Design & Simulation of S Band Planar Microwave Filter for Wireless Application

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Abstract. Reducing the size of today's wireless communication systems has become an important criterion in filter design with minimal possible value of filter parameters. To achieve this goal in wireless communication system, filter design is the most important part of the signal transmission process. Conventional filters are very important for modern wireless communication systems as they do not provide the desired miniaturization and results. Recently, using metamaterials and dielectric resonators, the filter size has been drastically reduced to a very small size for practical applications. This filter is flat and lightweight. It consumes very low power consumption. In this proposed work, a compact S-band microwave band stop filter was designed using a simple technique. These filters are small in size and light in weight. The design covers the S-band and is suitable for the desired frequency for Wi – Fi and wireless LAN application.

Key words – Planar microwave filter, Metamaterial, Square split ring resonator (SSRR), Wi - Fi range, Wireless LAN application.

1. Introduction

Now, in recent year wireless communication requires compact, less complex and easy to fabricated devices which necessitated the use of microstrip structures. Microstrip filters are inevitable part of communication system. Various filters are design according to this structure. Now a day's many people have focused on filter design with square split ring resonator (SSRR) or improved SRR structures. The split-ring resonator presented by Pendry can have a negative permeability and is used for the realization of left-handed materials (LHM) with a negative refractive index. The SRRs are made up of concentric rings of non-magnetic metal such as copper. When they are generated by a magnetic field, their real part of permeability can be very positive to negative near their resonance frequency. This resonance frequency is a narrow band that can be explained by analogy with the LC resonator, where the inductance L is the length of the ring and the capacitance C is the size of the cut. Because of their properties, the SRRs are used to reduce the size of the microwave filter. And these filters are also narrow-band. [8] The position and the width of the stop band filters are depend on the size, number and position of SRRs. Here SRRs with different size and position gives the dual frequency response with reduced structure of SRRs in S – band. By varying the size of SRRs we can varies the frequencies for desired frequency of response. And also by varying the distance between SRRs we can achieve good frequency of response.
2. Design of stop band filter
The Design of stop band filter with different geometry of SRRs and single feed line is proposed for different variation in results. Here in this proposed work by using reduced structure of SRRs designed stop band filter with dual frequency for wireless LAN application in S– band. Basic ideolgy behind this design is come from one of the reference paper which covers design for stopband filter with single frequency [1]. Here designed the stop band filter for dual frequency by changing size of ring and some of the parameters with compact size of filter. Stop band filter with compact size is the main research motive for today’s technology. For this here chose single microstrip line with two parallel sides of n-cells of SRRs. By which filter size is drastically reduced to very small size and getting good frequency of response.

2.1 Design for first iteration of stop band filter
Here for first iteration of stop band filter there is only 1 pair of SRRs arranged parallel to microstrip line. Which used to exhibits negative permeability and give good frequency of response. The gap between strip line and resonators are varies from design to others but it is constant between cells in one design. This design gives one frequency of response at Wi - Fi range in WLAN channel.

| Parameters | b    | c1  | c2  | d   | g1  | g2  | wf  | w1  | w   | l   |
|------------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Values(mm) | 13.268 | 1   | 0.5 | 2   | 1   | 0.5 | 4.8 | 0.4 | 40  | 22  |

2.2 Design for second iteration of stop band filter
Here for second iteration of stop band filter there is two pairs of SRRs are arranged parallel to microstrip line. These pair of SRRs consist same parametric loop. These loops of SRRs arranged at some distance from each other to get good frequency of response. This design gives one cut of frequency with higher insertion loss at Wi – Fi range in WLAN channel.
2.3 Design for final iteration of stop band filter

Here for final iteration of stop band filter two different parametric pair of SRRs are arranged parallel to microstrip line. To get dual frequency of response here the size variation is caused in second pair of SRR. So, by doing this variation we get dual frequency of response at reduced structure of SRRs. In this design we get required range of insertion loss and return loss at dual frequency for Wi – Fi and WLAN application.
3. Simulation and result

The different geometry of band stop filter gives different aspects of output. Here are some simulated designs and their results which gives varieties of responses. For simulation of these designs I used CST studio suit software. Which is basic software for filter design and easy to use. Here the iteration of band stop filter is chosen according to their geometry and compact size. Here to design this filter ground and upper patch of SRRs and feed line material is copper and substrate material is a RogerRT5880. These filters give response at 2.4 GHz and 3.6 GHz frequencies. Among all three iteration of this design first two design of band stop filters gives response at only 2.4 GHz Wi-Fi frequency range. And last and final iteration of these designs gives both frequency of response for Wi-Fi and WLAN application.

Here the Rogers RT5880 (lossy) substrate was used with a thickness of 1.57 mm and a relative permittivity of 2.2. The copper thickness is 0.035 mm. The simulation of final design shows good performance at 2.4 GHz (2.36 to 2.44 GHz) and 3.6 GHz (3.55 to 3.66 GHz). There are two waveguide port given to both the side of feed line for simulation. Overall thickness of this filter is 1.64 mm.

Here I choose Roger RT5880 (lossy) substrate in place of most common material FR-4. Because Roger gives better compactness compare to FR-4. And by using this material insertion loss also decreases at the reduced structure of SRRs. By using FR-4 material size of filter will increases for better response. And tangent loss of FR-4 material also high compare to Roger material which is results in a slow substrate. So, as tangent loss of substrate material is decreases the substrate becomes fast substrate.

3.1 Simulated design and result of first iteration

For first iteration of band stop filter we get insertion loss up to -22.465 dB and return loss up to 0.68 dB. Here B.W. of this filter is up to 85 MHz and one rejection is observed and located at 2.4 GHz.
3.2 Simulated design and result of second iteration

For second iteration of band stop filter we get insertion loss up to -37.915 dB and return loss up to 0.56 dB. Here B.W. of this filter is up to 150 MHz and one rejection is observed and located at 2.4 GHz.

![Fig.-2(a) Top-view of design-2](image1)
![Fig.-2(b) Cross-view of design-2](image2)

3.3 Simulated design and result of final iteration

For final iteration of band stop filter we get insertion loss at 2.4 GHz frequency up to -22.566 dB and at 3.6 GHz frequency insertion loss is -21.568 dB. Here B.W. of this filter is 85 MHz and 100 MHz at 2.4
GHz and 3.6 GHz frequencies. The rejection observed and located at 2.4 GHz and 3.6 GHz frequencies.

![Top-view of final design](image1)

![Cross-view of final design](image2)

![S - parameters of final design](image3)

**Insertion loss:**

![S-parameters](image4)
4. Fabrication work and result
Here fig.-4(a) shows the fabricated microwave band stop filter and fig.-4(b) shows the tested result of S-parameters. This result is measured in VNA of key sight at GEC Bhavnagar. Fabrication shows some deviation in frequency response because of the fabrication loss and loss. The overall result of fabricated filter was good and exists in the S-band. Here fabricated result shows result at 2.48 GHz and 3.69 GHz frequencies. The insertion loss at these frequencies is around 16.83dB and 21dB. The overall size of filter is around 4 cm.

5. Conclusion
This work is based on effect of metamaterial component on stop band filter using SRRs. The filters are loaded with two parallel sides of split ring resonators (SRRs). In which numbers and size of resonators varies in every design to get different frequency of response. Here by improving the same sized filter with some parameter changes in their geometry of design getting good frequency of response for Wi-Fi and WLAN application in S – band. By doing this, filter size becomes extremely compact. And these filters are becomes more suitable for new technology in wireless application. The fractional B.W. of proposed work is 3.54% (2.36 to 2.44 GHz) and 3.05% (3.55 to 3.66 GHz). Here you can see the fractional B.W. is lower than 5%. This causes sharp response at lower frequencies. Finally narrow band stop filter is designed and simulated for Wi-Fi and WLAN applications.
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