Ain Shams University
Faculty of Engineering
Electrical Power and Machines Department

Adaptive Automated Fault Identification for Enhancing Smart Network Operation

A thesis submitted to the Faculty of Engineering, Ain Shams University in partial fulfillment of the requirements for the Ph.D. degree in Electrical Power and Machines Engineering

Prepared by:
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M.Sc. in Electrical Power Engineering
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Reactors Dept., Nuclear Research Center, Atomic Energy Authority
Cairo – Egypt 2016

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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 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 other university or institute.

Name: **Ahmed Ramadan Adly**

Signature: *Ahmed Ramadan Adly*

Date: **26 /11/ 2016**

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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

A smart grid is a sophisticated electricity distribution and transmission grid that utilizes communication, information, and management technologies to boost economy, security, stability, reliability, and efficiency of the grid. Recently, one of the most important schemes that were developed to improve transient stability is the single pole tripping scheme. In this scheme, the faulted phase will be trip during single phase to ground fault while the phases are trip on a multi-phase (three phase and double phase) faults. The transmitted power can be still transferred across the healthy phases that remain in service during signal pole tripping. Several issues are necessary to be considered when applying single pole tripping schemes. These issues include: directional relay, negative sequence pilot protection, faulted phase selection, automatic reclosing considerations, unbalanced voltages, unbalanced currents and transient stability.

This thesis is conducted in three parts. In the first part, three adaptive automated schemes are developed to improve the fault identification process in transmission line. The first scheme has investigated an automated and sensitive fault identification scheme. The developed scheme distinguishes between a low impedance fault (LIF) and a high impedance fault (HIF) based on current signal only. This scheme is depends on an adaptive threshold, to alleviate the issue associated with load variations. The second scheme combines the merits of discrete wavelet transform (DWT) and Karen Bell transformation (KBT) for the fault analysis process. This scheme is does not depend on the threshold value and it leads to fast detection. Critical issues like a variation in fault inception angle, fault location, fault resistance and source capacity change are investigated using the proposed scheme. This scheme detects and classifies the fault using only 8 samples from the power cycle with the mean fault detection duration is 1.25 ms. The third scheme presents a simple technique for adaptive single pole automatic reclosure (ASPAR) for transmission lines using wavelet packet transform (WPT). The ASPAR aims to discriminate the faults' natures and to detect the instant of arc extinction. The proposed scheme uses an adaptive threshold level. The proposed scheme is tested for different network configurations, single and

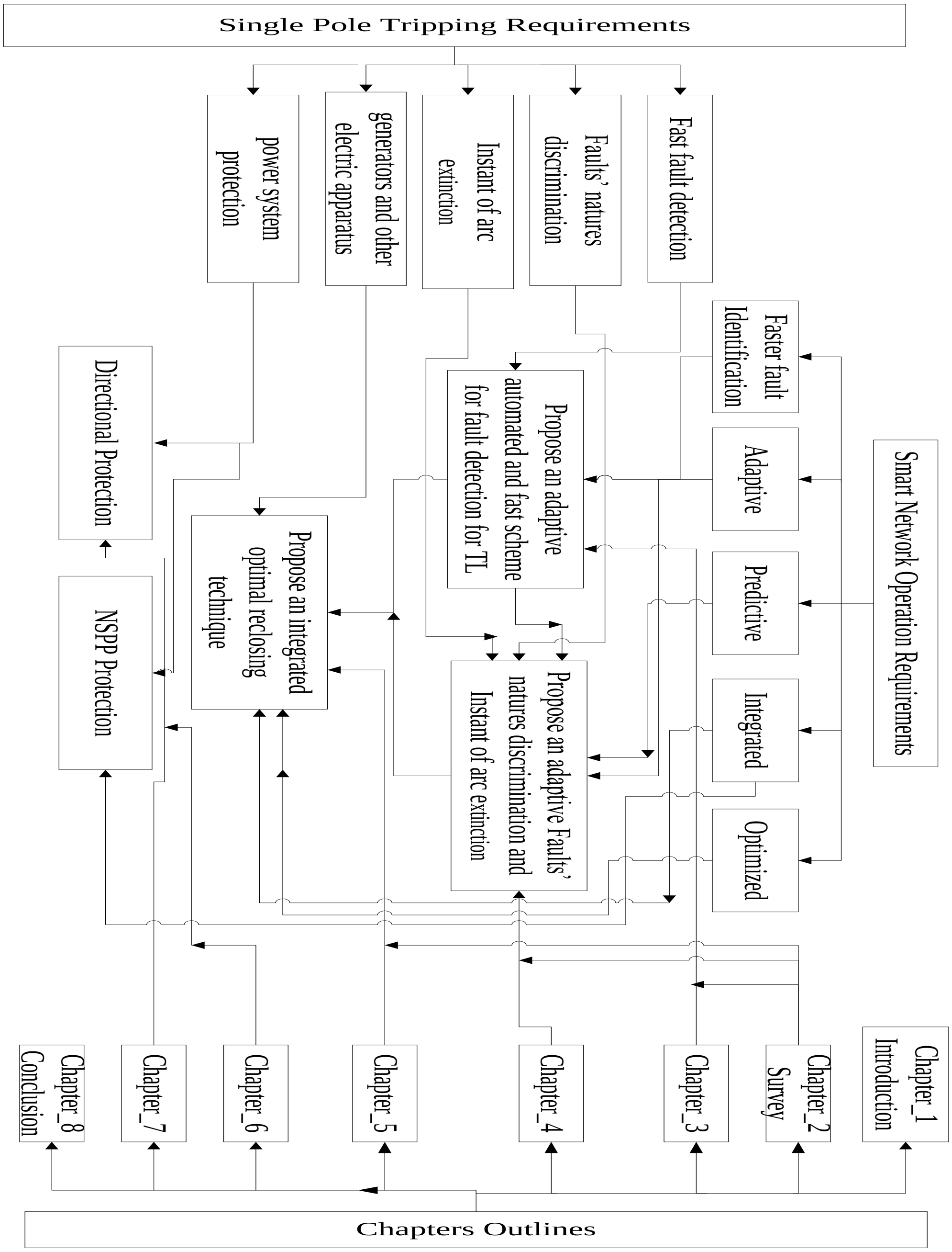
double circuits, to realize it is robustness and capability. Also, the proposed scheme discriminates correctly between permanent and transient faults for compensated and uncompensated networks.

The second part of this thesis aims to integrate the reclosing scheme in terms of real-time communications. It combines the merits of adaptive reclosing time (ART) scheme and the optimal reclosing time (ORT) scheme to improve the transient stability problem. The ART distinguishes the faults, and detects the instant of arc extinction of a transient fault. The ORT is dependent on the load angle of the synchronous generators. The performance of the integrated reclosing scheme is assessed compared with the conventional reclosing schemes in terms of voltage and speed indices. The simulation results indicate that the developed reclosing scheme of circuit breakers can enhance the transient stability.

The third part of this thesis addresses the protection relaying during single pole tripping schemes for a transmission system. It studies the negative sequence pilot protection (NSPP) and directional protection relays for faults during the single pole tripping condition. Then, negative and positive sequence superimposed schemes are developed to provide a solution for the problems of NSPP and directional protection, respectively. These schemes are able to correctly work during single pole tripping (SPT) with different situations, including different fault types, high fault resistances, fault locations, change in source capacity, cross country and far end faults for double circuit line.

Numerical studies show that the proposed schemes are simple, accurate and can be used for updating, improving, and refurbishing of the existing protection relays.

Graphical Abstract



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