DE-EMBEDDING MICROSTRIP DISCONTINUITIES

Giovanni Barabino*, Giulio Barabino*, Bruno Bianco*, Mauro Parodi**
* CNR Laboratory for Electronic Circuits, Via all'Opera Pia 11, 16145 Genova, Italy
** Electrical Engrng. Dept., University of Genova, Viale Causa 13, 16145 Genova, Italy

ABSTRACT

The experimental characterization of the discontinuities arising at the junction between two uniform microstrips having different characteristic impedances is obtained through a non-resonant method able to give broadband information.

In the present work we expose a non resonant method able to give broadband information on microstrip discontinuities. A schematic view of the structure used in the experiments is shown in Fig.1: a tract of uniform microstrip of characteristic impedance Z_1, l_1 in length, is attached to two tracts of lengths l_0 and characteristic impedance Z_0 (by "characteristic impedance" we mean the quasi-static value).
The composed microstrip structure is connected to the measuring instrument through two launchers L_1, L_2.

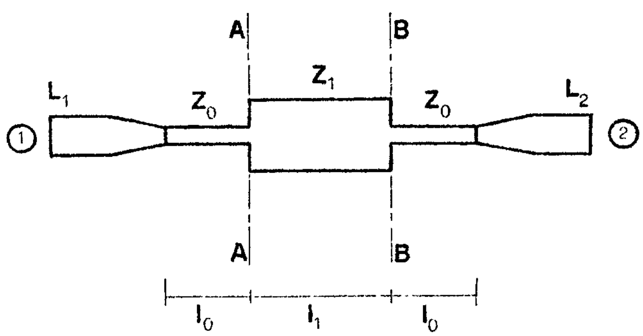

Fig. 1

In our actual experiments the measuring instrument was an 8542A Automatic Network Analyzer (Hewlett-Packard). The discontinuities at A-A, B-B are to be characterized, and this is done by a de-embedding procedure summarized in the following.
Firstly one should know the scattering parameters of both launchers. This is possible by a method recently developed[1]: one measures at the coaxial ports ① and ② of the launchers the two systems composed of the cascade launcher L_1 - a tract $l_{(k)}$ (k=1,2) of microstrip of characteristic impedance Z_0 - launcher L_2; in the quoted paper[1] it is shown that, from measurements taken on such systems, by a suitable mathematical treatment one can calculate at any frequency of interest (a) the propagation constant of the microstrip, (b) the full scattering matrix of L_1, including the launcher-microstrip discontinuity; and similarly for L_2.
It is shown[1] that the variation of the characteristic impedance with the frequency can be neglected, in the sense that its effects can be included in the launchers themselves.
Once L_1, L_2 and the two tracts of length l_0 are characterized, the de-embedding procedure on the structure of Fig.1 works as follows:

a) the scattering matrix S^* at ports ① and ② is measured
b) from S^* the effects of L_1, L_2 and of the tracts of lengths l_0 are subtracted

and finally one obtains the scattering matrix S of the structure composed of: (a) the discontinuity in A-A, (b) the uniform tract of impedance Z_1 and (c) the discontinuity in B-B.
Fig. 2 shows a result obtained by the above procedure. It refers to a case with Z_0=50 ohm, Z_1=14.88 ohm and a dielectric constant of the substrate (Alumina) 9.7. The figure shows, in the 2÷10 GHz band, the plots of $|S_{11}^*|$ (dotted line) and of $|S_{11}|$ (full line). It is apparent from this example that the launcher effects are by no means negligible.

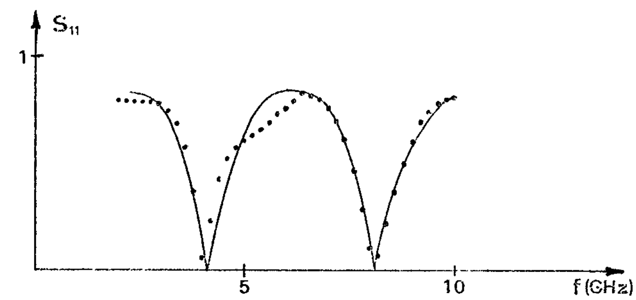

Fig. 2

Finally, in order to characterize the discontinuities, a standard lossless T network is assumed to represent them. The discontinuity in A-A is modelled by a shunt capacitor C inserted between two series inductors L_a, L_b, whereas for B-B the same circuit is considered, with the inductors in reverse order.
Now, since matrix S is known, the calculation of L_a, L_b and C is, in principle, a simple matter. In fact the tract of uniform microstrip between A-A and B-B has a calculable scattering matrix: the dispersion is taken into account by using a model due to Carlin[2] which was found highly accurate[3]. Hence the three unknown parameters can be calculated by imposing that the overall matrix of the cascade "discontinuity A-A - uniform tract l_1 - discontinuity B-B" be identical to the matrix S found through the de-embedding procedure. To minimize errors,

the three parameters were actually determined by an optimization procedure based on Fletcher's algoritm[4]. For Z_0 =50 ohm, Z_1 = 14.88 ohm, ε_r= 9.7 resulted

L_a= 0.027 nH

L_b= 0.127 nH

C = 0.115 pF

The above values are in reasonable agreement with other found in the literature. The characterization of discontinuities arising with other impedance values is in progress.

References

(1) B.Bianco,M.Parodi,S.Ridella and F.Selvaggi: "Launcher and microstrip characterization",IEEE Trans. on IM,vol. IM-25,N.4,Dec. 1976

(2) H.J.Carlin: "A simplified model for microstrip", IEEE Trans. on MTT, vol.MTT-19,p. 589-591,1973

(3) B.Bianco,M.Parodi: "Measurement of the effective relative permittivities of microstrips", Electronics Letters, vol.11,N.3,6th Febr. 1975

(4) R.Fletcher: "A new approach to variable metric algorithms",The Computer Journal, vol.13,N.3, Aug.1970