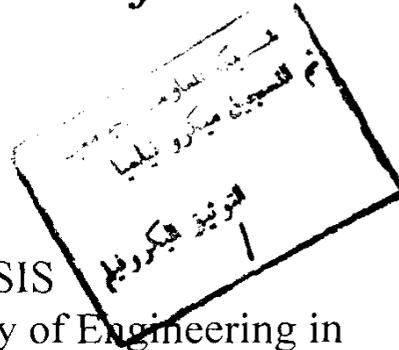


رسالة

# *Microstrip Six - port Reflectometer*



A THESIS

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In the Department of Electronics and Communications  
**Ain - Shams University**

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## STATEMENT

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

The work included in this thesis was carried out by the author in the the Electronics and Communications Engineering Department, 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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"MICROSTRIP SIX-PORT REFLECTOMETER"

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ABSTRACT

When one wishes to compare several different materials at a specific frequency, one particularly has to study the reflection in an open-ended transmission line such as waveguide or coaxial line, for instance by using a network analyzer. Because the network analyzer is very expensive and have a degree of electronic complexity, so the microwave impedance instrumentation has seen the emergence of the six-port reflectometer as an alternative to conventional network analyzers. The six-port reflectometers are inherently simple stable devices which do not need to be constructed of high precision components and require only power meters in order to measure complex impedances. The six-port reflectometer is a device which allows the phase and the magnitude of an unknown complex impedance to be measured directly at the operating frequency and in terms of power measurements alone, using a standard impedance and 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.

In this thesis the design parameters of a system of three coupled microstrip lines for both equal-width lines and equal-mode impedance lines are derived by using a direct method technique which is carried out for the substrate material in question in terms of known design parameters for any other substrate. The design parameters for a three coupled microstrip lines on teflon substrate ( $\epsilon_r = 2.32, 6.0, 10.2, \text{ and } 10.5$ ) are calculated in terms of the known design parameters of three coupled microstrip lines on each of teflon substrate ( $\epsilon_r = 2.2$ ), and alumina substrate ( $\epsilon_r = 9.8$ ).

Because the reading of a value from a curve is approximate value not accurate one, so a process of curve fitting was carried out for all the design parameters for both equal width lines, and equal mode impedance lines. Also, an empirical formula for calculating the mode numbers directly is derived. A derivation of a dispersion model for the three coupled microstrip lines is introduced.

An 8 dB coupler on teflon substrate with  $\epsilon_r = 6.0$  was designed to operate at 3.2 GHz center frequency. The scattering parameters of the coupler was calculated in the frequency range from 2 GHz up to 4 GHz. The coupler was fabricated using thin film technology and photolithographic technique and its performance (scattering matrix parameters) was measured. Good agreement was found between the theoretical and experimental results.

The analysis of the six-port reflectometer based on three coupled microstrip lines are explained, and a six-port reflectometer which consists of a section of three coupled microstrip lines was designed and fabricated on a teflon substrate ( $\epsilon_r = 6.0$ ). The measurement of its scattering parameters was carried out. Good agreement between the theoretical and experimental results was found. The calibration procedure was carried out for the realized microstrip six-port reflectometer using four known complex terminations, and the calibration constants are calculated. Then, these constants are used to calculate different unknown terminations. Good agreement was found between the measurements of the six-port reflectometer and the network analyzer especially in the frequency range from 2.6 GHz up to 3.4 GHz.

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