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Department of Veteran Affairs Electrical Study

at

Nashville Campus
Nashville, TN

for

ATS

Attn: Mr. Chad Brooks

March 3, 2010

Prepared By: Casey Stafford
Approved By: Scotty D. Carroll, PE

Reference Number: E10-006

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I. Executive Summary

ECHO Power Engineering (ECHO) was hired by ATS to complete an electrical study for a selected section of the Department of Veterans Affairs (VA) electrical system at their Nashville Campus. This study was conducted as part of the VA generator upgrade project which included the addition of a generator and multiple switchgear lineups. This study was conducted in a manner to include all new devices installed during the upgrade, along with some existing devices that are directly connected to the new equipment.

This study provides the necessary calculations to show that all installed devices were properly specified and the proper settings to coordinate with the existing VA electrical system.

The scope of this project did not allow ECHO to conduct an electrical study of the VA's entire electrical system.

II. Description of Work Completed

This electrical study consists of three main parts – short circuit calculations, protective device coordination, and arc flash calculations. These studies were conducted in accordance with all applicable IEEE standards.

Data for this project was collected on February 16th and 18th by Stan Whigham, Joe Maynard and Scotty Carroll, all from ECHO. A computer software program, SKM Software's Power Tools for Windows (v6.5), was used to model the data and make the necessary calculations. A previous electrical study was provided to ECHO by the VA as a starting point for this study. ECHO did not verify the data in the existing model and is not responsible for errors propagated due to incorrect data in the existing model. All new devices installed during the generator upgrade project were added to the SKM model by Scotty Carroll and Casey Stafford of ECHO and are shown in red in the single line. Utility data included in the VA provided SKM model was assumed to be correct and unchanged.

III. Findings and Recommendations

Short Circuit Analysis

A short circuit analysis was conducted for the newly installed generator panel (GEN) and the new switchgear (GH-MDP), along with the three existing panels EDS, ACRE MSB and GHPBA. The analysis considered two scenarios. The first scenario placed all system ATSS in their emergency positions and the newly installed MTS in its normal position. The second switched the new MTS to the emergency position.

Tabular results are located in the Device Evaluation Table in Appendix 1. The study found that all newly installed devices are properly rated for their respective short-circuit faults; however, the bus withstand rating of the existing Panel EDS and Panel GHPBA are inadequate. The maximum short circuit current at Panel EDS was calculated to be 30,914A, while the bus withstand rating is only 14,000A. For panel GHPBA, the maximum short circuit current was calculated to be 14,734A, while the bus withstand is only 14,000A.

ECHO recommends existing Panel EDS and existing Panel GHPBA be upgraded to withstand ratings above the calculated short circuit values (i.e. 35kA).

ECHO recommends that an expanded short circuit study be undertaken to identify other equipment that may be underrated.

System Coordination

Time characteristic curves (TCC) were developed to assist in achieving proper selectivity for the newly installed protective devices and to ensure all cables were properly protected. Five TCC curves were developed and are discussed below. The TCC curves can be found in Appendix 2. The curves in Appendix 2 are based on the recommended settings provided in the Device Settings Table in Appendix 3.

- Gen Install Curve1 – This curve shows the coordination for devices from the existing Paralleling SB to the existing Chiller Disconnect and includes the new breaker added to EDS and new breakers in GH-MDP. As can be seen in the curve, there is some minor overlap between devices mainly due to the fixed nature of the PD-EDS-NEW and PD-MDP-ATS breakers. Note that ECHO recommends that settings changes be made to an existing device, PD-EDS MAIN. All cables are properly protected.

- Gen Install Curve2 - This curve shows the coordination for devices from the new generator to the largest breaker in GHPBA and includes the breaker in the new generator panel and the breakers in the newly installed panel GH-MDP. As can be seen in the curve, there is some minor overlap between devices mainly due to the fact that existing device PD-ATS-13E has only instantaneous adjustment available.
- Gen Install Curve3 - This curve shows the coordination for devices from the existing ACRE MSB main breaker to the existing chiller disconnect and includes the existing breaker in ACRE MSB. The fuse data for the CHILLER DISC was not obtained, and in consequence, coordination with the fuse was not verified. As can be seen in the curve, 100% selectivity was achieved. All cables are also properly protected.
- Gen Install Curve4 - This curve shows the immediate downstream breakers protecting the new generator. The withstand and decrement curves were added manually from the generator data provided by Caterpillar. The TCC curves for the both protective devices show that each will trip before the withstand curve of the generator is reached. The TCC curves for both protective devices also cross the decrement curve at around the .25 sec point, which indicates that a trip would occur .25 seconds after a fault external to the generator occurs.
- Gen Install Curve5 – This curve shows the coordination between the ground protection for PD-MDP MAIN and the phase protection for the immediate downstream devices. PD-MDP MAIN is the only device in this section of the system with ground fault protection. Ideally, for a main only ground fault protection scheme, the ground trip for the main would be set to trip after the phase trips for the downstream protective devices. This allows the phase protection in the downstream devices to clear ground faults in the respective branches before the ground protection in the main. In this situation, 100% coordination could not be achieved due to the inability to adjust the settings for the downstream devices. The pickup and delay settings for the ground protection in PD-MDP MAIN were set to their maximum values, which maximized the coordination with the downstream devices, but decreased PD-MDP MAIN's ability to detect a low magnitude ground fault.

ECHO recommends that the settings changes to the existing devices covered by this study, be implemented.

ECHO recommends an expanded coordination study be undertaken to insure proper selective of the entire system.

Arc Flash Evaluation

The incident energies available were calculated for four new locations – the new generator panels, the new MTS, the new switchgear GH-MDP and the new ATS. Incident energies available were also calculated for existing locations that are being fed differently due to the generator upgrade. These locations include the chiller disconnect and Panel GHPBA. The arc flash Hazard Table can be found in Appendix 4 and the accompanying arc flash labels can be seen in Appendix 5.

The incident energies were calculated in three scenarios with the worst case reported in the Arc Flash Hazard Table and on the labels. These scenarios are as follows:

- Scenario 1 – All ATSs and MTSs in normal
- Scenario 2- All ATS in emergency, New MTS in normal
- Scenario 3- All ATS in emergency, New MTS in emergency

ECHO recommends an expanded arc flash study be undertaken to insure proper labeling across the entire electrical system, which will increase worker safety and bring the system into compliance with NFPA 70E.

IV. Conclusions

ECHO has documented in this study that the newly installed devices are properly rated and has provided settings to maximize system selectivity while maintaining equipment protection and minimizing arc flash hazards. The findings of the study also indicate that some existing equipment is underrated and should be strongly considered for upgrade. Additionally, more work should be considered to insure the proper ratings of existing equipment and to provide arc flash labeling for the system.

APPENDIX 1

DEVICE EVALUATION REPORT



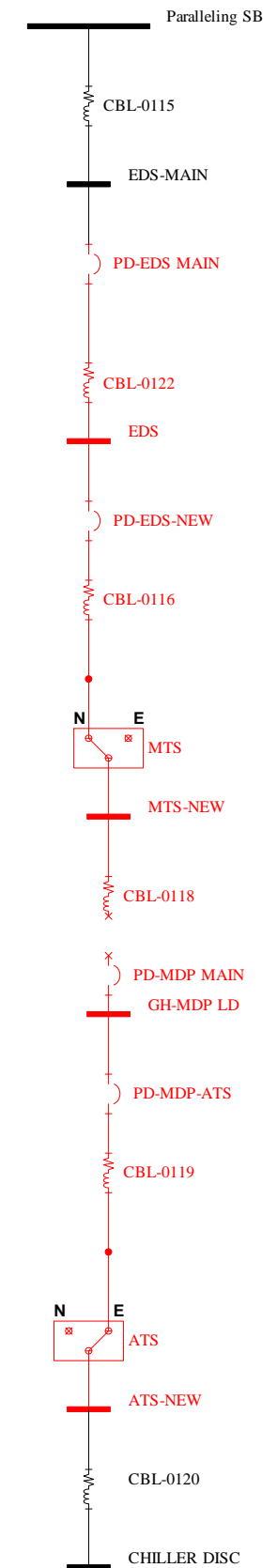
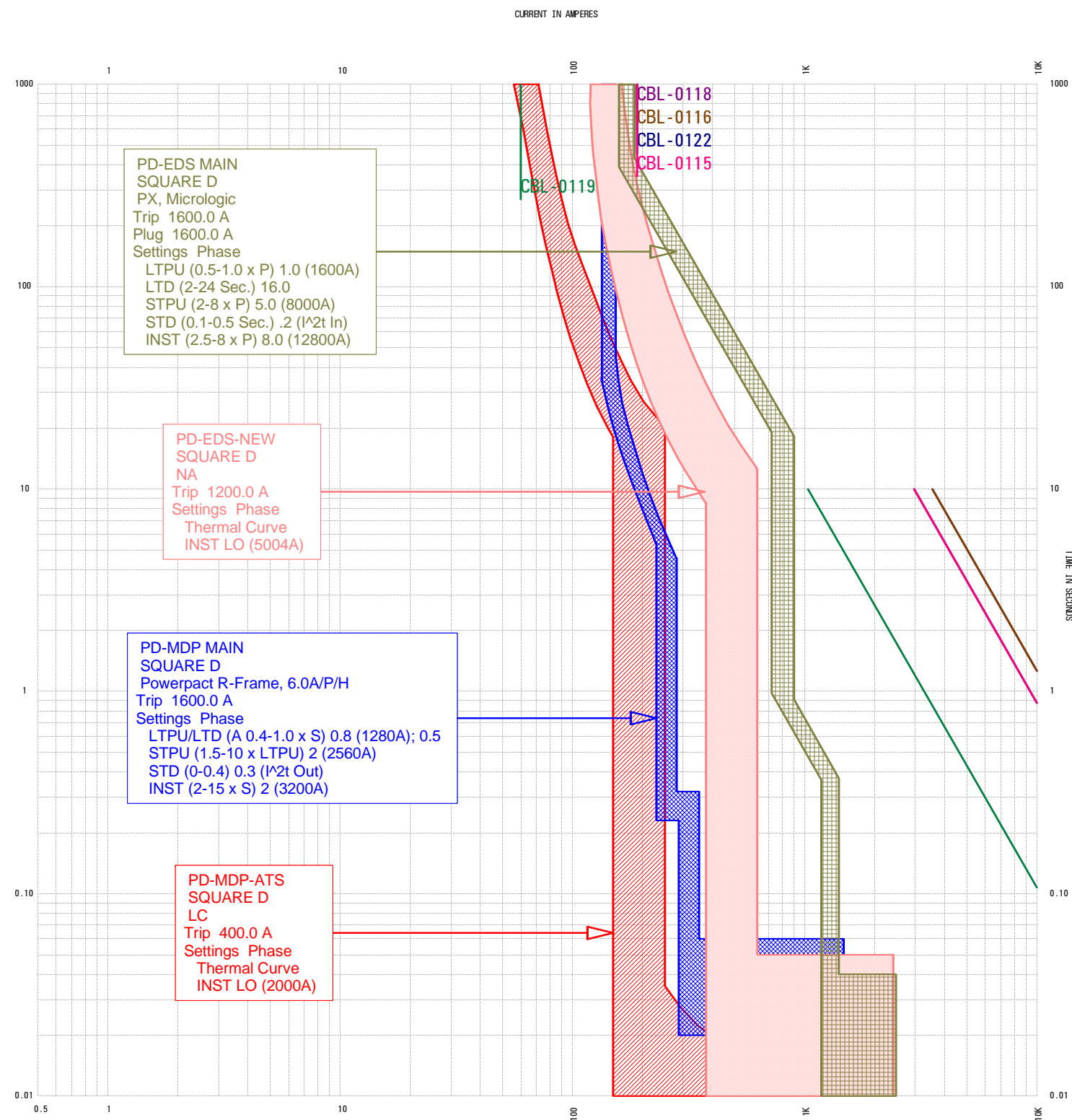
CLIENT: Department of Veterans Affairs
LOCATION: Nashville Campus
PROJECT: ARC FLASH HAZARD ANALYSIS
JOB #: E10-006

DEVICE EVALUATION TABLE

BUS NAME	VOLTAGE	PROTECTIVE DEVICE DESCRIPTION	CALCULATED VALUES			SELF RATED kA	SERIES RATED KA	ANSI KA/ RATED KA	NOTES
			Amps	X/R RATIO	ANSI Amps			* 100%	
EDS	480	Square D 480V 1600A 3P/4W Switchgear	24088.5	11.5	30914.2	14000		220.8%	VIOLATION
GEN	480	Square D RG 1600 Breaker	9786.3	23.9	12030.7	35000		34.4%	Adequate
GH-MDP	480	Square D RK Breaker	14736.5	4.2	14736.5	65000		22.7%	Adequate
ACRE MSB	480	Square D LX Breaker	22904.2	2.1	22904.2	65000		35.2%	Adequate
GHPBA	480	Square D 480V 800A 3P/4W Switchgear	13928.5	4.0	14734.2	14000		105.2%	VIOLATION

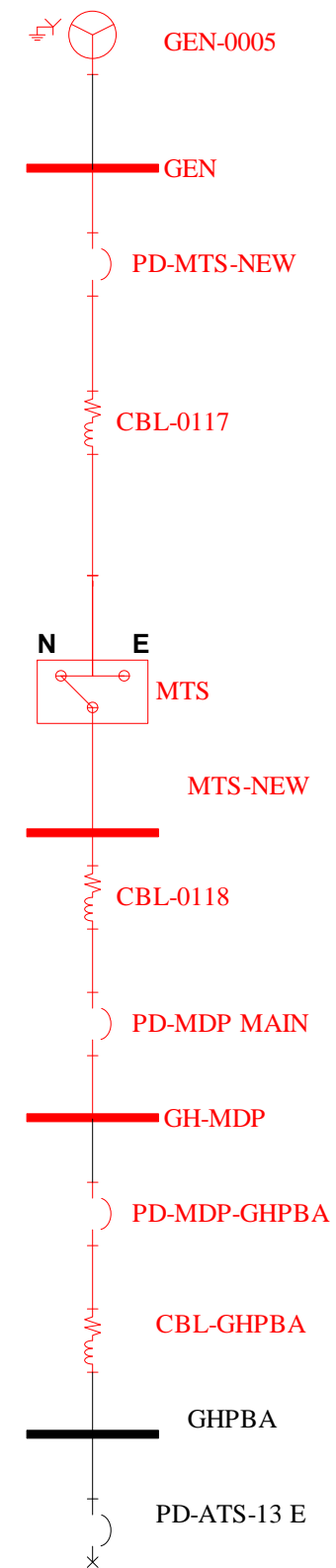
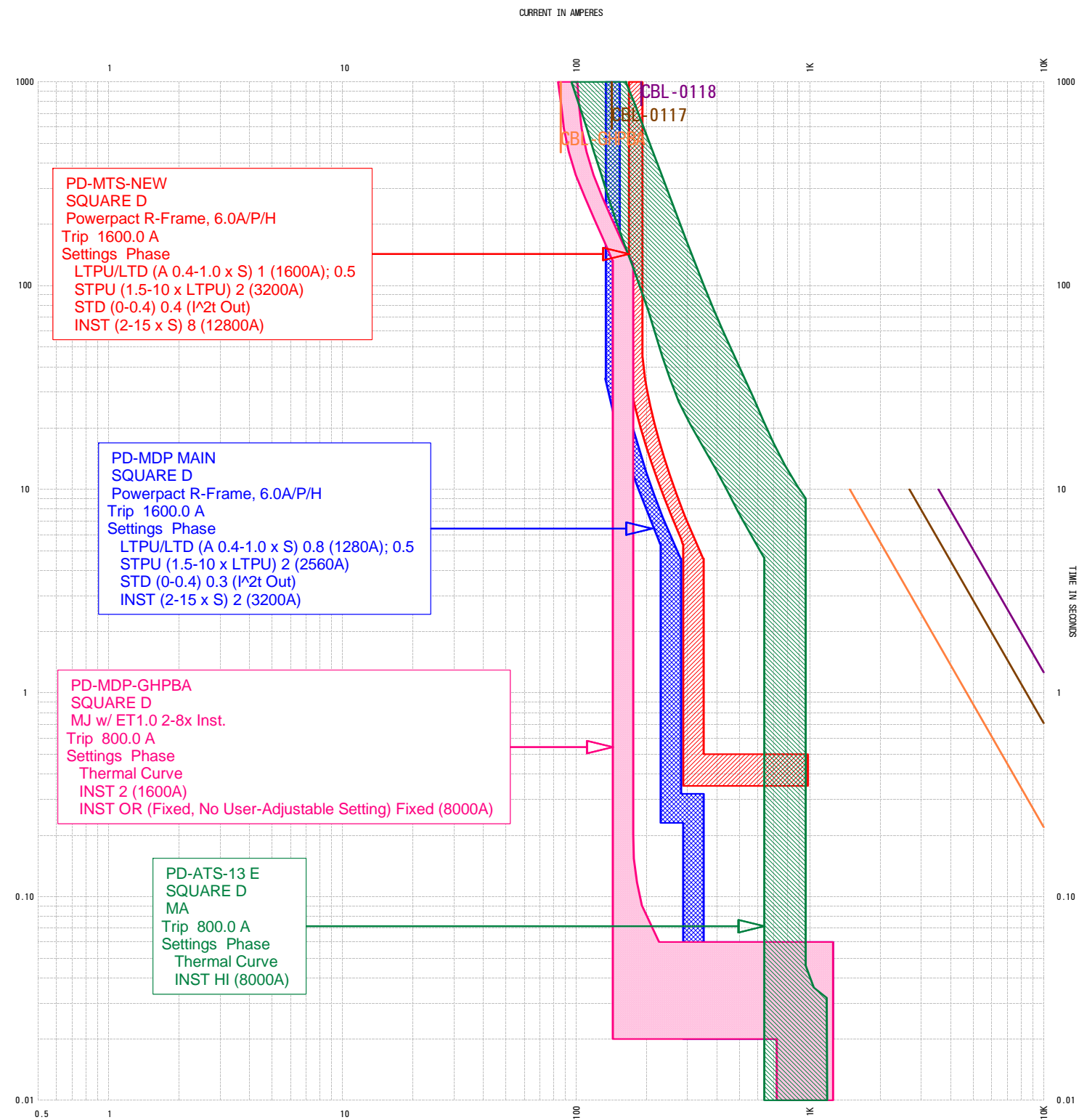
APPENDIX 2

TCC CURVES



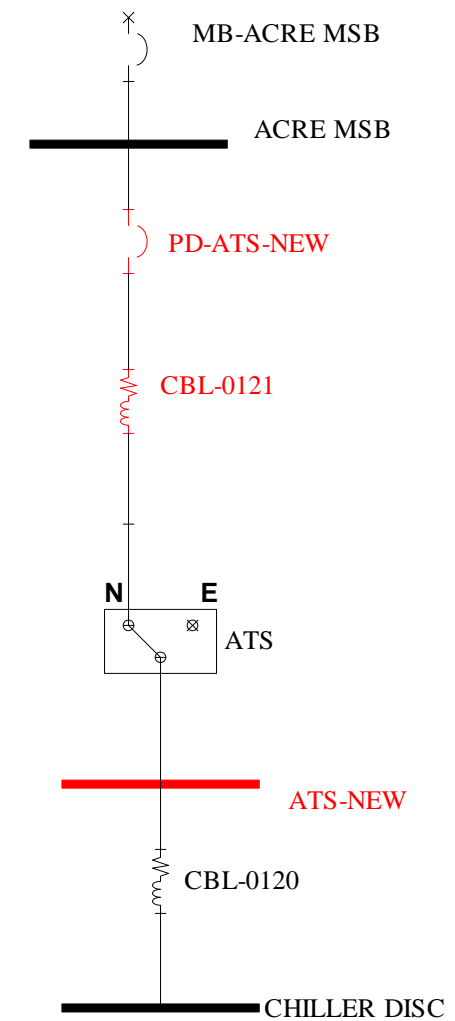
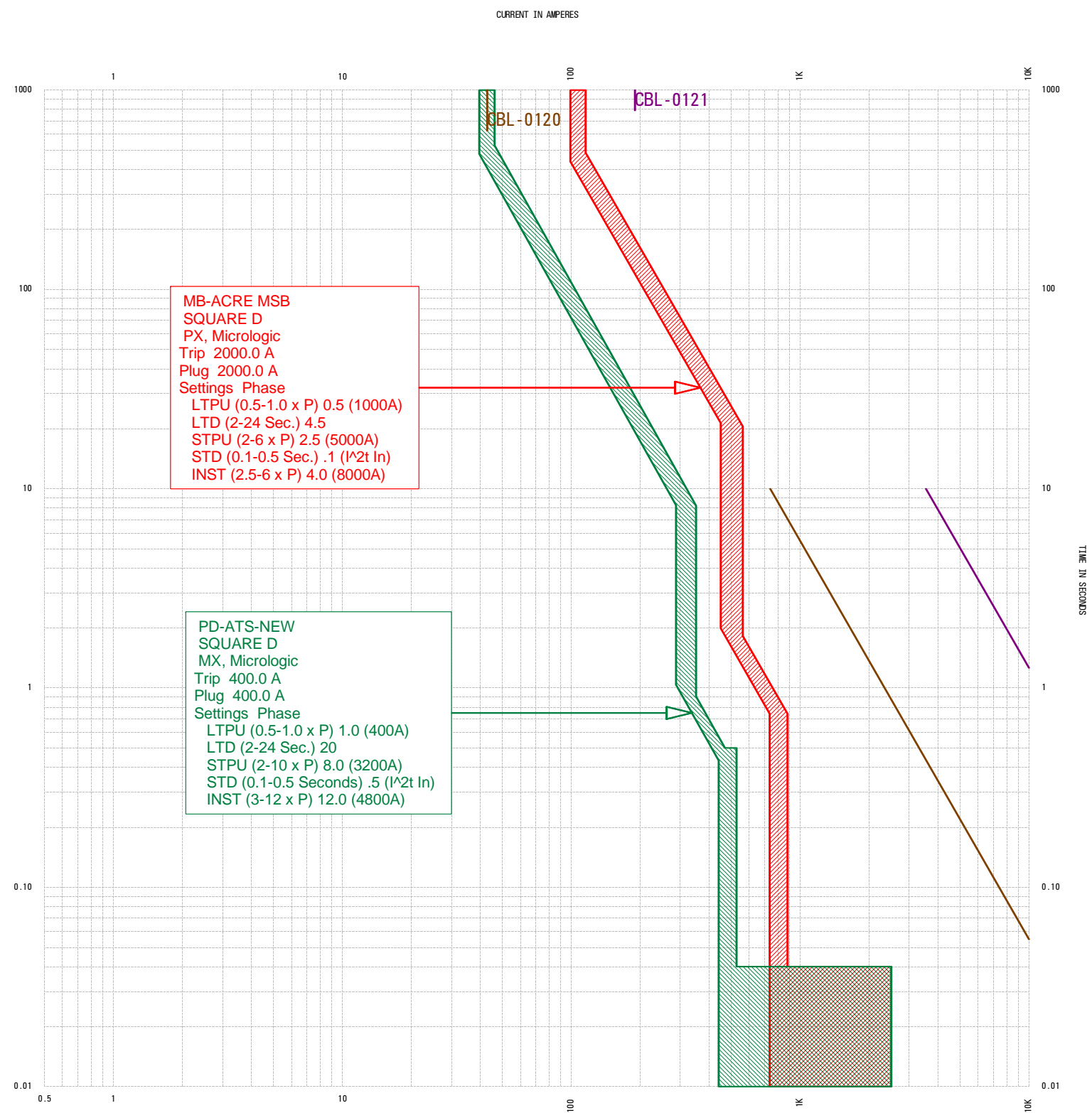
TCC Name: Gen Install Curve 1
Refernce Voltage: 480



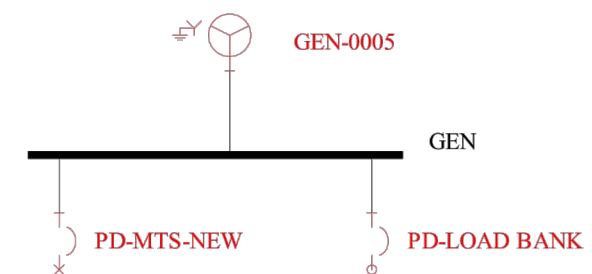
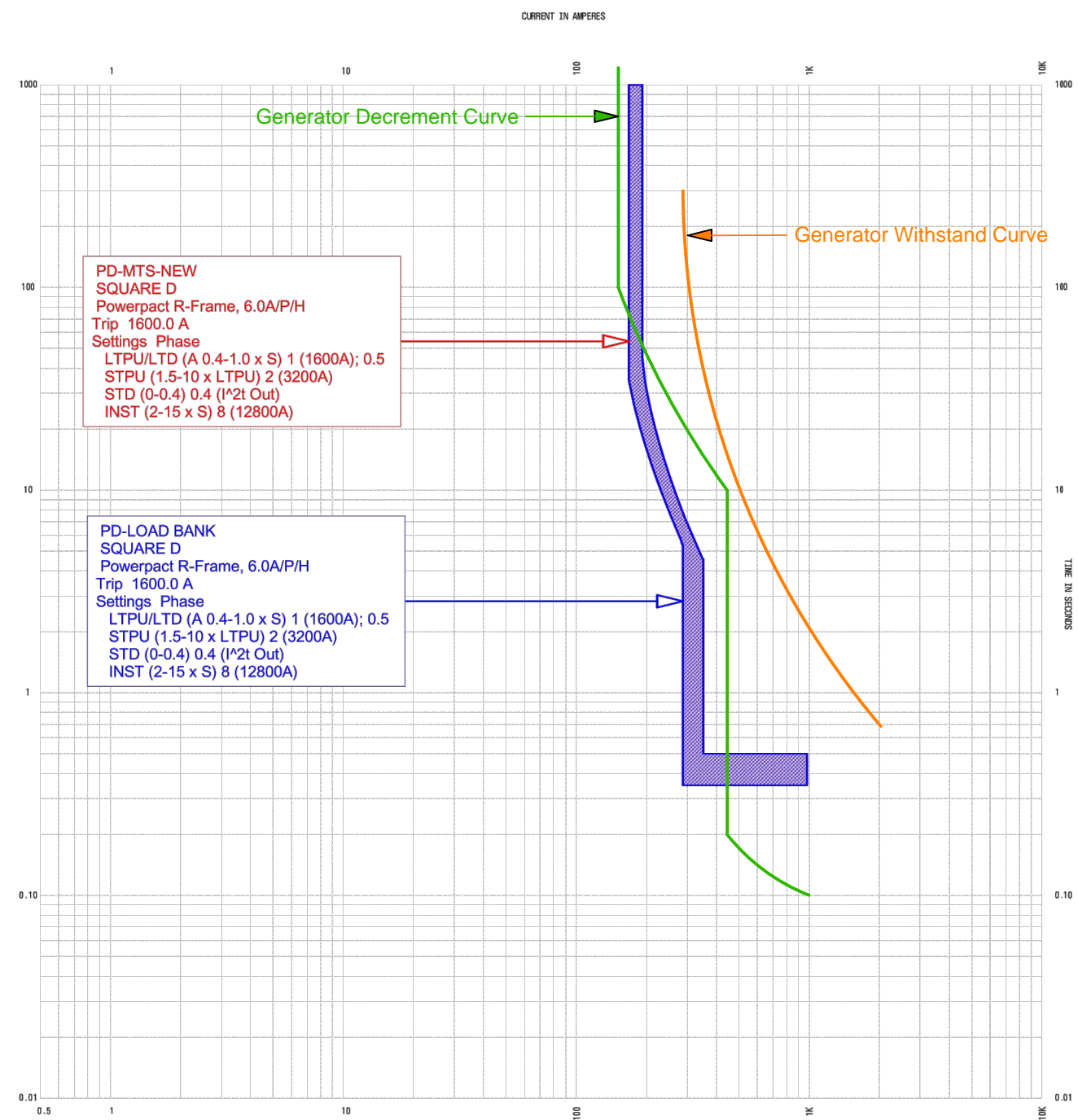


TCC Name: Gen Install Curve 2
 Reference Voltage: 480



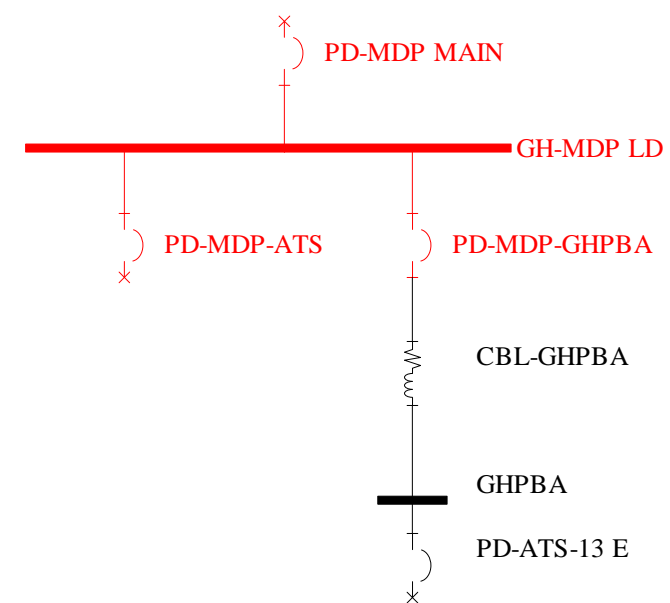
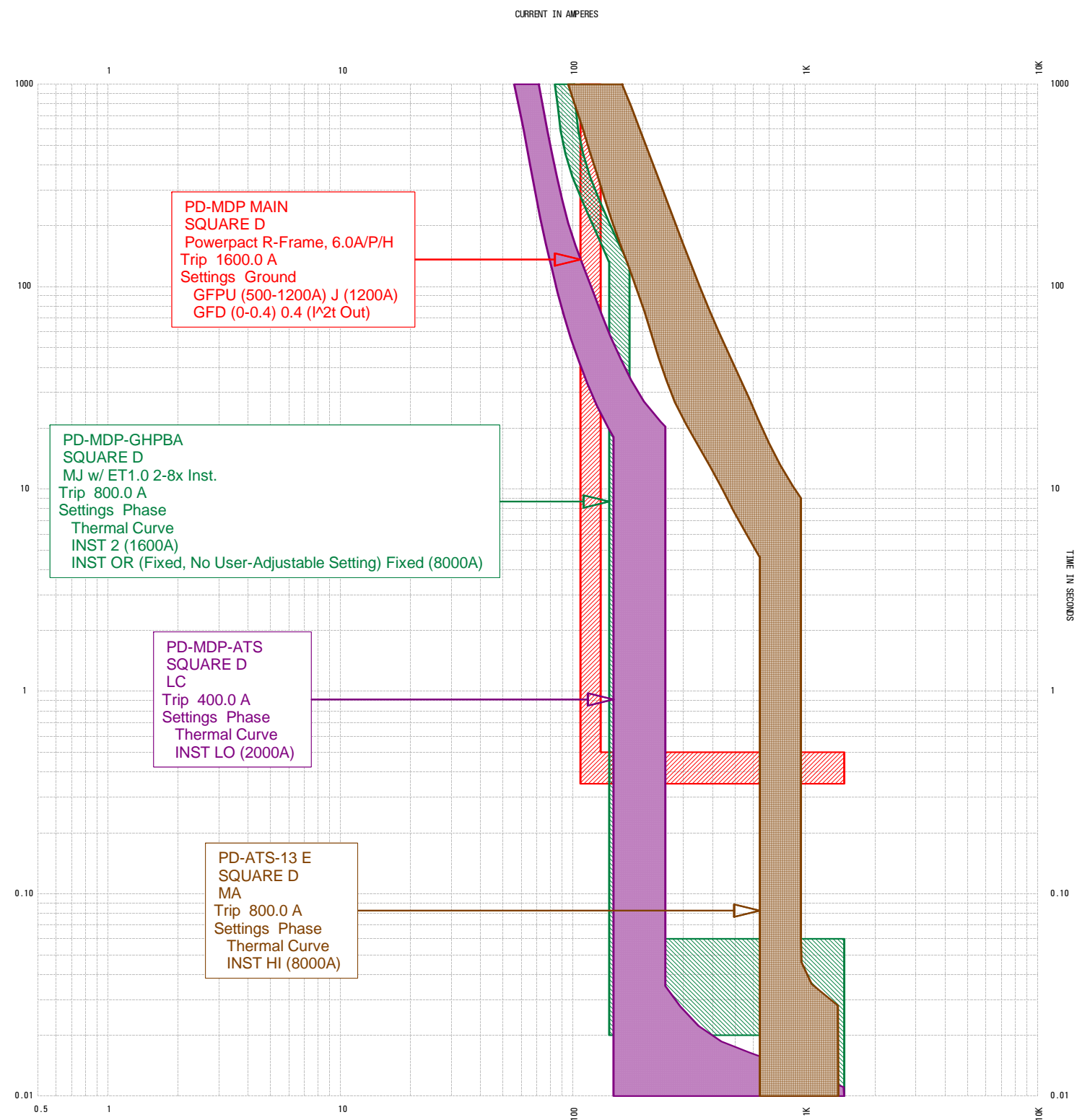


TCC Name: Gen Install Curve 3
Reference Voltage: 480



TCC Name: Gen Install Curve4
 Reference Voltage: 480





TCC Name: Gen Install Curve5
Reference Voltage: 480

APPENDIX 3

DEVICE SETTINGS



Project: Department of Veterans Affairs

JOB #: E10-006

Location: Nashville Campus

DEVICE SETTINGS TABLE
EXISTING & RECOMMENDED DEVICE SETTINGS

Connected Bus	Prot Device Name	Mfg/Frame	Type	Frame /Sensor /Plug	Existing Settings	Recommended Settings
ACRE MSB	PD-ATS-NEW	SQUARE D	MX	400.0A	LTPU (0.5-1.0 x P) 1.0 (400A)	LTPU (0.5-1.0 x P) 1.0 (400A)
	Static Trip	MX, Micrologic		400.0A	LTD (2-24 Sec.) 20	LTD (2-24 Sec.) 20
		LSI, 100-800A		400.0A	STPU (2-10 x P) 10 (4000A)	STPU (2-10 x P) 8.0 (3200A)
					STD (0.1-0.5 Seconds) .5 (1^2t In)	STD (0.1-0.5 Seconds) .5 (1^2t In)
					INST (3-12 x P) 12.0 (4800A)	INST (3-12 x P) 12.0 (4800A)
EDS-MAIN	PD-EDS MAIN	SQUARE D	PX	1600.0A	LTPU (0.5-1.0 x P) 1.0 (1600A)	LTPU (0.5-1.0 x P) 1.0 (1600A)
	Static Trip	PX, Micrologic		1600.0A	LTD (2-24 Sec.) 2.0	LTD (2-24 Sec.) 16.0
		LSI, 600-1600A		1600.0A	STPU (2-8 x P) 8.0 (12800A)	STPU (2-8 x P) 5.0 (8000A)
					STD (0.1-0.5 Sec.) .1 (1^2t In)	STD (0.1-0.5 Sec.) .2 (1^2t In)
					INST (2.5-8 x P) 2.5 (4000A)	INST (2.5-8 x P) 8.0 (12800A)
GEN	PD-LOAD BANK	SQUARE D	RG	2500.0A	NA	LTPU/LTD (A 0.4-1.0 x S) 1 (1600A); 0.5
	Static Trip	Powerpact R-Frame, 6.0A/P/H		1600.0A	NA	STPU (1.5-10 x LTPU) 2 (3200A)
		LSI, 600-2500A, UL			NA	STD (0-0.4) 0.4 (1^2t Out)
					NA	INST (2-15 x S) 8 (12800A)
GH-MDP	PD-MDP MAIN Ph	SQUARE D	RK	2500.0A		Phase
	Static Trip	Powerpact R-Frame, 6.0A/P/H		1600.0A	NA	LTPU/LTD (A 0.4-1.0 x S) 0.8 (1280A); 0.5
		LSI, 600-2500A, UL			NA	STPU (1.5-10 x LTPU) 2 (2560A)
					NA	STD (0-0.4) 0.3 (1^2t Out)
					NA	INST (2-15 x S) 2 (3200A)
GH-MDP	PD-MDP MAIN Gnd	SQUARE D	RK	2500.0A		Ground
	Static Trip	Powerpact R-Frame, 6.0A/P/H		1600.0A	NA	GFPD (500-1200A) J (1200A)
		LSI, 600-2500A, UL			NA	GFD (0-0.4) 0.4 (1^2t Out)
GH-MDP	PD-MDP-ATS	SQUARE D	LC	400.0A		Thermal Curve
	Thermal Magnetic	LC		400.0A	NA	INST LO (2000A)
		300-600A				
GH-MDP	PD-MDP-GHPBA	SQUARE D	MJ	800.0A		Thermal Curve
	Thermal Magnetic	MJ w/ ET1.0 2-8x Inst.		800.0A	NA	INST 2 (1600A)
		300-800A			NA	INST OR (Fixed, No User-Adjustable Setting)
						Fixed (8000A)
GEN	PD-MTS-NEW	SQUARE D	RG	2500.0A	NA	LTPU/LTD (A 0.4-1.0 x S) 1 (1600A); 0.5
	Static Trip	Powerpact R-Frame, 6.0A/P/H		1600.0A	NA	STPU (1.5-10 x LTPU) 2 (3200A)
		LSI, 600-2500A, UL			NA	STD (0-0.4) 0.4 (1^2t Out)
					NA	INST (2-15 x S) 8 (12800A)
EDS	PD-EDS-NEW	SQUARE D	NA	1200.0A		Thermal Curve
	Thermal Magnetic	NA		1200.0A	NA	INST LO (5004A)
		600-1200A				

Denotes new devices

Denotes existing devices to be changed

APPENDIX 4

ARC FLASH HAZARD TABLE

JOB: E10-006
LOCATION: Nashville, TN



Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category
GEN	MaxTripTime @2.0s	0.480	9.79	6.44	9.79	6.44	2	0	Yes	PNL	25	156	18	41.2	Dangerous! (*N2) (*N9) (*S2)
GEN	MaxTripTime @2.0s	0.480	9.79	6.44	9.79	6.44	2	0	Yes	PNL	25	156	18	41.2	Dangerous! (*N2) (*N9) (*S2)
GH-MDP	PD-MDP MAIN	0.480	14.74	9.13	2.21	1.37	0.083	0	Yes	PNL	25	22	18	1.7	Category 1 (*S2)
CHILLER DISC	PD-ATS-NEW	0.480	9	5.09	8.08	4.57	0.531	0	Yes	PNL	25	56	18	7.6	Category 2 (*N3) (*S1)
ATS-NEW	IndMtr Decay @5cycles	0.480	23.34	13.53	0.93	0.86	0.083	0	Yes	PNL	25	24	18	1.9	Category 1 (*S1)
MTS-NEW	PD-MDP MAIN	0.480	17.59	10.62	2.14	1.29	0.083	0	Yes	PNL	25	24	18	1.9	Category 1 (*S2)
GHPBA	PD-ATS-14 E	0.480	13.93	8.7	0.81	0.51	0.083	0	Yes	PNL	25	21	18	1.6	Category 1 (*S2)
Category 0: Long Sleeve Shirt & Pants, Safety Glasses, Hearing Protection, Leather Gloves												Scenario Descriptions		(*N2) < 99% Cleared Fault Threshold	
Category 1: FR Shirt & Pants (AR 4), Hardhat & Safety Glasses, Faceshield (AR 4), Hearing Protection, Leather Gloves & Work Shoes												S1 - All Normal		(*N3) - Arcing Current Low Tolerances Used	
Category 2: FR Shirt & Pants (AR 8), Hardhat, Safety Glasses, Faceshield (AR 8), Flash Suit Hood, Hearing Protection, Leather Gloves & Work Shoes												S2 - All ATS -- Emergency MTS-New -- Normal		(*N5) - Miscoordinated, Upstream Device Tripped	
Category 3: FR Shirt & Pants with FR Coverall all with combined AR of at least 25, Hardhat, Safety Glasses, Flash Suit Hood, Hearing Protection, Arc-Rated Gloves & Leather Work Shoes												S3 - All ATS -- Emergency MTS-New -- Emergency		(*N9) - Max Arcing Duration Reached	
Category 4: FR Shirt & Pants Plus Flash Suit and Hood all with combined AR of at least 40, Hardhat, Safety Glasses, Hearing Protection, Arc-Rated Gloves & Leather Work Shoes												IEEE 1584 - 2009 Edition Bus Report (99% Cleared Fault Threshold, include Ind. Motors >= 50.0hp for 5.0 Cycles), mis-coordination checked			
Category Dangerous!: ENERGIZED WORK PROHIBITED!															

APPENDIX 5

ARC FLASH DATA SAMPLE LABELS



DANGER

Arc Flash and Shock Hazard

Appropriate PPE Required

24 inches Flash Hazard Boundary
1.9 cal/cm² Flash Hazard at 18 inches

Category 1

FR Shirt & Pants (AR 4), Hardhat & Safety Glasses, Faceshield (AR 4), Hearing Protection, Leather Gloves & Work Shoes

480 VAC Shock Hazard when cover is removed
00 Class Glove with Leather Protectors
42 inches Limited Approach (Fixed Circuit)
12 inches Restricted Approach
1 inches Prohibited Approach

Location: ATS-NEW



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Warning: Changes in equipment settings or system configuration will invalidate the calculated values and PPE requirements



DANGER

NO SAFE PPE EXISTS

ENERGIZED WORK PROHIBITED

156 inches Flash Hazard Boundary
41 cal/cm² Flash Hazard at 18 inches

Dangerous! ENERGIZED WORK PROHIBITED!

480 VAC Shock Hazard when cover is removed
00 Class Glove with Leather Protectors
42 inches Limited Approach (Fixed Circuit)
12 inches Restricted Approach
1 inches Prohibited Approach

Location: GEN



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DANGER

Arc Flash and Shock Hazard

Appropriate PPE Required

56 inches Flash Hazard Boundary
7.6 cal/cm² Flash Hazard at 18 inches

Category 2

FR Shirt & Pants (AR 8), Hardhat, Safety Glasses, Faceshield (AR 8), Flash Suit Hood, Hearing Protection, Leather Gloves & Work Shoes

480 VAC Shock Hazard when cover is removed
00 Class Glove with Leather Protectors
42 inches Limited Approach (Fixed Circuit)
12 inches Restricted Approach
1 inches Prohibited Approach

Location: CHILLER DISC



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DANGER

NO SAFE PPE EXISTS

ENERGIZED WORK PROHIBITED

156 inches Flash Hazard Boundary
41 cal/cm² Flash Hazard at 18 inches

Dangerous! ENERGIZED WORK PROHIBITED!

480 VAC Shock Hazard when cover is removed
00 Class Glove with Leather Protectors
42 inches Limited Approach (Fixed Circuit)
12 inches Restricted Approach
1 inches Prohibited Approach

Location: GEN



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DANGER

Arc Flash and Shock Hazard

Appropriate PPE Required

22 inches Flash Hazard Boundary
1.7 cal/cm² Flash Hazard at 18 inches

Category 1

FR Shirt & Pants (AR 4), Hardhat & Safety Glasses, Faceshield (AR 4), Hearing Protection, Leather Gloves & Work Shoes

480 VAC Shock Hazard when cover is removed
00 Class Glove with Leather Protectors
42 inches Limited Approach (Fixed Circuit)
12 inches Restricted Approach
1 inches Prohibited Approach

Location: GH-MDP



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DANGER

Arc Flash and Shock Hazard

Appropriate PPE Required

24 inches Flash Hazard Boundary
1.9 cal/cm² Flash Hazard at 18 inches

Category 1

FR Shirt & Pants (AR 4), Hardhat & Safety Glasses, Faceshield (AR 4), Hearing Protection, Leather Gloves & Work Shoes

480 VAC Shock Hazard when cover is removed
00 Class Glove with Leather Protectors
42 inches Limited Approach (Fixed Circuit)
12 inches Restricted Approach
1 inches Prohibited Approach

Location: MTS-NEW



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DANGER

Arc Flash and Shock Hazard

Appropriate PPE Required

21 inches Flash Hazard Boundary
1.6 cal/cm² Flash Hazard at 18 inches

Category 1

FR Shirt & Pants (AR 4), Hardhat & Safety Glasses, Faceshield (AR 4), Hearing Protection, Leather Gloves & Work Shoes

480 VAC Shock Hazard when cover is removed
00 Class Glove with Leather Protectors
42 inches Limited Approach (Fixed Circuit)
12 inches Restricted Approach
1 inches Prohibited Approach

Location: GHPBA



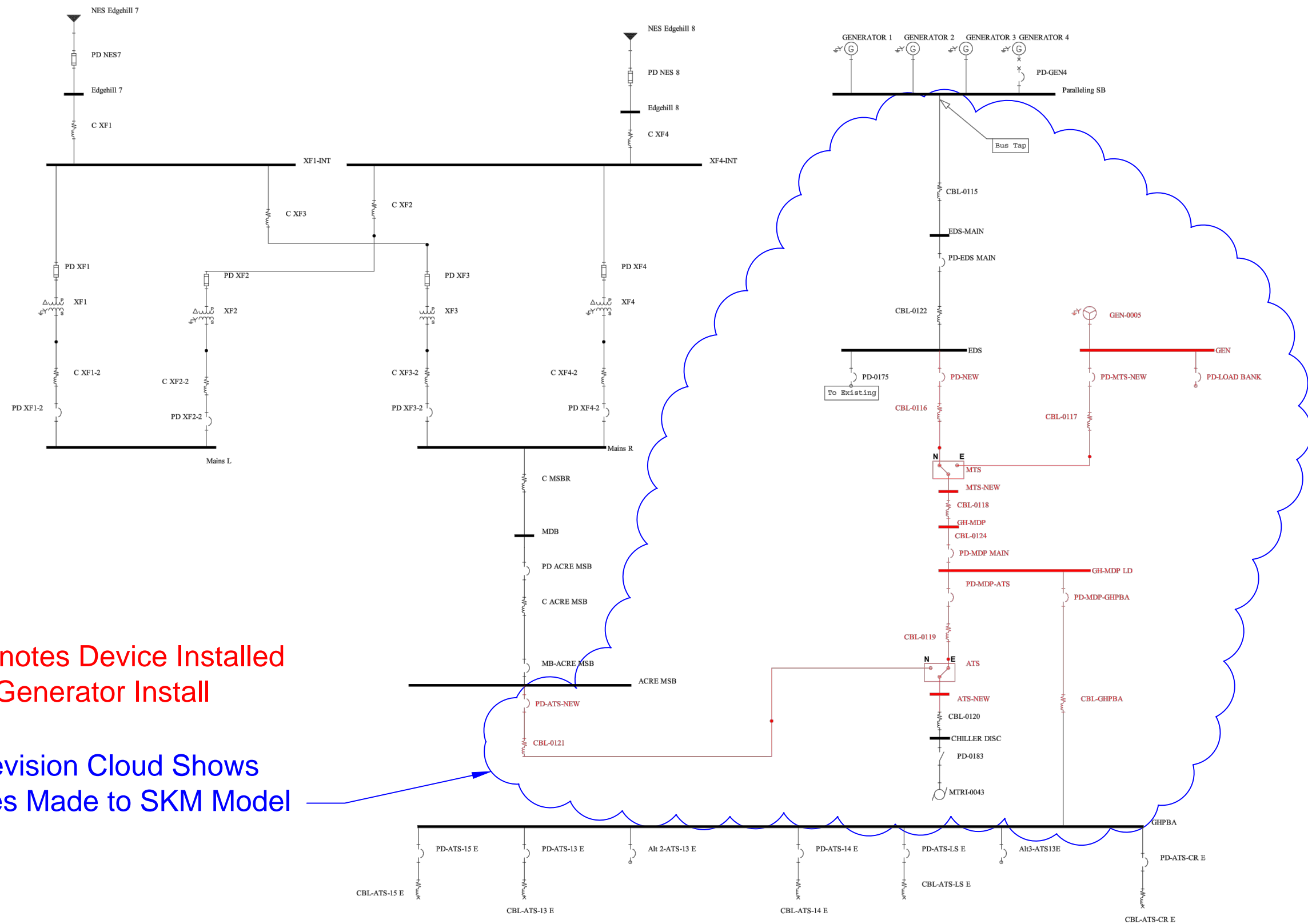
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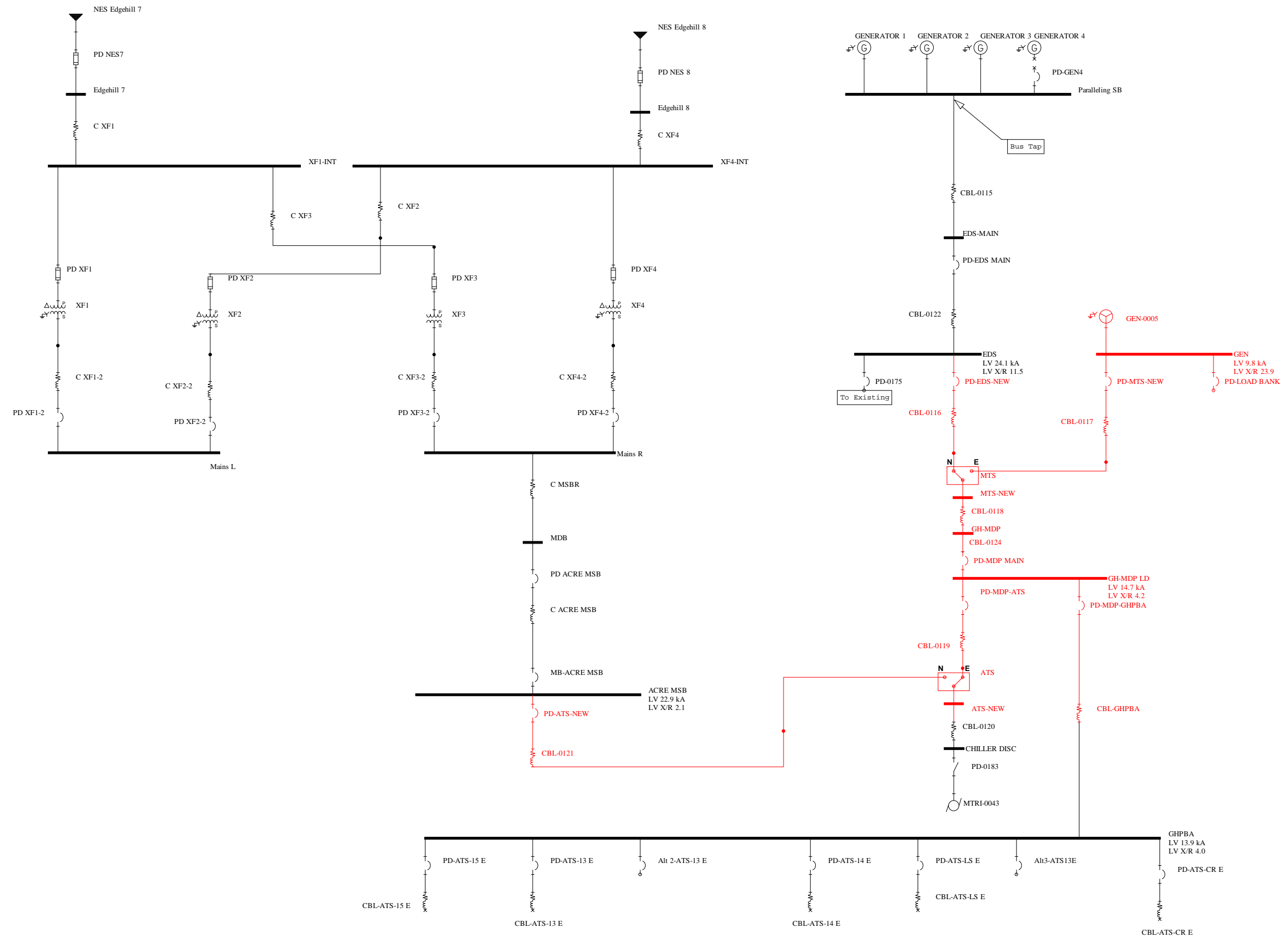
APPENDIX 6

ONE-LINE DIAGRAM



Red Denotes Device Installed During Generator Install

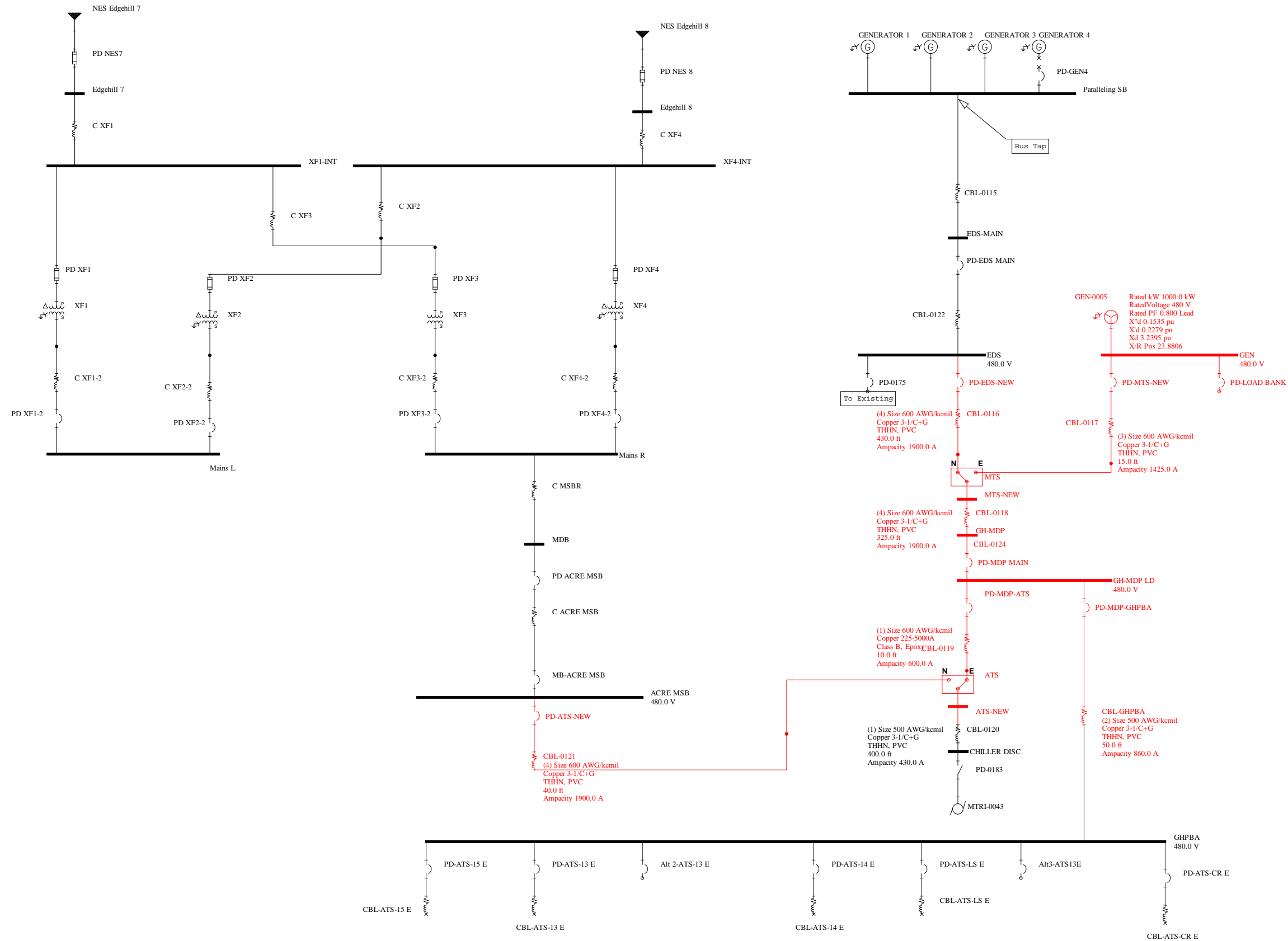
Blue Revision Cloud Shows Changes Made to SKM Model



ACRE

February 25, 2010





ACRE

February 25, 2010

