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SHORT CIRCUIT STUDY
PROTECTIVE DEVICE COORDINATION STUDY
ARC FLASH HAZARD ANALYSIS
FOR
PORTLAND STATE UNIVERSITY
NON-WEST CAMPUS LOOP
PORTLAND, OR

FEBRUARY 2013

1.0 EXECUTIVE SUMMARY

This report contains the results of analysis performed on the electrical distribution system for all buildings not supplied by the West Campus Loop at the Portland State University in Portland, Oregon. The purpose of this study is to evaluate the existing electrical system, as detailed below.

The executive summary contains the description and guide to the rest of the report. In addition, it also contains the recommendations of the entire study.

1.1 Objectives

1. Short-Circuit Study

Perform a short-circuit study on buildings not included in the existing electrical distribution system shown in order to determine the available fault current at pertinent locations throughout the distribution system. The scope of the study includes:

- For most locations, analysis begins at the incoming 12.47 kV utility service and continued to the main service entrance disconnect or disconnects. Exceptions to this statement are noted below.
   i. For the Fourth Avenue / Engineering Building (EB), analysis began at the primary metered service (12.47 kV) supplying Medium Voltage Switchgear 52-U1 and 52-U2 and continued through the medium voltage distribution system to low voltage substations USB-1, USB-2, USB-3, USB-5, USB-6, and USB-7.
   ii. For the Market Center Building, analysis began on the secondary side (480 V) of each of the PacifiCorp owned utility transformers and continued downstream to the first disconnect at each service entrance.

The available fault currents determined by the short-circuit study will be used in the coordination and device evaluation analysis.

2. Equipment Evaluation

Evaluate the short-circuit ratings of the service entrance protective devices found at the locations shown listed above.

3. Coordination Study

Review the existing system overcurrent protection and coordination. Where applicable, provide suggestions for improvement.

4. Arc Flash Analysis

Perform an arc flash hazard analysis per NFPA 70E on the electrical distribution system described in item #1 above.

5. Recommendations

Provide specific recommendations for improving the electrical distribution system performance and correcting any deficiencies found by the studies.

1.2 Results

1. Short-Circuit Study

Short-circuit currents were calculated for each bus shown on the one-line diagrams in Appendix D.

Utility transformer and source impedance information was provided by Tom Riddle with Portland General Electric (PGE) on 1/10/2013 via email. Information for all PGE utility sources is summarized in Appendix C.

The Market Center Building is not supplied by PGE, but is supplied by PacifiCorp. It was not possible to obtain fault current information from PacifiCorp at the time of this study. To ensure conservative results, an infinite bus was assumed on the primary side (12.47 kV) of utility transformers TX-MCB UTIL-A, TX-MCB UTIL-B and TX-MCB BSMT UTIL. The following values were calculated on the secondary side (480 V) of each transformer based on transformer nameplate information gathered during data collection:

TX-MCB UTIL-A

- Three-phase fault current: 15,826.5 A

TX-MCB UTIL-B

- Three-phase fault current: 16,705.7 A

TX-MCB BSMT UTIL

- Three-phase fault current: 8,018.8 A

Multiple short-circuit scenarios were only necessary when examining fault-current values at the 4th Avenue / Engineering Building, as it is the only building with multiple sources of power. The following short-circuit study cases were evaluated:

- Study Case No. 1 – System supplied from the Urban-Medical utility feed via Medium Voltage Switchgear B-EB-52-U1. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breakers BK-EB-52-G1 and BK-EB-52-U2 are open.
- Study Case No. 2 – System supplied from the Urban-Gibbs utility feed via Medium Voltage Switchgear B-EB-52-U2. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breakers BK-EB-52-G1 and BK-EB-52-U1 are open.
- Study Case No. 3 – System supplied from the Emergency Generator via Medium Voltage Switchgear B-EB-52-U3. Tie breakers BK-EB-52-T1 and

BK-EB-52-T2 are closed and the Main Breakers BK-EB-52-U1 and BK-EB-52-U2 are open.

- Study Case No. 4 – System supplied from the Urban-Medical utility feed and Emergency Generator via Medium Voltage Switchgear B-EB-52-U1 and B-EB-52-U3. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breaker BK-EB-52-U2 is open.
- Study Case No. 5 – System supplied from the Urban-Gibbs utility feed and Emergency Generator via Medium Voltage Switchgear B-EB-52-U2 and B-EB-52-U3. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breaker BK-EB-52-U1 is open. **This is the worst case scenario and the scenario show on the one-line diagram in Appendix D.**

See Section 2, Appendix A and Appendix B for more information.

2. Equipment Evaluation

The Equipment Evaluation is based on the power system worst-case short-circuit current configuration.

The short-circuit ratings of protective devices and other distribution equipment are evaluated in Section 2, Table 2.1.

In summary of Table 2.1, multiple locations failed the equipment evaluation. See Section 2 for more details.

3. Coordination Study

The time-current coordination plots of the protective overcurrent devices are shown in Section 3. In developing the device settings, consideration was given to both isolation of faults, protection of cables, and protection of transformers.

Efforts were made to provide the best coordination possible with existing protective devices. It should be understood that selective coordination between two instantaneous trip units cannot be achieved for fault levels above the instantaneous pickup of the upstream device. There is some overlapping of curves that cannot be avoided.

For all locations except the 4th Avenue / Engineering Building, the system coordination began at first overcurrent protective device upstream of the utility transformer, and continued downstream through the service entrance to the largest overcurrent protective device which is not in series with the utility overcurrent device.

For the 4th Avenue / Engineering Building, the normal side system coordination began at the 12.47 kV utility fault interrupter and continued downstream the Switchboards B-EB-52-U1 and B-EB-52-U2 to the largest feeder breaker in each of the Unit Substations B-EB-USB-1 – B-EB-USB-7. The emergency system coordination began at the12.47 kV main relay in B-

EB-52-E3 and continued downstream through Switchboards B-EB-52-U1 and B-EB-52-U2 to the largest feeder breaker in each of the Unit Substations B-EB-UB-1 – B-EB-USB-7.

See Section 3 for more information and Section 4 for device settings.

4. Suggested Protective Device Settings

Settings for the protective devices in the Portland State University – Non-West Campus Loop are shown in Section 4.

Each entry references a coordination plot number found in Section 3. The referenced plot illustrates the coordination of the listed device with the relevant "upstream" and "downstream" protective devices. The protective devices listed in Section 4 should be set per the suggested settings.

5. Arc Flash Analysis

Details of the arc flash analysis are shown in Section 5. This arc flash hazard analysis of the Portland State University Non-West Loop Service Entrances in Portland, Oregon required energy and boundary calculations for approximately seventy-seven (77) locations. In summary of Section 5, there are several locations that have incident energy levels that are above 40 cal/cm^2. According to NFPA 70E-2012, Article 130.7(A), Informational Note 3, greater emphasis must be placed on establishing an electrically safe work condition when working within the limited approach boundary at locations where the incident energy exceeds 40 cal/cm^2. The greater emphasis is due to additional hazards created from blast pressure associated with a possible arc. See NFPA 70E-2012, Article 120 for details on establishing an electrically safe work condition.

At the request of Portland State University, arc-flash incident energy calculations were performed at an 8' working distance. This distance is greater than the standard working distances prescribed by IEEE 1584-2002 and are applicable for energized work, including non-contact voltage testing, being performed by a qualified person using a hot-stick. A distance of 8' was chosen as it is the approximate distance the face and torso of a qualified person would be when using a 6' hot-stick. To minimize confusion, these values will not be shown on the arc-flash labels.

Please note for this study, the arc flash hazard has been calculated but not the risk. The risk associated with performing energized electrical work will vary based on the work being performed as well as the condition of the equipment and other factors that can be best determined by a qualified person.

See Table 5.1, Table 5.2, and Table 5.3 for a complete arc flash summary. **Note that the incident energy values listed in Table 5.1, Table 5.2, and Table 5.3 are only valid after the recommended protective device settings shown in Section 4 have been implemented.**

1.3 Recommendations

1. Overdutied Equipment

It is recommended that the overdutied equipment listed in Table 2.1 be reviewed for replacement to comply with the short-circuit current ratings required. Before replacement of any equipment, the short-circuit rating of the equipment should be verified. Additionally, the impedance of the conductor between the utility transformer and the service entrance was not available at the time of this study and was therefore not included in this study. As many of these conductors are underground, it would not be possible to verify the length or size of these conductors with on-site data collection. Work should be done in cooperation with PGE to determine the length of the conductors between the utility transformer and the service entrance disconnect before any equipment is replaced. See Section 2 for detailed short-circuit analysis.

2. Low Voltage Equipment Recommendations

The majority of the low voltage equipment on the West Campus loop at Portland State University is very old and appears to have not been tested and maintained over the life of the equipment. It is critical that Portland State University create a plan to inspect and test the low voltage equipment in these buildings, similar to the testing that has occurred in Science Building II, to determine whether the electrical distribution equipment is still operable

- University Honors Program

The type of the largest feeder breaker in low voltage panelboard in the University Honors Program building could not be field verified. The feeder breakers in this panel were not marked with a type. Due to the age of this equipment it is recommended that it be tested to ensure proper operation and verify the breaker type.

- King Albert Building

While performing data collection it was found that the electrical room in the King Albert Building smelled strongly of natural gas. It is recommended that this room be inspected immediately for gas leaks. Due to the presence of natural gas, it was not possible to field verify the breaker type of the feeder breakers in this switchboard. It is recommended that this room be inspected immediately for gas leaks. Additionally, it is recommended that this equipment be tested for proper operation as well as to verify breaker type and settings.

- Stratford Building

The fused disconnect in the Stratford Building was not labeled with an interrupting rating and this rating was not able to be verified during data collection. The interrupting rating is assumed to be 200 kAIC based on the rating of the fuse present.

- Parkway Building

All equipment in the Parkway Building was verified during data collection. When modeling it was not possible to locate a time-current curve for the Thomas & Betts, Type TB main circuit breaker in the service entrance panelboard. It is assumed the trip characteristics of this circuit breaker are similar to those of a Siemens, Type QJH. This assumption only affects the time-current curve presented for this location and does not affect the equipment evaluation or arc-flash hazard analysis. The difficulties in locating a time-current curve for this circuit breaker are due to the age of the device. Additionally, due to the age of this device, it is recommended that it be tested for proper operation and replaced if necessary.

- Simon Benson House

The fuses in fused disconnect F-SBH DISC B-USB were not able to be field verified. It was not possible to open the fused disconnect during data collection. It is assumed the fuses in this F-SBH DISC B-USB were the same as those in fused disconnect F-SBH DISC A-USB. Due to the age of this equipment, it should be inspected to ensure proper operation and during inspection, the fuse should be verified.

- Blackstone

The circuit breaker type of the main circuit breaker in Panelboards B-BLKS L1-USB, B-BLKS L2-USB, B-BLKS L3-USB, B-BLKS L4-USB, and B-BLKS L5-USB could not be field verified. The circuit breaker label did not contain information on the circuit breaker type. It is assumed this circuit breaker is type HQJ2H. This assumption only affects the time-current curve presented for this location and does not affect the equipment evaluation or arc-flash hazard analysis. It is recommended that this equipment be removed from service and inspected for proper operation and to see if the circuit breaker type can be determined.

- Shattuck Hall

The settings of the circuit breakers at Shattuck Hall could not be field verified. The electronic trip units were unresponsive during data collection. It is recommended these circuit breakers be tested to ensure they are properly programmed and a coordination study has been completed. If this study has not been completed, it is further recommended that a study be completed to determine proper settings for these circuit breakers. For the purposes of this study, it was assumed the circuit breakers are programmed at their maximum settings. This assumption only affects the time-current curve presented for this location and does not affect the equipment evaluation or arc-flash hazard analysis.

- East Hall

The size of cables C-EH JUNC-EHA, C-EH JUNC-EH b, and C-EH JUNC-EH C could not be field verified. It is assumed each of these cables is sized at 1

– 3/0 per phase. If any equipment in East Hall is tested in the future, this assumption should be verified.

The fuse in Fused Disconnect B-EH E DISC-USB could not be field verified. It was not possible to open the fused disconnect without de-energizing. It is assumed the interrupting rating of this fused disconnect is 100 kAIC. This is the lowest standard rating for a Cutler-Hammer fused disconnect of this type. During a maintenance outage, the fuse types and interrupting rating of this switch should be verified.

- University Center Building

The breaker type of the largest breaker in the switchboard in the University Center Building could not be field verified. The circuit breaker is very old and does not have a type listed on the nameplate. It is assumed this circuit breaker is a type THJK. Additionally, it is assumed the adjustable thermal magnetic trip in this circuit breaker is at its maximal setting. These assumptions only affect the time-current curve presented for this location and does not affect the equipment evaluation or arc-flash hazard analysis. Due to the age of this circuit breaker, it is recommended that it is tested to ensure proper operation. If found to not properly operate, it should be replaced.

- Ondine (Main Electrical Room)

The circuit breaker type of the main disconnect could not be field verified. The electrician was uncomfortable with opening equipment for data collection purposes due to the age of the equipment and the confusing layout / lack of labeling. The layout and lack of labeling made it difficult to determine the flow of power and which devices were being used as service disconnects. Additionally, there was no evidence that any of the equipment had been tested or maintained recently. It is assumed that the main disconnect circuit breaker type is PA. Additionally, it is assumed that the adjustable thermal magnetic trip in this circuit breaker was at its maximal setting. Based on this assumption, it is further assumed the interrupting rating of low voltage Switchboard B-OND MAIN SWBD-USB is 65 kAIC. It is recommended this equipment is inspected for proper operation and verification of study assumptions. Additionally, it is recommended that the equipment be clearly labeled to help a qualified person understand the flow of power for this equipment.

- Ondine (15^{th} Floor Electrical Room)

The circuit breaker type of the main disconnect could not be field verified. The circuit breaker was very old and the label did not state the circuit breaker type. It is assumed the circuit breaker was a type NN. Additionally, it is assumed that the adjustable thermal magnetic trip unit in this circuit breaker is at its maximum setting.

It was not possible to locate a time-current curve for the Zinsco, Type QFB circuit breaker in this switchboard. It is assumed the trip characteristics of this circuit breaker are similar to those of an Eaton, Type HJD.

These assumptions only affect the time-current curve presented for this location and does not affect the equipment evaluation or arc-flash hazard analysis.

Based on the age of the equipment, it is recommended that all circuit breakers in the Ondine, 15th Floor Electrical Room be tested for proper function. Additionally, it is known that many Zinsco breakers are prone to failure and all Zinsco breakers should be considered for replacement.

- Art Building

Fused Disconnect B-AB DISC-USB in the Art Building was not labeled with an interrupting rating and this rating was not able to be verified during data collection. The interrupting rating is assumed to be 200 kAIC based on the rating of the fuse present.

- Art Building Annex

While performing data collection it was found that disconnect in the electrical room of the Art Building Annex contained multiple fuse types and manufacturers. All fuses in a disconnect should be the same type with the same trip characteristics and all must be the proper type, specified by the manufacturer. This ensures safe operation of the fused disconnect in the event of a fault. It is recommended that a single fuse type and manufacturer be chosen and all fuses replaced to this standard.

Additionally, Fused Disconnect B-AB DISC ANNEX-USB in the Art Building Annex was not labeled with an interrupting rating and this rating was not able to be verified during data collection. The interrupting rating is assumed to be 10 kAIC based on the rating of the fuse present.

- 4th Avenue / Engineering Building

It was found that many feeder breakers in the unit substations at the 4th Avenue / Engineering building had the instantaneous portion of their trip curves set to 'OFF'. Specifically, this was found in Unit Substations:

i. USB-1
ii. USB-2
iii. USB-3
iv. USB-5
v. USB-6

All loads supplied by feeder breakers with the instantaneous trip function removed should be inspected to ensure they are properly protected by a local overcurrent device with instantaneous protection. If the equipment is not, the settings for these breakers must be revised to include an instantaneous trip function.

The current rating of bus busway BWY-EB-52-U3-52-U1 and BWY-EB-52-E3-52-U2 could not be verified. It was assumed each bus duct was rated at 1200 A. During a maintenance outage, this assumption should be verified.

- Science & Education Center

The fuse type in Fused Disconnect F-SEC SOUTH DISC 1A could not be verified. Based on fuses found in similar fused disconnects in this building, it is assumed this fuse is a type FLNR. During a maintenance outage, this assumption should be verified. This assumption only affects the time-current curve presented for this location and does not affect the equipment evaluation or arc-flash hazard analysis.

Fused Disconnects B-SEC SOUTH DISC 1S-USB, B-SEC SOUTH DISC 2A-USB, and B-SEC SOUTH DISC 2B-USB were not labeled with an interrupting rating and this rating was not able to be verified during data collection. The interrupting rating is assumed to be 200 kAIC based on the rating of the fuse present. During a maintenance outage, these assumptions should be verified.

- University Place

480 V Electrical Service: Upon inspection, it appears that Low Voltage Switchboard B-UP-A-USB, or the 480 V service in at University Place, has more than six disconnects without a main circuit breaker. This appears to be in violation of NEC Article 230.71, commonly known as the 'six disconnect rule.' It is recommended that this Switchboard be inspected for possible compliance to or exception from Article 230.71 before replacement.

208 V Electrical Service: While performing data collection, it was found that the electrical room housing the 208 V service at University Place is in disrepair. There were multiple holes in the ceiling resulting in leaks and standing water in the electrical room. There was also evidence of rodents. Rodents are known to get into equipment and cause damage by chewing through insulation. This can lead to an arc-flash and major equipment damage, injury to any personnel in the room at the time and a loss of service. The equipment in this room may not have been properly maintained as the last inspection sticker dates from 1992. Additionally, there was a large amount of rust and corrosion present on the equipment. Many of the exits from the section of University Place that houses the electrical equipment were blocked. It is recommended that this equipment be taken out of service for maintenance as well as being inspected for replacement. It is also recommended that the electrical room be repaired and all water issues corrected immediately.

- Academic & Student Rec Center

Based on the as-found settings for circuit breakers in the Academic & Student Rec Center, it appears there may not have been a coordination study performed when this equipment was commissioned. If a study were performed, the settings recommended in that study may not have been implemented. As currently set, a fault downstream of a feeder breaker may result in a loss of the entire service due to a lack of selectivity between the main circuit breaker and the largest feeder breaker. It is recommended to verify if a study were performed for this equipment and that the settings were properly implemented. If a study has not been performed, it is recommended that the coordination of this system be fully examined and breaker settings be adjusted based on that examination.

- Market Center Building

The fuse type on the primary side of PacifiCorp Transformer TX-MCB UTIL-B could not be verified. It is assumed to be the same fuse as on the primary side of PacifiCorp Transformer TX-MCB UTIL-A. If it is possible to obtain information from PacifiCorp, this assumption should be verified.

3. Arc Flash Hazard Analysis

It is recommended the scope of this study be expanded to include a system wide arc flash hazard analysis of all equipment at Portland State University not supplied by the West Campus Loop. The results of the arc flash hazard analysis are used to determine the incident energy, arc flash boundary, and personal protective equipment requirements for each location. The arc flash hazard analysis, for all equipment, is a requirement of NFPA 70E, and is required by OSHA through the general duty clause. Completion of this study will ensure all equipment in the Portland State University Non-West Loop distribution system complies with NFPA 70E guidelines regarding arc flash analysis and labeling. The analysis is performed in conjunction with a short-circuit analysis, and will utilize the existing settings and ratings of the protective devices. If a lack of selectivity is discovered among existing devices during the study, new settings will be recommended and will be used as the basis for the arc flash hazard analysis.

It is recommended these studies be conducted on a per building basis. Buildings with newer electrical equipment and buildings which may not need replacement of electrical equipment should have the studies conducted first. Studies in buildings with older equipment which may require replacement may be conducted later in order to replace the equipment first and not require a follow-up study.

4. Recommended Settings

Adjustable protective device settings should be set according to the settings tables provided in Section 4.

5. Reducing Incident Energy Levels

The calculated incident energy at a particular location is dependent on three main factors: short-circuit current, distance, and time. These three factors directly affect the incident energy in the following manner:

Short-circuit current: The short-circuit current for a given power system is dependent on the system impedance and source fault current, and cannot be easily reduced.

Distance: IEEE Std 1584™-2002 provides a table with typical working distances. Increasing the working distance reduces the amount of incident energy that reaches the worker; however it becomes difficult to perform many work tasks with an increased working distance, therefore, this is not an optimal solution for most cases.

Time: The incident energy decreases when reducing the exposure time of the arc. This exposure time is directly related to the clearing time of the protective device(s) which feed the fault location.

Based on the preceding summary, arc flash mitigation techniques are most effective and feasible when they involve reducing the arc exposure time. In many locations, the setting of the protective device can be adjusted in order to decrease the interrupting time, resulting in a decreased incident energy. However, in this study, settings for protective devices have not been adjusted to reduce incident energy if the chance of nuisance trips within critical circuits is introduced.

The other option involving reducing the arc exposure time is to consider equipment modifications and upgrades. Several solutions include upgrading trip units, installing “maintenance switches”, and using relays with multiple settings groups. Each specific location needs to be analyzed to determine which reduction method is best employed.

6. Testing and Preventative Maintenance

It is recommended that regularly scheduled testing and preventative maintenance be performed to ensure that the electrical distribution equipment continues to perform at an optimum level. Testing should entail primary injection testing of all circuit breakers to verify proper tripping ranges, contact resistance testing, insulation resistance testing and complete switchgear and transformer cleaning and inspection.

7. Periodic Arc Flash Analysis Review

The 2012 edition of NFPA 70E includes several new requirements regarding arc flash hazard analysis. One new requirement found in Article 130 is that an arc flash hazard analysis must be updated:

- Every five years (at minimum)
- When the electrical system is modified or renovated in any way, including renovations, additions, or subtractions to the system

It is recommended that a plan is implemented to schedule a review of the arc flash hazard analysis for the Portland State University Non-West Campus Loop in a period not to exceed five years, and that a review is performed whenever substantial modifications or renovations take place.

2.0 SHORT-CIRCUIT ANALYSIS

The short-circuit study determines the fault currents that flow in the system during various fault conditions. The calculated fault currents are used in the device evaluation and coordination studies. See Appendix A and Appendix B for the computer generated input data and output data. NEC-2011, Article 110.24(A) requires that service entrance equipment is labeled with the following pieces of information:

- Maximum available fault current
- Date on which the fault current was calculated

Article 110.24(B) adds that if there is a modification that may change this fault current value, it must be recalculated. The field marking must be updated to reflect the new value of maximum fault current.

The short-circuit calculations were done using A_FAULT, a computer software package by SKM Systems Analysis. The short-circuit analysis performed by A_FAULT is based on IEEE Std C37.010™-1999, IEEE Std C37.5™-1979, and IEEE Std C37.13™-2008.

Separate “Z” (complex), “X” (reactive), and "R" (resistive) networks are used by A_FAULT for the short-circuit analysis. A_FAULT uses complex network reduction and the relationship E/Z to calculate the fault current magnitude and angle at each faulted bus. The complex equivalent circuit impedance, Z, is calculated by the reduction of the “Z” (complex) network, and is reported as the “EQUIV. IMPEDANCE” in the A_FAULT reports. The X/R ratios calculated for each fault condition are based on the separate reduction of the X and R networks. These X/R ratios are used for the calculation of fault duty multipliers, to evaluate the short-circuit ratings of system components.

A_FAULT is capable of generating three types of short-circuit reports for both balanced (three-phase bolted) and unbalanced (line-to-ground) faults. The reports that are generated depend on the system that is being evaluated.

The three types of short-circuit reports are:

- Fault Report (for low voltage)
- Momentary Duty Report (for medium voltage)
- Interrupting Duty Report (for medium voltage)

1. <u>Fault Report</u>

The fault currents reported in the “Fault Report” are applicable to low voltage devices and components. The fault currents calculated in this report are based on the contribution data derived from IEEE Std C37.13-2008. The fault currents are calculated as follows:

- Motor and generator subtransient reactance values (Xd”) are adjusted per the first cycle duty multipliers described in IEEE Std 141™-1993 (Red Book).
- The complex equivalent circuit impedance, Z, is calculated by network reduction of the “Z” (complex) network.
- The momentary symmetrical current = E/Z.
- The X/R ratio is equal to the equivalent circuit reactance, X, divided by the equivalent circuit resistance, R. As discussed above, X is calculated by the reduction of the “X” (reactive) network and R is calculated by the reduction of the “R” (resistive) network.

Multiplying factors are determined, and used to adjust the calculated symmetrical fault current. The adjusted current is used to evaluate low voltage protective devices. Low voltage output algorithms and output reports reflect NEMA AB-1 molded case breaker de-rating multipliers. Breakers are de-rated for circuits where the power factor is lower than the NEMA test circuit (higher X/R ratio). The multipliers adjust the symmetrical fault current to the value associated with the systems fault point X/R ratio. The adjusted value listed on the report may then be compared directly with the manufacturer's published interrupting rating.

2. <u>Momentary Duty Report</u>

The “Momentary Duty Report” contains the calculated fault currents that occur during the first half-cycle of the fault. The momentary fault currents are used to evaluate medium and high voltage fuses, and the “closing and latching” capability (momentary rating) of medium and high voltage breakers. The fault currents reported in the “Momentary Duty Report” are calculated as follows:

- Motor and generator subtransient reactance values (Xd”) are adjusted per the first cycle duty multipliers described in IEEE Std 141-1993 (Red Book).
- The complex equivalent circuit impedance, Z, is calculated by network reduction of the “Z” (complex) network.
- The momentary symmetrical current = E/Z.
- The X/R ratio reported is equal to the equivalent circuit reactance, X, divided by the equivalent circuit resistance, R. As discussed above, X is calculated by the reduction of the “X” (reactive) network and R is calculated by the reduction of the “R” (resistive) network.
- A_FAULT calculates and reports the momentary asymmetrical current in two different ways, once as “sym*1.6” and again as “momentary based on X/R”. The “sym*1.6” value is the momentary symmetrical current multiplied by 1.6. The “momentary based on X/R” value is the momentary symmetrical current multiplied by

$$\sqrt{1+2e^{(-2\pi/(X/R))}}$$

3. Interrupting Duty Report

The fault currents reported in the "Interrupting Duty Report" are used to evaluate the interrupting rating of medium- and high-voltage breakers. The interrupting symmetrical current is calculated as follows:

- Motor and generator subtransient reactance values (Xd") are adjusted per the interrupting duty multipliers described in IEEE Std 141-1993 (Red Book).
- The complex equivalent circuit impedance, Z, is calculated by network reduction of the "Z" (complex) network.
- The interrupting symmetrical current = E/Z.
- The X/R ratio reported is equal to the equivalent circuit reactance, X, divided by the equivalent circuit resistance, R. As discussed above, X is calculated by the reduction of the "X" (reactive) network and R is calculated by the reduction of the "R" (resistive) network.
- A_FAULT uses the calculated X/R ratio to determine the minimum contact parting time multiplying factors for 2, 3, 5, and 8 cycle breakers. The multiplying factors are based on IEEE Std C37.5-1979 and IEEE Std C37.010-1999 standards. The multiplying factors are applied to the interrupting symmetrical current in order to calculate the RMS short-circuit current interrupting duty for 2, 3, 5, and 8 cycle breakers. This duty is compared to the symmetrical current interrupting rating of the circuit breaker. NACD (No AC Decrement) ratios are calculated with consideration of generator "Local" and "Remote" contributions as outlined in IEEE Std C37.010-1999.
- Motor and generator impedance multipliers for the short-circuit calculations are summarized in the following table. This is based on the recommended combination network for comprehensive multi-voltage system calculations (from IEEE Std 141-1993; Red Book):

Machine Type	Impedance (First Cycle Duty)	Impedance (Interrupting Duty)
Turbine generators, Condensers, Hydrogenerators with amortisseur windings	1.0 Xd"	1.0 Xd"
Synchronous motors	1.0 Xd"	1.5 Xd"
Induction motors > 1000 hp at speed ≤ 1800 RPM, or > 250 hp at 3600 RPM.	1.0 Xd"	1.5 Xd"
Induction motors ≥ 50 hp not covered above.	1.2 Xd"	3.0 Xd"
Induction motors < 50 hp	1.67 Xd"	Neglect

Note: Xd" is the subtransient reactance of the rotating machine.

2.1 Short-Circuit Objectives

The objective of the short-circuit analysis is to calculate the maximum short-circuit currents produced by balanced three-phase and unbalanced faults at each bus shown on the one-line diagrams in Appendix D.

2.2 System Modeling

For all systems with either a 480/277 V or 208/120 V, wye configured service, short-circuit currents were calculated for a three-phase bolted fault and single-line-to-ground fault at each bus shown on the one-line diagrams found in Appendix D. The system was modeled for worst-case fault currents.

For all systems with a 240/120 V, open delta configured service, short-circuit currents were calculated for a line-to-line bolted fault at each bus shown on the one-line diagrams found in Appendix D. It is not possible to model single winding transformers in SKM, therefore an equivalent three-phase transformer was modeled to provide the most accurate results possible while still remaining conservative. For all 240/120 V services with unequally sized transformers, or transformers with unequal impedances, a three-phase, delta winding, the kVA of the equivalent transformer is modeled as three times the kVA of the largest single transformer installed by PGE. The impedance of the equivalent transformer is modeled as equal to the %Z of the largest single transformer installed by PGE. For all 240/120 V services with equally sized transformers, the equipvalet transformer is modeled as three times the kVA of a single transformer winding. The impedance of the equivalent transformer is modeled as equal to the winding with the lowest %Z. In the equipment evaluation, the calculated line-to-line fault was reported to represent the worst-case scenario.

1. Cases:

Multiple scenarios were only necessary when examining fault-current values at the 4th Avenue / Engineering Building, as this is the only building with multiple sources of power. The following short-circuit study cases were evaluated:

- Study Case No. 1 – System supplied from the Urban-Medical utility feed via Medium Voltage Switchgear B-EB-52-U1. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breakers BK-EB-52-G1 and BK-EB-52-U2 are open.
- Study Case No. 2 – System supplied from the Urban-Gibbs utility feed via Medium Voltage Switchgear B-EB-52-U2. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breakers BK-EB-52-G1 and BK-EB-52-U1 are open.
- Study Case No. 3 – System supplied from the Emergency Generator via Medium Voltage Switchgear B-EB-52-U3. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breakers BK-EB-52-U1 and BK-EB-52-U2 are open.
- Study Case No. 4 – System supplied from the Urban-Medical utility feed and Emergency Generator via Medium Voltage Switchgear B-EB-52-U1 and B-EB-52-U3. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breaker BK-EB-52-U2 is open.
- Study Case No. 5 – System supplied from the Urban-Gibbs utility feed and Emergency Generator via Medium Voltage Switchgear B-EB-52-U2 and B-EB-52-U3. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breaker BK-EB-52-U1 is open. **This is the worst case scenario and the scenario illustrated in the one-line diagram found in Appendix D.**

2. Utility Information:

Utility transformer and source impedance information was provided by Tom Riddle with PGE on 1/10/2013 via email. Information for all PGE utility sources is summarized in Appendix C.

The Market Center Building is not supplied by PGE, but is supplied by PacifiCorp. It was not possible to obtain fault current information from PacifiCorp at the time of this study. To ensure conservative results, an infinite bus was assumed on the primary side (12.47 kV) of utility transformers TX-MCB UTIL-A, TX-MCB UTIL-B and TX-MCB BSMT UTIL. The following values were calculated on the secondary side (480 V) of each transformer based on transformer nameplate information gathered during data collection:

TX-MCB UTIL-A

- Three-phase fault current: 15,826.5 A

TX-MCB UTIL-B

- Three-phase fault current: 16,705.7 A

TX-MCB BSMT UTIL

- Three-phase fault current: 8,018.8 A

3. System Information:

Input data used in this study was obtained from the following sources:

- Building one-line diagrams provided by Portland State University
- Eaton on-site data collection performed October 2012 to February 2013.

4. Assumptions:

The following assumptions were used in modeling the power system, and ensure conservative, worst-case results:

- For fault currents in the Market Center Building (MCB), it was assumed that three-phase and single-line to ground fault currents were identical.
- An X/R ratio of 5.2402 was used to model utility fault contributions MCB INF UTIL-A and MCB INF UTIL-B. An X/R ratio of 4.1498 was used to model utility fault contribution MCB BSMT INF UTIL.
- It is assumed that fault current contributions from motors would be negligible.
- It is assumed that the impedance of cables from the utility transformer to each service entrance would be negligible; therefore these cables were excluded from the study.
- System voltage is modeled at 100% nominal.
- All low voltage cable is modeled in non-magnetic conduit.
- All medium voltage cable is modeled in non-magnetic conduit.
- Generator subtransient reactances for generator G-EB GEN (X''_d, X_2, and X_0) are assumed to be 10%.
- Unless otherwise provided, transformer X/R ratios are obtained from IEEE Std C37.010-1999.
- It was assumed the Urban-Gibbs and Urban-Medical utility feeds in the Engineering Building had the same fault current characteristics.

Complete information regarding the system model used for the computer simulation is included in Appendix A.

2.3 Short-Circuit Results

The results of the short-circuit analysis, including calculated branch contributions, are provided in Appendix B. The one-line diagrams with referenced bus identification are included in Appendix D.

2.4 Equipment Evaluation

The purpose of the equipment evaluation is to compare the ***maximum*** calculated short-circuit currents to the short-circuit ratings of protective devices. The comparison is made in order to determine if the device can interrupt or withstand the available fault currents of the electrical system to which the device is applied, as required by NEC-2011, Article 110.9 and NEC-2011, Article 110.10. The device evaluation follows the evaluation procedures outlined in IEEE Std C37.13-2008, IEEE Std C37.010-1999, IEEE Std C37.5-1979, IEEE Std C37.41™-2008, IEEE Std 1015™-2006 (Blue Book), and applicable ANSI, NEMA, and UL standards.

The results of the short-circuit equipment evaluation are summarized in Table 2.1. The table indicates "Bus I.D." (corresponds to bus designations used in the one-line diagrams of Appendix D), "Manufacturer", "Status" (Pass, fail, unknown, or marginal), "Type" (equipment category), "Equip Volts", calculated short-circuit duty, the equipment short-circuit rating, the series rating (if applicable), and the maximum duty rating.

The maximum duty rating is calculated by:

$$\frac{S.C.duty}{Device S.C.Rating} \times 100$$

For equipment with series ratings, the maximum duty rating is calculated using the series rating instead of the individual device short-circuit rating. All short-circuit current values are reported in units of kA.

1. <u>For low voltage devices:</u>

The calculated short-circuit duty is reported under "Calc Isc (kA)" and the device short-circuit rating is reported under "Equip Isc (kA)". The calculated duty has been adjusted accordingly per the system X/R and device test X/R. For all 240/120 V systems, the line-to-line fault current is presented under the column "Calc Isc (kA)". 240/120 V entries do not include an X/R adjustment. By examination it was determined that this adjustment will not change the pass/fail status of any 240/120 equipment and was therefore excluded.

2. <u>For medium/high voltage breakers:</u>

The calculated *interrupting* short-circuit duty is reported under "Calc Isc (kA)" and the breaker short-circuit interrupting rating is reported under "Equip Isc (kA)". The interrupting duty has been adjusted per multiplying factors based on the breaker clearing time and system X/R. The calculated momentary duty (i.e. close-and-latch duty) is reported under "Calc Mom (kA)". The breaker momentary (i.e. close-and-latch) rating is reported under "Equip Msc (kA)".

3. <u>For medium/high voltage fuses, switches, and motor starters:</u>

The calculated *momentary symmetrical* short-circuit duty is reported under "Calc Isc (kA)" and the device's momentary symmetrical short-circuit rating is reported under "Equip Isc (kA)". The calculated *momentary asymmetrical* duty is reported under "Calc Mom (kA)". The device's momentary asymmetrical short-circuit rating is reported under "Equip Mom (kA)".

Table 2.1 - Equipment Evaluation

Bus I.D.	Manufacturer	Status	Type	Bus Voltage (V)	Calc Isc (kA)	Equip Isc (kA)	Rating %	Calc Mom (kA)	Equip Mom (kA)	Rating %
B-SEC NORTH ECB-USB	ITE	Pass	LV Enclosed Circuit Breaker	240	35.167	42.00	83.73			
B-EB-FP DISC-USB	Eaton	Pass	LV Enclosed Circuit Breaker	480	1.90	35.00	5.43			
B-AB ANNEX DISC-USB	**GE**	**Fail**	**LV Fused Disconnect**	**208**	***33.77 (*N1)**	**10.00**	337.70			
B-AB DISC-USB	Pierce	Pass	LV Fused Disconnect	208	42.53	200.00	21.27			
B-BLKS K-USB	Siemens	Pass	LV Fused Disconnect	240	27.127	200.00	13.56			
B-EH E DISC-USB	Cutler-Hammer	Pass	LV Fused Disconnect	240	19.674	100.00	19.67			
B-PS3-USB	Circle W Products	Pass	LV Fused Disconnect	208	16.29	200.00	8.15			
B-SBH DISC A-USB	Siemens	Pass	LV Fused Disconnect	240	8.109	100.00	8.11			
B-SBH DISC B-USB	Siemens	Pass	LV Fused Disconnect	240	8.109	100.00	8.11			
B-SEC SOUTH DISC 1A-USB	Major	Pass	LV Fused Disconnect	240	31.585	200.00	15.79			
B-SEC SOUTH DISC 2A-USB	Major	Pass	LV Fused Disconnect	240	31.232	200.00	15.62			
B-SEC SOUTH DISC 2B-USB	Major	Pass	LV Fused Disconnect	240	31.232	200.00	15.62			
B-STFR-USB	Bulldog	Pass	LV Fused Disconnect	240	45.17	200.00	22.59			
B-URBN FP DISC-USB	GE	Pass	LV Fused Disconnect	480	40.74	100.00	40.74			
B-KHSE-USB	Square D	Pass	LV Fused Panelboard	208	30.43	200.00	15.22			
B-MONT-USB	Gould	Pass	LV Fused Switchboard	240	35.777	200.00	17.89			
B-AB PNLBRD-USB	**FPE**	**Fail**	**LV Panelboard**	**208**	***45.45 (*N1)**	**18.00**	302.50			
B-BLKS L1-USB	**Gould**	**Fail**	**LV Panelboard**	**240**	**32.633**	**10.00**	326.33			
B-BLKS L2-USB	**Gould**	**Fail**	**LV Panelboard**	**240**	**32.633**	**10.00**	326.33			
B-BLKS L3-USB	**Gould**	**Fail**	**LV Panelboard**	**240**	**32.633**	**10.00**	326.33			
B-BLKS L4-USB	**Gould**	**Fail**	**LV Panelboard**	**240**	**32.633**	**10.00**	326.33			
B-BLKS L5-USB	**Gould**	**Fail**	**LV Panelboard**	**240**	**32.633**	**10.00**	326.33			
B-BLKS X-USB	**Gould**	**Fail**	**LV Panelboard**	**240**	**24.199**	**10.00**	241.99			
B-EH A-USB	**Cutler-Hammer**	**Fail**	**LV Panelboard**	**240**	**19.674**	**10.00**	196.74			
B-EH B-USB	**Cutler-Hammer**	**Fail**	**LV Panelboard**	**240**	**19.674**	**10.00**	196.74			
B-EH C-USB	**Cutler-Hammer**	**Fail**	**LV Panelboard**	**240**	**19.674**	**10.00**	196.74			
B-HGDC-USB	Square D	Pass	LV Panelboard	240	38.765	65.00	59.64			

Bus I.D.	Manufacturer	Status	Type	Bus Voltage (V)	Calc Isc (kA)	Equip Isc (kA)	Rating %	Calc Mom (kA)	Equip Mom (kA)	Rating %
B-HH 1-USB	**GE**	**Fail**	**LV Panelboard**	**240**	**44.004**	**10.00**	440.04			
B-HH 2-USB	**GE**	**Fail**	**LV Panelboard**	**240**	**39.714**	**10.00**	397.14			
B-HSB-USB	**Cutler-Hammer**	**Fail**	**LV Panelboard**	**240**	**42.323**	**10.00**	423.23			
B-PRKW L1-USB	**ITE**	**Fail**	**LV Panelboard**	**240**	**35.121**	**10.00**	351.21			
B-PRKW L2-USB	**ITE**	**Fail**	**LV Panelboard**	**240**	**35.121**	**10.00**	351.21			
B-PRKW L3-USB	**ITE**	**Fail**	**LV Panelboard**	**240**	**35.121**	**10.00**	351.21			
B-PRKW L4-USB	**ITE**	**Fail**	**LV Panelboard**	**240**	**35.121**	**10.00**	351.21			
B-PRKW L5-USB	**ITE**	**Fail**	**LV Panelboard**	**240**	**35.121**	**10.00**	351.21			
B-PRKW X-USB	**ITE**	**Fail**	**LV Panelboard**	**240**	**35.121**	**10.00**	351.21			
B-SEC NORTH PNL-USB	**ITE**	**Fail**	**LV Panelboard**	**240**	**35.167**	**10.00**	351.67			
B-SEC SOUTH PNL 1B-USB	**Square D**	**Fail**	**LV Panelboard**	**240**	**31.232**	**10.00**	312.32			
B-SEC SOUTH PNL 1C-USB	**Square D**	**Fail**	**LV Panelboard**	**240**	**31.232**	**10.00**	312.32			
B-SEC SOUTH PNL 1D-USB	**Square D**	**Fail**	**LV Panelboard**	**240**	**31.232**	**10.00**	312.32			
B-STHL L1-USB	**ITE**	**Fail**	**LV Panelboard**	**240**	**16.123**	**10.00**	161.23			
B-STHL L2-USB	**ITE**	**Fail**	**LV Panelboard**	**240**	**15.98**	**10.00**	159.80			
B-STHL L3-USB	**ITE**	**Fail**	**LV Panelboard**	**240**	**15.838**	**10.00**	158.38			
B-STHL L4-USB	**ITE**	**Fail**	**LV Panelboard**	**240**	**15.698**	**10.00**	156.98			
B-STHL L5-USB	**ITE**	**Fail**	**LV Panelboard**	**240**	**15.559**	**10.00**	155.59			
B-STHL X-USB	**ITE**	**Fail**	**LV Panelboard**	**240**	**15.423**	**10.00**	154.23			
B-UHP-USB	**GE**	**Fail**	**LV Panelboard**	**240**	**13.47**	**10.00**	134.70			
B-ARC-A-USB	ITE	Pass	LV Switchboard	480	16.34 (*N1)	18.00	90.78			
B-ARC-B-USB	**ITE**	**Fail**	**LV Switchboard**	**208**	***23.42 (*N1)**	**18.00**	130.11			
B-BHB MSB-A-USB	Square D	Pass	LV Switchboard	480	18.55 (*N1)	65.00	28.54			
B-BHB MSB-B-USB	Square D	Pass	LV Switchboard	208	27.65	65.00	42.54			
B-BHB MSB-C-USB	Square D	Pass	LV Switchboard	208	27.65	65.00	42.54			
B-HOFF-USB	GE	Pass	LV Switchboard	208	33.25	65.00	51.15			
B-JCB-USB	GE	Pass	LV Switchboard	208	33.47	65.00	51.49			
B-KNGA-USB	**GE**	**Fail**	**LV Switchboard**	**240**	**42.323**	**10.00**	423.23			
B-MCB BSMT-USB	ITE	Pass	LV Switchboard	480	8.54 (*N1)	18.00	47.44			

Bus I.D.	Manufacturer	Status	Type	Bus Voltage (V)	Calc Isc (kA)	Equip Isc (kA)	Rating %	Calc Mom (kA)	Equip Mom (kA)	Rating %
B-MCB PNTHS-USB	**ITE**	**Fail**	**LV Switchboard**	**480**	***35.37 (*N1)**	**18.00**	196.50			
B-MSB-A SUB SWBD-USB	Square D	Pass	LV Switchboard	480	18.50 (*N1)	65.00	28.46			
B-NASC-USB	Square D	Pass	LV Switchboard	208	15.56	65.00	23.94			
B-OND 15 FLR-USB	**FPE**	**Fail**	**LV Switchboard**	**240**	**18.488**	**10.00**	184.88			
B-OND ANNEX SWBD-USB	Cutler-Hammer	Pass	LV Switchboard	208	39.76	65.00	61.17			
B-OND MAIN SWBD-USB	Cutler-Hammer	Pass	LV Switchboard	480	16.60	65.00	25.54			
B-SBA-USB	**ITE**	**Fail**	**LV Switchboard**	**208**	***33.13 (*N1)**	**18.00**	184.06			
B-SEH-USB	GE	Pass	LV Switchboard	208	33.25	65.00	51.15			
B-SH-USB	GE	Pass	LV Switchboard	208	52.21	85.00	61.42			
B-UCB-USB	GE	Pass	LV Switchboard	208	31.92	42.00	76.00			
B-UP-A-USB	**ITE**	**Fail**	**LV Switchboard**	**480**	***40.92 (*N1)**	**18.00**	227.33			
B-UP-B-USB	**ITE**	**Fail**	**LV Switchboard**	**208**	***72.32 (*N1)**	**10.00**	723.20			
B-URBN SWBD-USB	Cutler-Hammer	Pass	LV Switchboard	480	40.74	65.00	62.68			
B-EB-USB-1	Eaton	Pass	LV Switchgear	480	26.42	65.00	40.65			
B-EB-USB-2	Eaton	Pass	LV Switchgear	480	26.44	65.00	40.68			
B-EB-USB-3	Eaton	Pass	LV Switchgear	208	36.47	65.00	56.11			
B-EB-USB-5	Eaton	Pass	LV Switchgear	480	25.79	65.00	39.68			
B-EB-USB-6	Eaton	Pass	LV Switchgear	480	26.41	65.00	40.63			
B-EB-USB-7	Eaton	Pass	LV Switchgear	480	26.43	65.00	40.66			
B-EB-52-U1	Eaton	Pass	MV Switchgear	12470	5.91	23.00	25.70	7.44	37.00	20.12
B-EB-52-U2	Eaton	Pass	MV Switchgear	12470	5.92	23.00	25.74	7.46	37.00	20.16
B-EB-52-U3	Eaton	Pass	MV Switchgear	12470	5.91	23.00	25.70	7.45	37.00	20.15

(*N1) System X/R higher than Test X/R, Calc Isc kA modified based on low voltage factor.

3.0 PROTECTIVE DEVICE COORDINATION STUDY

The protective device coordination study determines overcurrent protective relay and circuit breaker settings in order to provide an optimal compromise between protection and selectivity.

The coordination plots were developed using SKM System Analysis' CAPTOR software. Protective device coordination was performed in accordance with IEEE Std 242™-2001 (Buff Book). Minimum guidelines for equipment protection, as outlined in the National Electrical Code (NEC) and applicable standards of the American National Standards Institute (ANSI), were followed.

3.1 General Description and Protection Philosophy

Using the appropriate maximum fault currents, the time-current coordination curves were plotted as operating time versus current magnitudes to show protective device tripping and/or clearing characteristics and coordination among these devices.

Consideration was given to provide both selective isolation of faults and maximum protection of equipment such as cables, transformers, motors, etc.

To achieve the optimum protection and selectivity, the following guidelines were followed throughout the study:

1. Ideally, the settings of any overcurrent device should be high enough to permit the continuous full-load operating capacity of the cables and the equipment they supply, and to ride through system temporary disturbances such as in-rush current. On the other hand, the settings should be low enough to provide overload and short-circuit protection under minimum fault conditions.
2. Considering any two protective devices in series:
   - The maximum available fault current at the downstream device determines the upper limit of the coordination range between these two devices.
   - The minimum available fault current at the downstream device or the pick-up setting of the upstream device determines the lower limit of the coordination range.
   - Series instantaneous devices do not coordinate unless there is sufficient impedance between the two devices.
   - When plotting coordination curves, certain time intervals must be maintained between the curves in order to ensure correct selectivity. These time intervals vary, depending on the device types. In general, however, the following must be taken into consideration when determining the appropriate time separation interval: Breaker clearing

time, relay tolerances, induction disk over-travel, and a reasonable safety margin for error.

3.2 Codes and Standards

The minimum protection requirements as outlined in the National Electric Code (NEC), ANSI, and IEEE Standards were used as guidelines for protective device settings.

Applicable requirements are summarized below.

1. Cables

Power cables require overload and short-circuit protection in order to meet the requirements stated in NEC-2011, Article 240, and IEEE Std 242-2001 (Buff Book). NEC further requires that the ampacity of low voltage cable (0-2000 Volts) be determined by NEC-2011, Article 310.15. Cable de-rating based upon ambient temperature and the number of current carrying conductors in a raceway must also be applied. Medium voltage cable (2001-35,000 Volts) ampacity is defined by NEC-2011, Article 240.100(A) and NEC-2011, Article 310.60.

2. Transformers

A transformer is recommended to have protective devices on both primary and secondary side in order to meet the basic protection requirements for overloads and short-circuit withstand values. However, a transformer is permitted to be protected by only a primary side device if it meets the exceptions listed in NEC-2011, Article 240.4(F). In addition, the transformer protective devices must be able to withstand magnetizing inrush currents without tripping.

NEC protection requirements for transformers: Overcurrent devices are selected, and settings are recommended to provide overcurrent protection in accordance with NEC-2011, Article 450.3. Paragraph (A) specifies that transformers over 600 V comply with Table 450.3(A). Paragraph (B) specifies that transformers less than 600 V comply with Table 450.3(B). These tables provide guidance for sizing of primary and secondary overcurrent protective devices based on transformer full load ampere ratings, transformer impedance, and transformer location.

Short-circuit thermal limits for transformers: The primary devices should be set on the basis that the transformers have short-circuit withstand capabilities as defined by IEEE Std C57.109™-1993.

3. Motors

The motors should have appropriate protective devices to meet the basic protection requirements for overloads and fault current withstand values. In addition, the motor short-circuit and ground fault protective devices should be set to ride through motor starting current.

3.3 Coordination Objectives

Review the existing system overcurrent protection and coordination. Provide suggestions for improvement.

3.4 Coordination Results

For all locations except the 4th Avenue / Engineering Building, the system coordination began at first overcurrent protective device upstream of the utility transformer, and continued downstream through the service entrance to the largest overcurrent protective device which is not in series with the utility overcurrent device.

For the 4th Avenue / Engineering Building, the normal side system coordination began at the 12.47 kV utility fault interrupter and continued downstream the Switchboards B-EB-52-U1 and B-EB-52-U2 to the largest feeder breaker in each of the Unit Substations B-EB-USB-1 – B-EB-USB-7. The emergency system coordination began at the12.47 kV main relay in B-EB-52-E3 and continued downstream through Switchboards B-EB-52-U1 and B-EB-52-U2 to the largest feeder breaker in each of the Unit Substations B-EB-UB-1 – B-EB-USB-7.

As shown on the time-current plots, each device curve is tagged with an arrow and label referencing its location on the plot's individual representative one-line diagram. This label also references the device to its' specific manufacturer information, including ratings and settings, as indicated in the text box on each plot. The device time-current characteristics are truncated at maximum through-fault current for a downstream fault.

Efforts were made to provide the best coordination possible with the existing protective devices. Areas where breaker trip curves overlap indicate areas of possible non-selective breaker operation. Where possible, efforts were made to reduce non-selective breaker operation while maintaining adequate system protection. In some cases, because of device limitations, little can be done to improve device selectivity. Such device limitations include the fixed operating characteristic of a fuse, the built-in instantaneous or instantaneous "over-ride" elements of molded case circuit breakers, and the limited instantaneous trip range of trip units with an instantaneous trip function.

In cases involving redundant protective devices, non-selective breaker operation is of little or no concern. Protective devices are redundant if, regardless of which device opens, the same system outage occurs. Often, in order to improve overall system protection and coordination, redundant devices are intentionally set to overlap (i.e. non-selectively coordinate with) one another.

Adequate coordination is achieved using the recommended protective devices, with settings and ratings as listed in Section 4. The recommended adjustments would maximize coordination in an attempt to allow the various downstream devices to isolate faults without operation of the upstream devices. Although instantaneous trip devices provide the highest degree of protection, when applied in series they compromise selectivity at high-magnitude fault currents.

3.5 Coordination Recommendations

All of the adjustable low voltage electronic trip and thermal magnetic circuit breakers and medium voltage equipment should be tested and adjusted according to the recommended settings given in Section 4.

If the largest feeder breaker in a service entrance disconnect was adjustable, the as-found settings were used to plot the coordination curve. It is not possible to ensure these breakers are properly set without expanding the scope of this study to downstream locations. Therefore, no settings are recommended for these locations.

Additionally, medium voltage coordination in the Engineering Building should be examined to ensure proper settings in all relays. Many of the relays have an instantaneous overcurrent function (ANSI function 50) programmed for both the phase and neutral trip settings. In many cases this is not desirable as it can lead to a lack of selectivity or a 'race' between two relays when a fault with a high current is detected. This 'race' may result in an operation of both the main and feeder breaker and may result in unnecessary loss of load to the system. It is recommended that these settings be examined to determine if there are any possible changes that would improve coordination. When reviewing the settings, it may be important to include PGE in the conversation to ensure new settings do not disrupt the use of the 3 MW turbine as a co-generation facility.

3.6 Time-Current Characteristic Plots

Refer to the following pages for the plotted coordination curves, which graphically indicate the degree of selectivity and protection obtained.

In some cases, a single time-current curve may be applicable to several locations in the system, where each location utilizes substantially similar devices, and serves similar loads.

The following list references the attached time-current curves for this report.

Table 3.1 – TCC Plots Index

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PS3	Page 3-7
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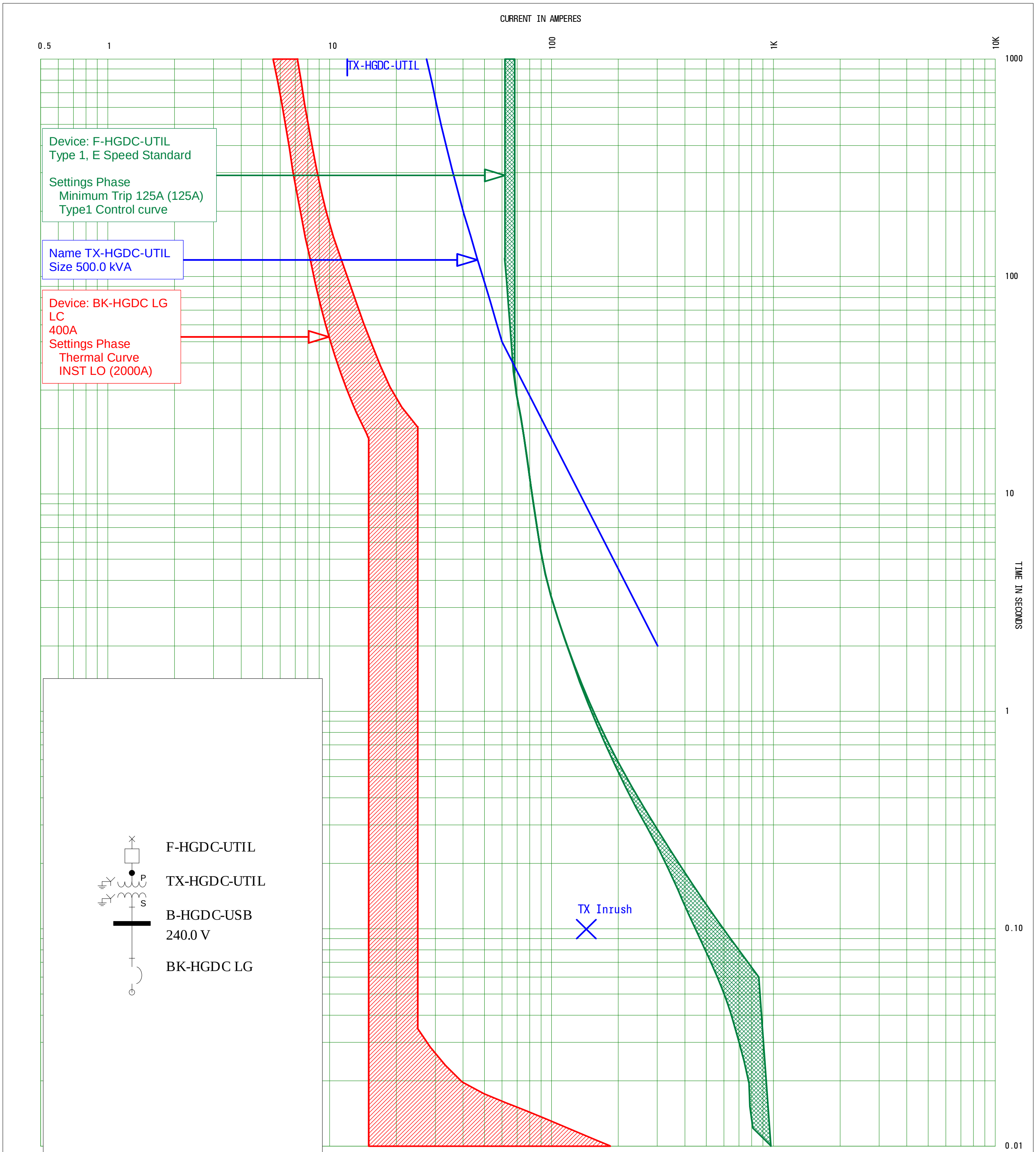
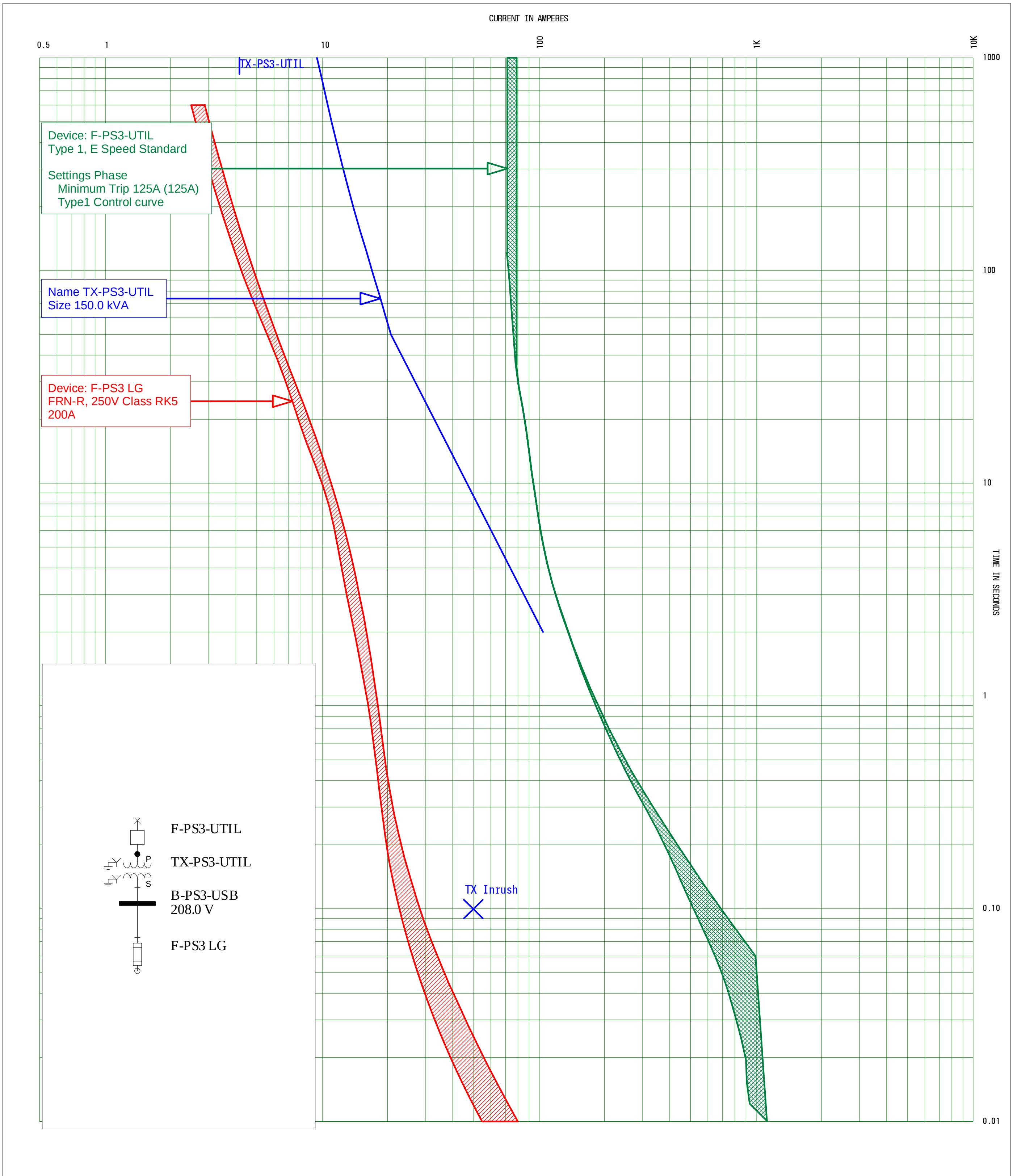
STHL L1	Page 3-10
STHL X	Page 3-11
SEH	Page 3-12
HOFF	Page 3-13
KNGA	Page 3-14
STFR	Page 3-15



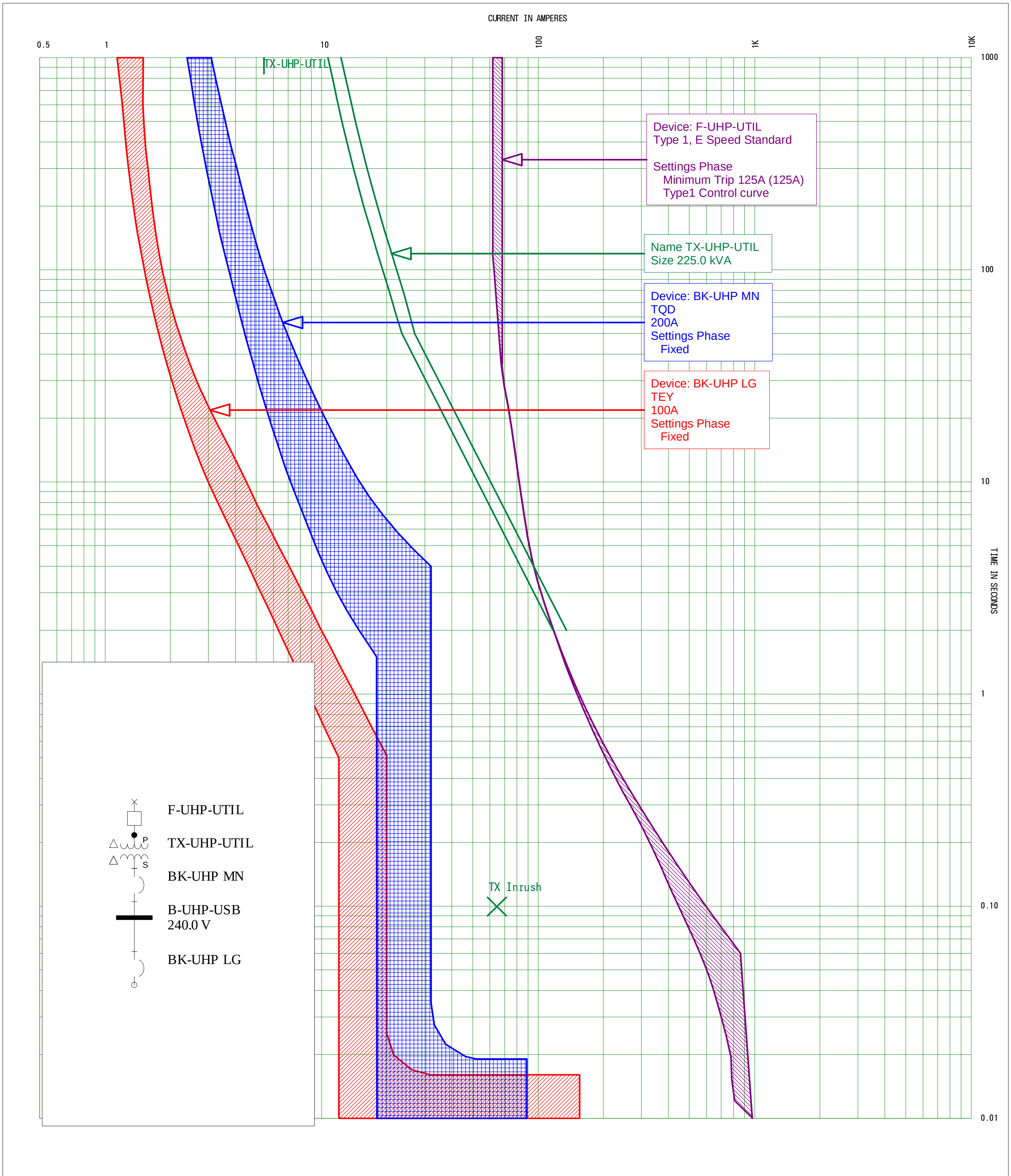
Eaton Electrical Services and Systems
February 21, 2013

Plot name: HGDC
Ref. Voltage: 240V
Current Scale: x 100

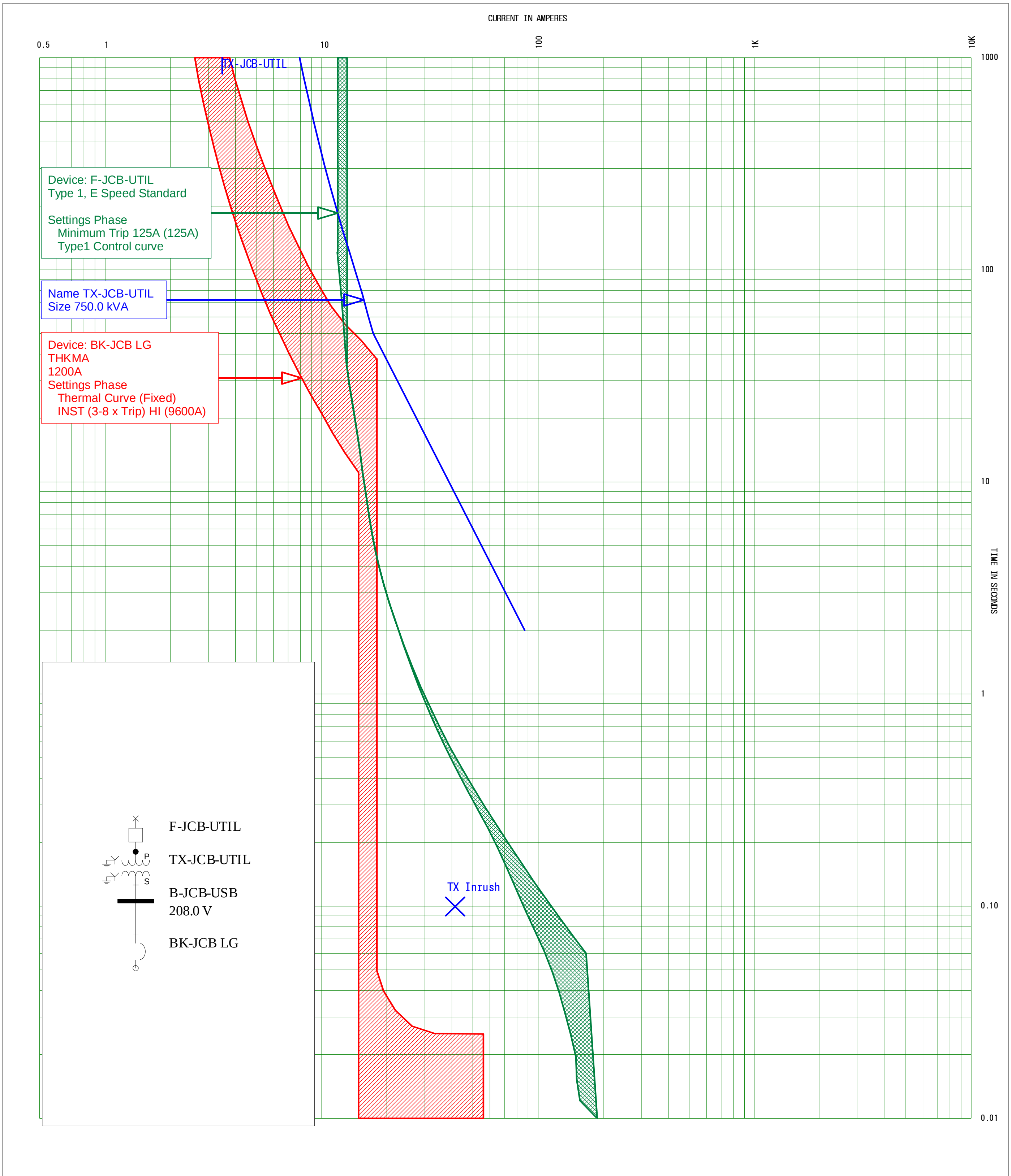


Eaton Electrical Services and Systems
February 21, 2013

Plot name: PS3
Ref. Voltage: 208V
Current Scale: x 100



Eaton Electrical Services and Systems February 21, 2013	Plot name: UHP Ref. Voltage: 240V Current Scale: x 100



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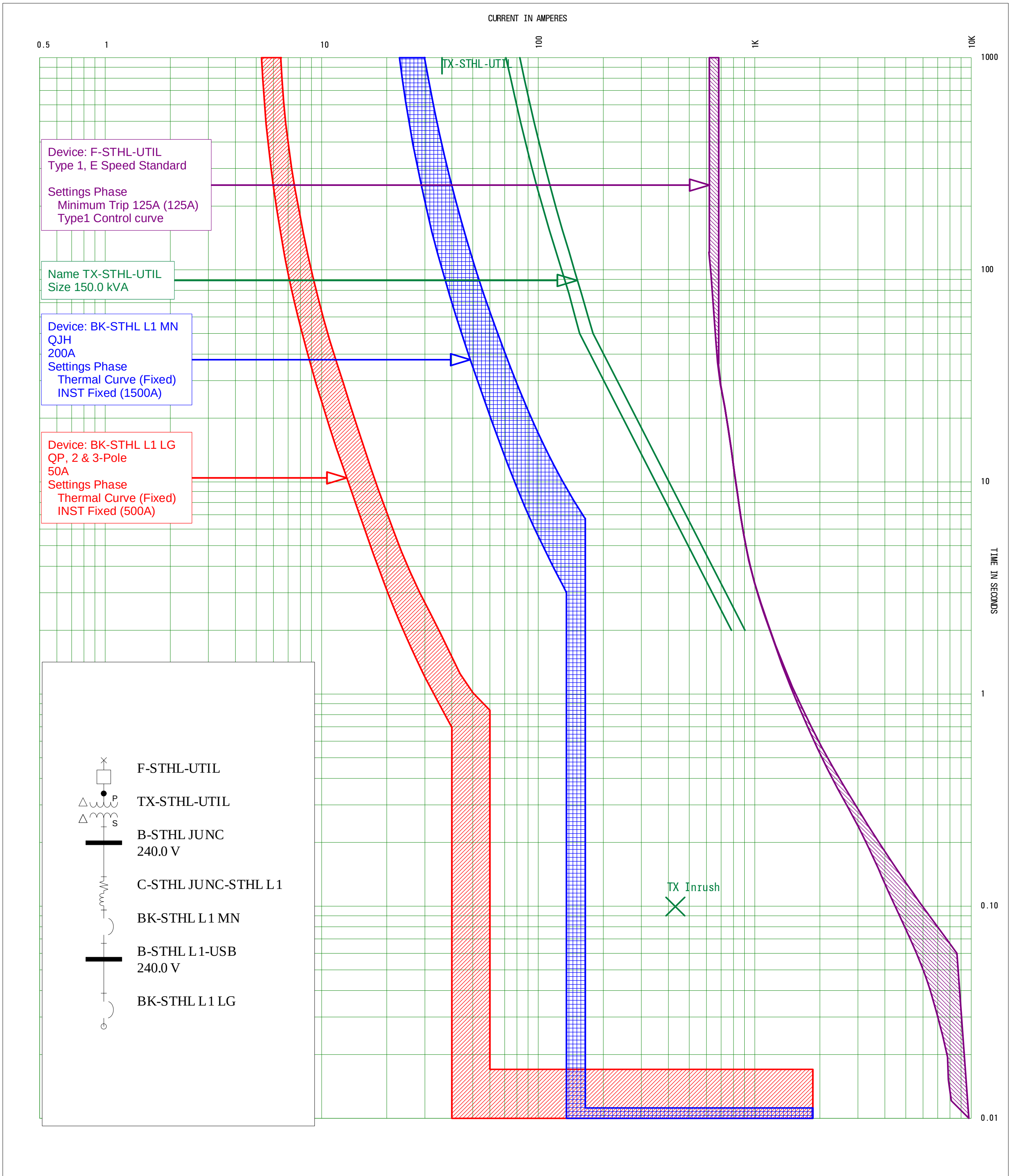

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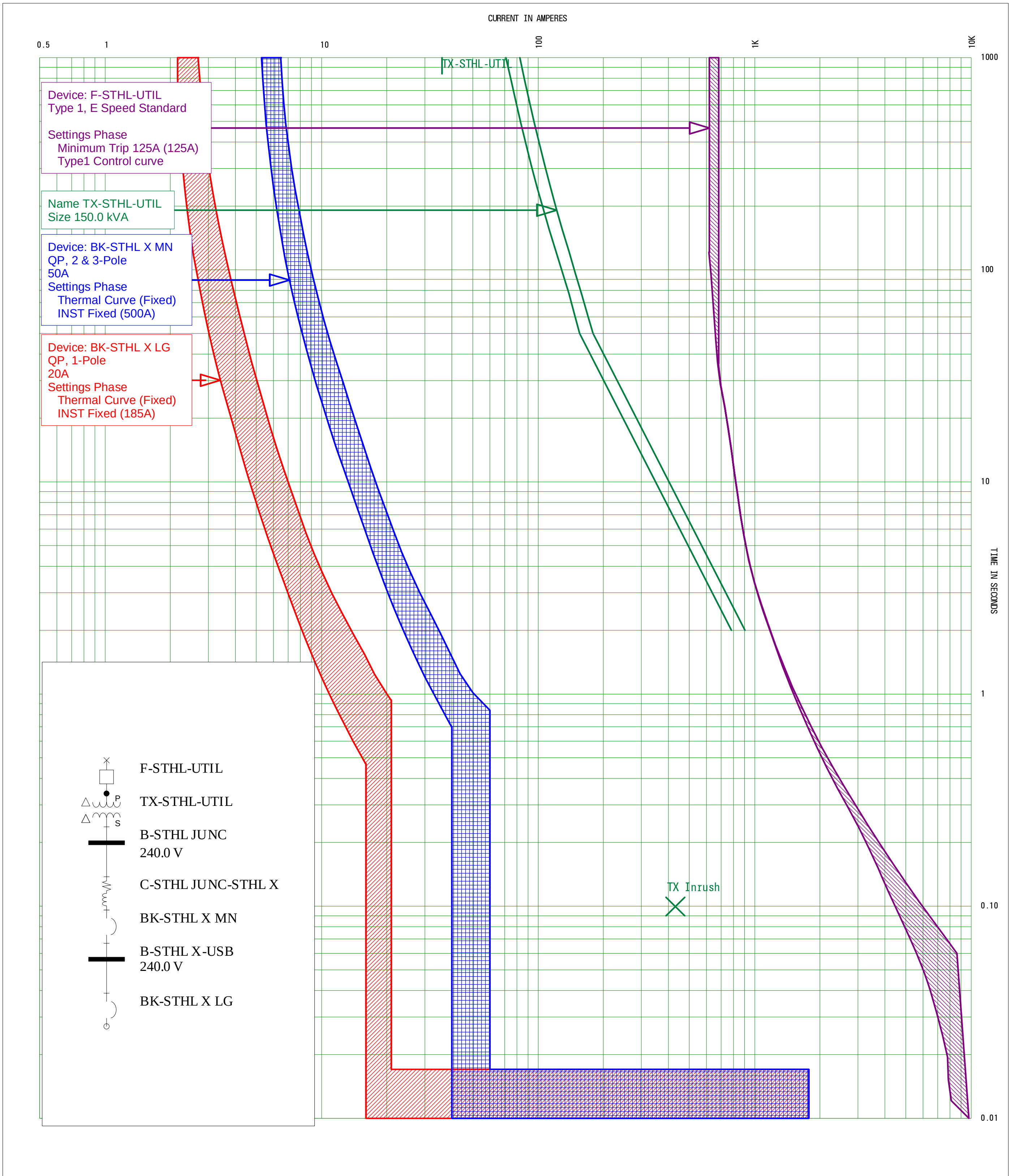

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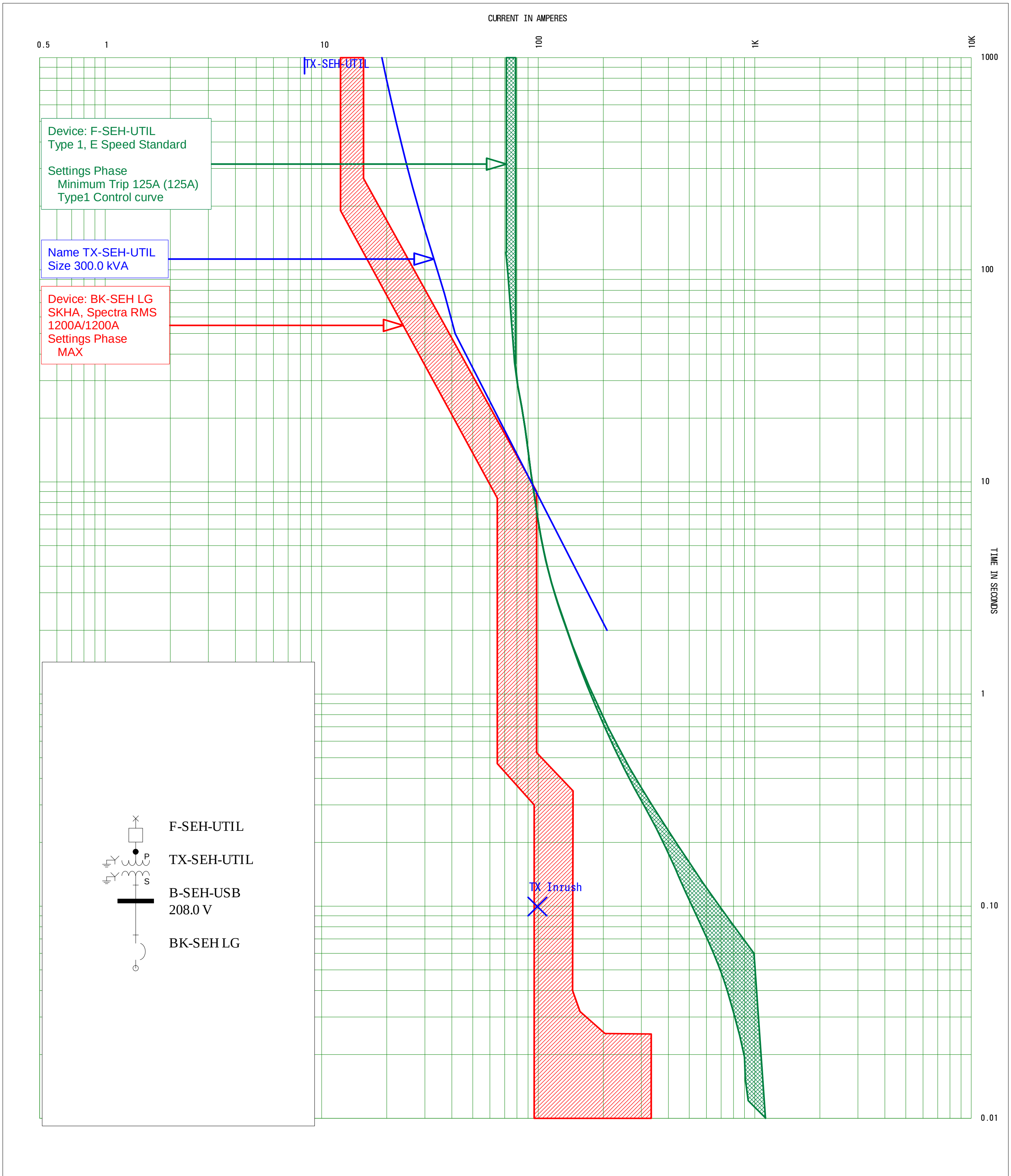
Plot name: STHL X
Ref. Voltage: 240V
Current Scale: x 10



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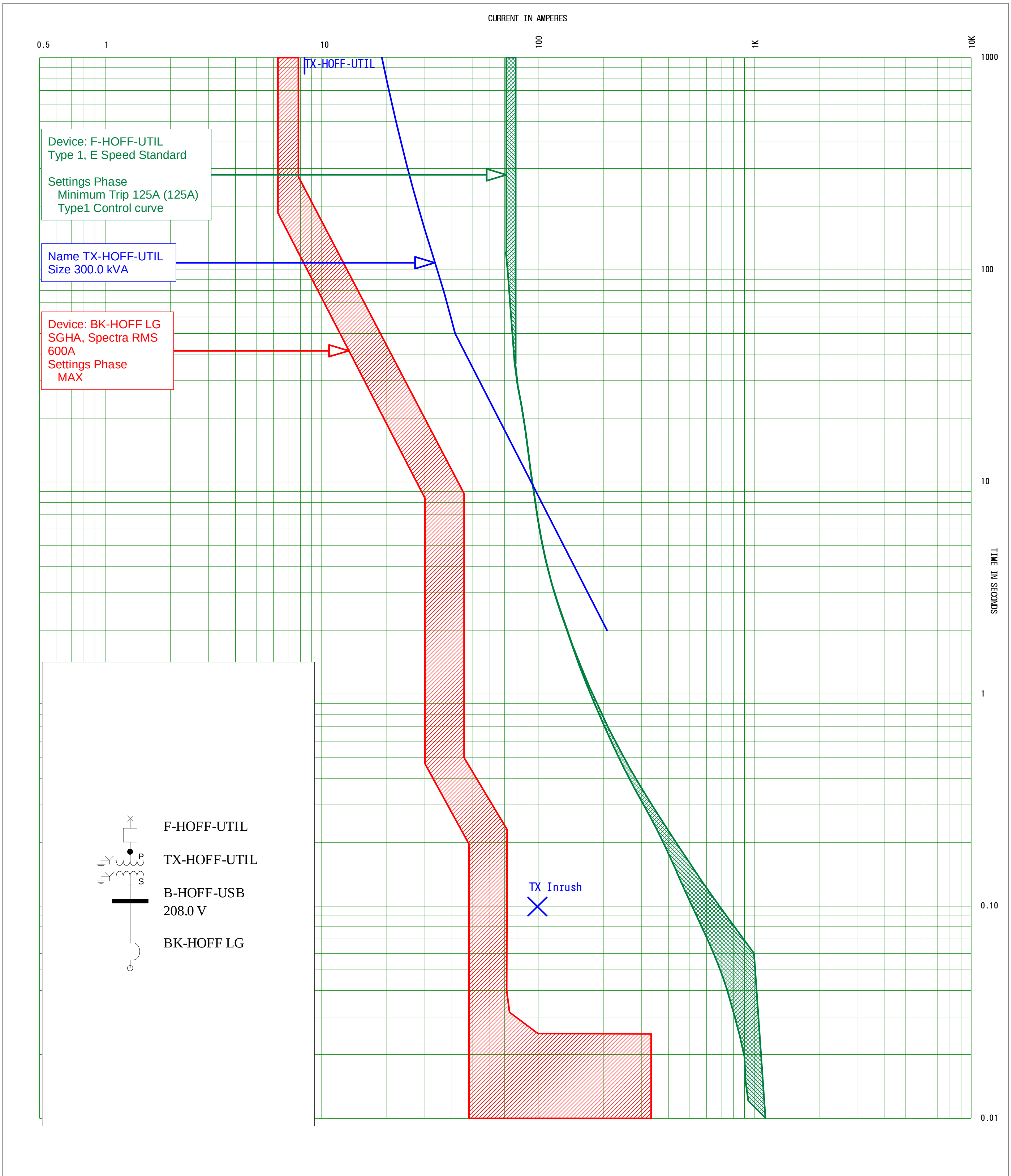

Eaton Electrical Services and Systems
February 21, 2013

Plot name: HOFF
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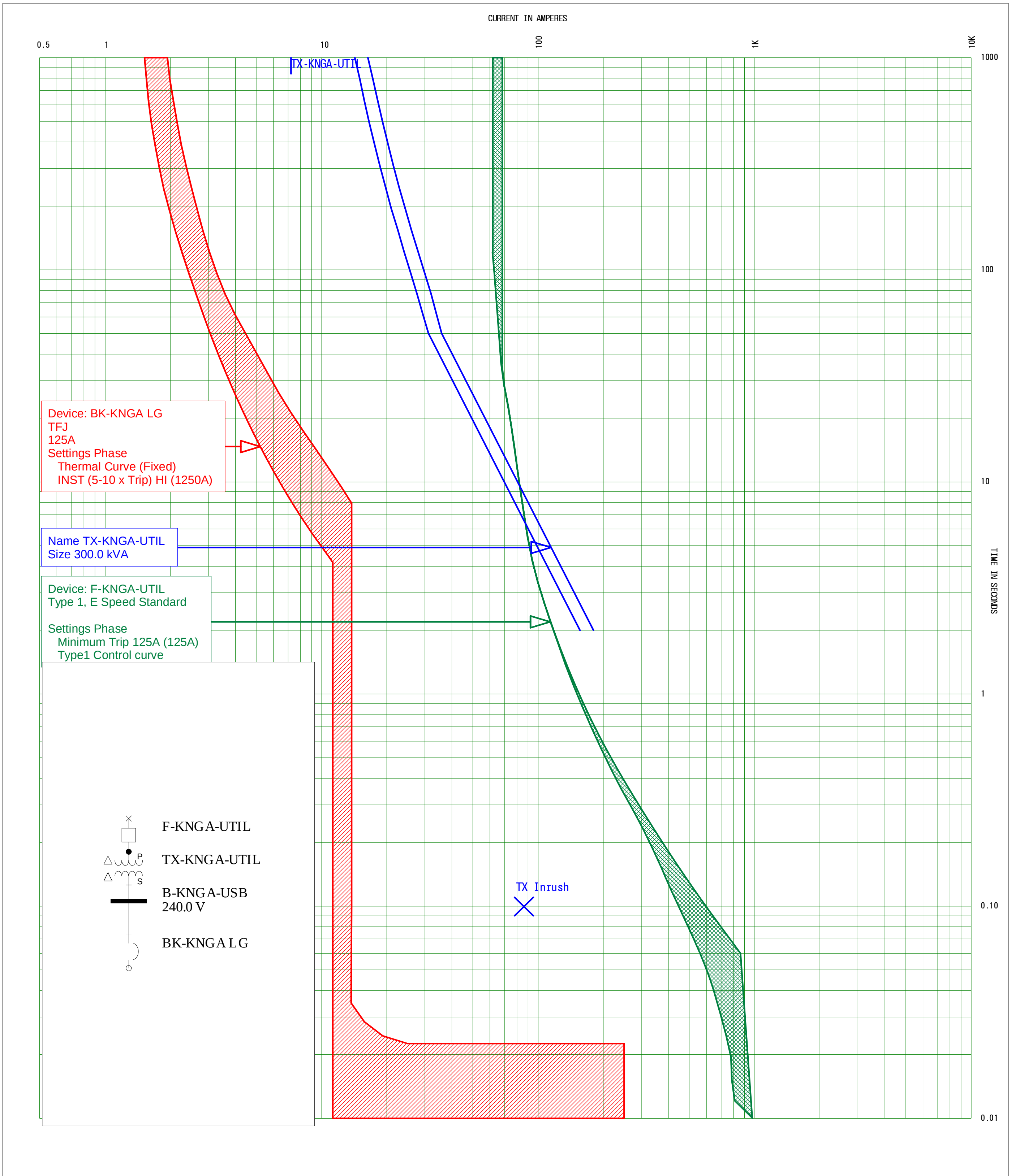
Current Scale: x 100



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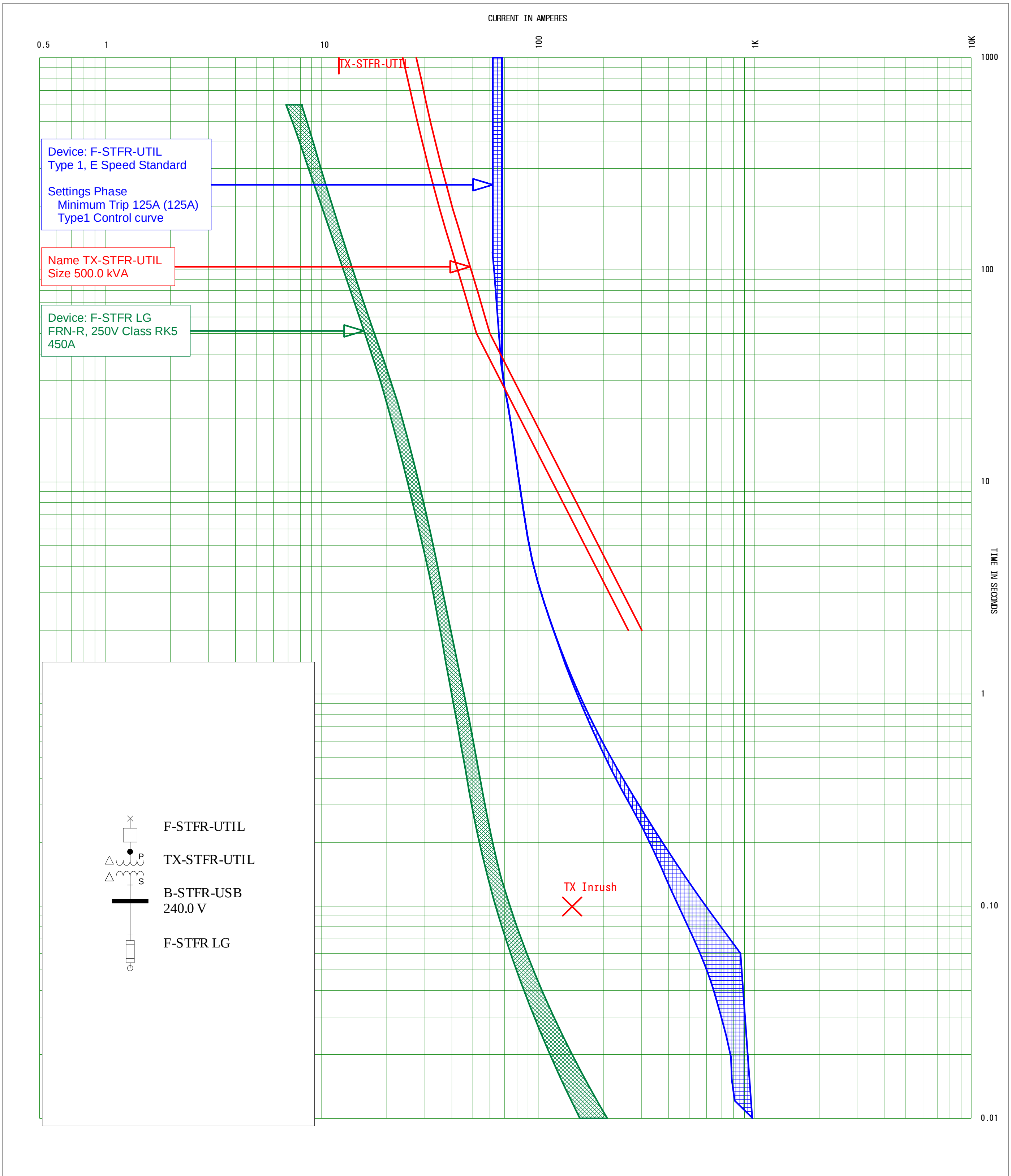
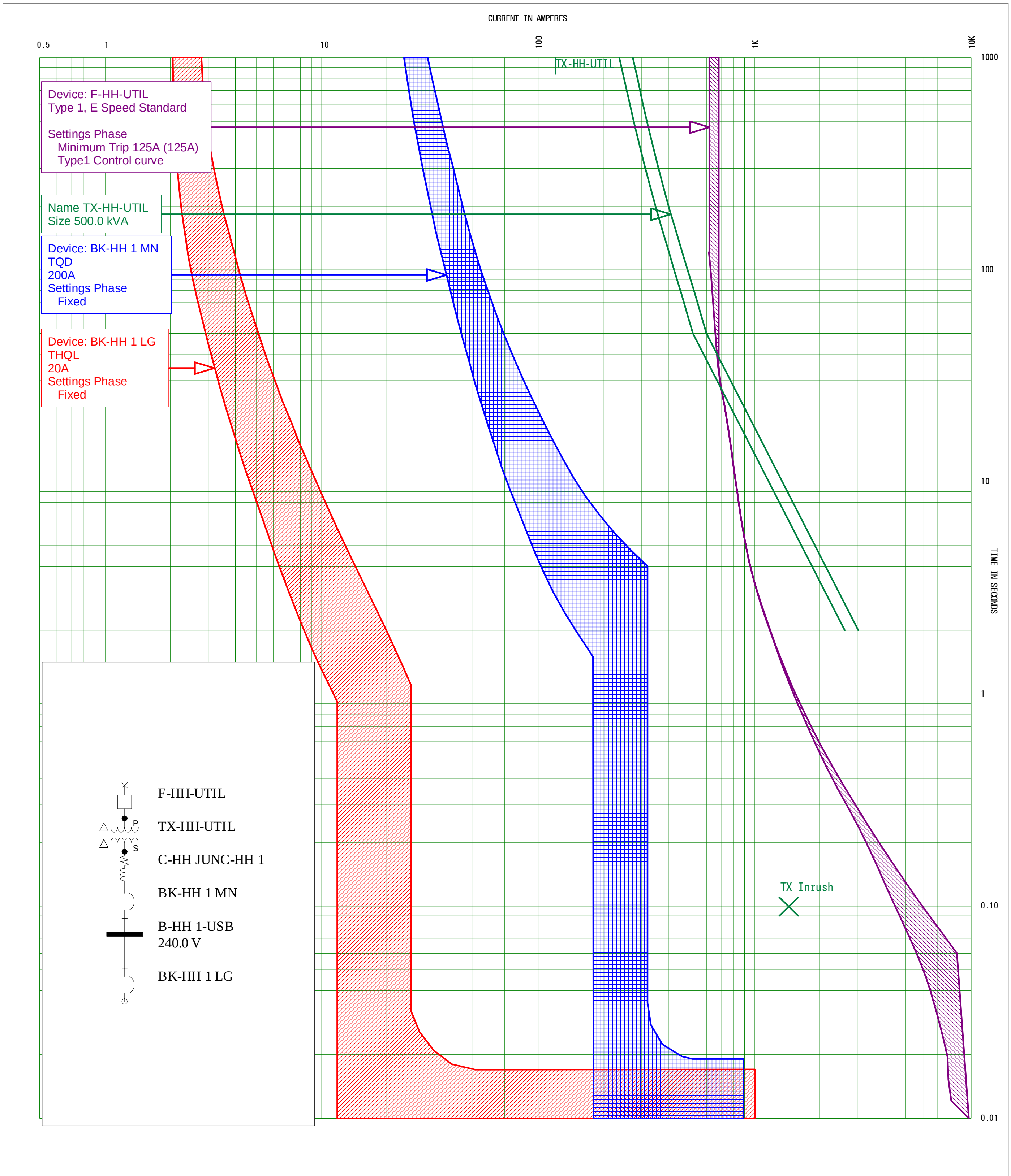


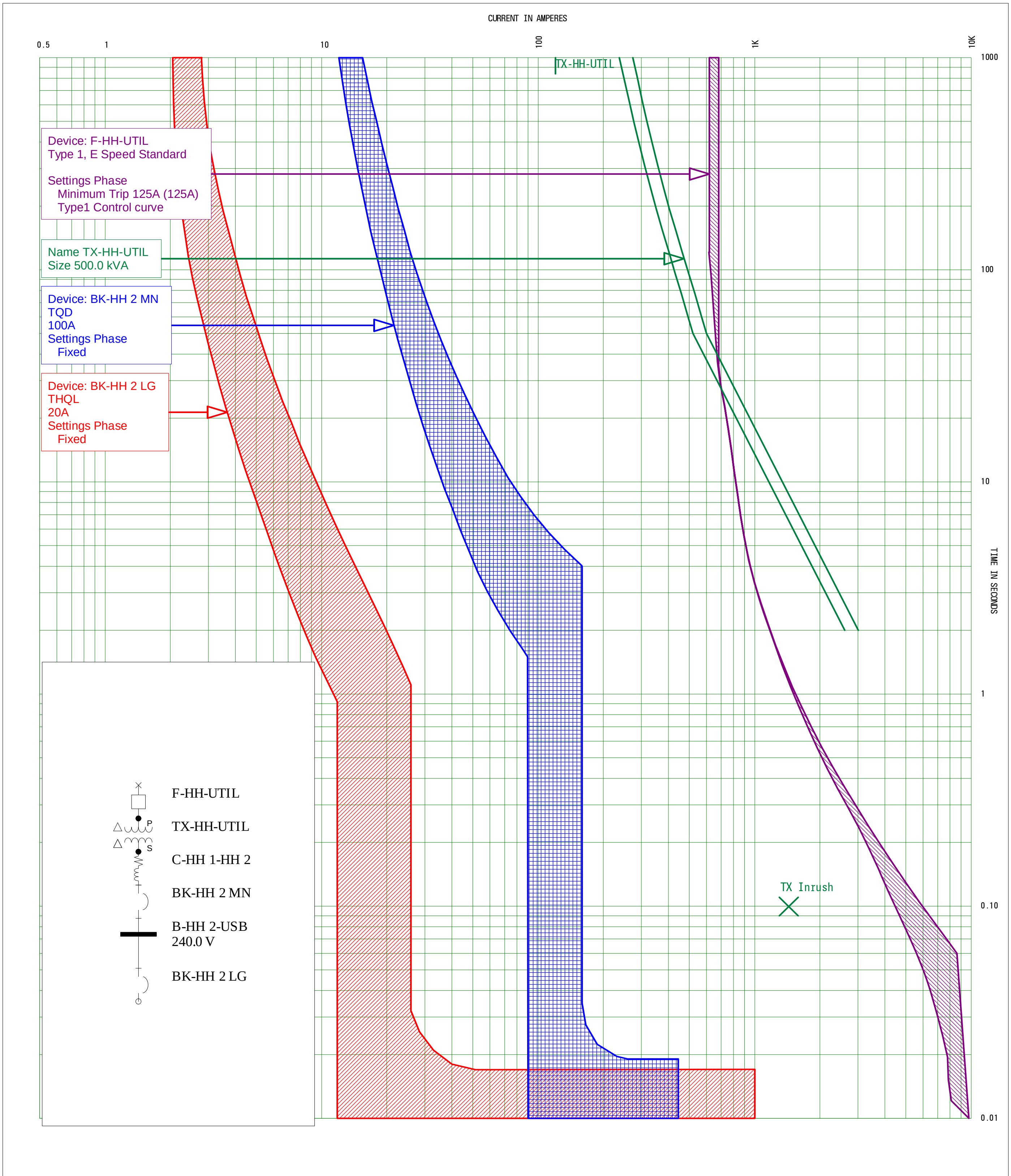
Eaton Electrical Services and Systems
February 21, 2013

Plot name: STFR
Ref. Voltage: 240V
Current Scale: x 100



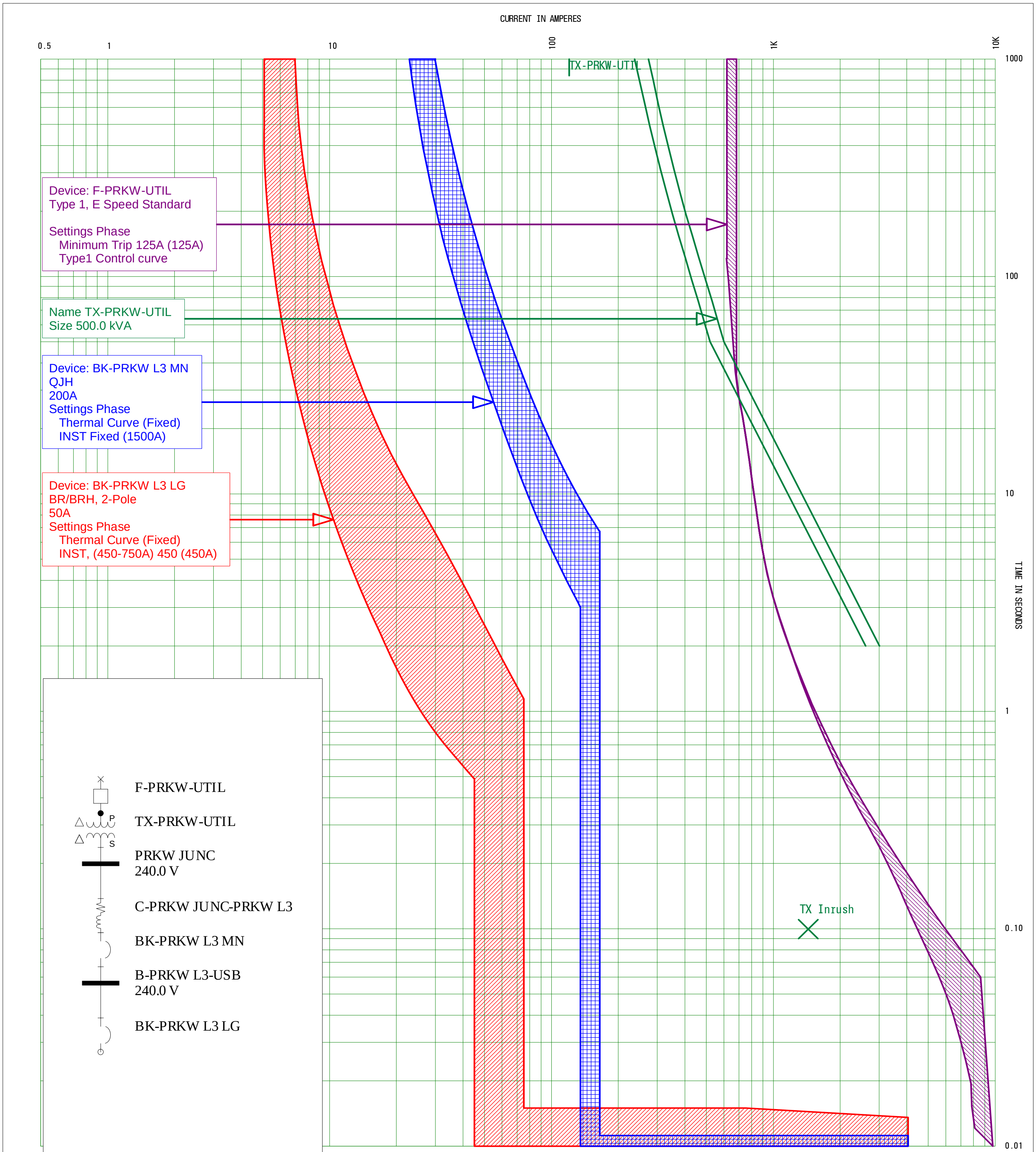
Eaton Electrical Services and Systems
February 21, 2013

Plot name: HH1
Ref. Voltage: 240V
Current Scale: x 10



Eaton Electrical Services and Systems
February 21, 2013

Plot name: HH 2
Ref. Voltage: 240V
Current Scale: x 10



Eaton Electrical Services and Systems
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Plot name: PRKW L3
Ref. Voltage: 240V
Current Scale: x 10

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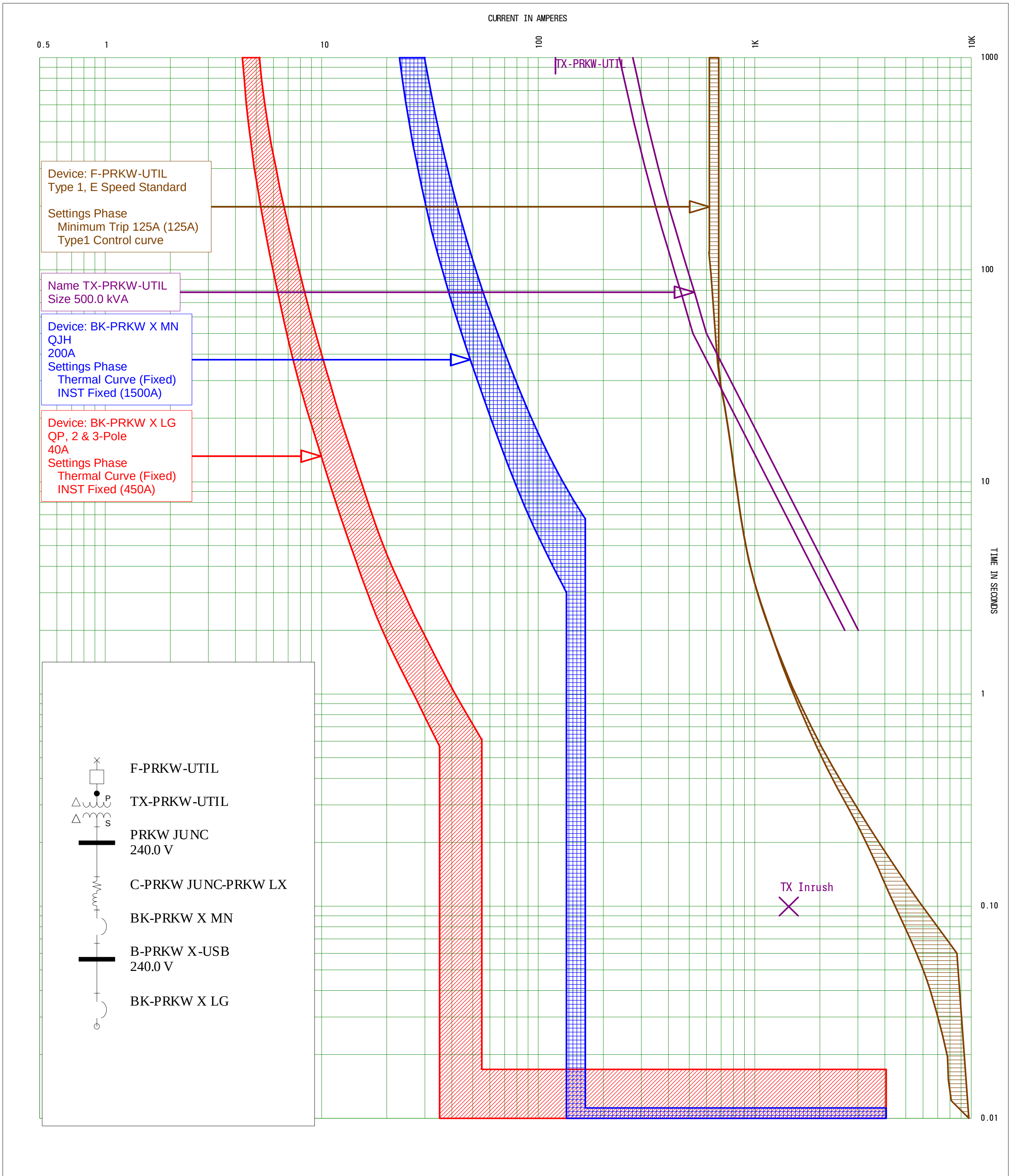

Eaton Electrical Services and Systems
February 21, 2013

Plot name: PRKW X
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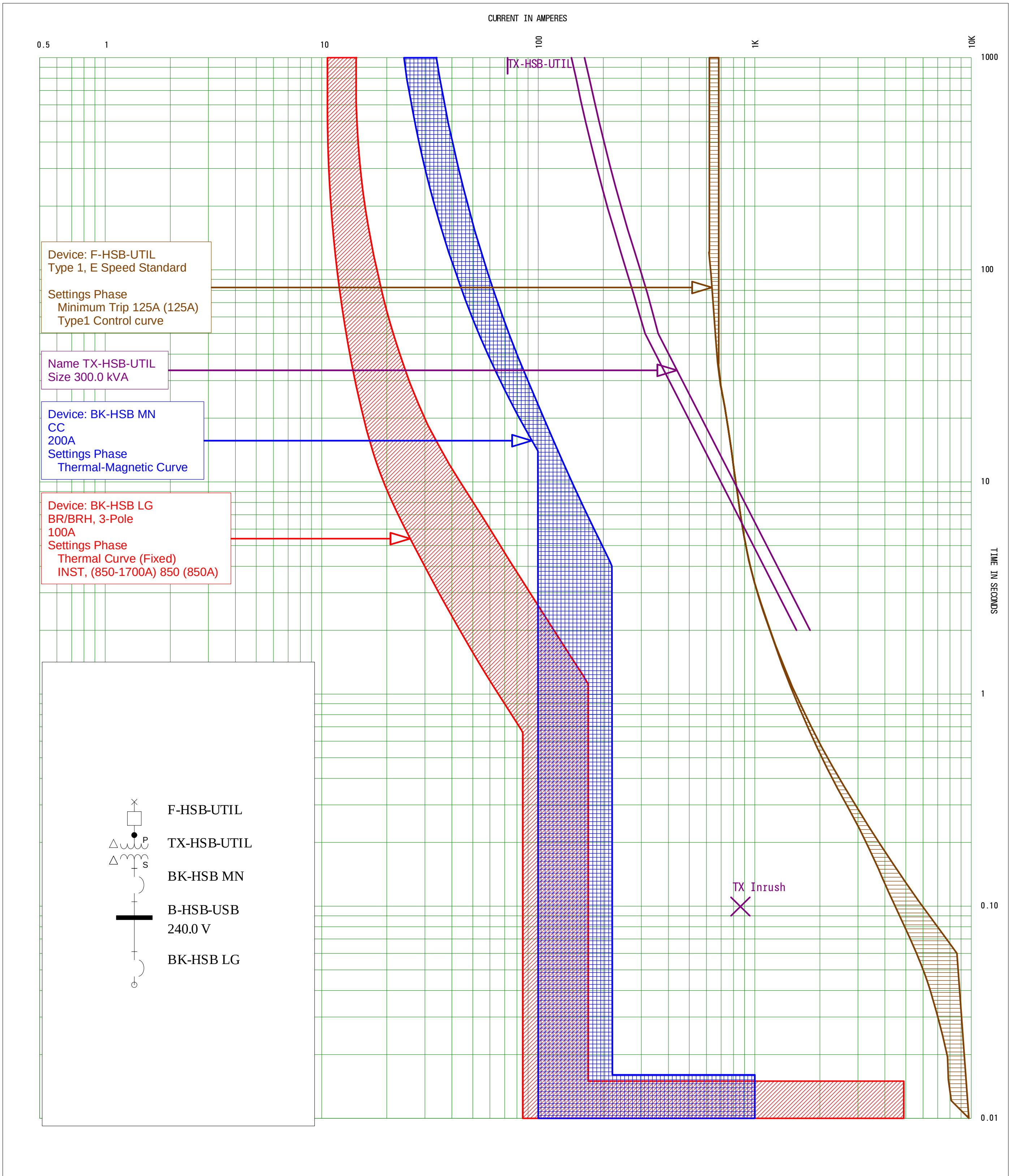
Current Scale: x 10



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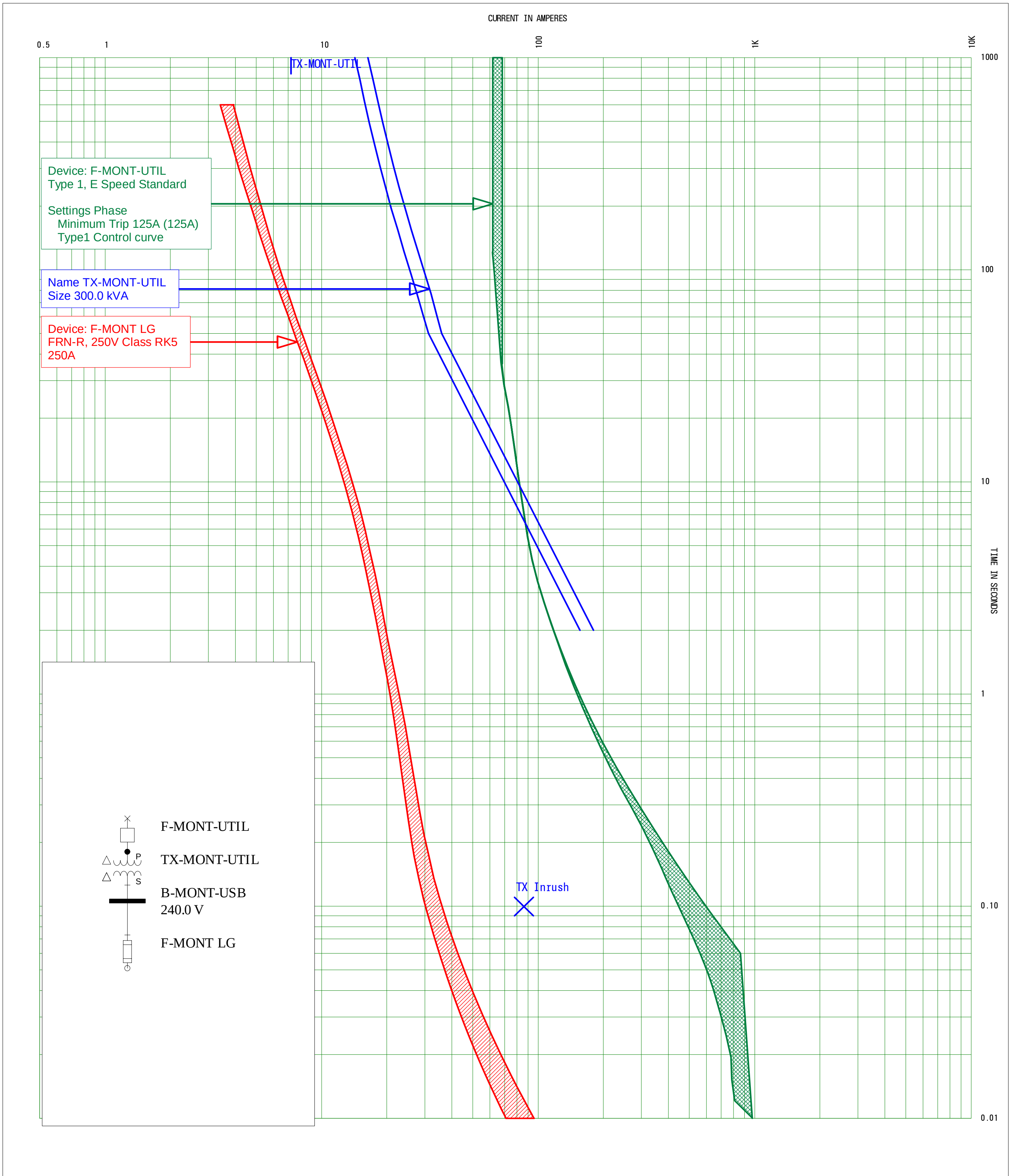
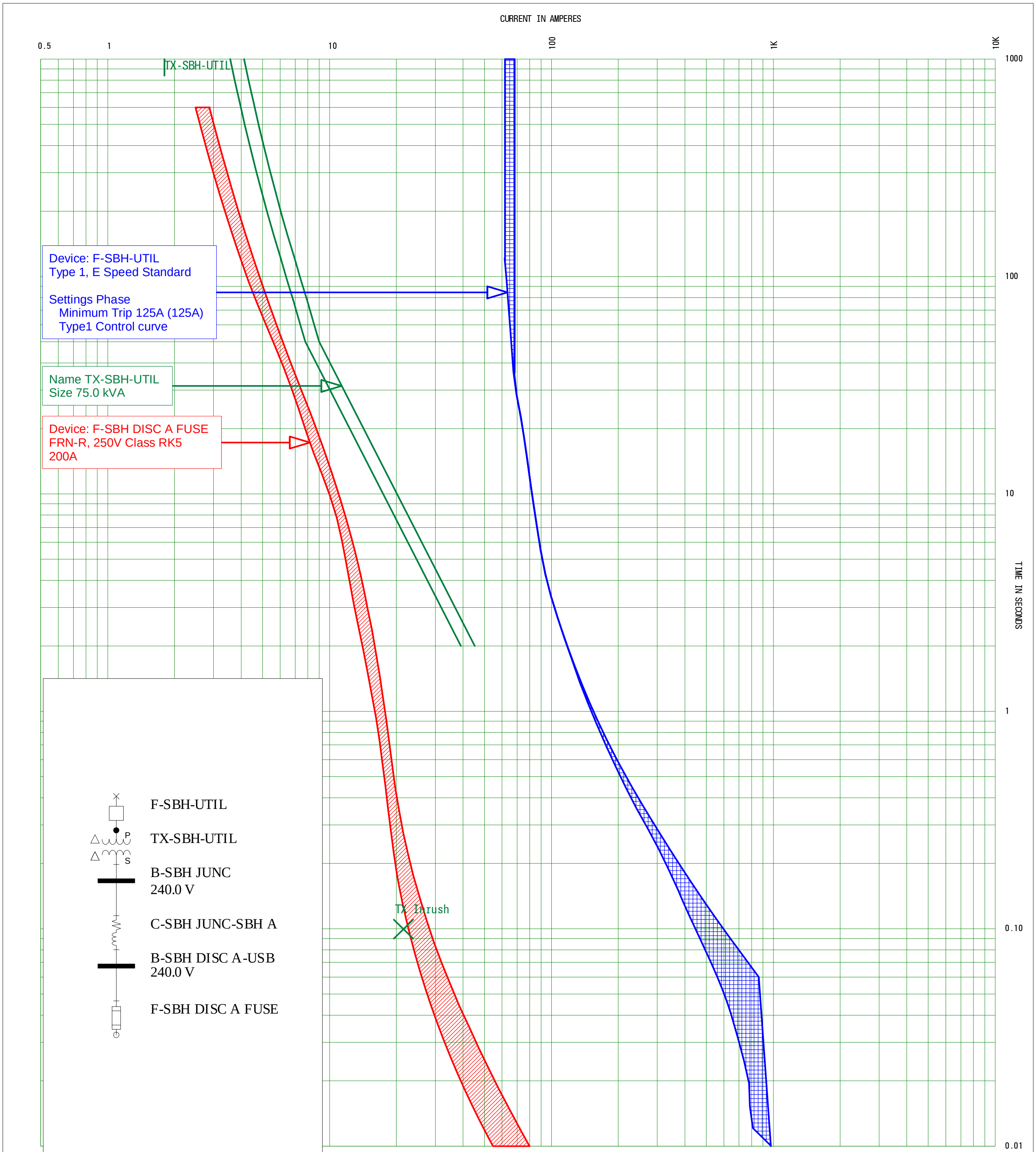


Eaton Electrical Services and Systems
February 21, 2013

Plot name: MONT
Ref. Voltage: 240V
Current Scale: x 100



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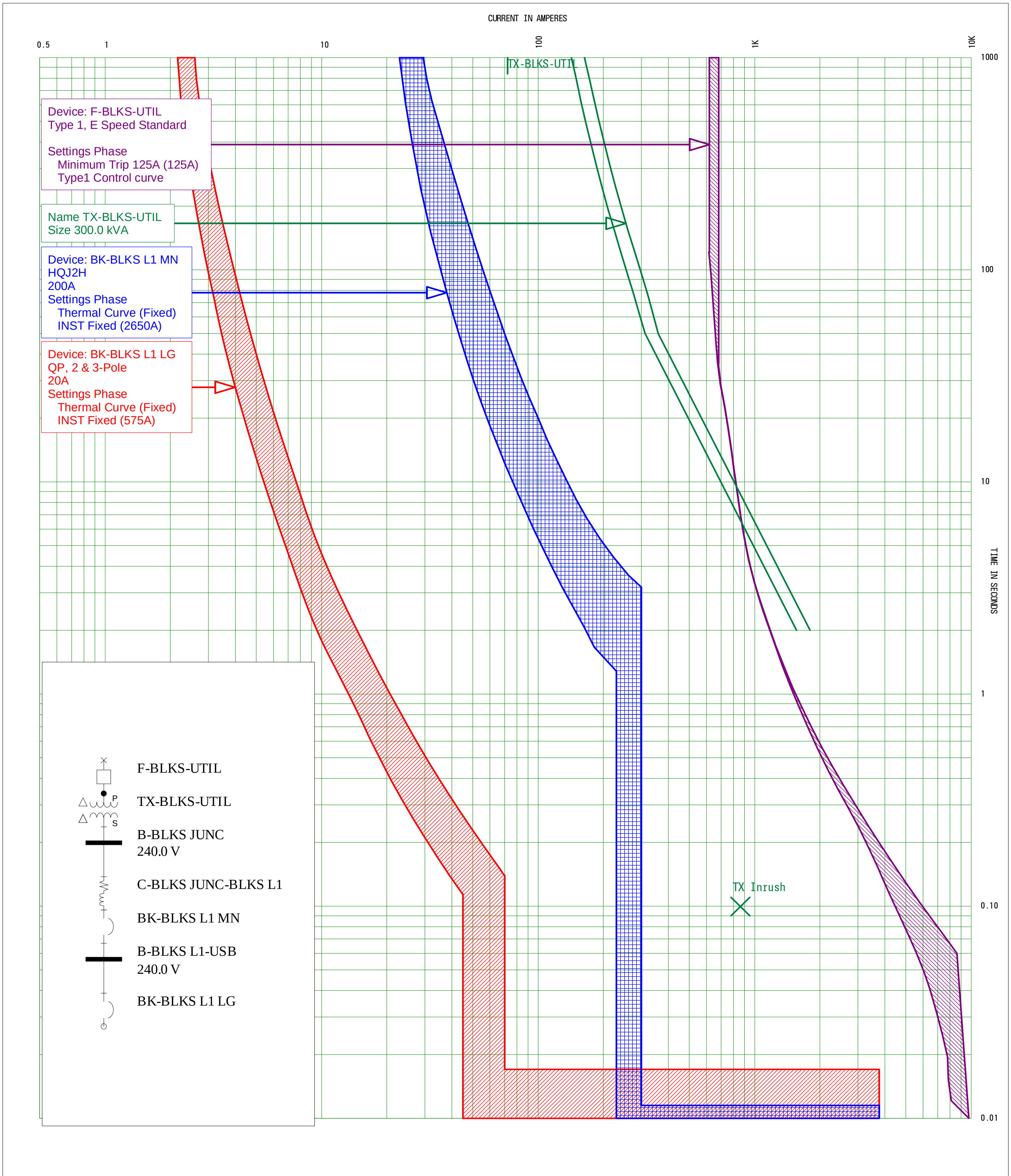

Eaton Electrical Services and Systems
February 21, 2013

Plot name: BLKS L1
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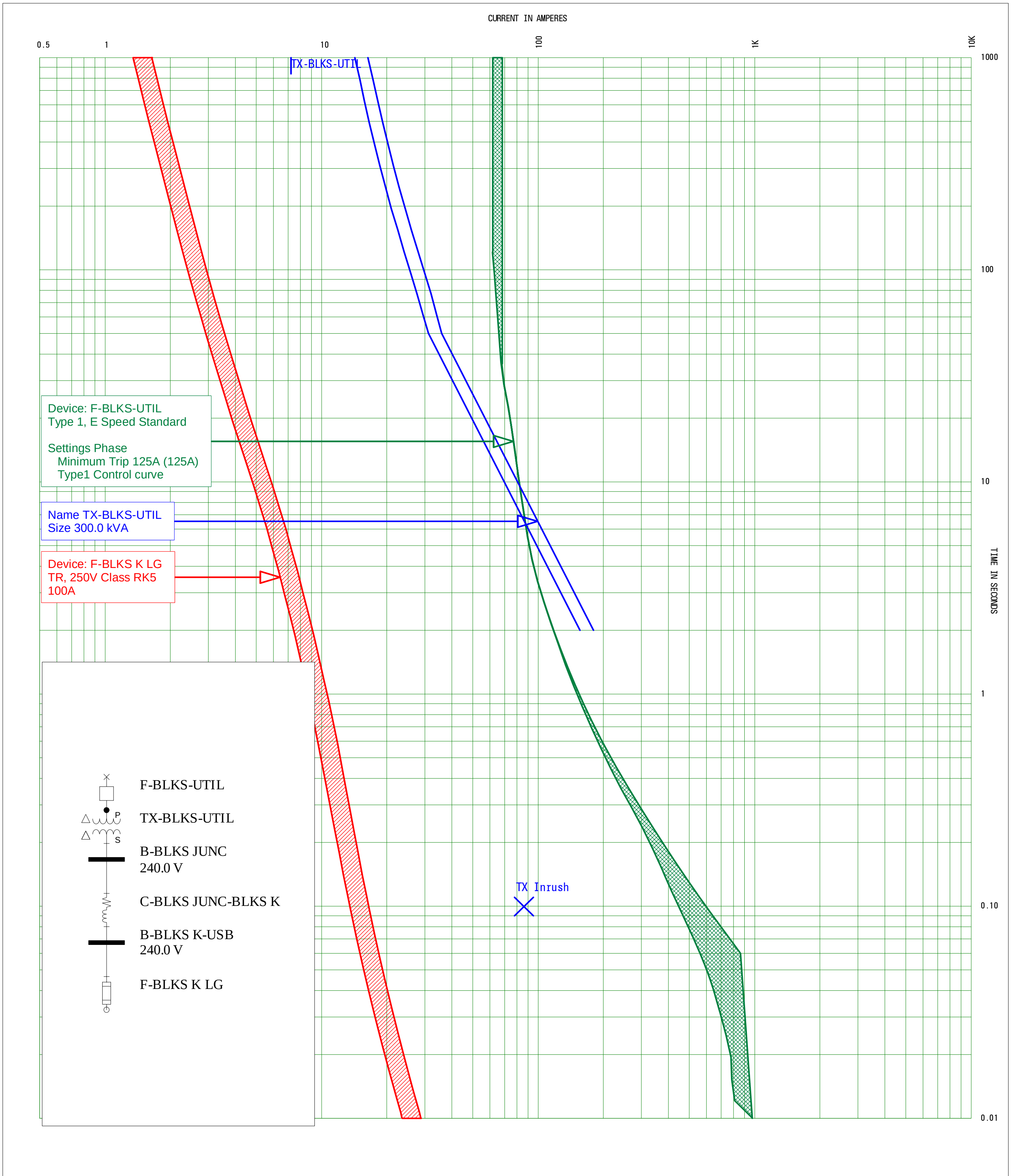
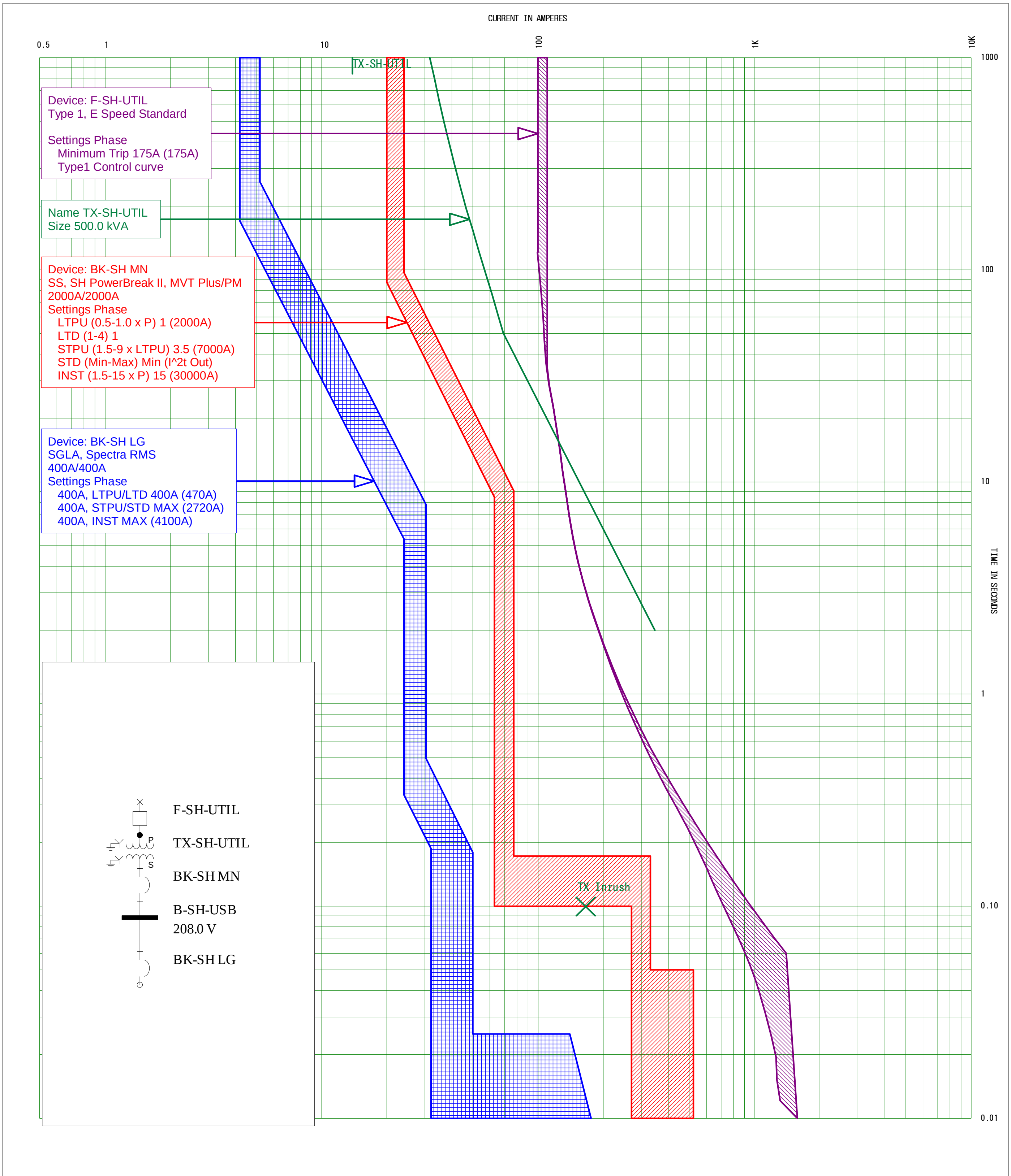
Current Scale: x 10



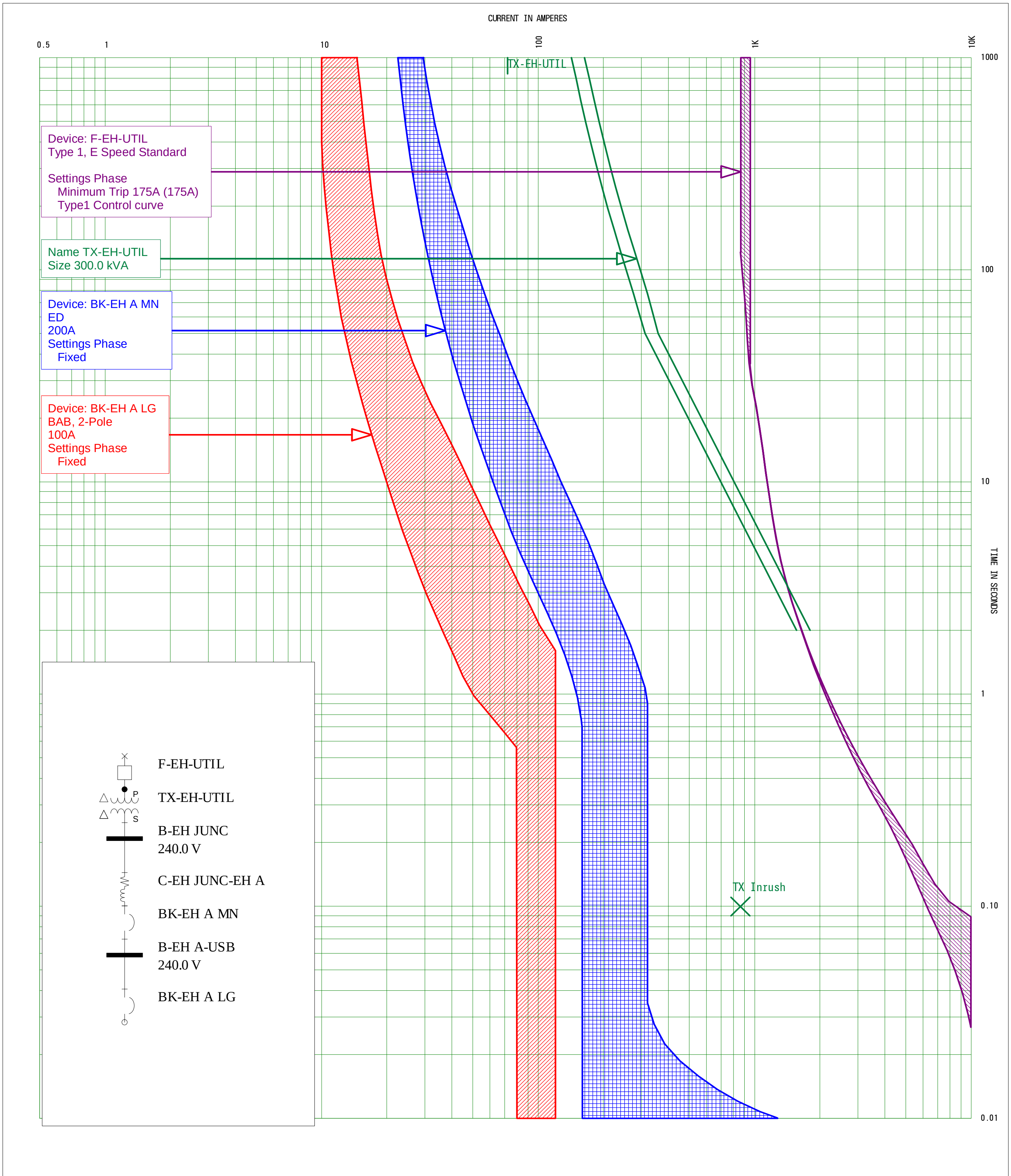
Eaton Electrical Services and Systems
February 21, 2013

Plot name: BLKS K
Ref. Voltage: 240V
Current Scale: x 100

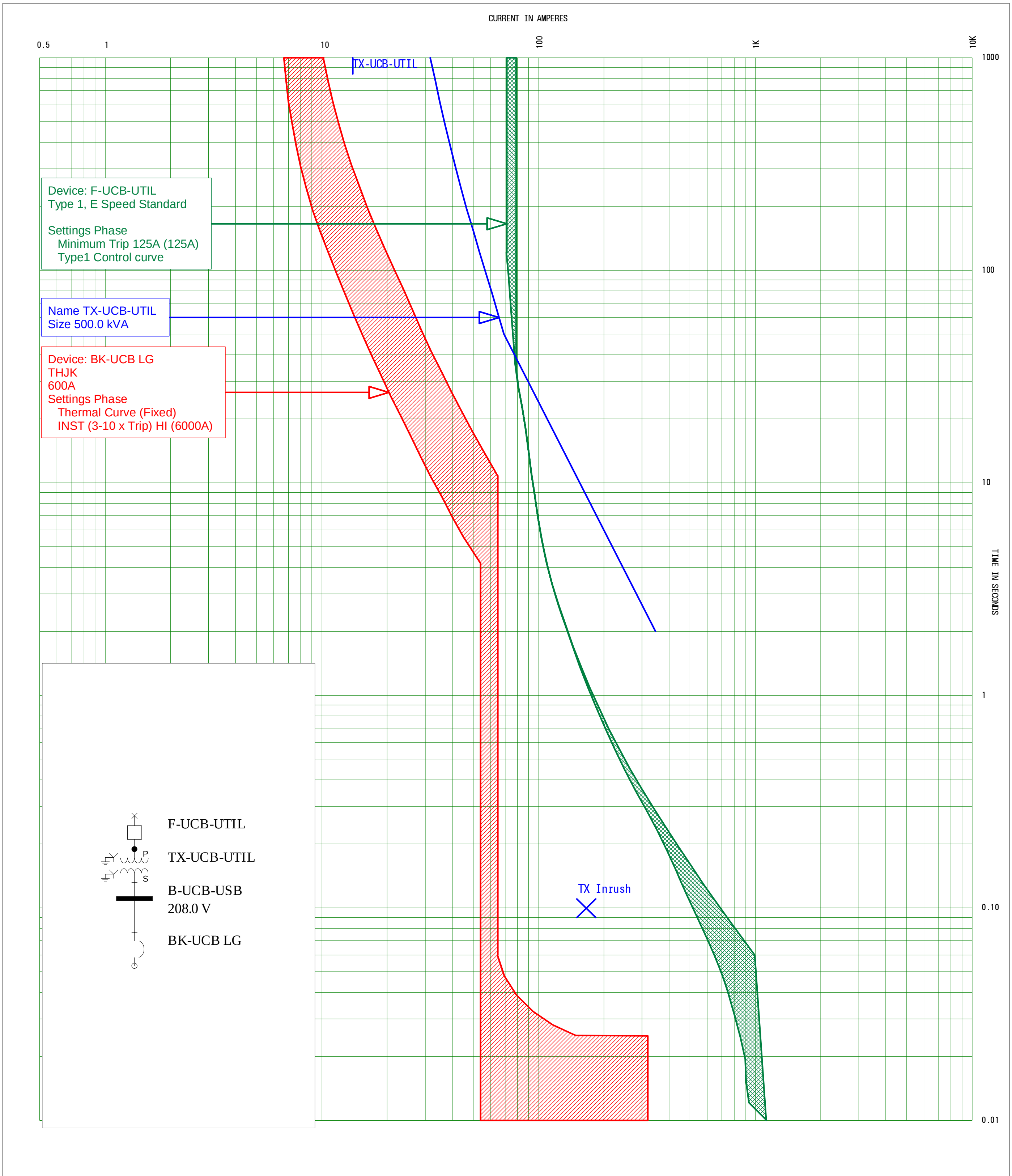


Eaton Electrical Services and Systems
February 21, 2013

Plot name: SH
Ref. Voltage: 208V
Current Scale: x 100



Eaton Electrical Services and Systems February 21, 2013	Plot name: EH Ref. Voltage: 240V Current Scale: x 10



Eaton Electrical Services and Systems
February 21, 2013

Plot name: UCB
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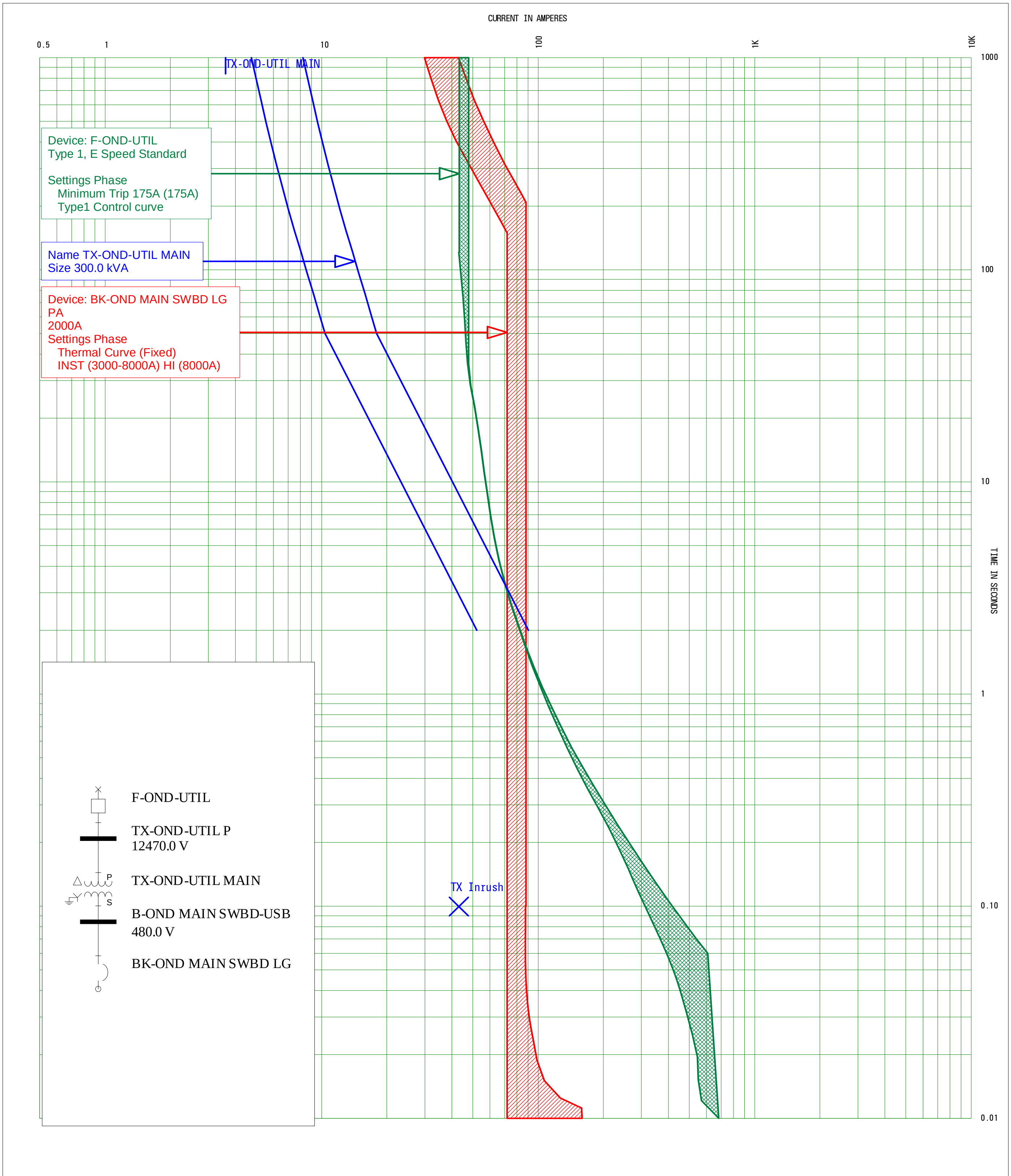
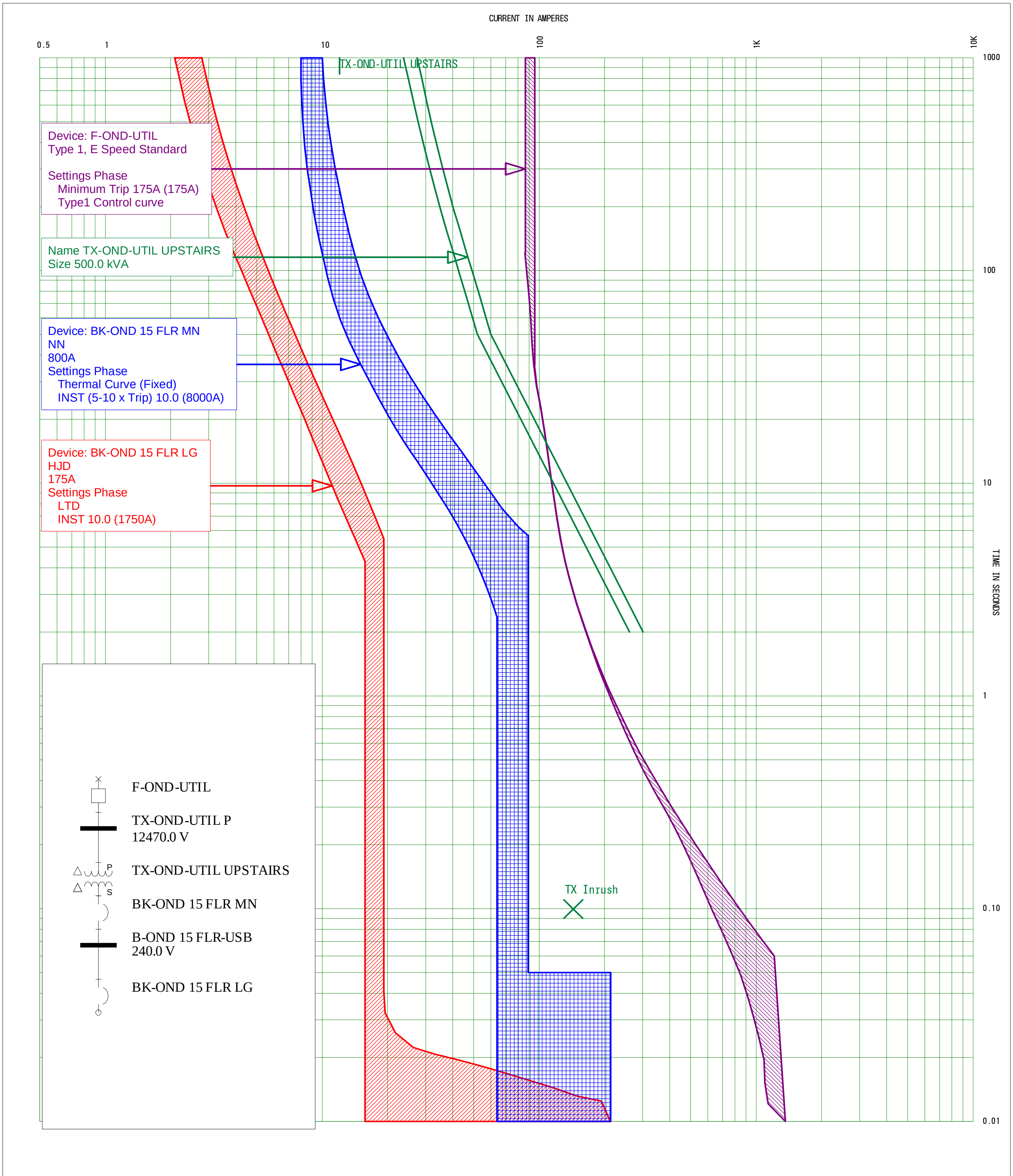
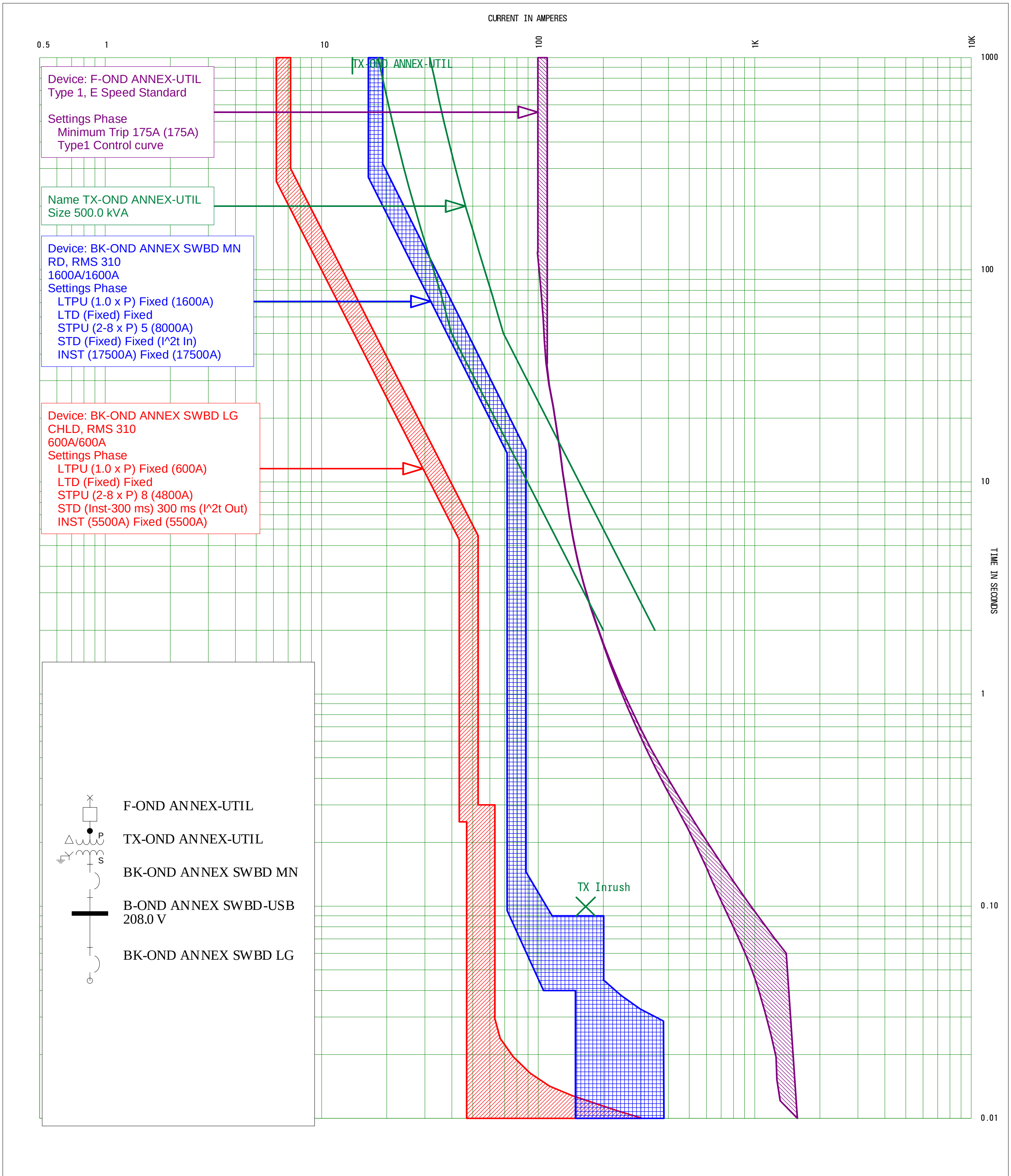
Current Scale: x 100



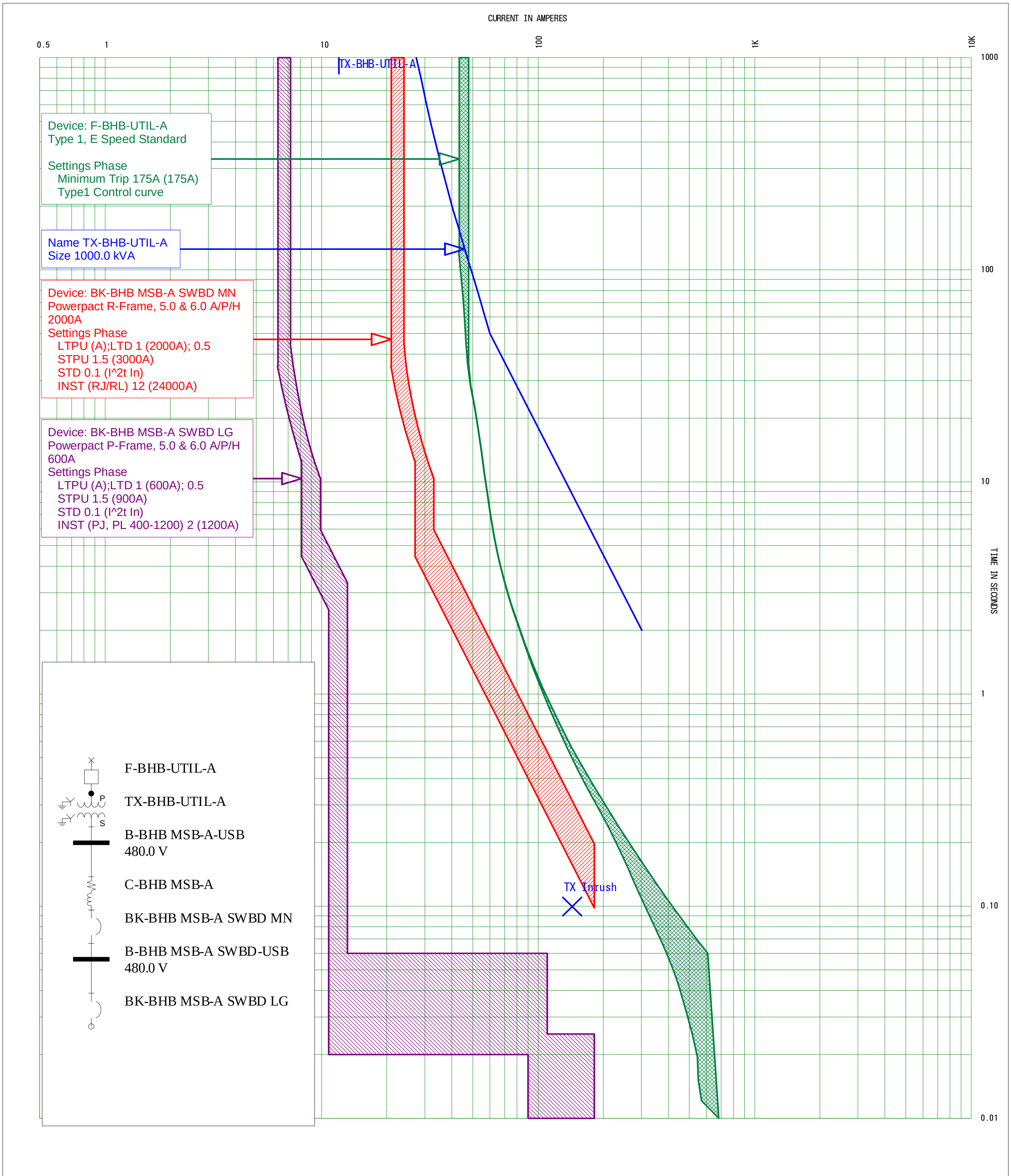
Eaton Electrical Services and Systems February 21, 2013	Plot name: OND MAIN Ref. Voltage: 480V Current Scale: x 100



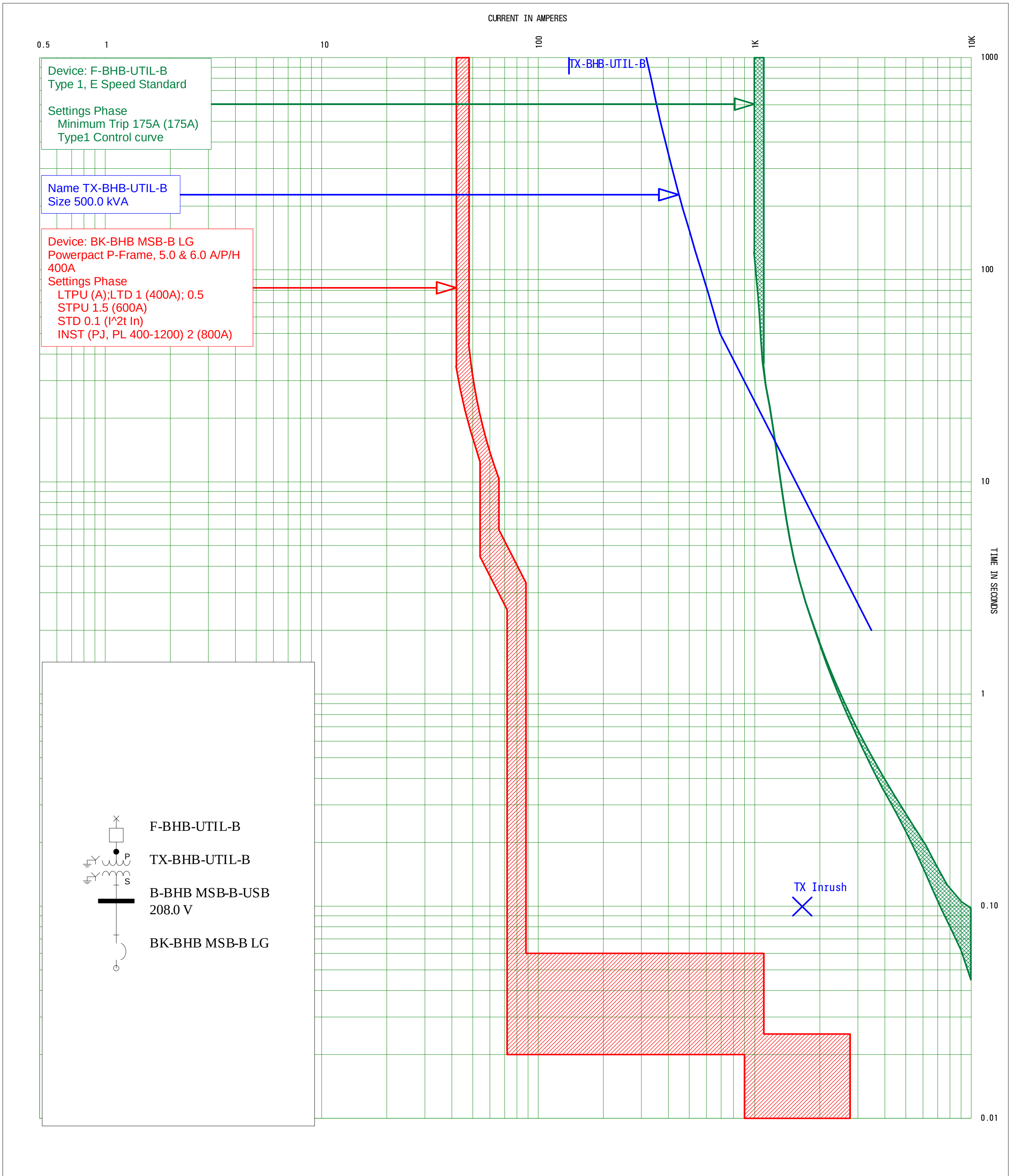
Eaton Electrical Services and Systems February 21, 2013	Plot name: OND 15TH FLR Ref. Voltage: 240V Current Scale: x 100



Eaton Electrical Services and Systems February 21, 2013	Plot name: OND ANNEX Ref. Voltage: 208V Current Scale: x 100



Eaton Electrical Services and Systems February 21, 2013	Plot name: BHB MSB-A Ref. Voltage: 480V Current Scale: x 100



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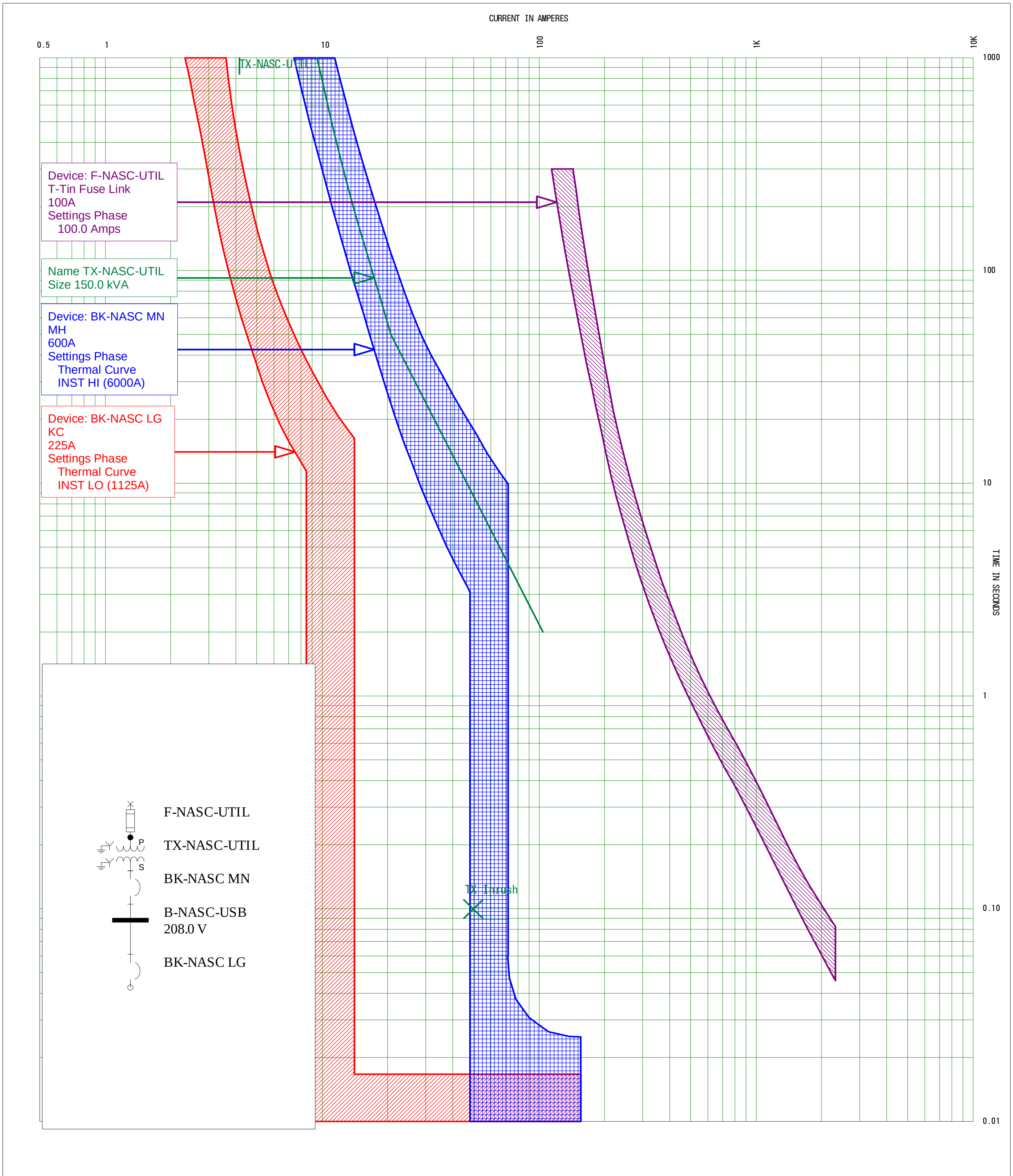
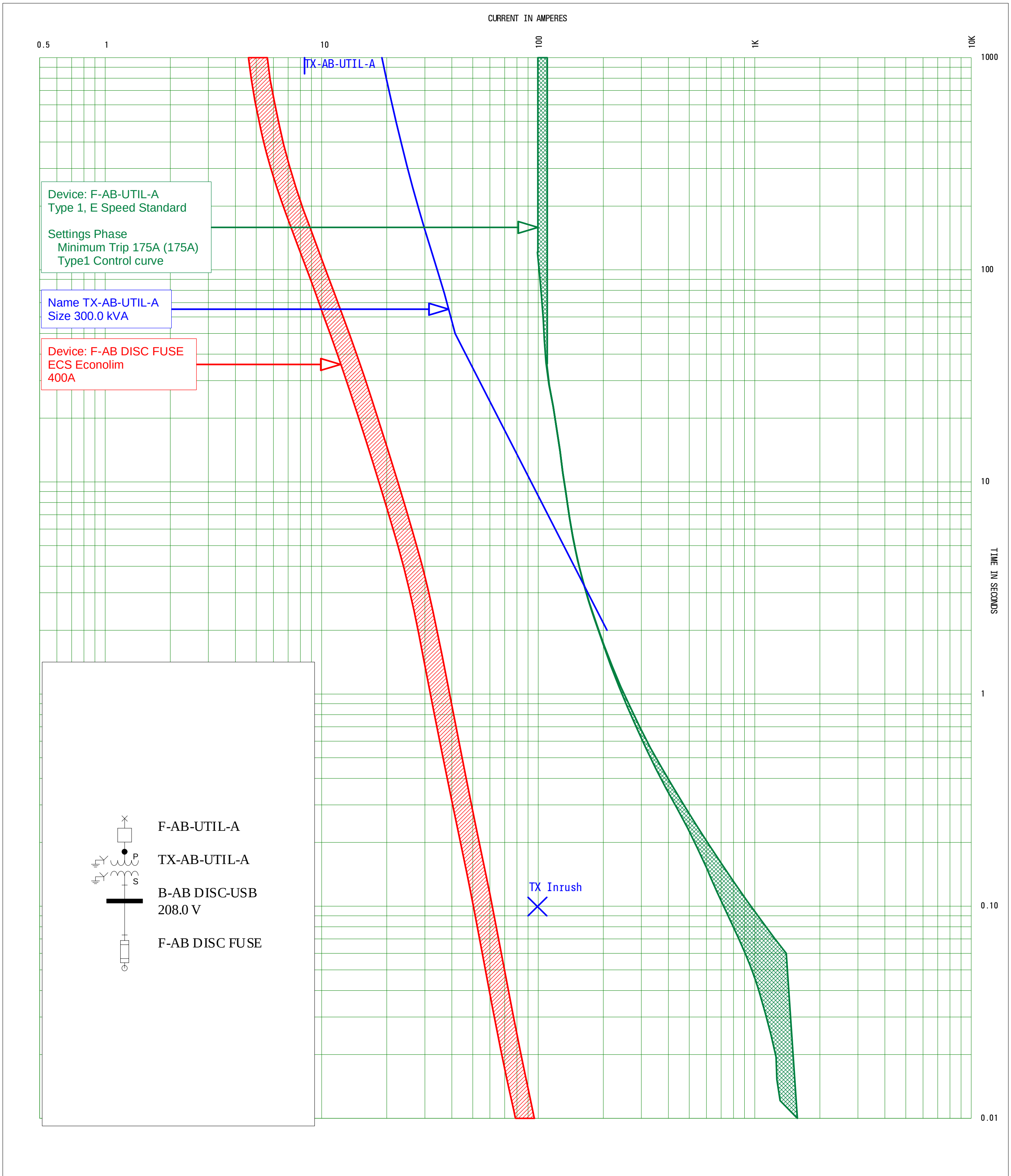
Plot name: BHB MSB-B
Ref. Voltage: 208V
Current Scale: x 10



Eaton Electrical Services and Systems
February 21, 2013

Plot name: NASC
Ref. Voltage: 208V
Current Scale: x 100



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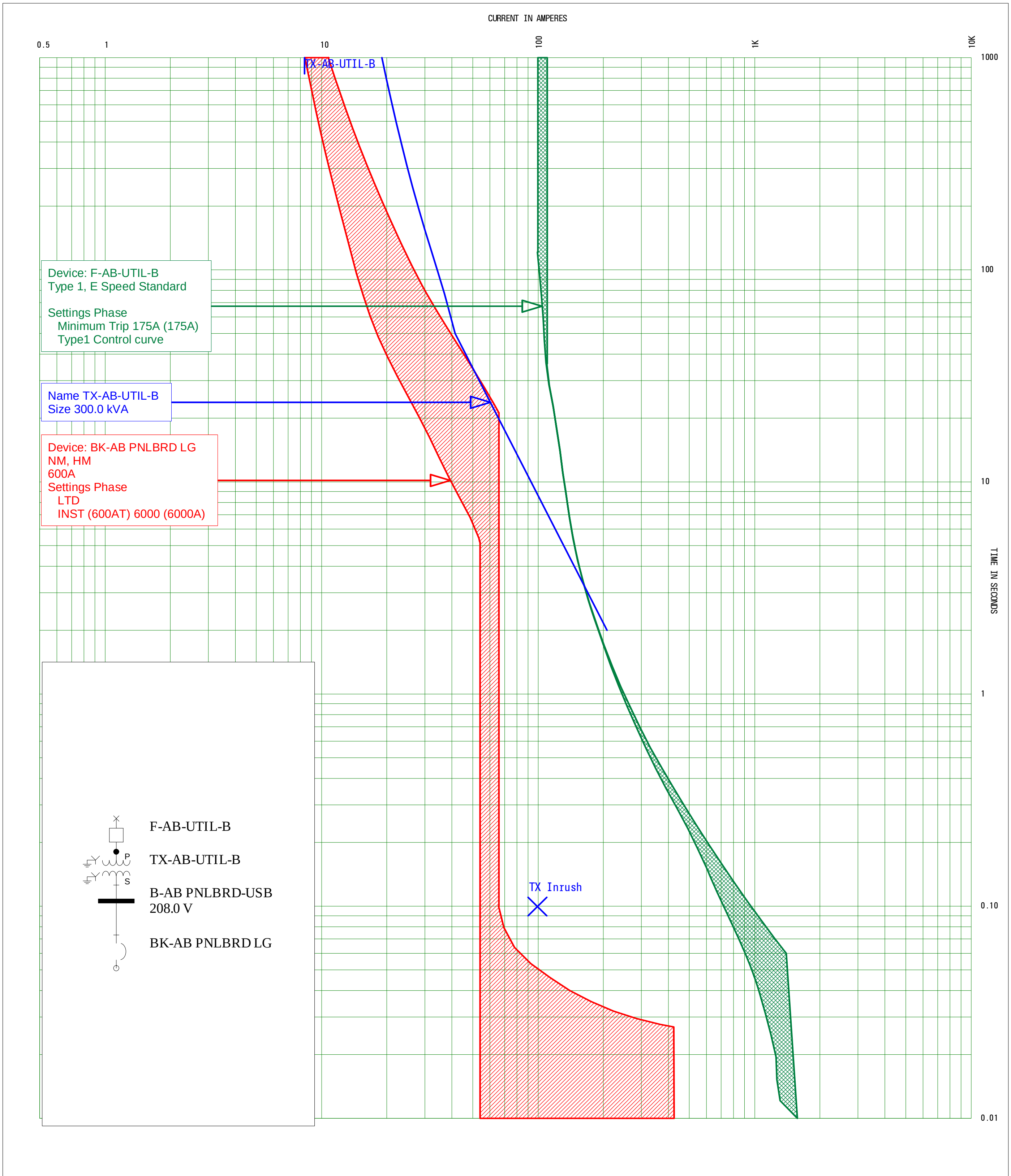
Plot name: AB DISC
Ref. Voltage: 208V
Current Scale: x 100



Eaton Electrical Services and Systems
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Plot name: AB PNLBD
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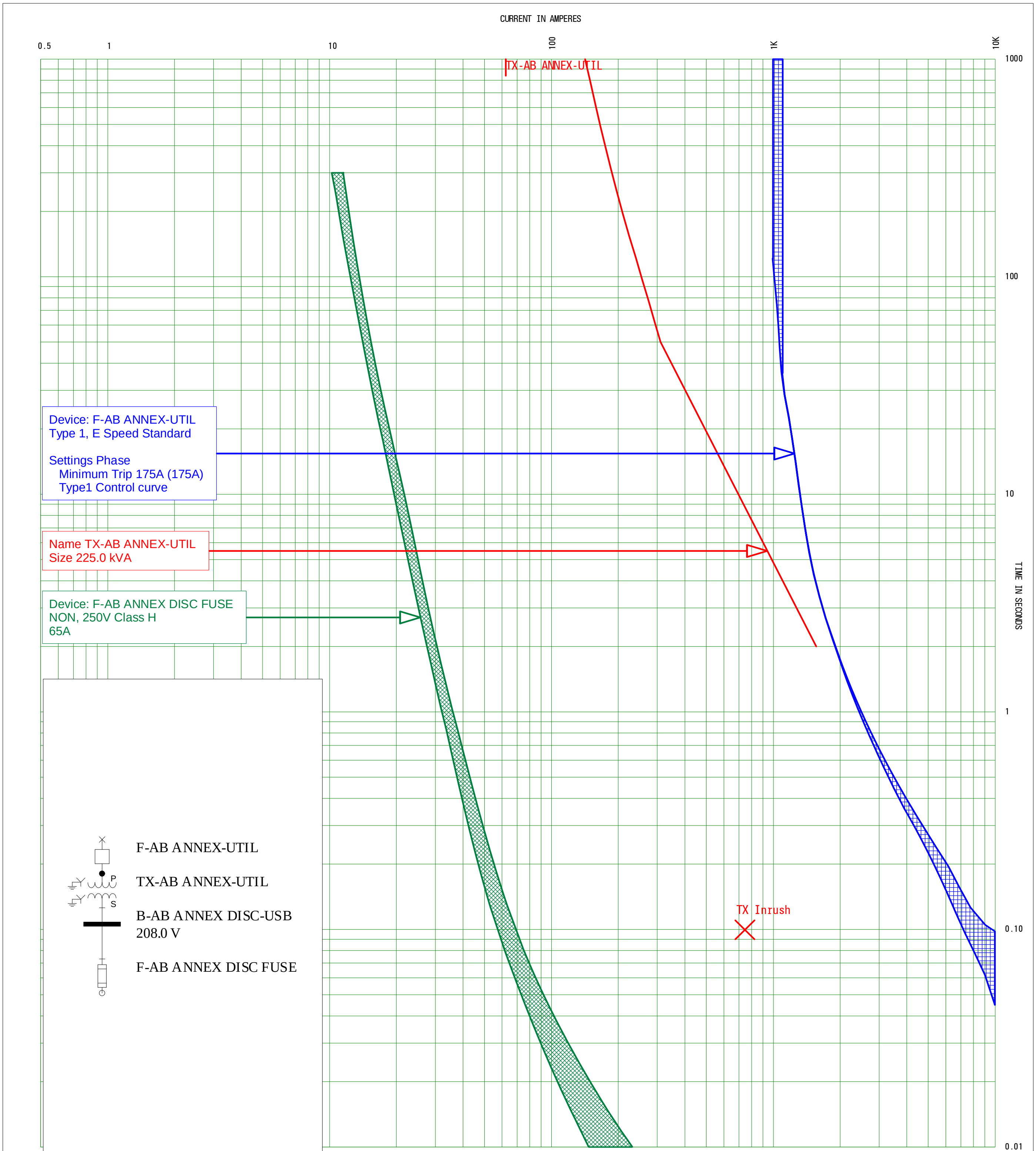
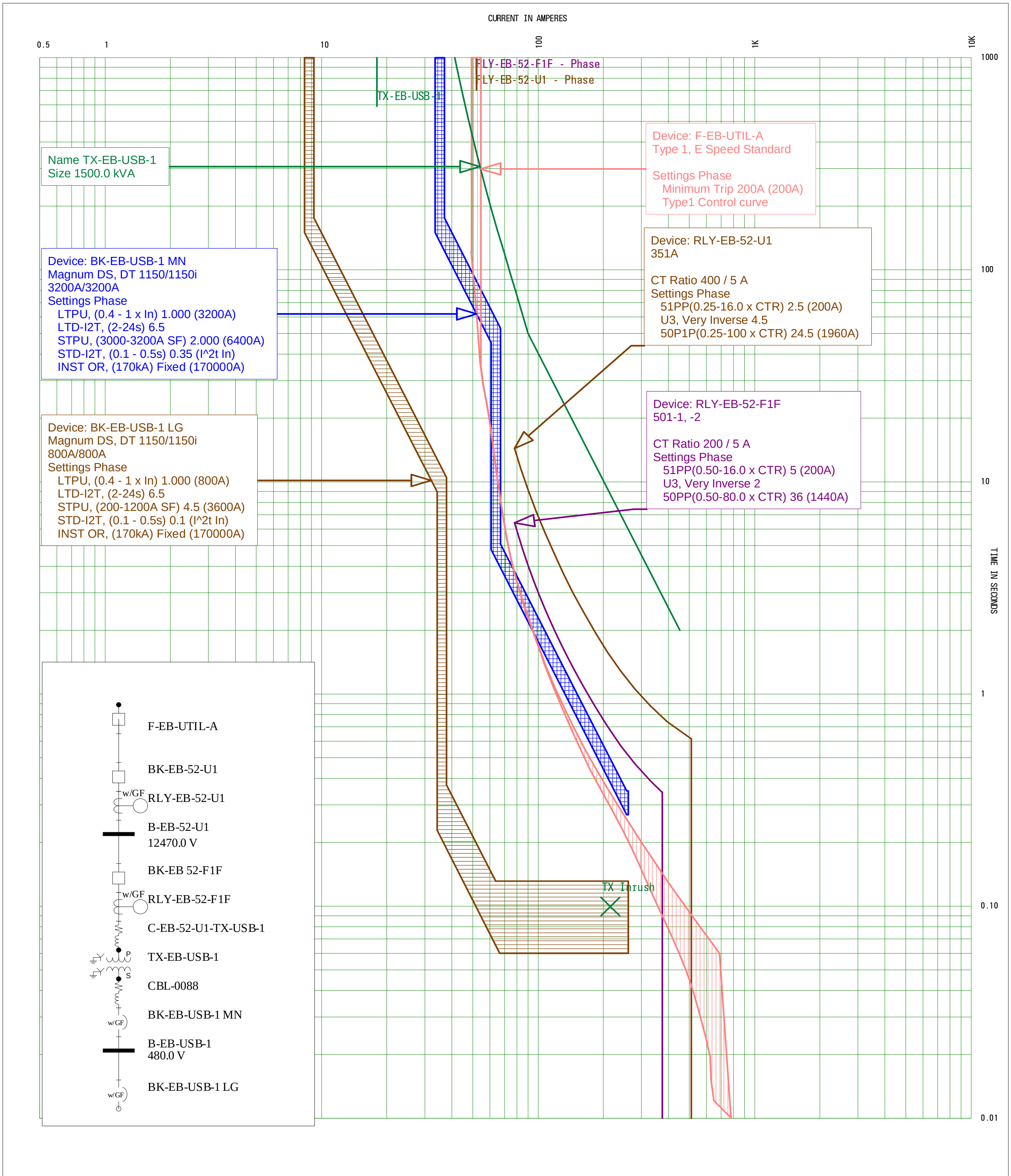
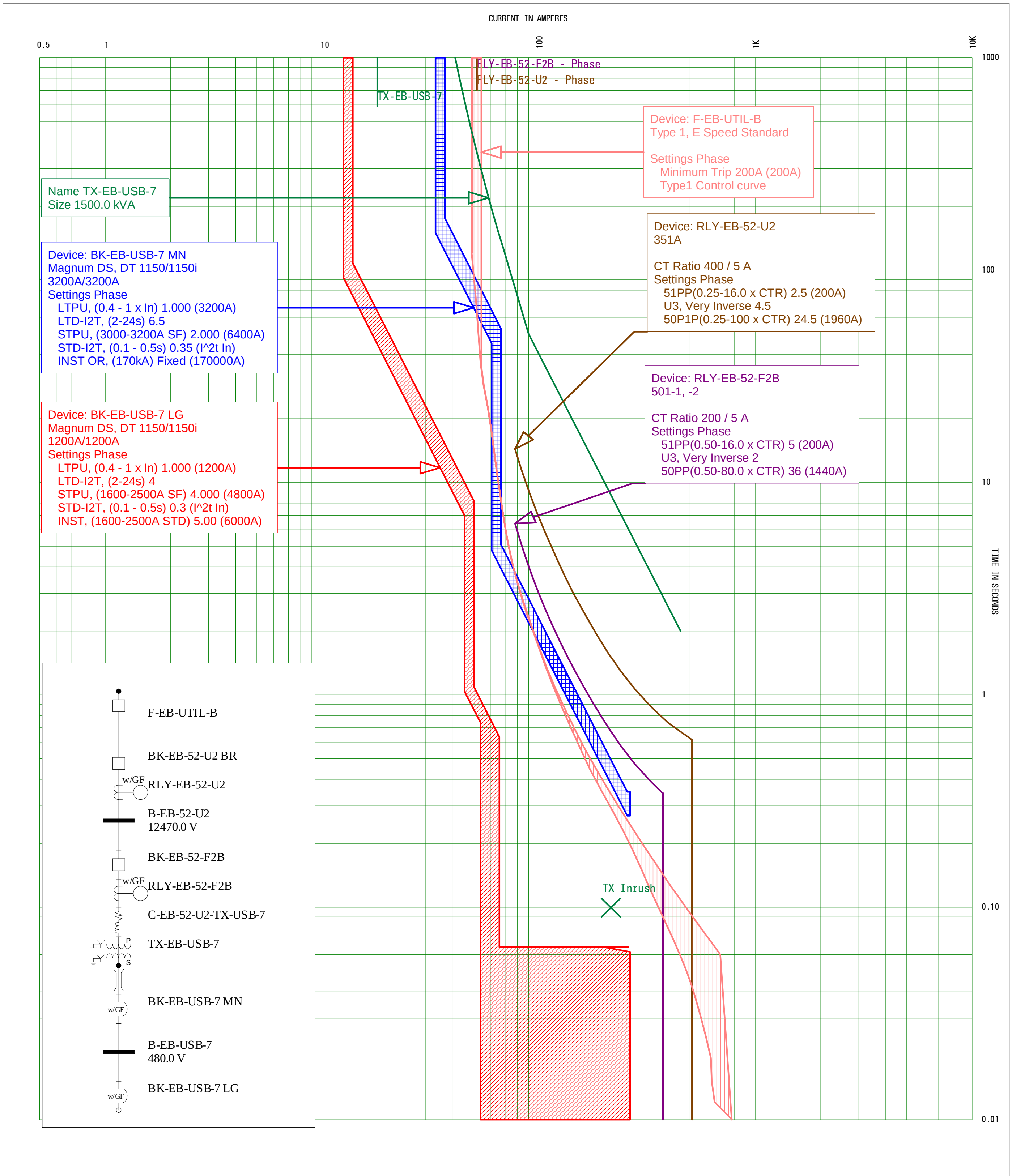
Current Scale: x 100



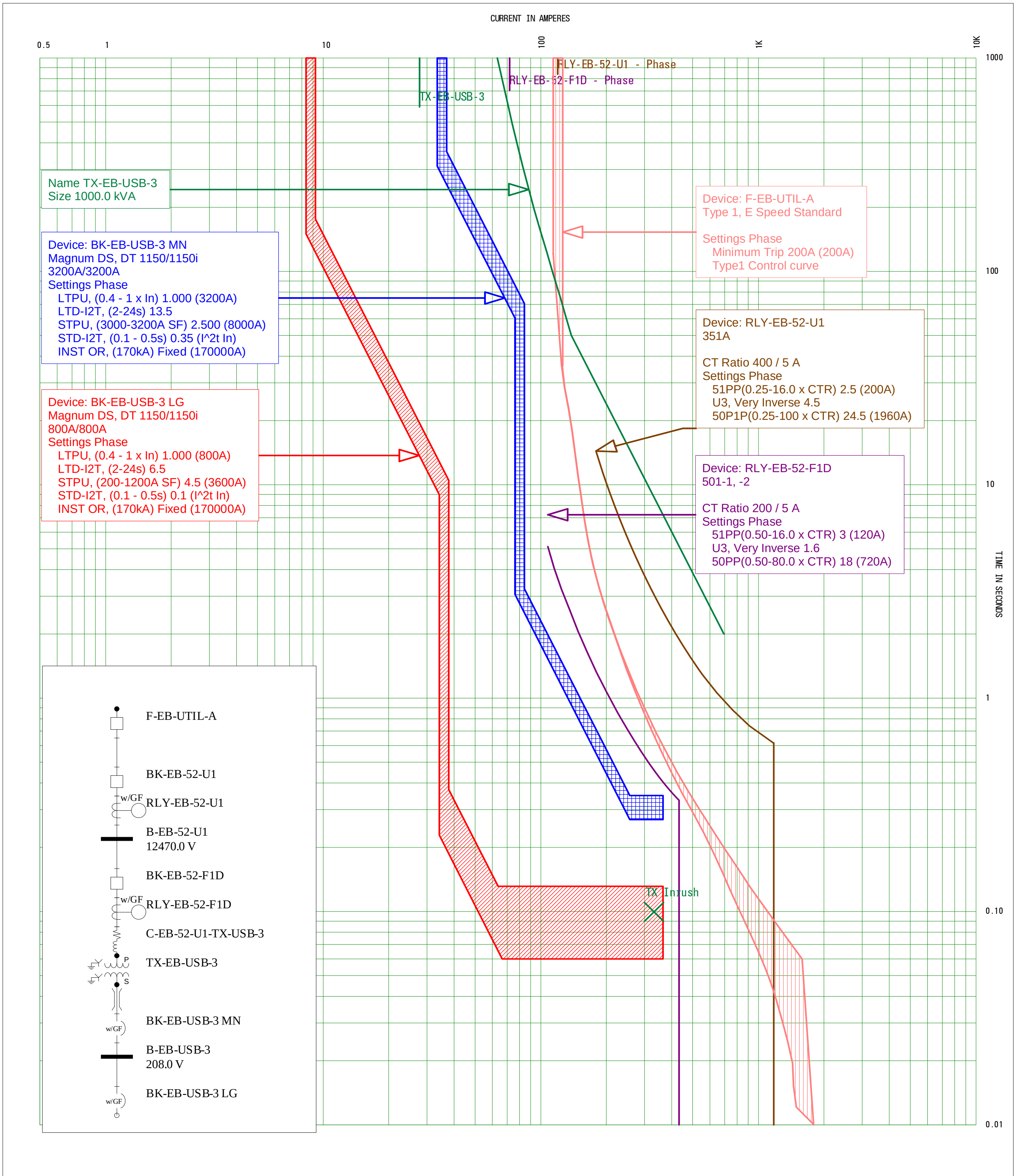
Eaton Electrical Services and Systems February 21, 2013	Plot name: AB ANNEX Ref. Voltage: 208V Current Scale: x 10



Eaton Electrical Services and Systems February 21, 2013	Plot name: EB USB-1 MV Ref. Voltage: 480V Current Scale: x 100



Eaton Electrical Services and Systems February 21, 2013	Plot name: EB USB-7 MV Ref. Voltage: 480V Current Scale: x 100



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Plot name: EB USB-3
Ref. Voltage: 208V
Current Scale: x 100

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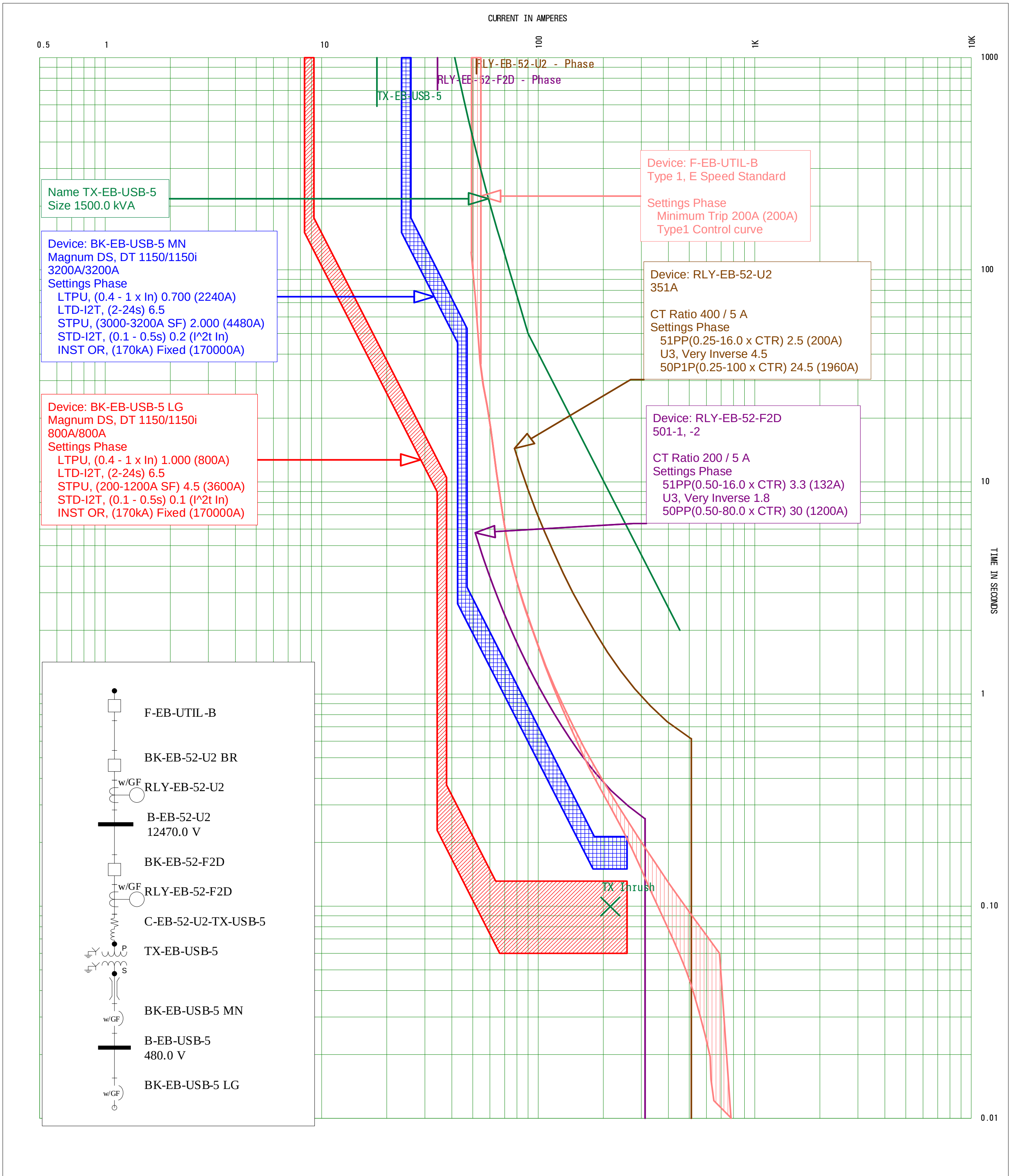

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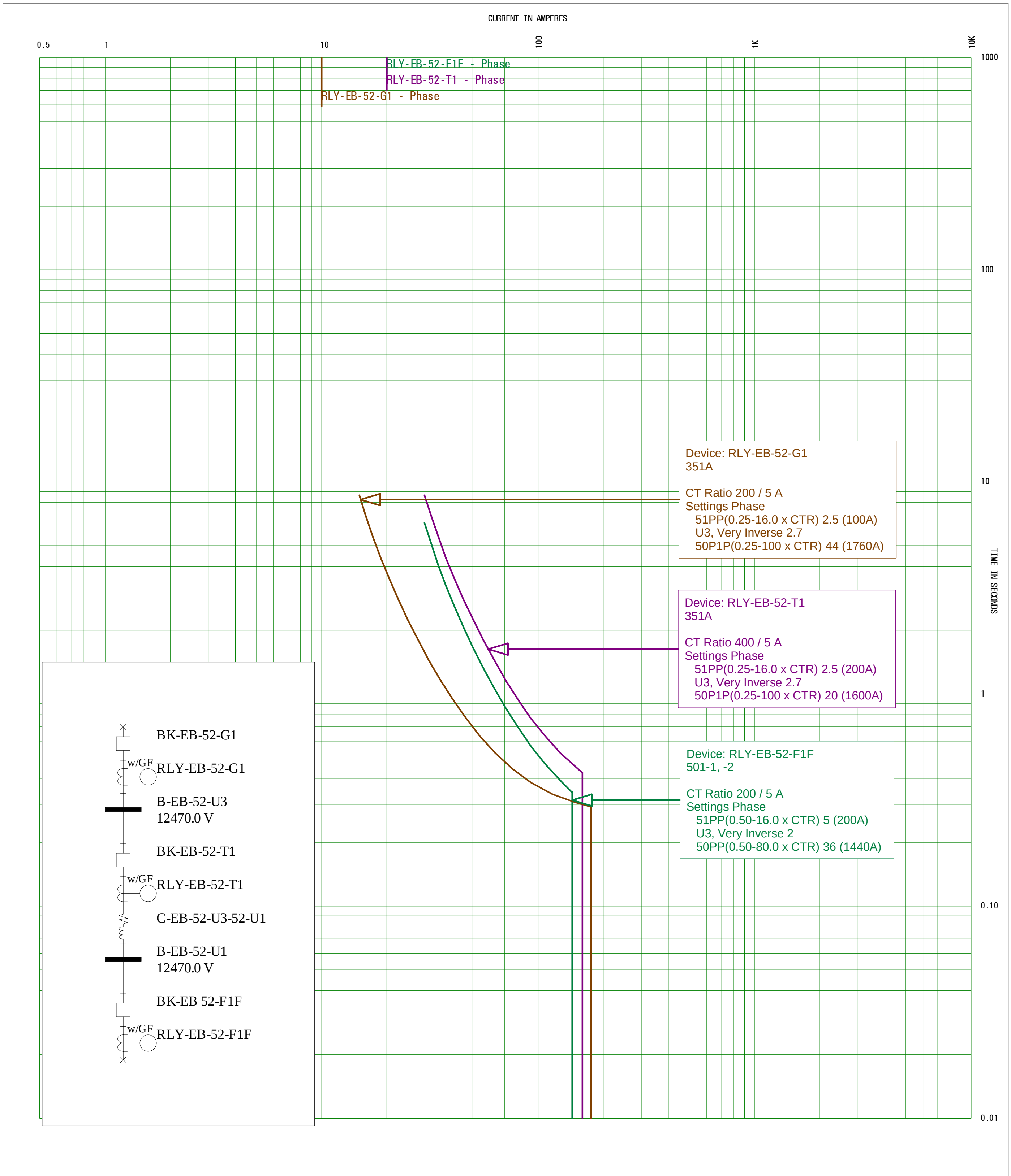
February 21, 2013

Plot name: EB USB-5
Ref. Voltage: 480V
Current Scale: x 100



Eaton Electrical Services and Systems February 21, 2013	Plot name: EB 52-U1 GEN Ref. Voltage: 12470V Current Scale: x 10

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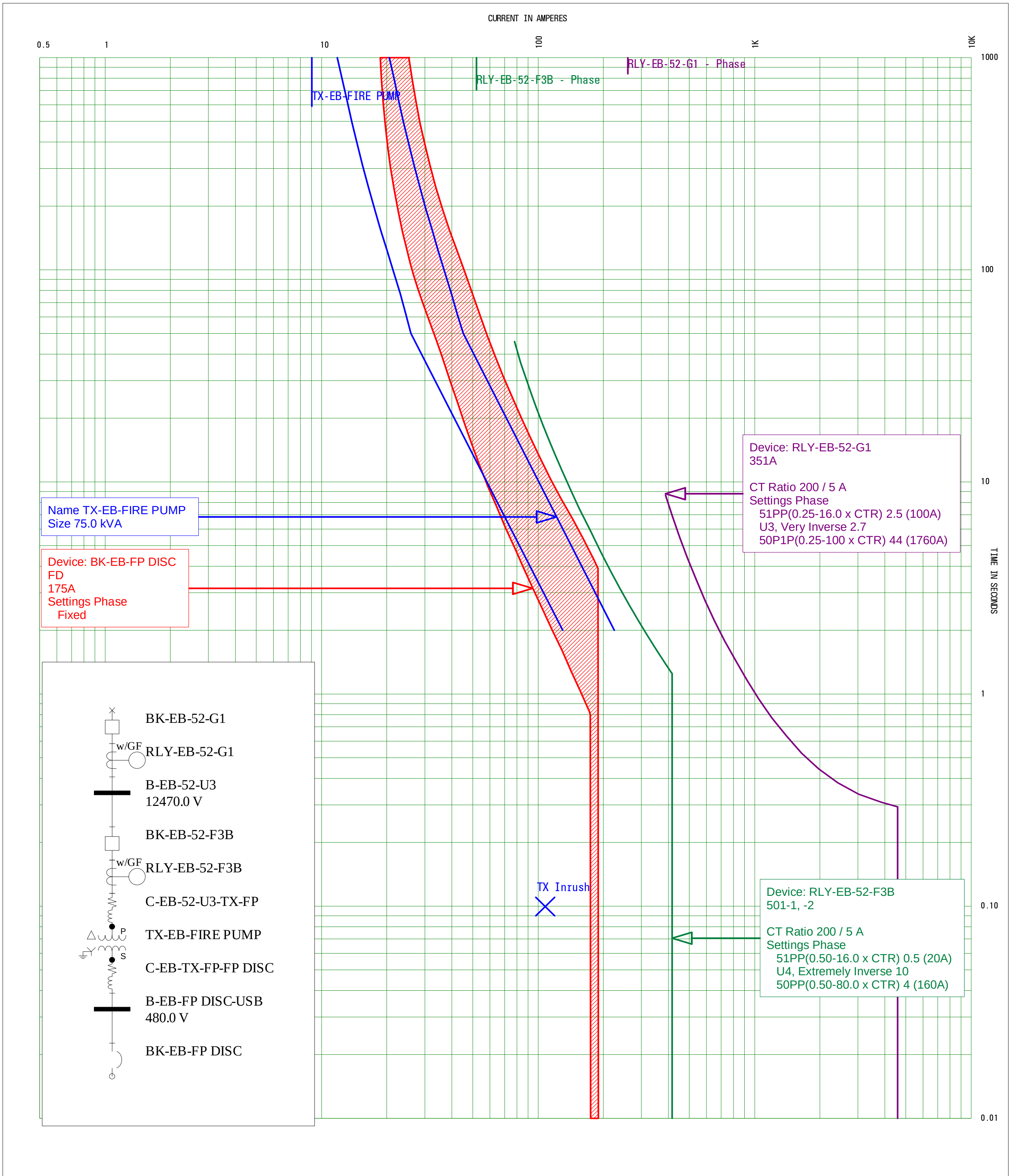

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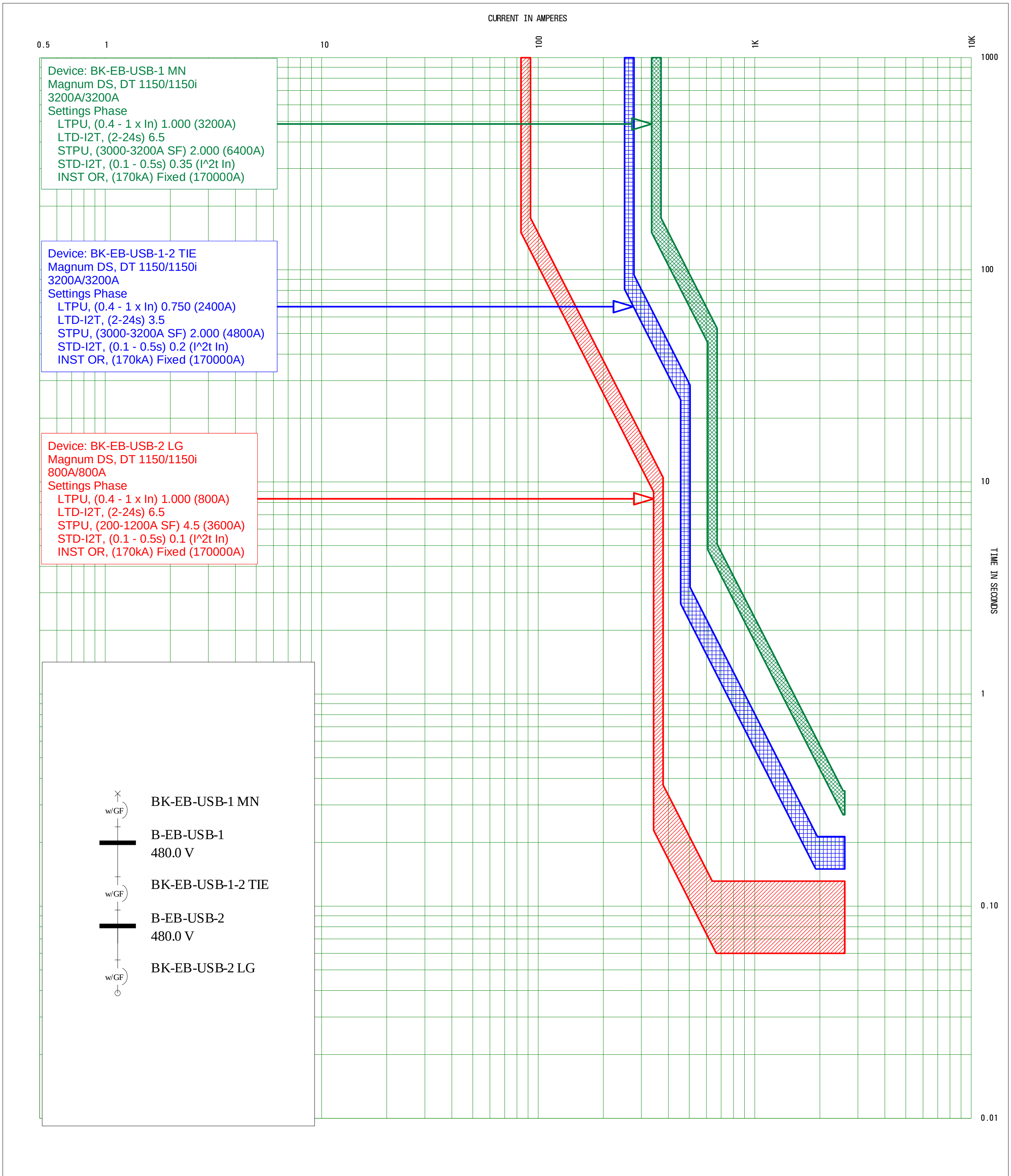
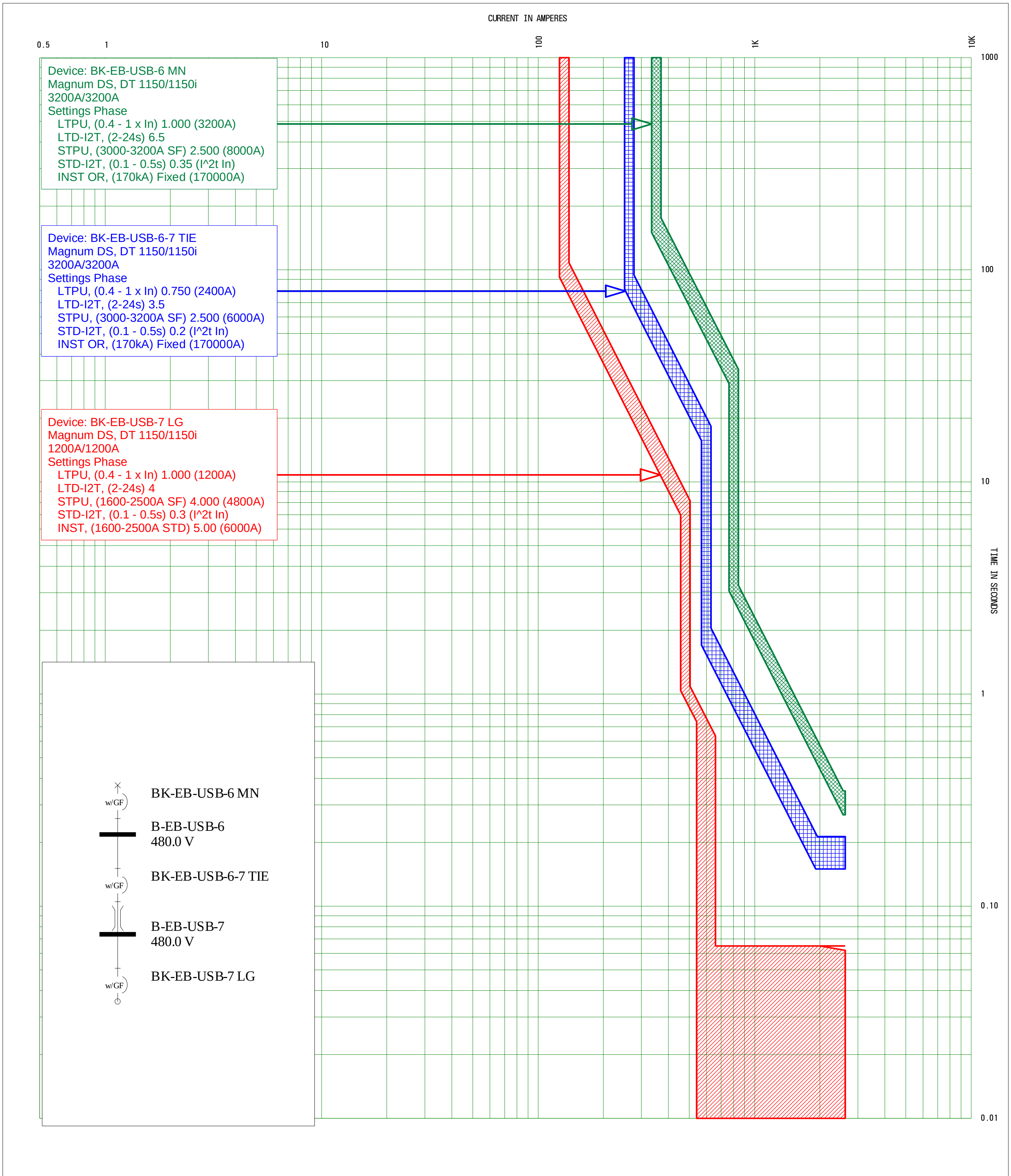
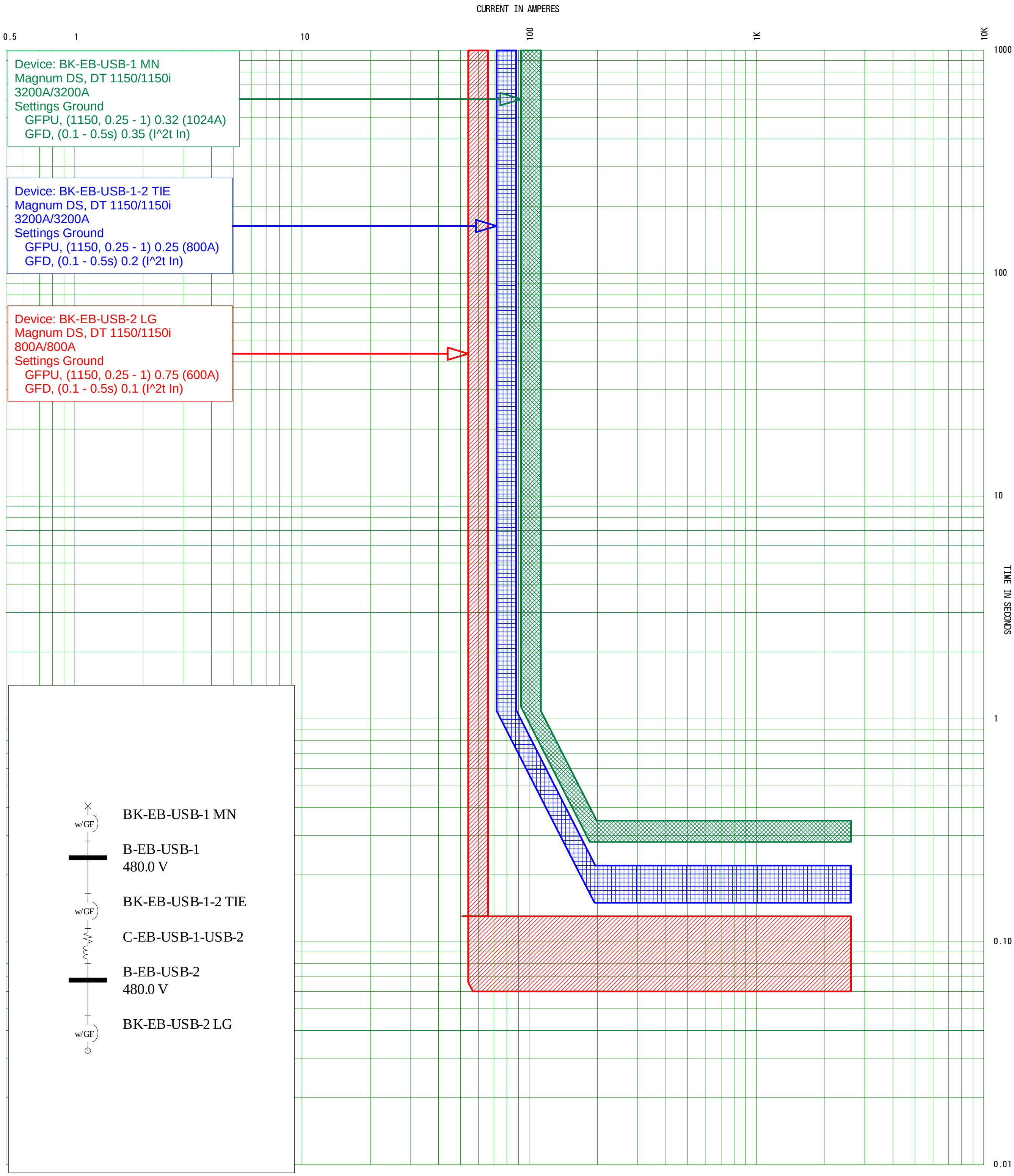


Eaton Electrical Services and Systems February 21, 2013	Plot name: EB USB-1-2 LV Ref. Voltage: 480V Current Scale: x 10



Eaton Electrical Services and Systems February 21, 2013	Plot name: EB USB-6-7 LV Ref. Voltage: 480V Current Scale: x 10



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Plot name: EB USB-1-2 GF
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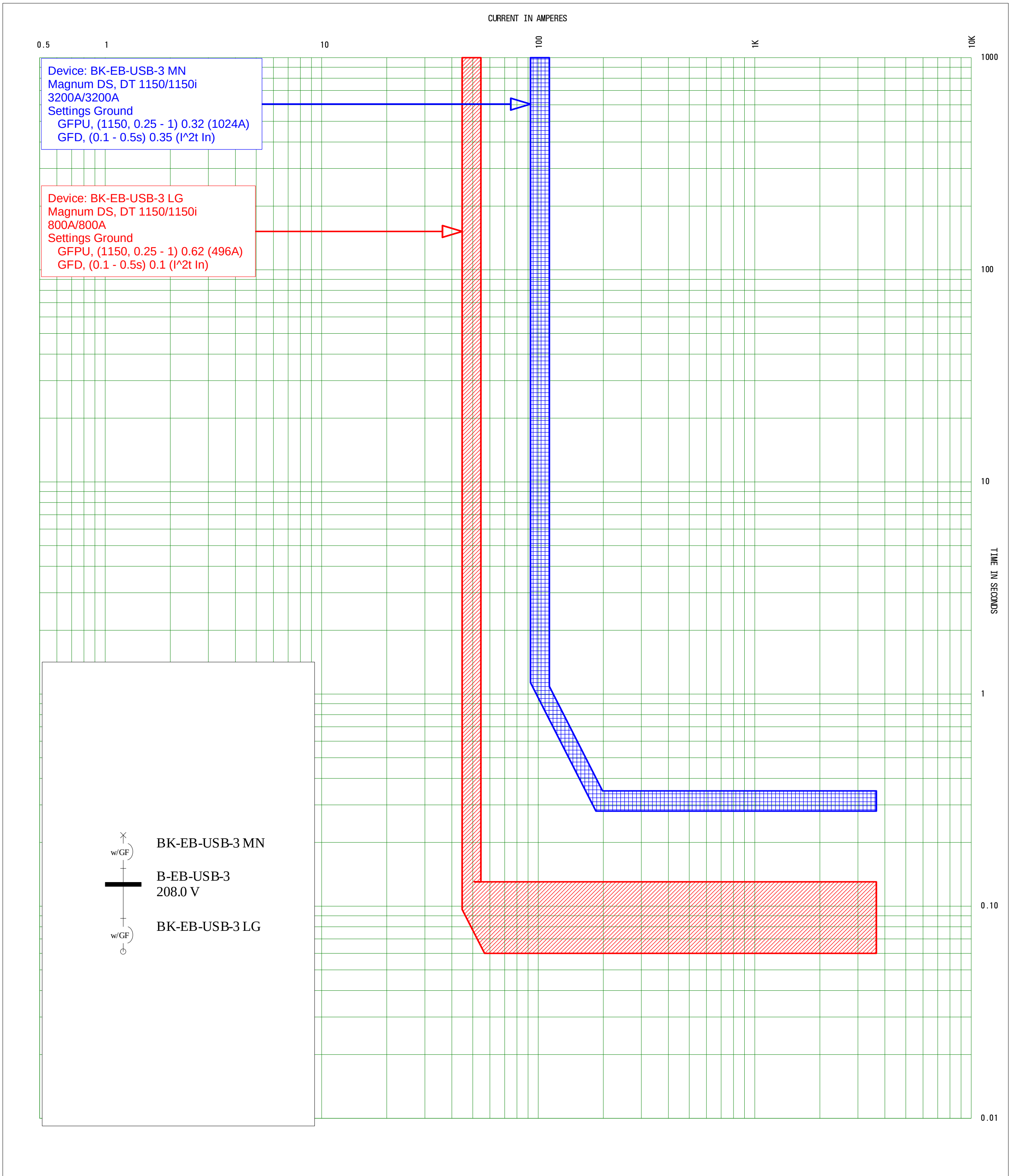
Current Scale: x 10



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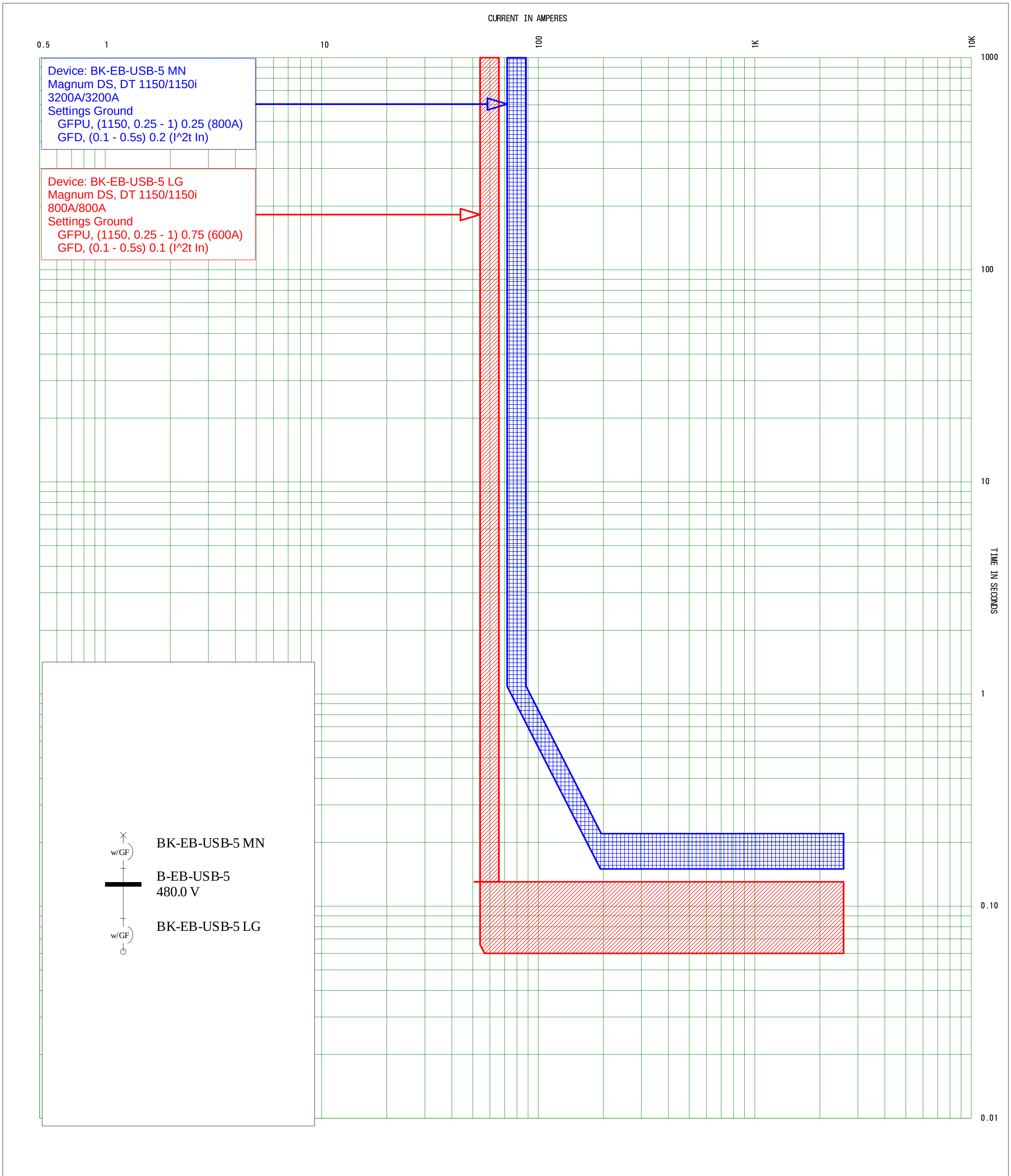
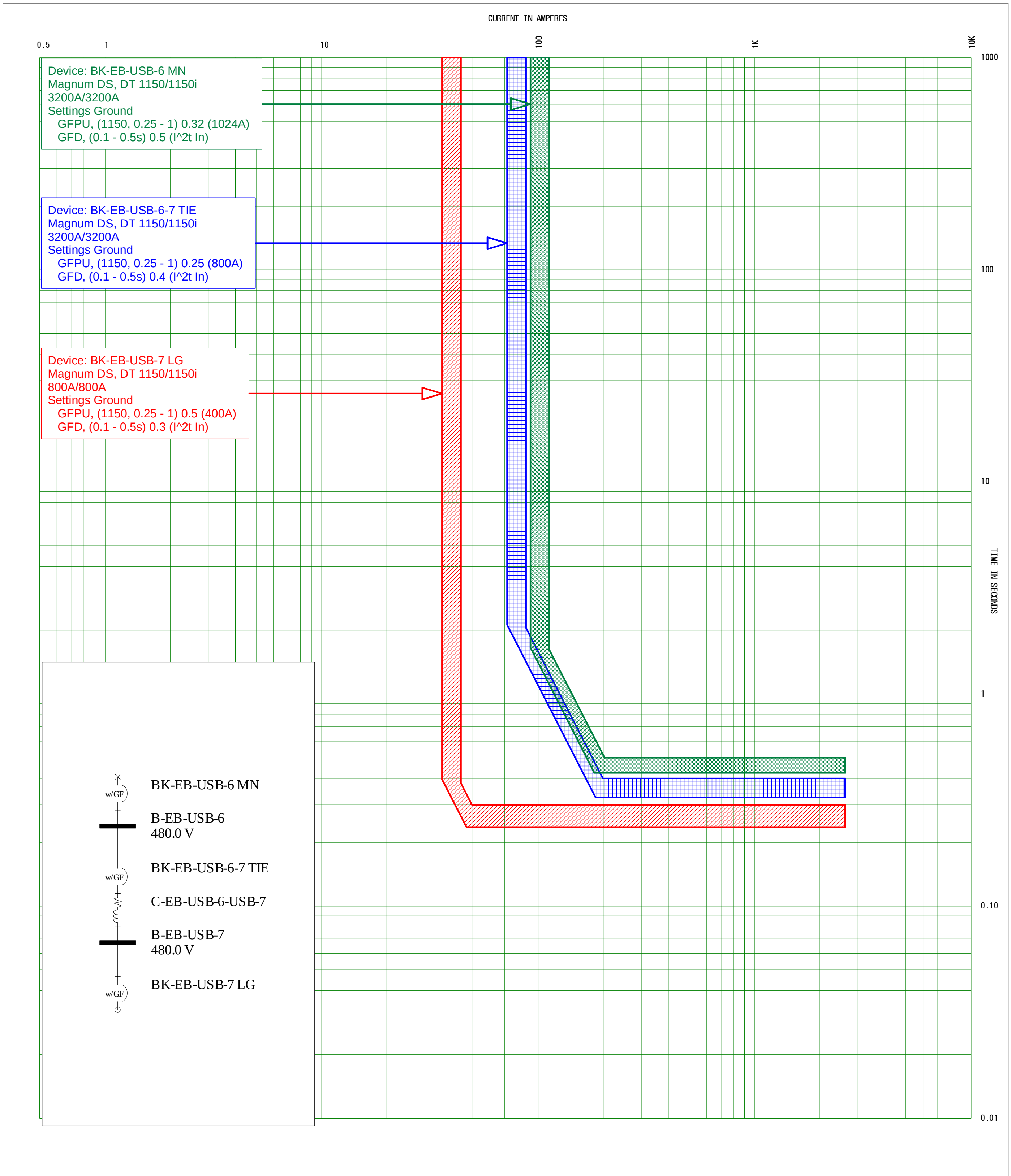
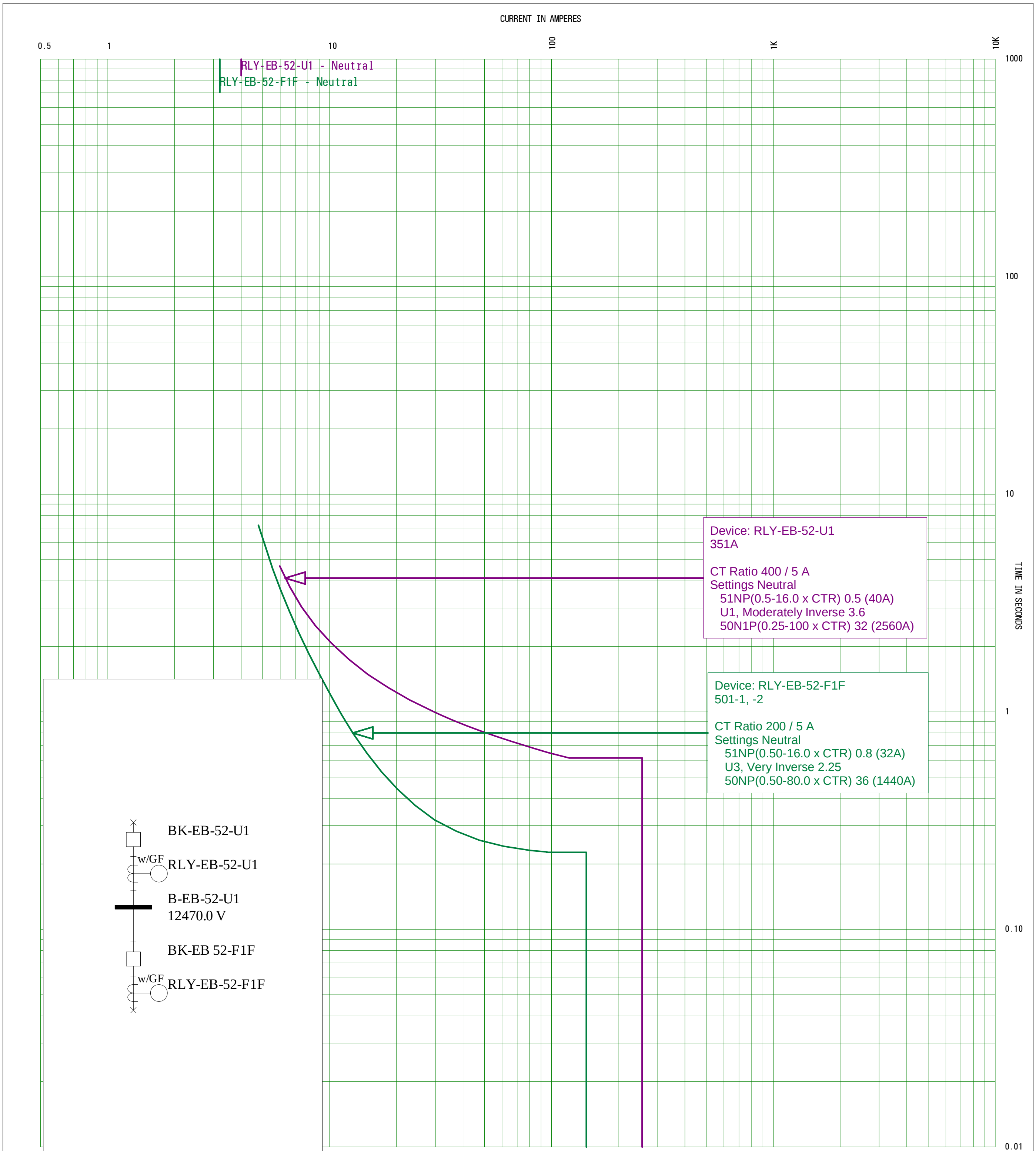


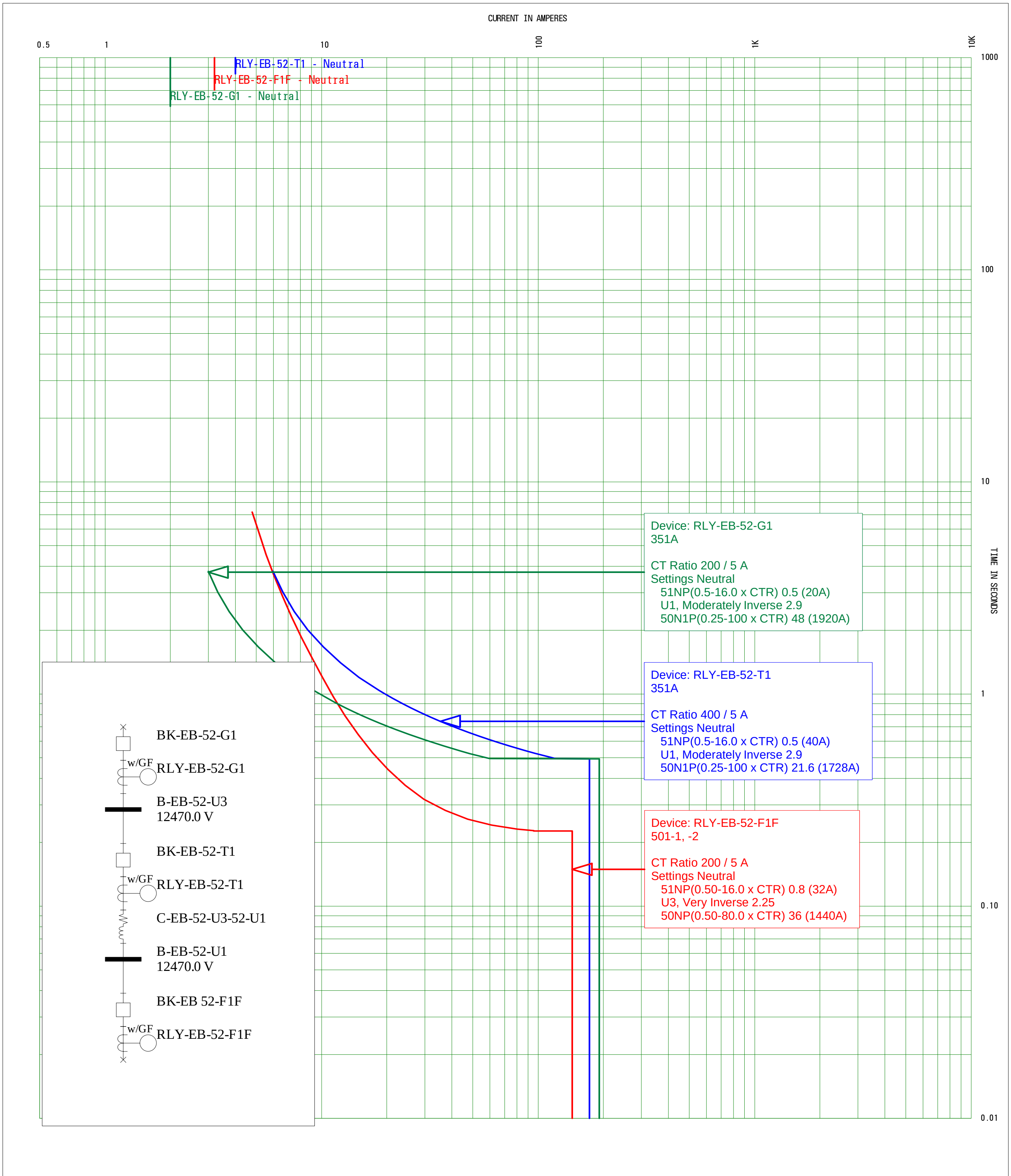
Eaton Electrical Services and Systems February 21, 2013	Plot name: EB USB-5 GF Ref. Voltage: 480V Current Scale: x 10



Eaton Electrical Services and Systems February 21, 2013	Plot name: EB USB-6-7 GF Ref. Voltage: 480V Current Scale: x 10



Eaton Electrical Services and Systems February 21, 2013	Plot name: EB 52-U1 GF Ref. Voltage: 12470V Current Scale: x 10



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Plot name: EB 52-U3 GF
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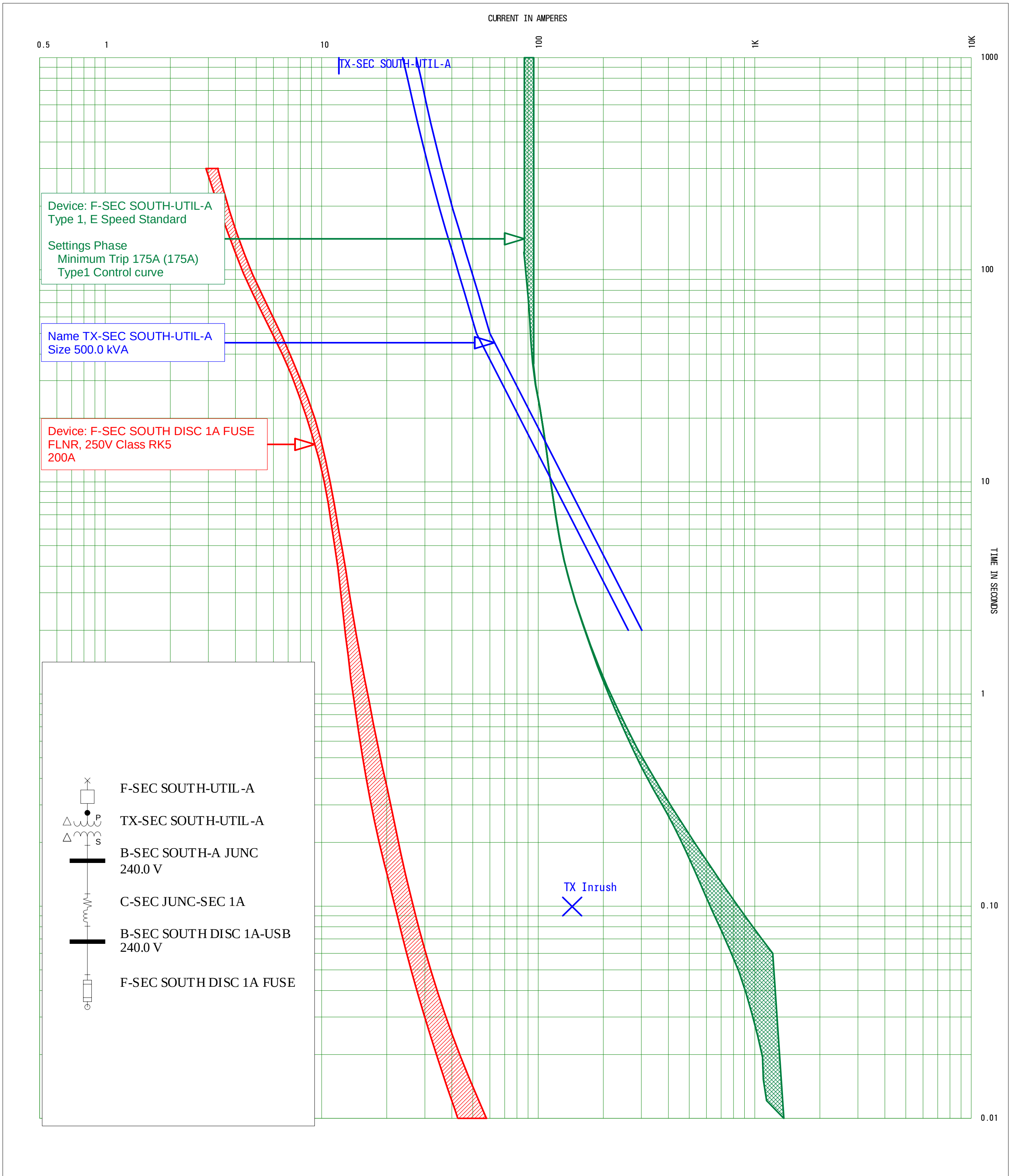
Current Scale: x 10



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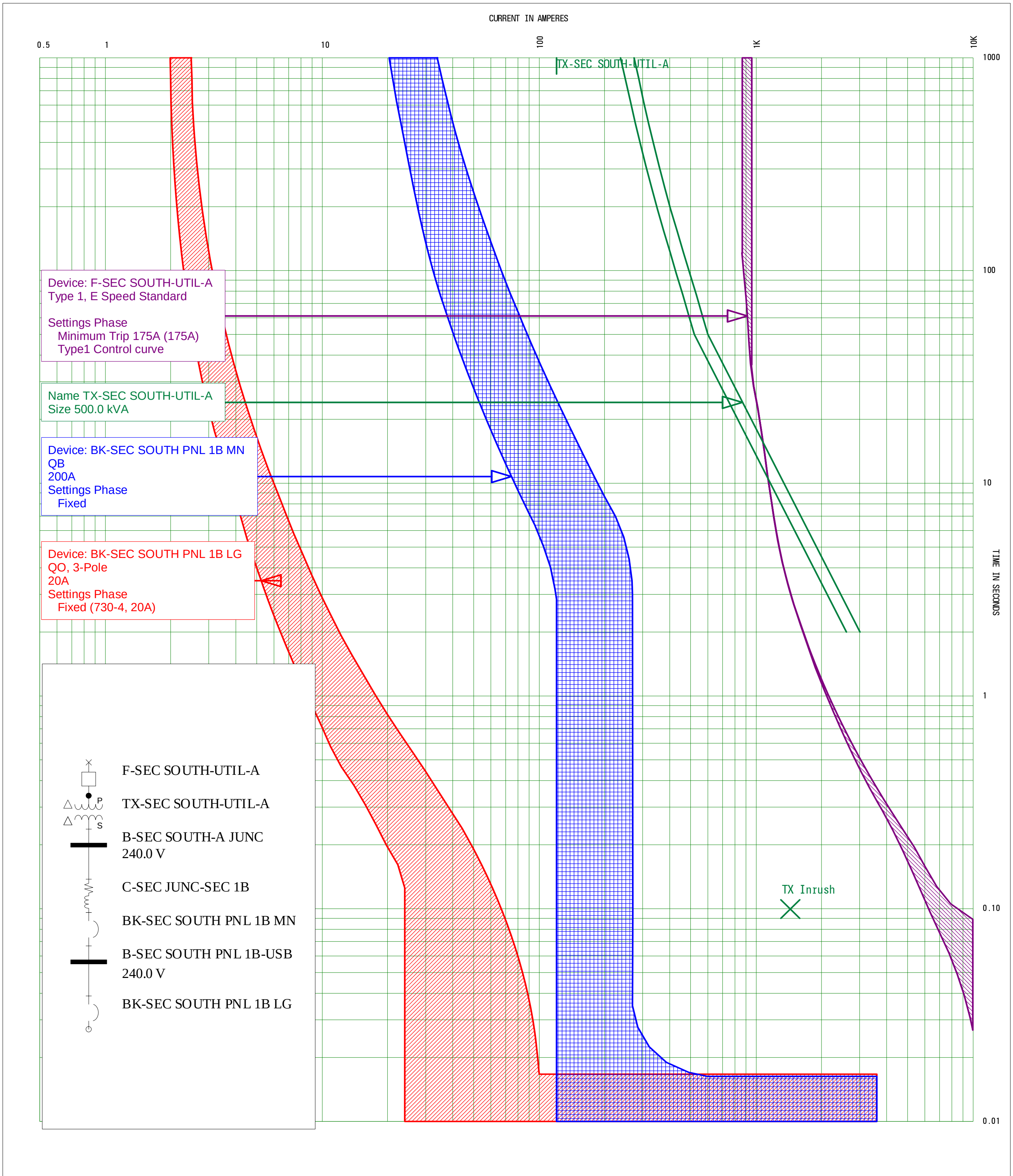
Plot name: SEC SOUTH DISC 1A
Ref. Voltage: 240V
Current Scale: x 100



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Plot name: SEC SOUTH PNL 1B
Ref. Voltage: 240V
Current Scale: x 10

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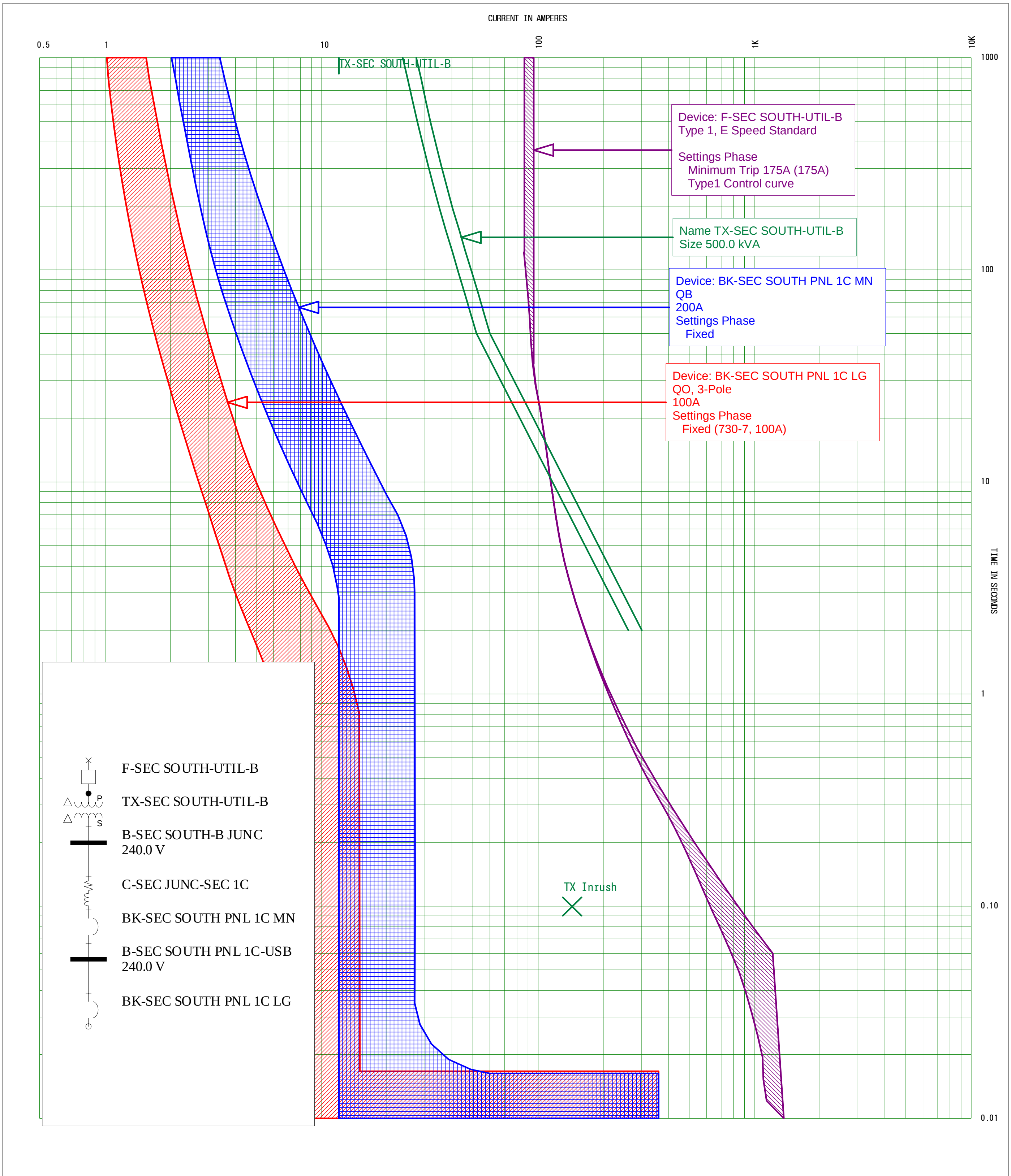
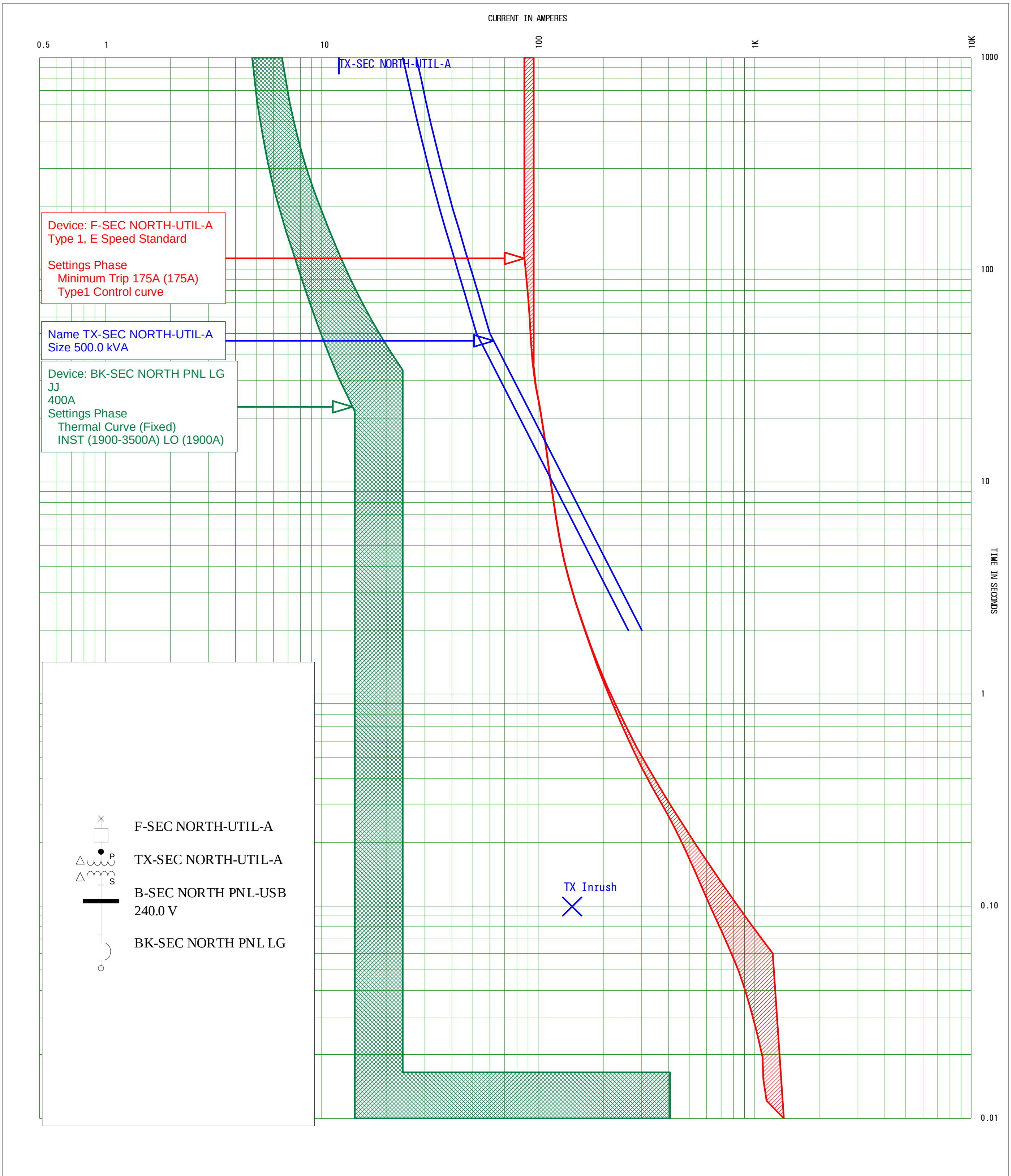
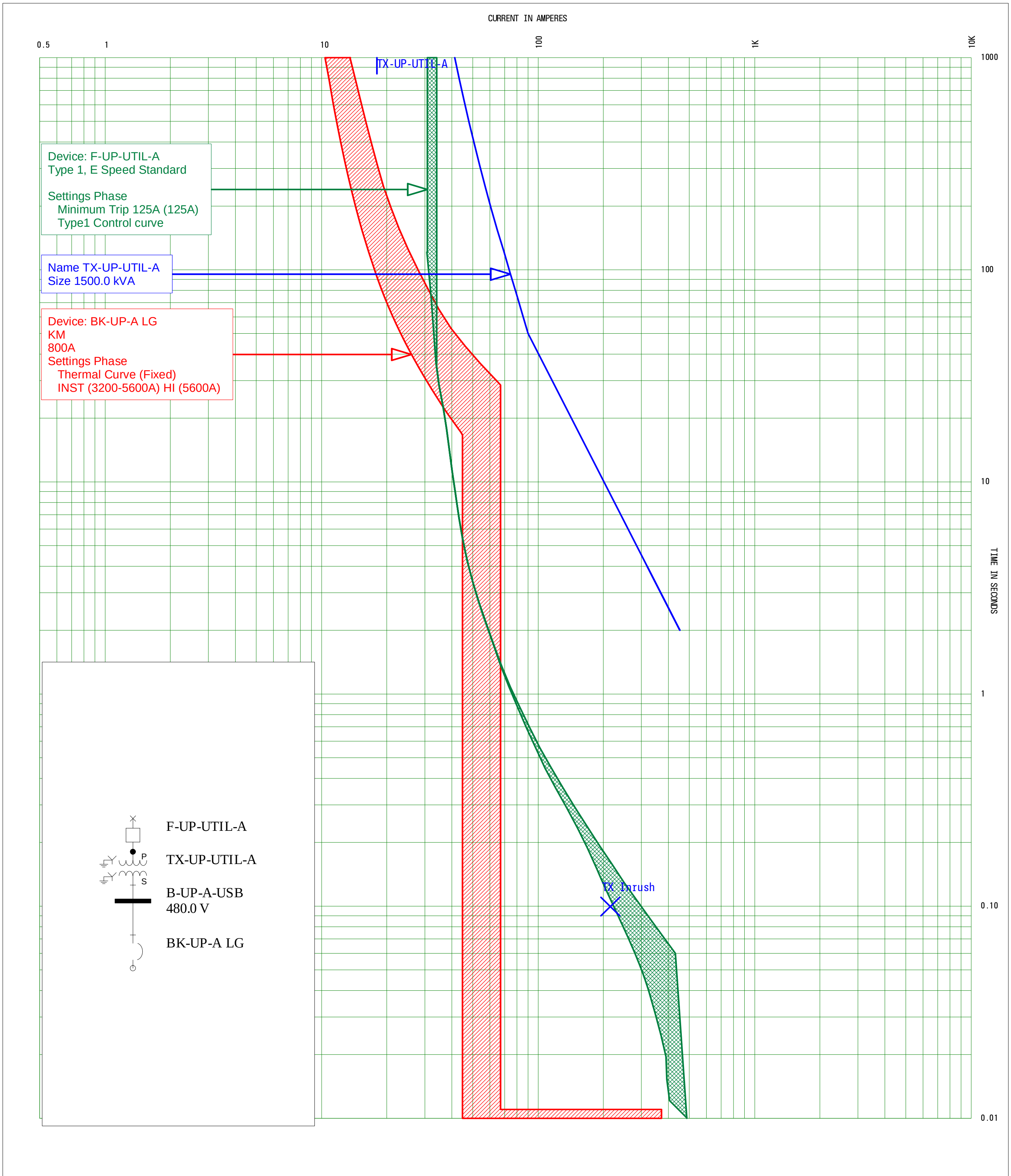


Eaton Electrical Services and Systems
February 21, 2013

Plot name: SEC SOUTH PNL 1C
Ref. Voltage: 240V
Current Scale: x 100

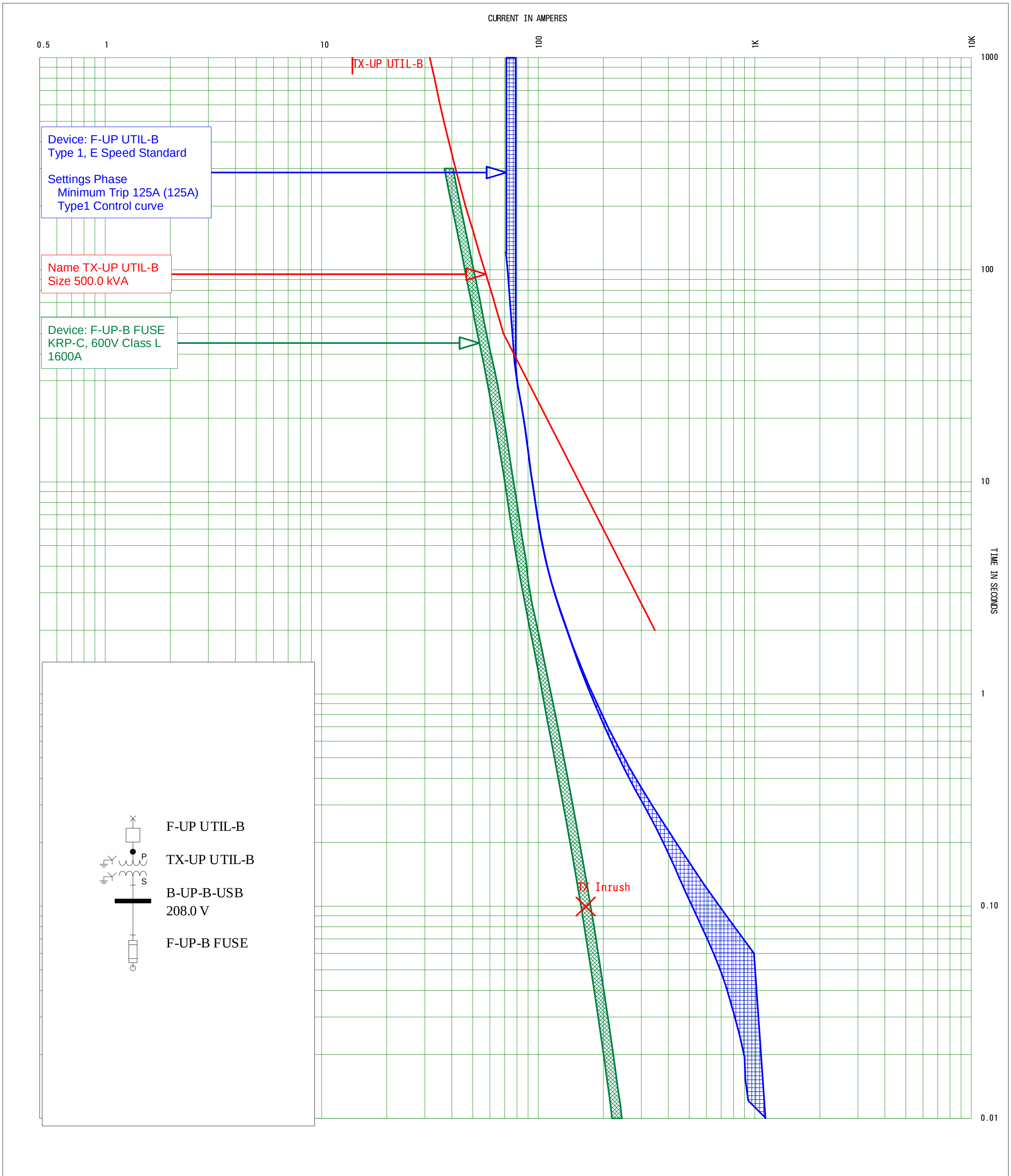


Eaton Electrical Services and Systems February 21, 2013	Plot name: SEC NORTH Ref. Voltage: 240V Current Scale: x 100



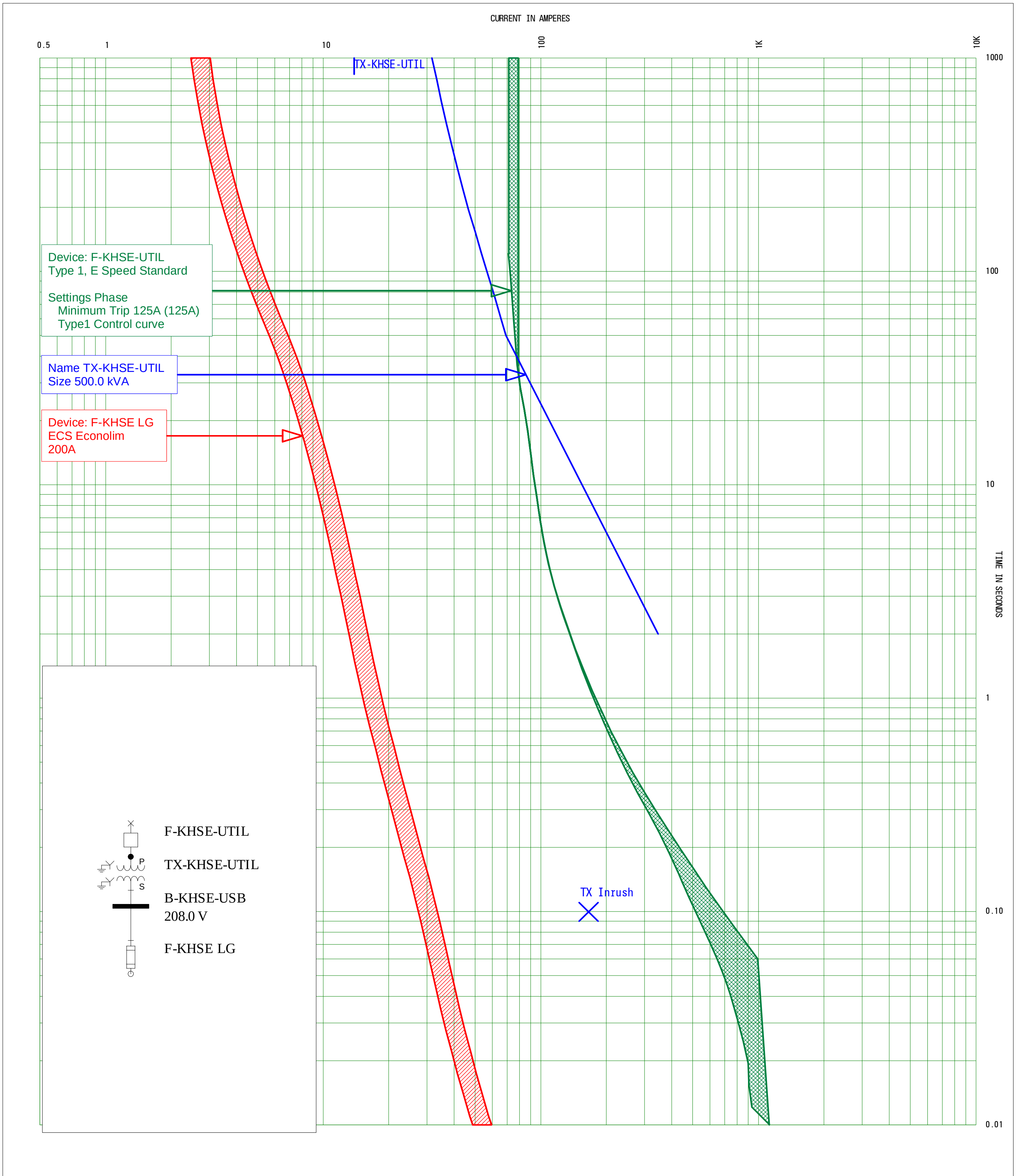
Eaton Electrical Services and Systems
February 21, 2013

Plot name: UP A
Ref. Voltage: 480V
Current Scale: x 100



Eaton Electrical Services and Systems
February 21, 2013

Plot name: UP B
Ref. Voltage: 208V
Current Scale: x 100



Eaton Electrical Services and Systems February 21, 2013	Plot name: KHSE Ref. Voltage: 208V Current Scale: x 100

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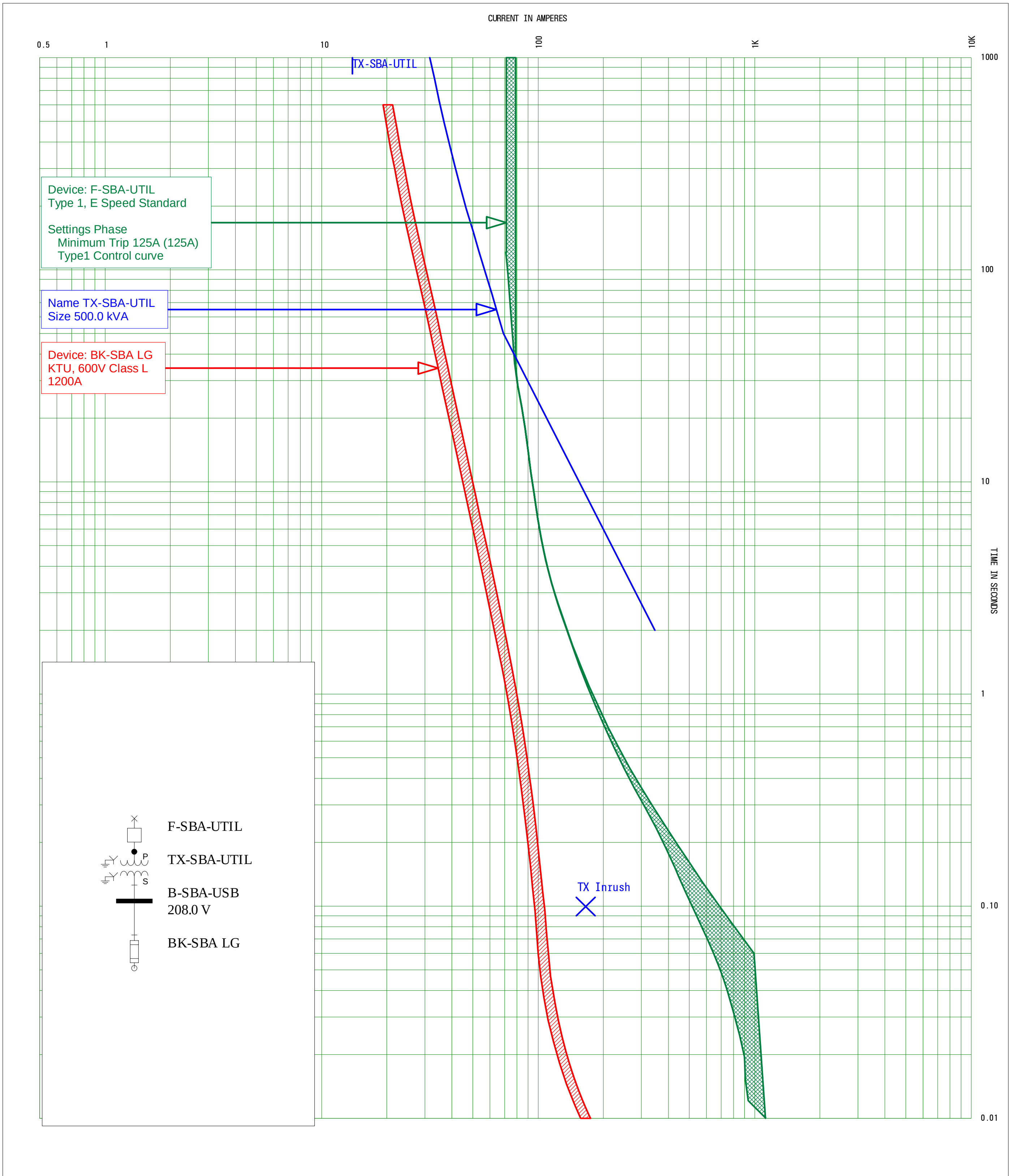
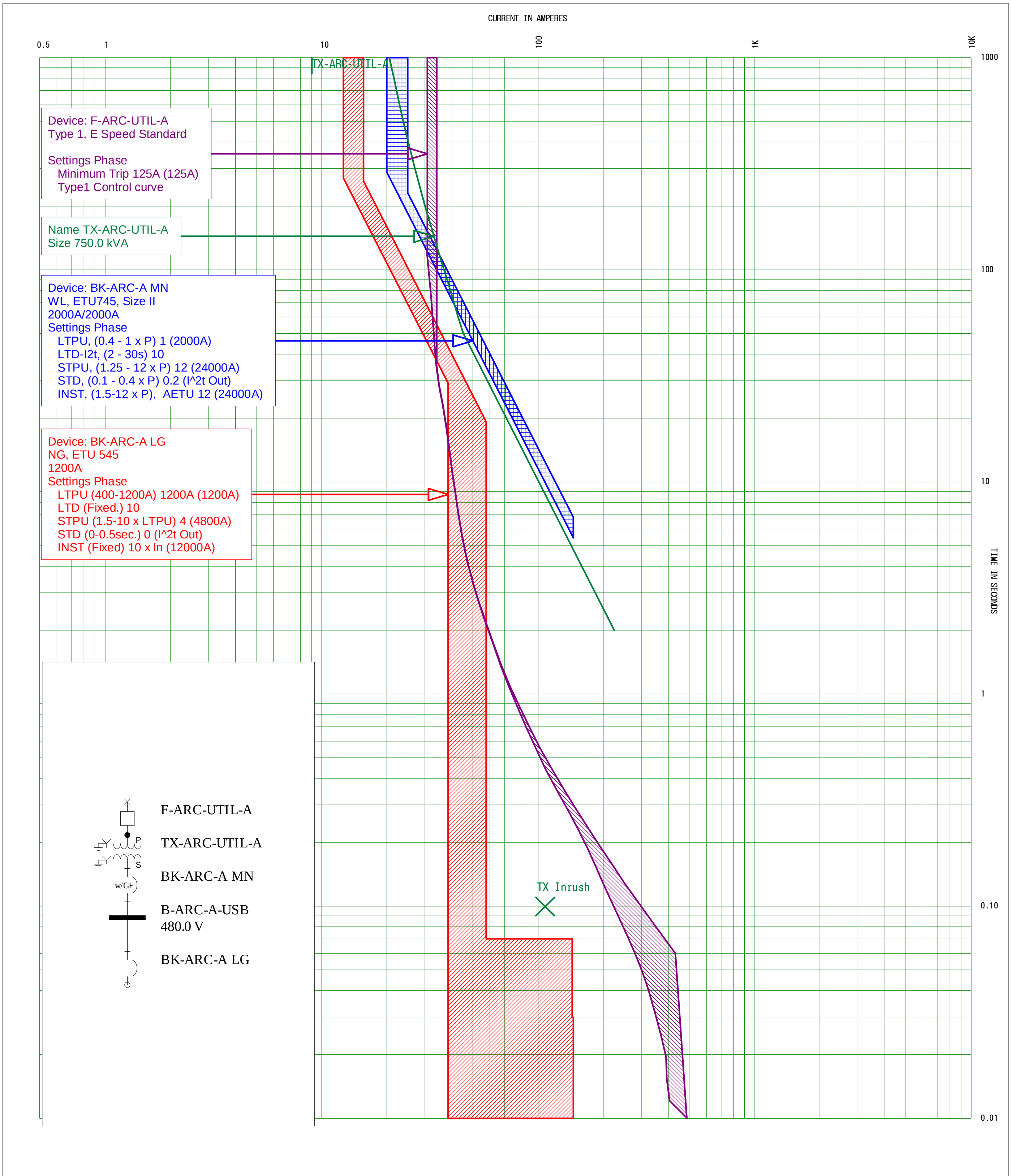
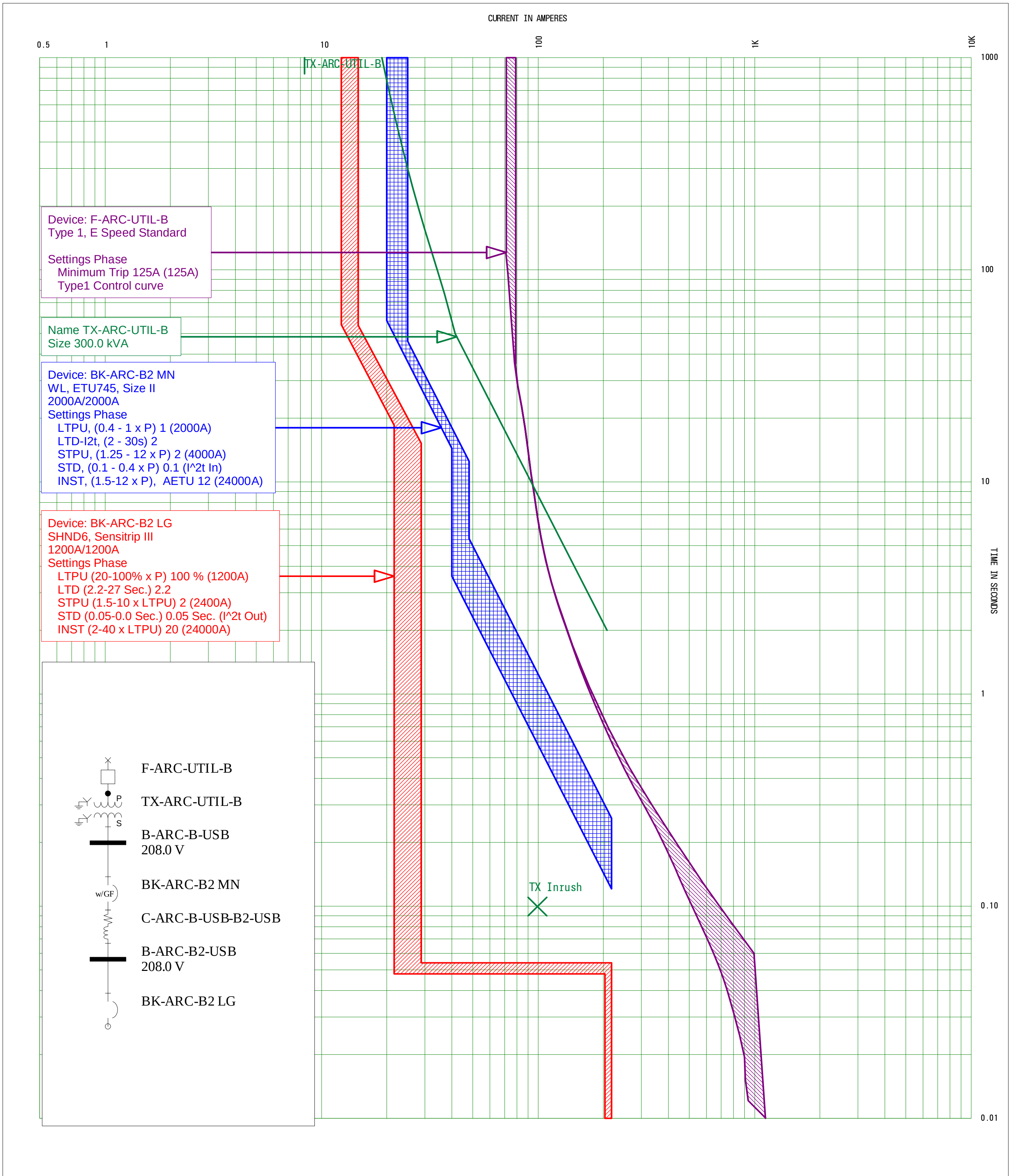


Eaton Electrical Services and Systems February 21, 2013	Plot name: SBA Ref. Voltage: 208V Current Scale: x 100

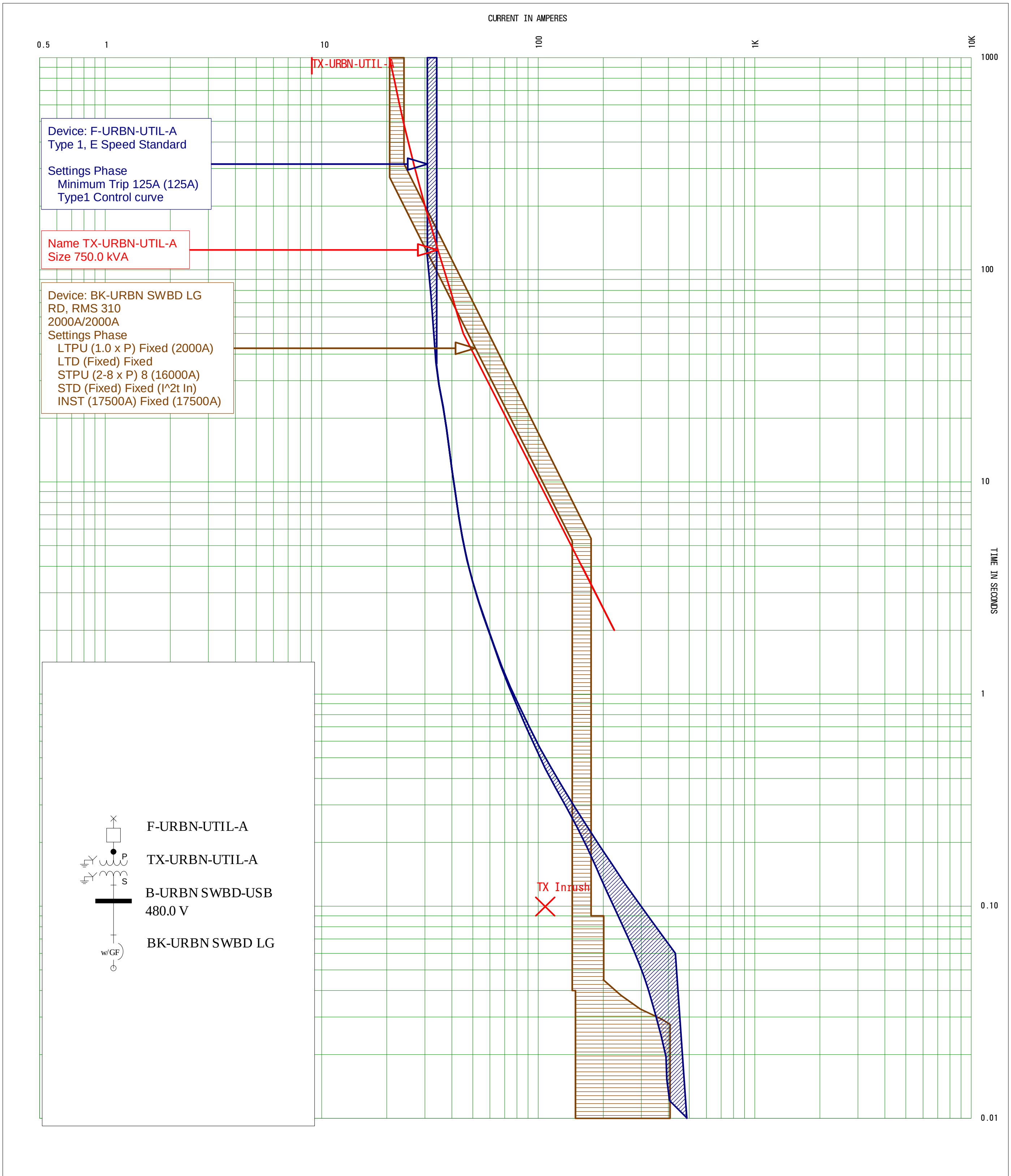


Eaton Electrical Services and Systems
February 21, 2013

Plot name: ARC A
Ref. Voltage: 480V
Current Scale: x 100

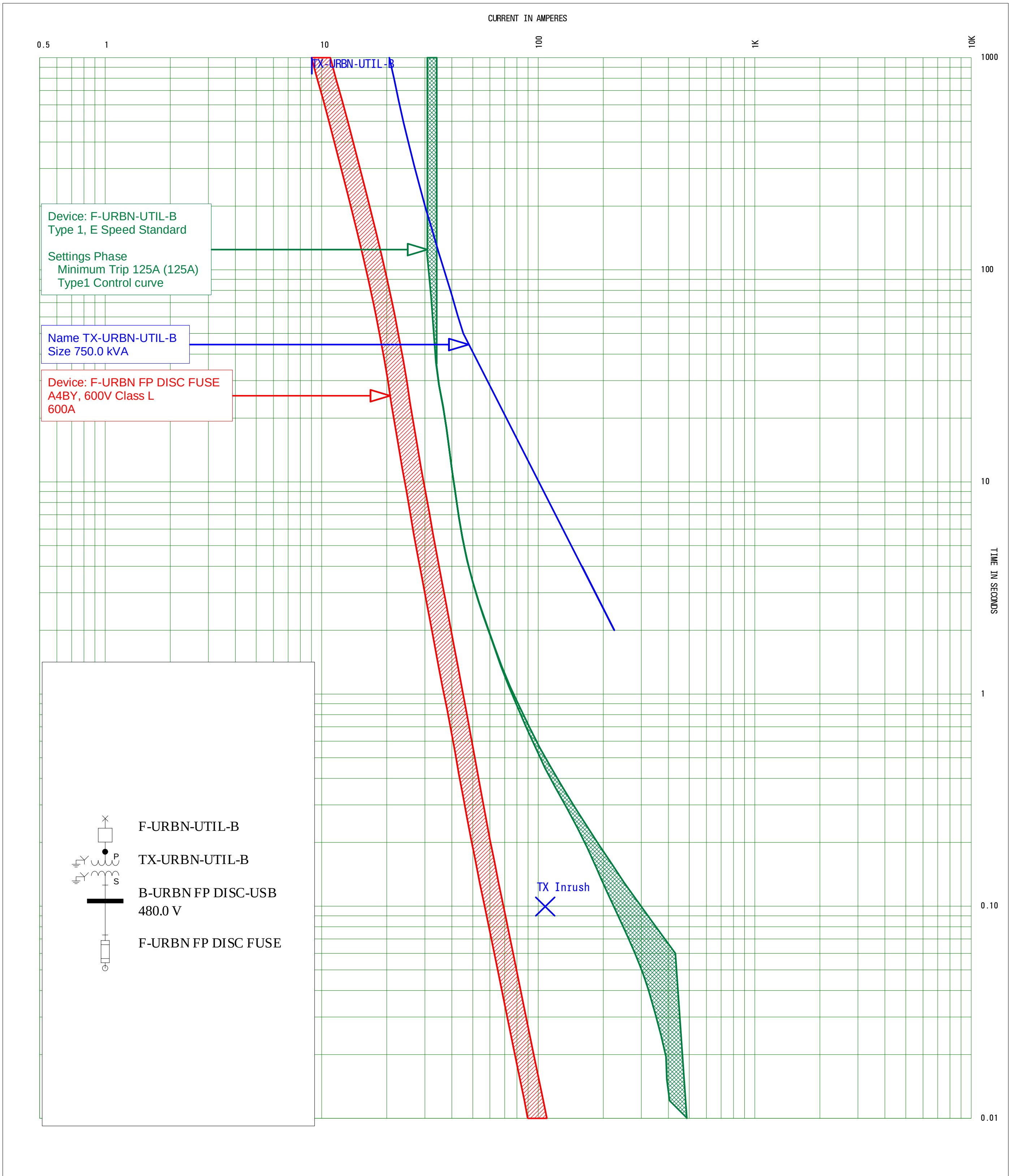


Eaton Electrical Services and Systems February 21, 2013	Plot name: ARC B Ref. Voltage: 208V Current Scale: x 100



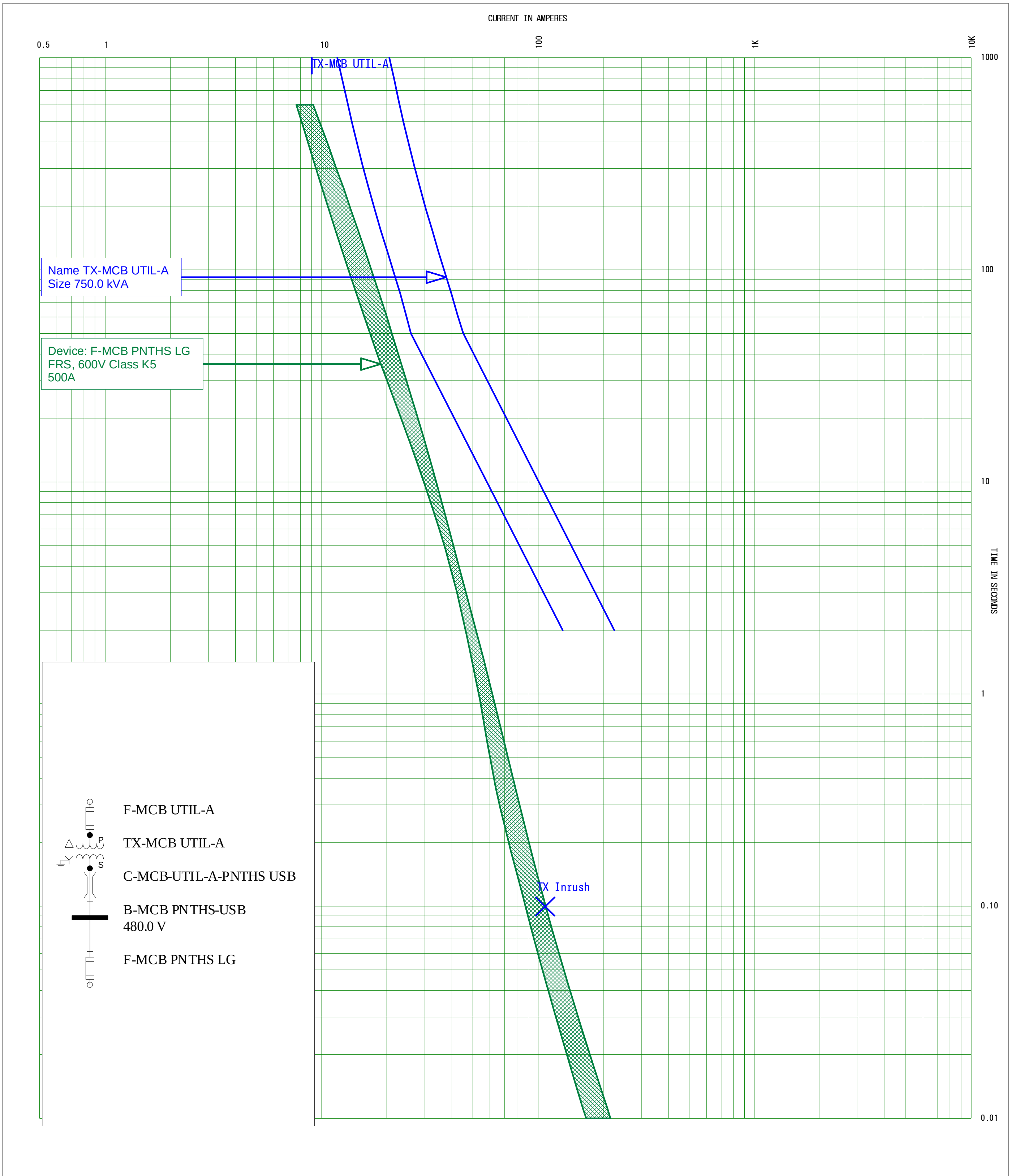
Eaton Electrical Services and Systems
February 21, 2013

Plot name: URBN SWBD
Ref. Voltage: 480V
Current Scale: x 100



Eaton Electrical Services and Systems
February 21, 2013

Plot name: URBN FP
Ref. Voltage: 480V
Current Scale: x 100



Eaton Electrical Services and Systems February 21, 2013	Plot name: MCB Ref. Voltage: 480V Current Scale: x 100

4.0 RECOMMENDED PROTECTIVE DEVICE SETTINGS

The following tables show a comprehensive summary of the recommended settings for the adjustable protective devices. The devices are grouped by system bus name/location. Refer to Appendix D for the system one-line diagrams.

Table 4.1 - Recommended Low-Voltage Protective Device Settings

BUS NUMBER	FEEDER BREAKER ID	BREAKER MODEL & MANUFACTURER	TRIP UNIT TYPE	CURRENT RATING		LONG DELAY		SHORT DELAY			INST.	GROUND		CURVE NAME
				FRAME	PLUG	PICKUP	TIME	PICKUP	TIME	I^2t		PICKUP	TIME, I^2t	
B-SH-USB	BK-SH MN Main Breaker	PowerBreak II GE	MVT Plus LSI	2000A	2000A	1 (?)	1 (?)	3.5 (?)	Min (?)	Out (?)	15 (?)	---	---	SH
B-OND ANNEX SWBD-USB	BK-OND ANNEX SWBD MN Main Breaker	RD Cutler-Hammer	RMS310 LSG	1600A	1600A	---	---	5 (4)	---	---	---	(F)	(0.15s, In)	OND ANNEX
B-BHB MSB-A SWBD-USB	BK-BHB MSB-A SWBD MN Main Breaker	RJ Square D	Micrologic 6.0A LSIG	2000A	2000A	1 (1)	0.5 (0.5)	1.5 (1.5)	0.1 (0.1)	In (In)	12 (2)	(A)	(0.1, Out)	BHB MSB-A
B-NASC-USB	BK-NASC MN Main Breaker	MH Square D	Thermal Magnetic	600A	600A	---	---	---	---	---	MAX (MIN)	---	---	NASC
B-EB-USB-1	BK-EB-USB-1 MN Main Breaker	MDS-632 Eaton	Optim1150 LSIG	3200A	3200A	(1)	(6.5)	(2)	(0.35)	(In)	(OFF)	(0.32)	(0.35, In)	EB USB-1-2 LV, EB USB-1-2 GF
B-EB-USB-1	BK-EB-USB-1-2 TIE Tie Breaker	MDS-632 Eaton	Optim1150 LSIG	3200A	3200A	(0.75)	(3.5)	(2)	(0.2)	(In)	(OFF)	(0.25)	(0.2, In)	EB USB-1-2 LV, EB USB-1-2 GF
B-EB-USB-2	BK-EB-USB-2 MN Main Breaker	MDS-632 Eaton	Optim1150 LSIG	3200A	3200A	(1)	(6.5)	(2)	(0.35)	(In)	(OFF)	(0.32)	(0.35, In)	EB USB-1-2 LV, EB USB-1-2 GF
B-EB-USB-3	BK-EB-USB-3 MN Main Breaker	MDS-632 Eaton	Optim1150 LSIG	3200A	3200A	(1)	(13.5)	(2.5)	(0.35)	(In)	(OFF)	(0.32)	(0.35, In)	EB-USB-3, EB-USB-3 GF
B-EB-USB-5	BK-EB-USB-5 MN Main Breaker	MDS-632 Eaton	Optim1150 LSIG	3200A	3200A	(0.70)	(6.5)	(2)	(0.2)	(In)	(OFF)	90.25)	(0.2, In)	EB-USB-5, EB-USB-5 GF
B-EB-USB-6	BK-EB-USB-6 MN Main Breaker	MDS-632 Eaton	Optim1150 LSIG	3200A	3200A	1 (1)	6.5 (6.5)	2.5 (2)	0.35 (0.35)	In (In)	OFF (OFF)	0.32 (0.32)	0.5, In (0.35, In)	EB-USB-6-7 LV, EB-USB-6-7 GF,
B-EB-USB-6	BK-EB-USB-6-7 TIE Tie Breaker	MDS-632 Eaton	Optim1150 LSIG	3200A	3200A	0.75 (0.75)	3.5 (3.5)	2.5 (2)	0.2 (0.2)	In (In)	OFF (OFF)	0.25 (0.25)	0.4, In (0.2, In)	EB-USB-6-7 LV, EB-USB-6-7 GF
B-EB-USB-7	BK-EB-USB-7 MN Main Breaker	MDS-632 Eaton	Optim1150 LSIG	3200A	3200A	1 (1)	6.5 (6.5)	2.5 (2)	0.35 (0.35)	In (In)	OFF (OFF)	0.32 (0.32)	0.5, In (0.35, In)	EB-USB-6-7 LV, EB-USB-6-7 GF
B-ARC-A-USB	BK-ARC-A MN Main Breaker	WLL Siemens	ETU745 LSIA	2000A	2000A	1 (1)	10 (10)	12 (12)	0.2 (0.2)	Out (Out)	12 (4)	C (C)	0.3, In (0.3, In)	ARC A
B-ARC-B-USB	BK-ARC-B MN Main Breaker	WLL Siemens	ETU745 LSIA	2000A	2000A	1 (1)	2 (2)	2 (2)	0.1 (0.1)	In (In)	12 (8)	C (C)	0.3, In (0.3, In)	ARC B

Where available, existing settings are shown in parenthesis. If existing settings were unavailable, (?) is shown.
When breaker information was not available and an adjustable breaker was assumed, that breaker was set to its maximum. Settings for these breakers are not shown in this table.

Table 4.2 - Recommended Medium-Voltage Protective Device Settings

CIRCUIT IDENTIFICATION		PROTECTIVE DEVICE DESCRIPTION					RECOMMENDED SETTINGS					
BUS NUMBER	BREAKER ID / FEEDER	DEVICE FUNCTION	DEVICE MAKER	MODEL NUMBER	RELAY RANGES	CT RATIO	TAP (A)	TIME DIAL	CURVE TYPE	INST (A)	INST DELAY	CURVE
B-EB-52-U1	RLY-EB-52-U1	50 / 51 P	Schweitzer	SEL-351A	0.25 – 16 (Tap) 0.25 – 100 (INST)	400:5	2.5 (200 A)	4.5	U3, Very Inverse	24.5 (1960 A)	---	EB USB-1 MV
		50 / 51 N			0.5 – 16 (Tap) 0.25 – 100 (INST)	400:5	0.5 (40 A)	3.6	U1, Moderately Inverse	32 (2560 A)	---	EB 52-U1 GF
	RLY-EB-52-F1B	50 / 51 P	Schweitzer	SEL-501-2	0.5 – 16 (Tap) 0.5 – 80 (INST)	200:5	5 (200 A)	2	U3, Very Inverse	36 (1440 A)	---	EB USB-1 MV
		50 / 51 N			0.5 – 16 (Tap) 0.5 – 80 (INST)	200:5	0.8 (32 A)	2.25	U3, Very Inverse	36 (1440 A)	---	EB 52-U1 GF
	RLY-EB-52-F1D	50 / 51 P	Schweitzer	SEL-501-2	0.5 – 16 (Tap) 0.5 – 80 (INST)	200:5	3 (120 A)	1.6	U3, Very Inverse	18 (720 A)	---	EB USB-3
		50 / 51 N			0.5 – 16 (Tap) 0.5 – 80 (INST)	200:5	1 (40 A)	1.87	U3, Very Inverse	16 (640 A)	---	EB 52-U1 GF
	RLY-EB-52-F1F	50 / 51 P	Schweitzer	SEL-501-2	0.5 – 16 (Tap) 0.5 – 80 (INST)	200:5	5 (200 A)	2	U3, Very Inverse	36 (1440 A)	---	EB USB-1 MV
		50 / 51 N			0.5 – 16 (Tap) 0.5 – 80 (INST)	200:5	0.8 (32 A)	2.25	U3, Very Inverse	36 (1440 A)	---	EB 52-U1 GF
B-EB-52-U2	RLY-EB-52-U2	50 / 51 P	Schweitzer	SEL-351A	0.25 – 16 (Tap) 0.25 – 100 (INST)	400:5	2.5 (200 A)	4.5	U3, Very Inverse	24.5 (1960 A)	---	EB USB-1 MV
		50 / 51 N			0.5 – 16 (Tap) 0.25 – 100 (INST)	400:5	0.5 (40 A)	3.6	U1, Moderately Inverse	32 (2560 A)	---	EB 52-U1 GF
	RLY-EB-52-F2B	50 / 51 P	Schweitzer	SEL-501-2	0.5 – 16 (Tap) 0.5 – 80 (INST)	200:5	5 (200 A)	2	U3, Very Inverse	36 (1440 A)	---	EB USB-1 MV
		50 / 51 N			0.5 – 16 (Tap) 0.5 – 80 (INST)	200:5	0.8 (32 A)	2.25	U3, Very Inverse	36 (1440 A)	---	EB 52-U1 GF
	RLY-EB-52-F2D	50 / 51 P	Schweitzer	SEL-501-2	0.5 – 16 (Tap) 0.5 – 80 (INST)	200:5	3.3 (132 A)	1.8	U3, Very Inverse	30 (1200 A)	---	EB USB-3
		50 / 51 N			0.5 – 16 (Tap) 0.5 – 80 (INST)	200:5	0.6 (24 A)	1.44	U1, Moderately Inverse	30.6 (1224 A)	---	EB 52-U1 GF
	RLY-EB-52-F2F	50 / 51 P	Schweitzer	SEL-501-2	0.5 – 16 (Tap) 0.5 – 80 (INST)	200:5	5 (200 A)	2	U3, Very Inverse	36 (1440 A)	---	EB USB-1 MV
		50 / 51 N			0.5 – 16 (Tap) 0.5 – 80 (INST)	200:5	0.8 (32 A)	2.25	U3, Very Inverse	36 (1440 A)	---	EB 52-U1 GF
B-EB-52-U3	RLY-EB-52-G1	50 / 51 P	Schweitzer	SEL-351A	0.25 – 16 (Tap) 0.25 – 100 (INST)	200:5	2.5 (100 A)	2.7	U3, Very Inverse	44 (1760 A)	---	EB 52-U1 GEN

CIRCUIT IDENTIFICATION		PROTECTIVE DEVICE DESCRIPTION					RECOMMENDED SETTINGS					
BUS NUMBER	BREAKER ID / FEEDER	DEVICE FUNCTION	DEVICE MAKER	MODEL NUMBER	RELAY RANGES	CT RATIO	TAP (A)	TIME DIAL	CURVE TYPE	INST (A)	INST DELAY	CURVE
B-EB-52-U3	RLY-EB-52-G1	50 / 51 P	Schweitzer	SEL-351A	0.5 – 16 (Tap) 0.25 – 100 (INST)	200:5	0.5 (20 A)	2.9	U1, Moderately Inverse	48 (1920 A)	---	EB 52-U3 GF
	RLY-EB-52-T1	50 / 51 P	Schweitzer	SEL-351A	0.25 – 16 (Tap) 0.25 – 100 (INST)	400:5	2.5 (200 A)	2.7	U3, Very Inverse	20 (1600 A)	---	EB 52-U1 GEN
		50 / 51 N			0.5 – 16 (Tap) 0.25 – 100 (INST)	400:5	0.5 (40 A)	2.9	U1, Moderately Inverse	21.6 (1728 A)	---	EB 52-U3 GF
	RLY-EB-52-T2	50 / 51 P	Schweitzer	SEL-351A	0.25 – 16 (Tap) 0.25 – 100 (INST)	400:5	2.5 (200 A)	2.7	U3, Very Inverse	20 (1600 A)	---	EB 52-U1 GEN
		50 / 51 N			0.5 – 16 (Tap) 0.25 – 100 (INST)	400:5	0.5 (40 A)	2.9	U1, Moderately Inverse	21.6 (1728 A)	---	EB 52-U3 GF
	RLY-EB-52-F3B	50 / 51 P	Schweitzer	SEL-501-2	0.5 – 16 (Tap) 0.5 – 80 (INST)	200:5	0.5 (20 A)	10	U4, Extremely Inverse	4 (160 A)	---	EB FP
		50 / 51 N			0.5 – 16 (Tap) 0.5 – 80 (INST)	200:5	0.5 (20 A)	4.22	U4, Extremely Inverse	16 (960 A)	---	EB 52-U3 GF

Table 4.2 is for informational purposes only and serves as a record of the relay settings used in calculation of the arc flash incident energies. All relay settings are as found and are not adjusted as part of this study. Any adjustment of settings must take place in cooperation with PGE Engineers.

5.0 ARC FLASH HAZARD ANALYSIS

This section of the report contains the interpretation for the arc flash hazard analysis. The calculations made in this arc flash hazard analysis conform to NFPA 70E, and are based on the information provided by the customer. Actual heat and radiation exposure may be more or less than reflected in the analysis.

Only qualified electricians who are familiar with the installation and maintenance of electrical distribution equipment should perform work associated with such products. All recommendations of the manufacturer, warnings and cautions relating to the safety of personnel and equipment should be followed. All applicable health and safety laws, codes, standards, and procedures should be adhered to. All equipment should be de-energized prior to any maintenance or service. OSHA 1910.333 requirements should be adhered to. All guidelines of NFPA 70E-2012 should be followed, and in particular appropriate personal protective equipment must be provided and worn.

Eaton Corporation will not be responsible for the misuse or misapplication of the information contained in this analysis. Those providing service for electrical equipment should contact an Eaton Electrical Services and Systems representative, or other qualified individual, if any questions arise.

5.1 Introduction

NFPA 70E-2012, Article 110.3(F) requires that an employer developed electrical safety program includes a hazard identification and risk evaluation procedure. This procedure is meant to be used before performing work on or near any equipment at or above 50 volts or any time work is being performed where an electrical hazard exists. This analysis presents only the results of an incident energy evaluation conducted in accordance with 130.5(B). The risk depends on a number of factors. These include the nature of the task being performed and the condition of the equipment. Selection of personal protective equipment (PPE) must be made based on the incident energy level that is presented in this report and a risk assessment to be made by the qualified person. NFPA 70E-2012, Article 130.7(A) requires that employees use and employers provide proper PPE for the tasks being performed. NFPA 70E-2012, Table H.3(b) provides guidance for the selection of PPE based on calculated incident energy exposure.

NFPA 70E-2012 and IEEE Std 1584-2002 provide equations and methods to accurately calculate the arc flash boundary and incident energy at specific locations within a facility's electrical system. Any location where work may be performed on or near energized electrical conductors and circuit parts is subject to the arc flash standards. PPE used to guard against arc flash hazard should be considered the last line of defense. It is also important to note that the use of PPE is not intended to prevent all injuries from an arc flash. The goal of determining PPE levels using the arc flash hazard approach is to identify the level of protection required to limit the injury to the onset of a second degree burn in the event of an arc flash while avoiding the use of more protection than is needed so as to minimize hazards of heat stress, reduced visibility and limited body movement.

Although the arc flash calculation procedure is based upon NFPA 70E and IEEE Std 1584-2002 equations and methods, it is a relatively new approach to determining the degree of required PPE. The calculations are derived from theory and research involving arc current incident energy measurements conducted under a specific set of controlled test conditions. Therefore, calculation results may be more severe or less severe than the hazard presented by an actual arc flash exposure. Also, the arc flash hazard calculations do not take into account hazards associated with the splattering of molten metal, explosively propelled pieces of equipment and air pressure shock waves.

The results of this arc flash hazard analysis are not intended to imply that personnel be permitted to work on exposed energized equipment or circuits. OSHA 1910.333 restricts the situations in which work is to be performed near or on energized equipment or circuits by stating, “Live parts to which an employee may be exposed shall be deenergized before the employee works on or near them, unless the employer can demonstrate that deenergizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations.”

Even if work is not being performed directly on energized equipment, it is important that the proper PPE be used during some load interruption actions, during visual verification of the state of disconnecting devices, and during lockout/tagout procedures.

5.2 Study Procedure

In accordance with NFPA 70E and IEEE Std 1584-2002, SKM Systems Analysis software provides the calculation of these values. The equations used in these calculations are based on actual test values. These tests measured the calories per square centimeter (cal/cm^2) radiating from a simulated arcing fault. The measurements were performed at a theorized working distance of 18 inches.

The intent of NFPA 70E and IEEE Std 1584-2002 guidelines is to establish standard calculations to determine an approach boundary that will prevent the onset of a second-degree burn to the face and the torso of the worker. An incident energy of 1.2 cal/cm^2 represents the onset of a second-degree burn.

NFPA 70E-2012, Article 130.7(A), Informational Note 3, states that greater consideration must be given to the decision to work within the limited approach boundary of energized electrical equipment when the incident energy exceeds 40 cal/cm^2. Locations with a calculated incident energy that exceeds 40 cal/cm^2 are shown in Table 5.2.

Before the arc flash equations can be applied, a comprehensive short-circuit and protective device coordination study must be completed to include all locations where work may be performed on or near energized components; e.g. motor control centers and power distribution panels. Since the short-circuit current must be calculated at every pertinent location and the clearing time of each location's upstream protective device is required, the arc flash circuit model is more detailed and extends deeper into the facility electrical distribution system than is typical of a basic short-circuit and protective device coordination study. Accurate fault currents and device clearing times are extremely important in deriving reliable results. A conservative (high) fault current value could yield a faster clearing time of a protective device, depending upon its curve shape, and the calculated incident energy may actually be less than the incident energy calculated for a lower magnitude of fault current and a longer clearing time.

1. Arc Flash Scenarios

Since the greatest arc flash hazards may not result from the highest fault current, multiple scenarios must be analyzed and compared. The following modes of operation have been evaluated in order to determine the worst-case incident energy at each location in the system. It is important to determine the available short-circuit current for modes of operation that provide both the maximum and minimum available short-circuit currents.

- Arc Flash Scenario 1 – 4th Avenue / Engineering Building system supplied from the Urban-Medical utility feed via Medium Voltage Switchgear B-EB-52-U1. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breakers BK-EB-52-G1 and BK-EB-52-U2 are open.
- Arc Flash Scenario 2 – 4th Avenue / Engineering Building system supplied from the Urban-Gibbs utility feed via Medium Voltage Switchgear B-EB-52-U2. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breakers BK-EB-52-G1 and BK-EB-52-U1 are open.
- Arc Flash Scenario 3 – 4th Avenue / Engineering Building system supplied from the Emergency Generator via Medium Voltage Switchgear B-EB-52-U3. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breakers BK-EB-52-U1 and BK-EB-52-U2 are open.
- Arc Flash Scenario 4 – 4th Avenue / Engineering Building system supplied from the Urban-Medical utility feed and Emergency Generator via Medium Voltage Switchgear B-EB-52-U1 and B-EB-52-U3. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breaker BK-EB-52-U2 is open.
- Arc Flash Scenario 5 – 4th Avenue / Engineering Building system supplied from the Urban-Gibbs utility feed and Emergency Generator via Medium Voltage Switchgear B-EB-52-U2 and B-EB-52-U3. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breaker BK-EB-52-U1 is open.

- Arc Flash Scenario 6 – 4th Avenue / Engineering Building system supplied from 50% of the maximum of the Urban-Medical utility feed via Medium Voltage Switchgear B-EB-52-U1. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breakers BK-EB-52-G1 and BK-EB-52-U2 are open.
- Arc Flash Scenario 7 – 4th Avenue / Engineering Building system supplied from 50% the maximum of the Urban-Gibbs utility feed via Medium Voltage Switchgear B-EB-52-U2. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breakers BK-EB-52-G1 and BK-EB-52-U1 are open.
- Arc Flash Scenario 8 – 4th Avenue / Engineering Building system supplied from 50% of the maximum of the Urban-Medical utility feed and Emergency Generator via Medium Voltage Switchgear B-EB-52-U1 and B-EB-52-U3. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breaker BK-EB-52-U2 is open.
- Arc Flash Scenario 9 – 4th Avenue / Engineering Building system supplied from 50% of the maximum of the Urban-Gibbs utility feed and Emergency Generator via Medium Voltage Switchgear B-EB-52-U2 and B-EB-52-U3. Tie breakers BK-EB-52-T1 and BK-EB-52-T2 are closed and the Main Breaker BK-EB-52-U1 is open.
- Arc Flash Scenario 10 – All locations other than the 4th Avenue / Engineering Building supplied with 50% of the utility maximum available fault current.

2. <u>Assumptions</u>

The following assumptions were used in performing the arc flash analysis and ensure conservative, worst-case results:

- The minimum available fault current at any location is equal to 50% of the fault current value provided by PGE.

For this arc flash hazard analysis of the Non-West Campus Loop at Portland State University, the circuit model included the service disconnects for all locations not supplied by the West Campus Loop. The analysis required energy and boundary calculations for approximately seventy-seven (77) locations.

5.3 Arc Flash Hazard Analysis Results

The incident energy associated with an arc flash is dependent upon the following parameters:

- The maximum “bolted fault” three-phase short-circuit current available at the equipment and the minimum fault level at which the arc will self-sustain.

- The total protective device clearing time (upstream of the prospective arc location) at the maximum short-circuit current and the minimum fault level at which the arc will self-sustain.
- The distance of the worker from the prospective arc for the task to be performed.

Table 5.3 is provided specifically at the request of Portland State Univeristy. It is their requirement that a second incident energy calculation be performed, with a greater working distance, for any location with an incident energy above 40 cal/cm^2. This is specifically to be used when a qualified person is performing non-contact voltage testing to ensure a piece of equipment is de-energized before performing work. All locations, not just those with an incident energy above 40 cal/cm^2, were included in Table 5.3 for reference.

The arc flash hazard analysis results shown in Table 5.1, Table 5.2, and Table 5.3 are based on a protective device clearing time that is capped at 2 seconds. This is based on IEEE Std 1584-2002 which states in Annex B, Instructions and Examples; *"If the time is longer than two seconds, consider how long a person is likely to remain in the location of the arc flash. It is likely that a person exposed to an arc flash will move away quickly if it is physically possible, and two seconds is a reasonable maximum time for calculations. A person in a bucket truck or a person who has crawled into equipment will need more time to move away."*

Two calculations are typically provided for labels on locations where there is adequate separation between the line side terminals of the main protective device, and the work location. The "Load Side" calculation provides the incident energy based on the main protective device clearing in the event of an arc flash incident. If the work location or task is such that the main breaker may not trip in the event of an arc flash incident, then the "Line Side" calculation for incident energy should be observed. This could occur if the main breaker is being racked-out, and a fault occurred on the line terminals. For this case, the next upstream device is the one that must clear the fault.

One should always remember that the terms "Line Side" and "Load Side" are always in reference to the main protective device (see example below).

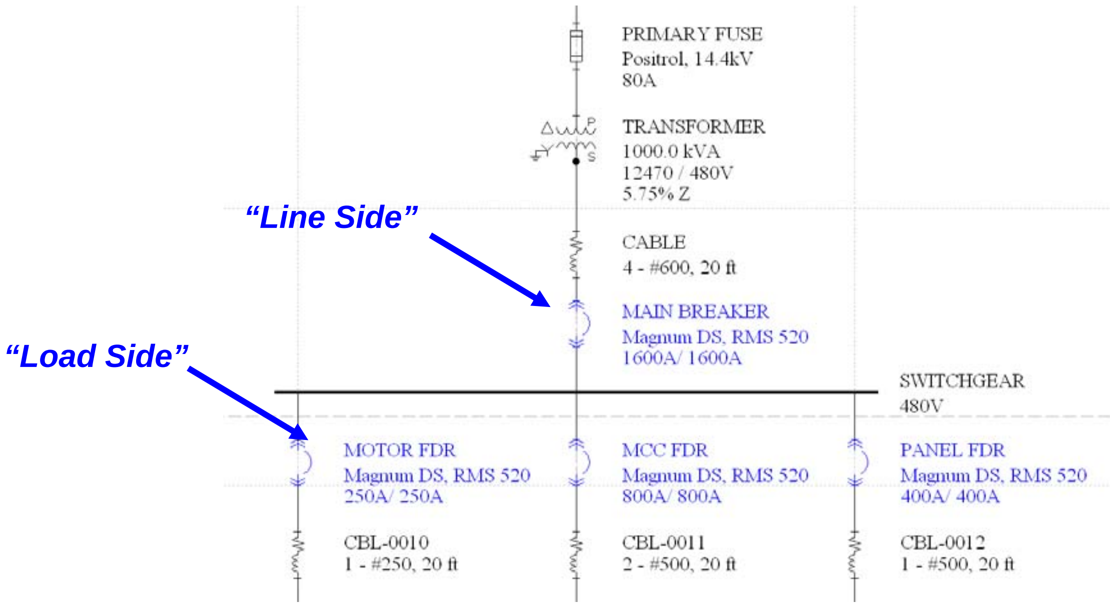


Figure 1: Line Side vs. Load Side

The fault current cannot easily be reduced nor can the working distance be easily increased to lessen the incident energy. In many locations the protective device setting can be adjusted or the trip unit upgraded to decrease the device interrupting time that will in turn decrease the incident energy. For a critical electrical distribution system, such as for Portland State University, it is essential that the system reliability not be compromised. Settings for protective devices cannot be adjusted if the chance of nuisance trips within critical circuits is introduced. *Each location where the hazard is determined to be unacceptable by Portland State University personnel must be individually evaluated to determine the most effective means of reducing the incident energy while maintaining the highest degree of reliability.*

All of the adjustable protective devices listed in Section 4 must be set per the recommended settings of this study to achieve the incident energy levels shown in Table 5.1, Table 5.2, and Table 5.3.

5.4 Arc Flash Summary Table Heading Descriptions

Table 5.1, Table 5.2, and Table 5.3 show results of the SKM PowerTools arc flash hazard analysis. The following column headings describe the results.

Column #1 - Bus Name: The names in this column correlate to the names implemented in the software system model (reference the one-lines included in Appendix D) These locations correspond to plant locations such as main switchboards, panelboards, enclosed breakers, etc.

Column #2 - Protective Device Name: This column lists the name of the device primarily responsible for clearing a potential fault at the associated bus. Again, these device names correlate to the system model.

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Column #3 - Bus Voltage (kV): The values in this column show the nominal voltage of the bus location noted in Column #1.

Column #4 - Bus Bolted Fault (kA): This column shows the bolted fault current available for the bus location referenced in Column #1. This current value corresponds to the system operating conditions that will result in the worst-case calculated value for incident energy. (See Column # 14.)

Column #5 - Prot Dev Bolted Fault (kA): This column displays the portion of calculated bolted fault currents (See Column #4) that is contributed through the protective device referenced in Column #2.

Column #6 - Prot Dev Arcing Fault (kA): This column displays the portion of calculated arcing fault currents that is contributed through the protective device referenced in Column #2. These values demonstrate a reduction in available fault current due to the arc resistance.

Column #7 - Trip/Delay Time (sec): This column displays the length of time required by the protective device (See Column #2) to trip in the presence of the arcing fault current calculated in Column #6. For low voltage breakers and fuses, this time represents the total clearing time of the device.

Column #8 - Breaker Opening Time (sec): For circuit breakers tripped by a relay, this column shows the opening time of the breaker. This time is added to the Trip time (See Column #7) to determine the total clearing time used in the calculation of incident energy. (See Column #14.)

Column #9 - Gnd: This column indicates whether the fault location includes a path to ground. Systems with high-resistance or low-resistance grounds are assumed to be ungrounded in the arc flash calculations.

Column #10 - Equip Type: This column indicates whether the equipment is Switchgear, Panel, Cable or Open Air. The equipment type provides a default Gap value, and a distance exponent used in the IEEE incident energy equations.

Column #11 – Gap (mm): This column displays the spacing between bus bars or conductors at the arc location.

Column #12 - Arc Flash Boundary: This column displays the distance within which a person must be clothed in the appropriate PPE (Personal Protection Equipment.) (See Column #14.)

Column #13 - Working Distance: This distance indicates the typical working distance associated with the system location referenced in Column #1.

Column #14 - Incident Energy (cal/cm^2): Based on the arcing fault current, the total clearing time of the protective device, the bus bar gap, the grounding method, and the typical working distance, the column displays the results of the arc flash calculations at the reference location. This energy level directly corresponds to the appropriate PPE required for each location. NFPA 70E-2012, Table H.3(b) provides guidance for the selection of PPE based on calculated incident energy exposure.

5.5 Arc Flash Hazard Analysis Recommendations

1) All of the adjustable protective devices listed in Section 4 must be set per the recommended settings to achieve the incident energy levels listed in Table 5.1, Table 5.2, and Table 5.3.
2) Each location where the arc flash hazard is unacceptable to Portland State University personnel should be individually evaluated to determine the most effective means of reducing the incident energy while maintaining the highest degree of reliability.

Table 5.1 – Arc Flash Analysis Summary Table

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm^2)
B-ARC-A-USB	F-ARC-UTIL-A	0.48	13.13	13.13	7.03	1.275	0.083	Yes	PNL	25	10' 10"	1' 6"	30.8
B-EB-52-U1	F-EB-UTIL-A	12.47	3.43	2.49	2.46	0.067	0.083	Yes	SWG	153	2' 3"	3'	0.9
B-EB-52-U2	F-EB-UTIL-B	12.47	3.43	2.49	2.46	0.067	0.083	Yes	SWG	153	2' 3"	3'	0.9
B-EB-52-U3	MaxTripTime @2.0s	12.47	0.95	0.95	0.95	2	0.000	Yes	SWG	153	5' 2"	3'	2.0
B-EB-USB-5	RLY-EB-52-G1	0.48	13.77	13.77	6.99	1.917	0.083	Yes	SWG	32	17' 3"	2'	28.6
B-MCB BSMT-USB	MaxTripTime @2.0s	0.48	8.00	8.00	5.42	2	0.000	Yes	PNL	25	11' 7"	1' 6"	34.2
B-NASC-USB	F-NASC-UTIL	0.208	15.56	15.56	5.93	2	0.000	Yes	PNL	25	12' 4"	1' 6"	37.8
B-PS3-USB	F-PS3-UTIL	0.208	16.29	16.29	6.13	1.917	0.083	Yes	PNL	25	12' 7"	1' 6"	39.1
B-SBH DISC A-USB	F-SBH-UTIL	0.240	9.36	9.36	4.35	1.917	0.083	No	PNL	25	11' 9"	1' 6"	35.1
B-SBH DISC B-USB	F-SBH-UTIL	0.240	9.36	9.36	4.35	1.917	0.083	No	PNL	25	11' 9"	1' 6"	35.1
B-UP-A-USB	F-UP-UTIL-A	0.48	28.02	28.02	13.44	0.35	0.083	Yes	PNL	25	8' 4"	1' 6"	19.8
B-URBN FP DISC-USB	F-URBN-UTIL-B	0.48	30.75	30.75	14.55	0.307	0.083	Yes	PNL	25	8' 2"	1' 6"	19.4
B-URBN SWBD-USB	F-URBN-UTIL-A	0.48	30.75	30.75	14.55	0.307	0.083	Yes	PNL	25	8' 2"	1' 6"	19.4
B-EB-FP DISC-USB	RLY-EB-52-F3B	0.48	1.90	1.90	1.58	1.917	0.083	Yes	PNL	25	5' 2"	1' 6"	9.1

Table 5.2 – Arc Flash Analysis Summary Table for Locations Greater Than 40 cal/cm^2

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm^2)
B-AB ANNEX DISC-USB	F-AB ANNEX-UTIL	0.208	27.20	27.20	8.78	1.917	0.083	Yes	PNL	25	15' 11"	1' 6"	57.7
B-AB DISC-USB	F-AB-UTIL-A	0.208	42.53	42.53	12.02	1.917	0.083	Yes	PNL	25	19' 7"	1' 6"	81.0
B-AB PNLBRD-USB	F-AB-UTIL-B	0.208	42.53	42.53	12.02	1.917	0.083	Yes	PNL	25	19' 7"	1' 6"	81.0
B-ARC-B-USB	F-ARC-UTIL-B	0.208	21.87	21.87	7.53	1.917	0.083	Yes	PNL	25	14' 5"	1' 6"	48.9
B-BHB MSB-A-USB	F-BHB-UTIL-A	0.48	16.05	16.05	8.35	1.917	0.083	Yes	PNL	25	15' 5"	1' 6"	54.6
B-BHB MSB-B-USB	F-BHB-UTIL-B	0.208	27.65	27.65	8.88	1.917	0.083	Yes	PNL	25	16'	1' 6"	58.4
B-BHB MSB-C-USB	F-BHB-UTIL-C	0.208	27.65	27.65	8.88	1.917	0.083	Yes	PNL	25	16'	1' 6"	58.4
B-BLKS K-USB	F-BLKS-UTIL	0.240	31.32	31.32	10.39	1.917	0.083	No	PNL	25	20' 10"	1' 6"	89.7
B-BLKS L1-USB	F-BLKS-UTIL	0.240	37.68	37.68	11.87	1.917	0.083	No	PNL	25	22' 9"	1' 6"	103.6
B-BLKS L2-USB	F-BLKS-UTIL	0.240	37.68	37.68	11.87	1.917	0.083	No	PNL	25	22' 9"	1' 6"	103.6
B-BLKS L3-USB	F-BLKS-UTIL	0.240	37.68	37.68	11.87	1.917	0.083	No	PNL	25	22' 9"	1' 6"	103.6
B-BLKS L4-USB	F-BLKS-UTIL	0.240	37.68	37.68	11.87	1.917	0.083	No	PNL	25	22' 9"	1' 6"	103.6
B-BLKS L5-USB	F-BLKS-UTIL	0.240	37.68	37.68	11.87	1.917	0.083	No	PNL	25	22' 9"	1' 6"	103.6
B-BLKS X-USB	F-BLKS-UTIL	0.240	27.94	27.94	9.57	1.917	0.083	No	PNL	25	19' 9"	1' 6"	82.1
B-EB-USB-1	RLY-EB-52-F1F	0.48	23.22	23.22	12.70	1.755	0.083	Yes	SWG	32	25' 3"	2'	50.2
B-EB-USB-2	RLY-EB-52-F2F	0.48	23.50	23.50	12.83	1.717	0.083	Yes	SWG	32	25' 1"	2'	49.7
B-EB-USB-3	RLY-EB-52-F1D	0.208	36.47	36.47	10.08	1.917	0.083	Yes	SWG	32	22' 7"	2'	42.5
B-EB-USB-6	RLY-EB-52-F1B	0.48	23.34	23.34	12.76	1.739	0.083	Yes	SWG	32	25' 3"	2'	50.0
B-EB-USB-7	RLY-EB-52-F2B	0.48	23.50	23.50	12.83	1.718	0.083	Yes	SWG	32	25' 1"	2'	49.7
B-EH A-USB	F-EH-UTIL	0.240	22.72	22.72	8.24	1.917	0.083	No	PNL	25	17' 11"	1' 6"	69.9
B-EH B-USB	F-EH-UTIL	0.240	22.72	22.72	8.24	1.917	0.083	No	PNL	25	17' 11"	1' 6"	69.9
B-EH C-USB	F-EH-UTIL	0.240	22.72	22.72	8.24	1.917	0.083	No	PNL	25	17' 11"	1' 6"	69.9
B-EH E DISC-USB	F-EH-UTIL	0.240	22.72	22.72	8.24	1.917	0.083	No	PNL	25	17' 11"	1' 6"	69.9
B-HGDC-USB	F-HGDC-UTIL	0.240	44.76	44.76	11.42	1.917	0.083	Yes	PNL	25	18' 11"	1' 6"	76.6
B-HH 1-USB	F-HH-UTIL	0.240	46.68	46.68	11.77	1.917	0.083	No	PNL	25	22' 8"	1' 6"	102.7

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm^2)
B-HH 2-USB	F-HH-UTIL	0.240	45.86	45.86	11.62	1.917	0.083	No	PNL	25	22' 5"	1' 6"	101.3
B-HOFF-USB	F-HOFF-UTIL	0.208	33.25	33.25	10.11	1.917	0.083	Yes	PNL	25	17' 6"	1' 6"	67.2
B-HSB-USB	F-HSB-UTIL	0.240	48.87	48.87	12.16	1.858	0.083	No	PNL	25	22' 9"	1' 6"	103.3
B-JCB-USB	F-JCB-UTIL	0.208	33.47	33.47	10.16	1.917	0.083	Yes	PNL	25	17' 6"	1' 6"	67.5
B-KHSE-USB	F-KHSE-UTIL	0.208	30.43	30.43	9.50	1.917	0.083	Yes	PNL	25	16' 9"	1' 6"	62.8
B-KNGA-USB	F-KNGA-UTIL	0.240	48.87	48.87	12.16	1.858	0.083	No	PNL	25	22' 9"	1' 6"	103.3
B-MCB PNTHS-USB	MaxTripTime @2.0s	0.48	32.03	32.03	17.73	2	0.000	Yes	PNL	25	25' 4"	1' 6"	123.3
B-MONT-USB	F-MONT-UTIL	0.240	38.00	38.00	11.94	1.917	0.083	No	PNL	25	22' 10"	1' 6"	104.3
B-OND 15 FLR-USB	F-OND-UTIL	0.240	21.35	21.35	7.88	1.917	0.083	No	PNL	25	17' 5"	1' 6"	66.6
B-OND ANNEX SWBD-USB	F-OND ANNEX-UTIL	0.208	38.17	38.17	11.14	1.917	0.083	Yes	PNL	25	18' 8"	1' 6"	74.6
B-OND MAIN SWBD-USB	F-OND-UTIL	0.48	15.96	15.96	8.31	1.917	0.083	Yes	PNL	25	15' 4"	1' 6"	54.4
B-PRKW L1-USB	F-PRKW-UTIL	0.240	37.80	37.80	11.89	1.917	0.083	No	PNL	25	22' 9"	1' 6"	103.9
B-PRKW L2-USB	F-PRKW-UTIL	0.240	37.80	37.80	11.89	1.917	0.083	No	PNL	25	22' 9"	1' 6"	103.9
B-PRKW L3-USB	F-PRKW-UTIL	0.240	37.80	37.80	11.89	1.917	0.083	No	PNL	25	22' 9"	1' 6"	103.9
B-PRKW L4-USB	F-PRKW-UTIL	0.240	37.80	37.80	11.89	1.917	0.083	No	PNL	25	22' 9"	1' 6"	103.9
B-PRKW L5-USB	F-PRKW-UTIL	0.240	37.80	37.80	11.89	1.917	0.083	No	PNL	25	22' 9"	1' 6"	103.9
B-PRKW X-USB	F-PRKW-UTIL	0.240	37.80	37.80	11.89	1.917	0.083	No	PNL	25	22' 9"	1' 6"	103.9
B-SBA-USB	F-SBA-UTIL	0.208	30.43	30.43	9.50	1.917	0.083	Yes	PNL	25	16' 9"	1' 6"	62.8
B-SEC NORTH ECB-USB	F-SEC NORTH-UTIL-B	0.240	40.61	40.61	12.52	1.917	0.083	No	PNL	25	23' 7"	1' 6"	109.8
B-SEC NORTH PNL-USB	F-SEC NORTH-UTIL-A	0.240	40.61	40.61	12.52	1.917	0.083	No	PNL	25	23' 7"	1' 6"	109.8
B-SEC SOUTH DISC 1A-USB	F-SEC SOUTH-UTIL-A	0.240	36.47	36.47	11.59	1.917	0.083	No	PNL	25	22' 5"	1' 6"	101.0
B-SEC SOUTH DISC 2A-USB	F-SEC SOUTH-UTIL-B	0.240	36.06	36.06	11.50	1.917	0.083	No	PNL	25	22' 3"	1' 6"	100.1
B-SEC SOUTH DISC 2B-USB	F-SEC SOUTH-UTIL-B	0.240	36.06	36.06	11.50	1.917	0.083	No	PNL	25	22' 3"	1' 6"	100.1
B-SEC SOUTH PNL 1B-USB	F-SEC SOUTH-UTIL-A	0.240	36.06	36.06	11.50	1.917	0.083	No	PNL	25	22' 3"	1' 6"	100.1
B-SEC SOUTH PNL 1C-USB	F-SEC SOUTH-UTIL-B	0.240	36.06	36.06	11.50	1.917	0.083	No	PNL	25	22' 3"	1' 6"	100.1
B-SEC SOUTH PNL 1D-USB	F-SEC SOUTH-UTIL-B	0.240	36.06	36.06	11.50	1.917	0.083	No	PNL	25	22' 3"	1' 6"	100.1
B-SEH-USB	F-SEH-UTIL	0.208	33.25	33.25	10.11	1.917	0.083	Yes	PNL	25	17' 6"	1' 6"	67.2

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm^2)
B-SH-USB	F-SH-UTIL	0.208	52.21	52.21	13.88	1.917	0.083	Yes	PNL	25	21' 6"	1' 6"	94.7
B-STFR-USB	F-STFR-UTIL	0.240	47.84	47.84	11.98	1.917	0.083	No	PNL	25	22' 11"	1' 6"	104.7
B-STHL L1-USB	F-STHL-UTIL	0.240	18.62	18.62	7.14	1.917	0.083	No	PNL	25	16' 3"	1' 6"	59.9
B-STHL L2-USB	F-STHL-UTIL	0.240	18.45	18.45	7.10	1.917	0.083	No	PNL	25	16' 3"	1' 6"	59.4
B-STHL L3-USB	F-STHL-UTIL	0.240	18.29	18.29	7.05	1.917	0.083	No	PNL	25	16' 2"	1' 6"	59.0
B-STHL L4-USB	F-STHL-UTIL	0.240	18.13	18.13	7.01	1.917	0.083	No	PNL	25	16'	1' 6"	58.6
B-STHL L5-USB	F-STHL-UTIL	0.240	17.97	17.97	6.96	1.917	0.083	No	PNL	25	16'	1' 6"	58.2
B-STHL X-USB	F-STHL-UTIL	0.240	17.81	17.81	6.92	1.917	0.083	No	PNL	25	15' 11"	1' 6"	57.8
B-UCB-USB	F-UCB-UTIL	0.208	31.92	31.92	9.83	1.917	0.083	Yes	PNL	25	17' 2"	1' 6"	65.2
B-UHP-USB	F-UHP-UTIL	0.240	15.55	15.55	6.27	1.917	0.083	No	PNL	25	14' 11"	1' 6"	52.0
B-UP-B-USB	F-UP UTIL-B	0.208	47.01	47.01	12.90	1.917	0.083	Yes	PNL	25	20' 6"	1' 6"	87.4

Table 5.3 – Arc Flash Analysis Summary Table for With Working Distance of 8’

Table 5.3 illustrates the arc-flash incident energy at a working distance of 8’. This is the approximate distance the face and body of a qualified person would be from energized equipment when performing a task with a 6’ hot stick. It is important to note that the incident energy values in this table are only applicable when the body and torso are 8’ or over from energized equipment. For arc-flash incident energies at standard working distances as defined by IEEE 1584-2002, please refer to Table 5.1 and Table 5.2.

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm^2)
B-AB ANNEX DISC-USB	F-AB ANNEX-UTIL	0.208	27.20	27.20	8.78	1.917	0.083	Yes	PNL	25	15' 11"	8'	3.7
B-AB DISC-USB	F-AB-UTIL-A	0.208	42.53	42.53	12.02	1.917	0.083	Yes	PNL	25	19' 7"	8'	5.2
B-AB PNLBRD-USB	F-AB-UTIL-B	0.208	42.53	42.53	12.02	1.917	0.083	Yes	PNL	25	19' 7"	8'	5.2
B-ARC-A-USB	F-ARC-UTIL-A	0.48	13.13	13.13	7.03	1.275	0.083	Yes	PNL	25	10' 10"	8'	2.0
B-ARC-B-USB	F-ARC-UTIL-B	0.208	21.87	21.87	7.53	1.917	0.083	Yes	PNL	25	14' 5"	8'	3.1
B-BHB MSB-A-USB	F-BHB-UTIL-A	0.48	16.05	16.05	8.35	1.917	0.083	Yes	PNL	25	15' 5"	8'	3.5
B-BHB MSB-B-USB	F-BHB-UTIL-B	0.208	27.65	27.65	8.88	1.917	0.083	Yes	PNL	25	16'	8'	3.8
B-BHB MSB-C-USB	F-BHB-UTIL-C	0.208	27.65	27.65	8.88	1.917	0.083	Yes	PNL	25	16'	8'	3.8
B-BLKS K-USB	F-BLKS-UTIL	0.240	31.32	31.32	10.39	1.917	0.083	No	PNL	25	20' 10"	8'	5.8
B-BLKS L1-USB	F-BLKS-UTIL	0.240	37.68	37.68	11.87	1.917	0.083	No	PNL	25	22' 9"	8'	6.6
B-BLKS L2-USB	F-BLKS-UTIL	0.240	37.68	37.68	11.87	1.917	0.083	No	PNL	25	22' 9"	8'	6.6
B-BLKS L3-USB	F-BLKS-UTIL	0.240	37.68	37.68	11.87	1.917	0.083	No	PNL	25	22' 9"	8'	6.6
B-BLKS L4-USB	F-BLKS-UTIL	0.240	37.68	37.68	11.87	1.917	0.083	No	PNL	25	22' 9"	8'	6.6
B-BLKS L5-USB	F-BLKS-UTIL	0.240	37.68	37.68	11.87	1.917	0.083	No	PNL	25	22' 9"	8'	6.6
B-BLKS X-USB	F-BLKS-UTIL	0.240	27.94	27.94	9.57	1.917	0.083	No	PNL	25	19' 9"	8'	5.3
B-EB-52-U1	F-EB-UTIL-A	12.47	3.43	2.49	2.46	0.067	0.083	Yes	SWG	153	2' 3"	8'	0.4
B-EB-52-U2	F-EB-UTIL-B	12.47	3.43	2.49	2.46	0.067	0.083	Yes	SWG	153	2' 3"	8'	0.4
B-EB-52-U3	MaxTripTime @2.0s	12.47	0.95	0.95	0.95	2	0.000	Yes	SWG	153	5' 2"	8'	0.8
B-EB-USB-1	RLY-EB-52-F1F	0.48	23.22	23.22	12.70	1.755	0.083	Yes	SWG	32	25' 3"	8'	6.5

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm^2)
B-EB-USB-2	RLY-EB-52-F2F	0.48	23.50	23.50	12.83	1.717	0.083	Yes	SWG	32	25' 1"	8'	6.4
B-EB-USB-3	RLY-EB-52-F1D	0.208	36.47	36.47	10.08	1.917	0.083	Yes	SWG	32	22' 7"	8'	5.5
B-EB-USB-5	RLY-EB-52-G1	0.48	13.77	13.77	6.99	1.917	0.083	Yes	SWG	32	17' 3"	8'	3.7
B-EB-USB-6	RLY-EB-52-F1B	0.48	23.34	23.34	12.76	1.739	0.083	Yes	SWG	32	25' 3"	8'	6.5
B-EB-USB-7	RLY-EB-52-F2B	0.48	23.50	23.50	12.83	1.718	0.083	Yes	SWG	32	25' 1"	8'	6.5
B-EH A-USB	F-EH-UTIL	0.240	22.72	22.72	8.24	1.917	0.083	No	PNL	25	17' 11"	8'	4.5
B-EH B-USB	F-EH-UTIL	0.240	22.72	22.72	8.24	1.917	0.083	No	PNL	25	17' 11"	8'	4.5
B-EH C-USB	F-EH-UTIL	0.240	22.72	22.72	8.24	1.917	0.083	No	PNL	25	17' 11"	8'	4.5
B-EH E DISC-USB	F-EH-UTIL	0.240	22.72	22.72	8.24	1.917	0.083	No	PNL	25	17' 11"	8'	4.5
B-HGDC-USB	F-HGDC-UTIL	0.240	44.76	44.76	11.42	1.917	0.083	Yes	PNL	25	18' 11"	8'	4.9
B-HH 1-USB	F-HH-UTIL	0.240	46.68	46.68	11.77	1.917	0.083	No	PNL	25	22' 8"	8'	6.6
B-HH 2-USB	F-HH-UTIL	0.240	45.86	45.86	11.62	1.917	0.083	No	PNL	25	22' 5"	8'	6.5
B-HOFF-USB	F-HOFF-UTIL	0.208	33.25	33.25	10.11	1.917	0.083	Yes	PNL	25	17' 6"	8'	4.3
B-HSB-USB	F-HSB-UTIL	0.240	48.87	48.87	12.16	1.858	0.083	No	PNL	25	22' 9"	8'	6.6
B-JCB-USB	F-JCB-UTIL	0.208	33.47	33.47	10.16	1.917	0.083	Yes	PNL	25	17' 6"	8'	4.3
B-KHSE-USB	F-KHSE-UTIL	0.208	30.43	30.43	9.50	1.917	0.083	Yes	PNL	25	16' 9"	8'	4.0
B-KNGA-USB	F-KNGA-UTIL	0.240	48.87	48.87	12.16	1.858	0.083	No	PNL	25	22' 9"	8'	6.6
B-MCB BSMT-USB	MaxTripTime @2.0s	0.48	8.00	8.00	5.42	2	0.000	Yes	PNL	25	11' 7"	8'	2.2
B-MCB PNTHS-USB	MaxTripTime @2.0s	0.48	32.03	32.03	17.73	2	0.000	Yes	PNL	25	25' 4"	8'	7.9
B-MONT-USB	F-MONT-UTIL	0.240	38.00	38.00	11.94	1.917	0.083	No	PNL	25	22' 10"	8'	6.7
B-NASC-USB	F-NASC-UTIL	0.208	15.56	15.56	5.93	2	0.000	Yes	PNL	25	12' 4"	8'	2.4
B-OND 15 FLR-USB	F-OND-UTIL	0.240	21.35	21.35	7.88	1.917	0.083	No	PNL	25	17' 5"	8'	4.3
B-OND ANNEX SWBD-USB	F-OND ANNEX-UTIL	0.208	38.17	38.17	11.14	1.917	0.083	Yes	PNL	25	18' 8"	8'	4.8
B-OND MAIN SWBD-USB	F-OND-UTIL	0.48	15.96	15.96	8.31	1.917	0.083	Yes	PNL	25	15' 4"	8'	3.5
B-PRKW L1-USB	F-PRKW-UTIL	0.240	37.80	37.80	11.89	1.917	0.083	No	PNL	25	22' 9"	8'	6.7
B-PRKW L2-USB	F-PRKW-UTIL	0.240	37.80	37.80	11.89	1.917	0.083	No	PNL	25	22' 9"	8'	6.7
B-PRKW L3-USB	F-PRKW-UTIL	0.240	37.80	37.80	11.89	1.917	0.083	No	PNL	25	22' 9"	8'	6.7

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm^2)
B-PRKW L4-USB	F-PRKW-UTIL	0.240	37.80	37.80	11.89	1.917	0.083	No	PNL	25	22' 9"	8'	6.7
B-PRKW L5-USB	F-PRKW-UTIL	0.240	37.80	37.80	11.89	1.917	0.083	No	PNL	25	22' 9"	8'	6.7
B-PRKW X-USB	F-PRKW-UTIL	0.240	37.80	37.80	11.89	1.917	0.083	No	PNL	25	22' 9"	8'	6.7
B-PS3-USB	F-PS3-UTIL	0.208	16.29	16.29	6.13	1.917	0.083	Yes	PNL	25	12' 7"	8'	2.5
B-SBA-USB	F-SBA-UTIL	0.208	30.43	30.43	9.50	1.917	0.083	Yes	PNL	25	16' 9"	8'	4.0
B-SBH DISC A-USB	F-SBH-UTIL	0.240	9.36	9.36	4.35	1.917	0.083	No	PNL	25	11' 9"	8'	2.3
B-SBH DISC B-USB	F-SBH-UTIL	0.240	9.36	9.36	4.35	1.917	0.083	No	PNL	25	11' 9"	8'	2.3
B-SEC NORTH ECB-USB	F-SEC NORTH-UTIL-B	0.240	40.61	40.61	12.52	1.917	0.083	No	PNL	25	23' 7"	8'	7.0
B-SEC NORTH PNL-USB	F-SEC NORTH-UTIL-A	0.240	40.61	40.61	12.52	1.917	0.083	No	PNL	25	23' 7"	8'	7.0
B-SEC SOUTH DISC 1A-USB	F-SEC SOUTH-UTIL-A	0.240	36.47	36.47	11.59	1.917	0.083	No	PNL	25	22' 5"	8'	6.5
B-SEC SOUTH DISC 2A-USB	F-SEC SOUTH-UTIL-B	0.240	36.06	36.06	11.50	1.917	0.083	No	PNL	25	22' 3"	8'	6.4
B-SEC SOUTH DISC 2B-USB	F-SEC SOUTH-UTIL-B	0.240	36.06	36.06	11.50	1.917	0.083	No	PNL	25	22' 3"	8'	6.4
B-SEC SOUTH PNL 1B-USB	F-SEC SOUTH-UTIL-A	0.240	36.06	36.06	11.50	1.917	0.083	No	PNL	25	22' 3"	8'	6.4
B-SEC SOUTH PNL 1C-USB	F-SEC SOUTH-UTIL-B	0.240	36.06	36.06	11.50	1.917	0.083	No	PNL	25	22' 3"	8'	6.4
B-SEC SOUTH PNL 1D-USB	F-SEC SOUTH-UTIL-B	0.240	36.06	36.06	11.50	1.917	0.083	No	PNL	25	22' 3"	8'	6.4
B-SEH-USB	F-SEH-UTIL	0.208	33.25	33.25	10.11	1.917	0.083	Yes	PNL	25	17' 6"	8'	4.3
B-SH-USB	F-SH-UTIL	0.208	52.21	52.21	13.88	1.917	0.083	Yes	PNL	25	21' 6"	8'	6.1
B-STFR-USB	F-STFR-UTIL	0.240	47.84	47.84	11.98	1.917	0.083	No	PNL	25	22' 11"	8'	6.7
B-STHL L1-USB	F-STHL-UTIL	0.240	18.62	18.62	7.14	1.917	0.083	No	PNL	25	16' 3"	8'	3.8
B-STHL L2-USB	F-STHL-UTIL	0.240	18.45	18.45	7.10	1.917	0.083	No	PNL	25	16' 3"	8'	3.8
B-STHL L3-USB	F-STHL-UTIL	0.240	18.29	18.29	7.05	1.917	0.083	No	PNL	25	16' 2"	8'	3.8
B-STHL L4-USB	F-STHL-UTIL	0.240	18.13	18.13	7.01	1.917	0.083	No	PNL	25	16'	8'	3.8
B-STHL L5-USB	F-STHL-UTIL	0.240	17.97	17.97	6.96	1.917	0.083	No	PNL	25	16'	8'	3.7
B-STHL X-USB	F-STHL-UTIL	0.240	17.81	17.81	6.92	1.917	0.083	No	PNL	25	15' 11"	8'	3.7
B-UCB-USB	F-UCB-UTIL	0.208	31.92	31.92	9.83	1.917	0.083	Yes	PNL	25	17' 2"	8'	4.2
B-UHP-USB	F-UHP-UTIL	0.240	15.55	15.55	6.27	1.917	0.083	No	PNL	25	14' 11"	8'	3.3
B-UP-A-USB	F-UP-UTIL-A	0.48	28.02	28.02	13.44	0.35	0.083	Yes	PNL	25	8' 4"	8'	1.3

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm^2)
B-UP-B-USB	F-UP UTIL-B	0.208	47.01	47.01	12.90	1.917	0.083	Yes	PNL	25	20' 6"	8'	5.6
B-URBN FP DISC-USB	F-URBN-UTIL-B	0.48	30.75	30.75	14.55	0.307	0.083	Yes	PNL	25	8' 2"	8'	1.3
B-URBN SWBD-USB	F-URBN-UTIL-A	0.48	30.75	30.75	14.55	0.307	0.083	Yes	PNL	25	8' 2"	8'	1.3
B-EB-FP DISC-USB	RLY-EB-52-F3B	0.48	1.90	1.90	1.58	1.917	0.083	Yes	PNL	25	5' 2"	8'	0.6

A. APPENDIX A – SHORT-CIRCUIT INPUT REPORT

Input Report Interpretation

Input Data Tables are provided on the following pages. The following is a guide for interpreting the input data.

1. Generation Contribution Data

- Utility contribution data includes the available fault current in MVA and amps, per unit impedance on a 100 MVA base, X/R, and the line-to-line bus voltage.
- Generator data includes the generator kW rating, X"d, X/R, line-to-line voltage and per unit impedance on a 100 MVA base.

2. Motor Contribution Data

Motor Contribution Data includes the horsepower rating (base kVA rating), speed, subtransient reactance adjusted per the *First Cycle Duty* multipliers described in IEEE Std 141-1993 (Red Book), per-unit impedance on a 100 MVA base, and the bus voltage. X/R ratios for induction motors are obtained from IEEE Std C37.010-1999.

3. Feeder Data

Feeder data includes the following cable and bus data: length, impedance in ohms per 1,000 feet, and per-unit impedance on a 100 MVA base. Impedance values for conductors were obtained from Tables 4A-7 and 4A-8 of IEEE Std 141-1993 (Red Book). The impedance values are based on conductor temperatures of 75°C for Copper and 90°C for Aluminum.

4. Transformer Data

Transformer data includes the transformer kVA rating and per-unit impedance on a 100 MVA base. Unless otherwise provided, transformer X/R ratios are obtained from IEEE Std C37.010-1999.

Short-Circuit Input Report

```
PSU - Non-West Campus Loop
Portland, OR
ESE0008355 / TQSISE0008355.1
Feb 21, 2013     17:45:50                                              Page 1
-----------------------------------------------------------------------------
 ALL INFORMATION PRESENTED IS FOR REVIEW, APPROVAL
 INTERPRETATION AND APPLICATION BY A REGISTERED ENGINEER ONLY
 SKM DISCLAIMS ANY RESPONSIBILITY AND LIABILITY RESULTING
 FROM THE USE AND INTERPRETATION OF THIS SOFTWARE.
 -----------------------------------------------------------------------------
 SKM POWER*TOOLS FOR WINDOWS
 INPUT DATA REPORT
 COPYRIGHT SKM SYSTEMS ANALYSIS, INC. 1995-2013
-----------------------------------------------------------------------------
 ALL PU VALUES ARE EXPRESSED ON A 100 MVA BASE.
```

FEEDER INPUT DATA

```
==============================================================================================================================================
CABLE                          FEEDER FROM                      FEEDER TO                         QTY  VOLTS   LENGTH           FEEDER
NAME                           NAME                             NAME                              /PH  L-L                   SIZE      TYPE
==============================================================================================================================================
BWY-ARC-B-USB-B2-USB           B-ARC-B-USB                      B-ARC-B2-USB                      1    208  1.000  FEET    2000     Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0066 + J  0.0035  Ohms/1000 ft      0.0153 + J  0.0081  PU
              Z0   Impedance: 0.0392 + J  0.0187  Ohms/1000 ft      0.0906 + J  0.0432  PU

BWY-BHB MSB-A                  B-BHB MSB-A-USB                  B-BHB MSB-A SWBD-USB              1    480    5.0  FEET    2500     Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0055 + J  0.0031  Ohms/1000 ft      0.0119 + J  0.0067  PU
              Z0   Impedance: 0.1375 + J  0.0775  Ohms/1000 ft      0.2984 + J  0.1682  PU

C-BLKS JUNC-BLKS K             B-BLKS JUNC                      B-BLKS K-USB                      1    240    8.0  FEET       2     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.2020 + J  0.0467  Ohms/1000 ft        2.81 + J  0.6486  PU
              Z0   Impedance: 0.3211 + J  0.1188  Ohms/1000 ft        4.46 + J    1.65  PU

C-BLKS JUNC-BLKS L1            B-BLKS JUNC                      B-BLKS L1-USB                     1    240    5.0  FEET     3/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft      0.6649 + J  0.3602  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        1.06 + J  0.9158  PU

C-BLKS JUNC-BLKS L2            B-BLKS JUNC                      B-BLKS L2-USB                     1    240    5.0  FEET     3/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft      0.6649 + J  0.3602  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        1.06 + J  0.9158  PU

C-BLKS JUNC-BLKS L3            B-BLKS JUNC                      B-BLKS L3-USB                     1    240    5.0  FEET     3/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft      0.6649 + J  0.3602  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        1.06 + J  0.9158  PU

C-BLKS JUNC-BLKS L4            B-BLKS JUNC                      B-BLKS L4-USB                     1    240    5.0  FEET     3/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft      0.6649 + J  0.3602  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        1.06 + J  0.9158  PU

C-BLKS JUNC-BLKS L5            B-BLKS JUNC                      B-BLKS L5-USB                     1    240    5.0  FEET     3/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft      0.6649 + J  0.3602  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        1.06 + J  0.9158  PU

C-BLKS JUNC-BLKS X             B-BLKS JUNC                      B-BLKS X-USB                      1    240    5.0  FEET       6     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.5100 + J  0.0548  Ohms/1000 ft        4.43 + J  0.4757  PU
              Z0   Impedance: 0.8123 + J  0.1394  Ohms/1000 ft        7.05 + J    1.21  PU
```

FEEDER INPUT DATA

```
===================================================================================================================================================
CABLE                          FEEDER FROM                     FEEDER TO                       QTY  VOLTS   LENGTH           FEEDER
NAME                           NAME                            NAME                            /PH  L-L                     SIZE       TYPE
===================================================================================================================================================
C-EB-52-U1-TX-USB-1            B-EB-52-U1                      TX-EB-USB-1 P                   1  12470   80.0  FEET    1/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0066 + J  0.0026  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0105 + J  0.0066  PU

C-EB-52-U1-TX-USB-3            B-EB-52-U1                      TX-EB-USB-3 P                   1  12470   75.0  FEET    1/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0062 + J  0.0024  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0098 + J  0.0062  PU

C-EB-52-U1-TX-USB-6            B-EB-52-U1                      TX-EB-USB-6 P                   1  12470   90.0  FEET    1/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0074 + J  0.0029  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0118 + J  0.0075  PU

C-EB-52-U2-TX-USB-2            B-EB-52-U2                      TX-EB-USB-2 P                   1  12470   20.0  FEET    1/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0016 + J 0.00065  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0026 + J  0.0017  PU

C-EB-52-U2-TX-USB-5            B-EB-52-U2                      TX-EB-USB-5 P                   1  12470  180.0  FEET    1/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0148 + J  0.0059  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0236 + J  0.0149  PU

C-EB-52-U2-TX-USB-7            B-EB-52-U2                      TX-EB-USB-7 P                   1  12470   50.0  FEET    1/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0041 + J  0.0016  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0065 + J  0.0041  PU

BWY-EB-52-U3-52-U1             B-EB-52-U3                      B-EB-52-U1                      1  12470   25.0  FEET   1200     Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0119 + J  0.0619  Ohms/1000 ft     0.00019 + J 0.00100  PU
              Z0   Impedance: 0.0710 + J  0.3314  Ohms/1000 ft      0.0011 + J  0.0053  PU

BWY-EB-52-U3-52-U2             B-EB-52-U3                      B-EB-52-U2                      1  12470   25.0  FEET   1200     Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0119 + J  0.0619  Ohms/1000 ft     0.00019 + J 0.00100  PU
              Z0   Impedance: 0.0710 + J  0.3314  Ohms/1000 ft      0.0011 + J  0.0053  PU

C-EB-52-U3-TX-FP               B-EB-52-U3                      TX-EB-FIRE PUMP P               1  12470   25.0  FEET      2     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.2020 + J  0.0547  Ohms/1000 ft      0.0032 + J 0.00088  PU
              Z0   Impedance: 0.3211 + J  0.1392  Ohms/1000 ft      0.0052 + J  0.0022  PU
```

```
                                          FEEDER  INPUT  DATA
===========================================================================================================================================
CABLE                         FEEDER FROM                     FEEDER TO                        QTY  VOLTS   LENGTH            FEEDER
NAME                          NAME                            NAME                             /PH  L-L                   SIZE       TYPE
===========================================================================================================================================
BWY-EB-GEN-USB-8              G-EB BUS                        USB-8 P                          1   4160  150.0  FEET    1200      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0119 + J  0.0619  Ohms/1000 ft      0.0103 + J  0.0537  PU
              Z0   Impedance: 0.0710 + J  0.3314  Ohms/1000 ft      0.0615 + J  0.2872  PU

C-EB-TX-FP-FP DISC            TX-EB-FIRE PUMP S               B-EB-FP DISC-USB                 1    480   20.0  FEET       2      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.2020 + J  0.0467  Ohms/1000 ft        1.75 + J  0.4054  PU
              Z0   Impedance: 0.3211 + J  0.1188  Ohms/1000 ft        2.79 + J    1.03  PU

BWY-EB-TX-USB-2-USB-2         TX-EB-USB-2 S                   B-EB-USB-2                       1    480    3.0  FEET    4000      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0033 + J  0.0019  Ohms/1000 ft      0.0043 + J  0.0025  PU
              Z0   Impedance: 0.0196 + J  0.0101  Ohms/1000 ft      0.0255 + J  0.0132  PU

BWY-EB-TX-USB-3-USB-3         TX-EB-USB-3 S                   B-EB-USB-3                       1    208    3.0  FEET    4000      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0033 + J  0.0019  Ohms/1000 ft      0.0229 + J  0.0132  PU
              Z0   Impedance: 0.0196 + J  0.0101  Ohms/1000 ft      0.1359 + J  0.0700  PU

BWY-EB-TX-USB-5-USB-5         TX-EB-USB-5 S                   B-EB-USB-5                       1    480    3.0  FEET    4000      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0033 + J  0.0019  Ohms/1000 ft      0.0043 + J  0.0025  PU
              Z0   Impedance: 0.0196 + J  0.0101  Ohms/1000 ft      0.0255 + J  0.0132  PU

BWY-EB-TX-USB-7-USB-7         TX-EB-USB-7 S                   B-EB-USB-7                       1    480    3.0  FEET    4000      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0033 + J  0.0019  Ohms/1000 ft      0.0043 + J  0.0025  PU
              Z0   Impedance: 0.0196 + J  0.0101  Ohms/1000 ft      0.0255 + J  0.0132  PU

BWY-EB-USB-1-USB-2            B-EB-USB-1                      B-EB-USB-2                       1    480    3.0  FEET    3200      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0047 + J  0.0026  Ohms/1000 ft      0.0061 + J  0.0034  PU
              Z0   Impedance: 0.1175 + J  0.0650  Ohms/1000 ft      0.1530 + J  0.0846  PU

BWY-EB-USB-6-USB-7            B-EB-USB-6                      B-EB-USB-7                       1    480    3.0  FEET    3200      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0047 + J  0.0026  Ohms/1000 ft      0.0061 + J  0.0034  PU
              Z0   Impedance: 0.1175 + J  0.0650  Ohms/1000 ft      0.1530 + J  0.0846  PU

C-EB-USB-8-52-U3              USB-8 S                         B-EB-52-U3                       1  12470   90.0  FEET     1/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0074 + J  0.0029  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0118 + J  0.0075  PU
```

FEEDER INPUT DATA

```
==============================================================================================================================================
CABLE                         FEEDER FROM                     FEEDER TO                       QTY  VOLTS   LENGTH            FEEDER
NAME                          NAME                            NAME                            /PH  L-L                     SIZE       TYPE
==============================================================================================================================================
C-EH JUNC-EH A                B-EH JUNC                       B-EH A-USB                       1   240    15.0  FEET     3/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft        1.99 + J    1.08  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        3.17 + J    2.75  PU

C-EH JUNC-EH B                B-EH JUNC                       B-EH B-USB                       1   240    15.0  FEET     3/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft        1.99 + J    1.08  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        3.17 + J    2.75  PU

C-EH JUNC-EH C                B-EH JUNC                       B-EH C-USB                       1   240    15.0  FEET     3/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft        1.99 + J    1.08  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        3.17 + J    2.75  PU

C-EH JUNC-EH DISC             B-EH JUNC                       B-EH E DISC-USB                  1   240    15.0  FEET     3/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft        1.99 + J    1.08  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        3.17 + J    2.75  PU

C-HH 1-HH 2                   B-HH JUNC                       B-HH 2-USB                       1   240     3.0  FEET       2      Copper
              Duct Material:    Magnetic
              +/-  Impedance: 0.2020 + J  0.0585  Ohms/1000 ft        1.05 + J  0.3047  PU
              Z0   Impedance: 0.6366 + J  0.1440  Ohms/1000 ft        3.32 + J  0.7500  PU

C-HH JUNC-HH 1                B-HH JUNC                       B-HH 1-USB                       1   240   1.000  FEET     3/0      Copper
              Duct Material:    Magnetic
              +/-  Impedance: 0.0805 + J  0.0519  Ohms/1000 ft      0.1398 + J  0.0901  PU
              Z0   Impedance: 0.2537 + J  0.1278  Ohms/1000 ft      0.4405 + J  0.2219  PU

BWY-MCB-UTIL-A-PNTHS USB      TX-MCB UTIL-A S                 B-MCB PNTHS-USB                  1   480    50.0  FEET    2000      Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0076 + J  0.0039  Ohms/1000 ft      0.1649 + J  0.0846  PU
              Z0   Impedance: 0.1900 + J  0.0975  Ohms/1000 ft        4.12 + J    2.12  PU

BWY-MCB-UTIL-B-PNTHS USB      TX-MCB UTIL-B S                 B-MCB PNTHS-USB                  1   480    50.0  FEET    2000      Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0076 + J  0.0039  Ohms/1000 ft      0.1649 + J  0.0846  PU
              Z0   Impedance: 0.1900 + J  0.0975  Ohms/1000 ft        4.12 + J    2.12  PU

BWY-MCB-UTIL-BSMT-USB         TX-MCB BSMT UTIL S              B-MCB BSMT-USB                   1   480    15.0  FEET    2000      Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0076 + J  0.0039  Ohms/1000 ft      0.0495 + J  0.0254  PU
              Z0   Impedance: 0.1900 + J  0.0975  Ohms/1000 ft        1.24 + J  0.6348  PU
```

```
                                          FEEDER  INPUT  DATA
===================================================================================================================================================
CABLE                         FEEDER FROM                      FEEDER TO                        QTY  VOLTS   LENGTH              FEEDER
NAME                          NAME                             NAME                             /PH  L-L                      SIZE        TYPE
===================================================================================================================================================
C-PRKW JUNC-PRKW L1           PRKW JUNC                        B-PRKW L1-USB                     1   240   10.0  FEET     3/0      Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0805 + J  0.0519  Ohms/1000 ft        1.40 + J  0.9010  PU
              Z0   Impedance: 0.2537 + J  0.1278  Ohms/1000 ft        4.40 + J    2.22  PU

C-PRKW JUNC-PRKW L2           PRKW JUNC                        B-PRKW L2-USB                     1   240   10.0  FEET     3/0      Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0805 + J  0.0519  Ohms/1000 ft        1.40 + J  0.9010  PU
              Z0   Impedance: 0.2537 + J  0.1278  Ohms/1000 ft        4.40 + J    2.22  PU

C-PRKW JUNC-PRKW L3           PRKW JUNC                        B-PRKW L3-USB                     1   240   10.0  FEET     3/0      Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0805 + J  0.0519  Ohms/1000 ft        1.40 + J  0.9010  PU
              Z0   Impedance: 0.2537 + J  0.1278  Ohms/1000 ft        4.40 + J    2.22  PU

C-PRKW JUNC-PRKW L4           PRKW JUNC                        B-PRKW L4-USB                     1   240   10.0  FEET     3/0      Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0805 + J  0.0519  Ohms/1000 ft        1.40 + J  0.9010  PU
              Z0   Impedance: 0.2537 + J  0.1278  Ohms/1000 ft        4.40 + J    2.22  PU

C-PRKW JUNC-PRKW L5           PRKW JUNC                        B-PRKW L5-USB                     1   240   10.0  FEET     3/0      Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0805 + J  0.0519  Ohms/1000 ft        1.40 + J  0.9010  PU
              Z0   Impedance: 0.2537 + J  0.1278  Ohms/1000 ft        4.40 + J    2.22  PU

C-PRKW JUNC-PRKW LX           PRKW JUNC                        B-PRKW X-USB                      1   240   10.0  FEET     3/0      Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0805 + J  0.0519  Ohms/1000 ft        1.40 + J  0.9010  PU
              Z0   Impedance: 0.2537 + J  0.1278  Ohms/1000 ft        4.40 + J    2.22  PU

C-SBH JUNC-SBH A              B-SBH JUNC                       B-SBH DISC A-USB                  1   240    6.0  FEET     3/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft      0.7979 + J  0.4323  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        1.27 + J    1.10  PU

C-SBH JUNC-SBH B              B-SBH JUNC                       B-SBH DISC B-USB                  1   240    6.0  FEET     3/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft      0.7979 + J  0.4323  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        1.27 + J    1.10  PU

C-SEC JUNC-SEC 1A             B-SEC SOUTH-A JUNC               B-SEC SOUTH DISC 1A-USB           1   240    6.0  FEET     4/0      Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0640 + J  0.0497  Ohms/1000 ft      0.6667 + J  0.5177  PU
              Z0   Impedance: 0.2017 + J  0.1224  Ohms/1000 ft        2.10 + J    1.28  PU
```

```
                                          FEEDER  INPUT  DATA
=========================================================================================================================================
CABLE                         FEEDER FROM                     FEEDER TO                        QTY  VOLTS   LENGTH            FEEDER
NAME                          NAME                            NAME                             /PH  L-L                   SIZE       TYPE
=========================================================================================================================================
C-SEC JUNC-SEC 1B             B-SEC SOUTH-A JUNC              B-SEC SOUTH PNL 1B-USB            1    240    6.0  FEET     3/0     Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0805 + J  0.0519  Ohms/1000 ft      0.8385 + J  0.5406  PU
              Z0   Impedance: 0.2537 + J  0.1278  Ohms/1000 ft        2.64 + J    1.33  PU

C-SEC JUNC-SEC 1C             B-SEC SOUTH-B JUNC              B-SEC SOUTH PNL 1C-USB            1    240    6.0  FEET     3/0     Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0805 + J  0.0519  Ohms/1000 ft      0.8385 + J  0.5406  PU
              Z0   Impedance: 0.2537 + J  0.1278  Ohms/1000 ft        2.64 + J    1.33  PU

C-SEC JUNC-SEC 1D             B-SEC SOUTH-B JUNC              B-SEC SOUTH PNL 1D-USB            1    240    6.0  FEET     3/0     Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0805 + J  0.0519  Ohms/1000 ft      0.8385 + J  0.5406  PU
              Z0   Impedance: 0.2537 + J  0.1278  Ohms/1000 ft        2.64 + J    1.33  PU

C-SEC JUNC-SEC 2A             B-SEC SOUTH-B JUNC              B-SEC SOUTH DISC 2A-USB           1    240    6.0  FEET     3/0     Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0805 + J  0.0519  Ohms/1000 ft      0.8385 + J  0.5406  PU
              Z0   Impedance: 0.2537 + J  0.1278  Ohms/1000 ft        2.64 + J    1.33  PU

C-SEC JUNC-SEC 2B             B-SEC SOUTH-B JUNC              B-SEC SOUTH DISC 2B-USB           1    240    6.0  FEET     3/0     Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0805 + J  0.0519  Ohms/1000 ft      0.8385 + J  0.5406  PU
              Z0   Impedance: 0.2537 + J  0.1278  Ohms/1000 ft        2.64 + J    1.33  PU

C-STHL JUNC-STHL L1           B-STHL JUNC                     B-STHL L1-USB                     1    240    4.0  FEET     3/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft      0.5319 + J  0.2882  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft      0.8451 + J  0.7326  PU

C-STHL JUNC-STHL L2           B-STHL JUNC                     B-STHL L2-USB                     1    240    5.0  FEET     3/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft      0.6649 + J  0.3602  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        1.06 + J  0.9158  PU

C-STHL JUNC-STHL L3           B-STHL JUNC                     B-STHL L3-USB                     1    240    6.0  FEET     3/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft      0.7979 + J  0.4323  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        1.27 + J    1.10  PU

C-STHL JUNC-STHL L4           B-STHL JUNC                     B-STHL L4-USB                     1    240    7.0  FEET     3/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft      0.9309 + J  0.5043  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        1.48 + J    1.28  PU
```

FEEDER INPUT DATA

```
==========================================================================================================================================
CABLE                         FEEDER FROM                     FEEDER TO                        QTY  VOLTS   LENGTH           FEEDER
NAME                          NAME                            NAME                             /PH  L-L                  SIZE       TYPE
==========================================================================================================================================
C-STHL JUNC-STHL L5           B-STHL JUNC                     B-STHL L5-USB                    1    240    8.0  FEET     3/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft        1.06 + J  0.5764  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        1.69 + J    1.47  PU

C-STHL JUNC-STHL X            B-STHL JUNC                     B-STHL X-USB                     1    240    9.0  FEET     3/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0766 + J  0.0415  Ohms/1000 ft        1.20 + J  0.6484  PU
              Z0   Impedance: 0.1217 + J  0.1055  Ohms/1000 ft        1.90 + J    1.65  PU

BWY-UTIL-BK-EB-52-U2          EB-UTIL-B BUS                   B-EB-52-U2                       1  12470    3.0  FEET    1200      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0119 + J  0.0619  Ohms/1000 ft     0.00002 + J 0.00012  PU
              Z0   Impedance: 0.0710 + J  0.3314  Ohms/1000 ft     0.00014 + J 0.00064  PU
```

TRANSFORMER INPUT DATA

```
==================================================================================================================================================
TRANSFORMER                    PRIMARY RECORD                     VOLTS  * SECONDARY RECORD                   VOLTS   FULL-LOAD   NOMINAL
NAME                           NO NAME                            L-L      NO NAME                            L-L     KVA         KVA
==================================================================================================================================================
TX-AB ANNEX-UTIL               TX-AB ANNEX-UTIL P            YG 12470.0   B-AB ANNEX DISC-USB          YG    208.00  225.00       225.00
               Pos. Seq. Z%:    0.522 + J   2.03    (Zpu   2.32 + j   9.04 )    Shell Type
               Zero Seq. Z%:    0.522 + J   2.03    (     Pri - Sec:  2.32 + j   9.04 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-AB-UTIL-A                   TX-AB-UTIL-A P                YG 12470.0   B-AB DISC-USB                YG    208.00  300.00       300.00
               Pos. Seq. Z%:    0.398 + J   1.65    (Zpu   1.33 + j   5.51 )    Shell Type
               Zero Seq. Z%:    0.398 + J   1.65    (     Pri - Sec:  1.33 + j   5.51 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-AB-UTIL-B                   TX-AB-UTIL-B P                YG 12470.0   B-AB PNLBRD-USB              YG    208.00  300.00       300.00
               Pos. Seq. Z%:    0.398 + J   1.65    (Zpu   1.33 + j   5.51 )    Shell Type
               Zero Seq. Z%:    0.398 + J   1.65    (     Pri - Sec:  1.33 + j   5.51 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-ARC-UTIL-A                  TX-ARC-UTIL-A P               YG 12470.0   B-ARC-A-USB                  YG    480.00  750.00       750.00
               Pos. Seq. Z%:     1.04 + J   5.43    (Zpu   1.38 + j   7.24 )    Shell Type
               Zero Seq. Z%:     1.04 + J   5.43    (     Pri - Sec:  1.38 + j   7.24 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-ARC-UTIL-B                  TX-ARC-UTIL-B P               YG 12470.0   B-ARC-B-USB                  YG    208.00  300.00       300.00
               Pos. Seq. Z%:    0.829 + J   3.44    (Zpu   2.76 + j  11.47 )    Shell Type
               Zero Seq. Z%:    0.829 + J   3.44    (     Pri - Sec:  2.76 + j  11.47 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-BHB-UTIL-A                  TX-BHB-UTIL-A P               YG 12470.0   B-BHB MSB-A-USB              YG    480.00 1000.00      1000.00
               Pos. Seq. Z%:    0.988 + J   5.64    (Zpu  0.988 + j   5.64 )    Shell Type
               Zero Seq. Z%:    0.988 + J   5.64    (     Pri - Sec: 0.988 + j   5.64 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.
```

```
                           TRANSFORMER  INPUT  DATA
=================================================================================================================================================
TRANSFORMER                    PRIMARY RECORD                    VOLTS  * SECONDARY RECORD                         VOLTS   FULL-LOAD   NOMINAL
NAME                           NO NAME                           L-L      NO NAME                                  L-L     KVA           KVA
=================================================================================================================================================
TX-BHB-UTIL-B                  TX-BHB-UTIL-B P              YG 12470.0   B-BHB MSB-B-USB                   YG    208.00  500.00        500.00
               Pos. Seq. Z%:    0.954 + J   4.48    (Zpu   1.91 + j   8.96 )    Shell Type
               Zero Seq. Z%:    0.954 + J   4.48    (      Pri - Sec:  1.91 + j   8.96 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-BHB-UTIL-C                  TX-BHB-UTIL-C P              YG 12470.0   B-BHB MSB-C-USB                   YG    208.00  500.00        500.00
               Pos. Seq. Z%:    0.954 + J   4.48    (Zpu   1.91 + j   8.96 )    Shell Type
               Zero Seq. Z%:    0.954 + J   4.48    (      Pri - Sec:  1.91 + j   8.96 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-BLKS-UTIL                   TX-BLKS-UTIL P               D  12470.0   B-BLKS JUNC                       D     240.00  300.00        300.00
               Pos. Seq. Z%:    0.374 + J   1.56    (Zpu   1.25 + j   5.18 )    Shell Type
               Zero Seq. Z%:    9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-EB-FIRE PUMP                TX-EB-FIRE PUMP P            D  12470.0   TX-EB-FIRE PUMP S                 YG    480.00   75.00         75.00
               Pos. Seq. Z%:     1.40 + J   4.41    (Zpu  18.65 + j  58.85 )    Shell Type
               Zero Seq. Z%:     1.40 + J   4.41    (Sec  18.65 + j  58.85 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-EB-USB-1                    TX-EB-USB-1 P                YG 12470.0   TX-EB-USB-1 S                     YG    480.00 1500.00       1500.00
               Pos. Seq. Z%:    0.867 + J   5.67    (Zpu  0.578 + j   3.78 )    Shell Type
               Zero Seq. Z%:    0.867 + J   5.67    (      Pri - Sec: 0.578 + j   3.78 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-EB-USB-2                    TX-EB-USB-2 P                YG 12470.0   TX-EB-USB-2 S                     YG    480.00 1500.00       1500.00
               Pos. Seq. Z%:    0.854 + J   5.59    (Zpu  0.569 + j   3.72 )    Shell Type
               Zero Seq. Z%:    0.854 + J   5.59    (      Pri - Sec: 0.569 + j   3.72 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.
```

TRANSFORMER INPUT DATA

```
=====================================================================================================================================================
TRANSFORMER                    PRIMARY RECORD                    VOLTS   * SECONDARY RECORD                             VOLTS   FULL-LOAD   NOMINAL
NAME                           NO NAME                           L-L       NO NAME                                      L-L     KVA           KVA
=====================================================================================================================================================
TX-EB-USB-3                    TX-EB-USB-3 P                YG 12470.0   TX-EB-USB-3 S                         YG    208.00 1000.00      1000.00
               Pos. Seq. Z%:     1.17 + J   6.71    (Zpu   1.17 + j   6.71 )    Shell Type
               Zero Seq. Z%:     1.17 + J   6.71    (     Pri - Sec:  1.17 + j   6.71 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-EB-USB-5                    TX-EB-USB-5 P                YG 12470.0   TX-EB-USB-5 S                         YG    480.00 1500.00      1500.00
               Pos. Seq. Z%:    0.878 + J   5.74    (Zpu  0.585 + j   3.83 )    Shell Type
               Zero Seq. Z%:    0.878 + J   5.74    (     Pri - Sec: 0.585 + j   3.83 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-EB-USB-6                    TX-EB-USB-6 P                YG 12470.0   TX-EB-USB-6 S                         YG    480.00 1500.00      1500.00
               Pos. Seq. Z%:    0.861 + J   5.63    (Zpu  0.574 + j   3.76 )    Shell Type
               Zero Seq. Z%:    0.861 + J   5.63    (     Pri - Sec: 0.574 + j   3.76 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-EB-USB-7                    TX-EB-USB-7 P                YG 12470.0   TX-EB-USB-7 S                         YG    480.00 1500.00      1500.00
               Pos. Seq. Z%:    0.854 + J   5.59    (Zpu  0.569 + j   3.72 )    Shell Type
               Zero Seq. Z%:    0.854 + J   5.59    (     Pri - Sec: 0.569 + j   3.72 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-EB-USB-8                    USB-8 P                      D  4160.00   USB-8 S                               YG   12470.0 2500.00      2500.00
               Pos. Seq. Z%:    0.506 + J   5.31    (Zpu  0.202 + j   2.12 )    Shell Type
               Zero Seq. Z%:    0.506 + J   5.31    (Sec  0.202 + j   2.12 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-EH-UTIL                     TX-EH-UTIL P                 D  12470.0   B-EH JUNC                             D     240.00  300.00       300.00
               Pos. Seq. Z%:    0.562 + J   2.33    (Zpu   1.87 + j   7.78 )    Shell Type
               Zero Seq. Z%:    9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.
```

TRANSFORMER INPUT DATA

```
=======================================================================================================================================
TRANSFORMER                    PRIMARY RECORD                    VOLTS   * SECONDARY RECORD                          VOLTS  FULL-LOAD  NOMINAL
NAME                           NO NAME                           L-L       NO NAME                                   L-L    KVA          KVA
=======================================================================================================================================
TX-HGDC-UTIL                   TX-HGDC-UTIL P              YG 12470.0   B-HGDC-USB                      YG    240.00 500.00       500.00
               Pos. Seq. Z%:    0.520 + J   2.45    (Zpu   1.04 + j   4.89 )    Shell Type
               Zero Seq. Z%:    0.520 + J   2.45    (      Pri - Sec:  1.04 + j   4.89 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-HH-UTIL                     TX-HH-UTIL P                 D  12470.0   B-HH JUNC                       D     240.00 500.00       500.00
               Pos. Seq. Z%:    0.437 + J   2.05    (Zpu  0.875 + j   4.11 )    Shell Type
               Zero Seq. Z%:    9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-HOFF-UTIL                   TX-HOFF-UTIL P              YG 12470.0   B-HOFF-USB                      YG    208.00 300.00       300.00
               Pos. Seq. Z%:    0.552 + J   2.29    (Zpu   1.84 + j   7.65 )    Shell Type
               Zero Seq. Z%:    0.552 + J   2.29    (      Pri - Sec:  1.84 + j   7.65 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-HSB-UTIL                    TX-HSB-UTIL P                D  12470.0   B-HSB-USB                       D     240.00 300.00       300.00
               Pos. Seq. Z%:    0.316 + J   1.31    (Zpu   1.05 + j   4.37 )    Shell Type
               Zero Seq. Z%:    9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-JCB-UTIL                    TX-JCB-UTIL P               YG 12470.0   B-JCB-USB                       YG    208.00 750.00       750.00
               Pos. Seq. Z%:     1.11 + J   5.80    (Zpu   1.47 + j   7.73 )    Shell Type
               Zero Seq. Z%:     1.11 + J   5.80    (      Pri - Sec:  1.47 + j   7.73 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-KHSE-UTIL                   TX-KHSE-UTIL P              YG 12470.0   B-KHSE-USB                      YG    208.00 500.00       500.00
               Pos. Seq. Z%:    0.854 + J   4.01    (Zpu   1.71 + j   8.02 )    Shell Type
               Zero Seq. Z%:    0.854 + J   4.01    (      Pri - Sec:  1.71 + j   8.02 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.
```

```
                           TRANSFORMER  INPUT  DATA
=========================================================================================================================================================
TRANSFORMER                    PRIMARY RECORD                    VOLTS  * SECONDARY RECORD                         VOLTS   FULL-LOAD  NOMINAL
NAME                           NO NAME                           L-L      NO NAME                                  L-L     KVA          KVA
=========================================================================================================================================================
TX-KNGA-UTIL                   TX-KNGA-UTIL P               D  12470.0   B-KNGA-USB                      D      240.00  300.00       300.00
               Pos. Seq. Z%:    0.316 + J   1.31    (Zpu   1.05 + j   4.37 )    Shell Type
               Zero Seq. Z%:    9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-MCB BSMT UTIL               TX-MCB BSMT UTIL P           D  12470.0   TX-MCB BSMT UTIL S              YG     480.00  300.00       300.00
               Pos. Seq. Z%:     4.50 + J  0.000    (Zpu  15.00 + j  0.000 )    Shell Type
               Zero Seq. Z%:     4.50 + J  0.000    (Sec  15.00 + j  0.000 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-MONT-UTIL                   TX-MONT-UTIL P               D  12470.0   B-MONT-USB                      D      240.00  300.00       300.00
               Pos. Seq. Z%:    0.374 + J   1.56    (Zpu   1.25 + j   5.18 )    Shell Type
               Zero Seq. Z%:    9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-NASC-UTIL                   TX-NASC-UTIL P               YG 12470.0   B-NASC-USB                      YG     208.00  150.00       150.00
               Pos. Seq. Z%:    0.671 + J   2.41    (Zpu   4.48 + j  16.05 )    Shell Type
               Zero Seq. Z%:    0.671 + J   2.41    (     Pri - Sec:  4.48 + j  16.05 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-OND ANNEX-UTIL              TX-OND ANNEX-UTIL P          D  12470.0   B-OND ANNEX SWBD-USB            YG     208.00  500.00       500.00
               Pos. Seq. Z%:    0.666 + J   3.13    (Zpu   1.33 + j   6.26 )    Shell Type
               Zero Seq. Z%:    0.666 + J   3.13    (Sec   1.33 + j   6.26 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-OND-UTIL MAIN               TX-OND-UTIL P                D  12470.0   B-OND MAIN SWBD-USB             YG     480.00  300.00       300.00
               Pos. Seq. Z%:    0.468 + J   1.94    (Zpu   1.56 + j   6.48 )    Shell Type
               Zero Seq. Z%:    0.468 + J   1.94    (Sec   1.56 + j   6.48 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.
```

```
                           TRANSFORMER  INPUT  DATA
=====================================================================================================================================================
TRANSFORMER                  PRIMARY RECORD                     VOLTS  * SECONDARY RECORD                             VOLTS  FULL-LOAD  NOMINAL
NAME                         NO NAME                            L-L      NO NAME                                      L-L    KVA          KVA
=====================================================================================================================================================
TX-OND-UTIL UPSTAIRS         TX-OND-UTIL P                    D  12470.0   B-OND 15 FLR-USB                D      240.00  500.00       500.00
               Pos. Seq. Z%:    1.37 + J   5.02    (Zpu   2.74 + j  10.03 )    Shell Type
               Zero Seq. Z%:   9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-PRKW-UTIL                 TX-PRKW-UTIL P                   D  12470.0   PRKW JUNC                       D      240.00  500.00       500.00
               Pos. Seq. Z%:   0.437 + J   2.05    (Zpu  0.875 + j   4.11 )    Shell Type
               Zero Seq. Z%:   9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-PS3-UTIL                  TX-PS3-UTIL P                    YG 12470.0   B-PS3-USB                       YG     208.00  150.00       150.00
               Pos. Seq. Z%:   0.671 + J   2.41    (Zpu   4.48 + j  16.05 )    Shell Type
               Zero Seq. Z%:   0.671 + J   2.41    (      Pri - Sec:  4.48 + j  16.05 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-SBA-UTIL                  TX-SBA-UTIL P                    YG 12470.0   B-SBA-USB                       YG     208.00  500.00       500.00
               Pos. Seq. Z%:   0.854 + J   4.01    (Zpu   1.71 + j   8.02 )    Shell Type
               Zero Seq. Z%:   0.854 + J   4.01    (      Pri - Sec:  1.71 + j   8.02 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-SBH-UTIL                  TX-SBH-UTIL S                    D  12470.0   B-SBH JUNC                      D      240.00   75.00        75.00
               Pos. Seq. Z%:   0.645 + J   1.71    (Zpu   8.61 + j  22.83 )    Shell Type
               Zero Seq. Z%:   9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-SEC NORTH-UTIL-A          TX-SEC NORTH-UTIL-A P            D  12470.0   B-SEC NORTH PNL-USB             D      240.00  500.00       500.00
               Pos. Seq. Z%:   0.527 + J   2.47    (Zpu   1.05 + j   4.95 )    Shell Type
               Zero Seq. Z%:   9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.
```

```
                           TRANSFORMER  INPUT  DATA
======================================================================================================================================================
TRANSFORMER                    PRIMARY RECORD                      VOLTS   * SECONDARY RECORD                    VOLTS   FULL-LOAD   NOMINAL
NAME                           NO NAME                             L-L       NO NAME                             L-L     KVA           KVA
======================================================================================================================================================
TX-SEC NORTH-UTIL-B            TX-SEC NORTH-UTIL-B P         D  12470.0   B-SEC NORTH ECB-USB          D     240.00  500.00        500.00
               Pos. Seq. Z%:    0.527 + J   2.47    (Zpu   1.05 + j   4.95 )    Shell Type
               Zero Seq. Z%:    9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-SEC SOUTH-UTIL-A            TX-SEC SOUTH-UTIL-A P         D  12470.0   B-SEC SOUTH-A JUNC           D     240.00  500.00        500.00
               Pos. Seq. Z%:    0.527 + J   2.47    (Zpu   1.05 + j   4.95 )    Shell Type
               Zero Seq. Z%:    9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-SEC SOUTH-UTIL-B            TX-SEC SOUTH-UTIL-B P         D  12470.0   B-SEC SOUTH-B JUNC           D     240.00  500.00        500.00
               Pos. Seq. Z%:    0.527 + J   2.47    (Zpu   1.05 + j   4.95 )    Shell Type
               Zero Seq. Z%:    9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-SEH-UTIL                    TX-SEH-UTIL P                 YG 12470.0   B-SEH-USB                    YG    208.00  300.00        300.00
               Pos. Seq. Z%:    0.552 + J   2.29    (Zpu   1.84 + j   7.65 )    Shell Type
               Zero Seq. Z%:    0.552 + J   2.29    (      Pri - Sec:  1.84 + j   7.65 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-SH-UTIL                     TX-SH-UTIL P                  YG 12470.0   B-SH-USB                     YG    208.00  500.00        500.00
               Pos. Seq. Z%:    0.458 + J   2.15    (Zpu  0.916 + j   4.30 )    Shell Type
               Zero Seq. Z%:    0.458 + J   2.15    (      Pri - Sec: 0.916 + j   4.30 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-STFR-UTIL                   TX-STFR-UTIL P                D  12470.0   B-STFR-USB                   D     240.00  500.00        500.00
               Pos. Seq. Z%:    0.437 + J   2.05    (Zpu  0.875 + j   4.11 )    Shell Type
               Zero Seq. Z%:    9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.
```

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                           TRANSFORMER  INPUT  DATA
===================================================================================================================================================
TRANSFORMER                    PRIMARY RECORD                      VOLTS   * SECONDARY RECORD                            VOLTS   FULL-LOAD   NOMINAL
NAME                           NO NAME                             L-L       NO NAME                                     L-L     KVA          KVA
===================================================================================================================================================
TX-STHL-UTIL                   TX-STHL-UTIL P                  D  12470.0   B-STHL JUNC                             D     240.00  150.00       150.00
               Pos. Seq. Z%:    0.577 + J   1.70    (Zpu   3.85 + j  11.36 )    Shell Type
               Zero Seq. Z%:    9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-UCB-UTIL                    TX-UCB-UTIL P                  YG 12470.0   B-UCB-USB                                YG    208.00  500.00       500.00
               Pos. Seq. Z%:    0.812 + J   3.81    (Zpu   1.63 + j   7.63 )    Shell Type
               Zero Seq. Z%:    0.812 + J   3.81    (      Pri - Sec:  1.63 + j   7.63 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-UHP-UTIL                    TX-UHP-UTIL P                   D  12470.0   B-UHP-USB                               D     240.00  225.00       225.00
               Pos. Seq. Z%:    0.845 + J   3.29    (Zpu   3.76 + j  14.64 )    Shell Type
               Zero Seq. Z%:    9999. + J  9999.    (Pri  Open, Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-UP-UTIL-A                   TX-UP-UTIL-A P                 YG 12470.0   B-UP-A-USB                               YG    480.00 1500.00      1500.00
               Pos. Seq. Z%:    0.498 + J   3.26    (Zpu  0.332 + j   2.17 )    Shell Type
               Zero Seq. Z%:    0.498 + J   3.26    (      Pri - Sec: 0.332 + j   2.17 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-UP UTIL-B                   TX-UP UTIL-B P                 YG 12470.0   B-UP-B-USB                               YG    208.00  500.00       500.00
               Pos. Seq. Z%:    0.395 + J   1.86    (Zpu  0.791 + j   3.72 )    Shell Type
               Zero Seq. Z%:    0.395 + J   1.86    (      Pri - Sec: 0.791 + j   3.72 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.

TX-URBN-UTIL-A                 TX-URBN-UTIL-A P               YG 12470.0   B-URBN SWBD-USB                          YG    480.00  750.00       750.00
               Pos. Seq. Z%:    0.281 + J   1.47    (Zpu  0.374 + j   1.96 )    Shell Type
               Zero Seq. Z%:    0.281 + J   1.47    (      Pri - Sec: 0.374 + j   1.96 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.
```

TRANSFORMER INPUT DATA

```
==========================================================================================================================================
TRANSFORMER                   PRIMARY RECORD                    VOLTS   * SECONDARY RECORD                         VOLTS   FULL-LOAD   NOMINAL
NAME                          NO NAME                           L-L       NO NAME                                  L-L     KVA          KVA
==========================================================================================================================================
TX-URBN-UTIL-B                TX-URBN-UTIL-B P             YG 12470.0   B-URBN FP DISC-USB              YG    480.00  750.00       750.00
               Pos. Seq. Z%:    0.281 + J   1.47    (Zpu  0.374 + j   1.96 )    Shell Type
               Zero Seq. Z%:    0.281 + J   1.47    (     Pri - Sec: 0.374 + j   1.96 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  0.000 Deg.
```

```
                       GENERATION  CONTRIBUTION  DATA
===============================================================================================
BUS                          CONTRIBUTION                    VOLTAGE
NAME                         NAME                               L-L     MVA      X"d    X/R
===============================================================================================
EB-UTIL-B BUS                EB-UTIL-B                       12470.0  107.74
                  Three Phase           Contribution:    4988.33 AMPS        3.27
                  Single Line to Ground Contribution:    4210.97 AMPS        2.56
                  Pos  Sequence Impedance (100 MVA Base)  0.2712 + J   0.8876 PU
                  Zero Sequence Impedance (100 MVA Base)  0.6572 + J     1.30 PU

G-EB BUS                     G-EB GEN                        4160.00   3.75   0.1000    27.58
                  KG:  0.9434  xdsat:    1.60  Excitation Limit:    1.30  Ik -   ON
                  Pos  Sequence Impedance (100 MVA Base) 0.0967 + J    2.67 PU
TX-AB ANNEX-UTIL P           AB ANNEX-UTIL                   12470.0  114.64
                  Three Phase           Contribution:    5307.96 AMPS        3.57
                  Single Line to Ground Contribution:    4401.36 AMPS        2.90
                  Pos  Sequence Impedance (100 MVA Base)  0.2355 + J   0.8399 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5581 + J     1.30 PU

TX-AB-UTIL-A P               AB-UTIL-A                       12470.0  116.40
                  Three Phase           Contribution:    5388.99 AMPS        3.92
                  Single Line to Ground Contribution:    4471.73 AMPS        3.15
                  Pos  Sequence Impedance (100 MVA Base)  0.2124 + J   0.8325 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5137 + J     1.30 PU

TX-AB-UTIL-B P               AB-UTIL-B                       12470.0  116.40
                  Three Phase           Contribution:    5388.99 AMPS        3.92
                  Single Line to Ground Contribution:    4471.73 AMPS        3.15
                  Pos  Sequence Impedance (100 MVA Base)  0.2124 + J   0.8325 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5137 + J     1.30 PU

TX-ARC-UTIL-A P              ARC-UTIL-A                      12470.0  111.89
                  Three Phase           Contribution:    5180.19 AMPS        4.28
                  Single Line to Ground Contribution:    4330.91 AMPS        3.09
                  Pos  Sequence Impedance (100 MVA Base)  0.2033 + J   0.8703 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5795 + J     1.31 PU

TX-ARC-UTIL-B P              ARC-UTIL-B                      12470.0  111.89
                  Three Phase           Contribution:    5180.19 AMPS        4.28
                  Single Line to Ground Contribution:    4330.91 AMPS        3.09
                  Pos  Sequence Impedance (100 MVA Base)  0.2033 + J   0.8703 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5795 + J     1.31 PU

TX-BHB-UTIL-A P              BHB-UTIL-A                      12470.0  113.21
                  Three Phase           Contribution:    5241.57 AMPS        3.83
                  Single Line to Ground Contribution:    4375.25 AMPS        3.03
                  Pos  Sequence Impedance (100 MVA Base)  0.2229 + J   0.8547 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5502 + J     1.30 PU

TX-BHB-UTIL-B P              BHB-UTIL-B                      12470.0  113.65
                  Three Phase           Contribution:    5261.72 AMPS        3.98
                  Single Line to Ground Contribution:    4397.84 AMPS        3.12
                  Pos  Sequence Impedance (100 MVA Base)  0.2143 + J   0.8534 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5347 + J     1.30 PU

TX-BHB-UTIL-C P              BHB-UTIL-C                      12470.0  113.65
                  Three Phase           Contribution:    5261.72 AMPS        3.98
                  Single Line to Ground Contribution:    4397.84 AMPS        3.12
                  Pos  Sequence Impedance (100 MVA Base)  0.2143 + J   0.8534 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5347 + J     1.30 PU
```

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                       GENERATION  CONTRIBUTION  DATA
===============================================================================================
BUS                            CONTRIBUTION                    VOLTAGE
NAME                           NAME                               L-L     MVA      X"d    X/R
===============================================================================================
TX-BLKS-UTIL P                 BLKS-UTIL                       12470.0  168.23
                  Three Phase          Contribution:    7788.97 AMPS      0.8433
                  Single Line to Ground Contribution:    6234.71 AMPS      0.7047
                  Pos  Sequence Impedance (100 MVA Base)  0.4544 + J   0.3832 PU
                  Zero Sequence Impedance (100 MVA Base)  0.9123 + J   0.5168 PU

TX-EH-UTIL P                   EH-UTIL                         12470.0  108.17
                  Three Phase          Contribution:    5008.20 AMPS        2.70
                  Single Line to Ground Contribution:    4114.65 AMPS        2.25
                  Pos  Sequence Impedance (100 MVA Base)  0.3215 + J   0.8667 PU
                  Zero Sequence Impedance (100 MVA Base)  0.7257 + J     1.35 PU

TX-HGDC-UTIL P                 HGDC-UTIL                       12470.0  258.06
                  Three Phase          Contribution:    11948.0 AMPS        1.92
                  Single Line to Ground Contribution:    10455.4 AMPS        1.39
                  Pos  Sequence Impedance (100 MVA Base)  0.1792 + J   0.3436 PU
                  Zero Sequence Impedance (100 MVA Base)  0.4186 + J   0.3904 PU

TX-HH-UTIL P                   HH-UTIL                         12470.0  230.13
                  Three Phase          Contribution:    10654.6 AMPS        1.64
                  Single Line to Ground Contribution:    8885.03 AMPS        1.16
                  Pos  Sequence Impedance (100 MVA Base)  0.2264 + J   0.3709 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5674 + J   0.4427 PU

TX-HOFF-UTIL P                 HOFF-UTIL                       12470.0  171.36
                  Three Phase          Contribution:    7933.67 AMPS      0.8630
                  Single Line to Ground Contribution:    6360.29 AMPS      0.7187
                  Pos  Sequence Impedance (100 MVA Base)  0.4418 + J   0.3813 PU
                  Zero Sequence Impedance (100 MVA Base)  0.8898 + J   0.5119 PU

TX-HSB-UTIL P                  HSB-UTIL                        12470.0  214.85
                  Three Phase          Contribution:    9947.58 AMPS        1.21
                  Single Line to Ground Contribution:    8189.81 AMPS      0.9537
                  Pos  Sequence Impedance (100 MVA Base)  0.2963 + J   0.3589 PU
                  Zero Sequence Impedance (100 MVA Base)  0.6347 + J   0.4527 PU

TX-JCB-UTIL P                  JCB-UTIL                        12470.0  201.46
                  Three Phase          Contribution:    9327.21 AMPS        1.09
                  Single Line to Ground Contribution:    7635.09 AMPS      0.8700
                  Pos  Sequence Impedance (100 MVA Base)  0.3363 + J   0.3651 PU
                  Zero Sequence Impedance (100 MVA Base)  0.6998 + J   0.4639 PU

TX-KHSE-UTIL P                 KHSE-UTIL                       12470.0  108.03
                  Three Phase          Contribution:    5001.52 AMPS        3.03
                  Single Line to Ground Contribution:    4153.36 AMPS        2.41
                  Pos  Sequence Impedance (100 MVA Base)  0.2904 + J   0.8790 PU
                  Zero Sequence Impedance (100 MVA Base)  0.7029 + J     1.33 PU

TX-KNGA-UTIL P                 KNGA-UTIL                       12470.0  214.85
                  Three Phase          Contribution:    9947.58 AMPS        1.21
                  Single Line to Ground Contribution:    8189.81 AMPS      0.9537
                  Pos  Sequence Impedance (100 MVA Base)  0.2963 + J   0.3589 PU
                  Zero Sequence Impedance (100 MVA Base)  0.6347 + J   0.4527 PU
```

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                       GENERATION  CONTRIBUTION  DATA
===============================================================================================
BUS                            CONTRIBUTION                     VOLTAGE
NAME                           NAME                                L-L     MVA      X"d    X/R
===============================================================================================
TX-MCB BSMT UTIL S             MCB BSMT INF UTIL                 480.00   6.67
                  Three Phase           Contribution:    8018.80 AMPS       4.15
                  Single Line to Ground Contribution:    8018.80 AMPS       4.15
                  Pos  Sequence Impedance (100 MVA Base)    3.51 + J    14.58 PU
                  Zero Sequence Impedance (100 MVA Base)    3.51 + J    14.58 PU

TX-MCB UTIL-A S                MCB INF UTIL-A                    480.00  13.16
                  Three Phase           Contribution:    15826.5 AMPS       5.24
                  Single Line to Ground Contribution:    15826.5 AMPS       5.24
                  Pos  Sequence Impedance (100 MVA Base)    1.42 + J     7.47 PU
                  Zero Sequence Impedance (100 MVA Base)    1.42 + J     7.47 PU

TX-MCB UTIL-B S                MCB INF UTIL-B                    480.00  13.89
                  Three Phase           Contribution:    16705.7 AMPS       5.24
                  Single Line to Ground Contribution:    16705.7 AMPS       5.24
                  Pos  Sequence Impedance (100 MVA Base)    1.35 + J     7.07 PU
                  Zero Sequence Impedance (100 MVA Base)    1.35 + J     7.07 PU

TX-MONT-UTIL P                 MONT-UTIL                        12470.0  168.23
                  Three Phase           Contribution:    7788.97 AMPS     0.8433
                  Single Line to Ground Contribution:    6234.71 AMPS     0.7047
                  Pos  Sequence Impedance (100 MVA Base)  0.4544 + J   0.3832 PU
                  Zero Sequence Impedance (100 MVA Base)  0.9123 + J   0.5168 PU

TX-NASC-UTIL P                 NASC-UTIL                        12470.0   83.50
                  Three Phase           Contribution:    3865.93 AMPS       1.84
                  Single Line to Ground Contribution:    2909.51 AMPS       1.88
                  Pos  Sequence Impedance (100 MVA Base)  0.5713 + J     1.05 PU
                  Zero Sequence Impedance (100 MVA Base)    1.10 + J     2.11 PU

TX-OND ANNEX-UTIL P            OND ANNEX-UTIL                   12470.0  114.55
                  Three Phase           Contribution:    5303.73 AMPS       4.16
                  Single Line to Ground Contribution:    4430.33 AMPS       3.25
                  Pos  Sequence Impedance (100 MVA Base)  0.2042 + J   0.8487 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5143 + J     1.30 PU

TX-OND-UTIL P                  OND-UTIL                         12470.0  115.07
                  Three Phase           Contribution:    5327.72 AMPS       4.37
                  Single Line to Ground Contribution:    4457.23 AMPS       3.38
                  Pos  Sequence Impedance (100 MVA Base)  0.1938 + J   0.8471 PU
                  Zero Sequence Impedance (100 MVA Base)  0.4957 + J     1.29 PU

TX-PRKW-UTIL P                 PRKW-UTIL                        12470.0  230.13
                  Three Phase           Contribution:    10654.6 AMPS       1.64
                  Single Line to Ground Contribution:    8885.03 AMPS       1.16
                  Pos  Sequence Impedance (100 MVA Base)  0.2264 + J   0.3709 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5674 + J   0.4427 PU

TX-PS3-UTIL P                  PS3-UTIL                         12470.0  262.81
                  Three Phase           Contribution:    12167.8 AMPS       2.04
                  Single Line to Ground Contribution:    10726.3 AMPS       1.46
                  Pos  Sequence Impedance (100 MVA Base)  0.1672 + J   0.3418 PU
                  Zero Sequence Impedance (100 MVA Base)  0.3970 + J   0.3850 PU
```

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                       GENERATION  CONTRIBUTION  DATA
===============================================================================================
BUS                            CONTRIBUTION                    VOLTAGE
NAME                           NAME                               L-L     MVA      X"d    X/R
===============================================================================================
TX-SBA-UTIL P                  SBA-UTIL                        12470.0  108.03
                  Three Phase           Contribution:    5001.52 AMPS        3.03
                  Single Line to Ground Contribution:    4153.36 AMPS        2.41
                  Pos  Sequence Impedance (100 MVA Base)  0.2904 + J   0.8790 PU
                  Zero Sequence Impedance (100 MVA Base)  0.7029 + J     1.33 PU

TX-SBH-UTIL S                  SBH-UTIL                        12470.0  144.92
                  Three Phase           Contribution:    6709.76 AMPS      0.7733
                  Single Line to Ground Contribution:    5527.95 AMPS      0.6695
                  Pos  Sequence Impedance (100 MVA Base)  0.5458 + J   0.4221 PU
                  Zero Sequence Impedance (100 MVA Base)  0.9962 + J   0.5536 PU

TX-SEC NORTH-UTIL-A P          SEC NORTH-UTIL-A                12470.0  115.57
                  Three Phase           Contribution:    5350.72 AMPS        3.67
                  Single Line to Ground Contribution:    4430.20 AMPS        2.98
                  Pos  Sequence Impedance (100 MVA Base)  0.2277 + J   0.8348 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5413 + J     1.30 PU

TX-SEC NORTH-UTIL-B P          SEC NORTH-UTIL-B                12470.0  115.57
                  Three Phase           Contribution:    5350.72 AMPS        3.67
                  Single Line to Ground Contribution:    4430.20 AMPS        2.98
                  Pos  Sequence Impedance (100 MVA Base)  0.2277 + J   0.8348 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5413 + J     1.30 PU

TX-SEC SOUTH-UTIL-A P          SEC SOUTH-UTIL-A                12470.0  115.57
                  Three Phase           Contribution:    5350.72 AMPS        3.67
                  Single Line to Ground Contribution:    4430.20 AMPS        2.98
                  Pos  Sequence Impedance (100 MVA Base)  0.2277 + J   0.8348 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5413 + J     1.30 PU

TX-SEC SOUTH-UTIL-B P          SEC SOUTH-UTIL-B                12470.0  115.57
                  Three Phase           Contribution:    5350.72 AMPS        3.67
                  Single Line to Ground Contribution:    4430.20 AMPS        2.98
                  Pos  Sequence Impedance (100 MVA Base)  0.2277 + J   0.8348 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5413 + J     1.30 PU

TX-SEH-UTIL P                  SEH-UTIL                        12470.0  171.36
                  Three Phase           Contribution:    7933.67 AMPS      0.8630
                  Single Line to Ground Contribution:    6360.29 AMPS      0.7187
                  Pos  Sequence Impedance (100 MVA Base)  0.4418 + J   0.3813 PU
                  Zero Sequence Impedance (100 MVA Base)  0.8898 + J   0.5119 PU

TX-SH-UTIL P                   SH-UTIL                         12470.0  108.17
                  Three Phase           Contribution:    5008.20 AMPS        2.70
                  Single Line to Ground Contribution:    4114.65 AMPS        2.25
                  Pos  Sequence Impedance (100 MVA Base)  0.3215 + J   0.8667 PU
                  Zero Sequence Impedance (100 MVA Base)  0.7257 + J     1.35 PU

TX-STFR-UTIL P                 STFR-UTIL                       12470.0  230.13
                  Three Phase           Contribution:    10654.6 AMPS        1.64
                  Single Line to Ground Contribution:    8885.03 AMPS        1.16
                  Pos  Sequence Impedance (100 MVA Base)  0.2264 + J   0.3709 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5674 + J   0.4427 PU
```

```
                       GENERATION  CONTRIBUTION  DATA
===============================================================================================
BUS                            CONTRIBUTION                    VOLTAGE
NAME                           NAME                               L-L     MVA      X"d    X/R
===============================================================================================
TX-STHL-UTIL P                 STHL-UTIL                       12470.0  199.62
                  Three Phase           Contribution:    9242.35 AMPS        1.15
                  Single Line to Ground Contribution:    7834.35 AMPS      0.9399
                  Pos  Sequence Impedance (100 MVA Base)  0.3279 + J   0.3787 PU
                  Zero Sequence Impedance (100 MVA Base)  0.6361 + J   0.4568 PU

TX-UCB-UTIL P                  UCB-UTIL                        12470.0  111.72
                  Three Phase           Contribution:    5172.33 AMPS        4.24
                  Single Line to Ground Contribution:    4319.57 AMPS        3.06
                  Pos  Sequence Impedance (100 MVA Base)  0.2057 + J   0.8712 PU
                  Zero Sequence Impedance (100 MVA Base)  0.5872 + J     1.31 PU

TX-UHP-UTIL P                  UHP-UTIL                        12470.0  279.04
                  Three Phase           Contribution:    12919.1 AMPS        2.53
                  Single Line to Ground Contribution:    11530.1 AMPS        1.73
                  Pos  Sequence Impedance (100 MVA Base)  0.1315 + J   0.3334 PU
                  Zero Sequence Impedance (100 MVA Base)  0.3387 + J   0.3768 PU

TX-UP-UTIL-A P                 UP-UTIL-A                       12470.0   94.79
                  Three Phase           Contribution:    4388.84 AMPS        2.95
                  Single Line to Ground Contribution:    3447.73 AMPS        2.57
                  Pos  Sequence Impedance (100 MVA Base)  0.3388 + J   0.9990 PU
                  Zero Sequence Impedance (100 MVA Base)  0.7829 + J     1.76 PU

TX-UP UTIL-B P                 UP UTIL-B                       12470.0   94.61
                  Three Phase           Contribution:    4380.19 AMPS        2.91
                  Single Line to Ground Contribution:    3439.67 AMPS        2.54
                  Pos  Sequence Impedance (100 MVA Base)  0.3434 + J   0.9997 PU
                  Zero Sequence Impedance (100 MVA Base)  0.7911 + J     1.76 PU

TX-URBN-UTIL-A P               URBN-UTIL-A                     12470.0  103.49
                  Three Phase           Contribution:    4791.28 AMPS        2.39
                  Single Line to Ground Contribution:    3932.60 AMPS        1.97
                  Pos  Sequence Impedance (100 MVA Base)  0.3727 + J   0.8916 PU
                  Zero Sequence Impedance (100 MVA Base)  0.8511 + J     1.37 PU

TX-URBN-UTIL-B P               URBN-UTIL-B                     12470.0  103.49
                  Three Phase           Contribution:    4791.28 AMPS        2.39
                  Single Line to Ground Contribution:    3932.60 AMPS        1.97
                  Pos  Sequence Impedance (100 MVA Base)  0.3727 + J   0.8916 PU
                  Zero Sequence Impedance (100 MVA Base)  0.8511 + J     1.37 PU
```

B. APPENDIX B – SHORT-CIRCUIT RESULTS

```
PSU - Non-West Campus Loop
Portland, OR
ESE0008355 / TQSISE0008355.1
Feb 21, 2013     17:45:50

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                T H R E E   P H A S E   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================

 B-AB ANNEX DISC-USB           3P Duty: 27.199 KA AT  -75.49 DEG (   9.80 MVA)  X/R:     3.86
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0011 + J  0.0043  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   27.199 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  27.199 KA
                TX-AB ANNEX-UTIL                TX-AB ANNEX-UTIL P               27.199 KA      ANG:  104.51

 B-AB DISC-USB                 3P Duty: 42.535 KA AT  -76.35 DEG (  15.32 MVA)  X/R:     4.12
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0007 + J  0.0027  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   42.535 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  42.535 KA
                TX-AB-UTIL-A                    TX-AB-UTIL-A P                   42.535 KA      ANG:  103.65

 B-AB PNLBRD-USB               3P Duty: 42.535 KA AT  -76.35 DEG (  15.32 MVA)  X/R:     4.12
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0007 + J  0.0027  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   42.535 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  42.535 KA
                TX-AB-UTIL-B                    TX-AB-UTIL-B P                   42.535 KA      ANG:  103.65

 B-ARC-A-USB                   3P Duty: 14.551 KA AT  -78.94 DEG (  12.10 MVA)  X/R:     5.12
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0037 + J  0.0187  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   14.551 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  16.341 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  14.690 KA
                TX-ARC-UTIL-A                   TX-ARC-UTIL-A P                  14.551 KA      ANG:  101.06

 B-ARC-B-USB                   3P Duty: 21.867 KA AT  -76.48 DEG (   7.88 MVA)  X/R:     4.16
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0013 + J  0.0053  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   21.867 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  21.867 KA
                TX-ARC-UTIL-B                   TX-ARC-UTIL-B P                  21.867 KA      ANG: -256.48

 B-BHB MSB-A-USB               3P Duty: 18.195 KA AT  -79.44 DEG (  15.13 MVA)  X/R:     5.37
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0028 + J  0.0150  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   18.195 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  18.555 KA
                TX-BHB-UTIL-A                   TX-BHB-UTIL-A P                  18.195 KA      ANG: -259.44

 B-BHB MSB-B-USB               3P Duty: 27.648 KA AT  -77.79 DEG (   9.96 MVA)  X/R:     4.62
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0009 + J  0.0042  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   27.648 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  27.648 KA
                TX-BHB-UTIL-B                   TX-BHB-UTIL-B P                  27.648 KA      ANG: -257.79
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                T H R E E   P H A S E   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================

 B-BHB MSB-C-USB               3P Duty: 27.648 KA AT  -77.79 DEG (   9.96 MVA)  X/R:     4.62
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0009 + J  0.0042  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   27.648 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  27.648 KA
                TX-BHB-UTIL-C                 TX-BHB-UTIL-C P                 27.648 KA      ANG:  102.21

 B-BLKS K-USB                  3P Duty: 31.323 KA AT  -54.05 DEG (  13.02 MVA)  X/R:     1.38
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0026 + J  0.0036  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   31.323 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  31.323 KA
                C-BLKS JUNC-BLKS K            B-BLKS JUNC                     31.323 KA      ANG:  -54.05

 B-BLKS L1-USB                 3P Duty: 37.681 KA AT  -68.22 DEG (  15.66 MVA)  X/R:     2.50
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0014 + J  0.0034  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   37.681 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  37.681 KA
                C-BLKS JUNC-BLKS L1           B-BLKS JUNC                     37.681 KA      ANG:  111.78

 B-BLKS L2-USB                 3P Duty: 37.681 KA AT  -68.22 DEG (  15.66 MVA)  X/R:     2.50
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0014 + J  0.0034  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   37.681 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  37.681 KA
                C-BLKS JUNC-BLKS L2           B-BLKS JUNC                     37.681 KA      ANG:  -68.22

 B-BLKS L3-USB                 3P Duty: 37.681 KA AT  -68.22 DEG (  15.66 MVA)  X/R:     2.50
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0014 + J  0.0034  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   37.681 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  37.681 KA
                C-BLKS JUNC-BLKS L3           B-BLKS JUNC                     37.681 KA      ANG:  -68.22

 B-BLKS L4-USB                 3P Duty: 37.681 KA AT  -68.22 DEG (  15.66 MVA)  X/R:     2.50
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0014 + J  0.0034  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   37.681 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  37.681 KA
                C-BLKS JUNC-BLKS L4           B-BLKS JUNC                     37.681 KA      ANG:  -68.22

 B-BLKS L5-USB                 3P Duty: 37.681 KA AT  -68.22 DEG (  15.66 MVA)  X/R:     2.50
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0014 + J  0.0034  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   37.681 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  37.681 KA
                C-BLKS JUNC-BLKS L5           B-BLKS JUNC                     37.681 KA      ANG:  -68.22

 B-BLKS X-USB                  3P Duty: 27.943 KA AT  -44.59 DEG (  11.62 MVA)  X/R:     0.99
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                T H R E E   P H A S E   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0035 + J  0.0035  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   27.943 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  27.943 KA
                C-BLKS JUNC-BLKS X            B-BLKS JUNC                        27.943 KA      ANG:   -44.59

 B-EB-52-U1                     3P Duty:  5.907 KA AT  -75.14 DEG ( 127.58 MVA)  X/R:     5.14
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3126 + J  1.1781  OHMS
                C-EB-52-U3-52-U1              B-EB-52-U3                          5.907 KA      ANG:   -75.14

 B-EB-52-U2                     3P Duty:  5.920 KA AT  -75.13 DEG ( 127.86 MVA)  X/R:     5.13
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3122 + J  1.1755  OHMS
                C-UTIL-BK-EB-52-U2            EB-UTIL-B BUS                       4.988 KA      ANG:  -253.01
                C-EB-52-U3-52-U2              B-EB-52-U3                          0.953 KA      ANG:   -86.25

 B-EB-52-U3                     3P Duty:  5.914 KA AT  -75.13 DEG ( 127.74 MVA)  X/R:     5.14
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3123 + J  1.1765  OHMS
                C-EB-USB-8-52-U3              USB-8 S                             0.953 KA      ANG:    93.74
                C-EB-52-U3-52-U2              B-EB-52-U2                          4.982 KA      ANG:  -253.02

 B-EB-USB-1                     3P Duty: 26.415 KA AT  -80.11 DEG (  21.96 MVA)  X/R:     6.16
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0018 + J  0.0103  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   26.415 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  27.691 KA
                C-EB-USB-1-USB-2              B-EB-USB-2                         26.415 KA      ANG:  -260.11

 B-EB-USB-2                     3P Duty: 26.441 KA AT  -80.18 DEG (  21.98 MVA)  X/R:     6.20
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0018 + J  0.0103  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   26.441 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  27.758 KA
                C-EB-TX-USB-2-USB-2           TX-EB-USB-2 S                      26.441 KA      ANG:  -260.18

 B-EB-USB-3                     3P Duty: 36.465 KA AT  -79.37 DEG (  13.14 MVA)  X/R:     5.54
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0006 + J  0.0032  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   36.465 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  37.431 KA
                C-EB-TX-USB-3-USB-3           TX-EB-USB-3 S                      36.465 KA      ANG:  -259.37

 B-EB-USB-5                     3P Duty: 25.794 KA AT  -80.06 DEG (  21.44 MVA)  X/R:     6.11
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0019 + J  0.0106  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   25.794 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  27.000 KA
                C-EB-TX-USB-5-USB-5           TX-EB-USB-5 S                      25.794 KA      ANG:  -260.05

 B-EB-USB-6                     3P Duty: 26.407 KA AT  -80.08 DEG (  21.95 MVA)  X/R:     6.14
```

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                T H R E E   P H A S E   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0018 + J  0.0103  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   26.407 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  27.666 KA
                C-EB-USB-6-USB-7               B-EB-USB-7                          26.407 KA      ANG: -260.08

 B-EB-USB-7                     3P Duty: 26.432 KA AT  -80.15 DEG (  21.98 MVA)  X/R:     6.19
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0018 + J  0.0103  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   26.432 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  27.733 KA
                C-EB-TX-USB-7-USB-7            TX-EB-USB-7 S                       26.432 KA      ANG: -260.15

 B-EH A-USB                     3P Duty: 22.718 KA AT  -66.69 DEG (   9.44 MVA)  X/R:     2.32
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0024 + J  0.0056  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   22.718 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  22.718 KA
                C-EH JUNC-EH A                 B-EH JUNC                           22.718 KA      ANG: -246.69

 B-EH B-USB                     3P Duty: 22.718 KA AT  -66.69 DEG (   9.44 MVA)  X/R:     2.32
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0024 + J  0.0056  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   22.718 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  22.718 KA
                C-EH JUNC-EH B                 B-EH JUNC                           22.718 KA      ANG:   -66.69

 B-EH C-USB                     3P Duty: 22.718 KA AT  -66.69 DEG (   9.44 MVA)  X/R:     2.32
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0024 + J  0.0056  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   22.718 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  22.718 KA
                C-EH JUNC-EH C                 B-EH JUNC                           22.718 KA      ANG:   -66.69

 B-EH E DISC-USB                3P Duty: 22.718 KA AT  -66.69 DEG (   9.44 MVA)  X/R:     2.32
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0024 + J  0.0056  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   22.718 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  22.718 KA
                C-EH JUNC-EH DISC              B-EH JUNC                           22.718 KA      ANG:   -66.69

 B-HGDC-USB                     3P Duty: 44.761 KA AT  -76.87 DEG (  18.61 MVA)  X/R:     4.29
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0007 + J  0.0030  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   44.761 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  44.761 KA
                TX-HGDC-UTIL                   TX-HGDC-UTIL P                      44.761 KA      ANG:  103.13

 B-HH 1-USB                     3P Duty: 50.812 KA AT  -74.80 DEG (  21.12 MVA)  X/R:     3.68
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0007 + J  0.0026  OHMS
```

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               T H R E E   P H A S E   F A U L T   R E P O R T
                  (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                        PRE FAULT VOLTAGE: 1.0000
                        MODEL TRANSFORMER TAPS: NO
==============================================================================================================
               LOW VOLTAGE POWER CIRCUIT BREAKER   50.812 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA  50.812 KA
               C-HH JUNC-HH 1               B-HH JUNC                    50.812 KA      ANG: -254.80

 B-HH 2-USB                    3P Duty: 45.858 KA AT  -65.76 DEG (  19.06 MVA)  X/R:     2.22
               VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0012 + J  0.0028  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER   45.858 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA  45.858 KA
               C-HH 1-HH 2                  B-HH JUNC                    45.858 KA      ANG:   -65.76

 B-HOFF-USB                    3P Duty: 33.251 KA AT  -74.12 DEG (  11.98 MVA)  X/R:     3.51
               VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0010 + J  0.0035  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER   33.251 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA  33.251 KA
               TX-HOFF-UTIL                 TX-HOFF-UTIL P               33.251 KA      ANG:   105.88

 B-HSB-USB                     3P Duty: 48.870 KA AT  -74.07 DEG (  20.31 MVA)  X/R:     3.50
               VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0008 + J  0.0027  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER   48.870 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA  48.870 KA
               TX-HSB-UTIL                  TX-HSB-UTIL P                48.870 KA      ANG:   105.93

 B-JCB-USB                     3P Duty: 33.473 KA AT  -77.39 DEG (  12.06 MVA)  X/R:     4.47
               VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0008 + J  0.0035  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER   33.473 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA  33.473 KA
               TX-JCB-UTIL                  TX-JCB-UTIL P                33.473 KA      ANG:   102.61

 B-KHSE-USB                    3P Duty: 30.433 KA AT  -77.34 DEG (  10.96 MVA)  X/R:     4.45
               VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0009 + J  0.0039  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER   30.433 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA  30.433 KA
               TX-KHSE-UTIL                 TX-KHSE-UTIL P               30.433 KA      ANG:   102.66

 B-KNGA-USB                    3P Duty: 48.870 KA AT  -74.07 DEG (  20.31 MVA)  X/R:     3.50
               VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0008 + J  0.0027  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER   48.870 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA  48.870 KA
               TX-KNGA-UTIL                 TX-KNGA-UTIL P               48.870 KA      ANG:   105.93

 B-MCB BSMT-USB                3P Duty:  7.999 KA AT  -76.29 DEG (   6.65 MVA)  X/R:     4.10
               VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0082 + J  0.0337  OHMS
```

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                T H R E E   P H A S E   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
                LOW VOLTAGE POWER CIRCUIT BREAKER    7.999 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA   8.538 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA   7.999 KA
                C-MCB-UTIL-BSMT-USB          TX-MCB BSMT UTIL S                 7.999 KA      ANG:  103.71

 B-MCB PNTHS-USB              3P Duty: 32.032 KA AT  -78.08 DEG (  26.63 MVA)  X/R:     4.74
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0018 + J  0.0085  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   32.032 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  32.032 KA
                C-MCB-UTIL-B-PNTHS USB        TX-MCB UTIL-B S                  16.442 KA      ANG: -258.05
                C-MCB-UTIL-A-PNTHS USB        TX-MCB UTIL-A S                  15.590 KA      ANG:  101.89

 B-MONT-USB                   3P Duty: 41.312 KA AT  -72.99 DEG (  17.17 MVA)  X/R:     3.27
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0010 + J  0.0032  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   41.312 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  41.312 KA
                TX-MONT-UTIL                  TX-MONT-UTIL P                   41.312 KA      ANG:  107.01

 B-NASC-USB                   3P Duty: 15.562 KA AT  -73.56 DEG (   5.61 MVA)  X/R:     3.39
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0022 + J  0.0074  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   15.562 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  15.827 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  15.562 KA
                TX-NASC-UTIL                  TX-NASC-UTIL P                   15.562 KA      ANG:  106.44

 B-OND 15 FLR-USB             3P Duty: 21.349 KA AT  -74.91 DEG (   8.87 MVA)  X/R:     3.71
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0017 + J  0.0063  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   21.349 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  21.349 KA
                TX-OND-UTIL UPSTAIRS          TX-OND-UTIL P                    21.349 KA      ANG:  105.09

 B-OND ANNEX SWBD-USB         3P Duty: 38.166 KA AT  -77.79 DEG (  13.75 MVA)  X/R:     4.62
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0007 + J  0.0031  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   38.166 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  38.166 KA
                TX-OND ANNEX-UTIL             TX-OND ANNEX-UTIL P              38.166 KA      ANG: -257.79

 B-OND MAIN SWBD-USB          3P Duty: 15.962 KA AT  -76.53 DEG (  13.27 MVA)  X/R:     4.17
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0040 + J  0.0169  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   15.962 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  17.111 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  15.962 KA
                TX-OND-UTIL MAIN              TX-OND-UTIL P                    15.962 KA      ANG:  103.47
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                T H R E E   P H A S E   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================

 B-PRKW L1-USB                  3P Duty: 40.555 KA AT  -65.08 DEG (  16.86 MVA)  X/R:     2.15
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0014 + J  0.0031  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   40.555 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  40.555 KA
                C-PRKW JUNC-PRKW L1             PRKW JUNC                         40.555 KA      ANG:   -65.08

 B-PRKW L2-USB                  3P Duty: 40.555 KA AT  -65.08 DEG (  16.86 MVA)  X/R:     2.15
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0014 + J  0.0031  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   40.555 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  40.555 KA
                C-PRKW JUNC-PRKW L2             PRKW JUNC                         40.555 KA      ANG:   -65.08

 B-PRKW L3-USB                  3P Duty: 40.555 KA AT  -65.08 DEG (  16.86 MVA)  X/R:     2.15
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0014 + J  0.0031  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   40.555 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  40.555 KA
                C-PRKW JUNC-PRKW L3             PRKW JUNC                         40.555 KA      ANG:   -65.08

 B-PRKW L4-USB                  3P Duty: 40.555 KA AT  -65.08 DEG (  16.86 MVA)  X/R:     2.15
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0014 + J  0.0031  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   40.555 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  40.555 KA
                C-PRKW JUNC-PRKW L4             PRKW JUNC                         40.555 KA      ANG:   -65.08

 B-PRKW L5-USB                  3P Duty: 40.555 KA AT  -65.08 DEG (  16.86 MVA)  X/R:     2.15
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0014 + J  0.0031  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   40.555 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  40.555 KA
                C-PRKW JUNC-PRKW L5             PRKW JUNC                         40.555 KA      ANG:   -65.08

 B-PRKW X-USB                   3P Duty: 40.555 KA AT  -65.08 DEG (  16.86 MVA)  X/R:     2.15
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0014 + J  0.0031  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   40.555 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  40.555 KA
                C-PRKW JUNC-PRKW LX             PRKW JUNC                         40.555 KA      ANG:   -65.08

 B-PS3-USB                      3P Duty: 16.289 KA AT  -74.18 DEG (   5.87 MVA)  X/R:     3.53
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0020 + J  0.0071  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   16.289 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  16.744 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  16.289 KA
                TX-PS3-UTIL                     TX-PS3-UTIL P                     16.289 KA      ANG:   105.82
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               T H R E E   P H A S E   F A U L T   R E P O R T
                  (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                        PRE FAULT VOLTAGE: 1.0000
                        MODEL TRANSFORMER TAPS: NO
==============================================================================================================

 B-SBA-USB                     3P Duty: 30.433 KA AT  -77.34 DEG (  10.96 MVA)  X/R:     4.45
               VOLTAGE:   208.   EQUIV. IMPEDANCE=  0.0009 + J  0.0039  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER   30.433 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA  30.433 KA
               TX-SBA-UTIL                    TX-SBA-UTIL P                  30.433 KA      ANG:  102.66

 B-SBH DISC A-USB              3P Duty:  9.363 KA AT  -67.21 DEG (   3.89 MVA)  X/R:     2.38
               VOLTAGE:   240.   EQUIV. IMPEDANCE=  0.0057 + J  0.0136  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER    9.363 KA
               MOLDED CASE CIRCUIT BREAKER < 20KA   9.363 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA   9.363 KA
               C-SBH JUNC-SBH A               B-SBH JUNC                      9.363 KA      ANG:  112.79

 B-SBH DISC B-USB              3P Duty:  9.363 KA AT  -67.21 DEG (   3.89 MVA)  X/R:     2.38
               VOLTAGE:   240.   EQUIV. IMPEDANCE=  0.0057 + J  0.0136  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER    9.363 KA
               MOLDED CASE CIRCUIT BREAKER < 20KA   9.363 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA   9.363 KA
               C-SBH JUNC-SBH B               B-SBH JUNC                      9.363 KA      ANG:  -67.21

 B-SBH JUNC                    3P Duty:  9.626 KA AT  -68.52 DEG (   4.00 MVA)  X/R:     2.54
               VOLTAGE:   240.   EQUIV. IMPEDANCE=  0.0053 + J  0.0134  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER    9.626 KA
               MOLDED CASE CIRCUIT BREAKER < 20KA   9.626 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA   9.626 KA
               TX-SBH-UTIL                    TX-SBH-UTIL S                   9.626 KA      ANG:  111.48

 B-SEC NORTH ECB-USB           3P Duty: 40.607 KA AT  -77.50 DEG (  16.88 MVA)  X/R:     4.51
               VOLTAGE:   240.   EQUIV. IMPEDANCE=  0.0007 + J  0.0033  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER   40.607 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA  40.607 KA
               TX-SEC NORTH-UTIL-B            TX-SEC NORTH-UTIL-B P          40.607 KA      ANG: -257.50

 B-SEC NORTH PNL-USB           3P Duty: 40.607 KA AT  -77.50 DEG (  16.88 MVA)  X/R:     4.51
               VOLTAGE:   240.   EQUIV. IMPEDANCE=  0.0007 + J  0.0033  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER   40.607 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA  40.607 KA
               TX-SEC NORTH-UTIL-A            TX-SEC NORTH-UTIL-A P          40.607 KA      ANG: -257.50

 B-SEC SOUTH DISC 1A-USB       3P Duty: 36.472 KA AT  -72.82 DEG (  15.16 MVA)  X/R:     3.23
               VOLTAGE:   240.   EQUIV. IMPEDANCE=  0.0011 + J  0.0036  OHMS
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                T H R E E   P H A S E   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
                LOW VOLTAGE POWER CIRCUIT BREAKER   36.472 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  36.472 KA
                C-SEC JUNC-SEC 1A              B-SEC SOUTH-A JUNC               36.472 KA      ANG:  107.18

 B-SEC SOUTH DISC 2A-USB        3P Duty: 36.064 KA AT  -71.46 DEG (  14.99 MVA)  X/R:     2.98
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0012 + J  0.0036  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   36.064 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  36.064 KA
                C-SEC JUNC-SEC 2A              B-SEC SOUTH-B JUNC               36.064 KA      ANG:  108.54

 B-SEC SOUTH DISC 2B-USB        3P Duty: 36.064 KA AT  -71.46 DEG (  14.99 MVA)  X/R:     2.98
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0012 + J  0.0036  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   36.064 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  36.064 KA
                C-SEC JUNC-SEC 2B              B-SEC SOUTH-B JUNC               36.064 KA      ANG:  -71.46

 B-SEC SOUTH PNL 1B-USB         3P Duty: 36.064 KA AT  -71.46 DEG (  14.99 MVA)  X/R:     2.98
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0012 + J  0.0036  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   36.064 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  36.064 KA
                C-SEC JUNC-SEC 1B              B-SEC SOUTH-A JUNC               36.064 KA      ANG:  -71.46

 B-SEC SOUTH PNL 1C-USB         3P Duty: 36.064 KA AT  -71.46 DEG (  14.99 MVA)  X/R:     2.98
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0012 + J  0.0036  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   36.064 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  36.064 KA
                C-SEC JUNC-SEC 1C              B-SEC SOUTH-B JUNC               36.064 KA      ANG:  -71.46

 B-SEC SOUTH PNL 1D-USB         3P Duty: 36.064 KA AT  -71.46 DEG (  14.99 MVA)  X/R:     2.98
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0012 + J  0.0036  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   36.064 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  36.064 KA
                C-SEC JUNC-SEC 1D              B-SEC SOUTH-B JUNC               36.064 KA      ANG:  -71.46

 B-SEH-USB                      3P Duty: 33.251 KA AT  -74.12 DEG (  11.98 MVA)  X/R:     3.51
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0010 + J  0.0035  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   33.251 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  33.251 KA
                TX-SEH-UTIL                    TX-SEH-UTIL P                    33.251 KA      ANG:  105.88

 B-SH-USB                       3P Duty: 52.211 KA AT  -76.53 DEG (  18.81 MVA)  X/R:     4.18
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0005 + J  0.0022  OHMS
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                T H R E E   P H A S E   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
                LOW VOLTAGE POWER CIRCUIT BREAKER   52.211 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  52.211 KA
                TX-SH-UTIL                      TX-SH-UTIL P                       52.211 KA     ANG: -256.53

 B-STFR-USB                     3P Duty: 52.158 KA AT  -76.18 DEG (  21.68 MVA)  X/R:     4.07
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0006 + J  0.0026  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   52.158 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  52.158 KA
                TX-STFR-UTIL                    TX-STFR-UTIL P                     52.158 KA     ANG: -256.18

 B-STHL L1-USB                  3P Duty: 18.617 KA AT  -68.61 DEG (   7.74 MVA)  X/R:     2.55
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0027 + J  0.0069  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   18.617 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  18.617 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  18.617 KA
                C-STHL JUNC-STHL L1             B-STHL JUNC                        18.617 KA     ANG:   -68.61

 B-STHL L2-USB                  3P Duty: 18.452 KA AT  -68.18 DEG (   7.67 MVA)  X/R:     2.50
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0028 + J  0.0070  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   18.452 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  18.452 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  18.452 KA
                C-STHL JUNC-STHL L2             B-STHL JUNC                        18.452 KA     ANG:   -68.18

 B-STHL L3-USB                  3P Duty: 18.288 KA AT  -67.76 DEG (   7.60 MVA)  X/R:     2.45
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0029 + J  0.0070  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   18.288 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  18.288 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  18.288 KA
                C-STHL JUNC-STHL L3             B-STHL JUNC                        18.288 KA     ANG:   -67.76

 B-STHL L4-USB                  3P Duty: 18.126 KA AT  -67.35 DEG (   7.53 MVA)  X/R:     2.40
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0029 + J  0.0071  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   18.126 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  18.126 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  18.126 KA
                C-STHL JUNC-STHL L4             B-STHL JUNC                        18.126 KA     ANG:   -67.35

 B-STHL L5-USB                  3P Duty: 17.966 KA AT  -66.94 DEG (   7.47 MVA)  X/R:     2.35
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0030 + J  0.0071  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   17.966 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  17.966 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  17.966 KA
                C-STHL JUNC-STHL L5             B-STHL JUNC                        17.966 KA     ANG:   -66.94
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                T H R E E   P H A S E   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================

 B-STHL X-USB                  3P Duty: 17.809 KA AT  -66.54 DEG (   7.40 MVA)  X/R:     2.30
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0031 + J  0.0071  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   17.809 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  17.809 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  17.809 KA
                C-STHL JUNC-STHL X            B-STHL JUNC                      17.809 KA     ANG:   -66.54

 B-UCB-USB                     3P Duty: 31.924 KA AT  -77.85 DEG (  11.50 MVA)  X/R:     4.64
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0008 + J  0.0037  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   31.924 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  31.924 KA
                TX-UCB-UTIL                   TX-UCB-UTIL P                    31.924 KA     ANG:  -257.85

 B-UHP-USB                     3P Duty: 15.554 KA AT  -75.44 DEG (   6.47 MVA)  X/R:     3.85
                VOLTAGE:    240.   EQUIV. IMPEDANCE=  0.0022 + J  0.0086  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   15.554 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  16.345 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  15.554 KA
                TX-UHP-UTIL                  TX-UHP-UTIL P                     15.554 KA     ANG:  -255.44

 B-UP-A-USB                    3P Duty: 37.078 KA AT  -78.06 DEG (  30.83 MVA)  X/R:     4.73
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0015 + J  0.0073  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   37.078 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  37.078 KA
                TX-UP-UTIL-A                 TX-UP-UTIL-A P                    37.078 KA     ANG:   101.94

 B-UP-B-USB                    3P Duty: 57.220 KA AT  -76.47 DEG (  20.61 MVA)  X/R:     4.15
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0005 + J  0.0020  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   57.220 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  57.220 KA
                TX-UP UTIL-B                 TX-UP UTIL-B P                    57.220 KA     ANG:  -256.47

 B-URBN FP DISC-USB            3P Duty: 40.741 KA AT  -75.33 DEG (  33.87 MVA)  X/R:     3.82
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0017 + J  0.0066  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   40.741 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  40.741 KA
                TX-URBN-UTIL-B               TX-URBN-UTIL-B P                  40.741 KA     ANG:   104.67

 B-URBN SWBD-USB               3P Duty: 40.741 KA AT  -75.33 DEG (  33.87 MVA)  X/R:     3.82
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0017 + J  0.0066  OHMS
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                T H R E E   P H A S E   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
                LOW VOLTAGE POWER CIRCUIT BREAKER   40.741 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  40.741 KA
                TX-URBN-UTIL-A                  TX-URBN-UTIL-A P                 40.741 KA      ANG:   104.67

 B-EB-FP DISC-USB              3P Duty:  1.896 KA AT  -71.05 DEG (   1.58 MVA)  X/R:     2.92
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0475 + J  0.1383  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER    1.896 KA
                MOLDED CASE CIRCUIT BREAKER < 10KA   2.186 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA   1.896 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA   1.896 KA
                C-EB-TX-FP-FP DISC              TX-EB-FIRE PUMP S                 1.896 KA      ANG:   -71.05
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                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                    KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                  (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-AB ANNEX DISC-USB           3P Duty:  27.199    4. Z1=  10.2052       32.108    29.706
                             SLG DUTY:  26.736    4. Z2=  10.2052       31.376
                   208. VOLTS    LN/LN:  23.555       Z0=  10.7367
                            LN/LN/GND: 27.116 ( 26.287 GND RETURN KA)

B-AB DISC-USB                 3P Duty:  42.535    4. Z1=   6.5258       50.950    46.841
                             SLG DUTY:  41.429    4. Z2=   6.5258       49.180
                   208. VOLTS    LN/LN:  36.836       Z0=   7.0497
                            LN/LN/GND: 42.319 ( 40.377 GND RETURN KA)

B-AB PNLBRD-USB               3P Duty:  42.535    4. Z1=   6.5258       50.950    46.841
                             SLG DUTY:  41.429    4. Z2=   6.5258       49.180
                   208. VOLTS    LN/LN:  36.836       Z0=   7.0497
                            LN/LN/GND: 42.319 ( 40.377 GND RETURN KA)

B-ARC-A-USB                   3P Duty:  14.551    5. Z1=   8.2665       18.324    16.494
                             SLG DUTY:  14.259    5. Z2=   8.2665       17.720
                   480. VOLTS    LN/LN:  12.601       Z0=   8.7758
                            LN/LN/GND: 14.544 ( 13.978 GND RETURN KA)

B-ARC-B-USB                   3P Duty:  21.867    4. Z1=  12.6938       26.254    24.112
                             SLG DUTY:  21.574    4. Z2=  12.6938       25.725
                   208. VOLTS    LN/LN:  18.937       Z0=  13.2129
                            LN/LN/GND: 21.848 ( 21.287 GND RETURN KA)

B-BHB MSB-A-USB               3P Duty:  18.195    5. Z1=   6.6107       23.160    20.756
                             SLG DUTY:  17.744    5. Z2=   6.6107       22.264
                   480. VOLTS    LN/LN:  15.757       Z0=   7.1172
                            LN/LN/GND: 18.152 ( 17.313 GND RETURN KA)

B-BHB MSB-B-USB               3P Duty:  27.648    5. Z1=  10.0394       34.017    30.919
                             SLG DUTY:  27.192    4. Z2=  10.0394       33.193
                   208. VOLTS    LN/LN:  23.944       Z0=  10.5468
                            LN/LN/GND: 27.590 ( 26.748 GND RETURN KA)

B-BHB MSB-C-USB               3P Duty:  27.648    5. Z1=  10.0394       34.017    30.919
                             SLG DUTY:  27.192    4. Z2=  10.0394       33.193
                   208. VOLTS    LN/LN:  23.944       Z0=  10.5468
                            LN/LN/GND: 27.590 ( 26.748 GND RETURN KA)
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                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                     KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                   (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-BLKS K-USB                3P Duty:  31.323    1. Z1=   7.6800        31.650    31.487
                           SLG DUTY:   0.000    1. Z2=   7.6800         0.000
                   240. VOLTS    LN/LN:  27.127       Z0= INFINITE
                         LN/LN/GND: 27.127 (  0.000 GND RETURN KA)

B-BLKS L1-USB               3P Duty:  37.681    3. Z1=   6.3841        40.627    39.168
                           SLG DUTY:   0.000    1. Z2=   6.3841         0.000
                   240. VOLTS    LN/LN:  32.633       Z0= INFINITE
                         LN/LN/GND: 32.633 (  0.000 GND RETURN KA)

B-BLKS L2-USB               3P Duty:  37.681    3. Z1=   6.3841        40.627    39.168
                           SLG DUTY:   0.000    1. Z2=   6.3841         0.000
                   240. VOLTS    LN/LN:  32.633       Z0= INFINITE
                         LN/LN/GND: 32.633 (  0.000 GND RETURN KA)

B-BLKS L3-USB               3P Duty:  37.681    3. Z1=   6.3841        40.627    39.168
                           SLG DUTY:   0.000    1. Z2=   6.3841         0.000
                   240. VOLTS    LN/LN:  32.633       Z0= INFINITE
                         LN/LN/GND: 32.633 (  0.000 GND RETURN KA)

B-BLKS L4-USB               3P Duty:  37.681    3. Z1=   6.3841        40.627    39.168
                           SLG DUTY:   0.000    1. Z2=   6.3841         0.000
                   240. VOLTS    LN/LN:  32.633       Z0= INFINITE
                         LN/LN/GND: 32.633 (  0.000 GND RETURN KA)

B-BLKS L5-USB               3P Duty:  37.681    3. Z1=   6.3841        40.627    39.168
                           SLG DUTY:   0.000    1. Z2=   6.3841         0.000
                   240. VOLTS    LN/LN:  32.633       Z0= INFINITE
                         LN/LN/GND: 32.633 (  0.000 GND RETURN KA)

B-BLKS X-USB                3P Duty:  27.943    1. Z1=   8.6091        27.991    27.967
                           SLG DUTY:   0.000    1. Z2=   8.6091         0.000
                   240. VOLTS    LN/LN:  24.199       Z0= INFINITE
                         LN/LN/GND: 24.199 (  0.000 GND RETURN KA)

B-EB-52-U1                  3P Duty:   5.907    5. Z1=   0.7838         7.445     6.699
                           SLG DUTY:   5.659    5. Z2=   0.7838         7.116
                 12470. VOLTS    LN/LN:   5.115       Z0=   0.8878
                         LN/LN/GND:  5.889 (  5.429 GND RETURN KA)
```

```
                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                      KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                    (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-EB-52-U2                    3P Duty:   5.920    5. Z1=   0.7821        7.459     6.713
                             SLG DUTY:   5.682    5. Z2=   0.7821        7.142
                 12470. VOLTS    LN/LN:   5.127       Z0=   0.8814
                            LN/LN/GND:  5.909 (  5.460 GND RETURN KA)

B-EB-52-U3                    3P Duty:   5.914    5. Z1=   0.7828        7.454     6.708
                             SLG DUTY:   5.676    5. Z2=   0.7828        7.138
                 12470. VOLTS    LN/LN:   5.122       Z0=   0.8824
                            LN/LN/GND:  5.902 (  5.454 GND RETURN KA)

B-EB-USB-1                    3P Duty:  26.415    6. Z1=   4.5535       34.652    30.682
                             SLG DUTY:  26.006    6. Z2=   4.5535       33.599
                   480. VOLTS    LN/LN:  22.876       Z0=   4.7715
                            LN/LN/GND: 26.549 ( 25.604 GND RETURN KA)

B-EB-USB-2                    3P Duty:  26.440    6. Z1=   4.5491       34.742    30.742
                             SLG DUTY:  26.233    6. Z2=   4.5491       34.378
                   480. VOLTS    LN/LN:  22.898       Z0=   4.6577
                            LN/LN/GND: 26.471 ( 26.027 GND RETURN KA)

B-EB-USB-3                    3P Duty:  36.465    6. Z1=   7.6119       46.742    41.772
                             SLG DUTY:  36.180    5. Z2=   7.6119       46.099
                   208. VOLTS    LN/LN:  31.580       Z0=   7.7930
                            LN/LN/GND: 36.543 ( 35.898 GND RETURN KA)

B-EB-USB-5                    3P Duty:  25.794    6. Z1=   4.6632       33.781    29.930
                             SLG DUTY:  25.579    6. Z2=   4.6632       33.394
                   480. VOLTS    LN/LN:  22.338       Z0=   4.7813
                            LN/LN/GND: 25.823 ( 25.366 GND RETURN KA)

B-EB-USB-6                    3P Duty:  26.407    6. Z1=   4.5549       34.618    30.660
                             SLG DUTY:  25.995    6. Z2=   4.5549       33.560
                   480. VOLTS    LN/LN:  22.869       Z0=   4.7747
                            LN/LN/GND: 26.541 ( 25.589 GND RETURN KA)

B-EB-USB-7                    3P Duty:  26.432    6. Z1=   4.5505       34.708    30.720
                             SLG DUTY:  26.221    6. Z2=   4.5505       34.336
                   480. VOLTS    LN/LN:  22.891       Z0=   4.6609
                            LN/LN/GND: 26.463 ( 26.013 GND RETURN KA)
```

```
Feb 21, 2013     17:45:50               UNBALANCED LOW VOLTAGE DUTY PAGE    4
PSU - Non-West Campus Loop
Portland, OR
ESE0008355 / TQSISE0008355.1

                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                     KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                   (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-EH A-USB                     3P Duty:  22.718    2. Z1=  10.5892        24.186    23.458
                              SLG DUTY:   0.000    1. Z2=  10.5892         0.000
                   240. VOLTS    LN/LN:  19.674       Z0= INFINITE
                             LN/LN/GND: 19.674 (  0.000 GND RETURN KA)

B-EH B-USB                     3P Duty:  22.718    2. Z1=  10.5892        24.186    23.458
                              SLG DUTY:   0.000    1. Z2=  10.5892         0.000
                   240. VOLTS    LN/LN:  19.674       Z0= INFINITE
                             LN/LN/GND: 19.674 (  0.000 GND RETURN KA)

B-EH C-USB                     3P Duty:  22.718    2. Z1=  10.5892        24.186    23.458
                              SLG DUTY:   0.000    1. Z2=  10.5892         0.000
                   240. VOLTS    LN/LN:  19.674       Z0= INFINITE
                             LN/LN/GND: 19.674 (  0.000 GND RETURN KA)

B-EH E DISC-USB                3P Duty:  22.718    2. Z1=  10.5892        24.186    23.458
                              SLG DUTY:   0.000    1. Z2=  10.5892         0.000
                   240. VOLTS    LN/LN:  19.674       Z0= INFINITE
                             LN/LN/GND: 19.674 (  0.000 GND RETURN KA)

B-HGDC-USB                     3P Duty:  44.761    4. Z1=   5.3743        54.119    49.556
                              SLG DUTY:  44.481    4. Z2=   5.3743        53.035
                   240. VOLTS    LN/LN:  38.765       Z0=   5.4788
                             LN/LN/GND: 45.141 ( 44.197 GND RETURN KA)

B-HH 1-USB                     3P Duty:  50.812    4. Z1=   4.7344        59.319    55.150
                              SLG DUTY:   0.000    1. Z2=   4.7344         0.000
                   240. VOLTS    LN/LN:  44.004       Z0= INFINITE
                             LN/LN/GND: 44.004 (  0.000 GND RETURN KA)

B-HH 2-USB                     3P Duty:  45.858    2. Z1=   5.2458        48.492    47.185
                              SLG DUTY:   0.000    1. Z2=   5.2458         0.000
                   240. VOLTS    LN/LN:  39.714       Z0= INFINITE
                             LN/LN/GND: 39.714 (  0.000 GND RETURN KA)

B-HOFF-USB                     3P Duty:  33.251    4. Z1=   8.3477        38.413    35.880
                              SLG DUTY:  32.921    3. Z2=   8.3477        37.547
                   208. VOLTS    LN/LN:  28.796       Z0=   8.6050
                             LN/LN/GND: 33.523 ( 32.589 GND RETURN KA)
```

```
                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                     KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                   (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-HSB-USB                      3P Duty:  48.870    4. Z1=   4.9225       56.423    52.717
                              SLG DUTY:   0.000    1. Z2=   4.9225        0.000
                   240. VOLTS    LN/LN:  42.323       Z0= INFINITE
                             LN/LN/GND: 42.323 (  0.000 GND RETURN KA)

B-JCB-USB                      3P Duty:  33.473    4. Z1=   8.2924       40.861    37.264
                              SLG DUTY:  33.235    4. Z2=   8.2924       40.005
                   208. VOLTS    LN/LN:  28.988       Z0=   8.4748
                             LN/LN/GND: 33.730 ( 32.995 GND RETURN KA)

B-KHSE-USB                     3P Duty:  30.433    4. Z1=   9.1207       37.119    33.863
                              SLG DUTY:  29.853    4. Z2=   9.1207       35.994
                   208. VOLTS    LN/LN:  26.356       Z0=   9.6560
                             LN/LN/GND: 30.424 ( 29.290 GND RETURN KA)

B-KNGA-USB                     3P Duty:  48.870    4. Z1=   4.9225       56.423    52.717
                              SLG DUTY:   0.000    1. Z2=   4.9225        0.000
                   240. VOLTS    LN/LN:  42.323       Z0= INFINITE
                             LN/LN/GND: 42.323 (  0.000 GND RETURN KA)

B-MCB BSMT-USB                 3P Duty:   7.999    4. Z1=  15.0362        9.572     8.804
                              SLG DUTY:   9.224    3. Z2=  15.0362       10.058
                   480. VOLTS    LN/LN:   6.928       Z0=  10.9149
                             LN/LN/GND: 10.178 ( 10.376 GND RETURN KA)

B-MCB PNTHS-USB                3P Duty:  32.032    5. Z1=   3.7551       39.632    35.938
                              SLG DUTY:  28.222    3. Z2=   3.7551       31.061
                   480. VOLTS    LN/LN:  27.740       Z0=   5.4400
                             LN/LN/GND: 33.004 ( 24.903 GND RETURN KA)

B-MONT-USB                     3P Duty:  41.312    3. Z1=   5.8230       46.967    44.186
                              SLG DUTY:   0.000    1. Z2=   5.8230        0.000
                   240. VOLTS    LN/LN:  35.777       Z0= INFINITE
                             LN/LN/GND: 35.777 (  0.000 GND RETURN KA)

B-NASC-USB                     3P Duty:  15.562    3. Z1=  17.8360       17.833    16.718
                              SLG DUTY:  15.231    3. Z2=  17.8360       17.400
                   208. VOLTS    LN/LN:  13.477       Z0=  19.0002
                             LN/LN/GND: 15.451 ( 14.914 GND RETURN KA)
```

```
                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                     KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                   (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-OND 15 FLR-USB               3P Duty:  21.349    4. Z1=  11.2683        24.966    23.194
                              SLG DUTY:   0.000    1. Z2=  11.2683         0.000
                   240. VOLTS    LN/LN:  18.488       Z0= INFINITE
                             LN/LN/GND: 18.488 (  0.000 GND RETURN KA)

B-OND ANNEX SWBD-USB           3P Duty:  38.166    5. Z1=   7.2727        46.958    42.682
                              SLG DUTY:  39.756    5. Z2=   7.2727        48.967
                   208. VOLTS    LN/LN:  33.053       Z0=   6.4000
                             LN/LN/GND: 38.987 ( 41.485 GND RETURN KA)

B-OND MAIN SWBD-USB            3P Duty:  15.962    4. Z1=   7.5355        19.181    17.610
                              SLG DUTY:  16.600    4. Z2=   7.5355        19.939
                   480. VOLTS    LN/LN:  13.824       Z0=   6.6665
                             LN/LN/GND: 16.311 ( 17.291 GND RETURN KA)

B-PRKW L1-USB                  3P Duty:  40.555    2. Z1=   5.9318        42.689    41.629
                              SLG DUTY:   0.000    1. Z2=   5.9318         0.000
                   240. VOLTS    LN/LN:  35.121       Z0= INFINITE
                             LN/LN/GND: 35.121 (  0.000 GND RETURN KA)

B-PRKW L2-USB                  3P Duty:  40.555    2. Z1=   5.9318        42.689    41.629
                              SLG DUTY:   0.000    1. Z2=   5.9318         0.000
                   240. VOLTS    LN/LN:  35.121       Z0= INFINITE
                             LN/LN/GND: 35.121 (  0.000 GND RETURN KA)

B-PRKW L3-USB                  3P Duty:  40.555    2. Z1=   5.9318        42.689    41.629
                              SLG DUTY:   0.000    1. Z2=   5.9318         0.000
                   240. VOLTS    LN/LN:  35.121       Z0= INFINITE
                             LN/LN/GND: 35.121 (  0.000 GND RETURN KA)

B-PRKW L4-USB                  3P Duty:  40.555    2. Z1=   5.9318        42.689    41.629
                              SLG DUTY:   0.000    1. Z2=   5.9318         0.000
                   240. VOLTS    LN/LN:  35.121       Z0= INFINITE
                             LN/LN/GND: 35.121 (  0.000 GND RETURN KA)

B-PRKW L5-USB                  3P Duty:  40.555    2. Z1=   5.9318        42.689    41.629
                              SLG DUTY:   0.000    1. Z2=   5.9318         0.000
                   240. VOLTS    LN/LN:  35.121       Z0= INFINITE
                             LN/LN/GND: 35.121 (  0.000 GND RETURN KA)
```

```
                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                    KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                  (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-PRKW X-USB                3P Duty:  40.555    2. Z1=   5.9318       42.689    41.629
                           SLG DUTY:   0.000    1. Z2=   5.9318        0.000
                   240. VOLTS    LN/LN:  35.121       Z0= INFINITE
                          LN/LN/GND: 35.121 (  0.000 GND RETURN KA)

B-PS3-USB                   3P Duty:  16.289    4. Z1=  17.0409       18.836    17.586
                           SLG DUTY:  16.255    3. Z2=  17.0409       18.733
                   208. VOLTS    LN/LN:  14.106       Z0=  17.1464
                          LN/LN/GND: 16.329 ( 16.222 GND RETURN KA)

B-SBA-USB                   3P Duty:  30.433    4. Z1=   9.1207       37.119    33.863
                           SLG DUTY:  29.853    4. Z2=   9.1207       35.994
                   208. VOLTS    LN/LN:  26.356       Z0=   9.6560
                          LN/LN/GND: 30.424 ( 29.290 GND RETURN KA)

B-SBH DISC A-USB            3P Duty:   9.363    2. Z1=  25.6916       10.010     9.689
                           SLG DUTY:   0.000    1. Z2=  25.6916        0.000
                   240. VOLTS    LN/LN:   8.109       Z0= INFINITE
                          LN/LN/GND:  8.109 (  0.000 GND RETURN KA)

B-SBH DISC B-USB            3P Duty:   9.363    2. Z1=  25.6916       10.010     9.689
                           SLG DUTY:   0.000    1. Z2=  25.6916        0.000
                   240. VOLTS    LN/LN:   8.109       Z0= INFINITE
                          LN/LN/GND:  8.109 (  0.000 GND RETURN KA)

B-SBH JUNC                  3P Duty:   9.626    3. Z1=  24.9904       10.406    10.020
                           SLG DUTY:   0.000    1. Z2=  24.9904        0.000
                   240. VOLTS    LN/LN:   8.337       Z0= INFINITE
                          LN/LN/GND:  8.337 (  0.000 GND RETURN KA)

B-SEC NORTH ECB-USB         3P Duty:  40.607    5. Z1=   5.9241       49.681    45.264
                           SLG DUTY:   0.000    1. Z2=   5.9241        0.000
                   240. VOLTS    LN/LN:  35.167       Z0= INFINITE
                          LN/LN/GND: 35.167 (  0.000 GND RETURN KA)

B-SEC NORTH PNL-USB         3P Duty:  40.607    5. Z1=   5.9241       49.681    45.264
                           SLG DUTY:   0.000    1. Z2=   5.9241        0.000
                   240. VOLTS    LN/LN:  35.167       Z0= INFINITE
                          LN/LN/GND: 35.167 (  0.000 GND RETURN KA)
```

```
                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                     KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                   (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-SEC SOUTH DISC 1A-USB        3P Duty:  36.472    3. Z1=   6.5959       41.369    38.960
                              SLG DUTY:   0.000    1. Z2=   6.5959        0.000
                   240. VOLTS    LN/LN:  31.585       Z0= INFINITE
                             LN/LN/GND: 31.585 (  0.000 GND RETURN KA)

B-SEC SOUTH DISC 2A-USB        3P Duty:  36.064    3. Z1=   6.6704       40.213    38.167
                              SLG DUTY:   0.000    1. Z2=   6.6704        0.000
                   240. VOLTS    LN/LN:  31.232       Z0= INFINITE
                             LN/LN/GND: 31.232 (  0.000 GND RETURN KA)

B-SEC SOUTH DISC 2B-USB        3P Duty:  36.064    3. Z1=   6.6704       40.213    38.167
                              SLG DUTY:   0.000    1. Z2=   6.6704        0.000
                   240. VOLTS    LN/LN:  31.232       Z0= INFINITE
                             LN/LN/GND: 31.232 (  0.000 GND RETURN KA)

B-SEC SOUTH PNL 1B-USB         3P Duty:  36.064    3. Z1=   6.6704       40.213    38.167
                              SLG DUTY:   0.000    1. Z2=   6.6704        0.000
                   240. VOLTS    LN/LN:  31.232       Z0= INFINITE
                             LN/LN/GND: 31.232 (  0.000 GND RETURN KA)

B-SEC SOUTH PNL 1C-USB         3P Duty:  36.064    3. Z1=   6.6704       40.213    38.167
                              SLG DUTY:   0.000    1. Z2=   6.6704        0.000
                   240. VOLTS    LN/LN:  31.232       Z0= INFINITE
                             LN/LN/GND: 31.232 (  0.000 GND RETURN KA)

B-SEC SOUTH PNL 1D-USB         3P Duty:  36.064    3. Z1=   6.6704       40.213    38.167
                              SLG DUTY:   0.000    1. Z2=   6.6704        0.000
                   240. VOLTS    LN/LN:  31.232       Z0= INFINITE
                             LN/LN/GND: 31.232 (  0.000 GND RETURN KA)

B-SEH-USB                      3P Duty:  33.251    4. Z1=   8.3477       38.413    35.880
                              SLG DUTY:  32.921    3. Z2=   8.3477       37.547
                   208. VOLTS    LN/LN:  28.796       Z0=   8.6050
                             LN/LN/GND: 33.523 ( 32.589 GND RETURN KA)

B-SH-USB                       3P Duty:  52.211    4. Z1=   5.3164       62.741    57.602
                              SLG DUTY:  50.413    4. Z2=   5.3164       59.577
                   208. VOLTS    LN/LN:  45.216       Z0=   5.8893
                             LN/LN/GND: 52.059 ( 48.723 GND RETURN KA)
```

```
                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                    KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                  (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-STFR-USB                    3P Duty:  52.158    4. Z1=   4.6122       62.298    57.345
                             SLG DUTY:   0.000    1. Z2=   4.6122        0.000
                   240. VOLTS    LN/LN:  45.170       Z0= INFINITE
                            LN/LN/GND: 45.170 (  0.000 GND RETURN KA)

B-STHL L1-USB                 3P Duty:  18.617    3. Z1=  12.9216       20.144    19.388
                             SLG DUTY:   0.000    1. Z2=  12.9216        0.000
                   240. VOLTS    LN/LN:  16.123       Z0= INFINITE
                            LN/LN/GND: 16.123 (  0.000 GND RETURN KA)

B-STHL L2-USB                 3P Duty:  18.452    2. Z1=  13.0375       19.887    19.176
                             SLG DUTY:   0.000    1. Z2=  13.0375        0.000
                   240. VOLTS    LN/LN:  15.980       Z0= INFINITE
                            LN/LN/GND: 15.980 (  0.000 GND RETURN KA)

B-STHL L3-USB                 3P Duty:  18.288    2. Z1=  13.1542       19.639    18.970
                             SLG DUTY:   0.000    1. Z2=  13.1542        0.000
                   240. VOLTS    LN/LN:  15.838       Z0= INFINITE
                            LN/LN/GND: 15.838 (  0.000 GND RETURN KA)

B-STHL L4-USB                 3P Duty:  18.126    2. Z1=  13.2715       19.398    18.768
                             SLG DUTY:   0.000    1. Z2=  13.2715        0.000
                   240. VOLTS    LN/LN:  15.698       Z0= INFINITE
                            LN/LN/GND: 15.698 (  0.000 GND RETURN KA)

B-STHL L5-USB                 3P Duty:  17.966    2. Z1=  13.3896       19.165    18.571
                             SLG DUTY:   0.000    1. Z2=  13.3896        0.000
                   240. VOLTS    LN/LN:  15.559       Z0= INFINITE
                            LN/LN/GND: 15.559 (  0.000 GND RETURN KA)

B-STHL X-USB                  3P Duty:  17.809    2. Z1=  13.5083       18.938    18.378
                             SLG DUTY:   0.000    1. Z2=  13.5083        0.000
                   240. VOLTS    LN/LN:  15.423       Z0= INFINITE
                            LN/LN/GND: 15.423 (  0.000 GND RETURN KA)

B-UCB-USB                     3P Duty:  31.924    5. Z1=   8.6949       39.317    35.721
                             SLG DUTY:  31.306    4. Z2=   8.6949       38.113
                   208. VOLTS    LN/LN:  27.647       Z0=   9.2126
                            LN/LN/GND: 31.900 ( 30.708 GND RETURN KA)
```

```
                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                     KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                   (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-UHP-USB                     3P Duty:  15.554    4. Z1=  15.4667        18.344    16.979
                             SLG DUTY:   0.000    1. Z2=  15.4667         0.000
                   240. VOLTS    LN/LN:  13.470       Z0= INFINITE
                             LN/LN/GND: 13.470 (  0.000 GND RETURN KA)

B-UP-A-USB                    3P Duty:  37.078    5. Z1=   3.2440        45.854    41.589
                             SLG DUTY:  34.143    4. Z2=   3.2440        41.044
                   480. VOLTS    LN/LN:  32.111       Z0=   4.0864
                             LN/LN/GND: 36.476 ( 31.621 GND RETURN KA)

B-UP-B-USB                    3P Duty:  57.220    4. Z1=   4.8510        68.683    63.088
                             SLG DUTY:  54.081    4. Z2=   4.8510        63.856
                   208. VOLTS    LN/LN:  49.554       Z0=   5.6994
                             LN/LN/GND: 56.506 ( 51.256 GND RETURN KA)

B-URBN FP DISC-USB            3P Duty:  40.741    4. Z1=   2.9523        47.967    44.431
                             SLG DUTY:  38.206    3. Z2=   2.9523        43.595
                   480. VOLTS    LN/LN:  35.283       Z0=   3.5504
                             LN/LN/GND: 40.669 ( 35.929 GND RETURN KA)

B-URBN SWBD-USB               3P Duty:  40.741    4. Z1=   2.9523        47.967    44.431
                             SLG DUTY:  38.206    3. Z2=   2.9523        43.595
                   480. VOLTS    LN/LN:  35.283       Z0=   3.5504
                             LN/LN/GND: 40.669 ( 35.929 GND RETURN KA)

B-EB-FP DISC-USB              3P Duty:   1.896    3. Z1=  63.4516         2.105     2.002
                             SLG DUTY:   1.894    3. Z2=  63.4516         2.097
                   480. VOLTS    LN/LN:   1.642       Z0=  63.6019
                             LN/LN/GND:  1.902 (  1.893 GND RETURN KA)
```

F A U L T   S T U D Y   S U M M A R Y
(FOR APPLICATION OF LOW VOLTAGE BREAKERS)
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

BUS RECORD NO NAME	VOLTAGE L-L	AVAILABLE FAULT DUTIES (KA) 3 PHASE	X/R	LINE/GRND	X/R
B-AB ANNEX DISC-USB	208.	27.199	3.86	26.736	3.77
B-AB DISC-USB	208.	42.535	4.12	41.429	3.96
B-AB PNLBRD-USB	208.	42.535	4.12	41.429	3.96
B-ARC-A-USB	480.	14.551	5.12	14.259	4.83
B-ARC-B-USB	208.	21.867	4.16	21.574	4.04
B-BHB MSB-A-USB	480.	18.195	5.37	17.744	5.04
B-BHB MSB-B-USB	208.	27.648	4.62	27.192	4.47
B-BHB MSB-C-USB	208.	27.648	4.62	27.192	4.47
B-BLKS K-USB	240.	31.323	1.38	0.000	1.00
B-BLKS L1-USB	240.	37.681	2.50	0.000	1.00
B-BLKS L2-USB	240.	37.681	2.50	0.000	1.00
B-BLKS L3-USB	240.	37.681	2.50	0.000	1.00
B-BLKS L4-USB	240.	37.681	2.50	0.000	1.00
B-BLKS L5-USB	240.	37.681	2.50	0.000	1.00
B-BLKS X-USB	240.	27.943	0.99	0.000	1.00
B-EB-52-U1	12470.	5.907	5.14	5.659	5.09
B-EB-52-U2	12470.	5.920	5.13	5.682	5.07
B-EB-52-U3	12470.	5.914	5.14	5.676	5.09
B-EB-USB-1	480.	26.415	6.16	26.006	5.74
B-EB-USB-2	480.	26.440	6.20	26.233	6.13
B-EB-USB-3	208.	36.465	5.54	36.180	5.39
B-EB-USB-5	480.	25.794	6.11	25.579	6.02
B-EB-USB-6	480.	26.407	6.14	25.995	5.72
B-EB-USB-7	480.	26.432	6.19	26.221	6.11
B-EH A-USB	240.	22.718	2.32	0.000	1.00
B-EH B-USB	240.	22.718	2.32	0.000	1.00
B-EH C-USB	240.	22.718	2.32	0.000	1.00
B-EH E DISC-USB	240.	22.718	2.32	0.000	1.00
B-HGDC-USB	240.	44.761	4.29	44.481	4.04
B-HH 1-USB	240.	50.812	3.68	0.000	1.00
B-HH 2-USB	240.	45.858	2.22	0.000	1.00
B-HOFF-USB	208.	33.251	3.51	32.921	3.32
B-HSB-USB	240.	48.870	3.50	0.000	1.00
B-JCB-USB	208.	33.473	4.47	33.235	4.21
B-KHSE-USB	208.	30.433	4.45	29.853	4.24
B-KNGA-USB	240.	48.870	3.50	0.000	1.00
B-MCB BSMT-USB	480.	7.999	4.10	9.224	2.66
B-MCB PNTHS-USB	480.	32.032	4.74	28.222	2.80
B-MONT-USB	240.	41.312	3.27	0.000	1.00
B-NASC-USB	208.	15.562	3.39	15.231	3.34
B-OND 15 FLR-USB	240.	21.349	3.71	0.000	1.00
B-OND ANNEX SWBD-USB	208.	38.166	4.62	39.756	4.64
B-OND MAIN SWBD-USB	480.	15.962	4.17	16.600	4.17
B-PRKW L1-USB	240.	40.555	2.15	0.000	1.00

F A U L T   S T U D Y   S U M M A R Y
(FOR APPLICATION OF LOW VOLTAGE BREAKERS)
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

BUS RECORD NO NAME	VOLTAGE L-L	A V A I L A B L E F A U L T D U T I E S (KA) 3 PHASE	X/R	LINE/GRND	X/R
B-PRKW L2-USB	240.	40.555	2.15	0.000	1.00
B-PRKW L3-USB	240.	40.555	2.15	0.000	1.00
B-PRKW L4-USB	240.	40.555	2.15	0.000	1.00
B-PRKW L5-USB	240.	40.555	2.15	0.000	1.00
B-PRKW X-USB	240.	40.555	2.15	0.000	1.00
B-PS3-USB	208.	16.289	3.53	16.255	3.48
B-SBA-USB	208.	30.433	4.45	29.853	4.24
B-SBH DISC A-USB	240.	9.363	2.38	0.000	1.00
B-SBH DISC B-USB	240.	9.363	2.38	0.000	1.00
B-SBH JUNC	240.	9.626	2.54	0.000	1.00
B-SEC NORTH ECB-USB	240.	40.607	4.51	0.000	1.00
B-SEC NORTH PNL-USB	240.	40.607	4.51	0.000	1.00
B-SEC SOUTH DISC 1A-USB	240.	36.472	3.23	0.000	1.00
B-SEC SOUTH DISC 2A-USB	240.	36.064	2.98	0.000	1.00
B-SEC SOUTH DISC 2B-USB	240.	36.064	2.98	0.000	1.00
B-SEC SOUTH PNL 1B-USB	240.	36.064	2.98	0.000	1.00
B-SEC SOUTH PNL 1C-USB	240.	36.064	2.98	0.000	1.00
B-SEC SOUTH PNL 1D-USB	240.	36.064	2.98	0.000	1.00
B-SEH-USB	208.	33.251	3.51	32.921	3.32
B-SH-USB	208.	52.211	4.18	50.413	3.88
B-STFR-USB	240.	52.158	4.07	0.000	1.00
B-STHL L1-USB	240.	18.617	2.55	0.000	1.00
B-STHL L2-USB	240.	18.452	2.50	0.000	1.00
B-STHL L3-USB	240.	18.288	2.45	0.000	1.00
B-STHL L4-USB	240.	18.126	2.40	0.000	1.00
B-STHL L5-USB	240.	17.966	2.35	0.000	1.00
B-STHL X-USB	240.	17.809	2.30	0.000	1.00
B-UCB-USB	208.	31.924	4.64	31.306	4.42
B-UHP-USB	240.	15.554	3.85	0.000	1.00
B-UP-A-USB	480.	37.078	4.73	34.143	4.18
B-UP-B-USB	208.	57.220	4.15	54.081	3.87
B-URBN FP DISC-USB	480.	40.741	3.82	38.206	3.32
B-URBN SWBD-USB	480.	40.741	3.82	38.206	3.32
B-EB-FP DISC-USB	480.	1.896	2.92	1.894	2.88

148 FAULTED BUSES, 150 BRANCHES,   44 CONTRIBUTIONS
UNBALANCED FAULTS REQUESTED

*** SHORT CIRCUIT STUDY COMPLETE ***

PSU - Non-West Campus Loop
Portland, OR
ESE0008355 / TQSISE0008355.1

```
     T H R E E   P H A S E   M O M E N T A R Y   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================

 B-AB ANNEX DISC-USB            VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-AB DISC-USB                  VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-AB PNLBRD-USB                VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-ARC-A-USB                    VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-ARC-B-USB                    VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-BHB MSB-A-USB                VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-BHB MSB-B-USB                VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-BHB MSB-C-USB                VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-BLKS K-USB                   VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-BLKS L1-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-BLKS L2-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-BLKS L3-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-BLKS L4-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-BLKS L5-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-BLKS X-USB                   VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-EB-52-U1                     E/Z:      5.907 KA AT  -75.14 DEG ( 127.58 MVA)  X/R:     5.14
                                SYM*1.6:    9.451 KA       MOMENTARY BASED ON X/R:    7.445 KA
                                SYM*2.7:   15.948 KA           CREST BASED ON X/R:   12.885 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3126 + J  1.1781  OHMS

 B-EB-52-U2                     E/Z:      5.920 KA AT  -75.13 DEG ( 127.86 MVA)  X/R:     5.13
                                SYM*1.6:    9.471 KA       MOMENTARY BASED ON X/R:    7.459 KA
                                SYM*2.7:   15.983 KA           CREST BASED ON X/R:   12.910 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3122 + J  1.1755  OHMS
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     T H R E E   P H A S E   M O M E N T A R Y   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
============================================================================================

                CONTRIBUTIONS TO  B-EB-52-U2                    (CONTINUED)

 B-EB-52-U3                     E/Z:      5.914 KA AT  -75.13 DEG ( 127.74 MVA)  X/R:     5.14
                                SYM*1.6:    9.463 KA       MOMENTARY BASED ON X/R:    7.454 KA
                                SYM*2.7:   15.969 KA           CREST BASED ON X/R:   12.901 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3123 + J  1.1765  OHMS

 B-EB-USB-1                     VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-EB-USB-2                     VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-EB-USB-3                     VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-EB-USB-5                     VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-EB-USB-6                     VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-EB-USB-7                     VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-EH A-USB                     VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-EH B-USB                     VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-EH C-USB                     VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-EH E DISC-USB                VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-HGDC-USB                     VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-HH 1-USB                     VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-HH 2-USB                     VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-HOFF-USB                     VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-HSB-USB                      VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-JCB-USB                      VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )
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T H R E E   P H A S E   M O M E N T A R Y   D U T Y   R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

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B-KHSE-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-KNGA-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-MCB BSMT-USB	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
B-MCB PNTHS-USB	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
B-MONT-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-NASC-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-OND 15 FLR-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-OND ANNEX SWBD-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-OND MAIN SWBD-USB	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
B-PRKW L1-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-PRKW L2-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-PRKW L3-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-PRKW L4-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-PRKW L5-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-PRKW X-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-PS3-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-SBA-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-SBH DISC A-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SBH DISC B-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SBH JUNC	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SEC NORTH ECB-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SEC NORTH PNL-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)

T H R E E   P H A S E   M O M E N T A R Y   D U T Y   R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

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B-SEC SOUTH DISC 1A-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SEC SOUTH DISC 2A-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SEC SOUTH DISC 2B-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SEC SOUTH PNL 1B-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SEC SOUTH PNL 1C-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SEC SOUTH PNL 1D-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SEH-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-SH-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-STFR-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-STHL L1-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-STHL L2-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-STHL L3-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-STHL L4-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-STHL L5-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-STHL X-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-UCB-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-UHP-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-UP-A-USB	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
B-UP-B-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-URBN FP DISC-USB	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
B-URBN SWBD-USB	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
B-EB-FP DISC-USB	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)

U N B A L A N C E D M O M E N T A R Y D U T Y R E P O R T

PRE FAULT VOLTAGE: 1.0000

MODEL TRANSFORMER TAPS: NO

LOCATION	VOLTAGE	FAULT TYPE	E/Z KA	X/R	EQUIVALENT IMPEDANCE (PU)	MOMENTARY FAULT DUTIES E/Z * 1.6	@ 0.5 CYCLE
		3P Duty:	5.91	5.1	Z1= 0.7838	9.45	7.44
B-EB-52-U1		SLG DUTY:	5.66	5.1	Z2= 0.7838	9.05	7.12
	12470.	VOLTS LN/LN:	5.12		Z0= 0.8878		
		LN/LN/GND:	5.89 (		5.43 GND RETURN KA)		
		3P Duty:	5.92	5.1	Z1= 0.7821	9.47	7.46
B-EB-52-U2		SLG DUTY:	5.68	5.1	Z2= 0.7821	9.09	7.14
	12470.	VOLTS LN/LN:	5.13		Z0= 0.8814		
		LN/LN/GND:	5.91 (		5.46 GND RETURN KA)		
		3P Duty:	5.91	5.1	Z1= 0.7828	9.46	7.45
B-EB-52-U3		SLG DUTY:	5.68	5.1	Z2= 0.7828	9.08	7.14
	12470.	VOLTS LN/LN:	5.12		Z0= 0.8824		
		LN/LN/GND:	5.90 (		5.45 GND RETURN KA)		

PSU - Non-West Campus Loop
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ESE0008355 / TQSISE0008355.1

M O M E N T A R Y   D U T Y   S U M M A R Y   R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO
SOLUTION METHOD   : E/Z

BUS RECORD NO NAME	VOLTAGE L-L	* 3 PHASE * KA	X/R	* * * SLG * * * KA	X/R
B-EB-52-U1	12470.	7.445	5.14	7.116	5.09
B-EB-52-U2	12470.	7.459	5.13	7.142	5.07
B-EB-52-U3	12470.	7.454	5.14	7.138	5.09

54 FAULTED BUSES, 150 BRANCHES,   44 CONTRIBUTIONS
UNBALANCED FAULTS REQUESTED

*** SHORT CIRCUIT STUDY COMPLETE ***

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     T H R E E   P H A S E   I N T E R R U P U T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================

 B-AB ANNEX DISC-USB            VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-AB DISC-USB                  VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-AB PNLBRD-USB                VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-ARC-A-USB                    VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-ARC-B-USB                    VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-BHB MSB-A-USB                VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-BHB MSB-B-USB                VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-BHB MSB-C-USB                VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-BLKS K-USB                   VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-BLKS L1-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-BLKS L2-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-BLKS L3-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-BLKS L4-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-BLKS L5-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-BLKS X-USB                   VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-EB-52-U1                     E/Z:      5.907 KA AT  -75.14 DEG ( 127.58 MVA)  X/R:     5.14
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3126 + J  1.1781  OHMS
                CONTRIBUTIONS:  B-EB-52-U3         5.907 KA      ANG:   -75.14

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            EB-UTIL-B                                     4.976     0.00         R
            G-EB GEN                                      0.952     0.45         L
                TOTAL REMOTE:     4.976 KA  NACD RATIO:  0.8424

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :    5.907    5.907    5.907    5.907

                               TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.049    1.000    1.000    1.000
                DUTY (KA) :    6.198    5.907    5.907    5.907
```

PSU - Non-West Campus Loop
Portland, OR
ESE0008355 / TQSISE0008355.1

```
  T H R E E   P H A S E   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================

 B-EB-52-U2                    E/Z:      5.920 KA AT  -75.13 DEG ( 127.86 MVA)  X/R:     5.13
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3122 + J  1.1755  OHMS
                C-UTIL-BK-EB-5  EB-UTIL-B BUS      4.988 KA      ANG:  -253.01
                C-EB-52-U3-52-  B-EB-52-U3         0.953 KA      ANG:   -86.25

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            EB-UTIL-B                                      4.988     0.00         R
            G-EB GEN                                       0.953     0.45         L
                TOTAL REMOTE:     4.988 KA  NACD RATIO:  0.8426

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :    5.920    5.920    5.920    5.920

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.049    1.000    1.000    1.000
                DUTY (KA) :    6.210    5.920    5.920    5.920

 B-EB-52-U3                    E/Z:      5.914 KA AT  -75.13 DEG ( 127.74 MVA)  X/R:     5.14
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3123 + J  1.1765  OHMS
                C-EB-USB-8-52-  USB-8 S            0.953 KA      ANG:    93.74
                C-EB-52-U3-52-  B-EB-52-U2         4.982 KA      ANG:  -253.02

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            EB-UTIL-B                                      4.982     0.00         R
            G-EB GEN                                       0.953     0.45         L
                TOTAL REMOTE:     4.982 KA  NACD RATIO:  0.8424

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :    5.914    5.914    5.914    5.914

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.049    1.000    1.000    1.000
                DUTY (KA) :    6.206    5.914    5.914    5.914
```

T H R E E   P H A S E   I N T E R R U P T I N G   D U T Y   R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO
NACD OPTION: INTERPOLATED

B-EB-USB-1	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
B-EB-USB-2	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
B-EB-USB-3	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-EB-USB-5	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
B-EB-USB-6	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
B-EB-USB-7	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
B-EH A-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-EH B-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-EH C-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-EH E DISC-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-HGDC-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-HH 1-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-HH 2-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-HOFF-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-HSB-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-JCB-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-KHSE-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-KNGA-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-MCB BSMT-USB	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)

T H R E E   P H A S E   I N T E R R U P U T I N G   D U T Y   R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

B-MCB PNTHS-USB	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
B-MONT-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-NASC-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-OND 15 FLR-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-OND ANNEX SWBD-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-OND MAIN SWBD-USB	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
B-PRKW L1-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-PRKW L2-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-PRKW L3-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-PRKW L4-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-PRKW L5-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-PRKW X-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-PS3-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-SBA-USB	VOLTAGE:	208.	(SEE LOW VOLTAGE REPORT)
B-SBH DISC A-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SBH DISC B-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SBH JUNC	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SEC NORTH ECB-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SEC NORTH PNL-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SEC SOUTH DISC 1A-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SEC SOUTH DISC 2A-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)
B-SEC SOUTH DISC 2B-USB	VOLTAGE:	240.	(SEE LOW VOLTAGE REPORT)

T H R E E   P H A S E   I N T E R R U P U T I N G   D U T Y   R E P O R T
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

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==============================================================================================

 B-SEC SOUTH PNL 1B-USB         VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-SEC SOUTH PNL 1C-USB         VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-SEC SOUTH PNL 1D-USB         VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-SEH-USB                      VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-SH-USB                       VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-STFR-USB                     VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-STHL L1-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-STHL L2-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-STHL L3-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-STHL L4-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-STHL L5-USB                  VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-STHL X-USB                   VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-UCB-USB                      VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-UHP-USB                      VOLTAGE:    240.  ( SEE LOW VOLTAGE REPORT )

 B-UP-A-USB                     VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-UP-B-USB                     VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-URBN FP DISC-USB             VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-URBN SWBD-USB                VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-EB-FP DISC-USB                VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )
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Feb 21, 2013     17:45:50             UNBALANCED INTERRUPTING DUTY PAGE    1
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   U N B A L A N C E D   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================
  LOCATION                           FAULT    E/Z    X/R        ANSI AC/DC         INTERRUPTING
                                     TYPE     KA                DECREMENT FACT.   DUTIES  (KA)
                                                                3 PHASE    SLG    3 PHASE  SLG
==============================================================================================

 B-EB-52-U1                        3P Duty:  5.91    5.1 SYM2:    1.00    1.00    5.91    5.66
                  VOLTS: 12470.0     SLG:  5.66    5.1 SYM3:    1.00    1.00    5.91    5.66
                   NACD:  0.842   LN/LN:  5.12        SYM5:    1.00    1.00    5.91    5.66
                              LN/LN/GND:  5.89        SYM8:    1.00    1.00    5.91    5.66
                             GND RETURN:  5.43        TOT2:    1.05    1.05    6.20    5.93
                                 Z1(PU):      0.78383 TOT3:    1.00    1.00    5.91    5.66
                                 Z2(PU):      0.78383 TOT5:    1.00    1.00    5.91    5.66
                                 Z0(PU):      0.88779 TOT8:    1.00    1.00    5.91    5.66

 B-EB-52-U2                        3P Duty:  5.92    5.1 SYM2:    1.00    1.00    5.92    5.68
                  VOLTS: 12470.0     SLG:  5.68    5.1 SYM3:    1.00    1.00    5.92    5.68
                   NACD:  0.843   LN/LN:  5.13        SYM5:    1.00    1.00    5.92    5.68
                              LN/LN/GND:  5.91        SYM8:    1.00    1.00    5.92    5.68
                             GND RETURN:  5.46        TOT2:    1.05    1.05    6.21    5.95
                                 Z1(PU):      0.78213 TOT3:    1.00    1.00    5.92    5.68
                                 Z2(PU):      0.78213 TOT5:    1.00    1.00    5.92    5.68
                                 Z0(PU):      0.88141 TOT8:    1.00    1.00    5.92    5.68

 B-EB-52-U3                        3P Duty:  5.91    5.1 SYM2:    1.00    1.00    5.91    5.68
                  VOLTS: 12470.0     SLG:  5.68    5.1 SYM3:    1.00    1.00    5.91    5.68
                   NACD:  0.842   LN/LN:  5.12        SYM5:    1.00    1.00    5.91    5.68
                              LN/LN/GND:  5.90        SYM8:    1.00    1.00    5.91    5.68
                             GND RETURN:  5.45        TOT2:    1.05    1.05    6.21    5.95
                                 Z1(PU):      0.78282 TOT3:    1.00    1.00    5.91    5.68
                                 Z2(PU):      0.78282 TOT5:    1.00    1.00    5.91    5.68
                                 Z0(PU):      0.88237 TOT8:    1.00    1.00    5.91    5.68
```

PSU - Non-West Campus Loop
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I N T E R R U P T I N G   D U T Y   S U M M A R Y   R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO
NACD OPTION: INTERPOLATED

BUS RECORD NO NAME	VOLTAGE L-L	NACD RATIO	* 3 PHASE * E/Z KA	* 3 PHASE * X/R	* * * S L G * * * E/Z KA	* * * S L G * * * X/R
B-EB-52-U1	12470.	0.842	5.907	5.14	5.659	5.09
B-EB-52-U2	12470.	0.843	5.920	5.13	5.682	5.07
B-EB-52-U3	12470.	0.842	5.914	5.14	5.676	5.09

54 FAULTED BUSES, 150 BRANCHES,   44 CONTRIBUTIONS
UNBALANCED FAULTS REQUESTED

*** SHORT CIRCUIT STUDY COMPLETE ***

C. APPENDIX C – UTILITY FAULT CURRENT INFORMATION

See attached spreadsheet with a summary of utility fault current and transformer information.

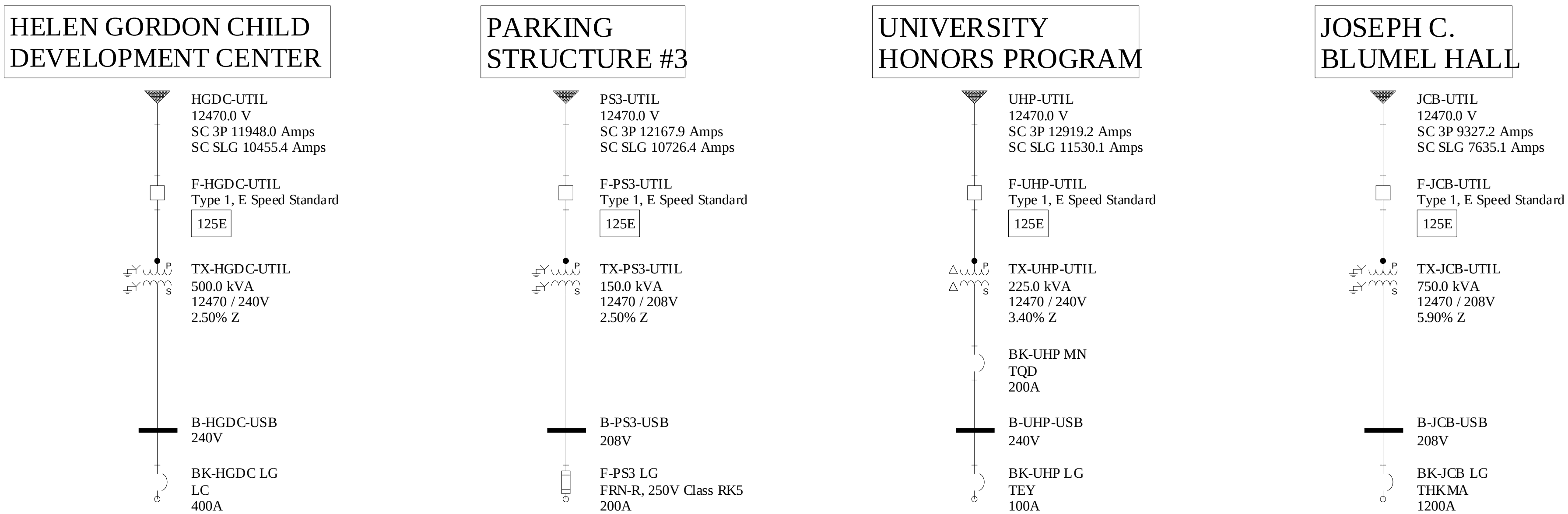
Building	Abbrev	Voltage		XFMR Winding		Transformer		Source Imp. (p.u., 100 MVA, 12.47 kVA base)						Three-Phase		Single-Line to Ground	
		Prim. (kV)	Sec. (V)	Prim.	Sec.	kVA	%Z	Positive			Zero			Calc. Fault Current (A)	X/R	Calc. Fault Current (A)	X/R
Helen Gordon Child Development Center	HGDC	12.47/7.2	240/120	Wye-Gnd	Wye-Gnd	167 167 167	3.2 2.5 2.5	0.179163	+j	0.343599	0.418583	+j	0.390416	11948	1.918	10455.4	1.387
Parking Structure #3	PS3	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	150	2.5	0.167202	+j	0.341799	0.39704	+j	0.38495	12167.9	2.044	10726.4	1.461
University Honors Program	UHP	12.47/7.2	240/120	Open Wye	Open Delta	15 75	1.6 3.4	0.13151	+j	0.333374	0.338712	+j	0.376847	12919.2	2.535	11530.1	1.734
Blumel Hall	JCB	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	750	5.9	0.336332	+j	0.365078	0.699803	+j	0.46392	9327.2	1.085	7635.1	0.87
St. Helens Building	STHL	12.47/7.2	240/120	1 Phase	1 Phase	50	1.8	0.327908	+j	0.378712	0.636073	+j	0.456782	9242.3	1.155	7834.4	0.94
Stephen Erpler Hall	SEH	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	300	2.36	0.441798	+j	0.381284	0.88977	+j	0.511894	7933.7	0.863	6360.3	0.719
Hoffman Hall	HOFF	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	300	2.36	0.441798	+j	0.381284	0.88977	+j	0.511894	7933.7	0.863	6360.3	0.719
King Albert Building	KNGA	12.47/7.2	240/120	Open Wye	Open Delta	15 100	1.7 1.35	0.296333	+j	0.358905	0.634659	+j	0.452666	9947.6	1.211	8189.8	0.954
Stratford Building	STFR	12.47/7.2	240/120	Open Wye	Open Delta	167 167	2.1 2.1	0.226365	+j	0.37093	0.567392	+j	0.442698	10654.6	1.639	8885	1.161
Harder House	HH	12.47/7.2	240/120	Open Wye	Open Delta	167 167	2.1 2.1	0.226365	+j	0.37093	0.567392	+j	0.442698	10654.6	1.639	8885	1.161
Parkway Building	PRKW	12.47/7.2	240/120	Open Wye	Open Delta	167 167	2.1 2.1	0.226365	+j	0.37093	0.567392	+j	0.442698	10654.6	1.639	8885	1.161
Harrison Street Building	HSB	12.47/7.2	240/120	Open Wye	Open Delta	15 100	1.7 1.35	0.296333	+j	0.358905	0.634659	+j	0.452666	9947.6	1.211	8189.8	0.954
Montgomery Court	MONT	12.47/7.2	240/120	Open Wye	Open Delta	15 100	1.9 1.6	0.454403	+j	0.383213	0.912278	+j	0.516846	7789	0.843	6234.7	0.705
Simon Benson House	SBH	12.47/7.2	240/120	1 Phase	1 Phase	25	1.83	0.545849	+j	0.42212	0.9962	+j	0.55363	6709.8	0.773	5527.9	0.67
Blackstone	BLKS	12.47/7.2	240/120	Open Wye	Open Delta	15 100	1.9 1.6	0.454403	+j	0.383213	0.912278	+j	0.516846	7789	0.843	6234.7	0.705
Shattuck Hall	SH	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	500	2.2	0.321542	+j	0.866747	0.725719	+j	1.352211	5008.2	2.696	4114.7	2.254
East Hall	EH	12.47/7.2	240/120	Open Wye	Open Delta	100 50	2.4 1.8	0.321542	+j	0.866747	0.725719	+j	1.352211	5008.2	2.696	4114.7	2.254
University Center	UCB	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	500	3.9	0.205658	+j	0.871185	0.587199	+j	1.314205	5172.3	4.236	4319.6	3.061
Ondine Residence	OND	12.47/7.2	480/277 240/120	Wye-Gnd 1 Phase	Wye-Gnd 1 Phase	300 167	2 5.2	0.193825	+j	0.847133	0.495688	+j	1.29414	5327.7	4.371	4457.2	3.383
Ondine Annex	OND ANNEX	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	500	3.2	0.204179	+j	0.848741	0.514274	+j	1.298835	5303.7	4.157	4430.3	3.248
The Broadway	BHB-A	12.47/7.2	480/277	Wye-Gnd	Wye-Gnd	1000	5.73	0.222893	+j	0.854722	0.550222	+j	1.30488	5241.6	3.835	4375.3	3.026
	BHB-B	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	500	4.58	0.214275	+j	0.853436	0.534724	+j	1.300957	5261.7	3.983	4397.8	3.123
	BHB-C	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	500	4.58	0.214275	+j	0.853436	0.534724	+j	1.300957	5261.7	3.983	4397.8	3.123
Native American Student Community Center	NASC	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	150	2.5	0.571251	+j	1.052598	1.100444	+j	2.108991	3865.9	1.843	2909.5	1.879
Art Building	AB-A	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	100 100 100	2.3 1.7 1.9	0.21241	+j	0.832471	0.513695	+j	1.296005	5389	3.919	4471.7	3.155
	AB-B	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	100 100 100	2.3 1.7 1.9	0.21241	+j	0.832471	0.513695	+j	1.296005	5389	3.919	4471.7	3.155
	AB-ANNEX	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	225	2.1	0.235497	+j	0.839867	0.558132	+j	1.303529	5308	3.566	4401.4	2.899
Fourth Avenue Building Engineering Building	EB	12.47/7.2	N/A	N/A	N/A	N/A	N/A	0.271188	+j	0.887648	0.657231	+j	1.297292	4988.3	3.273	4211	2.561
Science & Education Center	SEC SOUTH-A	12.47/7.2	240/120	Open Wye	Open Delta	167 100	2.53 2.37	0.227716	+j	0.834786	0.541283	+j	1.303015	5350.7	3.666	4430.2	2.982
	SEC SOUTH-B	12.47/7.2	240/120	Open Wye	Open Delta	167 100	2.53 2.37	0.227716	+j	0.834786	0.541283	+j	1.303015	5350.7	3.666	4430.2	2.982
	SEC NORTH-A	12.47/7.2	240/120	Open Wye	Open Delta	167 100	2.53 2.37	0.227716	+j	0.834786	0.541283	+j	1.303015	5350.7	3.666	4430.2	2.982
	SEC NORTH-B	12.47/7.2	240/120	Open Wye	Open Delta	167 100	2.53 2.37	0.227716	+j	0.834786	0.541283	+j	1.303015	5350.7	3.666	4430.2	2.982
University Place	UP-A	12.47/7.2	480/277	Wye-Gnd	Wye-Gnd	1500	3.3	0.33884	+j	0.99903	0.782889	+j	1.756517	4388.8	2.948	3447.7	2.571
	UP-B	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	500	1.9	0.343406	+j	0.999673	0.791121	+j	1.758575	4380.2	2.911	3439.7	2.543
Koinonia House	KHSE	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	500	4.1	0.290416	+j	0.878966	0.70289	+j	1.330089	5001.5	3.027	4153.4	2.406
Graduate School of Education School of Business Administration	SBA	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	500	4.1	0.290416	+j	0.878966	0.70289	+j	1.330089	5001.5	3.027	4153.4	2.406
Academic and Student Rec Center	ARC-A	12.47/7.2	480/277	Wye-Gnd	Wye-Gnd	750	5.53	0.203279	+j	0.870349	0.579547	+j	1.311054	5180.2	4.282	4330.9	3.095
	ARC-B	12.47/7.2	208/120	Wye-Gnd	Wye-Gnd	300	3.54	0.203279	+j	0.870349	0.579547	+j	1.311054	5180.2	4.282	4330.9	3.095
Urban Center	URBN-A	12.47/7.2	480/277	Wye-Gnd	Wye-Gnd	750	1.5	0.372667	+j	0.89157	0.851056	+j	1.367452	4791.3	2.392	3932.6	1.974
	URBN-B	12.47/7.2	480/277	Wye-Gnd	Wye-Gnd	750	1.5	0.372667	+j	0.89157	0.851056	+j	1.367452	4791.3	2.392	3932.6	1.974

D. APPENDIX D – ONE-LINE DIAGRAMS

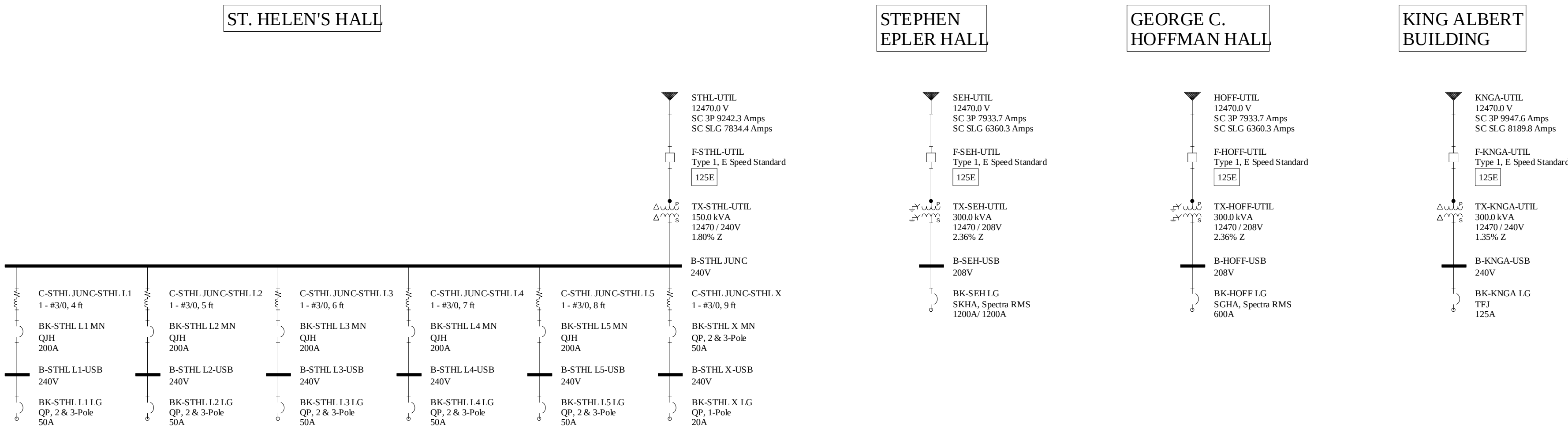
See power system study one-line diagrams on the attached sheets.

Table D.1 – One-Line Diagram Index

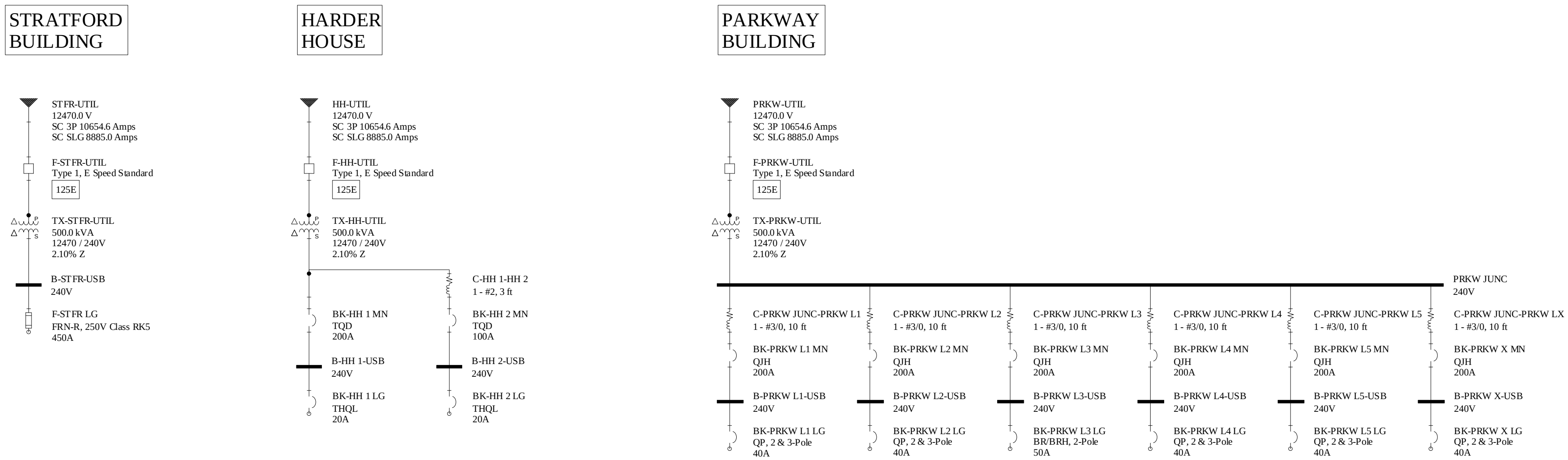
Campus Area	Page Number	Buildings
Northwest Campus	1 of 9	HGDC, PS3, UHP, JCB
	2 of 9	STHL, SEH, HOFF, KNGA
North-Central Campus	3 of 9	STFR, HH, PRKW
	4 of 9	HSB, MONT, SBH, BLKS
South-Central Campus	5 of 9	SH, EH, UCB
	6 of 9	OND, BHB, NASC
Southeast Campus	7 of 9	AB, EB
	8 of 9	SEC, UP
Northeast Campus	9 of 9	MCB, SBA, ARC, URBN, KHSE



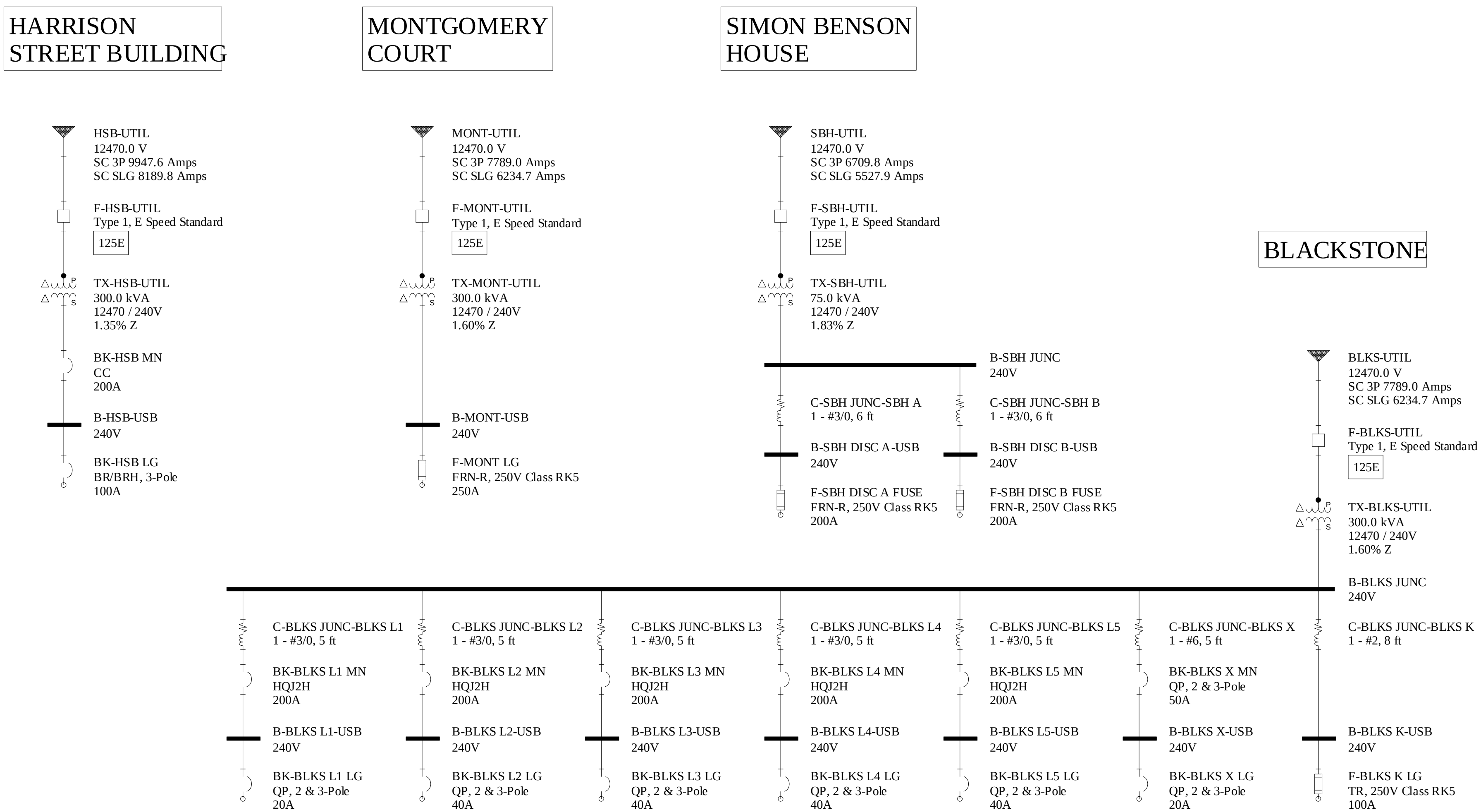
Eaton Electrical Services & Systems
PSU - Non-West Campus Loop
One-Line Diagram
February 22, 2013 Engineer: M. Moore



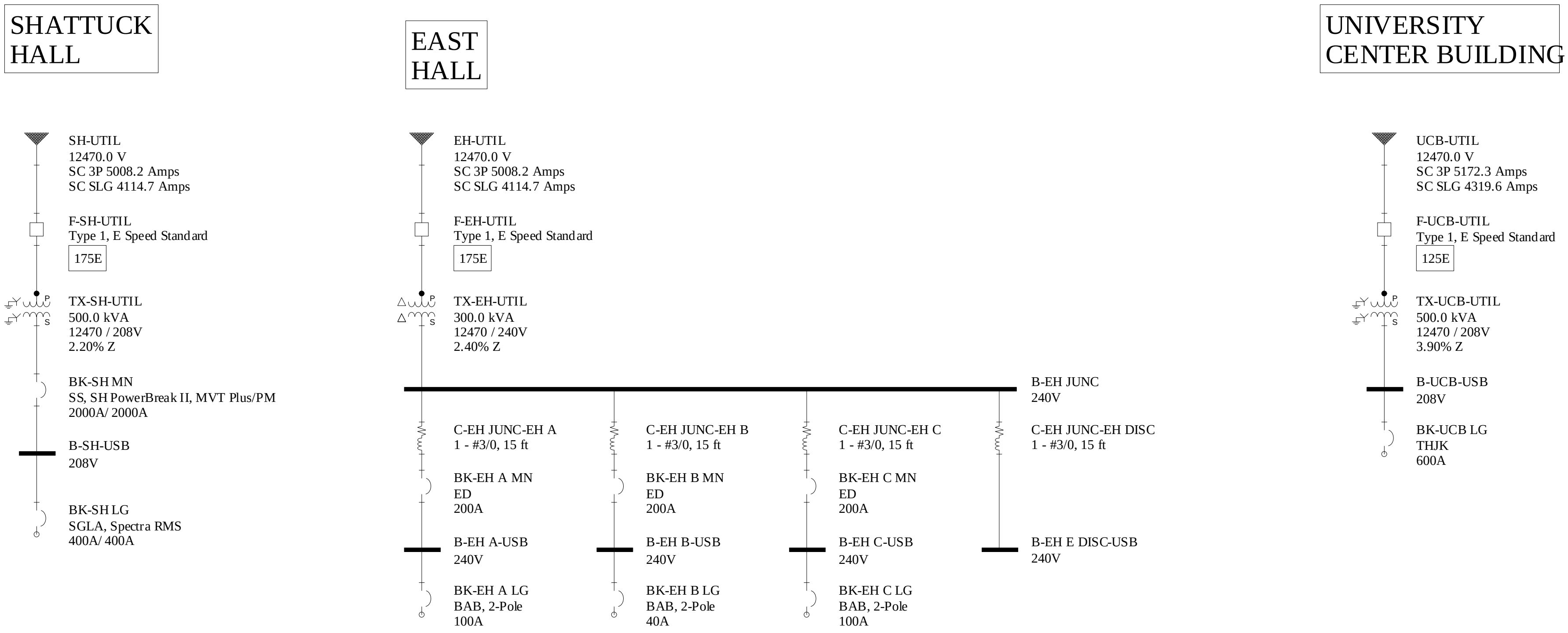
Eaton Electrical Services & Systems
PSU - Non-West Campus Loop
One-Line Diagram
February 22, 2013 Engineer: M. Moore



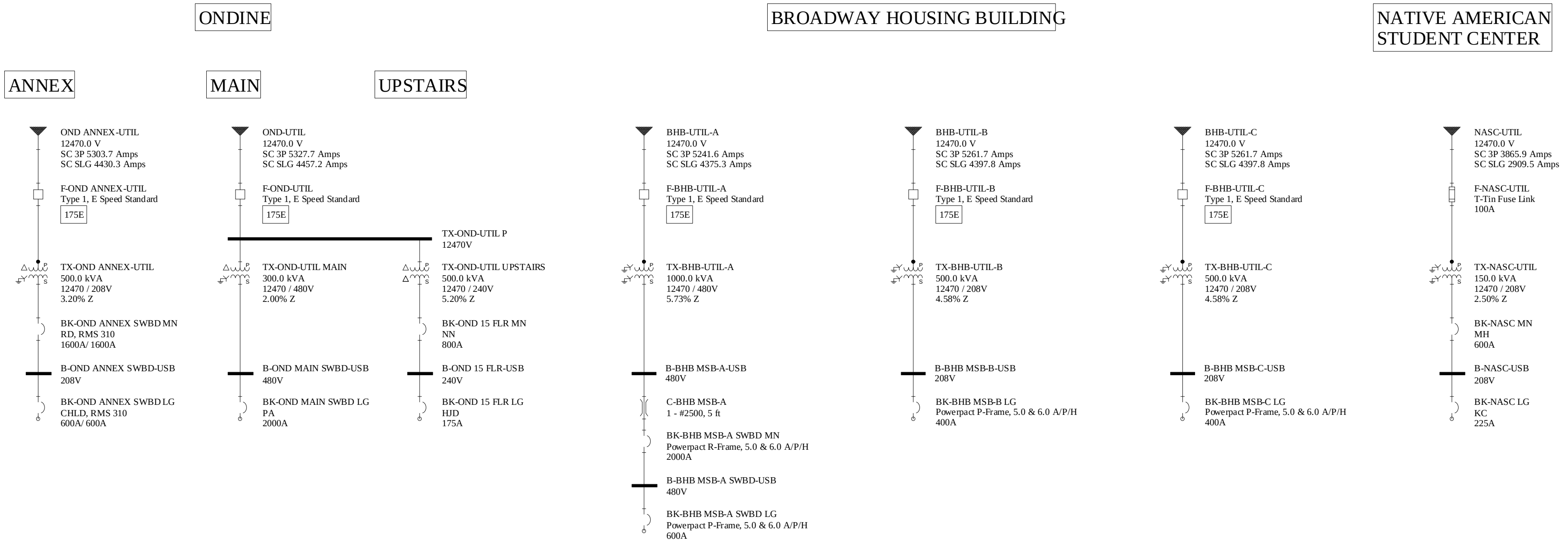
Eaton Electrical Services & Systems
PSU - Non-West Campus Loop
One-Line Diagram
February 21, 2013 Engineer: M. Moore



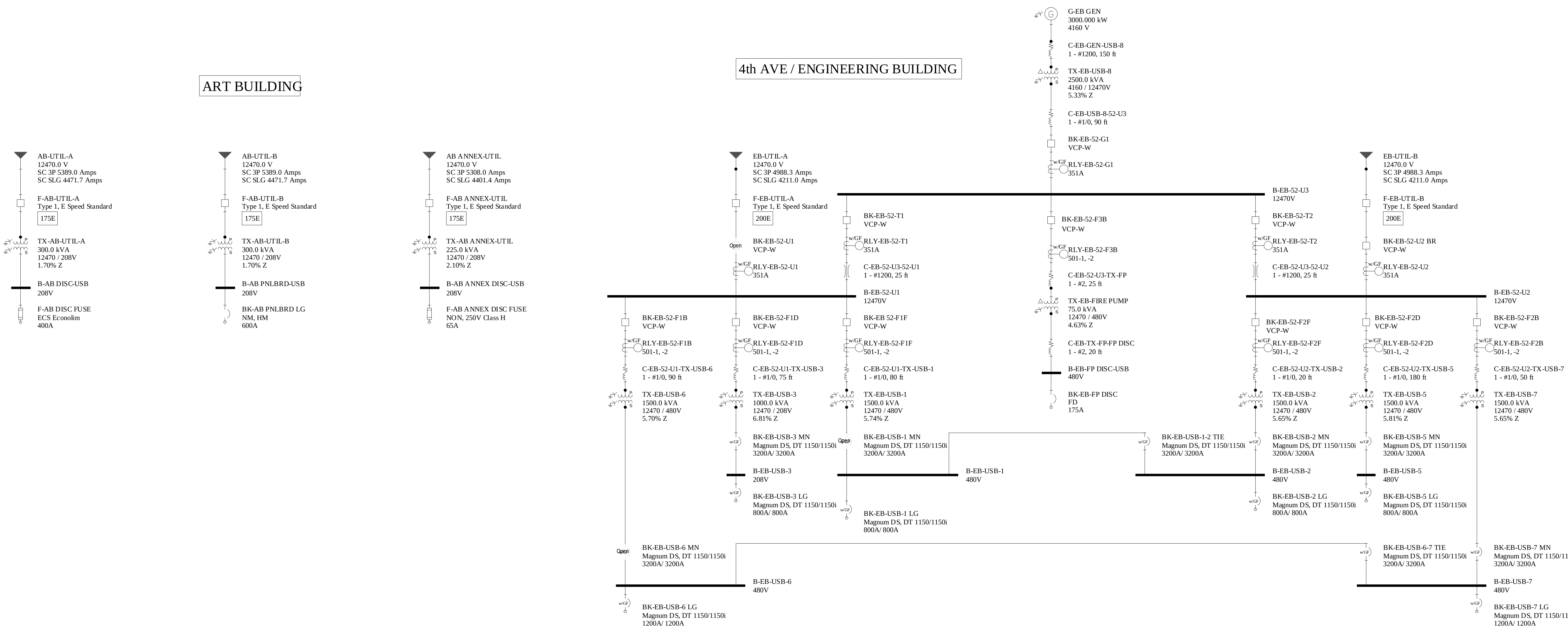
Eaton Electrical Services & Systems
PSU - Non-West Campus Loop
One-Line Diagram
February 22, 2013 Engineer: M. Moore



Eaton Electrical Services & Systems
PSU - Non-West Campus Loop
One-Line Diagram
February 22, 2013 Engineer: M. Moore



Eaton Electrical Services & Systems
PSU - Non-West Campus Loop
One-Line Diagram
February 22, 2013 Engineer: M. Moore



Eaton Electrical Services & Systems
PSU - Non-West Campus Loop
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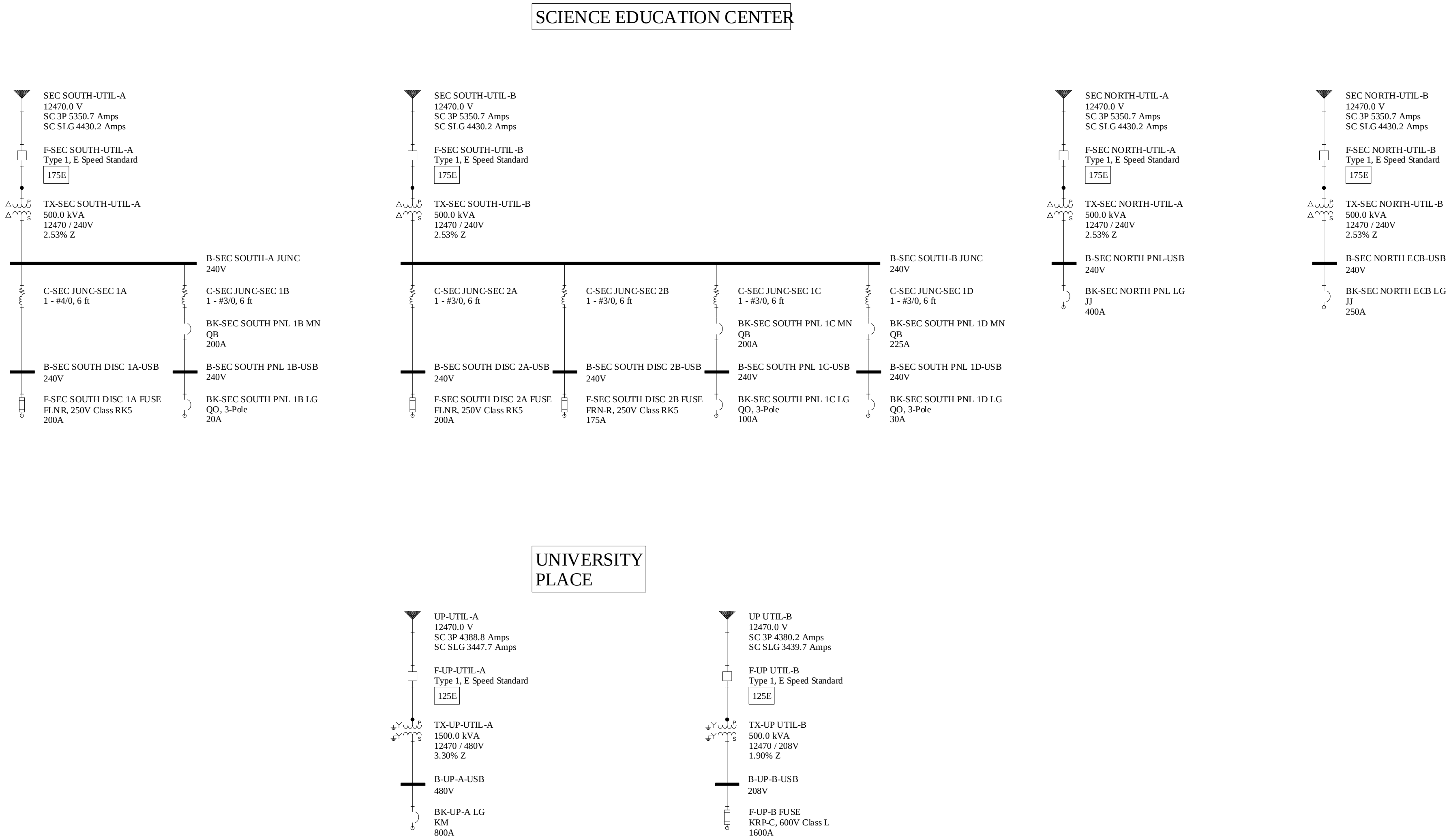

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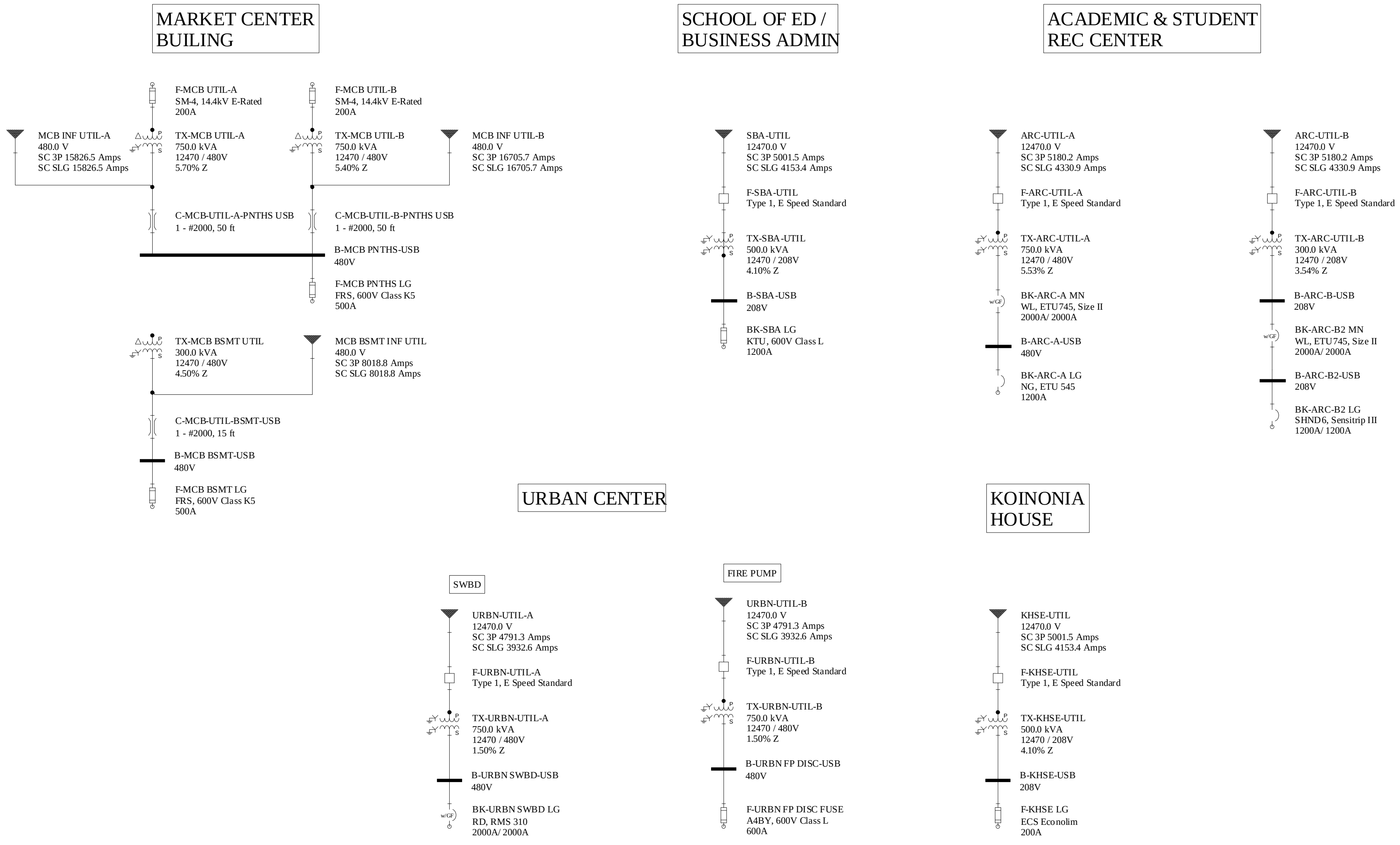

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One-Line Diagram
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GENERAL ORDER NUMBER: ESE0008353

REPORT NUMBER: TQSISE0008353.1

SUBMITTED BY: M. MOORE

SHORT CIRCUIT STUDY
PROTECTIVE DEVICE COORDINATION STUDY
ARC FLASH HAZARD ANALYSIS
FOR
PORTLAND STATE UNIVERSITY
WEST CAMPUS LOOP
PORTLAND, OREGON

FEBRUARY 2013

1.0 EXECUTIVE SUMMARY

This report contains the results of analysis performed on the electrical distribution system for the Portland State University – West Campus Loop, Portland, Oregon. The purpose of this study is to evaluate the existing electrical system, as detailed below.

The executive summary contains the description and guide to the rest of the report. In addition, it also contains the recommendations of the entire study.

1.1 Objectives

1. Short-Circuit Study

Perform a short-circuit study on the existing electrical distribution system shown in order to determine the available fault current at pertinent locations throughout the distribution system. The scope of the study includes:

- Analysis begins at the main 12.47 kV SRTC switchgear, continues through each medium voltage switchgear lineup on the West Campus Loop, and ends at the 480 V or 208 V service entrance disconnect in each West Campus Loop building shown in the contract drawing designated “12.47 kV Single Line Diagram” dated 6-20-88.

The available fault currents determined by the short-circuit study will be used in the coordination and device evaluation analysis.

2. Equipment Evaluation

Evaluate the short-circuit ratings of protective devices and other distribution equipment found at the locations shown in the drawing designated “12.47 kV Single Line Diagram” dated 6-20-88.

3. Coordination Study

Review the existing system overcurrent protection and coordination. Where applicable, provide suggestions for improvement.

4. Arc Flash Analysis

Perform an arc flash hazard analysis per NFPA 70E on the electrical distribution system described in item #1 above.

5. Recommendations

Provide specific recommendations for improving the electrical distribution system performance and correcting any deficiencies found by the studies.

1.2 Results

1. Short-Circuit Study

Short-circuit currents were calculated for each bus shown on the one-line diagram in Appendix D.

The following source impedance information was provided by Portland General Electric at the Preferred and Alternate feeds for the Science II Building:

Preferred Feed (Switch 1815):

- Voltage: 12.47 kV
- Positive Sequence Source Impedance: 0.1117 + *j*0.5581 Ω
- Zero-Sequence Source Impedance: 0.6837 + *j*0.7567 Ω

Alternate Feed (Switch 1998):

- Voltage: 12.47 kV
- Positive Sequence Source Impedance: 0.1175 + *j*0.5439 Ω
- Zero-Sequence Source Impedance: 0.3328 + *j*0.4914 Ω

A copy of the email provided by Mr. Tom Riddle with Portland General Electric can be found for review in Appendix C.

Short-circuit currents were calculated for a three-phase bolted fault and single-line-to-ground fault at each bus shown on the one-line diagram found in Appendix D. The system was modeled for worst-case fault currents.

The following short-circuit study cases were evaluated:

- Study Case No. 1 – System supplied from PGE Preferred Feed via 12.47 kV Switch 1815. Switchboard B-SRTC-SWBD1 supplied from the normal source.
- Study Case No. 2 – System supplied from PGE Preferred Feed via 12.47 kV Switch 1815. Switchboard B-SRTC-SWBD1 supplied from the emergency source.
- Study Case No. 3 – System supplied from PGE Alternate Feed via 12.47 kV Switch 1998. Switchboard B-SRTC-SWBD1 supplied from the normal source.
- Study Case No. 4 – System supplied from PGE Alternate Feed via 12.47 kV Switch 1998. Switchboard B-SRTC-SWBD1 supplied from the emergency source. **This is the worst case scenario and the scenario illustrated in the one-line diagram found in Appendix D.**

See Section 2, Appendix A and Appendix B for more information.

2. Equipment Evaluation

The Equipment Evaluation is based on the power system worst-case short-circuit current configuration.

The short-circuit ratings of protective devices and other distribution equipment are evaluated in Section 2, Table 2.1.

In summary of Table 2.1, the following equipment failed the equipment evaluation:

- LV Switchboard B-CH-SUB 4A
- LV Switchboard B-NH-USB EAST

Equipment evaluation status is listed as "UNKNOWN" and a "MINIMUM REQUIRED" short-circuit rating is suggested at locations for which distribution equipment information and/or short-circuit rating information is not available. Four locations were shown this way in this study. Each of the locations was missing a nameplate with short-circuit rating information and not enough information could be collected while on site to make a conservative assumption regarding the short-circuit rating of the equipment.

The short-circuit withstand ratings of low voltage disconnect switches are not evaluated in this study. Care should be taken in order to ensure that these devices are applied within their UL listed short-circuit withstand ratings. The typical withstand ratings for Eaton disconnect switches (safety switches) range from 10,000 A to 200,000 A for certain fused types.

3. Coordination Study

The time-current coordination plots of the protective overcurrent devices are shown in Section 3. In developing the device settings, consideration was given to both isolation of faults, protection of cables, and protection of transformers.

Efforts were made to provide the best coordination possible with the existing protective devices. It should be understood that selective coordination between two instantaneous trip units cannot be achieved for fault levels above the instantaneous pickup of the upstream device. There is some overlapping of curves that cannot be avoided.

The system coordination began at the main 12.47 kV SRTC switchgear and continued downstream through the West Campus Loop to the largest feeder breaker at each 480 V or 208 V service entrance disconnect within each West Campus Loop building. These buildings include the Science Research and Teaching Center, Science Building 1, West Heating Plant, Peter Stott Center, Millar Library, Cramer Hall, Smith Memorial Center, Library East, University Services Building, Neuberger Hall, Parking Structure 1, Lincoln Hall, and the Extended Studies Building.

See Section 3 for more information and Section 4 for device settings.

4. Suggested Protective Device Settings

Settings for the adjustable protective devices within the scope of work are shown in Section 4.

Each entry references a coordination plot number found in Section 3. The referenced plot illustrates the coordination of the listed device with the relevant “upstream” and “downstream” protective devices. The protective devices listed in Section 4 should be set per the suggested settings.

5. Arc Flash Analysis

Details of the arc flash analysis are shown in Section 5. This arc flash hazard analysis of the Portland State University – West Campus Loop in Portland, Oregon required energy and boundary calculations for approximately forty-eight (48) locations. In summary of Section 5, there are several locations that have incident energy levels that are above 40 cal/cm^2. According to NFPA 70E-2012, Article 130.7(A), Informational Note 3, greater emphasis must be placed on establishing an electrically safe work condition when working within the limited approach boundary at locations where the incident energy exceeds 40 cal/cm^2. The greater emphasis is due to additional hazards created from blast pressure associated with a possible arc. See NFPA 70E-2012, Article 120 for details on establishing an electrically safe work condition.

At the request of Portland State University, arc-flash incident energy calculations were performed at an 8’ working distance. This distance is greater than the standard working distances prescribed by IEEE 1584-2002 and are applicable for energized work, including non-contact voltage testing, being performed by a qualified person using a hot-stick. A distance of 8’ was chosen as it is the approximate distance the face and torso of a qualified person would be when using a 6’ hot-stick. To minimize confusion, these values will not be shown on the arc-flash labels.

Please note for this study, the arc flash hazard has been calculated but not the risk. The risk associated with performing energized electrical work will vary based on the work being performed as well as the condition of the equipment and other factors that can be best determined by a qualified person.

See Table 5.1, Table 5.2, and Table 5.3 for a complete arc flash summary. **Note that the incident energy values listed in Table 5.1, Table 5.2, and Table 5.3 are only valid after the recommended protective device settings shown in Section 4 have been implemented.**

1.3 Recommendations

1. Overdutied Equipment

It is recommended that the overdutied panelboards listed below be reviewed for switchboard/breaker replacement to comply with the short-circuit current ratings required. The short-circuit rating of each of these locations is based on the lowest interrupting rating of any device in the switchboard. It is possible that replacing only the circuit breakers that are overdutied, as opposed to the entire switchboard, will sufficiently increase the rating of the switchboards below. See Section 2 for detailed short-circuit analysis.

- LV Switchboard B-CH-SUB 4A
- LV Switchboard B-NH-USB EAST

2. <u>Additional Power Systems Studies</u>

The scope of the analysis ended at each 480 V or 208 V main switchboard within each West Campus Loop building. These buildings include the Science Research and Teaching Center, Science Building 1, West Heating Plant, Peter Stott Center, Millar Library, Cramer Hall, Smith Memorial Center, Library East, University Services Building, Neuberger Hall, Parking Structure 1, Lincoln Hall, and the Extended Studies Building. It is recommended that the studies be expanded to include all of the low voltage distribution equipment in each of these buildings.

There are many locations that would benefit from a full short-circuit and coordination study. For example, there is a lack of selectivity between the main circuit breaker and the largest feeder breaker in the Switchboard 2 located in Science Building 2. Under the scope of this project, insufficient information was collected to recommend adjustment the settings of the largest feeder breaker. This lack of selectivity may result in an unnecessary loss of load for a fault downstream of the largest feeder breaker. Expansion of scope to include coordination of the entire low voltage system may allow for adjustment of these settings and improve the selectivity at Switchboard 2. Another location which may benefit from a full coordination study is Panelboard PNL-B in Cramer Hall. It appears the minimum settings are currently being employed on the largest feeder breaker in this panelboard. As a result, there may be a lack of selectivity with downstream loads.

Expansion of scope to include an arc flash hazard analysis for all locations supplied by the West Campus Loop will ensure that all equipment at Portland State University is properly labeled per NFPA 70E-2012 and meets all OSHA requirements that result from the general duty clause.

3. <u>Medium Voltage Equipment Recommendations</u>

During the testing of the Medium Voltage Cables performed by Emerson Network Power, it was found that many of the Medium Voltage Switches had not been properly maintained and did not operate properly. In the report issued by Glumac, based on the results of the Emerson Network Power testing, there are a series of recommendations regarding cleaning and maintenance of these switches. Similarly, based on the results of the Emerson Network Power testing, Glumac issued a series of recommendations regarding replacement of medium voltage cables. Eaton agrees with all recommendations of this nature by Glumac.

Proper maintenance of the Medium Voltage Switches is vital to safe operation of this equipment. Failure to properly maintain these switches may result in a dangerous situation when they are operated. Cables which were found to need replacement in the Glumac study showed signs of insulation breakdown. This is a potentially dangerous situation which could result in an arc-flash in the event of insulation failure.

4. Low Voltage Equipment Recommendations

The majority of the low voltage equipment on the West Campus loop at Portland State University is very old and appears to have not been tested and maintained over the life of the equipment. It is critical that Portland State University create a plan to inspect and test the low voltage equipment supplied by this loop, similar to the testing that has occurred in Science Building, to determine if the electrical distribution equipment is still operable. Because testing has recently occurred at both Science Building 2 and Lincoln Hall, the remainder of the buildings should be given priority. If any equipment is found to not be performing as originally intended, a plan to replace the equipment should occur. The following discussion highlights specific recommendations and is broken out by building.

- Science Building 1

The low voltage equipment in Science Building 1 (208 V) has been verified in its entirety. The 208 V switchboard contains many older fused switches that supply the loads in Science Building 1. Based on the age of the equipment it is recommended that this equipment be replaced or tested and maintained according to manufacturer recommendations.

- Extended Studies Building

The protective devices contained in the low voltage main switchboard in the XSB Building have been verified. However, the transformer manufactured by Sorgel Electrical that steps the voltage down from 12.47 kV to 208 V does not have a nameplate installed. As a result, the transformer information including the kVA rating, voltage ratings, winding connections, and impedance could not be field verified at the time of the study. Additionally, it was determined that some fuses were mounted in an aftermarket enclosure which acts as secondary protection for the transformer supplying power to XSB. The fuses are not mounted in a switch, but rather bolted in place. It is recommended that this fuse assembly be replaced with a new, fused safety switch or main breaker.

- Science Research and Teaching Center, Switchboard #1, Section 1

The low voltage equipment in Science Building 2, Switchboard 1, Section 1 (208 V) has been verified. The main breaker in Section 1 has been retro-fit with an AC-Pro electronic trip unit. During data collection, the as found settings could not be determined. As a result, it is recommended that this trip unit be tested and the settings in Section 4 be implemented.

- Heating Plant

The low voltage equipment in the Heating Plant (480 V) has been verified in its entirety. Due to the age of this equipment it is highly recommended that the molded case circuit breakers and panelboard be tested to ensure proper operation. If the testing shows that these circuit breakers do not operate as intended, it is recommended that this panelboard be replaced.

- Physical Education (Peter Scott Center)

Several of the sub main breakers in the low voltage switchboard in the Peter Scott Center could not be field verified. The equipment covers and deadfronts for the 1600A sub main breakers manufactured by Mears Controls could not be removed while energized without tripping the breaker. As a result, the next time the Peter Scott Center 480 V switchboard is de-energized for maintenance, the fuses contained in these fused breakers should be verified.

- Library Building West (Millar)

The low voltage equipment in the Library West (Millar) building (480 V) has been verified in its entirety. The 480 V switchboard contains many older fused switches that supply the loads in Science Building 1. Based on the age of the equipment it is recommended that this equipment be tested and maintained according to manufacturer recommendations.

- Cramer Hall SE

The low voltage equipment in Cramer Hall – SE main distribution switchboard (208 V) has been verified. Due to the age and existing state of this equipment it is highly recommended that the switchboard and breakers be tested to ensure that the equipment is still operable.

- Cramer Hall Emergency

The low voltage equipment in Cramer Hall – Emergency switchboard (208 V) has been verified. Due to the age and existing state of this equipment it is highly recommended that the switchboard and breakers be tested to ensure that the equipment is still operable.

- Cramer Hall Panel B

The low voltage equipment in Cramer Hall – Panel B (480 V) has been verified. Panel B is a newer style, Square D, Type QED switchboard that appears to be in better condition compared to other equipment in Cramer Hall. However, it is still recommended that this equipment is tested and maintained according to manufacturer recommendations.

- Cramer Hall Sub 4A

The low voltage equipment in Cramer Hall – Substation 4A has been verified. However, it was not possible to verify the existing settings on the 1600 A and 1000 A feeder breakers as the trip unit batteries appeared to be dead. The trip units utilized in these circuit breakers are General Electric, MicroVersaTrip electronic trip units that are self-powered and require a certain amount of load current on the breaker. Without enough load current, the trip unit must be powered via the battery backup. It is recommended that the batteries be replaced and the settings verified.

- Cramer Hall Northwest

The protective devices contained in the low voltage main switchboard in Lincoln Hall (208 V) have been verified. However, these protective devices were made by ITE and appear to have been neglected and not tested over the years. It is highly recommended that these devices be tested and replaced as necessary. Additionally, the transformer that steps the voltage down from 12.47 kV to 208 V is housed in a separate electrical room near the low voltage equipment. However, due to the lack of enclosures, the transformer could not be safety accessed during data collection. As a result, the transformer nameplate information as well as the secondary conductor information could not be obtained for use in this analysis.

It is recommended that PSU consider replacing this bank of 3, single phase transformers with a new, three-phase transformer in a suitable enclosure. It is also recommended that all conductors are moved to conduits. This would ensure that if an unqualified person entered the room, the shock and arc flash hazard would be reduced significantly. Presently, it is critical only qualified people have access to the lock on the door.

- College Center Building (Smith Memorial Center)

The main low voltage equipment in Smith Memorial Center has been verified. However, four of the sub main breakers could not be accessed safely during data collection. These four breakers were manufactured by Federal Pacific and are rated at 50 kAIC at 208 V. If the covers of these sub-main breakers are removed it is possible that the circuit breaker could trip. As a result, the next time this low voltage equipment is taken down for maintenance, the circuit breaker settings should be verified. Additionally, based on the condition and appearance of the switchboard, it is highly recommended that the switchboard and all of the circuit breakers be tested and replaced as necessary.

Additionally, a 750 kVA transformer is used to supply this low voltage equipment. The low voltage conductors run from the transformer to the low voltage switchboard in the Smith Memorial Center. The conductor terminations on the secondary side of the transformer are not in a guarded enclosure. Electrical tape, which is used to provide insulation from energized equipment, is prone to breaking down. It is highly recommended that these conductors be re-run in an appropriately sized conduit to prevent personnel in the room from coming into contact with these energized conductors.

- College Center Building (2nd Addition)

The low voltage equipment in Smith Memorial Center – 2nd Addition (208 V) has been verified. Due to the age and existing state of this equipment it is highly recommended that the switchboard and breakers be tested to ensure that the equipment is still operable.

- Library Building East

The main breaker in the low voltage switchboard in the Library Building East could not be field verified. The equipment covers and deadfronts for the main breaker manufactured by Mears Controls could not be removed while energized without tripping the breaker. As a result, the next time this switchboard is de-energized for maintenance, the fuses contained in these fused breakers should be verified. Additionally, due to the age and existing state of this equipment it is highly recommended that the switchboard and breakers be tested to ensure that the equipment is still operable.

- University Services / Parking #2

The low voltage equipment in University Services Building / Parking Structure #1 (208 V) has been verified. Due to the age and existing state of this equipment it is highly recommended that the switchboard and breakers be tested to ensure that the equipment is still operable.

- Neuberger Hall – West and East

The low voltage equipment in Neuberger Hall – Both the East and West main switchboards (208 V) have been verified. Due to the age and existing state of this equipment it is highly recommended that the switchboard and breakers be tested to ensure that the equipment is still operable. Also, during the data collection it was observed that a meter located in the East Switchboard had been broken. A wooden cover had been constructed as an attempt to isolate this meter. This is a highly dangerous situation and needs to be corrected as soon as possible. The meter should be replaced and the wooden cover should be removed.

Figure 1-1 - Meter

- Parking #1

The low voltage equipment in Parking Structure #1 was very old ITE equipment. There are no published interrupting ratings for the equipment. As a result, a minimum required rating will be assigned to this switchboard that can be used if / when the interrupting rating of this equipment can be determined. Due to the age and existing state of this equipment it is highly recommended that the switchboard and breakers be tested to ensure that the equipment is still operable. Additionally, during the on-site data collection only one set of 500 kcmil copper conductors was noted. The one-line diagram illustrated two sets of conductors per phase at the time of construction. With only set of 500 kcmil copper conductors per phase, the upstream fusing cannot provide proper protection per NEC 240.4(F).

5. Recommended Settings

Adjustable protective device settings should be set according to the settings tables provided in Section 4.

6. Inaccessible data

In addition to individual breaker data that was unavailable due to operating mechanisms covering some breaker types and settings, the following equipment could not be verified during the data collection effort. As a result, some data such as fuse types, relay time dial curve selection, breaker types, equipment interrupting ratings, and equipment manufacturers could not be verified. It is recommended that the following list be reviewed to determine if any of the data can be accessed by the proper personnel during a maintenance shutdown or outage.

- Science Research and Teaching Center (SRTC)

The nameplates on the Science Building 2 switchgear (B-SRTC-SB2) did not show the speed rating of the S&C, Type SM-5 fuses installed in the switchgear. It was assumed that "standard speed" fuses were utilized in this switchgear.

The existing settings on the AC-Pro trip unit used on the main circuit breaker in switchboard 1 (B-SRTC-SWBD1) could not be verified during the data collection as the trip unit was non-responsive.

- Science Building 1

In the main 12.47 kV Science Building 1 Switchgear the nameplate for the fused switch that supplies Lincoln Hall indicated that fuses used in the switch were S&C, Type SM-5, 60E fuses. A time current curve for the 60E fuse could not be obtained and it was assumed that 80E fuses are used in this switch according to previous study documentation.

- Lincoln Hall

The main transformer for Lincoln Hall is contained in a utility vault that could not be accessed during data collection. As a result, it was assumed that this transformer was a 1000 kVA, delta-wye, 12.47 kV - 208 / 120 V transformer, as indicated on the contract one-line diagram, with an impedance of 5.32%. Furthermore, the secondary conductors were assumed to be eight (8) sets of 500 kcmil copper conductors per phase.

- Extended Studies Building

The main transformer for the Extended Studies Building was manufactured by Sorgel Electric and does not have a nameplate. As a result, it was assumed that this transformer was a 200 kVA, delta-wye, 12.47 kV - 208 / 120 V transformer, as indicated on the contract one-line diagram, with an impedance of 2.15%.

The nameplate on the 12.47 kV disconnect switch did not show the speed rating of the S&C, Type SM-4 fuses installed in the switch. It was assumed that "standard speed" fuses were utilized in this switchgear.

- Peter Stott Center

The feeder breakers in the 480 V main switchboard are manufactured by Mears Controls. The fuses contained in these fused breakers could not be determined during the data collection as the breaker needs to be de-energized to verify the fuse information.

- Cramer Hall

The main Cramer Hall medium voltage switchgear (B-CH) did not have fuse information for each feeder. As a result, the fuses used to supply transformer CH-003 were assumed to be S&C, Type SM-5, 25E. The fuses used to supply the Smith Memorial Student Union were assumed to be S&C, Type SM-5, 100E. The fuses used to supply the University Services Building were assumed to be S&C, Type SM-5, 50E. This information agrees with a previous study performed for Portland State University.

The Cramer Hall – NW distribution medium voltage switchgear (B-CH-NW SWBD DS) did not have a nameplate that listed the equipment rating or fuse type. As a result, it was assumed that S&C, Type SM-5, 40E fuses were used to supply the NW transformer (as indicated on the Cramer Hall one-line diagram provided by PSU).

The main transformer that supplies Cramer Hall – NW distribution could not be accessed safely during data collection. As a result, it was assumed that this transformer was a 500 kVA, delta-wye, 12.47 kV - 208 / 120 V transformer, with an impedance of 1.85% (as indicated on the Cramer Hall one-line diagram provided by PSU). Furthermore, the secondary conductors were assumed to be four (4) sets of 600 kcmil copper conductors per phase.

The main 12.47 kV disconnect at Sub 4A did not have any fuse information noted. A one-line diagram provided by PSU indicated that the fuses used in the switch were S&C, Type SM-5, Standard Speed 60E fuses. A time current curve for the 60E fuse could not be obtained and it was assumed that 65E fuses are used in this switch.

The fuses contained in the bolted pressure switch located in Cramer Hall that is used as a main disconnect for PNL B (B-CH-PNL B) could not be determined during the data collection. As a result, it was assumed that Bussmann, Type KRP-C, Class L, 1200 A fuses were used. These fuses are used in similar switches on the PSU campus.

- Library East:

The main breaker in the 208 V main switchboard was manufactured by Mears Controls. The fuses contained in this fused breaker could not be determined during the data collection as the breaker needs to be de-energized to verify the fuse information.

- Medium Voltage Distribution System:

The cable information for portions of the medium voltage distribution system could not be verified. If the cable was not tested during the December 2012 testing, the cable size and insulation type could not be verified. As a result, Table 1.1 illustrates the cable assumptions that were used in the analysis. If these cables or associated medium voltage switchgear is tested in the future, these assumptions should be verified and the study should be revised if necessary.

Table 1.1 – Conductor Assumptions			
From	**To**	**Conductor Size, # sets / phase**	**Distance**
Science Building 2 (B-SRTC-SB2)	Transformer TX-SRTC-SWBD1-1	1-#1/0 / ϕ	30’
Science Building 2 (B-SRTC-SB2)	Transformer TX-SRTC-SWBD1-2	1-#1/0 / ϕ	60’
Science Building 2 (B-SRTC-SB2)	Transformer TX-SRTC-SWBD2	1-#1/0 / ϕ	20’
Science Building 2 (B-SRTC-SB2)	Transformer TX-SRTC-SWBD3	1-#1/0 / ϕ	20’
Science Building 2 (B-SRTC-SB2)	B-SRTC-SWBD4 DS	1-#4/0 / ϕ	75’
B-SRTC-SWBD4 DS	Transformer TX-SRTC-SWBD4	1-#4/0 / ϕ	5’
West Heat Plant (B-WHP)	Transformer TX-WHP-USB	1-#1 / ϕ	5’
Peter Stott Center (B-PSC)	Transformer TX-PSC-USB	1-#1/0 / ϕ	5’
Millar Library (B-ML)	Transformer TX-ML-USB	1-#1/0 / ϕ	5’
Science Building 1 (B-SB1)	Transformer TX-SB1-USB	1-#1/0 / ϕ	10’
Extended Studies (B-XSB-TX DS)	Transformer TX-XSB-USB	1-#2 / ϕ	5’
Lincoln Hall (B-LH-TX DS)	Transformer TX-LH-USB	1-#2 / ϕ	175’
Cramer NW (B-CH-NW USB DS)	Transformer TX-CH-NW USB	1-#1/0 / ϕ	15’
Cramer Hall (B-CH CHLR)	Transformer TX-CH-002	1-#1/0 / ϕ	5’
Cramer Hall (B-CH CHLR)	B-CH-SUB 4A DS	1-#4/0 / ϕ	300’
Sub 4A (B-CH-SUB 4A DS)	Transformer TX-CH-006	1-#4/0 / ϕ	5’
Parking 2 (B-PS2-TX DS)	Transformer 1 TX-PS2-USB	1-#1/0 / ϕ	10’
Smith Memorial (B-SMC)	Transformer TX-SMC-USB	1-#1/0 / ϕ	30’
Smith Memorial (B-SMC 2ND USB DS)	Transformer TX-SMC 2ND USB	1-#1/0 / ϕ	5’
Library East (B-LE USB DS)	Transformer TX-LE USB	1-#1/0 / ϕ	5’
Neuberger Hall (B-NH EAST)	Transformer TX-NH-USB EAST	1-#1/0 / ϕ	5’
Neuberger Hall (B-NH WEST)	Transformer TX-NH-USB WEST	1-#1/0 / ϕ	5’
Parking 1 (B-PS1-TX DS)	Transformer TX-PS1-USB	1-#1 / ϕ	5’

7. Reducing Incident Energy Levels

The calculated incident energy at a particular location is dependent on three main factors: short-circuit current, distance, and time. These three factors directly affect the incident energy in the following manner:

Short-circuit current: The short-circuit current for a given power system is dependent on the system impedance and source fault current, and cannot be easily reduced.

Distance: IEEE Std 1584™-2002 provides a table with typical working distances. Increasing the working distance reduces the amount of incident energy that reaches the worker; however it becomes difficult to perform many work tasks with an increased working distance, therefore, this is not an optimal solution for most cases.

Time: The incident energy decreases when reducing the exposure time of the arc. This exposure time is directly related to the clearing time of the protective device(s) which feed the fault location.

Based on the preceding summary, arc flash mitigation techniques are most effective and feasible when they involve reducing the arc exposure time. In many locations, the setting of the protective device can be adjusted in order to decrease the interrupting time, resulting in a decreased incident energy. However, in this study, settings for protective devices have not been adjusted to reduce incident energy if the chance of nuisance trips within critical circuits is introduced.

The other option involving reducing the arc exposure time is to consider equipment modifications and upgrades. Several solutions include upgrading trip units, installing "maintenance switches", and using relays with multiple settings groups. Each specific location needs to be analyzed to determine which reduction method is best employed.

8. Testing and Preventative Maintenance

It is recommended that regularly scheduled testing and preventative maintenance be performed to ensure that the electrical distribution equipment continues to perform at an optimum level. Testing should entail primary injection testing of all power circuit breakers to verify proper tripping ranges, contact resistance testing, insulation resistance testing and complete switchgear and transformer cleaning and inspection.

9. Periodic Arc Flash Analysis Review

The 2012 edition of NFPA 70E includes several new requirements regarding arc flash hazard analysis. One new requirement found in Article 130 is that an arc flash hazard analysis must be updated:

- Every five years (at minimum)
- When the electrical system is modified or renovated in any way, including renovations, additions, or subtractions to the system

It is recommended that a plan is implemented to schedule a review of the arc flash hazard analysis for the Portland State University - West Campus Loop in a period not to exceed five years, and that a review is performed whenever substantial modifications or renovations take place.

10. Predictive Diagnostics Using Continuous Partial Discharge Measurements

Eaton recommends conducting Continuous Partial Discharge measurements on most medium voltage power transformers, bus ducts, switchgear, motors, generators, terminations, and splices of transmission and distribution cables. Partial Discharge (PD) analysis is a non-invasive, online method of collecting, filtering, and evaluating PD occurring in electrical apparatus. The goals are:

- To detect partial discharges as a result failing or compromised insulation
- To analyze the partial discharge activity, and if an insulation defect is detected:
    a. Make conclusions as to the severity of the defect.
    b. Advise as to possible defect locations and possible cause(s) of the defect.
    c. Advise as to urgency of inspection.
    d. Suggest preventive measures both immediate and long term.

Electrical insulation is very important to monitor as it defines a major item in the reliability of electrical machines. Continuous Partial Discharge on-line monitoring using the Eaton InsulGard™ is the most sensitive and reliable method for detecting failing insulation. PD monitoring when used in conjunction with Eaton's RM™ system offers customers the added benefit of prompt expert analysis and recommendation.

2.0 SHORT-CIRCUIT ANALYSIS

The short-circuit study determines the fault currents that flow in the system during various fault conditions. The calculated fault currents are used in the device evaluation and coordination studies. See Appendix A and Appendix B for the computer generated input data and output data. NEC-2011, Article 110.24(A) requires that service entrance equipment is labeled with the following pieces of information:

- Maximum available fault current
- Date on which the fault current was calculated

Article 110.24(B) adds that if there is a modification that may change this fault current value, it must be recalculated. The field marking must be updated to reflect the new value of maximum fault current.

The short-circuit calculations were done using A_FAULT, a computer software package by SKM Systems Analysis. The short-circuit analysis performed by A_FAULT is based on IEEE Std C37.010™-1999, IEEE Std C37.5™-1979, and IEEE Std C37.13™-2008.

Separate “Z” (complex), “X” (reactive), and "R" (resistive) networks are used by A_FAULT for the short-circuit analysis. A_FAULT uses complex network reduction and the relationship E/Z to calculate the fault current magnitude and angle at each faulted bus. The complex equivalent circuit impedance, Z, is calculated by the reduction of the “Z” (complex) network, and is reported as the “EQUIV. IMPEDANCE” in the A_FAULT reports. The X/R ratios calculated for each fault condition are based on the separate reduction of the X and R networks. These X/R ratios are used for the calculation of fault duty multipliers, to evaluate the short-circuit ratings of system components.

A_FAULT is capable of generating three types of short-circuit reports for both balanced (three-phase bolted) and unbalanced (line-to-ground) faults. The reports that are generated depend on the system that is being evaluated.

The three types of short-circuit reports are:

- Fault Report (for low voltage)
- Momentary Duty Report (for medium voltage)
- Interrupting Duty Report (for medium voltage)

1. Fault Report

The fault currents reported in the “Fault Report” are applicable to low voltage devices and components. The fault currents calculated in this report are based on the contribution data derived from IEEE Std C37.13-2008. The fault currents are calculated as follows:

- Motor and generator subtransient reactance values (Xd”) are adjusted per the first cycle duty multipliers described in IEEE Std 141™-1993 (Red Book).
- The complex equivalent circuit impedance, Z, is calculated by network reduction of the “Z” (complex) network.
- The momentary symmetrical current = E/Z.
- The X/R ratio is equal to the equivalent circuit reactance, X, divided by the equivalent circuit resistance, R. As discussed above, X is calculated by the reduction of the “X” (reactive) network and R is calculated by the reduction of the “R” (resistive) network.

Multiplying factors are determined, and used to adjust the calculated symmetrical fault current. The adjusted current is used to evaluate low voltage protective devices. Low voltage output algorithms and output reports reflect NEMA AB-1 molded case breaker de-rating multipliers. Breakers are de-rated for circuits where the power factor is lower than the NEMA test circuit (higher X/R ratio). The multipliers adjust the symmetrical fault current to the value associated with the systems fault point X/R ratio. The adjusted value listed on the report may then be compared directly with the manufacturer's published interrupting rating.

2. Momentary Duty Report

The “Momentary Duty Report” contains the calculated fault currents that occur during the first half-cycle of the fault. The momentary fault currents are used to evaluate medium and high voltage fuses, and the “closing and latching” capability (momentary rating) of medium and high voltage breakers. The fault currents reported in the “Momentary Duty Report” are calculated as follows:

- Motor and generator subtransient reactance values (Xd”) are adjusted per the first cycle duty multipliers described in IEEE Std 141-1993 (Red Book).
- The complex equivalent circuit impedance, Z, is calculated by network reduction of the “Z” (complex) network.
- The momentary symmetrical current = E/Z.
- The X/R ratio reported is equal to the equivalent circuit reactance, X, divided by the equivalent circuit resistance, R. As discussed above, X is calculated by the reduction of the “X” (reactive) network and R is calculated by the reduction of the “R” (resistive) network.
- A_FAULT calculates and reports the momentary asymmetrical current in two different ways, once as “sym*1.6” and again as “momentary based on X/R”. The “sym*1.6” value is the momentary symmetrical current multiplied by 1.6. The “momentary based on X/R” value is the momentary symmetrical current multiplied by

$$\sqrt{1+2e^{(-2\pi/(X/R))}}$$

3. Interrupting Duty Report

The fault currents reported in the “Interrupting Duty Report” are used to evaluate the interrupting rating of medium- and high-voltage breakers. The interrupting symmetrical current is calculated as follows:

- Motor and generator subtransient reactance values (Xd”) are adjusted per the interrupting duty multipliers described in IEEE Std 141-1993 (Red Book).
- The complex equivalent circuit impedance, Z, is calculated by network reduction of the “Z” (complex) network.
- The interrupting symmetrical current = E/Z.
- The X/R ratio reported is equal to the equivalent circuit reactance, X, divided by the equivalent circuit resistance, R. As discussed above, X is calculated by the reduction of the “X” (reactive) network and R is calculated by the reduction of the “R” (resistive) network.
- A_FAULT uses the calculated X/R ratio to determine the minimum contact parting time multiplying factors for 2, 3, 5, and 8 cycle breakers. The multiplying factors are based on IEEE Std C37.5-1979 and IEEE Std C37.010-1999 standards. The multiplying factors are applied to the interrupting symmetrical current in order to calculate the RMS short-circuit current interrupting duty for 2, 3, 5, and 8 cycle breakers. This duty is compared to the symmetrical current interrupting rating of the circuit breaker. NACD (No AC Decrement) ratios are calculated with consideration of generator "Local" and "Remote" contributions as outlined in IEEE Std C37.010-1999.
- Motor and generator impedance multipliers for the short-circuit calculations are summarized in the following table. This is based on the recommended combination network for comprehensive multi-voltage system calculations (from IEEE Std 141-1993; Red Book):

Machine Type	Impedance (First Cycle Duty)	Impedance (Interrupting Duty)
Turbine generators, Condensers, Hydrogenerators with amortisseur windings	1.0 Xd"	1.0 Xd"
Synchronous motors	1.0 Xd"	1.5 Xd"
Induction motors > 1000 hp at speed ≤ 1800 RPM, or > 250 hp at 3600 RPM.	1.0 Xd"	1.5 Xd"
Induction motors ≥ 50 hp not covered above.	1.2 Xd"	3.0 Xd"
Induction motors < 50 hp	1.67 Xd"	Neglect

Note: Xd" is the subtransient reactance of the rotating machine.

2.1 Short-Circuit Objectives

The objective of the short-circuit analysis is to calculate the maximum short-circuit currents produced by balanced three-phase and unbalanced faults at each bus shown on the one-line diagram in Appendix D.

2.2 System Modeling

Short-circuit currents were calculated for a three-phase bolted fault and single-line-to-ground fault at each bus shown on the one-line diagram found in Appendix D. The system was modeled for worst-case fault currents.

1. Cases:

The following short-circuit study cases were evaluated:

- Study Case No. 1 – System supplied from PGE Preferred Feed via 12.47 kV Switch 1815. Switchboard B-SRTC-SWBD1 supplied from the normal source.
- Study Case No. 2 – System supplied from PGE Preferred Feed via 12.47 kV Switch 1815. Switchboard B-SRTC-SWBD1 supplied from the emergency source.
- Study Case No. 3 – System supplied from PGE Alternate Feed via 12.47 kV Switch 1998. Switchboard B-SRTC-SWBD1 supplied from the normal source.
- Study Case No. 4 – System supplied from PGE Alternate Feed via 12.47 kV Switch 1998. Switchboard B-SRTC-SWBD1 supplied from the

emergency source. **This is the worst case scenario and the scenario illustrated in the one-line diagram found in Appendix D.**

2. Utility Information:

The following source impedance information was obtained from Mr. Tom Riddle with Portland General Electric on 1/16/13 via email.

Preferred Feed (Switch 1815):

- Voltage: 12.47 kV
- Positive Sequence Source Impedance: 0.1117 + *j*0.5581 Ω
- Zero-Sequence Source Impedance: 0.6837 + *j*0.7567 Ω

Alternate Feed (Switch 1998):

- Voltage: 12.47 kV
- Positive Sequence Source Impedance: 0.1175 + *j*0.5439 Ω
- Zero-Sequence Source Impedance: 0.3328 + *j*0.4914 Ω

A copy of the email provided by Portland General Electric can be found for review in Appendix C.

3. System Information:

Input data used in this study was obtained from the following sources:

- Contract drawing – "12.47 kV Single Line Diagram" dated 6-20-88.
- Eaton on-site data collection performed in August of 2012.
- Medium Voltage testing report issued by Glumac in February of 2013.

4. Assumptions:

The following assumptions were used in modeling the power system, and ensure conservative, worst-case results:

- It was assumed motor contributions to system fault currents would be negligible.
- System voltage is modeled at 100% nominal.
- All medium voltage cable was modeled in non-magnetic conduit.
- Unless otherwise provided, transformer X/R ratios are obtained from IEEE Std C37.010-1999.

Complete information regarding the system model used for the computer simulation is included in Appendix A.

2.3 Short-Circuit Results

The results of the short-circuit analysis, including calculated branch contributions, are provided in Appendix B. The one-line diagram with referenced bus identification is included in Appendix D.

2.4 Equipment Evaluation

The purpose of the equipment evaluation is to compare the ***maximum*** calculated short-circuit currents to the short-circuit ratings of protective devices. The comparison is made in order to determine if the device can interrupt or withstand the available fault currents of the electrical system to which the device is applied, as required by NEC-2011, Article 110.9 and NEC-2011, Article 110.10. The device evaluation follows the evaluation procedures outlined in IEEE Std C37.13-2008, IEEE Std C37.010-1999, IEEE Std C37.5-1979, IEEE Std C37.41™-2008, IEEE Std 1015™-2006 (Blue Book), and applicable ANSI, NEMA, and UL standards.

The results of the short-circuit equipment evaluation are summarized in Table 2.1. The table indicates “Bus I.D.” (corresponds to bus designations used in the one-line diagram of Appendix D), “Manufacturer”, “Status” (Pass, fail, unknown, or marginal), “Type” (equipment category), “Equip Volts”, calculated short-circuit duty, the equipment short-circuit rating, the series rating (if applicable), and the maximum duty rating.

The maximum duty rating is calculated by:

$$\frac{S.C.duty}{Device S.C.Rating} \times 100$$

If the short-circuit rating of a device is not known, a MINIMUM REQUIRED short-circuit rating is listed. The MINIMUM REQUIRED rating at each location below is the lowest common rating for each type of equipment which will pass the equipment evaluation. For equipment with series ratings, the maximum duty rating is calculated using the series rating instead of the individual device short-circuit rating. All short-circuit current values are reported in units of kA.

1. For low voltage devices:

The calculated short-circuit duty is reported under “Calc Isc (kA)" and the device short-circuit rating is reported under "Equip Isc (kA)". The calculated duty has been adjusted accordingly per the system X/R and device test X/R.

2. For medium/high voltage fuses, switches, and motor starters:

The calculated *momentary symmetrical* short-circuit duty is reported under "Calc Isc (kA)" and the device's momentary symmetrical short-circuit rating is reported under "Equip Isc (kA)". The calculated *momentary asymmetrical* duty is reported under "Calc Mom (kA)". The device's momentary asymmetrical short-circuit rating is reported under "Equip Mom (kA)".

Table 2.1 - Equipment Evaluation

Bus I.D.	Manufacturer	Status	Type	Bus Voltage (V)	Calc Isc (kA)	Equip Isc (kA)	Rating %	Calc Mom (kA)	Equip Mom (kA)	Rating %
B-CH-PNL B DS	Square D	Pass	LV Disconnect	480	19.74 (*N1)	200.00	9.87			
B-XSB USB DS	Bussmann	Pass	LV Disconnect	208	20.60	200.00	10.30			
B-PS1-USB	Coast Electric	Pass	LV Panelboard	208	8.56	40.00	21.39			
B-CH-EMER USB	GE	Pass	LV Switchboard	208	14.59	42.00	34.74			
B-CH-NW USB	ITE	Unknown	LV Switchboard	208	62.59	MIN REQUIRED = 65 KAIC				
B-CH-PNL B	Square D	Pass	LV Switchboard	480	18.29	30.00	60.97			
B-CH-SE USB	GE	Pass	LV Switchboard	208	47.16 (*N1)	65.00	72.55			
B-CH-SUB 4A	**GE**	**Fail**	**LV Switchboard**	**480**	***46.56 (*N1)**	**30.00**	***155.21**			
B-LE USB	Mears Controls, Inc.	Pass	LV Switchboard	208	25.76	42.00	61.34			
B-LH-USB	Siemens	Pass	LV Switchboard	208	43.96	65.00	67.64			
B-ML-USB	Square D	Pass	LV Switchboard	480	15.81	65.00	24.32			
B-NH-USB EAST	**Square D**	**Fail**	**LV Switchboard**	**208**	***46.14**	**42.00**	***109.87**			
B-NH-USB WEST	Square D	Pass	LV Switchboard	208	43.03	65.00	66.21			
B-PS2-USB	Zinsco	Pass	LV Switchboard	208	32.39	42.00	77.12			
B-PSC-USB	Mears Controls	Pass	LV Switchboard	480	15.02	20.00	75.10			
B-SB1-USB	GE	Pass	LV Switchboard	208	41.56	200.00	20.78			
B-SMC 2ND USB	GE	Pass	LV Switchboard	208	26.66	42.00	63.47			
B-SMC USB	Fouch Electric	Pass	LV Switchboard	208	34.05	50.00	68.09			
B-SRTC-SWBD1	Westinghouse	Pass	LV Switchboard	208	45.29 (*N1)	65.00	69.67			
B-SRTC-SWBD2	Westinghouse	Pass	LV Switchboard	480	15.46	22.00	70.27			
B-SRTC-SWBD3	Westinghouse	Pass	LV Switchboard	480	15.46	22.00	70.27			
B-SRTC-SWBD5	Eaton	Pass	LV Switchboard	480	40.26 (*N1)	65.00	61.94			
B-WHP-USB	Westinghouse	Pass	LV Switchboard	480	3.24	25.00	12.95			
B-XSB USB	Square D	Pass	LV Switchboard	208	20.48	25.00	81.93			
B-SRTC-SWBD4	Westinghouse	Pass	MV Disconnect	4160	3.66	40.00	9.14	4.82	61.00	7.90
B-SRTC-SWBD4 DS	Westinghouse	Pass	MV Disconnect	12470	12.63	27.50	45.94	15.06	40.00	37.66
B-CH CHLR DS	GE	Pass	MV Switch	12470	10.97	25.00	43.87	12.16	40.00	30.39

Bus I.D.	Manufacturer	Status	Type	Bus Voltage (V)	Calc Isc (kA)	Equip Isc (kA)	Rating %	Calc Mom (kA)	Equip Mom (kA)	Rating %
B-LH-TX DS	Eaton	Pass	MV Switch	12470	8.94	38.00	23.53	8.99	61.00	14.74
B-CH	S&C	Pass	MV Switchgear	12470	11.03	25.00	44.12	12.28	40.00	30.70
B-CH ATS	S&C	Pass	MV Switchgear	12470	11.04	25.00	44.15	12.29	40.00	30.72
B-CH CHLR	GE	Unknown	MV Switchgear	12470	10.91	MIN REQUIRED = 16.6 KAIC		12.04	MIN REQUIRED = 25 KAIC	
B-CH-NW USB DS	Unknown	Unknown	MV Switchgear	12470	10.35	MIN REQUIRED = 16.6 KAIC		10.95	MIN REQUIRED = 25 KAIC	
B-CH-SUB 4A DS	S&C	Pass	MV Switchgear	12470	10.59	25.00	42.37	11.56	40.00	28.89
B-LE USB DS	S&C	Pass	MV Switchgear	12470	10.36	25.00	41.45	10.99	40.00	27.47
B-ML	Square D	Pass	MV Switchgear	12470	11.17	25.00	44.69	12.12	40.00	30.30
B-NH EAST	S&C	Pass	MV Switchgear	12470	9.69	25.00	38.75	9.99	40.00	24.96
B-NH WEST	S&C	Pass	MV Switchgear	12470	9.90	25.00	39.60	10.27	40.00	25.68
B-PS1-TX DS	S&C	Pass	MV Switchgear	12470	9.49	25.00	37.95	9.76	40.00	24.39
B-PS2-TX DS	Zinsco	Pass	MV Switchgear	12470	10.47	25.00	41.86	11.14	40.00	27.86
B-PSC	S&C	Pass	MV Switchgear	12470	11.57	25.00	46.30	13.03	40.00	32.57
B-SB1	S&C	Pass	MV Switchgear	12470	12.07	25.00	48.28	13.61	40.00	34.03
B-SMC	S&C	Pass	MV Switchgear	12470	10.47	25.00	41.86	11.14	40.00	27.86
B-SMC 2ND USB DS	Unknown	Unknown	MV Switchgear	12470	10.41	MIN REQUIRED = 16.6 KAIC		11.05	MIN REQUIRED = 25 KAIC	
B-SRTC-SB2	S&C	Pass	MV Switchgear	12470	12.73	25.00	50.94	15.29	40.00	38.22
B-SRTC-USB1 PREF	S&C	Pass	MV Switchgear	12470	12.65	25.00	50.60	15.84	40.00	39.61
B-SRTC-USB2 ALT	S&C	Pass	MV Switchgear	12470	12.94	25.00	51.75	15.92	40.00	39.81
B-WHP	S&C	Pass	MV Switchgear	12470	11.65	25.00	46.62	13.24	40.00	33.09
B-XSB-TX DS	S&C	Pass	MV Switchgear	12470	6.66	25.00	26.62	6.66	40.00	16.64

(*N1) System X/R higher than Test X/R, Calc Isc kA modified based on low voltage factor.

3.0 PROTECTIVE DEVICE COORDINATION STUDY

The protective device coordination study determines overcurrent protective relay and circuit breaker settings in order to provide an optimal compromise between protection and selectivity.

The coordination plots were developed using SKM System Analysis' CAPTOR software. Protective device coordination was performed in accordance with IEEE Std 242™-2001 (Buff Book). Minimum guidelines for equipment protection, as outlined in the National Electrical Code (NEC) and applicable standards of the American National Standards Institute (ANSI), were followed.

3.1 General Description and Protection Philosophy

Using the appropriate maximum fault currents, the time-current coordination curves were plotted as operating time versus current magnitudes to show protective device tripping and/or clearing characteristics and coordination among these devices.

Consideration was given to provide both selective isolation of faults and maximum protection of equipment such as cables, transformers, motors, etc.

To achieve the optimum protection and selectivity, the following guidelines were followed throughout the study:

1. Ideally, the settings of any overcurrent device should be high enough to permit the continuous full-load operating capacity of the cables and the equipment they supply, and to ride through system temporary disturbances such as in-rush current. On the other hand, the settings should be low enough to provide overload and short-circuit protection under minimum fault conditions.
2. Considering any two protective devices in series:
   - The maximum available fault current at the downstream device determines the upper limit of the coordination range between these two devices.
   - The minimum available fault current at the downstream device or the pick-up setting of the upstream device determines the lower limit of the coordination range.
   - Series instantaneous devices do not coordinate unless there is sufficient impedance between the two devices.
   - When plotting coordination curves, certain time intervals must be maintained between the curves in order to ensure correct selectivity. These time intervals vary, depending on the device types. In general, however, the following must be taken into consideration when determining the appropriate time separation interval: Breaker clearing

time, relay tolerances, induction disk over-travel, and a reasonable safety margin for error.

3.2 Codes and Standards

The minimum protection requirements as outlined in the National Electric Code (NEC), ANSI, and IEEE Standards were used as guidelines for protective device settings.

Applicable requirements are summarized below.

1. Cables

Power cables require overload and short-circuit protection in order to meet the requirements stated in NEC-2011, Article 240, and IEEE Std 242-2001 (Buff Book). NEC further requires that the ampacity of low voltage cable (0-2000 Volts) be determined by NEC-2011, Article 310.15. Cable de-rating based upon ambient temperature and the number of current carrying conductors in a raceway must also be applied. Medium voltage cable (2001-35,000 Volts) ampacity is defined by NEC-2011, Article 240.100(A) and NEC-2011, Article 310.60.

2. Transformers

A transformer is recommended to have protective devices on both primary and secondary side in order to meet the basic protection requirements for overloads and short-circuit withstand values. However, a transformer is permitted to be protected by only a primary side device if it meets the exceptions listed in NEC-2011, Article 240.4(F). In addition, the transformer protective devices must be able to withstand magnetizing inrush currents without tripping.

NEC protection requirements for transformers: Overcurrent devices are selected, and settings are recommended to provide overcurrent protection in accordance with NEC-2011, Article 450.3. Paragraph (A) specifies that transformers over 600 V comply with Table 450.3(A). Paragraph (B) specifies that transformers less than 600 V comply with Table 450.3(B). These tables provide guidance for sizing of primary and secondary overcurrent protective devices based on transformer full load ampere ratings, transformer impedance, and transformer location.

Short-circuit thermal limits for transformers: The primary devices should be set on the basis that the transformers have short-circuit withstand capabilities as defined by IEEE Std C57.109™-1993.

3. Motors

The motors should have appropriate protective devices to meet the basic protection requirements for overloads and fault current withstand values. In addition, the motor short-circuit and ground fault protective devices should be set to ride through motor starting current.

3.3 Coordination Objectives

Review the existing system overcurrent protection and coordination. Provide suggestions for improvement.

3.4 Coordination Results

The system coordination began at the main 12.47 kV SRTC switchgear and continued downstream through the West Campus Loop to the largest feeder breaker at each 480 V or 208 V service entrance disconnect within each West Campus Loop building. These buildings include the Science Research and Teaching Center, Science Building 1, West Heating Plant, Peter Stott Center, Millar Library, Cramer Hall, Smith Memorial Center, Library East, University Services Building, Neuberger Hall, Parking Structure 1, Lincoln Hall, and the Extended Studies Building.

As shown on the time-current plots, each device curve is tagged with an arrow and label referencing its location on the plot's individual representative one-line diagram. This label also references the device to its' specific manufacturer information, including ratings and settings, as indicated in the text box on each plot. The device time-current characteristics are truncated at maximum through-fault current for a downstream fault.

Efforts were made to provide the best coordination possible with the protective devices supplied under this contract. Areas where breaker trip curves overlap indicate areas of possible non-selective breaker operation. Where possible, efforts were made to reduce non-selective breaker operation while maintaining adequate system protection. In some cases, because of device limitations, little can be done to improve device selectivity. Such device limitations include the fixed operating characteristic of a fuse, the built-in instantaneous or instantaneous "over-ride" elements of molded case circuit breakers, and the limited instantaneous trip range of trip units with an instantaneous trip function.

In cases involving redundant protective devices, non-selective breaker operation is of little or no concern. Protective devices are redundant if, regardless of which device opens, the same system outage occurs. Often, in order to improve overall system protection and coordination, redundant devices are intentionally set to overlap (i.e. non-selectively coordinate with) one another.

Adequate coordination is achieved using the recommended protective devices, with settings and ratings as listed in Section 4. The recommended adjustments would maximize coordination in an attempt to allow the various downstream devices to isolate faults without operation of the upstream devices. Although instantaneous trip devices provide the highest degree of protection, when applied in series they compromise selectivity at high-magnitude fault currents.

3.5 Coordination Recommendations

All of the adjustable low voltage electronic trip and thermal magnetic circuit breakers and medium voltage equipment should be tested and adjusted according to the recommended settings given in Section 4.

If the largest feeder breaker in a service entrance disconnect was adjustable, the as-found settings were used to plot the coordination curve. It is not possible to ensure these breakers are properly set without expanding the scope of this study to downstream locations. Therefore, no settings are recommended for these locations.

3.6 Time-Current Characteristic Plots

Refer to the following pages for the plotted coordination curves, which graphically indicate the degree of selectivity and protection obtained.

In some cases, a single time-current curve may be applicable to several locations in the system, where each location utilizes substantially similar devices, and serves similar loads.

The following list references the attached time-current curves for this report.

Table 3.1 – TCC Plots Index

SB2 SWBD 1-1	Page 3-5
SB2 SWBD 1-2	Page 3-6
SB2 SWBD2	Page 3-7
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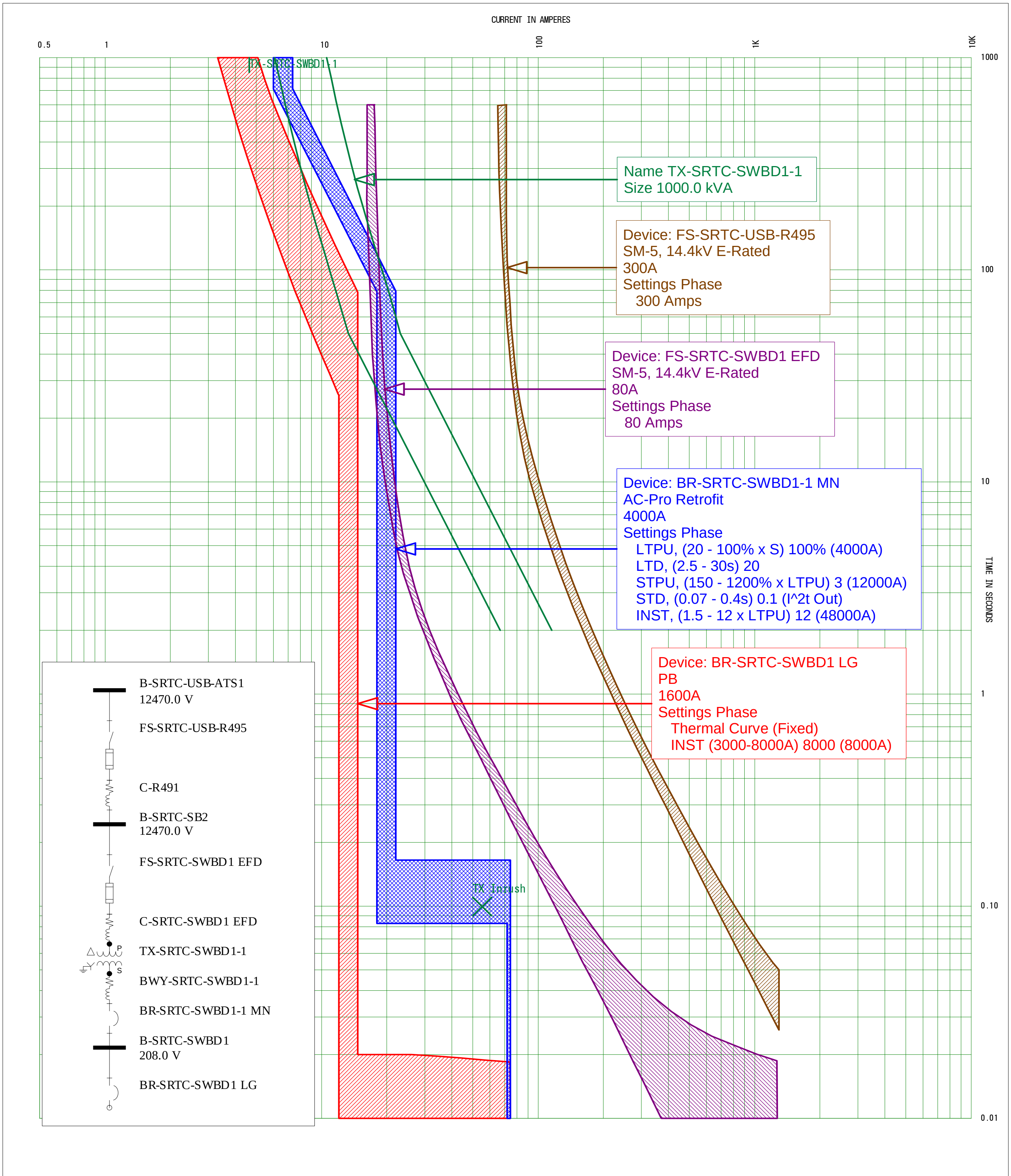
CH SE USB	Page 3-10
CH EMER USB	Page 3-11
LIB EAST	Page 3-12
SMC 2ND ADD	Page 3-13
NH E USB	Page 3-14
NH W USB	Page 3-15
PARK#1	Page 3-16
CH PNL B	Page 3-17
SB1 SWBD	Page 3-18
XSB USB	Page 3-19
WHP USB	Page 3-20
ML USB	Page 3-21



Eaton Electrical Services and Systems
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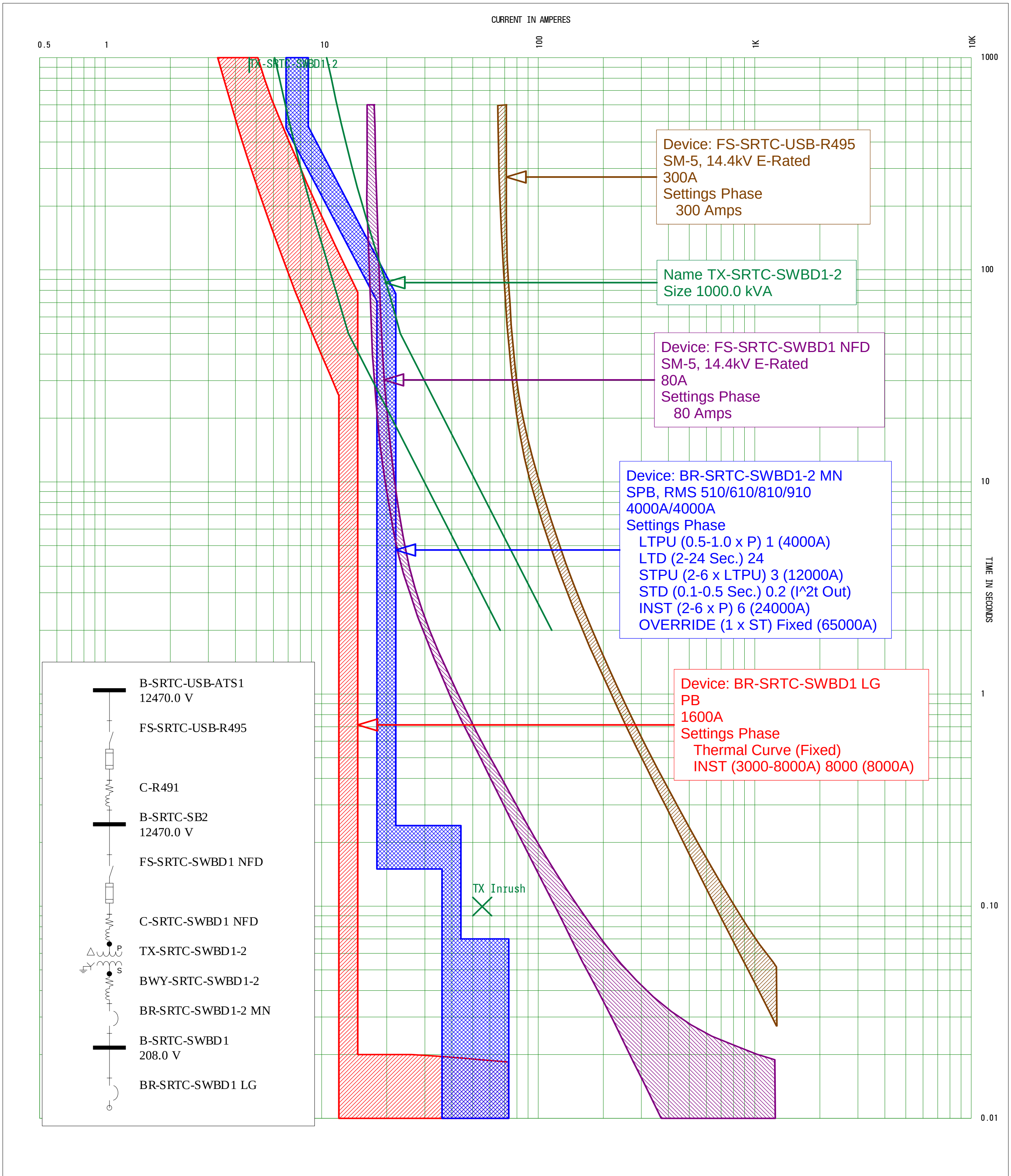
Ref. Voltage: 12470V
Current Scale: x 10



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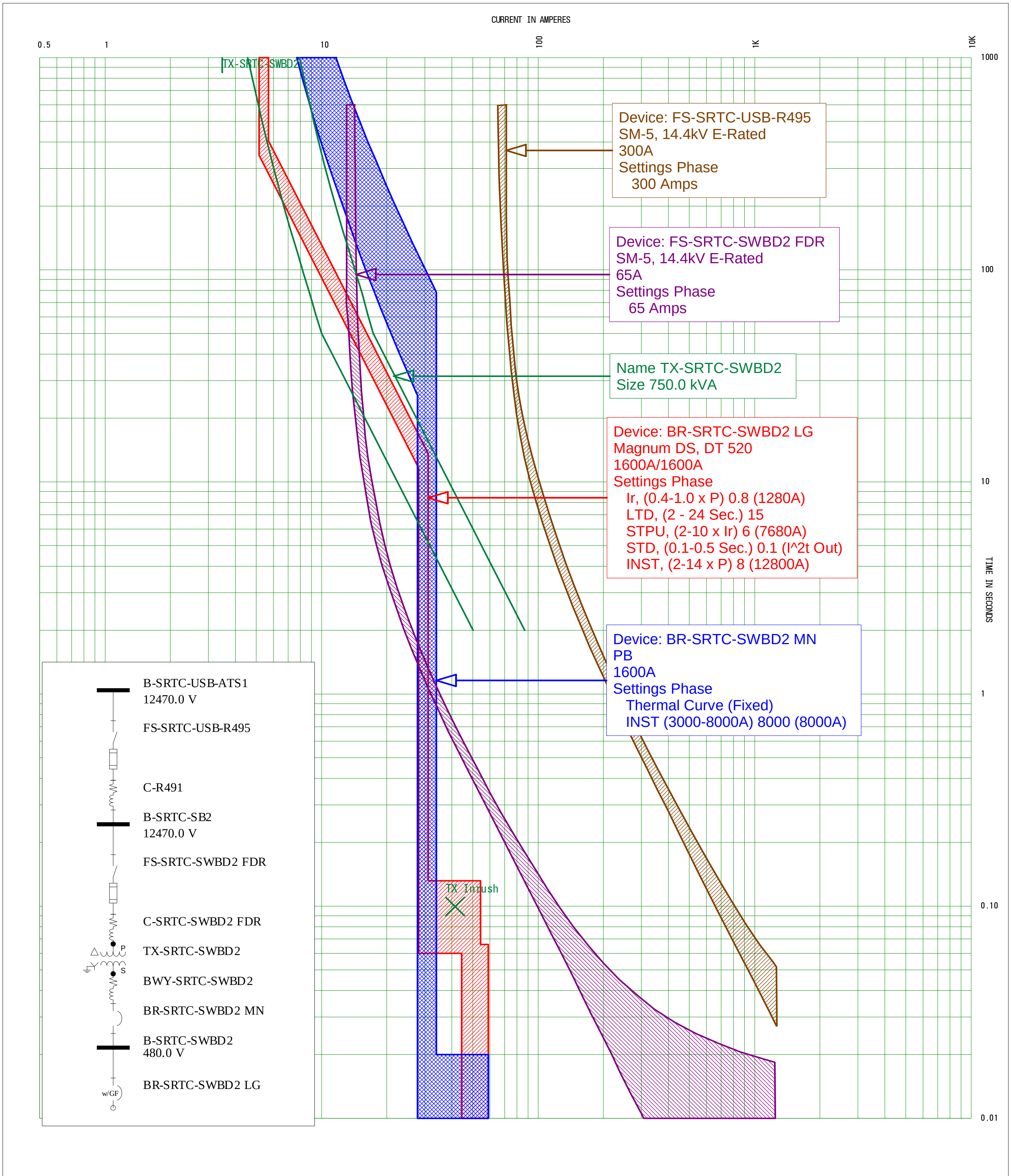

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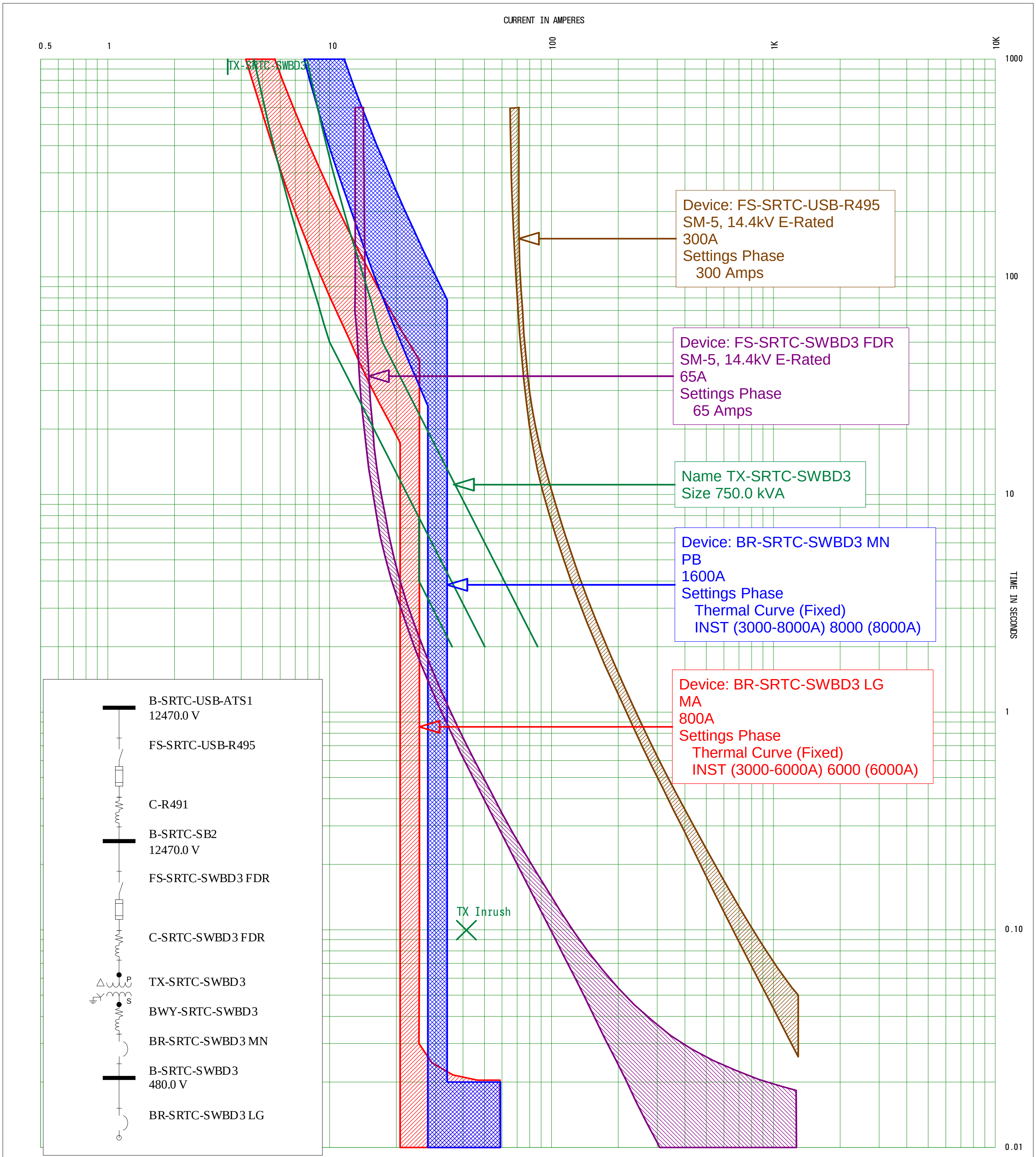
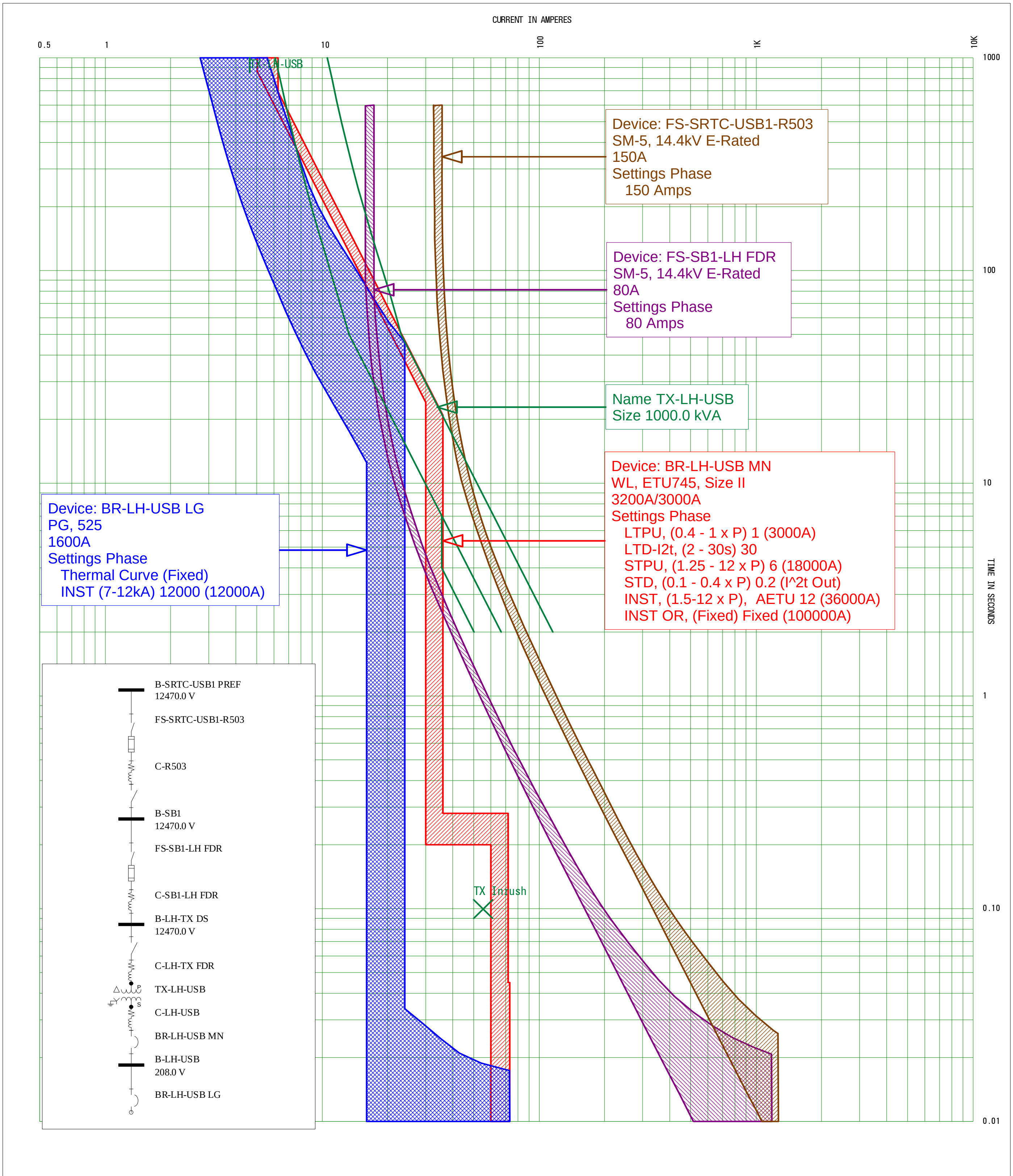
EATON Powering Business Worldwide



Eaton Electrical Services and Systems February 22, 2013	Plot name: SB2 SWBD3 Ref. Voltage: 12470V Current Scale: x 10

Powering Business Worldwide



Eaton Electrical Services and Systems
February 22, 2013

Plot name: LH USB
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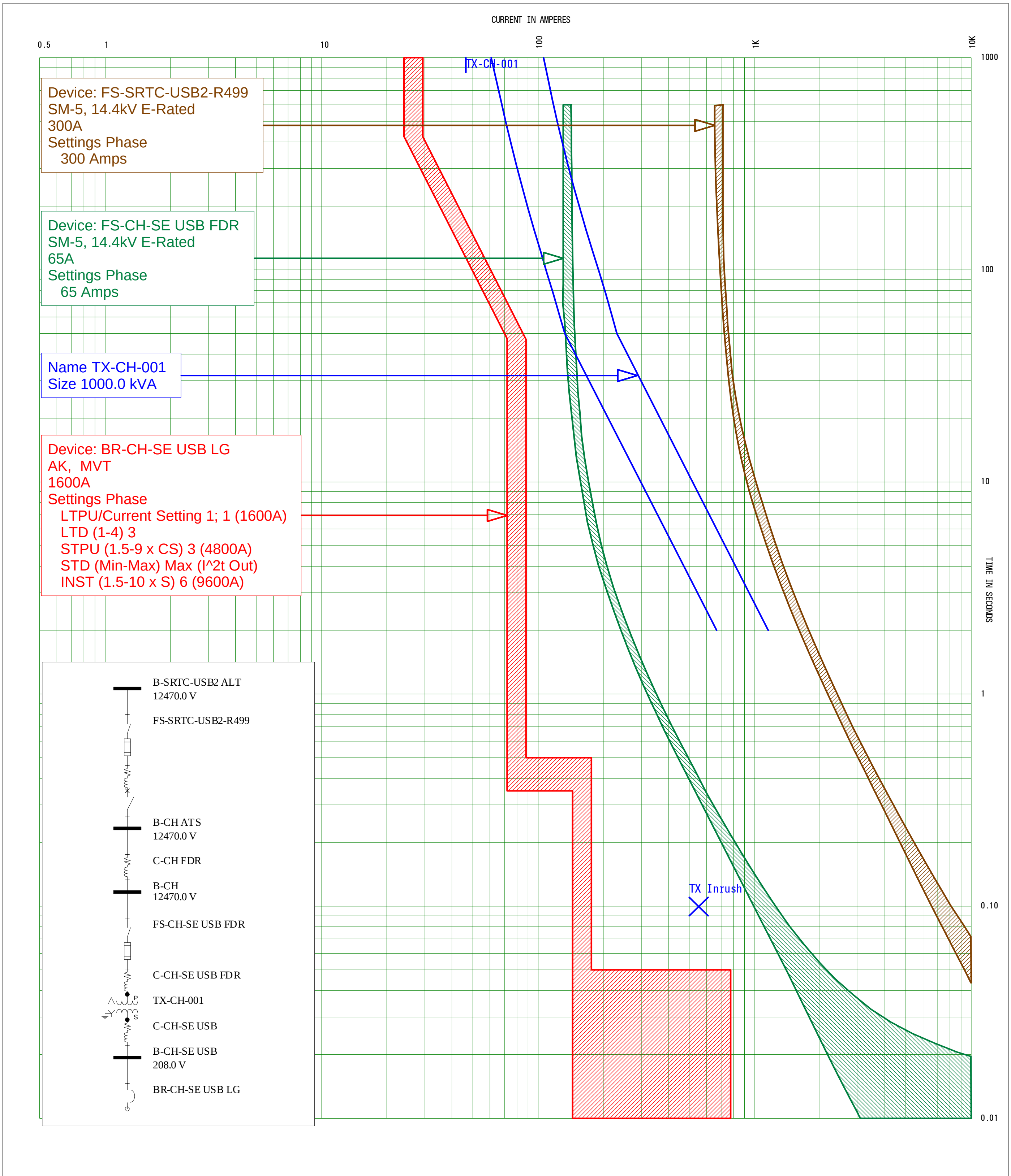
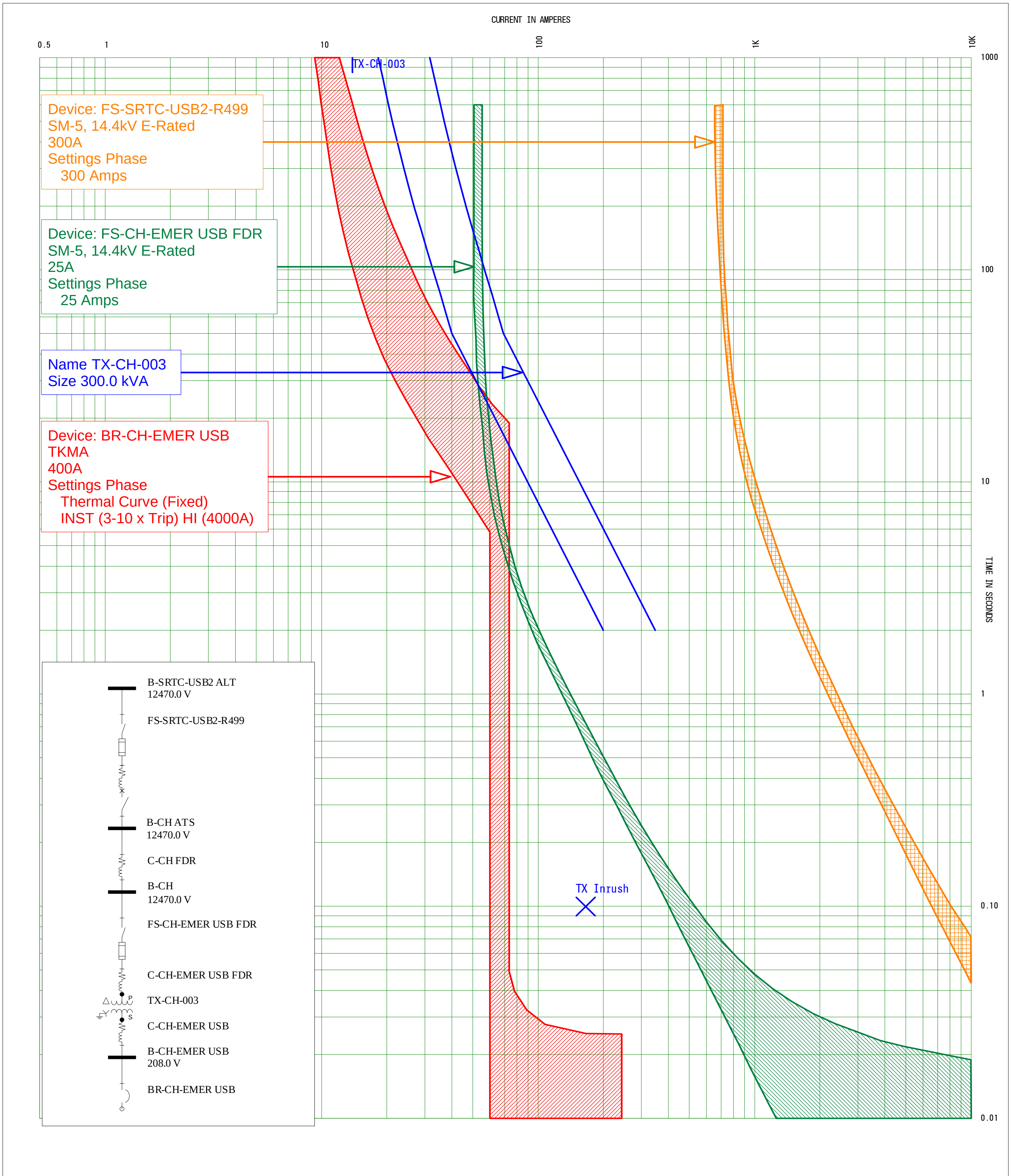
Current Scale: x 10



Eaton Electrical Services and Systems February 22, 2013	Plot name: CH SE USB Ref. Voltage: 12470V Current Scale: x 1

EATON Powering Business Worldwide



Eaton Electrical Services and Systems
February 22, 2013

Plot name: CH EMER USB
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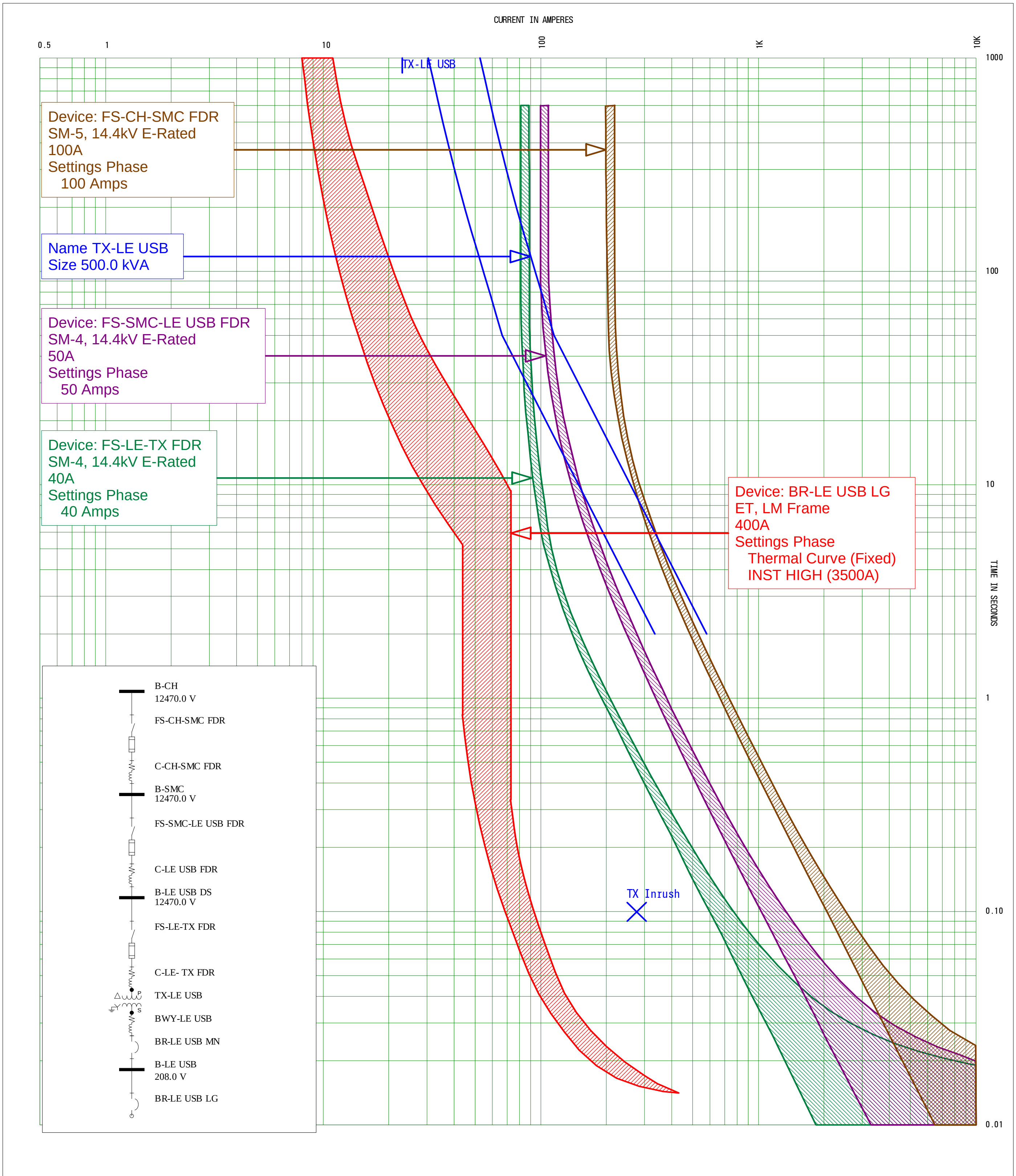
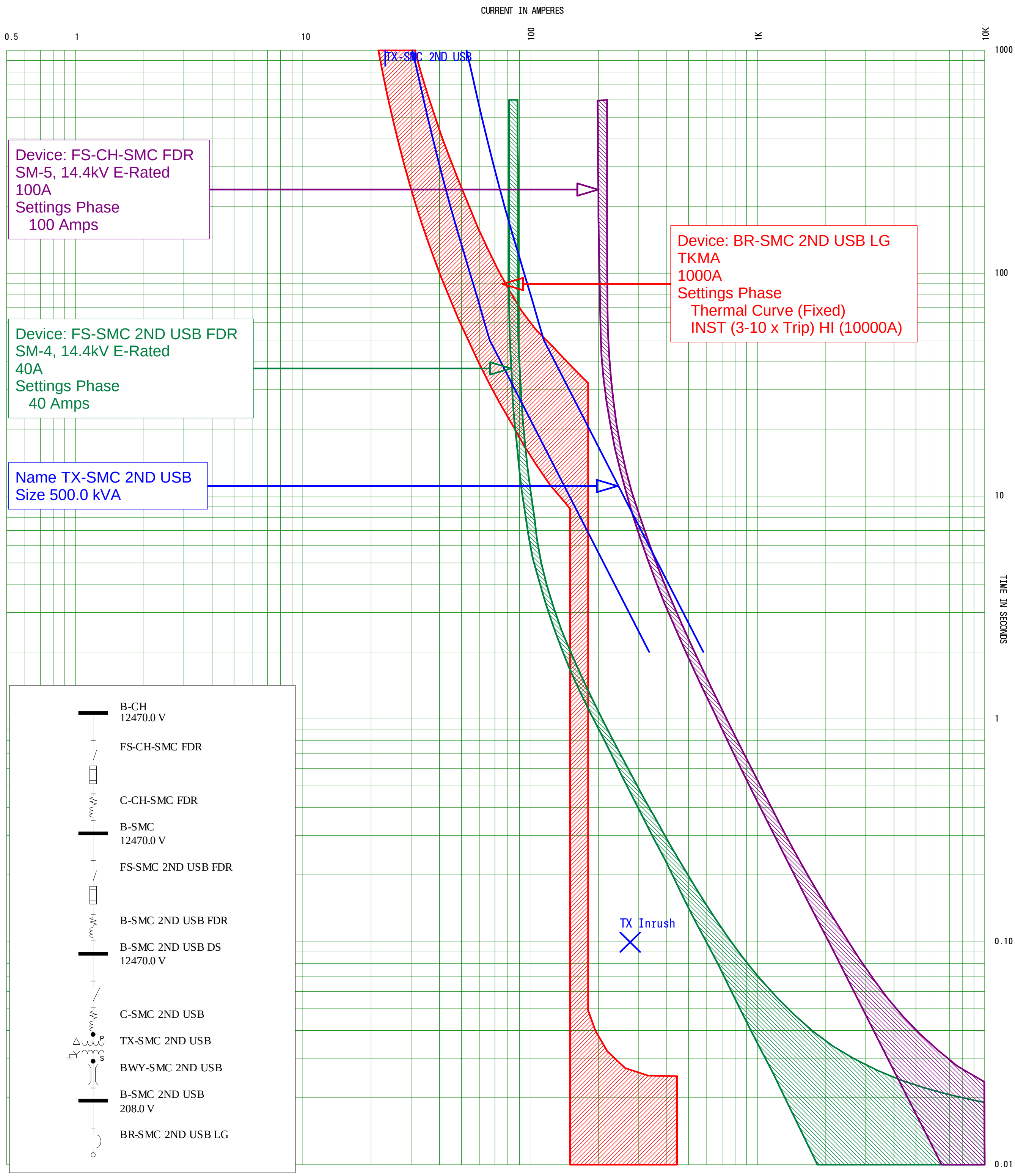
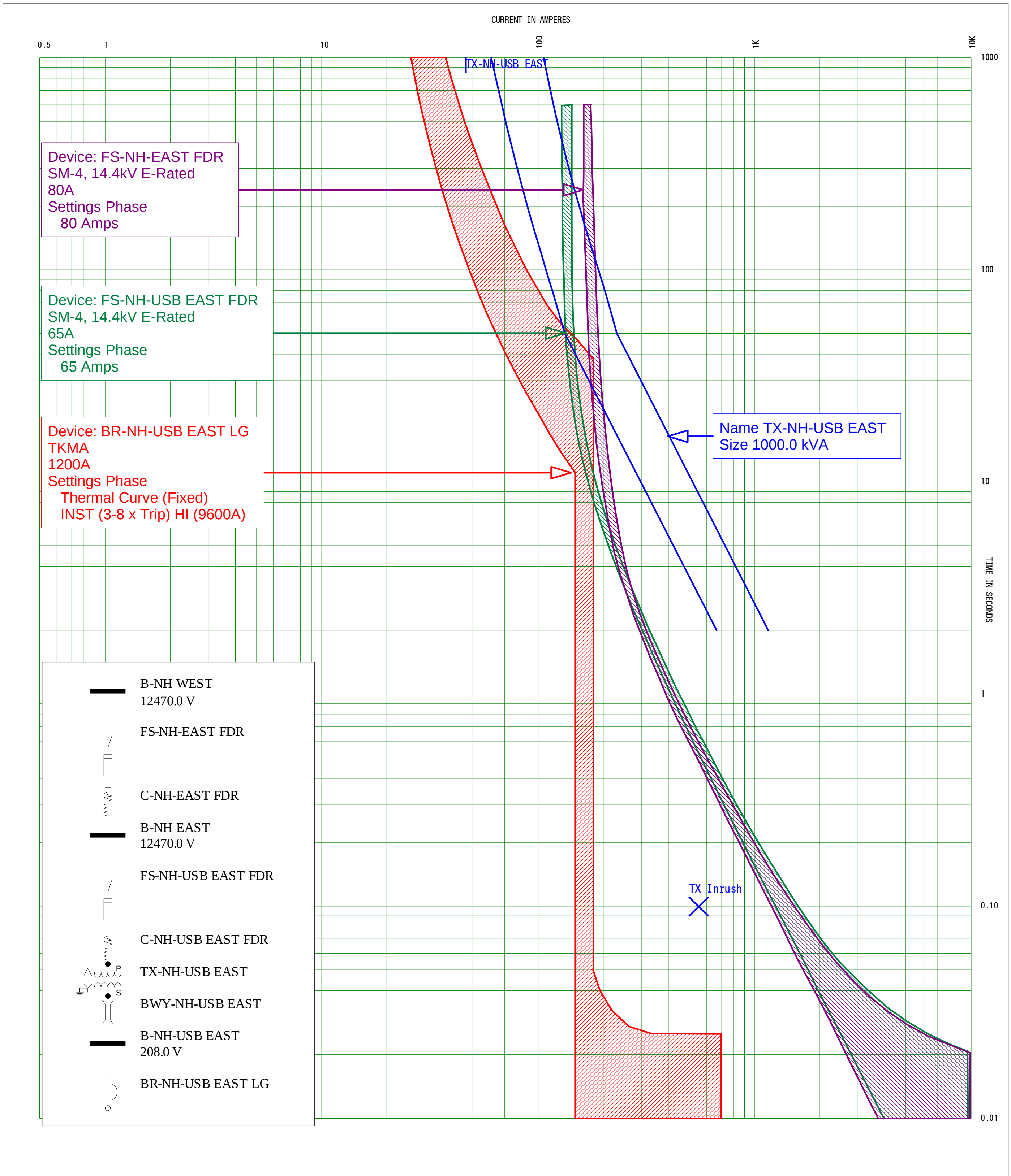
Current Scale: x 1



Eaton Electrical Services and Systems February 22, 2013	Plot name: LIB EAST Ref. Voltage: 12470V Current Scale: x 1



Eaton Electrical Services and Systems February 22, 2013	Plot name: SMC 2ND ADD Ref. Voltage: 12470V Current Scale: x 1



Eaton Electrical Services and Systems
February 22, 2013

Plot name: NH E USB
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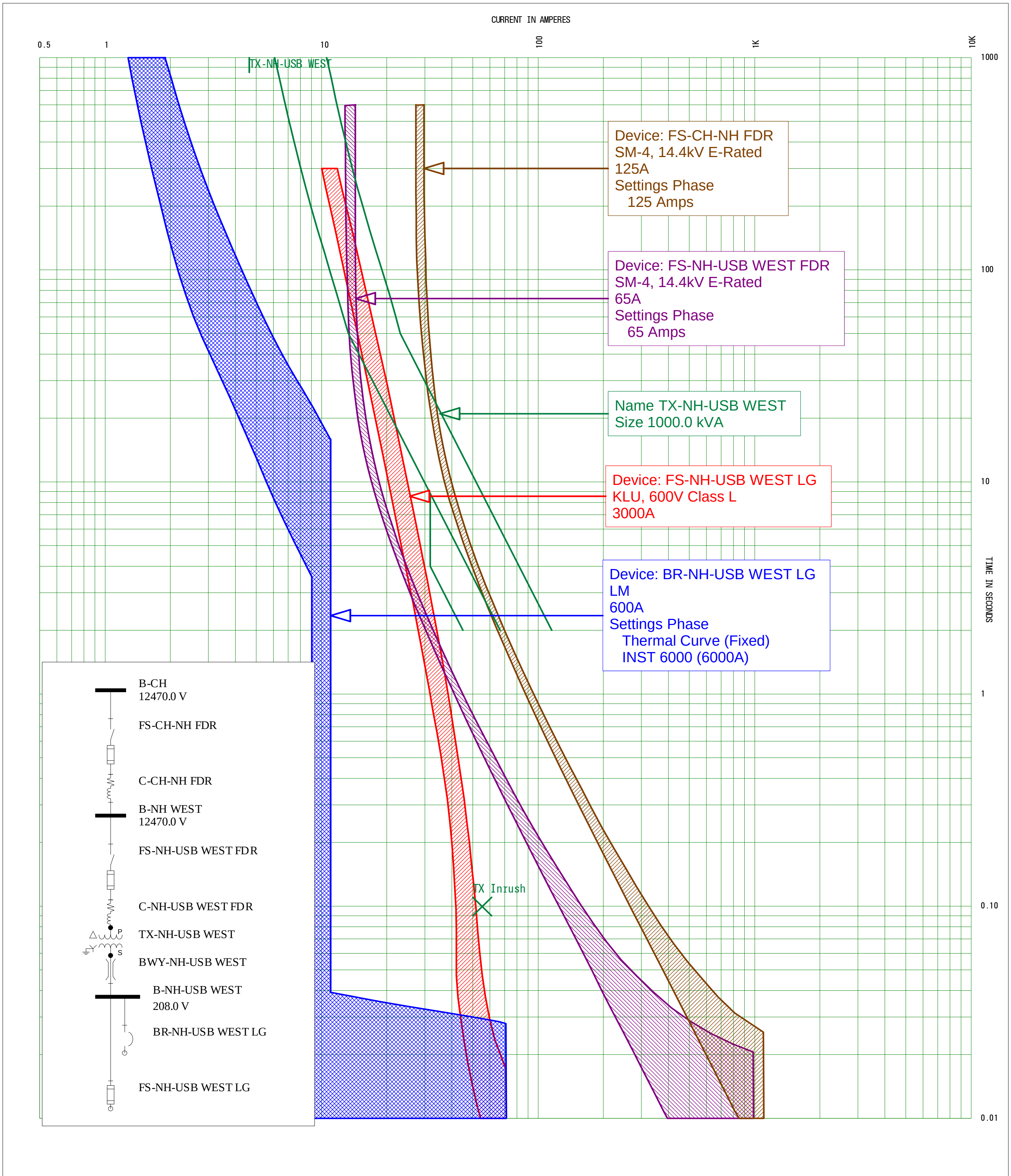
Current Scale: x 1



Eaton Electrical Services and Systems
February 22, 2013

Plot name: NH W USB
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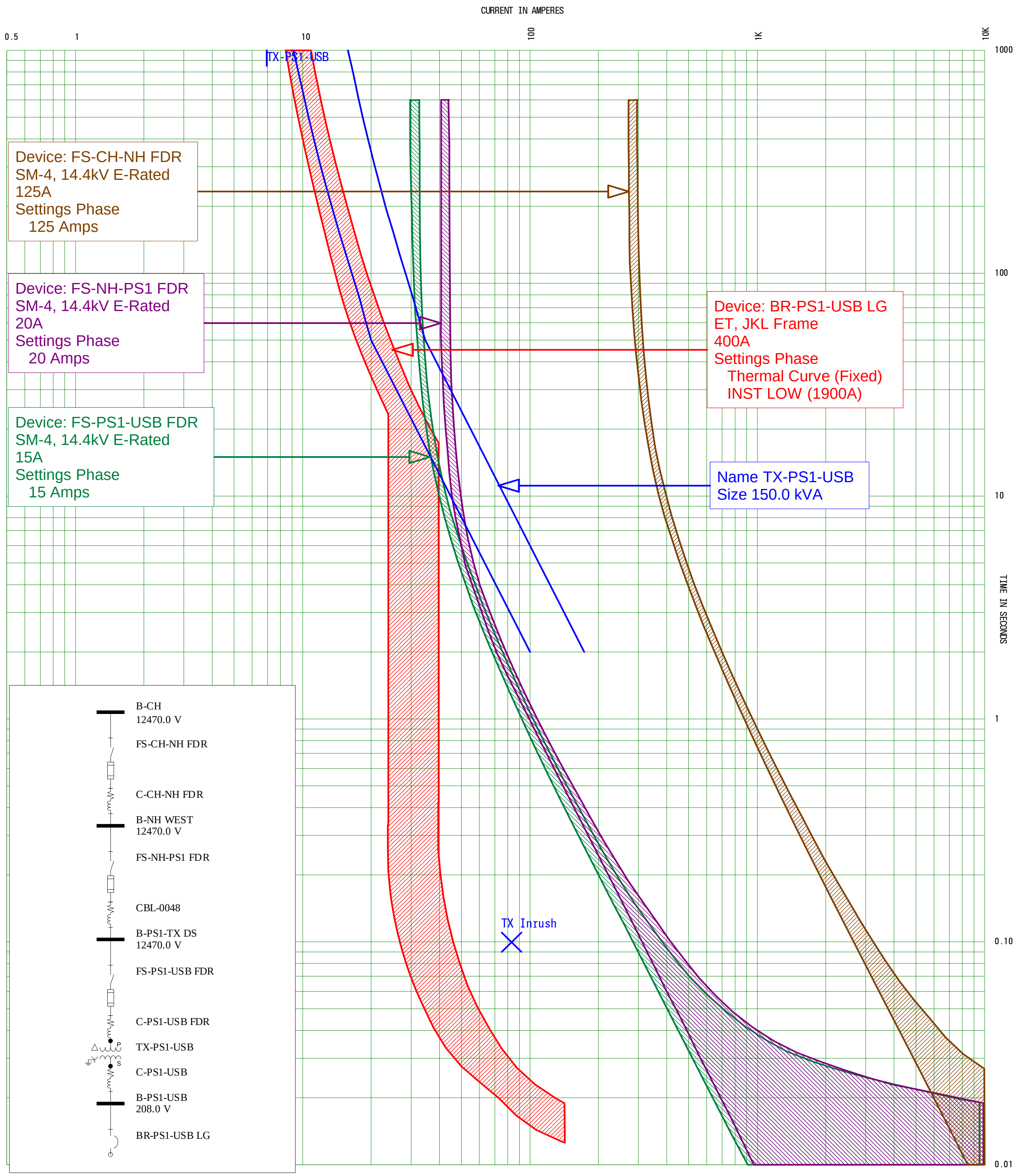

Eaton Electrical Services and Systems
February 22, 2013

Plot name: PARK#1
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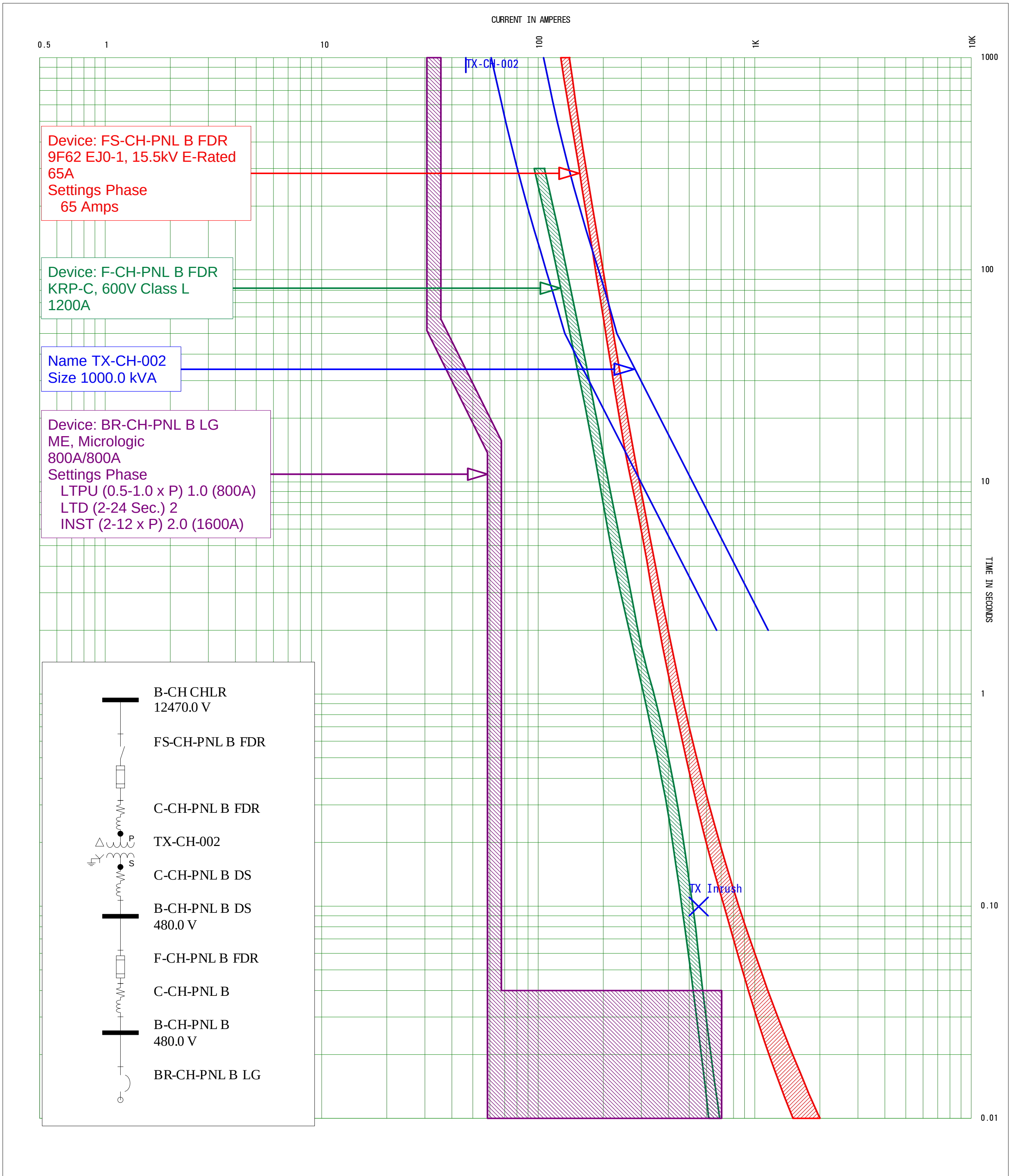
Current Scale: x 1



Eaton Electrical Services and Systems
February 22, 2013

Plot name: CH PNL B
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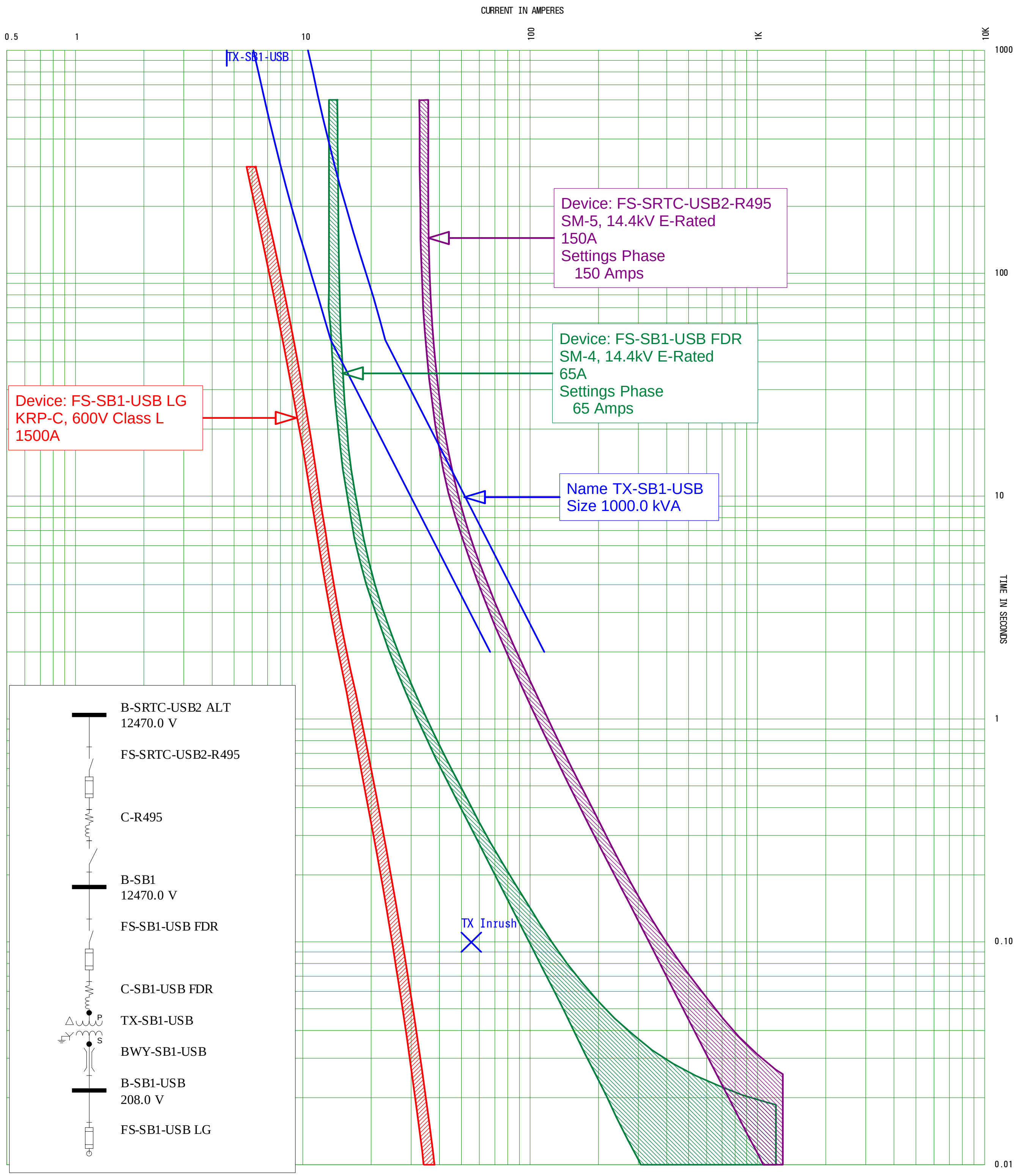
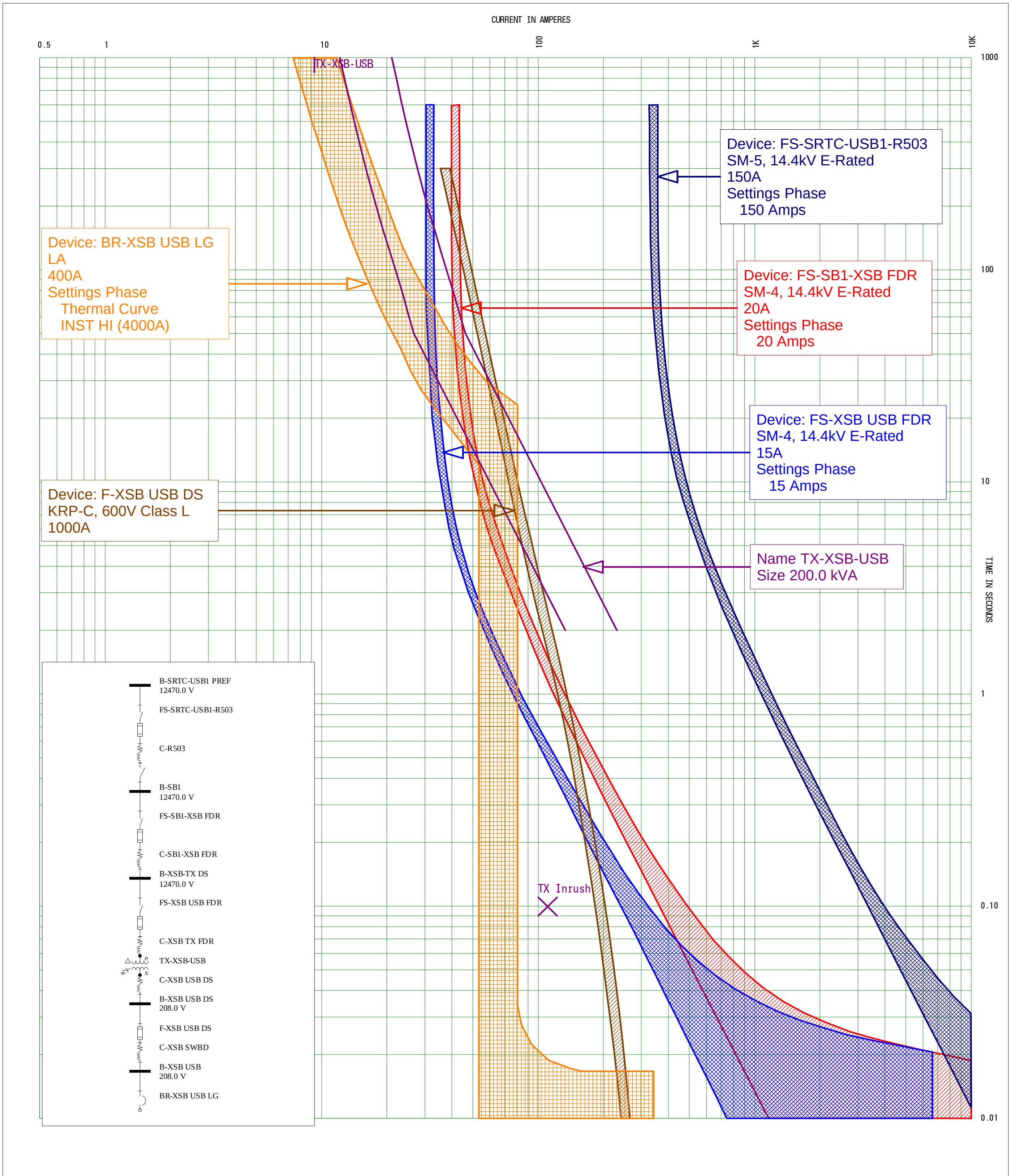


Eaton Electrical Services and Systems February 22, 2013	Plot name: SB1 SWBD Ref. Voltage: 12470V Current Scale: x 10



Eaton Electrical Services and Systems
February 22, 2013

Plot name: XSB USB
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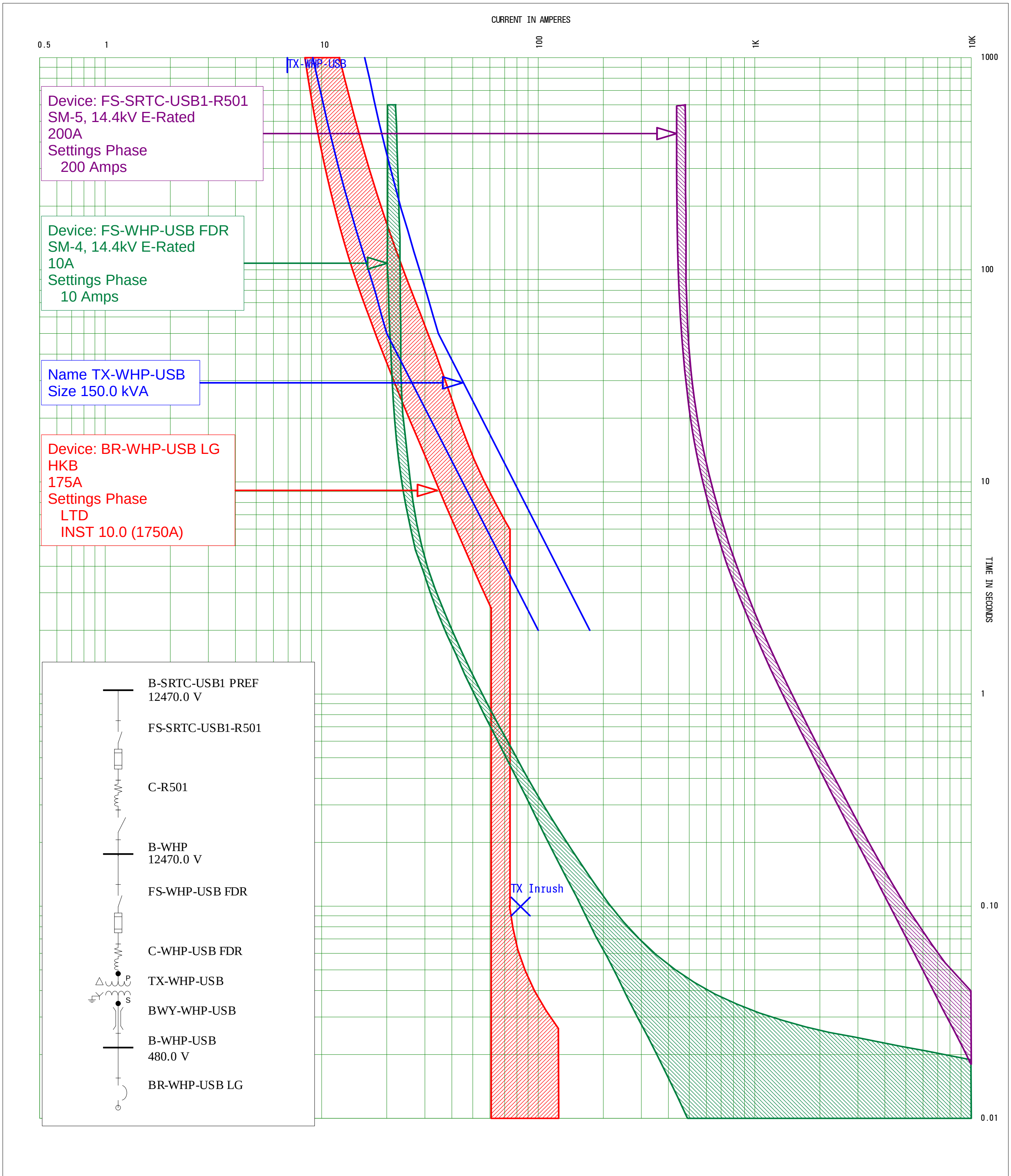
Current Scale: x 1



Eaton Electrical Services and Systems
February 22, 2013

Plot name: WHP USB
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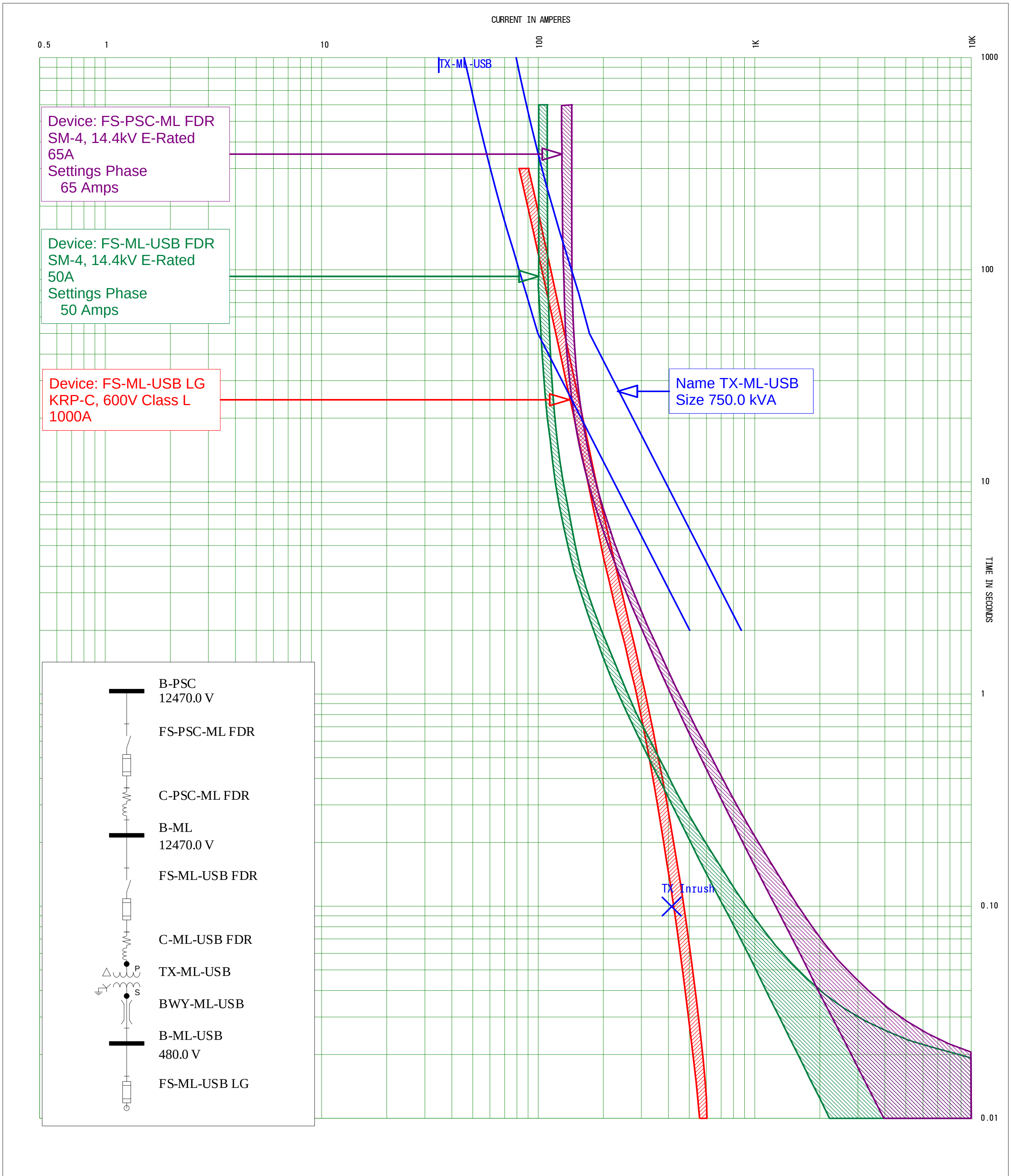
Current Scale: x 1



Eaton Electrical Services and Systems
February 22, 2013

Plot name: ML USB
Ref. Voltage: 12470V
Current Scale: x 1

4.0 RECOMMENDED PROTECTIVE DEVICE SETTINGS

The following table shows a comprehensive summary of the recommended settings for the adjustable protective devices. The devices are grouped by system bus name/location. Refer to Appendix D for the system one-line diagram.

Table 4.1 - Recommended Low-Voltage Protective Device Settings

BUS NUMBER	FEEDER BREAKER ID	BREAKER MODEL & MANUFACTURER	TRIP UNIT TYPE	CURRENT RATING		LONG DELAY		SHORT DELAY			INST.	GROUND		CURVE NAME
				FRAME	PLUG	PICKUP	TIME	PICKUP	TIME	I^2t		PICKUP	TIME, I^2t	
B-SRTC-SWBD1	BR-SRTC-SWBD1-1 MN Main Breaker	Westinghouse DB100	AC-PRO Retrofit	4000A	4000A	1	20	3	0.1	Out	12	---	---	SB2 SWBD 1-1
B-SRTC-SWBD1	BR-SRTC-SWBD1-2 MN Main Breaker	Westinghouse DB100	RMS 510 LSI	4000A	4000A	1 (1)	24 (2)	3 (2.5)	0.2 (0.2)	Out (Out)	6 (4)	---	---	SB2 SWBD 1-2
B-SRTC-SWBD2	BR-SRTC-SWBD2 MN Main Breaker	Westinghouse PB	T/M	2500A	1600A	---	---	---	---	---	HI (LO)	---	---	SB2 SWBD2
B-SRTC-SWBD3	BR-SRTC-SWBD3 MN Main Breaker	Westinghouse PB	T/M	2500A	1600A	---	---	---	---	---	HI (HI)	---	---	SB2 SWBD3
B-LH-USB	BR-LH-USB MN Main Breaker	Siemens WL	ETU745 LSI	3000A	3000A	1 (1)	30 (30)	6 (3)	0.2 (0.2)	Out (Out)	12 (6)	---	---	LH USB

*Note: If available, as-found settings are shown in parentheses

5.0 ARC FLASH HAZARD ANALYSIS

This section of the report contains the interpretation for the arc flash hazard analysis. The calculations made in this arc flash hazard analysis conform to NFPA 70E, and are based on the information provided by the customer. Actual heat and radiation exposure may be more or less than reflected in the analysis.

Only qualified electricians who are familiar with the installation and maintenance of electrical distribution equipment should perform work associated with such products. All recommendations of the manufacturer, warnings and cautions relating to the safety of personnel and equipment should be followed. All applicable health and safety laws, codes, standards, and procedures should be adhered to. All equipment should be de-energized prior to any maintenance or service. OSHA 1910.333 requirements should be adhered to. All guidelines of NFPA 70E-2012 should be followed, and in particular appropriate personal protective equipment must be provided and worn.

Eaton Corporation will not be responsible for the misuse or misapplication of the information contained in this analysis. Those providing service for electrical equipment should contact an Eaton Electrical Services and Systems representative, or other qualified individual, if any questions arise.

5.1 Introduction

NFPA 70E-2012, Article 110.3(F) requires that an employer developed electrical safety program includes a hazard identification and risk evaluation procedure. This procedure is meant to be used before performing work on or near any equipment at or above 50 volts or any time work is being performed where an electrical hazard exists. This analysis presents only the results of an incident energy evaluation conducted in accordance with 130.5(B). The risk depends on a number of factors. These include the nature of the task being performed and the condition of the equipment. Selection of personal protective equipment (PPE) must be made based on the incident energy level that is presented in this report and a risk assessment to be made by the qualified person. NFPA 70E-2012, Article 130.7(A) requires that employees use and employers provide proper PPE for the tasks being performed. NFPA 70E-2012, Table H.3(b) provides guidance for the selection of PPE based on calculated incident energy exposure.

NFPA 70E-2012 and IEEE Std 1584-2002 provide equations and methods to accurately calculate the arc flash boundary and incident energy at specific locations within a facility's electrical system. Any location where work may be performed on or near energized electrical conductors and circuit parts is subject to the arc flash standards. PPE used to guard against arc flash hazard should be considered the last line of defense. It is also important to note that the use of PPE is not intended to prevent all injuries from an arc flash. The goal of determining PPE levels using the arc flash hazard approach is to identify the level of protection required to limit the injury to the onset of a second degree burn in the event of an arc flash while avoiding the use of more protection than is needed so as to minimize hazards of heat stress, reduced visibility and limited body movement.

Although the arc flash calculation procedure is based upon NFPA 70E and IEEE Std 1584-2002 equations and methods, it is a relatively new approach to determining the degree of required PPE. The calculations are derived from theory and research involving arc current incident energy measurements conducted under a specific set of controlled test conditions. Therefore, calculation results may be more severe or less severe than the hazard presented by an actual arc flash exposure. Also, the arc flash hazard calculations do not take into account hazards associated with the splattering of molten metal, explosively propelled pieces of equipment and air pressure shock waves.

The results of this arc flash hazard analysis are not intended to imply that personnel be permitted to work on exposed energized equipment or circuits. OSHA 1910.333 restricts the situations in which work is to be performed near or on energized equipment or circuits by stating, “Live parts to which an employee may be exposed shall be deenergized before the employee works on or near them, unless the employer can demonstrate that deenergizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations.”

Even if work is not being performed directly on energized equipment, it is important that the proper PPE be used during some load interruption actions, during visual verification of the state of disconnecting devices, and during lockout/tagout procedures.

5.2 Study Procedure

In accordance with NFPA 70E and IEEE Std 1584-2002, SKM Systems Analysis software provides the calculation of these values. The equations used in these calculations are based on actual test values. These tests measured the calories per square centimeter (cal/cm^2) radiating from a simulated arcing fault. The measurements were performed at a theorized working distance of 18 inches.

The intent of NFPA 70E and IEEE Std 1584-2002 guidelines is to establish standard calculations to determine an approach boundary that will prevent the onset of a second-degree burn to the face and the torso of the worker. An incident energy of 1.2 cal/cm^2 represents the onset of a second-degree burn.

NFPA 70E-2012, Article 130.7(A), Informational Note 3, states that greater consideration must be given to the decision to work within the limited approach boundary of energized electrical equipment when the incident energy exceeds 40 cal/cm^2. Locations with a calculated incident energy that exceeds 40 cal/cm^2 are shown in Table 5.2.

The arc flash analysis considers each medium and low voltage system location within the scope of the work. IEEE Std 1584-2002 states that equipment below 240 V need not be considered unless it involves at least one 125 kVA or larger low-impedance transformer in its immediate power supply. Therefore, no detailed calculations will be performed for 120/208 V locations supplied by a transformer smaller than 125 kVA, however labels will be provided for these locations.

Before the arc flash equations can be applied, a comprehensive short-circuit and protective device coordination study must be completed to include all locations where work may be performed on or near energized components; e.g. motor control centers and power distribution panels. Since the short-circuit current must be calculated at every pertinent location and the clearing time of each location's upstream protective device is required, the arc flash circuit model is more detailed and extends deeper into the facility electrical distribution system than is typical of a basic short-circuit and protective device coordination study. Accurate fault currents and device clearing times are extremely important in deriving reliable results. A conservative (high) fault current value could yield a faster clearing time of a protective device, depending upon its curve shape, and the calculated incident energy may actually be less than the incident energy calculated for a lower magnitude of fault current and a longer clearing time.

1. Arc Flash Scenarios

Since the greatest arc flash hazards may not result from the highest fault current, multiple scenarios must be analyzed and compared. The following modes of operation have been evaluated in order to determine the worst-case incident energy at each location in the system. It is important to determine the available short-circuit current for modes of operation that provide both the maximum and minimum available short-circuit currents.

- Arc Flash Scenario 1 – System supplied from the preferred utility source. B-SRTC-SWBD 1 supplied from the Normal Feed.
- Arc Flash Scenario 2 – System supplied from the preferred utility source with the assumed minimum fault current. B-SRTC-SWBD 1 supplied from the Normal Feed.
- Arc Flash Scenario 3 – System supplied from the alternate utility source. B-SRTC-SWBD 1 supplied from the Normal Feed.
- Arc Flash Scenario 4 – System supplied from the alternate utility source with the assumed minimum fault current. B-SRTC-SWBD 1 supplied from the Normal Feed.
- Arc Flash Scenario 5 – System supplied from the preferred utility source. B-SRTC-SWBD 1 supplied from the Emergency Feed.

- Arc Flash Scenario 6 – System supplied from the preferred utility source with the assumed minimum fault current. B-SRTC-SWBD 1 supplied from the Emergency Feed.
- Arc Flash Scenario 7 – System supplied from the alternate utility source. B-SRTC-SWBD 1 supplied from the Emergency Feed.
- Arc Flash Scenario 8 – System supplied from the alternate utility source with the assumed minimum fault current. B-SRTC-SWBD 1 supplied from the Emergency Feed.

2. Assumptions

The following assumptions were used in performing the arc flash analysis, and ensure conservative, worst-case results:

- The minimum utility fault current from the preferred source is assumed to be 50% of the maximum available fault current values provided by Portland General Electric for the preferred source.
- The minimum utility fault current from the alternate source is assumed to be 50% of the maximum available fault current values provided by Portland General Electric for the alternate source.

For this arc flash hazard analysis of Portland State University the circuit model included the West Campus Loop distribution system. The analysis required energy and boundary calculations for approximately forty-eight (48) locations.

5.3 Arc Flash Hazard Analysis Results

The incident energy associated with an arc flash is dependent upon the following parameters:

- The maximum "bolted fault" three-phase short-circuit current available at the equipment and the minimum fault level at which the arc will self-sustain.
- The total protective device clearing time (upstream of the prospective arc location) at the maximum short-circuit current and the minimum fault level at which the arc will self-sustain.
- The distance of the worker from the prospective arc for the task to be performed.

Table 5.3 is provided specifically at the request of Portland State University. It is their requirement that a second incident energy calculation be performed, with a greater working distance, for any location with an incident energy above 40 cal/cm^2. This is specifically to be used when a qualified person is performing non-contact voltage testing to ensure a piece of equipment is de-energized before performing work. All locations, not just those with an incident energy above 40 cal/cm^2, were included in Table 5.3 for reference.

The arc flash hazard analysis results shown in Table 5.1, Table 5.2, and Table 5.3 are based on a protective device clearing time that is capped at 2 seconds. This is based on IEEE Std 1584-2002 which states in Annex B, Instructions and Examples; *"If the time is longer than two seconds, consider how long a person is likely to remain in the location of the arc flash. It is likely that a person exposed to an arc flash will move away quickly if it is physically possible, and two seconds is a reasonable maximum time for calculations. A person in a bucket truck or a person who has crawled into equipment will need more time to move away."*

Two calculations are typically provided for labels on locations where there is adequate separation between the line side terminals of the main protective device, and the work location. The "Load Side" calculation provides the incident energy based on the main protective device clearing in the event of an arc flash incident. If the work location or task is such that the main breaker may not trip in the event of an arc flash incident, then the "Line Side" calculation for incident energy should be observed. This could occur if the main breaker is being racked-out, and a fault occurred on the line terminals. For this case, the next upstream device is the one that must clear the fault.

One should always remember that the terms "Line Side" and "Load Side" are always in reference to the main protective device (see example below).

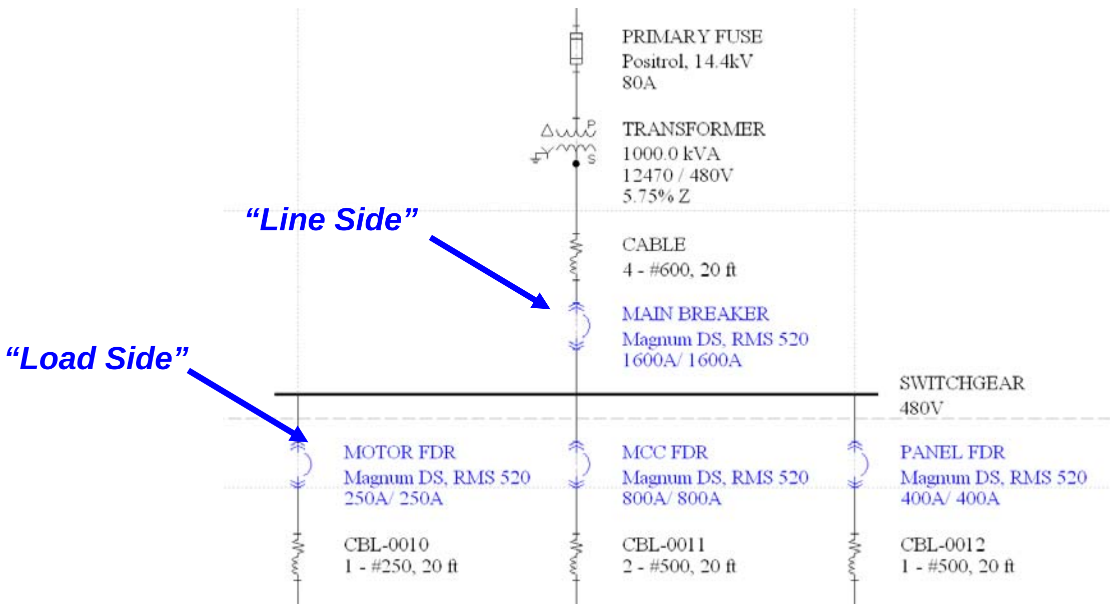


Figure 1: Line Side vs. Load Side

The fault current cannot easily be reduced nor can the working distance be easily increased to lessen the incident energy. In many locations the protective device setting can be adjusted or the trip unit upgraded to decrease the device interrupting time that will in turn decrease the incident energy. For a critical electrical distribution system, such as for the Portland State University campus, it is essential that the system reliability not be compromised. Settings for protective devices cannot be adjusted if the chance of nuisance trips within critical circuits is introduced. *Each location where the hazard is determined to be unacceptable by "Portland State University" must be individually evaluated to determine the most effective means of reducing the incident energy while maintaining the highest degree of reliability.*

All of the adjustable protective devices listed in Section 4 must be set per the recommended settings of this study to achieve the incident energy levels shown in Table 5.1, Table 5.2, and Table 5.3.

5.4 Arc Flash Summary Table Heading Descriptions

Table 5.1, Table 5.2, and Table 5.3 show results of the SKM PowerTools arc flash hazard analysis. The following column headings describe the results.

Column #1 - Bus Name: The names in this column correlate to the names implemented in the software system model (reference the one-lines included in Appendix D) These locations correspond to plant locations such as main switchboards, panelboards, enclosed breakers, etc.

Column #2 - Protective Device Name: This column lists the name of the device primarily responsible for clearing a potential fault at the associated bus. Again, these device names correlate to the system model.

Column #3 - Bus Voltage (kV): The values in this column show the nominal voltage of the bus location noted in Column #1.

Column #4 - Bus Bolted Fault (kA): This column shows the bolted fault current available for the bus location referenced in Column #1. This current value corresponds to the system operating conditions that will result in the worst-case calculated value for incident energy. (See Column # 14.)

Column #5 - Prot Dev Bolted Fault (kA): This column displays the portion of calculated bolted fault currents (See Column #4) that is contributed through the protective device referenced in Column #2.

Column #6 - Prot Dev Arcing Fault (kA): This column displays the portion of calculated arcing fault currents that is contributed through the protective device referenced in Column #2. These values demonstrate a reduction in available fault current due to the arc resistance.

Column #7 - Trip/Delay Time (sec): This column displays the length of time required by the protective device (See Column #2) to trip in the presence of the arcing fault current calculated in Column #6. For low voltage breakers and fuses, this time represents the total clearing time of the device.

Column #8 - Breaker Opening Time (sec): For circuit breakers tripped by a relay, this column shows the opening time of the breaker. This time is added to the Trip time (See Column #7) to determine the total clearing time used in the calculation of incident energy. (See Column #14.)

Column #9 - Gnd: This column indicates whether the fault location includes a path to ground. Systems with high-resistance or low-resistance grounds are assumed to be ungrounded in the arc flash calculations.

Column #10 - Equip Type: This column indicates whether the equipment is Switchgear, Panel, Cable or Open Air. The equipment type provides a default Gap value, and a distance exponent used in the IEEE incident energy equations.

Column #11 – Gap (mm): This column displays the spacing between bus bars or conductors at the arc location.

Column #12 - Arc Flash Boundary: This column displays the distance within which a person must be clothed in the appropriate PPE (Personal Protection Equipment.) (See Column #14.)

Column #13 - Working Distance: This distance indicates the typical working distance associated with the system location referenced in Column #1.

Column #14 - Incident Energy (cal/cm^2): Based on the arcing fault current, the total clearing time of the protective device, the bus bar gap, the grounding method, and the typical working distance, the column displays the results of the arc flash calculations at the reference location. This energy level directly corresponds to the appropriate PPE required for each location. NFPA 70E-2012, Table H.3(b) provides guidance for the selection of PPE based on calculated incident energy exposure.

5.5 Arc Flash Hazard Analysis Recommendations

1) All of the adjustable protective devices listed in Section 4 must be set per the recommended settings to achieve the incident energy levels listed in Table 5.1, Table 5.2, and Table 5.3.
2) Each location where the arc flash hazard is unacceptable to “Portland State University” should be individually evaluated to determine the most effective means of reducing the incident energy while maintaining the highest degree of reliability.

Table 5.1 – Arc Flash Analysis Summary Table

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm^2)
B-CH	FS-SRTC-USB1-R505	12.47	5.85	5.85	5.73	0.184	0.000	Yes	SWG	153	3' 3"	3'	1.3
B-CH ATS	FS-SRTC-USB1-R505	12.47	5.85	5.85	5.73	0.184	0.000	Yes	SWG	153	3' 3"	3'	1.3
B-CH CHLR	FS-SRTC-USB1-R505	12.47	5.81	5.81	5.70	0.186	0.000	Yes	SWG	153	3' 3"	3'	1.3
B-CH CHLR DS	FS-SRTC-USB1-R505	12.47	5.83	5.83	5.71	0.185	0.000	Yes	SWG	153	3' 3"	3'	1.3
B-CH-EMER USB	FS-CH-EMER USB FDR	0.208	14.59	14.59	5.67	2	0.000	Yes	PNL	25	11' 11"	1' 6"	36.0
B-CH-NW USB DS	FS-CH-NW USB FDR	12.47	5.78	5.78	5.66	0.069	0.000	Yes	SWG	153	1' 2"	3'	0.5
B-CH-PNL B	F-CH-PNL B FDR	0.48	17.31	17.31	8.90	0.997	0.000	Yes	PNL	25	10' 6"	1' 6"	29.2
B-CH-SUB 4A	FS-CH-SUB 4A DS	0.48	36.76	36.76	16.95	0.296	0.000	Yes	PNL	25	7' 8"	1' 6"	17.4
B-CH-SUB 4A DS	FS-SUB 4A FDR	12.47	5.84	5.84	5.72	0.082	0.000	Yes	SWG	153	1' 5"	3'	0.6
B-LE USB DS	FS-SMC-LE USB FDR	12.47	10.36	10.36	10.05	0.02	0.000	Yes	SWG	153	7"	3'	0.3
B-LH-TX DS	FS-SB1-LH FDR	12.47	8.86	8.86	8.62	0.024	0.000	Yes	SWG	153	8"	3'	0.3
B-ML	FS-PSC-ML FDR	12.47	11.17	11.17	10.82	0.02	0.000	Yes	SWG	153	8"	3'	0.3
B-ML-USB	FS-ML-USB FDR	0.48	14.89	14.89	7.83	0.724	0.000	Yes	PNL	25	7' 11"	1' 6"	18.5
B-NH EAST	FS-NH-EAST FDR	12.47	9.56	9.56	9.29	0.021	0.000	Yes	SWG	153	7"	3'	0.3
B-NH WEST	FS-CH-NH FDR	12.47	9.77	9.77	9.48	0.028	0.000	Yes	SWG	153	10"	3'	0.3
B-PS1-TX DS	FS-NH-PS1 FDR	12.47	9.37	9.37	9.10	0.019	0.000	Yes	SWG	153	6"	3'	0.2
B-PS1-USB	FS-PS1-USB FDR	0.208	8.55	8.55	3.90	2	0.000	Yes	PNL	25	9' 4"	1' 6"	24.0
B-PS2-TX DS	FS-CH-PS2 FDR	12.47	10.30	10.30	9.99	0.02	0.000	Yes	SWG	153	7"	3'	0.3
B-PSC	FS-WHP-PSC FDR	12.47	11.36	11.36	11.00	0.022	0.000	Yes	SWG	153	9"	3'	0.3
B-PSC-USB	FS-PSC-USB FDR	0.48	14.27	14.27	7.55	0.779	0.000	Yes	PNL	25	8' 1"	1' 6"	19.1
B-SB1	FS-SRTC-USB2-R495	12.47	6.25	6.25	6.12	0.055	0.000	Yes	SWG	153	1'	3'	0.4
B-SMC	FS-CH-SMC FDR	12.47	10.30	10.30	9.99	0.023	0.000	Yes	SWG	153	9"	3'	0.3
B-SMC 2ND USB DS	FS-SMC 2ND USB FDR	12.47	10.41	10.41	10.09	0.019	0.000	Yes	SWG	153	7"	3'	0.3
B-SRTC-SB2	FS-SRTC-USB-R495	12.47	6.28	6.28	6.14	0.163	0.000	Yes	SWG	153	3' 1"	3'	1.2
B-SRTC-SWBD2	FS-SRTC-SWBD2 FDR	0.48	14.61	14.61	7.71	1.496	0.000	Yes	PNL	25	12' 3"	1' 6"	37.5

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm^2)
B-SRTC-SWBD3	FS-SRTC-SWBD3 FDR	0.48	14.61	14.61	7.71	1.496	0.000	Yes	PNL	25	12' 3"	1' 6"	37.5
B-SRTC-SWBD4	FS-SRTC-SWBD4 FDR	4.16	3.24	3.24	3.20	0.763	0.000	Yes	SWG	104	6' 6"	3'	2.5
B-SRTC-SWBD4 DS	FS-SRTC-SWBD4 FDR	12.47	12.36	12.36	11.96	0.024	0.000	Yes	SWG	153	11"	3'	0.4
B-SRTC-USB1 PREF	MaxTripTime @2.0s	12.47	12.65	12.65	12.23	2	0.000	Yes	SWG	153	87' 11"	3'	32.0
B-SRTC-USB2 ALT	MaxTripTime @2.0s	12.47	12.94	12.94	12.50	2	0.000	Yes	SWG	153	90' 1"	3'	32.7
B-WHP	FS-SRTC-USB1-R501	12.47	6.01	6.01	5.88	0.078	0.000	Yes	SWG	153	1' 5"	3'	0.6
B-WHP-USB	FS-WHP-USB FDR	0.48	3.21	3.21	2.11	0.485	0.000	Yes	PNL	25	2' 8"	1' 6"	3.0
B-XSB USB	FS-XSB USB FDR	0.208	19.94	19.94	6.00	0.707	0.000	Yes	PNL	25	6' 7"	1' 6"	13.5
B-XSB USB DS	FS-XSB USB FDR	0.208	20.05	20.05	6.03	0.702	0.000	Yes	PNL	25	6' 7"	1' 6"	13.5
B-XSB-TX DS	FS-SB1-XSB FDR	12.47	6.63	6.63	6.48	0.021	0.000	Yes	SWG	153	5"	3'	0.2

Table 5.2 – Arc Flash Analysis Summary Table for Locations Greater Than 40 cal/cm^2

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm^2)
B-CH-NW USB	FS-CH-NW USB DS	0.208	57.73	57.73	12.66	0.972	0.000	Yes	PNL	25	13'	1' 6"	41.6
B-CH-PNL B DS	FS-CH-PNL B FDR	0.48	19.04	19.04	9.66	2	0.000	Yes	PNL	25	17'	1' 6"	64.0
B-CH-SE USB	FS-CH-SE USB FDR	0.208	46.54	46.54	12.81	2	0.000	Yes	PNL	25	20' 5"	1' 6"	86.8
B-LE USB	FS-LE-TX FDR	0.208	25.76	25.76	8.45	2	0.000	Yes	PNL	25	15' 6"	1' 6"	55.4
B-LH-USB	FS-SB1-LH FDR	0.208	43.96	43.96	12.30	2	0.000	Yes	PNL	25	19' 11"	1' 6"	83.1
B-NH-USB EAST	FS-NH-USB EAST FDR	0.208	45.92	45.92	12.69	2	0.000	Yes	PNL	25	20' 4"	1' 6"	85.9
B-NH-USB WEST	FS-NH-USB WEST FDR	0.208	42.85	42.85	12.08	2	0.000	Yes	PNL	25	19' 8"	1' 6"	81.5
B-PS2-USB	FS-PS2-USB FDR	0.208	32.39	32.39	9.93	2	0.000	Yes	PNL	25	17' 3"	1' 6"	65.9
B-SB1-USB	FS-SB1-USB FDR	0.208	41.56	41.56	11.83	2	0.000	Yes	PNL	25	19' 5"	1' 6"	79.6
B-SMC 2ND USB	FS-SMC 2ND USB FDR	0.208	26.66	26.66	8.66	2	0.000	Yes	PNL	25	15' 9"	1' 6"	56.8
B-SMC USB	FS-SMC USB FDR	0.208	34.05	34.05	10.28	2	0.000	Yes	PNL	25	17' 8"	1' 6"	68.4
B-SRTC-SWBD1	FS-SRTC-SWBD1 EFD	0.208	44.62	44.62	12.43	2	0.000	Yes	PNL	25	20'	1' 6"	84.0
B-SRTC-SWBD5	FS-SRTC-USB2-SUB5	0.48	38.29	38.29	20.64	2	0.000	Yes	PNL	25	28'	1' 6"	145.3
B-CH-NW USB	FS-CH-NW USB DS	0.208	57.73	57.73	12.66	0.972	0.000	Yes	PNL	25	13'	1' 6"	41.6
B-CH-PNL B DS	FS-CH-PNL B FDR	0.48	19.04	19.04	9.66	2	0.000	Yes	PNL	25	17'	1' 6"	64.0
B-CH-SE USB	FS-CH-SE USB FDR	0.208	46.54	46.54	12.81	2	0.000	Yes	PNL	25	20' 5"	1' 6"	86.8

Table 5.3 – Arc Flash Analysis Summary Table for With Working Distance of 8'

Table 5.3 illustrates the arc-flash incident energy at a working distance of 8'. This is the approximate distance the face and body of a qualified person would be from energized equipment when performing a task with a 6' hot stick. It is important to note that the incident energy values in this table are only applicable when the body and torso are 8' or over from energized equipment. For arc-flash incident energies at standard working distances as defined by IEEE 1584-2002, please refer to Table 5.1 and Table 5.2.

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm^2)
B-CH	FS-SRTC-USB1-R505	12.47	5.85	5.85	5.73	0.184	0.000	Yes	SWG	153	3' 3"	**8'**	0.5
B-CH ATS	FS-SRTC-USB1-R505	12.47	5.85	5.85	5.73	0.184	0.000	Yes	SWG	153	3' 3"	**8'**	0.5
B-CH CHLR	FS-SRTC-USB1-R505	12.47	5.81	5.81	5.70	0.186	0.000	Yes	SWG	153	3' 3"	**8'**	0.5
B-CH CHLR DS	FS-SRTC-USB1-R505	12.47	5.83	5.83	5.71	0.185	0.000	Yes	SWG	153	3' 3"	**8'**	0.5
B-CH-EMER USB	FS-CH-EMER USB FDR	0.208	14.58	14.58	5.67	2	0.000	Yes	PNL	25	11' 11"	**8'**	2.3
B-CH-NW USB	FS-CH-NW USB DS	0.208	57.73	57.73	12.66	0.972	0.000	Yes	PNL	25	13'	**8'**	2.7
B-CH-NW USB DS	FS-CH-NW USB FDR	12.47	5.68	5.68	5.56	0.071	0.000	Yes	SWG	153	1' 2"	**8'**	0.2
B-CH-PNL B	F-CH-PNL B FDR	0.48	17.31	17.31	8.90	0.997	0.000	Yes	PNL	25	10' 6"	**8'**	1.9
B-CH-PNL B DS	FS-CH-PNL B FDR	0.48	19.01	19.01	9.65	2	0.000	Yes	PNL	25	16' 11"	**8'**	4.1
B-CH-SE USB	FS-CH-SE USB FDR	0.208	46.48	46.48	12.79	2	0.000	Yes	PNL	25	20' 5"	**8'**	5.6
B-CH-SUB 4A	FS-CH-SUB 4A DS	0.48	36.76	36.76	16.95	0.296	0.000	Yes	PNL	25	7' 8"	**8'**	1.1
B-CH-SUB 4A DS	FS-SUB 4A FDR	12.47	5.84	5.84	5.72	0.082	0.000	Yes	SWG	153	1' 5"	**8'**	0.2
B-LE USB	FS-LE-TX FDR	0.208	25.74	25.74	8.45	2	0.000	Yes	PNL	25	15' 6"	**8'**	3.6
B-LE USB DS	FS-SMC-LE USB FDR	12.47	10.20	10.20	9.90	0.02	0.000	Yes	SWG	153	7"	**8'**	0.1
B-LH-TX DS	FS-SB1-LH FDR	12.47	8.86	8.86	8.62	0.024	0.000	Yes	SWG	153	8"	**8'**	0.1
B-LH-USB	FS-SB1-LH FDR	0.208	43.96	43.96	12.30	2	0.000	Yes	PNL	25	19' 11"	**8'**	5.3
B-ML	FS-PSC-ML FDR	12.47	10.98	10.98	10.64	0.02	0.000	Yes	SWG	153	8"	**8'**	0.1
B-ML-USB	FS-ML-USB FDR	0.48	14.92	14.92	7.85	0.722	0.000	Yes	PNL	25	7' 11"	**8'**	1.2
B-NH EAST	FS-NH-EAST FDR	12.47	9.56	9.56	9.29	0.021	0.000	Yes	SWG	153	7"	**8'**	0.1

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm^2)
B-NH WEST	FS-CH-NH FDR	12.47	5.66	5.66	5.54	0.048	0.000	Yes	SWG	153	9"	**8'**	0.1
B-NH-USB EAST	FS-NH-USB EAST FDR	0.208	45.92	45.92	12.69	2	0.000	Yes	PNL	25	20' 4"	**8'**	5.5
B-NH-USB WEST	FS-NH-USB WEST FDR	0.208	42.79	42.79	12.07	2	0.000	Yes	PNL	25	19' 8"	**8'**	5.2
B-PS1-TX DS	FS-NH-PS1 FDR	12.47	9.37	9.37	9.10	0.019	0.000	Yes	SWG	153	6"	**8'**	0.1
B-PS1-USB	FS-PS1-USB FDR	0.208	8.55	8.55	3.90	2	0.000	Yes	PNL	25	9' 4"	**8'**	1.5
B-PS2-TX DS	FS-CH-PS2 FDR	12.47	10.30	10.30	9.99	0.02	0.000	Yes	SWG	153	7"	**8'**	0.1
B-PS2-USB	FS-PS2-USB FDR	0.208	32.36	32.36	9.92	2	0.000	Yes	PNL	25	17' 3"	**8'**	4.2
B-PSC	FS-WHP-PSC FDR	12.47	11.36	11.36	11.00	0.022	0.000	Yes	SWG	153	9"	**8'**	0.1
B-PSC-USB	FS-PSC-USB FDR	0.48	14.30	14.30	7.57	0.777	0.000	Yes	PNL	25	8' 1"	**8'**	1.2
B-SB1	FS-SRTC-USB2-R495	12.47	6.25	6.25	6.12	0.055	0.000	Yes	SWG	153	1'	**8'**	0.2
B-SB1-USB	FS-SB1-USB FDR	0.208	41.51	41.51	11.82	2	0.000	Yes	PNL	25	19' 4"	**8'**	5.1
B-SMC	FS-CH-SMC FDR	12.47	10.30	10.30	9.99	0.023	0.000	Yes	SWG	153	9"	**8'**	0.1
B-SMC 2ND USB	FS-SMC 2ND USB FDR	0.208	26.64	26.64	8.65	2	0.000	Yes	PNL	25	15' 9"	**8'**	3.6
B-SMC 2ND USB DS	FS-SMC 2ND USB FDR	12.47	10.41	10.41	10.09	0.019	0.000	Yes	SWG	153	7"	**8'**	0.1
B-SMC USB	FS-SMC USB FDR	0.208	34.05	34.05	10.28	2	0.000	Yes	PNL	25	17' 8"	**8'**	4.4
B-SRTC-SB2	FS-SRTC-USB-R495	12.47	6.28	6.28	6.14	0.163	0.000	Yes	SWG	153	3' 1"	**8'**	0.5
B-SRTC-SWBD1	FS-SRTC-SWBD1 EFD	0.208	44.62	44.62	12.43	2	0.000	Yes	PNL	25	20'	**8'**	5.4
B-SRTC-SWBD2	FS-SRTC-SWBD2 FDR	0.48	14.64	14.64	7.72	1.489	0.000	Yes	PNL	25	12' 3"	**8'**	2.4
B-SRTC-SWBD3	FS-SRTC-SWBD3 FDR	0.48	14.64	14.64	7.72	1.489	0.000	Yes	PNL	25	12' 3"	**8'**	2.4
B-SRTC-SWBD4	FS-SRTC-SWBD4 FDR	4.16	3.25	3.25	3.21	0.757	0.000	Yes	SWG	104	6' 6"	**8'**	1.0
B-SRTC-SWBD4 DS	FS-SRTC-SWBD4 FDR	12.47	12.36	12.36	11.96	0.024	0.000	Yes	SWG	153	11"	**8'**	0.1
B-SRTC-SWBD5	FS-SRTC-USB2-SUB5	0.48	38.29	38.29	20.64	2	0.000	Yes	PNL	25	28'	**8'**	9.3
B-SRTC-USB1 PREF	MaxTripTime @2.0s	12.47	12.65	12.65	12.23	2	0.000	Yes	SWG	153	87' 11"	**8'**	12.3
B-SRTC-USB2 ALT	MaxTripTime @2.0s	12.47	12.94	12.94	12.50	2	0.000	Yes	SWG	153	90' 1"	**8'**	12.6
B-WHP	FS-SRTC-USB2-R497	12.47	6.14	6.14	6.01	0.076	0.000	Yes	SWG	153	1' 5"	**8'**	0.2
B-WHP-USB	FS-WHP-USB FDR	0.48	3.21	3.21	2.11	0.485	0.000	Yes	PNL	25	2' 8"	**8'**	0.2
B-XSB USB	FS-XSB USB FDR	0.208	19.96	19.96	6.01	0.706	0.000	Yes	PNL	25	6' 7"	**8'**	0.9

Bus Name	Protective Device Name	Bus Voltage (kV)	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm^2)
B-XSB USB DS	FS-XSB USB FDR	0.208	20.07	20.07	6.03	0.701	0.000	Yes	PNL	25	6' 7"	**8'**	0.9
B-XSB-TX DS	FS-SB1-XSB FDR	12.47	6.63	6.63	6.48	0.021	0.000	Yes	SWG	153	5"	**8'**	0.1

A. APPENDIX A – SHORT-CIRCUIT INPUT REPORT

Input Report Interpretation

Input Data Tables are provided on the following pages. The following is a guide for interpreting the input data.

1. Generation Contribution Data

- Utility contribution data includes the available fault current in MVA and amps, per unit impedance on a 100 MVA base, X/R, and the line-to-line bus voltage.
- Generator data includes the generator kW rating, X"d, X/R, line-to-line voltage and per unit impedance on a 100 MVA base.

2. Motor Contribution Data

Motor Contribution Data includes the horsepower rating (base kVA rating), speed, subtransient reactance adjusted per the *First Cycle Duty* multipliers described in IEEE Std 141-1993 (Red Book), per-unit impedance on a 100 MVA base, and the bus voltage. X/R ratios for induction motors are obtained from IEEE Std C37.010-1999.

3. Feeder Data

Feeder data includes the following cable and bus data: length, impedance in ohms per 1,000 feet, and per-unit impedance on a 100 MVA base. Impedance values for conductors were obtained from Tables 4A-7 and 4A-8 of IEEE Std 141-1993 (Red Book). The impedance values are based on conductor temperatures of 75°C for Copper and 90°C for Aluminum.

4. Transformer Data

Transformer data includes the transformer kVA rating and per-unit impedance on a 100 MVA base. Unless otherwise provided, transformer X/R ratios are obtained from IEEE Std C37.010-1999.

Short-Circuit Input Report

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PSU - West Campus Loop
Portland, OR
ESE0008353 / TQSISE0008353.1
Feb 22, 2013     15:42:55                                              Page 1
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 ALL INFORMATION PRESENTED IS FOR REVIEW, APPROVAL
 INTERPRETATION AND APPLICATION BY A REGISTERED ENGINEER ONLY
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 -----------------------------------------------------------------------------
 SKM POWER*TOOLS FOR WINDOWS
 INPUT DATA REPORT
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-----------------------------------------------------------------------------
 ALL PU VALUES ARE EXPRESSED ON A 100 MVA BASE.
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FEEDER INPUT DATA

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==========================================================================================================================================
CABLE                         FEEDER FROM                     FEEDER TO                       QTY  VOLTS   LENGTH          FEEDER
NAME                          NAME                            NAME                            /PH  L-L                  SIZE      TYPE
==========================================================================================================================================
B-SMC 2ND USB FDR             B-SMC                           B-SMC 2ND USB DS                  1  12470   40.0  FEET    1/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0033 + J  0.0013  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0052 + J  0.0033  PU

BWY-LE USB                    TX-LE USB S                     B-LE USB                          1    208   10.0  FEET   1600      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0092 + J  0.0048  Ohms/1000 ft      0.2126 + J  0.1109  PU
              Z0   Impedance: 0.0547 + J  0.0257  Ohms/1000 ft        1.26 + J  0.5938  PU

BWY-ML-USB                    TX-ML-USB S                     B-ML-USB                          1    480   10.0  FEET   1600      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0092 + J  0.0048  Ohms/1000 ft      0.0399 + J  0.0208  PU
              Z0   Impedance: 0.0547 + J  0.0257  Ohms/1000 ft      0.2374 + J  0.1115  PU

BWY-NH-USB EAST               TX-NH-USB EAST E                B-NH-USB EAST                     1    208   10.0  FEET   3000      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0046 + J  0.0026  Ohms/1000 ft      0.1063 + J  0.0601  PU
              Z0   Impedance: 0.0273 + J  0.0139  Ohms/1000 ft      0.6310 + J  0.3213  PU

BWY-NH-USB WEST               TX-NH-USB WEST S                B-NH-USB WEST                     1    208   10.0  FEET   3000      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0046 + J  0.0026  Ohms/1000 ft      0.1063 + J  0.0601  PU
              Z0   Impedance: 0.0273 + J  0.0139  Ohms/1000 ft      0.6310 + J  0.3213  PU

BWY-PS2-USB                   TX-PS2-USB S                    B-PS2-USB                         1    208   15.0  FEET   2500      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0049 + J  0.0030  Ohms/1000 ft      0.1699 + J  0.1040  PU
              Z0   Impedance: 0.0291 + J  0.0160  Ohms/1000 ft        1.01 + J  0.5547  PU

BWY-PSC-USB                   TX-PSC-USB S                    B-PSC-USB                         1    480   20.0  FEET   1600      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0092 + J  0.0048  Ohms/1000 ft      0.0799 + J  0.0417  PU
              Z0   Impedance: 0.0547 + J  0.0257  Ohms/1000 ft      0.4748 + J  0.2230  PU

BWY-SB1-USB                   TX-SB1-USB S                    B-SB1-USB                         1    208   50.0  FEET   2500      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0057 + J  0.0032  Ohms/1000 ft      0.6587 + J  0.3698  PU
              Z0   Impedance: 0.2850 + J  0.1600  Ohms/1000 ft       32.94 + J   18.49  PU

BWY-SMC 2ND USB               TX-SMC 2ND USB S                B-SMC 2ND USB                     1    208   10.0  FEET   1600      Copper
              Duct Material:       Busway
              +/-  Impedance: 0.0092 + J  0.0048  Ohms/1000 ft      0.2126 + J  0.1109  PU
              Z0   Impedance: 0.0547 + J  0.0257  Ohms/1000 ft        1.26 + J  0.5938  PU
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FEEDER INPUT DATA

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====================================================================================================================================
CABLE                          FEEDER FROM                     FEEDER TO                       QTY  VOLTS   LENGTH           FEEDER
NAME                           NAME                            NAME                            /PH  L-L                  SIZE       TYPE
====================================================================================================================================
BWY-SRTC-SWBD1-1               TX-SRTC-SWBD1-1 S               B-SRTC-SWBD1                    1     208   10.0  FEET    4000      Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0033 + J  0.0019  Ohms/1000 ft      0.0763 + J  0.0439  PU
              Z0   Impedance: 0.0196 + J  0.0101  Ohms/1000 ft      0.4530 + J  0.2335  PU

BWY-SRTC-SWBD2                 TX-SRTC-SWBD2 S                 B-SRTC-SWBD2                    1     480   10.0  FEET    1600      Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0092 + J  0.0048  Ohms/1000 ft      0.0399 + J  0.0208  PU
              Z0   Impedance: 0.0547 + J  0.0257  Ohms/1000 ft      0.2374 + J  0.1115  PU

BWY-SRTC-SWBD3                 TX-SRTC-SWBD3 S                 B-SRTC-SWBD3                    1     480   10.0  FEET    1600      Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0092 + J  0.0048  Ohms/1000 ft      0.0399 + J  0.0208  PU
              Z0   Impedance: 0.0547 + J  0.0257  Ohms/1000 ft      0.2374 + J  0.1115  PU

BWY-SRTC-SWBD4                 TX-SRTC-SWBD4 S                 B-SRTC-SWBD4                    1    4160    5.0  FEET     600      Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0119 + J  0.0619  Ohms/1000 ft     0.00034 + J  0.0018  PU
              Z0   Impedance: 0.0710 + J  0.3314  Ohms/1000 ft      0.0021 + J  0.0096  PU

BWY-SRTC-SWBD5                 TX-SRTC-SWBD5 S                 B-SRTC-SWBD5                    1     480   10.0  FEET    3200      Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0047 + J  0.0026  Ohms/1000 ft      0.0204 + J  0.0113  PU
              Z0   Impedance: 0.1175 + J  0.0650  Ohms/1000 ft      0.5100 + J  0.2821  PU

BWY-WHP-USB                    TX-WHP-USB S                    B-WHP-USB                       1     480    5.0  FEET     225      Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0425 + J  0.0323  Ohms/1000 ft      0.0922 + J  0.0701  PU
              Z0   Impedance: 0.2527 + J  0.1729  Ohms/1000 ft      0.5484 + J  0.3752  PU

CBL-0002                       B-SRTC-USB2 ALT                 B-SRTC-USB-ATS1                 1  12470  1.000  FEET     600      Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0119 + J  0.0619  Ohms/1000 ft     0.00001 + J 0.00004  PU
              Z0   Impedance: 0.0710 + J  0.3314  Ohms/1000 ft     0.00005 + J 0.00021  PU

CBL-0048                       B-NH WEST                       B-PS1-TX DS                     1  12470  300.0  FEET     1/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0247 + J  0.0098  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0393 + J  0.0249  PU

C-CH CHLR DS FDR               B-CH CHLR DS                    B-CH                            1  12470   50.0  FEET     4/0    Aluminum
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1050 + J  0.0410  Ohms/1000 ft      0.0034 + J  0.0013  PU
              Z0   Impedance: 0.1669 + J  0.1044  Ohms/1000 ft      0.0054 + J  0.0034  PU
```

FEEDER INPUT DATA

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===============================================================================================================================================
CABLE                          FEEDER FROM                     FEEDER TO                         QTY  VOLTS   LENGTH            FEEDER
NAME                           NAME                            NAME                              /PH  L-L                    SIZE       TYPE
===============================================================================================================================================
C-CH CHLR FDR                  B-CH CHLR DS                    B-CH CHLR                          1  12470   48.0  FEET     4/0   Aluminum
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1050 + J  0.0410  Ohms/1000 ft      0.0032 + J  0.0013  PU
              Z0   Impedance: 0.1669 + J  0.1044  Ohms/1000 ft      0.0052 + J  0.0032  PU

C-CH-EMER USB                  TX-CH-003 S                     B-CH-EMER USB                      3    208   20.0  FEET     250   Aluminum
              Duct Material:     Magnetic
              +/-  Impedance: 0.0896 + J  0.0384  Ohms/1000 ft        1.38 + J  0.5917  PU
              Z0   Impedance: 0.2824 + J  0.0946  Ohms/1000 ft        4.35 + J    1.46  PU

C-CH-EMER USB FDR              B-CH                            TX-CH-003 P                        1  12470   10.0  FEET     350     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0375 + J  0.0450  Ohms/1000 ft     0.00024 + J 0.00029  PU
              Z0   Impedance: 0.0596 + J  0.1144  Ohms/1000 ft     0.00038 + J 0.00074  PU

C-CH FDR                       B-CH ATS                        B-CH                               1  12470    8.0  FEET     350     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0375 + J  0.0450  Ohms/1000 ft     0.00019 + J 0.00023  PU
              Z0   Impedance: 0.0596 + J  0.1144  Ohms/1000 ft     0.00031 + J 0.00059  PU

C-CH-NH FDR                    B-CH                            B-NH WEST                          1  12470  600.0  FEET     1/0   Aluminum
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.2100 + J  0.0450  Ohms/1000 ft      0.0810 + J  0.0174  PU
              Z0   Impedance: 0.3339 + J  0.1145  Ohms/1000 ft      0.1288 + J  0.0442  PU

C-CH-NW TX FDR                 B-CH-NW USB DS                  TX-CH-NW USB P                     1  12470   15.0  FEET     1/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0012 + J 0.00049  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0020 + J  0.0012  PU

C-CH-NW USB                    TX-CH-NW USB S                  B-CH-NW USB                        4    208   10.0  FEET     600     Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0257 + J  0.0463  Ohms/1000 ft      0.1485 + J  0.2675  PU
              Z0   Impedance: 0.0809 + J  0.1140  Ohms/1000 ft      0.4675 + J  0.6587  PU

C-CH-NW USB FDR                B-CH                            B-CH-NW USB DS                     1  12470  360.0  FEET     1/0   Aluminum
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.2100 + J  0.0450  Ohms/1000 ft      0.0486 + J  0.0104  PU
              Z0   Impedance: 0.3339 + J  0.1145  Ohms/1000 ft      0.0773 + J  0.0265  PU

C-CH-PNL B                     B-CH-PNL B DS                   B-CH-PNL B                         9    480   90.0  FEET     250     Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0552 + J  0.0495  Ohms/1000 ft      0.2396 + J  0.2148  PU
              Z0   Impedance: 0.1739 + J  0.1219  Ohms/1000 ft      0.7548 + J  0.5291  PU
```

FEEDER INPUT DATA

```
===========================================================================================================================================
CABLE                         FEEDER FROM                     FEEDER TO                       QTY  VOLTS   LENGTH             FEEDER
NAME                          NAME                            NAME                            /PH  L-L                      SIZE       TYPE
===========================================================================================================================================
C-CH-PNL B DS                 TX-CH-002 S                     B-CH-PNL B DS                   9     480   10.0  FEET     250      Copper
              Duct Material:    Magnetic
              +/-  Impedance: 0.0552 + J  0.0495  Ohms/1000 ft      0.0266 + J  0.0239  PU
              Z0   Impedance: 0.1739 + J  0.1219  Ohms/1000 ft      0.0839 + J  0.0588  PU

C-CH-PNL B FDR                B-CH CHLR                       TX-CH-002 P                     1  12470    5.0  FEET     1/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft     0.00041 + J 0.00016  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft     0.00065 + J 0.00041  PU

C-CH-PS2 FDR                  B-CH                            B-PS2-TX DS                     1  12470  300.0  FEET     1/0    Aluminum
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.2100 + J  0.0450  Ohms/1000 ft      0.0405 + J  0.0087  PU
              Z0   Impedance: 0.3339 + J  0.1145  Ohms/1000 ft      0.0644 + J  0.0221  PU

C-CH-SE USB                   TX-CH-001 S                     B-CH-SE USB                     8     208   10.0  FEET     500      Copper
              Duct Material:    Magnetic
              +/-  Impedance: 0.0294 + J  0.0466  Ohms/1000 ft      0.0849 + J  0.1346  PU
              Z0   Impedance: 0.0926 + J  0.1147  Ohms/1000 ft      0.2675 + J  0.3314  PU

C-CH-SE USB FDR               B-CH                            TX-CH-001 P                     1  12470   10.0  FEET     350      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0375 + J  0.0450  Ohms/1000 ft     0.00024 + J 0.00029  PU
              Z0   Impedance: 0.0596 + J  0.1144  Ohms/1000 ft     0.00038 + J 0.00074  PU

C-CH-SMC FDR                  B-CH                            B-SMC                           1  12470  300.0  FEET     1/0    Aluminum
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.2100 + J  0.0450  Ohms/1000 ft      0.0405 + J  0.0087  PU
              Z0   Impedance: 0.3339 + J  0.1145  Ohms/1000 ft      0.0644 + J  0.0221  PU

C-CH-SUB 4A                   TX-CH-006 S                     B-CH-SUB 4A                     1     480   10.0  FEET    3000      Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0046 + J  0.0026  Ohms/1000 ft      0.0200 + J  0.0113  PU
              Z0   Impedance: 0.0273 + J  0.0139  Ohms/1000 ft      0.1185 + J  0.0603  PU

C-CH-SUB 4A DS FDR            B-CH CHLR                       B-CH-SUB 4A DS                  1  12470  300.0  FEET     4/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0640 + J  0.0466  Ohms/1000 ft      0.0123 + J  0.0090  PU
              Z0   Impedance: 0.1017 + J  0.1185  Ohms/1000 ft      0.0196 + J  0.0229  PU

C-CH-SUB 4A FDR               B-CH-SUB 4A DS                  TX-CH-006 P                     1  12470    5.0  FEET     4/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0640 + J  0.0466  Ohms/1000 ft     0.00021 + J 0.00015  PU
              Z0   Impedance: 0.1017 + J  0.1185  Ohms/1000 ft     0.00033 + J 0.00038  PU
```

FEEDER INPUT DATA

CABLE NAME	FEEDER FROM NAME	FEEDER TO NAME	QTY /PH	VOLTS L-L	LENGTH		FEEDER SIZE	TYPE
C-LE- TX FDR	B-LE USB DS	TX-LE USB P	1	12470	5.0	FEET	1/0	Copper
	Duct Material: Non-Magnetic							
	+/- Impedance: 0.1280 + J 0.0507 Ohms/1000 ft	0.00041 + J 0.00016 PU						
	Z0 Impedance: 0.2035 + J 0.1290 Ohms/1000 ft	0.00065 + J 0.00041 PU						
C-LE USB FDR	B-SMC	B-LE USB DS	1	12470	70.0	FEET	1/0	Copper
	Duct Material: Non-Magnetic							
	+/- Impedance: 0.1280 + J 0.0507 Ohms/1000 ft	0.0058 + J 0.0023 PU						
	Z0 Impedance: 0.2035 + J 0.1290 Ohms/1000 ft	0.0092 + J 0.0058 PU						
C-LH-TX FDR	B-LH-TX DS	TX-LH-USB P	1	12470	175.0	FEET	2	Copper
	Duct Material: Non-Magnetic							
	+/- Impedance: 0.2020 + J 0.0547 Ohms/1000 ft	0.0227 + J 0.0062 PU						
	Z0 Impedance: 0.3211 + J 0.1392 Ohms/1000 ft	0.0361 + J 0.0157 PU						
C-LH-USB	TX-LH-USB S	B-LH-USB	8	208	35.0	FEET	500	Copper
	Duct Material: Magnetic							
	+/- Impedance: 0.0294 + J 0.0466 Ohms/1000 ft	0.2973 + J 0.4712 PU						
	Z0 Impedance: 0.0926 + J 0.1147 Ohms/1000 ft	0.9364 + J 1.16 PU						
C-ML-USB FDR	B-ML	TX-ML-USB P	1	12470	5.0	FEET	1/0	Copper
	Duct Material: Non-Magnetic							
	+/- Impedance: 0.1280 + J 0.0507 Ohms/1000 ft	0.00041 + J 0.00016 PU						
	Z0 Impedance: 0.2035 + J 0.1290 Ohms/1000 ft	0.00065 + J 0.00041 PU						
C-NH-EAST FDR	B-NH WEST	B-NH EAST	1	12470	115.0	FEET	1/0	Aluminum
	Duct Material: Non-Magnetic							
	+/- Impedance: 0.2100 + J 0.0450 Ohms/1000 ft	0.0155 + J 0.0033 PU						
	Z0 Impedance: 0.3339 + J 0.1145 Ohms/1000 ft	0.0247 + J 0.0085 PU						
C-NH-USB EAST FDR	B-NH EAST	TX-NH-USB EAST P	1	12470	5.0	FEET	1/0	Copper
	Duct Material: Non-Magnetic							
	+/- Impedance: 0.1280 + J 0.0507 Ohms/1000 ft	0.00041 + J 0.00016 PU						
	Z0 Impedance: 0.2035 + J 0.1290 Ohms/1000 ft	0.00065 + J 0.00041 PU						
C-NH-USB WEST FDR	B-NH WEST	TX-NH-USB WEST P	1	12470	5.0	FEET	1/0	Copper
	Duct Material: Non-Magnetic							
	+/- Impedance: 0.1280 + J 0.0507 Ohms/1000 ft	0.00041 + J 0.00016 PU						
	Z0 Impedance: 0.2035 + J 0.1290 Ohms/1000 ft	0.00065 + J 0.00041 PU						
C-PS1-USB	TX-PS1-USB S	B-PS1-USB	1	208	5.0	FEET	500	Copper
	Duct Material: Non-Magnetic							
	+/- Impedance: 0.0276 + J 0.0373 Ohms/1000 ft	0.3190 + J 0.4311 PU						
	Z0 Impedance: 0.0438 + J 0.0999 Ohms/1000 ft	0.5062 + J 1.15 PU						

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                                          FEEDER  INPUT  DATA
===========================================================================================================================================
CABLE                         FEEDER FROM                     FEEDER TO                        QTY  VOLTS   LENGTH           FEEDER
NAME                          NAME                            NAME                             /PH  L-L                  SIZE        TYPE
===========================================================================================================================================
C-PS1-USB FDR                 B-PS1-TX DS                     TX-PS1-USB P                      1  12470     5.0  FEET       1      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1600 + J  0.0540  Ohms/1000 ft     0.00051 + J 0.00017  PU
              Z0   Impedance: 0.2543 + J  0.1374  Ohms/1000 ft     0.00082 + J 0.00044  PU

C-PS2-USB FDR                 B-PS2-TX DS                     TX-PS2-USB P                      1  12470    10.0  FEET     1/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft     0.00082 + J 0.00033  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0013 + J 0.00083  PU

C-PSC-ML FDR                  B-PSC                           B-ML                              1  12470   200.0  FEET     1/0    Aluminum
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.2100 + J  0.0450  Ohms/1000 ft      0.0270 + J  0.0058  PU
              Z0   Impedance: 0.3339 + J  0.1145  Ohms/1000 ft      0.0429 + J  0.0147  PU

C-PSC-USB FDR                 B-PSC                           TX-PSC-USB P                      1  12470     5.0  FEET     1/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft     0.00041 + J 0.00016  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft     0.00065 + J 0.00041  PU

C-R491                        B-SRTC-USB-ATS1                 B-SRTC-SB2                        1  12470   140.0  FEET     4/0    Aluminum
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1050 + J  0.0410  Ohms/1000 ft      0.0095 + J  0.0037  PU
              Z0   Impedance: 0.1669 + J  0.1044  Ohms/1000 ft      0.0150 + J  0.0094  PU

C-R495                        B-SRTC-USB2 ALT                 B-SB1                             1  12470   600.0  FEET     4/0    Aluminum
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1050 + J  0.0410  Ohms/1000 ft      0.0405 + J  0.0158  PU
              Z0   Impedance: 0.1669 + J  0.1044  Ohms/1000 ft      0.0644 + J  0.0403  PU

C-R497                        B-SRTC-USB2 ALT                 B-WHP                             1  12470 1000.0  FEET     4/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0640 + J  0.0466  Ohms/1000 ft      0.0412 + J  0.0300  PU
              Z0   Impedance: 0.1017 + J  0.1185  Ohms/1000 ft      0.0654 + J  0.0762  PU

C-R499-1                      B-SRTC-USB2 ALT                 C-R499 SPLICE                     1  12470   900.0  FEET     350    Aluminum
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0638 + J  0.0374  Ohms/1000 ft      0.0369 + J  0.0216  PU
              Z0   Impedance: 0.1014 + J  0.0951  Ohms/1000 ft      0.0587 + J  0.0550  PU

C-R499-2                      C-R499 SPLICE                   B-CH ATS                          1  12470   900.0  FEET     350      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0375 + J  0.0450  Ohms/1000 ft      0.0217 + J  0.0260  PU
              Z0   Impedance: 0.0596 + J  0.1144  Ohms/1000 ft      0.0345 + J  0.0662  PU
```

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                                          FEEDER  INPUT  DATA
=============================================================================================================================================
CABLE                         FEEDER FROM                     FEEDER TO                       QTY  VOLTS   LENGTH             FEEDER
NAME                          NAME                            NAME                            /PH  L-L                     SIZE       TYPE
=============================================================================================================================================
C-R505-1                      B-SRTC-USB1 PREF                C-R505 SPLICE                    1  12470  900.0  FEET     350   Aluminum
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0638 + J  0.0374  Ohms/1000 ft      0.0369 + J  0.0216  PU
              Z0   Impedance: 0.1014 + J  0.0951  Ohms/1000 ft      0.0587 + J  0.0550  PU

C-SB1-LH FDR                  B-SB1                           B-LH-TX DS                       1  12470 1000.0  FEET       2   Aluminum
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.3350 + J  0.0500  Ohms/1000 ft      0.2154 + J  0.0322  PU
              Z0   Impedance: 0.5326 + J  0.1272  Ohms/1000 ft      0.3425 + J  0.0818  PU

C-SB1-USB FDR                 B-SB1                           TX-SB1-USB P                     1  12470   10.0  FEET     1/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft     0.00082 + J 0.00033  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0013 + J 0.00083  PU

C-SB1-XSB FDR                 B-SB1                           B-XSB-TX DS                      1  12470 2000.0  FEET       2   Aluminum
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.3350 + J  0.0500  Ohms/1000 ft      0.4309 + J  0.0643  PU
              Z0   Impedance: 0.5326 + J  0.1272  Ohms/1000 ft      0.6850 + J  0.1636  PU

C-SMC 2ND USB                 B-SMC 2ND USB DS                TX-SMC 2ND USB P                 1  12470    5.0  FEET     1/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft     0.00041 + J 0.00016  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft     0.00065 + J 0.00041  PU

C-SMC SWBD FDR                B-SMC                           TX-SMC-USB P                     1  12470   30.0  FEET     1/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0025 + J 0.00098  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0039 + J  0.0025  PU

C-SMC USB                     TX-SMC-USB S                    B-SMC USB                        4    208   20.0  FEET     500     Copper
              Duct Material:     Magnetic
              +/-  Impedance: 0.0294 + J  0.0466  Ohms/1000 ft      0.3398 + J  0.5386  PU
              Z0   Impedance: 0.0926 + J  0.1147  Ohms/1000 ft        1.07 + J    1.33  PU

C-SRTC-SWBD1 EFD              B-SRTC-SB2                      TX-SRTC-SWBD1-1 P                1  12470   30.0  FEET     1/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0025 + J 0.00098  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0039 + J  0.0025  PU

C-SRTC-SWBD1 NFD              B-SRTC-SB2                      TX-SRTC-SWBD1-2 P                1  12470   60.0  FEET     1/0     Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0049 + J  0.0020  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0079 + J  0.0050  PU
```

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                                          FEEDER  INPUT  DATA
===========================================================================================================================================
CABLE                         FEEDER FROM                      FEEDER TO                        QTY  VOLTS   LENGTH            FEEDER
NAME                          NAME                             NAME                             /PH  L-L                     SIZE       TYPE
===========================================================================================================================================
C-SRTC-SWBD2 FDR              B-SRTC-SB2                       TX-SRTC-SWBD2 P                   1  12470   20.0  FEET     1/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0016 + J 0.00065  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0026 + J  0.0017  PU

C-SRTC-SWBD3 FDR              B-SRTC-SB2                       TX-SRTC-SWBD3 P                   1  12470   20.0  FEET     1/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1280 + J  0.0507  Ohms/1000 ft      0.0016 + J 0.00065  PU
              Z0   Impedance: 0.2035 + J  0.1290  Ohms/1000 ft      0.0026 + J  0.0017  PU

C-SRTC-SWBD4 FDR              B-SRTC-SB2                       B-SRTC-SWBD4 DS                   1  12470   75.0  FEET     4/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0640 + J  0.0466  Ohms/1000 ft      0.0031 + J  0.0022  PU
              Z0   Impedance: 0.1017 + J  0.1185  Ohms/1000 ft      0.0049 + J  0.0057  PU

C-SRTC-SWBD4 XFMR             B-SRTC-SWBD4 DS                  TX-SRTC-SWBD4 P                   1  12470    5.0  FEET     4/0      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.0640 + J  0.0466  Ohms/1000 ft     0.00021 + J 0.00015  PU
              Z0   Impedance: 0.1017 + J  0.1185  Ohms/1000 ft     0.00033 + J 0.00038  PU

C-SRTC-SWBD5                  B-SRTC-USB2 ALT                  TX-SRTC-SWBD5 P                   1  12470  190.0  FEET       2      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.2020 + J  0.0547  Ohms/1000 ft      0.0247 + J  0.0067  PU
              Z0   Impedance: 0.3211 + J  0.1392  Ohms/1000 ft      0.0392 + J  0.0170  PU

C-WHP-PSC FDR                 B-WHP                            B-PSC                             1  12470   40.0  FEET     1/0  Aluminum
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.2100 + J  0.0450  Ohms/1000 ft      0.0054 + J  0.0012  PU
              Z0   Impedance: 0.3339 + J  0.1145  Ohms/1000 ft      0.0086 + J  0.0029  PU

C-WHP-USB FDR                 B-WHP                            TX-WHP-USB P                      1  12470   40.0  FEET       1      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.1600 + J  0.0540  Ohms/1000 ft      0.0041 + J  0.0014  PU
              Z0   Impedance: 0.2543 + J  0.1374  Ohms/1000 ft      0.0065 + J  0.0035  PU

C-XSB SWBD                    B-XSB USB DS                     B-XSB USB                         1    208    3.0  FEET    1000      Copper
              Duct Material:      Busway
              +/-  Impedance: 0.0142 + J  0.0066  Ohms/1000 ft      0.0985 + J  0.0458  PU
              Z0   Impedance: 0.0844 + J  0.0353  Ohms/1000 ft      0.5852 + J  0.2448  PU

C-XSB TX FDR                  B-XSB-TX DS                      TX-XSB-USB P                      1  12470    5.0  FEET       2      Copper
              Duct Material: Non-Magnetic
              +/-  Impedance: 0.2020 + J  0.0547  Ohms/1000 ft     0.00065 + J 0.00018  PU
              Z0   Impedance: 0.3211 + J  0.1392  Ohms/1000 ft      0.0010 + J 0.00045  PU
```

FEEDER INPUT DATA

CABLE NAME	FEEDER FROM NAME	FEEDER TO NAME	QTY /PH	VOLTS L-L	LENGTH		FEEDER SIZE	FEEDER TYPE
C-XSB USB DS	TX-XSB-USB S	B-XSB USB DS	2	208	35.0	FEET	500	Copper

```
            Duct Material:     Magnetic
            +/-  Impedance: 0.0294 + J  0.0466  Ohms/1000 ft        1.19 + J    1.88  PU
            Z0   Impedance: 0.0926 + J  0.1147  Ohms/1000 ft        3.75 + J    4.64  PU
```

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                           TRANSFORMER  INPUT  DATA
=======================================================================================================================================================
TRANSFORMER                    PRIMARY RECORD                     VOLTS   * SECONDARY RECORD                      VOLTS   FULL-LOAD  NOMINAL
NAME                           NO NAME                            L-L       NO NAME                               L-L     KVA          KVA
=======================================================================================================================================================
TX-CH-001                      TX-CH-001 P                     D  12470.0   TX-CH-001 S                   YG    208.00 1573.00      1000.00
               Pos. Seq. Z%:    0.931 + J   5.32   (Zpu  0.931 + j   5.32 )    Shell Type
               Zero Seq. Z%:    0.931 + J   5.32   (Sec  0.931 + j   5.32 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-CH-002                      TX-CH-002 P                     D  12470.0   TX-CH-002 S                   YG    480.00 1000.00      1000.00
               Pos. Seq. Z%:     1.01 + J   5.78   (Zpu   1.01 + j   5.78 )    Shell Type
               Zero Seq. Z%:     1.01 + J   5.78   (Sec   1.01 + j   5.78 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-CH-003                      TX-CH-003 P                     D  12470.0   TX-CH-003 S                   YG    208.00  472.00       300.00
               Pos. Seq. Z%:     1.24 + J   5.15   (Zpu   4.14 + j  17.18 )    Shell Type
               Zero Seq. Z%:     1.24 + J   5.15   (Sec   4.14 + j  17.18 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-CH-006                      TX-CH-006 P                     D  12470.0   TX-CH-006 S                   YG    480.00 2500.00      2500.00
               Pos. Seq. Z%:    0.584 + J   6.12   (Zpu  0.233 + j   2.45 )    Shell Type
               Zero Seq. Z%:    0.584 + J   6.12   (Sec  0.233 + j   2.45 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-CH-NW USB                   TX-CH-NW USB P                  D  12470.0   TX-CH-NW USB S                YG    208.00  500.00       500.00
               Pos. Seq. Z%:    0.385 + J   1.81   (Zpu  0.770 + j   3.62 )    Shell Type
               Zero Seq. Z%:    0.385 + J   1.81   (Sec  0.770 + j   3.62 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-LE USB                      TX-LE USB P                     D  12470.0   TX-LE USB S                   YG    208.00  500.00       500.00
               Pos. Seq. Z%:     1.06 + J   4.98   (Zpu   2.12 + j   9.96 )    Shell Type
               Zero Seq. Z%:     1.06 + J   4.98   (Sec   2.12 + j   9.96 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.
```

TRANSFORMER INPUT DATA

```
==============================================================================================================================================
TRANSFORMER                    PRIMARY RECORD                    VOLTS   * SECONDARY RECORD                        VOLTS   FULL-LOAD   NOMINAL
NAME                           NO NAME                           L-L       NO NAME                                 L-L     KVA          KVA
==============================================================================================================================================
TX-LH-USB                      TX-LH-USB P                    D  12470.0   TX-LH-USB S                     YG     208.00 1000.00      1000.00
               Pos. Seq. Z%:    0.917 + J   5.24    (Zpu  0.917 + j   5.24 )    Shell Type
               Zero Seq. Z%:    0.917 + J   5.24    (Sec  0.917 + j   5.24 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-ML-USB                      TX-ML-USB P                    D  12470.0   TX-ML-USB S                     YG     480.00  750.00       750.00
               Pos. Seq. Z%:     1.02 + J   5.35    (Zpu   1.36 + j   7.14 )    Shell Type
               Zero Seq. Z%:     1.02 + J   5.35    (Sec   1.36 + j   7.14 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-NH-USB EAST                 TX-NH-USB EAST P               D  12470.0   TX-NH-USB EAST E                YG     208.00 1333.00      1000.00
               Pos. Seq. Z%:    0.950 + J   5.43    (Zpu  0.950 + j   5.43 )    Shell Type
               Zero Seq. Z%:    0.950 + J   5.43    (Sec  0.950 + j   5.43 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-NH-USB WEST                 TX-NH-USB WEST P               D  12470.0   TX-NH-USB WEST S                YG     208.00 1000.00      1000.00
               Pos. Seq. Z%:     1.03 + J   5.86    (Zpu   1.03 + j   5.86 )    Shell Type
               Zero Seq. Z%:     1.03 + J   5.86    (Sec   1.03 + j   5.86 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-PS1-USB                     TX-PS1-USB P                   D  12470.0   TX-PS1-USB S                    YG     208.00  150.00       150.00
               Pos. Seq. Z%:     1.27 + J   4.55    (Zpu   8.45 + j  30.31 )    Shell Type
               Zero Seq. Z%:     1.27 + J   4.55    (Sec   8.45 + j  30.31 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-PS2-USB                     TX-PS2-USB P                   D  12470.0   TX-PS2-USB S                    YG     208.00  750.00       750.00
               Pos. Seq. Z%:     1.12 + J   5.89    (Zpu   1.50 + j   7.86 )    Shell Type
               Zero Seq. Z%:     1.12 + J   5.89    (Sec   1.50 + j   7.86 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.
```

```
                           TRANSFORMER  INPUT  DATA
========================================================================================================================================================
TRANSFORMER                    PRIMARY RECORD                        VOLTS   * SECONDARY RECORD                          VOLTS   FULL-LOAD  NOMINAL
NAME                           NO NAME                               L-L       NO NAME                                   L-L     KVA         KVA
========================================================================================================================================================
TX-PSC-USB                     TX-PSC-USB P                     D  12470.0   TX-PSC-USB S                       YG    480.00  750.00       750.00
               Pos. Seq. Z%:    1.07 + J   5.60    (Zpu   1.42 + j   7.47 )    Shell Type
               Zero Seq. Z%:    1.07 + J   5.60    (Sec   1.42 + j   7.47 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-SB1-USB                     TX-SB1-USB P                     D  12470.0   TX-SB1-USB S                       YG    208.00 1333.00      1000.00
               Pos. Seq. Z%:   0.998 + J   5.70    (Zpu  0.998 + j   5.70 )    Shell Type
               Zero Seq. Z%:   0.998 + J   5.70    (Sec  0.998 + j   5.70 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-SMC 2ND USB                 TX-SMC 2ND USB P                 D  12470.0   TX-SMC 2ND USB S                   YG    208.00  500.00       500.00
               Pos. Seq. Z%:    1.02 + J   4.80    (Zpu   2.05 + j   9.60 )    Shell Type
               Zero Seq. Z%:    1.02 + J   4.80    (Sec   2.05 + j   9.60 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-SMC-USB                     TX-SMC-USB P                     D  12470.0   TX-SMC-USB S                       YG    208.00  750.00       750.00
               Pos. Seq. Z%:    1.00 + J   5.25    (Zpu   1.33 + j   6.99 )    Shell Type
               Zero Seq. Z%:    1.00 + J   5.25    (Sec   1.33 + j   6.99 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-SRTC-SWBD1-1                TX-SRTC-SWBD1-1 P                D  12470.0   TX-SRTC-SWBD1-1 S                  YG    208.00 1333.00      1000.00
               Pos. Seq. Z%:    1.00 + J   5.71    (Zpu   1.00 + j   5.71 )    Shell Type
               Zero Seq. Z%:    1.00 + J   5.71    (Sec   1.00 + j   5.71 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-SRTC-SWBD1-2                TX-SRTC-SWBD1-2 P                D  12470.0   TX-SRTC-SWBD1-2 S                  YG    208.00 1333.00      1000.00
               Pos. Seq. Z%:    1.02 + J   5.81    (Zpu   1.02 + j   5.81 )    Shell Type
               Zero Seq. Z%:    1.02 + J   5.81    (Sec   1.02 + j   5.81 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.
```

```
                           TRANSFORMER  INPUT  DATA
========================================================================================================================================
TRANSFORMER                    PRIMARY RECORD                      VOLTS   * SECONDARY RECORD                         VOLTS   FULL-LOAD  NOMINAL
NAME                           NO NAME                             L-L       NO NAME                                  L-L     KVA          KVA
========================================================================================================================================
TX-SRTC-SWBD2                  TX-SRTC-SWBD2 P               D  12470.0   TX-SRTC-SWBD2 S              YG    480.00 1000.00       750.00
               Pos. Seq. Z%:     1.05 + J   5.50    (Zpu   1.40 + j   7.33 )    Shell Type
               Zero Seq. Z%:     1.05 + J   5.50    (Sec   1.40 + j   7.33 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-SRTC-SWBD3                  TX-SRTC-SWBD3 P               D  12470.0   TX-SRTC-SWBD3 S              YG    480.00 1000.00       750.00
               Pos. Seq. Z%:     1.05 + J   5.50    (Zpu   1.40 + j   7.33 )    Shell Type
               Zero Seq. Z%:     1.05 + J   5.50    (Sec   1.40 + j   7.33 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-SRTC-SWBD4                  TX-SRTC-SWBD4 P               D  12470.0   TX-SRTC-SWBD4 S              YG   4160.00 2000.00      1500.00
               Pos. Seq. Z%:    0.804 + J   5.26    (Zpu  0.536 + j   3.51 )    Shell Type
               Zero Seq. Z%:    0.804 + J   5.26    (Sec  0.536 + j   3.51 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-SRTC-SWBD5                  TX-SRTC-SWBD5 P               D  12470.0   TX-SRTC-SWBD5 S              YG    480.00 2667.00      2000.00
               Pos. Seq. Z%:    0.750 + J   5.47    (Zpu  0.375 + j   2.73 )    Shell Type
               Zero Seq. Z%:    0.750 + J   5.47    (Sec  0.375 + j   2.73 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-WHP-USB                     TX-WHP-USB P                  D  12470.0   TX-WHP-USB S                 YG    480.00  150.00       150.00
               Pos. Seq. Z%:     1.48 + J   5.30    (Zpu   9.85 + j  35.32 )    Shell Type
               Zero Seq. Z%:     1.48 + J   5.30    (Sec   9.85 + j  35.32 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.

TX-XSB-USB                     TX-XSB-USB P                  D  12470.0   TX-XSB-USB S                 YG    208.00  200.00       200.00
               Pos. Seq. Z%:    0.547 + J   2.08    (Zpu   2.74 + j  10.40 )    Shell Type
               Zero Seq. Z%:    0.547 + J   2.08    (Sec   2.74 + j  10.40 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leads Sec.):  30.00 Deg.
```

```
                       GENERATION  CONTRIBUTION  DATA
=============================================================================================
BUS                            CONTRIBUTION                     VOLTAGE
NAME                           NAME                                L-L     MVA      X"d    X/R
=============================================================================================
B-SRTC-USB1 PREF               PGE-PREF                         12470.0  273.21
                  Three Phase           Contribution:    12649.2 AMPS        5.00
                  Single Line to Ground Contribution:    10378.9 AMPS        2.06
                  Pos  Sequence Impedance (100 MVA Base)  0.0718 + J   0.3589 PU
                  Zero Sequence Impedance (100 MVA Base)  0.4397 + J   0.4866 PU

B-SRTC-USB2 ALT                PGE-ALT                          12470.0  279.45
                  Three Phase           Contribution:    12938.4 AMPS        4.63
                  Single Line to Ground Contribution:    12870.3 AMPS        2.78
                  Pos  Sequence Impedance (100 MVA Base)  0.0756 + J   0.3498 PU
                  Zero Sequence Impedance (100 MVA Base)  0.2140 + J   0.3160 PU
```

B. APPENDIX B – SHORT-CIRCUIT RESULTS

```
PSU - West Campus Loop
Portland, OR
ESE0008353 / TQSISE0008353.1
Feb 22, 2013     15:42:55

-----------------------------------------------------------------------------
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-----------------------------------------------------------------------------
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A_FAULT SHORT CIRCUIT ANALYSIS REPORT
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Feb 22, 2013     15:42:55             THREE PHASE LOW VOLTAGE DUTY PAGE    1
PSU - West Campus Loop
Portland, OR
ESE0008353 / TQSISE0008353.1

                T H R E E   P H A S E   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================

 B-CH                           3P Duty: 11.029 KA AT  -71.33 DEG ( 238.22 MVA)  X/R:     2.96
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2090 + J  0.6184  OHMS
                C-CH FDR                    B-CH ATS                              11.029 KA      ANG:   -71.33

 B-CH ATS                       3P Duty: 11.037 KA AT  -71.34 DEG ( 238.38 MVA)  X/R:     2.96
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2087 + J  0.6181  OHMS
                C-R499-2                    C-R499 SPLICE                         11.037 KA      ANG:   108.66

 B-CH CHLR                      3P Duty: 10.910 KA AT  -70.59 DEG ( 235.63 MVA)  X/R:     2.84
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2193 + J  0.6224  OHMS
                C-CH CHLR FDR               B-CH CHLR DS                          10.910 KA      ANG:  -250.59

 B-CH CHLR DS                   3P Duty: 10.968 KA AT  -70.95 DEG ( 236.90 MVA)  X/R:     2.90
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2142 + J  0.6205  OHMS
                C-CH CHLR DS FDR            B-CH                                  10.968 KA      ANG:   -70.95

 B-CH-EMER USB                  3P Duty: 14.590 KA AT  -72.71 DEG (   5.26 MVA)  X/R:     3.21
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0024 + J  0.0079  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   14.590 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  14.631 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  14.590 KA
                C-CH-EMER USB              TX-CH-003 S                            14.590 KA      ANG:   -72.71

 B-CH-NW USB                    3P Duty: 62.595 KA AT  -75.59 DEG (  22.55 MVA)  X/R:     3.89
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0005 + J  0.0019  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   62.595 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  62.595 KA
                C-CH-NW USB                TX-CH-NW USB S                         62.595 KA      ANG:   -75.59

 B-CH-NW USB DS                 3P Duty: 10.352 KA AT  -65.85 DEG ( 223.58 MVA)  X/R:     2.23
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2846 + J  0.6346  OHMS
                C-CH-NW USB FDR             B-CH                                  10.352 KA      ANG:   -65.85

 B-CH-PNL B                     3P Duty: 18.290 KA AT  -77.53 DEG (  15.21 MVA)  X/R:     4.52
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0033 + J  0.0148  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   18.290 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  19.981 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  18.290 KA
                C-CH-PNL B                  B-CH-PNL B DS                         18.290 KA      ANG:  -257.53

 B-CH-PNL B DS                  3P Duty: 19.039 KA AT  -79.23 DEG (  15.83 MVA)  X/R:     5.26
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0027 + J  0.0143  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   19.039 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  19.333 KA
                C-CH-PNL B DS              TX-CH-002 S                            19.039 KA      ANG:   -79.23
```

```
                T H R E E   P H A S E   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================

 B-CH-SE USB                3P Duty: 46.543 KA AT  -78.87 DEG (  16.77 MVA)  X/R:     5.08
                VOLTAGE:    208.  EQUIV. IMPEDANCE=  0.0005 + J  0.0025  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   46.543 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  46.923 KA
                C-CH-SE USB                TX-CH-001 S                        46.543 KA      ANG:   -78.87

 B-CH-SUB 4A                3P Duty: 41.500 KA AT  -81.92 DEG (  34.50 MVA)  X/R:     7.04
                VOLTAGE:    480.  EQUIV. IMPEDANCE=  0.0009 + J  0.0066  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   41.995 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  44.587 KA
                C-CH-SUB 4A                TX-CH-006 S                        41.500 KA      ANG:   -81.92

 B-CH-SUB 4A DS             3P Duty: 10.593 KA AT  -69.46 DEG ( 228.80 MVA)  X/R:     2.67
                VOLTAGE:  12470.  EQUIV. IMPEDANCE=  0.2385 + J  0.6364  OHMS
                C-CH-SUB 4A DS FDR         B-CH CHLR                          10.593 KA      ANG:   -69.46

 B-LE USB                   3P Duty: 25.763 KA AT  -76.50 DEG (   9.28 MVA)  X/R:     4.17
                VOLTAGE:    208.  EQUIV. IMPEDANCE=  0.0011 + J  0.0045  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   25.763 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  25.763 KA
                BWY-LE USB                 TX-LE USB S                        25.763 KA      ANG:   -76.50

 B-LE USB DS                3P Duty: 10.362 KA AT  -66.15 DEG ( 223.81 MVA)  X/R:     2.26
                VOLTAGE:  12470.  EQUIV. IMPEDANCE=  0.2809 + J  0.6355  OHMS
                C-LE USB FDR               B-SMC                              10.362 KA      ANG:   -66.15

 B-LH-TX DS                 3P Duty:  8.942 KA AT  -50.19 DEG ( 193.13 MVA)  X/R:     1.20
                VOLTAGE:  12470.  EQUIV. IMPEDANCE=  0.5155 + J  0.6185  OHMS
                C-SB1-LH FDR               B-SB1                               8.942 KA      ANG:   -50.19

 B-LH-USB                   3P Duty: 43.965 KA AT  -75.61 DEG (  15.84 MVA)  X/R:     3.90
                VOLTAGE:    208.  EQUIV. IMPEDANCE=  0.0007 + J  0.0026  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   43.965 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  43.965 KA
                C-LH-USB                   TX-LH-USB S                        43.965 KA      ANG:   -75.61

 B-ML                       3P Duty: 11.171 KA AT  -68.91 DEG ( 241.29 MVA)  X/R:     2.59
                VOLTAGE:  12470.  EQUIV. IMPEDANCE=  0.2319 + J  0.6013  OHMS
                C-PSC-ML FDR               B-PSC                              11.171 KA      ANG:   -68.91
```

```
               T H R E E   P H A S E   F A U L T   R E P O R T
                  (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                        PRE FAULT VOLTAGE: 1.0000
                        MODEL TRANSFORMER TAPS: NO
==============================================================================================================

 B-ML-USB                    3P Duty: 15.614 KA AT  -78.38 DEG (  12.98 MVA)  X/R:     4.86
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0036 + J  0.0174  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   15.614 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  17.341 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  15.614 KA
                BWY-ML-USB                TX-ML-USB S                     15.614 KA     ANG:   -78.38

 B-NH EAST                   3P Duty:  9.688 KA AT  -61.10 DEG ( 209.25 MVA)  X/R:     1.81
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3591 + J  0.6506  OHMS
                C-NH-EAST FDR             B-NH WEST                        9.688 KA     ANG:   -61.10

 B-NH WEST                   3P Duty:  9.901 KA AT  -62.57 DEG ( 213.84 MVA)  X/R:     1.93
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3350 + J  0.6454  OHMS
                C-CH-NH FDR               B-CH                             9.901 KA     ANG:   -62.57

 B-NH-USB EAST               3P Duty: 45.919 KA AT  -77.70 DEG (  16.54 MVA)  X/R:     4.59
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0006 + J  0.0026  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   45.919 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  45.919 KA
                BWY-NH-USB EAST           TX-NH-USB EAST E                45.919 KA     ANG:   -77.70

 B-NH-USB WEST               3P Duty: 42.848 KA AT  -77.99 DEG (  15.44 MVA)  X/R:     4.70
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0006 + J  0.0027  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   42.848 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  42.848 KA
                BWY-NH-USB WEST           TX-NH-USB WEST S                42.848 KA     ANG:   -77.99

 B-PS1-TX DS                 3P Duty:  9.488 KA AT  -60.53 DEG ( 204.92 MVA)  X/R:     1.77
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3734 + J  0.6606  OHMS
                CBL-0048                  B-NH WEST                        9.488 KA     ANG:   -60.53

 B-PS1-USB                   3P Duty:  8.556 KA AT  -73.87 DEG (   3.08 MVA)  X/R:     3.46
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0039 + J  0.0135  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER    8.556 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA   8.748 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA   8.556 KA
                C-PS1-USB                 TX-PS1-USB S                     8.556 KA     ANG:   -73.87

 B-PS2-TX DS                 3P Duty: 10.465 KA AT  -66.71 DEG ( 226.03 MVA)  X/R:     2.32
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2720 + J  0.6319  OHMS
                C-CH-PS2 FDR              B-CH                            10.465 KA     ANG:   -66.71

 B-PS2-USB                   3P Duty: 32.389 KA AT  -77.57 DEG (  11.67 MVA)  X/R:     4.54
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0008 + J  0.0036  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   32.389 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  32.389 KA
                BWY-PS2-USB               TX-PS2-USB S                    32.389 KA     ANG:   -77.57
```

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                T H R E E   P H A S E   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================

 B-PSC                          3P Duty: 11.575 KA AT  -72.22 DEG ( 250.00 MVA)  X/R:     3.12
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1899 + J  0.5923  OHMS
                C-WHP-PSC FDR                B-WHP                                 11.575 KA      ANG:   -72.22

 B-PSC-USB                      3P Duty: 14.934 KA AT  -78.35 DEG (  12.42 MVA)  X/R:     4.85
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0037 + J  0.0182  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   14.934 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  16.575 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  14.934 KA
                BWY-PSC-USB                  TX-PSC-USB S                          14.934 KA      ANG:   -78.35

 B-SB1                          3P Duty: 12.070 KA AT  -72.39 DEG ( 260.70 MVA)  X/R:     3.15
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1805 + J  0.5685  OHMS
                C-R495                       B-SRTC-USB2 ALT                       12.070 KA      ANG:   -72.39

 B-SB1-USB                      3P Duty: 41.559 KA AT  -74.59 DEG (  14.97 MVA)  X/R:     3.63
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0008 + J  0.0028  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   41.559 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  41.559 KA
                BWY-SB1-USB                  TX-SB1-USB S                          41.559 KA      ANG:   -74.59

 B-SMC                          3P Duty: 10.465 KA AT  -66.71 DEG ( 226.03 MVA)  X/R:     2.32
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2720 + J  0.6319  OHMS
                C-CH-SMC FDR                 B-CH                                  10.465 KA      ANG:   -66.71

 B-SMC 2ND USB                  3P Duty: 26.657 KA AT  -76.46 DEG (   9.60 MVA)  X/R:     4.15
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0011 + J  0.0044  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   26.657 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  26.657 KA
                BWY-SMC 2ND USB              TX-SMC 2ND USB S                      26.657 KA      ANG:   -76.46

 B-SMC 2ND USB DS               3P Duty: 10.406 KA AT  -66.39 DEG ( 224.76 MVA)  X/R:     2.29
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2771 + J  0.6339  OHMS
                B-SMC 2ND USB FDR            B-SMC                                 10.406 KA      ANG:   -66.39

 B-SMC USB                      3P Duty: 34.047 KA AT  -76.87 DEG (  12.27 MVA)  X/R:     4.29
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0008 + J  0.0034  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   34.047 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  34.047 KA
                C-SMC USB                    TX-SMC-USB S                          34.047 KA      ANG:   -76.87
```

```
                T H R E E   P H A S E   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================

 B-SRTC-SB2                     3P Duty: 12.734 KA AT  -76.48 DEG ( 275.04 MVA)  X/R:     4.16
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1322 + J  0.5497  OHMS
                C-R491                          B-SRTC-USB-ATS1                   12.734 KA      ANG:  -76.48

 B-SRTC-SWBD1                   3P Duty: 44.616 KA AT  -79.22 DEG (  16.07 MVA)  X/R:     5.25
                VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0005 + J  0.0026  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   44.616 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  45.290 KA
                BWY-SRTC-SWBD1-1                TX-SRTC-SWBD1-1 S                 44.616 KA      ANG:  -79.22

 B-SRTC-SWBD2                   3P Duty: 15.305 KA AT  -78.80 DEG (  12.72 MVA)  X/R:     5.05
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0035 + J  0.0178  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   15.305 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  17.141 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  15.408 KA
                BWY-SRTC-SWBD2                  TX-SRTC-SWBD2 S                   15.305 KA      ANG:  -78.80

 B-SRTC-SWBD3                   3P Duty: 15.305 KA AT  -78.80 DEG (  12.72 MVA)  X/R:     5.05
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0035 + J  0.0178  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   15.305 KA
                MOLDED CASE CIRCUIT BREAKER < 20KA  17.141 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  15.408 KA
                BWY-SRTC-SWBD3                  TX-SRTC-SWBD3 S                   15.305 KA      ANG:  -78.80

 B-SRTC-SWBD4                   3P Duty:  3.546 KA AT  -80.82 DEG (  25.55 MVA)  X/R:     6.18
                VOLTAGE:   4160.   EQUIV. IMPEDANCE=  0.1081 + J  0.6686  OHMS
                BWY-SRTC-SWBD4                  TX-SRTC-SWBD4 S                    3.546 KA      ANG:  -80.82

 B-SRTC-SWBD4 DS                3P Duty: 12.633 KA AT  -76.09 DEG ( 272.85 MVA)  X/R:     4.04
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1370 + J  0.5532  OHMS
                C-SRTC-SWBD4 FDR                B-SRTC-SB2                        12.633 KA      ANG:  -76.09

 B-SRTC-SWBD5                   3P Duty: 38.288 KA AT  -80.92 DEG (  31.83 MVA)  X/R:     6.26
                VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0011 + J  0.0071  OHMS
                LOW VOLTAGE POWER CIRCUIT BREAKER   38.288 KA
                MOLDED CASE CIRCUIT BREAKER > 20KA  40.262 KA
                BWY-SRTC-SWBD5                  TX-SRTC-SWBD5 S                   38.288 KA      ANG:  -80.92

 B-SRTC-USB1 PREF               3P Duty: 12.649 KA AT  -78.68 DEG ( 273.21 MVA)  X/R:     5.00
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1117 + J  0.5581  OHMS
                CONTRIBUTIONS TO  B-SRTC-USB1 PREF               (CONTINUED)
                CONTRIBUTIONS:  PGE-PREF                                          12.649 KA      ANG:  -78.68
```

```
               T H R E E   P H A S E   F A U L T   R E P O R T
                  (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                        PRE FAULT VOLTAGE: 1.0000
                        MODEL TRANSFORMER TAPS: NO
==============================================================================================================

 B-SRTC-USB2 ALT               3P Duty: 12.938 KA AT  -77.81 DEG ( 279.45 MVA)  X/R:     4.63
               VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1175 + J  0.5439  OHMS
               CONTRIBUTIONS:  PGE-ALT                                           12.938 KA      ANG:   -77.81

 B-WHP                         3P Duty: 11.654 KA AT  -72.91 DEG ( 251.72 MVA)  X/R:     3.25
               VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1815 + J  0.5905  OHMS
               C-R497                         B-SRTC-USB2 ALT                    11.654 KA      ANG:   -72.91

 B-WHP-USB                     3P Duty:  3.237 KA AT  -74.29 DEG (   2.69 MVA)  X/R:     3.55
               VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0232 + J  0.0824  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER    3.237 KA
               MOLDED CASE CIRCUIT BREAKER < 10KA   3.933 KA
               MOLDED CASE CIRCUIT BREAKER < 20KA   3.333 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA   3.237 KA
               BWY-WHP-USB                    TX-WHP-USB S                        3.237 KA      ANG:   -74.29

 B-XSB USB                     3P Duty: 20.483 KA AT  -70.29 DEG (   7.38 MVA)  X/R:     2.79
               VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0020 + J  0.0055  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER   20.483 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA  20.483 KA
               C-XSB SWBD                     B-XSB USB DS                       20.483 KA      ANG:   -70.29

 B-XSB USB DS                  3P Duty: 20.599 KA AT  -70.61 DEG (   7.42 MVA)  X/R:     2.84
               VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.0019 + J  0.0055  OHMS
               LOW VOLTAGE POWER CIRCUIT BREAKER   20.599 KA
               MOLDED CASE CIRCUIT BREAKER > 20KA  20.599 KA
               C-XSB USB DS                   TX-XSB-USB S                       20.599 KA      ANG:   -70.61

 B-XSB-TX DS                   3P Duty:  6.655 KA AT  -38.17 DEG ( 143.75 MVA)  X/R:     0.79
               VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.8505 + J  0.6685  OHMS
               C-SB1-XSB FDR                  B-SB1                               6.655 KA      ANG:   -38.17
```

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                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                     KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                   (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-CH                          3P Duty:  11.029    3. Z1=   0.4198       12.278    11.662
                             SLG DUTY:  10.204    2. Z2=   0.4198       10.732
                 12470. VOLTS   LN/LN:   9.552       Z0=   0.5350
                            LN/LN/GND: 11.476 (  9.401 GND RETURN KA)

B-CH ATS                      3P Duty:  11.037    3. Z1=   0.4195       12.289    11.671
                             SLG DUTY:  10.213    2. Z2=   0.4195       10.742
                 12470. VOLTS   LN/LN:   9.558       Z0=   0.5344
                            LN/LN/GND: 11.486 (  9.411 GND RETURN KA)

B-CH CHLR                     3P Duty:  10.910    3. Z1=   0.4244       12.044    11.484
                             SLG DUTY:  10.050    2. Z2=   0.4244       10.525
                 12470. VOLTS   LN/LN:   9.448       Z0=   0.5465
                            LN/LN/GND: 11.322 (  9.228 GND RETURN KA)

B-CH CHLR DS                  3P Duty:  10.968    3. Z1=   0.4221       12.157    11.570
                             SLG DUTY:  10.125    2. Z2=   0.4221       10.625
                 12470. VOLTS   LN/LN:   9.499       Z0=   0.5409
                            LN/LN/GND: 11.397 (  9.312 GND RETURN KA)

B-CH-EMER USB                 3P Duty:  14.590    3. Z1=  19.0243       16.526    15.574
                             SLG DUTY:  14.254    3. Z2=  19.0243       15.667
                   208. VOLTS   LN/LN:  12.636       Z0=  20.4753
                            LN/LN/GND: 14.937 ( 13.908 GND RETURN KA)

B-CH-NW USB                   3P Duty:  62.595    4. Z1=   4.4345       74.010    68.427
                             SLG DUTY:  62.513    4. Z2=   4.4345       73.219
                   208. VOLTS   LN/LN:  54.208       Z0=   4.4532
                            LN/LN/GND: 63.097 ( 62.425 GND RETURN KA)

B-CH-NW USB DS                3P Duty:  10.352    2. Z1=   0.4473       10.953    10.654
                             SLG DUTY:   9.357    2. Z2=   0.4473        9.589
                 12470. VOLTS   LN/LN:   8.965       Z0=   0.6031
                            LN/LN/GND: 10.638 (  8.461 GND RETURN KA)

B-CH-PNL B                    3P Duty:  18.290    5. Z1=   6.5763       22.389    20.394
                             SLG DUTY:  18.246    4. Z2=   6.5763       21.829
                   480. VOLTS   LN/LN:  15.840       Z0=   6.6334
                            LN/LN/GND: 18.606 ( 18.193 GND RETURN KA)
```

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                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                     KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                   (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-CH-PNL B DS                3P Duty:  19.039    5. Z1=   6.3176       24.123    21.661
                            SLG DUTY:  19.423    5. Z2=   6.3176       24.633
                   480. VOLTS    LN/LN:  16.488       Z0=   5.9428
                           LN/LN/GND: 19.225 ( 19.823 GND RETURN KA)

B-CH-SE USB                  3P Duty:  46.543    5. Z1=   5.9638       58.526    52.715
                            SLG DUTY:  47.037    5. Z2=   5.9638       58.808
                   208. VOLTS    LN/LN:  40.307       Z0=   5.7763
                           LN/LN/GND: 46.995 ( 47.541 GND RETURN KA)

B-CH-SUB 4A                  3P Duty:  41.500    7. Z1=   2.8984       55.982    49.030
                            SLG DUTY:  43.316    7. Z2=   2.8984       58.471
                   480. VOLTS    LN/LN:  35.940       Z0=   2.5338
                           LN/LN/GND: 42.463 ( 45.298 GND RETURN KA)

B-CH-SUB 4A DS               3P Duty:  10.593    3. Z1=   0.4371       11.556    11.080
                            SLG DUTY:   9.657    2. Z2=   0.4371       10.063
                 12470. VOLTS    LN/LN:   9.174       Z0=   0.5765
                           LN/LN/GND: 10.912 (  8.798 GND RETURN KA)

B-LE USB                     3P Duty:  25.763    4. Z1=  10.7740       30.944    28.416
                            SLG DUTY:  25.538    4. Z2=  10.7740       29.928
                   208. VOLTS    LN/LN:  22.312       Z0=  11.0802
                           LN/LN/GND: 26.197 ( 25.300 GND RETURN KA)

B-LE USB DS                  3P Duty:  10.362    2. Z1=   0.4468       10.988    10.677
                            SLG DUTY:   9.370    2. Z2=   0.4468        9.614
                 12470. VOLTS    LN/LN:   8.974       Z0=   0.6018
                           LN/LN/GND: 10.648 (  8.477 GND RETURN KA)

B-LH-TX DS                   3P Duty:   8.942    1. Z1=   0.5178        8.989     8.966
                            SLG DUTY:   7.801    1. Z2=   0.5178        7.812
                 12470. VOLTS    LN/LN:   7.744       Z0=   0.7599
                           LN/LN/GND:  9.058 (  6.861 GND RETURN KA)

B-LH-USB                     3P Duty:  43.965    4. Z1=   6.3135       52.000    48.070
                            SLG DUTY:  43.172    4. Z2=   6.3135       50.558
                   208. VOLTS    LN/LN:  38.075       Z0=   6.6633
                           LN/LN/GND: 43.965 ( 42.403 GND RETURN KA)
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                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                     KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                   (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-ML                           3P Duty:  11.171    3. Z1=   0.4144       12.121    11.651
                              SLG DUTY:  10.364    2. Z2=   0.4144       10.725
                 12470. VOLTS    LN/LN:   9.675       Z0=   0.5268
                             LN/LN/GND: 11.702 (  9.555 GND RETURN KA)

B-ML-USB                       3P Duty:  15.614    5. Z1=   7.7034       19.436    17.580
                              SLG DUTY:  15.806    5. Z2=   7.7034       19.569
                   480. VOLTS    LN/LN:  13.522       Z0=   7.4237
                             LN/LN/GND: 15.777 ( 16.002 GND RETURN KA)

B-NH EAST                      3P Duty:   9.688    2. Z1=   0.4779        9.986     9.837
                              SLG DUTY:   8.592    1. Z2=   0.4779        8.700
                 12470. VOLTS    LN/LN:   8.390       Z0=   0.6732
                             LN/LN/GND:  9.843 (  7.660 GND RETURN KA)

B-NH WEST                      3P Duty:   9.901    2. Z1=   0.4676       10.274    10.088
                              SLG DUTY:   8.831    2. Z2=   0.4676        8.969
                 12470. VOLTS    LN/LN:   8.574       Z0=   0.6502
                             LN/LN/GND: 10.095 (  7.907 GND RETURN KA)

B-NH-USB EAST                  3P Duty:  45.919    5. Z1=   6.0449       56.390    51.296
                              SLG DUTY:  46.144    4. Z2=   6.0449       55.601
                   208. VOLTS    LN/LN:  39.767       Z0=   5.9622
                             LN/LN/GND: 46.737 ( 46.356 GND RETURN KA)

B-NH-USB WEST                  3P Duty:  42.848    5. Z1=   6.4780       52.918    48.023
                              SLG DUTY:  43.033    4. Z2=   6.4780       52.152
                   208. VOLTS    LN/LN:  37.108       Z0=   6.4004
                             LN/LN/GND: 43.581 ( 43.207 GND RETURN KA)

B-PS1-TX DS                    3P Duty:   9.488    2. Z1=   0.4880        9.756     9.622
                              SLG DUTY:   8.370    1. Z2=   0.4880        8.469
                 12470. VOLTS    LN/LN:   8.216       Z0=   0.6951
                             LN/LN/GND:  9.597 (  7.436 GND RETURN KA)

B-PS1-USB                      3P Duty:   8.556    3. Z1=  32.4431        9.848     9.214
                              SLG DUTY:   8.532    3. Z2=  32.4431        9.832
                   208. VOLTS    LN/LN:   7.409       Z0=  32.7153
                             LN/LN/GND:  8.534 (  8.508 GND RETURN KA)
```

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               U N B A L A N C E D   F A U L T   R E P O R T
                 (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                       PRE FAULT VOLTAGE: 1.0000
                       MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                      KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                    (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-PS2-TX DS                 3P Duty:  10.465    2. Z1=   0.4424        11.143    10.807
                           SLG DUTY:   9.493    2. Z2=   0.4424         9.759
                12470. VOLTS    LN/LN:   9.063       Z0=   0.5915
                          LN/LN/GND: 10.776 (  8.609 GND RETURN KA)

B-PS2-USB                   3P Duty:  32.389    5. Z1=   8.5699        39.675    36.129
                           SLG DUTY:  32.147    4. Z2=   8.5699        38.376
                  208. VOLTS    LN/LN:  28.050       Z0=   8.7789
                          LN/LN/GND: 32.936 ( 31.890 GND RETURN KA)

B-PSC                       3P Duty:  11.575    3. Z1=   0.4000        13.028    12.312
                           SLG DUTY:  10.907    2. Z2=   0.4000        11.496
                12470. VOLTS    LN/LN:  10.024       Z0=   0.4890
                          LN/LN/GND: 12.224 ( 10.187 GND RETURN KA)

B-PSC-USB                   3P Duty:  14.934    5. Z1=   8.0541        18.576    16.807
                           SLG DUTY:  15.020    5. Z2=   8.0541        18.415
                  480. VOLTS    LN/LN:  12.933       Z0=   7.9195
                          LN/LN/GND: 15.144 ( 15.105 GND RETURN KA)

B-SB1                       3P Duty:  12.070    3. Z1=   0.3836        13.614    12.854
                           SLG DUTY:  11.562    2. Z2=   0.3836        12.152
                12470. VOLTS    LN/LN:  10.453       Z0=   0.4522
                          LN/LN/GND: 12.940 ( 10.929 GND RETURN KA)

B-SB1-USB                   3P Duty:  41.559    4. Z1=   6.6789        48.361    45.027
                           SLG DUTY:  15.795    1. Z2=   6.6789        15.822
                  208. VOLTS    LN/LN:  35.992       Z0=  41.6775
                          LN/LN/GND: 38.962 (  9.395 GND RETURN KA)

B-SMC                       3P Duty:  10.465    2. Z1=   0.4424        11.143    10.807
                           SLG DUTY:   9.493    2. Z2=   0.4424         9.759
                12470. VOLTS    LN/LN:   9.063       Z0=   0.5915
                          LN/LN/GND: 10.776 (  8.609 GND RETURN KA)

B-SMC 2ND USB               3P Duty:  26.657    4. Z1=  10.4126        31.996    29.390
                           SLG DUTY:  26.414    4. Z2=  10.4126        30.909
                  208. VOLTS    LN/LN:  23.086       Z0=  10.7222
                          LN/LN/GND: 27.121 ( 26.157 GND RETURN KA)
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Portland, OR
ESE0008353 / TQSISE0008353.1

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                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                     KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                   (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-SMC 2ND USB DS               3P Duty:  10.406    2. Z1=   0.4449       11.054    10.732
                              SLG DUTY:   9.423    2. Z2=   0.4449        9.675
                 12470. VOLTS    LN/LN:   9.012       Z0=   0.5974
                             LN/LN/GND: 10.702 (  8.533 GND RETURN KA)

B-SMC USB                      3P Duty:  34.047    4. Z1=   8.1527       41.166    37.694
                              SLG DUTY:  33.365    4. Z2=   8.1527       39.611
                   208. VOLTS    LN/LN:  29.485       Z0=   8.6599
                             LN/LN/GND: 34.219 ( 32.700 GND RETURN KA)

B-SRTC-SB2                     3P Duty:  12.734    4. Z1=   0.3636       15.288    14.041
                              SLG DUTY:  12.546    3. Z2=   0.3636       13.607
                 12470. VOLTS    LN/LN:  11.028       Z0=   0.3981
                             LN/LN/GND: 13.893 ( 12.161 GND RETURN KA)

B-SRTC-SWBD1                   3P Duty:  44.616    5. Z1=   6.2214       56.512    50.749
                              SLG DUTY:  44.869    5. Z2=   6.2214       55.697
                   208. VOLTS    LN/LN:  38.639       Z0=   6.1216
                             LN/LN/GND: 45.400 ( 45.112 GND RETURN KA)

B-SRTC-SWBD2                   3P Duty:  15.305    5. Z1=   7.8589       19.217    17.320
                              SLG DUTY:  15.460    5. Z2=   7.8589       19.256
                   480. VOLTS    LN/LN:  13.255       Z0=   7.6236
                             LN/LN/GND: 15.477 ( 15.618 GND RETURN KA)

B-SRTC-SWBD3                   3P Duty:  15.305    5. Z1=   7.8589       19.217    17.320
                              SLG DUTY:  15.460    5. Z2=   7.8589       19.256
                   480. VOLTS    LN/LN:  13.255       Z0=   7.6236
                             LN/LN/GND: 15.477 ( 15.618 GND RETURN KA)

B-SRTC-SWBD4                   3P Duty:   3.546    6. Z1=   3.9138        4.656     4.121
                              SLG DUTY:   3.657    6. Z2=   3.9138        4.820
                  4160. VOLTS    LN/LN:   3.071       Z0=   3.5565
                             LN/LN/GND:  3.596 (  3.776 GND RETURN KA)

B-SRTC-SWBD4 DS                3P Duty:  12.633    4. Z1=   0.3665       15.064    13.876
                              SLG DUTY:  12.395    3. Z2=   0.3665       13.401
                 12470. VOLTS    LN/LN:  10.940       Z0=   0.4056
                             LN/LN/GND: 13.740 ( 11.970 GND RETURN KA)
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                 U N B A L A N C E D   F A U L T   R E P O R T
                   (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================================
  LOCATION     FAULT                     KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
  VOLTAGE      DUTIES                   (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==============================================================================================================

B-SRTC-SWBD5                   3P Duty:  38.288    6. Z1=   3.1415       50.401    44.566
                              SLG DUTY:  38.348    5. Z2=   3.1415       47.848
                   480. VOLTS    LN/LN:  33.158       Z0=   3.1437
                             LN/LN/GND: 39.679 ( 38.339 GND RETURN KA)

B-SRTC-USB1 PREF               3P Duty:  12.649    5. Z1=   0.3660       15.843    14.293
                              SLG DUTY:  10.379    2. Z2=   0.3660       10.863
                 12470. VOLTS    LN/LN:  10.955       Z0=   0.6558
                             LN/LN/GND: 13.271 (  8.486 GND RETURN KA)

B-SRTC-USB2 ALT                3P Duty:  12.938    5. Z1=   0.3578       15.924    14.472
                              SLG DUTY:  12.870    3. Z2=   0.3578       14.151
                 12470. VOLTS    LN/LN:  11.205       Z0=   0.3817
                             LN/LN/GND: 14.198 ( 12.588 GND RETURN KA)

B-WHP                          3P Duty:  11.654    3. Z1=   0.3973       13.236    12.458
                              SLG DUTY:  11.017    2. Z2=   0.3973       11.669
                 12470. VOLTS    LN/LN:  10.093       Z0=   0.4816
                             LN/LN/GND: 12.328 ( 10.319 GND RETURN KA)

B-WHP-USB                      3P Duty:   3.237    4. Z1=  37.1586        3.749     3.498
                              SLG DUTY:   3.236    4. Z2=  37.1586        3.739
                   480. VOLTS    LN/LN:   2.803       Z0=  37.1779
                             LN/LN/GND:  3.245 (  3.236 GND RETURN KA)

B-XSB USB                      3P Duty:  20.483    3. Z1=  13.5511       22.536    21.522
                              SLG DUTY:  18.970    3. Z2=  13.5511       20.473
                   208. VOLTS    LN/LN:  17.739       Z0=  16.8353
                             LN/LN/GND: 20.308 ( 17.649 GND RETURN KA)

B-XSB USB DS                   3P Duty:  20.599    3. Z1=  13.4750       22.745    21.686
                              SLG DUTY:  19.232    3. Z2=  13.4750       20.910
                   208. VOLTS    LN/LN:  17.839       Z0=  16.3731
                             LN/LN/GND: 20.374 ( 18.025 GND RETURN KA)

B-XSB-TX DS                    3P Duty:   6.655    1. Z1=   0.6957        6.658     6.656
                              SLG DUTY:   5.607    1. Z2=   0.6957        5.608
                 12470. VOLTS    LN/LN:   5.764       Z0=   1.0948
                             LN/LN/GND:  6.531 (  4.827 GND RETURN KA)
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F A U L T S T U D Y S U M M A R Y
(FOR APPLICATION OF LOW VOLTAGE BREAKERS)
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

BUS RECORD NO NAME	VOLTAGE L-L	AVAILABLE FAULT DUTIES (KA) 3 PHASE	X/R	LINE/GRND	X/R
B-CH	12470.	11.029	2.96	10.204	2.14
B-CH ATS	12470.	11.037	2.96	10.213	2.14
B-CH CHLR	12470.	10.910	2.84	10.050	2.07
B-CH CHLR DS	12470.	10.968	2.90	10.125	2.11
B-CH-EMER USB	208.	14.590	3.21	14.254	2.78
B-CH-NW USB	208.	62.595	3.89	62.513	3.73
B-CH-NW USB DS	12470.	10.352	2.23	9.357	1.71
B-CH-PNL B	480.	18.290	4.52	18.246	4.10
B-CH-PNL B DS	480.	19.039	5.26	19.423	5.28
B-CH-SE USB	208.	46.543	5.08	47.037	4.96
B-CH-SUB 4A	480.	41.500	7.04	43.316	7.07
B-CH-SUB 4A DS	12470.	10.593	2.67	9.657	2.00
B-LE USB	208.	25.763	4.17	25.538	3.74
B-LE USB DS	12470.	10.362	2.26	9.370	1.73
B-LH-TX DS	12470.	8.942	1.20	7.801	0.96
B-LH-USB	208.	43.965	3.90	43.172	3.73
B-ML	12470.	11.171	2.59	10.364	1.88
B-ML-USB	480.	15.614	4.86	15.806	4.75
B-NH EAST	12470.	9.688	1.81	8.592	1.44
B-NH WEST	12470.	9.901	1.93	8.831	1.51
B-NH-USB EAST	208.	45.919	4.59	46.144	4.22
B-NH-USB WEST	208.	42.848	4.70	43.033	4.33
B-PS1-TX DS	12470.	9.488	1.77	8.370	1.42
B-PS1-USB	208.	8.556	3.46	8.532	3.48
B-PS2-TX DS	12470.	10.465	2.32	9.493	1.76
B-PS2-USB	208.	32.389	4.54	32.147	4.06
B-PSC	12470.	11.575	3.12	10.907	2.17
B-PSC-USB	480.	14.934	4.85	15.020	4.55
B-SB1	12470.	12.070	3.15	11.562	2.13
B-SB1-USB	208.	41.559	3.63	15.795	0.99
B-SMC	12470.	10.465	2.32	9.493	1.76
B-SMC 2ND USB	208.	26.657	4.15	26.414	3.72
B-SMC 2ND USB DS	12470.	10.406	2.29	9.423	1.74
B-SMC USB	208.	34.047	4.29	33.365	3.96
B-SRTC-SB2	12470.	12.734	4.16	12.546	2.59
B-SRTC-SWBD1	208.	44.616	5.25	44.869	4.80
B-SRTC-SWBD2	480.	15.305	5.05	15.460	4.88
B-SRTC-SWBD3	480.	15.305	5.05	15.460	4.88
B-SRTC-SWBD4	4160.	3.546	6.18	3.657	6.29
B-SRTC-SWBD4 DS	12470.	12.633	4.04	12.395	2.54
B-SRTC-SWBD5	480.	38.288	6.26	38.348	4.91
B-SRTC-USB1 PREF	12470.	12.649	5.00	10.379	2.06
B-SRTC-USB2 ALT	12470.	12.938	4.63	12.870	2.78
B-WHP	12470.	11.654	3.25	11.017	2.25

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F A U L T S T U D Y S U M M A R Y
(FOR APPLICATION OF LOW VOLTAGE BREAKERS)
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

BUS RECORD NO NAME	VOLTAGE L-L	AVAILABLE FAULT DUTIES (KA) 3 PHASE	X/R	LINE/GRND	X/R
B-WHP-USB	480.	3.237	3.55	3.236	3.51
B-XSB USB	208.	20.483	2.79	18.970	2.52
B-XSB USB DS	208.	20.599	2.84	19.232	2.62
B-XSB-TX DS	12470.	6.655	0.79	5.607	0.67

99 FAULTED BUSES, 99 BRANCHES, 2 CONTRIBUTIONS
UNBALANCED FAULTS REQUESTED

*** SHORT CIRCUIT STUDY COMPLETE ***

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     T H R E E   P H A S E   M O M E N T A R Y   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================

 B-CH                           E/Z:     11.029 KA AT  -71.33 DEG ( 238.22 MVA)  X/R:     2.96
                                SYM*1.6:  17.647 KA       MOMENTARY BASED ON X/R:   12.278 KA
                                SYM*2.7:  29.779 KA           CREST BASED ON X/R:   20.993 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2090 + J  0.6184  OHMS

 B-CH ATS                       E/Z:     11.037 KA AT  -71.34 DEG ( 238.38 MVA)  X/R:     2.96
                                SYM*1.6:  17.659 KA       MOMENTARY BASED ON X/R:   12.289 KA
                                SYM*2.7:  29.799 KA           CREST BASED ON X/R:   21.012 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2087 + J  0.6181  OHMS

 B-CH CHLR                      E/Z:     10.910 KA AT  -70.59 DEG ( 235.63 MVA)  X/R:     2.84
                                SYM*1.6:  17.455 KA       MOMENTARY BASED ON X/R:   12.044 KA
                                SYM*2.7:  29.456 KA           CREST BASED ON X/R:   20.530 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2193 + J  0.6224  OHMS

 B-CH CHLR DS                   E/Z:     10.968 KA AT  -70.95 DEG ( 236.90 MVA)  X/R:     2.90
                                SYM*1.6:  17.549 KA       MOMENTARY BASED ON X/R:   12.157 KA
                                SYM*2.7:  29.614 KA           CREST BASED ON X/R:   20.754 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2142 + J  0.6205  OHMS

 B-CH-EMER USB                  VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-CH-NW USB                    VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-CH-NW USB DS                 E/Z:     10.352 KA AT  -65.85 DEG ( 223.58 MVA)  X/R:     2.23
                                SYM*1.6:  16.563 KA       MOMENTARY BASED ON X/R:   10.953 KA
                                SYM*2.7:  27.949 KA           CREST BASED ON X/R:   18.218 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2846 + J  0.6346  OHMS
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     T H R E E   P H A S E   M O M E N T A R Y   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================

 B-CH-PNL B                     VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-CH-PNL B DS                  VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-CH-SE USB                    VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-CH-SUB 4A                    VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-CH-SUB 4A DS                 E/Z:     10.593 KA AT  -69.46 DEG ( 228.80 MVA)  X/R:     2.67
                                SYM*1.6:   16.949 KA       MOMENTARY BASED ON X/R:   11.556 KA
                                SYM*2.7:   28.602 KA           CREST BASED ON X/R:   19.598 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2385 + J  0.6364  OHMS

 B-LE USB                       VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-LE USB DS                    E/Z:     10.362 KA AT  -66.15 DEG ( 223.81 MVA)  X/R:     2.26
                                SYM*1.6:   16.579 KA       MOMENTARY BASED ON X/R:   10.988 KA
                                SYM*2.7:   27.978 KA           CREST BASED ON X/R:   18.308 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2809 + J  0.6355  OHMS

 B-LH-TX DS                     E/Z:      8.942 KA AT  -50.19 DEG ( 193.13 MVA)  X/R:     1.20
                                SYM*1.6:   14.307 KA       MOMENTARY BASED ON X/R:    8.989 KA
                                SYM*2.7:   24.143 KA           CREST BASED ON X/R:   13.568 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.5155 + J  0.6185  OHMS

 B-LH-USB                       VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-ML                           E/Z:     11.171 KA AT  -68.91 DEG ( 241.29 MVA)  X/R:     2.59
                                SYM*1.6:   17.874 KA       MOMENTARY BASED ON X/R:   12.121 KA
                                SYM*2.7:   30.163 KA           CREST BASED ON X/R:   20.502 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2319 + J  0.6013  OHMS

 B-ML-USB                       VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-NH EAST                      E/Z:      9.688 KA AT  -61.10 DEG ( 209.25 MVA)  X/R:     1.81
                                SYM*1.6:   15.501 KA       MOMENTARY BASED ON X/R:    9.986 KA
                                SYM*2.7:   26.158 KA           CREST BASED ON X/R:   16.120 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3591 + J  0.6506  OHMS
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     T H R E E   P H A S E   M O M E N T A R Y   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================

 B-NH WEST                       E/Z:      9.901 KA AT  -62.57 DEG ( 213.84 MVA)  X/R:     1.93
                                 SYM*1.6:   15.841 KA       MOMENTARY BASED ON X/R:   10.274 KA
                                 SYM*2.7:   26.732 KA           CREST BASED ON X/R:   16.744 KA
                                 VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3350 + J  0.6454  OHMS

 B-NH-USB EAST                   VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-NH-USB WEST                   VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-PS1-TX DS                     E/Z:      9.488 KA AT  -60.53 DEG ( 204.92 MVA)  X/R:     1.77
                                 SYM*1.6:   15.180 KA       MOMENTARY BASED ON X/R:    9.756 KA
                                 SYM*2.7:   25.617 KA           CREST BASED ON X/R:   15.690 KA
                                 VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3734 + J  0.6606  OHMS

 B-PS1-USB                       VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-PS2-TX DS                     E/Z:     10.465 KA AT  -66.71 DEG ( 226.03 MVA)  X/R:     2.32
                                 SYM*1.6:   16.744 KA       MOMENTARY BASED ON X/R:   11.143 KA
                                 SYM*2.7:   28.256 KA           CREST BASED ON X/R:   18.629 KA
                                 VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2720 + J  0.6319  OHMS

 B-PS2-USB                       VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-PSC                           E/Z:     11.575 KA AT  -72.22 DEG ( 250.00 MVA)  X/R:     3.12
                                 SYM*1.6:   18.520 KA       MOMENTARY BASED ON X/R:   13.028 KA
                                 SYM*2.7:   31.252 KA           CREST BASED ON X/R:   22.348 KA
                                 VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1899 + J  0.5923  OHMS

 B-PSC-USB                       VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )
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     T H R E E   P H A S E   M O M E N T A R Y   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================

 B-SB1                          E/Z:     12.070 KA AT  -72.39 DEG ( 260.70 MVA)  X/R:     3.15
                                SYM*1.6:   19.313 KA       MOMENTARY BASED ON X/R:   13.614 KA
                                SYM*2.7:   32.590 KA           CREST BASED ON X/R:   23.366 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1805 + J  0.5685  OHMS

 B-SB1-USB                      VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-SMC                          E/Z:     10.465 KA AT  -66.71 DEG ( 226.03 MVA)  X/R:     2.32
                                SYM*1.6:   16.744 KA       MOMENTARY BASED ON X/R:   11.143 KA
                                SYM*2.7:   28.256 KA           CREST BASED ON X/R:   18.629 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2720 + J  0.6319  OHMS

 B-SMC 2ND USB                  VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-SMC 2ND USB DS               E/Z:     10.406 KA AT  -66.39 DEG ( 224.76 MVA)  X/R:     2.29
                                SYM*1.6:   16.650 KA       MOMENTARY BASED ON X/R:   11.054 KA
                                SYM*2.7:   28.097 KA           CREST BASED ON X/R:   18.444 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2771 + J  0.6339  OHMS

 B-SMC USB                      VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-SRTC-SB2                     E/Z:     12.734 KA AT  -76.48 DEG ( 275.04 MVA)  X/R:     4.16
                                SYM*1.6:   20.374 KA       MOMENTARY BASED ON X/R:   15.288 KA
                                SYM*2.7:   34.382 KA           CREST BASED ON X/R:   26.468 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1322 + J  0.5497  OHMS

 B-SRTC-SWBD1                   VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )
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     T H R E E   P H A S E   M O M E N T A R Y   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================

 B-SRTC-SWBD2                  VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-SRTC-SWBD3                  VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-SRTC-SWBD4                  E/Z:     3.546 KA AT  -80.82 DEG (  25.55 MVA)  X/R:     6.18
                               SYM*1.6:    5.674 KA       MOMENTARY BASED ON X/R:    4.656 KA
                               SYM*2.7:    9.574 KA           CREST BASED ON X/R:    8.032 KA
                               VOLTAGE:  4160.  EQUIV. IMPEDANCE=  0.1081 + J  0.6686  OHMS

 B-SRTC-SWBD4 DS               E/Z:    12.633 KA AT  -76.09 DEG ( 272.85 MVA)  X/R:     4.04
                               SYM*1.6:   20.212 KA       MOMENTARY BASED ON X/R:   15.064 KA
                               SYM*2.7:   34.108 KA           CREST BASED ON X/R:   26.071 KA
                               VOLTAGE:  12470.  EQUIV. IMPEDANCE=  0.1370 + J  0.5532  OHMS

 B-SRTC-SWBD5                  VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-SRTC-USB1 PREF              E/Z:    12.649 KA AT  -78.68 DEG ( 273.21 MVA)  X/R:     5.00
                               SYM*1.6:   20.239 KA       MOMENTARY BASED ON X/R:   15.843 KA
                               SYM*2.7:   34.153 KA           CREST BASED ON X/R:   27.428 KA
                               VOLTAGE:  12470.  EQUIV. IMPEDANCE=  0.1117 + J  0.5581  OHMS
                CONTRIBUTIONS: PGE-PREF                          12.649 KA      ANG:   -78.68

 B-SRTC-USB2 ALT               E/Z:    12.938 KA AT  -77.81 DEG ( 279.45 MVA)  X/R:     4.63
                               SYM*1.6:   20.702 KA       MOMENTARY BASED ON X/R:   15.924 KA
                               SYM*2.7:   34.934 KA           CREST BASED ON X/R:   27.580 KA
                               VOLTAGE:  12470.  EQUIV. IMPEDANCE=  0.1175 + J  0.5439  OHMS
                CONTRIBUTIONS: PGE-ALT                           12.938 KA      ANG:   -77.81

 B-WHP                         E/Z:    11.654 KA AT  -72.91 DEG ( 251.72 MVA)  X/R:     3.25
                               SYM*1.6:   18.647 KA       MOMENTARY BASED ON X/R:   13.236 KA
                               SYM*2.7:   31.466 KA           CREST BASED ON X/R:   22.757 KA
                               VOLTAGE:  12470.  EQUIV. IMPEDANCE=  0.1815 + J  0.5905  OHMS
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PSU - West Campus Loop
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    T H R E E   P H A S E   M O M E N T A R Y   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================

 B-WHP-USB                      VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-XSB USB                      VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-XSB USB DS                   VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-XSB-TX DS                    E/Z:      6.655 KA AT  -38.17 DEG ( 143.75 MVA)  X/R:     0.79
                                SYM*1.6:   10.648 KA       MOMENTARY BASED ON X/R:    6.658 KA
                                SYM*2.7:   17.969 KA           CREST BASED ON X/R:    9.585 KA
                                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.8505 + J  0.6685  OHMS
```

```
      U N B A L A N C E D   M O M E N T A R Y   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================
  LOCATION                            FAULT       E/Z    X/R  EQUIVALENT       MOMENTARY FAULT DUTIES
                  VOLTAGE      TYPE        KA          IMPEDANCE (PU)   E/Z * 1.6  @ 0.5 CYCLE
==============================================================================================


                               3P Duty:  11.03    3.0 Z1=   0.4198       17.65      12.28
B-CH                          SLG DUTY:  10.20    2.1 Z2=   0.4198       16.33      10.73
                 12470.     VOLTS LN/LN:   9.55        Z0=   0.5350
                              LN/LN/GND:  11.48 (    9.40 GND RETURN KA)

                               3P Duty:  11.04    3.0 Z1=   0.4195       17.66      12.29
B-CH ATS                      SLG DUTY:  10.21    2.1 Z2=   0.4195       16.34      10.74
                 12470.     VOLTS LN/LN:   9.56        Z0=   0.5344
                              LN/LN/GND:  11.49 (    9.41 GND RETURN KA)

                               3P Duty:  10.91    2.8 Z1=   0.4244       17.46      12.04
B-CH CHLR                     SLG DUTY:  10.05    2.1 Z2=   0.4244       16.08      10.53
                 12470.     VOLTS LN/LN:   9.45        Z0=   0.5465
                              LN/LN/GND:  11.32 (    9.23 GND RETURN KA)

                               3P Duty:  10.97    2.9 Z1=   0.4221       17.55      12.16
B-CH CHLR DS                  SLG DUTY:  10.12    2.1 Z2=   0.4221       16.20      10.63
                 12470.     VOLTS LN/LN:   9.50        Z0=   0.5409
                              LN/LN/GND:  11.40 (    9.31 GND RETURN KA)

                               3P Duty:  10.35    2.2 Z1=   0.4473       16.56      10.95
B-CH-NW USB DS                SLG DUTY:   9.36    1.7 Z2=   0.4473       14.97       9.59
                 12470.     VOLTS LN/LN:   8.96        Z0=   0.6031
                              LN/LN/GND:  10.64 (    8.46 GND RETURN KA)

                               3P Duty:  10.59    2.7 Z1=   0.4371       16.95      11.56
B-CH-SUB 4A DS                SLG DUTY:   9.66    2.0 Z2=   0.4371       15.45      10.06
                 12470.     VOLTS LN/LN:   9.17        Z0=   0.5765
                              LN/LN/GND:  10.91 (    8.80 GND RETURN KA)

                               3P Duty:  10.36    2.3 Z1=   0.4468       16.58      10.99
B-LE USB DS                   SLG DUTY:   9.37    1.7 Z2=   0.4468       14.99       9.61
                 12470.     VOLTS LN/LN:   8.97        Z0=   0.6018
                              LN/LN/GND:  10.65 (    8.48 GND RETURN KA)

                               3P Duty:   8.94    1.2 Z1=   0.5178       14.31       8.99
B-LH-TX DS                    SLG DUTY:   7.80    1.0 Z2=   0.5178       12.48       7.81
                 12470.     VOLTS LN/LN:   7.74        Z0=   0.7599
                              LN/LN/GND:   9.06 (    6.86 GND RETURN KA)
```

Feb 22, 2013 15:42:55 UNBALANCED MOMENTARY DUTY PAGE 2
PSU - West Campus Loop
Portland, OR
ESE0008353 / TQSISE0008353.1

U N B A L A N C E D   M O M E N T A R Y   D U T Y   R E P O R T
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

LOCATION	VOLTAGE	FAULT TYPE	E/Z KA	X/R	EQUIVALENT IMPEDANCE (PU)	MOMENTARY FAULT DUTIES E/Z * 1.6	@ 0.5 CYCLE
		3P Duty:	11.17	2.6	Z1= 0.4144	17.87	12.12
B-ML		SLG DUTY:	10.36	1.9	Z2= 0.4144	16.58	10.72
	12470.	VOLTS LN/LN:	9.67		Z0= 0.5268		
		LN/LN/GND:	11.70 (		9.55 GND RETURN KA)		
		3P Duty:	9.69	1.8	Z1= 0.4779	15.50	9.99
B-NH EAST		SLG DUTY:	8.59	1.4	Z2= 0.4779	13.75	8.70
	12470.	VOLTS LN/LN:	8.39		Z0= 0.6732		
		LN/LN/GND:	9.84 (		7.66 GND RETURN KA)		
		3P Duty:	9.90	1.9	Z1= 0.4676	15.84	10.27
B-NH WEST		SLG DUTY:	8.83	1.5	Z2= 0.4676	14.13	8.97
	12470.	VOLTS LN/LN:	8.57		Z0= 0.6502		
		LN/LN/GND:	10.09 (		7.91 GND RETURN KA)		
		3P Duty:	9.49	1.8	Z1= 0.4880	15.18	9.76
B-PS1-TX DS		SLG DUTY:	8.37	1.4	Z2= 0.4880	13.39	8.47
	12470.	VOLTS LN/LN:	8.22		Z0= 0.6951		
		LN/LN/GND:	9.60 (		7.44 GND RETURN KA)		
		3P Duty:	10.47	2.3	Z1= 0.4424	16.74	11.14
B-PS2-TX DS		SLG DUTY:	9.49	1.8	Z2= 0.4424	15.19	9.76
	12470.	VOLTS LN/LN:	9.06		Z0= 0.5915		
		LN/LN/GND:	10.78 (		8.61 GND RETURN KA)		
		3P Duty:	11.57	3.1	Z1= 0.4000	18.52	13.03
B-PSC		SLG DUTY:	10.91	2.2	Z2= 0.4000	17.45	11.50
	12470.	VOLTS LN/LN:	10.02		Z0= 0.4890		
		LN/LN/GND:	12.22 (		10.19 GND RETURN KA)		
		3P Duty:	12.07	3.1	Z1= 0.3836	19.31	13.61
B-SB1		SLG DUTY:	11.56	2.1	Z2= 0.3836	18.50	12.15
	12470.	VOLTS LN/LN:	10.45		Z0= 0.4522		
		LN/LN/GND:	12.94 (		10.93 GND RETURN KA)		
		3P Duty:	10.47	2.3	Z1= 0.4424	16.74	11.14
B-SMC		SLG DUTY:	9.49	1.8	Z2= 0.4424	15.19	9.76
	12470.	VOLTS LN/LN:	9.06		Z0= 0.5915		
		LN/LN/GND:	10.78 (		8.61 GND RETURN KA)		

```
      U N B A L A N C E D   M O M E N T A R Y   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================
  LOCATION                    FAULT       E/Z    X/R  EQUIVALENT       MOMENTARY FAULT DUTIES
                  VOLTAGE     TYPE        KA          IMPEDANCE (PU)   E/Z * 1.6  @ 0.5 CYCLE
==============================================================================================

                               3P Duty:  10.41    2.3 Z1=   0.4449       16.65      11.05
B-SMC 2ND USB DS              SLG DUTY:   9.42    1.7 Z2=   0.4449       15.08       9.68
                 12470.     VOLTS LN/LN:   9.01        Z0=   0.5974
                              LN/LN/GND:  10.70 (    8.53 GND RETURN KA)

                               3P Duty:  12.73    4.2 Z1=   0.3636       20.37      15.29
B-SRTC-SB2                    SLG DUTY:  12.55    2.6 Z2=   0.3636       20.07      13.61
                 12470.     VOLTS LN/LN:  11.03        Z0=   0.3981
                              LN/LN/GND:  13.89 (   12.16 GND RETURN KA)

                               3P Duty:   3.55    6.2 Z1=   3.9138        5.67       4.66
B-SRTC-SWBD4                  SLG DUTY:   3.66    6.3 Z2=   3.9138        5.85       4.82
                  4160.     VOLTS LN/LN:   3.07        Z0=   3.5565
                              LN/LN/GND:   3.60 (    3.78 GND RETURN KA)

                               3P Duty:  12.63    4.0 Z1=   0.3665       20.21      15.06
B-SRTC-SWBD4 DS               SLG DUTY:  12.39    2.5 Z2=   0.3665       19.83      13.40
                 12470.     VOLTS LN/LN:  10.94        Z0=   0.4056
                              LN/LN/GND:  13.74 (   11.97 GND RETURN KA)

                               3P Duty:  12.65    5.0 Z1=   0.3660       20.24      15.84
B-SRTC-USB1 PREF              SLG DUTY:  10.38    2.1 Z2=   0.3660       16.61      10.86
                 12470.     VOLTS LN/LN:  10.95        Z0=   0.6558
                              LN/LN/GND:  13.27 (    8.49 GND RETURN KA)

                               3P Duty:  12.94    4.6 Z1=   0.3578       20.70      15.92
B-SRTC-USB2 ALT               SLG DUTY:  12.87    2.8 Z2=   0.3578       20.59      14.15
                 12470.     VOLTS LN/LN:  11.21        Z0=   0.3817
                              LN/LN/GND:  14.20 (   12.59 GND RETURN KA)

                               3P Duty:  11.65    3.3 Z1=   0.3973       18.65      13.24
B-WHP                         SLG DUTY:  11.02    2.2 Z2=   0.3973       17.63      11.67
                 12470.     VOLTS LN/LN:  10.09        Z0=   0.4816
                              LN/LN/GND:  12.33 (   10.32 GND RETURN KA)

                               3P Duty:   6.66    0.8 Z1=   0.6957       10.65       6.66
B-XSB-TX DS                   SLG DUTY:   5.61    0.7 Z2=   0.6957        8.97       5.61
                 12470.     VOLTS LN/LN:   5.76        Z0=   1.0948
                              LN/LN/GND:   6.53 (    4.83 GND RETURN KA)
```

M O M E N T A R Y   D U T Y   S U M M A R Y   R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO
SOLUTION METHOD : E/Z

BUS RECORD NO NAME	VOLTAGE L-L	* 3 PHASE * KA	X/R	* * * SLG * * * KA	X/R
B-CH	12470.	12.278	2.96	10.732	2.14
B-CH ATS	12470.	12.289	2.96	10.742	2.14
B-CH CHLR	12470.	12.044	2.84	10.525	2.07
B-CH CHLR DS	12470.	12.157	2.90	10.625	2.11
B-CH-NW USB DS	12470.	10.953	2.23	9.589	1.71
B-CH-SUB 4A DS	12470.	11.556	2.67	10.063	2.00
B-LE USB DS	12470.	10.988	2.26	9.614	1.73
B-LH-TX DS	12470.	8.989	1.20	7.812	0.96
B-ML	12470.	12.121	2.59	10.725	1.88
B-NH EAST	12470.	9.986	1.81	8.700	1.44
B-NH WEST	12470.	10.274	1.93	8.969	1.51
B-PS1-TX DS	12470.	9.756	1.77	8.469	1.42
B-PS2-TX DS	12470.	11.143	2.32	9.759	1.76
B-PSC	12470.	13.028	3.12	11.496	2.17
B-SB1	12470.	13.614	3.15	12.152	2.13
B-SMC	12470.	11.143	2.32	9.759	1.76
B-SMC 2ND USB DS	12470.	11.054	2.29	9.675	1.74
B-SRTC-SB2	12470.	15.288	4.16	13.607	2.59
B-SRTC-SWBD4	4160.	4.656	6.18	4.820	6.29
B-SRTC-SWBD4 DS	12470.	15.064	4.04	13.401	2.54
B-SRTC-USB1 PREF	12470.	15.843	5.00	10.863	2.06
B-SRTC-USB2 ALT	12470.	15.924	4.63	14.151	2.78
B-WHP	12470.	13.236	3.25	11.669	2.25
B-XSB-TX DS	12470.	6.658	0.79	5.608	0.67

52 FAULTED BUSES,   99 BRANCHES,   2 CONTRIBUTIONS
UNBALANCED FAULTS REQUESTED

*** SHORT CIRCUIT STUDY COMPLETE ***

```
Feb 22, 2013     15:42:55             THREE PHASE INTERRUPTING DUTY PAGE    1
PSU - West Campus Loop
Portland, OR
ESE0008353 / TQSISE0008353.1

  T H R E E   P H A S E   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================

 B-CH                           E/Z:     11.029 KA AT  -71.33 DEG ( 238.22 MVA)  X/R:     2.96
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2090 + J  0.6184  OHMS
                CONTRIBUTIONS:  B-CH ATS          11.029 KA      ANG:   -71.33

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                       11.029     0.18         R
                TOTAL REMOTE:    11.029 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   11.029   11.029   11.029   11.029

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.027    1.000    1.000    1.000
                DUTY (KA) :   11.330   11.029   11.029   11.029

 B-CH ATS                       E/Z:     11.037 KA AT  -71.34 DEG ( 238.38 MVA)  X/R:     2.96
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2087 + J  0.6181  OHMS
                C-R499-2        C-R499 SPLICE     11.037 KA      ANG:   108.66

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                       11.037     0.18         R
                TOTAL REMOTE:    11.037 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   11.037   11.037   11.037   11.037

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.027    1.000    1.000    1.000
                DUTY (KA) :   11.338   11.037   11.037   11.037

 B-CH CHLR                      E/Z:     10.910 KA AT  -70.59 DEG ( 235.63 MVA)  X/R:     2.84
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2193 + J  0.6224  OHMS
                CONTRIBUTIONS:  B-CH CHLR DS      10.910 KA      ANG:  -250.59

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                       10.910     0.19         R
                TOTAL REMOTE:    10.910 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   10.910   10.910   10.910   10.910

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.026    1.000    1.000    1.000
                DUTY (KA) :   11.191   10.910   10.910   10.910
```

```
  T H R E E   P H A S E   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================

 B-CH CHLR DS                   E/Z:     10.968 KA AT  -70.95 DEG ( 236.90 MVA)  X/R:     2.90
               VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2142 + J  0.6205  OHMS
               CONTRIBUTIONS:  B-CH             10.968 KA      ANG:   -70.95

               GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
           PGE-ALT                                       10.968     0.19         R
               TOTAL REMOTE:    10.968 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
               MULT. FACT:    1.000    1.000    1.000    1.000
               DUTY (KA) :   10.968   10.968   10.968   10.968

                                TOT2     TOT3     TOT5     TOT8
               MULT. FACT:    1.026    1.000    1.000    1.000
               DUTY (KA) :   11.259   10.968   10.968   10.968

 B-CH-EMER USB                  VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-CH-NW USB                    VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-CH-NW USB DS                 E/Z:     10.352 KA AT  -65.85 DEG ( 223.58 MVA)  X/R:     2.23
               VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2846 + J  0.6346  OHMS
               CONTRIBUTIONS:  B-CH             10.352 KA      ANG:   -65.85

               GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
           PGE-ALT                                       10.352     0.27         R
               TOTAL REMOTE:    10.352 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
               MULT. FACT:    1.000    1.000    1.000    1.000
               DUTY (KA) :   10.352   10.352   10.352   10.352

                                TOT2     TOT3     TOT5     TOT8
               MULT. FACT:    1.018    1.000    1.000    1.000
               DUTY (KA) :   10.539   10.352   10.352   10.352
```

```
  T H R E E   P H A S E   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================

 B-CH-PNL B                     VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-CH-PNL B DS                  VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-CH-SE USB                    VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-CH-SUB 4A                    VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-CH-SUB 4A DS                 E/Z:     10.593 KA AT  -69.46 DEG ( 228.80 MVA)  X/R:     2.67
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2385 + J  0.6364  OHMS
                CONTRIBUTIONS:  B-CH CHLR         10.593 KA      ANG:   -69.46

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                       10.593     0.22         R
                TOTAL REMOTE:    10.593 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   10.593   10.593   10.593   10.593

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.024    1.000    1.000    1.000
                DUTY (KA) :   10.844   10.593   10.593   10.593

 B-LE USB                       VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-LE USB DS                    E/Z:     10.362 KA AT  -66.15 DEG ( 223.81 MVA)  X/R:     2.26
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2809 + J  0.6355  OHMS
                CONTRIBUTIONS:  B-SMC             10.362 KA      ANG:   -66.15

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                       10.362     0.27         R
                TOTAL REMOTE:    10.362 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   10.362   10.362   10.362   10.362

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.019    1.000    1.000    1.000
                DUTY (KA) :   10.554   10.362   10.362   10.362
```

```
  T H R E E   P H A S E   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================

 B-LH-TX DS                     E/Z:      8.942 KA AT  -50.19 DEG ( 193.13 MVA)  X/R:     1.20
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.5155 + J  0.6185  OHMS
                CONTRIBUTIONS:  B-SB1             8.942 KA      ANG:   -50.19

                GENERATOR NAME -- AT BUS --                   KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                         8.942     0.50         R
                TOTAL REMOTE:     8.942 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :    8.942    8.942    8.942    8.942

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.005    1.000    1.000    1.000
                DUTY (KA) :    8.988    8.942    8.942    8.942

 B-LH-USB                       VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-ML                           E/Z:     11.171 KA AT  -68.91 DEG ( 241.29 MVA)  X/R:     2.59
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2319 + J  0.6013  OHMS
                CONTRIBUTIONS:  B-PSC            11.171 KA      ANG:   -68.91

                GENERATOR NAME -- AT BUS --                   KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                        11.171     0.20         R
                TOTAL REMOTE:    11.171 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   11.171   11.171   11.171   11.171

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.023    1.000    1.000    1.000
                DUTY (KA) :   11.425   11.171   11.171   11.171
```

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     T H R E E   P H A S E   I N T E R R U P U T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
==============================================================================================

 B-ML-USB                       VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-NH EAST                      E/Z:      9.688 KA AT  -61.10 DEG ( 209.25 MVA)  X/R:     1.81
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3591 + J  0.6506  OHMS
                CONTRIBUTIONS:  B-NH WEST          9.688 KA      ANG:   -61.10

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                        9.688     0.36         R
                TOTAL REMOTE:     9.688 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :    9.688    9.688    9.688    9.688

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.013    1.000    1.000    1.000
                DUTY (KA) :    9.812    9.688    9.688    9.688

 B-NH WEST                      E/Z:      9.901 KA AT  -62.57 DEG ( 213.84 MVA)  X/R:     1.93
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3350 + J  0.6454  OHMS
                CONTRIBUTIONS:  B-CH               9.901 KA      ANG:   -62.57

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                        9.901     0.33         R
                TOTAL REMOTE:     9.901 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :    9.901    9.901    9.901    9.901

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.014    1.000    1.000    1.000
                DUTY (KA) :   10.042    9.901    9.901    9.901

 B-NH-USB EAST                  VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-NH-USB WEST                  VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-PS1-TX DS                    E/Z:      9.488 KA AT  -60.53 DEG ( 204.92 MVA)  X/R:     1.77
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.3734 + J  0.6606  OHMS
                CONTRIBUTIONS:  B-NH WEST          9.488 KA      ANG:   -60.53

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                        9.488     0.37         R
                TOTAL REMOTE:     9.488 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :    9.488    9.488    9.488    9.488

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.012    1.000    1.000    1.000
                DUTY (KA) :    9.604    9.488    9.488    9.488
```

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  T H R E E   P H A S E   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================


 B-PS1-USB                      VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-PS2-TX DS                    E/Z:     10.465 KA AT  -66.71 DEG ( 226.03 MVA)  X/R:     2.32
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2720 + J  0.6319  OHMS
                CONTRIBUTIONS:  B-CH             10.465 KA      ANG:   -66.71

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                      10.465     0.26         R
                TOTAL REMOTE:    10.465 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   10.465   10.465   10.465   10.465

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.019    1.000    1.000    1.000
                DUTY (KA) :   10.667   10.465   10.465   10.465

 B-PS2-USB                      VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-PSC                          E/Z:     11.575 KA AT  -72.22 DEG ( 250.00 MVA)  X/R:     3.12
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1899 + J  0.5923  OHMS
                CONTRIBUTIONS:  B-WHP            11.575 KA      ANG:   -72.22

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                      11.575     0.14         R
                TOTAL REMOTE:    11.575 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   11.575   11.575   11.575   11.575

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.029    1.000    1.000    1.000
                DUTY (KA) :   11.914   11.575   11.575   11.575
```

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  T H R E E   P H A S E   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================

 B-PSC-USB                      VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-SB1                          E/Z:     12.070 KA AT  -72.39 DEG ( 260.70 MVA)  X/R:     3.15
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1805 + J  0.5685  OHMS
                CONTRIBUTIONS:  B-SRTC-USB2 AL    12.070 KA      ANG:   -72.39

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                       12.070     0.11         R
                TOTAL REMOTE:    12.070 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   12.070   12.070   12.070   12.070

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.030    1.000    1.000    1.000
                DUTY (KA) :   12.429   12.070   12.070   12.070

 B-SB1-USB                      VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-SMC                          E/Z:     10.465 KA AT  -66.71 DEG ( 226.03 MVA)  X/R:     2.32
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2720 + J  0.6319  OHMS
                CONTRIBUTIONS:  B-CH             10.465 KA      ANG:   -66.71

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                       10.465     0.26         R
                TOTAL REMOTE:    10.465 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   10.465   10.465   10.465   10.465

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.019    1.000    1.000    1.000
                DUTY (KA) :   10.667   10.465   10.465   10.465
```

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  T H R E E   P H A S E   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================

 B-SMC 2ND USB                  VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-SMC 2ND USB DS               E/Z:     10.406 KA AT  -66.39 DEG ( 224.76 MVA)  X/R:     2.29
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.2771 + J  0.6339  OHMS
                CONTRIBUTIONS:  B-SMC            10.406 KA      ANG:   -66.39

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                       10.406     0.26         R
                TOTAL REMOTE:    10.406 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   10.406   10.406   10.406   10.406

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.019    1.000    1.000    1.000
                DUTY (KA) :   10.602   10.406   10.406   10.406

 B-SMC USB                      VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-SRTC-SB2                     E/Z:     12.734 KA AT  -76.48 DEG ( 275.04 MVA)  X/R:     4.16
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1322 + J  0.5497  OHMS
                CONTRIBUTIONS:  B-SRTC-USB-ATS    12.734 KA      ANG:   -76.48

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                       12.734     0.03         R
                TOTAL REMOTE:    12.734 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   12.734   12.734   12.734   12.734

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.042    1.000    1.000    1.000
                DUTY (KA) :   13.274   12.734   12.734   12.734
```

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  T H R E E   P H A S E   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================

 B-SRTC-SWBD1                   VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-SRTC-SWBD2                   VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-SRTC-SWBD3                   VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-SRTC-SWBD4                   E/Z:      3.546 KA AT  -80.82 DEG (  25.55 MVA)  X/R:     6.18
                VOLTAGE:   4160.   EQUIV. IMPEDANCE=  0.1081 + J  0.6686  OHMS
                BWY-SRTC-SWBD4  TX-SRTC-SWBD4      3.546 KA      ANG:   -80.82

                GENERATOR NAME -- AT BUS --                   KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                        3.546     0.91         R
                TOTAL REMOTE:     3.546 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :    3.546    3.546    3.546    3.546

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.090    1.000    1.000    1.000
                DUTY (KA) :    3.866    3.546    3.546    3.546

 B-SRTC-SWBD4 DS                E/Z:     12.633 KA AT  -76.09 DEG ( 272.85 MVA)  X/R:     4.04
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1370 + J  0.5532  OHMS
                CONTRIBUTIONS:  B-SRTC-SB2        12.633 KA      ANG:   -76.09

                GENERATOR NAME -- AT BUS --                   KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                       12.633     0.04         R
                TOTAL REMOTE:    12.633 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   12.633   12.633   12.633   12.633

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.041    1.000    1.000    1.000
                DUTY (KA) :   13.149   12.633   12.633   12.633
```

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  T H R E E   P H A S E   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================

 B-SRTC-SWBD5                   VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-SRTC-USB1 PREF               E/Z:     12.649 KA AT  -78.68 DEG ( 273.21 MVA)  X/R:     5.00
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1117 + J  0.5581  OHMS
                CONTRIBUTIONS:  PGE-PREF                          12.649 KA      ANG:   -78.68

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-PREF                                      12.649     0.00         R
                TOTAL REMOTE:    12.649 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   12.649   12.649   12.649   12.649

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.053    1.000    1.000    1.000
                DUTY (KA) :   13.319   12.649   12.649   12.649

 B-SRTC-USB2 ALT                E/Z:     12.938 KA AT  -77.81 DEG ( 279.45 MVA)  X/R:     4.63
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1175 + J  0.5439  OHMS
                CONTRIBUTIONS:  PGE-ALT                           12.938 KA      ANG:   -77.81

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                       12.938     0.00         R
                TOTAL REMOTE:    12.938 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   12.938   12.938   12.938   12.938

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.048    1.000    1.000    1.000
                DUTY (KA) :   13.564   12.938   12.938   12.938
```

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  T H R E E   P H A S E   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================

 B-WHP                          E/Z:     11.654 KA AT  -72.91 DEG ( 251.72 MVA)  X/R:     3.25
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1815 + J  0.5905  OHMS
                CONTRIBUTIONS:  B-SRTC-USB2 AL    11.654 KA      ANG:   -72.91

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                       11.654     0.13         R
                TOTAL REMOTE:    11.654 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :   11.654   11.654   11.654   11.654

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.031    1.000    1.000    1.000
                DUTY (KA) :   12.015   11.654   11.654   11.654

 B-WHP-USB                      VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

 B-XSB USB                      VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-XSB USB DS                   VOLTAGE:    208.  ( SEE LOW VOLTAGE REPORT )

 B-XSB-TX DS                    E/Z:      6.655 KA AT  -38.17 DEG ( 143.75 MVA)  X/R:     0.79
                VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.8505 + J  0.6685  OHMS
                CONTRIBUTIONS:  B-SB1              6.655 KA      ANG:   -38.17

                GENERATOR NAME -- AT BUS --                  KA    VOLTS PU  LOCAL/REMOTE
            PGE-ALT                                        6.655     0.69         R
                TOTAL REMOTE:     6.655 KA  NACD RATIO:  1.0000

                                SYM2     SYM3     SYM5     SYM8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :    6.655    6.655    6.655    6.655

                                TOT2     TOT3     TOT5     TOT8
                MULT. FACT:    1.000    1.000    1.000    1.000
                DUTY (KA) :    6.655    6.655    6.655    6.655
```

```
Feb 22, 2013     15:42:55              UNBALANCED INTERRUPTING DUTY PAGE    1
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   U N B A L A N C E D   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================
  LOCATION                           FAULT    E/Z    X/R        ANSI AC/DC        INTERRUPTING
                                     TYPE     KA                DECREMENT FACT.   DUTIES  (KA)
                                                                3 PHASE    SLG    3 PHASE  SLG
==============================================================================================

 B-CH                              3P Duty:  11.03    3.0 SYM2:    1.00    1.00   11.03   10.20
                  VOLTS: 12470.0     SLG:  10.20    2.1 SYM3:    1.00    1.00   11.03   10.20
                   NACD:  1.000   LN/LN:   9.55        SYM5:    1.00    1.00   11.03   10.20
                              LN/LN/GND:  11.48        SYM8:    1.00    1.00   11.03   10.20
                             GND RETURN:   9.40        TOT2:    1.03    1.02   11.33   10.38
                                 Z1(PU):       0.41979 TOT3:    1.00    1.00   11.03   10.20
                                 Z2(PU):       0.41979 TOT5:    1.00    1.00   11.03   10.20
                                 Z0(PU):       0.53505 TOT8:    1.00    1.00   11.03   10.20

 B-CH ATS                          3P Duty:  11.04    3.0 SYM2:    1.00    1.00   11.04   10.21
                  VOLTS: 12470.0     SLG:  10.21    2.1 SYM3:    1.00    1.00   11.04   10.21
                   NACD:  1.000   LN/LN:   9.56        SYM5:    1.00    1.00   11.04   10.21
                              LN/LN/GND:  11.49        SYM8:    1.00    1.00   11.04   10.21
                             GND RETURN:   9.41        TOT2:    1.03    1.02   11.34   10.39
                                 Z1(PU):       0.41951 TOT3:    1.00    1.00   11.04   10.21
                                 Z2(PU):       0.41951 TOT5:    1.00    1.00   11.04   10.21
                                 Z0(PU):       0.53439 TOT8:    1.00    1.00   11.04   10.21

 B-CH CHLR                         3P Duty:  10.91    2.8 SYM2:    1.00    1.00   10.91   10.05
                  VOLTS: 12470.0     SLG:  10.05    2.1 SYM3:    1.00    1.00   10.91   10.05
                   NACD:  1.000   LN/LN:   9.45        SYM5:    1.00    1.00   10.91   10.05
                              LN/LN/GND:  11.32        SYM8:    1.00    1.00   10.91   10.05
                             GND RETURN:   9.23        TOT2:    1.03    1.02   11.19   10.21
                                 Z1(PU):       0.42439 TOT3:    1.00    1.00   10.91   10.05
                                 Z2(PU):       0.42439 TOT5:    1.00    1.00   10.91   10.05
                                 Z0(PU):       0.54650 TOT8:    1.00    1.00   10.91   10.05

 B-CH CHLR DS                      3P Duty:  10.97    2.9 SYM2:    1.00    1.00   10.97   10.12
                  VOLTS: 12470.0     SLG:  10.12    2.1 SYM3:    1.00    1.00   10.97   10.12
                   NACD:  1.000   LN/LN:   9.50        SYM5:    1.00    1.00   10.97   10.12
                              LN/LN/GND:  11.40        SYM8:    1.00    1.00   10.97   10.12
                             GND RETURN:   9.31        TOT2:    1.03    1.02   11.26   10.29
                                 Z1(PU):       0.42213 TOT3:    1.00    1.00   10.97   10.12
                                 Z2(PU):       0.42213 TOT5:    1.00    1.00   10.97   10.12
                                 Z0(PU):       0.54088 TOT8:    1.00    1.00   10.97   10.12
```

```
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   U N B A L A N C E D   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================
  LOCATION                         FAULT    E/Z    X/R        ANSI AC/DC        INTERRUPTING
                                   TYPE     KA                DECREMENT FACT.   DUTIES  (KA)
                                                              3 PHASE    SLG    3 PHASE  SLG
==============================================================================================

 B-CH-NW USB DS                  3P Duty:  10.35    2.2 SYM2:    1.00    1.00   10.35    9.36
                  VOLTS: 12470.0    SLG:   9.36    1.7 SYM3:    1.00    1.00   10.35    9.36
                   NACD:  1.000  LN/LN:   8.96        SYM5:    1.00    1.00   10.35    9.36
                              LN/LN/GND:  10.64        SYM8:    1.00    1.00   10.35    9.36
                             GND RETURN:   8.46        TOT2:    1.02    1.01   10.54    9.46
                                 Z1(PU):       0.44727 TOT3:    1.00    1.00   10.35    9.36
                                 Z2(PU):       0.44727 TOT5:    1.00    1.00   10.35    9.36
                                 Z0(PU):       0.60308 TOT8:    1.00    1.00   10.35    9.36

 B-CH-SUB 4A DS                  3P Duty:  10.59    2.7 SYM2:    1.00    1.00   10.59    9.66
                  VOLTS: 12470.0    SLG:   9.66    2.0 SYM3:    1.00    1.00   10.59    9.66
                   NACD:  1.000  LN/LN:   9.17        SYM5:    1.00    1.00   10.59    9.66
                              LN/LN/GND:  10.91        SYM8:    1.00    1.00   10.59    9.66
                             GND RETURN:   8.80        TOT2:    1.02    1.02   10.84    9.80
                                 Z1(PU):       0.43706 TOT3:    1.00    1.00   10.59    9.66
                                 Z2(PU):       0.43706 TOT5:    1.00    1.00   10.59    9.66
                                 Z0(PU):       0.57651 TOT8:    1.00    1.00   10.59    9.66

 B-LE USB DS                     3P Duty:  10.36    2.3 SYM2:    1.00    1.00   10.36    9.37
                  VOLTS: 12470.0    SLG:   9.37    1.7 SYM3:    1.00    1.00   10.36    9.37
                   NACD:  1.000  LN/LN:   8.97        SYM5:    1.00    1.00   10.36    9.37
                              LN/LN/GND:  10.65        SYM8:    1.00    1.00   10.36    9.37
                             GND RETURN:   8.48        TOT2:    1.02    1.01   10.55    9.48
                                 Z1(PU):       0.44681 TOT3:    1.00    1.00   10.36    9.37
                                 Z2(PU):       0.44681 TOT5:    1.00    1.00   10.36    9.37
                                 Z0(PU):       0.60179 TOT8:    1.00    1.00   10.36    9.37

 B-LH-TX DS                      3P Duty:   8.94    1.2 SYM2:    1.00    1.00    8.94    7.80
                  VOLTS: 12470.0    SLG:   7.80    1.0 SYM3:    1.00    1.00    8.94    7.80
                   NACD:  1.000  LN/LN:   7.74        SYM5:    1.00    1.00    8.94    7.80
                              LN/LN/GND:   9.06        SYM8:    1.00    1.00    8.94    7.80
                             GND RETURN:   6.86        TOT2:    1.01    1.00    8.99    7.82
                                 Z1(PU):       0.51778 TOT3:    1.00    1.00    8.94    7.80
                                 Z2(PU):       0.51778 TOT5:    1.00    1.00    8.94    7.80
                                 Z0(PU):       0.75992 TOT8:    1.00    1.00    8.94    7.80
```

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Feb 22, 2013     15:42:55             UNBALANCED INTERRUPTING DUTY PAGE    3
PSU - West Campus Loop
Portland, OR
ESE0008353 / TQSISE0008353.1

   U N B A L A N C E D   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================
  LOCATION                        FAULT    E/Z    X/R       ANSI AC/DC        INTERRUPTING
                                  TYPE     KA               DECREMENT FACT.   DUTIES  (KA)
                                                            3 PHASE    SLG    3 PHASE  SLG
==============================================================================================

 B-ML                           3P Duty:  11.17    2.6 SYM2:    1.00    1.00   11.17   10.36
                  VOLTS: 12470.0    SLG:  10.36    1.9 SYM3:    1.00    1.00   11.17   10.36
                   NACD:  1.000   LN/LN:   9.67        SYM5:    1.00    1.00   11.17   10.36
                              LN/LN/GND:  11.70        SYM8:    1.00    1.00   11.17   10.36
                             GND RETURN:   9.55        TOT2:    1.02    1.01   11.42   10.51
                                 Z1(PU):       0.41445 TOT3:    1.00    1.00   11.17   10.36
                                 Z2(PU):       0.41445 TOT5:    1.00    1.00   11.17   10.36
                                 Z0(PU):       0.52682 TOT8:    1.00    1.00   11.17   10.36

 B-NH EAST                      3P Duty:   9.69    1.8 SYM2:    1.00    1.00    9.69    8.59
                  VOLTS: 12470.0    SLG:   8.59    1.4 SYM3:    1.00    1.00    9.69    8.59
                   NACD:  1.000   LN/LN:   8.39        SYM5:    1.00    1.00    9.69    8.59
                              LN/LN/GND:   9.84        SYM8:    1.00    1.00    9.69    8.59
                             GND RETURN:   7.66        TOT2:    1.01    1.01    9.81    8.66
                                 Z1(PU):       0.47789 TOT3:    1.00    1.00    9.69    8.59
                                 Z2(PU):       0.47789 TOT5:    1.00    1.00    9.69    8.59
                                 Z0(PU):       0.67316 TOT8:    1.00    1.00    9.69    8.59

 B-NH WEST                      3P Duty:   9.90    1.9 SYM2:    1.00    1.00    9.90    8.83
                  VOLTS: 12470.0    SLG:   8.83    1.5 SYM3:    1.00    1.00    9.90    8.83
                   NACD:  1.000   LN/LN:   8.57        SYM5:    1.00    1.00    9.90    8.83
                              LN/LN/GND:  10.09        SYM8:    1.00    1.00    9.90    8.83
                             GND RETURN:   7.91        TOT2:    1.01    1.01   10.04    8.91
                                 Z1(PU):       0.46763 TOT3:    1.00    1.00    9.90    8.83
                                 Z2(PU):       0.46763 TOT5:    1.00    1.00    9.90    8.83
                                 Z0(PU):       0.65019 TOT8:    1.00    1.00    9.90    8.83

 B-PS1-TX DS                    3P Duty:   9.49    1.8 SYM2:    1.00    1.00    9.49    8.37
                  VOLTS: 12470.0    SLG:   8.37    1.4 SYM3:    1.00    1.00    9.49    8.37
                   NACD:  1.000   LN/LN:   8.22        SYM5:    1.00    1.00    9.49    8.37
                              LN/LN/GND:   9.60        SYM8:    1.00    1.00    9.49    8.37
                             GND RETURN:   7.44        TOT2:    1.01    1.01    9.60    8.44
                                 Z1(PU):       0.48800 TOT3:    1.00    1.00    9.49    8.37
                                 Z2(PU):       0.48800 TOT5:    1.00    1.00    9.49    8.37
                                 Z0(PU):       0.69510 TOT8:    1.00    1.00    9.49    8.37
```

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Feb 22, 2013     15:42:55              UNBALANCED INTERRUPTING DUTY PAGE    4
PSU - West Campus Loop
Portland, OR
ESE0008353 / TQSISE0008353.1

   U N B A L A N C E D   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
==============================================================================================
  LOCATION                             FAULT   E/Z    X/R         ANSI AC/DC         INTERRUPTING
                                       TYPE    KA                 DECREMENT FACT.    DUTIES  (KA)
                                                                  3 PHASE    SLG     3 PHASE  SLG
==============================================================================================

 B-PS2-TX DS                         3P Duty:  10.47    2.3 SYM2:    1.00     1.00   10.47     9.49
                  VOLTS: 12470.0      SLG:   9.49    1.8 SYM3:    1.00     1.00   10.47     9.49
                   NACD:  1.000   LN/LN:   9.06        SYM5:    1.00     1.00   10.47     9.49
                              LN/LN/GND:  10.78        SYM8:    1.00     1.00   10.47     9.49
                             GND RETURN:   8.61        TOT2:    1.02     1.01   10.67     9.61
                                 Z1(PU):       0.44242 TOT3:    1.00     1.00   10.47     9.49
                                 Z2(PU):       0.44242 TOT5:    1.00     1.00   10.47     9.49
                                 Z0(PU):       0.59150 TOT8:    1.00     1.00   10.47     9.49

 B-PSC                               3P Duty:  11.57    3.1 SYM2:    1.00     1.00   11.57    10.91
                  VOLTS: 12470.0      SLG:  10.91    2.2 SYM3:    1.00     1.00   11.57    10.91
                   NACD:  1.000   LN/LN:  10.02        SYM5:    1.00     1.00   11.57    10.91
                              LN/LN/GND:  12.22        SYM8:    1.00     1.00   11.57    10.91
                             GND RETURN:  10.19        TOT2:    1.03     1.02   11.91    11.10
                                 Z1(PU):       0.40000 TOT3:    1.00     1.00   11.57    10.91
                                 Z2(PU):       0.40000 TOT5:    1.00     1.00   11.57    10.91
                                 Z0(PU):       0.48898 TOT8:    1.00     1.00   11.57    10.91

 B-SB1                               3P Duty:  12.07    3.1 SYM2:    1.00     1.00   12.07    11.56
                  VOLTS: 12470.0      SLG:  11.56    2.1 SYM3:    1.00     1.00   12.07    11.56
                   NACD:  1.000   LN/LN:  10.45        SYM5:    1.00     1.00   12.07    11.56
                              LN/LN/GND:  12.94        SYM8:    1.00     1.00   12.07    11.56
                             GND RETURN:  10.93        TOT2:    1.03     1.02   12.43    11.76
                                 Z1(PU):       0.38358 TOT3:    1.00     1.00   12.07    11.56
                                 Z2(PU):       0.38358 TOT5:    1.00     1.00   12.07    11.56
                                 Z0(PU):       0.45217 TOT8:    1.00     1.00   12.07    11.56

 B-SMC                               3P Duty:  10.47    2.3 SYM2:    1.00     1.00   10.47     9.49
                  VOLTS: 12470.0      SLG:   9.49    1.8 SYM3:    1.00     1.00   10.47     9.49
                   NACD:  1.000   LN/LN:   9.06        SYM5:    1.00     1.00   10.47     9.49
                              LN/LN/GND:  10.78        SYM8:    1.00     1.00   10.47     9.49
                             GND RETURN:   8.61        TOT2:    1.02     1.01   10.67     9.61
                                 Z1(PU):       0.44242 TOT3:    1.00     1.00   10.47     9.49
                                 Z2(PU):       0.44242 TOT5:    1.00     1.00   10.47     9.49
                                 Z0(PU):       0.59150 TOT8:    1.00     1.00   10.47     9.49
```

```
   U N B A L A N C E D   I N T E R R U P T I N G   D U T Y   R E P O R T
                         PRE FAULT VOLTAGE: 1.0000
                         MODEL TRANSFORMER TAPS: NO
                         NACD OPTION:  INTERPOLATED
============================================================================================
  LOCATION                          FAULT    E/Z    X/R        ANSI AC/DC        INTERRUPTING
                                    TYPE     KA                DECREMENT FACT.   DUTIES  (KA)
                                                               3 PHASE    SLG    3 PHASE  SLG
============================================================================================

 B-SMC 2ND USB DS             3P Duty:  10.41    2.3 SYM2:    1.00    1.00   10.41    9.42
                  VOLTS: 12470.0    SLG:   9.42    1.7 SYM3:    1.00    1.00   10.41    9.42
                   NACD:  1.000  LN/LN:   9.01        SYM5:    1.00    1.00   10.41    9.42
                              LN/LN/GND:  10.70        SYM8:    1.00    1.00   10.41    9.42
                             GND RETURN:   8.53        TOT2:    1.02    1.01   10.60    9.54
                                 Z1(PU):      0.44492 TOT3:    1.00    1.00   10.41    9.42
                                 Z2(PU):      0.44492 TOT5:    1.00    1.00   10.41    9.42
                                 Z0(PU):      0.59738 TOT8:    1.00    1.00   10.41    9.42

 B-SRTC-SB2                   3P Duty:  12.73    4.2 SYM2:    1.00    1.00   12.73   12.55
                  VOLTS: 12470.0    SLG:  12.55    2.6 SYM3:    1.00    1.00   12.73   12.55
                   NACD:  1.000  LN/LN:  11.03        SYM5:    1.00    1.00   12.73   12.55
                              LN/LN/GND:  13.89        SYM8:    1.00    1.00   12.73   12.55
                             GND RETURN:  12.16        TOT2:    1.04    1.02   13.27   12.83
                                 Z1(PU):      0.36359 TOT3:    1.00    1.00   12.73   12.55
                                 Z2(PU):      0.36359 TOT5:    1.00    1.00   12.73   12.55
                                 Z0(PU):      0.39814 TOT8:    1.00    1.00   12.73   12.55

 B-SRTC-SWBD4                 3P Duty:   3.55    6.2 SYM2:    1.00    1.00    3.55    3.66
                  VOLTS:  4160.0    SLG:   3.66    6.3 SYM3:    1.00    1.00    3.55    3.66
                   NACD:  1.000  LN/LN:   3.07        SYM5:    1.00    1.00    3.55    3.66
                              LN/LN/GND:   3.60        SYM8:    1.00    1.00    3.55    3.66
                             GND RETURN:   3.78        TOT2:    1.09    1.09    3.87    4.00
                                 Z1(PU):      3.91381 TOT3:    1.00    1.00    3.55    3.66
                                 Z2(PU):      3.91381 TOT5:    1.00    1.00    3.55    3.66
                                 Z0(PU):      3.55645 TOT8:    1.00    1.00    3.55    3.66

 B-SRTC-SWBD4 DS              3P Duty:  12.63    4.0 SYM2:    1.00    1.00   12.63   12.39
                  VOLTS: 12470.0    SLG:  12.39    2.5 SYM3:    1.00    1.00   12.63   12.39
                   NACD:  1.000  LN/LN:  10.94        SYM5:    1.00    1.00   12.63   12.39
                              LN/LN/GND:  13.74        SYM8:    1.00    1.00   12.63   12.39
                             GND RETURN:  11.97        TOT2:    1.04    1.02   13.15   12.67
                                 Z1(PU):      0.36650 TOT3:    1.00    1.00   12.63   12.39
                                 Z2(PU):      0.36650 TOT5:    1.00    1.00   12.63   12.39
                                 Z0(PU):      0.40563 TOT8:    1.00    1.00   12.63   12.39
```

U N B A L A N C E D I N T E R R U P T I N G D U T Y R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO
NACD OPTION: INTERPOLATED

LOCATION		FAULT TYPE	E/Z KA	X/R		ANSI AC/DC DECREMENT FACT. 3 PHASE	SLG	INTERRUPTING DUTIES (KA) 3 PHASE	SLG
B-SRTC-USB1 PREF		3P Duty:	12.65	5.0	SYM2:	1.00	1.00	12.65	10.38
	VOLTS: 12470.0	SLG:	10.38	2.1	SYM3:	1.00	1.00	12.65	10.38
	NACD: 1.000	LN/LN:	10.95		SYM5:	1.00	1.00	12.65	10.38
		LN/LN/GND:	13.27		SYM8:	1.00	1.00	12.65	10.38
		GND RETURN:	8.49		TOT2:	1.05	1.02	13.32	10.55
		Z1(PU):		0.36602	TOT3:	1.00	1.00	12.65	10.38
		Z2(PU):		0.36602	TOT5:	1.00	1.00	12.65	10.38
		Z0(PU):		0.65583	TOT8:	1.00	1.00	12.65	10.38
B-SRTC-USB2 ALT		3P Duty:	12.94	4.6	SYM2:	1.00	1.00	12.94	12.87
	VOLTS: 12470.0	SLG:	12.87	2.8	SYM3:	1.00	1.00	12.94	12.87
	NACD: 1.000	LN/LN:	11.21		SYM5:	1.00	1.00	12.94	12.87
		LN/LN/GND:	14.20		SYM8:	1.00	1.00	12.94	12.87
		GND RETURN:	12.59		TOT2:	1.05	1.03	13.56	13.19
		Z1(PU):		0.35784	TOT3:	1.00	1.00	12.94	12.87
		Z2(PU):		0.35784	TOT5:	1.00	1.00	12.94	12.87
		Z0(PU):		0.38166	TOT8:	1.00	1.00	12.94	12.87
B-WHP		3P Duty:	11.65	3.3	SYM2:	1.00	1.00	11.65	11.02
	VOLTS: 12470.0	SLG:	11.02	2.2	SYM3:	1.00	1.00	11.65	11.02
	NACD: 1.000	LN/LN:	10.09		SYM5:	1.00	1.00	11.65	11.02
		LN/LN/GND:	12.33		SYM8:	1.00	1.00	11.65	11.02
		GND RETURN:	10.32		TOT2:	1.03	1.02	12.02	11.22
		Z1(PU):		0.39727	TOT3:	1.00	1.00	11.65	11.02
		Z2(PU):		0.39727	TOT5:	1.00	1.00	11.65	11.02
		Z0(PU):		0.48157	TOT8:	1.00	1.00	11.65	11.02
B-XSB-TX DS		3P Duty:	6.66	0.8	SYM2:	1.00	1.00	6.66	5.61
	VOLTS: 12470.0	SLG:	5.61	0.7	SYM3:	1.00	1.00	6.66	5.61
	NACD: 1.000	LN/LN:	5.76		SYM5:	1.00	1.00	6.66	5.61
		LN/LN/GND:	6.53		SYM8:	1.00	1.00	6.66	5.61
		GND RETURN:	4.83		TOT2:	1.00	1.00	6.66	5.61
		Z1(PU):		0.69567	TOT3:	1.00	1.00	6.66	5.61
		Z2(PU):		0.69567	TOT5:	1.00	1.00	6.66	5.61
		Z0(PU):		1.09475	TOT8:	1.00	1.00	6.66	5.61

I N T E R R U P T I N G D U T Y S U M M A R Y R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO
NACD OPTION: INTERPOLATED

BUS RECORD NO NAME	VOLTAGE L-L	NACD RATIO	* 3 PHASE * E/Z KA	* 3 PHASE * X/R	* * * S L G * * * E/Z KA	* * * S L G * * * X/R
B-CH	12470.	1.000	11.029	2.96	10.204	2.14
B-CH ATS	12470.	1.000	11.037	2.96	10.213	2.14
B-CH CHLR	12470.	1.000	10.910	2.84	10.050	2.07
B-CH CHLR DS	12470.	1.000	10.968	2.90	10.125	2.11
B-CH-NW USB DS	12470.	1.000	10.352	2.23	9.357	1.71
B-CH-SUB 4A DS	12470.	1.000	10.593	2.67	9.657	2.00
B-LE USB DS	12470.	1.000	10.362	2.26	9.370	1.73
B-LH-TX DS	12470.	1.000	8.942	1.20	7.801	0.96
B-ML	12470.	1.000	11.171	2.59	10.364	1.88
B-NH EAST	12470.	1.000	9.688	1.81	8.592	1.44
B-NH WEST	12470.	1.000	9.901	1.93	8.831	1.51
B-PS1-TX DS	12470.	1.000	9.488	1.77	8.370	1.42
B-PS2-TX DS	12470.	1.000	10.465	2.32	9.493	1.76
B-PSC	12470.	1.000	11.575	3.12	10.907	2.17
B-SB1	12470.	1.000	12.070	3.15	11.562	2.13
B-SMC	12470.	1.000	10.465	2.32	9.493	1.76
B-SMC 2ND USB DS	12470.	1.000	10.406	2.29	9.423	1.74
B-SRTC-SB2	12470.	1.000	12.734	4.16	12.546	2.59
B-SRTC-SWBD4	4160.	1.000	3.546	6.18	3.657	6.29
B-SRTC-SWBD4 DS	12470.	1.000	12.633	4.04	12.395	2.54
B-SRTC-USB1 PREF	12470.	1.000	12.649	5.00	10.379	2.06
B-SRTC-USB2 ALT	12470.	1.000	12.938	4.63	12.870	2.78
B-WHP	12470.	1.000	11.654	3.25	11.017	2.25
B-XSB-TX DS	12470.	1.000	6.655	0.79	5.607	0.67

52 FAULTED BUSES, 99 BRANCHES, 2 CONTRIBUTIONS
UNBALANCED FAULTS REQUESTED

*** SHORT CIRCUIT STUDY COMPLETE ***

C. APPENDIX C – UTILITY CORRESPONDENCE

See email from Mr. Tom Riddle with Portland General Electric stating available fault current and source impedance information on the attached sheets.

Moore, Matthew A

From: Moore, Matthew A
Sent: Wednesday, February 20, 2013 1:19 PM
To: Moore, Matthew A
Subject: West Loop Util Info

From: **Thomas Riddle** <Tom.Riddle@pgn.com>
Date: Wed, Jan 16, 2013 at 11:35 AM
Subject: FW: Request for Information - PSU Arc Flash
To: "Quinn Soifer (soiferq@pdx.edu)" <soiferq@pdx.edu>

Hi Quinn,

Here is the information for Eaton's question 1&3. As I stated in my e-mail yesterday the Market Center Building is in PP&L's territory, as also confirmed by PGE engineering.

1) Values haven't significantly changed.

PSU Science II BLDG	12.47KV Primary Fault Current & System Impedance					
	3-Phase Fault Current	Line-to-Ground Fault Current	R1 (Ω)	X1 (Ω)	R0 (Ω)	X0 (Ω)
Preferred Source (Switch 1815)	12,649	10,379	0.1117	0.5581	0.6837	0.7567
Alt Source (Switch 1998)	12,937	12,870	0.1175	0.5439	0.3328	0.4914

2) Confirmed – 1600 SW 4th PP&L service territory.

3) Recommend Eaton/PSU field verify or make assumptions.

If needed, we would gladly meet with you and Eaton to discuss this information and as engineering mentioned in question #3, they would recommend field verification.

Thanks Quinn, and I hope this information answers the questions. If a meeting is needed, or you feel field verification is required, please work through me and I will set it up.

Tom Riddle

Key Customer Manager

Portland General Electric

121 SW Salmon Street

3WTCBR07

Portland, Oregon 97201

Office: 503-464-7637

Cell: 503-969-9344

tom.riddle@pgn.com

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Quinn Soifer, P.E.
Facilities Engineer
soiferq@pdx.edu
503-725-4316

D. APPENDIX D – ONE-LINE DIAGRAM

See power system study one-line diagram on the attached sheet.

THE INFORMATION ON THIS DOCUMENT WAS CREATED BY EATON ELECTRICAL. IT WAS DISCLOSED IN CONFIDENCE AND IS ONLY TO BE USED FOR THE PURPOSE IN WHICH IT WAS SUPPLIED.		
DFTR: MAM	DATE: 2-20-13	EATON | Electrical Services & Systems
ENGR: MAM	DATE: 2-20-13	TITLE: PORTLAND STATE UNIVERSITY WEST CAMPUS LOOP
SCALE: NONE		TYPE: POWER SYSTEM STUDY — ONE LINE
CAD FILENAME: SSF-0269	PRODUCT CODE: U0160	REVISION: 01
G.O.: ESE0008353	DWG: SSF-0269	SHEET 1 OF 01

REVISION 01