COMPLETE DESIGN FOR FIVE-POLE IN LINE ELLIPTIC FILTER.

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ABSTRACT

The complete design of a five-pole in line elliptic filter using TE_{113} and TM_{012} modes is presented. A multimodal variational method is used in order to determine all iris dimensions and positions. Simultaneous TE / TE and TE / TM mode couplings between the dual and triple mode cavities are provided by a single displaced rectangular iris. A filter has been designed and realized using our theoretical iris dimensions (central frequency : 12.57 GHz and bandwidth 47 MHz). The required and experimental responses are in very good agreement.

INTRODUCTION

The electromagnetic coupling of cavities by irises is an important topic in the design of microwave filters [1-5]. In this paper, a variational multimodal method [6] is used to characterize the discontinuities involved by such filter design. This approach allows to determine accurately and rapidly the admittance matrix of each discontinuity. This characterization is optimized using a contour integral formulation [7]. The discontinuities are cascaded using an admittance matrix formulation. Then the transmission of the following structure (fig. 1a) is calculated and can be characterized by the corresponding bandwidth (fig. 1b).

This bandwidth will be the characteristic parameter. The input and output couplings are ensured by a centered rectangular iris. Simultaneous TE/TE and TE/TM mode couplings between the dual and the triple mode cavities are provided by a single displaced iris. The dimensions and the position of this iris have to be calculated to ensure both couplings.

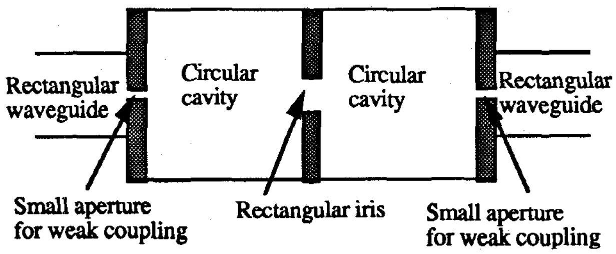

Fig. 1a : Coupling between two circular cavities by a rectangular iris.

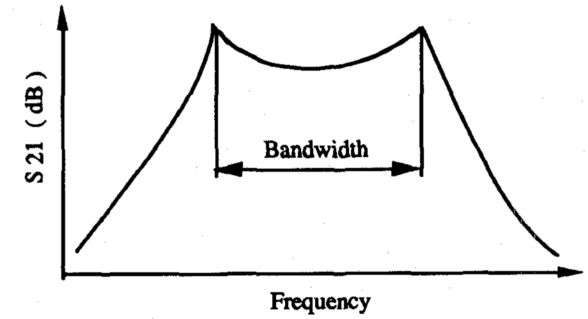

Fig. 1b : Bandwidth, characteristic parameter.

THEORY

The dimensions of the cavities (diameter D and cavity length l) of the five-pole dual / triple mode in line filter, using TE_{113} and TM_{012} modes, can be calculated by the following equations :

$$\left(\frac{2}{\lambda_0}\right)^2 = \left(\frac{3}{l}\right)^2 + \left(2\,\frac{1.841}{\pi D}\right)^2$$

$$\left(\frac{2}{\lambda_0}\right)^2 = \left(\frac{2}{l}\right)^2 + \left(2\,\frac{2.405}{\pi D}\right)^2$$

λ_0 is the free-space wavelength
l is the cavity length
D is the cavity diameter

Such filter design can be performed by a single displaced rectangular iris. So the bandwidth of the corresponding structure (fig. 1a) should be calculated as a function of the iris position (fig. 2).

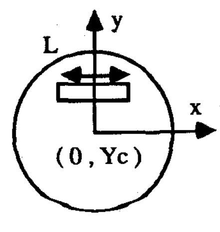

Fig. 2: Filter coupling iris form.

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The TE / TE coupling (fig. 1a) has been studied as a function of the position of the iris center. The bandwidth has been plotted as a function of Yc (along the Oy axis, Xc=0). The results are shown in figure 3. The theoretical values are in good agreement with experimental data. The measurements have been realized by ALCATEL ESPACE, France. The obtained results agree with the variation of the magnetic coupling field Hx of the TE113 mode [5]. The maximum coupling is obtained for an iris placed at the center of the circular cavities.

The TE / TM coupling has been also studied. The bandwidth has been plotted as a function of the position of Yc (fig. 4). The coupling iris center has only be displaced along the Oy axis. The maximum coupling is obtained for Yc/R = 0.65, where R is the radius of the cavity. This result is in good agreement with the theoretical variation of the magnetic field Hx of the TM012 mode [5]. This field is maximum for Yc/R = 0.7.

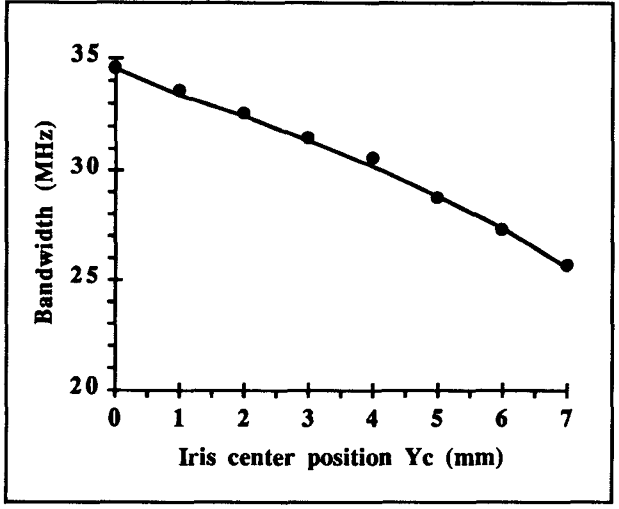

Fig. 3 : (TE/TE) Coupling (— theory • measured)

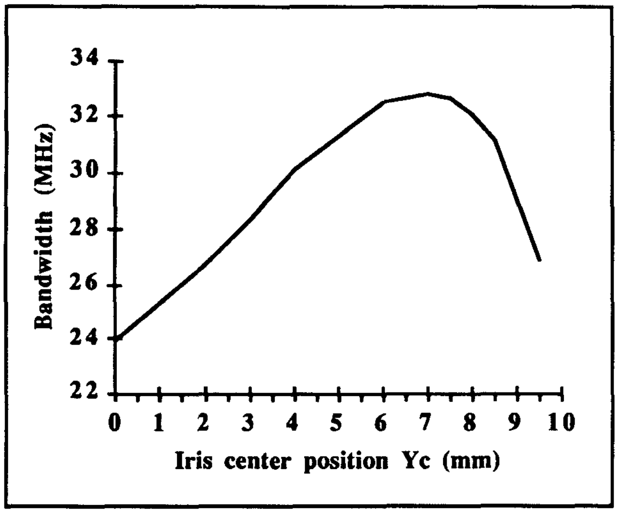

Fig.4 : (TE/TM) Coupling, cavity radius : 10.75 mm

In the filter design, the two different TE/TE and TE/TM couplings should be ensured by a single rectangular iris (fig. 2). Both couplings have to be obtained simultaneously.

An optimum iris length (L) and position (0, Yc) have to be calculated. For each position, the optimum length is calculated to obtain both required couplings (TE/TE and TE/TM).

These variations are presented in figure 5. The optimum length and position are given by the intersection of the two curves.

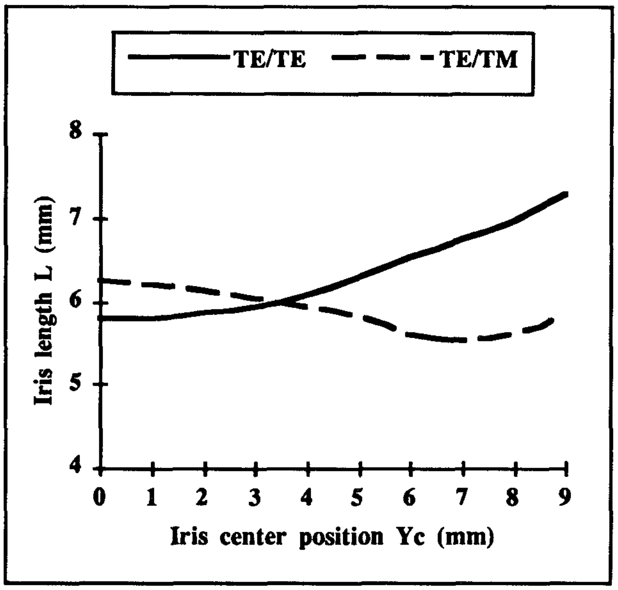

Fig. 6 : Optimized length as a function of Yc involving both required couplings.

NUMERICAL AND EXPERIMENTAL RESULTS

Using this method, a five-pole in line elliptic filter has been designed (fig. 7). The required central frequency (12.57 GHz), the bandwidth (47 MHz), the normalized coupling matrix and the theoretical response (fig. 8) of the filter are given by Touchstone. The required precision on the bandwidth is 1 MHz (0,01 %).

The filter has been realized using our theoretical dimensions, determined by this approach.

The theoretical (fig. 8) and experimental (fig. 9) responses of the filter are in very good agreement. The measurements have been made by Alcatel Espace, France.

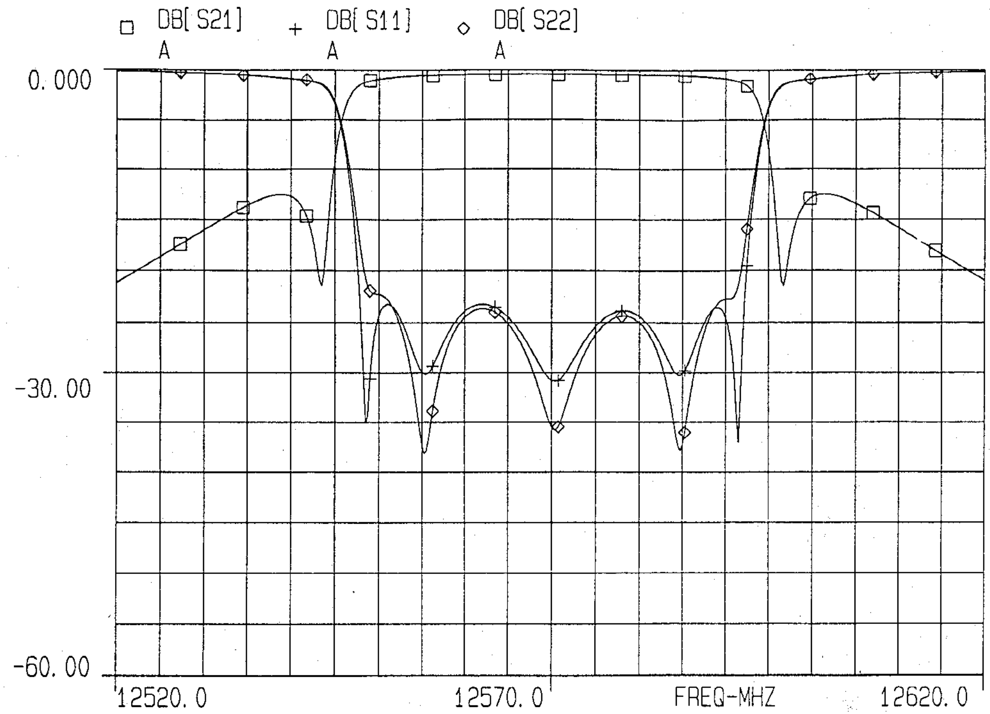

Fig. 8 : Required filter response.

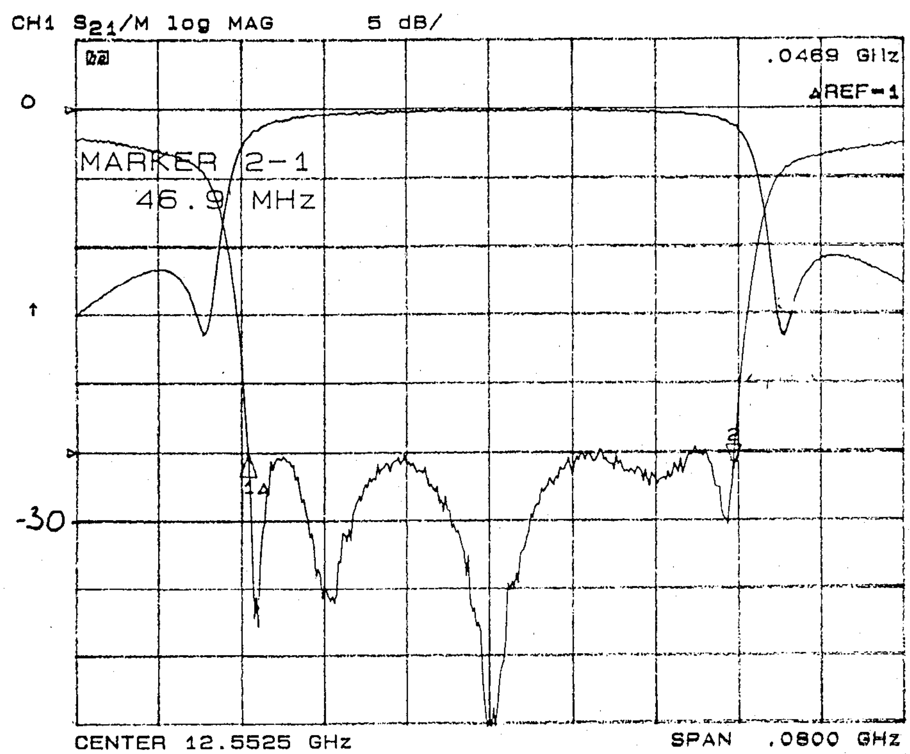

Fig. 9 : Experimental filter response.

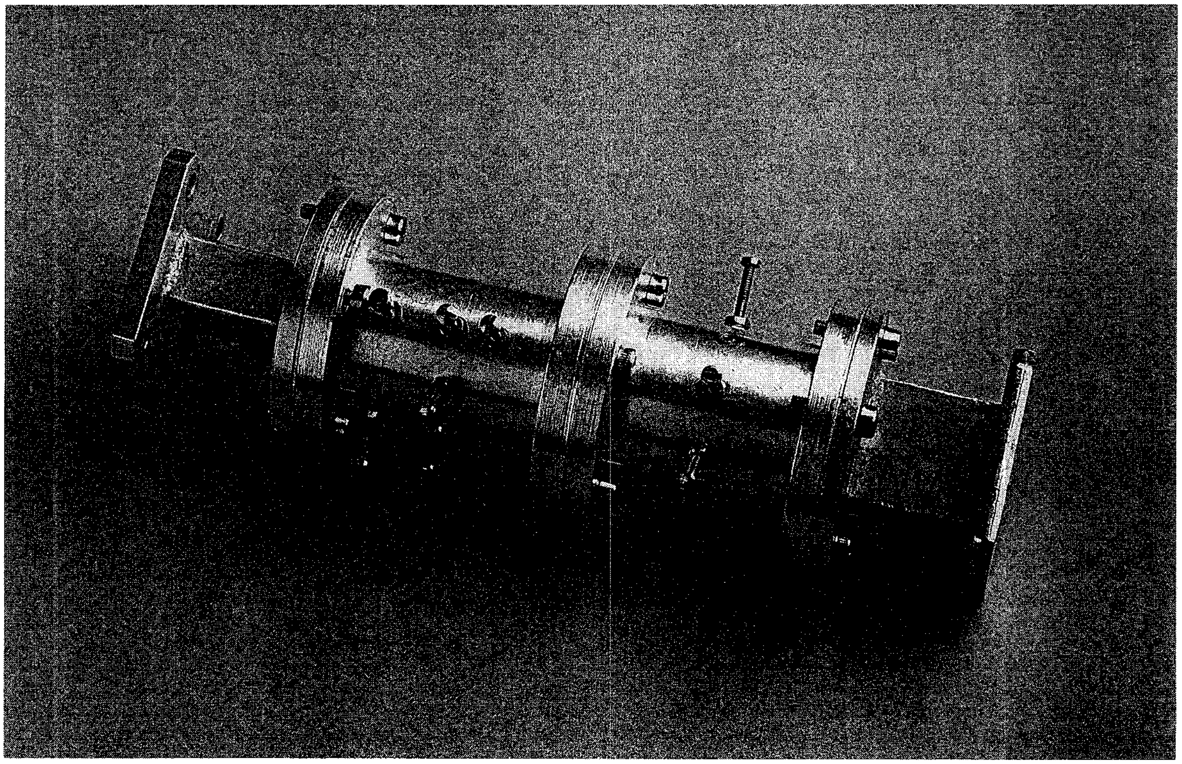

Fig. 7 : Five-pole in line elliptic filter.

CONCLUSION

In this paper, a multimodal variational method is used to characterize the coupling between two circular cavities by a displaced rectangular iris.
The method allows to calculate both TE/TE and TE/TM couplings.
Associated with an optimization procedure, this approach allows to determine the optimum dimensions and position of the coupling iris in the design of five-pole in line elliptic filters.
A good agreement has been obtained between the required and the experimental data. The required precision of 0.01% on the bandwidth has been reached.

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