TWO WAY POWER FLOW IN ADVANCE DISTRIBUTIONS AND MICRO GRID

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ABSTRACT

The Power Flow is most important issue to ensure an efficient yet affordable system. To maintain a low failure electrical breakdown or blackout times can be too subjective if a new approaches or solution and idea is never be made to improve it. Nowadays, a Two Way Power Flow has played a big role in this issue.

One day, a retro and old technique generation in example coal-fired generator that used by IPP (Independent Power Plant) or TNB is not to be available anymore due to its difficulty to find a raw material. An alternative ways has been come out through the global IEEE conferences worldwide and a replacement and suggestion of renewable energy being a good solution to overcome this problem.

With this two way power flow or known as bidirectional power flow, an advanced and complex system will be introduced. Main consideration to focus is totally based on the electrical equipments and power cables. Transformers would having a problem to adopt this scenario since it only capable to do 1 way power flow either step up to step down or step down to step up voltage.

The objective of the project is to perform simulation via PSSE and analysis the data via MATLAB for Two Way Power Flow In Advance Distributions and Micro-Grid. This project aim is to apply concept of Two Way Power Flow in a real case with an additional of Micro-Grid in the system. In this thesis, there will be further explanation about Advance Distribution, Micro-Grid, Renewable Energy, Distributed Generator (DG), Electrical devices and Voltage stability.

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CHAPTER I

INTRODUCTION

1.1 General Background Of Distributions Network

Distribution network is the end of transmission and distribution systems, directly facing the majority of electricity customers, so the reliability of the distribution network directly relates to the satisfaction of customers' needs, and also presents the quality and management of the planning, design, equipment selection, construction and production of the power system.

The factors that directly Impact the reliability of the distribution network are power failures, which are divided into faults- related power failures and pre-arranged outage. Pre arrangements can be divided into scheduled power outage and temporary power outages. Scheduled power outage can be subdivided into repair power outage and construction of power outages, and user application outage. Temporary power outages divided into temporary repair power failures and temporary power failure for construction and temporary application. Different measures and methods are used to solve different power failures. The power failures with related to faults. Though unavoidable, to some extent can be minimized through effective methods. [1]

However, to improve the reliability of the distribution network is also an important aspect that power system is working on and paying attention to, especially when during the highly developed information technology time, the urban customers more and more depend on the incessant of the supply of electricity.

Network structure of distribution network and equipment status plays important roles on the reliability of the supply. Whether it is a power failure related to fault or it is pre-arranged power outages, it should minimize the scope of power failure. Network structured play a key role in minimizing the power failure which is an objective factor. [2]

1.2 Hot-line work on improving the reliability of the power supply

Hot-line work is one of the most effective methods on improving the reliability of the distribution network. Hot-line work now develops fast and we have more than 20 projects right now which include the replacement of suspension type bottles with loads replacement drop insurance with load, replacement for additional switches with load, setting poles, poles withdrawal, large-scale Bypass live working, etc. Large-scale live "bypass working method" is a new technology in hot-live work, under the highly developed information technology time, because of its unique charm of zero power failures and perfect combination of hot-line work, largely replaced the traditional the blackout mode of operation, infiltrated all aspects of electricity supply industry.

But the development of the hot-live work is subject to geographical constraints. There are more distribution network and poles, the existence of compact lines. And with the development of the cables with cities, hot plug cable and large scale bypass operation do not be started because of financial and technical factors which also limit the development of hot-line work. So the design, planning, construction and operation of the network distribution should consider the hot-line work. [2]

1.3 Comprehensive Maintenance Mode in improving the reliability of power supply

Regional Comprehensive Maintenance is "repair for every stop, replacement for every stop" work principle, it is the coordination of the large scale operation and small scale operation and the combination of planned maintenance and status maintenance. Whenever encountered required power outage, power failure, without increasing the power failures, there is a need to overhaul all the devices in the blackout area.

The implementation of integrated, comprehensive overhaul, scientific use of the principle of co-ordination method and barrel, comprehensive utilization of the integrated approach is very effective to reduce the interruption frequency and interruption duration, and even in a certain period of time to eliminate the duplication of power failure. [3]

The barrel water storage depends only on the minimum number of boards, so the reliability of each line of the distribution network depends on the worst line of equipment or accessories. In example, replacing the conductor of a line, various types of work will happen at the same time: pruning trees under wires, new utility distribution transformer, circuit breakers, replacement of defective pole, line switch, knife, clamp the replacement equipment maintenance, replacement of high voltage lightning deflectors, transformation of low-voltage power box, and transformer oil cleaning, ground equipment reconstruction, fastening bolt connections, meter rotation etc. [3]

The adoption of regional comprehensive overhaul, make once a power failure occurred, can complete the whole year tasks in the power failures areas. Major projects cover a range of small projects, not only reduce the outage time, and significantly reduce the interruption frequency, so that all defects within the blackout area, and the hidden dangers also been completely removed, which greatly improved the overall health of lines and equipment standards, also put an end to the repeated power failures because of the repair tree, new equipment or eliminating defects such as power outages caused by duplication. If such a regional maintenance mode is promoted throughout the country, we will achieve a qualitative leap in the reliability of power supply, after decades of the reconstruction of the Urban Network equipment, it has high promotion value. [3]

1.4 Ring switching operation

Switching operation in distribution network is quite frequently. Normal load transfer before construction, fault isolation after fault with troubleshooting load transfer and final recovery of whether can take ring switching operation to transfer load is determined by the structure of distribution network, so the structure of distribution network has a great impact on the reliability of power supply. Before the ring switching operation, need to calculate the closing loop and check the phase sequence of the network, in order to prevent wrong operation. Closing loop operation may result a ring circulation, increase the line loss.

For instance, urban network 10kv line, between the two substations there is only one interconnection switch to take the closing loop operation and the time controlled within 10 minutes, the bus terminal voltage of the closing loop is no more than 0.1 KV, under this condition, it can have ring switching operation. Once the line phase sequence is correct, it will be more effective, but if construct, repair or adjust phase, we need to recheck it before we supply. [4]

1.5 Advanced Distributions

To achieve the system security and stability, maintenance of high service quality and enable high penetration of renewable power generation in the power system. With the advancement of information and computer technology (ICT), the smart distribution becomes more cost effective by applying the wide area monitoring and control to increase the system controllability. Besides, it provides more flexibility for distribution system operation and maintenance by advanced management of distribution assets.[5]

Distribution grids need data and systems to drive safe and reliable operations. As SCADA, distribution automation, and outage management systems prove, dramatic improvement in grid efficiency and reliability can be achieved through increased real-time analytics driven by larger data volumes. Utility modernization and related Smart Grid projects increase the volume and variety of grid management data available by hundreds-potentially thousands-of orders of magnitude. Legacy applications for grid operations are generally not equipped to handle even the increase in data from today's smart meters and sensors, much less maximize data use for optimal grid performance. A new set of functions is emerging to respond to this challenge Advanced Distribution Management (ADM). ADM organizes and analyzes the enormous volumes of new near-real-time data, then uses this data to achieve goals: [6]

- Decreasing the number and length of outages by using self-healing unfaulted circuit sections to restore customers automatically.
- Integrating larger amounts of intermittent renewable generation into the grid.
- Supporting electric vehicle recharging.
- Managing micro grids and virtual power plants.
- Supporting demand reduction programs.

ADM can connect between grid modernization technology initiatives such as distributed resources, and utility operations technologies, and beyond-the-meter customer energy technologies to a utility's real-time information-rich distribution network.

1.6 Utilities are using advanced Distribution management

A number of utilities are enhancing safe and reliable automated operations by building out their Outage Management System (OMS) electrical connectivity model with full engineering impedance model attributes to run real-time load flow optimization functions and link to SCADA. This ensures operational safety through use of a common network model, along with tagging, clearance and switching logs. [7]

1.6.1 Asset Analytics

Other utilities are finding near real-time asset analytics used with ADM minimizes outages. ADM can, for instance, gather temperature, loading, and operational history at device locations, use a device model to recalculate expected life in light of its operational history, and alter grid operations, such as dynamic ratings and load-transfers in order to minimize negative consequences.

1.6.2 Self-Healing Fault Restoration

A number of utilities can automatically minimize the impact of outages using self-healing capabilities like Fault Location, Isolation, and Service Restoration (FLlSR). FLISR reduces the number of customers affected by an outage by automatically sensing faults and circuit lockouts to identify and isolate the faulted circuit sections. It then restores power to all of the unfaulted circuit section's affected customers by automatically switching them to adjacent sections of the line.

1.6.3 Optimize Reliability

ADM might, for instance, forecast what the circuit loading will be during the peak hours of the day and identify any overload equipment or lines. Then ADM could generate an optimal switching plan to relieve the overload by transferring loads to adjacent circuit sections with available capacity. Automated switching could be done by a click of the button, with manual switching scheduled and dispatched.

1.6.4 Reduce Distribution System Losses

In a process called volt/var optimization, ADM calculates the amount of active and reactive power on a line. It then reduces the effect of the loss-producing reactive power by switching on devices like capacitor banks in locations close to the loads consuming the reactive power (e.g. electric motors, fluorescent lights).

1.6.5 Reduce Demand Through Conservation Voltage Regulation (CVR).

CVR is an extension of volt/var optimization used to fine-tune the end-use customer voltage levels toward the lower-end of service voltage standards. Many smart grid business cases have found CVR to yield major benefits, especially when utilities operate under a regulatory mechanism that incents load reduction to improve overall grid efficiency. Without such incentives, CVR ultimately reduces revenue. Manage Distributed Intelligent Devices. These may include smart switches, sensors, controls, substation automation, and micro grid controllers that need a simplified model of electrical connectivity in order to optimize their distributed processes.

1.7 Problem Statement

The generating plants are built recently where primary energy sources are plenty for future expend.The stations are far away from city where they are connected with high voltage transmission network to transport the transformed energy in electrical form to load centers. The next generation of power grid i.e., smart power grid some more complexity are going to introduced. Most importantly, there will be two way power flows. [8]

The grid features would be having lots of nodes that leading to an advance system with the inclusion of renewable sources instead of smart meters technology. Various intricate social behaviors like flocking, swarming and human psychology will also be integrated with the grid more and more. This is a turning point where leads to advanced and effective power flow.

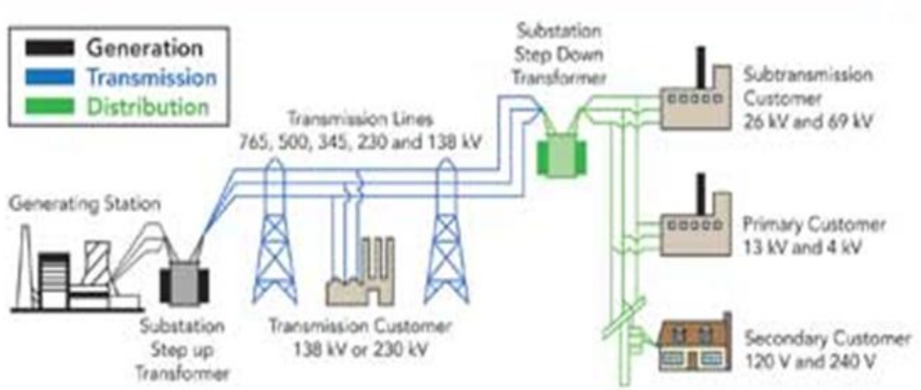

Figure 1: Power system flow

1.8 Power System Flow

Power system can categorized as the most complex human-made system and its complexity is increasing day by day. In the other hand, a typical power system consists of generation, transmission, distribution and loads side.

For instance, in substations the voltage is reduced and distributed through medium/low voltage distribution network. Consumers or loads are at the end of the distribution system. This is what a typical scenario of complex power grid where the demand and supply needs to be balance very carefully. [8]

1.8.1 Power Flow Control

Power flow control, should be designed to having features such as it ensures reliability, affords economy of operation using optimum generation and uses low cost generation. The control of active power and reactive power is important part for satisfactory performance of power systems. As a result, the frequency should remain nearly constant. A micro-grid can operate smoothly by controlling the generating capacity as needed to match the load demand.

Constant frequency and voltage determine the quality of power supply. This ensures constancy of speed of induction and synchronous motors. The frequency of systems is dependent on active power balance. As frequency is a common factor in the system, a change in active power demand at one point will reflected throughout the system by a change in frequency. Generation and frequency can be controlled by using Load Frequency Control (LFC) while optimum generator operation is set by Automatic Generation Control (AGC). [9]

A speed governor on each DG unit provides the primary speed control function (LFC), while supplementary control (AGC) allocates generation. The electrical torque output Te of the generator is reflected instantaneously when there is a load changes.

Figure below shown power flow control in a micro-grid consisting of several DERs (dispatchable or non-dispatchable) and loads (controllable and non-controllable). The PET allows a restricted active power supply Pgrid from the main power grid to the micro-grid, at the PCC. [9]

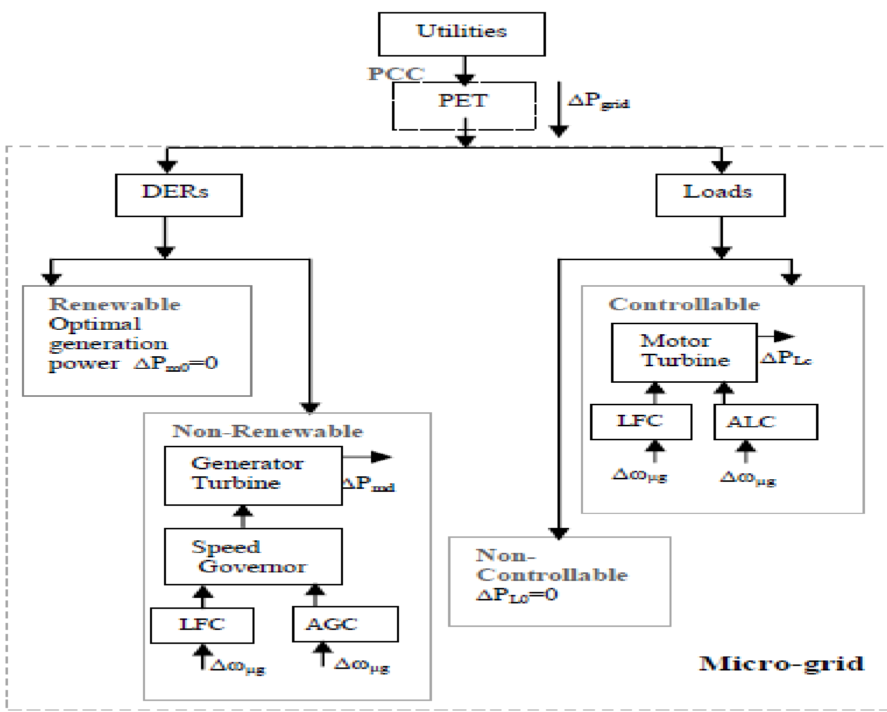

Figure 2: Power Flow Control

1.8.2 Two Way Power Flow

A two way power flow system is defined when there is a 'bidirectional flow' in aspect of voltage flow, current flow, active power flow (P), reactive power flow (Q) and apparent power flow (S) at a point of the sending end, receiving end, bus bar and nodes of the grid system.

The advantages of this bidirectional power flow is, if the generator fail to generate the power to the system or in other words there is a power outage occurring at the national grid, there is still a back up components that called as renewable energy such as solar energy system and wind energy system even though the generated power by the system is not as higher as primary generator.

The figure below show an example of simple bidirectional power flow or in other word called two way power flows.

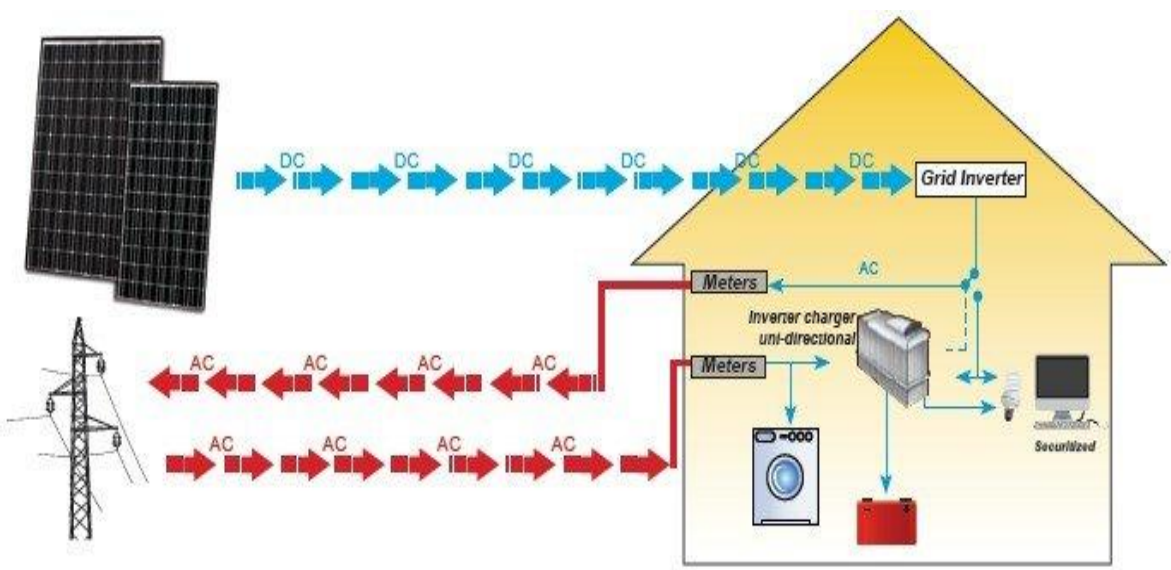

Figure 3: Two way power flow system

The two ways or bidirectional power flow changes the whole power flow pattern of the existing grid. Analytical methods, technical strategies, control system and protecting devices need to be changed along. Metering and protecting equipments will experience flows coming from the reverse side. Proper operation of the equipments used earlier can be ensured either by changing the instruments themselves or by incorporating new measurement techniques.

Power grid topology has been analyzed recently to explore its strength and weakness using complex network framework. The strength of the grid is found to be, from a pure topological analysis of power grid, small-world property. This implies that various nodes within the system can be reached easily, which will make the communication that comes along with the smart grid easy and effective. The scale freeness of the topology of the grid is shown to be a weakness of the grid since it makes the system very much vulnerable to targeted attack. This targeted attack can trigger cascading failure which will lead to blackout. [10]

The research on power grid from a system point of view has been triggered after the preliminary topology based analytical results. Since results from pure topological approach is quite misleading, several researchers have a mix of both topological and electrical characteristics based complex network analysis of power system to find reasonably improved results.

Based on analytical results, that found the power grid robust against random failure but vulnerable to targeted attacks, critical node and link analysis of power grid have been carried out to explore the criticality of the power grid. If critical components can be spotted out which can initiate cascading effect, special preventive actions could be exercised to prevent large scale blackouts from happening.

Network efficiency, a topological measure of performance change after the inclusion or removal of nodes or lines from a grid, is analyzed in. A weighted line betweenness based approach is utilized to find out critical lines responsible for spreading of large scale blackouts from small initial shock. Vulnerable region of power system is identified employing complex network theory based on qualitative simulation. [11]

A link is explored between power system reliability and small world effect. Maximum flow based centrality approach is used to find out critical lines which removes the shortcoming of the assumption of power flowing through the shortest paths between source and load nodes. The flow based method has slow convergence but can be useful when used in conjunction of planning issues. A DC power flow model is used and hidden failure of protective equipment is considered to model the structural vulnerability of power grid. Electrical parameters are incorporated extensively to improve the centrality indices for power system. An extended topological approach proposed in takes into consideration traditional topological metrics as well as operational behavior of power grids like real power flow allocation and line flow limits. [11]

Factor (PTDF) is used to simulate cascading event in an attempt to identify correlated lines. All these analysis are carried out mainly on non directional models where the direction of power flow has not been considered. But since with the inclusion of distributed generations the power flow pattern is going to change, new methodologies have to be proposed which take into account bidirectional power flow. Since communication is an important factor in smart grid, identifying those nodes in the system would be very much useful which are important for communication.

Bidirectional power flow based centrality measure has been proposed in a closeness based centrality measure considering bidirectional power flow have been analyzed in while focuses on betweenness based variant. A comparison of the bidirectional flow based method has been made with non directional power flow based method. This method is a modification of closeness centrality which takes into account power flow distribution among various transmission lines during steady state. This is a reasonable extension of previous work carried out since it captures the power flow in smart grid environment. [12]

1.8.3 Measure of Impact

The nominal network is solved and nodes are removed from the system one by one in the descending order of centrality measure. In order to measure the impact of removing critical nodes from the system various measures are being used. The first two of them, path length and connectivity loss are purely topological. The last measure is percentage of load lost due to the removal of critical nodes.

A. Path Length

The path length is used as a measure of network connectedness. It is the average length of the shortest paths between any two nodes in the network. It is found that if a node is removed from a system, it generally increases the distance between other nodes. So, the increase in network characteristic path length is considered as a measure of impact analysis of removing critical nodes from the system. Distance between two vertices can be computed as:

$d(u; v) = min|P|$ (3)

where P is a path from u to v. Path length can be defined as:

$d = \frac{1}{k} \sum_{u \neq v \in V} d(u; v)$ (4)

where $0 \leq d(u; v) \leq \infty$. k is the number of connected pairs.

This is topological path length. Another electrical path length is also measured where the distance is computed in terms of impedance of transmission lines. It is clear that the impact of removing critical nodes based on bidirectional flow rather than bidirectional flow model is comparatively higher. Initially the impact is higher in nondirectional measure but after four nodes removal the bidirectional model shows impact in large scale. Electrical path length based measure shows similar characteristic. In the later measure the impact is always higher in bidirectional flow model.[13]

B. Connectivity Loss

This is a purely topological measure of impact a power grid encounters when some nodes are removed from the system. In this measure we calculate how much connectivity is lost in terms of how many generators a transmission or distribution node can access due to effect of removing a node from the system. The less is the number of generators a node is connected with, the less is the redundancy and the more is the vulnerability of the node. It is given as originally proposed in.

$C = 1 - \langle \frac{N_{ig}}{N_g} \rangle_I$ (5)

where the averaging is done over each intermediate nodes, i.e., substations.

N_g is the total number of generators

N_{ig} is the number of generators that a node i can reach.

It is found that connectivity is lost to a great extent in both cases, although the effect is higher in case of bidirectional flow model. In case of bidirectional flow model almost 50% connectivity is lost after six nodes removal while if we remove nodes according to nondirectional model even after 10 nodes removal the connectivity is very high. It takes 17 nodes removal according to nondirectional model to decrease the connectivity loss to 50%.

C. Load Loss

Since it is not possible to exactly model the blackout, various approximate measures have been taken to mimic the situation. Power system is a very much complex interconnected system whose exact modeling would require consideration of dynamics of rotating machines and devices within the system, discrete dynamics of switchgear elements, non-linear algebraic equations that govern line flows and social dynamics of governing and operating bodies.

1.8.4 Introduction of Micro-Grid

Micro-Grid is basically an aggregation of Distributed Generator (DG) sources and loads. It can work in island stand alone mode or in parallel with the main grid.

Control micro grids and virtual power plants. Microgrids-semi-independent sections of the gridefficiently marshal local distributed generation and storage to handle some or even most local demand. While distributed master controllers oversee routine microgrid activities, ADM coordinates those controllers to provide power to microgrids with a supply deficit, adjust energy flows elsewhere to accommodate excess electricity from distributed resources, and route excess supply to other microgrids or to storage.

On the environmental perspective, a Micro-Grid capable to integration of renewable energy sources, thus contributing to reducing emissions from fossil fuel based sources. On the technical side, a Micro-Grid can reduce energy losses, mitigate voltage variation, relief peak loading, and enhance supply reliability. [14]

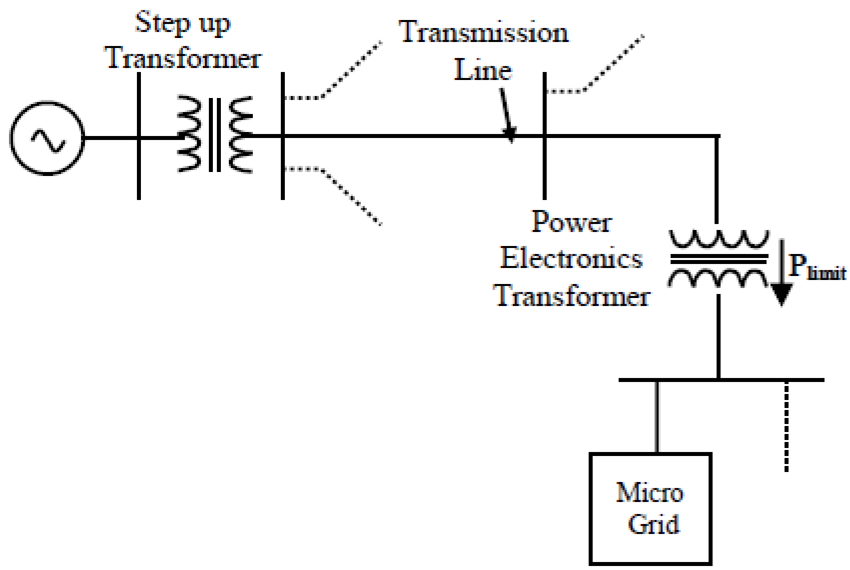

Figure 4: Micro Grid in Three Phase Transmission and Distribution

To increase reliability, energy storage systems within a Micro-Grid are important. Energy was stored when the Micro-Grid is connected to the main grid and it can be used during power outage.

Besides that, they can also be used to boost the power supplied by the Micro-Grid in grid-connected mode if the DG sources are not supplying the expected level of energy due to their natural power variation.

Line interactive UPS systems can be good candidates to provide power storage for Micro-Grid as they are connected in parallel with the main grid and with the local load. [14]

1.8.5 System Overview

The overall system of a Micro-Grid is shown in Figure 3. DG modules are connected in parallel. The point of common coupling is connected to the grid through a main static switch which has the ability to isolate the Micro-Grid from the grid in case of grid faults and reconnect seamlessly to the grid when the faults are cleared.

Critical loads are connected on the Micro-Grid side of the main switch so they are always supplied with electrical power regardless of the state of the switch.

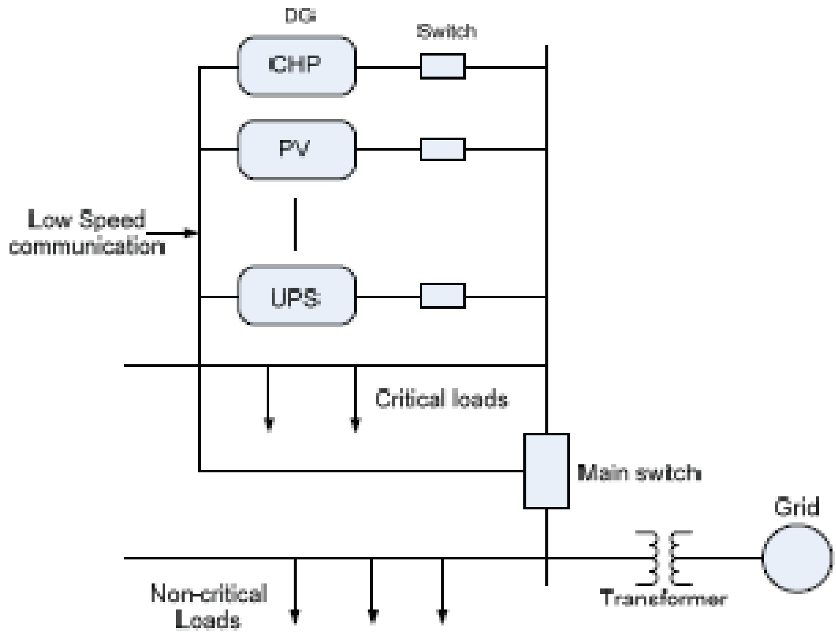

Figure 5: Micro-Grid Structure

The non-critical loads are connected at the grid side of the switch. Each DG controller uses local measurements of voltage and current to control the output voltage and power flow. Figure 4 illustrate an example of typical micro-grid system. [14]

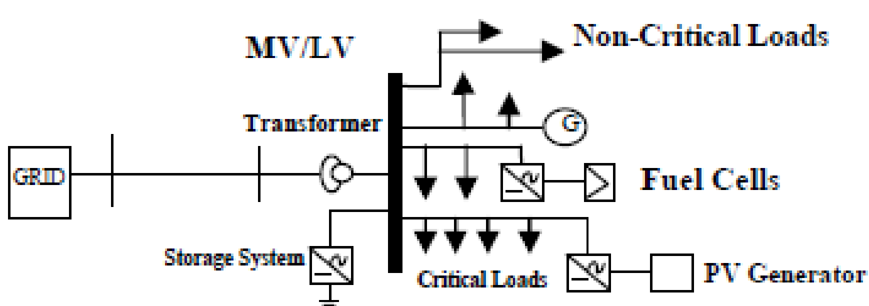

Figure 6 : Typical Micro-Grid

1.9 Objectives and Scopes

1.9.1 Objective

The main purpose of this project is to be able to looks into methods on employing two way power flows in advance distribution and micro grid into PSSE programming. There are three major topics that need to understand while doing this project which is Advanced Distributions system, Distributed Generation (DG) in Micro Grid and Two way power flow system.

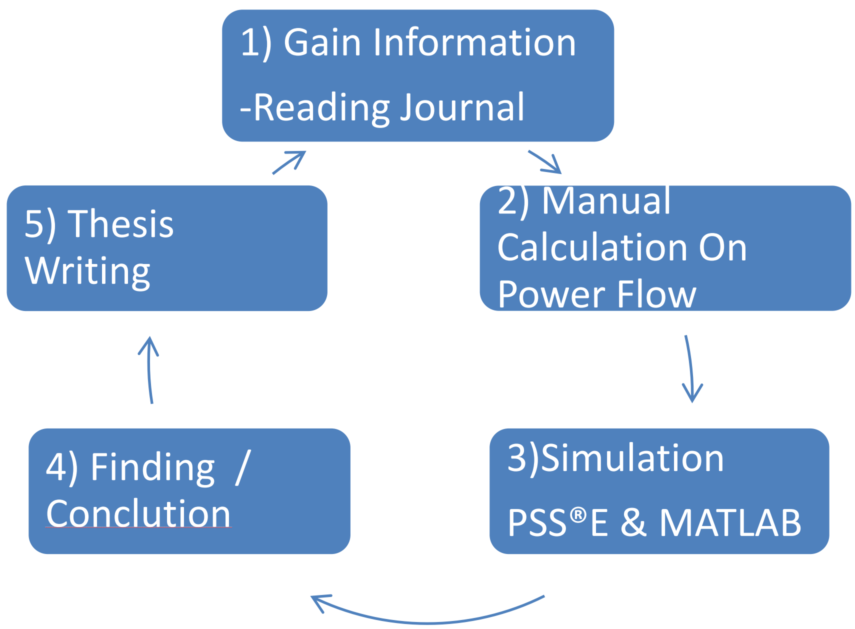

Figure 7: Flow Diagram

1.9.2 Scope of Work

The scope of this project is able to looks into parameter settings of generator, distributed generator (DG), transformer and also value impedance of each bus by using PSSE software. This project also requires knowledge in software skills. The scope of work in this project is as follows:-

Design network case parameter and create diagram network and demonstrate simulation, and perform a complete two way power flow in a micro grid system via PSSE software.

i. Construct and build Micro Grid to perform two way power flow system.
ii. Creating a Two Way Power Flow programming by using Matlab.
iii. Perform all calculation in per unit (p.u) for voltage, real power scheduled, real power injected and real power calculated by using Newton-Raphson approach.
iv. Analyzing and comparing the results from PSSE, Matlab and manual calculation.

1.9.3 Thesis Overview

This thesis contains 5 chapters with appendices at the end. Each of the chapters represents of enough information for better understanding due on this project.

Chapter 1

Briefly explain the scope and objective for this project to achieve and a general view of electrical power flow enhanced with two way flow directions.

Chapter 2

Introduces the basic concept and definition of distributed generator (DG), Micro-Grid, Renewable energy and also brief description on two way power flow.

Chapter 3

Describe about methodology for two way power flow setup and design using network case and diagram via PSSE software.

Chapter 4

Step for power flow simulation via PSSE, Micro-Grid calculation system by using Newton-Raphson approach.

Chapter 5

A brief conclusion, discussed and compare a result obtain from PSSE, Matlab and manual calculation.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

In this chapter, the review on the research is done for a past semester. The review included distributed generation in micro grid and also two way power systems. These research are been done through the journals, power system books and from the competence person who has a great knowledge in this subject.

2.2 Electrical System and Equipments

2.2.1 Distributed Generation (DG)

Distributed Generation (DG) can be done on a large scale with combustion turbines or solar system rated at several megawatts, but there is also considerable interest in generation on a much smaller scale, for instance in the form of micro turbines and fuel cells. Because of their smaller output, these units recommended to be placed much closer to the consumer side.

An energy storage system (ESS) can augment a DG unit by generating at almost of instantaneous response to load steps and by supplying short peak loads, while the generator provides the average system load at high efficiency. Since many of the loads on the ESS are momentary loads that could be provided by other storage devices, such as capacitors, it is often desirable for the ESS to provide a block of energy for a black start of the generator. A battery is the most practical storage device to provide this capability. Battery energy storage (BES) also provides increased flexibility in the type of system loads that can be supported, so it is the storage medium of choice for this type of application.[16]

Another form of DG is provided by renewable energy sources, such as solar and wind energy. The intermittent and/or cyclical nature of many renewables presents a strong opportunity for energy storage, particularly with new regulations coming into place that are aimed at increasing the proportion of total generation provided by renewable sources.

With the impending deregulated environment, electric utilities are seeking new technologies to provide acceptable power quality and reliability to their customers. Small nonconventional generation option is rapidly becoming attractive to many utilities across the country because these technologies produce energy with less environmental impact, easy to site, and are highly efficient.

Distributed generation (DG) can be considered as "taking power to the load". DG promises to generate electricity with high efficiency and low pollution. Unlike large central power plants, DG can be installed at or near the load. DG ratings range from 5 kW up to 100 MW. Maintenance cost for DG such as fuel cells and photovoltaic is quite low because of the absence of moving parts [16].

Several recent developments have encouraged the entry of power generation and energy storage at the distribution level. Some of the major ones are listed below.

a. Retail competition brought upon by utility structuring

b. With expanded choice, customers are demanding customized power supplies to suit their needs and transmission lines

d. Advent of several technologies with reduced environmental impacts and high conversion efficiencies

e. Advent of efficient and cost-effective power electronic interfaces to improve reliability and power quality

f. Ability to effectively control a number of components and subsystems using state-of-the-art computers to manage loads, demands, power flows, and customer requirements.

Several DG technologies are under various stages of development. They include micro turbines, photovoltaic systems (PV), wind energy conversion systems (WECS), gas turbines, gas-fired IC engines, diesel engines, and fuel cell systems [5-7]. At present, wind energy has become the most competitive among all renewable energy technologies [16].

Integration of DG into an existing utility can result in several benefits. These benefits include line loss reduction, reduced environmental impacts, peak shaving, increased overall energy efficiency, relieved transmission and distribution congestion, voltage support, and deferred investments to upgrade existing generation, transmission, and distribution systems.

With the introduction of DG, line loss reduction can be expected. Two simple radial systems are considered: [16]

(i) System with the inclusion of DG
(ii) System without DG

Both systems have a concentrated load at the line end. The total length of the line is assumed to be L km. Schematics of the two cases are shown in Figures 1 and 2.

(i) System with the inclusion of DG

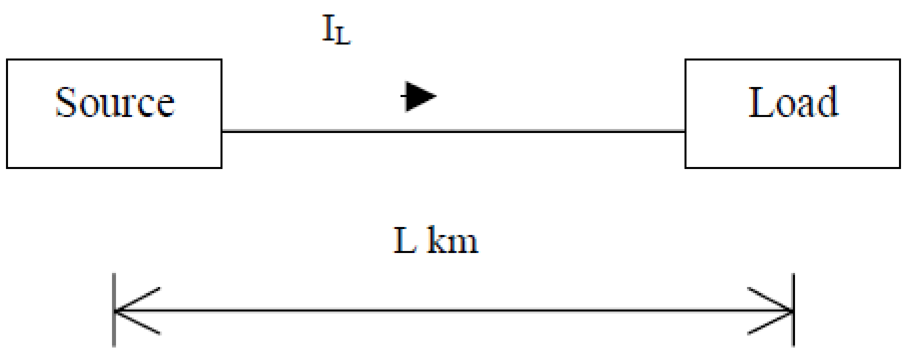

Figure 8: With DG distance

For the system with DG, the location of DG is assumed to be G km from source.

(ii) System without DG

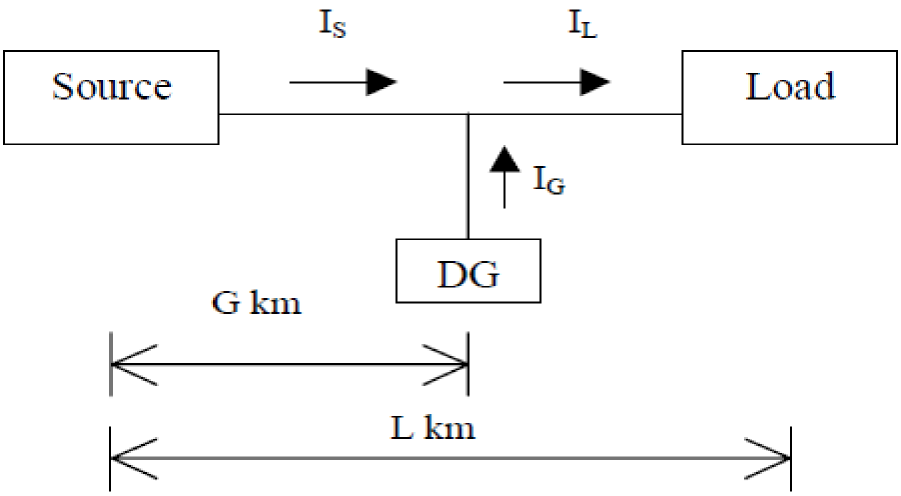

Figure 9: Without DG distance

The following assumptions are made in this case:

i) Load is Y-connected; line current is the same as phase current; IL = IP

ii) Load absorbs real power at some specified power factor

iii) DG produces real power at a lagging or leading or unity power factor

iv) VP is the RMS load phase voltage. VP is the reference phasor, VP∠° 0

The load complex power is SL = PL + jQL, therefore, the
current absorbed by load is:

$$I_L = \frac{(P_L - jQ_L)}{3V_P}$$

2.3 Voltage Stability in Power System

Voltage stability has often been view as steady state “viability” problem suitable for static power flow analysis. Although voltage stability involve in dynamic analysis, power flow base static analysis method are often used for rapid, approximate analysis. The ability to transfer reactive power from production to consumption sink during steady state operating condition is a major aspect of voltage stability. The network maximum power transfer is not necessary the voltage stability limit. [17]

Voltage stability can be described as the ability of a power system to maintain steady acceptable voltages at all buses in the system under normal operating conditions and after being subjected to a disturbance. A system enters a state of voltage instability when a disturbance causes a progressive and uncontrollable decline in voltage. The main factor that causes this form of instability is an inability of the power system to meet the demand for reactive power (ie. a mismatch between supply of, and demand for reactive power). Voltage stability is associated with the transfer of active and reactive power over a highly inductive network. Stability problems occur in heavily stressed systems, with the primary underlying problem being an inherent weakness in the power system. [17]

Generally voltage stability is problem associated with transfer of real power, P and reactive power, Q through a highly inductive network. There are several factors contributing to voltage stability. There are:- [17]

2.3.1 Load Characteristic

The characteristic of different load can be influence the voltage stability of the system because the active and reactive components of load vary with the system voltage that is affected by the transmission characteristic by changing the power flow through the system. Normally the increasing of load can cause voltage stability problem.

2.3.2 Generator Reactive Power and Voltage Control

Under normal condition, the generator operates to maintain constant terminal voltage. However during condition of low voltage, the reactive power demand on generator may exceed their field current and armature current limit. Thus the terminal voltage cannot be maintained at a constant value and voltage collapse occurs.

2.3.3 Action Voltage Control Device

The action of voltage control device such as transformer under load tap changer (ULTC) is used to maintain constant voltage at load buses. When the ULTCs reach their maximum tap limit under contingent condition, the distribution system voltage will begin to drop and have a destabilizing effect on the system.

2.3.4 Characteristic of Reactive Compensation Device

The characteristic of different type of compensation devices can influence voltage stability. Although the compensation devices can be use to improve the voltage stability limit, the limitation and drawback of each type of reactive compensation devices on voltage stability and control should be considered.

The voltage stability can divided into two categories which is large disturbance voltage stability and small disturbance voltage stability. The large disturbance voltage stability is concerned with a system ability to control voltage following large disturbance such as system fault, loss of load generation.

Determination of this form of stability requires the examination of the dynamic performance of the system over the period of the time sufficient to capture the interaction of device such as ULTCs and generator filed current limiter. Large disturbance voltage stability can be study by non linear time domain simulation which type of dynamic analysis.

Small disturbance or small signal voltage stability is concern with a system ability to control voltage following small disturbance such as gradual changes in load. This form of stability can effectively study with steady state approach or static analysis.

2.4 Factor Influencing Power Flow Stability

2.4.1 Transmission System Characteristic

Depending on load, transmission line can supply and observed reactive power. Bulk power transmission line is quite long and heavily loaded during peak load on the other hand they may be lightly loaded during off peak.

A fundamental aspect of reactive power compensation and control is reactive power balance. Transmission line both produce and consume reactive power and the net value must be either absorbed or generated by the system at each line thermal. Transmission line shunt capacitances produce reactive power proportional to the square of the voltage.

Since the voltage must keep within about 5% of nominal voltage, the reactive power production is relatively constant. Meanwhile, transmission line series inductances consume reactive power proportional to the square of current. Since the current varies, therefore the transmission line reactive power varies over the load cycle. [18]

Transmission Line Production $= V^2\omega C$

Transmission Line Consumption $= I^2\omega L$

a) Surge Current

Surge impedance loading is the ideal loading. Not only the reactive power production equal to reactive consumption, but the voltage and current profiles are uniform along the line.

The uniform voltage profile is especially desirable voltage can be held near maximum value. The voltage and current are also in phase at every point along the line.

In situation when the line loading less than SIL, transmission line will produce reactive power. On the other hand, when the line load more then SIL, transmission line will absorb reactive power.

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