Improvement of Microstrip Open Loop Resonator Filter Using Aperture

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Abstract — **Apertures has been employed on the ground plane in the open loop resonator filter. The bandwidth has been widen maximally 40% and the passband ripple has been flatten compared with the conventional open loop resonator filter. The coupling spacing between loops has been widened to easily implement filter.**

I. INTRODUCTION

In modern satellite communication, RF(IF) filter is required to be small, to be easily fabricated, to have flat group delay and especially, wide bandwidth because of high-speed data rate. Although the saw filter has been widely used in mobile communication for high selectivity, it is not applicable to broadband system for bad group delay ripple and narrow bandwidth.

Microstrip filter is easy to be fabricated and built in, and many kinds of researches on various types of microstrip filter has been performed.

A half wavelength open loop resonator type has advantage of smaller size than other half wave length types of filter and there were some trial to reduce the size of them[1-8]. They were not mainly focused on broadband filter, but on narrow band filter for mobile communication. However, in broadband application like IF bandpass filter for satellite communication system, the broadband filter is necessary. Broadening of filter bandwidth can be obtained by tight coupling between loops which means higher coupling coefficient. Reduction of strip line width and coupling space between loops make it possible.

However, as the difference between two resonant frequencies is large, the passband ripple also is large. Also there is limitation on reducing coupling space between loops for tight coupling. When the coupling space between loops is extremely narrow, the sensitivity depending on it can become serious problem and it is very difficult to implement it.

So, aperture can be alternative solution instead of narrow coupling space for tight coupling. When aperture is employed on the ground of the coupled line, coupling between strip line and ground plane is decreased and more tight coupling can be achieved[9].

In this paper, the effect of the aperture on electric, magnetic, and mixed coupling was explained and the aperture was applied to four pole and six pole open loop resonator filter for broadening of bandwidth without reducing coupling space.

II. THE COUPLING OF CONVENTIONAL AND THE OPEN LOOP RESONATOR EMPLOYING APERTURE

There are three types of coupling in open loop resonator; electric, magnetic, and mixed coupling. We applied aperture to electric coupling and magnetic coupling for comparison of conventional open loop resonator and open loop resonator employing aperture.

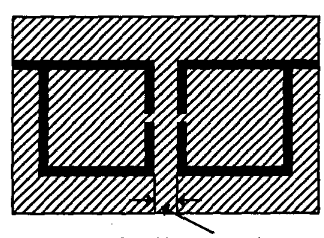
A. Electric coupling

The coupling coefficient and two resonance frequencies for electric coupling are[7-8].

$$k_E = C_m / C \quad (1a)$$

$$f_e = 1/2\pi\sqrt{L(C+C_m)} \quad (1b)$$

$$f_m = 1/2\pi\sqrt{L(C-C_m)} \quad (1c)$$



(a)

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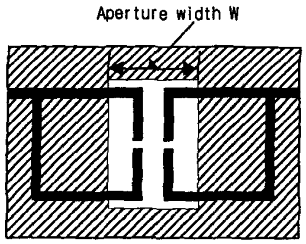
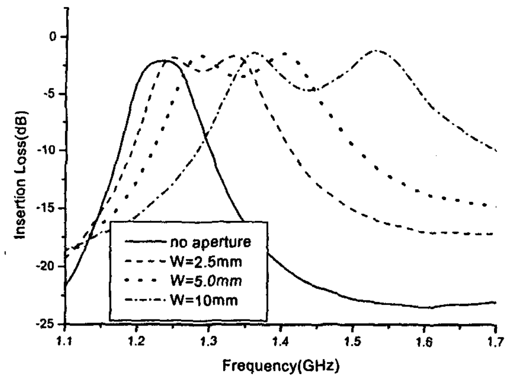
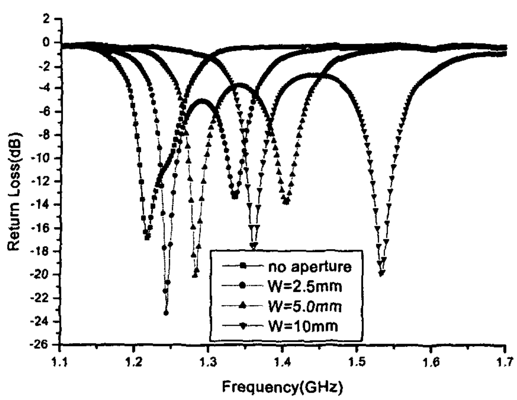


(b)

Fig. 1. The electric coupling structure. (a) The conventional open loop resonator. (b) The open loop resonator employing aperture.



(a)



(b)

Fig. 2. Measured insertion loss and return loss of the open loop resonator employing aperture for Electric coupling. (a) Insertion loss. (b) Return loss.

C, L, and C_m represent self capacitance, self inductance, and mutual capacitance, respectively.

Fig. 1 presents the electric coupling structure of the conventional and the open loop resonator employing aperture. In conventional structure of Fig. 1(a), it is known that the coupling coefficient is increased and two natural resonance frequencies, f_e and f_m, move toward outside as the coupling space d is decreased[7-8]. This implies wider bandwidth which is achieved by higher coupling co-efficient.

Fig. 2 shows the insertion loss and return loss of the conventional and open loop resonator employing aperture. As the aperture width is increased, the difference between two resonance frequencies become wider in Fig. 2. So the effect of the increased aperture width W in Fig. 1(b) is same as that of decreased coupling space d of the conventional electric coupling structure in Fig. 1(a).

But in aperture applied structure, the center frequency become higher, because the self capacitance C of (1a-1c) is decreased.

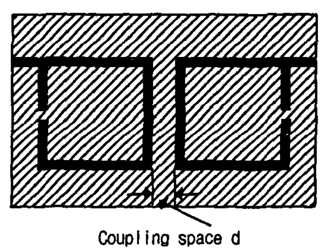
B. Magnetic coupling

The coupling coefficient and two resonance frequencies for magnetic coupling are[7-8].

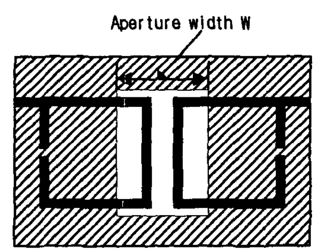
$$k_M = L_m / L \tag{2a}$$

$$f_e = 1/2\pi\sqrt{(L - L_m)C} \tag{2b}$$

$$f_m = 1/2\pi\sqrt{(L + L_m)C} \tag{2c}$$



(a)



(b)

Fig. 3. (a) Magnetic coupling structure of the conventional open loop resonator. (b) Magnetic coupling structure of the open loop resonator employing aperture.

Fig. 3 presents the magnetic coupling structure of the conventional and the open loop resonator employing aperture. In conventional structure of Fig. 3(a), as the coupling space d is decreased, the coupling coefficient increased and this is the same as electric coupling characteristic.

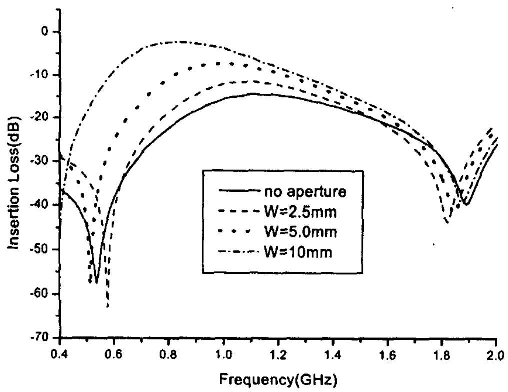


Fig. 4. Measured insertion loss of the open loop resonator employing aperture for magnetic coupling.

Fig. 4 shows the insertion loss of the magnetic coupling of the open loop resonator employing aperture. S_{21} is increased as the aperture width is increased which means L_m is increased. But the center frequency became lower in the magnetic coupling which means L is also increased.

III. APERTURE APPLIED MIXED COUPLING

In section II, we showed that the open lop resonator employing aperture had stronger coupling coefficient than that of conventional open loop resonator with the same coupling space d. But the center frequency of electric and magnetic coupling became higher and lower, respectively.

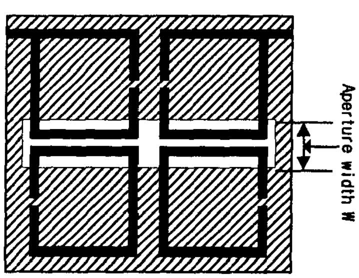
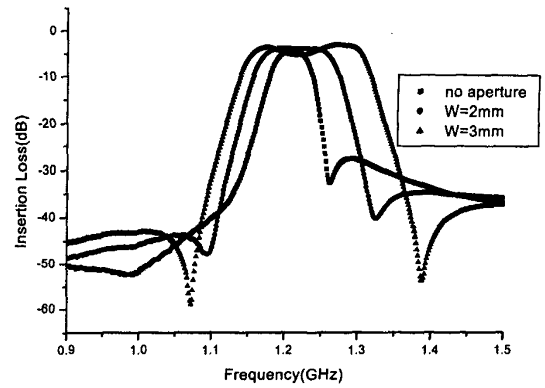
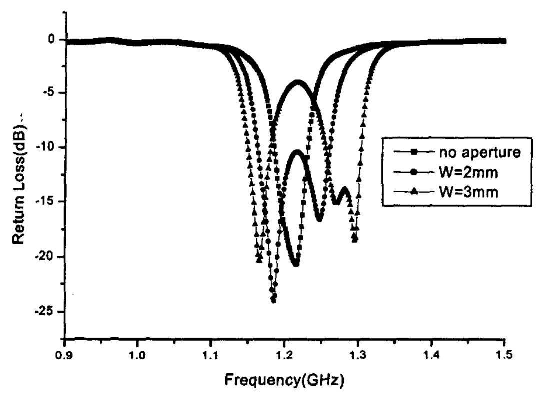


Fig. 5. Four pole open loop resonator filter employing aperture.

So we applied aperture on ground of mixed coupling in four pole open loop resonator filter in Fig. 5.



(a)



(b)

Fig. 6. Measured insertion loss and return loss of the four pole open loop resonator filter employing aperture. (a) Insertion loss. (b) Return loss.

Fig. 6 presents the insertion loss and the return loss of fabricated filter of the four pole open loop resonator filter employing aperture in Fig. 5 for various aperture width W. It is shown that bandwidth of the filter is broaden as the aperture width is widen in Fig. 6.

IV. BROADBAND OPEN LOOP RESONATOR FILTER EMPLOYING APERTURE

Aperture is also available on the broadband open loop resonator filter. The four pole open loop resonator filter employing aperture shown in Fig. 5 was fabricated again for broadband. Aperture having width of 2mm was made on the ground of magnetic coupling. GML1000 substrate with relative dielectric constant of 3.2 and a thickness of 0.76mm is used.

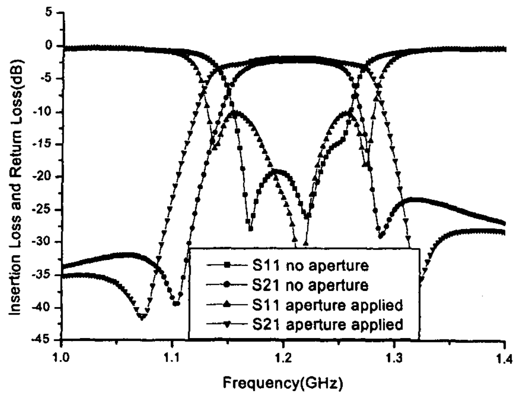


Fig. 7. Measured insertion loss and return loss of the four pole open loop resonator filter employing aperture for broadband application.

Fig. 7 shows 40% of bandwidth expansion from 100MHz to140MHz at center frequency of 1.2GHz.

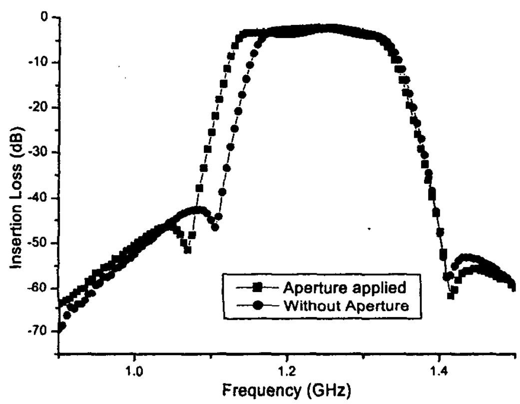


Fig. 8. Measured insertion loss of the six pole open loop resonator filter employing aperture on the ground of magnetic coupling.

Finally aperture was employed to the six pole filter on the ground of magnetic coupling. The bandwidth was increased by 25%, from 148MHz to 185MHz at center frequency of 1.25GHz. So it is shown that the aperture on the ground of magnetic coupling is also available for broadening of the bandwidth.

V. Conclusion

In this paper, aperture was employed in the four pole open loop resonator filter. As a result, maximally 40% of the bandwidth expansion was obtained with same geometric parameters without reducing coupling space between loops of filter. It is also possible to expend more bandwidth with a little degradation of the passband ripple. Aperture can reduce the sensitivity caused by too small geometric parameter; the width of line and the coupling space for broad bandwidth.

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