

POWER SYSTEM ANALYSIS WITH SPECIAL
REFERENCE TO SHORT-CIRCUIT EFFECTS



by

Wiwat Trutasnawint

B.Eng., Chulalongkorn University, 1965

007049

Thesis

Submitted in partial fulfillment of the requirements for the

Degree of Master of Engineering

in

The Chulalongkorn University Graduate School

Department of Electrical Engineering

May, 1967

(B.E. 2510)

Accepted by the Graduate School, Chulalongkorn University,
in partial fulfillment of the requirements for the Degree of Master
of Engineering.

T. Nilasri

.....
Dean of the Graduate School

Thesis Committee

P. Pattabongse

..... Chairman

P. Vanapum

Allan Senisek

Thesis Supervisor

Allan Senisek

Date

15th May '67



ACKNOWLEDGEMENTS

Acknowledgement is due to the Yankee Electricity Authority and the Applied Science Research Corporation of Thailand for financial support of the thesis work. The author is grateful to Mr. H.C. Porter and Mr. A.C. Sensicle for their unfailing support and advice. Acknowledgement must also be made of the assistance and co-orporation of Mr. Pratin Pathanaporn and Mr. Payack Lintang of the Y.E.A., and of Mrs. Narasri Padunchewit and Mr. Suphoch Kosiyachinda of the Statistical Computer Centre, Chulalongkorn University. The author thanks Miss Kanjane Tasavongnonta for her hard work on stencil typing.

หัวข้อวิทยานิพนธ์เรื่อง ... การวิเคราะห์ระบบไฟฟ้ากำลังด้วยวิธีใหม่เนื่องจากการตัดวงจร.....
 ชื่อ นายวิวัฒน์ อรุณโกวิท.....
 แขนงวิชา วิศวกรรมไฟฟ้า.....
 วันที่ ๑๕ เดือน พฤษภาคม ปี ๒๕๑๑.....

บทคัดย่อ

ในการวิเคราะห์ ได้ศึกษาโปรแกรมสำหรับเครื่องคำนวณอิเล็กทรอนิกส์แบบดิจิทัล
 เพื่อวิเคราะห์ผลของการตัดวงจรแบบสามเฟสและเฟสเดียว วิธีการคำนวณใช้วิธีใหม่ของ
 ดิมิทริเยฟ และวิกทอร์ และได้ศึกษาโปรแกรมที่สร้างขึ้นโดยใช้วิเคราะห์ผลดังกล่าวในระบบไฟฟ้า
 กำลังของการไฟฟ้าพลัง ในสภาพของระบบไฟฟ้าในปัจจุบัน เมื่อมีการจ่ายกำลังสูงสุดและต่ำสุด
 และผลการของระบบไฟฟ้าใหม่ พ.ศ. ๒๕๑๑ (ค.ศ. ๑๙๖๘) เครื่องคำนวณอิเล็กทรอนิกส์ที่ใช้
 คือเครื่องคำนวณ ไซบีเรียน ๑๖๒๐ แบบที่ ๑ ที่ศูนย์สำบางสถิติ จุฬาลงกรณ์มหาวิทยาลัย

Thesis Title Power System Analysis with Special Reference to Short-
Circuit Effects:.....
.....
Name.. Wiyat Trutsapornit. Department. Electrical Engineering. Date. May 2, 1967.

ABSTRACT

Some Fortran programs have been developed to analyse the effects of a three-phase short-circuit and a one-phase short-circuit on a power system. The method used is the nodal impedance matrix method. The programs have been used to analyse the short-circuit effects on the Yambes Electricity Authority power system of the nowadays conditions, at both maximum and minimum generations, and of the condition in 1970. The electronic digital computer used is the I.B.M. 1960 Model 1 at the Statistical Computer Centre, Chulalongkorn University.

ABSTRACT

Some Fortran programs have been developed to analyse the effects of a three-phase short circuit and a one-phase short circuit on a power system. The method used is the nodal impedance matrix method. The programs have been used to analyse the short circuit effects on the Yanhee Electricity Authority power system **at present day** conditions, at both maximum and minimum generations, and of the condition in 1970. The electronic digital computer used is the IBM 1620 Model 1 at the Statistical Computer Center, Chulalongkorn University.

CONTENTS

<u>CHAPTER</u>	<u>TITLE</u>	<u>PAGE</u>
	Title Page.....	i
	Thesis Approval.....	ii
	Acknowledgements.....	iii
	Abstract.....	iv
	Table of Contents.....	v
	Lists of Symbols.....	vii
I	INTRODUCTION.....	1
II	REPRESENTATION OF A POWER SYSTEM.....	4
	The One-Line Diagram.....	4
	Generators and Loads.....	5
	Transformers.....	6
	Generalized Representation of a Branch.....	9
	Representation of a Unbalanced System.....	10
III	MATRIX METHOD IN SHORT CIRCUIT STUDIES.....	12
	Network Equations.....	12
	Three Phase Short Circuit.....	14
	One - Phase Short Circuit.....	16
IV	DESCRIPTION OF THE DEVELOPED PROGRAMS.....	20
	Introduction.....	20
	Program For Nodal Admittance Matrix Formations.....	22
	Program For Matrix Inversion.....	24
	Program For Modifying a Nodal Impedance Matrix.....	27



	Program For Prefault Voltage Calculation.....	29
	Program For Fault Current and Voltage.....	30
	Distribution in a System with a Three Phase circuit.	
	Program For Calculation of Fault Current.....	33
	Distribution in a System with a One-Phase Short Circuit.	
	Tests of Programs.....	35
V	PROCEDURES IN PROGRAMING	36
	Equipment and Facilities.....	36
	Assumptions.....	37
	Method of Formulating Problem.....	37
	Data Preparation.....	38
	Processing on the IBM 1620 computer.....	43
VI	SHORT CIRCUIT ANALYSES ON THE YEA POWER SYSTEM	45
VII	CONCLUSIONS.....	47
	REFERENCES	
	APPENDICES	

LIST OF SYMBOLS

- Y = nodal admittance matrix
 Y_{ij} = element of nodal admittance matrix
 Z = nodal impedance matrix
 Z_{ij} = element of nodal impedance matrix
 $Y = G+jB$ = admittance value
 $Z = R+jX$ = impedance value
 b = a half of shunt susceptance of a Transmission line
 V_K = voltage at busbar K
 E_G = generator internal voltage
 I_k = injected current at busbar k
 P_k = injected active power at busbar k
 Q_k = injected reactive power at busbar k
 $S_k = P_k + jQ_k$
 I_{ij} = current flowing in a line from busbar i
 $S_{ij} = P_{ij} + jQ_{ij}$ = power flowing in a line from busbar i
 t = transformer tap (%)
 n = off-nominal turn ratio

Subscripts

- g = generation quantities
- l = load quantities
- f = fault quantities
- 1 = positive sequence quantities
- 2 = negative sequence quantities
- 0 = zero sequence quantities
- a = phase quantities in phase a
- b = phase quantities in phase b
- c = phase quantities in phase c

An asterisk above a symbol indicates a complex conjugate quantities.