



شبكة المعلومات الجامعية

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ





شبكة المعلومات الجامعية



شبكة المعلومات الجامعية

التوثيق الالكتروني والميكرو فيلم

جامعة عين شمس

التوثيق الالكتروني والميكرو فيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأفلام قد اعدت دون أية تغيرات



يجب أن

تحفظ هذه الأفلام بعيداً عن الغبار

في درجة حرارة من 15 – 20 مئوية ورطوبة نسبية من 20-40 %

To be kept away from dust in dry cool place of
15 – 25c and relative humidity 20-40 %



شبكة المعلومات الجامعية



بعض الوثائق الأصلية تالفة



شبكة المعلومات الجامعية



بالرسالة صفحات
لم ترد بالأصل

**ACCURATE FAULT LOCATION IN UNDERGROUND CABLES
USING ADVANCED SIGNAL PROCESSING TECHNIQUES**

By
DOAA KHALIL IBRAHIM

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the Requirements for the Degree of
DOCTOR OF PHILOSOPHY

In
ELECTRICAL POWER ENGINEERING

m. Elmetan

**FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT**

July 2005

B1790

**ACCURATE FAULT LOCATION IN UNDERGROUND CABLES
USING ADVANCED SIGNAL PROCESSING TECHNIQUES**

By

DOAA KHALIL IBRAHIM

A Thesis Submitted to the

Faculty of Engineering at Cairo University

In Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

In

ELECTRICAL POWER ENGINEERING

Under the Supervision of

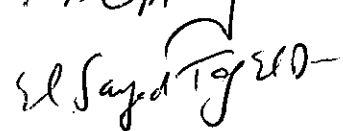
Prof. DR. MOHAMED MAMDOUH ABD EL-AZIZ

Ass. Prof. DR. MAHMOUD IBRAHIM GILANY

DR. EI SAYED MOHAMED TAG ELDIN

Electrical power and Machines Department





FACULTY OF ENGINEERING, CAIRO UNIVERSITY

GIZA, EGYPT

July 2005

**ACCURATE FAULT LOCATION IN UNDERGROUND CABLES
USING ADVANCED SIGNAL PROCESSING TECHNIQUES**

By

DOAA KHALIL IBRAHIM

A Thesis Submitted to the

Faculty of Engineering at Cairo University

In Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

In

ELECTRICAL POWER ENGINEERING

Approved by the
Examining Committee:-

Prof. Dr. M. MAMDOUH ABD EL-AZIZ



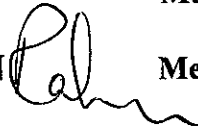
Thesis Main Advisor

Prof. Dr. ESSAM EL-DIN ABOU EL-ZAHAB



Member

Prof. Dr. MANSOUR HASSAN ABD EL-RAHMAN



Member

FACULTY OF ENGINEERING, CAIRO UNIVERSITY

GIZA, EGYPT

July 2005

TABLE OF CONTENTS

LIST OF TABLES.....	ix
LIST OF FIGURES	xi
LIST OF SYMBOLS AND ABBREVIATIONS.....	xv
ACKNOWLEDGEMENT.....	xx
ABSTRACT	xxi
 CHAPTER 1.....	
INTRODUCTION	1
1.2 Objectives of the thesis	8
1.1 Thesis overview and organization	9
 CHAPTER 2.....	
OVERVIEW ON CABLE FAULT DETECTION AND LOCATION.....	11
2.1 Common fault causes in underground systems	11
2.2 Fault process and types of faults in underground cables	13
2.2.1 Shunt faults.....	14
2.2.2 Series faults.....	14
2.2.3 High impedance faults	15
2.2.3.1 Active faults.....	16
2.2.3.2 Passive faults	16
2.2.4 Low impedance faults.....	17
2.3 Fault location in underground cables.....	17
2.3.1 Off-line methods.....	18
2.3.1.1 Terminal methods	19
A).Conventional locating methods	19
B).Non conventional locating methods	25
2.3.1.2 Tracer methods	30
2.3.2 On-line methods	34

2.3.2.1 On-line fault location system for 66kV underground cables with fast O/E and A/D technique	35
2.3.2.2 Fault location algorithm based on voltage and current phasor estimation	37
2.3.2.3 Fault location using artificial neural networks	39
2.3.2.4 Utilizing global positioning system in fault location system estimation...	40
2.3.2.5 Fault Location scheme using fault generated high frequency voltage transients.....	42
2.3.2.6 Wavelet transform based fault location	43
2.4 Evaluation of the existing fault location techniques.....	44
2.5 Propagation velocity in cables.....	45
2.6 Cables changed parameters	46

CHAPTER 3.....	
SIGNAL PROCESSING TOOLS	50
3.1 Basic concepts	51
3.2 Fourier Transform.....	51
3.2.1 Discrete Fourier Transform DFT.....	52
3.2.2 Fast Fourier Transform FFT	53
3.2.3. Windowed Fourier Transform WFT.....	54
3.3 Application of wavelets in power system engineering.....	55
3.3.1 Wavelet transform in power system protection.....	56
3.3.2 Fundamental concepts and overview on wavelet theory	56
3.3.2.1 Mother wavelet.....	57
3.3.2.2 Continuous Wavelet Transform (CWT)	58
3.3.2.3 Wavelet properties.....	59
3.3.2.4 Discrete Wavelet Transform (DWT).....	61
3.3.2.5 Multi-Resolution analysis using filter banks (MRA)	62
3.3.2.6 Dissimilarities between Fourier and Wavelet transforms.....	64
3.4 Modal decomposition (Transformation)	65
3.4.1 Transformation for fully transposed systems	66
3.4.2 Transformation for untransposed systems.....	68

CHAPTER 4.....	
RELAYING SCHEMES REQUIRMENTS.....	70
4.1 Pilot protection communications requirements	70
4.1.1 Transmission media.....	70
4.1.1.1 Satellites.....	71
4.1.2 Techniques for synchronization	72
4.1.3 Global positioning system (GPS).....	74
4.1.3.1 Objectives of GPS.....	74
4.1.3.2 Construction of GPS	74
4.1.3.3 GPS in electric system stations	75
4.1.3.4 GPS time standards	77
4.1.4 Communication revolution.....	77
4.2 Transducers with wide bandwidth.....	79
4.2.1 Optical CT operation	79
4.2.2 Coupling capacitor voltage transformer (CCVT) operation using a high frequency tap	81
4.2.3 Fiber optic voltage sensors operation.....	83
CHAPTER 5.....	
WAVELET-BASED FAULT LOCATION SCHEME USING VOLTAGE TRAVELLING WAVES.....	85
5.1 Theory of travelling waves	86
5.2 Proposed fault location algorithm for plain aged cables	88
5.2.1 Fault location algorithm for a fault in the first half of the cable at $(x < l/2)$	89
5.2.2 Fault location algorithm for a fault in the second half of the cable at $(x > l/2)$	90
5.2.3 Fault location algorithm for faults close to busbars	92
5.3 Proposed fault location scheme for three phase aged cable	95
5.3.1 Gathering signals.....	95
5.3.2 Phase to modal transformation.....	96
5.3.3 Appropriate mode selection according to fault type	97
5.3.4 Wavelet decomposition of travelling waves	97
5.3.5 Discrimination between transient signals waves.....	100

5.4 Testing the proposed scheme for three phase aged cable	101
5.4.1 Simulated radial system.....	101
5.4.2 Alternating Transients Program	102
5.4.3 Simulation results and scheme evaluation.....	104
5.5 Testing the proposed scheme for multi-end aged cable system	110
5.5.1 Fault location algorithm for multi-end aged cable system	110
5.5.2 Evaluation of the proposed scheme for multi-end aged cable system	115
5.6 Testing the proposed scheme for aged underground cable combined with overhead Line.....	121
5.6.1 Fault location algorithm for aged underground cables combined with overhead lines	121
5.6.2 Evaluation of the proposed fault location scheme for aged underground cables combined with overhead lines.....	126
5.7 Feasibility study of the proposed scheme.....	131
5.8 Overview on the travelling wave-based fault location scheme	132
 CHAPTER 6.....	
PHASOR MEASUREMENTS-BASED FAULT LOCATION SCHEME.....	134
6.1 Fault location solution for three phase cable	135
6.2 Adaptive feature for aged cable changed parameters estimation	139
6.3 Proposed fault location scheme for three phase aged cable	140
6.3.1 Signals processing	140
6.3.1.1 Full-cycle fourier algorithm.....	142
6.3.2 Estimating aged cables parameters	145
6.3.3 Appropriate mode selection according to fault type	146
6.3.4 Fault location according to modal phasors.....	146
6.3.5 Calculation of the fault resistance	147
6.4 Testing the proposed scheme for radial three phase aged cable.....	148
6.5 Testing the proposed scheme for multi-end aged cable system	153
6.5.1 Fault location algorithm for multi-end aged cable system.....	155
6.5.1.1 Preliminary fault locations estimation	155
6.5.1.2 Correct fault location identification.....	156