MULTI-PORT LATTICE-TYPE HYBRID NETWORK

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As a new method to design microwave branching or combining circuit which has many terminals, Multi-Port Lattice-type Hybrid network is proposed. We have analyzed the network, and several useful networks have been designed practically.

Introduction.

In a microwave branching or combining circuit where many input and output terminals are needed, a combination of several four-terminal pair hybrid circuits has generally been employed. A bigger and more complex composition is formed as the required number of input and output terminals is increased.

In order to solve this problem, a composition applying the multi-terminal pair network theory is proposed. This network can be applied to all kinds of transmission lines such as waveguides, coaxial cables, strip lines and so on.

Composition of the Network.

Figure 1 shows the diagram of the Multi-Port Lattice-type Hybrid network. This network is composed of arbitrarily selected M and N pieces of parallel transmission line arranged orthogonally. Spacing between the lines can be selected arbitrarily. The example analyzed in this paper uses a spacing of 1/4 wave length of the center frequency. This network is called the N sections 2M-Port (Lattice-type) Hybrid network. Each terminal pair and transmission line in Figure 1 is shown as one line. The conventional four-terminal pair hybrid network is shown as a 4-Port Hybrid (M=2).

Analysis of the Network.

The various characteristics of the Multi-Port Hybrid network can be obtained by using a matrix. That is, given the terms of any one matrix (ABCD, impedance, admittance, scattering etc.), the terms of any other matrix may be obtained by applying a conversion formula. Thus, the characteristics such as coupling, isolation and impedance among the various ports can be computed. The frequency band characteristic of a hybrid can also be obtained by mathematical calculation if line length is given. To analyze a Multi-Port Hybrid network, a computor was used for converting the matrices and to calculate the various characteristics.

Numerical Solution.

Several examples of numerically analyzed data about the Multi-Port Hybrid network are shown as follows:

First take an example of the hybrid network M=3 and N=2 (${}_3H_2$) shown in Figure 2. Here, the normalized admittance of all transmission lines is 1, and the spacing between the lines is 1/4 wave length of the center frequency. Power at the center frequency applied to port 2 can be distributed equally among ports 1,3,4 and 6. The curve marked 2 → 1 and 2 → 3 shows the transmission characteristics from port 2 to ports 1 and 3. The figure shows that the coupling at the center frequency is 6 dB. As the frequency increases, the coupling (dB) also increases. In the same way, curve 2 → 4 and 2 → 6 shows the transmission characteristics between ports 2 → 4 and 2 → 6. The coupling at the center frequency is 6 dB as with curve 2 → 1 and 2 → 3. That is, at the center frequency applied power is divided equally into the four ports. As the frequency increases the coupling (dB) of 2 → 4 and 2 → 6 also increases, but more gradually than 2 → 1 and 2 → 3. Curve 2 → 2 shows reflected power caused by impedance mismatching. At the center frequency, return loss is infinitive since impedance is matched. Increased deviation from the center frequency causes the return loss (dB) to be decreased as shown in Figure 2. Curve 2 → 5 shows the isolation characteristic between ports 2 and 5.

Figure 3 shows an example of the network N= M+1 (${}_MH_{M+1}$). The number of section in this network is one more than the line number. The normalized admittance and spacing of lines are selected as same as Figure 2. The characteristic of this network is that the transmission loss between two ports, symmetrically located in the geometrical center of the network is zero dB. That is, there is no transmission loss between ports 1 → 6, 2 → 5 and 3 → 4 at the center frequency as shown in Figure 3. The characteristics of the network ${}_MH_{M+1}$ can be considered to be the same as those of an expanded type of well known ${}_2H_3$ network (M=2, N=3).

Figure 4 shows the characteristics of a practically designed 3-way divider M=3, N=2 (${}_3H_2$). The input power applied to port 2 is equally divided among ports 4,5 and 6. By applying the odd and even mode method[1], the matrix was solved and normalized admittance 1 and $\sqrt{3}$ were obtained. The transmission characteristic curves are also shown in Figure 4.

Figure 5 shows the characteristics of a practically designed 3-way divider M=3, N=3 (${}_3H_3$). This network adds one more section to the ${}_3H_2$ network of Figure 4. A computor was employed to solve the matrix. It is clear by comparing Figure 4 and Figure 5 that the transmission frequency band is increased as the number of section is increased. The measured characteristics and photograph of this network are shown in Figure 6 and Figure 7, respectively.

Conclusion.

As a new method to design microwave branching and combining circuits, the Multi-Port Lattice-type Hybrid network is proposed. Several networks designed in this way have already been used in practice.

A calculation has been made by using NEC made Type NEAC-Series 2200 Model 500 computor.

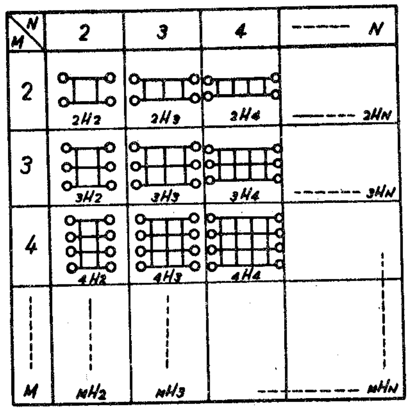

Figure 1. Diagram of Multi-Port Lattice-Type Hybrid Network

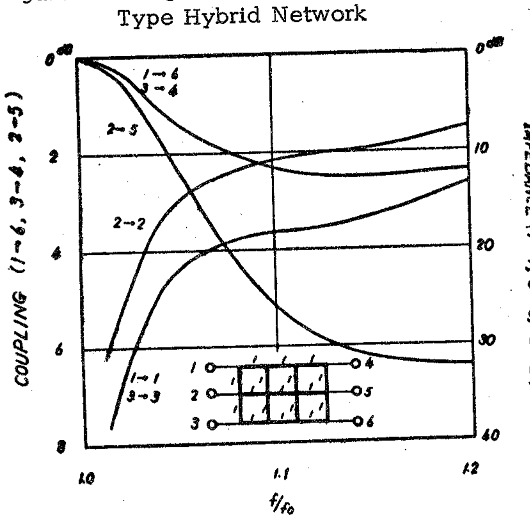

Figure 3. Theoretical Characteristics of 3-Way Cross Network

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Reference.

1. J. Reed and G. J. Wheeler, "A Method of Analysis of Symmetrical Four-Port Networks", IRE Trans. on MTT, Vol. 4, No. 4, pp. 246-252, October, 1956.

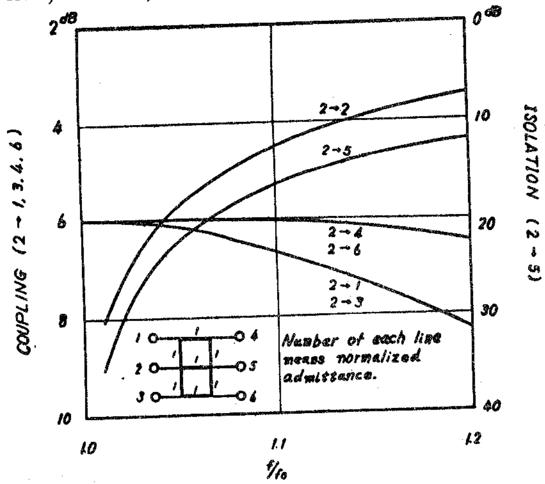

Figure 2. Theoretical Characteristics of 4-Way Divider

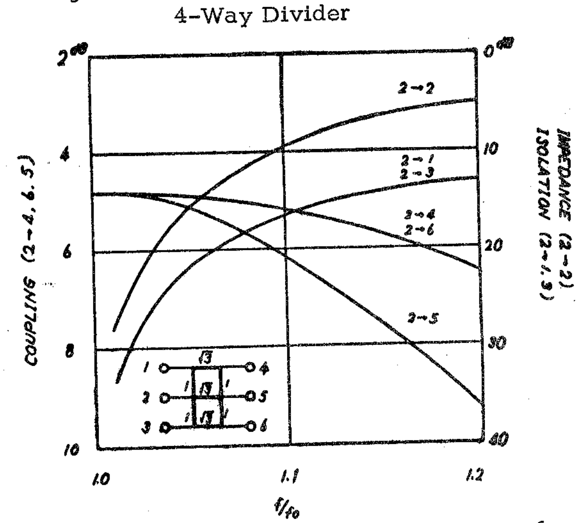

Figure 4. Theoretical Characteristics of 3-Way Divider (2 Sections)

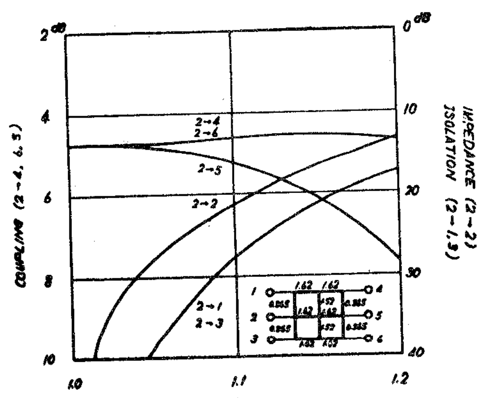

Figure 5. Theoretical Characteristics of 3-Way Divider (3 Sections)

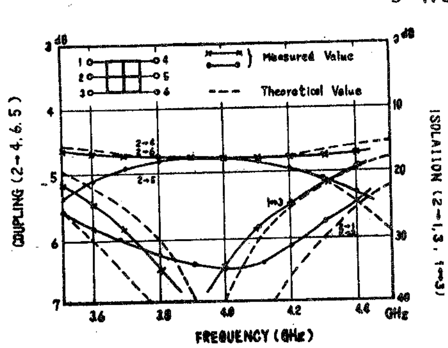

Figure 6. Measured Characteristics of 3-Way Divider (3 Sections)

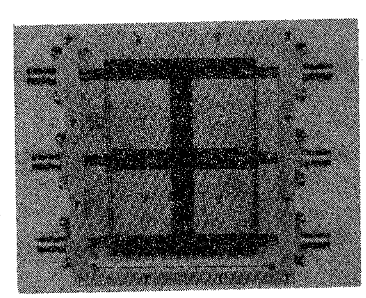

Figure 7. Photograph of 3-Way Divider (3 Sections)