Multi-Purpose Building

University of Calgary

Alberta, Canada

Short Circuit, Coordination, and Arc Flash Study Report

Revision: 1

Date:

3/04/2024

Authorization

	Name	Date	Signature
Developed By			
Reviewed By			

Table of Contents

Contents

1. Executive Summary

The purpose of this study is to establish the protective device settings and evaluate the arc flash hazard at Multi-Purpose Building located at Alberta, Canada. The power flow analysis examined the network under steady normal operation and offered useful data for organizing upcoming expansions and figuring out how best to run current systems.

The short circuit study determined that the interrupting capacities of the equipment at this station are adequate, i.e. they exceed the largest possible short circuit current experienced by a given equipment.

The coordination study established protective device settings that would provide adequate selectivity between devices at calculated fault levels, minimizing the project's overall annoyance trips and confining the issue to the particular subcircuit. Ultimately, the incident energy at the location was ascertained by the arc flash study, which is crucial information for guaranteeing the security of workers who handle or are near electrical equipment.

2. Foreword

2.1. Purpose of the study

Short circuit, protection coordination and arc flash studies were performed for the LV electrical system of this project. The short circuit study is performed to ensure that the electrical equipment has sufficient fault interrupting capability and short circuit withstand capacity. The coordination study examines the proper settings for the protection devices. The Arc Flash study establishes and analyzes arc flash hazards in identified electrical equipment in the site, and if applicable, identifies concerns associated with such hazards.

2.2. Scope of studies

This includes [3] → 0.208kV panels. Short circuit, coordination, and arc flash results for downstream devices will be studied.

2.3. Methodology

The study will be based on current codes, industry standards, practices, and expectations.

- For Component sizing, Voltage drops, active & reactive power measurement:
- Load Flow (by Newton Raphson method- with 99 iterations for convergence were used) and it was performed with the help of ETAP 19.01 Software
- For Short Circuit Study: To find Maximum 3 phase fault, in the Network 3-Phase, LG, LL, & LLG Fault Currents ANSI Standard was used. For protection & coordination& arc flash: A minimum 0.1 sec time difference is adopted used and Reference Standards: NFPA 70 (NEC), IEEE Std 242, IEEE Std 446, IEEE Std C37.91, IEEE Std C37.96 are used.

2.4. System Description

This Installation consists of the 25kV Utility grid that feeds the 225KVA, 25kV/0.208KV Distribution Transformer.

This transformer provides power to the whole Project along with the 85kW Generator and the 70 KVA PV plant for the emergency case or loss of power due to unforeseen circumstances.

Transformers along with the generator and the Solar system are connected to the MAIN DB or MAIN LV PANEL rated at 208/120V 60Hz. Which feed further panels LV panel-1 and LV PANEL-2 along with HVAC and Fire pump.

A 11.3kVA UPS is also provided for the critical loads that must not be interrupted in any scenario.

This system is detailed in the Single Line Diagrams in Appendix A

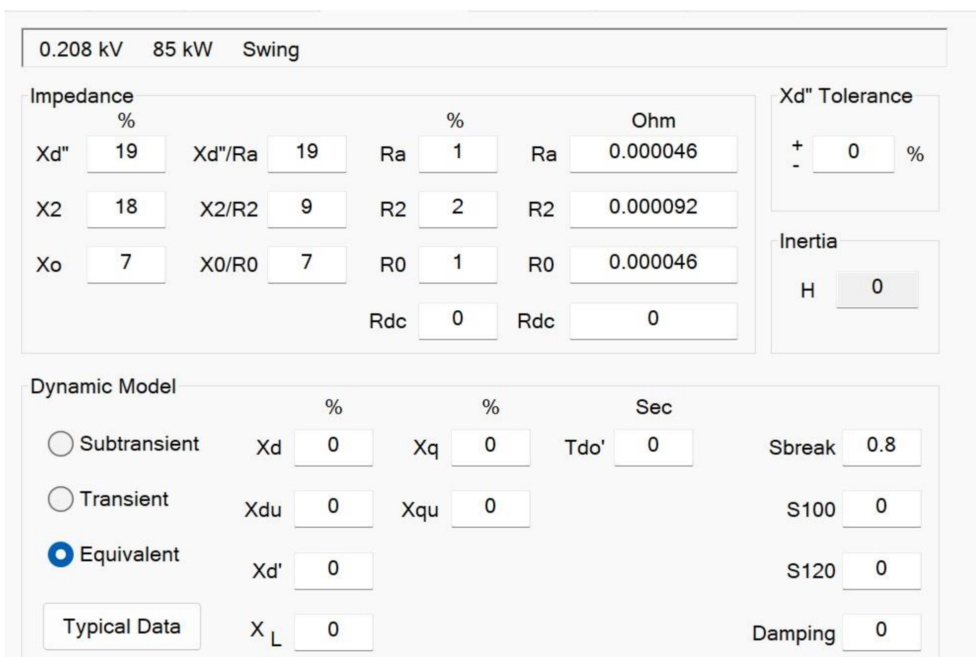
2.5. Basis and assumptions

- The Electrical Transient Analyzer Program (ETAP, version 19.01) is used for performing the studies.
- Priority Loads are not listed to some power and lighting loads and are given an uninterrupted power supply.
- Cable lengths are calculated in milestone 3.
- Utility short circuit is assumed to be for 250 MVASC as it is not provided.

2.6. Input Data

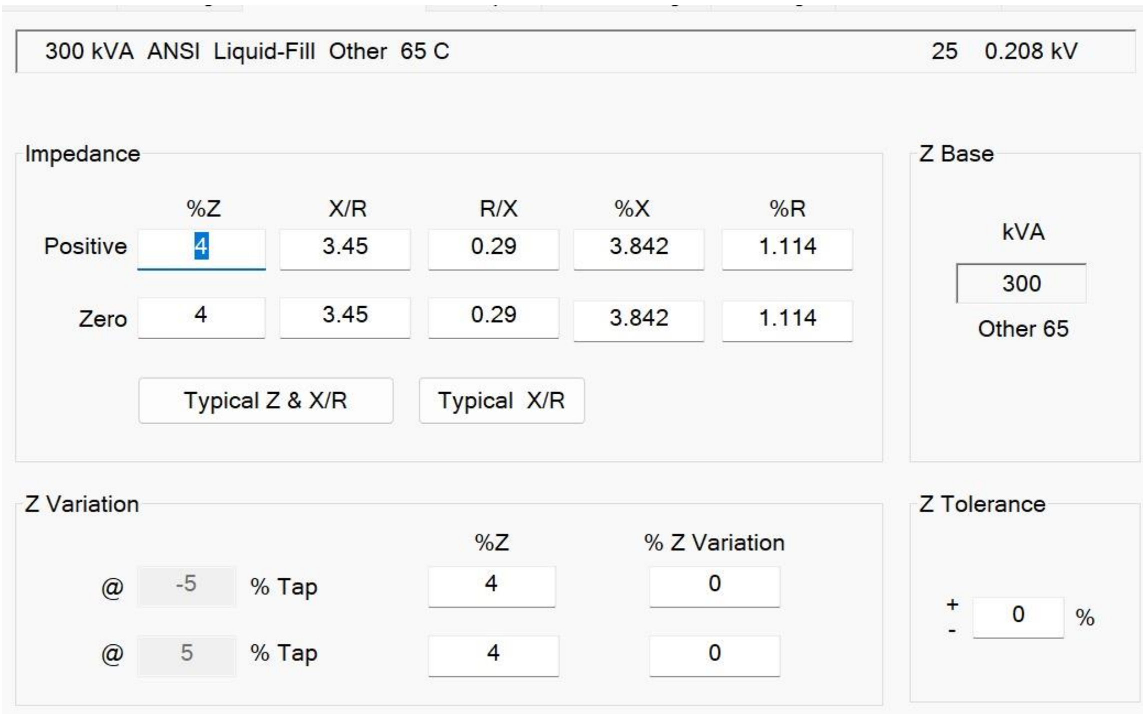
2.6.1. Generator Impedance

Genset for 85KW (208/120V) was used in the project. Technical information for the Genset units is available in the data sheet along with this report. Typical impedances provided by ETAP were utilized. The impedance values are shown below:



2.6.2. Transformer Impedance

Technical information for the transformers was not available at the time of the studies. Therefore, typical impedances provided by ETAP were utilized. The impedance values are shown below:



2.6.3. Conductors

Technical information for the conductors was not available at the time of the studies. Therefore, typical impedances provided by ETAP were utilized.

EQUIPMENT DATA SHEETS

The equipment data sheet of all the equipment listed is attached below.

1. Generator 85kW
2. Distribution panels
3. LED downlight 38W & 21W
4. LED spotlight 9W
5. Transformer (225KVA, 25/0.208KV)
6. Uninterruptible power supply 15 kVa
7. 350-Watt Solar Panels
8. Solar panels Battery 460.8 V, 400 AH
9. 70K hybrid Inverter
10. External batteries 25KW (UPS)
11. Circuit Breakers
12. Conduit and fittings
13. Fire pump 30 HP

3. Short Circuit Study

To make sure that the equipment's short circuit rating and the protective devices' interrupting rating are more than the maximum short circuit current that is available, a short circuit analysis was conducted. It was discovered that all equipment had adequate short circuit ratings. Appendix A contains the short circuit values for each bus, and Appendix B has the whole short circuit report. Table 1 summarizes the short circuit levels at each bus. Different types of faults such as three-phase faults, line-to-line faults, and line-to-ground faults can be analyzed.

Through this short circuit analysis, we might be able to select switch gear equipment that is required for protection, such as fuses, circuit breakers, and isolators. It also helps with relay settings that distinguish between full load current and fault current.

Short-Circuit Summary Report

1/2 Cycle - 3-Phase, LG, LL, & LLG Fault Currents

Prefault Voltage = 100 % of the Bus Nominal Voltage

Bus		3-Phase Fault			Line-to-Ground Fault			Line-to-Line Fault			*Line-to-Line-to-Ground		
ID	kV	Real	Imag.	Mag.	Real	Imag.	Mag.	Real	Imag.	Mag.	Real	Imag.	Mag.
Bus 12B	0.208	2.057	-13.192	13.351	2.050	-13.096	13.256	-11.402	-1.781	11.541	-12.431	4.746	13.306
Bus M2C	0.208	0.559	-4.004	4.043	0.446	-3.692	3.719	-3.444	-0.484	3.478	3.272	2.218	3.953
Bus M2E	0.208	0.372	-3.379	3.399	0.367	-3.303	3.323	-2.911	-0.323	2.929	2.736	1.965	3.369
LV Bus	0.208	0.826	-7.729	7.773	0.734	-7.312	7.349	-6.676	-0.715	6.714	6.367	4.251	7.655
Main Bus	25.000	5.774	-0.072	5.775	5.774	-0.067	5.774	-0.063	-5.001	5.001	-2.949	-4.969	5.779

All fault currents are symmetrical (1/2 Cycle network) values in rms kA.
* LLG fault current is the larger of the two faulted line currents.

Short circuit levels

Analysis summary:

- The Main Bus that has an Isc 3-phase Fault level of 5.775 Ka.
- Similarly, the M2C LV panel will have a 3-phase fault of 4.043 Ka and the LG fault of 3.719.
- The LV panel M2E will have a 3-phase fault of 3.399 Ka and the LG fault of 3.323.
- The LV bus Panel will have a 3-phase fault of 7.773 Ka and the LG fault of 7.349.
- As per this simulation results, we can clearly see that the Fault level is decreasing in magnitude as we are moving from the utility towards the final loads (DBs).

4. Protective Device Coordination

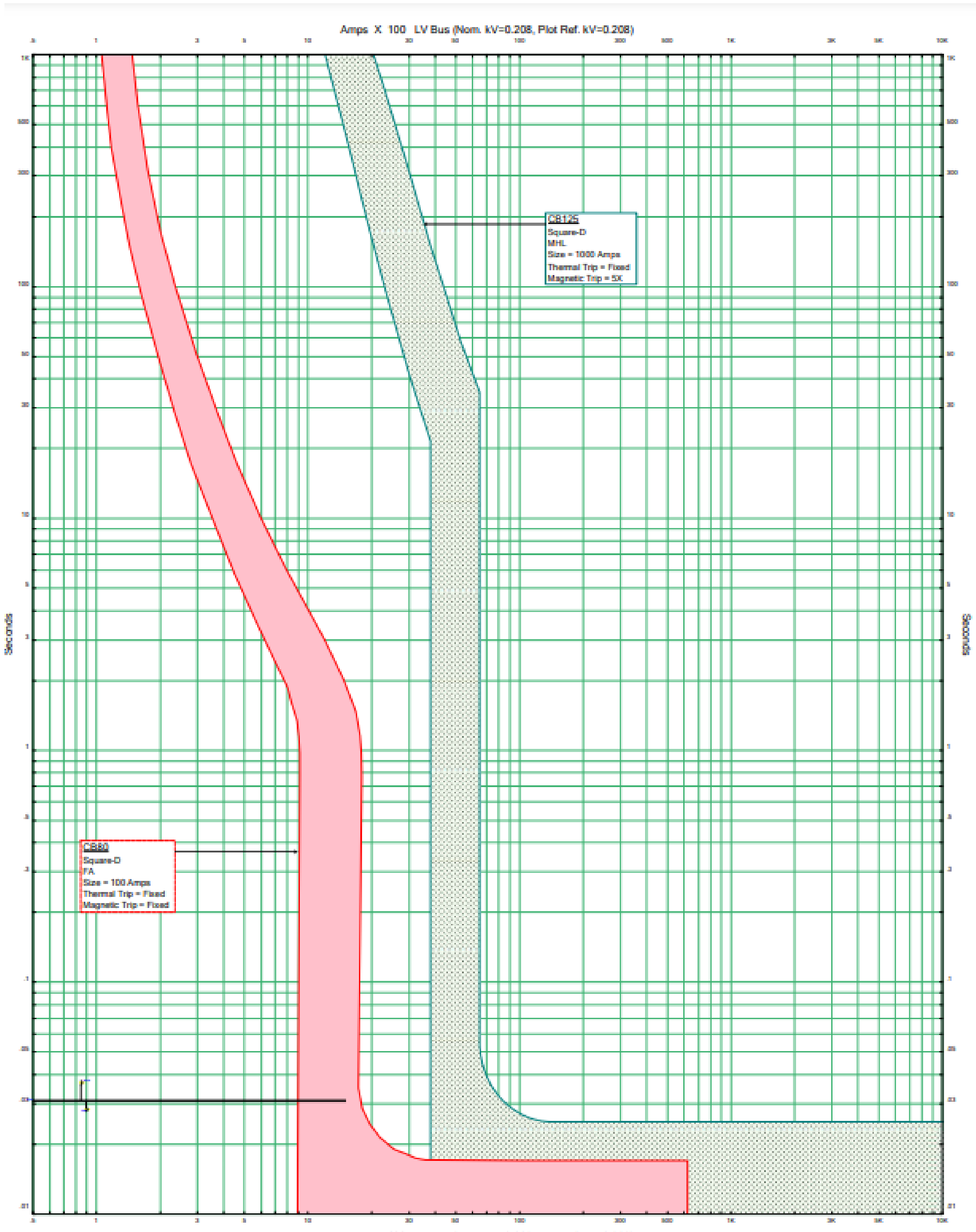
The coordination study is performed to determine the appropriate protective device settings to achieve the following objectives:

a) Ensure all electrical equipment are adequately protected without exceeding their thermal limits,
b) Ensure settings are sensitive enough to detect all faults within the capability of the protective device, and
c) Ensure selectivity between protective devices when possible.

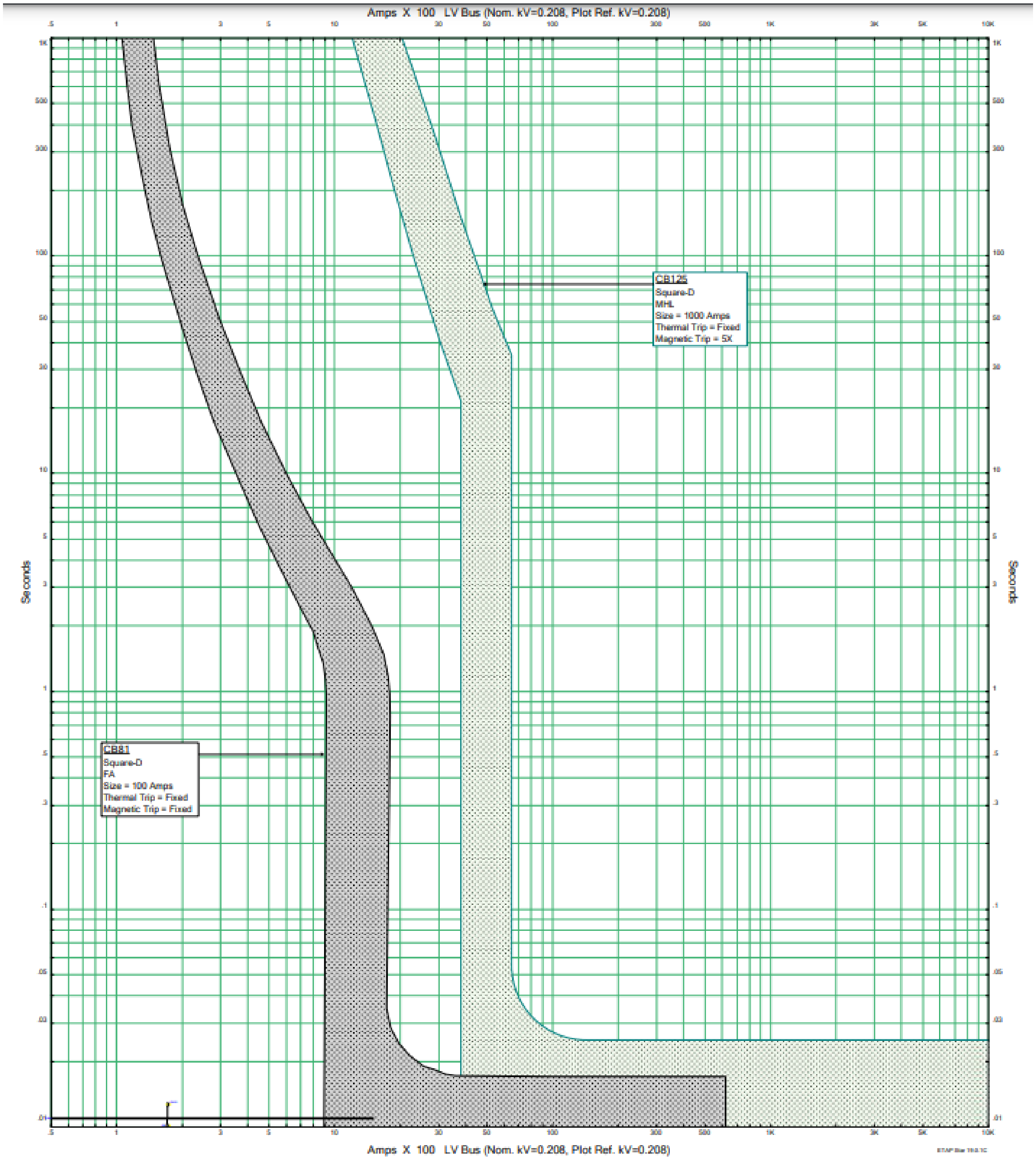
In addition to preventing or minimizing equipment damage, a properly coordinated power system will isolate only the faulted portion of the power system, and hence minimize the extent of the outage or also known as tripping.

4.1. Main Panel (LV Panel) Protection and

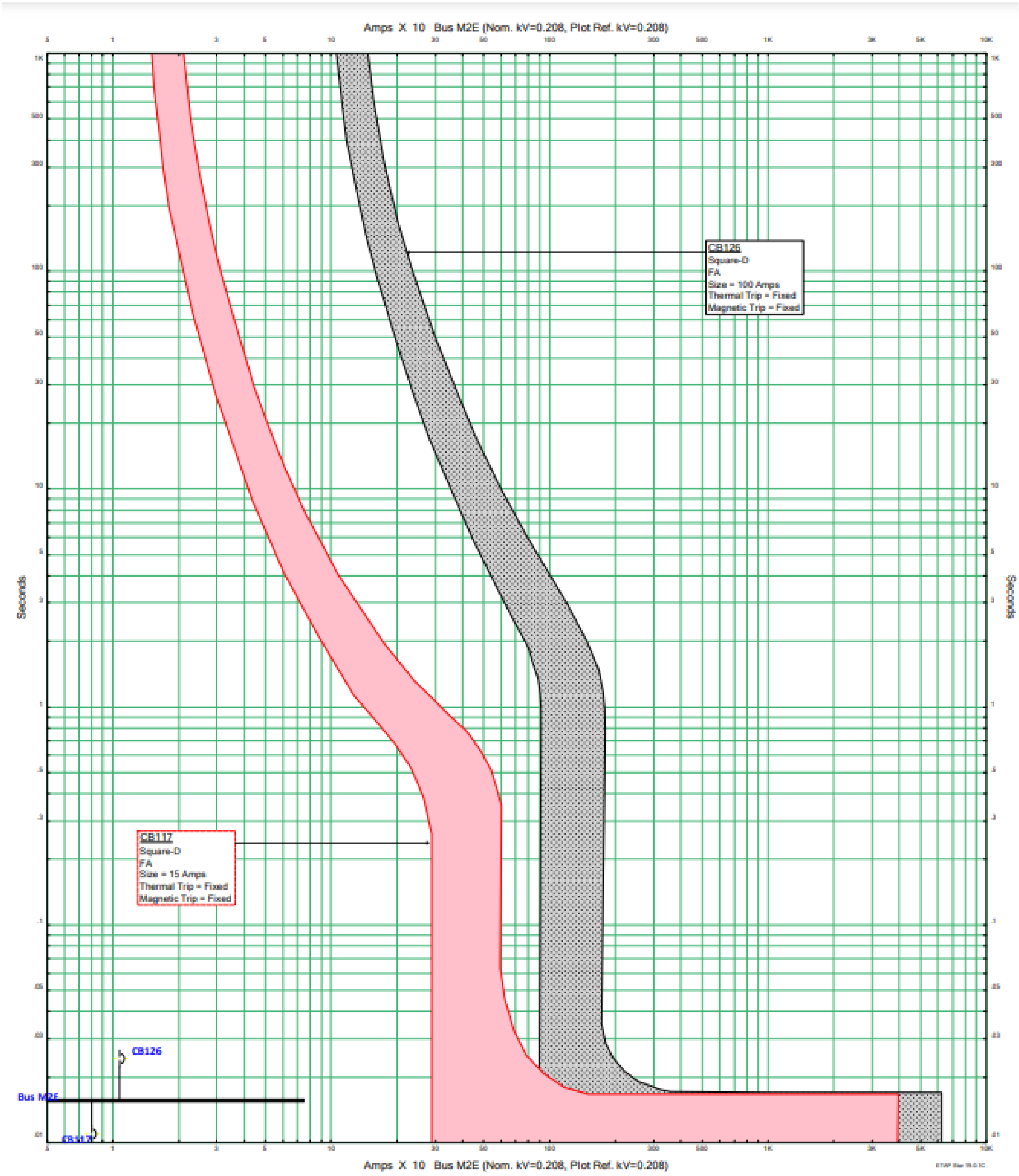
The following time current corves show how the above objectives were achieved.



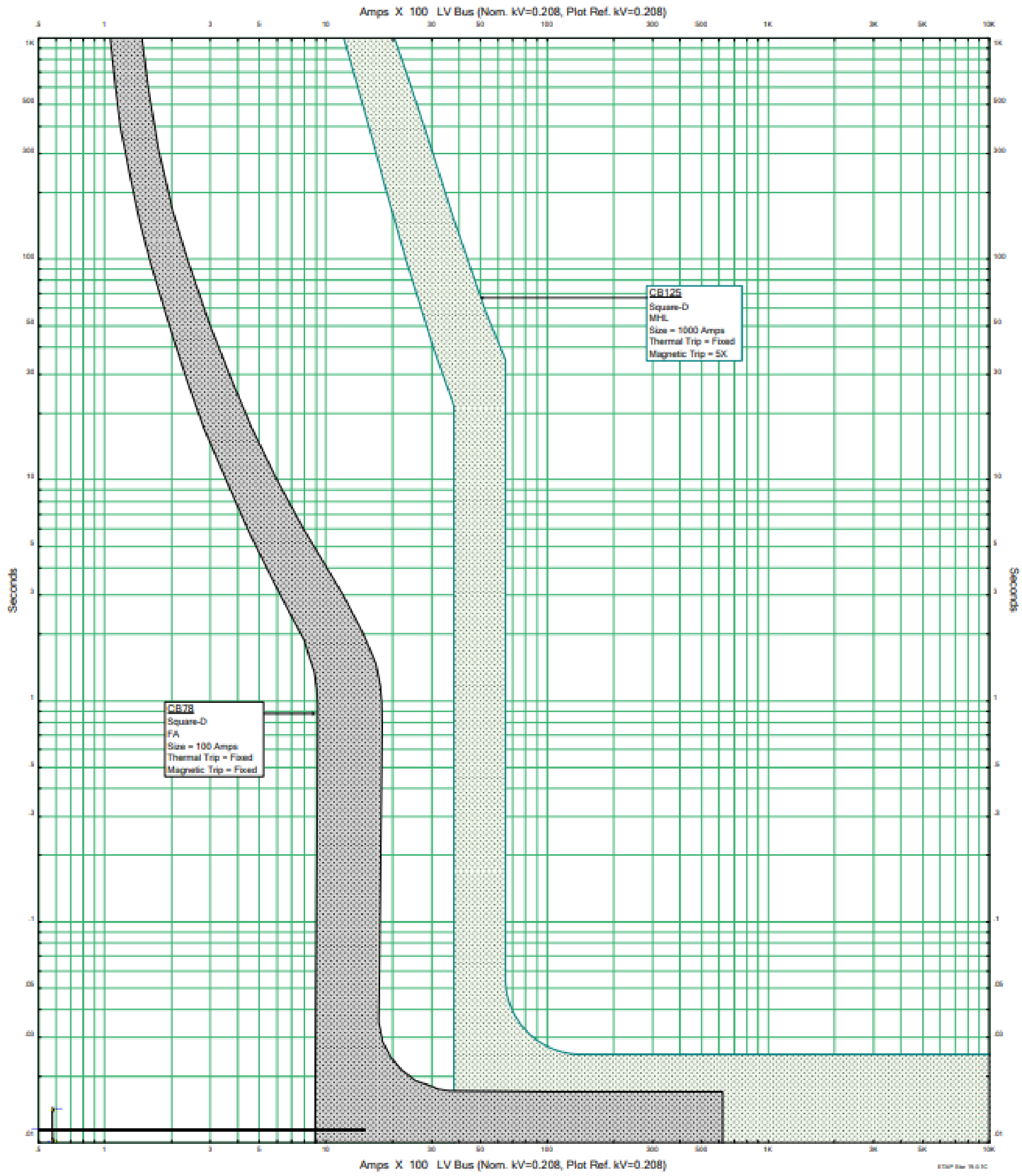
Main Panel (LV Panel) Protection and coordination with M2C Panel (LV Panel)



Main Panel (LV Panel) Protection and coordination with M2E Panel (LV Panel)



Main Panel (LV Panel) Protection and coordination with M2E Panel (LV Panel)



SUMMARY RESULTS

Time current curves and detailed protective device settings are presented in the above example, and we can clearly see a time difference of more than 0.2 sec in each case.
That shows that the discrimination as per IEEE242 has been achieved in all the panels.
Partial or Selective coordination exists between the Some Circuit Breakers, where both incoming are outing are fed from the Same CB frame rate for example the Output M2E Panel & incoming of M2C Panel.

Recommendations and Modifications NEEDED as per IEEE 242.

According to the guideline below, we should have a correct mode of operation, which means that the regular mode, emergency mode, usage of PV modules, percentage of battery storage, and utility should all be clearly specified in our sequence of operation since every mode has a unique coordination and fault current. Inquiring into the client's normal mode of operation, as well as how the generator and PV are used at different times, should be our priority. A P&C study should also be completed in those situations.

Priority loads and UPS usage should be specified as well, whether the UPS will be used continuously or only occasionally in an emergency. This can be explained more during the client meeting.
Which loads such as power or small are essential enough to require a UPS alone since the UPS alone has a capacity of 11.35KW.

When coordination is impossible due to a selectivity issue, it should be done at the stage with the least amount of economic disruption. indicates that it will be isolated or that it shouldn't have an impact on the overall system. However, problems should never arise in the main panels. By using the same circuit breaker for UPS panel (M2A) and feeding the same rating downstream with this clause, we may justify our selective issue.

5. Arc Flash Study

The short circuit calculations and the Fault Clearing Time (FCT) required by the protective devices are calculated by ETAP. The results are summarized in Table 2.

Bus Incident Energy Summary

Bus			Total Fault Current (kA)		Arc-Flash Analysis Results			
ID	Nom. kV	Type	Bolted	Arcing	FCT (cycles)	Incident E (cal/cm²)	AFB (ft)	Energy Level
Bus 12B	0.208	Panelboard	13.351	5.329	120.000	33.629	11.43	Level E
Bus M2C	0.208	Panelboard	4.043	1.957	120.000	11.391	5.91	Level D
Bus M2E	0.208	Panelboard	3.399	2.039	120.000	11.904	6.07	Level D
LV Bus	0.208	Other	7.773	3.871				
# Main Bus	25.000	Other	5.775	5.775				

Table 2: Arc flash energy results

Complete arc flash results are available in Appendix E.

Appendix A: Definitions and Concepts from NFPA 70E-2004

NFPA Standard 70E is a critical reference for the performance of this study. For the benefit of this report's reader, NFPA's definitions that are relevant to the study have been re-iterated as follows:

"Arc Rating: The maximum incident energy resistance demonstrated by a material (or a layered system of materials) prior to break open or at the onset of a second-degree skin burn. Arc rating is normally expressed in cal/cm^2."

"De-energized: Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from that of the earth"

"Electrical Hazard: A dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn, or blast.
FPN: Class 2 power supplies, listed low voltage lighting systems, and similar sources are examples of circuits or systems that are not considered an electrical hazard"

"Electrical Safety: Recognizing hazards associated with the use of electrical energy and taking precautions so that hazards do not cause injury or death"

"Electrical Single-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used in the circuit or system"

"Electrically Safe Work Condition: A state in which the conductor or circuit part to be worked on or near has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to ensure the absence of voltage, and grounded if determined necessary"

"Enclosed: Surrounded by a case, housing, fence, or wall(s) that prevents persons from accidentally contacting energized parts"

"Enclosure: The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage"

"Energized: Electrically connected to or having a source of voltage"

"Flame-Resistant (FR): The property of a material whereby combustion is prevented, terminated, or inhibited following the application of a flaming or non-flaming source of ignition, with or without subsequent removal of the ignition source.
FPN: Flame resistance can be an inherent property of a material, or it can be imparted by a specific treatment applied to the material"

"Flash Hazard: A dangerous condition associated with the release of energy caused by an electric arc"

"Flash Hazard Analysis: A study investigating a worker's potential exposure to arc-flash energy, conducted for the purpose of injury prevention and the determination of safe work practices and the appropriate levels of PPE"

"Flash Protection Boundary: An approach limit at a distance from exposed live parts within which a person could receive a second degree burn if an electrical arc flash were to occur"

"Flash Suit: A complete FR clothing and equipment system that covers the entire body, except for the hands and feet. This includes pants, jacket, and bee-keeper-type hood fitted with a face shield"

"Incident Energy: The amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event. One of the units used to measure incident energy is calories per centimeter squared (cal/cm^2)"

"Limited Approach Boundary: An approach limit at a distance from an exposed live part within which a shock hazard exists"

"Live Parts: Energized conductive components"

"Prohibited Approach Boundary: An approach limit at a distance from an exposed live part within which work is considered the same as making contact with the live part"

"Qualified Person: One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training on the hazards involved"

"Restricted Approach Boundary: An approach limit at a distance from an exposed live part within which there is an increased risk of shock, due to electrical arc over combined with inadvertent movement, for personnel working in close proximity to the live part"

For the benefit of this report's reader, NFPA's concepts that are relevant to the study have been re-iterated as follows:

Electrical Hazard Analysis. If the live parts operating at 50 volts or more are not placed in an electrically safe work condition, other safety-related work practices shall be used to protect employees who might be exposed to the electrical hazards involved. Such work practices shall protect each employee from arc flash and from contact with live parts operating at 50 volts or more directly with any part of the body or indirectly through some other conductive object. Work practices that are used shall be suitable for the conditions under which the work is to be performed and for the voltage level of the live parts. Appropriate safety-related work practices shall be determined before any person approaches exposed live parts within the Limited Approach Boundary by using both shock hazard analysis and flash hazard analysis.

(a) Shock Hazard Analysis. A shock hazard analysis shall determine the voltage to which personnel will be exposed, boundary requirements, and the personal protective equipment necessary in order to minimize the possibility of electrical shock to personnel.
FPN: See 130.2 for the requirements of conducting a shock hazard analysis.

(b) Flash Hazard Analysis. A flash hazard analysis shall be done in order to protect personnel from the possibility of being injured by an arc flash. The analysis shall determine the Flash Protection Boundary and the personal protective equipment that people within the Flash Protection Boundary shall use.
FPN: See 130.3 for the requirements of conducting a flash hazard analysis.

130.2 Approach Boundaries to Live Parts

(A) Shock Hazard Analysis. A shock hazard analysis shall determine the voltage to which personnel will be exposed, boundary requirements, and the personal protective equipment necessary in order to minimize the possibility of electric shock to personnel.

(B) Shock Protection Boundaries. The shock protection boundaries identified as Limited, Restricted, and Prohibited Approach Boundaries are applicable to the situation in which approaching personnel are exposed to live parts. See Table 130.2(C) for the distances associated with various system voltages.
FPN: In certain instances, the Flash Protection Boundary might be a greater distance from the exposed live parts than the Limited Approach Boundary.

(C) Approach to Exposed Live Parts Operating at 50 Volts or More. No qualified person shall approach or take any conductive object closer to exposed live parts operating at 50 volts or more than the Restricted Approach Boundary set forth in Table 130.2(C), unless any of the following apply:

1. The qualified person is insulated or guarded from the live parts operating at 50 volts or more (insulating gloves or insulating gloves and sleeves are considered insulation only with regard to the energized parts upon which work is being performed), and no un-insulated part of the qualified person's body crosses the Prohibited Approach Boundary set forth in Table 130.2(C).
2. The live part operating at 50 volts or more is insulated from the qualified person and from any other conductive object at a different potential.
3. The qualified person is insulated from any other conductive object as during live-line bare-hand work.

(D) Approach by Unqualified Persons. Unqualified persons shall not be permitted to enter spaces that are required under 400.16(A) to be accessible to qualified employees only, unless the electric conductors and equipment involved are in an electrically safe work condition.

Working At or Close to the Limited Approach Boundary: Where one or more unqualified persons are working at or close to the Limited Approach Boundary, the designated person in charge of the work space where the electrical hazard exists shall cooperate with the designated person in charge of the unqualified person(s) to ensure that all work can be done safely. This shall include advising the unqualified person(s) of the electrical hazard and warning him or her to stay outside of the Limited Approach Boundary.

Entering the Limited Approach Boundary: Where there is a need for an unqualified person(s) to cross the Limited Approach Boundary, a qualified person shall advise him or her of the possible hazards and continuously escort the unqualified person(s) while inside the Limited Approach Boundary. Under no circumstance shall the escorted unqualified person(s) be permitted to cross the Restricted Approach Boundary.

130.3 Flash Hazard Analysis

A flash hazard analysis shall be done in order to protect personnel from the possibility of being injured by an arc flash. The analysis shall determine the Flash Protection Boundary and the personal protective equipment that people within the Flash Protection Boundary shall use.

(A) Flash Protection Boundary. For systems that are 600 volts or less, the Flash Protection Boundary shall be 4.0 ft, based on the product of clearing times of 6 cycles (0.1 second) and the available bolted fault current of 50 kA or any combination not exceeding 300 kA cycles (5000 ampere seconds). For clearing times and bolted fault currents other than 300 kA cycles, or under engineering supervision, the Flash Protection Boundary shall alternatively be permitted to be calculated in accordance with the following general formula:

$$D_c = \left[62.65 \times MVA_{bf} \times t\right]^{\frac{1}{2}}$$

Or

$$D_c = \left[53 \times MVA \times t\right]^{\frac{1}{2}}$$

Where:
D_c = distance in feet from an arc source for a second-degree burn
MVA_{bf} = bolted fault capacity available at point involved (in mega volt-amps)
MVA = capacity rating of transformer (mega volt-amps). For transformers with *MVA* ratings below 0.75 MVA, multiply the transformer *MVA* rating by 1.25
t = time of arc exposure (in seconds)

At voltage levels above 600 volts, the Flash Protection Boundary is the distance at which the incident energy equals 5 J/cm^2(1.2 cal/cm^2). For situations where fault clearing time is 0.1 second (or faster), the Flash Protection Boundary is the distance at which the incident energy level equals 6.24 J/cm^2(1.5 cal/cm^2).

(B) Protective Clothing and Personal Protective Equipment for Application with a Flash Hazard Analysis. Where it has been determined that work will be performed within the Flash Protection Boundary by 130.3(A), the flash hazard analysis shall determine, and the employer shall document, the incident energy exposure of the worker (in calories per square centimeter). The incident energy exposure level shall be based on the working distance of the employee's face and chest areas from a prospective arc source for the specific task to be performed. Flame-resistant (FR) clothing and personal protective equipment (PPE) shall be used by the employee based on the incident energy exposure associated with the specific task. Recognizing that incident energy increases as the distance from the arc flash decreases, additional PPE shall be used for any parts of the body that are closer than the distance at which the incident energy was determined As an alternative, the PPE requirements of 130.7(C) (9) shall be permitted to be used in lieu of the detailed flash hazard analysis approach described in 130.3(A).

Table 130.2(C) Approach Boundaries to Live Parts for Shock Protection. (All dimensions are distance from live part to employee.)

(1)	(2)	(3)	(4)	(5)
	Limited Approach Boundary1		**Restricted Approach Boundary1; Includes Inadvertent Movement Adder**	**Prohibited Approach Boundary1**
Nominal System Voltage Range, Phase to Phase	**Exposed Movable Conductor**	**Exposed Fixed Circuit Part**		
Less than 50	Not specified	Not specified	Not specified	Not specified
50 to 300	3.05 m (10 ft 0 in.)	1.07 m (3 ft 6 in.)	Avoid contact	Avoid contact
301 to 750 3.	05 m (10 ft 0 in.)	1.07 m (3 ft 6 in.)	304.8 mm (1 ft 0 in.)	25.4 mm (0 ft 1 in.)
751 to 15 kV	3.05 m (10 ft 0 in.)	1.53 m (5 ft 0 in.)	660.4 mm (2 ft 2 in.)	177.8 mm (0 ft 7 in.)
15.1 kV to 36 kV	3.05 m (10 ft 0 in.)	1.83 m (6 ft 0 in.)	787.4 mm (2 ft 7 in.)	254 mm (0 ft 10 in.)
36.1 kV to 46 kV	3.05 m (10 ft 0 in.)	2.44 m (8 ft 0 in.)	838.2 mm (2 ft 9 in.)	431.8 mm (1 ft 5 in.)
46.1 kV to 72.5 kV	3.05 m (10 ft 0 in.)	2.44 m (8 ft 0 in.)	965.2 mm (3 ft 2 in.)	635 mm (2 ft 1 in.)
72.6 kV to 121 kV	3.25 m (10 ft 8 in.)	2.44 m (8 ft 0 in.)	991 mm (3 ft 3 in.)	812.8 mm (2 ft 8 in.)
138 kV to 145 kV	3.36 m (11 ft 0 in.)	3.05 m (10 ft 0 in.)	1.093 m (3 ft 7 in.)	939.8 mm (3 ft 1 in.)
161 kV to 169 kV	3.56 m (11 ft 8 in.)	3.56 m (11 ft 8 in.)	1.22 m (4 ft 0 in.)	1.07 m (3 ft 6 in.)
230 kV to 242 kV	3.97 m (13 ft 0 in.)	3.97 m (13 ft 0 in.)	1.6 m (5 ft 3 in.)	1.45 m (4 ft 9 in.)
345 kV to 362 kV	4.68 m (15 ft 4 in.)	4.68 m (15 ft 4 in.)	2.59 m (8 ft 6 in.)	2.44 m (8 ft 0 in.)
500 kV to 550 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)	3.43 m (11 ft 3 in.)	3.28 m (10 ft 9 in.)
765 kV to 800 kV	7.24 m (23 ft 9 in.)	7.24 m (23 ft 9 in.)	4.55 m (14 ft 11 in.)	4.4 m (14 ft 5 in.)

Note: For Flash Protection Boundary, see 130.3(A).
1 See definition in Article 100 and text in 130.2(D) (2) and Annex C for elaboration.

Table 130.7(C) (10) Protective Clothing and Personal Protective Equipment (PPE) Matrix

Protective Clothing and Equipment	**Protective Systems for Hazard/Risk Category**					
Hazard/Risk Category Number	**-1** (Note 3)	**0**	**1**	**2**	**3**	**4**
Non-melting (according to ASTM F 1506-00) or Untreated Natural Fiber						
a. T-shirt (short-sleeve)	X			X	X	X
b. Shirt (long-sleeve)		X				
c. Pants (long)	X	X	X (Note 4)	X (Note 6)	X	X
FR Clothing (Note 1)						
a. Long-sleeve shirt			X	X	X (Note 9)	X
b. Pants			X (Note 4)	X (Note 6)	X (Note 9)	X
c. Coverall			(Note 5)	(Note 7)	X (Note 9)	(Note 5)
d. Jacket, parka, or rainwear			AN	AN	AN	AN
FR Protective Equipment						
a. Flash suit jacket (multilayer)						X
b. Flash suit pants (multilayer)						X
c. Head protection						
1. Hard hat			X	X	X	X
2. FR hard hat liner					AR	AR
d. Eye protection		—	—	—	—	—
1. Safety glasses	X	X	X	AL	AL	AL
2. Safety goggles				AL	AL	AL
e. Face and head area protection		—	—	—	—	—
1. Arc-rated face shield, or flash suit hood				X (Note 8)		
2. Flash suit hood					X	X
3. Hearing protection (ear canal inserts)				X (Note 8)	X	X
f. Hand protection			—	—	—	—
Leather gloves (Note 2)			AN	X	X	X
g. Foot protection						
Leather work shoes			AN	X	X	X

AN = As needed
AL = Select one in group
AR = As required
X = Minimum required

Notes:
1. See Table 130.7(C) (11). Arc rating for a garment is expressed in cal/cm^2.

2. If voltage-rated gloves are required, the leather protectors worn external to the rubber gloves satisfy this requirement.

3. Hazard/Risk Category Number "-1" is only defined if determined by Notes 3 or 6 of Table 130.7(C)(9)(a).

4. Regular weight (minimum 12 oz/yd2 fabric weight), untreated, denim cotton blue jeans are acceptable in lieu of FR pants. The FR pants used for Hazard/Risk Category 1 shall have a minimum arc rating of 4.

5. Alternate is to use FR coveralls (minimum arc rating of 4) instead of FR shirt and FR pants.

6. If the FR pants have a minimum arc rating of 8, long pants of non-melting or untreated natural fiber are not required beneath the FR pants.

7. Alternate is to use FR coveralls (minimum arc rating of 4) over non-melting or untreated natural fiber pants and T-shirt.

8. A face shield with a minimum arc rating of 8, with wrap-around guarding to protect not only the face, but also the forehead, ears, and neck (or, alternatively, a flash suit hood), is required.

9. Alternate is to use two sets of FR coveralls (the inner with a minimum arc rating of 4 and outer coverall with a minimum arc rating of 5) over non-melting or untreated natural fiber clothing, instead of FR coveralls over FR shirt and FR pants over non-melting or untreated natural fiber clothing.

Table 130.7(C) (11) Protective Clothing Characteristics

Hazard/Risk Category	Typical Protective Clothing Systems	Required Minimum Arc Rating of PPE [J/cm^2 (cal/cm^2)]
	Clothing Description (Typical number of clothing layers is given in parentheses)	
0	Non-melting, flammable materials (i.e., untreated cotton, wool, rayon, or silk, or blends of these materials) with a fabric weight at least 4.5 oz/yd^2 (1)	N/A
1	FR shirt and FR pants or FR coverall (1)	16.74 (4)
2	Cotton underwear — conventional short sleeve and brief/shorts, plus FR shirt and FR pants (1 or 2)	33.47 (8)
3	Cotton underwear plus FR shirt and FR pants plus FR coverall, or cotton underwear plus two FR coveralls (2 or 3)	104.6 (25)
4	Cotton underwear plus FR shirt and FR pants plus multilayer flash suit (3 or more)	167.36 (40)

Note: Arc rating is defined in Article 100 and can be either ATPV or EBT. ATPV is defined in ASTM F 1959-99 as the incident energy on a fabric or material that results in sufficient heat transfer through the fabric or material to cause the onset of a second-degree burn based on the Stoll curve. E_{BT} is defined in ASTM F 1959-99 as the average of the five highest incident energy exposure values below the Stoll curve where the specimens do not exhibit break-open. E_{BT} is reported when ATPV cannot be measured due to FR fabric break open.

Clothing Material Characteristics. FR clothing shall meet the requirements described in 130.7(C) (14) (a) through 130.7(C) (15).
FPN: FR materials, such as flame-retardant treated cotton, meta-aramid, para-aramid, and poly-benzimidazole (PBI) fibers, provide thermal protection. These materials can ignite but will not continue to burn after the ignition source is removed. FR fabrics can reduce burn injuries during an arc flash exposure by providing a thermal barrier between the arc flash and the wearer. In aramid and PBI blends, paraaramid adds strength to a fabric to prevent the fabric from breaking open due to the blast shock wave and high thermal energy of the arc.
(a) Melting. Clothing made from flammable synthetic materials that melt at temperatures below 315°C (600°F), such as acetate, nylon, polyester, polypropylene, and spandex, either alone or in blends, shall not be used.
FPN: These materials melt as a result of arc flash exposure conditions, form intimate contact with the skin, and aggravate the burn injury.

Exception: Fiber blends that contain materials that melt, such as acetate, nylon, polyester, polypropylene, and spandex, shall be permitted if such blends in fabrics meet the requirements of ASTM F 1506, Standard Performance Specification for Textile Material for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards, and if such blends in fabrics do not exhibit evidence of a melting and sticking hazard during arc testing according to ASTM F 1959 [see also 130.7(C)(15)]. Non–flame-resistant synthetic *materials, such as acetate, nylon, polyester, rayon, either alone or in blends with non–flame resistant cotton, can melt into the skin when exposed to high temperatures and aggravate the burn injury.*

(b) Flammability. Clothing made from non-melting flammable natural materials, such as cotton, wool, rayon, or silk, shall be permitted for Hazard/Risk Categories 0 and considered acceptable if it is determined by flash hazard analysis that the exposure level is 8.36 J/cm2 (2.0 cal/cm2) or less, and that the fabric will not ignite and continue to burn under the arc exposure hazard conditions to which it will be exposed (using data from tests done in accordance with ASTM F 1958.) See also 130.7(C) (12) (a) for layering requirements.
FPN No. 1: Non-FR cotton, polyester-cotton blends, nylon, nylon-cotton blends, silk, rayon, and wool fabrics are flammable. These fabrics could ignite and continue to burn on the body, resulting in serious burn injuries.
FPN No. 2: Rayon is a cellulose-based (wood pulp) synthetic fiber that is a flammable but non-melting material.

(c) Hand Protection. Leather or FR gloves shall be worn where required for arc flash protection. Where insulating rubber gloves are used for shock protection, leather protectors shall be worn over the rubber gloves.
FPN: Insulating rubber gloves and gloves made from layers of flame-resistant material provide hand protection against the arc flash hazard. Heavy-duty leather (e.g., greater than 12 oz/yd2) gloves provide protection suitable up to Hazard/Risk Category 2. The leather protectors worn over insulating rubber gloves provide additional arc flash protection for the hands. During high arc flash exposures leather can shrink and cause a decrease in protection.

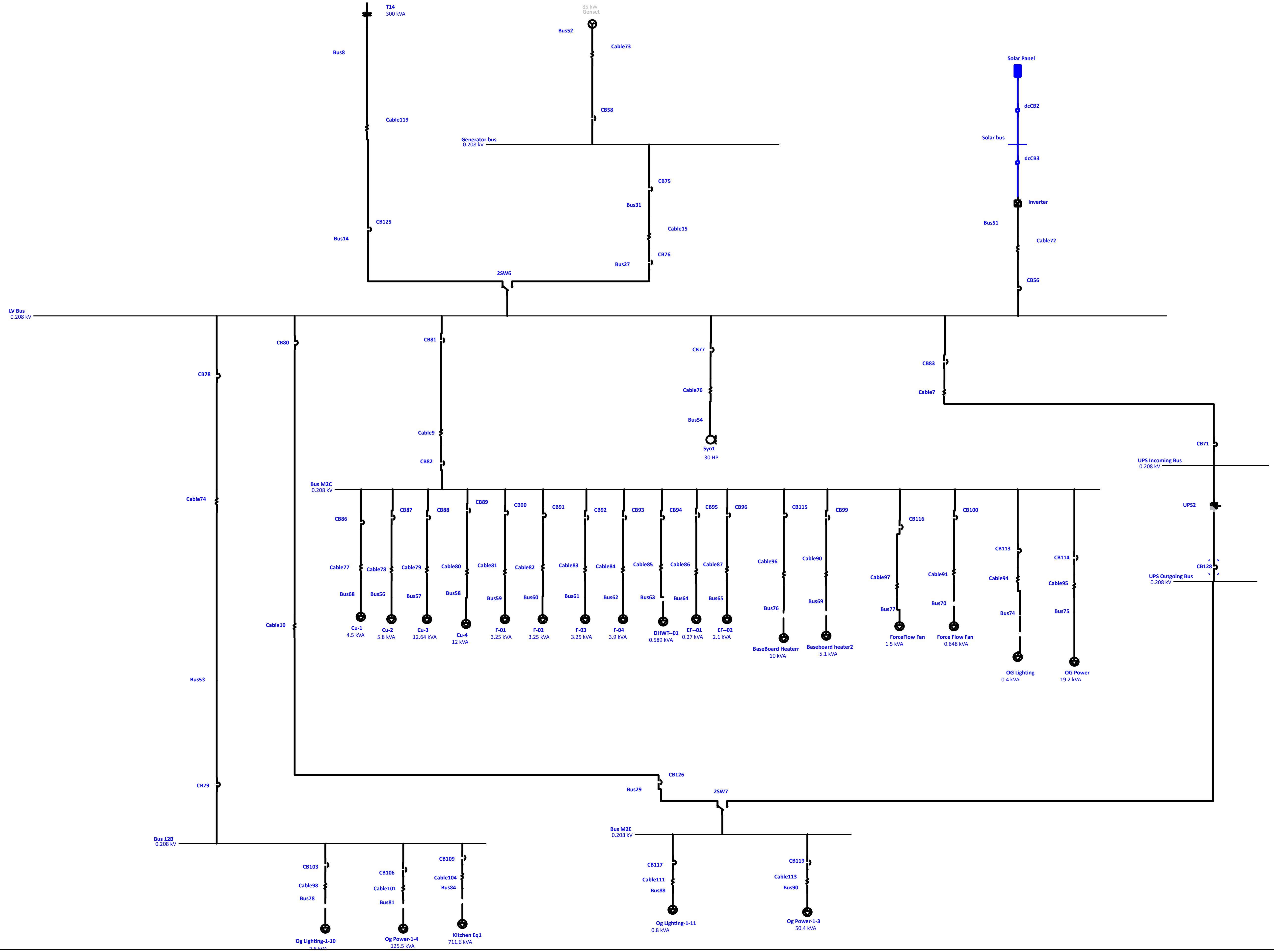
(d) Foot Protection. Heavy-duty leather work shoes provide some arc flash protection to the feet and shall be used in all tasks in Hazard/Risk Category 2 and higher.

Clothing Not Permitted. Clothing made from materials that do not meet the requirements of 130.7(C)(14)(a) regarding melting, or made from materials that do not meet the flammability requirements of 130.7(C)(14)(b), shall not be permitted to be worn.
FPN: Some flame-resistant fabrics, such as non-FR modacrylic and nondurable flame-retardant treatments of cotton, are not recommended for industrial electrical or utility applications.
Exception: Non-melting, flammable (non-FR) materials shall be permitted to be used as under-layers to FR clothing, as described in 130.7(C)(14)(a) and also shall be permitted to be used for Hazard/Risk Category 0 and .1 as described in Table 130.7(C)(10).

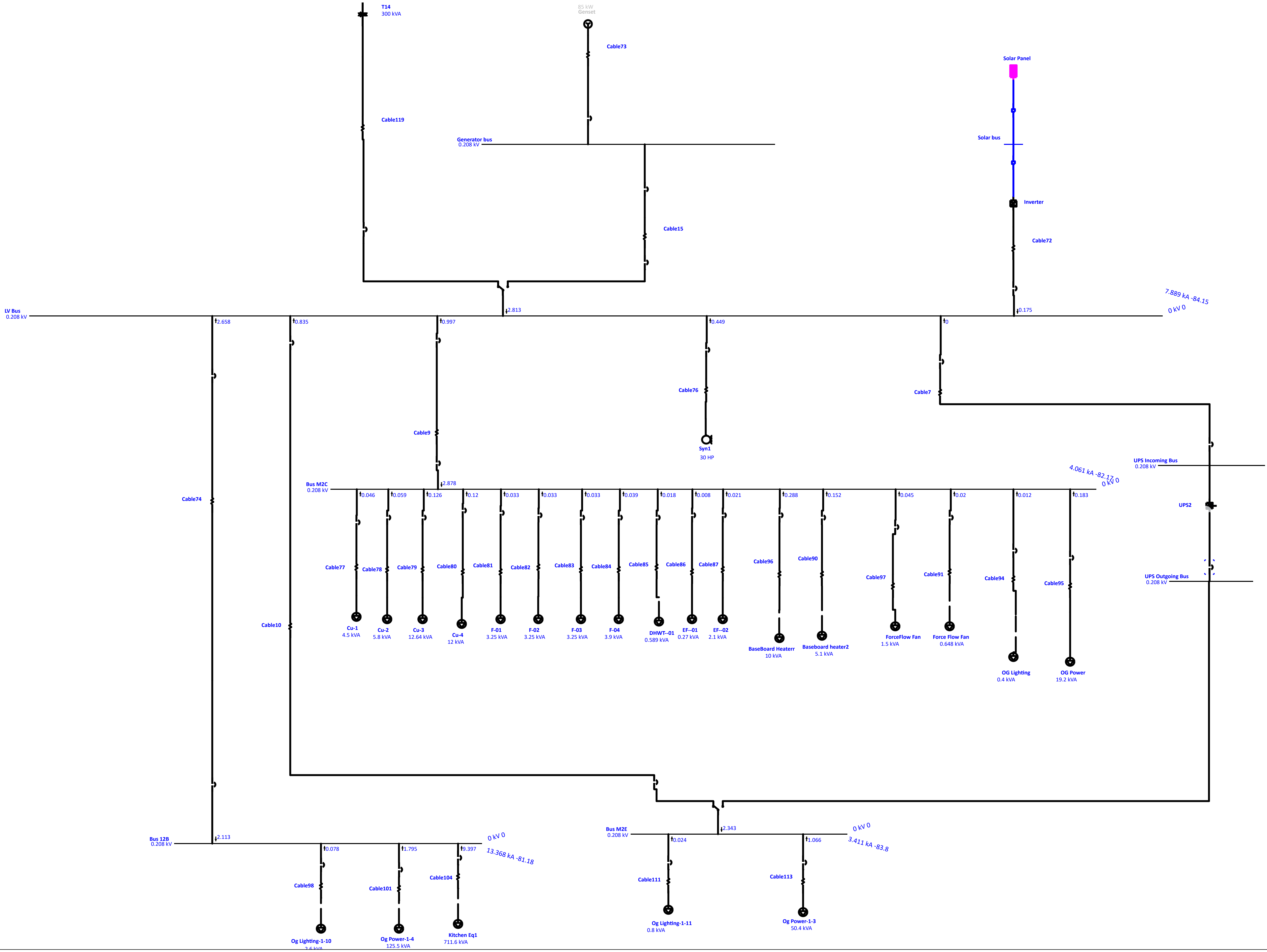
Appendix B: Single Line Diagrams with Short Circuit and Arc Flash Energy Levels

Appendix C: Data from the Short Circuit Study

Appendix D: Time Current Characteristics (TCC) Curve


T14
300 kVA
Bus8
85 kW
Genset
Bus52
Cable73
Cable119
CB58
Generator bus
0.208 kV
CB75
Bus31
CB125
Bus14
Cable15
CB76
Bus27
2SW6
Solar Panel
dcCB2
Solar bus
dcCB3
Inverter
Bus51
Cable72
CB56
LV Bus
0.208 kV
CB80
CB81
CB77
CB83
CB78
Cable76
Cable7
Bus54
Syn1
30 HP
Cable9
CB82
CB71
UPS Incoming Bus
0.208 kV
Bus M2C
0.208 kV
Cable74
CB86
CB87
CB88
CB89
CB90
CB91
CB92
CB93
CB94
CB95
CB96
CB115
CB99
CB116
CB100
UPS2
CB113
CB114
CB128
UPS Outgoing Bus
0.208 kV
Cable77
Cable78
Cable79
Cable80
Cable81
Cable82
Cable83
Cable84
Cable85
Cable86
Cable87
Cable96
Cable90
Cable97
Cable91
Cable94
Cable95
Bus68
Bus56
Bus57
Bus58
Bus59
Bus60
Bus61
Bus62
Bus63
Bus64
Bus65
Bus76
Bus69
Bus77
Bus70
Bus74
Bus75
Cable10
Cu-1
4.5 kVA
Cu-2
5.8 kVA
Cu-3
12.64 kVA
Cu-4
12 kVA
F-01
3.25 kVA
F-02
3.25 kVA
F-03
3.25 kVA
F-04
3.9 kVA
DHWT--01
0.589 kVA
EF--01
0.27 kVA
EF--02
2.1 kVA
BaseBoard Heaterr
10 kVA
Baseboard heater2
5.1 kVA
ForceFlow Fan
1.5 kVA
Force Flow Fan
0.648 kVA
OG Lighting
0.4 kVA
OG Power
19.2 kVA
Bus53
CB126
Bus29
2SW7
CB79
Bus 12B
0.208 kV
Bus M2E
0.208 kV
CB103
CB106
CB109
CB117
CB119
Cable98
Cable101
Cable104
Cable111
Cable113
Bus78
Bus81
Bus84
Bus88
Bus90
Og Lighting-1-10
Og Power-1-4
125.5 kVA
Kitchen Eq1
711.6 kVA
Og Lighting-1-11
0.8 kVA
Og Power-1-3
50.4 kVA

One-Line Diagram - OLV1 (Short-Circuit Analysis)



Electrical Transient Analyzer Program

Short-Circuit Analysis

ANSI Standard

3-Phase, LG, LL, & LLG Fault Currents

1/2 Cycle Network

	Swing	V-Control	Load	Total
Number of Buses:	1	1	32	34

	XFMR2	XFMR3	Reactor	Line/Cable/ Busway	Impedance	Tie PD	Total
Number of Branches:	1	0	0	29	0	3	33

	Synchronous Generator	Power Grid	Synchronous Motor	Induction Machines	Lumped Load	Total
Number of Machines:	0	1	1	0	22	24

System Frequency:	60.00
Unit System:	English
Project Filename:	Power System
Output Filename:	C:\ETAP 1901\Power System\test1.SA2S

Adjustments

Tolerance	Apply Adjustments	Individual /Global	Percent
Transformer Impedance:	Yes	Individual	
Reactor Impedance:	Yes	Individual	
Overload Heater Resistance:	No		
Transmission Line Length:	No		
Cable / Busway Length:	No		

Temperature Correction	Apply Adjustments	Individual /Global	Degree C
Transmission Line Resistance:	Yes	Individual	
Cable / Busway Resistance:	Yes	Individual	

Bus Input Data

Bus					Initial Voltage	
ID	Type	Nom. kV	Base kV	Sub-sys	%Mag.	Ang.
Bus M2C	Load	0.208	0.208	1	100.00	-30.00
Bus8	Load	0.208	0.208	1	100.00	-30.00
Bus 12B	Load	0.208	0.208	1	100.00	-30.00
Bus M2E	Load	0.208	0.208	1	100.00	-30.00
Bus14	Load	0.208	0.208	1	100.00	-30.00
Bus29	Load	0.208	0.208	1	100.00	-30.00
Bus51	Gen.	0.208	0.208	1	0.00	-30.00
Bus53	Load	0.208	0.208	1	100.00	-30.00
Bus54	Load	0.208	0.208	1	100.00	-30.00
Bus56	Load	0.208	0.208	1	100.00	-30.00
Bus57	Load	0.208	0.208	1	100.00	-30.00
Bus58	Load	0.208	0.208	1	100.00	-30.00
Bus59	Load	0.208	0.208	1	100.00	-30.00
Bus60	Load	0.208	0.208	1	100.00	-30.00
Bus61	Load	0.208	0.208	1	100.00	-30.00
Bus62	Load	0.208	0.208	1	100.00	-30.00
Bus63	Load	0.208	0.208	1	100.00	-30.00
Bus64	Load	0.208	0.208	1	100.00	-30.00
Bus65	Load	0.208	0.208	1	100.00	-30.00
Bus68	Load	0.208	0.208	1	100.00	-30.00
Bus69	Load	0.208	0.208	1	100.00	-30.00
Bus70	Load	0.208	0.208	1	100.00	-30.00
Bus74	Load	0.208	0.208	1	100.00	-30.00
Bus75	Load	0.208	0.208	1	100.00	-30.00
Bus76	Load	0.208	0.208	1	100.00	-30.00
Bus77	Load	0.208	0.208	1	100.00	-30.00
Bus78	Load	0.208	0.208	1	100.00	-30.00
Bus81	Load	0.208	0.208	1	100.00	-30.00
Bus84	Load	0.208	0.208	1	100.00	-30.00
Bus88	Load	0.208	0.208	1	100.00	-30.00
Bus90	Load	0.208	0.208	1	100.00	-30.00
LV Bus	Load	0.208	0.208	1	100.00	-30.00
Main Bus	SWNG	25.000	25.000	1	100.00	0.00
UPS Incoming Bus	Load	0.208	0.208	1	100.00	-30.00

34 Buses Total

All voltages reported by ETAP are in % of bus Nominal kV.
Base kV values of buses are calculated and used internally by ETAP.

Line/Cable/Busway Input Data

Line/Cable/Busway			Length		ohms or siemens per 1000 ft per Conductor (Cable) or per Phase (Line/Busway)							
ID	Library	Size	Adj. (ft)	% Tol.	#/Phase	T (°C)	R1	X1	Y1	R0	X0	Y0
Cable7			118.1	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable9			65.6	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable10			91.9	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable72			98.4	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable74			91.9	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable76			65.6	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable77			72.2	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable78			72.2	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable79			72.2	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable80			72.2	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable81			118.1	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable82			118.1	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable83			118.1	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable84			95.1	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable85			137.8	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable86			275.6	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable87			150.9	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable90			68.9	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable91			108.3	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable94			137.8	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable95			124.7	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable96			75.5	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable97			108.3	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable98			98.4	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable101			98.4	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable104			20.0	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable111			98.4	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable113			98.4	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001
Cable119			98.4	0.0	1	75	0.001	0.37699	0.001	0.001	0.37699	0.001

Line / Cable / Busway resistances are listed at the specified temperatures.

2-Winding Transformer Input Data

Transformer	Rating					Z Variation			% Tap Setting		Adjusted	Phase Shift	
ID	MVA	Prim. kV	Sec. kV	% Z	X/R	+ 5%	- 5%	% Tol.	Prim.	Sec.	% Z	Type	Angle
T14	0.225	25.000	0.208	4.00	3.45	0	0	0	0	0	4.00	Dyn	30.00

2-Winding Transformer Grounding Input Data

				Grounding								
Transformer	Rating			Conn.	Primary				Secondary			
ID	MVA	Prim. kV	Sec. kV	Type	Type	kV	Amp	ohm	Type	kV	Amp	ohm
T14	0.225	25.000	0.208	D/Y					Solid			

Branch Connections

CKT/Branch		Connected Bus ID		% Impedance, Pos. Seq., 100 MVAb			
ID	Type	From Bus	To Bus	R	X	Z	Y
T14	2W XFMR	Main Bus	Bus8	494.93	1707.50	1777.78	
Cable7	Cable	LV Bus	UPS Incoming Bus	27.30	10291.78	10291.82	0.0000051
Cable9	Cable	LV Bus	Bus M2C	15.17	5717.66	5717.68	0.0000028
Cable10	Cable	LV Bus	Bus29	21.23	8004.72	8004.75	0.0000040
Cable72	Cable	Bus51	LV Bus	22.75	8576.49	8576.52	0.0000043
Cable74	Cable	LV Bus	Bus53	21.23	8004.72	8004.75	0.0000040
Cable76	Cable	LV Bus	Bus54	15.17	5717.66	5717.68	0.0000028
Cable77	Cable	Bus M2C	Bus68	16.68	6289.42	6289.45	0.0000031
Cable78	Cable	Bus M2C	Bus56	16.68	6289.42	6289.45	0.0000031
Cable79	Cable	Bus M2C	Bus57	16.68	6289.42	6289.45	0.0000031
Cable80	Cable	Bus M2C	Bus58	16.68	6289.42	6289.45	0.0000031
Cable81	Cable	Bus M2C	Bus59	27.30	10291.78	10291.82	0.0000051
Cable82	Cable	Bus M2C	Bus60	27.30	10291.78	10291.82	0.0000051
Cable83	Cable	Bus M2C	Bus61	27.30	10291.78	10291.82	0.0000051
Cable84	Cable	Bus M2C	Bus62	21.99	8290.60	8290.63	0.0000041
Cable85	Cable	Bus M2C	Bus63	31.85	12007.08	12007.12	0.0000060
Cable86	Cable	Bus M2C	Bus64	63.70	24014.16	24014.25	0.0000119
Cable87	Cable	Bus M2C	Bus65	34.88	13150.61	13150.66	0.0000065
Cable90	Cable	Bus M2C	Bus69	15.92	6003.54	6003.56	0.0000030
Cable91	Cable	Bus M2C	Bus70	25.02	9434.14	9434.17	0.0000047
Cable94	Cable	Bus M2C	Bus74	31.85	12007.08	12007.12	0.0000060
Cable95	Cable	Bus M2C	Bus75	28.82	10863.55	10863.59	0.0000054
Cable96	Cable	Bus M2C	Bus76	17.44	6575.31	6575.33	0.0000033
Cable97	Cable	Bus M2C	Bus77	25.02	9434.14	9434.17	0.0000047
Cable98	Cable	Bus 12B	Bus78	22.75	8576.49	8576.52	0.0000043
Cable101	Cable	Bus 12B	Bus81	22.75	8576.49	8576.52	0.0000043
Cable104	Cable	Bus 12B	Bus84	4.62	1742.74	1742.75	0.0000009
Cable111	Cable	Bus M2E	Bus88	22.75	8576.49	8576.52	0.0000043
Cable113	Cable	Bus M2E	Bus90	22.75	8576.49	8576.52	0.0000043
Cable119	Cable	Bus8	Bus14	22.75	8576.49	8576.52	0.0000043
CB79	Tie Breakr	Bus53	Bus 12B				
2SW6	Tie Switch	LV Bus	Bus14				
2SW7	Tie Switch	Bus M2E	Bus29				

Power Grid Input Data

Power Grid	Connected Bus	Rating		% Positive Seq. Impedance 100 MVA Base			Grounding	% Zero Seq. Impedance 100 MVA Base		
ID	ID	MVASC	kV	X/R	R	X	Type	X/R	R0	X0
U1	Main Bus	250.000	25.000	0.01	39.99800	0.39998	Wye - Solid	0.01	39.998000	0.39998

Total Power Grids (= 1) 250.000 MVA

Synchronous Motor Input Data

Synchronous Motor			Rating (Base)			Positive Sequence Imp.					Grounding			Zero Seq. Imp.		
								Xd"								
ID	Type	Qty	kVA	kV	RPM	X"/R	% R	Adj.	Tol.	% X'	Conn.	Type	Amp	X/R	% R0	% X0
Syn1	Motor	1	28.1	0.200	1800	4.27	3.907	16.667	0.0	25.000	Wye	Open		4.27	3.91	16.67

Total Connected Synchronous Motors (= 1): 28.1 kVA

Lumped Load Input Data

Lumped Load					Motor Loads									
Lumped Load	Rating		% Load		Loading		X/R Ratio		Impedance (Machine Base)			Grounding		
ID	kVA	kV	MTR	STAT	kW	kvar	X"/R	X'/R	% R	% X"	% X'	Conn.	Type	Amp.
Baseboard heater2	5.1	0.120	80	20	3.7	1.8	2.38	2.38	8.403	20.00	50.00	Wye	Solid	
BaseBoard Heaterr	10.0	0.120	80	20	7.2	3.5	2.38	2.38	8.403	20.00	50.00	Wye	Solid	
Cu-1	4.5	0.208	80	20	3.2	1.6	2.38	2.38	8.403	20.00	50.00	Delta		
Cu-2	5.8	0.208	80	20	4.2	2.0	2.38	2.38	8.403	20.00	50.00	Delta		
Cu-3	12.6	0.208	80	20	9.1	4.4	2.38	2.38	8.403	20.00	50.00	Delta		
Cu-4	12.0	0.208	80	20	8.6	4.2	2.38	2.38	8.403	20.00	50.00	Delta		
DHWT--01	0.6	0.120	80	20	0.4	0.2	2.38	2.38	8.403	20.00	50.00	Wye	Solid	
EF--01	0.3	0.120	80	20	0.2	0.1	2.38	2.38	8.403	20.00	50.00	Wye	Solid	
EF--02	2.1	0.208	80	20	1.5	0.7	2.38	2.38	8.403	20.00	50.00	Delta		
F-01	3.3	0.208	80	20	2.3	1.1	2.38	2.38	8.403	20.00	50.00	Delta		
F-02	3.3	0.208	80	20	2.3	1.1	2.38	2.38	8.403	20.00	50.00	Delta		
F-03	3.3	0.208	80	20	2.3	1.1	2.38	2.38	8.403	20.00	50.00	Delta		
F-04	3.9	0.208	80	20	2.8	1.4	2.38	2.38	8.403	20.00	50.00	Delta		
Force Flow Fan	0.6	0.120	80	20	0.5	0.2	2.38	2.38	8.403	20.00	50.00	Wye	Solid	
ForceFlow Fan	1.5	0.120	80	20	1.1	0.5	2.38	2.38	8.403	20.00	50.00	Wye	Solid	
Kitchen Eq1	711.6	0.120	80	20	512.4	248.2	2.38	2.38	8.403	20.00	50.00	Wye	Solid	
OG Lighting	0.4	0.120	80	20	0.3	0.1	2.38	2.38	8.403	20.00	50.00	Wye	Solid	
Og Lighting-1-10	2.6	0.120	80	20	1.9	0.9	2.38	2.38	8.403	20.00	50.00	Wye	Solid	
Og Lighting-1-11	0.8	0.120	80	20	0.6	0.3	2.38	2.38	8.403	20.00	50.00	Wye	Solid	
OG Power	19.2	0.208	80	20	13.8	6.7	2.38	2.38	8.403	20.00	50.00	Delta		
Og Power-1-3	50.4	0.120	80	20	36.3	17.6	2.38	2.38	8.403	20.00	50.00	Wye	Solid	
Og Power-1-4	125.5	0.120	80	20	92.0	40.1	2.38	2.38	8.403	20.00	50.00	Wye	Solid	

Total Connected Lumped Loads (= 22): 979.3 kVA

SHORT- CIRCUIT REPORT

Fault at bus: **Bus 12B**

Prefault voltage = 0.208 kV = 100.00 % of nominal bus kV (0.208 kV)
= 100.00 % of base kV (0.208 kV)

Contribution		3-Phase Fault		Line-To-Ground Fault					Positive & Zero Sequence Impedances Looking into "From Bus"			
From Bus ID	To Bus ID	% V From Bus	kA Symm. rms	% Voltage at From Bus Va	Vb	Vc	kA Symm. rms Ia	3I0	% Impedance on 100 MVA base R1	X1	R0	X0
Bus 12B	Total	0.00	13.351	0.00	100.34	100.38	13.256	13.256	3.23E+002	2.06E+003	3.29E+002	2.09E+003
Bus78	Bus 12B	2.42	0.078	2.42	100.33	100.37	0.078	0.079	1.34E+005	3.29E+005	1.34E+005	3.29E+005
Bus81	Bus 12B	55.45	1.795	55.45	100.11	100.21	1.795	1.814	2.81E+003	1.52E+004	2.81E+003	1.52E+004
Bus84	Bus 12B	59.00	9.397	59.00	100.10	100.19	9.397	9.496	4.96E+002	2.91E+003	4.96E+002	2.91E+003
LV Bus	Bus53	60.43	2.095	57.66	101.68	101.40	1.999	1.880	7.80E+002	1.32E+004	8.43E+002	1.49E+004

\# Indicates fault current contribution is from three-winding transformers
* Indicates a zero sequence fault current contribution (3I0) from a grounded Delta- Y transformer

Fault at bus: **Bus M2C**

Prefault voltage = 0.208 kV = 100.00 % of nominal bus kV (0.208 kV)
= 100.00 % of base kV (0.208 kV)

Contribution		3-Phase Fault		Line-To-Ground Fault					Positive & Zero Sequence Impedances Looking into "From Bus"			
From Bus ID	To Bus ID	% V From Bus	kA Symm. rms	% Voltage at From Bus Va	Vb	Vc	kA Symm. rms Ia	3I0	% Impedance on 100 MVA base R1	X1	R0	X0
Bus M2C	Total	0.00	4.043	0.00	105.75	102.67	3.719	3.719	9.77E+002	6.89E+003	7.61E+002	8.54E+003
LV Bus	Bus M2C	58.88	2.858	57.44	103.09	101.79	2.789	3.125	3.32E+002	9.71E+003	3.22E+002	1.02E+004
Bus68	Bus M2C	1.03	0.046	0.64	106.01	102.74	0.028	0.000	2.33E+005	5.62E+005		
Bus56	Bus M2C	1.33	0.059	0.82	106.08	102.75	0.036	0.000	1.81E+005	4.37E+005		
Bus57	Bus M2C	2.85	0.126	1.76	106.46	102.86	0.078	0.000	8.31E+004	2.04E+005		
Bus58	Bus M2C	2.71	0.120	1.68	106.42	102.85	0.074	0.000	8.76E+004	2.15E+005		
Bus59	Bus M2C	1.22	0.033	0.75	106.06	102.75	0.020	0.000	3.23E+005	7.80E+005		
Bus60	Bus M2C	1.22	0.033	0.75	106.06	102.75	0.020	0.000	3.23E+005	7.80E+005		
Bus61	Bus M2C	1.22	0.033	0.75	106.06	102.75	0.020	0.000	3.23E+005	7.80E+005		
Bus62	Bus M2C	1.18	0.039	0.73	106.05	102.74	0.024	0.000	2.69E+005	6.49E+005		
Bus63	Bus M2C	0.78	0.018	0.78	105.70	102.67	0.018	0.021	5.94E+005	1.42E+006	5.94E+005	1.42E+006
Bus64	Bus M2C	0.71	0.008	0.71	105.70	102.67	0.008	0.009	1.29E+006	3.11E+006	1.29E+006	3.11E+006
Bus65	Bus M2C	1.01	0.021	0.62	106.00	102.73	0.013	0.000	5.00E+005	1.20E+006		
Bus69	Bus M2C	3.29	0.152	3.29	105.51	102.66	0.152	0.175	6.86E+004	1.69E+005	6.86E+004	1.69E+005
Bus70	Bus M2C	0.67	0.020	0.67	105.70	102.67	0.020	0.023	5.40E+005	1.29E+006	5.40E+005	1.29E+006
Bus74	Bus M2C	0.53	0.012	0.53	105.71	102.67	0.012	0.014	8.74E+005	2.09E+006	8.74E+005	2.09E+006
Bus75	Bus M2C	7.18	0.183	4.43	107.51	103.20	0.113	0.000	5.47E+004	1.41E+005		
Bus76	Bus M2C	6.82	0.288	6.82	105.25	102.65	0.288	0.331	3.50E+004	8.98E+004	3.50E+004	8.98E+004
Bus77	Bus M2C	1.55	0.045	1.55	105.64	102.67	0.045	0.052	2.33E+005	5.64E+005	2.33E+005	5.64E+005

\# Indicates fault current contribution is from three-winding transformers

* Indicates a zero sequence fault current contribution (3I0) from a grounded Delta- Y transformer

Fault at bus: **Bus M2E**

Prefault voltage = 0.208 kV = 100.00 % of nominal bus kV (0.208 kV)
= 100.00 % of base kV (0.208 kV)

Contribution		3-Phase Fault		Line-To-Ground Fault					Positive & Zero Sequence Impedances Looking into "From Bus"			
From Bus ID	To Bus ID	% V From Bus	kA Symm. rms	% Voltage at From Bus Va	Vb	Vc	kA Symm. rms Ia	3I0	% Impedance on 100 MVA base R1	X1	R0	X0
Bus M2E	Total	0.00	3.399	0.00	100.66	100.58	3.323	3.323	9.16E+002	8.20E+003	9.38E+002	8.51E+003
Bus88	Bus M2E	0.75	0.024	0.75	100.65	100.58	0.024	0.025	4.37E+005	1.05E+006	4.37E+005	1.05E+006
Bus90	Bus M2E	32.94	1.066	32.94	100.36	100.49	1.066	1.092	6.96E+003	2.51E+004	6.96E+003	2.51E+004
LV Bus	Bus29	67.20	2.330	65.01	100.95	100.67	2.254	2.228	3.99E+002	1.19E+004	3.59E+002	1.28E+004

# Indicates fault current contribution is from three-winding transformers

* Indicates a zero sequence fault current contribution (3I0) from a grounded Delta- Y transformer

Fault at bus: **LV Bus**

Prefault voltage = 0.208 kV = 100.00 % of nominal bus kV (0.208 kV)
= 100.00 % of base kV (0.208 kV)

Contribution		**3-Phase Fault**		**Line-To-Ground Fault**					**Positive & Zero Sequence Impedances Looking into "From Bus"**			
From Bus	To Bus	% V	kA	% Voltage at From Bus			kA Symm. rms		% Impedance on 100 MVA base			
ID	ID	From Bus	Symm. rms	Va	Vb	Vc	Ia	3I0	R1	X1	R0	X0
LV Bus	Total	0.00	7.773	0.00	104.26	103.03	7.349	7.349	3.97E+002	3.63E+003	3.68E+002	4.15E+003
UPS Incoming Bus	LV Bus	0.00	0.000	0.00	104.26	103.03	0.000	0.000				
Bus M2C	LV Bus	20.54	0.997	16.71	106.07	103.78	0.811	0.544	8.39E+003	2.65E+004	1.89E+004	5.31E+004
Bus29	LV Bus	24.08	0.835	24.08	103.06	102.50	0.835	0.922	6.89E+003	3.25E+004	6.89E+003	3.25E+004
Bus51	LV Bus	5.40	0.175	3.03	107.28	106.06	0.098	0.000	7.51E-003	1.59E+005		
Bus53	LV Bus	76.67	2.658	76.67	100.87	100.82	2.658	2.936	4.44E+002	1.04E+004	4.44E+002	1.04E+004
Bus54	LV Bus	9.24	0.449	5.84	106.21	104.02	0.284	0.000	1.29E+004	6.05E+004		
Bus8	Bus14	83.27	2.695	83.28	100.64	100.57	2.695	2.977	5.58E+002	1.03E+004	5.18E+002	1.03E+004

\# Indicates fault current contribution is from three-winding transformers

* Indicates a zero sequence fault current contribution (3I0) from a grounded Delta- Y transformer

Fault at bus: **Main Bus**

Prefault voltage = 25.000 kV = 100.00 % of nominal bus kV (25.000 kV)
= 100.00 % of base kV (25.000 kV)

Contribution		3-Phase Fault		Line-To-Ground Fault					Positive & Zero Sequence Impedances Looking into "From Bus"			
From Bus ID	To Bus ID	% V From Bus	kA Symm. rms	% Voltage at From Bus Va	Vb	Vc	kA Symm. rms Ia	3I0	% Impedance on 100 MVA base R1	X1	R0	X0
Main Bus	Total	0.00	5.775	0.00	99.93	100.08	5.774	5.774	4.00E+001	5.00E-001	4.00E+001	4.00E-001
Bus8	Main Bus	11.40	0.015	62.31	60.12	100.08	0.010	0.000	1.24E+003	1.55E+004		
U1	Main Bus	100.00	5.774	100.00	100.00	100.00	5.774	5.774	4.00E+001	4.00E-001	4.00E+001	4.00E-001

\# Indicates fault current contribution is from three-winding transformers

* Indicates a zero sequence fault current contribution (3I0) from a grounded Delta- Y transformer

Short-Circuit Summary Report

1/2 Cycle - 3-Phase, LG, LL, & LLG Fault Currents

Prefault Voltage = 100 % of the Bus Nominal Voltage

Bus		3-Phase Fault			Line-to-Ground Fault			Line-to-Line Fault			*Line-to-Line-to-Ground		
ID	kV	Real	Imag.	Mag.	Real	Imag.	Mag.	Real	Imag.	Mag.	Real	Imag.	Mag.
Bus 12B	0.208	2.057	-13.192	13.351	2.050	-13.096	13.256	-11.402	-1.781	11.541	-12.431	4.746	13.306
Bus M2C	0.208	0.559	-4.004	4.043	0.446	-3.692	3.719	-3.444	-0.484	3.478	3.272	2.218	3.953
Bus M2E	0.208	0.372	-3.379	3.399	0.367	-3.303	3.323	-2.911	-0.323	2.929	2.736	1.965	3.369
LV Bus	0.208	0.826	-7.729	7.773	0.734	-7.312	7.349	-6.676	-0.715	6.714	6.367	4.251	7.655
Main Bus	25.000	5.774	-0.072	5.775	5.774	-0.067	5.774	-0.063	-5.001	5.001	-2.949	-4.969	5.779

All fault currents are symmetrical (1/2 Cycle network) values in rms kA.
* LLG fault current is the larger of the two faulted line currents.

Sequence Impedance Summary Report

Bus		Positive Seq. Imp. (ohm)			Negative Seq. Imp. (ohm)			Zero Seq. Imp. (ohm)			Fault Zf (ohm)		
ID	kV	Resistance	Reactance	Impedance	Resistance	Reactance	Impedance	Resistance	Reactance	Impedance	Resistance	Reactance	Impedance
Bus 12B	0.208	0.00140	0.00892	0.00903	0.00140	0.00892	0.00903	0.00142	0.00904	0.00915	0.00000	0.00000	0.00000
Bus M2C	0.208	0.00423	0.02981	0.03011	0.00423	0.02981	0.03011	0.00329	0.03695	0.03710	0.00000	0.00000	0.00000
Bus M2E	0.208	0.00396	0.03547	0.03569	0.00396	0.03547	0.03569	0.00406	0.03680	0.03702	0.00000	0.00000	0.00000
LV Bus	0.208	0.00172	0.01571	0.01580	0.00172	0.01571	0.01580	0.00159	0.01798	0.01805	0.00000	0.00000	0.00000
Main Bus	25.000	2.49922	0.03124	2.49942	2.49922	0.03124	2.49942	2.49988	0.02500	2.50000	0.00000	0.00000	0.00000

CB: CB125

MFR:	Square-D	Tag #:		3-Phase kA:	0.00	Sym. (Calc.)
Model:	MHL	Rating:	25 kA, 0.6 kV	LG kA:	0.00	Sym. (Calc.)
Size:	1000	Cont. Amp:	1000.000	Base kV:	0.000	(Calc.)

Thermal Magnetic Trip Device

MFR:	Square-D	Thermal Trip:	FIXED
Model:	MHL	Magnetic Trip:	5.000
ID:	1000		

CB: CB78

MFR:	Square-D	Tag #:		3-Phase kA:	0.00	Sym. (Calc.)
Model:	FA 240V	Rating:	10 kA, 0.24 kV	LG kA:	0.00	Sym. (Calc.)
Size:	100	Cont. Amp:	100.000	Base kV:	0.000	(Calc.)

Thermal Magnetic Trip Device

MFR:	Square-D	Thermal Trip:	FIXED
Model:	FA	Magnetic Trip:	FIXED
ID:	100		

CB: CB125

MFR:	Square-D	Tag #:		3-Phase kA:	0.00	Sym. (Calc.)
Model:	MHL	Rating:	25 kA, 0.6 kV	LG kA:	0.00	Sym. (Calc.)
Size:	1000	Cont. Amp:	1000.000	Base kV:	0.000	(Calc.)

Thermal Magnetic Trip Device

MFR:	Square-D	Thermal Trip:	FIXED
Model:	MHL	Magnetic Trip:	5.000
ID:	1000		

CB: CB80

MFR:	Square-D	Tag #:		3-Phase kA:	0.00	Sym. (Calc.)
Model:	FA 240V	Rating:	10 kA, 0.12 kV	LG kA:	0.00	Sym. (Calc.)
Size:	100	Cont. Amp:	100.000	Base kV:	0.000	(Calc.)

Thermal Magnetic Trip Device

MFR:	Square-D	Thermal Trip:	FIXED
Model:	FA	Magnetic Trip:	FIXED
ID:	100		

CB: CB125

MFR:	Square-D	Tag #:		3-Phase kA:	0.00	Sym. (Calc.)
Model:	MHL	Rating:	25 kA, 0.6 kV	LG kA:	0.00	Sym. (Calc.)
Size:	1000	Cont. Amp:	1000.000	Base kV:	0.000	(Calc.)

Thermal Magnetic Trip Device

MFR:	Square-D	Thermal Trip:	FIXED
Model:	MHL	Magnetic Trip:	5.000
ID:	1000		

CB: CB81

MFR:	Square-D	Tag #:		3-Phase kA:	0.00	Sym. (Calc.)
Model:	FA 240V	Rating:	10 kA, 0.24 kV	LG kA:	0.00	Sym. (Calc.)
Size:	100	Cont. Amp:	100.000	Base kV:	0.000	(Calc.)

Thermal Magnetic Trip Device

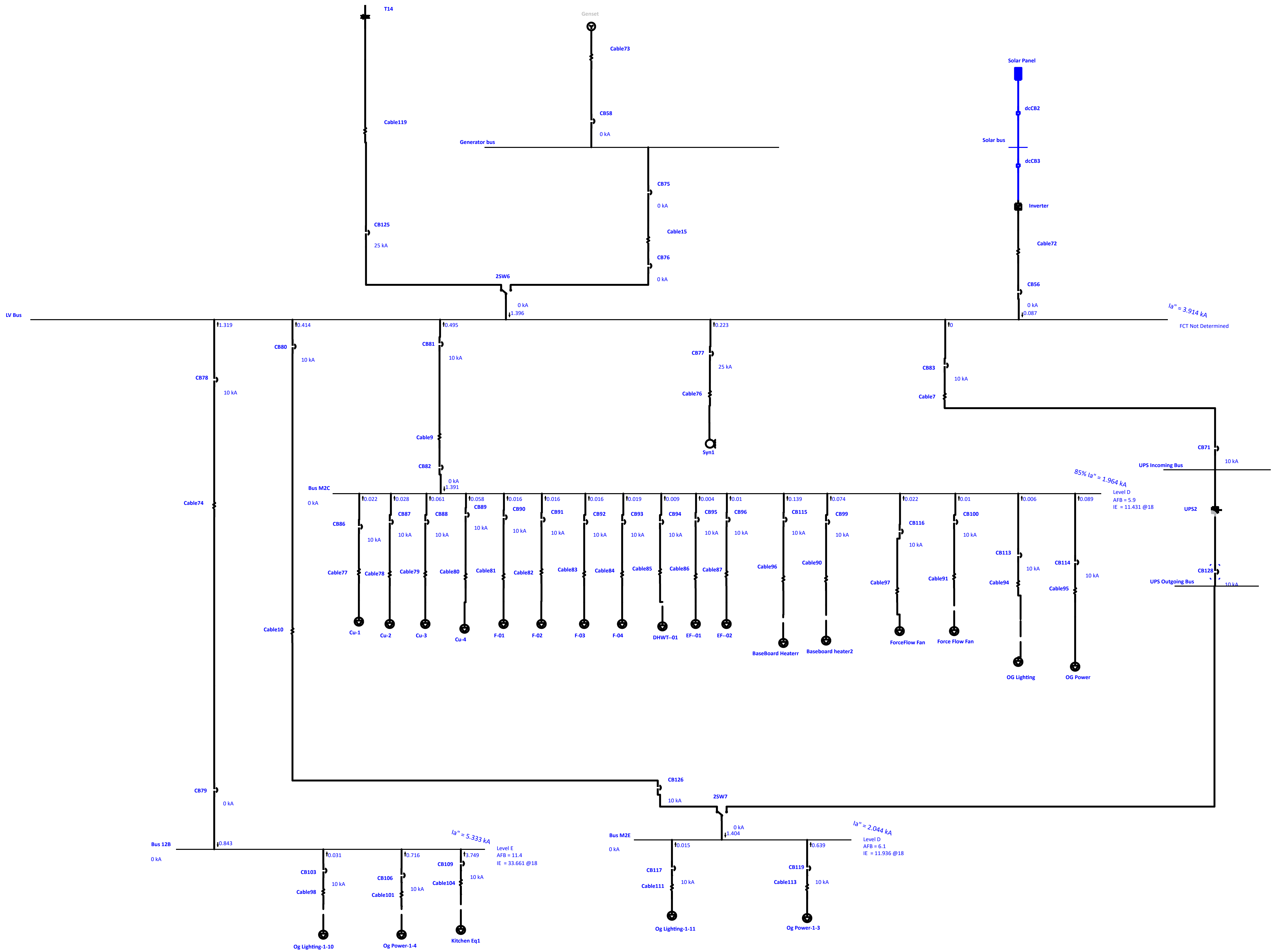
MFR:	Square-D	Thermal Trip:	FIXED
Model:	FA	Magnetic Trip:	FIXED
ID:	100		

CB: CB117

MFR:	Square-D	Tag #:		3-Phase kA:	0.00	Sym. (Calc.)
Model:	FA 240V	Rating:	10 kA, 0.24 kV	LG kA:	0.00	Sym. (Calc.)
Size:	15	Cont. Amp:	15.000	Base kV:	0.000	(Calc.)

Thermal Magnetic Trip Device

MFR:	Square-D	Thermal Trip:	FIXED
Model:	FA	Magnetic Trip:	FIXED
ID:	15		


T14
Genset
Cable73
Solar Panel
Cable119
CB58
0 kA
dcCB2
Solar bus
Generator bus
dcCB3
CB75
0 kA
Inverter
Cable15
CB125
25 kA
Cable72
CB76
0 kA
CB56
2SW6
0 kA
1.396
0 kA
0.087
Ia" = 3.914 kA
FCT Not Determined
LV Bus
1.319
0.414
0.495
0.223
0
CB80
10 kA
CB81
10 kA
CB77
25 kA
CB83
10 kA
CB78
10 kA
Cable76
Cable7
Cable9
Syn1
CB71
10 kA
CB82
0 kA
1.391
UPS Incoming Bus
85% Ia" = 1.964 kA
Level D
AFB = 5.9
IE = 11.431 @18
Bus M2C
0 kA
Cable74
UPS2
CB86
CB87
CB88
CB89
CB90
CB91
CB92
CB93
CB94
CB95
CB96
CB115
CB99
CB116
CB100
CB113
CB114
CB128
UPS Outgoing Bus
Cable77
Cable78
Cable79
Cable80
Cable81
Cable82
Cable83
Cable84
Cable85
Cable86
Cable87
Cable96
Cable90
Cable97
Cable91
Cable94
Cable95
Cu-1
Cu-2
Cu-3
Cu-4
F-01
F-02
F-03
F-04
DHWT--01
EF--01
EF--02
BaseBoard Heaterr
Baseboard heater2
ForceFlow Fan
Force Flow Fan
OG Lighting
OG Power
Cable10
CB126
10 kA
2SW7
CB79
0 kA
Ia" = 5.333 kA
Level E
AFB = 11.4
IE = 33.661 @18
0 kA
1.404
Ia" = 2.044 kA
Level D
AFB = 6.1
IE = 11.936 @18
Bus 12B
0 kA
0.843
Bus M2E
0 kA
0.031
0.716
3.749
0.015
0.639
CB103
CB106
CB109
CB117
CB119
Cable98
Cable101
Cable104
Cable111
Cable113
Og Lighting-1-10
Og Power-1-4
Kitchen Eq1
Og Lighting-1-11
Og Power-1-3

Electrical Transient Analyzer Program

Arc Flash Analysis

IEEE 1584-2002
ANSI Short-Circuit

	Swing	V-Control	Load	Total
Number of Buses:	1	1	32	34

	XFMR2	XFMR3	Reactor	Line/Cable	Impedance	Tie PD	Total
Number of Branches:	1	0	0	29	0	3	33

	Synchronous Generator	Power Grid	Synchronous Motor	Induction Machines	Lumped Load	Total
Number of Machines:	0	1	1	0	22	24

System Frequency:	60.00
Unit System:	English
Project Filename:	Power System
Output Filename:	C:\ETAP 1901\Power System\arc_flash.AAFS

Adjustments

Tolerance	Apply Adjustments	Individual /Global	Percent
Transformer Impedance:	Yes	Individual	
Reactor Impedance:	Yes	Individual	
Overload Heater Resistance:	No		
Transmission Line Length:	No		
Cable / Busway Length:	No		

Temperature Correction	Apply Adjustments	Individual /Global	Degree C
Transmission Line Resistance:	Yes	Individual	
Cable / Busway Resistance:	Yes	Individual	

Energy Levels

NFPA 70E 2012 to 2018 / User-Defined

Level ID	cal/cm^2
Level A	2.00
Level B	4.00
Level C	8.00
Level D	25.00
Level E	40.00
Level F	100.00
Level G	120.00
Level H	0.00
Level I	0.00
Level J	0.00

Bus Input Data

Bus					Initial Voltage	
ID	Type	Nom. kV	Base kV	Sub-sys	%Mag.	Ang.
Bus M2C	Load	0.208	0.208	1	100.00	0.00
Bus8	Load	0.208	0.208	1	100.00	0.00
Bus 12B	Load	0.208	0.208	1	100.00	0.00
Bus M2E	Load	0.208	0.208	1	100.00	0.00
Bus14	Load	0.208	0.208	1	100.00	0.00
Bus29	Load	0.208	0.208	1	100.00	0.00
Bus51	Gen.	0.208	0.208	1	0.00	0.00
Bus53	Load	0.208	0.208	1	100.00	0.00
Bus54	Load	0.208	0.208	1	100.00	0.00
Bus56	Load	0.208	0.208	1	100.00	0.00
Bus57	Load	0.208	0.208	1	100.00	0.00
Bus58	Load	0.208	0.208	1	100.00	0.00
Bus59	Load	0.208	0.208	1	100.00	0.00
Bus60	Load	0.208	0.208	1	100.00	0.00
Bus61	Load	0.208	0.208	1	100.00	0.00
Bus62	Load	0.208	0.208	1	100.00	0.00
Bus63	Load	0.208	0.208	1	100.00	0.00
Bus64	Load	0.208	0.208	1	100.00	0.00
Bus65	Load	0.208	0.208	1	100.00	0.00
Bus68	Load	0.208	0.208	1	100.00	0.00
Bus69	Load	0.208	0.208	1	100.00	0.00
Bus70	Load	0.208	0.208	1	100.00	0.00
Bus74	Load	0.208	0.208	1	100.00	0.00
Bus75	Load	0.208	0.208	1	100.00	0.00
Bus76	Load	0.208	0.208	1	100.00	0.00
Bus77	Load	0.208	0.208	1	100.00	0.00
Bus78	Load	0.208	0.208	1	100.00	0.00
Bus81	Load	0.208	0.208	1	100.00	0.00
Bus84	Load	0.208	0.208	1	100.00	0.00
Bus88	Load	0.208	0.208	1	100.00	0.00
Bus90	Load	0.208	0.208	1	100.00	0.00
LV Bus	Load	0.208	0.208	1	100.00	0.00
Main Bus	SWNG	25.000	25.000	1	100.00	0.00
UPS Incoming Bus	Load	0.208	0.208	1	100.00	0.00

34 Buses Total

All voltages reported by ETAP are in % of bus Nominal kV.
Base kV values of buses are calculated and used internally by ETAP .

Bus Arc Flash Input Data

Faulted Bus		Arc Flash Ratings			Approach Boundary (ft)			Avail. Protection
ID	Nom. kV	Equip. Type	Gap (mm)	X Factor	Exp. Movable	Fixed Circuit	Restricted	cal/cm²
Bus 12B	0.208	Panelboard	25	1.641	10.000	3.500	1.000	0.00
Bus M2C	0.208	Panelboard	25	1.641	10.000	3.500	1.000	0.00
Bus M2E	0.208	Panelboard	25	1.641	10.000	3.500	1.000	0.00
LV Bus	0.208	Other	13	2.000	10.000	3.500	1.000	0.00
Main Bus	25.000	Other			10.000	6.000	2.750	0.00

The Gap and X-Factors are not utilized if the theoretically derived Lee method was used to determine the incident energy and arc flash boundary .
The Lee method is used if the bus voltage and/or short-circuit parameters are outside the range covered by the IEEE 1584 empirical equations.

Line/Cable/Busway Input Data

ohms or siemens/1000 ft per Conductor (Cable) or per Phase (Line/Busway)

Line/Cable/Busway			Length						
ID	Library	Size	Adj. (ft)	% Tol.	#/Phase	T (°C)	R	X	Y
Cable7			118.1	0	1	75	0.00100	0.37699	0.0010000
Cable9			65.6	0	1	75	0.00100	0.37699	0.0010000
Cable10			91.9	0	1	75	0.00100	0.37699	0.0010000
Cable72			98.4	0	1	75	0.00100	0.37699	0.0010000
Cable74			91.9	0	1	75	0.00100	0.37699	0.0010000
Cable76			65.6	0	1	75	0.00100	0.37699	0.0010000
Cable77			72.2	0	1	75	0.00100	0.37699	0.0010000
Cable78			72.2	0	1	75	0.00100	0.37699	0.0010000
Cable79			72.2	0	1	75	0.00100	0.37699	0.0010000
Cable80			72.2	0	1	75	0.00100	0.37699	0.0010000
Cable81			118.1	0	1	75	0.00100	0.37699	0.0010000
Cable82			118.1	0	1	75	0.00100	0.37699	0.0010000
Cable83			118.1	0	1	75	0.00100	0.37699	0.0010000
Cable84			95.1	0	1	75	0.00100	0.37699	0.0010000
Cable85			137.8	0	1	75	0.00100	0.37699	0.0010000
Cable86			275.6	0	1	75	0.00100	0.37699	0.0010000
Cable87			150.9	0	1	75	0.00100	0.37699	0.0010000
Cable90			68.9	0	1	75	0.00100	0.37699	0.0010000
Cable91			108.3	0	1	75	0.00100	0.37699	0.0010000
Cable94			137.8	0	1	75	0.00100	0.37699	0.0010000
Cable95			124.7	0	1	75	0.00100	0.37699	0.0010000
Cable96			75.5	0	1	75	0.00100	0.37699	0.0010000
Cable97			108.3	0	1	75	0.00100	0.37699	0.0010000
Cable98			98.4	0	1	75	0.00100	0.37699	0.0010000
Cable101			98.4	0	1	75	0.00100	0.37699	0.0010000
Cable104			20.0	0	1	75	0.00100	0.37699	0.0010000
Cable111			98.4	0	1	75	0.00100	0.37699	0.0010000
Cable113			98.4	0	1	75	0.00100	0.37699	0.0010000
Cable119			98.4	0	1	75	0.00100	0.37699	0.0010000

Line / Cable / Busway resistances are listed at the specified temperatures.

2-Winding Transformer Input Data

Transformer	Rating					Z Variation			% Tap Setting		Adjusted
ID	MVA	Prim. kV	Sec. kV	% Z	X/R	+ 5%	- 5%	% Tol.	Prim.	Sec.	% Z
T14	0.225	25.000	0.208	4.00	3.45	0	0	0	0	0	4.0000

Branch Connections

CKT/Branch		Connected Bus ID		% Impedance, Pos. Seq., 100 MVAb			
ID	Type	From Bus	To Bus	R	X	Z	Y
T14	2W XFMR	Main Bus	Bus8	494.93	1707.50	1777.78	
Cable7	Cable	LV Bus	UPS Incoming Bus	27.30	10291.78	10291.82	
Cable9	Cable	LV Bus	Bus M2C	15.17	5717.66	5717.68	
Cable10	Cable	LV Bus	Bus29	21.23	8004.72	8004.75	
Cable72	Cable	Bus51	LV Bus	22.75	8576.49	8576.52	
Cable74	Cable	LV Bus	Bus53	21.23	8004.72	8004.75	
Cable76	Cable	LV Bus	Bus54	15.17	5717.66	5717.68	
Cable77	Cable	Bus M2C	Bus68	16.68	6289.42	6289.45	
Cable78	Cable	Bus M2C	Bus56	16.68	6289.42	6289.45	
Cable79	Cable	Bus M2C	Bus57	16.68	6289.42	6289.45	
Cable80	Cable	Bus M2C	Bus58	16.68	6289.42	6289.45	
Cable81	Cable	Bus M2C	Bus59	27.30	10291.78	10291.82	
Cable82	Cable	Bus M2C	Bus60	27.30	10291.78	10291.82	
Cable83	Cable	Bus M2C	Bus61	27.30	10291.78	10291.82	
Cable84	Cable	Bus M2C	Bus62	21.99	8290.60	8290.63	
Cable85	Cable	Bus M2C	Bus63	31.85	12007.08	12007.12	
Cable86	Cable	Bus M2C	Bus64	63.70	24014.16	24014.25	
Cable87	Cable	Bus M2C	Bus65	34.88	13150.61	13150.66	
Cable90	Cable	Bus M2C	Bus69	15.92	6003.54	6003.56	
Cable91	Cable	Bus M2C	Bus70	25.02	9434.14	9434.17	
Cable94	Cable	Bus M2C	Bus74	31.85	12007.08	12007.12	
Cable95	Cable	Bus M2C	Bus75	28.82	10863.55	10863.59	
Cable96	Cable	Bus M2C	Bus76	17.44	6575.31	6575.33	
Cable97	Cable	Bus M2C	Bus77	25.02	9434.14	9434.17	
Cable98	Cable	Bus 12B	Bus78	22.75	8576.49	8576.52	
Cable101	Cable	Bus 12B	Bus81	22.75	8576.49	8576.52	
Cable104	Cable	Bus 12B	Bus84	4.62	1742.74	1742.75	
Cable111	Cable	Bus M2E	Bus88	22.75	8576.49	8576.52	
Cable113	Cable	Bus M2E	Bus90	22.75	8576.49	8576.52	
Cable119	Cable	Bus8	Bus14	22.75	8576.49	8576.52	
CB79	Tie Breaker	Bus53	Bus 12B				
2SW6	Tie Switch	LV Bus	Bus14				
2SW7	Tie Switch	Bus M2E	Bus29				

Power Grid Input Data

Power Grid	Connected Bus	Rating		% Impedance 100 MVA Base		
ID	ID	MVAsc	kV	X/R	R	X
U1	Main Bus	250.000	25.000	0.01	39.99800	0.39998

Total Connected Power Grids (= 1): 250.000 MVA

Synchronous Motor Input Data

Synchronous Motor			Connected Bus	Rating			X/R Ratio		% Impedance in Machine Base			
										Xd"		
ID	Type	Qty	ID	kVA	kV	RPM	X"/R	X'/R	R	Adj.	Tol.	Xd'
Syn1	Motor	1	Bus54	28.1	0.200	1800	4.27	4.27	3.907	16.67	0.0	25.00

Total Connected Synchronous Machines (= 1): 28.1 kVA

Lumped Load Input Data

Lumped Load						Motor Loads							Static Loads	
Lumped Load	Connected Bus	Rating		% Load		Loading		X/R Ratio		% Impedance (Machine Base)			Loading	
ID	ID	kVA	kV	MTR	STAT	kW	kvar	X"/R	X'/R	R	X"	X'	kW	kvar
Baseboard heater2	Bus69	5.1	0.120	80	20	3.7	1.8	2.38	2.38	8.403	20.00	50.00	0.92	0.45
BaseBoard Heaterr	Bus76	10.0	0.120	80	20	7.2	3.5	2.38	2.38	8.403	20.00	50.00	1.80	0.87
Cu-1	Bus68	4.5	0.208	80	20	3.2	1.6	2.38	2.38	8.403	20.00	50.00	0.81	0.39
Cu-2	Bus56	5.8	0.208	80	20	4.2	2.0	2.38	2.38	8.403	20.00	50.00	1.04	0.51
Cu-3	Bus57	12.6	0.208	80	20	9.1	4.4	2.38	2.38	8.403	20.00	50.00	2.28	1.10
Cu-4	Bus58	12.0	0.208	80	20	8.6	4.2	2.38	2.38	8.403	20.00	50.00	2.16	1.05
DHWT--01	Bus63	0.6	0.120	80	20	0.4	0.2	2.38	2.38	8.403	20.00	50.00	0.11	0.05
EF--01	Bus64	0.3	0.120	80	20	0.2	0.1	2.38	2.38	8.403	20.00	50.00	0.05	0.02
EF--02	Bus65	2.1	0.208	80	20	1.5	0.7	2.38	2.38	8.403	20.00	50.00	0.38	0.18
F-01	Bus59	3.3	0.208	80	20	2.3	1.1	2.38	2.38	8.403	20.00	50.00	0.59	0.28
F-02	Bus60	3.3	0.208	80	20	2.3	1.1	2.38	2.38	8.403	20.00	50.00	0.59	0.28
F-03	Bus61	3.3	0.208	80	20	2.3	1.1	2.38	2.38	8.403	20.00	50.00	0.59	0.28
F-04	Bus62	3.9	0.208	80	20	2.8	1.4	2.38	2.38	8.403	20.00	50.00	0.70	0.34
Force Flow Fan	Bus70	0.6	0.120	80	20	0.5	0.2	2.38	2.38	8.403	20.00	50.00	0.12	0.06
ForceFlow Fan	Bus77	1.5	0.120	80	20	1.1	0.5	2.38	2.38	8.403	20.00	50.00	0.27	0.13
Kitchen Eq1	Bus84	711.6	0.120	80	20	512.4	248.2	2.38	2.38	8.403	20.00	50.00	128.28	62.13
OG Lighting	Bus74	0.4	0.120	80	20	0.3	0.1	2.38	2.38	8.403	20.00	50.00	0.07	0.03
Og Lighting-1-10	Bus78	2.6	0.120	80	20	1.9	0.9	2.38	2.38	8.403	20.00	50.00	0.47	0.23
Og Lighting-1-11	Bus88	0.8	0.120	80	20	0.6	0.3	2.38	2.38	8.403	20.00	50.00	0.14	0.07
OG Power	Bus75	19.2	0.208	80	20	13.8	6.7	2.38	2.38	8.403	20.00	50.00	3.46	1.67
Og Power-1-3	Bus90	50.4	0.120	80	20	36.3	17.6	2.38	2.38	8.403	20.00	50.00	9.09	4.40
Og Power-1-4	Bus81	125.5	0.120	80	20	92.0	40.1	2.38	2.38	8.403	20.00	50.00	23.03	10.04

Total Connected Lumped Loads (= 22): 979.3 kVA

Arc Flash Analysis

1/2 Cycle Calculation Method

Arc Fault at Bus: **Bus 12B**

Solution Method: **1/2 Cycle**

Nominal kV = 0.208 Prefault Voltage = 100% of nominal bus kV System Grounding = Grounded

Base kV = 0.208 = 100% of base kV Working Distance = 18 inches

Bus Arc Flash Results

Total Bolted (kA)	Total Arcing (kA)		Fault Clearing Time (cycles)	Fault Clearing Time (Seconds)		(cal/cm²)
Ibf" = 13.351	Ia" = 5.329	FCT =	120.0	2.000	Incident Energy =	33.629
	⧣	**Fault Clearing Time =**	120.0	2.000	**Total Incident Energy =**	33.629

For Protective Device: CB78@ Ia" =0.836 kA

Energy Level* **Level E**

Arc Flash Boundary = 11.43 ft

Arc Fault at Device			Individual Contribution to Bus Arc Fault			Incident Energy					
ID	Phase Type	Type	Bolted (kA)	Arcing (kA)	FCT (cycles)	Arcing (kA)	FCT (cycles)	Protective Device ID for FCT	Incident E (cal/cm²)	AFB (ft)	Energy Level*
⧣ CB103	3Ph	LV CB	0.078	0.031		5.329	120.0	CB78	33.629		
						FCT =	120.0	**Total =**	33.629	11.43	**Level E**
⧣ CB106	3Ph	LV CB	1.795	0.716		5.329	120.0	CB78	33.629		
						FCT =	120.0	**Total =**	33.629	11.43	**Level E**
⧣ CB109	3Ph	LV CB	9.397	3.750		5.329	120.0	CB78	33.629		
						FCT =	120.0	**Total =**	33.629	11.43	**Level E**
⧣ CB79	3Ph	LV CB	2.095	0.836		5.329	120.0	CB78	33.629		
						FCT =	120.0	**Total =**	33.629	11.43	**Level E**

⧣This Fault Clearing Time (FCT) has been limited to the maximum value allowed in the study case. The incident energy will be calculated using this value.

* User-Defined energy levels are used.

♦ Arcing current variation was applied at this location.

Arc Flash Analysis

1/2 Cycle Calculation Method

Arc Fault at Bus: **Bus M2C**

Solution Method: **1/2 Cycle**

Nominal kV = 0.208 Prefault Voltage = 100% of nominal bus kV System Grounding = Grounded

Base kV = 0.208 = 100% of base kV Working Distance = 18 inches

Bus Arc Flash Results

Total Bolted (kA)	Total Arcing (kA)		Fault Clearing Time (cycles)	Fault Clearing Time (Seconds)		(cal/cm²)
Ibf" = 4.043	♦Ia" = 1.957	FCT =	120.0	2.000	Incident Energy =	11.391
	⧣	**Fault Clearing Time =**	120.0	2.000	**Total Incident Energy =**	11.391

For Protective Device: CB81@ 85% Ia" =1.384 kA

Energy Level* **Level D**

Arc Flash Boundary = 5.91 ft

Arc Fault at Device ID	Phase Type	Type	Individual Contribution to Bus Arc Fault: Bolted (kA)	Arcing (kA)	FCT (cycles)	Incident Energy: Arcing (kA)	FCT (cycles)	Protective Device ID for FCT	Incident E (cal/cm²)	AFB (ft)	Energy Level*
♦ ⧣ CB100	3Ph	LV CB	0.020	0.010		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB113	3Ph	LV CB	0.012	0.006		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB114	3Ph	LV CB	0.183	0.089		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB115	3Ph	LV CB	0.288	0.139		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB116	3Ph	LV CB	0.045	0.022		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB82	3Ph	LV CB	2.858	1.384		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB86	3Ph	LV CB	0.046	0.022		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**

Arc Flash Analysis

1/2 Cycle Calculation Method

Arc Fault at Bus: **Bus M2C**

Solution Method: **1/2 Cycle**

Nominal kV = 0.208   Prefault Voltage = 100% of nominal bus kV   System Grounding = Grounded

Base kV = 0.208   = 100% of base kV   Working Distance = 18 inches

Bus Arc Flash Results

Total Bolted (kA)	Total Arcing (kA)		Fault Clearing Time (cycles)	Fault Clearing Time (Seconds)		(cal/cm²)
Ibf" = 4.043	♦Ia" = 1.957	FCT =	120.0	2.000	Incident Energy =	11.391
	⧣	**Fault Clearing Time =**	120.0	2.000	**Total Incident Energy =**	11.391

For Protective Device: CB81@ 85% Ia" =1.384 kA   Energy Level* **Level D**

Arc Flash Boundary = 5.91 ft

Arc Fault at Device: ID	Phase Type	Type	Individual Contribution to Bus Arc Fault: Bolted (kA)	Arcing (kA)	FCT (cycles)	Incident Energy: Arcing (kA)	FCT (cycles)	Protective Device ID for FCT	Incident E (cal/cm²)	AFB (ft)	Energy Level*
♦ ⧣ CB87	3Ph	LV CB	0.059	0.028		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB88	3Ph	LV CB	0.126	0.061		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB89	3Ph	LV CB	0.120	0.058		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB90	3Ph	LV CB	0.033	0.016		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB91	3Ph	LV CB	0.033	0.016		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB92	3Ph	LV CB	0.033	0.016		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB93	3Ph	LV CB	0.039	0.019		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**

Arc Flash Analysis

1/2 Cycle Calculation Method

Arc Fault at Bus: **Bus M2C**

Solution Method: **1/2 Cycle**

Nominal kV = 0.208   Prefault Voltage = 100% of nominal bus kV   System Grounding = Grounded

Base kV = 0.208   = 100% of base kV   Working Distance = 18 inches

Bus Arc Flash Results

Total Bolted (kA)	Total Arcing (kA)		Fault Clearing Time (cycles)	(Seconds)		(cal/cm²)
Ibf" = 4.043	♦Ia" = 1.957	FCT =	120.0	2.000	Incident Energy =	11.391
	⧣	**Fault Clearing Time =**	120.0	2.000	**Total Incident Energy =**	11.391

For Protective Device: CB81@ 85% Ia" =1.384 kA

Energy Level* **Level D**

Arc Flash Boundary = 5.91 ft

Arc Fault at Device			Individual Contribution to Bus Arc Fault			Incident Energy					
ID	Phase Type	Type	Bolted (kA)	Arcing (kA)	FCT (cycles)	Arcing (kA)	FCT (cycles)	Protective Device ID for FCT	Incident E (cal/cm²)	AFB (ft)	Energy Level*
♦ ⧣ CB94	3Ph	LV CB	0.018	0.009		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB95	3Ph	LV CB	0.008	0.004		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB96	3Ph	LV CB	0.021	0.010		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**
♦ ⧣ CB99	3Ph	LV CB	0.152	0.074		1.957	120.0	CB81	11.391		
						FCT =	120.0	**Total =**	11.391	5.91	**Level D**

⧣This Fault Clearing Time (FCT) has been limited to the maximum value allowed in the study case. The incident energy will be calculated using this value.

* User-Defined energy levels are used.

♦ Arcing current variation was applied at this location.

Arc Flash Analysis

1/2 Cycle Calculation Method

Arc Fault at Bus: **Bus M2E**

Solution Method: **1/2 Cycle**

Nominal kV = 0.208	Prefault Voltage = 100% of nominal bus kV	System Grounding	= Grounded
Base kV = 0.208	= 100% of base kV	Working Distance	= 18 inches

Bus Arc Flash Results

Total Bolted (kA)	Total Arcing (kA)		Fault Clearing Time (cycles)	Fault Clearing Time (Seconds)		(cal/cm²)
Ibf" = 3.399	Ia" = 2.039	FCT =	120.0	2.000	Incident Energy =	11.904
	⧣	**Fault Clearing Time =**	120.0	2.000	**Total Incident Energy =**	11.904

For Protective Device: CB126@ Ia" =1.398 kA

Energy Level* **Level D**

Arc Flash Boundary = 6.07 ft

Arc Fault at Device: ID	Phase Type	Type	Individual Contribution to Bus Arc Fault: Bolted (kA)	Arcing (kA)	FCT (cycles)	Incident Energy: Arcing (kA)	FCT (cycles)	Protective Device ID for FCT	Incident E (cal/cm²)	AFB (ft)	Energy Level*
⧣ CB117	3Ph	LV CB	0.024	0.015		2.039	120.0	CB126	11.904		
						FCT =	120.0	**Total =**	11.904	6.07	**Level D**
⧣ CB119	3Ph	LV CB	1.066	0.640		2.039	120.0	CB126	11.904		
						FCT =	120.0	**Total =**	11.904	6.07	**Level D**

⧣This Fault Clearing Time (FCT) has been limited to the maximum value allowed in the study case. The incident energy will be calculated using this value.

* User-Defined energy levels are used.

♦ Arcing current variation was applied at this location.

Arc Flash Analysis

1/2 Cycle Calculation Method

Arc Fault at Bus: **LV Bus**

Solution Method: **1/2 Cycle**

Nominal kV = 0.208	Prefault Voltage = 100% of nominal bus kV	System Grounding	= Grounded
Base kV = 0.208	= 100% of base kV	Working Distance	= 18 inches

Bus Arc Flash Results

Total Bolted (kA)	Total Arcing (kA)	Fault Clearing Time (cycles) (Seconds)	Incident Energy (cal/cm²)
Ibf" = 7.773	Ia" = 3.871	FCT Cannot be Determined!	Incident Energy Cannot be Determined!

Arc Fault at Device			Individual Contribution to Bus Arc Fault			Incident Energy					
ID	Phase Type	Type	Bolted (kA)	Arcing (kA)	FCT (cycles)	Arcing (kA)	FCT (cycles)	Protective Device ID for FCT	Incident E (cal/cm²)	AFB (ft)	Energy Level*
CB56	3Ph	LV CB	0.175	0.087				Cannot be Determined			
CB77	3Ph	LV CB	0.449	0.223				Cannot be Determined			
CB78	3Ph	LV CB	2.658	1.324				Cannot be Determined			
CB80	3Ph	LV CB	0.835	0.416				Cannot be Determined			
CB81	3Ph	LV CB	0.997	0.497				Cannot be Determined			
CB83	3Ph	LV CB	0.000	0.000				Cannot be Determined			

♦ Arcing current variation was applied at this location.

Arc Flash Analysis

1/2 Cycle Calculation Method

Arc Fault at Bus: **Main Bus**

Solution Method: **1/2 Cycle**

Nominal kV = 25.000 Prefault Voltage = 100% of nominal bus kV System Grounding = Grounded

Base kV = 25.000 = 100% of base kV Working Distance = 18 inches

Bus Arc Flash Results

Total Bolted (kA)	Total Arcing (kA)	Fault Clearing Time (cycles) (Seconds)	Incident Energy (cal/cm²)
Ibf" = 5.775	Ia" = 5.775	FCT Cannot be Determined!	Incident Energy Cannot be Determined!

Arc Fault at Device			Individual Contribution to Bus Arc Fault			Incident Energy					
ID	Phase Type	Type	Bolted (kA)	Arcing (kA)	FCT (cycles)	Arcing (kA)	FCT (cycles)	Protective Device ID for FCT	Incident E (cal/cm²)	AFB (ft)	Energy Level*

♦ Arcing current variation was applied at this location.

Bus Incident Energy Summary

Bus			Total Fault Current (kA)		Arc-Flash Analysis Results			
ID	Nom. kV	Type	Bolted	Arcing	FCT (cycles)	Incident E (cal/cm²)	AFB (ft)	Energy Level
Bus 12B	0.208	Panelboard	13.351	5.329	120.000	33.629	11.43	Level E
Bus M2C	0.208	Panelboard	4.043	1.957	120.000	11.391	5.91	Level D
Bus M2E	0.208	Panelboard	3.399	2.039	120.000	11.904	6.07	Level D
LV Bus	0.208	Other	7.773	3.871				
# Main Bus	25.000	Other	5.775	5.775				

The theoretically-derived Lee method was used to determine the incident energy and arc -flash boundary for this location since some of the input parameters may be outside the range of the IEEE 1584 methods.

Bus Arc Flash Hazard Analysis Summary

Faulted Bus				Fault Current			Trip Device							
ID	Nom. kV	Equipment Type	Gap (mm)	Bolted Fault (kA) Bus	Bolted Fault (kA) PD	PD Arc Fault (kA)	Source Trip Device ID	Trip (cycle)	Open (cycle)	FCT (cycle)	Arc Flash Boundary (ft)	Incident Energy (cal/cm²)	Working Distance (inches	Energy Level
Bus 12B	0.208	Panelboard	25	13.351	2.095	0.836	CB78	120.00	0.00	120.00	11.4	33.6	18	Level E
Bus M2C	0.208	Panelboard	25	4.043	2.858	1.384	CB81	120.00	0.00	120.00	5.9	11.4	18	Level D
Bus M2E	0.208	Panelboard	25	3.399	2.330	1.398	CB126	120.00	0.00	120.00	6.1	11.9	18	Level D
LV Bus	0.208	Other	13	7.773							0.0	0.0	18	
# Main Bus	25.000	Other		5.775							0.0	0.0	18	

The theoretically-derived Lee method was used to determine the incident energy and arc -flash boundary for this location since some of the input parameters may be outside the range of the IEEE 1584 methods.