Novel Approach for Center Frequency and Bandwidth Tuning in Multimode Resonator Based Microstrip Dual-Mode Bandpass Filter

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Abstract. In this paper, a novel approach for both center frequency and bandwidth tuning in a dual mode bandpass filter is demonstrated. The proposed filter is configured from a half wavelength multimode resonator structure. The Ultra-wide bandpass response of the multimode resonator is extracted using an inter-digital feed structure which provides good input/output coupling. By deploying stepped admittance structure perturbation element into the symmetrical plane of the multimode resonator, the dual-mode response is achieved with three upper stopband transmission zeros (TZs). The coupling between two degenerative mode frequencies is controlled by the admittance ratio (Y) of the stepped admittance structure. Changing admittance ratio (Y) of stepped admittance structure, resulted in the change in even mode resonance frequency and location of three upper stopband transmission zeros while keeping odd mode frequency fixed. The proposed filter has a size of 14.0 x 30.0 mm^2.

Keywords: Multi-mode resonator, Ultra-wideband, Transmission Zeros.

1. Introduction

Modern wireless communication system needs compact, high frequency selective, wide stopband tunable bandpass filters. In literature many tunable filters have been reported using dual mode resonators [1]-[12].Tuning is achieved in 3 ways i) Fixed center frequency and tunable bandwidth ii) Fixed bandwidth and tunable center frequency iii) Both center frequency and bandwidth tuning. In literature, electronic tuning also has been reported where semiconductor and MEMs switches are used for center frequency and bandwidth tuning. By varying dimensions of perturbations in microstrip loop resonators even mode frequencies are controlled and thus bandwidth tuning has been reported in [5]-[7]. By varying size of T shaped DGS and inter-digital capacitance, center frequency of ultra wideband filter is controlled [2]. S-band microstrip triple mode bandpass [3] filter has been proposed with T shaped resonators, both upper and lower transmission zeros were controlled by tuning the length of the T resonator. Parallel-coupled stepped impedance resonators (SIRs) [4] have been proposed to design Bandpass filters with an optimal rejection bandwidth. Dual-mode bandpass filter using square loop resonator DGS [8] with square patch in corner has been proposed to excite odd and even modes. But filter suffers from poor Roll-off at lower passband edge. An open loop resonator [10] with inter-digital unit cells which provide capacitive loading effect has been used to configure dual mode filter. By varying gap between fingers and width of fingers odd and even mode resonant frequencies were observed. But filter suffers from poor frequency selectivity. Dual mode DGS resonator composed of folded slot line resonator (FSLR) and coplanar stepped impedance resonator (CSIR) has been proposed to develop filter. Each of the resonator controls one resonant frequency [12].

In this paper a novel approach for center frequency and bandwidth tuning in MMR based dual mode BPF is proposed. Using an inter-digital feed structure Ultra-wide bandpass response of multimode resonator is obtained. By deploying stepped admittance structure perturbation in to the symmetrical plane of multimode resonator, dual mode response is achieved with three upper stopband transmission zeros(TZs).Change in admittance ratio(Y) of stepped admittance structure, results in shift in even mode resonance frequency and location of three upper stopband transmission zeros.

2. Modeling of UWB bandpass filter from MMR

Basic structure of half wavelength MMR is depicted in Figure 1 which consists of low and high impedance sections Z1 and Z2 respectively and resonates at fundamental frequency f_0=4.4 GHz and at $2f_0$ = 10.14 GHz,and $3f_0$=14.6 GHz as shown in Figure 2. By providing proper coupling at input and output through an inter-digital feed structure UWB filter is modeled as shown in Figure 3. Figure 4 shows response of UWB response. The proposed resonator is modeled using RT Duroid substrate with dielectric constant 10.8 and thickness 1.27mm and tangential loss of 0.0023.

Dual- mode bandpass filter is configured by deploying stepped admittance structure perturbation in to the symmetrical plane of proposed MMR as shown in Figure 5 which excites two degenerative odd and even mode resonant frequencies. As filter topology is symmetrical, odd and even mode resonant frequencies are analyzed based on the equivalent circuits shown in Figure 6 and 7, respectively.

Fig.1.Structure of multimode resonator

DOI: http://dx.doi.org/10.32452/IJAMT.2020.234236

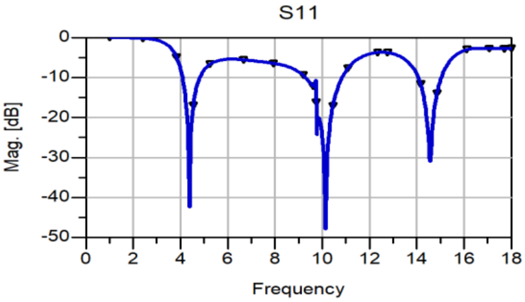

Fig.2. Resonance frequencies of MMR

Fig.3. Proposed UWB Filter

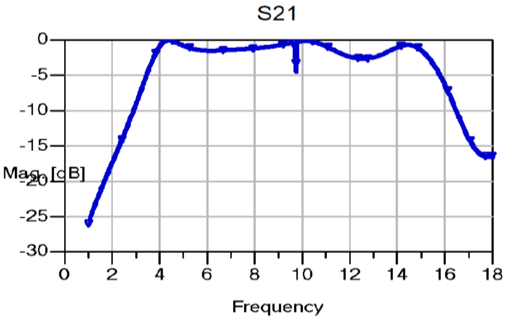

Fig.4. UWB response of MMR

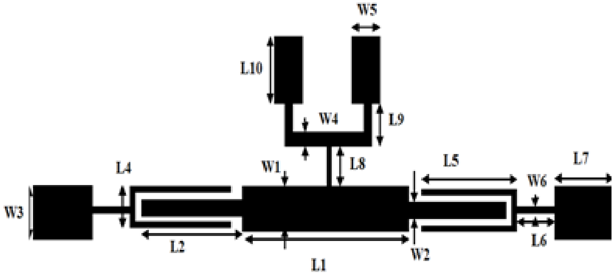

Fig.5. Proposed MMR based dual mode Bandpass filter

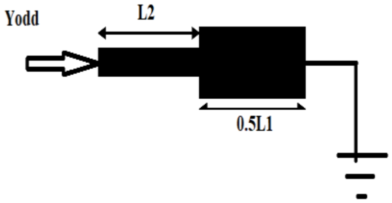

Fig.6. Equivalent circuit for odd mode resonance

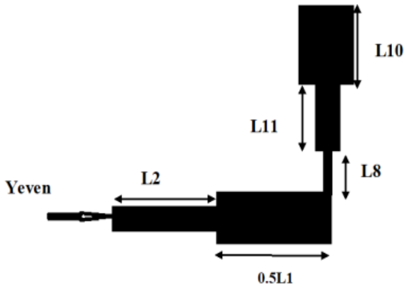

Fig.7. Equivalent circuit for even mode resonance

Mathematical model for Odd and even mode resonance frequencies are given by expressions (1) and (2) respectively.

$$f_{odd} = \frac{c}{\left(L_2 + 0.5L_1\right)\sqrt{\varepsilon_{eff}}} \tag{1}$$

$$f_{even} = \frac{c}{\left(L_2 + 0.5L_1 + L_8 + L_{11} + L_{10}\right)\sqrt{\varepsilon_{eff}}} \tag{2}$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[\sqrt{1 + \frac{12h}{t}}\right]^{-1} + 0.04\left(1 - \frac{w}{h}\right)^2 \tag{3}$$

where, c is velocity of light, ε_{eff} effective dielectric constant. For an admittance ratio (Y) of 0.8, the response of filter is shown in Figure 8. Odd and even mode frequencies are found at 4.55 GHz and 6.0 GHz, respectively with three upper stopband transmission zeros at 8.88 GHz, 9.75 GHz and 10.86 GHz. From simulation results, it is observed that the designed filter has input reflection coefficient (S_{11}) > -10 dB and transmission loss (S_{21}) -0.08 dB in pass band and bandwidth of 3.4 GHz. The dimensions of proposed filter are as follows.

L_1=5.7mm, W_1=0.8mm, L_2=2.7mm, W_2=0.5mm, W_3=1.1 mm, W_4=0.33mm, L_4=0.7mm, L_5=2.7mm, W_5=(0.6, 0.7, 0.9)mm, W_6=0.1mm, L_6=0.2mm, L_7=2mm, L_8=0.2mm, L_9=0.3mm and L_{10}=1.4mm .

3. Tuning Center frequency and Bandwidth

Both center frequency and bandwidth of the proposed filter are tuned by varying admittance ratio(Y) of stepped admittance perturbation as 0.7, 0.77 and 0.8. From simulation results shown in Figure 9. it is observed that, even mode resonance frequency changes with change in admittance ratio where as the odd mode resonance frequency remains fixed. In Figure 10 shows shift in position of upper stop band transmission zeros with changing admittance ratio (Y).

4. Result and discussion

To tune both center frequency and bandwidth, admittance ratio Y is varied as 0.7, 0.77 and 0.8. For Y=0.7, 0.77, and 0.8, even mode resonance frequencies are found at 5.75 GHz, 6.0 GHz, and 6.1 GHz respectively. Whereas for odd

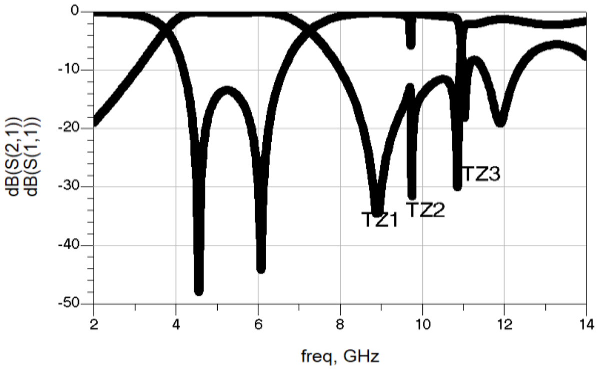

Fig.8. Response of proposed filter for Y=0.8

DOI: http://dx.doi.org/10.32452/IJAMT.2020.234236

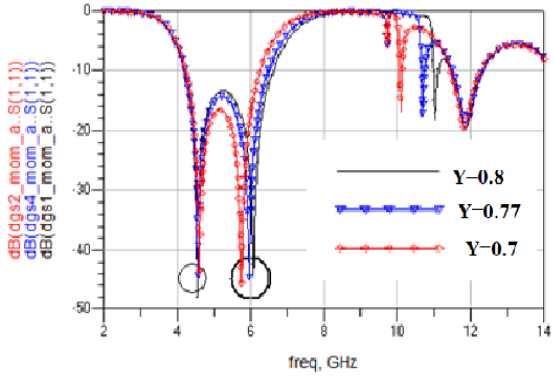

Fig.9. Shift in even mode resonant frequency.

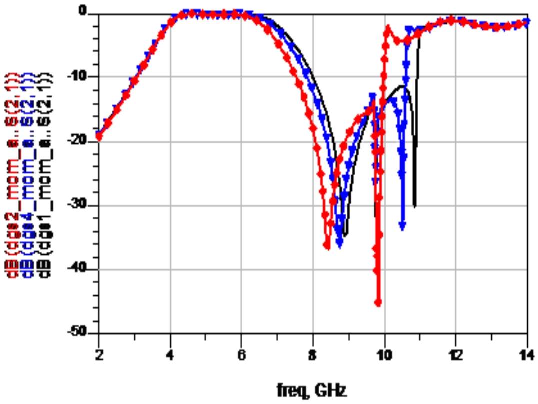

Fig.10. Shift in position of upper stop band transmission zeros in S_{21} response.

Tablel 1: Measured values of center frequency and bandwidth for various values of admittance ratio (Y)

Admittance Ratio (Y)	Center frequency in GHz	Bandwidth in GHz	Location of Upper stopband transmission zeros at
0.7	5.157	3	8.44 GHz and 9.8GHz.
0.77	5.3	3.2	8.750GHz,9.75GHz and 10.50GHz
0.8	5.4	3.4	8.750GHz,9.75GHz and 10.50GHz

mode frequency is at 4.6 GHz for all values of Y. For Y=0.7 two upper stop band transmission zeros are reported at 8.44 GHz and 9.8 GHz. For Y=0.77, three upper stop band transmission zeros are reported at 8.750 GHz, 9.75 GHz, and 10.50 GHz, respectively. For Y=0.8, three upper stop band transmission zeros are reported at 8.75 GHz, 9.75 GHz and 10.7 GHz, respectively. The input reflection coefficient (S_{11})>-10dB and transmission loss (S_{21}) of -0.07dB are reported for Y= 0.7, 0.77,and 0.8.

5. Conclusion

In proposed work, dual-mode bandpass filter is realized from multimode resonator. Dual mode response is achieved by integrating an stepped admittance perturbation in to the MMR. By changing admittance ratio Y of stepped admittance perturbation, center frequency and Bandwidth are tuned and three upper stopband transmission zeros are created. The location of all upper stopband transmission zeros are controlled by admittance ratio.

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Biography of the authors

Shobha Hugar: She did B.E. in Elecetronics and Communication from Karnataka University Dharwadr and M.Tech. in VLSI Design &Embedded System from Visvesvaraya Technological University in 2000 and 2009 respectively. Presently she is working as Assistant Professor at Department Of Electronics & Communication Engineering, Sapthagiri College of Engineering, Banglore, Karnataka. Her reaserch area includes UWB filters and microstrip antennas.

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DOI: http://dx.doi.org/10.32452/IJAMT.2020.234236