EXTRA BROAD BAND PHASE-SHIFTER MODULES

K-7

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FOREWORD

The design theory of diode phase-shifters is well known (2). This has balanced phase bits connected to the opposite ports of a 3 dB hybrid coupler.

The simple equations obtained in this case are no longer valid when strip-line technology is applied to the design of this type of circuit. The complexity of the resulting equations prevents a simple description. The only possibility is the optimization using a simulation programme.

The method by which the equations required for this programme are obtained, is given here. Theoretical results and values for the constituent elements of a standard design are also included. Finally theoretical and practical results are shown, representing the optimized design of a phase-shifter operating in the 6 to 18 GHz band.

I. INTRODUCTION

The different circuits capable of carrying out constant phase-shifting in broad frequency bands are well known. Those that use Schiffman type circuit or line switching have relatively high losses, and present disadvantages from the point of view of compactness. On the other band those that use a 3 dB hybrid coupler allied with PIN diodes producting variable phase bits have the advantage in theory of being very broad band and of low attenuation, their only losses being due to the low series resistance of the diodes used (possibility of thin diodes) and the temperature rise of the conductors.

II. PHASE-SHIFTER DESIGN AND CONSTRUCTION

The benefit of applying strip-line technology to this type of phase-shifter lies in the resulting availability of the experience gained in the field of 3 dB couplers. These couplers employ the ion machining technique which, while problem free, is nonetheless costly. The models produced use a single section interdigital coupler.

This type of phase-shifter module is easily integrated with more complex assemblies used for a variety of purposes.

The results would appear to present certain disadvantages : the inductance and capacitance values required are very low ; and in addition the frequency ratio of three supplied by the 90° module has an error factor of 10°.

However, these results do not apply to the strip-line technique where wave propagation is carried out in a non-homogeneous dielectric.

The full calculations for a general example are very complex and cannot be incorporated into a single description.

A parametric study resulted in the optimization of modules of 1, 2 and 3 bits in the 6 to 18 GHz band.

An actual equivalent diagram of the PIN diode was used in order to assess insertion losses. In this way the reactive JX and therefore an optimum diode were defined for each different case. 90° and 180° one bit modules were first produced with integral biasing circuits.

The practical and theoretical results obtained from these 90° and 180° phase shifters are given in sheets 1 and 2.

The similarity of the curves is noticeable. A view of the module is given in sheet 4. Theoretical results for a three bit phase-shifter are given in sheet 3.

III. CONCLUSION

It would seem therefore, that the technology for this type of phase-shifter is attainable. Progress towards loss reduction is possible, thanks to the introduction of thin diodes with very low series resistance.

The frequency ration of 3 constitutes the upper limit if error is to be acceptable (10°). An octave size band would allow a much lower error factor.

In addition the replacement of certain PIN diodes by varactor diodes (3) would facilitate setting of the phase-shifter modules as capacitance CD could be adjusted.

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REFERENCES

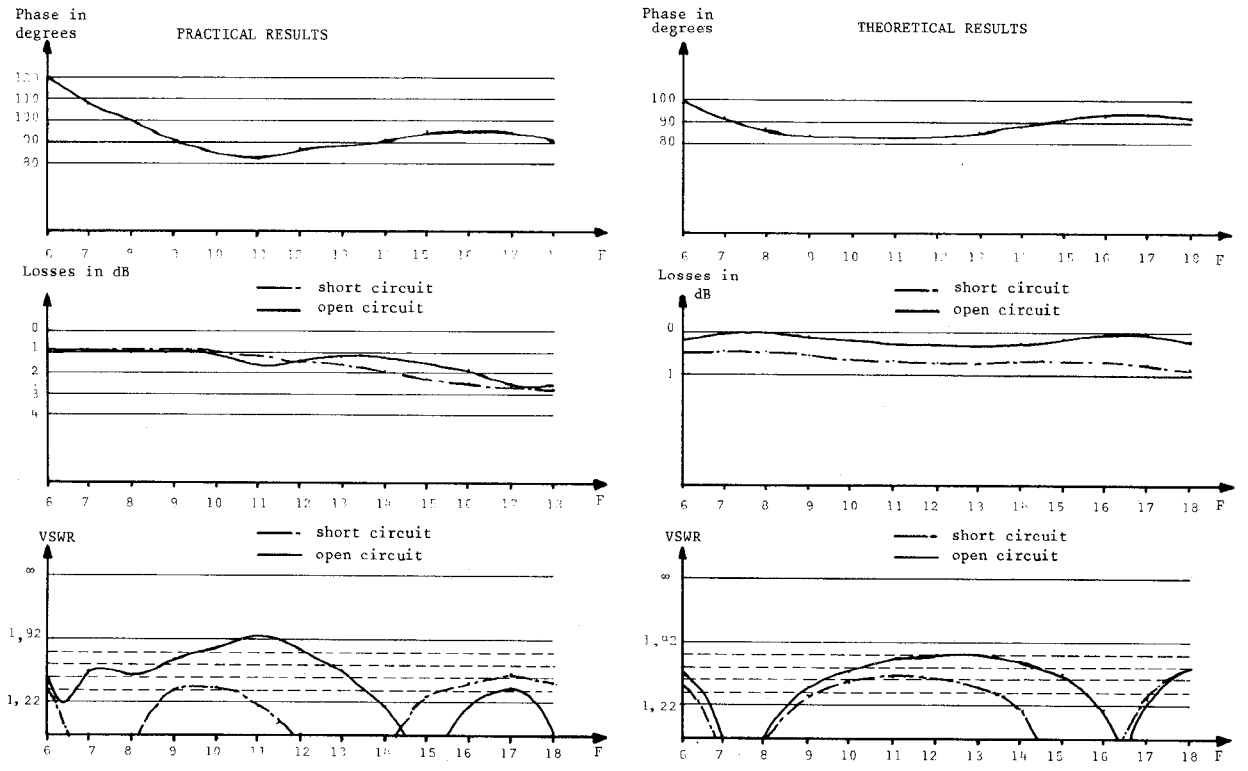
(1) W. MARTINI, "Coupleurs directifs à lignes couplées", Annales de Radio-électricité, October 1966.

(2) Robert V. GARVER, "Broadband diode phase shifter", I.E.E.E, M.T.T, May 1972, pp. 314 - 323.

(3) S. HOPPER, "Analog phase shifter for 8 - 18 GHz", Microwave Journal, March 1979, pp. 48 - 83.

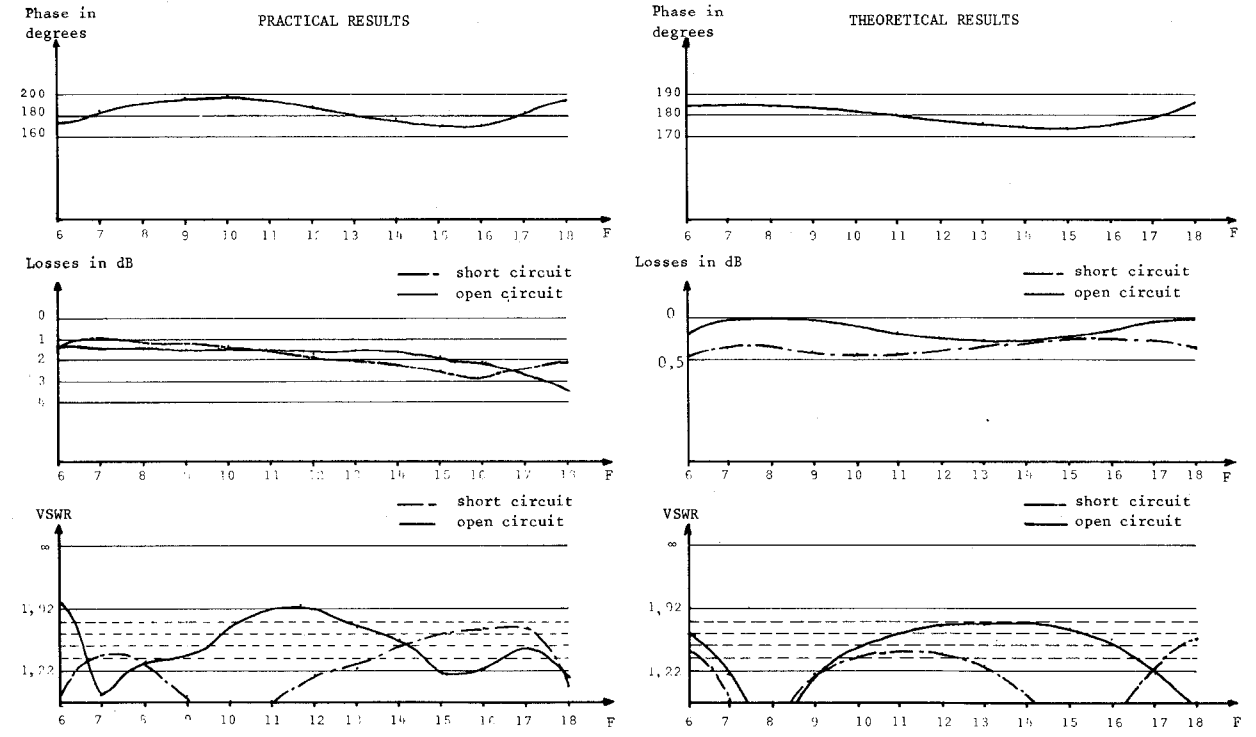
90° PHASE-SHIFTER

SHEET 1



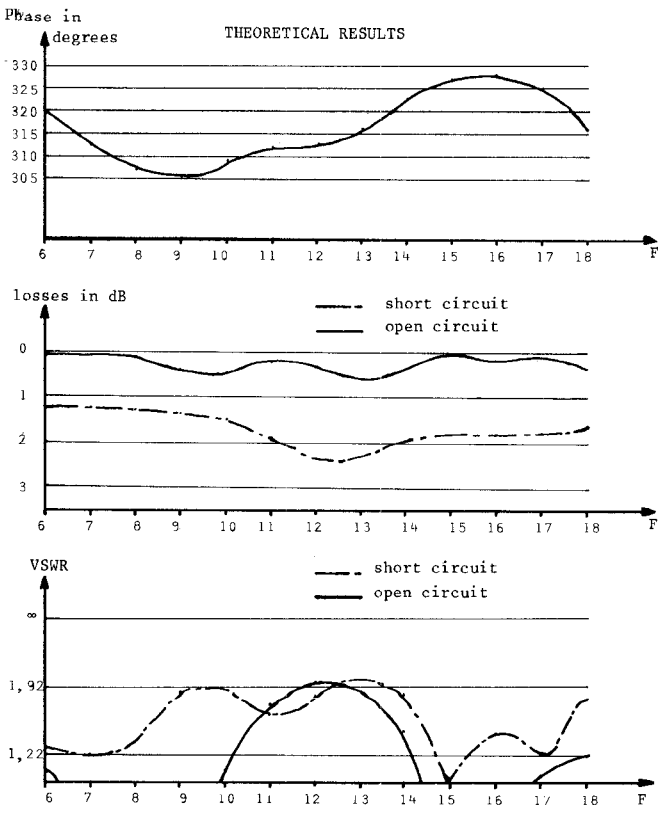
SHEET 2

180° PHASE SHIFTER



3 BITS PHASE SHIFTER

Example $\Delta\phi = 315°$



C_{D_1} = 1,29 pF
C_{P_1} = .264 pF
L_1 = .283 nH

C_{D_2} = .461 pF
C_{P_2} = .198 pF
L_2 = .291 nH

C_{D_3} = .137 pF
C_{P_3} = .108 pF
L_3 = .529 nH