Design of a Dual-Band Band Pass Filter Using Stepped Impedance Stub Resonator

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Abstract— A stub resonator of stepped impedance is used to design a dual-band bandpass filter (BPF). The proposed SISR has merits that even-mode resonant frequencies are controllable, and the odd-mode resonant frequencies are fixed. A dual-band bandpass filter (BPF) has been implemented using the proposed SISR. The performance of dual-band bandpass filter has been improved by tuning its geometric parameters. A suitable feeding structure has been introduced to improve selectivity. A dual-band bandpass filter centred at 1.80 and 2.56 GHz has been designed and simulated. The design has been simulated on HFSS.

Key words: Stepped-Impedance Stub Resonator (SISR), Dual-band bandpass filter (BPF), Reflection Zeros (RZ), Transmission Zeros (TZ)

I. INTRODUCTION

The wireless communication has various applications. It demands radio frequency (RF) transceivers operating in frequency bands which are different and separated with guard band. Thus, the users can use two or more services with help of a single multimode device. The user can enjoy services of global system for mobile communication (GSM) and code division multiple access (CDMA) on single mobile phone, the transceiver has ability to receive and transmit both frequency bands i.e. 900 MHz and 1900 MHz signals.

The bandpass filters (BPFs) with two pass bands are desired in modern systems in the field of wireless communication. Different techniques have been reviewed for designing dual-band filters [1-5]. In [1], two similar and independently controllable microstrip cross-slotted patch resonators has been used to design a dual-band bandpass filter (BPF) . In [2], a dual-band bandpass filter was proposed using two E-shaped resonators to reduce circuit size. In [3], a dual-band bandpass filter was proposed using stub-loaded resonators controlled by centrally loaded open stub.

The size of dual-band BPFs can be reduced using multimode resonator. These have been attracting much attention, because one multi-mode resonator functions as multiple cascaded single mode resonator. Narrow-band applications need coupled resonator filters. Dual-band bandpass filter can achieve multiple resonant modes using stepped-impedance resonators (SIRs) [4, 5]. In [4], a dual-wideband bandpass filter was proposed using shorted SIRs featuring two controllable frequency bands, but it has disadvantage of poor selection of frequencies and very low guard band. In [5], single modified SIR has been used to design a dual-band band pass filter that reduce size of filter and wide rejection band, but it has disadvantage of difficult designing and several has uncontrollable resonance frequencies.

This paper uses combination of two stepped-impedance stub resonator (SISRs) in design of proposed microstrip dual-band BPF. The centre frequencies can be changed with geometric dimension variation. The proposed filter provides better selection of frequencies and reduced filter size.

II. DESIGN OF FILTER

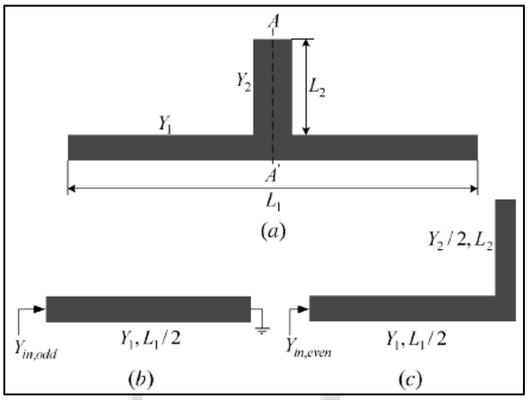

Fig. 1: (a)Structure of SISR, (b)equivalent circuit of odd-mode and (c) equivalent circuit ofeven- mode

The proposed resonator has used a traditional SIR, a stepped-impedance stub resonator (SISRs) as shown in figure 1, where (Y1, L1) and (Y2, L2) denotes the characteristic admittance and lengths of the traditional SIR. The planner resonator has similar structure about the A-A' axis, the odd-mode and even-mode methods can be analyzed it.

The equivalent circuit of odd-mode shown in figure(b) where A-A' plane is short circuited. The input admittance for odd-mode is [1]–

$$Y_{in,}odd = jY_2 \frac{Y_2 \tan\theta_2 - Y_1 \tan\theta_1}{Y_2 + Y_1 \tan\theta_2 \tan\theta_1} \ldots\ldots 1$$

$Y_{in,}odd$ = 0 at resonance and resonating frequency is –

$$f_1 = \frac{c}{2\pi L_2} \tan^{-1}\sqrt{\frac{K}{2+K}} \ldots\ldots 2$$

The figure 1(c) depicts the even-mode equivalent circuit in which current less about symmetrical line. The input admittance is [1]-

$$Y_{in,Even} = jY_2 \frac{(2\tan[(\theta_1+\theta_3/2]+\tan\theta_2)\,(K-\tan[(\theta_1+\theta_3/2]\tan\theta_2)}{K(1-tan^2\theta_2)(1-tan^2[(\theta_1+\theta_3)/2]} \text{-}2\,(1-K^2)\tan[(\theta_1+\theta_3/2]\tan\theta_2) \ldots\ldots 3$$

The resonant frequencies are for even mode –

$$f_1 = \frac{c}{2\pi L_2} \tan^{-1}\sqrt{\frac{K}{2+K}} \ldots\ldots 4$$

$$f_2 = \frac{c}{2\pi L_2} \tan^{-1}\sqrt{\frac{K+2}{K}} \ldots\ldots 5$$

$$f_3 = \frac{c}{4L_2} \ldots\ldots 6$$

$f_4 = \frac{c}{2L_2}$ … ….7

where f1, f2, f3 and f4 resonant frequencies, admittance ratio is K and c is velocity of light.

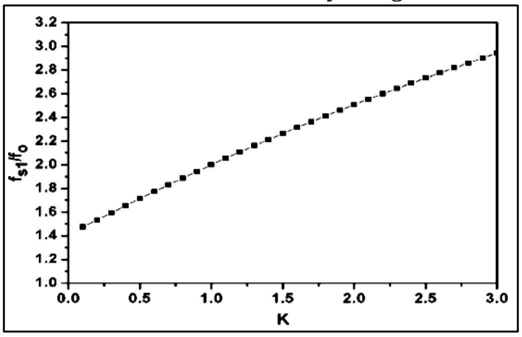

Fig. 2: Frequency ratio with respect to the impedance ratio K

The resonant frequencies of filter are related to admittance ratio K as shown in figure 2. The graph concludes that as the value of K decreases, the resonant frequencies differ from fundamental frequencies. This is very useful in narrowband filters where a wide stop-band required. The resonant frequencies are closer to each other for higher values of K.

III. Experimental

A Band pass filter with two pass bands is proposed and designed using SISR on dielectric material having relative permittivity of 2.65 , loss tangent of 0.001 and height = 1mm. The structure of the proposed filter is shown in figure 3, It consists of two similar stub resonator of stepped impedance and a suitable feeding line.

The gap between two SISRs is 0.3 mm for efficient coupling which provides five transmission zeros. The variation in width W2 gives two reflection zeros in each pass band.

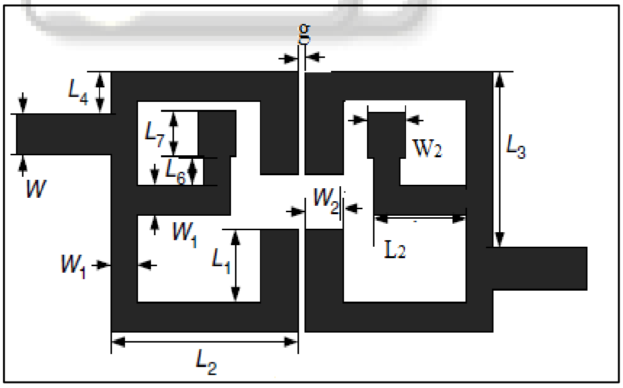

Fig. 3: Layout of proposed Filter

The physical dimensions are as given in below table-

Sl. No.	Parameters	Measurements in mm	Sl. No.	Parameters	Measurements in mm
1.	L1 , L5	6.9	6.	L7	3.9
2.	L2	11.7	7.	W	2.73
3.	L3	12.97	8.	W1	1.2
4.	L4	3.5	9.	W2	2.3
5.	L6	2.9	10.	g	0.3

Table 1:

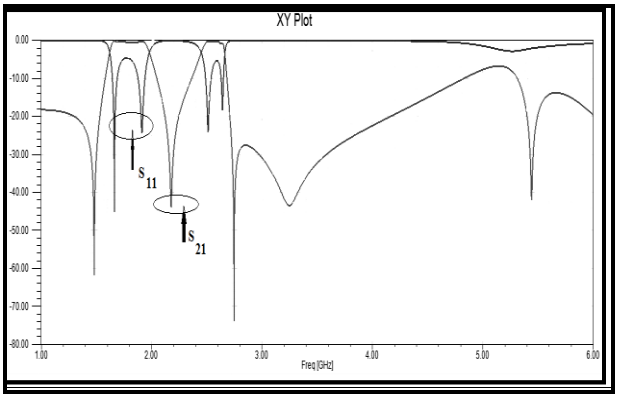

Fig. 4: Simulated results of proposed Filter

The simulated result is illustrated in figure 4. The dual-band bandpass filter using SISRs has two frequency bands centred at 1.80 and 2.56 GHz. The minimum insertion losses that are measured from S21 values to 0.20 and 0.10 dB at respectively centre frequency. The return losses that are measured from S11 values to 40 and 20 dB at respectively centre frequency.

The proposed dual-band bandpass filter has five transmission zeros (TZs) at 1.50, 2.23, 2.90, 3.45 and 5.35 GHz located at pass band edges due to sufficient gap between two SISRs. The additional two reflection zeros (RZ) in both pass bands has been achieved due to widened W2.

IV. Conclusion

This paper has presented a dual-band filter using stepped impedance stub resonator (SISR). The resonator has been mathematically analyzed based on equations. The increased performance has been achieved with two reflection zeros in two pass bands and five transmission zeros at pass band edges.

The proposed filter response shows very good selectivity with large return loss and small insertion loss. The proposed dual-band bandpass filter design has been simulated and verified.

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