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A Ku-BAND CONTIGUOUS MULTIPLEXER EMPLOYING LOW-LOSS, ODD-ORDER, MIXED DUAL-TRIPLE MODE CAVITY FILTERS

Michael Pley and Wai Cheung Tang

COM DEV Ltd., 155 Sheldon Drive, Cambridge, Ontario, Canada, N1R 7H6.

ABSTRACT

A Ku-band, 3-channel contiguous multiplexer has been developed using 5-pole quazi-elliptic function filters. The channel filters are realized as a cascade of dual- and triple-mode cavities operating in the higher order TE_{113} and TM_{012} resonant modes. Measured data from the triplexer correlates well with theory.

This multiplexer configuration yields an optimum overall electrical performance when multipath effects in an operating satellite are taken into account. Use of a low-loss triple-mode cavity provides the most compact and light weight structure. It is, therefore, expected that this new multiplexer design will be used for future Ku-band satellite systems.

INTRODUCTION

Recent studies have demonstrated that contiguous band multiplexing systems for satellite application have significant advantages over non-contiguous systems [1]. These include over 1 dB improvement in satellite EIRP, simplified antenna design and reduced weight and volume.

To date, even order 6-2 channel filters have been utilized for the contiguous band multiplexer configuration [1-3]. A recent study conducted for a U.S. prime contractor (COM DEV Internal Report) has clearly demonstrated that 5-pole, quazi-elliptic function filters yield the best overall channel performance for contiguous band multiplexing when multipath effects for an operating satellite are taken into account. This key tradeoff study forms the basis of the work described here.

A Ku-band contiguous band triplexer has been developed utilizing 5-pole quazi-elliptic filters realized as a cascade of dual- and triple-mode cavities. The triple-mode cavity employs the higher order TE_{113} and TM_{012} resonant modes whereas the dual-mode cavity operates in the TE_{113} modes. Measured data for this triplexer correlates well with computed performance.

FILTER DESIGN APPROACH

Triple-mode cavities have been realized recently for potential application in multiplexing networks for C-band satellites [3]. These triple-mode cavities operated in the dominant TM_{010} and two TE_{111} resonant modes in the same physical cavity. For the present applications at Ku-band, this approach has been extended to higher order TE_{113} and TM_{012} resonant modes in the same physical cavity. The higher order modes allow for a high achievable unloaded Q while maintaining a wide spurious free window, an essential requirement for Ku-band satellite multiplexers.

The channel filters realized for the triplexer are of the 5-pole, quazi-elliptic design employing dual- and triple-mode cavities operating in the low loss TE_{113} and TM_{012} resonant modes. The coupling matrices of the three channel filters are listed below:

Channel 1

$$M1 = \begin{bmatrix} 0.5765 & 0.7633 & 0.0000 & -0.2278 & 0.0000 \\ 0.7633 & 0.1148 & 0.7217 & 0.0000 & 0.0000 \\ 0.0000 & 0.7217 & -0.0691 & 0.5009 & 0.0000 \\ -0.2278 & 0.0000 & 0.5009 & -0.0295 & 0.6514 \\ 0.0000 & 0.0000 & 0.0000 & 0.6514 & -0.0029 \end{bmatrix}$$

Channel 2

$$M2 = \begin{bmatrix} 0.0000 & 0.5653 & 0.0000 & -0.2278 & 0.0000 \\ 0.5653 & 0.0000 & 0.7217 & 0.0000 & 0.0000 \\ 0.0000 & 0.7217 & 0.0000 & 0.5009 & 0.0000 \\ -0.2278 & 0.0000 & 0.5009 & 0.0000 & 0.6514 \\ 0.0000 & 0.0000 & 0.0000 & 0.6514 & 0.0000 \end{bmatrix}$$

Channel 3

$$M3 = \begin{bmatrix} -0.0644 & 0.8675 & 0.0000 & -0.2278 & -0.0000 \\ 0.8675 & -0.1920 & 0.7217 & 0.0000 & 0.0000 \\ 0.0000 & 0.7217 & 0.0232 & 0.5009 & 0.0000 \\ -0.2278 & 0.0000 & 0.5009 & -0.0152 & 0.6514 \\ 0.0000 & 0.0000 & 0.0000 & 0.6514 & -0.0462 \end{bmatrix}$$

MULTIPLEXER DESIGN APPROACH

The 3-channel multiplexer has a channel spacing of 40 MHz and each channel has a usable bandwidth of 36 MHz. The contiguous band multiplexer could be realized for other frequency plans and a greater number of channels using the same design approach [4].

All three channel filters are singly-terminated; the end channels are asymmetric so that no nulling networks are required. Spacings on the waveguide manifold were derived using COM DEV's simulation software package.

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MEASURED RESULTS

The silver-plated brass model of the triplexer is depicted in Figure 1. The measured common port return loss and channel isolations are shown in Figures 2 and 3 respectively. Figures 4 and 5 illustrate the measured and computed performance of the middle channel. Good correlation between the measured and computed performance is evident and this indicates that an accurate prediction of contiguous multiplexer performance using the software package can be made prior to hardware development. The measured worst case insertion loss at a channel band-center of this triplexer is 0.80 dB.

CONCLUSIONS

The design and measured data of a 3-channel contiguous band multiplexer employing low-loss, mixed dual-triple mode cavity channel filters have been presented. Key features of this work include:

- Channel filters realized as a cascade of two physical cavities operating in the dual- and triple-mode configuration to yield the odd-order, 5-2 quazi-elliptic response function
- Successful implementation of the low-loss TM_{012} and two TE_{113} resonant modes in the same physical cavity
- Prototype hardware demonstration of the contiguous band multiplexer showing good correlation with theory.

This multiplexer configuration yields an optimum overall electrical performance when multipath effects in an operating satellite are taken into account. Use of a low-loss triple-mode cavity provides the most compact and light weight structure. It is, therefore, expected that this new multiplexer design will be used for future Ku-band satellite systems.

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[4] "A 12-Channel Contiguous Band Multiplexer for Satellite Application", by R. Tong & D. Smith, paper presented at 1984 IEEE MTT-S International Microwave Symposium, San Francisco, California, May 29 - June 1, 1984.

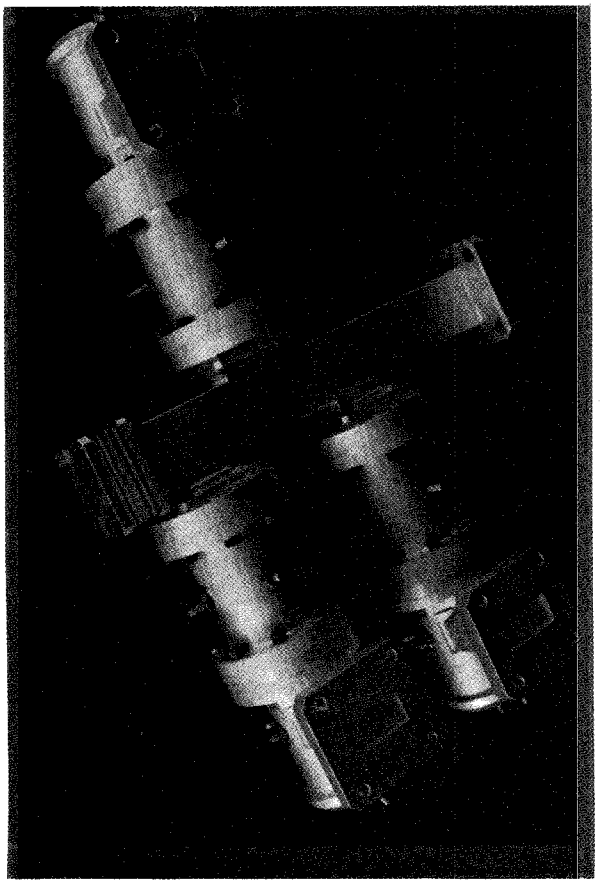

FIGURE 1 : Prototype Engineering Silver-Plated Model

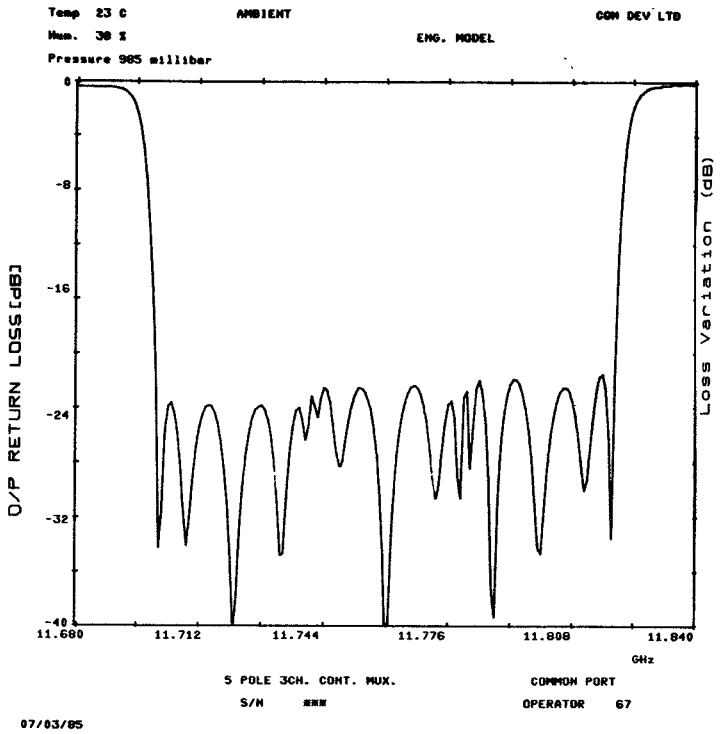

FIGURE 2 : Measured Data - Common Port Return Loss

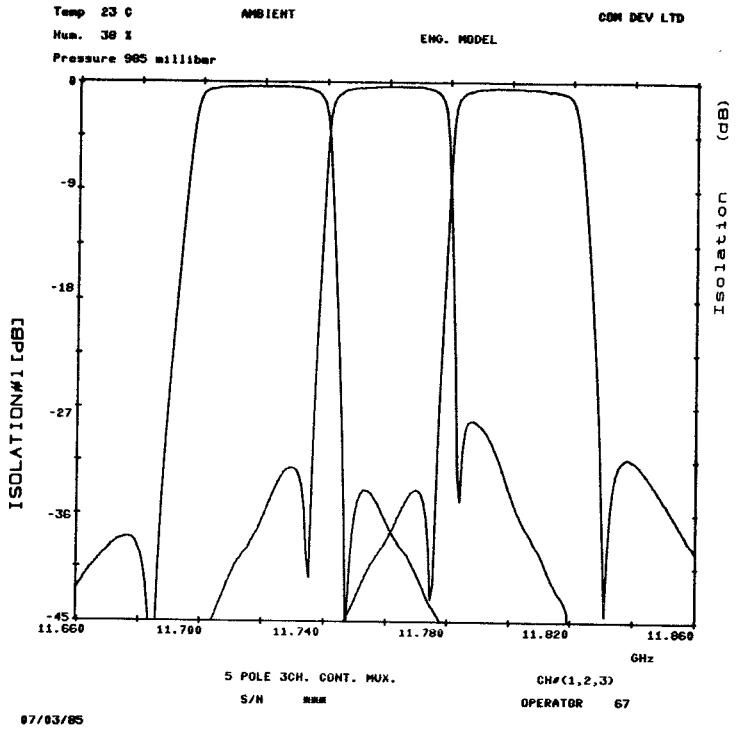

FIGURE 3 : Measured Data - Channel Isolation

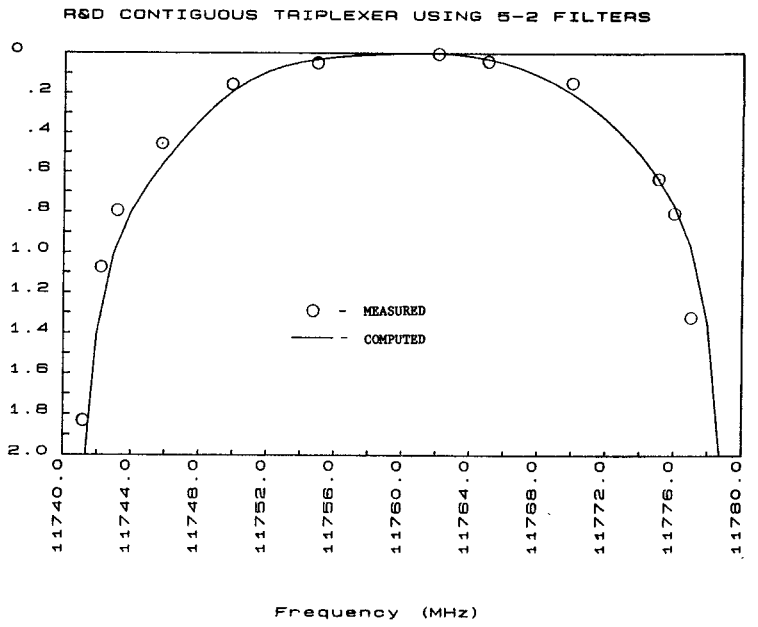

FIGURE 4 : Computed & Measured Loss Variation for Middle Channel

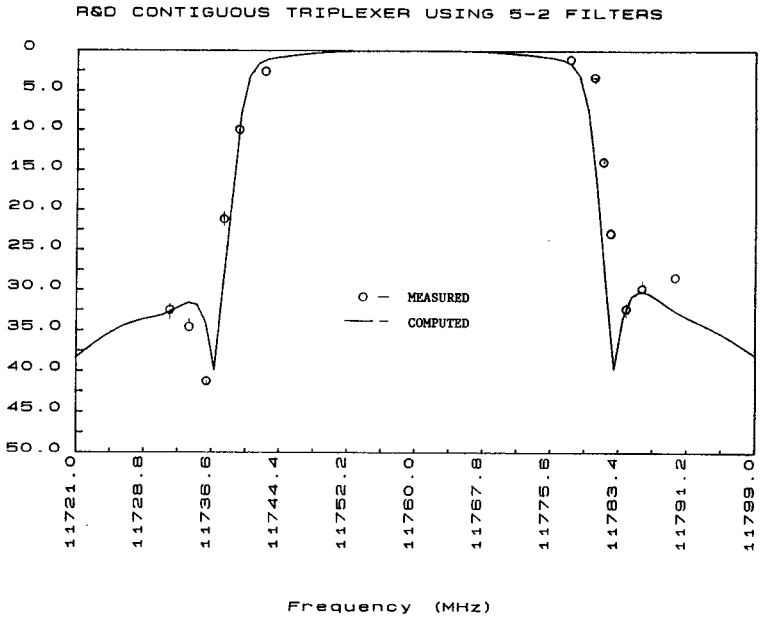

FIGURE 5 : Computed & Measured Isolation for Middle Channel