Utility Scale Lithium-Ion Energy Storage Project (sddec-10)

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Project Plan: Problem Statement

- Mission:
  - Design a Battery Energy Storage System (BESS) following NFPA, IEEE, and NEC standards for Iowa State's campus.
- Goal:
  - The BESS will be designed to provide 2 hours of backup power generation incases of blackout or high demands.

Project Plan: Functional Requirements

- Can perform the following sequence:
  - Receives a DC voltage from Iowa State University's power generation facilities
  - Steps down the DC voltage to the BESS' level
  - Stores power in the BESS
  - Converts DC to AC voltage when the power stored in the BESS is required
  - Steps up the AC voltage to that of Iowa State's power grid
  - Delivers power to the grid

Project Plan: Deliverables

The Iowa State BESS has five main deliverables split between two semesters.

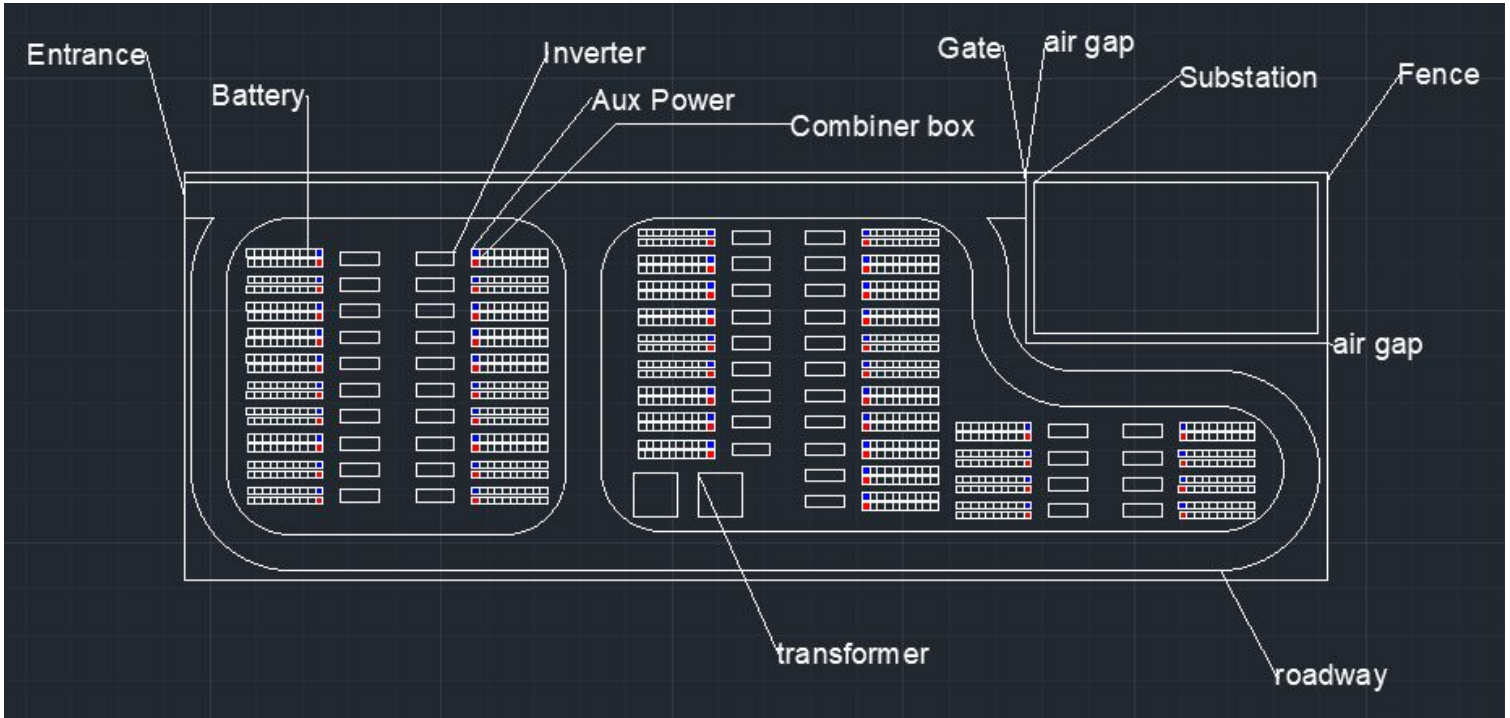
1. **Site Layout** : This is the fundamental system design and shows the physical layout and overall size of the system.
2. **One LIne Diagram**: This is the fundamental logistical layout of the system and is used to represent the flow of power.
3. **Grounding Plan**: This is the under-laid bare copper, grounding rods, and jumper connections to the system used to ensure IEEE, NEC, and NFPA safety measures.
4. **Wire schedule**: This is the diagram that physically maps out every wire connection and size between components from the first battery rack to the substation.
5. **Load flow and ISC analysis**: This is the testing analysis to determine the overall safety and reliability of our system. This was simulated in ETAP software to follow client protocol.

Project Plan: Site Layout

- The site layout was the first conceptual design piece created in designing the Iowa State BESS.
- The total system is comprised of:

	Quantity	Size (ft)
CATL battery racks	864	4.27 x 4.27
PCS Inverters	48	21.7 x 7
Aux Transformers	2	25 x 25
Auxiliary power boxes	48	4.27 x 4.27
Combiner boxes	48	4.27 x 4.27
Substation	1	160 x 85
Fencing	2012.81 ft	644.5 x 228.9

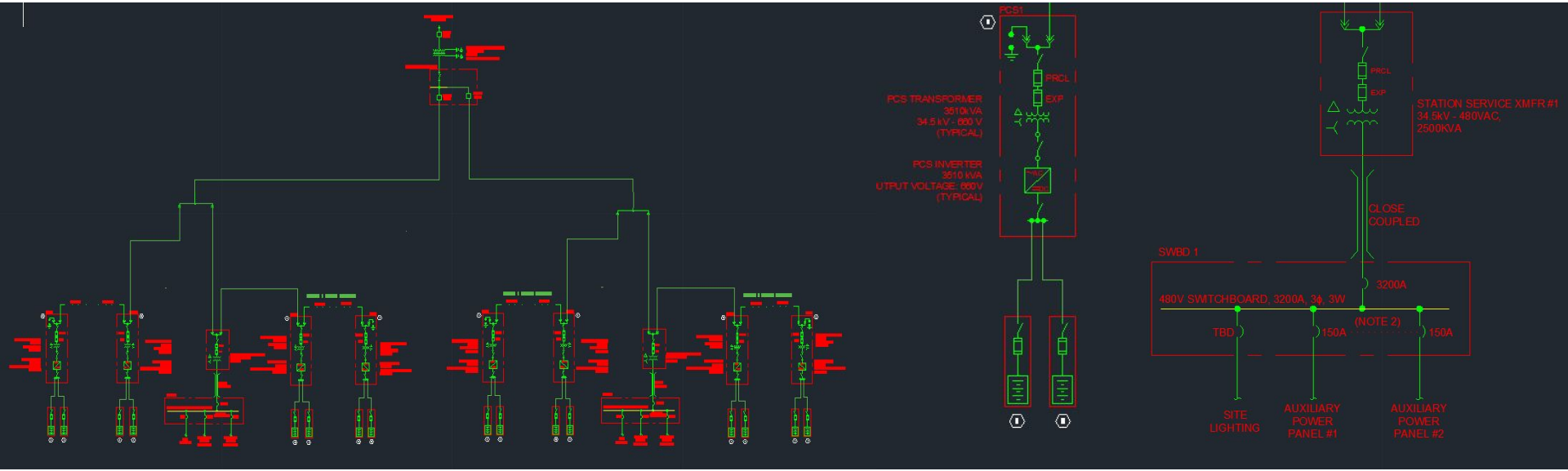
Project Plan: Site Layout



Project Plan: One Line Diagram

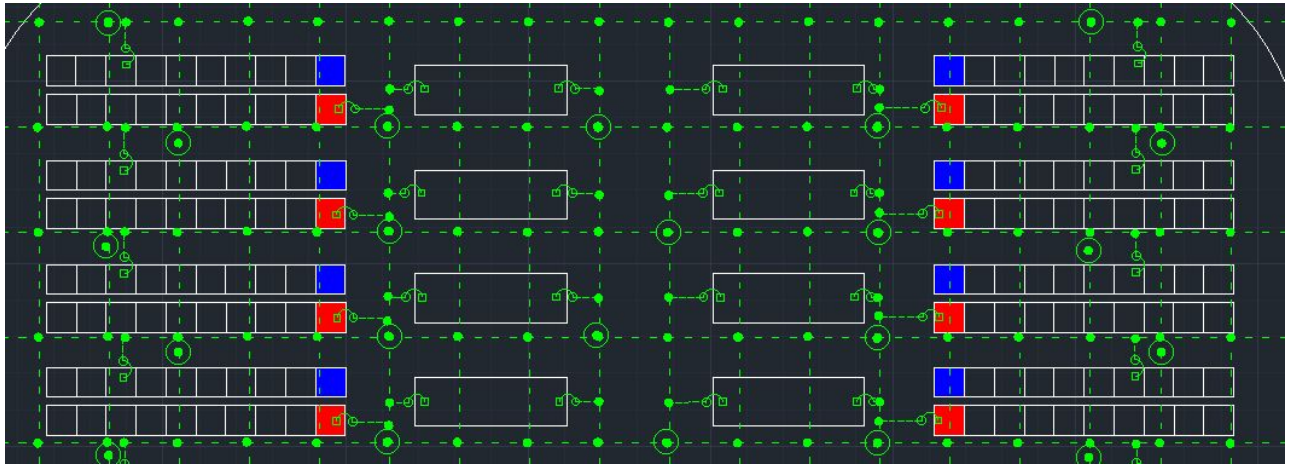
- The one line diagram is used to represent the connection of components in simplistic terms.
- Two battery banks, comprised of eighteen battery racks, are connected to each PCS inverter, which is then connected to another eleven PCS inverter subsystems.
- There are four chains of twelve PCS subsystems that connect back to a substation.
- Along with the four PCS subsystems there are two additional auxiliary transformers connected to switchboards used to feed auxiliary power panels for the systems auxiliary power boxes.

Project Plan: One Line Diagram



Project Plan: Grounding Plan

- Using the completed site layout from last semester the Grounding plan was designed to protect against any faults, or step and touch potentials that could occur in our system.
- The entire BESS grounding system follows a layout pattern of rows and columns spaced 10’ and 15’ respectively.
- Grounding rods are placed no less than 6’ apart from one another and placed more frequently near large clusters of grounding jumpers.

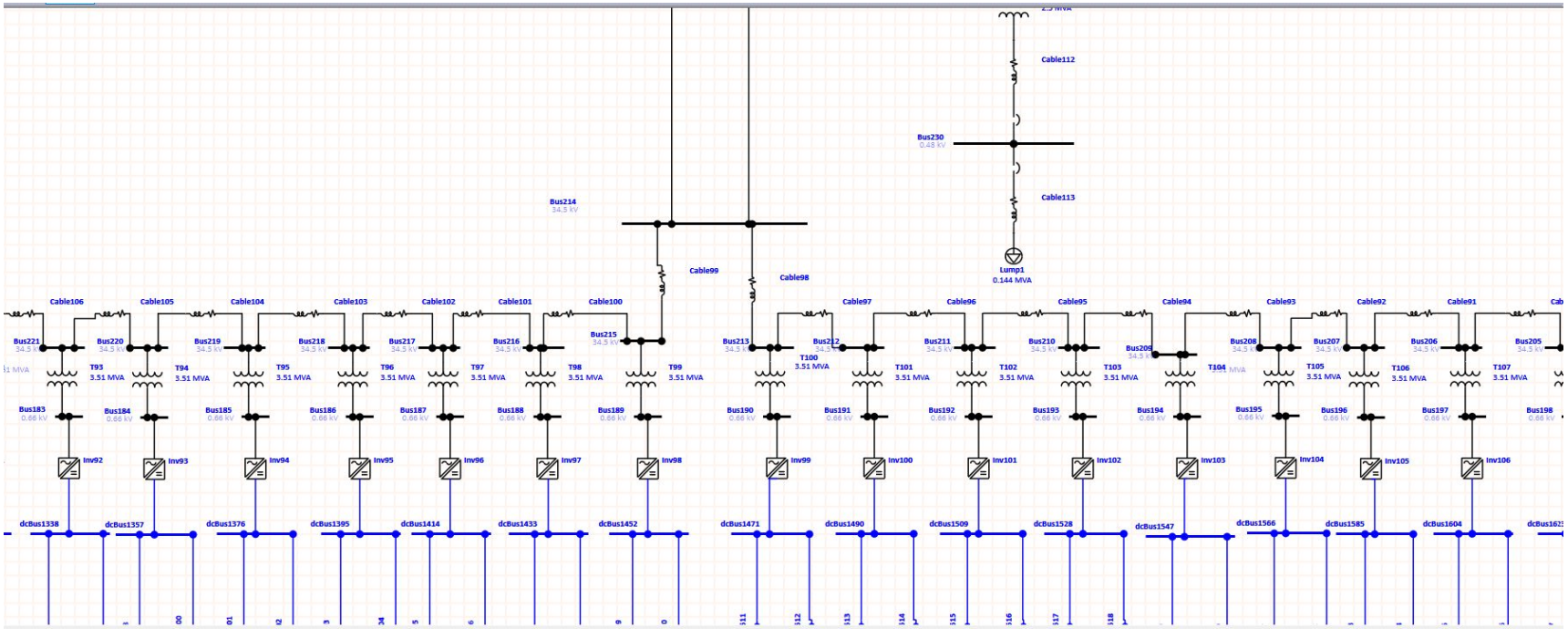


Connection Diagrams

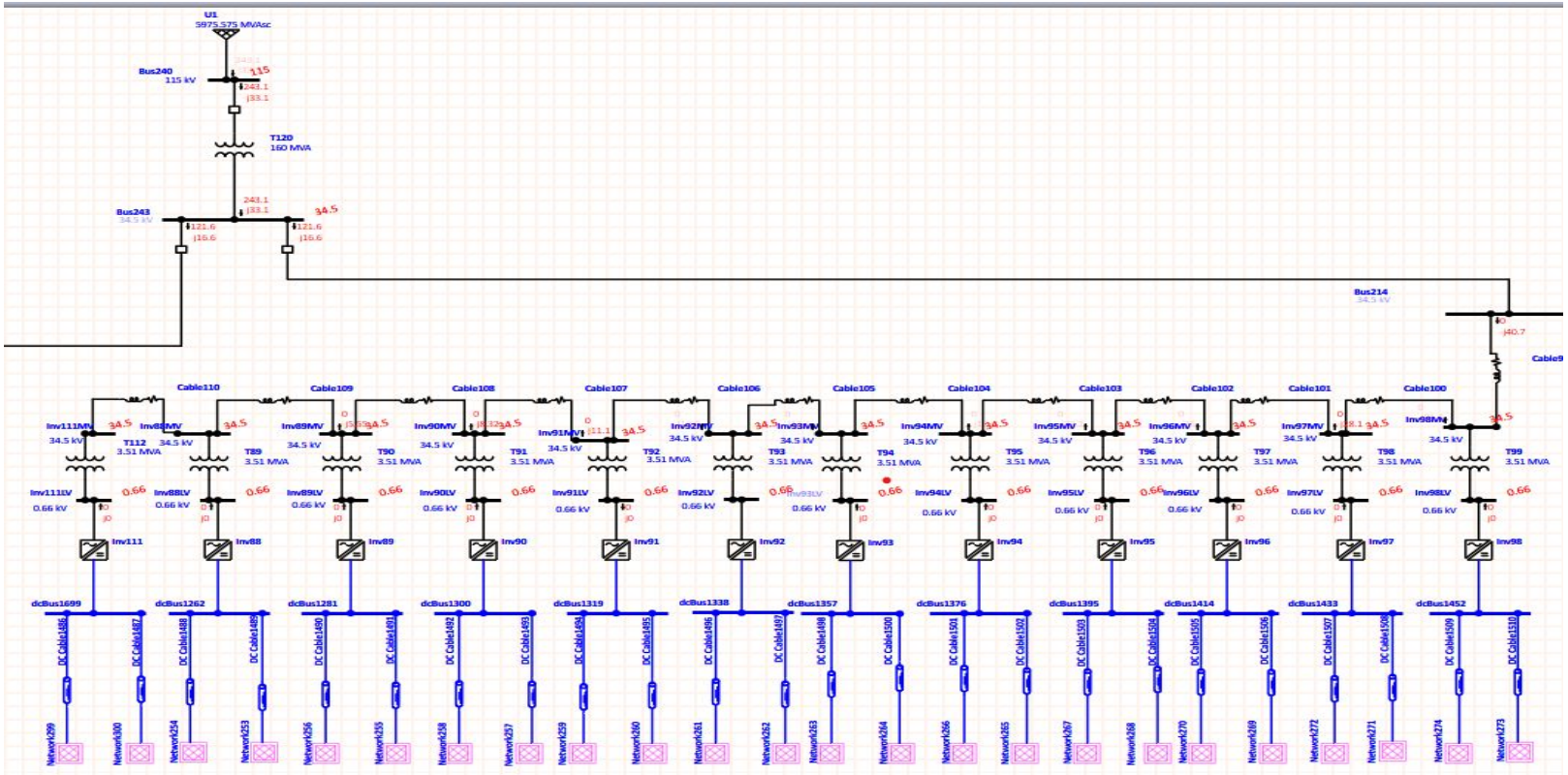
Numbering/ Wiring

BB1.1-CB1	CB1	Combiner box 1 DC	BB1.1	Battery Bank 1.1	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.1-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.1	Battery Bank 1.1	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.2-CB1	CB1	Combiner box 1 DC	BB1.2	Battery Bank 1.2	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.2-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.2	Battery Bank 1.2	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.3-CB1	CB1	Combiner box 1 DC	BB1.3	Battery Bank 1.3	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.3-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.3	Battery Bank 1.3	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.4-CB1	CB1	Combiner box 1 DC	BB1.4	Battery Bank 1.4	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.4-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.4	Battery Bank 1.4	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.5-CB1	CB1	Combiner box 1 DC	BB1.5	Battery Bank 1.5	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.5-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.5	Battery Bank 1.5	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.6-CB1	CB1	Combiner box 1 DC	BB1.6	Battery Bank 1.6	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.6-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.6	Battery Bank 1.6	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.7-CB1	CB1	Combiner box 1 DC	BB1.7	Battery Bank 1.7	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.7-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.7	Battery Bank 1.7	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.8-CB1	CB1	Combiner box 1 DC	BB1.8	Battery Bank 1.8	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.8-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.8	Battery Bank 1.8	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.9-CB1	CB1	Combiner box 1 DC	BB1.9	Battery Bank 1.9	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.9-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.9	Battery Bank 1.9	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.10-CB1	CB1	Combiner box 1 DC	BB1.10	Battery Bank 1.10	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.10-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.10	Battery Bank 1.10	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.11-CB1	CB1	Combiner box 1 DC	BB1.11	Battery Bank 1.11	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.11-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.11	Battery Bank 1.11	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.12-CB1	CB1	Combiner box 1 DC	BB1.12	Battery Bank 1.12	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.12-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.12	Battery Bank 1.12	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.13-CB1	CB1	Combiner box 1 DC	BB1.13	Battery Bank 1.13	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.13-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.13	Battery Bank 1.13	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.14-CB1	CB1	Combiner box 1 DC	BB1.14	Battery Bank 1.14	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.14-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.14	Battery Bank 1.14	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.15-CB1	CB1	Combiner box 1 DC	BB1.15	Battery Bank 1.15	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.15-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.15	Battery Bank 1.15	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.16-CB1	CB1	Combiner box 1 DC	BB1.16	Battery Bank 1.16	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.16-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.16	Battery Bank 1.16	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.17-CB1	CB1	Combiner box 1 DC	BB1.17	Battery Bank 1.17	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.17-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.17	Battery Bank 1.17	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
BB1.18-CB1	CB1	Combiner box 1 DC	BB1.18	Battery Bank 1.18	HEN 5,000-Volt		2-1/C #2/0AWG
BB1.18-AP1	AP1	Auxiliary Power Cabinet 1 AC	BB1.18	Battery Bank 1.18	SEN 600-Volt		1-3/C#8AWG W/ GND & 1-4PRCAT6-SHIELDED
CB1-PCS1	CB1	Combiner box 1 DC	PCS1	Inverter 1	HEN 5,000-Volt		16-1/C 750 kcmil
AP1-PCS1CAT	AP1	Auxiliary Power Cabinet 1 AC	PCS1	Inverter 1	COMMUNICATION		1-4PRCAT6-SHIELDED

ETAP One-Line Diagram



Load Flow


U1
5975.575 MVAsc
Bus240
115 kV
T120
160 MVA
Bus243
34.5 kV
Bus214
34.5 kV
Cable110
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Cable108
Cable107
Cable106
Cable105
Cable104
Cable103
Cable102
Cable101
Cable100
Cable9
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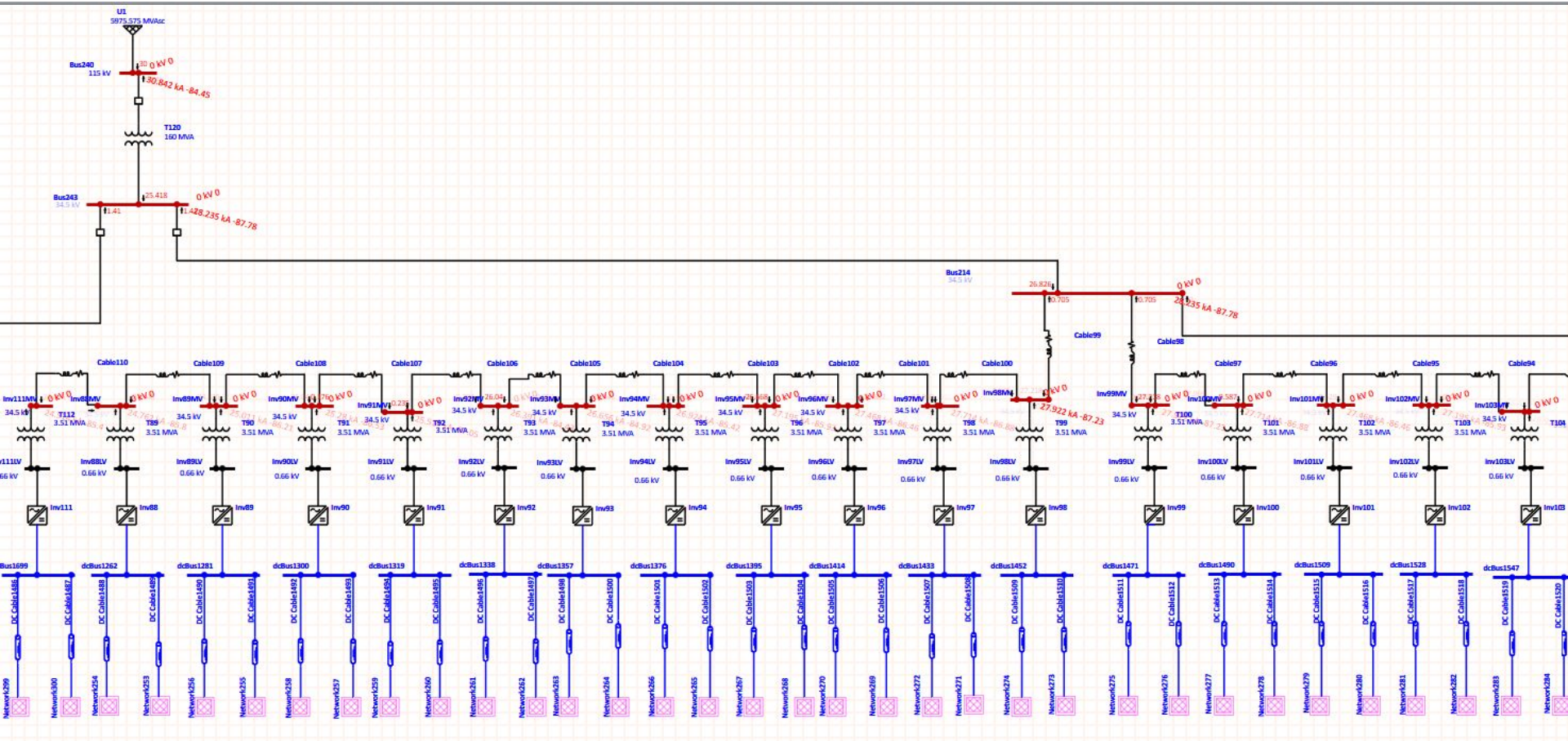
Short Circuit(AC)



Conclusion: Project Status

The Iowa State Lithium-Ion Energy Storage System, otherwise known as Cyclone BESS, has completed all of its expected deliverables across its two semester working session and has received approval from our client contact at Burns & McDonnell. While the system is far from operational, the initial groundwork has been laid and has provided a team of undergraduate students with invaluable experience designing realworld systems following industry standards and practices.

Q&A