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

Saish M. Kanekar1, Amita Dessai2
1 Goa College of Engineering/Electronics & Telecommunication Department, Goa, India
Email: kanekar.saish@gmail.com
2 Goa College of Engineering / Electronics & Telecommunication Department, Goa, India
Email: amitachari@gec.ac.in

Abstract—In this paper compact microstrip quad-mode 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 L1 and width w0, at both sides and another open circuited stub (L2, w1) at the center plane along a high impedance microstrip line with length of (2L0+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
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 w0, w1/2, and w2 is Y0, and the electrical lengths of the four sections with physical lengths Lo, Li, L2 and s are θ0, θ1, θ2, and θs, respectively. The input admittance Y_{even} of the even-mode equivalent circuit is expressed as

\[ Y_{even} = jY_0 \frac{\tan \theta_0 + \tan \theta_2 + \tan(\theta_1 + \theta_3)}{1 - \tan \theta_0 \tan(\theta_2 + \tan(\theta_1 + \theta_3))} \]  

(1)

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

\[ Y_{odd} = jY_0 \frac{\tan \theta_0 + \tan \theta_2 - \cot \theta_s}{1 - \tan \theta_0 \cot \theta_2 - \cot \theta_s} \]  

(2)

From the resonant conditions Y_{even} = 0 and Y_{odd} = 0, the resonant frequencies can be expressed as

\[ \tan \theta_0 + \tan \theta_2 + \tan(\theta_1 + \theta_3) = 0 \]  

(3)

\[ \tan \theta_0 + \tan \theta_2 - \cot \theta_s = 0 \]  

(4)

According to (3) and (4), it is found that the even-mode resonant frequencies are determined by Lo, Li, L2 and Ls, whereas the odd-mode resonant frequencies can be controlled by tuning Lo, L2 and Ls. 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 ohm 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.

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 Zeolland 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 L0=14.15, w0=1.71, L0=21.75, L1=22, L2=19, w0=0.5, w1=1, g=0.2 and s = 2.55 (all in millimetres). The designed 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 narrowband 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.
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.

**ACKNOWLEDGMENT**

I would like to thank the H.O.D of our ETC Department Dr. H.G. Virani for their valuable inputs, encouragement and support. I would like to thank all those who helped me whenever I called on them for any assistance. I am grateful to my parents and all my friends who were supportive throughout the course of this work.

**REFERENCES**


