FREQUENCY MULTIPLEXING WITH ACTIVE NETWORKS

N. M. Swamy and V. P. Kodali
Tata Institute of Fundamental Research
Homi Bhabha Road, Bombay 400 005, India

Abstract

The realisation of UHF and microwave frequency active multiplexers and measured characteristics for diplexers and triplexers, with both contiguous and non-contiguous channels, are described.

Introduction

The possibility of using an inverted-common-collector transistor circuit as a two terminal network element provides the basis for a class of UHF and microwave active filters, as described by Adams and Ho[1]. Circuit elements of this type are used by Snyder and Bozarth[2] in the synthesis of active band-pass filters using the direct-coupled-resonator filter configuration, which was previously devised by Cohn[3]. It is shown by Bindra and Kodali[4,5] that compact, stable and highly selective narrow-band bandpass filters can be realised by using this approach.

The purpose of this paper is to further extend the work of the above referenced authors and illustrate the realisability of active multiplexers, with both contiguous and non-contiguous channels.

Synthesis of Active Multiplexers

Consider the schematic of a multiplexer shown in Fig. 1. The networks $N_1 .. N_k .. N_n$ are bandpass filters, each having a desired and specified frequency response. When several networks are connected in parallel, as is the case here, it is necessary to ensure that net input immittance offered by the combination of these networks matches with generator immittance over the complete frequency band[6]. Since each filter is normally designed from a doubly terminated prototype, this condition is not immediately met unless special techniques are used for ensuring this. A means for providing this immittance match is to include a network S, as shown in Fig. 1. The terminal immittance of this network is specified such that the following pair of relationships are satisfied:

$$\mathrm{Re}\, Y_g = \mathrm{Re}\, Y_s + \sum_k \mathrm{Re}\, Y_k \qquad (1)$$

and

$$\mathrm{Im}\, Y_g = \mathrm{Im}\, Y_s + \sum_k \mathrm{Im}\, Y_k \qquad (2)$$

If each of the networks $N_1 .. N_k .. N_n$ is a direct-coupled-resonator filter, these networks are then realisable as active bandpass filters by merely substituting properly designed inverted-common-collector transistor circuits for individual inductors in the filter[2,4]. It is interesting to note that the terminal immittance of a direct-coupled-resonator bandpass filter exhibits the following properties:

i) The real part of its input admittance is approximately constant over a band (corresponding to the pass-band) of frequencies and rapidly goes to zero outside this band, and

ii) On an average, the imaginary part of its input admittance has a negative slope in the pass-band and a positive slope in the stop-band.

Further, when several bandpass filters of this type - say two or three filters - are connected in parallel, the terminal admittance of the combined circuit also possesses the above listed property pair.

Through an appropriate choice of the impedance levels in the circuit, the designer can ensure that over the bands of frequencies of interest

$$\mathrm{Re}\, Y_g = \sum_k \mathrm{Re}\, Y_k \qquad (3)$$

In order to 'complement' the multiplexing network terminal immittance (as defined by equations 1 and 2), the network S may be now designed so that its terminal susceptance effectively cancels the net susceptance. The terminal susceptance of the S-network must be, therefore, such that

$$\mathrm{Im}\, Y_s = \mathrm{Im}\, Y_g - \sum_k \mathrm{Im}\, Y_k \qquad (4)$$

Furthermore, if the generator terminal immittance is purely resistive, then due to the aforementioned property pair of the bandpass filters and by virtue of equation 3, the susceptance annuling network can be conveniently devised. The S-network becomes a simple tank circuit - consisting of an inductance and a capacitance connected in parallel. The elements in this susceptance annuling network are calculated from the equation

$$\mathrm{Im}\, Y_s = - \sum_k \mathrm{Im}\, Y_k \qquad (5)$$

Although this equation cannot be satisfied at all the frequencies of interest, a satisfactory solution is to select the network elements such that equation 5 is satisfied at the centre of the bands and at the upper band edge of the bandpass filter. This procedure gives results that are approximate; yet they are rewarding.

Characteristics of Active Multiplexers

Using the above described principles, an active diplexer and an active triplexer are designed, with bandpass filters designed to yield a 3-dB bandwidth of 1 MHz. Guard-bands which are 4 MHz and 5 MHz wide are provided for the non-contiguous channel diplexer and triplexer, respectively. Measured characteristics of the active diplexer with contiguous and non-contiguous channels are shown in Figs. 2 and 3, respectively, and those of the active triplexer with contiguous and non-contiguous channels are shown in Figs. 4 and 5, respectively. In these multiplexers, the individual bandpass networks consist of two-section direct-coupled-resonator filters and the susceptance annuling networks consist of linear, lumped, passive inductances and capacitances.

Conclusions

In this paper, a technique for the realisation of active multiplexers has been described. An example diplexer and a triplexer, both with contiguous and non-contiguous channels, have been designed using the principles outlined and the measured performances have been given. These results indicate that multiplexers capable of providing high selectivity contiguous or non-contiguous channels can be built by using active filters. Multiplexers of this nature are believed to have potential applications in signal processing and in channel separation.

References

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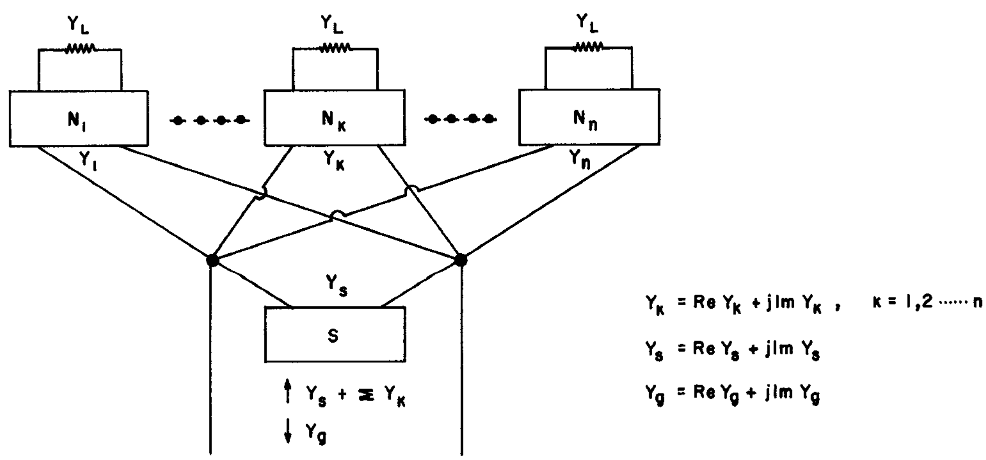

FIG. 1 A Multiplexer

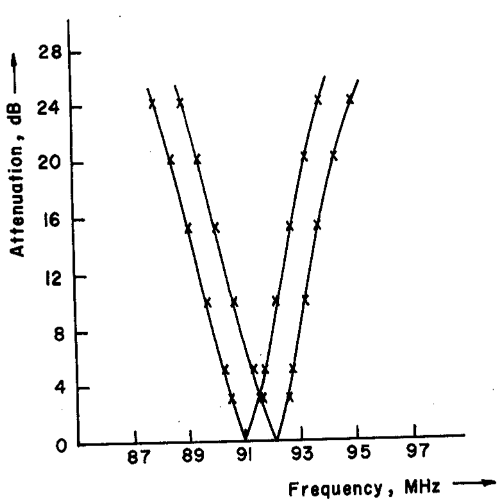

FIG. 2 Characteristics of a Contiguous Channel Diplexer

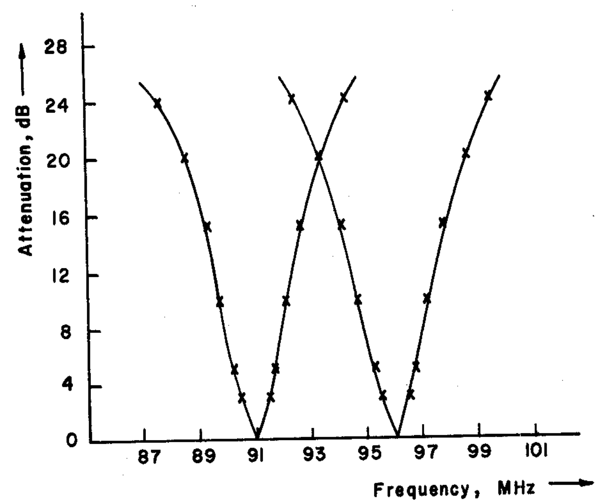

FIG. 3 Characteristics of a Non-contiguous Channel Diplexer

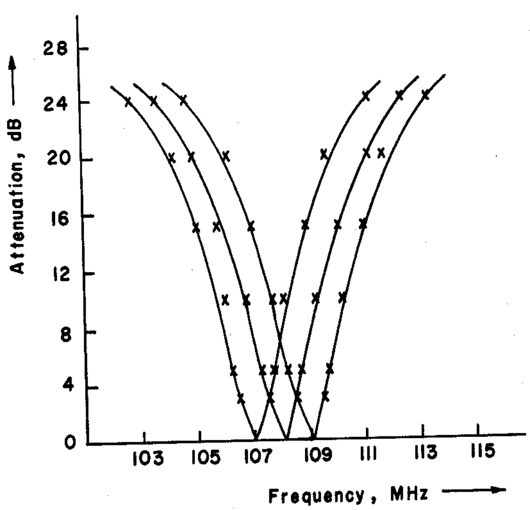

FIG. 4 Characteristics of a Contiguous Channel Triplexer

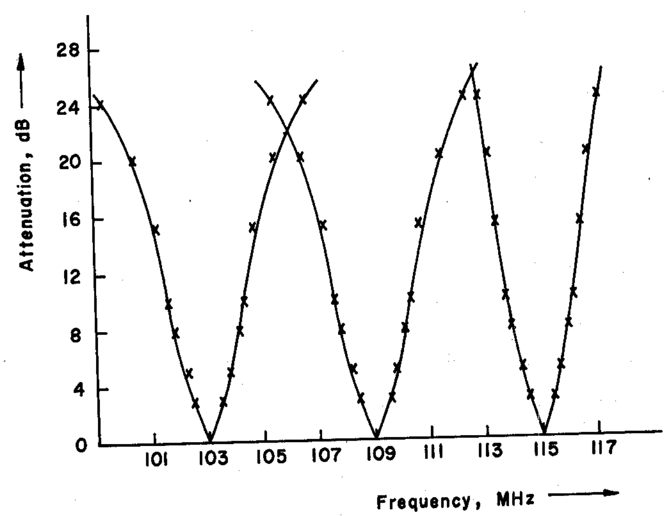

FIG. 5 Characteristics of a Non-contiguous Channel Triplexer