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Microstrip Dualband Bandpass Filter Using Stub Loaded Resonator for Wireless Communication Applications

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Abstract— **In this paper compact microstrip quadmode stub- loaded resonator is used to design a dualband BPF. The multiband behaviour is obtained by using mode splitting characteristics of the quadmode stub loaded resonator. The passbands can be easily tuned to desired frequencies by controlling the corresponding resonator dimensions with a high degree of design freedom. The lower band of dual band BPF is broadband and is designed in such a way that it operates at frequency 1.8GHz. The upper band of the dual band BPF is made narrowband with high selectivity and is designed to operate at frequency 2.4GHz. If dual band BPF is made to operate at center frequencies 1.8GHz and 2.4GHz then it can find use in mobile and wireless communication applications respectively. The filter has been designed using IE3D software for a substrate with dielectric constant of 3.5 and a thickness of 0.76mm.**

Index Terms— **Bandpass Filter (BPF), Dualband, Fractional Bandwidth (FBW), Quad-Mode Resonator, Stub-Loaded Resonator.**

I. INTRODUCTION

Earlier the single-stage multi-band bandpass filters had narrow bandwidths and inadequate out of band rejections, which cannot be used for commercial applications. In order to solve these problems, one or more resonators are required to be cascaded together to get wider bandwidth and larger out-of-band rejection. But it resulted in higher insertion losses and large pattern sizes of designed filters thereby limiting their use.

Also many of the modern wireless communication applications practices quite different procedures, especially in bandwidth. The method of cascading usually upsurges the bandwidths of all operating frequencies, and to control the bandwidths of each passband becomes slightly difficult. Due to the advancement in the field of mobile and wireless communication the need for multi-band bandpass filters (BPFs) has been increasing, and this has seek the attention of many researchers.

The dual band bandpass filter using DGS resonator [1] and hexagonal resonators [2] were presented before, but they can't meet the requirements of multiple passband at the same time. A miniaturized dual-band BPF which consists of two quarter-wavelength stepped impedance resonators and two symmetrical half-wavelength stepped impedance resonators is proposed in [3].This method however requires separate set of resonators so that each BPF be independently designed and then combined to form a dual band BPF.

In this paper, a microstrip quad-mode stub-loaded resonator is used to design dual-band BPFs. The methodology about the mode splitting characteristics of the quadmode resonator will be used to design a dualband filter for wireless communication applications. Autonomous tuning of pass bands provides high degree of design freedom in proposed filter.

Microstrip filters have found large number of applications in microwave circuits because of their compact size, low cost and easy integration. Many methods have been developed to improve the filtering characteristics, multiband bandpass filters with compact size, and wide bandwidth and high out of band rejection are vital requirements for the swift advancement of modern wireless communication system.

II. QUADMODE RESONATOR ANALYSIS

In this work, multiband behaviour is obtained by using mode splitting characteristics [4] of Quadmode resonator. The design of quadmode resonator as shown in Figure 1 is adapted from [5]. Resonator is formed by adding two identical open circuited stubs, denoted by length L_2 and width w_2, at both sides and another open circuited stub (L_1, w_1) at the center plane along a high impedance microstrip line with length of ($2L_0$+2s) and width of w0. Because of its symmetrical structure its operating mechanism can be justified by an even and odd mode analysis which was proposed in [6]. "Figure 1" shows a quadmode resonator, which upon splitting gives even and odd mode equivalent circuits as shown in "figure 2" from [5].

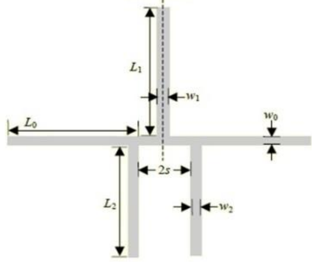

Figure 1. Structure of Quad Mode Resonator

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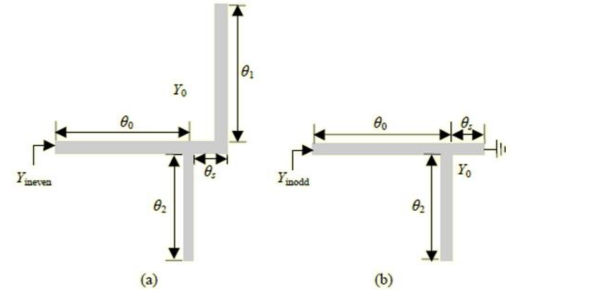

Figure 2. Equivalent Circuits (a) Even Mode & (b) Odd Mode

In "figure 2(a)", the equivalent circuit for even-mode excitation is shown .The following analysis has been adapted from [5] to provide an insight into the working of the quadmode resonator. The characteristic admittance of the widths w_0, $w_{1/2}$, and w_2 is Y_0, and the electrical lengths of the four sections with physical lengths L_0, L_1, L_2 and s are θ_0, θ_1, θ_2, and θ_s, respectively. The input admittance Y_{ineven} of the even-mode equivalent circuit is expressed as

$$Y_{ineven} = jY_0 \frac{\tan\theta_0 + \tan\theta_2 + \tan(\theta_1 + \theta_s)}{1 - \tan\theta_0[\tan\theta_2 + \tan(\theta_1 + \theta_s)]} \quad (1)$$

Similarly, the input admittance Y_{inodd} of the odd-mode equivalent circuit in Figure 2(b) can be expressed as

$$Y_{inodd} = jY_0 \frac{\tan\theta_0 + \tan\theta_2 - \cot\theta_s}{1 - \tan\theta_0(\tan\theta_2 - \cot\theta_s)} \quad (2)$$

From the resonant conditions $Y_{ineven} = 0$ and $Y_{inodd} = 0$, the resonant frequencies can be expressed as

$$\tan\theta_0 + \tan\theta_2 + \tan(\theta_1 + \theta_s) = 0 \quad (3)$$

$$\tan\theta_0 + \tan\theta_2 - \cot\theta_s = 0 \quad (4)$$

According to (3) and (4), it is found that the even-mode resonant frequencies are determined by L_0, L_1, L_2 and L_s, whereas the odd-mode resonant frequencies can be controlled by tuning L_0, L_2 and L_s. Thus, multiband performances are obtained by using above mentioned physical parameters.

Length L1 can be adjusted for the bandwidth of first passband and bandwidth of second passband can be changed by adjusting length L2. Hence, a dual-band BPF is generated with the help of the quad-mode resonator.

III. Bandpass Filter Design & Results

From the above discussion, a dualband bandpass filter is designed as shown in "figure 3" with the help of quadmode resonator. The coupled-line structure is employed to design the input and output coupling structure. A pair of 50 Ω T-shape feed lines is used to provide necessary coupling to quad mode resonator. The coupling structure increases the design freedom and also realizes the compactness of the structure.

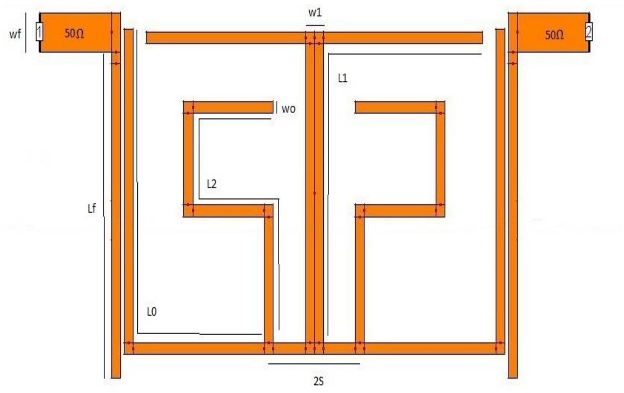

Figure 3: Design of Dualband BPF using IE3D software

The lower band is made broadband and is designed in such a way that it operate at 1.8 GHz. The upper band of the dualband BPF is made narrowband with high selectivity and is designed to operate at 2.4GHz .The Dualband BPF is designed and simulated using Zealand IE3D software on a substrate with a relative dielectric constant of 3.5 and a thickness of 0.76mm.

The dimensions of the filter are L_f=14.15, w_f=1.71, L_0=21.75, L_1=22, L_2=19, w_0=0.5, w_1=1, g=0.2 and s = 2.55 (all in millimetres).The designed the filter is then optimized to obtain best results.

Simulated frequency responses of the designed dual-band BPF are shown in "figure 4". The center frequencies of two pass bands of the designed filter are 1.8GHz and 2.4GHz respectively. The lower passband with center frequency at 1.8GHz is a wideband and has a 3dB fractional bandwidth of 7.72% with minimum insertion loss of -0.65dB and maximum return loss of -17.44dB. The upper passband with center frequency at 2.4GHz is a narrowband and has a 3dB fractional bandwidth of 4.38% with minimum insertion loss of - 1.17dB and maximum return loss of -14.74dB.

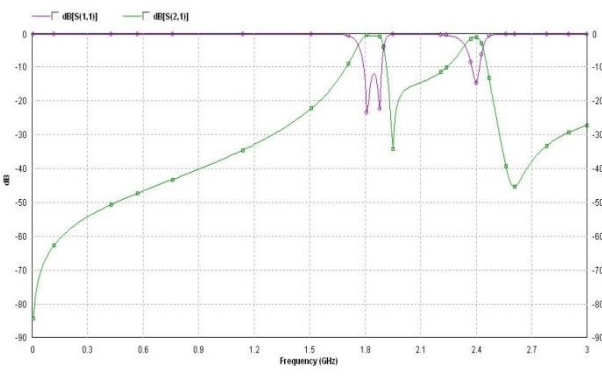

Figure 4: Simulated frequency response of Dualband BPF using IE3D software

Values of insertion loss return loss and FBW obtained after simulation are mentioned in "Table1".

Table 1: Parameter values obtained after simulation

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Center Frequency (GHz)	Return Loss (dB)	Insertion Loss (dB)	Fractional Bandwidth (%)
F_c	S_{11}	S_{12}	FBW
1.8	-17.44	-0.65	7.72
2.4	-14.74	-1.17	4.38

Conclusions

Using a Quadmode Stub loaded resonator a dual band BPF was designed and simulated using IE3D software. The designed filter has center frequencies 1.8GHz and 2.4GHz.This design can be used to filter signals at GSM and WLAN frequencies which are specified for mobile and wireless communication applications in India.

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