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Design a dual band pass filter using triangular head defective ground structure for Wi max technology

Shalni Sharma[1], Kapil Kumar[2], Neera Agarwal[3], Preet Kamal Goel[4]

[1] *Department of Electronics & Communication Engineering , Vivekanad Institute of Technology & Science Ghaziabad*
[2] *Department of Electronics & Communication Engineering , Sanskar College of Engineering & Technology, Ghaziabad*
[3] *Department of Electronics & Communication Engineering , Bhartividyapeeth College of Engineering, Paschim Vihar, New Delhi*
[4]*Department of Electronics & Communication Engineering Bhabha Engineering & Research Institute, Bhopal india,*

Abstract

In this paper introduces the design of Dual-band band-pass microwave filter using DGS approach. In this paper proposed design technique, the analog specifications of desired dual band-pass filter are converted into the digital specifications. The digital filter zeros removed by an appropriate optimization technique. By using arrow head DGS to get desired filter coefficients of dual pass-band filter. The filter coefficients are computed in term of forwarding transfer scattering matrix (S21). These filter coefficients give appropriate vales of characteristics impedance of open circuit stubs, short circuit stubs & transmission line sections. The theoretical result dual band pass microwave filter verified on CST Microwave studio Simulation tool.

Keywords: Dual BPF; DGS; Scattering Matrix; CST Microwave studio

1. Introduction

Today's era, most of the Radio Frequency (RF) components and devices must be able to handle with the increase in demand of wireless communication applications. Ring-based resonators are amongst the most solicited topologies when the selectivity and compactness are targeted to be achieved [1]-[2]. There are various techniques have been implemented to filters in order to improve their S-parameters and minimization of their sizes. One of them is to use a defective ground structure (DGS). The DGS is a deliberately etched cascaded structure defect on the ground plane. There are various DGS shapes that have been observed such as square, rectangular, circular, dumbbell, concentric ring, spiral, L-shaped, U-shaped and V-shaped, hairpin, hexagonal, cross-shaped, arrow head slot and inter-digital DGS [3]-[7] as shown in Figure 1. Each shape of the DGS has its own exclusive characteristics to improve the response of a filter. In [8] the dumbbell-shaped DGS can be used to tune the center frequency of the filter by varying its dimensions. The dimensions play an important role for the DGS to be effective. A finite pass-band and rejection band can be achieved along with slow-wave characteristics by etching a DGS on the ground plane [9]. There are also different techniques other than DGS such as Photonic Band Gap (PBG). PBG is known to provide rejection for certain frequency bands. However, due to its complex parameters that can affect the band gap makes it difficult to be used for microwave applications [10]. In [11], the use of DGS had improved the band-pass filter response significantly. By using triangular head geometry with some other parametric variations, the pass band had increased. The frequency resonance was also affected by the position of the triangle. The frequency resonance tends to vary with different positions of the DGS. The lumped inductors are realized through the equilateral triangular DGS slots. A triangular DGS slot provides sharper transition region as compared to the square and dumbbell DGS of the same area of the slot-heads.

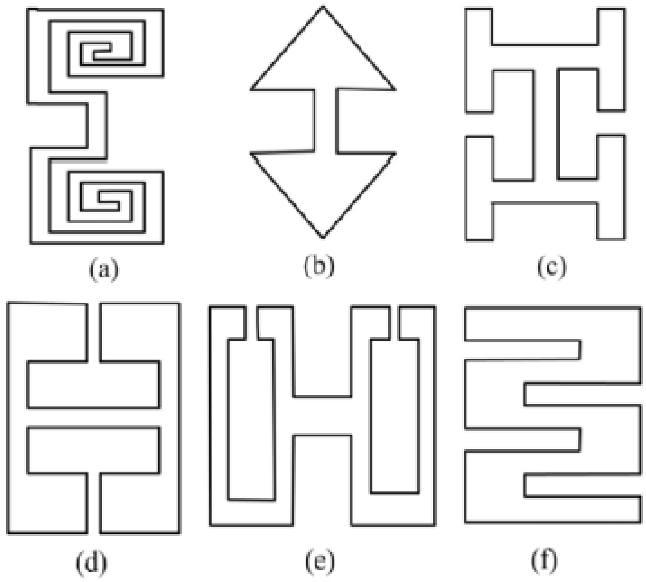

Figure 1 Various DGS shapes (a) Spiral head (b)Arrow-head (c) H-shaped (d) a square open loop with slots in the middle (e) Open loop dumbbell (f) Inter-digital DGS [7]

Three parallel DGS structures are used in this design. The defected ground structure is the etched out areas in the ground plane. DGS changes the shield current distribution through the ground plane. The shield current, in turn, changes the transmission line characteristics such as line capacitance and inductance. Hence the DGS circuit is used as the LC equivalent circuit

In this paper, dual band-pass coupled resonator filters with same DGS shape and with different feed line configuration is designed and simulated to operate at a center frequency of 5.4GHz and are suitable for WLAN applications The performance of the filters is investigated with simulation results using commercial CST microwave studio software filter Design.

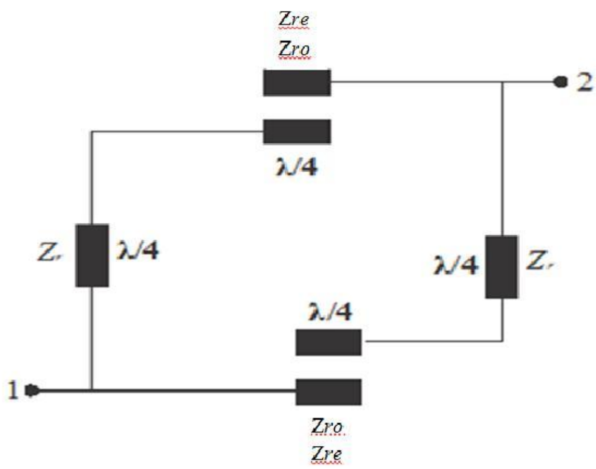

Figure 2 Proposed topology of the dual-band band-pass filter [2]

2. Design of Dual Band Pass Filter

Figure 2 shows the existing topology of the dual-band band-pass filter [12]. An ideal response of BPF is shown in Figure 3 without any DGS. It shows that a deep and sharp rejection region outside of the symmetrical pass-band resulting in a dual-band response. [5, 6] The center frequency acts as the reference frequency and it is situated in between the two pass-bands. For the other two pass-bands, the center frequency is denoted as f1 and f2, resulting in three transmission zeros that will ensure a good selectivity between the frequencies.[7,8]

The dual-band band-pass filter layout is presented in Figure 4 where parallel-coupled lines are coupled to quarter wavelength transmission lines.

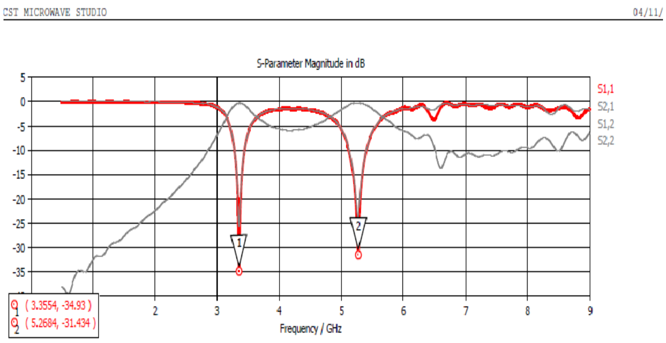

Figure 3 Ideal frequency response of the dual-band band-pass filter [2,3]

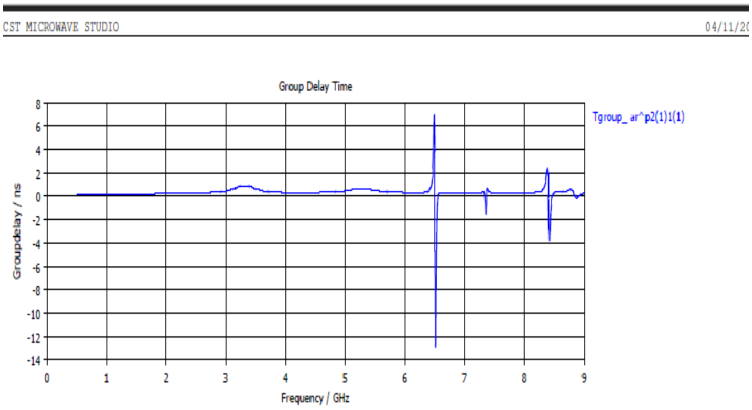

Figure 4 Group Delay vs freq [12, 13]

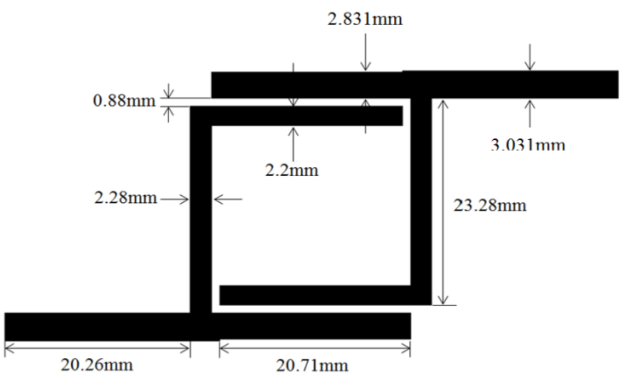

Figure 4 2D circuit layout of the dual-band band-pass filter [12]

3. Design of Proposed Dual Band Pass Filter with Triangular Shaped DGS

The proposed DGS shape for this dual-band band-pass filter is a rectangular shape. The DGS is intended to change the characteristic of the microstrip line in terms of the line inductance and capacitance [8]. The DGS shape can help to increase the impedance matching that cannot be achieved due to the limits of the microstrip line width. Figure 7 depicts the DGS structure at various positions on the ground plane in order to find the best position that can maximize the response of the filter. The tested positions are along the center line and at the four corners of the ground plane. [12,13]The length (l) and width (w) of the DGS are 16.5 mm and 16 mm respectively. The filter is modeled in CST on a Rogers RO3010 substrate which has a relative dielectric constant, r = 10.2, substrates thickness, h = 1.6 mm and loss tangent, tan δ = 0.001 as shown in Figure 5. Optimization on the transmission lines and parallel-coupled structures are performed to obtain a perfect matching and the final dimensions are shown in Figure 4. Figure 6 shows the comparison between simulated and measured results of the filter. It can be observed that the simulated result produces two pass-bands centered at f1, 3.54 GHz and f2 4.5 GHz, although the measured centered frequencies shifted slightly. Both results are comparable; however, the second band differs significantly. It is observed that the measured and simulated S11 are 34.41 dB and 31.93 dB respectively.

Overall, the isolation level between the two pass-bands is more than 30 dB and the insertion losses are around 0.5 dB for both bands. The outer rejection level for the first pass-band is more than 10 dB with the second pass-band achieving a much lower value

4. Result Analysis and Comparison

In this paper, design a dual pass-band filter using arrows shaped DGS and ring resonator. The dual pass-band characteristic is achieved by ring resonator. DGS structure has good frequency selectivity and can be used to adjust the distance among the passbands. The distance between the feed line and ring resonator can be utilized to adjust coupling coefficient. [12, 13]The filter working in WLAN and Wi-MAX frequency bands is eventually designed. Test results show that the return loss in pass-band is more than 34 dB, a ripple in pass-band is small.

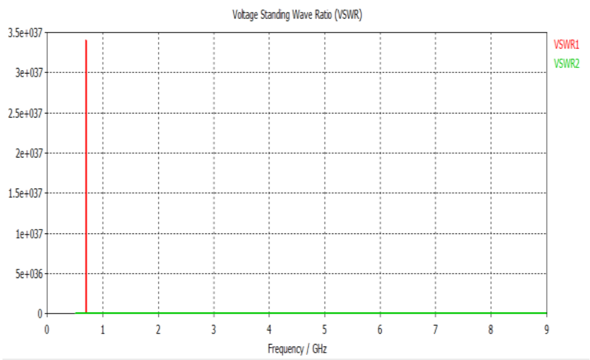

Figure 5 VSWR VS Frequency Diagram for Dual-band BPF

Group Delay is less than 0.25nsec.VSWR in the range of 1.2 in both band. The filter has a compact structure and small size, which is suitable for application in wireless network and communication equipment

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