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

Senior Design Team 18 - May 2024

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Agenda

- Safety Moment
- AutoCAD Drawings

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- Voltage Drops + Cost calculations
- ETAP



Safety Moment - Cyber Security

Why it is important:

- Protect sensitive information
- Protect company equipment
- Prevent potential cyber attacks and various network issues

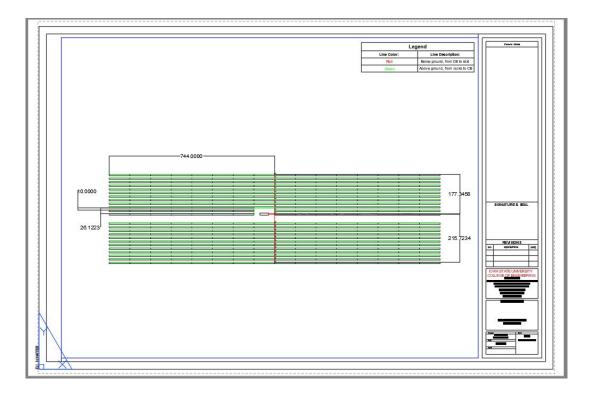
How to practice it:

- Keep login information private
- Ensure login details are complex
- Keep an eye out for phishing attempts
- Do not access sensitive information on vulnerable networks
- Deny access to unauthorized personnel





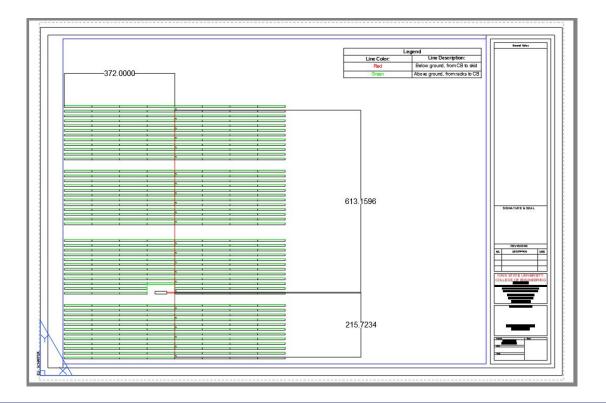
PV104 - Horizontal Wiring Layout

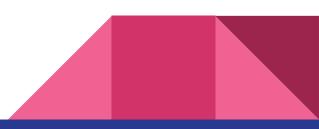


- Added dimensions for wire distances
- Color coordinated wire types

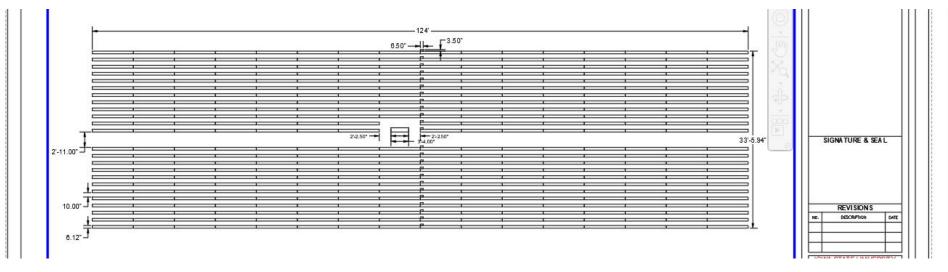


PV105 - Vertical Wiring Layout



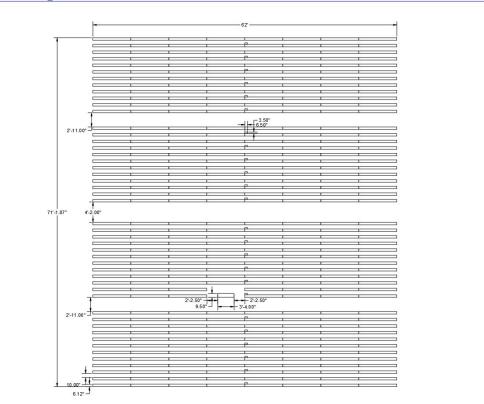


Array Plan - Horizontal - UPDATED





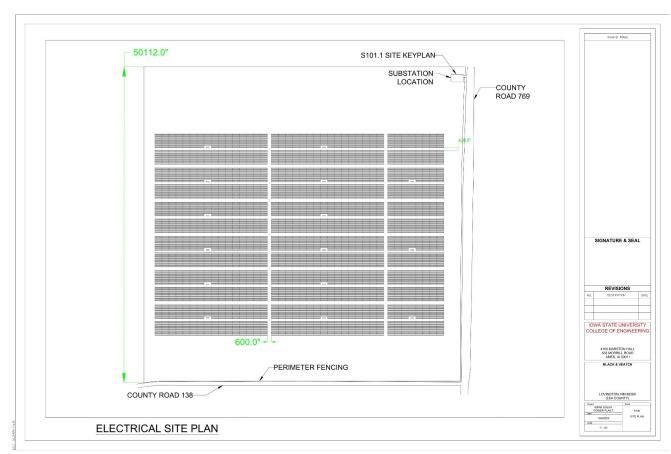
Array Plan - Vertical - UPDATED







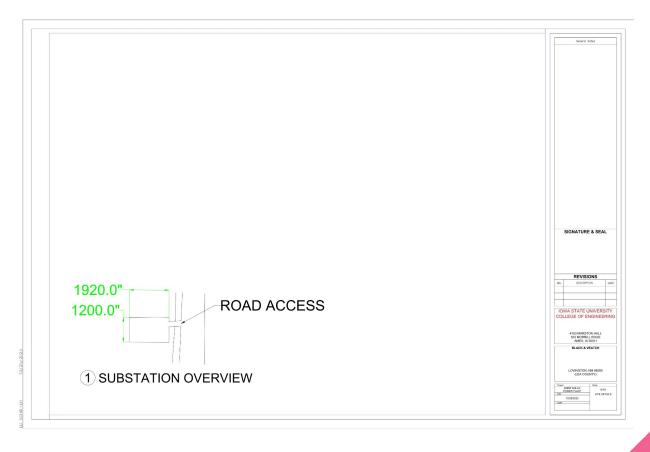
Site Plan - UPDATED



- Brought in overall solar array layout
- Added additional dimensions
- Detailed view for substation
- Add another details for road access to solar field



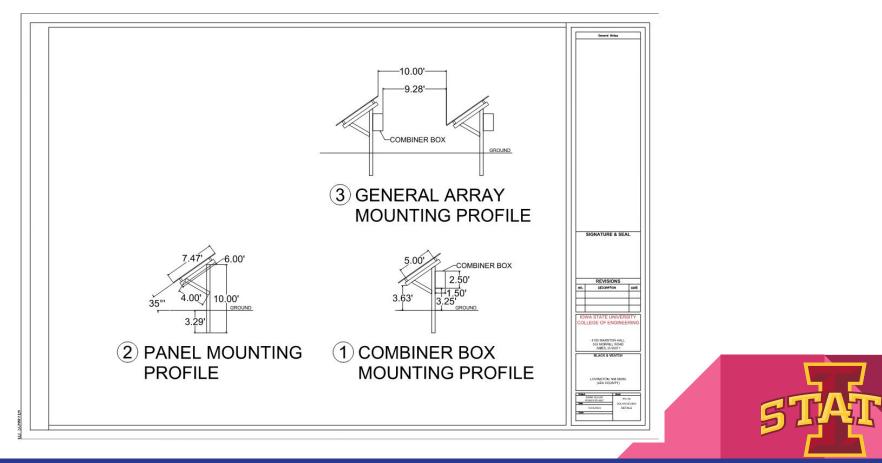
Site Plan Detailed Views



- Call out detailed plan for the substation location
- Will add more dimensioning and line work details



PV106 - PV Details



Existing Transmission Lines



From project location it is about 10 miles.



Voltage Drop calculation

Horizontal array

A	В	C	D	E	F	G	н	1	J	к	L
to Dean Calculation = c	-38/					Resources	NEC Table 8 Conductor Properties				
ltage-Drop Calculation = <3%							NEC AWG Chart	+			
racks Combiner box (Horizontal Array)				T				<u> </u>			
DCB	Strings per rack	ISC for string	String length	String wire size	String conductor resistance	e String resistance	voltage drop of string(AWG #12)) Voltage drop of string			
DCB#-##	per rack	Amp	feet	AWG	ohm/kft	ohm	Volts	%	1		
DCB1-01	1	13.89	93	12	1.98	0.18414	5.115	0.341	1		
DCB1-02	1	13.89	93	12	1.98	0.18414	5.115	0.341	1		
DCB1-03	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-04	1	13.89	93	12	1.98	0.18414	5.115	0.341	1		
DCB1-05	1	13.89	93	12	1.98	0.18414	5.115	0.341	· · · · · · · · · · · · · · · · · · ·		
DCB1-06	1	13.89	93	12	1.98	0.18414	5.115	0.341	· · · · · · · · · · · · · · · · · · ·		
DCB1-07	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-08	1	13.89	93	12	1.98	0.18414	5.115	0.341	· · · · · · · · · · · · · · · · · · ·		
DCB1-09	1	13.89	93	12	1.98	0.18414	5.115	0.341	1		
DCB1-10	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-11	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-12	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-13	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-14	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-15	1	13.89	93	12	1.98	0.18414	5.115	0.341	/		
DCB1-16	1	13.89	93	12	1.98	0.18414	5.115	0.341			
AWG=600											
-	In the base			-		A second second			the second second		A second second
DCB		s IMP For DCB Circuit				Feeder resistance		Voltage drop for feeder	Voltage drop for circuit		Voltage drop for circu
DCB#-## DCB1	# 16	Amp 222.24	Feet 161	600	0.0241	0.004	Volt 1.725	0.11	Volt 11.96	Volt 1500	0.80
DCB1 DCB2	16	222.24	161	600	0.0241	0.004	1.725	0.11	11.96	1500	0.80
DCB2 DCB3	16	222.24	151	600	0.0241	0.004	1.618	0.11	11.85	1500	0.79
DCB3 DCB4	16	222.24	141	600	0.0241	0.003	1.510	0.10	11.74	1500	0.78
DCB4 DCB5	16	222.24	131	600	0.0241	0.003	1.403	0.09	11.53	1500	0.78
DCB5 DCB6	16	222.24	121	600	0.0241	0.003	1.296	0.09	11.53	1500	0.76
DCB6	16	222.24	101	600	0.0241	0.003	1.082	0.08	11.42	1500	0.75
DCB7	16	222.24	91	600	0.0241	0.002	0.975	0.07	11.21	1500	0.75
DCB9	16	222.24	81	600	0.0241	0.002	0.868	0.06	11.21	1500	0.74
DCB9	16	222.24	71	600	0.0241	0.002	0.761	0.05	10.99	1500	0.74
DCB10	16	222.24	61	600	0.0241	0.001	0.653	0.04	10.88	1500	0.73
DCB12	14	222.24	51	600	0.0241	0.001	0.546	0.04	10.78	1500	0.72
DCB12	14	222.24	41	600	0.0241	0.001	0.439	0.03	10.67	1500	0.71
DCB14	16	222.24	82	600	0.0241	0.002	0.878	0.06	11.11	1500	0.74
DCB15	16	222.24	92	600	0.0241	0.002	0.986	0.07	11.22	1500	0.75
DCB16	16	222.24	102	600	0.0241	0.002	1.093	0.07	11.32	1500	0.75
DCB17	16	222.24	112	600	0.0241	0.003	1.200	0.08	11.43	1500	0.76
DCB18	16	222.24	122	600	0.0241	0.003	1.307	0.09	11.54	1500	0.77
DCB19	16	222.24	132	600	0.0241	0.003	1.414	0.09	11.64	1500	0.78
DCB20	16	222.24	142	600	0.0241	0.003	1.521	0.10	11.75	1500	0.78
DCB21	16	222.24	152	600	0.0241	0.004	1.628	0.11	11.86	1500	0.79
DCB22	16	222.24	162	600	0.0241	0.004	1.735	0.12	11.97	1500	0.80
DCB23	16	222.24	172	600	0.0241	0.004	1.842	0.12	12.07	1500	0.80
DCB24	16	222.24	182	600	0.0241	0.004	1.950	0.13	12.18	1500	0.81
									,	Average of worst-case DCB Voltage drop (%)	
										Average of worst-case DOD voltage utop (74)	0.70

Met the NEC requirement Vd < 3%



Voltage Drop Calculation

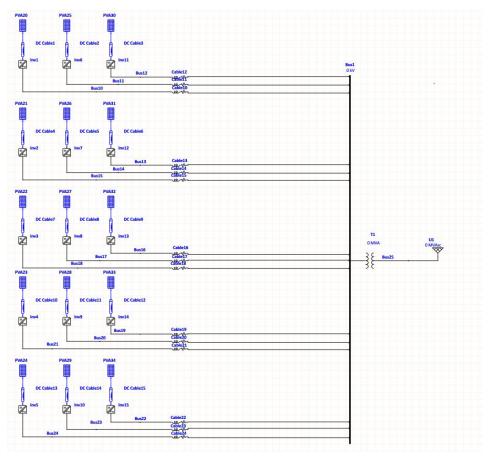
Vertical array

e-Drop Calculation = <	3%					Resources	NEC Table 8 Conductor Properties NEC AWG Chart				
							NEO ANO ONAN				
Combiner box (Horizontal Array)											
DCB	Strings per rack	ISC for string	String length	String wire size	String conductor resistance	String resistance	Voltage drop of string (AWG=12)	Voltage drop of string			
DCB#-##	per rack	Amp	feet	AWG	ohm/kft	ohm	Volts	%			
DCB1-01	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-02	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-03	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-04	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-05	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-06	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-07	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-08	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-09	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-10	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-11	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-12	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-13	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-14	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-15	1	13.89	93	12	1.98	0.18414	5.115	0.341			
DCB1-16	1	13.89	93	12	1.98	0.18414	5.115	0.341			
= 600, diameter = 22-32mm											
DCB	No.of Rack Inputs	IMP For DCB Circuit	Feeder Length	Feeder wire size	Feeder resistance	Feeder resistance	Voltage drop for feeder	Voltage drop for feeder	Voltage drop for circuit	VMP for circuit	Voltage drop for circu
DCB#-##	#	Amp	Feet	kcmil	Ohm/kft	Ohm	Volt	per cent	Volt	Volt	per cent
DCB1	16	222.24	607	600	0.0214	0.013	5.774	0.38	16.005	1500	1.07
DCB2	16	222.24	585	600	0.0214	0.013	5.564	0.37	15.795	1500	1.05
DCB3	16	222.24	563	600	0.0214	0.012	5.355	0.36	15.586	1500	1.04
DCB4	16	222.24	541	600	0.0214	0.012	5.146	0.34	15.377	1500	1.03
DCB5	16	222.24	519	600	0.0214	0.011	4.937	0.33	15.167	1500	1.01
DCB6	16	222.24	497	600	0.0214	0.011	4.727	0.32	14.958	1500	1.00
DCB7	16	222.24	440	600	0.0214	0.009	4.185	0.28	14.416	1500	0.96
DCB8	16	222.24	418	600	0.0214	0.009	3.976	0.27	14.207	1500	0.95
DCB8 DCB9	16	222.24	396	600	0.0214	0.008	3.976 3.767	0.27 0.25	13.998	1500	0.93
DCB8 DCB9 DCB10	16 16	222.24 222.24	396 374	600 600	0.0214 0.0214	0.008	3.976 3.767 3.557	0.27 0.25 0.24	13.998 13.788	1500 1500	0.93
DCB8 DCB9 DCB10 DCB11	16 16 16	222.24 222.24 222.24	396 374 352	600 600 600	0.0214 0.0214 0.0214	0.008 0.008 0.008	3.976 3.767 3.557 3.348	0.27 0.25 0.24 0.22	13.998 13.788 13.579	1500 1500 1500	0.93 0.92 0.91
DC88 DC89 DC810 DC811 DC811 DC812	16 16 16 14	222.24 222.24 222.24 222.24 222.24	396 374 352 330	600 600	0.0214 0.0214 0.0214 0.0214	0.008 0.008 0.008 0.007	3.976 3.767 3.557 3.348 3.139	0.27 0.25 0.24 0.22 0.21	13.998 13.788 13.579 13.370	1500 1500 1500 1500	0.93 0.92 0.91 0.89
DC88 DC89 DC810 DC811 DC811 DC812 DC813	16 16 16 14 14	222.24 222.24 222.24 222.24 222.24 222.24	396 374 352 330 258	600 600 600 600 600	0.0214 0.0214 0.0214 0.0214 0.0214 0.0214	0.008 0.008 0.008 0.007 0.006	3.976 3.767 3.557 3.348 3.139 2.454	0.27 0.25 0.24 0.22 0.21 0.16	13.998 13.788 13.579	1500 1500 1500 1500 1500	0.93 0.92 0.91 0.89 0.85
DC88 DC89 DC810 DC811 DC812 DC813 DC813 DC814	16 16 16 14 14 14 16	222.24 222.24 222.24 222.24 222.24 222.24 222.24	396 374 352 330 258 236	600 600 600 600 600 600	0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214	0.008 0.008 0.008 0.007 0.006 0.005	3.976 3.767 3.557 3.348 3.139 2.454 2.245	0.27 0.25 0.24 0.22 0.21 0.16 0.15	13.998 13.788 13.579 13.370 12.685 12.476	1500 1500 1500 1500 1500 1500 1500	0.93 0.92 0.91 0.89 0.85 0.83
DC88 DC89 DC810 DC811 DC812 DC813 DC813 DC814 DC815	16 16 14 14 14 16 16	222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24	396 374 352 330 258 236 214	600 600 600 600 600 600 600	0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214	0.008 0.008 0.008 0.007 0.006 0.005 0.005	3.976 3.767 3.567 3.348 3.139 2.454 2.245 2.036	0.27 0.25 0.24 0.22 0.21 0.16 0.15 0.14	13.998 13.788 13.579 13.370 12.685 12.476 12.266	1500 1500 1500 1500 1500 1500 1500 1500	0.93 0.92 0.91 0.89 0.85 0.83 0.82
DC88 DC89 DC810 DC811 DC812 DC812 DC813 DC814 DC815 DC816	16 16 14 14 16 16 16 16	222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24	396 374 352 330 258 236 214 192	600 600 600 600 600 600 600 600	0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214	0.008 0.008 0.008 0.007 0.006 0.005 0.005 0.005	3.976 3.767 3.557 3.348 3.139 2.454 2.245 2.036 1.826	0.27 0.25 0.24 0.22 0.21 0.16 0.15 0.15 0.14 0.12	13.998 13.788 13.579 13.370 12.685 12.476 12.266 12.266 12.057	1500 1500 1500 1500 1500 1500 1500 1500	0.93 0.92 0.91 0.89 0.85 0.83 0.82 0.82 0.80
DC88 DC89 DC810 DC811 DC812 DC812 DC813 DC814 DC815	16 16 14 14 16 16 16 16 16	222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24	396 374 352 330 258 236 214 192 170	600 600 600 600 600 600 600	0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214	0.008 0.008 0.007 0.006 0.005 0.005 0.004 0.004	3.976 3.767 3.557 3.348 3.139 2.454 2.245 2.036 1.826 1.827	0.27 0.25 0.24 0.22 0.21 0.16 0.15 0.15 0.14 0.12 0.11	13.998 13.788 13.579 13.370 12.685 12.476 12.266 12.057 11.848	1500 1500 1500 1500 1500 1500 1500 1500	0.93 0.92 0.91 0.89 0.85 0.83 0.82 0.82 0.80 0.79
DC88 DC89 DC810 DC811 DC812 DC812 DC813 DC814 DC815 DC816	16 16 14 14 16 16 16 16	222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24	396 374 352 330 258 236 214 192 170 148	600 600 600 600 600 600 600 600 600 600	0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214	0.008 0.008 0.007 0.006 0.005 0.005 0.005 0.004 0.004 0.004	3.876 3.767 3.557 3.348 2.454 2.245 2.036 1.825 1.817 1.408	0.27 0.25 0.24 0.22 0.21 0.15 0.15 0.14 0.12 0.11 0.09	13.998 13.788 13.579 13.370 12.685 12.476 12.266 12.057 11.848 11.639	1500 1500 1500 1500 1500 1500 1500 1500	0.93 0.92 0.91 0.89 0.85 0.83 0.82 0.80 0.79 0.78
DC88 DC89 DC810 DC811 DC812 DC813 DC814 DC814 DC815 DC816 DC817 DC818 DC819	16 16 14 14 14 16 16 16 16 16 16	222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24	396 374 352 330 258 236 214 192 170 148 91	600 600 600 600 600 600 600 600 600 600	0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214	0.008 0.008 0.007 0.006 0.005 0.005 0.005 0.004 0.004 0.004 0.003 0.002	3 979 3 767 3 367 3 348 2 348 2 245 2 236 1 828 1 828 1 828 1 847 1 409 0 866	0.27 0.25 0.24 0.21 0.16 0.15 0.15 0.14 0.12 0.11 0.11 0.10 0.09	13.998 13.788 13.579 13.370 12.685 12.476 12.266 12.057 11.848 11.639 11.096	1500 1500 1500 1500 1500 1500 1500 1500	0.93 0.92 0.91 0.89 0.85 0.83 0.82 0.80 0.79 0.78 0.74
DC88 DC89 DC810 DC811 DC813 DC813 DC814 DC815 DC816 DC816 DC817 DC819 DC819 DC819	16 16 14 14 16 16 16 16 16 16	222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24	396 374 352 330 258 236 214 192 170 148	600 600 600 600 600 600 600 600 600 600	0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214	0.008 0.008 0.007 0.006 0.005 0.005 0.005 0.004 0.004 0.004 0.003 0.002 0.002	3.979 3.877 3.857 3.348 3.139 2.454 2.245 1.825 1.825 1.825 1.617 1.408 0.866 1.075	0.27 0.25 0.24 0.22 0.21 0.16 0.15 0.14 0.12 0.11 0.09 0.06 0.07	13.998 13.759 13.379 12.685 12.476 12.266 12.267 11.848 11.639 11.096 11.306	1500 1500 1500 1500 1500 1500 1500 1500	0.93 0.92 0.91 0.89 0.85 0.83 0.82 0.80 0.79 0.78 0.74 0.75
DC88 DC89 DC810 DC811 DC812 DC813 DC814 DC815 DC816 DC816 DC817 DC818 DC819	16 16 14 14 14 16 16 16 16 16 16	222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24	396 374 352 330 258 236 214 192 170 148 91	600 600 600 600 600 600 600 600 600 600	0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214	0.008 0.008 0.007 0.006 0.005 0.005 0.005 0.004 0.004 0.004 0.003 0.002	3 979 3 767 3 367 3 348 2 348 2 245 2 236 1 828 1 828 1 828 1 847 1 409 0 866	0.27 0.25 0.24 0.21 0.16 0.15 0.15 0.14 0.12 0.11 0.11 0.10 0.09	13.998 13.788 13.579 13.370 12.685 12.476 12.266 12.057 11.848 11.639 11.096	1500 1500 1500 1500 1500 1500 1500 1500	0.93 0.92 0.91 0.89 0.85 0.83 0.82 0.80 0.79 0.78 0.74
DC88 DC89 DC810 DC811 DC813 DC813 DC814 DC815 DC816 DC816 DC817 DC816 DC819 DC819	16 16 14 14 16 16 16 16 16 16 16 16	222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24	396 374 352 258 238 214 192 170 148 91 113	600 600 600 600 600 600 600 600 600 600	0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214	0.008 0.008 0.007 0.006 0.005 0.005 0.005 0.004 0.004 0.004 0.003 0.002 0.002	3.979 3.877 3.857 3.348 3.139 2.454 2.245 1.825 1.825 1.825 1.617 1.408 0.866 1.075	0.27 0.25 0.24 0.22 0.21 0.16 0.15 0.14 0.12 0.11 0.09 0.06 0.07	13.998 13.759 13.379 12.685 12.476 12.266 12.267 11.848 11.639 11.096 11.306	1500 1500 1500 1500 1500 1500 1500 1500	0.93 0.92 0.91 0.89 0.85 0.83 0.82 0.80 0.79 0.78 0.74 0.75
DC88 DC89 DC810 DC811 DC812 DC813 DC814 DC814 DC814 DC815 DC819 DC819 DC820 DC821	16 16 14 14 16 16 16 16 16 16 16 16 16 16	222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24	396 374 352 330 258 236 214 192 170 148 91 113 135	600 600 600 600 600 600 600 600 600 600	0.0214 0.0214 0.0214 0.0224 0.0224 0.0224 0.0224 0.0224 0.0224 0.0224 0.0224 0.0224 0.0224 0.0224 0.0224	0.008 0.008 0.008 0.007 0.006 0.005 0.005 0.004 0.004 0.004 0.004 0.002 0.002 0.002	3 879 3 787 3 .857 3 .349 2 .454 2 .245 1 .829 1 .829 1 .848 0 .866 1 .075 1 .284	0.27 0.25 0.24 0.22 0.21 0.15 0.15 0.14 0.12 0.12 0.12 0.09 0.06 0.07 0.09	13.998 13.759 13.379 12.685 12.476 12.266 12.057 11.848 11.639 11.096 11.306 11.515	1500 1500 1500 1500 1500 1500 1500 1500	0.93 0.92 0.91 0.85 0.83 0.82 0.82 0.80 0.79 0.78 0.74 0.75 0.77
DC88 DC89 DC810 DC811 DC812 DC813 DC814 DC815 DC815 DC815 DC816 DC817 DC819 DC819 DC820 DC821 DC822	16 16 16 14 14 16 16 16 16 16 16 16 16 16 16	222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24 222.24	396 374 352 330 258 236 214 192 170 148 91 113 135 157	600 600 600 600 600 600 600 600 600 600	0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214 0.0214	0.008 0.008 0.008 0.007 0.006 0.005 0.005 0.005 0.004 0.004 0.004 0.003 0.002 0.002 0.002 0.003	3.979 3.707 3.657 3.348 2.348 2.245 2.039 1.829 1.829 1.817 1.008 0.866 1.775 1.284 1.433	0.27 0.25 0.24 0.22 0.21 0.16 0.16 0.14 0.14 0.12 0.11 0.09 0.09 0.09 0.07 0.09 0.00	13.998 13.759 13.579 12.685 12.475 12.266 12.057 11.848 11.639 11.096 11.306 11.515 11.724	1500 1500 1500 1500 1500 1500 1500 1500	0.93 0.92 0.91 0.89 0.85 0.83 0.82 0.80 0.79 0.78 0.74 0.75 0.77 0.78

Met the NEC requirement Vd < 3%



ETAP Simulation



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STATE

Feedback and Updates

- Saw the comments back
- Advisor presentations on 12/6
- Tasks: Pick up comments
 - Chicheng ETAP, AC One Line
 - Liam DC One Line
 - Baylor Site Plans (Roads/feeders etc)
 - Bell Has stuff
 - Eduardo String Connection Diagram
 - Eli Title Block Updates, Details,

