Reconfigurable Band pass Filter using Stepped Impedance Resonator

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Abstract:* —— Design of a stepped impedance resonator based frequency reconfigurable band pass filter has been reported in this paper. Basic filter is implemented using stepped impedance resonator interdigital configuration which provides harmonic suppression and size reduction. Frequency reconfigurabilty is then achieved by loading the stepped impedance resonators with varactor diodes When the applied voltage to varactor diodes change, the loading capacitance changes and in turn changing the electrical lengths of the resonators. Change in frequency happened when the length of the resonators changed. The proposed frequency reconfigurable filter is designed for a bandwidth of 300MHz and the frequency tuning range of 1.25GHz to 1.95GHz. The maximum insertion loss of the reconfigurable filter over entire tuning range is 5.0dB and the return loss is better than 10dB. The filter is compact and measures a size of 32mm×30mm× 0.8mm. The filter can be used in multiband communication systems and software defined communication system replacing traditional switched filter banks.

Key Words***: filter; stepped impedance resonator; varactor; microstrip; interdigital; reconfigurable***

I INTRODUCTION

Recent advancements in communication systems call for cost effectiveness, miniaturization and frequency reconfigurable characteristics with improved performance. RF and microwave reconfigurable filters are the key elements for designing communication systems with reconfigurable frequencies of operation. A simple way of designing frequency reconfigurable communication system is to use bank of filters along with switches in the system, but this occupies more space and increases the overall size of the system. One of the easy ways of making compact reconfigurable system is to use electronically tunable filter. Electronically reconfigurable filters can be designed using varactor diodes along with the basic filter structure. This leads to compactness due to reduction in number of filters and switches in the systems.

Traditional microstrip parallel coupled line filter shown in Fig 1 are used in many wireless systems since it is simple in structure and easy to implement. But this structure suffers from the existence of harmonics at nf_o(n times the fundamental frequency) due to unequal even and odd mode phase velocities[1] at nf_o. Various structures have been reported in literature [2]-[8] to suppress the spurious response. These methods use phase equalization method, substrate suspension method, wiggly coupled lines and floating conductor in the ground. The spurious frequency response can also be shifted by providing a step in the resonator width. The step in the resonator (shown in Fig 2) shifts the spurious response and also leads to overall size reduction. The impedance ratio Z_3/Z_4 plays the main role relocating the spurious band.

Fig.1. Conventional parallel coupled line filter

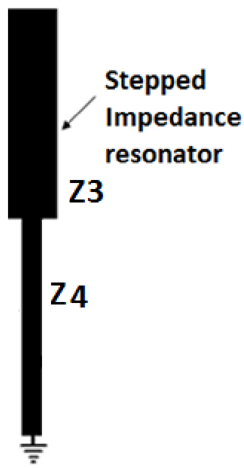

Fig. 2.Stepped Impedance resonator

This paper proposes an electronically tunable stepped impedance resonator band pass filter. The resonators are loaded with varactor diodes. Stepped impedance resonators play role in moving the harmonics away from $2f_o$(twice the center frequency). Tunability in frequency is achieved by varying the capacitance of the varactor diodes. The capacitance is varied for the variation in the applied voltage to the varactor diodes. The organization of the paper is as follows: Section II reports the design and simulation of the stepped impedance resonator reconfigurable filter. The simulated results of the proposed reconfigurable filter are presented in Section II. Experimental results of the filter are discussed in section III and Section IV concludes the paper.

II. DESIGN OF RECONFIGURABLE FILTER

The specifications of the frequency reconfigurable filter are listed in Table I.

Table I. Specifications of the Reconfigurable filter

Parameters	Values
Frequency Range	1.25GHz to 1.95GHz
Bandwidth	300MHz
Insertion loss	<5dB
Return Loss	Better than 10dB

At first a basic stepped impedance resonator based interdigital band pass filter is designed using the structure shown in Fig.3 with centre frequency of 1.95 GHz and 300 MHz bandwith. The filter is implemented in microstrip medium having permittivity of '2.22' and height of 0.8*mm*. The impedance ratio of the SIR(Z_3/Z_4) is maintained at 0.65 to achieve a second harmonic rejection of more than 35*dB*. The electrical length of the filter is 78° (L_1+L_2) and spacing(s) between the resonators is 2*mm*.

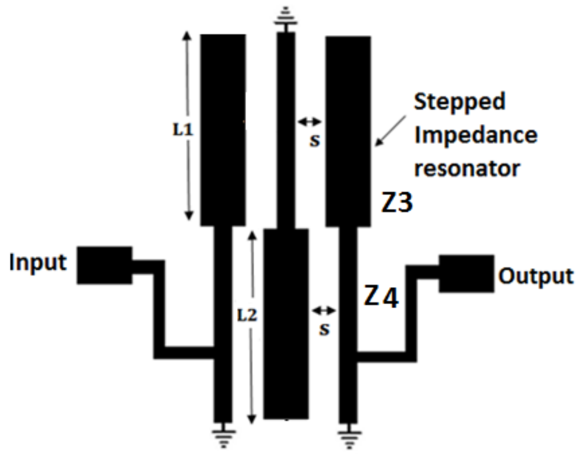

Fig.3. The basic stepped impedance interdigital filter

Once the basic filter is designed, the SIRs in the filter are loaded with varactor diodes for varying resonator length for the purpose of changing the center frequency of operation. The frequency reconfigurablity is achieved for the variation in control voltages to the diodes. The structure for the reconfigurable filter is shown in Fig. 4.

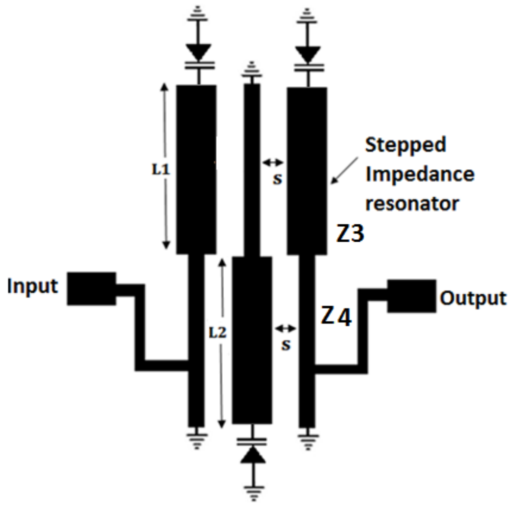

Fig.4. Frequency reconfigurable band pass filter

The designed filter is simulated in full wave EM simulation tool for the purpose of analysis and optimization. The insertion loss and return loss characteristics of varactor loaded step impedance resonator band pass filter response is plotted in Fig. 5 and Fig. 6 respectively. The control voltage for the varactor is varied from 1V to 8V to change the frequency of operation from 1.25GHz to 1.95GHz is achieved. Since the control voltage is inversely proportional to varactor equivalent capacitance it is visible that with increase in varactor control voltage, the centre frequency of the band pass filter shifts to higher value.

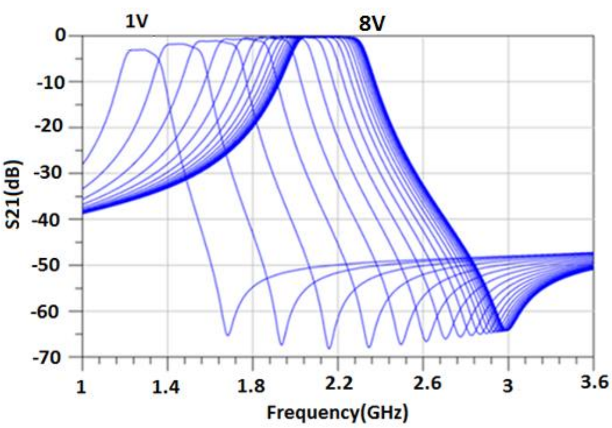

Fig.5. Insertion Loss of proposed Filter(EM Simulation)

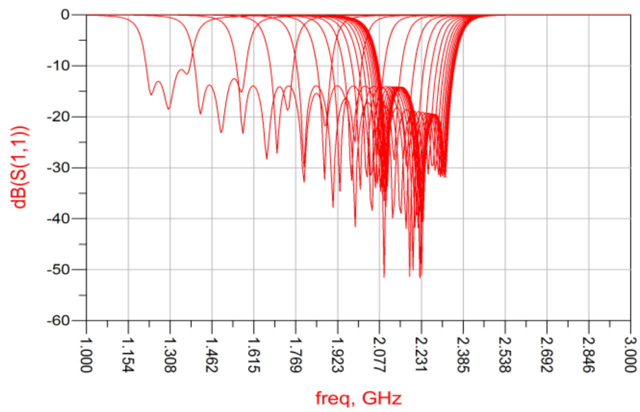

Fig.6. Return loss of proposed Filter (EM Simulation)

III. EXPERIMENTAL RESULTS

The filter designed in Section II has been developed using standard print circuit board fabrication method. The assembled frequency reconfigurable band pass filter is shown in Fig. 7. The filter was tested using vector network analyzer and measured results are shown in Fig. 8. Measurement results show the frequency tuning range from 1.25 GHz to 1.95GHz. The measured insertion loss is from 3dB to 5dB for the tuning range. The filter is highly compact and measures a size of 32mm× 30mm× 0.8mm.

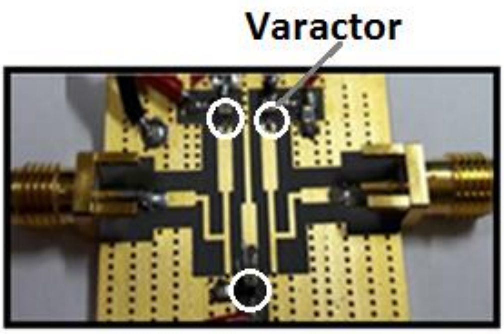

Fig. 7. Assembled reconfigurable filter

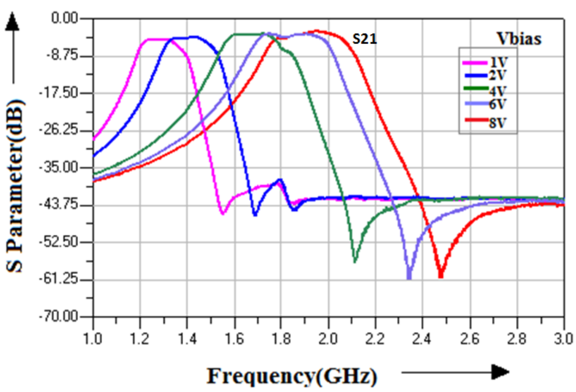

Fig. 8. Measured results of proposed reconfigurable filter

IV. CONCLUSIONS

In this paper, a frequency reconfigurable band pass filter has been designed using stepped impedance resonators and varactor diodes. The center frequency of the filter can be reconfigured to any frequency between 1.25GHz to 1.95GHz with a bandwidth of 300 MHz. The designed filter has been simulated using fullwave EM simulation tool. The filter has been made and tested. The measured results of the filter are in close agreement with the EM simulation results. The maximum pass band insertion loss is 5dB and minimum return loss is 10dB over the entire tuning range. The filter is highly miniaturized and measures a size $32mm\times 30mm\times 0.8mm$.

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