Upper UWB Interference Free Filter Using Dumb-Bell Resonator and Vias

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***Abstract*-This paper presents the resonator band pass filter design using the stepped impedance resonator technique. The proposed resonator consists of cross dumbbell shape stepped impedance resonator (SIR) with via holes. The equivalent circuit model of the proposed resonator band pass filter is presented. The filter provides response with a pass band of 8.5GHz-10.2GHz. The filter is designed with single as well as cascaded structure of cross dumbbell shape resonator. The filter is operated in upper UWB frequency and hence provides good noise immunity. The filter has reduced insertion loss and out-bands rejection better than 25 dB up to 12 GHz. All simulations are performed in Agilent Advanced Design System.**

***Keywords*-Resonator, UWB-Ultra Wide Band, noise immunity, SIR-Stepped Impedance Resonator.**

I. INTRODUCTION

Microwave band pass filters play a vital role in communication systems. Better blocking performance, reduced size and cost are the major constraints in designing a microwave filter. It is known that the traditional micro strip coupled lines filters suffer from the spurious responses at 2*f*0[1]. The even-mode and the odd-mode phase velocities for a micro strip coupled lines are unequal. Because of its inherent structure, which is a non homogeneous medium, consisted of air above and dielectric below medium. Many methods have been proposed stepped impedance resonators have been found advantageous in designing band pass filters [2].

To suppress or reject this spurious response, we introduce the resonator band pass filter design using the stepped impedance resonators. The SIRs are well known from the literature and used to shift or suppress the higher order frequencies. Many communication equipment functions in UWB frequency band as it is available free of cost [3]. The ultra-wide band is an unlicensed band and hence several narrow band wireless applications such as Wi-Fi, WLAN makes use of it. The various applications should not interfere with each other. Many communication equipment are designed to function in lower UWB frequency band (3.1-4.8 GHz) and hence effects of interference is high [4]. Hence new communication techniques are being developed at upper UWB frequencies to prevent interference effects. The proposed filter operates in upper UWB band and are less affected by interferences from other communication systems operating at lower UWB bands.

II. DESIGN

Cross Dumbbell Shape Resonators

The design of BPF using SIR is discussed. This paper discusses the design of BPF by using SIR. Stepped Impedance resonator provides suppression of higher order frequencies and act as low pass filter. The conventional Stepped Impedance Resonator (SIR) is composed of an inductor and capacitor connected in series [5]. **Figure 1.1 and 1.2** shows the lumped model of the proposed resonator structure and its simulated frequency response. The filter produces a low pass response with an attenuation zero. The conditions for determining the resonance frequencies of SIR [6] are given as

$$\tan\theta_1 = R\cot\theta_2 (\text{odd} - \text{mode}) \text{ at } f = f1$$
$$\cot\theta_1 = -R\cot\theta_2 (\text{even} - \text{mode}) \text{ at } f=f2$$

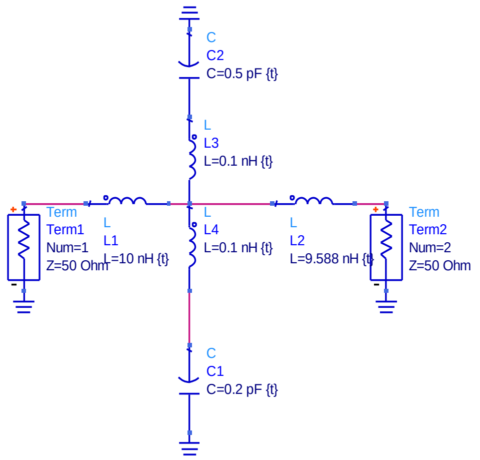

Figure 1.1 Lumped LC model for resonator (L1=10nH, L2=9.5nH, L3=0.1nH, L4=0.1nH, C1=0.2Pf, C2=0.5pF)

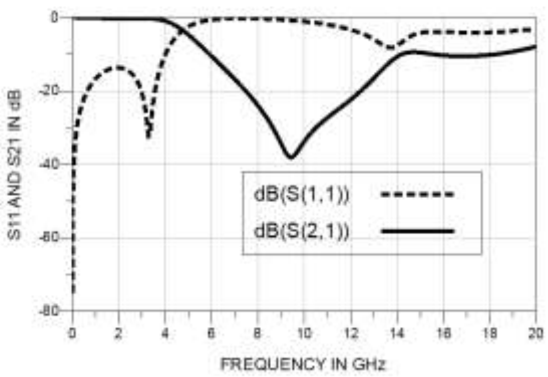

Figure 1.2 Simulated frequency response of Lumped LC model resonator

Two SIR are placed in cross shape to form dumbbell shape resonator. The centre impedance of the resonator placed horizontal in the design is reduced to form a thin structure. Thin central horizontal line is used in order to increase the shunt inductance on both upper and lower sides. **Figure 1.2** shows the layout of the proposed cross dumbbell shape resonator using Stepped Impedance Resonator Structure.

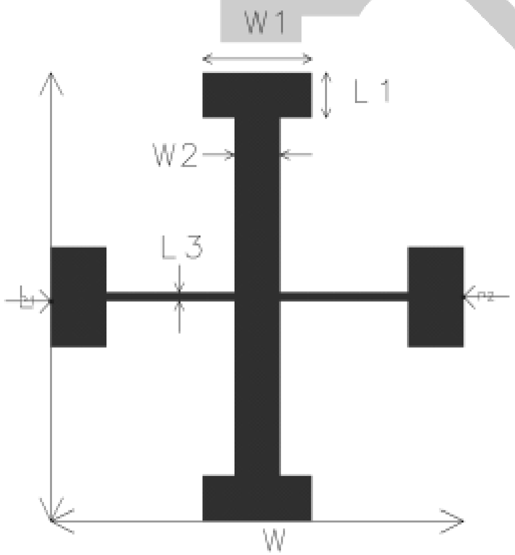

Figure 2 Layout of RESONATOR(L1=1.2mm, L3=0.2mm, W1=1.2mm W2=1 mm, L=10.2mm, W=9mm).

BPF Using cross dumbbell shape resonator

The proposed band pass filter is yielded by short circuiting the inductances and capacitances by means of via holes placed in between them. The cross dumbbell shape SIR is a multimode resonator and short circuiting yields a band pass response to the filter.

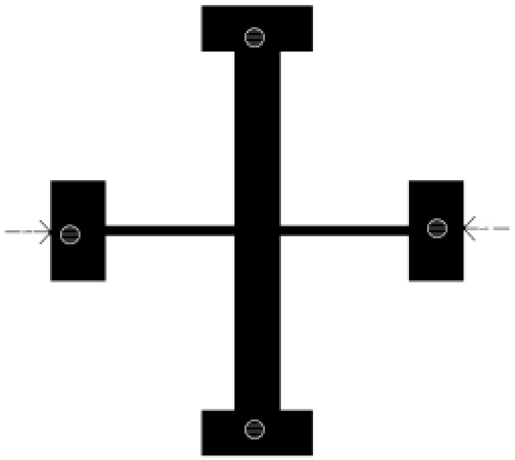

Figure 3.1. BPF using cross dumbbell shape SIR

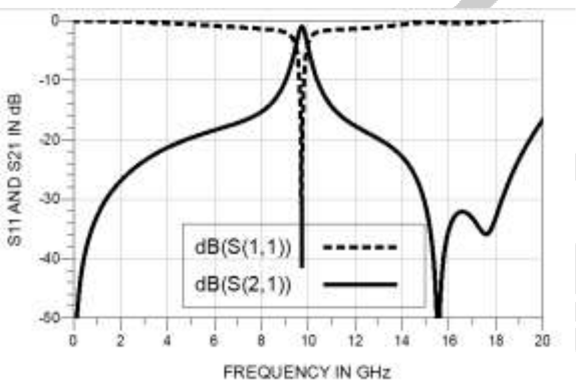

Figure 3.2. Simulated frequency response plot of BPF using cross dumbbell shape SIR

Figure 3.1 and 3.2 shows the physical layout of the proposed BPF using cross dumbbell shape resonator and its frequency response. The plot shows a band pass response with pass band at 8.5-10.1 GHz. Insertion loss is -0.1dB and return loss is over -30 dB. Attenuation is over -30 dB at upper and lower bands. The simulation results shows that the filter has reduced losses and good out band rejection.

BPF design using cascaded cross dumbbell shape resonator

A cascaded structure is developed by joining two cross dumbbell shape SIR together. The purpose of cascading the resonators is to improve the out of band rejection and reduce the losses**. Figure 4 and 5** shows the layout and simulated response of the BPF with ports being placed at two different positions.

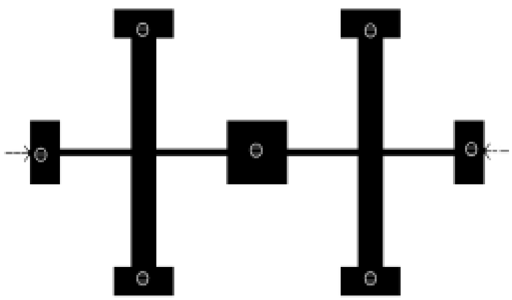

Figure 4.1. Layout of cascaded cross dumbbell shape SIR BPF (Ports placed at the middle)

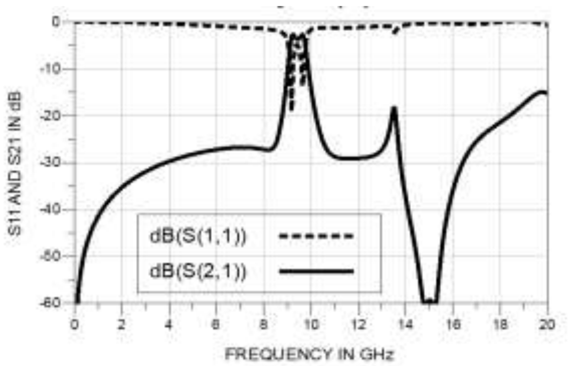

Figure 4.2.Simulated response of cascaded cross dumbbell shape SIR BPF (Ports placed at the middle)

On clear observation we can understand that the response of **Fig. 5.2** has less return loss when compared to the plot in **Fig. 4.2.** Also out band rejection is also improved in BPF with ports placed at the lower ends of the filter structure.

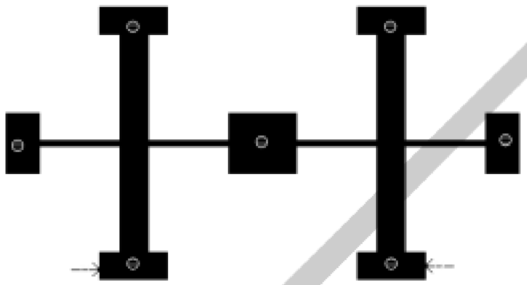

Figure 5.1. Layout of cascaded cross dumbbell shape SIR BPF (Ports placed at the lower impedance terminals)

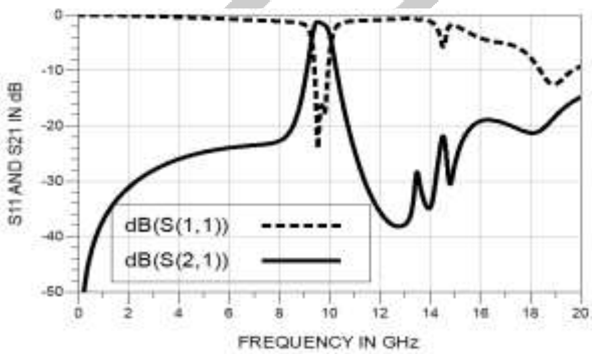

Figure 5.2. Simulated response of cascaded cross dumbbell shape SIR BPF (Ports placed at the lower impedance terminals)

Stepped impedance transmission lines are employed both in input and output port to step down the port's impedance close to the magnitude of characteristic impedance Z0.The input and output ports are the coupling lines with parallel of each resonator. This configuration of input and output port feeding causes the magnitude of input/output impedances pulled raise up.

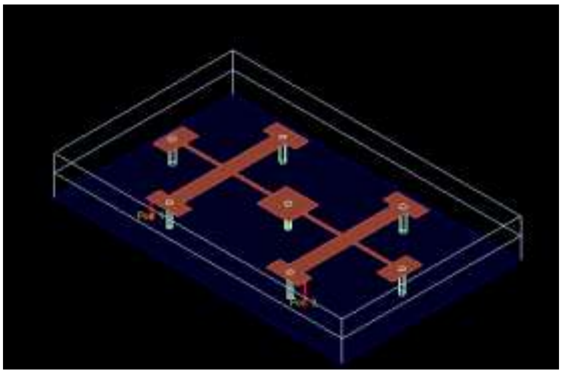

Figure 6. dimension view of the proposed BPF

The coupling is more in bottom fed filter when compared to mid fed filter and hence bottom fed filter produces good responses. Cascaded structure is introduced in order to reduce the losses and to provide good out of band rejection better than single structure design**. Figure 6** depicts how the filter looks in 3 D view. The filter is miniature in structure and has high frequency band operations and finds extended applications in upper Ultra wide band frequency range.

III. CONCLUSION

In this paper a simple design procedure for band pass filter using Cross Dumb-bell shape Stepped Impedance Resonator is presented. The resonators in filter gives more efficiency of performance to reduce spurious responses and to reduce the losses and improve out of band rejection. The band pass filters are easy to construct. The filter can be used in many wireless and microwave applications in upper UWB frequency band.

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