Electrical Power System Modeling and Simulation of Putrajaya Precinct 5 Gas District Cooling Plant

by

Nurul Nashwar binti Mohd Taib

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Electrical and Electronics Engineering)

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CERTIFICATION OF APPROVAL

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UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
December 2004

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.

NURUL NASHWAR BINTI MOHD TAIB

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Equation 5 : $I_{Short\ circuit} = (V / Z_{Thevenin})\ puA$

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Equation 8 : $I = P+jQ / E_2*$

Equation 9 : $V_d = I(R+jX)$

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ABSTRACT

As a prerequisite for FYP, the author is required to submit a dissertation that records on-going study of electrical power system in a Gas District Cooling (GDC) Plant located in Putrajaya Precinct 5, which subsequently is simulated to explore the system behaviour and response. Two major approaches of power system analysis, which has been covered, are load flow and short circuit studies. In relation with the operation of the plant, it is necessary to conduct such studies to ensure system's stability and robustness.

The robustness of a power system is measured by the ability of the system to operate in a state of equilibrium under normal and perturbed conditions. Power system stability deals with the study of power system's behaviour under conditions such as sudden changes in load or short circuits on buses or branches.

The first section of this report will elaborate on the introductory part, which consists of the brief description on the project, the scope of work and also the main activities that the author has participated.

The second part of the report will cover the details of the literature review that the author has undergone. The first study being carried out is the process requirements, which encompass mechanical principles of the GDC system that is very important in designing Electrical Load Analysis (ELA). ELA is then evaluated to calculate maximum demand and peak load. Equipment sizing, power flow study using Newton-Raphson method and short circuit study using Per Unit method based on comprehensive study has also been conducted.

The third section will focus on the methodology that has been taken by the author throughout her final year period in UTP. Consequently, this section will highlight procedures and tools that have been utilized in

SKM® Power Tools [4]. SKM® Power Tools [4] have been extensively used in industry as it usually has the simplest solution for most cases. The aim of this project is to understand how the system works by creating a software simulation that represents electrical power utilization. Prior to this, there is a need in understanding an electrical system response with presence of a disturbance and interruption.

This next slot represents results and discussion that has been covered especially on short circuit and load flow studies. The main intention is to develop a model for load flow and short circuit studies to validate the accuracy based on the relevant data obtained from the plant.

The last section will outline some recommendations and will represent as conclusion of the report. This chapter is focusing on the relevancy of this study and the achievement of this project according to the objective and mile stone set that can be made out of this project for the next project's development.

ACKNOWLEDGEMENT

Sir Isaac Newton once said, "If I have seen farther from other men, it is because I have stood on the shoulders of giants." I am most grateful to all personnel whose works I have drawn from them. They are the giants on whose shoulders I stood while working for my final year project. Upon completing the two semesters of my final year project, I would like to express my deepest appreciation, first and foremost to ALLAH, The Al-Mighty, for giving me the strength and perseverance to undertake all the tasks assigned.

Millions of thanks are specially dedicated to my supervisor, Mr. Zuhairi bin Haji Baharudin, for his support and enthusiasm throughout my final year semesters. I have discovered that a major project like this is a formidable task. Whenever I stumbled on problems during the course, he gave me the chance to think out of the box and assist me in solving the problems critically. My utmost gratitude aptly is also dedicated to the management of Electrical Department in Oil, Gas & Petrochemical Technical Services Sdn. Bhd, for helping me in obtaining all the data required for my project especially Ir. Zakariya Ibrahim, Electrical Manager of Engineering Division and my training supervisor, Puan Adita Johara Mat Husin for their unfailing assistance.

Last but not least, I wish to pay tribute to my family, especially my parents, Tn Dr. Haji Mohd Taib bin Haji Hashim and Mrs. Hajah Mazhariah binti Mansor for their encouragement and tolerance in many ways during my final year project period. And also to my friends, who shared their ideas, experiences and encouragement.

Thank you

May ALLAH SWT bless all of you.

CHAPTER 1
INTRODUCTION

1.1 Background of Study

The emphasis is on the consideration of the system as a whole rather than on the engineering details of its constituents. According to S.Mattson (1998), modern electric power systems are the most complex large-scale technical systems developed by mankind since its main goal is providing continuous power supply to the facility with little or no interruptions [1]. The power supply for GDC Plant is obtained from 11kV feeder of Tenaga Nasional Berhad (TNB) supply for Phase 1. The computation for various buses and interconnecting lines are as follows, starting from down-stream loads at 415V Switchgear/MCC buses A and B that are supplied from 11/0.415-Tx1A and 11/0.415-Tx1B respectively. These 11/0.415kV transformers are supplied at 11kV from the 11kV Switchboard buses. Similarly, the 3.3kV Switchgear/MCC buses A and B are supplied by 11/3.3kV power transformers; 11/3.3-TxA and 11/3.3-TxB respectively, which in turn are fed from the 11kV Switchboard buses. 33kV feeder is going to be tapped during development of Phase 2 onwards due to the additional of future loads. The study analysis that has been carried out is based on the power intake taken at 11kV to cater for the present estimated loads. Distributions of electrical power to various loads of the plant via different buses are as follows: -

- 11kV Switchboard Bus A and B (Phase 1)
- 3.3kV Switchgear/MCC Bus A and B (Phase 1 to Phase 4), as the 11/3.3kV step down transformers has to be purchased at Phase 1 of the project
- 415V Switchgear/MCC Bus A and Bus B (Phase 1)

The anticipated maximum demand for all phases of the plant is approximately 7.5MVA during basic engineering design. Additional equipment during detail engineering design leads to increment in load demand up to 9.0MVA. Phase wise approximate load demand estimated is as shown below: -

Table 1: Load Demand Estimation

Description	Year	Basic Engineering Design	Detail Engineering Design
Phase 1	2004	3.4 MVA	4.8 MVA
Phase 2	2007	1.7 MVA	1.8 MVA
Phase 3	2008	1.4 MVA	1.4 MVA
Phase 4	2012	1.0 MVA	1.0 MVA

1.2 Problem Statement

"Electrical Power System Modeling and Simulation"
"Electrical Power System" defines a set of complete electrical network that consists of all the electrical distribution panels and loads at certain level of voltage rating. "Modeling" here refers mathematical representation of electrical motor and non-motor various loads. "Simulation" is defined as generation of tests on a virtual-time basis to predict the short circuit behavior and load flow analysis of the real system. Computer-aided tool that will be used is SKM® Power Tools [4]; an electrical engineering software.

1.2.1 Problem Identification

Electrical Engineers need to perform specific study to avoid fault current from occurring and load flow study to determine power consumption. Accurate load flow and short circuit is of great importance for power system operation to be stable under any circumstances and conceivable disturbances. Disturbances in industrial power systems are large in magnitude and the typical duration of a fault is tenths of a second. Right assumptions need to be obtained especially in short circuit and load flow analysis to simplify calculation. [2]

1.2.2 Project Significance

The results of the analysis can conclude on how much electricity needed by the plant, how big the equipment will be and what type of protective devices required. The project can serve as a baseline for modelling of more advanced and complex power systems. Further expansion plans for the power system in the plant can be facilitated more easily with the help of the model and simulation. It serves as a starting point for future undergraduates to acquire more knowledge on power systems and expand the models developed for further refinement and extended studies.

1.3 Objectives and Scope of Study

- To develop the GDC plant power system model in the SKM® Power Tools [4] environment to simulate comprehensive short circuit and load flow studies
- To specify losses for all busses
- To obtain the switchgear rating and size of capacitor banks

The scope of study will be narrowed to a specific section in the GDC Plant where the electrical loads are concern. Continuous load will be the major type of load to be studied followed by Intermittent Load and Stand-by Load. The power system that covers all important elements and components will be modelled and simulated to predict the system performance and manners. Comprehensive studies based on per unit method for short circuit simulation and Newton-Raphson method for load flow analysis is the major concern involved.

1.4 Feasibility of Project

Supported data on electrical power system obtained from the engineering consultant company should be adequate to view general concept of the electrical components of the system and to impart all the required data for the analysis. The availability of SKM® Power Tools [4] software in the laboratory proved to be helpful and the project is feasible to be carried out within the given time and scope.

CHAPTER 2
LITERATURE REVIEW / THEORY

2.1 Per Unit Method Short Circuit

2.1.1 Objectives

The fault current study can be evaluated by circuit simplification when all data ratings are collected and all the impedances are converted to per unit values. Per unit system is convenient to normalize system variables due to computational simplicity by eliminating units and expressing system quantities as dimensionless ratios. The objectives of short circuit currents can be summarized as follows: -

- Determination of short circuit duties on switching devices, i.e., high-, medium- and low voltage circuit breakers and fuses.
- Evaluations of adequacy of short-circuit withstand ratings of static equipment like cables, conductors, bus bars, reactors and transformers.

2.1.2 Per Unit (PU) Notation

1) For utility contributions:

$Z_{pu} = kVA_{Base} / kVA_{Utility}$ puΩ -- Equation 1

Where

- kVA_{Base} = The system three-phase power base specified for the study
- $kVA_{Utility}$ = The utility system three-phase short circuit capability

2) For motor and generator contributions:

$Z_{pu} = X''d\ (kV_{Motor} / kV_{Base})^2\ (kVA_{Base} / kVA_{Motor})\ pu\Omega$ -------------------------- Equation 2

Where

- $X''d$ = Motor subtransient reactance
- kV_{Motor} = Line-to-line motor rated voltage
- kV_{Base} = Line-to-line bus nominal system voltage at the point of the motor

3) For feeders:

$Z_{pu} = Z_{Cable} / (kV_{Base}{}^2 * 1000 / kVA_{Base})\ pu\Omega$ -- Equation 3

Where

- Z_{Cable} = Per phase feeder impedance in ohms

4) For transformers:

$$Z_{pu} = \frac{(Z_{Transformer}\ \%)}{(100)} * \frac{(kV_{Transformer})^2}{(kV_{Base})^2} * \frac{(kVA_{Base})}{(kVA_{Transformer})}\ pu\Omega \text{ -------------------- Equation 4}$$

Where

- $Z_{Transformer}$ = Transformer % impedance on its self-cooled

The three-phase fault current base is:

$I_{Short\ circuit} = (V / Z_{Thevenin})\ puA$ -- Equation 5

Expressed in Amperes:

$I_{Short\ circuit} = I_{Short\ circuit}\ pu * I_{Base}$ -- Equation 6

Where the base current is defined as:

$I_{Base} = kVA_{Base} / 3^{1/2} * kV_{Base}$ --- Equation 7

2.2 Load Flow Studies

The load flow study is intended to:

- Determine the steady-state loading of the various buses and lines (cables) in the GDC Plant to ensure that they are operating within their performance ratings

- Determine the voltages at the various buses to ensure voltage drops do not exceed +5% and –10%, consistent with the tap-changer range at the distribution transformers
- Evaluate the amount of capacitive reactive power compensation necessary to bring the power factor level to 0.93 lagging

The modelling of loads is complicated because a typical load bus is composed of a large number of devices such as pumps. Consider a simple system as shown in **Figure 1**. [2]

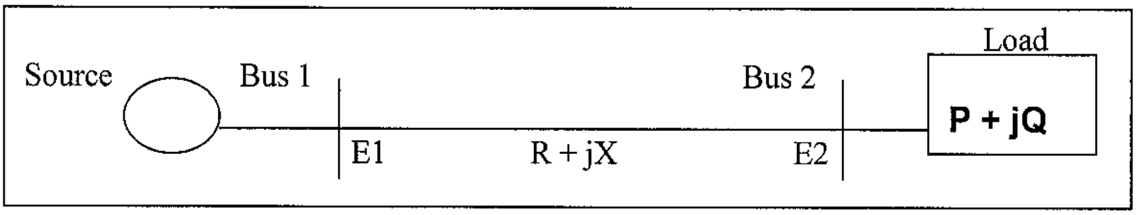

Figure 1: Radial System Losses

The equations relating the above diagram are as follows: -

$I = P+jQ / E_2^*$ -- Equation 8

Where E_2 is the voltage conjugate at bus 2. The voltage drop along the line is:

$V_d = I(R+jX)$ -- Equation 9

Therefore,

$E_2 = (E_{r1} - IR) + j(E_{i1} - IX)$ --- Equation 10

Putting **Equations 8** and **10** in another form, three unknowns are existed as follows:

$I = I_r + jI_i$, $E_2 = E_{r2} + jE_{2i}$ and ($E2^* = E_{r2} + jE_{2i}$)

Equations above can be solved by iterative technique, Newton-Raphson.

2.3 Overview of SKM® Application Software

SKM® Power Tools [4] offers a full spectrum of analysis capabilities such as: -

- *I*SIM Transient Stability* - to evaluate performance and stability of power system
- *Harmonic Analysis* – to simulate harmonic content and distribution
- *DAPPER balanced system studies* – to simulate load flow and short circuit studies.

The sub-tool that will be concentrated is DAPPER Balanced System Study.

Single line diagrams drawn in SKM® Power Tools for basic and detail engineering design of Putrajaya Precinct 5 GDC Plant are as shown in Figure 2 and Figure 3.

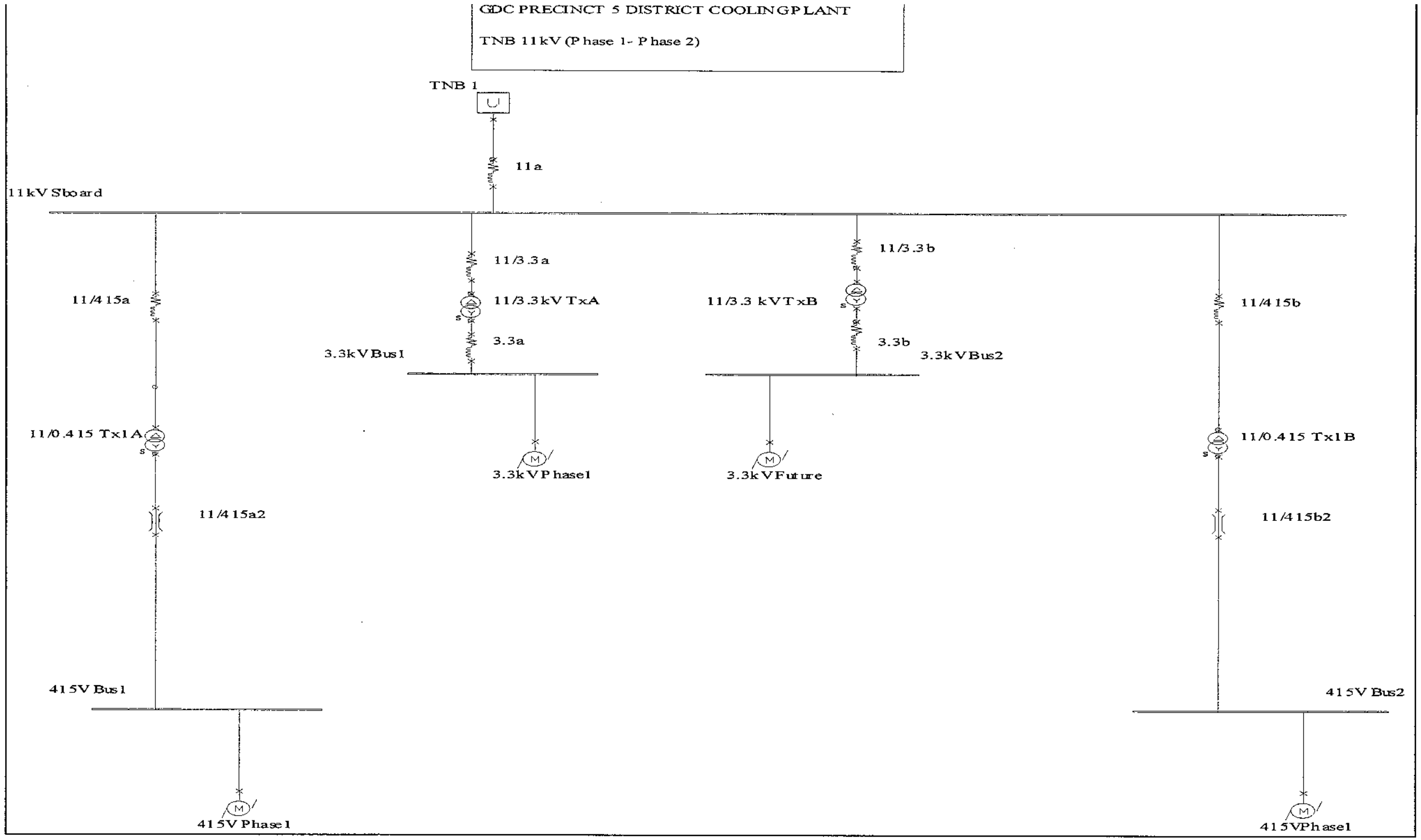

Figure 2: Single Line Diagram for Basic Engineering Design

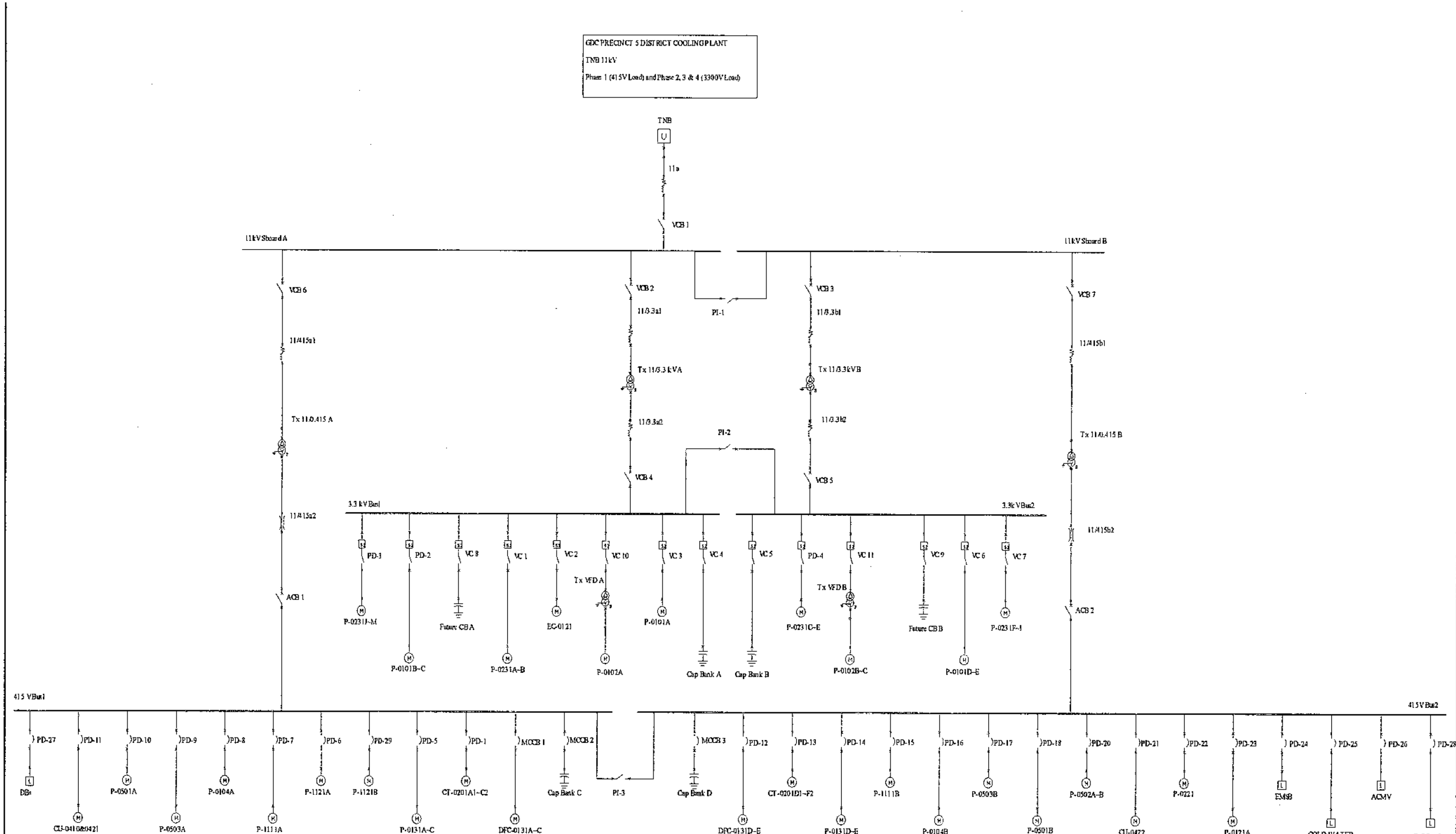

Figure 3: Single Line Diagram for Basic Engineering Design

CHAPTER 3
METHODOLOGY/PROJECT WORK

Literature reviews on books and journals are accomplished throughout the early stage. Apart from that, the author has chosen a case study for a better understanding in real application. The next step is to simulate the electrical power system using appropriate power analysis software. Suggested milestone for whole year is shown in **APPENDIX 1.**

3.1 Load Flow Analysis Method

Load flow steps in SKM® Power Tools [4] are illustrated as below: -

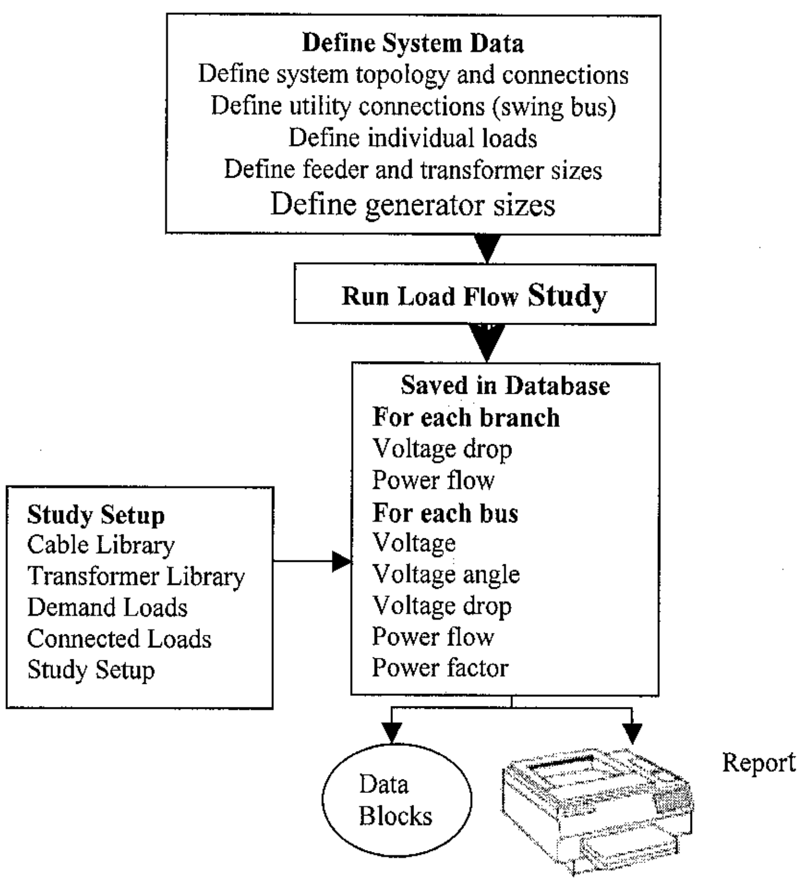

Figure 4: Load Flow Analysis Flow Chart

In order to come out with ELA, process and mechanical equipment data need to be analysed first since it plays myriad roles to meet the required demand and conditions of the GDC Plant. The absorbed load for all equipments will be converted to electrical load using certain formulas. Overall process flow diagram is as shown in **APPENDIX 2.** Demand load and connected load can be determined from ELA, shown in **APPENDIX 3** for both basic and detail engineering design.

3.2 Short Circuit Analysis Method

Figure 5 below shows procedures in SKM® Power Tools [4].to develop comprehensive short circuit study.

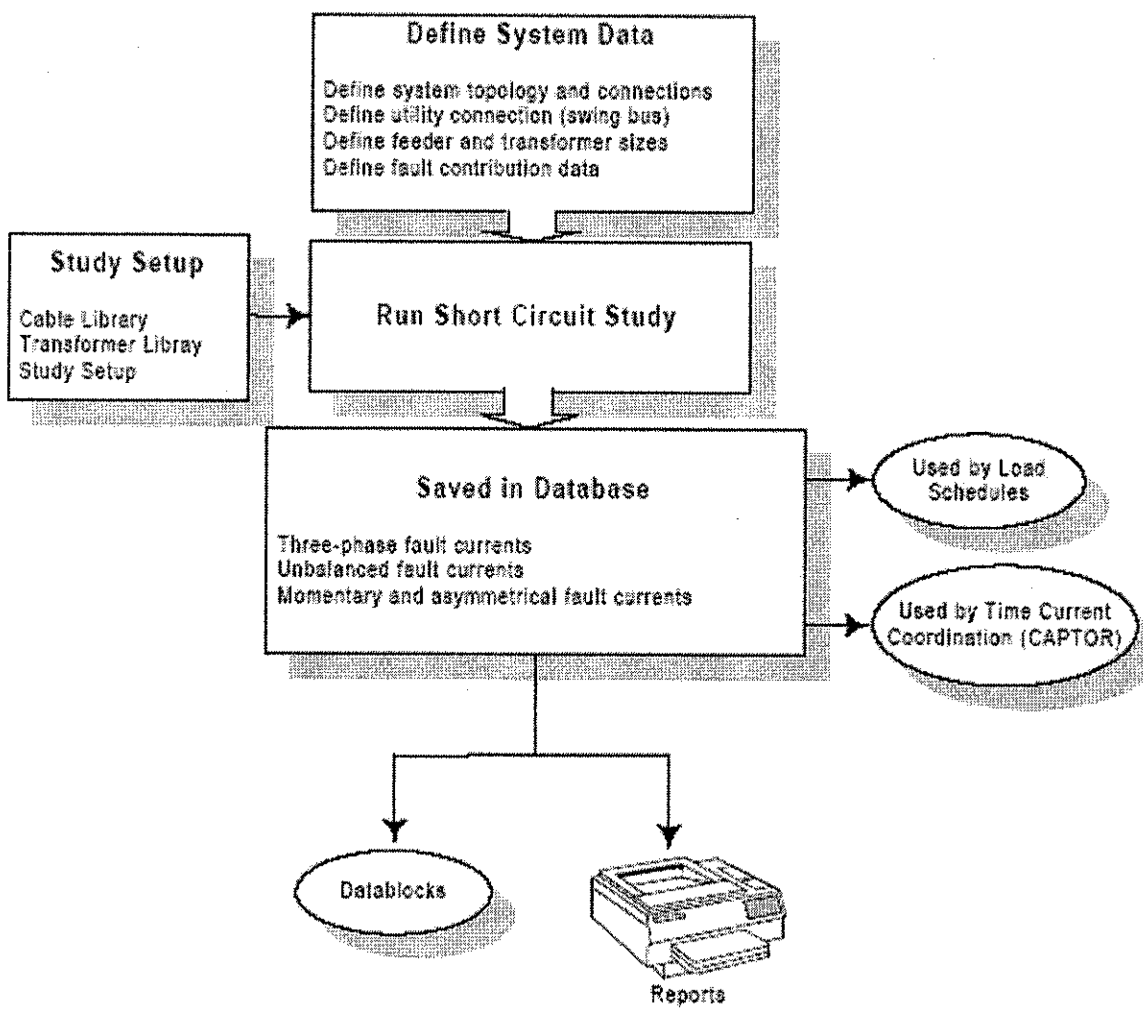

Figure 5: Comprehensive Short Circuit Study Flow Chart

Comprehensive short circuit study models the current that flows in the power system under abnormal conditions and determines the prospective fault currents in an electrical power system. [3]. Comprehensive short circuit analysis procedure involves reducing the network at the short circuit location to a single Thevenin equivalent impedance, determining the associated fault point R/X ratio calculated using complex vector algebra and defining a driving point voltage (assuming the effect of the transformer taps on bus voltage).

3.3 Developing Model in SKM® Power Tools [4]

In developing model for analysis in SKM® Systems Analysis [4], design specifications and descriptions of all major equipments need to be verified first as depicted below: -

3.3.1 Switchboard

The switchboard is designed for each voltage rating. An example of switchboard buses component editor that displays essential data to be entered is as shown in **Figure 6.**

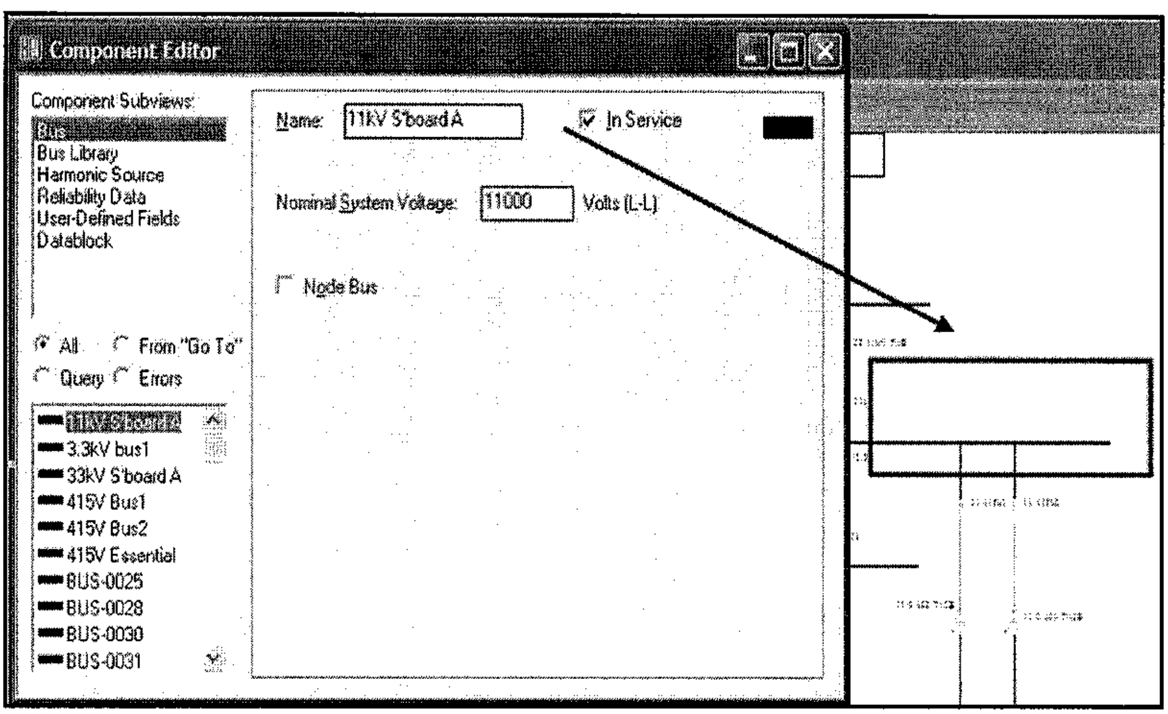

Figure 6: Switchboard Component Editor

3.3.2 TNB Utility

TNB Utility is designed based on Tenaga Nasional Berhad's (TNB's) requirement. Supply may be provided at any of the declared voltages: -

Low Voltage

1. Single-phase, two-wire, 240V, up to 12kVA maximum demand
2. Three-phase, four-wire, 415V, up to 45kVA maximum demand
3. Three-phase, four-wire, C.T. metered, 415V, up to 1500kVA maximum demand

Medium Voltage and High Voltage

1. 3-phase, 3-wire and 11kV for load of 1.5MVA maximum demand and above
2. 3-phase, 3-wire, 22kV and 33kV for load of 5MVA maximum demand and above
3. 3-phase, 3-wire, 66kV, 132kV and 275kV for exceptionally large load of above 20MVA maximum demand

Data from TNB that has been included in SKM® Power Tools [4] is 3-phase, 3-wire and 11kV as shown in utility component editor in **Figure 7**.

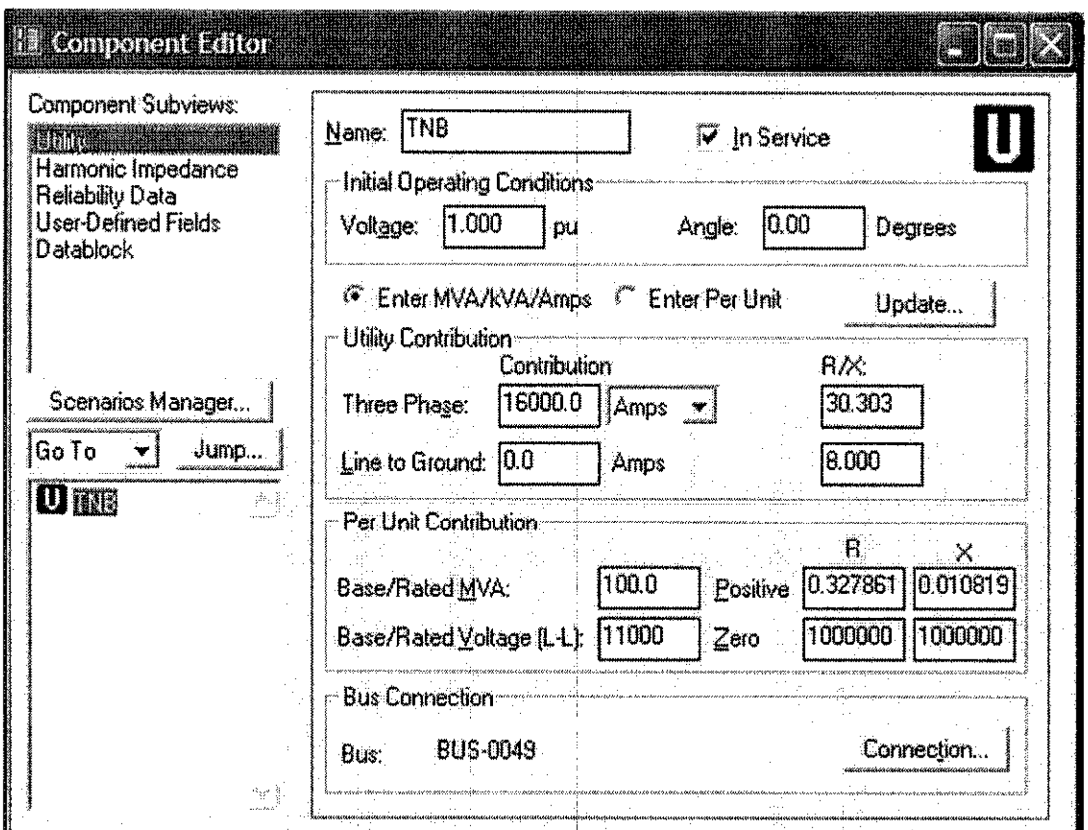

Figure 7: Utility Component Editor

3.3.3 Transformer

Transformers shall be connected in parallel, where each transformer capacity shall be adequate to carry all the loads connected via bus-tie in case of failure or maintenance of either of transformers (100% redundancy). All the data required to be entered for transformer is as shown in 11/0.415kV transformer component editor in **Figure 8** to **Figure 11**. Pop-menu windows for component sub views as listed below will not be shown since all the data need not to be entered as it is automatically calculated by SKM® Power Tools [4]: -

- Reliability Data
- User-Defined Fields
- Datablock

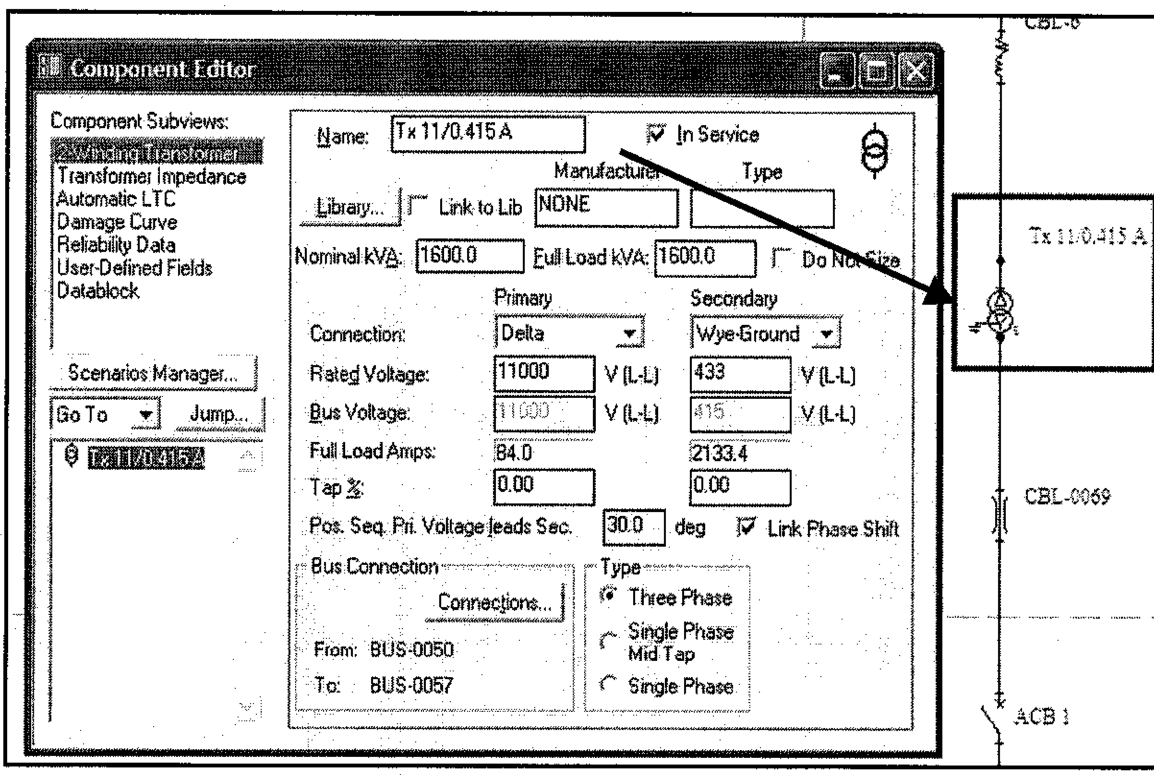

Figure 8: Transformer Component Editor (2-Winding Transformer)

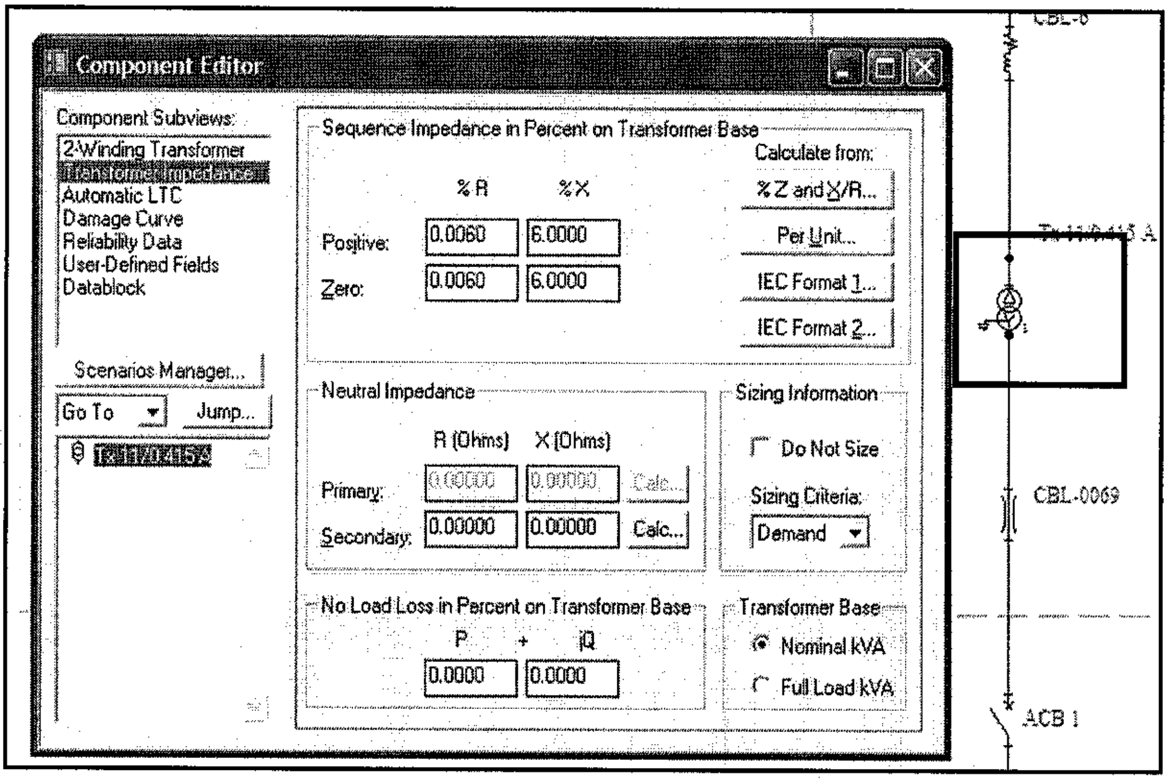

Figure 9: Transformer Component Editor (Transformer Impedance)

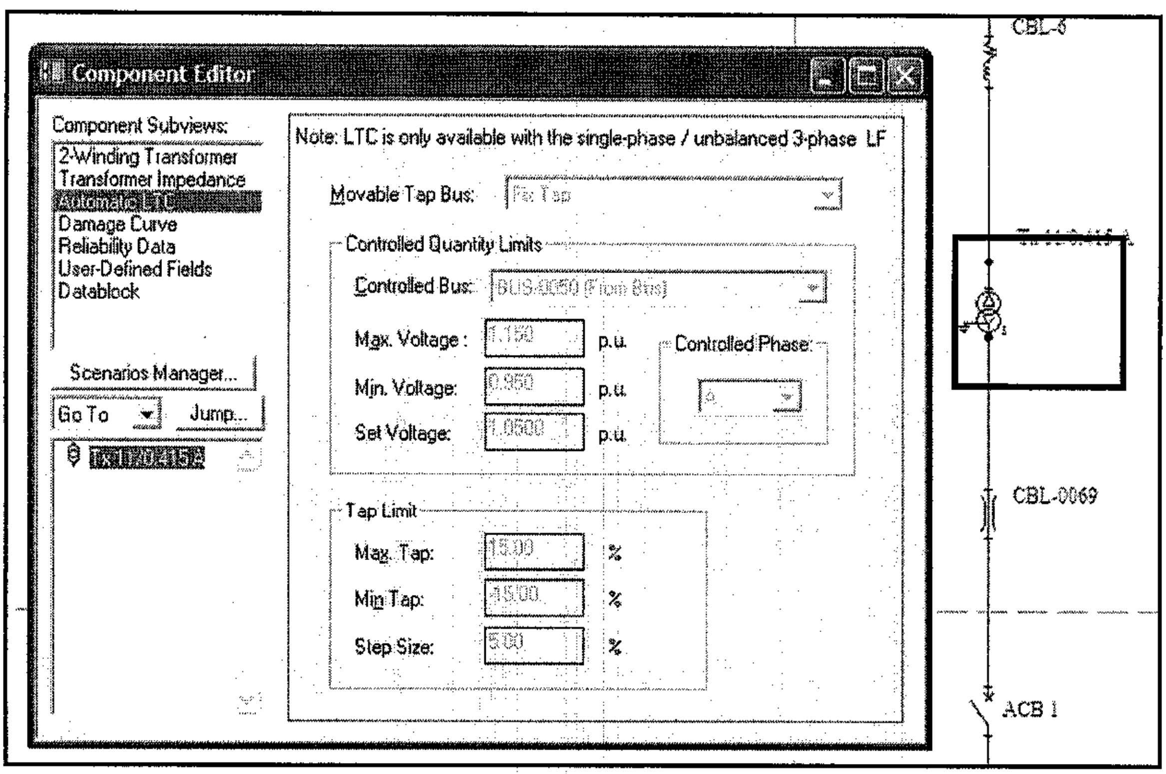

Figure 10: Transformer Component Editor (Automatic LTC)

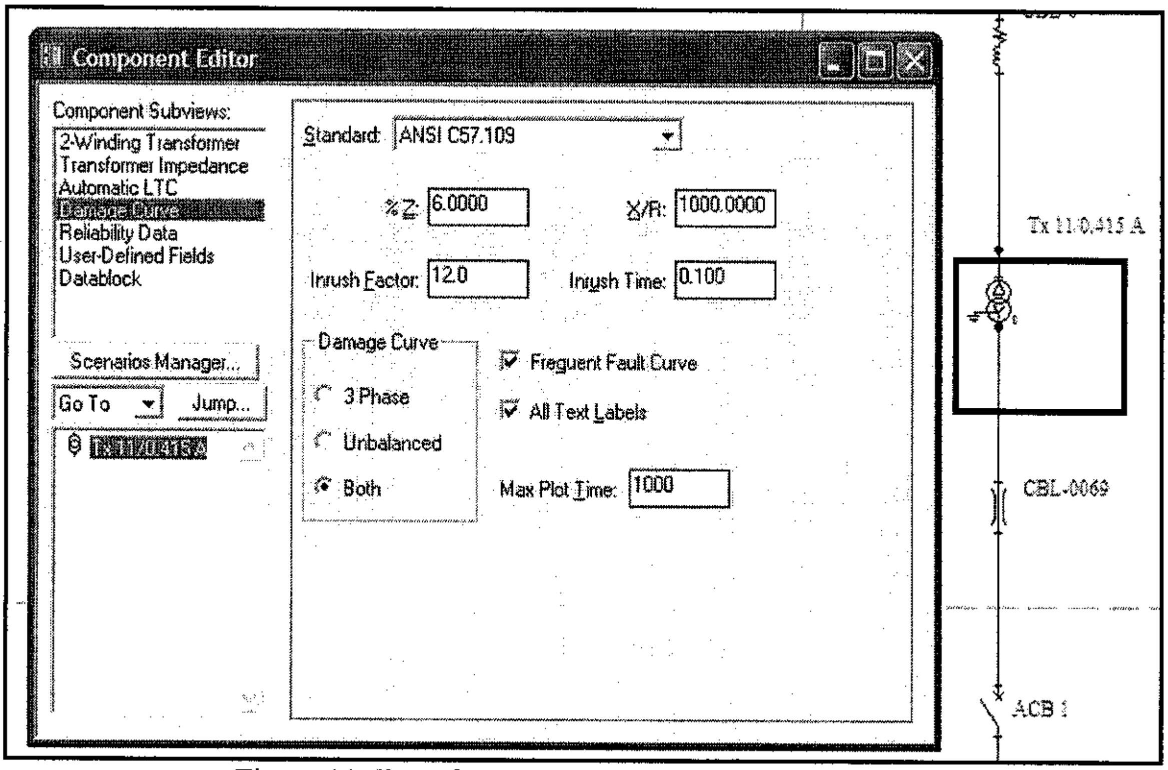

Figure 11: Transformer Component Editor (Damage Curve)

3.3.4 Cables

Current ratings for cables shall be calculated in accordance with the cable manufacturers declared current ratings, and rating factors derived from the laying pattern, and local environmental conditions. A positive tolerance of 5-10% can be allowed on the overall rating factor. Allowable voltage drop percentage during motor running and motor starting is fixed to be 5% and 20% respectively for safety in design. All the data required for cable is as shown in cable component editor in **Figure 12** to **Figure 15**. Pop-menu windows for component sub views as listed below will not be shown since all the data need not to be entered as it is automatically calculated by SKM® Power Tools [4]: -

- Conductor and Raceway
- Reliability Data
- User-Defined Fields
- Datablock

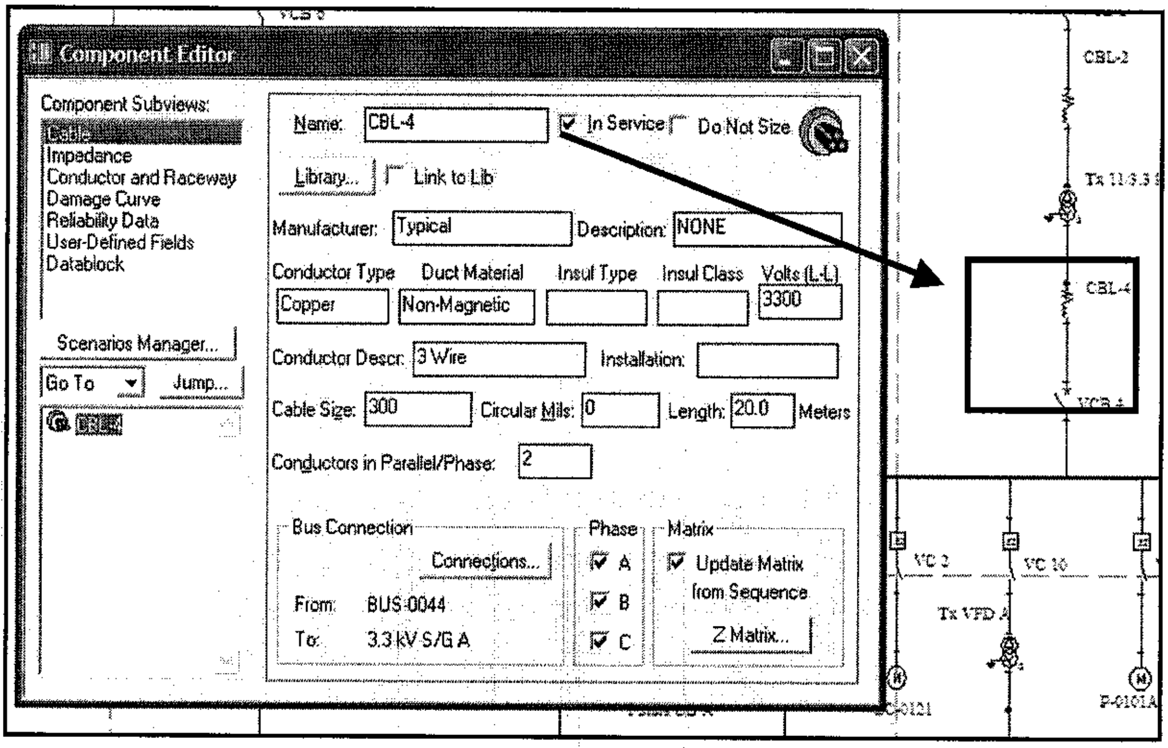

Figure 12: Cable Component Editor (Cable)

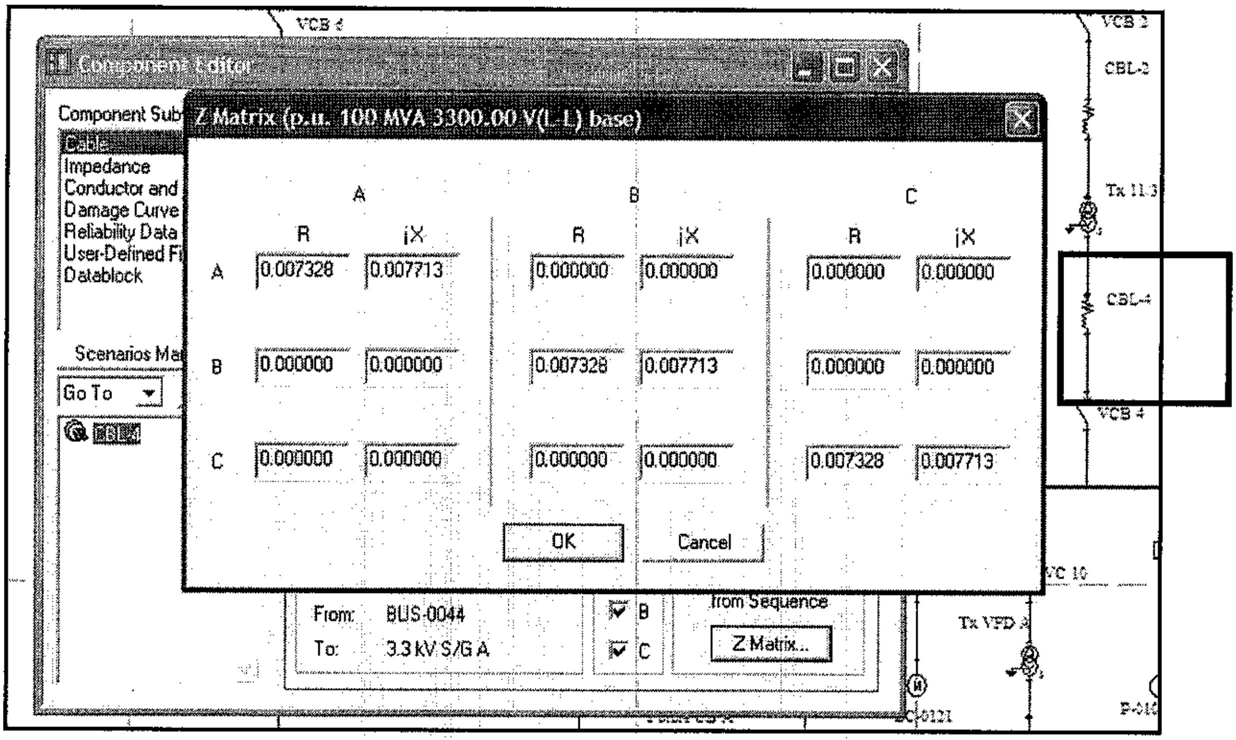

Figure 13: Cable Component Editor (Cable Z Matrix)

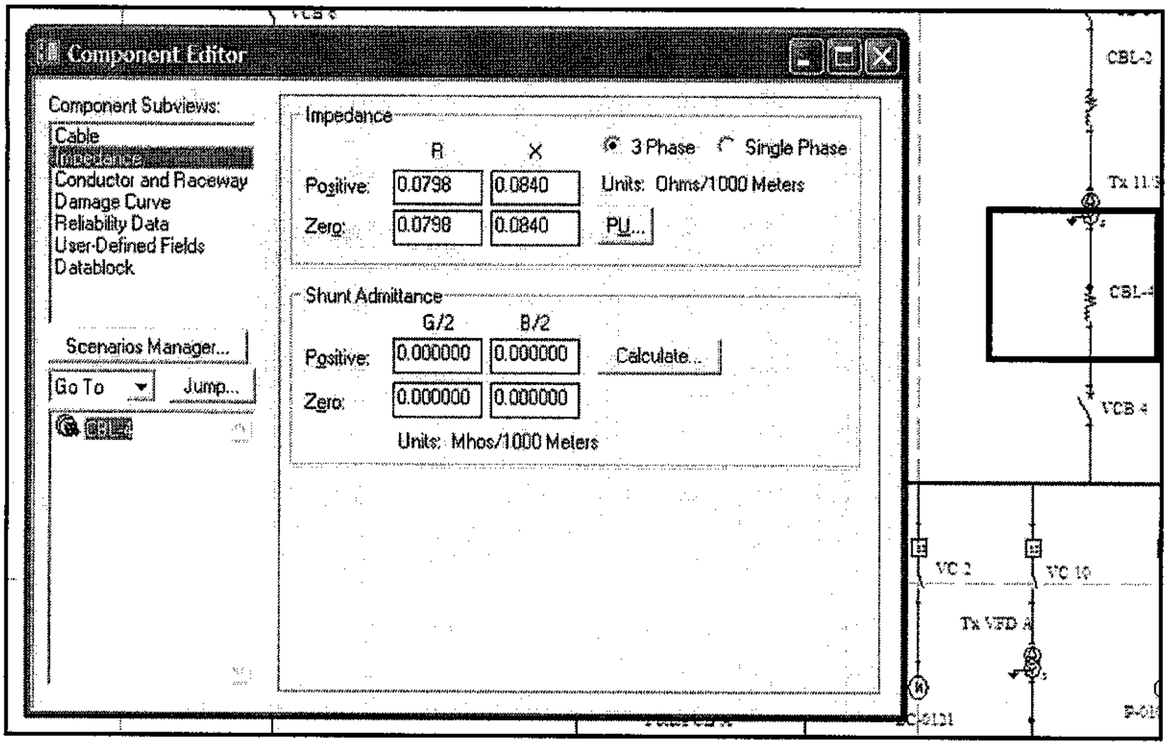

Figure 14: Cable Component Editor (Impedance)

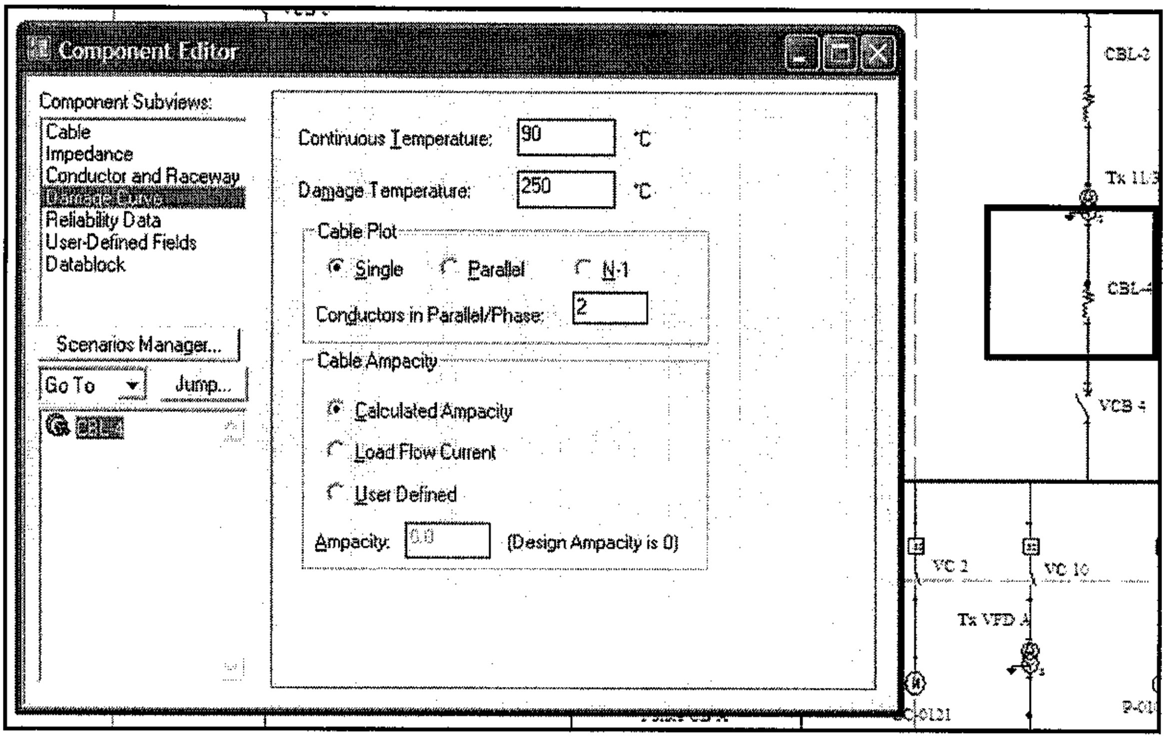

Figure 15: Cable Component Editor (Damage Curve)

3.3.5 Induction Machines – Motor Load

Induction motors are calculated based on maximum demand as shown below from **Figure 16** to **Figure 22**. Pop-menu windows for component sub views as listed below will not be shown since all the data need not to be entered as it is automatically calculated by SKM® Power Tools [4]: -

- Harmonic Source
- Reliability Data
- Load Profiles
- User-Defined Fields
- Datablock

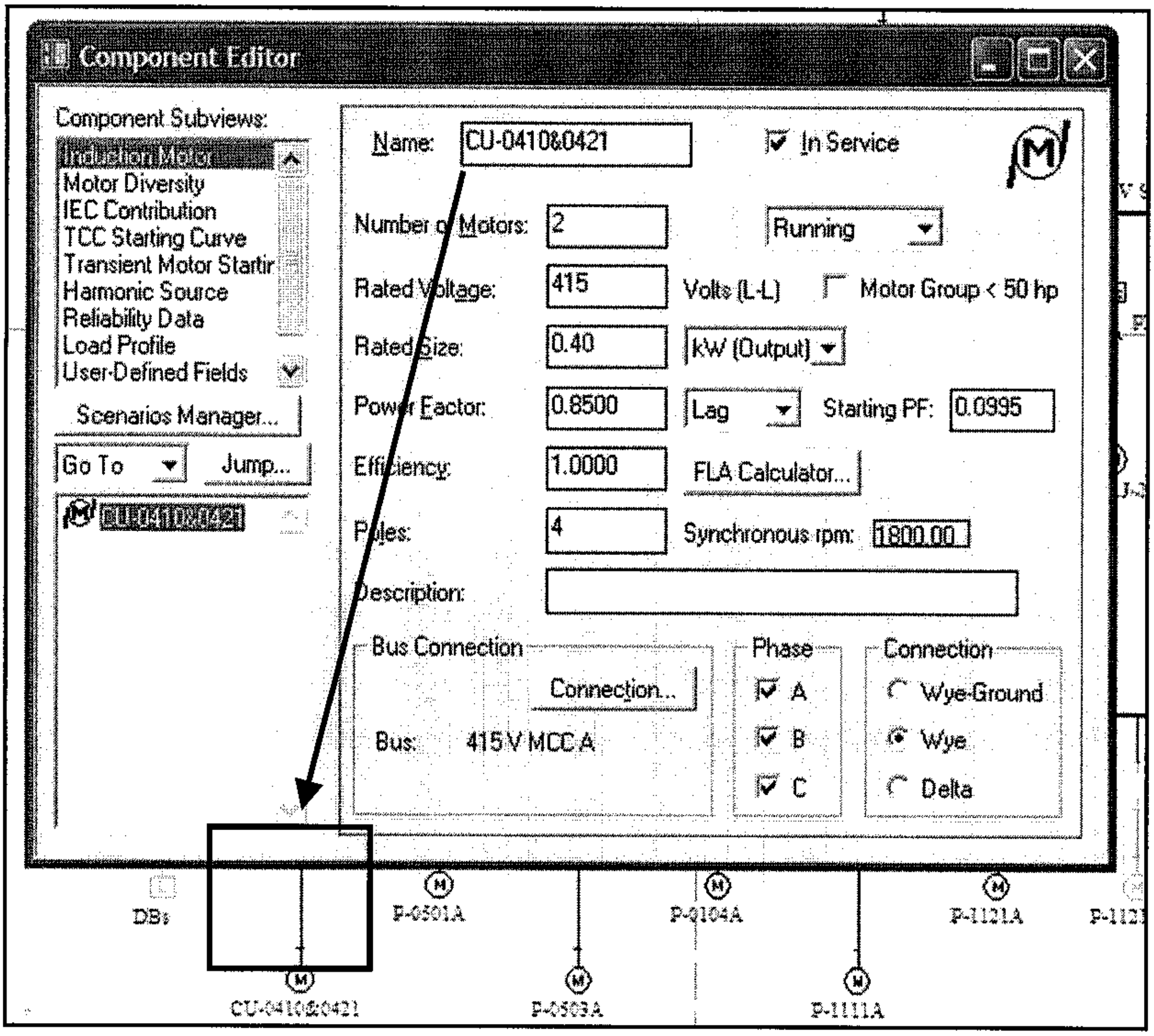

Figure 16: Motor Component Editor (Induction Motor)

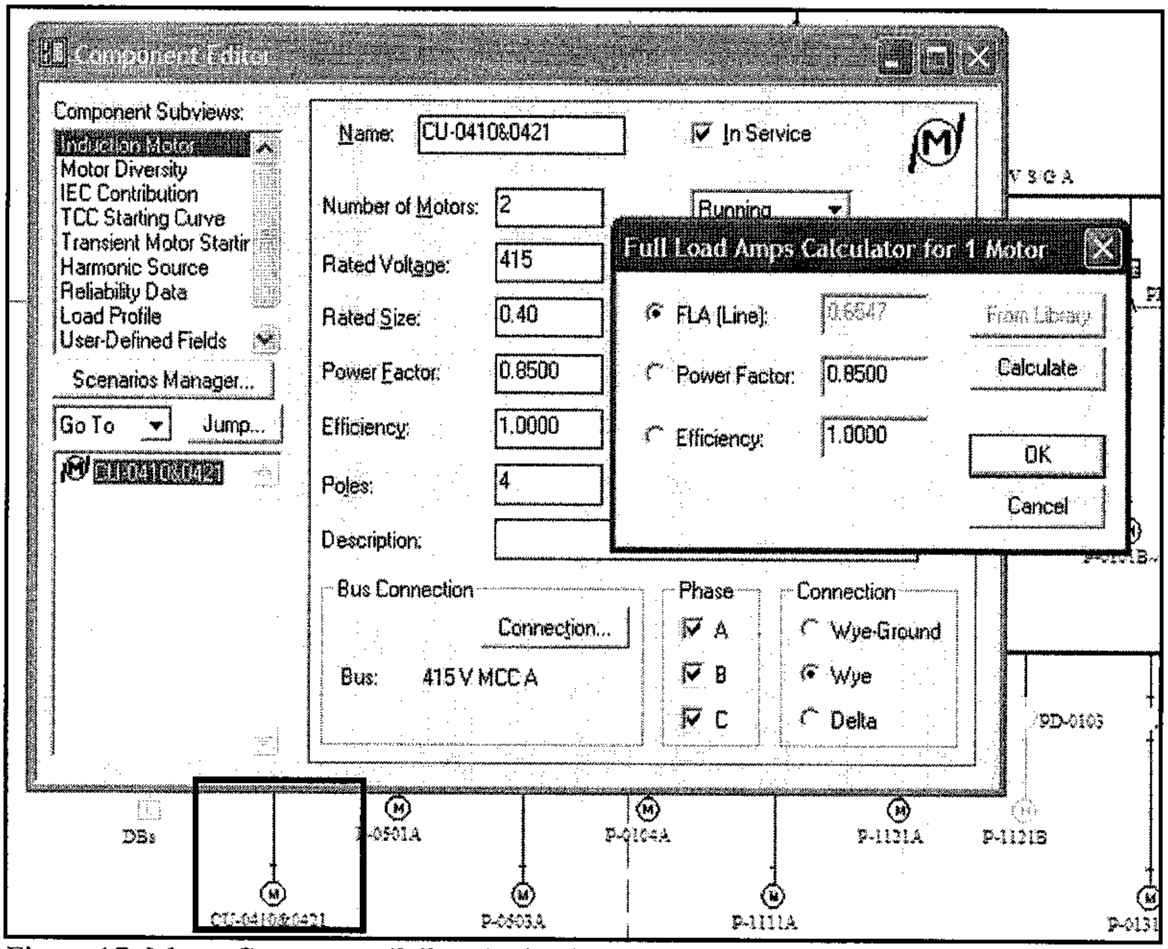

Figure 17: Motor Component Editor (Induction Motor-FLA Calculator, Power Factor and Efficiency)

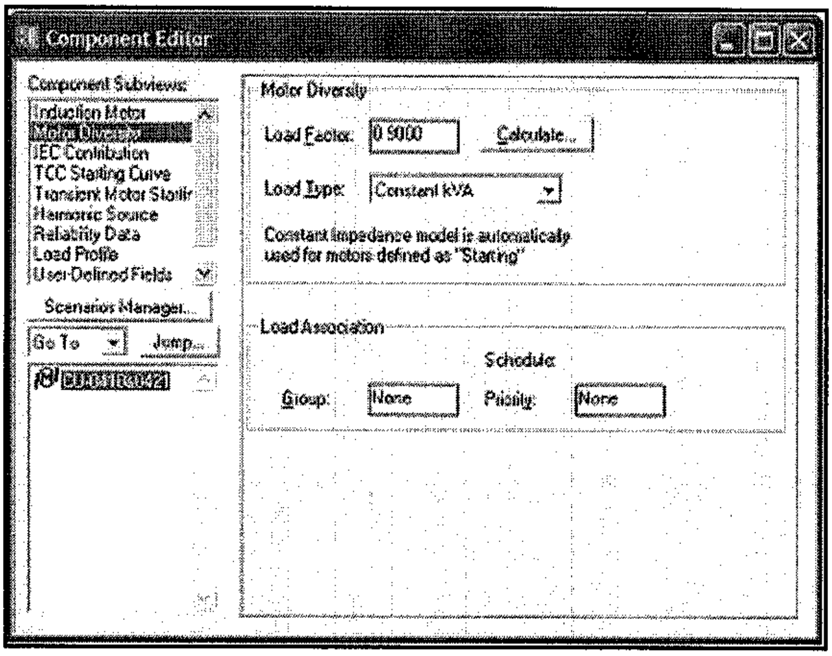

Figure 18: Motor Component Editor (Motor Diversity)

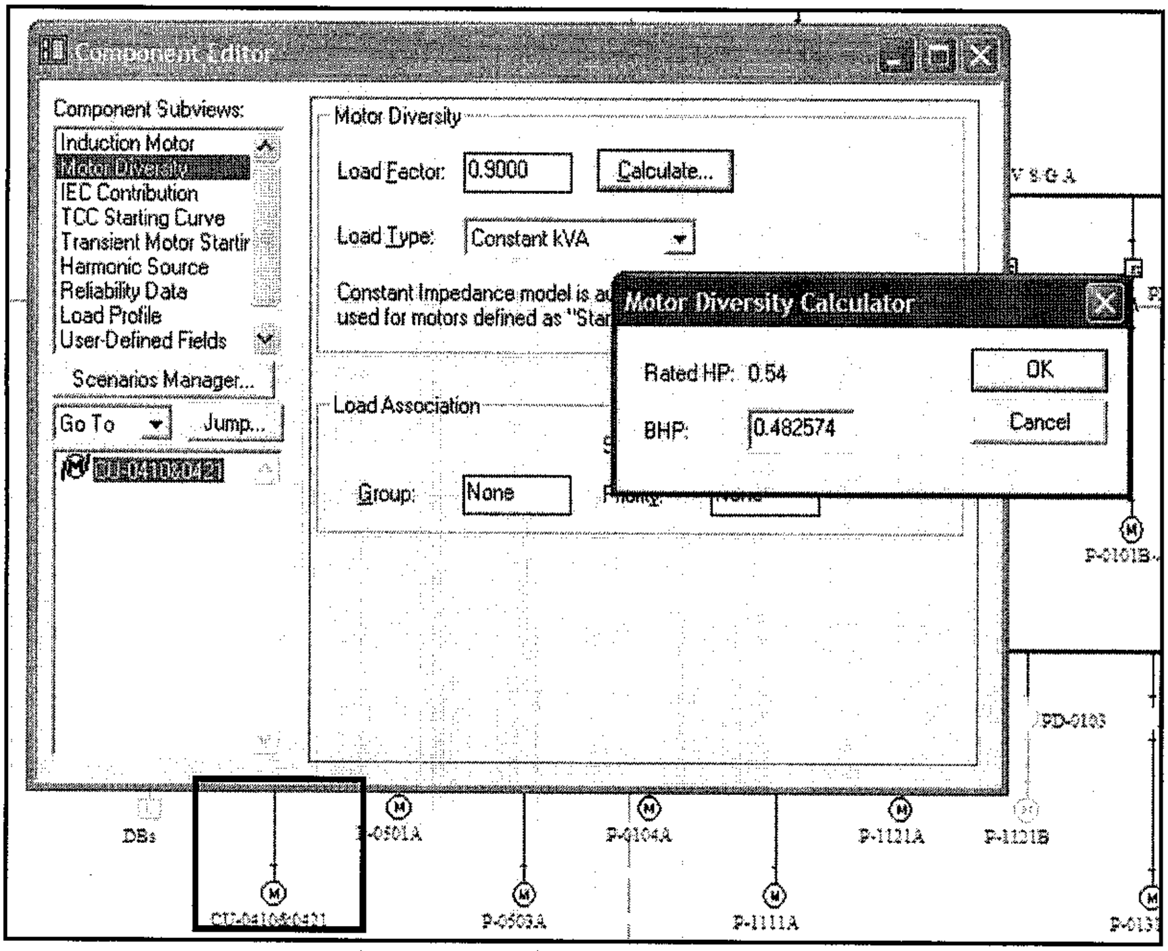

Figure 19: Motor Component Editor (Motor Diversity-Rated HP)

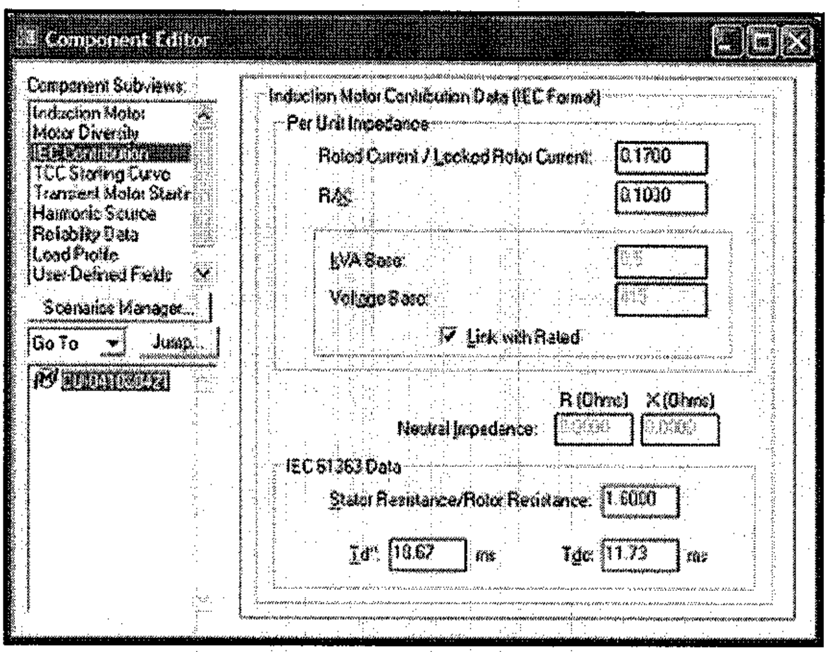

Figure 20: Motor Component Editor (IEC Contribution)

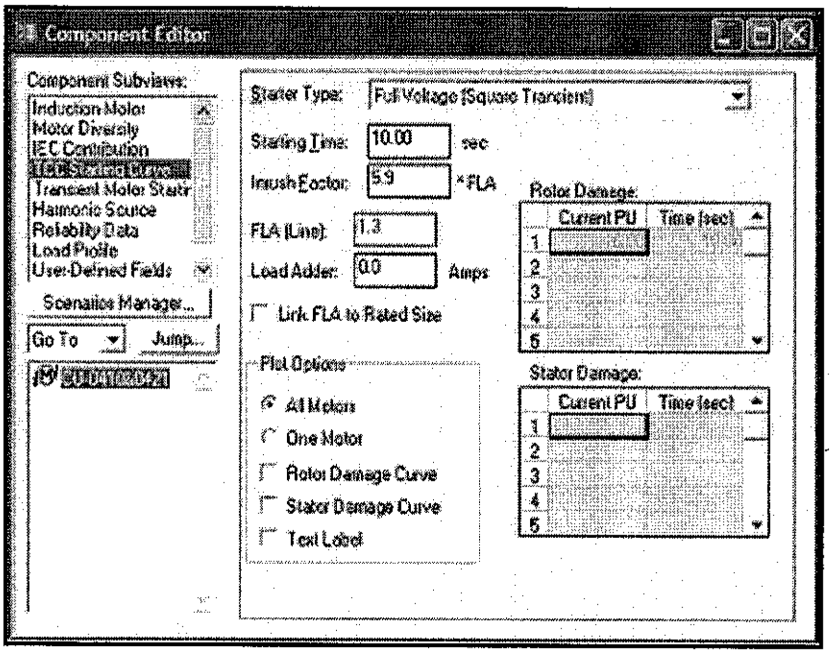

Figure 21: Motor Component Editor (TCC Starting Curve)

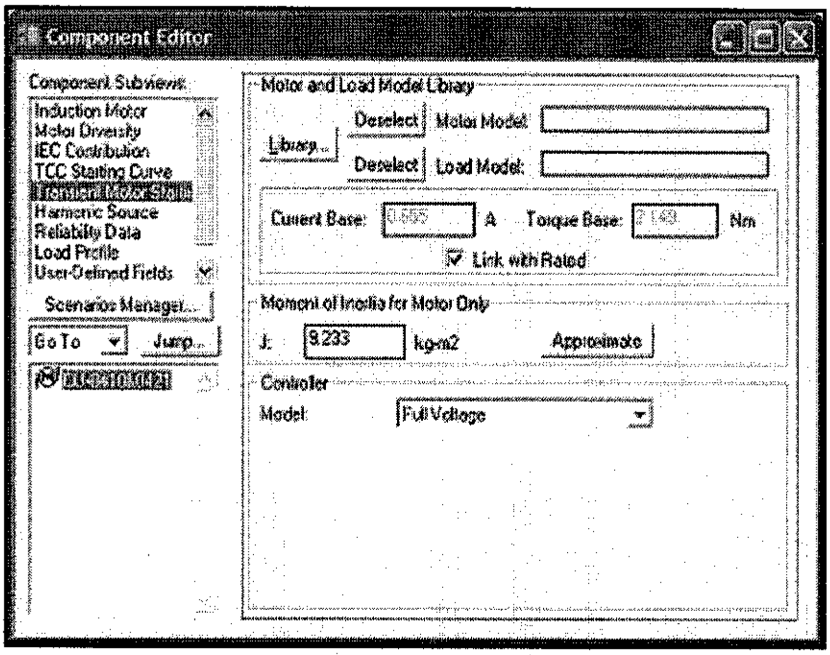

Figure 22: Motor Component Editor (TCC Starting Curve)

3.3.6 Distribution Load – Non-motor Load

Distribution loads are non-motor loads such as lighting. The essential data that need to be entered is as shown in **Figure 23** and **Figure 24**.

Pop-menu windows for component sub views as listed below will not be shown since all the data need not to be entered as it is automatically calculated by SKM® Power Tools [4]: -

- Harmonic Source
- Reliability Data
- Load Profiles
- User-Defined Fields
- Datablock

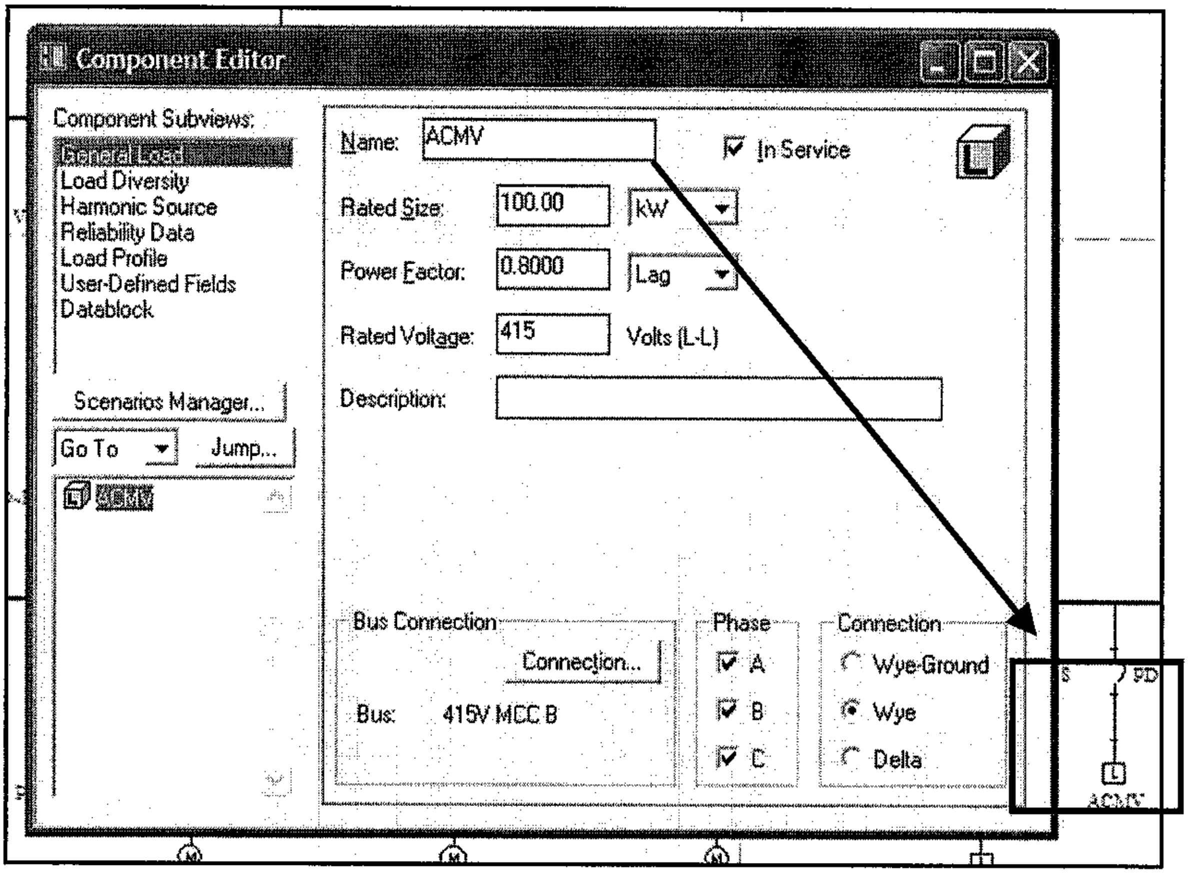

Figure 23: Distribution Load Component Editor (General Load)

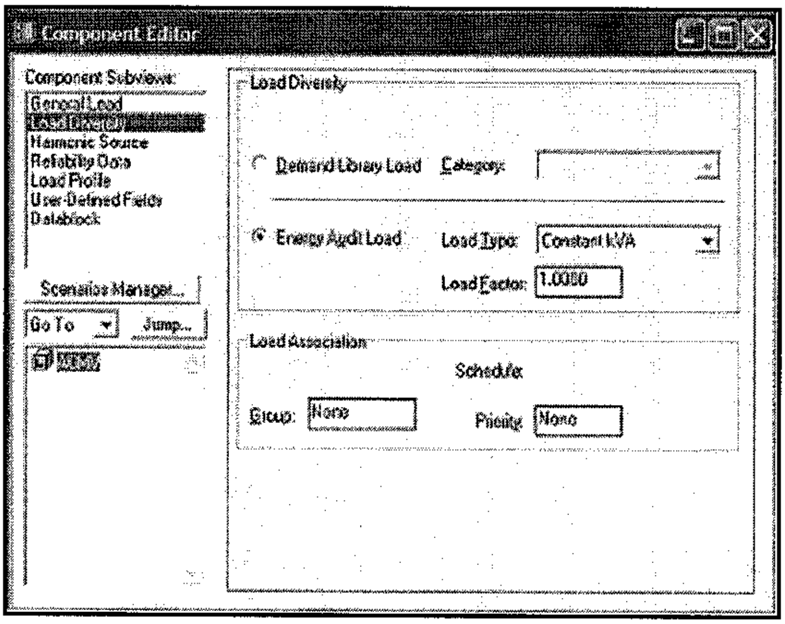

Figure 24: Distribution Load Component Editor (Load Diversity)

3.3.7 Protective Devices

Protective devices are used for power flow control and safe maintenance purposes. Numbers of protective devices available in industry but only Air Circuit Breakers (**Figure 25**), Vacuum Circuit Breakers (**Figure 26**), Capacitor Banks (**Figure 27**) and Bus-Ties (**Figure 28**) are used in this project. Pop-menu windows for component sub views as listed below will not be shown since all the data need not to be entered as it is automatically calculated by SKM® Power Tools [4]: -

- Settings
- Reliability Data
- User-Defined Fields
- Datablock

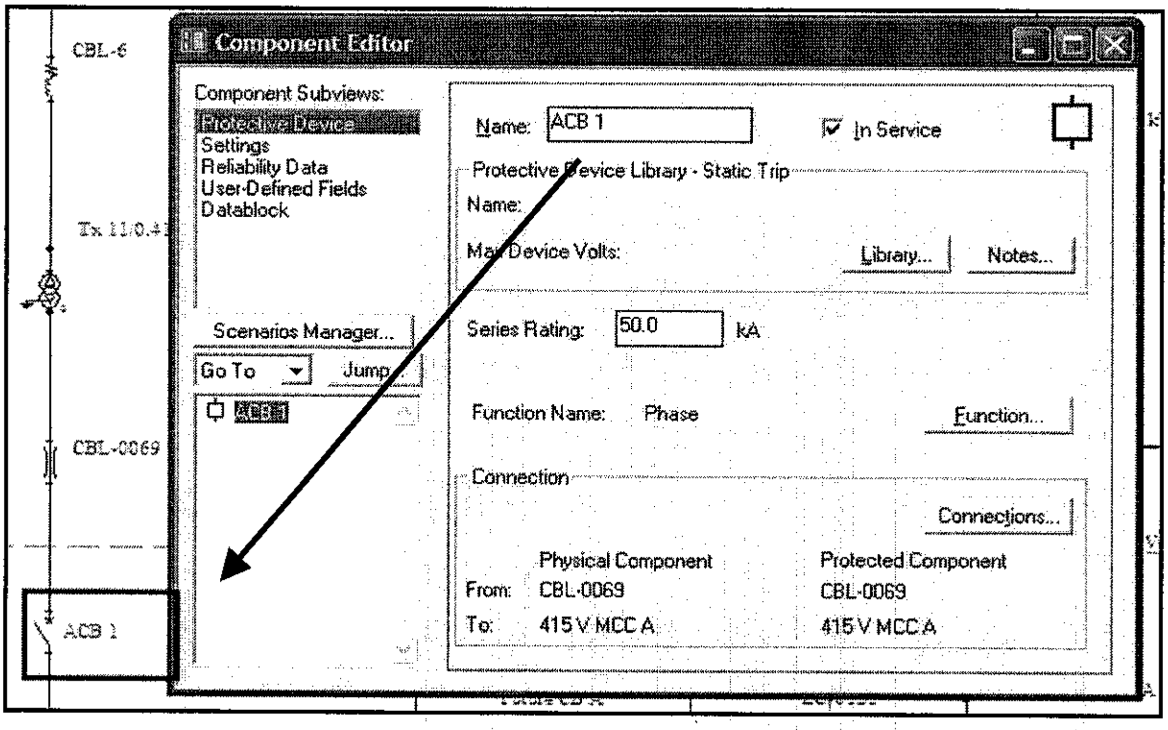

Figure 25: Air Circuit Breaker Component Editor (Protective Device)

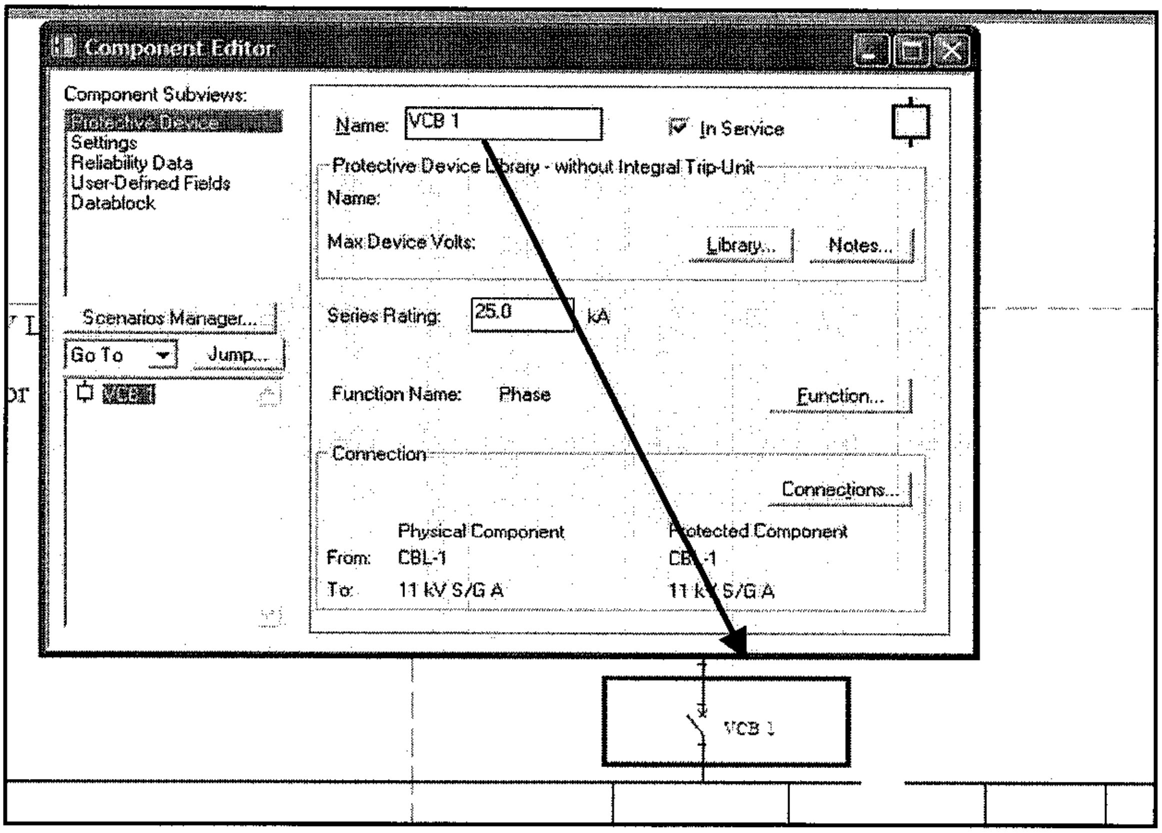

Figure 26: Vacuum Circuit Breaker Component Editor (Protective Device)

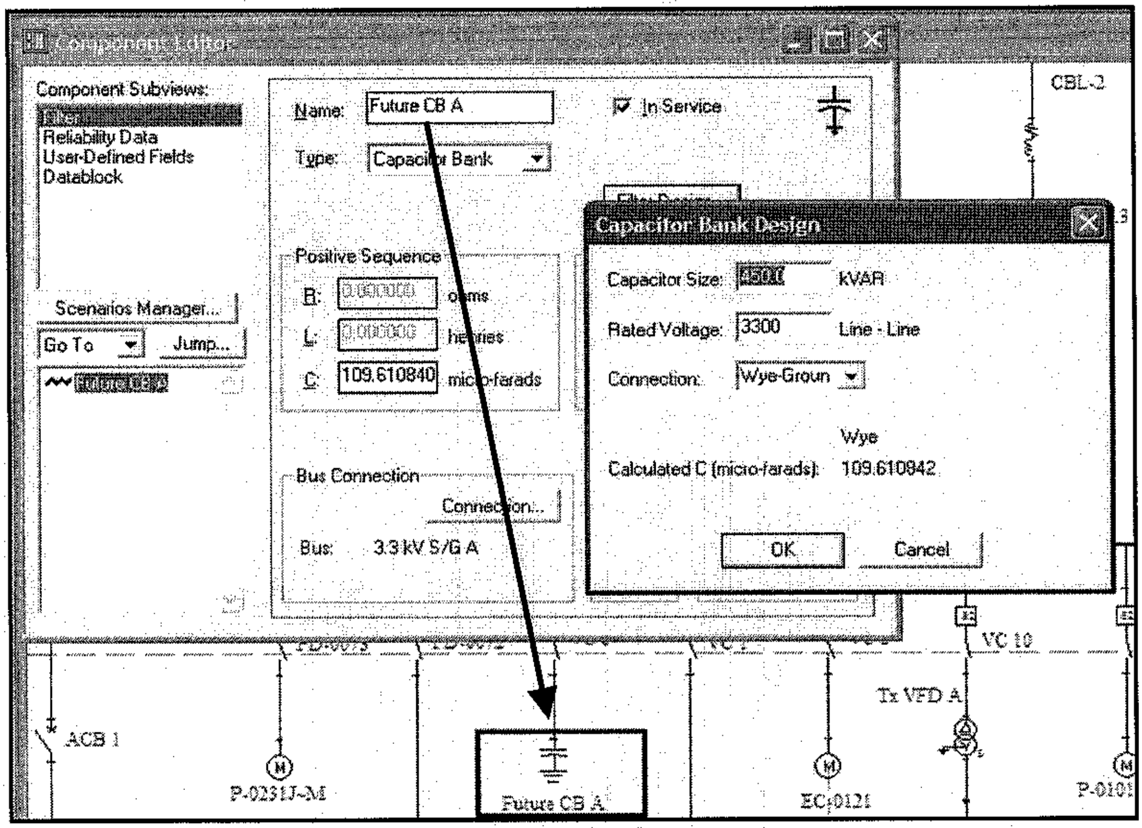

Figure 27: Capacitor Bank Component Editor (Protective Device)

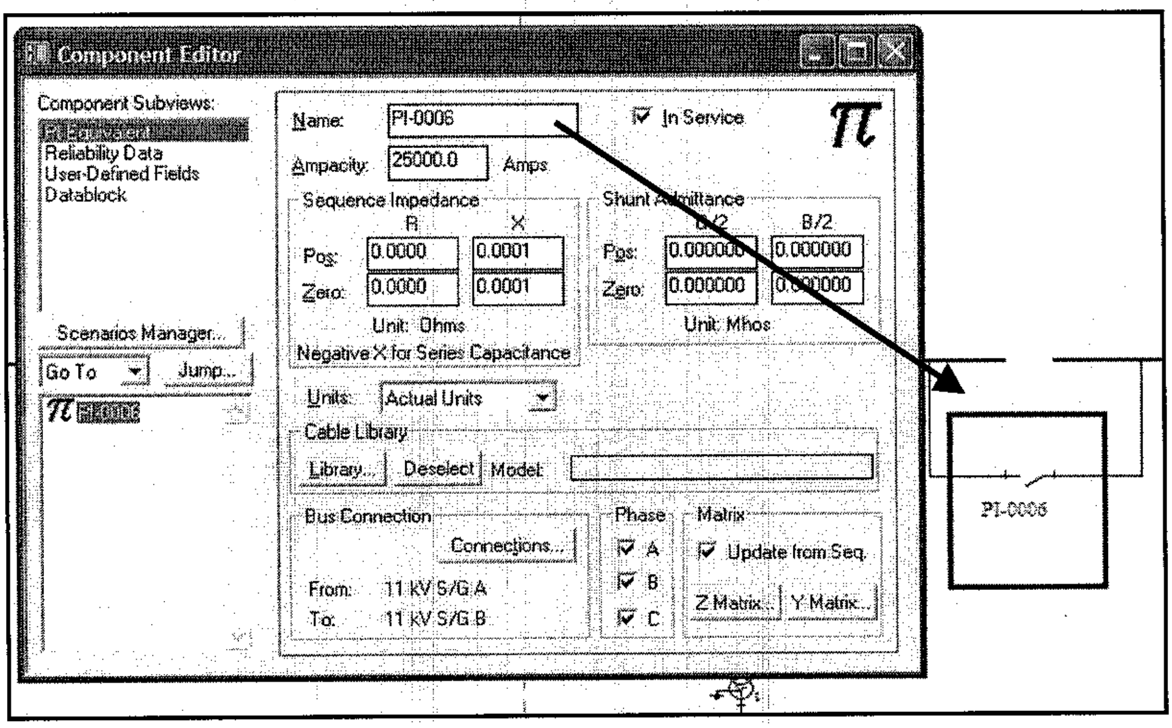

Figure 28: Bus-tie Component Editor

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Electrical Equipment Sizing

Charles A.Gross (1979) wrote that attempts to model mathematically the electrical power system for analysis is heavily dependent on circuit concepts [1]. Crucial information such as transformer rating, distribution cable impedance, generator rating is important before designing the single line diagram in SKM® Power Tools [4].

4.1.1 Transformer Sizing

Table 2: Calculation Results for Transformers

Design	Rated kV	Phase 1 (kVA) A	Phase 2+3+4 (kVA) B	Maximum Demand Load (kVA) C=A+B	Size (kVA) D=1.25C	Standard Rated (MVA)
Basic Engineering	11 / 0.415	1253	Future Stage	1253	1563.3	1.6
	11 / 3.3	1836.2	2328.2	4164.4	5205.5	6.0
Detail Engineering (Without power factor correction)	11 / 0.415	1719	Future Stage	1719	2148.7	2.2
	11 / 3.3	3082	2464	5547	6933	6.95
Detail Engineering (With power factor correction)	11 / 0.415	1414	Future Stage	1414	1768	1.77
	11 / 3.3	2646	2412	5058	6323	6.325

Transformer kVA size = Maximum demand load on the transformer + 5% losses + 20% spare capacity

From the table, it is shown that two 11 / 3.3kV transformers at rated size of 6MVA and two 11 / 0.415kV transformers at rated size of 1.6MVA are used for basic engineering design. Detail engineering design is encompassed of two 11 / 3.3kV transformers at rated size of 6.325MVA and two 11 / 0.415kV transformers at rated size of 1.77MVA since the main focus and interest is on detail engineering design with power factor correction.

4.1.2 Cable Rating and Sizing

The current carrying capacity is based on the assumption that the ambient temperature is at 40°C. The cable arrangement diagrams are as shown in **APPENDIX 4.**

- Sample calculation in determining sizes for high voltage (3.3kV) cables: -

a) Cable ampacity

Cable ampacity derating is taken from the IEE Wiring Regulation book. Cable ampacity shall be bigger than the motor rated current. In this case, for highest rated pump of 280kW, the rated current after diversity (100%) is 61A.

For example:

The running current of Secondary Chilled Water Pump, P-0101 shall be as follows:-

= (Rated motor) / (3 ^{½} *voltage*power factor*efficiency) ---------------------- Equation 11

= (280*1000) / (3 ^{½} *3300*0.84*0.955) = 61 Ampere

Therefore, cable used shall have ampacity greater than 61A. The cable size to be used can be as small as 25 sq mm as shown in Table 2 for 3-core cables in **APPENDIX 5.**

b) Fault level at load terminals

Cables used shall have short circuit (SC) withstand capacity greater than short circuit level at cable terminal point.

However it is safe to use a cable having SC withstand capacity smaller than SC at cable terminal as long as its SC withstand capacity is greater than let through energy of fuse. SC withstand capacity of 25mm^2 cable for 0.2 sec = 8.5kA as shown in **APPENDIX 6**.

Therefore, SC withstands energy shall be as follows:-

= I^2t -- Equation 12

= $(8.5*10^3)^2$A*0.2sec = $1.45*10^7$ A sec

c) *Fuse selection:*

This is done by referring to fuse selection curves graph for motor starting as shown in **APPENDIX 7**. Selection of rated current of the fuse relies on 3 criteria, which are:

- I_A = motor starting current
- N_h = number of motor starts per hour
- T_A = maximum starting starting time

  In our case:

- I_A = 61A x 6 = 366A (Actual vendor data = 400A)
- N_h = 6
- T_A = 5s (typical values for DOL started motors)

From the graph, for which the motor run-up times not exceeding 6 seconds, the fuse rating is 160 A. The maximum let through energy of fuse rating 160A is 50x10^4. Let through energy of the fuse (50x10^4 sec) must be less than cable SC withstand capacity (1.45x10^7 A sec) and SC at cable terminal (13.2kA or 1.32x10^4). Ratio is as follows:-

= (Let through energy of fuse) / (Cable S.C. withstand capacity)*100% -Equation 13

= (50x10^4 A^2 sec) / (1.45x10^7 A^2 sec) * 100%

= 3.45%

The ratio implies that the cable SC withstand capacity is 1/0.0345 or 29 times bigger than the maximum let through energy of the 160A fuse. So, the 25mm^2 cable is well protected by the 160A fuse. Full result of proposed cables sizes can be referred to **APPENDIX 8.**

4.2 SKM® Power Tools Report

The pop up menu window that show the studies that need to be run is shown below: -

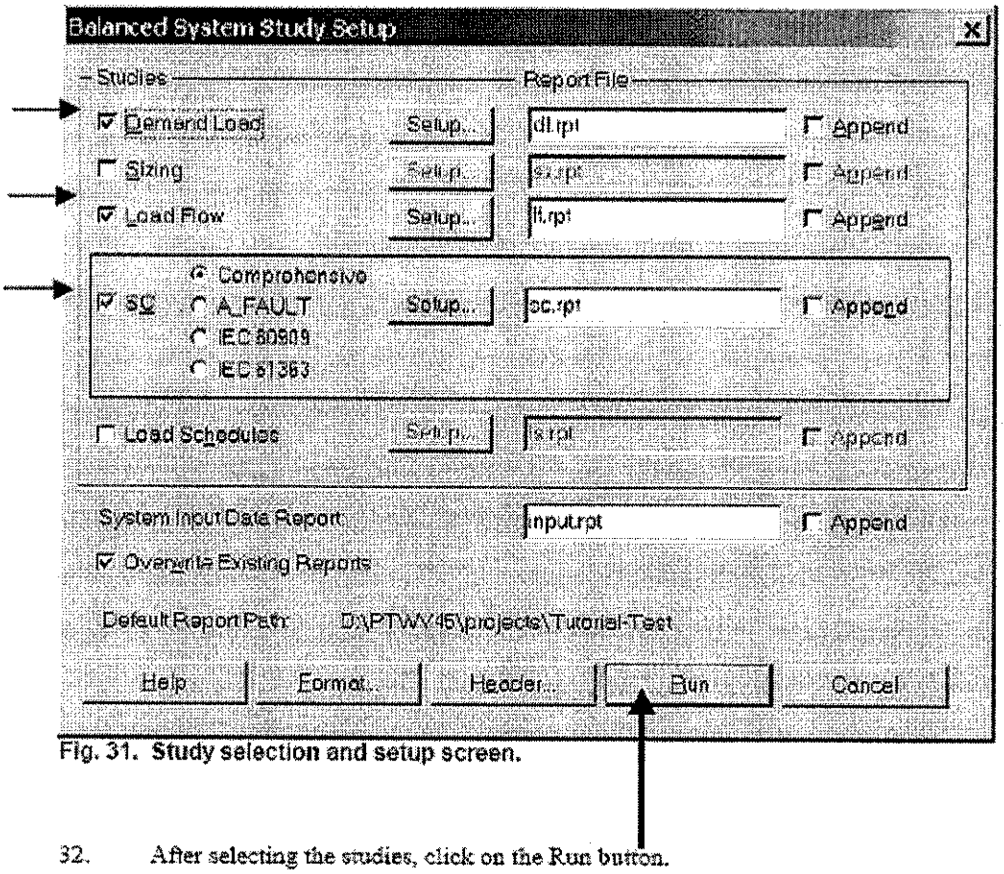

Figure 29: Study Selection and Setup Screen

Comprehensive short circuit study will calculate the initial symmetrical and asymmetrical short circuit current given the fault location R/X ratios at various times during the onset of the fault as shown in **APPENDIX 9** based on basic engineering design drawing and **APPENDIX 10** based on detail engineering design drawing. Both results are in crystal report format. Load flow study indicates the apparent power and current at each buses and within each branches in the electrical power system, excluding local generation and power lost through impedance devices. Load flow study results in crystal report format are as shown in **APPENDIX 11** based on basic engineering design drawing and **APPENDIX 12** based on detail engineering design drawing.

4.3 Data Comparison

To attain maximum power consumption at various switchgear buses, the worst but practical operational configuration is considered for this study. According to the consideration:-

- Only one out of two TNB supply is on and supplying all loads to the plant
- Both transformers at each voltage level is supplying power to the entire switchgear
- Bus tie breakers of all switchgear are opened

To get maximum short circuit current at various switchgear buses, the worst but practical operational configuration is considered for this study. According to that consideration,

- Only one out of two TNB supply is on and supplying all loads to the plant
- Only one out of two transformers at each voltage level is supplying power to the entire switchgear
- Bus tie breakers of all switchgear are closed
- All motor and non-motor loads are running

The study settings specified for both simulation analyses are as follows: -

Table 3: Parameter Settings for Both Simulation Analyses

Short Circuit Study	**Load Flow Study**
▪ 3-phase fault ▪ Single-line-to-ground fault ▪ Transformer tap and phase shift ▪ Faulted buses at all buses ▪ Initial symmetrical RMS with ½ cycle asymmetrical ▪ Asymmetrical fault current at time 0.5s	• Newton-Raphson solution method • Connected load specification • Source impedance is included • Generation acceleration factor is 1.00 • Load acceleration factor is 1.00 • Bus voltage drop is 5.00% • Branch voltage drop is 3.00%

From the simulation results obtained in SKM® Power Tools [4], the below data for both designs is extracted, compared and summarized.

Table 4: Data Comparison for Fault Contribution Report

Data	Location	Basic Engineering Design	Detail Engineering Design
Initial symmetrical amps-3Phase	11kV Switchboard A	17313 A	15819 A
	11kV Switchboard B	-	15818 A
	3.3kV Bus 1	17613 A	20055 A
	3.3kV Bus 2	-	20041 A
	415V Bus 1	43782 A	42578 A
	415V Bus 2	0 A	42064 A
Asymmetrical amps-3Phase	11kV Switchboard A	27641 A	15819 A
	11kV Switchboard B	-	15818 A
	3.3kV Bus 1	28446 A	24571 A
	3.3kV Bus 2	-	24559 A
	415V Bus 1	52188 A	52793 A
	415V Bus 2	0 A	52335 A
Initial symmetrical amps-Single Line to Ground (SLG)	11kV Switchboard A	0 A	0 A
	11kV Switchboard B	-	0 A
	3.3kV Bus 1	17560 A	16559 A
	3.3kV Bus 2	-	16548 A
	415V Bus 1	41133 A	38730 A
	415V Bus 2	0 A	38252 A
Asymmetrical amps-Single Line to Ground (SLG)	11kV Switchboard A	0 A	0 A
	11kV Switchboard B	-	0 A
	3.3kV Bus 1	28940 A	23001 A
	3.3kV Bus 2	-	22990 A
	415V Bus 1	47984 A	48937 A
	415V Bus 2	0 A	48490 A

Table 5: Data Comparison for Load Flow Summary Report

Data	**Basic Engineering Design**		**Detail Engineering Design**	
TNB Source				
Per Unit Voltage	1.00		1.00	
Angle	0.00°		0.00°	
Active Power	4451.0kW		6102.3kW	
Reactive Power	3459.6kVAR		1681.0kVAR	
Voltage Drop	1.21%		2.14%	
Utility Impedance	0.01+j0.33		0.33+j0.01	
	Busbar A or Busbar 1	**Busbar B or Busbar 2**	**Busbar A or Busbar 1**	**Busbar B or Busbar 2**
11kV Switchboard				
Busbar				
Voltage Drop	1.21%	-	2.14%	2.14%
Equivalent to Bus Voltage	10866V	-	10764V	10764V
Angle Degree	-0.82°	-	0.26°	0.26°
PU Volts	0.99	-	0.98	0.98
Incoming Feeder to Bus				
Active Load	4451.0kW	-	6102.3kW	-
Reactive Load	3459.6kVAR	-	1681.0kVAR	-
Power Factor	0.79	-	0.964	-
Load Flow Current	263 A	-	339.21 A	-
Outgoing Feeder from Bus				
Active Load	4450.6kW	-	6097.9kW	-
Reactive Load	3459.3kVAR	-	1667.5kVAR	-
Power Factor	0.79	-	0.96	-
Load Flow Current	299.50 A	-	339.21 A	-

Losses for 11kV Bus	*0.4kW+0.3kVAR	-	*4.4kW+13.5kVAR	-
	Busbar A or Busbar 1	**Busbar B or Busbar 2**	**Busbar A or Busbar 1**	**Busbar B or Busbar 2**
3.3kV Switchboard				
Busbar				
Voltage Drop	2.47%	2.68%	-1.21%	-1.55%
Equivalent to Bus Voltage	3218V	3211V	3340V	3351V
Angle Degree	-31.78°	-31.93°	-1.68°	-1.14°
PU Volts	0.98	0.97	1.01	1.02
Power Factor Correction	N/A	N/A	900kVAR	750kVAR
Incoming Feeder to 11/3.3kV Transformer				
Active Load	1601.6kW	1862.8kW	2718.5kW	1973.1kW
Reactive Load	1243.4kVAR	1454.3kVAR	882.7kVAR	604.5kVAR
Power Factor	0.79	0.79	0.95	0.95
Load Flow Current	107.73 A	125.57 A	153.3 A	110.68 A
Outgoing Feeder from 11/3.3kV Transformer				
Active Load	1601.6kW	1862.8kW	2718.1kW	1972.8kW
Reactive Load	1201.2kVAR	1397.1kVAR	782.1kVAR	552.0kVAR
Power Factor	0.79	0.79	0.96	0.96
Load Flow Current	359.10 A	418.55 A	488.8 A	352.89 A
Losses for 3.3kV Bus	*0kW+42.2kVAR	*0kW+57.2kVAR	*0.4kW+100.6kVAR	*0.3kW+52.5kVAR
	Busbar A or Busbar 1	**Busbar B or Busbar 2**	**Busbar A or Busbar 1**	**Busbar B or Busbar 2**

415V Switchboard				
Busbar				
Voltage Drop	3.17%	3.17%	-1.41%	-1.05%
Equivalent to Bus Voltage	402V	402V	421V	419V
Angle Degree	-31.63°	-31.63°	-0.97°	-1.83°
PU Volts	0.97	0.97	1.01	1.01
Power Factor Correction	N/A	N/A	250kVAR	450kVAR
Incoming Feeder to 11/0.415kV Transformer				
Active Load	493.1kW	493.1kW	524.8kW	881.5kW
Reactive Load	380.8kVAR	380.8kVAR	77.9kVAR	112.4kVAR
Power Factor	0.79	0.79	0.99	0.99
Load Flow Current	33.10 A	33.10 A	28.46 A	47.66 A
Outgoing Feeder from 11/0.415kV Transformer				
Active Load	493.1kW	493.1kW	524.8kW	881.4kW
Reactive Load	368.9kVAR	368.9kVAR	66.8kVAR	81.5kVAR
Power Factor	0.79	0.79	0.99	0.99
Load Flow Current	877.43 A	877.43 A	722.94 A	1210.78 A
Losses for 415V Bus	*0kW+11.9kVAR	*0kW+11.9kVAR	*0kW+11.1kVAR	*0.1kW+30.9kVAR

*Note: Losses = Incoming values – Outgoing values

4.4 SKM® Power Tools Simulation Studies Diagram

Diesel engine generator in this GDC plant is only functional to cater essential loads for building services, which involves small amount of load. For simplicity in simulation, the emergency standby switchboard will not be drawn in the power system model for both designs since its absence will not affect the study result.

4.4.1 Comprehensive Short Circuit Study Simulation Diagram

Comprehensive short circuit study simulation diagrams that indicate branch and bus fault current for basic and detail engineering design are as shown in **APPENDIX 13** and **APPENDIX 14** respectively. The voltage drops are very minimal for high voltage cables and not a dominant factor in cable sizing for the higher voltages. However, the thermal capacity of the cables against short-circuit fault has to be verified by use of the heat equation:

$$I^2t = S^2k^2$$

Where S – nominal cross-sectional area of the conductor (sq.mm)

I – fault current that can flow through the cable (A)

T– opening time of protective breakers associated with the cable (S) including that for fuse rupturing (maximum fuse operating time)

K– factor, which takes into account the resistivity, temperature coefficient and heat capacity of the conductor material, and the appropriate initial and final temperatures

Full thermal capacity of cables are normally evaluated for t at1.0 second (circuit breaker operation normally within 1 second for back-up circuit breakers). As the cables selected are mainly of XLPE insulated type, over copper conductor material, the corresponding k value is 143 (assuming initial temperature 90°C and final temperature 250°C). For 3.3kV cables feeding large 3.3kV motors or 3.3/0.433kV inverter transformers, the thermal capacity is normally evaluated for at 0.2 second as these cables are protected by high votage fuses which have current or fault limitation capabilities.

4.4.2 Load Flow Study Simulation Diagram

A load flow study will be carried out based on the present estimated loads to check the following: -

- The voltages on the 3.3kV and 415V bus are within their limits
- The proper tapping set range for the step down transformers
- The quantum of capacitor banks required to maintain the power factor at the (temporary) TNB 11kV supply point (Point of Common Coupling-PCC)

Load flow study under full load conditions is based on three criteria: -

a) Basic engineering design without any power factor correction capacitor banks shown in **APPENDIX 15**

b) Detail engineering design with the adequate amount of capacitor banks to correct the power factor (PF) at the TNB 11kV incomer to 0.93 PF lagging shown in **APPENDIX 16**

The load flow study is focused more on detail engineering design as it involves capacitor bank and it may be seen that the power factor correction required is as follows: -

a) At 3.3 kV = 1650kVAR (for all phases)

b) At 415 V = 700kVAR (for Phase 1 only)

Total capacitor banks to be added at 3.3kV and 415V are 2350kVAR, so that the TNB 11kV incomer power factor is more than 0.93. Any shortfall below 0.85 will incur penalty charges from TNB. Hence, for economic operation, the power factor level of the GDC plant must be continuously monitored and regulated to be above 0.93 power factor lagging. By definition, power factor, cos θ where θ is the phase angle between the voltage vector and the current vector. For a lagging power factor, the current is 'lagging' behind the voltage by a phase angle of θ. An equivalent definition for power factor is the cosine of the phase angle between the real power flow P and the apparent power flow S as shown in **Figure 30**.

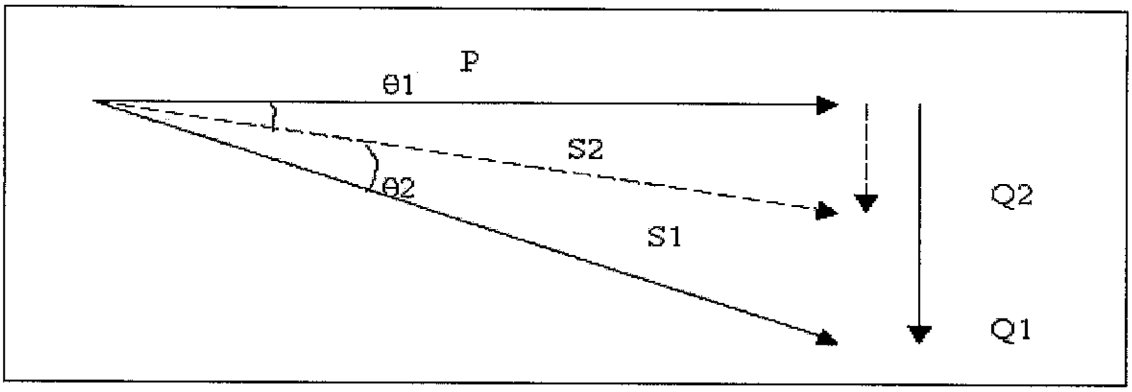

Figure 30: Voltage Drop

Before capacitive compensation, cos θ is equal to P/S1.

To improve the power factor cos θ1, the angle θ1 must be reduced to θ2. As real power P is fixed, apparent power S1 must be reduced to S2 such that cos θ2 is equal to P divided by S2, bigger than 0.93.

The load-flow analysis involves calculation of power flows and voltages of a transmission network for specified terminal or bus conditions. Associated with each bus are four quantities; active power P, reactive power Q, voltage magnitude V and voltage angle, θ. The following types of buses (nodes) are represented and at each bus two of the above four quantities are specified:-

- *Voltage-controlled (PV) bus*: Active power, voltage magnitude and limits to the reactive power are specified depending on the characteristics of the devices.
- *Load (PQ) bus*: Active and reactive power are specified. Normally loads are assumed to have constant power. If the effect of distribution transformer operation is neglected, load P and Q are assumed to vary as a function of bus voltage.
- *Device bus*: Special boundary conditions associated with devices are recognized.
- *Slack (swing) bus*: Voltage magnitude and phase angle are specified. One bus must have unspecified P and Q because the power losses in the system are not known a priori.

Overall single line diagrams for basic, detail and construction engineering design are shown in **APPENDIX 17.** GDC Plant Layout is shown in **APPENDIX 18** as reference.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

- **Short Circuit Analysis**

The three-phase symmetrical rms fault current (balanced circuit) is often considered the maximum fault current and the most severe type occurred at the bus [4]. The selection short circuit rating of each bus shall be from the next available rating of bus bar obtained from manufacturer's standard based on initial symmetrical three-phase fault. The asymmetrical peak current is the sum of the dc decay and ac decrement components produced by a sudden application of a sinusoidal voltage source on resistors, capacitors and inductors.

After analyzing the study results, short circuit ratings of various switchboards for reliability of the design are recommended as follows:

- 11kV switchgear & accessories shall be suitable for 25kA for 3 sec
- 3.3kV switchgear & accessories shall be suitable for 25kA for 1 sec
- 0.415kV switchgear for phase 1 shall be suitable for 50kA for 1 sec

The results are verified by comparing the above to contractor's electrical equipment selection drawing. The magnitudes of fault currents are usually important parameters and help system engineers in determining the type of protective devices to be used to isolate the fault at a given location safely with minimum damage to circuits and equipment and also a minimum amount of shutdown of plant operation. Cables thermal withstand capabilities during short circuit are also checked.

- **Load Flow Analysis**

The lesser the power factor than unity the larger will the apparent power be than real power. It can be concluded from **Table 5** that the power system is efficient and well performed since the line losses for each buses are considered small. These losses are the difference between the kW and kVAR flowing into the bus from another bus and the value that reaches the bus. Prior to the analysis, the magnitude of all the voltages is set to be one per unit. Subsequently, the network elements such as lines or cables, switchboard buses, circuit breakers and transformers have been verified against manufacturer's data for adequate capacity to carry the loads.

Voltage drops over the transformers and lines are found to be insignificant and well within the limit of 5% and -10%. The transformer tap setting is set at 0% for each transformer. Power factor improvement in the system is considered to maintain the TNB power factor at 11kV to be more than 0.93 power factor lagging. Capacitor banks are required to be added at 3.3kV and 415V to maintain this power factor. Power factor improvement in the system required is as follows: -

a) At 3.3 kV = 1650kVAR (for all phases)
b) At 415 V = 700kVAR (for Phase 1 only)

Total capacitor banks to be added at 3.3kV and 415V are 2350kVAR, so that the TNB 11kV incomer power factor is more than 0.93 power factor.

- **Data Comparison Analysis**

Based on the short circuit report in **Table 4,** most of the fault currents have increased in Detail Engineering Design compared to Basic Engineering Design due to the additional equipment as noted below. This concept is also applied to the load flow currents at every bus namely 11kV bus, 3.3kV buses and 415V buses as shown in **Table 5**. Real, reactive and apparent power at every bus is larger in Detail Engineering Design rather than Basic Engineering Design due to bigger power consumption.

Additional equipment in detail engineering design includes:-

- Additional busbar and pie equivalent bus-tie added to each existing busbar
- Protective devices which includes vacuum circuit breaker, air circuit breaker and fuses
- Additional motors
- 3.3/0.415kV transformer
- Capacitor bank

- **Power System Utilisation**

This project is carried out in several phases namely collection of data, calculation of short circuit currents and load flow, development of mathematical model of each component in the power system, and finally implementation and simulation of model on simulation tool SKM® Power Tools [4]. Based on the model developed, system behaviour and response to any disturbance in real-time operation should be able to be predicted.

- **Case Study on GDC Putrajaya Precinct 5 Plant**

In order to enhance the knowledge on electrical power system, a real application is taken into study for further analysis. The GDC power plant of Putrajaya Precinct 5 has adopted this scheme into implementation. A case study helps in widening the knowledge not only in theory but also for real application in power plant such as GDC Plant. Dynamic studies shall be used to verify the electrical power system. In this project, the dynamic studies are conducted via computer-analysis simulation. SKM® Power Tools [4] is the software used to demonstrate the power system network. A circuit is constructed using components that are available from the software library. Using this circuit, a number of conditions are set and the results of the simulations are analyzed. From the start, there are several stages that need to be completed from the collection of data, calculation until the development of the model. From the model, the author can simulate the behaviour of the system. The accuracy of the simulation depends on the type of parameter entered to the input file.

5.2 Recommendation

Apart from demonstrating the short circuit and load flow analysis through computer simulations, one can develop a hardware prototype to represent the power system network. A microcontroller PIC can be used as the power system CPU where all data are processed and outputs are produced. Loss of generation can be demonstrated by connecting a voltage regulator to the system and the voltage is varies from it. Fault can easily be done by short-circuiting the wire to ground by a push button or a toggle switch. This could make the project more interesting and easier to understand. Other software for example ERACS, PSCAD, MATLAB can be used to simulate the electrical power system. It is an advantage if the user has the basic knowledge not only in using the existing software but also the other electrical software.

Conducting a full protection study, which will include breaker ratings and relay setting using positive or zero sequence impedance network calculation and verifying the required setting using SKM® Power Tools [4] is also recommended. Circuit breaker ratings are determined by the fault MVA at their particular locations, not only has the circuit breaker to extinguish the fault-current arc, with the substation connections it has also to withstand the considerable forces up by short circuit currents which can be very high. License for other tools such as harmonic analysis, transient stability and others in SKM® Power Tools [4] should also be purchased by UTP. This is to ensure that any students who are interested in continuing this study for future phases, Phase 2, Phase 3 and Phase 4 can improvise the scopes of the project.

REFERENCES

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[2] G.Stagg, "*Computer Methods in Power System Analysis*", Mc Graw-Hill

[3] J.Storry,H.E.Brown, *"Improved Method of Incorporating Mutual "*, PICA Proc

[4] SKM® Power Tools, *"Electrical Engineering Software"*, **www.skm.com**

APPENDICES

- *Appendix 1*

Suggested Milestones

- *Appendix 2*

Overall Process Flow Diagram

- *Appendix 3*

Electrical Load Analysis for Basic and Detail Engineering Design

- *Appendix 4*

Grouping Derating Factor

- *Appendix 5*

Cables Reference Tables

- *Appendix 6*

Short Circuit Ratings

- *Appendix 7*

Fuse Link Type CMF

- *Appendix 8*

Proposed Cables Sizes

- *Appendix 9*

Crystal Report-Short Circuit Simulation for Basic Engineering Design

- *Appendix 10*

Crystal Report-Short Circuit Simulation for Detail Engineering Design

- *Appendix 11*

Crystal Report-Load Flow Simulation for Basic Engineering Design

- *Appendix 12*

Crystal Report-Load Flow Simulation for Detail Engineering Design

- *Appendix 13*

Simulation Diagram-Branch and Bus Fault Currents for Basic Engineering Design

- *Appendix 14*

Simulation Diagram-Branch and Bus Fault Currents for Detail Engineering Design

- *Appendix 15*

Simulation Diagram-Load Flow Study without Power Factor Correction for Basic Engineering Design

- *Appendix 16*

Simulation Diagram-Load Flow Study with Power Factor Correction for Detail Engineering Design

- *Appendix 17*

Single Line Diagrams for Basic, Detail and Construction Engineering Design

- *Appendix 18*

Putrajaya Precinct 5 Gas District Cooling Plant Layout

APPENDIX 1

Suggested Milestones

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

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Topic	■													
	-Propose topic														
	-Topic assigned to the student														
2	Logbook – Week 3		■	■											
	-Study on process requirement for GDC Plant														
	-Study on mechanical requirement for GDC Plant														
3	Submission of Logbook – Week 3				●										
4	Preliminary Research Work		■	■											
	-Introduction														
	-Objective														
	-List of references/literature														
	-Project planning														
5	Submission of Preliminary Report				●										
6	Logbook – Week 4				■										
	-Literature review on load flow study for the system														
	-Literature review on power flow for the system														
7	Submission of Logbook – Week 4					●									
8	Logbook – Week 5					■									
	-Electrical load analysis based on the real system														
	-Calculate maximum demand and peak load														
9	Submission of Logbook – Week 5						●								

10	Logbook – Week 6						■								
	-Design single line diagram														
	-Calculate sizing for all major equipments														
11	Submission of Logbook – Week 6							●							
12	Logbook – Week 7							■							
	-Calculate sizing for all cables														
13	Submission of Logbook – Week 7								●						
14	Submission of Progress Report								●						
15	Logbook – Week 8								■						
	-Literature review on short circuit														
16	Submission of Logbook – Week 8									●					
17	Logbook – Week 9									■					
	-Calculate short circuit for each bubsbar manually														
18	Submission of Logbook – Week 9										●				
19	Logbook – Week 10										■				
	-Calculate short circuit for each bubsbar manually														
	-Start doing software simulation														
20	Submission of Logbook – Week 10											●			
8	Oral Presentation & Interim Report Preparation									■	■				
9	Submission of Interim Report											●			

● Suggested milestone

■ Process

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

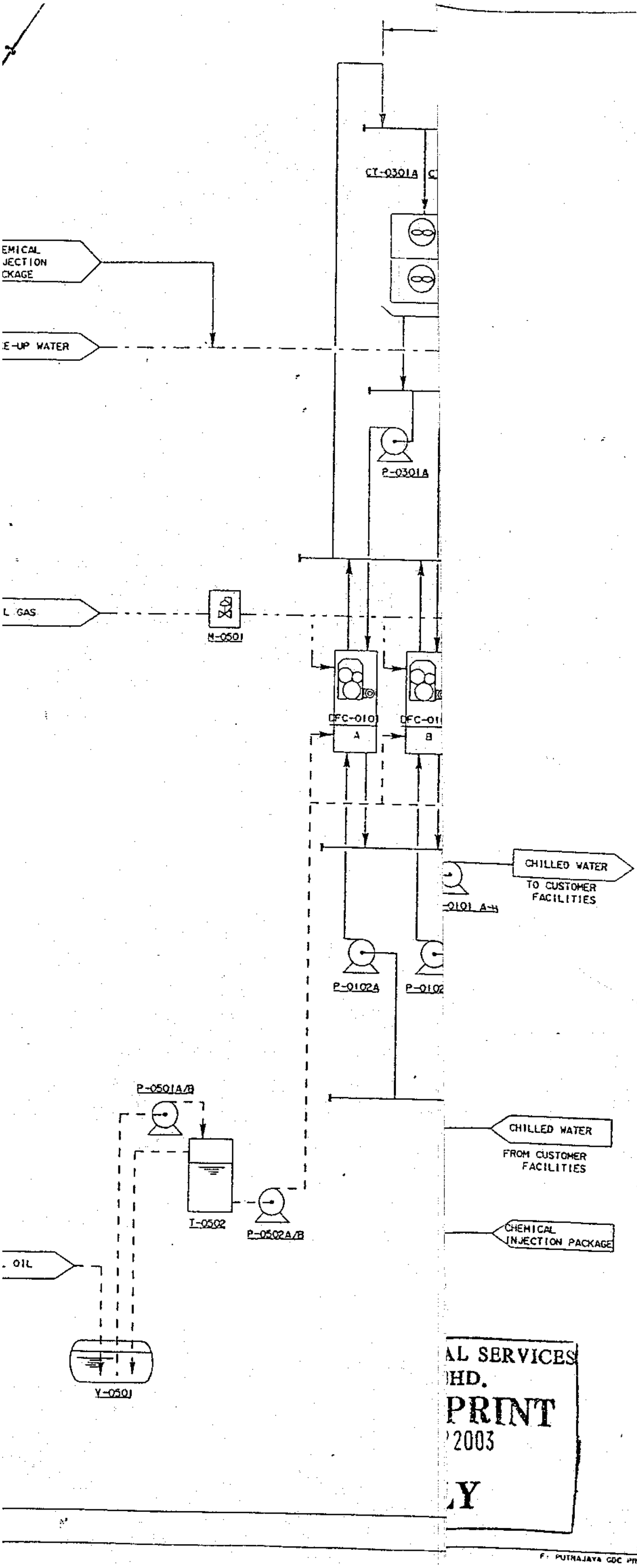
No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Logbook – Week 2		■												
	-Continue software simulation														
2	Submission of Logbook – Week 2			●											
3	Logbook – Week 3			■											
	-Continue software simulation														
	-Design SLD for detail design														
4	Submission of Logbook – Week 3				●										
5	Submission of Progress Report 1			●											
6	Logbook – Week 4				■										
	-Continue software simulation														
	-Comparing simulation result of basic and design														
7	Submission of Logbook – Week 4					●									
8	Logbook – Week 5					■									
	-Checking simulation results with manual calculation														
9	Submission of Logbook – Week 5						●								
10	Logbook – Week 6						■								
	-Checking simulation results with manual calculation														
	-Adjust any calculated values if required														
11	Submission of Logbook – Week 6							●							

12	Logbook – Week 7							■							
	-Checking simulation results with manual calculation														
	-Adjust any calculated values if required														
13	Submission of Logbook – Week 7								●						
14	Submission of Progress Report 2								●						
15	Logbook – Week 8								■						
	-Preparing thesis & oral presentation														
16	Submission of Logbook – Week 8									●					
17	Logbook – Week 9									■					
	-Preparing thesis & oral presentation														
18	Submission of Logbook – Week 9										●				
19	Project work continue										■	■	■		
	-Simulation Work														
19	Submission of Dissertation Final Draft												●		
20	Oral Presentation													●	
21	Submission of Project Dissertation														●

● Suggested milestone
■ Process

APPENDIX 2

Major Process Flow Diagram



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(Authorised Representative)	
For the Owner	Date

Rev. No	Description	Date
A	WORKING COPY	

Project Title :

PUTRAJAYA
PRECINCT 5
DISTRICT COOLING PLANT PROJECT

Drawing Title :

OVERALL PROCESS
FLOW DIAGRAM

Scale :	NTS	CadFile :	
Designed :		Checked :	
Drawn :	HAZ	Checked :	
Approved :		Date :	08.09.03

Drawing Number :	Revision
PJP5-PR2-01-0001	A

F: PUTRAJAYA GDC PROJECT/PRECINCT 5/PROCESS/...

APPENDIX 3

Electrical Load Analysis for Basic and Detail Engineering Design

LOAD LIST FOR 3.3 kV SWITCHGEAR

EQUIP. TAG NO.	DESCRIPTION	QUANTITY				CONDITION			KIND OF MCC GROUP	MOTOR SPECIFICATION						CONTINUOUS			INTERMITTENT			STAND-BY			REMARK
		1st STAGE	2nd STAGE	3rd STAGE	4th STAGE	Continuous	Intermittent	Stand-by		KIND OF MOTOR	MOTOR RATING (kW)	LOAD FACTOR	EFFI.	P.F	MOTOR LOAD (kW)	TOTAL LOAD (kW)	kVAR	kVA	TOTAL LOAD (kW)	kVAR	kVA	TOTAL LOAD (kW)	kVAR	kVA	
P-0201 A-F	COOLING WATER PUMP FOR DFC	6				5	1		A	IM	160	0.800	0.931	0.830	137.5	687.4	462.0	828.2	137.5	92.4	165.6	0.0	0.0	0.0	Load Is Confirmed
P-0101 A-D	CUSTOMER TRANSFERING PUMP (SECONDARY PUMP)	4				3	1		A	IM	250	0.800	0.938	0.846	213.2	639.7	403.1	756.1	213.2	134.4	252.0	0.0	0.0	0.0	Load Is Confirmed
	Phase 1 GRAND TOTAL	10	0	0	0	8	2									1327.1	865.1	1584.3	350.7	226.8	417.7	0.0	0.0	0.0	

EQUIP. TAG NO.	DESCRIPTION	QUANTITY				CONDITION			KIND OF MCC GROUP	MOTOR SPECIFICATION						CONTINUOUS			INTERMITTENT			STAND-BY			REMARK
		1st STAGE	2nd STAGE	3rd STAGE	4th STAGE	Continuous	Intermittent	Stand-by		KIND OF MOTOR	MOTOR RATING (kW)	LOAD FACTOR	EFFI.	P.F	MOTOR LOAD (kW)	TOTAL LOAD (kW)	kVAR	kVA	TOTAL LOAD (kW)	kVAR	kVA	TOTAL LOAD (kW)	kVAR	kVA	
P-0201 G-N	COOLING WATER PUMP FOR DFC		3	3	2	8			B	IM	160	0.800	0.931	0.830	137.5	1099.9	739.1	1325.2	0.0	0.0	0.0	0.0	0.0	0.0	Load Is Confirmed
P-0101 E-H	CUSTOMER TRANSFERING PUMP (SECONDARY PUMP)		2	1	1	4			B	IM	250	0.800	0.938	0.846	213.2	852.9	537.6	1008.1	0.0	0.0	0.0	0.0	0.0	0.0	Load Is Confirmed
	Phase 2 to Phase 4 GRAND TOTAL	0	5	4	3	12	0									1952.8	1276.7	2333.3	0.0	0.0	0.0	0.0	0.0	0.0	

LOAD LIST FOR 415V SWITCHGEAR

EQUIP. TAG NO.	DESCRIPTION	Q'TY 1st STAGE	Q'TY 2nd STAGE	Q'TY 3rd STAGE	Q'TY 4th STAGE	CONDITION Continuous	CONDITION Intermittent	CONDITION Stand-by	KIND OF MCC GROUP	KIND OF MOTOR	MOTOR SPECIFICATION MOTOR RATING (kW)	MOTOR SPECIFICATION LOAD FACTOR	MOTOR SPECIFICATION EFFI.	MOTOR SPECIFICATION P.F	MOTOR SPECIFICATION MOTOR LOAD (kW)	CONTINUOUS TOTAL LOAD (kW)	CONTINUOUS kVAR	CONTINUOUS kVA	INTERMITTENT TOTAL LOAD (kW)	INTERMITTENT kVAR	INTERMITTENT kVA	STAND-BY TOTAL LOAD (kW)	STAND-BY kVAR	STAND-BY kVA	REMARK
A) COOLING WATER SYSTEM																									
CT-0201 A-L	COOLING TOWER (FANS X 2NOS)	12				10	2		A	IM	30	0.800	0.926	0.869	25.92	259.2	147.8	298.3	51.8	29.5	59.7				Load is Confirmed
P-0301 A,B	MAKE-UP WATER PUMP FOR COOLING WATER	2				1	1		A	IM	11	0.800	0.906	0.786	9.71	9.7	7.6	12.4	9.7	7.6	12.4				Load is Confirmed
B) CHILLED WATER SYSTEM																									
P-0302 A,B	MAKE-UP WATER PUMP FOR CHILLED WATER	1				1	0		A	IM	0.55	0.800	0.748	0.671	0.59	0.6	0.7	0.9	0.0	0.0	0.0				Load is Confirmed
P-0103 A,B	SIDE STREAM FILTER PUMP	1				1	0		A	IM	3.7	0.800	0.857	0.809	3.45	3.5	2.5	4.3	0.0	0.0	0.0				Load is Confirmed
DFC-0101 A-F	DIRECT FIRED CHILLER / No.1 Absorbent pump	6				5	1		A	IM	7.5	0.800	0.882	0.789	6.80	34.0	26.5	43.1	6.8	5.3	8.6				Load is Confirmed
	/ No.2 Absorbent pump	6				5	1		A	IM	3.7	0.800	0.857	0.809	3.45	17.3	12.5	21.3	3.5	2.5	4.3				Load is Confirmed
	/ Refrigerant pump	6				5	1		A	IM	0.4	0.800	0.723	0.664	0.44	2.2	2.5	3.3	0.4	0.5	0.7				Load is Confirmed
	/ Purge pump	6				5	1		A	IM	0.75	0.800	0.748	0.671	0.80	4.0	4.4	6.0	0.8	0.9	1.2				Load is Confirmed
	/ burner blower	6				5	1		A	IM	15	0.800	0.915	0.795	13.11	65.6	50.0	82.5	13.1	10.0	16.5				Load is Confirmed
P-0102 A-F	CHILLED WATER PUMP FOR DFC (PRIMARY)	6				5	1		A	IM	90	0.800	0.936	0.861	76.92	384.6	227.2	446.7	76.9	45.4	89.3				Load is Confirmed
C) FUEL SYSTEM																									
P-0401 A,B	DIESEL TRANSFER PUMP	2				1	1		A	IM	0.55	0.800	0.748	0.671	0.59	0.6	0.7	0.9	0.6	0.7	0.9				Load is Confirmed
P-0402 A,B	OIL SUPPLY PUMP FOR DFC	2				1	1		A	IM	0.75	0.800	0.748	0.671	0.80	0.8	0.9	1.2	0.8	0.9	1.2				Load is Confirmed
P-0403 A,B	OIL SUPPLY PUMP FOR GENERATOR	2				1	1		A	IM	0.75	0.800	0.748	0.671	0.80	0.8	0.9	1.2	0.8	0.9	1.2				Load is Confirmed
D) ADDITIONAL LOADS																									
	Building services	1				1					150	1.000	1.000	1.000	150.00	150.0	0.0	150.0	0.0	0.0	0.0				
	MOV	24				24				IM	0.3	0.800	0.723	0.664	0.33	8.0	9.0	12.0	0.0	0.0	0.0				
	UPS systems	1				1					80	1.000	1.000	1.000	80.00	80.0	0.0	80.0	0.0	0.0	0.0				
	CCS Distribution Board	1				1					27	1.000	1.000	1.000	27.00	27.0	0.0	27.0	0.0	0.0	0.0				
	Remote I/O Cabinet	2				2					3.5	1.000	1.000	1.000	3.50	7.0	0.0	7.0	0.0	0.0	0.0				
	Phase 1 GRAND TOTAL	87	0	0	0	75	12									1054.8	493.0	1198.0	165.3	104.2	195.9				

LOAD LIST FOR 415V SWITCHGEAR

EQUIP. TAG NO.	DESCRIPTION	Q'TY 1st STAGE	Q'TY 2nd STAGE	Q'TY 3rd STAGE	Q'TY 4th STAGE	CONDITION Continuous	CONDITION Intermittent	CONDITION Stand-by	KIND OF MCC GROUP	MOTOR SPECIFICATION KIND OF MOTOR	MOTOR RATING (kW)	LOAD FACTOR	EFFI.	P.F	MOTOR LOAD (kW)	CONTINUOUS TOTAL LOAD (kW)	CONTINUOUS kVAR	CONTINUOUS kVA	INTERMITTENT TOTAL LOAD (kW)	INTERMITTENT kVAR	INTERMITTENT kVA	STAND-BY TOTAL LOAD (kW)	STAND-BY kVAR	STAND-BY kVA	REMARK
A. COOLING WATER SYSTEM																									
CT-0201 M-AB	COOLING TOWER (FANS X 2NOS)		6	6	4	16			B	IM	30	0.800	0.926	0.869	25.92	414.7	236.1	477.2	0.0	0.0	0.0				Load is Confirmed
B. CHILLED WATER SYSTEM																									
P-0302 A,B	MAKE-UP WATER PUMP FOR CHILLED WATER		1			1			B	IM	0.55	0.800	0.748	0.671	0.59	0.6	0.7	0.9	0.0	0.0	0.0				Load is Confirmed
P-0103 A,B	SIDE STREAM FILTER PUMP		1			1			B	IM	3.7	0.800	0.857	0.809	3.45	3.5	2.5	4.3	0.0	0.0	0.0				Load is Confirmed
DFC-0101 G-N	DIRECT FIRED CHILLER / No.1 Absorbent pump		3	3	2	8			B	IM	7.5	0.800	0.882	0.789	6.80	54.4	42.4	69.0	0.0	0.0	0.0				Load is Confirmed
	/ No.2 Absorbent pump		3	3	2	8			B	IM	3.7	0.800	0.857	0.809	3.45	27.6	20.1	34.2	0.0	0.0	0.0				Load is Confirmed
	/ Refrigerant pump		3	3	2	8			B	IM	0.4	0.800	0.723	0.664	0.44	3.5	4.0	5.3	0.0	0.0	0.0				Load is Confirmed
	/ Purge pump		3	3	2	8			B	IM	0.75	0.800	0.748	0.671	0.80	6.4	7.1	9.6	0.0	0.0	0.0				Load is Confirmed
	/ burner blower		3	3	2	8			B	IM	15	0.800	0.915	0.795	13.11	104.9	80.1	132.0	0.0	0.0	0.0				Load is Confirmed
P-0102 G-N	CHILLED WATER PUMP FOR DFC (PRIMARY)		3	3	2	8			B	IM	90	0.800	0.936	0.861	76.92	615.4	363.5	714.7	0.0	0.0	0.0				Load is Confirmed
C. ADDITIONAL LOADS																									
	MOV		12	12	8	32				IM	0.3	0.800	0.723	0.664	0.33	10.6	12.0	16.0	0.0	0.0	0.0				
	Remote I/O Cabinet		1	1	1	3					3.5	1.000	1.000	1.000	3.50	10.5	0.0	10.5	0.0	0.0	0.0				
	Phase 2 to Phase 4 GRAND TOTAL	0	39	37	25	101	0									1252.2	768.4	1473.6	0.0	0.0	0.0				

1	TOTAL HV BOARD	3279.86	2141.75	3917.65	330.71	220.77	417.08	0.00	0.00	0.00

B) MAXIMUM LOAD

NO	DESCRIPTION	kW	kVAr	kVA
1	TOTAL CONTINUOUS LOAD	3279.86	2141.75	3917.22
2	30% OF TOTAL INTERMITTENT LOAD	105.21	68	125.29
3	LARGEST INTERMITTENT LOAD	213.22	134.38	252.03
	MAXIMUM LOAD (REFER NOTE 1)	3493.08	2276.13	4169.22

C) PEAK LOAD

NO	DESCRIPTION	kW	kVAr	kVA
1	MAXIMUM LOAD	3493.08	2276.13	4169.22
2	10% OF TOTAL STANDBY LOAD	0.00	0.00	0.00
3	LARGEST STANDBY LOAD	0.00	0.00	0.00
	PEAK LOAD (REFER NOTE 2)	3493.08	2276.13	4169.22

LV DB

A) SUMMARY

NO.	DESCRIPTION	Continuous			Intermittent			Standby		
		kW	kVAr	kVA	kW	kVAr	kVA	kW	kVAr	kVA
1	TOTAL LV BOARD	2306.95	1261.31	2629.25	165.28	104.22	195.39	0.00	0.00	0

B) MAXIMUM LOAD

NO	DESCRIPTION	kW	kVAr	kVA
1	TOTAL CONTINUOUS LOAD	2306.95	1261.31	2629.25
2	30% OF TOTAL INTERMITTENT LOAD	49.58	31.26	58.62
3	LARGEST INTERMITTENT LOAD	76.92	45.44	89.34
	MAXIMUM LOAD (REFER NOTE 1)	2383.88	1306.75	2718.54

C) PEAK LOAD

NO.	DESCRIPTION	kW	kVAr	kVA
1	MAXIMUM LOAD	2383.88	1306.75	2718.54
2	10% OF TOTAL STANDBY LOAD	0.00	0.00	0.00
3	LARGEST STANDBY LOAD	0.00	0.00	0.00
	PEAK LOAD (REFER NOTE 2)	2383.88	1306.75	2718.54

TOTAL LOAD TO CATER

Maximum Load 3.3KV + Maximum Load 415V = 5876.96 kW
6887.76 kVA

NOTES:

1. MAXIMUM LOAD = TOTAL CONTINUOUS LOAD + (30% OF INTERMITTENT LOAD OR LARGEST INTERMITTENT LOAD WHICHEVER IS GREATER)

2. PEAK LOAD = MAXIMUM LOAD + (10% OF STANDBY LOAD OR LARGEST STANDBY LOAD WHICHEVER IS GREATER)

PJP5 District Cooling Plant Project - 3.3 kV Tran:

[redacted]
Rev. 1

Equip. No	Serial No	Equipment Name	St 1	Continuous Load (kVA) Phase 2	3	4	Total	Remarks
P-0101	A to E	Secondary Chilled Water Pumps (Fix Speed)	1	628	314	314	1,571	
P-0102	A to C	Secondary Chilled Water Pumps (VARIABLE FREQUENCY DRIVE)	2	0	0	0	990	
EC-0121	A	Electrical Chiller	1	0	0	0	1,023	
P-0231	A to M	Cooling Water Pump for DFC	2	453	453	302	1,963	
				,081	767	616	5,547	Uncorrected kVA PF before correction = 0.82
				270	192	154	1,387	
				,352	959	770	6,933	
				3,081			8,933 (kVA)	

Condition for Transformer Capacity Selection

1 For General Operation

1.1 Status for Transformer Operation

- Individual operation condition, each transformer to supply the
- Air cooled fan (AF) for transformer NOT to be operated during

1.2 11/3.3kV Transformer Load Estimation (AN Operation) :

Minimum required transformer capacity WITHOUT forced air co

- For Phase 1 only = 2750 kVA (with 3.3k
- For All Phases (1, 2, 3 & 4) = 5100 kVA (with 3.3k

kVA (AN) with 1650 kVAR Capacitor Bank Added

The above AN rating is selected with PF correction capacitor ba

...rected Continuous Load (kVA) Phase 2, 3, and 4	Total	Remarks
2412	5,058	PF after correction = 0.95
603	1,265	
3015	6,323	

2 For Urgent or Maintenance Operation (as Back-up operatior

.1 Status for Transformer Operation

- During either one (1) transformer is fail or under maintenance, electricity to both busbars of the 3.3 kV switchgear (with 1650 l
- The 5100 kVA (AN rating) transformer is still capable of supply

.2 Transformer Load Estimation for Spare Load of 25%

- For Phase 1 only = 3800 kVA AF (with PF co
- For Phase 1 and Future = 6325 kVA AF (with PF co

CONCLUSION

Proposed Selection for 11/3.3 kV Transformer rating (AN/AF) sh:
Dyn11, ±5% in 2.5 step, Z% = 6.0% on 5.1 MVA, where AF ratin

Note

AF rating of 7140 kVA > maximum loaad of 6993 kVA (uncorrect
at AF rating can supply total load WITHOUT power factor correcti

PJP5 District Cooling Plant Project - 11 / 0.433 kV Transfon

[redacted]
Ver. 1

Equip. No	Serial No	Equipment Name	Phase					
			1			2	3	
			Sl 1	Sl 2	Total			
)FC-0131	A to N "I" not used	Direct-Fired Absorption Chiller	2	3	5	3	3	2
:T-0201	A to M	Cooling Tower for DFC-0201	3	3	6	3	3	
?-0221		Cooling Water Pump for EC	1	0	1	0	0	[illegible]
?-0131	A to N	Chilled Water Pump for DFC	2	3	5	3	3	[illegible]
?-0121		Chilled Water Pump for EC	1	0	1	0	0	[illegible]
?-1111	A to B	Make up water Pump for Chilled Water (1 standby)	2	0	2	0	0	[illegible]
?-1121	A to C	Make up water pump for cooling water (1 standby)	2	0	2	1	0	[illegible]
?-0104	A to B	Circulating Pump for Side Stream Filter (1 standby)	2	0	2	0	0	0
:U-0410		Chemical dosing unit for Chilled Water	1	0	1	0	0	0
:U-0421		Chemical dosing unit for Cooling Water	1	0	1	0	0	0
:U-0422		Chemical dosing unit for Cooling Water	1	0	1	0	0	0
?-0501	A - B	Oil supply pump for T-0501	2	0	2	0	0	0
?-0502	A - B	Oil supply pump for T-0501	0	0	0	2	0	0
?-0503	A - B	Oil supply pump for T-0503	2	0	2	0	0	0
ilities		Fire Fighting	1	0	0	0	0	0
		Cold Water	1	0	1	0	0	0
		Building Services	1	0	1	0	0	0
		ACMV Equipment	1	0	1	0	0	0
		EMSB	1	0	1	0		

35·

:ondition for Transformer Capacity Selection

1 For General Operation

1.1 Status for Transformer Operation

- Individual operation condition, each transformer to supply the electricity for each bu
- Air cooled fan (AF) for transformer NOT to be operated during this status

1.2 11 / 0.433 kV Transformer Load Estimation (AN Operation) :

Minimum Required Transformer Capacity WITHOUT Forced Air Cooled fan operatio

- For Phase 1 only = 1500 kVA (with 415V power factor correction
- For Phase 1, 2, 3 & 4 = 1600 kVA x 2 (estimated from uncorrected kVA)

The above AN rating is selected with PF correction capacitor banks to improve the P

2 For Urgent or Maintenance Operation (as Back-up operation)

2.1 Status for Transformer Operation

- During either one (1) transformer is fail or under maintenance, the alternative transf to supply the electricity to both busbar in 415V switchgear / MCC
- The 1600 kVA (AN rating) transformer is still capable of supplying the total load

2.2 Transformer Load Estimation for Spare Load of 25%

- For Phase 1 only = 1770 kVA AF (with PF correction capac
- For Phase 1 & Future = 1770 kVA x 2 AF (with PF correction capac

CONCLUSION

Proposed Selection for 11 / 0.433 kV Transformer rating (AN/AF) shal Dyn 11, ± 5% in 2.5 STEP, Z% = 6.0 % on 1600 kVA, where AF rating i:

Note

AF rating of 2240 kVA > maximum load of 2149 kVA (uncorrected), therefore one (1
at AF rating can supply total load WITHOUT power factor correction

APPENDIX 4

Group Derating Factor

I.

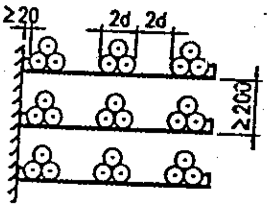
INSTALLATION ON CABLE LADDERS

;END

I	METHOD 11
	LADDER
	TRAY
	TOUCHING
	SPACED
	TREFOIL FORMATION

.E CORE CABLES IN TREFOIL FORMATION

NGEMENT ABLES	NUMBER OF CABLE LADDERS (LAYERS)	INSTALLATION IN TREFOIL CLEARANCE = 2d DISTANCE FROM WALL ≥ 20mm			
		NUMBER OF RUNS			
		1	2	3	
BLE S	1	1.00	0.98	0.96	
	2	1.00	0.95	0.93	
	3, 4 & 5	1.00	0.94	0.92	
	6	1.00	0.93	0.90	

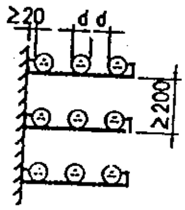


M 11
- SINGLE CORE
- TREFOIL
- SPACING

M11-LD-1C-TRE-SP

RE CABLES – SPACED

:MENT ES	NUMBER OF CABLE LADDERS (LAYERS)	CLEARANCE = CABLE DIAMETER d DISTANCE FROM WALL ≥ 20mm				
		NUMBER OF CABLES PER LADDER				
		1	2	3	6	9
:	1	1.00	0.98	0.96	0.93	0.92
	2	1.00	0.95	0.93	0.90	0.89
	3, 4 & 5	1.00	0.94	0.92	0.89	0.88
	6	1.00	0.93	0.90	0.87	0.86

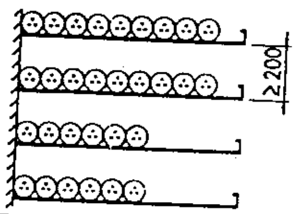


M 11
- MULTI CORE
- SPACING

M11-LD-3C-SP

CABLES – TOUCHING

NT	NUMBER OF CABLE LADDERS (LAYERS)	SIDE BY SIDE WITHOUT CLEARANCE AND TOUCHING WALL				
		NUMBER OF CABLES PER LADDER				
		1	2	3	6	9
	1	0.95	0.84	0.80	0.75	0.73
	2	0.95	0.80	0.76	0.71	0.69
	3, 4 & 5	0.95	0.78	0.74	0.70	0.68
	6	0.95	0.76	0.72	0.68	0.66



M 11
- MULTI CORE
- SINGLE LAYER
- TOUCHING

M11-LD-3C-TC

APPENDIX 5

Cables Reference Tables

IRUKAWA MALAYSIA

IEC 60502-1

BLE 1: SINGLE–CORE 600/1000V (CVWAZV) XLPE/PVC/SWA(AL)/PVC STRANDED COPPER CONDUCTOR

Conductor: Shape of Conductor	Conductor: Approx. outer dia. (mm)	Thick of XLPE insulation (mm)	PVC inner covering: Thick (mm)	PVC inner covering: Approx. outer dia. (mm)	Dia. of hard drawn wire (mm)	Thick of PVC sheath (mm)	Approx. overall dia. (mm)	Approx. net weight (kg/km)	Current rating: In air at 40°C (A)	Current rating: In the ground (A)	Conductor resistance: D.C. at 20°C (Ω/km)	Conductor resistance: 50 Hz at 90°C (Ω/km)	Reactance at 50 Hz (Ω/km)	Short circuit current for 1 sec. (kA)
Circular Compacted	4.7	0.7	1.0	8.0	1.0	1.8	14.0	330	100	115	1.15	1.47	0.126	2.41
	5.9	0.9	1.0	9.7	1.0	1.8	15.5	450	135	150	0.727	0.927	0.119	3.72
	7.0	0.9	1.0	10.8	1.0	1.8	16.5	560	165	170	0.524	0.668	0.113	5.18
	8.1	1.0	1.0	12.1	1.0	1.8	18.0	710	200	205	0.387	0.494	0.113	7.36
	9.7	1.1	1.0	13.9	1.0	1.8	20.0	940	255	250	0.268	0.342	0.107	10.2
	11.4	1.1	1.0	15.6	1.0	1.8	21.5	1,210	310	300	0.193	0.247	0.102	13.8
	12.8	1.2	1.0	17.2	1.6	1.8	24.5	1,560	365	340	0.153	0.196	0.101	17.4
	14.3	1.4	1.0	19.2	1.6	1.8	26.5	1,870	415	385	0.124	0.159	0.0999	21.8
	16.0	1.6	1.0	21.3	1.6	1.8	28.5	2,270	480	435	0.0991	0.128	0.0975	26.8
	18.4	1.7	1.0	23.9	1.6	1.9	31.0	2,890	570	500	0.0754	0.0982	0.0946	34.7
	20.6	1.8	1.0	26.3	1.6	1.9	33.5	3,520	650	565	0.0601	0.0793	0.0920	43.4
	23.3	2.0	1.2	29.9	2.0	2.1	38.5	4,550	760	635	0.0470	0.0632	0.0923	57.7
	26.3	2.2	1.2	33.3	2.0	2.2	42.0	5,620	870	715	0.0366	0.0509	0.0903	72.1
Circular non Compacted	32.76	2.4	1.2	40.3	2.0	2.3	49.5	7,290	995	800	0.0283	0.0415	0.0878	90.8
	37.05	2.6	1.4	45.4	2.5	2.5	55.5	9,320	1,150	890	0.0221	0.0347	0.0863	115.2
	41.6	2.8	1.4	50.3	2.5	2.7	61.0	11,580	1,250	940	0.0176	0.0300	0.0847	143.9

dentification : Natural

BLE 2: TWO–CORE 600/1000V (CVWAZV) XLPE/PVC/SWA/PVC STRANDED COPPER CONDUCTOR

Conductor: Shape of Conductor	Conductor: Approx. outer dia. (mm)	Thick of XLPE insulation (mm)	PVC inner covering: Thick (mm)	PVC inner covering: Approx. outer dia. (mm)	Dia. of galvanized steel wire (mm)	Thick of PVC sheath (mm)	Approx. overall dia. (mm)	Approx. net weight (kg/km)	Current rating: In air at 40°C (A)	Current rating: In the ground (A)	Conductor resistance: D.C. at 20°C (Ω/km)	Conductor resistance: 50 Hz at 90°C (Ω/km)	Reactance at 50 Hz (Ω/km)	Short circuit current for 1 sec. (kA)
Circular Compacted	3.7	0.7	1.0	12.4	0.9	1.8	17.5	610	79	98	1.83	2.33	0.0780	1.52
	4.7	0.7	1.0	14.4	0.9	1.8	19.5	780	105	125	1.15	1.47	0.0767	2.41
Stranded Shape	4.5	0.9	1.0	15.1	1.6	1.8	22.0	1,210	140	160	0.727	0.927	0.0770	3.72
	5.2	0.9	1.0	16.5	1.6	1.8	23.5	1,450	170	195	0.524	0.669	0.0746	5.18
	6.1	1.0	1.0	18.7	1.6	1.8	25.5	1,800	210	230	0.387	0.494	0.0738	7.36
	7.4	1.1	1.0	21.7	1.6	2.0	29.0	2,350	260	280	0.268	0.342	0.0726	10.2
	8.7	1.1	1.2	24.7	2.0	2.1	33.0	3,230	320	335	0.193	0.247	0.0808	13.8
	9.7	1.2	1.2	27.1	2.0	2.2	35.5	3,840	370	380	0.153	0.196	0.0709	17.4
	10.7	1.4	1.2	30.1	2.0	2.3	38.5	4,570	425	425	0.124	0.160	0.0719	21.8
	12.0	1.6	1.4	33.9	2.5	2.5	44.0	5,900	485	480	0.0991	0.128	0.0720	26.8
	13.8	1.7	1.4	37.9	2.5	2.7	48.0	7,350	575	555	0.0754	0.0987	0.0713	34.7
	15.4	1.8	1.6	41.9	2.5	2.8	52.5	8,760	650	620	0.0601	0.0798	0.0707	43.4
	17.2	2.0	1.6	46.5	2.5	3.1	57.5	10,810	745	695	0.0470	0.0640	0.0704	57.7

dentification : Red and Black

URUKAWA MALAYSIA

IEC 60502-2

ble 1 3.6/6(Max. 7.2) KV THREE-CORE CABLES

Copper conductor		Thick. of XLPE insulation	PVC separation sheath		Dia. of galvanized steel wire	Thick. of PVC outer-sheath	Approx. overall dia.	Approx. net. weight	Electrical characteristics						
Shape of strand	Approx. outer dia.		Thick.	Approx. outer dia.					Current rating In air at 40°C	Current rating In the ground at 25°C	Conductor resistance D.C. at 20°C	Conductor resistance 50Hz at 90°C	Capacitance	Reactance at 50Hz	Short circuit current for 1 sec.
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(kg/km)	(A)	(A)	(Ω/km)	(Ω/km)	(μF/km)	(Ω/km)	(kA)
Circular compact	4.7	2.5	1.2	31.6	2.0	2.2	40.5	2,830	105	110	1.15	1.47	0.21	0.117	2.41
	5.9	2.5	1.2	34.2	2.0	2.3	43.0	3,330	135	140	0.727	0.927	0.24	0.109	3.72
	7.0	2.5	1.2	37.0	2.0	2.3	46.0	3,840	165	170	0.524	0.668	0.28	0.105	5.18
	8.1	2.5	1.3	39.6	2.5	2.5	50.0	4,870	195	200	0.387	0.494	0.31	0.100	7.36
	9.7	2.5	1.4	43.7	2.5	2.6	54.0	5,910	245	245	0.268	0.342	0.35	0.0949	10.2
	11.4	2.5	1.4	47.3	2.5	2.7	58.0	7,020	300	290	0.193	0.247	0.40	0.0914	13.8
	12.8	2.5	1.5	50.6	2.5	2.8	61.5	8,080	340	330	0.153	0.196	0.43	0.0885	17.4
	14.3	2.5	1.5	53.8	2.5	2.9	65.0	9,210	385	365	0.124	0.160	0.47	0.0860	21.8
	16.0	2.5	1.6	57.7	2.5	3.0	69.0	10,710	440	415	0.0991	0.128	0.52	0.0837	26.8
	18.4	2.6	1.7	63.5	2.5	3.2	75.0	13,090	515	475	0.0754	0.0988	0.56	0.0817	34.7
	20.6	2.8	1.8	69.3	3.15	3.5	83.0	16,410	585	530	0.0601	0.0800	0.57	0.0805	43.4
	23.3	3.0	2.0	76.3	3.15	3.8	90.5	19,880	665	590	0.0470	0.0643	0.60	0.0790	57.7
	26.3	3.2	2.1	83.9	3.15	4.0	98.5	23,820	745	650	0.0366	0.0522	0.62	0.0779	72.1

entification : red, yellow & blue

ble 2 6/10 (Max. 12) KV THREE-CORE CABLES

opper conductor		Thick. of XLPE insulation	PVC separation sheath		Dia. of galvanized steel wire	Thick. of PVC outer-sheath	Approx. overall dia.	Approx. net. weight	Electrical characteristics						
Shape of strand	Approx. outer dia.		Thick.	Approx. outer dia.					Current rating In air at 40°C	Current rating In the ground at 25°C	Conductor resistance D.C. at 20°C	Conductor resistance 50Hz at 90°C	Capacitance	Reactance at 50Hz	Short circuit current for 1 sec.
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(kg/km)	(A)	(A)	(Ω/km)	(Ω/km)	(μF/km)	(Ω/km)	(kA)
Circular compact	4.7	3.4	1.2	35.5	2.0	2.3	44.5	3,220	105	110	1.15	1.47	0.17	0.128	2.41
	5.9	3.4	1.3	38.3	2.5	2.4	48.5	4,130	140	140	0.727	0.927	0.19	0.118	3.72
	7.0	3.4	1.3	41.1	2.5	2.5	51.5	4,740	170	170	0.524	0.668	0.22	0.113	5.18
	8.1	3.4	1.4	43.7	2.5	2.6	54.0	5,380	200	200	0.387	0.494	0.24	0.108	7.36
	9.7	3.4	1.4	47.6	2.5	2.7	58.0	6,420	250	245	0.268	0.342	0.27	0.102	10.2
	11.4	3.4	1.5	51.4	2.5	2.9	62.5	7,600	300	290	0.193	0.247	0.31	0.0976	13.8
	12.8	3.4	1.6	54.6	2.5	3.0	66.0	8,690	345	330	0.153	0.196	0.33	0.0944	17.4
	14.3	3.4	1.6	57.9	2.5	3.1	69.5	9,840	390	365	0.124	0.160	0.36	0.0915	21.8
	16.0	3.4	1.7	61.7	2.5	3.2	73.5	11,370	445	410	0.0991	0.128	0.40	0.0888	26.8
	18.4	3.4	1.8	67.1	3.15	3.4	80.5	14,560	520	475	0.0754	0.0986	0.44	0.0856	34.7
	20.6	3.4	1.9	72.1	3.15	3.6	86.0	16,960	585	525	0.0601	0.0798	0.48	0.0833	43.4
	23.3	3.4	2.0	78.1	3.15	3.8	92.0	20,210	665	590	0.0470	0.0641	0.53	0.0809	57.7
	26.3	3.4	2.1	84.7	3.15	4.0	99.5	24,000	745	650	0.0366	0.0521	0.59	0.0788	72.1

tification : red, yellow & blue

le 3 8.7/15 (Max. 17.5) KV THREE-CORE CABLES

per conductor		Thick. of XLPE insulation	PVC separation sheath		Dia. of galvanized steel wire	Thick. of PVC outer-sheath	Approx. overall dia.	Approx. net. weight	Electrical characteristics						
Shape of strand	Approx. outer dia.		Thick.	Approx. outer dia.					Current rating In air at 40°C	Current rating In the ground at 25°C	Conductor resistance D.C. at 20°C	Conductor resistance 50Hz at 90°C	Capacitance	Reactance at 50Hz	Short circuit current for 1 sec.
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(kg/km)	(A)	(A)	(Ω/km)	(Ω/km)	(μF/km)	(Ω/km)	(kA)
Circular compact	5.9	4.5	1.4	43.3	2.5	2.6	54.0	4,790	140	140	0.727	0.927	0.16	0.131	3.72
	7.0	4.5	1.4	46.1	2.5	2.7	57.0	5,420	170	170	0.524	0.663	0.18	0.124	5.18
	8.1	4.5	1.5	48.7	2.5	2.8	59.5	6,080	200	200	0.387	0.494	0.20	0.118	7.36
	9.7	4.5	1.5	52.6	2.5	2.9	63.5	7,160	250	245	0.268	0.342	0.22	0.112	10.2
	11.4	4.5	1.6	56.4	2.5	3.0	67.5	8,350	305	290	0.193	0.247	0.25	0.107	13.8
	12.8	4.5	1.7	59.7	2.5	3.1	71.0	9,460	350	330	0.153	0.196	0.27	0.103	17.4
	14.3	4.5	1.7	62.9	2.5	3.2	74.5	10,640	395	370	0.124	0.159	0.29	0.0994	21.8
	16.0	4.5	1.8	66.7	3.15	3.4	80.0	13,090	450	410	0.0991	0.128	0.31	0.0962	26.8
	18.4	4.5	1.9	72.1	3.15	3.6	86.0	15,550	520	475	0.0754	0.0983	0.35	0.0924	34.7
	20.6	4.5	2.0	77.1	3.15	3.7	91.0	17,950	590	530	0.0601	0.0794	0.38	0.0896	43.4
	23.3	4.5	2.1	83.1	3.15	4.0	97.5	21,300	665	590	0.0470	0.0636	0.42	0.0868	57.7
	26.3	4.5	2.2	89.7	3.15	4.2	104.5	25,140	750	650	0.0366	0.0515	0.46	0.0842	72.1

APPENDIX 6

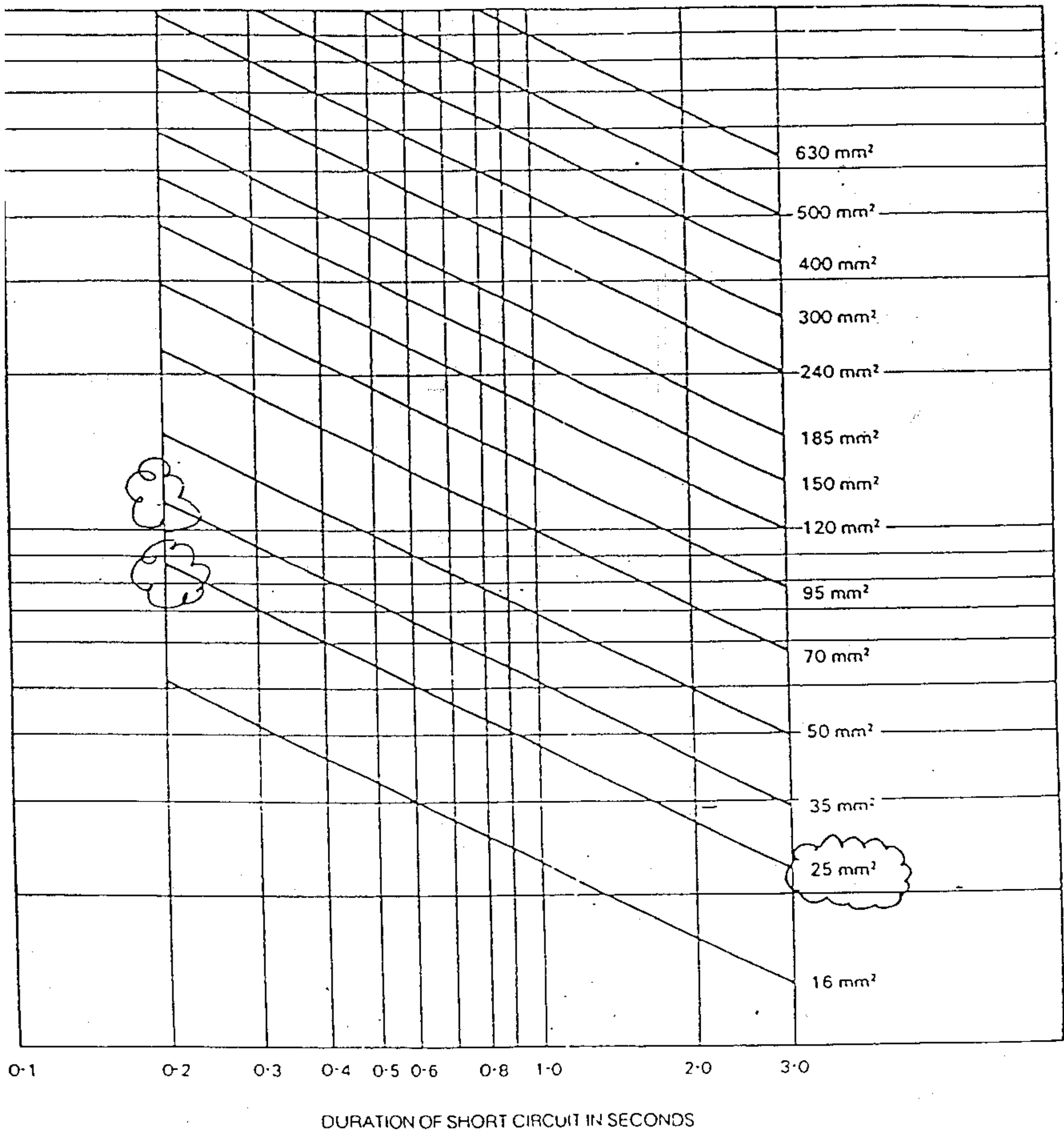
Short Circuit Ratings

Appendix - 6

...ort circuit ratings
...PPER CONDUCTORS

FIGURE 2

...values of fault current given in the graph Figure 2 ...ased on the cable being fully loaded at the start ... short circuit (conductor temperature 90°C) and ...l conductor temperature of 250°C, and it should be ensured that the accessories associated with the cable are also capable of operation at these values of fault current and temperature.



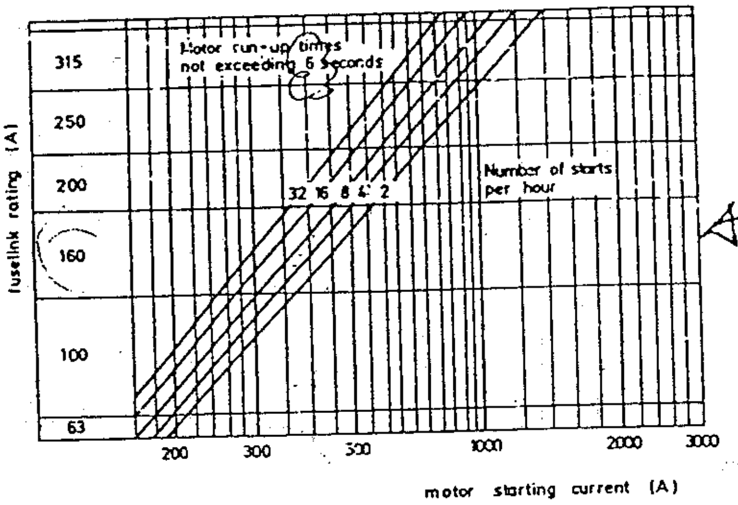
Note:
The use of soldered type connectors (instead of the compression type) is not recommended since their use in the system would limit the final conductor temperature to 160°C (and consequently reduce the fault current by approximately 30 per cent).

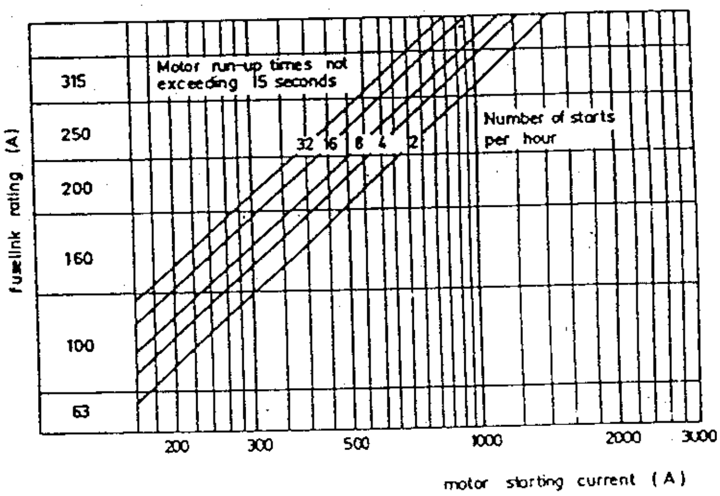
Data for stranded aluminium conductors are available on request

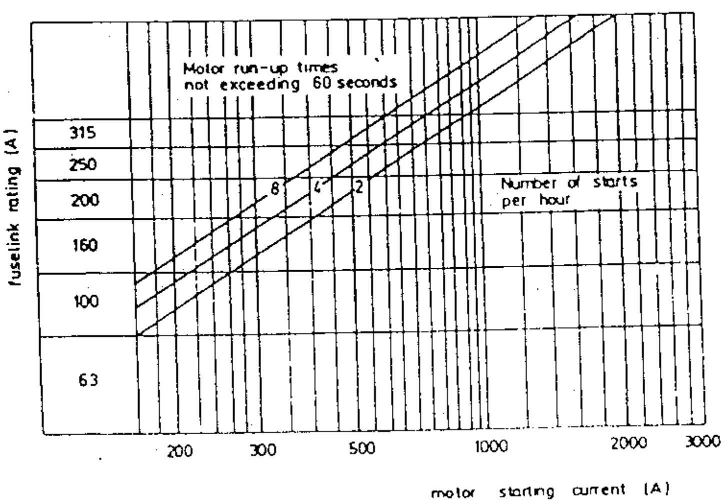
APPENDIX 7

Fuse Link Type CMF

Fuse link type CMF · Appendix 5·







10. Choice of fuse links

Choice of rated voltage U_N:

The rated voltage of the fuse links must be equal to, or higher than the operating line voltage. By choosing fuse link rated voltage considerably higher than the line voltage, the maximum arc voltage must not exceed the insulation level of the network.

Choice of rated current I_N:

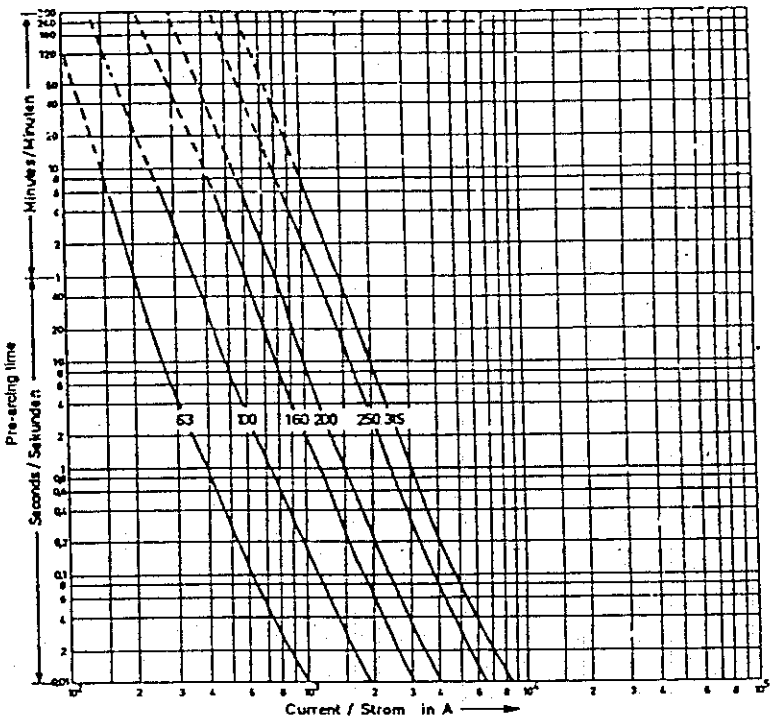
The minimum permissible current rating of the fuse link for motor protection may be determined from the selection charts I, II and III. The three different charts are for run-up times of 6, 15 and 60 seconds respectively. Each chart contains different characteristics, depending on the number of starts per hour. Of this specific number of starts per hour, *the first two are in immediate succession*; the rest being evenly spaced in the 1 hour period. The number of starts per hour indicates the time interval between seperate starts. For example, *4 starts in 15 minutes are represented by 16 starts per hour.*

On the horizontal axis of the selection chart, the motor starting current is given, and along the vertical axis the current rating of the fuse link is found.

Selection procedure:

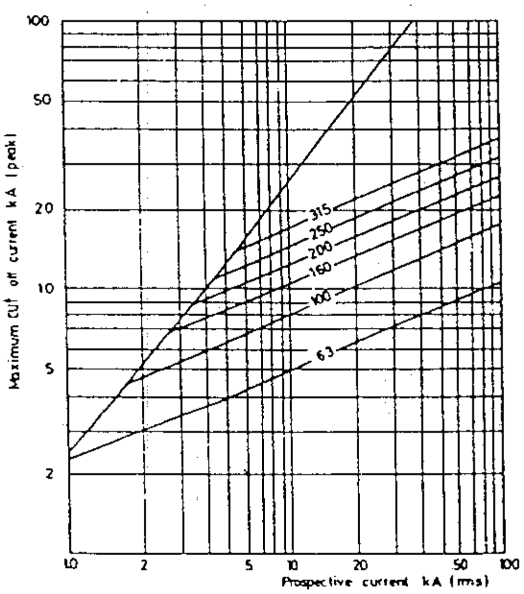
- Select the charts which are appropriate for the run-up time of the motor,
- select the starting current along the horizontal axis,
- depending on the number of starts per hour, select the correct characteristic (2, 4, 8, 16, 32),
- read of the correct rating of the fuse link on the vertical axis.

Example:	A	B
Starting current of the motor	850A	250A
Run-up time	6 sec.	15 sec.
Number of starts per hour	2	16
Chart number	1	2
Rated current of fuse link	250A	160A



7. Pre-arcing times

The characteristics are equal for all rated voltages and are recorded from cold condition.
In the uncertain interrupting zone the curves are dotted.



8. Current limitation

CMF fuse links are current limiting. A large short circuit current will therefore not reach its full value. The diagram shows the relation between the prospective short circuit current and the peak value og the cut off current.

9. Overvoltages

In order to be current limiting, the fuse links must generate an arc voltage exceeding the instantaneous value of the operating voltage. The overvoltage generated by the CMF fuse link is below the maximum permissible value acc to IEC 282-1.
CMF fuse links can safely be used if the system line voltage is 50-100% of the rated fuse link voltage.

Fuse link type CMF

11. Replacement of melted fuse links

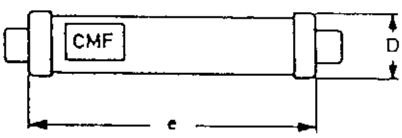
The fuse link cannot be regenerated. According to IEC. Publication 282-1, all 3 fuse links should be replaced, even if only 1 or 2 of the fuse links in the threephase system have operated. Exceptions are allowed when it can be verified that the fuse link(s) have not experienced any overcurrent.

12. The K-factor

According to the IEC 644, the K-factor is a factor (less than unity) defining an overload characteristic to which the fuse link may be repeatedly subjected under specified motor starting conditions without deterioration. The overload characteristic is obtained by multiplying the *current* on the prearcing characteristic (melting time characteristics) by K. The Value of K given in the data table is chosen at 10 seconds melting time, and is valid for melting times between 5 and 60 seconds.

13. Data and dimensions CMF

U_N	I_N	e	D	K*	I_1	I_3	R_o	P_N	Minimum I^2t	Maximum I^2t
kV	A	mm	mm	–	kA	A	mohm	Watt	Pre-arc A^2s	Interruption A^2s
3,6	100	292	65	0,75	50	275	3,25	49	$1,4 \cdot 10^4$	$17 \cdot 10^4$
	160	292	65	0,7	50	400	1,94	75	$3,8 \cdot 10^4$	$50 \cdot 10^4$
	200	292	87	0,7	50	500	1,42	75	$7,6 \cdot 10^4$	$71 \cdot 10^4$
	250	292	87	0,6	50	760	1,03	90	$14 \cdot 10^4$	$115 \cdot 10^4$
	315	292	87	0,6	50	900	0,85	122	$21 \cdot 10^4$	$180 \cdot 10^4$
7,2	63	442	65	0,75	50	175	8,63	45	$0,48 \cdot 10^4$	$6,5 \cdot 10^4$
	100	442	65	0,75	50	275	4,93	67	$1,40 \cdot 10^4$	$18 \cdot 10^4$
	160	442	65	0,7	50	400	2,96	119	$3,8 \cdot 10^4$	$54 \cdot 10^4$
	200	442	87	0,7	50	500	2,15	118	$7,6 \cdot 10^4$	$75 \cdot 10^4$
	250	442	87	0,6	50	800	1,56	142	$14 \cdot 10^4$	$120 \cdot 10^4$
	315	442	87	0,6	50	950	1,30	193	$21 \cdot 10^4$	$220 \cdot 10^4$
12	63	442	65	0,75	50	190	13,3	77	$0,48 \cdot 10^4$	$11 \cdot 10^4$
	100	442	87	0,75	50	275	6,72	103	$1,4 \cdot 10^4$	$20 \cdot 10^4$
	160	442	87	0,7	50	480	4,04	155	$3,8 \cdot 10^4$	$70 \cdot 10^4$
	200	442	87	0,7	50	650	2,89	173	$9,3 \cdot 10^4$	$91 \cdot 10^4$



*) The K-factor is referred to the average value of current.

Legends:

e = see figure
D = see figure
K = K-factor acc. to IEC 644
I_1 = max. short circuit current tested
I_3 = minimum breaking current
R_O = resistance at room temperature
P_N = power loss at rated current

APPENDIX 8

Proposed Cable Sizes

SHINRYO (M) SDN BHD
PROJECT : PUTRAJAYA PRECINCT 5
POWER CABLES SCHEDULE SUMMARY - 415V

Item	From	To		No of Cables	No of Core	Type Of Cable	Proposed Cable Size (sq.mm)
1	415V S/Board	DFC-0131A		1	4	X/S/P (Cu)	25
2	415V S/Board	DFC-0131B		1	4	X/S/P (Cu)	25
3	415V S/Board	DFC-0131C		1	4	X/S/P (Cu)	25
4	415V S/Board	DFC-0131D		1	4	X/S/P (Cu)	25
5	415V S/Board	DFC-0131E		1	4	X/S/P (Cu)	25
6	415V S/Board	CT-0201A1		1	3	X/S/P (Cu)	16
7	415V S/Board	CT-0201A2		1	3	X/S/P (Cu)	16
8	415V S/Board	CT-0201B1		1	3	X/S/P (Cu)	16
9	415V S/Board	CT-0201B2		1	3	X/S/P (Cu)	16
10	415V S/Board	CT-0201C1		1	3	X/S/P (Cu)	16
11	415V S/Board	CT-0201C2		1	3	X/S/P (Cu)	16
12	415V S/Board	CT-0201D1		1	3	X/S/P (Cu)	16
13	415V S/Board	CT-0201D2		1	3	X/S/P (Cu)	16
14	415V S/Board	CT-0201E1		1	3	X/S/P (Cu)	16
15	415V S/Board	CT-0201E2		1	3	X/S/P (Cu)	16
16	415V S/Board	CT-0201F1		1	3	X/S/P (Cu)	16
17	415V S/Board	CT-0201F2		1	3	X/S/P (Cu)	16
20	415V S/Board	P-1111A	Make	1	3	P/S/P (Cu)	2.5
21	415V S/Board	P-1111B	Make	1	3	P/S/P (Cu)	2.5
22	415V S/Board	P-1121A	Make	1	3	P/S/P (Cu)	10
23	415V S/Board	P-1121B	Make	1	3	P/S/P (Cu)	10
24	415V S/Board	CU-0401	Chem	1	4	P/S/P (Cu)	2.5
25	415V S/Board	CU-0421	Chem	1	4	P/S/P (Cu)	2.5
26	415V S/Board	CU-0422	Chem	1	4	P/S/P (Cu)	2.5
27	415V S/Board	P-0501A		1	3	P/S/P (Cu)	2.5
28	415V S/Board	P-0501B		1	3	P/S/P (Cu)	2.5
29	415V S/Board	P-0503A		1	3	P/S/P (Cu)	2.5
30	415V S/Board	P-0503B		1	3	P/S/P (Cu)	2.5
31	415V S/Board	P-0221		1	3	X/S/P (Cu)	95
32	415V S/Board	P-0121		1	3	X/S/P (Cu)	50
33	415V S/Board	P-0402A		1	3	P/S/P (Cu)	2.5
34	415V S/Board	P-0402B		1	3	P/S/P (Cu)	2.5
35	415V S/Board	P-0104A	Circul	1	3	P/S/P (Cu)	4
36	415V S/Board	P-0104B	Circul	1	3	P/S/P (Cu)	4
37	415V S/Board	P-0131A	C	1	3	X/S/P (Cu)	35
38	415V S/Board	P-0131B	C	1	3	X/S/P (Cu)	35
39	415V S/Board	P-0131C	C	1	3	X/S/P (Cu)	35
40	415V S/Board	P-0131D	C	1	3	X/S/P (Cu)	35
41	415V S/Board	P-0131E	C	1	3	X/S/P (Cu)	35
43	415 S/Booard	Fire Fighting		1	4	X/S/P (Cu)	25
44	415 S/Booard	Cold Water		1	4	X/S/P (Cu)	4
45	415 S/Booard	Building		1	4	X/S/P (Cu)	70
46	415 S/Booard	ACMV Equip.		1	4	X/S/P (Cu)	95
47	415 S/Booard	EMSB		1	4	X/S/P (Cu)	25

*Group Derating Factor = 0.73

SHINRYO (M) SDN BHD
PROJECT : PUTRAJAYA PRECINCT 5
POWER CABLE SCHEDULE SUMMARY - 3.3kV Swit

Item	From	To		Type Of Cable	Proposed Cable Size (sq.mm)	Ampacity of cable at 40 deg. C	Remarks
1	3.3kV S/Board	P-0101A	Seconda	X/S/P (Cu)	25	140	
2	3.3kV S/Board	Transformer A	Tran	X/S/P (Cu)	35	170	
3	3.3kV S/Board	Transformer B	Trans	X/S/P (Cu)	35	170	
4	3.3kV S/Board	Transformer C	Trans	X/S/P (Cu)	35	170	
5	3.3kV S/Board	EC-0111	E	X/S/P (Cu)	70	250	
6	3.3kV S/Board	P-0231A	Coolin	X/S/P (Cu)	25	140	
7	3.3kV S/Board	P-0231B	Coolin	X/S/P (Cu)	25	140	
8	3.3kV S/Board	P-0231C	Cooling	X/S/P (Cu)	25	140	
9	3.3kV S/Board	P-0231D	Cooling	X/S/P (Cu)	25	140	
10	3.3kV S/Board	P-0231E	Cooling	X/S/P (Cu)	25	140	
				X/S/P (Cu)	25	140	

SHINRYO (M) SDN BHD
PROJECT : PUTRAJAYA PRECINCT 5
POWER CABLE SCHEDULE SUMMARY - 415V VSD Loa

Item	From	To	Serv	of le	No of Core	Type Of Cable	Proposed Cable Size (sq.mm)	Ampacity of cable at 40 deg. C	Remarks
1	Transformer A	VFD A	Variable Frequ		1	X/S/P (Cu)	500	870	
2	Transformer B	VFD B	Variable Frequ		1	X/S/P (Cu)	500	870	
3	Transformer C	VFD C	Variable Frequ		1	X/S/P (Cu)	500	870	
4	VFD A	P-0102A	Secondary Chille		1	X/S/P (Cu)	400	760	
5	VFD B	P-0102B	Secondary Chille		1	X/S/P (Cu)	400	760	
6	VFD C	P-0102C	Secondary Chille		1	X/S/P (Cu)	400	760	

APPENDIX 9

Crystal Report-Short Circuit Simulation for Basic Engineering Design

DAPPER Fault Contribution Complete Report

Date: 2 December 2004
Time: 4:02:54PM

Comprehensive Short Circuit Study Settings

Three Phase Fault	Yes	**Faulted Bus**	All Buses
Single Line to Ground	Yes	**Bus Voltages**	First Bus From Fault
Line to Line Fault	No	**Branch Currents**	First Branch From Fault
Line to Line to Ground	No	**Phase or Sequence**	Report phase quantities
Motor Contribution	Yes	**Fault Current Calculation**	Initial Symmetrical RMS (with 1/2 Cycle Asym)
Transformer Tap	No	**Asym Fault Current at Time**	0.50
Xformer Phase Shift	Yes		

			------------Initial Symmetrical Amps----------				---------------Asymmetrical Amps---------------				---Init Sym Neutral Amps--	
Bus Name			**3 Phase**	**SLG**	**LLG**	**LL**	**3 Phase**	**SLG**	**LLG**	**LL**	**SLG**	**LLG**
11kV S'board			17,313	0	0	0	27,641	0	0	0		
11/3.3a	In	Cable	1,061	0	0	0	1,694	0	0	0		
11/3.3b	Ou	Cable										
11/415a	In	Cable	296	0	0	0	473	0	0	0		
11/415b	Ou	Cable										
11a	In	Cable	15,958	0	0	0	25,478	0	0	0		
3.3kV Bus			17,613	17,560	0	0	28,446	28,940	0	0		
3.3a	In	Cable	13,191	14,620	0	0	21,305	24,095	0	0	17,560	
3.3b	Ou	Cable										
3.3kV Future	In	Ind Mtr	2,384	1,585	0	0	3,851	2,612	0	0		
3.3kV Phase1	In	Ind Mtr	2,050	1,362	0	0	3,311	2,246	0	0		
415V Bus1			43,782	41,133	0	0	52,188	47,984	0	0		
11/415a2	In	Cable	33,968	34,979	0	0	40,490	40,805	0	0	41,133	
415V Phase1	In	Ind Mtr	4,973	3,115	0	0	5,928	3,633	0	0		
415VPhase1	In	Ind Mtr	4,973	3,115	0	0	5,928	3,633	0	0		

Bus Name			Initial Symmetrical Amps				Asymmetrical Amps				Init Sym Neutral Amps	
			3 Phase	SLG	LLG	LL	3 Phase	SLG	LLG	LL	SLG	LLG
415V Bus2			0	0	0	0	0	0	0	0		
11/415b2	In	Cable	0	0	0	0	0	0	0	0		
415V Phase2	In	Ind Mtr	2,256	1,480	0	0	2,637	1,709	0	0		
415VPhase2	In	Ind Mtr	2,256	1,480	0	0	2,637	1,709	0	0		
11kV Node Bus4			17,260	0	0	0	27,295	0	0	0		
11/415a	In	Cable	16,966	0	0	0	26,829	0	0	0		
11/0.415 Tx1A	In	Xformer2	296	0	0	0	468	0	0	0		
11kV Node Bus7			0	0	0	0	0	0	0	0		
11/415b	Ou	Cable										
11/0.415 Tx1B	Ou	Xformer2										
11kV Node Bus9			17,271	0	0	0	27,456	0	0	0		
11/3.3a	In	Cable	16,210	0	0	0	25,770	0	0	0		
11/3.3kV TxA	In	Xformer2	1,061	0	0	0	1,687	0	0	0		
3.3kV Node4			17,635	17,590	0	0	28,594	29,144	0	0		
3.3a	In	Cable	4,431	2,946	0	0	7,184	4,881	0	0		
11/3.3kV TxA	In	Xformer2	13,218	14,652	0	0	21,432	24,276	0	0	17,591	
11kV Node Bus3			17,354	0	0	0	27,860	0	0	0		
11a	In	Cable	1,357	0	0	0	2,178	0	0	0		
TNB 1	In	Util.	16,000	0	0	0	25,686	0	0	0		
11kV Node Bus2			0	0	0	0	0	0	0	0		
11/3.3b	Ou	Cable										
11/3.3 kV TxB	Ou	Xformer2										
3.3kV Node5			0	0	0	0	0	0	0	0		
3.3b	Ou	Cable										
11/3.3 kV TxB	Ou	Xformer2										

Bus Name			Initial Symmetrical Amps 3 Phase	SLG	LLG	LL	Asymmetrical Amps 3 Phase	SLG	LLG	LL	Init Sym Neutral Amps SLG	LLG
415V Node Bus4			51,360	49,590	0	0	82,922	82,043	0	0		
11/415a2	In	Cable	9,427	6,068	0	0	15,220	10,039	0	0		
11/0.415 Tx1A	In	Xformer2	42,042	43,587	0	0	67,878	72,112	0	0	49,590	
415 Node Bus5			0	0	0	0	0	0	0	0		
11/415b2	In	Cable	0	0	0	0	0	0	0	0		
11/0.415 Tx1B	Ou	Xformer2										

APPENDIX 10

Crystal Report-Short Circuit Simulation for Detail Engineering Design

DAPPER Fault Contribution Complete Report

Date: 2 December 2004
Time: 4:10:35PM

Comprehensive Short Circuit Study Settings

Three Phase Fault	Yes	**Faulted Bus**	All Buses
Single Line to Ground	Yes	**Bus Voltages**	First Bus From Fault
Line to Line Fault	No	**Branch Currents**	First Branch From Fault
Line to Line to Ground	No	**Phase or Sequence**	Report phase quantities
Motor Contribution	Yes	**Fault Current Calculation**	Initial Symmetrical RMS (with 1/2 Cycle Asym)
Transformer Tap	Yes	**Asym Fault Current at Time**	0.50
Xformer Phase Shift	Yes		

			---Initial Symmetrical Amps---				---Asymmetrical Amps---				---Init Sym Neutral Amps---	
Bus Name			**3 Phase**	**SLG**	**LLG**	**LL**	**3 Phase**	**SLG**	**LLG**	**LL**	**SLG**	**LLG**
11kV S'board B			15,818	0	0	0	15,818	0	0	0		
11/3.3b1	Ou	Cable										
11/415b1	Ou	Cable										
PI-1	In	Pi	15,818	0	0	0	15,818	0	0	0		
11kV S'board A			15,819	0	0	0	15,819	0	0	0		
11/3.3a1	In	Cable	1,450	0	0	0	1,450	0	0	0		
11/415a1	In	Cable	320	0	0	0	320	0	0	0		
11a	In	Cable	15,487	0	0	0	15,487	0	0	0		
PI-1	In	Pi	0	0	0	0	0	0	0	0		
3.3kV Bus2			20,041	16,548	0	0	24,559	22,990	0	0		
11/3.3b2	Ou	Cable										
Tx VFD B	In	Xformer2	590	325	0	0	723	451	0	0		
PI-2	In	Pi	17,258	15,016	0	0	21,149	20,860	0	0	16,548	
P-0101D~E	In	Ind Mtr	836	460	0	0	1,024	639	0	0		
P-0231C~E	In	Ind Mtr	593	326	0	0	727	453	0	0		

			Initial Symmetrical Amps				Asymmetrical Amps				Init Sym Neutral Amps	
Bus Name			3 Phase	SLG	LLG	LL	3 Phase	SLG	LLG	LL	SLG	LLG
P-0231F~I	In	Ind Mtr	790	435	0	0	969	605	0	0		
3.3 kV Bus1			20,055	16,559	0	0	24,571	23,001	0	0		
11/3.3a2	In	Cable	13,265	12,816	0	0	16,252	17,801	0	0	16,559	
Tx VFD A	In	Xformer2	369	203	0	0	452	282	0	0		
PI-2	In	Pi	2,808	1,546	0	0	3,440	2,147	0	0		
EC-0121	In	Ind Mtr	1,246	686	0	0	1,527	953	0	0		
P-0101A	In	Ind Mtr	418	230	0	0	512	320	0	0		
P-0101B~C	In	Ind Mtr	836	460	0	0	1,024	639	0	0		
P-0231A~B	In	Ind Mtr	397	218	0	0	486	303	0	0		
P-0231J~M	In	Ind Mtr	794	437	0	0	972	607	0	0		
415 V Bus1			42,578	38,730	0	0	52,793	48,937	0	0		
11/415a2	In	Cable	31,852	32,221	0	0	39,493	40,712	0	0	38,730	
PI-3	In	Pi	5,543	3,361	0	0	6,872	4,247	0	0		
CT-0201A1~C2	In	Ind Mtr	1,909	1,158	0	0	2,368	1,463	0	0		
CU-0410&0421	In	Ind Mtr	8	5	0	0	10	6	0	0		
DFC-0131A~C	In	Ind Mtr	1,357	823	0	0	1,683	1,040	0	0		
P-0104A	In	Ind Mtr	67	41	0	0	83	51	0	0		
P-0131A~C	In	Ind Mtr	1,741	1,056	0	0	2,158	1,334	0	0		
P-0501A	In	Ind Mtr	22	13	0	0	27	17	0	0		
P-0503A	In	Ind Mtr	7	4	0	0	8	5	0	0		
P-1111A	In	Ind Mtr	29	18	0	0	36	22	0	0		
P-1121A	In	Ind Mtr	126	76	0	0	156	96	0	0		
P-1121B	Ou	Ind Mtr										
415V Bus2			42,064	38,252	0	0	52,335	48,490	0	0		
11/415b2	Ou	Cable										
PI-3	In	Pi	36,543	34,904	0	0	45,467	44,246	0	0	38,252	
CT-0201D1~F2	In	Ind Mtr	1,909	1,158	0	0	2,376	1,467	0	0		
CU-0422	In	Ind Mtr	10	6	0	0	12	8	0	0		
DFC-0131D~E	In	Ind Mtr	905	549	0	0	1,126	695	0	0		
P-0104B	Ou	Ind Mtr										

			Initial Symmetrical Amps				Asymmetrical Amps				Init Sym Neutral Amps	
Bus Name			3 Phase	SLG	LLG	LL	3 Phase	SLG	LLG	LL	SLG	LLG
P-0121A	In	Ind Mtr	580	352	0	0	722	446	0	0		
P-0131D~E	In	Ind Mtr	1,161	704	0	0	1,444	892	0	0		
P-0221	In	Ind Mtr	918	557	0	0	1,143	706	0	0		
P-0501B	In	Ind Mtr	22	13	0	0	27	17	0	0		
P-0502A~B	In	Ind Mtr	43	26	0	0	54	33	0	0		
P-0503B	In	Ind Mtr	7	4	0	0	8	5	0	0		
P-1111B	Ou	Ind Mtr										
11kV Node Bus1			15,642	0	0	0	15,642	0	0	0		
11/3.3a1	In	Cable	15,358	0	0	0	15,358	0	0	0		
Tx 11/3.3 kV A	In	Xformer2	1,451	0	0	0	1,451	0	0	0		
3.3kV Node1			20,129	16,635	0	0	24,694	23,204	0	0		
11/3.3a2	In	Cable	6,846	3,772	0	0	8,398	5,261	0	0		
Tx 11/3.3 kV A	In	Xformer2	13,356	12,898	0	0	16,384	17,991	0	0	16,635	
11kV Node Bus2			0	0	0	0	0	0	0	0		
11/3.3b1	Ou	Cable										
Tx 11/3.3kV B	Ou	Xformer2										
3.3kV Node2			0	0	0	0	0	0	0	0		
11/3.3b2	Ou	Cable										
Tx 11/3.3kV B	Ou	Xformer2										
11kV Node Bus3			16,292	0	0	0	16,292	0	0	0		
11a	In	Cable	1,764	0	0	0	1,764	0	0	0		
TNB	In	Util.	16,000	0	0	0	16,000	0	0	0		
11kV Node Bus4			15,610	0	0	0	15,610	0	0	0		
11/415a1	In	Cable	15,521	0	0	0	15,521	0	0	0		
Tx 11/0.415 A	In	Xformer2	320	0	0	0	320	0	0	0		
11kV Node Bus5			0	0	0	0	0	0	0	0		
11/415b1	Ou	Cable										

			Initial Symmetrical Amps				Asymmetrical Amps				Init Sym Neutral Amps	
Bus Name			3 Phase	SLG	LLG	LL	3 Phase	SLG	LLG	LL	SLG	LLG
Tx 11/0.415 B	Ou	Xformer2										
415V Node Bus1			45,430	41,632	0	0	64,984	63,747	0	0		
11/415a2	In	Cable	10,517	6,425	0	0	15,044	9,838	0	0		
Tx 11/0.415 A	In	Xformer2	34,928	35,216	0	0	49,962	53,922	0	0	41,632	
415V Node Bus2			0	0	0	0	0	0	0	0		
11/415b2	Ou	Cable										
Tx 11/0.415 B	Ou	Xformer2										
415V Node Bus3			14,142	12,984	0	0	22,685	21,424	0	0		
Tx VFD A	In	Xformer2	10,396	10,691	0	0	16,676	17,639	0	0	12,984	
P-0102A	In	Ind Mtr	3,756	2,299	0	0	6,024	3,793	0	0		
415V Node Bus4			17,884	14,893	0	0	27,985	24,325	0	0		
Tx VFD B	In	Xformer2	10,388	10,730	0	0	16,256	17,525	0	0	14,893	
P-0102B~C	In	Ind Mtr	7,511	4,170	0	0	11,754	6,811	0	0		

APPENDIX 11

Crystal Report-Load Flow Simulation for Basic Engineering Design

Date: 2 December 2004
Time: 3:58:04PM

Load Flow Summary Report

Load Flow Study Settings

Include Source Impedance	Yes	**Load Acceleration Factor**	1.00
Solution Method	Exact (Iterative)	**Bus Voltage Drop %**	5.00
Load Specification	Connected Load	**Branch Voltage Drop %**	3.00
Generation Acceleration Factor	1.00		

Swing Generators

Source	In/Out Service	Vpu	Angle	kW	kvar	VD%	Utility Impedance
TNB 1	In	1.00	0.00	4,451.0	3,459.6	1.21	0.01 +j 0.33

Buses

Bus Name	In/Out Service	Design Volts	LF Volts	Angle Degree	PU Volts	%VD
11kV Node Bus2	In	11.000	10.866	-0.82	0.99	1.22
11kV Node Bus3	In	11.000	10.867	-0.82	0.99	1.21
11kV Node Bus4	In	11.000	10.866	-0.82	0.99	1.22
11kV Node Bus7	In	11.000	10.866	-0.82	0.99	1.22
11kV Node Bus8	In	11.000	0	0.00	0.00	100.00
11kV Node Bus9	In	11.000	10.866	-0.82	0.99	1.22
11kV S'board	In	11.000	10.866	-0.82	0.99	1.21

Bus Name	In/Out Service	Design Volts	LF Volts	Angle Degree	PU Volts	%VD
3.3kV Bus1	In	3.300	3.218	-31.78	0.98	2.47
3.3kV Bus2	In	3.300	3.211	-31.93	0.97	2.68
3.3kV Node3	In	3.300	0	0.00	0.00	100.00
3.3kV Node4	In	3.300	3.219	-31.78	0.98	2.46
3.3kV Node5	In	3.300	3.212	-31.94	0.97	2.67
33kV Node Bus1	In	33.000	0	0.00	0.00	100.00
33kV Node Bus2	In	33.000	0	0.00	0.00	100.00
33kV Node Bus3	In	33.000	0	0.00	0.00	100.00
415 Node Bus5	In	415	405	-31.70	0.98	2.36
415V Bus1	In	415	402	-31.63	0.97	3.17
415V Bus2	In	415	402	-31.63	0.97	3.17
415V Node Bus4	In	415	405	-31.70	0.98	2.36
BUS-33kV	In	33.000	0	0.00	0.00	100.00

Cables

From Bus To Bus	Component Name	In/Out Service	%VD	kW Loss	kvar Loss	kVA Loss	LF Amps Rating %	PF
11kV Node Bus3 11kV S'board	11a	In	0.01	4,451.0 0.3	3,459.6 0.3	5,637.4 0.4	299.5 0.0	0.79
11kV S'board 11kV Node Bus2	11/3.3b	In	0.00	1,862.8 0.0	1,454.3 0.0	2,363.3 0.1	125.6 0.0	0.79
11kV S'board 11kV Node Bus4	11/415a	In	0.00	493.1 0.0	380.8 0.0	623.0 0.0	33.1 0.0	0.79
11kV S'board	11/415b	In	0.00	493.1	380.8	623.0	33.1	0.79

From Bus To Bus	Component Name	In/Out Service	%VD	kW Loss	kvar Loss	kVA Loss	LF Amps Rating %	PF
11kV Node Bus7				0.0	0.0	0.0	0.0	
11kV S'board 11kV Node Bus9	11/3.3a	In	0.00	1,601.6 0.0	1,243.4 0.0	2,027.6 0.0	107.7 0.0	0.79
3.3kV Node4 3.3kV Bus1	3.3a	In	0.01	1,601.6 0.2	1,201.2 0.1	2,002.0 0.2	359.1 0.0	0.80
3.3kV Node5 3.3kV Bus2	3.3b	In	0.01	1,862.8 0.2	1,397.1 0.2	2,328.4 0.3	418.6 0.0	0.80
415 Node Bus5 415V Bus2	11/415b2	In	0.81	493.1 4.5	368.9 2.5	615.8 5.2	877.4 0.0	0.80
415V Node Bus4 415V Bus1	11/415a2	In	0.81	493.1 4.5	368.9 2.5	615.8 5.2	877.4 0.0	0.80

2-Winding Transformers

From Bus To Bus	Component Name	In/Out Service	%VD	kW Loss	kvar Loss	kVA Loss	LF Amps Rating %	PF
11kV Node Bus 3.3kV Node5	11/3.3 kV TxB	In	1.45	1,862.8 0.0	1,454.3 57.2	2,363.2 57.2	126.0 39.9	0.79
11kV Node Bus 415V Node Bus	11/0.415 Tx1A	In	1.15	493.1 0.0	380.8 11.9	623.0 11.9	33.0 31.5	0.79
11kV Node Bus 415 Node Bus5	11/0.415 Tx1B	In	1.15	493.1 0.0	380.8 11.9	623.0 11.9	33.0 31.5	0.79
11kV Node Bus 3.3kV Node4	11/3.3kV TxA	In	1.25	1,601.6 0.0	1,243.3 42.1	2,027.6 42.1	108.0 34.2	0.79

APPENDIX 12

Crystal Report-Load Flow Simulation for Detail Engineering Design

Date: 2 December 2004
Time: 4:07:54PM

Load Flow Summary Report

Load Flow Study Settings

Include Source Impedance	Yes	Load Acceleration Factor	1.00
Solution Method	Exact (Iterative)	Bus Voltage Drop %	5.00
Load Specification	1st Level Demand or Energy Factor	Branch Voltage Drop %	3.00
Generation Acceleration Factor	1.00		

Swing Generators

Source	In/Out Service	Vpu	Angle	kW	kvar	VD%	Utility Impedance
TNB	In	1.00	0.00	6,102.3	1,681.0	2.06	0.33 +j 0.01

Buses

Bus Name	In/Out Service	Design Volts	LF Volts	Angle Degree	PU Volts	%VD
11kV Node Bus1	In	11.000	10.763	0.26	0.98	2.16
11kV Node Bus2	In	11.000	10.763	0.26	0.98	2.15
11kV Node Bus3	In	11.000	10.773	0.28	0.98	2.06
11kV Node Bus4	In	11.000	10.764	0.26	0.98	2.14
11kV Node Bus5	In	11.000	10.764	0.26	0.98	2.15
11kV S'board A	In	11.000	10.764	0.26	0.98	2.14
11kV S'board B	In	11.000	10.764	0.26	0.98	2.14

Bus Name	In/Out Service	Design Volts	LF Volts	Angle Degree	PU Volts	%VD
3.3 kV Bus1	In	3.300	3.340	-1.68	1.01	-1.21
3.3kV Bus2	In	3.300	3.351	-1.14	1.02	-1.55
3.3kV Node1	In	3.300	3.341	-1.67	1.01	-1.24
3.3kV Node2	In	3.300	3.352	-1.14	1.02	-1.56
415 V Bus1	In	415	421	-0.97	1.01	-1.41
415V Bus2	In	415	419	-1.83	1.01	-1.05
415V Node Bus1	In	415	423	-0.92	1.02	-1.81
415V Node Bus2	In	415	422	-1.72	1.02	-1.71
415V Node Bus3	In	415	429	-3.71	1.03	-3.31
415V Node Bus4	In	415	420	-5.27	1.01	-1.14

Cables

From Bus To Bus	Component Name	In/Out Service	%VD	kW Loss	kvar Loss	kVA Loss	LF Amps Rating %	PF
11kV Node Bus3 11kV S'board A	11a	In	0.08	6,102.3 4.4	1,681.0 3.5	6,329.6 5.6	339.2 0.0	0.96
11kV S'board A 11kV Node Bus1	11/3.3a1	In	0.01	2,718.5 0.3	882.7 0.3	2,858.3 0.4	153.3 0.0	0.95
11kV S'board A 11kV Node Bus4	11/415a1	In	0.00	524.8 0.0	77.9 0.0	530.6 0.0	28.5 0.0	0.99
11kV S'board B 11kV Node Bus2	11/3.3b1	In	0.01	1,973.1 0.2	604.5 0.1	2,063.6 0.2	110.7 0.0	0.96
11kV S'board B 11kV Node Bus5	11/415b1	In	0.00	881.5 0.0	112.4 0.0	888.6 0.0	47.7 0.0	0.99

From Bus To Bus	Component Name	In/Out Service	%VD	kW Loss	kvar Loss	kVA Loss	LF Amps Rating %	PF
3.3kV Node1 3.3 kV Bus1	11/3.3a2	In	0.03	2,718.1 0.6	782.1 0.6	2,828.4 0.8	488.8 0.0	0.96
3.3kV Node2 3.3kV Bus2	11/3.3b2	In	0.02	1,972.8 0.3	552.0 0.3	2,048.6 0.4	352.9 0.0	0.96
415V Node Bus1 415 V Bus1	11/415a2	In	0.39	524.8 2.0	66.8 0.8	529.0 2.1	722.9 0.0	0.99
415V Node Bus2 415V Bus2	11/415b2	In	0.65	881.4 5.5	81.5 2.2	885.2 5.9	1,210.8 0.0	1.00

2-Winding Transformers

From Bus To Bus	Component Name	In/Out Service	%VD	kW Loss	kvar Loss	kVA Loss	LF Amps Rating %	PF
11kV Node Bus 3.3kV Node1	Tx 11/3.3 kV A	In	-3.39	2,718.2 0.1	882.4 100.4	2,857.9 100.4	153.0 57.3	0.95
11kV Node Bus 3.3kV Node2	Tx 11/3.3kV B	In	-3.72	1,972.9 0.1	604.3 52.3	2,063.4 52.3	111.0 41.3	0.96
11kV Node Bus 415V Node Bus	Tx 11/0.415 A	In	-3.95	524.8 0.0	77.9 11.0	530.6 11.0	28.0 33.9	0.99
11kV Node Bus 415V Node Bus	Tx 11/0.415 B	In	-3.85	881.4 0.0	112.4 30.9	888.6 30.9	48.0 56.8	0.99
3.3 kV Bus1 415V Node Bus	Tx VFD A	In	-2.10	283.8 0.0	182.2 13.9	337.2 13.9	58.0 83.3	0.84
3.3kV Bus2 415V Node Bus	Tx VFD B	In	0.41	567.6 0.1	394.7 57.9	691.3 57.9	119.0 170.2	0.82

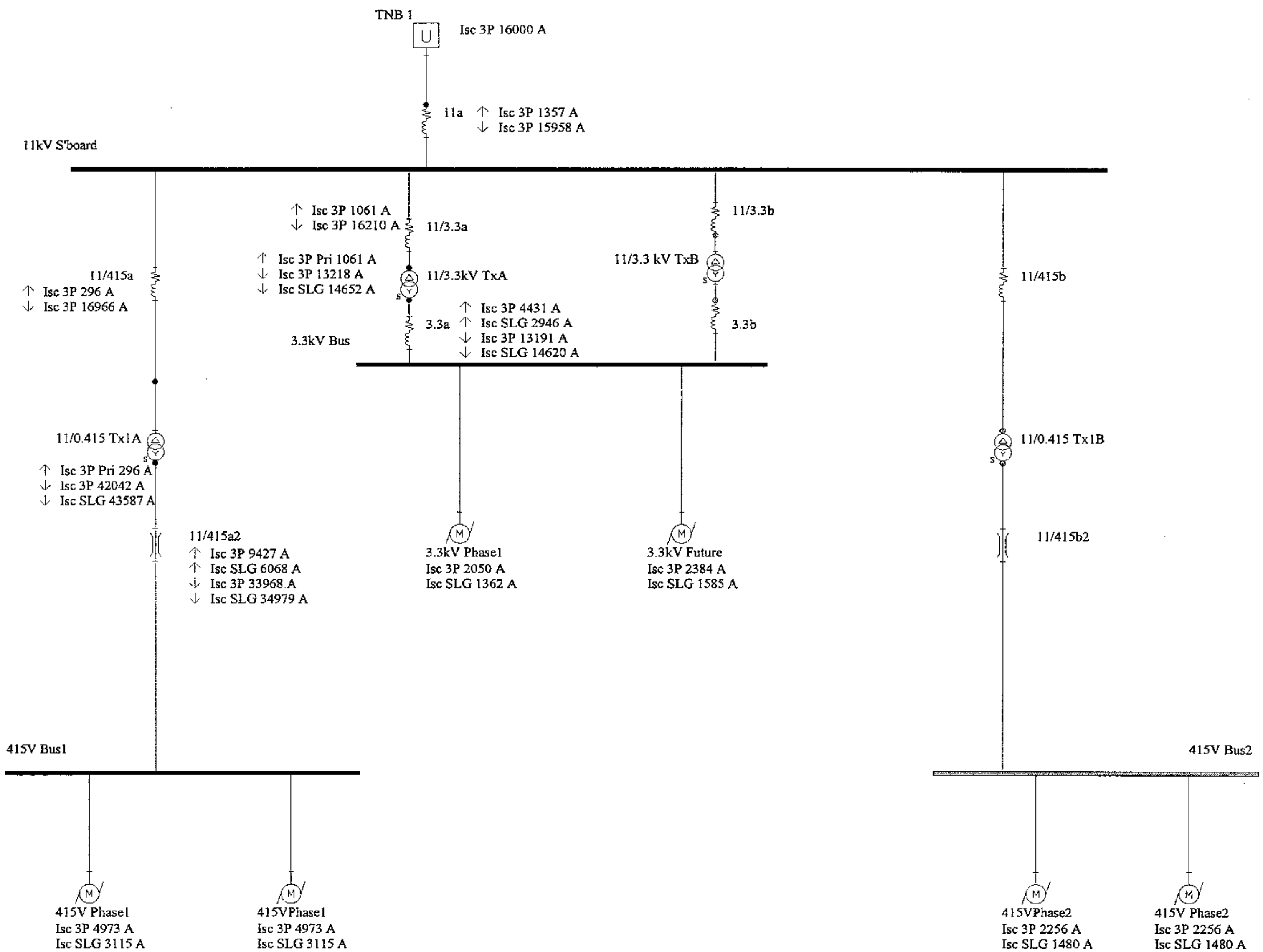
Pi Impedances

From Bus To Bus	Component Name	%VD	kW Loss	kvar Loss	kVA Loss	LF Amps Rating %	PF
11kV S'board A	PI-1	0.00	2,854.5	716.9	2,943.2	157.9	0.97
11kV S'board B			0.0	0.0	0.0	0.6	
3.3kV Bus2	PI-2	0.00	0.0	0.0	0.0	0.0	0.00
3.3 kV Bus1			0.0	0.0	0.0	0.0	
415V Bus2	PI-3	0.00	0.0	0.0	0.0	0.0	0.00
415 V Bus1			0.0	0.0	0.0	0.0	

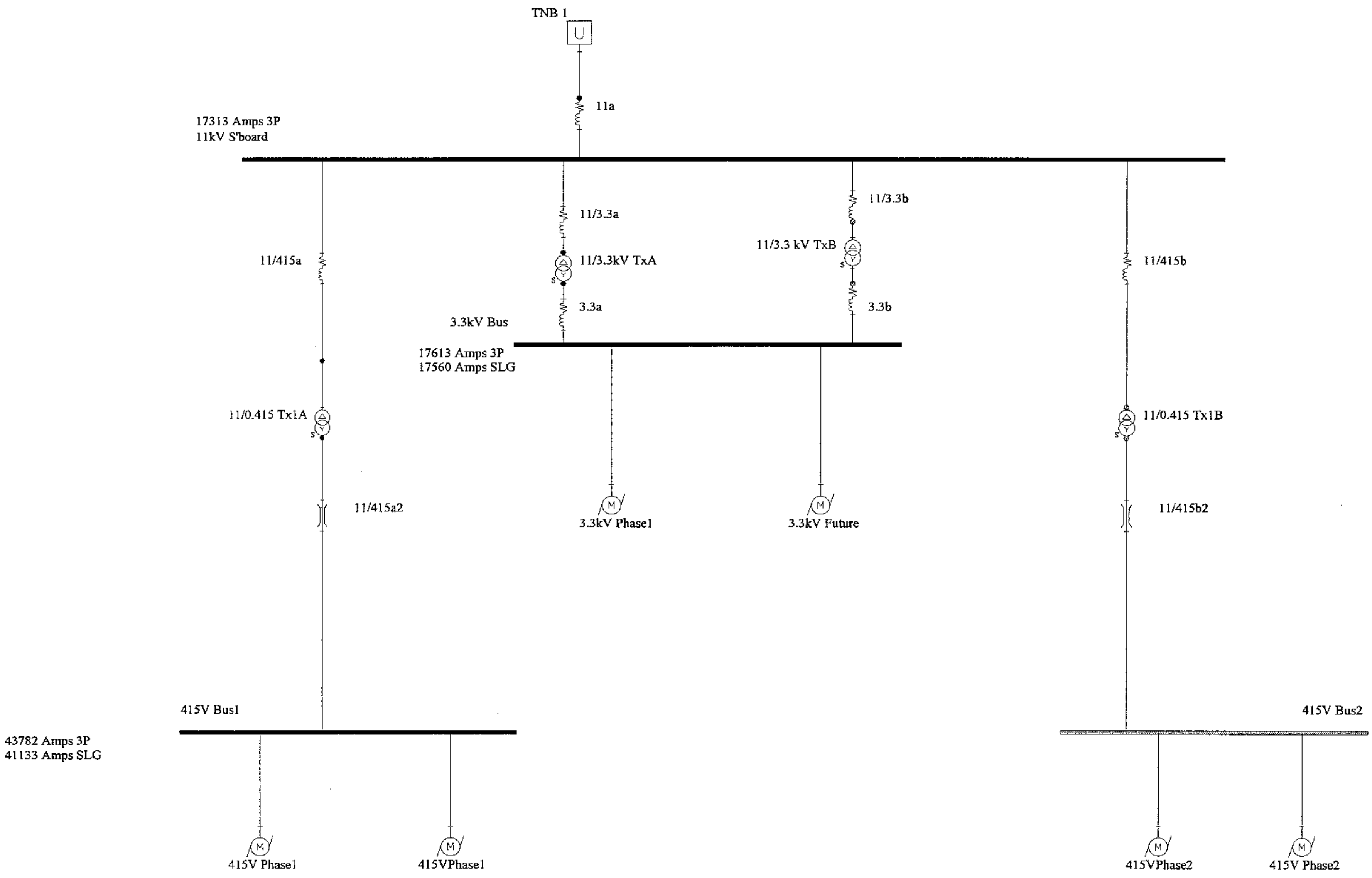
APPENDIX 13

Simulation Diagrams-Branch and Bus Fault Currents
for Basic Engineering Design

TNB 11kV (Phase 1- Phase 2)

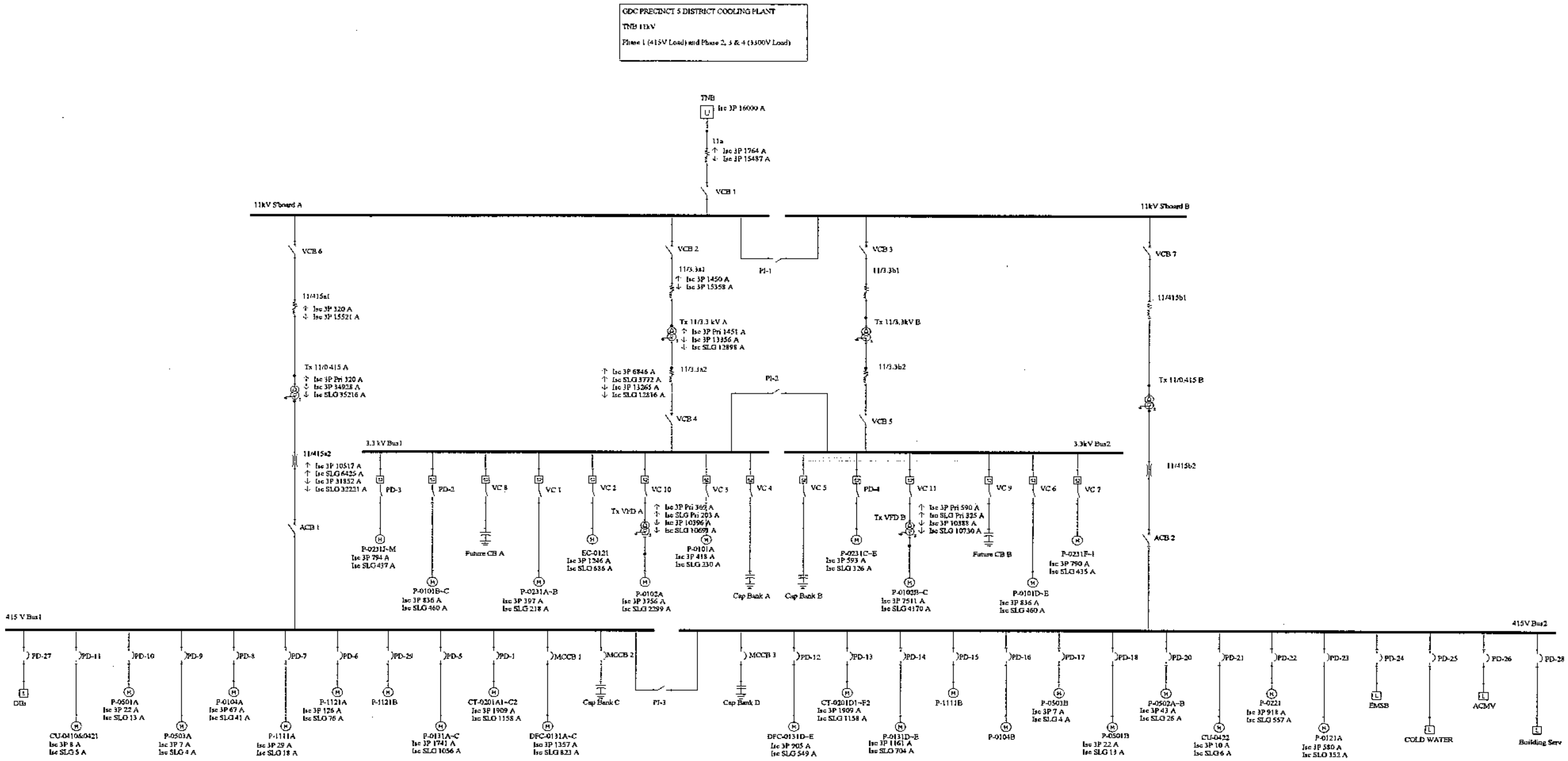


TNB 11kV (Phase 1- Phase 2)

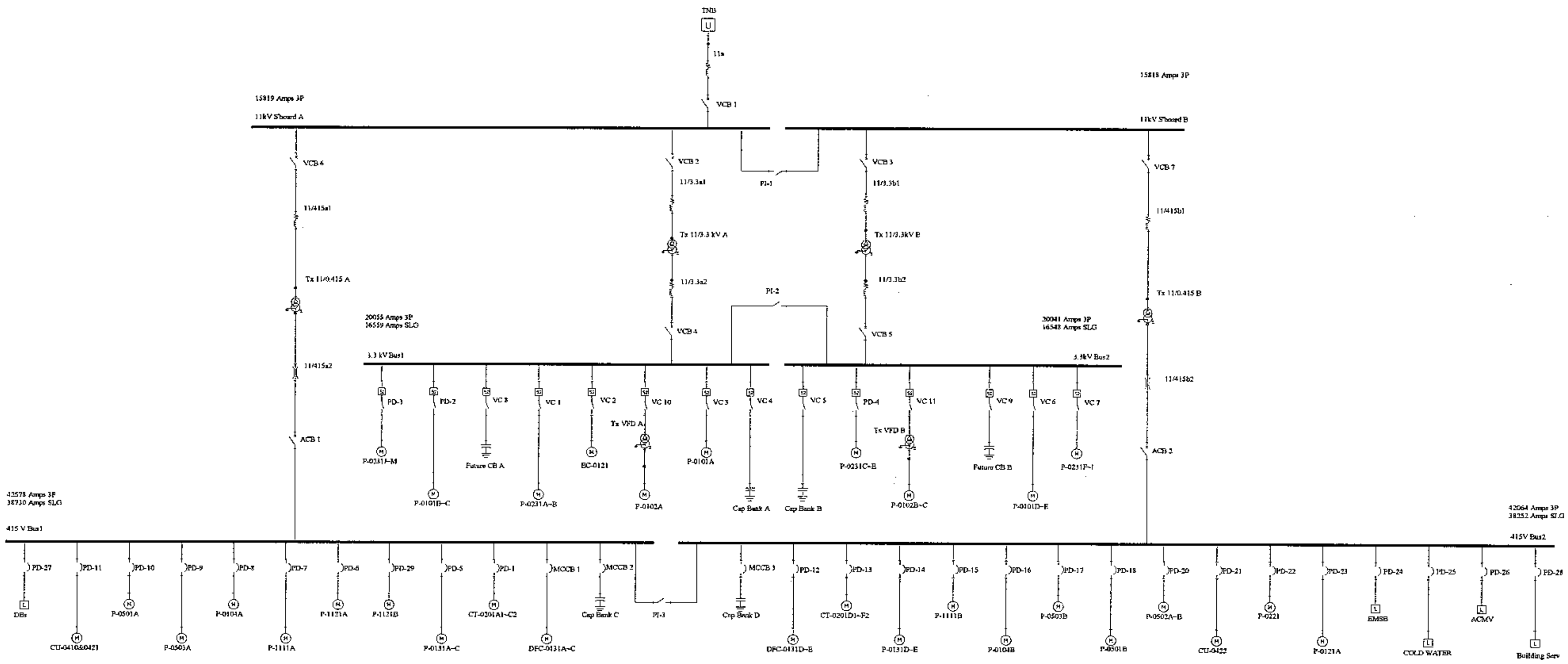


APPENDIX 14

Simulation Diagrams-Branch and Bus Fault Currents for Detail Engineering Design

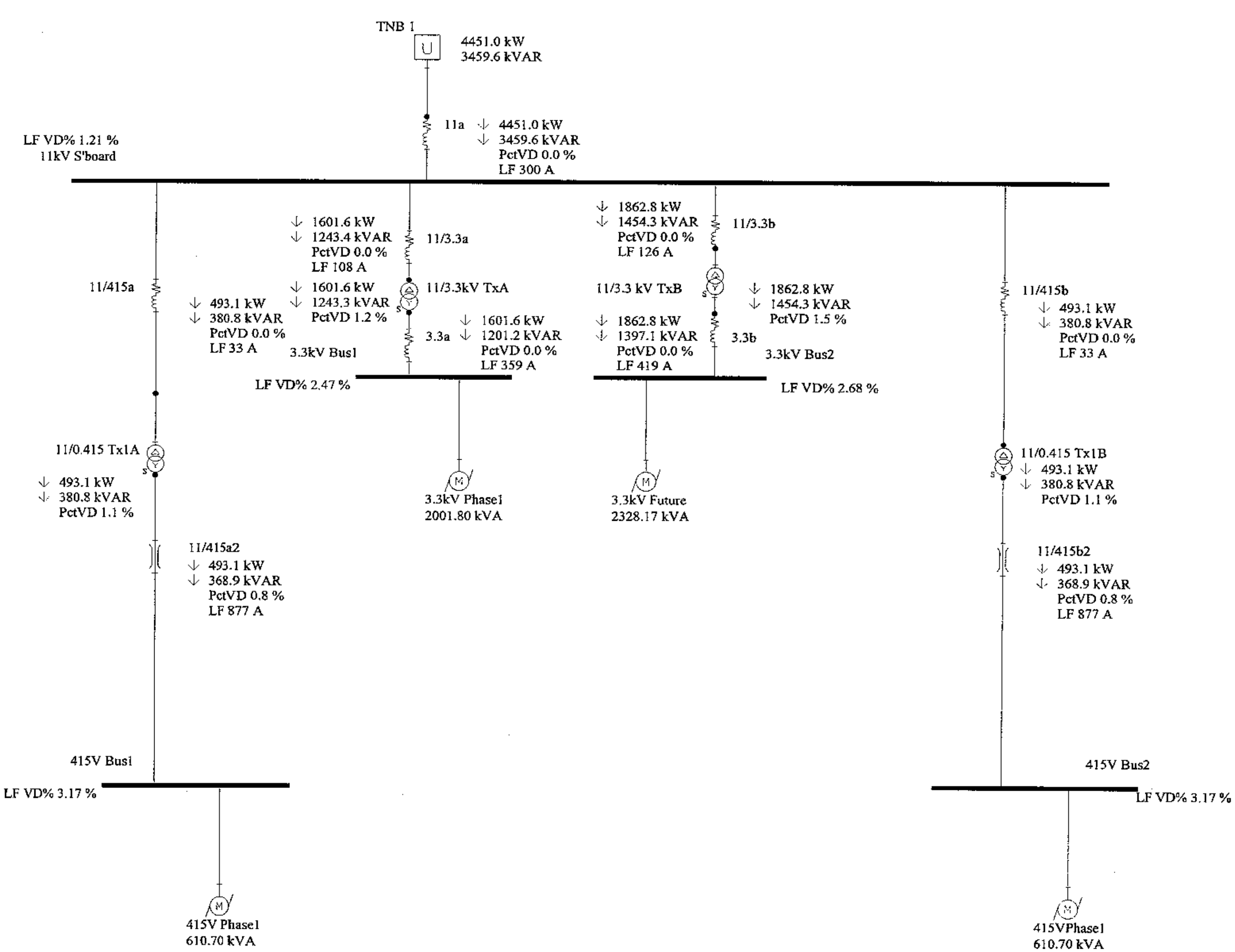

GDC PRECINCT 5 DISTRICT COOLING PLANT
TNB 11kV
Phase 1 (415V Load) and Phase 2, 3 & 4 (3300V Load)
TNB
Isc 3P 16000 A
11a
Isc 3P 1764 A
Isc 3P 15487 A
VCB 1
11kV S'board A
11kV S'board B
VCB 6
VCB 2
VCB 3
VCB 7
PI-1
11/3.3a1
Isc 3P 1450 A
Isc 3P 15358 A
11/3.3b1
11/415a1
Isc 3P 320 A
Isc 3P 15521 A
11/415b1
Tx 11/3.3 kV A
Isc 3P Pri 1451 A
Isc 3P 13356 A
Isc SLG 12898 A
Tx 11/3.3kV B
Tx 11/0.415 A
Isc 3P Pri 320 A
Isc 3P 34928 A
Isc SLG 35216 A
Tx 11/0.415 B
Isc 3P 6846 A
Isc SLG 3772 A
Isc 3P 13265 A
Isc SLG 12816 A
11/3.3a2
11/3.3b2
PI-2
VCB 4
VCB 5
3.3 kV Bus1
3.3kV Bus2
11/415a2
Isc 3P 10517 A
Isc SLG 6425 A
Isc 3P 31852 A
Isc SLG 32221 A
11/415b2
ACB 1
ACB 2
PD-3
PD-2
VC 8
VC 1
VC 2
VC 10
VC 3
VC 4
VC 5
PD-4
VC 11
VC 9
VC 6
VC 7
Tx VFD A
Isc 3P Pri 369 A
Isc SLG Pri 203 A
Isc 3P 10396 A
Isc SLG 10691 A
Tx VFD B
Isc 3P Pri 590 A
Isc SLG Pri 325 A
Isc 3P 10383 A
Isc SLG 10730 A
P-0231J~M
Isc 3P 794 A
Isc SLG 437 A
P-0101B~C
Isc 3P 836 A
Isc SLG 460 A
Future CB A
P-0231A~B
Isc 3P 397 A
Isc SLG 218 A
EC-0121
Isc 3P 1246 A
Isc SLG 686 A
P-0102A
Isc 3P 3756 A
Isc SLG 2299 A
P-0101A
Isc 3P 418 A
Isc SLG 230 A
Cap Bank A
Cap Bank B
P-0231C~E
Isc 3P 593 A
Isc SLG 326 A
P-0102B~C
Isc 3P 7511 A
Isc SLG 4170 A
Future CB B
P-0101D~E
Isc 3P 836 A
Isc SLG 460 A
P-0231F~I
Isc 3P 790 A
Isc SLG 435 A
415 V Bus1
415V Bus2
PD-27
PD-11
PD-10
PD-9
PD-8
PD-7
PD-6
PD-29
PD-5
PD-1
MCCB 1
MCCB 2
PI-3
MCCB 3
PD-12
PD-13
PD-14
PD-15
PD-16
PD-17
PD-18
PD-20
PD-21
PD-22
PD-23
PD-24
PD-25
PD-26
PD-28
DBs
CU-0410&0421
Isc 3P 8 A
Isc SLG 5 A
P-0501A
Isc 3P 22 A
Isc SLG 13 A
P-0503A
Isc 3P 7 A
Isc SLG 4 A
P-0104A
Isc 3P 67 A
Isc SLG 41 A
P-1111A
Isc 3P 29 A
Isc SLG 18 A
P-1121A
Isc 3P 126 A
Isc SLG 76 A
P-1121B
P-0131A~C
Isc 3P 1741 A
Isc SLG 1056 A
CT-0201A1~C2
Isc 3P 1909 A
Isc SLG 1158 A
DFC-0131A~C
Isc 3P 1357 A
Isc SLG 823 A
Cap Bank C
Cap Bank D
DFC-0131D~E
Isc 3P 905 A
Isc SLG 549 A
CT-0201D1~F2
Isc 3P 1909 A
Isc SLG 1158 A
P-0131D~E
Isc 3P 1161 A
Isc SLG 704 A
P-1111B
P-0104B
P-0503B
Isc 3P 7 A
Isc SLG 4 A
P-0501B
Isc 3P 22 A
Isc SLG 13 A
P-0502A~B
Isc 3P 43 A
Isc SLG 26 A
CU-0422
Isc 3P 10 A
Isc SLG 6 A
P-0221
Isc 3P 918 A
Isc SLG 557 A
P-0121A
Isc 3P 580 A
Isc SLG 352 A
EMSB
COLD WATER
ACMV
Building Serv

GDC PRECINCT 5 DISTRICT COOLING PLANT
TNB 11kV
Phase 1 (415V Load) and Phase 2, 3 & 4 (3300V Load)



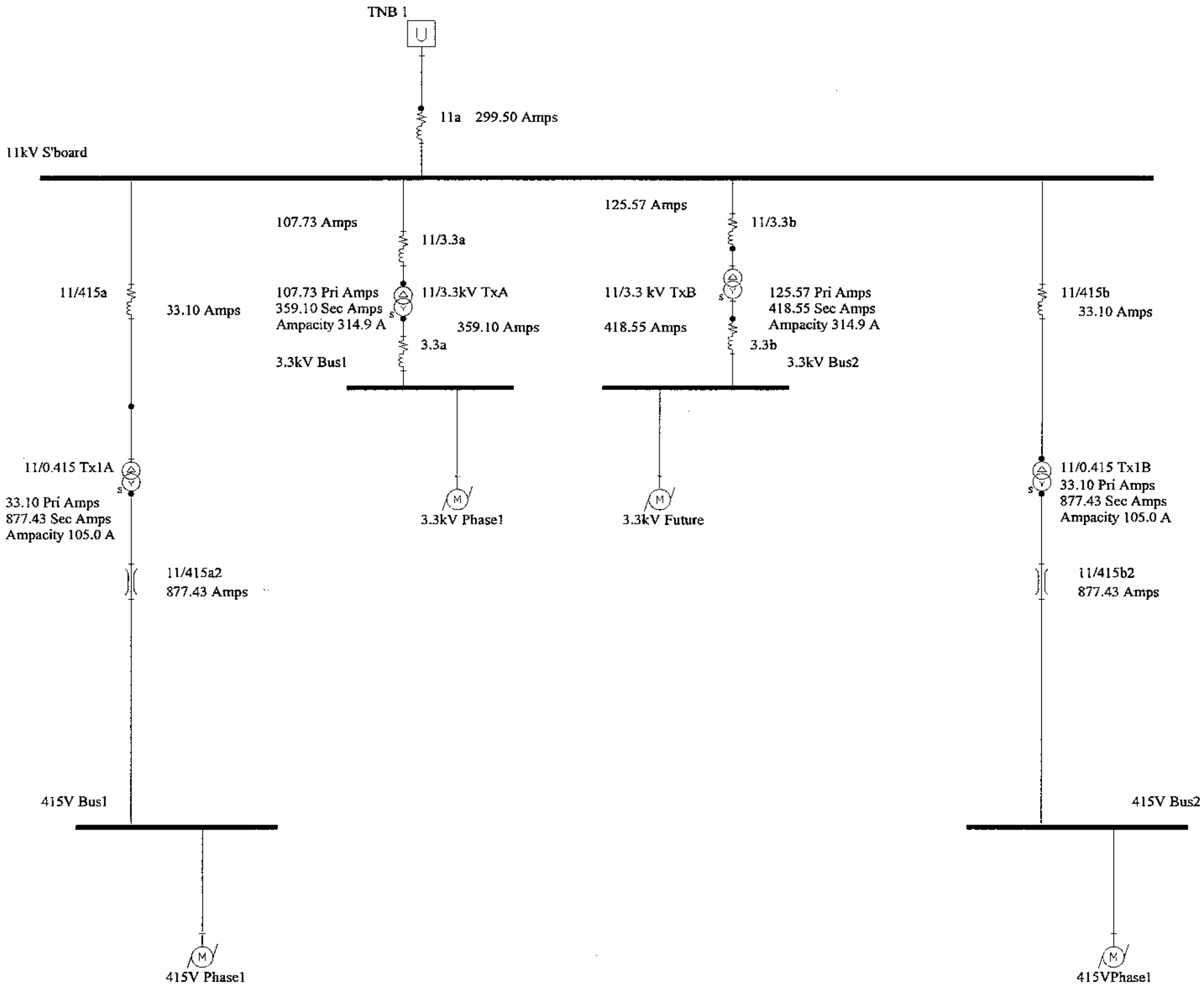
APPENDIX 15

Simulation Diagrams-Load Flow Study without Power Factor Correction for Basic Engineering Design



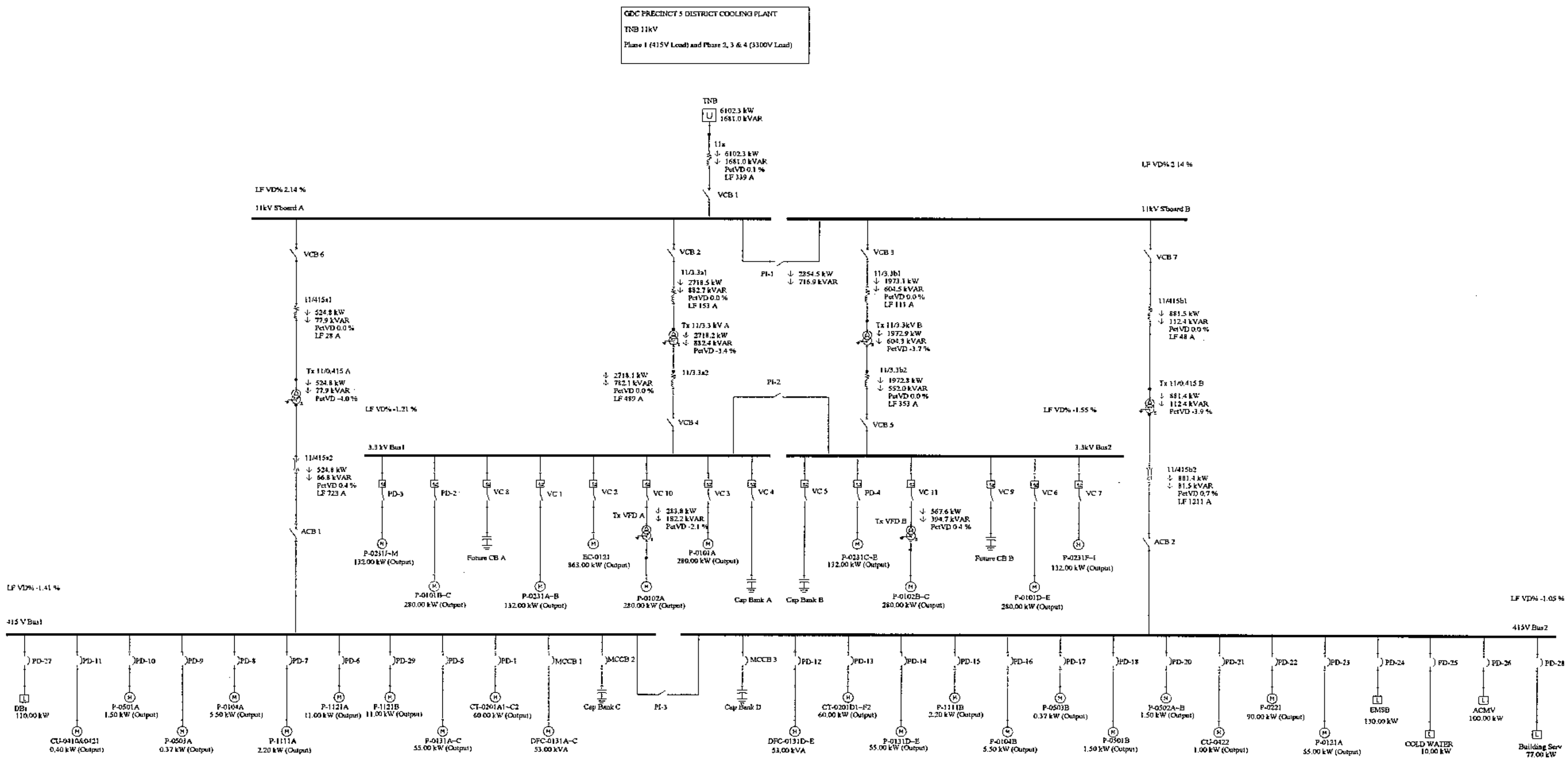
TNB 1
4451.0 kW
3459.6 kVAR
11a
4451.0 kW
3459.6 kVAR
PctVD 0.0 %
LF 300 A
LF VD% 1.21 %
11kV S'board
11/415a
1601.6 kW
1243.4 kVAR
PctVD 0.0 %
LF 108 A
11/3.3a
11/3.3kV TxA
1601.6 kW
1243.3 kVAR
PctVD 1.2 %
493.1 kW
380.8 kVAR
PctVD 0.0 %
LF 33 A
3.3a
1601.6 kW
1201.2 kVAR
PctVD 0.0 %
LF 359 A
3.3kV Bus1
LF VD% 2.47 %
3.3kV Phase1
2001.80 kVA
1862.8 kW
1454.3 kVAR
PctVD 0.0 %
LF 126 A
11/3.3b
11/3.3 kV TxB
1862.8 kW
1454.3 kVAR
PctVD 1.5 %
1862.8 kW
1397.1 kVAR
PctVD 0.0 %
LF 419 A
3.3b
3.3kV Bus2
LF VD% 2.68 %
3.3kV Future
2328.17 kVA
11/415b
493.1 kW
380.8 kVAR
PctVD 0.0 %
LF 33 A
11/0.415 Tx1A
493.1 kW
380.8 kVAR
PctVD 1.1 %
11/0.415 Tx1B
493.1 kW
380.8 kVAR
PctVD 1.1 %
11/415a2
493.1 kW
368.9 kVAR
PctVD 0.8 %
LF 877 A
11/415b2
493.1 kW
368.9 kVAR
PctVD 0.8 %
LF 877 A
415V Bus1
LF VD% 3.17 %
415V Bus2
LF VD% 3.17 %
415V Phase1
610.70 kVA
415VPhase1
610.70 kVA

TNB 11kV (Phase 1- Phase 2)

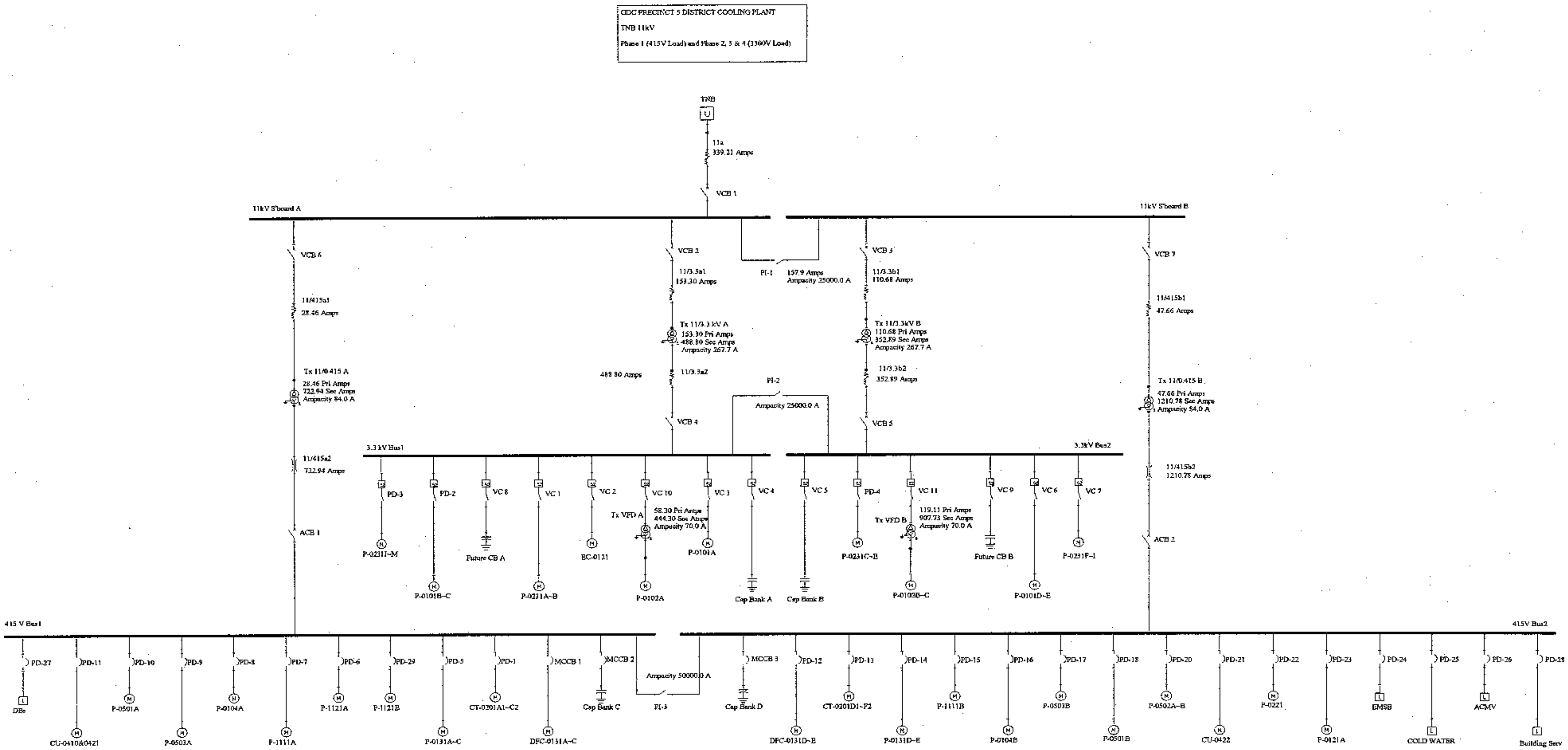


APPENDIX 16

Simulation Diagrams-Load Flow Study with Power Factor Correction for Detail Engineering Design



GDC PRECINCT 5 DISTRICT COOLING PLANT
TNB 11kV
Phase 1 (415V Load) and Phase 2, 3 & 4 (3300V Load)
TNB
6102.3 kW
1681.0 kVAR
VCB 1
11kV S'board A
11kV S'board B
LF VD% 2.14 %
VCB 6
VCB 2
VCB 3
VCB 7
PI-1
2254.5 kW
716.9 kVAR
Tx 11/0.415 A
Tx 11/3.3kV A
Tx 11/3.3kV B
Tx 11/0.415 B
PI-2
VCB 4
VCB 5
3.3 kV Bus1
3.3kV Bus2
LF VD% -1.21 %
LF VD% -1.55 %
ACB 1
ACB 2
Tx VFD A
Tx VFD B
Future CB A
Future CB B
Cap Bank A
Cap Bank B
Cap Bank C
Cap Bank D
PI-3
415 V Bus1
415V Bus2
LF VD% -1.41 %
LF VD% -1.05 %
EMSB
COLD WATER
ACMV
Building Serv


CDC PRECINCT 5 DISTRICT COOLING PLANT
TNB 11kV
Phase 1 (415V Load) and Phase 2, 3 & 4 (3300V Load)
TNB
11a
339.21 Amps
VCB 1
11kV S'board A
11kV S'board B
VCB 6
11/415a1
28.46 Amps
Tx 11/0.415 A
28.46 Pri Amps
722.94 Sec Amps
Ampacity 84.0 A
11/415a2
722.94 Amps
ACB 1
VCB 2
11/3.3a1
153.30 Amps
Tx 11/3.3 kV A
153.30 Pri Amps
488.80 Sec Amps
Ampacity 267.7 A
488.80 Amps
11/3.3a2
VCB 4
PI-1
157.9 Amps
Ampacity 25000.0 A
PI-2
Ampacity 25000.0 A
VCB 3
11/3.3b1
110.68 Amps
Tx 11/3.3kV B
110.68 Pri Amps
352.89 Sec Amps
Ampacity 267.7 A
11/3.3b2
352.89 Amps
VCB 5
VCB 7
11/415b1
47.66 Amps
Tx 11/0.415 B
47.66 Pri Amps
1210.78 Sec Amps
Ampacity 54.0 A
11/415b2
1210.78 Amps
ACB 2
3.3 kV Bus1
3.3kV Bus2
PD-3
PD-2
VC 8
VC 1
VC 2
VC 10
VC 3
VC 4
VC 5
PD-4
VC 11
VC 9
VC 6
VC 7
Tx VFD A
58.30 Pri Amps
444.30 Sec Amps
Ampacity 70.0 A
Tx VFD B
119.11 Pri Amps
907.73 Sec Amps
Ampacity 70.0 A
P-0231I~M
P-0101B~C
Future CB A
P-0231A~B
EC-0121
P-0102A
P-0101A
Cap Bank A
Cap Bank B
P-0231C~E
P-0103B~C
Future CB B
P-0101D~E
P-0231F~1
415 V Bus1
415V Bus2
PD-27
PD-11
PD-10
PD-9
PD-8
PD-7
PD-6
PD-29
PD-5
PD-1
MCCB 1
MCCB 2
Ampacity 50000.0 A
PI-3
MCCB 3
PD-12
PD-13
PD-14
PD-15
PD-16
PD-17
PD-18
PD-20
PD-21
PD-22
PD-23
PD-24
PD-25
PD-26
PD-28
DBs
CU-0410&0421
P-0501A
P-0503A
P-0104A
P-1111A
P-1121A
P-1121B
P-0131A~C
CT-0201A1~C2
DFC-0131A~C
Cap Bank C
Cap Bank D
DFC-0131D~E
CT-0201D1~F2
P-0131D~E
P-1111B
P-0104B
P-0503B
P-0501B
P-0502A~B
CU-0422
P-0221
P-0121A
EMSB
COLD WATER
ACMV
Building Serv

APPENDIX 17

Single Line Diagrams for Basic, Detail and Construction Engineering Design

TES:

PHASE 1 EQUIPMENT SYSTEM IS SHOWN IN FIRM LINES.
THE FUTURE EQUIPMENT SYSTEM (PHASE 2,3, & 4)
IS SHOWN IN DOTTED LINES.

THE POWER FACTOR AT 33kV TNB INCOMING PANEL SHALL BE AT LEAST 0.93. IT IS CONTRACTOR'S RESPONSIBILITY TO DETERMINE THE NEEDS OF CAPACITOR FOR EACH SWITCHBOARD.

THE TRANSFORMER QUANTITY AND RATING TO BE VERIFY BY CONTRACTOR.

THE FEEDER AND MCC QUANTITY AND RATING FOR 11kV, 3.3kV AND 415V SHALL BE VERIFY BY CONTRACTOR.

FOR FUTURE INSTALLATION (SHOWN IN DOTTED LINES), FEEDERS SHALL C
ALL PHASES 2 TO 4 WHILE MCC SHALL BE INTALLED IN THEIR RESPECTIV
(MODULAR)

LEGEND

VOLTAGE TRANSFORMER

ATS SECONDARY SELECTIVE AUTOMATIC TRANSFER SYSTEM

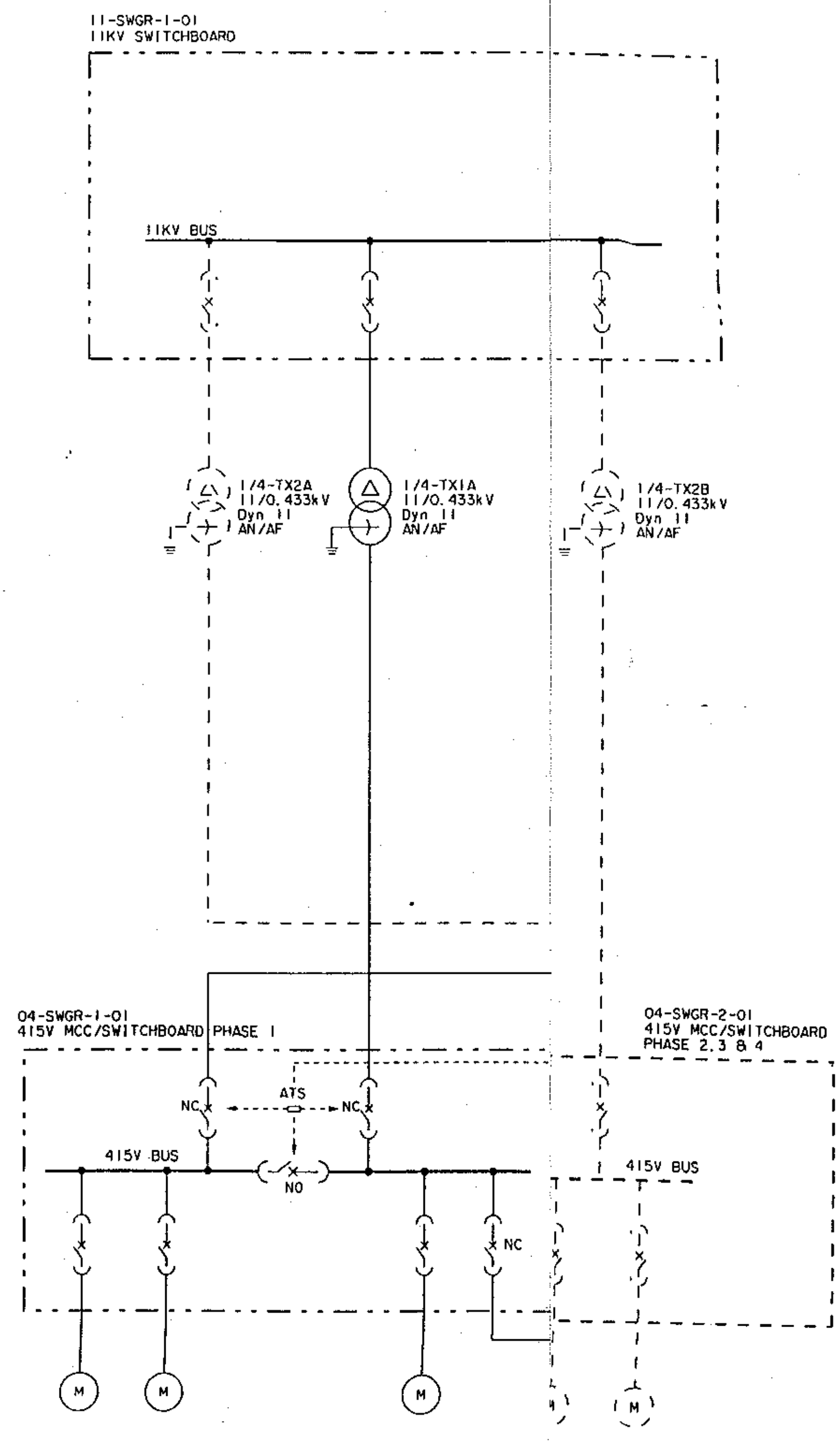
EARTHING SWITCH

CIRCUIT BREAKER

INDUCTION MOTOR

GENERATOR

TWO WINDING TRANSFORMER



Client :

GAS DISTRICT COOLING (PUTRAJAYA) SDN. BHD.
LEVEL 46, TOWER 1,
PETRONAS TWIN TOWERS,
KUALA LUMPUR CITY CENTRE,
50088 KUALA LUMPUR, MALAYSIA.
Tel No : 03-2051 7579
Fax. No: 03-2051 7600.

Consultant :

OGP Technical Services Sdn. Bhd.
LEVEL 9 to 11, TOWER 2,
PETRONAS TWIN TOWERS,
KUALA LUMPUR CITY CENTRE,
50088 KUALA LUMPUR, MALAYSIA.
Tel. No : 03-2051 7110.
Fax. No: 03-2051 7311.

For the Owner	Date
.... (Authorised Representative)	

Rev. No	Description	Date
0	ISSUED FOR ITB	29.10.03

Project Title :

PUTRAJAYA
PRECINCT 5
DISTRICT COOLING PLANT PROJECT

Drawing Title :

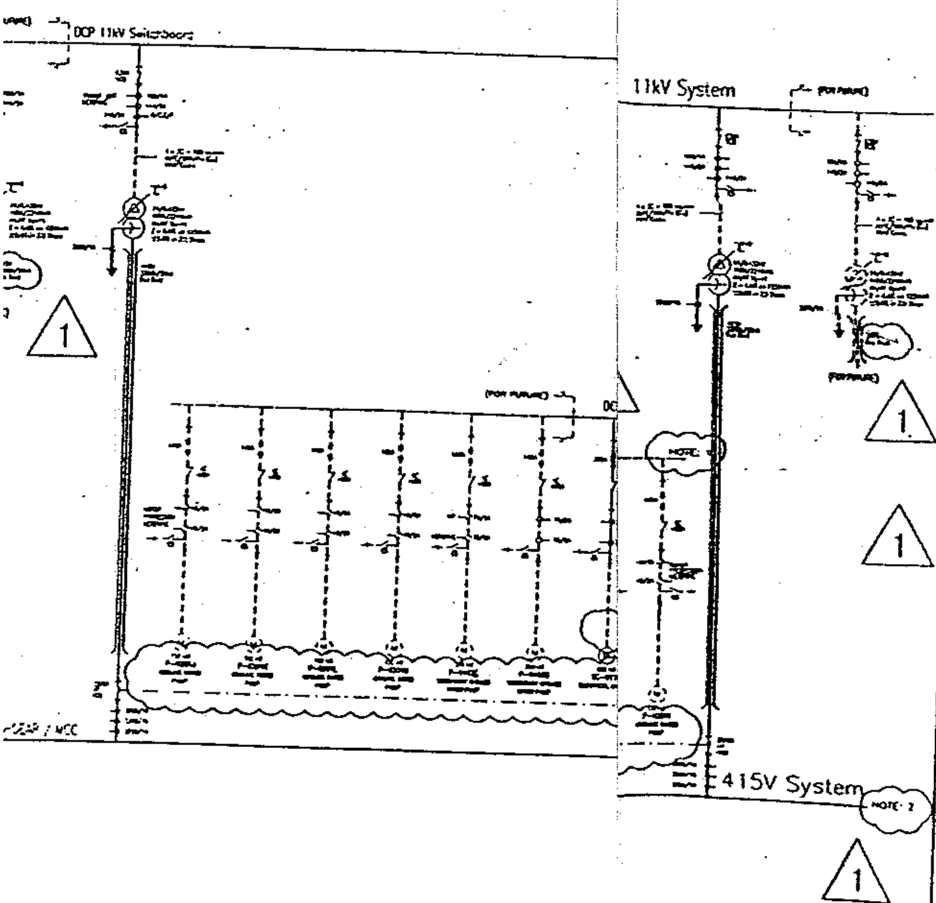
PRELIMINARY KEY
SINGLE LINE DIAGRAM

Scale :	NTS	CadFile :	
Designed :		Checked :	
Drawn		Checked :	
Approved :		Date :	
Drawing Number			

01 | 02 | 03 | 10

Note:

- The detail specification of Components, cable size, etc. will be fixed at the future stage.
- Refer to drawing no.: E/SCC/PJP5(CP)/E/003 for details.
- Refer to drawing no.: E/SCC/PJP5(CP)/E/002 for details.



Concessionaire :

GAS DISTRICT COOLING (PUTRAJAYA)

GAS DISTRICT COOLING (PUTRAJAYA) SDN. BHD.

Project Management Consultant :

OGP Technical Services Sdn Bhd

EPCC Contractor :

STEAMLINE (M) - SHINRYO (M) CONSORTIUM

Architect :

SNO ARCHITECTS SDN BHD

C&S Consultant :

TG TAN CONSULT

M&E Consultant :

For the Owner	Date
(Authorised Representative)	

- A APPROVED
- B APPROVED WITH COMMENTS
- C REVIEWED
- D REJECTED, REVISED AND RESUBMIT

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APPROVAL		Signature	Date
PMC	Civil / Building		
	Electrical		
	Instrument		
	Process		
	Mech. / Piping		
	Project Manager		
GDC	Civil / Building		
	Mech. / Process		
	Instrument		
	Electrical		
	Package Leader		
	Project Manager		

REFERENCE DRAWING NO.

E/SSC/PJP5(CP)/E/002, 003, 004, 013 & 014

Rev.	Description	Checked	Date
1	RESUBMIT FOR APPROVAL		06/05/04
0	ISSUE FOR APPROVAL		09/04/04

Project Title :

PUTRAJAYA PRECINCT 5
DISTRICT COOLING PLANT PROJECT
(CHILLER PLANT PACKAGE)

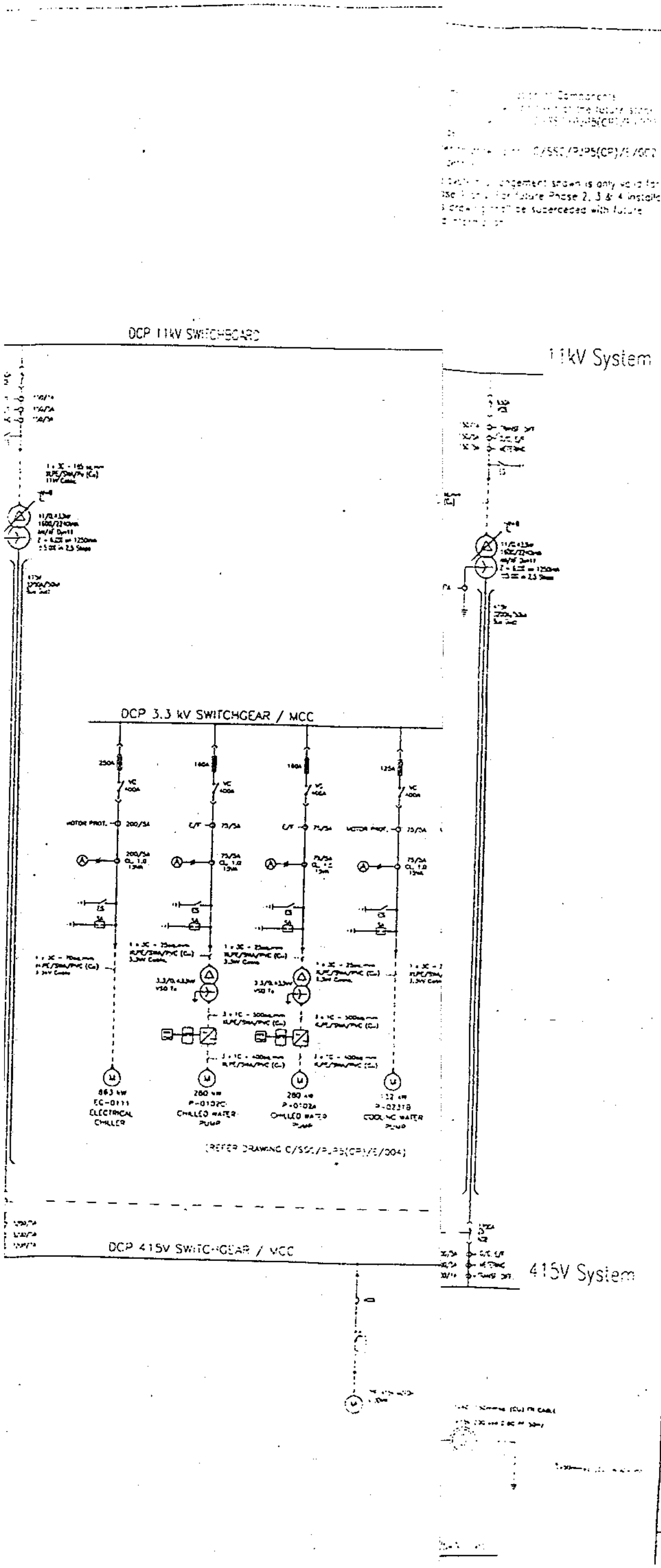
Drawing Title :

ELECTRICAL SYSTEM
SINGLE LINE DIAGRAM

Drawing Category :

ENGINEERING

Scale : NTS	CadFile : EPJP5CPE001R1
Drawn by : Aishah	Approved By :
Designed By : CHAN SH	Date : MAY '04
Drawing Number : E/SSC/PJP5(CP)/E/001	Revision : 1
Client Drawing Number :	Revision :



GAS

STEAMLINE (M) - SHINRYO (M) CONSORTIUM

SNO ARCHITECTS SDN BHD

TG TAN CONSULT

M&E Consultant

For the Owner | Date

(Authorized Representative)

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B APPROVED WITH COMMENTS

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PMC	Civil / Building		
	Electrical		
	Instrument		
	Process		
	Mech / Piping		
	Project Manager		
GDC	Civil / Building		
	Mech / Process		
	Instrument		
	Electrical		
	[illegible] Leader		
	Project Manager		

REFERENCE DRAWING NO.

PUTRAJAYA PRECINCT 5
DISTRICT COOLING PLANT PROJECT
(CHILLER PLANT PACKAGE)

... ELECTRICAL SYSTEM
... LINE DIAGRAM
PHASE 1

CONSTRUCTION

APPENDIX 18

Putrajaya Precinct 5 Gas District Cooling Plant

Layout