Electrical and Electronic Engineering 2014, 4(1): 20-23
DOI: 10.5923/j.eee.20140401.03

Compact Ultrawide Band Bandpass Filter with Notched Band at WLAN

Suman kumari, Mithilesh kumar*

Electronics Engg. Department, University College of Engineering, Rajasthan Technical University, Kota, India

Abstract This paper presents a compact band notch ultrawide band bandpass filter. This filter comprise of interdigital finger structure with planar configuration. The interdigital finger resonator is used for getting UWB band and as well as for notch at WLAN band (5.55 to 5.85 GHz). As for UWB radio system WLAN is interference. The filter is compact in size with dimension 17 X 17 X 1 mm3 with the ground plane. For designing and fabrication of this structure FR-4 substrate of thickness 1 mm with Dielectric constant 4.9 is used. The electromagnetic simulation software, computer simulation technology microwave studio (CST MWS) is used for the simulation and analysis of the designed structure. The simulated and measured results show that the working frequency of UWB filter is 3.1 to 10.6GHz and rejecting the frequency band from 5.55GHz to 5.85GHz. The insertion loss of notch band is -15dB and return loss at this band is -1dB. The compact size and good measured results of this filter make it advantageous for use in various practical applications.

Keywords Interdigital, Microstrip, Notch filter, Open stubs, Shunt stubs, Ultra-wideband (UWB), Wireless local area network (WLAN)

1. Introduction

Ultra-wideband (UWB) is a radio technology which was introduced by Robert A. Scholtz and others this technology can be used at a very low energy level for short-range, high-bandwidth communications using a large portion of the radio spectrum [1]. Ultra-wideband is a technology for transmitting information spread over a large bandwidth (>500 MHz). Basically UWB is used in real-time location systems its precision capabilities and low power make it best suited for radio-frequency-identification (RFID) environments, such as in hospitals, in military for radar systems for detecting humans and other objects, in wireless sensor networks and widely used in personal area network (pan) IEEE 802.15etc. The Federal Communications Commission (FCC) has approved on the 3.1-10.6 GHz unlicensed band for UWB communication since 2002 which has overcast the band of WLAN (5.15- 5.825GHz) and may interfere with some communication systems as in [2]. So, for avoiding the interference in UWB we have to band-notch the WLAN frequency.

For designing the UWB systems bandpass filters were the essential part so, many bandpass filter designs were proposed for it. But due to interference from the WLAN band filters with notched bands were extremely required. In [3]-[11] many designs for bandpass and bandstop filters have been reported. Various stepped impedance resonators (SIRs) are presented in [3]-[5], defected-ground structures (DGS) are widely used in tri-band bandpass filters [6-7]. SIRs [8] and DGS [9] are also employed for bandstop filters. UWB bandpass filter with interdigital coupled line has been introduced in [10]. UWB bandpass filter with notched band has been proposed in [11] for antenna application.

This paper presents a compact and high selectivity planar band notched UWB BPF for wireless communication applications. The structure and simulated results of UWB filter in [12] are referred for designing this new band notched filter. In this paper the fabricated structure and measured results of UWB filter are included. The proposed filter is composed of an interdigital finger resonator. Using the interdigital resonator we are getting the ultra wide band as well as by increasing the no of fingers in resonator it is providing us the notch in ultra wide band by adjusting the length of the fingers we can get the notch at desired frequency.

The filter is designed using five coupled micostrip lines to increase the coupling these five coupled lines are so arranged that these are making an interdigital resonator. The coupling degree of interdigital resonators is very high so by using such resonators the return loss of filter is improved. The simulated and measured results of filter allow us to use this designed or fabricated structure to use in various wireless applications without inference of existing bands.

In this paper there are three sections. In second section the designed and fabricated structure of filter is explained. In

* Corresponding author:
mith_kr@yahoo.com (Mithilesh kumar)
Published online at http://journal.sapub.org/eee

third section the simulated and measured results of the designed and fabricated filter are explained, in results we are calculating return loss, insertion loss and group delay of filter. And in final section there is conclusion of the paper.

2. Filter Designing

The interdigital resonator used for designing this filter is shown in Figure 1. Firstly we designed a UWB bandpass filter by using the three interdigital fingers in [12]. The geometry and simulated results of this UWB filter are in [12]. Figure 3. (a) shows the fabricated structure of the UWB filter. Next for getting the notch at WLAN in UWB band we increased the number of interdigital fingers in the previous structure and by adjusting the coupling between the fingers we get the perfect notched band at WLAN.

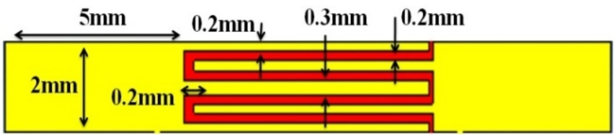


Figure 1. Interdigital resonator used in proposed filter

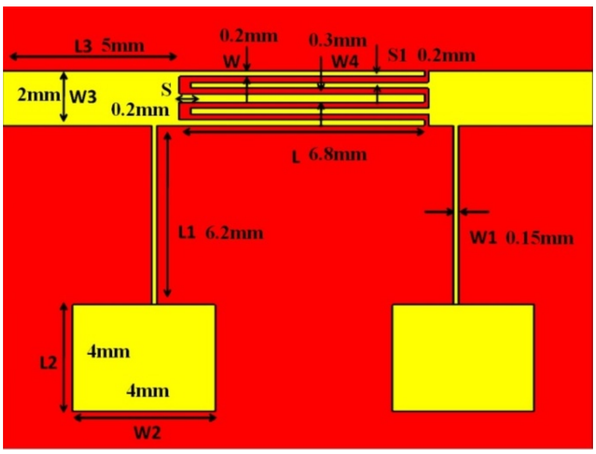
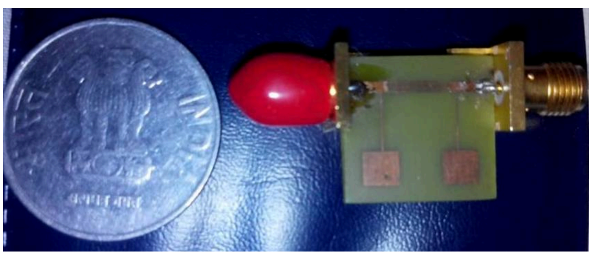
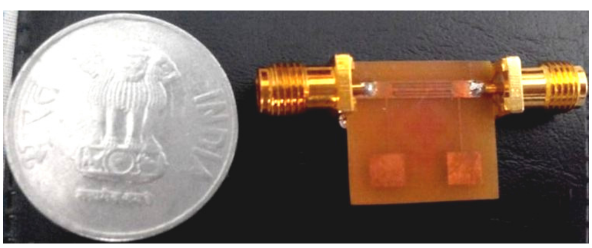


Figure 2. Geometry of proposed filter



(a)



(b)

Figure 3. Fabricated (a) UWB filter (b) filter with notch at WLAN

The filter is designed and fabricated on the FR-4 substrate with the dimension of 17 X 17 mm^2 and the thickness of substrate is 1mm. The FR-4 substrate used for designing filter has the dielectric constant of 4.9.

The 50 ohm microstrip feeding lines are fixed at the width W3 = 2 mm and the length L3 = 5mm. In this filter the interdigital resonator used is shown in Figure 1. As explained earlier that we are using it because of its high coupling degree. The Length of microstrip coupled lines used in designing resonator is L = 6.8 mm and the width of the upper and lower four microstrip lines is W = 0.2 mm. And the central line is of same length and its width is W4 = 0.3.

Spacing between the microstrip lines is the important factor which is responsible for the coupling in the interdigital resonator. The spacing between the interdigital lines is S = 0.2 mm both sides. The spacing between the interdigital lines and the Microstrip feeding lines also have to be so adjusted so that we get the notch at perfect frequency. The spacing between the interdigital lines and feeding lines is S1 = 0.2mm. The variation due to spacing on notched frequency is shown in Figure 4.

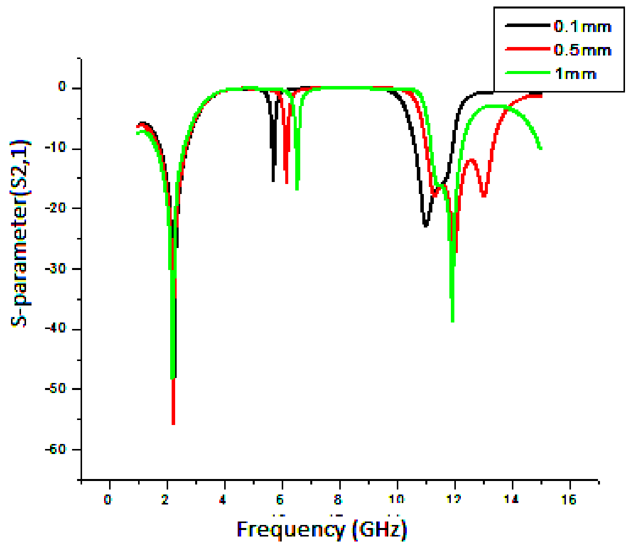


Figure 4. Variation in S21 by varying the spacing

With interdigital resonators two shunt stubs are also attached to 50 ohm lines which have square pads at its ends. Shunt stubs attached to Microstrip feeding lines have width W1 = 0.15 mm and length L1 = 6.2 mm. In this filter structure the shunt stubs are working as inductors and providing us lower sharp band.

The square pads attached to it are working as capacitors in it. We have to attach the square pads to stubs perfectly for getting perfect ultrawide band otherwise the results will vary too much. If we decrease the width these square pads our results will be more accurate for lower band. The square pads we have attached in structure are of length L2 = 4 mm and W2 = 4 mm. The final filter structure is shown in Figure.2. and the fabricated structure of notched UWB filter is shown in Figure 3.(b). The dimensions of proposed filter are written in Table 1.

Table 1. Dimensions of proposed UWB filter with notch design

S. No	Filter parameters	Values
1	L	6.8 mm
2	L1	6.2 mm
3	L2	4 mm
4	L3	5 mm
5	W	0.2 mm
6	W1	0.15 mm
7	W2	4mm
8	W3	2 mm
9	W4	0.3 mm
10	S	0.2mm
11	S1	0.2mm

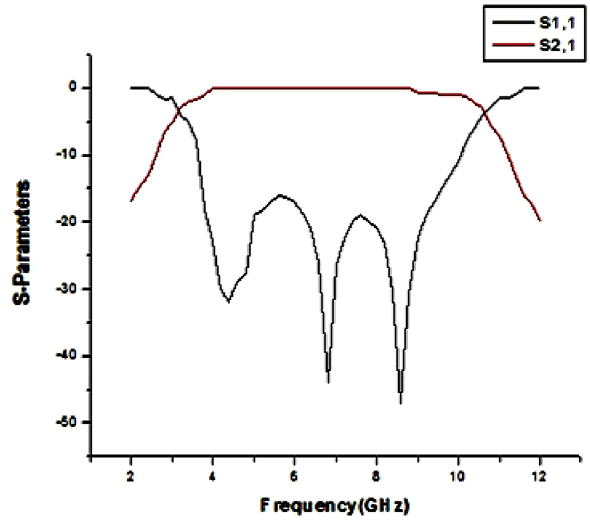
The simulated and measured results show that by using the three fingered interdigital resonator we are getting the ultra wide band and by adding two more fingers to it we get the notch in band and for desired frequency we adjusted the length of fingers and spacing between them.

3. Simulated and Measured Results

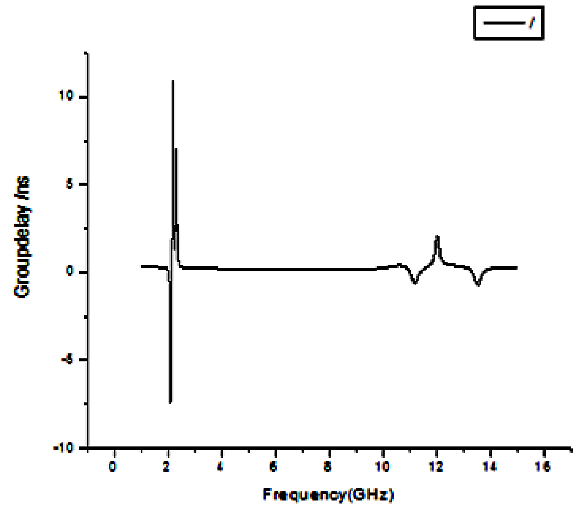
Firstly the measured results of the UWB filter are explained and then the simulated and measured results of the proposed WLAN notched band bandpass filter are explained. The proposed filter is simulated with the help of Electromagnetic (EM) simulation software. In results the return loss, insertion loss and group delay are discussed.

Figure 5. Shows the measured results of UWB bandpass filter Figure 5.(a) is for the S-Parameters of UWB filter in S-Parameters S11 and S21 are included for whole band from 3.1 to 10.6 GHz S11 ≤ -10dB and S21 ≥ -1dB and Figure 5(b) is showing the group delay of this filter as from figure it is clear that for whole band the group delay is constant and it is approximate 0.4ns for whole band. From measured results it is clear that this filter is working for whole UWB band from 3.1 to 10.6GHz.

Figure.6 (a) is showing the comparison of simulated and measured S-Parameters as the simulated S-Parameters are similar to measured S-Parameters so this filter can be used for practical applications also. From results it is very clear that this filter is working for whole ultra wide band from 3.1 GHz to 10.6 GHz except for band 5.55 to 5.85GHz which is for WLAN. The return loss whole band except for WLAN reaches up to -40dB and the insertion loss for whole band except for WLAN is -0.5 dB. The insertion loss and return loss for notched band are -15dB and -1dB respectively. Comparison of simulated and measured group delay of the notched UWB bandpass filter is shown in Figure.6 (b) as the measured group delay is also similar to the simulated group delay or even we can say that it is much better than the simulated. The group delay for whole band from 3.1 to 10.6GHz is constant except for notched band at WLAN. The negative group delay at WLAN band shows that the proposed filter is stopping this band to interfere with the UWB band.

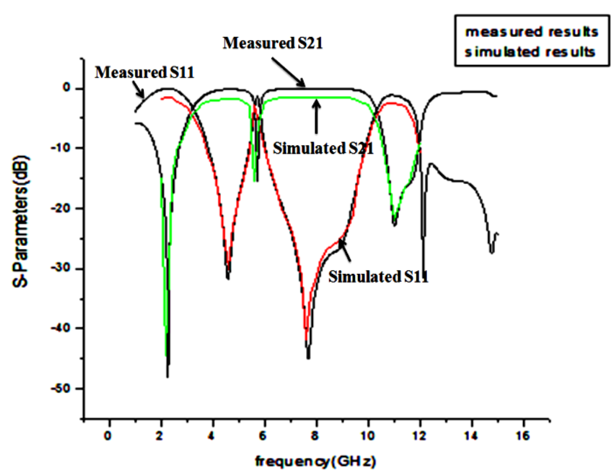


(a)

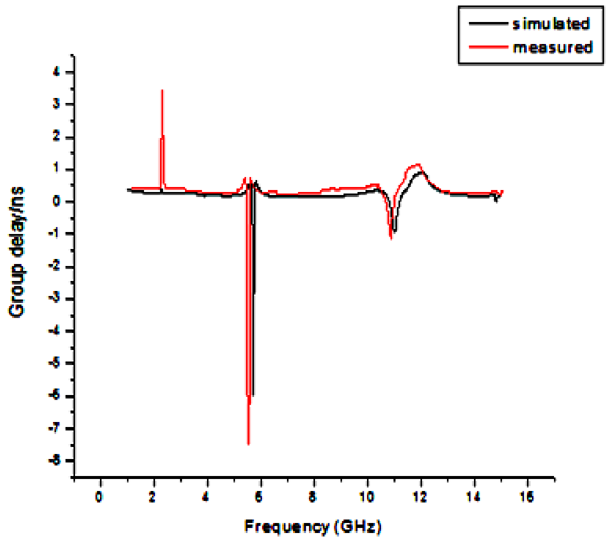


(b)

Figure 5. Measured results of UWB filter (a) S-Parameters (b) group delay



(a)



(b)

Figure 6. Comparison of simulated and measured results of proposed filter. (a) S-Parameters (b) Group delay

4. Conclusions

In this paper we have presented a new design of ultrawide band bandpass filter with notch at WLAN (5.55 to 5.85). The simulated and measured results are compared in this both results are very good as the insertion loss of notched band is -15dB and return loss is -1dB. This designed filter is working for whole UWB band from 3.1 to 10.6GHz and rejecting the band from 5.55 to 5.85GHz for reducing the inference in UWB band. Interdigital resonator with five fingers is used to design this compact structured filter. We can get better results from these by adjusting coupling degree of such filters. The overall characteristics of filter are good and can be used for modern wireless device. As for mobile communication and modern wireless communication we require compact sized filters. The simulated results are good and its simple planar geometry makes it suitable for microwave integrated circuits.

REFERENCES

[1] USC Viterbi School of Engineering. Archived from the original 2012-03-21.

[2] Ruan Cheng-li. “UWB antenna theory and technology [M]”. Harbin industrial university press, 2005.

[3] Fu-Chang Chen and Qing-Xin Chu, “Design of compact tri-band bandpass filters using assembled resonators,” IEEE Transactions on Microwave Thoery and Techniques, vol. 57, no. 1, pp. 165-171, January 2009.

[4] Bo-Jiun Chen, Tze-Min Shen, and Ruey-Beei Wu, “Design of tri-band filters with improved band allocation,” IEEE Transactions on Microwave Thoery and Technique , vol. 57, no. 7, pp. 1790-1797, July 2009.

[5] Ching-Her Lee, Chung-I. G. Hsu, and He-Kai Jhuang “Design of a new tri-band microstrip BPF using combined quarter-wavelength SIRs,” IEEE Microwave and Wireless Components Letters, vol. 16, no. 11, pp. 594-596, November 2006.

[6] Xin Lai, Chang-Hong Liang, Hao Di, and Bian Wu “Design of tri-band filter based on stub loaded resonator and DGS resonator,” IEEE Microwave and Wireless Components Letters, vol. 20, no. 5, pp. 265-267, May 2010.

[7] L.-Y. Ren, “Tri-band bandpass filters based on dual-plane microstrip/DGS slot structure,” IEEE Microwave and Wireless Components Letters, vol. 20, no.8, pp. 429-431, August 2010.

[8] Chih-Kang Lung, Kuo-Sheng Chin, and Jeffrey S. Fu “Tri-section stepped-impedance resonators for design of dual-band bandstop filter,” 39th European Microwave Conference, pp. 771-774, September 2009.

[9] Adel Z. El Dein, Adel B. Abdel-Rahman, Raafat E. Fat-Helbary, and A. M. Montaser, “Tunable-compact bandstop defected ground structure (DGS) with lumped element,” 7th International Multi-Conference on Systems, Signals and Devices, pp. 1-3, June 2010.

[10] Sheng Sun and Lei Zhu, “Capacitive-ended interdigital coupled lines for UWB bandpass filters with improved out-of-band performances,” IEEE Microwave and Wireless Components Letters, vol. 16, no. 8, pp. 440-442, August 2006.

[11] Azzeddine Djaiz, Mohamed A. Habib, Mourad Nedil, and Tayeb A. Denidni, “Design of UWB filter-antenna with notched band at 5.8GHz,” Antennas and Propagation Society International Symposium, pp. 1-4, June 2009.

[12] Suman kumari (student MIEEE) and Mithilesh Kumar (MIEEE) “Design of planar bandpass filter for ultrawide band applications” IEEE ICCSNT, 7-9 april 2014.