A NARROWBAND FILTER WITH A WIDE SPURIOUS-FREE STOPBAND*

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ABSTRACT

This paper describes a 6-pole, 12-GHz, pseudo-elliptic 76-MHz bandpass filter which achieves a stopband attenuation of greater than 50 dB up to 25 GHz. This design eliminates the need for a separate low-pass filter in applications such as output multiplexers of satellite transponders.

INTRODUCTION

Single, dual, triple, quadruple, and hexa-mode degenerate waveguide cavities are typically used as basic building blocks for high-Q waveguide narrow bandpass filters [1],[2],[3]. Particularly for applications such as combining filters on output multiplexers in communications satellite transponders, it is important not only to achieve high Q or minimum filter loss—to save scarce power resources in space—but also to minimize out-of-band spurious transmissions up to at least twice the filter operating frequency. Unfortunately, conventional waveguide filters suffer from poor stopband performance. Figure 1 illustrates the typical wide transmission response of a dual-mode TE_{113}, Ku-band filter.

Conventional output multiplexer designs eliminate these spurious transmission bands by using a low-pass filter—in series with the output port of an output multiplexer for low-power operation, or in series with each filter at the input ports of the multiplexer for high-power operation (see Figure 2). This paper presents a new type of filter which uses a combination of dual-mode cylindrical cavities and cavities resonant in the cylindrical TM_{010} mode. Wide stopband transmission at high frequencies was realized by selecting a large down-link ratio for the telemetry cavities and coupling them by a specially designed coupling-suppressing iris.

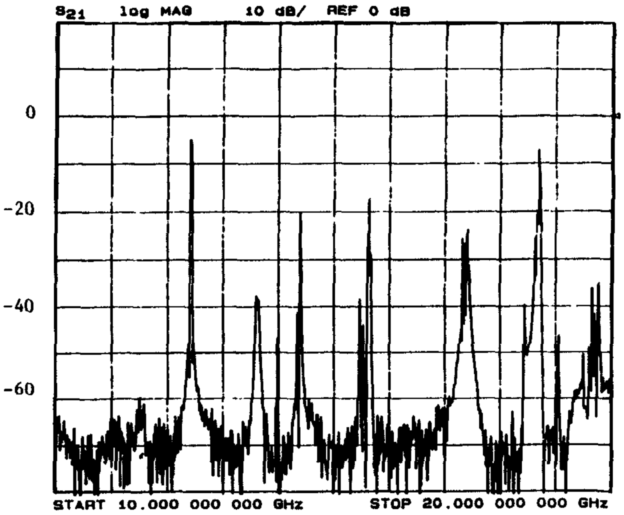

Figure 1. Typical Wideband Frequency Response of Ku-Band, TE_{113} Dual-Mode Filter

FILTER DESIGN

From the standard cylindrical cavity mode chart shown in Figure 3 [4], it is clear that if the TM_{010} mode cavity is designed to resonate at a diameter-to-length-ratio greater than 3, the only possible spurious resonance up to twice the operating frequency is the TM_{110} mode. Suppression of the next higher mode, TM_{210}, would also be desirable.

One potential disadvantage in using this mode is its poor unloaded Q (3 to 4K at 12 GHz) compared to 12/13,000 for the dual TE_{113} mode. Thus, designing a bandpass filter which makes use of the wide stopband properties of the TM_{010} mode represents a compromise between minimizing the effect of this poor Q and achieving adequate out-of-band attenuation.

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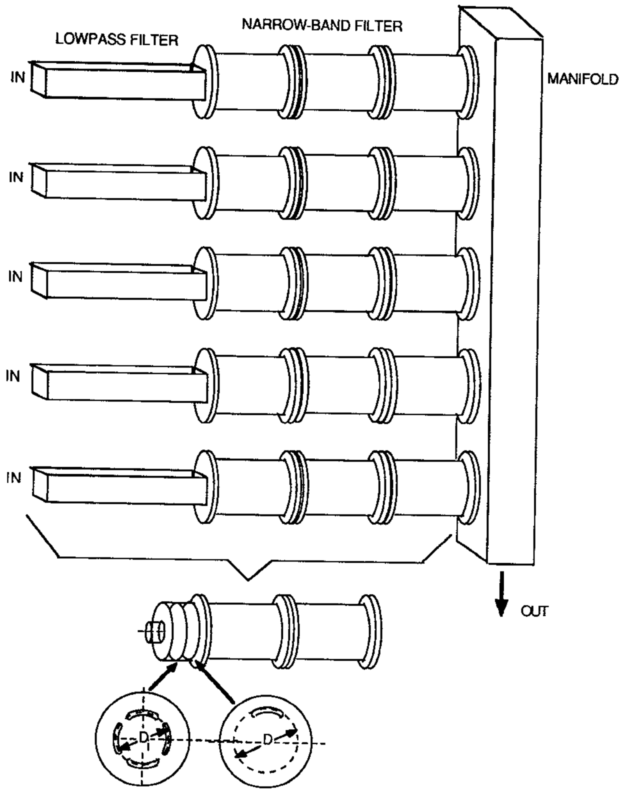

Figure 2. Output Multiplexer Schematic for Both Conventional and Composite Filters

For a typical satellite communications transponder output multiplexer which requires a 6-pole filter response, this compromise results in a design which uses two TM_{010} cavities in cascade with two dual TE_{113} cavities.

The sketch in Figure 2 compares the composite 6-pole filter to a standard three-cavity dual TE_{113} mode design. Coupling into and out of the filter is achieved via a center coaxial probe in the first TM_{010} cavity and the last TE_{113} cavity. The filter uses standard coupling between the TE_{113} modes together with a specially designed iris between the TM_{010} cavities which allows fundamental mode coupling but suppresses both higher TM modes. A single angular iris couples the second TM_{010} cavity to the first TE_{113} mode.

EXPERIMENTAL RESULTS

A 6-pole, 12-GHz bandpass filter was designed to realize a quasi-elliptic transmission response with a 76-MHz bandwidth. Figures 4 and 5 show the in-band and wideband transmission performance, respectively, of this filter. Figure 6 is a photograph of the experimental filter. Note that spurious rejection of >50 dB was realized to about 25 GHz, and the in-band loss of 0.6 dB compares favorably with the total loss of bandpass and low-pass filters in series.

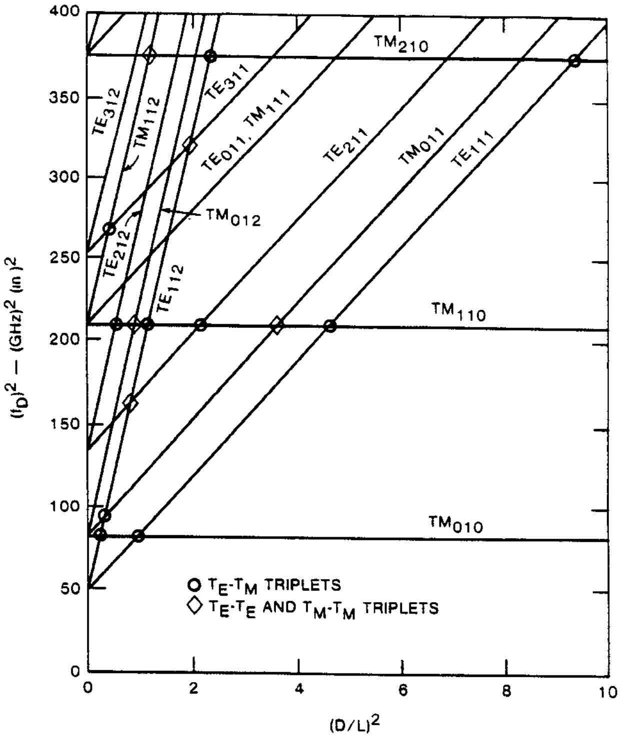

Figure 3. Mode Chart for a Right-Circular Cylindrical Resonator of Diameter D and Length L

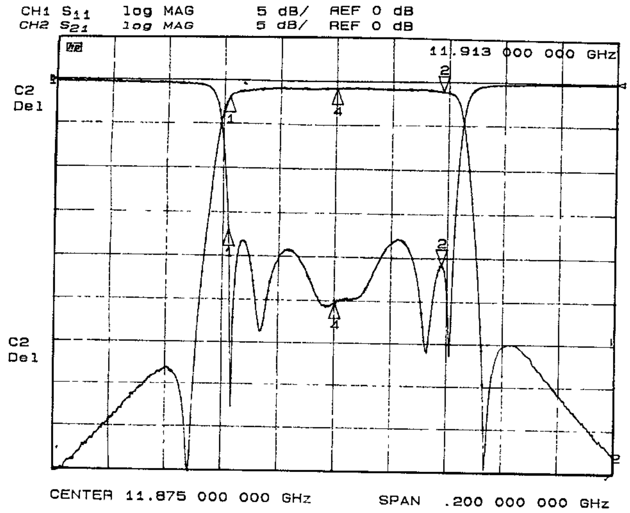

Figure 4. Narrowband Performance of 12-GHz-Wide Stopband Bandpass Filter

CONCLUSIONS

A design technique for realizing narrow bandpass/wide stopband filters has been presented. This type of filter serves as a direct replacement for the bandpass/low-pass filters currently used on communications satellite payload output multiplexers. Equivalent loss

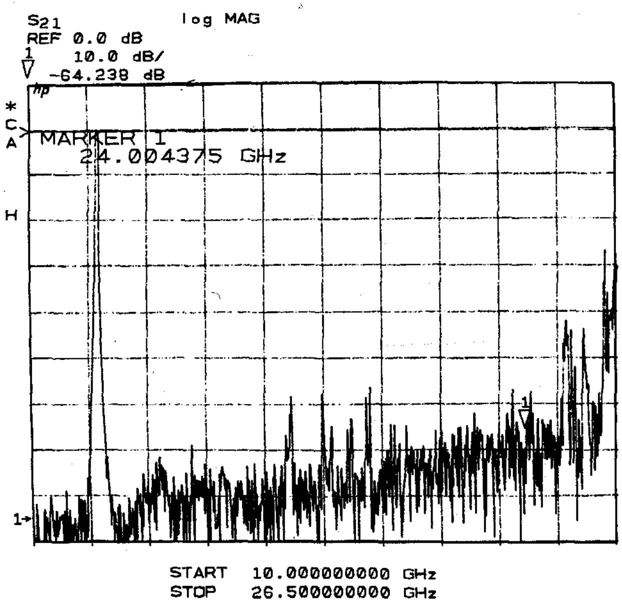

Figure 5. Wideband Performance of 12-GHz-Wide Stopband Bandpass Filter

performance can be achieved for substantial savings in mass and volume.

ACKNOWLEDGMENTS

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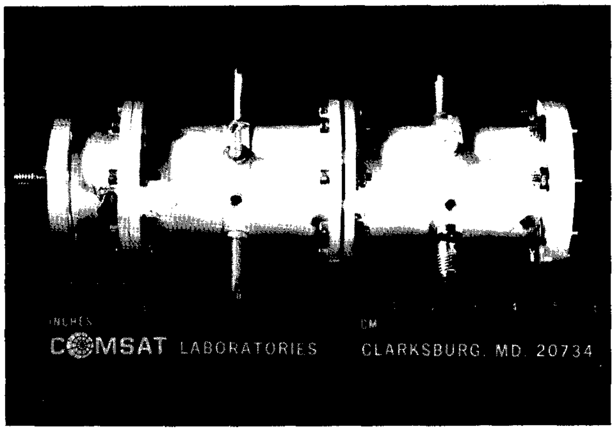

Figure 6. 12-GHz-Wide Stopband Bandpass Filter

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