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Design of Dual-Wideband Bandpass Filter & Dual-Band Bandpass Filter

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Abstract

This paper proposes a class of dual-wideband bandpass filters (BPF) with stepped-impedance resonators (SIRs). Firstly, SIRs are designed to generate their first two resonant modes in the two specified passbands, and they are sequentially cascaded by alternative and inverters. In design, SIRs need to be chosen not only to satisfy the prescribed dual-wideband central frequencies, but also to compensate for the deficient values of inverters at these two frequencies. Following that, a generalized synthesis method is extensively described for design and exploration of novel dual-wideband filters on the microstrip-line topology. Second-order dual-wideband BPF with dual passbands are at 2.8-3.9 and 7.4-8.4 GHz are fabricated for the experiment, and simulated results validate the theoretical ones successfully. Second design is simulated and fabricated on FR4 substrate. Permittivity of the material is 4.4 and height of the substrate is 0.8mm. First passband is achieved on 2.4GHz for Bluetooth application and second passband is achieved on 4.8GHz-5.9GHz for Wi-Fi application.

Keywords

Dual wide-band bandpass filter, Dual band bandpass filter, Stepped-impedance resonator, Open stub and Short circuited stub.

I. Introduction

With the advance of modern wireless communication systems, a single transceiver operating at multiple frequency bands had become very popular. Besides the dual-band CMOS transceiver chipset [1] and the dual-band antenna [2], the dual-band bandpass filter is another essential microwave frontend component for integration of miniaturized dual-band systems. The most intuitive method to implement a dual-band bandpass filter is to simply combine two bandpass filters with two distinctive central frequencies [3] in parallel, at the cost of enlarged circuit size and complicated matching network. In [4], a dual-band BPF was constituted by embedding a band-stop filter inside a wideband bandpass filter. Recently, a large number of dual-band BPF have been designed based on the two different-order resonant modes of various transmission-line resonators [5]–[15], namely, a dual-mode resonator. Wide-band BPF provides the coherence bandwidth so that data or signal can travel from input to output without interference. There are three kind of step impedance resonator that is full wavelength, half wavelength and quarter wavelength SIR. In these days quarter wavelength SIR are used more that other SIR because it provides good frequency response and reduce the size of filter.

Coupling is used to create the transmission zero in the stop-band to improve the selectivity of the filter. By adjusting the position of resonator we can adjust the position of the transmission zero in the stop-band. Transmission pole is created by creating the "via" in the design. Transmission pole is existed in the passband which improve the role off factor of the filter.

Fig. 1 shows the transmission zero (TZ) in the stop-band and transmission pole (TP) in the pass-band.

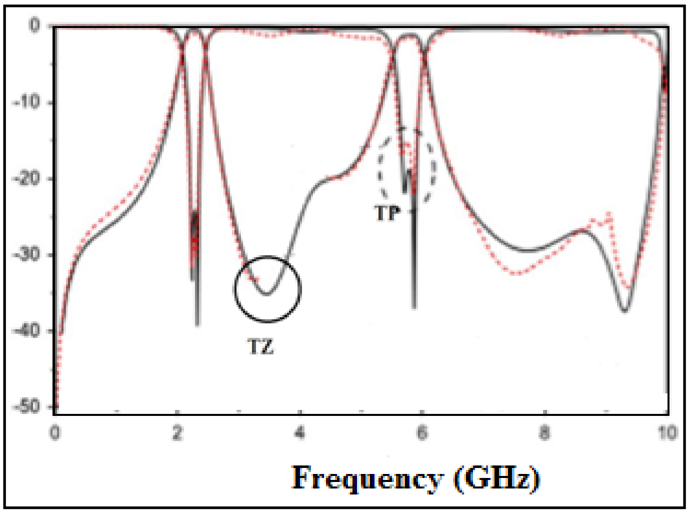

Fig. 1: Location of TZ & TP

II. Designing Method

Adding open stub at the required position of dual-band BPF, dual wide-band BPF can be designed. It is very important to achieve the desired passband that means proper frequency band is required for the desired application. Designing of the proposed filter is done on the HFSS tool, which provides very accurate result as comparison to the other software. Quarter wavelength step impedance resonator is used in the proposed design. It provides the miniaturization of the circuit and provides the same performance as like full wavelength SIR.

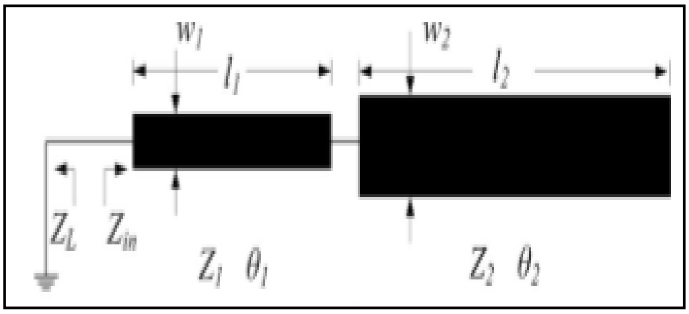

Fig. 2: Quarter Wavelength SIR

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Fig. 2 shows the diagram of quarter wavelength SIR, where l_1 & l_2 are the lengths, w_1 & w_2 are width, Z_1 & Z_2 are impedance, Θ_1 & Θ_2 are phase length or electrical length, Z_{in} is input impedance and $Z_L=0$ because of short circuited end. Input impedance can be calculated by the following formula:

$$Z_{in}=\frac{Z_0}{J}\left[\frac{(1-\tan 2\theta_1 \tan\theta_2)-\tan\theta_2(\tan\theta_2+\tan 2\theta_1)}{(\tan\theta_2+\tan 2\theta_1)+(1-\tan 2\theta_1 \tan\theta_2)\tan\theta_2}\right]$$

Where Z_O is characteristic impedance and calculated by the following formula:

$$Z_0=\begin{cases}\dfrac{60}{\sqrt{\epsilon\, eff}}\ln\left(\dfrac{8d}{W}+\dfrac{W}{4d}\right) & \text{for } \dfrac{W}{d}\ll 1\\ \dfrac{120\pi}{\sqrt{\epsilon\, eff}\left[\dfrac{W}{d}\right]+1.393+0.667\ln\left(\dfrac{W}{d}+1.444\right)} & \text{for } \dfrac{W}{d}\gg 1\end{cases}$$

Where ε_r and ε_{eff} is dielectric and effective dielectric constant respectively. W is width of the feed and d is height of the substrate.

III. Layout Design of Filter

(a) Design with Rogger RT6010 substrate

Two SIRs are coupled with each other by the help of inverters. J and K inverters are use to combine the two resonators type filter into one resonator type filter & it can also convert the two resonators type filter into one resonator type filter. Inverters are also use to invert the impedance that means series impedance is converted into shunt admittance and shunt admittance into series impedance into shunt admittance. Fig. 3 show the two coupled λ/4 SIR.

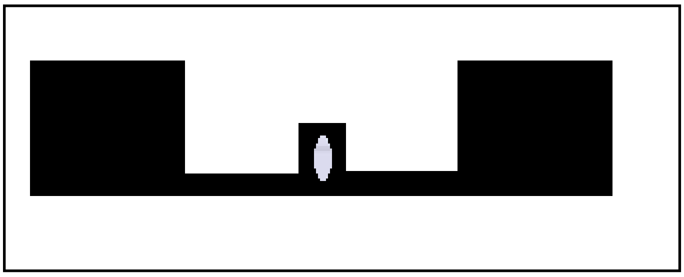

Fig.3: Schematic of two coupled λ/4 SIR

In the above figure it is clearly seen that two SIRs are combined with each other and one via is present to create the TP in the pass band.

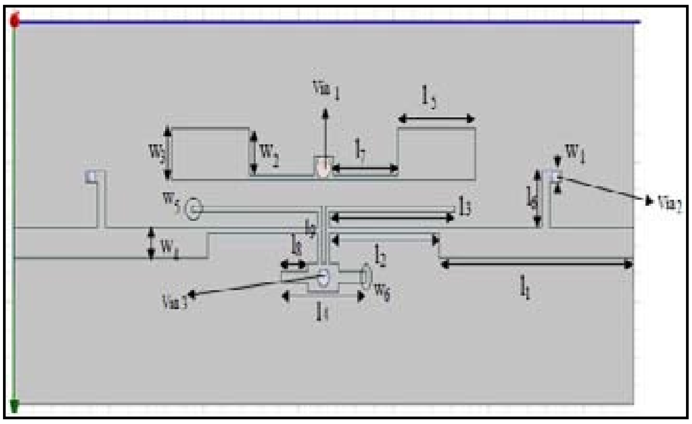

Fig. 4: Dual Wide-band BPF

Fig. 4 shows the design of dual wide-band BPF with two passband. Measurements of the filter are given as follows: l_1 = 10.2mm, l_2 = 5.8mm, l_3=6.6mm, l_4 = 4.5mm, l_5 = 4.1mm, l_6 = 2mm, l_7 = 3.4mm, l_8 = 1.45mm, l_9 = 185mm, w_1 = 0.4mm, w_2 = 1.7mm, w_3 = 1.85mm, w_4 = 1.1mm, w_5=0.2mm, w_6=0.4mm, diameter of via_1 =0.8mm, via_2 = 0.4mm and via_3 = 0.6mm.

(b) Design with FR4 substrate

Two SIRs are coupled with each other at the coupling distance of 0.2mm. Six open stubs and one short circuited stub are united to each SIR. All stubs are distributed at equal distance of 0.3mm to achieve the desired passband. Measurements of the filter are given as follows: l_1 = 8mm, l_2 = 13mm, l_3=5.2mm, l_4 = 4.55mm, l_5 = 3mm, l_6 = 2.05mm, l_7 = 3.3mm w_1 = 0.6mm, w_2 = 1.1mm, w_3 = .25mm, w_4 = 0.6mm. Fig.5 shows the diagram of dual band BPF.

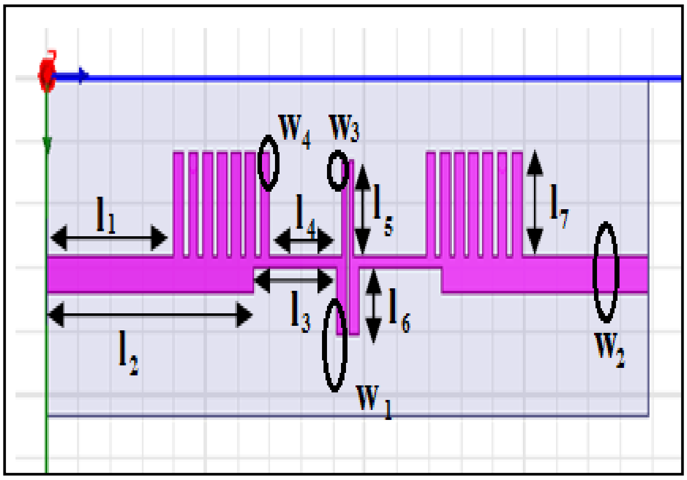

Fig.5 Dual band BPF

IV. Simulated Result of The Filter

A. Simulated Result of 1st Filter

Frequency range of first passband is 2.8-3.9 GHz and for second pass band is 7.4-8.4 GHz. Insertion loss for first pass band is 0.5995 dB and for the second passband is 0.6767 dB. Return loss for the first passband is 17.0330dB and for second passband is 20.7135dB. Fig.6 shows the simulated result of the dual wide-band BPF.

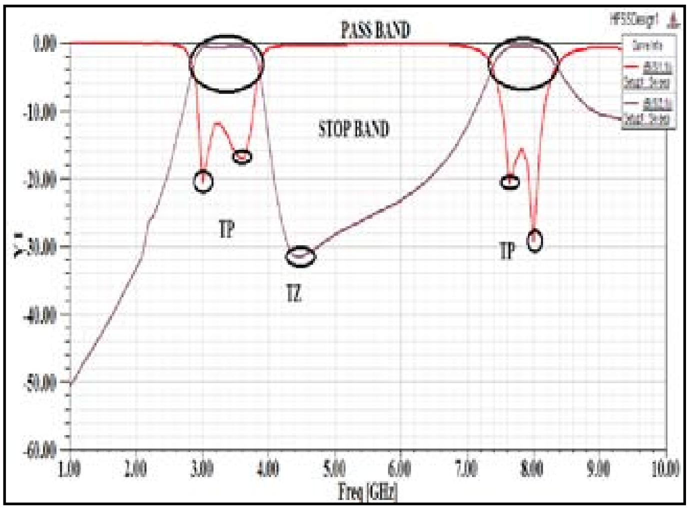

Fig. 6: Simulated Results of Dual Wide-band BPF

B. Simulated result of 2nd Filter

Frequency of first passband is 2.4GHz and for second pass band is

4.8-8.5.9GHz. Insertion loss for first pass band is 2.27dB and for the second passband is 1.49dB. Return loss for the first passband is 18.53dB and for second passband is 29.57dB. Fig.7 shows the simulated result of the dual-band BPF.

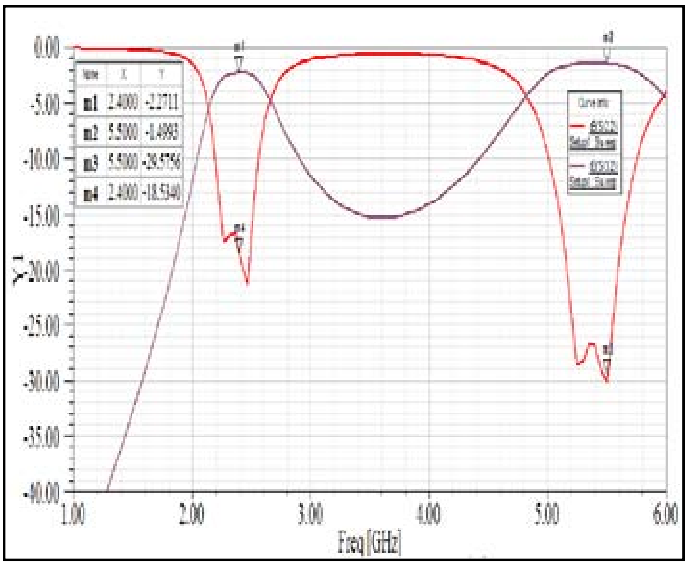

Fig. 7: Simulated Results of Dual-band BPF

V. Conclusion

In proposed design- electric and magnetic coupling is done by cross coupling methods that helps in bandwidth control and generation of TZ for skirt off and selectivity improvement. This filter was designed on ROGER substrate material that has loss tangent of 0.0027, its advantage is almost zero insertion losses are obtained. Three TZS are introduced the circuit size is very compact due to its simple design. It is designed for S-band and C band applications. In the proposed work dual wide band BPF has been designed. First pass band is in S band and second pass band is in C band. Advantage of this design is that it has two wide bands so that it will work for two frequency band. In proposed design only two resonators are coupled with each other.

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Author's Profile

Peeyush Chandra was born in Gorakhpur, U.P. India. He has completed his secondary and higher secondary examination with science stream in 2004 and 2006 respectively. He has completed his schooling from Govt. Jubilee Inter College Gorakhpur U.P. He received the B.Tech degree in Electronics & Communication Engineering, from Institute Of Technology & Management GIDA Gorakhpur, U.P. He is pursuing M.Tech in Electronics & Communication Engineering from Ajay Kumar Garg Engineering College, Ghaziabad, U.P. (2014-2016). His current interest includes Filter designing on HFSS.

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