A NEW ENHANCED COUPLING STRUCTURE OF MICROSTRIP RING RESONATOR WITH TWO COUPLED LINES AND A SLIT

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ABSTRACT

A new type of enhanced coupling structure of microstrip ring resonator with two coupled lines and a slit is suggested. The insertion and return losses are shown to be improved compared with those of conventional line-to-ring resonator. Also, it has an intensive suppression above the third harmonic which is very useful for its application to microwave circuits.

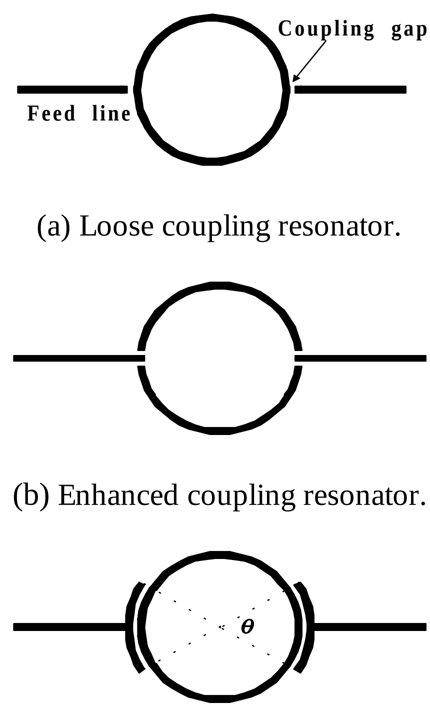
INTRODUCTION

The microstrip ring resonator has been widely used as a circuit for the measurement of dispersion, phase velocity, and effective dielectric constant in microstrip lines. It has good characteristics of high Q-factor and no open-end effect[1]. Its simple structure has an advantage in the application such as filters, duplexers, oscillators, mixers, couplers, and antennas in microwave and millimeter wave circuits[2-4]. Also, it can be used as an optical control device because of its potential application in signal switching, mixing, and frequency modulation[5-7]. This structure would only support waves that have an integral multiple of the guided wavelength equal to its mean circumference[6]. This can be expressed as

$$2\pi r = n\lambda, \quad n = 1,2,3\ldots \qquad (1)$$

where n is the mode number, r is the mean radius of the ring, and λ is the guided wavelength in the ring.

The size of the coupling gap determines the coupling effect between the microstrip feed line and the resonator. While the loose coupling resonator shown in Fig. 1 (a) has high insertion and return losses, the tight coupling or enhanced coupling resonator shown in Fig. 1 (b) has low insertion and return losses even though the Q-factor becomes low[1]. Recently, line-to-ring coupling resonator shown in Fig. 1 (c) has been reported to improve insertion and return losses[2].



(a) Loose coupling resonator.

(b) Enhanced coupling resonator.

(c) Line-to-ring coupling resonator.

Fig. 1. Various coupling ring resonators.

NOVEL ENHANCED COUPLING MICROSTRIP RING RESONATOR

In this paper, a more improved two lines-to-ring coupling structure with a slit as shown in Fig. 2 is suggested and its microwave characteristics are obtained by simulation and measurement. This structure consists of two coupled lines and open ring with the slits at both input and output sides so as to maximize coupling effects. The open ring with the slit at $\phi = 90°$ supports the modes, $n = 1.5, 2, 2.5, 3.5, 4\ldots$, and so on. The ring with slits at $\phi = 90°$ and $\phi = 270°$ supports the modes, $n = 2, 4, 6\ldots$, and so on, while the ring with slits at $\phi = 0°$ and $\phi = 180°$ has the same resonant characteristics as the conventional ring resonator [8,9].

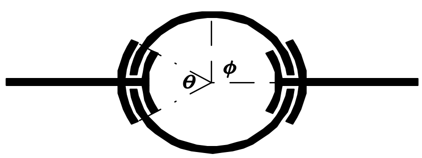
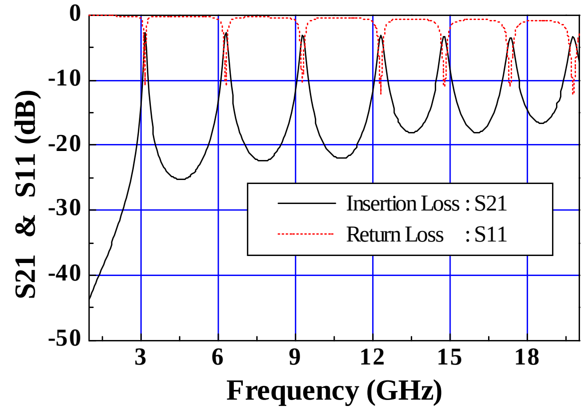


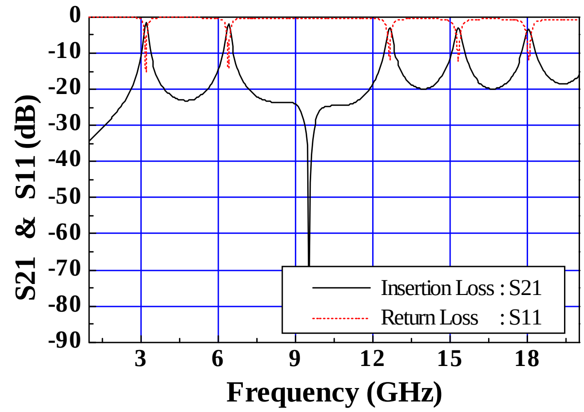
Fig. 2. Novel enhanced coupling resonator with two lines and a slit.

The novel coupling structure of two lines-to-ring resonator with a slit shown in Fig. 2 is compared with the conventional line-to-ring coupling resonator of Fig. 1 (c). Each ring is fabricated on Teflon ($\varepsilon_r = 10.0$) substrate with a thickness of 0.634 mm and the effective radius, all widths of the ring (ring, feed line, and two coupled lines), coupling gap, and the electrical length of the coupled line of the ring are 6.13 mm, 0.58 mm, 0.18 mm, and 45° , respectively. A simulation CAD tool, TOUCHSTONE is used for predicting the microwave characteristics of this novel resonator while a HP8510C Network Analyzer is used for actual measurement.

The results of simulation and measurement for the structure of Fig. 1 (c) and Fig. 2 are shown in Fig. 3 and Fig. 4, respectively.



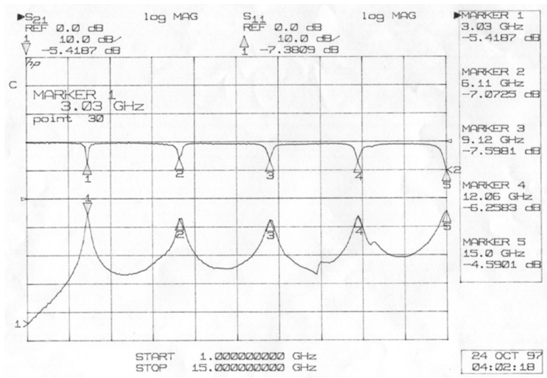
(a) Conventional line-to-ring coupling resonator.



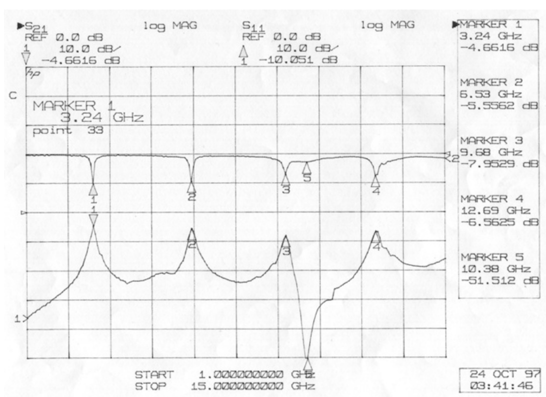
(b) Novel two lines-to-ring coupling resonator with a slit.

Fig. 3. The results of the simulation for two ring resonators shown in Fig. 1 (c) and Fig. 2.

As it can be seen from Fig. 3, the insertion and return losses are better for the suggested novel structure than those for the conventional line-to-ring coupling resonator. The experimental results shown in Fig. 4 agree well with those of simulation results. These results are summarized in Table 1. The improved values of insertion and return losses are 0.76 dB and 2.4 dB, respectively. By providing a suitable slit in the ring, its circumference can be reduced, thereby the resonance is shifted to a little higher frequency compared with line-to-ring coupling resonator. For the novel structure suggested in this paper, the simulation results indicate intensive suppression takes place at the third resonant mode whereas the experimental results show that this suppression takes place at a slightly high frequency.



(a) Conventional line-to-ring coupling resonator.



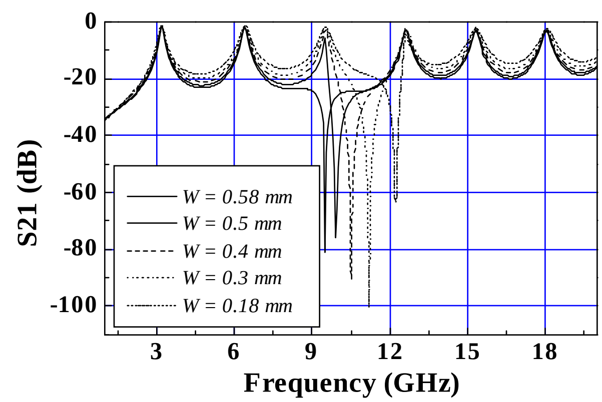
(b) Novel two lines-to-ring coupling resonator with a slit.

Fig. 4. The results of the measurement for two ring resonators shown in Fig. 1 (c) and Fig. 2.

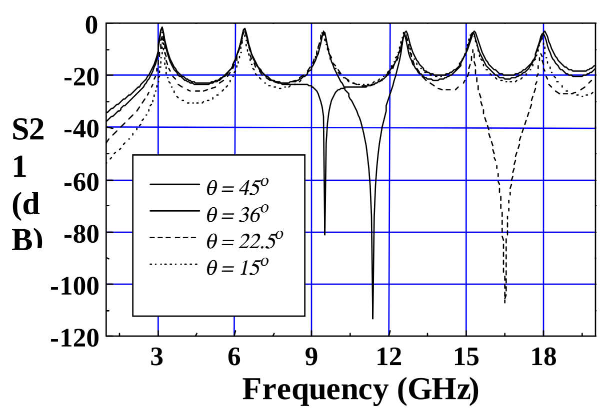
To further investigate this effect, the width and length of two coupled lines (inner and outer line) of this novel structure have been varied from 0.58 mm to 0.18 mm and from $\theta = 45°$ to $\theta = 5.42°$, respectively. The resulting S_{21} characteristics due to these effects are shown in Fig. 5.

Structure		Fig. 1 (c)			Fig. 2		
Resonant mode		1	2	3	1	2	3
Simulation	f_r	3.16	6.28	9.27	3.19	6.39	×
	Q	32	36	44	22	35	•
Measure-ment	f_r	3.03	6.11	9.12	3.24	6.53	9.68
	IL	-5.4	-7.1	-7.6	-4.7	-5.6	-8.0
	RL	-7.6	-5.5	-6.5	-10	-9.2	-6.9

Table 1. The results of simulation and measurement for the structures shown in Fig. 1 (c) and Fig. 2. (f_r : resonant frequency (GHz), Q : Q-factor, IL: insertion loss (dB), RL : return loss (dB))



(a) Effects of the width of two coupled lines.



(b) Effects of the length of two coupled lines.

Fig. 5. Effects of the width and the length of

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the two coupled lines shown in Fig. 2.

As the width and the length of two coupled lines are decreased, the intensive suppression frequency is shifted toward high frequency within the range of 9-13 GHz and 9-17 GHz, respectively. It is clearly seen from Fig. 5 that the suppression frequency can be controlled and the insertion and return losses can be optimized by choosing a suitable width and length of the coupled line of the novel structure suggested.

CONCLUSIONS

A novel coupling structure is suggested for a microstrip ring resonator with the following superior microwave characteristics to those of the existing ring resonators. It has improved insertion and return losses. Also it shows the special suppression frequency which is advantageous for its application in microwave circuits such as filters, duplexers and mixers, etc. This suppression frequency can be optimized by varying the width and length of the coupled lines.

To analyze this structure more precisely, the equivalent circuit model and its parameters are being studied.

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