SLOTLINE-MICROSTRIP TRANSITION ON ISO/ANISOTROPIC SUBSTRATE : BROADBAND DESIGN

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Abstract

The two-stub transition design is analysed on isotropic and anisotropic substrates.Broad band design is made by optimizing the slotline and the stub lengths. Sensibility analysis of the behaviour of the whole structure with these parameters shows the slotline length and impedance to be the dominant factors.An extended-octave design can easily be achieved, with VWSR less than 1.5, for double-transitions.

Introduction

Slotline-microstrip transitions have already been presented by several authors using: two quarter-wave stubs[1],open and short-circuit[2], and other structures[3,4].Transitions employing linear stubs are interesting not only because they need no substrate holes, but also because of the well known behavior of these stubs. Recently, the authors presented a letter[5] on an accurate design of this transition under maximum power transfer conditions at the central frequency. However, an analysis of the influence of the various parameters on the bandwidth is not available and will be presented in this paper.

Broadband Analysis

The design equations for the stub lengths were obtained by applying maximum power transfer conditions to the transition model of Chambers, Cohn, Cristal and Young[6] at the central frequency (see Fig. 1), with a separate cancellation of their end reactances in the transition reference plane :

$$\ell_s = (\lambda_s/2\pi)\ tg^{-1}(Z_{os}/2\pi f_o\ L_{sc})$$

$$\ell_m = (\lambda_m/2\pi)\ tg^{-1}(1/2\pi f_o\ Z_{om}\ C_{om})$$

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The subscripts s and m refer to the slotline and microstrip respectively, f_o is the central frequency, L_{sc} is the end inductance of the slotline and C_{om} is the open-circuit end capacitance of the microstrip.

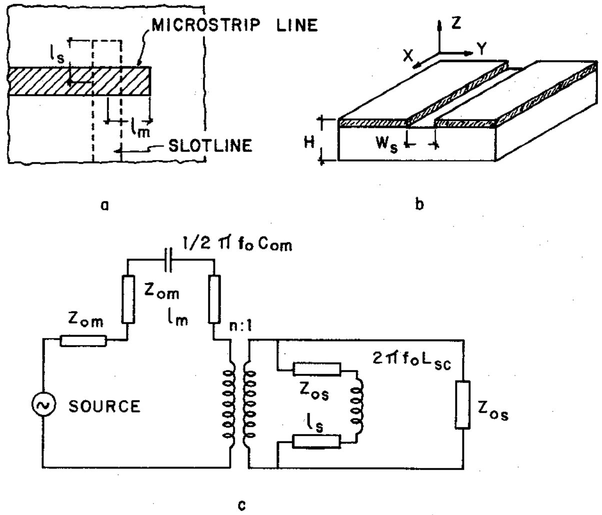

Fig. 1 SLOTLINE-MICROSTRIP TRANSITION
a TWO-STUB TRANSITION
b PARAMETERS OF SLOTLINE
c EQUIVALENT CIRCUIT

Table 1 - Common-substrates transition computation for 50Ω microstrip

Substrate H=0.635mm f_o=4.8GHz	AlsiMag 838 ε_r = 10.2	Epsilam - 10 $\varepsilon_{r,xy}$ = 13 $\varepsilon_{r,z}$ = 10.2	Rogers 6010 ε_r = 10.5
Z_{os},Ω	60.28	61.34	60.38
W_s ,mm	0.087	0.165	0.091
ℓ_s ,mm	7.590	7.124	7.523
ℓ_s/λ_s	0.244	0.243	0.244
ℓ_m ,mm	5.796	5.453	5.714
ℓ_m/λ_m	0.242	0.241	0.242

These design equations give a perfect-match condition (VWSR=1) at f_o.Outside this frequency a reactive component arises and a computer-aided evaluation was carried out using a numerical expression for L_{sc} which was obtained by curve fitting results reported elsewhere[7]. Double-transitions are often used for practical rea

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sons and the above mentioned reactive component is transfered through the slotline, and is phase added to that of the second transition. The performance thus, depends on the slotline lenght L_s, and also on Z_{os}, ℓ_s and ℓ_m. The parameters L_s, ℓ_s and ℓ_m were used as variables in a computer simulation/optimization program. The results, and the comparison with measured data, are presented later.

Anisotropic Substrate

As some of the dielectric substrates used for MIC present anisotropy in the permittivity (eg: sapphire and 'Epsilam-10'), it is useful to have a model for the slotline microstrip transition considering this effect. Due to the particular electric field configuration, the authors have already suggested using $\varepsilon_{r,xy}$ for the evaluation of λ_s and slotwidth W_s, and $\varepsilon_{r,z}$ for the transform ratio[5] n . Microstrip circuitry design has already been reported elsewhere[8,9]. Anisotropic substrates with $\varepsilon_{r,xy} > \varepsilon_{r,z}$ will lead to a wider slot, compared with an isotropic one with $\varepsilon_r = \varepsilon_{r,z}$, which may be useful.

Simulation and Results

The computation of transitions on three common substrates having the same heigth H=0.635mm, is shown in Table 1 for the central frequency f_o=4.8 GHz. As there is no benefit, concerning wideband response, in using a slotline longer than $\lambda_s/2$, simulation starts with this length value. Also, it is assumed in this work that a VWSR $\leqslant$1.5 is acceptable.

The anisotropic substrate was first chosen to be used in a double-transition simulation and the results are shown in Fig.2 for $L_s = (\lambda_s/2)$ with ℓ_s, ℓ_m and Z_{os} as given in Table 1. A perfect-match condition is obtained at the central frequency. Using the VWSR $\leqslant$1.5 criteria, a relative bandwidth of 55% is observed. If only the stub lengths are allowed to vary, no substantial bandwidth increase is obtained, altough there is a small change in the shape of the responce. An equiripple situation is also shown in Fig. 2 for stub lengths of ℓ_s = 7.029mm (0.239λ_s), and ℓ_m=5.348mm (0.236λ_m) yielding a relative bandwidth of 58%. This example ilustrates how ineffective stub-tuning is. These cases were not tested experimentally.

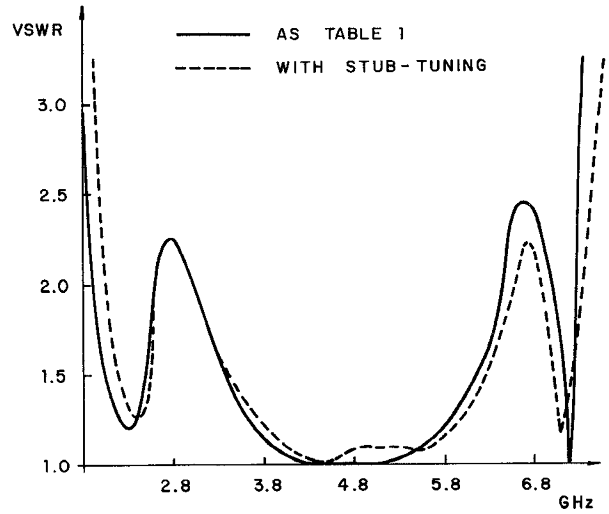

Fig. 2 SIMULATED DOUBLE-TRANSITIONS WITH NON-OPTIMAL SLOTLINE LENGTHS

In the second simulation, only the slotline length is allowed to vary, as distinct from the former example. The stub lengths are those from Table 1. The simulated response when the slotline length is quasi-optimal, L_s=8.0mm(0.273ℓ_s), is shown in Ref.|5|. Such a transition was tested experimentally and the results are shown there. A 93% relative bandwidth is obtained, ilustrating the significant importance of the slotline length.

In the third simulation all the parameters were varied. The best result obtained is shown in Fig. 3. The corresponding stub lengths are ℓ_s=7.054mm and ℓ_m=5.523mm, and the slotline has a length of 8.8 mm with Z_{os}=61.34Ω. Measured results are also shown and a relative bandwidth of 106% is obtained.

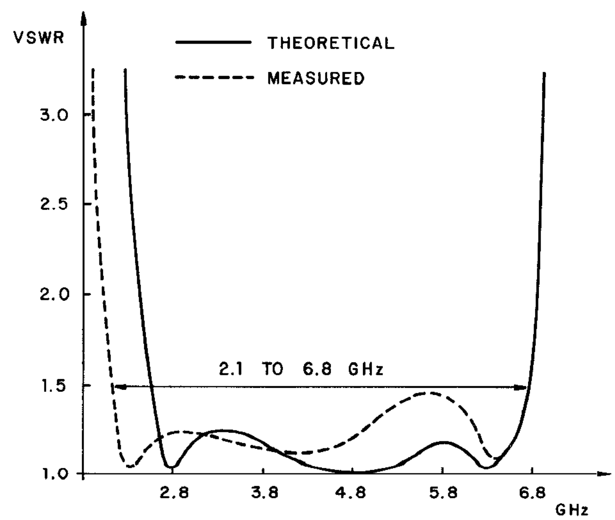

Fig. 3 OPTIMIZED DOUBLE-TRANSITION ON EPSILAM-10

A similar procedure with the isotropic substrate Rogers 6010 was followed with the best simulated response shown in Fig. 4 for L_s=8.8mm, ℓ_s=7.455mm, ℓ_m=5.725 and Z_{os}=60.38Ω. Measured results show a relative bandwidth of 101%, quite similar to the anisotropic case.

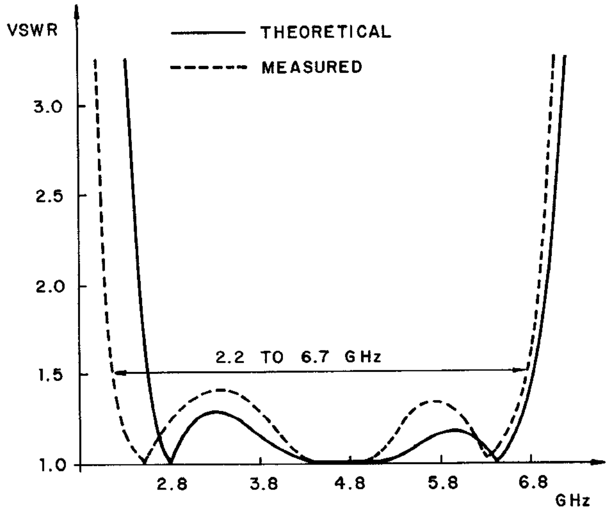

Fig. 4 OPTIMIZED DOUBLE-TRANSITION ON ROGERS-6010

The experimental devices were made with a copper coating of 12μm. The final-art dimensions were checked with a Carl Zeiss tracking microscope yielding an accuracy of ± 2μm; no tuning was done.

Conclusions

From an accurate maximum-power-transfer at central frequency method, a broadband design was implemented for the two-stub transition. Several simulations on diferent substrates have shown that slotline length has a major influence on the double-transition performance if a low VWSR, broad band and sharp cutoff are wanted. Stub-tuning has less effect on the bandwidth ; it may rather alter the ripple inside the band. Simulations also showed that the slotline impedance must be the correct one-within a tolerance not greater than 3 to 5% - otherwise poor results are obtained. Experimental results are in good agreement with those predicted by the simulations.

It is believed that the extended-octave design, obtained here, is in most cases sufficient for the realization of practical devices with this transition, such as filters, transformers, hybrids and couplers.

Acknowledgements

The authors are in debt with Prof$^{\underline{a}}$ Maria Cristina Ribeiro Carvalho, from our Center, for valuable discussions, and with Gino Vita for technological help. This work was supported by Telecomunicações Brasileiras S.A., under contract 017/79-PUC/TELEBRÁS.

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