Two-Stage Bandpass Filters Based on Rotated Excitation of Circular Dual-Mode Resonators

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***Abstract*—A new excitation method for dual-mode circular resonators is studied. The bandwidth and the frequency of attenuation poles of the resulting two-stage bandpass filter (BPF) are determined by the angle between I/O ports. Addition of a shunt susceptance at the I/O ports gives an independent control of the bandwidth.**

I. Introduction

THERE are many kinds of circular dual-mode filters, e.g., hollow waveguide, microstrip ring, coplanar ring, microstrip patch, and dielectric disk configuration. The planar type has the advantage of a low-profile structure, resulting in a wide application to monolithic microwave integrated circuits (MMIC's).

In this letter, we study a rotated excitation of resonator by the external circuits. This method was originally suggested by Wolf [1] for a microstrip ring resonator and recently applied to a circular waveguide resonator by Moretti *et al.* [2]. But the important thing they did not point out is that it is applicable to any type of circular resonators. We will show this by experiments for microstrip and coplanar ring resonators. Rotated excitation can control the filter bandwidth and the frequency of the attenuation poles within a certain range. A shunt susceptance is also added to control coupling constant and external Q to a larger extent. The equivalent circuit of any circular dual mode resonators can be represented by a branch line model.

II. Rotated Excitation of a Ring Resonator

Two orthogonal resonant modes can usually be coupled each other by adding a perturbation. But rotated excitation does not need it. Instead, the external circuits produce the perturbation. In this method, the coupling between two degenerate modes is decided by the angle of I/O ports without discontinuous parts in the resonator. Changing the angle of I/O ports from 90°, the coupling increases and also the attenuation poles shift. In the case of the angle $\theta > 90°$, they exist on the higher frequency side and in another case of the angle $\theta < 90°$, two attenuation poles exist on both sides of the resonant frequency f_0 as long as the coupling susceptance is capacitive. The experimental results of microstrip ring and coplanar ring bandpass filter for some patterns of the angle θ are shown in Figs. 1 and 2. As the dual-mode circular resonators are represented by a branch line model, it can be easily simulated by using a CAD. The simulation model and result are shown in Fig. 3. The results are in good agreement with experiments.

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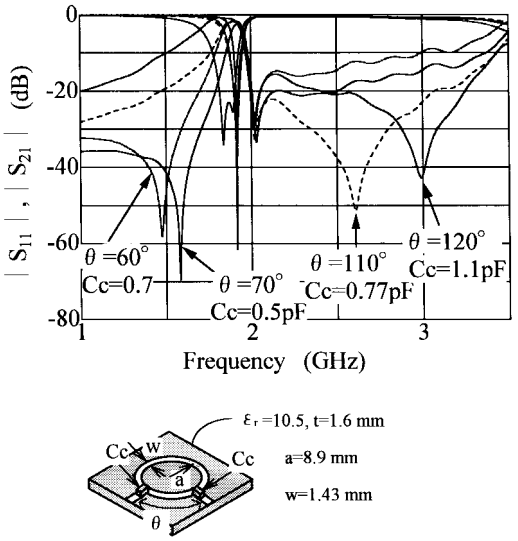

Fig. 1. Measured characteristics of dual-mode bandpass filter by rotated excitation (microstrip ring).

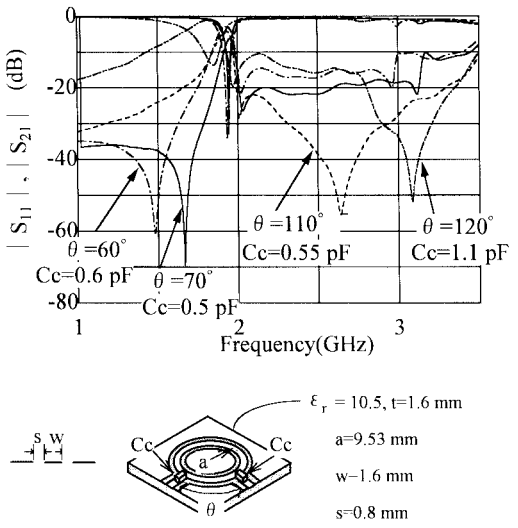

Fig. 2. Measured characteristics of dual-mode bandpass filter by rotated excitation (coplanar ring).

III. Series-Shunt Susceptance Excitation

It is important for fabricating a bandpass filter to keep the proper balance of external Q and coupling coefficient k. Addition of shunt susceptance can control external Q and

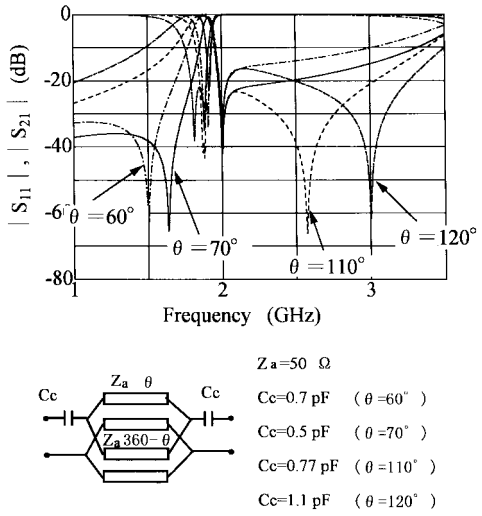

Fig. 3. Simulation characteristics of dual-mode bandpass filter by rotated excitation.

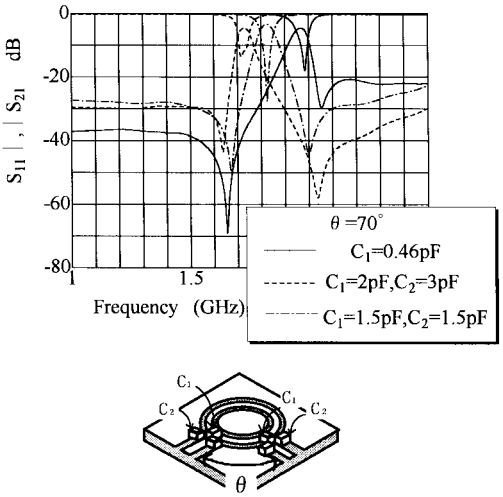

Fig. 4. Measured characteristics of dual-mode bandpass filter by series-shunt susceptance excitation (coplanar ring).

coupling coefficient k rather independently. The series excitation of dual-mode ring resonator mentioned above usually gives a small perturbation. Adding the shunt susceptance to the external circuit increases the total susceptance and thus perturbation. But as the current passes through the shunt susceptance, the external Q can keep moderate value in spite of the large series susceptance. It should be noted that the attenuation poles do not move at all in this procedure.

The combination of rotated excitation and series-shunt susceptance can extend the limitation for fabricating the bandpass

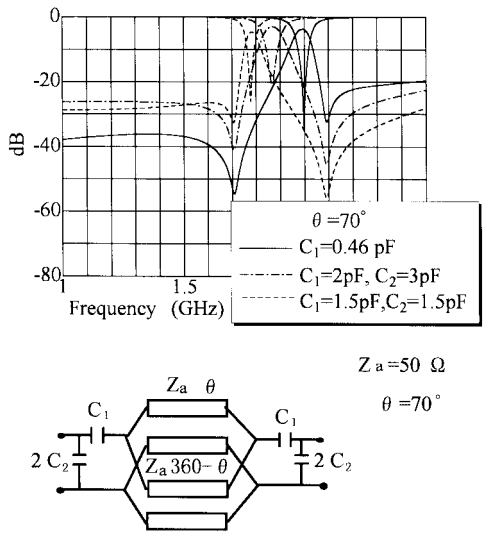

Fig. 5. Simulation characteristics of dual-mode bandpass filter by series-shunt susceptance excitation.

filter. Since coplanar waveguides have the advantage of easy insertion of lumped elements between the load and the ground, they are good for the proposed series-shunt susceptance excitation. These experimental and simulation results for coplanar ring resonators are shown in Figs. 4 and 5. The results show a good agreement.

IV. Conclusions

We confirmed the common characteristics of circular resonator-based dual-mode BPF's at a rotated excitation by microstrip ring and coplanar ring resonators. Control of the angle between the I/O ports and the coupling susceptance can change the frequency of attenuation poles and the filter bandwidth. Since these types of filters have no discontinuous parts inside, it is easy to fabricate and good for high-power application.

Acknowledgment

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