Project Report (Milestone- 4) on

Short Circuit, Coordination, and Arc Flash Study Report

Course Code: ENEL 674 (L01)

Course Name: Industrial and Commercial Power Systems

Submitted By,

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Project Summary

This milestone-4 examines the proper installation of safety equipment and the evaluation of arc flash risks at the Complex in Lethbridge, Southern Alberta.

We started by performing a short-circuit analysis to determine the fault current at various locations in the system. According to the findings, every protective device is capable of securely handling the maximum short-circuit current. We then conducted a coordination study to optimize the protective device settings, making sure they operate in unison to reduce interruptions and preserve safety.

Last but not least, we measured the possible incident energy on-site using an arc flash investigation. From grid to load, the incidence energy level is 0.7 cal/cm² Cal/cm². On the other hand, from generator to load, the incident energy level is 4.569 cal/cm² Cal/cm².

Foreword

Purpose of the Study

Short circuits, protection coordination and arc flash studies were performed for the 25KV generator to load and 208V grid to load system. The purpose of the short circuit study is to make sure the equipment can tolerate short circuits and interrupt faults sufficiently. The coordination research looks at how to put up the safety equipment correctly. Arc flash dangers in specified electrical equipment at the site are established and analyzed by the Arc Flash study, which also, if appropriate, identifies issues related to these hazards.

Scope of the Study

The scope of this study includes 2 different scenarios which are 25 KV generator to load and 208V grid to load.

Methodology

This study will be based on owner requirements, project restrictions and relevant codes and standards.

System Description

The local utility provides power to this system at 25kV, which is then stepped down to 208V via a 112 kVA rated transformer. 30hp motor will be fed directly from this distribution board. We need to calculate short circuit, protection co-ordination and arc-flash studies in this system.

Basis and Assumptions

- The Electrical Transient Analyzer Program (ETAP, version 20.6.0E) is used for performing the studies.
- ETAP had the limitation of using a maximum of 25 buses only, hence some of the mechanical loads are directly fed from distribution board.
- For transformers, the typical impedance values as provided by the ETAP have been considered.
- For generators, typical impedance values as provided by the ETAP have been considered.
- IEC standards have been followed throughout the studies.
- The software has limitations to consider maximum 25 buses. Our design had 10 buses where 2 buses are main bus and 8 buses are specific load wise buses.

Input Data

Generator Impedance

The impedance value for the generator is given below:

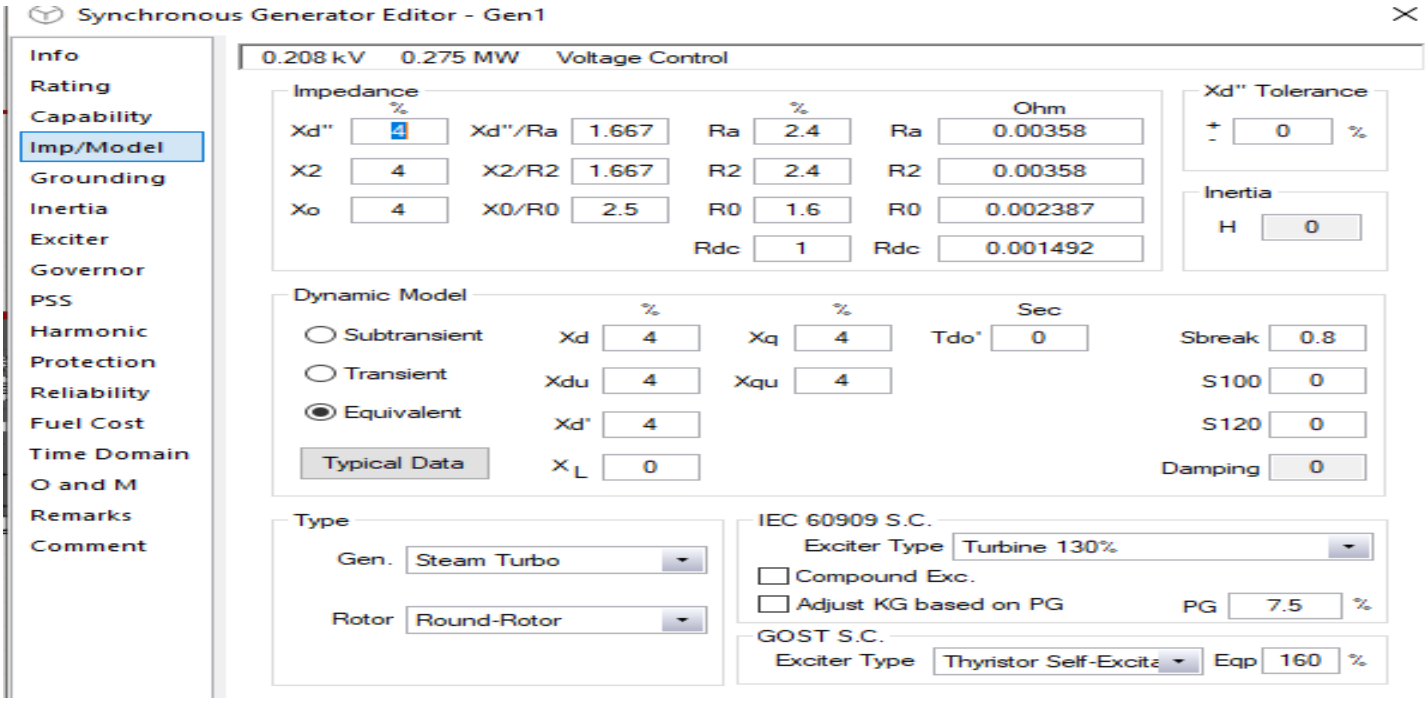


Fig: Parameter Settings for Impedance at Generator.

Transformer Impedance:

The transformer impedance settings have been given below:

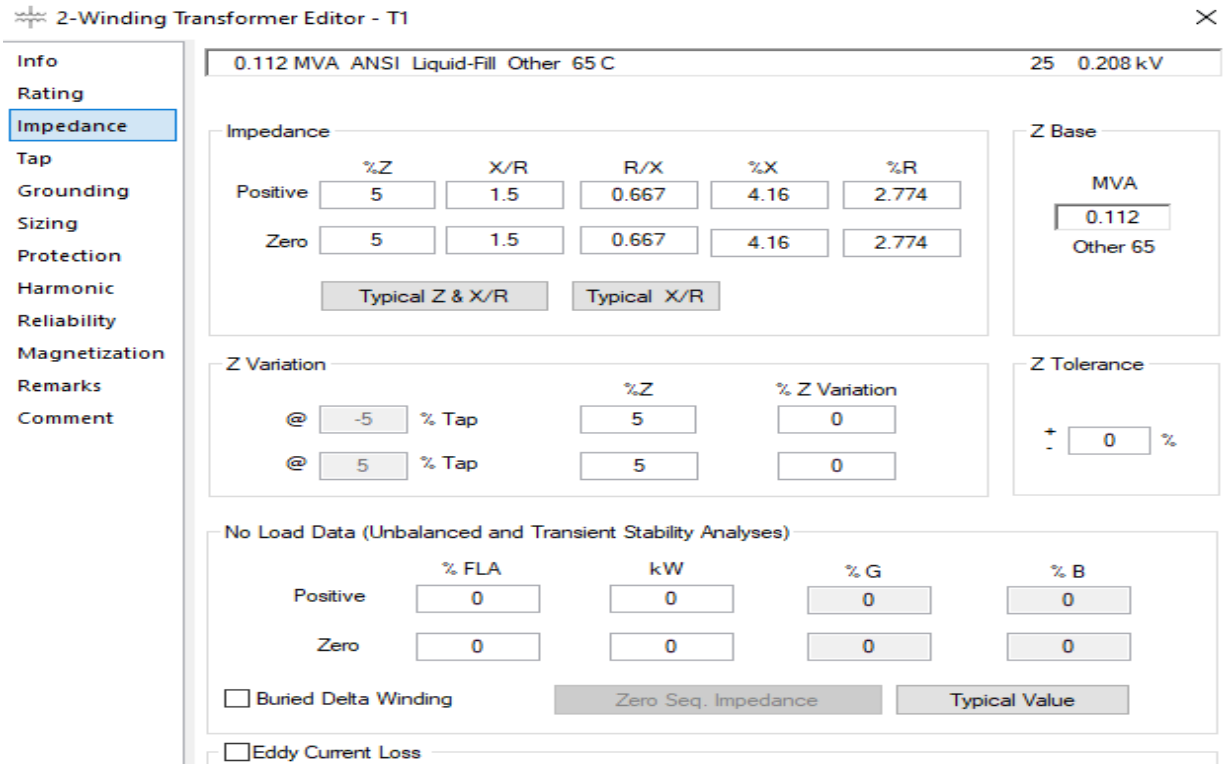


Fig: Parameter Settings for Impedance at Transformer.

Current Transformer Rating

The current transformer rating is given below:

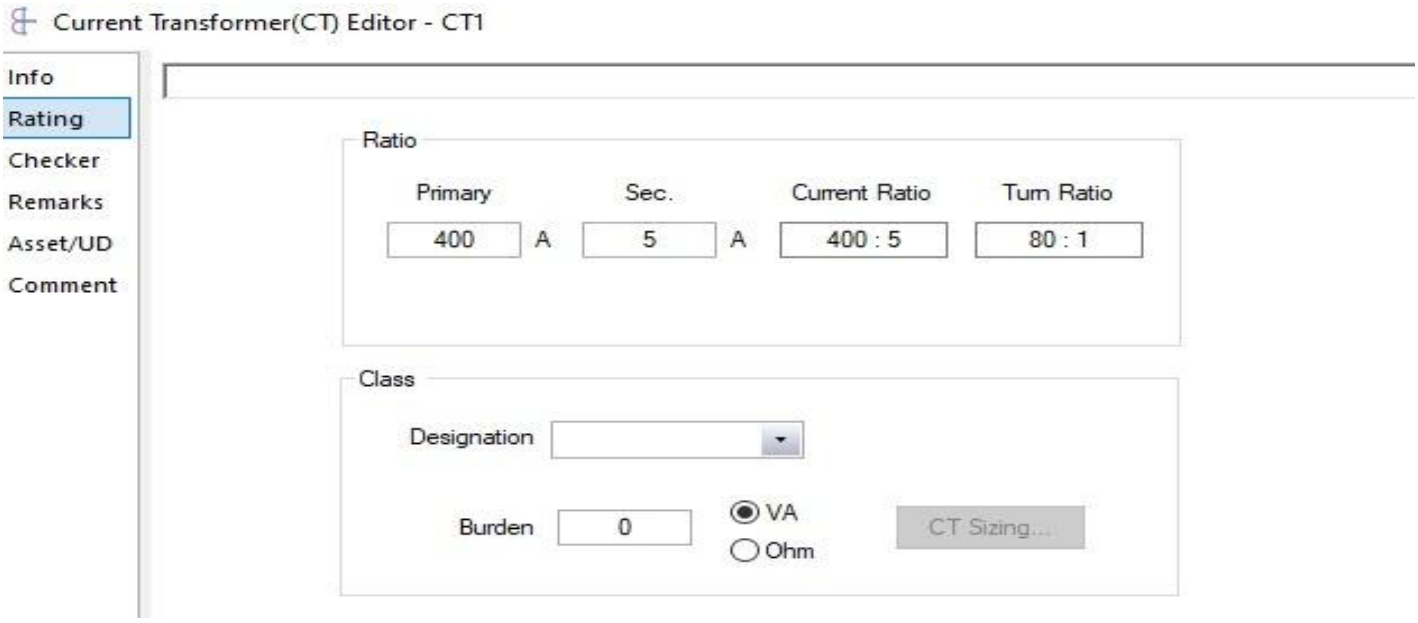


Fig: Transformer Rating

Power Grid Settings

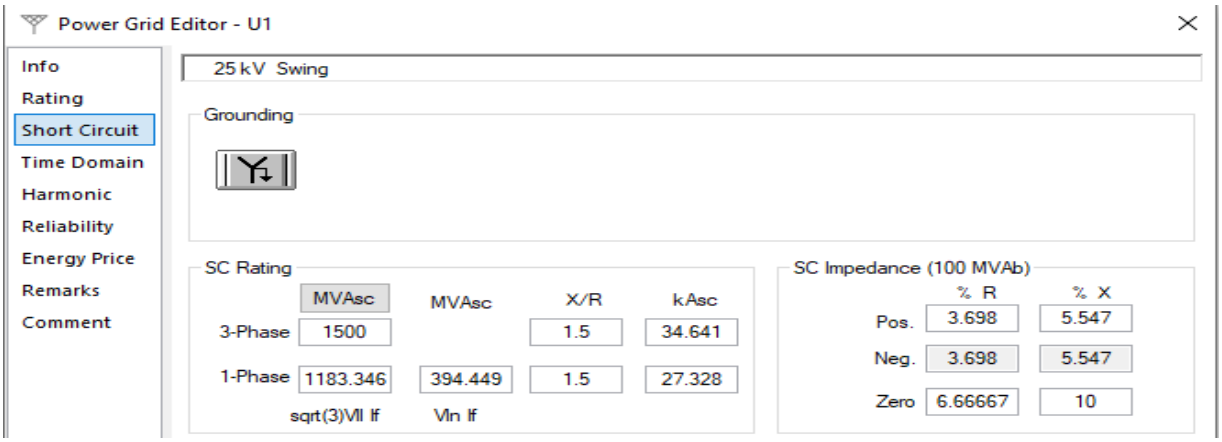


Fig: Parameter Settings for Short Circuit at Grid.

Arc Flash Bus-1 Parameter Settings

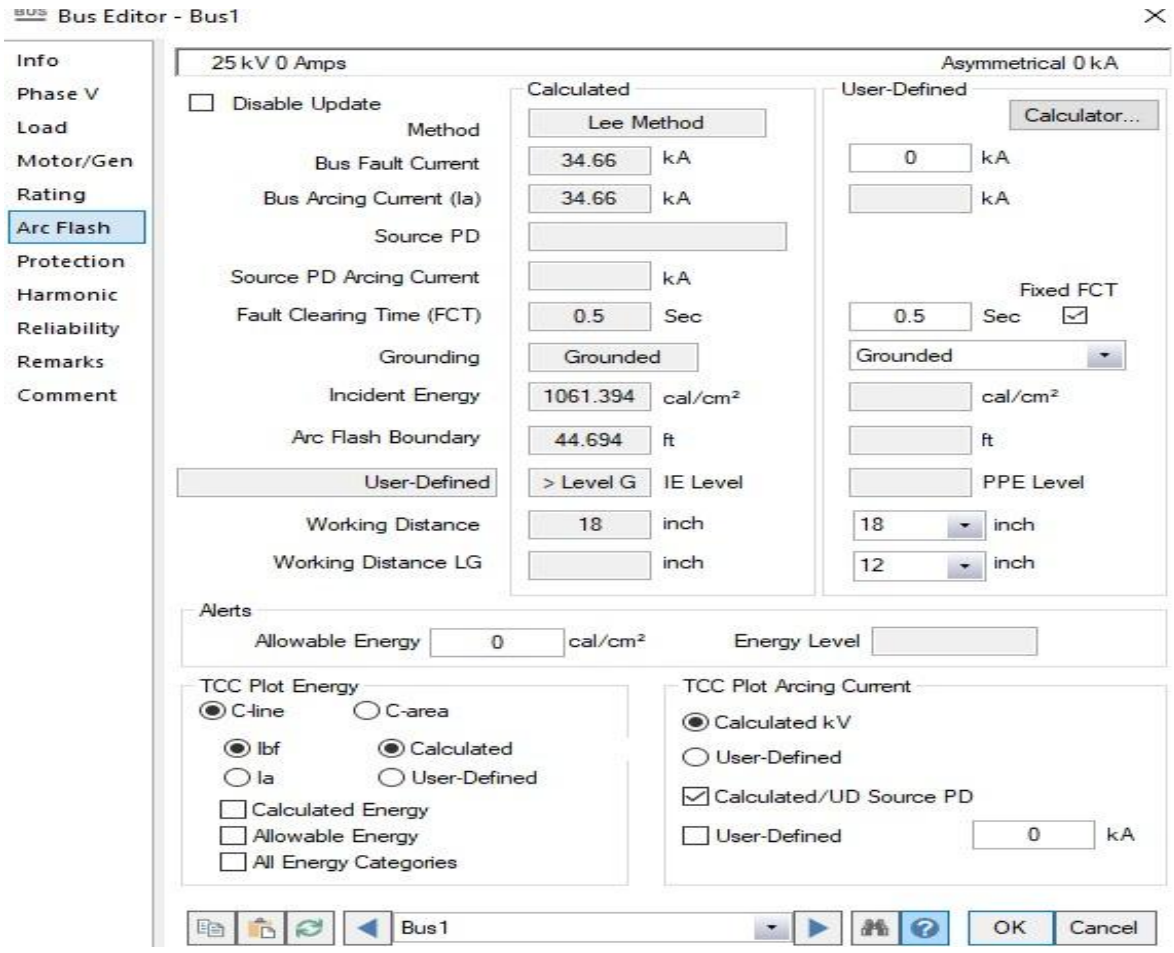


Fig: Arc-Flash Settings for Bus-1 for Grid to load scenario.

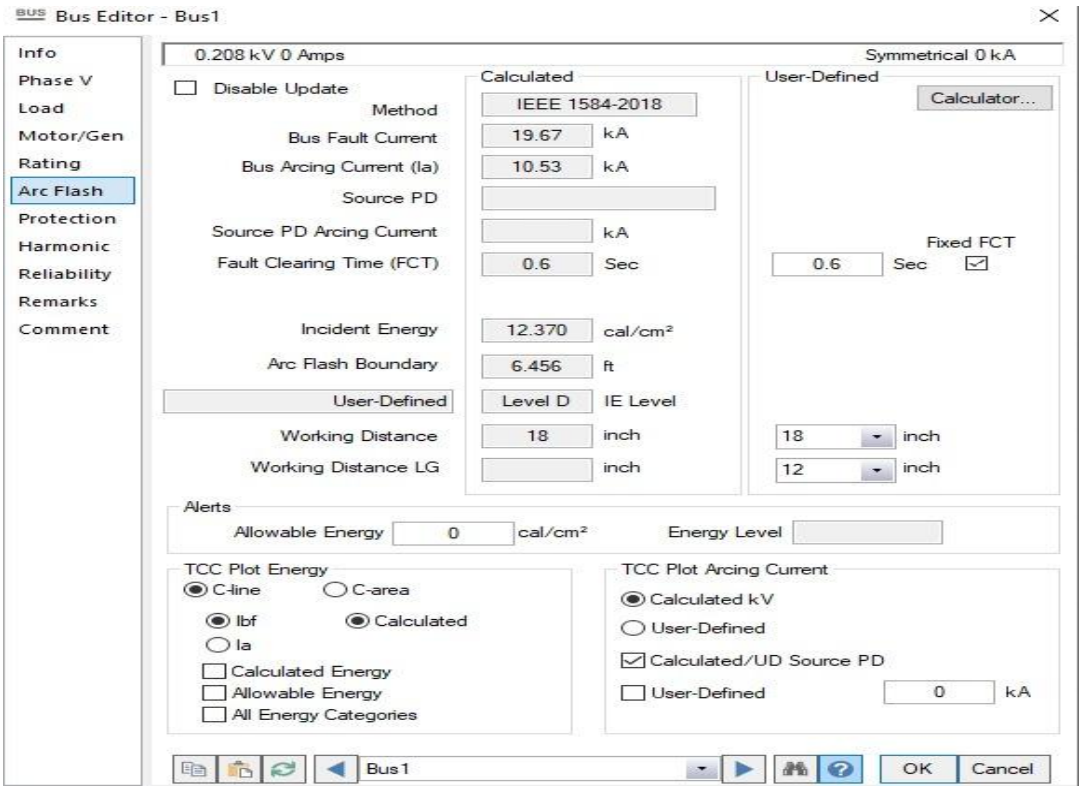


Fig: Arc-Flash Settings for Bus-1 for generator to load scenario.

Arc Flash Bus-2 Parameter Settings

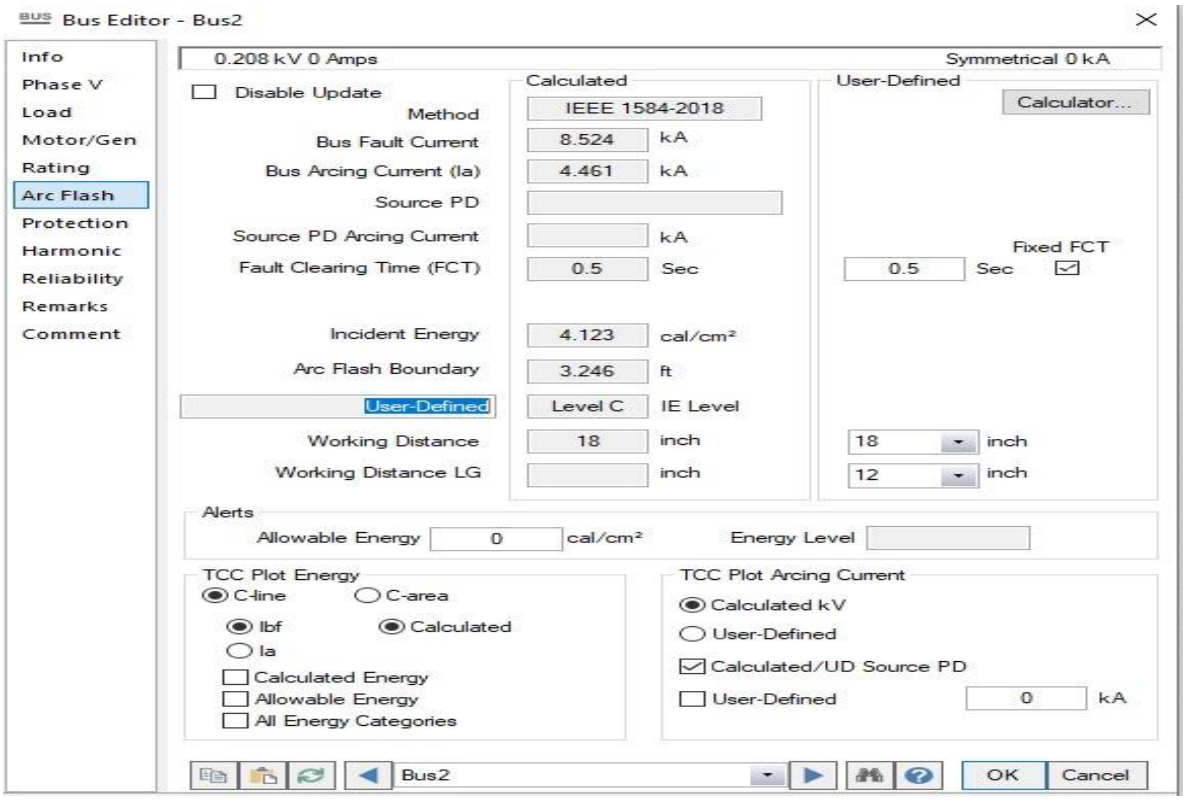


Fig: Arc-Flash Settings for Bus-2 for Grid to load scenario.

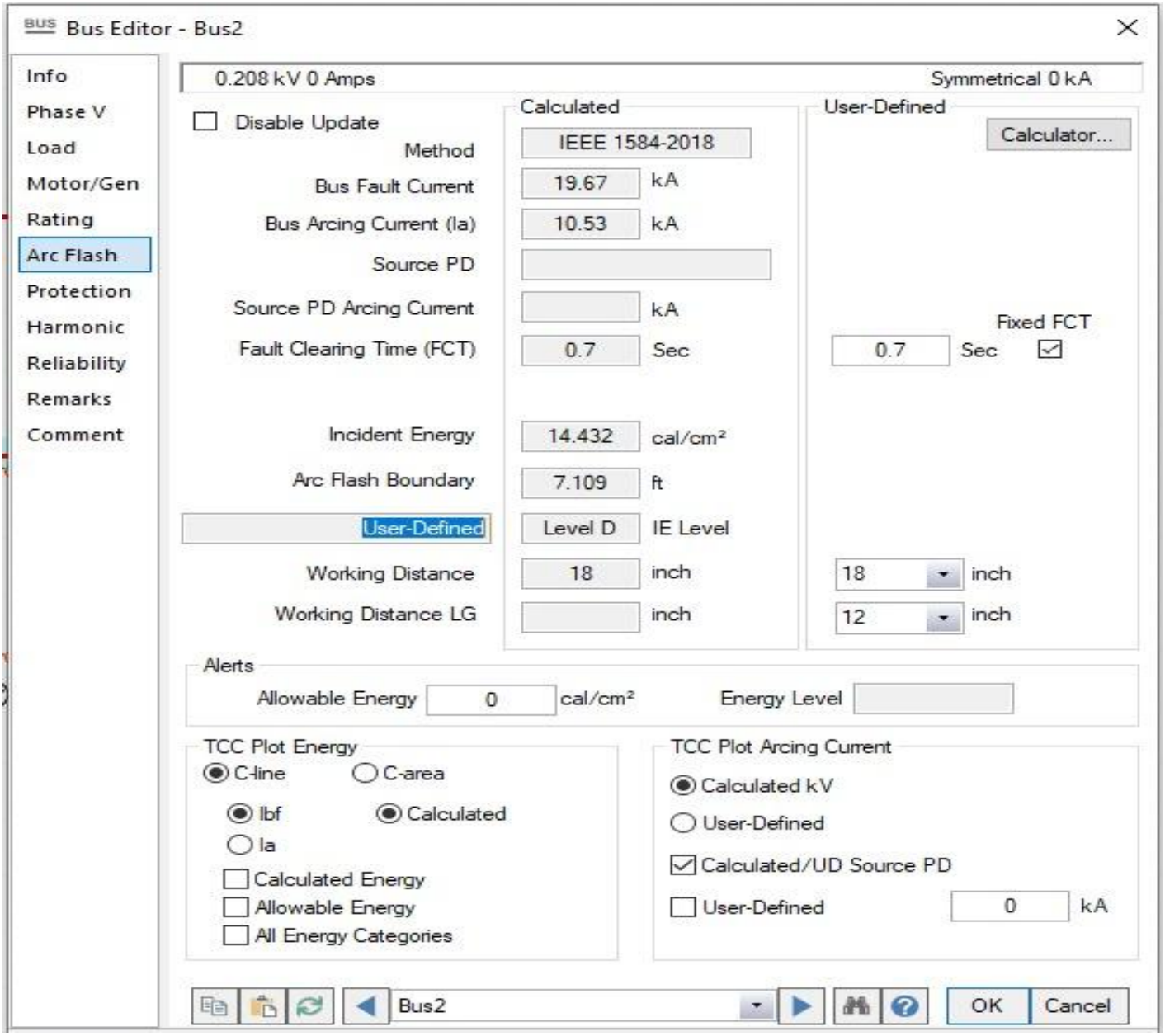
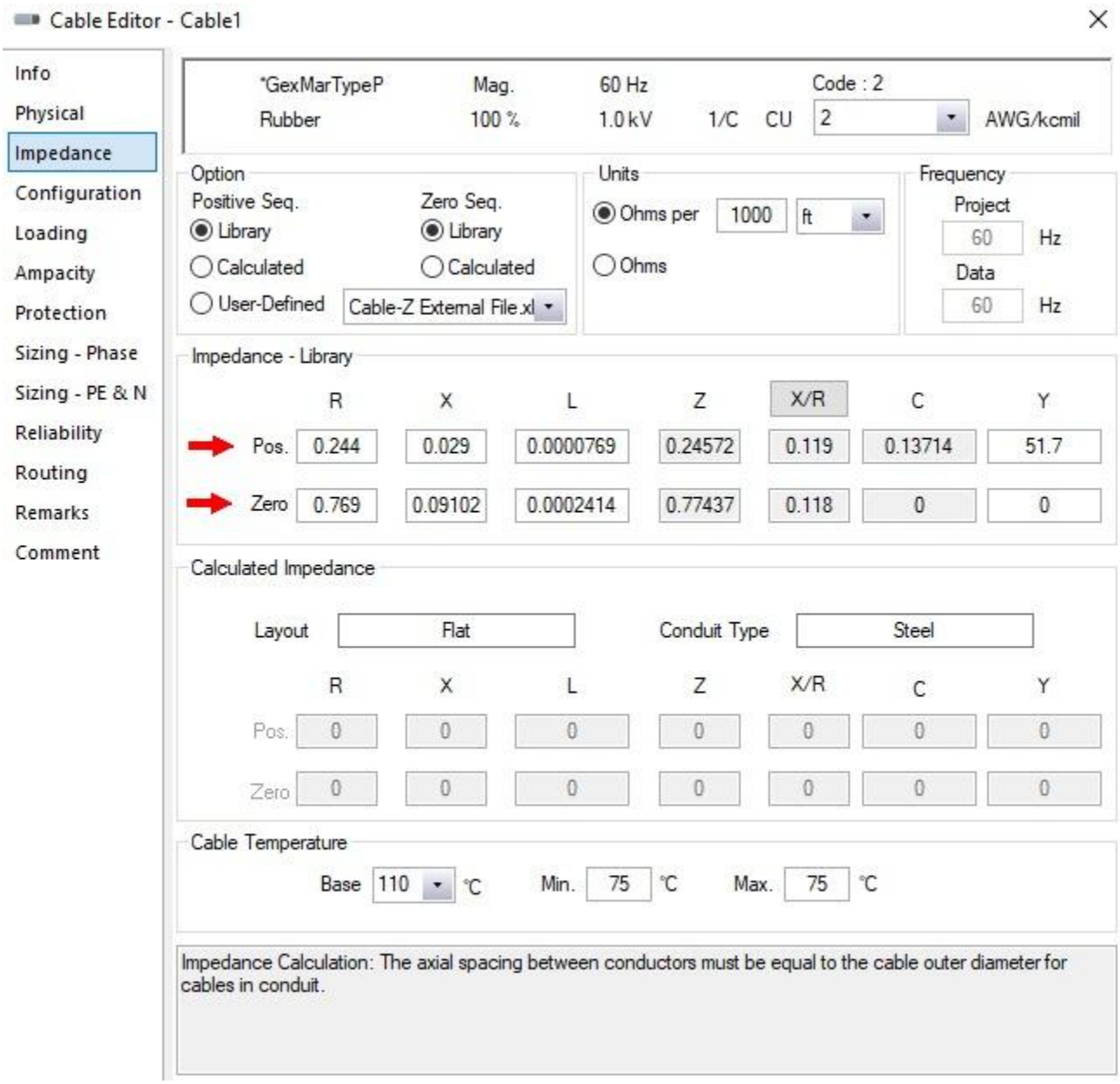


Fig: Arc-Flash Settings for Bus-2 for generator to load scenario.

Conductors

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



Cable Editor - Cable7

- Info
- Physical
- Impedance
- Configuration
- Loading
- Ampacity
- Protection
- Sizing - Phase
- Sizing - PE & N
- Reliability
- Routing
- Remarks
- Comment

NEC	Non-Mag.	50 Hz			Code : 2	
Rubber 2	100 %	0.6 kV	1/C	CU	2	AWG/kcmil

Option

Positive Seq.: (•) Library ( ) Calculated ( ) User-Defined — Cable-Z External File.xl

Zero Seq.: (•) Library ( ) Calculated

Units

(•) Ohms per 1000 ft ( ) Ohms

Frequency

Project: 60 Hz

Data: 50 Hz

Impedance - Library

	R	X	L	Z	X/R	C	Y
Pos.	0.19	0.0456	0.000121	0.1954	0.24	0	0
Zero	0.3021	0.1143	0.0003032	0.323	0.378	0	0

Calculated Impedance

Layout: Flat

	R	X	L	Z	X/R	C	Y
Pos.	0.19404	0.10158	0.0002694	0.21902	0.524	0.12983	48.9432
Zero	0.19741	0.49333	0.0013086	0.53136	2.499	0.12983	48.9432

Cable Temperature

Base 75 °C Min. 75 °C Max. 75 °C

Impedance Calculation: DC resistance from the Physical page has been used.

Cable7 OK Cancel

Short Circuit Study

A short circuit analysis ensured that all equipment and protective devices have sufficient ratings to handle the maximum available fault current. We have conducted short circuit analysis in ETAP version 20.0.1. Two distinct simulations were conducted: one is grid to load and other is generator to load.

Grid to Load Short Circuit Current Analysis:

Bus	**Voltage Level (V)**	**RMS Symmetrical Short Circuit Current (kA)**
Bus1	25000	34.648
Bus2	208	6.208
12B (Cable1)	208	0.095
12C (Cable6)	208	0.222
12D (Cable7)	208	0.127
12E (Cable8)	208	0.139
12F (Cable12)	208	0.048
12G (Cable11)	208	0.108
M2H (Cable10)	208	0.220
12A (Cable9)	208	0.127

Generator to Load Short Circuit Current Analysis:

Bus Name	**Voltage Level (V)**	**RMS Symmetrical Short Circuit Current (kA)**
Bus1	208 V	17.256 kA
Bus2	208 V	0.101 kA
12B	208 V	0.101 kA
12C	208 V	0.232 kA
12D	208 V	0.127 kA
12E	208 V	0.140 kA
12F	208 V	0.038 kA
12G	208 V	0.105 kA
M2H	208 V	0.230 kA
12A	208 V	0.131 kA

Protection and Co-ordination Study:

The primary goal of overcurrent coordination is to establish optimal characteristics, ratings, and settings for overcurrent protective devices to minimize equipment damage while ensuring the rapid interruption of short circuits. Proper coordination ensures that the closest protective device to the fault operates first, limiting disruptions to the electrical system.

The term pickup refers to the minimum current required to activate a protective device. In the case of relays, pickup is defined as the minimum current that causes the relay to close its contacts. For overcurrent protective relays, the pickup current corresponds to the relay's current (or tap) setting.

Time-Current Characteristic (TCC) Curve Interpretation

From the ETAP-generated TCC curve, we can observe the following:

- Relay 02 (LV Side Relay): The pickup setting is calculated as:

$$Pickup\ Current = \frac{\text{Transformer Rated Current} \times\ 1.2}{\text{CT Ratio in LV Side}}$$

With a considered factor of 4, Relay 02 is expected to trip first for a fault near the feeder.

- Relay 01 (HV Side Relay): The pickup value is 3.10, ensuring that it provides backup protection by operating only after Relay 02 has had sufficient time to clear the fault.

Protection Device ID	Device Type	Manufacturer	Model	Max KV	Short Circuit I(Initial) amp
CB 208-2	Low-Voltage Circuit Breaker	ABB	SACE Tmax XT1	0.48	50
CB208-15	Low-Voltage Circuit Breaker	ABB	SACE Tmax XT1	0.48	50
CB 208-16	Low-Voltage Circuit Breaker	ABB	SACE Tmax XT1	0.48	50
CB 208 -17	Low-Voltage Circuit Breaker	ABB	SACE Tmax XT1	0.48	50
CB 208- 21	Low-Voltage Circuit Breaker	ABB	SACE Tmax XT1	0.48	50
CB 208- 19	Low-Voltage Circuit Breaker	ABB	SACE Tmax XT1	0.48	50
CB 208- 18	Low-Voltage Circuit Breaker	ABB	SACE Tmax XT1	0.48	50

CB 208- 13	Low-Voltage Circuit Breaker	ABB	SACE Tmax XT1	0.48	50
CB 208- 1	Low-Voltage Circuit Breaker	ABB	HD4_36_06_16	36	630

Protection Device ID	**Device Type**	**Manufacturer**	**Model**	**Primary Current(amp)**	**Secondary Current(amp)**	**Pick UP Range (sec)**	**FLA**
Relay 2	Electronic	Siemens	7SG11_Argus 1-6	400	5	0.05-2.5*CT	310.8
Relay 3	Electronic	Siemens	7SA 522_CIP RoTec 4	400	5	0.1-4	310

From the TCC plot, starting at 0.01s and for a given fault current, the first intersected curve belongs to Relay 02, meaning it will operate first. As we move further along the plot, the next intersected curve is Relay 01, confirming that it acts as a backup. This ensures selective coordination and minimizes unnecessary service interruptions.

Protection Device ID	**Device Type**	**Manufacturer**	**Model**	**Primary Current(amp)**	**Secondary Current(amp)**	**Turn Ratio**
CT 1	Electric Device	ABB	ABB CMV-0.5-400/5	400	5	80:1
CT2	Electric Device	ABB	ABB CMV-0.5-400/5	400	5	80:1

MCCB Considerations:

Molded-case circuit breakers (MCCBs) with thermal trip elements generally sustain 100% of their rated current at 25°C in open air. However, they should be applied at 80% of their continuous-current rating unless otherwise labeled. To ensure proper ventilation and prevent overheating, MCCBs must be installed according to Underwriters Laboratories (UL) specifications when placed within a panel board.

The ETAP TCC Curve validates that:

1. Relay 02 (LV side) is the first to trip for feeder faults, ensuring localized protection.
2. Relay 01 (HV side) acts as a backup, tripping after a coordination interval of 0.3s.
3. MCCBs are applied with correct continuous-current ratings to maintain system reliability.

This coordination ensures a selective and reliable protection scheme, reducing the risk of widespread outages while maintaining system integrity.

TCC Curve Analysis

Below figure is the TCC curve implementation using ETAP. The image contains multiple protective devices (relays and transformer withstand curves), each with a distinct TCC profile:

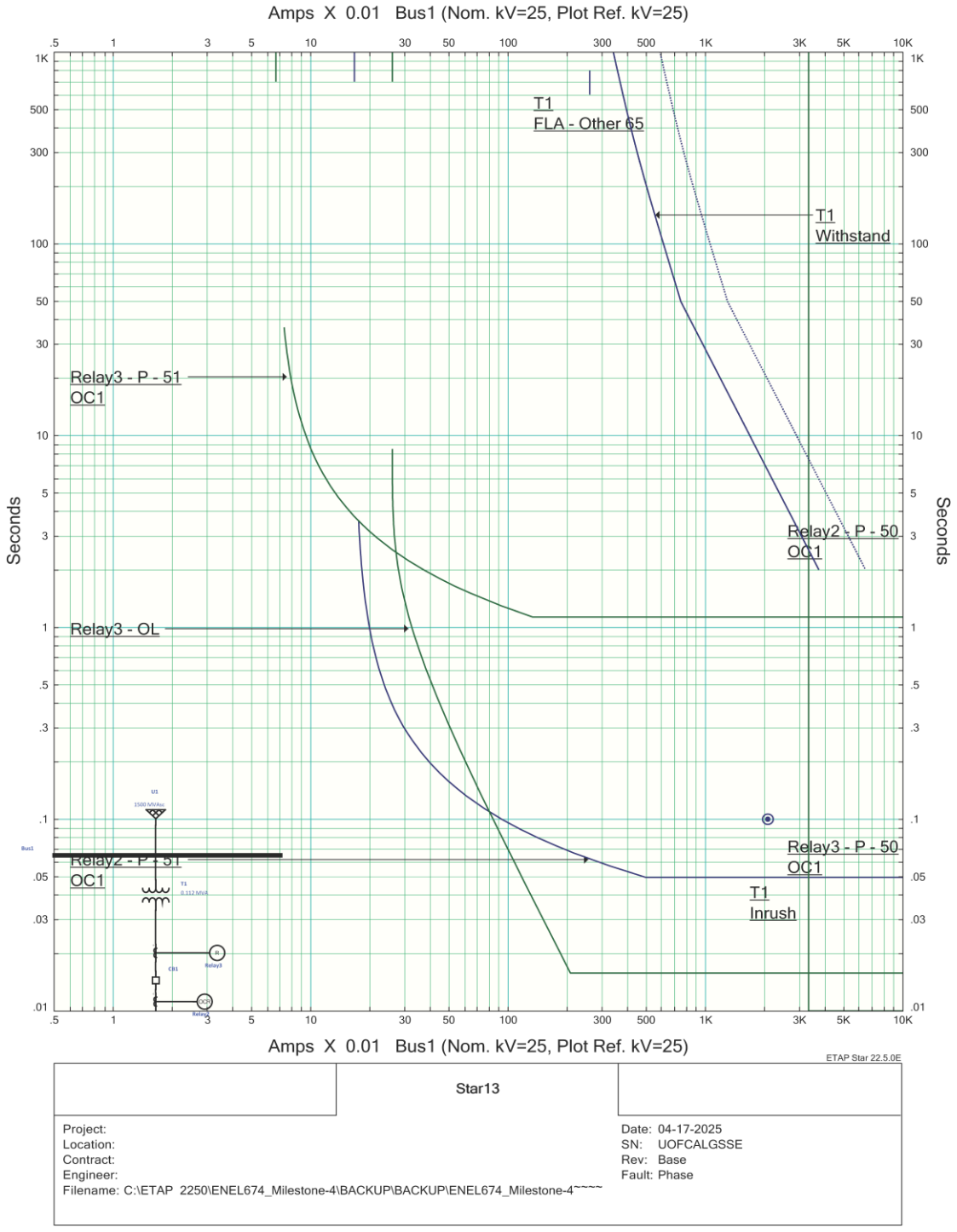


Figure: TCC Curve for Bus-1 (Grid to Load)

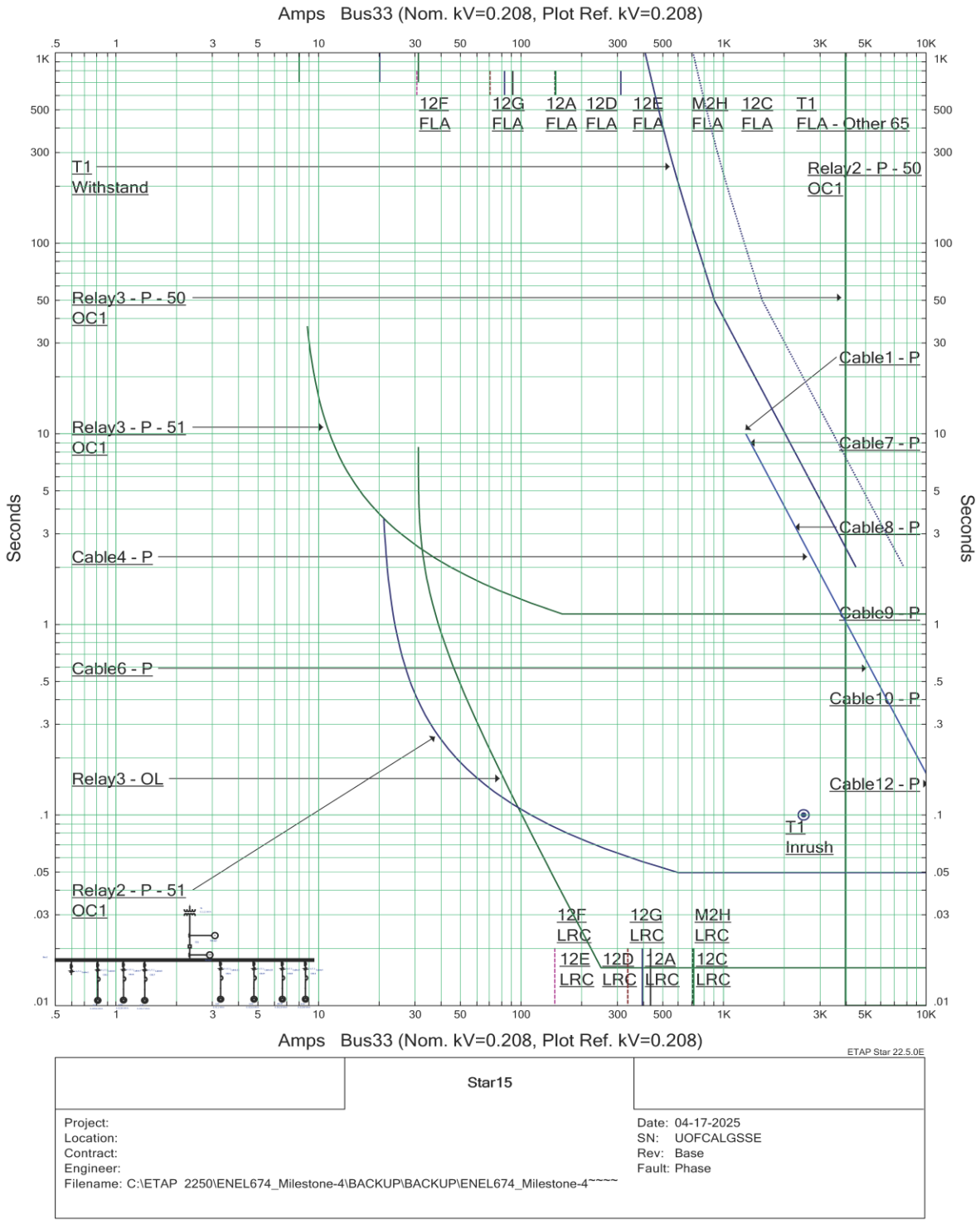


Fig: TCC Curve for Bus 2 (Grid to Load)

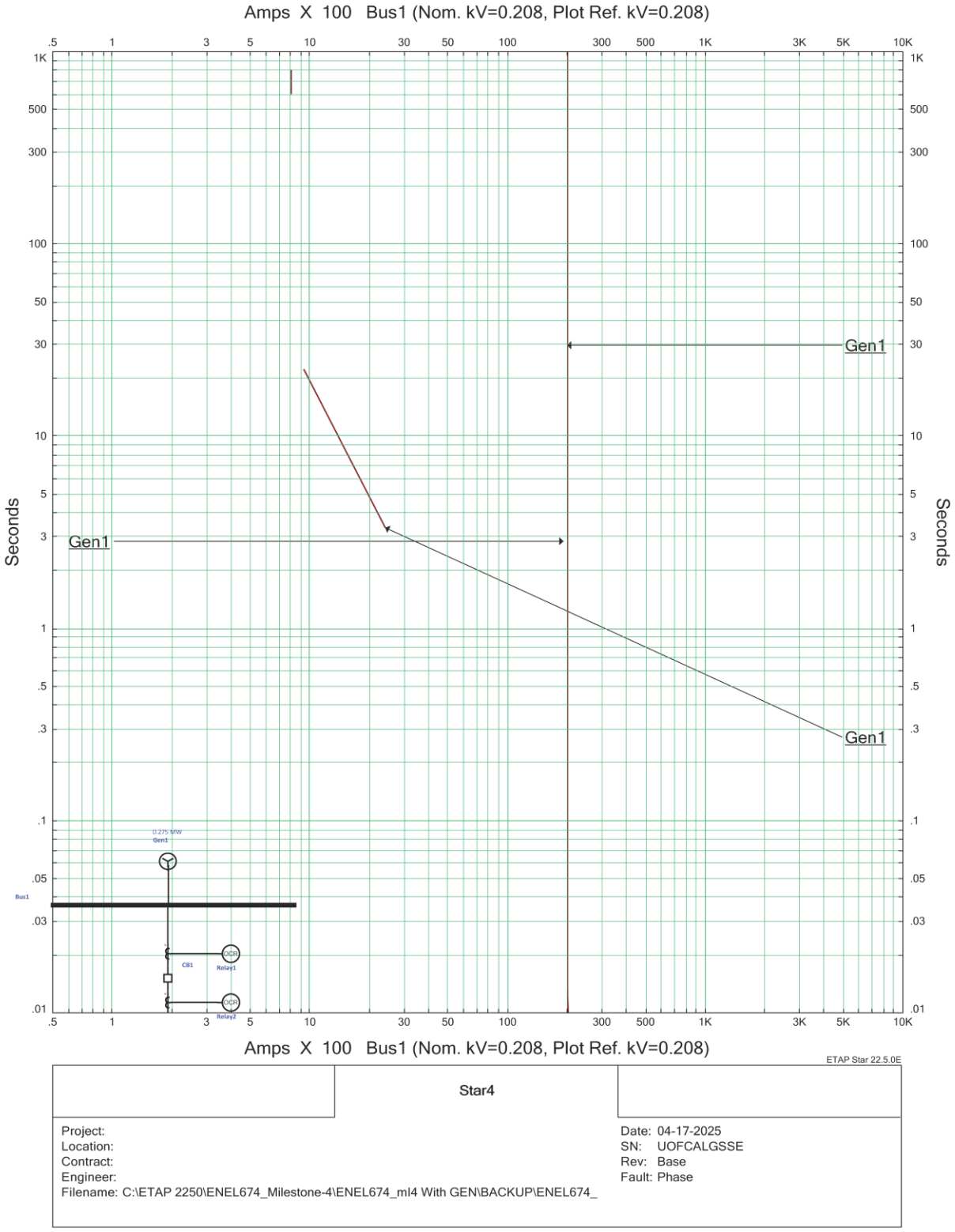
Key Analysis for Bus1 (Grid to Load)

- Transformer T1 withstand and inrush characteristics are properly coordinated with protective devices.
- Relay2 - P-50 (Instantaneous OC) and Relay2 - P-51 (Time OC) are set to trip before T1 withstand is violated.
- Relay3 protection curves (OL and P-51) show selective coordination, protecting downstream without overlapping the upstream device timings.
- FLA (Full Load Amps) and transformer inrush are well below the relay trip thresholds.
- Coordination: Excellent separation between relay operating curves ensuring minimal overlap — indicating good coordination.

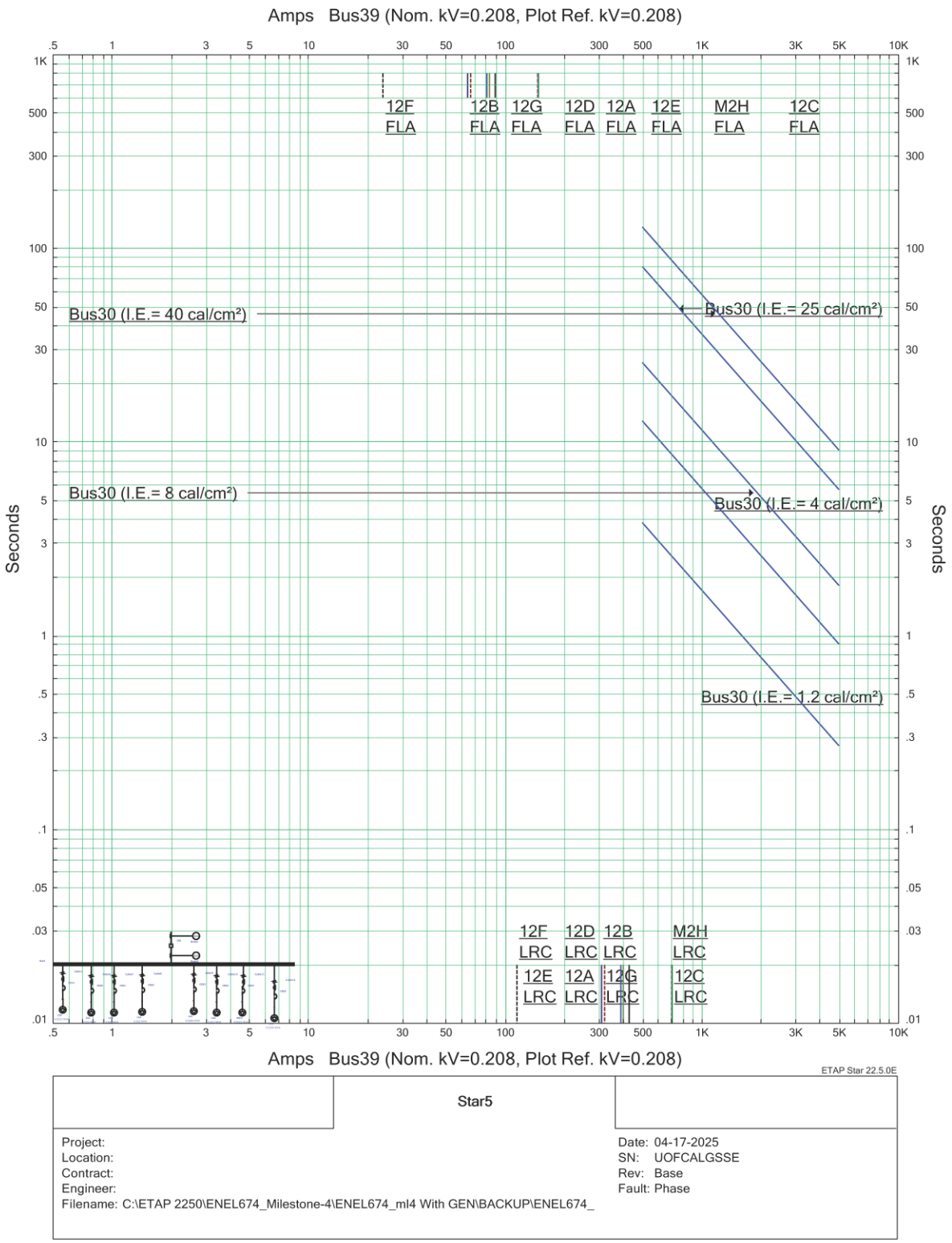
Key Analysis for Bus 2 (Grid to Load)

- More complex downstream system with multiple cables (Cable1 through Cable12) and relays involved.
- Relay3 and Relay2 (P-50, P-51, OL) offer layered protection with time-delayed and instantaneous trip settings.
- Transformer T1 withstand and inrush clearly marked and respected by relay settings.
- Motor loads (12E, 12G, 12A, etc.) show both FLA and LRC (Locked Rotor Current); LRCs are below trip curves, avoiding nuisance tripping during motor starting.
- Cable protections are well coordinated with relay curves — providing discrimination without unnecessary overlap.

TCC Curve for Bus 1 (Generator to Load):



TCC Curve for Bus 2 (Generator to Load):



TCC for Bus1 (Generator to Load)

Analysis:

- Gen1 shows two separate trip curves—likely for long-time and short-time protection.
- Relay pickup current begins around 300 A (x100 = 30,000 A).
- Clearing time at lower fault currents (~1,000 A actual) ranges from 10–30 seconds, and much faster (~0.1 sec) for high fault currents (e.g., >5,000 A actual).
- Curve separation suggests time grading for backup coordination.
- Selective coordination is present between upstream and downstream protective elements.
- Arc Flash Energy levels would depend on clearing times and current magnitude.

TCC for Bus 2 (Generator to Load)

Analysis:

- Load protection is defined with motor full-load amps (FLA) and locked rotor current (LRC) indicators.
- Protective curves are coordinated well with motor characteristics, minimizing nuisance trips during starting.
- Arc flash boundaries are clearly illustrated, indicating hazard levels and PPE categories.
  - ✓ IE ≥ 40 cal/cm² suggests extreme hazard and need for remote operation.
  - ✓ IE ≤ 1.2 cal/cm² areas are safe zones with minimal PPE required.
- There is good separation between LRC and trip curves, ensuring starting current does not trip protection.

IEEE 242 Recommendations

IEEE 242, also known as the IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (commonly called the Buff Book), provides guidelines for the protection, coordination, and reliability of power systems in industrial and commercial facilities. The recommendations cover various aspects of electrical system design and operation to ensure safety, reliability, and efficiency.

Protection Devices and Settings **(Grid to Load)**

Device	Location	Protection Type	Observations
Relay3	Secondary of Transformer (T1)	Overcurrent Relay	Set to 16 kA max fault; primary device for main protection
Relay7	Feeder to Bus2	Overcurrent Relay	Set to 3.24 kA; coordinates with downstream loads
Feeder CBs (CB2–CB21)	Individual Loads	Thermal Magnetic / Electronic	Protect motors/load cables; LRC considered

Coordination Assessment (As per IEEE 242)

Criterion	Analysis
Relay Coordination	Relay3 and Relay7 show proper grading with fault currents; upstream relay has higher pickup and time delay.
Short-Circuit Ratings	All breakers and relays appear to be rated above the calculated fault currents 16 kA at transformer sec.
Time-Current Coordination	Based on TCC curves , device curves are well-separated to avoid nuisance tripping.
Motor Starting Coordination	Locked Rotor Currents (LRCs) for motors do not intersect protection curves, ensuring smooth starting.
Selective Coordination	Feeder protection (CB2–CB21) isolates faults locally without tripping upstream relays. This prevents total outages.

Breaker & Relay Coordination Comparison with IEEE 242

Protection Device	Function	Trip Setting / Curve	Actual Coordination	IEEE 242 Requirement	Compliance
CB1 + Relay3 (Main)	Protect transformer secondary and Bus1	Pickup: 3.24 kA Trip: 16 kA Inverse Time	Coordinates with Relay7 Clears Bus1/transformer faults	Should coordinate with downstream relays	Yes
Relay7 (Feeder Bus2)	Protects Bus2 and feeds CB2–CB21	Pickup: ~150 A Inverse Time	Coordinates with CB2–CB21	Should clear Bus2 faults without tripping upstream	Yes
CB2–CB21 (Load CBs)	Motor/Load protection	Instantaneous + short delay FLA aligned	Trips locally for faults at each load	Must coordinate with upstream feeder relay	Yes
CB19 (12A)	Motor 12A breaker	LRC support, 0.244 kA fault	Selective trip observed	Breaker must not trip on motor start	Yes
CB15 (12D)	Motor 12D breaker	LRC: 0.135 kA	TCC matches Relay7 delay	Should trip first under fault	Yes
CB21 (12F)	Load breaker	LRC 0.057 kA	Fast trip, upstream delay	First tripping device for 12F faults	Yes

Arc Flash Result and Analysis:

There are two Arc Flash result, one where the grid is feeding the loads and one where the load is being fed from the emergency generator. The results are shown below:

Scenario 1: Arc Flash with Grid Source

The system consists of a transformer (T1) feeding Bus2, with multiple outgoing feeders. The arc flash calculations were performed at Bus2, considering a fault occurring at this location.

Key Arc Flash Parameters:

- Maximum Arcing Current (Ia'): 5.352 kA
- Bus Location: Bus2
- Incident Energy (IE): 0.7 cal/cm² at 18 inches
- Arc Flash Protection Boundary (AFB): 1.1 ft
- Arc Flash Hazard Category: Level A

Arc Flash Current Analysis Grid to Load:

Location	Voltage Level (KV)	Arcing Current (kA)	Fault Clearing Time (s)	Arc Flash Boundary (ft)
Bus1	0.208	34.655	0.8	44.7
Bus2	0.208	4.461	0.5	3.2
12B	0.208	0.099	0.5	3.2
12C	0.208	0.246	0.5	3.2
12D	0.208	0.136	0.5	3.2
12E	0.208	0.149	0.5	3.2
12F	0.208	0.05	0.5	3.2
12G	0.208	0.115	0.5	3.2
M2H	0.208	0.244	0.5	3.2
12A	0.208	0.136	0.5	3.2

Scenario 2: Arc Flash with Generator Source

The second scenario involves a generator (Gen1) feeding Bus1, which in turn supplies Bus2. This configuration affects the fault current levels and subsequently alters the arc flash hazard parameters.

Key Arc Flash Parameters:

- Maximum Arcing Current (Ia'): 4.916 kA

- Bus Location: Bus2
- Incident Energy (IE): 4.569 cal/cm² at 18 inches
- Arc Flash Protection Boundary (AFB): 3.5 ft
- Arc Flash Hazard Category: Level C

Arc Flash Current Analysis Generator to Load:

Location	Voltage (KV)	Arcing Current (kA)	Fault Clearing Time (s)	Arc Flash Boundary (ft)
Bus1	0.208	10.529	0.8	6.5
Bus2	0.208	10.529	0.7	7.1
12B	0.208	0.117	0.5	7.1
12C	0.208	0.27	0.5	7.1
12D	0.208	0.147	0.5	7.1
12E	0.208	0.162	0.5	7.1
12F	0.208	0.043	0.5	7.1
12G	0.208	0.121	0.5	7.1
M2H	0.208	0.267	0.5	7.1
12A	0.208	0.151	0.5	7.1

PPE Recommendation & Requirements

Technicians must never enter an arc flash hazard zone without the appropriate Personal Protective Equipment (PPE). The level of PPE required depends on the incident energy levels at each location. Using IEEE 1584 calculations and NFPA 70E guidelines, the required PPE Category (CAT) is determined based on the incident energy (cal/cm²) at the specific bus locations in each scenario.

Recommended PPE for Scenario 1 (Grid Source):

Since the **incident energy is below 1.2 cal/cm²**, arc-rated PPE is **not mandatory**. However, technicians must still follow basic electrical safety protocols:

1. **Standard flame-resistant (FR) work clothing**
2. **Safety goggles or face shield**
3. **Leather safety shoes** (electrically rated)
4. **Hard hat** (if required for worksite safety)
5. **Hearing protection** (optional, recommended for electrical work)
6. **Rubber insulating gloves** (if working near live conductors)

Key Consideration: Workers can operate within the arc flash boundary **without a full arc-rated PPE suit**, but precautions should still be taken.

Recommended PPE for Scenario 2 (Bus2 - Generator Source):

Since the incident energy is **above 4 cal/cm²**, **Category 2 arc-rated PPE** is required for safety:

1. **Arc-rated long-sleeve uniform (minimum 8 cal/cm² rating)**
2. **Arc-rated face shield with balaclava** (or arc-rated hood)
3. **Rubber insulating gloves with leather protectors**
4. **Leather safety shoes** (EH-rated, non-conductive)
5. **Hard hat** (insulated and arc-rated)
6. **Hearing protection** (earplugs or earmuffs for arc blast noise protection)

Key Consideration: Technicians must wear **full CAT 2 PPE** when working within **3.5 feet** of the energized equipment.

Summary of PPE Requirements for Both Scenarios:

Scenario	Arcing Current (kA)	Incident Energy (cal/cm²)	Arc Flash Boundary (ft)	PPE Category	Required PPE
Scenario 1 (Transformer Source, Bus2)	5.352 kA	0.7 cal/cm²	1.1 ft	Below CAT 1	Standard workwear, leather gloves, safety goggles
Scenario 2 (Generator Source, Bus2)	4.916 kA	4.569 cal/cm²	3.5 ft	CAT 2	Arc-rated clothing (8 cal/cm²), face shield/balaclava, gloves, hearing protection

Appendices

Appendix A - Single Line Diagrams with Short Circuit and Arc Flash Energy Levels

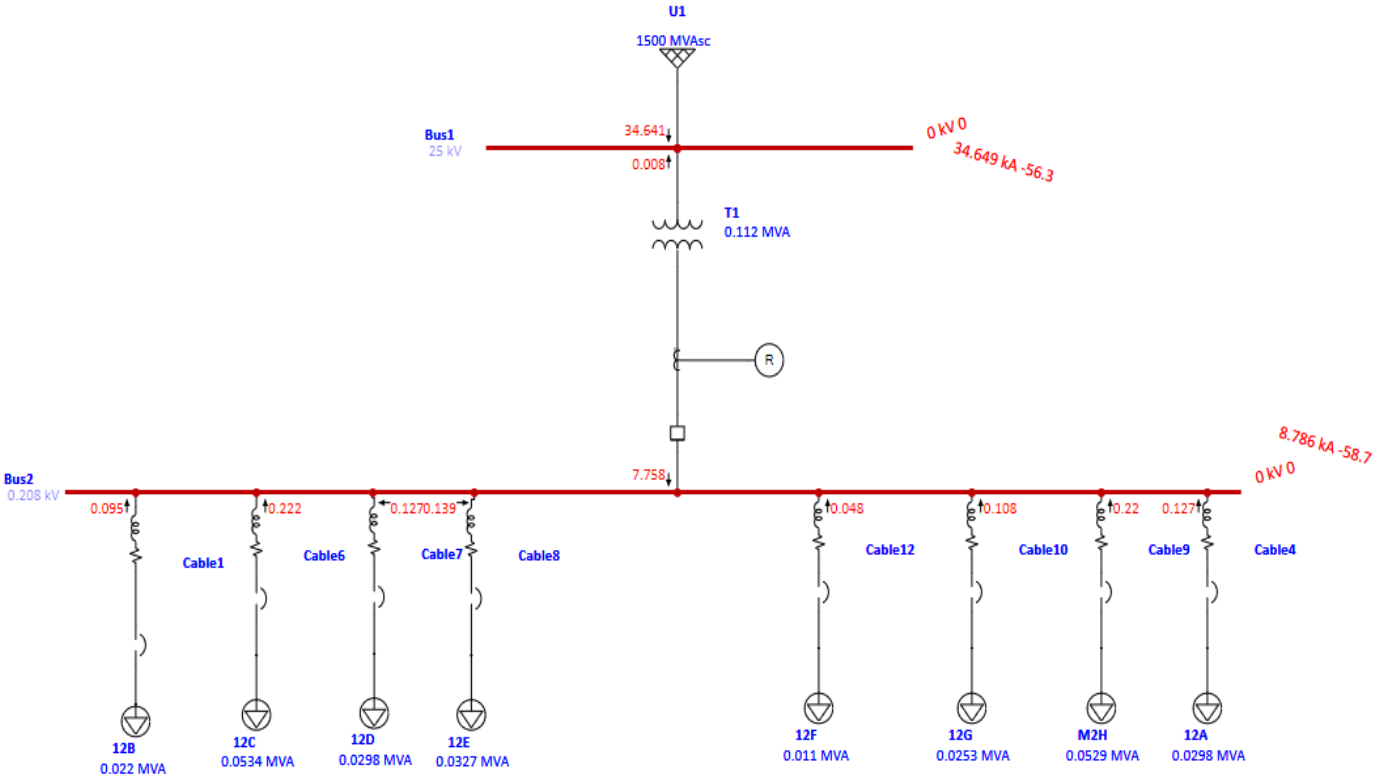


Fig: SLD of Short Circuit with Grid

SLD of Short Circuit with Generator

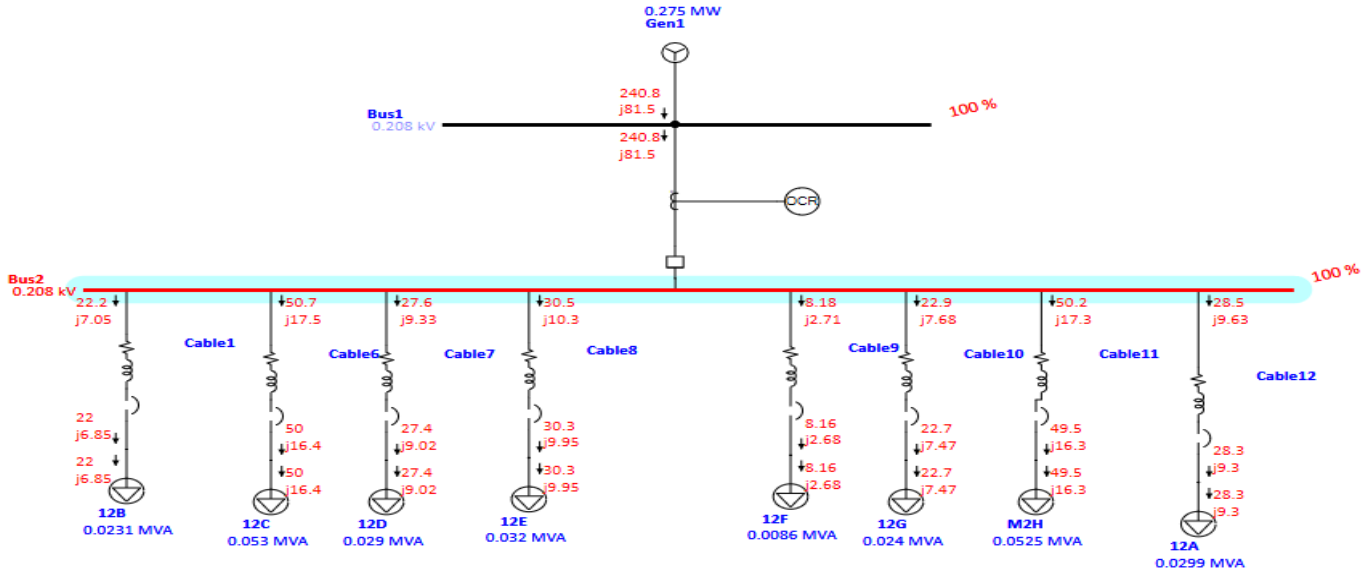


Fig: SLD of Short Circuit with Generator

Arc Flash Analysis with Grid

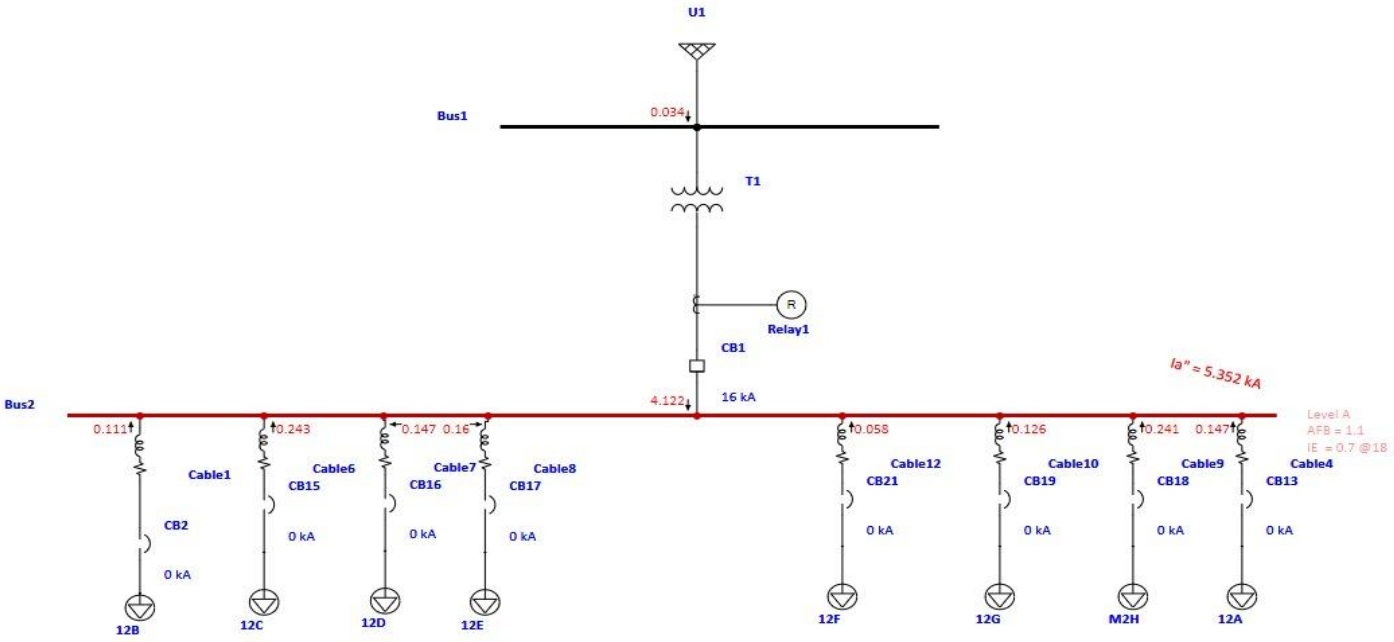


Fig: SLD of Arc Flash Analysis with Grid

Arc Flash Analysis with Generator

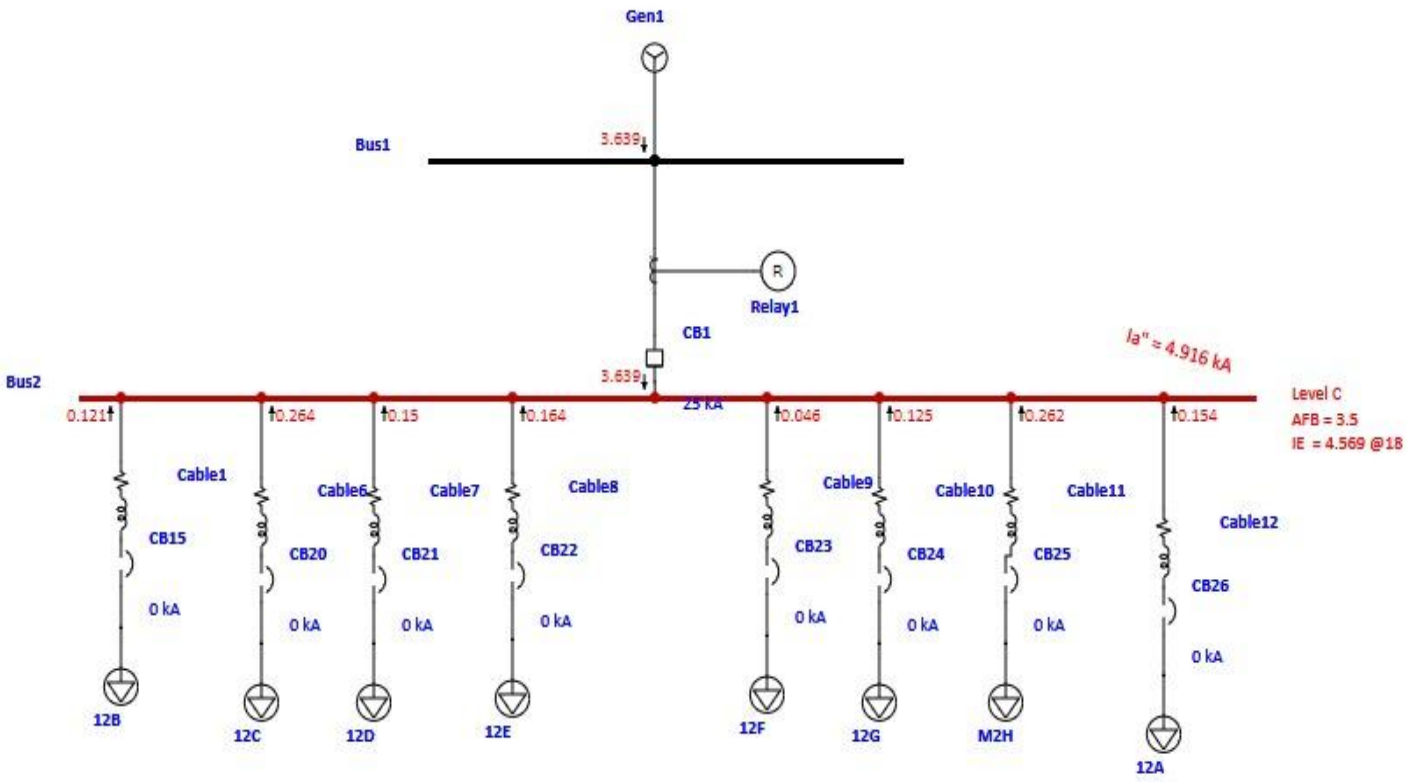


Fig: SLD of Arc Flash Analysis with Generator.

Appendix B: Data from the Short Circuit Study

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	0	9	10

	XFMR2	XFMR3	Reactor	Line/Cable/ Busway	Impedance	Tie PD	Total
Number of Branches:	1	0	0	8	0	0	9

	Synchronous Generator	Power Grid	Synchronous Motor	Induction Machines	Lumped Load	Inverter	Total
Number of Machines:	0	1	0	0	8	0	9

System Frequency:	60.00
Unit System:	English
Project Filename:	ENEL674_Milestone-4~~
Output Filename:	C:\ETAP 2250\ENEL674_Milestone-4\BACKUP\Untitled.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.
Bus1	SWNG	25.000	25.000	1	100.00	0.00
Bus2	Load	0.208	0.208	1	100.00	-30.00
Bus25	Load	0.208	0.208	1	100.00	-30.00
Bus27	Load	0.208	0.208	1	100.00	-30.00
Bus29	Load	0.208	0.208	1	100.00	-30.00
Bus30	Load	0.208	0.208	1	100.00	-30.00
Bus31	Load	0.208	0.208	1	100.00	-30.00
Bus32	Load	0.208	0.208	1	100.00	-30.00
Bus33	Load	0.208	0.208	1	100.00	-30.00
Bus35	Load	0.208	0.208	1	100.00	-30.00

10 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

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

Line/Cable/Busway			Length									
ID	Library	Size	Adj. (ft)	% Tol.	#/Phase	T (°C)	R1	X1	Y1	R0	X0	Y0
Cable1	1.0MCUS1	2	328.1	0.0	1	75	0.2192104	0.029	0.0000517	0.6908723	0.09102	
Cable4	0.6NCUN1	2	328.1	0.0	1	75	0.19	0.0456		0.3021	0.1143	
Cable6	0.6NCUN1	2	328.1	0.0	1	75	0.19	0.0456		0.3021	0.1143	
Cable7	0.6NCUN1	2	328.1	0.0	1	75	0.19	0.0456		0.3021	0.1143	
Cable8	0.6NCUN1	2	328.1	0.0	1	75	0.19	0.0456		0.3021	0.1143	
Cable9	0.6NCUN1	2	328.1	0.0	1	75	0.19	0.0456		0.3021	0.1143	
Cable10	0.6NCUN1	2	328.1	0.0	1	75	0.19	0.0456		0.3021	0.1143	
Cable12	0.6NCUN1	2	328.1	0.0	1	75	0.19	0.0456		0.3021	0.1143	

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
T1	0.112	25.000	0.208	5.00	1.50	0	0	0	0	0	5.00	Dyn	30.00

2-Winding Transformer Grounding Input Data

Transformer	Rating			Conn.	Grounding							
					Primary				Secondary			
ID	MVA	Prim. kV	Sec. kV	Type	Type	kV	Amp	ohm	Type	kV	Amp	ohm
T1	0.112	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
T1	2W XFMR	Bus1	Bus2	2476.34	3714.51	4464.29	
Cable1	Cable	Bus27	Bus2	16623.39	2199.16	16768.22	0.0000007
Cable4	Cable	Bus25	Bus2	14408.27	3457.99	14817.42	
Cable6	Cable	Bus29	Bus2	14408.27	3457.99	14817.42	
Cable7	Cable	Bus30	Bus2	14408.27	3457.99	14817.42	
Cable8	Cable	Bus31	Bus2	14408.27	3457.99	14817.42	
Cable9	Cable	Bus32	Bus2	14408.27	3457.99	14817.42	
Cable10	Cable	Bus33	Bus2	14408.27	3457.99	14817.42	
Cable12	Cable	Bus35	Bus2	14408.27	3457.99	14817.42	

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	Bus1	1500.000	25.000	1.50	3.69800	5.54700	Wye - Solid	1.50	6.666667	10.00000

Total Power Grids (= 1) 1500.000 MVA

Lumped Load Input Data

Lumped Load					Motor Loads									
	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.
12A	29.8	0.208	80	20	22.6	7.4	2.38	2.38	8.403	20.00	50.00	Delta		
12B	22.0	0.208	80	20	16.7	5.5	2.38	2.38	8.403	20.00	50.00	Delta		
12C	53.4	0.208	80	20	40.6	13.4	2.38	2.38	8.403	20.00	50.00	Delta		
12D	29.8	0.208	80	20	22.6	7.4	2.38	2.38	8.403	20.00	50.00	Delta		
12E	32.7	0.208	80	20	24.9	8.2	2.38	2.38	8.403	20.00	50.00	Delta		
12F	11.0	0.208	80	20	8.4	2.7	2.38	2.38	8.403	20.00	50.00	Delta		
12G	25.3	0.208	80	20	19.2	6.3	2.38	2.38	8.403	20.00	50.00	Delta		
M2H	52.9	0.208	80	20	40.2	13.2	2.38	2.38	8.403	20.00	50.00	Delta		

Total Connected Lumped Loads (= 8): 257.0 kVA

SHORT- CIRCUIT REPORT

Fault at bus: **Bus1**

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
Bus1	Total	0.00	34.655	0.00	112.07	112.07	27.334	27.334	3.70E+000	5.54E+000	6.67E+000	1.00E+001
Bus2	Bus1	27.16	0.014	73.45	72.90	100.00	0.007	0.000	8.66E+003	1.40E+004		
U1	Bus1	100.00	34.641	100.00	100.00	100.00	27.327	27.334	3.70E+000	5.55E+000	6.67E+000	1.00E+001

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

Fault at bus: **Bus2**

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
Bus2	Total	0.00	8.524	0.00	105.57	106.29	7.586	7.586	1.77E+003	2.73E+003	2.48E+003	3.71E+003
Bus27	Bus2	12.65	0.209	7.51	104.48	110.05	0.124	0.000	6.44E+004	1.16E+005		
Bus25	Bus2	14.75	0.276	8.75	104.80	110.62	0.164	0.000	4.97E+004	8.73E+004		
Bus29	Bus2	24.41	0.457	14.48	104.96	113.37	0.271	0.000	3.41E+004	5.02E+004		
Bus30	Bus2	14.75	0.276	8.75	104.80	110.62	0.164	0.000	4.97E+004	8.73E+004		
Bus31	Bus2	16.04	0.300	9.51	104.79	111.00	0.178	0.000	4.65E+004	7.98E+004		
Bus32	Bus2	24.23	0.454	14.37	104.95	113.31	0.269	0.000	3.42E+004	5.07E+004		
Bus33	Bus2	12.69	0.238	7.53	104.84	110.03	0.141	0.000	5.60E+004	1.02E+005		
Bus35	Bus2	5.80	0.109	3.44	105.12	108.01	0.064	0.000	1.10E+005	2.31E+005		
Bus1	Bus2	99.85	6.208	99.93	100.00	99.93	6.212	7.586 *	2.48E+003	3.72E+003	2.48E+003	3.71E+003

\# 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.
Bus1	25.000	19.223	-28.835	34.655	15.162	-22.743	27.334	24.972	16.647	30.012	-31.231	-7.259	32.063
Bus2	0.208	4.641	-7.150	8.524	4.162	-6.343	7.586	6.192	4.019	7.382	-8.078	-1.170	8.162

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
Bus1	25.000	0.23103	0.34655	0.41650	0.23103	0.34655	0.41650	0.41667	0.62500	0.75116	0.00000	0.00000	0.00000
Bus2	0.208	0.00767	0.01182	0.01409	0.00767	0.01182	0.01409	0.01071	0.01607	0.01931	0.00000	0.00000	0.00000

Electrical Transient Analyzer Program

Short-Circuit Analysis

ANSI Standard

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

1.5-4 Cycle Network

	Swing	V-Control	Load	Total
Number of Buses:	1	0	9	10

	XFMR2	XFMR3	Reactor	Line/Cable/ Busway	Impedance	Tie PD	Total
Number of Branches:	0	0	0	8	0	1	9

	Synchronous Generator	Power Grid	Synchronous Motor	Induction Machines	Lumped Load	Inverter	Total
Number of Machines:	1	0	0	0	8	0	9

System Frequency:	60.00
Unit System:	English
Project Filename:	ENEL674_mI4 With GEN~~
Output Filename:	C:\ETAP 2250\ENEL674_Milestone-4\ENEL674_mI4 With GEN\BACKUP\Untitled.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.
Bus1	SWNG	0.208	0.208	1	100.00	0.00
Bus2	Load	0.208	0.208	1	100.00	0.00
Bus30	Load	0.208	0.208	1	100.00	0.00
Bus35	Load	0.208	0.208	1	100.00	0.00
Bus36	Load	0.208	0.208	1	100.00	0.00
Bus37	Load	0.208	0.208	1	100.00	0.00
Bus38	Load	0.208	0.208	1	100.00	0.00
Bus39	Load	0.208	0.208	1	100.00	0.00
Bus40	Load	0.208	0.208	1	100.00	0.00
Bus41	Load	0.208	0.208	1	100.00	0.00

10 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

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

Line/Cable/Busway ID	Library	Size	Length Adj. (ft)	Length % Tol.	#/Phase	T (°C)	R1	X1	Y1	R0	X0	Y0
Cable1			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029
Cable6			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029
Cable7			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029
Cable8			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029
Cable9			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029
Cable10			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029
Cable11			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029
Cable12			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029

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

Branch Connections

CKT/Branch		Connected Bus ID		% Impedance, Pos. Seq., 100 MVAb			
ID	Type	From Bus	To Bus	R	X	Z	Y
Cable1	Cable	Bus2	Bus30	2473.60	3668.41	4424.46	0.0000003
Cable6	Cable	Bus2	Bus35	2473.60	3668.41	4424.46	0.0000003
Cable7	Cable	Bus2	Bus36	2473.60	3668.41	4424.46	0.0000003
Cable8	Cable	Bus2	Bus37	2473.60	3668.41	4424.46	0.0000003
Cable9	Cable	Bus2	Bus38	2473.60	3668.41	4424.46	0.0000003
Cable10	Cable	Bus2	Bus39	2473.60	3668.41	4424.46	0.0000003
Cable11	Cable	Bus2	Bus40	2473.60	3668.41	4424.46	0.0000003
Cable12	Cable	Bus2	Bus41	2473.60	3668.41	4424.46	0.0000003
CB1	Tie Breakr	Bus1	Bus2				

Synchronous Generator Input Data

Synchronous Generator		Rating			Positive Seq. Impedance					Grounding			Zero Seq. Impedance		
							% Xd"								
ID	Type	MVA	kV	RPM	X"/R	% R	Adj.	Tol.	% Xd'	Conn.	Type	Amp	X/R	% R0	% X0
Gen1	Steam Turbo	0.290	0.208	1800	1.67	2.400	4.00	0.0	4.00	Wye	Solid		2.50	1.600	4.00

Total Connected Synchronous Generators (= 1): 0.290 MVA

Lumped Load Input Data

Lumped Load					Motor Loads									
	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.
12A	29.9	0.208	80	20	22.7	7.5	2.38	2.38	8.403	20.00	50.00	Delta		
12B	23.1	0.208	80	20	17.7	5.5	2.38	2.38	8.403	20.00	50.00	Delta		
12C	53.0	0.208	80	20	40.3	13.2	2.38	2.38	8.403	20.00	50.00	Delta		
12D	29.0	0.208	80	20	22.0	7.2	2.38	2.38	8.403	20.00	50.00	Delta		
12E	32.0	0.208	80	20	24.3	8.0	2.38	2.38	8.403	20.00	50.00	Delta		
12F	8.6	0.208	80	20	6.5	2.1	2.38	2.38	8.403	20.00	50.00	Delta		
12G	24.0	0.208	80	20	18.2	6.0	2.38	2.38	8.403	20.00	50.00	Delta		
M2H	52.5	0.208	80	20	39.9	13.1	2.38	2.38	8.403	20.00	50.00	Delta		

Total Connected Lumped Loads (= 8): 252.1 kVA

SHORT- CIRCUIT REPORT

Fault at bus: **Bus1**

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
Bus1	Total	0.00	18.268	0.00	102.45	94.28	18.899	18.899	7.54E+002	1.32E+003	5.52E+002	1.38E+003
Gen1	Bus1	100.00	17.256	100.00	100.00	100.00	17.776	18.899	8.28E+002	1.38E+003	5.52E+002	1.38E+003
Bus30	Bus2	1.59	0.100	1.71	102.13	94.48	0.107	0.000	4.79E+004	2.74E+005		
Bus35	Bus2	3.58	0.225	3.77	101.81	94.74	0.236	0.000	2.23E+004	1.22E+005		
Bus36	Bus2	1.99	0.125	2.12	102.06	94.53	0.133	0.000	3.87E+004	2.19E+005		
Bus37	Bus2	2.19	0.137	2.33	102.03	94.56	0.146	0.000	3.53E+004	1.99E+005		
Bus38	Bus2	0.60	0.037	0.65	102.32	94.36	0.040	0.000	1.25E+005	7.30E+005		
Bus39	Bus2	1.65	0.104	1.77	102.12	94.49	0.111	0.000	4.62E+004	2.64E+005		
Bus40	Bus2	3.55	0.222	3.73	101.82	94.74	0.234	0.000	2.25E+004	1.23E+005		
Bus41	Bus2	2.05	0.129	2.18	102.05	94.54	0.137	0.000	3.76E+004	2.13E+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: **Bus2**

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
Bus2	Total	0.00	18.268	0.00	102.45	94.28	18.899	18.899	7.54E+002	1.32E+003	5.52E+002	1.38E+003
Bus30	Bus2	1.59	0.100	1.71	102.13	94.48	0.107	0.000	4.79E+004	2.74E+005		
Bus35	Bus2	3.58	0.225	3.77	101.81	94.74	0.236	0.000	2.23E+004	1.22E+005		
Bus36	Bus2	1.99	0.125	2.12	102.06	94.53	0.133	0.000	3.87E+004	2.19E+005		
Bus37	Bus2	2.19	0.137	2.33	102.03	94.56	0.146	0.000	3.53E+004	1.99E+005		
Bus38	Bus2	0.60	0.037	0.65	102.32	94.36	0.040	0.000	1.25E+005	7.30E+005		
Bus39	Bus2	1.65	0.104	1.77	102.12	94.49	0.111	0.000	4.62E+004	2.64E+005		
Bus40	Bus2	3.55	0.222	3.73	101.82	94.74	0.234	0.000	2.25E+004	1.23E+005		
Bus41	Bus2	2.05	0.129	2.18	102.05	94.54	0.137	0.000	3.76E+004	2.13E+005		
Gen1	Bus1	100.00	17.256	100.00	100.00	100.00	17.776	18.899	8.28E+002	1.38E+003	5.52E+002	1.38E+003

\# 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

1.5-4 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.
Bus1	0.208	9.068	-15.859	18.268	8.631	-16.813	18.899	14.224	8.177	16.406	10.319	16.343	19.328
Bus2	0.208	9.068	-15.859	18.268	8.631	-16.813	18.899	14.224	8.177	16.406	10.319	16.343	19.328

All fault currents are symmetrical (1.5-4 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
Bus1	0.208	0.00326	0.00571	0.00657	0.00306	0.00528	0.00610	0.00239	0.00597	0.00643	0.00000	0.00000	0.00000
Bus2	0.208	0.00326	0.00571	0.00657	0.00306	0.00528	0.00610	0.00239	0.00597	0.00643	0.00000	0.00000	0.00000

Appendix C: Time Current Characteristics (TCC) Curves

Project:		**ETAP**		Page:	1
Location:		22.5.0E		Date:	04-17-2025
Contract:				SN:	UOFCALGSSE
Engineer:			Study Case: SM	Revision:	Base
Filename:	ENEL674_Milestone-4~~			Config.:	Normal

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	0	9	10

	XFMR2	XFMR3	Reactor	Line/Cable/ Busway	Impedance	Tie PD	Total
Number of Branches:	1	0	0	8	0	0	9

	Synchronous Generator	Power Grid	Synchronous Motor	Induction Machines	Lumped Load	Inverter	Total
Number of Machines:	0	1	0	0	8	0	9

System Frequency:	60.00
Unit System:	English
Project Filename:	ENEL674_Milestone-4~~
Output Filename:	C:\ETAP 2250\ENEL674_Milestone-4\BACKUP\Untitled.ST1S

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.
Bus1	SWNG	25.000	25.000	1	100.00	0.00
Bus2	Load	0.208	0.208	1	100.00	-30.00
Bus25	Load	0.208	0.208	1	100.00	-30.00
Bus27	Load	0.208	0.208	1	100.00	-30.00
Bus29	Load	0.208	0.208	1	100.00	-30.00
Bus30	Load	0.208	0.208	1	100.00	-30.00
Bus31	Load	0.208	0.208	1	100.00	-30.00
Bus32	Load	0.208	0.208	1	100.00	-30.00
Bus33	Load	0.208	0.208	1	100.00	-30.00
Bus35	Load	0.208	0.208	1	100.00	-30.00

10 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

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

Line/Cable/Busway			Length									
ID	Library	Size	Adj. (ft)	% Tol.	#/Phase	T (°C)	R1	X1	Y1	R0	X0	Y0
Cable1	1.0MCUS1	2	328.1	0.0	1	75	0.2192104	0.029	0.0000517	0.6908723	0.09102	
Cable4	0.6NCUN1	2	328.1	0.0	1	75	0.19	0.0456		0.3021	0.1143	
Cable6	0.6NCUN1	2	328.1	0.0	1	75	0.19	0.0456		0.3021	0.1143	
Cable7	0.6NCUN1	2	328.1	0.0	1	75	0.19	0.0456		0.3021	0.1143	
Cable8	0.6NCUN1	2	328.1	0.0	1	75	0.19	0.0456		0.3021	0.1143	
Cable9	0.6NCUN1	2	328.1	0.0	1	75	0.19	0.0456		0.3021	0.1143	
Cable10	0.6NCUN1	2	328.1	0.0	1	75	0.19	0.0456		0.3021	0.1143	
Cable12	0.6NCUN1	2	328.1	0.0	1	75	0.19	0.0456		0.3021	0.1143	

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
T1	0.112	25.000	0.208	5.00	1.50	0	0	0	0	0	5.00	Dyn	30.00

2-Winding Transformer Grounding Input Data

Transformer	Rating			Conn.	Grounding							
					Primary				Secondary			
ID	MVA	Prim. kV	Sec. kV	Type	Type	kV	Amp	ohm	Type	kV	Amp	ohm
T1	0.112	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
T1	2W XFMR	Bus1	Bus2	2476.34	3714.51	4464.29	
Cable1	Cable	Bus27	Bus2	16623.39	2199.16	16768.22	0.0000007
Cable4	Cable	Bus25	Bus2	14408.27	3457.99	14817.42	
Cable6	Cable	Bus29	Bus2	14408.27	3457.99	14817.42	
Cable7	Cable	Bus30	Bus2	14408.27	3457.99	14817.42	
Cable8	Cable	Bus31	Bus2	14408.27	3457.99	14817.42	
Cable9	Cable	Bus32	Bus2	14408.27	3457.99	14817.42	
Cable10	Cable	Bus33	Bus2	14408.27	3457.99	14817.42	
Cable12	Cable	Bus35	Bus2	14408.27	3457.99	14817.42	

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	Bus1	1500.000	25.000	1.50	3.69800	5.54700	Wye - Solid	1.50	6.666667	10.00000

Total Power Grids (= 1) 1500.000 MVA

Lumped Load Input Data

Lumped Load	Lumped Load				Motor Loads									
	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.
12A	29.8	0.208	80	20	22.6	7.4	2.38	2.38	8.403	20.00	50.00	Delta		
12B	22.0	0.208	80	20	16.7	5.5	2.38	2.38	8.403	20.00	50.00	Delta		
12C	53.4	0.208	80	20	40.6	13.4	2.38	2.38	8.403	20.00	50.00	Delta		
12D	29.8	0.208	80	20	22.6	7.4	2.38	2.38	8.403	20.00	50.00	Delta		
12E	32.7	0.208	80	20	24.9	8.2	2.38	2.38	8.403	20.00	50.00	Delta		
12F	11.0	0.208	80	20	8.4	2.7	2.38	2.38	8.403	20.00	50.00	Delta		
12G	25.3	0.208	80	20	19.2	6.3	2.38	2.38	8.403	20.00	50.00	Delta		
M2H	52.9	0.208	80	20	40.2	13.2	2.38	2.38	8.403	20.00	50.00	Delta		

Total Connected Lumped Loads (= 8): 257.0 kVA

SHORT- CIRCUIT REPORT

Fault at bus: **Bus1**

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
Bus1	Total	0.00	34.655	0.00	112.07	112.07	27.334	27.334	3.70E+000	5.54E+000	6.67E+000	1.00E+001
Bus2	Bus1	27.16	0.014	73.45	72.90	100.00	0.007	0.000	8.66E+003	1.40E+004		
U1	Bus1	100.00	34.641	100.00	100.00	100.00	27.327	27.334	3.70E+000	5.55E+000	6.67E+000	1.00E+001
Bus27	Bus2	33.75	0.153	77.60	72.61	100.00	0.069	0.000	2.67E+004	1.40E+005		
Bus25	Bus2	35.65	0.201	78.34	73.14	100.00	0.092	0.000	1.92E+004	1.06E+005		
Bus29	Bus2	42.38	0.333	81.55	74.11	100.00	0.152	0.000	6.50E+003	6.49E+004		
Bus30	Bus2	35.65	0.201	78.34	73.14	100.00	0.092	0.000	1.92E+004	1.06E+005		
Bus31	Bus2	36.51	0.219	78.77	73.23	100.00	0.100	0.000	1.66E+004	9.78E+004		
Bus32	Bus2	42.25	0.331	81.49	74.08	100.00	0.151	0.000	6.65E+003	6.54E+004		
Bus33	Bus2	34.30	0.173	77.65	73.02	100.00	0.079	0.000	2.44E+004	1.23E+005		
Bus35	Bus2	30.13	0.079	75.36	72.81	100.00	0.036	0.000	6.82E+004	2.66E+005		
12B	Bus27	100.00	0.153	100.00	100.00	100.00	0.069	0.000	4.77E+004	1.14E+005		
12A	Bus25	100.00	0.201	100.00	100.00	100.00	0.092	0.000	3.52E+004	8.39E+004		
12C	Bus29	100.00	0.333	100.00	100.00	100.00	0.152	0.000	1.97E+004	4.68E+004		
12D	Bus30	100.00	0.201	100.00	100.00	100.00	0.092	0.000	3.52E+004	8.39E+004		
12E	Bus31	100.00	0.219	100.00	100.00	100.00	0.100	0.000	3.21E+004	7.64E+004		
M2H	Bus32	100.00	0.331	100.00	100.00	100.00	0.151	0.000	1.98E+004	4.72E+004		
12G	Bus33	100.00	0.173	100.00	100.00	100.00	0.079	0.000	4.16E+004	9.90E+004		
12F	Bus35	100.00	0.079	100.00	100.00	100.00	0.036	0.000	9.54E+004	2.27E+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: **Bus2**

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
Bus2	Total	0.00	8.524	0.00	105.57	106.29	7.586	7.586	1.77E+003	2.73E+003	2.48E+003	3.71E+003
Bus27	Bus2	12.65	0.209	7.51	104.48	110.05	0.124	0.000	6.44E+004	1.16E+005		
Bus25	Bus2	14.75	0.276	8.75	104.80	110.62	0.164	0.000	4.97E+004	8.73E+004		
Bus29	Bus2	24.41	0.457	14.48	104.96	113.37	0.271	0.000	3.41E+004	5.02E+004		
Bus30	Bus2	14.75	0.276	8.75	104.80	110.62	0.164	0.000	4.97E+004	8.73E+004		
Bus31	Bus2	16.04	0.300	9.51	104.79	111.00	0.178	0.000	4.65E+004	7.98E+004		
Bus32	Bus2	24.23	0.454	14.37	104.95	113.31	0.269	0.000	3.42E+004	5.07E+004		
Bus33	Bus2	12.69	0.238	7.53	104.84	110.03	0.141	0.000	5.60E+004	1.02E+005		
Bus35	Bus2	5.80	0.109	3.44	105.12	108.01	0.064	0.000	1.10E+005	2.31E+005		
Bus1	Bus2	99.85	6.208	99.93	100.00	99.93	6.212	7.586 *	2.48E+003	3.72E+003	2.48E+003	3.71E+003
12B	Bus27	100.00	0.209	100.00	100.00	100.00	0.124	0.000	4.77E+004	1.14E+005		
12A	Bus25	100.00	0.276	100.00	100.00	100.00	0.164	0.000	3.52E+004	8.39E+004		
12C	Bus29	100.00	0.457	100.00	100.00	100.00	0.271	0.000	1.97E+004	4.68E+004		
12D	Bus30	100.00	0.276	100.00	100.00	100.00	0.164	0.000	3.52E+004	8.39E+004		
12E	Bus31	100.00	0.300	100.00	100.00	100.00	0.178	0.000	3.21E+004	7.64E+004		
M2H	Bus32	100.00	0.454	100.00	100.00	100.00	0.269	0.000	1.98E+004	4.72E+004		
12G	Bus33	100.00	0.238	100.00	100.00	100.00	0.141	0.000	4.16E+004	9.90E+004		
12F	Bus35	100.00	0.109	100.00	100.00	100.00	0.064	0.000	9.54E+004	2.27E+005		
U1	Bus1	100.00	0.052	100.00	100.00	100.00	0.027	0.000	3.70E+000	5.55E+000	6.67E+000	1.00E+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.
Bus1	25.000	19.223	-28.835	34.655	15.162	-22.743	27.334	24.972	16.647	30.012	-31.231	-7.259	32.063
Bus2	0.208	4.641	-7.150	8.524	4.162	-6.343	7.586	6.192	4.019	7.382	-8.078	-1.170	8.162

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
Bus1	25.000	0.23103	0.34655	0.41650	0.23103	0.34655	0.41650	0.41667	0.62500	0.75116	0.00000	0.00000	0.00000
Bus2	0.208	0.00767	0.01182	0.01409	0.00767	0.01182	0.01409	0.01071	0.01607	0.01931	0.00000	0.00000	0.00000

Electrical Transient Analyzer Program

Short-Circuit Analysis

ANSI Standard

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

1.5-4 Cycle Network

	Swing	V-Control	Load	Total
Number of Buses:	1	0	9	10

	XFMR2	XFMR3	Reactor	Line/Cable/ Busway	Impedance	Tie PD	Total
Number of Branches:	0	0	0	8	0	1	9

	Synchronous Generator	Power Grid	Synchronous Motor	Induction Machines	Lumped Load	Inverter	Total
Number of Machines:	1	0	0	0	8	0	9

System Frequency:	60.00
Unit System:	English
Project Filename:	ENEL674_mI4 With GEN~~~~
Output Filename:	C:\ETAP 2250\ENEL674_Milestone-4\ENEL674_mI4 With GEN\BACKUP\BACKUP\Untitled.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.
Bus1	SWNG	0.208	0.208	1	100.00	0.00
Bus2	Load	0.208	0.208	1	100.00	0.00
Bus30	Load	0.208	0.208	1	100.00	0.00
Bus35	Load	0.208	0.208	1	100.00	0.00
Bus36	Load	0.208	0.208	1	100.00	0.00
Bus37	Load	0.208	0.208	1	100.00	0.00
Bus38	Load	0.208	0.208	1	100.00	0.00
Bus39	Load	0.208	0.208	1	100.00	0.00
Bus40	Load	0.208	0.208	1	100.00	0.00
Bus41	Load	0.208	0.208	1	100.00	0.00

10 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

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

Line/Cable/Busway ID	Library	Size	Length Adj. (ft)	Length % Tol.	#/Phase	T (°C)	R1	X1	Y1	R0	X0	Y0
Cable1			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029
Cable6			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029
Cable7			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029
Cable8			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029
Cable9			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029
Cable10			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029
Cable11			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029
Cable12			328.1	0.0	1	75	0.032619	0.0483748	0.0000184	0.032619	0.0483748	0.0000029

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

Branch Connections

CKT/Branch		Connected Bus ID		% Impedance, Pos. Seq., 100 MVAb			
ID	Type	From Bus	To Bus	R	X	Z	Y
Cable1	Cable	Bus2	Bus30	2473.60	3668.41	4424.46	0.0000003
Cable6	Cable	Bus2	Bus35	2473.60	3668.41	4424.46	0.0000003
Cable7	Cable	Bus2	Bus36	2473.60	3668.41	4424.46	0.0000003
Cable8	Cable	Bus2	Bus37	2473.60	3668.41	4424.46	0.0000003
Cable9	Cable	Bus2	Bus38	2473.60	3668.41	4424.46	0.0000003
Cable10	Cable	Bus2	Bus39	2473.60	3668.41	4424.46	0.0000003
Cable11	Cable	Bus2	Bus40	2473.60	3668.41	4424.46	0.0000003
Cable12	Cable	Bus2	Bus41	2473.60	3668.41	4424.46	0.0000003
CB1	Tie Breakr	Bus1	Bus2				

Synchronous Generator Input Data

Synchronous Generator		Rating			Positive Seq. Impedance					Grounding			Zero Seq. Impedance		
							% Xd"								
ID	Type	MVA	kV	RPM	X"/R	% R	Adj.	Tol.	% Xd'	Conn.	Type	Amp	X/R	% R0	% X0
Gen1	Steam Turbo	0.290	0.208	1800	1.67	2.400	4.00	0.0	4.00	Wye	Solid		2.50	1.600	4.00

Total Connected Synchronous Generators (= 1): 0.290 MVA

Lumped Load Input Data

Lumped Load	Lumped Load				Motor Loads									
	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.
12A	29.9	0.208	80	20	22.7	7.5	2.38	2.38	8.403	20.00	50.00	Delta		
12B	23.1	0.208	80	20	17.7	5.5	2.38	2.38	8.403	20.00	50.00	Delta		
12C	53.0	0.208	80	20	40.3	13.2	2.38	2.38	8.403	20.00	50.00	Delta		
12D	29.0	0.208	80	20	22.0	7.2	2.38	2.38	8.403	20.00	50.00	Delta		
12E	32.0	0.208	80	20	24.3	8.0	2.38	2.38	8.403	20.00	50.00	Delta		
12F	8.6	0.208	80	20	6.5	2.1	2.38	2.38	8.403	20.00	50.00	Delta		
12G	24.0	0.208	80	20	18.2	6.0	2.38	2.38	8.403	20.00	50.00	Delta		
M2H	52.5	0.208	80	20	39.9	13.1	2.38	2.38	8.403	20.00	50.00	Delta		

Total Connected Lumped Loads (= 8): 252.1 kVA

SHORT- CIRCUIT REPORT

Fault at bus: **Bus1**

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
Bus1	Total	0.00	18.268	0.00	102.45	94.28	18.899	18.899	7.54E+002	1.32E+003	5.52E+002	1.38E+003
Gen1	Bus1	100.00	17.256	100.00	100.00	100.00	17.776	18.899	8.28E+002	1.38E+003	5.52E+002	1.38E+003
Bus30	Bus2	1.59	0.100	1.71	102.13	94.48	0.107	0.000	4.79E+004	2.74E+005		
Bus35	Bus2	3.58	0.225	3.77	101.81	94.74	0.236	0.000	2.23E+004	1.22E+005		
Bus36	Bus2	1.99	0.125	2.12	102.06	94.53	0.133	0.000	3.87E+004	2.19E+005		
Bus37	Bus2	2.19	0.137	2.33	102.03	94.56	0.146	0.000	3.53E+004	1.99E+005		
Bus38	Bus2	0.60	0.037	0.65	102.32	94.36	0.040	0.000	1.25E+005	7.30E+005		
Bus39	Bus2	1.65	0.104	1.77	102.12	94.49	0.111	0.000	4.62E+004	2.64E+005		
Bus40	Bus2	3.55	0.222	3.73	101.82	94.74	0.234	0.000	2.25E+004	1.23E+005		
Bus41	Bus2	2.05	0.129	2.18	102.05	94.54	0.137	0.000	3.76E+004	2.13E+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: **Bus2**

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
Bus2	Total	0.00	18.268	0.00	102.45	94.28	18.899	18.899	7.54E+002	1.32E+003	5.52E+002	1.38E+003
Bus30	Bus2	1.59	0.100	1.71	102.13	94.48	0.107	0.000	4.79E+004	2.74E+005		
Bus35	Bus2	3.58	0.225	3.77	101.81	94.74	0.236	0.000	2.23E+004	1.22E+005		
Bus36	Bus2	1.99	0.125	2.12	102.06	94.53	0.133	0.000	3.87E+004	2.19E+005		
Bus37	Bus2	2.19	0.137	2.33	102.03	94.56	0.146	0.000	3.53E+004	1.99E+005		
Bus38	Bus2	0.60	0.037	0.65	102.32	94.36	0.040	0.000	1.25E+005	7.30E+005		
Bus39	Bus2	1.65	0.104	1.77	102.12	94.49	0.111	0.000	4.62E+004	2.64E+005		
Bus40	Bus2	3.55	0.222	3.73	101.82	94.74	0.234	0.000	2.25E+004	1.23E+005		
Bus41	Bus2	2.05	0.129	2.18	102.05	94.54	0.137	0.000	3.76E+004	2.13E+005		
Gen1	Bus1	100.00	17.256	100.00	100.00	100.00	17.776	18.899	8.28E+002	1.38E+003	5.52E+002	1.38E+003

\# 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: **Bus30**

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
Bus30	Total	0.00	4.759	0.00	100.23	98.61	4.816	4.816	3.13E+003	4.92E+003	3.03E+003	5.05E+003
Bus2	Bus30	74.38	4.666	75.06	100.54	98.48	4.709	4.816	3.23E+003	4.99E+003	3.03E+003	5.05E+003
12B	Bus30	100.00	0.101	100.00	100.00	100.00	0.110	0.000	4.54E+004	2.70E+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: **Bus35**

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
Bus35	Total	0.00	4.872	0.00	99.88	98.81	4.940	4.940	3.01E+003	4.84E+003	3.03E+003	5.05E+003
Bus2	Bus35	74.25	4.658	74.93	100.50	98.48	4.701	4.940	3.24E+003	5.00E+003	3.03E+003	5.05E+003
12C	Bus35	100.00	0.232	100.00	100.00	100.00	0.247	0.000	1.98E+004	1.18E+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: **Bus36**

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
Bus36	Total	0.00	4.781	0.00	100.15	98.64	4.841	4.841	3.11E+003	4.91E+003	3.03E+003	5.05E+003
Bus2	Bus36	74.35	4.664	75.04	100.53	98.48	4.707	4.841	3.24E+003	4.99E+003	3.03E+003	5.05E+003
12D	Bus36	100.00	0.127	100.00	100.00	100.00	0.137	0.000	3.62E+004	2.16E+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: **Bus37**

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
Bus37	Total	0.00	4.793	0.00	100.12	98.66	4.853	4.853	3.09E+003	4.90E+003	3.03E+003	5.05E+003
Bus2	Bus37	74.34	4.664	75.02	100.53	98.48	4.707	4.853	3.24E+003	4.99E+003	3.03E+003	5.05E+003
12E	Bus37	100.00	0.140	100.00	100.00	100.00	0.151	0.000	3.28E+004	1.95E+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: **Bus38**

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
Bus38	Total	0.00	4.705	0.00	100.45	98.52	4.754	4.754	3.19E+003	4.96E+003	3.03E+003	5.05E+003
Bus2	Bus38	74.44	4.670	75.13	100.57	98.48	4.714	4.754	3.23E+003	4.99E+003	3.03E+003	5.05E+003
12F	Bus38	100.00	0.038	100.00	100.00	100.00	0.041	0.000	1.22E+005	7.27E+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: **Bus39**

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
Bus39	Total	0.00	4.762	0.00	100.22	98.61	4.820	4.820	3.13E+003	4.92E+003	3.03E+003	5.05E+003
Bus2	Bus39	74.37	4.666	75.06	100.54	98.48	4.709	4.820	3.23E+003	4.99E+003	3.03E+003	5.05E+003
12G	Bus39	100.00	0.105	100.00	100.00	100.00	0.114	0.000	4.38E+004	2.60E+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: **Bus40**

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
Bus40	Total	0.00	4.870	0.00	99.89	98.81	4.938	4.938	3.01E+003	4.84E+003	3.03E+003	5.05E+003
Bus2	Bus40	74.25	4.658	74.93	100.50	98.48	4.701	4.938	3.24E+003	5.00E+003	3.03E+003	5.05E+003
M2H	Bus40	100.00	0.230	100.00	100.00	100.00	0.245	0.000	2.00E+004	1.19E+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: **Bus41**

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
Bus41	Total	0.00	4.785	0.00	100.14	98.65	4.844	4.844	3.10E+003	4.90E+003	3.03E+003	5.05E+003
Bus2	Bus41	74.35	4.664	75.03	100.53	98.48	4.707	4.844	3.24E+003	4.99E+003	3.03E+003	5.05E+003
12A	Bus41	100.00	0.131	100.00	100.00	100.00	0.141	0.000	3.51E+004	2.09E+005		

\# 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

1.5-4 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.
Bus1	0.208	9.068	-15.859	18.268	8.631	-16.813	18.899	14.224	8.177	16.406	10.319	16.343	19.328
Bus2	0.208	9.068	-15.859	18.268	8.631	-16.813	18.899	14.224	8.177	16.406	10.319	16.343	19.328
Bus30	0.208	2.554	-4.016	4.759	2.550	-4.085	4.816	3.554	2.265	4.214	2.316	4.236	4.828
Bus35	0.208	2.573	-4.137	4.872	2.588	-4.208	4.940	3.719	2.318	4.382	2.473	4.276	4.939
Bus36	0.208	2.557	-4.040	4.781	2.557	-4.110	4.841	3.587	2.275	4.247	2.347	4.244	4.850
Bus37	0.208	2.559	-4.052	4.793	2.561	-4.122	4.853	3.603	2.281	4.264	2.362	4.248	4.861
Bus38	0.208	2.544	-3.957	4.705	2.531	-4.024	4.754	3.474	2.238	4.132	2.239	4.217	4.775
Bus39	0.208	2.554	-4.020	4.762	2.551	-4.089	4.820	3.559	2.266	4.219	2.320	4.238	4.831
Bus40	0.208	2.573	-4.135	4.870	2.587	-4.206	4.938	3.716	2.317	4.380	2.471	4.275	4.938
Bus41	0.208	2.558	-4.044	4.785	2.559	-4.114	4.844	3.592	2.277	4.253	2.351	4.245	4.853

All fault currents are symmetrical (1.5-4 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
Bus1	0.208	0.00326	0.00571	0.00657	0.00306	0.00528	0.00610	0.00239	0.00597	0.00643	0.00000	0.00000	0.00000
Bus2	0.208	0.00326	0.00571	0.00657	0.00306	0.00528	0.00610	0.00239	0.00597	0.00643	0.00000	0.00000	0.00000
Bus30	0.208	0.01354	0.02129	0.02523	0.01298	0.02033	0.02412	0.01309	0.02184	0.02546	0.00000	0.00000	0.00000
Bus35	0.208	0.01302	0.02093	0.02465	0.01209	0.01935	0.02281	0.01309	0.02184	0.02546	0.00000	0.00000	0.00000
Bus36	0.208	0.01343	0.02122	0.02512	0.01280	0.02013	0.02385	0.01309	0.02184	0.02546	0.00000	0.00000	0.00000
Bus37	0.208	0.01338	0.02119	0.02506	0.01271	0.02003	0.02372	0.01309	0.02184	0.02546	0.00000	0.00000	0.00000
Bus38	0.208	0.01380	0.02147	0.02553	0.01346	0.02084	0.02481	0.01309	0.02184	0.02546	0.00000	0.00000	0.00000
Bus39	0.208	0.01352	0.02128	0.02522	0.01295	0.02030	0.02408	0.01309	0.02184	0.02546	0.00000	0.00000	0.00000
Bus40	0.208	0.01303	0.02094	0.02466	0.01211	0.01936	0.02284	0.01309	0.02184	0.02546	0.00000	0.00000	0.00000
Bus41	0.208	0.01342	0.02121	0.02510	0.01277	0.02010	0.02381	0.01309	0.02184	0.02546	0.00000	0.00000	0.00000

Appendix D: Recommended Protection Settings

Low Voltage Circuit Breaker Trip Device Settings

CB:	**CB13**						
MFR:	ABB	Tag #:		3-Phase kA:	1.82	Sym. (Calc.)
Model:	DSM	Rating:	50 kA, 0.24 kV	LG kA:	1.42	Sym. (Calc.)
Size:	3	Cont. Amp:	3.000	Base kV:	0.208	(Calc.)
CB:	**CB15**						
MFR:	ABB	Tag #:		3-Phase kA:	2.01	Sym. (Calc.)
Model:	DSM	Rating:	50 kA, 0.24 kV	LG kA:	1.49	Sym. (Calc.)
Size:	3	Cont. Amp:	3.000	Base kV:	0.208	(Calc.)
CB:	**CB16**						
MFR:	ABB	Tag #:		3-Phase kA:	1.82	Sym. (Calc.)
Model:	DSM	Rating:	50 kA, 0.24 kV	LG kA:	1.42	Sym. (Calc.)
Size:	3	Cont. Amp:	3.000	Base kV:	0.208	(Calc.)
CB:	**CB17**						
MFR:	ABB	Tag #:		3-Phase kA:	1.84	Sym. (Calc.)
Model:	DSM	Rating:	50 kA, 0.24 kV	LG kA:	1.43	Sym. (Calc.)
Size:	3	Cont. Amp:	3.000	Base kV:	0.208	(Calc.)
CB:	**CB18**						
MFR:	ABB	Tag #:		3-Phase kA:	2.00	Sym. (Calc.)
Model:	DSM	Rating:	50 kA, 0.24 kV	LG kA:	1.49	Sym. (Calc.)
Size:	3	Cont. Amp:	3.000	Base kV:	0.208	(Calc.)
CB:	**CB19**						
MFR:	ABB	Tag #:		3-Phase kA:	1.78	Sym. (Calc.)
Model:	DSM	Rating:	50 kA, 0.24 kV	LG kA:	1.40	Sym. (Calc.)
Size:	3	Cont. Amp:	3.000	Base kV:	0.208	(Calc.)
CB:	**CB2**						
MFR:	ABB	Tag #:		3-Phase kA:	0.00	Sym. (Calc.)
Model:	DSM	Rating:	50 kA, 0.24 kV	LG kA:	0.00	Sym. (Calc.)
Size:	3	Cont. Amp:	3.000	Base kV:	0.000	(Calc.)
CB:	**CB21**						
MFR:	ABB	Tag #:		3-Phase kA:	1.68	Sym. (Calc.)
Model:	DSM	Rating:	50 kA, 0.24 kV	LG kA:	1.36	Sym. (Calc.)
Size:	3	Cont. Amp:	3.000	Base kV:	0.208	(Calc.)

Overcurrent Relay Settings

OCR: Relay2

MFR: Siemens
Tag #:
Model: 7SG11

	CT	Base kV	If (kA)	
Phase:	400:5	0.208	8.52	3 ph, Sym. (Calc.)
			7.59	LG, Sym. (Calc.)
GND:	400:5	0.208	7.59	LG, Sym. (Calc.)
Sen. GND:	400:5	0.208	7.59	LG, Sym. (Calc.)

OC Level: OC1

		Range	Setting
Phase TOC	IEC - Normal Inverse		
	Pickup (Tap)	0.05 - 2.5 xCT Sec	0.050
	Time Dial		0.025
Phase INST	Pickup	0.05 - 52.5 xCT Sec	52.500
	Time Delay	0 - 300 Sec	0.010
Ground TOC	IEC - Extremely Inverse		
	Pickup (Tap)	0.05 - 2.5 xCT Sec	0.050
	Time Dial		0.025
Ground INST	Pickup	0.05 - 52.5 xCT Sec	52.500
	Time Delay	0 - 300 Sec	0.010
Sen. GND INST	Pickup	0.005 - 0.96 xCT Sec	0.960
	Time Delay	0 - 300 Sec	0.010

OCR: Relay3

MFR: Siemens
Tag #:
Model: 7SA522

	CT	Base kV	If (kA)	
Phase:	400:5	0.208	8.52	3 ph, Sym. (Calc.)
			7.59	LG, Sym. (Calc.)
GND:	400:5	0.208	7.59	LG, Sym. (Calc.)

Please refer to the "Excel Device Settings Report" for Base Current Multiplier settings of this relay.

OC Level: OC1

		Range	Setting
Phase TOC	IEC-Normal Inverse		
	Pickup (Tap)	0.1 - 4 Sec - 1A	0.100
	Time Dial		0.500
Phase INST	Pickup	0.05 - 50 Sec - 1A	50.000
	Time Delay	0 - 30 Sec	0.010
Ground TOC	ANSI-Extremely Inverse		
	Pickup (Tap)	0.05 - 4 Sec - 1A	0.050
	Time Dial		0.500
Ground INST	Pickup	0.05 - 25 Sec - 1A	25.000
	Time Delay	0 - 30 Sec	0.010

Study Case: A_SC

Appendix E: Incident Arc Flash

Energy

Electrical Transient Analyzer Program

Arc Flash Analysis

IEEE 1584-2018
ANSI Short-Circuit

	Swing	V-Control	Load	Total
Number of Buses:	1	0	9	10

	XFMR2	XFMR3	Reactor	Line/Cable	Impedance	Tie PD	Total
Number of Branches:	1	0	0	8	0	0	9

	Synchronous Generator	Power Grid	Synchronous Motor	Induction Machines	Lumped Load	Inverter	Total
Number of Machines:	0	1	0	0	8	0	9

System Frequency:	60.00
Unit System:	English
Project Filename:	ENEL674_Milestone-4~~
Output Filename:	C:\ETAP 2250\ENEL674_Milestone-4\BACKUP\Untitled.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 2021/ Z462 2021 / User-Defined

Level ID	cal/cm²
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.
Bus1	SWNG	25.000	25.000	1	100.00	0.00
Bus2	Load	0.208	0.208	1	100.00	0.00
Bus25	Load	0.208	0.208	1	100.00	0.00
Bus27	Load	0.208	0.208	1	100.00	0.00
Bus29	Load	0.208	0.208	1	100.00	0.00
Bus30	Load	0.208	0.208	1	100.00	0.00
Bus31	Load	0.208	0.208	1	100.00	0.00
Bus32	Load	0.208	0.208	1	100.00	0.00
Bus33	Load	0.208	0.208	1	100.00	0.00
Bus35	Load	0.208	0.208	1	100.00	0.00

10 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 / Enclosure Input Data

Faulted Bus			Arc Flash Ratings								
					Conductor		Enclosure Dimensions (inches)				
Enclosure ID	ID	Nom. kV	Equipment Type	Electrode Configuration	Type	Gap (mm)	Height	Width	Depth	Working Distance (in.)	Avail. Protection cal/cm²
	Bus1	25.000	Other	VCB	Copper					18.00	
	Bus2	0.208	Other	VCB	Copper	13	14.00	12.00	8.03	18.00	

The Gap is 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 ID	Library	Size	Length Adj. (ft)	% Tol.	#/Phase	T (°C)	R	X	Y
Cable1	1.0MCUS1	2	328.1	0	1	75	0.21921	0.02900	0.0000517
Cable4	0.6NCUN1	2	328.1	0	1	75	0.19000	0.04560	0.0000000
Cable6	0.6NCUN1	2	328.1	0	1	75	0.19000	0.04560	0.0000000
Cable7	0.6NCUN1	2	328.1	0	1	75	0.19000	0.04560	0.0000000
Cable8	0.6NCUN1	2	328.1	0	1	75	0.19000	0.04560	0.0000000
Cable9	0.6NCUN1	2	328.1	0	1	75	0.19000	0.04560	0.0000000
Cable10	0.6NCUN1	2	328.1	0	1	75	0.19000	0.04560	0.0000000
Cable12	0.6NCUN1	2	328.1	0	1	75	0.19000	0.04560	0.0000000

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
T1	0.112	25.000	0.208	5.00	1.50	0	0	0	0	0	5.0000

Branch Connections

CKT/Branch		Connected Bus ID		% Impedance, Pos. Seq., 100 MVAb			
ID	Type	From Bus	To Bus	R	X	Z	Y
T1	2W XFMR	Bus1	Bus2	2476.34	3714.51	4464.29	
Cable1	Cable	Bus27	Bus2	16623.39	2199.16	16768.22	
Cable4	Cable	Bus25	Bus2	14408.27	3457.99	14817.42	
Cable6	Cable	Bus29	Bus2	14408.27	3457.99	14817.42	
Cable7	Cable	Bus30	Bus2	14408.27	3457.99	14817.42	
Cable8	Cable	Bus31	Bus2	14408.27	3457.99	14817.42	
Cable9	Cable	Bus32	Bus2	14408.27	3457.99	14817.42	
Cable10	Cable	Bus33	Bus2	14408.27	3457.99	14817.42	
Cable12	Cable	Bus35	Bus2	14408.27	3457.99	14817.42	

Power Grid Input Data

Power Grid	Connected Bus	Rating		% Impedance 100 MVA Base		
ID	ID	MVASC	kV	X/R	R	X
U1	Bus1	1500.000	25.000	1.50	3.69800	5.54700

Total Connected Power Grids (= 1): 1500.000 MVA

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
12A	Bus25	29.8	0.208	80	20	22.6	7.4	2.38	2.38	8.403	20.00	50.00	5.66	1.86
12B	Bus27	22.0	0.208	80	20	16.7	5.5	2.38	2.38	8.403	20.00	50.00	4.18	1.37
12C	Bus29	53.4	0.208	80	20	40.6	13.4	2.38	2.38	8.403	20.00	50.00	10.15	3.34
12D	Bus30	29.8	0.208	80	20	22.6	7.4	2.38	2.38	8.403	20.00	50.00	5.66	1.86
12E	Bus31	32.7	0.208	80	20	24.9	8.2	2.38	2.38	8.403	20.00	50.00	6.22	2.04
12F	Bus35	11.0	0.208	80	20	8.4	2.7	2.38	2.38	8.403	20.00	50.00	2.09	0.69
12G	Bus33	25.3	0.208	80	20	19.2	6.3	2.38	2.38	8.403	20.00	50.00	4.80	1.58
M2H	Bus32	52.9	0.208	80	20	40.2	13.2	2.38	2.38	8.403	20.00	50.00	10.06	3.31

Total Connected Lumped Loads (= 8): 257.0 kVA

Arc Flash Analysis
½ Cycle Calculation Method

Arc Fault Location						Correction Factors		Incident Energy						
		Enclosure		Electrode	Prefault	Iarc	Encl.			Source PD	FCT		IE	AFB
Element ID	Connected Bus ID	ID	Type	Config.	kV	Var. (%)	CF (pu)	Ibf" (kA)	Ia" (kA)	Ia" (kA)	(Cycles)	Source PD ID	(cal/cm²)	(ft)
Bus1	Bus1		Bus Arc Fault	VCB		0		34.655	34.655	0.000	30.0		1061.394	
										FCT =	30.0	(+) Total =	1061.394	44.69
Bus2	Bus2		Bus Arc Fault	VCB	0.208	0	1.000	8.524	4.461	0.000	30.0		4.123	
										FCT =	30.0	Total =	4.123	3.25
CB1	Bus2		Source PD Line Side	VCB	0.208	0		8.524	0.000	0.000			0.000	
												Total =	0.000	0.00

\# The FCT (fault clearing time) has been limited to the maximum value allowed in the study case. The incident energy is calculated using this value.

\+ The theoretically derived Lee method was used to determine the incident energy and flash protection boundary for this location since the bolted fault current or nominal voltage or gap values are outside the empirical IEEE 1584-2018 method range.

0 The incident energy has been automatically assigned at this location (i.e. 2000 A/ 240 Volt limit guideline) based on actual study case settings.

1 The user-defined fault clearing PD, as specified in the bus/enclosure editor, is outside the region for calculating short-circuit contributions.

2 The user-defined Relay, as specified in the bus/enclosure editor, is not connected to an energized phase CT or has no interlock PDs.

3 The user-defined fault clearing PD, as specified in the bus/enclosure editor, is not energized.

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
# Bus1	25.000	Other	34.655	34.655	30.000	1061.394	44.69	> Level G
Bus2	0.208	Other	8.524	4.461	30.000	4.123	3.25	Level C

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 (in)	Energy Level
# Bus1	25.000	Other		34.655						30.00	44.7	1061.4	18	> Level G
Bus2	0.208	Other	13	8.524						30.00	3.2	4.1	18	Level C

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.

Electrical Transient Analyzer Program

Arc Flash Analysis

IEEE 1584-2018
ANSI Short-Circuit

	Swing	V-Control	Load	Total
Number of Buses:	1	0	9	10

	XFMR2	XFMR3	Reactor	Line/Cable	Impedance	Tie PD	Total
Number of Branches:	0	0	0	8	0	1	9

	Synchronous Generator	Power Grid	Synchronous Motor	Induction Machines	Lumped Load	Inverter	Total
Number of Machines:	1	0	0	0	8	0	9

System Frequency:	60.00
Unit System:	English
Project Filename:	ENEL674_mI4 With GEN~~~~
Output Filename:	C:\ETAP 2250\ENEL674_Milestone-4\ENEL674_mI4 With GEN\BACKUP\BACKUP\Untitled.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 2021/ Z462 2021 / User-Defined

Level ID	cal/cm²
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.
Bus1	SWNG	0.208	0.208	1	100.00	0.00
Bus2	Load	0.208	0.208	1	100.00	0.00
Bus30	Load	0.208	0.208	1	100.00	0.00
Bus35	Load	0.208	0.208	1	100.00	0.00
Bus36	Load	0.208	0.208	1	100.00	0.00
Bus37	Load	0.208	0.208	1	100.00	0.00
Bus38	Load	0.208	0.208	1	100.00	0.00
Bus39	Load	0.208	0.208	1	100.00	0.00
Bus40	Load	0.208	0.208	1	100.00	0.00
Bus41	Load	0.208	0.208	1	100.00	0.00

10 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 / Enclosure Input Data

Faulted Bus			Arc Flash Ratings								
					Conductor		Enclosure Dimensions (inches)			Working	Avail. Protection
Enclosure ID	ID	Nom. kV	Equipment Type	Electrode Configuration	Type	Gap (mm)	Height	Width	Depth	Distance (in.)	cal/cm²
	Bus1	0.208	Other	VCB	Copper	13	14.00	12.00	8.03	18.00	
	Bus2	0.208	Other	VCB	Copper	13	14.00	12.00	8.03	18.00	
	Bus30	0.208	Other	VCB	Copper	13	14.00	12.00	8.03	18.00	
	Bus35	0.208	Other	VCB	Copper	13	14.00	12.00	8.03	18.00	
	Bus36	0.208	Other	VCB	Copper	13	14.00	12.00	8.03	18.00	
	Bus37	0.208	Other	VCB	Copper	13	14.00	12.00	8.03	18.00	
	Bus38	0.208	Other	VCB	Copper	13	14.00	12.00	8.03	18.00	
	Bus40	0.208	Other	VCB	Copper	13	14.00	12.00	8.03	18.00	
	Bus41	0.208	Other	VCB	Copper	13	14.00	12.00	8.03	18.00	

The Gap is 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 ID	Library	Size	Length Adj. (ft)	% Tol.	#/Phase	T (°C)	R	X	Y
Cable1			328.1	0	1	75	0.03262	0.04837	0.0000184
Cable6			328.1	0	1	75	0.03262	0.04837	0.0000184
Cable7			328.1	0	1	75	0.03262	0.04837	0.0000184
Cable8			328.1	0	1	75	0.03262	0.04837	0.0000184
Cable9			328.1	0	1	75	0.03262	0.04837	0.0000184
Cable10			328.1	0	1	75	0.03262	0.04837	0.0000184
Cable11			328.1	0	1	75	0.03262	0.04837	0.0000184
Cable12			328.1	0	1	75	0.03262	0.04837	0.0000184

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

Branch Connections

CKT/Branch		Connected Bus ID		% Impedance, Pos. Seq., 100 MVAb			
ID	Type	From Bus	To Bus	R	X	Z	Y
Cable1	Cable	Bus2	Bus30	2473.60	3668.41	4424.46	
Cable6	Cable	Bus2	Bus35	2473.60	3668.41	4424.46	
Cable7	Cable	Bus2	Bus36	2473.60	3668.41	4424.46	
Cable8	Cable	Bus2	Bus37	2473.60	3668.41	4424.46	
Cable9	Cable	Bus2	Bus38	2473.60	3668.41	4424.46	
Cable10	Cable	Bus2	Bus39	2473.60	3668.41	4424.46	
Cable11	Cable	Bus2	Bus40	2473.60	3668.41	4424.46	
Cable12	Cable	Bus2	Bus41	2473.60	3668.41	4424.46	
CB1	Tie Breaker	Bus1	Bus2				

Synchronous Generator Input Data

Synchronous Generator		Connected Bus	Rating			X/R Ratio		% Impedance in Machine Base			
									Xd"		
ID	Type	ID	MVA	kV	RPM	X"/R	X'/R	R	Adj.	Tol.	Xd'
Gen1	Steam Turbo	Bus1	0.290	0.208	1800	1.67	1.67	2.400	4.00	0.0	4.00

Total Connected Synchronous Generators (= 1): 0.290 MVA

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
12A	Bus41	29.9	0.208	80	20	22.7	7.5	2.38	2.38	8.403	20.00	50.00	5.68	1.87
12B	Bus30	23.1	0.208	80	20	17.7	5.5	2.38	2.38	8.403	20.00	50.00	4.42	1.37
12C	Bus35	53.0	0.208	80	20	40.3	13.2	2.38	2.38	8.403	20.00	50.00	10.07	3.31
12D	Bus36	29.0	0.208	80	20	22.0	7.2	2.38	2.38	8.403	20.00	50.00	5.51	1.81
12E	Bus37	32.0	0.208	80	20	24.3	8.0	2.38	2.38	8.403	20.00	50.00	6.08	2.00
12F	Bus38	8.6	0.208	80	20	6.5	2.1	2.38	2.38	8.403	20.00	50.00	1.63	0.54
12G	Bus39	24.0	0.208	80	20	18.2	6.0	2.38	2.38	8.403	20.00	50.00	4.56	1.50
M2H	Bus40	52.5	0.208	80	20	39.9	13.1	2.38	2.38	8.403	20.00	50.00	9.97	3.28

Total Connected Lumped Loads (= 8): 252.1 kVA

Arc Flash Analysis
½ Cycle Calculation Method

Arc Fault Location						Correction Factors		Incident Energy						
		Enclosure		Electrode	Prefault	Iarc	Encl.			Source PD	FCT		IE	AFB
Element ID	Connected Bus ID	ID	Type	Config.	kV	Var. (%)	CF (pu)	Ibf" (kA)	Ia" (kA)	Ia" (kA)	(Cycles)	Source PD ID	(cal/cm²)	(ft)
Bus1	Bus1		Bus Arc Fault	VCB	0.208	0	1.000	19.673	10.529	0.000	42.0		14.432	
										FCT =	42.0	Total =	14.432	7.11
CB1	Bus1		Load PD Line Side	VCB	0.208	0	1.000	19.673	10.529	0.000	42.0		14.432	
										FCT =	42.0	Total =	14.432	7.11
Bus2	Bus2		Bus Arc Fault	VCB	0.208	0	1.000	19.673	10.529	0.000	46.8		16.081	
										FCT =	46.8	Total =	16.081	7.61
Bus30	Bus30		Bus Arc Fault	VCB	0.208	0	1.000	4.979	2.460	0.000		Cannot be Determined	0.000	
												Total =	0.000	0.00
CB15	Bus30		Source PD Line Side	VCB	0.208	0		4.979	0.000	0.000		Cannot be Determined	0.000	
												Total =	0.000	0.00

Arc Fault Location						Correction Factors		Incident Energy						
		Enclosure		Electrode	Prefault	Iarc	Encl.			Source PD	FCT		IE	AFB
Element ID	Connected Bus ID	ID	Type	Config.	kV	Var. (%)	CF (pu)	Ibf" (kA)	Ia" (kA)	Ia" (kA)	(Cycles)	Source PD ID	(cal/cm²)	(ft)
Bus35	Bus35		Bus Arc Fault	VCB	0.208	0	1.000	5.264	2.617	0.000		Cannot be Determined	0.000	
												Total =	0.000	0.00
CB20	Bus35		Source PD Line Side	VCB	0.208	0		5.264	0.000	0.000		Cannot be Determined	0.000	
												Total =	0.000	0.00
Bus36	Bus36		Bus Arc Fault	VCB	0.208	0	1.000	5.034	2.491	0.000		Cannot be Determined	0.000	
												Total =	0.000	0.00
CB21	Bus36		Source PD Line Side	VCB	0.208	0		5.034	0.000	0.000		Cannot be Determined	0.000	
												Total =	0.000	0.00
Bus37	Bus37		Bus Arc Fault	VCB	0.208	0	1.000	5.063	2.507	0.000		Cannot be Determined	0.000	
												Total =	0.000	0.00
CB22	Bus37		Source PD Line Side	VCB	0.208	0		5.063	0.000	0.000		Cannot be Determined	0.000	
												Total =	0.000	0.00

Arc Fault Location						Correction Factors		Incident Energy						
		Enclosure		Electrode	Prefault	Iarc	Encl.			Source PD	FCT		IE	AFB
Element ID	Connected Bus ID	ID	Type	Config.	kV	Var. (%)	CF (pu)	Ibf" (kA)	Ia" (kA)	Ia" (kA)	(Cycles)	Source PD ID	(cal/cm²)	(ft)
Bus38	Bus38		Bus Arc Fault	VCB	0.208	0	1.000	4.840	2.385	0.000		Cannot be Determined	0.000	
												Total =	0.000	0.00
CB23	Bus38		Source PD Line Side	VCB	0.208	0		4.840	0.000	0.000		Cannot be Determined	0.000	
												Total =	0.000	0.00
Bus40	Bus40		Bus Arc Fault	VCB	0.208	0	1.000	5.259	2.615	0.000		Cannot be Determined	0.000	
												Total =	0.000	0.00
CB25	Bus40		Source PD Line Side	VCB	0.208	0		5.259	0.000	0.000		Cannot be Determined	0.000	
												Total =	0.000	0.00
Bus41	Bus41		Bus Arc Fault	VCB	0.208	0	1.000	5.043	2.496	0.000		Cannot be Determined	0.000	
												Total =	0.000	0.00
CB26	Bus41		Source PD Line Side	VCB	0.208	0		5.043	0.000	0.000		Cannot be Determined	0.000	
												Total =	0.000	0.00

Arc Fault Location						Correction Factors		Incident Energy						
		Enclosure		Electrode	Prefault	Iarc	Encl.			Source PD	FCT		IE	AFB
Element ID	Connected Bus ID	ID	Type	Config.	kV	Var. (%)	CF (pu)	Ibf" (kA)	Ia" (kA)	Ia" (kA)	(Cycles)	Source PD ID	(cal/cm²)	(ft)

The FCT (fault clearing time) has been limited to the maximum value allowed in the study case. The incident energy is calculated using this value.

+ The theoretically derived Lee method was used to determine the incident energy and flash protection boundary for this location since the bolted fault current or nominal voltage or gap values are outside the empirical IEEE 1584-2018 method range.

0 The incident energy has been automatically assigned at this location (i.e. 2000 A/ 240 Volt limit guideline) based on actual study case settings.

1 The user-defined fault clearing PD, as specified in the bus/enclosure editor, is outside the region for calculating short-circuit contributions.

2 The user-defined Relay, as specified in the bus/enclosure editor, is not connected to an energized phase CT or has no interlock PDs.

3 The user-defined fault clearing PD, as specified in the bus/enclosure editor, is not energized.

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
Bus1	0.208	Other	19.673	10.529	42.000	14.432	7.11	Level D
Bus2	0.208	Other	19.673	10.529	46.800	16.081	7.61	Level D
Bus30	0.208	Other	4.979	2.460				
Bus35	0.208	Other	5.264	2.617				
Bus36	0.208	Other	5.034	2.491				
Bus37	0.208	Other	5.063	2.507				
Bus38	0.208	Other	4.840	2.385				
Bus40	0.208	Other	5.259	2.615				
Bus41	0.208	Other	5.043	2.496				

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 (in)	Energy Level
Bus1	0.208	Other	13	19.673						42.00	7.1	14.4	18	Level D
Bus2	0.208	Other	13	19.673						46.80	7.6	16.1	18	Level D
Bus30	0.208	Other	13	4.979							0.0	0.0	18	
Bus35	0.208	Other	13	5.264							0.0	0.0	18	
Bus36	0.208	Other	13	5.034							0.0	0.0	18	
Bus37	0.208	Other	13	5.063							0.0	0.0	18	
Bus38	0.208	Other	13	4.840							0.0	0.0	18	
Bus40	0.208	Other	13	5.259							0.0	0.0	18	
Bus41	0.208	Other	13	5.043							0.0	0.0	18	