A NEW 6-18GHz, -3DB MULTISECTION HYBRID COUPLER USING ASYMMETRIC BROADSIDE, AND EDGE COUPLED LINES

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Traditionally, the design of broad band couplers on microstrip has been accomplished by the well known Lange coupler. This paper will present a new asymmetric broadside coupler which could potentially replace the Lange coupler and is shown to have superior performance. An asymmetric broadside coupled line is used as the middle section of a 3-section coupler, the two outside sections being realized by symmetric edge coupled lines. This new configuration utilizes a thin polyimide layer separating the two broadside coupled lines which offers additional design freedom and requires no tuning, or bonding, thus providing higher yield and lower manufacturing cost. The performance of two couplers, one using a Lange section and another using the new asymmetric broadside section are presented and compared. An accurate numerical model for the asymmetric broadside coupled section was developed and used to design the present coupler. Calculated and measured results which exhibit excellent agreement will be presented. The development of the numerical model for this coupler will be reported in the future.

INTRODUCTION

In the absence of symmetry, there are two modes that can exist on a pair of coupled lines. These modes are generally referred to as the C and PI modes[1]. The propagation constants of these two modes are the eigen values of coupled transmission lines equations and the eigen vectors correspond to the voltage and currents on each line. The asymmetry on the broadside coupled configuration is illustrated in Figure 1. The strip widths are assumed to be the same to simplify the analysis. A computer model for this structure has been developed and used to design the present coupler which will be discussed at the conference.

Although several authors have presented design guidelines and tables for symmetric couplers[2-3], no synthesis procedure seems to have been published for the design of asymmetric couplers. In this work, the synthesis procedure outlined by Toulios et al[2], Cristal et al[3], and Cristal[4] for the symmetric coupler and the multisection transformer procedure presented by Riblet[5] are used as the starting point for the design of the new multisection asymmetric coupler made from an asymmetric center section and two symmetric edge coupled sections as shown in Figure 2.

THE DESIGN

A broad band -3dB coupler covering the 6-18 GHz band was desired to have .1 dB equal ripple. THe table of parameters for symmetrical TEM-Mode coupled lines provided by Cristal et al[3] were used to find the odd and even mode parameters for a three section coupler . As a starting point, the center broadside section was modeled as a symmetric broadside by reducing the cover height to be the same as the alumina substrate and the dielectric to be the same as alumina substrate of the bottom layer. The parameters for this symmetric coupler were then found which approximated the TEM mode design. Then, the model was gradually made asymmetric by changing the dielectric of the top layer to approach air and the cover height increased to the height of the final package.

The response of the ideal coupler and the optimized asymmetric coupler are shown in Figure 3. The ideal coupler shows a -3dB split and with .1 dB ripple. The resulting asymmetric coupler shows a little higher loss of -3.5 dB average power splitting between the thru and the coupled ports.

Figure 4. shows the simulated return loss to be at worst -12 dB at 18 GHz. Figure 5 shows the phase of each output port compared to the ideal design.

RESULTS

based on the above procedure two asymmetric 3-section couplers were designed, one with the crossed arms to have the coupled and the thru ports on the same side and another with no crossing arms. This design is shown in Figure 2.

The measured coupled and thru arm responses are shown in Figures 6 and 7 for the crossed and the regular couplers respectively. It can be seen that the coupled and thru arms demonstrate average coupling of -4.5 dB which is one dB more than predicted. This discrepancy is expected because the computer model does not include the effect of loss. The measured response is flat and broadband as desired. It must be kept in mind that the effects of the test-fixture are also included in the measured data and no effort was made to de-embed the data. The measured return loss for the design

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was at worst -10 dB which also includes the effect of the test-fixture. The isolation was about -15 dB worst case.

COMPARISON WITH LANGE

An analogous design using a Lange section for the middle coupler was developed. This coupler is shown in Figure 8. The simulated response of this coupler compared to the ideal one is shown in Figure 9. The measured response of this design is shown in Figure 10. Figure 10 shows that the flatness of the Lange design is about 2 dB as compared with the 1 dB of the asymmetric broadside coupler.

ADVANTAGES

The present design offers the following advantage over the Lange coupler

* This design requires no bonding
* Small gaps for tight coupling are not a problem
* The thru and coupled lines can easily be on the same side or opposite sides by crossing or not crossing the broadside section
* Very easy to manufacture, it however requires a polyimide process.

APPLICATIONS

This design can easily replace the Lange coupler in applications such as:

* Balanced amplifier designs
* Balun designs
* Image reject mixers
* Balanced mixer designs
* Power splitters and hybrids
* monopulse comparators

CONCLUSIONS

A new way of designing broadband -3dB couplers has been introduced which potentially can be a replacement for the well known Lange coupler. This design uses an asymmetric broadside coupled section to realize a tightly coupled center section.

It was shown in this report that the three section design using a combination of asymmetric broadside and symmetric edge coupled sections performs better than that using a Lange section for the center section. Another aspect of this is that there is a process limitation in realization of gaps in the Lange coupler, the present polyimide capability provides polyimide thicknesses between 4-25 microns which covers a wide range of coupling for the broadside couplers.

The present design is very manufacturable and requires no assembly thus providing lower cost. The future development will incorporate unequal width strips with partial coupling which will provide additional degrees of freedom for design.

REFERENCES:

[1] Tripathi, V.J.,"Asymmetric Coupled Transmission Lines in an Inhomogeneous Medium",IEEE Transactions on Microwave Theory and Techniques, Vol. MTT-23, No. 9, September 1975.

[2] Toulios P.P., and A.C. Todd,"Synthesis of Symmetrical TEM-Mode Directional Couplers",IEEE Transactions on Microwave Theory and Techniques, September 1965.

[3] Cristal E.G., and L. Young,"Theory and Tables of Optimum Symmetrical TEM-Mode Coupled-Transmission-Line Directional Couplers",IEEE transactions on Microwave Theory and Techniques, Vol. MTT-13, No. 5., September 1965.

[4] Cristal ,E.G.,"Coupled-Transmission-Line Directional Couplers with Coupled Lines of Unequal Characteristic Impedances",IEEE Transactions on Microwave Theory and Techniques, Vol. MTT-14, No. 7, July 1966.

[5] Riblet, H.J.,"A General Design Procedure for Quarter-Wavelength Inhomogeneous Impedance Transformers Having Approximately Equal-Ripple Performance",IEEE Transactions on Microwave Theory and Techniques, September 1965.

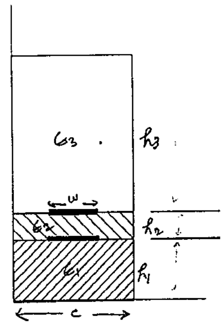

Figure 1: The nature of the asymmetry of the problem is due to the different dielectric materials used for each layer, the alumina, the polyimide, and air, the strip widths are the same.

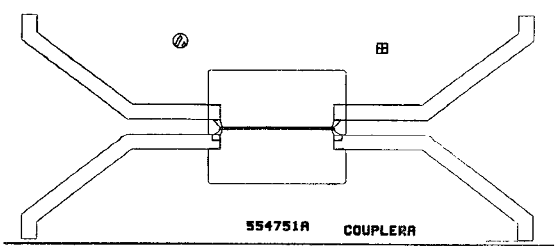

Figure 2: The new 6-18 GHz coupler with asymmetric broadside coupled center section and two symmetric edge coupled sections.

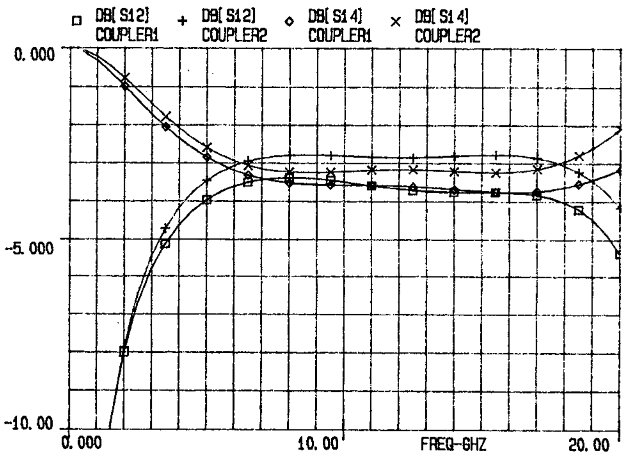

Figure 3: Simulated response of an ideal coupler and the new asymmetric broadside coupler which was used to design coupler of Figure 2.

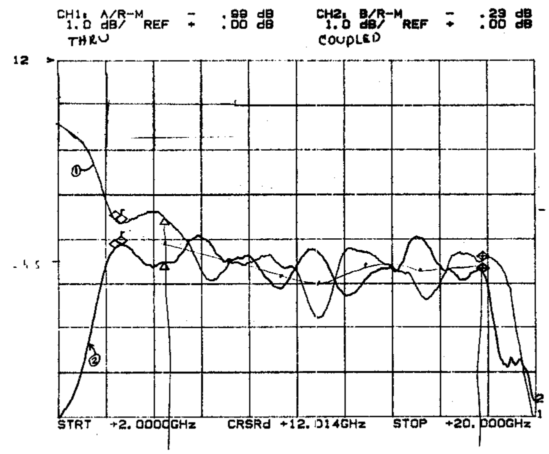

Figure 6: The measured response of the asymmetric broadside coupler of Figure 2a shows average -4.5 dB splitting and flatness of about 1 dB.

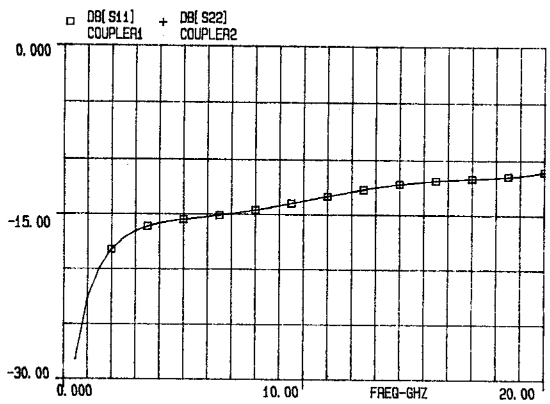

Figure 4: The simulated return loss of the asymmetric coupler shows at worst -12dB at 18 GHz.

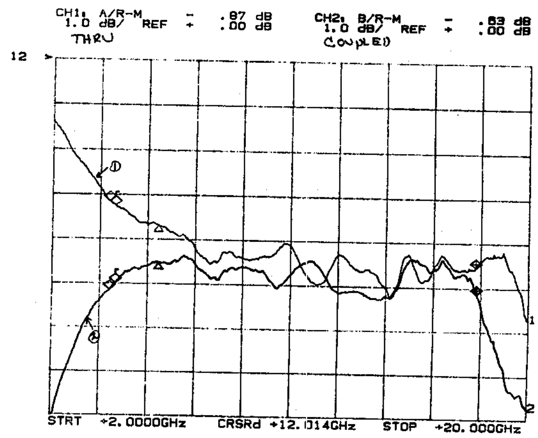

Figure 7: The measured response of the asymmetric broadside coupler of Figure 2 show an average -4.5 dB splitting and flatness of about 1 dB(folded arms).

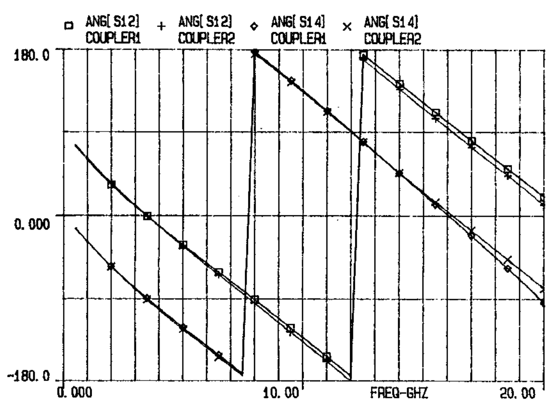

Figure 5: The simulated phase response of the asymmetric broadside coupler compared to the ideal response.

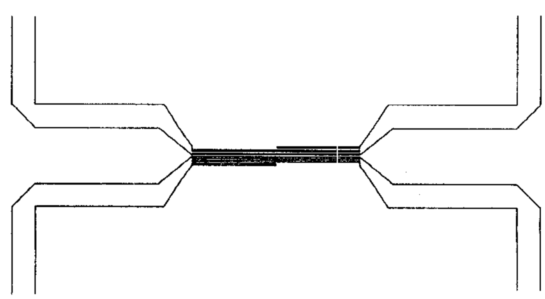

Figure 8: An analogous 3-Section design using a Lange coupler center section to be compared to the asymmetric broadside coupler(none folded arms).

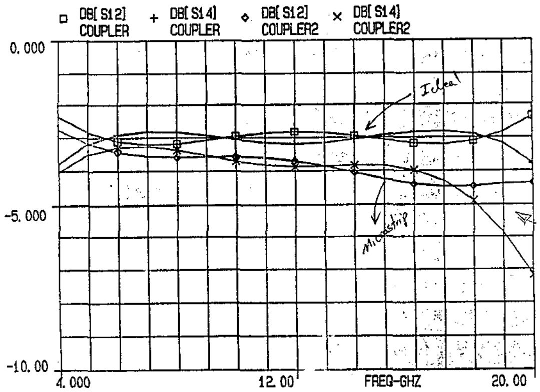

Figure 9: The simulated response of the Lange coupler of Figure 8 compared to the ideal design.

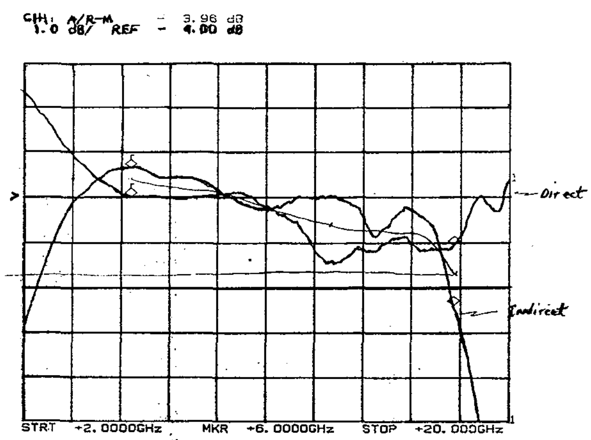

Figure 10: The measured response of the Lange coupler of Figure 8 shows a flatness of about 2 dB as compared to that of the 1 dB of Figure 6 and 7 for the asymmetric broadside couplers.