A BROADBAND, HIGH DIRECTIVITY 3 DB COUPLER USING COPLANAR WAVEGUIDE TECHNOLOGY.

E. RIUS, T. LE GOUGUEC, K. HETTAK, J. P. COUPEZ, S. TOUTAIN

Laboratoire d'Electronique et Systèmes de Télécommunications (L.E.S.T.) - URA CNRS n° 1329
U.B.O.- 6, av. Le Gorgeu - BP 809 -29285 BREST CEDEX-FRANCE-Tel : 98 01 61 26-Fax : 98 01 63 95
ENSTBr - BP.832 - 29285 BREST CEDEX-FRANCE-Tel : 98 00 13 68-Fax : 98 00 13 43

ABSTRACT

We propose to design high directivity - high level couplers using coplanar waveguide technology. This allows geometrical parameters to be chosen to design 3 dB couplers while limiting the difference between the phase velocities of the normal modes in order to obtain higher directivity. A 40 % bandwidth, 30 dB directivity 3 dB coupler is achieved.

Introduction

Microstrip couplers present instrinsic limitations for the obtention of high level - high directivity couplers. We propose to design such couplers by using coplanar waveguide technology. As this technology allows different geometrical parameters to be chosen to obtain the same characteristics, it is possible to design a large range of coupling with high directivity, while limiting the difference between the phase velocities of the normal modes. In this paper we present the design of 3 dB coupler using the coplanar technology. To illustrate our purpose, a 40 % bandwidth 30 dB directivity 3 dB coupler is achieved.

Microstrip technology limitations

Two difficulties arise for the design of 3 dB microstrip couplers :

1 - the necessity to make very tiny slots between the two coupled lines in order to obtain high level coupling.

2 - the difference in the phase velocities of the two normal modes (even and odd modes) which drastically limits isolation between the coupled arms.

Coplanar technology flexibility

Some compensation techniques have been proposed [1],[2],[3],[4],[5] but then, the design and the technological process are complicated. As more parameters can be varied, the design of coplanar couplers is easier. As presented in table 1, it is possible to choose different values for the geometrical parameters (w, s, g,) in order to obtain, for instance, a 8 dB coupler. The coupled region is characterized by two transmission lines with characteristic impedances, Zoo and Zoe, and two effective relative dielectric constants εreffo and εreffe. The second subscript refers to odd and even modes respectively. The characteristic impedance Zo and the coupling factor K can be determined by the following expressions :

$$Zo = \sqrt{Zoe \cdot Zoo} \qquad (1)$$

$$K = 20 \cdot \log\left(\frac{Zoe - Zoo}{Zoe + Zoo}\right) \qquad (2)$$

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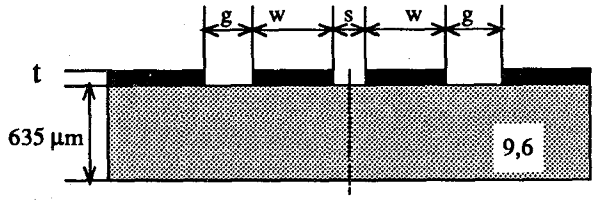


fig.1 : A coplanar coupler

(a)

g µm	30,8	36,8	42,8	127	161	245
v µm	75,5	92,5	110	48,5	59,7	85
s µm	25	30	35	40	50	75
t µm	2,5	2,5	2,5	2,5	2,5	2,5
Zoe Ω	76,2	76,2	76,2	76,2	76,2	76,2
Zoo Ω	32,8	32,8	32,8	32,8	32,8	32,8
Zo Ω	50	50	50	50	50	50
K dB	-8	-8	-8	-8	-8	-8
εreffe	5,11	5,13	5,13	5,13	5,11	5,02
εreffo	5,06	5,1	5,13	5,15	5,18	5,21

table 1

Such flexibility in the design allows the difference between the phase velocities of the two normal modes to be compensated so as to obtain theoretical infinite isolation.

We applied this technique to the design of high isolation 3 dB couplers in coplanar waveguide technology. As dispersion is weak for the coplanar waveguide we used quasi static approaches to define the geometry of the coupler. Conformal transformations [6] enables a first design to obtained this is corrected by the use of the finite difference method [7].

As presented in figure 2a, the optimum design requires a 10 µm width slot to be made.

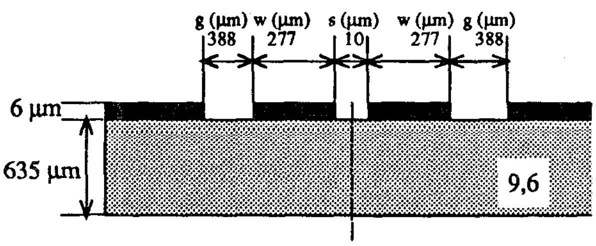


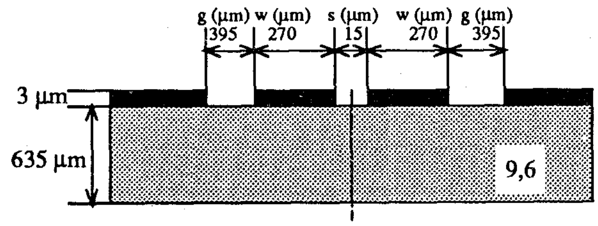
fig. 2.a : The optimum design

k = 3 dB
Z0 = 50 Ω
εreffe = 4,65
εreffo = 4,66
isolation = 70 dB

fig. 2.a : The optimum design

Experimental results

From a technological point of view, some difficulties appear, in this case, in making such a slot dimension. So, we preferred to fix the slot width at 15 µm as presented in figure 2b, the other geometric parameters being determined to limit the difference between the phase velocities of the two normal modes.



k = 3,46 dB
Z0 = 54,29 Ω
εreffe = 4,67
εreffo = 5,03
isolation = 40 dB

fig. 2.b : Dimension of the design

The structure we chosen is presented in figure 2b. Figures 3.a, 3.b, 3.c and 3.d present the variations with the frequency of the main characteristics of the coupler. We can observe a good agreement between theoretical and experimental results. Some differences appear at higher frequencies in relation to the difficulty of taking into account all the effects of the discontinuities which appear in the input and the output plane of such a coupler.

As presented in figure 4a and 4b, the relative bandwidth of the coupler designed is about 40 %.

Conclusion

The flexibility of coplanar technology permits the design of high level - high directivity couplers. Moreover, the possibility of equalizing the odd and even mode velocities simply allow broadband couplers to be made at a lower cost. We are currently studying the possibility of obtaining very broadband designs with the same technique. A multioctave coupler will be designed in the future.

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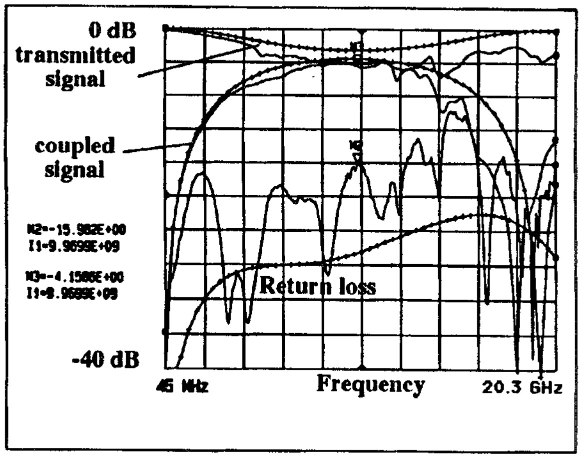

fig. 3.a

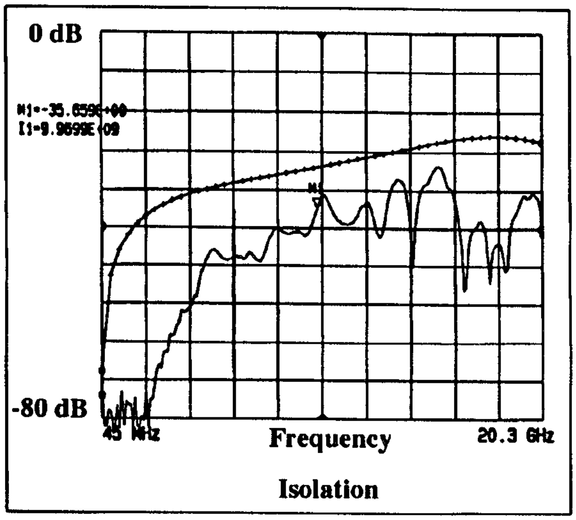

fig. 3.b

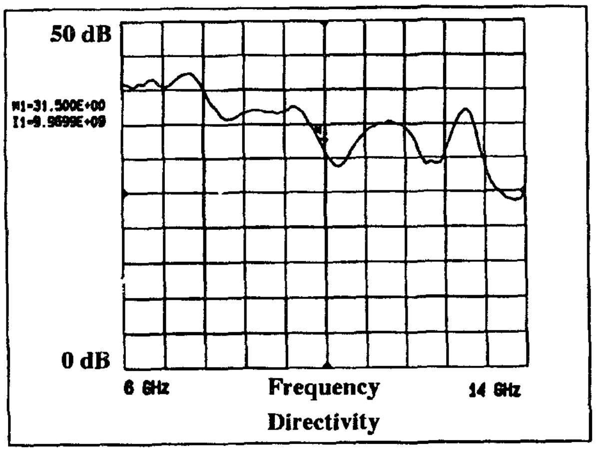

fig. 3.c

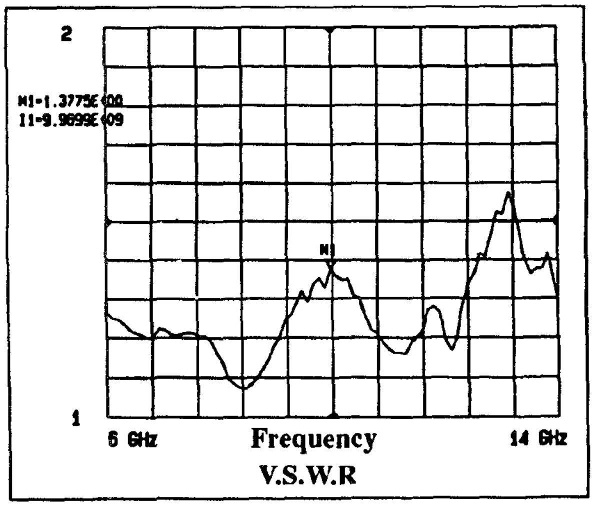

fig. 3.d

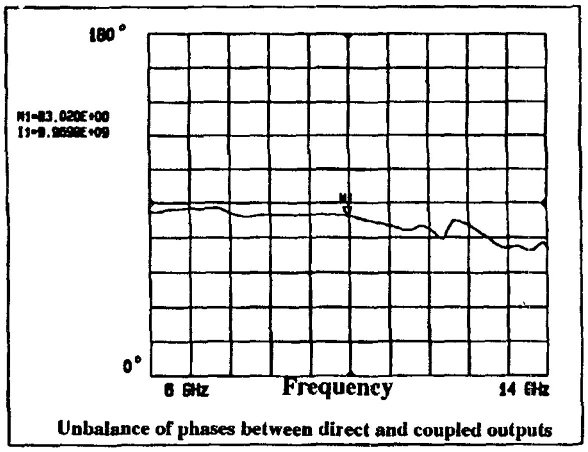

fig. 4.a

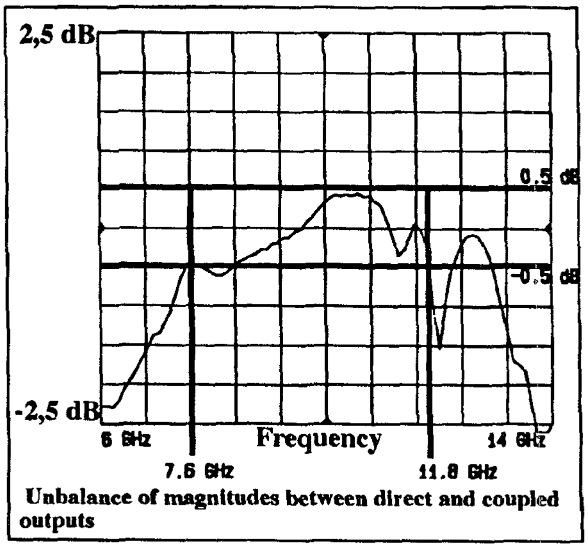

fig. 4.b