ON THE SUPPRESSION OF HIGHER ORDER MODES IN WAVEGUIDE COMPONENTS

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ABSTRACT

This contribution describes a method to reduce the excitation of higher order modes in waveguide circuits, e. g. filters. This reduction is achieved - in the given example of a filter - by a suitable choice of the iris form. To demonstrate this procedure, results of two simple filter structures with standard as well as modified irises are given.

ZUSAMMENFASSUNG

Es wird ein Verfahren zur Reduzierung der Anregung höherer Moden in Hohlleiterschaltungen, z. B. Filtern beschrieben. Diese Reduzierung wird - in dem vorgestellten Beispiel - durch geeignete Formgebung der Blenden in Filtern erreicht. Zur Demonstration des Verfahrens sind die Ergebnisse von je einem einfachen Filter mit Standardblenden und mit modifizierten Blenden angegeben.

INTRODUCTION

In spite of the increasing trend towards hybrid and monolithic integrated circuits, waveguide components still are playing an important role if low loss or high power is required, e.g. for filters. Primary attention is paid to the performance of components in the specified frequency range of operation. In addition, however, further requirements may exist for higher frequencies (spurious responses of filters, spurious frequencies of oscillators, frequency doublers, or mixers). In these cases, higher order modes in the waveguide strongly can influence the performance of the component as well as the (often uncontrollable) interaction with the other circuits. A simple but typical example is given in Fig. 1 and 2. The Ka-band single resonator filter with two inductive irises can be designed easily using the mode matching technique, and typically, theoretical and experimental results agree quite well. This can be seen in Fig. 2 up to a frequency of 63 GHz; then however, a strong ripple in the measurements appears which is due to TE_{30} interaction with the measurement system (reflections in the waveguide taper from Ka- to V- or W-band). The same happens in system applications, deteriorating the out-of-band system performance. Furthermore, the higher frequency filter response is affected.

METHOD OF HIGHER ORDER MODE SUPPRESSION

A successful procedure to inprove the stop band performance of filters by modified multiple inductive elements is given in /1/. In an optimization process, the geometry of these elements is modified for maximum stop band attenuation. In this contribution, a ***direct*** method is presented to reduce considerably the excitation of the strongest higher order mode. Basically, this has already been done in the example given in Figs. 1 and 2 employing symmetrical irises, suppressing the unsymmetrical TE_{20}-mode. In many cases, waveguide structures are analyzed and designed using the mode matching technique /2/.

The reduction of the excitation of other modes most easily can be explained using the coupling integrals in the mode matching technique. Typically, such an integral has the form of

$$K_{mn} = \iint_{\substack{field \\ cross\ section}} \vec{e}_{tm} \cdot \vec{e}_{tn} dA, \tag{1}$$

where $\vec{e}_{tm}$ and $\vec{e}_{tn}$ represent the tangential vector field distribution of two different modes m and n. The excitation of mode m by mode n now can be reduced considerably if this coupling integral is made zero $\left(K_{mn} = 0\right)$ by a special selection of the geometry (of course, some excitation of mode m via other modes $i \neq n$ is possible; this however, mostly is an order of magnitude weaker). A typical example is the excitation of the TE_{30}-mode by the TE_{10}-mode in an inductive iris as shown in Fig. 1 and 2. The coupling is determined by

$$K_{31} = \int_{\substack{iris \\ width}} \cos\left(\frac{\pi}{c}x\right) \cdot \cos\left(\frac{3\pi}{a}x\right) dx, \tag{2}$$

where c is the iris width. If the form of the inductive iris now is modified according to Fig. 3, an additional degree of freedom arises, and $K_{31} = 0$ can be achieved by a proper choice of the geometry. This can easily be seen from Fig. 4 representing the electric field dependence and the geometry of the modified iris. In a similar way, the excitation of TE_{13} and TM_{13} modes in symmetrical capacitive E-plane filters can be suppressed. For other combinations of modes, more complex irises may be selected, possibly including some optimization procedure as described in /1/. With increasing complexity of the iris, however, the achievable maximum transmission through the iris - which is directly related to filter bandwidth - is getting rather low. Using irises fabricated (etched) from a thin sheet of metal may give some way out of this problem.

EXPERIMENTAL VERIFICATION

To demonstrate the result of this technique, a single resonator filter with the same low frequency performance as in the first example (Figs. 1 and 2) has been designed and tested (Fig.3 and 5). The high frequency performance, however, differs remarkably from the old results, showing less spurious passbands, and the measurement results agree excellent with theory up to 110 GHz, while the interaction with the measurement system is negligible.

REFERENCES

/1/ Arndt, F., Beike, J., Grauerholz, D., Lingemann,Ch., Bornemann, J.: E-Plane Integrated Parallel-Strip Screen Waveguide Filters. IEEE Trans. on Microw. Theory Techn., Vol. MTT-33, July 1985, 654 - 659.

/2/ Itoh, T. (Editor): Numerical Techniques for Microwave and Millimeter-Wave Passive Structures. J. Wiley & Sons, New York, 1989.

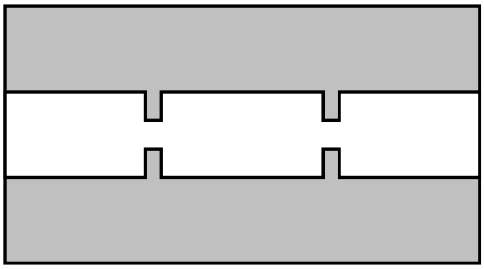

Fig. 1: H-plane single resonator waveguide filter with simple symmetric irises.

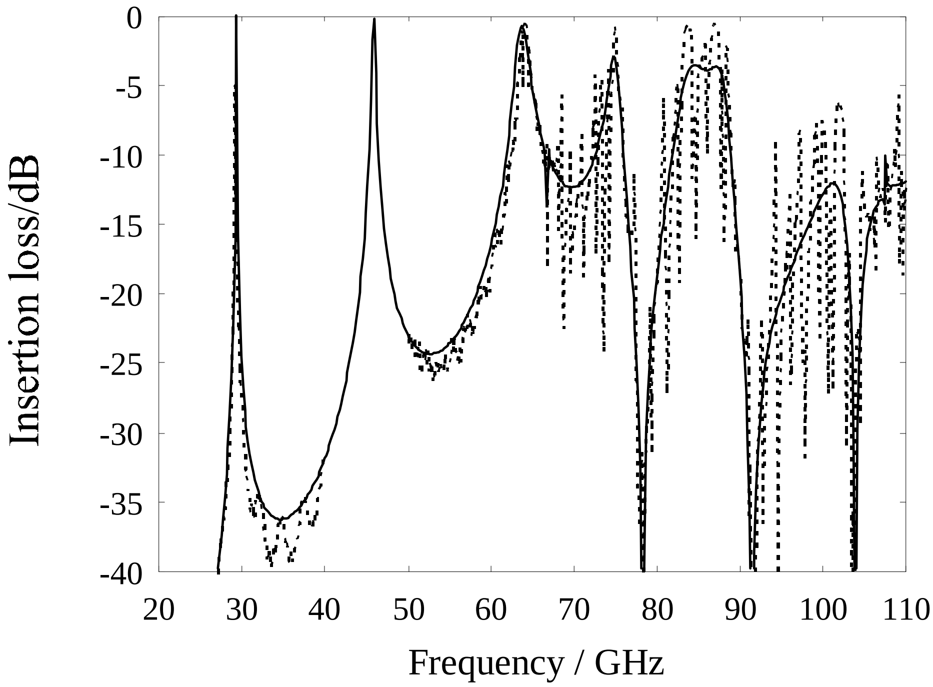

Fig. 2: Theoretical (—)and experimental (**......**) results of the filter according to Fig. 1.

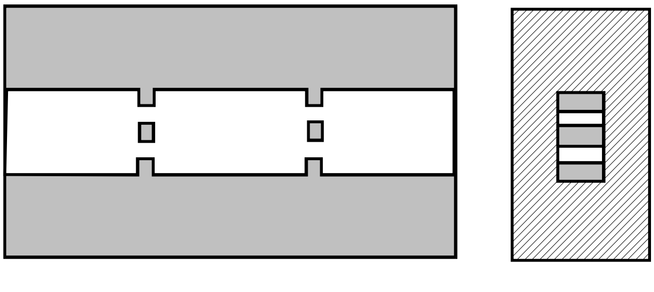

Fig. 3: Single resonator waveguide filter with modified irises.

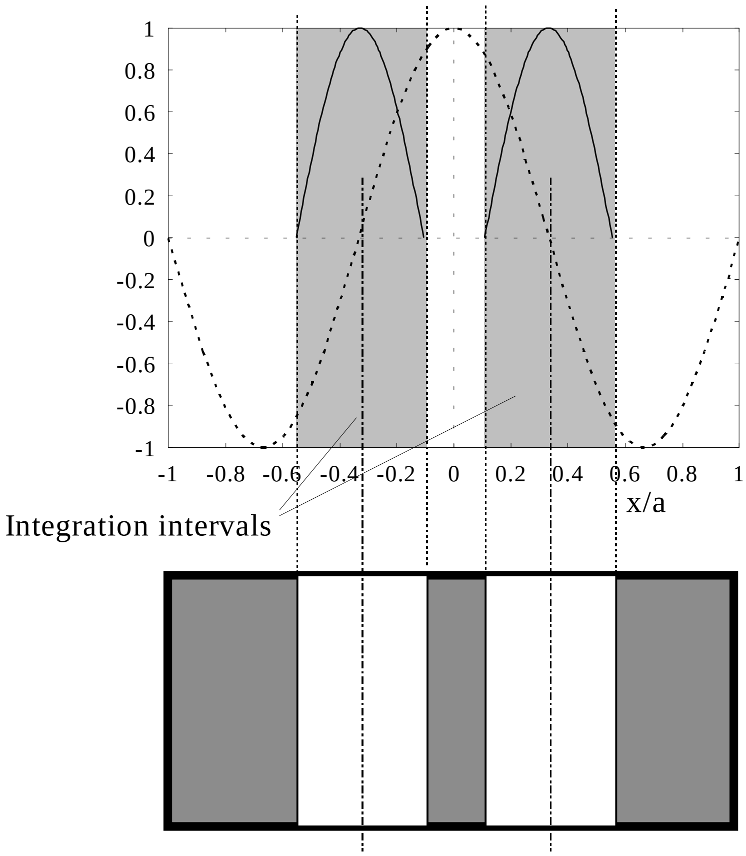

Fig. 4: Field distribution and iris geometry for TE_{10}-modes in the iris and TE_{30}-mode in the waveguide.

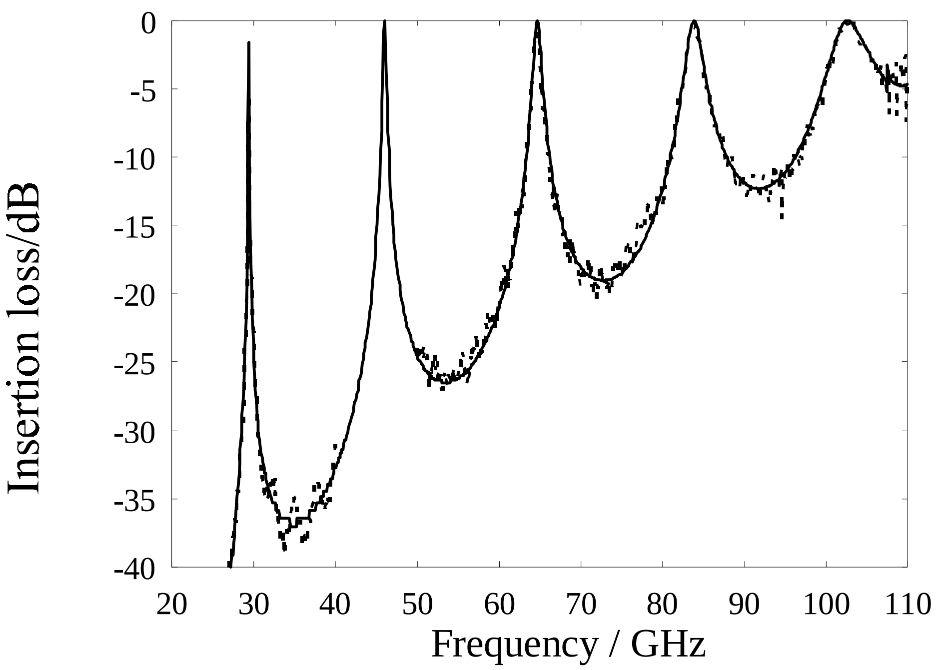

Fig. 5: Theoretical and experimental results of the filter according to Fig. 3.