

Design of Microstrip UWB Bandpass Filter using open-circuited resonators

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Abstract:- A compact band pass filter with a fractional bandwidth of 59% is designed for Ultra Wide Band (UWB) applications using a microstrip structure consisting of open circuit resonators. Transmission zeros are utilized at the passband edges to enhance the signal selectivity. The filter is characterized by sharp roll-off characteristics due to the presence of transmission zeros. The insertion loss and return loss are found to be 0.1dB and -15dB respectively. This filter has a measured 3-dB passband of (3 to 5.5) GHz, with a compact size of (13.2 x 9.7) mm. The filter offers desirable performance for the lower-band frequency of a UWB system and exhibits low insertion loss. As the structure comprises of only transmission line sections and no coupling gap, the filter is made easy for fabrication. This UWB BPF is useful to alleviate the strong WLAN signals interference to UWB receivers. To illustrate the concept, band pass filter was designed using Agilent® ADS software and simulated results are obtained.

Keywords:- Resonators, Band pass filter, Microstrip, Transmission zeros, WLAN.

I. INTRODUCTION

In 2002, Ultra-wideband (UWB) frequency range of (3.1-10.6) GHz was released by the U.S. Federal Communication Commission (FCC) for commercial purposes. UWB transmission is normally realized using Impulse Radio or MB-OFDM techniques. The entire UWB spectrum is divided into 4 groups using MB-OFDM technique, which are further subdivided into 14 sub-bands. Group A consist of first 3 sub-bands operating in the frequency range of (3.1 to 4.8) GHz and group B is in the range of (4.9 to 6) GHz. In such applications, filter with required bandwidth and low insertion loss is one of the critical components. Ultra-Wideband (UWB) technology has drawn attention of researchers for high speed wireless connectivity applications.

Design of ultra wideband filters for using in wireless technology systems is mainly to transmit data over spectrum of frequency bands for short distance with very low power and high data rates. As a key component of UWB communication system, the designed band pass filter should have low insertion loss over the operating band, good band rejection, which is important for many wireless applications.

Ultra-wideband (UWB) systems have aroused a great deal of attention and a number of UWB band pass filter design techniques have been proposed in the past year such as multi-mode resonators (MMR) [1,2]. A systematic and analytical method for the exact synthesis of generalised Chebyshev wideband hybrid ring based bandpass filters with a controllable transmission zero pair was developed in [3].

A wideband bandpass filter composed of a shorted microstrip line fed by two open-ended side-coupled lines was presented in [4]. A cross-coupled wideband bandpass filter developed from a standard short-circuited stub filter with additional coupled lines was proposed in [5]. Low insertion loss microstrip bandpass filters with sharp rejection were proposed, where the direct synthesis method of elliptic function transmission-line filters was presented [6]. A compact bandpass filter is presented for ultra-wideband (UWB) applications with a reconfigurable notched band to reject unwanted signals from the WiMAX systems [7].

A wide band bandpass filter with a bandwidth 1 GHz at a mid-band frequency of 3 GHz leading to 40% FBW using two open circuit resonators was reported with a filter size of (42 X 19.2 mm) [8].

In this work we report the development of a more compact and high-selective UWB band pass filter with about 59% FBW at a mid-band frequency of 4.25 GHz. This scheme also leads to compact structures with low insertion loss. As the structure comprises of only transmission line sections and no coupling gap, the filter is easy for fabrication.

II. UWB BANDPASS FILTER DESIGN

The proposed filter as shown in Fig. 1 is a third-order bandpass filter composed of a single $\lambda_g/2$ resonator, which is placed initially between a pair of $\lambda_g/4$ short-circuited resonators (i.e) it has two open-circuited lines and a connecting transmission line [7].

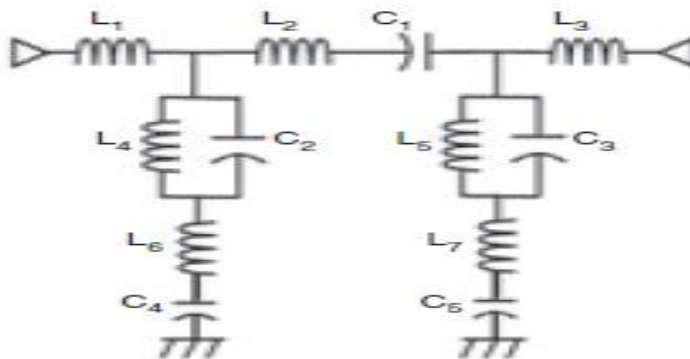


Fig. 1: Equivalent circuit of a Proposed UWB filter

A. Filter Analysis

A bandpass filter is designed with the following specifications: Centre frequency of 4.25 GHz and fractional bandwidth of 59%. The filter was designed on Taconic RF substrate with details shown in Table 1.

Table I: Substrate Details

Parameters	Substrate
Material	Taconic RF35
Dielectric constant	3.5
Substrate thickness	0.76 mm
Loss tangent	0.0028

To get the signal coupled to the other lines they have to be kept closer to each other intentionally. But, when they are kept closer unintentionally to minimize the area and to get a compact structure, it still provides coupling and results in unwanted effects.

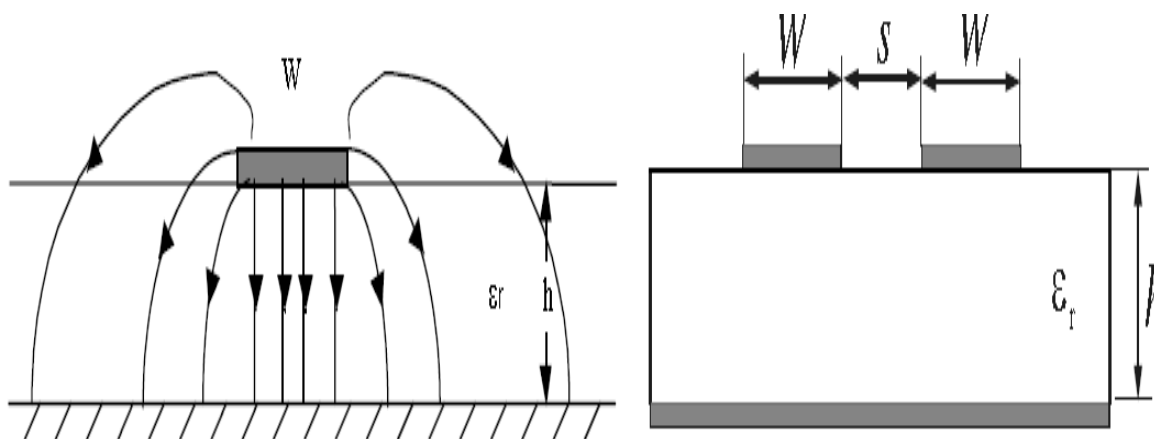


Fig.3: Cross section of a transmission line and coupled lines

However, if the traces can be placed close to each other, the area needed could be reduced which makes the filter compact and required one. In order to make the filter layout compact, meandering of the resonator is carried out. This approach leads to a filter size of 13.7 mm x 9.2 mm. This structure is illustrated in Fig.4.

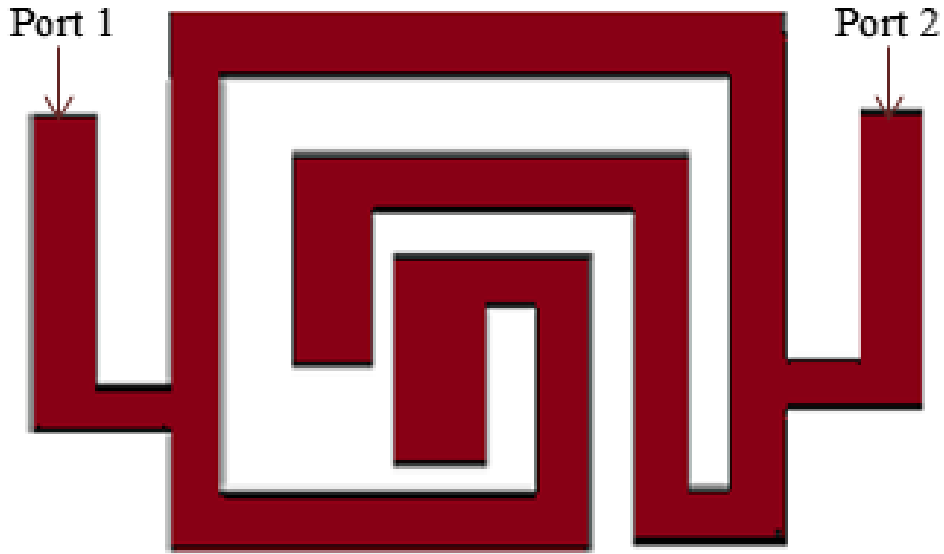


Fig.4: Layout of UWB band pass filter using meandered lines and resonators

The simulation was carried out using a commercially available EM tool (Advanced Design System). The final layout of the proposed filter, including the physical dimensions, is shown in Figure. 5.

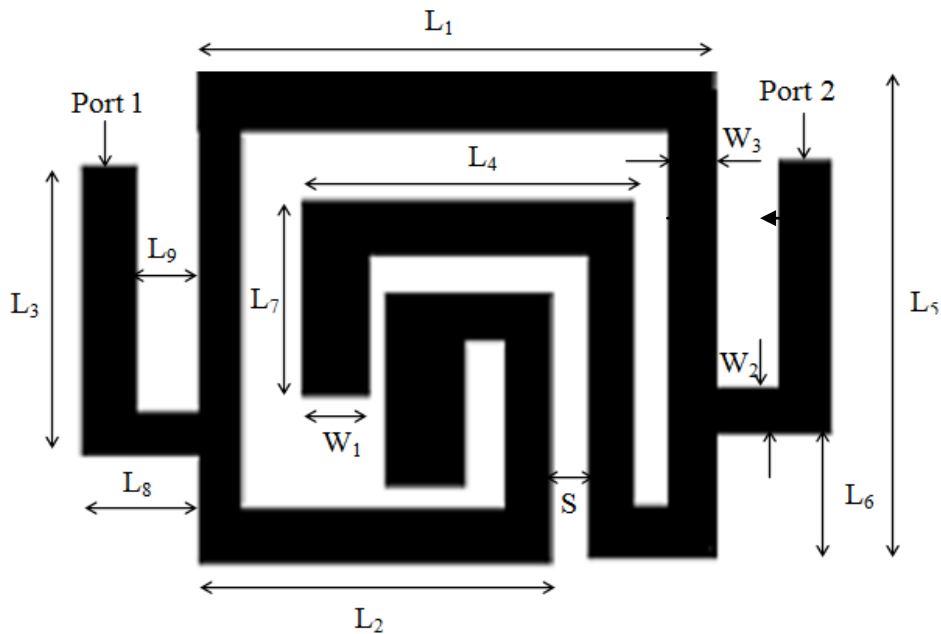


Fig.5: Layout of proposed band pass filter

The two open-circuited resonators are meandered to reduce the circuit size. The optimised parameters of the filter are: $L_1 = 13.2$ mm, $L_2 = 9.7$ mm, $L_3 = 6.1$ mm, $L_4 = 8$ mm, $L_5 = 9.7$ mm, $L_6 = 2.5$ mm, $L_7 = 5.1$ mm, $L_8 = 2.7$ mm, $L_9 = 1.1$ mm, $W_1 = 2$ mm, $W_2 = 1$ mm, $W_3 = 1$ mm, $S = 0.5$ mm. The 3D view of the proposed UWB filter structure is shown in the figure 6.

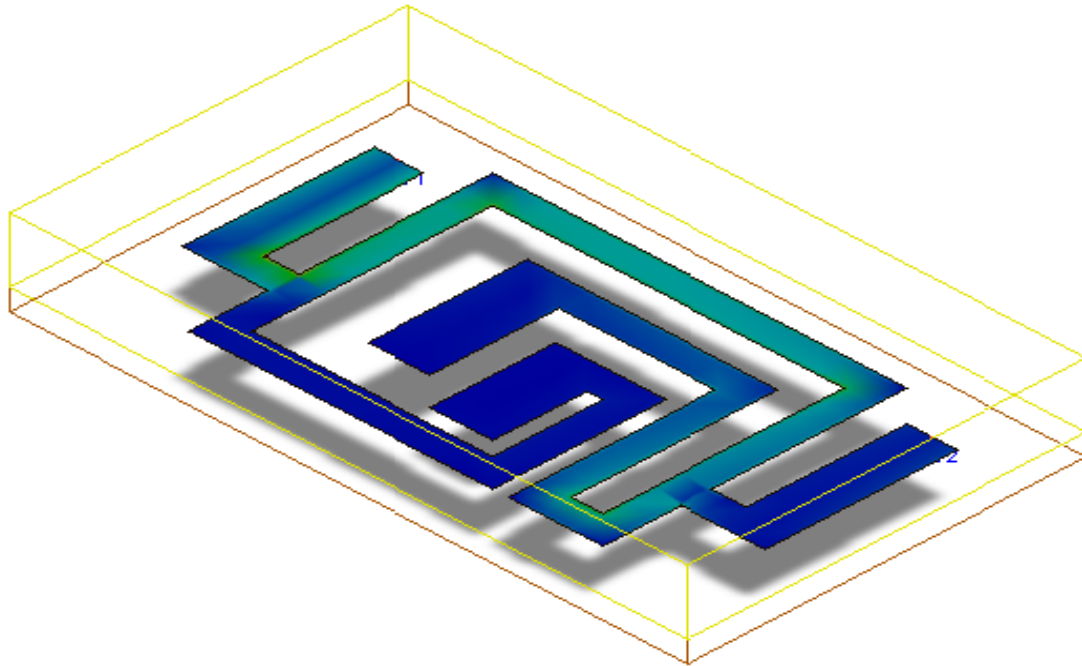


Fig. 6: Isometric view – 3D view

III. SIMULATION RESULTS

The simulated results of a typical bandpass filter centered at 4.25 GHz are shown in figure 7. The insertion loss is about 0.1 dB and the return loss is about -15 dB. The designed filter is capable of rejecting the WLAN frequencies (2.4GHz and 5.8GHz) in order to avoid interference.

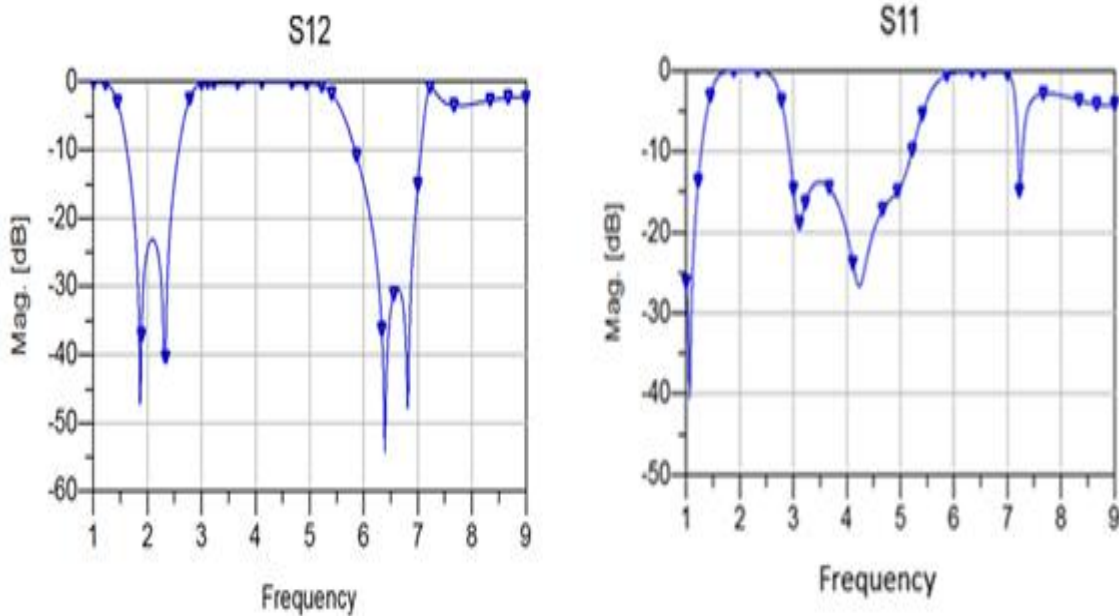


Fig. 7: S_{12} and S_{11} Response using meandered lines and resonators

Figure 8 shows the colour bar for average current distribution. The overall design is comprehensible from the current distribution in the proposed band pass filter is illustrated in figure 7.1

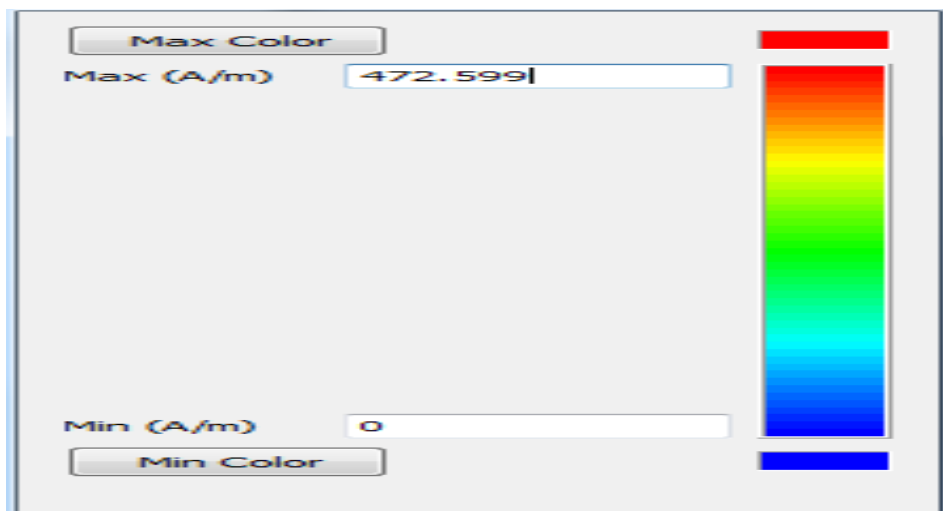


Fig. 8: Colour Bar for Average current distribution

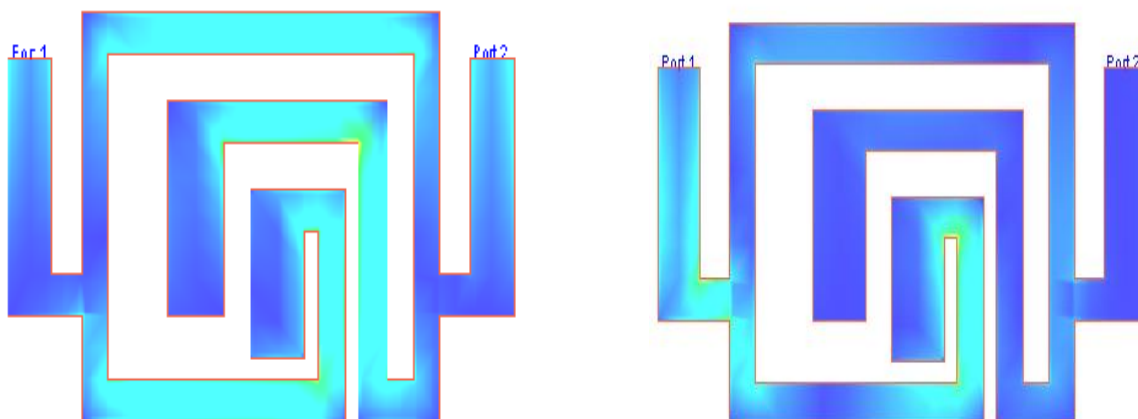


Fig .8.1: (a) Average Current Distribution at 4 GHz

(b) Average Current Distribution at 6 GHz

IV. APPLICATION OF UWB FILTERS

Filters are used in different applications such as radio and television broadcasting, mobile communications, satellite communications, traffic radar, air traffic radar, automotive radar and synthetic aperture radar. In many applications. UWB filters are used to reduce harmonics and help in designing mixers, power amplifiers and voltage controlled oscillators. These are also used in removing the DC offsets and removal of low-frequency noise. UWB filters also help in separating different frequency bands like diplexers and multiplexers.

V. CONCLUSION

In this Letter, a modified bandpass filter is realised using open-circuited resonators. A compact prototype filter with 59% bandwidth is demonstrated. The designed filter is capable of rejecting the WLAN frequencies (2.4GHz and 5.8GHz) in order to avoid interference. The measured insertion loss is about 0.1 dB, while the return loss is -15 dB. The measured 3-dB bandwidth is found to be (3 to 5.5) GHz. The total size of the filter is (13.2 x 9.7) mm. As the structure comprises of only transmission line sections and no coupling gap, the filter will be easy for fabrication .The filter provides better low insertion loss, sharp rejection and high selectivity. The proposed UWB bandpass filter can be used be for various UWB wireless communication systems due to its simple structure, compact size, and good performance.

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REFERENCES

- [1]. Zhu, L., Sun, S., and Menzel, W. 'Ultra-wideband (UWB) bandpass filter using multiple-mode resonator,' *IEEE Microw. Wirel. Compon. Lett.*, 2005, 15, (11), pp. 796–798
- [2]. Sohail Khalid, Wong Peng Wen and Lee Yen Cheong, "Highly Selective, Compact Ultra-Wide Band Bandpass Filter Using a Novel Multiple Resonances Resonator (MRR)" *IEEE*, 978-1-4673-2141-9/13,2013.
- [3]. Li, J.-Y., Chi, C.-H., and Chang, C.-Y.: 'Synthesis and design of generalized Chebyshev wideband hybrid ring based band pass filters with a controllable transmission zero pair,' *IEEE Trans. Microw. Theory Tech.*, 58, (12), pp. 3720–3731,2010.
- [4]. Li, L., and Li, Z.-F.: 'Side-coupled shorted microstrip line for compact quasi-elliptic wideband band pass filter design,' *IEEE Microw. Wirel. Compon. Lett.*, 2010, 20, (6), pp. 322–324
- [5]. Shaman, H., and Hong, J.-S.: 'Input and output cross-coupled wideband band pass filter,' *IEEE Trans. Microw. Theory Tech.*, 55, (12), pp.2562–2568,2007.
- [6]. Lee, H.M, "Direct synthesis of transmission-line elliptic bandpass Filters", *IEEE MTT-S Int. Microwave Symp. Dig.*, Baltimore, MD, pp. 1–4,USA, 2011.
- [7]. K. Rabbi, L. Athukorala, C. Panagamuwa, J.C. Vardaxoglou and D. Budimir, "Compact UWB bandpass filter with reconfigurable notched band", *ELECTRONICS LETTERS*, Vol. 49 No. 11.
- [8]. Fu-Chang Chen, Jie-Ming Qiu, Zhi-Han Chen and Quig-Xin Chu, "Low Insertion Loss wideband Band pass Filter with six transmission zeros," *IEEE Electronics Letters.*, vol.49 (7), 2013.
- [9]. Pozar D.M.: 'Microwave engineering' (Wiley, 1998, 2nd edn.)
- [10]. Reinhold Ludwig, Gene Bogdanov: "RF circuit design" (2nd edn.)