



Ain Shams University
Faculty of Engineering
Electrical Power and Machines Department

Coordination of the Synchronous Generator Protection with Generator Capability Charts

By

Wael Hamdy Mahmoud Yousef

A thesis submitted to the Faculty of Engineering, Ain Shams University in
partial fulfillment of the requirements for

Doctor of Philosophy (Ph.D.) Degree

In

Electrical Power and Machines Engineering

Under Supervision of

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CAIRO, EGYPT 2018



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STATEMENT

This thesis is submitted to Ain Shams University in partial fulfillment of the requirement for the Ph.D. degree in Electrical Power and Machines Engineering. The included work in this thesis has been carried out by the author at the Electrical Power and Machine Department, Ain-Shams University. No Part of this thesis has been submitted for a degree or a qualification at another university or institute.

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Signature:

Date: 01 /03/ 2018

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Thanks to ALLAH who gives us the power and hope to succeed.

Thanks must go to Allah the creator of this universe who ordered us to study and explore his creations in order to know him better. However, as I come to understand more, I find that there is so much more knowledge to absorb and to get to grips.

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ABSTRACT

The large generating units are one of the important components in producing electric power to the power system. Therefore, it requires highly reliable protection relays to minimize the possibility of damage occurring under fault conditions. There are varieties of protective relays to provide secure and reliable protection for Synchronous Generators (SG) and Generator Step-Up Transformer (GSUT). The differential protection is a reliable method of protecting generators, transformers, large motors, buses, cables and transmission lines from the effects of internal faults. The main benefits of this protection type are isolating the faulty unit accurately and fast. The generator-transformer unit overall differential protection relay (87O) is designed to be a backup protection for SG, GSUT, and Unit Auxiliary Transformer (UAT) differential protection systems. The setting of the relay (87O) usually coordinated with differential protection for SG, GSUT, and UAT by a time delay, Pickup current, and/or slope of restrained curve to avoid mal-operation during normal operating conditions .

The relay may be operated in the normal operating condition or external system disturbances and blocks during internal faults. It is important for the relays to provide protection during fault while avoiding undesirable operation during large system disturbances thereby preserving the integrity of the power grid.

The IEEE rotating machinery subcommittee of the power system relaying committee stated in their report the need to improve the coordination between the generator protections with generator capability curves. After that, the researchers carried out a new technique to

coordinate between generator capability curves and some of the generator protection functions that are loss of excitation and generator distance phase backup protection. Based on the literature review, up-to-date no significant work is proposed for coordination between generator-transformer unit overall protection and the generator capability curve.

In this thesis, a new approach is presented for generator-transformer unit overall digital differential protection in order to improve the relay performance during normal and abnormal operating conditions. The proposed approach distinguishes between internal faults and system disturbances based on coordination between differential current protection curve and generator capability curve. The generator capability curve is divided into four operating regions each one has a different dual-slope differential characteristic setting. The new adaptive approach rapidly detects all internal faults, while it is secure during major system disturbances. The real dynamic simulation of the power station and relay has been conducted by using the ATP/EMTP software for a large steam turbine synchronous generator in Egypt. The coordination between protection setting and generator capability curve has been programmed in MATLAB. The results reveal the performance of the new proposed adaptive approach which is faster and smarter than the traditional differential protection schemes during extensive simulation case studies for internal fault and system disturbances.

In addition, this thesis provides a complete performance evaluation of the traditional generator-transformer unit overall differential protection relay. The results reveal the performance of the traditional differential protection function used in Generator-Transformer unit

protection during major system disturbances and abnormal operating conditions. Three different methodologies for relay settings are used to cover all different design concepts. The aim is to evaluate the traditional relay performance under various stressed system operating conditions and to provide a recommended protection relay setting to increase power generation stability and reliability for Egyptian grid.

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