A 12 GHz 12 CHANNEL CONTIGUOUS MULTIPLEXER FOR SATELLITE APPLICATIONS

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ABSTRACT

A 12 GHz 12 channel contiguous multiplexer realization for satellite applications is presented. Utilization of extensive computer modeling and optimization resulted in excellent performance of the multiplexer. The selected configuration employs an H-plane T-junction manifold.

Introduction

Satellite transponders have traditionally employed odd-even channel configurations in order to simplify output multiplexer construction. Although this is acceptable as far as multiplexers are concerned, an odd-even system also requires the use of a more complex antenna array and a duplication of components, limiting the practical number of channels available. Moreover, an odd-even design also increases individual filter rejection requirements in order to reduce adjacent channel interference, as well as introducing a degradation in antenna performance.

A solution to this problem is the use of a contiguous band multiplexer to cover a large number of channels(1-2-3-4). In the past, this option has not been chosen because of the difficulty of designing a contiguous mux with more than about 6 channels and the degraded insertion loss, bandedge variation, and group delay of each channel associated with this type of design(2).

The technique described in this paper utilizes filters coupled to a common manifold via a waveguide stub attached to a waveguide tee junction. Careful adjustment of this stub length allows the filter's admittance to be reduced outside of its own passband in order to minimally affect adjacent filters, enabling the construction of a multiplexer with any number of channels. The degraded channel performance is still present, although this can be compensated for with improved antenna loss and decreased adjacent channel interference due to the superior filter rejection of the contiguous design as opposed to the odd-even design.

12 Channel Contiguous Mux Design

T-Junction Circuit Model

The equivalent circuit for the H-plane tee (or any other tee) is shown in Fig. 1. In the case where the stub arm is identical in dimension to the thru arms, the characterization is reasonably straight forward. If the tee is taken with the boundaries shown in Fig. 1, Y11, Y22 and Y33 are simply the input admittance of a short circuited length of waveguide. Y12 is the transfer admittance of that same length. Y13 is more difficult to calculate(5) and thus was found experimentally. This was done by placing a short circuit plunger in arm 3 and varying its position until minimum power was detected in arm 2 (arm 1 as input). From this information Y23 and Y32 are easily calculated. The results agree well with previous measured data taken by Allanson, Cooper, and Cowling(6).

Multiplexer Design

The filters used in the multiplexer were 6-pole, quasi-elliptic singly terminated prototypes best suited for the contiguous design(1). The tee and the filters were combined onto a common manifold using the total equivalent circuit shown in Fig. 2. This was then implemented into a computer routine which summed the filter responses at 132 frequencies across the multiplexer bandwidth and displayed the VSWR at each. These values were then optimized by adjusting the spacing between each filter, the stub length between each filter and the tee, and the coupling elements in each filter. Initially, manifold spacing was set to a guide wavelength and stub length at 1/2 guide wavelength. In general, it was necessary to adjust the filter coupling elements in order to achieve a low VSWR (below 1.25). The theoretical response for the 12 channel mux is shown in Fig. 3.

Contiguous Multiplexer Implementation

A 12 channel multiplexer was built and excellent performance was achieved. A typical channel response is shown in Fig. 4, and a photograph of the entire multiplexer in Fig. 5. The extremely good return loss was obtained without any adjustment to the predicted manifold spacing or waveguide stub lengths. The optimum tuning procedure consisted of initially tuning each filter apart from the manifold in a doubly terminated configuration to ensure approximately correct filter couplings. The filters were then mounted on the multiplexer and adjusted for a smooth passband and low VSWR. Most of the adjustment was limited to the filter cavity closest to the manifold.

Conclusion

The results presented indicate that the design approach used is very effective and can be applied to a very large number of channels. This type of

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multiplexer will simplify satellite transponder design, reduce weight and introduce transponders with greater channel capacity.

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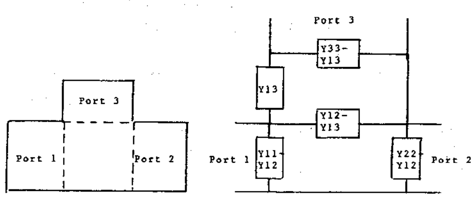

Figure 1
T-Junction Equivalent Circuit

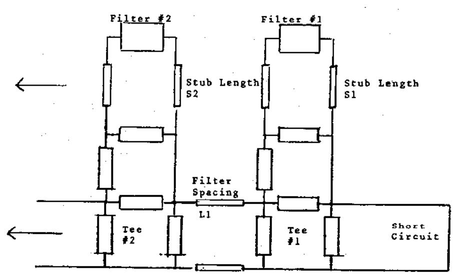

Figure 2
Multiplexer Equivalent Circuit - Channels 1 & 2 only

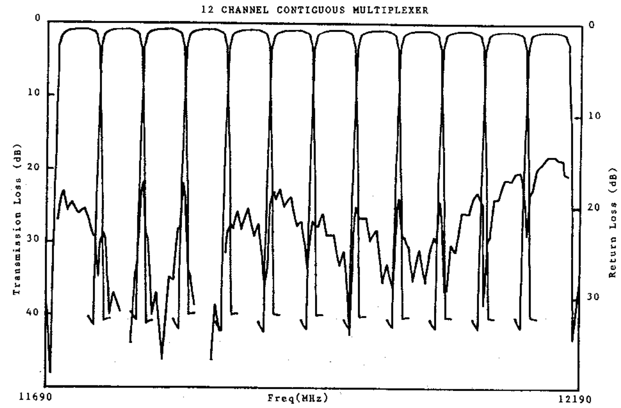

Figure 3
Theoretical Response of Multiplexer

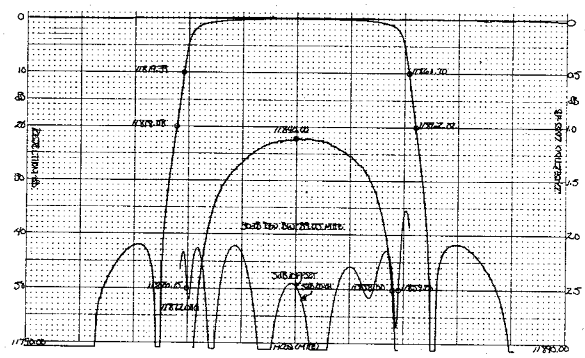

Figure 4
Typical Channel Response

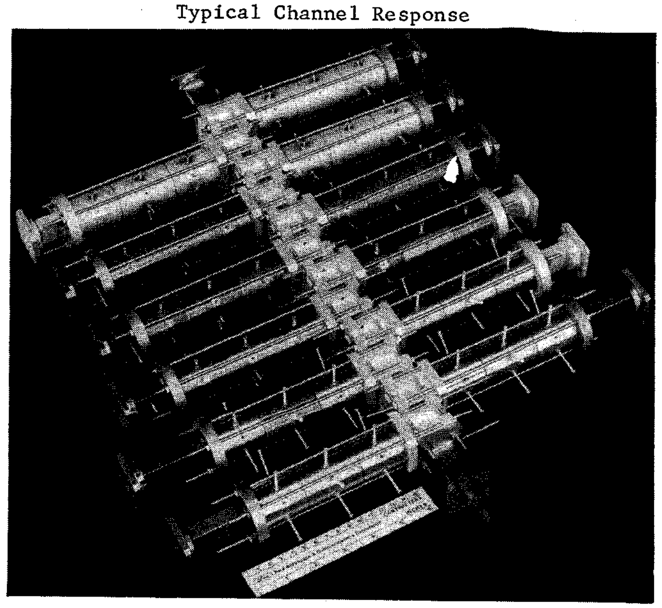

Figure 5
12 Channel Multiplexer