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A 12-CHANNEL CONTIGUOUS BAND MULTIPLEXER FOR SATELLITE APPLICATION

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ABSTRACT

A 12-channel contiguous-band output multiplexer has been designed to meet the stringent performance requirements of an Operational Communications Satellite working in the 14/12 GHz frequency band. A working unit has been built and tested. Results show an extemely close correlation between predicted and measured performance.

INTRODUCTION

A 12-channel contiguous band multiplexer at Ku-band has been developed. The primary push for this development was generated by recent studies [1] showing that use of contiguous multiplexers in conjunction with single-mode antennas would

(a) yield an improvement in communications satellite EIRP of more than 1 dB when compared to existing designs using non-contiguous multiplexers and dual-mode antennas

and

(b) simplify the antenna subsystem and provide a significant reduction in weight and volume.

EIRP, weight, volume are scarce resources on board communications satellites and improvements can have a significant effect on the overall system. They are, however, contingent on practical realization of contiguous multiplexers that would incorporate all channels of a given polarization. Present satellites and those currently under construction have a maximum of twelve channels on a given polarization. Thus, it was clear that a 12-channel multiplexer meeting all performance requirements as predicted by theory, was needed to establish confidence for using contiguous multiplexers for all future satellites. The work described in this paper has achieved that objective.

Work in the past has included development of 5-channel contiguous multiplexers at 4 and 11 GHz [2 - 5]. Beyond 5 channels the level of performance achieved has been unacceptable due to excessive waveguide manifold dispersion and resonances [5,6]. The work described in this paper has successfully overcome these drawbacks and achieved performance goals with 12 channels which are comparable to those previously accomplished with 5 channels.

ENGINEERING MODEL DESIGN APPROACH

The 12-channel contiguous band multiplexer has a channel frequency separation of 59 MHz and a usable bandwidth of 54 MHz. This covers a wider frequency band than is required by communications satellites. However, scaling down in bandwidth is easily accomplished.

The engineering model, as shown in Figure 1, consists of 10 singly-terminated filters and 2 modified singly-terminated filters. Nulling networks for end channels are neither present nor required. Locations of channel filters on waveguide manifold were determined based on the work done by Rhodes and Levy [7]. No adjustment of these locations were required during the tuning process. Channel filters are 6-pole dual-mode quazi-elliptic designs operating in the TE_{113} propagation mode. The input termination of the filters is 1.09. The output termination, which is connected to the waveguide manifold, varies from channel to channel averaging about 0.70. The coupling coefficients of the filters are as shown in the following:

$$M = \begin{bmatrix} 0 & 0.594 & 0 & 0 & 0 & 0 \\ 0.594 & 0 & 0.535 & 0 & 0 & 0 \\ 0 & 0.535 & 0 & 0.425 & 0 & -0.400 \\ 0 & 0 & 0.425 & 0 & 0.834 & 0 \\ 0 & 0 & 0 & 0.834 & 0 & 0.763 \\ 0 & 0 & -0.400 & 0 & 0.763 & 0 \end{bmatrix}$$

The filter function presented in this paper offers optimum tradeoffs between return loss and isolation skirt steepness. The filter function chosen by Chen in [6] will yield excessive return loss and hence sacrifice isolation performance.

MEASURED RESULTS

Figures 2 and 3 show the measured results of the 12-channel contiguous band multiplexer. The measured response for the best and worst channel is as shown in Table 1. The difference in performance is a consequence of centre frequency and bandwidth alignment only. No waveguide manifold dispersion effects can be observed. The waveguide manifold has no tuning elements and is completely free from destructive resonances in the operating frequency band. Figures 4, 5 and 6 illustrate the measured and computed channel performance of the 12-channel contiguous band multiplexer. Extremely good correlation of measured and computed response is evident from these plots. This provides increased confidence on the accuracy of the contiguous band multiplexer simulation program. Accurate prediction of channel performance can be achieved prior to the hardware development of contiguous band multiplexer.

CONCLUSIONS

A Ku-band 12-channel contiguous band multiplexer has been developed with enhanced performance that would satisfy communications satellite performance requirements. This represents an important advance in contiguous band multiplexer hardware development.

ACKNOWLEDGEMENT

The authors thank the management of COM DEV Limited for permission to present this paper. We acknowledge S. Lundquist in the Satellite Laboratory, also D. Szymanski and his team in the Machine Shop. The authors would like to thank Dr. C. M. Kudsia for reviewing this manuscript.

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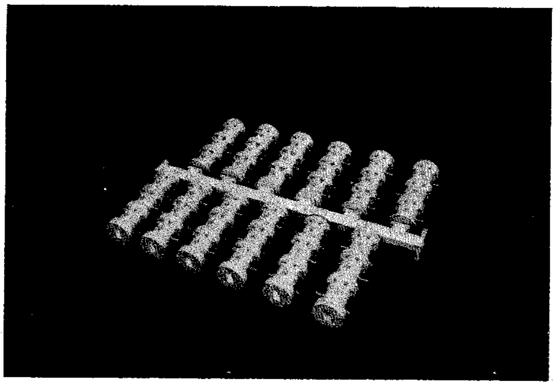

Figure 1 : Photograph of a 12 GHz Contiguous Band Multiplexer

Table 1 : Measured Vs. Computed Performance Summary for 12-Channel Contiguous Band Multiplexer

Frequency Band : 11.5 to 12.2 GHz
Usable Bandwidth : 54 MHz
Channel Separation : 59 MHz

Parameter	Computed Response	Measured Response Best Channel	Measured Response Worst Channel
Insertion Loss at CF, dB	.79	.79	1.0
Loss Variation, dB			
CF ± 18 MHz	.23	.23	.18
CF ± 23.5 MHz	.60	.54	.61
CF ± 26 MHz	1.17	.98	1.16
CF ± 27 MHz	1.62	1.35	1.78
Gain Slope, dB/MHz			
CF ± 18 MHz	.045	.028	.04
CF ± 23.5 MHz	.15	.12	.13
CF ± 26 MHz	.39	.27	.41
CF ± 27 MHz	.71	.55	.91
Group Delay, ns			
CF ± 18 MHz	10	7.7	9
CF ± 23.5 MHz	24	19	24
CF ± 26 MHz	36	34	46
CF ± 27 MHz	48	44	59
Isolation, dB			
CF ± 33 MHz	13	18	14
CF ± 35 MHz	27	29	26
CF ± 40 MHz	35	>38	>38

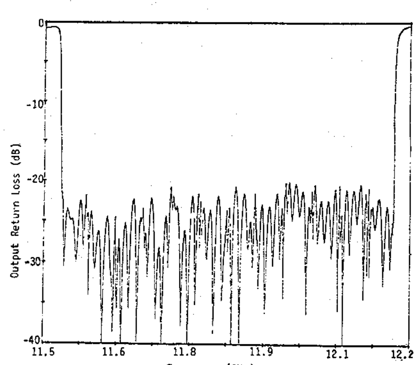

Figure 2 : Output Return Loss Measurement of 12-Channel Contiguous Band Multiplexer

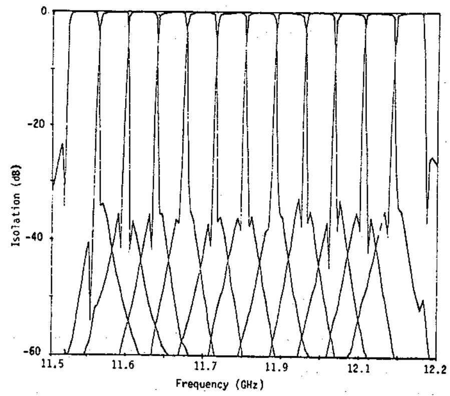

Figure 3 : Broadband Isolation Measurement of 12-Channel Contiguous Band Multiplexer

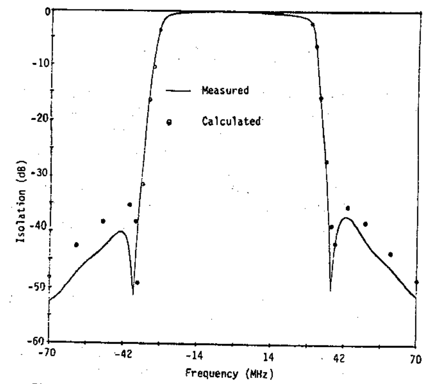

Figure 4 : Measured Vs. Computed Isolation Response for a Typical Channel

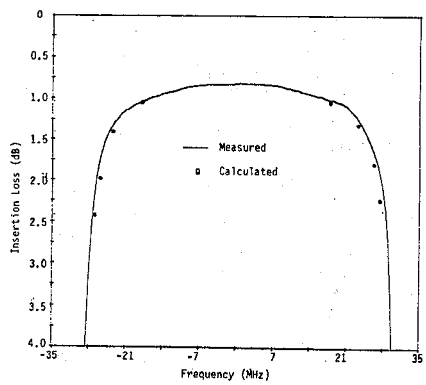

Figure 5 : Measured Vs. Computed Insertion Loss Variation Response for a Typical Channel

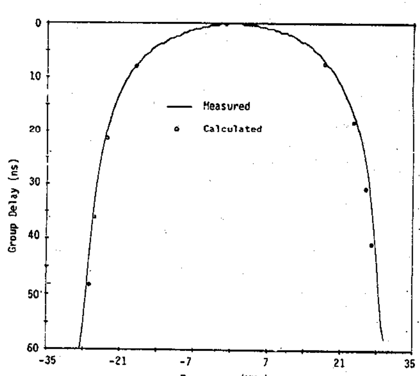

Figure 6 : Measured Vs. Computed Group Delay Response for a Typical Channel