III-3. Quasioptical Waveguide Filters

J. J. Taub, H. J. Hindin and G. P. Kurpis

Airborne Instruments Laboratory, Deer Park, N. Y.

Oversize waveguide has recently been used successfully to develop a variable attenuator, directional coupler, phase shifter, and a duplexer at 330 Gc.[1,2] Use of oversize waveguide results in lower loss components at millimeter and submillimeter wavelengths. Filter structures using quasi-optical techniques in oversize waveguides are described in this paper.

In an oversize waveguide (typically 10 times greater in each dimension than standard-size rectangular guide), coupling structures normally used in filters such as irises, posts, etc., are inadequate because they generate higher-order modes. Optical type structures such as dielectric slabs and gratings must be used. Examples of quasioptical waveguide filters are shown in Figs. 1 and 2. Figure 1 shows a low-pass filter consisting of a series of *n* cascaded dielectric slabs each having an electrical thickness of $\lambda/4$ and separated by $\lambda/4$ (where λ is the free-space wavelength). The structure is essentially a dielectric reflector[3] housed in oversize waveguide. This device has a cutoff at a frequency where the slab separations are $\lambda/2$. By placing a similar series of dielectric slabs at a 45° angle in the center of a four port waveguide junction (Fig. 2), we obtain a low-pass directional filter. This filter has low-pass properties at port 2 and high-pass at port 4 and is matched at port 1.

A direct-coupled bandpass filter can be realized by forming resonant cavities with gratings placed at multiple half-wavelength intervals along the waveguide. A typical grating consists of a series of holes in a thin conducting plate; each hole is separated from the next by less than $\lambda/2$ to avoid higher-order modes; the hole diameters determine the degree of coupling between resonators. A directional version of this filter would use a structure analogous to that of Fig. 2; the gratings are placed at a 45° angle. This filter has bandpass properties at port 2, band-reject at port 4, and is matched at port 1.

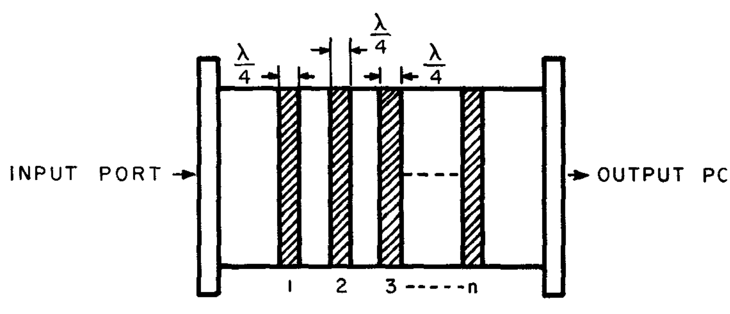

Fig. 1 Cascaded dielectric slab low-pass filter.

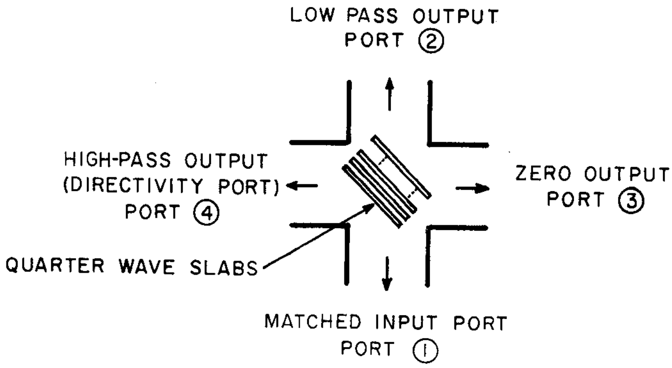

Fig. 2 Low-pass filter structures.

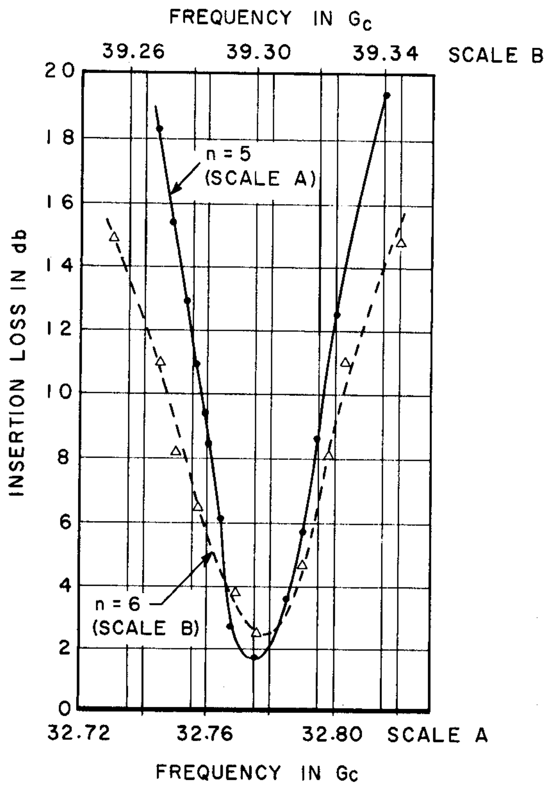

Fig. 3 Insertion loss vs frequency of quasioptical two-resonator filter.

At present we have constructed a bandpass filter and a low-pass directional filter. The bandpass filter consists of two coupled resonators and operates in the 9 mm region with a 22.5 Mc bandwidth and 1.7 db of insertion loss at its center frequency. The filter uses standard *S*-band brass waveguide. Each resonator is five half-wavelengths long. A similar design in standard size rectangular waveguide (WR28 coin-silver waveguide) would have had 6.6 db of insertion loss.

A graph of the insertion loss vs frequency for the oversize waveguide filter is shown in Fig. 3. This figure also shows the insertion loss vs frequency characteristics at frequencies where each resonator is six wavelengths long. Tuning the two cavities to the same center frequency was accomplished by slight waveguide deformation—that is, pressure on the broad or narrow waveguide wall. No tuning screws were used because they generate higher order modes. Figure 4 shows the two-cavity filter; the inter-resonator grating is shown on the top of the waveguide. Identical input and output gratings are used. A similar design can be used to construct a filter operating at 330 Gc, with a 3 db bandwidth of 225 Mc and an insertion loss of less than 3 db.

A low-pass directional filter has been constructed and is shown in Fig. 5. It employs four quartz slabs. The slab thickness and the air separation are

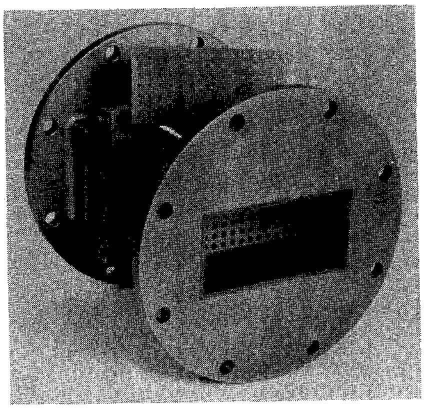

Fig. 4 Two-cavity filter.

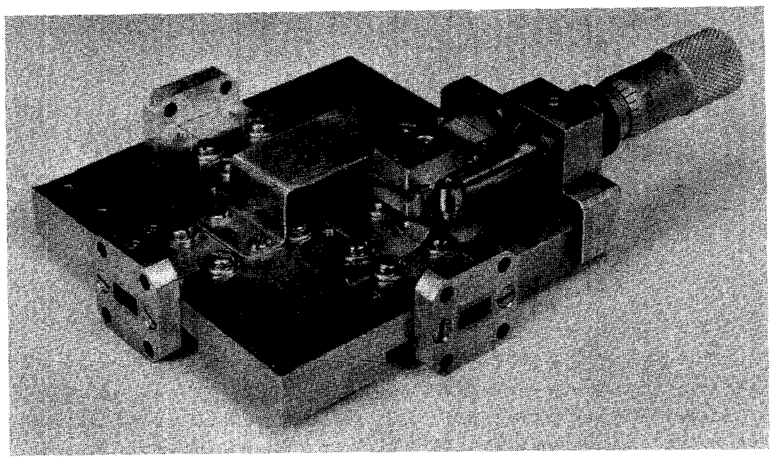

Fig. 5 Low-pass directional filter.

chosen to be $\lambda/4$ at 330 Gc. It has not been possible to evaluate the frequency response at this time; however, data at 330 Gc, shown in Fig. 6, is encouraging. The insertion loss at ports 3 and 4 are plotted as a function of the air separation (S) between the second and third slabs. The loss at port 4 is well below that of port 3, indicating the directionality of the device. The port 3 loss varies cyclicly, as predicted. The minimum loss of 2 db is mainly due to dielectric dissipation. This data suggests that the desired frequency behavior is obtainable.

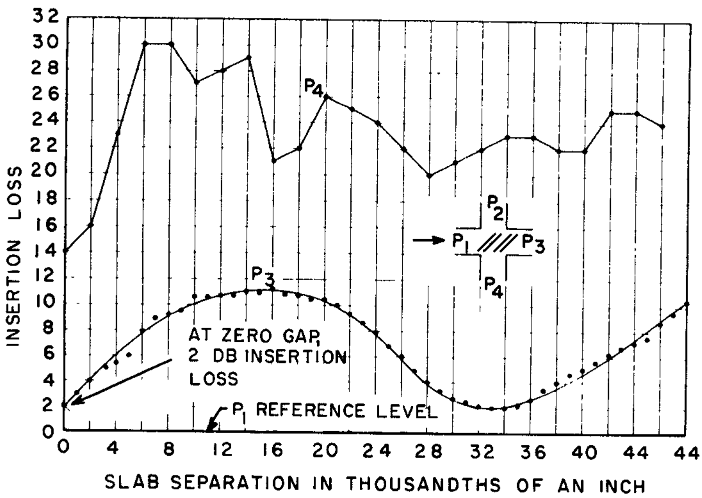

Fig. 6 Test data on a four-slab directional filter at 330Gc.

The results, to date, indicate that filters can be designed in oversize waveguide. Use of these techniques will make it possible to obtain, at millimeter and submillimeter wavelengths, lower insertion loss and more ease of construction than is possible using standard size waveguide structures. Work is continuing to obtain experimental models of a directional bandpass filter and a low-pass filter at 330 Gc.

ACKNOWLEDGMENT

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REFERENCES

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3. W. Calshaw, "Reflectors for a Microwave Fabry-Perot Interferometer," *IRE Trans. on Microwave Theory and Techniques*, p. 220–221, April 1959.

HEWLETT-PACKARD CO.

1501 Page Mill Road, Palo Alto, California

Telephone: (415) 326-7000