow frequency bands that currently allocated various applications such as Wireless Local Area Network(WLAN) bands in the 2.4GHz(2.4–2.484GHz), 5.2GHz (5.15–5.35GHz),and 5.8GHz(5.725–5.825GHz) bands, World Interoperability for Microwave Access (WiMAX) system bands 2.5GHz(2.5–2.69GHz), 3.5GHz (3.4–3.69GHz), and 5.8GHz (5.25–5.825GHz) and X Band for Satellite communication 7.9GHz(7.25-8.395GHz) etc. Therefore, an unwanted interference will be expected from these frequency bands to other adjacent frequencies, now a day's many systems operate across several frequency bands, requiring a band-notched or band-rejected function. Many methods to accomplish band notch characteristics for UWB antennas are available in literature.

In this study, some of these techniques are deliberated. The remnant of this paper is organized as follows. In Section 2 the various techniques for achieving band notch characteristics are reviewed and the in table 1 shows the comparison between the bands notched UWB antennas, section 3 present our conclusion.

2) TECHNIQUES FOR ACHIEVING BAND NOTCH CHARACTERISTICS

In order to reduce the effect of interference from narrow band services like WLAN, WiMAX, HIPERLAN and FBWA UWB antennas with band notch characteristics are an effective solution. In reference [5] the band-notch functions are accomplished by loading two approximate half-wavelength U-shaped slots which change the current distribution on the Y-shaped patch. In reference [6] inserting a U-shaped slot in the half elliptical ring radiating patch a notch band 5.12 GHz to 5.99 GHz was achieved. For a micro strip fed annular ring UWB a antenna, band notch property for WLAN and DSRC (dedicated short range communication) can be realized by etching a partial annular slot in the antenna radiator [7]. We can control the band width and centre frequency of the notched band by varying the width and position of the annular slot. A UWB planar patch antenna with band notch characteristics and integrated band pass filter can avoid interference from WLAN and WiMAX [8]. In reference [9] Band notch characteristics are achieved using a square slot with a coupling strip. Two band notches can be introduced in a planar monopole UWB antenna using two different types of slots. A half wavelength slot in the radiator is used to reject the WiMAX band and two symmetrical open ended quarter wavelength slots in the ground plane are used to reject the WLAN frequency band.

By etching two C-shaped nested slots in the patch, band-notching in the WiMAX/WLAN bands are accomplished. By adjusting the total length of the C-shaped slot to be approximately half wavelength of the desired notched frequency, a destructive interference can take place, causing the antenna to nonresponsive at that frequency. Therefore it is easy to tune the notch centre frequency by changing total length of C-shaped slot [10]. Reference [11] describes a 5GHz WLAN band notch characteristics for a coplanar waveguide fed planar monopole staircase shaped antenna by etching a U-shaped slot in the feed line of the antenna, which effectively avoid interference from lower (5.15-5.35 GHz) and upper (5.725-5.825 GHz) WLAN bands and uses cost effective substrate FR4 Epoxy. Micro strip line fed UWB antenna attached with two parasitic patches to the bottom layer can reject the frequency band 5.15-5.825 GHz [12]. This antenna has planar structure with omnidirectional pattern. In reference[13] a printed planar monopole UWB antenna with ∏ shaped notch can reject the 5 GHZ WLAN in the range 5.42-5.74 GHz. Bevel shaped symmetrical slots are used in the lower and upper parts of the radiating element of the antenna.

A compact UWB monopole antenna with two meandered slots on a semi-elliptical radiator produces notch at 3.5 GHz and at 5.25 GHz [13]. Reference [14] Hilbert-curve slots are etched on the radiating patch is to have band-notched properties in the WiMAX/WLAN bands. The Hilbert-curve slots works as the LC resonator whose resonance frequency depends on its geometrical size. The notched bands are from 3.3 to 3.7 GHz and from 5.4 to 6 GHz. Another available band notching technique is in a micro strip fed planar monopole UWB antenna with T-shaped stubs inside an ellipse slot cut in the radiating patch [15] and the notch is around the 5.5 GHz WLAN band. Also a micro strip fed planar monopole UWB antenna

***Manuscript received May, 2017*.**
Anju A Chandran, *Assistant Professor, Department of ECE, College of Engineering Aranmula, Pathanamthitta, Kerala, India*

with band notch function in the range 5.1-5.9 GHz can be realized using a H-shaped conductor backed plane [16]. In reference [17] the antenna consists of etching three CSRRs a large portion of electromagnetic energy of the antenna at 2.37-2.9, 3.27-3.76, 5.2-5.89, and 8.06-8.8 GHz bands has been stored in each CSRR as a non-radiating energy so that the radiation was dropped over the rejection bands. Here also the mutual coupling among the band rejection elements is minimized.

A CPW fed UWB planar monopole band-notched characteristics are obtained by embedding split ring resonator (SRR) array at the slot region between antenna and ground plane. The presence of SRR array acts as cascaded parallel LC circuit. This gives high input impedance to the incoming signal corresponding to its resonance frequency thereby causing reflection. This reflection of signal in the unwanted region creates the band notch to reject the IEEE 802.11 and HIPERLAN/2A frequencies [18]. A planar monopole UWB antenna having fork shape notched band around 5GHz WLAN can be obtained using an open looped resonator and two tapped lines [19]. In [20] a CPW fed UWB antenna which is terminated to a fractal patch. It has only one layer of dielectric substrate and metallization and notched band from 4.65 to 6.08 GHz. A tuning line resonator is used in the CPW fed of antenna to act as a band-stop filter. The tuning stub is folded over the transmission line. Therefore the electro-magnetic field will be coupled and the effective length of the stub would be slightly more than its actual size. The use of the resonator in the feeder of the antenna efficiently rejects undesired sub-band of 4.9-5.9 GHz [21]. The Table-1 gives the comparison of band notch techniques.

Table -1: Comparison between band notch techniques

Sl. No.	Antenna Type	Notched Bands	Notching Technique	Reg. No.
1	Microstrip fed UWB Antenna	WLAN and WiMAX	Loading two approximate half wavelength U-shaped slots	5
2	UWB monopole antenna	5.12 GHz to 5.99 GHz	U-shaped slot inserted in the radiation patch	6
3	UWB micro strip fed antenna	WLAN DSRC	A partial annular slot at the lower portion of the ring radiator	7
4	Planar UWB patch antenna	WLAN Wi MAX	Square slot and coupling strip	8
5	Planar monopole UWB antenna	WLAN	2 symmetrical open ended quarter wavelength slots in ground plane	9
		WiMAX	Half wave length slot in the radiator	
6	CPW-fed planar UWB antenna	3.3–3.8 GHz 5–6 GHz	Etching of two nested C-shaped slots in the radiating patch.	10
7	CPW fed symmetrical staircase shaped planar monopole UWB antenna	5GHz WLAN	U-shaped slot resonator in the feed line	11
8	Microstrip fed planar monopole UWB antenna	5.15-5.8 25 GHz	Attaching two parasitic patches to the bottom layer of the antenna	12
11	CPW fed UWB monopole antenna	3.3–3.7 GHz and 5.12–5.3 7 GHz	Two meandered slots	13
12	CPW fed UWB antenna	3.3–3.7 GHz and 5.4-6 GHz	Hilbert-curve shaped slot	14
13	Micro strip fed planar UWB antenna	5.5 GHz WLAN	2 T-shaped stubs inside an ellipse slot cut in the radiation pattern	15
14	Micro strip fed UWB planar monopole antenna	5.1-5.9 GHz	Modified H-shaped conductor backed plane	16
15	CPW fed UWB antenna	2.37-2.9 GHz, 3.27-3.7 6 GHz 5.2-5.89 GHz 8.06-8.8 GHz	Three co-directional CSRRs	17
16	CPW fed monopole UWB antenna	WLAN HIPERL AN/2A	Split ring resonator slot	18
17	Planar monopole UWB antenna	5 GHz WLAN	Using a resonator at the centre of fork shaped antenna	19
18	CWP fed UWB Antenna	4.65 to 6.08 GHz	fractal patch	20
19	CPW fed UWB antenna	4.9 - 5.9 GHz	Tuning stub	21

3) Conclusion

A detailed investigation on the different band-notched characteristics for UWB antennas have been presented here. Most of the antennas considered here are planar monopole UWB antennas. Most of these designs aim at the rejection of narrow frequency bands like WLAN, WiMAX, DSRC and HIPELAN/2A that may cause serious interference with the UWB system. The band-notched characteristics using the method of slots such as shaped slot, meandered slots and other techniques such as split ring resonators, tuning stub parasitic element, and fractal geometry and other methods of antenna designs are used to achieve band notch characteristics without compromising with the antenna performance.

REFERENCES

[1] J. B. Pendry, A. J. Holden, D. J. Robbins and W. J. Stewart, "Magnetism from conductors and enhanced non linear phenomena," IEEE Trans. Microw. Theory Tech., vol. 47, no. 11, pp. 2075–2084, Nov.1999.

[2] V. G. Veselago, "The electrodynamics of substances with simultaneously negative values of permittivity and permeability," Sov. Phys. Usp., vol. 10, pp.509-514, 1968.

[3] J. B. Pendry, "Negative refraction makes perfect lens," Phys. Rev. Lett., vol.85, pp. 3966-3969, 2000.

[4] J. D. Baena, J. Bonache, F. Martín, R. Marques, F. Falcone, T. Lopetegi, M. Beruete, M. A. G. Laso, J. Garcia–Garcia, F. Medina, and M. Sorolla, "Modified and complementary split ring resonators for metasurface and metamaterial design," in Proc. 10th Bianisotropics Conf., Ghent, Belgium, 2004, pp. 168–171.

[5] F. Martin, F. Falcone, J. Bonache, T. Lopetegi, R. Marques and M. Sorolla, " Miniaturized CPW stop band filters based on multiple tuned split ring resonators" IEEE Microw. and Wireless Component Lett., Vol. 13, pp. 511-513, Dec. 2003.

[6] J. Garcia-Garcia, J. Bonache, I. Gil, F. Martin, R. Marques, F. Falcone, T. Lopetegi, M.A.G. Laso, and M. Sorolla, "Comparision of electromagnetic band gap and split-ring resonator microstrip lines as band stop structures" Microw. and opt. tech. lett., Vol. 44, No. 4, Feb. 2005, pp. 376-379.

[7] Y. Qi, B. Hou and W. Wen, "Band gaps from ring resonators and structural periodicity," J. Phys. D: Applied Phys. 38, pp. 590—595, 2005.

[8] Mithilesh Kumar ,Shilpa Jangid, , "Compact Planar UWB Patch Antenna with Integrated Bandpass Filter& Band Notched characteristics ",2012 ICCSN

[9] Emad Tammam, Kuniaki Yoshitomi, Ahmed Allam, Mohammed El-Sayed, Haruichi Kanaya, and Keiji Yoshida, "A Highly Miniaturized Planar Antenna With Dual Band-Notched Using Two Slot Types for UWB Wireless Communications ",Proceedings of APMC 2012, Kaohsiung, Taiwan, Dec. 4-7, 2012

[10] Qing-Xin Chu, Member, IEEE, and Ying-Ying Yang "*A Compact Ultra wideband Antenna With 3.4/5.5GHz Dual Band-Notched Characteristics"* IEEE Transactions on Antennas and Propagation, VOL. 56, NO. 12, December 2008,pp 3637-3644.

[11] Zeeshan Ahmed1, Gul Perwasha1, Saleem Shahid2, H. Zahra3, Ilyas Saleem1, S. Muzahir Abbas, "Ultra Wideband Antenna with WLAN Band-Notch Characteristic", 978-1-4673-5885-9/13/$31.00 © 2013 IEEE

[12] K.-H. Kim, Y.-J. Cho, S.-H. Hwang and S.-O. Park, "Band-notched UWB planar monopole antenna with two parasitic patches ",Electronics Letters 7th July 2005 Vol. 41 No. 14

[13] L. Xie, G. Zhao, Y.-C. Jiao, And F.-S. Zhang *"Ultra-Wideband Antenna Using Meandered Slots For Dual Band-Notched Characteristics"* Progress In Electromagnetics Research Letters, Vol. 16, 171-180, 2010.

[14] D. O. Kim and C. Y. Kim "*Planar UWB Antenna with WLAN/WiMAX Dual Band-notched Characteristics Using the Hilbert-curve Slots"* PIERS Proceedings, Kuala Lumpur, MALAYSIA, March 27-30,pp 1494- 1497 2012

[15] Chong-Yu Hong, Ching-Wei Ling, I-Young Tarn, and Shyh-Jong Chung, "Design of a Planar Ultrawideband Antenna with a New Band-Notch Structure", IEEE Transaction on Antennas And Propagation, vol. 55, NO. 12, December 2007

[16] Reza Zaker, Changiz Ghobadi, and Javad Nourinia, "Novel Modified UWB Planar Monopole Antenna With Variable Frequency Band-Notch Function", IEEE Antennas And Wireless Propagation Letters, vol. 7, 2008

[17] D.-O. Kim, N.-I. Jo, H.-A. Jang and C.-Y. Kim*, "Design of the ultra wide band antenna with a quadruple-band rejection characteristics using a combination of the complementary split ring resonators,"* Progress in Electromagnetics Research, vol. 112,pp. 93–107, 2011

[18] Rowdra Ghatak , R Debnath , D R Poddar , R K Mishra and S R Bhadra Chaudhuri, "A CPW Fed Planar Monopole Band Notched UWB Antenna with Embedded Split Ring Resonators", 2009 Loughborough Antennas & Propagation Conference.

[19] Sung-Jung Wu, Cheng-Hung Kang, Keng-Hsien Chen, and Jenn-Hwan Tarng, "Study of an Ultrawideband Monopole Antenna with a Band-Notched Open-Looped Resonator", IEEE Transactions on Antennas and Propagation, vol. 58, NO. 6, June 2010

[20] A. A. Lotfi Neyestanak, M. R. Azadi Naeini, M. Naser-Moghadasi and Gh. Dadashzadeh*, "Band Notched CPW Fed Hexagonal Fractal Antenna,"* Journal of Electro-magnetic Waves and Applications, Vol. 23, No. 17, 2009, pp. 2461-2470

[21] A. M. Abbosh, *"Design of a CPW-Fed Band-Notched UWB Antenna Using a Feeder-Embedded Slot Line Resonator,"* International Journal of Antennas and Pro pagation, Vol. 2008, 2008, Article ID: 564317

Ms Anju A Chandran is an Engineering Graduate in Electronics and Communication Engineering from TKM Institute of Technology, CUSAT. Did her MTech in Wireless Technology from College of Engineering Kidangoor, CUSAT. At present she is associated with Electronics and Communication Department, College of Engineering Aranmula, Pathanamthitta. Her working areas include Antenna design and HFSS.