Ain Shams University
Faculty of Engineering

An Effective Adaptive Overcurrent Protection Scheme for Microgrids

By

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A Thesis Submitted for the Requirement of Master Degree of Sciences in Electrical Power Engineering

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Statement

This thesis is submitted to Ain Shams University in partial fulfillment of the requirements for the degree of Master of Sciences in Electrical Engineering.

The work included in the thesis was carried out by the author at the department of Electrical Power and Machines, Ain Shams University.
No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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List of Abbreviations

BIL	Basic Insulation Level
C.B	Circuit Breaker
CSG	Conventional Synchronous Generators
CT	Current Transformer
CTI	Coordination Time Interval
DER	Distributed Energy Resources
DG	Distributed Generation
DOCR	Directional over Current Relay
FCL	Fault Current Limiter
FLA	Full Load Ampere
GTG	Gas Turbine Generator
HIF	High Impedance Fault
Ic.u	Maximum breaking capacity of LVCB
IEA	International Energy Agency
IIDG	Inverter Interfaced DG
IS	Islanded
L.F.	Load Flow
LOM	Loss of Main
LRC	Locked Rotor Current
LVMG	Low Voltage MG
LVPCB	Low Voltage Power CB
MG	Microgrid
MGCC	MG Central Controller
MGMS	MG Management System
MGCPU	MG central protection unit
MMG	Multi Microgrid
M.V.	Medium Voltage
MVAs.c	Mega Volt Ampere short circuit
MVCB	Medium Voltage C.B
O.C.	Overcurrent
OCR	Over Current Relay
O.L.	Overload
OLD	One Line Diagram
PDS	Power Delivery System
PG	Power Grid
PSM	Plug setting Multiplication
PV	PhotoVoltaic
RES	Renewable Energy Resources
S.C.	Short Circuit

TCC	Time Current Characteristic
TDS	Time Dial Settings
TMS	Time Multiplying Settings
WTG	Wind Turbine Generator

ABSTRACT

Conventional distribution systems have some concerns related to the finite availability of conventional power sources and the green house impacts of these sources. These concerns create a significant interest in the research and development in renewable energy fields and encourage the generations from clean sources at the customer area. Basically renewable energy sources interfaced with the distribution system are called Distributed Generators (DGs) and hence forming a Microgrid (MG), which can operate either in grid connected or islanded modes.

As a result of the major benefits that DG brings to distribution systems, its proliferation is anticipated to be increased, and this inevitably will change the traditional operation and protection principles of power distribution systems. This leads to some protection challenges such as difference in fault current level among different operating modes and bidirectional power flow which will lead to loss of coordination between protection devices.

Based on challenges that face conventional protection systems due to DG insertion, new protection techniques have to be developed to mitigate negative impacts of DGs on protection system. One of these techniques is the adaptive overcurrent protection technique, in which the relays settings are automatically adapted to be continuously suitable for the current prevailing condition. Practical implementation of adaptive protection require relays with multi switch group factors and communication networks to connect relays and DGs with the system monitoring and controlling unit.

In this thesis, an adaptive protection technique, based on topological analysis method, is presented to adapt relay settings for each configuration. The proposed adaptive protection scheme is applied to a part of the IEEE 13 bus radial system and also to the same system but after converting it to a looped one. The results obtained by using ETAP software show the effectiveness of the proposed adaptive method in maintaining coordination between protective relays among different operating topologies, and also in achieving system selectivity and stability.

CHAPTER 1
INTRODUCTION

1.1 Background

The generated energy in conventional power system is mainly depending on huge hydro-electric plants or fossil fuel sources, which are existed normally at suitable places remote from the consumer entities. Therefore, transmission systems are required to handle this generated power to loads at the distribution area. During power long travel from generation to utilization, a considerable power is lost in transmission systems [1].

Due to the wide spread of loads, the eager need for an uprising amount of generated power, the high cost for constructing transmission and distribution (T&D) networks to feed these loads, besides the large amount of power loss in long transmission networks, as well as the environmental impacts of traditional power sources, all these reasons make the notion of generating a nearby energy from the consuming area to found an acceptance from power system operators, which finally leads to the expression of MicroGrids (MG).

MG can be defined as a collection of distributed generators (DGs) and loads with some local storage [2], which is operated as a unique system to provide electricity and heat energies to nearby customers. Although MG has a multi generators and loads, it appears to the broader network as a total generator or a total load. Also MG can operate in two modes either islanded or grid connected [3]. MG uses different DG technologies such as wind turbine, hydroelectric, combined heat and power, photovoltaic (PV). Basically, not only green technologies are used in MG, but also combustion engines and fuel cells may be used.

Even though DG connection to distribution system brings numerous benefits for MG, it poses significant challenges due to unforeseen short circuit (S.C.) increase in radial distribution system [4], different fault levels during different topologies due to source change [5], [6], bidirectional Power flow [7], lack or in some cases completely loss of coordination in the existed protection scheme which leads to undesired islanding and untimely tripping of DGs protection relays [4], [7]. Further a high DG penetration has resulted in the possibility of operating the distributed system in an island mode which