IMPROVEMENT OF MICROSTRIP BAND PASS FILTER HARMONIC SPURIOUS SUPPRESSION PERFORMANCE USING BAND STOP FILTER FEED LINES

Somchat Sonasang[1] and Ravee Phromloungsri[2]

[1]Department of Electronic Technology, Faculty of Industrial Technology, Nakhon Phanom University, Nakhon Phanom, Thailand.

[2] Department of Computer and Communication Engineering (CCE), Faculty of Technology, Udon Thani Rajabhat University, Udon Thani, Thailand

ABSTRACT

In this paper, a simple design technique to suppress the 2nd harmonic frequencies spurious responses of microstrip band pass filter (BPF) is presented. The technique is accomplished by using the parallel-coupled lines band stop filter (BSF) operating at $2f_0$ frequency as feed lines. The practicable feasibility of the technique is demonstrated by the 3rd order microstrip coupled line bandpass filter at 1.8 GHz with the 3.6 GHz coupled line band stop filters feed lines on AD600 microwave substrate. The experimental results of the proposed 1.8 GHz bandpass filters were evidently shown the spurious suppression improvement more than 30 dB at $2f_0$.

KEYWORDS: microstrip band pass filter, harmonic spurious suppression, band stop filter feed lines

1. Introduction

In the RF front-end of modern communication systems, the BPF with wide stop band and high selectivity are usually required to enhance the overall system performances. Over the past 30 years, microstrip filter based parallel coupled lines has been one of the most commonly used filters, due to its planar structure, ease of synthesis method, and low cost [1]. These lead the parallel coupled lines structure in microstrip and stripline technologies are very particular employed for the implementations of the BPF and BSF with required bandwidths up to 20% of the center frequency [2]. The main problem of the microstrip parallel-coupled lines bandpass filter is the suffering from the spurious responses at $2f_0$, twice the passband frequency, which may seriously degrade the attenuation level in the stopband and passband response symmetry [3.[These complication results from the lack of even- and odd-mode phase velocities of each coupled section in the microstrip filter. Usually, BPF circuits are designed with quarter-wavelength $(\lambda/4)$ coupled lines, variety shape of closed or open loop resonators, coupled lines stubs, transmission line stub and etc [4].

In this paper, capability improvement of microstrip BPF for harmonic spurious suppression using BSF feed lines as shown in Figure 1. is proposed. The proposed BPF and BSF feed lines were designed and implemented at 1.6 GHz and 3.6 GHz, respectively. The paper is organized as follows: Section II presents proposed the microstrip BPF with improvement the harmonic spurious suppression based on BSF feed lines. Section III presents the design and experimental results and the paper is finally concluded in Section IV.

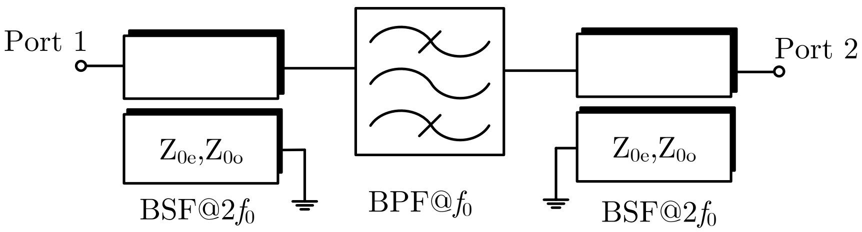

Figure 1 Proposed schematic diagram microstrip BPF BSF using coupled lines feed

2. Theory

2.1 Band Stop Filter Feed Lines

The BSF are significant devices in microwave frequency and millimeter-wave applications to reject higher harmonics and spurious passbands [5]. The microstrip parallel coupled lines are widely used for implementing microstrip filter, Figure 2 (a) schematics of the BSF feed microstrip coupled lines was proposed. Simulations of the proposed topology are performed. Figures 2 (b) simulated results of frequency response were insertion loss (S_{21}) and return loss (S_{11}) performances of the proposed BSF feed lines. Maximum coupling to the BSF resonator is achieved when only for $\lambda/4$ length of the resonator is microstrip parallel coupled line. The general parallel coupled-lines of BSF design in [1, 5]

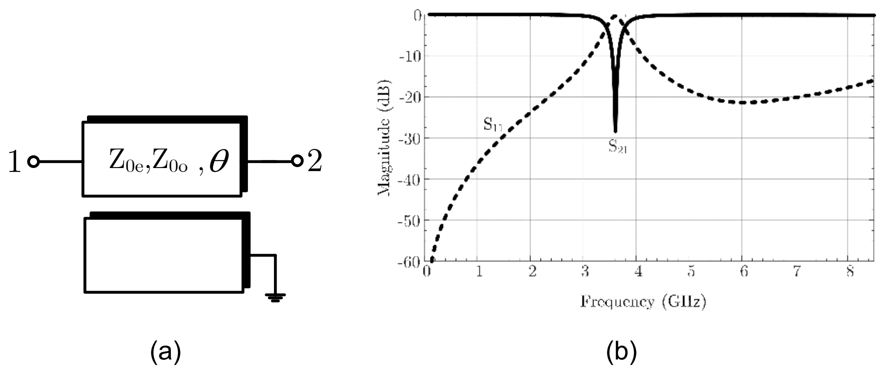

Figure 2 (a) Schematic BSF based on coupled lines and (b) Simulated S-parameters

2.2 BPF

Normally, microstrip band pass filter [1, 5] as shown in Figure 3 (a) as well as microwave resonator, power combiner/splitter [6], are design and implement by using quarter-wavelength ($\lambda/4$) parallel coupled lines. Figure 3(b) shows the frequency response (S_{21}) and return loss (S_{11}) performances of the conventional BPF without the BSF feed lines. Obviously, the BPF with microstrip parallel coupled lines structure itself suffered from spurious responses located at twice of the fundamental frequency f_0.

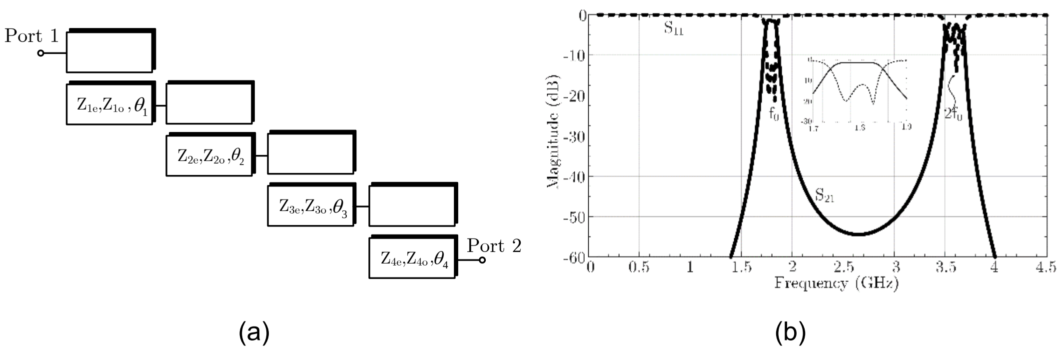

Figure 3 (a) Schematic BPF and (b) S-parameters of Conventional BPF

These spurious responses cause asymmetry of frequencies response either in the upper of the BPF transition bands. Another major limitation from the parallel coupled lines structure is the weak coupling due to its lateral coupling between the lines in inhomogeneous media [7]., which lead the odd-mode phase velocity faster than the even-mode value [8].

3. Design and Experimental Results

To prove the validity of the technique for the harmonic spurious suppression performance of microstrip BPF with BSF feed lines, the filter prototype is a third-order Chebyshev bandpass filter designed at center frequency (f_0) of 1.8 GHz, fractional bandwidth (Δ) of 5%, and passband ripple of 0.1 dB. The circuits were designed and fabricated on the AD600 substrate from RT/duroid. The schematic of BPF with BSF feed lines is shown Figure 4. The BSF feed lines were designed and implemented by employing the coupled lines with -10 dB voltage coupling factor at 3.6GHz, which is twice the center frequency of BPF with the follow design parameters, $\varepsilon_r = 6.15$, $H = 1.52\text{mm}$, and $\tan\delta = 0.003$. The BPF were designed and implemented with the section coupled lines of $\lambda/4$ wavelength at the centre frequency at 1.8 GHz, electrical parameters of each coupled lines sections were listed in Table 1. Where Z_0 is characteristic impedance (50 ohm), Z_{ne} is the even-mode characteristic impedance, and Z_{no} is the odd-mode characteristic impedance of the parallel coupled lines, respectably. The proposed circuit is consisted of six coupled lines from n=0 to n=5, where coupled lines n= 0 is the BSF feed lines connected to the input and output ports, while the coupled n=2 to n=5 denoted the coupled lines of the conventional BPF. The design and simulation process were done by using Sonnet Lite™ [9]. It is obviously shown in Figure. 5 that, microstrip BPF harmonic spurious suppression performance were improved by employing the BSF based coupled lines as the feed lines at input and output ports. The measured results were obtained from Vector network analyser E5063A ENA from KEYSIGHT Technology calibrated from 0.1 to 4.5 GHz. Sonnet-Lite™ and Matlab® were used for simulation, data processing, and display.

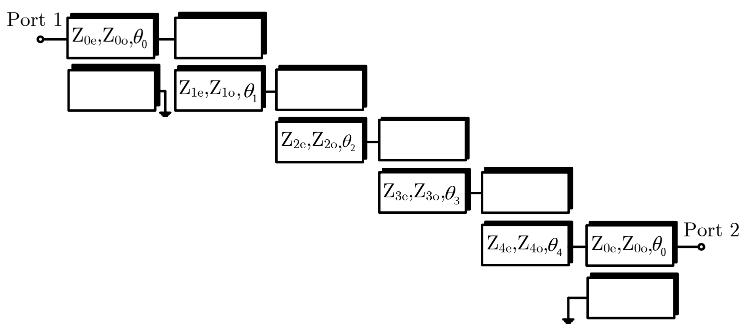

Figure 4 Schematic of the proposed BPF with BSF coupled lines feeds for harmonic spurious suppression

Table 1 Parameters of the designed BPF with BSF for harmonic spurious suppression

Coupled lines N	Electrical parameters	W, S, L (mm)
Section 0,5	$Z_{0e} = 69.37\Omega$, $Z_{0o} = 36.03\Omega$, $\theta_0 = \pi/2$	1.86, 0.39, 10.01
Section 1	$Z_{1e} = 67.94\Omega$, $Z_{1o} = 39.55\Omega$, $\theta_1 = \pi/2$	1.84, 0.58, 20.6
Section 2	$Z_{2e} = 57.70\Omega$, $Z_{2o} = 50.6\Omega$, $\theta_2 = \pi/2$	1.88, 2.96, 19.95
Section 3	$Z_{3e} = 57.70\Omega$, $Z_{3o} = 50.6\Omega$, $\theta_3 = \pi/2$	1.88, 2.96, 19.95
Section 4	$Z_{4e} = 67.94\Omega$, $Z_{4o} = 39.55\Omega$, $\theta_4 = \pi/2$	1.84, 0.58, 20.6

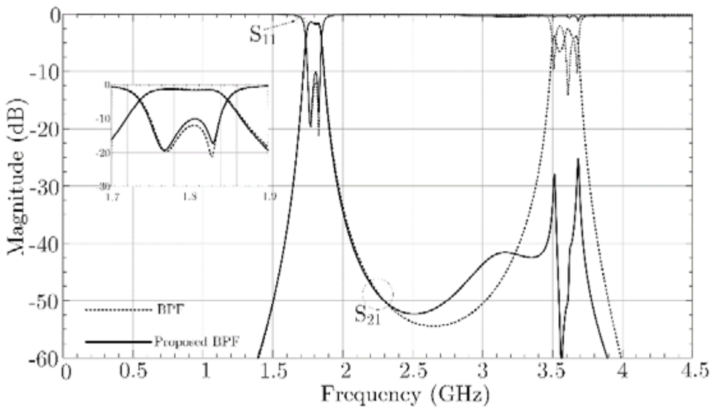

Figure 5 EM simulated results of the proposed BPF with BSF for harmonic spurious suppression

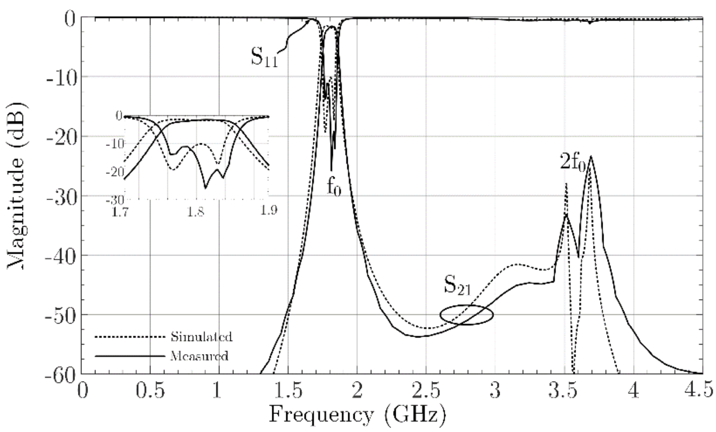

Figure 6 Measured results of the proposed BPF with BSF for harmonic spurious suppression

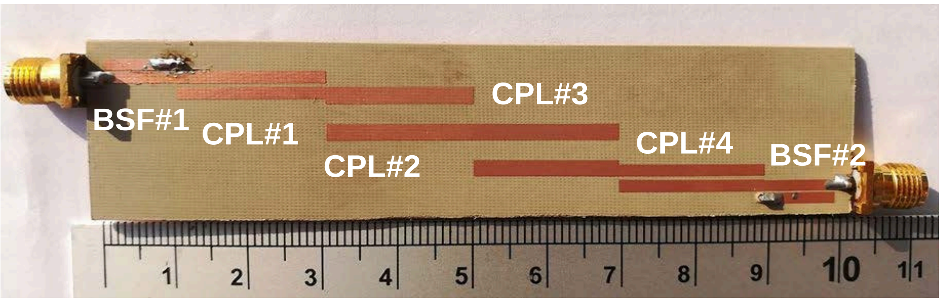

Figure 7 **PCB of the proposed BPF with BSF for harmonic spurious suppression**

The proposed BPF achieved less than 1.77 dB insertion loss (S_{21}) and better than 20.30 dB input and output return loss (S_{11}) performances at the centre frequency 1.8 GHz, as shown in Figure 6. More than 30 dB suppression of spurious response at $2f_0$ is obtained from the proposed band pass filter. The total size of the proposed BPF coupled lines filters with BSF feed lines is 20×85 mm^2 as shown in Figure 7.

4. Conclusions

The paper presented a simple method to suppress harmonics spurious response of bandpass filter based microstrip parallel-coupled lines. This is achieved by employing the BSF feed lines operating at $2f_0$ frequency band connected to input and output ports of the conventional filter. The proposed bandpass filter evidently shows the high spurious suppression performances in the wide range of stopband frequency response. The proposed BPF are suitable to use in many wireless and microwave applications.

Acknowledgement

The authors are grateful to Faculty of Industrial Technology, Nakhon Phanom University (NPU) and Research and Development Institute (RDI), NPU for financially supported, Department Electronic Technology, Faculty of Industrial and Technology. Department of Electronic Technology for supporting the tools measurement.

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Author’s Profile

Somchat Sonasang was born in Nong Bua Lam Phu, Thailand, in 1982. He received the B. Eng degree in Electronic and Telecommunication from Rajamangala University of Technology Isan (RMUTI), Nakhon Ratchasima, Thailand, in 2006, and the M.Eng degree in Electrical Engineering from Khon Kaen University (KKU), Khon Kaen, Thailand, in 2013. Since 2017-Present, Lecturer with the Department of Electronic Technology, Nakhon Phanom University (NPU), Nakhon Phanom, Thailand. Email: somchat.s@npu.ac.th. His current research interests include microwave circuits and nondestructive test.

Ravee Phomlungsri was born in Khon Kaen, Thailand. He received the B.Sc. degree in applied physics in solid-state electronics from the King Mongkut Institute of Technology, Ladkrabang (KMITL), Thailand, in 1992, the M.Eng. degree in electrical engineering (telecommunication) from Mahanakorn University of Technology (MUT), Bangkok, Thailand, in 2000, and is currently working toward the D.Eng. degree in electrical engineering in MUT. 1992-2009, he has been a Lecturer with the Department of Telecommunication Engineering, and a member of the Research Center of Electromagnetic Waves Applications (RCEWs), MUT. Since 2009-Present, Lecturer with the Department of Computer and Communication Engineering, Udon Thani Rajabhat University, Udon Thani, Thailand. His research and teaching interests include electronic design, microwave passive/active and RF circuits design.