



Ain Shams University
Faculty Of Engineering
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ADAPTIVE COORDINATION OF OVERCURRENT RELAYS IN MICROGRIDS

A Thesis Submitted
For The Degree of Masters of Science of Engineering

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TABLE OF CONTENTS

ACKNOWLEDGEMENT	i
SUMMARY	v
LIST OF TABLES	vi
LIST OF FIGURES	vii
LIST OF ABBREVIATIONS	viii
1 INTRODUCTION	1
1.1 General	
1.1.1 Types of Relays based on structure	
1.1.2 Types of Relays based on purposes.	
1.2 Power System protection Requirements	
1.3 Coordination Requirements	
1.3.1 Coordination problem requirements	
1.3.2 Types of overcurrent relays	
1.4 Thesis objective	
1.5 Thesis outlines	
2 COORDINATION OF OVERCURRENT RELAYS	15
2.1 General	
2.2 Literature Review	
2.3 Problem Description	
2.4 Problem Formulation	
2.4.1 Objective Function	
2.4.2 Constraints	

2.4.2.1	Constraint of Relay Operating Time	
2.4.2.2	Constraint of Time and Current Settings	
2.4.2.3	Constraint of Coordination	
2.4.2.4	Topological Changes	
2.5	Adaptive protection for optimal coordination of overcurrent relay	
2.5.1	Case Of Distribution System with DG	
3	SIMULATION RESULTS AND OPTIMIZATION TECHNIQUES	31
3.1	Differential Evolution and Genetic Algorithm	
3.2	Simulation and Optimization Results	
3.3	Analysis of results using Genetic Algorithm in comparison with Modified Differential Evolution Algorithm.	
3.3.1	A Comparison of Genetic Algorithms and Differential Evolution	
4	Flyfire Swarm Optimization Technique	51
4.1	Behaviour of Fireflies	
4.2	Firefly Algorithm	
4.3	Attractiveness	
4.4	Distance and Movement	
4.5	Analysis of FA Optimization results with that of MDE and GA	
4.6	Advantages of Firefly algorithm (FA).	
5	Conclusions and future works	61
	Publications	63
	References	64

SUMMARY

This thesis proposes an adaptive schema to the coordination of inverse-time over current relays that achieve possible optimization for changes in power system as network-topology, load or generation-level to ensure appropriate protective coordination and operating time. The optimal settings for the relays are determined by using Modified Differential Evolution (MDE) algorithm and Firefly algorithm (FA) compared with Genetic algorithm (GA). The aim in selecting the settings of the relays is to achieve the possible minimum operating times while preserving coordination among all relays. The thesis shows that the results using the MDE algorithm and FA algorithm are close to the optimal solutions, and hence demonstrates and proves the validity of the two methods.

LIST OF TABLES

Table 3-1. 3 Bus System parameters.....	37
Table 3-2. 3 Bus System Relay pairs.....	38
Table 3-3. 3 Bus System Optimization Results.....	38
Table 3-4. Microgrid System parameters.....	41
Table 3-5. Microgrid System Relay pairs.....	41
Table 3-6. Microgrid System Optimization Results.....	42
Table 3-7. Microgrid System connected with utility Relay pairs.....	42
Table 3-8. Microgrid System connected with utility Optimization Results.....	45
Table 4-1. 3 Bus System Optimization Results.....	55
Table 4-2. Microgrid System Optimization Results.....	56
Table 4-3. Microgrid System connected with utility Optimization Results.....	57

LIST OF FIGURES

Figure 1-1. Instantaneous Over Current Relay (Define Current)	6
Figure 1-2. Definite Time Over current Relays	7
Figure 1-3. Inverse Time Over current Relays (IDMT Relay)	9
Figure 1-4. Types Of Inverse Time Over current Relays (IDMT Relay).....	12
Figure 2-1. Multisource/Closed Loop System-(3) Bus System	16
Figure 2-2. Case Of Distribution System with DG	26
Figure 2-3. Effect Of DG On Coordination Time	27
Figure 2-4. (3) bus System	28
Figure 2-5. Microgrid System	29
Figure 2-6. Adaptive Algorithm Flow Chart	30
Figure 3-1. GA Flow Chart	33
Figure 3-2. DE Flow Chart.....	34
Figure 3-3. 3 bus System Single Line Diagram	35
Figure 3-4. Three bus system-Simulation Model	36
Figure 3-5. Case 2-case3 Single Line Diagram	39
Figure 3-6. Case 2-Simulation Model.....	40
Figure 3-7. Case 3-Simulation Model.....	43
Figure 4-1. FA Flow Chart.....	54

LIST OF ABBREVIATIONS

1. GA stands for Genetic Algorithm
2. MDE stands for Modified Differential Evolution
3. DE stands for Differential Evolution
4. FA stands for Firefly Algorithm
5. FN stands for Function
6. PSO stands for Particle Swarm Optimization
7. MPSO stands for Modified Particle Swarm Optimization

Chapter 1: INTRODUCTION

1.1 General

The function of a relay is to control the tripping of a circuit breaker in case a fault arises in power system. The preliminary relays depends on electromagnetic technology, in which the detection of irregular conditions of operation is provided by coils operate by means of movable parts, these conditions may be over-voltage, over-current, over/under frequency or reverse power flow. Microprocessor- digital based protection relays now are equivalent to the original devices, in addition to superior features for protection in comparison with that of electromechanical devices. The microprocessor-digital based relay can often provide features of protection equivalent to more than one relay of the electromechanical devices. The numerical relays precede electromechanical ones from the economic point of view regarding the principal cost and cost of service as well, by combining several functions in one case. A lot of electromechanical relays are existing till nowadays because of their long duration of life, serving for protection of many electrical grids and equipment worldwide. For an essential generator unit, urgent electrical equipment or transmission line, the duplication of protection techniques is necessary, using one or two microprocessor relays or many individual electromechanical devices.

The theories and applications of the protection using relays in the power system are mandatory in the electrical engineering science. The protection system requirement is to respond in a very fast manner for the protection of electrical networks and apparatus, Also in most of the times it is required that the relay should send the trip signal to the circuit breaker in a very short time. Therefore it is mandatory to care about the maintenance and testing of protective relays in order to have an efficient operation [1].

1.1.1 Types of relays based on structure

- i. Analogue
- ii. Digital
- iii. Static
- iv. Electromechanical (Induction disc overcurrent relay)

1.1.2 Types of relays based on purposes

A relay can perform multiple functions for protection, where each function can be defined using standard number for the device. As a sample, The number Fifty one defined on a relay means that the operation function is timed overcurrent relay [2] [3].

i. Over current relay

The aim of over current relay is to protect the power system against the excess value of definite load current. The number Fifty defined on a relay means that the operation function is instantaneous overcurrent relay while the number Fifty one defined on a relay means that the operation function is timed overcurrent relay. Regarding this protection technique, a current transformer is attached to the over current relay where it is adjusted in order to be in action if the current exceeds a definite level. In case a fault detected by the relay, contacts are energized in order to open a certain circuit by tripping the concerned circuit breaker.

ii. Distance relay

The protection technique using distance relay is very familiar in transmission systems on high voltage level. The fault distance can be specified using the values of current and voltage in comparison to impedance per distance of power lines. The number Twenty one defined on a relay means that the operation function is distance relay. Impedance relay is another name for distance relay as well since the fault is calculated by using the transmission line impedance per meter.

Reactance distance, impedance distance, mho distance and offset distance are considered various sorts of impedance relays [4].

iii. Current differential protection

The current differential relay is considered as an important technique for equipment protection like generators, transformers, and power lines. The Kirchhoff's current law is the basic theory of this protection type, this theory illustrates that the summation for values of currents which enter and exit a node must equal zero. Current transformers are required in differential protection at both sides of the transformer and both ends of the power line. Therefore all the currents are compared and the difference among them are calculated, where this is the concept of work for the current protection relay.

iv. Directional relay

A supplemental polarizing current or voltage source is used by the directional relay to detect the fault direction. The fault may occur in or out the relay protection zone, where the suitable protective relays could operate in or out the relay protection zone.

v. Synchronism check

The synchronism check relay operates and allow contact in case the phase sequence and frequency of two electrical sources are the same with accepted tolerance. This relay is used in case the connection of two different power systems, or two power networks (switchyard), or to close generator circuit breaker to assure the possibility of generator synchronization to the system before connection.

1.2 Power System Protection Requirements

1.2.1 Speed

Speed limits stress and damages on lines, busbars and equipment. Speed results in stability, less damage, less stress and less ionization.

1.2.2 Sensitivity

The protection system should be sensitive to the minimum fault current to enhance/improve the accuracy of the protection system.

1.2.3 Selectivity

Selectivity limits the consequences for the power system. It is defined as the capability of a protection system to detect fault in a specified zone of a network and to trip the appropriate circuit breaker(s) to clear this fault.

1.2.4 Reliability

Power system reliability-referring to interruption of power supply to customers. High reliability results in high cost in grids. Low reliability results in more interruption to customers.

1.2.5 Coordination

The power system consists of multiple devices and many protection relays for the aim of protection.

Every relay in the power network should be coordinated with the relay that protects the device in adjacent.

In case the backup relays are not coordinated correctly, maloperation could occur.

The coordination of over current relays is an important issue in the studies of protection for power system. The overall coordination problem is thus very complicated.

1.3 Coordination Requirements

In multiloop systems which have different generation sources at various locations, currents for either fault and load may flow in different directions.

The relays protecting the power lines can sense the fault currents in either directions.

The directional relays are considered the best solution in these cases since their operation/tripping depend only on certain direction for the fault current.

The primary protection for subtransmission/distribution systems and the secondary protection for the transmission lines depend on directional overcurrent relaying.

The coordination problem of protection relays in the multisource and multiloop networks is considered the main concern for achieving the optimal solution.