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Dual Band Bandpass Filter With Sharp Passband Resonances Using Dual-Mode SIRs

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***Abstract*—Bandpass filter with square loop shaped uniform impedance resonator and L-shaped stepped impedance resonators is proposed here. By using dual mode loop resonators and 2 stepped impedance resonators in the structure, the passbands are controlled in the expected range. The parameters are adjusted in the proposed structure so as to get optimum resonances without any ripples in the passband. The lengths of the low-Z and high-Z sections of SIRs are so chosen that the resonant frequencies do not alter from the band of interests. Dual bands are realized due to dual coupling paths present as loop resonators, in the structure. This dual segment loop resonator helps in achieving second order mode bandpass filter. The proposed filter occupies 48x48x1.6mm footprint.**

Keywords*— *Dual mode SIR, Loop Resonator, Uniform Impedance Resonator.

1.INTRODUCTION

Filter plays an important role in wireless and mobile communication systems. They also are the essential component in RF transmitter and receiver designs. They can also be designed on various materials and fabricated using printed circuit board technology due to their miniaturized size and low cost integration [1]. Nowadays, multiband multi mode wireless communications are achieving advancements, in which filter with multimode operation are being widely preferred for RF devices and are widely investigated with various structures on planar transmission lines [2-11].

Multiband bandpass filters can be constructed using multimode stepped impedance resonators[12],[13]. SIR can possess multiband operation when the electrical length of the two line sections are different [12]. The conventional SIR design used here is similar to that of used commonly, consisting of 2 line sections with different characteristic impedances[14].

Here the proposed second order dual band filter has a two section conventional stepped impedance resonator for achieving multiband operation. It has been optimized in such a way that the resonant frequencies 1.8GHz, 1.57GHz, 2.45GHz, 3.5GHz are covered within the band of operation.

2.DUAL MODE RESONATORS

A. Conventional Stepped Impedance Resonator :

In the proposed bandpass filter the bandpass response in achieved by using the conventional SIR, with varying characteristic impedances. A conventional SIR is shown in figure 1. It represents the transmission line model of the symmetric SIR which is formed by low and high impedance sections (Z_1 & Z_2). By keeping the two sections of SIR with varying impedances and same electrical length helps in achieving multimode responses. SIR is employed here to reduce the size relatively and they are used where sharp-cut-off frequencies are not required. The dominant mode of SIR is TEM (or) Quasi-TEM mode. The input impedance of the SIR is determined using the formula [15]

$$Z_{in} = \frac{Z_2 tanx + Z_1 tany}{Z_1 - Z_2 tanxtany} jZ_1 \qquad (1)$$

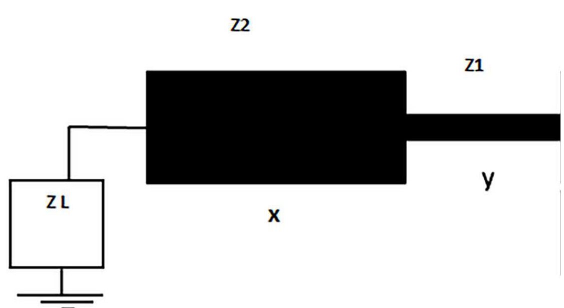

Figure 1. Conventional SIR used in proposed bandpass filter.

3.FILTER DESIGN

The proposed microstrip filter is derived from the fundamental dual mode square loop resonator [16,17]. The basic deisgn is shown in figure 2. The layout of this filter is modeled on the substrate with dielectric constant $\varepsilon_r = 4.4$. It has a very low loss tangent value 0.019 and a thickness of 1.6mm.

Microstrip transmission line is considered here for its ease of construction and reliability. The microstrip bandpass filters are realized using one or more resonators coupled to each other. The resonator components are those which represents the physical elements that can store both electric and magnetic field energy. Here a square loop resonator with closed structure is investigated with dual-mode for multi band response[18]. The dimensions of the proposed bandpass filter is as follows: L1=35mm, L2=30mm, L3=25mm, W1=16.5mm,L4=9mm, W2=30mm, W3=25mm, W4=20mm. The overall footprint of the structure is 48mmx48mmx1.6mm. The top view of the filter is shown in fig.2. With the above mentioned dimensions the proposed structure is simulated using 3D frequency based electromagnetic simulator.

The proposed filter is implemented using microstrip transmission line for ease of fabrication and parametric study. Implementing a bandpass filter using closed square loop resonator is already investigated in [17], but combined with SIR's the response is been analysed here. The S11 and S21 plots are given in figures 3 and 4 respectively. Figure 5 represents the bandpass response of the proposed structure from which it is found that there is a good butterworth response in the 1st band, chebyshev response with some ripples in the second passband skirt.

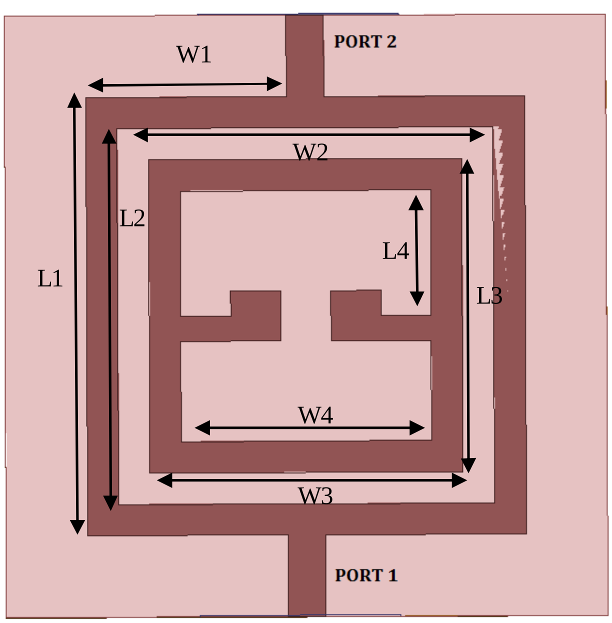

Figure 2 : Proposed structure with Square Loop Resonator & SIR.

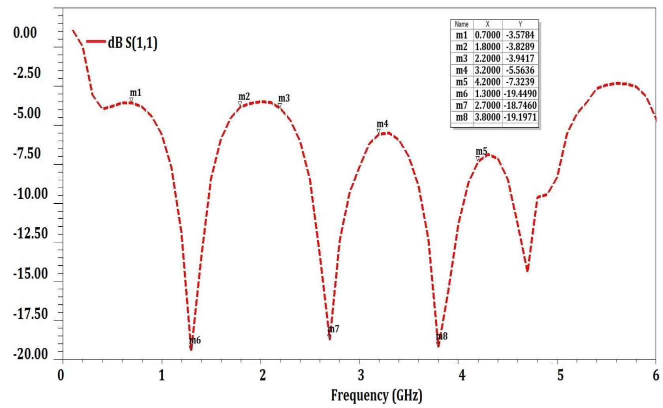

Figure 3 : S(1,1) of the proposed structure. Resonant frequencies are at 1.3GHz, 2.8GHz,3.8GHz.

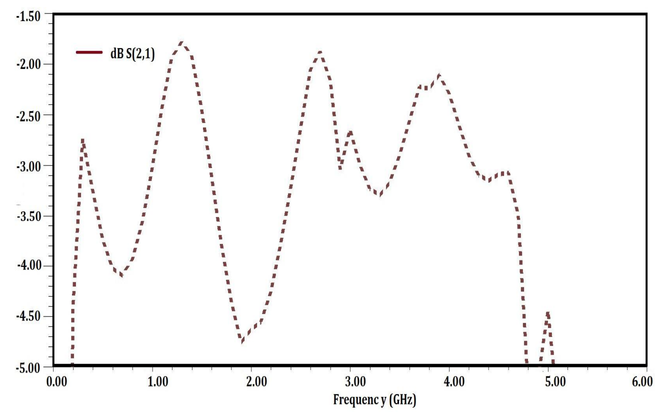

Figure 4 : S(2,1) of the proposed structure.

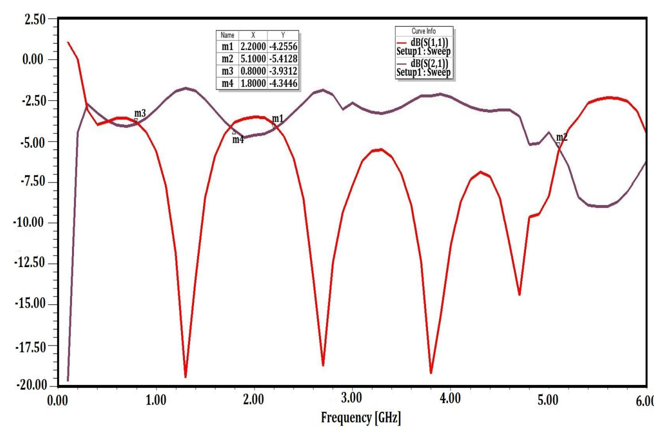

Figure 5: Bandpass response of the proposed structure.

The dual-mode resonator is found to achieve a wideband coverage which is determined from the passband response 2.2GHz to 5.1GHz, which achieved 200% impedance bandwidth. The 2nd pass band is found to cover the 2.4GHz (WLAN), 2.45GHz(Bluetooth), 3.5GHz(Wi-Max), 4.2GHz. Also, first passband is found to cover 1.8GHz.

From the results discussed, the proposed filter can be used for WLAN, Wi-MAX and GPS application. The even and odd mode of the filter can be controlled using SIR. Generally SIR is used for many objectives, here it is used for miniaturization and for achieving good isolation characteristics[19,20] which is shown in figure 3. The isolation is found to be satisfying since they are minimum. From the result it is evident that the proposed bandpass filter is able to avoid harmonic distributions upto -0.3dB which is negligible level at the 2nd passband coverage. It also achieved a smooth response in 1st passband.

Figure 6 represents the surface current distribution in the proposed filter structure. The higher density level 9A/m, which shows that it has reduced surface current distribution which will be responsible for radiation characteristics for a structure. The coupling effect between the two closed square loo resonators is also found to be minimum which is responsible for the reduction of harmonics in the 1st passband and minimal occurrence of spurious bands at 2nd passband. The proposed structure is fed with 50ohms input impedance. The coupling gap between the resonators is the reason for minimum isolation between them and good resonances in the passband of the filter.

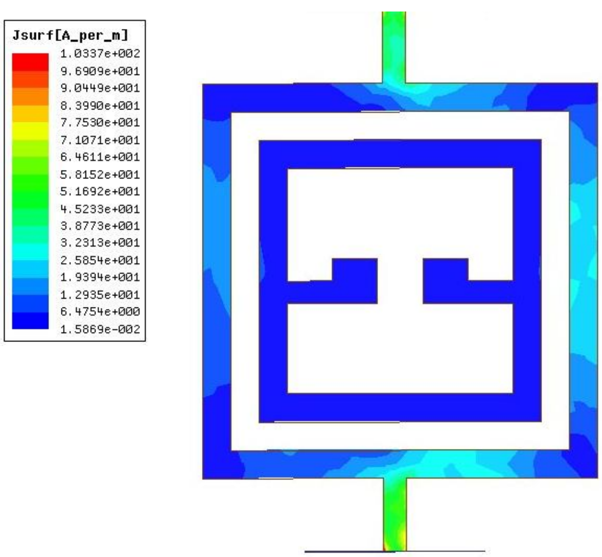

Figure 6. Surface current distribution.

4.CONCLUSION

here in this paper a microstrip dual band bandpass filter with dual mode square loop uniform impedance resonators along with dual mode stepped impedance resonators is proposed here. The propsed structure has minimum value of RL of about -20dB in each passband skirts. Multiband operation is achieved using the SIRs in the structure. 1st passband ranges from 0.8GHz to 1.8 GHz and the 2nd passband covers from 2.2GHz to 5.1GHz. 1st band is a narrow band with a bandwidth of 1000MHz and the 2nd passband of 2900MHz. Each band had an impedance bandwidth of about 160% and 200% respectively. The proposed filter with its band coverages it is said that this filter can be suitable for 1.8ghz,2.45GHz,3.5GHz wireless applications.

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