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Design and Analysis of Band Notched Filter Using Quarter Wave Transmission Line

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ABSTRACT

In this paper, a selective band pass filter with single notched band is proposed using split ring resonator. The notched band is created using quarter wave transmission line. The outer transmission line has 50 ohm line impedance and the inner stub has 102 ohm line impedance. The notched band is created to stop the particular frequencies for wireless networks. The operating frequency of this filter is 2.2GHz. The proposed filter is experimentally simulated, fabricated and tested. Both the predicted and the measured results are in good agreement and replicating the behaviour of the proposed filter.

Keywords: *Notched filter, Split ring resonator, Band pass filter*

1. INTRODUCTION

The FCC(Federal Communication Commission) has allocated and unlicensed commercial band from 3.1-10.6GHz in 2002 for short range high speed transmission. Earlier, this technology is used for military applications. But, as of now UWB technology is very interesting and getting much attention. The frequency band of military application gets interference from other frequency bands such as mobile application and WLAN applications. Several methods have been made to reject these interferences. However, rejecting the interfering bands without disturbing the military application bands. In this paper, split ring resonators are used to produce the negative effect in the structure. Here, a micro strip transmission is loaded with split rings for designing the proposed filter. The split ring resonator implements a pure negative property called Metamaterial. Metamaterials are not a material in the usual sense and cannot be found in nature. Metamaterials are artificial structures designed to obtain controllable electromagnetic and optical properties.

2. LITERATURE REVIEW

Sandeep Kumar and Ravi Dutt Gupta mentioned the concept of UWB band pass filter with triple notched band using C-shaped and E-shaped along with the triangular ring loaded stub resonator. This filter has the advantage to choose any combination of the notched band such as single, dual, triple. This filter is simulated in finite integral technique based CST microwave studio [1].

Leung Chiu and Quan Xue discussed that the implementation of a shunt open circuited stub for multi layered microwave circuit. The design has three layers namely ground plane, middle strip layer, upper strip layer. The design consists of a pair of quarter wave length open circuited stubs separated by quarter wave length. This filter is designed using integrated circuit design.[2]

Fathinasri and Zhebin Wang designed a dual band notched UWB band pass filter which controls harmonic components. λg/4 transmission line is used for suppressing the harmonic. The dual notched band can be easily controlled by changing the parameters of each filter. This filter is compact in size because of the folded finger structure.

Harish Kumar and MD. Upadhayay discussed UWB technology based filter with WLAN notch. In this structure a λ/4 open circuited stub is introduced to achieve the notch to avoid the interference with WLAN frequency. Thenotch behaviour of this UWB filter is not achievable at width of stub less than 0.3mm. The design structure was simulated in electromagnetic circuit software [4].

Haibin Sun and Cai Feng designed dual band rectangular waveguide notch filter. This filter is realized by integrating two pairs of split ring resonators. This filter exhibits two resonant states due to the coupling effect between the twist SRR's and the original SRR's and their mirror images. The filter is fabricated using standard printed circuit board fabrication technique [5].

2.1 Characteristics of Band Stop Filter

Band stop filters or band reject filters, reject signals within a frequency band by a lower and upper limit and allow transmission at frequencies out of this band. The ideal band stop filter amplitude response in frequency domain is given in figure 2.In figure 2 f_{c1} and f_{c2} are the lower and upper corner frequencies and f_0 is the centre frequency of the ideal band stop filter.

In ideal band stop filter, attenuation in pass band is zero, attenuation in pass band is infinity and transmission from pass band to stop band is infinitely sharp. Such an ideal filter(Brick wall filter) characteristics is not possible to obtain in practice. Ideal characteristics can be approximated using approximating functions like Butterworth, Chebyshev, elliptic, etc. Typical approximate band stop amplitude responses using these functions are given in figure 3. A band stop filter with a narrow stop band is called a notch filter. Notch filters reject or notch out a specific frequency. So, ideally they are as if all pass filters except an abrupt attenuation at a specific frequency.

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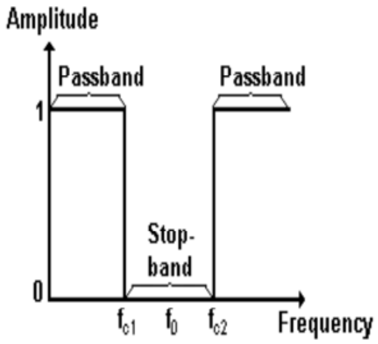

Figure2: Ideal band stop filter

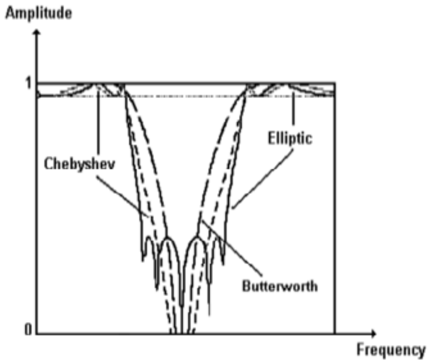

Figure3: Approximation for ideal band stop filter

2.2 Design of Split Ring Resonator

The artificially produced structure which is common to a metamaterial is a split ring resonator (SRR).The SRRs are used to produce magnetic susceptibility up to 200 terahertz in various types of metamaterials. SRRs have splits at the opposite ends and also a pair of enclosed loops in a single cell.Copper is a non-magnetic material and is used to make loops with little gaps between them.The shape of the loops can be square or concentric.The rotating current will be induced by the penetrating power of the magnetic flux in the metal rings.Split ring resonators are made up of metallic rings which are concentric.On a dielectric substrate, the SRRs are cut with slits on opposite sides.SRRs can produce an electrically smaller effect and they can respond to an oscillating electromagnetic field.

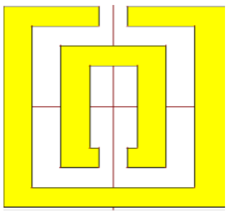

Figure 1: Square split ring resonator

3 FABRICATION AND EXPERIMENTAL RESULT

3.1 Software: Ansoft HFSS

The Ansoft High Frequency Structure Simulator (HFSS) is a full-wave electromagnetic software package. Using HFSS basic electromagnetic field quantities, open boundary, radiated near and far fields can be calculated.

Based on the proposed design, the notch filter is designed using two open circuited stubs. The stub is a high ohm inductance which is connected in parallel. The variation in length and width of the stub affects the notch frequency and the insertion loss. The structure of band notched filter using quarter wave transmission line is shown in figure 4.

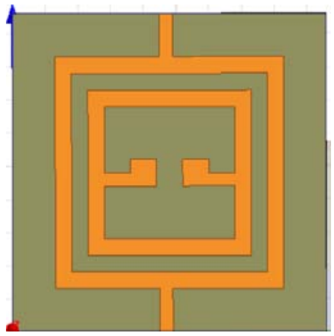

Figure 4: Structure of the filter

The size of the proposed filter is 42x 27x1.6. Here 1.6 is the thickness of the filter. Figure 5 shows the result of the simulated graph. From this simulated graph, we conclude that the stop band ranges from 0.8-5.1GHz and passes other frequencies either side of this range.

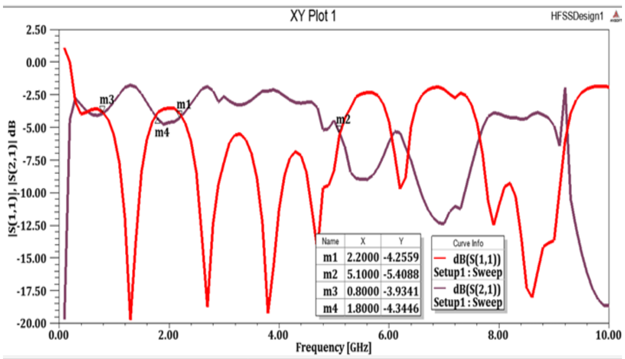

Figure 5: Simulated result of the filter

The return loss is lesser than -10dB. Hence from the result, the aim of designing a metamaterial bandstop filter using a transmission line for RF military and satellite applications which are stopped within the covered band 0.8-5.1 GHz was achieved with return losses which are -19.15dB, -18.22dB, -18.12dB for the frequencies 1.5GHz, 2.6GHz, 3.8GHz. It shows that it has wide band coverage. Figure 5a and 5b shows the tested result.

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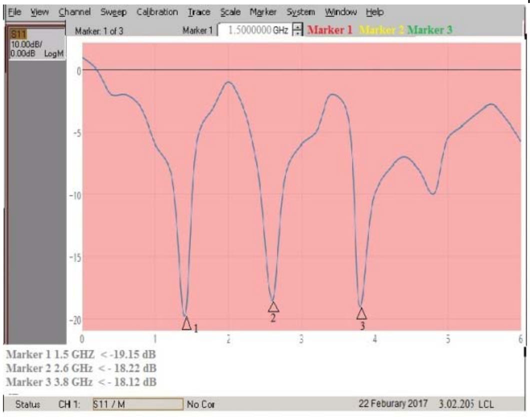

Figure 5a: Tested result for S_{11}

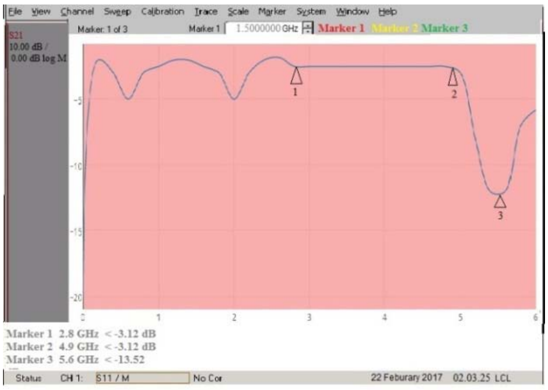

Figure 5b: Tested result for S_{21}

The tested result is plotted in the figure above which are compared along with the simulated results. From the comparison plot, the simulated and fabricated results were same but with the return loss lesser than -10dB. These graphs give evident of simulated and measured results in the proposed SRRs-BSF. From the above discussed results, it is evident that the proposed SRRs-BSF achieved the desired stop band from 0.8GHz – 5.1 GHz, with no resonance before or after the corresponding lower and higher cut-off frequencies. Hence this design can be used for military applications.Figure 6a and 6b shows the simulated graph for S_{11} and S_{21}.

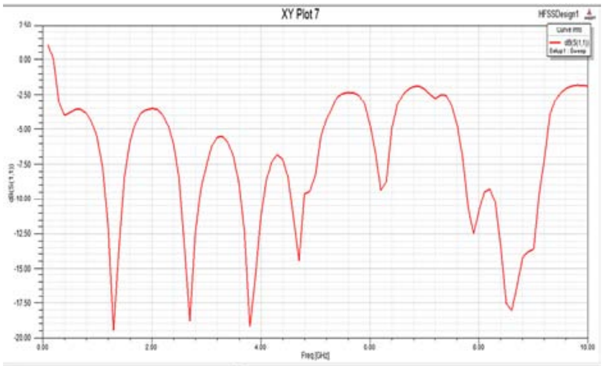

Figure 6a: simulated result for S_{11}

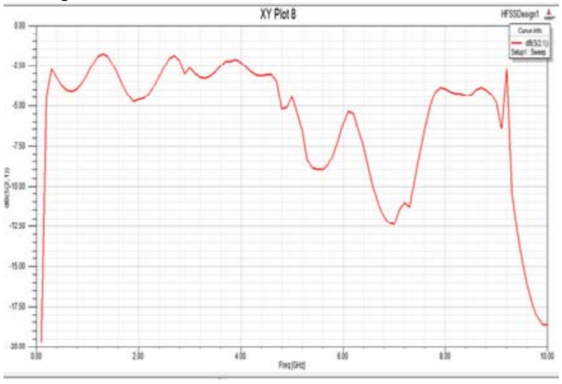

Figure 6b: Simulated result for S_{21}

Comparing both simulated and measured results, the conclusion is made that the measured frequency response is agreed with the simulated frequency response and the return losses are -19.15dB, -18.22dB and -18.12dB for the frequencies 1.5GHz, 2.6GHz, and 3.8GHz respectively. The fabricated filter is characterised by network analyser. Figure 7 shows the front view of the fabricated filter.

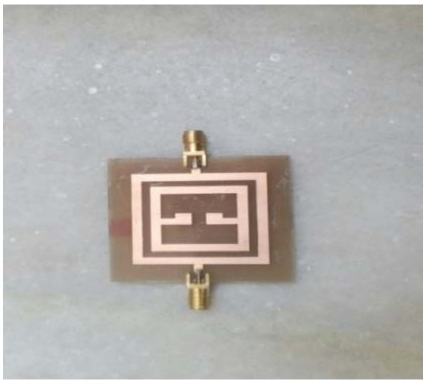

Figure 7: Structure of fabricated filter

4. CONCLUSION AND FUTURE WORK

A band notched filter using quarter wave transmission line has been presented. The desired notch band is introduced by an open circuited stub in the 1Ø2 feed line. The notched band can be controlled by the width of the stub and the length of the stub. A filter using quarter wave transmission line is designed, simulated and fabricated. The measured results and the simulated results validate the proposed filter design. At the pass band a flat response of group delay is achieved. In future the RF band notched filter that is designed can be optimized by reducing the complications in the design and further improving the performance of the RF filter.

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