Hence, only one of the output arms may be isolated by matching. The parameter η represents the phase shift in the internal four-port and can have essential influence on the possibilities to minimize $|S_4|$ when both D and R differ from zero.

The validity of the four-port circulator model has not been experimentally verified, but there is no reason to believe that there is a difference between the three- and four-port models in this respect.

VI. Conclusion

The method of transforming a nonreciprocal lossless three-port into an ideal circulator by connecting appropriate external two-ports to each arm is easily understandable if the three-port in question is represented by its model. In that case, the network consists of an ideal circulator with two cascaded two-ports connected to each arm. It is clear that if the outer two-port has the appropriate characteristics, it will cancel the reflections from the inner two-port and the whole device will appear to be matched. It is also easy to see why this method is not sufficient for junctions with more than three arms. If external two-ports are connected to each arm in the flow graph in Fig. 10 so that the reflections disappear, the network will not represent a circulator. Only one of the output arms can be isolated in this way.

It has been shown in Section II that the phase shift has a considerable influence on the properties of a general lossless three-port network. Also, in the models of the three- and four-port circulators, the phase shift has great influence and it appears in a form that can be easily measured. It is then possible to describe the relation between isolation and reflection coefficient of a nonideal three-port circulator more exactly than if the relation $A \approx C$ is used.

VII. Acknowledgment

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Correction

J. Paul Shelton, Jr., author of the paper "Impedances of Offset Parallel-Coupled Strip Transmission Lines," which appeared in these Transactions, vol. MTT-14, no. 1, January 1966, pp. 7–14, is indebted to Steven March for his careful reading of the paper and pointing out the following.

References [4] and [6] should be interchanged.

Under *Derivation for Loose Coupling*, bottom of the first column, page 10, the equation from ΔC should read:

$$\Delta C = C_0 - C_e = \frac{120\pi}{\sqrt{\epsilon_r} Z_0}\left(\frac{\rho - 1}{\sqrt{\rho}}\right) \qquad \text{[from (7)]}$$

$$= \frac{2}{\pi} \log\left(\frac{1 + aq}{aq}\right). \qquad \text{[from (3), (4), and (9)]}$$

The last paragraph under *Derivation for Loose Coupling* should read:

The explicit solution for loose coupling, given Z_0, ϵ_r, ρ, and s, is now accomplished by solving (9) for ΔC, (15) for k, (16) and a and q, (3) or (4) for C_{f0} and C_{fe}, (9) for w, and (6) for w_c.