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To Study and Realization of Quad-Band Bandpass Filter using Advanced Design System (ADS) Software

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Abstract: ***The increasing development of multi-service wireless communication networks, microwave components and systems that support various modern communication standards have become a widespread tendency. As a key passive component in the RF front-end, multiband bandpass filter (BPF) design with compact size, high performance and low loss is in great demand for enhancing system functionality. However, multi-band filters have attracted considerable attention as essential components for combination of GPS, WLAN, WiMAX and RFID applications. In this paper, Quad-Band Bandpass filter is design and simulated using advanced design system software(ADS) for WLAN, WiMAX and RFID applications. The quadband BPF provided compact size, low insertion loss, high return loss and more transmission zeros(TZs) with proper source load coupling . The filter is design using set of dual resonator operating at 2.4 GHz, 3.5 GHz and 4.4 GHz, 5.9 GHz. The two dual-band BPFs are combined by common feed lines to get the quadband respond in addition more transmission zeros (TZs) are achieved by strengthening the source-load coupling.***

Keywords: Quadband pass filter, Microstrip resonators, Even and odd mode , Advance design system(ADS)

1. Introduction

The bandpass filters (BPFs) with multi-band responses attract more and more interest in microwave filter design, such as universal mobile telecommunications system/long term evolution 1500 (UMTS/LTE 1500, 1.5 GHz), WiMAX (2.5 and 3.5 GHz), military application (4.4 GHz) and IEEE 802.11a (5.5 GHz). To combine with the RF front end of the transmitter and receiver, BPFs are deeply demanded with the advantages of compact size, wide stopband, and good selectivity. The quad-band bandpass filter used as an essential component in the quad-band operation system has received attention in recent years. Nevertheless, there is very little research on quadband filter design until now. Due to the rapid expansion of the various wireless communication service, multi-band filters have attracted considerable attention as essential components for combination of GPS, WLAN, WiMAX and RFID applications [1].

Compact microstrip resonators with superior performance are continuously developed to meet the high frequency demands [3]. These microstrip resonators can be classified into single-mode and multimode resonators. The single mode resonator can be categorized into six sub classes. They are half wavelength resonator, quarter wavelength resonator, stepped impedance resonator, quarter wavelength stepped impedance resonator, patch resonator and ring resonator [2].

2. Filter Design Procedure

The layout of proposed quadband bandpass filter is shown in fig.1. In this design of bandpass filter , cascaded dual-mode resonator are combined by common feed line.The feedline is consist of interdigital capacitance structure to obtain quadband response of filter. The even-odd mode theory can be adopted to obtained the symmetric resonators.

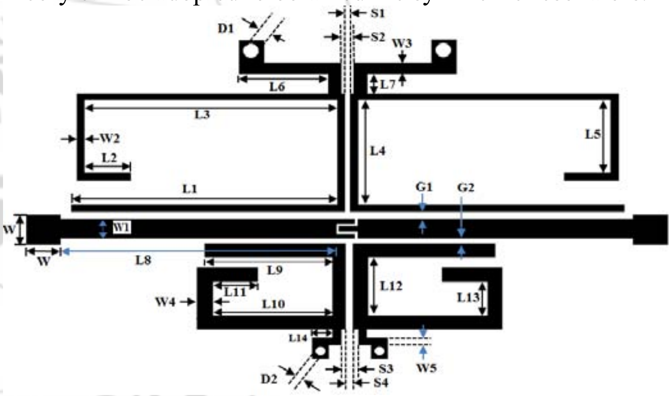

Figure 1: Layout of the proposed quad-band BPF

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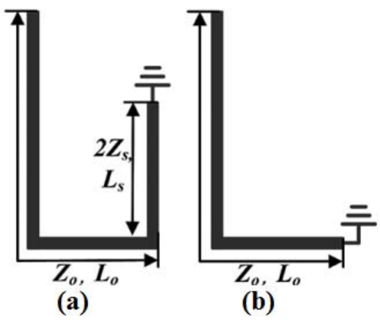

Figure 2: (a) Even-odd mode (b) Odd-mode equivalent circuit

The Even and Odd mode equivalent circuits, which implies that the even mode governs the lower passband and the odd mode governs the upper passband. For simplicity here, we set, then even and odd mode resonant frequencies are shown as follows,

$$f_{\text{even}} = \frac{c}{4(L_o + L_s)\sqrt{\varepsilon_{\text{eff}}}} \quad \text{..............(1)}$$

$$f_{\text{odd}} = \frac{c}{4L_o\sqrt{\varepsilon_{\text{eff}}}} \quad \text{...............(2)}$$

Where, c denotes the light speed in free space and the εeff is the effective dielectric constant of the substrate. Accordingly, four passband frequencies can be obtained by further procedure. Filter 1 used to realize the frequency $f1$ and $f2$. The upper resonant frequency $f$odd for $f2$ is obtained first by varing length the length of the open stub L_0. Then $f$even for $f1$ is further controlled by tunning L_s which having little impact on $f2$. In addition, same procedure is used obtained $f3$ and $f4$ for Filter 2 using above method.

3. Simulated Results

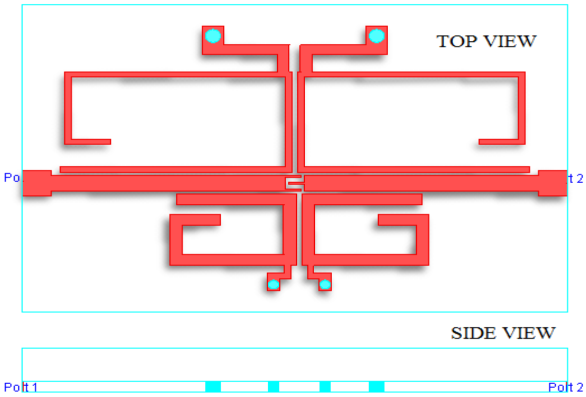

Figure 3: ADS layout of quadband BPF

The fig.3. shows the compact structure of quadband pass filter designed in ADS. The filter having four resonator along with proper interdigital capacitance structure for effective coupling.

The quad-band BPF is fabricated on a Rogers4350B having relative dielectric constant 3.66 and loss tangent is 0.009 substrate with thickness of 0.508 mm as shown in the inset plot of Fig. 1. The dimension values are summarized as follows (all in mm) L1 = 8.89,L=1.75, L3=8.64, L4=4.15, L5=2.85, L6=3.2, L7=0.8, L8=9.44, L9=4.33, L10=4.1, L11=1.54, L12=2.3, L13=1.35, L14=0.7, W=1.15, W1=0.75, W2=W5=0.25, W3=0.455, W4=0.25, S1=0.25, S2=0.45, S3=0.69, S4=0.24, D1=0.3R, D2=0.2R. The overall size of the circuit is 12.5 mm x 22 mm.

Table 1: S Parameter value for Quad BPF

	M1	M2	M3	M4
Central frequency (GHz)	2.4	3.5	4.4	5.9
S11(RL)	32.45	29.89	33.26	29.69
S21(IL)	0.02	0.01	0.04	0.03
Bandwidth(MHZ)	170	240	310	380

In table 1, shows simulated value of quad band BPF.The value of insertion loss is less than 0.04 dB and return loss s more than 29 dB.

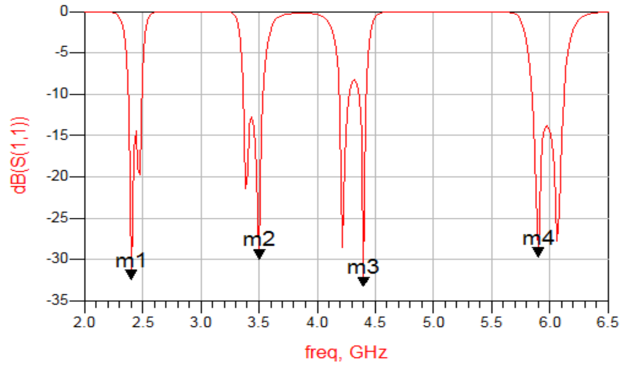

Figure 4: Simulated S11-parameter results of quad-band BPF

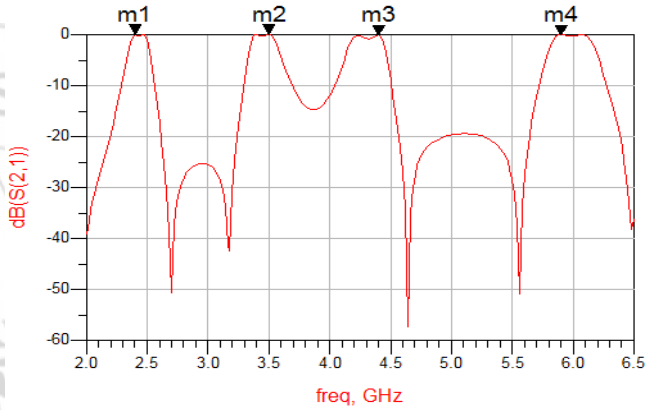

Figure 5: Simulated S21-parameter results of quad-band BPF

In fig.4 and fig.5, shows the simulated results of s parameter of quadband response of filter at frequency of 2.4 GHz , 3.5 GHz ,4.4 GHz and 5.9 GHz . In above results shows that filter has higher return loss (m1, m2, m3, m4) and lower insertion loss(m5, m6, m7, m8). The transmission zeros is more than 40 dBs which shows that the coupling between source and load is effective and we achieved proper filtering.

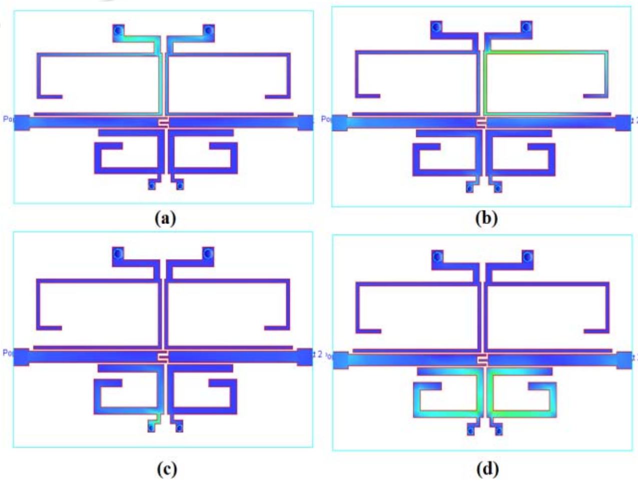

Figure 5: Quad-Band Bandpass Filter current distribution in ADS for (a) 2.4 GHz (b) 3.5GHz (c) 4.4GHz (d) 5.9GHz

The fig.5, show the current distribution of quadband BPF, the current distribution shows the conduction of resonator at give frequency. The table 2, shows the comparison between the quadband bandpass filter and the previous works BPF.

Table 2: Comparison between the quadband bnadpass filter and the previous works BPF

Year	Research title	f1 /f2 /f3 /f4	IL (dB)	RL (dB)
2011 [1]	Microstrip Dual/Quad-Band Filters With Coupled Lines an Quasi-Lumped Impedance Inverters Based on Parallel-Path Transmission	1.55 2.79 3.29 4.47	3.63 2.57 2.89 4.48	More than 15
2011 [2]	A New Quad-Band Bandpass filter Using Asymmetric Stepped Impedance Resonators	2.4 3.5 5.2 6.8	0.5 1.3 1.3 1	13 38 19 26
2012 [3]	Compact high isolation quad-band bandpass filter using quad-mode resonator	1.9 2.8 4.3 5.2	2.3 3.6 3.5 3.4	More than 12
2012 [4]	Compact Wide-Stopband Quad- Band Bandpass Filter with Tunable Transmission Zeros	1.5 2.5 3.5 5.5	1.8 2.3 0.9 1.8	-
2013 [5]	Independently switchable quad-band bandpass filter	1.5 2.5 3.4 4.5	3.13 3.02 3.22 3.35	29 16 19 24
This work	**A Novel Quad-Band Bandpass Filter Using Effective Source-load Coupling For WLAN, WiMAX and RFID Applications**	**2.4 3.5 4.4 5.9**	**0.02 0.01 0.04 0.03**	**32.4 29.8 33.2 29.6**

4. Conclusion

A quad-band bandpass filter has been realized and simulated through the EM simulation of ADS. Simulated results reveal quad-band BPF provided compact size, low insertion loss, high return loss and more transmission zeros(TZs) having value greater than 40dB. This superior features indicate that the filter has a potential to be utilized in WLAN, WiMAX , RFID and military applications.

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