Power System Study
for the
Meranto 2975 Zone Reservoir
Las Vegas, Nevada

Resubmittal

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The following is a general response to several comments by LVVWD found throughout the submitted Power System Study:

1) The Power System Study provided was designed to model unique devices (motors, circuit breakers, cables, etc.) as found on the single line provided. Repeated devices (such as motors) were not modeled multiple times, but rather included as a group device (M GROUP – 14.25HP) and evaluated as part of the Short Circuit Study. The practice of performing the Power System Study in this manner is not uncommon.

2) The comment "Please re-evaluate after MCC1-Main recommended setting" with regards to the 15E FG Feeder Fuse is unclear. In addition, a comment was found on the "TX-1 500KVA HV" Time Current Curve referring that the setting of MCC1-Main be based on the (results) of the load flow (study). The practice referred to is uncommon; and the results of the Coordination Analysis should have been explained better on our part.

   In the Coordination Analysis, the Single Line was evaluated based on what was presented by the Design Engineer of Record; on the 12kV side, a 175E main fuse, a 15E feeder fuse, a 500kVA transformer, and on the secondary 480V side, a GE 600A SGL Spectra series breaker.

   Generally, a 480V main breaker would not re-sized based on the load flow analysis as this type of study does not address future growth of the plant, and generally design intentions are not known. Any recommendations conveyed as part of this study to change the size of the 480V MCC1 Main breaker might be easily defeated by operations personnel, such as by changing a breaker's programmer setting from 0.85 Long Time pickup (for 510A - arbitrary) to 1.0 Long Time pickup (for 600A). In fact, many jurisdictions do not allow breaker programmers to be set at long-time pickup settings that are less than 100% of the rating plug itself. Therefore, the Coordination Analysis provided in this study recommended the setting of MCC1 Main breaker to a long-time setting of 100% of the value as indicated on the Single Line Diagram.

   Next, the 500kVA transformer's primary side feeder fuse in the 12kV switchgear was evaluated based on characteristics related to the transformer itself and the general settings of MCC1's 600A Main breaker. The selection and recommendation of a 30E fuse is based on full load current of 23.1A @ 12.47kV. This is actually one size up from a 25E Fuse, yet is not outside the code allowable value of 300% of primary with max 125% protection on the secondary.

It should be noted that the written report references ANSI C37.010 for evaluating transformer curves. This statement in the report was incorrect, and in fact the study was performed using the curves from the ANSI/IEEE C57.109 standard for oil filled transformers (see the equipment database tables – transformers section).

In addition, the 500kVA transformer's ground impedance was left at "0" to simulate a fault within the first 10% region of the secondary winding. Faults occurring within in this region are difficult to capture by protective devices since one must account for the turns-ratio of the transformer and a lower voltage potential across fewer secondary windings. It is for this reason that there are two transformer curves on each Time Current Curve. The first (and right most) curve represents the transformer's 100% rating, while the second (left most) curve represents the 58% or 87% curve (depending on Transformer configuration). An appropriately rated fuse (curve) will pass just under, and to the left of, the left most line transformer damage curve line for a Delta-Wye configured transformer.

The next step is to evaluate the transformer's inrush point with respect to the primary-side protective device. The inrush point should be to the left of the selected device's protective curve.

Lastly, a comparison of the primary side device is made with respect to the secondary side protective device. The secondary side device does not specifically protect the transformer from instantaneous faults, but rather long-time overload conditions. Therefore, it is unlikely that one could set the secondary protective device to a value greater than the inrush current of the transformer (in fact, no "transformer" inrush current passes through the secondary device). One should consider that transformer inrush is unrelated to load inrush current (such as inrush current created by 480V motors in this particular system). Typically, transformer inrush current is greater during low load or non-load conditions than during partial or fully loaded conditions. It is for this reason that the MCC1 main breaker is set to coordinate with down-stream loads only.

Therefore, the basis of the final fuse selection and recommendation is derived from all of the above considerations. It is desired that minimal overlap occur between a secondary and primary protective device, and that the fuse must provide appropriate instantaneous fault protection for the transformer. By implementing the recommended fuse, it is less likely that changes to the downstream system will adversely affect the overall desired coordination.

Specific responses to comments by LVVWD:

1) Sheet R-1
The recommendation has been re-written to specifically state that an S&C, SMU-40, Slow-Speed 30E fuse should be implemented on the primary side of the 500kVA transformer.

2) Sheet I-1
Motors have been re-entered as 94.5% efficiency; all motors have been entered and modeled individually (not as a group) in the resubmittal of the Power System Study. The impact of these changes affected the calculated short circuit current contribution by reducing it from 12.89kA on the MCC1 bus to 12.83kA

3) Sheet SC-2
ANSI C37.010 has been changed to ANSI/IEEE C57.109. ANSI/IEEE C57.109 was used for the 500kVA transformer in the original Power System Study.

4) Sheet SC-4 / Table SCI-2
The value of 3600RPM for 250HP motors in Table SCI-2 are not applicable to the motors modeled in the Power System Study. The modeled motors in the Meranto study used Motor Code "4" – Induction Motor Group <50 HP, 1.67Xd" for First cycle Low Voltage Interrupting and Momentary Duty ratings. This table is "generic" and for use with a much broader scope of motors not necessarily described in this project.

5) Sheet SCA-3 / Table SCA-1
The values in Table SCA-1 are for "general" reference. Actual breaker characteristics were modeled in the Power System Study based on manufacturer datasheets (in this case GE). ESA's EasyPower software database contains virtually every all manufacturer's breakers, fuses, overload relays and relay characteristics, and is updated once a month, or as new equipment data is available. Each breaker and its associated trip-device (MVT-Plus electronic programmer, for example) is separately chosen from within the database and modeled as per the Single Line Diagram supplied.

6) Sheet CA-1
Please reference the original discussion (page 1) regarding the settings of MCC1-Main. The recommendation has been re-written to specifically state that an S&C, SMU-40, Slow-Speed 30E fuse should be implemented on the primary side of the 500kVA transformer. No changes to MCC1-Main settings are needed.

7) Sheet - Equipment Database (Summary)
The study was re-run using "contract specific labels".

8) Sheet - Equipment Database (Motors pg.6)
The motors were re-entered using 94.5% efficiency motors. Specification 16222.2.02.5 was not provided to us by the equipment vendor at anytime with regards to conducting the Power System Study (though other sections were provided). No changes to equipment duty ratings or breaker settings are necessary with each of the motors rated at 94.5%. Often, lower efficiency values are use in Power System Studies since re-wound motors (often used in the industry) are of lower efficiency. The study is designed to evaluate "worst-case" scenarios in actual applications. In fact, in most industrial applications, motors are considerably oversized and operate well within efficiency ranges much lower than that stated on the nameplate.

9) Sheet - Equipment Database (Motors pg.7)
References to "SCADA" were incorrectly included in the printout by default. ESA's EasyPower software has extended capabilities which were not used in conducting this Power System Study.

10) Sheet - Equipment Database (Motors pg.8)
Motors defined in the Power System Study model were of "unique" sizes. Motors of duplicate sizes were not (re)modeled but rather included as part of a "GROUP" motor called "M Group". The cumulative HP quantity of duplicate motors was 14.5HP. To accommodate "contract specific labels", the study was re-performed using each motor as shown on the Record Drawing Single Line Diagram. It should be noted that replicated Time Current Curves are not provided for motors of duplicate sizes.

11) Sheet - Equipment Database (2W-Xformers pg.11)
As discussed in the General Response section, the grounding impedances have been set to "zero" to account for secondary winding faults and proper reflection to the primary side for fuse selection and/or relay coordination. This provides a more "comprehensive" approach to transformer protection, and provides better protection when low current faults occur within the first few turns of a secondary winding. Typically, as ground impedance is added (through grounding resistors) the amount of secondary fault current is greatly reduced thereby allowing continued operation of the transformer in a fault condition. However, to implement such practice, one should also use a ground detection and transformer differential protection relay scheme. For a 500kVA transformer, this is generally not practical or cost effective.

12) Sheet - Equipment Database (Cables pg.13)
Cables defined in the Power System Study model were related to motors of "unique" sizes. Motors of duplicate sizes were not (re)modeled but rather included as part of a "GROUP" motor called "M Group". Generally, a breaker / cable / motor size combination only requires one evaluation. No new information is obtained by or from replicating duplicate devices

The re-performed study contains “contract specific labels” for cables.

13) Sheet - Equipment Database (LV breakers pg.18)
Breakers defined in the Power System Study model were related to motors of “unique” sizes. Motors of duplicate sizes were not (re)modeled but rather included as part of a “GROUP” motor called “M Group”. Generally, a breaker / cable / motor size combination only requires one evaluation. No new information was obtained by or from replicating duplicate devices.

The re-performed study contains “contract specific labels” for breakers.

14) Sheet - Equipment Database (Fuses pg.20)
Breaker MCC1-Main should be considered one of the driving factors for selecting the primary side fuse for the 500kVA transformer. A 600A rated MCC is rated for 498kVA of load at 480V. The range of selectable fuses in this application is much greater than the range of breaker fault current pickup values. If, by nature of this project, little or no room is given to change the primary side fuse, then the equipment should be re-specified by the Design Engineer of record based on planned operation.

15) Single Line Diagrams – Fault Current Contributions (phase and GF)
Both single lines have been re-submitted using “contract specific labeling”.

16) Short Circuit Study Printouts - ALL
All printouts now reference “contract specific labeling”.

17) Adjustable Breaker Settings
MCC1-Main is set based on 100% pickup of the long-time band for the 600A rated breaker. It is unclear why it is requested that the load flow analysis be used to select the value of the setting for the Main Breaker. Engineering design practices, National Electrical Code, and other factors determine the size and settings of the main breaker. Individual loads are protected by the individual feeder breakers in the MCC, conversely, the 600A main breaker protects the (bus in the) MCC itself and the transformer serving the MCC from long-time overload. Down-rating the ampacity of the main breaker serves little functionality.

18) Time Current Curves – All
Transformer damage curves: The right most curve represents the transformer’s 100% rating, while the left most curve represents the 58% or 87% curve (depending on Transformer configuration). This is standard on all TCCs.

Short Circuit current “tick” marks have been moved to provide better illustration. The original TCCs in the PDF were color, and figures stood out better.

The rounded curve to the left of breakers shown with Motor Damage curves represents the Motor Overloads in the MCC bucket. Specific overloads are recorded with the individual breakers in the equipment database – motors section.

19) <u>Time Current Curves – "TX – 1 500kVA HV"</u>
This TCC shows that the 15E fuse as shown on the Record Drawings is not appropriate. A comment to this effect is made on the TCC. The inrush current for the 500kVA transformer is correct with respect to the chosen value of MCC1-Main settings.

20) <u>Time Current Curves – "TX – T-L HV"</u>
This TCC does indicate considerable overlap (or lack of selectivity). This is common for thermal magnetic breakers. Increasing primary side protection to 150% leaves the transformer unprotected with these particular types of breakers. The general understanding of operation for the setup shown on the single line is that either the primary or secondary breaker *will* trip because of "racing". The secondary "Main" breaker in a low voltage panel is provided more as a convenience (for maintenance purposes to turn off the panel) than to improve selectivity. Ultimately, the result is the same during a fault condition; the panel will experience an outage. Troubleshooting the location of the fault *may* or *may not* be made easier by which breaker trips. Often, panels are provided with Main Lugs Only (MLO), though this is not the case on this project, it is often a cost saving factor. Selecting breakers with complicated programmer schemes is effective for improving selectivity, but generally not cost effective. No specific problems are seen with the devices selected and programmed based on the settings provided here-in.

21) <u>Time Current Curves – "TX – T4" (and other transformers <15kVA)</u>
Transformer damage curves and inrush points are not available for transformers smaller than 15kVA. Generally, breakers are shown only to indicate that cables are protected at these smaller transformer rating values.

RECOMMENDATIONS

EXECUTIVE SUMMARY

Each aspect of the study, its pertinent results, and recommendations are summarized below. Detailed discussions appear later in each respective section of this report.

1. The main purpose of the **Short-Circuit Study** was to determine if each protective device was rated to handle the maximum fault current that it may be subjected to during a fault condition. This was done by comparing the device's published short-circuit current rating to its calculated fault current duty.

    - The Short Circuit Study indicates that all devices and panels are appropriately rated.

2. The **Coordination Study** found that the majority of the adjustable protective devices could be set to provide the greatest selectivity and minimize overall system impact in the event of a fault. As a result, it is recommended that all adjustable low voltage (277/480V through 120/208V) breakers be set and tested at the recommended settings.

    - The 15E FG Feeder Fuse Selection for the 500kVA transformer has considerable overlap with the MCC1 Main breaker in the short-time region of protection. The medium voltage FG feeder fuse should be increased to an S&C SMU-40 Slow-speed 30E unit (based on up to 300% primary side full load current rating with secondary side protection set to a max of 125%). The secondary protective device will protect the transformer from long-time overload while the primary fuse allows for transformer inrush and protects against instantaneous faults within the transformer.

    - A complete listing of all breaker settings can be found in the *Appendix / Coordination Study - Analysis/Tables* section of this report.

3. No Problems were found in the **Load Flow Analysis**.

Electronic File Availability

A complete electronic copy of this report is available in PDF form. The PDF document contains a fully indexed version of the report, and includes COLOR Time Current Curves. Please contact the author of this report for additional information via Phone or email.

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INTRODUCTORY SECTION

Study Objective

Power Quality Technical Services, Inc. was contracted to perform a Short Circuit, Coordination Analysis, and Load Flow Study for the *Meranto 2975 Zone Reservoir* project located in *Las Vegas*, *Nevada*. The scope of the short-circuit study included the electrical system from the incoming 12kV utility feeder through a Medium Voltage Fuse Gear, a stepdown transformer and a 480V Motor Control Center.

The purpose of a **Short-Circuit Study** is to determine if each protective device, within the scope of this study, is rated to handle the maximum fault current that it may be subjected to in the event of a fault. This is done by comparing each device's published short-circuit current rating to its individually calculated fault current duty. The calculated short-circuit current values are also used in selecting protective device settings in the Coordination Study. A discussion of the method of calculation is contained in the *Short-Circuit Study - Introduction* section of this report. The results are discussed in the *Short-Circuit Study – Analysis* section of this report. The report also contains documentation of the system components in the *Appendix* / *Short-Circuit Study - Analysis* section, including information on each transformer and motor, utility fault current contributions, installed feeder conductors and their respective conduits.

The **Coordination Study** work scope includes the determination of recommended settings for all adjustable protective devices down to low voltage 120/208V distribution panel main breakers. The settings recommended in this study provide a reasonable compromise between the often-conflicting goals of service continuity and equipment protection. The nature of the load and its tolerance to service interruptions must be considered as well as the consequences of delays in clearing a fault. Where possible, the minimum amount of equipment is removed from service when a system protective device operates to clear a fault or system abnormality. This is known as selectivity. The recommended settings, tabulated according to the device location, are located in the *Appendix / Coordination Study - Analysis* section of this report.

A high degree of selectivity was achieved for the majority of the studied electrical system. The section entitled *Coordination Study - Analysis* should be referenced for identifying and setting breakers to achieve the highest level of protection and selectivity. The time current curves found in the *Appendix / Coordination Study - Curve/Graphics* section of the report were generated using recognized industry software.

The methods used in the course of these studies conform to NEC, ANSI, and other applicable standards and accepted industry practices.

All insulated cables within the scope of the study have been checked for protection to insure compliance with the National Electrical Code standard for over-current-protection.

Primary transformer protection was examined to insure avoidance of nuisance outages from inrush currents, as well as providing over-current protection as required by the 1999 National Electrical Code, and fault protection as provided by the American National Standards Institute (ANSI). Coordination with secondary protective equipment was also an objective. This protection was examined by means of time current curves.

Compliance with the 2002 National Electric Code (NEC) sections pertaining to system protection was evaluated. Motor starting was also examined to identify the impact of starting each of the larger motors within the system (assuring breaker settings were sufficient to allow proper starting). Motor curves are found on several of the Time Current Curves located in this report.

Motor starting was also examined to identify the impact of starting each of the larger motors within the system (assuring breaker settings were sufficient to allow proper starting). Motor curves are found on several of the Time Current Curves located in this report.

Description of the Electrical System

A one-line diagram was entered into ESA's EasyPower 7.0 Software to accurately model the electrical system from the utility source, the Fuse Gear, the Main 500kVA transformer, and the subsequent downstream MCC1. All MCC loads were also modeled. The single-line diagram(s) illustrated in the Appendix of this report represent the Single Line Diagram(s) provided by the design Engineer of Record.

Study Approach

When performing the power system study, the equipment Bill of Material and Engineering / Contractor supplied information was reviewed and entered into the analysis software. By using this information, it was possible to evaluate the system in its truest terms and recommend optimum engineering changes, where necessary.

Before a study of any system can begin, a variety of data must be collected and entered in the analysis software. All protective and impedance elements must be closely inspected to determine their true arrangement sufficient for construction of the single-line model. This includes the true circuit arrangement including all breaker types, ratings, and interrupting capacities. Additional information regarding cable sizes, types, and lengths; transformer sizes and impedances; and utility related data is also entered into the software.

When all necessary electrical system data has been collected from the field, the information is entered into a software database for short-circuit, protective device evaluation, and coordination analysis. The short-circuit program determines the maximum fault current available at each of the pre-selected fault buses as identified on the one-line diagram. The program output shows both the first cycle of fault duty (as needed for momentary evaluations, fuse and low-voltage breaker interrupting capacity), and interrupting duties for the slower, five-cycle, medium voltage breakers.

The Short-Circuit Device Evaluation Report, found in the *Appendix / Short-Circuit Study - Analysis* section of this report, compares the interrupting capacities of each device with the interrupting duty calculated from this study.

These fault levels are equally important for proper coordination, and it will be noted that each time-current coordination plot uses these values. Advantage is taken of the various line and transformer impedances to set primary instantaneous devices above the level of a secondary transformer fault. For example, it is desired that the secondary instantaneous device operate first to clear the fault without primary interruption. Also, transformer inrush current varies with circuit impedance, and is considered in the calculations to select smaller than normally required fuse or relay setting.

Coordination in practice is generally a compromise between the mutually desirable but somewhat inconsistent goals of maximum protection and maximum service continuity. For this reason, and because of factors such as established system design, there may be combinations of device settings that are classified as acceptable. The settings suggested in this study are based on an exercise of judgment as to the best balance between competing objectives.

SHORT-CIRCUIT STUDY INTRODUCTION

Introduction

A power system short-circuit study is used to check or determine:

1. The calculated fault duty against the rating of circuit interrupting devices, such as circuit breakers and fuses.
2. The selection and rating or setting of short-circuit protective devices such as direct-acting trips, fuses and relays.
3. The calculated fault duty against the short-circuit ratings of non-interrupting equipment such as busway, motor control centers, switchgear, and distribution panels.

General Discussion

The study procedure consists of representing the electrical power system in a software based modeling program. Each of the power system components (utility sources, generators, motors, transformers, cables, etc.) is represented by a resistance value and a reactance value.

Bus IDs are used to assign short-circuit sources, base voltages, and per-unit impedance values to the correct locations within the modeled system. The output data is referenced to these Bus IDs. These buses do not necessarily represent real buses or readily accessible connection points in the actual electrical system. They may identify hypothetical buses that are the junction points of impedance elements in the real system, such as cable and busway with transformers or reactors. Separate Bus IDs facilitate data collection and organization with the operation of the software.

The software places an assumed three-phase fault on each bus located in the system and a set of short-circuit currents is calculated that can be compared with the published short-circuit rating of the actual power system equipment. Any interrupting device must be able to withstand and interrupt the most severe short-circuit current available. Generally, three-phase bolted faults and the maximum utility short-circuit duty result in the greatest required equipment duty ratings.

The calculation techniques used are in accordance with American National Standards C37.13-1981 for low-voltage breakers, C37.010-1979 and C37.5-1979 for medium and high-voltage breakers.

System Impedance Data

The one-line diagram included in this report represents the modeled electrical power distribution system. Impedance values for this study are listed in the Database Report found in the *Appendix / Database Report* section. The Database Report is a tabulation of all system components relative to the scope of this study. This includes Utility Sources, Generators, Motors, Transformers, Circuit Breakers, Switches, Fuses, Cables, and Busways.

The voltage bases used in the impedance network generally are those associated with the rated winding voltages of the main transformers and the load-centers on their "flat-tap" positions. Therefore, the system study results typically are based on 12470, 4160, 2400, 480 and 208 Volts as the "system" voltage bases.

The **utility system** is represented as an infinite bus connected to a line whose impedance equals the utility's equivalent source impedance at the facility's incoming service. The other end of this line is connected to the incoming service point. The utility impedance is typically given on the one-line diagram on a 10 or 100 MVA base.

The **transformer** nameplate impedances are given in percent, and are based on the self-cooled kVA rating of the transformer. Normally, the X/R ratios of the transformers are derived from the "medium-typical" curves in IEEE C57.109 although specific X/R ratios may also be used for particular applications. Additional transformer data is entered into the software, and may include its type, such as oil, gas, or dry, silicone or vapor. The transformer class may also include various combinations of forced air, water or forced oil. Examples are shown below.

Type	Class
Oil	- OA, OA/FA, FOA, OW, OW/A, FOW, OA/FA/FA, OA/FA/FOA, OA/FOA/FOA
Gas	- VA, VA/FA
Silicon	- SA, SA/FA
VP Dry	- AA, AFA, AAFA
Cast Coil	- AA, AFA, AAFA

Other transformer data parameters include its connection (delta, wye-ungrounded or wye-grounded), its ground impedance (if wye-grounded) and its ANSI temperature rating, as shown below.

ANSI Temperature Ratings		
45^{o}C	65^{o}C	80/110^{o}C
55^{o}C	65/80^{o}C	150^{o}C
55/65^{o}C	80^{o}C	150/180^{o}C

A transformer's Load Tap Changer data is also used in the model. Its step size may be defined as either 5/8 or 10/8 percentage steps along with its minimum and maximum tap values. Its control type may be either voltage or MVAR controlled for load-flow analysis. The software does not model single phase or dual single phase transformer secondaries (such as 480V-120/240V), and therefore are modeled at the highest three phase secondary voltage (i.e. 240V) to achieve the proper fault current.

The system's **cable** and **busway** impedances are represented in per unit on the study-base impedance, using typical impedance values for such equipment available in standard references, such as the IEEE "Red Book".

Cables may be defined as one of five different types, 1/C-one conductor, 3/C-three conductor, IAA-interlocked armor aluminum, IAS-interlocked armor steel or MAC-messenger aerial cable. Other variables include material (copper or aluminum), size, length, number of conductors per phase temperature (25°C to 250°C) and insulation. Some common insulation abbreviations are shown below:

Low voltage Insulation (1000 volts or less):

THHN	- Heat Resistant Thermoplastic
THWN	- Moisture and Heat Resistant Thermoplastic
THW	- Moisture and Heat Resistant Thermoplastic
RHH	- Heat Resistant Rubber
RHW	- Moisture and Heat Resistant Rubber
XHHW	- Moisture and Heat Resistant Crosslinked Synthetic Polymer (480V equivalent of XLPE)

High Voltage Insulation (Over 1000 volts):

XLPE	- Crosslinked Polyethylene
XLPE-133%	- Crosslinked Polyethylene with 133% insulation
XLPE-NJ	- Non-Jacketed Crosslinked Polyethylene
XLPE-NJ-133%	- Non-Jacketed Crosslinked Polyethylene with 133% insulation
XLPES	- Shielded Crosslinked Polyethylene
XLPES-133%	- Shielded Crosslinked Polyethylene with 133% insulation
EPR	- Ethylene Propylene Rubber
EPR-133%	- Ethylene Propylene Rubber with 133% insulation
EPR -NJ	- Non-Jacketed Ethylene Propylene Rubber
EPR -NJ -133%	- Non-Jacketed Ethylene Propylene Rubber with 133% insulation
EPRS	- Shielded Ethylene Propylene Rubber
EPRS-133%	- Shielded Ethylene Propylene Rubber with 133% insulation
PILC	- Paper Insulated Lead Sheath
PILC-133%	- Paper Insulated Lead Sheath with 133% insulation

Busways are defined by manufacturer, material (copper or aluminum) and length.

The modeling software sometimes requires a zero-impedance branch for certain device configurations. Cables indicated with 10 - 500MCM conductors per phase or a 5000A Copper bus-duct with a length of ten feet is used to represent this requirement. This is used mainly with bifurcated feeder breakers where two conductors are connected to the load terminals of the breaker. A zero-impedance branch is connected through the breaker between its line-side connection to the bus and its load-side cable connections.

The **motors** in each unit substation are grouped (lumped) and a single impedance is determined based on the total connected motor kVA. Typical sub-transient reactance (X''_d) or locked rotor (X_{lr}) for each motor within the group is determined and averaged.

The total equivalent kVA and impedance is based on the following assumptions when exact motor impedances are not known.

Table SCI-1

Induction motor	1 hp = 1 kVA
Synchronous motor, 0.8 PF	1 hp = 1 kVA
Synchronous motor, 1.0 PF	1 hp = 0.8 kVA
Induction motor not greater than 600V	X_{lr} = 0.25 per unit
Induction motors greater than 600V	X_{lr} = 0.17 per unit
Synchronous motors not less than 1200 rpm	X''_d = 0.15 per unit
Synchronous motors less than 1200 rpm	X''_d = 0.20 per unit

(The motor impedances are in per unit on the motor kVA rating. These reactances and motor base kVA ratings listed above were taken from data and assumptions in IEEE Publication No. 141, Fourteenth Edition, "IEEE Red Book".)

The sub-transient reactance (X''_d) values listed in the Table SCI-2 are used in first-cycle (momentary) current calculations while a modified sub-transient reactance is used for the interrupting duties for the medium and high-voltage breakers. These values are in accordance with the pertinent circuit breaker application standards.

The ANSI standards for calculating short-circuit duties require that the actual motor or generator reactances be modified under certain conditions. The modification factors are listed in the following table for both momentary (close and latch) and interrupting-duty calculations. Low-Voltage Duty is calculated per ANSI C37.13-1981 while Momentary and Interrupting Duty is calculated per ANSI C37.010-1979 and C37.5-1979.

Table SCI-2

Motor Code	Motor Type	First Cycle - Low Voltage	First Cycle - Momentary Duty for Medium & High Voltage Breakers	1.5-4 Cycles - Interrupting Duty for Medium & High Voltage Breakers
1	Synchronous	1.0 X_d''	1.0 X_d''	1.5 X_d''
2	Induction > 1000HP or > 250HP @3600 RPM	1.0 X_d''	1.0 X_d''	1.5 X_d''
3	Induction Motor Group >= 50 HP	1.2 X_d''	1.2 X_d''	3.0 X_d''
4	Induction Motor Group < 50 HP	1.67 X_d''	1.67 X_d''	Neglect
5	Lumped Induction Motor Group	1.0 X_d''	1.0 X_d'' *	3.0 X_d''

Note- X_d'' for induction motor groups are assumed equal to 0.167. This corresponds to an equivalent motor contribution of 3.6 to 4.8 times the full load current.

* = X_d'' assumed equal to 0.25.

When exact data is not known, the X/R ratios of induction motors and transformers are determined by using the "medium typical" curves from ANSI C37.010-1979. For synchronous motors less than 1000 horsepower, an X/R ratio from the curve of induction motor X/R ratios is determined.

When hand calculations are performed, the above approximations may be used along with the X/R ratios, provided in the next table, unless more accurate calculations are required. Motor code letters are usually listed on the nameplate, and correspond to kilovolt-amperes per horsepower with locked rotor in accordance with Section 430 of the National Electrical Code. The reciprocal of this kVA/horsepower value may be used as the motor impedance on its own kVA base. This is especially desirable for low-voltage motors with two pole or ratings over 250 HP.

Table SCI-3
Table of Typical Induction Motor Short-Circuit X/R Ratios

Nameplate Horsepower	X/R Ratio	Nameplate Horsepower	X/R Ratio	Nameplate Horsepower	X/R Ratio
5	2.5	50	5.7	300	15.0
7.5	2.7	60	6.3	350	16.3
10	3.2	75	7.0	400	17.4
15	3.6	100	8.2	450	18.5
20	3.9	125	9.0	500	19.4
25	4.3	150	10.0	600	20.7
30	4.5	200	11.7	700	22.1
40	5.1	250	13.4	800	23.4

Short-Circuit Calculations

There are four possibilities for a fault in a three-phase system:

1. Three-phase fault - the three-phase conductors are shorted together.
2. Line-to-line fault - any two phase conductors are shorted together.
3. Double line-to-ground fault - any two phase conductors are shorted together and simultaneously to ground.
4. Line-to-ground fault - one phase conductor is shorted to ground.

For a particular location in a power system, the magnitude of fault current is generally the greatest for three-phase faults and least for phase-to-ground faults. However, ground-fault current magnitude can exceed the three-phase fault current under certain conditions. This can occur near (1) solidly grounded synchronous machines, (2) solidly grounded wye connection of a delta-wye transformer of the three-phase core (three leg) design, (3) grounded wye-delta "tertiary" auto-transformers, or (4) grounded wye-grounded wye-delta tertiary three-winding transformers.

The short-circuit study does not include prefault steady-state load currents. The effect of system load currents is usually negligible in short-circuit studies for industrial and commercial power distribution systems.

Bus IDs used on the one-line diagrams are assigned to establish the locations that are faulted, and typically match the system nomenclature on the Design / Construction Drawings. Contributions from sources of short-circuit current such as the electric utility system, generators, and motors are indicated on the Single Line Diagram printout.

Switchgear Ratings

The short-circuit rating assigned to a power circuit breaker design by the manufacturer is significant in two ways. First, the rating represents a conservative statement of the actual capability of the breaker design to close against, to withstand, and to interrupt short-circuit currents. Thus, the rating is the maximum condition under which the breaker design may be safely applied. Secondly, the rating is the maximum condition of application for which the manufacturer guarantees that the breaker will perform satisfactorily. It is essential, then, that a circuit breaker be applied within the rating assigned to its design if the installation is to be safe and if it is to be covered to the full extent of the manufacturer's warranty. One purpose of a short-circuit study is to determine the conditions under which switchgear will be applied in a specific system.

From a series of laboratory tests, the manufacturer determines the actual breaker capability. Then a rating is selected and assigned to the breaker. In the United States the procedures for testing breakers the rating structure, and the listing of preferred ratings are industry standards dictated by the Sectional Committee on Power Switchgear (C37) of the American National Standards Institute.

The short-circuit rating of a circuit breaker is its capability at the maximum voltage at which the breaker may be applied. Therefore, there is a distinction that must be made between the rating of the breaker and its capability in a specific application.

Prior to 1964, breakers were assigned a short-circuit interrupting capacity in asymmetrical MVA, and it was stated that the interrupting capacity was a constant over a defined range of voltages. An equivalent interrupting capacity in amperes could be calculated at each voltage level. This is called a total-current basis for rating breakers. Since 1964, however, breakers have been assigned an interrupting capacity in symmetrical RMS amperes at a specified maximum voltage, and the capacity is said to increase in inverse proportion to voltage up to a specified maximum current. This is the so-called symmetrical current basis of rating. Under the new rating structure, an MVA rating is still assigned to breakers for class distinction, but it is not the interrupting capability of the device in most cases.

Under the symmetrical current basis of rating switchgear, the factor k defines the permissible range of voltage and fault current. The interrupting capabilities of the breaker then fall into one of three categories:

1. Voltage is greater than the rated maximum voltage; the breaker may not be applied.
2. Voltage is between the rated maximum voltage and l/k times the rated voltage; the interrupting capacity is:

$$\frac{\text{(Interrupting capacity at rated voltage)} \quad \text{(Rated voltage)}}{\text{(Actual Voltage)}}$$

3. Voltage is less than l/k times the rated voltage; the interrupting capacity is k times the interrupting capacity at the rated voltage.

The momentary current capability, defined as the fully offset RMS fault current against which the breaker must be able to close and latch its contacts, is 1.5k times the symmetrical RMS interrupting capacity of the breaker at rated maximum voltage and is not a function of the actual voltage of application.

Under the total-current basis of rating switchgear, the breaker is assigned an interrupting MVA and rated voltage from which an interrupting capability in amperes at rated voltage can be calculated. The breaker is also assigned a range of voltages over which the interrupting MVA is a constant number. If the upper limit of voltage can be exceeded in application, the application is not proper. Below the lower limit, the interrupting capability is not proper. Below the lower limit, the interrupting capability in amperes is constant at a value calculated from the interrupting MVA at the lower-limit voltage. Momentary (or first-cycle) current capability is defined as the maximum fully offset RMS current the breaker can withstand for one second and is assigned by the manufacturer.

Low-voltage breakers are tested and applied in accordance with ANSI C37.13. Low-voltage breakers of present and recent manufacture have symmetrical current interrupting ratings. For low-voltage breakers, calculated first-cycle symmetrical short-circuit currents are compared with the manufacturer's symmetrical ratings since these breakers may be operated rapidly enough to part their contacts during the first-cycle of short-circuit current. Low-voltage breakers manufactured prior to 1957 had average symmetrical short-circuit interrupting current ratings which were compared with 1.25 times calculated first-cycle symmetrical short-circuit currents.

Fuses are fast-acting protective devices that operate in the first-cycle of fault and are rated on a total symmetrical or asymmetrical fault current, depending on the fuse type and voltage rating.

Standards for Short-Circuit Duty Calculations

Electrical power system operating conditions change constantly with system loading and operating procedures. The available short-circuit current also changes with system operating conditions. For any operating condition, the short-circuit current decreases from a maximum value at the inception of a fault until the fault is removed. The rate of this short-circuit current decay depends on many factors.

The American National Standards Institute (ANSI) has developed standards to be used by the electrical industry for calculating short-circuit currents to be compared with short-circuit ratings or capabilities of electrical equipment.

Industrial and commercial power system studies are made by calculating short-circuit current values in accordance with these standards.

Duty and Relay Short-Circuit Current Calculations

The following gives a brief description of the type of calculations that can be made:

1. **First-Cycle Duty per ANSI C37.13-1981 (similar to ASA C37.5-1953)**
   The momentary duty calculated by following ANSI C37.13-1981 is used to compare with the interrupting rating for low-voltage breakers and fuses since their interrupting time is within the first-cycle.

   Impedances represent the utility source, generators, motors, transformers and lines. Sub-transient impedances are used for the utility sources, generators, and synchronous motors. Locked rotor impedances are used for induction motors. For a simplified and more conservative answer only reactances need be used.

   Present-day, low-voltage breaker ratings are compared to the symmetrical current obtained by an E/A calculation at the fault point, while some older low-voltage ratings are compared to an average asymmetrical current 1.25 times the symmetrical current. For symmetrically rated low-voltage circuit breakers, when the X/R ratio is greater than 6.6, the calculated duty is multiplied by a number greater than 1.00 as listed in Table 3 of ANSI C37.13-1981 for comparison with breaker rating. If the X/R ratio is not known, the multiplier should be 1.15. Fuse rating are compared to an asymmetrical current equal to 1.6 times the symmetrical currents in some cases. For low-voltage current-limiting fuses the multiplier is 1.0.

2. **First-Cycle Duty per ANSI C37.010-1979 and C37.5-1979**
   Momentary duty calculated by following ANSI C37.010-1979 and C37.5-1979 is compared with the closing and latching capability of medium and high-voltage circuit breakers. Total impedances, or reactance portions of the utility source impedance, generator, motor, transformer and line impedances are used for the momentary current calculations. The reactances used for the utility source, generator, and synchronous machines are sub-transient reactances. The reactances of the induction motors are entered per Table SCI-3. The circuit E/X current at the fault point is the symmetrical momentary (short time) duty for the breakers. The close-and-latch duty is found by multiplying the symmetrical duty by 1.6 or by using the actual X/R ratio multiplier.

   The superseded ASA 37.5-1953 calculating procedure or the procedure given in C37.13-1981 for low-voltage breakers is sometimes used to evaluate the medium and high-voltage breaker first-cycle duties, along with fuses and low-voltage breaker duties. Using either of the above procedures will yield a slightly higher calculated duty (usually 2%-5%) for medium and high-voltage breakers than ANSI C37.010-1979 because all induction motors are included at their locked rotor impedance.

3. **Interrupting Duty per ANSI C37.010-1979 and C37.5-1981**
The interrupting duty calculated by following ANSI C37.010-1979 for symmetrical-current-rated breakers and ANSI C37.5-1979 for total current rated circuit breakers is compared with the medium and high-voltage breaker interrupting ratings.

   The interrupting current is lower than the momentary current because it takes into account the short-circuit decrement with respect to time while the power circuit breaker is opening. The interrupting duty is calculated by using the reactances given in Table SC-3 of this introductory section.

   The interrupting duty is found by calculating the short-circuit current (E/X) from the reactance network only and then finding the equivalent resistance for the circuit at the fault point, using a resistance-only network reduction. The breaker interrupting time, electrical distance away from generators (measured by the number of intervening transformers) and X/R ratio at the fault are used to determine a multiplying factor to be applied to the symmetrical current to take into account the appropriate direct-current decrements for breakers rated from two- to eight-cycles interrupting time. The multipliers are taken from curves given in ANSI Standard C37.5-1979 for total-current-rated breakers.

   Frequently, interrupting current calculations are made using IEEE Transactions Paper 60TP146-IGA Sept/Oct 1969, "Interpretation of New American National Standards for Power Circuit Breaker Application" (GER-2550) as a guide. The principal extension of the ANSI standards is that a ratio of remote-generator fault current to the sum of the local-generator fault current and remote-generator fault current is used as a measure of the electrical distance from the fault to the generation. The resulting fault-current multiplier takes into account reactors and line impedances that may be equivalent to transformer impedances, as well as variations in the size of transformers.

4. **Short-Circuit Relay Currents**
Short-circuit studies are also made to determine the branch current required to determine settings for relays and protective devices in coordination studies. The impedances of generators and motors depend on the time of interest subsequent to the fault. For long time periods after the fault, the utility source and transient impedance of the generators may be the only short-circuit sources in the network.

One-Line Diagram Discussion

All switching devices indicated on the one-line are assumed “closed” unless designated as "open". Unless specifically requested, multiple utility feeders are not faulted together in a parallel arrangement. Generally, Main-Tie-Main breaker arrangements incorporate "Krik-Lock" type devices that prevent accidentally paralleling of multiple utility sources.

SHORT CIRCUIT ANALYSIS

Utility Short-Circuit Impedance

The Utility short-circuit contributions used in this study are shown below on a 100 MVA, 12.47kV base. The System Protection department of Nevada Power Company provided the values shown below. The X/R values were chosen as typical values for a delivery system of this size. A sensitivity analysis was performed to verify these X/R values as reasonable by running the Short Circuit Analysis at X/R = 1 and X/R = 100. No equipment was found to fail equipment duty ratings within this range of X/R.

At the Utility Service Entrance (@12.47kV):

	System 1
Three Phase Fault	13kA
Three Phase X/R	8
Ground Fault	13kA
Ground Fault X/R	8

Database Printout

The first computerized printout represents the equipment database that includes all system components used in generating this report. The utility, generator and motor contributions are detailed first, then transformers, cables, and panels. The output is generally self-explanatory.

Cable sizes were determined from Single Line Diagrams and Tables submitted by the Engineer of Record and/or electrical contractor. Additional information regarding cable lengths was also determined from the Single Line Diagrams, and typically provided by the electrical contractor based on estimated take-offs. When cable lengths were not provided, a value of 11' is used (this is for simplicity in finding such cables in future data reviews). Low-voltage motor speeds were assumed as 1800 RPM.

Short-Circuit Program Output Explanation

ESA's EasyPower Version 7.0 was used to calculate the three-phase fault duties using a nodal admittance network. Pre-fault steady-state load currents are omitted since the effects of system load current through a device during a fault is usually negligible in typical industrial and commercial electrical distribution systems.

This short-circuit program provides full implementation of ANSI Standards C37.010-1979, C37.5-1979 and C37.13-1981.

For **momentary duty** (1/2 cycle) fault calculations, the positive sequence impedance is assumed equal to the negative sequence impedance. X/R ratios are derived from the complex network.

For **interrupting duty** fault calculations, rotating machine subtransient impedances are modified by multipliers outlined in ANSI Standards C37.010-1979, and C37.5-1979. Negative sequence impedances are modeled using the rotating machine subtransient impedances with no multipliers. A separate "R" (resistance) network is formed for the calculation of the fault point X/R ratio. The X/R ratio used for the calculation of the interrupting duty multipliers is then found from the relationship Z/R. This method fully complies with the ANSI standard and has the advantage of accurate currents and voltages and increased accuracy of a separate X separate R solution technique. NACD (No AC Decrement) ratios are calculated with consideration of generator "Local" and "Remote" contributions as outlined in ANSI Standard C37.010-1979 and Reference 4. Medium and high-voltage interrupting multipliers are also derived from Reference 4.

The first printout is the *Equipment Duty Violation and Warning Report.*

The interrupting duty shown in this device evaluation report is the available fault current taken from the Short-Circuit Reports at the appropriate point in the system minus the contributions generated downstream of that point. The interrupting duty is the symmetrical rating specified by the device manufacturer. The comparison is shown as a percent under-duty (negative percentage) or a percent over-duty (positive number) e.g. (1 - 16.1 kA/37 kA) = 56.6%. Comments indicate whether the equipment is not capable of safely interrupting the available fault current i.e. "VIOLATION".

Devices that are calculated as over-dutied (VIOLATION) should be replaced as indicated in the *Results - Discussion* found at the end of this section. The devices shown with a "WARNING" comment should be replaced if further motor loading or increased incoming capacity is foreseen. A "WARNING" indicates that a device’s calculated fault current is within 10% of its rating. The result of a device applied in excess of its rating may be the destruction of the device as well as the load it was supposed to protect in the event of a major fault.

Molded-Case Circuit Breakers
An important consideration in the application of molded-case and insulated case circuit breakers is that often the interrupting rating given to the equipment is higher than its tested interrupting capacity. In testing circuit breakers for short circuit interrupting ratings, Underwriter's Laboratories (UL) uses an additional four feet, ten inches of cable sized to 125% of the trip setting of the breaker. Thus a 15 amp trip circuit breaker is tested with 4'10" of 14 AWG wire between it and the fault point. This added impedance can severely limit the test current actually applied to the device. The above breaker may have an interrupting rating of 14,000 amps symmetrical short-circuit current at 50% power factor but is only tested at 7,353 amps at 77% power factor at the line connections of the breaker. This discrepancy is most significant at lower trip sizes and at higher interrupting ratings. This may mean that the application of a circuit breaker whose interrupting capacity is less than the

available fault current is a violation of the NEC even though the interrupting rating is sufficient. Similar testing procedures and ratings differences also exist for motor starters, enclosures, distribution panels and motor control centers.

Table SCA-1 lists some common interrupting ratings and capacities for smaller breaker sizes at 480 Volts.

Table SCA-1 [6]

Interrupting Rating	Trip Size	Tested Int. Capacity	Interrupting Rating	Trip Size	Tested Int. Capacity
10,000 A	15 A	7,353 A	14,000 A	15 A	9,772 A
10,000 A	20 A	8,203 A	14,000 A	20 A	11,226 A
10,000 A	25&30A	8,882 A	14,000 A	25&30A	12,354 A
10,000 A	40&50A	9,249 A	14,000 A	40&50A	12,926 A
25,000 A	15 A	13,530 A	42,000 A	15 A	15,714 A
25,000 A	20 A	17,037 A	42,000 A	20 A	21,526 A
25,000 A	25&30A	20,248 A	42,000 A	25&30A	28,352 A
25,000 A	40&50A	21,948 A			
25,000 A	60 A	23,104 A			

The next printout is the *Interrupting Breaker Duties Using Interrupting Impedance Circuit*.

The interrupting duty short-circuit program output gives the calculated 1-1/2 to 4 cycle (interrupting) short-circuit currents which are used to determine the interrupting duties for medium and high-voltage circuit breakers. Interrupting-duty currents are calculated using modified subtransient reactances for all sources of short-circuit current, as specified in the appropriate ANSI calculating procedures.[1,2,3,5] The ANSI Standard method uses a separate R network for the interrupting duty network to determine a conservative Z/R ratio. This ratio is used as the Thevenin equivalent fault point X/R ratio for determining the appropriate breaker contact parting time multipliers and NACD (No AC Decrement) ratios.

Up to six of the standard duties are given (3, 5 and 8 cycle on a Total basis and on a Symmetrical basis), along with the multiplying factors. Fault current values based listed with these interrupting times are based on circuit breaker contact parting times of 0.0333, 0.05 and 0.0667 seconds respectively (2, 3 and 4 cycles, for 60 hertz systems). "Total" refers to a circuit breaker rated on a total current basis and the calculated fault duty is based on references 2 and 4. "Symmetrical" refers to a circuit breaker rated on a symmetrical current basis and the calculated fault duty is based on references 1 and 4. The Adj. Factor times the symmetrical current gives the maximum duty level. The Adj. Factor is determined from curves in Reference 1 and 2, the fault point X/R ratio and the ratio of "Remote/Total" currents as given in Reference 4.

The contributions from adjacent buses are also listed.

The last printout from the Short-Circuit Program is the *Low Voltage Momentary (First Cycle) Breaker Duties Using Momentary Impedance Circuit*.

Calculated first-cycle (momentary) short-circuit currents are used to evaluate interrupting duty for fast-operating interrupters such as fuses and low-voltage circuit breakers, and to calculate relay currents used in protective-device coordination studies. First-cycle duty currents are calculated using subtransient or modified subtransient reactance (X"d) for all sources of short-circuit current as specified in the appropriate ANSI calculating procedures.[1,2,3,4,5]

As indicated, this printout shows the symmetrical amps and the fault X/R ratio as well as asymmetrical amps for each faulted bus in the system. X/R ratios are derived from the complex network. Contributions from adjacent buses are also shown. The "duty" affecting a protective device is normally defined as the contribution from buses "upstream" of the device in the electrical system.

Power Circuit Breaker Duty is shown under the heading "Symmetrical Amps", while Molded-Case Breakers may be shown with multiple duties. This is because molded-case breakers have different Test Power Factors. If the actual fault PF is less than that at which the device was tested (fault X/R ratio greater than test X/R ratio), the device must be derated or a multiplier applied to its duty before comparing the duty with the device's rating for interrupting evaluation.

The Test Power Factors for the above devices are listed here at their worst-case, highest values. This means that for a fault PF less than this, a multiplier is applied to the calculated fault current before it is compared to the device's rating. Breakers with interrupting ratings 10kA or less have a Test Power Factor of 0.50. Breakers with interrupting ratings from 10kA to 20kA have a Test Power Factor of 0.30. Breakers with interrupting ratings of 20kA, or greater, have a Test Power Factor of 0.20. Power Circuit Breakers have a Test Power Factor of 0.15. Similarly, Low-Voltage Fuses have Test PF associated with them as well. There are two different Test PFs, 0.20 and 0.50.

The multiplier to increase the calculated fault current so that it may be compared to the device's nameplate interrupting rating may be calculated by equation SC-E1.

Equation SC-E1.

$$\text{Multiplier} = \frac{1 + \in^{\frac{-\Pi}{(X/R)}}}{1 + \in^{\frac{-\Pi}{K}}}$$

where X/R= Fault X/R ratio
K = tan { $\cos^{-1}$(PF)}

and PF= Test Power Factor (device dependent)

The multiplier to change the calculated symmetrical amperes to asymmetrical amperes is shown in the right half of Equation SC-E2.

Equation SC-E2.

$$\text{Asym} = \text{Sym} * \sqrt{1 + 2 \in^{\frac{-2\pi}{(X/R)}}}$$

where Sym = symmetrical amperes calculated
and Asym = asymmetrical amperes

References

1. "Application Guide for AC High-Voltage Breakers Rated on a Symmetrical Current Basis," ANSI Standard C37.010-1979.

2. "Calculation of Fault Currents for Application of Power Circuit Breakers Rated on a Total-Current Basis," ANSI Standard C37.5-1979.

3. "American National Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures," ANSI Standard C37.13-1981.

4. "Interpretation of New American National Standard for Power Circuit Breakers Applications,", W.C. Huening Jr., IEEE Transaction on Industry and General Applications, Vol. IGA-5, No. 5, Sept./Oct. 1969.

5. "Calculating Short-Circuit Currents With Contributions From Induction Motors," W.C. Huening, Jr., Conference Record Industry Applications Society, IAS-1981: 21A, 81CH1678-2, page 427-33.

6. "Short Circuit Ratings, Labels, and Fault Withstandability of Molded-case and Insulated-case Circuit Breakers and Combination Motor Starters," Arthur J. Smith, Conference Record of the 1989 IEEE Industry Applications Society Annual Meeting, 89CH2792-0.

Results - Discussion

The Equipment Duty Rating printouts indicate that all of the protective devices or panels in the scope of this study were not overdutied (or within 10% of their rating) – except for the following:

- No devices were found to be in “Violation”.

New protective devices added to the system should be checked per the short circuit levels given in the program to insure adequate interrupting ratings are provided. Any major change or addition to the power system can significantly change the short circuit levels. The program should particularly be re-examined in the event of a change in the utility service, a change of one of the principal transformers, or a significant addition of motor load to the studied electrical system.

COORDINATION STUDY INTRODUCTION

Introduction

The purpose of a coordination study is to properly select the circuit protective devices and to provide coordinated settings for adjustable protection devices in the facility that are within the scope of the study. The scope of this study includes the 12kV utility feeder through a Medium Voltage Fuse Gear, a stepdown transformer and a 480V Motor Control Center. This study includes a tabulation of all appropriate feeder breaker settings.

The protective device ratings and settings were chosen to provide a reasonable compromise, based on a thorough engineering evaluation, between the often-conflicting goals of maximum protection and greatest service continuity. Judgments were made as to the best balance between these factors. When a balance is attained, the protective system is described as being "coordinated". It is not always possible to obtain the desired degree of system and equipment protection in a selective fashion. Selectivity means that for a fault at a given location, only the protective device nearest the fault will operate to isolate the fault from the circuit. Other "upstream" devices see the fault but allow the "downstream" device to operate first.

The Coordination Study's methods and recommendations are in conformance with the National Electrical Code (NEC), ANSI/IEEE Standard 242-1986 (IEEE Buff Book), and accepted industry practice. A general explanation of the methods used for this study is found under this tab in a section entitled *Procedures.*

The Coordination Study section of the report is organized as follows, *Compliance with Codes and Standards*, *Procedures*, and *General Discussion of Protective Devices.* The next section is titled *Coordination Study - Analysis* and includes the specific discussion and recommendations for the *Meranto 2975 Zone Reservoir* project. Time Current Curves used during the evaluation of this particular electrical distribution system are included in the *Appendix*.

Compliance with Codes and Standards

The following discussion addresses the study's compliance with the National Electric Code and ANSI/IEEE Standards.

Lack of selectivity normally occurs with the **use of molded-case circuit breakers and fuses** for both feeder protection and branch circuit protection. Underwriter's Laboratory standard (UL489) requires that the molded-case circuit breakers incorporate an instantaneous trip. This provides self-protection for the molded-case breaker. At high levels of fault current, the instantaneous trip sensor of both the upstream substation feeder breaker and the downstream molded-case breaker or fuse will sense the fault current. Either or both may trip. This lack of selectivity occurs under severe fault conditions when molded-case breakers or fuses are applied as feeder protective devices. It should also be noted that utilizing series rated combinations of circuit breakers would also compromise selectivity.

The electrical system is examined to find areas that do not conform to the current (2002) version of the **National Electric Code (NEC)**. The NEC is not necessarily enforced retroactively and it is not possible to determine the provisions of the NEC that were in force at the time that a particular installation was made. However, since the NEC provisions cited pertain to basic electrical system protection concepts, facility management should be cognizant of them and initiate corrective action when necessary.

Cable Ampacity - The ratings of all protective devices within the scope of this study were examined to see if they conformed to the requirements of NEC Article 240.4 which states that *"Conductors, . . ., shall be protected against overcurrent in accordance with their ampacities . . . "*

Ampacity values for wires with either a 60^{O}C or 75^{O}C thermal rating were used for this evaluation because these wire thermal ratings are stipulated in the UL listing instructions for the terminations of distribution equipment. The termination provisions are based on the use of 60^{O}C rated wire for wire sizes #14 to #1 AWG and 75^{O}C rated wire for wire sizes Nos. 1/0 and greater. Wire with a higher thermal rating may be used but this wire must have a cross-sectional area not less than that of the 60^{O}C or 75^{O}C rated wire in order to comply with the listing instructions. These listing instructions must be followed as required by NEC Article 110.3(B).

The next higher device rating is allowed in the code if the standard ampere rating of the fuse or circuit breaker doesn't correspond to the cable ampacity and if this rating does not exceed 800 amperes. The NEC contains tables of ampacities, which provide standard values for various cable types and voltage ranges. Adjustable trip circuit breaker settings can be considered acceptable if the minimum setting is within the limit imposed by the next largest standard device ampacity. The National Electric Code defines standard ampere ratings for fuses and inverse time circuit breakers in section 240-6 as ". . . 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000, and 6000 amperes".

The protective device that protects each of the non conforming circuits should be replaced with one having a rating not greater than that indicated as the maximum device rating <u>or</u> the wire should be replaced with a quantity and size which will provide an ampacity not less than that indicated for the minimum wire size.

The National Electric Code Table 310-16 provides the ampacity of the system's 480V cables.

SIZE	AMPACITY
1/0	150
2/0	175
3/0	200
4/0	230
250	255
300	285
350	310
400	335
500	380
600	420
700	460
750	475
800	490
900	520
1000	545
1250	590
1500	625
1750	650
2000	665

Cable Ampacity for Capacitors is addressed in NEC article 460.8, which states, *"The ampacity of capacitor circuit conductors shall not be less than 135 percent of the rated current of the capacitor."*

Ground fault protection is examined on the 480V system pursuant to NEC articles 230.95 and 215.10. Equipment ground fault protection is required on service and feeder disconnecting means rated 1,000A or more in solidly grounded wye systems with greater than 150V to ground, but not exceeding 600 volts phase-to-phase. Feeder ground fault protection is not required if ground fault protection is installed on the supply side of the feeder, for example, at a main circuit breaker.

The inability of phase overcurrent devices to protect equipment from the damage caused by arcing ground faults is well documented. The arc is resistive and can limit the fault current to levels below the pickup settings of short-time and instantaneous devices. The ground fault may only be isolated through the action of an overload device, which allows the fault to continue for an extended period of time before tripping occurs. This extended time will result in greater damage to equipment than had the ground fault been isolated rapidly. Many instances have been recorded where equipment was literally consumed by an arcing ground fault.

While ground fault protection will greatly reduce the extent of damage that a ground fault arc can cause, the ground fault device may not necessarily operate selectively with phase overcurrent devices downstream. For this reason, ground fault protection on both main and feeder circuit breakers should be contemplated in order to improve selectivity for feeder ground faults. The decision to install ground fault protection on feeder circuit breakers as well as main circuit breakers should consider the following issues:

1. Presence of critical loads on the feeders. Will critical loads experience an outage due to ground faults on other feeders?

2. Rating and type of downstream overcurrent devices. Are downstream phase overcurrent devices capable of sensing ground fault currents within their zone of protection? Is the degree of protection provided by these devices adequate to limit the extent of potential damage to a tolerable level?

3. Main ground fault protection sensitivity. Can the main ground fault device pickup and/or delay be set high enough to allow downstream overcurrent devices to isolate ground fault currents within their protective zone?

The analysis outlined above is beyond the scope of this study. A minimum recommendation would be to have ground fault protection at the main circuit breakers.

Transformer overcurrent protective devices applied at the primary and secondary of transformers were evaluated for compliance with NEC section 450.3. NEC Article 450-3(b)(2) permits the secondary protective device to be set no greater than 125 percent of the transformer rated secondary current when the primary device is not greater than 250 percent of the transformer rated primary current. Note that this article of the NEC *does not* permit the next highest rated device to be applied for the secondary protection when 125% of the rated current does not correspond to a standard rating.

Maximum Continuous Ratings of Fuses and Circuit Breakers
Permitted For Various Transformer Voltage Levels and Impedances
NEC Table 450.3(A)

Transformers with Primaries Over 600V

Location Limitations	Transformer Rated Impedance	Primary Protection		Secondary Side Protection *N2		
				Over 600V		600V or Below
		Maximum Breaker Rating	Maximum Fuse Rating	Maximum Breaker Rating *N4	Maximum Fuse Rating	Maximum Circuit Breaker or Fuse Rating
Any Location	6% & Below	600% *N1	300% *N1	300% *N1	250% *N1	125% *N1
	More than 6% & not more than 10%	400% *N1	300% *N1	250% *N1	225% *N1	125% *N1
Supervised Locations Only *N3	Any	300% *N1	250% *N1	Not Req'd	Not Req'd	Not Req'd
	6% & Below	600%	300%	300% *N5	250% *N5	250% *N5
	More than 6% & not more than 10%	400%	300%	250% *N5	225% *N5	250% *N5

*N = Notes for Table 450.3(A)

1. Where the required fuse rating or circuit breaker setting does not correspond to a standard rating or setting, a higher rating or setting that does not exceed the next higher standard rating or setting shall be permitted.
2. Where secondary overcurrent protection is required, the secondary overcurrent device shall be permitted to consist of not more than six circuit breakers or six sets of fuses grouped in one location. Where multiple overcurrent devices are utilized, the total of all the device ratings shall not exceed the allowed value of a single overcurrent device. If both circuit breakers and fuses are used as the overcurrent device, the total of the device ratings shall not exceed that allowed for fuses.
3. A supervised location is a location where conditions of maintenance and supervision ensure that only qualified persons will monitor and service the transformer installation.
4. Electronically actuated fuses that may be set to open at a specific current shall be set in accordance with settings for circuit breakers.
5. A transformer equipped with a coordinated thermal overload protection by the manufacturer shall be permitted to have separate secondary protection omitted.

NEC Table 450.3(B)

Transformers with Primaries 600V and Below

Protection Method	Primary Protection			Secondary Protection *N2	
	Currents of 9 Amperes or More	**Currents Less than 9 Amperes**	**Currents Less than 2 Amperes**	**Currents of 9 Amperes or More**	**Currents Less than 9 Amperes**
Primary Only	125% *N1	167%	300%	Not Req'd	Not Req'd
Primary & Secondary	250% *N3	250% *N3	250% *N3	125% *N3	167%

*N = Notes for Table 450.3(B)

1. Where 125 percent of this current does not correspond to a standard rating of a fuse or nonadjustable circuit breaker, a higher rating that does not exceed the next higher standard rating shall be permitted.
2. Where secondary overcurrent protection is required, the secondary overcurrent device shall be permitted to consist of not more than six circuit breakers or six sets of fuses grouped in one location. Where multiple overcurrent devices are utilized, the total of all the device ratings shall not exceed the allowed value of a single overcurrent device. If both breakers and fuses are utilized as the overcurrent device, the total of the device ratings shall not exceed that allowed for fuses.
3. A transformer equipped with coordinated thermal overload protection by the manufacturer and arranged to interrupt the primary current, shall be permitted to have primary overcurrent protection rated or set at a current value that is not more than six times the rated current of the transformer for transformers having not more than 6 percent and not more than four times the rated current of the transformer for transformers having more than 6 percent but not more than 10 percent impedance.

Conductors that supply motor loads are subject to special requirements found in Article 430 of the NEC. First, it should be noted that NEC Table 430.150 shall be utilized for the full load current values applied to cable ampacity calculations for three-phase motors as specified in Article 430.6. The table supplies full load current values for motors rated up to 200HP. Current values for motors rated greater than 200HP can be interpolated from the table data.

References to motor full load current ratings in this report, when related to conductor ampacity, pertain to the values found in the NEC tables. Motor branch conductors supplying a single motor must have an ampacity greater or equal to 125 percent of the motor full load current rating (Article 430.24). The ampacity of both branch and feeder conductors which supply several motors must have a minimum ampacity greater or equal to the sum of the full load currents of the connected motors plus 25 percent of the full load current rating of the highest rated motor. These requirements must be applied when motors are operated simultaneously and continuously. However, special consideration can be granted from the authority having jurisdiction to these requirements when it can be shown that on-duty cycle, demand factor is less than 100 percent, operational procedures, production demands or nature of the work is such that not all motors are running at the same time and reduce the conductor heating sufficiently to allow use of a smaller conductor size (Article 430.26). In this report, motors are assumed to be run on a continuous basis unless stated otherwise.

Procedures

The coordination study generally begins at the Main Service Fuse. Settings were chosen with the goal of providing the best coordination that was possible with the largest downstream fixed-setting protective device (such as a transformer breaker). The study then proceeds by coordinating each of the feeder and sub-panel breakers. Time-current curves were used to determine the settings that provided optimum coordination. This report contains those time-current curves that were deemed to contain essential information.

The following is a tested, generally accepted philosophy for selecting and setting protective devices:

1. A feeder "first-line" or "primary" protective device will remove fault current as quickly as possible.
2. If the feeder primary protection fails, a "back-up" protective device will remove the fault. An upstream device that acts as the primary device in its zone usually provides the back-up function. Therefore, time-current coordination is required between the feeder primary and back-up protective devices.

The protective device settings are individually chosen to accommodate circuit parameters. The criteria used in determining the recommended feeder protective device settings are:

1. System or feeder circuit full-load current.
2. Allowance for coordination with the largest downstream protective device set to the highest pickup and time delay including substation secondary circuit protective devices.
3. Transformer protection in compliance with American National Standards Institute (ANSI) and National Electrical Code (NEC) requirements.
4. Avoidance of nuisance tripping due to transformer magnetizing inrush currents or motor inrush currents.
5. Short circuit for faults occurring in the protected zone of the system, including faults on transformer secondaries.
6. Protection of cables per NEC requirements and published heating limits.

Included in the report are protective device one-line diagrams which functionally depict connections of protective devices to instrument transformers (current transformers, potential transformers).

Calibration and Testing of Protective Devices

The time-current relationships between protective devices as established in this report require that the individual relay operating characteristics do not depart appreciably from those shown on the published time-current curves from the manufacturer. The specified settings will provide operation of the devices essentially as shown. However, device tolerance and the difficulty in obtaining exact field settings may result in deviations from the specified operating times. Therefore, it is recommended that the device settings be calibrated by field tests to insure the desired response.

Satisfactory device coordination depends on operation of the protective devices when required, even though they may be inactive for long periods of time. To assure continued proper device action, it is essential the devices be calibrated and checked at regular intervals.

Low Voltage Cable Protection
Article 240.3 of the National Electric Code states that *"Conductors, . . . , shall be protected against overcurrent in accordance with their ampacities . . . "* The next higher standard overcurrent device rating (above the ampacity of the conductors being protected) is allowed in the code with some conditions if the standard rating of the fuse or circuit breaker doesn't correspond to the cable ampacity (below 800 amperes). NEC section 220.10(B) precludes setting an overcurrent protective device above its ampere rating in most situations.

System Medium Voltage Relay Settings
The medium voltage system relay settings are given in the *Relay Settings Table*.

One protection philosophy followed in this study in most cases is the avoidance of 0.5 relay time dial settings with standard non-static overcurrent relays. This is because experience has shown that nuisance tripping can be caused in this situation due to simple vibration. As much as possible, 0.75 is the lowest time dial setting used.

Low Voltage Circuit Breaker Settings
The low voltage circuit breaker device settings are provided in the *Adjustable Breaker Settings Table*. The protection and coordination for many of these circuit breakers becomes highly redundant, and many settings can be derived from a single curve.

As the table may indicate, some of the long time band settings may be set higher than minimum to allow coordination with downstream circuit breakers or fuses. In most cases the long time pickup is set for cable protection. Short time trip settings are chosen for close coordination with downstream devices, while the instantaneous trip settings are set at their highest value to allow maximum selectivity with upstream coordination. Also taken into account is the fault current available at the end of a feeder. This is to assure that a breaker operates when subjected to fault current levels.

ANSI STANDARD DEVICE FUNCTION NUMBERS

Dev. No.	Function
1.	Master Element
2.	Time-delay Starting or Closing Relay
3.	Checking or Interlocking Relay
4.	Master Contactor
5.	Stopping Device
6.	Starting Circuit Breaker
7.	Anode Circuit Breaker
8.	Control-Power Disconnecting Device
9.	Reversing Device
10.	Unit Sequence Switch
11.	Reserved for Future Application
12.	Over-speed Device
13.	Synchronous-speed Device
14.	Under-speed Device
15.	Speed or Frequency-Matching Device
16.	Reserved for Future Application
17.	Shunting or Discharge Switch
18.	Accelerating or Decelerating Device
19.	Starting-to-Running Transition Contactor
20.	Electrically Operated Valve
21.	Distance Relay
22.	Equalizer Circuit Breaker
23.	Temperature Control Device
24.	Reserved for Future Application
25.	Synchronizing or Synchronism-Check Device
26.	Apparatus Thermal Device
27.	Undervoltage Relay
28.	Flame Detector
29.	Isolating Contactor
30.	Annunciator Relay
31.	Separate Excitation Device
32.	Directional Power Relay
33.	Position Switch
34.	Master Sequence Device
35.	Brush-Operating or Slip-Ring Short-Circuiting Device
36.	Polarity or Polarizing Voltage Device
37.	Undercurrent or Underpower Relay
38.	Bearing Protective Device
39.	Mechanical-Condition Monitor
40.	Field Relay
41.	Field Circuit Breaker
42.	Running Circuit Breaker
43.	Manual Transfer or Selector Device
44.	Unit Sequence Starting Relay
45.	Atmospheric Condition Monitor
46.	Reverse-Phase or Phase-Balance Current Relay
47.	Phase-Sequence Voltage Relay
48.	Incomplete Sequence Relay
49.	Machine or Transformer Thermal Relay
50.	Instantaneous Overcurrent or Rate-of-Rise Relay

Dev. No.	Function
51.	AC Time Overcurrent Relay
52.	AC Circuit Breaker
53.	Exciter of DC Generator Relay
54.	Reserved for Future Application
55.	Power Factor Relay
56.	Field-Application Relay
57.	Short-Circuiting or Grounding Device
58.	Rectification Failure Relay
59.	Overvoltage Relay
60.	Voltage or Current Balance Relay
61.	Reserved for Future Application
62.	Time-Delay Stopping or Opening Relay
63.	Pressure Switch
64.	Ground Protective Relay
65.	Governor
66.	Notching or Jogging Device
67.	AC Directional Overcurrent Relay
68.	Blocking Relay
69.	Permissive Control Device
70.	Rheostat
71.	Level Switch
72.	DC Circuit Breaker
73.	Load-Resistor Contactor
74.	Alarm Relay
75.	Position Changing Mechanism
76.	DC Overcurrent Relay
77.	Pulse Transmitter
78.	Phase Angle Measuring or Out-of-Step Protective Relay
79.	AC Reclosing Relay
80.	Flow Switch
81.	Frequency Relay
82.	DC Reclosing Relay
83.	Automatic Selective Control or Transfer Relay
84.	Operating Mechanism
85.	Carrier or Pilot-Wire Receiver Relay
86.	Locking-Out Relay
87.	Differential Protective Relay
88.	Auxiliary Motor or Motor Generator
89.	Line Switch
90.	Regulating Device
91.	Voltage Directional Relay
92.	Voltage and Power Directional Relay
93.	Field-Changing Contactor
94.	Tripping or Trip-Free Relay
95.)	
96.)	Used only for specific applications on individual
97.)	installations where none of the assigned numbered
98.)	functions from 1 to 94 are suitable.
99.)	

General Discussion of Protective Devices

The elements that make up a protected system include relays, direct-acting trip devices, and fuses. Low-voltage power circuit breakers and insulated-case circuit breakers can be adjusted within certain limits to meet protection and coordination requirements. In medium and high-voltage systems, relays are used almost exclusively in the design of a flexible and coordinated protective system.

A brief description of some common relay types used in power distribution systems follows. Appropriate instruction books should be consulted to obtain further information concerning equipment details and their application.

Time-Overcurrent Relays (Device 51) - These relays operate on the electromagnetic induction principle and are available with several time-current operating characteristics. This flexibility makes it possible to select operating characteristics in close harmony with the protective requirements of a particular system component. These relays are non-directional in their operation and are used for both phase and ground fault overcurrent protection of transformers and distribution circuits. Special types are available for motor and generator protection.

The theoretical minimum current at which the relay will operate is called the *pickup current*, which is adjustable within a specified range by changing the *ampere tap* plug. Because of extremely low torques at low-current magnitude, electromechanical relays cannot generally be expected to operate predictably for currents less than 1.5 times the ampere tap setting. This accounts for the termination of the published time operating characteristics at this current level.

Generally, the time delay can be changed by means of a continuously adjustable time dial marked 0 to 10 or 0 to 11. Time-dial markings are arbitrary reference points and are not related to the actual time delay in seconds.

On time-current plots, relay operating characteristics are extended to the maximum short-circuit current value to which a relay is expected to respond. If the overcurrent relay is equipped with an instantaneous attachment (Device 50), then the curve will be terminated at the intersection with the instantaneous relay characteristic.

Overcurrent relays intended for phase fault protection are denoted as 51. Residually connected ground fault relays carry the designation 51N while ground fault relays connected to current transformers in the neutral of a transformer or generator are designated as 51G.

Time overcurrent relays employing electronic circuitry are also available. While these relays have different operating principles from their electromechanical counterparts, the general application procedures described still apply.

Instantaneous Overcurrent Relays (Device 50) - Instantaneous relays have extremely fast operating times (about one cycle). They are essential for fast clearing of extremely high fault currents to reduce burning damage and the possibility of unstable operation of rotating machinery.

However, instantaneous relays cannot always be used when selectivity is desired. Since they cannot be made selective with other instantaneous relays, they are generally only used as the last downstream relay of a series of protective devices which respond to essentially the same magnitude of short-circuit current. This may be a branch-circuit protector, such as a motor starter, or a transformer primary protector.

Whenever there is a large impedance in the circuit (such as a current-limiting reactor or a transformer) the fault current level on the load side may differ significantly from that on the source side. In such cases, the instantaneous relay on the source side of the impedance may be able to be set above the current that would flow to a fault on the load side.

Selectivity between instantaneous relays and fuses for fault clearing times of less than 0.1 second cannot be evaluated on a time-current basis. Since sufficient data are not available to verify selectivity, extreme caution should be exercised in predicting coordination on the basis of the time current characteristics of these devices.

Instantaneous relays may be either self-contained or provided as an attachment to a time-overcurrent relay. Many instantaneous relays operate on the electromagnetic attraction principle. These relays will operate equally well on dc and ac currents and the settings determined for them must recognize the possibility of asymmetry in the fault current. Induction cup type instantaneous relays are available for special applications.

Ground instantaneous relays are given designation suffixes in the same manner as ground time overcurrent relays.

Ground Relays (Devices 50GS and 51GS) - A sensitive ground-fault relay is used to take full advantage of a resistance-grounded system. This ground-fault relay is connected to a low-ratio, window-type current transformer encompassing the three-phase conductors. A matched combination is commonly referred to as a ground sensor. Both time-overcurrent and instantaneous ground sensors can be used (Devices 51GS and 50GS, respectively) to obtain selectivity.

The low-burden capability of window-type transformers introduces a ratio error which is taken into account by the use of operating curves applicable to the ground sensor package being used; that is, the relay-CT combination. These curves may be obtained only by test and are available from the manufacturer. Note that directional ground overcurrent relays should never be connected to low ratio window-type current transformers.

The ground sensor is not responsive to positive and negative sequence load currents but is sensitive to zero sequence (ground fault) currents. Hence, the current transformer ratio is not governed by the anticipated load currents. A 50/5 current transformer ratio is generally used.

Differential Relays (Devices 87G, 87T, 87B and 87L) - Differential relays are employed to permit fast and sensitive protection for phase and ground faults in a bus (87B), a generator (87G), a transformer (87T), or a line (87L). Their use will not only reduce fault point burning damage, but will also improve the ability of rotating machines in the system to return to a stable, steady state mode of operation following a disturbance in the differential zone.

Differential relays are connected to two or more sets of current transformers located at the perimeters of the zone to be protected. Current transformers ideally should have identical characteristics so that through currents will not result in false operation of the differential relays. To allow for normal current transformer tolerances, differential relays are designed to be insensitive to small error currents.

Transformer differential relays are normally designed to provide restraint for harmonic currents predominant in transformer magnetizing inrush currents that are sensed by the transformer source-side current transformers. An adjustable percentage slope adjustment permits de-sensitizing the relay to prevent misoperation for a through fault due to current transformer ratio errors. Ratio tap adjustments are provided to match as nearly as possible the secondary currents in the primary and secondary current transformers.

COORDINATION STUDY ANALYSIS

Discussion and Recommendations

The coordination study analysis is provided below.

- The 15E FG Feeder Fuse Selection for the 500kVA transformer has considerable overlap with the MCC1 Main breaker in the short-time region of protection. The medium voltage FG feeder fuse should be increased to an S&C SMU-40 Slow-speed 30E unit (based on up to 300% primary side full load current rating with secondary side protection set to a max of 125%). The secondary protective device will protect the transformer from long-time overload while the primary fuse allows for transformer inrush and protects against instantaneous faults within the transformer.

- All Feeder Breakers should be set and tested at the recommended settings.

- All low-voltage breakers should be set and tested at their recommended settings for proper coordination with upstream breakers and for proper protection of equipment.

LOAD FLOW ANALYSIS

Introduction

The Load Flow Analysis was conducted by modeling the medium voltage and low voltage system in SKM software. Transformer sizing, cable data, and motor sizes were entered as per the supplied single line.

Methodology

The System was modeled using Source Impedance basis and the Exact (iterative) solution method via a current injection Calculation Method. Bus voltage drop was limited to 5%, and branch voltage drop was limited to 3%

Results

The results of the Load Flow Analysis can be found in the Appendix under Load Flow Analysis.

APPENDIX

Database Report

Project Name: Meranto 2975 Zone Reservoir
Comment: Equipment Database report

Summary

1	Base MVA	100
2	Frequency	60
3	Buses	34
4	MCC Schedules	0
5	Panel Schedules	0
6	Utilities	1
7	Generators	0
8	UPS	1
9	Motors	12
10	Capacitors	0
11	Loads	0
12	Shunts	0
13	Filters	0
14	2-Transformers	6
15	3-Transformers	0
16	Zigzags	0
17	Cables	26
18	Busways	0
19	Xmission Lines	0
20	CL Reactors	0
21	HV Breakers	0
22	LV Breakers	22
23	Switches	0
24	Fuses	2
25	ATS	0
26	Meters	0
27	CTs	0
28	Relays	0
29	Notes	0
30	Lines	0

Buses

	ID Name	Status	Base kV	AF Type	AF Option	Comment
1	1/2 STARTER	On	0.24	Int Switch	Specified	
2	3/4 STARTER P	On	0.24	Int Switch	Specified	
3	3/4 STARTER P	On	0.24	Int Switch	Specified	
4	FUSEGEAR	On	12.47	Switchgear	Specified	
5	L	On	0.208	Panelboard	Specified	
6	MCC1	On	0.48	MCC	Specified	
7	P-WR1-001	On	0.48	Other	Specified	
8	PUMP P-3	On	0.48	Conductor	Specified	
9	PUMP P-4	On	0.24	Conductor	Specified	
10	PUMP P-5	On	0.24	Conductor	Specified	
11	PUMP P-6	On	0.48	Conductor	Specified	
12	PUMP P-7	On	0.48	Conductor	Specified	
13	PUMP P-8	On	0.48	Conductor	Specified	
14	PUMP P-9	On	0.48	Conductor	Specified	
15	PUMP P-10	On	0.48	Conductor	Specified	
16	PUMP P-11	On	0.24	Conductor	Specified	
17	PUMP P-12	On	0.48	Conductor	Specified	
18	PUMP P-13	On	0.48	Conductor	Specified	
19	PUMP P-14	On	0.48	Conductor	Specified	
20	TX T-L H	On	0.48	Other	Specified	
21	TX T-L L	On	0.208	Other	Specified	
22	TX T-UPS H	On	0.48	Other	Specified	
23	TX T-UPS UPS	On	0.208	Other	Specified	
24	TX T4-H	On	0.48	Other	Specified	
25	TX T4-L	On	0.24	Other	Specified	
26	TX T5-H	On	0.48	Other	Specified	
27	TX T5-L	On	0.24	Other	Specified	
28	TX T11-H	On	0.48	Other	Specified	
29	TX T11-L	On	0.24	Other	Specified	
30	U-1	On	0.208	Panelboard	Specified	
31	UPS-IN	On	0.208	Other	Specified	
32	UPS-OUT	On	0.208	Other	Specified	
33	XF - T1 H	On	12.47	Other	Specified	
34	XF- T1 L	On	0.48	Other	Specified	

Utilities

	ID Name	Status	To bus	Base kV	Util kV	Fault Unit	3Ph SC1	3Ph SC2	SLG SC1	SLG SC2	Model	MW	MVAR	CTL kV pu	MVAR Min	MVAR Max	kV pu Min	kV pu Max
1	NPC	On	FUSEGEAR	12.47	12.47	kA	13	8	13	8	Swing	0	0	1	-100000	100000	0.8	1.2

Utilities

	ID Name	Ctl Angle	Ctl Bus	Ctl Base kV	R1 pu	X1 pu	R0 pu	X0 pu	Hrm RC Factor	Hrm RC Value	I Hrm Rating	Comment
1	NPC	0	FUSEGEAR	12.47	0.04417	0.35339	0.04417	0.35339	R-EXP	0.5	4629.91	

UPSs

	ID Name	Status	Input Bus	Output Bus	kVA	X/R	1/2 Cycle SC	Int SC	30 Cycle SC	Ctl kV PU	Ctl Angle	% Efficiency	% Battery	Input PF	Comment
1	UPS	On	UPS-IN	UPS-OUT	15	2.5971	3	0	0	1	0	90	1	0.8	

Motors

	ID Name	Status	To Bus	Base kV	Model	Motor kV	Hp or kW	Type	RPM	Power Factor	Eff	ANSI Code	Connected	X"dv or Xlr	X/R	Load Model	Motor kVA
1	M PUMP P-3	On	PUMP P-3	0.48	Individual	0.46	2	Inductio	1800	0.82	0.945	< 50	100	16.7	1.37989	Spec	1.92541
2	M PUMP P-4	On	PUMP P-4	0.24	Individual	0.208	0.75	Inductio	1800	0.82	0.945	< 50	100	16.7	0.78736	Spec	0.72202
3	M PUMP P-5	On	PUMP P-5	0.24	Individual	0.208	0.75	Inductio	1800	0.82	0.945	< 50	100	16.7	0.78736	Spec	0.72202
4	M PUMP P-6	On	PUMP P-6	0.48	Individual	0.46	7.5	Inductio	1800	0.82	0.945	< 50	100	16.7	2.17837	Spec	7.22028
5	M PUMP P-7	On	PUMP P-7	0.48	Individual	0.46	7.5	Inductio	1800	0.82	0.945	< 50	100	16.7	2.17837	Spec	7.22028
6	M PUMP P-8	On	PUMP P-8	0.48	Individual	0.46	1.5	Inductio	1800	0.82	0.945	< 50	100	16.7	1.2061	Spec	1.44405
7	M PUMP P-9	On	PUMP P-9	0.48	Individual	0.46	1.5	Inductio	1800	0.82	0.945	< 50	100	16.7	1.2061	Spec	1.44405
8	M PUMP P-10	On	PUMP P-10	0.48	Individual	0.46	1.5	Inductio	1800	0.82	0.945	< 50	100	16.7	1.2061	Spec	1.44405
9	M PUMP P-11	On	PUMP P-11	0.24	Individual	0.208	0.5	Inductio	1800	0.82	0.945	< 50	100	16.7	0.54241	Spec	0.48135
10	M PUMP P-12	On	PUMP P-12	0.48	Individual	0.46	2	Inductio	1800	0.82	0.945	< 50	100	16.7	1.37989	Spec	1.92541
11	M PUMP P-13	On	PUMP P-13	0.48	Individual	0.46	2	Inductio	1800	0.82	0.945	< 50	100	16.7	1.37989	Spec	1.92541
12	M PUMP P-14	On	PUMP P-14	0.48	Individual	0.46	10	Inductio	1800	0.82	0.945	< 50	100	16.7	2.35216	Spec	9.62704

Motors

	ID Name	Load Type	Load Scaling	Hrm RC Value	Hrm RC Factor	R1 pu	X1 pu	Int MF	TCC Starter	Plot TCC	Service Factor	Locked Rotor Mult	Asym Offset	Reduced Inrush Mult	Accel Time	Stall Time	Stall Time To	Comment
1	M PUMP P-3	kVA	100	0.5	R-EXP	7806.16	10771.6	10000	Full Volt		1	6	1.6	100	5	6	200	
2	M PUMP P-4	kVA	100	0.5	R-EXP	22794.6	17947.6	10000	Full Volt		1	6	1.6	100	5	6	200	
3	M PUMP P-5	kVA	100	0.5	R-EXP	22794.6	17947.6	10000	Full Volt		1	6	1.6	100	5	6	200	
4	M PUMP P-6	kVA	100	0.5	R-EXP	1479.97	3223.94	10000	Full Volt		1	6	1.6	100	5	6	200	
5	M PUMP P-7	kVA	100	0.5	R-EXP	1479.97	3223.94	10000	Full Volt		1	6	1.6	100	5	6	200	
6	M PUMP P-8	kVA	100	0.5	R-EXP	11320.9	13654.2	10000	Full Volt		1	6	1.6	100	5	6	200	
7	M PUMP P-9	kVA	100	0.5	R-EXP	11320.9	13654.2	10000	Full Volt		1	6	1.6	100	5	6	200	
8	M PUMP P-10	kVA	100	0.5	R-EXP	11320.9	13654.2	10000	Full Volt		1	6	1.6	100	5	6	200	
9	M PUMP P-11	kVA	100	0.5	R-EXP	38253.4	20749.3	10000	Full Volt		1	6	1.6	100	5	6	200	
10	M PUMP P-12	kVA	100	0.5	R-EXP	7806.16	10771.6	10000	Full Volt		1	6	1.6	100	5	6	200	
11	M PUMP P-13	kVA	100	0.5	R-EXP	7806.16	10771.6	10000	Full Volt		1	6	1.6	100	5	6	200	
12	M PUMP P-14	kVA	100	0.5	R-EXP	1040.94	2448.47	10000	Full Volt		1	6	1.6	100	5	6	200	

2W-Xformers

	ID Name	Status	From bus	From Base kV	From Conn	To Bus	To Base kV	To Conn	Type	Class	Temp	Form	From Nom kV	From Tap kV	From Gnd R	From Gnd jX	To Nom kV
1	TX T-L	On	TX T-L H	0.48	D	TX T-L L	0.208	YG	Dry	OA	115	Core	0.48	0.48	0	0	0.208
2	TX T-UPS	On	TX T-UPS H	0.48	D	TX T-UPS UPS	0.208	YG	Dry	OA	115	Core	0.48	0.48	0	0	0.208
3	TX T4	On	TX T4-H	0.48	D	TX T4-L	0.24	YG	Dry	OA	115	Core	0.48	0.48	0	0	0.24
4	TX T5	On	TX T5-H	0.48	D	TX T5-L	0.24	YG	Dry	OA	115	Core	0.48	0.48	0	0	0.24
5	TX T11	On	TX T11-H	0.48	D	TX T11-L	0.24	YG	Dry	OA	115	Core	0.48	0.48	0	0	0.24
6	TX-1	On	XF - T1 H	12.47	D	XF- T1 L	0.48	YG	Oil	OA	55/65	Core	12.47	12.47	0	0	0.48

2W-Xformers

	ID Name	To Tap kV	To Gnd R	To Gnd jX	MVA	MVA O/L	Z	Z0	X/R	LTC Tap	LTC Step	LTC Min Tap	LTC Max Tap	Ctl Type	Ctl Value	Zps R1 pu	Zps X1 pu	Zps R0 pu	Zps X0 pu
1	TX T-L	0.208	0	0	0.045	0.045	2.9	2.465	1.65901	None	0.625	0.1	1500	V (PU)	1	33.2687	55.1931	10000	1e+007
2	TX T-UPS	0.208	0	0	0.015	0.015	4.8	4.08	1.55252	None	0.625	0.1	1500	V (PU)	1	173.281	269.023	10000	1e+007
3	TX T4	0.24	0	0	0.002	0.002	4	3.4	1.74811	None	0.625	0.1	1500	V (PU)	1	993.086	1736.02	10000	1e+007
4	TX T5	0.24	0	0	0.002	0.002	4	3.4	1.74811	None	0.625	0.1	1500	V (PU)	1	993.086	1736.02	10000	1e+007
5	TX T11	0.24	0	0	0.002	0.002	4	3.4	1.74811	None	0.625	0.1	1500	V (PU)	1	993.086	1736.02	10000	1e+007
6	TX-1	0.48	0	0	0.5	0.56	4.5	3.825	4.57467	None	0.625	0.1	1500	V (PU)	1	1.92197	8.79238	10000	1e+007

2W-Xformers

	ID Name	Rps0+3Rpsg	Xps0+3Xpsg	TCC Standard	TCC FLA Based On	Freq Fault Curve	TCC Max Plot Time	TCC Inrush FLA Mult	TCC Inrush Cycles	Hrm RC Factor	Hrm RC Value	Hrm Pec-r %	Hrm From I Rating	Hrm To I Rating
1	TX T-L	28.2784	46.91415	ANSI C57.12.59	kVA O/L	Yes	500	8	6	R-EXP	0	15	54.1265	124.907
2	TX T-UPS	147.2894	228.6697	ANSI C57.12.59	kVA O/L	Yes	500	8	6	R-EXP	0	15	18.0422	41.6358
3	TX T4	844.1233	1475.62	ANSI C57.12.59	kVA O/L	Yes	500	8	6	R-EXP	0	15	2.40562	4.81125
4	TX T5	844.1233	1475.62	ANSI C57.12.59	kVA O/L	Yes	500	8	6	R-EXP	0	15	2.40562	4.81125
5	TX T11	844.1233	1475.62	ANSI C57.12.59	kVA O/L	Yes	500	8	6	R-EXP	0	15	2.40562	4.81125
6	TX-1	1.633676	7.473527	ANSI C57.109	kVA O/L	Yes	500	8	6	R-EXP	0	15	23.1495	601.406

2W-Xformers

	ID Name	Comment
1	TX T-L	
2	TX T-UPS	
3	TX T4	
4	TX T5	
5	TX T11	
6	TX-1	

Cables

	ID Name	Status	From Bus ID	From Base kV	To Bus ID	To Base kV	Type	No/Ph	Size	Length	Temp	Insulation	Rating (A)	Material	Raceway Type
1	C L	On	TX T-L L	0.208	L	0.208	1/C	1	4/0	10	50	THWN	230	Copper	Conduit
2	C MCC1	On	XF- T1 L	0.48	MCC1	0.48	1/C	2	350	11	50	THWN	620	Copper	Conduit
3	C P-WR1-001	On	MCC1	0.48	P-WR1-001	0.48	1/C	1	6	11	50	THWN	65	Copper	Conduit
4	C PUMP P-3	On	MCC1	0.48	PUMP P-3	0.48	1/C	1	8	90	50	THWN	50	Copper	Conduit
5	C PUMP P-4	On	3/4 STARTER P	0.24	PUMP P-4	0.24	1/C	1	12	650	50	THWN	25	Copper	Conduit
6	C PUMP P-5	On	3/4 STARTER P	0.24	PUMP P-5	0.24	1/C	1	12	875	50	THWN	25	Copper	Conduit
7	C PUMP P-6	On	MCC1	0.48	PUMP P-6	0.48	1/C	1	8	975	50	THWN	50	Copper	Conduit
8	C PUMP P-7	On	MCC1	0.48	PUMP P-7	0.48	1/C	1	8	975	50	THWN	50	Copper	Conduit
9	C PUMP P-8	On	MCC1	0.48	PUMP P-8	0.48	1/C	1	12	250	50	THWN	25	Copper	Conduit
10	C PUMP P-9	On	MCC1	0.48	PUMP P-9	0.48	1/C	1	12	375	50	THWN	25	Copper	Conduit
11	C PUMP P-10	On	MCC1	0.48	PUMP P-10	0.48	1/C	1	12	675	50	THWN	25	Copper	Conduit
12	C PUMP P-11	On	1/2 STARTER	0.24	PUMP P-11	0.24	1/C	1	12	250	50	THWN	25	Copper	Conduit
13	C PUMP P-12	On	MCC1	0.48	PUMP P-12	0.48	1/C	1	8	200	50	THWN	50	Copper	Conduit
14	C PUMP P-13	On	MCC1	0.48	PUMP P-13	0.48	1/C	1	8	200	50	THWN	50	Copper	Conduit
15	C PUMP P-14	On	MCC1	0.48	PUMP P-14	0.48	1/C	1	10	200	50	THWN	35	Copper	Conduit
16	C TX T-L	On	MCC1	0.48	TX T-L H	0.48	1/C	1	4	35	50	THWN	85	Copper	Conduit
17	C TX T-UPS	On	MCC1	0.48	TX T-UPS H	0.48	1/C	1	4	50	50	THWN	85	Copper	Conduit
18	C TX T4 H	On	MCC1	0.48	TX T4-H	0.48	1/C	1	12	11	50	THWN	25	Copper	Conduit
19	C TX T4 L	On	TX T4-L	0.24	3/4 STARTER P	0.24	1/C	1	12	11	50	THWN	25	Copper	Conduit
20	C TX T5 H	On	MCC1	0.48	TX T5-H	0.48	1/C	1	12	11	50	THWN	25	Copper	Conduit
21	C TX T5 L	On	TX T5-L	0.24	3/4 STARTER P	0.24	1/C	1	12	11	50	THWN	25	Copper	Conduit
22	C TX T11 H	On	MCC1	0.48	TX T11-H	0.48	1/C	1	12	11	50	THWN	25	Copper	Conduit
23	C TX T11 L	On	TX T11-L	0.24	1/2 STARTER	0.24	1/C	1	12	11	50	THWN	25	Copper	Conduit
24	C U-1	On	UPS-OUT	0.208	U-1	0.208	1/C	1	6	11	50	THWN	65	Copper	Conduit
25	C UPS	On	TX T-UPS UPS	0.208	UPS-IN	0.208	1/C	1	4/0	11	50	THWN	230	Copper	Conduit
26	C XF-T1	On	FUSEGEAR	12.47	XF - T1 H	12.47	1/C	1	6	11	25	EPRS_133	83	Copper	Conduit

Cables

	ID Name	Raceway Mtl	R1	X1	R0	X0	Xc	Xc0	Gnd Num	Gnd Size	Gnd Mtl	Gnd Type	Gnd Insul	Neutral Num	Neutral Size	Neutral Rating	Neutral Mtl
1	C L	Steel	0.05587	0.03847	0.22349	0.15390	0.00476	0.00476	1	2	Copper	Separate	Yes	1	4/0	10	Copper
2	C MCC1	PVC	0.03479	0.03047	0.06959	0.06094	0.00446	0.00446	2	2	Copper	Separate	Yes	1	Other	10	Copper
3	C P-WR1-001	Steel	0.45045	0.04222	1.80182	0.16890	0.00776	0.00776	1	10	Copper	Separate	Yes	1	Other	10	Copper
4	C PUMP P-3	Steel	0.71590	0.04436	2.86363	0.17746	0.00946	0.00946	1	12	Copper	Separate	Yes	1	Other	10	Copper
5	C PUMP P-4	Steel	1.81903	0.06737	7.27612	0.26948	0.00776	0.00776	1	12	Copper	Separate	Yes	1	Other	10	Copper
6	C PUMP P-5	Steel	1.81903	0.06737	7.27612	0.26948	0.00776	0.00776	1	12	Copper	Separate	Yes	1	Other	10	Copper
7	C PUMP P-6	Steel	0.71590	0.04436	2.86363	0.17746	0.00946	0.00946	1	12	Copper	Separate	Yes	1	Other	10	Copper
8	C PUMP P-7	Steel	0.71590	0.04436	2.86363	0.17746	0.00946	0.00946	1	12	Copper	Separate	Yes	1	Other	10	Copper
9	C PUMP P-8	Steel	1.81903	0.06737	7.27612	0.26948	0.00776	0.00776	1	12	Copper	Separate	Yes	1	Other	10	Copper
10	C PUMP P-9	Steel	1.81903	0.06737	7.27612	0.26948	0.00776	0.00776	1	12	Copper	Separate	Yes	1	Other	10	Copper
11	C PUMP P-10	Steel	1.81903	0.06737	7.27612	0.26948	0.00776	0.00776	1	12	Copper	Separate	Yes	1	Other	10	Copper
12	C PUMP P-11	Steel	1.81903	0.06737	7.27612	0.26948	0.00776	0.00776	1	12	Copper	Separate	Yes	1	Other	10	Copper
13	C PUMP P-12	Steel	0.71590	0.04436	2.86363	0.17746	0.00946	0.00946	1	12	Copper	Separate	Yes	1	Other	10	Copper
14	C PUMP P-13	Steel	0.71590	0.04436	2.86363	0.17746	0.00946	0.00946	1	12	Copper	Separate	Yes	1	Other	10	Copper
15	C PUMP P-14	Steel	1.13918	0.04271	4.55673	0.17084	0.00814	0.00814	1	12	Copper	Separate	Yes	1	Other	10	Copper
16	C TX T-L	Steel	0.28320	0.04271	1.13283	0.17084	0.00814	0.00814	1	10	Copper	Separate	Yes	0	Other	10	Copper
17	C TX T-UPS	Steel	0.28320	0.04271	1.13283	0.17084	0.00814	0.00814	1	10	Copper	Separate	Yes	0	Other	10	Copper
18	C TX T4 H	Steel	1.81903	0.06737	7.27612	0.26948	0.00776	0.00776	1	12	Copper	Separate	Yes	1	Other	10	Copper
19	C TX T4 L	Steel	1.81903	0.06737	7.27612	0.26948	0.00776	0.00776	1	12	Copper	Separate	Yes	1	Other	10	Copper
20	C TX T5 H	Steel	1.81903	0.06737	7.27612	0.26948	0.00776	0.00776	1	12	Copper	Separate	Yes	1	Other	10	Copper
21	C TX T5 L	Steel	1.81903	0.06737	7.27612	0.26948	0.00776	0.00776	1	12	Copper	Separate	Yes	1	Other	10	Copper
22	C TX T11 H	Steel	1.81903	0.06737	7.27612	0.26948	0.00776	0.00776	1	12	Copper	Separate	Yes	1	Other	10	Copper
23	C TX T11 L	Steel	1.81903	0.06737	7.27612	0.26948	0.00776	0.00776	1	12	Copper	Separate	Yes	1	Other	10	Copper
24	C U-1	Steel	0.45045	0.04222	1.80182	0.16890	0.00776	0.00776	1	8	Copper	Separate	Yes	1	6	10	Copper
25	C UPS	Steel	0.05587	0.03847	0.22349	0.15390	0.00476	0.00476	1	2	Copper	Separate	Yes	1	4/0	10	Copper
26	C XF-T1	PVC	0.411	0.06667	0.822	0.13334	0.05569	0.05569	1	6	Copper	Separate	Yes	0	Other	10	Copper

Cables

	ID Name	Neutral Insul	Conductor Lay	Conductor Form	Spacing	R1 pu	X1 pu	R0 pu	X0 pu	B1 pu	B0 pu	Hrm RC Factor	Hrm RC Value	I Hrm Rating	Comment
1	C L	Yes	Triangle	Round	0	1.29146	0.88932	5.16586	3.55732	9.07144	9.07144	R-EXP	0.5	230	
2	C MCC1	Yes	Triangle	Round	0	0.08307	0.07274	0.16614	0.14548	1.13579	1.13579	R-EXP	0.5	620	
3	C P-WR1-001	Yes	Triangle	Round	0	2.15061	0.20160	8.60244	0.80641	3.26570	3.26570	R-EXP	0.5	65	
4	C PUMP P-3	Yes	Triangle	Round	0	27.9651	1.73305	111.860	6.93218	2.19046	2.19046	R-EXP	0.5	50	
5	C PUMP P-4	Yes	Triangle	Round	0	2052.72	76.0268	8210.9	304.107	4.82433	4.82433	R-EXP	0.5	25	
6	C PUMP P-5	Yes	Triangle	Round	0	2763.28	102.343	11053.1	409.375	6.49430	6.49430	R-EXP	0.5	25	
7	C PUMP P-6	Yes	Triangle	Round	0	302.955	18.7747	1211.82	75.0987	2.37299	2.37299	R-EXP	0.5	50	
8	C PUMP P-7	Yes	Triangle	Round	0	302.955	18.7747	1211.82	75.0987	2.37299	2.37299	R-EXP	0.5	50	
9	C PUMP P-8	Yes	Triangle	Round	0	197.377	7.31027	789.509	29.2411	7.42205	7.42205	R-EXP	0.5	25	
10	C PUMP P-9	Yes	Triangle	Round	0	296.066	10.9654	1184.26	43.8616	1.11330	1.11330	R-EXP	0.5	25	
11	C PUMP P-10	Yes	Triangle	Round	0	532.919	19.7377	2131.67	78.9509	2.00395	2.00395	R-EXP	0.5	25	
12	C PUMP P-11	Yes	Triangle	Round	0	789.509	29.2411	3158.03	116.964	1.85551	1.85551	R-EXP	0.5	25	
13	C PUMP P-12	Yes	Triangle	Round	0	62.1447	3.85122	248.579	15.4048	4.86769	4.86769	R-EXP	0.5	50	
14	C PUMP P-13	Yes	Triangle	Round	0	62.1447	3.85122	248.579	15.4048	4.86769	4.86769	R-EXP	0.5	50	
15	C PUMP P-14	Yes	Triangle	Round	0	98.8871	3.70754	395.549	14.8301	5.65639	5.65639	R-EXP	0.5	35	
16	C TX T-L	Yes	Triangle	Round	0	4.30217	0.64882	17.2087	2.59527	9.89869	9.89869	R-EXP	0.5	85	
17	C TX T-UPS	Yes	Triangle	Round	0	6.14596	0.92688	24.5839	3.70753	1.41409	1.41409	R-EXP	0.5	85	
18	C TX T4 H	Yes	Triangle	Round	0	8.68460	0.32165	34.7384	1.28660	3.26570	3.26570	R-EXP	0.5	25	
19	C TX T4 L	Yes	Triangle	Round	0	34.7384	1.28660	138.953	5.14643	8.16426	8.16426	R-EXP	0.5	25	
20	C TX T5 H	Yes	Triangle	Round	0	8.68460	0.32165	34.7384	1.28660	3.26570	3.26570	R-EXP	0.5	25	
21	C TX T5 L	Yes	Triangle	Round	0	34.7384	1.28660	138.953	5.14643	8.16426	8.16426	R-EXP	0.5	25	
22	C TX T11 H	Yes	Triangle	Round	0	8.68460	0.32165	34.7384	1.28660	3.26570	3.26570	R-EXP	0.5	25	
23	C TX T11 L	Yes	Triangle	Round	0	34.7384	1.28660	138.953	5.14643	8.16426	8.16426	R-EXP	0.5	25	
24	C U-1	Yes	Triangle	Round	0	11.4529	1.07363	45.8118	4.29453	6.13227	6.13227	R-EXP	0.5	65	
25	C UPS	Yes	Triangle	Round	0	1.42061	0.97826	5.68245	3.91305	9.97859	9.97859	R-EXP	0.5	230	
26	C XF-T1	Yes	Triangle	Round	0	0.00290	0.00047	0.00581	0.00094	3.07124	3.07124	R-EXP	0.5	83	

LV Breakers

	ID Name	Status	On Bus	Base kV	Conn Type	Class	Options	Breaker Mfr	Breaker Type	Breaker Style	Cont Current (A)	SC Int kA	SC Test Std
1	B L-MAIN	On	L	0.208	Feeder	MCCB	Breaker On	GE	Q Line	TQD	150	10	ANSI-SYM
2	B MCC1-MAIN	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SGL6	600	65	ANSI-SYM
3	B P-WR1-001	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	0	65	ANSI-SYM
4	B PUMP P-3	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	15	65	ANSI-SYM
5	B PUMP P-4	On	3/4 STARTER P	0.24	Feeder	MCCB	Breaker On	GE	Spectra	SEL	15	100	ANSI-SYM
6	B PUMP P-5	On	3/4 STARTER P	0.24	Feeder	MCCB	Breaker On	GE	Spectra	SEL	15	100	ANSI-SYM
7	B PUMP P-6	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	30	65	ANSI-SYM
8	B PUMP P-7	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	30	65	ANSI-SYM
9	B PUMP P-8	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	15	65	ANSI-SYM
10	B PUMP P-9	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	15	65	ANSI-SYM
11	B PUMP P-10	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	15	65	ANSI-SYM
12	B PUMP P-11	On	1/2 STARTER	0.24	Feeder	MCCB	Breaker On	GE	Spectra	SEL	15	100	ANSI-SYM
13	B PUMP P-12	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	15	65	ANSI-SYM
14	B PUMP P-13	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	15	65	ANSI-SYM
15	B PUMP P-14	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	30	65	ANSI-SYM
16	B SPARE	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	50	65	ANSI-SYM
17	B TX T-L	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	70	65	ANSI-SYM
18	B TX T-UPS	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	25	65	ANSI-SYM
19	B TX T4	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	30	65	ANSI-SYM
20	B TX T5	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	30	65	ANSI-SYM
21	B TX T11	On	MCC1	0.48	Feeder	MCCB	Breaker On	GE	Spectra	SEL	30	65	ANSI-SYM
22	B U-1 MAIN	On	U-1	0.208	Feeder	MCCB	Breaker On	GE	Q Line	THQB	60	10	ANSI-SYM

LV Breakers

	ID Name	Normal State	Trip	Trip Mfr	Trip Type	Trip Style	Sensor/Frame	Plug/Tap/Trip	LTPU Setting	LTPU Mult	LTPU (A)	LTD Band
1	B L-MAIN	Closed	TMGN	GE	Q Line	TQD	225A(100-225AT)	150				
2	B MCC1-MAIN	Closed	SST	GE	Spectra RMS	MCCB SG	600	600	1	1	600	Fixed
3	B P-WR1-001	Closed	SST	GE	Spectra RMS	MCCB SE	60A (60AT)	60	1	1	60	Fixed
4	B PUMP P-3	Closed	SST	GE	Spectra RMS	MCCB SE	30A (15AT)	15	1	1	15	Fixed
5	B PUMP P-4	Closed	SST	GE	Spectra RMS	MCCB SE	30A (15AT)	15	1	1	15	Fixed
6	B PUMP P-5	Closed	SST	GE	Spectra RMS	MCCB SE	30A (15AT)	15	1	1	15	Fixed
7	B PUMP P-6	Closed	SST	GE	Spectra RMS	MCCB SE	30A (30AT)	30	1	1	30	Fixed
8	B PUMP P-7	Closed	SST	GE	Spectra RMS	MCCB SE	30A (30AT)	30	1	1	30	Fixed
9	B PUMP P-8	Closed	SST	GE	Spectra RMS	MCCB SE	30A (15AT)	15	1	1	15	Fixed
10	B PUMP P-9	Closed	SST	GE	Spectra RMS	MCCB SE	30A (15AT)	15	1	1	15	Fixed
11	B PUMP P-10	Closed	SST	GE	Spectra RMS	MCCB SE	30A (15AT)	15	1	1	15	Fixed
12	B PUMP P-11	Closed	SST	GE	Spectra RMS	MCCB SE	30A (15AT)	15	1	1	15	Fixed
13	B PUMP P-12	Closed	SST	GE	Spectra RMS	MCCB SE	30A (15AT)	15	1	1	15	Fixed
14	B PUMP P-13	Closed	SST	GE	Spectra RMS	MCCB SE	30A (15AT)	15	1	1	15	Fixed
15	B PUMP P-14	Closed	SST	GE	Spectra RMS	MCCB SE	30A (30AT)	30	1	1	30	Fixed
16	B SPARE	Closed	SST	GE	Spectra RMS	MCCB SE	60A (50AT)	50	1	1	50	Fixed
17	B TX T-L	Closed	SST	GE	Spectra RMS	MCCB SE	100A (70AT)	70	1	1	70	Fixed
18	B TX T-UPS	Closed	SST	GE	Spectra RMS	MCCB SE	30A (25AT)	25	1	1	25	Fixed
19	B TX T4	Closed	SST	GE	Spectra RMS	MCCB SE	30A (30AT)	30	1	1	30	Fixed
20	B TX T5	Closed	SST	GE	Spectra RMS	MCCB SE	30A (30AT)	30	1	1	30	Fixed
21	B TX T11	Closed	SST	GE	Spectra RMS	MCCB SE	30A (30AT)	30	1	1	30	Fixed
22	B U-1 MAIN	Closed	TMGN	GE	Q Line	THQB	100A(60-100AT)	60				

LV Breakers

	ID Name	STPU Setting	STPU Band	STPU I2T	STPU (A)	Inst Setting	Inst Override	Inst (A)	Gnd Pickup	Gnd Delay	Gnd I2T	Gnd (A)	Fuse Mfr	Fuse Type
1	B L-MAIN												<None>	<None>
2	B MCC1-MAIN	3	Fixed	In	1470	3	Pickup	2910			Out		<None>	<None>
3	B P-WR1-001	5	Fixed	In	228	5	Pickup	462			Out		<None>	<None>
4	B PUMP P-3	Max	Fixed	In	90	Max	Pickup	187.5			Out		<None>	<None>
5	B PUMP P-4	Max	Fixed	In	90	Max	Pickup	187.5			Out		<None>	<None>
6	B PUMP P-5	Max	Fixed	In	90	Max	Pickup	187.5			Out		<None>	<None>
7	B PUMP P-6	Max	Fixed	In	243	Max	Pickup	375			Out		<None>	<None>
8	B PUMP P-7	Max	Fixed	In	243	Max	Pickup	375			Out		<None>	<None>
9	B PUMP P-8	Max	Fixed	In	90	Max	Pickup	187.5			Out		<None>	<None>
10	B PUMP P-9	Max	Fixed	In	90	Max	Pickup	187.5			Out		<None>	<None>
11	B PUMP P-10	Max	Fixed	In	90	Max	Pickup	187.5			Out		<None>	<None>
12	B PUMP P-11	Max	Fixed	In	90	Max	Pickup	187.5			Out		<None>	<None>
13	B PUMP P-12	Max	Fixed	In	90	Max	Pickup	187.5			Out		<None>	<None>
14	B PUMP P-13	Max	Fixed	In	90	Max	Pickup	187.5			Out		<None>	<None>
15	B PUMP P-14	5	Fixed	In	111	5	Pickup	231			Out		<None>	<None>
16	B SPARE	Max	Fixed	In	350	Max	Pickup	625			Out		<None>	<None>
17	B TX T-L	6	Fixed	In	350	6	Pickup	693			Out		<None>	<None>
18	B TX T-UPS	Max	Fixed	In	187.5	Max	Pickup	250			Out		<None>	<None>
19	B TX T4	2	Fixed	In	55.5	2	Pickup	111			Out		<None>	<None>
20	B TX T5	2	Fixed	In	55.5	2	Pickup	111			Out		<None>	<None>
21	B TX T11	Max	Fixed	In	243	Max	Pickup	375			Out		<None>	<None>
22	B U-1 MAIN												<None>	<None>

LV Breakers

	ID Name	Fuse Style	Fuse Size	Mtr O/L Mfr	Mtr O/L Type	Mtr O/L Style	Motor FLA	Service Factor	PCC kVA Demand	PCC Isc/ILoad	Comment
1	B L-MAIN	<None>	<None>	<None>	<None>	<None>		1			
2	B MCC1-MAIN	<None>	<None>	<None>	<None>	<None>		1			
3	B P-WR1-001	<None>	<None>	<None>	<None>	<None>		1			
4	B PUMP P-3	<None>	<None>	GE	CR324X	Class 10 Cold	7	1			
5	B PUMP P-4	<None>	<None>	<None>	<None>	<None>		1			
6	B PUMP P-5	<None>	<None>	<None>	<None>	<None>		1			
7	B PUMP P-6	<None>	<None>	GE	CR324X	Class 10 Cold	20	1			
8	B PUMP P-7	<None>	<None>	GE	CR324X	Class 10 Cold	20	1			
9	B PUMP P-8	<None>	<None>	GE	CR324X	Class 10 Cold	3	1			
10	B PUMP P-9	<None>	<None>	GE	CR324X	Class 10 Cold	3	1			
11	B PUMP P-10	<None>	<None>	GE	CR324X	Class 10 Cold	3	1			
12	B PUMP P-11	<None>	<None>	<None>	<None>	<None>		1			
13	B PUMP P-12	<None>	<None>	GE	CR324X	Class 10 Cold	7	1			
14	B PUMP P-13	<None>	<None>	GE	CR324X	Class 10 Cold	7	1			
15	B PUMP P-14	<None>	<None>	GE	CR324X	Class 10 Cold	20	1			
16	B SPARE	<None>	<None>	<None>	<None>	<None>		1			
17	B TX T-L	<None>	<None>	<None>	<None>	<None>		1			
18	B TX T-UPS	<None>	<None>	<None>	<None>	<None>		1			
19	B TX T4	<None>	<None>	<None>	<None>	<None>		1			
20	B TX T5	<None>	<None>	<None>	<None>	<None>		1			
21	B TX T11	<None>	<None>	<None>	<None>	<None>		1			
22	B U-1 MAIN	<None>	<None>	<None>	<None>	<None>		1			

Fuses

	ID Name	Status	On Bus	Base kV	Conn Type	Normal State	Options	Manufacturer	Type	Style	TCC Model	TCC kV
1	FS FG FEEDER	On	FUSEGEAR	12.47	Feeder	Closed	Fused Brea	S&C	SMU	SMU-40	Slow Speed	15.5
2	FS FUSEGEAR	On	FUSEGEAR	12.47	Feeder	Closed	Fused Brea	S&C	SMU	SMU-40	Slow Speed	15.5

Project Name: Meranto 2975 Zone Reservoir
Comment: Equipment Database report

Fuses

	ID Name	TCC Size	SC Int kA	SC Test X/R	SC Test Std	TCC Mom kA	TCC Int kA	TCC 30 cyc kA	Mtr O/L Mfr	Mtr O/L Type	Mtr O/L Style	Motor FLA	Service Factor
1	FS FG FEEDER	15E	25	15	ANSI-SYM				<None>	<None>	<None>		1
2	FS FUSEGEAR	175E	25	15	ANSI-SYM				<None>	<None>	<None>		1

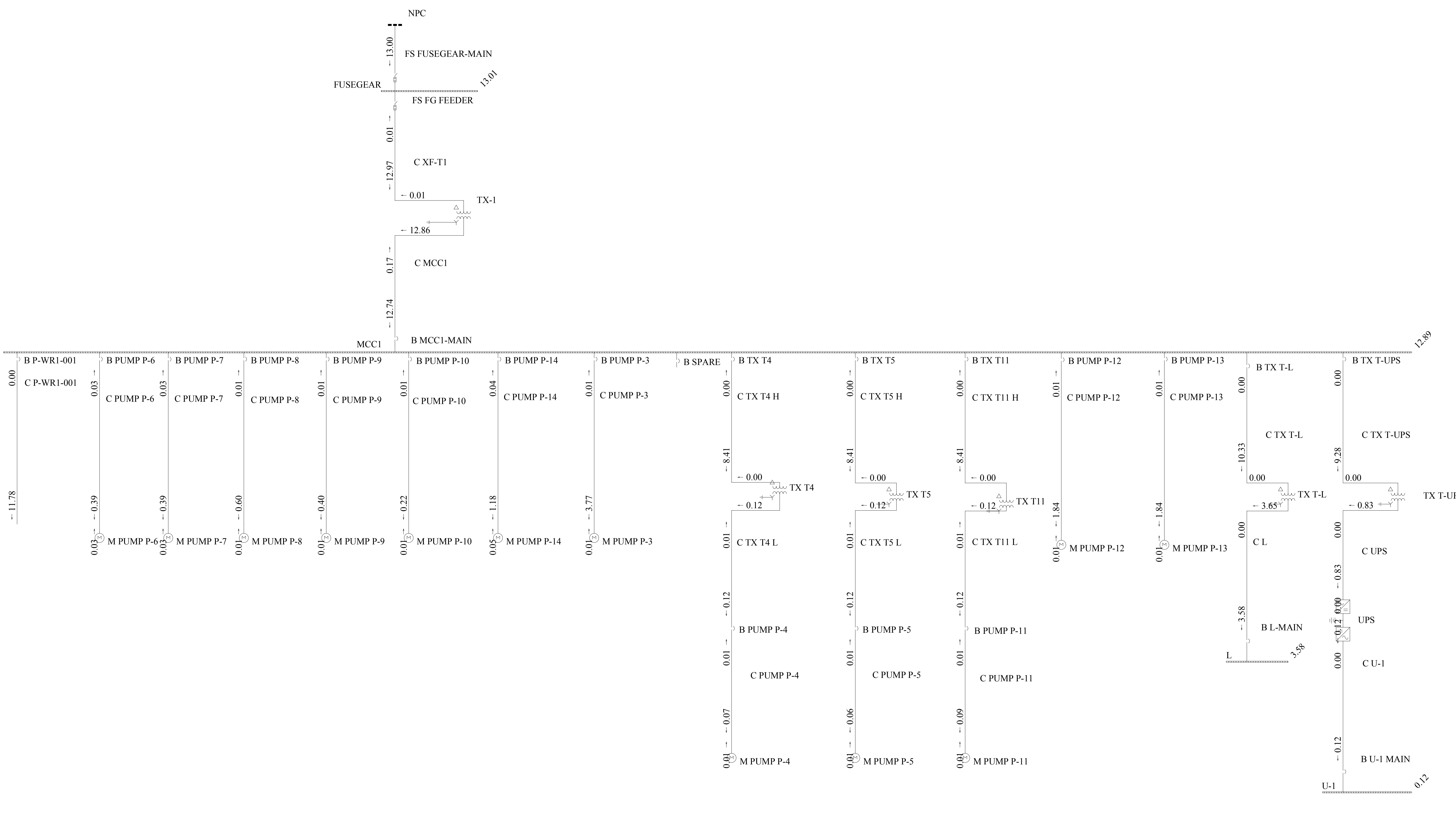
Fuses

	ID Name	PCC kVA Demand	PCC Isc/ILoad	Comment
1	FS FG FEEDER			
2	FS FUSEGEAR			

Single Line Faults

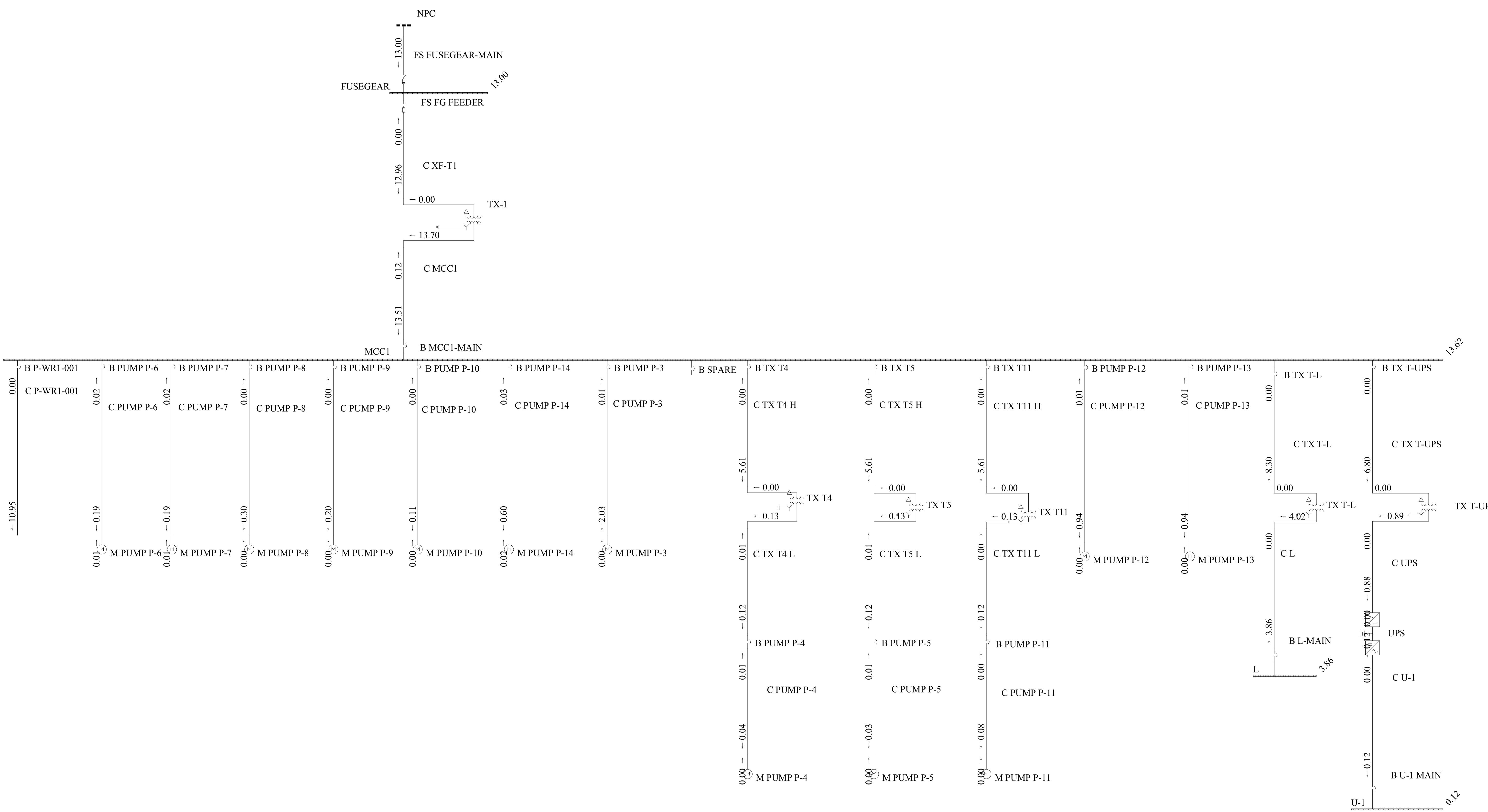
Phase and Ground Fault Contributions

(11” x 17” Sheets)



Meranto 2975 Zone Reservoir
Single Line Model - Three Phase SC
PQTSI - March 13, 2006

Printed by EasyPower



Meranto 2975 Zone Reservoir
Single Line Model - Ground Fault SC
PQTSI - March 13, 2006

Printed by EasyPower

Three Phase Bolted Fault

Equipment Duty Ratings

Project Name: Meranto 2975 Zone Reservoir
Comment: Three Phase Fault - Equipment Duty Report

EQUIPMENT DUTY VIOLATION AND WARNING DETAILED REPORTS
Driving Point Voltage (P.U.) = 1.00000

****

Equipment Duty Comparison Report For Bus:
1/2 STARTER Area: 1 Zone: 1 Bus kV: 0.24 kV

Equipment ID	Manufacturer	/ Style	Test Standard	Ratings: 1/2 Cycle (kA)	Ratings: Interrupting (kA)	Cyc	Duties: 1/2 Cycle kA (%)	Duties: Interrupting kA (%)	Comments
B PUMP P-11	GE	/SEL	ANSI-SYM	100.00			0.12(-99.9%)		
1/2 STARTER		/	ANSI-SYM	65.00			0.12(-99.8%)		

****

Equipment Duty Comparison Report For Bus:
3/4 STARTER P-4 Area: 1 Zone: 1 Bus kV: 0.24 kV

Equipment ID	Manufacturer	/ Style	Test Standard	Ratings: 1/2 Cycle (kA)	Ratings: Interrupting (kA)	Cyc	Duties: 1/2 Cycle kA (%)	Duties: Interrupting kA (%)	Comments
B PUMP P-4	GE	/SEL	ANSI-SYM	100.00			0.12(-99.9%)		
3/4 STARTER P-4		/	ANSI-SYM	65.00			0.13(-99.8%)		

****

Equipment Duty Comparison Report For Bus:
3/4 STARTER P-5 Area: 1 Zone: 1 Bus kV: 0.24 kV

Equipment ID	Manufacturer	/ Style	Test Standard	Ratings: 1/2 Cycle (kA)	Ratings: Interrupting (kA)	Cyc	Duties: 1/2 Cycle kA (%)	Duties: Interrupting kA (%)	Comments
B PUMP P-5	GE	/SEL	ANSI-SYM	100.00			0.12(-99.9%)		
3/4 STARTER P-5		/	ANSI-SYM	65.00			0.13(-99.8%)		

****

Equipment Duty Comparison Report For Bus:
FUSEGEAR Area: 1 Zone: 1 Bus kV: 12.47 kV

Equipment ID	Manufacturer	/ Style	Test Standard	Ratings: 1/2 Cycle (kA)	Ratings: Interrupting (kA)	Cyc	Duties: 1/2 Cycle kA (%)	Duties: Interrupting kA (%)	Comments
FS FUSEGEAR-MAIN	S&C	/SMU-40	ANSI-SYM	25.00			13.00(-48.0%)		
FS FG FEEDER	S&C	/SMU-40	ANSI-SYM	25.00			13.00(-48.0%)		
FUSEGEAR		/	ANSI-TOT	61.00			18.09(-70.3%)		

Project Name: Meranto 2975 Zone Reservoir
Comment: Three Phase Fault - Equipment Duty Report

EQUIPMENT DUTY VIOLATION AND WARNING DETAILED REPORTS
Driving Point Voltage (P.U.) = 1.00000

****

Equipment Duty Comparison Report For Bus:
L Area: 1 Zone: 1 Bus kV: 0.21 kV

ID	Manufacturer	/ Style	Test Standard	Ratings: 1/2 Cycle (kA)	Ratings: Interrupting (kA)	Cyc	Duties: 1/2 Cycle kA (%)	Duties: Interrupting kA (%)	Comments
B L-MAIN	GE	/TQD	ANSI-SYM	10.00			3.58(-64.2%)		
L		/	ANSI-SYM	10.00			3.58(-64.2%)		

****

Equipment Duty Comparison Report For Bus:
MCC1 Area: 1 Zone: 1 Bus kV: 0.48 kV

ID	Manufacturer	/ Style	Test Standard	Ratings: 1/2 Cycle (kA)	Ratings: Interrupting (kA)	Cyc	Duties: 1/2 Cycle kA (%)	Duties: Interrupting kA (%)	Comments
B MCC1-MAIN	GE	/SGL6	ANSI-SYM	65.00			12.74(-80.4%)		
B P-WR1-001	GE	/SEL	ANSI-SYM	65.00			12.89(-80.2%)		
B PUMP P-6	GE	/SEL	ANSI-SYM	65.00			12.86(-80.2%)		
B PUMP P-8	GE	/SEL	ANSI-SYM	65.00			12.89(-80.2%)		
B PUMP P-14	GE	/SEL	ANSI-SYM	65.00			12.85(-80.2%)		
B TX T11	GE	/SEL	ANSI-SYM	65.00			12.89(-80.2%)		
B PUMP P-3	GE	/SEL	ANSI-SYM	65.00			12.88(-80.2%)		
B SPARE	GE	/SEL	ANSI-SYM	65.00			12.89(-80.2%)		
B TX T-L	GE	/SEL	ANSI-SYM	65.00			12.89(-80.2%)		
B TX T-UPS	GE	/SEL	ANSI-SYM	65.00			12.89(-80.2%)		
B PUMP P-7	GE	/SEL	ANSI-SYM	65.00			12.86(-80.2%)		
B PUMP P-9	GE	/SEL	ANSI-SYM	65.00			12.89(-80.2%)		
B PUMP P-10	GE	/SEL	ANSI-SYM	65.00			12.89(-80.2%)		
B TX T4	GE	/SEL	ANSI-SYM	65.00			12.89(-80.2%)		
B TX T5	GE	/SEL	ANSI-SYM	65.00			12.89(-80.2%)		
B PUMP P-12	GE	/SEL	ANSI-SYM	65.00			12.88(-80.2%)		
B PUMP P-13	GE	/SEL	ANSI-SYM	65.00			12.88(-80.2%)		
MCC1		/	ANSI-SYM	42.00			12.89(-69.3%)		

****

Equipment Duty Comparison Report For Bus:
P-WR1-001 Area: 1 Zone: 1 Bus kV: 0.48 kV

ID	Manufacturer	/ Style	Test Standard	Ratings: 1/2 Cycle (kA)	Ratings: Interrupting (kA)	Cyc	Duties: 1/2 Cycle kA (%)	Duties: Interrupting kA (%)	Comments
P-WR1-001		/	ANSI-SYM	65.00			11.78(-81.9%)		

Project Name: Meranto 2975 Zone Reservoir
Comment: Three Phase Fault - Equipment Duty Report

EQUIPMENT DUTY VIOLATION AND WARNING DETAILED REPORTS
Driving Point Voltage (P.U.) = 1.00000

****

Equipment Duty Comparison Report For Bus:
U-1 Area: 1 Zone: 1 Bus kV: 0.21 kV

Equipment				Ratings			Duties		Comments
ID	Manufacturer	/ Style	Test Standard	1/2 Cycle (kA)	Interrupting (kA)	Cyc	1/2 Cycle kA (%)	Interrupting kA (%)	
B U-1 MAIN	GE	/THQB	ANSI-SYM	10.00			0.13(-98.7%)		
U-1		/	ANSI-SYM	10.00			0.12(-98.8%)		

Three Phase Bolted Fault

High Voltage Momentary Report

Project Name: Meranto 2975 Zone Reservoir

Comment: Three Phase Fault - High Voltage Momentary Report

First Cycle Results 3 PHASE

Driving Point Voltage (P.U.) = 1.00000

```
*Bus FUSEGEAR           12.470 kV, Zone     1, Area     1
      E/Z =     13.006 kA (      280.91 MVA)  At   -82.86DEG, X/R =     7.99
      Z1 =    0.044226 +j   0.353233 pu,  Z0 =   0.000000 +j   0.000000 pu
      1.6*ISYM=     20.809     IASYM Based on X/R ratio =     18.093
```

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
NPC		FUSEGEAR	13.00	-82.87	Util	1	1	
XF - T1 H		FUSEGEAR	0.01	-58.35	Branch	1	1	C XF-T1

```
*Bus XF - T1 H          12.470 kV, Zone     1, Area     1
      E/Z =     12.975 kA (      280.25 MVA)  At   -82.41DEG, X/R =     7.50
      Z1 =    0.047131 +j   0.353703 pu,  Z0 =   0.000000 +j   0.000000 pu
      1.6*ISYM=     20.760     IASYM Based on X/R ratio =     17.850
```

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
XF- T1 L		XF - T1 H	0.01	-58.35	Branch	1	1	TX-1
FUSEGEAR		XF - T1 H	12.97	-82.42	Branch	1	1	C XF-T1

Three Phase Bolted Fault

Low Voltage Momentary Report

(Serial #34798)
Project Name: Meranto 2975 Zone Reservoir
Comment: Three Phase Fault - Low Voltage Momentary Report

First Cycle Results 3 PHASE
Driving Point Voltage (P.U.) = 1.00000

```
*Bus 1/2 STARTER         0.240 kV, Zone     1, Area     1
       E/Z =      0.123 kA (        0.05 MVA)  At   -57.95DEG, X/R =     1.60
       Z1 =  ********** +j ********** pu,  Z0 =   0.000000 +j   0.000000 pu
       1.6*ISYM=      0.197   IASYM Based on X/R ratio =    0.127

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       TX T11-L          1/2 STARTER              0.12    -59.27  Branch      1      1  C TX T11 L
       PUMP P-11         1/2 STARTER              0.01    -28.02  Branch      1      1  C PUMP P-11

*Bus 3/4 STARTER P-4     0.240 kV, Zone     1, Area     1
       E/Z =      0.126 kA (        0.05 MVA)  At   -57.85DEG, X/R =     1.59
       Z1 =  ********** +j ********** pu,  Z0 =   0.000000 +j   0.000000 pu
       1.6*ISYM=      0.201   IASYM Based on X/R ratio =    0.130

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       TX T4-L           3/4 STARTER P-4          0.12    -59.27  Branch      1      1  C TX T4 L
       PUMP P-4          3/4 STARTER P-4          0.01    -35.96  Branch      1      1  C PUMP P-4

*Bus 3/4 STARTER P-5     0.240 kV, Zone     1, Area     1
       E/Z =      0.125 kA (        0.05 MVA)  At   -57.83DEG, X/R =     1.59
       Z1 =  ********** +j ********** pu,  Z0 =   0.000000 +j   0.000000 pu
       1.6*ISYM=      0.201   IASYM Based on X/R ratio =    0.130

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       TX T5-L           3/4 STARTER P-5          0.12    -59.27  Branch      1      1  C TX T5 L
       PUMP P-5          3/4 STARTER P-5          0.01    -35.23  Branch      1      1  C PUMP P-5

*Bus L                   0.208 kV, Zone     1, Area     1
       E/Z =      3.581 kA (        1.29 MVA)  At   -58.13DEG, X/R =     1.61
       Z1 =   40.928252 +j  65.830139 pu,  Z0 =   0.000000 +j   0.000000 pu
       1.6*ISYM=      5.729   IASYM Based on X/R ratio =    3.702

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       TX T-L L          L                        3.58    -58.13  Branch      1      1  C L

*Bus MCC1                0.480 kV, Zone     1, Area     1
       E/Z =     12.891 kA (       10.72 MVA)  At   -77.21DEG, X/R =     4.40
       Z1 =    2.065905 +j   9.098875 pu,  Z0 =   0.000000 +j   0.000000 pu
       1.6*ISYM=     20.626   IASYM Based on X/R ratio =   15.934

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       XF- T1 L          MCC1                    12.74    -77.45  Branch      1      1  C MCC1
       P-WR1-001         MCC1                     0.00      0.00  Branch      1      1  C P-WR1-001
       PUMP P-6          MCC1                     0.03    -61.20  Branch      1      1  C PUMP P-6
       PUMP P-8          MCC1                     0.01    -49.87  Branch      1      1  C PUMP P-8
       PUMP P-14         MCC1                     0.04    -65.07  Branch      1      1  C PUMP P-14
       PUMP P-3          MCC1                     0.01    -53.98  Branch      1      1  C PUMP P-3
       TX T11-H          MCC1                     0.00    -29.33  Branch      1      1  C TX T11 H
       TX T-L H          MCC1                     0.00      0.00  Branch      1      1  C TX T-L
       TX T-UPS H        MCC1                     0.00      0.00  Branch      1      1  C TX T-UPS
       PUMP P-7          MCC1                     0.03    -61.20  Branch      1      1  C PUMP P-7
       PUMP P-9          MCC1                     0.01    -49.63  Branch      1      1  C PUMP P-9
       PUMP P-10         MCC1                     0.01    -49.08  Branch      1      1  C PUMP P-10
       TX T4-H           MCC1                     0.00    -37.36  Branch      1      1  C TX T4 H
       TX T5-H           MCC1                     0.00    -36.65  Branch      1      1  C TX T5 H
       PUMP P-12         MCC1                     0.01    -53.86  Branch      1      1  C PUMP P-12
       PUMP P-13         MCC1                     0.01    -53.86  Branch      1      1  C PUMP P-13
```

```
Project Name: Meranto 2975 Zone Reservoir
Comment: Three Phase Fault - Low Voltage Momentary Report

First Cycle Results 3 PHASE
Driving Point Voltage (P.U.) = 1.00000


*Bus P-WR1-001           0.480 kV, Zone     1, Area     1
      E/Z =     11.779 kA (        9.79 MVA)  At   -65.61DEG, X/R =     2.21
      Z1 =    4.216520 +j   9.300480 pu,  Z0 =   0.000000 +j   0.000000 pu
      1.6*ISYM=     18.846   IASYM Based on X/R ratio =   12.693

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      MCC1              P-WR1-001              11.78    -65.61  Branch      1      1  C P-WR1-001

*Bus PUMP P-3            0.480 kV, Zone     1, Area     1
      E/Z =      3.775 kA (        3.14 MVA)  At   -19.92DEG, X/R =     0.36
      Z1 =   29.955738 +j  10.857246 pu,  Z0 =   0.000000 +j   0.000000 pu
      1.6*ISYM=      6.040   IASYM Based on X/R ratio =    3.775

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-3        PUMP P-3                0.01    -54.07  Motor       1      1
      MCC1              PUMP P-3                3.77    -19.85  Branch      1      1  C PUMP P-3

*Bus PUMP P-4            0.240 kV, Zone     1, Area     1
      E/Z =      0.075 kA (        0.03 MVA)  At   -31.37DEG, X/R =     0.61
      Z1 =  ********** +j ********** pu,  Z0 =   0.000000 +j   0.000000 pu
      1.6*ISYM=      0.120   IASYM Based on X/R ratio =    0.075

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-4        PUMP P-4                0.01    -38.22  Motor       1      1
      3/4 STARTER P-4   PUMP P-4                0.07    -30.53  Branch      1      1  C PUMP P-4

*Bus PUMP P-5            0.240 kV, Zone     1, Area     1
      E/Z =      0.065 kA (        0.03 MVA)  At   -27.49DEG, X/R =     0.52
      Z1 =  ********** +j ********** pu,  Z0 =   0.000000 +j   0.000000 pu
      1.6*ISYM=      0.104   IASYM Based on X/R ratio =    0.065

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-5        PUMP P-5                0.01    -38.22  Motor       1      1
      3/4 STARTER P-5   PUMP P-5                0.06    -25.94  Branch      1      1  C PUMP P-5

*Bus PUMP P-6            0.480 kV, Zone     1, Area     1
      E/Z =      0.411 kA (        0.34 MVA)  At    -9.33DEG, X/R =     0.16
      Z1 =  289.030743 +j  47.491628 pu,  Z0 =   0.000000 +j   0.000000 pu
      1.6*ISYM=      0.657   IASYM Based on X/R ratio =    0.411

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-6        PUMP P-6                0.03    -65.34  Motor       1      1
      MCC1              PUMP P-6                0.39     -5.23  Branch      1      1  C PUMP P-6

*Bus PUMP P-7            0.480 kV, Zone     1, Area     1
      E/Z =      0.411 kA (        0.34 MVA)  At    -9.33DEG, X/R =     0.16
      Z1 =  289.030743 +j  47.491628 pu,  Z0 =   0.000000 +j   0.000000 pu
      1.6*ISYM=      0.657   IASYM Based on X/R ratio =    0.411

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-7        PUMP P-7                0.03    -65.34  Motor       1      1
      MCC1              PUMP P-7                0.39     -5.23  Branch      1      1  C PUMP P-7
```

Project Name: Meranto 2975 Zone Reservoir
Comment: Three Phase Fault - Low Voltage Momentary Report

First Cycle Results 3 PHASE
Driving Point Voltage (P.U.) = 1.00000

*Bus PUMP P-8 0.480 kV, Zone 1, Area 1
E/Z = 0.606 kA (0.50 MVA) At -5.16DEG, X/R = 0.09
Z1 = 197.737964 +j 17.867747 pu, Z0 = 0.000000 +j 0.000000 pu
1.6*ISYM= 0.969 IASYM Based on X/R ratio = 0.606

Contributions In kA

Bus	to Bus	kA	Angle	Device	Zone	Area	Branch
M PUMP P-8	PUMP P-8	0.01	-50.34	Motor	1	1	
MCC1	PUMP P-8	0.60	-4.70	Branch	1	1	C PUMP P-8

*Bus PUMP P-9 0.480 kV, Zone 1, Area 1
E/Z = 0.407 kA (0.34 MVA) At -4.54DEG, X/R = 0.08
Z1 = 294.429815 +j 23.394712 pu, Z0 = 0.000000 +j 0.000000 pu
1.6*ISYM= 0.652 IASYM Based on X/R ratio = 0.407

Contributions In kA

Bus	to Bus	kA	Angle	Device	Zone	Area	Branch
M PUMP P-9	PUMP P-9	0.01	-50.34	Motor	1	1	
MCC1	PUMP P-9	0.40	-3.85	Branch	1	1	C PUMP P-9

*Bus PUMP P-10 0.480 kV, Zone 1, Area 1
E/Z = 0.229 kA (0.19 MVA) At -4.33DEG, X/R = 0.08
Z1 = 523.373632 +j 39.637636 pu, Z0 = 0.000000 +j 0.000000 pu
1.6*ISYM= 0.367 IASYM Based on X/R ratio = 0.229

Contributions In kA

Bus	to Bus	kA	Angle	Device	Zone	Area	Branch
M PUMP P-10	PUMP P-10	0.01	-50.34	Motor	1	1	
MCC1	PUMP P-10	0.22	-3.09	Branch	1	1	C PUMP P-10

*Bus PUMP P-11 0.240 kV, Zone 1, Area 1
E/Z = 0.100 kA (0.04 MVA) At -43.31DEG, X/R = 0.94
Z1 = ********** +j ********** pu, Z0 = 0.000000 +j 0.000000 pu
1.6*ISYM= 0.160 IASYM Based on X/R ratio = 0.100

Contributions In kA

Bus	to Bus	kA	Angle	Device	Zone	Area	Branch
M PUMP P-11	PUMP P-11	0.01	-28.48	Motor	1	1	
1/2 STARTER	PUMP P-11	0.09	-44.17	Branch	1	1	C PUMP P-11

*Bus PUMP P-12 0.480 kV, Zone 1, Area 1
E/Z = 1.843 kA (1.53 MVA) At -11.60DEG, X/R = 0.21
Z1 = 63.934124 +j 13.122339 pu, Z0 = 0.000000 +j 0.000000 pu
1.6*ISYM= 2.949 IASYM Based on X/R ratio = 1.843

Contributions In kA

Bus	to Bus	kA	Angle	Device	Zone	Area	Branch
M PUMP P-12	PUMP P-12	0.01	-54.07	Motor	1	1	
MCC1	PUMP P-12	1.84	-11.41	Branch	1	1	C PUMP P-12

*Bus PUMP P-13 0.480 kV, Zone 1, Area 1
E/Z = 1.843 kA (1.53 MVA) At -11.60DEG, X/R = 0.21
Z1 = 63.934124 +j 13.122339 pu, Z0 = 0.000000 +j 0.000000 pu
1.6*ISYM= 2.949 IASYM Based on X/R ratio = 1.843

Contributions In kA

Bus	to Bus	kA	Angle	Device	Zone	Area	Branch
M PUMP P-13	PUMP P-13	0.01	-54.07	Motor	1	1	
MCC1	PUMP P-13	1.84	-11.41	Branch	1	1	C PUMP P-13

Project Name: Meranto 2975 Zone Reservoir
Comment: Three Phase Fault - Low Voltage Momentary Report

First Cycle Results 3 PHASE
Driving Point Voltage (P.U.) = 1.00000

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*Bus PUMP P-14           0.480 kV, Zone     1, Area     1
       E/Z =      1.205 kA (        1.00 MVA)  At    -9.10DEG, X/R =     0.16
       Z1 =   98.531533 +j  15.788864 pu,  Z0 =   0.000000 +j   0.000000 pu
       1.6*ISYM=      1.929   IASYM Based on X/R ratio =    1.205

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       M PUMP P-14       PUMP P-14                0.05    -66.97  Motor       1      1
       MCC1              PUMP P-14                1.18     -7.25  Branch      1      1  C PUMP P-14

*Bus TX T-L H            0.480 kV, Zone     1, Area     1
       E/Z =     10.330 kA (        8.59 MVA)  At   -56.84DEG, X/R =     1.53
       Z1 =    6.368080 +j   9.747695 pu,  Z0 =   0.000000 +j   0.000000 pu
       1.6*ISYM=     16.529   IASYM Based on X/R ratio =   10.629

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       TX T-L L          TX T-L H                 0.00      0.00  Branch      1      1  TX T-L
       MCC1              TX T-L H                10.33    -56.84  Branch      1      1  C TX T-L

*Bus TX T-L L            0.208 kV, Zone     1, Area     1
       E/Z =      3.648 kA (        1.31 MVA)  At   -58.60DEG, X/R =     1.64
       Z1 =   39.636783 +j  64.940810 pu,  Z0 =   0.000000 +j   0.000000 pu
       1.6*ISYM=      5.837   IASYM Based on X/R ratio =    3.779

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       TX T-L H          TX T-L L                 3.65    -58.60  Branch      1      1  TX T-L
       L                 TX T-L L                 0.00      0.00  Branch      1      1  C L

*Bus TX T-UPS H          0.480 kV, Zone     1, Area     1
       E/Z =      9.281 kA (        7.72 MVA)  At   -50.68DEG, X/R =     1.22
       Z1 =    8.211868 +j  10.025761 pu,  Z0 =   0.000000 +j   0.000000 pu
       1.6*ISYM=     14.850   IASYM Based on X/R ratio =    9.399

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       TX T-UPS UPS      TX T-UPS H               0.00      0.00  Branch      1      1  TX T-UPS
       MCC1              TX T-UPS H               9.28    -50.68  Branch      1      1  C TX T-UPS

*Bus TX T-UPS UPS        0.208 kV, Zone     1, Area     1
       E/Z =      0.834 kA (        0.30 MVA)  At   -56.96DEG, X/R =     1.54
       Z1 =  181.493500 +j 279.048954 pu,  Z0 =   0.000000 +j   0.000000 pu
       1.6*ISYM=      1.334   IASYM Based on X/R ratio =    0.858

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       TX T-UPS H        TX T-UPS UPS             0.83    -56.96  Branch      1      1  TX T-UPS
       UPS-IN            TX T-UPS UPS             0.00      0.00  Branch      1      1  C UPS

*Bus TX T4-H             0.480 kV, Zone     1, Area     1
       E/Z =      8.418 kA (        7.00 MVA)  At   -41.24DEG, X/R =     0.88
       Z1 =   10.744867 +j   9.418464 pu,  Z0 =   0.000000 +j   0.000000 pu
       1.6*ISYM=     13.469   IASYM Based on X/R ratio =    8.440

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       TX T4-L           TX T4-H                  0.00    -37.37  Branch      1      1  TX T4
       MCC1              TX T4-H                  8.41    -41.24  Branch      1      1  C TX T4 H
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Project Name: Meranto 2975 Zone Reservoir
Comment: Three Phase Fault - Low Voltage Momentary Report

First Cycle Results 3 PHASE
Driving Point Voltage (P.U.) = 1.00000


*Bus TX T4-L            0.240 kV, Zone     1, Area     1
      E/Z =      0.127 kA (       0.05 MVA)  At   -58.65DEG, X/R =     1.64
      Z1 =  988.281359 +j ********** pu,  Z0 =   0.000000 +j   0.000000 pu
      1.6*ISYM=      0.203   IASYM Based on X/R ratio =    0.131

      Contributions In kA
      Bus      to      Bus                       kA     Angle  Device   Zone   Area  Branch
      TX T4-H          TX T4-L                 0.12    -60.10  Branch      1      1  TX T4
      3/4 STARTER P-4  TX T4-L                 0.01    -35.92  Branch      1      1  C TX T4 L

*Bus TX T5-H            0.480 kV, Zone     1, Area     1
      E/Z =      8.418 kA (       7.00 MVA)  At   -41.24DEG, X/R =     0.88
      Z1 =   10.744992 +j   9.418432 pu,  Z0 =   0.000000 +j   0.000000 pu
      1.6*ISYM=     13.469   IASYM Based on X/R ratio =    8.440

      Contributions In kA
      Bus      to      Bus                       kA     Angle  Device   Zone   Area  Branch
      TX T5-L          TX T5-H                 0.00    -36.66  Branch      1      1  TX T5
      MCC1             TX T5-H                 8.41    -41.24  Branch      1      1  C TX T5 H

*Bus TX T5-L            0.240 kV, Zone     1, Area     1
      E/Z =      0.126 kA (       0.05 MVA)  At   -58.63DEG, X/R =     1.64
      Z1 =  990.057752 +j ********** pu,  Z0 =   0.000000 +j   0.000000 pu
      1.6*ISYM=      0.202   IASYM Based on X/R ratio =    0.131

      Contributions In kA
      Bus      to      Bus                       kA     Angle  Device   Zone   Area  Branch
      TX T5-H          TX T5-L                 0.12    -60.10  Branch      1      1  TX T5
      3/4 STARTER P-5  TX T5-L                 0.01    -35.20  Branch      1      1  C TX T5 L

*Bus TX T11-H           0.480 kV, Zone     1, Area     1
      E/Z =      8.417 kA (       7.00 MVA)  At   -41.23DEG, X/R =     0.88
      Z1 =   10.746756 +j   9.418521 pu,  Z0 =   0.000000 +j   0.000000 pu
      1.6*ISYM=     13.468   IASYM Based on X/R ratio =    8.439

      Contributions In kA
      Bus      to      Bus                       kA     Angle  Device   Zone   Area  Branch
      TX T11-L         TX T11-H                0.00    -29.33  Branch      1      1  TX T11
      MCC1             TX T11-H                8.41    -41.24  Branch      1      1  C TX T11 H

*Bus TX T11-L           0.240 kV, Zone     1, Area     1
      E/Z =      0.124 kA (       0.05 MVA)  At   -58.76DEG, X/R =     1.65
      Z1 =  ********** +j ********** pu,  Z0 =   0.000000 +j   0.000000 pu
      1.6*ISYM=      0.199   IASYM Based on X/R ratio =    0.129

      Contributions In kA
      Bus      to      Bus                       kA     Angle  Device   Zone   Area  Branch
      TX T11-H         TX T11-L                0.12    -60.10  Branch      1      1  TX T11
      1/2 STARTER      TX T11-L                0.01    -28.00  Branch      1      1  C TX T11 L

*Bus U-1                0.208 kV, Zone     1, Area     1
      E/Z =      0.125 kA (       0.04 MVA)  At   -68.68DEG, X/R =     2.56
      Z1 =  809.959995 +j ********** pu,  Z0 =   0.000000 +j   0.000000 pu
      1.6*ISYM=      0.199   IASYM Based on X/R ratio =    0.138

      Contributions In kA
      Bus      to      Bus                       kA     Angle  Device   Zone   Area  Branch
      UPS-OUT          U-1                     0.12    -68.68  Branch      1      1  C U-1
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Project Name: Meranto 2975 Zone Reservoir
Comment: Three Phase Fault - Low Voltage Momentary Report

First Cycle Results 3 PHASE
Driving Point Voltage (P.U.) = 1.00000

*Bus UPS-IN 0.208 kV, Zone 1, Area 1
E/Z = 0.830 kA (0.30 MVA) At -56.85DEG, X/R = 1.53
Z1 = 182.914115 +j 280.027216 pu, Z0 = 0.000000 +j 0.000000 pu
1.6*ISYM= 1.328 IASYM Based on X/R ratio = 0.854

Contributions In kA

Bus to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T-UPS UPS	UPS-IN	0.83	-56.85	Branch	1	1	C UPS

*Bus UPS-OUT 0.208 kV, Zone 1, Area 1
E/Z = 0.125 kA (0.05 MVA) At -68.94DEG, X/R = 2.60
Z1 = 798.507019 +j ********** pu, Z0 = 0.000000 +j 0.000000 pu
1.6*ISYM= 0.200 IASYM Based on X/R ratio = 0.138

Contributions In kA

Bus to	Bus	kA	Angle	Device	Zone	Area	Branch
UPS	UPS-OUT	0.12	-68.94	Gen	1	1	
U-1	UPS-OUT	0.00	0.00	Branch	1	1	C U-1

*Bus XF- T1 L 0.480 kV, Zone 1, Area 1
E/Z = 13.012 kA (10.82 MVA) At -77.61DEG, X/R = 4.55
Z1 = 1.984220 +j 9.028580 pu, Z0 = 0.000000 +j 0.000000 pu
1.6*ISYM= 20.819 IASYM Based on X/R ratio = 16.195

Contributions In kA

Bus to	Bus	kA	Angle	Device	Zone	Area	Branch
XF - T1 H	XF- T1 L	12.86	-77.85	Branch	1	1	TX-1
MCC1	XF- T1 L	0.17	-58.11	Branch	1	1	C MCC1

Three Phase Bolted Fault

Low Voltage Interrupting Report

Project Name: Meranto 2975 Zone Reservoir
Comment: Three Phase Fault - Low Voltage Interrupting Report

Interrupting Results 3 PHASE
Driving Point Voltage (P.U.) = 1.00000

*Bus 1/2 STARTER 0.240 kV, Zone 1, Area 1
E/Z = 0.118 kA (0.049 MVA) At -59.27DEG, X/R = 1.96
Z1 = ********** +j ********** pu, Z0 = 0.000000 +j 0.000000 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T11-L		1/2 STARTER	0.12	-59.27	Branch	1	1	C TX T11 L
PUMP P-11		1/2 STARTER	0.00	0.00	Branch	1	1	C PUMP P-11

*Bus 3/4 STARTER P-4 0.240 kV, Zone 1, Area 1
E/Z = 0.118 kA (0.049 MVA) At -59.27DEG, X/R = 1.96
Z1 = ********** +j ********** pu, Z0 = 0.000000 +j 0.000000 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T4-L		3/4 STARTER P-4	0.12	-59.27	Branch	1	1	C TX T4 L
PUMP P-4		3/4 STARTER P-4	0.00	0.00	Branch	1	1	C PUMP P-4

*Bus 3/4 STARTER P-5 0.240 kV, Zone 1, Area 1
E/Z = 0.118 kA (0.049 MVA) At -59.27DEG, X/R = 1.96
Z1 = ********** +j ********** pu, Z0 = 0.000000 +j 0.000000 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T5-L		3/4 STARTER P-5	0.12	-59.27	Branch	1	1	C TX T5 L
PUMP P-5		3/4 STARTER P-5	0.00	0.00	Branch	1	1	C PUMP P-5

*Bus L 0.208 kV, Zone 1, Area 1
E/Z = 3.576 kA (1.288 MVA) At -58.19DEG, X/R = 1.90
Z1 = 40.914472 +j 65.950249 pu, Z0 = 0.000000 +j 0.000000 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T-L L		L	3.58	-58.19	Branch	1	1	C L

*Bus MCC1 0.480 kV, Zone 1, Area 1
E/Z = 12.735 kA (10.588 MVA) At -77.45DEG, X/R = 4.60
Z1 = 2.052124 +j 9.218986 pu, Z0 = 0.000000 +j 0.000000 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
XF- T1 L		MCC1	12.74	-77.45	Branch	1	1	C MCC1
P-WR1-001		MCC1	0.00	0.00	Branch	1	1	C P-WR1-001
PUMP P-6		MCC1	0.00	0.00	Branch	1	1	C PUMP P-6
PUMP P-8		MCC1	0.00	0.00	Branch	1	1	C PUMP P-8
PUMP P-14		MCC1	0.00	0.00	Branch	1	1	C PUMP P-14
PUMP P-3		MCC1	0.00	0.00	Branch	1	1	C PUMP P-3
TX T11-H		MCC1	0.00	0.00	Branch	1	1	C TX T11 H
TX T-L H		MCC1	0.00	0.00	Branch	1	1	C TX T-L
TX T-UPS H		MCC1	0.00	0.00	Branch	1	1	C TX T-UPS
PUMP P-7		MCC1	0.00	0.00	Branch	1	1	C PUMP P-7
PUMP P-9		MCC1	0.00	0.00	Branch	1	1	C PUMP P-9
PUMP P-10		MCC1	0.00	0.00	Branch	1	1	C PUMP P-10
TX T4-H		MCC1	0.00	0.00	Branch	1	1	C TX T4 H
TX T5-H		MCC1	0.00	0.00	Branch	1	1	C TX T5 H
PUMP P-12		MCC1	0.00	0.00	Branch	1	1	C PUMP P-12
PUMP P-13		MCC1	0.00	0.00	Branch	1	1	C PUMP P-13

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Project Name: Meranto 2975 Zone Reservoir
Comment: Three Phase Fault - Low Voltage Interrupting Report

Interrupting Results 3 PHASE
Driving Point Voltage (P.U.) = 1.00000


*Bus P-WR1-001           0.480 kV, Zone     1, Area     1
      E/Z =     11.660 kA (       9.694 MVA)  At   -65.96DEG, X/R =     2.45
      Z1 =    4.202739 +j   9.420590 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      MCC1              P-WR1-001              11.66    -65.96  Branch      1      1  C P-WR1-001

*Bus PUMP P-3            0.480 kV, Zone     1, Area     1
      E/Z =      3.764 kA (       3.130 MVA)  At   -20.04DEG, X/R =     1.06
      Z1 =   30.017235 +j  10.952039 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-3        PUMP P-3                0.00      0.00  Motor       1      1
      MCC1              PUMP P-3                3.76    -20.04  Branch      1      1  C PUMP P-3

*Bus PUMP P-4            0.240 kV, Zone     1, Area     1
      E/Z =      0.067 kA (       0.028 MVA)  At   -30.53DEG, X/R =     1.16
      Z1 =  ********** +j ********** pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-4        PUMP P-4                0.00      0.00  Motor       1      1
      3/4 STARTER P-4   PUMP P-4                0.07    -30.53  Branch      1      1  C PUMP P-4

*Bus PUMP P-5            0.240 kV, Zone     1, Area     1
      E/Z =      0.057 kA (       0.024 MVA)  At   -25.94DEG, X/R =     1.11
      Z1 =  ********** +j ********** pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-5        PUMP P-5                0.00      0.00  Motor       1      1
      3/4 STARTER P-5   PUMP P-5                0.06    -25.94  Branch      1      1  C PUMP P-5

*Bus PUMP P-6            0.480 kV, Zone     1, Area     1
      E/Z =      0.393 kA (       0.326 MVA)  At    -5.24DEG, X/R =     1.00
      Z1 =  305.006046 +j  27.995868 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-6        PUMP P-6                0.00      0.00  Motor       1      1
      MCC1              PUMP P-6                0.39     -5.24  Branch      1      1  C PUMP P-6

*Bus PUMP P-7            0.480 kV, Zone     1, Area     1
      E/Z =      0.393 kA (       0.326 MVA)  At    -5.24DEG, X/R =     1.00
      Z1 =  305.006046 +j  27.995868 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-7        PUMP P-7                0.00      0.00  Motor       1      1
      MCC1              PUMP P-7                0.39     -5.24  Branch      1      1  C PUMP P-7

*Bus PUMP P-8            0.480 kV, Zone     1, Area     1
      E/Z =      0.601 kA (       0.500 MVA)  At    -4.74DEG, X/R =     1.00
      Z1 =  199.429364 +j  16.529411 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-8        PUMP P-8                0.00      0.00  Motor       1      1
      MCC1              PUMP P-8                0.60     -4.74  Branch      1      1  C PUMP P-8
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Project Name: Meranto 2975 Zone Reservoir
Comment: Three Phase Fault - Low Voltage Interrupting Report

Interrupting Results 3 PHASE
Driving Point Voltage (P.U.) = 1.00000

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*Bus PUMP P-9           0.480 kV, Zone     1, Area     1
      E/Z =      0.403 kA (       0.335 MVA)  At    -3.87DEG, X/R =     1.00
      Z1 =  298.117885 +j  20.184742 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-9        PUMP P-9                 0.00      0.00  Motor       1      1
      MCC1              PUMP P-9                 0.40     -3.87  Branch      1      1  C PUMP P-9

*Bus PUMP P-10          0.480 kV, Zone     1, Area     1
      E/Z =      0.225 kA (       0.187 MVA)  At    -3.10DEG, X/R =     1.00
      Z1 =  534.969969 +j  28.957860 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-10       PUMP P-10                0.00      0.00  Motor       1      1
      MCC1              PUMP P-10                0.22     -3.10  Branch      1      1  C PUMP P-10

*Bus PUMP P-11          0.240 kV, Zone     1, Area     1
      E/Z =      0.094 kA (       0.039 MVA)  At   -44.17DEG, X/R =     1.39
      Z1 =  ********** +j ********** pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-11       PUMP P-11                0.00      0.00  Motor       1      1
      1/2 STARTER       PUMP P-11                0.09    -44.17  Branch      1      1  C PUMP P-11

*Bus PUMP P-12          0.480 kV, Zone     1, Area     1
      E/Z =      1.836 kA (       1.526 MVA)  At   -11.51DEG, X/R =     1.02
      Z1 =   64.196807 +j  13.070227 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-12       PUMP P-12                0.00      0.00  Motor       1      1
      MCC1              PUMP P-12                1.84    -11.51  Branch      1      1  C PUMP P-12

*Bus PUMP P-13          0.480 kV, Zone     1, Area     1
      E/Z =      1.836 kA (       1.526 MVA)  At   -11.51DEG, X/R =     1.02
      Z1 =   64.196807 +j  13.070227 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-13       PUMP P-13                0.00      0.00  Motor       1      1
      MCC1              PUMP P-13                1.84    -11.51  Branch      1      1  C PUMP P-13

*Bus PUMP P-14          0.480 kV, Zone     1, Area     1
      E/Z =      1.182 kA (       0.983 MVA)  At    -7.30DEG, X/R =     1.01
      Z1 =  100.939048 +j  12.926841 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-14       PUMP P-14                0.00      0.00  Motor       1      1
      MCC1              PUMP P-14                1.18     -7.30  Branch      1      1  C PUMP P-14

*Bus TX T-L H           0.480 kV, Zone     1, Area     1
      E/Z =     10.248 kA (       8.520 MVA)  At   -57.22DEG, X/R =     1.85
      Z1 =    6.354299 +j   9.867806 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T-L L          TX T-L H                 0.00      0.00  Branch      1      1  TX T-L
      MCC1              TX T-L H                10.25    -57.22  Branch      1      1  C TX T-L
```

Project Name: Meranto 2975 Zone Reservoir
Comment: Three Phase Fault - Low Voltage Interrupting Report

Interrupting Results 3 PHASE
Driving Point Voltage (P.U.) = 1.00000

```
*Bus TX T-L L            0.208 kV, Zone     1, Area     1
      E/Z =      3.644 kA (       1.313 MVA)  At   -58.66DEG, X/R =     1.92
      Z1 =   39.623003 +j  65.060921 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T-L H          TX T-L L                 3.64    -58.66  Branch      1      1  TX T-L
      L                 TX T-L L                 0.00      0.00  Branch      1      1  C L

*Bus TX T-UPS H          0.480 kV, Zone     1, Area     1
      E/Z =      9.221 kA (       7.666 MVA)  At   -51.06DEG, X/R =     1.59
      Z1 =    8.198088 +j  10.145872 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T-UPS UPS      TX T-UPS H               0.00      0.00  Branch      1      1  TX T-UPS
      MCC1              TX T-UPS H               9.22    -51.06  Branch      1      1  C TX T-UPS

*Bus TX T-UPS UPS        0.208 kV, Zone     1, Area     1
      E/Z =      0.834 kA (       0.300 MVA)  At   -56.97DEG, X/R =     1.83
      Z1 =  181.479720 +j 279.169065 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T-UPS H        TX T-UPS UPS             0.83    -56.97  Branch      1      1  TX T-UPS
      UPS-IN            TX T-UPS UPS             0.00      0.00  Branch      1      1  C UPS

*Bus TX T4-H             0.480 kV, Zone     1, Area     1
      E/Z =      8.374 kA (       6.962 MVA)  At   -41.62DEG, X/R =     1.34
      Z1 =   10.736730 +j   9.540638 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T4-L           TX T4-H                  0.00      0.00  Branch      1      1  TX T4
      MCC1              TX T4-H                  8.37    -41.62  Branch      1      1  C TX T4 H

*Bus TX T4-L             0.240 kV, Zone     1, Area     1
      E/Z =      0.119 kA (       0.050 MVA)  At   -60.10DEG, X/R =     2.01
      Z1 =  ********** +j ********** pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T4-H           TX T4-L                  0.12    -60.10  Branch      1      1  TX T4
      3/4 STARTER P-4   TX T4-L                  0.00      0.00  Branch      1      1  C TX T4 L

*Bus TX T5-H             0.480 kV, Zone     1, Area     1
      E/Z =      8.374 kA (       6.962 MVA)  At   -41.62DEG, X/R =     1.34
      Z1 =   10.736730 +j   9.540638 pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T5-L           TX T5-H                  0.00      0.00  Branch      1      1  TX T5
      MCC1              TX T5-H                  8.37    -41.62  Branch      1      1  C TX T5 H

*Bus TX T5-L             0.240 kV, Zone     1, Area     1
      E/Z =      0.119 kA (       0.050 MVA)  At   -60.10DEG, X/R =     2.01
      Z1 =  ********** +j ********** pu,  Z0 =   0.000000 +j   0.000000 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T5-H           TX T5-L                  0.12    -60.10  Branch      1      1  TX T5
      3/4 STARTER P-5   TX T5-L                  0.00      0.00  Branch      1      1  C TX T5 L
```

Project Name: Meranto 2975 Zone Reservoir
Comment: Three Phase Fault - Low Voltage Interrupting Report

Interrupting Results 3 PHASE
Driving Point Voltage (P.U.) = 1.00000

*Bus TX T11-H   0.480 kV, Zone   1, Area   1
E/Z =   8.374 kA (6.962 MVA) At   -41.62DEG, X/R =   1.34
Z1 =   10.736731 +j   9.540638 pu, Z0 =   0.000000 +j   0.000000 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T11-L		TX T11-H	0.00	0.00	Branch	1	1	TX T11
MCC1		TX T11-H	8.37	-41.62	Branch	1	1	C TX T11 H

*Bus TX T11-L   0.240 kV, Zone   1, Area   1
E/Z =   0.119 kA (0.050 MVA) At   -60.10DEG, X/R =   2.01
Z1 = ********** +j ********** pu, Z0 =   0.000000 +j   0.000000 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T11-H		TX T11-L	0.12	-60.10	Branch	1	1	TX T11
1/2 STARTER		TX T11-L	0.00	0.00	Branch	1	1	C TX T11 L

*Bus U-1   0.208 kV, Zone   1, Area   1
E/Z =   0.000 kA (0.000 MVA) At   0.00DEG, X/R =   2.78
Z1 = ********** +j ********** pu, Z0 =   0.000000 +j   0.000000 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
UPS-OUT		U-1	0.00	0.00	Branch	1	1	C U-1

*Bus UPS-IN   0.208 kV, Zone   1, Area   1
E/Z =   0.830 kA (0.299 MVA) At   -56.86DEG, X/R =   1.83
Z1 = 182.900335 +j 280.147326 pu, Z0 =   0.000000 +j   0.000000 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T-UPS UPS		UPS-IN	0.83	-56.86	Branch	1	1	C UPS

*Bus UPS-OUT   0.208 kV, Zone   1, Area   1
E/Z =   0.000 kA (0.000 MVA) At   0.00DEG, X/R =   2.78
Z1 = ********** +j ********** pu, Z0 =   0.000000 +j   0.000000 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
UPS		UPS-OUT	0.00	0.00	Gen	1	1	
U-1		UPS-OUT	0.00	0.00	Branch	1	1	C U-1

*Bus XF- T1 L   0.480 kV, Zone   1, Area   1
E/Z =   12.856 kA (10.689 MVA) At   -77.85DEG, X/R =   4.75
Z1 =   1.969054 +j   9.146241 pu, Z0 =   0.000000 +j   0.000000 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
XF - T1 H		XF- T1 L	12.86	-77.85	Branch	1	1	TX-1
MCC1		XF- T1 L	0.00	0.00	Branch	1	1	C MCC1

Ground Fault

Equipment Duty Ratings

Project Name: Meranto 2975 Zone Reservoir
Comment: Ground Fault - Equipment Duty Report

EQUIPMENT DUTY VIOLATION AND WARNING DETAILED REPORTS
Driving Point Voltage (P.U.) = 1.00000

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Equipment Duty Comparison Report For Bus:
1/2 STARTER Area: 1 Zone: 1 Bus kV: 0.24 kV

ID	Manufacturer	/ Style	Test Standard	Ratings 1/2 Cycle (kA)	Ratings Interrupting (kA) Cyc	Duties 1/2 Cycle kA (%)	Duties Interrupting kA (%)	Comments
B PUMP P-11	GE	/SEL	ANSI-SYM	100.00		0.12(-99.9%)		
1/2 STARTER		/	ANSI-SYM	65.00		0.13(-99.8%)		

****

Equipment Duty Comparison Report For Bus:
3/4 STARTER P-4 Area: 1 Zone: 1 Bus kV: 0.24 kV

ID	Manufacturer	/ Style	Test Standard	Ratings 1/2 Cycle (kA)	Ratings Interrupting (kA) Cyc	Duties 1/2 Cycle kA (%)	Duties Interrupting kA (%)	Comments
B PUMP P-4	GE	/SEL	ANSI-SYM	100.00		0.12(-99.9%)		
3/4 STARTER P-4		/	ANSI-SYM	65.00		0.13(-99.8%)		

****

Equipment Duty Comparison Report For Bus:
3/4 STARTER P-5 Area: 1 Zone: 1 Bus kV: 0.24 kV

ID	Manufacturer	/ Style	Test Standard	Ratings 1/2 Cycle (kA)	Ratings Interrupting (kA) Cyc	Duties 1/2 Cycle kA (%)	Duties Interrupting kA (%)	Comments
B PUMP P-5	GE	/SEL	ANSI-SYM	100.00		0.12(-99.9%)		
3/4 STARTER P-5		/	ANSI-SYM	65.00		0.13(-99.8%)		

****

Equipment Duty Comparison Report For Bus:
FUSEGEAR Area: 1 Zone: 1 Bus kV: 12.47 kV

ID	Manufacturer	/ Style	Test Standard	Ratings 1/2 Cycle (kA)	Ratings Interrupting (kA) Cyc	Duties 1/2 Cycle kA (%)	Duties Interrupting kA (%)	Comments
FS FUSEGEAR-MAIN	S&C	/SMU-40	ANSI-SYM	25.00		13.00(-48.0%)		
FS FG FEEDER	S&C	/SMU-40	ANSI-SYM	25.00		13.00(-48.0%)		
FUSEGEAR		/	ANSI-TOT	61.00		18.09(-70.3%)		

EQUIPMENT DUTY VIOLATION AND WARNING DETAILED REPORTS
Driving Point Voltage (P.U.) = 1.00000

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Equipment Duty Comparison Report For Bus:
L Area: 1 Zone: 1 Bus kV: 0.21 kV

Equipment ID	Manufacturer	/ Style	Test Standard	Ratings 1/2 Cycle (kA)	Ratings Interrupting (kA)	Cyc	Duties 1/2 Cycle kA (%)	Duties Interrupting kA (%)	Comments
B L-MAIN	GE	/TQD	ANSI-SYM	10.00			3.86(-61.4%)		
L		/	ANSI-SYM	10.00			3.86(-61.4%)		

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Equipment Duty Comparison Report For Bus:
MCC1 Area: 1 Zone: 1 Bus kV: 0.48 kV

Equipment ID	Manufacturer	/ Style	Test Standard	Ratings 1/2 Cycle (kA)	Ratings Interrupting (kA)	Cyc	Duties 1/2 Cycle kA (%)	Duties Interrupting kA (%)	Comments
B MCC1-MAIN	GE	/SGL6	ANSI-SYM	65.00			13.51(-79.2%)		
B P-WR1-001	GE	/SEL	ANSI-SYM	65.00			13.62(-79.0%)		
B PUMP P-6	GE	/SEL	ANSI-SYM	65.00			13.60(-79.1%)		
B PUMP P-8	GE	/SEL	ANSI-SYM	65.00			13.62(-79.0%)		
B PUMP P-14	GE	/SEL	ANSI-SYM	65.00			13.59(-79.1%)		
B TX T11	GE	/SEL	ANSI-SYM	65.00			13.62(-79.0%)		
B PUMP P-3	GE	/SEL	ANSI-SYM	65.00			13.62(-79.1%)		
B SPARE	GE	/SEL	ANSI-SYM	65.00			13.62(-79.0%)		
B TX T-L	GE	/SEL	ANSI-SYM	65.00			13.62(-79.0%)		
B TX T-UPS	GE	/SEL	ANSI-SYM	65.00			13.62(-79.0%)		
B PUMP P-7	GE	/SEL	ANSI-SYM	65.00			13.60(-79.1%)		
B PUMP P-9	GE	/SEL	ANSI-SYM	65.00			13.62(-79.0%)		
B PUMP P-10	GE	/SEL	ANSI-SYM	65.00			13.62(-79.0%)		
B TX T4	GE	/SEL	ANSI-SYM	65.00			13.62(-79.0%)		
B TX T5	GE	/SEL	ANSI-SYM	65.00			13.62(-79.0%)		
B PUMP P-12	GE	/SEL	ANSI-SYM	65.00			13.62(-79.1%)		
B PUMP P-13	GE	/SEL	ANSI-SYM	65.00			13.62(-79.1%)		
MCC1		/	ANSI-SYM	42.00			13.62(-67.6%)		

****

Equipment Duty Comparison Report For Bus:
P-WR1-001 Area: 1 Zone: 1 Bus kV: 0.48 kV

Equipment ID	Manufacturer	/ Style	Test Standard	Ratings 1/2 Cycle (kA)	Ratings Interrupting (kA)	Cyc	Duties 1/2 Cycle kA (%)	Duties Interrupting kA (%)	Comments
P-WR1-001		/	ANSI-SYM	65.00			10.95(-83.1%)		

Project Name: Meranto 2975 Zone Reservoir
Comment: Ground Fault - Equipment Duty Report

EQUIPMENT DUTY VIOLATION AND WARNING DETAILED REPORTS
Driving Point Voltage (P.U.) = 1.00000

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Equipment Duty Comparison Report For Bus:
U-1 Area: 1 Zone: 1 Bus kV: 0.21 kV

Equipment				Ratings			Duties		Comments
ID	Manufacturer /	Style	Test Standard	1/2 Cycle (kA)	Interrupting (kA)	Cyc	1/2 Cycle kA (%)	Interrupting kA (%)	
B U-1 MAIN	GE	/THQB	ANSI-SYM	10.00			0.13(-98.7%)		
U-1		/	ANSI-SYM	10.00			0.12(-98.8%)		

Ground Fault

High Voltage Momentary Report

(Serial #34798)
Project Name: Meranto 2975 Zone Reservoir
Comment: Ground Fault - High Voltage Momentary Report

First Cycle Results S L-GND
Driving Point Voltage (P.U.) = 1.00000

*Bus FUSEGEAR 12.470 kV, Zone 1, Area 1
E/Z = 13.004 kA (280.87 MVA) At -82.87DEG, X/R = 7.99
Z1 = 0.044226 +j 0.353233 pu, Z0 = 0.044175 +j 0.353397 pu
1.6*ISYM= 20.806 IASYM Based on X/R ratio = 18.092

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
NPC		FUSEGEAR	13.00	-82.87	Util	1	1	
XF - T1 H		FUSEGEAR	0.00	-58.35	Branch	1	1	C XF-T1

*Bus XF - T1 H 12.470 kV, Zone 1, Area 1
E/Z = 12.963 kA (279.98 MVA) At -82.26DEG, X/R = 7.36
Z1 = 0.047131 +j 0.353703 pu, Z0 = 0.049989 +j 0.354340 pu
1.6*ISYM= 20.741 IASYM Based on X/R ratio = 17.770

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
XF- T1 L		XF - T1 H	0.00	-58.20	Branch	1	1	TX-1
FUSEGEAR		XF - T1 H	12.96	-82.27	Branch	1	1	C XF-T1

Ground Fault

Low Voltage Momentary Report

Project Name: Meranto 2975 Zone Reservoir
Comment: Ground Fault - Low Voltage Momentary Report

First Cycle Results S L-GND
Driving Point Voltage (P.U.) = 1.00000

```
*Bus 1/2 STARTER         0.240 kV, Zone     1, Area     1
       E/Z =      0.127 kA (        0.05 MVA)  At   -57.47DEG, X/R =     1.57
       Z1 =  ********** +j ********** pu,  Z0 = 982.828071 +j ********** pu
       1.6*ISYM=      0.203   IASYM Based on X/R ratio =    0.131

       Contributions In kA
       Bus      to       Bus                         kA     Angle  Device   Zone   Area  Branch
       TX T11-L          1/2 STARTER               0.12    -58.34  Branch      1      1  C TX T11 L
       PUMP P-11         1/2 STARTER               0.00    -27.54  Branch      1      1  C PUMP P-11

*Bus 3/4 STARTER P-4     0.240 kV, Zone     1, Area     1
       E/Z =      0.129 kA (        0.05 MVA)  At   -57.40DEG, X/R =     1.56
       Z1 =  ********** +j ********** pu,  Z0 = 982.828071 +j ********** pu
       1.6*ISYM=      0.206   IASYM Based on X/R ratio =    0.133

       Contributions In kA
       Bus      to       Bus                         kA     Angle  Device   Zone   Area  Branch
       TX T4-L           3/4 STARTER P-4           0.12    -58.32  Branch      1      1  C TX T4 L
       PUMP P-4          3/4 STARTER P-4           0.01    -35.50  Branch      1      1  C PUMP P-4

*Bus 3/4 STARTER P-5     0.240 kV, Zone     1, Area     1
       E/Z =      0.129 kA (        0.05 MVA)  At   -57.39DEG, X/R =     1.56
       Z1 =  ********** +j ********** pu,  Z0 = 982.828071 +j ********** pu
       1.6*ISYM=      0.206   IASYM Based on X/R ratio =    0.133

       Contributions In kA
       Bus      to       Bus                         kA     Angle  Device   Zone   Area  Branch
       TX T5-L           3/4 STARTER P-5           0.12    -58.32  Branch      1      1  C TX T5 L
       PUMP P-5          3/4 STARTER P-5           0.01    -34.78  Branch      1      1  C PUMP P-5

*Bus L                   0.208 kV, Zone     1, Area     1
       E/Z =      3.863 kA (        1.39 MVA)  At   -57.66DEG, X/R =     1.58
       Z1 =   40.928252 +j  65.830139 pu,  Z0 =  33.443997 +j  50.471329 pu
       1.6*ISYM=      6.181   IASYM Based on X/R ratio =    3.986

       Contributions In kA
       Bus      to       Bus                         kA     Angle  Device   Zone   Area  Branch
       TX T-L L          L                         3.86    -57.66  Branch      1      1  C L

*Bus MCC1                0.480 kV, Zone     1, Area     1
       E/Z =     13.622 kA (       11.33 MVA)  At   -77.06DEG, X/R =     4.35
       Z1 =    2.065905 +j   9.098875 pu,  Z0 =   1.799800 +j   7.618983 pu
       1.6*ISYM=     21.796   IASYM Based on X/R ratio =   16.795

       Contributions In kA
       Bus      to       Bus                         kA     Angle  Device   Zone   Area  Branch
       XF- T1 L          MCC1                     13.51    -77.22  Branch      1      1  C MCC1
       P-WR1-001         MCC1                      0.00      0.00  Branch      1      1  C P-WR1-001
       PUMP P-6          MCC1                      0.02    -61.05  Branch      1      1  C PUMP P-6
       PUMP P-8          MCC1                      0.00    -49.72  Branch      1      1  C PUMP P-8
       PUMP P-14         MCC1                      0.03    -64.92  Branch      1      1  C PUMP P-14
       PUMP P-3          MCC1                      0.01    -53.83  Branch      1      1  C PUMP P-3
       TX T11-H          MCC1                      0.00    -29.28  Branch      1      1  C TX T11 H
       TX T-L H          MCC1                      0.00      0.00  Branch      1      1  C TX T-L
       TX T-UPS H        MCC1                      0.00      0.00  Branch      1      1  C TX T-UPS
       PUMP P-7          MCC1                      0.02    -61.05  Branch      1      1  C PUMP P-7
       PUMP P-9          MCC1                      0.00    -49.48  Branch      1      1  C PUMP P-9
       PUMP P-10         MCC1                      0.00    -48.93  Branch      1      1  C PUMP P-10
       TX T4-H           MCC1                      0.00    -37.28  Branch      1      1  C TX T4 H
       TX T5-H           MCC1                      0.00    -36.57  Branch      1      1  C TX T5 H
       PUMP P-12         MCC1                      0.01    -53.72  Branch      1      1  C PUMP P-12
       PUMP P-13         MCC1                      0.01    -53.72  Branch      1      1  C PUMP P-13
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Project Name: Meranto 2975 Zone Reservoir
Comment: Ground Fault - Low Voltage Momentary Report

First Cycle Results S L-GND
Driving Point Voltage (P.U.) = 1.00000

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*Bus P-WR1-001           0.480 kV, Zone     1, Area     1
       E/Z =     10.954 kA (        9.11 MVA)  At   -55.13DEG, X/R =     1.43
       Z1 =    4.216520 +j   9.300480 pu,  Z0 =  10.402241 +j   8.425402 pu
       1.6*ISYM=     17.526   IASYM Based on X/R ratio =   11.209

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       MCC1              P-WR1-001              10.95    -55.13  Branch      1      1  C P-WR1-001

*Bus PUMP P-3            0.480 kV, Zone     1, Area     1
       E/Z =      2.035 kA (        1.69 MVA)  At   -11.80DEG, X/R =     0.21
       Z1 =   29.955738 +j  10.857246 pu,  Z0 = 113.660357 +j  14.551171 pu
       1.6*ISYM=      3.256   IASYM Based on X/R ratio =    2.035

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       M PUMP P-3        PUMP P-3                0.00    -45.95  Motor       1      1
       MCC1              PUMP P-3                2.03    -11.75  Branch      1      1  C PUMP P-3

*Bus PUMP P-4            0.240 kV, Zone     1, Area     1
       E/Z =      0.047 kA (        0.02 MVA)  At   -19.24DEG, X/R =     0.35
       Z1 =  ********** +j ********** pu,  Z0 = ********** +j ********** pu
       1.6*ISYM=      0.074   IASYM Based on X/R ratio =    0.047

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       M PUMP P-4        PUMP P-4                0.00    -26.08  Motor       1      1
       3/4 STARTER P-4   PUMP P-4                0.04    -18.69  Branch      1      1  C PUMP P-4

*Bus PUMP P-5            0.240 kV, Zone     1, Area     1
       E/Z =      0.037 kA (        0.02 MVA)  At   -15.92DEG, X/R =     0.29
       Z1 =  ********** +j ********** pu,  Z0 = ********** +j ********** pu
       1.6*ISYM=      0.060   IASYM Based on X/R ratio =    0.037

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       M PUMP P-5        PUMP P-5                0.00    -26.65  Motor       1      1
       3/4 STARTER P-5   PUMP P-5                0.03    -14.93  Branch      1      1  C PUMP P-5

*Bus PUMP P-6            0.480 kV, Zone     1, Area     1
       E/Z =      0.200 kA (        0.17 MVA)  At    -5.66DEG, X/R =     0.10
       Z1 =  289.030743 +j  47.491628 pu,  Z0 = ********** +j  82.717685 pu
       1.6*ISYM=      0.321   IASYM Based on X/R ratio =    0.200

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       M PUMP P-6        PUMP P-6                0.01    -61.68  Motor       1      1
       MCC1              PUMP P-6                0.19     -2.97  Branch      1      1  C PUMP P-6

*Bus PUMP P-7            0.480 kV, Zone     1, Area     1
       E/Z =      0.200 kA (        0.17 MVA)  At    -5.66DEG, X/R =     0.10
       Z1 =  289.030743 +j  47.491628 pu,  Z0 = ********** +j  82.717685 pu
       1.6*ISYM=      0.321   IASYM Based on X/R ratio =    0.200

       Contributions In kA
       Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
       M PUMP P-7        PUMP P-7                0.01    -61.68  Motor       1      1
       MCC1              PUMP P-7                0.19     -2.97  Branch      1      1  C PUMP P-7
```

Project Name: Meranto 2975 Zone Reservoir
Comment: Ground Fault - Low Voltage Momentary Report

First Cycle Results S L-GND
Driving Point Voltage (P.U.) = 1.00000

```
*Bus PUMP P-8            0.480 kV, Zone     1, Area     1
      E/Z =      0.303 kA (        0.25 MVA)  At    -3.50DEG, X/R =     0.06
      Z1 =  197.737964 +j  17.867747 pu,  Z0 = 791.309443 +j  36.860091 pu
      1.6*ISYM=      0.486   IASYM Based on X/R ratio =    0.303

      Contributions In kA
      Bus      to       Bus                       kA     Angle  Device   Zone   Area  Branch
      M PUMP P-8        PUMP P-8                0.00    -48.67  Motor       1      1
      MCC1              PUMP P-8                0.30     -3.20  Branch      1      1  C PUMP P-8

*Bus PUMP P-9            0.480 kV, Zone     1, Area     1
      E/Z =      0.203 kA (        0.17 MVA)  At    -3.17DEG, X/R =     0.06
      Z1 =  294.429815 +j  23.394712 pu,  Z0 = ********** +j  51.480643 pu
      1.6*ISYM=      0.325   IASYM Based on X/R ratio =    0.203

      Contributions In kA
      Bus      to       Bus                       kA     Angle  Device   Zone   Area  Branch
      M PUMP P-9        PUMP P-9                0.00    -48.96  Motor       1      1
      MCC1              PUMP P-9                0.20     -2.71  Branch      1      1  C PUMP P-9

*Bus PUMP P-10           0.480 kV, Zone     1, Area     1
      E/Z =      0.113 kA (        0.09 MVA)  At    -2.99DEG, X/R =     0.05
      Z1 =  523.373632 +j  39.637636 pu,  Z0 = ********** +j  86.569972 pu
      1.6*ISYM=      0.181   IASYM Based on X/R ratio =    0.113

      Contributions In kA
      Bus      to       Bus                       kA     Angle  Device   Zone   Area  Branch
      M PUMP P-10       PUMP P-10               0.00    -48.99  Motor       1      1
      MCC1              PUMP P-10               0.11     -2.16  Branch      1      1  C PUMP P-10

*Bus PUMP P-11           0.240 kV, Zone     1, Area     1
      E/Z =      0.079 kA (        0.03 MVA)  At   -32.67DEG, X/R =     0.64
      Z1 =  ********** +j ********** pu,  Z0 = ********** +j ********** pu
      1.6*ISYM=      0.127   IASYM Based on X/R ratio =    0.079

      Contributions In kA
      Bus      to       Bus                       kA     Angle  Device   Zone   Area  Branch
      M PUMP P-11       PUMP P-11               0.00    -17.84  Motor       1      1
      1/2 STARTER       PUMP P-11               0.08    -33.24  Branch      1      1  C PUMP P-11

*Bus PUMP P-12           0.480 kV, Zone     1, Area     1
      E/Z =      0.946 kA (        0.79 MVA)  At    -7.42DEG, X/R =     0.13
      Z1 =   63.934124 +j  13.122339 pu,  Z0 = 250.378825 +j  23.023845 pu
      1.6*ISYM=      1.514   IASYM Based on X/R ratio =    0.946

      Contributions In kA
      Bus      to       Bus                       kA     Angle  Device   Zone   Area  Branch
      M PUMP P-12       PUMP P-12               0.00    -49.89  Motor       1      1
      MCC1              PUMP P-12               0.94     -7.29  Branch      1      1  C PUMP P-12

*Bus PUMP P-13           0.480 kV, Zone     1, Area     1
      E/Z =      0.946 kA (        0.79 MVA)  At    -7.42DEG, X/R =     0.13
      Z1 =   63.934124 +j  13.122339 pu,  Z0 = 250.378825 +j  23.023845 pu
      1.6*ISYM=      1.514   IASYM Based on X/R ratio =    0.946

      Contributions In kA
      Bus      to       Bus                       kA     Angle  Device   Zone   Area  Branch
      M PUMP P-13       PUMP P-13               0.00    -49.89  Motor       1      1
      MCC1              PUMP P-13               0.94     -7.29  Branch      1      1  C PUMP P-13
```

Project Name: Meranto 2975 Zone Reservoir
Comment: Ground Fault - Low Voltage Momentary Report

First Cycle Results S L-GND
Driving Point Voltage (P.U.) = 1.00000

```
*Bus PUMP P-14           0.480 kV, Zone     1, Area     1
      E/Z =      0.605 kA (        0.50 MVA)  At    -5.19DEG, X/R =     0.09
      Z1 =   98.531533 +j  15.788864 pu,  Z0 = 397.349299 +j  22.449107 pu
      1.6*ISYM=      0.967   IASYM Based on X/R ratio =    0.605

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-14       PUMP P-14               0.02    -63.06  Motor       1      1
      MCC1              PUMP P-14               0.60     -3.96  Branch      1      1  C PUMP P-14

*Bus TX T-L H            0.480 kV, Zone     1, Area     1
      E/Z =      8.299 kA (        6.90 MVA)  At   -43.10DEG, X/R =     0.94
      Z1 =    6.368080 +j   9.747695 pu,  Z0 =  19.008556 +j  10.214286 pu
      1.6*ISYM=     13.279   IASYM Based on X/R ratio =    8.330

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T-L L          TX T-L H                0.00      0.00  Branch      1      1  TX T-L
      MCC1              TX T-L H                8.30    -43.10  Branch      1      1  C TX T-L

*Bus TX T-L L            0.208 kV, Zone     1, Area     1
      E/Z =      4.024 kA (        1.45 MVA)  At   -58.69DEG, X/R =     1.64
      Z1 =   39.636783 +j  64.940810 pu,  Z0 =  28.278131 +j  46.914006 pu
      1.6*ISYM=      6.438   IASYM Based on X/R ratio =    4.169

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T-L H          TX T-L L                4.02    -58.69  Branch      1      1  TX T-L
      L                 TX T-L L                0.00      0.00  Branch      1      1  C L

*Bus TX T-UPS H          0.480 kV, Zone     1, Area     1
      E/Z =      6.799 kA (        5.65 MVA)  At   -36.24DEG, X/R =     0.73
      Z1 =    8.211868 +j  10.025761 pu,  Z0 =  26.383731 +j  11.326576 pu
      1.6*ISYM=     10.878   IASYM Based on X/R ratio =    6.804

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T-UPS UPS      TX T-UPS H              0.00      0.00  Branch      1      1  TX T-UPS
      MCC1              TX T-UPS H              6.80    -36.24  Branch      1      1  C TX T-UPS

*Bus TX T-UPS UPS        0.208 kV, Zone     1, Area     1
      E/Z =      0.888 kA (        0.32 MVA)  At   -57.03DEG, X/R =     1.54
      Z1 =  181.493500 +j 279.048954 pu,  Z0 = 147.282650 +j 228.666642 pu
      1.6*ISYM=      1.421   IASYM Based on X/R ratio =    0.914

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T-UPS H        TX T-UPS UPS            0.89    -57.03  Branch      1      1  TX T-UPS
      UPS-IN            TX T-UPS UPS            0.00      0.00  Branch      1      1  C UPS

*Bus TX T4-H             0.480 kV, Zone     1, Area     1
      E/Z =      5.610 kA (        4.66 MVA)  At   -25.55DEG, X/R =     0.48
      Z1 =   10.744867 +j   9.418464 pu,  Z0 =  36.538164 +j   8.905723 pu
      1.6*ISYM=      8.976   IASYM Based on X/R ratio =    5.610

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T4-L           TX T4-H                 0.00    -21.93  Branch      1      1  TX T4
      MCC1              TX T4-H                 5.61    -25.55  Branch      1      1  C TX T4 H
```

Project Name: Meranto 2975 Zone Reservoir
Comment: Ground Fault - Low Voltage Momentary Report

```
First Cycle Results S L-GND
Driving Point Voltage (P.U.) = 1.00000


*Bus TX T4-L             0.240 kV, Zone     1, Area     1
       E/Z =      0.131 kA (       0.05 MVA)  At   -59.14DEG, X/R =     1.67
       Z1 =  988.281359 +j ********** pu,  Z0 = 843.874367 +j ********** pu
       1.6*ISYM=      0.210   IASYM Based on X/R ratio =    0.136

       Contributions In kA
       Bus      to       Bus                      kA     Angle  Device   Zone   Area  Branch
       TX T4-H           TX T4-L                0.13    -60.08  Branch      1      1  TX T4
       3/4 STARTER P-4   TX T4-L                0.01    -36.41  Branch      1      1  C TX T4 L

*Bus TX T5-H             0.480 kV, Zone     1, Area     1
       E/Z =      5.610 kA (       4.66 MVA)  At   -25.55DEG, X/R =     0.48
       Z1 =   10.744992 +j   9.418432 pu,  Z0 =  36.538164 +j   8.905723 pu
       1.6*ISYM=      8.976   IASYM Based on X/R ratio =    5.610

       Contributions In kA
       Bus      to       Bus                      kA     Angle  Device   Zone   Area  Branch
       TX T5-L           TX T5-H                0.00    -21.22  Branch      1      1  TX T5
       MCC1              TX T5-H                5.61    -25.55  Branch      1      1  C TX T5 H

*Bus TX T5-L             0.240 kV, Zone     1, Area     1
       E/Z =      0.131 kA (       0.05 MVA)  At   -59.13DEG, X/R =     1.67
       Z1 =  990.057752 +j ********** pu,  Z0 = 843.874367 +j ********** pu
       1.6*ISYM=      0.210   IASYM Based on X/R ratio =    0.136

       Contributions In kA
       Bus      to       Bus                      kA     Angle  Device   Zone   Area  Branch
       TX T5-H           TX T5-L                0.13    -60.08  Branch      1      1  TX T5
       3/4 STARTER P-5   TX T5-L                0.01    -35.69  Branch      1      1  C TX T5 L

*Bus TX T11-H            0.480 kV, Zone     1, Area     1
       E/Z =      5.610 kA (       4.66 MVA)  At   -25.55DEG, X/R =     0.48
       Z1 =   10.746756 +j   9.418521 pu,  Z0 =  36.538164 +j   8.905723 pu
       1.6*ISYM=      8.976   IASYM Based on X/R ratio =    5.610

       Contributions In kA
       Bus      to       Bus                      kA     Angle  Device   Zone   Area  Branch
       TX T11-L          TX T11-H               0.00    -14.00  Branch      1      1  TX T11
       MCC1              TX T11-H               5.61    -25.55  Branch      1      1  C TX T11 H

*Bus TX T11-L            0.240 kV, Zone     1, Area     1
       E/Z =      0.129 kA (       0.05 MVA)  At   -59.21DEG, X/R =     1.68
       Z1 =  ********** +j ********** pu,  Z0 = 843.874367 +j ********** pu
       1.6*ISYM=      0.207   IASYM Based on X/R ratio =    0.134

       Contributions In kA
       Bus      to       Bus                      kA     Angle  Device   Zone   Area  Branch
       TX T11-H          TX T11-L               0.13    -60.09  Branch      1      1  TX T11
       1/2 STARTER       TX T11-L               0.00    -28.45  Branch      1      1  C TX T11 L

*Bus U-1                 0.208 kV, Zone     1, Area     1
       E/Z =      0.124 kA (       0.04 MVA)  At   -68.41DEG, X/R =     2.53
       Z1 =  809.959995 +j ********** pu,  Z0 = 844.318825 +j ********** pu
       1.6*ISYM=      0.199   IASYM Based on X/R ratio =    0.137

       Contributions In kA
       Bus      to       Bus                      kA     Angle  Device   Zone   Area  Branch
       UPS-OUT           U-1                    0.12    -68.41  Branch      1      1  C U-1
```

Project Name: Meranto 2975 Zone Reservoir
Comment: Ground Fault - Low Voltage Momentary Report

First Cycle Results S L-GND
Driving Point Voltage (P.U.) = 1.00000

```
*Bus UPS-IN              0.208 kV, Zone     1, Area     1
      E/Z =      0.879 kA (        0.32 MVA)  At   -56.79DEG, X/R =     1.53
      Z1 =  182.914115 +j 280.027216 pu,  Z0 = 152.965102 +j 232.579697 pu
      1.6*ISYM=      1.406   IASYM Based on X/R ratio =    0.904

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T-UPS UPS      UPS-IN                   0.88    -56.79  Branch      1      1  C UPS

*Bus UPS-OUT             0.208 kV, Zone     1, Area     1
      E/Z =      0.125 kA (        0.05 MVA)  At   -68.94DEG, X/R =     2.60
      Z1 =  798.507019 +j ********** pu,  Z0 = 798.507019 +j ********** pu
      1.6*ISYM=      0.200   IASYM Based on X/R ratio =    0.138

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      UPS               UPS-OUT                  0.12    -68.94  Gen         1      1
      U-1               UPS-OUT                  0.00      0.00  Branch      1      1  C U-1

*Bus XF- T1 L            0.480 kV, Zone     1, Area     1
      E/Z =     13.805 kA (       11.48 MVA)  At   -77.62DEG, X/R =     4.56
      Z1 =    1.984220 +j   9.028580 pu,  Z0 =   1.633661 +j   7.473495 pu
      1.6*ISYM=     22.088   IASYM Based on X/R ratio =   17.188

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      XF - T1 H         XF- T1 L                13.70    -77.79  Branch      1      1  TX-1
      MCC1              XF- T1 L                 0.12    -58.13  Branch      1      1  C MCC1
```

Ground Fault

Low Voltage Interrupting Report

Project Name: Meranto 2975 Zone Reservoir
Comment: Ground Fault - Low Voltage Interrupting Report

Interrupting Results S L-GND
Driving Point Voltage (P.U.) = 1.00000

*Bus 1/2 STARTER 0.240 kV, Zone 1, Area 1
E/Z = 0.125 kA (0.052 MVA) At -57.94DEG, X/R = 1.92
Z1 = ********** +j ********** pu, Z0 = 982.828071 +j ********** pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T11-L		1/2 STARTER	0.12	-58.37	Branch	1	1	C TX T11 L
PUMP P-11		1/2 STARTER	0.00	-28.01	Branch	1	1	C PUMP P-11

*Bus 3/4 STARTER P-4 0.240 kV, Zone 1, Area 1
E/Z = 0.126 kA (0.052 MVA) At -57.91DEG, X/R = 1.91
Z1 = ********** +j ********** pu, Z0 = 982.828071 +j ********** pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T4-L		3/4 STARTER P-4	0.12	-58.36	Branch	1	1	C TX T4 L
PUMP P-4		3/4 STARTER P-4	0.00	-36.02	Branch	1	1	C PUMP P-4

*Bus 3/4 STARTER P-5 0.240 kV, Zone 1, Area 1
E/Z = 0.126 kA (0.052 MVA) At -57.91DEG, X/R = 1.91
Z1 = ********** +j ********** pu, Z0 = 982.828071 +j ********** pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T5-L		3/4 STARTER P-5	0.12	-58.36	Branch	1	1	C TX T5 L
PUMP P-5		3/4 STARTER P-5	0.00	-35.30	Branch	1	1	C PUMP P-5

*Bus L 0.208 kV, Zone 1, Area 1
E/Z = 3.861 kA (1.391 MVA) At -57.68DEG, X/R = 1.87
Z1 = 40.914472 +j 65.950249 pu, Z0 = 33.443997 +j 50.471329 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T-L L		L	3.86	-57.68	Branch	1	1	C L

*Bus MCC1 0.480 kV, Zone 1, Area 1
E/Z = 13.564 kA (11.277 MVA) At -77.15DEG, X/R = 4.51
Z1 = 2.052124 +j 9.218986 pu, Z0 = 1.799800 +j 7.618983 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
XF- T1 L		MCC1	13.51	-77.23	Branch	1	1	C MCC1
P-WR1-001		MCC1	0.00	0.00	Branch	1	1	C P-WR1-001
PUMP P-6		MCC1	0.01	-61.14	Branch	1	1	C PUMP P-6
PUMP P-8		MCC1	0.00	-49.80	Branch	1	1	C PUMP P-8
PUMP P-14		MCC1	0.02	-65.01	Branch	1	1	C PUMP P-14
PUMP P-3		MCC1	0.00	-53.92	Branch	1	1	C PUMP P-3
TX T11-H		MCC1	0.00	-29.46	Branch	1	1	C TX T11 H
TX T-L H		MCC1	0.00	0.00	Branch	1	1	C TX T-L
TX T-UPS H		MCC1	0.00	0.00	Branch	1	1	C TX T-UPS
PUMP P-7		MCC1	0.01	-61.14	Branch	1	1	C PUMP P-7
PUMP P-9		MCC1	0.00	-49.57	Branch	1	1	C PUMP P-9
PUMP P-10		MCC1	0.00	-49.02	Branch	1	1	C PUMP P-10
TX T4-H		MCC1	0.00	-37.42	Branch	1	1	C TX T4 H
TX T5-H		MCC1	0.00	-36.72	Branch	1	1	C TX T5 H
PUMP P-12		MCC1	0.00	-53.80	Branch	1	1	C PUMP P-12
PUMP P-13		MCC1	0.00	-53.80	Branch	1	1	C PUMP P-13

Project Name: Meranto 2975 Zone Reservoir
Comment: Ground Fault - Low Voltage Interrupting Report

Interrupting Results S L-GND
Driving Point Voltage (P.U.) = 1.00000

```
*Bus P-WR1-001            0.480 kV, Zone     1, Area     1
      E/Z =     10.924 kA (       9.082 MVA)  At   -55.27DEG, X/R =     1.80
      Z1 =    4.202739 +j   9.420590 pu,  Z0 =  10.402241 +j   8.425402 pu

      Contributions In kA
      Bus      to       Bus                       kA     Angle  Device   Zone   Area  Branch
      MCC1              P-WR1-001              10.92    -55.27  Branch      1      1  C P-WR1-001

*Bus PUMP P-3             0.480 kV, Zone     1, Area     1
      E/Z =      2.034 kA (       1.691 MVA)  At   -11.83DEG, X/R =     1.03
      Z1 =   30.017235 +j  10.952039 pu,  Z0 = 113.660357 +j  14.551171 pu

      Contributions In kA
      Bus      to       Bus                       kA     Angle  Device   Zone   Area  Branch
      M PUMP P-3        PUMP P-3                0.00    -45.97  Motor       1      1
      MCC1              PUMP P-3                2.03    -11.80  Branch      1      1  C PUMP P-3

*Bus PUMP P-4             0.240 kV, Zone     1, Area     1
      E/Z =      0.045 kA (       0.019 MVA)  At   -19.35DEG, X/R =     1.05
      Z1 =  ********** +j ********** pu,  Z0 = ********** +j ********** pu

      Contributions In kA
      Bus      to       Bus                       kA     Angle  Device   Zone   Area  Branch
      M PUMP P-4        PUMP P-4                0.00    -26.19  Motor       1      1
      3/4 STARTER P-4   PUMP P-4                0.04    -19.09  Branch      1      1  C PUMP P-4

*Bus PUMP P-5             0.240 kV, Zone     1, Area     1
      E/Z =      0.036 kA (       0.015 MVA)  At   -15.90DEG, X/R =     1.03
      Z1 =  ********** +j ********** pu,  Z0 = ********** +j ********** pu

      Contributions In kA
      Bus      to       Bus                       kA     Angle  Device   Zone   Area  Branch
      M PUMP P-5        PUMP P-5                0.00    -26.63  Motor       1      1
      3/4 STARTER P-5   PUMP P-5                0.03    -15.43  Branch      1      1  C PUMP P-5

*Bus PUMP P-6             0.480 kV, Zone     1, Area     1
      E/Z =      0.199 kA (       0.165 MVA)  At    -5.00DEG, X/R =     1.00
      Z1 =  305.006046 +j  27.995868 pu,  Z0 = ********** +j  82.717685 pu

      Contributions In kA
      Bus      to       Bus                       kA     Angle  Device   Zone   Area  Branch
      M PUMP P-6        PUMP P-6                0.01    -61.01  Motor       1      1
      MCC1              PUMP P-6                0.20     -3.67  Branch      1      1  C PUMP P-6

*Bus PUMP P-7             0.480 kV, Zone     1, Area     1
      E/Z =      0.199 kA (       0.165 MVA)  At    -5.00DEG, X/R =     1.00
      Z1 =  305.006046 +j  27.995868 pu,  Z0 = ********** +j  82.717685 pu

      Contributions In kA
      Bus      to       Bus                       kA     Angle  Device   Zone   Area  Branch
      M PUMP P-7        PUMP P-7                0.01    -61.01  Motor       1      1
      MCC1              PUMP P-7                0.20     -3.67  Branch      1      1  C PUMP P-7

*Bus PUMP P-8             0.480 kV, Zone     1, Area     1
      E/Z =      0.303 kA (       0.252 MVA)  At    -3.43DEG, X/R =     1.00
      Z1 =  199.429364 +j  16.529411 pu,  Z0 = 791.309443 +j  36.860091 pu

      Contributions In kA
      Bus      to       Bus                       kA     Angle  Device   Zone   Area  Branch
      M PUMP P-8        PUMP P-8                0.00    -48.61  Motor       1      1
      MCC1              PUMP P-8                0.30     -3.28  Branch      1      1  C PUMP P-8
```

Project Name: Meranto 2975 Zone Reservoir
Comment: Ground Fault - Low Voltage Interrupting Report

Interrupting Results S L-GND
Driving Point Voltage (P.U.) = 1.00000

```
*Bus PUMP P-9            0.480 kV, Zone     1, Area     1
      E/Z =      0.203 kA (       0.168 MVA)  At    -3.06DEG, X/R =     1.00
      Z1 =  298.117885 +j  20.184742 pu,  Z0 = ********** +j  51.480643 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-9        PUMP P-9                 0.00    -48.85  Motor       1      1
      MCC1              PUMP P-9                 0.20     -2.83  Branch      1      1  C PUMP P-9

*Bus PUMP P-10           0.480 kV, Zone     1, Area     1
      E/Z =      0.113 kA (       0.094 MVA)  At    -2.78DEG, X/R =     1.00
      Z1 =  534.969969 +j  28.957860 pu,  Z0 = ********** +j  86.569972 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-10       PUMP P-10                0.00    -48.79  Motor       1      1
      MCC1              PUMP P-10                0.11     -2.37  Branch      1      1  C PUMP P-10

*Bus PUMP P-11           0.240 kV, Zone     1, Area     1
      E/Z =      0.078 kA (       0.033 MVA)  At   -33.06DEG, X/R =     1.22
      Z1 =  ********** +j ********** pu,  Z0 = ********** +j ********** pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-11       PUMP P-11                0.00    -18.23  Motor       1      1
      1/2 STARTER       PUMP P-11                0.08    -33.34  Branch      1      1  C PUMP P-11

*Bus PUMP P-12           0.480 kV, Zone     1, Area     1
      E/Z =      0.945 kA (       0.786 MVA)  At    -7.41DEG, X/R =     1.01
      Z1 =   64.196807 +j  13.070227 pu,  Z0 = 250.378825 +j  23.023845 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-12       PUMP P-12                0.00    -49.88  Motor       1      1
      MCC1              PUMP P-12                0.94     -7.35  Branch      1      1  C PUMP P-12

*Bus PUMP P-13           0.480 kV, Zone     1, Area     1
      E/Z =      0.945 kA (       0.786 MVA)  At    -7.41DEG, X/R =     1.01
      Z1 =   64.196807 +j  13.070227 pu,  Z0 = 250.378825 +j  23.023845 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-13       PUMP P-13                0.00    -49.88  Motor       1      1
      MCC1              PUMP P-13                0.94     -7.35  Branch      1      1  C PUMP P-13

*Bus PUMP P-14           0.480 kV, Zone     1, Area     1
      E/Z =      0.602 kA (       0.501 MVA)  At    -4.90DEG, X/R =     1.00
      Z1 =  100.939048 +j  12.926841 pu,  Z0 = 397.349299 +j  22.449107 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      M PUMP P-14       PUMP P-14                0.01    -62.76  Motor       1      1
      MCC1              PUMP P-14                0.60     -4.29  Branch      1      1  C PUMP P-14

*Bus TX T-L H            0.480 kV, Zone     1, Area     1
      E/Z =      8.286 kA (       6.889 MVA)  At   -43.23DEG, X/R =     1.42
      Z1 =    6.354299 +j   9.867806 pu,  Z0 =  19.008556 +j  10.214286 pu

      Contributions In kA
      Bus      to       Bus                        kA     Angle  Device   Zone   Area  Branch
      TX T-L L          TX T-L H                 0.00      0.00  Branch      1      1  TX T-L
      MCC1              TX T-L H                 8.29    -43.23  Branch      1      1  C TX T-L
```

Project Name: Meranto 2975 Zone Reservoir
Comment: Ground Fault - Low Voltage Interrupting Report

Interrupting Results S L-GND
Driving Point Voltage (P.U.) = 1.00000

*Bus TX T-L L 0.208 kV, Zone 1, Area 1
E/Z = 4.022 kA (1.449 MVA) At -58.71DEG, X/R = 1.93
Z1 = 39.623003 +j 65.060921 pu, Z0 = 28.278131 +j 46.914006 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T-L H		TX T-L L	4.02	-58.71	Branch	1	1	TX T-L
L		TX T-L L	0.00	0.00	Branch	1	1	C L

*Bus TX T-UPS H 0.480 kV, Zone 1, Area 1
E/Z = 6.791 kA (5.646 MVA) At -36.35DEG, X/R = 1.28
Z1 = 8.198088 +j 10.145872 pu, Z0 = 26.383731 +j 11.326576 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T-UPS UPS		TX T-UPS H	0.00	0.00	Branch	1	1	TX T-UPS
MCC1		TX T-UPS H	6.79	-36.35	Branch	1	1	C TX T-UPS

*Bus TX T-UPS UPS 0.208 kV, Zone 1, Area 1
E/Z = 0.888 kA (0.320 MVA) At -57.04DEG, X/R = 1.85
Z1 = 181.479720 +j 279.169065 pu, Z0 = 147.282650 +j 228.666642 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T-UPS H		TX T-UPS UPS	0.89	-57.04	Branch	1	1	TX T-UPS
UPS-IN		TX T-UPS UPS	0.00	0.00	Branch	1	1	C UPS

*Bus TX T4-H 0.480 kV, Zone 1, Area 1
E/Z = 5.606 kA (4.661 MVA) At -25.65DEG, X/R = 1.14
Z1 = 10.736730 +j 9.540638 pu, Z0 = 36.538164 +j 8.905723 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T4-L		TX T4-H	0.00	-22.27	Branch	1	1	TX T4
MCC1		TX T4-H	5.61	-25.65	Branch	1	1	C TX T4 H

*Bus TX T4-L 0.240 kV, Zone 1, Area 1
E/Z = 0.129 kA (0.053 MVA) At -59.65DEG, X/R = 2.01
Z1 = ********** +j ********** pu, Z0 = 843.874367 +j ********** pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T4-H		TX T4-L	0.13	-60.11	Branch	1	1	TX T4
3/4 STARTER P-4		TX T4-L	0.00	-36.92	Branch	1	1	C TX T4 L

*Bus TX T5-H 0.480 kV, Zone 1, Area 1
E/Z = 5.606 kA (4.661 MVA) At -25.65DEG, X/R = 1.14
Z1 = 10.736730 +j 9.540638 pu, Z0 = 36.538164 +j 8.905723 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T5-L		TX T5-H	0.00	-21.57	Branch	1	1	TX T5
MCC1		TX T5-H	5.61	-25.65	Branch	1	1	C TX T5 H

*Bus TX T5-L 0.240 kV, Zone 1, Area 1
E/Z = 0.129 kA (0.053 MVA) At -59.64DEG, X/R = 2.02
Z1 = ********** +j ********** pu, Z0 = 843.874367 +j ********** pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T5-H		TX T5-L	0.13	-60.11	Branch	1	1	TX T5
3/4 STARTER P-5		TX T5-L	0.00	-36.21	Branch	1	1	C TX T5 L

Project Name: Meranto 2975 Zone Reservoir

Comment: Ground Fault - Low Voltage Interrupting Report

Interrupting Results S L-GND

Driving Point Voltage (P.U.) = 1.00000

*Bus TX T11-H 0.480 kV, Zone 1, Area 1

E/Z = 5.606 kA (4.661 MVA) At -25.65DEG, X/R = 1.14

Z1 = 10.736731 +j 9.540638 pu, Z0 = 36.538164 +j 8.905723 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T11-L		TX T11-H	0.00	-14.44	Branch	1	1	TX T11
MCC1		TX T11-H	5.61	-25.65	Branch	1	1	C TX T11 H

*Bus TX T11-L 0.240 kV, Zone 1, Area 1

E/Z = 0.128 kA (0.053 MVA) At -59.68DEG, X/R = 2.03

Z1 = ********** +j ********** pu, Z0 = 843.874367 +j ********** pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T11-H		TX T11-L	0.13	-60.11	Branch	1	1	TX T11
1/2 STARTER		TX T11-L	0.00	-28.92	Branch	1	1	C TX T11 L

*Bus U-1 0.208 kV, Zone 1, Area 1

E/Z = 0.000 kA (0.000 MVA) At 0.00DEG, X/R = 1.39

Z1 = ********** +j ********** pu, Z0 = 844.318825 +j ********** pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
UPS-OUT		U-1	0.00	0.00	Branch	1	1	C U-1

*Bus UPS-IN 0.208 kV, Zone 1, Area 1

E/Z = 0.879 kA (0.317 MVA) At -56.80DEG, X/R = 1.83

Z1 = 182.900335 +j 280.147326 pu, Z0 = 152.965102 +j 232.579697 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
TX T-UPS UPS		UPS-IN	0.88	-56.80	Branch	1	1	C UPS

*Bus UPS-OUT 0.208 kV, Zone 1, Area 1

E/Z = 0.000 kA (0.000 MVA) At 0.00DEG, X/R = 1.39

Z1 = ********** +j ********** pu, Z0 = 798.507019 +j ********** pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
UPS		UPS-OUT	0.00	0.00	Gen	1	1	
U-1		UPS-OUT	0.00	0.00	Branch	1	1	C U-1

*Bus XF- T1 L 0.480 kV, Zone 1, Area 1

E/Z = 13.747 kA (11.429 MVA) At -77.71DEG, X/R = 4.71

Z1 = 1.969054 +j 9.146241 pu, Z0 = 1.633661 +j 7.473495 pu

Contributions In kA

Bus	to	Bus	kA	Angle	Device	Zone	Area	Branch
XF - T1 H		XF- T1 L	13.69	-77.79	Branch	1	1	TX-1
MCC1		XF- T1 L	0.06	-58.23	Branch	1	1	C MCC1

Fuses

Meranto 2975 Zone Reservoir
Fuse installation
March 13, 2006

Existing / Installed Fuses	Manufacturer	Type	Style	Model	kV	Size
As Found						
FS FUSEGEAR-MAIN	S&C	SMU	SMU-40	Slow Speed	15.5	175E
FS FG FEEDER	S&C	SMU	SMU-40	Slow Speed	15.5	15E
Recommended						
FS FG FEEDER	S&C	SMU	SMU-40	Slow Speed	15.5	30E

Breaker Settings

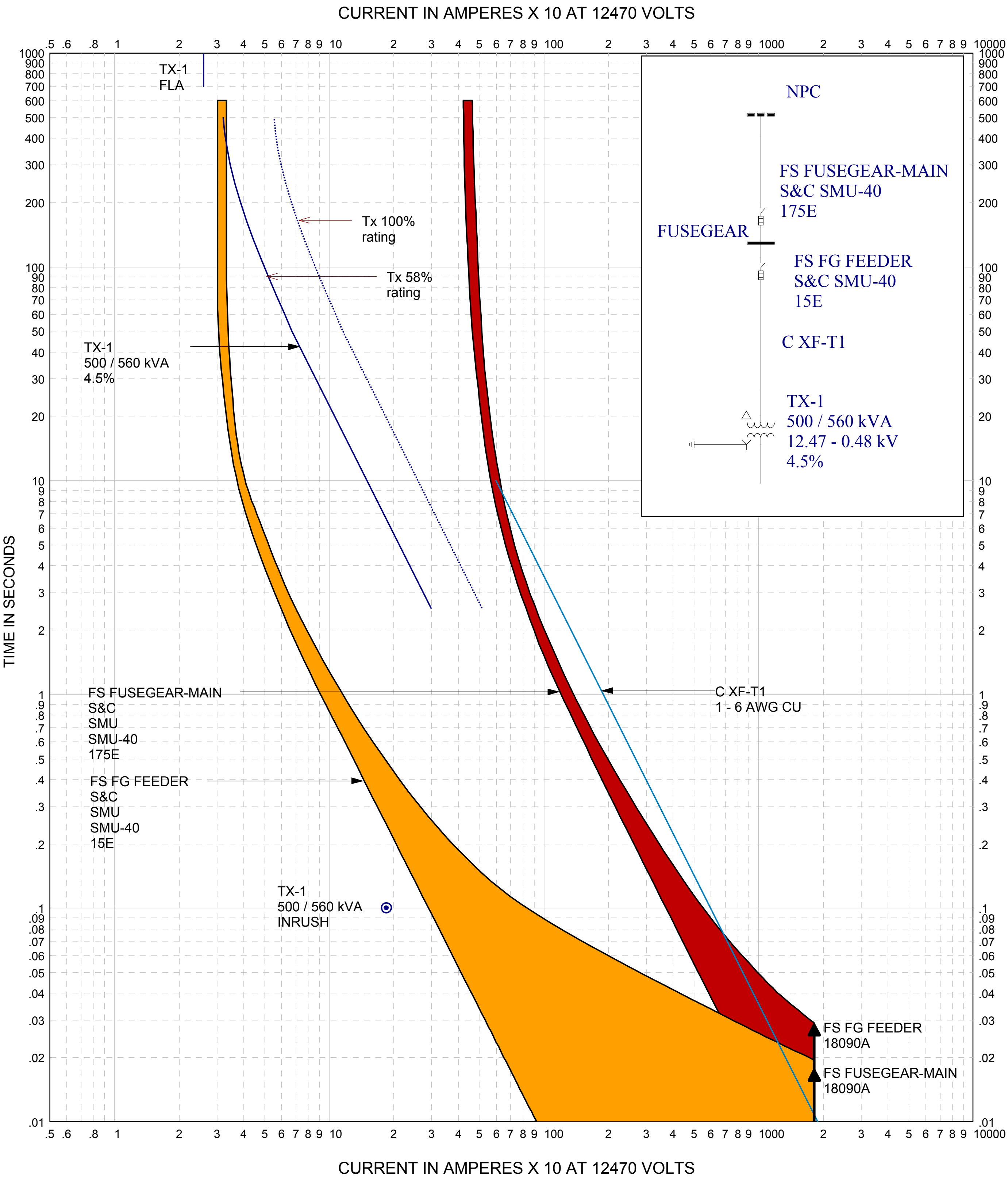
Meranto 2975 Zone Reservoir
Adjustable Breaker Settings
March 13, 2006

Adjustable Breaker Name	Manufacturer	Type	Style	Sensor/ Frame	Plug/ Tap	LTPU				LT Delay		STPU					Inst			Ground Trip			
						Name	Setting	Mult	Trip (A)	Name	Band	Name	Setting	Trip (A)	Band	I2t	Setting	Override	Trip (A)	Pickup	Trip (A)	Delay	I2t
B MCC1-MAIN	GE	Spectra RMS	MCCB SG	600	600	LT Pickup	1	1	600	LT Delay	Fixed	ST Pickup	2	1080	Fixed	In	2	Pickup	2310				Out
B PUMP P-3	GE	Spectra RMS	MCCB SE	30A (15AT)	15	LT Pickup	1	1	15	LT Delay	Fixed	ST Pickup	Max	90	Fixed	In	Max	Pickup	187.5				Out
B PUMP P-4	GE	Spectra RMS	MCCB SE	30A (15AT)	15	LT Pickup	1	1	15	LT Delay	Fixed	ST Pickup	4	43.5	Fixed	In	4	Pickup	88.5				Out
B PUMP P-5	GE	Spectra RMS	MCCB SE	30A (15AT)	15	LT Pickup	1	1	15	LT Delay	Fixed	ST Pickup	Max	90	Fixed	In	Max	Pickup	187.5				Out
B PUMP P-6	GE	Spectra RMS	MCCB SE	30A (30AT)	30	LT Pickup	1	1	30	LT Delay	Fixed	ST Pickup	Max	243	Fixed	In	Max	Pickup	375				Out
B PUMP P-7	GE	Spectra RMS	MCCB SE	30A (30AT)	30	LT Pickup	1	1	30	LT Delay	Fixed	ST Pickup	Max	243	Fixed	In	Max	Pickup	375				Out
B PUMP P-8	GE	Spectra RMS	MCCB SE	30A (15AT)	15	LT Pickup	1	1	15	LT Delay	Fixed	ST Pickup	Max	90	Fixed	In	Max	Pickup	187.5				Out
B PUMP P-9	GE	Spectra RMS	MCCB SE	30A (15AT)	15	LT Pickup	1	1	15	LT Delay	Fixed	ST Pickup	Max	90	Fixed	In	Max	Pickup	187.5				Out
B PUMP P-10	GE	Spectra RMS	MCCB SE	30A (15AT)	15	LT Pickup	1	1	15	LT Delay	Fixed	ST Pickup	Max	90	Fixed	In	Max	Pickup	187.5				Out
B PUMP P-11	GE	Spectra RMS	MCCB SE	30A (15AT)	15	LT Pickup	1	1	15	LT Delay	Fixed	ST Pickup	4	43.5	Fixed	In	4	Pickup	88.5				Out
B PUMP P-12	GE	Spectra RMS	MCCB SE	30A (15AT)	15	LT Pickup	1	1	15	LT Delay	Fixed	ST Pickup	Max	90	Fixed	In	Max	Pickup	187.5				Out
B PUMP P-13	GE	Spectra RMS	MCCB SE	30A (15AT)	15	LT Pickup	1	1	15	LT Delay	Fixed	ST Pickup	Max	90	Fixed	In	Max	Pickup	187.5				Out
B PUMP P-14	GE	Spectra RMS	MCCB SE	30A (30AT)	30	LT Pickup	1	1	30	LT Delay	Fixed	ST Pickup	4	87	Fixed	In	4	Pickup	177				Out
B P-WR1-001	GE	Spectra RMS	MCCB SE	60A (60AT)	60	LT Pickup	1	1	60	LT Delay	Fixed	ST Pickup	5	228	Fixed	In	5	Pickup	462				Out
B SPARE	GE	Spectra RMS	MCCB SE	60A (50AT)	50	LT Pickup	1	1	50	LT Delay	Fixed	ST Pickup	Max	350	Fixed	In	Max	Pickup	625				Out
B TX T11	GE	Spectra RMS	MCCB SE	30A (30AT)	30	LT Pickup	1	1	30	LT Delay	Fixed	ST Pickup	Max	243	Fixed	In	Max	Pickup	375				Out
B TX T4	GE	Spectra RMS	MCCB SE	30A (30AT)	30	LT Pickup	1	1	30	LT Delay	Fixed	ST Pickup	2	55.5	Fixed	In	2	Pickup	111				Out
B TX T5	GE	Spectra RMS	MCCB SE	30A (30AT)	30	LT Pickup	1	1	30	LT Delay	Fixed	ST Pickup	2	55.5	Fixed	In	2	Pickup	111				Out
B TX T-L	GE	Spectra RMS	MCCB SE	100A (70AT)	70	LT Pickup	1	1	70	LT Delay	Fixed	ST Pickup	6	350	Fixed	In	6	Pickup	693				Out
B TX T-UPS	GE	Spectra RMS	MCCB SE	30A (25AT)	25	LT Pickup	1	1	25	LT Delay	Fixed	ST Pickup	Max	187.5	Fixed	In	Max	Pickup	250				Out

Meranto 2975 Zone Reservoir
Thermal Magnetic Breakers
March 13, 2006

Thermal Magnetic Breaker	Manufacturer	Type	Style	Frame	Trip	Instantaneous	
						Setting	Trip (A)
B L-MAIN	GE	Q Line	TQD	225A(100-225AT)	150		
B U-1 MAIN	GE	Q Line	THQB	100A(60-100AT)	60		

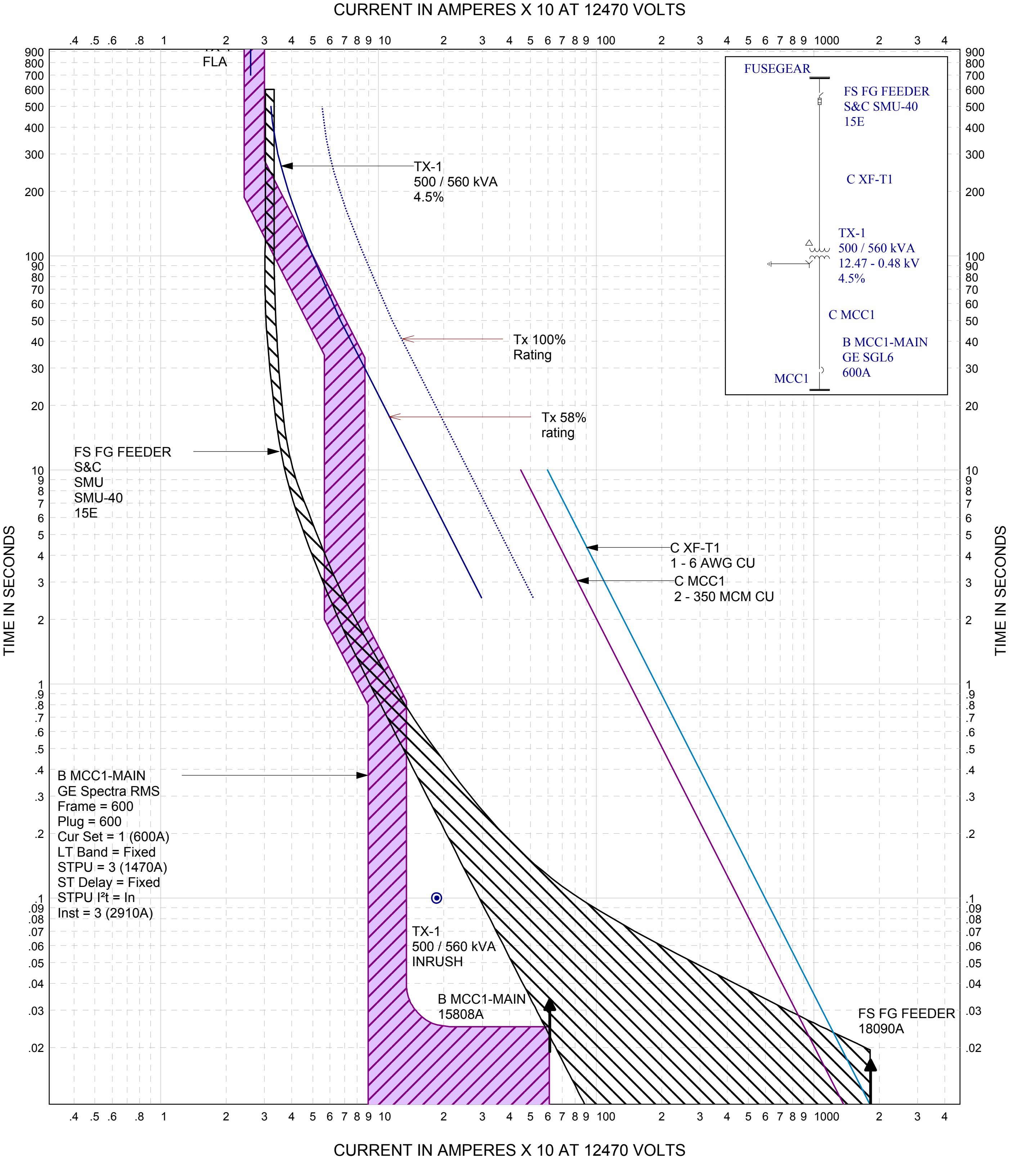
Time Current Curves



PQTSi	***EasyPower*** ® **TIME-CURRENT CURVES**	Fuse Gear Fusing

Meranto Lift Station
Fuse Selection - AS FOUND
This TCC represents the Fuse Curves as indicated by the SLD provided in the Record Drawings. It does not necessarily represent the best solution.

FAULT: Phase
DATE: Mar 13, 2006
BY: Joe Dietrich
REVISION: 1

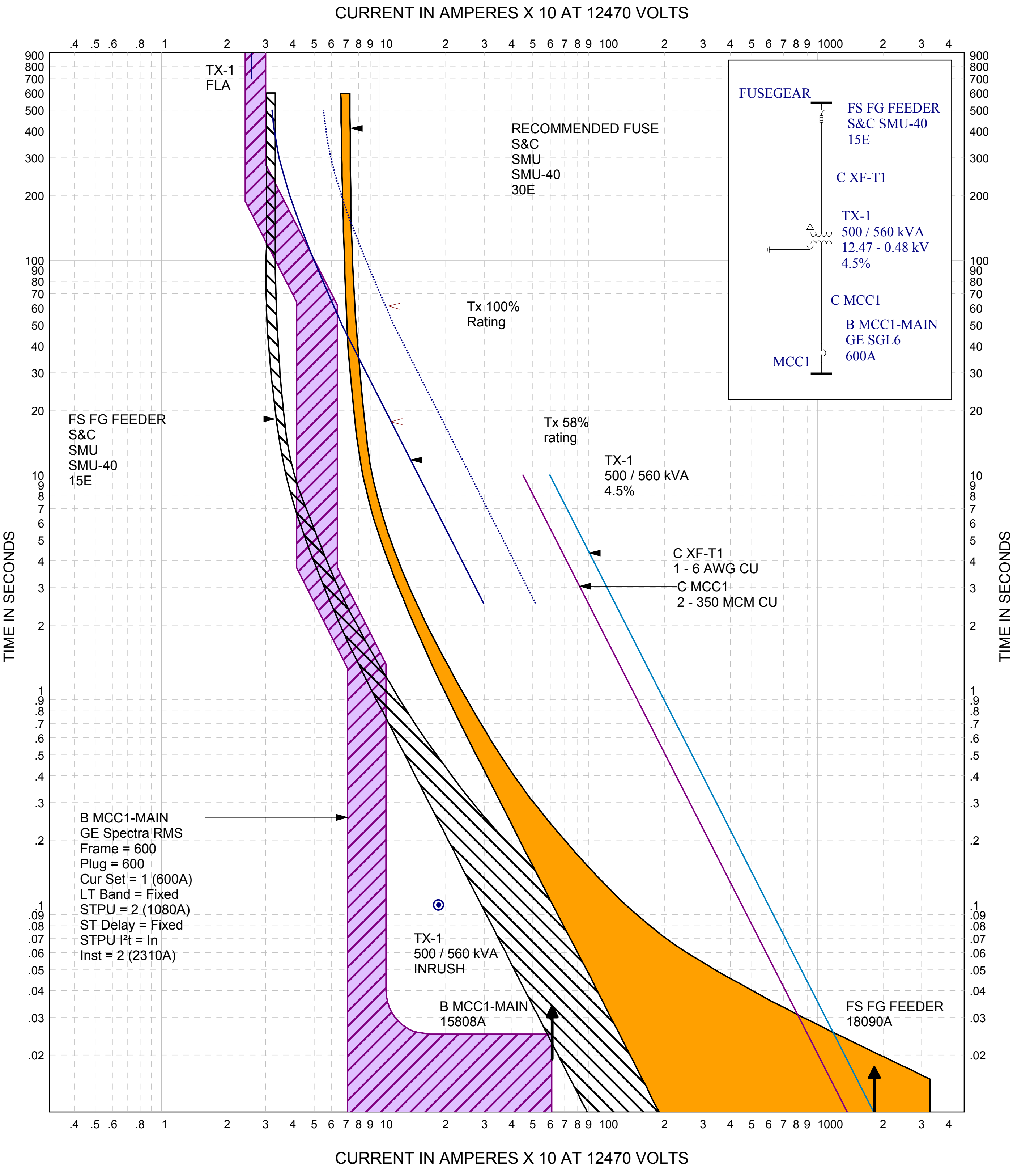


PQTSi	***EasyPower*** ® **TIME-CURRENT CURVES**	TX - 1 500KVA HV

Meranto Lift Station

Fuse Selection - AS FOUND. This TCC represents the Fuse Curve with respect to MCC1-Main as indicated by the SLD provided in the Record Drawings. It does not necessarily represent the best solution.

FAULT: Phase
DATE: Mar 13, 2006
BY: Joe Dietrich
REVISION: 1

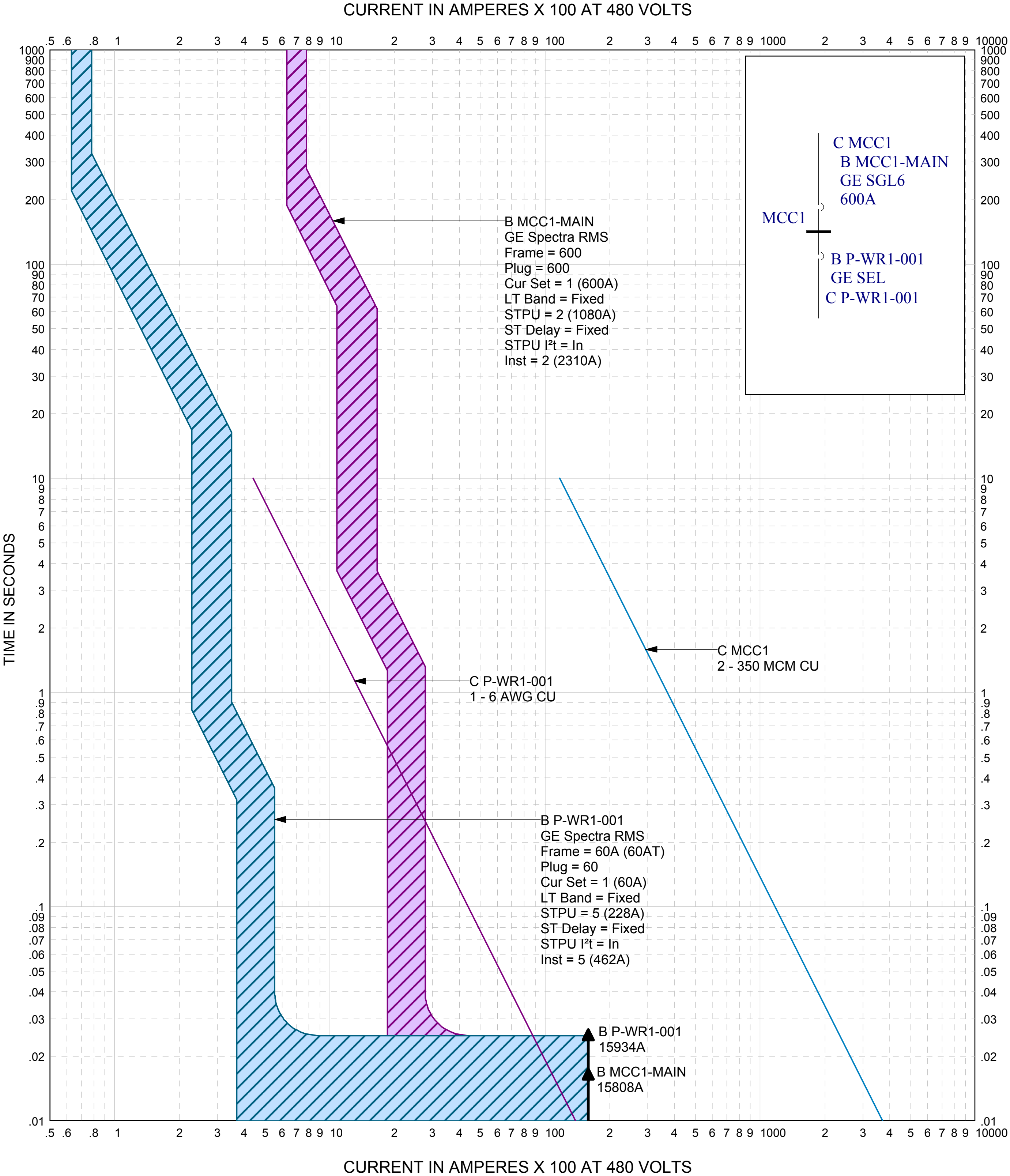


PQTSi	***EasyPower*** ® **TIME-CURRENT CURVES**	TX - 1 500KVA HV Rec

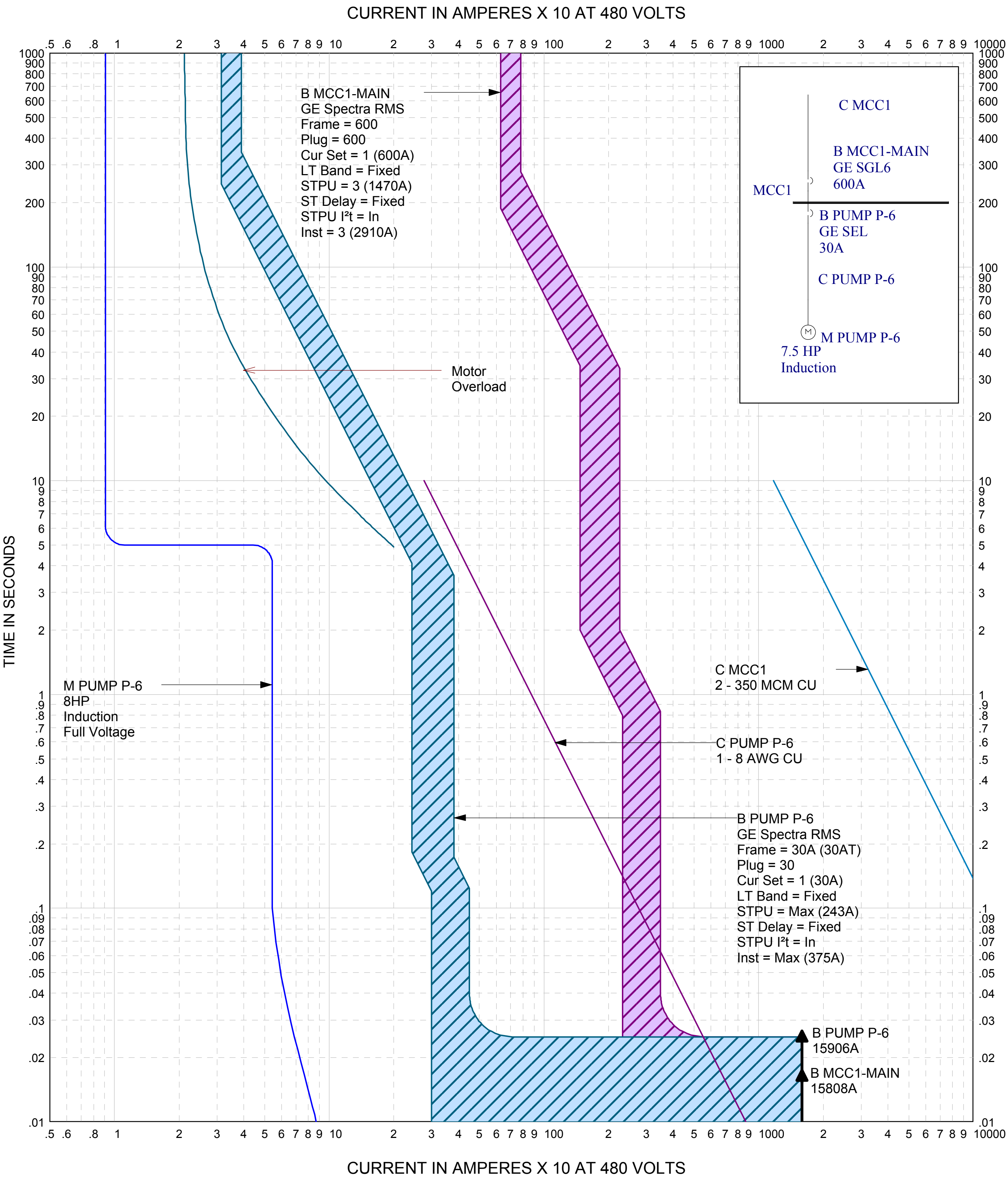
Meranto Lift Station
Fuse Selection - RECOMMENDED.
This TCC represents a 30E Fuse Curve with respect to MCC1-Main that provides better selectivity. The 15E is shown for comparison.

FAULT: Phase
DATE: Mar 13, 2006
BY: Joe Dietrich
REVISION: 1

MERANTO - RESUBMITTAL



PQTSi	*EasyPower* ® **TIME-CURRENT CURVES**	P-WR1-001
MERANTO 2975 ZONE RESERVOIR MCC1-MAIN & P-WR1-001		FAULT: Phase DATE: March 13, 2006 BY: Joe Dietrich REVISION: 1



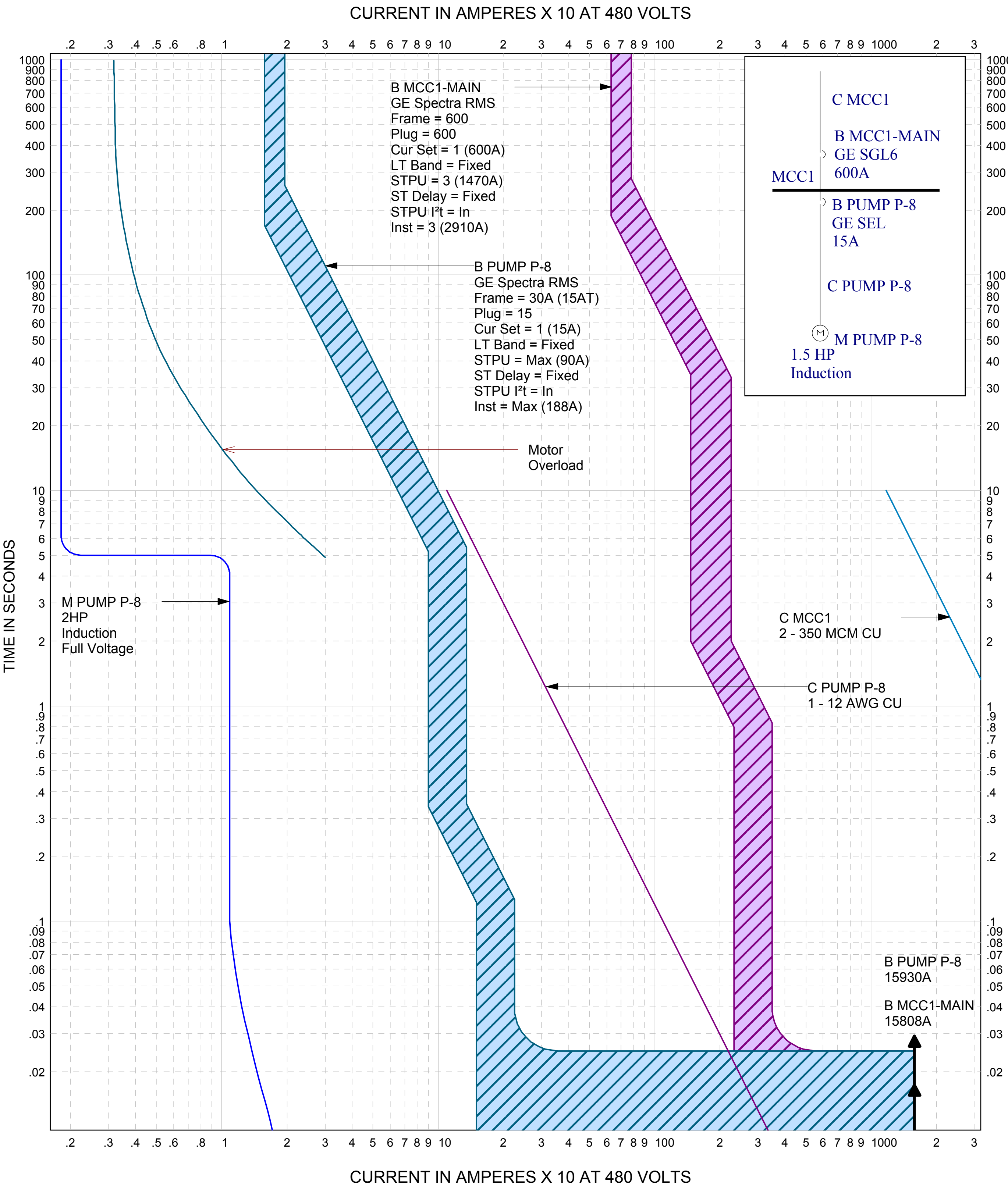
PQTSi	***EasyPower*** ® **TIME-CURRENT CURVES**	7.5 HP - Typical

Meranto Lift Station

Breaker Settings: MCC1-Main, Feeders Pumps P-6 and P-7

FAULT: Phase
DATE: Mar 13, 2006
BY: Joe Dietrich
REVISION: 1

MERANTO - RESUBMITTAL



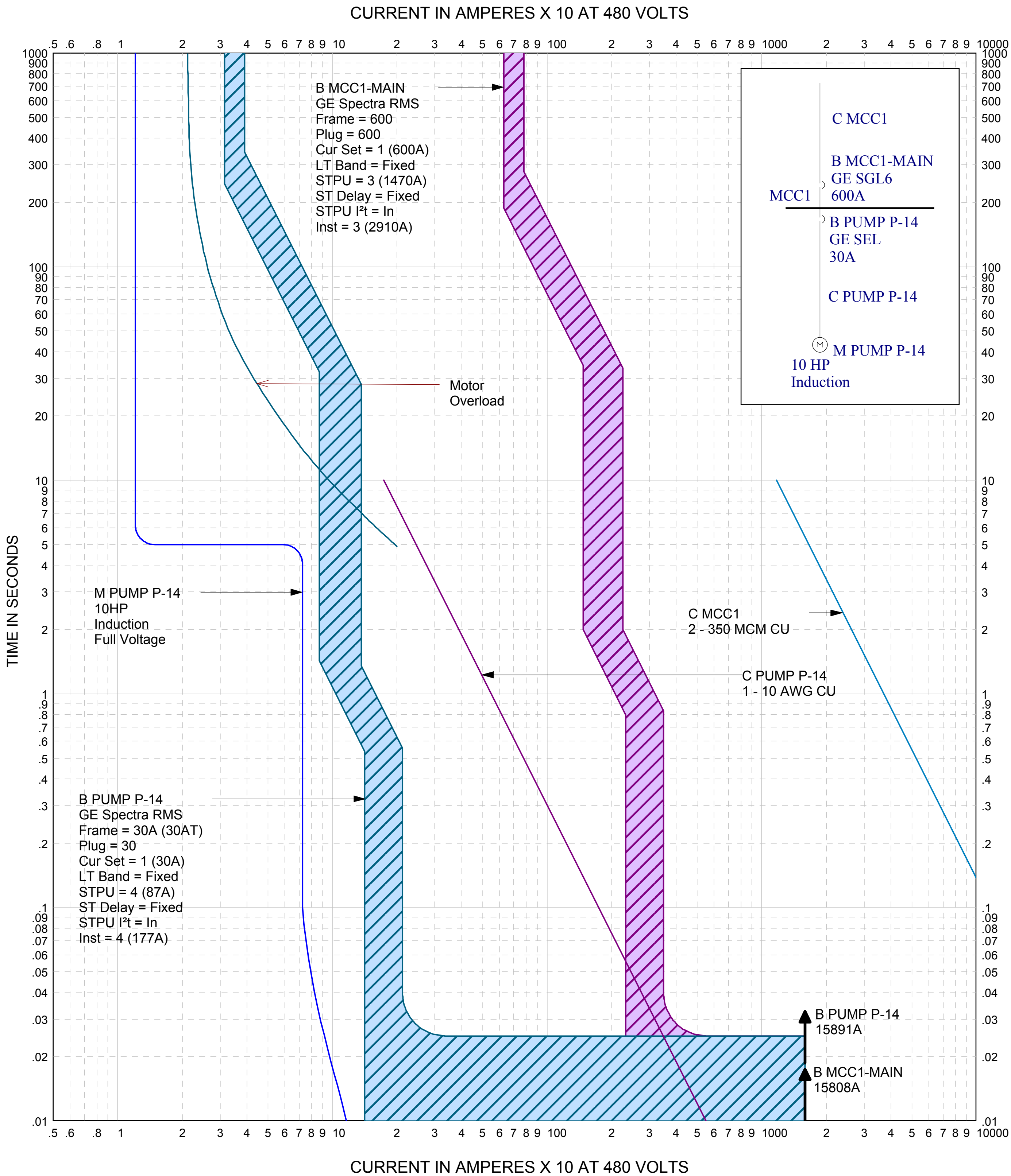
PQTSi	***EasyPower*** ® **TIME-CURRENT CURVES**	1.5HP - Typical

Meranto Lift Station

Breaker Settings: MCC1-Main, Feeders Pumps P-8, P-9, P-10

FAULT: Phase
DATE: Mar 13, 2006
BY: Joe Dietrich
REVISION: 1

MERANTO - RESUBMITTAL

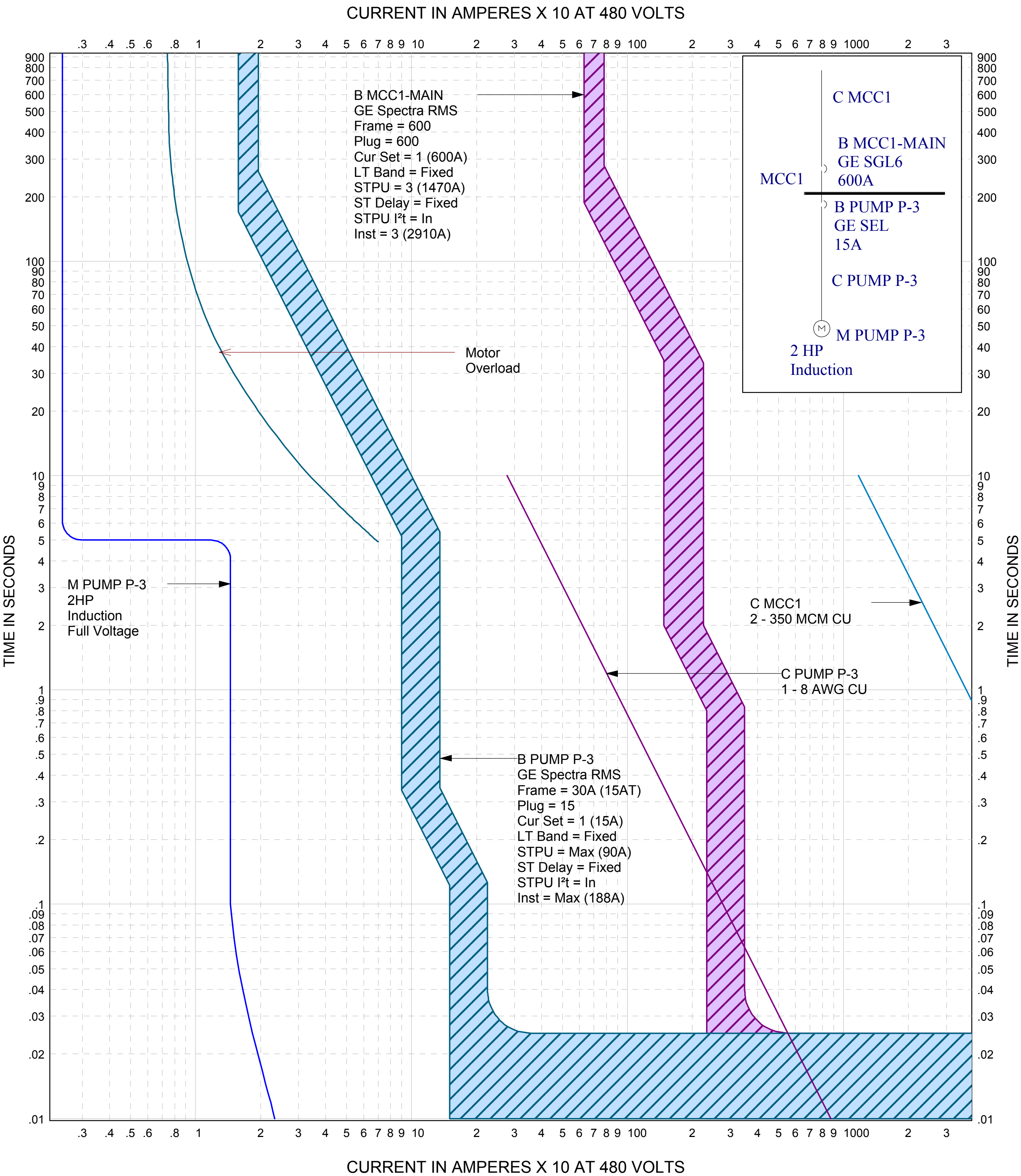


PQTSi	***EasyPower*** ® **TIME-CURRENT CURVES**	10 HP (Pump P-14)

Meranto Lift Station

Breaker Settings: MCC1-Main, Feeder Pump P-14

FAULT: Phase
DATE: Mar 13, 2006
BY: Joe Dietrich
REVISION: 1

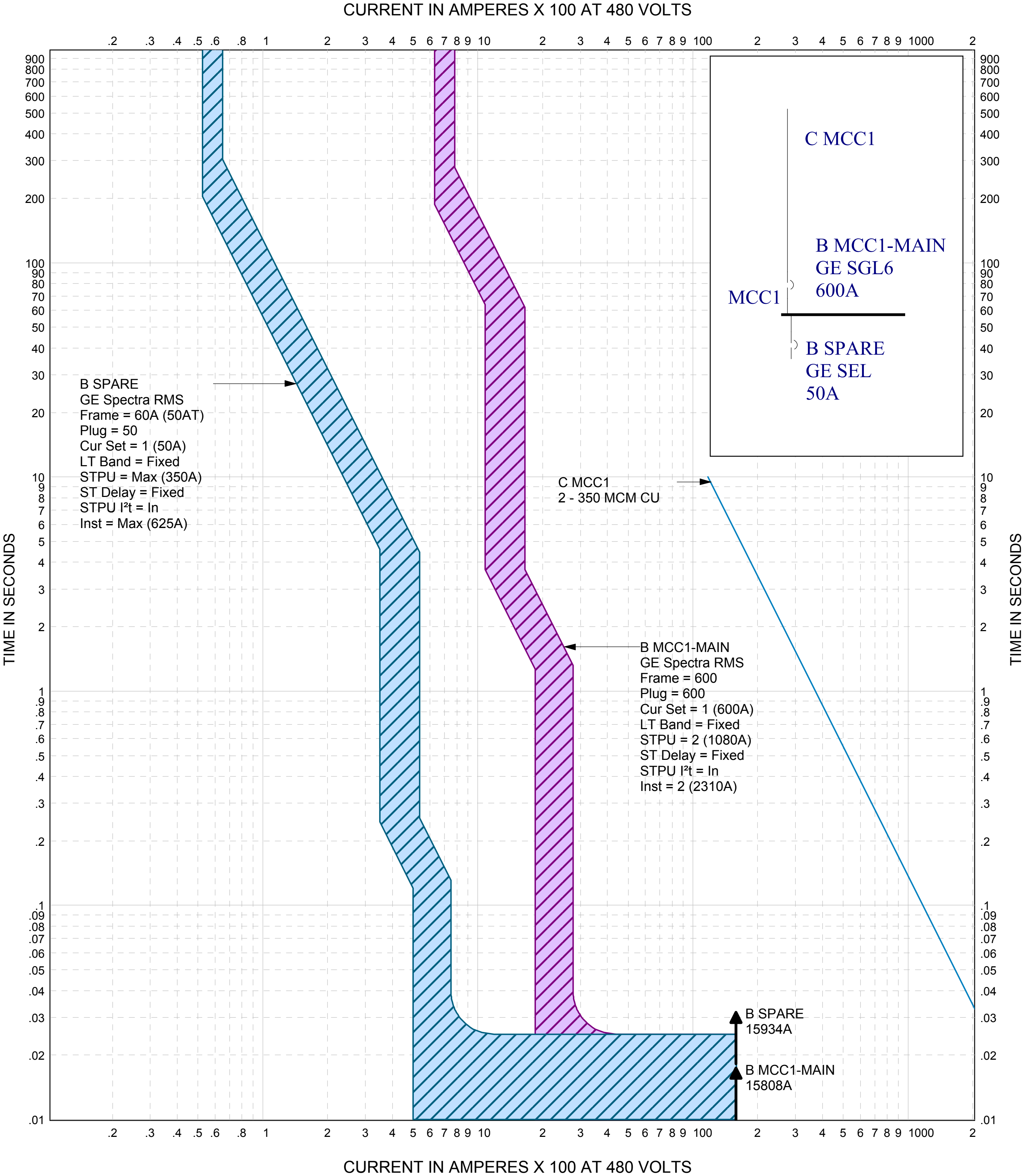


PQTSi	*EasyPower* ® **TIME-CURRENT CURVES**	2 HP - Typical

Meranto Lift Station

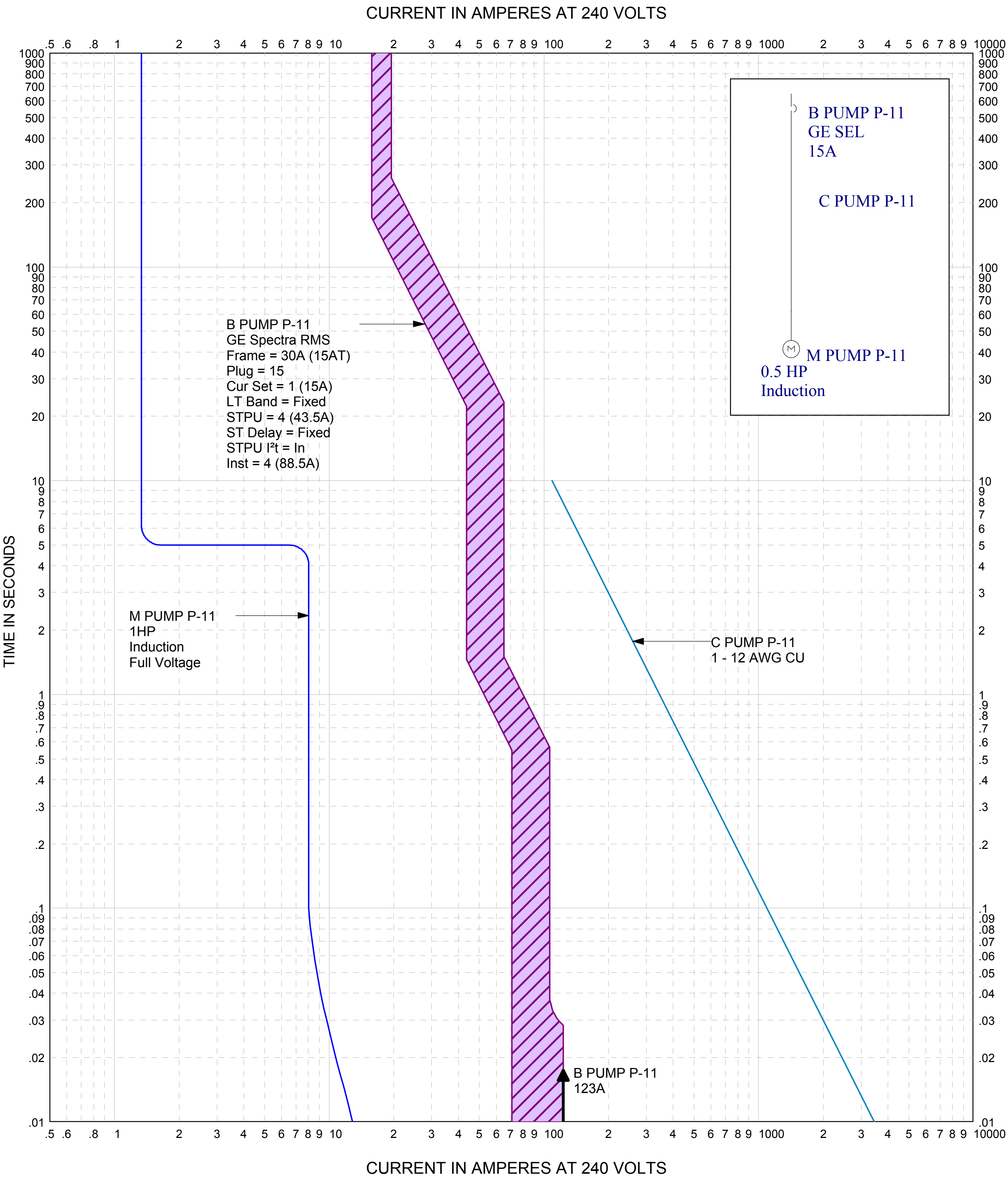
Breaker Settings: MCC1-Main, Feeders Pump P-3, P-12 and P-13

FAULT: Phase
DATE: Mar 13, 2006
BY: Joe Dietrich
REVISION: 1



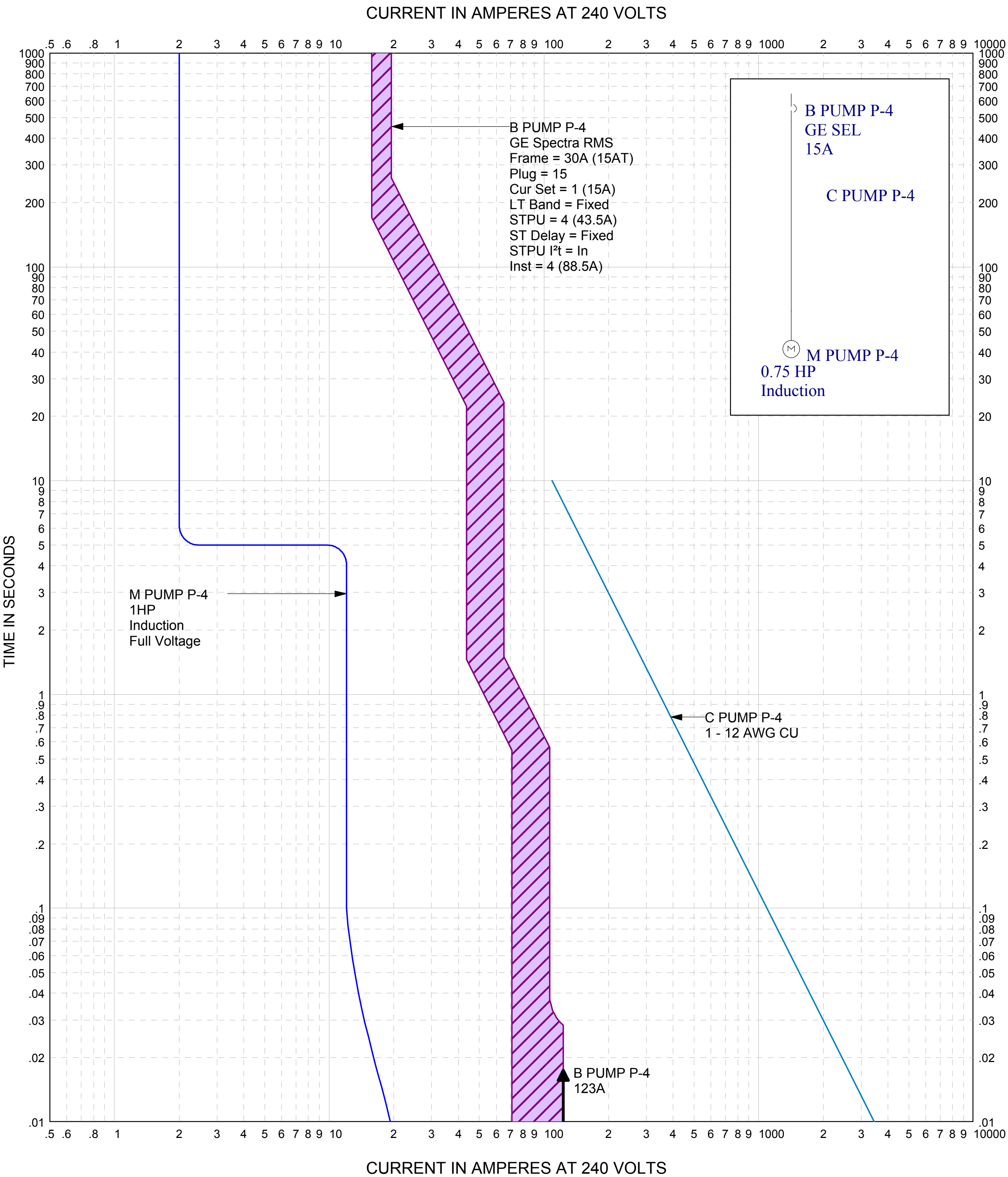
PQTSi	***EasyPower*** ® **TIME-CURRENT CURVES**	50A SPARE
MERANTO 2975 ZONE RESERVOIR		FAULT: Phase
		DATE: March 13, 2006
MCC1-MAIN & 50A SPARE		BY: Joe Dietrich
		REVISION: 1

MERANTO - RESUBMITTAL



PQTSi	***EasyPower*** ® **TIME-CURRENT CURVES**	1/2HP (Pump P-11)
Meranto Lift Station		FAULT: Phase
		DATE: Mar 13, 2006
Breaker Settings: Transformer T-11 / Pump P-11		BY: Joe Dietrich
		REVISION: 0

MERANTO - RESUBMITTAL



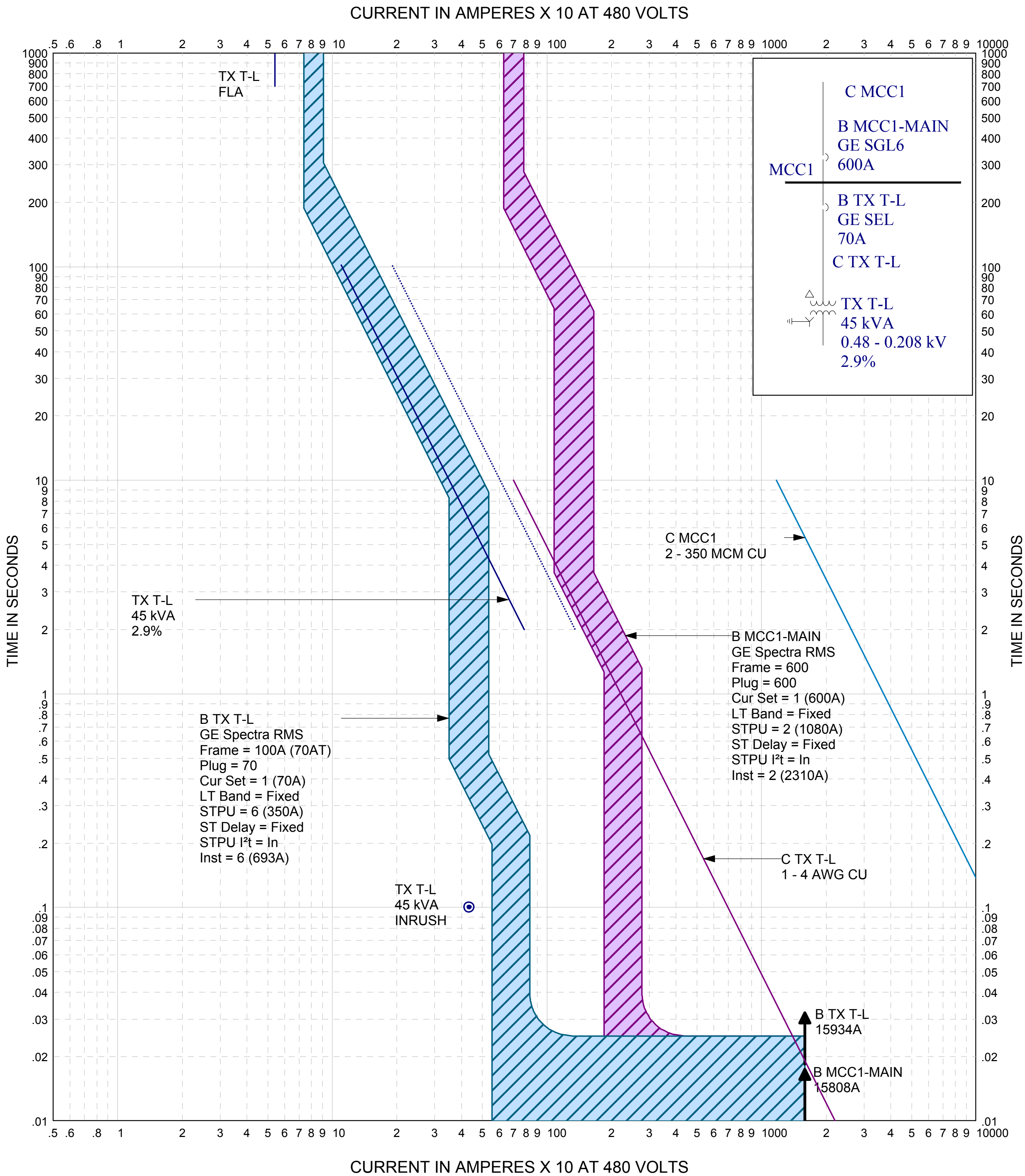
PQTSi	*EasyPower* ® **TIME-CURRENT CURVES**	3/4HP - Typical

Meranto Lift Station

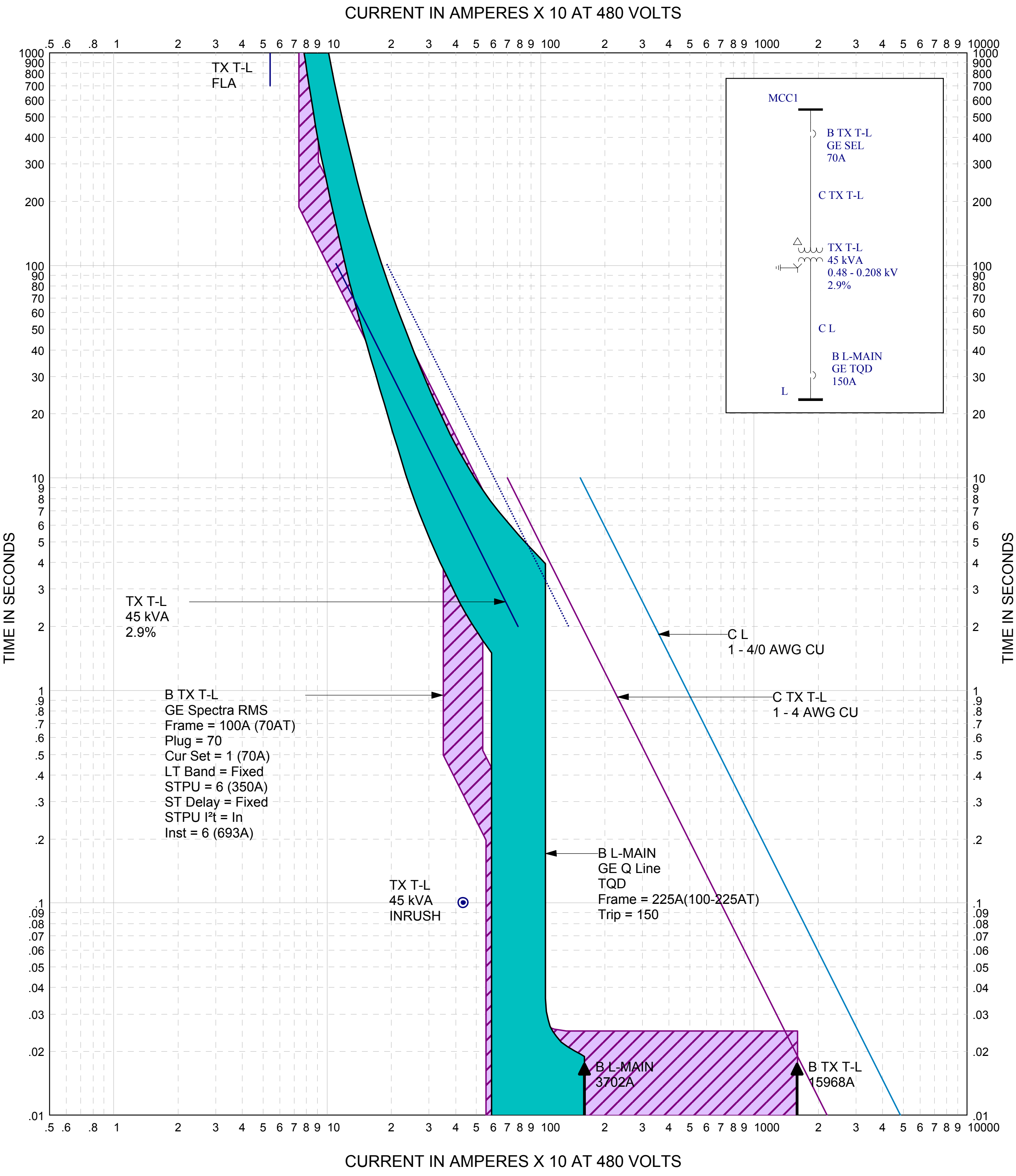
Breaker Settings: Transformers T-4 & T-5 / Pumps P-4 and P-5

FAULT: Phase
DATE: Mar 13, 2006
BY: Joe Dietrich
REVISION: 1

MERANTO - RESUBMITTAL



PQTSi	***EasyPower*** ® **TIME-CURRENT CURVES**	TX T-L
MERANTO 2975 ZONE RESERVOIR		FAULT: Phase
		DATE: March 13, 2006
MCC1-MAIN & TX T-L		BY: Joe Dietrich
		REVISION: 1



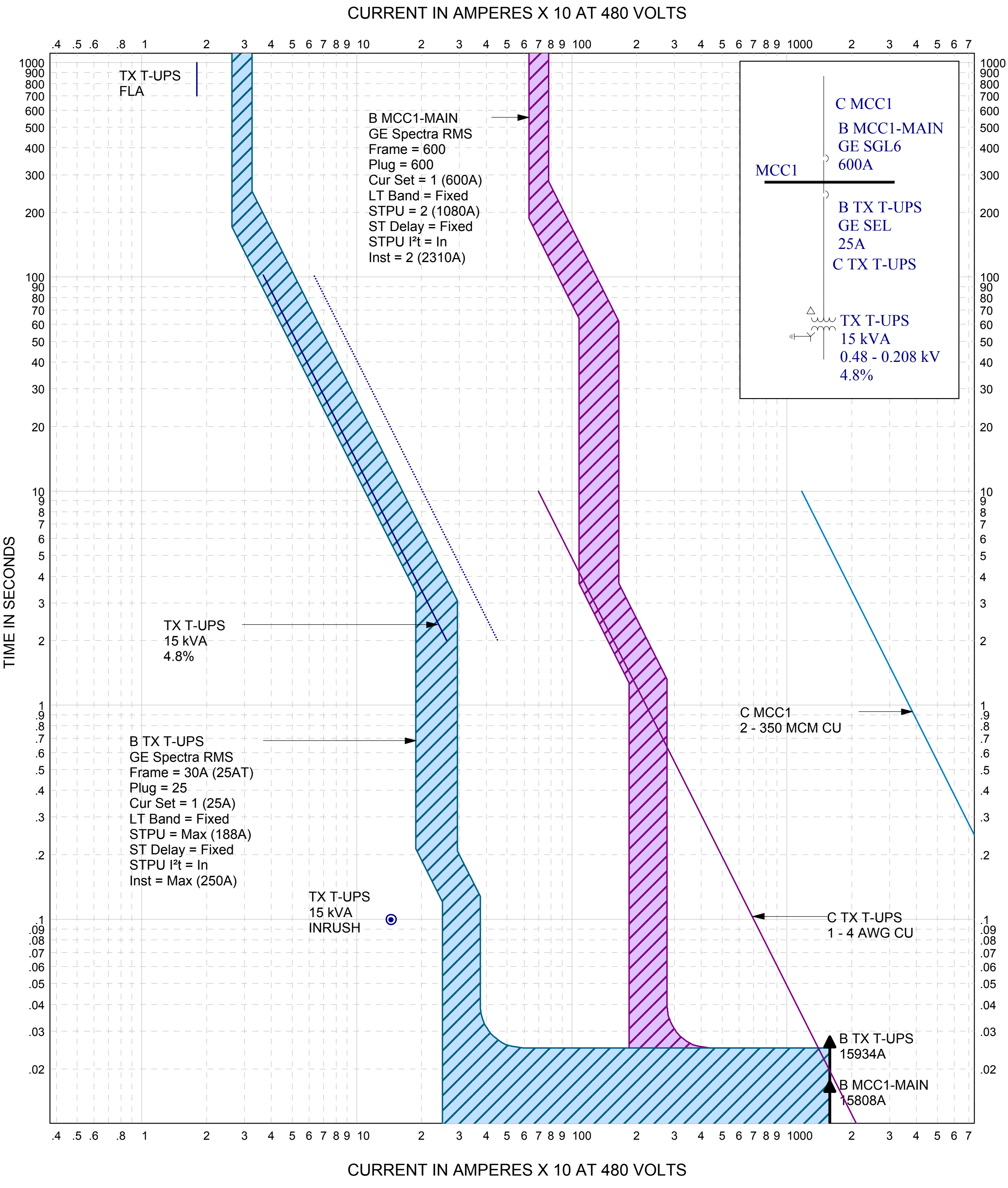
PQTSi	***EasyPower ®*** **TIME-CURRENT CURVES**	TX T-L HV

MERANTO 2975 ZONE RESERVOIR

TX T-L HIGH AND LOW SIDE PROTECTION

FAULT: Phase
DATE: Feb 01, 2006
BY: Joe Dietrich
REVISION: 0

MERANTO



PQTSi	***EasyPower*** ® **TIME-CURRENT CURVES**	TX T-UPS

MERANTO 2975 ZONE RESERVOIR

MCC1-MAIN & TX T-UPS

FAULT: Phase
DATE: March 13, 2006
BY: Joe Dietrich
REVISION: 1

Load Flow Analysis

Project: Meranto

Date: 1 February 2006
Time: 9:22:18PM

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
NPC	In	1.00	0.00	46.9	35.6	0.01	0.04 +*j* 0.35

Buses

Bus Name	In/Out Service	Design Volts	LF Volts	Angle Degree	PU Volts	%VD
BUS B1 STR	In	240	235	-0.66	0.98	2.08
BUS CH VLV STR	In	240	236	-0.50	0.98	1.52
BUS FUSEGEAR	In	12.470	12.468	-0.01	1.00	0.01
BUS MTR 1.5HP	In	480	477	-0.09	0.99	0.72
BUS MTR 1/2HP	In	240	235	-0.34	0.98	1.92
BUS MTR 10HP	In	480	473	0.17	0.99	1.45
BUS MTR 2HP	In	480	477	-0.15	0.99	0.57

Bus Name	In/Out Service	Design Volts	LF Volts	Angle Degree	PU Volts	%VD
BUS MTR 3/4HP	In	240	231	-0.03	0.96	3.68
BUS MTR 7.5HP	In	480	467	0.63	0.97	2.81
BUS T1-H	In	12.470	12.468	-0.01	1.00	0.01
BUS T1-L	In	480	478	-0.21	1.00	0.42
BUS TL-H	In	480	478	-0.21	1.00	0.42
BUS -TL-L	In	208	207	-0.21	1.00	0.42
BUS-MCC1	In	480	478	-0.21	1.00	0.42
BUS-T11-H	In	480	478	-0.21	1.00	0.43
BUST11-L	In	240	236	-0.51	0.99	1.50
BUS-T4-H	In	480	478	-0.21	1.00	0.43
BUS-T4-L	In	240	235	-0.67	0.98	2.06
BUS-TUPS-H	In	480	476	-0.08	0.99	0.76
BUS-TUPS-L	In	208	197	-1.59	0.95	5.13
BUS-UPS	In	208	197	-1.53	0.95	5.32
PANEL L	In	208	207	-0.21	1.00	0.42

Cables

From Bus To Bus	Component Name	In/Out Service	%VD	kW Loss	kvar Loss	kVA Loss	LF Amps Rating %	PF
BUS B1 STR BUS MTR 3/4HP	CBL-M-3/4HP1	In	1.59	0.7 0.0	0.5 0.0	0.9 0.0	2.2 10.9	0.81
BUS CH VLV S BUS MTR 1/2HP	CBL-M-1/2HP1	In	0.40	0.5 0.0	0.3 0.0	0.6 0.0	1.4 7.1	0.80
BUS FUSEGEA BUS T1-H	CBL XF - T1	In	0.00	46.9 0.0	35.6 0.0	58.9 0.0	2.7 2.1	0.80

From Bus To Bus	Component Name	In/Out Service	%VD	kW Loss	kvar Loss	kVA Loss	LF Amps Rating %	PF
BUS T1-L BUS-MCC1	CBL-MCC1	In	0.01	46.9 0.0	35.3 0.0	58.7 0.0	70.9 11.4	0.80
BUS -TL-L PANEL L	CBL-PANEL L	In	0.00	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.00
BUS-MCC1 BUS MTR 1.5HP	CBL-P-C8-001	In	0.30	1.4 0.0	1.0 0.0	1.8 0.0	2.1 10.6	0.80
BUS-MCC1 BUS MTR 10HP	CBL-P-P14-001	In	1.02	9.5 0.1	7.0 0.0	11.8 0.1	14.2 47.4	0.80
BUS-MCC1 BUS MTR 2HP	CBL-P-P3-001	In	0.14	1.9 0.0	1.4 0.0	2.3 0.0	2.8 14.1	0.80
BUS-MCC1 BUS MTR 7.5HP	CBL-P-P6-001	In	2.38	7.2 0.2	5.3 0.0	9.0 0.3	10.8 21.6	0.81
BUS-MCC1 BUS TL-H	CBL-T-1	In	0.00	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.00
BUS-MCC1 BUS-T11-H	CBL-TX-T11	In	0.00	0.5 0.0	0.4 0.0	0.6 0.0	0.7 3.6	0.80
BUS-MCC1 BUS-T4-H	CBL-TX-T4	In	0.01	0.7 0.0	0.5 0.0	0.9 0.0	1.1 5.5	0.80
BUS-MCC1 BUS-TUPS-H	CBL-TUPS	In	0.34	12.4 0.1	9.8 0.0	15.8 0.1	19.1 63.5	0.79
BUST11-L BUS CH VLV S	CBL-M-1/2HP	In	0.02	0.5 0.0	0.3 0.0	0.6 0.0	1.4 7.1	0.80
BUS-T4-L BUS B1 STR	CBL-M-3/4HP	In	0.02	0.7 0.0	0.5 0.0	0.9 0.0	2.2 10.9	0.81

From Bus / To Bus	Component Name	In/Out Service	%VD	kW Loss	kvar Loss	kVA Loss	LF Amps Rating %	PF
BUS-TUPS-L	CBL-UPS	In	0.18	12.0	9.0	15.0	44.0	0.80
BUS-UPS				0.0	0.0	0.0	67.7	

2-Winding Transformers

From Bus / To Bus	Component Name	In/Out Service	%VD	kW Loss	kvar Loss	kVA Loss	LF Amps Rating %	PF
BUS T1-H	XF - T1	In	0.40	46.9	35.6	58.9	3.0	0.80
BUS T1-L				0.1	0.3	0.3	11.8	
BUS TL-H	XF-T-L	In	0.00	0.0	0.0	0.0	0.0	0.00
BUS -TL-L				0.0	0.0	0.0	0.0	
BUS-T11-H	XF-T11	In	1.07	0.5	0.4	0.6	1.0	0.80
BUST11-L				0.0	0.0	0.0	29.7	
BUS-T4-H	XF-T4	In	1.63	0.7	0.5	0.9	1.0	0.80
BUS-T4-L				0.0	0.0	0.0	45.4	
BUS-TUPS-H	XF-T-UPS	In	4.37	12.3	9.7	15.7	19.0	0.78
BUS-TUPS-L				0.3	0.7	0.8	105.6	

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FEEDER INPUT DATA

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==============================================================================================================
CABLE         FEEDER FROM    FEEDER TO      QTY  VOLTS   LENGTH            FEEDER
NAME          NAME           NAME           /PH  L-L                   SIZE      TYPE
==============================================================================================================
CBL XF - T1   BUS FUSEGEAR   BUS T1-H         1  12470   11.0  FEET       6     Copper
              Duct Material: Non-Magnetic     Insulation Type:        EPR    Insulation Class:         MV
              +/-  Impedance: 0.5100 + J  0.0636  Ohms/1000 ft      0.0036 + J 0.00045  PU
              Z0   Impedance: 0.8123 + J  0.1618  Ohms/1000 ft      0.0057 + J  0.0011  PU

CBL-M-1/2HP   BUST11-L       BUS CH VLV STR   1    240   11.0  FEET      12     Copper
              Duct Material:    Magnetic      Insulation Type:        PVC    Insulation Class:       THWN
              +/-  Impedance:   1.87 + J  0.0910  Ohms/1000 ft       35.71 + J    1.74  PU
              Z0   Impedance:   5.89 + J  0.2241  Ohms/1000 ft      112.55 + J    4.28  PU

CBL-M-1/2HP1  BUS CH VLV STR  BUS MTR 1/2HP   1    240  250.0  FEET      12     Copper
              Duct Material:    Magnetic      Insulation Type:        PVC    Insulation Class:       THWN
              +/-  Impedance:   1.87 + J  0.0910  Ohms/1000 ft      811.63 + J   39.50  PU
              Z0   Impedance:   5.89 + J  0.2241  Ohms/1000 ft     2557.90 + J   97.27  PU

CBL-M-3/4HP   BUS-T4-L       BUS B1 STR       1    240   10.0  FEET      12     Copper
              Duct Material:    Magnetic      Insulation Type:        PVC    Insulation Class:       THWN
              +/-  Impedance:   1.87 + J  0.0910  Ohms/1000 ft       32.47 + J    1.58  PU
              Z0   Impedance:   5.89 + J  0.2241  Ohms/1000 ft      102.32 + J    3.89  PU

CBL-M-3/4HP1  BUS B1 STR     BUS MTR 3/4HP    1    240  650.0  FEET      12     Copper
              Duct Material:    Magnetic      Insulation Type:        PVC    Insulation Class:       THWN
              +/-  Impedance:   1.87 + J  0.0910  Ohms/1000 ft     2110.24 + J  102.69  PU
              Z0   Impedance:   5.89 + J  0.2241  Ohms/1000 ft     6650.54 + J  252.89  PU

CBL-MCC1      BUS T1-L       BUS-MCC1         2    480   11.0  FEET     350     Copper
              Duct Material:    Magnetic      Insulation Type:        PVC    Insulation Class:       THWN
              +/-  Impedance: 0.0378 + J  0.0491  Ohms/1000 ft      0.0902 + J  0.1172  PU
              Z0   Impedance: 0.1191 + J  0.1209  Ohms/1000 ft      0.2843 + J  0.2886  PU

CBL-P-C8-001  BUS-MCC1       BUS MTR 1.5HP    1    480  250.0  FEET      12     Copper
              Duct Material:    Magnetic      Insulation Type:        PVC    Insulation Class:       THWN
              +/-  Impedance:   1.87 + J  0.0910  Ohms/1000 ft      202.91 + J    9.87  PU
              Z0   Impedance:   5.89 + J  0.2241  Ohms/1000 ft      639.47 + J   24.32  PU

CBL-P-P14-001 BUS-MCC1       BUS MTR 10HP     1    480  200.0  FEET      10     Copper
              Duct Material:    Magnetic      Insulation Type:        PVC    Insulation Class:       THWN
              +/-  Impedance:   1.18 + J  0.0854  Ohms/1000 ft      102.43 + J    7.41  PU
              Z0   Impedance:   3.72 + J  0.2103  Ohms/1000 ft      322.81 + J   18.26  PU

CBL-P-P3-001  BUS-MCC1       BUS MTR 2HP      1    480   90.0  FEET      12     Copper
              Duct Material:    Magnetic      Insulation Type:        PVC    Insulation Class:       THWN
              +/-  Impedance:   1.87 + J  0.0910  Ohms/1000 ft       73.05 + J    3.55  PU
              Z0   Impedance:   5.89 + J  0.2241  Ohms/1000 ft      230.21 + J    8.75  PU
```

FEEDER INPUT DATA

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===============================================================================================================
CABLE         FEEDER FROM    FEEDER TO       QTY  VOLTS   LENGTH            FEEDER
NAME          NAME           NAME            /PH  L-L                  SIZE       TYPE
===============================================================================================================
CBL-P-P6-001  BUS-MCC1       BUS MTR 7.5HP    1    480  875.0  FEET      8      Copper
              Duct Material:    Magnetic     Insulation Type:       PVC    Insulation Class:       THWN
              +/-  Impedance: 0.8110 + J  0.0754  Ohms/1000 ft     308.00 + J   28.63  PU
              Z0   Impedance:   2.56 + J  0.1856  Ohms/1000 ft     970.67 + J   70.49  PU

CBL-PANEL L   BUS -TL-L      PANEL L          1    208   11.0  FEET     4/0     Copper
              Duct Material:    Magnetic     Insulation Type:       PVC    Insulation Class:       THWN
              +/-  Impedance: 0.0640 + J  0.0497  Ohms/1000 ft       1.63 + J    1.26  PU
              Z0   Impedance: 0.2017 + J  0.1224  Ohms/1000 ft       5.13 + J    3.11  PU

CBL-T-1       BUS-MCC1       BUS TL-H         1    480   35.0  FEET      4      Copper
              Duct Material:    Magnetic     Insulation Type:       PVC    Insulation Class:       THWN
              +/-  Impedance: 0.3210 + J  0.0632  Ohms/1000 ft       4.88 + J  0.9601  PU
              Z0   Impedance:   1.01 + J  0.1556  Ohms/1000 ft      15.37 + J    2.36  PU

CBL-TUPS      BUS-MCC1       BUS-TUPS-H       1    480   50.0  FEET     10      Copper
              Duct Material:    Magnetic     Insulation Type:       PVC    Insulation Class:         TW
              +/-  Impedance:   1.18 + J  0.0854  Ohms/1000 ft      25.61 + J    1.85  PU
              Z0   Impedance:   3.72 + J  0.2103  Ohms/1000 ft      80.70 + J    4.56  PU

CBL-TX-T11    BUS-MCC1       BUS-T11-H        1    480   11.0  FEET     12      Copper
              Duct Material:    Magnetic     Insulation Type:       PVC    Insulation Class:       THWN
              +/-  Impedance:   1.87 + J  0.0910  Ohms/1000 ft       8.93 + J  0.4345  PU
              Z0   Impedance:   5.89 + J  0.2241  Ohms/1000 ft      28.14 + J    1.07  PU

CBL-TX-T4     BUS-MCC1       BUS-T4-H         1    480   11.0  FEET     12      Copper
              Duct Material:    Magnetic     Insulation Type:       PVC    Insulation Class:       THHN
              +/-  Impedance:   1.87 + J  0.0910  Ohms/1000 ft       8.93 + J  0.4345  PU
              Z0   Impedance:   5.89 + J  0.2241  Ohms/1000 ft      28.14 + J    1.07  PU

CBL-UPS       BUS-TUPS-L     BUS-UPS          1    208   11.0  FEET      6      Copper
              Duct Material:    Magnetic     Insulation Type:       PVC    Insulation Class:       THWN
              +/-  Impedance: 0.5100 + J  0.0685  Ohms/1000 ft      12.97 + J    1.74  PU
              Z0   Impedance:   1.61 + J  0.1687  Ohms/1000 ft      40.86 + J    4.29  PU
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TRANSFORMER INPUT DATA

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==============================================================================================
TRANSFORMER    PRIMARY RECORD      VOLTS   * SECONDARY RECORD    VOLTS   FULL-LOAD    NOMINAL
NAME           NO NAME             L-L       NO NAME             L-L     KVA          KVA
==============================================================================================
XF - T1        BUS T1-H      D  12470.0   BUS T1-L       YG    480.00  500.00       500.00
               Pos. Seq. Z%:    0.937 + J   4.40    (Zpu:  1.88 + j   8.80 )
               Zero Seq. Z%:    0.937 + J   4.40    (Zpu: Sec:  1.88 + j   8.80     Pri: Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leading Sec.):  30.00 Deg.

XF-T-L         BUS TL-H      D   480.00   BUS -TL-L      YG    208.00   45.00        45.00
               Pos. Seq. Z%:    0.945 + J   2.74    (Zpu: 21.01 + j  60.92 )
               Zero Seq. Z%:    0.945 + J   2.74    (Zpu: Sec: 21.01 + j  60.92     Pri: Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leading Sec.):  30.00 Deg.

XF-T-UPS       BUS-TUPS-H    D   480.00   BUS-TUPS-L     YG    208.00   15.00        15.00
               Pos. Seq. Z%:     1.80 + J   4.45    (Zpu: 120.1 + j  296.6 )
               Zero Seq. Z%:     1.80 + J   4.45    (Zpu: Sec: 120.1 + j  296.6     Pri: Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leading Sec.):  30.00 Deg.

XF-T11         BUS-T11-H     D   480.00   BUST11-L       D     240.00    2.00         2.00
               Pos. Seq. Z%:     1.83 + J   3.56    (Zpu: 915.9 + j  1777. )
               Zero Seq. Z%:     1.83 + J   3.56    (Zpu: Pri: Open, Sec: Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leading Sec.):  0.000 Deg.

XF-T4          BUS-T4-H      D   480.00   BUS-T4-L       D     240.00    2.00         2.00
               Pos. Seq. Z%:     1.83 + J   3.56    (Zpu: 915.9 + j  1777. )
               Zero Seq. Z%:     1.83 + J   3.56    (Zpu: Pri: Open, Sec: Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leading Sec.):  0.000 Deg.
```

GENERATION DATA

BUS NAME	GENERATION	VOLT	SIZE	InitKW	MaxKVAR	TYPE
BUS FUSEGEAR	NPC	1 pu				SB

Three Phase Contribution: 13000.0 AMPS X/R : 8.00
Line to Earth Contribution: 13000.0 AMPS X/R : 8.00
Pos sequence impedance (100 MVA base) 0.0442 + J 0.3534 PU
Zero sequence impedance (100 MVA base) 0.0442 + J 0.3534 PU

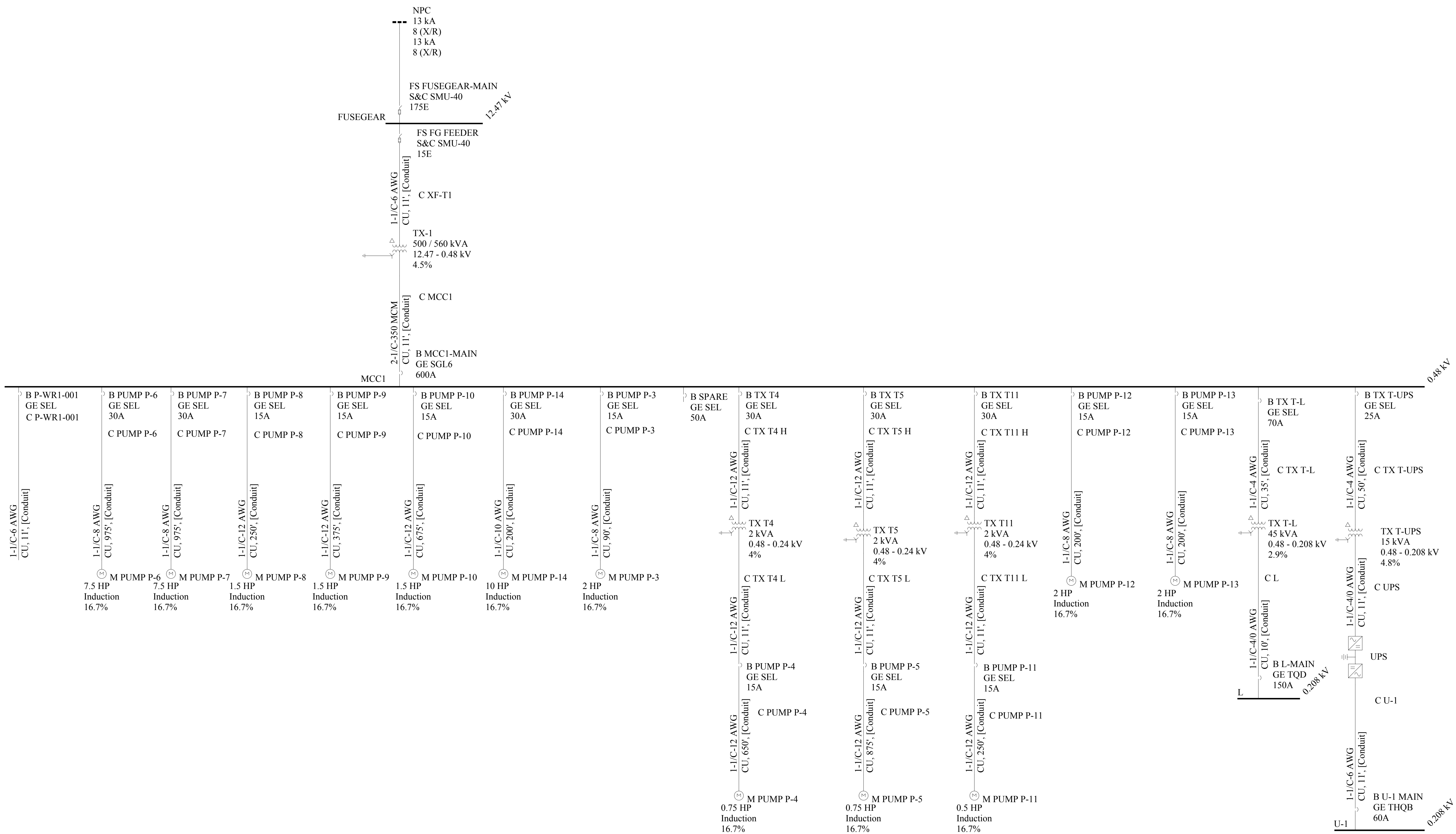
ENERGY AUDIT LOADS

BUS NAME	LOAD NAME	VOLTS	SIZE	LOADTYPE	PF	LAG/LEAD
BUS-UPS	LOAD-UPS	208	15.0*1.00kVA	KVA	0.80	LAG

MOTOR LOAD DATA

BUS NAME	LOAD NAME	VOLT	SIZE	#	TYPE	EFF	PF
BUS MTR 1.5HP	MTR 1-1/2HP	480	1.5*	1	HP KVA	0.80	0.80 LAG
BUS MTR 1/2HP	MTR 1/2HP	240	0.5*	1	HP KVA	0.80	0.80 LAG
BUS MTR 10HP	MTR 10HP	480	10.0*	1	HP KVA	0.80	0.80 LAG
BUS MTR 2HP	MTR 2HP	480	2.0*	1	HP KVA	0.80	0.80 LAG
BUS MTR 3/4HP	MTR 3/4HP	240	0.8*	1	HP KVA	0.80	0.80 LAG
BUS MTR 7.5HP	MTR 7-1/2HP	480	7.5*	1	HP KVA	0.80	0.80 LAG
BUS-MCC1	MTR GROUP	480	14.3*	1	HP KVA	0.80	0.80 LAG

Single Line Diagram



Meranto 2975 Zone Reservoir
Single Line Model - Base Model
PQTSI - March 13, 2006

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