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DETERMINATION OF CHARACTERISTIC IMPEDANCES OF THREE CONDUCTOR STRIP LINE

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Abstract. The universal method for determining the characteristic impedance of microwave strip transmission lines is applied to find impedances of three conductor strip transmission line in three cases of excitation. The influence of the third conductor on the electric parameters of coupled strip line is clarified.

Recently multiconductor lines as coupled, slot, coplanar, three conductors have been introduced in practice. The three conductors strip line is used in the development of directional couplers, filters and matching devices [5, 7–9]. Different methods for line characteristics calculation are developed [6, 9]. Characteristic impedances in case of different excitation of three conductors strip line with finite thickness of the strip conductors are analyzed in the present paper.

Three conductor strip line is shown in Fig. 1. Along the line three different types TEM waves may spread over or the line can be excited by three different ways, illustrated in Fig. 2*a*, *b*, *c*. Each conductor within the line is characterized by three values of the characteristic impedance, corresponding to the three ways of exciting the line. If the strip conductors are with different sizes or are situated in different way towards each other and towards the ground plane, the three conductor strip line is characterized by 9 parameters.

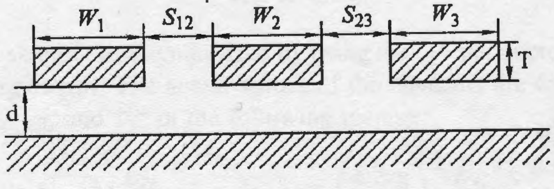

Fig. 1. Cross section of three conductor strip line

If $W_1 = W_2 = W_3 = W$ and $S_{12} = S_{23} = S$ (Fig. 1) the two end conductors have equal electric parameters. The number of parameters of those transmission line reduces 9 to 6. An essential difference exists in this case between the end (1) and the middle conductor (2). The determination of characteristic impedances of this strip line includes the calculation of characteristic impedances of the end (Z_1) and the middle (Z_2) conductor in case of three types of excitation.

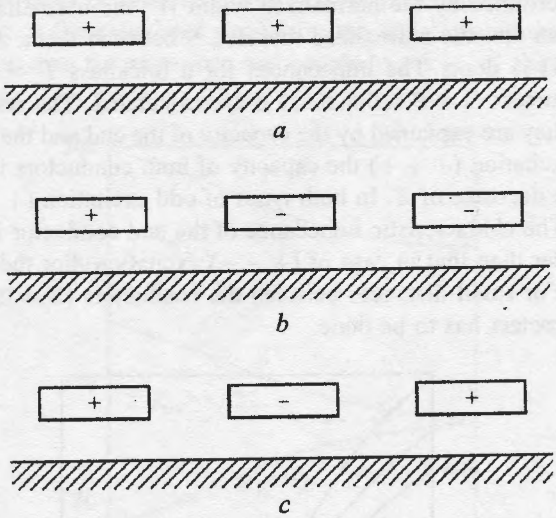

Fig. 2. Three kinds of excitation of three conductor strip line (*a*) even — (+ + +); (*b*) odd — (+ − −); (*c*) odd — (+ − +)

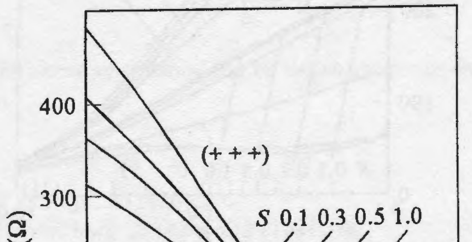

Fig. 3. Characteristic impedance of the end conductor Z_1 ($W = 1.0; T = 0.1$)

The universal method for determining the characteristic impedances of multiconductor strip line [1] is used for the analyses. The perimeters of the three conductors are divided in straight line parts. To minimize the calculation time minimal part number is chosen — 12 (every conductor wall is a single part).

The characteristic impedance is a function of the geometrical parameters of the strip line, which is determined by the normalized width W, the normalized thickness T of the strip conductors and the normalized distance S between them. A normalization to distance d (Fig. 1) is done. The impedances for a thickness $T = 0.1$ and distances between the conductors $S = 0.1, 0.3, 0.5, 1.0$ are calculated. The results are presented in Figs 3 and 4. They are explained by the capacity of the end and the middle conductor. In case of even excitation $(+ + +)$ the capacity of both conductors is growing with S, which leads to the decrease of Z. In both types of odd excitation $(+ - +)$ and $(+ - -)$ are the opposite. The characteristic impedance of the end conductor in case of $(+ - -)$ excitation is smaller than that in case of $(+ - +)$ excitation. For the middle conductor $Z_2^{+--} > Z_2^{+-+}$. For small distances between the conductors ($S = 0.1$) a more precise separation of perimeters has to be done.

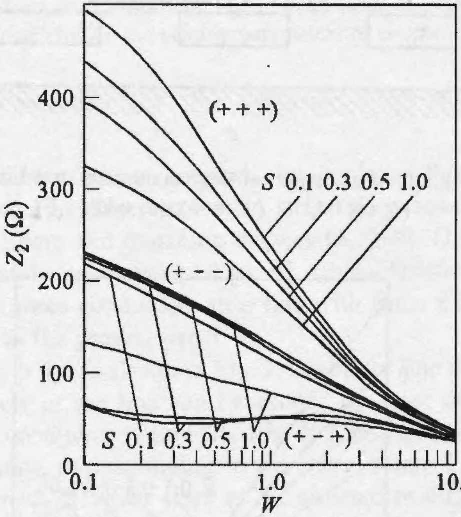

Fig. 4. Characteristic impedance of the middle conductor Z_2 ($W = 1.0; T = 0.1$)

The same method may be used for evaluation of the influence of a third conductor on the properties of a coupled strip line. The determination of the impedances of the two end conductors in this case must be done separately for each of them, because they are not equivalent. In this case the influence of the third conductor is estimated varying distance S_{23}. The third (3) conductor can be considered as a parasite, on a coupled strip line. The characteristic impedances of the line middle conductor Z_2^{+++}, Z_2^{+-+} and Z_2^{+--} are influenced by the parasite conductor. The results in case $W = 1.0$, $T = 0.1$ and $S_{12} = 0.5$ and $S_{23} = 0.3 - 10$ are presented in Fig. 5. The impedances Z_{oe} and Z_{oo} for coupled strip line with dimensions $W = 1.0$ and $S = 0.5$ [2] are given with dashed line. In case of $S_{23} \to \infty$ $Z_2^{+++} \to Z_{oe}$ and $Z^{+-+} \to Z_{oo}$, Z^{+--} with values bigger than Z_{oo} and Z^{+-} with lower. The influence of the parasite conductor can be ignored if it is situated on a distance bigger than $(8-10)S_1$.

If the third conductor is far from the other two, the three conductor strip line disintegrates in a single and a coupled strip line without interaction between them.

The comparison of the calculated results for the disintegrated three conductor strip lines with published data for microstrip and coupled lines [3, 4] shows (indirectly) 5% accuracy of results.

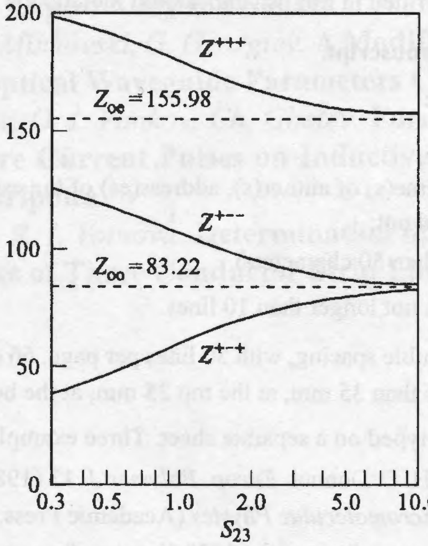

Fig. 5. The influence of distance S_{23} on the characteristic impedance Z_2

References

1. V. R. Voinov. *Bulg. J. of Phys.* 7 (1980) 224.
2. V. R. Voinov, S. A. Ivanov. *Bulg. J. of Phys.* 8 (1981) 78.
3. H. Wheeler. *IEEE MTT-13*, 3 (1965) 172.
4. T. Bryant and J. Weiss. *IEEE MTT-16*, 12 (1968) 1021.
5. P. Pavlidis, H. L. Hartnagel. *IEEE MTT-24*, 10 (1976) 631.
6. T. R. Arabi, A. T. Murphy, T. K. Sarkar. *IEEE MTT-40*, 10 (1992) 1857.
7. F. Masot, F. Medina, M. Harno. *IEEE MTT-42*, 9 (1994) 1551.
8. S. Schwindt, C. Nguyen. *IEEE MTT-42*, 7 (1994) 1183.
9. S. Kirchoefer. *IEEE MTT-42*, 1 (1994) 142.