BANDPASS PERFORMANCE OF THE SHORT-CIRCUITED QUARTER-WAVELENGTH PARALLEL-COUPLED LINE EXCITED BY THE SLOT-LINE RESONATOR

Hon-Kuan,[1] Min-Hang Weng,[2] Ru-Yuan Yang,[3] and Wen-Lang Chen[1]
[1] Department of Technology Electro-Optical Engineering, Southern Taiwan University, Taiwan
[2] National Nano Device Laboratories, Taiwan
[3] Department of Material Engineering, National Pingtung University of Science and Technology, Pingtung, Taiwan; Corresponding author: ruyuan.yang@gmail.com

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ABSTRACT: *In this article, a wideband bandpass performance of the short-circuited quarter-wavelength parallel-coupled line excited by the slot-line resonator (SLR) is proposed. The filter performance is characterized based on the even and odd-mode analysis of the microstrip parallel-coupled line. And the coupling consideration between the short-circuited quarter-wavelength parallel-coupled line and the SLR is also discussed for obtaining the proper wide passband response. With the multiple transmission zeros, the designed filter exhibits an improved passband selectivity and a good out-of-band performance. Predicted results are confirmed by the experiment.* © 2008 Wiley Periodicals, Inc. Microwave Opt Technol Lett 51: 301–303, 2009; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.24026

Key words: *parallel-coupled lines; transmission zeros; bandpass filter (BPF)*

1. INTRODUCTION

Recently, the design of bandpass filters (BPFs) with large fractional bandwidths (FBWs) is highly required since the use of wideband communication systems for indoor/outdoor use is increased [1]. Because of the simple design procedure, the technology of parallel-coupled lines has been widely used in the development of microwave BPF in [2–5]. However the parallel-coupled lines filters with large FBW are difficult to realize due to the small coupling between the resonators. The etched slots in the ground plane of the parallel coupled lines can significantly increase the tight coupling for large FBW as shown in [6–8]. Moreover, a compact wideband parallel coupled BPF is presented in [9], which uses two microstrip parallel-coupled lines coupled to a single coplanar waveguide (CPW) resonator with only a quarter-wavelength long on the other side of a common substrate. The performance of the disclosed filter is obtained and improved by the electromagnetic (EM) simulation [8, 9]. However, the generation of the wideband performance is not described in detail.

In this article, we investigate the bandpass performance of the short-circuited quarter-wavelength parallel-coupled line excited by the slot-line resonator (SLR). The short-circuited quarter-wavelength parallel-coupled line of the proposed filter is characterized first by means of the even- and odd-mode analysis. Furthermore, the procedure for generating the bandpass response excited by using SLR with different wavelength is discussed for optimized bandpass design. Finally, a wideband BPF, as shown in Figure 1, can be deigned with good passband selectivity and out-of-band performances and experimented to verify the design concept.

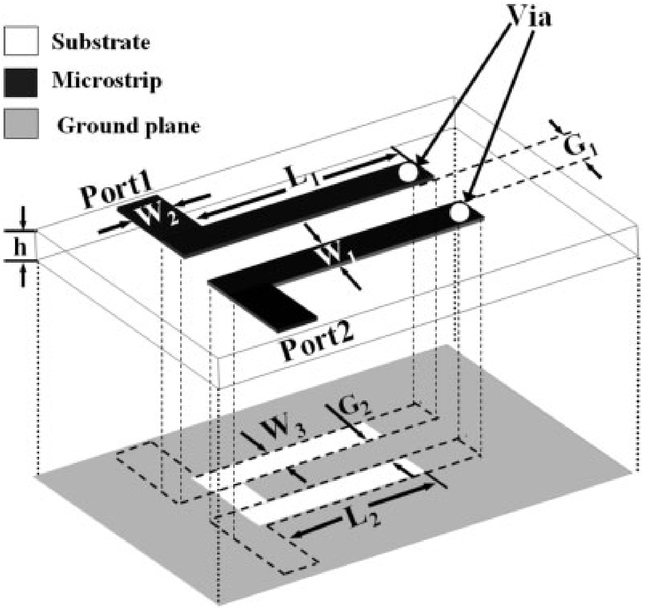


Figure 1 Configuration of the proposed bandpass filter using the short-circuited parallel-coupled lines and slot-line resonator on the other side of a common substrate

2. FILTER STRUCTURE AND DESIGN PROCEDURE

Figure 1 depicts the schematic of the proposed BPF. This filter mainly has two short-circuited quarter-wavelength parallel coupled lines on the top surface of the substrate and a single SLR coupled to the two parallel lines on the other side of the common substrate. The characteristic for the transmission zeros of the short-circuited parallel coupled lines is derived from the classical analysis of even- and odd-mode excitation. Figure 2 (a) shows the general equivalent circuit of the parallel coupled lines with the load Z_L at one end. The even- and odd-mode input impedances Z_{ine} and Z_{ino} are given as [10]:

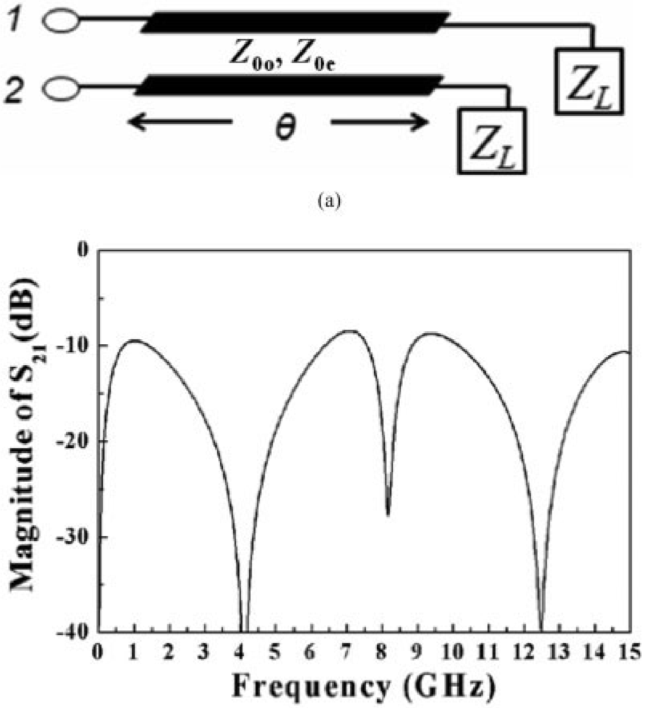
$$Z_{ine} = Z_{0e}\frac{Z_L + jZ_{0e}\tan\theta_e}{Z_{0e} + jZ_L\tan\theta_e} \tag{1}$$

$$Z_{ino} = Z_{0o}\frac{Z_L + jZ_{0o}\tan\theta_e}{Z_{0o} + jZ_L\tan\theta_o} \tag{2}$$

where Z_{0e} and Z_{0o} are the characteristic impedances of the coupled lines, θ_e and θ_o are the electrical lengths for even- and odd-mode excitations, respectively. The condition for the transmission zero, namely $S_{21} = 0$, is $Z_{ine} = Z_{ino}$. As $Z_L = 0$, the condition for obtaining the location of transmission zeros of the shorted parallel-coupled line is:

$$Z_{0e}\cot\theta_o = Z_{0o}\cot\theta_e \tag{3}$$

For obtaining the good stopband performance of the proposed filter, the electrical length of the microstrip parallel-coupled lines with short-circuit is equivalent to quarter-wavelength since the structure can exhibit all-stop response with multiple transmission zeros [10]. In our design, the proposed filter is implemented on the RT/Duroid 5880 with a dielectric constant of $\varepsilon_r = 2.2$, a loss tangent of 0.002, and a thickness h of 0.787 mm. The input/output ports are all designed for 50 Ω. When the circuit parameters are $L_1 = 14.3$ mm, $W_1 = 0.4$ mm, $W_2 = 2.4$ mm and $G_1 = 0.4$ mm, as shown in Figure 1, the characteristic impedances Z_{0e} and Z_{0o} of the



(a)

(b)

Figure 2 (a) The equivalent circuit of the coupled lines with a load at one end and (b) the simulated S_{21}-magnitude of the short-circuited quarter-wavelength parallel-coupled line. (The circuit parameters are $L_1 = 14.3$ mm, $W_1 = 0.4$ mm, $W_2 = 2.4$ mm, and $G_1 = 0.4$ mm, as shown in Fig. 1)

shorted parallel-coupled line with quarter-wavelength at 8 GHz are selected to be 159.73 and 90.01 Ω, respectively. The full wave EM simulator IE3D [11] is used for characterizing the frequency response. Figure 2(b) shows the frequency response of the shorted parallel-coupled line with quarter-wavelength long at 8 GHz. It is clearly observed that the multiple transmission zeros appeared at 4, 8, and 12 GHz. Furthermore, the coupling between the short-circuited quarter-wavelength parallel-coupled line and the SLR with different electrical lengths is shown in Figure 3. In this design, the width and gap of the SLR are equal to those of two parallel coupled lines for simplifying the design. Namely, $W_1 = W_3 = 0.4$ mm, and $G_1 = G_2 = 0.4$ mm. The simulated result exhibits that when the electrical length of the SLR is 90° or 270° at 8 GHz, the passband response cannot be obtained. However, when the electrical length of the SLR is 180° ($L_2 = 7.5$ mm) at 8 GHz, a passband response can be excited. Additionally, it is noted that two transmission zeros at the passband edges can be obtained to improve the passband selectivity. It is verified that based on this characteristic of the all stop-response of the short-circuited quarter-wavelength parallel-coupled line, the good out of band rejection of the proposed filter can be obtained.

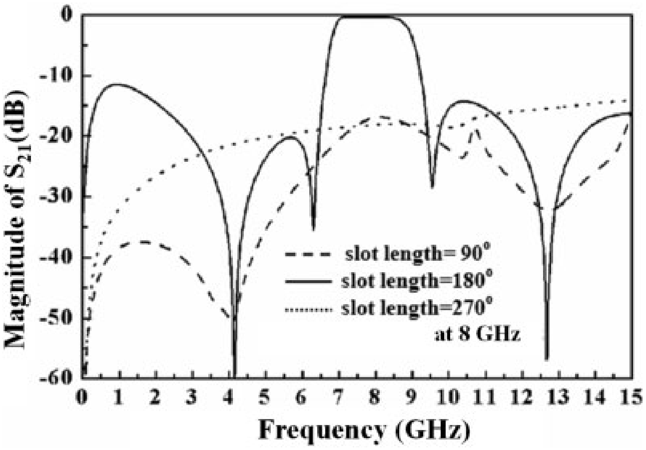
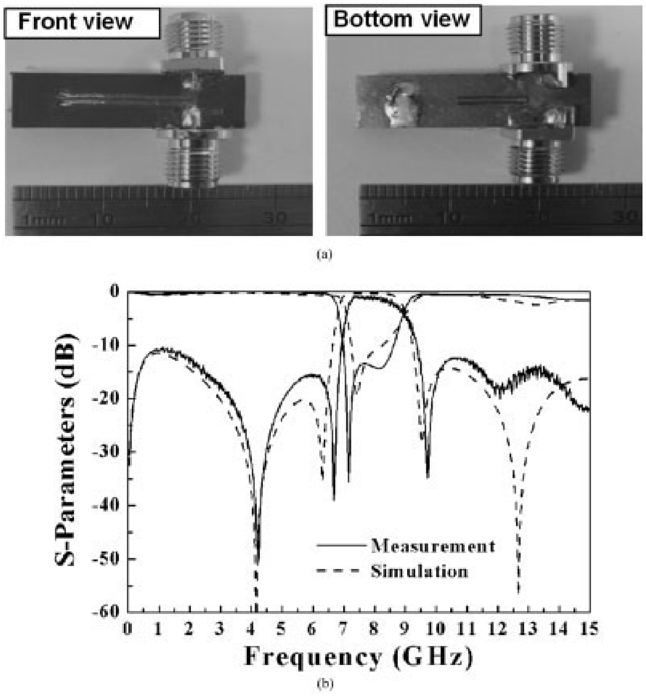


Figure 3 Simulated S_{21}-magnitude of the parallel-coupled lines coupled with the slot-line resonator on the other side of a common substrate with different slot lengths

3. EXPERIMENTAL RESULTS AND DISCUSSION

The proposed filter is then fabricated and measured by an HP8510C Network Analyzer. The photographs of the fabricated filter, including the front and bottom views, are shown in Figure 4(a). The fabricated filter occupies a small size, around 7 mm × 14.3 mm, which is only about 0.25 $\lambda_g \times 0.52\ \lambda_g$ at 8 GHz, where λ_g is guided wavelength at the designed center frequency. The comparison between the measured and simulated results is displayed in Figure 4(b). The measured results of the fabricated filter have a central frequency f_0 of 7.97 GHz, a minimum insertion loss of 1.44 dB, and a 3-dB FWB of 21.1%. Moreover, it is clearly observed that the transmission zeros are located at 4.14, 6.3, and 9.53 GHz, respectively, which result in good passband selectivity and out-of-band performances with a 10 dB rejection below 7.45 GHz and above 9.35 GHz for the fabricated filter. Measured results are slightly different from the simulated results, due to the some mismatch of the fabricated filter. The mismatch could be attributed to a misalignment between the top and bottom patterned circuits during the fabrication [9].



(a)

(b)

Figure 4 (a) The photographs of the fabricated device and (b) the comparison between the simulated and measured results of the proposed wideband BPF. (The circuit parameters are $L_1 = 14.3$ mm, $L_2 = 7.5$ mm, $W_1 = W_3 = 0.4$ mm, $W_2 = 2.4$ mm, and $G_1 = G_2 = 0.4$ mm, as shown in Fig. 1)

4. CONCLUSIONS

In this article, we investigated a wideband bandpass performance of the short-circuited quarter-wavelength parallel-coupled line excited by the SLR. The short-circuited quarter-wavelength parallel-coupled line of the proposed filter is characterized first by using the even- and odd-mode analysis. Furthermore, the procedure for generating the bandpass response excited by using SLR with different wavelength is discussed for optimized bandpass design. The measured results of the fabricated filter have a central frequency f_0 of 7.97 GHz, a minimum insertion loss of 1.44 dB, and a 3-dB FBW of 21.1%. Moreover, with the multiple transmission zeros generated by the microstrip parallel-coupled lines, a wideband BPF can be deigned with a good passband selectivity and an out-of-band performance. Therefore, the proposed filter has a good potential for implementing in the wideband wireless system after further optimizing the design.

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AN UWB SPIRALLY RIDGED ANTENNA FOR HIGH DIRECTIVE CP RADIATIONS

Hsi-Tseng Chou and Li-Ruei Kuo
Department of Communications Engineering, and Communications Research Center, Yuan Ze University, Chung-Li, Taiwan;
Corresponding author: hchou@saturn.yzu.edu.tw

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ABSTRACT: *A broadband antenna designed to radiate high directive circularly polarized radiations is presented. This design utilizes spiral arms to achieve a broad frequency bandwidth and radiates circularly polarized fields. To enhance the directivity, the spiral arms are axially elevated to have a radiation beamwidth narrower than that radiated from an analogous spiral antenna in the upward direction. This antenna is suitable for many microwave applications.* © 2008 Wiley Periodicals, Inc. Microwave Opt Technol Lett 51: 303–305, 2009; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.24040

Key words: *broadband antenna; circular polarization; spiral arms and directivity enhancement*

1. INTRODUCTION

This article presents a broadband antenna that radiates circularly polarized fields with higher directivity as interested in many microwave applications. The design is inspired by the spiral antenna [1] configurations that are capable of simultaneously achieving a wide bandwidth and producing a circular polarization (CP). It comprises two spirally rotating ridges with a gradually enlarged opening [1, 2]. This antenna configuration leads to high directivity and a wide CP bandwidth, and overcomes the gain limitations on spiral antennas. This new design may use a same feeding structure as on an ordinary spiral antenna [3, 4], and thus inherits its radiation characteristics with an additional directivity improvement. The expected performance characteristics include wide CP bandwidth, high directivity, and high gain.

In this article, Section 2 summaries the antenna structure and its design equations. Radiation characteristics are investigated in Section 3 using numerical simulations and experimental measurements. Finally, a short remark is discussed in Section 4 as a conclusion.

2. ANTENNA DESIGN SCENARIO

The configuration is inspired by both spiral- and ridged-horn antennas. As illustrated in Figure 1, its projection on a *x–y* plane exhibits two spiral curves with one described by [5, 6]

$$r = a^{\theta}, \tag{1}$$

where a is an exponential rate. Note that θ in (1), measured from x-axis, increases from 0 to $\theta_{\max}$, which can be as large as one prescribes. In particular, $\theta_{\max}$determines the horizontal diameter, d, of the antenna on the *x–y* plane. The second arm is determined by rotating the first arm with an angle of π. Thus, the first arm's coordinates in a rectangular coordinate system can be expressed as

$$\begin{cases} x = r\cos\theta \\ y = r\sin\theta \end{cases}. \tag{2}$$

Note that (1) and (2) with a zero z-coordinate are previously used to design an ordinary spiral antenna. This current design introduces a z-coordinate by

$$z = \frac{\theta \cdot h}{\theta_{\max}}, \tag{3}$$