A Compact Dual Band-notched UWB Band-pass Filter by Using a Stub and a Folded Stepped Impedance Resonator

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Abstract— In this paper, an ultra-wideband (UWB) band-pass filter with dual band-notch characteristic is proposed and its performance is verified numerically. The proposed UWB filter is realized by using stubs and folded stepped impedance resonators (FSIRs) to provide two desired notch bands at 5.0 GHz and 8.0 GHz, respectively. The center frequencies of these band notches can be easily tuned by adjusting the dimensions of the stubs and folded stepped impedance resonators. The proposed UWB filter with dual band-notched function can provide a wide bandwidth of 2.29–11.51 GHz. The simulated results are given to show that the proposed UWB band-pass filter with compact structure can provide desired notch bands and wide bandwidth, which make it suitable for UWB communication applications.

1. INTRODUCTION

In 2002 Federal Communications Commission (FCC) authorized the frequency band from 3.1 to 10.6 GHz for commercial UWB communication applications [1]. Consequently, the UWB wireless communication technology has attractive much more attentions in recent years. UWB filter is one of the basic components in the UWB communication system [2]. Then, many scholars in home and abroad have done a lot of studies to improve the performance of UWB band-pass filter. However, there exist several narrowband systems which have been used for a long time, such as 5.0 GHz WLAN band and 8.0 GHz ITU band. These narrowband signals may give potential interferences to ultra-wideband system. Thus, many ultra-wideband filters have been designed to eliminate or reduce the potential interferences from those narrow-band systems [3–5]. One of the effective methods is to design a band-pass UWB filter with desired notch band. Recently, a great number of band-notched band-pass UWB filters with necessary notch bands have been presented [6–11], including resonant cavity structure [8, 9], non-uniform periodic grounding slot structure [10] and asymmetric coupling structure twists [11]. Unluckily, most of these structures can only produce a single notch band which limits their applications when two interferences appear in the UWB band. In [12, 13], a stub and a folded stepped impedance resonator have been employed to design a dual notch band band-pass UWB filter. By adjusting the length of the stubs, the center frequency of the notch bands can be tuned to filter out arrow band interference signals of which the range is 5.1–5.8 GHz. By using these band-notched UWB filters, ultra-wideband communication systems can enhance the anti-jamming capability.

In this paper, a UWB band-pass filter with dual band-notched characteristic is presented and discussed on the basis of [14]. Folded stepped impedance resonators and stubs are utilized to generate the designated notch bands to filter 5.0 GHz WALN and 8.0 GHz ITU signals. The center frequencies of the notch bands are tunable by adjusting the dimensions of the proposed folded stepped impedance resonators and stubs. The proposed filter is well designed and investigated, and the simulated results show that the proposed band-pass UWB filter can provide a good dual band notch characteristic and a wide bandwidth, which are suitable for UWB applications.

2. DESIGN OF THE PROPOSED DUAL BAND-NOTCHED UWB FILTER

A schematic of the proposed dual band-notched UWB bandpass filter is shown in Fig. 1, which is realized by using stepped impedance ports, back to back triple-mode SIR, stub and folded stepped impedance resonator. The proposed UWB filter is designed on a RT/duroid 5880 substrate with a relative dielectric constant 2.2 and a thickness of 0.7874 mm. In this design, stepped impedance ports and back to back SIR are employed to improve the performance of the filter. The width of stepped impedance ports is 3.6 mm and its length is 1.3 mm. The proposed filter is optimized by using the HFSS and the optimal parameters are given in Table 1.

In order to filter out the narrowband interference signals from 5.0 GHz WLAN band, two stubs are inserted into the input and output ports between the back to back triple-mode SIR. The

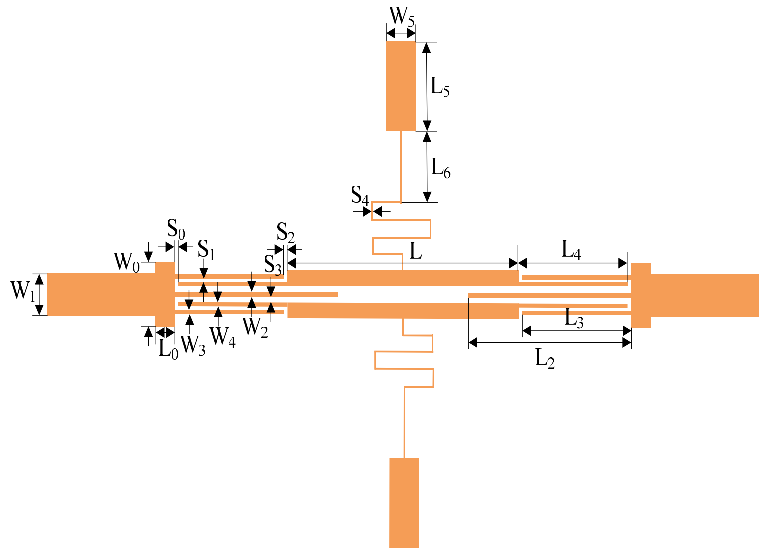


Figure 1: Schematic of the proposed dual notched-band UWB filter.

Table 1: Specifications of the designed filter (unit: mm).

L	L_0	W_0	W_1	L_2	W_2	L_3	W_3	L_4
15.7	1.3	3.6	2.35	12.5	0.3	7.4	0.23	7.4
W_4	L_5	W_5	L_6	S_0	S_1	S_2	S_3	S_4
0.23	5.0	2.0	5.0	0.1	0.05	0.1	0.3	0.1

design procedure of the proposed dual band-notched UWB filter has two steps: 1) single band-notched UWB filter; 2) dual band-notched UWB filter. Firstly, a single notch band is obtained by using stubs and the performance is in Fig. 2(a). We can note that a passband bandwidth of 3.2–11.38 GHz and a notch-band at 5.0 GHz are achieved. Also, the proposed filter has a sharp rising edge and falling edge. To realize a dual band-notched band-pass UWB filter, folded stepped impedance resonators are used to generate another notch near 8.0 GHz and its performance is shown in Fig. 2(b). It is found that the proposed UWB band-pass filter achieves a wide pass-band bandwidth of 2.29–11.51 GHz and has two notch bands operating at 4.9–5.2 GHz and 7.9–8.1 GHz, respectively.

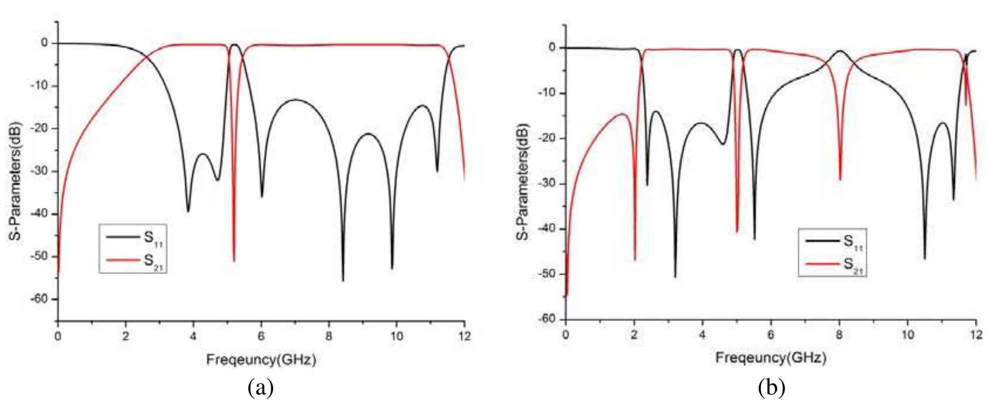
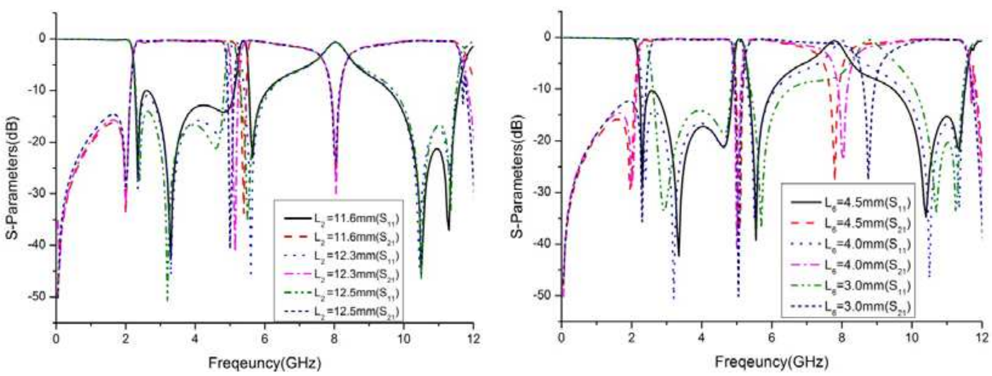


Figure 2: S-parameters of the proposed band-notched UWB filter. (a) Single notch band UWB filter. (b) Dual notch band UWB filter

3. TUNABILITIES OF THE PROPOSED DUAL BAND-NOTCHED UWB FILTER

Since the stubs and folded stepped impedance resonators have important roles in the dual notch bands, L_2 and L_6 are selected to investigate the tunable band-notched characteristics. Fig. 3(a) gives the effects of L_2 on the performance of the designed UWB filter. It is found that the lower notch band operating at 5.0 GHz moves from 5.4 GHz to 5.0 GHz when L_2 increases from 11.6 mm to 12.5 mm. This is caused by the increased resonance length of the stubs and the enhanced coupling between the stubs and the back to back triple-mode SIR. In addition, the center frequency of the upper notch band at 8.0 GHz keeps constant. The effects of L_6 are illustrated in Fig. 3(b). It is observed that the center frequency of the upper notch band shifts from 8.5 GHz to 7.9 GHz with an increment of L_6, which is caused by the prolonged resonance length of the folded stepped impedance resonator. Thus, we can conclude that the lower notch band is produced by the stubs, while the upper notch band is realized by the use of the folded stepped impedance resonators. Additionally, the center frequencies of the notch bands can be tuned by adjusting the dimensions of the stubs and the folded stepped impedance resonators.



(a) L_2 (b) L_6

Figure 3: S-parameters with different L_2 and L_6.

4. CONCLUSION

In this paper, we proposed a compact UWB bandpass filter with dual band notched characteristic by using stepped impedance ports, back to back triple-mode SIR, stubs and folded stepped impedance resonators. The simulated results showed that the proposed UWB filter has a wide bandwidth of 2.29–11.51 GHz and two tunable notch bands operating at 4.9–5.2 GHz and 7.9–8.1 GHz, which is promising for the application of UWB communication systems.

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