A Dual-Mode Dual-Band Bandpass Filter with Novel Perturbation Element Using Open Loop Resonator

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***Abstract* - A novel dual-mode dual-band bandpass filter (BPF) is proposed by placing a couple of open-circuited stubs in each corner of the square loop resonator. The two degenerate modes are excited by moving the gaps between the ends of the two open stubs to obtain perturbation effect. No extra perturbation element is needed resulting in flexibility in tuning dual-mode characteristic and a compact structure. The proposed dual-mode dual-band bandpass filter operating at 1.8GHz and 4.6GHz is simulated, fabricated and measured. The 3dB fractional bandwidths are 2.5% and 4.3% for the two passbands respectively. The experimental results agree well with the predicted ones.**

***Index Terms* — Dual-mode, dual band, open-circuited stubs, square loop resonator.**

I. INTRODUCTION

The dual-band bandpass filter (BPF) has been exploited extensively with the fast development of modern multiservice communication systems. The compactness, good passband performance and high selectivity are the features designers always pursuing. Among the current design methods, dual-mode filters have been an attractive solution for dual-band applications due to its intrinsic compactness and dual-band characteristic. Different approaches in designing dual-mode dual-band filters are proposed [1]-[7].

Some dual-mode microstrip loop resonator structures were proposed in [1] by using the perturbation arrangement with square patches and corner cuts. Asymmetric perturbation in [2] shows that if the patch or cut perturbation is moved away from the symmetric plane, the two zeros will change frequencies, showing a flexible technique for realizing various passbands. In [3], either capacitive or inductive perturbation at an arbitrary position was used to design a dual-mode ring resonator. In [4], two proper degenerate modes could be generated and controlled by installing an inductive cut and a capacitive patch in the corner of two loops, respectively. The two degenerate modes of dual-mode resonators of the above filters are all excited and coupled to each other by adding different forms of perturbations on the resonator. The strength and nature of the coupling between the degenerate modes of the dual-mode resonator is mainly determined by the perturbation's size and shape.

In this paper, a dual-mode dual-band bandpass filter with novel perturbation element is proposed. A couple of open stubs are placed in each inner corner points of the square loop resonator. The designed filter using a novel perturbation arrangement without extra perturbation elements is different from the other dual-mode dual-band filter configurations in [1]-[7]. The two degenerate modes are excited by the movement of gaps between the open stubs. Measured results of a fabricated filter operating at 1.8 and 4.6GHz verify the proposed design principle.

II. PROPOSED SQUARE LOOP RESONATORS

The schematic of the proposed dual-mode dual-band bandpass filter is shown in Fig. 1.

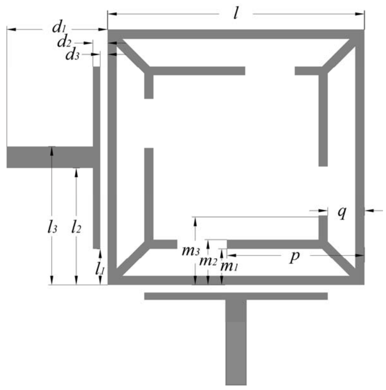

Fig. 1. Layout of the proposed dual-mode dual-band filter.

The filter is designed by placing a couple of open stubs in each inner corner points of the square loop resonator. The gaps between the open stubs are the perturbation elements and appropriate arrangement of gaps can excite the two degenerate modes of the square loop resonator. Dual passbands are obtained by controlling the harmonics of the resonator.

The equivalent transmission line model of the square loop resonator as shown in Fig. 2 is composed of two branches in parallel. The capacitance C_T is equivalent to the open circuited stubs attached to each inner corner of the loop. The input and output coupling capacitance is equivalent to C_g .

The characteristic impedance of the transmission line in each side of the square loop is Z_0 and $2\theta_0$ is the electronic length.

As we all know, an open circuited stub is equivalent to a shunt capacitance. At the open end of a microstrip line, the fields do not stop abruptly but extend slightly further due to the effect of the fringing field. By the movement of gaps between the open stubs in each inner corner of the square loop, appropriate perturbation effect can be excited and dual-mode dual-band characteristic will be achieved.

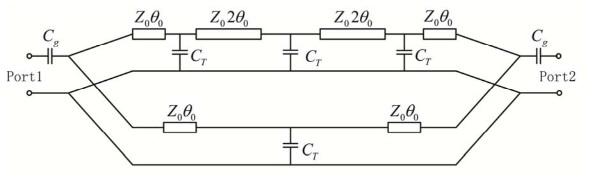

Fig. 2. Equivalent transmission line model of the proposed filter.

III. Filter design and experimental result

The proposed dual-mode dual-band filter is fabricated on a commercially available substrate with $h = 1.27$ mm and ε_r=10.2. The photograph of the fabricated filter is shown in Fig. 3a. The physical dimensions of the proposed filter are: $l = 14$ mm, $d_1 = 5.5$ mm, $d_2 = 0.8$ mm, $d_3 = 0.4$ mm, $l_1 = 2$ mm, $l_2 = 6.42$ mm, $l_3 = 7.58$ mm, $m_1 = 2$ mm, $m_2 = 2.5$ mm, $m_3 = 3.8$ mm, $p = 7.5$ mm, $q = 2$ mm. Fig. 3b and Fig. 3c show the simulated and measured frequency responses of the fabricated filter.

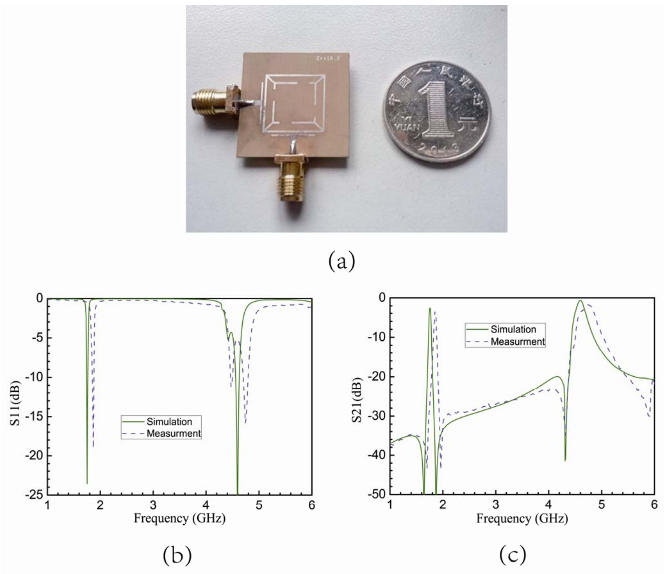

Fig. 3. (a)Photograph of the fabricated filter.
(b)Measured and simulated S11 of the proposed filter.
(c)Measured and simulated S21 of the proposed filter.

It is seen that the measured results are in good agreement with the simulated ones. The center frequencies of the two passbands are at 1.8GHz and 4.6GHz, respectively. The 3dB fractional bandwidths are 2.5% and 4.3%. The measured insertion losses are 3.5dB in the first passband and 1.1dB in the second passband, while the measured return losses in the dual passbands are both higher than 15dB. The deviation between simulation and measurement might be due to the fabrication error and unperfected ground. It can be improved by more careful fabrication and measurement technology.

The dual-mode dual-band bandpass filter performance is due to appropriate selection of the gaps between the open stubs, without extra perturbation elements. In addition, the application of the open stubs inside the square loop resonator significantly increases the length of the current path, which effectively reduces the resonance frequency and the size of the resonator. The proposed filter has smaller size as compared with the basic topology of dual-mode dual-band bandpass filters in [3], [4] and [6].

IV. Conclusion

In this paper, a compact single substrate dual-mode dual-band bandpass filter is proposed, and a new approach has been presented to design dual-mode dual-band filter with novel perturbation element. The two degenerate modes are excited by moving the gaps between the ends of the two open stubs in each corner of the square loop resonator to obtain perturbation effect. No extra perturbation element is needed resulting in flexibility in tuning dual-mode characteristic and a compact structure. The measured results prove the design principle very well. The proposed filter will be very useful for dual-band wireless applications.

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