

# 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 - Eye Strain

## Causes of Eye Strain:

- Prolonged exposure to electronics (computers and cell phones)
- Bright lights or flashing lights (natural or artificial light)
- Poor posture and continuous eye muscle stress

## Symptoms of Eye Strain:

- Blurry or double vision
- Headaches
- Reduced concentration
- Sore and/or heavy eyes

## How to avoid Eye Strain:

- 20-20-20 Rule (stretching for your eyes)
- Improve posture and set up workspace
- Reduce glare and bright lights when using electronics



# 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 111 Ah capacity with 61 Ah removed, and uses flooded lead acid batteries. Our continuous load is 3.896 A. Typical recharge times are usually 8, 12, or 24 hours.

A recharge time of 8 hours results in a charger output of 12.665 A.

A recharge time of 12 hours results in a charger output of 9.742 A.

A recharge time of 24 hours results in a charger output of 6.819 A.



# Calculations

AT EVO Battery Charger from MDS Power:

Input (AC) - 240 V, 17 A

Output (DC) - 130 V, 12 A

Cost - \$3,771.00

AT EVO Battery Charger from MDS Power:

Input (AC) - 240 V, 20 A

Output (DC) - 130 V, 16 A

Cost - \$4,634.00

[IEEE 946 \(see pages 24 and 25 for charger calculations\)](#)

[Battery Charger website](#)

[Battery Charger Spec Sheet](#)



# Calculations

AC Load Calculation :  
Assuming larger battery charger

Total worst case load:  
40.8 kW at 188 A  
(10% worst case scenario added)  
Reduced XFMR fan load per our  
last meeting

Require 50 kVA station XFMR  
Require 200 A MTS

	Quantity	Load/Unit(W)	Amps (ea)	Voltage(V)	Total(W)	Amps Total	
AC Panel - Control Building	Breaker Receptile and Lights	4	210	1.75	120	840	7.00
	Transformer Fans	1	12,000	50.00	240	12,000	50.00
	Transformer Sump Pump	1	2,000	8.33	240	2,000	8.33
	Control House Lighting	20	36	0.30	120	720	6.00
	Yard Lights	6	56	0.46	120	330	2.75
	HVAC System	1	10,000	41.67	240	10,000	41.67
	Fire Detection Equipment	1	150	1.25	120	150	1.25
	Exhaust Fan	1	132	1.10	120	132	1.10
	AC Battery Charger	1	4,800	20.00	240	4,800	20.00
	Power Outlet	10	180	1.50	120	1,800	15.00
	Feeder Motor	2	720	3.00	240	1,440	6.00
		0	0	0.00	120	0	0.00
		0	0	0.00	120	0	0.00
	<b>Worst Case Tripping:</b>						
	High Side Breaker Motor	1	720	3.00	240	720	3.00
Low Side Breaker Motor	3	720	3.00	240	2,160	9.00	
<b>Total Worst Case AC Panel Load</b>					<b>37,092</b>	<b>171.10</b>	

<b>Total Worst Case Load (+10 %)</b>	<b>40,801</b>	<b>188.21</b>
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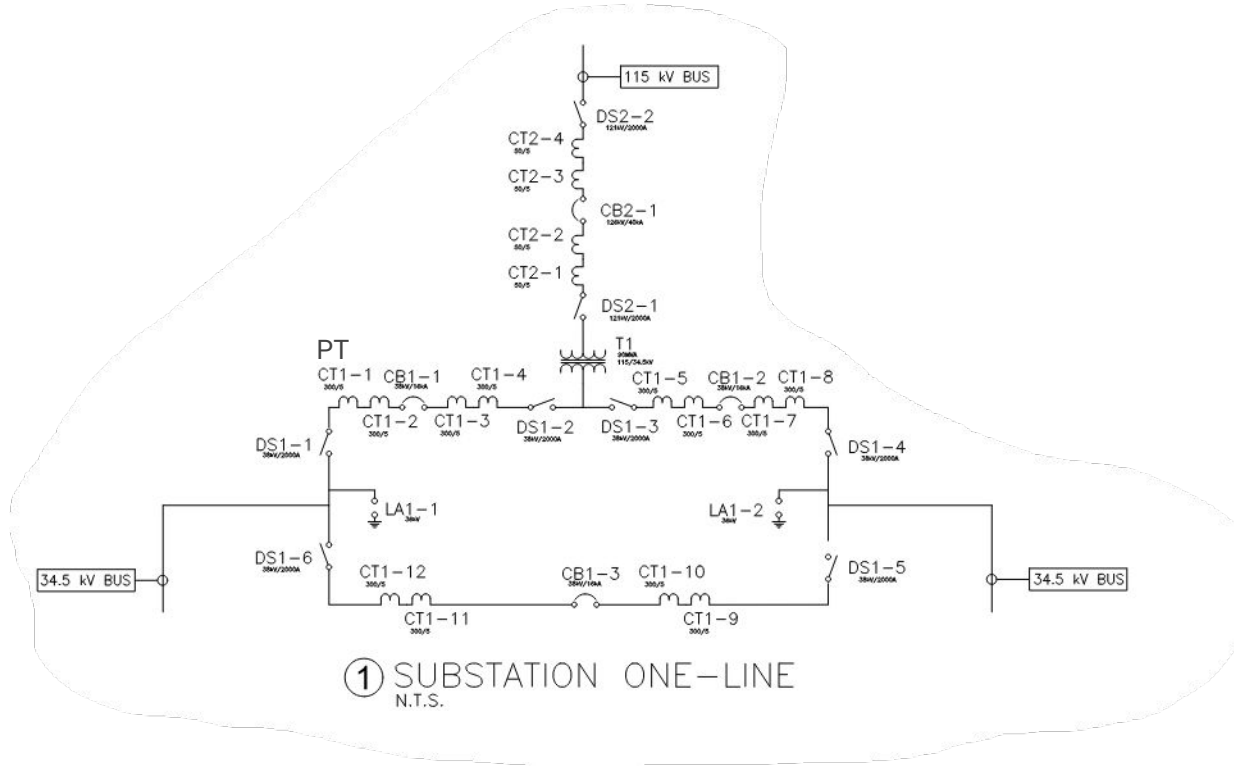
<b>Sizing Recommendations:</b>
Station Service - 50 kVA
MTS, Safety Switch - 200 A

[240 V/200 A MTS from SIEMENS \(\\$842.73\)](#)  
[50 kVA Pad Mount XFMR \(34.5 kV to 120/240 V\) \(\\$18,641.04\)](#)





# AutoCAD - Updates



	Vmax (kV rms)	Curr Ratio	Model No.
CT1-X	34.5	300:5	G950300SA
CT2-X	123	50:5	OSKF123





# AutoCAD - Updates

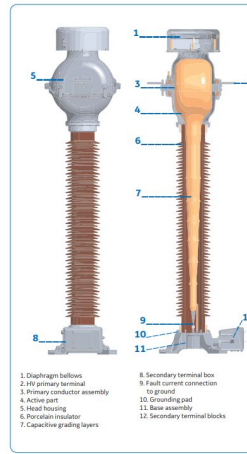
GE  
Grid Solutions

HV

## OSKF

Oil-Insulated Current Transformers  
72.5 kV to 800 kV

Construction Overview



**KUHLMAN ELECTRIC CORPORATION**  
A MEMBER OF THE ABB GROUP

BB-34-975(H)



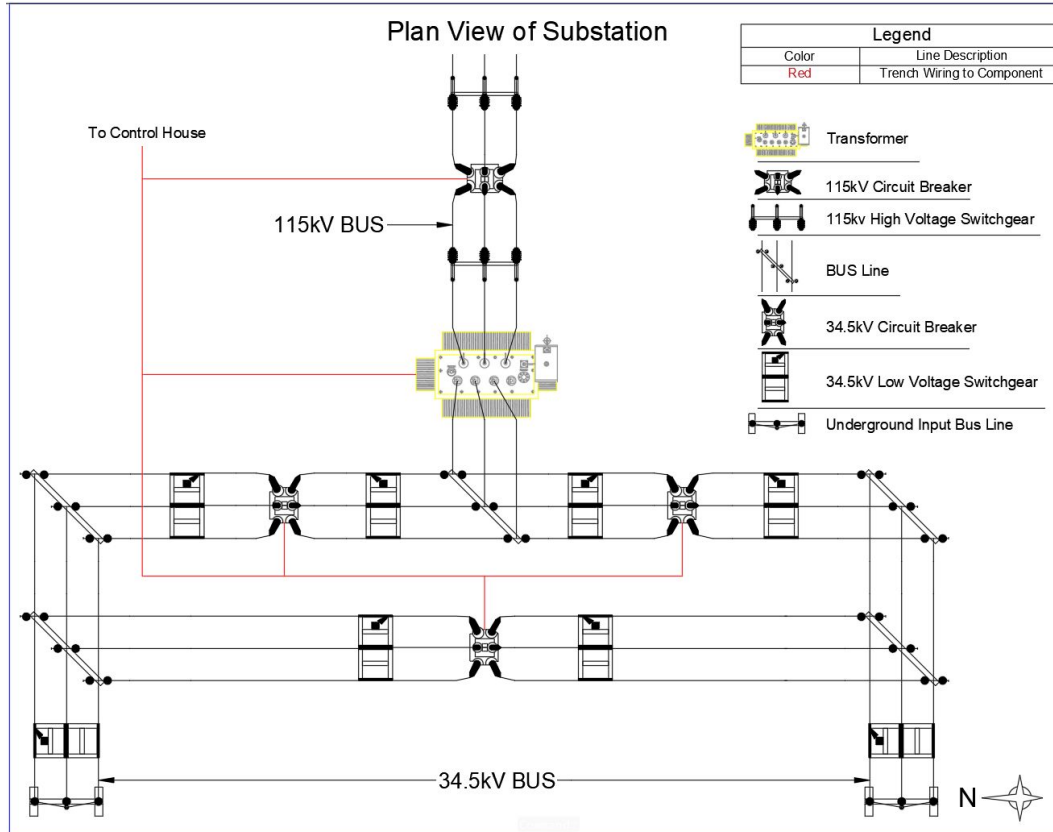
G950300SA  
300:5 Ratio

LV



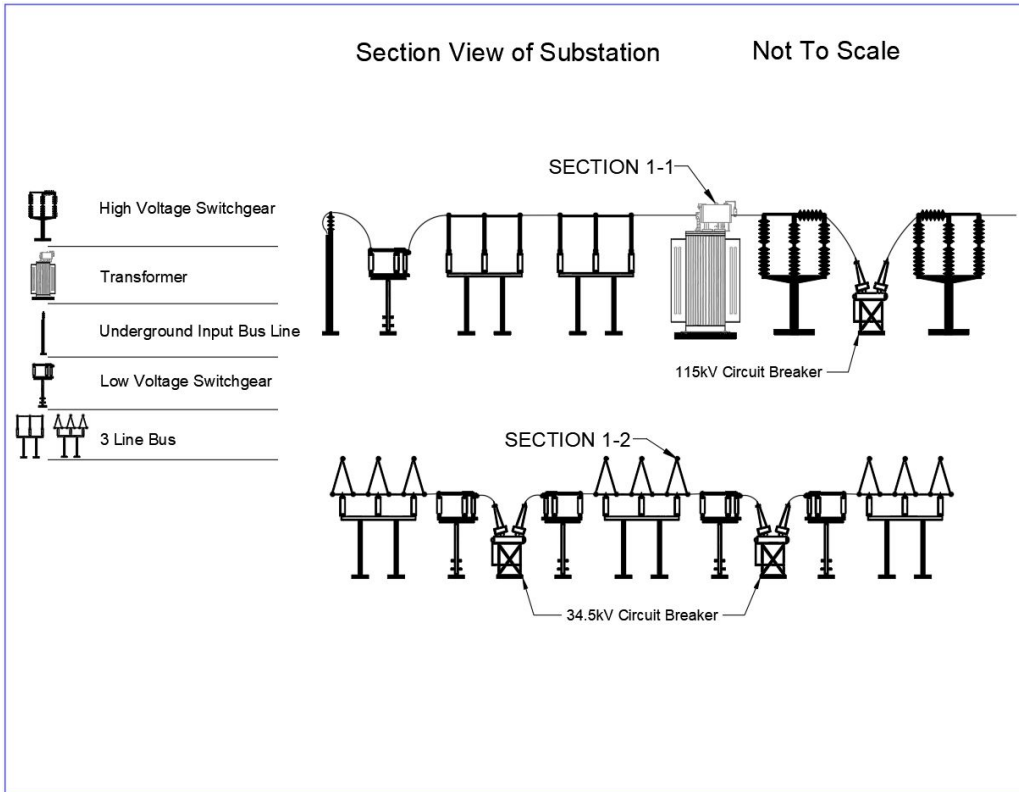
Type		OSKF72		OSKF123		OSKF145		OSKF170		OSKF245	
Highest voltage for equipment (U <sub>m</sub> )	kV	72.5		123		145		170		245	
Lightning impulse withstand voltage (BIL)	kV	350		550		650		750		1050	
		mm	in	mm	in	mm	in	mm	in	mm	in
Minimum creepage distance		1813	71.4	3150	124.0	3750	147.6	4583	180.4	6300	248.0
Dimensions	A	1844	72.6	2224	87.6	2582	101.7	2837	111.7	3442	135.5
	B	1414	55.7	1795	70.7	2029	79.9	1720	67.9	2305	91.4
	C	305	12.0	305	12.0	305	12.0	305	12.0	305	12.0
	D	798	31.4	798	31.4	849	33.4	849	33.4	935	36.8
	E	450	17.7	450	17.7	450	17.7	450	17.7	600	23.6
		kg	lb	kg	lb	kg	lb	kg	lb	kg	lb
Total weight (approx.)		270	595	340	750	446	983	489	1078	609	1342
Oil volume (approx.)	gal.	11.6		15.5		26.2		31.8		37.8	

# AutoCAD - Updates

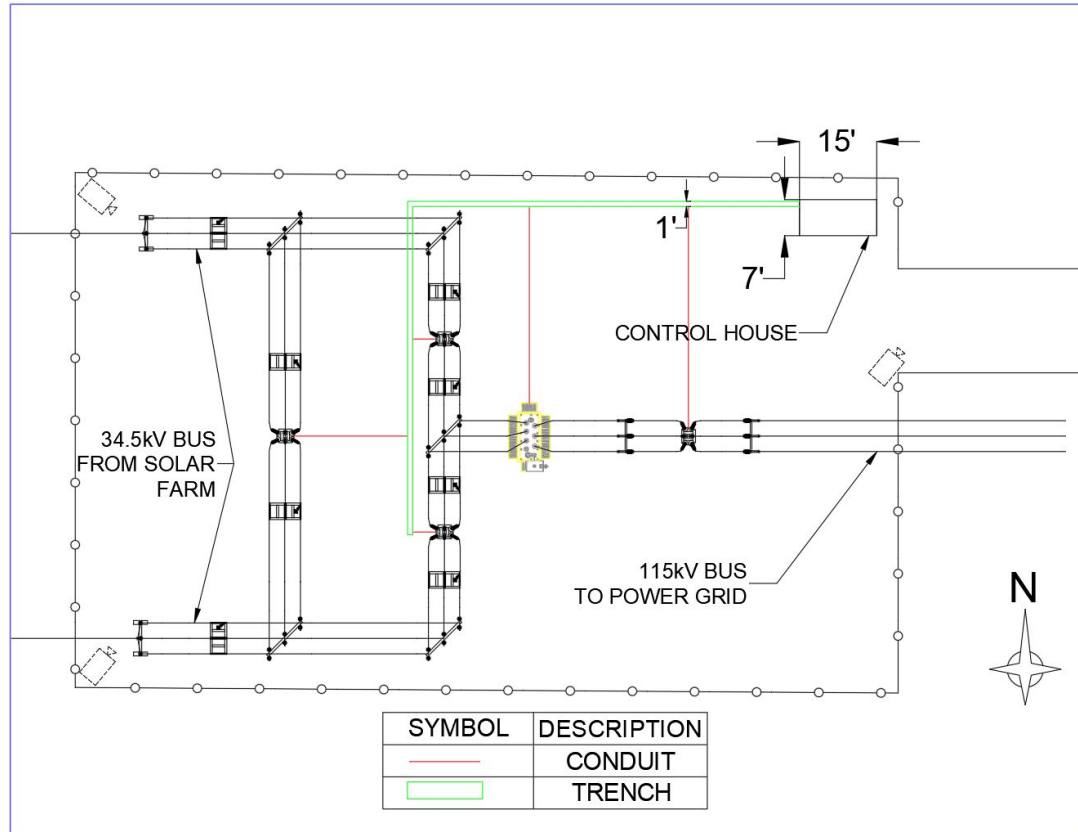


STATE

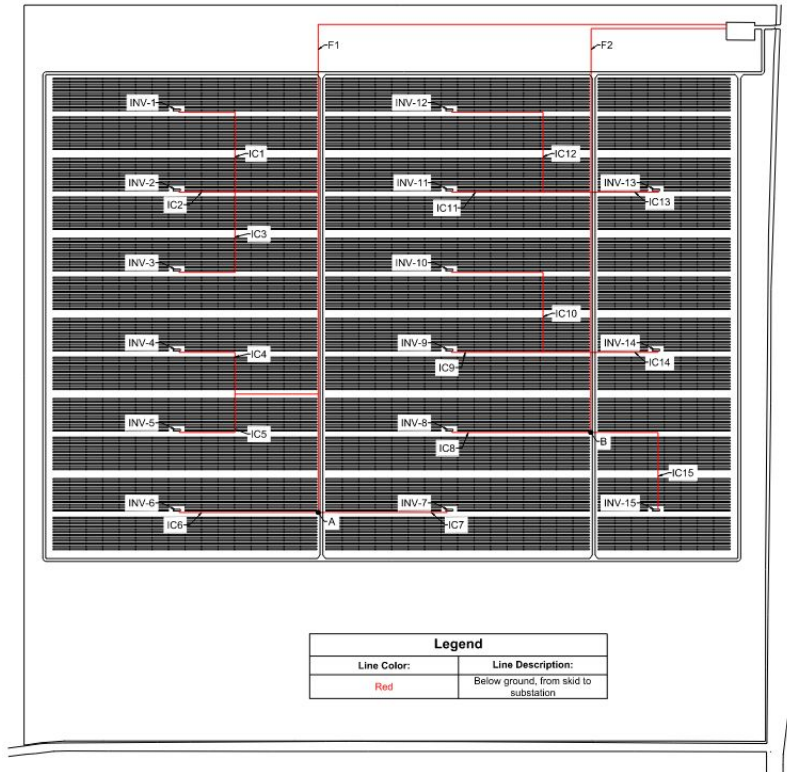
# AutoCAD - Updates



# AutoCAD - Updates



# AutoCAD - Updates

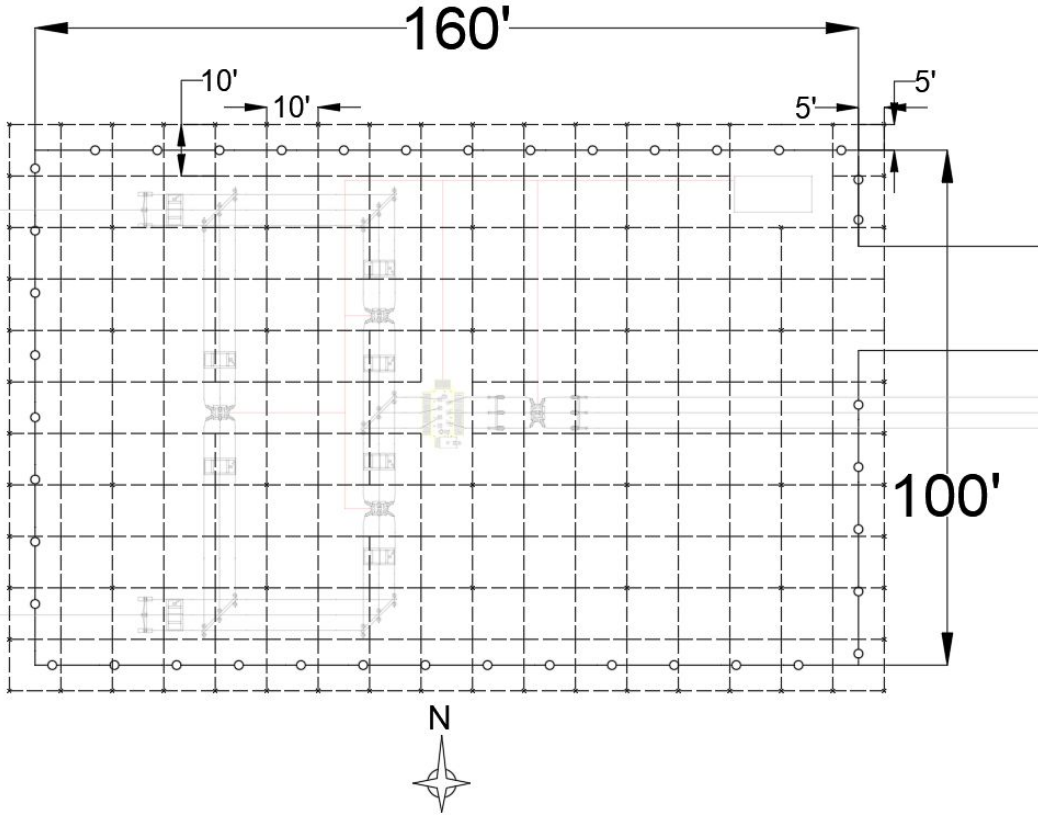


FEEDER SITE PLAN

CABLE NAME	CABLE LENGTH	START	END
F1	4778' - 4"	A	SUB
F2	3043' - 3"	B	SUB
IC1	1242' - 6"	INV-1	F1
IC2	791' - 8"	INV-2	F1
IC3	1243' - 6"	INV-3	F1
IC4	1027'	INV-4	F1
IC5	1008'	INV-5	F1
IC6	791' - 8"	INV-6	A
IC7	734'	INV-7	A
IC8	794' - 5"	INV-8	B
IC9	794' - 5"	INV-9	F2
IC10	1246' - 5"	INV-10	F2
IC11	794' - 5"	INV-11	F2
IC12	1246' - 5"	INV-12	F2
IC13	388' - 10"	INV-13	F2
IC14	388' - 10"	INV-14	F2
IC15	814' - 9"	INV-15	B



# AutoCAD - Updates



# Conductor Sizing

## Copper RHH, RHW, USE

Underground Service Entrance Cable. 600 Volt. Copper Conductors. Cross-Linked Polyethylene (XLP) Insulation. High-Heat, Moisture, and Sunlight Resistant. Sizes 6 Through 4/0 AWG Also Rated SIS.

### APPLICATIONS

Southwire® Type RHH or RHW-2 or USE-2 conductors are used with conduit as specified in the 2011 National Electrical Code. When used as Type USE-2, conductor is suitable for use as underground service entrance cable for direct burial at conductor temperatures not to exceed 90°C. When used as RHH, conductor temperatures shall not exceed 90°C in dry locations. When used as RHW-2 or USE-2, conductor temperatures shall not exceed 90°C in wet or dry locations. Voltage rating for RHH or RHW-2 or USE-2 conductors is 600 volts.

### STANDARDS & REFERENCES

- Southwire® Type RHH or RHW-2 or USE-2 comply with the following:
- ASTM - B3, B8 (7, 19, 37, 61 Strands), B787 (19 Wire Combination Unilay Strand)
- UL Standard 44 for RHH or RHW-2
- UL Standard 854 for USE-2
- Federal Specification A-A-59544
- National Electrical Code, NFPA 70 - 2011 Edition
- NEMA WC 70 Construction Requirements
- RoHS/REACH Compliant

### CONSTRUCTION

Southwire® Type RHH or RHW-2 or USE-2 copper conductors are annealed (soft) copper. Insulation is an abrasion, moisture, heat, and sunlight resistant black cross-linked polyethylene (XLP). An optional CT rated product is available upon request for sizes 1/0 and larger.



Southwire-PV USE2	Non-Mag. 100 %	60 Hz 2.0 kV	1/C	CU	Code : 10 10	AWG/kcmil
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Installation for Ampacity/Capacity

Standard  Type

NEC  
A/G Trays

Base Ampacity is from NEC Tables.  
1/C in Trays must be 1/0 AWG or larger.

Tray

Top Cover  Maintained Spacing

Results

Operating	Base	Derated
0	0	0

Allowable Ampacity/Capacity

Derated  
 User-Defined  
 UGS Calculated

Temperature

	Ta	Tc
Base	30	90
Operating	35	90

Ta Adjustment per NEC Table

Additional Derating

User Defined

Report

Prompt

Fire Protection

Correction Factors

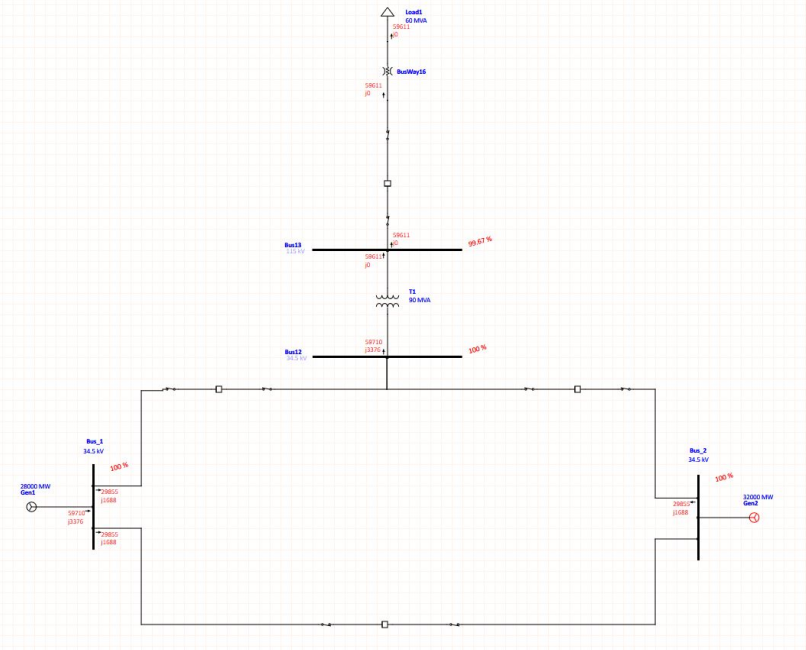
There is no base ampacity available.

## Allowable Ampacities

- 10 kcmil = 30 A
- 600 kcmil = 420 A



# ETAP\_Substation Power flow analysis test



The screenshot shows the 'Load Flow Analyzer' software interface. At the top, a table displays the results for 'Load1':

ID	Rating/Limit	Rated k.V	k.W	kvar	Amp	% PF	% Loading	Terminal
Load1	60000 k.VA	115	59610.5	0	300.2	100	99.7	99.67

Below the table, the 'Project Report' section shows 'substation' as the active project. The 'Report Type' is set to 'Loads'. The 'Load Type' includes 'Induction', 'Synchronous', 'Lumped', 'Static', 'MDV', 'Capacitor', 'SVC', and 'Filter'. The 'Load Info' section shows 'Terminal Bus', 'Type', 'Rating/Limit', and 'Rated KV' are selected. The 'Load Flow Results' section shows 'kW Loading', 'kvar Loading', 'Amp Loading', '% Loading', and 'Terminal Voltage' are selected. The 'Alert' section shows 'Critical' and 'Margin' are selected. The 'Display Options' section shows 'Actual Value' is selected.





# Questions

- Next steps

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# Feedback and Updates

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

