34.5/115 kV Solar Power Plant & Substation Senior Design Project

Senior Design Team 18 - May 2024

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BLACK & VEATCH

Agenda

- Safety Moment
- Calculation Documents
- AutoCAD Update
- ETAP
- Feedback

Safety Moment - Emergency Exits & Routes

- Location and prevalence of emergency exits are vital in public buildings and the workplace for safety of individuals in them
- Facilities hopefully will provide maps to aid in emergency exit routes
- Regulated by NEC and OSHA
- Signage indicating emergency exits should always be visible and not obstructed
- Keep paths of egress clear of any cords or obstructions
- Buildings should perform inspections to assure all emergency exit signs are working properly

Source Link Image Link

Calculations

Battery Charger Equation:

$$A = L + \frac{AHR * K}{T}$$

A = Battery charger output current (A)
L = Continuous load current (A)
AHR = Amp hours removed of the battery system (Ah)
K = Efficiency factor (1.15 for flooded lead acid, 1.4 for NiCa)
T = Recharge time (hours)

Our system has a 100 Ah capacity with 60 Ah removed, and uses flooded lead acid batteries. Our continuous load is 3.576 A. Typical recharge times are usually 8, 12, or 24 hours.

A recharge time of 8 hours results in a charger output of 12.201 A (was 12.665 A before).

This will require the same battery charging system as before.

Calculations

EnerSys

Summary Margin Report

Customer: Iowa State University
Location: Lovington, New Mexico
Project: 115/34.5 kV Solar Power Plant & Substation
Date Prepared: 4/10/24
Prepared By: Liam Gossman
Phone: 5153180150
E-Mail: lgossman@iastate.edu

Sizing Parameters
Application: Utility
Lowest Temp (°F): 77.00
Min. Voltage (Vpc): 1.75
Design Margin: 1.10
Aging Factor: 1.25

Line	Cell Model	Margin
1	CA-05M	1.0%
2	CA-03M (2 Strings)	1.0%
3	CC-05M	1.0%
4	CC-03M (2 Strings)	1.0%
5	6 OGi 110	27.7%
6	6 OGi 60 (2 Strings)	27.7%
7	ESG-05	86.4%
8	DSG-05	200.8%
9	EA-05M	108.6%
10	EC-05M	109.3%
11	GC-09M	765.6%
12	4 OPzS 200	123.4%
13	Vb 2408	867.6%

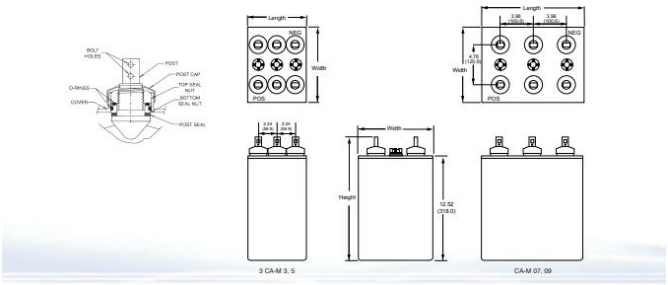
Battery Load Details
Number of Cells: 60
Total Time (Minutes): 241.00
Amp Hour Removed: 59.96

Period	Time (Mins.)	Load
1	0.00	20.08 A
2	1.00	3.58 A
3	240.00	14.98 A

General Specifications

Cell Type*	Nominal Ah Capacity†	Nominal Dimensions: Length** in	Length** mm	Width in	Width mm	Height in	Height mm	Weight - Volumes: Unpacked lbs	Unpacked kg	Electrolyte only/1.215 SG lbs	Electrolyte only/1.215 SG kg	Electrolyte only/1.215 SG gal	Electrolyte only/1.215 SG L	Short Circuit Current Amp
3CA-3M	50	7.0	178	9.0	229	14.8	375	57.0	25.9	16.0	7.3	1.6	6.1	494
3CA-5M	100	7.0	178	9.0	229	14.8	375	74.0	33.6	15.0	6.8	1.5	5.7	972
3CA-7M	150	12.2	310	9.0	229	14.8	375	114.0	51.7	33.0	15.0	3.3	12.5	1434
3CA-9M	200	12.2	310	9.0	229	14.8	375	132.0	59.9	33.0	15.0	3.2	12.1	1862

* Prefix number indicates cells per unit. Suffix number indicates total plates per cell.
** 0.25" must be added between cells for spacing purposes when calculating total battery length.
† Nominal Ah Capacity is based on an 8 hour discharge rate to 1.75 final voltage per cell @ 77°F (25°C)



Our system will require 1 string of 20 CA-05M batteries

Calculations - BOM

Solar Component

Component Type	SKU/Model Number	Quantity	Price	Datasheet Link	Total Price	Pricing Link
PV Panels	ZXM7-SHDB144-550/M	143250	$270.00	Link	$38,677,500.00	Link
Combiner Boxes	BHSZ-16-1-1500V	360	$1,921.00	Link	$691,560.00	Link
Inverters	PVS980-MWS-4000kVA-K-34.5-Dry	15	$200,000.00	Link	$3,000,000.00	Page 31
2" Conduit	2 in. x 10 ft. Sch. 40 PVC Conduit	1331	$25.90		$34,472.90	Link
3" Conduit	3 in. x 10 ft. PVC Schedule 40 Conduit	798	$60.78		$48,502.44	Link
600 MCM		21128.92	$15.65		$330,667.60	Link
10 AWG		1395	$0.38		$530.10	Link
					$0.00	
					$0.00	
					$0.00	
					$0.00	
					$0.00	
					$0.00	
					$0.00	
				Total Solar Farm Cost	$42,783,233.04	

Misc Component

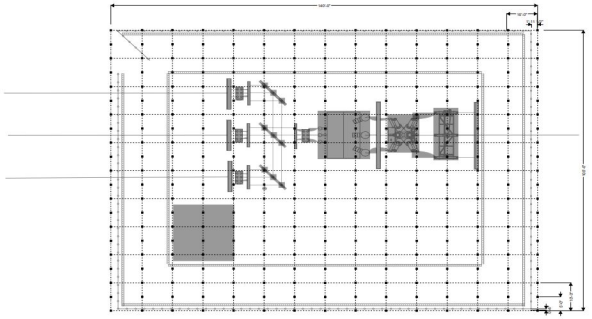
Component Type	SKU/Model Number	Quantity	Price	Datasheet/Website Link	Total Price	Pricing Link
Bus Bars					$0.00	
Fence (50' Segment)		340	$633.00		$215,220.00	Link
					$0.00	
					$0.00	
					$0.00	
					$0.00	
					$0.00	
					$0.00	
					$0.00	
					$0.00	
					$0.00	
					$0.00	
				Total Misc Cost	$215,220.00	

Substation Component

Component Type	SKU/Model Number	Quantity	Price	Datasheet/Website Link	Total Price	Pricing Link
SEL-411L	0411L1X6X1C7CDXH5C424XX	1	$11,170.00	Link	$11,170.00	Link
SEL-311L	0311L03C0325XXXX	1	$6,920.00	Link	$6,920.00	Link
SEL-487E	0487E3X611XXC5X5H675XXX	1	$8,860.00	Link	$8,860.00	Link
GE Multilin T35	T35J03AKHF8MH6DM8RP6EU67WXX	1	$4,500.00	Link	$4,500.00	Link
SEL-751	751301ACA3A70851F00	2	$1,270.00	Link	$2,540.00	Link
ABB REU615	2rca025340a0001b	2	$750.00	Link	$1,500.00	Link
SEL-352	035211425H2X4XX	4	$4,690.00	Link	$18,760.00	Link
CB1	OHB 36.25.25	3	$35,000.00	Link	$105,000.00	Circuit Breaker (35 kV)
CB2	SPS2-123-40-2	1	$95,500.00	Link	$95,500.00	Circuit Breaker (115kV)
DS1	EV-H	8	$7,000.00	Link	$56,000.00	Discon. Switch (34.5 kV)
DS2	65742-A	2	$20,000.00	Link	$40,000.00	Discon. Switch (138 kV)
LA1	PEXLIM Q36-XN36 (H)	6	$500.00	Link	$3,000.00	Surge Arrestor (34.5kV)
LA2	AZES013G115144	3	$2,000.00	Link	$6,000.00	Surge Arrestor (138kV)
T1 (Power XFMR)	SF-9000000/15	1	$2,000,000.00	Link	$2,000,000.00	Page 7
T2 (Station Power)	MT-PML-R50-1P-GMA-50KVA-SZ-LT-DF-Z6-BB-CS-2BZ-M1	1	$18,641.04	Link	$18,641.04	Link
CT1	G953000DA	24		Link	$0.00	
CT2	OSKF123	6	$15,000.00	Link	$90,000.00	Current XFMR (138kV)
PT1	G840520TA	3	$2,000.00	Link	$6,000.00	Volt XFMR (34.5kV)
PT2	Unavailable	1	$7,000.00	Link	$7,000.00	Cap Volt XFMR (138kV)
Battery MTS	GF224NR	1	$842.73	Link	$842.73	Link
Battery Backup	3CA-5M	20	$1,152.75	Link	$23,055.00	Link
				Total Substation Cost	$2,505,288.77	

Total Project Materials Cost	$45,420,766.47

AutoCAD - Grounding



SDMAY23-27 had 315 grounding rods

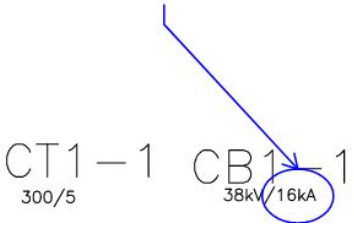
- 315 rods in 140’x100’ area
  - 0.0225 rods/ft^2
- We have 18700 ft^2 (170’x110’)
  - Total of 420 rods

This seems low for our application. Assume 8.35% impedance for the transformer. Reference the transformer nameplate on the last drawing.

Line current = 90MVA/(sqrt(3)*34.5kV) = 1506.13A

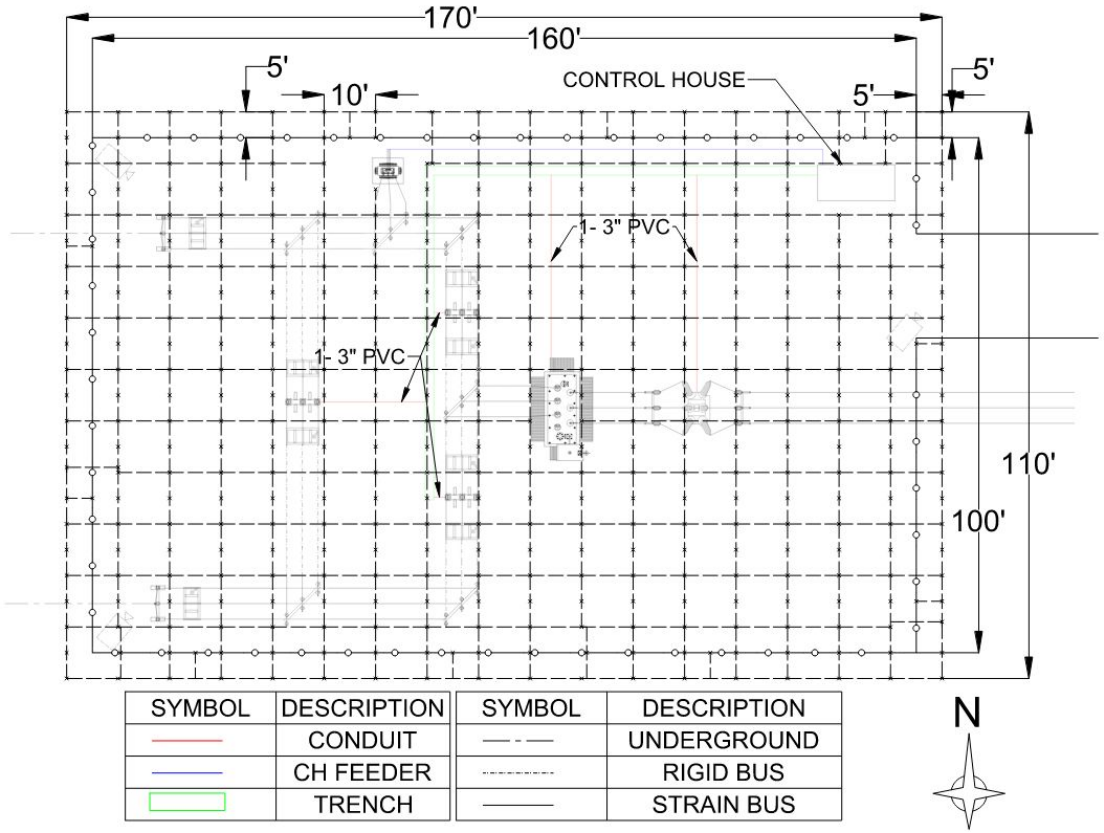
Infinite Bus method:
$I_{sc} = I_L/\%Z =$

1506.13/.0835 = 18037A = 20kA



- Using 60MVA instead of 90MVA we get a line current of 1004A
- Dividing by 0.0835 we get 12kA for Isc

AutoCAD - Grounding



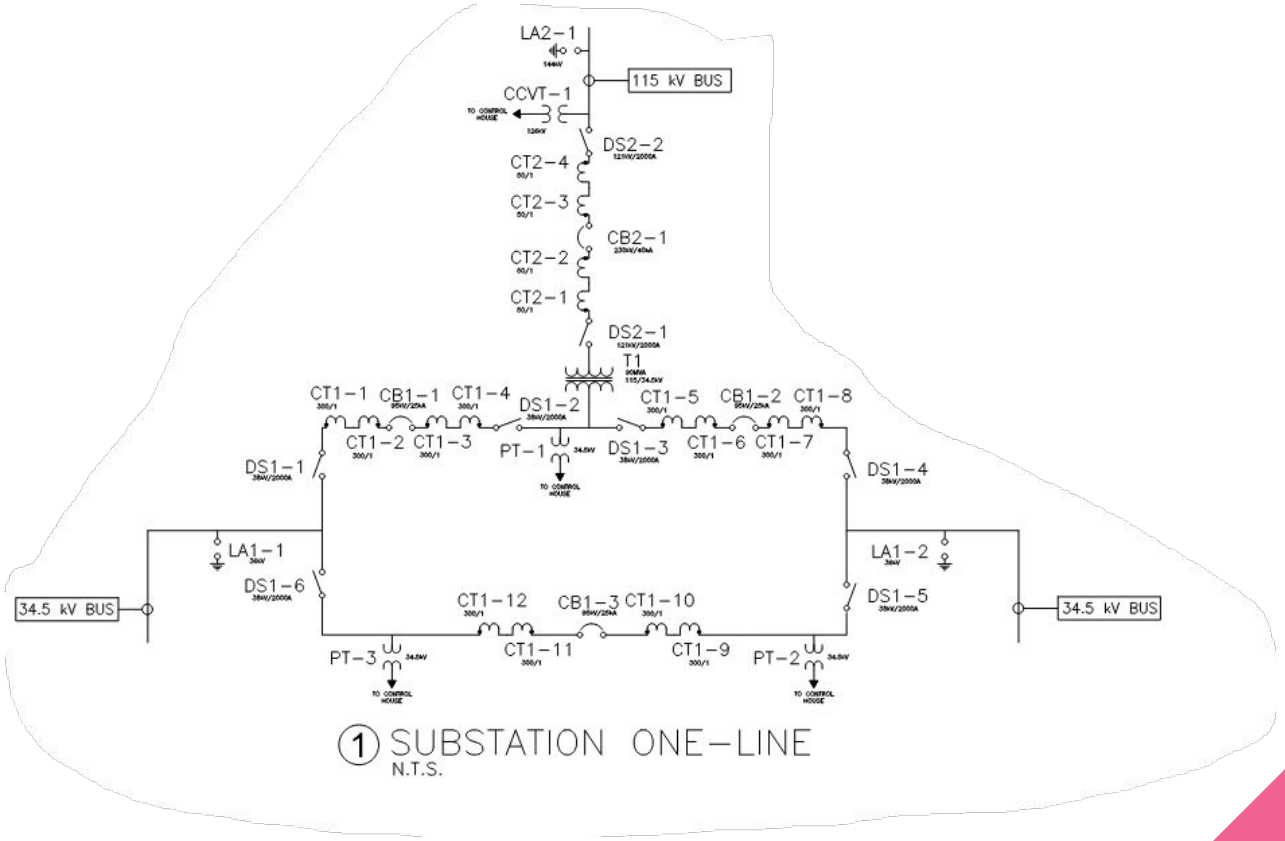
SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	CONDUIT		UNDERGROUND
	CH FEEDER		RIGID BUS
	TRENCH		STRAIN BUS

ST TABLE

SHEET NUMBER	SHEET TITLE
SS100	SUB DESIGN SYMBOLS
SS101	SUB ONE-LINE
SS102	SUB KEY PLAN
SS103	SUB ONE-LINE DETAILS
SS104	SUB GROUNDING INFO
SS105	SUB THREE-LINE
SS106	SUB ONE-LINE PLAN VIEW
SS107	SUB SECTION VIEW
SS108	SUB SITE ENLARGED
SS109	SUB RELAY INFO
SS110	CB1-X DATASHEET
SS111	CB2-X DATASHEET
SS112	DS1-X DATASHEET
SS113	DS2-X DATASHEET
SS114	LA1-X DATASHEET
SS115	LA2-X DATASHEET
SS116	T1 NAMEPLATE

- Adding stingers before 90%

AutoCAD - Updates



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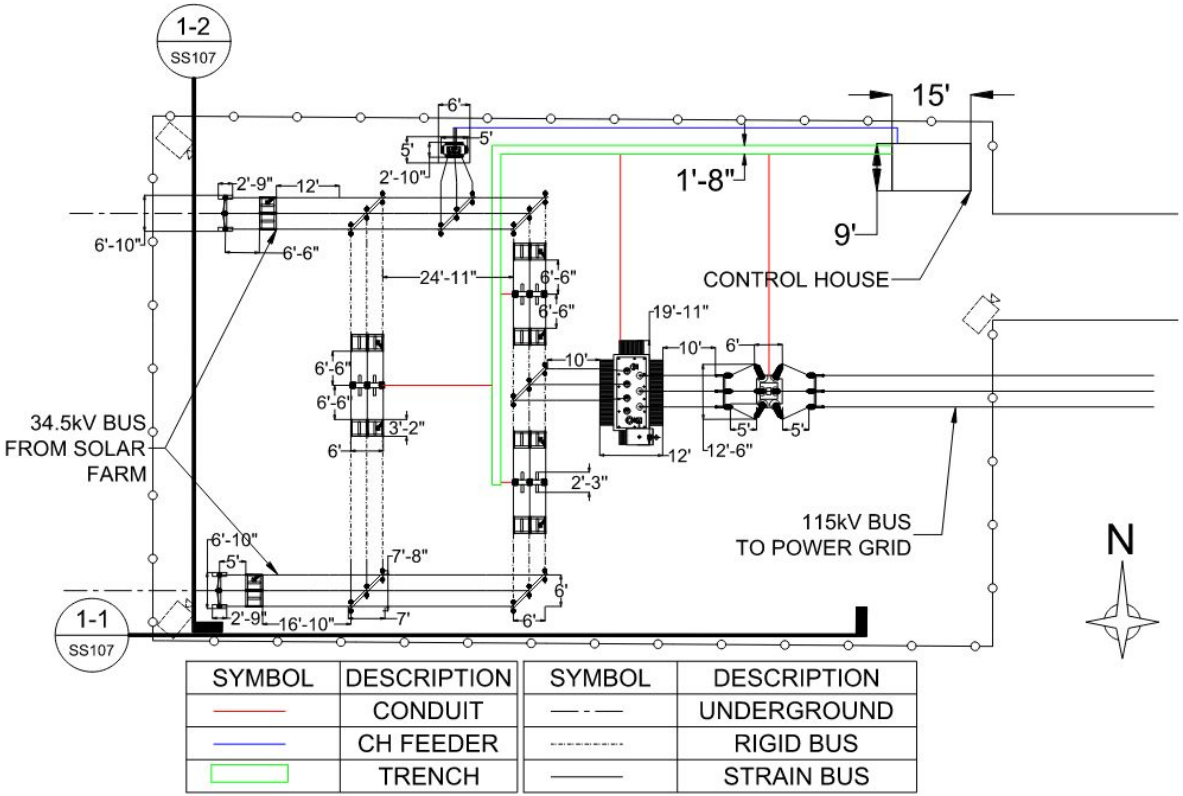
AutoCAD - Updates



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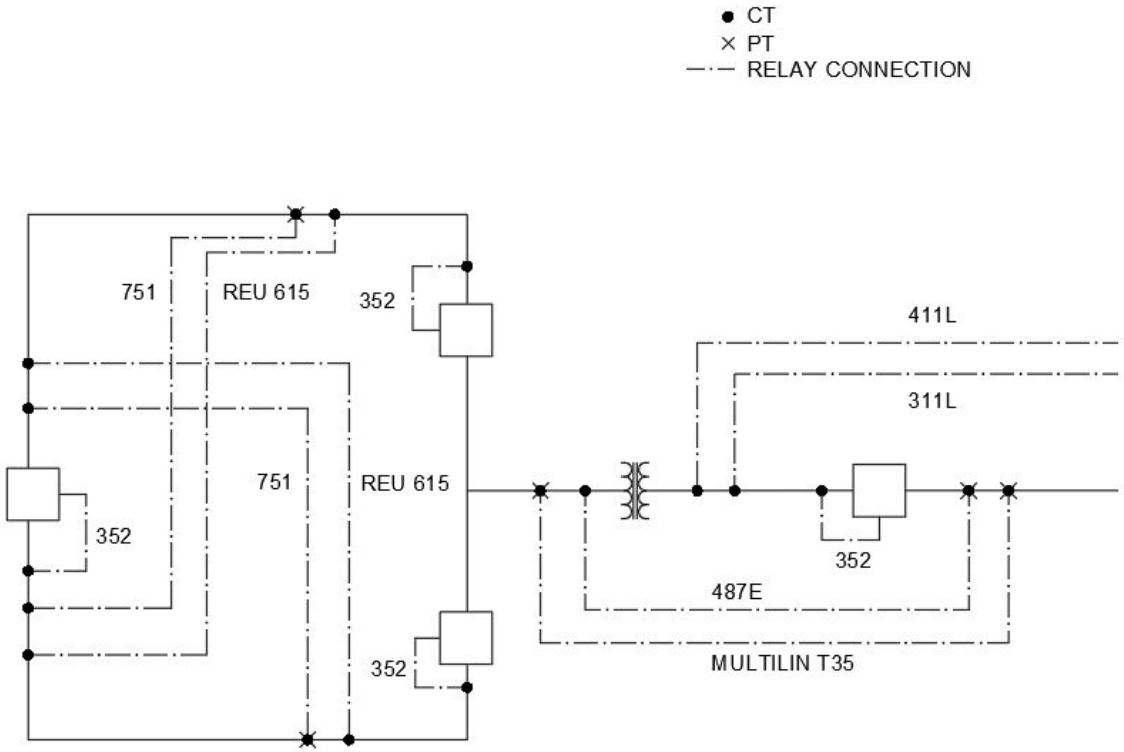

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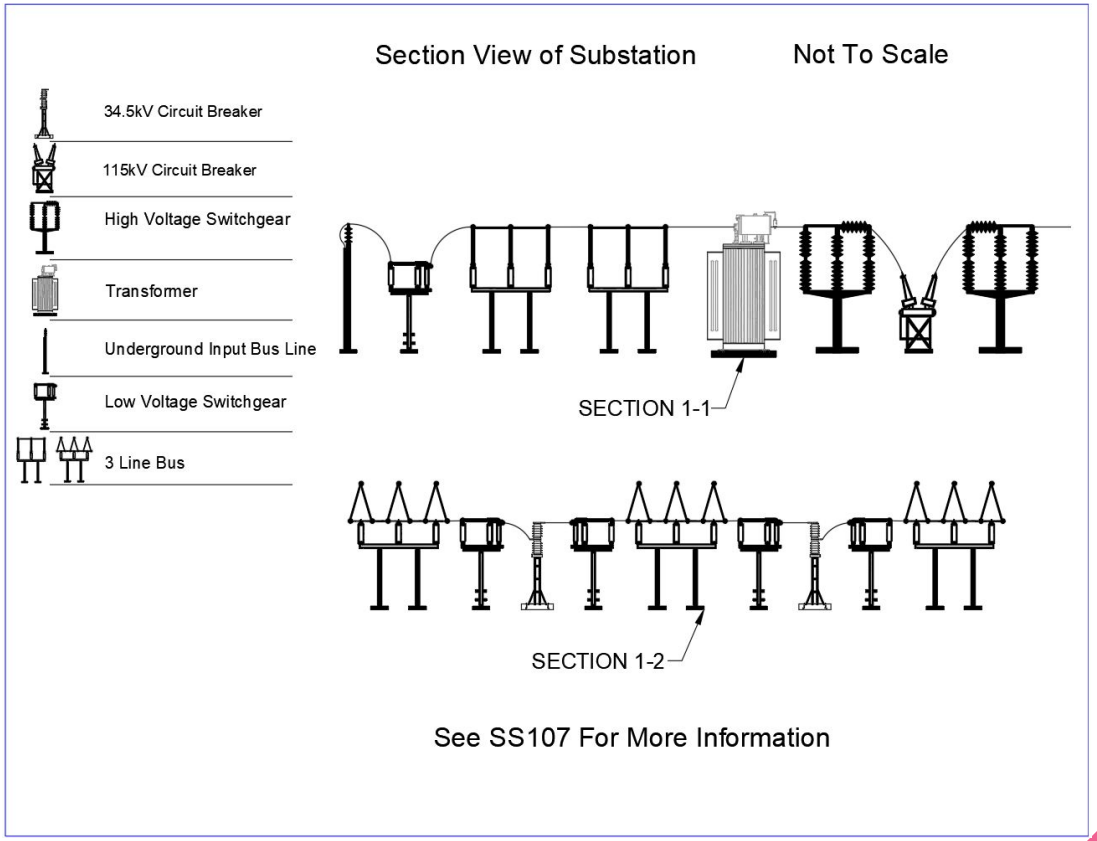

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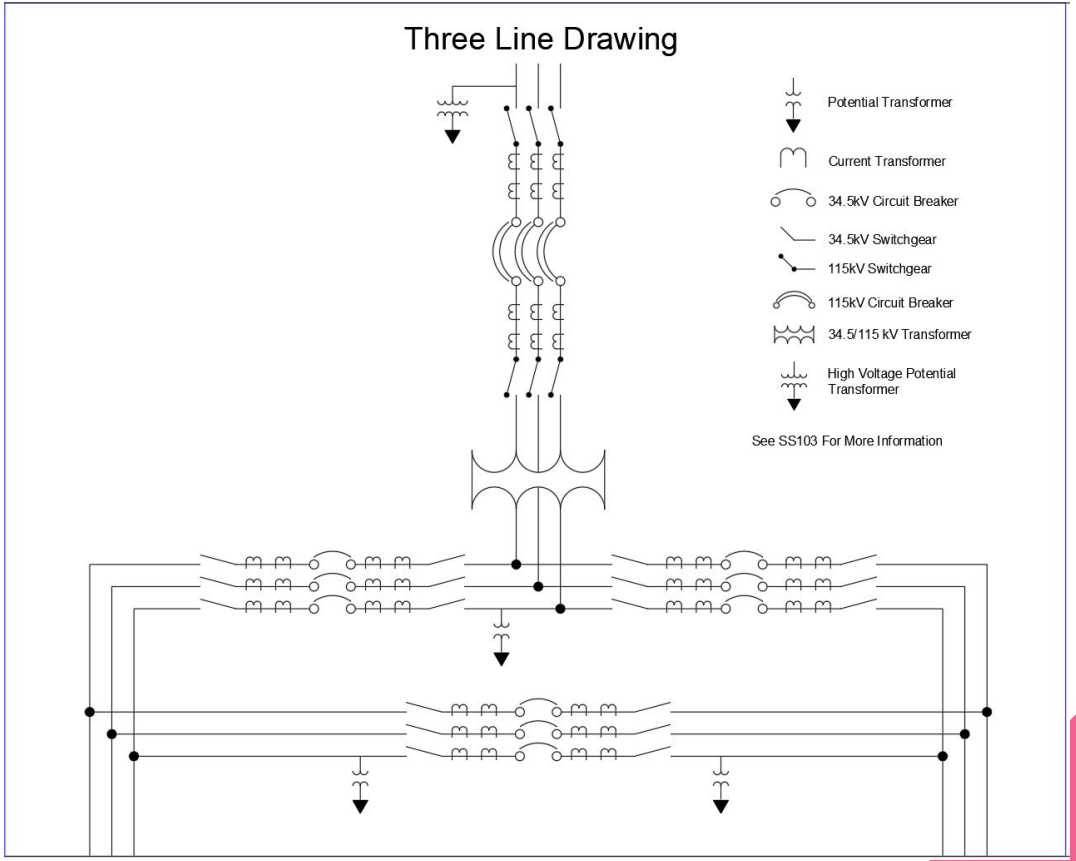

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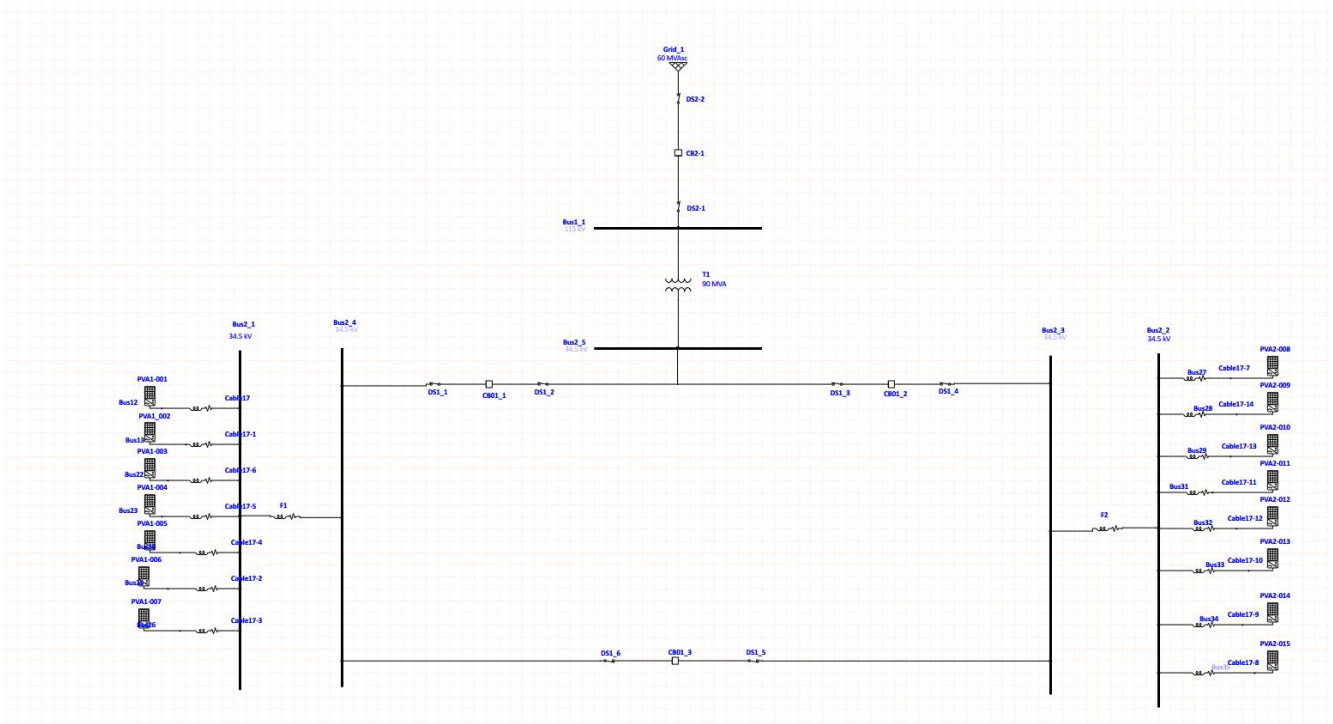
ETAP PV & Substation Power Flow Analysis



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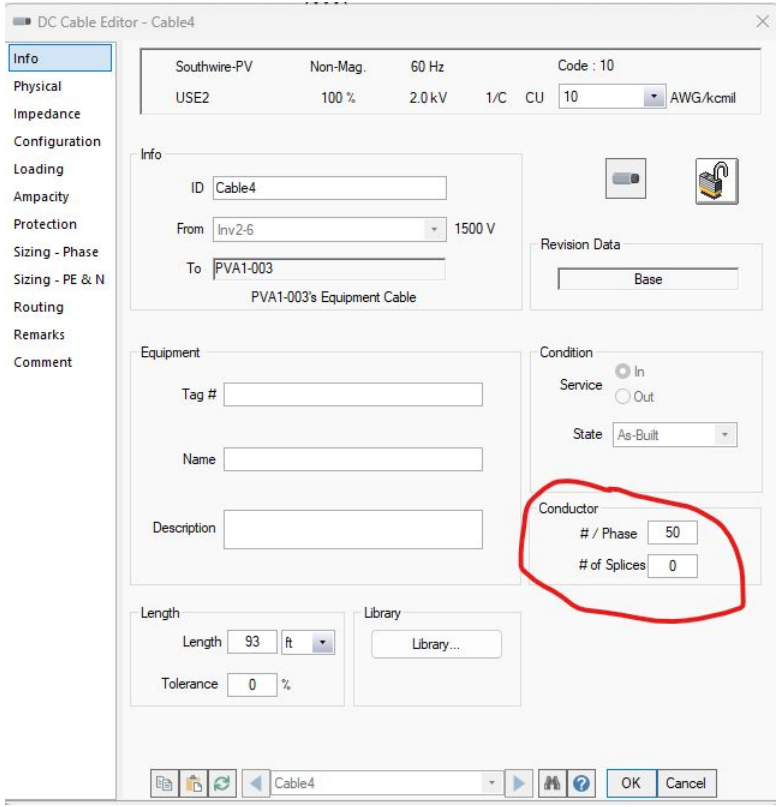

#/Phase = Amps/Ampacity
Base on the NEC table 310.15(B)(16), the smallest Ampacity for copper 600kcmil wire is 350A, So the #/Phase = 1 for the DC cable. And we supposed use 600kcmil wire in this model.

Reference:
https://www.physicsforums.com/threads/determining-conductors-per-phase-451-amps-ampacity.585804/

Questions

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Feedback and Updates

- Tasks: Updates
  - Bell: Design documents
  - Liam:
  - Eli:
  - Baylor:
  - Eduardo:
  - Chicheng: