AN ACCURATE UNDERGRADUATE PROGRAM FOR A FINLINE COUPLER ON SEMICONDUCTOR SUBSTRATE

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Abstract - *Computer programs are developed in FORTRAN 77 language, given the results in 3-D of the dispersion and of the coupling, as functions of the frequency, conductivity and permittivity for the unilateral fin lines coupler asymmetric in E-plane, on semiconductor substrate. The characteristic impedance and complex propagation constant, for the odd and even-modes excitation are obtained by Transverse Transmission Line method - TTL. These programs are easily used in graduate and undergraduate courses with good efficiency.*

1. Introduction and Development

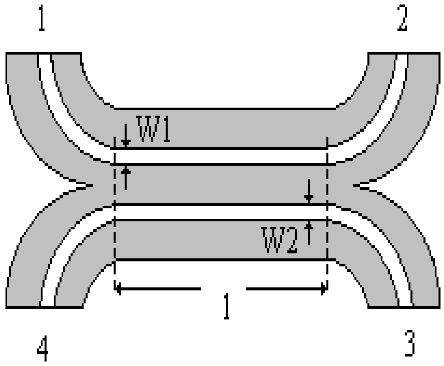
In this work are used computer programs to obtain the main characteristics parameters of structures with the finline and was developed supported in the theory enveloped in designers of the finline coupler. The parameters considered are the phase constant, the attenuation constant, the characteristic impedance and the coupling factor.

This report pertains to application of computer programs in design of directional coupler, most particularly the parallel-coupled finline coupler shown in the Fig 1. This type of coupler offers forward wave coupling, i. e., if a signal is fed to port 1, port 3 is the coupled port and port 4 is the isolated port. The coupling is periodic along the length of line, and the modes even and odd propagate with different phase velocities.

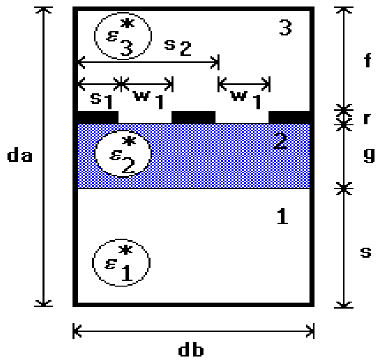
In the direct and concise TTL method, the Maxwell's equations in Fourier transform domain, are firstly used to obtain the electromagnetic fields in terms of the transversal electromagnetic fields [2]. By applying the boundary conditions, the fields in all dielectric regions are determined as functions of the electric fields in the slots. An inhomogeneous equation system is obtained, in which the current densities in the fins are related to the electric fields in the slots. By expanding these fields in terms of suitable basis functions and using the moment method and the Parseval's theorem, the current densities are eliminated, and an homogeneous equation system is obtained with two variables.

The complex propagation constant is obtained by setting the determinant of the system matrix equal to zero. The effective dielectric constant is determined by means of the relation between the phase constant and the wave number of the free space.

The computer programs, EELLUASS.FOR and ICLLUASS.FOR, were developed in FORTRAN 77 language, and the results in 2-D and 3-D are obtained using a 233 MHz Pentium microcomputer, of the effective dielectric constant, the attenuation constant. The COUPL.FOR program given the results of the coupling factor with parameters such as the operating frequency, the thickness of the semiconductor substrate and its conductivity, and the slots widths and their location. These results are compared with references and the agreement is quite good [1], [3].



(a)



(b)

Fig. 1. a) Top and internal view of the unilateral fin-line. b) Cross section of arbritary unilateral finline with coupled slots.

2. Theory

For the unilateral fin-line with two coupled slots in the Fig 1.b, when used to be a parallel coupled fin-line coupler, the results obtained for even and odd modes of the phase constant using this TTL method, are used to given the coupling length L [1], where a complete transfer of power from port 1 to port 3 is present:

$$L = \pi / (\beta_{\text{even}} - \beta_{\text{odd}}) \qquad (1)$$

The amplitude of the coupling coefficient between ports 1 and 3 is:

$$|S_{13}| = \sin(\pi l / 2L) \qquad (2)$$

and the coupling coefficient between ports 1 and 2 is:

$$|S_{12}| = \cos(\pi l / 2L) \qquad (3)$$

where the length of the coupling region l, for any L can be calculated by using (2).

The expression for the coupling is defined as:

$$C_3 = 20.\log\left(\frac{1}{|S_{13}|}\right) \qquad (4)$$

and various results are presented.

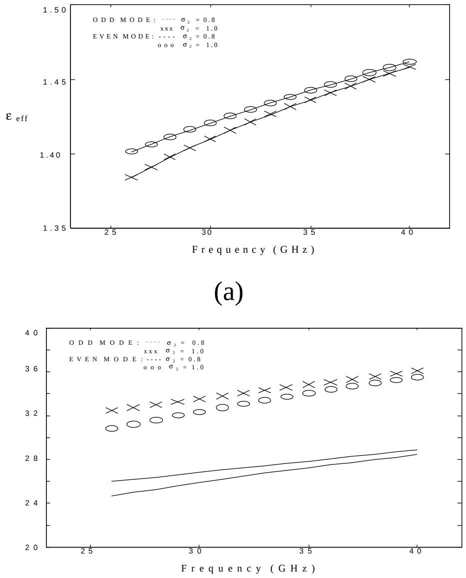
3 . Results

Computer programs were developed to given the numerical results of the planar structures analyzed. Various results will be presented. A fast computational convergence was observed by using the TTL method. These educational programs are used with success in graduate and undergraduate courses.

In the Fig. 2 results of the a) effective dielectric constant and b) attenuation constant as a function of the frequency are showed, for the unilateral fin-line on semiconductor substrate, and with two coupled slots.

In these results is used a WR-28 with g=0.254 mm, s=3.302 mm (thickness of the region 1), x_1=1.078 mm x_2=2.278 mm, w_1=w_2=0.2 mm, ε_{r2}= 12.0, ½ distance between the slots s'=0.5 mm, and for two different conductivity's σ_2. The odd and even modes are presented and the influence in the attenuation constant is more noted for different conductivity, in Fig 2.b.

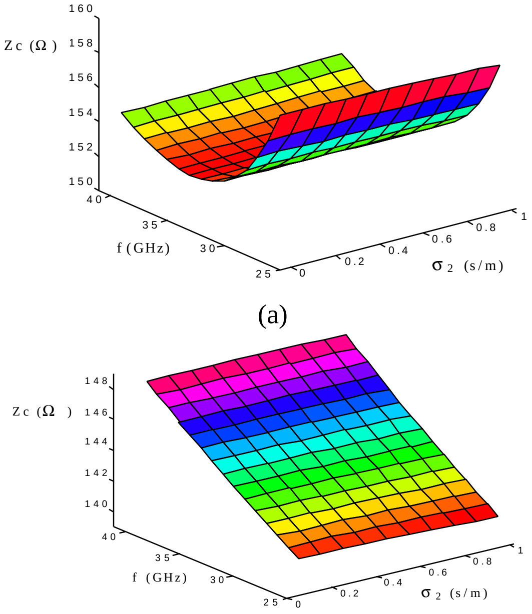
In Fig. 3, curves for the two excitation modes of the characteristic impedance of the unilateral finline are showed. The structure is a WR-28, da = 7.112 mm and db = 3.556 mm, g = 0.254 mm, s = 3.302 mm, x1 = 0.789 mm, x2 = 2.567 mm, w1 = w2 = 0.2 mm. Was considered a dielectric substrate with relative permittivity ε_{r2} = 2,22 and values of σ_2 between 0 S/m and 1 S/m. The range of frequency is 25 GHz until 40 GHz.



(a)

(b)

Fig. 2 - Curves of a) effective dielectric constant and b) attenuation constant as function of the frequency for the unilateral fin-line with two coupled slots , on semiconductor substrate in a WR-28.

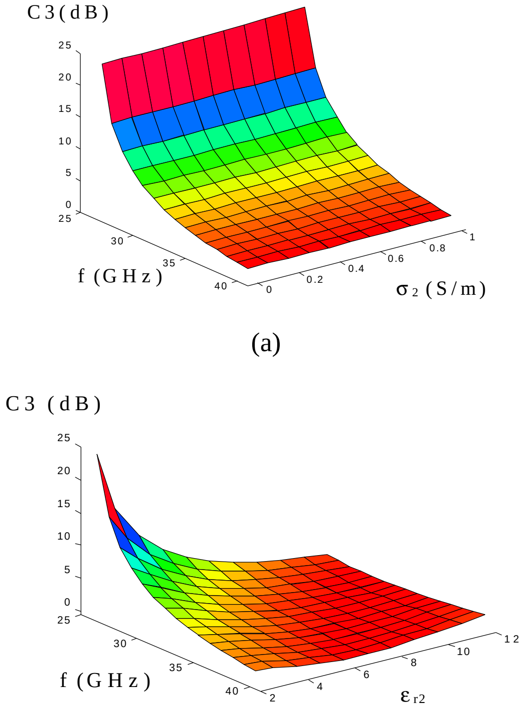


(a)

(b)

Fig. 3 - Results in 3-D of the characteristic impedance Zc_1 = Zc_2 = Zc, as functions of the frequency and of the conductivity of the coupled unilateral finline for a) odd mode end b) even mode.

Results of the coupling in the port 3 as functions of the frequency and of the conductivity and permittivity, in 3-D, of the arbitrary unilateral fin-line coupler, on semiconductor substrate are shown, respectively, in Fig 4.a and b. In these results are considered, WR-28, $w_1 = w_2 = 0.2$ mm, relative permittivity in region 2, $\varepsilon_{r2} = 12.0$, L = 0.5 mm, g = 0.254 mm e s = 3.302 mm. 2s'=0.789 (s' = distance from the slot to the middle structure). Computer programs are developed in FORTRAN 77 language and the results obtained, using a microcomputer Pentium, provide the analysis of the variation of the parameters such as the frequency, the thickness of the semiconductor substrate and its conductivity, the slots widths and their location. These results are compared with references in which the substrate is a loss less material in 2-D and the agreement is quite good [1].



(a)

(b)

Fig. 4 - Coupling as functions of the frequency and in a) conductivity and in b) permitivity, in region 2 of the unilateral fin-line coupler on semiconductor substrate, in 3-D.

4. Conclusions

Computer programs, with good appeal, are developed for to be used in graduate and under graduate courses. The theory and numerical results were presented to the unilateral fin lines and coupler with semiconductor substrate. The full wave analysis of the Transverse Transmission Line method - TTL in the FTD was used in determination of the electric and magnetic fields in all dielectric regions. Results in 2-D were obtained to the complex propagation constant and to the attenuation to the fin-line structure. Good results in 3-D were presented for the characteristic impedance and for the coupling parameters. The results were compared with that of the literature [6]-[7]. It was observed a considerable reduction in algebraic development using the transverse transmission line method for the fin line coupler. This work was supported by CNPq and CAPES.

References

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