Parallel coupled microstrip filter with narrow transverse slit for improves the upper stopband rejection

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1. Introduction

Microwave planar bandpass filters are presently required in wide applications of wireless communication systems [1]. In present day, the filters with compact size, suppression of spurious sideband and wider upper stopband are necessarily required for several wireless communication systems. However, most of the planar bandpass filters built on the microstrip structures are large in size and their first spurious resonant frequencies appear at $2f_0$ and $3f_0$, where $f_0$ is the center frequency, which maybe closed to the desired frequencies. Previously, many papers proposed techniques for spurious suppression of the microstrip bandpass filters. The microstrip parallel-coupled line filters with over-coupled end stages have been proposed in order to extend the electrical length of the odd-mode, resulting in compensation of the different phase velocities [2]. The microstrip parallel-coupled filters with the ground slots to compensate unequal modal electrical lengths have been proposed for spurious suppression in the upper stopband [3]. The substrate suspension structure has been substantially designed to speed up the even-mode phase velocity to make the equal modal phase velocities for suppression of spurious [4]. The microstrip bandpass filter used a continuous perturbation of the width of coupled lines following a sinusoidal law so called wiggly-lines has been studied for spurious suppression [5]. These published microstrip coupled line filters have some key drawbacks of large size, high complexity, and high cost.

In the previous work [6], we have proposed the asymmetrical parallel-coupled microstrip bandpass filter. It can be seen that the asymmetrical parallel coupled-lines have notches closed to the resonance and the first spurious frequencies of the proposed resonator. These odd- and even-mode responses will certainly affect the resonator characteristics, resulting in bandstop responses. In this paper, a narrow transverse slit is represented as the series inductance [7]. The effective inductive compensation technique to improve the directivity of the parallel coupled microstrip [8]. As the application of this structure, a new broad band harmonic suppression filter. This filter can be controlled by the variation of the depth and width of the slit.

![Figure 1](image-url)

Figure 1 (a) A conventional resonator, (b) the proposed ASIR with $L_1 = 50$ mm, $L_{11} = 20$ mm, $L = 6.5$ mm, $W = 0.5$ mm, $W_1 = 20$ mm, $G = 0.25$ mm and (c) the equivalent circuit.
2. Bandstop Characteristic

Fig. 1 (a) shows a conventional asymmetric stepped impedance resonator (ASIR) from the literature [6]. The proposed ASIR composed of a microstrip line loaded with triangular and rectangular ends by using narrow transverse slit as shown in Fig. 1 (b). Its equivalent circuit is shown in Fig. 1 (c). The proposed resonator has an inherent bandpass characteristic with the fundamental resonance frequency at 0.95 GHz. Two resonators can be formed to be an asymmetrical parallel coupled-line, supporting the odd- and even-modes. The IE3D has been then employed to evaluate the characteristics of the coupled-lines when exciting in the odd- and even-modes, respectively, resulting in the frequency responses ($S_{21}$) as demonstrated in Fig. 2 (a) for the rectangular-rectangular and Fig. 2 (b) for triangle-triangle coupled-lines, respectively. It can be seen that the asymmetrical parallel coupled-lines have notches closed to the resonance and the first spurious frequencies of the proposed resonator. These odd- and even-mode responses will certainly affect the resonator characteristics, resulting in bandstop responses, therefore, superior suppression of the spurious response in the upper stopband could be obtained when they have been applied for the proposed bandpass filter.

![Figure 2](image1)

Figure 2 Frequency responses ($S_{21}$) of the proposed asymmetrical parallel coupled-lines with odd- and even-mode excitations (a) rectangular-rectangular and (b) triangle-triangle couplers.

3. Filter Design and Measured Results

The filter is an example of a four-resonator parallel-coupled line bandpass filter, which consists of the proposed microstrip ASIRs, as illustrated in Fig. 3(a). The filter has been designed on an RT/Duroid 4003 substrate with a relative dielectric constant of 3.38 and a thickness of 1.524 mm. The four-resonator parallel-coupled line Chebyshev bandpass filter with a 0.1 dB ripple level has been designed with the given specifications. The center frequency of the filter is 0.95 GHz. In order to determine the physical dimensions of the filter, the external quality factor $Q_e$ and the coupling coefficient are calculated [9].

![Figure 3](image2)

Figure 3 (a) Layout of the designed filter and (b) a photograph of the fabricated four-resonator parallel-coupled bandpass filter using the narrow transverse slit.
The resonator layout parameters have been obtained in the following: \( L_1 = 50 \text{ mm} \), \( L_{11} = 20 \text{ mm} \), \( L = 6.5 \text{ mm} \), \( W_1 = 20 \text{ mm} \), \( W = 0.5 \text{ mm} \), \( S_{12} = 0.25 \text{ mm} \), \( S_{23} = 0.8 \text{ mm} \), \( S_{34} = 0.25 \text{ mm} \) and \( G = 38 \text{ mm} \). Fig. 3(b) shows a photograph of the fabricated filter. The fabricated filter has been then measured on an Agilent 8719ES network analyzer, resulting in measured and theoretical performances as shown in Fig. 4. We can notice that the measured result has a slight deviation in the center frequency and bandwidth. Also from the measured data, we found that the passband insertion loss is approximately 2.9 dB at the center frequency of 0.95 GHz, which is mainly due to the substrate loss and conductor loss of copper. The passband return loss is greater than 20 dB. The proposed filter exhibits a wide upper stopband from 0.5 to 13.5 GHz. With this new structure, it is significant that the stopband rejection of the filter is better than 40 dB from 1 to 10 GHz caused by the bandstop characteristic of the asymmetrical parallel coupled-line structures of the proposed resonator.

Figure 4 Comparison of measured and simulated responses of the four-resonator parallel-coupled line bandpass filter.

4. Conclusions

This paper proposed a modified ASIR with narrow transverse slit for improving stopband characteristics. The bandpass filter has been designed at the operating frequency about 0.95 GHz. The proposed have a low insertion loss with a width upper stopband characteristic that the spurious suppression of better than 40 dB has been measured for a frequency range up to \( 10f_0 \). The measured responses have good agreement with simulation expectations.

References


