IMPACT OF DISTRIBUTION GENERATION ON AN OVERCURRENT PROTECTION IN POWER SYSTEM NETWORK

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DECLARATION

"I declare that this thesis entitle "Impact of Distribution Generation On An Overcurrent Protection in Power System Network" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality as a partial fulfillment of Master of Electrical Engineering.

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DEDICATION

To my beloved mother and father

ABSTRACT

In power system network, protection system is an important element that needs to be concerned because it is able to detect the presence of interference and can prevent damage from occurs. The protective device is needed to isolate the fault element quickly as possible to keep the healthy section of the system in normal operation when the faults occur in the power system network. The protection system can improve the reliability of the system to maintain the continuity of supply to the load. Overcurrent protection is among the important protection scheme on the power system network. The basic element of the overcurrent protection is overcurrent relay. An overcurrent relay will operate when the current exceeds its pick up value, but some problems have been raised due to the overcurrent relay fails to operate in the presence of a fault. The aim of overcoming the problems is by taking into the consideration of relay operation time of overcurrent protection for the power system network. The relay operation time will be analyzed. PSCAD software has been used as simulating tools to validate the model and analysis of the overcurrent protection system. The overcurrent protection analysis indicates the protection, performance based on the type of relay characteristic curve (standard inverse, very inverse and extremely inverse), type of fault applied (single line to ground, double line to ground and three phase to ground fault) and location such as source 132kV, grid 33kV, load 33kV and load 2 (11kV). Besides, the characteristic curve standard IEC 60255 and IEE C37.112 are used in order to analyze the effect of relay operation time. The result will be studied in order to understand the performance of the overcurrent protection system in the power system network.

ABSTRAK

Didalam rangkaian sistem kuasa, sistem perlindungan kuasa merupakan perkara yang perlu dititik beratkan kerana ianya berfungsi mengesan kehadiran sesuatu ganguan dan mampu mengcegah kerosakan daripada berlaku. Peralatan perlindungan amatlah penting bagi mengasingkan kerosakkan daripada berlaku secara pantas bagi menggekalkan perlindungan sistem yang selamat dan mampu beroperasi dalam keadaan normal sekiranya kerosakkan berlaku. Secara tidak langsung, dapat meningkatkan tahap keberkesanan sistem dalam memastikan kesinambungan belakan elektrik kepada beban secara terus. Perkara asas dalam perlindungan arus lebih adalah geganti arus lebih. Geganti arus lebih akan beroperasi apabila arus elektrik yang mengalir melaluinya melebihi had arus yang telah ditetapkan. Tetapi beberapa masalah telah berlaku kesan daripada geganti arus lebih yang gagal beroperasi apabila keroskan berlaku. Matlamat utama dalam mengatasi masalah ini adalah mengambil kira masa operasi gegenti dalam sistem perlindungan arus lebih di rangkaian sistem kuasa. Masa operasi geganti akan dianalisis. Perisian PSCAD akan digunakan dalam memodelkan dan menganalisis sistem perlindungan arus terus. Perlindungan arus terus akan dianalysis mengikut perlaksanaan perlindungan berdasarkan jenis-jenis kriteria geganti (geganti masa tertentu, geganti masa sangat songsang dan geganti masa lampau, jenis-jenis kerosakkan dan tempat-tempat yang berlaku seperti sumber janakuasa 132kV, grid 33kV, beban 33kV dan beban 2 (11kV). Walaubagaimanapun, kiteria geganti akan mengikut standard IEC 60255 dan IEE C37.112 bagi menganalysis berdasarkan kesan masa operasi geganati. Keputusan kajian yang diperolehi daripada simulasi yang akan dikaji dan difahami berdasarkan prestasi geganti dalam sistem perlindungan.

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A	-	Ampere
AC	-	Alternating Current
DG	-	Distribution Generation
EG	-	Embedded Generation
GTO	-	Gate Turn Off thyristors
HV	-	High Voltage
IDMT	-	Inverse Definite Minimum Time Relays
IEC	-	International Electrotechnical Commission
LV	-	Low Voltage
MTCP	-	Metacorp
MV	-	Medium Voltage
PMU	-	Pencawang Masuk Utama
PSCAD	-	Power Systems Computer Aided Design
PSM	-	Plug Setting Multiplier
RTT		Relay Tripping Time
SI	-	Standard Inverse
SLG	-	Single line to ground

TD	-	Time Dial Setting
TLG	-	Three Line to Ground Fault
TMS	-	Time Setting Multiplier
TNB	-	Tenaga Nasional Berhad
WECS	-	Wind energy conversion systems
V	-	Voltage

CHAPTER 1

INTRODUCTION

1.1 Background

Distribution generation (DG) is important for electricity in the world, especially for the next generations in order to become sustainable users. Distribution generation is an electric power source connected directly to the distribution network or on the customer side of the meter[1]. DG used a new approach and technologies that generate electricity by using renewable energy such as solar photovoltaic (PV) modules, small wind turbines (WT), other small renewable (such as biogas digestors) and combined heat and power (CHP). Other than that, the used of DG within distribution system is followed the latest governmental policy change from "conventional" energy to "green" energy[2]. High levels of penetration of DG have significant benefits but also come with many drawbacks especially in protection schemes.

So, the protection scheme of the power system network becomes important issues that must considered after installed distribution generation especially when overcurrent occur. Therefore, DG must adapt to existing scheme or DG must have sufficient protection to figure out that something is going wrong with the utility system and disconnected promptly to allow the normal utility fault clearing process to proceed. The protection methods have been chosen to achieve satisfactory protection at acceptable costs due to the expensive costs that installed on the distribution system.

Overcurrent happens when current flow is larger than the allowable rated current through the circuit. It is leading to unnecessary generation of heat risk of fire or damage. Therefore, overcurrent protection is needed in order to protect human life and equipment. Improvements of overcurrent protective devices configuration and setting can improve utility, reliability by minimizing the effect of faults on the customer and also distribution side. Overcurrent protection is the relay will picks up and disconnected the circuit when the magnitude of current exceeds the pickup level. The basic element in overcurrent protection is overcurrent relay.

1.2 Problem Statement

Distributed generation (DG) is predicted to play an increasing role in the electric power system in the near future. Distributed generation is by definition that which is of limited size and interconnected at the substation, distribution feeder or customer load levels. In future, the power system network becomes an active and conventional protection turns out be unsuitable. This increase causes a lot of problems to the existing protection devices in the network, the type of protection defect depends on the situation of the DG and where it is placed in the network as the penetration of DG changes the configuration of the network parameters. The connection of DGs has the potential to create problems for power system protection mostly during short circuit faults[3], [4].

Protection issues that become more concerned in the future when DGs installed on distribution system include protection grading failure, unwanted islanding, sympathetic tripping, reduced reach of impedance relays and short circuit and fault level[5]. This paper focuses on the particular problem of sympathetic tripping which is a relatively common protection on the distribution level especially installing distribution generation.

Sympathetic tripping is widely quoted as representing a challenge for protection of networks with DGs. This tripping occurs due to one device detecting the fault while it is out of its local protection area and tripping before the required tripping device. This type of tripping causes the isolation of a healthy part of the network while it is not required to be isolated, and this reduces the reliability of the distribution network.

1.3 Objectives

The objectives of this project are:

1. To investigate and simulate he phenomena of sympathetic tripping by using PSCAD software.
2. To analyze the relay operation tripping time (RTT) and time grading of overcurrent protection relay during fault with and without DG in operation.
3. To examine the change in distribution generation locations at 3 different location which at Feeder 1 (Load 33kV), Feeder 2 (Load 1 11kV) and Feeder 3 (Load 2 11kV) towards sympathetic tripping.
4. To compare the result of RTT with DG and without installation DG.

1.3 Scope of Research

The project totally focused on the impact of distribution generation on the overcurrent protection in the distribution power system. The scopes for this research are specially detailed as follows:

1. To analyze the different location of distribution generation in a power system network, which at distribution and transmission system

2. The faults applied are single-line-to-ground fault (SLG) and three-line-to-ground fault (TLG) only.

3. To analyze the delay of relay tripping time (RTT) depends on 3 different locations of distribution generation which is 2 points at distribution system and 1 point at transmission system.

4. The IDMT characteristic curve was choses in IEC 60255 standards.

5. The analysis is done in PSCAD software.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Distributed generation (DG) becomes more and more important in recent years, since bold actions are necessary to ensure the needs of future generations and to reduce fossil fuel consumption. Using renewable sources for producing energy plays an important role to achieve sustainable development. In the European Union, there is a 2020 target of 20% of final energy consumption from renewable sources and a target to reduce greenhouse gases from energy production by 80-95% by 2050[6]. The trend of increased connections of distribution generations is likely to continue in the future and had been widened over the world. The majority of modern distribution generations connected to the power system are inverted-interfaced on solar photovoltaic and nearly all emerging energy storage technologies that used for stabilization purposes.

The connection of distribution generations has the potential to create problems for power system protection. With distribution generation, the network get active and conventional protection turns out to be unsuitable. It is because of the protection system design in common MV and LV distribution networks is determined by passive paradigm, i.e no generation expected in the network. Passive network means distribution system are planned to carry the power unidirectionally from the central generation (HV level) downstream to the load MV/LV level. The key issues concerning DG applications include grading failure, unwanted islanding, reversed power flow and voltage profile and sympathetic tripping.

The selection of protective equipment used in electrical power system is based on the working voltage, the ability of the circuit when full-load current through it and the prospective fault level at the location where the equipment and distribution generations is installed. The fault level will refer the fault current that flow through the equipment when a short circuit occurs in electrical power system and/or distribution generations.

2.2 Distribution Generation

Distributed generation is an electric power source connected directly to the distribution network or on the customer side of the meter. Distributed, dispersed, decentralized or embedded generation (DG, EG) are keywords for an upcoming probable paradigm shift in electric power generation. Distribution generation include fuel cells and renewable power generation methods such as wind, solar, or low-head hydro generation, heat and electricity storage and controllable loads are expected to play a significant role in future electricity supply. Indirectly, the penetration of DG ability to greenhouse gas emissions reduction targets (typically based on Kyoto Protocol), or otherwise substantially reduces carbon footprint.

However, many distributed power sources have some characteristic in common:

- Distributed generation rating is small compared to conventional power plants,
- Privately owned,
- Not centrally dispatched,
- Connected to MV and LV distribution networks
- Not contribute to frequency or voltage control,
- And usually are not considered when the local grid was planned. Hence, there are infrastructural needs as, for example, means of communication.

The combined of distribution generation will produce microgrid or in other word the power system become smart grid which distribution system part able to generate electricity.

2.2.1 Type of Distributed Generation

Renewable or non-conventional electricity generators employed in DG systems are known as distributed energy resources (DERs). One major aim installing DG in power system network is DER produce low-carbon which helps to reduce environmental pollution by generating clean power [7]. DG can be classified into two major groups such as inverter based DG and rotating machine DG. Usually inverters are used in DG systems after the generation process, as the generated voltage may be in DC form or AC but it is required to be changed to the nominal voltage and frequency so it has to converted first to DC then back to AC with the nominal parameters through the rectifier.

2.2.1.1 Solar Photovoltaic (PV) System

Solar photovoltaic (PV) system is an environmental friendly system as it has no emissions, sustainable nature of solar energy as fuel, minimum environmental impact, long functional lifetime of over 30 years with minimum maintenance and able to reduce customers' electricity bills due to free availability of sunlight. Nowadays, this type of DERs becomes a trend due to advancement technology with to potential to supply a significant part of the world's energy needs in a sustainable and renewable manner. Many organization such as governments, environmental organizations and commercial organizations honored to invest due to extensive improvement especially in inverter technologies.

Besides, a large number of cells are arranged in series-parallel combination to produce PV arrays or modules of higher voltage and power rating due to the voltage and current output of a single cell are very small. Most PV modules are equipped with maximum point tracking (MPPT) systems that maximize the power output from the modules by shifting the operating point depending on the solar irradiance. There are many types of PV cells, which are monocrystalline silicon, multicrystalline silicon, thin-film silicon and hybrid [7].

2.2.1.2 Fuel Cell

A fuel cell converts chemical energy of a fuel directly into electrical energy. It consists of two electrodes (an anode and a cathode) and an electrolyte. The operation is similar to that of a storage battery except that the reactants and products are not stored, but are continuously fed to the cell. During operation, the hydrogen-rich fuel and oxidant (usually air) are separately supplied to the electrodes. Fuel is fed to the anode and oxidant to the cathode, and the two streams are separated by an electrode-electrolyte system. Electrochemical oxidation and reduction take place at the electrodes to produce electricity. Heat and water are produced as by-products. Figure 2.1 below shows the basic construction of a fuel cell.

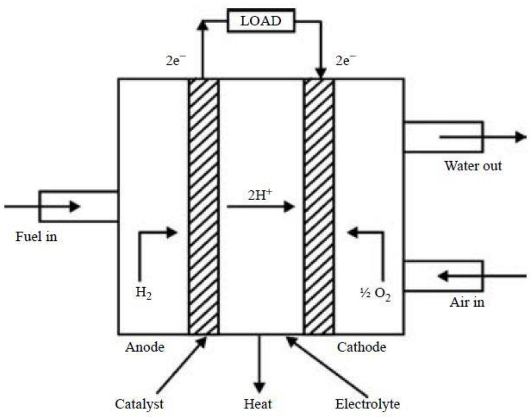

Figure 2.1: Basic construction of fuel cell [7].

2.2.1.3 Wind energy conversion systems (WECS)

Wind energy conversion systems (WECS) convert wind energy into electrical energy. The principle component of WECS is the wind turbine. This is coupled to the generator such as induction generator through a multiple-ratio gearbox. The main parts of a wind turbine are the tower, the rotor and the nacelle. The nacelle accommodates the transmission mechanisms and the generator. Rotor may have two or more blades. Wind turbine capture the kinetic energy of wind flow through rotor blades and transfers the energy to the induction generator side through the gearbox. The generator shaft is driven by the wind turbine to generate electric power. The function of the gearbox is to transform the slower rotational speeds of the wind turbine to higher rotational speeds on the induction generator side. Supervisory metering, control and protection technique is used to maintain the output voltage and frequency within specified range. There are two types of configuration wind turbine such as horizontal axis configuration and vertical axis configuration [7].

2.3 Protection System

Nowadays, electrical system is huge system that need to focusing more because if any failure and not appropriately controlled occur, it will damage the equipment even innocent life. Protection system is important role in order to detect efficient and continuous precondition of power system. Besides, protection system also must be able to detect and operate if there are any abnormal condition occur on that system and able to minimize the negative impact that maybe happen.

The protection system must be able to eliminate such condition by isolate the smallest portion of the system and possible operate in shortest time[8]. This is because to prevent injury to person and to prevent damage on equipment because high voltage equipment are very expensive.

Protection system has three basic components such as instrument transformers, relays and circuit breakers. The relays are supposed to monitor continuously system parameter (current, voltage, frequency, power, etc) and has to do with supreme selectivity, sensitivity and speed. Besides, the relay must be able to operate quickly when necessary, no operating faultily and able to controls a circuit breaker. The best relay must have a good sense in order to ensure quick and reliablility operate on the power system.

Protection relays will activate only after an abnormal or fault situation that has occurred and monitor the current or voltage of the power system to detect problems with the power system. Current and voltages to relays are supplied via current transformer and potential transformer. This protection does not mean that protection relays can prevent problems. So, there are five aspects which are;