

Letters

On Design of Coupled Microstrip Lines

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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 device 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

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

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 $W/H >$

TABLE I

Dimensions		Comparison of Theoretical Results $\epsilon_r=9.6$					
		Bryant & Weiss [2]		Akhtarzad [1]		Using (2) in [1]	
S/H	W/H	Z_{oe}^*	Z_{oo}^*	Z_{oe}	Z_{oo}	Z_{oe}	Z_{oo}
.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 $\sqrt{1+\epsilon_r}$

0.5 and for all W/H shown with Bryant and Weiss.

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.

Correction to "Characteristics of Coupled Microstriplines"

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In the above paper¹, the following typographical errors should be corrected.

On page 701, (7a) should read

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

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

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

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