UNIVERSITI PUTRA MALAYSIA

DESIGN AND SIMULATION OF DIFFERENTIAL P.ROTECTIVE RELAY (DPR) TO 33/11kV DELTA-WYE TRANSFORMER USING SABER SOFTWARE SIMULATOR

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BY

MUHAMMAD MURTADHA BIN OTHMAN

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Science Universiti Putra Malaysia

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DEDICATION

To my beloved mother Jamilah Bte Abd. Basit,

my father Othman Bin Nor

&

to all my brothers and sisters.

May Allah bless all of you.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

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Chairman: **Norman Mariun, Ph.D.**

Faculty: **Engineering**

Substation automation constitutes the integral part of distribution automation. An automated distribution system may require many remote and central intelligent controllers or computers running synchronously in a very large boundary that are capable of making decisions and performing control actions. A protective relay is a device that responds to abnormal conditions in an electrical power system to operate a circuit breaker to disconnect the faulty section of the system with the minimum interruption of supply. Reliability, speed and selectivity are the most desirable characteristics of a protective relay. Numerical relays play an essential role in various distribution automation functions, and instead of mere protection relays it is also able to interact with the other instruments. In most utilities, power transformers often represent the expensive and also the largest capital purchase in the transmission and distribution system. The gas relay or bucholz relays is particularly important since it gives early warning of a slowly developing fault, permitting shutdown and repair before serious damage can occur. For short-circuit condition or internal faults, differential protective relays (DPR) are usually employed. In this project, SABER software simulator was used to implement solid-state digital-type components for the DPR. The project focused on the protection of 33/11kv delta-wye transformer when internal fault happens. 3 packages solid-state digital-type DPR were designed to protect delta-wye transformer when internal fault happens. There are several problems encountered in this project where in SABER, 1) it is difficult to configure an initial values for delta-wye transformer due to obtain a desired outputs on wye-side, 2) 3-phase generator cannot do any partial changes either leading or lagging power factor, and 3) during circuit breakers switching, very high surges appear which can cause destruction to the power system components. Hence to reduce surges below the allowable maximum value during switching, this can be solve by implementing circuit breakers that not only works as a switch but also as impedance. Circuit breakers impedance can also be assume as an arc extinguisher. By extinguish the arc, the surges also will be reduce. Hence the results of this project are not only to isolate the delta-wye transformer from the generator and as well loads when fault happened, but is also capable to reduce surges during circuit breakers switching.

Abstrak tesis yang dikemukakan Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

REKAAN DAN SIMULASI GEGANTI PELINDUNG PEMBEZA (DPR) TERHADAP 33/11kV TRANSFORMASI DELTA -WAI MENGGUNAKAN PERISIAN KOMPUTER SABER

Oleh

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Keperluan stesen-pencawang automasi terkandung dalam bahagian automasi pengagihan. Automasi pengagihan juga memerlukan banyak kawalan jarak jauh dan juga pusat kawalan pintar atau komputer agar bahagian-bahagian sempadan yang luas dapat beroperasi secara selaras, berupaya untuk membuat keputusan sendiri dan juga kawalan. Fungsi geganti pelindung adalah untuk mengesan keadaan yang tidak stabil dalam sistem kuasa elektrik, dan juga berupaya memisahkan bahagian sistem yang rosak dengan mengawal operasi suis pemisah-litar, tanpa menganggu penjanaan elektrik secara maksima. Boleh dipercayai, kelajuan dan pemilihan adalah ciri-ciri yang diperlukan oleh geganti pelindung. Geganti numerikal memainkan peranan yang penting dalam beberapa fungsi automasi pengagihan. Geganti numerikal juga berupaya berhubung dengan peralatan-peralatan yang lain Transformasi merupakan suatu alat yang mahal dan juga

merupakan jumlah pembelian yang terbanyak dalam sistem transmisi dan pengagihan. Geganti jenis gas atau geganti bucholz juga merupakan satu alat yang penting sebagai penunjuk amaran bahawa kerosakan mula berlaku. Sejurus itu tindakan memberhentikan operasi dilakukan untuk melaksanakan kerja baikpulih sebelum kerosakan yang lebih teruk berlaku. Untuk litar-pintas dan kerosakan dalaman transformasi, geganti pelindung pembeza atau DPR selalunya digunakan. Dalam projek ini, program komputer jenis SABER digunakan untuk merekabentuk DPR mengunakan komponen digital. Fokus dalam projek ini adalah untuk melindungi 33/11kV transformasi delta-wai apabila berlakunya kerosakan dalaman atau litar-pintas. Tiga pakej digital DPR telah direka untuk melindungi transformasi delta-wai apabila kerosakan dalaman berlaku. Terdapat beberapa masalah dihadapi dalam projek ini dimana dalam pengunaan SABER, 1) adalah sukar untuk menetapkan nilai dalaman yang tepat untuk transfromasi delta-wai, agar voltan keluaran bahagian wai diperolehi juga adalah tepat, 2) penjanaan elektrik jenis 3-fasa tidak boleh melakukan perubahan terhadap faktor kuasa atau p.f., dan 3) apabila suis pemisah-litar beroperasi, renjatan elektrik akan berlaku dan menyebabkan kerosakan pada komponen-komponen sistem kuasa elektrik. Untuk menggurangkan renjatan elektrik daripada nilai maksima yang dibenarkan, maka suis pemisah-litar bukan sahaja beroperasi sebagai suis tetapi juga sebagai perintang. Perintang yang terdapat pada suis pemisah-litar diandaikan sebagai penyah-ark, agar renjatan elektrik dapat dikurangkan. Jadi hasil yang diperolehi dalam projek ini, bukan saja untuk melindungi transformasi delta-wai apabila kerosakan atau litar-pintas berlaku, tetapi berupaya mengurangkan renjatan elektrik semasa suis pemisah-litar beroperasi.

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CHAPTER 1

INTRODUCTION

Automated substations are becoming increasingly important subject for the power utilities as well as for the electricity generation and distribution With the increasing load density of networks, it is becoming more important to consider more elaborate designs with local automation and recording of information. The main goal for these customers is uninterrupted, high quality and cost-optimised power supply, by obtaining a better performance and to improve the reliability of supplies to customers, by faster clearance of faults and restoration of supplies The substation automation concept is based on a distributed system for automated protection, control and monitoring of power transmission and distribution substations.

The capital investment for generation, transmission and distribution of electrical power is so great that the proper precautions must be taken to ensure that the equipment not only operates as nearly as possible to peak efficiency, but also it is protected from accidents [1] The normal path is from the power source through conductors in generators, transformers and transmission lines to the load and it is confined to this path by insulation The insulation however may be broken down, either by the effect of the temperature and age or by a physical accident, so that the current then flows an abnormal path generally known as short circuit or fault Whenever this occurs the destructive capabilities of the enormous energy of the power system may cause expensive damage to the equipment, serve drop in voltage loss of revenue due to interruption of service.

The purpose of protective relays and relaying system is to operate the correct circuit breakers so as to disconnect the faulty equipment from the system as quickly as possible thus minimizing the trouble and the damage caused by the faults when they do occur With all other equipment it is only possible to mitigate the effects of short circuit by disconnecting the equipment as quickly as possible, so that the destructive effects of the energy into the faults may be minimized Hence it is obvious that reliability, speed and selectivity are the most desired qualities of a protective relays There are many types of relay used for power transformer protection such as electromechanical, solid-state (analogue and digital) and numerical

Electromechanical relays that are commonly used in protection are attracted armature, moving coil, induction and motor operated Attracted armature relays are the simplest class and the most extensively used [2] It operates by the movement of a piece of iron into the field produced by a coil Moving coil relays are based on the ' motor' action of a current carrying conductor in a magnetic field produces a moving coil instrument and relays The moving coil instruments is a rotary movement comprising a short coil pivoted on an axis in its plane so that it is free to rotate between the poles of a permanent magnet Induction relays are based on shifting by field effect Induction relay comprises an electromagnet system that operates on a movable conductor usually in the form of a metal disc Torque is produced by the interaction of two alternating magnetic fields which are mutually displace both in space and phase In the induction relay, the upper and lower electromagnets can be energised by separate quantities and produce corresponding fluxes which satisfy the spatial displacement requirements and produce torque on the disc Motor-operated relays are a miniature motor that can be used to perform relaying function The operations of motor-operated relays are equivalent to the instance of induction relays operation

Solid-state relays comprise of two components, analogue and digital. Solid-state relays give several potential advantages, among which are,

a) due to the amplification of energising signals obtainable, the sources need only provide low power. Therefore the size of the associated current and voltage transformers could be reduced,
b) the accuracy and hence selectivity could be improved,
c) the fast response of the circuits could give fast tripping and clearance of faults,
d) the flexibility of circuitry would allow new and improved characteristics, and
e) the relays would be unaffected by the number of operations.

Solid-state relays conventionally based on the operation principles of level detector, polarity detector and phase comparator. Solid-state relays require lower burdens than electromagnetic relays but need to have less accurate characteristics because of feedback between the inputs This limitation can easily be overcome by amplifying the output of the comparator

Electromechanical and solid-state (static) relays have been almost completely phased out because numerical relays are now preferred by the users due to their distinctive advantages [3]. The use of microprocessor-based relay or numerical relays, which can measure a number of input signals to derive the required operating sequence fault condition, as well as having in-built self-checking facilities, has resulted in sophisticated protection and fault-clearing schemes being developed. Increasing use of microprocessor logic-controlled sectionalisers is removing the dependence on utility control staff intervention, leading to more rapid isolation of faults and restoration of supplies [4]. Using suitable computer hardware and programs, network configuration can be automatically re-arranged on the occurrence of faults to minimise the consequences of further system outages. The microprocessor components integrated with RAM and ROM devices, and software programs make up basic unit in microprocessors relay design. Smart microprocessors are now available for control and protection. They are intelligent and surpass the performance of their conventional predecessors by far, and are at the same time highly available due to inherent self-monitoring capabilities. The evolutionary growth in the use and application of microprocessors in the substations has brought the industry to the point of considering integrated substation protection, control and monitoring system, or SCADA (Supervisory Control and Data Acquisition) [5]. Hence substation automation compromise a prototype of an intelligent controller which is equipped with many facilities to perform monitoring and control functions in substation [6]. They can communicate with each other and with higher control levels (SCADA) and provide valuable data for more effective and secure system operation.

It would be ideal if protection could anticipate and prevent faults but this is obviously impossible except where the original cause of a fault creates some effect which can