Ain Shams University
Faculty of Engineering

COMPUTER AIDED DESIGN OF MICROSTRIP CIRCUITS

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الله

بسم الله الرحمن الرحيم

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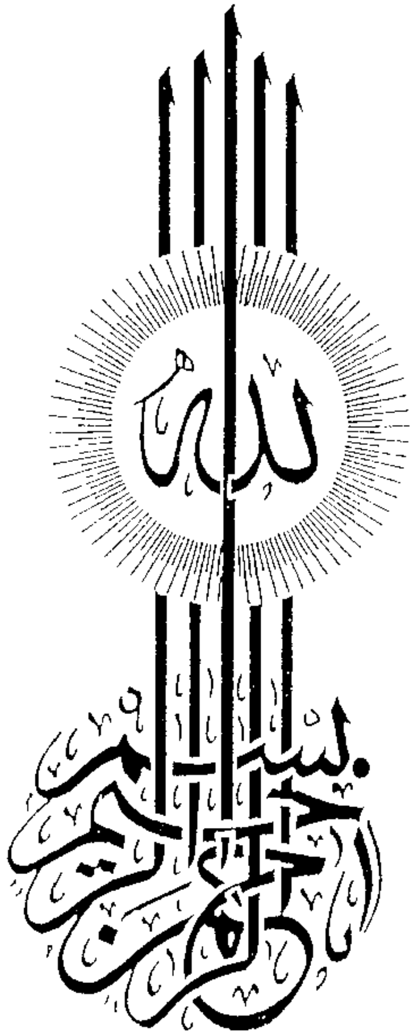
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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Electronic and Computer Engineering .The work included in this thesis was carried out by the author in the Department of Electronics and Computer , Ain shams University , and in the microstrip department , Electronics Research Institute , from 15/10/1986 to 31/10/1990 .

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

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ABSTRACT

Realization of masks is the most important step in production of microstrip circuits . It is also the most critical and time - consuming one . Up to now there are two ways to make the mask :

1) From a large-scale drawing , the mask is cut by hand or by hand - driven coordinograph on a cut "n" strip film .
2) With the help of a powerful computer running analysis and synthesis program and driving the coordinograph via a graphic program . This approach is the most complete one but is very expensive , in both software and hardware .

In this thesis we produced a program written in BASIC and running on a micro-computer connected to a plotter . The program is interactive and self documented and all necessary informations and instructions appear on a screen . The desgin data such as : permittivity and thickness of the substrate , input impedance , frequency , ...etc. are entered . The program computes all necessary parameters using formulas which yield an excellent approximation , taking into account metal thickness and dispersion . After indicating the final dimensions , the plotter draws automatically the mask on a paper - sheet .

A circuit of the balanced mixer is chosen as an application example that contains many components all connected together . The mixer is realized and measured to illustrate the applicability of the design procedure and compatibility with the theoretical behaviour .

The material of the thesis is divided into seven chapters and five appendices .

Chapter (1) presents an introduction about the computer aided design approach with its three important segments namely modeling, analysis and optimization .It also introduces a brief summary about the available programs , microstrip technology , and the scope of this thesis .

Chapter (2) describes the design and synthesis of a single microstrip line , the design of symmetric coupled lines and hybrid junctions namely the branch line coupler and the rat - race junction . Design examples for these types of elements are given by the aid of subroutine programs .

Chapter (3) presents different types of microstrip filters namely low pass using single and coupled microstrip lines , high pass filter and parallel coupled band pass filter . Design examples for each type of filter are also presented and drawn using the subroutine program and the plotter .

Chapter (4) describes representation of discontinuities such as : open end , short circuit ends , right angled bends , steps in widths , T- junctions ,...etc. Some matching sections are also presented namely : tapered lines , edge coupled impedance transformers , open ended coupled microstrip stubs , shorted coupled microstrip stubs and microstrip radial stub .

Chapter (5) introduces the design of a single balanced mixer circuit . This circuit is chosen as an example that contains many elements such as branch-line coupler , matching sections , transformers and low pass filter . The mask of the mixer is drawn automatically on the screen and on the plotter , according to the given specifications .

Chapter (6) includes steps of fabrication and measurement of the practical mixer .

Chapter (7) includes discussions and suggestions for further work .

LIST OF SYMBOLS

Z_o: characteristic impedance of the microstrip line in (Ω).

W : strip conductor width in (mm).

h : substrate thickness in (mm).

t : strip conductor thickness in (mm).

W_{eff}: effective conductor width = W_e

ε_r: relative dielectric constant of the substrate material .

ε_{eff} : effective dielectric conctant = ε_e.

ε_o: permittivity of air .

F : frequency in (GHz) .

c : speed of ligth in (mm/sec) .

λ_o : free space wavelength in (mm).

λ_s: microstrip wavelength in (mm) = λ_g = λ_m .

η : intrinsic impedance of air = 376.9911 Ω.

μ_o: free space permeability = $4\pi \times 10^{-10}$ (h/mm).

δ : conductivity of the microstrip material (Ω^{-1}).

β : propagation constant in (mm^{-1}) .

s : line spacing in (mm).

u : $u = W / h$.

g : $g = s / h$.

$\varepsilon_{effe}(0)$: static even mode effective dielectric constant .

$\varepsilon_{effo}(0)$: static odd mode effective dielectric constant .

$\varepsilon_{effe}(fn)$: frequency dispersion even mode microstrip effective dielectric constant .

$\varepsilon_{effo}(fn)$: frequency dispersion odd mode microstrip effective dielectric constant.

Y_o: characteristic admittance (Ω^{-1}) .

γ : propagation constant.

K : a gain factor .

n : number of sections in the filters .

L_A: the attenuation in (dB) at the frequency (F).

L_R : the pass-band edge at the filter = 3 dB .

l_L: the length of the inductance section .

l_C: the length of the capacitance section .

B : The band width .

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[illegible]

[illegible] They [illegible]

[illegible] ... paper.

(3) [illegible] :

[illegible] ripple. The passband [illegible] ϵ^2, and the following results are obtained [85] :

$$|S_{11}(\lambda)|^2 = \frac{[illegible]\,\lambda^4 - n2\,\lambda^2 + n0}{d4\,\lambda^4 - d2\,\lambda^2 + d0} \qquad [illegible]$$

[illegible]