A Parallel-Coupled Microstrip Bandpass Filter with Hook Feed-Line for Wide Harmonics Rejection

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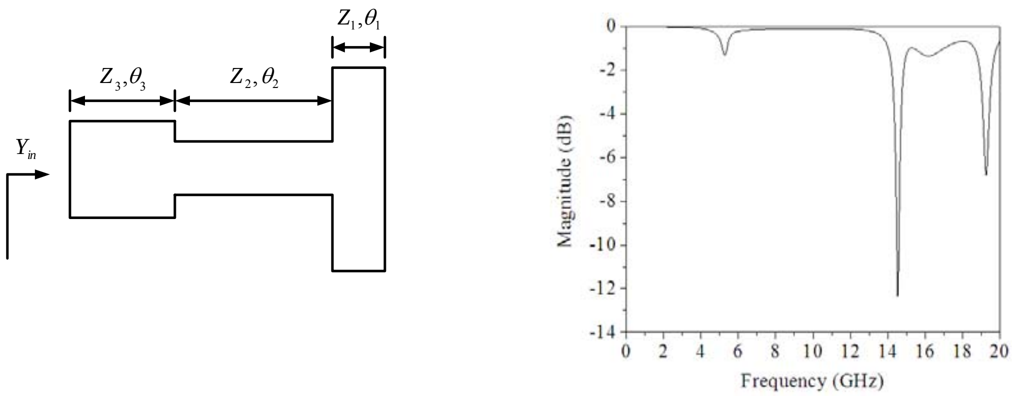
1. Introduction

In this decade, compact bandpass filters are essential components in microwave systems for passing desired signals and suppressing unwanted signals. Microstrip bandpass filter is rapidly going up in the design and fabrication in RF front-ends of wireless communication systems. The microstrip structure is well-known because of its light weight and simple design method. As knowing, the bandpass filter characteristics need strict requirements for bandpass filters including low insertion loss, high selectivity and wide upper stopband [1-2]. The configurations of the microstrip resonators such as the stepped impedance resonator (SIR) might be the most popular candidate for the filter design for reduced size and the controllable second harmonic [3]. Parallel-coupled line resonator is a basic structure for designing to be a bandpass filter, but it generates harmonic signals. A parallel-coupled line bandpass filter with over coupled end stages has been proposed to compensate the difference in phase velocities by extending the electrical length of the odd mode for 1st and 2rd harmonic rejection [4]. Besides that, the stacked SIRs in parallel coupled-line have been proposed for suppressing undesired bands [5]. In order to enhance the circuit performance, a bandpass filter must also have wide stopband response. Many useful methods have shown promising results dealing with the harmonic problems. The electromagnetic-bandgap (EBG) based filter has shown over 25 dB rejection at the second harmonic [6]. The asymmetrical structure can be used to suppress the harmonic responses [7].

In this paper we propose a parallel coupled-line resonator bandpass filter for wide harmonic suppression with the hook feed-line used as input and output port for increasing the coupling factor between the microstrip lines and ports. Section 2 explains the technical background of the proposed structure. Section 3 attends to the consideration of harmonic suppression. Section 4 exhibits the measured responses comparison with the simulated excitations and section 5 represents the conclusion.

2. Circuit design

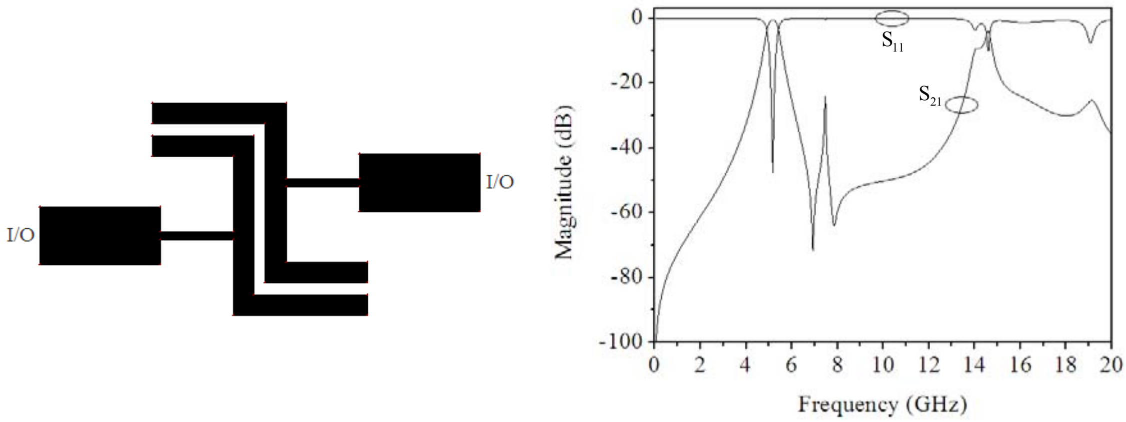
In our study, the microstrip resonator with the hook feed-line is a good structure for harmonic suppression. So that we take this idea to apply for the bandpass filter at 5.20 GHz resonance frequency. First, the basic asymmetrical stepped impedance resonator as shown in figure 1(a) is desired. The characteristic impedances of three cascaded section are Z_1, Z_2, and Z_3 which their electrical lengths are θ_1, θ_2, and θ_3, respectively. The resonator has been designed at the operating frequency of 5.20 GHz using the Arlon 25N substrate, which has a given dielectric constant of 3.38, a thickness of 0.8 mm, and the loss tangent of 0.002. The asymmetrical stepped impedance resonator has been optimized, resulting in the impedances Z_1= 11.58 Ω, Z_2 = 117.76 Ω and Z_3 = 46.08 Ω and their electrical lengths θ_1 = 8.22°, θ_2 = 25.65°, and θ_3 =44.60°, respectively. The total length of the optimized resonator is around $\lambda g/2$. Its response is shown in figure 1(b).



(a) (b)

Figure 1 (a) Basic structure of asymmetrical stepped impedance resonator and (b) the simulated response of the resonator.

The high impedance segment of the resonator has been bent and optimized for increasing the internal coupling as shown in figure 2(a). The simulated bandpass filter response is still being the resonance frequency, but the harmonic signal is generated at 14.5 GHz or around $3f_0$. Then a method to resolve this problem is interested.

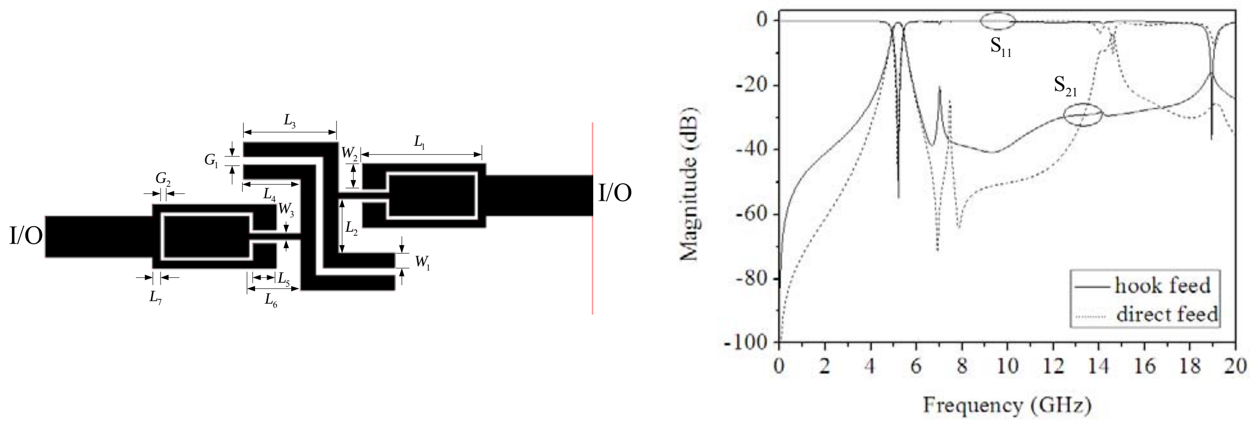


(a) (b)

Figure 2 (a) The folded parallel coupled-line bandpass filter with direct feed-line (b) the simulated response of the filter.

3. Hook feed and harmonic suppression

In our study, the hook feed-line characteristic can reject the unwanted signals, so that instead of using the direct feed-line, the hook feed-line is applied to the proposed stepped impedance resonator bandpass filter as shown in Figure 3(a). The resonator has also an inherent response of 5.20 GHz. The hook feed-line has the frequency notch responses around 14.56 GHz and 14.75 GHz of the odd and even-mode excitations. So the harmonic signal is suppressed as shown in figure 3(b).



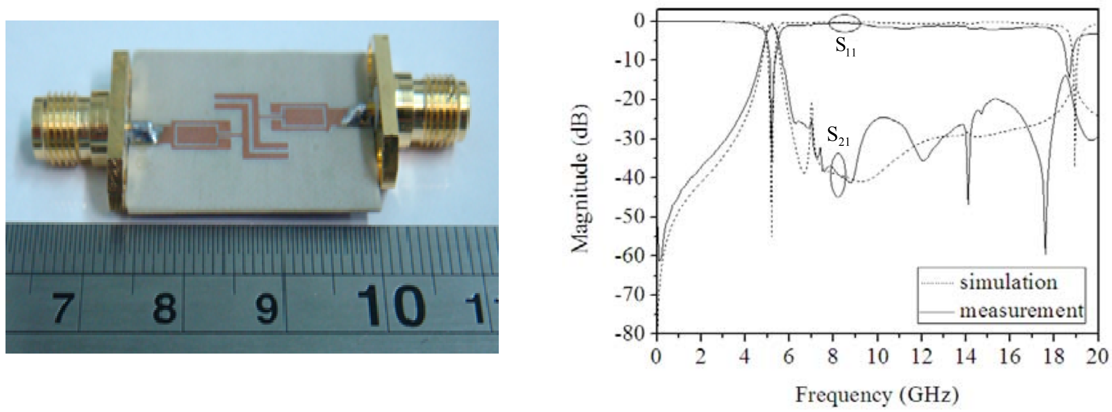
(a) (b)

Figure 3 (a) The bandpass filter with parallel coupled-line and hook feed-line (b) a comparison of the direct and hook feed-line on the proposed filter

4. Filter implementation and results

Figure 3(a) shows the proposed bandpass filter which is designed on asymmetrical stepped impedance resonator and hook feed structure for harmonic suppression. The proposed bandpass filter is fabricated at the center frequency of 5.20 GHz on the Arlon25N substrate which has a dielectric constant of 3.38, a thickness of 0.8 mm. and loss tangent of 0.002 mm. The dimensions of the proposed filter are following: L_1 = 6.33 mm, L_2 = 2.81 mm, L_3 = 4.83 mm, L_4 = 2.92 mm, L_5 = 1.18 mm, L_6 = 2.65 mm, L_7 = 0.40 mm, G_1 = 0.41 mm, G_2 = 0.20 mm, W_1 = 0.75 mm, W_2 = 1.30 mm, W_3 = 0.30 mm. A photograph of the fabricated filter is shown in Figure 4(a).

Figure 4(b) shows the comparisons between simulated and measured performances of the proposed filter. The insertion loss of the bandpass filter is 1.58 dB and the return loss is 19.62 dB at the center frequency of 5.20 GHz.



(a) (b)

Figure 4 (a) A photograph of the fabricated filter (b) comparison of the simulated and measured results of the proposed bandpass.

5. Conclusion

A microstrip bandpass filter with asymmetrical stepped impedance resonators has been demonstrated. The simulation and measurement results show a good passband performance at 5.20 GHz. The measured insertion and return loss are 1.58 dB and 19.62 dB, respectively. The proposed bandpass filter has a wide-stopband up to 20 GHz. All theoretical and experimental results are verifying this concept. The measured results are good agreement with the simulated predictions. This bandpass filter may be applied for several communication systems, when the superior spurious suppress is necessarily required. This bandpass filter can suppress harmonics up to 20 GHz and all rejection level is kept below 16 dB.

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