A Four-Pole Dual Mode Elliptic Filter Realized in Circular Cavity Without Screws

Luciano Accatino, Giorgio Bertin, and Mauro Mongiardo

Abstract— **A four-pole dual mode elliptic filter is realized in circular cavity without screws. The desired coupling and tuning actions are achieved by using a novel arrangement consisting in the insertion of a short section of inclined rectangular waveguide in the middle of the cavity body. In this way we realize dual-mode filters by using only junctions of waveguides with rectangular and circular cross sections, thus enabling a very efficient CAD of such filters. This arrangement also proves particularly convenient from the manufacturing viewpoint. Measured response of a breadboard channel filter operating at Ku-Band shows good agreement with theoretical simulations; a sensitivity analysis confirms the validity of the proposed design.**

I. Introduction

DUAL MODE BANDPASS channel filters are widely employed in satellite communication systems [1]–[4] where severe constraints, concerning their design, electrical performances, manufacturing, and tuning aspects, are present. Satisfaction of these challenging constraints have raised a considerable interest over the last few years. In particular, researchers' attention has focused on tuning filters with finite transmission zeros [5], [6] and, more recently, on the complete elimination of tuning screws in order to get improved filter performances both in terms of increased power handling capability and reduction of passive intermodulation risks. Moreover, elimination of tuning screws leads to accurate computer predictions which are an effective mean to decrease development and production costs of flight hardware.

Previously published works on dual mode cavity filters make use either of a modification of the cavity transverse cross-section, so as to obtain the desired coupling effect [7], or of the direct modeling of screws, seen as short posts protruding out of the cavity wall [8]. Unfortunately the very high degree of accuracy required, owing to the stringent specifications imposed on channel filters for satellite bands, poses considerable difficulties. The latter are due to the necessity of numerically computing a very large number of modes, when dealing with modal approaches using nonseparable waveguides cross sections; or to unlikely time and memory requirements when using purely numerical methods.

It seems apparent that, in order to develop an efficient and accurate CAD of dual mode filters, it would be highly desirable to use only waveguide cross-sections with analytically known modal spectra, i.e., cross-sections geometries which allows solution of the transverse Helmholtz equation by separation of variables. This is actually the case for the structure recently appeared in [9], which describes an implementation of a dual mode filter using rectangular cavities. Though being an advance over previous solutions, the latter structure requires an external phase equalization, thus making difficult the realization of multicavity filters. Moreover, it still seems subject to improvements from the manufacturing viewpoint. Similar considerations also apply to the filter presented in [10].

In order to overcome all the previously mentioned difficulties, while retaining the efficiency of modal analyzes, we propose the novel type of circular cavity structure[1] shown in Figs. 1 and 2. In this arrangement, coupling and tuning functions are obtained by inserting in the middle of a circular cavity resonator a short section (i.e., a thick iris) of waveguide with rectangular cross-section. The iris is properly rotated with respect to electric field polarizations in circular waveguide. It is this very rotation that introduces the desired coupling and tuning actions as discussed in the next section. Note that, by using this arrangement, no external adjustment is necessary, thus making feasible the realization of multicavity filters.

A further advantage of the proposed structure is that the entire filter is completely modeled by using a computer code for the well-established analysis of rectangular-to-rectangular and rectangular-to-circular waveguides junctions. Mode-matching analysis of these discontinuities significantly enhances both the efficiency and the accuracy of numerical simulations; in fact, it is possible to consider a fairly large number of modes at the cost of only a modest increase of numerical expenses. A few details on the rigorous full-wave modeling of the filter are provided in Section III.

In order to ascertain the feasibility of the proposed approach a four-pole 72 MHz channel filter prototype at Ku-Band, suitable for an output multiplexer application has been designed, built and measured. The filter design is illustrated in Section IV, while in Section V measured and theoretical results are provided and discussed.

Finally, sensitivity data regarding the cavity structure are illustrated and discussed in Section VI.

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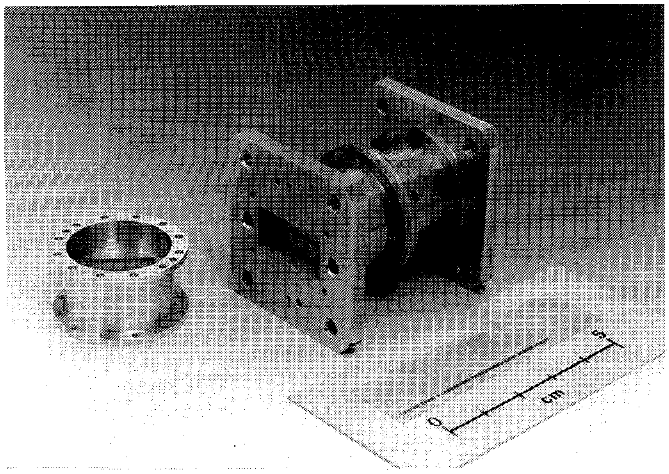


Fig. 1. Photograph of the 4-pole dual mode filter in circular cavity without tuning screws. On the left side it is shown one of the rectangular irises to be placed inside the circular cavity in order to realize desired tuning and coupling actions.

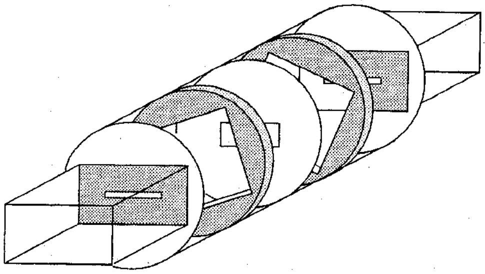


Fig. 2. Sketch of the 4-pole dual mode filter in circular cavity without tuning screws. The coupling and tuning actions are realized by the inclined short sections of rectangular waveguides in the middle of the cavity body.

II. Coupling and Tuning Properties of a Rotated Rectangular Iris Inside a Cylindrical Cavity

Conventional dual mode cavities use a typical three-screw arrangement [see Fig. 3(a)] in order to achieve the desired tuning and coupling actions. In particular screws 1 and 2, placed orthogonally and aligned with the polarization plane of resonant modes, are used, almost independently, for tuning purposes. The third screw, placed in the symmetry plane with respect to resonance polarizations, performs the coupling action, also showing a tuning effect on both resonant modes. All these screws may be doubled, for symmetry reasons, by placing an additional screw on the same axis but on the opposite cavity wall.

We replace this screw-based tuning and coupling section with a short section of rectangular waveguide having an inclination angle, θ in Fig. 3(b), with respect to resonant modes in the circular cavity. In the following it is shown that the proposed configuration provides complete tuning and coupling capabilities, being in addition particularly suited to efficient electromagnetic modeling.

In order to understand the electrical behavior of the rotated rectangular diaphragm inside a circular cylindrical cavity, it is convenient to separate the problem into the following parts: the effect of the iris when this is placed in the same direction of the field; and the effect of the rotation of the reference

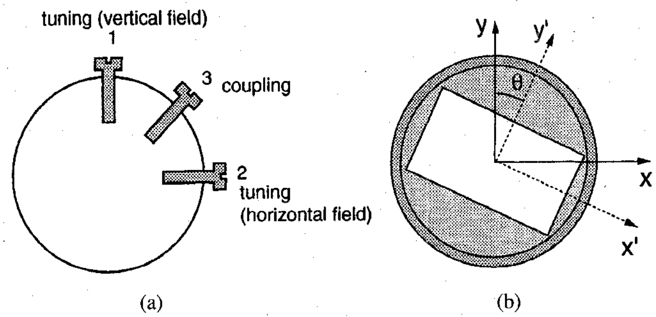


Fig. 3. (a) Screw arrangement in a conventional dual mode cavity. (b) New tuning and coupling arrangement.

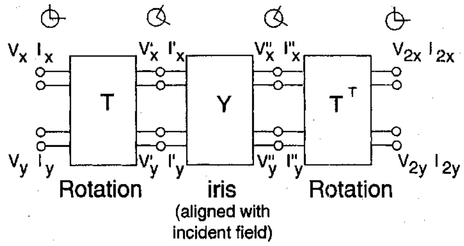


Fig. 4. The incident field is rotated so as to be aligned with the iris. This effect is described by the $ABCD$ matrix $\mathbf{T}$. The effect of the iris is described by its $ABCD$ matrix $\mathbf{Y}$. Finally the field is rotated back to its original by the matrix $\mathbf{T}^T$.

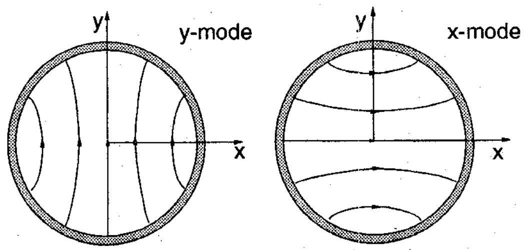


Fig. 5. The TE_{11} modes inside a circular cylindrical cavity are referred to as y-modes (left) and x-modes (right).

system. By composing these effect as described in Fig. 4 we can describe the rotated iris inside the circular cavity.

A. The Straight Rectangular Iris

Let us first consider a cylindrical cavity and denote by V_x, I_x the electric and magnetic field amplitudes of the fundamental TE_{11} mode, as shown in Fig. 5, and referred in the following as the x-mode. In a similar manner let us denote by V_y, I_y the amplitude of the electric and magnetic fields of the fundamental TE_{11} mode when polarized as shown in Fig. 5 and referred to as y-mode.

Consider an infinitesimally thin rectangular iris inside the cylindrical cavity; although the infinitesimally thin iris hypothesis is made here in order to simplify the following discussion, it can easily be removed and the theoretical computations in the remaining of this work have taken into account the iris thickness.

From symmetry consideration it is apparent that, if the x-mode is incident on the *straight* (i.e., not inclined) rectangular iris, see Fig. 6, the y-mode is not excited and vice versa. As a

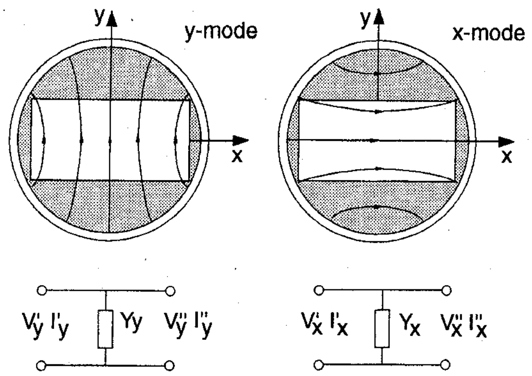


Fig. 6. A rectangular iris in the cavity is described by different equivalent circuit under x-mode (right) or y-mode (left) incidence. Note that no mode coupling is originated when the iris is placed straight, i.e., along the x- or y-directions.

consequence, we can describe the iris discontinuity, for the x-mode, as a two-port with the following $ABCD$ representation

$$\begin{pmatrix} V'_x \\ I'_x \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ Y_x & 1 \end{pmatrix} \begin{pmatrix} V''_x \\ I''_x \end{pmatrix} \tag{1}$$

where Y_x is the shunt admittance representing the iris discontinuity for the x-mode. A similar description can also be adopted for the y-mode yielding

$$\begin{pmatrix} V'_y \\ I'_y \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ Y_y & 1 \end{pmatrix} \begin{pmatrix} V''_y \\ I''_y \end{pmatrix} \tag{2}$$

where in the above Y_y is the shunt admittance representing the iris discontinuity as seen from the y-mode. For following use it is convenient to cast the two above equations together in the form

$$\begin{pmatrix} V'_x \\ V'_y \\ I'_x \\ I'_y \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ Y_x & 0 & 1 & 0 \\ 0 & Y_y & 0 & 1 \end{pmatrix} \begin{pmatrix} V''_x \\ V''_y \\ I''_x \\ I''_y \end{pmatrix} = \mathbf{Y} \begin{pmatrix} V''_x \\ V''_y \\ I''_x \\ I''_y \end{pmatrix}. \tag{3}$$

B. The Rotation Operation

In the previous subsection we have described the electrical behavior of an infinitesimally thin iris under incidence of either an x-mode or an y-mode. However, if we rotate the iris of an angle θ, as shown in Fig. 3(b), we have that the primed field amplitudes (referred to the coordinate system in the iris frame) and the unprimed field amplitudes (referred to the coordinate system in the cylindrical cavity frame) are related by the following transformation

$$\begin{pmatrix} V_x \\ V_y \\ I_x \\ I_y \end{pmatrix} = \begin{pmatrix} c & s & 0 & 0 \\ -s & c & 0 & 0 \\ 0 & 0 & c & s \\ 0 & 0 & -s & c \end{pmatrix} \begin{pmatrix} V'_x \\ V'_y \\ I'_x \\ I'_y \end{pmatrix} = \mathbf{T} \begin{pmatrix} V'_x \\ V'_y \\ I'_x \\ I'_y \end{pmatrix} \tag{4}$$

where

$$c = \cos(\theta) \quad s = \sin(\theta). \tag{5}$$

By using this coordinate transformation we can transform the field of amplitude V_x, V_y, I_x, I_y incident in the cylindrical cavity at the left of the iris to the field V'_x, V'_y, I'_x, I'_y (see Fig. 4). We can then relate the latter field to that present at the right side of the iris, call it $V''_x, V''_y, I''_x, I''_y$ also expressed in the iris frame, by using (3). Finally, we can express this field in terms of the field expressed in the coordinate system of the cylindrical cavity $V_{2x}, V_{2y}, I_{2x}, I_{2y}$, as

$$\begin{pmatrix} V''_x \\ V''_y \\ I''_x \\ I''_y \end{pmatrix} = \mathbf{T}^T \begin{pmatrix} V_{2x} \\ V_{2y} \\ I_{2x} \\ I_{2y} \end{pmatrix}. \tag{6}$$

By following this approach and by using (4), (3), (6), we have the following representation for the rotated rectangular iris

$$\begin{pmatrix} V_x \\ V_y \\ I_x \\ I_y \end{pmatrix} = \mathbf{T} \begin{pmatrix} V'_x \\ V'_y \\ I'_x \\ I'_y \end{pmatrix} = \mathbf{TY} \begin{pmatrix} V''_x \\ V''_y \\ I''_x \\ I''_y \end{pmatrix} = \mathbf{TYT}^T \begin{pmatrix} V_{2x} \\ V_{2y} \\ I_{2x} \\ I_{2y} \end{pmatrix} \tag{7}$$

or, written in explicit form

$$\begin{pmatrix} V_x \\ V_y \\ I_x \\ I_y \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ c^2Y_x + s^2Y_y & sc(Y_y - Y_x) & 1 & 0 \\ sc(Y_y - Y_x) & c^2Y_y + s^2Y_x & 0 & 1 \end{pmatrix} \begin{pmatrix} V_{2x} \\ V_{2y} \\ I_{2x} \\ I_{2y} \end{pmatrix}. \tag{8}$$

The above equation provides the $ABCD$ matrix, $\mathbf{A}$, of a rotated rectangular iris inside a cylindrical cavity.

C. Coupling and Tuning Effects

Several interesting properties can be retrieved from (8) and a brief discussion of the most relevant ones is the topic of this subsection. It is noted that the terms $A_{32} = A_{41} = sc(Y_y - Y_x)$ provide the coupling between the two modes. The terms $A_{31} = c^2Y_x + s^2Y_y$ and $A_{42} = c^2Y_y + s^2Y_x$ are the reactive loading as seen from x-modes and y-modes, respectively. The difference of this two reactances gives the difference in cavity length as seen from the two modes; as such, this difference is related to the tuning effects.

The square aperture: In the case the rectangular aperture degenerates into a square one, yielding $Y_x = Y_y = Y_s$ and, consequently, (8) becomes

$$\begin{pmatrix} V_x \\ V_y \\ I_x \\ I_y \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ Y_s & 0 & 1 & 0 \\ 0 & Y_s & 0 & 1 \end{pmatrix} \begin{pmatrix} V_{2x} \\ V_{2y} \\ I_{2x} \\ I_{2y} \end{pmatrix} \tag{9}$$

showing that whatever is the rotation angle θ:

1) no coupling is present between x-modes and y-modes; ($A_{32} = A_{41}$ are always zero);
2) no tuning action is obtained, since the reactive loading seen from the x-modes and the y-modes is the same.

The above considerations show that the square iris is useless for achieving coupling and tuning actions inside a circular cylindrical cavity.

Coupling effects of a rectangular iris: The coupling is related to the coefficient m given by the term

$$m = sc(Y_y - Y_x) = \frac{(Y_y - Y_x)}{2}\sin(2\theta).$$

Naturally, the values of Y_y, Y_x depend on the values of the geometrical dimension a, b. For a given value of a, b, i.e., for a given value of Y_y, Y_x, it is readily seen that the coupling goes with the angle as $\sin(2\theta)$ and is maximum for $\theta = \frac{\pi}{4}$. It is also noted that no coupling occurs for $\theta = 0, \pi/2$ Curves providing the behavior of the coupling coefficient as a function of the a, b, θ have been reported in [14].

Tuning effects of the rectangular iris: The tuning is related to the difference

$$A_{31} - A_{42} = (Y_x - Y_y)(c^2 - s^2) = (Y_x - Y_y)\cos(2\theta).$$

It is thus apparent that tuning is zero when either $Y_x = Y_y$ or $\theta = \pi/4$. It is also observed that maximum tuning effects are achieved when $\theta = 0, \pi/2$. Curves providing the behavior of the tuning coefficient as a function of the a, b, θ have also been reported in [14].

D. Discussion

From the previous discussion it is clear that

1) coupling can be achieved *without introducing any tuning* by considering an iris inclined of $\theta = \pi/4$;
2) further irises with no inclination can be used to realize the desired tuning effects *without introducing any coupling*.

However, it is also possible to *use just one iris*, with the proper values of a, b and θ selected in order to achieve, at the same time, the sought tuning and coupling actions. Since this latter choice provides a simpler and lighter structure it is to be preferred for practical applications. The values of a, b and θ can be selected according to the CAD procedure described in [14].

III. Electromagnetic Modeling

Let us consider now the rigorous full-wave modeling of the cavity structure and also of the entire filter. It is noted that only two junction types need to be studied, namely:

1) rectangular-to-circular;
2) rectangular-to-rectangular.

The case of the inclined rectangular-to-circular junction is readily decomposed in the cascade of a standard rectangular-to-circular junction plus a rotation of coordinate axes in circular waveguide. This second junction takes a simple form and requires no computations of coupling integrals. A detailed analysis of the rectangular-to-circular discontinuity has been recently presented [12] and is not repeated here for the sake of conciseness. The rectangular-to-rectangular transition is also considered as a well-assessed problem [13]. In all cases, the modal spectra of the guides are analytically known and it is straightforward to account for a large number of modes in the spectral expansions. Moreover, whenever required, increased accuracy can be attained by using a field expansion including the edge condition as described in [15] and [16].

IV. Filter Design and Pretuning of Cavities

In order to validate the above concepts, a preliminary prototype test cavity has been fabricated and measured. The sample cavity has been selected so as to possess a coupling value for a typical narrowband channel filter at Ku-Band. Considerable care has been applied in order to maintain mechanical accuracy within ± 10 μm; this is generally considered a minimum baseline reference to be used in narrowband applications at frequencies above 10 GHz. Moreover, in order to provide a reliable proof of the cavity behavior, the prototype has been designed with alignment pins allowing different mounting positions, with a fixed angular difference between each other of 30 degrees. Representative comparisons related to this preliminary cavity and showing very good agreement between theory and experiment, are reported in [14].

Afterwards, a 4-pole elliptic filter having an equiripple bandwidth of 72 MHz centered at 12 GHz has been selected as the prototype to be realized. Design parameters for this filter, which is a typical candidate for output multiplexing networks, are reported in Table I.

Full-wave modeling of the filter shown in Fig. 2, though requiring only the analysis of simple discontinuities, needs to account for a large number of modes in each waveguide section in order to achieve the desired accuracy. As a consequence, the resulting computing time is of the order of a few minutes for frequency point on an HP 735 workstation, while the complete analysis requires about 3 h. It is therefore highly advisable to reduce the total number of analyzes necessary to design a filter, especially when, in order to obtain the desired final response, optimization techniques are used. Accordingly, special care has been dedicated to achieve a good starting point. To this aim some tuning techniques, originally developed as an aid to proper setting of tuning screws [6], have been retrieved and adapted. In particular, full-wave mode-matching simulations are used in place of actual measurements and the filter parameters are adjusted by following a step-by-step procedure. The first step is to consider one cavity alone by fixing the input iris so as to get the sought value of external Q (Fig. 7). This may be done either by finding the bandwidth defined by the two points having a $\pm 90°$ phase offset with respect to resonance [5], or by computing the phase slope at resonance and directly working out the external Q value [6]. Next, the intercavity iris dimensions are determined using the two cavity arrangement of Fig. 2 with the output shorted and a small input iris (undercoupled condition). The result has the appearance of Fig. 8. The final step consists in presetting the tuning and coupling section (inclined rectangular guide) of the input cavity. This is done following the general approach suggested in [6], and here examined in some details for the two pole case. Consider first the input cavity properly coupled to the external guide via the input iris and with the two resonant modes perfectly tuned to the operating frequency. This situation is depicted in its low-pass equivalent form in Fig. 10(a) and with its actual frequency response in Fig. 9. Observing now [5] that phase jumps represent the poles of the LC network under analysis and zero crossings represent the zeros, we deduce that starting

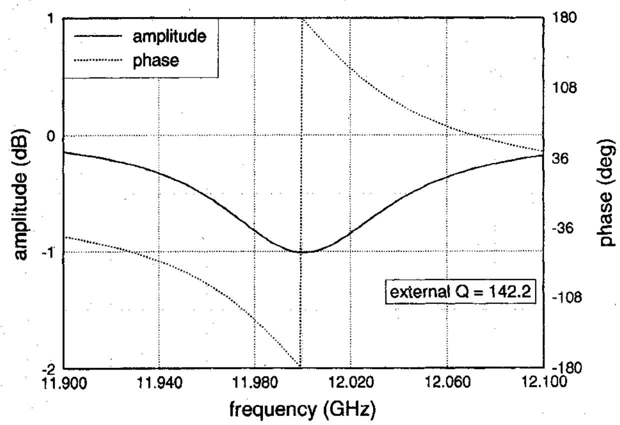


Fig. 7. Simulated reflection response (overcoupled) of input cavity shorted and input coupling iris set for external $Q = 142.2$.

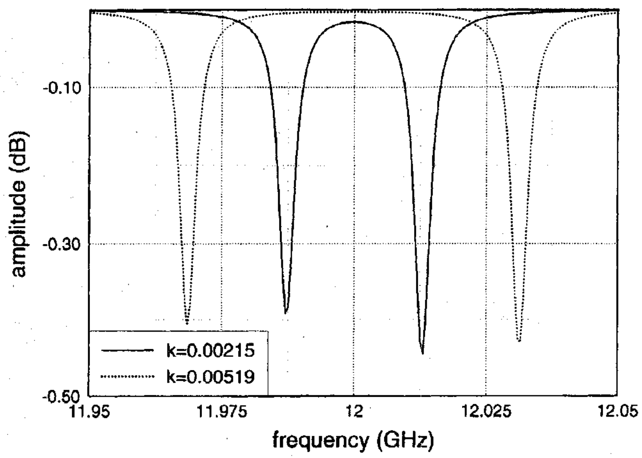


Fig. 8. Simulated reflection responses (undercoupled) of two cavities shorted and intercavity iris placed in between.

from the frequency response we may detect the singularities of our network (two poles with an interlacing zero in our case). By considering constant reactances/susceptances in the network representation [17], [18], we may keep into account also resonators not perfectly tuned at the operating frequency [see Fig. 10(b)]. At this point, from the frequency response of this detuned situation we can detect the singularities and, by means of LCX synthesis methods [17], compute the constant susceptances or, in other words, the exact detuning of each resonator. Using this technique it is then possible to pretune a dual-mode cavity not only to a synchronous configuration, but also to a slightly detuned situation where reactive loadings caused by intercavity iris are properly accounted for. In the present case these have been estimated to be equivalent to a detuning of +13 MHz for the first (vertical) mode, and +31 MHz for the second (horizontal) mode. This preset phase leads to the final result displayed in Fig. 11.

V. Results

The starting point obtained by using the previously reported pretuning technique is illustrated in Fig. 12, where also the final design, achieved after a few optimization steps, is shown. Both results come from a full-wave mode-matching analysis

TABLE I
4-Pole Elliptic Prototype Parameters.

center frequency (GHz)	12
bandwidth (MHz)	72
external Q	142.2
k (1,2)	0.00529
k (2,3)	0.00519
k (1,4)	-0.00215

TABLE I
4-POLE ELLIPTIC PROTOTYPE PARAMETERS

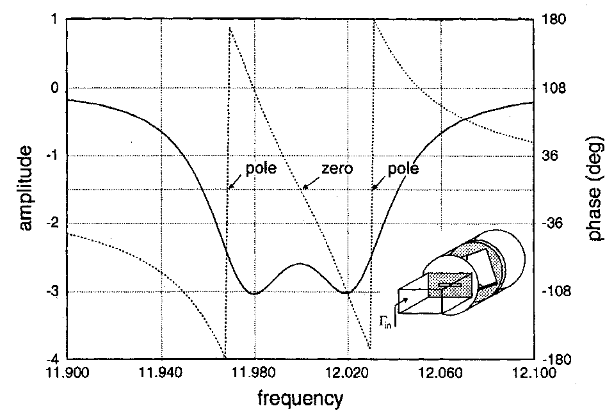
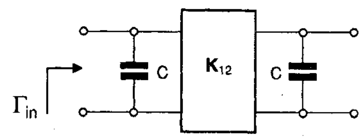
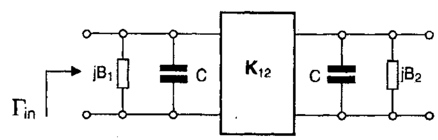


Fig. 9. Simulated reflection coefficient of short-circuited input cavity with the two resonant modes tuned.



(a)



(b)

Fig. 10. Low-pass equivalent network of the dual mode cavity. (a) The two modes are synchronously tuned. (b) Each mode shows a different detuning represented by susceptances B_1 and B_2.

of the structure of Fig. 2. The physical dimensions obtained from computer simulations have turned out to be as follows. The two circular cavities have a diameter of 22 mm and length of 16.39 mm. Central rectangular irises are 15.2 $\times$ 15.6 mm with an inclination of 10.6° with respect to the horizontal axis. Input and intercavity rectangular irises have a cross-section of 10.31 $\times$ 1 mm and 3.81 $\times$ 5.74 mm, respectively. Irises thickness is always 1 mm. A prototype aluminum filter with these dimensions has been manufactured with a nominal mechanical accuracy of $\pm 10\ \mu$m.

The measured response of this prototype is shown in Fig. 13. Several issues may now be considered.

A. Transmission Response

As can be noticed, the elliptic response is correctly reproduced, the center frequency and the operating bandwidth are in close agreement with design values, and asymmetries in

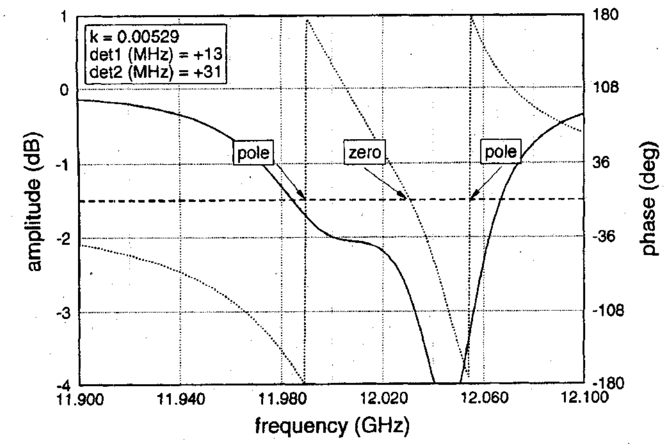


Fig. 11. Input cavity pretuned to its operating condition as from theoretical simulation.

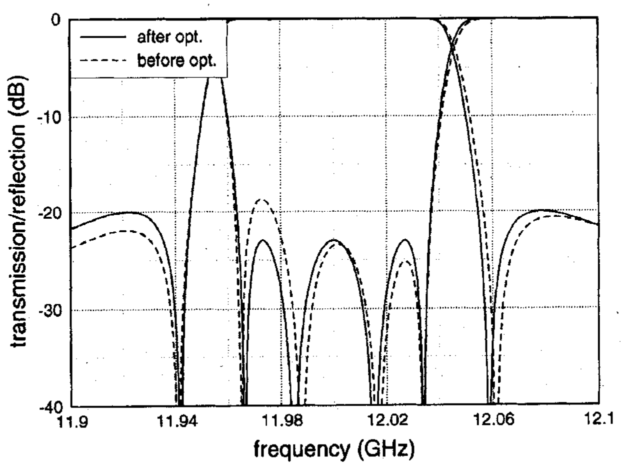


Fig. 12. Computed filter response. The starting point is represented by the dashed line while the optimized result (full-wave) is represented by the continuous line.

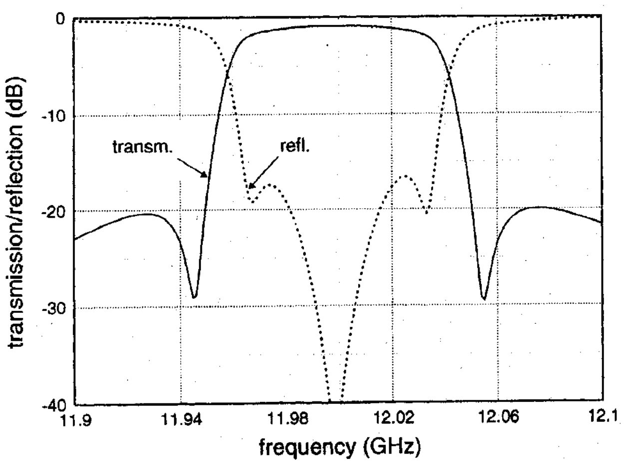


Fig. 13. Measured response of the dual mode, four pole, elliptic filter realized without using screws.

the transmission response are reduced to a minimum. The attained accuracy demonstrates the validity of the proposed filter structure and its suitability to be electromagnetically modeled.

B. Reflection Response

This is notably the most sensitive parameter with respect to mechanical inaccuracies. Some dedicated calculations have shown that errors in dimensions of the order of 10 to 20 μm can lead to variations of 6 dB or more in the return loss value. Since, as it is apparent, small variations in geometry entail significant changes in return loss without great impairments in the transmission response, a sensitivity analysis is advisable.

C. Further Developments

The positive results obtained on a 4-pole structure with a 0.6% relative bandwidth is the basis for estimating the feasibility of possible developments either toward a higher number of poles or to achieve smaller bandwidths. Concerning the first issue it is believed that the nominal ± 10 μm accuracy currently adopted also allows the realization of a 6-pole structure. Finally, with regard to decreasing the relative bandwidth, experimental results reported in [14] show that coupling of the order of half those displayed by the present structure are still under good control. It seems therefore reasonable to place the present limit for bandwidths around 0.3%.

VI. Sensitivity Analysis

The novel cavity arrangement replaces tuning and coupling screws with a section of inclined rectangular waveguide. Since no adjustment is feasible once the filter is manufactured, a sensitivity analysis with respect to variations of geometrical parameters becomes of considerable importance. The latter analysis also provides valuable insight about mechanical tolerances necessary to fulfill specifications. The sensitivity of coupling and detuning has been studied on a single dual-mode cavity with respect to variations of one side of the rectangular section, inclination and thickness. Reference variation bands of $\pm$ 2 % for coupling and ± 2 MHz for detunings, have been plotted together with results. These bands may be generally considered acceptable margins for a narrowband filter such as the one considered.

A. Sensitivity with Respect to Variation of One Side of the Rectangular Iris (Fig. 14)

This is the most sensitive parameter. By looking at Fig. 14 it is clear that the permissible variation is of the order 10 μm. This may pose mechanical problems and indicates where maximum accuracy must be sought for.

B. Sensitivity with Respect to the Inclination of the Rectangular Iris (Fig. 15)

As expected, a variation of this parameter has little effect on detuning but has a relevant effect on coupling. As apparent from Fig. 15 variations of 2/10 of a degree are acceptable from the electrical point of view and are well within the range of accurate mechanical manufacturing.

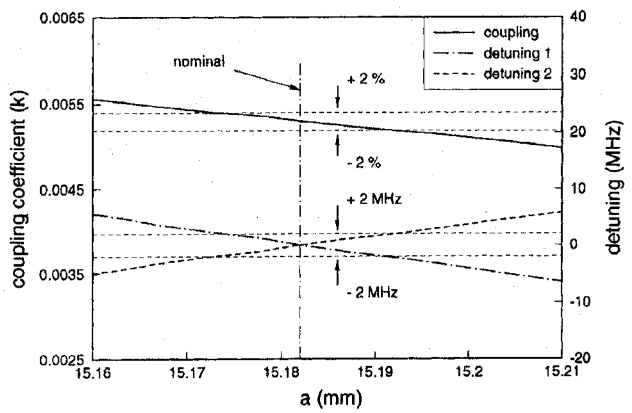


Fig. 14. Coupling and tuning sensitivities with respect to variation of larger side of the rectangular iris.

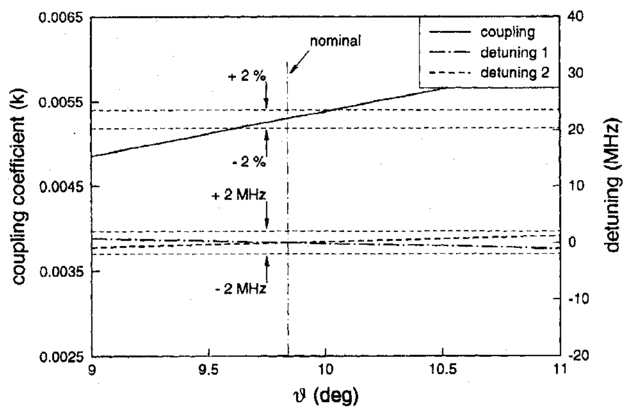


Fig. 15. Coupling and tuning sensitivities with respect to the inclination of the rectangular iris.

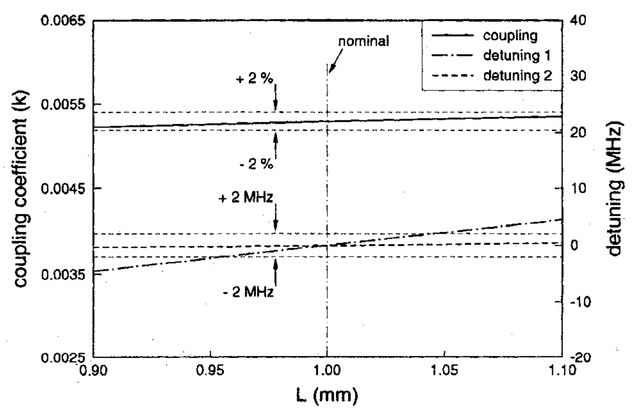


Fig. 16. Coupling and tuning sensitivities with respect to the thickness of the rectangular iris.

C. Sensitivity with Respect to the Thickness of the Rectangular Iris (Fig. 16)

Variations of this parameter have little influence on the coupling response and, for fixed cavity dimensions, also detuning effects are marginal. Of the considered parameters this is by far the least critical one.

VII. Conclusion

We have introduced a novel filter structure, where tuning and coupling of dual modes in circular cavity are achieved by means of inclined rectangular irises. The mechanism by which the inclined rectangular iris produce coupling and tuning has been described.

The structure has been modeled with mode-matching techniques and a prototype 4-pole elliptic filter has been entirely designed at computer level, mechanically manufactured and assembled without any further adjustment. Close agreement of measured results with field theoretical analyzes shows that high accuracy both in the electromagnetic model and in the mechanical realization enables the fabrication of no-screw dual mode channel filters up to Ku-band.

Sensitivity investigations have provided considerable insight concerning critical geometrical dimensions and required mechanical tolerances.

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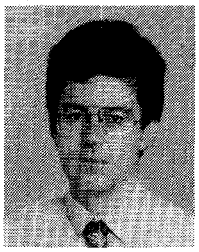

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Mauro Mongiardo, for a photograph and biography, see this issue, p. 2570.