A 12-CHANNEL CONTIGUOUS BAND MULTIPLEXER AT KU-BAND

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Abstract

A 12-Channel contiguous band Multiplexer at Ku-band has been developed. The multiplexer has 0.01 fractional channel bandwidths with A 10 percent guard band. This development should provide system engineers some confidence to use contiguous band multiplexers more often.

Introduction

The first contiguous band multiplexer of waveguide manifold type developed seven years ago[1] had four channels. Since then, some modifications and improvements in design have been made,[2,3] but the number of channels has not been increased significantly. This may be due to the lack of a need for such a multiplexer, but it may also be true that a system engineer would consider it a great risk if he specified a contiguous band multiplexer with more than five channels. The motivation of this paper is to demonstrate that the feasibility of a contiguous band multiplexer may have more than five channels.

A 12-channel contiguous band multiplexer has been developed and is presented here. The reason for selecting 12 channels as a development goal was that some early INTELSAT systems had 12 channels to cover the full 3.7 to 4.2 GHz band. Twelve channels may be considered as the upper bound for the number of channels required in most systems. Ku-band was selected as the frequency band for this experimental model because there is a larger demand for Ku-band multiplexers than for C band. Also, scaling down in frequency would be much easier than scaling up in frequency.

Multiplexer Design

The frequency plan for this multiplexer is given in Table I. Each channel has a useful bandwidth of 135 MHz with a channel separation of 150 MHz between adjacent channels. Twelve singly terminated channel filters and two nulling networks have been used. All 12 channel filters are six-pole pseudo elliptic function filters having the same filter parameters but different resonance frequencies. The output impedance for the filters is 1.9745 and the coupling coefficients for the filters are given in the following matrix:

$$M = \begin{bmatrix} 0 & 0.62575 & 0 & 0 & 0 & 0 \\ 0.62575 & 0 & 0.57615 & 0 & 0 & 0 \\ 0 & 0.57615 & 0 & 0.32348 & 0 & -0.74957 \\ 0 & 0 & 0.32348 & 0 & 1.04102 & 0 \\ 0 & 0 & 0 & 1.04102 & 0 & 1.04239 \\ 0 & 0 & -0.74957 & 0 & 1.04329 & 0 \end{bmatrix}$$

The major task in designing the multiplexer is to determine the location of the channel filters and the dimensions of the coupling slots on the waveguide manifold. This is accomplished by performing an optimization[4] based on an equivalent network model for the multiplexer (Figure 1). The equivalent network contains channel filters, matching reactances, and three-port waveguide junction networks. The optimization is to minimize the reflected power on the manifold by varying the channel filter separations, input impedances, and matching reactances. Using the reflected power on the manifold as the only criterion for optimization would be appropriate if the coupling coefficients of the filter were not altered because the isolation between channels is maintained by the correct coupling coefficient of the filter.

Table I. Frequency Plan For a 12-Channel Contiguous Band Multiplexer

Channel	Center Frequency (GHz)	Usable Bandwidth (MHz)
1 (Nulling Network)	15.75	135
2	15.60	135
3	15.45	135
4	15.30	135
5	15.15	135
6	15.00	135
7	14.85	135
8	14.70	135
9	14.55	135
10	14.40	135
11	14.25	135
12	14.10	135
13	13.95	135
14 (Nulling Network)	13.80	135

After computer optimization, the input impedance, the matching reactance, and the channel filter separation are obtained. The input impedance and the matching reactance of the individual channel determine the slot dimensions. The channel filter separation determines the filter location of the short circuited waveguide manifold. The computer performance of the sample multiplexer is given in Figure 2.

Experimental Model

The experimental model of a 12-channel contiguous band multiplexer has been fabricated as shown in Figure 3. It has 12 dual mode channel filters and two nulling structures assembled on a WR62 waveguide. These channel filters and nulling structures have been individually tuned by a short circuit tuning method[5]. After the assembly of these filters and nulling structures on the manifold, as expected, only minor retuning of the first cavity had been required. The measured performances for this multiplexer are shown in Figure 4(a) and 4(b).

Conclusion

A 12-channel contiguous band multiplexer has been developed with good performance. Most multiplexers required in communication systems are either less than 12 channels and/or have relaxed requirements on the guard bands. Therefore, the task should be easier than the one presented here. Hopefully, the result of this prototype multiplexer will provide system engineers with confidence of using contiguous band multiplexers over five channels.

References

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5. M. H. Chen, "Short-Circuit Tuning Method for Singly Terminated Filters," IEEE Trans. on Microwave Theory & Tech., Vol. MTT-25, No. 12, Dec. 1977, pp. 1032-1036.

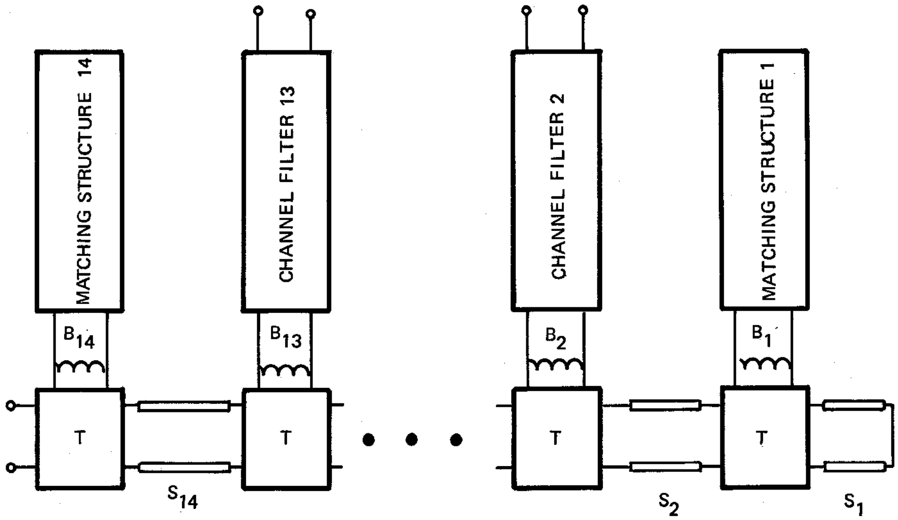

Figure 1. Equivalent Network for a 12-Channel Contiguous Band Multiplexer

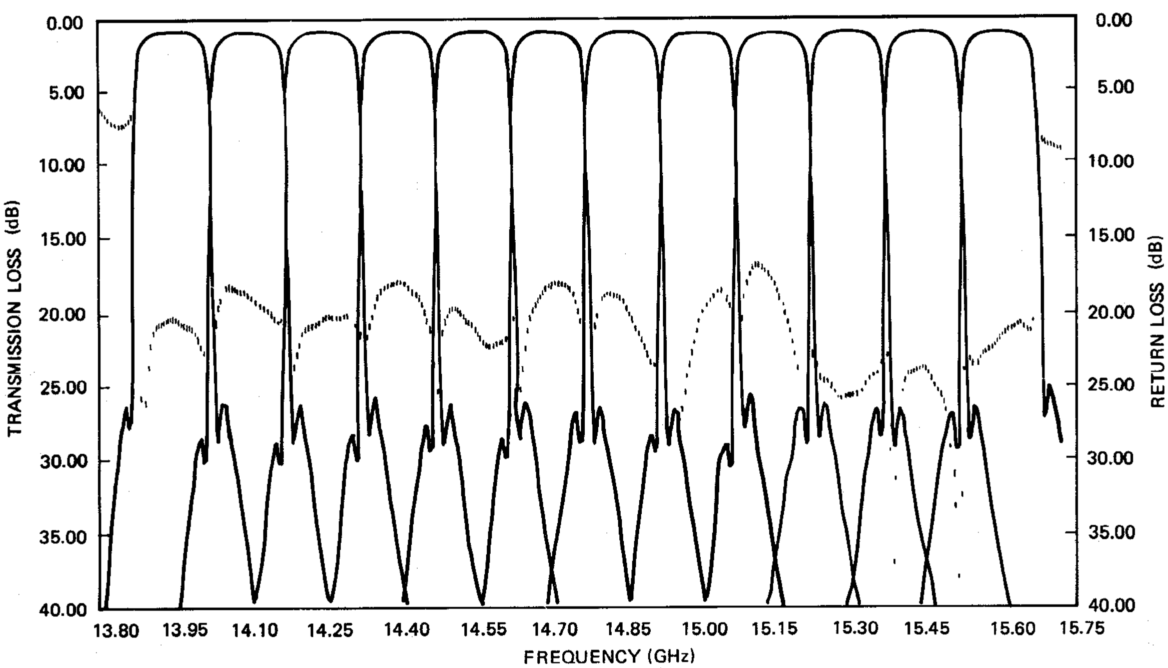

Figure 2. Computed Performances for the Prototype Multiplexer

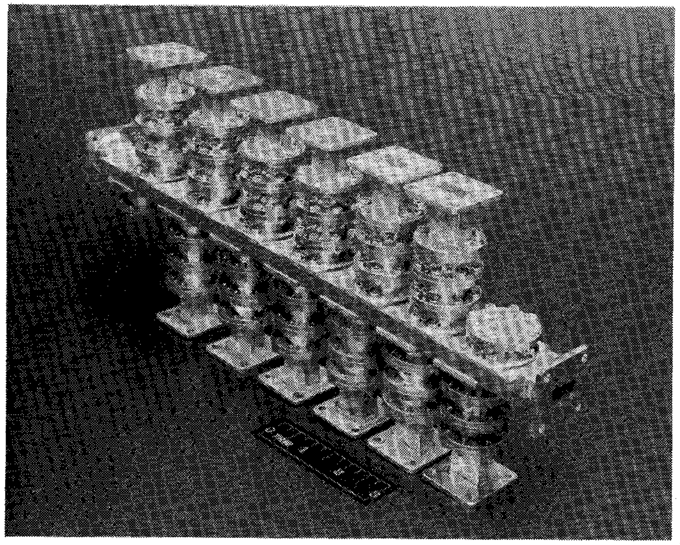

Figure 3. A Prototype 12-Channel Contiguous Band Multiplexer

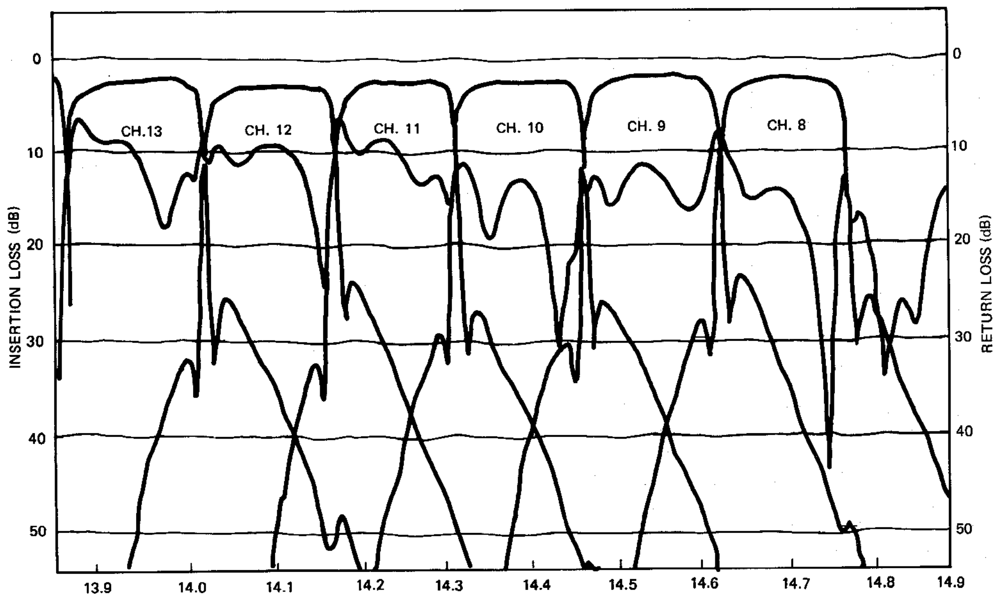

Figure 4(a). Measured Performances for the Prototype 12-Channel Contiguous Band Multiplexer (Channels 8-13)

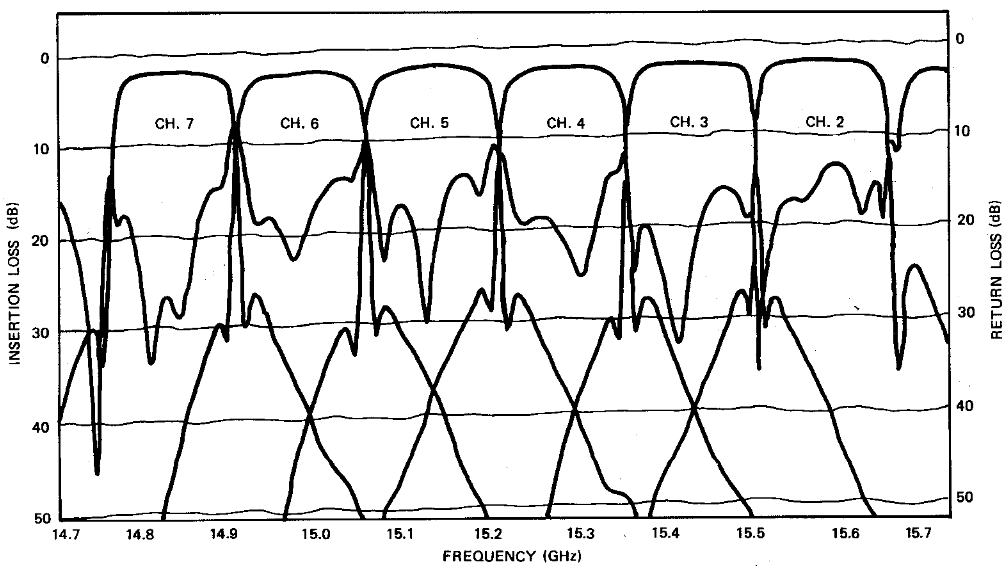

Figure 4(b). Measured Performances for the Prototype 12-Channel Contiguous Band Multiplexer (Channels 2-7)