

## N-Terminal Power Divider\*

Recently Wilkinson<sup>1</sup> has described an  $N$ -way hybrid power divider which decouples the outputs. This device can be arrived at by observing that its scattering matrix is

$$S = \frac{j}{\sqrt{n}} \begin{bmatrix} 0 & 1 & 1 & 1 & 1 & \dots & \dots & \dots \\ 1 & 0 & & & & & & \\ 1 & & 0 & & & & & \\ 1 & & & 0 & & & & \\ \vdots & & & & 0 & & & \\ \vdots & & & & & & & \end{bmatrix}.$$

Then

$$S^2 = \frac{1}{n} \begin{bmatrix} n & 0 & & & & & & \\ & 1 & 1 & 1 & 1 & 1 & 1 & \\ & 1 & 1 & 1 & 1 & 1 & 1 & \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & \\ \vdots & & & & & & & \\ \vdots & & & & & & & \end{bmatrix}$$

and

$$S^3 = \frac{-j}{n\sqrt{n}} \begin{bmatrix} 0 & n & n & n & n & \dots & & \\ n & 0 & & & & & & \\ n & & 0 & & & & & \\ n & & & 0 & & & & \\ \vdots & & & & 0 & & & \\ \vdots & & & & & & & \end{bmatrix} = -S.$$

Then

$$\begin{aligned} y &= (1 - S)(1 + S)^{-1} \\ &= (1 - S)^2(1 - S^2)^{-1} \\ &= (1 - 2S + S^2)S(S - S^3)^{-1} = -S \\ &\quad (\text{See below}^2) \\ &= -S^2S^{-1} = (S - S^2 + S^3)S^{-1} \\ &= 1 - S + S^2 \end{aligned}$$

$$Y = \begin{bmatrix} 0 & -j & -j & -j & \dots & \dots & \dots \\ -j & \frac{n-1}{\sqrt{n}} & -1 & -1 & \dots & \dots & \dots \\ \sqrt{n} & n & n & n & \dots & \dots & \dots \\ -j & -1 & n-1 & -1 & \dots & \dots & \dots \\ \sqrt{n} & n & n & n & \dots & \dots & \dots \\ -j & -1 & -1 & n-1 & \dots & \dots & \dots \\ \sqrt{n} & n & n & n & \dots & \dots & \dots \\ \vdots & \vdots & \vdots & \vdots & \ddots & \ddots & \ddots \\ \vdots & \vdots & \vdots & \vdots & \ddots & \ddots & \ddots \end{bmatrix}.$$

This represents  $n(3\lambda/4)$  transmission lines of characteristic admittance  $\sqrt{(n/n)}Y_0$ , each terminated in a pure conductance of value  $(n-1)/n$  and coupled to the output of every other line by transfer admittance (conductance) of  $1/n$  in units of  $Y_0$ , when all outputs except the one considered are short circuited. It is not hard to see that the termination shown in Fig. 1 satisfies this requirement. Moving the reference of  $S$  by  $\lambda/2$ , lines in  $Y$  become  $\lambda/4$  lines and the final network is (Fig. 2).

coupled. It is not hard to see that the termination shown in Fig. 1 satisfies this requirement. Moving the reference of  $S$  by  $\lambda/2$ , lines in  $Y$  become  $\lambda/4$  lines and the final network is (Fig. 2).

varied from 9.9 db to 10.2 db over the same frequency range with greater than 20-db directivity. A maximum VSWR of 1.13 was obtained in the secondary arm.

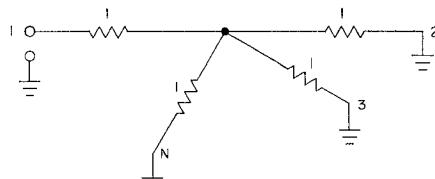


Fig. 1.

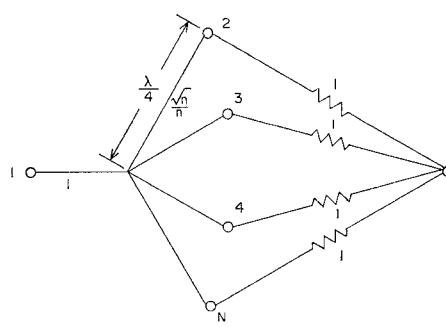


Fig. 2.

R. W. PETERSON  
Control Data Corp.  
Minneapolis, Minn.

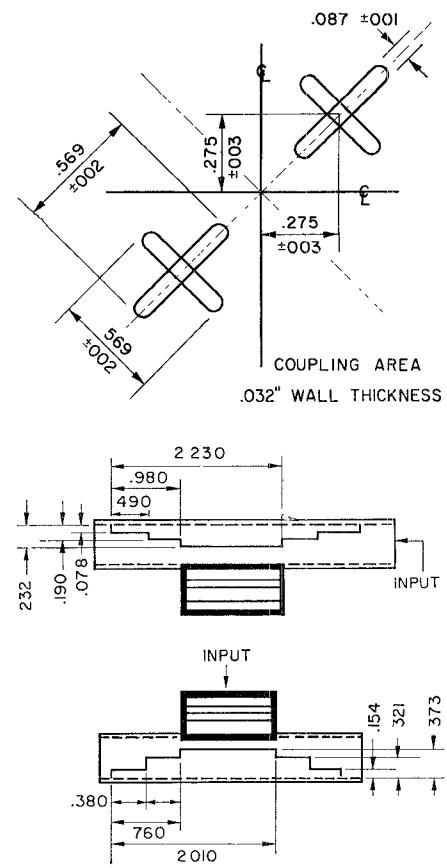


Fig. 1.

10-DB  $X_L$  Cross Guide Coupler\*

Two interesting points were noted while working with half-height cross guide couplers. The first was that if the same size coupling holes were used as in the full size waveguide, coupling was increased approximately 3 db. The second, and more important, was that the value of coupling was much more constant over a given frequency band, with essentially no change in directivity.

With this information, a standard  $15 \pm 1$  db coupler in WR 112 waveguide was taken, and step transitions of various heights were designed to insert into the coupling area. By inserting steps to reduce the waveguide to a half-height size, the 3-db increase in coupling was noted and the coupling flattened out to  $12 \pm 0.5$  db over the desired 7.5 to 8.5 kMc frequency range. By using only one step, coupling was increased to  $13 \pm 0.5$  over the same frequency band.

The need of a 10-db cross guide coupler resulted in Fig. 1.

Coupling, previous to inserting the steps, was 13.8 db to 15.8 db over the 7.5- to 8.5-kMc range with greater than 20-db directivity. After inserting the steps, coupling

Electrically, a good coupler is needed to start with since a change in VSWR due to the step causes a decrease in directivity. Also a smaller step in the primary arm is desirable both for input VSWR and higher power requirements. Mechanically the steps should be brazed in place since a loose step causes large variations in coupling.

Cross guide couplers with greater coupling have been built at the expense of directivity which drops down to 15 db or lower.

RICHARD Z. GERLACK  
Heavy Military Electronics Dept.  
General Electric Company  
Syracuse, N. Y.

## Design Note on an L-Band Strip-Line Circulator\*

The technique of using magnetized yttrium-iron-garnet slabs in dielectrically-loaded strip transmission line as the non-reciprocal elements in a UHF and low-

\* Received by the PGM TT, July 20, 1961.

<sup>1</sup> E. J. Wilkinson, "An  $N$ -way hybrid power divider," IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-8, pp. 116-118; January, 1960.

<sup>2</sup>  $Y = -S$  does not lead to a realizable microwave network.

\* Received by the PGM TT, May 10, 1961.

\* Received by the PGM TT, July 7, 1961.