A LOW-LOSS, WIDEBAND TRANSMITTER MULTIPLEXER

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Abstract

A network capable of multiplexing two 850 MHz transmitter channel groups is described. This combining network has a theoretical ratio of channel group bandwidth to minimum group separation of 150 to 1 for a 1 dB maximum loss.

Introduction

The addition (multiplexing) of two transmitter channel groups into a single antenna is usually accomplished by means of a 3 dB hybrid or by the use of narrowband multiplexing cavities [1,2]. Fixed-tuned cavity multiplexers are only acceptable if each transmitter channel group does not occupy a large percentage bandwidth and if the frequency separation between groups is not too small. Hybrid combiners, on the other hand, have no frequency limitations and they are simple and cheap. Their principal disadvantage is that because of lack of coherency half of the power for each combiner is lost in the terminating resistance of the hybrid.

It has been shown that coherent addition of channels over a fairly wide bandwidth is possible using two couplers interconnected by matched lines of the proper electrical length [3,4]. For the purpose of combining channel groups with maximum possible bandwidth and minimum group separation, the interconnecting lines should have a dispersive phase characteristic. The proper phase versus frequency characteristic is obtained using reflecting cavities in a new circuit shown in Fig. 1. This circuit provides, with ideal components, a 150 to 1 ratio between the maximum attainable bandwidth in the combiner and the minimum possible channel separation.

Analysis

Detailed analysis of the circuit in Fig. 1 shows that there are two frequencies in the band of either Channel A or B where the loss of the combiner is zero. These zero loss points occur at frequencies where the reflection phase from the cavities is, for Channel A, either ϕ_0 or $\pi - \phi_0$. The angle ϕ_0 is a small angle whose precise value depends on the coupler coefficient. A curve of combiner loss in dB versus reflection phase ϕ is given in Fig. 2 assuming 3 dB couplers. The maximum in-band loss is at $\phi = 90°$ and is under 1 dB. For $\phi < \phi_0$, the 1 dB loss point due to imperfect coherence in the signal outputs in ports I and II occurs for

$$\phi_{min} = 6.4° < \phi_0. \tag{1}$$

and for $\phi > \pi - \phi_0$, the 1 dB loss point occurs for

$$\phi_{max} = 173.6° > \pi - \phi_0. \tag{2}$$

Now note that the phase of signals reflected from either cavity in Fig. 1 varies as an arc-tangent function of the normalized deviation of frequency off cavity resonance. Thus

$$\phi = 2 \tan^{-1} 2Q_E \frac{\Delta f}{f_0} \tag{3}$$

so that the phase limits in (1) and (2) are translated into very wide frequency limits by the dispersive phase characteristic of these cavities. One finds that the minimum frequency spacing allowable between Channels A and B for a 1 dB loss in the ideal combiner is

$$2\Delta f_{min} = \frac{f_0}{Q_E} \tan \frac{\phi_{min}}{2} = .056 \frac{f_0}{Q_E}, \tag{4}$$

and that the maximum bandwidth available in either channel is

$$\Delta f_{max} - \Delta f_{min} = \frac{f_0}{2Q_E} \left\{ \tan \frac{\phi_{max}}{2} - \tan \frac{\phi_{min}}{2} \right\} = 8.9 \frac{f_0}{Q_E}. \tag{5}$$

Experimental Results

In practice, the channel separation is increased over the minimum given by (4) because of loss in the circulators and because of the finite unloaded Q of the cavities. The practicably attained maximum bandwidth is less than predicted by (5) because of time delay in the circulators. Measurements were made for a base station multiplexer for a mobile telephone application at 850 MHz. The important parameters were

Cavity external Q_E = 400

Cavity unloaded Q_U = 20000

Circulator loss = .5 dB

Circulator delay = 4 nanoseconds.

A photograph of this combiner is shown in Fig. 3 and the measured response in Fig. 4. The measured minimum channel group spacing was 380 kHz; the maximum bandwidth obtained was 4 MHz per group - in good agreement with calculated responses. If circulator loss were reduced to .25 dB and the circulator time delay to 2 nsec., the available bandwidth would increase to 7 MHz.

References

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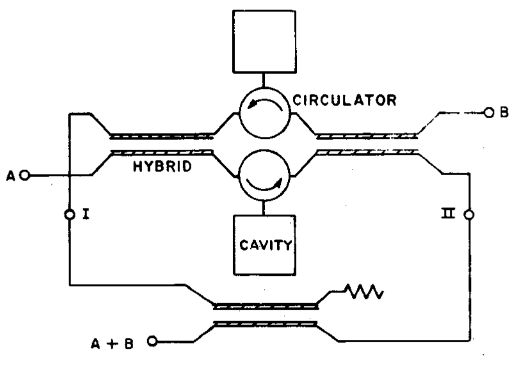

FIG. I A COHERENT COMBINER

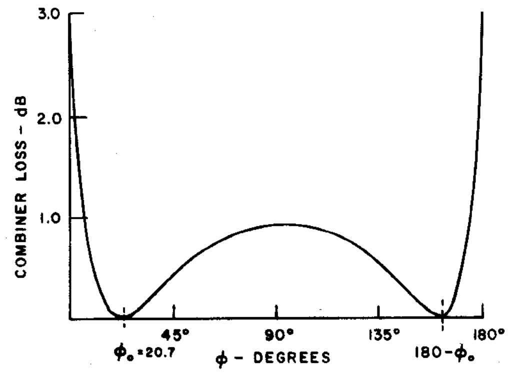

FIG. 2 COMBINER LOSS VERSUS PHASE

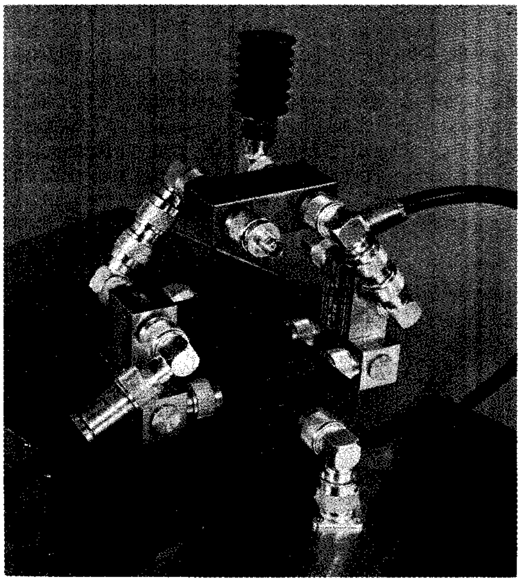

FIG. 3 PHOTOGRAPH OF AN 850 MHZ COMBINER

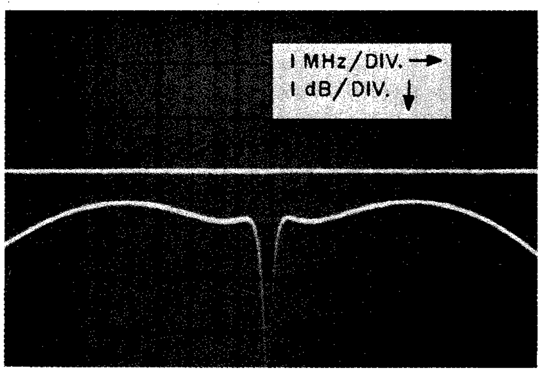

FIG. 4 MEASURED FREQUENCY RESPONSE OF THE COMBINER