بسـم ا لله الرحمن الرحيم

قالوا سبحانك لا علم لنا إلا ما علمتنا
إنك أنت العليم الحكيم

صدق ا لله العظيم

سورة البقرة / الآية ٣٢

Ain Shams University
Faculty of Engineering
Electronics & Communication Engineering Department

ANALYSIS OF ACTIVE

MICROWAVE NONLINEAR DEVICES

A Thesis Submitted in Partial Fulfillment of

the requirements of the Degree of

Doctor of Philosophy

in

Electrical Engineering

(Electronics & Communication Engineering)

By

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Statement

This dissertation is submitted to Ain Shams University for the degree of Ph.D. in Electrical Engineering (Electronics and Communication Engineering)

The work included in this thesis was carried out by the author in the department of Electronics and Communication Engineering, Faculty of Engineering, Ain Shams University

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

Date   : 22/6 / 1996

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ANALYSIS OF
ACTIVE MICROWAVE
NONLINEAR DEVICES

TO THE MEMORY OF ....

              MY FATHER

              MY MOTHER

ACKNOWLEDGMENT

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Title of the Thesis
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Supervised by

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Summary

This thesis concerned with the design and analysis of linear and nonlinear microwave active circuits. The analysis of the nonlinear circuits used both time domain and frequency domain analysis techniques. Detailed comparisons between the methods used for the analysis of nonlinear (NL) microwave (MW) circuits and the available packages are performed in order to determine their features and shortcomings.
Frequency-domain analysis of microwave circuits especially for diode and MESFET mixers using Harmonic

Balance is illustrated. The nonlinear diode and MESFET models and the characteristic of each element are shown. Newton and reflection algorithms are explained and discussed.

Two new computer programs are developed for the analysis of the diode mixers. The first one used Newton's algorithm while the second one used the reflection algorithm. Using these new developed programs, the performances of the millimetric diode mixer and resistive multipliers are investigated. The nonlinearities responsible for the frequency conversion are fully taken into consideration in the model used for the analysis.

The computer program for the design and analysis of nonlinear microwave circuit using the modified time domain method is explained. The computer program comprises essentially two main parts, a CAD procedure, and a CAA procedure.

A new procedure for overcoming the numerical efficiency problem of the time domain method is proposed . This new approach was found to be very useful in enhancing the numerical efficiency of the time domain program. The CAD procedure is described for MW mixers , MW amplifiers and MW oscillators. New procedures for the design of these devices are proposed and incorporated in the CAD program. The performance of MW mixers is investigated using the CAA part of the program. The effect of the diode and circuit parameters on the MW mixer performance is investigated. The design and analysis of the performance of the microstrip MESFET oscillator is performed. A NL model for the active element is incorporated in the CAD program. The initial design of the oscillator is based on a linear small-signal approach. Then the results of the NL analysis can be used to modify this initial design in order to satisfy the required specifications. The effects of transmission line section comprising the terminating and load

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network of the oscillator circuit are studied. The effects of the parameters constituting the NL model of the transistor are also investigated. The design and analysis of the performance of 19 G Hz microstrip amplifiers are developed. A nonlinear model of the active element is incorporated in the program. The program takes fully into account all the nonlinear effects pertinent to the amplifier operation. The effects of the matching elements on the performance are investigated and the results are presented in graphs that can be used as guidelines for the optimization of microwave amplifiers. The effects of the different elements and parameters constituting the NL MESFET model on the performance are also studied.

Two new computer programs concerning with the formulation of the state equations of RLCM and linear active circuits were developed. These two developed programs can be considered as extension for the state-space approach program.

The thesis illustrates the general description of the developed new user-oriented program for linear active and passive microstrip circuit design.