DEFECTED GROUND COPLANAR MULTI-BAND-PASS MICROSTRIP FILTER

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Abstract: This paper presents a combination of an inductive coupling technique and coplanar ground plane microstrip filter. Here, inductive coupling technique is used to overcome the unwanted radiation loss generated by the gap between the co-planar ground plane and the transmission line which improves filter characteristics. A defected ground structure (DGS) is integrated with the proposed filter to achieve a tri-bandpass characteristic (1.85, 3.53, and 5 GHz) without hampering the filter performance. The experimental results of the proposed filter are found in good agreement with simulated results.

Keywords: Tri-bandpass filter; Multi-band filter;Microstrip filter;Defected ground structure;Inductive coupling.

1. Introduction

The ever increasing demand for modern wireless communication applications it requires compact and high performance transceivers [1-2]. Planar antenna, filter, and power circuit are some of the essential elements in such devices [3-6]. Performance and compactness of these components play a vital role in choice of the device. In recent years there has been an increasing interest in planar filters because of their low profile, compact size, light weight, and ease of fabrication [7-30]. Multi-band operating device needs a single filter/antenna which can operate in the desired band to miniaturise the wireless device. Researchers shows interest in different techniques like photonic bandgap (PBG) [7-9], electronic bandgap (EBG) [10-12], and defected ground structures (DGS) [13-30] due to their metamaterial characteristics which results in a compact and high performance device. An etching a certain pattern from the ground plane is known as DGS. An increased inductive and capacitive response is observed due to perturbation of current distribution. Such patterns show a parallel LC combination and are useful to develop high performance compact microwave components such as antennas, filers, power dividers etc to fulfil the requirements of modern communication systems.

The need of modern communication systems is compact structure, low insertion loss, and better isolation. Few design methods are reported to realize such filters like end-coupled, open-loop, and tapped [2-6] resonators. DGA is another solution to realize different microwave components. In 2000, Kim et al [13] reported one dimension periodic DGS for planar circuits which was further used for designing a low pass filter [14].Namsang and Akkaraekthalin [15] proposed asymmetrical step-impedance resonators bandpass filters for suppressing a wide stopband to produce low passband insertion loss and high return loss. In same year, Mendez et al [16] introduce a DGS to improve the performance of a traditional stepped-impedance microstrip lowpass filter by enhancing its attenuation in the stop-band by 15 dB. Marcotegui et al [17] proposed combination of parallel-coupled microstrip line with a Complementary Split Ring Resonator to obtain a broadband, sharp rejection, low insertion loss, and low return loss bandpass filter.Chang et al [18] proposed a $\lambda/4$ stepped impedance resonator for inductive coupling which minimize the size of bandpass filter size and also improve its bandstop rejection. Munir et al [19] proposed a dumbbell shaped DGS design an ultra wideband microstrip bandpass filter(f_o=4.52 GHz, BW=5.36 GHz).

In this paper, an inductively coupled multiband pass filter is designed and developed using defected ground coplanar structure. Here, the shunt inductive coupled structure is introduced to overcome coplanar waveguide radiation loss while symmetrical circular defects on the ground plane introduce a new band and also reduce the size of the proposed filter. The dimensions of the ground defects and the inductive coupled structure of the filter are optimized to obtain the desired results. Here, the filter implementation is carried out in multiple phases with optimization to get the

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desired performance. Finally, optimised filter is developed to validate its simulated results. This paper is organized as follows: need of multiband-pass filter, and state of art is discussed in Section 1. In Section 2, design procedure which includes the concept of inductive coupling in the context band-pass rejection filter and the role of DGS is explained. In Section 3, simulated and measured results of the proposed filter are discussed.

2. Design Procedure

The basic structure of proposed filter is a coplanar waveguide which works as a simple transmission line made on a 1.59 mm thick FR4 substrate. However, the desired band pass characteristics of the inductive-coupled structure filter are achieved by precisely optimizing its dimensions and positions. Similarly, coupling line and slots are chosen over the end-coupled to minimize the radiation loss occurs in the gap of the end-coupled structure.

To achieve a perfect matching between input and output ports a simple 50 Ω CPW is converted to a band-pass filter by introducing an inductive coupled structure. Because of, perfect matching with ports, the transmission is nearly 0 dB and reflections are lower than -10 dB in the desired pass band. After inductive loading, a pass-band is obtained at 3.02 GHz with transmission coefficient -1.78 dB, reflection coefficient -2.93 dB, and bandwidth of 178 MHz.

A rectangular slot DGS is observed as a combination of inductor and capacitor and suitable to introduce an additional resonance. A circular head is introduced at the end of slot which reduces the length of the slot and also controls the inductive reactance of DGS. The capacitive reactance of DGS can be control by varying the length of strip line and gap. Thus, desire filter response like area, cut-off frequency, sharpness factor etc can be obtain by precisely optimizing the dimensions of slot, circular head, and gap of the proposed design. A prototype is developed to validate simulated results of proposed filter as shown in Figure 2.

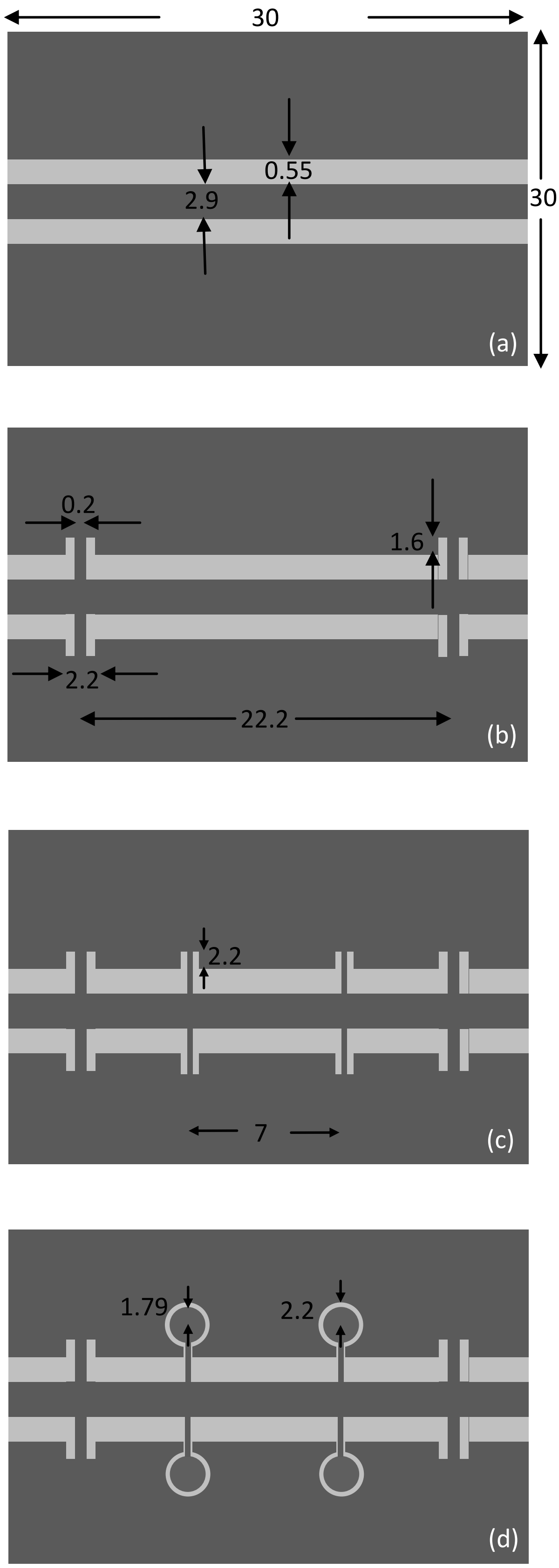

Figure 1: Different stages of proposed filter structure (a) CPW, (b)& (c)inductive-coupled CPW, and (d) final proposed filter(all dimensions are in mm).

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3. Results and discussion

Figure 2: Prototype of the proposed multi-band-pass filter

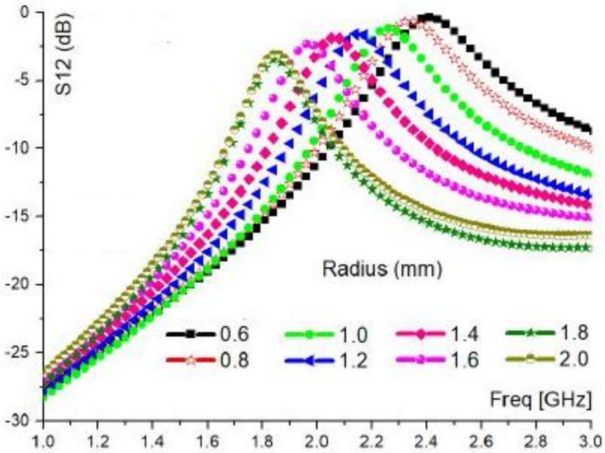

Figure 3: Variation of reflection coefficient with outer radius of circular conductor.

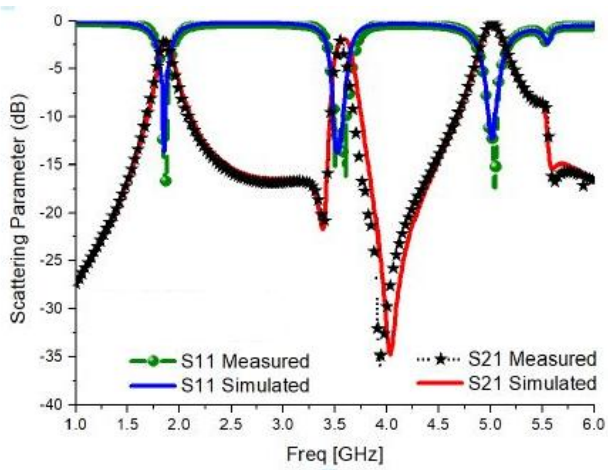

Figure 4: Comparison between simulated and measured S12 of the proposed filter.

HFSS software is used to design and optimize the proposed filter. A passband is observed at 1.85 GHz when a DGS with inductive coupling is integrated with a simple CPW. Figure 3 shows the variation of reflection coefficient with radius and inner circle. It is observed that filter works satisfactorily for inner radius varying from 0.6-2.0 mm. The most compact size is achieved when radius of inner circle is 1.79 mm. When radius of circle is increasing; the operating frequency is reducing, thus miniaturizing the proposed filter. It also degrades the transmission coefficient of the proposed structure. But on the other hand, it improves cut-off frequency attenuation pole frequency of the proposed filter. Similarly, the other parts of the proposed configuration are optimized to achieve the desired results.

A prototype is developed and measured using Vector Network Analyzer to validate simulated results of the proposed filter as depicted in Figure 4. It is clear that the measured S21 of the proposed filter is less than 1 dB (which shows a good impedance matching) for all three pass-bands (1.86, 3.5, and 5 GHz). It is also observed that measured results are in good agreement with simulated results as shown in Figure 4.4**.**

Conclusion

A defected ground is integrated with a CPW based inductive coupled multi-bandpass filter. The coefficient of inductive coupling can be easily controlled by the length of the short-end stub. It mitigates the radiation loss occurred by the gap between CPW transmission line. Integration of DGS offered additional band-pass and compactness without degrading original filter performance. The proposed filter has good impedance matching, good stop-band rejection, better transmission characteristics, and compactness.

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