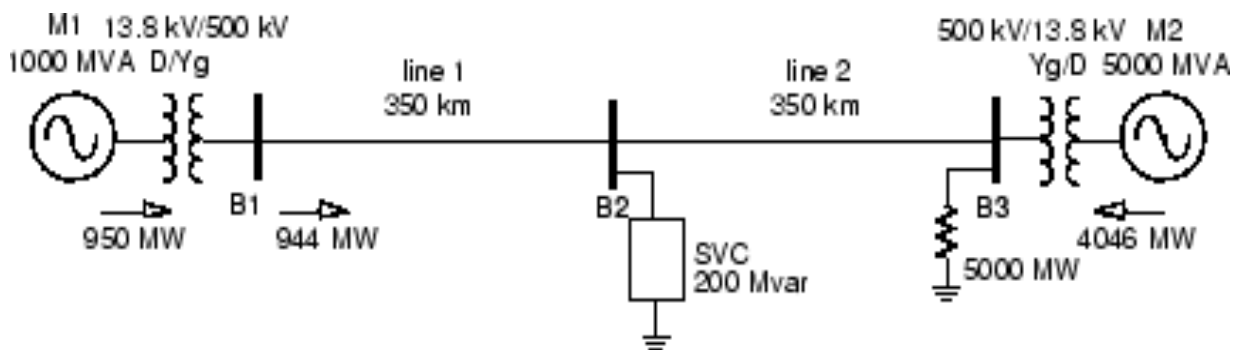
CAL POLY ELECTRICAL DISTRIBUTION COORDINATION & SHORT CIRCUIT ANALYSIS

SENIOR PROJECT REPORT



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Abstract

The purpose of this project is to maintain the California Polytechnic State University Electrical Distribution System by performing short circuit and protective device coordination studies for the Baker Science Building. When a short circuit arises in a system, there is no finite way in telling what protective device will be tripped, which can cause outages, arc flashes and electrical explosions. The best way in determining the outcomes of these occurrences are to perform precise simulated reports. To output these reports, design and analysis of the single line through a commercialized software, Power Tools for Windows (SKM) was used. To name a few, the analyses that the software can provide are load flow, short circuit, and protective device coordination studies. With the data that we collected from SKM, electricians will now be able to update protective device settings as well as localize any short circuits or faults.

Key Words: Distribution System, Short Circuit, Protective Device, Coordination Study, SKM

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Thank you for accepting to be our mentor for our senior project and being able to have input on how to accomplish our goals.

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Thank you for getting us the contact information to obtain the full licensed copy of the SKM software.

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Thank you for providing us with the SKM software, and answering questions regarding the software.

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1.0 INTRODUCTION

Power is a basic necessity for many people and is essential for their everyday life. Because power is such a crucial element of everyday life, it is important that people are provided with reliable power in a safe manner. Utility companies serve as the entity responsible for generating and distributing this power to customers in a safe and reliable manner. A crucial element of a well-designed and functional power system is protection. Whether it be large scale transmission lines, or the electrical distribution system of a house, the system needs to be able to remain stable in the event of electrical faults.

Power-system protection is a branch of electrical power engineering that deals with the protection of electrical power systems from faults through the isolation of faulted parts from the rest of the electrical network. The objective of a protection scheme is to keep the power system stable by isolating only the components that are under fault, while leaving as much of the network as possible in operation. Typical protection schemes consist of the following components:

1. Voltage and Current Transformers: step down current and voltage levels
2. Protective Relays: Sense a fault and can initiate a trip
3. Circuit Breakers: Open or close the system based on relay commands
4. Batteries: Provide back up power
5. Communication Channels: Allow for remote tripping

A protective device coordination study provides an evaluation of all of these protective devices and their relation to one another. A protective study is required to be performed every 5 years by the NEC (National Electric Code articles 110-9, 110-10, 240, and 517.17) in order to ensure reliable power distribution to utility customers. The study compares the operating levels and times of the protective devices to withstand levels and times that the equipment can sustain without damage or failure. Its goals are to provide power transformers, switchgear, substations, motor control centers, panel boards, and other electrical equipment with the required protection while selecting appropriate types,

ampere ratings, and device settings to ensure minimum service interruption during overload and short-circuit conditions.

In the event that a fault does occur, coordination studies ensure that the protective device closest to the overload or short-circuit condition is the one to operate. This isolates the failure as quickly as possible. If the circuit breaker or other protective devices are set too low, then the protective devices may trip unnecessarily causing critical loads to be dropped. Conversely, if the protective devices are improperly set too high then the protective device closest to the failure may not trip causing another protective device further upstream to trip resulting in an outage to a much larger part of your distribution system and possibly cause a complete blackout at your facility.

We are acting as a mock consulting firm as if Cal Poly asked us to perform a short circuit and coordination study on the new Baker Science Building. The report that would be submit to the school starts on the Appendix (pg. 37) while the rest of the report, preceding the appendix, consists of the work we did in order to lead us to the official consulting firm deliverable.

***Disclaimer**

The information in this report is intended for educational purposes. It does not constitute for professional engineering conclusions, nor is it a substitute for engineering conclusions. Please consult with a licensed engineer for information on short circuit and coordination studies of this system. Alexander Gomez, Kaylynn Rothleder, and Cal Poly State University personnel will not be held responsible for misinterpretation of this educational report.

2.0 BACKGROUND

2.1 Needs Addressed

A crucial element of a well-designed and functional power system is protection. Whether it is large-scale transmission lines, or the electrical distribution system of a house, the system needs to be able to remain stable in the event of faults on the system. The Cal Poly distribution system is no exception. Because the Cal Poly campus serves as an academic and residential facility to over 20,000 students and faculty it is vital that the campus facilities are electrically sound. The occurrence of a blackout could be detrimental to the student body and faculties' work and everyday life.

This presents the need for a reliable and up to date protection system on Cal Poly's electrical distribution system. While regulatory standards are maintained by PG&E, a full fledge evaluation of the system would provide campus electricians with up to date and more detailed information they need to recognize any updates or modifications to the system that need to be made. This project aims to perform a protective coordination study on the Cal Poly distribution system of the Baker Science Building in order to maintain its reliability. The study will focus on two main tests, a short circuit test and a coordination study.

2.2 Market Research

The power utility industry is a multi-million dollar industry. Every utility company has some department that is responsible for ensuring that they are distributing power to their customers in a reliable and safe manner. It can be then be justified that power system protection is not only a large, but also a critical part of the utility market.

Throughout California, there are a large amount of companies that provide protective coordination studies. The following table provides an overview of some of these companies (ranging from large firms to small consulting companies) and their services.

Table 1: Industry Competitors in Protective Coordination Studies

Industry Competitors	Services
	Powernet has over 20 years of experience in assisting clients with electrical testing, maintenance field services, uninterruptible power supply services, and electrical engineering experience. Their services include the following: • Short-circuit & coordination studies • Load flow analysis • Transient studies • Load monitoring
	KTI assists its customers by performing short circuit and coordination studies and Single Line drawings of their Electrical Power Systems, including their normal power & emergency power supply systems, switchgear controls, protection metering, relaying, and motor control systems.
	BERG Power Engineers, Inc. provides a wide range of electrical, architectural, and automation - instrumentation and control services in the following categories: • Electrical Power System Analysis and Studies - Short Circuit Analysis - Coordination Study - Arc-Flash Study - Load Flow Study - Grounding Study - Motor Impact Study - System Stability Study
	Siemens is committed to maintaining and improving electrical system productivity and efficiency. They offer a complete portfolio of services for electrical distribution equipment - from start up and commissioning to maintenance. They perform consulting, analytical study and specialized field service. Services include arc flash studies, short circuit and protective device coordination studies and much more.

Many businesses, schools, and other large facilities rely on their utility company and electricians to maintain and ensure reliability of their electrical system. In some cases these entities hire out consulting firms to perform the protection services for them. However, at the distribution level, potential problems with the system can slip through the cracks due to insufficient and out of date maintenance checkups. Problems can include errors in the data, lack of communication between electricians of the facility and the consultant, and inability to have direct access to facilities. In addition, hiring a contractor can be costly. Prices for a coordination study range within the thousands of dollars depending upon the size of the facility being evaluated.

Our protection coordination system can offer the Cal Poly campus a cheep and efficient protection study that can be used for years to come. Our familiarity with the campus and on campus resources will allow us to perform a detailed study that accurately captures the functionality and safety of the school's electrical system. Furthermore, because we will be performing a walk around of the Cal Poly distribution system with the school's lead electrician, we will receive first hand and up to date accurate data. The table below provides a list of key partners we will be working with throughout the completion of our project.

Table 2: Key Partners	
Partner	**Role**
Professor Nafisi	Senior projects advisor
Professor Ahlgren	Advisor and provider of SKM license
Ben Johnson	Lead electrician
Johnny Ma	SKM Systems Analyst, SKM software advisor

Table 3: Protective Device Coordination Study Requirements and Specifications		
Marketing Requirements	Engineering Specifications	Justification
1,5	Provide clear printouts of the settings for all adjustable devices such as, ground fault equipment, relays, etc.	Data needs to be provided in order to ensure that the Cal Poly system is being maintained and that devices are functioning consistently
2,4	Use the SKM software, which is student accessible, available on campus, and free of use	To keep costs down, software equipment should be chosen to perform the necessary analysis tasks while having little cost this provides maximum protection at minimum cost
1,3,6	Provide a new computer generated single-line diagram of the Cal Poly distribution system modeling devices, system connections, and short circuit levels	This will provide electricians with a clear and updated model of the system
1,3,5	Results include time-current curves of the protective devices illustrating the resulting protection and their coordination	This ensures that devices function consistently and avoid unwarranted false trips
1,4	Perform a walk through	This will provide us with

Marketing Requirements
1. Provide accurate and reliable data from protective coordination study for the Cal Poly campus
2. Keep equipment costs below $100
3. User friendly results
4. Perform all measurements and analysis safely including:
    - Protective relay settings
    - Bus voltages, currents, and load
    - Protective device ratings
5. Identify and recommend corrective action for under-protected equipment
6. Simplicity

3.0 REQUIREMENTS AND SPECIFICATIONS

3.1 Block Diagram

The high-level black box diagram seen in Figure A shows the main item we need to catalyze our project which are the single line diagrams of the Cal Poly Electrical Distribution System.

Figure A: High Level Black Box Diagram

The lower-level black box diagram seen in Figure B show the many specifications and settings we need to obtain from the single lines as well as spot checks to generate a single line in SKM.

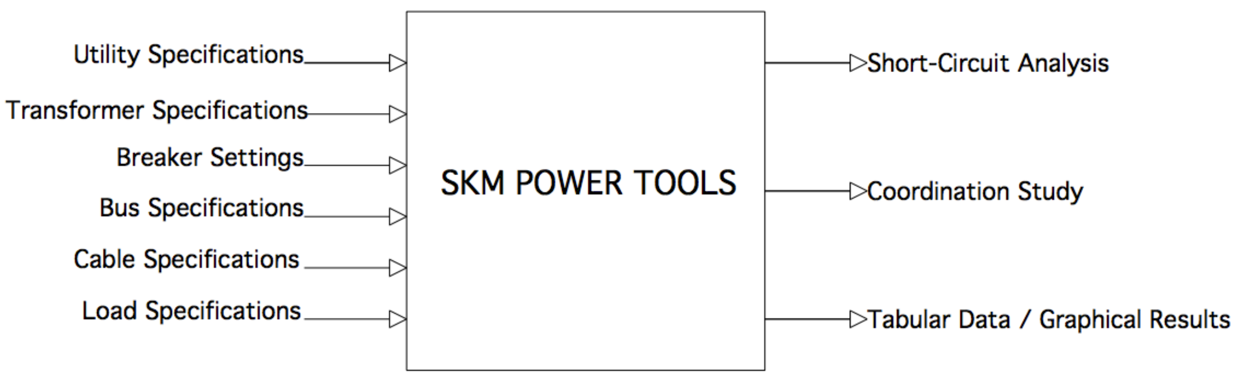

Figure B: Low-Level Black Box Diagram

Tables 4 - 8 below lays out a more in depth list of the ratings for each component we would need to produce the most accurate analyses.

The first step in analyzing a power system is to get the data for the available power at the utility. This information could be easily obtained from the local power company, or the document might be onsite with an Electrical Engineer.

Table 4: Utility Specifications	
KVA	Rated Voltage that the Utility is supply into the System(L-L)
3 Phase MVA	Power available at a bolted 3 phase fault. When a fault occurs with all 3 phases connected with no impedance
Line to Ground MVA	The apparent power from the phase to the neutral
X/R Ratio	Ratio of Reactance to resistance in the supply

Transformers are specified by the data listed below. This data could be gathered from the one-line diagrams. Usually on the one-line diagrams they are complimented with the kVA rating, turns ratio, and type of connection.

Table 5: Transformer Specifications		
Nominal kVA		The system voltage at the distribution point
Full Load kVA		The maximum apparent power the transformer could run at full load
X/R Ratio		Ratio of reactance and resistance
Type		3 phase or single phase
Primary	**Secondary**	
Connection	Connection	Delta of Wye Configuration
Rated Voltage	Rated Voltage	The voltage the transformer is supplied or supplies
Full Load Amps	Full Load Amps	The maximum amperage the transformer could take at full load
Tap %	Tap %	A connection point along the transformer that allows certain number of turn to be selected to vary the voltage

Impedances and cable data are crucial when dealing with line losses and fault currents. The numbers needed are the resistance, reactance and the length of cables. Luckily the software we are using calculated the resistance and reactance using the conductor type and length.

Table 6: Cable Specifications	
Conductor Type	The type of metal used to send the electrical current throughout the distribution system
Insulation	The type of insulation the cable is covered in
Cable Size	The size of the wire in American Wire Gage
Voltage	The voltage the cable is carrying
Length	How long the cable runs from termination points

Protective device settings will be more difficult to gather, because most the information given on the dingle line is the rated amperage and the trip amperage, leaving the type or breaker and settings to be ambiguous. It will be necessary to have a walkthrough with an Electrician to gather documentation to be able to model the protective devices properly.

Table 7: Breaker Settings	
Sensor Trip	Breakers tripping current
Long Time Pick-Up	The current level at which the circuit breaker long time delay function begins timing
Long Time Delay	The length of time the circuit breaker will carry a sustained overcurrent before tripping
Short Time Pick Up	The current level at which the circuit breaker short time delay function begins timing
Short Time Delay	The length of time the circuit breaker will carry a sustained overcurrent before tripping
Instantaneous Trip	No delay introduced in the tripping action of the circuit breaker

Loads are the main source of short-circuit current. When a short occurs they act as a supplier to the short supplying a current more than at least double the rated current. Settings can be acquired from documentation supplied from an electrician with readings of HP, efficiency, and power factor.

Table 8: Load Specifications (Motor)	
Count	How many motors coming off of the same bus
kV	Motor rated voltage
Rated Size	Motor horse power
Power Factor	Motor operating power factor
Starting PF	Motor power factor at the transient starting point
Efficiency	Motor operating efficiency
Full Load Amps	Motor current at full load
Connection	Motor connection configuration (Delta or Wye)

If some information is not found, calculated estimations can be made in order to run the simulation.

3.2 Software Definition

We have not done any work on this software yet, but from what we have seen in tutorials this software is very simple to grab a hold of. Most of the components needed are shown in the toolbar such as transformers, cables, buses, and loads. They once a component is selected it can be placed on the workspace area. As shown below in Figure C many components can be connected together to reflect an electrical system.

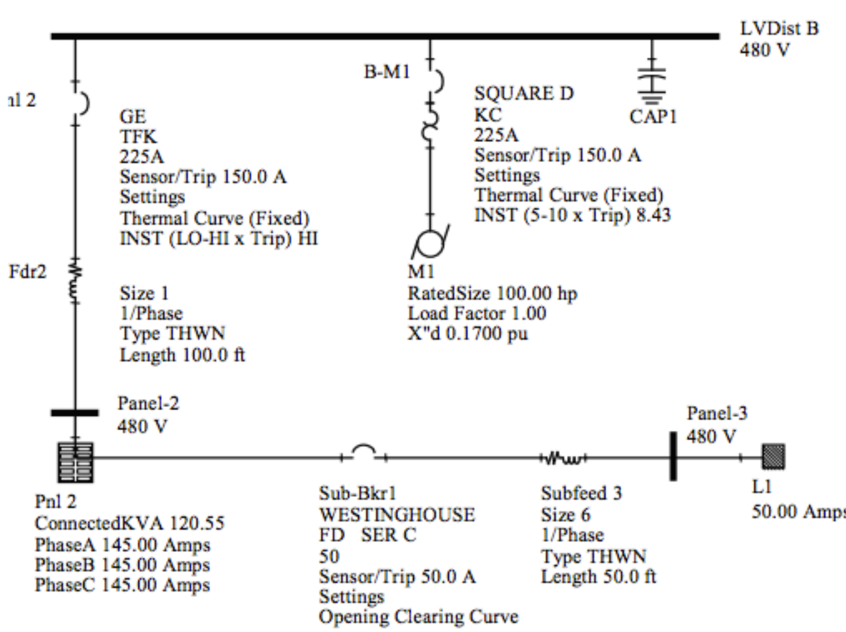

Figure C: Electrical System in SKM

After the whole single line is constructed in the workspace, single components can be selected and a "Component Editor" window will pop up shown in Figure D. Here is where all the specifications would be input to mirror the actual module.

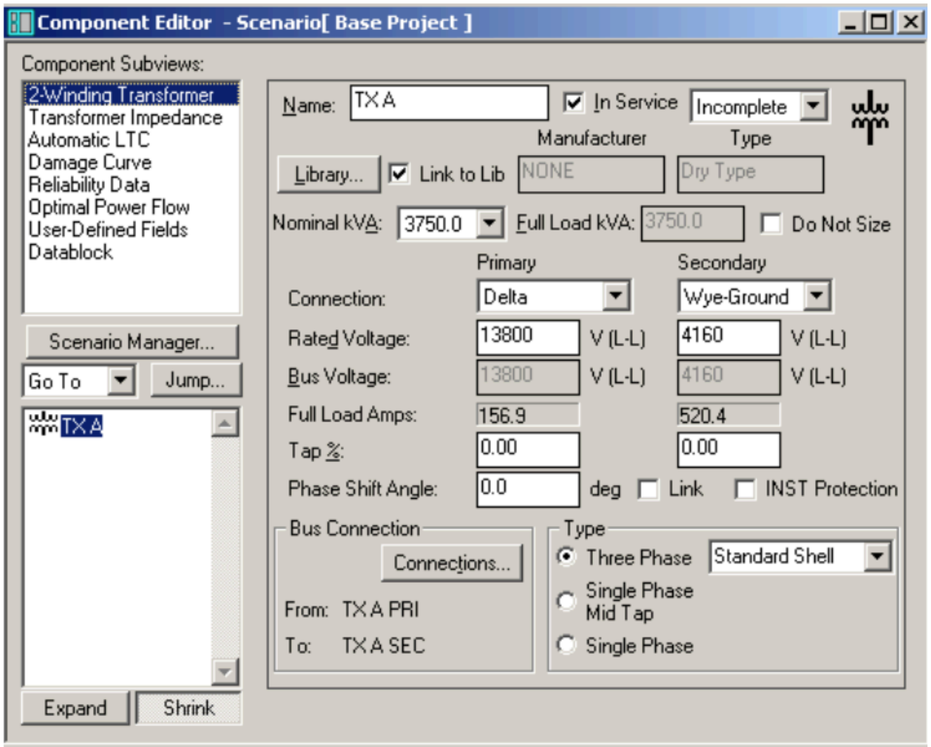

Figure D: Transformer Component Editor

When complete with inputting information, we would like to extract many tables of calculated data that the software will perform. Another executable we would like to obtain are the Time-Current Curves (TCC's), shown in Figure E below, which will show how fast a breaker will trip at any magnitude of current.

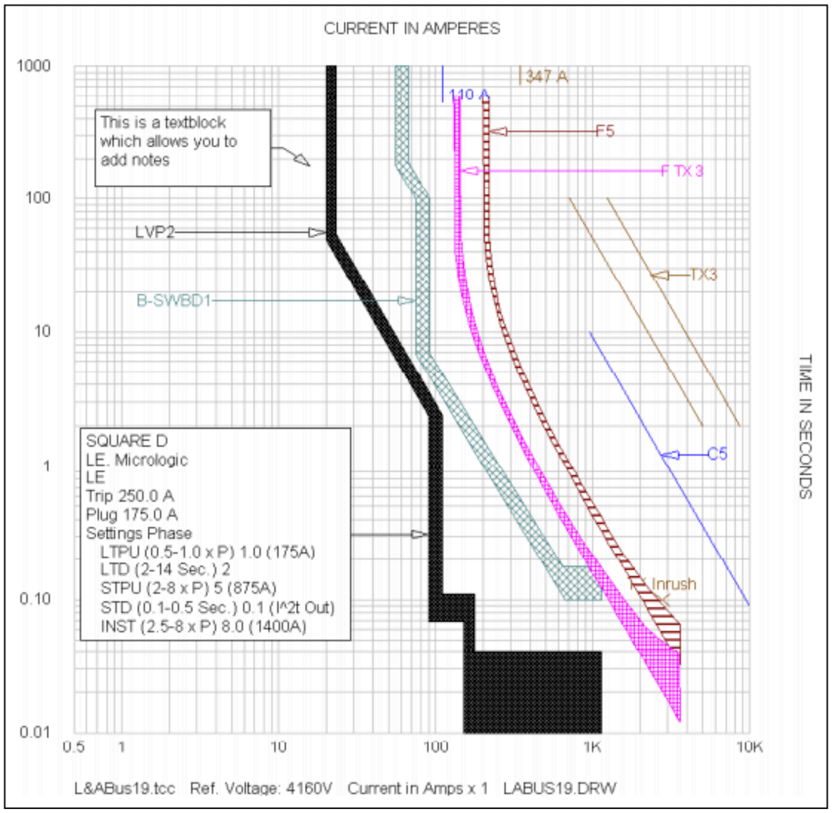

Figure E: TCC Example for a Bus

3.2 Testing and Verification

The whole software portion of this project is to verify the settings of the protective devices in the current system. If lucky, we will not find any glitches in the system knowing that that the system is fully protected to the best of its ability. Short-circuit test will confirm that any and all components are rated to withstand and interrupt any the current. These can be calculated by hand to verify that the software is performing calculations correctly. On the other hand the protective device coordination study will ensure that the closes breaker to the overload will operate properly to isolate the failure as quickly as possible. This can be verified by the actual settings that the breakers are currently set to.

4.0 SCHEDULE

4.1 Milestones

Table 9 below lays out the main deliverables we set for ourselves to complete this project in a timely manor. We also go into go more in depth in Table 10 and show the distribution of work within our group. For more detail of smaller milestones Figures F - H give a good representation of time spend throughout the execution of the final product.

Table 9: Milestones	
Milestone Date	**Milestone Description**
October 27th	1st Draft of Senior Project Write-Up
December 5th	2nd Draft of Senior Project Write-Up
February 12th	Complete Single Line in SKM with all input data
February 19-20th	Design Review
March 13th	Complete Short Circuit, Coordination Study, and 3rd Draft of Report
April 25th	Complete Final Draft of Senior Project Report
May 29th	College of Engineering Project Expo

Table 10: Partner Breakdown	
Alex	**Kaylynn**
Collect Data	Contact Electrician
Research SKM Software	Take Pictures of all Equipment
Build Single Line in SKM	Check the Validity of Build Single Lines
Create TCC’s	Run Simulations after Single Lines Built
Obtain Hardware for Expo	Revise our Final Report
Practice Expo Presentations	Practice Expo Presentations

Electrical Distribution System (Fall)

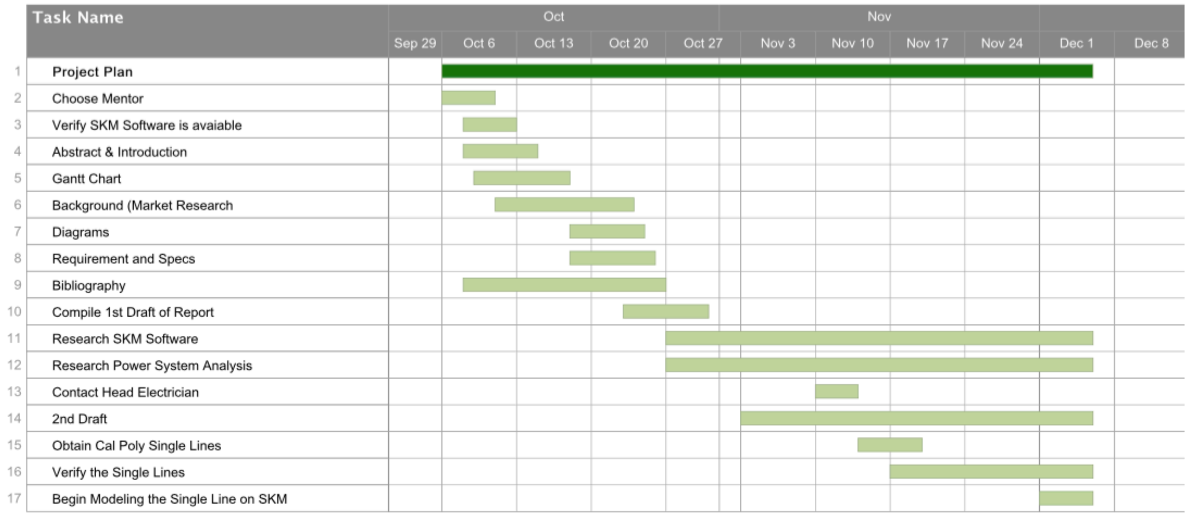

Figure F: Fall 2014 Gantt Chart

Electrical Distribution System (Winter)

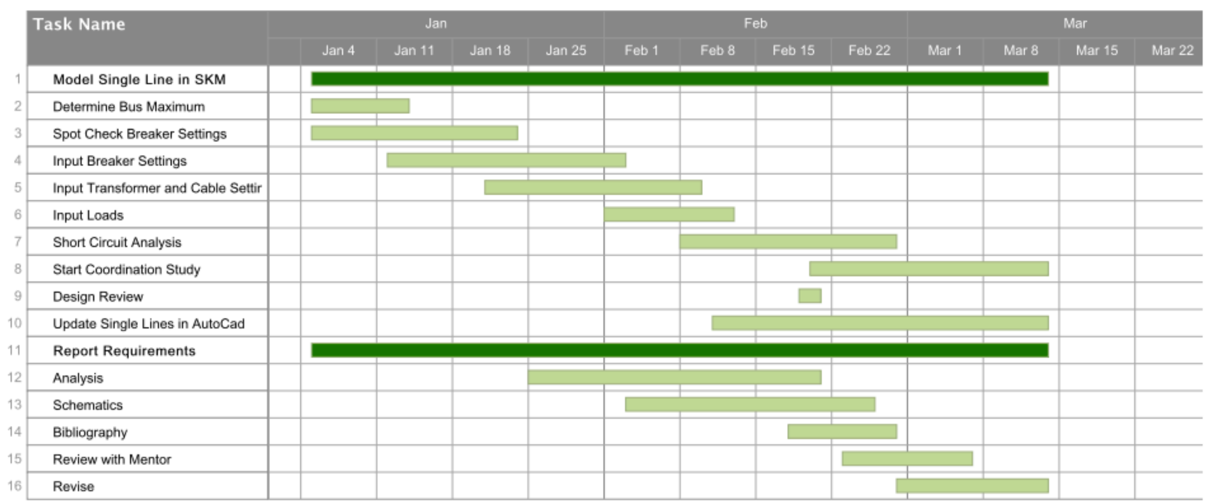

Figure G: Winter 2015 Gantt Chart

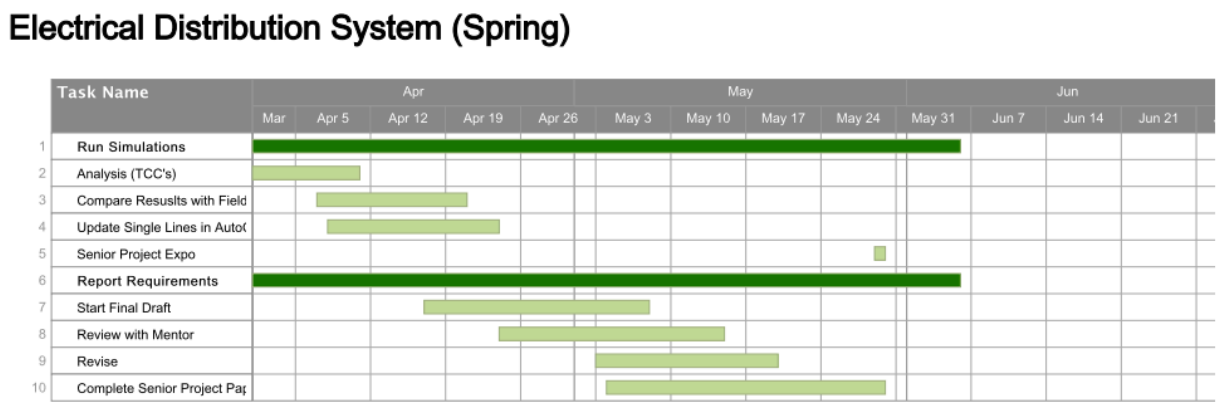

Figure H: Spring 2015 Gantt Chart

4.2 High Risk

Since this project includes significant software definition, we have to spend a lot of time to become familiar with the given software (SKM). We have however used similar forms of power systems software's, and there are a lot of similarities to them, given that the same studies will be ran. We expect to put a lot of time during winter break to brush up on SKM we could start to build the single line In late January.

We would like to be able to tackle a bit more than utilizing the SKM software to output short circuit and coordination studies. We would like to be able to update the existing single line diagrams in AutoCad. This assignment is not a priority in the case we don't get to complete the main analysis portion. Depending on how updated the current single lines of the distribution system here at Cal Poly are getting a hands on experience of AutoCad would be a great asset for us when we go into industry. Since there aren't any classes at Cal Poly that require Electrical Engineers to take, this will be a steep learning curve with the amount already on our plate.

When having to rely on other people to assist you in your project, it is smart to leave yourself plenty of time to account for their schedule. In our projects case, we have to rely on the Electrician here at Poly in order to give us a full walk through which is time consuming as it is. So we plan on getting a hold of him before winter break in order to give

him at least 2 weeks to schedule is in. This would be a great detriment if he weren't able to assist us in a timely manner.

Another wall we might run into is the bus limit on the SKM software license. Usually the limit on the license is 200 buses, therefore we might not be able to match the distribution system at its full capacity. We will be able to work around this by cutting out lower voltage panels and transformers lower than 75kVA.

4.3 Cost Estimation

Since most of the work we completed was software based, the project costs only included the labor of two entry-level Electrical Engineers with the use of no hardware. In order to get a perspective on how pricey the commercial power tools software license's can be, we will also include this quantity in our breakdown and total cost.

According to a few employers that would have their entry level/Junior Engineers perform this study such as PG&E, Southern California Edison, SDG&E, and SFPUC the staring salary is roughly $65,000. This would boil down to about $32.50 hourly. Calculating a ballpark value for the labor giving a confident timeframe of 300 hours and a poor evaluation at 375 hours we ended up with $12,187.50.

$$Cost\ Estimate\ (labor) = \frac{\left(\$\ 32.50 / _{hour}\ x\ 275\ hours\right) + \left(\$\ 32.50 / _{hour}\ x\ 375\ hours\right)}{2}$$

$$Cost\ Estimate\ (labor) = \frac{\$8{,}937.50 + \$12{,}187.5.50}{2}$$

$$\boldsymbol{Cost\ Estimate\ (labor) = \$10{,}562.50}$$

It is also custom in industry to consider the cost of the Supervisor's time, in our case our Mentor, Dr. Nafisi, played the role of our supervisor. His time is taken to view progress and aid your development. We will take the salary of an Assistant Engineer with an average salary of $75,000.00 ($37.50/hour). On average we will say that our supervisor had bi-weekly meetings that's lasted an hour long. The project lasted 30 weeks, which leaves us at a total of **$1,125.00** in supervisor costs. The SKM software would cost at least $15,000 with all the capabilities we need to have.

Table 11: Cost Estimation Breakdown	
Title	**Amount**
Assistant Engineer (Professor Nafisi)	$1,125.00
Junior Engineer (Kaylynn)	$5,281.25
Junior Engineer (Alex)	$5,281.25
Software (SKM Power Tools)	$15,000.00
Total	**$26,687.50**

4.4 Resources

The bulk of this project will require us to accurately model the Cal Poly Distribution System on Power Tools for Windows (SKM). There isn't any hardware involved in this project other than the Single line Diagrams we referred to when modeling the system in SKM, but if we were going to tally the materials used to convey the electrical system in SKM refer to Table 12 below.

Table 12: Material Breakdown	
Equipment	**Amount**
Utility	1
Buses	150
Transformers	6
Cables	70
Breakers	145

In order for this project to be successful there will be a lot of research to do on distribution systems, and how they respond to short circuits and well as protective device settings. We will both be using software that is somewhat familiar to us, but stretching comfort levels we haven't reaches before in the analysis. We will also need to be ready to read the single lines that we will be receiving form the Electrician at Cal Poly. In all we do not believe these skills are to out of reach and will be able to succeed in our final task while learning a new power systems software.

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5.0 DESIGN AND COSTRUCTION

Prior to mapping out the schematic in SKM, initial research and data collection needed to be obtained from the Baker Science facilities. The head electrician at Cal Poly, Ben Johnson, supplies the As-Built Drawings of the Baker Science building in order to take any information off of them to assist in building the schematic in the software. The equipment lists also aided us in the search of as many component settings to input. Although much of this information was useful in building the physical schematic in SKM, few amounts of input data and information was found on these drawings. The only elements that were useful were cable sizes, bus voltages, transformer ratings and some breaker sizes.

Once all the information was extruded form the drawings, we consulted Ben and asked for a full walk through of the Baker Science electrical system. This walk proved to be extremely helpful since we were able to now connect what he have analyzed on the drawings to physical components in the field, verify values, as well as being able to document each Switchboard, Breaker, Transformer, and Panel. The walkthrough had to be highly organized and methodical as we took pictures involving the system as a whole and all the ratings shown below in Figure I and J.

Figure I: Transformer 6L-E

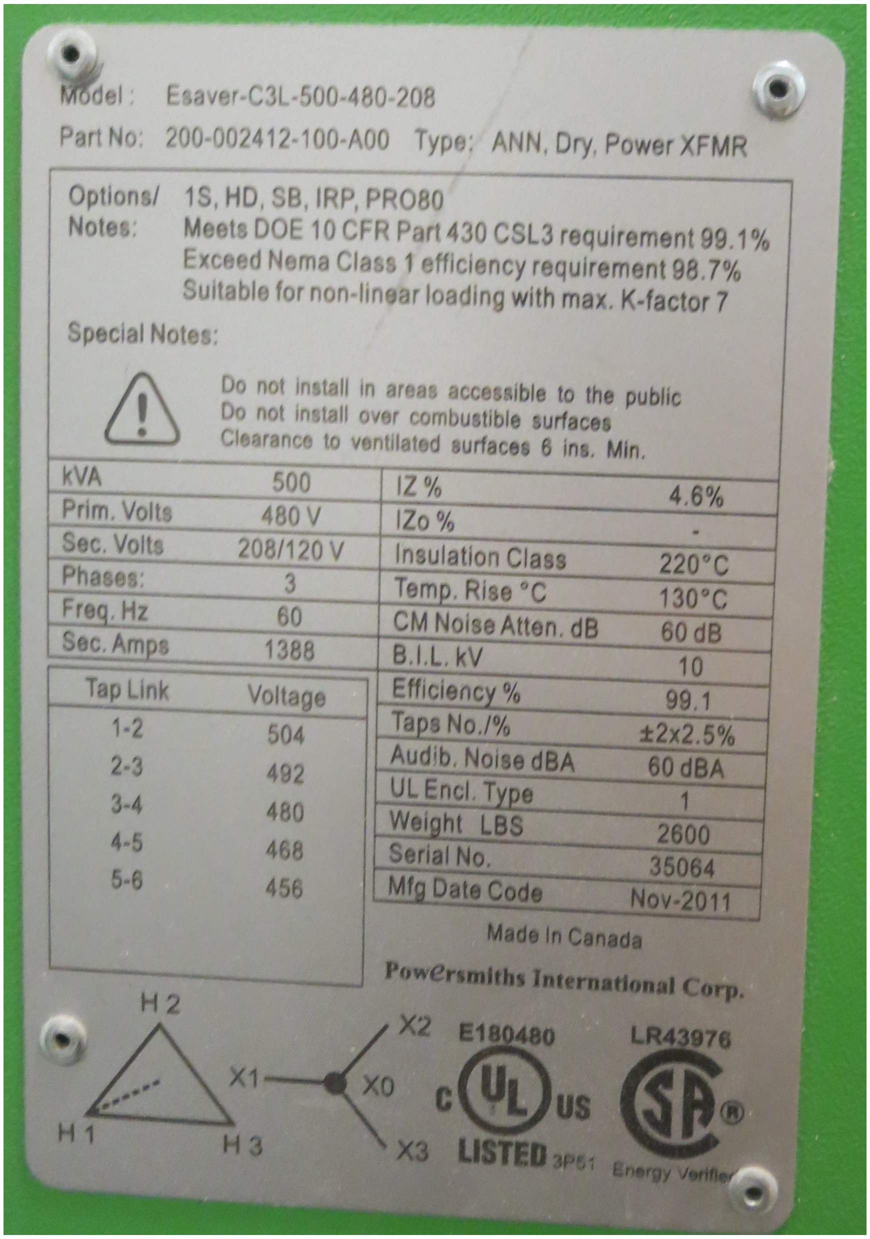

Figure J: Rating Plate of Transformer 6L-E

When performing a coordination study the breaker types, ratings and sizes have to be exactly what is shown on the field and knowing the frame rating was insufficient for this study. In the field visit we made sure to look at every breaker in the system relevant to the study. Like the transformer above, circuit breaker pictures were also taken shown in Figure K and L.

Figure K: Switchboard 3L-E

Figure L: Circuit Breaker 3LP4-W

After the successful field visit all of the data was now transferred into the software, which took a bulk of the project hours. Learning to sift through the library of the many breakers and transformers selecting the right ones. The example we have below in Figure N refers back to the breaker shown in Figure L. The breaker in the library titled "QG", selected in Figure M, matches with the one on the field.

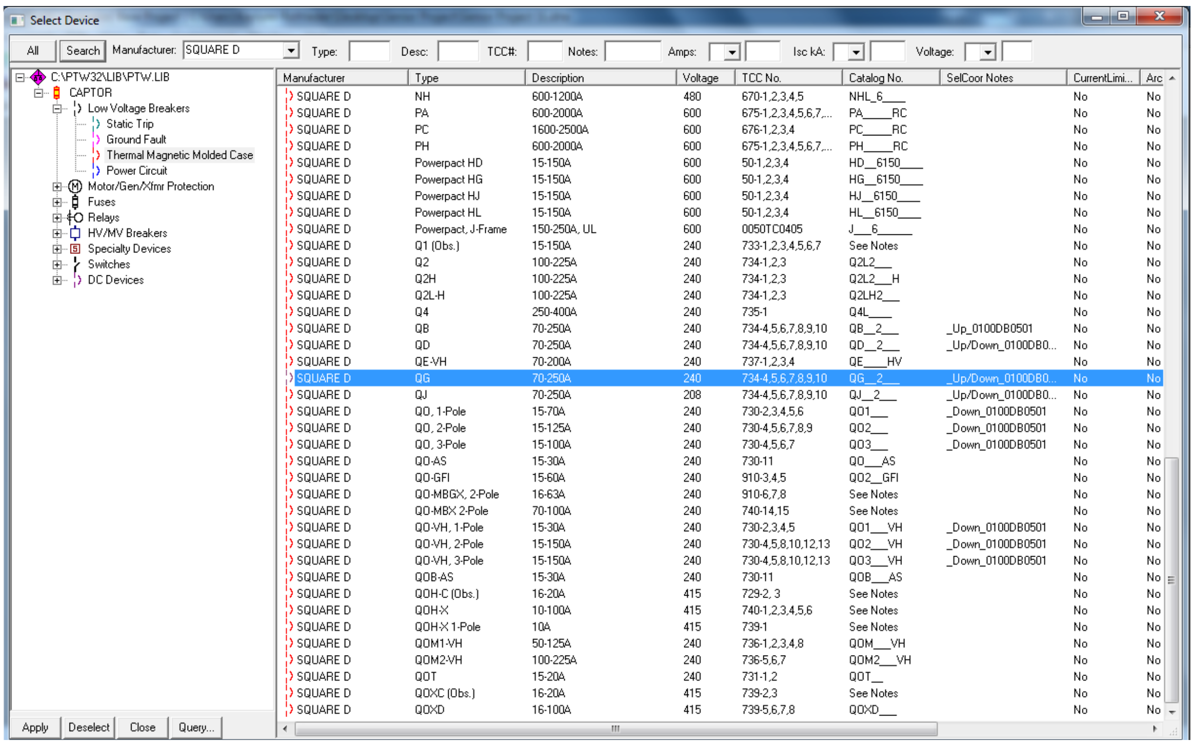

Figure M: Circuit Breaker Library

Once the right breaker is picked we have to go into component settings to choose the right voltage rating as well as the current frame and trip ratings. Figure N is a screenshot of the inputs needed to match the breaker in Figure L.

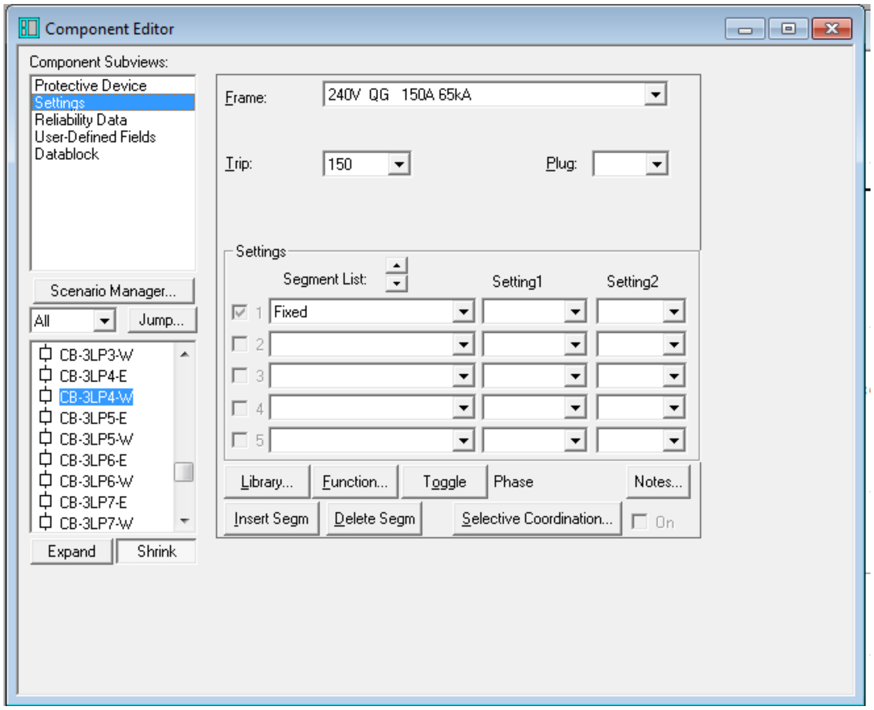

Figure N: Circuit Breaker Component Editor

Some however were not found in the library and after calling the SKM hotline; they instructed us to pick a similar breaker with similar settings in order to complete the one line in a timelier manner than implementing a new library. After all the input data was complete, we were able to run an Arc Flash analysis to be able to find what category PPE equipment an electrician needs to wear when each component is charged. We would never advise for an electrician to ever work on charged equipment only in emergency situations. The coordination study was more involved by having to select the different breakers on the load side of the bus and see if the breakers are opening in the correct order. Once the TCC's were created with their complimentary one-line we had to go through them analyzing if the breakers were well coordinated. For the most part every bus was well coordinated with the breakers on the load and line sides. With the few mistakes we found, we were able to go back to the breaker and find that we had input the wrong values in the software. After all the bugs were taken care of we were able to output all the curves and results to be submit.

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6.0 ANALYSIS

6.1 Summary of Functional Requirements

The short circuit and coordination study provides a well-documented report of the electrical system. What the report entails are One-line diagrams showing the protective device amp rating and associated designations, cable size/length, transformer kVA, motors, generators and switchgears/switchboards/panel boards. There will also be tabular data of the worst-case calculated short circuit duties shown as a percentage of the rated amps. Protective Device time versus current coordination curves will be generated as well as the corresponding adjustable circuit breaker trip settings.

6.2 Primary Constraints

The constraint that we are most concerned with is the actual licensing limitations. Although it is more than sufficient enough to perform studies on a full-scale system of this school, our license will only let us represent 200 of those buses. We will have to take time to actually map out how many we would need using the single-lines, and decide if it is feasible to try the whole school, or only a section of the system.

The software itself is also of concern, trying to learn how to utilize it at its full capacity while trying to learn the process of these studies.

6.3 Economic

There isn't any hardware in use for this project other than the paper repot executable. I am still in the process of getting in contact with someone that knows how much the license costs to use this software in a commercially owned business rather than a school entity.

6.4 Commercially Manufactured

Our product is not a piece of hardware that could be manufactured and sold. Each electrical system is unique in its own way, so although the steps in creating the report are similar, the product cannot be commercially manufactured.

6.5 Environmental

There are currently no known environmental concerns associated with the design or studies of an electrical distribution system. With the studies being done, we are indirectly trying to save the environment from electrical arc flashed, explosions, and large scale power outages.

6.6 Manufacturable

The only physical component to our project would be a written report that would show the data collected, and the studies done on the distribution system. If we would like to make the report more professional, we could add vellum printed single lines for better visual aid to the reader. Per each Electrical Distribution system, only about 4-5 copies would need to be made.

6.7 Sustainability

According to the NEC this study must be done every 5 years. This is solely to maintain the system, and make sure there haven't been any changes in load flow or any undocumented electrical work on the system.

6.8 Ethical

There are currently no known ethical concerns associated with the design or studies of an electrical distribution system.

6.9 Health and Safety

According to National Fire Protection Agency Chapter 70E Article 130.5©(15)(a&b) they emphasize the protection when work involves electrical hazards. The main reason for performing our study is to protect not only the electrical distribution system and all the components downstream of a short circuit, but to protect the electricians that must to work on/upkeep the system. With these tests they will verify or change the settings that are currently on breakers. This will also reduce the unplanned downtime in any kind of outages that can occur.

6.10 Social and Political

There are currently no known social and political concerns associated with the design or studies of an electrical distribution system.

6.11 Development

The work we have put in can be used as a head start for future work conducted on the Electrical Distribution here at Cal Poly. Since all of the data and design will already be complete and simulated, someone could build off of the design to integrate alternative energy sources, electrical additions, and other theoretical modifications. Additionally, the software can be used as a teaching tool in power system courses. Students can perform hand calculations on particular segments of the power system and then use the software to verify their results. Now that the basic structure of the Cal Poly Power System is within a manageable software program, the possibilities for future work are vast.

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7.0 CONCLUSION

In this project, we were able to expand our knowledge on distribution systems for a whole building ranging from analyzing the one line diagrams, going out into the field to verify documentation, and finally designing the schematic on a power tools software. Most of the time was spend designing the actual schematic to have it be as accurate and complete as possible. This requires not only knowledge of reading drawings, but research on how to use this new software. Although some information had to be assumed for the short circuit study many of our results came out to be similar to the study that has been preformed already. With the coordination of the system, we were able to locate all breakers in the field making the study for coordination successful. After analyzing all the TCC's we were able to see how the system is well coordinated with the lower stream breakers opening prior to the ones upstream. This project served us well for future applications in the real word. In the power industry it will be essential to be able to read drawings, go on field verifications, and use software to map out systems.

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8.0 FUTURE WORK

The work that we performed can be built upon in the future by completing the input data for all components without assuming anything. This will ensure that the short circuit test will be more accurate and therefore directing electricians toward the right PPE when working on charged equipment. Also being able to run the arc flash evaluation with different scenarios. The only scenario we ran was normal load, but there can also be an emergency scenario where the generator is activated under a unique situation. With this schematic already build other buildings could be added onto the schematic to see how the system differs. By building off of this system, students can determine ways on adding equipment and other alternative energy sources to become more energy efficient.

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WORK CITED

[1] "Arc Flash Analysis | Aim Electrical Consultants." *Aim Electrical Consultants*. N.p., n.d. Web. 24 Oct. 2014.

This Article gave us may examples of codes from the National Electric Code that deal with power systems.

[2] Carney, William J. "Shareholder Coordination Costs, Shark Repellents, and Takeout Mergers: The Case against Fiduciary Duties." *American Bar Foundation Research Journal* 8.2 (1983): 341-92. Web.

This article listed the many specifications we needed to enter into the software.

[3] E. O. Schweitzer, B. Fleming, T. J. Lee, and P. M. Anderson, "Reliability Analysis of Transmission Protection Using Fault Tree Methods," 51st Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, April 1998.

This article steps through the methods of power system protection.

[4] "Identifying Pitfalls in the Arc Flash Calculation Process." *Arc Flash Calculation Errors*. N.p.,n.d. Web. 24 Oct. 2014.

This article listed a number of ways to make educated estimations on specifications to put into the software when some variables aren't given.

[5] "Introduction to Practical Power System." http://www.ece.uidaho.edu /ee/classes/ECE526S05/text/Ch1.PDF, Web

This source provided an overview of power system protection.

[6] Short-Circuit Current Calculations for Industrial and Commercial Power Systems. Place of Publication Not Identified: Systems Engineering, Apparatus Distribution Sales Division, General Electric, 1982. Web.

This source will help up later on when we verify short circuit currents with all the equations we will need to calculate by hand.

[7] Xingbin Yu; Singh, C. "Integrated power system vulnerability analysis considering protection failures", *Power Engineering Society General Meeting, 2003, IEEE,* Volume: 2, 13-17 July 2003

This article described power system reliability evaluation including protection system failures.

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APPENDIX

Coordination and Short Circuit Analysis

Revision Log

0. Senior Project First Draft
1. Senior Project Second Draft
2. ____________________
3. ____________________

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Owner: California Polytechnic State University

Project Site: Baker Science

Title: Coordination and Short Circuit Analysis

Revision: Rev 1

Prepared By:

Alexander Gomez Kaylynn Rothleder

Date: May 30, 2015

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1.0 Arc Flash Information

NFPA 70E requires maintenance workers to wear Personal Protective Equipment while performing any type of work on electrical equipment in the case of a potential Arc Flash. The Risk/Category of PPE is determined by the type of work being done as well as the voltage and available short circuit current at that specific location. In order to identify the specific arc flash hazard at a given piece of equipment within a facility, an arc flash study must be performed. An arc flash study (sometimes called an arc flash analysis or a hazard analysis) is an on-site study of your facility, conducted by a trained expert qualified to evaluate your electrical system and note areas that could present a risk to your personnel or equipment. An arcing fault is the flow of current through the air between phase conductors, or between phase conductors and neutral ground. An arcing fault can release tremendous amounts of concentrated radiant energy at the point of the arcing in a small fraction of a second, resulting in extremely high temperatures, a tremendous pressure blast, and shrapnel hurling at high velocity.

1.1 Arc Flash Methodology

The Arc Flash Study was performed using a computer-based software program: Power Tools for Windows (PTW) by SKM System Analysis, Arc Flash Evaluation Module. PTW Arc Flash Evaluation calculated the incident energy and arc flash boundary for each location in a power system. Arc Flash saves time by automatically determining trip times from the protective device setting and arcing fault current values. Incident energy and arc flash boundaries are calculated following the NFPA 70E, IEEE 1584 and NESC standards.

1.2 Arc Flash Data

The data generated by the Power Tools for Windows (PTW) Arc Flash Evaluation Studies consists of the following:

- Incident Energy
- Arc Flash Boundaries
- PPE Selection

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2.0 Short Circuit Study Information

Short Circuit Studies are typically conducted on power systems in order to facilitate the selection of protective device interrupt ratings. This is done through the calculation of available short circuit current or fault current at each bus location. A protective device has to interrupt the available fault current at its location in the power system, therefore the protective device must have an interrupting rating equal to or greater than the available short current. Typically, the three phase symmetrical RMS fault current is considered the maximum available fault current and therefore used as the basis for selecting protective device ratings. For the purpose of this project, the reason for performing a Short Circuit Study on the Baker Science Building is to calculate the available three phase symmetrical RMS fault current at each bus location to be used as part of a Protective Device Coordination Study.

2.1 Short Study Circuit Study Methodology

The Short Circuit Study was performed using a computer-based software program: Power Tools for Windows (PTW) by SKM System Analysis, DAPPER Comprehensive Fault Analysis Module. The systematic Short Circuit Study methodology begins by developing a system one-line drawing (within the software program) that defines the electrical characteristics of the power system. Each of the power system components (utility sources, induction motors, transformers, cables, protective devices, etc.) is modeled accordingly. When the study is run the software program places an assumed three-phase fault at each bus location in the system and the available short circuit (fault) current is calculated for each bus location. The results of the computer-generated study are described below (5.0 RESULTS).

2.2 Short Circuit Study Data

The data generated by the Power Tools for Windows (PTW) DAPPER Comprehensive Fault Analysis software program consists of the following:

- One Line Drawing (Reference)
- Input Data Report (Reference)
- Fault Analysis Summary Report - Normal (Reference)

The One Line Drawing shows each of the relevant power system components (utility sources, induction motors, transformers, cables, protective devices, etc.) and their interconnections.

The Input Data Report summarizes the bus-to-bus interconnections and data used in performing the Short Circuit Study. The identification of buses was taken from the project documents. Each bus represents one of the following: a utility contribution point, a service end box, a switchboard a panel board bus, or a motor connection point.

The Fault Analysis Summary Report - Normal provides the three phase symmetrical RMS fault current for each major point (bus) in the power system under “normal” conditions (when the system is being fed by power from the utility).

3.0 Coordination Study Information

The major reason for performing a Protective Device Coordination Study on a power system is to determine if the protective devices in that system provide a system of selective coordination. Coordination is defined as "properly localizing a fault condition to restrict outages to the equipment affected, accomplished by the choice of selective fault-protective devices". A coordination study analyzes the characteristic curves of the fuses and breakers and compares them against one another on log-log plots. Any areas of miscoordination will be apparent by overlapping of curves from the various devices.

3.1 Coordination Study Methodology

The Protective Device Coordination Study was performed using a computer based software program: Power Tools for Windows (PTW) by SKM System Analysis, CAPTOR Protective Device Coordination Module. The systematic Protective Device Coordination Study methodology begins by utilizing the system one-line diagram that defines the electrical characteristics of the power system. Time vs. current coordination drawings that display the time-current curve(s) of one or more of the protective devices to be analyzed are then created. Each of the protective devices is individually modeled based on its specific time-current characteristics and the available three phase symmetrical RMS fault current. The results of the computer-generated study are described below.

3.2 Coordination Study Data

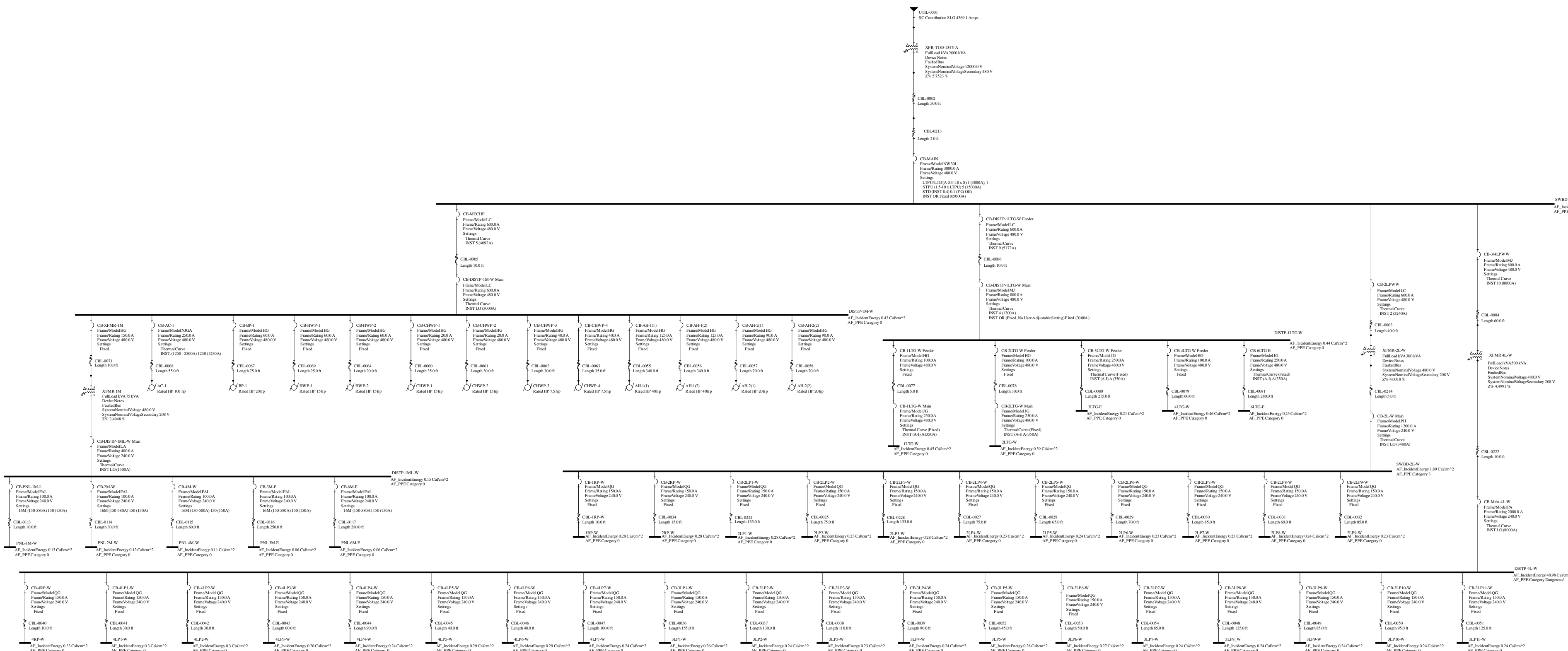
The data generated by the Power Tools for Windows (PTW) CAPTOR Protective Device Coordination Module consists of the following:

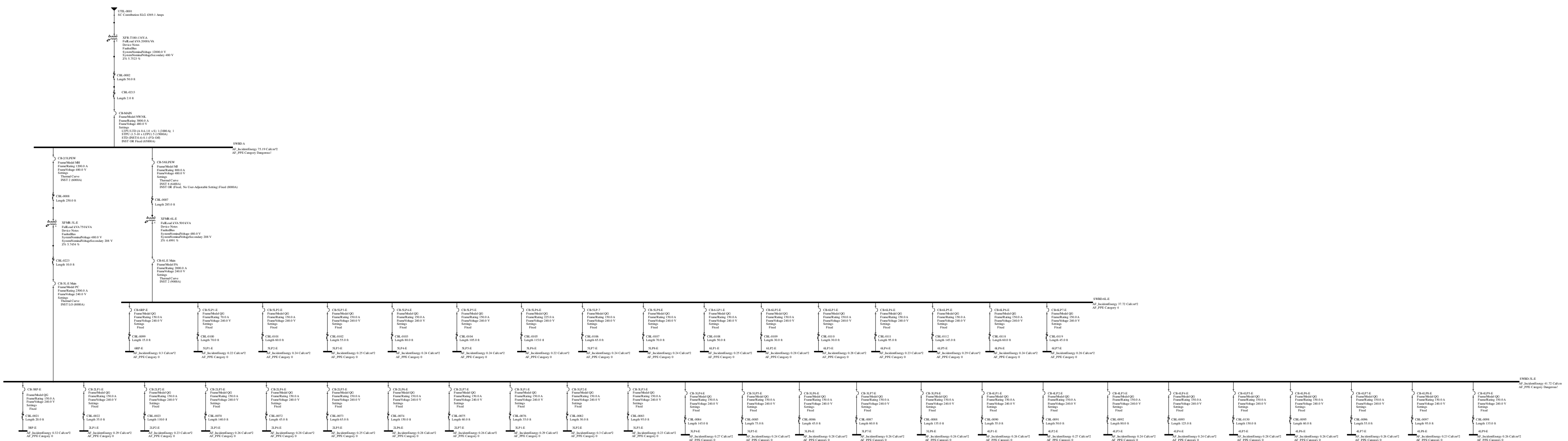
- Time Current Curves - Normal
- Component Setting Reports

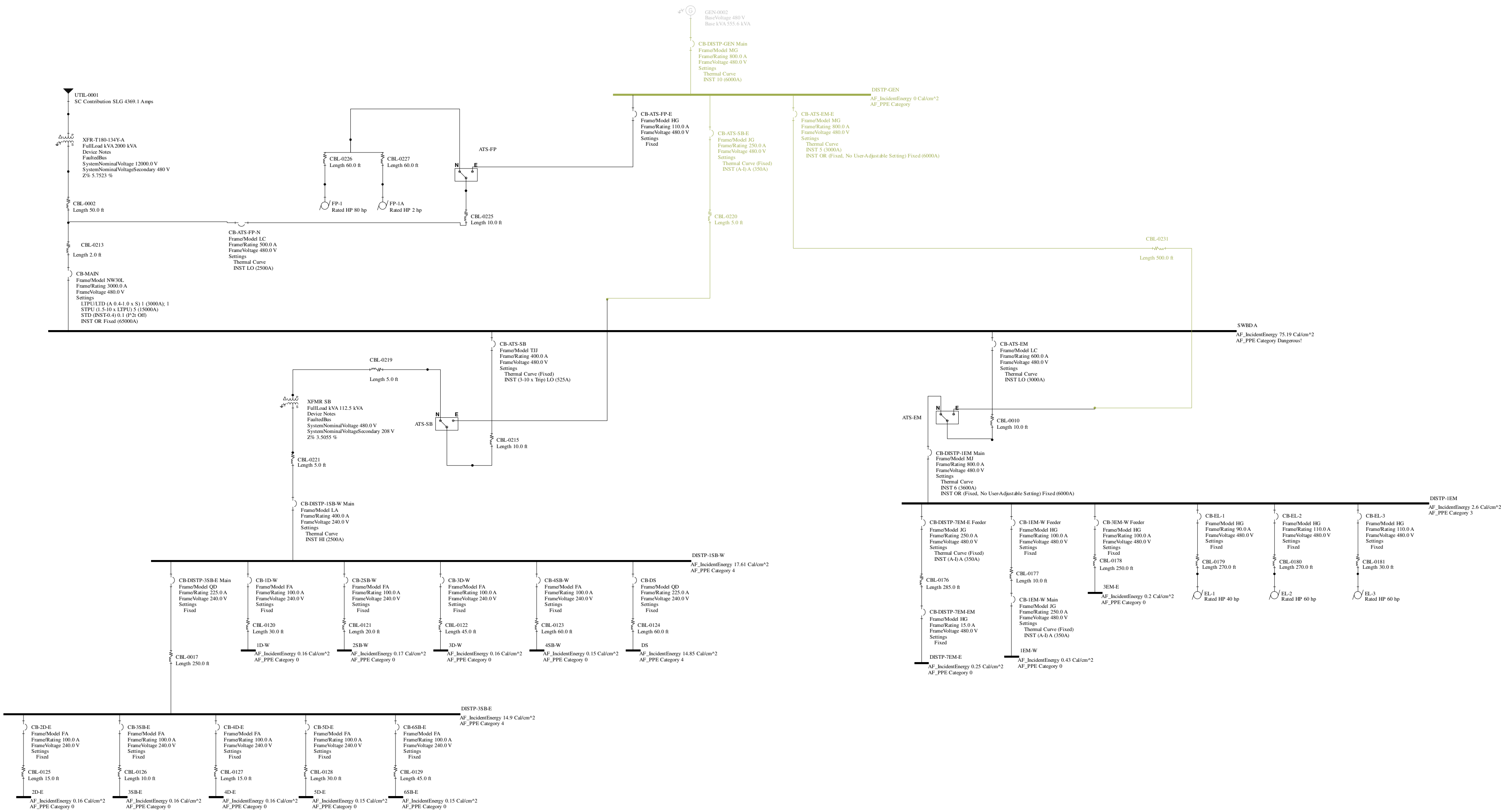
The Time Current Curves - Normal provides protective device coordination data for the power system under "normal" conditions (when the system is being fed by power from the utility).

The software is programmed to plot the curves such that the right-most point plotted for any of the individual device curves is at the calculated three phase symmetrical RMS fault current at the bus that feeds the device.

TAB 1


UTIL-0001
SC Contribution SLG 4369.1 Amps
XFR-T180-134Y-A
FullLoad kVA 2000 kVA
Device Notes
FaultedBus
SystemNominalVoltage 12000.0 V
SystemNominalVoltageSecondary 480 V
Z% 5.7523 %
CBL-0002
Length 50.0 ft
CBL-0213
Length 2.0 ft
CB-MAIN
Frame/Model NW30L
Frame/Rating 3000.0 A
FrameVoltage 480.0 V
Settings
LTPU/LTD (A 0.4-1.0 x S) 1 (3000A); 1
STPU (1.5-10 x LTPU) 5 (15000A)
STD (INST-0.4) 0.1 (I^2t Off)
INST OR Fixed (65000A)
SWBD A
AF_IncidentEnergy 75.19 Cal/cm^2
AF_PPE Category Dangerous!
CB-DISTP-1LTG-W Feeder
Frame/Model LC
Frame/Rating 600.0 A
FrameVoltage 480.0 V
Settings
Thermal Curve
INST 9 (5172A)
CBL-0006
Length 10.0 ft
CB-DISTP-1LTG-W Main
Frame/Model MJ
CB-2LPWW
Frame/Model LC
Frame/Rating 600.0 A
FrameVoltage 480.0 V
Settings
Thermal Curve
INST 2 (3240A)
CBL-0003
Length 40.0 ft
XFMR-2L-W
FullLoad kVA 300 kVA
Device Notes
FaultedBus
SystemNominalVoltage 480.0 V
SystemNominalVoltageSecondary 208 V
Z% 4.0018 %
CBL-0214
Length 5.0 ft
CB-2L-W Main
Frame/Model PH
Frame/Rating 1200.0 A
FrameVoltage 240.0 V
Settings
Thermal Curve
INST LO (3480A)
SWBD-2L-W
AF_IncidentEnergy 1.89 Cal/cm^2
AF_PPE Category 3
CB-3/4LPWW
Frame/Model MJ
Frame/Rating 800.0 A
FrameVoltage 480.0 V
Settings
Thermal Curve
INST 10 (8000A)
CBL-0004
Length 60.0 ft
XFMR 4L-W
FullLoad kVA 500 kVA
Device Notes
FaultedBus
SystemNominalVoltage 480.0 V
SystemNominalVoltageSecondary 208 V
Z% 4.4991 %
CBL-0222
Length 10.0 ft
CB-Main-4L-W
Frame/Model PA
Frame/Rating 2000.0 A
FrameVoltage 240.0 V
Settings
Thermal Curve
INST LO (8000A)
CB-2LP9-W
Frame/Model QG
Frame/Rating 150.0 A
FrameVoltage 240.0 V
Settings
Fixed
CBL-0032
Length 85.0 ft
2LP9-W
AF_IncidentEnergy 0.23 Cal/cm^2


UTIL-0001
SC Contribution SLG 4369.1 Amps
XFR-T180-134Y-A
FullLoad kVA 2000 kVA
Device Notes
FaultedBus
SystemNominalVoltage 12000.0 V
SystemNominalVoltageSecondary 480 V
Z% 5.7523 %
CBL-0002
Length 50.0 ft
CBL-0213
Length 2.0 ft
CB-MAIN
Frame/Model NW30L
Frame/Rating 3000.0 A
FrameVoltage 480.0 V
Settings
LTPU/LTD (A 0.4-1.0 x S) 1 (3000A); 1
STPU (1.5-10 x LTPU) 5 (15000A)
STD (INST-0.4) 0.1 (I^2t Off)
INST OR Fixed (65000A)
SWBD A
AF_IncidentEnergy 75.19 Cal/cm^2
AF_PPE Category Dangerous!
CB-2/3LPEW
Frame/Model MH
Frame/Rating 1200.0 A
FrameVoltage 480.0 V
Settings
Thermal Curve
INST 2 (6000A)
CBL-0008
Length 250.0 ft
XFMR-3L-E
FullLoad kVA 750 kVA
Device Notes
FaultedBus
SystemNominalVoltage 480.0 V
SystemNominalVoltageSecondary 208 V
Z% 5.7454 %
CBL-0223
Length 10.0 ft
CB-3L-E Main
Frame/Model PC
Frame/Rating 2500.0 A
FrameVoltage 240.0 V
Settings
Thermal Curve
INST LO (8000A)
CB-5/6LPEW
Frame/Model MJ
Frame/Rating 800.0 A
FrameVoltage 480.0 V
Settings
Thermal Curve
INST 8 (6400A)
INST OR (Fixed, No User-Adjustable Setting) Fixed (8000A)
CBL-0007
Length 285.0 ft
XFMR-6L-E
FullLoad kVA 500 kVA
Device Notes
FaultedBus
SystemNominalVoltage 480.0 V
SystemNominalVoltageSecondary 208 V
Z% 4.4991 %
CB-6L-E Main
Frame/Model PA
Frame/Rating 2000.0 A
FrameVoltage 240.0 V
Settings
Thermal Curve
INST 2 (9000A)
CB-6RP-E
Frame/Model QG
Frame/Rating 150.0 A
FrameVoltage 240.0 V
Settings
Fixed
CBL-0099
Length 15.0 ft
6RP-E
AF_IncidentEnergy 0.3 Cal/cm^2
AF_PPE Category 0
CB-5LP1-E
Frame/Model QG
Frame/Rating 70.0 A
FrameVoltage 240.0 V
Settings
Fixed
CBL-0100
Length 70.0 ft
5LP1-E
AF_IncidentEnergy 0.22 Cal/cm^2
AF_PPE Category 0
CB-5LP2-E
CBL-0101
Length 60.0 ft
5LP2-E
SWBD-6L-E
AF_IncidentEnergy 37.72 Cal/cm^2
AF_PPE Category 4
CB-6LP7-E
Frame/Model QG
Frame/Rating 150.0 A
FrameVoltage 240.0 V
Settings
Fixed
CBL-0119
Length 45.0 ft
6LP7-E
AF_IncidentEnergy 0.26 Cal/cm^2
AF_PPE Category 0
SWBD-3L-E
AF_IncidentEnergy 41.72 Cal/cm
AF_PPE Category Dangerous!
CB-4LP9-E
Frame/Model QG
Frame/Rating 150.0 A
FrameVoltage 240.0 V
Settings
Fixed
CBL-0098
Length 135.0 ft
4LP9-E
AF_IncidentEnergy 0.26 Cal/cm^2
AF_PPE Category 0



GEN-0002
BaseVoltage 480 V
Base kVA 555.6 kVA
CB-DISTP-GEN Main
Frame/Model MG
Frame/Rating 800.0 A
FrameVoltage 480.0 V
Settings
Thermal Curve
INST 10 (6000A)
DISTP-GEN
AF_IncidentEnergy 0 Cal/cm^2
AF_PPE Category
UTIL-0001
SC Contribution SLG 4369.1 Amps
XFR-T180-134Y-A
FullLoad kVA 2000 kVA
Device Notes
FaultedBus
SystemNominalVoltage 12000.0 V
SystemNominalVoltageSecondary 480 V
Z% 5.7523 %
CBL-0226
Length 60.0 ft
CBL-0227
Length 60.0 ft
FP-1
Rated HP 80 hp
FP-1A
Rated HP 2 hp
ATS-FP
N
E
CB-ATS-FP-E
Frame/Model HG
Frame/Rating 110.0 A
FrameVoltage 480.0 V
Settings
Fixed
CB-ATS-SB-E
Frame/Model JG
Frame/Rating 250.0 A
FrameVoltage 480.0 V
Settings
Thermal Curve (Fixed)
INST (A-I) A (350A)
CB-ATS-EM-E
Frame/Model MG
Frame/Rating 800.0 A
FrameVoltage 480.0 V
Settings
Thermal Curve
INST 5 (3000A)
INST OR (Fixed, No User-Adjustable Setting) Fixed (6000A)
CBL-0002
Length 50.0 ft
CBL-0225
Length 10.0 ft
CBL-0220
Length 5.0 ft
CBL-0231
Length 500.0 ft
CB-ATS-FP-N
Frame/Model LC
Frame/Rating 500.0 A
FrameVoltage 480.0 V
Settings
Thermal Curve
INST LO (2500A)
CBL-0213
Length 2.0 ft
CB-MAIN
Frame/Model NW30L
Frame/Rating 3000.0 A
FrameVoltage 480.0 V
Settings
LTPU/LTD (A 0.4-1.0 x S) 1 (3000A); 1
STPU (1.5-10 x LTPU) 5 (15000A)
STD (INST-0.4) 0.1 (I^2t Off)
INST OR Fixed (65000A)
SWBD A
AF_IncidentEnergy 75.19 Cal/cm^2
AF_PPE Category Dangerous!
CB-ATS-SB
Frame/Model TJJ
Frame/Rating 400.0 A
FrameVoltage 480.0 V
Settings
Thermal Curve (Fixed)
INST (3-10 x Trip) LO (525A)
CBL-0219
Length 5.0 ft
XFMR SB
FullLoad kVA 112.5 kVA
Device Notes
FaultedBus
SystemNominalVoltage 480.0 V
SystemNominalVoltageSecondary 208 V
Z% 3.5055 %
ATS-SB
N
E
CBL-0215
Length 10.0 ft
CBL-0221
Length 5.0 ft
CB-DISTP-1SB-W Main
Frame/Model LA
Frame/Rating 400.0 A
FrameVoltage 240.0 V
Settings
Thermal Curve
INST HI (2500A)
DISTP-1SB-W
AF_IncidentEnergy 17.61 Cal/cm^2
AF_PPE Category 4
CB-ATS-EM
Frame/Model LC
Frame/Rating 600.0 A
FrameVoltage 480.0 V
Settings
Thermal Curve
INST LO (3000A)
ATS-EM
N
E
CBL-0010
Length 10.0 ft
CB-DISTP-1EM Main
Frame/Model MJ
Frame/Rating 800.0 A
FrameVoltage 480.0 V
Settings
Thermal Curve
INST 6 (3600A)
INST OR (Fixed, No User-Adjustable Setting) Fixed (6000A)
DISTP-1EM
AF_IncidentEnergy 2.6 Cal/cm^2
AF_PPE Category 3
CB-DISTP-3SB-E Main
Frame/Model QD
Frame/Rating 225.0 A
FrameVoltage 240.0 V
Settings
Fixed
CB-1D-W
Frame/Model FA
Frame/Rating 100.0 A
FrameVoltage 240.0 V
Settings
Fixed
CB-2SB-W
Frame/Model FA
Frame/Rating 100.0 A
FrameVoltage 240.0 V
Settings
Fixed
CB-3D-W
Frame/Model FA
Frame/Rating 100.0 A
FrameVoltage 240.0 V
Settings
Fixed
CB-4SB-W
Frame/Model FA
Frame/Rating 100.0 A
FrameVoltage 240.0 V
Settings
Fixed
CB-DS
Frame/Model QD
Frame/Rating 225.0 A
FrameVoltage 240.0 V
Settings
Fixed
CBL-0120
Length 30.0 ft
CBL-0121
Length 20.0 ft
CBL-0122
Length 45.0 ft
CBL-0123
Length 60.0 ft
CBL-0124
Length 60.0 ft
1D-W
AF_IncidentEnergy 0.16 Cal/cm^2
AF_PPE Category 0
2SB-W
AF_IncidentEnergy 0.17 Cal/cm^2
AF_PPE Category 0
3D-W
AF_IncidentEnergy 0.16 Cal/cm^2
AF_PPE Category 0
4SB-W
AF_IncidentEnergy 0.15 Cal/cm^2
AF_PPE Category 0
DS
AF_IncidentEnergy 14.85 Cal/cm^2
AF_PPE Category 4
CBL-0017
Length 250.0 ft
CB-DISTP-7EM-E Feeder
Frame/Model JG
Frame/Rating 250.0 A
FrameVoltage 480.0 V
Settings
Thermal Curve (Fixed)
INST (A-I) A (350A)
CB-1EM-W Feeder
Frame/Model HG
Frame/Rating 100.0 A
FrameVoltage 480.0 V
Settings
Fixed
CB-3EM-W Feeder
Frame/Model HG
Frame/Rating 100.0 A
FrameVoltage 480.0 V
Settings
Fixed
CB-EL-1
Frame/Model HG
Frame/Rating 90.0 A
FrameVoltage 480.0 V
Settings
Fixed
CB-EL-2
Frame/Model HG
Frame/Rating 110.0 A
FrameVoltage 480.0 V
Settings
Fixed
CB-EL-3
Frame/Model HG
Frame/Rating 110.0 A
FrameVoltage 480.0 V
Settings
Fixed
CBL-0176
Length 285.0 ft
CBL-0177
Length 10.0 ft
CBL-0178
Length 250.0 ft
3EM-E
AF_IncidentEnergy 0.2 Cal/cm^2
AF_PPE Category 0
CBL-0179
Length 270.0 ft
CBL-0180
Length 270.0 ft
CBL-0181
Length 30.0 ft
EL-1
Rated HP 40 hp
EL-2
Rated HP 60 hp
EL-3
Rated HP 60 hp
CB-DISTP-7EM-EM
Frame/Model HG
Frame/Rating 15.0 A
FrameVoltage 480.0 V
Settings
Fixed
CB-1EM-W Main
Frame/Model JG
Frame/Rating 250.0 A
FrameVoltage 480.0 V
Settings
Thermal Curve (Fixed)
INST (A-I) A (350A)
1EM-W
AF_IncidentEnergy 0.43 Cal/cm^2
AF_PPE Category 0
DISTP-7EM-E
AF_IncidentEnergy 0.25 Cal/cm^2
AF_PPE Category 0
DISTP-3SB-E
AF_IncidentEnergy 14.9 Cal/cm^2
AF_PPE Category 4
CB-2D-E
Frame/Model FA
Frame/Rating 100.0 A
FrameVoltage 240.0 V
Settings
Fixed
CB-3SB-E
Frame/Model FA
Frame/Rating 100.0 A
FrameVoltage 240.0 V
Settings
Fixed
CB-4D-E
Frame/Model FA
Frame/Rating 100.0 A
FrameVoltage 240.0 V
Settings
Fixed
CB-5D-E
Frame/Model FA
Frame/Rating 100.0 A
FrameVoltage 240.0 V
Settings
Fixed
CB-6SB-E
Frame/Model FA
Frame/Rating 100.0 A
FrameVoltage 240.0 V
Settings
Fixed
CBL-0125
Length 15.0 ft
CBL-0126
Length 10.0 ft
CBL-0127
Length 15.0 ft
CBL-0128
Length 30.0 ft
CBL-0129
Length 45.0 ft
2D-E
AF_IncidentEnergy 0.16 Cal/cm^2
AF_PPE Category 0
3SB-E
AF_IncidentEnergy 0.16 Cal/cm^2
AF_PPE Category 0
4D-E
AF_IncidentEnergy 0.16 Cal/cm^2
AF_PPE Category 0
5D-E
AF_IncidentEnergy 0.15 Cal/cm^2
AF_PPE Category 0
6SB-E
AF_IncidentEnergy 0.15 Cal/cm^2
AF_PPE Category 0

TAB 2

FEEDER SCHEDULE

Cable Name	From Bus To Bus	FEEDER VOLT	NO. PH	WIRE	FDR SIZE	RACEWAY SIZE	GROUND SIZE	LENGTH FEET
CBL-0002	BUS-0232 BUS-0231	480	1	4-1/C+G	1/0	1 1/2"	6	50.00
CBL-0003	SWBD A BUS-0043	480	2	4-1/C+G	250	2 1/2"	1	40.00
CBL-0004	SWBD A BUS-0009	480	3	4-1/C+G	350	3"	3/0	60.00
CBL-0005	SWBD A DISTP-1M-W	480	2	4-1/C+G	300	2 1/2"	1/0	10.00
CBL-0006	SWBD A DISTP-1LTG-W	480	2	4-1/C+G	300	2 1/2"	1/0	10.00
CBL-0007	SWBD A BUS-0255	480	3	4-1/C+G	300	2 1/2"	2/0	285.00
CBL-0008	SWBD A BUS-0042	480	4	4-1/C+G	350	3"	4/0	250.00
CBL-0010	SWBD A BUS-0021	480	2	4-1/C+G	300	2 1/2"	1/0	10.00
CBL-0017	DISTP-1SB-W DISTP-3SB-E	208	4	4-1/C+G	250	2 1/2"	3/0	250.00
CBL-0021	SWBD-3L-E 3RP-E	208	1	4-1/C+G	4/0	2"	4	20.00
CBL-0022	SWBD-3L-E 2LP1-E	208	1	4-1/C+G	4/0	2"	4	35.00
CBL-0023	SWBD-3L-E 2LP2-E	208	1	4-1/C+G	4/0	2"	4	110.00
CBL-0025	SWBD-2L-W 2LP2-W	208	1	4-1/C+G	4/0	2"	4	75.00
CBL-0027	SWBD-2L-W 2LP4-W	208	1	4-1/C+G	4/0	2"	4	75.00
CBL-0028	SWBD-2L-W 2LP5-W	208	1	4-1/C+G	4/0	2"	4	65.00
CBL-0029	SWBD-2L-W 2LP6-W	208	1	4-1/C+G	4/0	2"	4	70.00
CBL-0030	SWBD-2L-W 2LP7-W	208	1	4-1/C+G	4/0	2"	4	85.00
CBL-0031	SWBD-2L-W 2LP8-W	208	1	4-1/C+G	4/0	2"	4	60.00
CBL-0032	SWBD-2L-W 2LP9-W	208	1	4-1/C+G	4/0	2"	4	85.00
CBL-0034	SWBD-2L-W 2RP-W	208	1	4-1/C+G	4/0	2"	4	15.00
CBL-0036	DISTP-4L-W 3LP1-W	208	1	4/C	4/0	2"	4	155.00
CBL-0037	DISTP-4L-W 3LP2-W	208	1	4/C	4/0	2"	4	130.00

FEEDER SCHEDULE

Cable Name	From Bus To Bus	FEEDER VOLT	NO. PH	WIRE	FDR SIZE	RACEWAY SIZE	GROUND SIZE	LENGTH FEET
CBL-0038	DISTP-4L-W 3LP3-W	208	1	4/C	4/0	2"	4	110.00
CBL-0039	DISTP-4L-W 3LP4-W	208	1	4/C	4/0	2"	4	90.00
CBL-0040	DISTP-4L-W 4RP-W	208	1	4/C	4/0	2"	4	10.00
CBL-0041	DISTP-4L-W 4LP1-W	208	1	4/C	4/0	2"	4	30.00
CBL-0042	DISTP-4L-W 4LP2-W	208	1	4/C	4/0	2"	4	30.00
CBL-0043	DISTP-4L-W 4LP3-W	208	1	4/C	4/0	2"	4	60.00
CBL-0044	DISTP-4L-W 4LP4-W	208	1	4/C	4/0	2"	4	90.00
CBL-0045	DISTP-4L-W 4LP5-W	208	1	4/C	4/0	2"	4	40.00
CBL-0046	DISTP-4L-W 4LP6-W	208	1	4/C	4/0	2"	4	40.00
CBL-0047	DISTP-4L-W 4LP7-W	208	1	4/C	4/0	2"	4	100.00
CBL-0048	DISTP-4L-W 3LP8_W	208	1	4/C	4/0	2"	4	125.00
CBL-0049	DISTP-4L-W 3LP9-W	208	1	4/C	4/0	2"	4	85.00
CBL-0050	DISTP-4L-W 3LP10-W	208	1	4/C	4/0	2"	4	95.00
CBL-0051	DISTP-4L-W 3LP11-W	208	1	4/C	4/0	2"	4	125.00
CBL-0052	DISTP-4L-W 3LP5-W	208	1	4/C	4/0	2"	4	45.00
CBL-0053	DISTP-4L-W 3LP6-W	208	1	4/C	4/0	2"	4	50.00
CBL-0054	DISTP-4L-W 3LP7-W	208	1	4/C	4/0	2"	4	85.00
CBL-0055	DISTP-1M-W BUS-0077	480	1	3-1/C+G	4	1"	8	340.00
CBL-0056	DISTP-1M-W BUS-0078	480	1	3-1/C+G	4	1"	8	340.00
CBL-0057	DISTP-1M-W BUS-0079	480	1	3-1/C+G	4	1"	8	70.00
CBL-0058	DISTP-1M-W BUS-0080	480	1	3-1/C+G	4	1"	8	70.00
CBL-0060	DISTP-1M-W BUS-0082	480	1	3-1/C+G	8	3/4"	10	35.00

FEEDER SCHEDULE

Cable Name	From Bus To Bus	FEEDER VOLT	NO. PH	WIRE	FDR SIZE	RACEWAY SIZE	GROUND SIZE	LENGTH FEET
CBL-0061	DISTP-1M-W BUS-0083	480	1	3-1/C+G	8	3/4"	10	30.00
CBL-0062	DISTP-1M-W BUS-0084	480	1	3-1/C+G	12	3/4"	12	30.00
CBL-0063	DISTP-1M-W BUS-0085	480	1	3-1/C+G	12	3/4"	12	35.00
CBL-0064	DISTP-1M-W BUS-0086	480	1	3-1/C+G	8	3/4"	10	20.00
CBL-0067	DISTP-1M-W BUS-0089	480	1	3-1/C+G	10	3/4"	10	75.00
CBL-0068	DISTP-1M-W BUS-0090	480	1	3-1/C+G	3/0	2"	4	55.00
CBL-0069	DISTP-1M-W BUS-0091	480	1	3-1/C+G	8	3/4"	10	25.00
CBL-0070	SWBD-3L-E 2LP3-E	208	1	4-1/C+G	4/0	2"	4	140.00
CBL-0071	DISTP-1M-W BUS-0093	480	1	4-1/C+G	1	1 1/2"	6	10.00
CBL-0072	SWBD-3L-E 2LP4-E	208	1	4-1/C+G	4/0	2"	4	45.00
CBL-0073	SWBD-3L-E 2LP5-E	208	1	4-1/C+G	4/0	2"	4	65.00
CBL-0074	SWBD-3L-E 2LP6-E	208	1	4-1/C+G	4/0	2"	4	150.00
CBL-0075	SWBD-3L-E 2LP7-E	208	1	4-1/C+G	4/0	2"	4	60.00
CBL-0076	SWBD-3L-E 3LP1-E	208	1	4-1/C+G	4/0	2"	4	35.00
CBL-0077	DISTP-1LTG-W 1LTG-W	480	1	4-1/C+G	1	1 1/2"	6	5.00
CBL-0078	DISTP-1LTG-W 2LTG-W	480	1	4-1/C+G	1	1 1/2"	6	30.00
CBL-0079	DISTP-1LTG-W 4LTG-W	480	1	4-1/C+G	1	1 1/2"	6	60.00
CBL-0080	DISTP-1LTG-W 3LTG-E	480	1	4-1/C+G	1	1 1/2"	6	215.00
CBL-0081	DISTP-1LTG-W 6LTG-E	480	1	4-1/C+G	4/0	2"	4	280.00
CBL-0082	SWBD-3L-E 3LP2-E	208	1	4-1/C+G	4/0	2"	4	30.00
CBL-0083	SWBD-3L-E 3LP3-E	208	1	4-1/C+G	4/0	2"	4	95.00
CBL-0084	SWBD-3L-E 3LP4-E	208	1	4-1/C+G	4/0	2"	4	145.00

FEEDER SCHEDULE

Cable Name	From Bus To Bus	FEEDER VOLT	NO. PH	WIRE	FDR SIZE	RACEWAY SIZE	GROUND SIZE	LENGTH FEET
CBL-0085	SWBD-3L-E 3LP5-E	208	1	4-1/C+G	4/0	2"	4	75.00
CBL-0086	SWBD-3L-E 3LP6-E	208	1	4-1/C+G	4/0	2"	4	45.00
CBL-0087	SWBD-3L-E 3LP7-E	208	1	4-1/C+G	4/0	2"	4	60.00
CBL-0088	SWBD-3L-E 3LP8-E	208	1	4-1/C+G	4/0	2"	4	135.00
CBL-0090	SWBD-3L-E 4LP1-E	208	1	4-1/C+G	4/0	2"	4	55.00
CBL-0091	SWBD-3L-E 4LP2-E	208	1	4-1/C+G	4/0	2"	4	50.00
CBL-0092	SWBD-3L-E 4LP3-E	208	1	4-1/C+G	4/0	2"	4	80.00
CBL-0093	SWBD-3L-E 4LP4-E	208	1	4-1/C+G	4/0	2"	4	125.00
CBL-0095	SWBD-3L-E 4LP6-E	208	1	4-1/C+G	4/0	2"	4	60.00
CBL-0096	SWBD-3L-E 4LP7-E	208	1	4-1/C+G	4/0	2"	4	55.00
CBL-0097	SWBD-3L-E 4LP8-E	208	1	4-1/C+G	4/0	2"	4	95.00
CBL-0098	SWBD-3L-E 4LP9-E	208	1	4-1/C+G	4/0	2"	4	135.00
CBL-0099	SWBD-6L-E 6RP-E	208	1	4-1/C+G	4/0	2"	4	15.00
CBL-0100	SWBD-6L-E 5LP1-E	208	1	4-1/C+G	4/0	2"	4	70.00
CBL-0101	SWBD-6L-E 5LP2-E	208	1	4-1/C+G	4/0	2"	4	60.00
CBL-0102	SWBD-6L-E 5LP3-E	208	1	4-1/C+G	4/0	2"	4	55.00
CBL-0103	SWBD-6L-E 5LP4-E	208	1	4-1/C+G	4/0	2"	4	80.00
CBL-0104	SWBD-6L-E 5LP5-E	208	1	4-1/C+G	4/0	2"	4	105.00
CBL-0105	SWBD-6L-E 5LP6-E	208	1	4-1/C+G	4/0	2"	4	115.00
CBL-0106	SWBD-6L-E 5LP7-E	208	1	4-1/C+G	4/0	2"	4	65.00
CBL-0107	SWBD-6L-E 5LP8-E	208	1	4-1/C+G	4/0	2"	4	70.00
CBL-0108	SWBD-6L-E 6LP1-E	208	1	4-1/C+G	4/0	2"	4	50.00

FEEDER SCHEDULE

Cable Name	From Bus To Bus	FEEDER VOLT	NO. PH	WIRE	FDR SIZE	RACEWAY SIZE	GROUND SIZE	LENGTH FEET
CBL-0109	SWBD-6L-E 6LP2-E	208	1	4-1/C+G	4/0	2"	4	30.00
CBL-0110	SWBD-6L-E 6LP3-E	208	1	4-1/C+G	4/0	2"	4	30.00
CBL-0111	SWBD-6L-E 6LP4-E	208	1	4-1/C+G	4/0	2"	4	95.00
CBL-0112	SWBD-6L-E 6LP5-E	208	1	4-1/C+G	4/0	2"	4	145.00
CBL-0113	DISTP-1ML-W PNL-1M-W	208	1	4-1/C+G	1	1 1/2"	6	10.00
CBL-0114	DISTP-1ML-W PNL 2M-W	208	1	4-1/C+G	1	1 1/2"	6	30.00
CBL-0115	DISTP-1ML-W PNL 4M-W	208	1	4-1/C+G	1	1 1/2"	6	60.00
CBL-0116	DISTP-1ML-W PNL 3M-E	208	1	4-1/C+G	1	1 1/2"	6	250.00
CBL-0117	DISTP-1ML-W PNL 6M-E	208	1	4-1/C+G	1	1 1/2"	6	280.00
CBL-0118	SWBD-6L-E 6LP6-E	208	1	4-1/C+G	4/0	2"	4	60.00
CBL-0119	SWBD-6L-E 6LP7-E	208	1	4-1/C+G	4/0	2"	4	45.00
CBL-0120	DISTP-1SB-W 1D-W	208	1	4-1/C+G	1	1 1/2"	6	30.00
CBL-0121	DISTP-1SB-W 2SB-W	208	1	4-1/C+G	1	1 1/2"	6	20.00
CBL-0122	DISTP-1SB-W 3D-W	208	1	4-1/C+G	1	1 1/2"	6	45.00
CBL-0123	DISTP-1SB-W 4SB-W	208	1	4-1/C+G	1	1 1/2"	6	60.00
CBL-0124	DISTP-1SB-W DS	208	1	4-1/C+G	4/0	2"	4	60.00
CBL-0125	DISTP-3SB-E 2D-E	208	1	4-1/C+G	1/0	1 1/2"	6	15.00
CBL-0126	DISTP-3SB-E 3SB-E	208	1	4-1/C+G	1	1 1/2"	6	10.00
CBL-0127	DISTP-3SB-E 4D-E	208	1	4-1/C+G	1	1 1/2"	6	15.00
CBL-0128	DISTP-3SB-E 5D-E	208	1	4-1/C+G	1	1 1/2"	6	30.00
CBL-0129	DISTP-3SB-E 6SB-E	208	1	4-1/C+G	1/0	1 1/2"	6	45.00
CBL-0130	SWBD-3L-E 4LP5-E	208	1	4-1/C+G	4/0	2"	4	150.00

FEEDER SCHEDULE

Cable Name	From Bus To Bus	FEEDER VOLT	NO. PH	WIRE	FDR SIZE	RACEWAY SIZE	GROUND SIZE	LENGTH FEET
CBL-0176	DISTP-1EM DISTP-7EM-E	480	1	4-1/C+G	4/0	2"	4	285.00
CBL-0177	DISTP-1EM 1EM-W	480	1	4-1/C+G	1	1 1/2"	6	10.00
CBL-0178	DISTP-1EM 3EM-E	480	1	4-1/C+G	1	1 1/2"	6	250.00
CBL-0179	DISTP-1EM BUS-0193	480	1	4-1/C+G	4	1"	8	270.00
CBL-0180	DISTP-1EM BUS-0194	480	1	4-1/C+G	4	1"	8	270.00
CBL-0181	DISTP-1EM BUS-0195	480	1	4-1/C+G	4	1"	8	30.00
CBL-0213	BUS-0231 SWBD A	480	1	4-1/C+G	1/0	1 1/2"	6	2.00
CBL-0214	BUS-0234 SWBD-2L-W	208	4	4-1/C+G	350	3"	4/0	5.00
CBL-0215	SWBD A BUS-0235	480	1	4-1/C+G	1/0	1 1/2"	6	10.00
CBL-0219	BUS-0242 BUS-0241	480	1	4-1/C+G	1/0	1 1/2"	6	5.00
CBL-0220	DISTP-GEN BUS-0244	480	1	4-1/C+G	1/0	1 1/2"	6	5.00
CBL-0221	BUS-0245 DISTP-1SB-W	208	1	4-1/C+G	500	3"	2	5.00
CBL-0222	BUS-0246 DISTP-4L-W	208	4	4-1/C+G	500	3"	250	10.00
CBL-0223	BUS-0247 SWBD-3L-E	208	7	4-1/C+G	500	3"	500	10.00
CBL-0224	SWBD-2L-W 2LP1-W	208	1	4-1/C+G	4/0	2 1/2"	4	135.00
CBL-0225	BUS-0249 BUS-0231	480	2	4-1/C+G	250	2 1/2"	1	10.00
CBL-0226	BUS-0252 BUS-0250	480	2	4-1/C+G	250	2 1/2"	1	60.00
CBL-0227	BUS-0252 BUS-0251	480	2	4-1/C+G	250	2 1/2"	1	60.00
CBL-0228	SWBD-2L-W 2LP3-W	208	1	4-1/C+G	4/0	2 1/2"	4	135.00
CBL-0231	DISTP-GEN BUS-0268	480	2	4-1/C+G	500	3"	2/0	500.00
CBL-1RP-W	SWBD-2L-W 1RP-W	208	1	4-1/C+G	4/0	2"	4	10.00

TRANSFORMER SCHEDULE

NAME	kVA RATING	TYPE	-------PRIMARY------		-------SECONDARY------	
			VOLTAGE	CONNECTION.	VOLTAGE	CONNECTION.
XFMR 1M	75	PADMOUNT	480	D	208	WG
XFMR 4L-W	500	PADMOUNT	480	D	208	WG
XFMR SB	113	PADMOUNT	480	D	208	WG
XFMR-2L-W	300	PADMOUNT	480	D	208	WG
XFMR-3L-E	750	PADMOUNT	480	D	208	WG
XFMR-6L-E	500	PADMOUNT	480	D	208	WG
XFR-T180-134Y-A	2,000	PADMOUNT	12,000	D	480	WG

Project: Senior Project 1L

LOW VOLTAGE THERMAL MAGNETIC MOLDED CASE BREAKERS SETTINGS

DESIGNATION		FRAME		TRIP UNIT				
Location/Name	Amps Frame	MFR	TYPE MODEL	Amps Sensor/Plug	Description	TYPE/MODEL	LT SETTING	INST SETTING
DISTP-1SB-W CB-1D-W	100	SQUARE D	FA	100 0	15-100A	FA	Fixed	
DISTP-1EM CB-1EM-W Feeder	100	SQUARE D	HG	100 0	15-150A	Powerpact HG	Fixed	
1EM-W CB-1EM-W Main	250	CUTLER-HAMMER	JG	225 0	175-250A	JG	Thermal Curve (Fixed)	INST (A-I) A
DISTP-1LTG-W CB-1LTG-W Feeder	100	SQUARE D	HG	100 0	15-150A	Powerpact HG	Fixed	
1LTG-W CB-1LTG-W Main	250	CUTLER-HAMMER	JG	225 0	175-250A	JG	Thermal Curve (Fixed)	INST (A-I) A
SWBD-2L-W CB-1RP-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD A CB-2/3LPEW	1,200	SQUARE D	MH	1,200 0	125-1200A	MH	Thermal Curve	INST 2
DISTP-3SB-E CB-2D-E	100	SQUARE D	FA	100 0	15-100A	FA	Fixed	
SWBD-2L-W CB-2L-W Main	1,200	SQUARE D	PH	1,200 0	600-2000A	PH	Thermal Curve	INST LO
SWBD-3L-E CB-2LP1-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-2L-W CB-2LP1-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-2LP2-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-2L-W CB-2LP2-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-2LP3-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	

DESIGNATION		FRAME		TRIP UNIT				
Location/Name	Amps Frame	MFR	TYPE MODEL	Amps Sensor/Plug	Description	TYPE/MODEL	LT SETTING	INST SETTING
SWBD-2L-W CB-2LP3-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-2LP4-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-2L-W CB-2LP4-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-2LP5-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-2L-W CB-2LP5-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-2LP6-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-2L-W CB-2LP6-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-2LP7-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-2L-W CB-2LP7-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-2L-W CB-2LP8-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-2L-W CB-2LP9-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD A CB-2LPWW	600	SQUARE D	LC	600 0	300-600A	LC	Thermal Curve	INST 2
DISTP-1LTG-W CB-2LTG-W Feeder	100	SQUARE D	HG	100 0	15-150A	Powerpact HG	Fixed	
2LTG-W CB-2LTG-W Main	250	CUTLER-HA MMER	JG	225 0	175-250A	JG	Thermal Curve (Fixed)	INST (A-I) A
SWBD-2L-W CB-2RP-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-1SB-W CB-2SB-W	100	SQUARE D	FA	100 0	15-100A	FA	Fixed	

DESIGNATION		FRAME		TRIP UNIT				
Location/Name	Amps Frame	MFR	TYPE MODEL	Amps Sensor/Plug	Description	TYPE/MODEL	LT SETTING	INST SETTING
SWBD A CB-3/4LPWW	800	SQUARE D	MJ	800 0	300-800A	MJ w/ ET1.0 10x Inst.	Thermal Curve	INST 10
DISTP-1SB-W CB-3D-W	100	SQUARE D	FA	100 0	15-100A	FA	Fixed	
DISTP-1EM CB-3EM-W Feeder	100	SQUARE D	HG	100 0	15-150A	Powerpact HG	Fixed	
SWBD-3L-E CB-3L-E Main	2,500	SQUARE D	PC	2,500 0	1600-2500A	PC	Thermal Curve	INST LO
SWBD-3L-E CB-3LP1-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-3LP1-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-3LP10-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-3LP11-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-3LP2-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-3LP2-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-3LP3-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-3LP3-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-3LP4-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-3LP4-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-3LP5-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-3LP5-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	

DESIGNATION		FRAME		TRIP UNIT				
Location/Name	Amps Frame	MFR	TYPE MODEL	Amps Sensor/Plug	Description	TYPE/MODEL	LT SETTING	INST SETTING
SWBD-3L-E CB-3LP6-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-3LP6-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-3LP7-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-3LP7-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-3LP8-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-3LP8-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-3LP9-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-1LTG-W CB-3LTG-W Feeder	250	CUTLER-HA MMER	JG	175 0	175-250A	JG	Thermal Curve (Fixed)	INST (A-I) A
SWBD-3L-E CB-3RP-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-3SB-E CB-3SB-E	100	SQUARE D	FA	100 0	15-100A	FA	Fixed	
DISTP-3SB-E CB-4D-E	100	SQUARE D	FA	100 0	15-100A	FA	Fixed	
SWBD-3L-E CB-4LP1-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-4LP1-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-4LP2-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-4LP2-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-4LP3-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	

DESIGNATION		FRAME		TRIP UNIT				
Location/Name	Amps Frame	MFR	TYPE MODEL	Amps Sensor/Plug	Description	TYPE/MODEL	LT SETTING	INST SETTING
DISTP-4L-W CB-4LP3-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-4LP4-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-4LP4-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-4LP5-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-4LP5-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-4LP6-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-4LP6-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-4LP7-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-4L-W CB-4LP7-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-4LP8-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-3L-E CB-4LP9-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-1LTG-W CB-4LTG-W Feeder	100	SQUARE D	HG	100 0	15-150A	Powerpact HG	Fixed	
DISTP-4L-W CB-4RP-W	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-1SB-W CB-4SB-W	100	SQUARE D	FA	100 0	15-100A	FA	Fixed	
SWBD A CB-5/6LPEW	800	SQUARE D	MJ	800 0	300-800A	MJ w/ ET1.0 2-8x Inst.	Thermal Curve	INST 2
DISTP-3SB-E CB-5D-E	100	SQUARE D	FA	100 0	15-100A	FA	Fixed	

DESIGNATION		FRAME		TRIP UNIT				
Location/Name	Amps Frame	MFR	TYPE MODEL	Amps Sensor/Plug	Description	TYPE/MODEL	LT SETTING	INST SETTING
SWBD-6L-E CB-5LP-7	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-6L-E CB-5LP1-E	70	SQUARE D	QG	70 0	70-250A	QG	Fixed	
SWBD-6L-E CB-5LP2-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-6L-E CB-5LP3-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-6L-E CB-5LP4-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-6L-E CB-5LP5-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-6L-E CB-5LP6-E	225	SQUARE D	QG	225 0	70-250A	QG	Fixed	
SWBD-6L-E CB-5LP8-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-6L-E CB-6-LP1-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-6L-E CB-6L-E Main	2,000	SQUARE D	PA	2,000 0	600-2000A	PA	Thermal Curve	INST 2
SWBD-6L-E CB-6LP2-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-6L-E CB-6LP3-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-6L-E CB-6LP4-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-6L-E CB-6LP5-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-6L-E CB-6LP6-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
SWBD-6L-E CB-6LP7-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	

DESIGNATION		FRAME		TRIP UNIT				
Location/Name	Amps Frame	MFR	TYPE MODEL	Amps Sensor/Plug	Description	TYPE/MODEL	LT SETTING	INST SETTING
DISTP-1LTG-W CB-6LTG-E	250	CUTLER-HAMMER	JG	175 0	175-250A	JG	Thermal Curve (Fixed)	INST (A-I) A
SWBD-6L-E CB-6RP-E	150	SQUARE D	QG	150 0	70-250A	QG	Fixed	
DISTP-3SB-E CB-6SB-E	100	SQUARE D	FA	100 0	15-100A	FA	Fixed	
DISTP-1M-W CB-AC-1	250	SIEMENS	NJGA	250 0	250-400A	JG, 2-4 Poles	Thermal Curve	INST, (1250 - 2500A) 1250
DISTP-1M-W CB-AH-1(1)	125	SQUARE D	HG	125 0	15-150A	Powerpact HG	Fixed	
DISTP-1M-W CB-AH-1(2)	125	SQUARE D	HG	125 0	15-150A	Powerpact HG	Fixed	
DISTP-1M-W CB-AH-2(1)	90	SQUARE D	HG	90 0	15-150A	Powerpact HG	Fixed	
DISTP-1M-W CB-AH-2(2)	90	SQUARE D	HG	90 0	15-150A	Powerpact HG	Fixed	
SWBD A CB-ATS-EM	600	SQUARE D	LC	600 0	300-600A	LC	Thermal Curve	INST LO
DISTP-GEN CB-ATS-EM-E	800	SQUARE D	MG	600 0	300-800A	MG w/ ET1.0, 2-8x Inst.	Thermal Curve	INST 5
DISTP-GEN CB-ATS-FP-E	110	SQUARE D	HG	110 0	15-150A	Powerpact HG	Fixed	
BUS-0231 CB-ATS-FP-N	500	SQUARE D	LC	500 0	300-600A	LC	Thermal Curve	INST LO
SWBD A CB-ATS-SB	400	GE	TJJ	175 0	125-400A	TJJ	Thermal Curve (Fixed)	INST (3-10 x Trip) LO
DISTP-GEN CB-ATS-SB-E	250	CUTLER-HAMMER	JG	175 0	175-250A	JG	Thermal Curve (Fixed)	INST (A-I) A
DISTP-1M-W CB-BP-1	60	SQUARE D	HG	60 0	15-150A	Powerpact HG	Fixed	
DISTP-1M-W CB-CHWP-1	20	SQUARE D	HG	20 0	15-150A	Powerpact HG	Fixed	

DESIGNATION		FRAME		TRIP UNIT				
Location/Name	Amps Frame	MFR	TYPE MODEL	Amps Sensor/Plug	Description	TYPE/MODEL	LT SETTING	INST SETTING
DISTP-1M-W CB-CHWP-2	20	SQUARE D	HG	20 0	15-150A	Powerpact HG	Fixed	
DISTP-1M-W CB-CHWP-3	40	SQUARE D	HG	40 0	15-150A	Powerpact HG	Fixed	
DISTP-1M-W CB-CHWP-4	40	SQUARE D	HG	40 0	15-150A	Powerpact HG	Fixed	
DISTP-1EM CB-DISTP-1EM Main	800	SQUARE D	MJ	600 0	300-800A	MJ w/ ET1.0 2-8x Inst.	Thermal Curve	INST 6
SWBD A CB-DISTP-1LTG-W Feeder	600	SQUARE D	LC	600 0	300-600A	LC	Thermal Curve	INST 9
DISTP-1LTG-W CB-DISTP-1LTG-W Main	800	SQUARE D	MJ	300 0	300-800A	MJ w/ ET1.0 2-8x Inst.	Thermal Curve	INST 4
DISTP-1M-W CB-DISTP-1M-W Main	600	SQUARE D	LC	600 0	300-600A	LC	Thermal Curve	INST LO
DISTP-1ML-W CB-DISTP-1ML-W Main	400	SQUARE D	LA	300 0	125-400A	LA	Thermal Curve	INST LO
DISTP-1SB-W CB-DISTP-1SB-W Main	400	SQUARE D	LA	250 0	125-400A	LA	Thermal Curve	INST HI
DISTP-1EM CB-DISTP-7EM-E Feeder	250	CUTLER-HA MMER	JG	225 0	175-250A	JG	Thermal Curve (Fixed)	INST (A-I) A
DISTP-7EM-E CB-DISTP-7EM-EM	15	SQUARE D	HG	15 0	15-150A	HG	Fixed	
DISTP-GEN CB-DISTP-GEN Main	800	SQUARE D	MG	600 0	300-800A	MG w/ ET1.0, 10x Inst.	Thermal Curve	INST 10
DISTP-1SB-W CB-DS	225	SQUARE D	QD	225 0	70-250A	QD	Fixed	
DISTP-1EM CB-EL-1	90	SQUARE D	HG	90 0	15-150A	Powerpact HG	Fixed	
DISTP-1EM CB-EL-2	110	SQUARE D	HG	110 0	15-150A	Powerpact HG	Fixed	
DISTP-1EM CB-EL-3	110	SQUARE D	HG	110 0	15-150A	Powerpact HG	Fixed	

DESIGNATION		FRAME		TRIP UNIT				
Location/Name	Amps Frame	MFR	TYPE MODEL	Amps Sensor/Plug	Description	TYPE/MODEL	LT SETTING	INST SETTING
DISTP-1M-W CB-HWP-1	60	SQUARE D	HG	60 0	15-150A	Powerpact HG	Fixed	
DISTP-1M-W CB-HWP-2	60	SQUARE D	HG	60 0	15-150A	Powerpact HG	Fixed	
DISTP-4L-W CB-Main-4L-W	2,000	SQUARE D	PA	2,000 0	600-2000A	PA	Thermal Curve	INST LO
SWBD A CB-MECHP	600	SQUARE D	LC	600 0	300-600A	LC	Thermal Curve	INST 5
DISTP-1M-W CB-XFMR-1M	150	SQUARE D	HG	150 0	15-150A	Powerpact HG	Fixed	

TAB 3

Project: Senior Project 1L

Arc Flash Evaluation Report

Arc Flash Evaluation Study Options

Standard:	IEEE 1584	**Max Arcing Duration:**	2.0 seconds
Unit:	English	**Include Transformer Phase Shift:**	No
Clear Fault Threshold:	80 %	**Define Grounded as SLG/3P Fault >= :**	5.0 %
Check Upstream Miscoordination:	No		

-- Flash Boundary Calculation Adjustment Option --

-- Incident Energy Report Option for Equipment Below 240 V --

Report calculated incident energy from equation

-- Generator and Synchronous Motor Decay Option --

-- Induction Motor Decay Option --

Include induction motors for 5 cycles.

-- Fuse Current Limiting Option --

Specify fuses as current limiting in the protective device library, manufacturer’s equipment-specific Incident Energy equations will be used if available.

-- Report Option --

Include Line and Load Side contributions (protective device failed to open)

Report last trip device

Bus Name	Bus kV	Protective Device Name	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Bolted Fault (kA)	Prot Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Arc Duration	Arc Type	ArcFlash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	PPE
1D-W	0.208	CB-1D-W	6.02	3.04	6.02	3.04	0.017	0.000	0.017	In Box	5.29	18.00	0.16	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
1EM-W	0.480	CB-1EM-W Main	19.74	11.72	19.74	11.72	0.011	0.000	0.011	In Box	9.71	18.00	0.43	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
1LTG-W	0.480	CB-1LTG-W Main	20.73	12.22	20.73	12.22	0.011	0.000	0.011	In Box	9.88	18.00	0.45	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
1RP-W	0.208	CB-1RP-W	13.17	5.28	13.17	5.28	0.017	0.000	0.017	In Box	7.51	18.00	0.28	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2D-E	0.208	CB-2D-E	5.46	2.84	5.46	2.84	0.018	0.000	0.018	In Box	5.20	18.00	0.16	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP1-E	0.208	CB-2LP1-E	13.60	5.40	13.60	5.40	0.017	0.000	0.017	In Box	7.60	18.00	0.29	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP1-W	0.208	CB-2LP1-W	6.94	2.86	6.94	2.86	0.032	0.000	0.032	In Box	7.37	18.00	0.28	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP2-E	0.208	CB-2LP2-E	8.34	3.25	8.34	3.25	0.024	0.000	0.024	In Box	6.67	18.00	0.23	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP2-W	0.208	CB-2LP2-W	8.68	3.35	8.68	3.35	0.023	0.000	0.023	In Box	6.64	18.00	0.23	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP3-E	0.208	CB-2LP3-E	7.20	2.94	7.20	2.94	0.030	0.000	0.030	In Box	7.18	18.00	0.26	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP3-W	0.208	CB-2LP3-W	6.94	2.86	6.94	2.86	0.032	0.000	0.032	In Box	7.37	18.00	0.28	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP4-E	0.208	CB-2LP4-E	12.56	5.11	12.56	5.11	0.017	0.000	0.017	In Box	7.37	18.00	0.28	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber

Bus Name	Bus kV	Protective Device Name	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Bolted Fault (kA)	Prot Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Arc Duration	Arc Type	ArcFlash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	PPE
2LP4-W	0.208	CB-2LP4-W	8.68	3.35	8.68	3.35	0.023	0.000	0.023	In Box	6.64	18.00	0.23	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP5-E	0.208	CB-2LP5-E	10.88	4.62	10.88	4.62	0.017	0.000	0.017	In Box	6.95	18.00	0.25	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP5-W	0.208	CB-2LP5-W	9.18	4.09	9.18	4.09	0.019	0.000	0.019	In Box	6.69	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP6-E	0.208	CB-2LP6-E	6.89	2.85	6.89	2.85	0.033	0.000	0.033	In Box	7.41	18.00	0.28	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP6-W	0.208	CB-2LP6-W	8.92	4.02	8.92	4.02	0.019	0.000	0.019	In Box	6.66	18.00	0.23	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP7-E	0.208	CB-2LP7-E	11.26	4.73	11.26	4.73	0.017	0.000	0.017	In Box	7.05	18.00	0.26	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP7-W	0.208	CB-2LP7-W	8.24	3.23	8.24	3.23	0.024	0.000	0.024	In Box	6.68	18.00	0.23	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP8-W	0.208	CB-2LP8-W	9.44	4.18	9.44	4.18	0.018	0.000	0.018	In Box	6.73	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LP9-W	0.208	CB-2LP9-W	8.24	3.23	8.24	3.23	0.024	0.000	0.024	In Box	6.68	18.00	0.23	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2LTG-W	0.480	CB-2LTG-W Main	16.32	9.96	16.32	9.96	0.012	0.000	0.012	In Box	9.06	18.00	0.39	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2RP-W	0.208	CB-2RP-W	12.69	5.14	12.69	5.14	0.017	0.000	0.017	In Box	7.39	18.00	0.28	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
2SB-W	0.208	CB-2SB-W	6.42	3.19	6.42	3.19	0.017	0.000	0.017	In Box	5.43	18.00	0.17	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber

Bus Name	Bus kV	Protective Device Name	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Bolted Fault (kA)	Prot Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Arc Duration	Arc Type	ArcFlash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	PPE
3D-W	0.208	CB-3D-W	5.47	2.85	5.47	2.85	0.018	0.000	0.018	In Box	5.20	18.00	0.16	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3EM-E	0.480	CB-3EM-W Feeder	5.30	3.81	5.30	3.81	0.018	0.000	0.018	In Box	6.15	18.00	0.20	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP1-E	0.208	CB-3LP1-E	13.60	5.40	13.60	5.40	0.017	0.000	0.017	In Box	7.60	18.00	0.29	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP1-W	0.208	CB-3LP1-W	7.19	2.93	7.19	2.93	0.030	0.000	0.030	In Box	7.19	18.00	0.26	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP10-W	0.208	CB-3LP10-W	9.53	4.21	9.53	4.21	0.018	0.000	0.018	In Box	6.74	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP11-W	0.208	CB-3LP11-W	8.20	3.22	8.20	3.22	0.024	0.000	0.024	In Box	6.68	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP2-E	0.208	CB-3LP2-E	14.18	5.56	14.18	5.56	0.017	0.000	0.017	In Box	7.73	18.00	0.30	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP2-W	0.208	CB-3LP2-W	8.02	3.17	8.02	3.17	0.025	0.000	0.025	In Box	6.70	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP3-E	0.208	CB-3LP3-E	9.05	4.05	9.05	4.05	0.019	0.000	0.019	In Box	6.68	18.00	0.23	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP3-W	0.208	CB-3LP3-W	8.82	3.98	8.82	3.98	0.019	0.000	0.019	In Box	6.65	18.00	0.23	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP4-E	0.208	CB-3LP4-E	7.04	2.89	7.04	2.89	0.031	0.000	0.031	In Box	7.29	18.00	0.27	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP4-W	0.208	CB-3LP4-W	9.79	4.29	9.79	4.29	0.018	0.000	0.018	In Box	6.77	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber

Bus Name	Bus kV	Protective Device Name	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Bolted Fault (kA)	Prot Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Arc Duration	Arc Type	ArcFlash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	PPE
3LP5-E	0.208	CB-3LP5-E	10.20	4.41	10.20	4.41	0.018	0.000	0.018	In Box	6.82	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP5-W	0.208	CB-3LP5-W	12.92	5.21	12.92	5.21	0.017	0.000	0.017	In Box	7.45	18.00	0.28	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP6-E	0.208	CB-3LP6-E	12.56	5.11	12.56	5.11	0.017	0.000	0.017	In Box	7.37	18.00	0.28	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP6-W	0.208	CB-3LP6-W	12.49	5.08	12.49	5.08	0.017	0.000	0.017	In Box	7.35	18.00	0.27	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP7-E	0.208	CB-3LP7-E	11.26	4.73	11.26	4.73	0.017	0.000	0.017	In Box	7.05	18.00	0.26	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP7-W	0.208	CB-3LP7-W	10.07	4.37	10.07	4.37	0.018	0.000	0.018	In Box	6.80	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP8-E	0.208	CB-3LP8-E	7.37	2.98	7.37	2.98	0.029	0.000	0.029	In Box	7.06	18.00	0.26	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP8_W	0.208	CB-3LP8-W	8.20	3.22	8.20	3.22	0.024	0.000	0.024	In Box	6.68	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LP9-W	0.208	CB-3LP9-W	10.07	4.37	10.07	4.37	0.018	0.000	0.018	In Box	6.80	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3LTG-E	0.480	CB-3LTG-W Feeder	5.95	4.21	5.95	4.21	0.016	0.000	0.016	In Box	6.29	18.00	0.21	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3RP-E	0.208	CB-3RP-E	15.48	5.91	15.48	5.91	0.017	0.000	0.017	In Box	8.01	18.00	0.32	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
3SB-E	0.208	CB-3SB-E	5.54	2.87	5.54	2.87	0.018	0.000	0.018	In Box	5.21	18.00	0.16	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber

Bus Name	Bus kV	Protective Device Name	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Bolted Fault (kA)	Prot Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Arc Duration	Arc Type	ArcFlash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	PPE
4D-E	0.208	CB-4D-E	5.39	2.82	5.39	2.82	0.018	0.000	0.018	In Box	5.19	18.00	0.16	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP1-E	0.208	CB-4LP1-E	11.67	4.85	11.67	4.85	0.017	0.000	0.017	In Box	7.15	18.00	0.26	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP1-W	0.208	CB-4LP1-W	14.40	5.62	14.40	5.62	0.017	0.000	0.017	In Box	7.78	18.00	0.30	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP2-E	0.208	CB-4LP2-E	12.10	4.97	12.10	4.97	0.017	0.000	0.017	In Box	7.26	18.00	0.27	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP2-W	0.208	CB-4LP2-W	14.40	5.62	14.40	5.62	0.017	0.000	0.017	In Box	7.78	18.00	0.30	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP3-E	0.208	CB-4LP3-E	9.88	4.31	9.88	4.31	0.018	0.000	0.018	In Box	6.78	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP3-W	0.208	CB-4LP3-W	11.69	4.86	11.69	4.86	0.017	0.000	0.017	In Box	7.16	18.00	0.26	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP4-E	0.208	CB-4LP4-E	7.73	3.09	7.73	3.09	0.026	0.000	0.026	In Box	6.82	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP4-W	0.208	CB-4LP4-W	9.79	4.29	9.79	4.29	0.018	0.000	0.018	In Box	6.77	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP5-E	0.208	CB-4LP5-E	6.89	2.85	6.89	2.85	0.033	0.000	0.033	In Box	7.41	18.00	0.28	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP5-W	0.208	CB-4LP5-W	13.39	5.34	13.39	5.34	0.017	0.000	0.017	In Box	7.55	18.00	0.29	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP6-E	0.208	CB-4LP6-E	11.26	4.73	11.26	4.73	0.017	0.000	0.017	In Box	7.05	18.00	0.26	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber

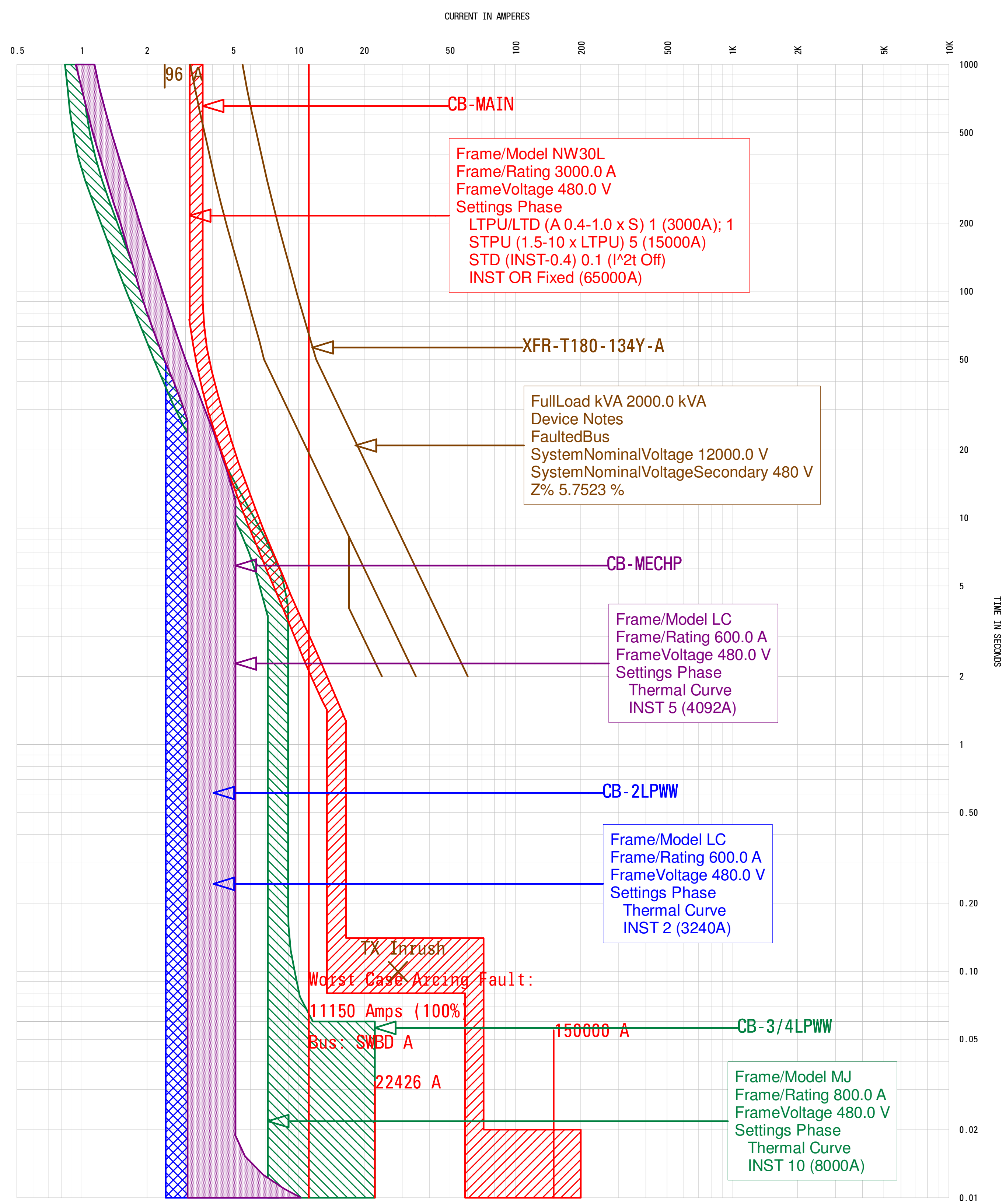
Bus Name	Bus kV	Protective Device Name	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Bolted Fault (kA)	Prot Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Arc Duration	Arc Type	ArcFlash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	PPE
4LP6-W	0.208	CB-4LP6-W	13.39	5.34	13.39	5.34	0.017	0.000	0.017	In Box	7.55	18.00	0.29	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP7-E	0.208	CB-4LP7-E	11.67	4.85	11.67	4.85	0.017	0.000	0.017	In Box	7.15	18.00	0.26	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP7-W	0.208	CB-4LP7-W	9.28	4.13	9.28	4.13	0.019	0.000	0.019	In Box	6.71	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP8-E	0.208	CB-4LP8-E	9.05	4.05	9.05	4.05	0.019	0.000	0.019	In Box	6.68	18.00	0.23	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LP9-E	0.208	CB-4LP9-E	7.37	2.98	7.37	2.98	0.029	0.000	0.029	In Box	7.06	18.00	0.26	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4LTG-W	0.480	CB-4LTG-W Feeder	12.84	8.12	12.84	8.12	0.018	0.000	0.018	In Box	10.11	18.00	0.46	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4RP-W	0.208	CB-4RP-W	16.88	6.28	16.88	6.28	0.017	0.000	0.017	In Box	8.29	18.00	0.33	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
4SB-W	0.208	CB-4SB-W	5.00	2.67	5.00	2.67	0.019	0.000	0.019	In Box	5.14	18.00	0.15	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
5D-E	0.208	CB-5D-E	4.95	2.65	4.95	2.65	0.019	0.000	0.019	In Box	5.13	18.00	0.15	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
5LP1-E	0.208	CB-5LP1-E	9.70	4.26	9.70	4.26	0.016	0.000	0.016	In Box	6.38	18.00	0.22	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
5LP2-E	0.208	CB-5LP2-E	10.32	4.45	10.32	4.45	0.018	0.000	0.018	In Box	6.83	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
5LP3-E	0.208	CB-5LP3-E	10.66	4.55	10.66	4.55	0.017	0.000	0.017	In Box	6.90	18.00	0.25	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber

Bus Name	Bus kV	Protective Device Name	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Bolted Fault (kA)	Prot Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Arc Duration	Arc Type	ArcFlash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	PPE
5LP4-E	0.208	CB-5LP4-E	9.15	4.09	9.15	4.09	0.019	0.000	0.019	In Box	6.69	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
5LP5-E	0.208	CB-5LP5-E	8.01	3.16	8.01	3.16	0.025	0.000	0.025	In Box	6.70	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
5LP6-E	0.208	CB-5LP6-E	7.62	3.06	7.62	3.06	0.024	0.000	0.024	In Box	6.44	18.00	0.22	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
5LP7-E	0.208	CB-5LP-7	10.00	4.35	10.00	4.35	0.018	0.000	0.018	In Box	6.80	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
5LP8-E	0.208	CB-5LP8-E	9.70	4.26	9.70	4.26	0.018	0.000	0.018	In Box	6.76	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
6LP1-E	0.208	CB-6-LP1-E	11.02	4.66	11.02	4.66	0.017	0.000	0.017	In Box	6.99	18.00	0.25	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
6LP2-E	0.208	CB-6LP2-E	12.72	5.15	12.72	5.15	0.017	0.000	0.017	In Box	7.40	18.00	0.28	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
6LP3-E	0.208	CB-6LP3-E	12.72	5.15	12.72	5.15	0.017	0.000	0.017	In Box	7.40	18.00	0.28	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
6LP4-E	0.208	CB-6LP4-E	8.43	3.28	8.43	3.28	0.024	0.000	0.024	In Box	6.66	18.00	0.23	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
6LP5-E	0.208	CB-6LP5-E	6.66	2.78	6.66	2.78	0.035	0.000	0.035	In Box	7.59	18.00	0.29	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
6LP6-E	0.208	CB-6LP6-E	10.32	4.45	10.32	4.45	0.018	0.000	0.018	In Box	6.83	18.00	0.24	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
6LP7-E	0.208	CB-6LP7-E	11.40	4.77	11.40	4.77	0.017	0.000	0.017	In Box	7.08	18.00	0.26	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber

Bus Name	Bus kV	Protective Device Name	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Bolted Fault (kA)	Prot Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Arc Duration	Arc Type	ArcFlash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	PPE
6LTG-E	0.480	CB-6LTG-E	8.04	5.44	8.04	5.44	0.015	0.000	0.015	In Box	7.02	18.00	0.25	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
6RP-E	0.208	CB-6RP-E	14.36	5.61	14.36	5.61	0.017	0.000	0.017	In Box	7.77	18.00	0.30	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
6SB-E	0.208	CB-6SB-E	4.74	2.57	4.74	2.57	0.020	0.000	0.020	In Box	5.10	18.00	0.15	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
DISTP-1EM	0.480	CB-DISTP-1EM Main	21.90	12.81	20.78	12.15	0.060	0.000	0.060	In Box	28.93	18.00	2.60	Level 3 - Arc-rated shirt & pants + arc-rated coverall + arc-rated arc flash suit
DISTP-1LTG-W	0.480	CB-DISTP-1LTG-W Feeder	21.85	12.78	21.85	12.78	0.010	0.000	0.010	In Box	9.73	18.00	0.44	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
DISTP-1M-W	0.480	CB-DISTP-1M-W Main	21.95	12.84	19.75	11.55	0.010	0.000	0.010	In Box	9.72	18.00	0.43	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
DISTP-1ML-W	0.208	CB-DISTP-1ML-W Main	5.28	2.78	5.28	2.78	0.018	0.000	0.018	In Box	5.05	18.00	0.15	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
DISTP-1SB-W	0.208	CB-DISTP-1SB-W Main	7.35	2.98	7.35	2.98	2.000	0.000	2.000	In Box	92.73	18.00	17.61	Level 4 - Arc-rated shirt & pants + arc-rated coverall + arc-rated arc flash suit
DISTP-3SB-E	0.208	CB-DISTP-1SB-W Main	5.88	3.00	5.88	3.00	2.000	0.000	2.000	In Box	93.21	18.00	17.76	Level 4 - Arc-rated shirt & pants + arc-rated coverall + arc-rated arc flash suit
DISTP-4L-W	0.208	CB-Main-4L-W	18.39	6.67	18.39	6.67	2.000	0.000	2.000	In Box	155.17	18.00	40.98	Level Dangerous! - DO NOT WORK ON LIVE!
DISTP-7EM-E	0.480	CB-DISTP-7EM-E Feeder	7.96	5.40	7.96	5.40	0.015	0.000	0.015	In Box	6.99	18.00	0.25	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
DS	0.208	CB-DS	5.85	2.54	5.85	2.54	2.000	0.000	2.000	In Box	83.57	18.00	14.85	Level 4 - Arc-rated shirt & pants + arc-rated coverall + arc-rated arc flash suit

Bus Name	Bus kV	Protective Device Name	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Bolted Fault (kA)	Prot Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Arc Duration	Arc Type	ArcFlash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	PPE
PNL 2M-W	0.208	CB-2M-W	4.56	2.51	4.56	2.51	0.016	0.000	0.016	In Box	4.41	18.00	0.12	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
PNL 3M-E	0.208	CB-3M-E	2.05	1.43	2.05	1.43	0.016	0.000	0.016	In Box	3.05	18.00	0.06	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
PNL 4M-W	0.208	CB-4M-W	3.97	2.27	3.97	2.27	0.016	0.000	0.016	In Box	4.14	18.00	0.11	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
PNL 6M-E	0.208	CB-6M-E	1.90	1.36	1.90	1.36	0.016	0.000	0.016	In Box	2.94	18.00	0.06	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
PNL-1M-W	0.208	CB-PNL-1M-L	5.03	2.68	5.03	2.68	0.016	0.000	0.016	In Box	4.62	18.00	0.13	Level 0 - Shirt & pants or coverall, Nonmelting (ASTM F1506) or Untreated Fiber
SWBD A	0.480	CB-MAIN	22.43	13.07	19.13	11.15	2.000	0.000	2.000	In Box	224.60	18.00	75.19	Level Dangerous! - DO NOT WORK ON LIVE!
SWBD-2L-W	0.208	CB-2L-W Main	14.26	4.74	14.26	4.74	0.129	0.000	0.129	In Box	23.77	18.00	1.89	Level 3 - Arc-rated shirt & pants + arc-rated coverall + arc-rated arc flash suit
SWBD-3L-E	0.208	CB-3L-E Main	18.87	6.79	18.87	6.79	2.000	0.000	2.000	In Box	156.86	18.00	41.72	Level Dangerous! - DO NOT WORK ON LIVE!
SWBD-6L-E	0.208	CB-6L-E Main	16.42	6.16	16.42	6.16	2.000	0.000	2.000	In Box	147.52	18.00	37.72	Level 4 - Arc-rated shirt & pants + arc-rated coverall + arc-rated arc flash suit

TAB 4



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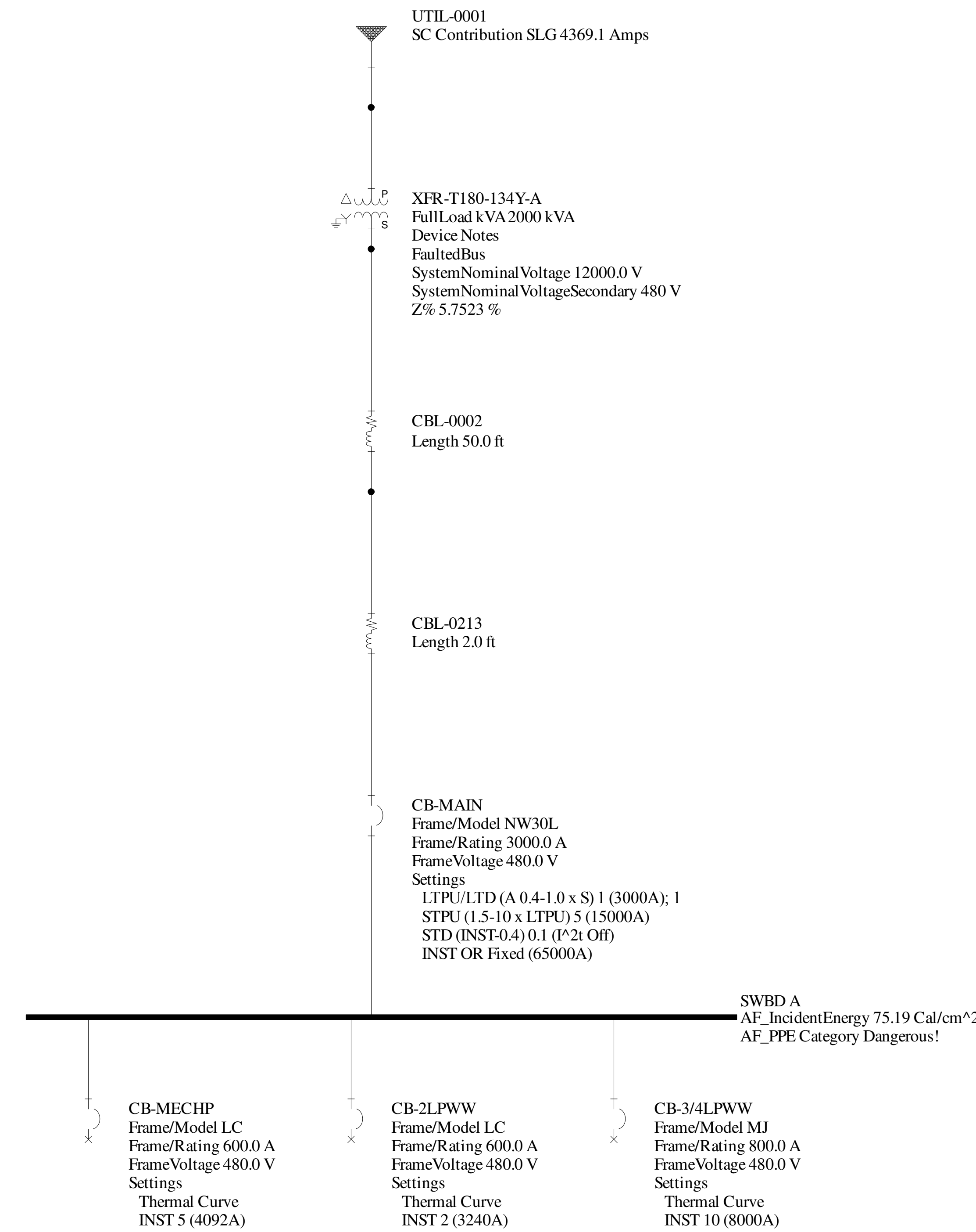

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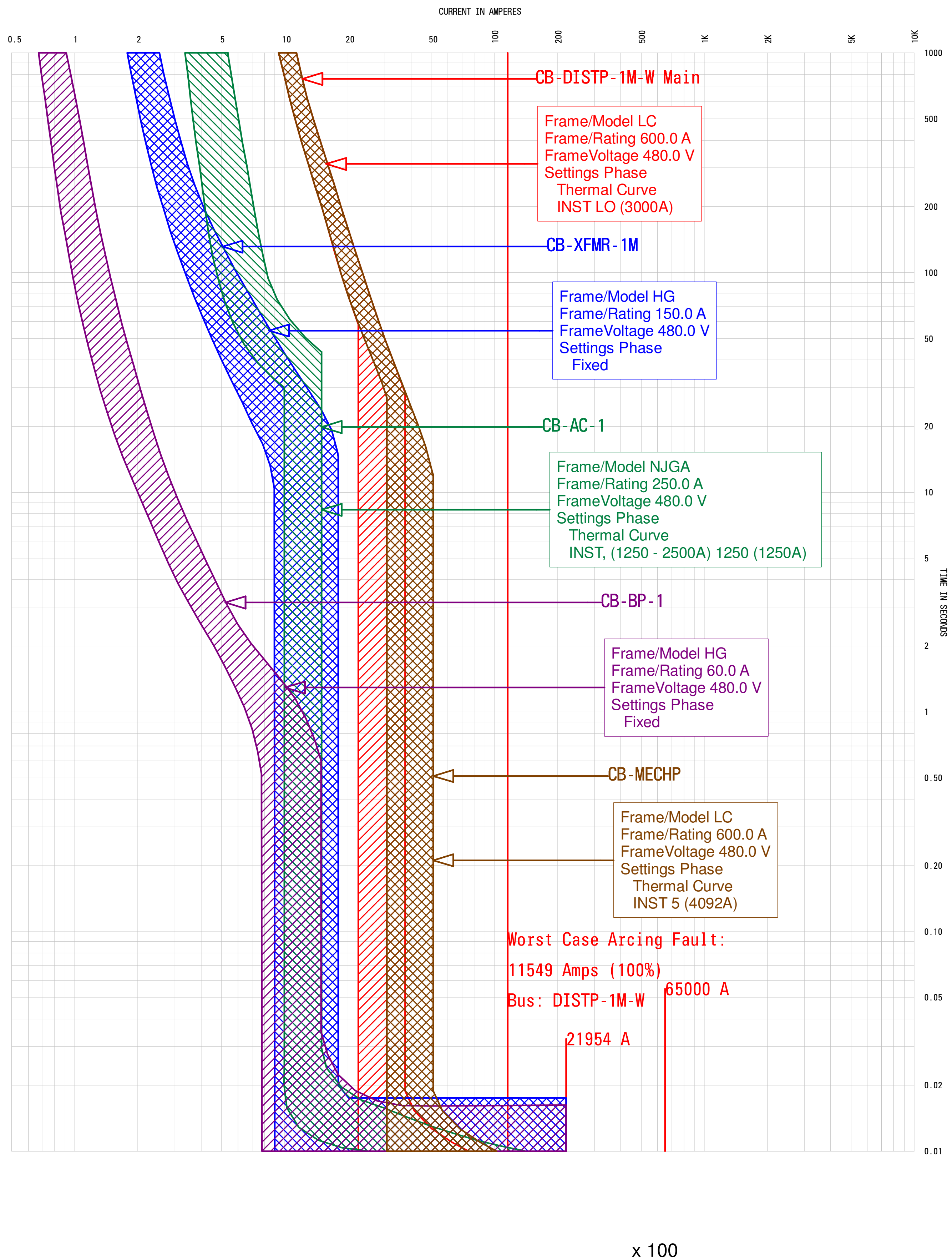
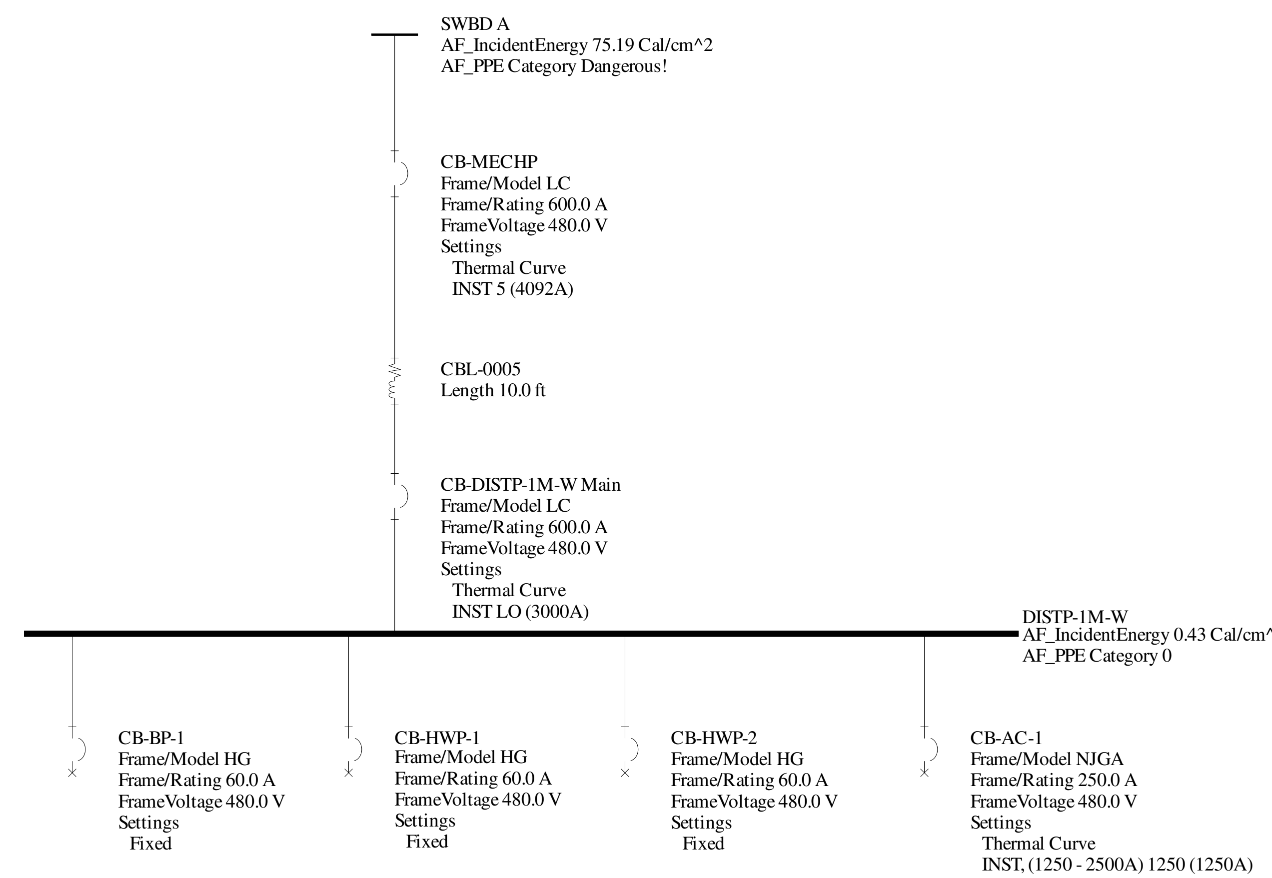
Oneline: SWBD-A

Reference Voltage: 480

May 21, 2015





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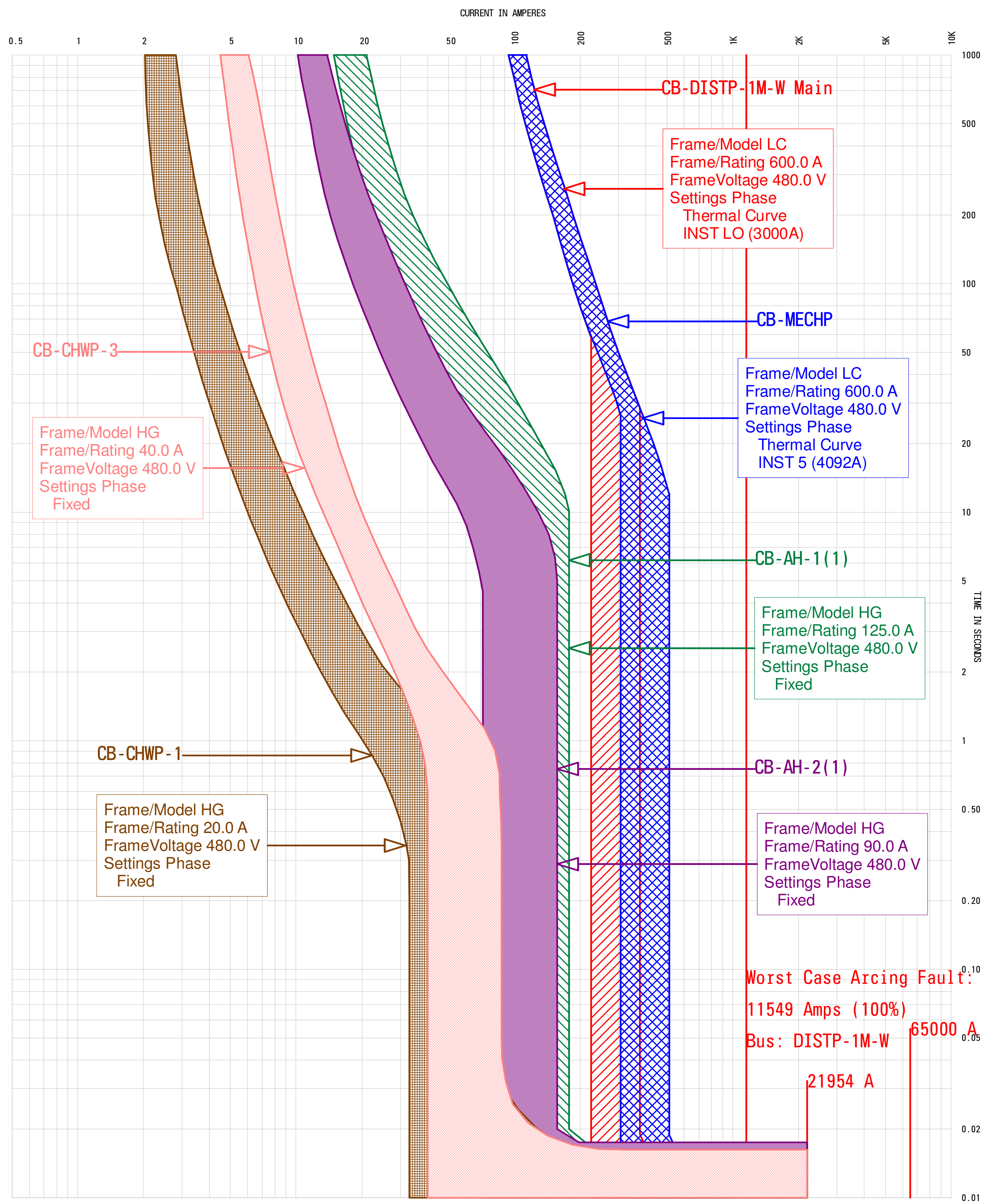

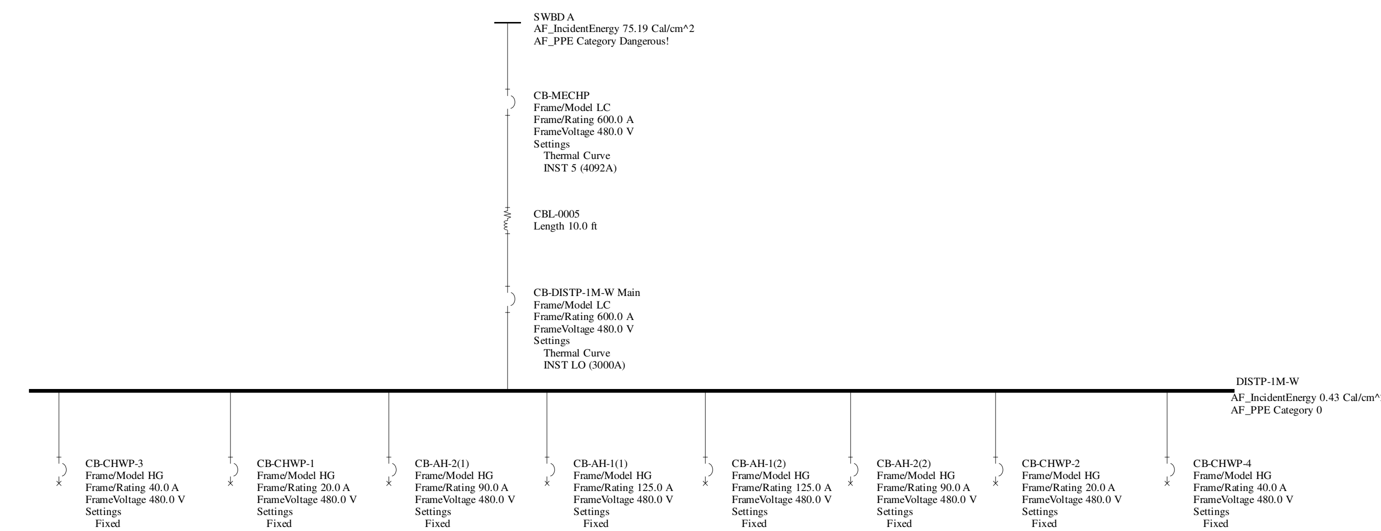

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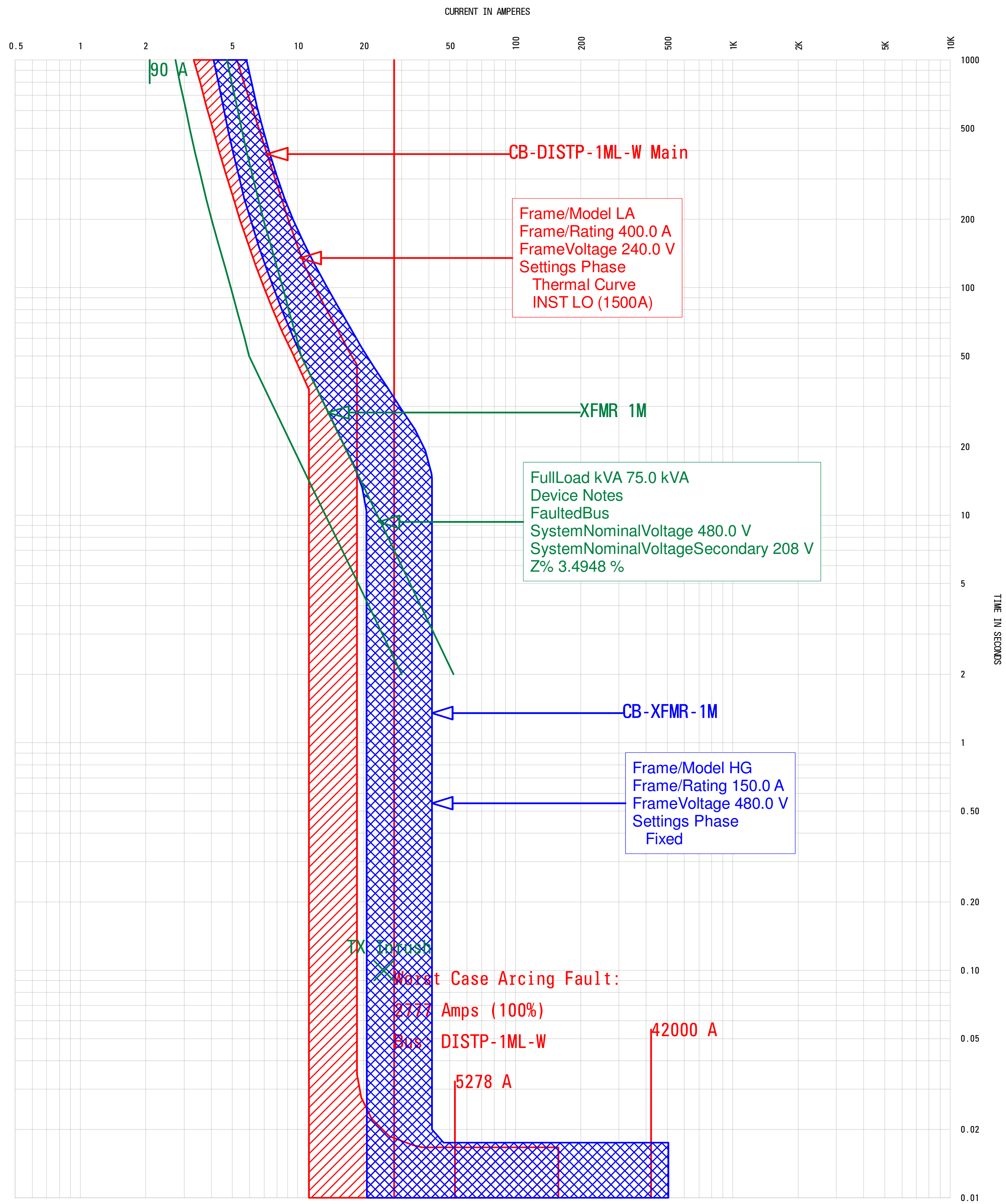
May 21, 2015



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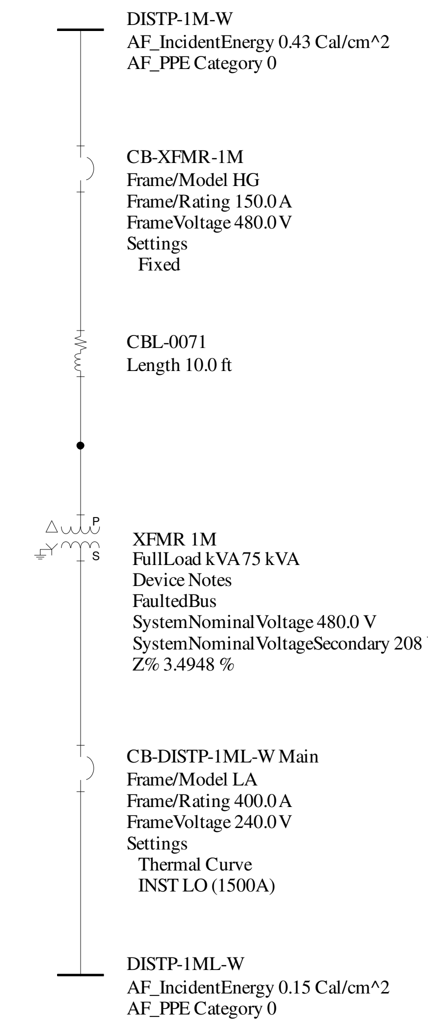

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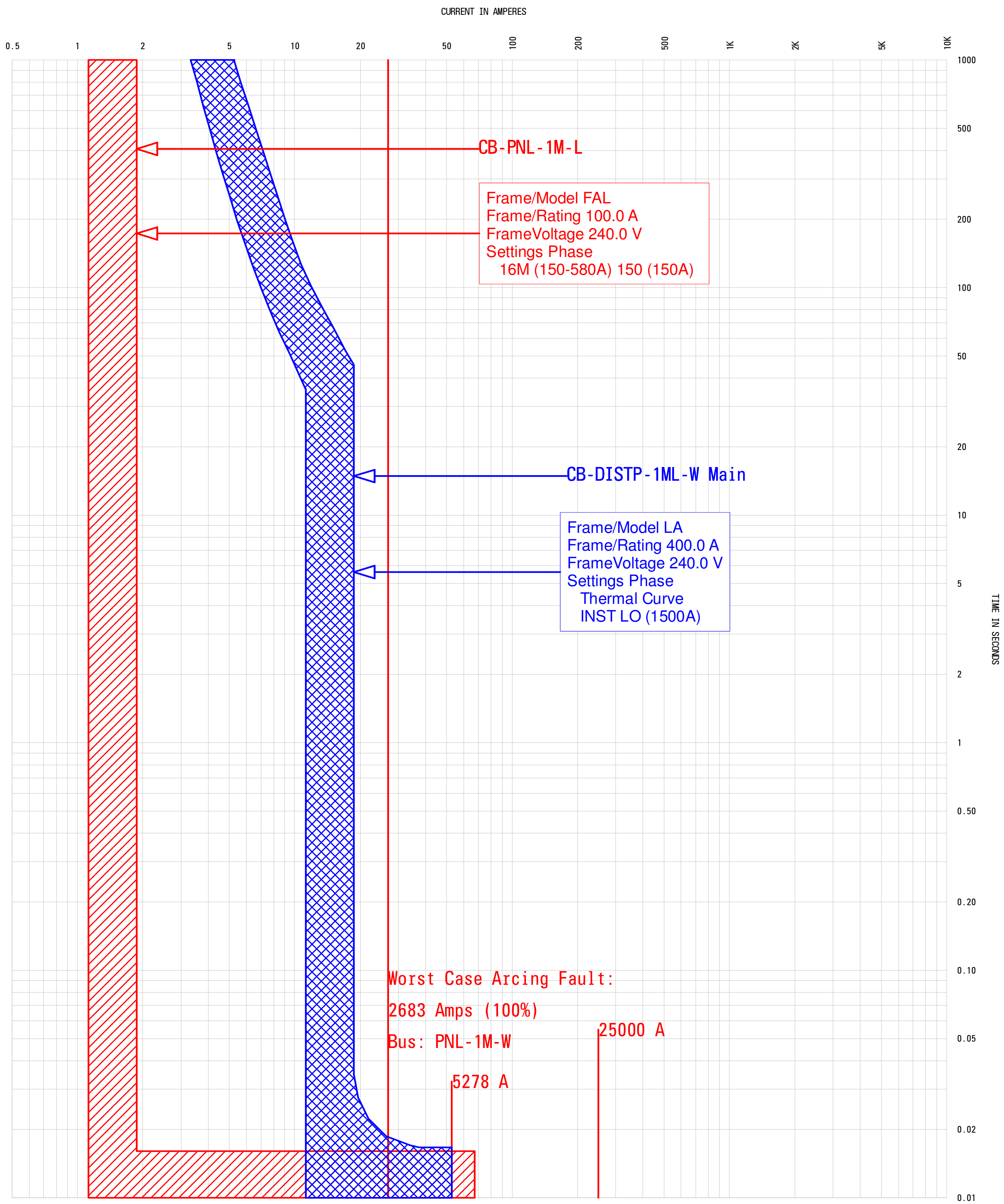
Reference Voltage: 208

May 21, 2015



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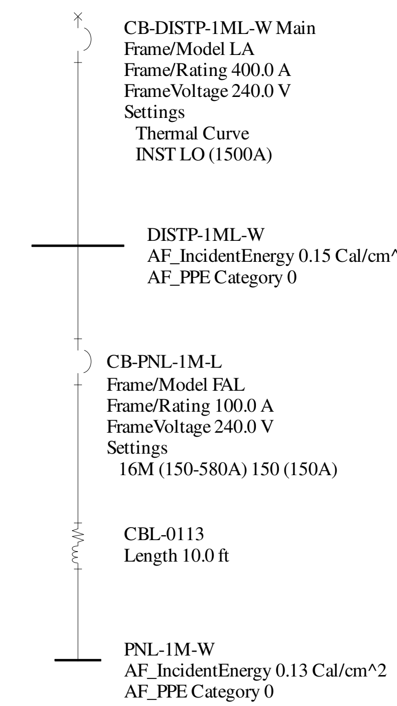

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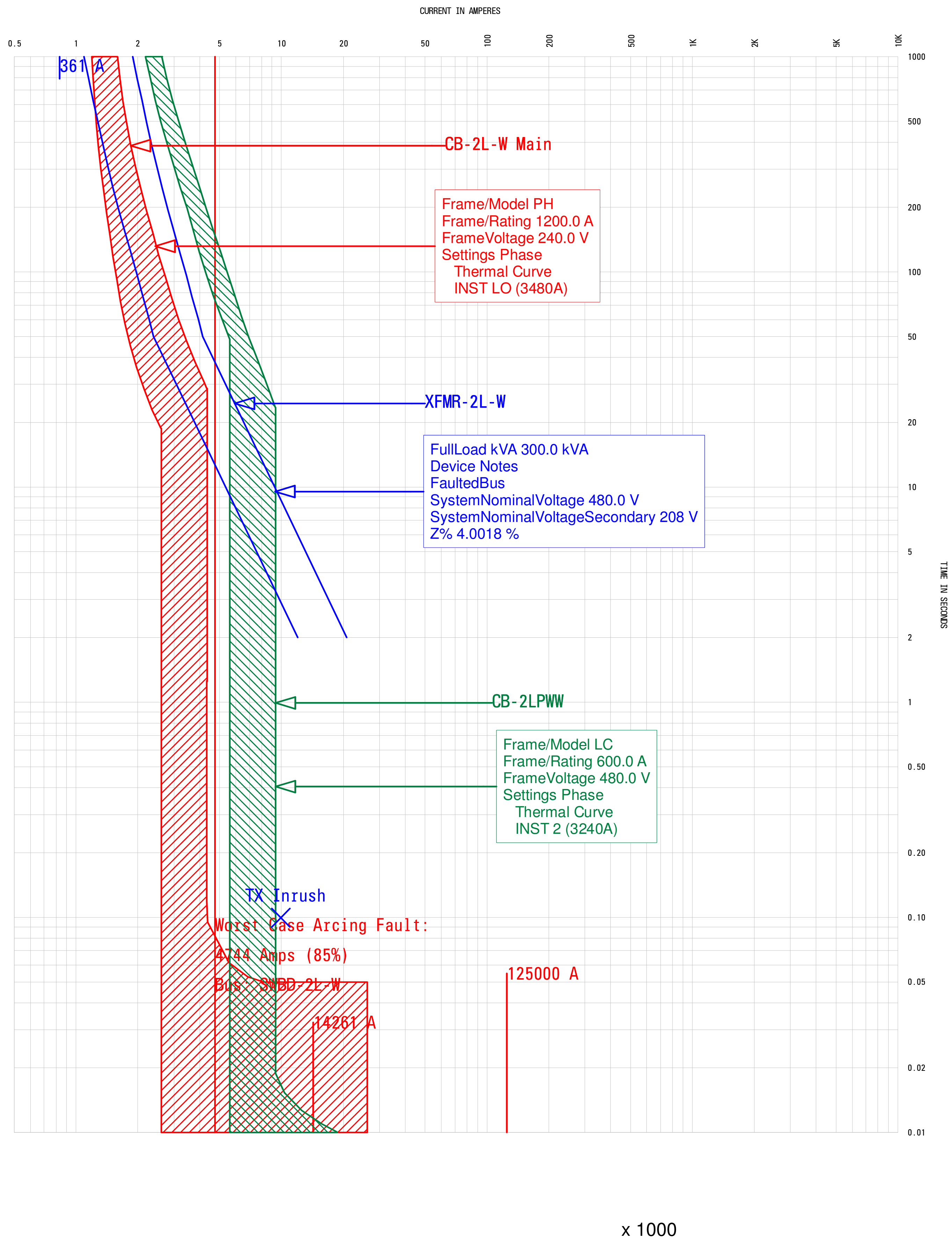
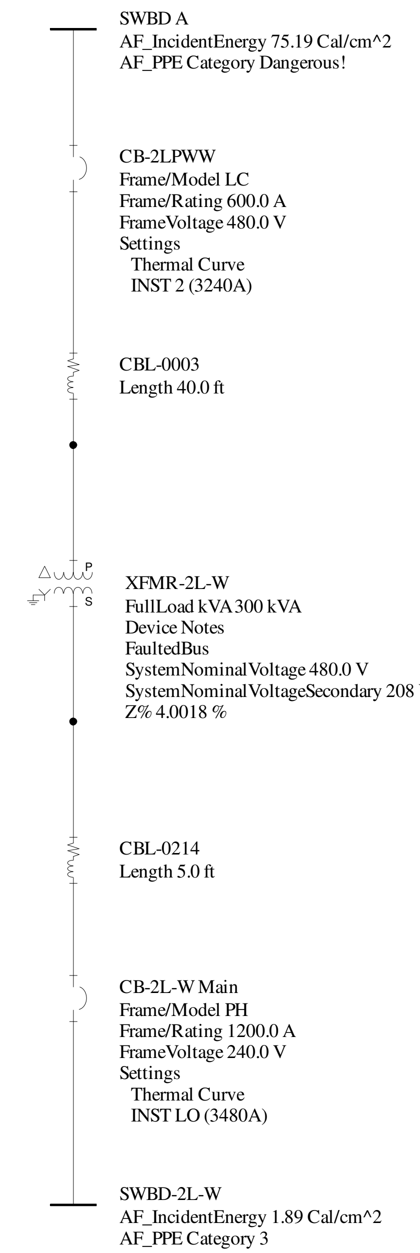
Oneline: PNL-1M-W

Reference Voltage: 208

May 21, 2015





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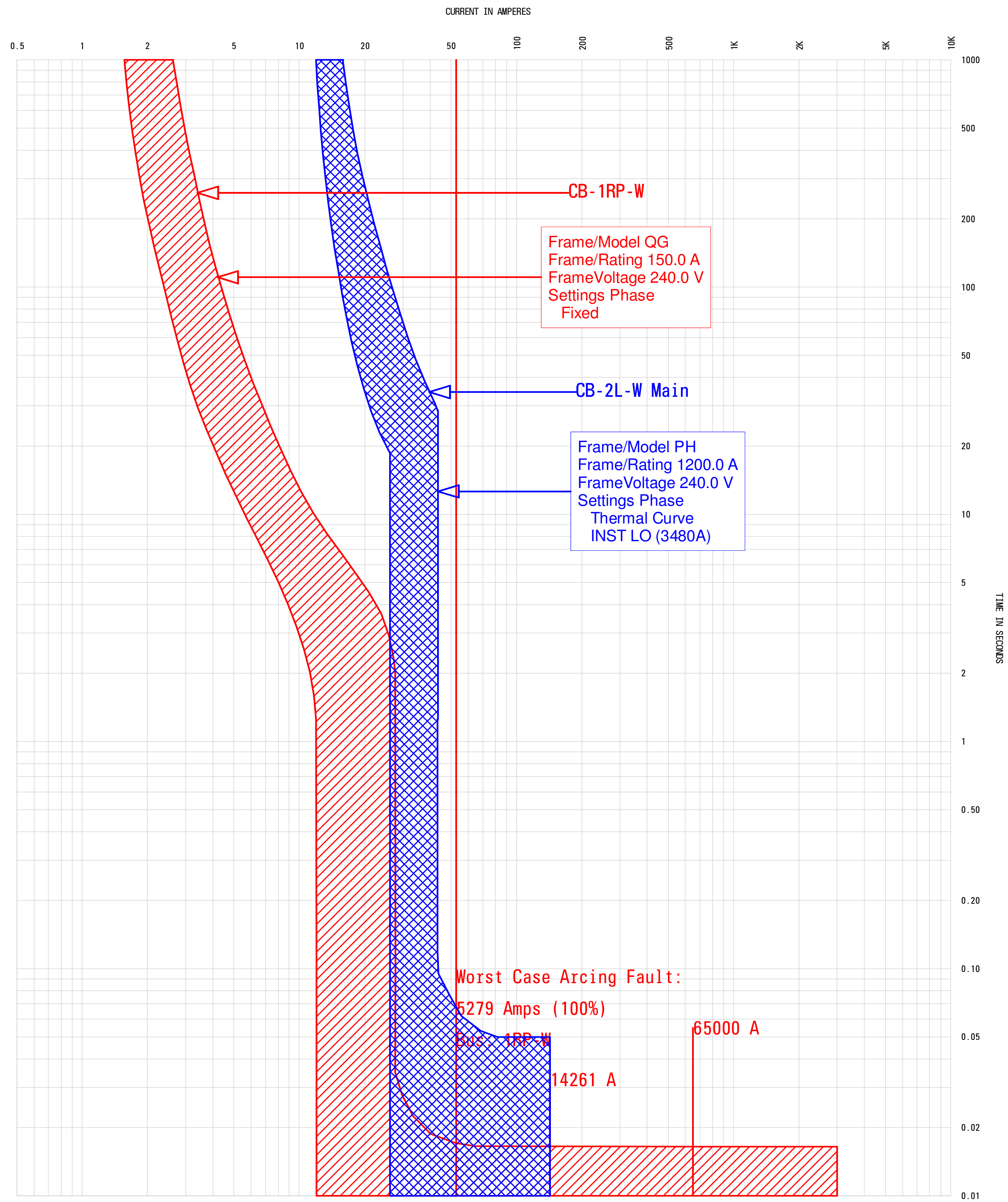
Oneline: SWBD-2L-W

Reference Voltage: 208

May 21, 2015



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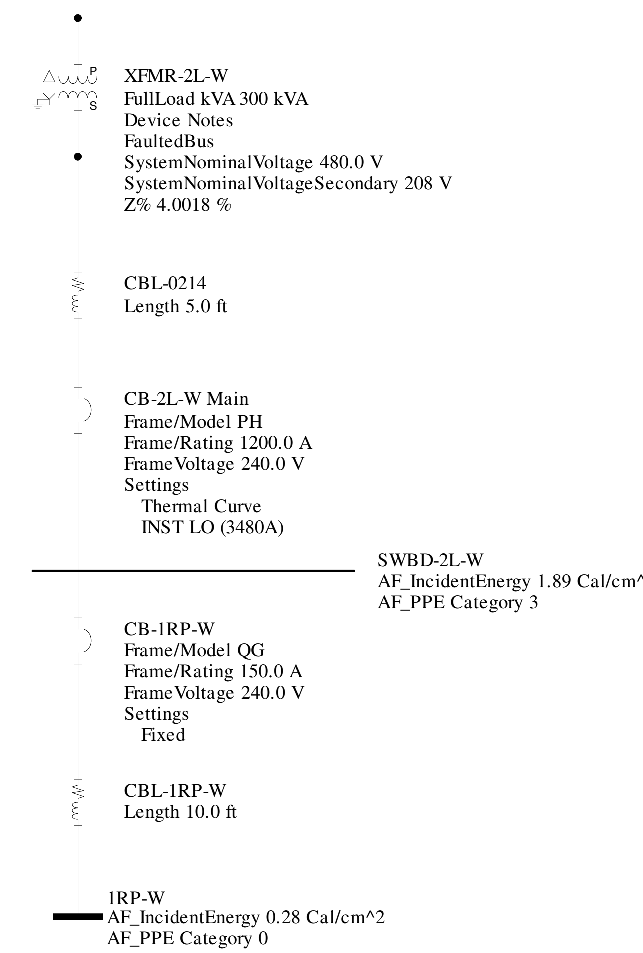

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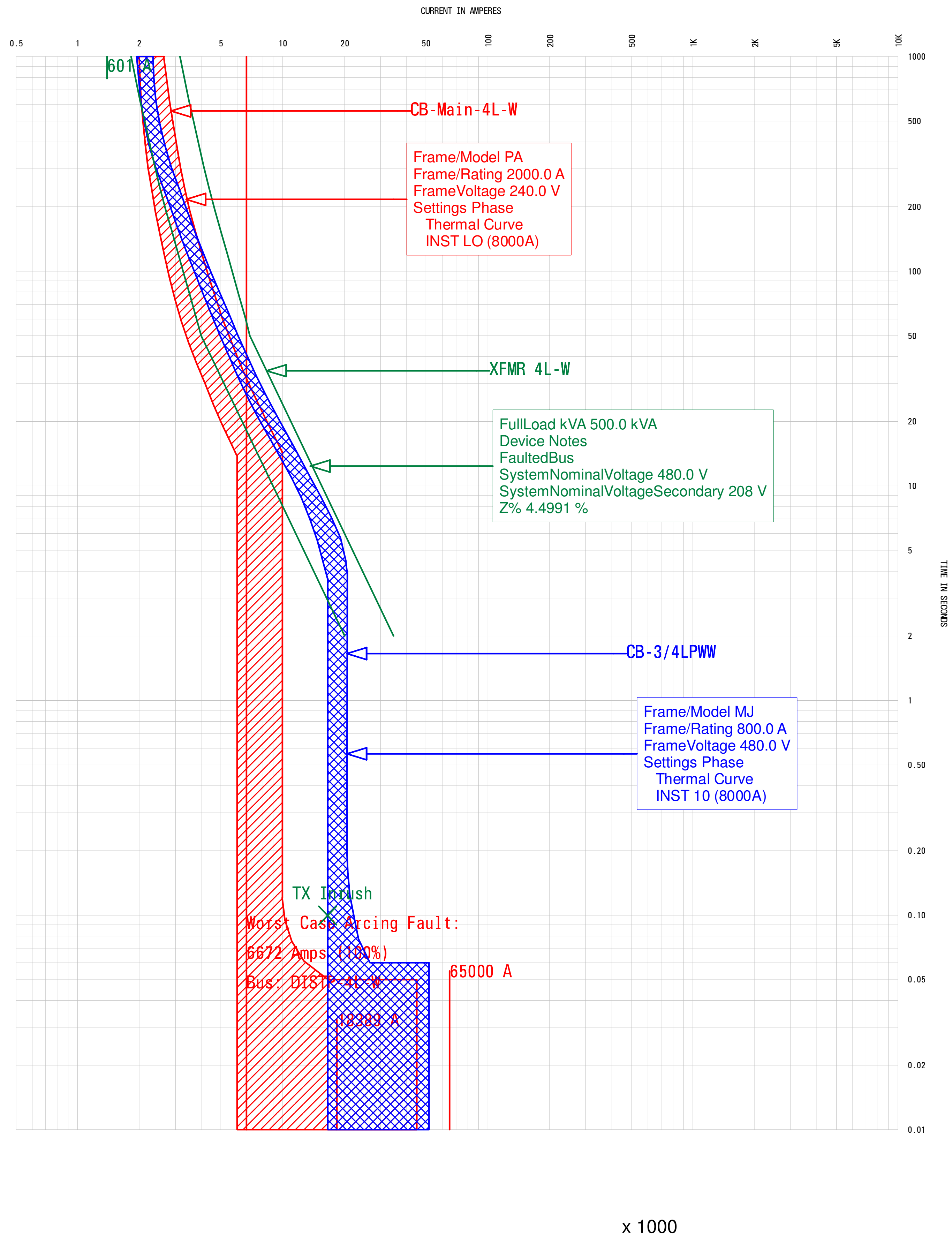
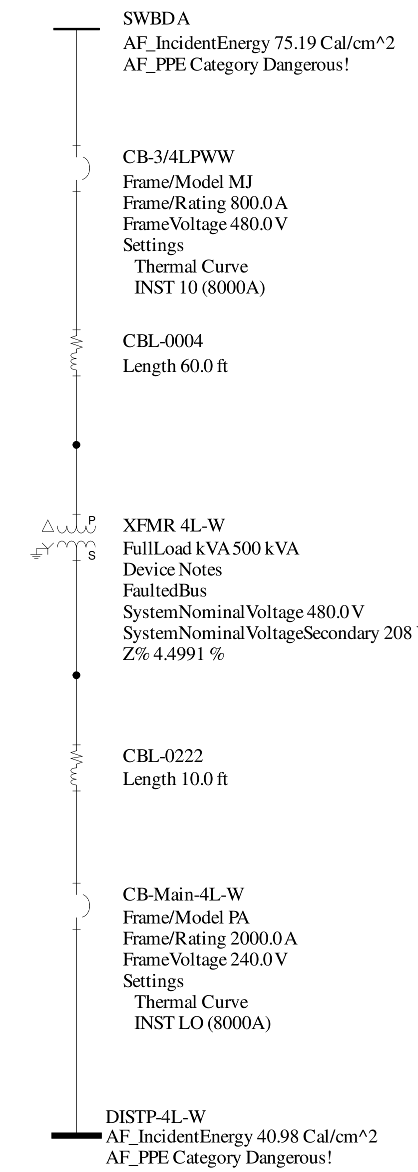
Oneline: 1RP-W

Reference Voltage: 208

May 21, 2015





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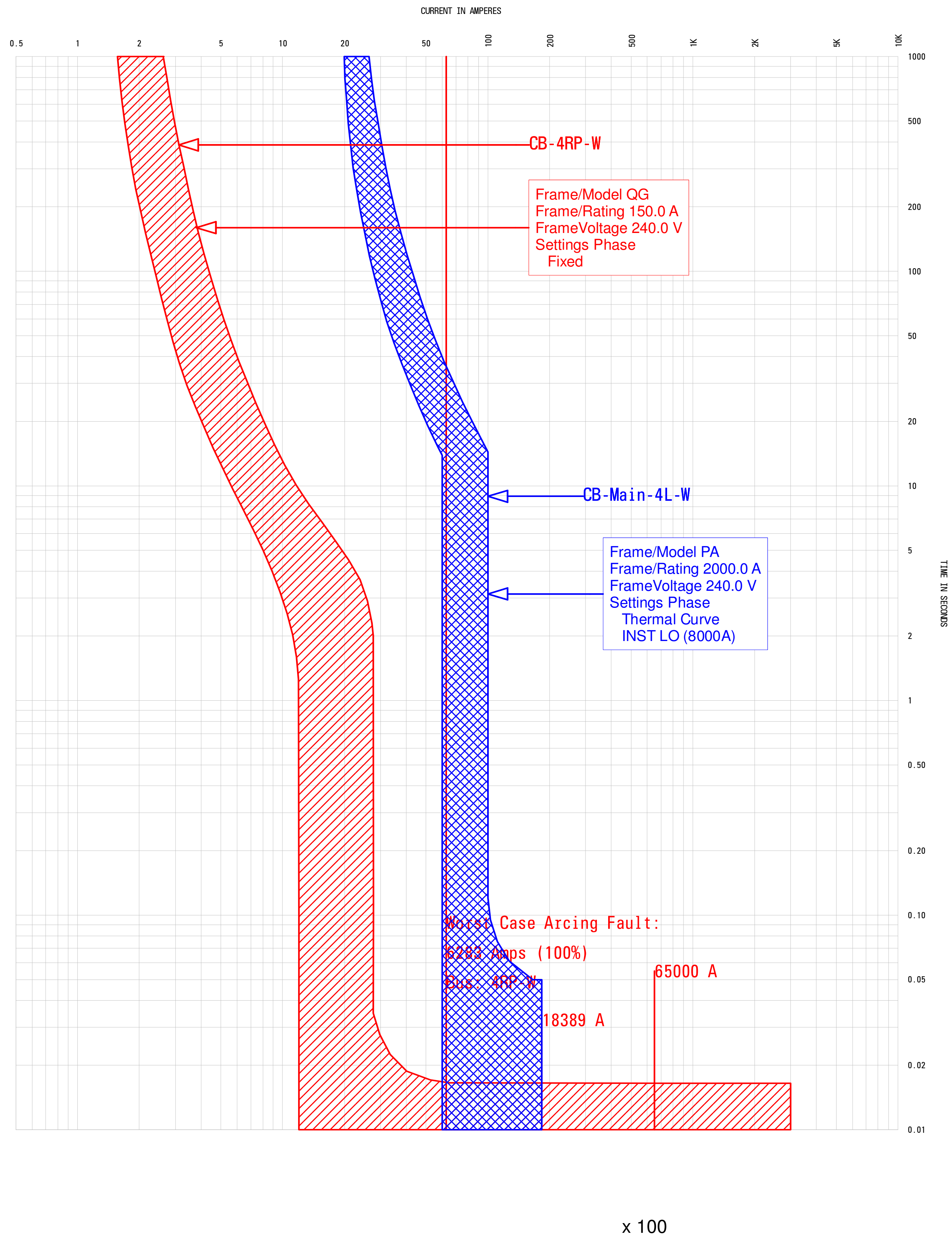
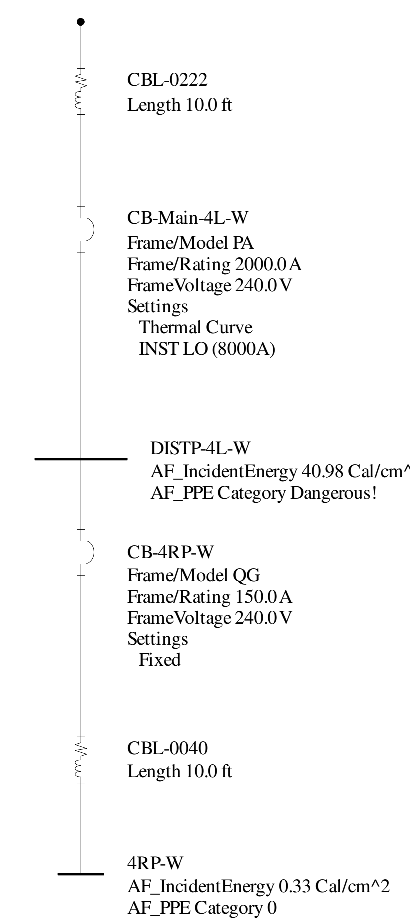
Reference Voltage: 208

May 21, 2015





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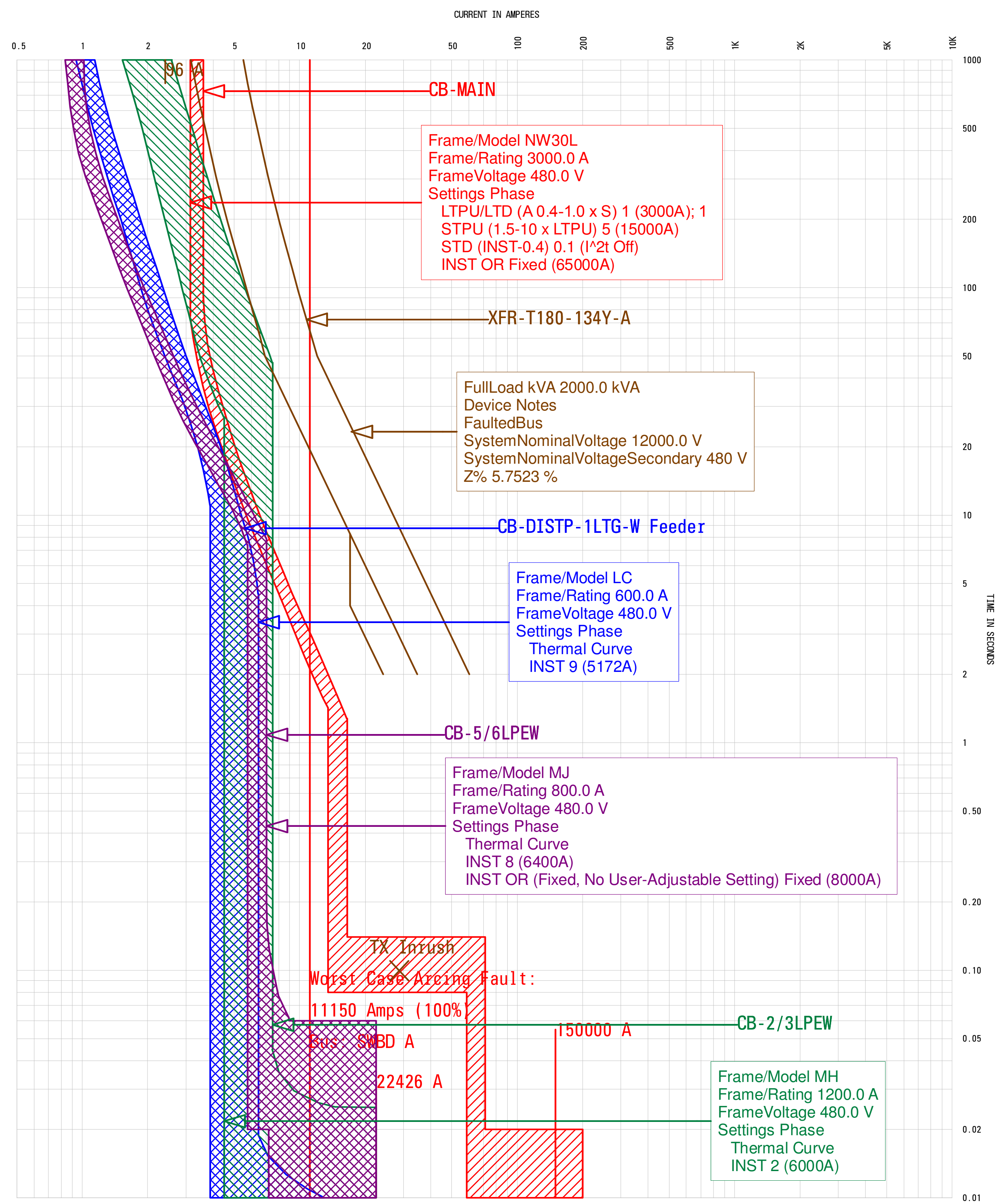
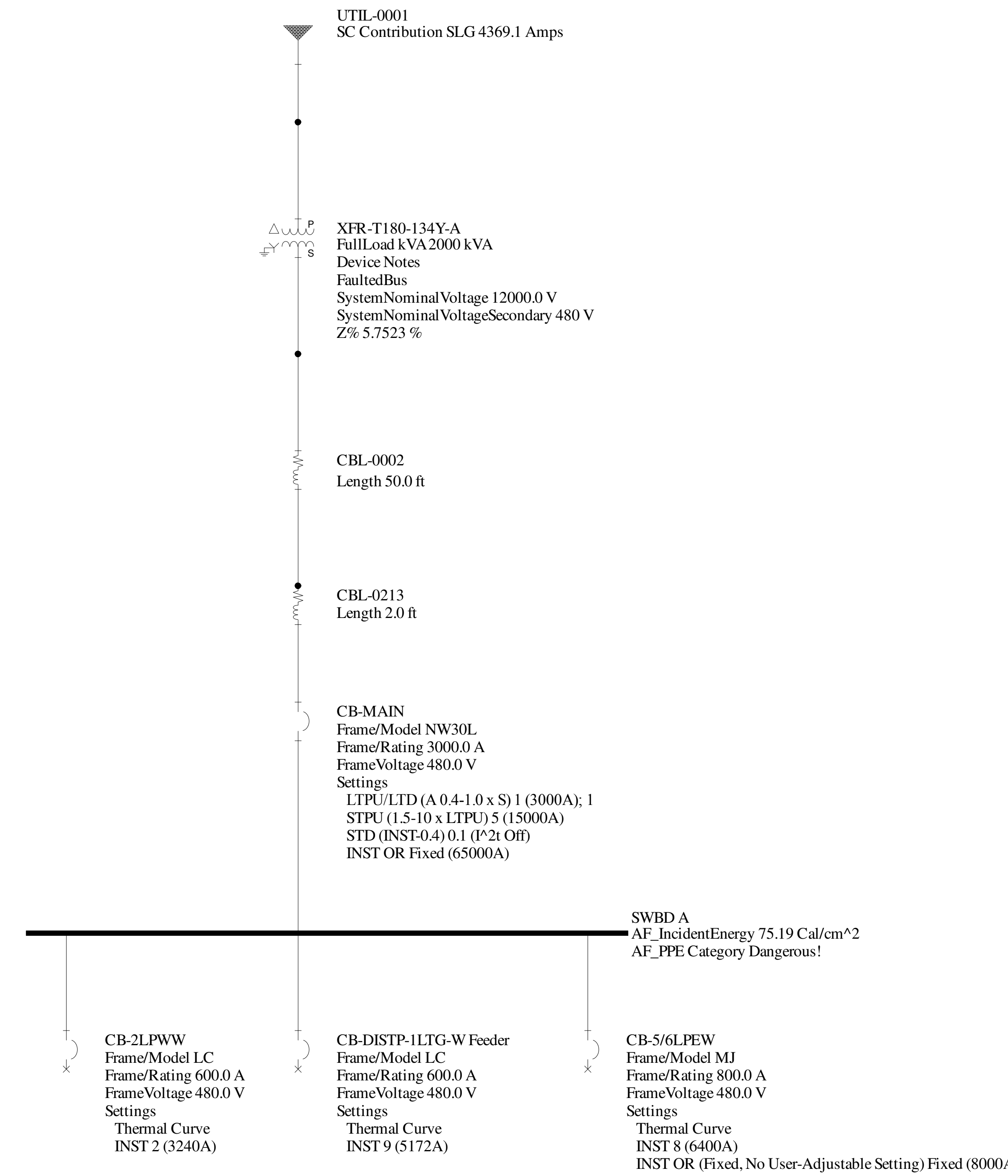
May 21, 2015



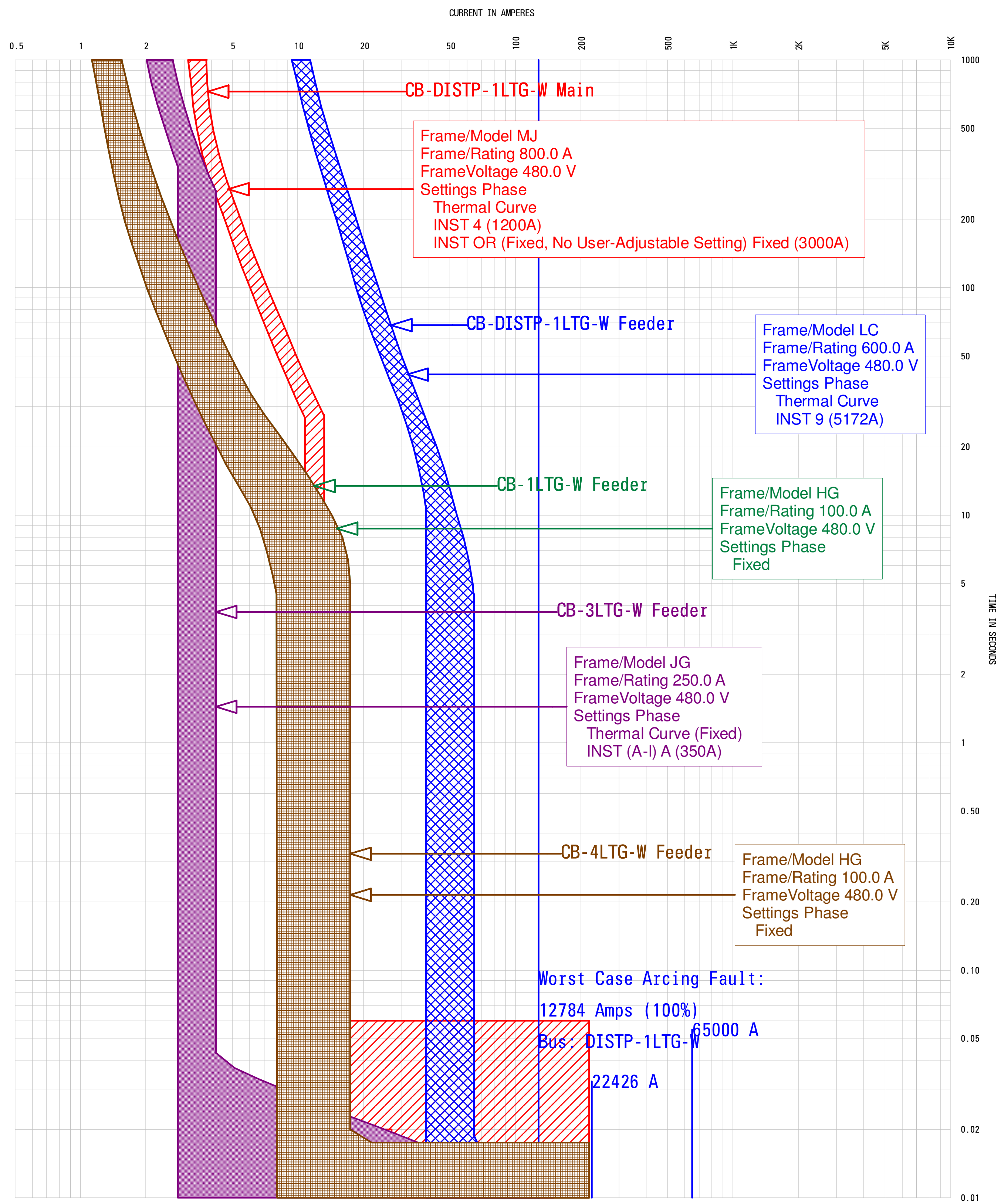


x 1000

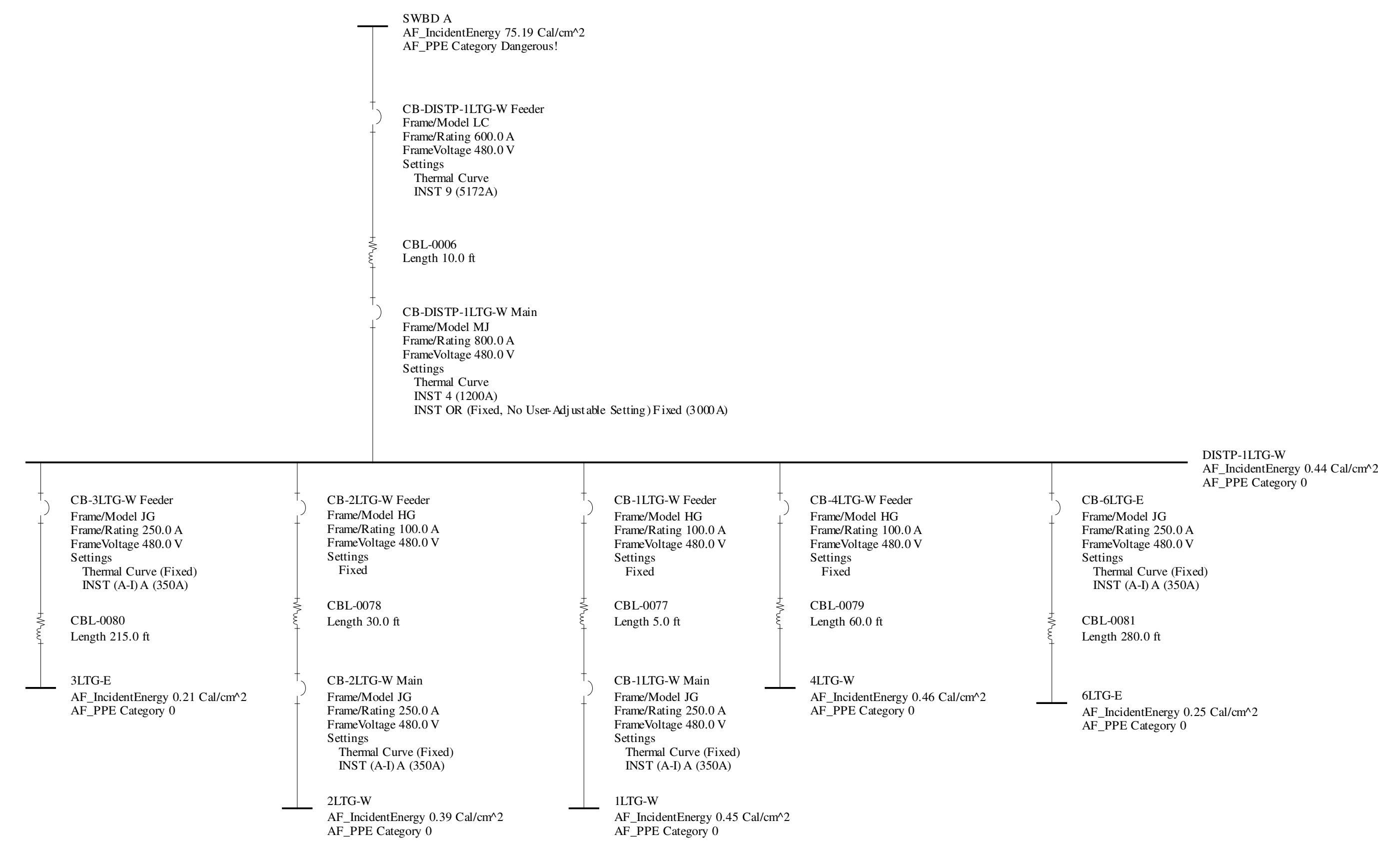
TCC Name: SWBD-A(2)
Oneline: SWDBD-A(2)

Reference Voltage: 480

May 21, 2015



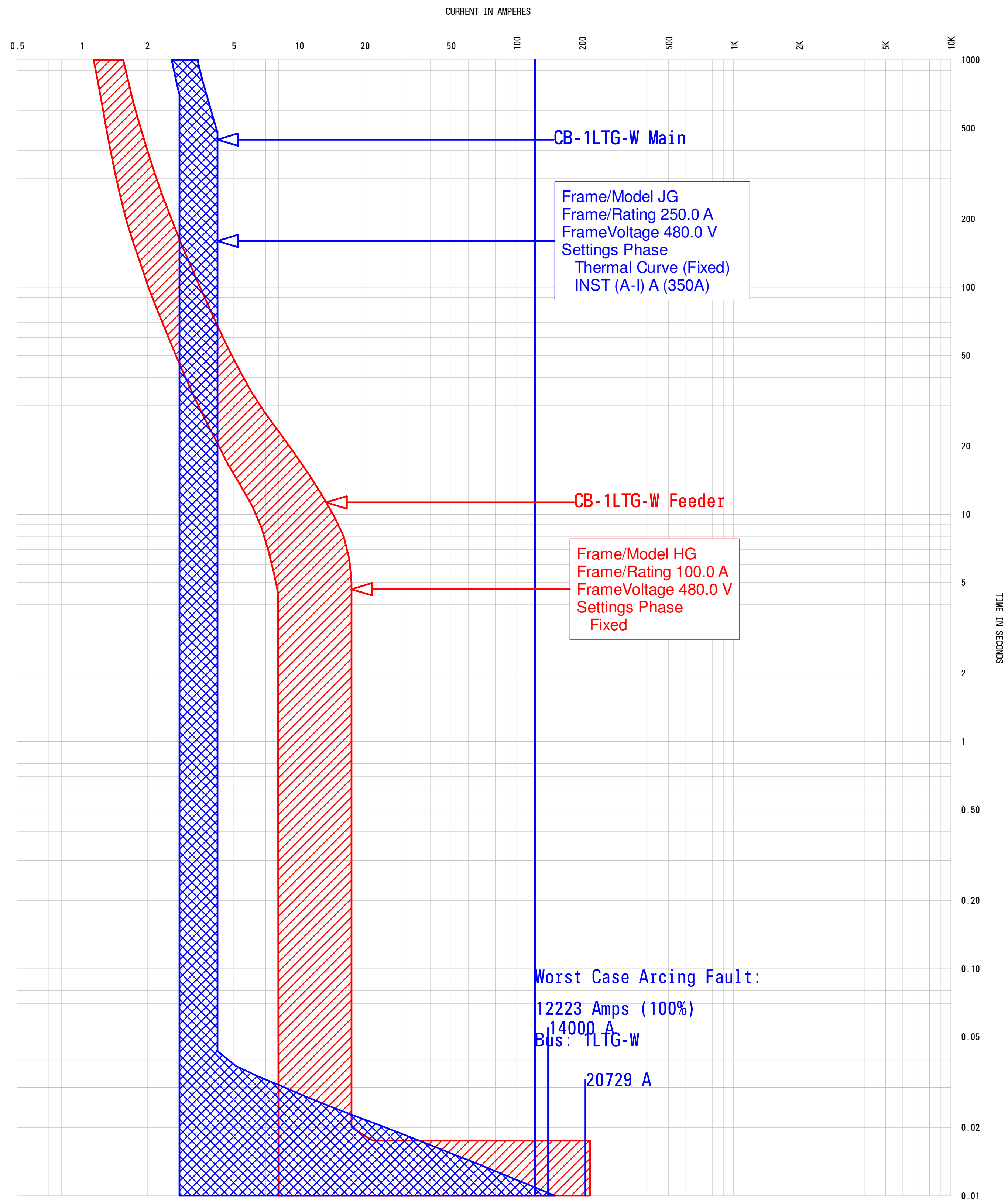
x 100

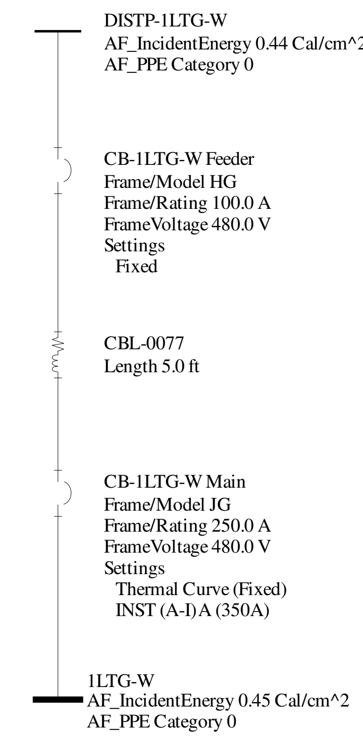


TCC Name: DISTP-1LTG-W
Oneline: DISTP-1LTG-W

Reference Voltage: 480

May 21, 2015



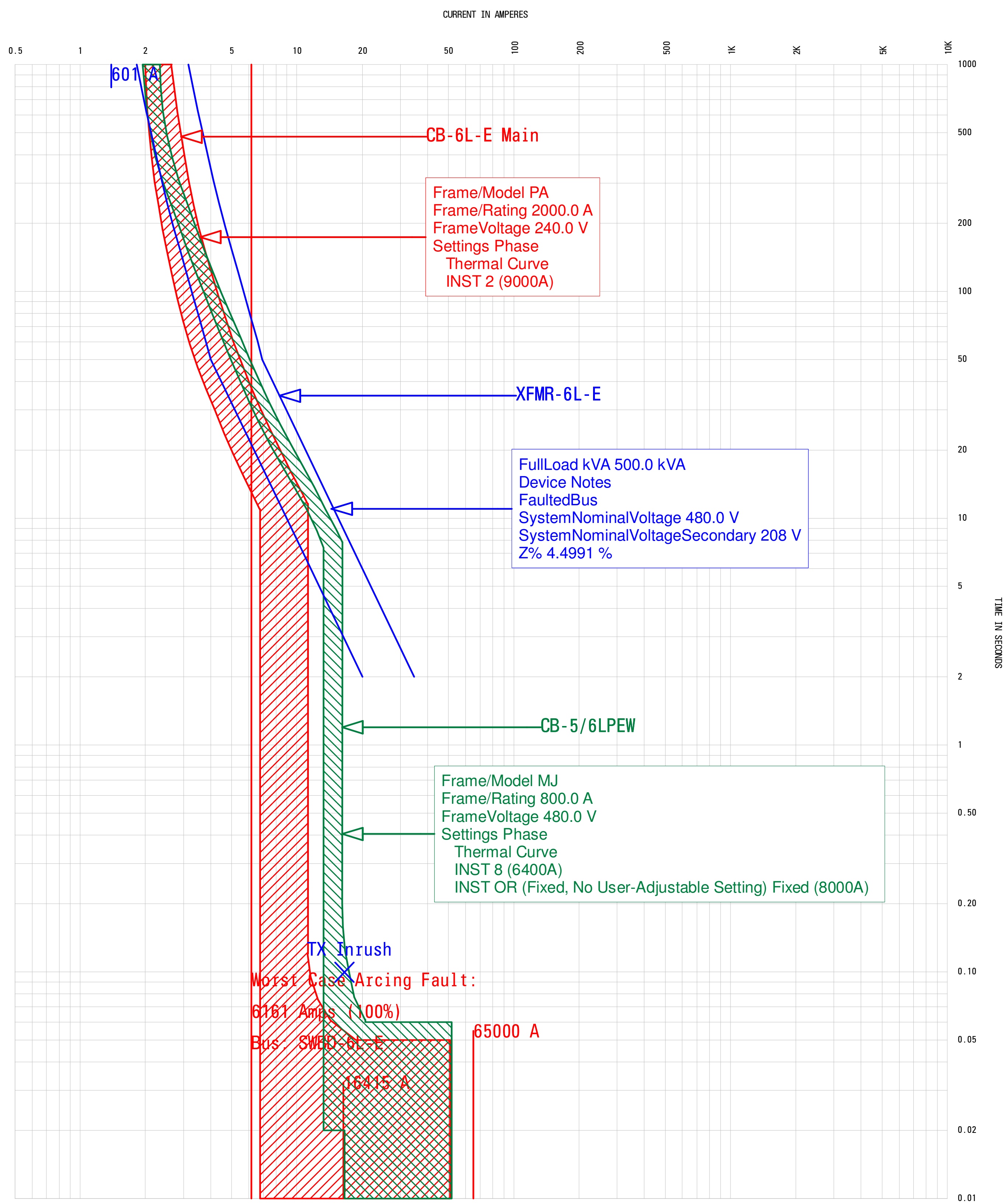


x 100

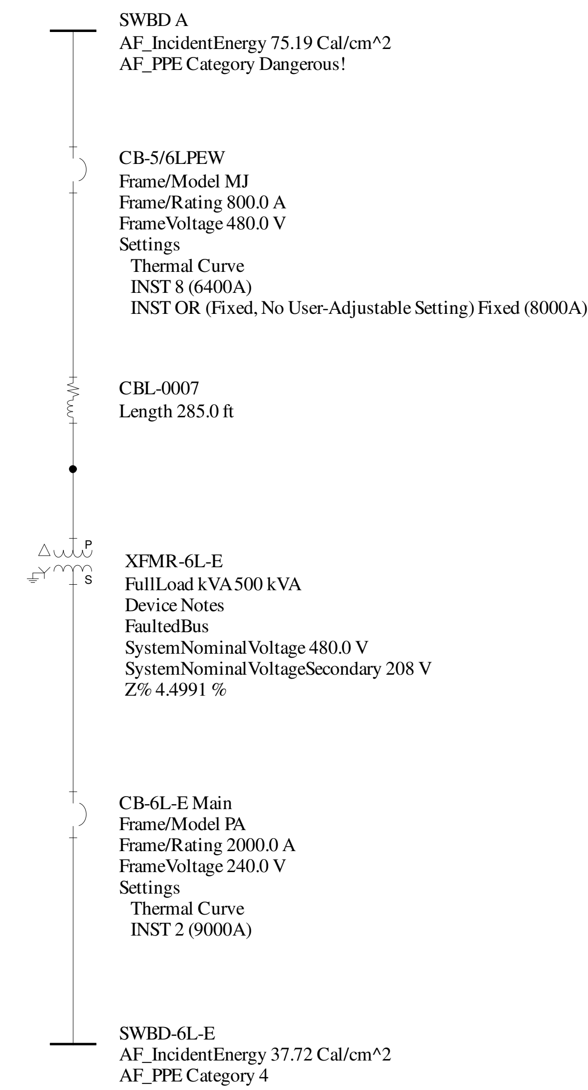
TCC Name: 1LTG-W
Oneline: 1LTG-W

Reference Voltage: 480

May 21, 2015



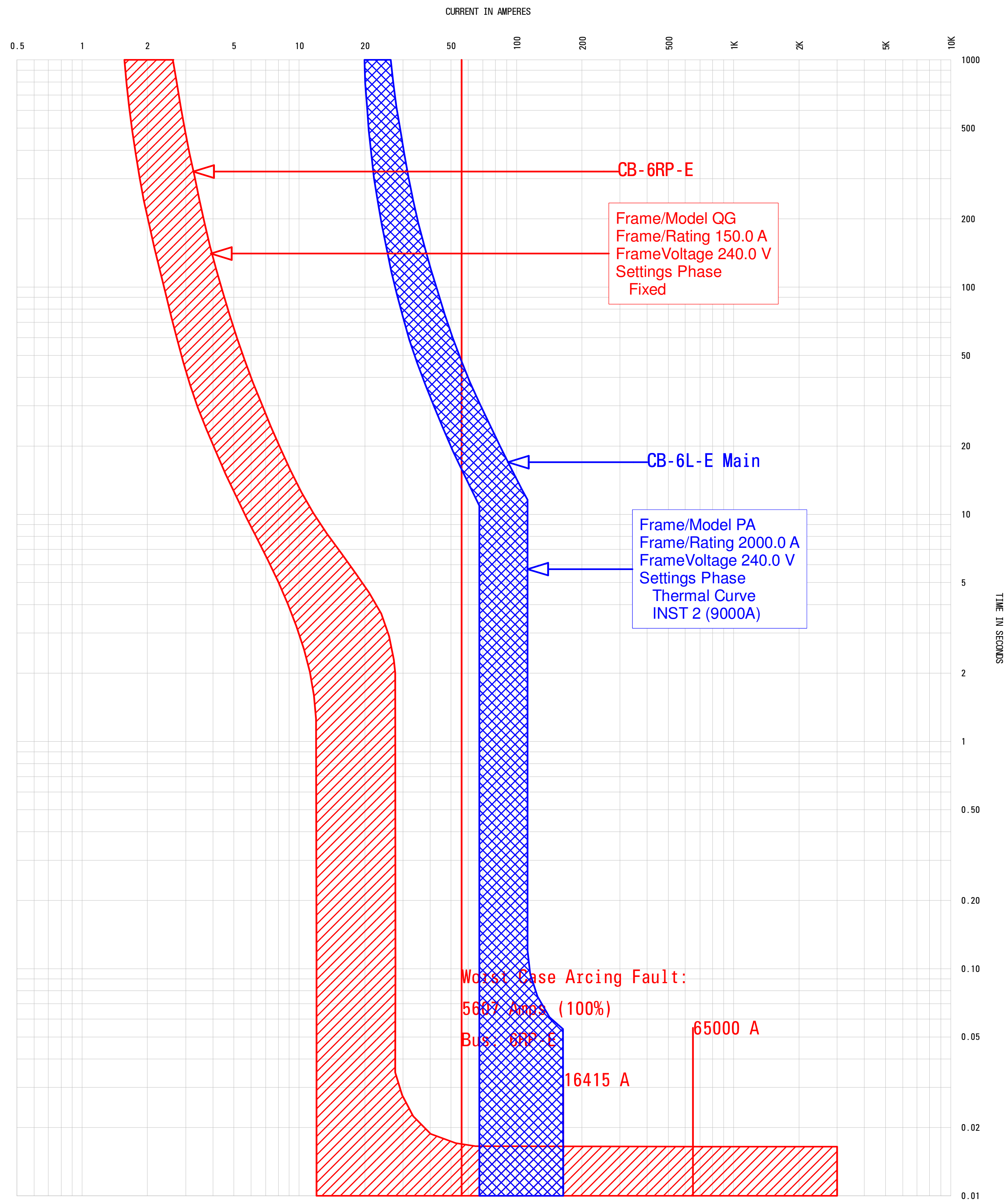
x 1000

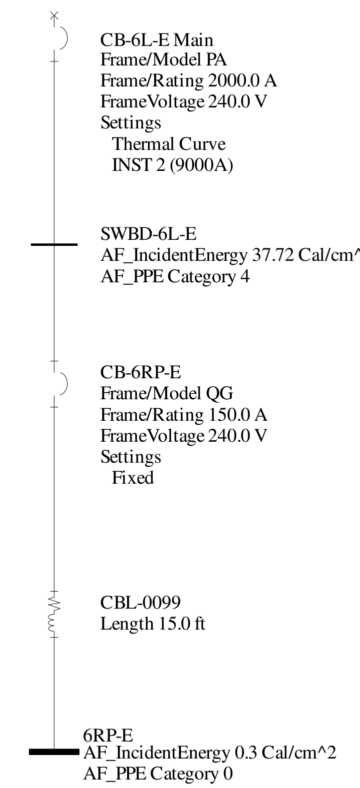


TCC Name: SWBD-6L-E
Oneline: SWBD-6L-E

Reference Voltage: 208

May 21, 2015



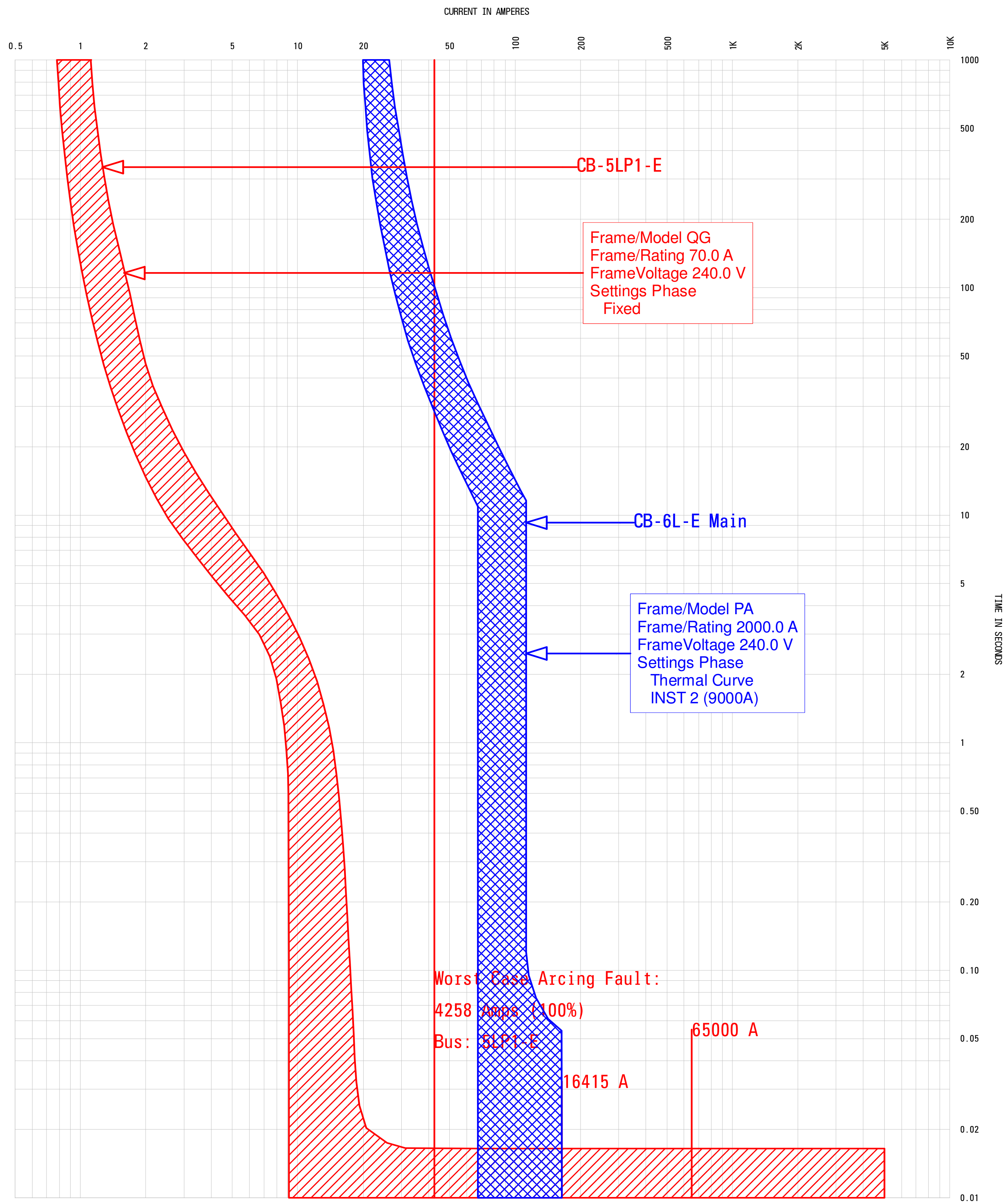


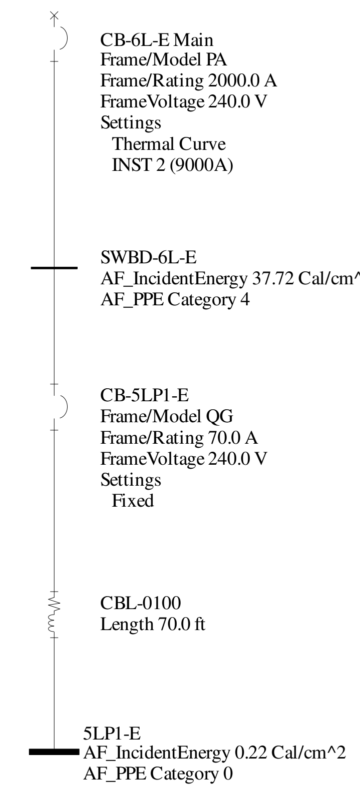
x 100

TCC Name: 6RP-E
Oneline: 6RP-E

Reference Voltage: 208

May 21, 2015



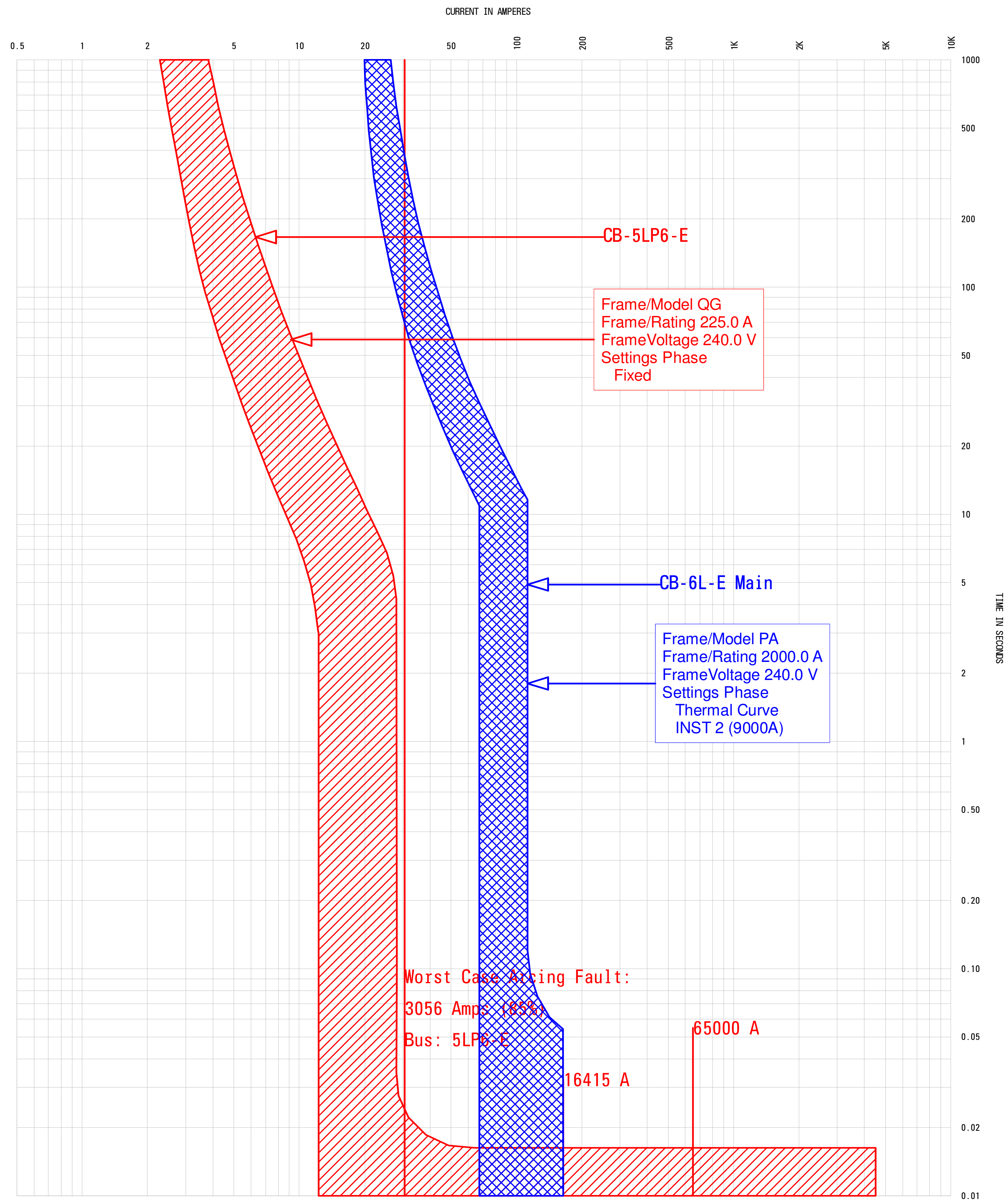


x 100

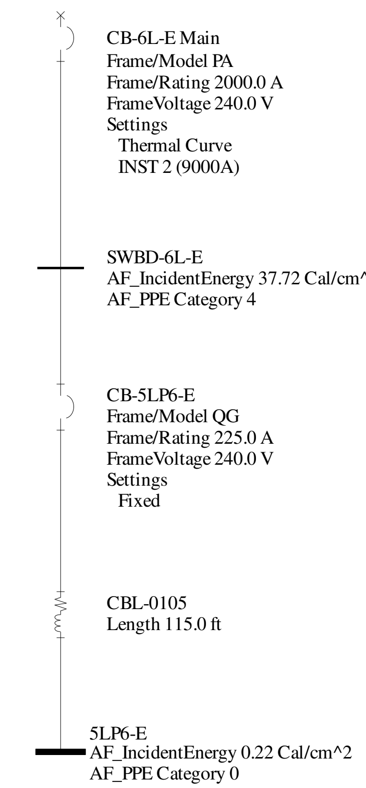
TCC Name: 5LP1-E
Oneline: 5LP1-E

Reference Voltage: 208

May 21, 2015



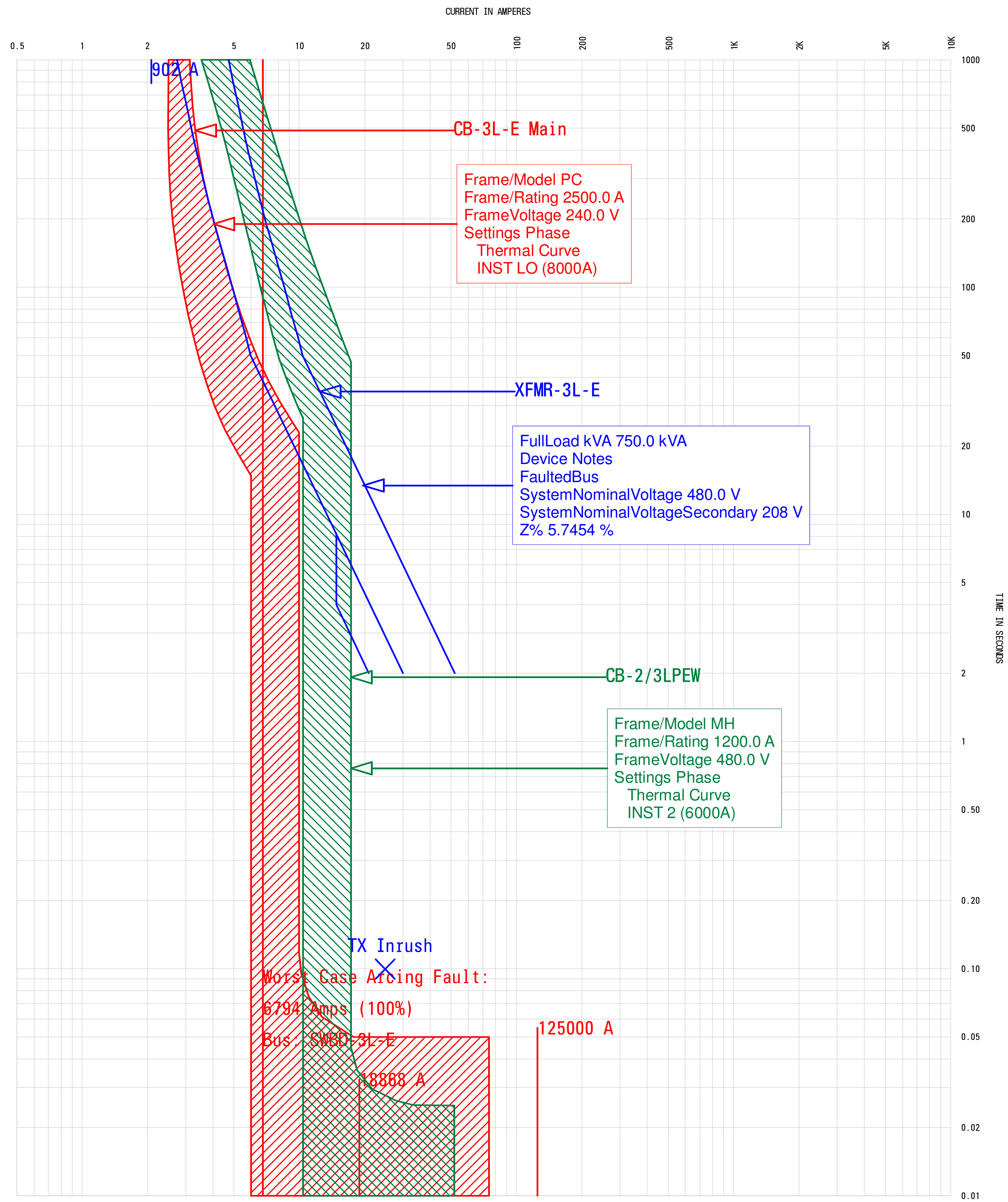
x 100



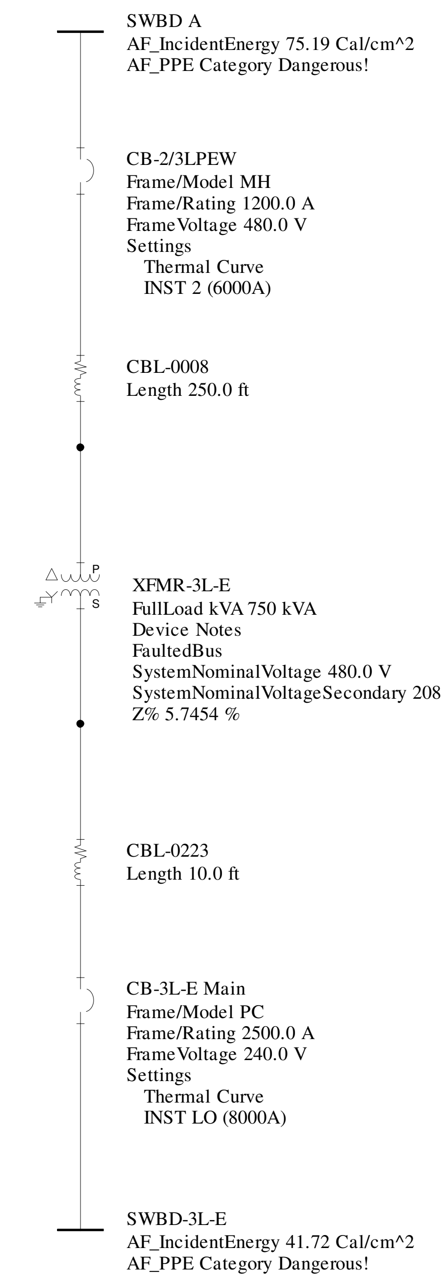
TCC Name: 5LP6-E
Oneline: 5LP6-E

Reference Voltage: 208

May 21, 2015



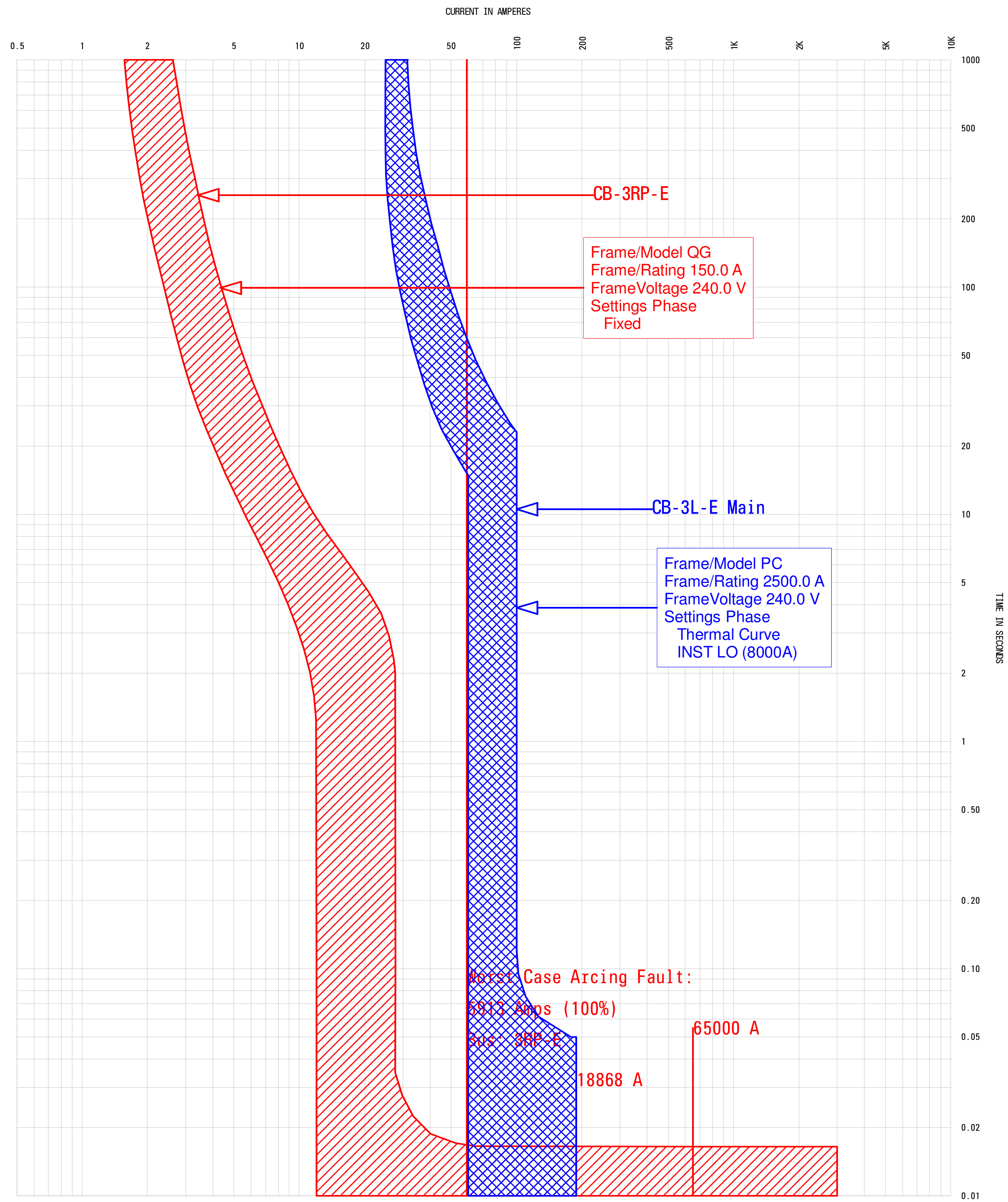
x 1000

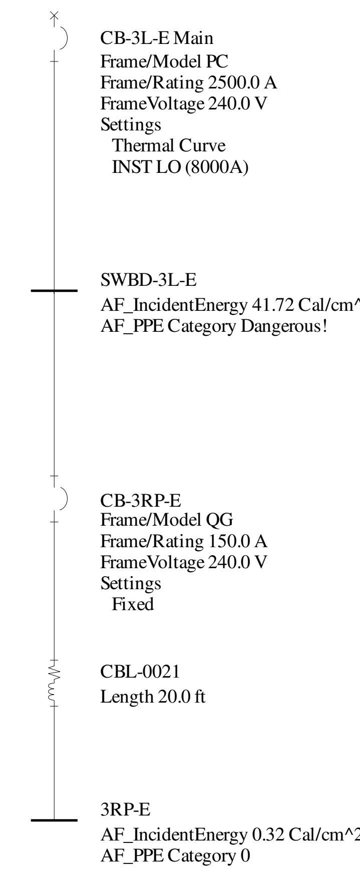


TCC Name: SWBD-3L-E
Oneline: SWBD-3L-E

Reference Voltage: 208

May 21, 2015



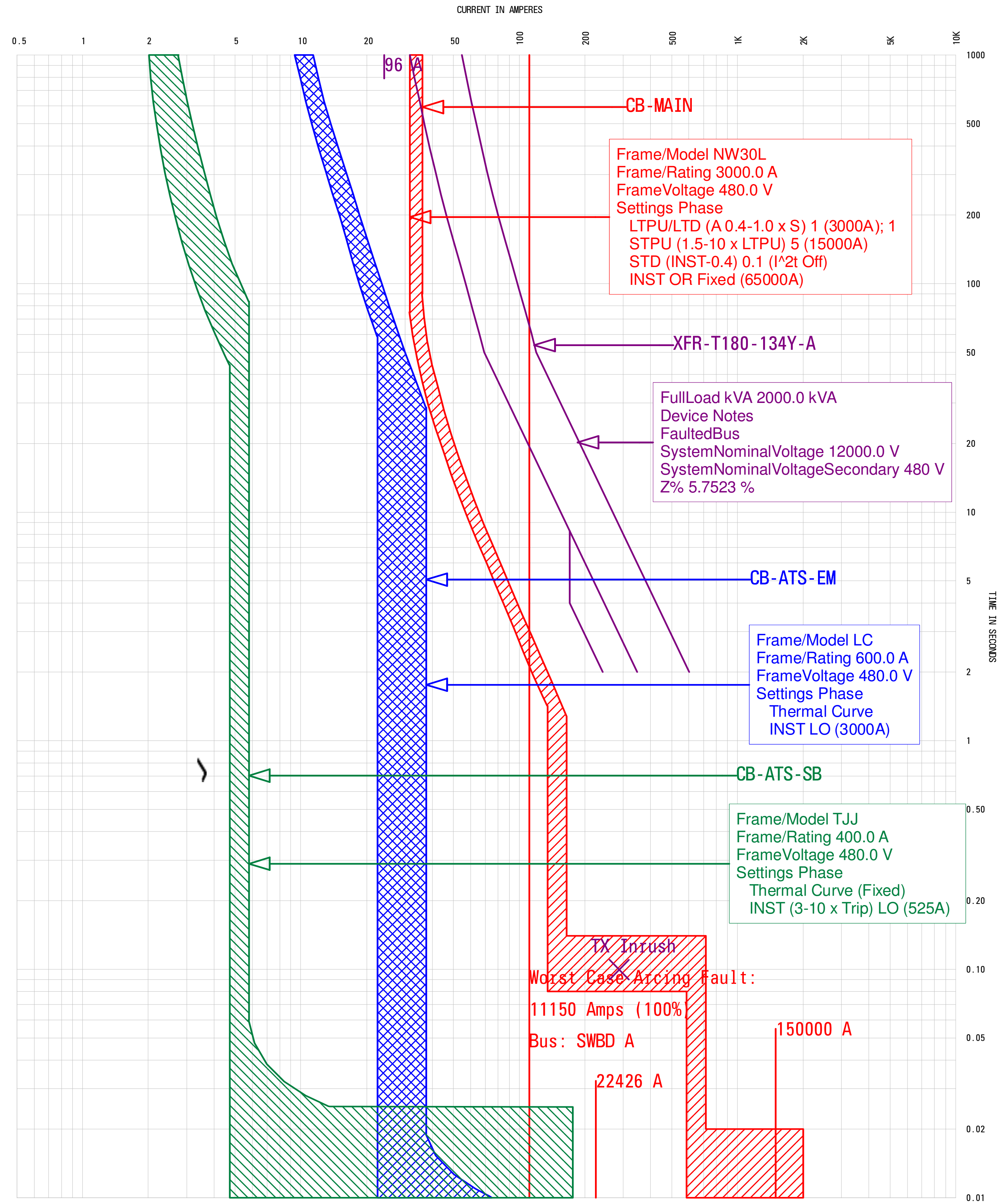


x 100

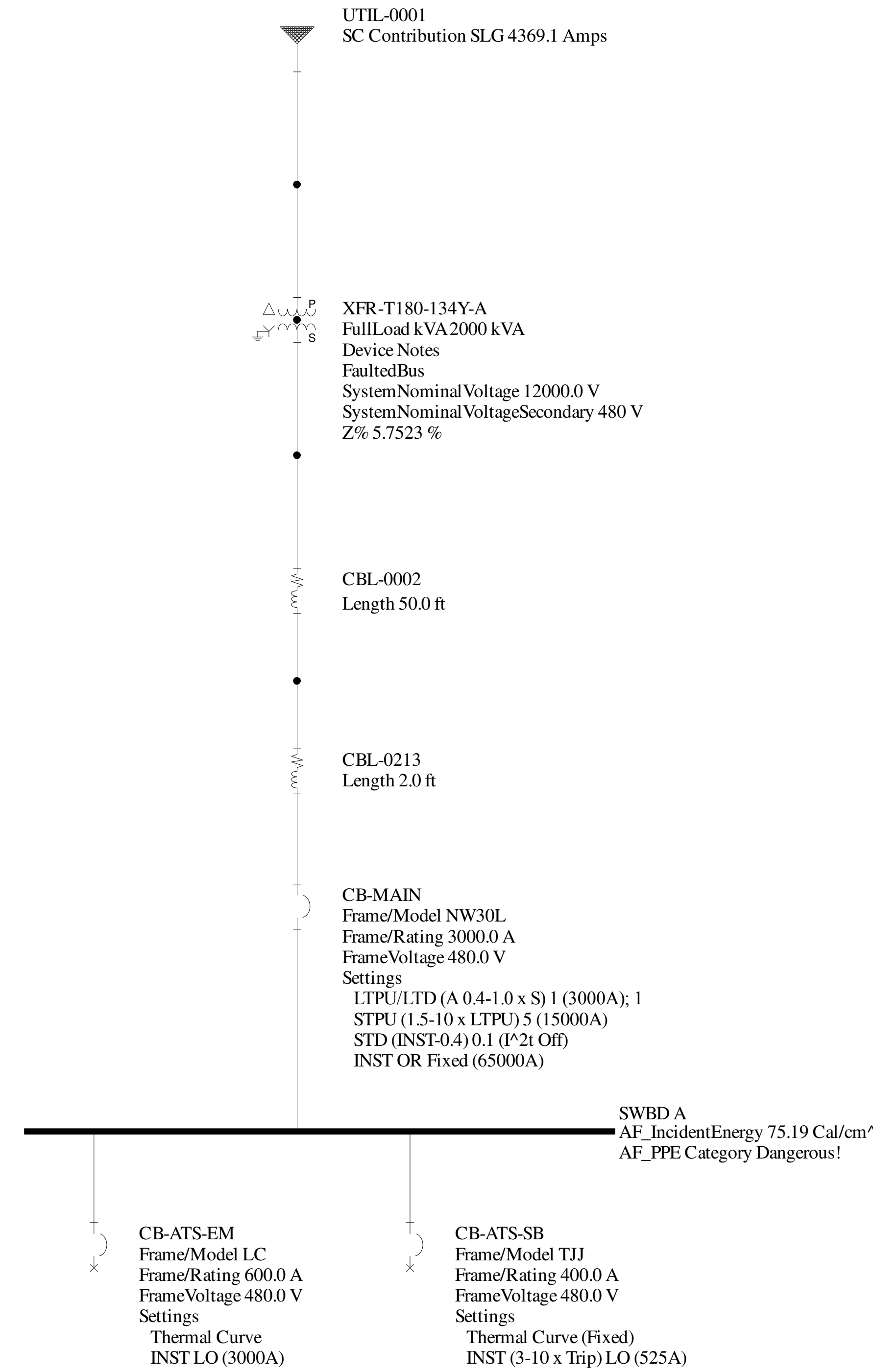
TCC Name: 3RP-E
Oneline: 3RP-E

Reference Voltage: 208

May 21, 2015



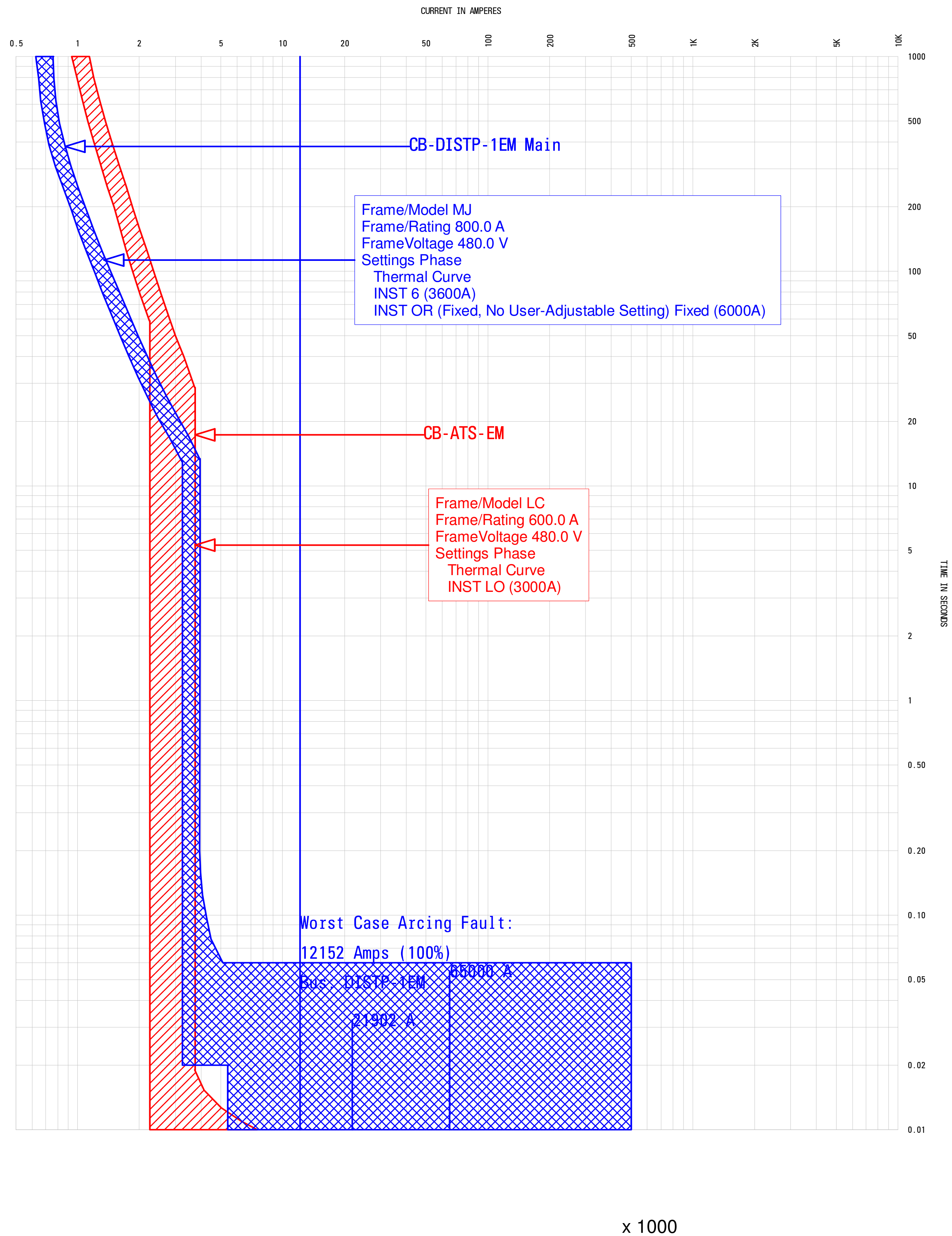
x 100

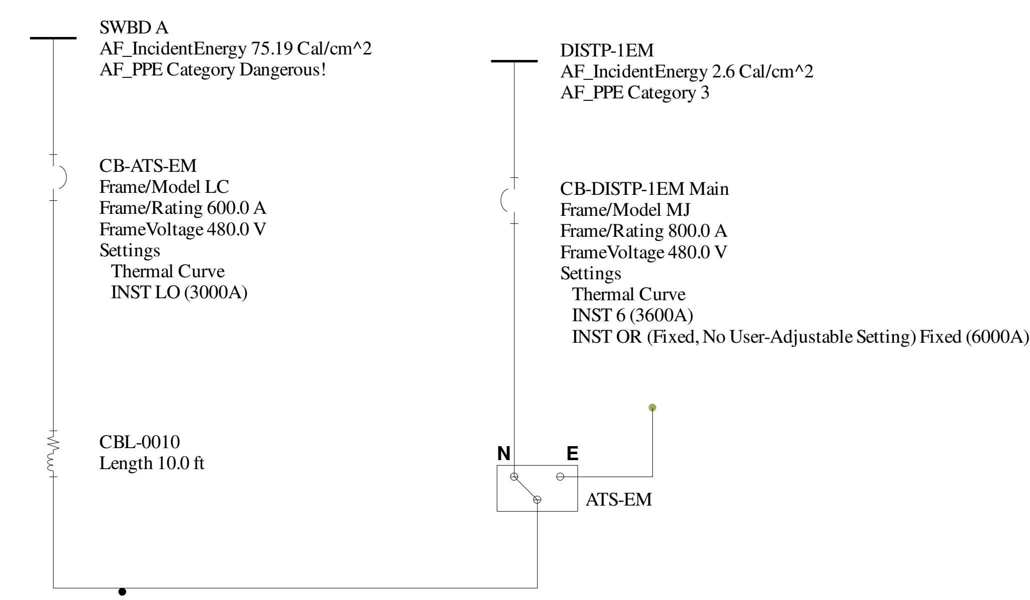


TCC Name: SWBD-A(3)
Oneline: SWBD-A(3)

Reference Voltage: 480

May 21, 2015

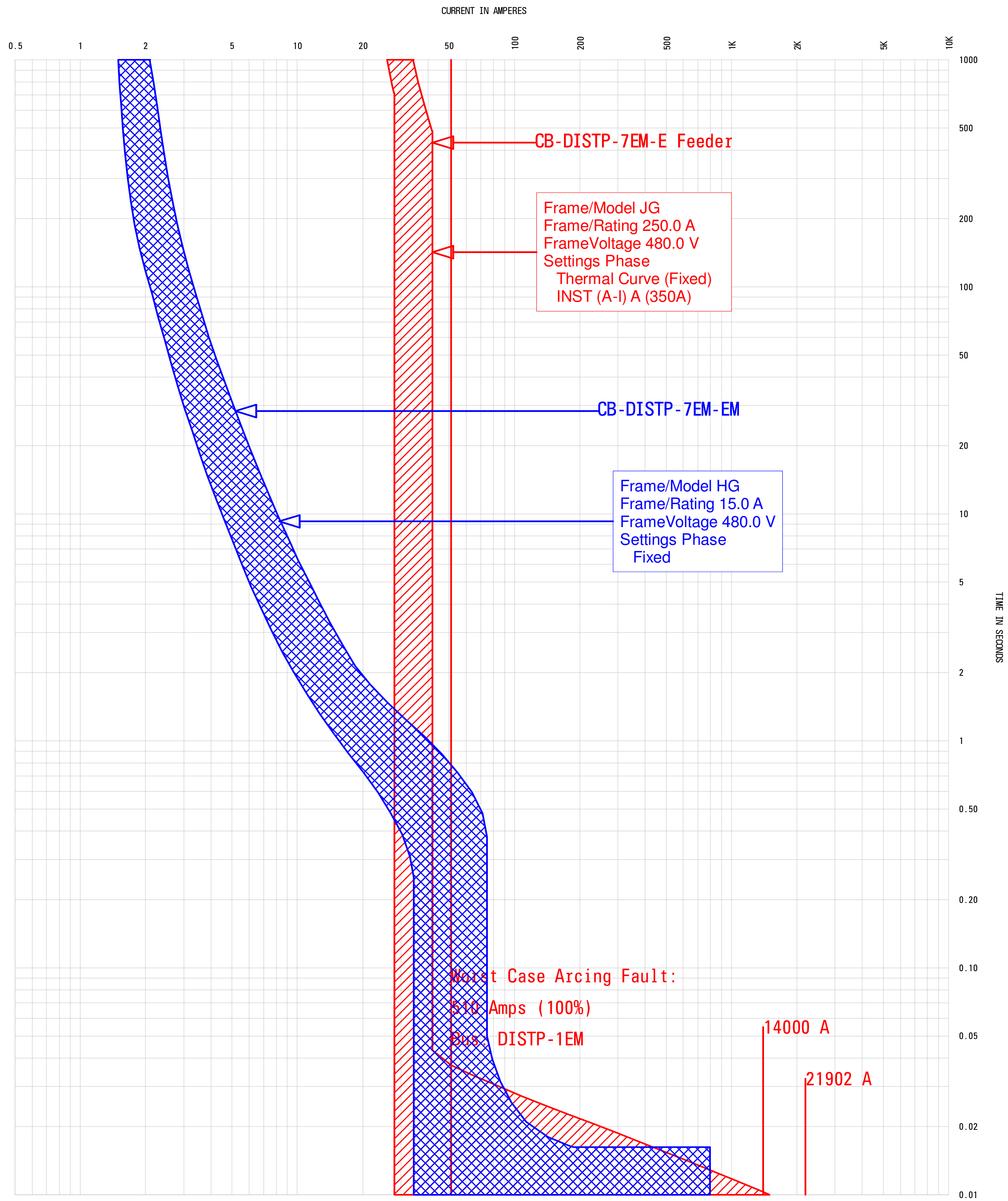




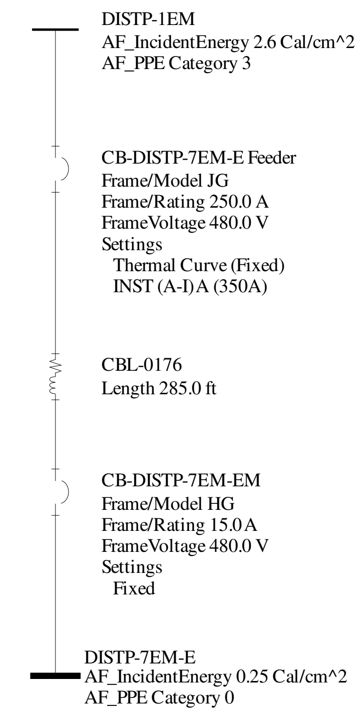
TCC Name: DISTP-1EM
Oneline: DISTP-1EM

Reference Voltage: 480

May 21, 2015



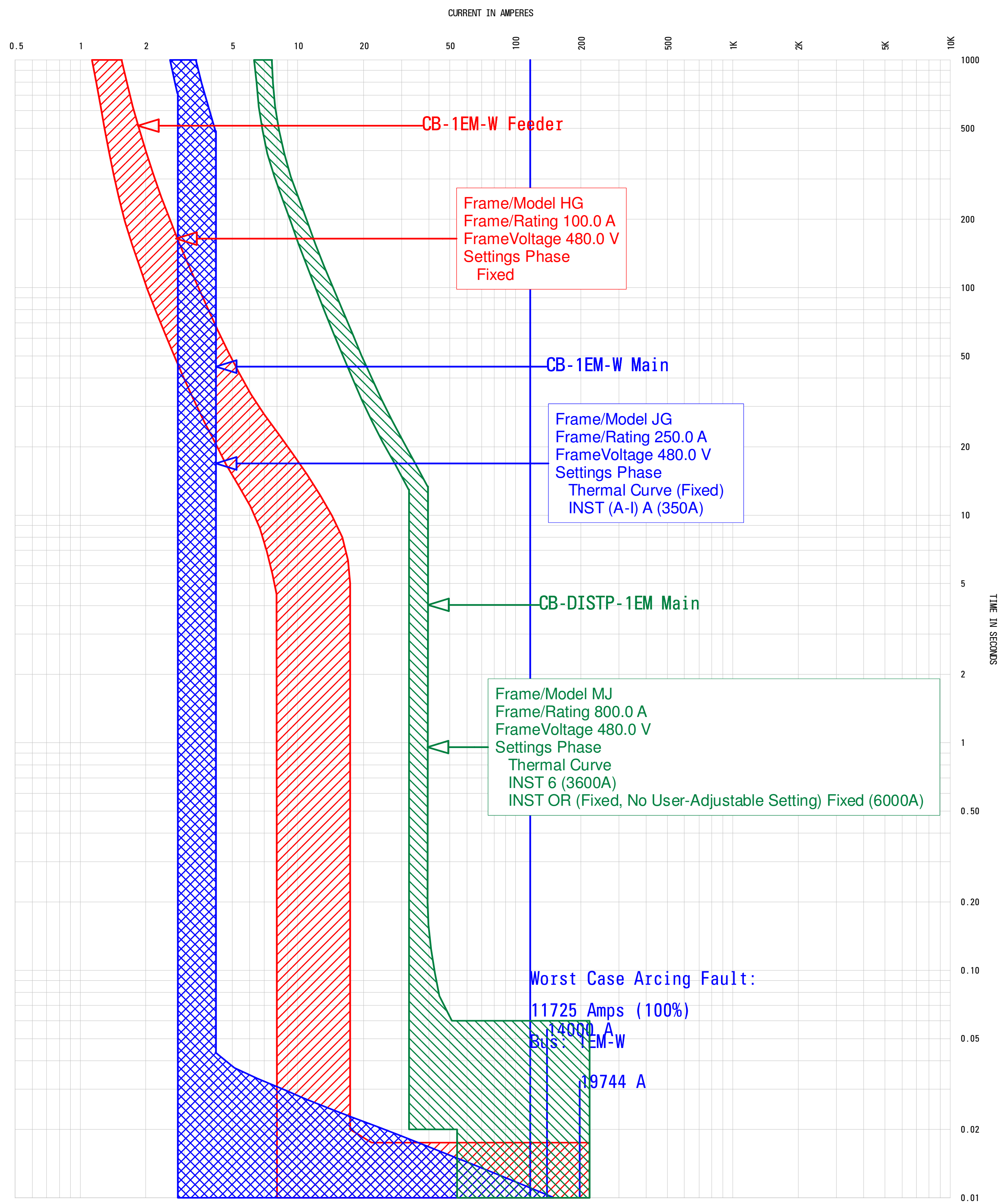
x 10



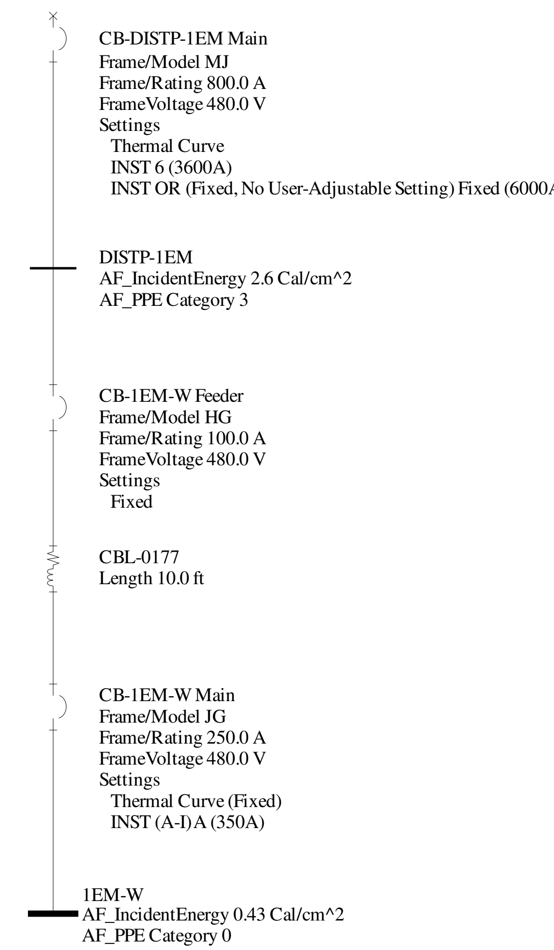
TCC Name: DISTP-7EM-E
Oneline: DISTP-7EM-E

Reference Voltage: 480

May 21, 2015



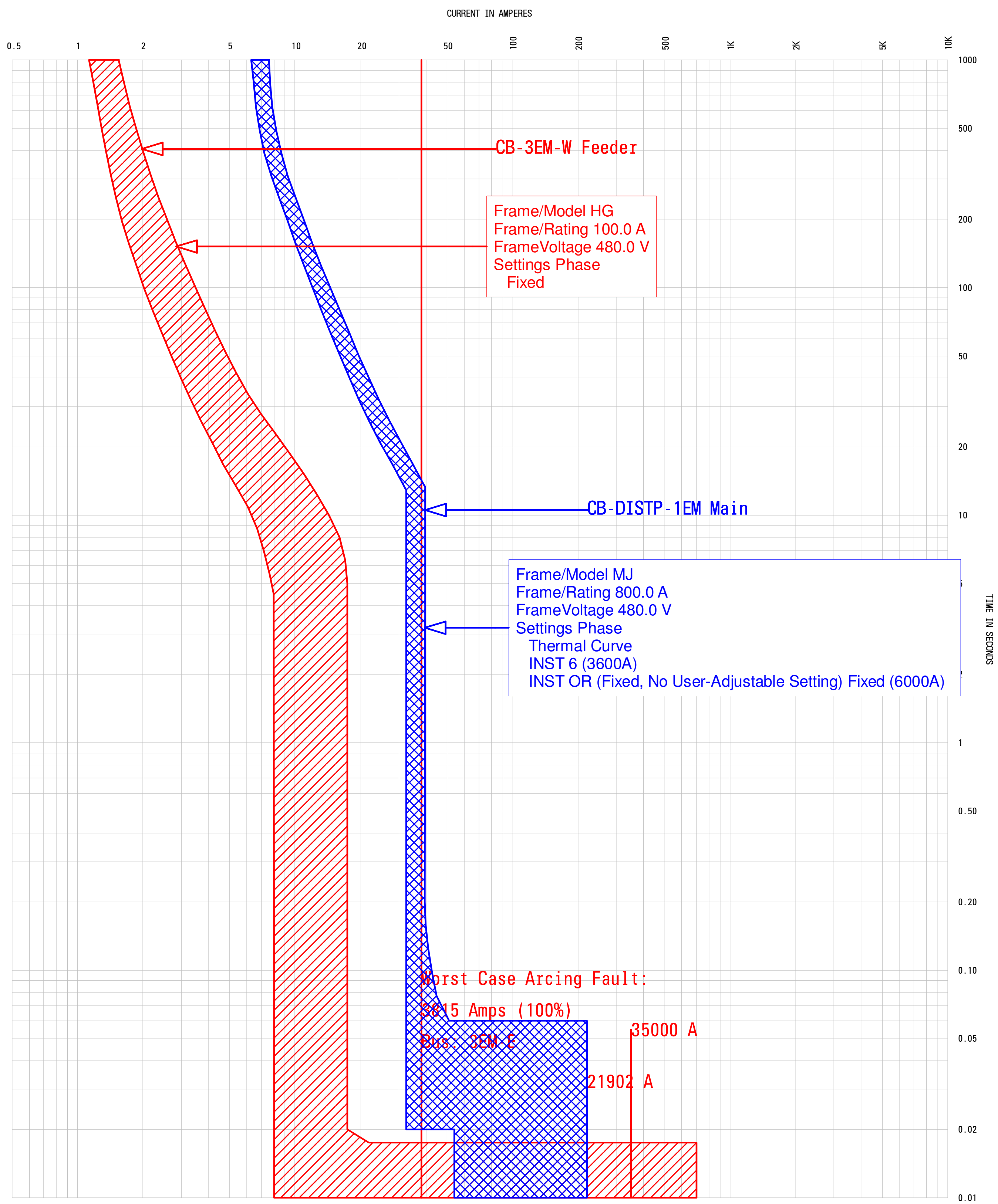
x 100



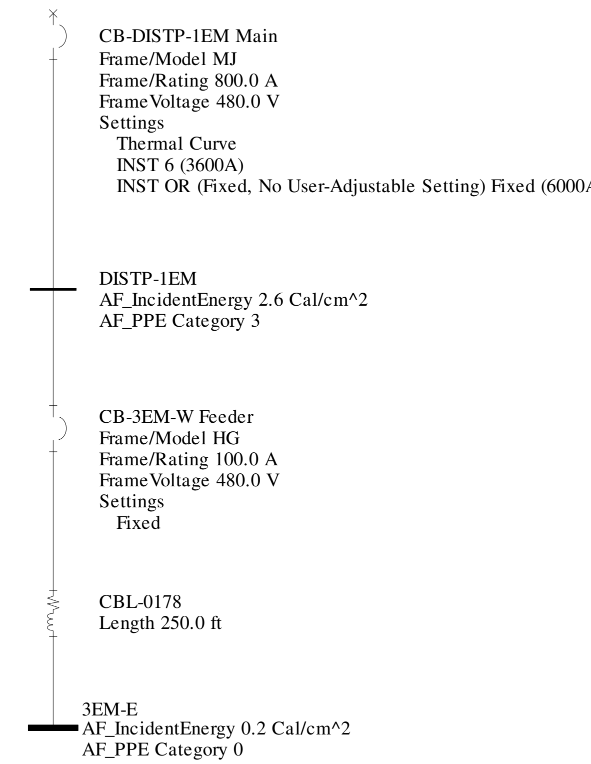
TCC Name: 1EM-W
Oneline: 1EM-W

Reference Voltage: 480

May 21, 2015



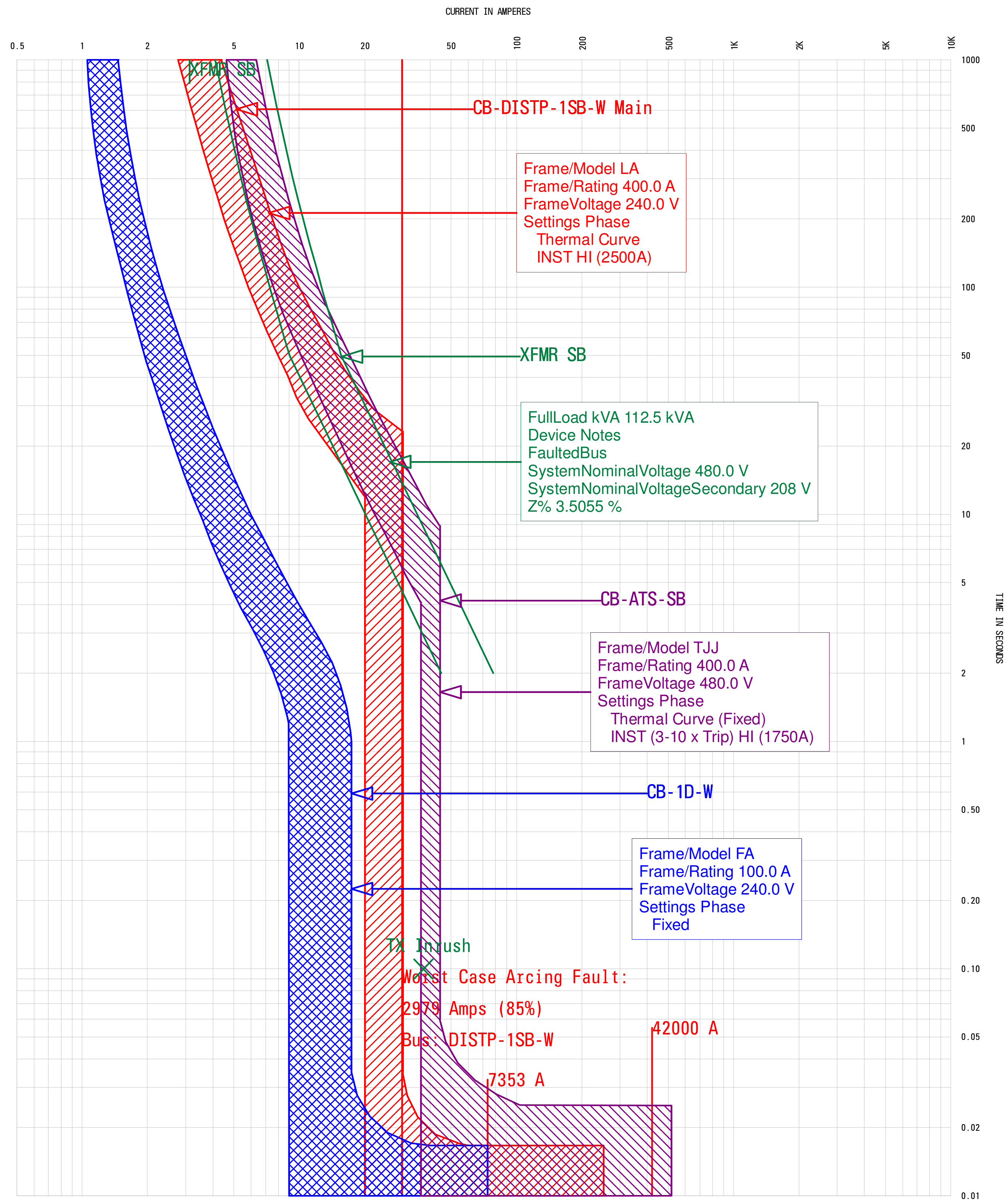
x 100



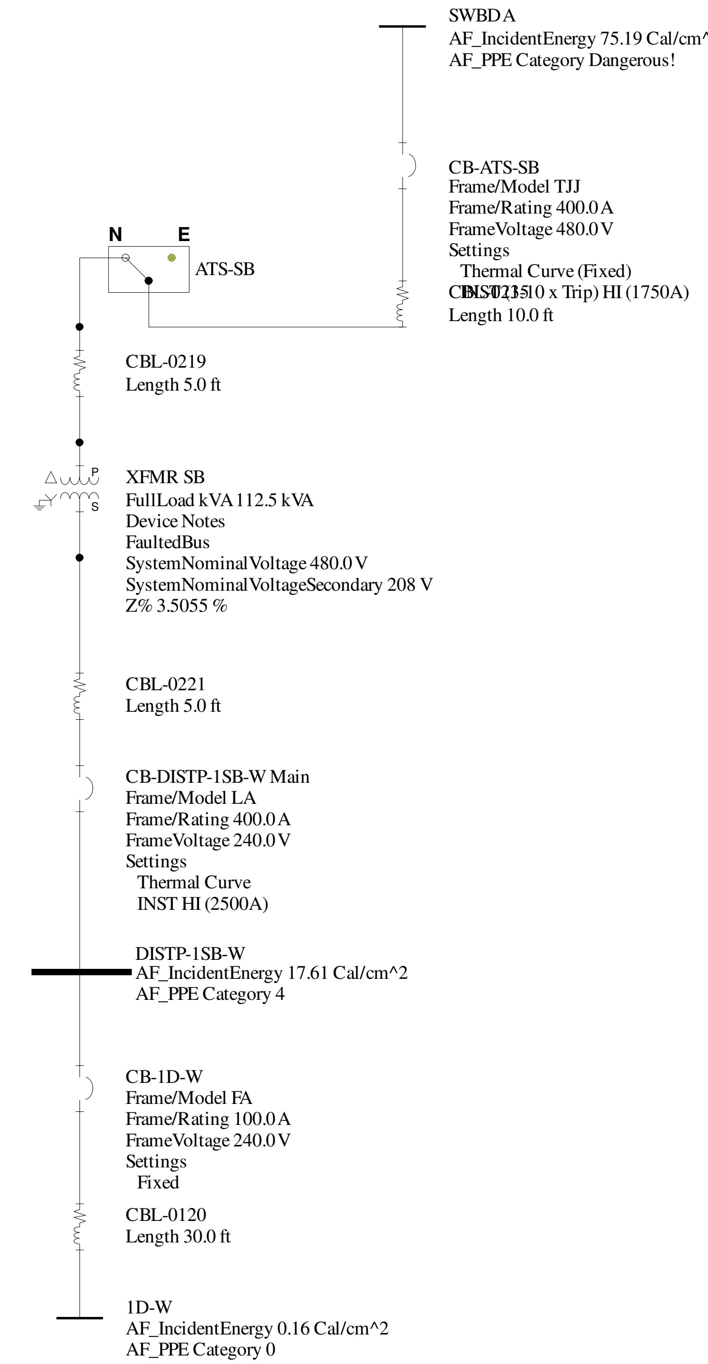
TCC Name: 3EM-E
Oneline: 3EM-E

Reference Voltage: 480

May 21, 2015



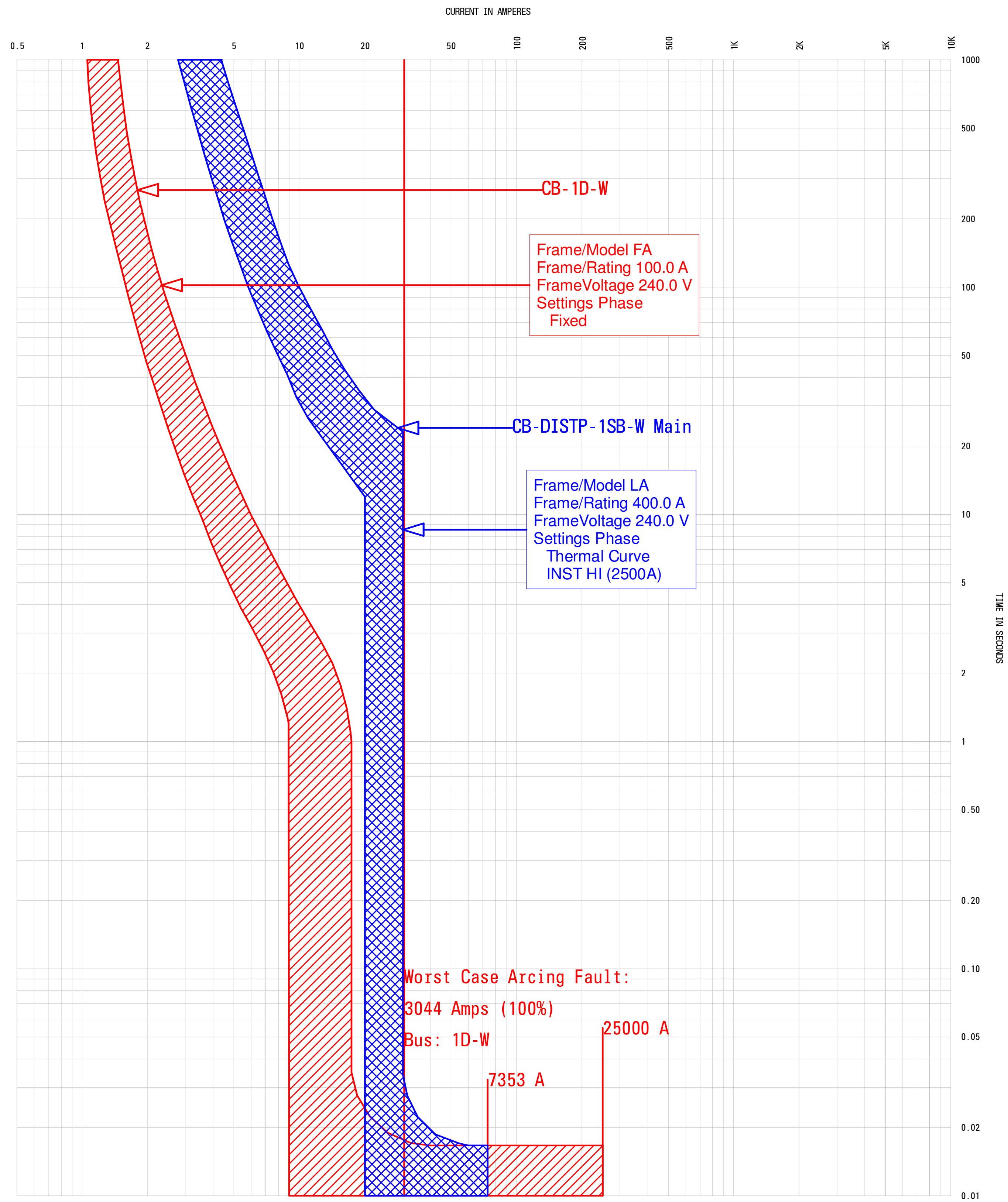
x 100



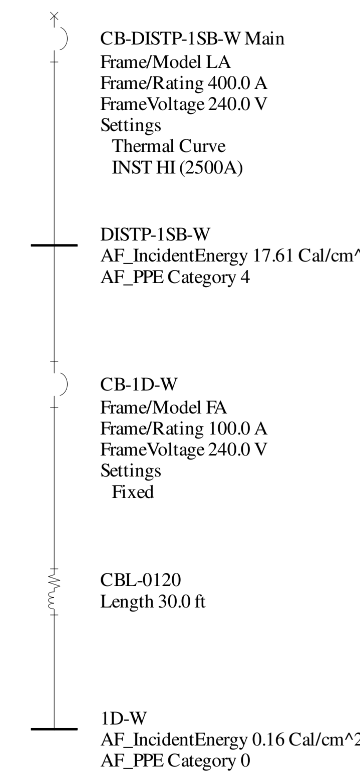
TCC Name: DISTP-1SB-W
Oneline: DISTP-1SB-W

Reference Voltage: 208

May 21, 2015



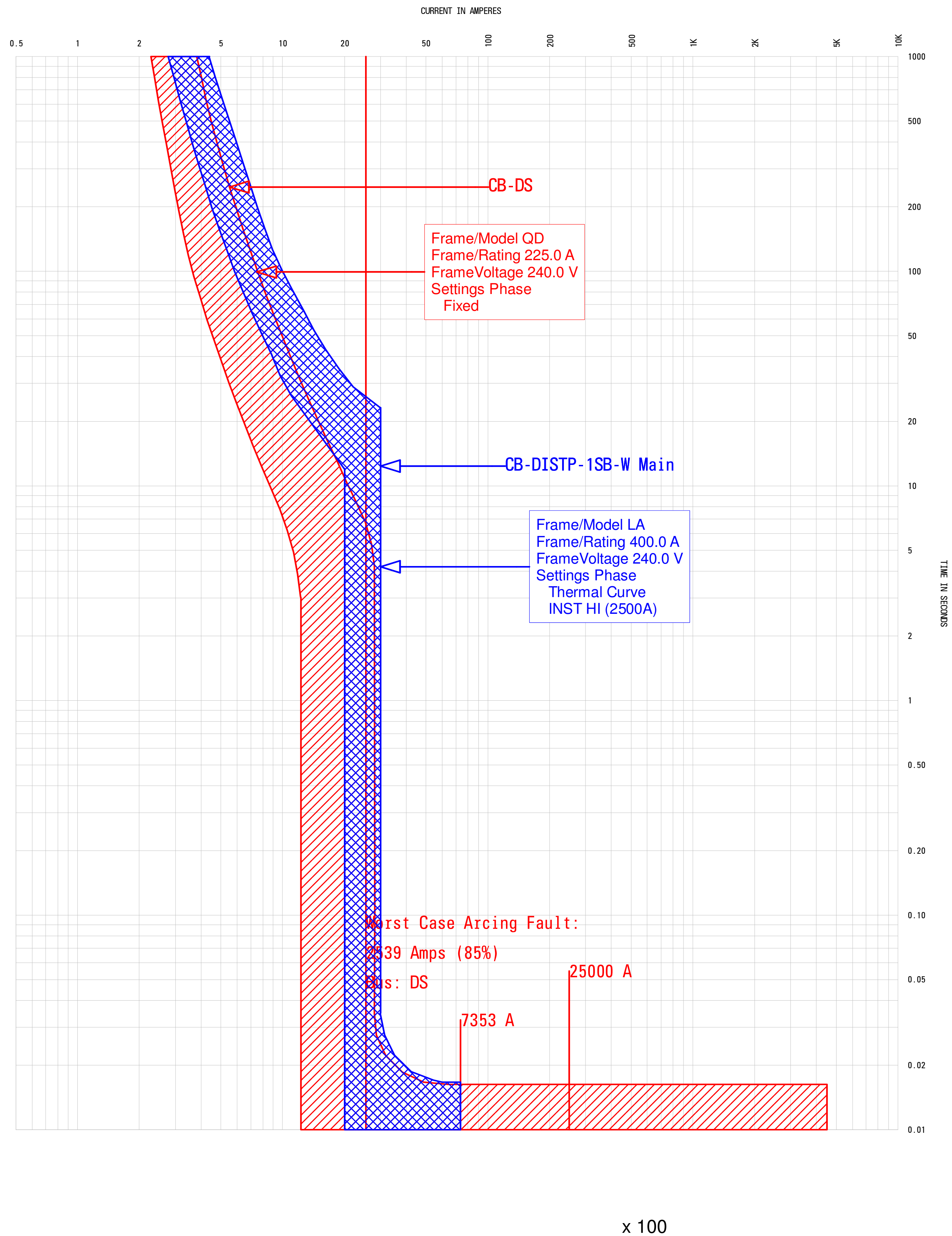
x 100

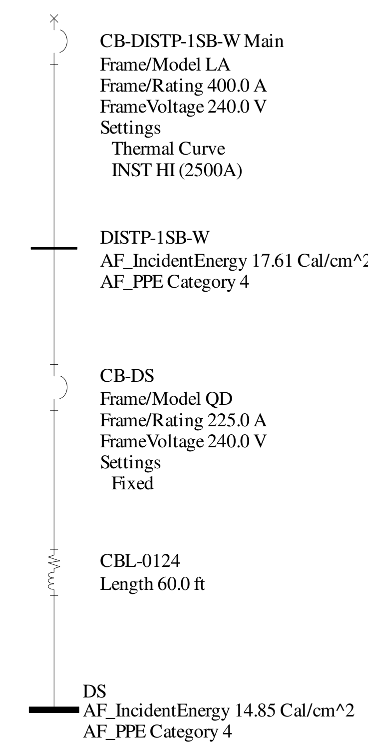


TCC Name: 1D-W
Oneline: 1D-W

Reference Voltage: 208

May 21, 2015

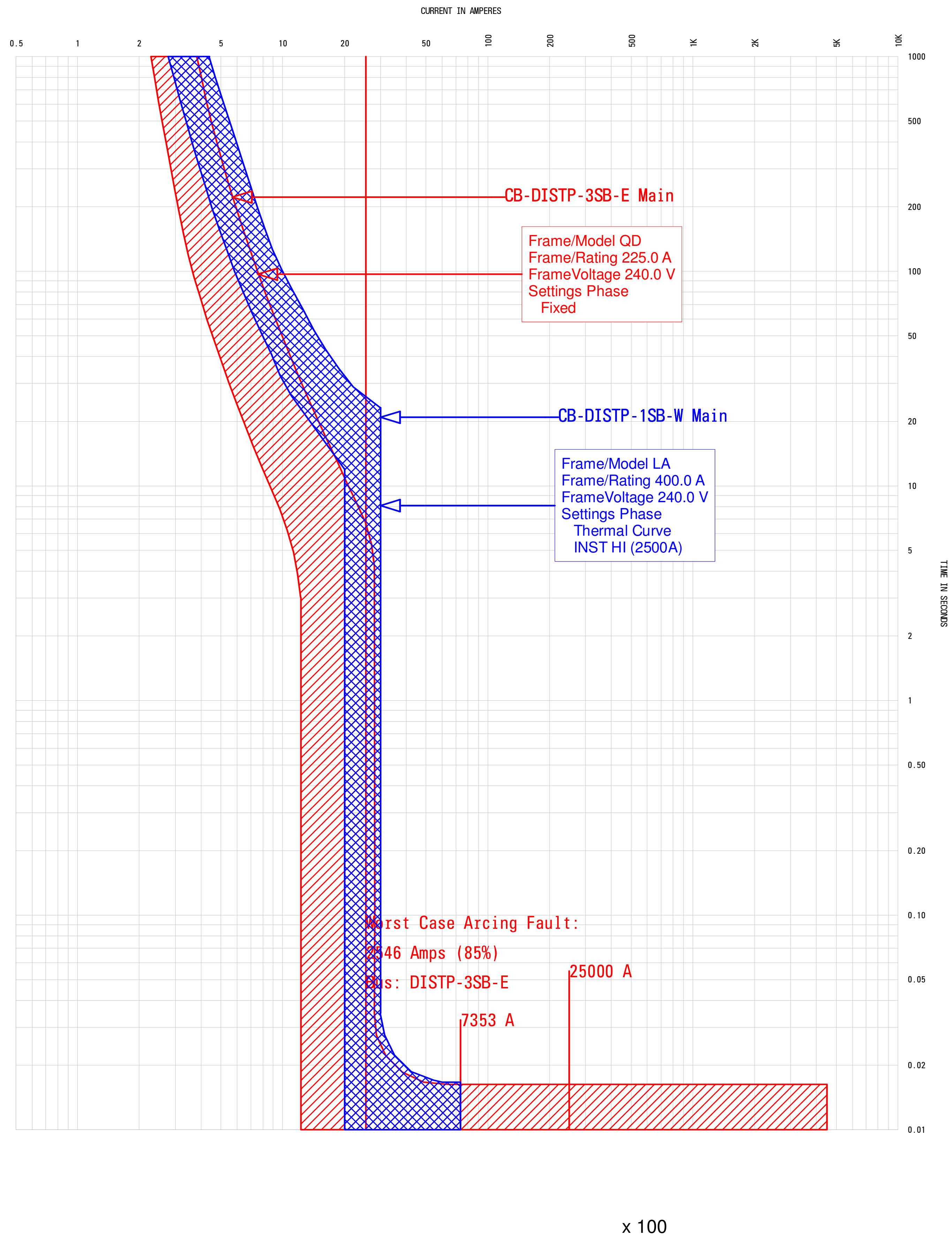


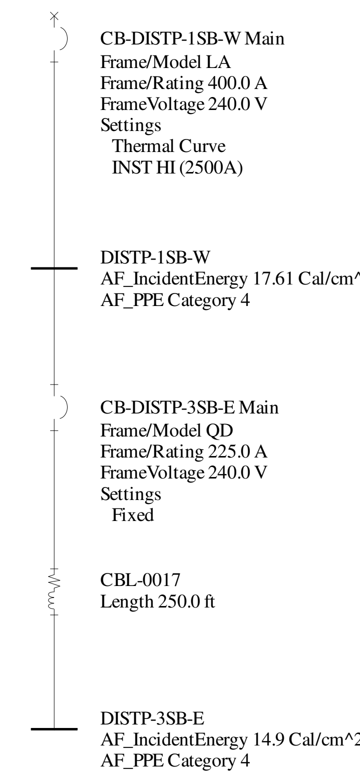


TCC Name: DS
Oneline: DS

Reference Voltage: 208

May 21, 2015

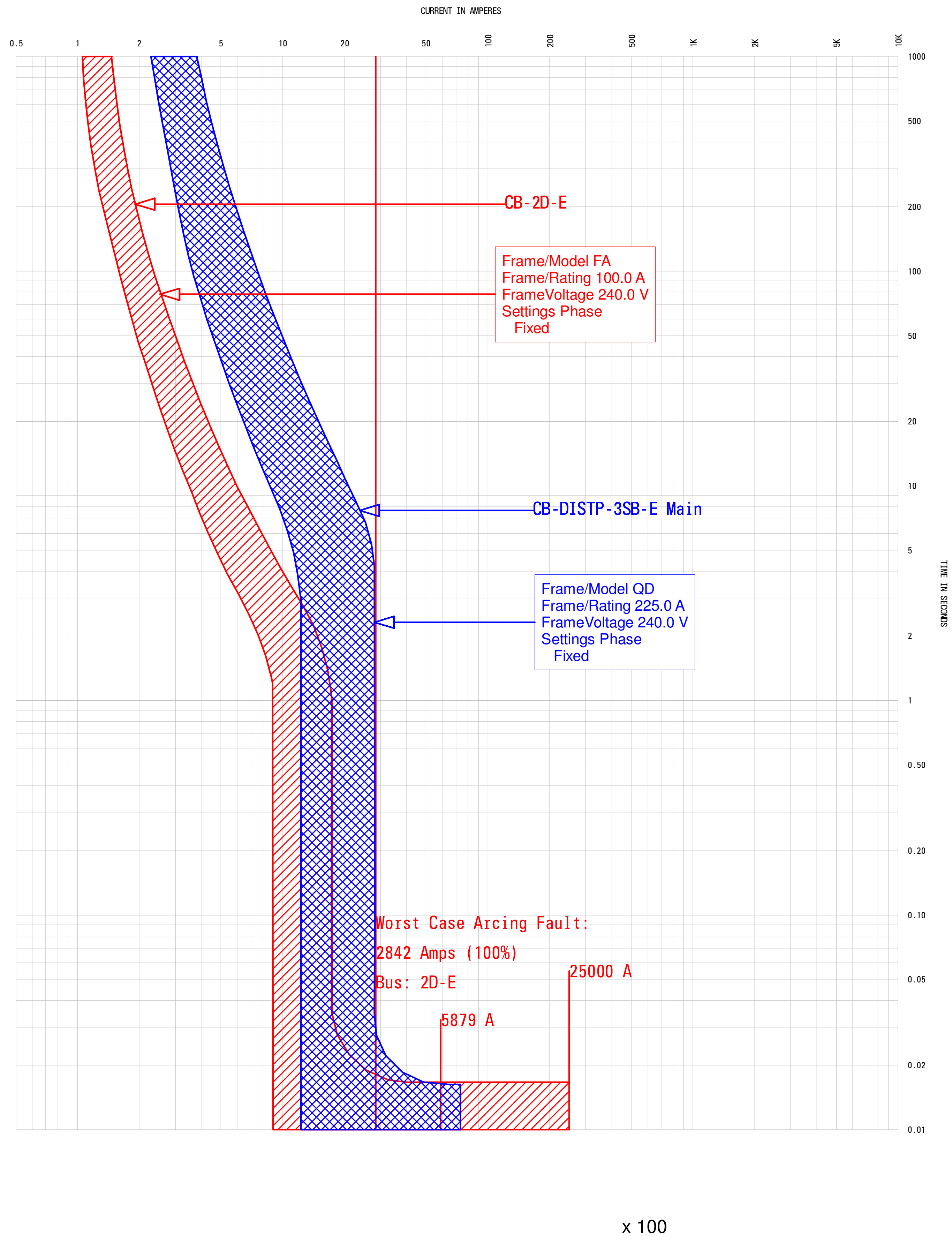


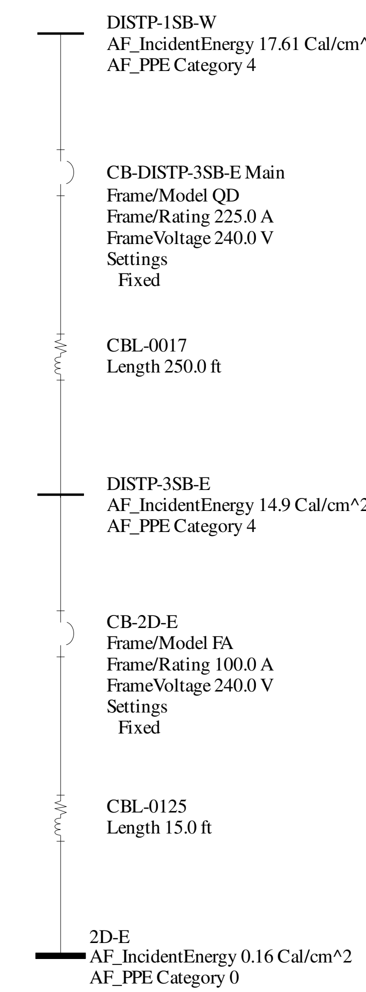


TCC Name: DISTP-3SB-E
Oneline: DISTP-3SB-E

Reference Voltage: 208

May 21, 2015





TCC Name: 2D-E
Oneline: 2D-E

Reference Voltage: 208

May 21, 2015