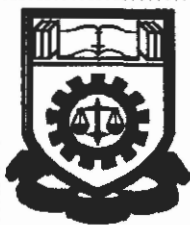


**CIRCUIT DESIGN FOR MULTIPLE-ORDER SYSTEM WITH  
FRACTIONAL POWER USING SINGULARITY  
FUNCTION APPROACH**

**Thesis presented in partial fulfilment for the award of the  
Advanced Diploma in Electrical Engineering of  
INSTITUT TEKNOLOGI MARA**



**NOR HASALINA BT. ABU BAKAR  
Department of Electrical Engineering  
INSTITUT TEKNOLOGI MARA  
46450 Shah Alam,  
SELANGOR  
JUNE 1995**

## ABSTRACT

A fractional slope on the log-log bode plot has been observed in characterizing a certain type of physical phenomena and has been called the fractal system or the fractional power pole.

This thesis present the analysis and synthesis of multiple fractal system with fractal dimension  $0 < m_i < 1$ . Multiple fractal system consists of numbers of fractional power pole. A singularity function method is used to approximate the fractional-order function. This method represents the structure of pole-zero pairs on the real axis. The function is then synthesized to circuit form and simulated using PSPICE for its frequency and unit-step responses. The simulation results are presented and compared with the responses from the approximated function that were plotted using MATHCAD.

## ACKNOWLEDGMENT

I would like to express my sincere gratitude to my project advisor, Ramli Adnan for his guidance, valuable suggestion and concern with fruitful advices during this project.

My great appreciation also to my lovely parents, Abu Bakar Othman and for their support throughout the advance diploma course. I wish to express my sincere thanks to my lovely fiance, Muhammad Ma'aruf Yathini for his stimulation and encouragement.

Finally, my thanks also to lecturers, friends and those who has directly or indirectly contributed to my project.

# **CIRCUIT DESIGN FOR MULTIPLE-ORDER SYSTEM WITH FRACTIONAL POWER USING SINGULARITY FUNCTION APPROACH**

<b><u>CONTENTS</u></b>		<b><u>Page No</u></b>
	<b>Abstract</b>	<b>i</b>
	<b>Acknowledgement</b>	<b>ii</b>
	<b>Contents</b>	<b>iii</b>
	<b>List of Illustrations</b>	<b>v</b>
	<b>List of Table</b>	<b>vii</b>
<b>1.</b>	<b>Introduction</b>	<b>1</b>
<b>2.</b>	<b>Singularity Structure</b>	<b>4</b>
	<b>2.1 Method of Choosing The Singularities</b>	<b>5</b>
<b>3.</b>	<b>Multiple Fractal System</b>	<b>7</b>
	<b>3.1 Number of Network Section</b>	<b>11</b>
	<b>3.2 Location Ratio</b>	<b>11</b>
	<b>3.3 Fractal Dimension</b>	<b>18</b>
<b>4.</b>	<b>Design</b>	<b>23</b>
	<b>4.1 Magnitude Scaling</b>	<b>23</b>
	<b>4.2 Circuit Model</b>	<b>24</b>
	<b>4.3 Circuit Design</b>	<b>26</b>

# CHAPTER 1

## 1. INTRODUCTION

Numerous studies have been made about the fractal system ever since the phenomena of  $1/f$  noise spectrum was first introduced by Van Der Zeil back in 1950 [1]. The concept of fractals provides a precise description and a mathematical model for many of complex structures found in nature.

Fractional power pole has been suggested for representation of fractal system in frequency domain. A fractal system or the fractional power pole generally represented as follows:

$$H(s) = \frac{1}{s^m} \quad (1)$$

where  $s = j\omega$  is the complex frequency and  $m$  is a positive fractional number and can also be called the fractal dimension. A single fractal system can be modeled in the frequency domain by the transfer function of a single-fractional power pole as follows:

$$H(s) = \frac{1}{\left(1 + \frac{s}{P_T}\right)^m} \quad (2)$$

where  $1/P_T$  is the relaxation time constant and  $0 < m < 1$ . This type of