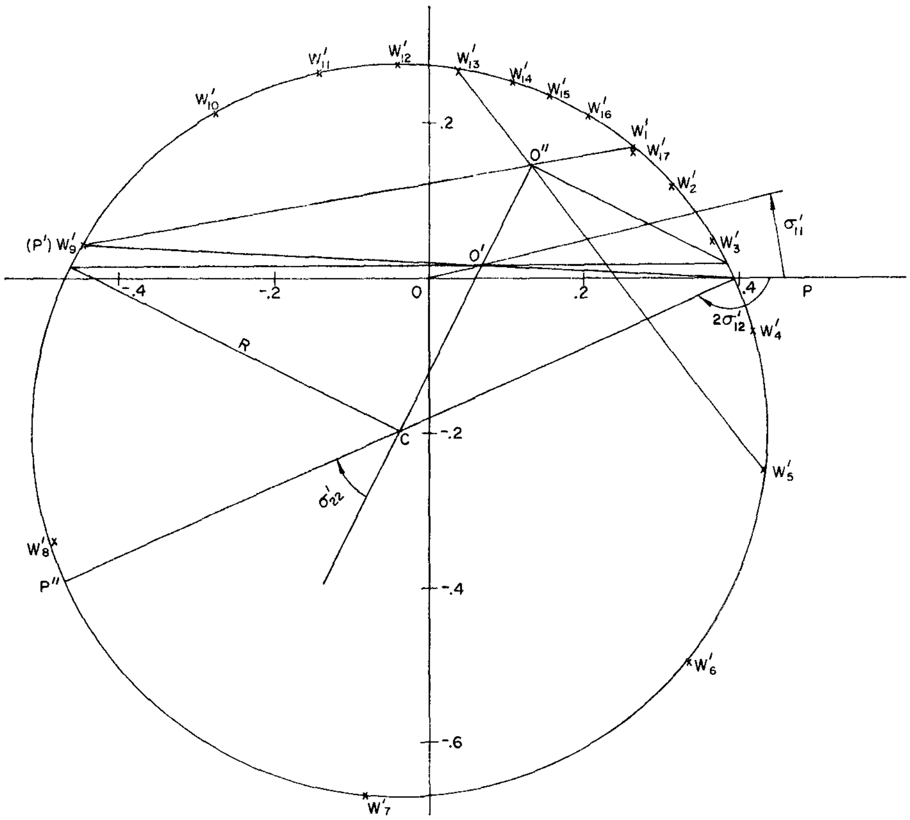

Fig. 1. Deschamps' construction for a reduced multiport waveguide junction with measurement done at port one and movable short placed at port two, and the other ports terminated with nearly matched loads. σ_{11}', σ_{22}', and σ_{12}' are phases of S_{11}', S_{22}', and S_{12}', respectively. Deschamps' notations are adopted in this graph.

difference between (5) and (6) yields the correction for mismatch:

$$\Delta_{1k} \equiv \frac{S_{1k}^2\Gamma_k}{1 - S_{kk}\Gamma_k} = S_{11}^{(0)} - S_{11}^{(k)}. \qquad (7)$$

With these corrections, the multiport scattering coefficients may be readily obtained from (3) and (4).

Scattering coefficients of an L-band hybrid-tee waveguide junction were measured at 1.271 GHz to verify our procedure. By neglecting mismatches, 6 Deschamps' constructions (as those shown in Fig. 1) are required for the entire scattering matrix. With corrections, 9 Deschamps' constructions and 3 additional measurements outlined in 1) are needed. The microwave source was carefully matched. VSWRs of the loads were 1.03 or less. Standing-wave measurements were done at input arm with a movable short placed at $n\lambda/32$ from the output reference plane of the hybrid tee, where λ is the wavelength and $n = 0, 1, \cdots, 16$. The 17th point was provided mainly as a check point. The reflection coefficient was obtained from averaging the amplitudes and phases of several slotted-line measurements. These reflection coefficients W_i' were then least square fitted to a circle to find its radius and center (R and point C in Fig. 1). The inconocenter O′ was obtained from O″, which is the average of all intersections of chords $W_i'W_{1+8}'$, where $i = 1, 2, \cdots, 8$. The modified scattering coefficients were directly calculated using (6) and (7). The whole process was done by IBM 360 and lasted several seconds. The correction Δ_{1k} in the above measurements are small and all $|S_{ij}|$ (reflection coefficient measured at arm i with movable short at arm j) differ from $|S_{ji}|$ by less than one percent.

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Mode Chart for E-Plane Circulators

J. HELSZAJN AND M. McDERMOTT

***Abstract*—The mode chart of the E-plane junction circulator is given. The geometry considered consists of two ferrite disks placed against the narrow walls at the plane of symmetry of a symmetrical 3-port E-plane waveguide junction.**

It is experimentally found to exhibit two modes. One of these modes has a resonant frequency which increases with the spacing between the two ferrite disks. The other mode has a resonant frequency which decreases with the spacing between the disks. Both modes are independent of the disk spacing when the spacing is large. It is also found that the frequency of both modes is proportional to the thickness of the ferrite disks. Finally, circulators obtained by magnetizing each of the two modes circulate in opposite directions.

Experimental results on a circulator obtained in this way are included.

A number of authors have made brief references in the literature to the E-plane junction circulator [1]–[7]. Such references have been mostly of an experimental nature. One advantage of the E-plane junction compared to the more usual H-plane one is its peak power capability. The purpose of this correspondence is to give the mode chart for this type of circulator. Mode charts of circulators may be constructed by observing that their center frequency coincides with the frequency at which the VSWR of the reciprocal 3-port junction

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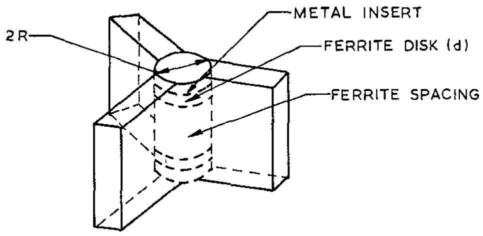

Fig. 1. Schematic of E-plane circulator.

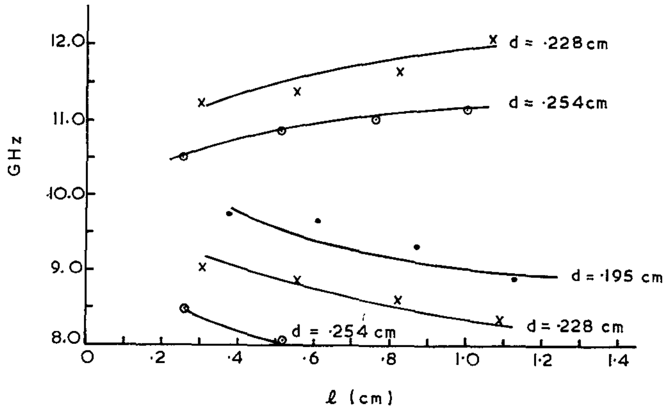

Fig. 2. Mode chart of 3-port junction containing unmagnetized disks.

is a minimum. Mode charts may, therefore, be constructed by determining the frequency at which the VSWR is exactly 2. This approach, although well known, appears to be little used in the formal literature of junction circulators [8], [9]. Its simplicity will be demonstrated in this contribution in connection with the adjustment of the E-plane circulator.

The geometry used is shown in Fig. 1. This geometry has been studied in [2], [3], and [7]. It consists of two ferrite disks placed against the narrow walls at the plane of symmetry of a symmetrical 3-port E-plane waveguide junction. The two variables used to obtain the mode chart were the ferrite thickness and the spacing between the two disks. The spacing between the ferrite disks was adjusted by introducing metal inserts as shown in Fig. 1. The thickness of the metal disks does not appear as a variable in the mode chart because the frequency of the junction is only determined by l, d, and R. The diameter of the ferrite disk was held constant at 1.20 cm. The inside dimensions of the X-band waveguide used were 2.286 by 1.016 cm. The mode charts were plotted over the full frequency range appropriate to the waveguide size. The material used was a garnet one with a saturation magnetization of 0.16 Wb/m^2 and a relative dielectric constant of 15.1.

The relation between the frequency and the spacing between the two ferrite disks for parametric values of ferrite thickness is shown in Fig. 2. It is seen from this illustration that two modes are obtained within the X-band frequency range. The frequency of one mode decreases as the spacing between the two ferrite disks increases. The frequency of the other one increases as the spacing increases. Both modes become independent of ferrite spacing when the spacing is large. It is also seen that the frequency of each mode is proportional to ferrite thickness.

Fig. 3 shows the performance of a circulator obtained by simply magnetizing the first mode using ferrite disks 0.195 cm thick spaced 0.87 cm apart. The magnetic field used was about 3100 A/m. The center frequency obtained with this arrangement is 9.40 GHz which is in close agreement with the prediction of the mode chart. The bandwidth of the resultant circulator is about 400 MHz wide at the 20-dB points. The insertion loss between ports 1 and 2 is 0.40 dB. It should be emphasized that equally good performance can be obtained anywhere on the mode chart.

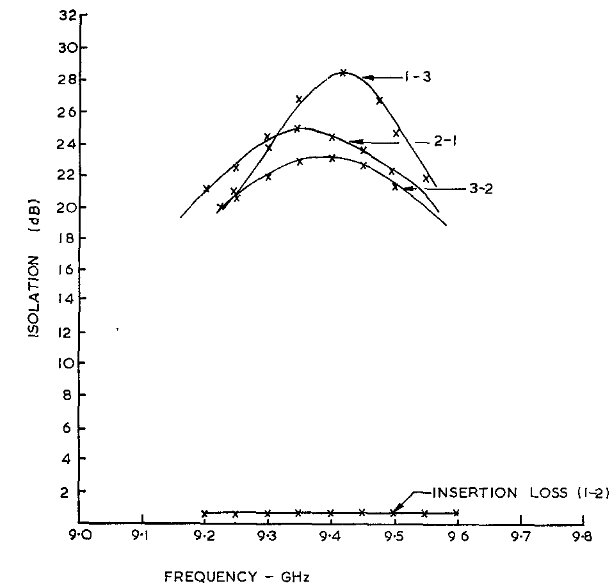

Fig. 3. Frequency response of E-plane circulator using first circulation mode.

The circulator obtained by magnetizing the other mode using the same geometry was one in which circulation occurred in the opposite direction. A similar result has been mentioned in [3].

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Phase Corrections for Weighted Acoustic Surface-Wave Dispersive Filters

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***Abstract*—Phase errors incurred by a surface acoustic wave propagating through or generated by an apodized interdigital array have been found to cause severe distortions of the filter response. The amount of error is a function of the piezoelectric coupling constant of the delay material and it is found that the distortions are most severe in high-coupling materials. A simple modification to the current method of array design is presented which corrects this phase error. Experimental results for a pulse-compression loop using apodized lithium-niobate surface-wave filters are presented which demonstrate the effectiveness of this method of phase correction.**

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