On Some Five-Way Hybrid Power Dividers

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ABSTRACT

New five-way hybrid power dividers are synthesized by making use of two sections of five-wire uncoupled transmission-lines of equal length with isolation resistors which are connected by the ends of the neighboring wires. As for the theoretical analysis of five-way planar HPD, the isolation characteristics among five ports show more than 20 dB, and the VSWR's of six ports show less than 1.4 in 2:1 bandwidth.

Introduction

It has been presented that an n-way hybrid power divider (henceforce HPD) are synthesized by using some sections of n-wire coupled (or uncoupled) lines of equal length with isolation resistors which are connected by the ends of the neighboring wires[3]. That is, an n-way planar HPD needs n-1 sections of n-wire lines and the planar isolation resistors for matching at the center frequency where the electrical length of the line section equals $\pi/2$, and an n-way coaxial-type HPD needs n/2 (n: even number) or (n-1)/2 (n: odd number) sections of n-wire lines and the coaxial-type isolation resistors for matching at the center frequency.

The analysis of the n-way HPD is done by getting the eigenvalues and the corresponding eigenvectors of the characteristic admittance matrices for n-wire coupled (or uncoupled) lines and of admittance matrices for the isolation resistors, and then by getting the equivalent circuit representation of the n-way HPD.[2] The equivalent circuit representation is presented by n circuits which consist of a two-port for the even-mode circuit and n-1 one-ports for the odd-mode circuits.

A three-way and a four-way planar HPD's have been presented in Ref. 3, and the isolation characteristics among three ports show more than 20 dB, and the VSWR's of four ports show less than 1.4 in 2:1 bandwidth for the three-way planar HPD. In this paper we consider five-way HPD's, and let the bandwidth for the circuit be selected by the characteristics that isolation responses in five output ports show more than 20 dB, and the VSWR characteristics of six ports show less than 1.4.

Coaxial-type Five-Way Hybrid Power Divider

A five-way coaxial-type HPD needs two sections of the five-wire lines and the coaxial-type isolation resistors as shown in Fig.1(a) for matching at the center frequency. If we use uncoupled transmission-lines for the 5-wire lines, the characteristic impedances of the lines and resistances of the isolation resistors are selected as presented in Fig.1(a). The Fig.1(b) shows the equivalent circuit representation of the 5-way HPD. The theoretical VSWR and isolation characteristics are shown in Fig.2. The 5-way HPD shows 1.8:1 bandwidth.

Broadband Five-Way Coaxial-type Hybrid Power Divider

We can make a broadband five-way coaxial-type HPD by adding a transmission-line to a five-way coaxial-type HPD as shown in Fig.3(a). Fig.3(b) shows the equivalent circuit representation of the 5-way HPD. The two-port circuit is represented by a quarter-wave transformer of three sections with a transformation ratio 250Ω : 50Ω. If we consider the Tchebyscheff transformer, the characteristic impedances are selected as shown in Fig.3(a). And the resistances of isolation resistors are also selected as shown in Fig.3(a). The theoretical VSWR and isolation characteristics are shown in Fig.4. The 5-way HPD shows 3:1 bandwidth.

Five-Way Planar Hybrid Power Divider

A five-way planar HPD needs four sections of five-wire lines and the planar isolation resistors for matching at the center frequency. If we permit a very little impedance mismatches of the output ports at the center frequency, then such a five-way planar HPD does not need four sections of the lines and the planar isolation resistors.

We can obtain a five-way planar HPD constructed with a transmission-line, and two sections of five-wire lines and the planar isolation resistors. The five-way planar HPD is shown in Fig.5(a).

Fig.5(b) shows the equivalent circuit representation of the 5-way HPD. The two-port is represented by a quarter-wave transformer of 3 sections with a transformation ratio 250Ω : 50Ω. If we consider the maximally flat transformer, the characteristic impedances are selected as shown in Fig.5(a). Let the resistances of isolation resistors be selected with the two one-ports of eigenvalues h_2 and h_4, then they are selected as shown in Fig.5(a).[2] The theoretical VSWR and isolation characteristics are shown in Fig.6. The 5-way HPD shows 2:1 bandwidth.

Experiment of a 5-Way Planar Hybrid Power Divider

The experimental circuit for a 5-way planar HPD is shown in Fig.7, and the VSWR and isolation responses for the 5-way HPD is shown in fig.8. Though there are some problems in isolation responses, these characteristics are in agreement with the theoretical analysis.

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. N.Nagai and E.Maekawa, "A new analysis of n-way hybrid power dividers with equiamplitudes," Monograph Series of the Research Institute of Applied Electricity, Hokkaido Univ., No.24, 1977.

3. N.Nagai, E.Maekawa and K.Ono, "New n-way hybrid power dividers," IEEE Trans. Microwave Theory Tech., vol. MTT-25, pp. 1008-1012, Dec. 1977.

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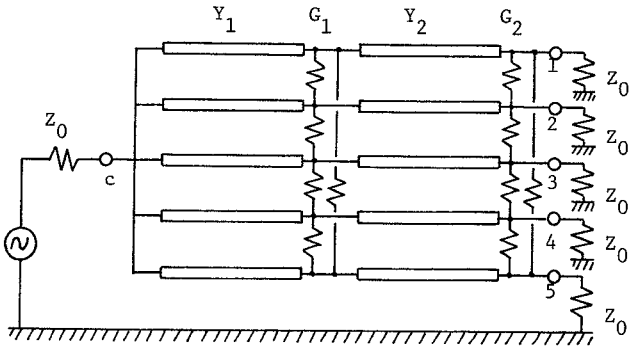
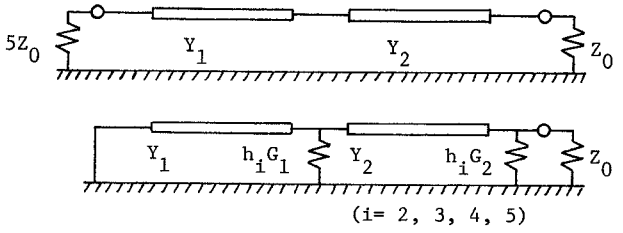


$Z_0 = 50\Omega$, $Z_1 = 1/Y_1 = 167.2\Omega$, $Z_2 = 1/Y_2 = 74.8\Omega$,
$R_1 = 1/G_1 = 111.8\Omega$, $R_2 = 1/G_2 = 250\Omega$.

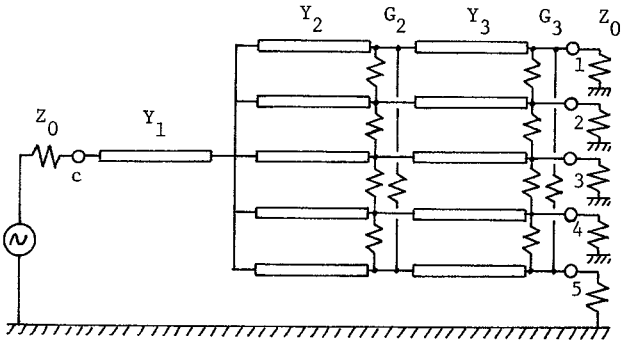
(a)



$h_2 = h_3 = 1.3820$, $h_4 = h_5 = 3.6180$

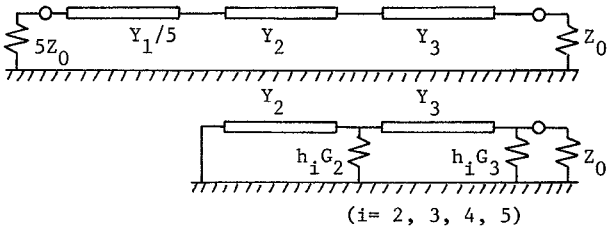
(b)

Fig.1. (a) Coaxial-type five-way hybrid power divider. (b) The equivalent circuit representation.



$Z_0 = 50\Omega$, $Z_1 = 1/Y_1 = 35.0\Omega$,
$Z_2 = 1/Y_2 = 111.8\Omega$, $Z_3 = 1/Y_3 = 71.3\Omega$,
$R_2 = 1/G_2 = 102.0\Omega$, $R_3 = 1/G_3 = 250\Omega$.

(a)



$h_2 = h_3 = 1.3820$, $h_4 = h_5 = 3.6180$.

(b)

Fig.3. (a) Broadband 5-way coaxial-type HPD. (b) The equivalent circuit representation.

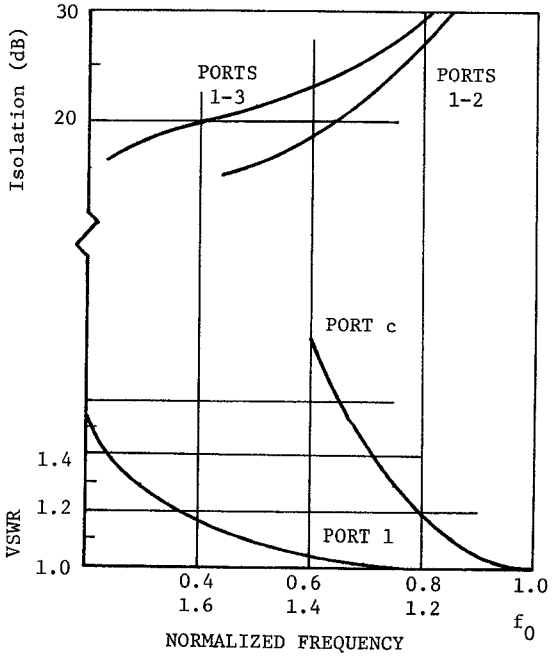


Fig.2. Theoretical VSWR and isolation responses of the 5-way HPD shown in Fig.1(a).

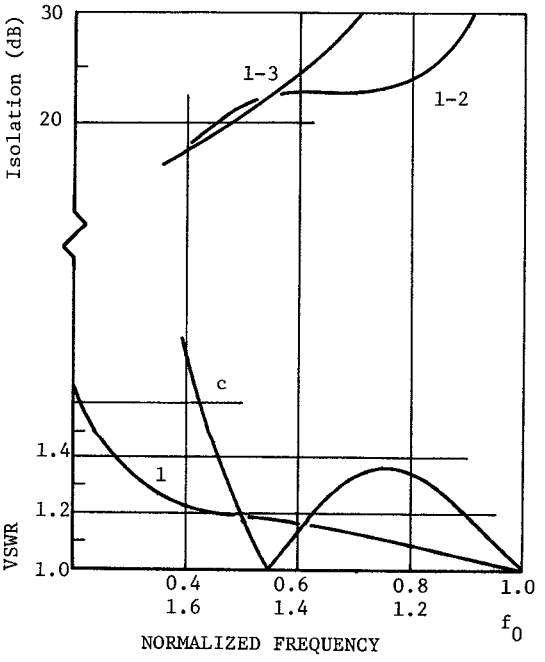
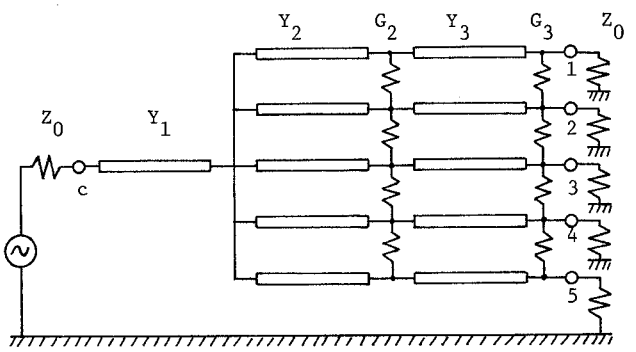
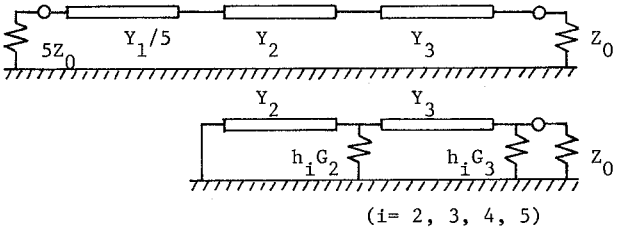


Fig.4. Theoretical VSWR and isolation responses of the 5-way HPD shown in Fig.3(a).



$Z_0 = 50\Omega$, $Z_1 = 1/Y_1 = 40.8\Omega$,
$Z_2 = 1/Y_2 = 111.8\Omega$, $Z_3 = 1/Y_3 = 61.3\Omega$,
$R_2 = 1/G_2 = 25.0\Omega$, $R_3 = 1/G_3 = 150\Omega$.

(a)



(i= 2, 3, 4, 5)

h_2=0.3820, h_3=1.3820, h_4=2.6180, h_5=3.6180.

(b)

Fig.5. (a) A five-way planar hybrid power divider. (b) The equivalent circuit representation.

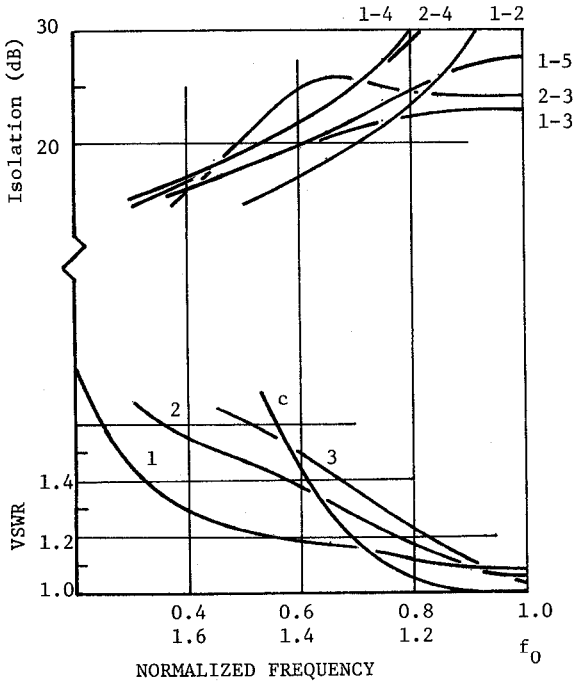


Fig.6. Theoretical VSWR and isolation responses of the 5-way HPD shown in Fig.5(a).

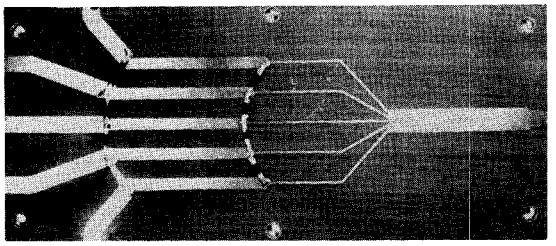


Fig.7. Photograph of an Experimental 5-Way Planar Hybrid Power Divider.

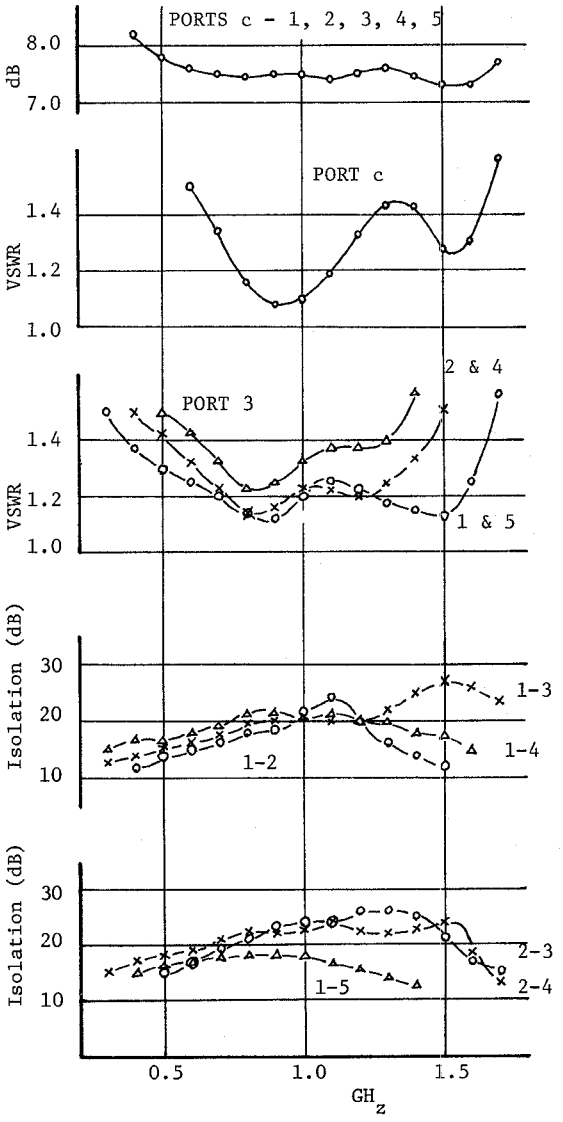


Fig.8. The VSWR and isolation responses for the experimental planar five-way hybrid power divider.