

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS♦

JUDUL: **TOOLBOX FOR POWER SYSTEM FAULT ANALYSIS
USING MATLAB**

SESI PENGAJIAN: **2007/2008**

Saya MOHD FITRY BIN ISMAIL (850609-10-5453)
(HURUF BESAR)

mengaku membenarkan tesis (Sarjana Muda/Sarjana /Doktor Falsafah)* ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hak milik Kolej Universiti Kejuruteraan & Teknologi Malaysia.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

SULIT

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

TERHAD

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

Disahkan oleh:

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat Tetap:

**NO. 15, JALAN KIAI KHUSAIRI
11/KS 3, TAMAN ANEKA BARU,
SUNGAI UDANG, 41250 KLANG,
SELANGOR DARUL EHSAN.**

NORHAFIDZAH BINTI MOHD SAAD
(Nama Penyelia)

Tarikh: _____

Tarikh: _____

- CATATAN: * Potong yang tidak berkenaan.
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh tesis ini perlu dikelaskan sebagai atau TERHAD.
♦ Tesis dimaksudkan sebagai tesis bagi Ijazah doktor Falsafah dan Sarjana secara Penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).

TOOLBOX FOR POWER SYSTEM FAULT ANALYSIS USING MATLAB

MOHD FITRY BIN ISMAIL

This thesis is submitted as partial fulfillment of the requirements for the award of the
Bachelor of Electrical Engineering (Power System)

Faculty of Electrical & Electronics Engineering
University Malaysia Pahang

NOVEMBER 2007

TABLE OF CONTENTS

| CHAPTER | TITLE | PAGE |
|----------------|--|-------------|
| | TITLE PAGE | i |
| | DECLARATION | ii |
| | DEDICATION | iii |
| | ACKNOWLEDGEMENT | iv |
| | ABSTRACT | v |
| | ABSTRAK | vi |
| | TABLE OF CONTENTS | vii |
| | LIST OF TABLES | x |
| | LIST OF FIGURES | xii |
| | LIST OF ABREVIATION | xv |
| | LIST OF APPENDICES | xvi |
| 1 | INTRODUCTION | 1 |
| | 1.1 Background | 1 |
| | 1.2 Objectives of Project | 2 |
| | 1.3 Scopes of Project | 2 |
| 2 | LITERATURE REVIEW | 4 |
| | 2.1 Fault Analysis | 4 |
| | 2.2 Types of Fault | 4 |
| | 2.2.1 Balanced Three-Phase Fault Analysis | 6 |
| | 2.2.2 Unbalanced Fault Analysis | 9 |

| | | |
|----------|--|-----------|
| 2.2.2.1 | Single Line-To-Ground Fault Analysis | 9 |
| 2.2.2.2 | Line-To-Line Fault Analysis | 11 |
| 2.2.2.3 | Double Line-To-Ground Fault Analysis | 14 |
| 2.3 | GUI (Graphical User Interface) | 16 |
| 2.4 | MATLAB GUIDE | 17 |
| 2.5 | Fault Analysis Software | 18 |
| 3 | METHODOLOGY | 23 |
| 3.1 | Introduction | 23 |
| 3.2 | Developed Commands | 25 |
| 3.3 | Topology of the Basic Program | 26 |
| 3.4 | Simulation & Analysis | 27 |
| 3.5 | GUI Development | 29 |
| 3.5.1 | Building GUI | 29 |
| 3.5.2 | Command Integration | 32 |
| 3.6 | Toolbox Benchmarking | 38 |
| 3.6.1 | Simulation on 3-Bus System | 38 |
| 3.6.2 | Simulation on 11-Bus System | 39 |
| 3.6.3 | Simulation on 32-Bus System | 41 |
| 4 | RESULTS AND ANALYSIS | 43 |
| 4.1 | Introduction | 43 |
| 4.2 | Development of Fault Pro v1.0 Software Package | 43 |
| 4.3 | About Fault Pro v1.0 | 45 |
| 4.4 | Results from the Simulation of Previous Chapter | 60 |
| 4.4.1 | Results of Simulation from Section 3.4 (3-Bus Network) | 60 |
| 4.4.2 | Results of simulation from chapter 3.6.1 (3- | 62 |

| | |
|--|-----------|
| bus network) | |
| 4.4.3 Results of simulation from chapter 3.6.2 (11- bus network) | 63 |
| 4.4.4 Results of simulation from chapter 3.6.3 (32- bus network) | 67 |
| 4.5 Discussions | 72 |
| 5 CONCLUSIONS AND RECOMMENDATION | 73 |
| 5.1 Conclusion | 73 |
| 5.2 Future Recommendations | 73 |
| 5.2.1 Commercialization | 74 |
| REFERENCES | 75 |
| APPENDICES | 77 |
| APPENDIX A Original Program Results | 78 |
| APPENDIX B Customized Program Results | 81 |
| APPENDIX C symfault Program | 84 |

LIST OF TABLES

| TABLE NO. | TITLE | PAGE |
|-------------|--|------|
| 3.4 | Line Impedance Data | 27 |
| 3.13 | Command Integration with GUI Layout | 36 |
| 3.17 | Line and Transformer Data | 40 |
| 3.18 | Generator Transient Impedance Data | 40 |
| 3.20 | Line Impedance of 32-Bus Networks | 42 |
| 4.9 | Input Data Characteristics | 50 |
| 4.10 | Positive/Negative Sequence Impedance Data | 51 |
| 4.13 | Zero Sequence Impedance Data | 52 |
| 4.21 | Bus Impedance Matrix for Positive and Negative Sequence Impedance (Zbus1/Zbus2) in 3-By-3 Matrix | 60 |
| 4.22 | Bus Impedance Matrix For Zero Sequence Impedance (Zbus0) in 3-By-3 Matrix | 60 |
| 4.23 | Fault Location and Impedance | 60 |
| 4.24 | Three Phase Balanced Fault Analysis | 61 |
| 4.25 | Single Line-To-Ground Fault Analysis | 61 |
| 4.26 | Line-To-Line Fault Analysis | 62 |
| 4.27 | Double Line-To-Ground Fault Analysis | 62 |
| 4.28 | Three Phase Balanced Fault Analysis | 63 |
| 4.29 | Single Line-To-Ground Fault Analysis | 64 |
| 4.30 | Double Line-To-Ground Fault Analysis | 65 |
| 4.31 | Line-To-Line Fault Analysis | 66 |
| 4.32 | Three Phase Balanced Fault Analysis | 67 |

| | | |
|-------------|--|----|
| 4.33 | Single Line-To-Ground Fault Analysis | 68 |
| 4.34 | Double Line-To-Ground Fault Analysis | 69 |
| 4.35 | Line-To-Line Fault Analysis | 70 |
| 4.36 | Faulted Current From Previous Simulation | 72 |

LIST OF FIGURES

| FIGURE NO | TITLE | PAGE |
|----------------|--|------|
| 2.1 | 4 Common Types of Fault | 5 |
| 2.2(a) | One Line Diagram of a Simple Three-Bus Power System | 7 |
| 2.2(b) | Impedance Network for Fault at Bus | 7 |
| 2.2(c) | Thevenin's Equivalent Network | 7 |
| 2.2(d) | Thevenin's Equivalent Network Simplified | 8 |
| 2.3 | Positive, Negative & Zero Sequence Network | 9 |
| 2.4 | 3-Phase Equivalent Circuit | 9 |
| 2.5 | Single Line-To-Ground Fault Sequence | 11 |
| 2.6 | Three Phase Generators with Fault Between Phase 'b' and 'c' | 11 |
| 2.7 | Line-To-Line Fault Equivalent Network | 13 |
| 2.8 | Three Phase Generators with Fault on Phase 'b' And 'c' through Impedance Z_f To Ground | 14 |
| 2.9 | Double Line-To-Ground Equivalent Circuit | 16 |
| 2.10 | Hierarchical Nature of Handle Graphics | 17 |
| 2.11 | Window Overview of CYMFAULT | 19 |
| 2.12 | Leonardo Expert System Shell | 20 |
| 2.13 | Leonardo's Introduction Layout | 20 |
| 2.14(a) | Examples of Fault Analysis | 21 |
| 2.14(b) | Step By Step Solution | 21 |
| 2.14(c) | Step By Step Solution | 22 |
| 2.15 | ANN Design Methodology | 22 |

| | | |
|----------------|--|----|
| 3.1 | Work Flow of the Project | 24 |
| 3.2 | Flow Chart of the Program | 26 |
| 3.3 | Basic 3 Bus System | 27 |
| 3.5 | MATLAB M.File Programming | 28 |
| 3.6 | Guide Quick Start | 29 |
| 3.7 | Untitled GUI Figure | 30 |
| 3.8 | The Property Inspector | 31 |
| 3.9 | Fault Calculator Layout Design | 32 |
| 3.10 | Topology of the Newly Modified Program | 33 |
| 3.11 | Fault Calculator Design Layout | 34 |
| 3.12 | Part of the Generated .M File | 35 |
| 3.14 | Fault Calculator Program Topology | 37 |
| 3.15 | Line Data of the 3-Bus System | 38 |
| 3.16 | 11-Bus System Network | 39 |
| 3.19 | 32-Bus System Network | 41 |
| 4.1 | Setting the Preference Path | 44 |
| 4.2 | Main Topology of Fault Pro V1.0 | 45 |
| 4.3 | Fault Pro v1.0 Main Layout | 46 |
| 4.4 | Tutorial Menu Layout | 47 |
| 4.5 | Transformer Configurations Information | 48 |
| 4.6 | Wye-Gnd-Wye-Gnd Information | 48 |
| 4.7 | Fault Pro Tutor Layout | 49 |
| 4.8 | Input Help | 50 |
| 4.11 | Circuit Equivalent from Table 4.10 | 51 |
| 4.12 | Simplified Connections for Zero Sequence Impedance | 52 |
| 4.14 | Zbus | 53 |
| 4.15 | View Data | 53 |
| 4.16 | Fault Calculator | 54 |
| 4.17 | Balance Three Phase Fault Analysis | 55 |
| 4.18 | Examples | 56 |
| 4.19(a) | 3-Bus System Network | 57 |

| | | |
|----------------|-----------------------|----|
| 4.19(b) | 11-Bus System Network | 57 |
| 4.19(c) | 32-Bus System Network | 58 |
| 4.20 | Fault Pro v1.0 Layout | 59 |

LIST OF ABREVIATION

| | |
|--------|--|
| GUI | - Graphical User Interface |
| GUIDE | - Graphical User Interface Development Environment |
| MATLAB | - Matrix Laboratory |
| p.u | - Per Unit |
| R | - Resistive Impedance |
| X | - Reactive Impedance |
| Ybus | - Bus Admittance Matrix |
| Zbus | - Bus Impedance Matrix |
| Zbus0 | - Bus Impedance Matrix for Zero Sequence Impedance |
| Zbus1 | - Bus Impedance Matrix for Positive Sequence Impedance |
| Zbus2 | - Bus Impedance Matrix for Negative Sequence Impedance |

LIST OF APPENDICES

| APPENDIX | TITLE | PAGE |
|-----------------|----------------------------|-------------|
| A | Original Program Results | 78 |
| B | Customized Program Results | 81 |
| C | symfault Program | 84 |