POWER NETWORK LOADING LIMIT DETERMINATION USING NOSE POINT CONCEPT

By

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FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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Approved:

Associate Professor Dr. R. N Mukerjee
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

December 2006

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Nur Saleha Binti Jayiddin

ABSTRACT

The objective of the study is to provide a comprehensive load flow analysis to determine the transformer tap setting under different Cogeneration plant operating condition. The analysis covers the PETRONAS Penapisan (Melaka) Cogeneration plant which supply power to the existing PETRONAS Second Refinery 1 and PETRONAS Second Refinery 2 loads. In order to conduct the analysis, a simulation software called Power System Analysis Toolbox (P.S.A.T) is used to determine the voltage, real power and reactive power to be transfer at each bus during the load flow analysis. The maximum loading limit of the power network is determined from the point of voltage collapse of P-V curve and Q-V curve. In this project, the baseline parameters values are first defined and entered as the data input, then the load flow analysis is done to identify the weakest bus. Variation of a real power and reactive power on the weakest bus and repetition of load flow analysis with the change of loads and transformer tap setting is conducted in order to plot the P-V and Q-V curve and to determine the maximum loading limit.

ACKNOWLEDGEMENTS

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Maintenance of voltages on the network buses at their respective rated values is a prime requisite. The voltages occurring depend on the network condition VIZ exchange of generation, over excitation and under excitation limits, network configuration, and presents of shunt compensation, transformer tap settings and exchange of loading. System operators usually control the voltage collapse at some buses by increasing reactive generation, capacitor switching and/ or tap changing. As some devices reach their limits, the ability of controlling the voltage is lost and at certain loading of the system, one type of instability occur which called voltage collapse. This phenomenon is characterized by a sharp and fast decrease in voltage magnitude. This fact illustrated by PV / QV curves. In this study, the load on a particular bus is increased until the voltage collapse occurs. Then the minimum reactive power to be injected at the particular load bus is calculated by an iterative method. The same procedure is repeated for different load conditions and the corresponding kVAR to be injected has been calculated.

1.2 Problem Statement

1.2.1 Problem Identification

A specific power transmission or distribution network has a maximum loading limit. If the network is loaded beyond this limit, network operation will not be feasible. The maximum loading limit for a specific practical power network will be determined using point of voltage collapse on the PV and QV curve.

1.2.2 Significant of the Project

The strategies help in determining network limitations during design planning and operational planning.

1.3 Scope of Study

1.3.1 Objectives of the Project

The main objective of this project is to determine the maximum loading limit of a practical power system and the transformer tap setting under different operating condition. The power system network of the PETRONAS Penapisan (Melaka) Cogeneration plant which supply power to the existing PETRONAS Second Refinery 1 and PETRONAS Second Refinery 2 loads will be used. Other purpose of this project are to study and understand the load flow analysis and learn how to do the load flow using a power flow analysis software.

1.3.2 Feasibility of the Project within the Scope and Time Frame

The study spans over duration of two academic semesters and the scope of work covers exploring problems, building design objectives, applying appropriate methodology, producing and analyzing outcomes, as well as reporting the findings.

The first half of the project mainly involves research and study to acquire as much knowledge as possible to ease the design work later on. Research work for these 10 weeks of the first semester revolves around familiarization with the software used to do the load flow, identifying parameters used to initialize the load flow in a power system, running load flow on existing power network provided in the software, learn how to interpret the simulation results, creating and developing data file and Simulink model for a real power distribution network, running the load flow analysis for the system. The work is then continued with the determination of the maximum loading limit using P-V curve (nose curve). In the first half of the project, the analysis only covers the PETRONAS Second Refinery 2 (PSR2) of the power distribution network of PETRONAS Penapisan (Melaka) Sdn. Bhd.

For the second half of the project, the duration is also 10 weeks, the same load flow analysis and maximum loading limit determination process will be done but for the overall power distribution network. The analysis covers the PETRONAS Penapisan (Melaka) Cogeneration plant which supply power to the existing PETRONAS Second Refinery 1 and PETRONAS Second Refinery 2 loads. This part focuses more on improving power flow of the power network system by introducing shunt compensation into the system and to determine the correct transformer tap setting under different Cogeneration plant operating condition which helps to maintain the bus voltage at its rated voltage during the operation without causing any over-voltage.

The area and scope of this project has been carefully planned, hence the project is feasible and could be completed within the allocated time frame. A project plan and Gantt chart has been develop to guide the progress of the project. If the plans are strictly followed, the project will be a successful one.

(See Appendix A)

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction to Voltage Stability

2.1.1 Voltage Stability

Power system voltage stability is the capability of the power system to maintain the acceptable voltages at all nodes under normal conditions and abnormal conditions. Abnormal condition is a condition where the power system is being subjected to contingency conditions.

A power system is said to have entered a state of voltage instability when a disturbance causes a progressive and uncontrollable decline in voltage values. The main factor for voltage collapse is basically caused by an unavailability of reactive power support in an area of the network, where the voltage drops uncontrollably. Besides, the voltage stability of a power system is also influenced by several factors which are the transmission line characteristic, generator characteristics, reactive power compensating devices, under-load tap-changing transformers and the loads.

The process of instability may be caused by some form of disturbance, resulting in changes in the reactive power requirement. The disturbance may either be small or large changes in essentials load. The consequence of the voltage instability may, however, have widespread impact on the system.

Main contributing factors to voltage stability

1) Transmission line characteristic
2) Generator field and armature current limits
3) Generation automatic dispatch function (governor and AGC)
4) Reactive compensating devices
5) Co-ordination of protection and control system.
6) Under-Load Tap-Changing Transformers
7) Loads connected to the power network

2.1.2 Voltage Collapse

Voltage collapse is an instability of heavily loaded electric power systems which leads to declining voltages and blackout. It is associated with bifurcation and reactive power limitations of the power system. It is a problem associated with transfer of real power (P) and reactive power (Q) through a highly inductive network. It is generally associated with bifurcation of the nonlinear power system equations; that is, the disappearance as parameters vary of the stable equilibrium at which the power system is normally operated. System limits such as generator reactive power limits and tap changing transformer limits are thought to be important in voltage collapse. Heavily loaded power systems are closer to their stability limits and voltage collapse blackouts will occur if suitable monitoring and control measures are not taken.

Voltage collapse typically occurs on power systems which are heavily loaded, faulted and/or has reactive power shortages. There are six main contributing factors to the voltage collapse which are the load characteristics and under-load tap changer, generator field and armature current limits, transmission line characteristics, generation automatic dispatch functions, reactive power compensation and co-ordination of protection and control system.

2.1.3 Maximum Loading Limit

Maximum loading limit or transfer limit of an electrical power network is the maximal real or reactive power that the system can deliver from the generation sources to the load area. Specifically, the transfer limit is the maximal amount of power corresponds to at least one power flow solution. From the well known P-V or Q-V curves, one can observe that the voltage gradually decreases as the power transfer amount is increased. Beyond the maximum loading limit, the power flow solution does not exist, which implies that the system has lost its steady-state equilibrium point.

2.2 Nose Curve Concept

This concept used P-V and Q-V curve to determine the maximum loading limit of a power network.

2.2.1 P-V Curve

PV curve is also known as nose curve. It shows the relationship between real power and the voltage at the selected bus. The loads and generations in selected areas are increased in a predetermined manner to find the distance to voltage instability. A full power flow solution is performed at each load level to obtain bus voltages to ensure all system non-linearity are represented as the system is stressed. Stressing the system by increasing the load is the most relevant measure for assessing the voltage stability of the system. The voltage stability limit is reached when power flow solution fails to converge.

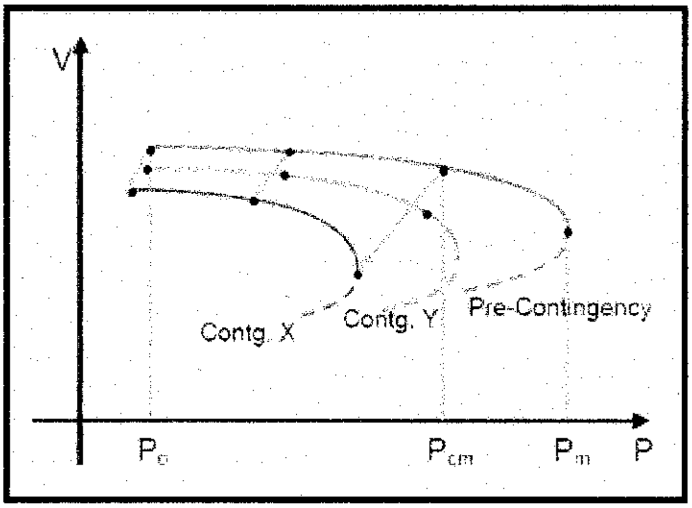


Figure 1 : P-V Curve

The PV plot above show the sensitivity (variation) of the bus voltages with the load, the distance to instability where the pre-contingency margin is between Pm and Po while the post – contingency margin is between Pcm and Po. The PV curve presents load voltage as function of loads or sum of loads. It present both solution of power system. The power system has low current – high voltage and high current – low voltage solutions. Power system only operates at the upper part of the PV curve. This part of the PV curve is statically and dynamically stable. The head of the curve is called the maximum loading point. The critical point where the solutions unite is the voltage collapse point. The power system becomes more unstable at voltages unite point. Voltage decreased rapidly due to requirement for infinite amount of reactive power. The lower part of the PV curve is statically stable, but dynamically unstable.

2.2.2 Q-V Curve

In a QV curve, a variable reactive power source is placed at the selected bus to control the bus voltage within a range. A full power flow is solved at each voltage set point and the injected reactive power is computed to obtain a plot of injected reactive power versus the bus voltage. QV plot shows the MVAR margin at the bus, the voltage at which instability occurs, and the sensitivity of bus voltage to reactive injection. In order to obtain a reasonable picture of the condition of the system, many buses may have to be examined, requiring a vast number of full power flow solutions. The main drawback is that the system is stressed in an unrealistic manner. The slopes may be misleading; the combination of the voltage margin and reactive margin is required.

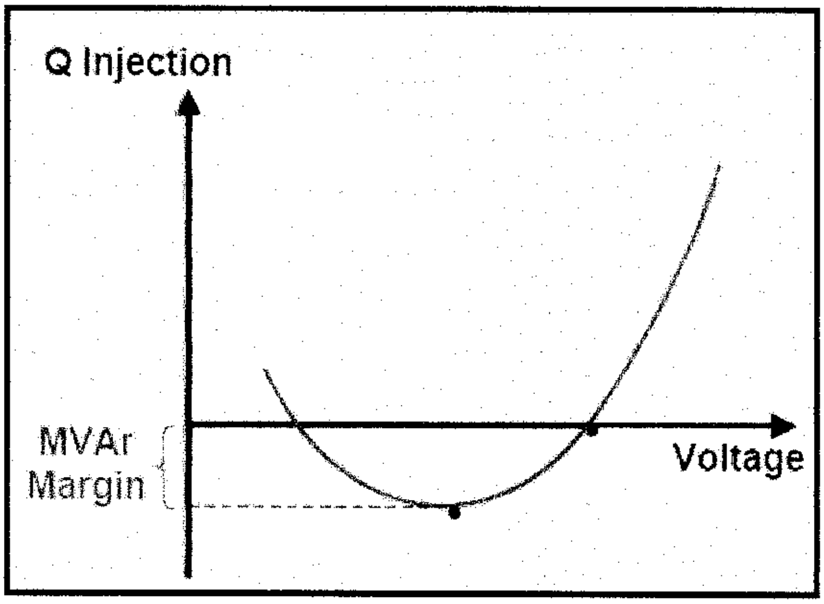


Figure 2 : Q-V Curve

2.3 Power Flow Analysis

Power flow analysis, commonly referred to as load flow, are the backbone of power system analysis and design. It is an important tool involving numerical analysis applied to a power system. A power flow study usually uses simplified notation such as a one-line diagram and per-unit system, and focuses on various forms of AC power (ie: reactive, real, and apparent) rather than voltage and current. The analysis is necessary for planning, operation, economic scheduling and exchange of power between utility. In addition, power flow analysis is required for many other analyses such as transient stability and contingency studies. The purpose of a power flow analysis program is to compute precise steady-state voltages of all buses in the network, and from them the real and reactive power flows into every line and transformer, under the assumption of known generation and load.

In order to evaluate the performance of a power distribution network and to examine the effectiveness of proposed alterations to a system in the planning stage, it is essential that a load flow analysis of the network is carried out. The load flow studies are carried out to determine:

i. The flow of active and reactive power in the power distribution network branches.
ii. Confirm the bus bar voltages are within limits (±5% of the rated voltage).
iii. Power distribution network losses.

2.3.1 Power Flow Problem

The problem with solving a power flow is that it is a non-linear problem, which greatly increases the difficulty of calculation. The only point where the solution is initially known is at the buses where values are set as reference values. It is the computation of the voltage magnitude and phase angle at each bus in the power network under balanced three-phase steady-state conditions. As a by product of this calculation, real and reactive power flows in the lines, transformers and loads can be determined. The starting point of the power flow problem is a single-line diagram of the power system, from which the input data for the PSAT software can be obtained. Input data consist of bus data, transmission line data and transformers data.

Each bus bar is associated with four variables which are

- Voltage Magnitude
- Phase Angle
- Real Power
- Reactive Power

At each bus, two of these variables (commonly the voltage magnitude and phase angle) are specified as input data, and the other two variables are unknowns to be computed by the power-flow program. Each bus is categorized into one of the following three bus types:

Slack Bus (Reference bus)

Slack bus or Swing bus: a slack bus or swing bus is a special generator bus that serves as the reference bus for the power system. The reference bus is generally connected to a generator. The input data for slack bus is $1.0\angle 0^{0}$ per unit. After calculating system power flows, the residual of the sum of the loads, minus total generation, is injected at the swing bus. This value is equivalent to system losses which can only be determined after network solution.Generally often it is taken to be 1 p.u. The real and reactive power for this bus is uncontrolled, it supplies whatever P or Q is necessary to make the power flows in the system balance.

PV Bus (Generator bus)

A generator bus is a bus at which the magnitude of the voltage is kept constant (by adjusting the field current of a synchronous gen. tied to the bus). A generator bus is also known as PV bus, because the real power and magnitude of the bus voltage |Vi| at the bus are specified. Furthermore, the generator bus is a bus to which a generator or multiple generators are linked. Voltage and real power flow are regarded as known quantities, while reactive power and phase angle are unknown.

PQ Bus (Load bus)

A load bus is a bus at which the real and reactive power is specified. A load bus is also known as PQ bus (normally, real power Pi and reactive power Qi at the bus are specified). Load buses comprise over 80% of most systems. In the load bus real and reactive power flows are known but voltage and phase angle must be calculated.

2.4 Per-Unit System (p.u system)

Per Unit System is a normalization procedure which provides a mathematical basis for analyzing power networks with relative ease and convenience. In the per-unit system, voltages, currents, impedances, and powers are expressed in a normalized fashion a percentages (or per-unit) of predefined base quantities. Per-unit (p.u) quantity is one that is expressed as a decimal fraction of a predefined base quantity. For example, if a base voltage were selected as 100V, then an actual voltage of 20V would be expressed as 0.20 per unit.

The advantages of this method of description include ease of system representation; elimination of transformer turns ratios and simplicity of number manipulation. The per-unit representation results in a more meaningful and correlated data. It gives relative magnitude information. There will be less chance of missing up between single and three phase powers or between line and phase voltage. Besides, the p.u. system is very useful in simulating machine systems on analog, digital, and hybrid computers for steady-state and dynamic analysis.

In per-unit system, by properly specifying the base quantities, the transformer equivalent circuit can be simplified. The ideal transformer winding can be eliminated, such that voltages, currents, and external impedances and admittance expressed in per-unit do not change when they are referred from one side of the transformer to the other side.

Manufacturers usually specify the impedance of a piece of apparatus in p.u. (or per cent) on the base of the name plate rating of power (S) and voltage (V). Hence, it can be used directly if the bases chosen are the same as the name plate rating. The p.u. impedance value of the various apparatus lies in a narrow range, though the actual values vary widely.

In general, the per-unit value is the ratio of the actual value and the base value of the same quantity.

$$\text{per unit value} = \frac{\text{actual value}}{\text{base value}}$$

Usually, manufacturers give impedance of equipment in percent on own base. The percent value is the per unit value multiplied by 100: $Z_{\%} = Z_{p.u.} \times 100\%$. The expression "own base" means that the base voltage is the rated voltage of the equipment, and the base power is the rated apparent power (in VA) of the equipment. The following formulas is commonly used in per-unit system

$$S_{base} = P_{base} = Q_{base}$$

$$I_{base} = \frac{S_{base}}{V_{base}}$$

$$Z_{base} = R_{base} = X_{base} = \frac{V_{base}^2}{S_{base}}$$

$$Y_{base} = G_{base} = B_{base} = \frac{1}{Z_{base}}$$

2.4.1 Change of base

When pieces of equipment with various different ratings are connected to a system, it is necessary to convert their impedances to a per unit value expressed on the same base. The base that we are converting from will be denoted by subscript M, the base we are converting to will be denoted by subscript N. The base impedance for the bases M and N are, respectively,

$$Z_{\text{M base}} = \frac{V^2_{\text{M base}}}{S_{\text{M base}}} \qquad Z_{\text{N base}} = \frac{V^2_{\text{N base}}}{S_{\text{N base}}}$$

The per unit impedances on the bases M and N are , respectively

$$Z_{\text{M p.u.}} = \frac{Z}{Z_{\text{M base}}} \qquad Z_{\text{N p.u.}} = \frac{Z}{Z_{\text{N base}}}$$

where Z is the actual ohmic value of the impedance of the equipment. It follows that

$$Z = Z_{\text{M p.u.}}\, Z_{\text{M base}} = Z_{\text{N p.u.}}\, Z_{\text{N base}}$$

Substituting for the base impedances we get

$$Z_{M\,p.u.}\frac{V_{M\,base}^2}{S_{M\,base}} = Z_{N\,p.u.}\frac{V_{N\,base}^2}{S_{N\,base}}$$

$$\therefore \quad Z_{N\,p.u.} = Z_{M\,p.u.}\frac{S_{N\,base}}{S_{M\,base}}\cdot\frac{V_{M\,base}^2}{V_{N\,base}^2}$$

Using the MVA and kV notation,

$$\boxed{Z_{N\,p.u.} = Z_{M\,p.u.}\frac{MVA_{N\,base}}{MVA_{M\,base}}\cdot\frac{(kV_{M\,base})^2}{(kV_{N\,base})^2}}$$

2.5 Introduction to Cogeneration Plant

2.5.1 Power Generation

A cogeneration plant is designed to generate electricity and HP steam required by the refinery complex. It will utilize natural gas as fuel to drive a Gas Turbine / Heat Recovery Steam Generation Package (GT/HRSG). [3]

2.5.2 Gas Turbine Generator and Heat Recovery Steam Generators

This is an open cycle gas turbine cogeneration. Two units of GTG / HRSG with supplementary firing capability, operating at 85% of designed load will be installed. Additional high pressure steam requirement of 87 ton/hr will be generated via the two existing boilers [3]

Electricity generation specifications [3]

Average normal load	= 75MW
Peak Load	= 90MW
Installed capacity	= GTG = 24MW
	= STG = 25MW
Top-up	= ZERO
Non – firm standby	= 21MW

2.5.3 Cogeneration Operating Condition

Three cogeneration operating condition will be analyzed throughout the project. The operating condition are as follows:

- 2 gas turbine generator and 1 steam turbine generator
- 3 gas turbine generator and 1 steam turbine generator
- 4 gas turbine generator and 1 steam turbine generator

CHAPTER 3

METHODOLOGY AND PROJECT WORK

3.1 Procedure Identification

Some methodologies or procedures are planned and to be used to accomplish this project as well as to meet all the objectives. In overall, the work execution of the first part of the project is divided into several stages and is illustrated in the flow chart below.

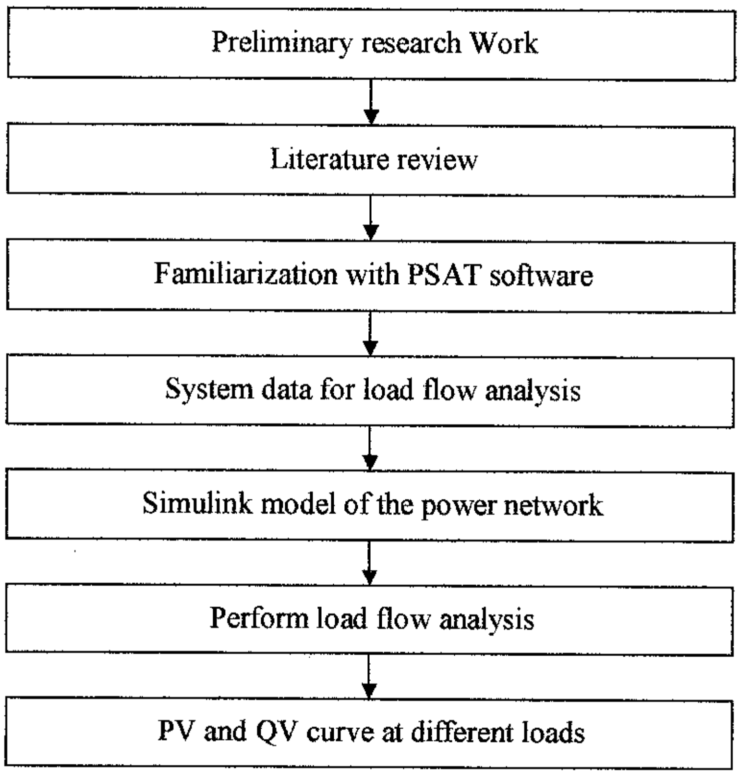


Figure 3 : Project Methodology

3.2 PV and QV method

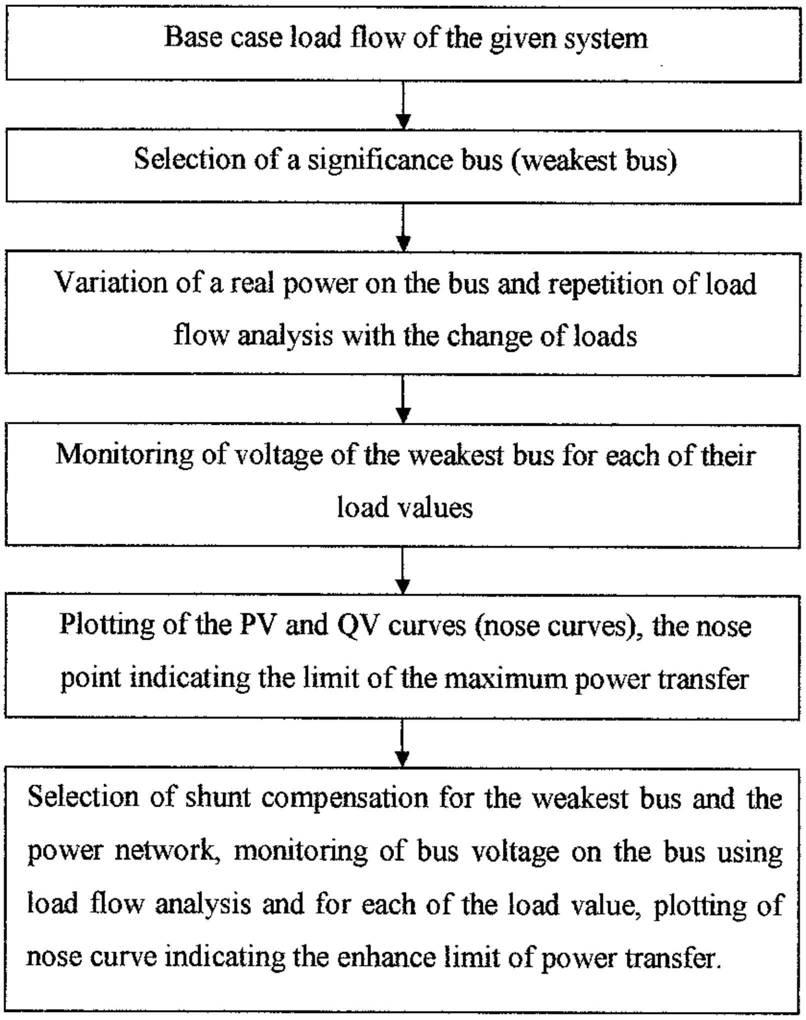


Figure 4 : PV and QV methodology

3.3 Tools Required

3.3.1 MATLAB 6.1 (R12.1) or 7.0 (R14)

MATLAB is programming software. Therefore, it is the most appropriate software to run any MATLAB based software packages for power system analysis.

3.3.2 PSAT 1.3.4

Power System Analysis Toolbox (PSAT) is required in order to carry out a load flow analysis. PSAT is a MATLAB toolbox for electric power system analysis and control. The command line version of PSAT is also GNU Octave compatible. PSAT includes power flow, continuation power flow, optimal power flow, time domain simulation and small signal stability analysis. All operations can be assessed by means of graphical user interfaces (GUIs) and a Simulink-based library provides an user friendly tool for the network design [3].

PSAT core is the power flow routine, which also takes care of state variable initialization. Once the power flow has been solved, further static and/or dynamic analysis can be performed. These routines are as follows: [3]

1. Continuation power flow
2. Optimal power flow
3. Small signal stability analysis
4. Time domain simulations
5. Phasor measurement unit (PMU) placement

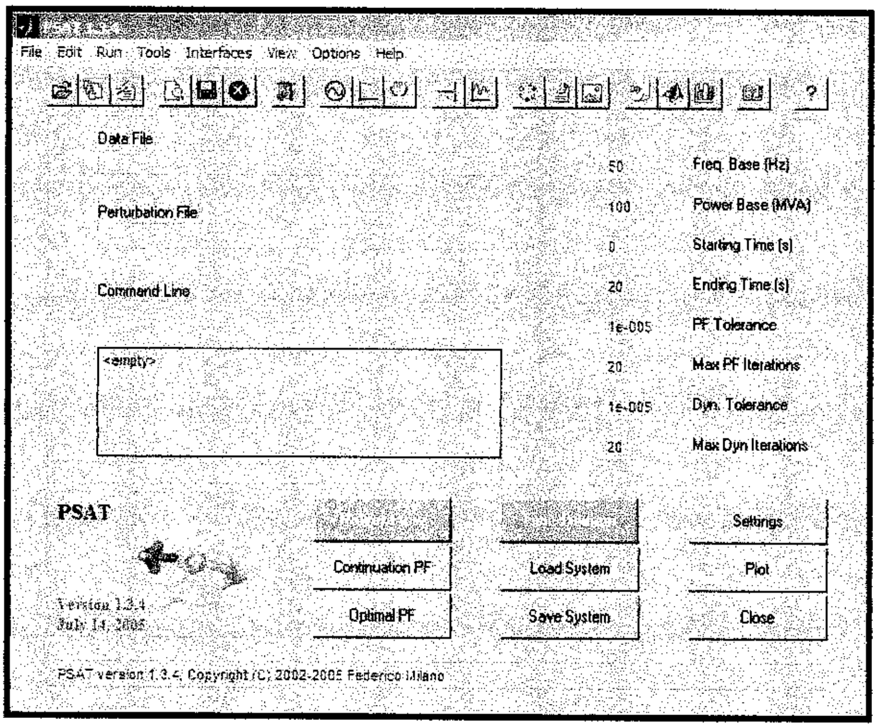


Figure 5 : P.S.A.T user interface

3.4 Project Work and Case Study

The maximum loading of the power network will be determine based on three Cogeneration operating conditions. The Simulink model of each network is modeled in the Simulink using MATLAB 7.0. The system model is based on the existing data from PETRONAS Penapisan (Melaka) Refinery 1 (PSR1) and PETRONAS Penapisan (Melaka) Refinery 2 (PSR2). The power is supply by the co-generation plant to the existing PETRONAS Penapisan (Melaka) Refinery 1 (PSR1) and PETRONAS Penapisan (Melaka) Refinery 2 (PSR2) loads. The loads for each Cogeneration operating condition will be the same. Power networks with capacitor banks switched ON and OFF drawn using Simulink.

3.4.1 Case 1 : 2 Gas Turbine and 1 Steam Turbine

Network Statistic :

- Buses : 43
- Lines : 19
- Transformers: 23
- Generators : 2
- Loads : 22

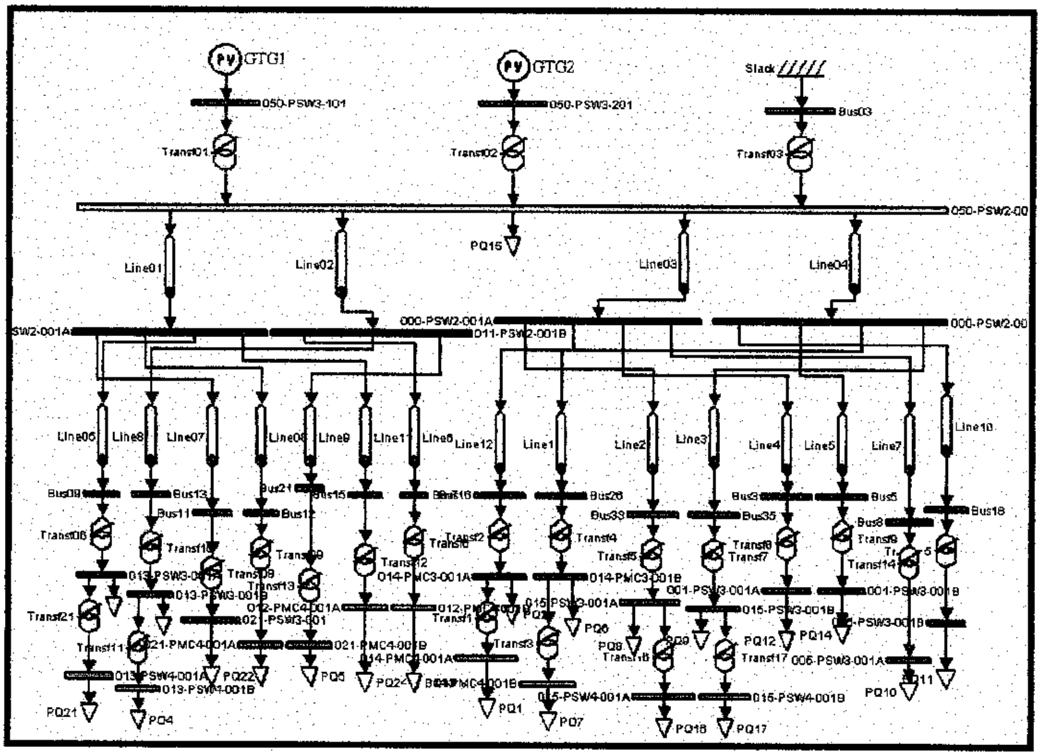


Figure 6 : Simulink model for case 1 (capacitor bank OFF)

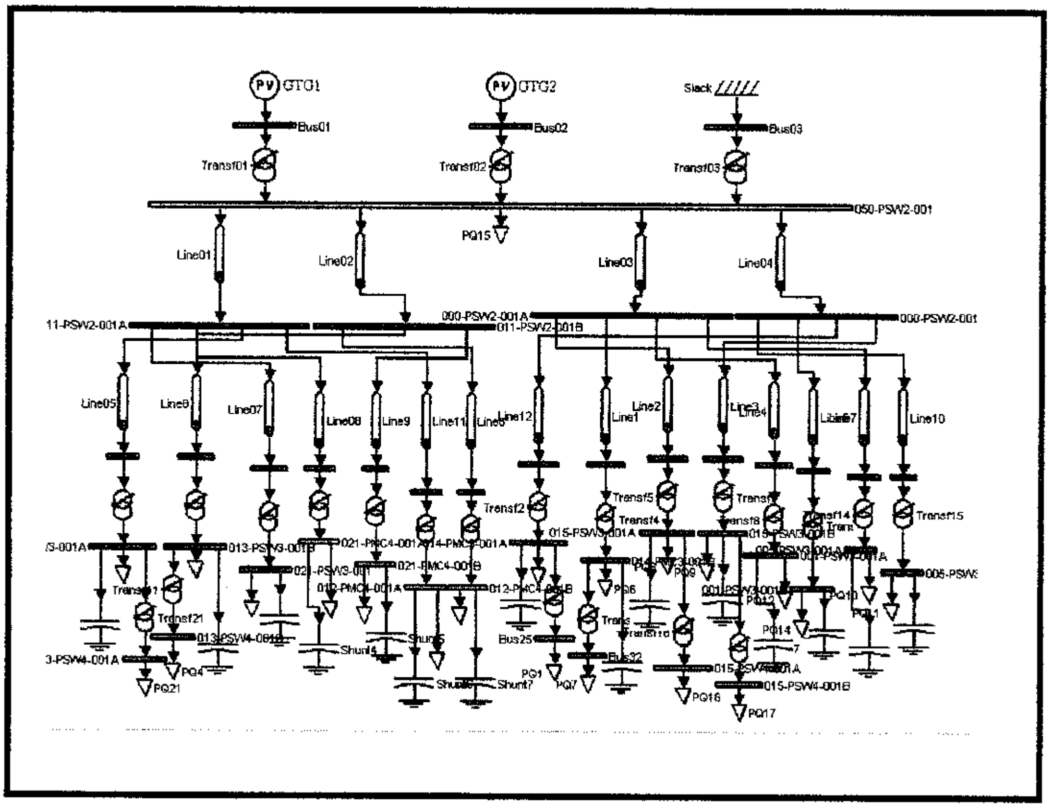


Figure 7 : Simulink model for case 1 (capacitor bank ON)

3.4.2 Case 2 : 3 Gas Turbine and 1 Steam Turbine

Network Statistic

- Buses : 44
- Lines : 19
- Transformers: 24
- Generators : 3
- Loads : 22

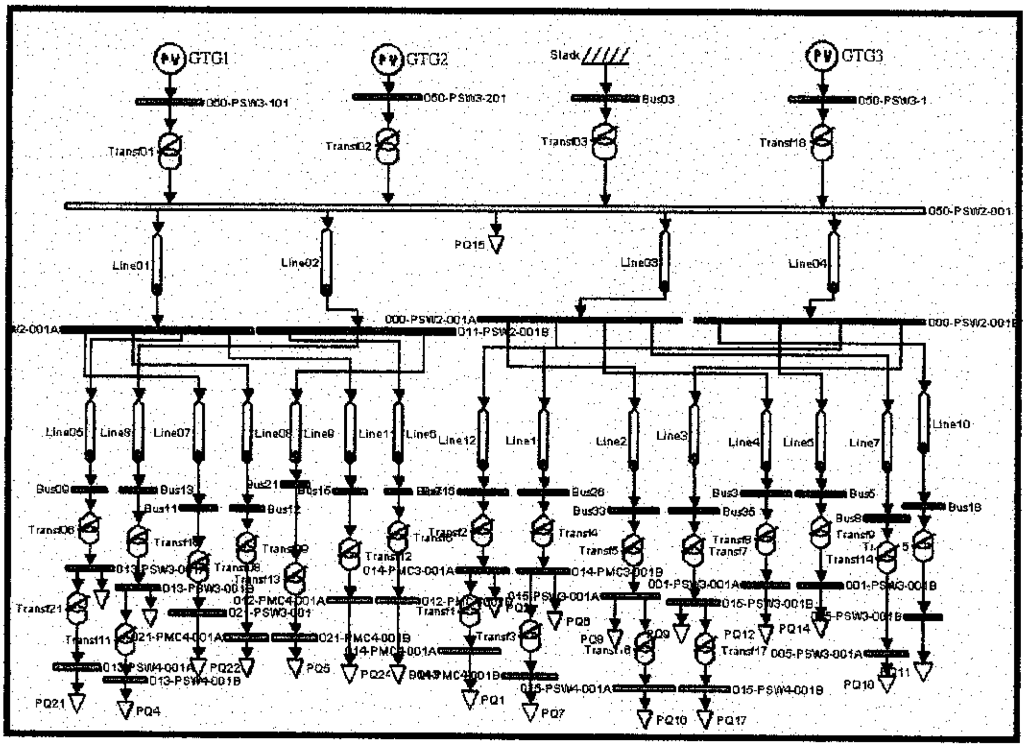


Figure 8 : Simulink model for case 2 (capacitor bank OFF)

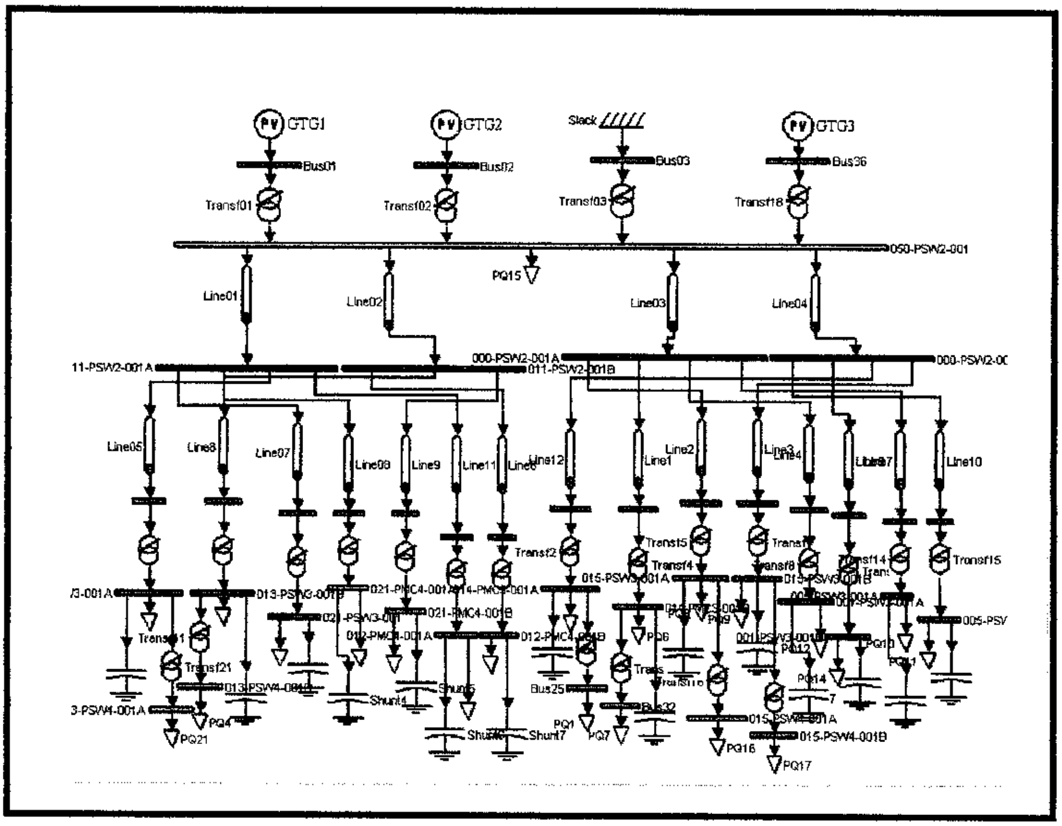


Figure 9 : Simulink model for case 2 (capacitor bank ON)

3.4.3 Case 3 : 4 Gas Turbine and 1 Steam Turbine

Network Statistic

- Buses : 46
- Lines : 19
- Transformers: 26
- Generators : 5
- Loads : 22

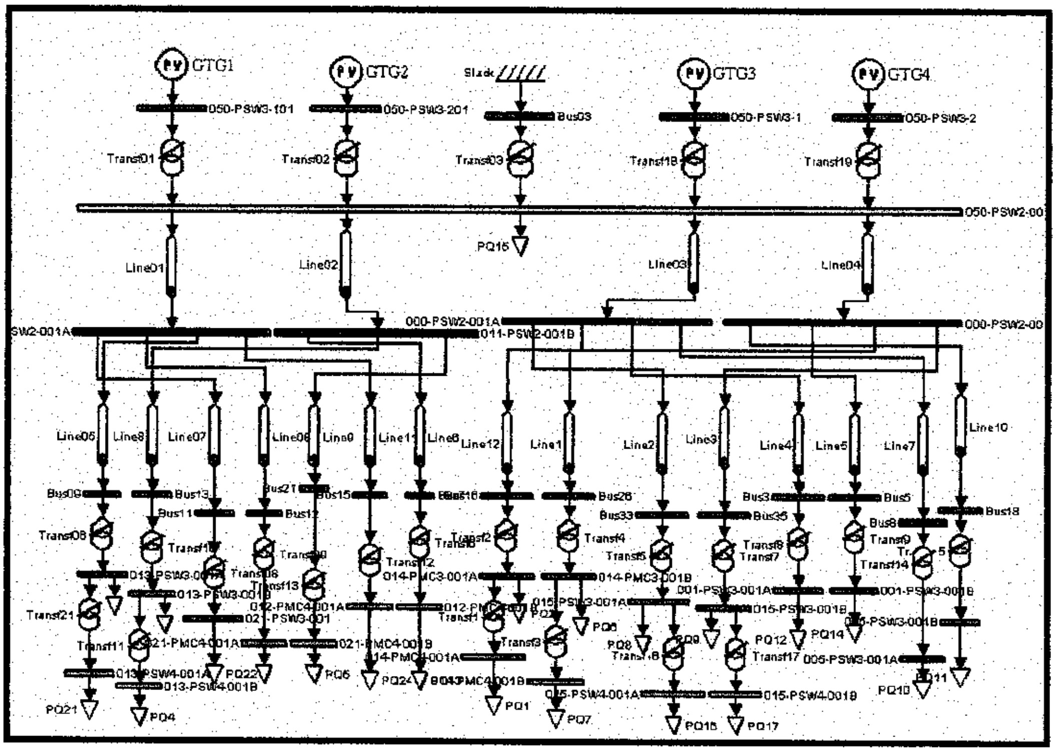


Figure 10 : Simulink model for case 3 (capacitor bank OFF)

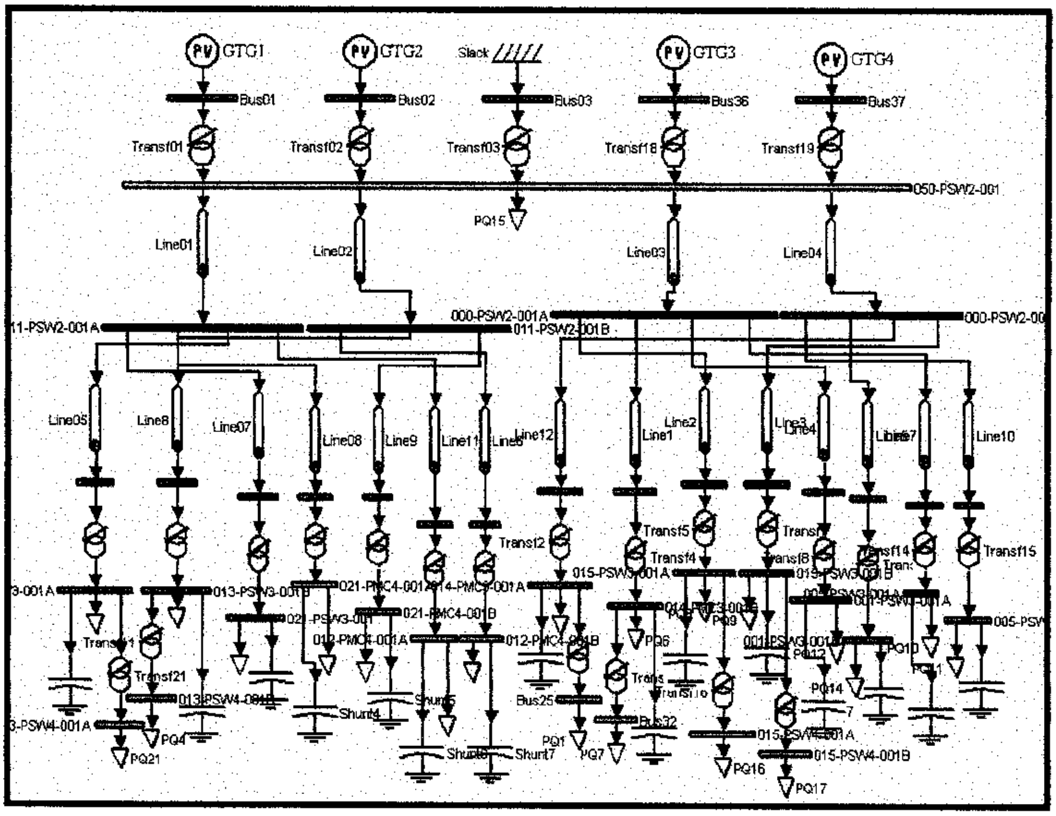


Figure 11 : Simulink model for case 3 (capacitor bank ON)

CHAPTER 4
RESULT AND DISCUSSION

Load flow analysis for each Cogeneration operating conditions is performed using Power System Analysis Toolbox (PSAT) software. A simulation report is generated for each cogeneration operating condition (See Appendix F). From the generated report, the voltage of each bus of the power system can be obtained. The bus voltage should be within 5% of its rated voltage. The weakest bus in power system is determine by selecting a bus which have the lowest or the highest voltage level.

From the load flow analysis, it is found that the weakest bus in the system is bus 005-PSW3-001, 11 kV bus at Substation 5. The bus supply 8.36724 kW and 5.033735 kVAR to the connected loads at both feeder A and B. Variation of a real power and reactive power on the weakest bus and repetition of load flow analysis with the change of loads, change of transformer tap setting and introduction of capacitor banks are done while monitoring and recording the voltage of bus 005-PSW3-001.

P-V and Q-V curve for each cogeneration operating condition are plotted to determine the nose point which indicates the limit of the maximum power transfer. Each case of cogeneration operating condition is analyzed when all capacitor banks in the power network to be switched OFF, when all capacitor banks in the network to be switched ON and when all capacitor banks in the power network are switched OFF except the capacitor bank at the weakest bus. The analysis is also done for different tap setting of transformer (005-PTR3-001A/B) which are for nominal tap, -2.5% tap, -5.0% tap and + 2.5% tap. Lower the tap setting results in higher voltage at the secondary voltage while higher the tap will result in lower voltage at the secondary.

From PV and QV curve, the bus voltage at different transformer tap setting while supplying its current load can be obtained. The voltage will vary if the tap setting of the transformer changed. It is important to set the correct transformer tap setting to ensure the bus voltage is near to its nominal voltage. If the bus voltage is higher than its nominal voltage, insulation could be damaged and if the bus voltage is lower more than 5% from its nominal voltage, the system operation will not be feasible. The system stability is much more influenced by the reactive power. Lack of reactive power leads to low voltage or voltage drop. The QV curve effects the voltage stability more compare to the PV curve.

The PV and QV curve represent the maximum loading limit of the power network, but for a plant like Melaka Refinery, the load connected at each bus are fixed. The main concern of this project is to ensure that the bus voltage are kept near to the nominal voltage of the respective bus when the power are delivered to the normal load. The bus voltage can be kept near to its nominal voltage by either changing the transformer tap setting or by adding the capacitors to the power network. In the PV curve, the nominal transformer tap setting is represented by blue curve, the -2.5% of tap setting is represented by pink curve, the -5.0% tap setting is represented by orange curve and the +2.5% tap setting is represented by the green curve. Transformer tap setting which leads to a bus voltage near to the nominal voltage should be set. The bus voltage should not be higher than the nominal voltage as it could cause insulation and cables damaged.

4.1 P-V Curves

4.1.1 PV Curves for Cogeneration operating condition 1

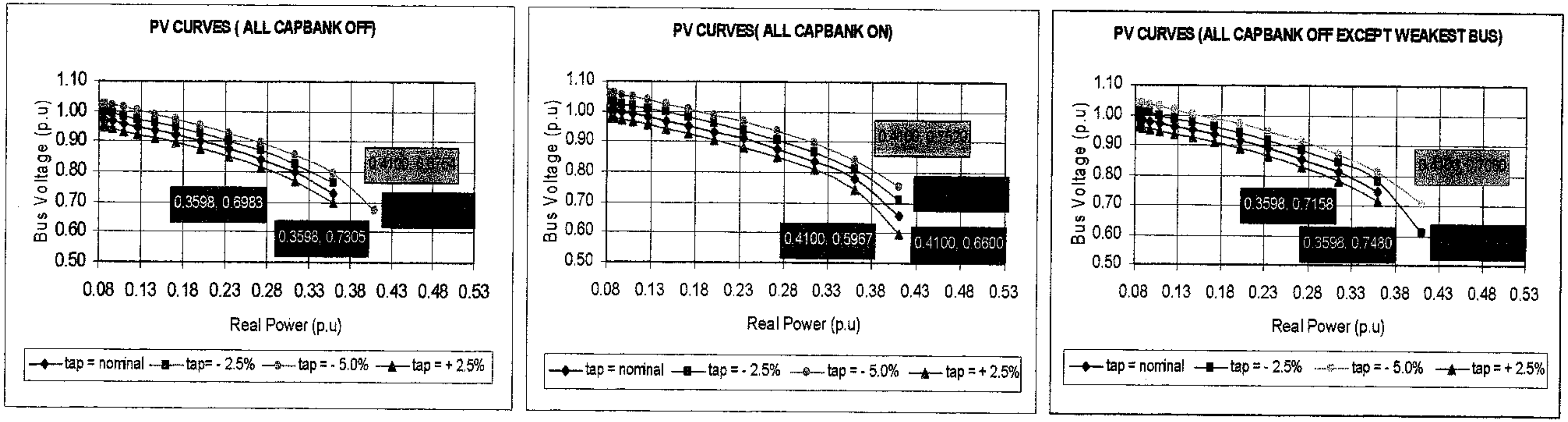


Figure 12 : PV curves for Cogeneration Operating 1

As shown in Figure 12, when capacitor connected at all bus as well as the weakest bus (005-PSW3-001A/B) are switched OFF, the bus voltage will be at 0.94554 p.u when the transformer tap setting is set to +2.5%. The transformer tap setting is then set to its nominal tap to increase the bus voltage. When the tap setting is set to the nominal tap (blue curve), the bus voltage increase to 0.97022 p.u. Then the transformer tap setting is further reduced to -2.5% and the bus voltage increase to 0.99835 p.u (pink curve). When the tap setting is set to -5.0%, the bus voltage increase to 1.02340 p.u (orange curve). In order to kept the bus voltage to the nominal voltage of the weakest bus (005-PSW3-001A/B), the tap setting of -2.5% need to be set. The bus voltage should not be higher than the nominal voltage because higher voltage can cause damaged to the insulations and cables. So, tap setting of -5.0% should not be chosen.

The suitable transformer tap setting when all capacitor banks are OFF except at the weakest bus and when all capacitor bank is ON is also determined. When all capacitor banks are OFF except the weakest bus, the nominal tap setting should be chosen to ensure the bus voltage is kept near to its nominal voltage and when all capacitor bank in the network are ON, the tap setting of -2.5% should be chosen. It can be seen that the capacitor banks and the transformer tap setting influenced the voltage of the weakest bus.

4.1.2 PV Curves for Cogeneration operating condition 2

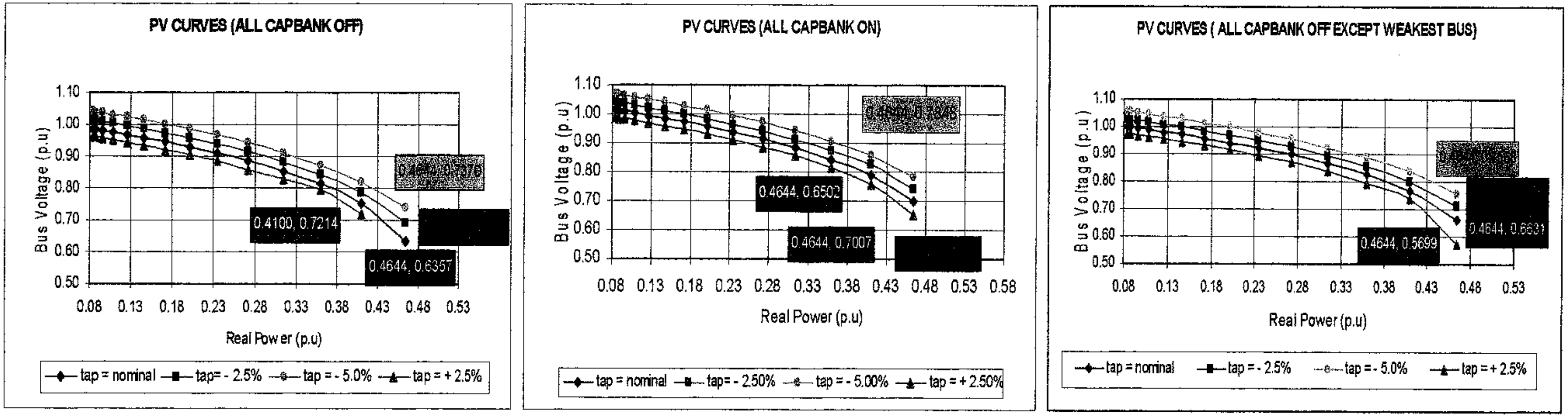


Figure 13 : PV curves for Cogeneration Operating 2

4.1.3 PV Curves for Cogeneration operating condition 3

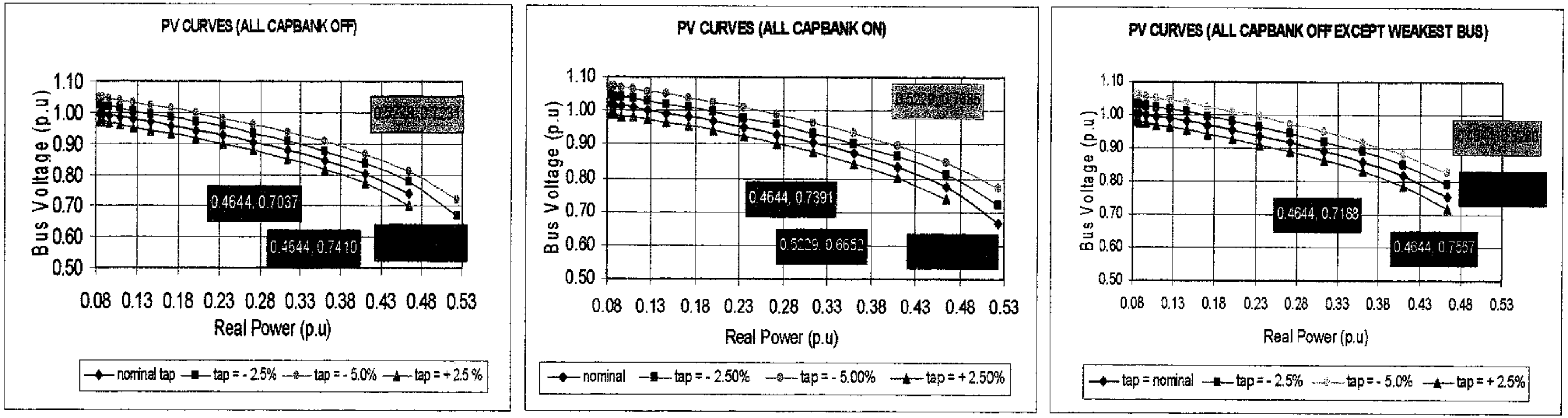


Figure 14 : PV curves for Cogeneration Operating 3

4.2 Q-V Curves

4.2.1 QV Curves for Cogeneration operating condition 1

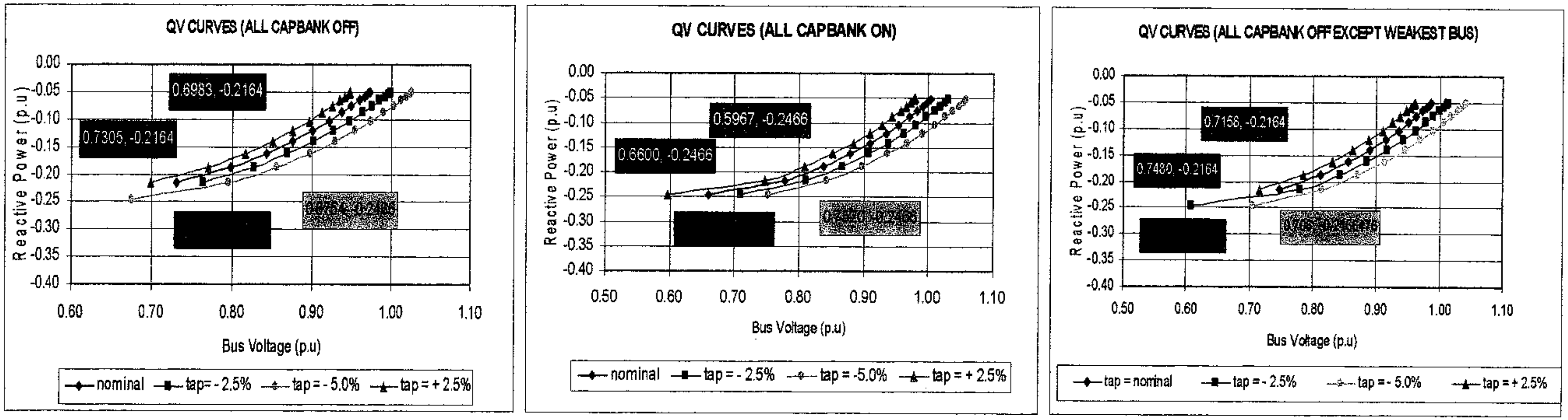


Figure 15 : QV curves for Cogeneration Operating 1

4.2.2 QV Curves for Cogeneration operating condition 2

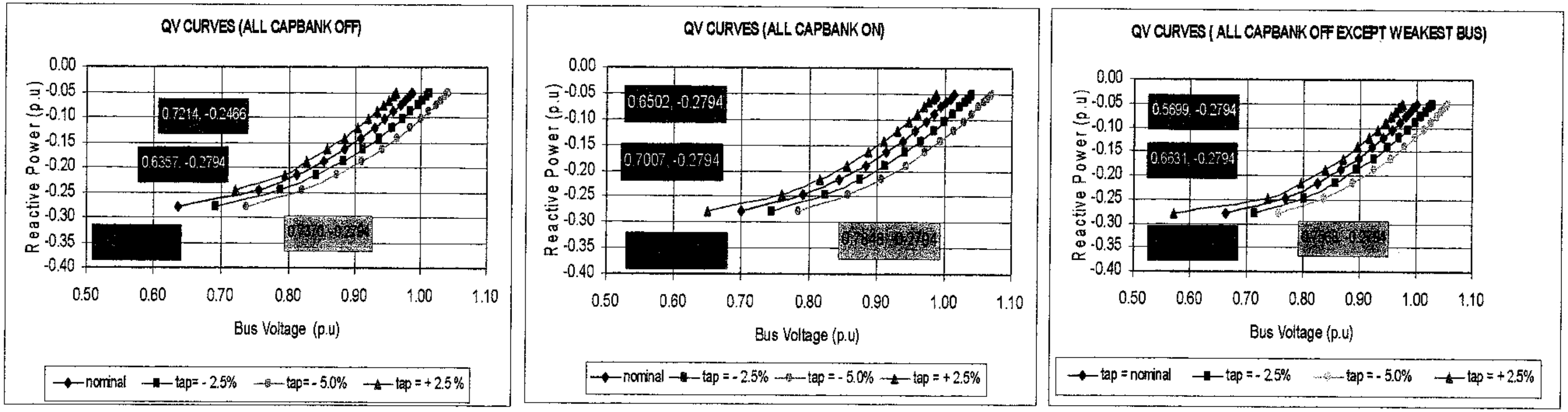


Figure 16 : QV curves for Cogeneration Operating 2

4.2.3 QV Curves for Cogeneration operating condition 3

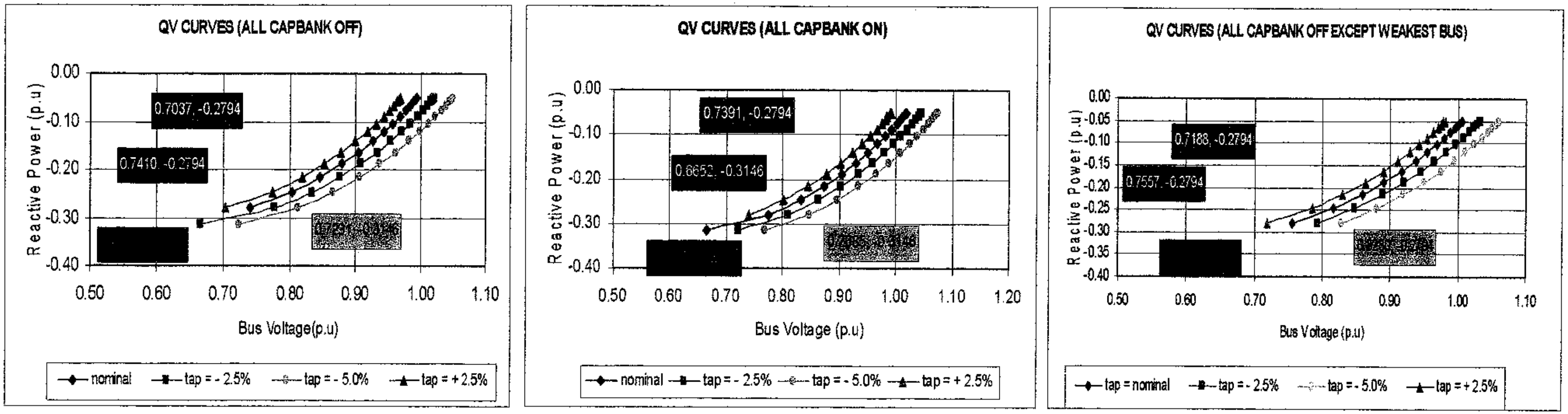


Figure 17 : QV curves for Cogeneration Operating 3

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Project work in the first semester and second semester has met the objectives of the project. The maximum loading limit of the power network has been determined by running a load flow analysis and plotting the P-V and Q-V curves (nose curve). The result has also proved that better load compensation will results in higher power transfers in the power network while change of the tap setting of a transformer also improves the bus voltage to a satisfactory value, enhance the load serving ability. It is important to ensure that the all bus voltage are at their rated voltage during the operation to prevent over-voltage or insulation damage. An recommend operational planning for the PETRONAS Penapisan (Melaka) Sdn. Bhd has been prepared. The success of the project depends on the effort of the student to grab and apply the knowledge gained through out the learning stage. A constant meeting and discussion with lecturers and supervisors has benefited the project a lot. Thus the management and planning of the project is very critical due to the time constraint. Every stages of the project have its own set of dateline to be accomplished and met. The author will also get a valuable knowledge on the load flow analysis and voltage stability analysis. The knowledge and experiences gained in the related field throughout the project is indeed very precious in the job market.

5.2 Recommendation

5.2.1 *Operational Planning (Recommendation)*

Based on P-V Curve

[illegible]	[illegible]	[illegible]	[illegible]
2GTG + 1 STG	-2.50%	nominal	-2.50%
3GTG + 1 STG	nominal	2.50%	nominal
4GTG + 1 STG	nominal	2.50%	nominal

Table 1 : Operational Planning based on P-V curve

Based on Q-V Curve

[illegible]	[illegible]	[illegible]	[illegible]
2GTG + 1 STG	-2.50%	nominal	nominal
3GTG + 1 STG	nominal	2.50%	nominal
4GTG + 1 STG	nominal	2.50%	nominal

Table 2 : Operational Planning based on Q-V curve

5.2.2 Recommendation for further work

Analysis based on all the weak buses in the network using nose point concept to further enhance the results of the analysis and to determine the optimum capacitor deployment and optimum transformer tap setting as well as to obtain more accurate and reliable value of maximum loading limit of the power network.

REFERENCES

[1] Ahmad Reza Bin Azman, " Power Flow Using Power System Simulation Software / SKM Power Tools" , Final Year Report, Universiti Teknologi PETRONAS, June 2004

[2] Chan Chee Ying, " A Proposed Strategy of Implementation for Load Shedding and Load Recovery with Dynamic Simulation" , Final Year Report, Universiti Teknologi PETRONAS, June 2004

[3] Federico Milano, " psat-1.3.4 manual " , 2005

[4] PETRONAS Technical Standard, PTS 33.64.10.10 : "Electrical Engineering Guidelines"

[5] P. Sauer and M. Pai, "Power System Steady-State Stability and the Load Flow Jacobian," IEEE Transactions on Power Systems, Vol.5, No.4, Nov.1990.

[6] S. Greene, I. Dobson, and F. Alvarado, "Sensitivity of the Loading Margin to Voltage Collapse with Respect to Arbitrary Parameters," IEEE Transactions on Power Systems, Vol.12, No.1 Feb. 1997, pp.232-240.

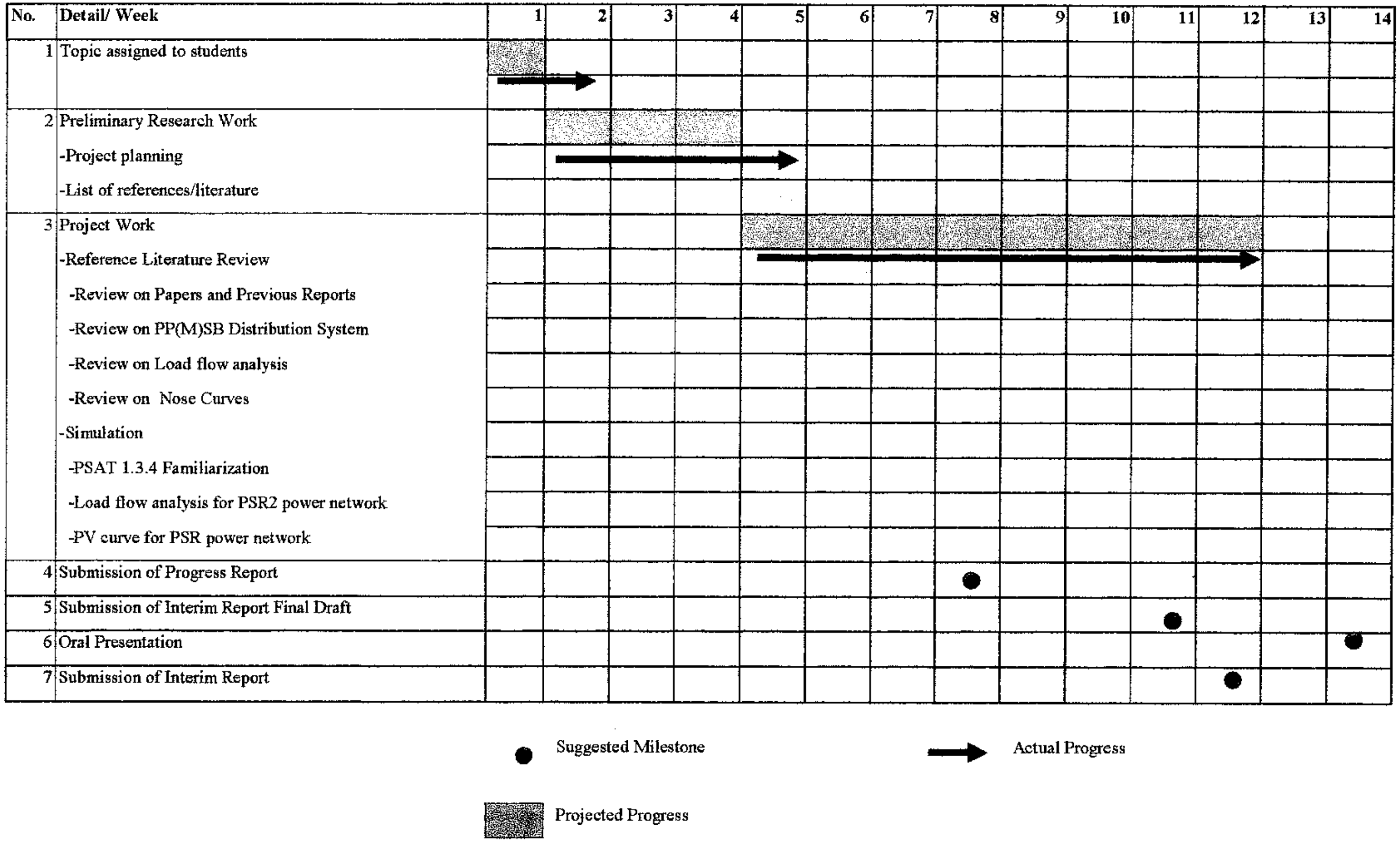
[7] www. power.uwaterloo.ca/~fmilano

APPENDICES

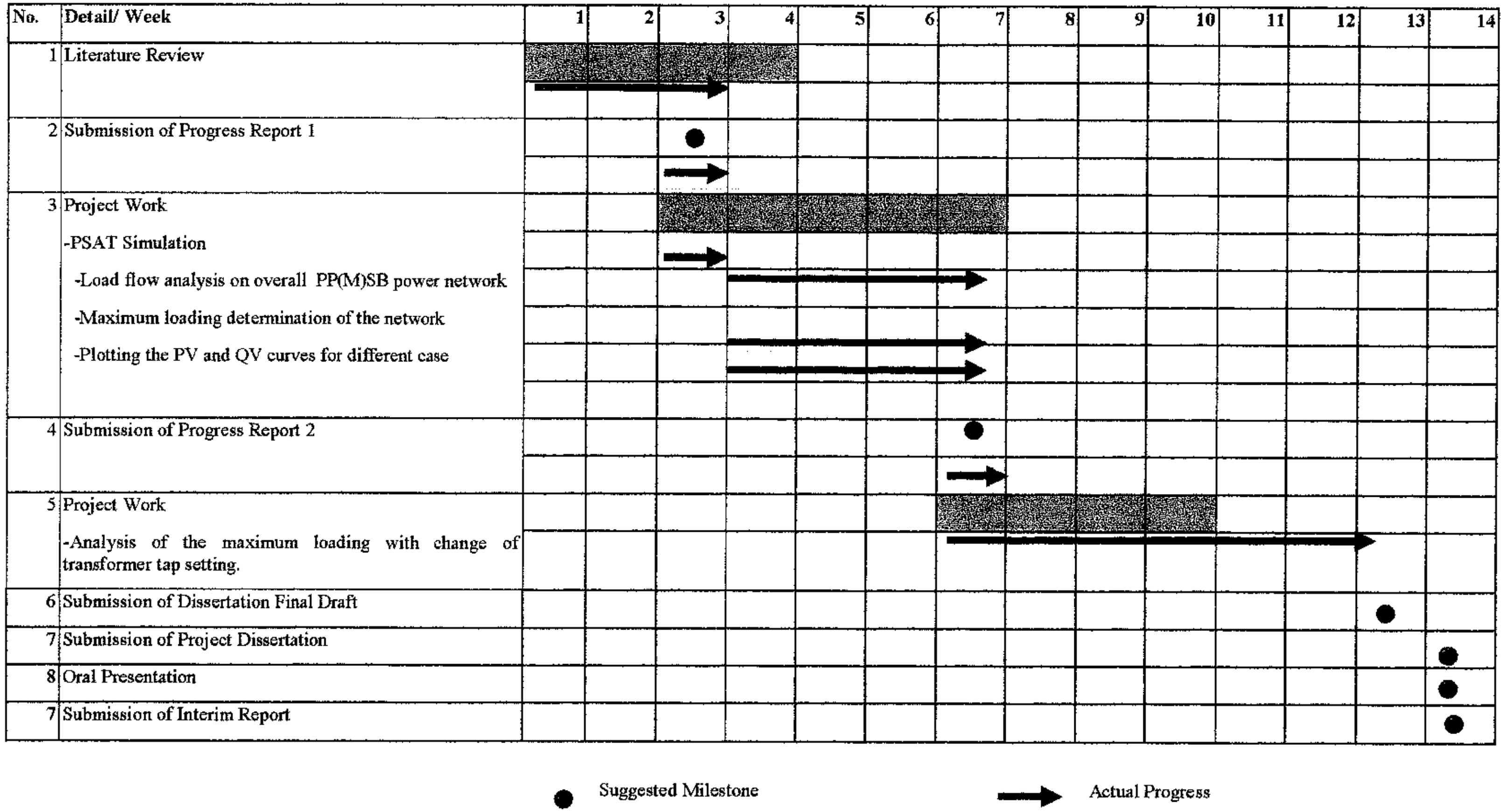
APPENDIX A

PROJECT GANTT CHARTS

Milestone Chart for the First Semester of 2 Semester Final Year Project



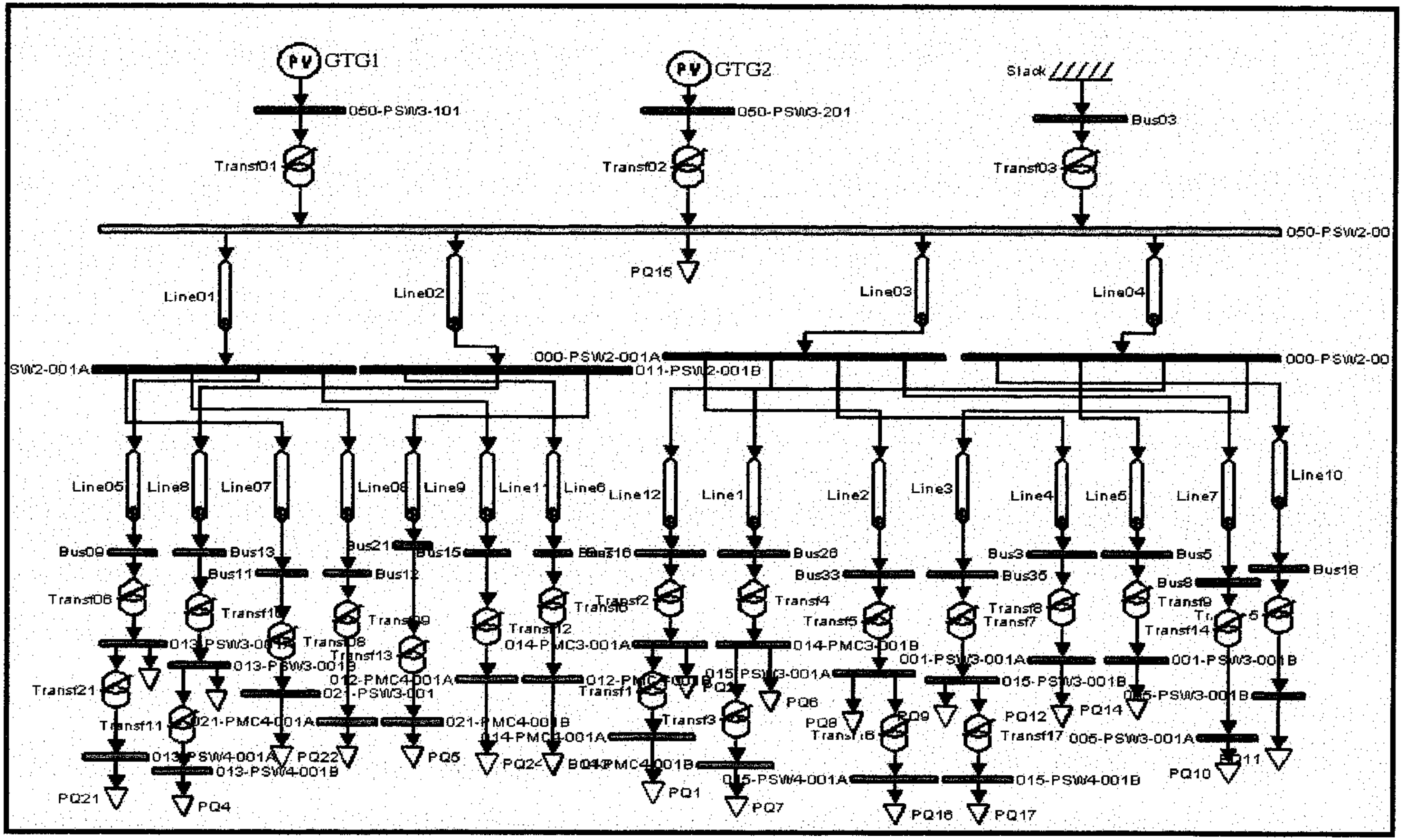
Milestone Chart for the Second Semester of 2 Semester Final Year Project



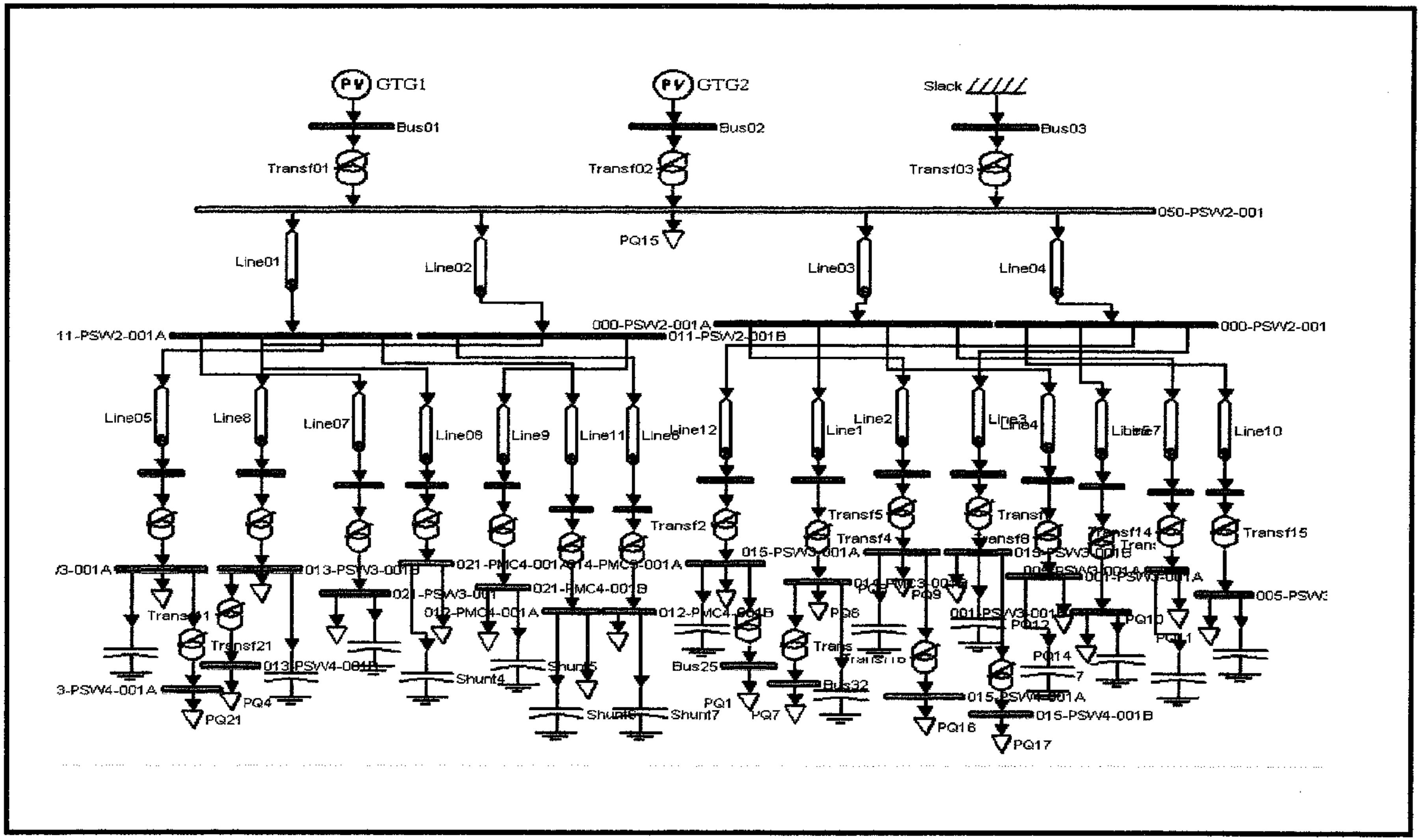
APPENDIX B

SIMULINK MODEL OF THE POWER SYSTEM

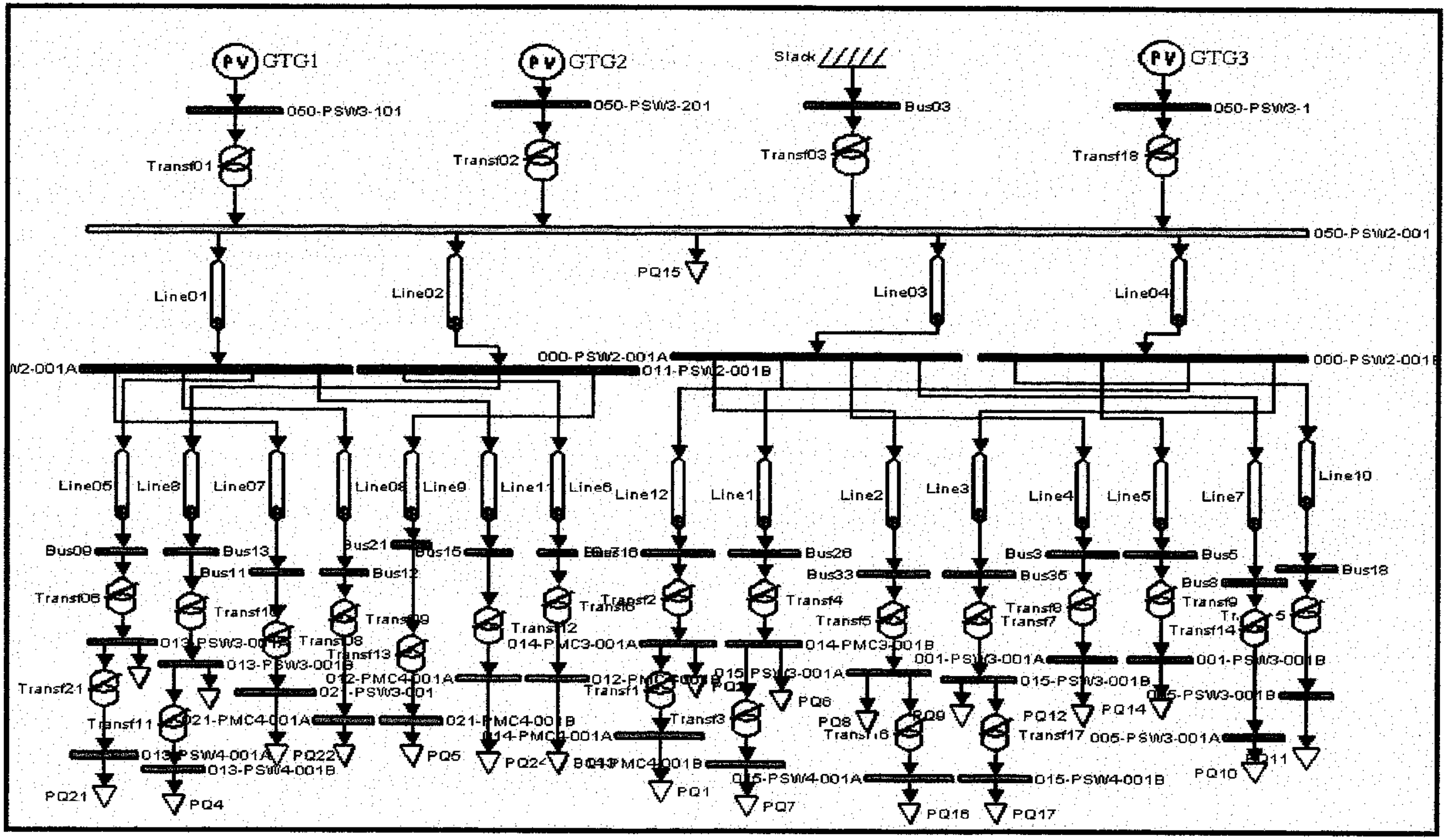
Case 1 : 2GTG + 1 STG (capacitor bank OFF)



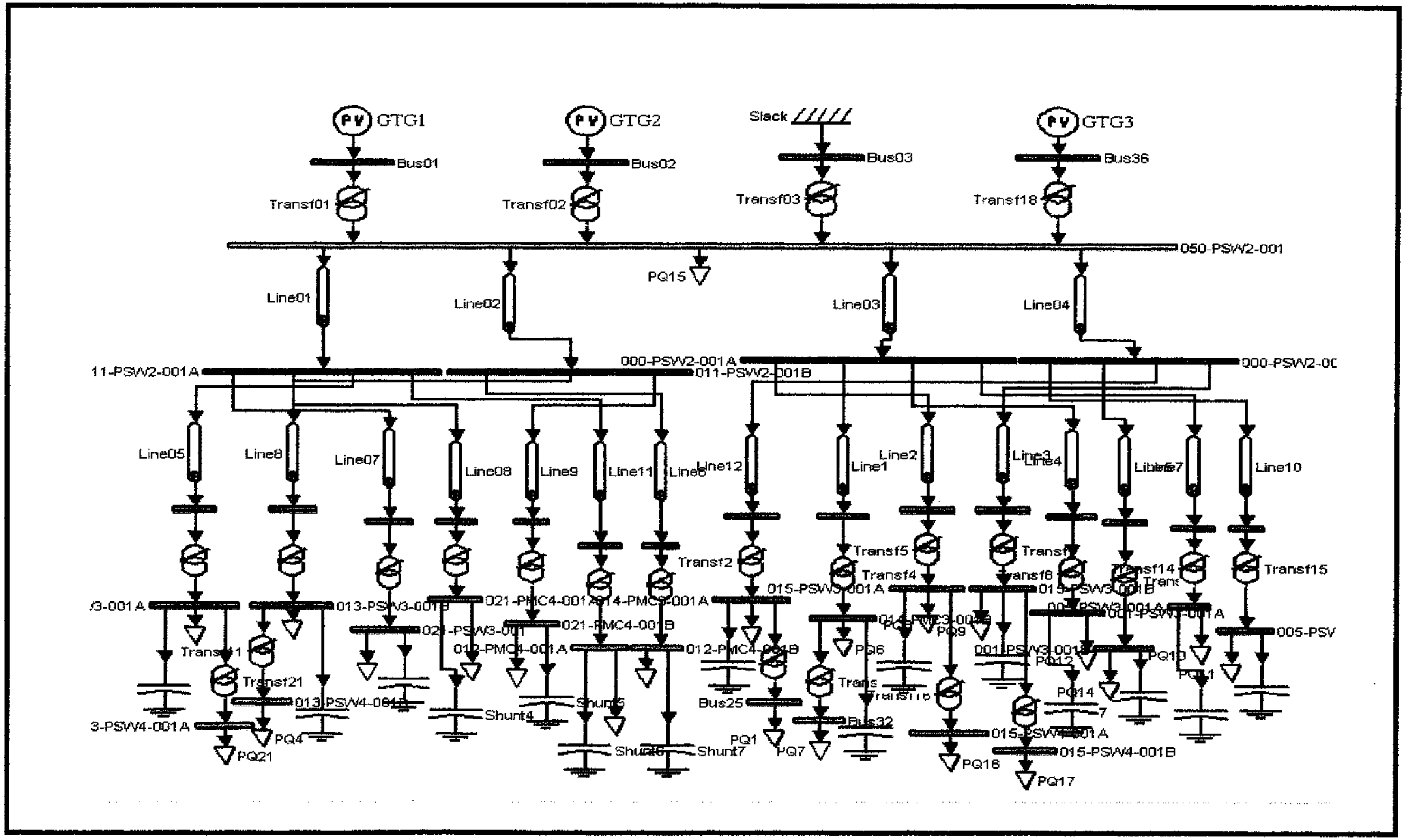
Case 1 : 2GTG + 1 STG (capacitor bank ON)



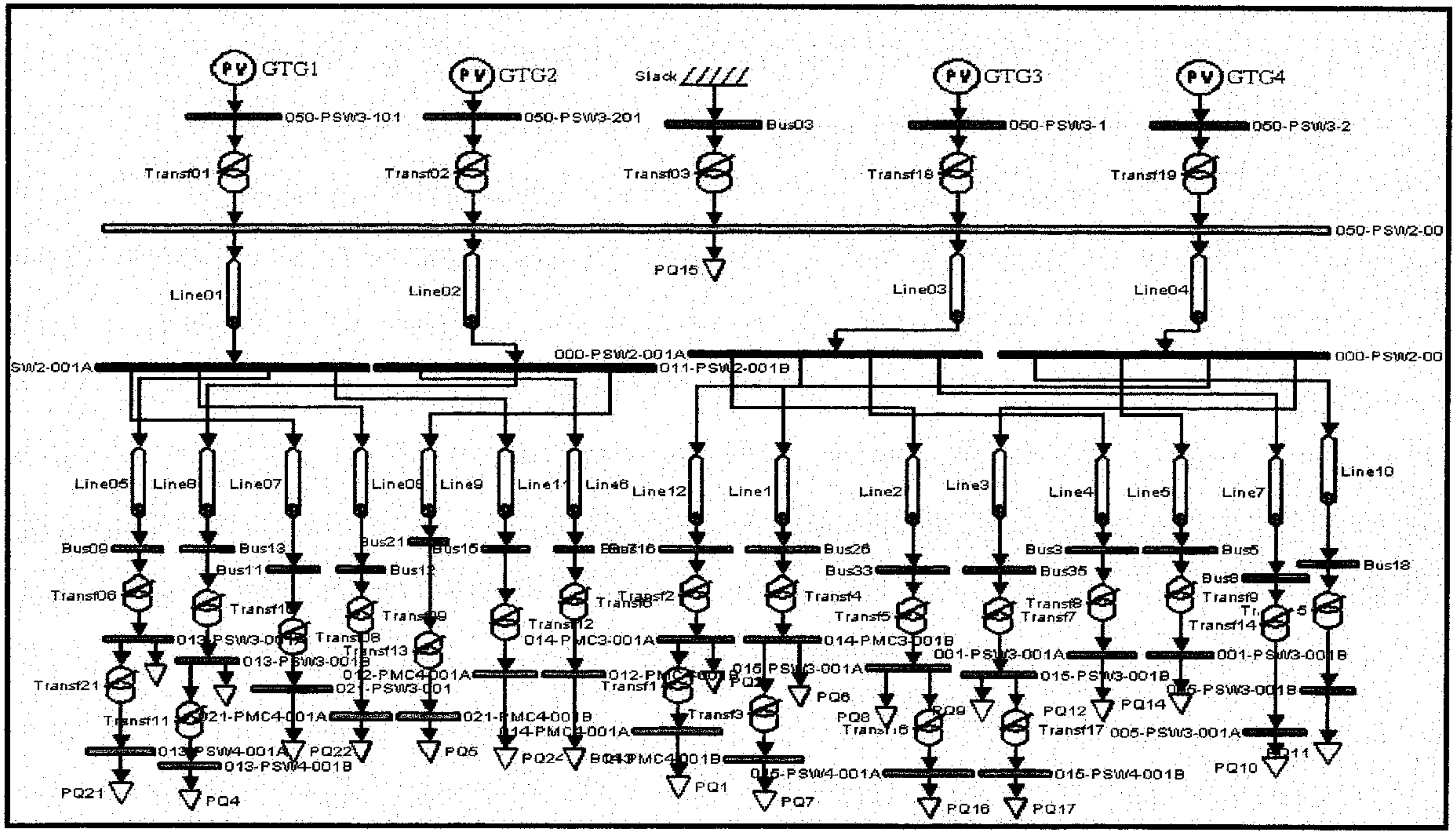
Case 2 : 3GTG + 1 STG (capacitor bank OFF)



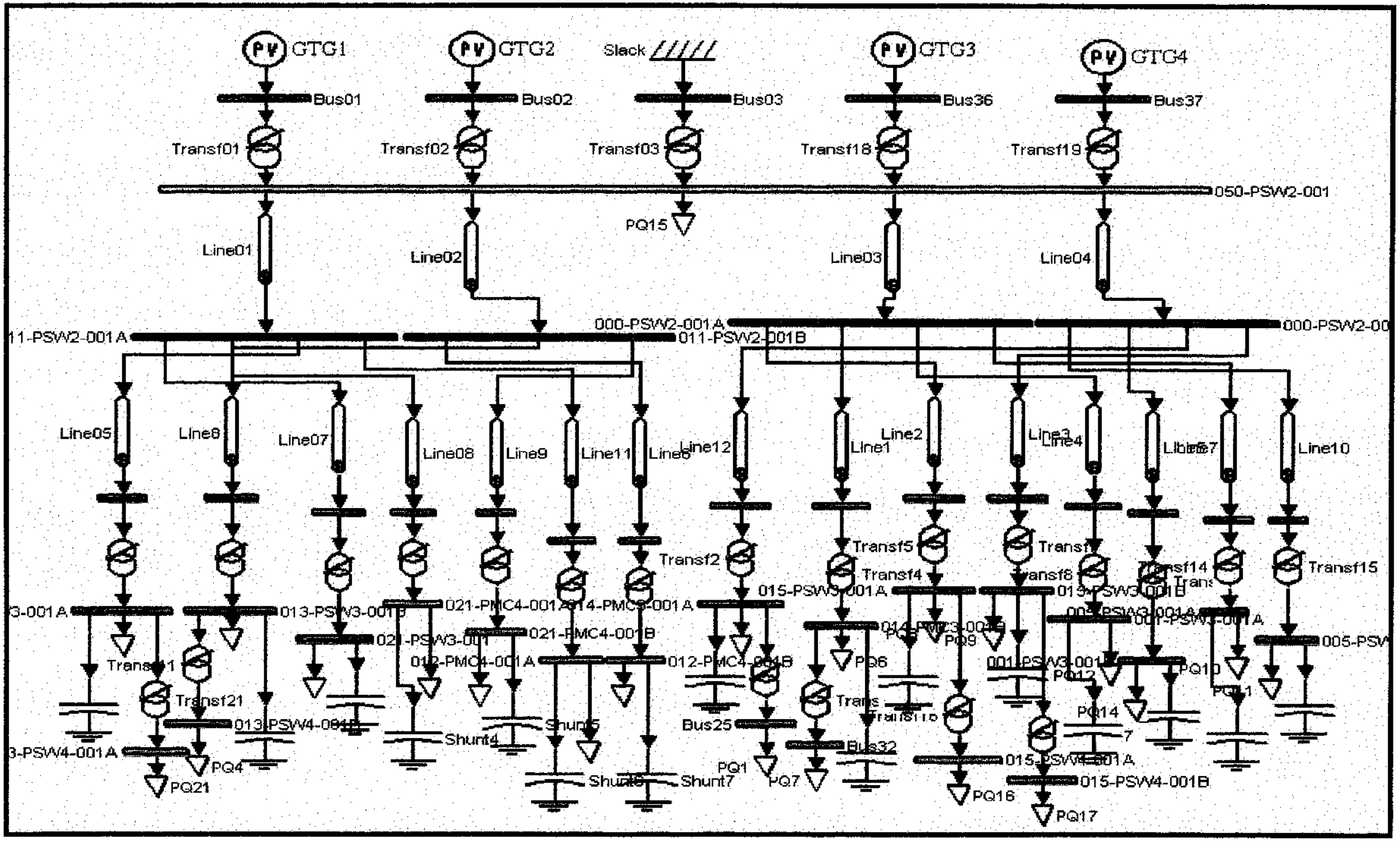
Case 2 : 3GTG + 1 STG (capacitor bank ON)



Case 3 : 4GTG + 1 STG (capacitor bank OFF)



Case 3 : 4GTG + 1 STG (capacitor bank ON)



APPENDIX C

PETRONAS TECHNICAL STANDARD

PTS 33.64.10.10 Electrical Engineering Guidelines

Peak load is calculated from the following formula:

Peak Load = x (%) E + y (%) F + z (%) G

Where

E: sum of all continuously operating loads

F: sum of all intermittent loads

G: sum of all stand-by loads

x , y , z are diversity factors

The following diversity factors are used:

X : 100%

Y : 30% is considered for MOV panels. For other switchgears / switchboards. It is as much as the largest individual intermittent drive or consumer to be operated, unless otherwise specified in the following note.

Z : 0%

APPENDIX D

DATA FILE

FLOW REPORT

T 1.3.4

: Federico Milano, (c) 2002-2005
: fmilano@thunderbox.uwaterloo.ca
e: http://thunderbox.uwaterloo.ca/~fmilano

D:\Final Year Project\sem2\simulink file\no compensation\two
\notnbtwo_feeder_nocapbank_1_7sept.mdl
09-Dec-2006 05:53:25

K STATISTICS

:	44
:	19
ormers:	24
tors:	3
:	22

ON STATISTICS

of Iterations:	4
m P mismatch [p.u.]	0
m Q mismatch [p.u.]	0
rate [MVA]	100

FLOW RESULTS

	V [p.u.]	phase [rad]	P gen [p.u.]	Q gen [p.u.]	P load [p.u.]	Q load [p.u.]
SW2-0	0.99157	-0.15382	0	0	0	0
SW2-0	0.99157	-0.15382	0	0	0	0
SW3-0	1.0109	-0.16352	0	0	0.01306	0.00779
SW3-0	1.0109	-0.16352	0	0	0.01306	0.00779
SW3-0	0.97244	-0.18377	0	0	0.08367	0.05034
SW3-0	0.97244	-0.18377	0	0	0.08367	0.05034
SW2-0	1.0015	-0.14603	0	0	0	0
SW2-0	1.0016	-0.14599	0	0	0	0
MC4-0	0.98611	-0.16599	0	0	0.04762	0.02912
MC4-0	0.98815	-0.16711	0	0	0.04762	0.02912
SW3-0	0.99793	-0.16898	0	0	0.10329	0.01061
SW3-0	0.99799	-0.16895	0	0	0.10329	0.01061
SW4-0	0.99167	-0.18154	0	0	0.00994	0.0049
SW4-0	0.99173	-0.1815	0	0	0.00994	0.0049
MC3-0	1.0131	-0.1726	0	0	0.06282	-0.00403
MC3-0	1.0131	-0.1726	0	0	0.06282	-0.00403
MC4-0	1.0045	-0.18571	0	0	0.02668	0.0171
MC4-0	1.0045	-0.18571	0	0	0.02668	0.0171
SW3-0	1.006	-0.17003	0	0	0.0629	0.03703
SW3-0	1.006	-0.17003	0	0	0.0629	0.03703
SW4-0	1.0022	-0.17649	0	0	0.00261	0.0015
SW4-0	1.0022	-0.17649	0	0	0.00261	0.0015
MC4-0	0.99285	-0.16096	0	0	0.01782	0.00994
MC4-0	0.99291	-0.16092	0	0	0.01782	0.00994
SW3-0	1.0192	-0.15866	0	0	0.01654	0.00977
SW2-0	1.0021	-0.14552	0	0	0.0324	0.02009
SW3-1	1	-0.06052	0.24651	0.15691	0	0
SW3-2	1	-0.06052	0.24651	0.15691	0	0
SW3-3	1	0	0.42103	0.17712	0	0
	1.0013	-0.14632	0	0	0	0
	1.0013	-0.14601	0	0	0	0
	1.0013	-0.14602	0	0	0	0
	1.0014	-0.14628	0	0	0	0
	0.99925	-0.14484	0	0	0	0
	0.99052	-0.15521	0	0	0	0
	0.98991	-0.1551	0	0	0	0
	1.0014	-0.14598	0	0	0	0

0.99052	-0.15521	0	0	0	0
0.99134	-0.15387	0	0	0	0
0.9899	-0.15464	0	0	0	0
0.9899	-0.15464	0	0	0	0
0.99134	-0.15387	0	0	0	0
1.0013	-0.14605	0	0	0	0
0.98991	-0.1551	0	0	0	0

LOWS

us	To Bus	Line	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u.]	Q Loss [p.u.]
SW2-0	011-PSW2-0	1	0.19546	0.06793	7e-005	-0.00016
SW2-0	011-PSW2-0	2	0.17877	0.05812	6e-005	-0.00019
SW2-0	000-PSW2-0	3	0.25371	0.1102	0.00175	-0.00068
SW2-0	000-PSW2-0	4	0.25371	0.1102	0.00175	-0.00068
SW2-0	Bus09	5	0.11325	0.01806	2e-005	-0.00023
SW2-0	Bus11	6	0.01654	0.00977	0	-0.00028
SW2-0	Bus12	7	0.01782	0.01001	0	-0.00028
SW2-0	Bus26	8	0.08957	0.01378	7e-005	-0.00139
SW2-0	Bus18	9	0.08375	0.05144	7e-005	-0.00222
SW2-0	Bus15	10	0.04777	0.03024	0.00015	-0.00028
SW2-0	Bus16	11	0.08957	0.01378	7e-005	-0.00139
SW2-0	Bus33	12	0.06558	0.03844	8e-005	-0.00148
SW2-0	Bus35	13	0.06558	0.03844	8e-005	-0.00148
SW2-0	Bus3	14	0.01306	0.00723	0	-0.00074
SW2-0	Bus5	15	0.01306	0.00723	0	-0.00074
SW2-0	Bus7	16	0.04763	0.03023	1e-005	-0.00028
SW2-0	Bus8	17	0.08375	0.05144	7e-005	-0.00222
SW2-0	Bus13	18	0.11325	0.01806	2e-005	-0.00023
SW2-0	Bus21	19	0.01782	0.01001	0	-0.00028
SW3-1	050-PSW2-0	20	0.24651	0.15691	0	0.028
SW3-2	050-PSW2-0	21	0.24651	0.15691	0	0.028
SW3-3	050-PSW2-0	22	0.42103	0.17712	0	0.06841
	013-PSW3-0	23	0.11323	0.01829	0	0.00262
	021-PSW3-0	24	0.01654	0.01005	0	0.00028
	021-PMC4-0	25	0.01782	0.01029	0	0.00035
MC3-0	014-PMC4-0	26	0.02667	0.0176	0	0.0005
	013-PSW3-0	27	0.11323	0.01829	0	0.00262
SW3-0	013-PSW4-0	28	0.00994	0.00506	0	0.00016
	012-PMC4-0	29	0.04762	0.03052	0	0.0014
	021-PMC4-0	30	0.01782	0.01029	0	0.00035
	005-PSW3-0	31	0.08367	0.05366	0	0.00332
	005-PSW3-0	32	0.08367	0.05366	0	0.00332
SW3-0	015-PSW4-0	33	0.0026	0.00152	0	2e-005
SW3-0	015-PSW4-0	34	0.0026	0.00152	0	2e-005
	014-PMC3-0	35	0.08949	0.01516	0	0.0016
SW3-0	013-PSW4-0	36	0.00994	0.00506	0	0.00016
MC3-0	014-PMC4-0	37	0.02667	0.0176	0	0.0005
	014-PMC3-0	38	0.08949	0.01516	0	0.0016
	015-PSW3-0	39	0.0655	0.03992	0	0.00137
	012-PMC4-0	40	0.04762	0.03052	0	0.0014
	015-PSW3-0	41	0.0655	0.03992	0	0.00137
	001-PSW3-0	42	0.01306	0.00796	0	0.00017
	001-PSW3-0	43	0.01306	0.00796	0	0.00017

LOWS

us	To Bus	Line	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u.]	Q Loss [p.u.]
SW2-0	050-PSW2-0	1	-0.19539	-0.06809	7e-005	-0.00016
SW2-0	050-PSW2-0	2	-0.17871	-0.0583	6e-005	-0.00019
SW2-0	050-PSW2-0	3	-0.25196	-0.11088	0.00175	-0.00068
SW2-0	050-PSW2-0	4	-0.25196	-0.11088	0.00175	-0.00068
	011-PSW2-0	5	-0.11323	-0.01829	2e-005	-0.00023
	011-PSW2-0	6	-0.01654	-0.01005	0	-0.00028
	011-PSW2-0	7	-0.01782	-0.01029	0	-0.00028
	000-PSW2-0	8	-0.08949	-0.01516	7e-005	-0.00139

	000-PSW2-0	9	-0.08367	-0.05366	7e-005	-0.00222
	011-PSW2-0	10	-0.04762	-0.03052	0.00015	-0.00028
	000-PSW2-0	11	-0.08949	-0.01516	7e-005	-0.00139
	000-PSW2-0	12	-0.0655	-0.03992	8e-005	-0.00148
	000-PSW2-0	13	-0.0655	-0.03992	8e-005	-0.00148
	000-PSW2-0	14	-0.01306	-0.00796	0	-0.00074
	000-PSW2-0	15	-0.01306	-0.00796	0	-0.00074
	011-PSW2-0	16	-0.04762	-0.03052	1e-005	-0.00028
	000-PSW2-0	17	-0.08367	-0.05366	7e-005	-0.00222
	011-PSW2-0	18	-0.11323	-0.01829	2e-005	-0.00023
	011-PSW2-0	19	-0.01782	-0.01029	0	-0.00028
SW2-0	050-PSW3-1	20	-0.24651	-0.12892	0	0.028
SW2-0	050-PSW3-2	21	-0.24651	-0.12892	0	0.028
SW2-0	050-PSW3-3	22	-0.42103	-0.10871	0	0.06841
SW3-0	Bus09	23	-0.11323	-0.01566	0	0.00262
SW3-0	Bus11	24	-0.01654	-0.00977	0	0.00028
MC4-0	Bus12	25	-0.01782	-0.00994	0	0.00035
MC4-0	014-PMC3-0	26	-0.02667	-0.0171	0	0.0005
SW3-0	Bus13	27	-0.11323	-0.01566	0	0.00262
SW4-0	013-PSW3-0	28	-0.00994	-0.0049	0	0.00016
MC4-0	Bus15	29	-0.04762	-0.02912	0	0.0014
MC4-0	Bus21	30	-0.01782	-0.00994	0	0.00035
SW3-0	Bus8	31	-0.08367	-0.05034	0	0.00332
SW3-0	Bus18	32	-0.08367	-0.05034	0	0.00332
SW4-0	015-PSW3-0	33	-0.0026	-0.0015	0	2e-005
SW4-0	015-PSW3-0	34	-0.0026	-0.0015	0	2e-005
MC3-0	Bus16	35	-0.08949	-0.01357	0	0.0016
SW4-0	013-PSW3-0	36	-0.00994	-0.0049	0	0.00016
MC4-0	014-PMC3-0	37	-0.02667	-0.0171	0	0.0005
MC3-0	Bus26	38	-0.08949	-0.01357	0	0.0016
SW3-0	Bus33	39	-0.0655	-0.03855	0	0.00137
MC4-0	Bus7	40	-0.04762	-0.02912	0	0.0014
SW3-0	Bus35	41	-0.0655	-0.03855	0	0.00137
SW3-0	Bus3	42	-0.01306	-0.00779	0	0.00017
SW3-0	Bus5	43	-0.01306	-0.00779	0	0.00017

SUMMARY REPORT

GENERATION

WER [p.u.]	0.91405
E POWER [p.u.]	0.49095

LOAD

WER [p.u.]	0.90975
E POWER [p.u.]	0.35844

SHUNT

WER [p.u.]	0
E POWER (IND) [p.u.]	0
E POWER (CAP) [p.u.]	0

LOSSES

WER [p.u.]	0.0043
E POWER [p.u.]	0.13251

FLOW REPORT

T 1.3.4

': Federico Milano, (c) 2002-2005
: fmilano@thunderbox.uwaterloo.ca
:e: http://thunderbox.uwaterloo.ca/~fmilano

D:\Final Year Project\sem2\simulink file\wif compensation\two
'\noTNB_two_feeder_capbank_1_4novlatest.mdl
09-Dec-2006 06:02:25

ιK STATISTICS

	44
	19
'ormers:	24
ιtors:	3
	22

:ON STATISTICS

' of Iterations:	4
ιm P mismatch [p.u.]	0
ιm Q mismatch [p.u.]	0
rate [MVA]	100

FLOW RESULTS

	V [p.u.]	phase [rad]	P gen [p.u.]	Q gen [p.u.]	P load [p.u.]	Q load [p.u.]
'SW2-0	1.016	-0.15126	0	0	0	0
'SW2-0	1.016	-0.15126	0	0	0	0
'SW3-0	1.0422	-0.16054	0	0	0.01306	0.00779
'SW3-0	1.0422	-0.16054	0	0	0.01306	0.00779
'SW3-0	1.0046	-0.1797	0	0	0.08367	0.05034
'SW3-0	1.0046	-0.1797	0	0	0.08367	0.05034
'SW2-0	1.0236	-0.14269	0	0	0	0
'SW2-0	1.0237	-0.14265	0	0	0	0
'MC4-0	1.0147	-0.16227	0	0	0.04762	0.02911
'MC4-0	1.0166	-0.16279	0	0	0.04762	0.02911
'SW3-0	1.022	-0.16463	0	0	0.10329	0.01061
'SW3-0	1.022	-0.16459	0	0	0.10329	0.01061
'MC3-0	1.0403	-0.1692	0	0	0.06282	-0.00403
'MC3-0	1.0403	-0.1692	0	0	0.06282	-0.00403
'SW3-0	1.035	-0.16683	0	0	0.0629	0.03703
'SW3-0	1.035	-0.16683	0	0	0.0629	0.03703
'SW4-0	1.0314	-0.17293	0	0	0.00261	0.0015
'SW4-0	1.0314	-0.17293	0	0	0.00261	0.0015
'MC4-0	1.0203	-0.15696	0	0	0.01782	0.00994
'MC4-0	1.0203	-0.15692	0	0	0.01782	0.00994
'SW3-0	1.0459	-0.15478	0	0	0.01654	0.00977
'SW2-0	1.024	-0.14215	0	0	0.0324	0.02009
'SW3-1	1	-0.05897	0.24651	0.09311	0	0
'SW3-2	1	-0.05897	0.24651	0.09311	0	0
'SW3-3	1	0	0.42033	0.11278	0	0
	1.0234	-0.14298	0	0	0	0
	1.0234	-0.14272	0	0	0	0
	1.0234	-0.14274	0	0	0	0
	1.0235	-0.14294	0	0	0	0
	1.0214	-0.14217	0	0	0	0
	1.0152	-0.15267	0	0	0	0
	1.0148	-0.15263	0	0	0	0
	1.0159	-0.17656	0	0	0.00994	0.0049
	1.0235	-0.1427	0	0	0	0
	1.032	-0.18162	0	0	0.02668	0.0171
	1.0152	-0.15267	0	0	0	0
	1.0159	-0.1766	0	0	0.00994	0.0049

1.0159	-0.1514	0	0	0	0
1.032	-0.18162	0	0	0.02668	0.0171
1.0147	-0.15223	0	0	0	0
1.0147	-0.15223	0	0	0	0
1.0159	-0.1514	0	0	0	0
1.0234	-0.14276	0	0	0	0
1.0148	-0.15263	0	0	0	0

FLOWS

Bus	To Bus	Line	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u.]	Q Loss [p.u.]
PSW2-0	011-PSW2-0	1	0.19541	0.03271	6e-005	-0.00019
PSW2-0	011-PSW2-0	2	0.17876	0.02785	5e-005	-0.00021
PSW2-0	000-PSW2-0	3	0.25339	0.05536	0.00147	-0.00139
PSW2-0	000-PSW2-0	4	0.25339	0.05536	0.00147	-0.00139
PSW2-0	Bus09	5	0.11325	0.00848	2e-005	-0.00024
PSW2-0	Bus11	6	0.01654	0.00477	0	-0.00029
PSW2-0	Bus12	7	0.01782	0.00367	0	-0.00029
PSW2-0	Bus26	8	0.08956	0.00381	7e-005	-0.00147
PSW2-0	Bus18	9	0.08373	0.03035	6e-005	-0.00239
PSW2-0	Bus15	10	0.04773	0.01598	0.00011	-0.00029
PSW2-0	Bus16	11	0.08956	0.00381	7e-005	-0.00147
PSW2-0	Bus33	12	0.06557	0.02359	6e-005	-0.00158
PSW2-0	Bus35	13	0.06557	0.02359	6e-005	-0.00158
PSW2-0	Bus3	14	0.01306	-0.00101	0	-0.00078
PSW2-0	Bus5	15	0.01306	-0.00101	0	-0.00078
PSW2-0	Bus7	16	0.04763	0.01592	1e-005	-0.0003
PSW2-0	Bus8	17	0.08373	0.03035	6e-005	-0.00239
PSW2-0	Bus13	18	0.11325	0.00848	2e-005	-0.00024
PSW2-0	Bus21	19	0.01782	0.00367	0	-0.00029
PSW3-1	050-PSW2-0	20	0.24651	0.09311	0	0.02277
PSW3-2	050-PSW2-0	21	0.24651	0.09311	0	0.02277
PSW3-3	050-PSW2-0	22	0.42033	0.11278	0	0.0621
	013-PSW3-0	23	0.11323	0.00872	0	0.00246
	021-PSW3-0	24	0.01654	0.00506	0	0.00022
	021-PMC4-0	25	0.01782	0.00396	0	0.00027
PMC3-0	Bus25	26	0.02668	0.01757	0	0.00047
	013-PSW3-0	27	0.11323	0.00872	0	0.00246
PSW3-0	Bus20	28	0.00994	0.00505	0	0.00015
	012-PMC4-0	29	0.04762	0.01628	0	0.00106
	021-PMC4-0	30	0.01782	0.00396	0	0.00027
	005-PSW3-0	31	0.08367	0.03274	0	0.00258
	005-PSW3-0	32	0.08367	0.03274	0	0.00258
PSW3-0	015-PSW4-0	33	0.00261	0.00152	0	2e-005
PSW3-0	015-PSW4-0	34	0.00261	0.00152	0	2e-005
	014-PMC3-0	35	0.0895	0.00528	0	0.00148
PSW3-0	Bus27	36	0.00994	0.00505	0	0.00015
PMC3-0	Bus32	37	0.02668	0.01757	0	0.00047
	014-PMC3-0	38	0.0895	0.00528	0	0.00148
	015-PSW3-0	39	0.06551	0.02518	0	0.00109
	012-PMC4-0	40	0.04762	0.01622	0	0.00106
	015-PSW3-0	41	0.06551	0.02518	0	0.00109
	001-PSW3-0	42	0.01306	-0.00023	0	0.00012
	001-PSW3-0	43	0.01306	-0.00023	0	0.00012

FLOWS

Bus	To Bus	Line	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u.]	Q Loss [p.u.]
PSW2-0	050-PSW2-0	1	-0.19535	-0.0329	6e-005	-0.00019
PSW2-0	050-PSW2-0	2	-0.17871	-0.02806	5e-005	-0.00021
PSW2-0	050-PSW2-0	3	-0.25192	-0.05675	0.00147	-0.00139
PSW2-0	050-PSW2-0	4	-0.25192	-0.05675	0.00147	-0.00139
	011-PSW2-0	5	-0.11323	-0.00872	2e-005	-0.00024
	011-PSW2-0	6	-0.01654	-0.00506	0	-0.00029
	011-PSW2-0	7	-0.01782	-0.00396	0	-0.00029
	000-PSW2-0	8	-0.0895	-0.00528	7e-005	-0.00147

	000-PSW2-0	9	-0.08367	-0.03274	6e-005	-0.00239
	011-PSW2-0	10	-0.04762	-0.01628	0.00011	-0.00029
	000-PSW2-0	11	-0.0895	-0.00528	7e-005	-0.00147
	000-PSW2-0	12	-0.0655	-0.02518	6e-005	-0.00158
	000-PSW2-0	13	-0.06551	-0.02518	6e-005	-0.00158
	000-PSW2-0	14	-0.01306	0.00023	0	-0.00078
	000-PSW2-0	15	-0.01306	0.00023	0	-0.00078
	011-PSW2-0	16	-0.04762	-0.01622	1e-005	-0.0003
	000-PSW2-0	17	-0.08367	-0.03274	6e-005	-0.00239
	011-PSW2-0	18	-0.11323	-0.00872	2e-005	-0.00024
	011-PSW2-0	19	-0.01782	-0.00396	0	-0.00029
›SW2-0	050-PSW3-1	20	-0.24651	-0.07034	0	0.02277
›SW2-0	050-PSW3-2	21	-0.24651	-0.07034	0	0.02277
›SW2-0	050-PSW3-3	22	-0.42033	-0.05068	0	0.0621
›SW3-0	Bus09	23	-0.11323	-0.00625	0	0.00246
›SW3-0	Bus11	24	-0.01654	-0.00485	0	0.00022
›MC4-0	Bus12	25	-0.01782	-0.00369	0	0.00027
	014-PMC3-0	26	-0.02668	-0.0171	0	0.00047
›SW3-0	Bus13	27	-0.11323	-0.00625	0	0.00246
	013-PSW3-0	28	-0.00994	-0.0049	0	0.00015
›MC4-0	Bus15	29	-0.04762	-0.01522	0	0.00106
›MC4-0	Bus21	30	-0.01782	-0.00369	0	0.00027
›SW3-0	Bus8	31	-0.08367	-0.03016	0	0.00258
›SW3-0	Bus18	32	-0.08367	-0.03016	0	0.00258
›SW4-0	015-PSW3-0	33	-0.00261	-0.0015	0	2e-005
›SW4-0	015-PSW3-0	34	-0.00261	-0.0015	0	2e-005
›MC3-0	Bus16	35	-0.0895	-0.0038	0	0.00148
	013-PSW3-0	36	-0.00994	-0.0049	0	0.00015
	014-PMC3-0	37	-0.02668	-0.0171	0	0.00047
›MC3-0	Bus26	38	-0.0895	-0.0038	0	0.00148
›SW3-0	Bus33	39	-0.06551	-0.02408	0	0.00109
›MC4-0	Bus7	40	-0.04762	-0.01516	0	0.00106
›SW3-0	Bus35	41	-0.06551	-0.02408	0	0.00109
›SW3-0	Bus3	42	-0.01306	0.00035	0	0.00012
›SW3-0	Bus5	43	-0.01306	0.00035	0	0.00012

. SUMMARY REPORT

GENERATION

›OWER [p.u.]	0.91335
:VE POWER [p.u.]	0.299

LOAD

›OWER [p.u.]	0.90975
:VE POWER [p.u.]	0.35843

SHUNT

›OWER [p.u.]	0
:VE POWER (IND) [p.u.]	0
:VE POWER (CAP) [p.u.]	0.16913

LOSSES

›OWER [p.u.]	0.00361
:VE POWER [p.u.]	0.1097

FLOW REPORT

T 1.3.4

r: Federico Milano, (c) 2002-2005
l: fmilano@thunderbox.uwaterloo.ca
te: http://thunderbox.uwaterloo.ca/~fmilano

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\two_feeder_nocapbank_2_7sept.mdl
09-Dec-2006 05:57:17

K STATISTICS

	45
	19
ormers:	25
tors:	4
	22

ON STATISTICS

of Iterations:	4
m P mismatch [p.u.]	0
m Q mismatch [p.u.]	0
rate [MVA]	100

FLOW RESULTS

	V [p.u.]	phase [rad]	P gen [p.u.]	Q gen [p.u.]	P load [p.u.]	Q load [p.u.]
'SW2-0	1.0065	-0.0673	0	0	0	0
'SW2-0	1.0065	-0.0673	0	0	0	0
'SW3-0	1.0262	-0.07671	0	0	0.01306	0.00779
SW3-0	1.0262	-0.07671	0	0	0.01306	0.00779
SW3-0	0.98763	-0.09634	0	0	0.08367	0.05034
SW3-0	0.98763	-0.09634	0	0	0.08367	0.05034
SW2-0	1.0163	-0.05972	0	0	0	0
SW2-0	1.0163	-0.05969	0	0	0	0
MC4-0	1.0011	-0.07909	0	0	0.04762	0.02912
MC4-0	1.0031	-0.08018	0	0	0.04762	0.02912
SW3-0	1.0127	-0.08201	0	0	0.10329	0.01061
SW3-0	1.0128	-0.08198	0	0	0.10329	0.01061
SW4-0	1.0066	-0.0942	0	0	0.00994	0.0049
SW4-0	1.0066	-0.09416	0	0	0.00994	0.0049
MC3-0	1.0284	-0.08552	0	0	0.06282	-0.00403
MC3-0	1.0284	-0.08552	0	0	0.06282	-0.00403
MC4-0	1.02	-0.09824	0	0	0.02668	0.0171
MC4-0	1.02	-0.09824	0	0	0.02668	0.0171
SW3-0	1.0214	-0.08303	0	0	0.0629	0.03703
SW3-0	1.0214	-0.08303	0	0	0.0629	0.03703
SW4-0	1.0177	-0.08929	0	0	0.00261	0.0015
SW4-0	1.0177	-0.08929	0	0	0.00261	0.0015
MC4-0	1.0077	-0.07421	0	0	0.01782	0.00994
MC4-0	1.0078	-0.07418	0	0	0.01782	0.00994
SW3-0	1.0345	-0.07198	0	0	0.01654	0.00977
SW2-0	1.0168	-0.05923	0	0	0.0324	0.02009
	1	0.02454	0.24651	0.11413	0	0
	1	0.02454	0.24651	0.11413	0	0
	1	0	0.17439	0.10897	0	0
	1.0161	-0.06	0	0	0	0
	1.016	-0.05971	0	0	0	0
	1.016	-0.05971	0	0	0	0
	1.0161	-0.05997	0	0	0	0
	1.014	-0.05857	0	0	0	0
	1.0054	-0.06865	0	0	0	0
	1.0048	-0.06854	0	0	0	0
	1.0161	-0.05968	0	0	0	0

1.0054	-0.06865	0	0	0	0
1.0062	-0.06734	0	0	0	0
1.0048	-0.06809	0	0	0	0
1.0048	-0.06809	0	0	0	0
1	0.02454	0.24651	0.11413	0	0
1.0062	-0.06734	0	0	0	0
1.016	-0.05974	0	0	0	0
1.0048	-0.06854	0	0	0	0

:LOWS

;us	To Bus	Line	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u.]	Q Loss [p.u.]
'SW2-0	011-PSW2-0	1	0.19545	0.06774	7e-005	-0.00018
'SW2-0	011-PSW2-0	2	0.17877	0.05795	6e-005	-0.0002
'SW2-0	000-PSW2-0	3	0.25365	0.10957	0.0017	-0.0009
'SW2-0	000-PSW2-0	4	0.25365	0.10957	0.0017	-0.0009
'SW2-0	Bus09	5	0.11325	0.01797	2e-005	-0.00024
'SW2-0	Bus11	6	0.01654	0.00976	0	-0.00029
'SW2-0	Bus12	7	0.01782	0.00999	0	-0.00029
'SW2-0	Bus26	8	0.08957	0.01366	7e-005	-0.00144
'SW2-0	Bus18	9	0.08374	0.05126	7e-005	-0.0023
'SW2-0	Bus15	10	0.04776	0.03019	0.00014	-0.00029
'SW2-0	Bus16	11	0.08957	0.01366	7e-005	-0.00144
'SW2-0	Bus33	12	0.06558	0.03835	8e-005	-0.00153
'SW2-0	Bus35	13	0.06558	0.03835	8e-005	-0.00153
'SW2-0	Bus3	14	0.01306	0.0072	0	-0.00076
'SW2-0	Bus5	15	0.01306	0.0072	0	-0.00076
'SW2-0	Bus7	16	0.04763	0.03018	1e-005	-0.00029
'SW2-0	Bus8	17	0.08374	0.05126	7e-005	-0.0023
'SW2-0	Bus13	18	0.11325	0.01797	2e-005	-0.00024
'SW2-0	Bus21	19	0.01782	0.00999	0	-0.00029
	050-PSW2-0	20	0.24651	0.11413	0	0.0242
	050-PSW2-0	21	0.24651	0.11413	0	0.0242
	050-PSW2-0	22	0.17439	0.10897	0	0.01386
	013-PSW3-0	23	0.11323	0.0182	0	0.00255
	021-PSW3-0	24	0.01654	0.01005	0	0.00028
	021-PMC4-0	25	0.01782	0.01028	0	0.00034
'MC3-0	014-PMC4-0	26	0.02668	0.01758	0	0.00048
	013-PSW3-0	27	0.11323	0.0182	0	0.00255
'SW3-0	013-PSW4-0	28	0.00994	0.00505	0	0.00015
	012-PMC4-0	29	0.04762	0.03048	0	0.00136
	021-PMC4-0	30	0.01782	0.01028	0	0.00034
	005-PSW3-0	31	0.08367	0.05356	0	0.00322
	005-PSW3-0	32	0.08367	0.05356	0	0.00322
'SW3-0	015-PSW4-0	33	0.00261	0.00152	0	2e-005
'SW3-0	015-PSW4-0	34	0.00261	0.00152	0	2e-005
	050-PSW2-0	35	0.24651	0.11413	0	0.0242
	014-PMC3-0	36	0.0895	0.0151	0	0.00155
'SW3-0	013-PSW4-0	37	0.00994	0.00505	0	0.00015
'MC3-0	014-PMC4-0	38	0.02668	0.01758	0	0.00048
	014-PMC3-0	39	0.0895	0.0151	0	0.00155
	015-PSW3-0	40	0.06551	0.03988	0	0.00133
	012-PMC4-0	41	0.04762	0.03047	0	0.00135
	015-PSW3-0	42	0.06551	0.03988	0	0.00133
	001-PSW3-0	43	0.01306	0.00796	0	0.00017
	001-PSW3-0	44	0.01306	0.00796	0	0.00017

:LOWS

;us	To Bus	Line	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u.]	Q Loss [p.u.]
'SW2-0	050-PSW2-0	1	-0.19538	-0.06791	7e-005	-0.00018
'SW2-0	050-PSW2-0	2	-0.17871	-0.05814	6e-005	-0.0002
'SW2-0	050-PSW2-0	3	-0.25195	-0.11047	0.0017	-0.0009
'SW2-0	050-PSW2-0	4	-0.25195	-0.11047	0.0017	-0.0009
	011-PSW2-0	5	-0.11324	-0.0182	2e-005	-0.00024
	011-PSW2-0	6	-0.01654	-0.01005	0	-0.00029

011-PSW2-0	7	-0.01782	-0.01028	0	-0.00029
000-PSW2-0	8	-0.0895	-0.0151	7e-005	-0.00144
000-PSW2-0	9	-0.08367	-0.05356	7e-005	-0.0023
011-PSW2-0	10	-0.04762	-0.03048	0.00014	-0.00029
000-PSW2-0	11	-0.0895	-0.0151	7e-005	-0.00144
000-PSW2-0	12	-0.06551	-0.03988	8e-005	-0.00153
000-PSW2-0	13	-0.06551	-0.03988	8e-005	-0.00153
000-PSW2-0	14	-0.01306	-0.00796	0	-0.00076
000-PSW2-0	15	-0.01306	-0.00796	0	-0.00076
011-PSW2-0	16	-0.04762	-0.03047	1e-005	-0.00029
000-PSW2-0	17	-0.08367	-0.05356	7e-005	-0.0023
011-PSW2-0	18	-0.11324	-0.0182	2e-005	-0.00024
011-PSW2-0	19	-0.01782	-0.01028	0	-0.00029
'SW2-0 Bus01	20	-0.24651	-0.08994	0	0.0242
'SW2-0 Bus02	21	-0.24651	-0.08994	0	0.0242
'SW2-0 Bus03	22	-0.17439	-0.0951	0	0.01386
'SW3-0 Bus09	23	-0.11323	-0.01566	0	0.00255
'SW3-0 Bus11	24	-0.01654	-0.00977	0	0.00028
'MC4-0 Bus12	25	-0.01782	-0.00994	0	0.00034
'MC4-0 014-PMC3-0	26	-0.02668	-0.0171	0	0.00048
'SW3-0 Bus13	27	-0.11323	-0.01566	0	0.00255
'SW4-0 013-PSW3-0	28	-0.00994	-0.0049	0	0.00015
'MC4-0 Bus15	29	-0.04762	-0.02912	0	0.00136
'MC4-0 Bus21	30	-0.01782	-0.00994	0	0.00034
'SW3-0 Bus8	31	-0.08367	-0.05034	0	0.00322
'SW3-0 Bus18	32	-0.08367	-0.05034	0	0.00322
'SW4-0 015-PSW3-0	33	-0.00261	-0.0015	0	2e-005
'SW4-0 015-PSW3-0	34	-0.00261	-0.0015	0	2e-005
'SW2-0 Bus36	35	-0.24651	-0.08994	0	0.0242
'MC3-0 Bus16	36	-0.0895	-0.01355	0	0.00155
'SW4-0 013-PSW3-0	37	-0.00994	-0.0049	0	0.00015
'MC4-0 014-PMC3-0	38	-0.02668	-0.0171	0	0.00048
'MC3-0 Bus26	39	-0.0895	-0.01355	0	0.00155
'SW3-0 Bus33	40	-0.06551	-0.03855	0	0.00133
'MC4-0 Bus7	41	-0.04762	-0.02912	0	0.00135
'SW3-0 Bus35	42	-0.06551	-0.03855	0	0.00133
'SW3-0 Bus3	43	-0.01306	-0.00779	0	0.00017
'SW3-0 Bus5	44	-0.01306	-0.00779	0	0.00017

. SUMMARY REPORT

GENERATION

'OWER [p.u.]	0.91392
:VE POWER [p.u.]	0.45137

LOAD

'OWER [p.u.]	0.90975
VE POWER [p.u.]	0.35844

SHUNT

'OWER [p.u.]	0
:VE POWER (IND) [p.u.]	0
:VE POWER (CAP) [p.u.]	0

LOSSES

'OWER [p.u.]	0.00417
VE POWER [p.u.]	0.09293

FLOW REPORT

T 1.3.4

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'\two_feeder_capbank_2_25sept.mdl
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ιK STATISTICS

	45
	19
'ormers:	25
ιtors:	4
	22

:ON STATISTICS

' of Iterations:	4
ım P mismatch [p.u.]	0
ım Q mismatch [p.u.]	0
rate [MVA]	100

FLOW RESULTS

	V [p.u.]	phase [rad]	P gen [p.u.]	Q gen [p.u.]	P load [p.u.]	Q load [p.u.]
'SW2-0	1.0252	-0.06707	0	0	0	0
'SW2-0	1.0252	-0.06707	0	0	0	0
'SW3-0	1.0516	-0.07618	0	0	0.01306	0.00779
'SW3-0	1.0516	-0.07618	0	0	0.01306	0.00779
'SW3-0	1.0139	-0.09499	0	0	0.08367	0.05034
'SW3-0	1.0139	-0.09499	0	0	0.08367	0.05034
'SW2-0	1.0326	-0.05862	0	0	0	0
'SW2-0	1.0327	-0.05858	0	0	0	0
'MC4-0	1.0239	-0.07787	0	0	0.04762	0.02911
'MC4-0	1.0258	-0.07836	0	0	0.04762	0.02911
'SW3-0	1.031	-0.08018	0	0	0.10329	0.01061
'SW3-0	1.0311	-0.08014	0	0	0.10329	0.01061
'MC3-0	1.0497	-0.08468	0	0	0.06282	-0.00403
'MC3-0	1.0497	-0.08468	0	0	0.06282	-0.00403
'SW3-0	1.0445	-0.08236	0	0	0.0629	0.03703
'SW3-0	1.0445	-0.08236	0	0	0.0629	0.03703
'SW4-0	1.0409	-0.08835	0	0	0.00261	0.0015
'SW4-0	1.0409	-0.08835	0	0	0.00261	0.0015
'MC4-0	1.0294	-0.07264	0	0	0.01782	0.00994
'MC4-0	1.0295	-0.0726	0	0	0.01782	0.00994
'SW3-0	1.0552	-0.0705	0	0	0.01654	0.00977
'SW2-0	1.033	-0.05808	0	0	0.0324	0.02009
	1	0.02437	0.24651	0.06694	0	0
	1	0.02437	0.24651	0.06694	0	0
	1	0	0.17375	0.06182	0	0
	1.0324	-0.0589	0	0	0	0
	1.0324	-0.05865	0	0	0	0
	1.0324	-0.05867	0	0	0	0
	1.0325	-0.05886	0	0	0	0
	1.0305	-0.05812	0	0	0	0
	1.0243	-0.06845	0	0	0	0
	1.024	-0.06842	0	0	0	0
	1.025	-0.09189	0	0	0.00994	0.0049
	1.0325	-0.05863	0	0	0	0
	1.0415	-0.09688	0	0	0.02668	0.0171
	1.0243	-0.06845	0	0	0	0
	1.025	-0.09194	0	0	0.00994	0.0049

1.025	-0.0672	0	0	0	0
1.0415	-0.09688	0	0	0.02668	0.0171
1.0238	-0.06802	0	0	0	0
1.0238	-0.06802	0	0	0	0
1	0.02437	0.24651	0.06694	0	0
1.025	-0.0672	0	0	0	0
1.0324	-0.05869	0	0	0	0
1.024	-0.06842	0	0	0	0

:LOWS

ius	To Bus	Line	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u.]	Q Loss [p.u.]
'SW2-0	011-PSW2-0	1	0.19541	0.03198	6e-005	-0.0002
'SW2-0	011-PSW2-0	2	0.17876	0.02722	5e-005	-0.00022
'SW2-0	000-PSW2-0	3	0.25336	0.05402	0.00144	-0.00151
'SW2-0	000-PSW2-0	4	0.25336	0.05402	0.00144	-0.00151
'SW2-0	Bus09	5	0.11325	0.00826	2e-005	-0.00025
'SW2-0	Bus11	6	0.01654	0.00467	0	-0.0003
'SW2-0	Bus12	7	0.01782	0.00354	0	-0.0003
'SW2-0	Bus26	8	0.08956	0.00357	7e-005	-0.00151
'SW2-0	Bus18	9	0.08373	0.02987	6e-005	-0.00244
'SW2-0	Bus15	10	0.04773	0.0157	0.00011	-0.0003
'SW2-0	Bus16	11	0.08956	0.00357	7e-005	-0.00151
'SW2-0	Bus33	12	0.06557	0.02327	6e-005	-0.00161
'SW2-0	Bus35	13	0.06557	0.02327	6e-005	-0.00161
'SW2-0	Bus3	14	0.01306	-0.00117	0	-0.00079
'SW2-0	Bus5	15	0.01306	-0.00117	0	-0.00079
'SW2-0	Bus7	16	0.04763	0.01564	1e-005	-0.0003
'SW2-0	Bus8	17	0.08373	0.02987	6e-005	-0.00244
'SW2-0	Bus13	18	0.11325	0.00826	2e-005	-0.00025
'SW2-0	Bus21	19	0.01782	0.00354	0	-0.0003
	050-PSW2-0	20	0.24651	0.06694	0	0.02139
	050-PSW2-0	21	0.24651	0.06694	0	0.02139
	050-PSW2-0	22	0.17375	0.06182	0	0.01115
	013-PSW3-0	23	0.11324	0.0085	0	0.00242
	021-PSW3-0	24	0.01654	0.00497	0	0.00021
	021-PMC4-0	25	0.01782	0.00384	0	0.00026
'MC3-0	Bus25	26	0.02668	0.01756	0	0.00046
	013-PSW3-0	27	0.11324	0.0085	0	0.00242
'SW3-0	Bus20	28	0.00994	0.00505	0	0.00015
	012-PMC4-0	29	0.04762	0.016	0	0.00104
	021-PMC4-0	30	0.01782	0.00384	0	0.00026
	005-PSW3-0	31	0.08367	0.03231	0	0.00253
	005-PSW3-0	32	0.08367	0.03231	0	0.00253
'SW3-0	015-PSW4-0	33	0.00261	0.00152	0	2e-005
'SW3-0	015-PSW4-0	34	0.00261	0.00152	0	2e-005
	050-PSW2-0	35	0.24651	0.06694	0	0.02139
	014-PMC3-0	36	0.0895	0.00507	0	0.00146
'SW3-0	Bus27	37	0.00994	0.00505	0	0.00015
'MC3-0	Bus32	38	0.02668	0.01756	0	0.00046
	014-PMC3-0	39	0.0895	0.00507	0	0.00146
	015-PSW3-0	40	0.06551	0.02489	0	0.00107
	012-PMC4-0	41	0.04762	0.01594	0	0.00104
	015-PSW3-0	42	0.06551	0.02489	0	0.00107
	001-PSW3-0	43	0.01306	-0.00039	0	0.00012
	001-PSW3-0	44	0.01306	-0.00039	0	0.00012

:LOWS

ius	To Bus	Line	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u.]	Q Loss [p.u.]
'SW2-0	050-PSW2-0	1	-0.19535	-0.03218	6e-005	-0.0002
'SW2-0	050-PSW2-0	2	-0.17871	-0.02744	5e-005	-0.00022
'SW2-0	050-PSW2-0	3	-0.25192	-0.05553	0.00144	-0.00151
'SW2-0	050-PSW2-0	4	-0.25192	-0.05553	0.00144	-0.00151
	011-PSW2-0	5	-0.11323	-0.0085	2e-005	-0.00025
	011-PSW2-0	6	-0.01654	-0.00497	0	-0.0003

	011-PSW2-0	7	-0.01782	-0.00384	0	-0.0003
	000-PSW2-0	8	-0.0895	-0.00507	7e-005	-0.00151
	000-PSW2-0	9	-0.08367	-0.03231	6e-005	-0.00244
	011-PSW2-0	10	-0.04762	-0.016	0.00011	-0.0003
	000-PSW2-0	11	-0.0895	-0.00507	7e-005	-0.00151
	000-PSW2-0	12	-0.06551	-0.02489	6e-005	-0.00161
	000-PSW2-0	13	-0.06551	-0.02489	6e-005	-0.00161
	000-PSW2-0	14	-0.01306	0.00039	0	-0.00079
	000-PSW2-0	15	-0.01306	0.00039	0	-0.00079
	011-PSW2-0	16	-0.04762	-0.01594	1e-005	-0.0003
	000-PSW2-0	17	-0.08367	-0.03231	6e-005	-0.00244
	011-PSW2-0	18	-0.11323	-0.0085	2e-005	-0.00025
	011-PSW2-0	19	-0.01782	-0.00384	0	-0.0003
ᵓSW2-0	Bus01	20	-0.24651	-0.04555	0	0.02139
ᵓSW2-0	Bus02	21	-0.24651	-0.04555	0	0.02139
ᵓSW2-0	Bus03	22	-0.17375	-0.05067	0	0.01115
ᵓSW3-0	Bus09	23	-0.11324	-0.00608	0	0.00242
ᵓSW3-0	Bus11	24	-0.01654	-0.00476	0	0.00021
ᵓMC4-0	Bus12	25	-0.01782	-0.00358	0	0.00026
	014-PMC3-0	26	-0.02668	-0.0171	0	0.00046
ᵓSW3-0	Bus13	27	-0.11324	-0.00608	0	0.00242
	013-PSW3-0	28	-0.00994	-0.0049	0	0.00015
ᵓMC4-0	Bus15	29	-0.04762	-0.01496	0	0.00104
ᵓMC4-0	Bus21	30	-0.01782	-0.00358	0	0.00026
ᵓSW3-0	Bus8	31	-0.08367	-0.02978	0	0.00253
ᵓSW3-0	Bus18	32	-0.08367	-0.02978	0	0.00253
ᵓSW4-0	015-PSW3-0	33	-0.00261	-0.0015	0	2e-005
ᵓSW4-0	015-PSW3-0	34	-0.00261	-0.0015	0	2e-005
ᵓSW2-0	Bus36	35	-0.24651	-0.04555	0	0.02139
ᵓMC3-0	Bus16	36	-0.0895	-0.00362	0	0.00146
	013-PSW3-0	37	-0.00994	-0.0049	0	0.00015
	014-PMC3-0	38	-0.02668	-0.0171	0	0.00046
ᵓMC3-0	Bus26	39	-0.0895	-0.00362	0	0.00146
ᵓSW3-0	Bus33	40	-0.06551	-0.02382	0	0.00107
ᵓMC4-0	Bus7	41	-0.04762	-0.01491	0	0.00104
ᵓSW3-0	Bus35	42	-0.06551	-0.02382	0	0.00107
ᵓSW3-0	Bus3	43	-0.01306	0.0005	0	0.00012
ᵓSW3-0	Bus5	44	-0.01306	0.0005	0	0.00012

. SUMMARY REPORT

GENERATION

ᵓOWER [p.u.]	0.91328
[VE POWER [p.u.]	0.26266

LOAD

ᵓOWER [p.u.]	0.90975
[VE POWER [p.u.]	0.35843

SHUNT

ᵓOWER [p.u.]	0
[VE POWER (IND) [p.u.]	0
[VE POWER (CAP) [p.u.]	0.17222

LOSSES

ᵓOWER [p.u.]	0.00354
[VE POWER [p.u.]	0.07645

FLOW REPORT

T 1.3.4

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ŧK STATISTICS

:	46
:	19
Formers:	26
ıtors:	5
:	22

ION STATISTICS

· of Iterations:	4
ım P mismatch [p.u.]	0
ım Q mismatch [p.u.]	0
rate [MVA]	100

FLOW RESULTS

	V [p.u.]	phase [rad]	P gen [p.u.]	Q gen [p.u.]	P load [p.u.]	Q load [p.u.]
ᵓSW2-0	1.0136	0.01637	0	0	0	0
ᵓSW2-0	1.0136	0.01637	0	0	0	0
ᵓSW3-0	1.0335	0.00709	0	0	0.01306	0.00779
ᵓSW3-0	1.0335	0.00709	0	0	0.01306	0.00779
ᵓSW3-0	0.99487	-0.01226	0	0	0.08367	0.05034
ᵓSW3-0	0.99487	-0.01226	0	0	0.08367	0.05034
ᵓSW2-0	1.0233	0.02385	0	0	0	0
ᵓSW2-0	1.0233	0.02388	0	0	0	0
ᵓMC4-0	1.0082	0.00474	0	0	0.04762	0.02912
ᵓMC4-0	1.0102	0.00367	0	0	0.04762	0.02912
ᵓSW3-0	1.0198	0.00186	0	0	0.10329	0.01061
ᵓSW3-0	1.0198	0.0019	0	0	0.10329	0.01061
ᵓSW4-0	1.0136	-0.01016	0	0	0.00994	0.0049
ᵓSW4-0	1.0137	-0.01012	0	0	0.00994	0.0049
ᵓMC3-0	1.0357	-0.0016	0	0	0.06282	-0.00403
ᵓMC3-0	1.0357	-0.0016	0	0	0.06282	-0.00403
ᵓMC4-0	1.0273	-0.01414	0	0	0.02668	0.0171
ᵓMC4-0	1.0273	-0.01414	0	0	0.02668	0.0171
ᵓSW3-0	1.0288	0.00086	0	0	0.0629	0.03703
ᵓSW3-0	1.0288	0.00086	0	0	0.0629	0.03703
ᵓSW4-0	1.0251	-0.00531	0	0	0.00261	0.0015
ᵓSW4-0	1.0251	-0.00531	0	0	0.00261	0.0015
ᵓMC4-0	1.0148	0.00955	0	0	0.01782	0.00994
ᵓMC4-0	1.0148	0.00959	0	0	0.01782	0.00994
ᵓSW3-0	1.0417	0.01176	0	0	0.01654	0.00977
ᵓSW2-0	1.0238	0.02434	0	0	0.0324	0.02009
	1	0.10753	0.24651	0.09376	0	0
	1	0.10753	0.24651	0.09376	0	0
	1	0	-0.07218	0.08438	0	0
	1.0231	0.02357	0	0	0	0
	1.0231	0.02386	0	0	0	0
	1.023	0.02386	0	0	0	0
	1.0231	0.02361	0	0	0	0
	1.021	0.02498	0	0	0	0
	1.0125	0.01504	0	0	0	0
	1.0119	0.01514	0	0	0	0
	1.0231	0.02389	0	0	0	0

1.0125	0.01504	0	0	0	0
1.0133	0.01633	0	0	0	0
1.0119	0.01559	0	0	0	0
1.0119	0.01559	0	0	0	0
1	0.10753	0.24651	0.09376	0	0
1	0.10753	0.24651	0.09376	0	0
1.0133	0.01633	0	0	0	0
1.023	0.02383	0	0	0	0
1.0119	0.01514	0	0	0	0

=LOWS

3us	To Bus	Line	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u.]	Q Loss [p.u.]
›SW2-0	011-PSW2-0	1	0.19545	0.06765	7e-005	-0.00018
›SW2-0	011-PSW2-0	2	0.17877	0.05787	6e-005	-0.0002
›SW2-0	000-PSW2-0	3	0.25362	0.10927	0.00167	-0.001
›SW2-0	000-PSW2-0	4	0.25362	0.10927	0.00167	-0.001
›SW2-0	Bus09	5	0.11325	0.01793	2e-005	-0.00024
›SW2-0	Bus11	6	0.01654	0.00975	0	-0.00029
›SW2-0	Bus12	7	0.01782	0.00998	0	-0.00029
›SW2-0	Bus26	8	0.08957	0.01361	7e-005	-0.00146
›SW2-0	Bus18	9	0.08374	0.05117	7e-005	-0.00234
›SW2-0	Bus15	10	0.04776	0.03017	0.00014	-0.00029
›SW2-0	Bus16	11	0.08957	0.01361	7e-005	-0.00146
›SW2-0	Bus33	12	0.06558	0.0383	7e-005	-0.00155
›SW2-0	Bus35	13	0.06558	0.0383	7e-005	-0.00155
›SW2-0	Bus3	14	0.01306	0.00719	0	-0.00077
›SW2-0	Bus5	15	0.01306	0.00719	0	-0.00077
›SW2-0	Bus7	16	0.04763	0.03016	1e-005	-0.0003
›SW2-0	Bus8	17	0.08374	0.05117	7e-005	-0.00234
›SW2-0	Bus13	18	0.11325	0.01793	2e-005	-0.00024
›SW2-0	Bus21	19	0.01782	0.00998	0	-0.00029
	050-PSW2-0	20	0.24651	0.09376	0	0.02281
	050-PSW2-0	21	0.24651	0.09376	0	0.02281
	050-PSW2-0	22	-0.07218	0.08438	0	0.00404
	013-PSW3-0	23	0.11323	0.01817	0	0.00251
	021-PSW3-0	24	0.01654	0.01004	0	0.00027
	021-PMC4-0	25	0.01782	0.01028	0	0.00034
›MC3-0	014-PMC4-0	26	0.02668	0.01758	0	0.00048
	013-PSW3-0	27	0.11323	0.01817	0	0.00251
›SW3-0	013-PSW4-0	28	0.00994	0.00505	0	0.00015
	012-PMC4-0	29	0.04762	0.03046	0	0.00134
	021-PMC4-0	30	0.01782	0.01028	0	0.00034
	005-PSW3-0	31	0.08367	0.05351	0	0.00318
	005-PSW3-0	32	0.08367	0.05351	0	0.00318
›SW3-0	015-PSW4-0	33	0.00261	0.00152	0	2e-005
›SW3-0	015-PSW4-0	34	0.00261	0.00152	0	2e-005
	050-PSW2-0	35	0.24651	0.09376	0	0.02281
	050-PSW2-0	36	0.24651	0.09376	0	0.02281
	014-PMC3-0	37	0.0895	0.01507	0	0.00153
›SW3-0	013-PSW4-0	38	0.00994	0.00505	0	0.00015
›MC3-0	014-PMC4-0	39	0.02668	0.01758	0	0.00048
	014-PMC3-0	40	0.0895	0.01507	0	0.00153
	015-PSW3-0	41	0.06551	0.03986	0	0.00131
	012-PMC4-0	42	0.04762	0.03046	0	0.00134
	015-PSW3-0	43	0.06551	0.03986	0	0.00131
	001-PSW3-0	44	0.01306	0.00796	0	0.00016
	001-PSW3-0	45	0.01306	0.00796	0	0.00016

=LOWS

3us	To Bus	Line	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u.]	Q Loss [p.u.]
›SW2-0	050-PSW2-0	1	-0.19538	-0.06783	7e-005	-0.00018
›SW2-0	050-PSW2-0	2	-0.17871	-0.05807	6e-005	-0.0002
›SW2-0	050-PSW2-0	3	-0.25195	-0.11027	0.00167	-0.001
›SW2-0	050-PSW2-0	4	-0.25195	-0.11027	0.00167	-0.001

	011-PSW2-0	5	-0.11324	-0.01817	2e-005	-0.00024
	011-PSW2-0	6	-0.01654	-0.01004	0	-0.00029
	011-PSW2-0	7	-0.01782	-0.01028	0	-0.00029
	000-PSW2-0	8	-0.08949	-0.01507	7e-005	-0.00146
	000-PSW2-0	9	-0.08367	-0.05351	7e-005	-0.00234
	011-PSW2-0	10	-0.04762	-0.03046	0.00014	-0.00029
	000-PSW2-0	11	-0.08949	-0.01507	7e-005	-0.00146
	000-PSW2-0	12	-0.0655	-0.03986	7e-005	-0.00155
	000-PSW2-0	13	-0.06551	-0.03986	7e-005	-0.00155
	000-PSW2-0	14	-0.01306	-0.00796	0	-0.00077
	000-PSW2-0	15	-0.01306	-0.00796	0	-0.00077
	011-PSW2-0	16	-0.04762	-0.03046	1e-005	-0.0003
	000-PSW2-0	17	-0.08367	-0.05351	7e-005	-0.00234
	011-PSW2-0	18	-0.11323	-0.01817	2e-005	-0.00024
	011-PSW2-0	19	-0.01782	-0.01028	0	-0.00029
'SW2-0	Bus01	20	-0.24651	-0.07095	0	0.02281
'SW2-0	Bus02	21	-0.24651	-0.07095	0	0.02281
'SW2-0	Bus03	22	0.07218	-0.08034	0	0.00404
'SW3-0	Bus09	23	-0.11323	-0.01565	0	0.00251
'SW3-0	Bus11	24	-0.01654	-0.00977	0	0.00027
'MC4-0	Bus12	25	-0.01782	-0.00994	0	0.00034
'MC4-0	014-PMC3-0	26	-0.02668	-0.0171	0	0.00048
'SW3-0	Bus13	27	-0.11323	-0.01565	0	0.00251
'SW4-0	013-PSW3-0	28	-0.00994	-0.0049	0	0.00015
'MC4-0	Bus15	29	-0.04762	-0.02912	0	0.00134
'MC4-0	Bus21	30	-0.01782	-0.00994	0	0.00034
'SW3-0	Bus8	31	-0.08367	-0.05034	0	0.00318
'SW3-0	Bus18	32	-0.08367	-0.05034	0	0.00318
'SW4-0	015-PSW3-0	33	-0.00261	-0.0015	0	2e-005
'SW4-0	015-PSW3-0	34	-0.00261	-0.0015	0	2e-005
'SW2-0	Bus36	35	-0.24651	-0.07095	0	0.02281
'SW2-0	Bus37	36	-0.24651	-0.07095	0	0.02281
'MC3-0	Bus16	37	-0.0895	-0.01355	0	0.00153
'SW4-0	013-PSW3-0	38	-0.00994	-0.0049	0	0.00015
'MC4-0	014-PMC3-0	39	-0.02668	-0.0171	0	0.00048
'MC3-0	Bus26	40	-0.0895	-0.01355	0	0.00153
'SW3-0	Bus33	41	-0.06551	-0.03855	0	0.00131
'MC4-0	Bus7	42	-0.04762	-0.02912	0	0.00134
'SW3-0	Bus35	43	-0.06551	-0.03855	0	0.00131
'SW3-0	Bus3	44	-0.01306	-0.00779	0	0.00016
'SW3-0	Bus5	45	-0.01306	-0.00779	0	0.00016

. SUMMARY REPORT

GENERATION

'OWER [p.u.] 0.91386
VE POWER [p.u.] 0.45942

LOAD

'OWER [p.u.] 0.90975
VE POWER [p.u.] 0.35844

SHUNT

'OWER [p.u.] 0
VE POWER (IND) [p.u.] 0
VE POWER (CAP) [p.u.] 0

LOSSES

'OWER [p.u.] 0.00411
VE POWER [p.u.] 0.10099

FLOW REPORT

T 1.3.4

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K STATISTICS

	46
	19
formers:	26
tors:	5
	22

ON STATISTICS

of Iterations:	4
m P mismatch [p.u.]	0
m Q mismatch [p.u.]	0
rate [MVA]	100

FLOW RESULTS

	V [p.u.]	phase [rad]	P gen [p.u.]	Q gen [p.u.]	P load [p.u.]	Q load [p.u.]
SW2-0	1.0289	0.0153	0	0	0	0
SW2-0	1.0289	0.0153	0	0	0	0
SW3-0	1.0555	0.00626	0	0	0.01306	0.00779
SW3-0	1.0555	0.00626	0	0	0.01306	0.00779
SW3-0	1.0178	-0.01242	0	0	0.08367	0.05034
SW3-0	1.0178	-0.01242	0	0	0.08367	0.05034
SW2-0	1.0363	0.0237	0	0	0	0
SW2-0	1.0363	0.02374	0	0	0	0
MC4-0	1.0276	0.00458	0	0	0.04762	0.02911
MC4-0	1.0296	0.0041	0	0	0.04762	0.02911
SW3-0	1.0347	0.00229	0	0	0.10329	0.01061
SW3-0	1.0348	0.00234	0	0	0.10329	0.01061
MC3-0	1.0536	-0.00219	0	0	0.06282	-0.00403
MC3-0	1.0536	-0.00219	0	0	0.06282	-0.00403
SW3-0	1.0484	0.00013	0	0	0.0629	0.03703
SW3-0	1.0484	0.00013	0	0	0.0629	0.03703
SW4-0	1.0448	-0.00582	0	0	0.00261	0.0015
SW4-0	1.0448	-0.00582	0	0	0.00261	0.0015
MC4-0	1.0332	0.00978	0	0	0.01782	0.00994
MC4-0	1.0332	0.00982	0	0	0.01782	0.00994
SW3-0	1.059	0.01191	0	0	0.01654	0.00977
SW2-0	1.0367	0.02423	0	0	0.0324	0.02009
	1	0.10639	0.24651	0.05625	0	0
	1	0.10639	0.24651	0.05625	0	0
	1	0	-0.07279	0.047	0	0
	1.0361	0.02342	0	0	0	0
	1.0361	0.02367	0	0	0	0
	1.0361	0.02365	0	0	0	0
	1.0362	0.02346	0	0	0	0
	1.0341	0.02419	0	0	0	0
	1.028	0.01393	0	0	0	0
	1.0277	0.01396	0	0	0	0
	1.0287	-0.00934	0	0	0.00994	0.0049
	1.0361	0.02369	0	0	0	0
	1.0453	-0.0143	0	0	0.02668	0.0171
	1.028	0.01393	0	0	0	0
	1.0287	-0.00938	0	0	0.00994	0.0049

1.0288	0.01517	0	0	0	0
1.0453	-0.0143	0	0	0.02668	0.0171
1.0276	0.01435	0	0	0	0
1.0276	0.01435	0	0	0	0
1	0.10639	0.24651	0.05625	0	0
1	0.10639	0.24651	0.05625	0	0
1.0288	0.01517	0	0	0	0
1.0361	0.02363	0	0	0	0
1.0277	0.01396	0	0	0	0

FLOWS

Bus	To Bus	Line	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u.]	Q Loss [p.u.]
PSW2-0	011-PSW2-0	1	0.19541	0.03168	6e-005	-0.0002
PSW2-0	011-PSW2-0	2	0.17876	0.02696	5e-005	-0.00022
PSW2-0	000-PSW2-0	3	0.25334	0.05347	0.00143	-0.00157
PSW2-0	000-PSW2-0	4	0.25334	0.05347	0.00143	-0.00157
PSW2-0	Bus09	5	0.11325	0.00817	2e-005	-0.00025
PSW2-0	Bus11	6	0.01654	0.00463	0	-0.0003
PSW2-0	Bus12	7	0.01782	0.00349	0	-0.0003
PSW2-0	Bus26	8	0.08956	0.00347	7e-005	-0.00152
PSW2-0	Bus18	9	0.08373	0.02967	6e-005	-0.00246
PSW2-0	Bus15	10	0.04773	0.01559	0.00011	-0.0003
PSW2-0	Bus16	11	0.08956	0.00347	7e-005	-0.00152
PSW2-0	Bus33	12	0.06557	0.02314	6e-005	-0.00163
PSW2-0	Bus35	13	0.06557	0.02314	6e-005	-0.00163
PSW2-0	Bus3	14	0.01306	-0.00124	0	-0.0008
PSW2-0	Bus5	15	0.01306	-0.00124	0	-0.0008
PSW2-0	Bus7	16	0.04763	0.01552	1e-005	-0.00031
PSW2-0	Bus8	17	0.08373	0.02967	6e-005	-0.00246
PSW2-0	Bus13	18	0.11325	0.00817	2e-005	-0.00025
PSW2-0	Bus21	19	0.01782	0.00349	0	-0.0003
	050-PSW2-0	20	0.24651	0.05625	0	0.02096
	050-PSW2-0	21	0.24651	0.05625	0	0.02096
	050-PSW2-0	22	-0.07279	0.047	0	0.00246
	013-PSW3-0	23	0.11324	0.00842	0	0.0024
	021-PSW3-0	24	0.01654	0.00493	0	0.00021
	021-PMC4-0	25	0.01782	0.00379	0	0.00026
PMC3-0	Bus25	26	0.02668	0.01756	0	0.00046
	013-PSW3-0	27	0.11324	0.00842	0	0.0024
PSW3-0	Bus20	28	0.00994	0.00505	0	0.00015
	012-PMC4-0	29	0.04762	0.01589	0	0.00103
	021-PMC4-0	30	0.01782	0.00379	0	0.00026
	005-PSW3-0	31	0.08367	0.03213	0	0.00251
	005-PSW3-0	32	0.08367	0.03213	0	0.00251
PSW3-0	015-PSW4-0	33	0.00261	0.00152	0	2e-005
PSW3-0	015-PSW4-0	34	0.00261	0.00152	0	2e-005
	050-PSW2-0	35	0.24651	0.05625	0	0.02096
	050-PSW2-0	36	0.24651	0.05625	0	0.02096
	014-PMC3-0	37	0.0895	0.00498	0	0.00145
PSW3-0	Bus27	38	0.00994	0.00505	0	0.00015
PMC3-0	Bus32	39	0.02668	0.01756	0	0.00046
	014-PMC3-0	40	0.0895	0.00498	0	0.00145
	015-PSW3-0	41	0.06551	0.02477	0	0.00106
	012-PMC4-0	42	0.04762	0.01583	0	0.00103
	015-PSW3-0	43	0.06551	0.02477	0	0.00106
	001-PSW3-0	44	0.01306	-0.00045	0	0.00012
	001-PSW3-0	45	0.01306	-0.00045	0	0.00012

FLOWS

Bus	To Bus	Line	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u.]	Q Loss [p.u.]
PSW2-0	050-PSW2-0	1	-0.19535	-0.03188	6e-005	-0.0002
PSW2-0	050-PSW2-0	2	-0.17871	-0.02718	5e-005	-0.00022
PSW2-0	050-PSW2-0	3	-0.25191	-0.05504	0.00143	-0.00157
PSW2-0	050-PSW2-0	4	-0.25191	-0.05504	0.00143	-0.00157

011-PSW2-0	5	-0.11323	-0.00842	2e-005	-0.00025
011-PSW2-0	6	-0.01654	-0.00493	0	-0.0003
011-PSW2-0	7	-0.01782	-0.00379	0	-0.0003
000-PSW2-0	8	-0.0895	-0.00498	7e-005	-0.00152
000-PSW2-0	9	-0.08367	-0.03213	6e-005	-0.00246
011-PSW2-0	10	-0.04762	-0.01589	0.00011	-0.0003
000-PSW2-0	11	-0.0895	-0.00498	7e-005	-0.00152
000-PSW2-0	12	-0.06551	-0.02477	6e-005	-0.00163
000-PSW2-0	13	-0.06551	-0.02477	6e-005	-0.00163
000-PSW2-0	14	-0.01306	0.00045	0	-0.0008
000-PSW2-0	15	-0.01306	0.00045	0	-0.0008
011-PSW2-0	16	-0.04762	-0.01583	1e-005	-0.00031
000-PSW2-0	17	-0.08367	-0.03213	6e-005	-0.00246
011-PSW2-0	18	-0.11324	-0.00842	2e-005	-0.00025
011-PSW2-0	19	-0.01782	-0.00379	0	-0.0003
'SW2-0 Bus01	20	-0.24651	-0.03528	0	0.02096
'SW2-0 Bus02	21	-0.24651	-0.03528	0	0.02096
'SW2-0 Bus03	22	0.07279	-0.04453	0	0.00246
'SW3-0 Bus09	23	-0.11324	-0.00601	0	0.0024
'SW3-0 Bus11	24	-0.01654	-0.00472	0	0.00021
'MC4-0 Bus12	25	-0.01782	-0.00354	0	0.00026
014-PMC3-0	26	-0.02668	-0.0171	0	0.00046
'SW3-0 Bus13	27	-0.11324	-0.00601	0	0.0024
013-PSW3-0	28	-0.00994	-0.0049	0	0.00015
'MC4-0 Bus15	29	-0.04762	-0.01486	0	0.00103
'MC4-0 Bus21	30	-0.01782	-0.00354	0	0.00026
'SW3-0 Bus8	31	-0.08367	-0.02962	0	0.00251
'SW3-0 Bus18	32	-0.08367	-0.02962	0	0.00251
'SW4-0 015-PSW3-0	33	-0.00261	-0.0015	0	2e-005
'SW4-0 015-PSW3-0	34	-0.00261	-0.0015	0	2e-005
'SW2-0 Bus36	35	-0.24651	-0.03528	0	0.02096
'SW2-0 Bus37	36	-0.24651	-0.03528	0	0.02096
'MC3-0 Bus16	37	-0.0895	-0.00354	0	0.00145
013-PSW3-0	38	-0.00994	-0.0049	0	0.00015
014-PMC3-0	39	-0.02668	-0.0171	0	0.00046
'MC3-0 Bus26	40	-0.0895	-0.00354	0	0.00145
'SW3-0 Bus33	41	-0.06551	-0.02371	0	0.00106
'MC4-0 Bus7	42	-0.04762	-0.0148	0	0.00103
'SW3-0 Bus35	43	-0.06551	-0.02371	0	0.00106
'SW3-0 Bus3	44	-0.01306	0.00056	0	0.00012
'SW3-0 Bus5	45	-0.01306	0.00056	0	0.00012

. SUMMARY REPORT

GENERATION

'OWER [p.u.]	0.91325
VE POWER [p.u.]	0.27198

LOAD

'OWER [p.u.]	0.90975
VE POWER [p.u.]	0.35843

SHUNT

'OWER [p.u.]	0
VE POWER (IND) [p.u.]	0
VE POWER (CAP) [p.u.]	0.1735

LOSSES

'OWER [p.u.]	0.00351
VE POWER [p.u.]	0.08704