DIELECTRIC RESONATOR OUTPUT MULTIPLEXER FOR C-BAND SATELLITE APPLICATIONS

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ABSTRACT

A 3-channel C-band manifold-coupled multiplexer using dielectric-loaded filters has demonstrated a viable approach for future satellite output multiplexers. The new multiplexer configuration utilizes dual- and triple-mode dielectric resonator filters coupled onto a ridged waveguide manifold. This design offers significant size and weight reduction while preserving the optimum electrical performance. It is therefore expected that this new output multiplexer design will be used for future C-band satellite systems.

INTRODUCTION

Recent advances in the ceramic technology for low-loss ($\tan\delta$ <0.0001) temperature stable ($\alpha \cong 0$ ppm/°C) dielectric materials has encouraged the development of microwave filters employing dielectric resonators of relatively high permittivity ($\varepsilon_r \cong 37$) [1]. Microwave bandpass filters employing dielectric resonators operating in the dual-mode configuration having coaxial interface has been reported by Fiedziuszko [2]. Using the well-proven channel dropping scheme, such filters can be implemented to provide an input multiplexing network for the satellite payload. To date, no work has been reported to realize a manifold-coupled output multiplexer using dielectric resonator filters. The likely reasons are the difficulty in coupling such a filter to a waveguide manifold and their power handling capability in the space environment. The work described in this paper clearly shows that dielectric-loaded filters in a dual- or dual/triple-mode configuration can be coupled to a waveguide manifold with no loss of performance. Furthermore, the thermal design and subsequently measured data under high power in vacuum has established the suitability of dielectric-loaded output multiplexers for C-band satellite applications.

FILTER DESIGN

Current design for output multiplexers consists of either 4-pole elliptic or 6-pole quazi-elliptic channel filters. A recent study conducted for a U.S. satellite prime contractor (COM DEV Internal Report) has clearly demonstrated that a 5-pole quazi-elliptic function filter yielded the best overall channel performance when multipath effects for an operating satellite are taken into account [3]. Such an odd-order filter is realized by cascading dual- and triple-mode cavities. Triple-mode cavities with air dielectric have been realized recently for potential applications for satellite multiplexers at C-band frequencies [4]. Use of a triple- and dual-mode dielectric-loaded cavities in cascade, form the basis of the filter design employed here. This provides an optimal electrical performance along with a compact and light-weight structure.

The dimension of the dielectric resonator determines the frequencies at which the modes will resonate [5]. In the case of the triple-mode filter the proper diameter/length ratio is calculated such that the TM_{011} mode and the HE_{112} mode will resonate at the same frequency. The dielectric resonators are planar-mounted for ease of fabrication as well as for power handling capabilities.

MULTIPLEXER DESIGN APPROACH

The design of manifold-coupled multiplexers is well documented [6,7]. However, all existing designs for such multiplexers have used channel filters with air dielectric. Such filters are readily coupled to a standard waveguide manifold. To match the dielectric-loaded filter onto a manifold, a ridge waveguide structure was chosen. This permits a small aperture to couple the dielectric-loaded filter and yields a compact and least sensitive design configuration.

The application of the dielectric resonator filter for output multiplexers in a space environment requires power handling capabilities in vacuum. A

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thermal analysis and mechanical design was carried out for planar-mounted dielectric-loaded filters and the complete multiplexer for a typical C-band satellite system. A 12-channel contiguous band multiplexer with 12 watts per channel was used as the base-line model. Results of this analysis indicate a temperature rise of only 12°C under these conditions. Since the filters are planar-mounted, the multiplexer assembly can be mounted flat on a flight panel. This configuration would facilitate heat flow away from the multiplexer and provide a small thermal temperature gradient across the structure in addition to being mechanically stable.

MEASURED RESULTS

Based upon the design presented, a three channel multiplexer has been built and tested. The channel filters consist of two 6-pole and one 5-pole dielectric loaded cavities realizing quazi-elliptic response functions. Figure 1 illustrates a breadboard model of a 3-channel C-band manifold-coupled multiplexer using dielectric-loaded filters.

Electric and magnetic field energy transfer is achieved through internal inter-cavity coupling. The channel inputs are SMA female and the output of the multiplexer is WR-229 waveguide. The isolation and return loss response of the channel pertaining to the 5-2 channel filter is described in Figures 2 and 3 respectively. The triplexer channel isolation and common port return loss is illustrated in Figures 4 and 5 respectively. The measured usable bandwidth was 38 MHz with a return loss of 20 dB for each channel. The effective measured unloaded Q of the multiplexer channel is 8000.

High power tests (>12 watts) on a single dielectric-loaded filter were carried out in vacuum. Measured temperature rise and electrical performance indicated good correlation with computed performance and hence confirmed the thermal and mechanical design for the unit.

CONCLUSION

The design and measured data presented here for the 3-channel C-band manifold-coupled multiplexer has clearly established the feasibility of using dielectric-loaded filters for satellite output multiplexers. The key features for the work described are:

- Design and realization of odd-order 5-pole filters comprising a dual- and triple-mode dielectric-loaded waveguide cavity in cascade
- Implementation of such dielectric-loaded filters on a ridged waveguide manifold to realize low loss and compact output multiplexers
- Implementation of the planar filters and hence multiplexer design to ensure power handling capability required of C-band satellite in a vacuum environment.

This design approach represents an electrical performance equivalent to current designs with a weight and volume reduction of 30% and 50% respectively. This design, therefore, will most likely be used for the next generation of C-band satellites.

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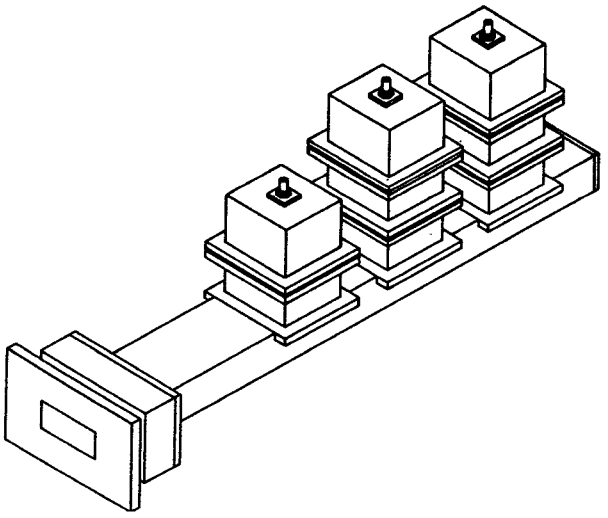

FIGURE 1 : Breadboard Dielectric Resonator Output Multiplexer

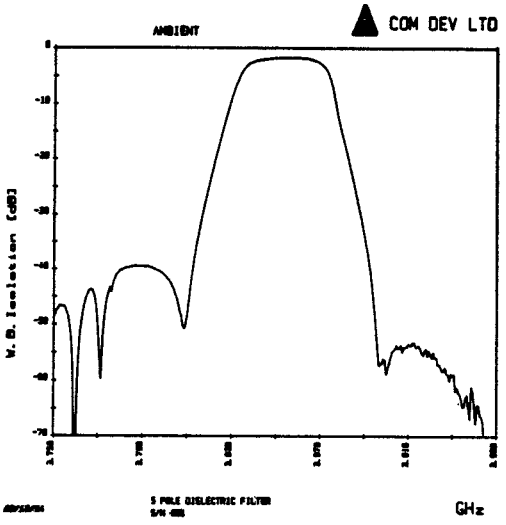

FIGURE 2 : Measured Isolation Response of a 5-Pole Dual-Triple-Mode Dielectric-Loaded Filter

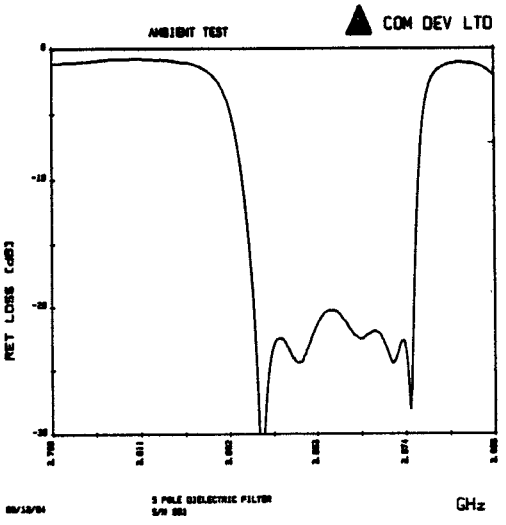

FIGURE 3 : Measured Return Loss Response of a 5-Pole Dual-Triple-Mode Dielectric-Loaded Filter

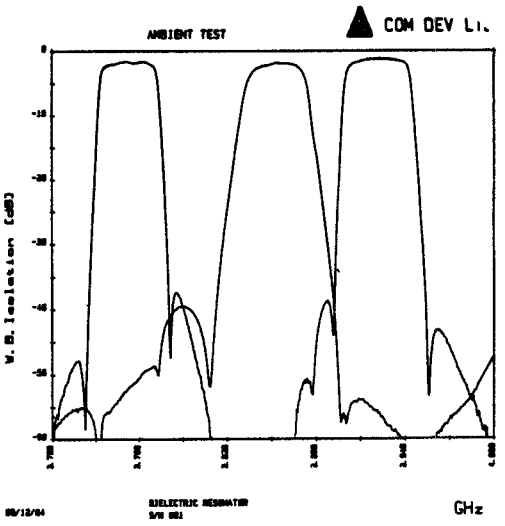

FIGURE 4 : Measured Isolation Response of the Dielectric-Loaded Triplexer

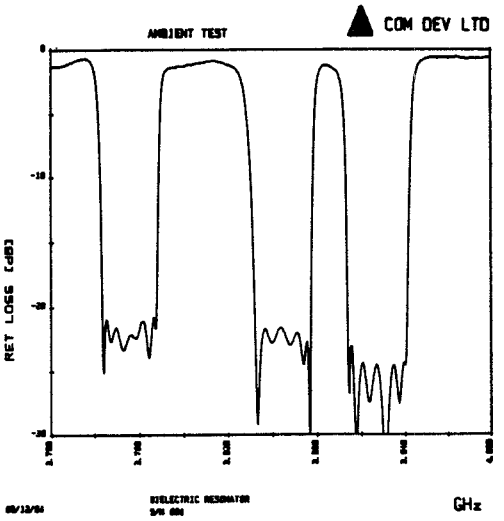

FIGURE 5 : Measured Common Port Return Loss Response of the Dielectric-Loaded Triplexer