A FOUR-POLE DUAL MODE ELLIPTIC FILTER REALIZED IN CIRCULAR CAVITY WITHOUT SCREWS

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I. Abstract

A 4-pole filter displaying an elliptic type response and implemented in circular cavity without tuning screws is presented. The cavity employs a novel arrangement, consisting in the insertion of a short length of inclined rectangular waveguide in the middle of the cavity body, in order to obtain the desired coupling and tuning actions.
A full-wave model of the complete filter has been developed and specialized pretuning techniques are used. The measured response of a breadboard channel filter operating at Ku-Band shows good agreement with computed data and proves the proposed approach to be valid and viable

II. Introduction

Dual mode bandpass channel filters are widely employed in satellite communication systems 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 [1], [2] 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. Previously published works on these subjects have considered implementations in rectangular cavities [3], [4], that may present shortcomings in their manufacturing phase, or are limited to single mode structures [5] for the circular waveguide case.

This paper presents the realization of a 4-pole elliptic transfer function filter employing a novel type of dual mode circular cavity without tuning and coupling screws. In the proposed 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[1]. The latter is placed at an inclination angle with respect to electric field polarizations in circular waveguide. In order to get the attenuation peaks of the elliptic response the inclination angle in the second cavity is the opposite of the first cavity, as shown in Fig. 1. The structure is entirely modeled by using a computer code for the analysis of rectangular-to-rectangular and rectangular-to-circular waveguides junctions. This fact significantly enhances both the efficiency and the accuracy of numerical simulations, since enables to consider a fairly large number of modes at the cost of only a modest increase of numerical expenses.

[1]patent pending

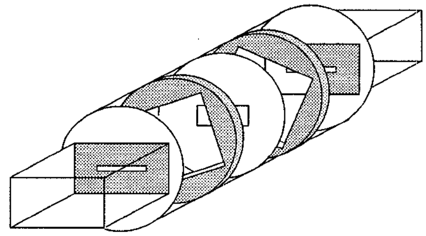

Fig. 1. 4-pole dual mode filter in circular cavity with no tuning screws.

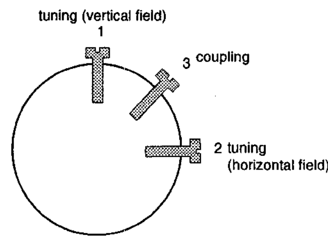

Fig. 2. Screw arrangement in a conventional dual mode cavity.

In order to prove 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 the next section, while in section IV. measured and theoretical results are provided and discussed.

III. Filter design and pretuning of cavities

Tuning and coupling actions, usually accomplished in a conventional dual mode cavity by using the three-

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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

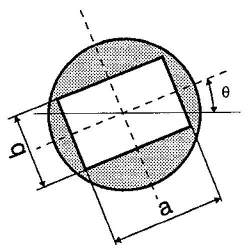

Fig. 3. Cross section of the proposed cavity.

screw scheme of Fig. 2, are in our case obtained by proper selection of aspect ratio (a/b), inclination angle of the rectangular guide and total cavity length. A complete electromagnetic model of the whole structure in terms of the generalized S-matrix requires only the study of two waveguide discontinuities, namely: rectangular-to-rectangular and rectangular-to circular. The inclination shown in Fig. 3 is handled as a tilt in the field polarizations of circular waveguide and takes a simple form involving no matrix inversion. Input and central irises are both of rectangular shape; the former is a thin slot which couples only the vertical polarization, the latter is of dual-mode type [6]: by controlling both sides of the rectangle two independent coupling values are obtained.

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. 1, 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, while the complete analysis requires about 3 hours. It is therefore highly advisable to reduce the total number of analyses 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 [2], have been retrieved and adapted.

Following this approach, the full-wave mode-matching analyses of the physical structure are used in place of actual measurements and the filter parame-

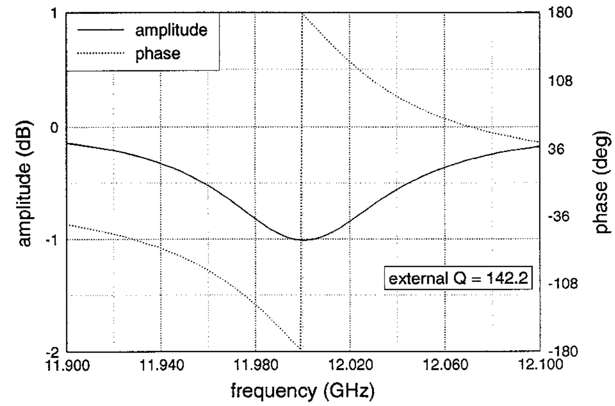

Fig. 4. Reflection response (overcoupled) of input cavity shorted and input coupling iris set for external Q = 142.2.

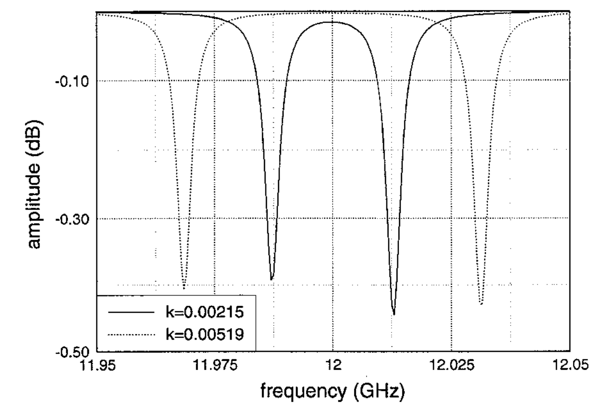

Fig. 5. Reflection responses (undercoupled) of two cavities shorted and intercavity iris placed in between.

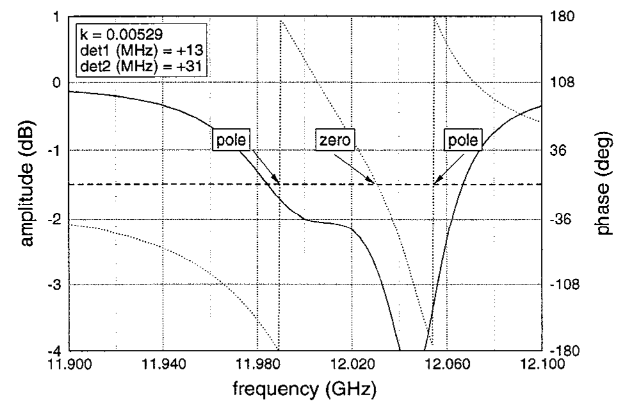

Fig. 6. Input cavity pretuned to its operating condition.

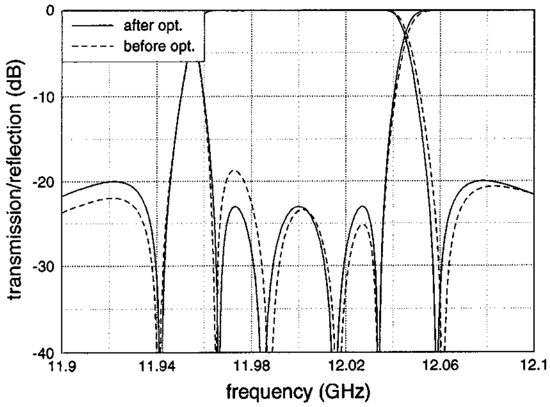

Fig. 7. Computed filter response. The starting point is represented by the dashed line while the optimized result (full-wave) is represented by the continuous line.

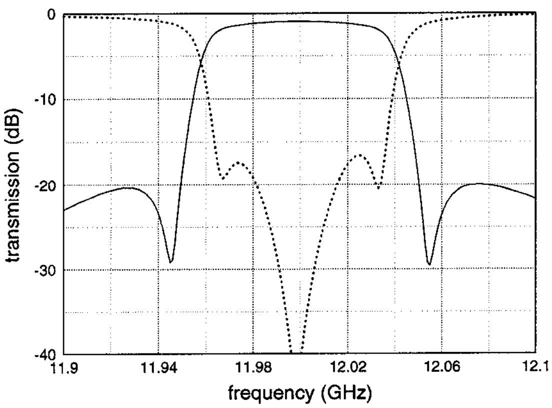

Fig. 8. Measured response of the dual mode, four pole, elliptic filter realized without using screws.

ters are adjusted by following a step-by-step procedure. The first step is to consider the first cavity alone fixing the input iris so as to get the sought value of external Q (Fig. 4). Next, the intercavity iris dimensions are determined using the two cavity arrangement of Fig. 1 with the output shorted and a small input iris (undercoupled condition). The result has the appearance of Fig. 5. The final step consists in presetting the tuning and coupling section (inclined rectangular guide) of the input cavity. In this case the cavity is shortened and the input iris is the one determined in the first step. In order to keep into account the reactive loading due to intercavity iris, the resonant modes (vertical and horizontal) are detuned by +13 and +31 MHz respectively. This final preset phase produces the result shown in Fig. 6. Coupling and detuning values are worked out using the methods described in [2].

IV. Experimental and Theoretical Results

The starting point obtained by using the previously reported pretuning technique is displayed in Fig. 7, where also the final design, achieved after a few optimization steps, is shown. Both results come from a full-wave mode-matching analysis of the structure of Fig. 1. The physical dimensions obtained from computer simulations have been used for internally manufacturing an aluminum prototype with a nominal mechanical accuracy of +/- 10 microns and a goal of +/- 5 microns, that has been attained for most dimensions. This latter figure is the accuracy that can be achieved by qualified workshops still at reasonable costs.

The measured response of the prototype filter is shown in Fig. 8. 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 the transmission response are reduced to a minimum. Note that it is not trivial to obtain such an accuracy at Ku-Band, where errors of the order of 0.1 % correspond to frequency shifts of at least 10 MHz, that is 15 % of the filter operating bandwidth. This demonstrates the full validity of the proposed filter structure and its suitability to be electromagnetically modeled.

V. Conclusions

A novel filter structure, in which tuning and coupling of dual modes in circular cavity can be effected without resorting to screws, has been presented. The structure has been modeled with mode-matching techniques and a prototype 4-pole elliptic filter has been fully designed at computer level and subsequently mechanically manufactured and assembled without any further adjustment. Close agreement of measured results with computer predictions 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.

References

[1] A.E. Williams, R.G. Egri and R.R. Johnson, "Automatic measurement of filter coupling parameters", in *IEEE MTT-S Int. Symp. Dig.*, pp. 418-420, 1983

[2] L. Accatino, "Computer-aided tuning of microwave filters", in *IEEE MTT-S Int. Symp. Dig.*, pp. 249-252, 1986

[3] X.-P. Liang, K.A. Zaki and A.E. Atia, "Dual mode coupling by square corner cut in resonators and filters", *IEEE Trans. Microwave Theory Tech.*, vol. 40, pp. 2294-2302, Dec. 1992

[4] R. Orta, P. Savi, R. Tascone and D. Trinchero, "Rectangular waveguide dual-mode filters without discontinuities inside the resonators", *IEEE Microwave Guided wave Lett.*, vol. 5, pp. 302-304, Sept. 1995.

[5] U. Papziner and F. Arndt, "Field theoretical computer-aided design of rectangular and circular iris coupled rectangular or circular waveguide cavity filters", *IEEE Trans. Microwave Theory Tech.*, vol. 41, pp. 462-471, Mar. 1993

[6] L. Accatino and G. Bertin, "Design of coupling irises between circular cavities by modal analysis", *IEEE Trans. Microwave Theory Tech.*, vol. 42, pp. 1307-1313, July 1994.