RELIABLE POWER SYSTEM OPERATION PLAN - STEADY STATE CONTINGENCY ANALYSIS

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ABSTRACT

To ensure that Sabah Grid transmission system is planned and operated safely, economically and reliably, steady state contingency analysis must be performed. This analysis is performed to ensure that the system meets all requirements and Grid Code standards under normal operations and given a variety of outages or contingencies and other operating condition, where applicable. Steady state contingency analysis is the study of the outage of elements such as transmission lines, transformers and generators, and investigation of the resulting effects on line power flows and bus voltages of the remaining system. This study is prepared with the intent to put forward issues and recommendations towards achieving a reliable power system operation plan. This will enable the day-to-day system operation in the Sabah Grid to meet system demand while maintaining the reliability of the grid system within acceptable standards by maximizing the use of available and existing generation and transmission resources for system operation. The task of steady state contingency analysis is to calculate power flows in outage states in which one or more system components are out of service. A transmission system must satisfy security criteria in both normal and outage states. This project presents the steady state contingency analysis for the period of year 2014 to year 2016. In this study, the contingency analysis will be performed using the power flow method and contingency analysis using Siemens PTI software Power System Power System Simulator for Engineering (PSS/E).

ABSTRAK

Memastikan sistem penghantaran Grid Sabah dirancang dan dikendalikan dengan selamat, ekonomi dan pasti, mantap analisis luar jangka mesti dilakukan. Analisis ini dilakukan untuk memastikan bahawa sistem itu memenuhi semua keperluan dan Grid Kod di bawah operasi normal dan pelbagai gangguan atau luar jangka dan keadaan operasi lain, jika berkenaan. Analisis luar jangka dalam keadaan tanpa gangguan adalah kajian gangguan unsur-unsur seperti talian penghantaran, transformer dan alat penjana, dan penyiasatan kesan menyebabkan aliran kuasa talian dan voltan bas sistem yang tinggal. Kajian ini disediakan dengan niat untuk mengemukakan isu-isu dan cadangan-cadangan ke arah mencapai pelan operasi sistem kuasa yang boleh dipercayai. Ini akan membolehkan sistem operasi sehari-hari di Grid Sabah bagi memenuhi permintaan sistem di samping mengekalkan kebolehpercayaan sistem grid dalam standard yang boleh diterima dengan memaksimumkan penggunaan yang ada dengan kapasiti penjanaan yang sedia ada dan sumber penghantaran untuk operasi sistem. Tugas analisis luar jangka adalah untuk mengira aliran kuasa di mana gangguan pada satu atau lebih komponen sistem berada di luar perkhidmatan. Sistem penghantaran mesti memenuhi kriteria keselamatan di kedua-dua situasi normal dan keadaan dengan gangguan. Projek ini membentangkan kajian analisis luar jangka bagi tahun 2014 sehingga tahun 2016. Dalam kajian ini, analisis luar jangka akan dilakukan menggunakan kaedah aliran kuasa dan analisis luar jangka menggunakan perisian Siemens PTI Kuasa Sistem Kuasa Sistem Simulator untuk Kejuruteraan (PSS / E).

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CHAPTER 1

INTRODUCTION

1.1 Project Background

A reliable, continues supply of electrical energy is essential part of today's complex societies. In recent years the power systems are pushed to operate closer to their limits due to the combination of increased energy consumption and various kinds of obstructions to extension of existing transmission system. A power system is said to be secured when it is free from danger or risk.

Recently many blackouts were caused by significant imbalance between loads and generations and by consequent instability. Therefore, as evidenced by recent incident of blackouts, power system security has become a major concern.

The lack of planning and understanding of the impact of a serious attack to the electric grid is itself a threat to the grid. There is no clear understanding of what a worst case scenario could be. Therefore, contingency analysis is prepared with the intent to identify the next worst case contingency.

A power system under normal operating conditions may face a contingency such as transmission element outages or generator outages or loss of transformer, sudden change in the load or faults. These contingencies may result in severe violations of the operating constraints. Line outages are important because they may result in line over flow violations and therefore, an immediate need arises for the preventive action for the alleviation of over load on the system. Consequently, planning for contingencies forms an important aspect of secure operation.

To ensure that Sabah Grid transmission system is planned and operated safely, economically and reliably, steady state contingency analysis must be performed. This analysis is performed to ensure that the system meets all requirements and Grid Code standards under normal operations and given a variety of outages or contingencies and other operating condition, where applicable. Steady state contingency analysis is the study of the outage of elements such as transmission lines, transformers and generators, and investigation of the resulting effects on line power flows and bus voltages of the remaining system.

This study is prepared with the intent to put forward issues and recommendations towards achieving a reliable power system operation plan. This will enable the day-to-day system operation in the Sabah Grid to meet system demand while maintaining the reliability of the grid system within acceptable standards by maximizing the use of available and existing generation and transmission resources for system operation.

The task of steady state contingency analysis is to calculate power flows in outage states in which one or more system components are out of service. A transmission system must satisfy security criteria in both normal and outage states. In this study, the contingency analysis will be performed using the power flow method.

This study therefore provides inputs in identifying the most appropriate solution to ensure supply reliability to the customers accompanied with continuing strong growth in electricity demand in Sabah. This study also can examine the capability of the grid network.

In carrying out the analysis, steady state contingency analysis for transmission system includes the network expansion programme with forecasted load demand; operation scenarios were divided into six base cases to reflect the staging of several major projects planned for the system as well as to capture the highest load demand for the study scenario. The steady state contingency analysis was conducted on system peak load and system trough load conditions for 2014 up to year 2016.

In order to be more alert on the system condition especially in the event of forced transmission equipment or generator outages thus this research is conducted.

1.2 Sabah Transmission System

The interconnected electric power system is designed to deliver power safety and reliable wherever it is needed, every second of every day. In Sabah Grid, the transmission system consists of lines rated at 66kV, 132kV and 275kV. The distribution system comprises all lines at voltage lower than 66kV which links up all major towns in Sabah and Federal Territory of Labuan.

Sabah and Labuan Grid network consists of a network with about 492.0km of 275kV lines, 1596.5km of 132kV lines and 100.34km of 66kV lines.. Sabah Grid is essentially divided into two; West Coast Grid and East Coast Grid, with the bulk of the generation and load in the West Coast Grid. Currently, these two areas are linked via a double-circuit 275kV overhead line crossing the Crocker mountain range from Kolopis in the West Coast to Segaliud in the East Coast. The interconnection helps to transfer some available generation capacity in West Coast Region to the East Coast Region. Power transfer quantum from West Coast to East Coast will depend on the availability of generation in West Coast, usually during early morning trough period, or during weekend. A map of Sabah Transmission Network System shown in Figure 1.2(a) and The Sabah Electricity Sdn. Bhd. Transmission Grid Network is as shown in Figure 1.2(b).

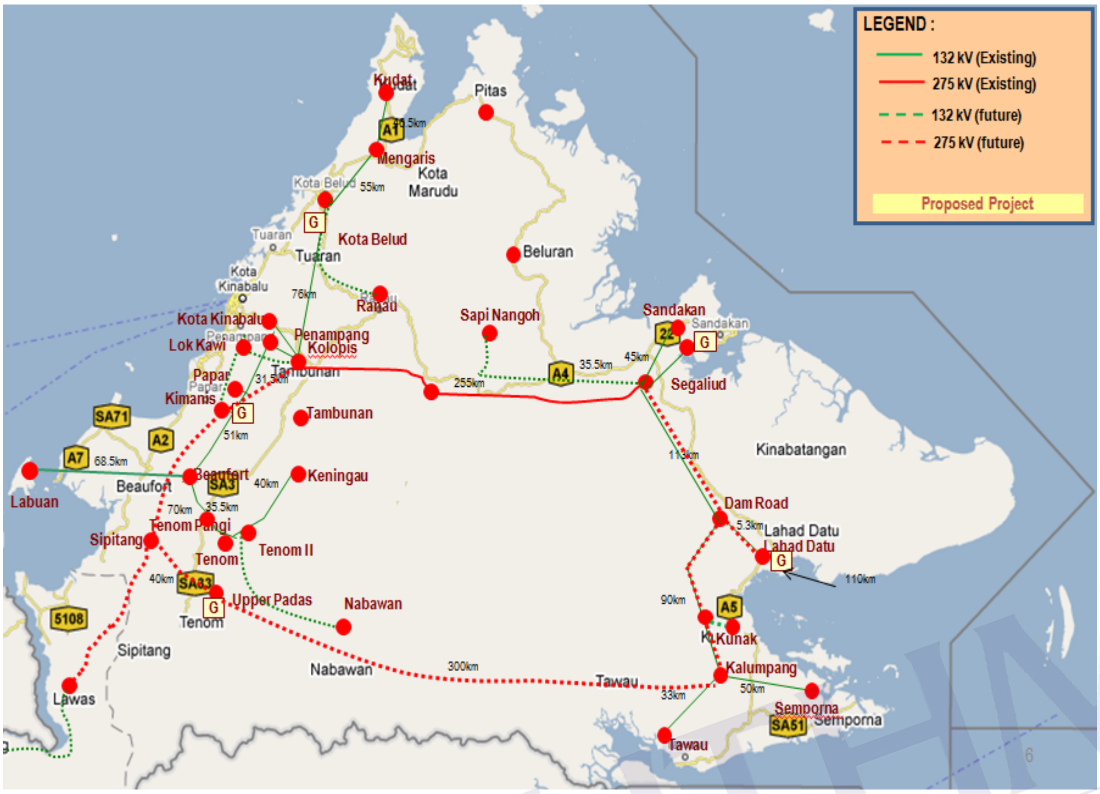

Figure 1.2(a): Sabah Transmission Map.

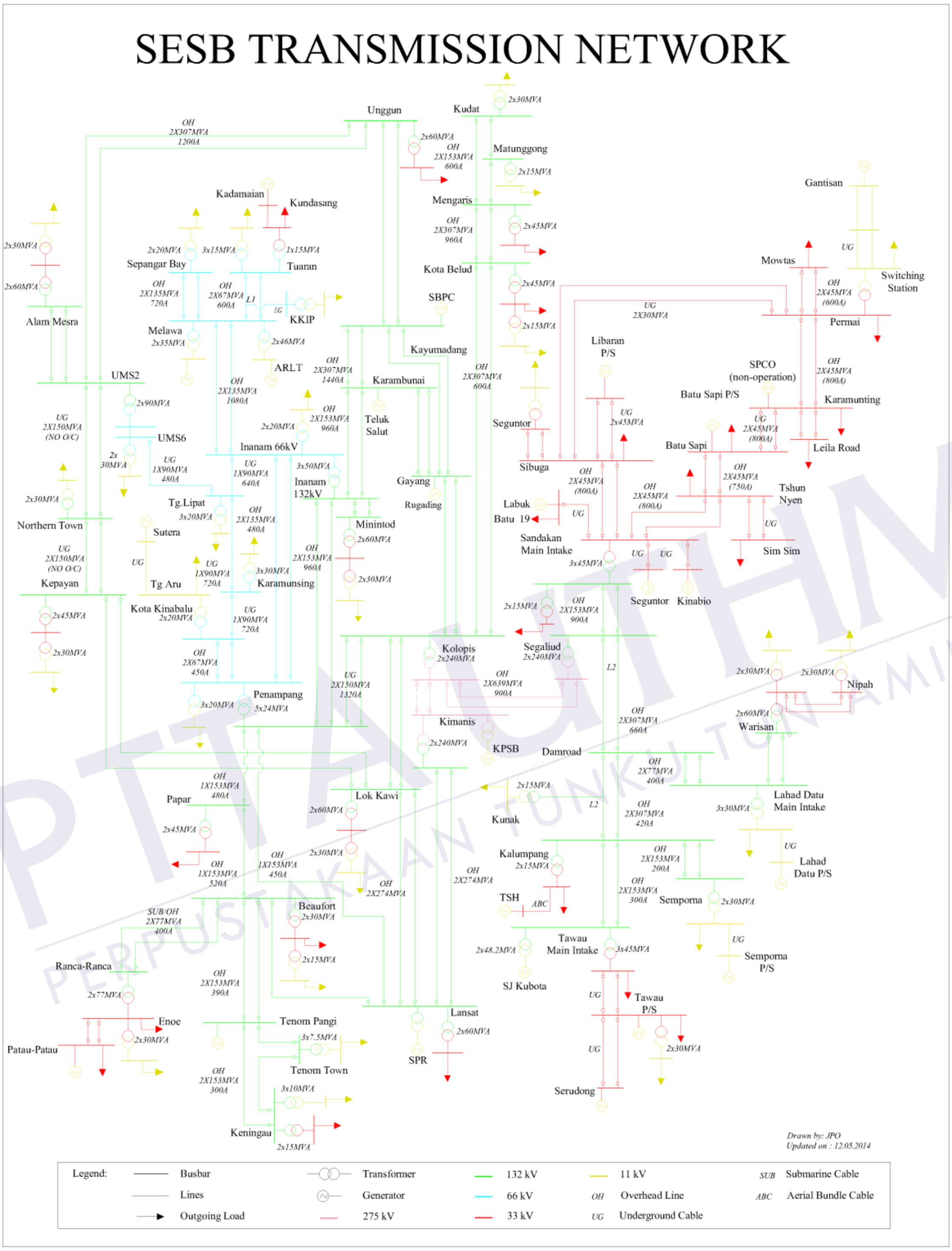

Figure 1.2(b): Sabah Electricity Sdn. Bhd. Transmission Grid Network

The details of the existing Transmission Substations are shown in Table 1.2.

Table 1.2: Details of the existing Transmission Substations

No.	Bus Name/ Substation	Area Number/Name	Zone Number/Name
1	LANGSAT 33.000	1 WCG	2 WCGSOUTH
2	RNCAA132 132.00	1 WCG	1 LABUAN
3	RNCA LBI 33.000	1 WCG	1 LABUAN
4	BFRT 132.00	1 WCG	2 WCGSOUTH
5	TMTN 132.00	1 WCG	2 WCGSOUTH
6	KGAU 132.00	1 WCG	2 WCGSOUTH
7	PPAR 132.00	1 WCG	2 WCGSOUTH
8	TLPID275 275.00	2 CENTRAL	5 KGUI/LGU
9	PNPG 132.00	2 CENTRAL	3 K-BALU
10	INAM 132.00	2 CENTRAL	3 K-BALU
11	LKWI 132.00	2 CENTRAL	3 K-BALU
12	UGGN 132.00	2 CENTRAL	4 NORTH
13	KPYN 132.00	2 CENTRAL	3 K-BALU
14	ALMS 132.00	2 CENTRAL	4 NORTH
15	NORT 132.00	2 CENTRAL	3 K-BALU
16	MTOD 132.00	2 CENTRAL	3 K-BALU
17	TUA2 132.00	2 CENTRAL	4 NORTH
18	KIPC 66.000	2 CENTRAL	4 NORTH
19	CNTN5 132.00	2 CENTRAL	3 K-BALU
20	DAMAI 132.00	2 CENTRAL	3 K-BALU
21	TG LPAT 132.00	2 CENTRAL	3 K-BALU
22	KKBU 66.000	2 CENTRAL	3 K-BALU
23	KRMG 66.000	2 CENTRAL	3 K-BALU
24	TGLT 66.000	2 CENTRAL	3 K-BALU
25	UMS2 132.00	2 CENTRAL	4 NORTH
26	SPGR 66.000	2 CENTRAL	4 NORTH
27	TUAR 66.000	2 CENTRAL	4 NORTH
28	KRMG 132.00	2 CENTRAL	3 K-BALU
29	KBLD 132.00	4 NORTHERN	8 KDATBLUD
30	MGRS 132.00	4 NORTHERN	8 KDATBLUD
31	KDAT 132.00	4 NORTHERN	8 KDATBLUD
32	MTGG 132.00	4 NORTHERN	8 KDATBLUD
33	SDMI 132.00	5 ECG	9 SDKN
34	LHDU 132.00	5 ECG	10 LHATDATU
35	SEMP 132.00	5 ECG	11 TWAU/SNA
36	KBTG 132.00	5 ECG	10 LHATDATU
37	KNAK 132.00	5 ECG	10 LHATDATU
38	TGE 132 132.00	5 ECG	11 TWAU/SNA

An area typically represents the small region. Areas can be utilized to represent an regional electric market, i.e., the majority of load within an area is served with the majority of generation in that same area. Load can be served with generation from another area.

Typically, Areas are represented as a collection of Zones. An area should contain one or more zones. The reasoning behind this is to allow Areas to have many subset (Zones) such that details analysis and criteria can be applied to a particular Zone. By breaking Areas into Zones, the flexibility to apply different scenarios to avoid any outages or blackout when overloads occur and could be fixed fast and easy.

The basic power system is the combination of three major components which are generation, transmission or distribution and load or consumption. When the basic power systems are connected together through transmission or distribution lines or equipment, they become an interconnected power system.

The objective of power system operation is to keep the electrical flows and bus voltage magnitudes and angles within acceptable limit, despite changes in load or available resources. Security may be define as the probability of the system's operating point remaining in a viable state space, given the probabilities of the changes in the system (contingencies) and its environment (weather, demand, etc.)

1.3 Problem Statements

Evaluation of power system contingency analysis is necessary in order to develop ways to maintain system operation when one or more elements fail. An "element" of a power system usually refers to its electrical equipment (e.g. generator, transformer, transmission line, circuit breaker, etc.) A power system is "secure".

Experienced transmission outages which lead to millions of losses in term of the availability of supply power, jeopardise local industries and electricity consumers. Due to rapid growth of developments, there is a need to conduct contingency analysis on transmission system to enhance reliability of Sabah Grid and to identify emerging constraint in the grid system and to analysis the impact or improvement on upgrading primary facilities on transmission line.

Steady State contingency analysis a most important tasks for planning and secured Sabah Grid Operation, especially as network stability issues become of prime importance in the current era of electricity deregulation. Contingency analysis is used to study the performance of a power system and to assess transmission expansion due to the rapid growth of developments or generation expansion.

Steady state power system insecurity such as transmission line being overloaded causes transmission elements cascade outages which may lead to complete blackout. The contingency analysis is used to predict the contingencies which make system violations. It represents an important tool to study the effect of elements outages in power system security during operation and planning. This study is also to prepare and develop mitigation plan against any adverse conditions that may occur in future.

Steady state contingency analysis traditionally involves analyse the contingency in a system in order to investigate system reliability and performance under different operating conditions.

As the demand and consumption of electricity keep on changing due to the increase population and the high number of developing company in this industries. The steady state contingency analysis is very important to prepare with the intent to put forward issues towards achieving a reliable power system operation plan.

1.4 Project Objectives

The major objective of this study is to prepare steady state contingency analysis in order to improve the reliability of Sabah Grid system operation to meets the statutory requirements of the Energy Commission's License Condition and Grid Code.

Its measurable objectives are as follows:

a) To analyse the steady state contingency analysis of the Sabah Grid System.

b) To prepare contingencies to develop the stability and brings on better solution and backups plans for any worst case contingency.

1.5 Project Scopes

This project focuses its deliberations on the outlook of the grid system operation in the next three years. This project is primarily concerned with the steady state contingency analysis on Sabah Transmission Network. This study covers the operation for year 2014, 2015 and 2016. It includes the generation and network expansion programme up to year 2016 with forecasted load demand. This study does not intend to address planning in the context of network expansion.

This study to ensure high security, high system reliability and availability of supply by control and manage the capacity and transmission in a normal condition and a single contingency condition to meet the performance standard and ensure all network components operate within standards limits also can reduce the number of outages. To ease the maintenance work without affect normal operation. To identify and avoid risks on overload on transmission circuits under (n-1) contingencies and proposed corrective action.

This study will involve a series of activities as follows:-

(a) Input and data verification.
(b) Developing specific number of network models for the year 2014 up to year 2016.
(c) Prepare base cases for the consecutive year.
(d) Simulation using Power system simulator for engineering (PSS/E) steady state analysis.
(e) Measure and assessment of the network operation in term of stability.
(f) Case study on SESB on contingency analysis.

This analysis is carried out firstly for load flow analysis, to ensure that the system is performing within the planning and operation criteria under normal system configuration. Secondly, for contingency analysis, which is to determine what the system goes through under n-1 conditions.

The system study in this project only limited to Sabah region only through Sabah Electricity Sdn. Bhd. (SESB) data without any segmentation of countries and localization.

1.6 Thesis Outline

The subsequent chapters of the thesis are organized as follows:

Chapter 1 highlights on the background of Sabah Transmission system. The objectives of this research are stated clearly in this chapter. The project scope as well as the structure of this thesis also describes in this chapter.

The literature review of this project will be discussed in Chapter 2. This chapter will give the details about the basic theory of application steady state contingency analysis, definition of reliability and security also some theory on contingency analysis.

Chapter 3 will discusses and elaborates the project procedure starting from collecting data, conduct simulation and analyse simulation result. The basic simulation procedure will be discussed in this chapter. This chapter also mention the operation planning criteria and project assumption while doing this thesis.

Chapter 4 shows the results and data analysis. The simulation results using PSS/E software for six cases consists of peak and trough load for year 2014 to year 2016 for Sabah Grid system is showed and discussed here.

Chapter 5 presents the project discussions, conclusions and recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section contains a brief review of literature useful for understanding the material presented in this report. The references in this section are relevant to the general framework presented in Chapter 2 and the report as a whole.

Several technical papers outside the field of high power were particularly useful for this report. System Reliability and Risk Management: Effects on System Planning, Operation, Asset Management, and Security is required advanced development and understanding of risk attributes impacting reliability performance. This paper developing method to measure acceptable levels of reliability, which must include consideration of the risk present in order to appropriately prioritize and manage the system risk.

Contingencies are defined as potential harmful disturbance that occur during the steady state operation of a power system.

To ensure this study is completed, some theories about the relationship between the concepts of reliability, security and stability of a power system must be clearly understood. Stability refers to the continuance of intact operation following a disturbance which depends on the operating condition and the nature of the physical disturbance. Security is the degree of risk in the ability to survive imminent disturbances (contingencies) without interruption of customer service. It is depends on the system operating condition as well as the contingent probability of disturbances. Reliability is probability of satisfactory operation over the long run and also denotes the ability to supply adequate electric service on a nearly continuous basis, with few interruptions over an extended time period. Reliability is the overall objective in power system design and operation which is to be reliable the power system must be secure most of the time.

As well, a system may be stable following a contingency, yet insecure due to post-fault system conditions resulting in equipment overloads or voltage violations. The general practice is to design and operate the power system so that the more probable contingencies can be sustained without loss of system integrity is "Normal Design Contingencies". Loss of any single element, either spontaneously or proceeded by a fault. This is referred to as the "n-1 criterion" because it examines the behaviour of an n-component grid following the loss of any one major component.

Contingency analysis purpose is to analyse the power system in order to identify the overloads and problems that can occur due to contingency. Contingency analysis is abnormal condition in electrical network. It put whole system or a part of the system under stress. It occurs due to sudden opening of a transmission line, generator tripping, sudden change in generation, sudden change in load value. Systems are designed to withstand one contingency, i.e (N-1) criterion. However some events trigger others and cascading failures might occur. Therefore not all contingency are equal, and the number of components in a given system make it prohibitive to evaluate all (single) contingencies. The system is considered (N-1) secure when a single contingency will not cause any system limits to be violated.

2.2 Steady State Analysis

Power System Simulator for Engineering (PSS/E) is a software tool used for electrical transmission networks. It is an integrated, interactive program for simulating, analyzing, and optimizing power system performance and provides probabilistic and dynamic modeling features. Since its introduction in 1976 it has become the most widely used commercial program of its type. The probabilistic analyses and advanced dynamics modeling capabilities included in PSS®E provide transmission planning and operations engineers a broad range of methodologies for use in the design and operation of reliable networks.

Since its introduction in 1976, the Power System Simulator for Engineering tool has become the most comprehensive, technically advanced, and widely used commercial program of its type. It is widely recognized as the most fully featured, time-tested and best performing commercial program available. PSS/E is an integrated, interactive program for simulating, analyzing, and optimizing power system performance. It provides the user with the most advanced and proven methods in many technical areas, including:

- Power Flow
- Optimal Power Flow
- Balanced or Unbalanced Fault Analysis
- Dynamic Simulation
- Extended Term Dynamic Simulation
- Open Access and Pricing
- Transfer Limit Analysis
- Network Reduction

Power flow module is widely recognized as one of the most fully featured, time-tested and best performing commercial programs available for power systems analysis. Over 30 years of commercial use and user-suggested enhancements have made the PSS/E Power Flow base package comprehensively superior in analytical depth, modeling and user convenience and flexibility.

Power system simulator for engineering (PSS/E) software used to prepare the steady state contingency analysis for this study. This study will focus on the power flow and the way it behaves in normal conditions, n-1 contingencies. At first it is necessary to be educated about the power plant, substation and its main elements such as buses, branches, generators, and transformers. Buses connect components (machines, loads, etc.) in the circuit to one another; it often referred as node in circuit analysis and includes the buses name, number, voltage in kV. Branches represent transmission lines and loads are the elements which consume power; loads in AC systems consume real and reactive power. While machine generate power and provide it for the system. These are the important components used to analyse the power flow study.

This study introduce the save file *.sav which is a binary image of the load power flow working case or case load flow file. The file specified to 22 tabs of all components and functions in the system but for this study we only focused on six tabs; bus, branch, load, machine, two winding transformer and switched shunt. Two winding transformers shows the data records block of the system, while switched shunt shows the capacitive or inductive that reduces the reactive power in the system. The save file is storage of all data of any power system that need to analyse for configure the power flow behaviour Figure 2.2(a).

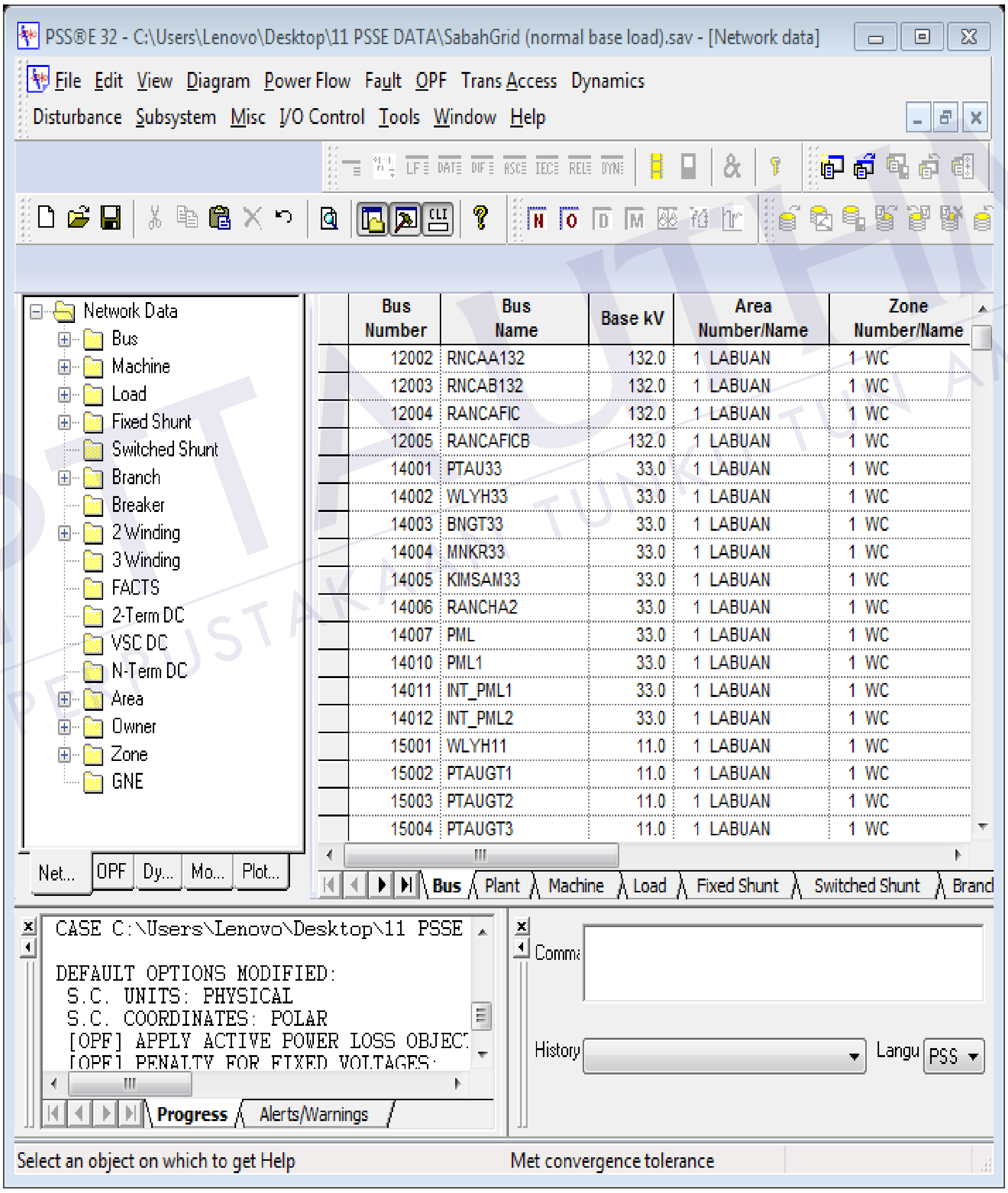

Figure 2.2(a): Sample case load flow file *.sav capture

Modeling of network element in load flow that consists of generator, Transformer, lines and cables, etc. to learn how the power flow performance changes through the system. File *.sld is a one-line diagram represent of three phases power system. A slider file is as a grid as in Figure 2.2(b) where it shows the power system in Southern Sabah Grid. A slider file is linked to the save file where it shows all the data records so any changes in either file will change in the other one. Solve the system using PSS/E to create all necessary calculations in a power flow analysis.

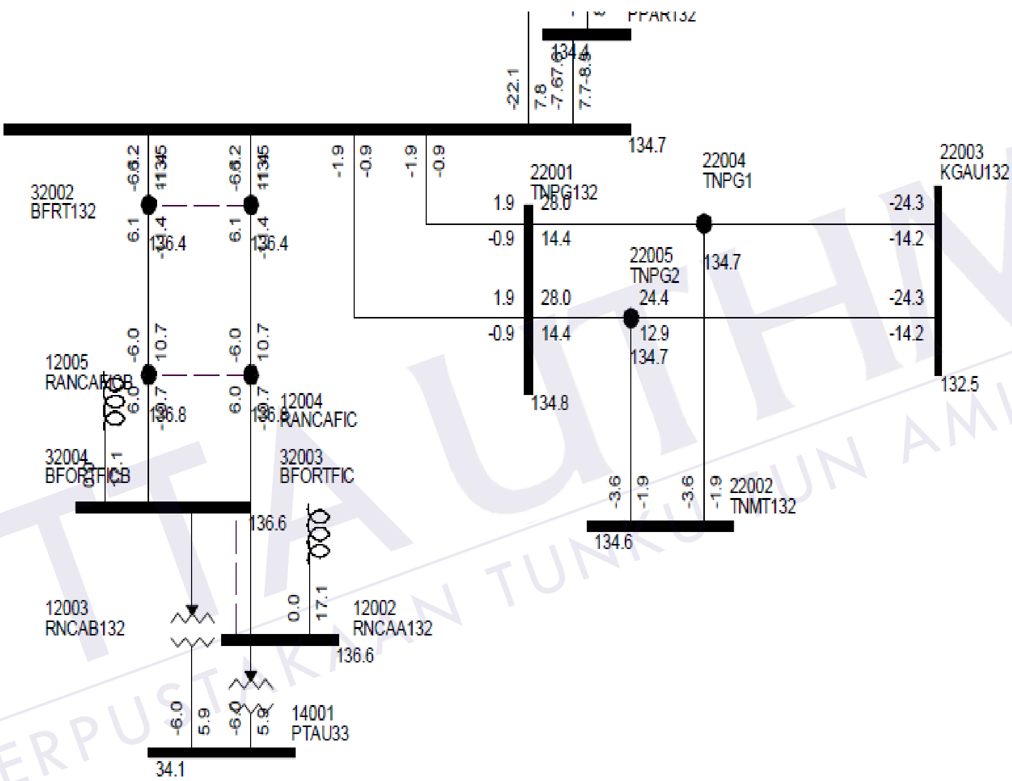

Figure 2.2(b): Sample file *.sld capture

AC contingency calculation (ACCC) is a result of a power flow study on a specific zone. In order to interpret an ACCC report, three important files which are contingency file *.con, monitor file *.mon, and subsystem file *.sub was set up to overcome any necessary overloads that need to be taking care.

Generally, steady state contingency analysis is used for assessing the performance of a power system under different equipment outage conditions by comparing it against predefined criteria, such as acceptable bus voltage limits and branch loading limits.

The basic contingency analysis process consists of:

(a) Disconnecting one or more system elements.

(b) Solving the power flow.

(c) Examining the post-contingency system conditions using the reporting functions.

The modeling of the system's response to a contingency can be pre-defined or automatically determine by an optimization algorithm whose objective is to resolve system performance criteria violations. The contingency events to be analysed and the system performance criteria are defined in a set of input data files consisting of a subsystem description data file (with file name extension "sub"), a monitored element data file ("mon") and a contingency description data file ("con") .

Normal condition or n-0 is the system that operates without any tripped transmission equipment or power plant. A single contingency condition or n-1 is the loss of any power system element that has only one of the transmission equipment or power plant tripped but not include the busbar. Where, two simultaneous events called as n-2 contingencies.

Power systems are affected by events that depend upon the state of the power system. For instance, as load increase, the flows on transmission line increase. When the flow on a line exceeds a certain limit for a certain time period, a relay will open a circuit breaker removing the line form the network. The operation of the relay is triggered by the state of the transmission line (voltage, current, temperature, power), and the state is determined by system parameters such as load and import levels. The opening of the circuit breaker and removal of the line from the network in turn causes the flows on other lines to change and can lead to cascading events and the loss of system stability.

The transmission networks are design under normal operating conditions to operate within specific ranges. However, under some system stress conditions the voltage range can go outside this range. Such condition are summarised in Table 2.2.

Table 2.2: Voltage Excursion

Under normal operating conditions	$\pm$ 5% at 275kV, 132 kV, 33kV
Under System Stress conditions following a system Fault	$\pm$ 10% at all power system voltages, however in the case of the transmission network, this condition should not occur for more than 30 minutes

Power flow analysis is probably the most important of all network calculations since it concerns the network performance in its normal operating conditions. It is performed to investigate the magnitude and phase angle of the voltage at each bus and the real and reactive power flows in the system components.

Power flow analysis has a great importance in future expansion planning, in stability studies and in determining the best economical operation for existing systems. Also load flow result are very valuable for setting the proper protection devices to ensure the security of the system, such as connection diagram, parameter of transformer and lines, rated value of each equipment, and the assumed values of real and reactive power for each load.

For bus classification in this study, each bus in the system has four variables: voltage magnitude, voltage angle, real power and apparent power. During, the operation of the power system, each bus has two unknown variables and two unknowns. Generally, the bus must be classified as one of the following bus type:

(i) Swing Bus

This bus is considered as the reference bus. It is must be connected to a generator of high rating relative to the other generator. During the operation, the voltage of this bus is always specified and remains constant in magnitude and angle. In addition to the generation assigned to it according to economic operation, this bus is responsible for supplying the losses of the system.

(ii) Generator or Voltage Controlled Bus

During the operation, the voltage magnitude at this, the bus is kept constant. Also, the active power supplied is kept constant at the value that satisfies the economic operation of the system. Most probably, this bus is connected to a generator where the voltage is controlled using the excitation and the power is controlled using the prime mover control.

(iii) Load Bus

This bus is connected to a generator so that neither its voltage nor its real power can be controlled. On the other hand, the load connected to this bus will change the active and reactive power at the bus in a random manner.

2.3 Reliability and Security

The degree of performance of the elements of the bulk electric system that results in electricity being delivered to customers within accepted standards and in the amount desired. Reliability may be measured by frequency, duration, and magnitude of adverse effects on electric supply. Electric system reliability can be addressed by considering two basic functional aspects of the electric system, which are adequacy and security.

System security is a subset of power system reliability which comprises of two components which are related to the time-frame of power system dynamics:

(i) Adequacy

the ability of the power system to supply the aggregate electric power and energy requirements of the customers within component ratings & voltage limits, taking into account planned and unplanned component outages.

(ii) Security

The ability of the system to withstand specific sudden disturbance such as unanticipated loss of system components. Power system security is the ability of a system to withstand without serious consequences any one of pre-selected list of “credible” disturbances (“contingencies”).

2.4 Contingency Analysis

Contingency analysis is the subject about evaluating adequacy and security through software application to give an indication of what might happen to the power system in the event of unplanned (or unscheduled) equipment outage. Contingency Analysis actually provides the prioritizes the impacts on an electric power system when problem occur. A contingency is the loss or failure of a small part of the power system (e.g. a transmission line), or an individual equipment failure (such as a generator or transformer). This is also called an “unplanned outage”. Contingency analysis is a computer application that uses a simulated model of the power system, to evaluate the effects, and calculate any overloads resulting from each outage event. In other word, Contingency Analysis is essentially a “preview” analysis tool that simulates and quantifies the results of problems that could occur in the power system in the immediate future.

PSS/E has an effective way of performing a contingency analysis without having to trip each line by itself manually. To execute a contingency analysis in PSS/E you will first have to create files of three different file types; one that describe the subsystem concerned by the analysis (.sub), one that describes what changes should be mad in the system (.con) and finally one that controls which values that should be monitored (.mon). These files then combined in the Distribution Factor Data File (.dfx) which in turn is used to create the Contingency Solution Output file (.acc) which gives the contingency report with the specified data given. The .sob, .con and .mon files can be automatically created within PSS/E or manually. This also has been mention in section 2.2 above.

In power system operation, the results of contingency analysis are used to operate the system defensively where load flow program is used extensively for evaluating adequacy.

For this study we focused on steady state security analysis which is to determine state of the following disturbance when transients have settled by using load flow calculations.

CHAPTER 3

METHODOLOGY

3.1 Study Approach

The studies carried out for the period of year 2014 to year 2016 to determine the adequacy and reliability of the transmission systems are power flow analysis and stability analysis. The study also caters peak demand and trough demand for each year studied. The trough demand is assumed to 50% of peak demand loading. The analysis was performed using the AC Contingency Analysis Tool in the PSS/E software.

The methodology used in this study involves the following steps as shown in the flow chart below.

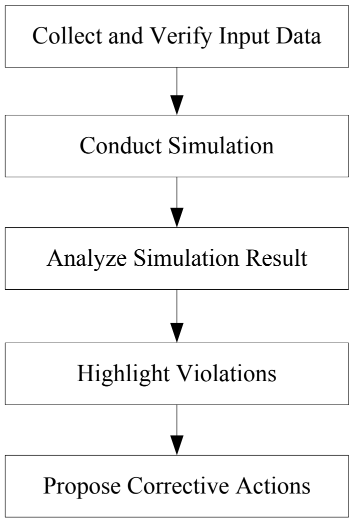

Figure 3.1: Steady State Contingency Analysis Flowchart

In each year, the base cases are prepared and categorised into two different months. In each year, the base cases carry two scenarios:

(a) System peak load scenario
(b) System trough load scenario

Table 3.1 represents the six base cases during system peak load and system trough load.

Table 3.1: Cases considered during system peak and system trough

Case	Year	Forecasted System Demand (MW)
System peak load	2014	1074
	2015	1150
	2016	1222
System trough load	2014	537
	2015	575
	2016	611

Prior to carrying out the contingency analysis, the loading of transmission circuits under none-contingency conditions (n-0) has to be determined.

Data is collected for database preparation for Sabah Grid Network, to be able to analyse the contingency of the power system Network of Sabah and Labuan.

According to the database, below are the following major components:-

(i) Buses: 445

(ii) Generators: 176

(iii) Fixed Tap Transformer: 413

(iv) Transmission Lines: 411

(v) Loads: 160

3.2 Operation Planning Criteria

Operation planning criteria is to ensure that the operation of the grid network will be within the specified level of supply reliability and security in accordance with and not less than its obligations under the Sabah and Labuan Grid Code and Energy Commission's License Conditions. The operation planning criteria used in studies are shown in Table 3.2 below:

Table 3.2: Operation planning criteria used in this study

Operation Planning Parameter	**Operational limits to be met under specific operating conditions**		
	Normal operation	**n-1 contingencies**	**n-2 contingencies**
Load loss	None	Not allowed except for radial single circuit of 66kV and 132kV	Must not result in total black out of the sending end system (West Coast network) but black out of the receiving end system (East Coast network) is acceptable however must be followed by fast restoration of supply
Equipment loading	Not exceeding 100% of equipment thermal rating	Emergency loading not exceeding 130% of equipment rating.	Emergency loading not exceeding 130% of equipment rating.
Busbar voltage (steady state variation)	All voltage levels 1.00 – 1.05 p.u.	275kV: 0.90 – 1.10 p.u. 132kV: 0.90 – 1.10 p.u. Below 132kV: 0.94 – 1.06 p.u.	275kV: 0.90 – 1.10 p.u. 132kV: 0.90 – 1.10 p.u. Below 132kV: 0.94 – 1.06 p.u.

Generally, the transmission system must have the capacity to enable the generating plants to be dispatched economically and to deliver power to the load areas and centers (i.e. main intake transmission substations).

Transmission network planning criteria is closely related to the reliability standard of supply. In transmission development planning, (N-1) is adopted as the main transmission criterion. N-1 single element outage should not result in instability or loss of load. It should also not result in overload on any other part of the network (except in the case of a radial feeder arrangement).

The voltage levels for normal steady-state conditions are maintained within 1.00 – 1.05 per-units and the system frequency will be nominally 50 Hz and shall be controlled within the limits of 49.75 – 50.25 Hz.

3.3 Project Assumptions

The list of system parameter changes used in this report for base cases and the sources of data are shown in Table 3.3 below.

Table 3.3: List of System Parameter Changes

System parameters	Assumptions
SESB Grid System model	Modelled from 275kV down to 33kV networks
Electricity Demand Forecast	Assuming 7% load growth annually

System parameters	Assumptions
New major generation to come into the grid system 2014-2016	IPP SPR (100MW) – 2014 IPP KIMANIS (285MW) – 2014 TENOM PANGI UPGRADE (8MW) – 2014 RE AFIE (8.9MW) – 2014 RE ECO BIOMASS (20MW) – 2014 RE KALANSA (5MW) - 2014 RE TAWAU GREEN ENERGY (30MW) - 2015 IPP EAST SABAH POWER CORP. (LNG) (300MW) – 2016
New transmission addition coming on-line for year 2014 and 2016	PMU Kimanis – Nov 2013 PMU Lansat - Nov 2013 PMU Sapi Nangoh –Nov 2014 PMU Ranau – July 2015 PMU Nabawan – Nov 2015 TMSS – Nov 2015
Generation dispatching	According to merit order

It is assumed that there is no prolonged generation and transmission outage. All generators and transmission equipment are assumed to be available.

The simulation results are carried out according to the current condition of Sabah Grid System as follows:

(a) 66kV Karambunai - Karamunsing line and 66kV Penampang - 66kV Inanam both line are currently opened for the grid voltage control purpose.
(b) Currently, only one remaining transformer left at 66kV UMS substation. The other one was transferred to 66kV Inanam substation.

In this study, the installed shunt capacitors, reactors and SVC are modelled.

3.4 System Simulation Process

Utilising the input data based on assumption Table 3.3, simulations are conducted on each base case define in Table 3.1, in order to assess the following points:

(a) To determine whether or not they meet the Planning Criteria.

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