THE DESIGN OF BAND-PASS FILTERS MADE OF BOTH DIELECTRIC AND COAXIAL RESONATORS

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Abstract

Two different kinds of resonators can be used to construct a microwave band-pass filter that has a low spurious response. The band-pass filter made with coaxial resonators and disk dielectric resonators shows a good spurious response.

I. Introduction

Recently, Dielectric materials with a high relative dielectric constant, high-Q values as well as low temperature coefficients have been developed and widely adopted for many types of miniaturized resonators[1]. Circular dielectric resonators are in use because of their high quality factor. The quality factor of the disk resonators is comparable to TE_{101} copper waveguide resonator for frequencies below 6GHz[2]. However the poor spurious response of the dielectric resonator is the main problem, which is caused by higher order modes other than the desired $TE_{01\delta}$ mode. On the other hand, a quarter-wavelength coaxial line resonator has lower Q than that of the dielectric resonator but has relatively low spurious response.

When a filter is constructed with quarter-wavelength coaxial line resonators, the first higher mode is appear at the frequency corresponding to 3/4 λ wavelength. So, the DR-coaxial hybrid band-pass filter has coaxial resonator-like spurious response as well as low insertion loss in the pass band.

II. A construction of hybrid band-pass filter

When the two resonators are coupled as Fig.1, the coupling coefficient k is defined as follows[4];

$$k \equiv \frac{J_{12}}{\sqrt{b_1 b_2}} = \frac{w}{\sqrt{g_1 g_2}} \qquad (1)$$

where, J_{12} is inter-resonator admittance inverter value, b_i is susceptance slop parameter, w is fractional band width, and g_i is low-pass prototype element value.

One can make the pass-band ripple L_{ar} to be large(>20dB) with loose coupling so that the J_{01} and J_{23} are very small. Then the g_1 products g_2 is approaches to value 2.0 and the coupling coefficient eq.(1) is simplified as follows.

$$k \approx \frac{w}{\sqrt{2}}. \qquad (2)$$

The experimental coupling coefficient values of a DR to coaxial resonator is shown in Fig.2.

Using tubular dielectric resonators with εr=38 ZST-series ceramics, a two pole band-pass filter was constructed. The center frequency is 1.755GHz and the higher order modes appear in numerous number of points as shown in Fig.3. In the case of coaxial type filter as Fig.4, the spurious response is very clean to about 4.5GHz. Around the 5.0GHz point, the 3/4λ coaxial resonant point, the main higher order mode peak appears.

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To design a four pole hybrid band-pass filter, the resonators are positioned in such a way that the first and last resonators are coaxial types, and the second and third resonators are DR types as shown in Fig.5. The spurious response of the designed filter is shown in Fig.6.

The spurious around 3/4λ coaxial resonant point can be also improved by using more DR's, as shown in fig 7. In this 5-pole band-pass filter, three DR's and two coaxial resonators are used. The peak 3/4λ coaxial resonant point is well degraded.

In operation, the first and second TEM-mode resonators transmit only their natural resonant frequency and higher resonance above the cutoff frequency of the waveguide enclosure. These higher frequencies are odd integer multiples of the dominant resonant frequency. The two $TE_{01\delta}$ mode DR's are designed so that their resonant frequency is the same as those of the TEM mode resonators. As a result, only the dominant $TE_{01\delta}$ mode in the DR's propagates through the TEM mode coaxial resonators, but the DR's spurious modes cannot be transmitted through the TEM mode resonators unless the resonant frequencies of the spurious modes coincide with those of the TEM mode. By filtering the non-dominant modes at each stage of inter-resonator coupling between the two types of resonators operating in completely different resonant modes, the composite spurious suppression is greatly improved.

The measured quality factors of the DR and coaxial resonator(see fig.1) are about 12000 and 5000 respectively. For a low loss band-pass filter, the pass-band insertion loss L_a is given as below[4].

$$La = \frac{4.343}{w} \sum_{i=1}^{n} \frac{g_i}{Q_i} \qquad (3)$$

Therefore, in order to obtain better spurious response, more coaxial resonators have to be used. But in this case, the pass band insertion loss is increased. Hence, when designing this DR-coaxial filters, the ratio of DR's to coaxial resonators in number is directly dependent upon the insertion loss as well as the desired spurious response.

III. Conclusions

The band-pass filters made of DR's and coaxial resonators shows good characteristics in both insertion loss and spurious response as expected. In the case of four pole BPF, the pass band insertion loss is 0.5dB max. The DR spurious response is suppressed well and the high Q characteristics are conserved. Therefore, many other types of resonators also could be used for similar purposes.

IV. References

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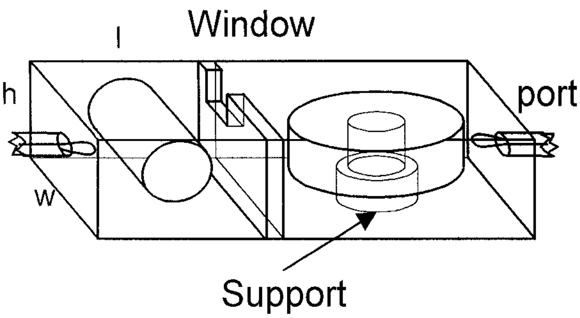


Fig.1 Coupling structure with a coaxial resonator (box: $l \times w \times h = 31.75 \times 45 \times 35$, Core : l =36. ϕ=10), and a DR(box: $l \times w \times h = 48 \times 52 \times 35$, DR: εr=38, ϕ=33, 10, h=13.2, support: εr=3.5,ϕ=16, h=10). (window :$w \times H \times t = 19.5 \times H \times 3.5$, unit: mm)

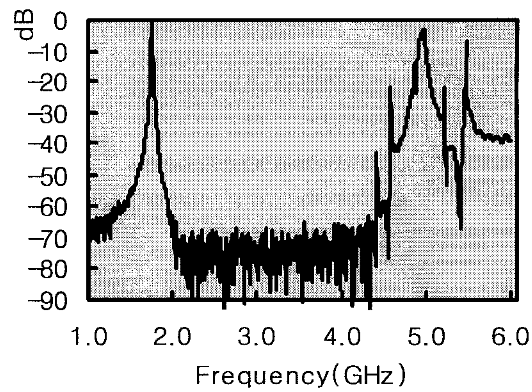


Fig.4 A Spurious response of the two pole coaxial resonator band-pass filter

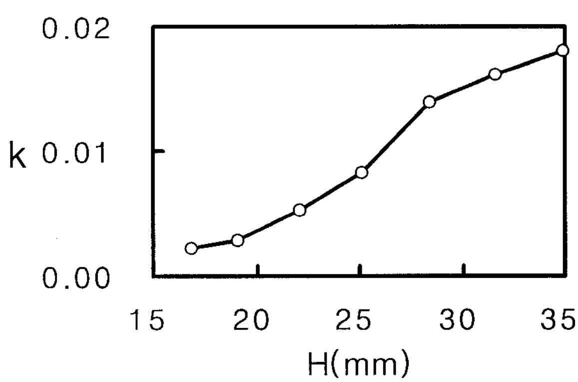


Fig.2 Coefficient k of DR to coaxial resonator coupling (see Fig1).

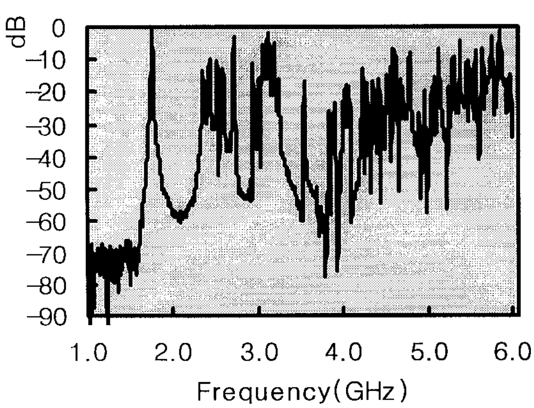
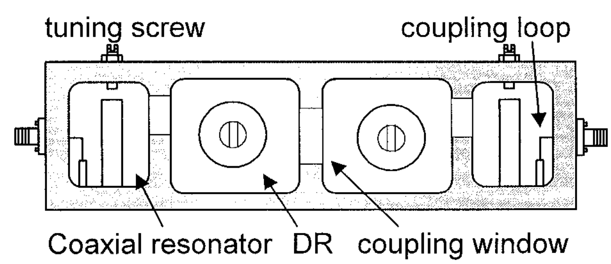
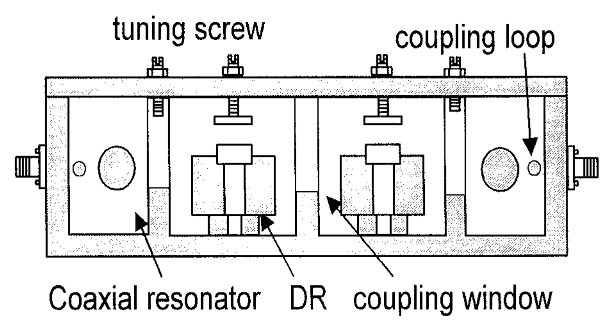


Fig.3 A Spurious response of the two pole DR band-pass filter



(a)Top view



(b) front view

Fig.5 The configuration of the 4-pole hybrid band-pass filter

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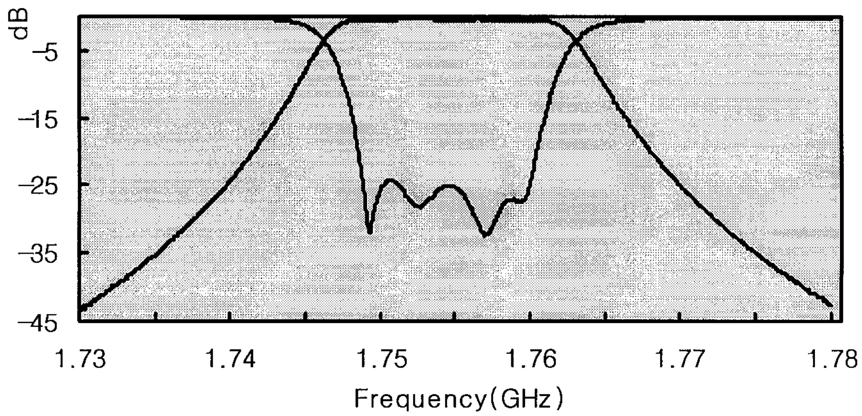
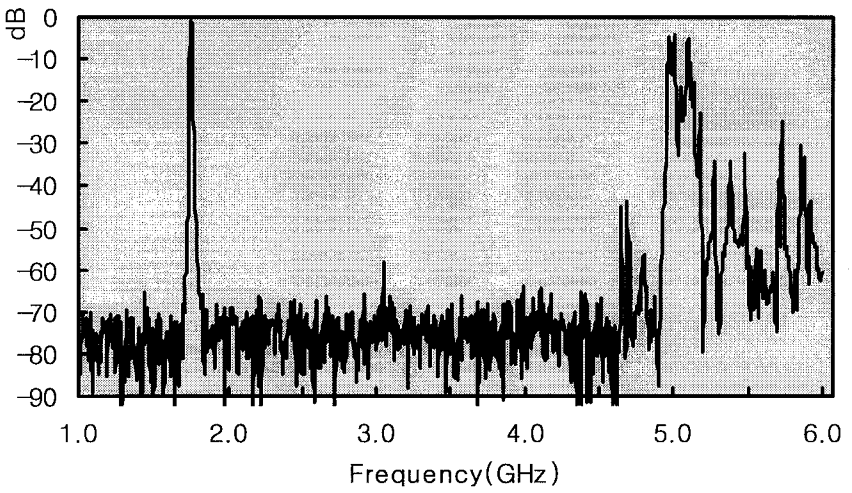


(a)



(b)

Fig.6 The responses of the filter for Fig.5; (a) narrow band, and (b) wide band.

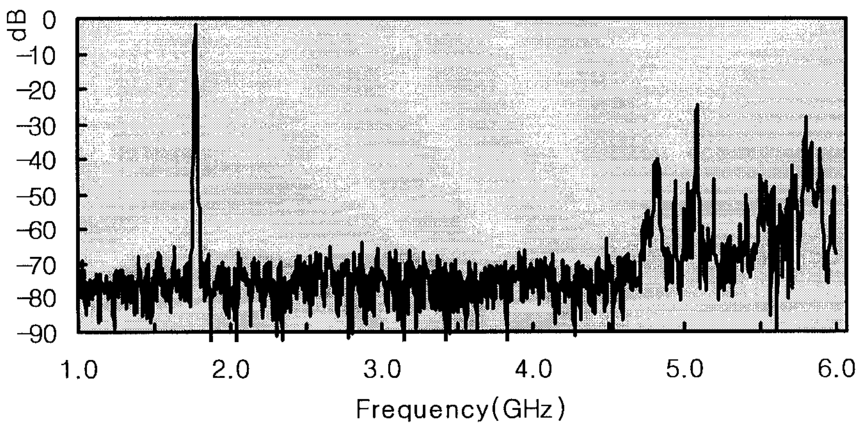


Fig.7 A spurious response of the hybrid 5-pole band-pass filter.

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