

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
- Protection & Grounding
- Calculations
- Relays
- Ring Justification
- Site Plan Update
- Symbols Update
- One-Line Update
- Feedback



Safety Moment - Fire Prevention



<https://eastrandfire.co.za/transformer-fire-protection-step-up-your-fire-suppression/>

- Reasons
 - Many transformer contain insulating mineral oils that highly flammable.
 - Arc flashes or other fault condition might cause fire.
- Prevention
 - Designed to comply with safety guidelines
 - Install and keep maintaining fire suppression systems
 - Establish emergency plan in case of fire

STATE

Grounding

- **Grounding Grid Grounded**
 - Reduce step voltage/touch voltage
 - Increase stability
 - Increase Cost(huge amount excavation and Laying work)
 - Maintenance and repairs may be required over time
- **Resistance Grounded**
 - Limited Grounding fault current
 - Allows system continue to operate in ground fault event
 - Difficulty in detecting faults
- **Impedance Grounded**
 - Limited Grounding fault current
 - Allows system continue to operate in ground fault event
 - Complexity in detecting faults(Lower fault current levels may make it difficult for protective devices to detect faults.)
 - In some cases may not be completely eliminate the risk of overvoltage



Calculations

- Equipment sizing calculation (breakers, transformers, etc)
- DC load
- DC Battery bank sizing (IEEE 485) & EnerSys BSP

https://ewh.ieee.org/r3/atlanta/ias/2014-2015_Presentations/2015-04-20_EEE%20IAS%20Stationary%20Battery%20Sizing.pdf

- AC load
- Bus calculation (IEEE 605)

https://ewh.ieee.org/cmte/substations/scd0/wgd3/605%20Draft%20Versions/605-2010_clean.pdf

- Grounding calculation (IEEE-80)

<https://community.ptc.com/sejnu66972/attachments/sejnu66972/PTCMathcad/175612/1/Earthing%20Exercise%20B1%20IEEE%20Std%2080%20PDF.pdf>

- Lightning protection (IEEE 998-2012)

https://documents.pserc.wisc.edu/documents/general_information/presentations/pserc_seminars/pserc_seminars0/sen_2001.pdf

- Cost Estimation & Economic Analysis

Excel calculation sheet :

https://docs.google.com/spreadsheets/d/1FV_eP3owzE400fz0dbgijHGbeqEIA08JDowW-ktVsm

sharing



Calculations

Bus

IEEE Std 605-2008
IEEE Guide for Bus Design in Air Insulated Substations

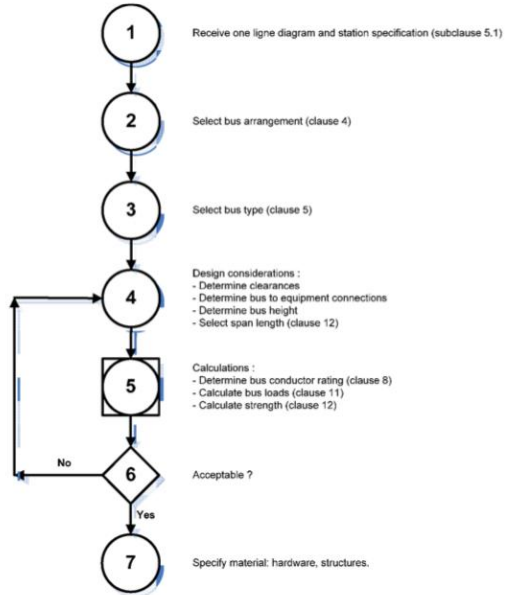


Figure 7—Bus design procedure flow chart

Grounding

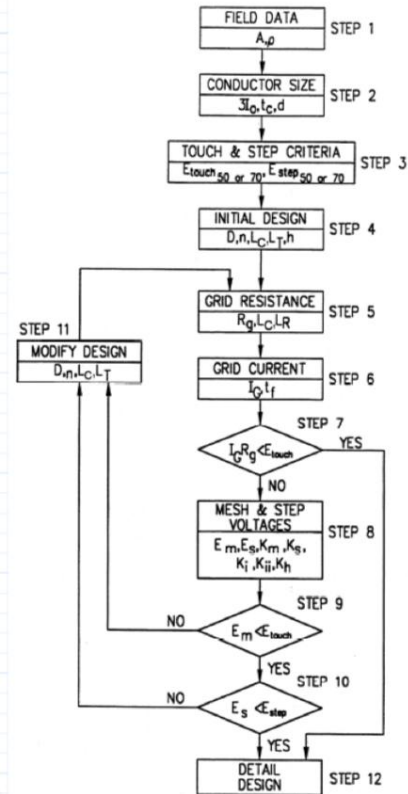


Figure 32—Design procedure block diagram

Relays

Standard Protection Relays:

- SEL X11
- SEL X51
- SEL X87

Other notes:

Most of the above relays take 5 amp inputs from CTs. 300 series much are much cheaper but are not as advanced. For example, 311L is \$7,000 vs 411L which is \$11,000, but 411L has more accurate fault distance detection. 400 series also offer a wider variety of protection relays to choose from. Other series (500 and 700) require more research.

Relay Explanations:

- SEL 311/411 - Differential current protection
- SEL 351/451 - Overcurrent protection
- SEL 387/487 - Transformer/breaker protection (overcurrent, differential current, etc.)



Ring Justification

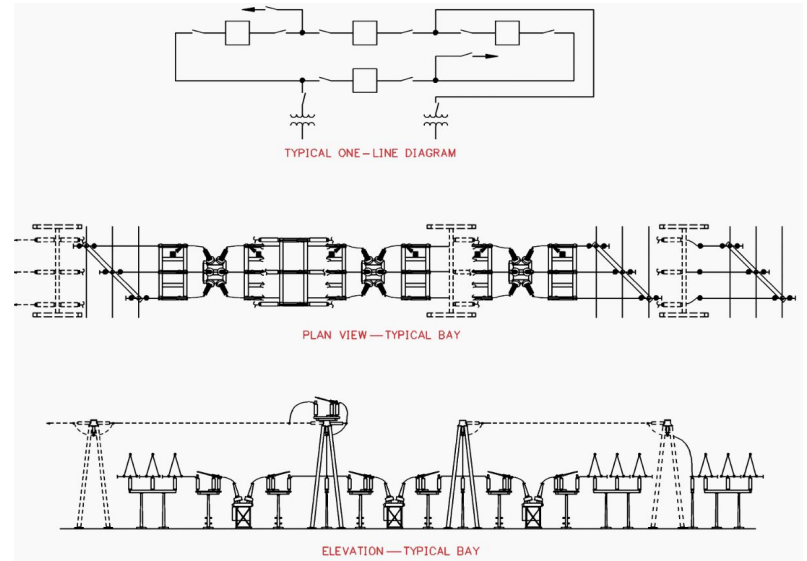
It connects two ends of the busses with a breaker to then a transformer

Advantages

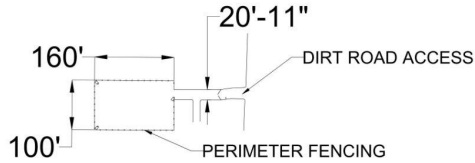
- Isolation of buses and breakers for maintenance
- No main buses
- Max reliability
- High flexibility on operation
- No interruption while in operation

Disadvantages

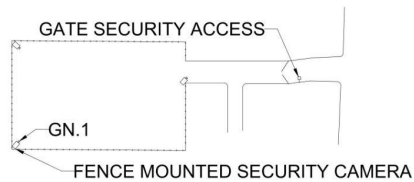
- Limited to 4 circuit positions but the design will not need more than 4
- Could be complex on reclosing automatically
- Higher cost



Site Plan Updates



① SUBSTATION SITE DETAIL



② TECH & SECURITY DETAIL



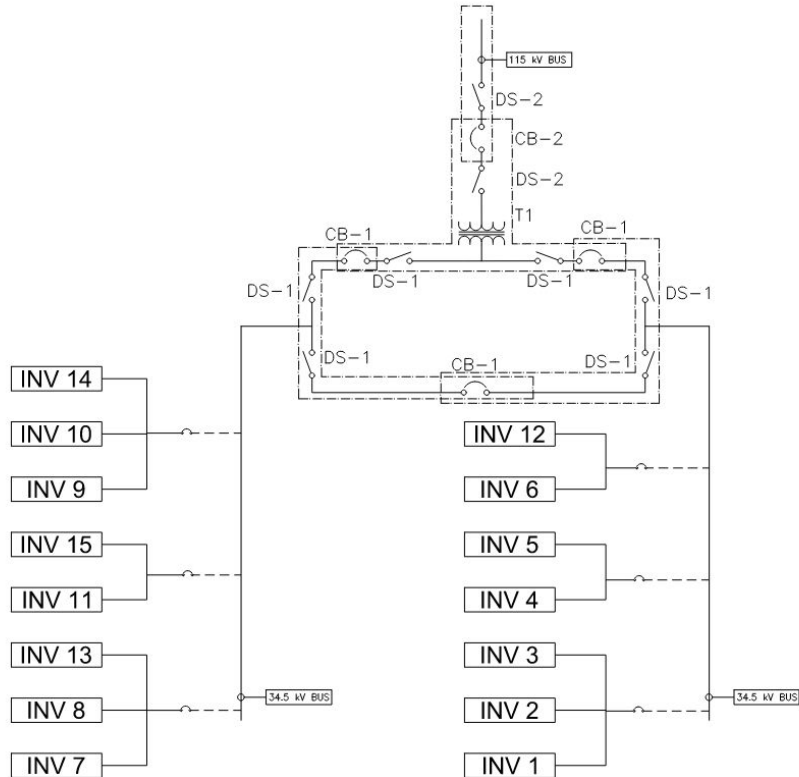
③ CAMERA LOCATIONS

General Notes		
1. SECURITY CAMERAS TO BE INSTALLED TO DETERMINE FENCE POINT TO POINT OF CAMERA TO BE COORDINATED WITH OWNER. LOCATION OF CAMERA SHALL BE WITHIN SUBSTATION LIMIT.		
SIGNATURE & SEAL		
REVISIONS		
NO.	DESCRIPTION	DATE
IOWA STATE UNIVERSITY COLLEGE OF ENGINEERING SCHEMATIC BY BAYLOR CLARK, EIT SCHEPHER, LEAH GOSWAMI, GEORGINA KING, ERIC SCHAEFER, GEOFFREY WRENCH, CORINNE WELLS 4100 MARSHALL HALL 500 MORRIS, HOOD AMES, IA 50011 BLACK & VEATCH		
LOVINGTON, NM 8000 (LEA COUNTY)		
DATE	PROJECT	DATE

- Updated line-type on site plan fencing
- Added dimensions to account for the altered feeder wiring
- Created substation detail plan and added some security
- Changed fencing linetypes



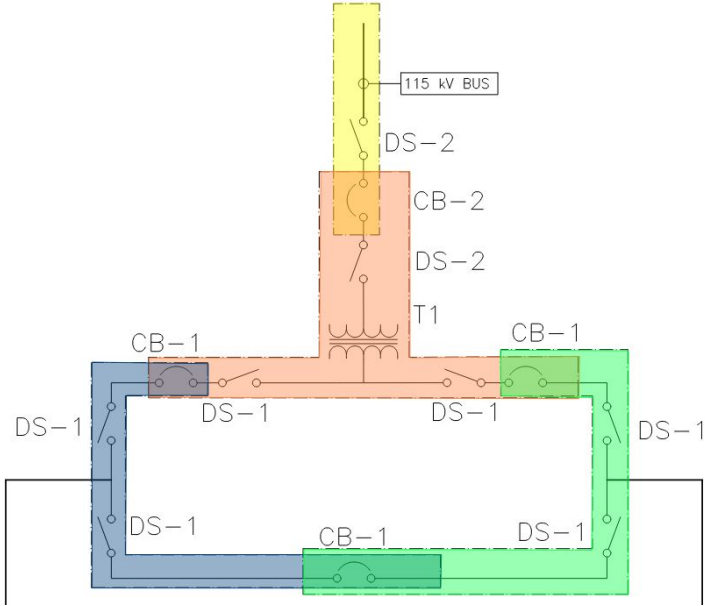
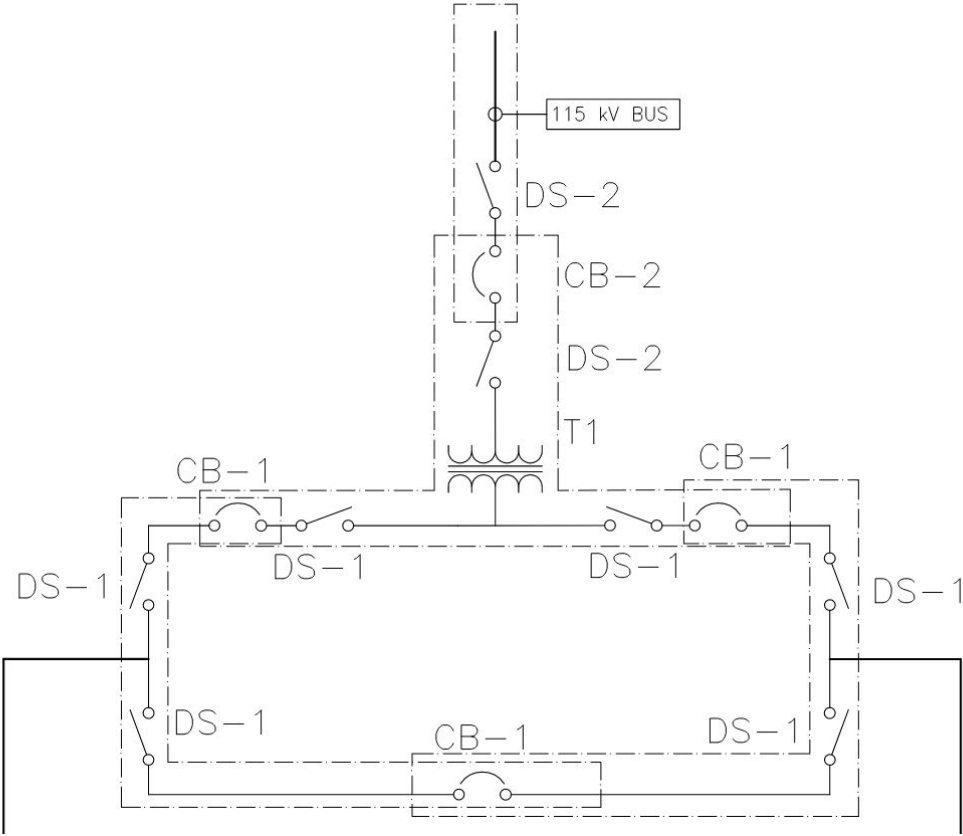
One Line Update



- Changed line type back to solid lines
- Dashed out what feeders see what equipment
- More specifics on equipment to come



One Line Update



Questions

- Solar Design/Substation Optimization Tool?
- Do we need CT/VT?

Feedback and Updates

- Tasks: Updates
 - Bell: Calc spreadsheets
 - Liam: DSs and CBs/low side stuff
 - Eli: DS and CBs, Autocad stuff
 - Baylor: Help ETAP/Review last semester power flow
 - Eduardo: Ring Bus top view
 - Chicheng: ETAP

