Letters

Expressions for Wavelength and Impedance of a Slotline

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Abstract—**Closed-form approximate expressions for slot wavelength and characteristic impedance for a slotline are presented. These expressions have an accuracy of about 2 percent for substrate permittivity ranging between 9.7 and 20.**

The slotline was introduced in 1969 [1] but its usage in microwave integrated circuits has been relatively slow. It may be partly due to the nonavailability of closed-form expressions for slot wavelength λ' and the slotline characteristic impedance Z_0. A method of calculating λ' and Z_0 has been given by Cohn [1]. In this method slot wavelength is obtained by equating the total susceptance at the iris plane to zero. The calculation of Z_0 involves differentials of total susceptance and slot wavelength with frequency. These computations are iterative in nature and thus fairly involved. The numerical results for λ' and Z_0 for some set of parameters have been presented in the form of graphs by Mariani *et al.* [2]. They have selected five values of the dielectric constant ranging between 9.6 and 20. These graphs are useful only for the set of parameters indicated since the method of interpolation has not been provided.

This letter provides closed-form expressions for the slot wavelength and characteristic impedance. These expressions have been arrived at by means of curve fitting the numerical results based on Cohn's analysis and valid for the values of dielectric constant between 9.7 and 20. The upper limit on the value of W/d has been restricted to unity since Cohn's analysis of slot line is valid for $W \le d$, where W and d are defined in Fig. 1.

The closed-form expressions given in this letter have an accuracy of about 2 percent for the following set of parameters:

$$9.7 \le \varepsilon_r \le 20$$

$$0.02 \le W/d \le 1.0$$

and

$$0.01 \le d/\lambda \le (d/\lambda)_0$$

where $(d/\lambda)_0$ is equal to the cutoff for the TE_{10} surface-wave mode on the slotline, and is given by

$$(d/\lambda)_0 = 0.25/\sqrt{\varepsilon_r - 1}. \quad (1)$$

The expressions obtained by curve fitting the numerical results, based on Cohn's analysis [1] are given as follows.

1) *For* $0.02 \le W/d < 0.2$:

$$\lambda'/\lambda = 0.923 - 0.448 \log \varepsilon_r + 0.2 W/d - (0.29 W/d + 0.047) \log (d/\lambda \times 10^2) \quad (2)$$

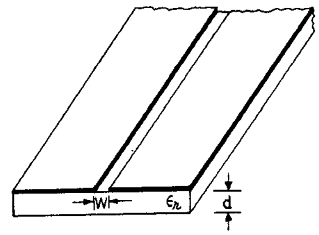

Fig. 1. Slotline configuration.

$$Z_0 = 72.62 - 35.19 \log \varepsilon_r + 50 \frac{(W/d - 0.02)(W/d - 0.1)}{W/d} + \log (W/d \times 10^2)[44.28 - 19.58 \log \varepsilon_r] - [0.32 \log \varepsilon_r - 0.11 + W/d(1.07 \log \varepsilon_r + 1.44)] \cdot (11.4 - 6.07 \log \varepsilon_r - d/\lambda \times 10^2)^2. \quad (3)$$

2) *For* $0.2 \le W/d \le 1.0$:

$$\lambda'/\lambda = 0.987 - 0.483 \log \varepsilon_r + W/d(0.111 - 0.0022\varepsilon_r) - (0.121 + 0.094 W/d - 0.0032\varepsilon_r) \log (d/\lambda \times 10^2) \quad (4)$$

$$Z_0 = 113.19 - 53.55 \log \varepsilon_r + 1.25 W/d(114.59 - 51.88 \log \varepsilon_r) + 20(W/d - 0.2)(1 - W/d) - [0.15 + 0.23 \log \varepsilon_r + W/d(-0.79 + 2.07 \log \varepsilon_r)] \cdot [(10.25 - 5 \log \varepsilon_r + W/d(2.1 - 1.42 \log \varepsilon_r) - d/\lambda \times 10^2)^2]. \quad (5)$$

The logarithms are to the base 10 in the previous expressions.

It is expected that approximate results reported in this letter will be useful in the design of slotline circuits.

References

[1] S. B. Cohn, "Slotline on a dielectric substrate," *IEEE Trans. Microwave Theory and Tech.*, vol. MTT-17, pp. 768–778, Oct. 1969.
[2] E. A. Mariani *et al.*, "Slotline characteristics," *IEEE Trans. Microwave Theory and Tech.*, vol. MTT-17, pp. 1091–1096, Dec. 1969.

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Comments on "Approximation for the Symmetrical Parallel-Strip Transmission Line"

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In a recent article,[1] Rochelle gave an approximation for the capacitance of both "wide" and "narrow" parallel-strip transmission lines in a homogeneous, lossless, dielectric medium. The author obtained a final, unique formula, which is an advantage.

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[1] J. M. Rochelle, *IEEE Trans. Microwave Theory Tech.*, vol. MTT-23, pp. 712–714, Aug. 1975.