COMPACT DUAL-MODE MICROSTRIP RESONATOR FOR 900 MHz BANDPASS FILTER APPLICATIONS

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ABSTRACT: *A novel dual-mode microstrip filter operating at 900 MHz is proposed using degenerate modes of a microstrip-loop resonator. The resonator structure that is formed of meandered microstrip-line elements has a smaller size than the other dual-mode microstrip resonators in the literature. The dual-mode filter is verified by both simulation and measurement.* © 2005 Wiley Periodicals, Inc. Microwave Opt Technol Lett 45: 376–377, 2005; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.20828

Key words: *dual-mode resonator; microstrip filter; miniaturization*

INTRODUCTION

Modern microwave communications systems such as satellite- and mobile-communications systems require compact size, high performance, and low-cost bandpass filters. Therefore, dual-mode microstrip filters have been widely used in wireless-communications systems because of their advantages in applications requiring high-quality narrowband microwave bandpass filters with features such as small size, low mass, and low loss. Many authors [1–3] have proposed dual-mode resonators for miniaturization of dual-mode microstrip filters. However, the present dual-mode resonator configurations occupy still a fairly large circuit area, which is not quite suitable for low-frequency bands, such as the 900-MHz band of the general-packet radio service (GPRS), where miniaturization is an important factor. Therefore, it is desirable to develop new types of dual-mode microstrip resonators, not only for offering alternative designs but also for miniaturizing filters.

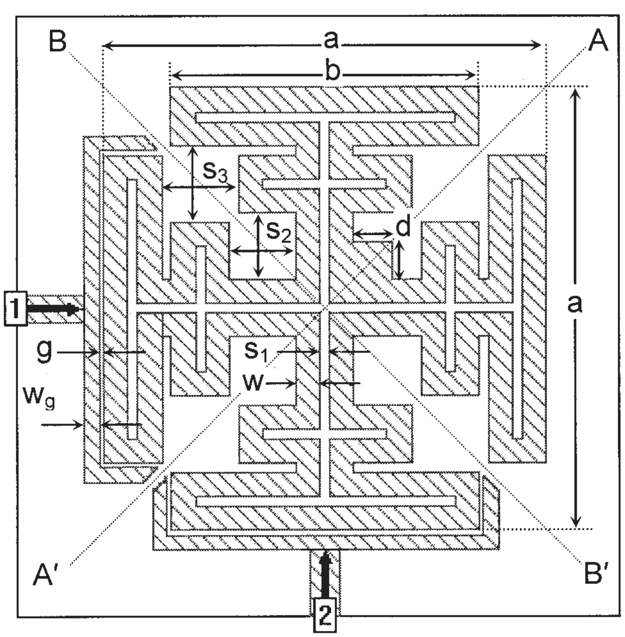

Figure 1 Proposed dual-mode microstrip resonator

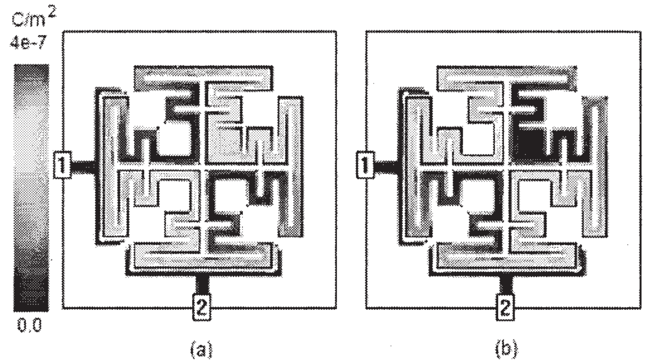

Figure 2 Simulated charge density at the resonance frequencies of degenerate modes for $d \neq 0$: (a) mode I ($f = 889$ MHz); (b) mode II ($f = 915$ MHz)

In this paper, we focus on the design of a novel dual-mode microstrip filter operating at 900 MHz, which is the most frequently used band in the current wireless communication systems. This dual-mode filter uses degenerate modes of a microstrip meander-loop resonator for maximum miniaturization. The microstrip dual-mode resonator consists of four identical arms and each arm may be considered as a microstrip meander line element, as illustrated in Figure 1. The novel filter structure has a smaller size than the other dual-mode microstrip filters [1–4], as well as easy fabrication. The dual-mode filter is verified by both simulation and measurement.

DUAL-MODE RESONATOR

Figure 1 shows the new dual-mode microstrip meander-loop resonator, which is basic element for the proposed dual-mode filter. The meander resonator consists of four identical meander microstrip lines. There is an electrical length of 90° between the input and output ports. A square perturbation element is attached to the dual-mode resonator at a symmetrical location along the symmetry plane A–A′, 135° apart from both the input and output ports. The degenerate modes are excited and coupled to each other due to this perturbation element within the meander-loop resonator. To simply our description, these modes are named mode I and mode II. It can be shown that the two fundamental degenerate modes correspond to the TM^z_{100} and TM^z_{010} modes in a square-patch resonator (where z is perpendicular to the ground plane) [3]. Figure 2 shows the charge-density patterns computed using a full-wave EM simulator [5], when the square perturbation is added ($d \neq 0$). Indeed, it can be clearly observed from these patterns that the two degenerate modes correspond to the TM^z_{100} and TM^z_{010} modes in a square-patch resonator, as mentioned above. The locations of the poles along the symmetry plane A–A′ and zeros along the symmetry plane B–B′ of mode I for $d \neq 0$ are rotated by 90° from those of mode II.

To observe the mode splitting, a dual-mode resonator has been simulated using a full-wave EM simulator [5] with different perturbation size d. Figure 3 shows the simulated split-resonance frequencies of the degenerate modes of the meander-loop resonator with different perturbation sizes. The split between the modes also increases as the perturbation size d increases. Without perturbation ($d = 0$), only the single mode is excited and, consequently, neither splitting of the resonance frequency nor bandpass response has been observed from our simulations. This situation can easily be seen from simulation results in Figure 3. In addition, the coupling coefficient k between these modes can be computed using the relationship between the split in the resonance frequency of two modes and the coupling, as described by

$$k = \frac{(f_2^2 - f_1^2)}{(f_2^2 + f_1^2)}, \tag{1}$$

where f_1 and f_2 are resonance frequencies of modes I and II, respectively. The coupling coefficient k as a function of the perturbation size d is shown in Figure 3.

The dual-mode microstrip resonator of 18.4×18.4 mm^2 operating at 900 MHz has the smallest size, with a size reduction of about 70% as compared with the dual-mode microstrip loop resonator [4] having a surface area of 33.8×33.8 mm^2. The size reduction is 35% versus that of the dual-mode microstrip resonator with open-loop arms [3] having a surface area of 22.8×22.8 mm^2 at the same center frequency.

DUAL-MODE FILTER

The dual-mode microstrip bandpass filter was fabricated on an RT/Duroid substrate having a thickness of 1.27 mm and a relative dielectric constant of 10.2. The filter was designed and simulated using a full-wave EM simulator [5]. The filter dimensions are a = 18.4 mm, b = 12.8 mm, w = 1 mm, w_g = 0.6 mm, g = 0.2 mm, d = 1.2 mm, s_1 = 0.4 mm, s_2 = 2.8 mm, and s_3 = 3.2 mm. Figure 4 shows the simulated and measured frequency responses. The simulated bandwidth is about 2.4% at the center frequency of 900 MHz, while the measured bandwidth is 3% at the center frequency of 902 MHz. The reason for this discrepancy is that the realized coupling gaps between the feed lines and the filter circuit are somewhat different from the designed coupling gaps, due to the chemical-etching process. The minimum insertion loss is 2.4 dB, which is higher than the simulated value of 0.6 dB. The loss is due to circuit loss, including conductor and dielectric losses, as well as radiation loss. In addition to coupling gaps at the input and output ports, the coupled meander lines lead to the radiation loss. The return loss is better than 11 dB within the passband. The simulated and measured results are in good agreement. The differences between the results are again due to the fabrication tolerances. The proposed filter has attractive features, including narrower bandwidth and smaller size.

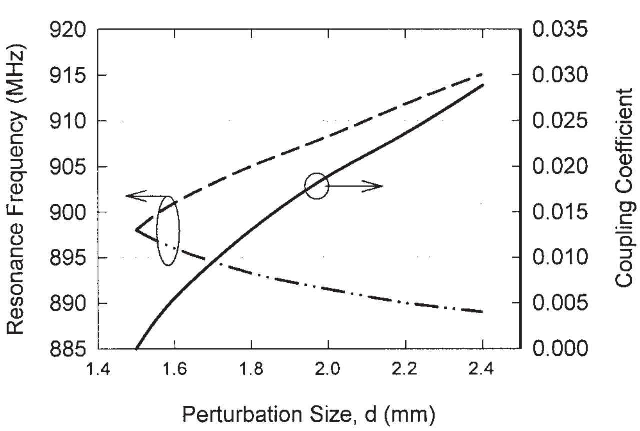

Figure 3 Simulated coupling coefficient (solid line) and two resonance frequencies of degenerate modes (mode I: dashed-dotted-dotted, mode II: dashed) vs. the perturbation size, where the resonator dimensions are a = 18.4 mm, b = 12.8 mm, w = 1 mm, w_g = 0.6 mm, g = 0.2 mm, s_1 = 0.4 mm, s_2 = 2.8 mm, and s_3 = 3.2 mm

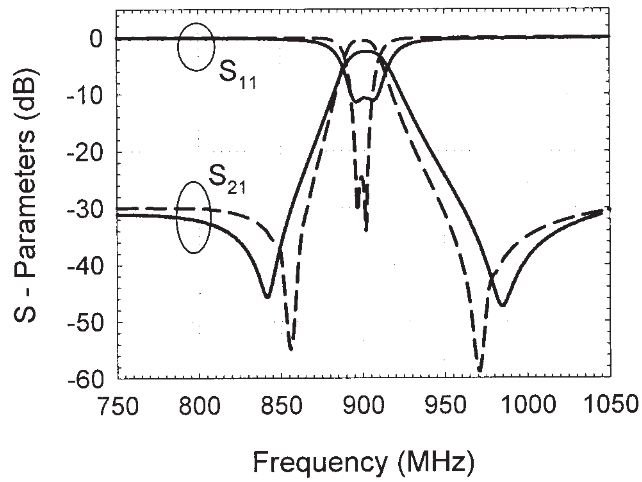

Figure 4 Simulated (dashed line) and measured (solid line) filter performances

CONCLUSION

A novel dual-mode meander microstrip resonator has been proposed for maximum miniaturization. A dual-mode bandpass filter with a 2.4% bandwidth at the center frequency of 900 MHz has been designed, simulated, and fabricated to demonstrate the application of the proposed meander-loop resonator for designing the compact microstrip filters. The simulated results have been compared with the measured data and a good agreement has been reported. Also, the filter has a size reduction of about 70% with respect to the dual-mode microstrip square-loop resonator, and 35% versus the dual-mode microstrip resonator with open-loop arms at the same center frequency.

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