A Novel Dual-mode Bandpass Filter Using U-Shaped Defected Ground Structure

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1. Introduction

In recent year, the size of the radio frequency (RF) devices and mobile communication systems continued to reduce and microstrip ring resonator has been extensively developed in the design of filters, Wolff [1] proposed a dual-mode ring resonator to develop a dual-mode microstrip bandpass filter (BPF), and in [2, 3], the feed lines (input and output) of the dual-mode microstrip resonators were arranged at 90° (or 270°) and the perturbation point is adopted inside the ring resonator at the asymmetrical location (135°).

For the radio frequency (RF) circuits, the advantages of the defected ground structure (DGS) are size reduction and harmonic response suppression [4, 5]. In this letter, unlike the adjusting of the perturbation point for previous designs, a dual-mode microstrip loop resonator using U-shaped defected ground structure (DGS) is developed to excite the degenerate modes. And the bottom is used to couple these degenerate modes of this dual-mode BPF, in addition, the ground surface is considered as a perturbation plane in this design, and the top layer is a square loop resonator.

2. Design methods

The structure of the proposed dual-mode bandpass filter is shown in Fig. 1, in which, the feed lines (two 50−Ω microstrip lines) are arranged at 180° on the top of a Al_2O_3 ceramic substrate (dielectric constant=9.8), and a microstrip loop resonator is involved. On the bottom layer (ground plane), a defected ground structure (DGS) is adopted to design this filter. The fundamental resonance is according to following equation:

$$a \approx \lambda/4 \approx \frac{c}{4f\sqrt{\varepsilon_{eff}}} \qquad (1)$$

Where f is the resonant frequency, λ is the guided wavelength, c is the velocity of light for free space, and ε_{eff} is effective dielectric constant. This filter is screen-printed on the high quality factor Al_2O_3 substrate with thickness h = 1.0 mm. Fig. 2 show the dimension of the filter, in addition, the input/output microstrip line is designed to match 50-Ω, and the detailed parameters are: a = 11.1 mm, b = 0.5 mm, c = 11.5 mm, d = 11.7 mm, e = 8.8 mm, f = 8.1 mm, and g= 7.8 mm.

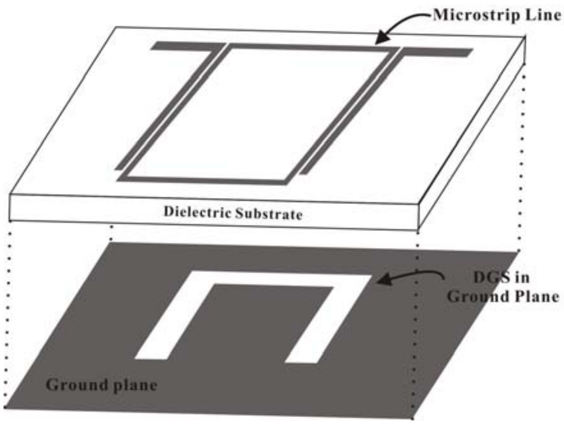

Fig. 1 Proposed dual-mode bandpass filter.

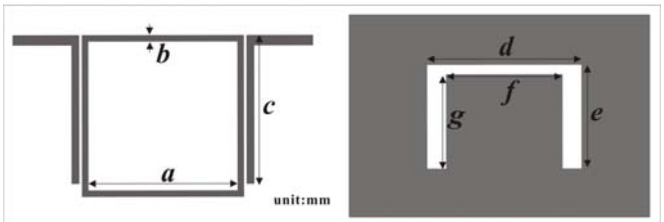

Fig. 2 The top view and bottom view of the proposed dual-mode bandpass filter.

The inference of defected ground structure (DGS) for the designed filter is shown in Fig. 3, in addition, the solid line is the frequency response (S_{21}) of the microstrip loop resonator with no DGS is added, however, the dashed line is the frequency response (S_{21}) of the filter embed defected ground structure on the ground plane. For the filter with DGS (dashed line), the degenerate modes are coupled with each other and then induce to the generation of two transmission zeros on the both sides of the passband. However, no coupling effect could be found between these two modes as the DGS is removed (solid line).

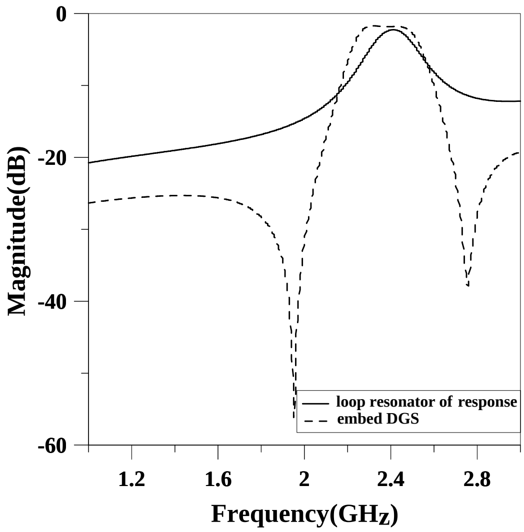

Fig. 3 The inference of the DGS for BPF design.

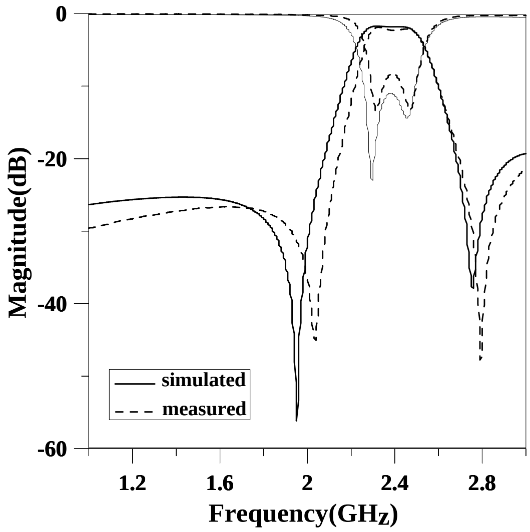

Fig.4 Simulated and measured results of the dual-mode BPF.

3. Results and Discussion

The simulated (using Ansoft HFSS9.2) and measured results (S_{21} and S_{11}) of the designed filter are shown in Fig. 4, in addition, the operated frequency of the propose dual-mode filter is designed at 2.4 GHz. For the measured results of the propose dual-mode BPF, the insertion loss of the filter is −2.3 dB (2.4 GHz), and the depths of the transmission zeros are −45 dB (2.04 GHz) and −48 dB (2.8 GHz), respectively. The measured results are good agree with the simulated ones and this filter is suitable for the applications of modern wireless communication systems. And finally, Fig. 5 shows the photograph of the proposed filter, the size of this miniature filter is only 2.4×1.9 mm.

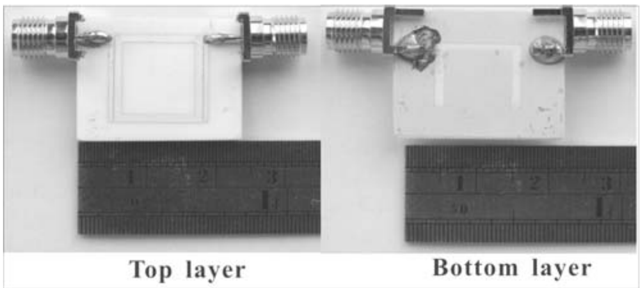

Fig. 5 Photograph of the dual-mode BPF.

4. Conclusions

In this letter, a new-type dual-mode microstrip loop resonator filter by the use of the defected ground structure was proposed, and in analysis of this design method, the ground plane was considered as a perturbation element, the excited degenerated modes are coupled with each other by the use of a defected ground structure (DGS). And this DGS has been identified as a new perturbation structure, which could improve the performance of the filter effectively.

References

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