GENERALIZED TE_{011} MODE WAVEGUIDE BANDPASS FILTERS

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Abstract

The realization of the general transfer functions of bandpass coupled cavity filters in the high Q circular waveguide TE_{011} mode is presented in this paper. In addition, a novel method of suppressing the degeneracy of the TM_{111} mode is described. Finally, experimental results obtained from a fourth-order, elliptic function, 20-MHz, bandpass filter centered at 12 GHz and having an unloaded Q of 16,000 are discussed.

Introduction

Narrow bandpass waveguide filters are generally constructed from direct coupled rectangular, square, or circular cavities oscillating in the fundamental TE_{101} or TE_{111} modes.[1-4] However, for specific applications such as channelization filters for satellite transponders, the fundamental mode's unloaded Q may not be adequate, especially if the percentage bandwidths become less than 1 percent.

This paper describes the use of the circular cavity TE_{011} mode to increase the realizable unloaded Q. It also describes the realization of the nth-order symmetrical coupled cavity TE_{011} mode filter geometry. Finally, it presents a novel method of suppressing the degenerate TM_{111} mode. Experimental results using this realization show excellent agreement with theory.

Theory

Synthesis of a multiple coupled cavity network from the low-pass transfer function is described in Reference 5. Figure 1 illustrates the unique canonical realization of couplings assuming a symmetrical n even ($n = 2m$) coupled cavity network. All couplings are zero except the "series" $(i, i + 1)$ couplings and the "shunt" $(i, n - i + 1)$, $i = 1, 2, \ldots, m - 1$ couplings. The realization for n odd follows in a nearly identical manner. It is important to note that in general all "series" couplings are of the same sign, while "shunt" couplings may be positive or negative.

TE_{011} Mode Filter Design

The TE_{011} mode filter design previously described in the literature has used couplings via the side wall magnetic field,[6] although an alternative method of coupling via the radial end wall magnetic field may also be employed. Both of these geometries, shown in Figures 2a and 2b, generate "shunt" couplings of the same sign (all positive or all negative). Both negative and positive "shunt" couplings may be realized with the geometry shown in Figure 2c. This structure employs both side wall and end wall couplings, with the negative couplings generated by positioning the cavity ends at overlapping half diameters.

The degenerate TM_{111} mode can be suppressed by adding to the tuning plunger four short "tuning posts" spaced at 90° angular positions at a radius of maximum electric field of the TM_{111} mode (see Figure 3). Perturbation analysis of this configuration shows that these posts shift the resonant frequencies of the TE_{011} and TM_{111} modes in opposite directions, and that the unloaded Q of the desired mode is not degraded.

A fourth-order elliptic function filter having a bandwidth of 20 MHz and a center frequency of 12 GHz is shown in Figure 4. Experimental results in Figure 5 show excellent agreement with the designed response, and the insertion loss of 0.5 dB for the silver plated cavities corresponds to an unloaded Q of 16,000.

Conclusions

This paper has described the realization of general coupled cavity transfer functions in TE_{011} mode circular waveguide cavities. Experimental results at 12 GHz demonstrate that unloaded silver plated cavity Q's of 16,000, as opposed to 5,500 for the fundamental cavity mode, can be achieved.

References

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5. A. E. Atia, A. E. Williams, and R. Newcomb, "Narrow-Band Multiple-Coupled Cavity Synthesis," IEEE Transactions on Circuits and Systems, CAS-21, No. 5, September 1974.
6. Matthaei, Young, and Jones, Microwave Filters, Impedance Matching Networks and Coupling Structures, New York: McGraw-Hill, Chapter 15, 1965.

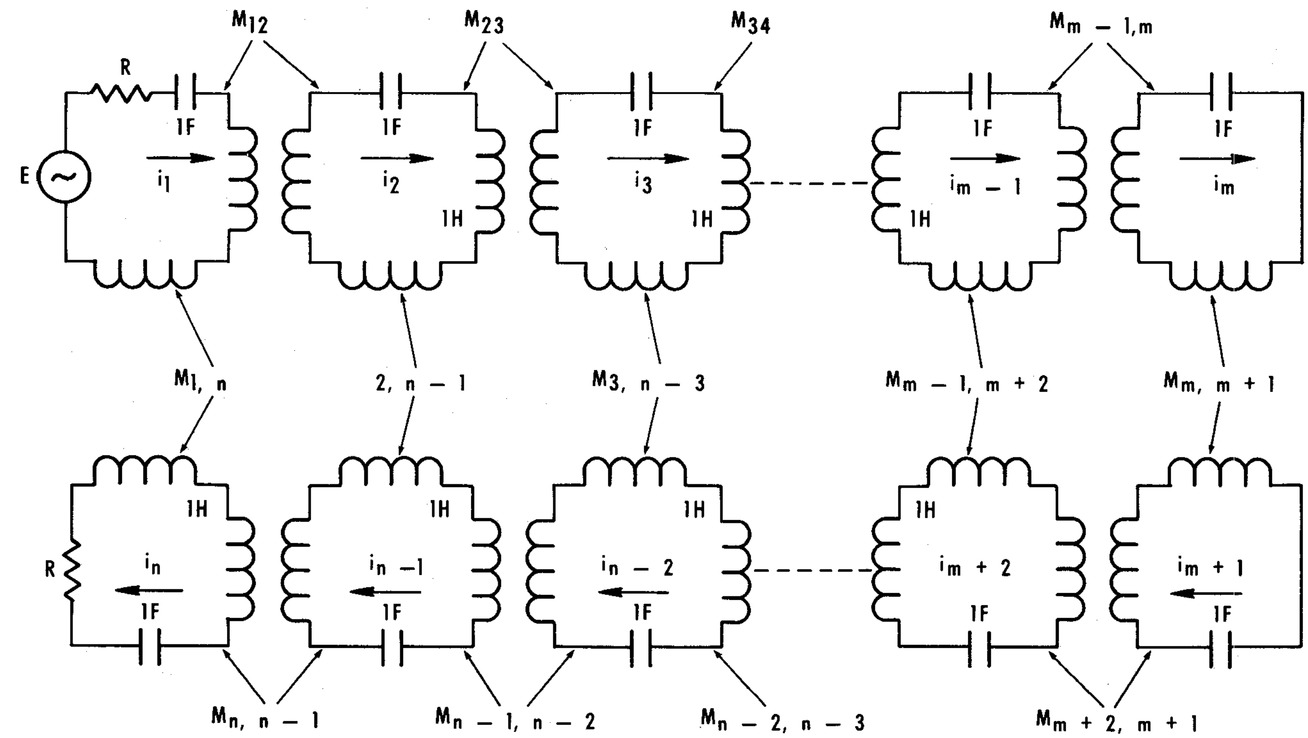

Figure 1. Canonical Form of the Equivalent Circuit for a Symmetrical Network of Order n = 2m

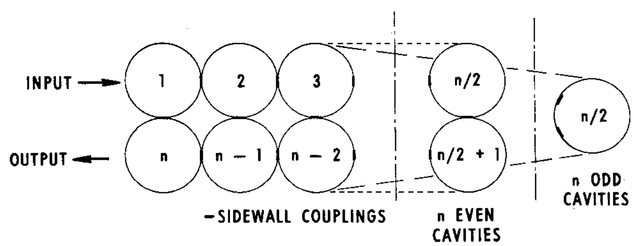

Figure 2a. TE_{011} Mode Filter with Sidewall Couplings ["shunt" couplings all +ne (or all -ne)]

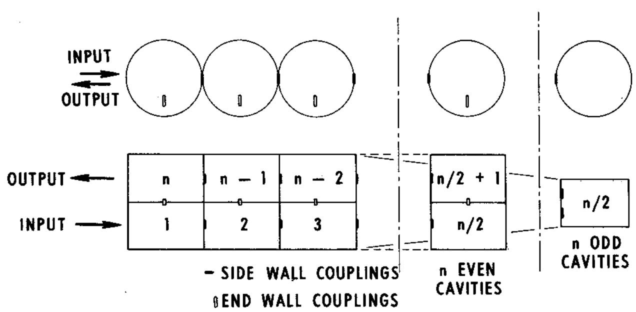

Figure 2b. TE_{011} Mode Filter with Sidewall and Endwall Couplings ["shunt" couplings all +ne (or all -ne)]

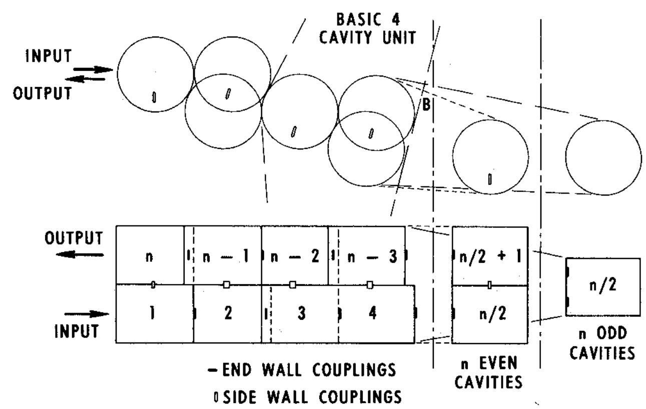

Figure 2c. TE_{011} Mode Filter with Sidewall and Endwall Couplings ("shunt" couplings may be +ne or -ne)

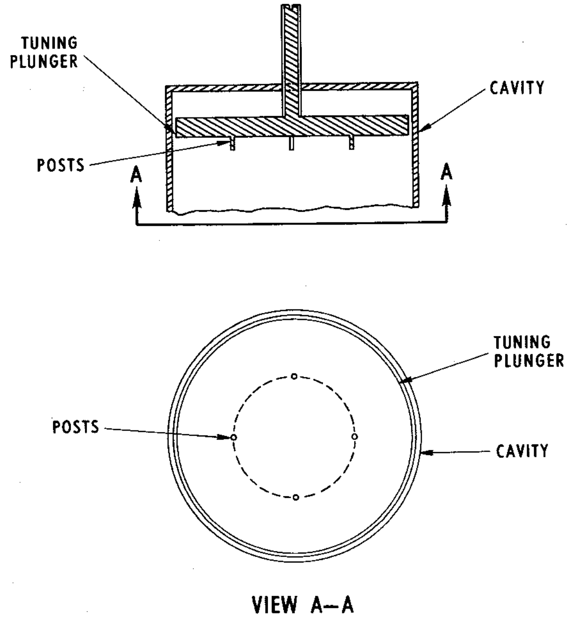

Figure 3. Tuning Post Design Which Splits the Degeneracy of the TE_{011} and TM_{111} Modes

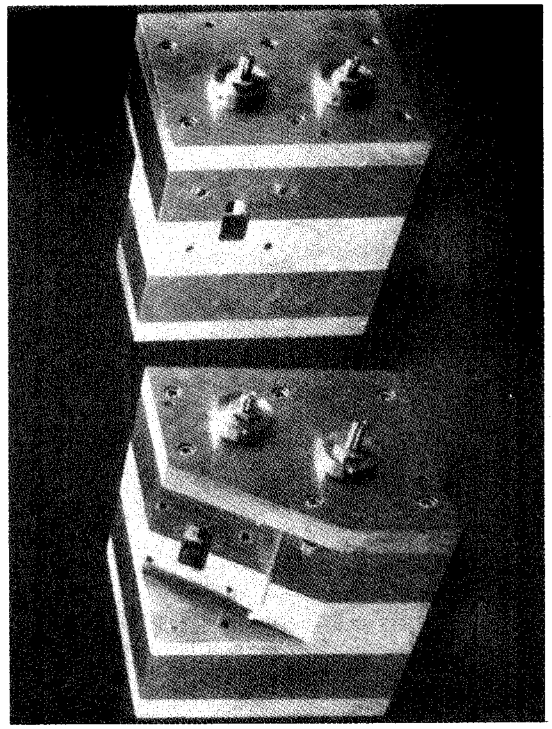

Figure 4. 12-GHz TE_{011} Mode 4-Pole Elliptic Function Filter

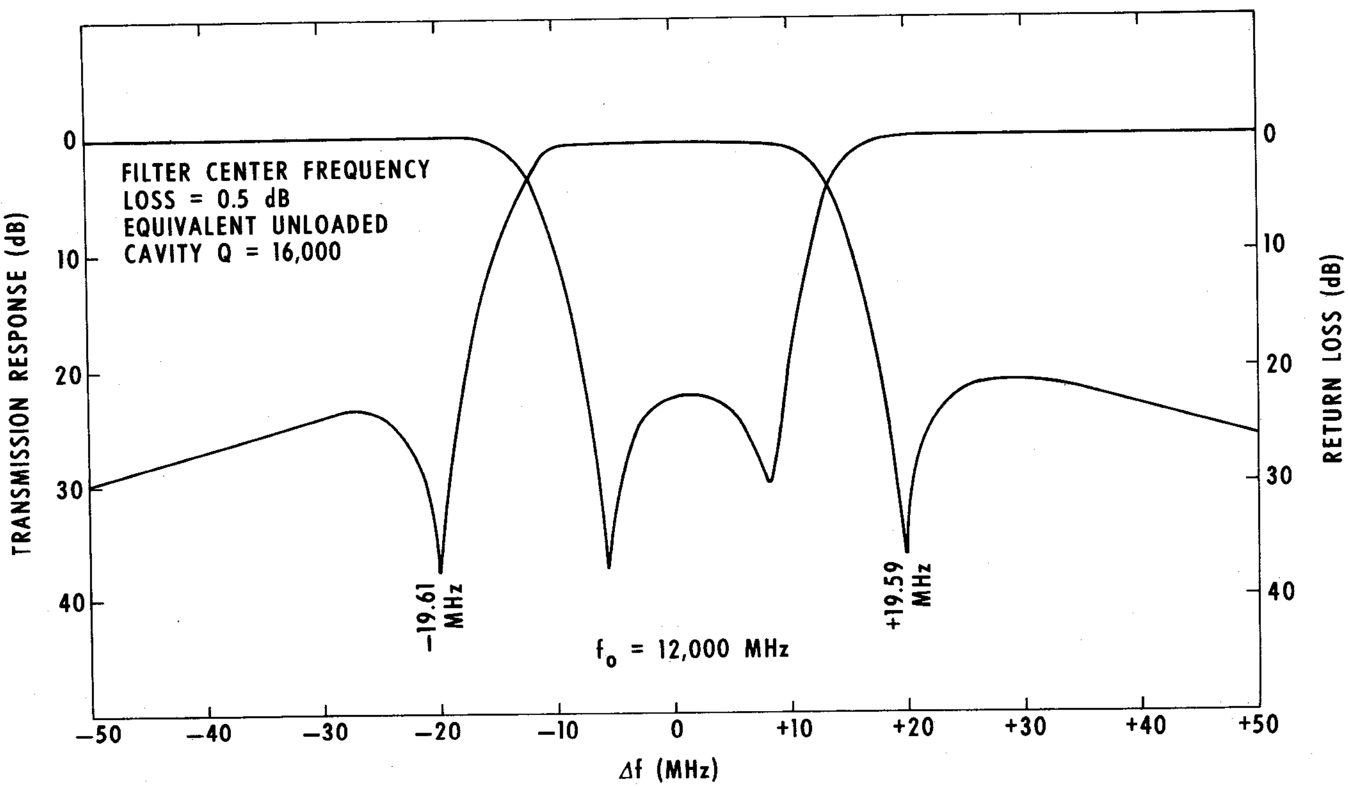

Figure 5. Transmission and Return Loss Response of 12-GHz TE_{011} Mode Filter