New n-Way Hybrid Power Dividers

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Abstract

New n-way hybrid power dividers are synthesized by using M sections of n-wire coupled (or uncoupled) transmission-lines of equal length with isolation resistors which are connected among neighboring wires.

Introduction

The objective of this paper is to propose some new n-way hybrid power dividers (henceforce HPD) constructed by new synthesis method. N-way HPD's described by Wilkinson[1] and Yee et al.[4] are synthesized by using M sections of n uncoupled transmission-lines of equal length with isolation resistors of the Y-connection which are connected from the end of the n transmission-lines to a common junction. N-way HPD's presented by this paper are synthesized by using M sections of n-wire coupled (or uncoupled) lines of equal length with isolation resistors which are connected among neighboring wires.

The analysis of the n-way HPD is done by getting the eigenvalues and the corresponding eigenvectors of characteristic admittance matrices of M sections of n-wire coupled (or uncoupled) lines[7] and of M admittance matrices for the isolation resistors, and then by getting the equivalent circuit representation of the n-way HPD. The equivalent circuit representation is represented by n circuits which consist of a two-port for the even-mode circuit and n-1 one-ports for the odd-mode circuits.

From the analysis, it can be shown that the (n+1)-port made with a coupled n-wire line with isolation resistors of the Y-connection acts as an n-way HPD at narrow-band frequencies[6]. If we use isolation resistors different from the Y-connection, it needs some sections of isolation resistors and n-wire segments to perform matching and isolation among output ports at the required frequency.

Basic Hybrid Power Dividers

Here we propose n-way HPD of planar structure and coaxial type n-way HPD.

(1) N-way HPD of planar structure: The circuit shown in Fig.1 is an n-way HPD which can be designed by planar structure. The n-way HPD needs n-1 sections of n-wire lines and isolation resistors for matching at the center frequency (where electrical length of the line section θ equals $\pi/2$).

(2) Coaxial type n-way HPD: The circuit shown in Fig.2 is an n-way HPD which can be designed by coaxial type lines. The n-way HPD needs n/2 (n: even number) or (n-1)/2 (n: odd number) sections of n-wire lines and isolation resistors for matching at the center frequency.

3-Way Planar Hybrid Power Divider

From the circuit shown in Fig.1, a 3-way planar HPD can be obtained by using 2 sections of 3-wire lines and planar isolation resistors as shown in Fig.3(a). If we use uncoupled transmission-lines for the 3-wire lines, the characteristic impedances of the lines and resistances of the isolation resistors are decided as presented in Fig.3(a). The Figure 3(b) shows the equivalent circuit representation of the 3-way planar HPD shown in Fig.3(a).

4-Way Planar Hybrid Power Divider

A 4-way planar HPD can be obtained by using 3 sections of 4-wire lines and planar isolation resistors from the circuit shown in Fig.1. The circuit is, however, rather complicated. Here we propose the circuit shown in Fig.4(a) which is obtained by combining 2-way HPD's and transmission-lines as a 4-way planar HPD. Figure 4(b) shows the equivalent circuit representation for the circuit shown in Fig.4(a). The theoretical VSWR and isolation characteristics are shown in Fig.5.

5-Way Planar Hybrid Power Divider

An n-way planar HPD can be constituted by combining 2-way HPD's, the 3-way planar HPD's and transmission-lines. For example, a 5-way planar HPD can be obtained as the circuit depicted in Fig.6.

Experiment of a 3-Way Planar Hybrid Power Divider

The experimental circuit for a 3-way planar HPD is shown in Fig.7, and the VSWR and isolation responses for the 3-way HPD is shown in Fig.8 with the theoretical curves (solid lines in Fig.8). The isolation characteristics among three output ports show more than 20dB in 2:1 bandwidth and VSWR characteristics of four ports show less than 1.4 in 2:1 band width, and these characteristics are in good agreement with the theoretical analysis.

Conclusion

Some n-way hybrid power dividers are proposed, and these circuit will find further application fields in the microwave transmission systems.

References

[1] E.J.Wilkinson, "An n-way hybrid power divider," IRE Trans. Microwave Theory Tech., vol. MTT-8, pp. 116-118, Jan. 1960.

[2] L.Parad and R.Moynihan, "Split-tee power divider," IEEE Trans. Microwave Theory Tech., vol. MTT-13, pp. 91-95, Jan. 1965.

[3] S.B.Cohn, "A class of broadband three-port TEM-mode hybrids," IEEE Trans. Microwave Theory Tech., vol. MTT-16, pp. 110-116, Feb. 1968.

[4] H.Y.Yee, F.C.Chang and N.F.Audeh, "N-way TEM-mode broad-band power dividers," IEEE Trans. Microwave Theory Tech., vol. MTT-18, pp. 682-688, Oct. 1970.

[5] R.B.Ekinge, "A new method of synthesizing matched broadband TEM-mode three-ports," IEEE Trans. Microwave Theory Tech., vol. MTT-19, pp. 81-88, Jan. 1971.

[6] N.Nagai and A.Matsumoto, "Basic considerations on TEM-mode hybrid power dividers," in Dig. Tech. Papers 1973 IEEE G-MTT Int. Microwave Symp. (Univ. Colorado, Boulder, June 4-6, 1973), pp. 218-220.

[7] N.Nagai and A.Matsumoto, "A restatement of mathematical considerations of TEM modes on an n-wire line," IEEE Trans. Microwave Theory Tech., vol. MTT-22, pp. 353-359, April 1974.

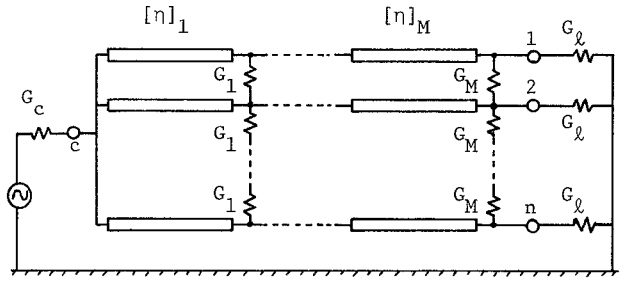


Fig. 1 N-Way Hybrid Power Divider of Planar Structure.

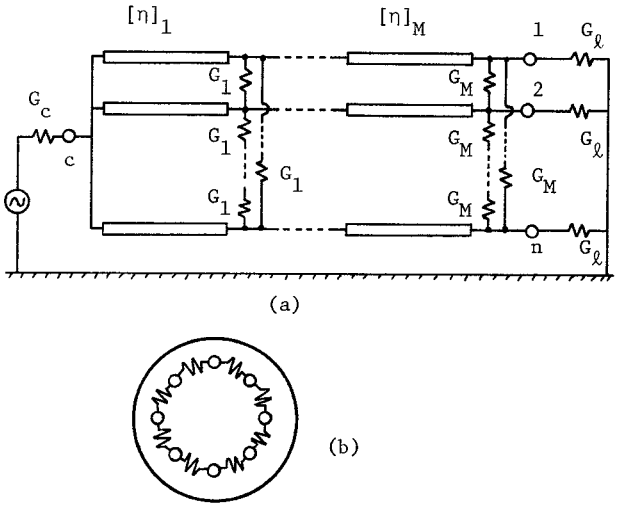
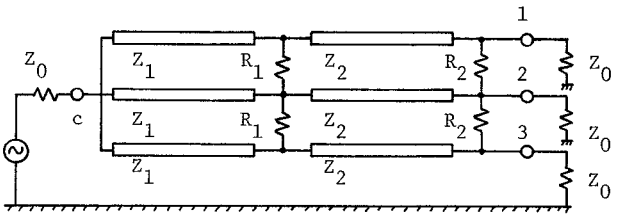


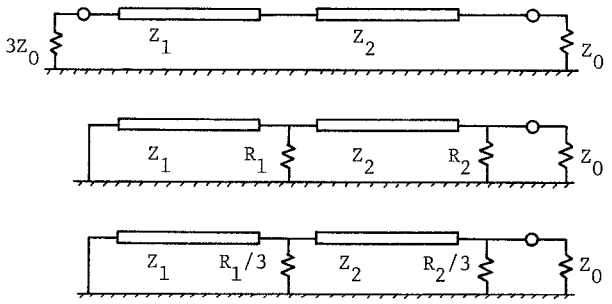
Fig. 2 (a) Coaxial Type n-Way Hybrid Power Divider, and (b) Its Inner Arrangement of n Wires and Conductances.



$Z_0 = 50\Omega$, $Z_1 = 114.0\Omega$, $Z_2 = 65.80\Omega$,

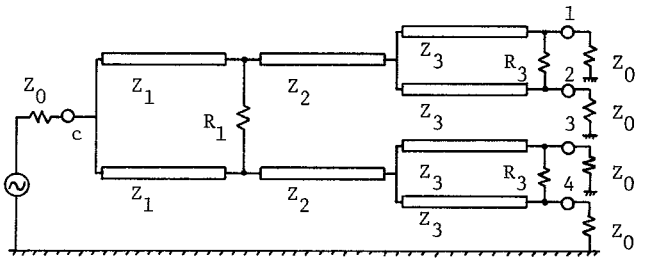
$R_1 = 64.95\Omega$, $R_2 = 200\Omega$.

(a)



(b)

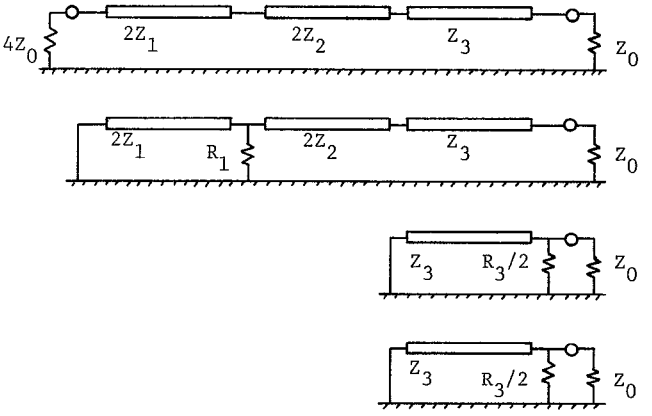
Fig. 3 (a) A 3-Way Planar Hybrid Power Divider, and (b) The Equivalent Circuit Representation.



$Z_0 = 50\Omega$, $Z_1 = 77.48\Omega$, $Z_2 = 50\Omega$, $Z_3 = 64.53\Omega$,

$R_1 = 120.1\Omega$, $R_3 = 100\Omega$.

(a)



(b)

Fig. 4 (a) A 4-Way Planar Hybrid Power Divider, and (b) The Equivalent Circuit Representation.

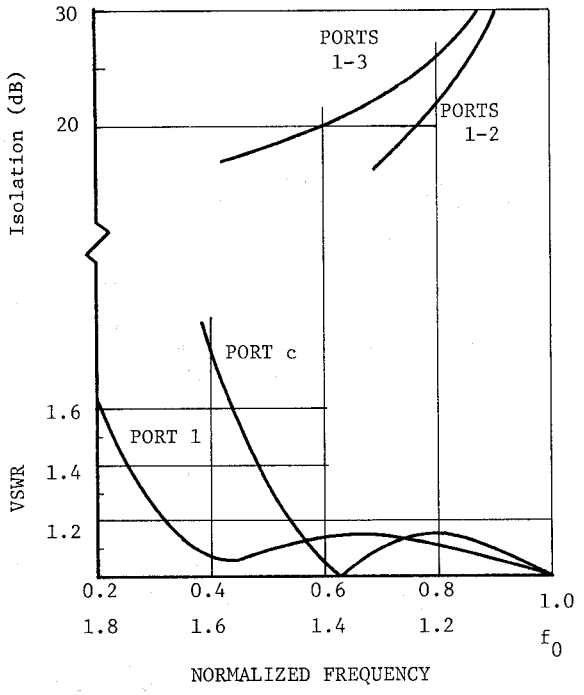


Fig. 5 Theoretical VSWR and Isolation Responses of the 4-Way HPD shown in Fig.4.

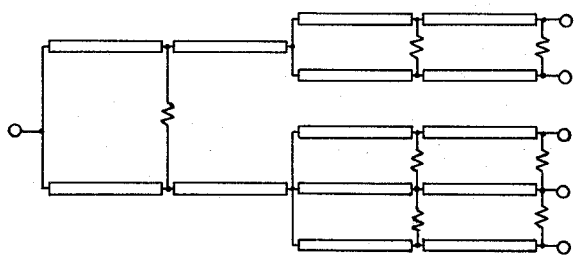


Fig. 6 A 5-Way Planar Hybrid Power Divider.

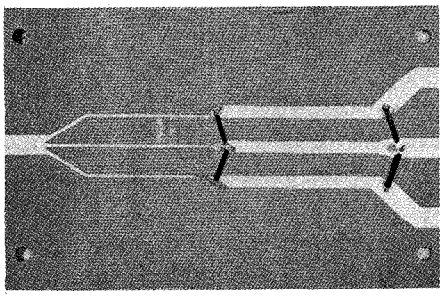


Fig. 7 Photograph of an Experimental 3-Way Planar Hybrid Power Divider.

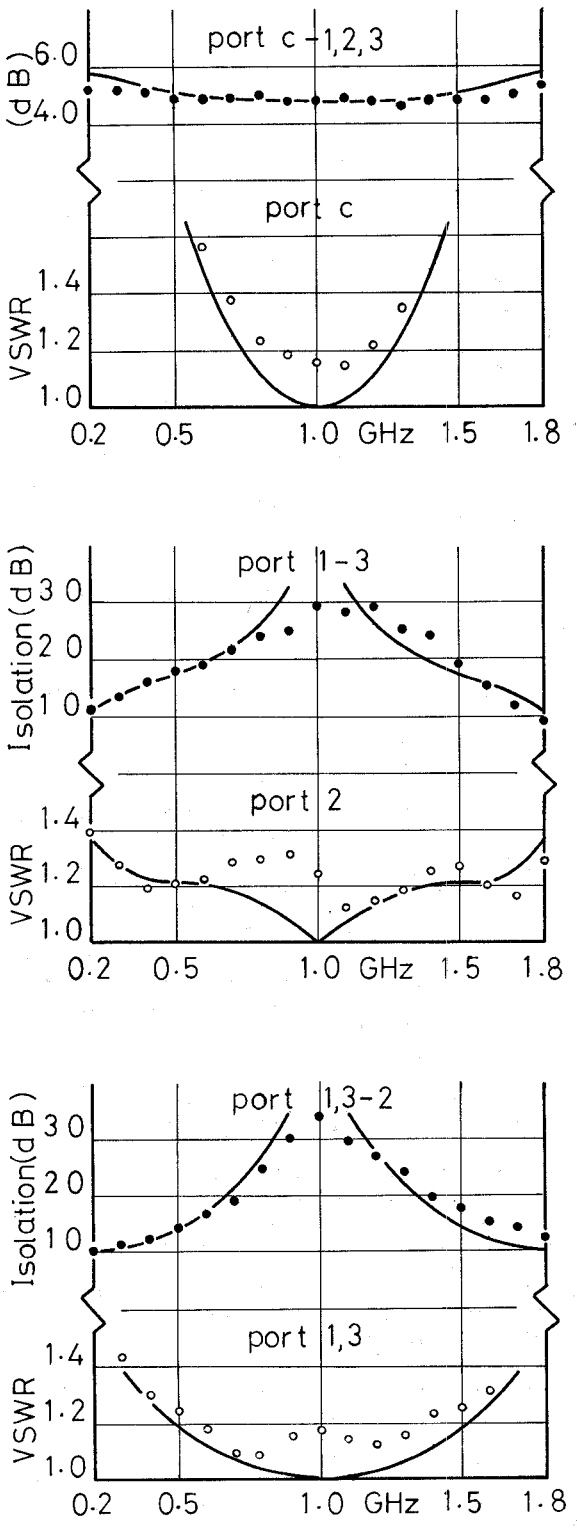


Fig. 8 VSWR and Isolation Responses of the Experimental 3-Way Planar Hybrid Power Divider.