شبكة المعلومات الجامعية

بسم الله الرحمن الرحيم

شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الالكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأفلام قد أعدت دون أية تغيرات

يجب أن

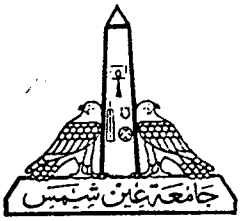
:حفظ هذه الأفلام بعيدا عن الغبار

في درجة حرارة من 15-25 مئوية ورطوبة نسبية من 20-40%

To be Kept away from Dust in Dry Cool place of 15-25- c and relative humidity 20-40%

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم



Ain Shams University
Faculty of Engineering

Six-Port Reflectometer

Thesis submitted in partial fulfillment of the requirements for the Degree of
Doctor of Philosophy
in Electronics and Communications Engineering

submitted by
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Date : / /2000

STATEMENT

This dissertation is submitted to Ain Shams University, Faculty of Engineering for the degree of Doctor of philosophy in Electrical Engineering .

The work included in this thesis was carried out by the author in the Electronics and Communications Engineering Department, Faculty of Engineering, Ain shams University and in the Microstrip Department, Electronics Research Institute

No part of this thesis has been submitted for a degree or a qualification at any other university or institution

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Date : / /2000
Signature :

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ABSTRACT

The six-port reflectometer is an alternative to the network analyzer, it is simple device that does not need high precision components and requires only power meters in order to measure complex impedances. The six-port reflectometer is a device which allows the phase and magnitude of an unknown complex impedance to be measured directly at the operating frequency and in terms of power measurement alone using a standard impedances and a calibrating procedure. The calibrating procedure is carried out in order to take into consideration the imperfections of the reflectometer hardware and imperfect matching and isolation between different ports. There are different configurations of six-port reflectometers such as three lines coupler, four directional couplers, quadrature hybrids, five-port junction plus a coupler, ...etc.

In this thesis, the analysis and design of the three-section backward couplers is carried out by taking the advantages of the four fold symmetry of the structures and the chosen excitations. The three-section coupler has two symmetry planes corresponding to an electric wall or a magnetic wall, and consequently one has to determine two even-mode and two odd-mode impedances. Then its S-parameters and physical dimensions can be determined.

From the analysis it was found that, the S-parameters are not uniform around the center frequency. Changes of the electrical lengths for the center and outer sections lead to uniform performance keeping the overall coupling lengths equal to $3/4\lambda$ at the center frequency. Accordingly, some shift in the center frequency occurs. A curve fitting process was carried out to determine this shift with an error not exceeding 2%.

Two couplers (single-section coupler and three-section coupler) with coupling coefficient of -15 dB were designed and fabricated using thin film technology and photolithography technique on Teflon substrate (ε_r=2.2, H0.062") at center frequency 4 GHz. It is found from the measurements of

the S-parameters that, the three-section backward coupler gave broader bandwidth (2-6 GHz), better isolation, reflection and transmission as compared with the single section coupler.

A six port reflectometer is analyzed and designed by using four of the prescribed three-section backward coupler. After some mathematical analysis, three equations for the power ratios are obtained. To make these equations similar to that of the six-port reflectometer traditional equations, there are three solutions which depend on the variations of inter-connection sections between couplers and terminating impedances at couplers ports. The system is arranged so that it has two sliding short circuits adjusted at certain positions, matched load and a fixed short circuit at four ports of the system, while the other ports are connected to the I/P, DUT and four power meters.

The system was first simulated by IE3D software package and then fabricated and tested. The measured S-parameters gave good agreement with the theoretical ones. The six-port was calibrated with a matched load and three positions of a sliding short circuit in order to obtain the calibration constants.

The measurements of an unknown using the six-port reflectometer leads to three circles equations. The intersection point of these circles give the required reflection coefficient (magnitude and phase angle). Due to the errors in the measurements, these circles do not intersect in one point but they intersect in six points. The three points (which have reflection coefficient less than unity), represent the vertices of a triangle. From this triangle, four solutions can be obtained which are barycenter, circumcenter, incenter and orthocenter which represent the intersection point of each of, the medians, the perpendicular bisectors of the triangle sides, the bisectors of the triangle interior angles and the three altitude of the triangle, respectively. In fact the choice of one of the above four solutions depend on the triangle type (equilateral, bilateral, acute and obtuse). The measurements of some unknown impedances using the realized and calibrated six-port reflectometer give good agreement with the measurements of the same unknowns using the vector network analyzer (HP8510C), with an error not exceeding 5% in magnitude and 7° in phase in the frequency range (3-5 GHz).

Two types of symmetrical five-port ring junctions were analyzed, one without stubs and the other with short circuit stubs. By changing the width of the ring and width and length of the stubs, using IE3D simulator, it was found that, the variations of S-parameters for the five-port junction without stub were still less than that of the five-port with stubs, added to that, any errors in the connections of the stubs to the ground cause a shift in the center frequency. Although both types suffer from bad reflection at input port, a transmission line matching was used as an example to overcome such a problem.

A six port reflectometer which consists of a symmetrical five port junction with a three-section backward coupler was analyzed and simulated by IE3D software package. The measurements of the S-parameters give good agreement with the theoretical ones. The six-port reflectometer was then fabricated using thin film technology and photolithographic technique on Teflon substrate ($\varepsilon_r = 6.15, H = 0.025"$). The realized six-port reflectometer was first calibrated and then used to measure some unknown complex impedances. The measurements gave good agreement with the measurements of the same unknowns using the vector network analyzer (HP8510C) with an error not exceeding 3% in magnitude and 5° in phase in the frequency rang (3.5-4.5 GHz).