DUAL-MODE DIELECTRIC RESONATOR FILTERS WITH IMPROVED SPURIOUS PERFORMANCE

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ABSTRACT

This paper presents novel configurations for dual-mode dielectric resonators operating in the HEH_{11} mode or the HEE_{11} mode. The use of the proposed configurations in the design of dual-mode dielectric resonator filters leads to a design with a remarkably improved spurious performance. Techniques to control the frequency separation between the resonance frequencies of the two dual-modes HEH_{11} and HEE_{11} are discussed. Experimental results are presented to verify the validity of the proposed configurations.

I. INTRODUCTION

Dual-mode dielectric resonator filters have been widely used in cellular radios and satellite multiplexers. Implementation of such filters have been conventionally accomplished by using the resonator configuration shown in Figure 1, where a solid cylindrical DR resonator housed within a metallic enclosure, operating either in the dual HEH_{11} mode or the dual HEE_{11} mode. In satellite multiplexers, improving the spurious performance of such filters will readily translate to higher communication capacity, or cost saving, or further reduction in weight and size or a combination of these factors.

Figure 2 illustrates the typical mode chart for the conventional dielectric resonator given in Figure 1 as generated by [1]. For filters employing dielectric resonators operating in either HEH_{11} or HEE_{11}, it can be seen that the proximity of the resonant frequency of the HEE_{11} mode to that of HEH_{11} mode can cause undesirable spurious performance. Although, the location of the spurious response can be somewhat controlled by adjusting the resonator dimensions, the attainable spurious separation is not adequate to meet the stringent requirements of recent satellite systems. A need has therefore arisen for dual-mode dielectric resonators with improved spurious performance.

The idea of the novel configurations proposed in this paper stems from the following observation; In view of Figure 2, It can be seen that for a fixed diameter D, the rate of change of the resonant frequency with the resonator height L is much higher for the HEE_{11} than that for the HEH_{11} mode. This is attributed to the fact that the field intensity of the HEH_{11} is high at the resonator center (z=0) while that associated with the HEE_{11} mode is high near the resonator top and bottom faces ($z = \pm L/2$).

By slightly deforming the conventional resonator cylindrical shape, it is possible to shift the resonance frequency of the spurious mode to a higher frequency zone, while negligibly affect that of the principal mode. It is the objective of this paper to show how to control the frequency separation between the two modes HEH_{11} and HEE_{11}.

Over the past years, a number of methods have been reported [2]-[7] to improve the spurious performance of dielectric resonators filters operating in the single-modes (TEH_{01} modes). The present paper deals with the performance of dielectric resonator filters operating in dual-mode. The goal is to provide a dielectric resonator structure operating either in the dual HEH_{11} mode or the dual HEE_{11} mode that has an improved spurious performance as compared to conventional-type resonators.

II. PROPOSED CONFIGURATIONS AND EXPERIMENTAL RESULTS

Case 1: Resonators Operating In The HEH_{11} mode where $F_{HEH11} < F_{HEE11}$

Figures 3a and 3b illustrate two proposed configurations for a dielectric resonator operating in the HEH_{11} mode, whereby the resonant frequency of the spurious HEE_{11} mode is shifted into a higher frequency zone. The structure given in Figure 3a consists of a solid dielectric disc sandwiched between two other discs having through holes in the center. The three discs have the same diameter and are attached together by a bonding material. Since the bonding layers are allocated away from the center (z=0) where, the electric field intensity of the HEH_{11} mode is high, the unloaded Q of the resonator is little affected by the loss tangent of the bonding material. The resonator structure given in Figure 3b provides a similar function to that of Figure 3a. It is constructed by machining two blind holes at the top and bottom faces of a solid

L

cylindrical resonator.

Figure 4 illustrates the measured return loss of a single cavity enclosing the dielectric resonator shown in Figure 3b for three different values of Hs/L. The D/L ratio is chosen such that the resonance frequency of the HEE_{11} mode is higher than that of the HEE_{11} mode. The percentage frequency separation $(F_{HEE11} - F_{HEH11})/F_{HEH11}$ between the operating mode HEH_{11} and the spurious mode HEE_{11} for the three cases is summarized in Figure 6. The cases Hs/L=0, and Hs/L=0.5 represent respectively the percentage spurious separation exhibited by the conventional solid resonator and by a dielectric resonator in a ring form. It can be seen that the proposed resonator configuration described, offers close to 30 % improvement in the percentage frequency separation over that exhibited by the conventional solid resonators and 55 % improvement over that exhibited by a ring resonator.

The experimental results given in Figure 4 were obtained using a probe placed parallel to the dielectric resonator top surface. This probe could not couple enough energy to the fundamental TEH_{01} mode. This explains why this mode is not shown in the measured data given in Figure 4. However, since, the electric field intensity of the TEH_{01} and HEH_{11} modes is minimum at ($z= \pm L/2$), the provision of shallow apertures at the top and bottom faces has a negligible effect on the resonance frequency between these two modes, and consequently on the frequency separation between them.

For a given diameter D, height L and aperture depth Hs, the frequency separation between the HEH_{11} mode and the HEE_{11} mode is controlled by the aperture diameter Ds. An improvement in the frequency separation of even more than 30 percent can be achieved by the choice of the optimum values of Ds and Hs.

Case 2: Resonators Operating in The HEE_{11} mode where $F_{HEE11} < F_{HEH11}$

Figures 6a shows a dielectric resonator configuration, whereby the basic mode of operation is the HEE_{11} mode. The resonator comprises of three dielectric discs having the same diameter attached together by a bonding material. The middle disc has a through small hole in the center. This disc deforms the fields of the HEH_{11} mode causing its resonance frequency to be shifted into a higher frequency range while negligibly affects that of the operating HEE_{11} mode. Since the discs are bonded close to the resonator center (z=0) where the electric field of the HEE_{11} mode is minimum, the loss tangent of the adhesive layers which holds the three discs together has a little effect on the loss performance of the resonator.

Figure 6b illustrates a dielectric resonator which functions in the same manner as the dielectric resonator described in Figure 6a. The resonator comprises of two identical dielectric discs having blind apertures attached together by a bonding material. Since the electric field of the TEH_{01} mode is zero at r=0, the aperture in the disclosed resonators given in Figures 6a and 6b have a negligible effect on the separation between the resonance frequency of the fundamental TEH_{01} mode.

Figures 7 illustrates the measured return loss and frequency separation between the HEE_{11} and HEH_{11} modes for the two-disc resonator configuration given in Figure 6b. In this example the D/L ratio is chosen such that the resonance frequency of the HEH_{11} mode is higher than that of the HEE_{11} mode. In view of Figure 7 it can be seen that a 50 % increase in the percentage frequency separation between the operating HEE_{11} and spurious HEH_{11} is achieved by the proposed two-disc resonator. With the optimum choice of Hs and Ds, more than 50 percent improvement can be even achieved in percentage frequency separation between these two modes.

III. CONCLUSIONS

The spurious performance of dual-mode filters operating in the HEH_{11} mode or the HEE_{11} mode can be improved by slightly deforming the conventional cylindrical resonator shape. Experimental results have been presented for a number of novel dual-mode dielectric resonator configurations. The proposed configurations promise to be useful in the design of dual-mode dielectric resonator filters for satellite multiplexers having stringent rejection requirements.

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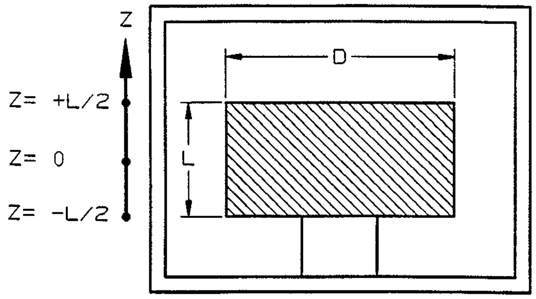


Figure 1 Conventional dielectric resonator

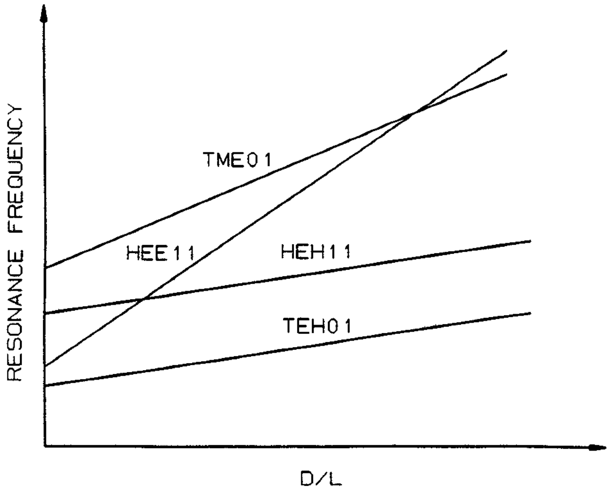


Figure 2 The typical mode chart for the conventional dielectric resonator given in Figure 1.

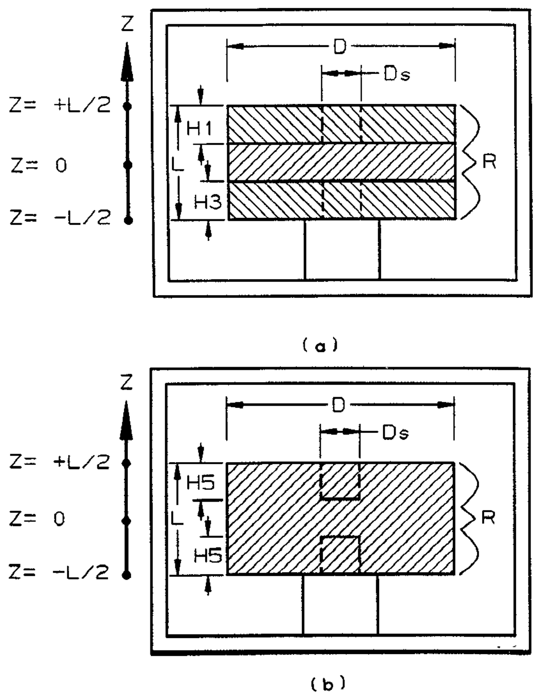


Figure 3. Two proposed dielectric resonator configurations operating in the HEH_{11} mode.

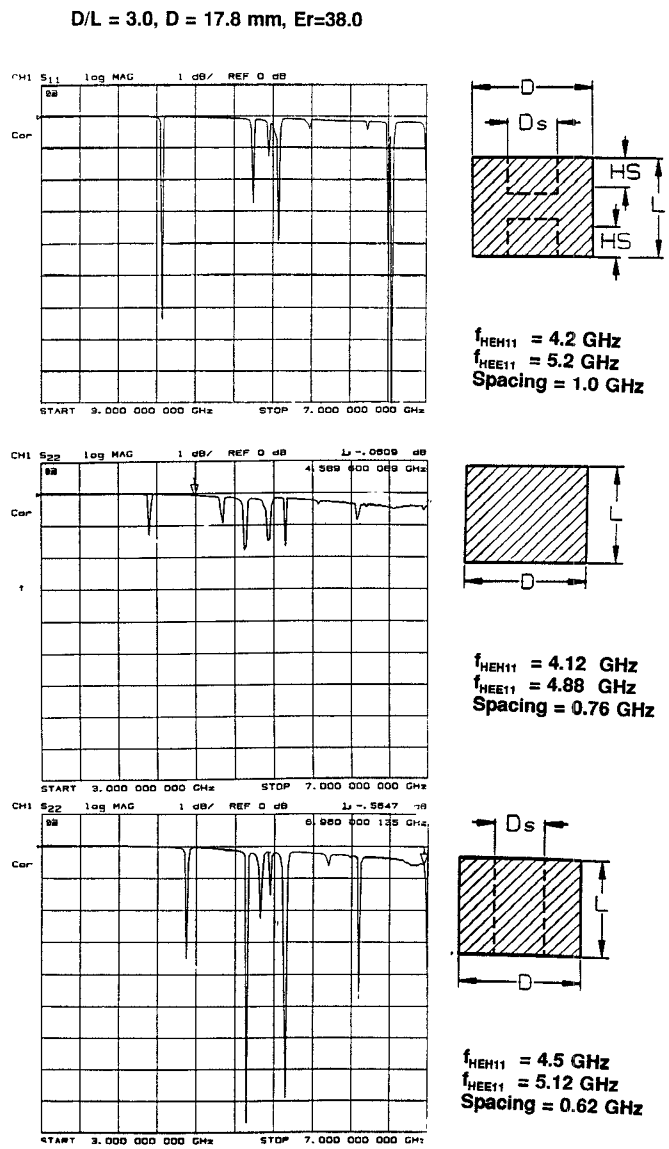


Figure 4. The measured return loss of a single cavity containing the resonator configuration given in Figure 3b for different values of Hs/L.

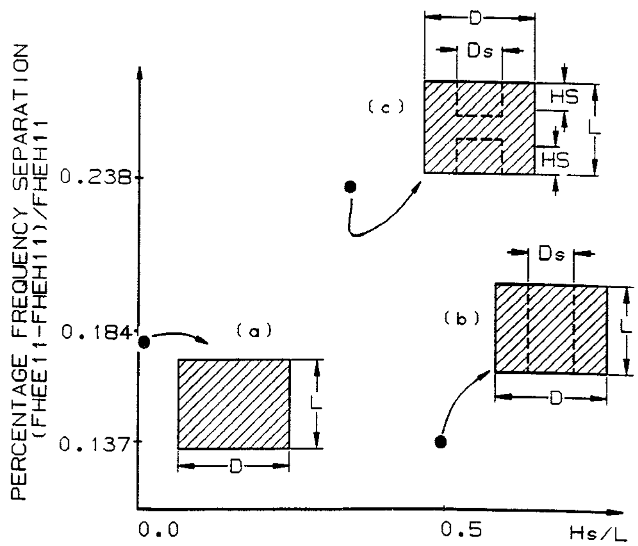
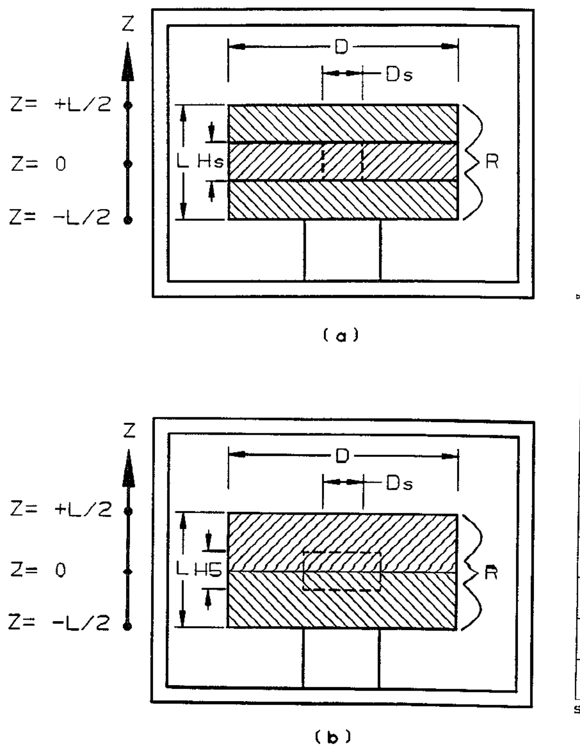


Figure 5 The spurious performance of the resonator described in Figure 4.



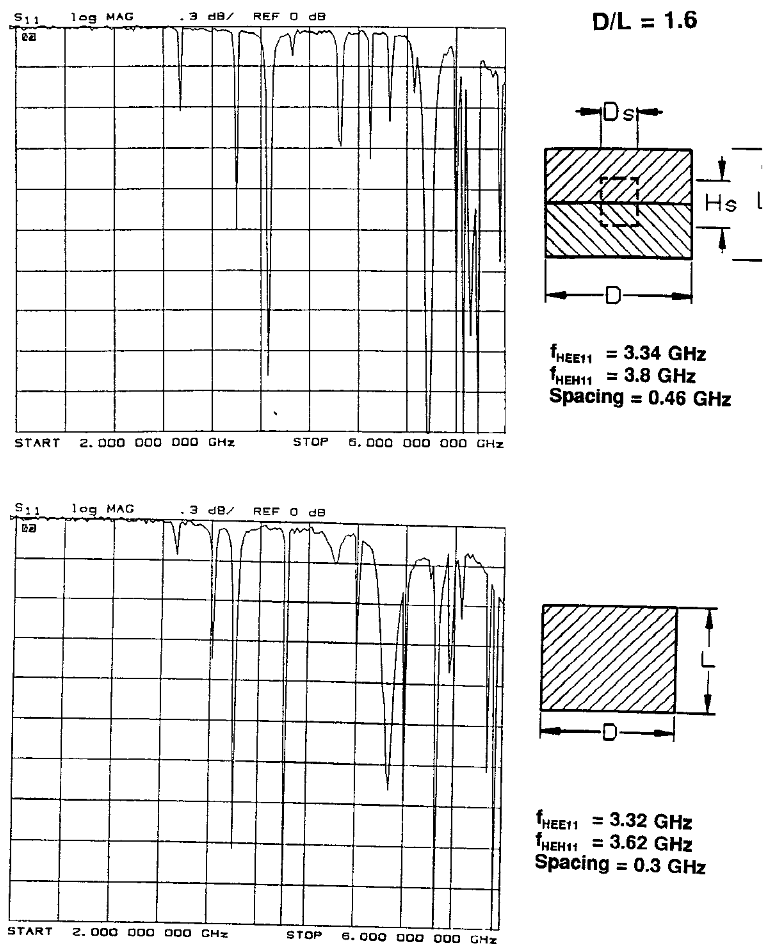


Figure 6 Two proposed dielectric resonator configurations operating in the HEE_{11} mode.

Figure 7 The measured return loss of a single cavity containing the resonator configuration given in Figure 6b, for two values of Hs/L.