Microstrip Bandstop Filter based on Coupled SIR for Communication Systems

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Abstract

In this paper, a microstrip bandstop filter (BSF) is designed and simulated for X-band wireless communication system. It consists of open stubs (parallel line with T-shaped) coupled with high impedance of stepped impedance resonator (SIR) at 7.5 GHz for X-band system applications. All the stubs are optimized to have the stopband characteristics. The layout pattern is simulated using Sonnet EM tool on Teflon substrate with a dielectric constant of 2.54 and thickness of 0.54 mm. The main features of this work are smaller size, low cost, and controllable bandwidth. The bandwidth can be controlled by adjusting the parallel line open stubs connected with open T-stub. The 3dB bandwidth is achieved as 0.3 GHz at 7.5 GHz with good frequency responses. The overall physical dimension of the designed BSF is 23.62 mm by 8.0 mm excluding reference lines.

Key words: Microstrip BPF, X-band filter, narrow band BSF, microstrip filter

1. Introduction

In receiver and transmitting system of communications, a filter plays very important role to reject the unnecessary frequency with reducing spurious frequencies. Especially, in the receiver end, the designed bandstop filter (BSF) can be used as shown in Figure 1. This Figure shows wireless receiver end showing the key blocks such as antenna, bandstop filter (BSF), low noise amplifier (LNA), mixer, and local oscillator and A/D converter. The characteristics of rejecting interference or unnecessary frequencies and having pure spectrum of desired band, are beneficial to X-band wireless communication networks The BSF is designed and simulated using Sonnet Electro-magnetic (EM) simulator, especially for the X-band application. In X band, the frequency range is from 7 to 11.2 GHz fixed by communication engineering which can be implemented in satellite communication downlink, especially for naval and land mobile earth stations. However, there are many researchers who are working on the same BSF to achieve good performance with various kinds of patterns like ring resonator filter, stepped impedance resonator (SIR) BSF, parallel line resonator filters, hairpin resonator filter with various open stubs etc but their sizes are bigger. Therefore, we have developed microstrip narrow bandstop filter (BSF) to implement in such wireless satellite communication system with reduced size and improved performance [1-6]. Generally, wireless communication system requires BSF with high performance.

Figure 1. The receiver end of wireless communication system.
For this purpose, we used basic SIR in the design with open parallel stubs on both sides (upper and lower). Due to flexibility of design pattern and frequency range, we used this configuration for X-band satellite communication systems.

2. Design and Simulation

This design is based on stepped impedance resonator (SIR) which has wide range of applicable frequency and flexibility in design pattern. It has also TEM (transverse electromagnetic) or quasi TEM mode so that it allows both electric and magnetic field propagating to the direction of propagation. In this design we used $\lambda/2$ type of SIR on which parallel open stubs on both sides (upper and lower) are coupled.

The designed BSF is developed by improving its performance and for this purpose, we chose the $T$-shaped parallel open stub with SIR with the following dimensions: Length of SIR = 18.82 mm, length and width of parallel coupled lines = 10.82 mm and 0.24 mm, length and height of T-shaped = 6.2 mm, and 5.92 mm. These dimensions are optimized value and simulated using electromagnetic simulator, Sonnet. It is simulated on Teflon substrate with dielectric constant of 2.54 and thickness of 0.54 mm. The T-shape open stub used to have single frequency operating at 7.5 GHz. The overall dimension of is shown in Figure 2. The simulated results of the BSF is shown in Figure 3. In the simulation, the frequency responses of S-parameters can be observed which shows the insertion loss (S21) and return loss (S11) are 20 dB and 0.6 dB respectively at the center frequency of 7.5 GHz. The 3 dB bandwidth of the designed bandpass filter is 0.3 GHz. The frequency can be adjusted by reducing and increasing the height of T-shaped open stub. In this design, SIR is coupled with parallel coupling stub with T-shape open stub. Due to high coupling between SIR and parallel coupling stub, we can have a narrow bandwidth which is the requirement of the most of the wireless communication systems. The gap between high impedance part of SIR and open stubs in up and down shows capacitive effect while high impedance part of SIR shows inductive effect. The overall dimension of the designed microstrip hairpin resonator bandpass filter is 23.62 mm by 8.0 mm. The overall BSF performance is tabulated in Table 1 for more clearance.

![Figure 2. The layout pattern of the designed bandstop filter.](image)

![Figure 3. The simulation result of the designed BSF.](image)
### Table 1. Overall BSF performance

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Simulation Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center Frequency</td>
<td>GHz</td>
<td>7.5</td>
</tr>
<tr>
<td>Insertion Loss (S21)</td>
<td>dB</td>
<td>20</td>
</tr>
<tr>
<td>Return Loss (S11)</td>
<td>dB</td>
<td>0.3</td>
</tr>
<tr>
<td>Rejection Bandwidth</td>
<td>GHz</td>
<td>0.3</td>
</tr>
<tr>
<td>Size</td>
<td>mm</td>
<td>(23.62 × 8.0) mm²</td>
</tr>
</tbody>
</table>

3. Conclusion

A microstrip narrow bandstop filter is designed and simulated using Sonnet EM simulator based on Teflon substrate with dielectric constant of 2.54 for radio cognition network system. The bandstop filter is adjustable so that we can easily reject the unnecessary frequencies selectively. The designed narrow band bandstop filter showed good S-parameter frequency responses. The frequency can be adjusted by decreasing or increasing the length of T-shape open stubs which is coupling with SIR in upper and lower sides. The designed bandstop filter exhibited 0.3 GHz as its 3dB bandwidth at the center frequency of 7.5GHz. The designed BSF achieved the insertion loss (S21) and return loss (S11) are 20 dB and 0.3 dB respectively at the center frequency of 7.5 GHz with the bandwidth of 0.3 GHz. The size is miniaturized up to 23.62 mm by 8.0 mm and it has potential to further reduction of size so that it is possible to miniaturize using IPD technology for the higher frequency applications. This BSF can be implemented in high frequency applications such as X-band downlink of satellite communication system.

References


