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PERFORMANCE ANALYSIS OF DUAL BAND BANDPASS FILTER DESIGN TECHNOLOGIES

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ABSTRACT
This paper focuses on different design techniques of dual band band-pass filter and their results are compared. Improvement of filter performance and reduction in components size is became prime concern with rapid advancement of technologies. In this paper, Coupled Stepped Impedance Resonators,Series Coupled Ring Resonator, Single Ring Resonator and Stub-Loaded Meander Line Resonator.

INTRODUCTION

These days, there is an extraordinary interest for multiband and multimode transceivers with the end goal that diverse wireless gauges coincide and permit worldwide use. For instance, a GSM-CDMA handset must have the option to get and transmit signals at 900 MHz and 1900 MHz [1, 2]. To obtain this multi-usefulness, one can utilize separate chips for every standard, which implies that everyone must be independently planned, tried and stuffed and, along these lines, a costly arrangement. The profoundly attractive arrangement depends on equipment reuse. In this unique circumstance, we present a double band structure system for one of the RF front-end obstructs the pass-band channel. Different dual-band band-pass filters have been introduced, [3-5].

Double band bandpass channels (DBBPF) have as of late become appealing parts in wireless correspondence frameworks [6-13]. In [6] the DBBPF is accomplished by combining two individual single-band channels by means of a common input/output port. This sort of DBBPF is anything but difficult to acknowledge, in light of the fact that the sign of the two bands go through various resonators, allowing the two individual single band channels to be designed independently. Be that as it may, this sort of channel requires in any event four resonators, on the grounds that a single-band channel design requires multiple resonators. In [7-9], a double mode resonator, which has a controllable first harmonic resonant frequency, is utilized to make the second passband. This kind of DBBPF can just determine the focal frequencies of two passbands. They experience issues in regulating the bandwidths of the two passbands in request to accomplish different particulars for each passband. DBBPFs with controllable bandwidths have been examined [10-13]. Nonetheless, these channels have constrained controllable bandwidth resulting from the common coupling way and require a complex design methodology. In this paper, diverse design systems for double band-pass channel is contrasted with break down their presentation.

LITERATURE SURVEY

He Zhu and Amin M. Abbosh [14proposed new sort of stepped-impedance resonator with embedded coupled-line section. Contrasted and the creators' design [15] where a double band channel was designed using multi-mode resonators, the new channel utilizes a couple of coupled stepped-impedance resonator with embedded coupled-line for both of single-and double band channel designs. The investigation of the proposed resonator is firstly introduced, and afterward

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two BPFs (a single-band and a double band model) are assembled and tried for confirmation of the design approach.

N. A. Wahab[16] displayed a novel ring based topology which utilizes just one quarter-wavelength coupled-line. This design proposed two rings cascaded in series side by side, coupled by means of a single quarter-wavelength coupled-line to display double band double mode bandpass channel. By using just one coupled-line and two identical rings had diminished the quantity of controlled parameters along these lines rearranges the tuning procedure. Adding to this, the pseudo-elliptic attributes of the two rings will improve the selectivity of the double band channel since transmission zeros are shaped both at the lower and upper stopbands of the double band. . Further examination on the channel bandwidth, passband reaction and out-of-band reaction are additionally displayed by controlling the channel components of line impedances, Zr, odd-and even-mode impedances of the coupled-line, Zoo and Zoe separately reaction.

ShaLuo [17] centers around a novel double mode double band BPF with two transmission shafts in two passbands is designed dependent on a single microstrip ring resonator on a single-layer substrate. The two energized ports are put along the ring with a partition of 135 and they are capacitively coupled to this ring through parallel-coupled lines. The remaining pieces of this work depict the principle of the proposed ring resonator double band channel and show its double band execution through an equal circuit model. Finally, a reduced double BPF with occasionally loading of opened stubs is designed for 2.4/5.8 GHz wireless local area network applications, and the anticipated outcomes are affirmed tentatively.

Naoto Sekiya[18] introduced a minimized high-temperature superconductor (HTS) double band bandpass channels by using stub-stacked wander open-circle resonator. Specifically, they depict the new technique for deftly adjusting the coupling coefficient for two bands. Use of the double band bandpass channels to a tri-band bandpass channels was portrayed with simulation.

DUAL BAND BANDPASS FILTER DESIGING TECHNIQUES

A pair of coupled stepped-impedance resonators andits use to build single- and dual-band bandpass filter (BPF) is shown in fig.1.

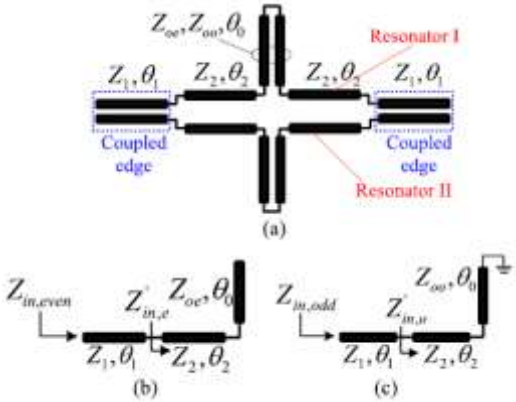

Fig. 1 (a) coupled stepped-impedance resonators (b) even- and (c) odd-mode equivalent circuits

This design includes apair of coupled stepped-impedance resonators with embeddedcoupled-line sections. The utilized resonator is composed oftwo stepped-impedance transmission lines (Z_1, Z_2, θ_1, andθ_2) and an embedded coupled-line section (Z_{oe} ,Z_{oo} ,θ_0). Theoverall length of the structure is about half guided-wavelength($\lambda_g/2$) at the center frequency f_0. The proposed resonator issymmetric, and thus, odd- and even analysis method can beadopted to analyse its structure and deduce its resonant frequencies.Fig. 1(b) and (c) show the even- and odd-mode equivalentcircuits, which can be used to derive the resonant frequencies.For the even-mode case, the resultant input impedance can beexpressed as

$$Z_{in,even} = Z_1 \frac{Z'_{in,e} + jZ_1 tan\theta_1}{Z_1 + jZ'_{in,e} tan\theta_1}$$

$$Z'_{in,e} = jZ_2 \frac{Z_2 tan\theta_2 - Z_{oe} tan\theta_0}{Z_2 + Z_{oe} tan\theta_2 tan\theta_0}$$

The even-mode resonant frequencies can be determined bysetting $Z_{in,even} = 0$. Here the first three even-modes (f_{e1}, f_{e2},and f_{e3}) are investigated. For odd-mode case, the resultant input
impedance can be expressed as

$$Z_{\text{in,odd}} = Z_1 \frac{Z'_{\text{in},o} + jZ_1 \tan\theta_1}{Z_1 + jZ'_{\text{in},o} \tan\theta_1}$$

$$Z'_{\text{in},o} = jZ_2 \frac{Z_2 \tan\theta_2 + Z_{oo} \tan\theta_0}{Z_2 - Z_{oo} \tan\theta_2 \tan\theta_0}.$$

The odd-mode resonant frequencies can be determined bysetting *Z*in,odd = 0. Here, the first three odd-modes (*fo*1, *fo*2,and *fo*3) are investigated. This filter is a second-order structure composed oftwo resonators. The

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coupling between the two resonators isrealized by the open-ended transmission line ($Z1$ and $\theta 1$), asmarked as coupling edges in Fig. 1(a). The electrical length (atthe center frequency of the first passband $f1$) of the steppedimpedanceand coupled-line section should meet the equation

$$2(\theta_1 + \theta_2) + \theta_0 = 180^\circ.$$

For different kinds of filter types (single- or dual-band), thefollowing relation should be satisfied to find the values of $\theta 0$,$\theta 1$, and $\theta 2$ based on extensive parametric studies:

$$\begin{cases} \theta_1 = 2\theta_0 & \text{single-band} \\ \theta_1 = \theta_0 & \text{dual-band.} \end{cases}$$

Equation (6) defines the conditions of exciting or highly suppressingthe first even-mode resonant frequency $fe1$.

A dual-band ring filter using two identical microstrip dual-mode ring resonators shown in Fig.2 (a), two identical rings are coupled inseries with a single quarter-wavelength coupled-line at thecenter of the structure to form a dual-band bandpass filter. Theinput and output power of the resonator is fed via the ring lineswhich created a dual-path effect. The basic cell having onewavelengthlong at frequency $fo$with a coupled-line produced adual-mode response with two transmission zeros. It is alsoknown that a quarter-wavelength coupled-line behaves as abandstop filter. Hence, by having a four-port coupled-line atthe center of the structure has help to create isolation betweenthe two passbands resulting to a center transmission zero.

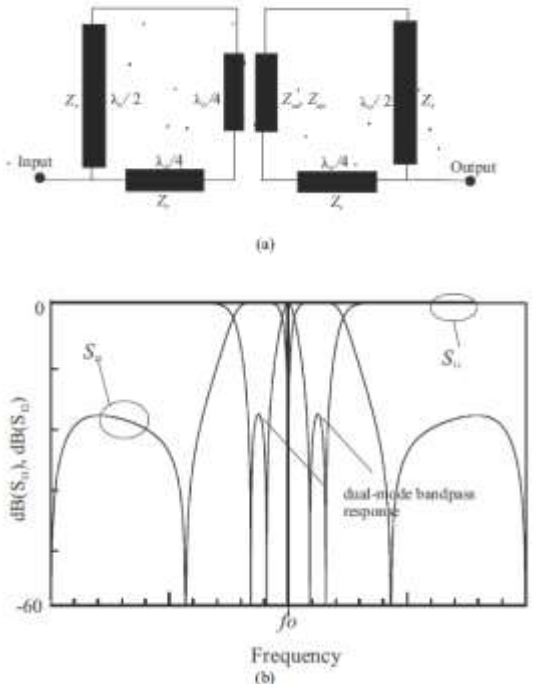

Fig.2 (a) A proposed dual-band ring filter topology, (b) Ideal response of thedual-band [16]

A set of impedance values of the ring resonators arechosen to obtain an ideal response of the bandpass filter, i.e.Zr= 50 _, Zoe = 243 _ and Zoo = 74 _ for referencefrequency, foat 2 GHz. Fig. 2(b) demonstrates the dual-modedual-band response with sharp rejection skirt and centertransmission zero at $fo$to isolate the two passband.

Further investigation to analyze the filter behavior is performed. Figs. 3, 4, and 5 illustrate the characteristics of thebandpass filter with center frequency, foat 2 GHz. The filterelements of Zr, Zoe and Zoo are investigated to analyze theirinfluence as the controlling parameters on the responses of thedual-band filter. The investigation is conducted by varying oneof the controlling parameters while the other two impedancesare fixed.

Figs. 3 and 4 illustrate the bandwidth variations when ZrorZoe is varied. Fig. 3 demonstrates the effect of Zr, in whichwhen the impedance is increased while fixing both Zoe and Zoo,the bandwidth is decreased. Whereas when the impedance $Zoe$is increased and $Zr$and Zoo are fixed, the bandwidth will beincreased.

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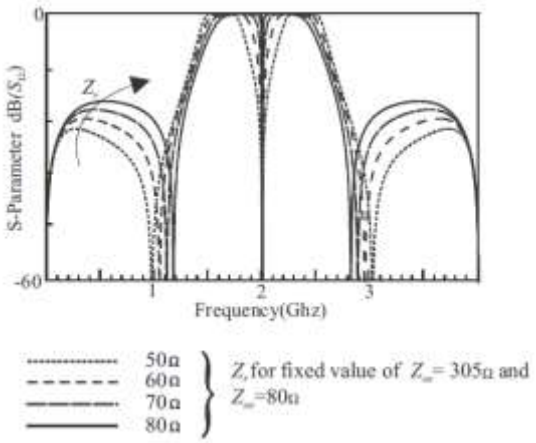

Fig. 3 Variations of bandwidth and rejection level when *Zr*is varied while *Zoe*and *Zoo* are fixed

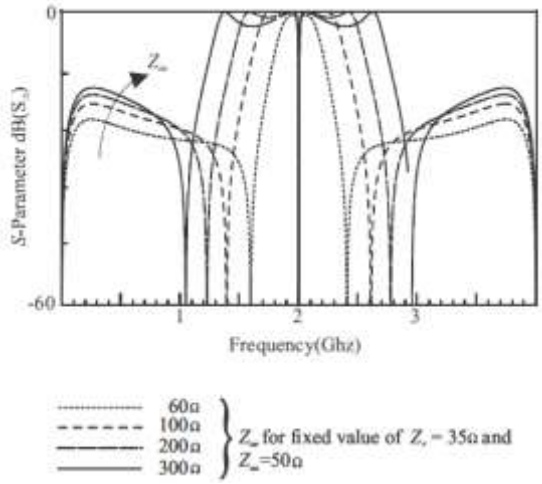

Fig. 4 Variations of bandwidth when Zoe is varied while Zr and Zoo are fixed

Next, when *Zoo* is varied, and both *Zr*and *Zoe* are fixed, theinsertion loss and rejection level will be affected. Fig. 5illustrates the outcome of varying *Zoo* while the other twoparameters are fixed. Meanwhile, by increasing *Zoo*, theinsertion loss deteriorates but the rejection level will beimproved.

These observations had demonstrated that to achievedesired response, all the three parameters i.e. *Zr*, *Zoe* and *Zoo*must be tuned to achieve desired bandwidth, insertion loss andrejection level. Therefore, the filter elements that influencedthe overall response of this design is contributed by the lineimpedance of the two rings, *Zr*and the single quarterwavelengthcoupled-line impedances, *Zoe* and *Zoo* respectively.

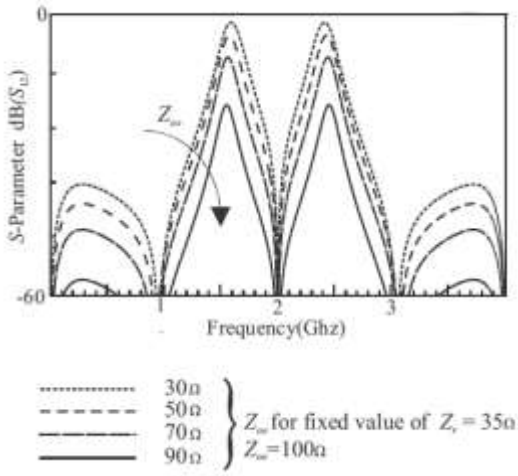

Fig. 5 Variations of passband and insertion loss when *Zoo* is varied while *Zoe*and *Zr*are fixed

Fig. 6(a) depicts the schematic of the proposed **dual-mode dual-band microstrip ring resonator**, where is the input andoutput port impedance, and are the inner and outer radiiof this ring, and is the characteristic impedance of the ring.In our design, the parallel-coupled lines are one quarter of thelength of the ring, with a width of or and a spacing of. As illustrated in Fig. 6(a), a three-port parallel-coupled linecan be treated as a capacitive impedance , a voltage transformerwith turns ratio and two parallel-connected lines atport 2 and 3 as discussed in [19]. and denote the even and odd-mode characteristic impedances of this parallel-coupledline, while is their effective electrical length.

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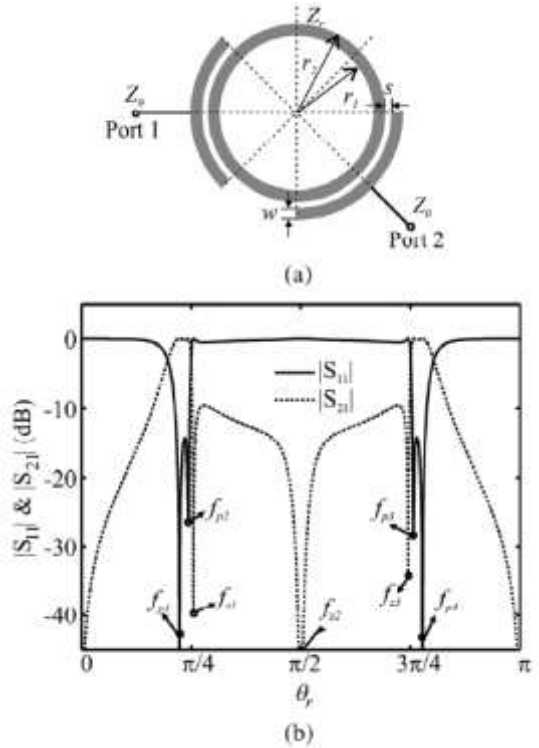

Fig. 6 Proposed dual-mode dual-band BPF using a single uniform ring resonator.(a) Schematic. (b) S-parameters versus electrical length □□ _ with _ ___ _, _ _ ___, _ _ __ _and _ _ ___

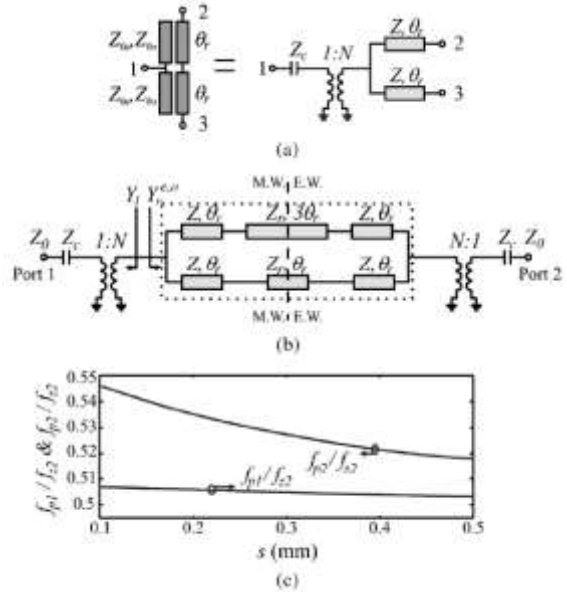

Fig. 7 (a) Equivalent-circuit diagram of three-port parallel-coupled lines. (b)Complete equivalent-circuit model for the filter in Fig. 1(a). (c) Normalizedfrequencies of the two poles (□ _□ and □ _) in the first passbandversus spacing □__ with _ _ __ _, _ _ __ _. Substrate: _ _ ___ and_____ _ ____ __.

Follow thework in [20], the relationship between all the element parameters of the two networks in Fig. 7(a) can be derived as

$$Z_c = -j\frac{Z_{0e}Z_{0o}}{\tan\theta_r(Z_{0e}+Z_{0o})}$$

$$N = \frac{Z_{0e}+Z_{0o}}{Z_{0e}-Z_{0o}}.$$

As such, the equivalent-circuit model of the filter in Fig. 6(a)can be derived as shown in Fig. 7(b). Fig. 6(b) plots its simulatedparameters versus electrical length . As can be observed,the first and second passbandswith two transmission poles ateach band appear at and , respectively.

The two lower ones (and) are symmetrically located atthe low sides of the two higher ones (and) with respectto . In addition, there exist three transmission zeros,, and , between the two passbands. We can analyzethis proposed ring resonator filter based on Fig. 7(b).According to the transmission theory, transmission zeros ofthis ring filter occur at the frequencies where the overall mutualadmittance of the network inside the dash square in Fig. 7(b) equals to 0, such that

$$Z\sin 2\theta_r(\cos\theta_r+\cos 3\theta_r)+A(\sin\theta_r+\sin 3\theta_r)=0$$

where and .

By solving (2), all the zeros can be determined as

$$\theta_r = \sin^{-1}\sqrt{\frac{Z_r}{Z+Z_r}}$$

$$\theta_r = \left(n+\frac{1}{2}\right)\pi.$$

Equation (3a) determines the first and third transmissionzeros, and while the second zero, , is derived underin (3b).

Stub-loaded resonators, which have an easily controlled resonantfrequency, have been applied to normal conductor DBPFs. They have two resonance

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modes of even and oddmodes. The even-mode resonant frequency can be easily tunedwhile keeping the odd-mode one basically the same. However,it is difficult to keep the even-mode one basically the samewhile tuning the odd-mode one. Therefore, we proposed a noveldual-band bandpass stub-loaded resonator which can be independentlycontrolled of the resonant frequency of the even andodd modes.

Fig. 8(a) shows the configuration of the double band bandpass stub-stacked resonator we created. It comprises of a meander open-loop resonator and an open stub. The meander resonator is utilized for miniaturizing the double band resonator size as well as decreasing the space between resonators because of feeble coupling property. This symmetric configuration empowers investigation as far as even-and odd-mode excitation's (the An A_ plane carries on as an electric/magnetic wall for odd/even excitation). Fig. 8(b) and (c) show the odd-mode excitation and even-mode excitation.

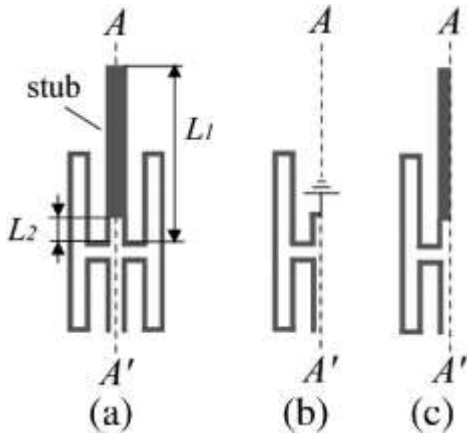

Fig. 8 (a) Configuration of proposed dual-band resonator, (b) odd-mode, and(c) even-mode excitation

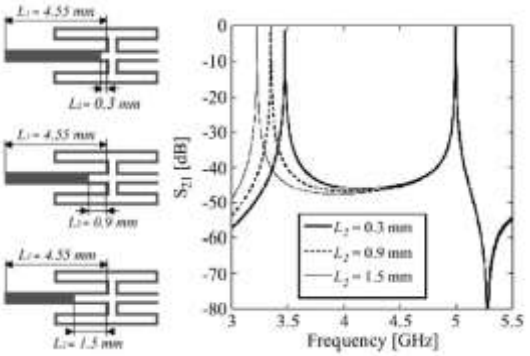

Fig. 9 Configuration of proposed resonator with length *L*2 of 0.3, 0.9,1.5 mm and simulated resonant frequency responses for different values of *L*2.

For odd-mode excitation, there is a voltage null along themiddle of the resonator, as shown in Fig. 8(b). Hence, the tappingpoint of the stub is actually a virtual ground for theodd-mode. As a consequence, the stub does not affect the odd moderesonant frequency. For even-mode excitation, there is nocurrent flow through the symmetrical plane. Thus, we can bisectthe circuit with open circuits at the A-A_ plane, so that an even moderesonator which is constructed with meander line and theopen stub is obtained, as shown in Fig. 8(c).

To investigate the frequency response of the developed resonator,we used full-wave simulation using electromagnetic(EM) analysis software (Sonnet EM) based on the momentmethod [21].The odd-mode resonant frequency was mainly determined bythe length of the meander open-loop resonator as in Fig. 8(b).The configuration of the proposed resonator for three values oflength *L*2, and the simulated resonant frequency responses forthe three values are plotted in Fig. 2. Increasing *L*2 from 0.3to 1.5 mm effectively shifted the odd-mode resonant frequency250 MHz while leaving the even-mode resonant frequencybasically the same. This is because the electrical length of even moderesonance was not changed, as shown in Fig. 9, and thestub does not affect the odd-mode resonant frequency.

The even-mode resonant frequency is mainly determined bythe total length of the meander open-loop resonator and stubsee Fig. 8(c). The configuration of the proposed resonator forthree values of length *L*1, and the simulated resonant frequencyresponses for the three values are plotted in Fig. 10 Reducing *L*1from 4.55 to 3.55 mm without changing *L*2 effectively shiftedthe even-mode resonant frequency 407 MHz while leavingthe odd-mode resonant frequency basically the same. This is

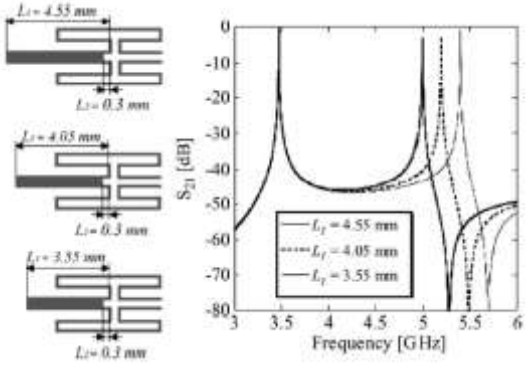

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Fig. 10 Configuration of proposed resonator with length $L1$ of 4.55, 4.05,3.55 mm and simulated resonant frequency response for different values of $L1$

because the electrical length of odd-mode resonance was notchanged, as shown in Fig. 10, and the stub does not affect theodd-mode resonant frequency.

CONCLUSION

There are several methods are available to design a filter, In this paper some of methods are discussed and compared along with the results and advantages. Compatibility of methods may differ according to the desired filter specification required for the particular use. Discussed filtering techniques led the evolution of number of filters. These filters have been used in wide range of applications.

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