Letters

On Design of Coupled Microstrip Lines

J. H. HINTON

***Abstract*—The synthesis approach by Akhtarzad, Rowbotham, and Jones [1] for coupled microstrip lines shows close agreement with the Bryant and Weiss results [2] except for small W/H where the deviation is about 14 percent in computing Z_{oo}. It is shown that the approach in [1] will produce close agreement with [2] for all W/H when Wheeler's formula [4] for single microstrip line is incorporated in the synthesis procedure.**

Coupling between parallel microstrip lines has been synthesized by Akhtarzad, Rowbotham, and Jones [1] which facilitates the determination of the geometry of a devise when the even- and odd-mode characteristic impedances (Z_{oe} and Z_{oo}) are known. The procedure involves computing single-line $W/H)_{se}$ and $W/H)_{so}$ ratios for $Z_{oe}/2$ and $Z_{oo}/2$, respectively, by existing formulations. These ratios serve as references for $W/H)_{se}$ and $W/H)_{so}$ computed using S/H and W/H in relations (2) and (3) of [1] derived for conformal mapping.

As indicated in Table 1 of [1] close agreement between the results of [1] and those of Bryant and Weiss [2] occurs except when W/H is small. For small W/H and S/H the deviation is about 14 percent for Z_{oe} and this deviation was attributed to the Bryant and Weiss data.

The significant differences in Z_{oe} at small W/H is a result of the choice of the formulation used to compute the reference single-line $W/H)_{se}$ and $W/H)_{so}$ in the synthesis. The formula used in [1] is

$$(W/H)_s=\frac{2}{\pi}(d-1)-\frac{2}{\pi}\ln(2d-1)+\frac{\epsilon_r-1}{\pi\epsilon_r}\left[\ln(d-1)+0.293-\frac{0.517}{\epsilon_r}\right] \quad (1)$$

where

$$d=60\pi^2/Z_o\sqrt{\epsilon_r}\,,\ Z_o\leftrightarrow Z_{oe}/2, \text{ and } Z_{oo}/2.$$

This is Wheeler's formula [3] modified for balanced stripline and is valid only for large W/H. Wheeler's updated formula [4] for single microstripline,

$$W/H)_s=\frac{8\sqrt{\left[\exp\left(\frac{R}{42.4}\sqrt{\epsilon_r+1}\right)-1\right]\frac{7+4/\epsilon_r}{11}+\frac{1+1/\epsilon_r}{0.81}}}{\left[\exp\left(\frac{R}{42.4}\sqrt{\epsilon_r+1}\right)-1\right]} \quad (2)$$

is valid for a wider range of W/H. In the synthesis for coupled lines this formula may be used instead of (1) to determine the reference $W/H)_{se}$ and $W/H)_{so}$ using $R\leftrightarrow Z_{oe}/2$ and $Z_{oo}/2$.

A program for the synthesis relations [1] was written for the HP65 incorporating (2) and exercised in an analysis manner to compute Z_{oe} and Z_{oo} for several S/H and W/H. As shown in Table I the results are in good agreement with [1] for $W/H >$ 0.5 and for all W/H shown with Bryant and Weiss.

TABLE I

Comparison of Theoretical Results $\epsilon_r=9.6$

Dimensions		Bryant & Weiss [2]		Akhtarzad [1]		Using (2) in [1]	
S/H	W/H	Zoe*	Zoo*	Zoe	Zoo	Zoe	Zoo
.1	.1	164.1	55.4	141.7	53.8	164.3	54.3
1	.5	96.2	34.5	92.1	35.2	95.8	35.3
.1	1.0	66.5	27.8	65.0	29.0	66.0	28.8
.1	2.0	41.7	21.6	41.3	22.7	41.5	22.7
.2	.1	156.0	66.1	136.0	64.6	154.2	65.7
.2	.5	92.2	39.9	89.0	41.1	91.7	41.2
.2	1.0	64.5	31.6	63.4	33.1	64.2	33.1
.2	2.0	41.0	23.7	40.7	25.1	40.7	25.1
.5	.1	138.4	83.5	125.2	80.9	137.2	83.2
.5	.5	84.5	49.7	82.2	50.8	84.3	51.0
.5	1.0	60.5	38.1	59.7	39.5	60.3	39.5
.5	2.0	39.4	27.4	39.2	28.7	39.2	28.7
1.0	.1	126.0	96.6	116.4	92.5	125.0	96.1
1.0	.5	77.4	57.7	76.1	58 3	77 7	58.8
1.0	1.0	56.5	43.2	56.2	44.3	56.7	44.4
1.0	2.0	37.6	30.1	37.6	31.2	37.7	31.2

*Scaled by $\sqrt{1+\epsilon_r}$

References

[1] S. Akhtarzad, T. R. Rowbotham, and P. B. Jones, "The design of coupled microstrip lines," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-23, pp. 486–492, June 1975.

[2] T. G. Bryant and J. A. Weiss, "Parameters of microstrip transmission lines and of coupled pairs of microstrip lines," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-16, pp. 1021–1027, Dec. 1968.

[3] H. A. Wheeler, "Transmission-line properties of parallel strips separated by a dielectric sheet," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-13, pp. 172–185, Mar. 1965.

[4] ——, "Transmission line properties of a strip on a dielectric sheet on a plane," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-25, pp. 631–647, Aug. 1977.

Manuscript received August 27, 1979; October 23, 1979.
The author is with E-Systems, Inc., Dallas TX 75266.

Correction to "Characteristics of Coupled Microstriplines"

RAMESH GARG AND I. J. BAHL

In the above paper[1], the following typographical errors should be corrected.

On page 701, (7a) should read

$$C_{ga}=\epsilon_0\frac{K(k')}{K(k)}, \qquad k=\frac{S/h}{S/h+2W/h}, \qquad k'=\sqrt{1-k^2}$$

On the same page the left-hand side of (7b) should read $K(k')/K(k)$ and the right-hand side of (9) should read

$$\left[c\sqrt{C_iC_i^a}\ \right]^{-1}.$$

Manuscript received October 10, 1979.
R. Garg is with the Advanced Centre for Electronic Systems, Department of Electrical Engineering, Indian Institute of Technology, Kanpur 208016, India.

I. J. Bahl is with the Department of Electrical Engineering, University of Ottawa, Ottawa, Canada.

[1] R. Garg and I. J. Bahl, *IEEE Trans. Microwave Theory Tech.*, vol. MTT-27, pp. 700–705, July 1979.

0018-9480/80/0300-0272$00.75 ©1980 IEEE