IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

BLACK & VEATCH

115/34.5kV Solar Plant & Substation
Senior Design Project

Andrew M Chizek, David W Ntako, Ben Palkovic Mohamed A Sam, Sergio Sanchez Gomez & Dallas R Wittenburg

| Senior Design Team 41

| 02/03/2025

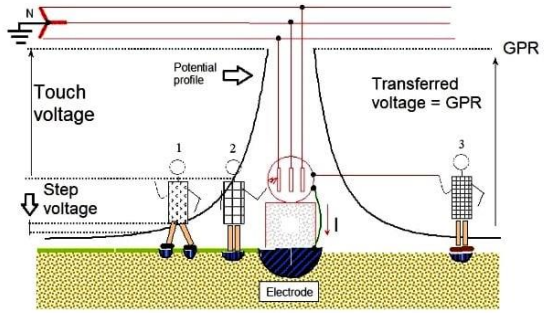
IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

AGENDA

- Safety Moment
- New Technology
- Gantt Chart
- Access to ETAP
- Transformers
- Disconnect switches
- Circuit Breakers
- CCVTs
- Discuss Action Items for Next Meeting

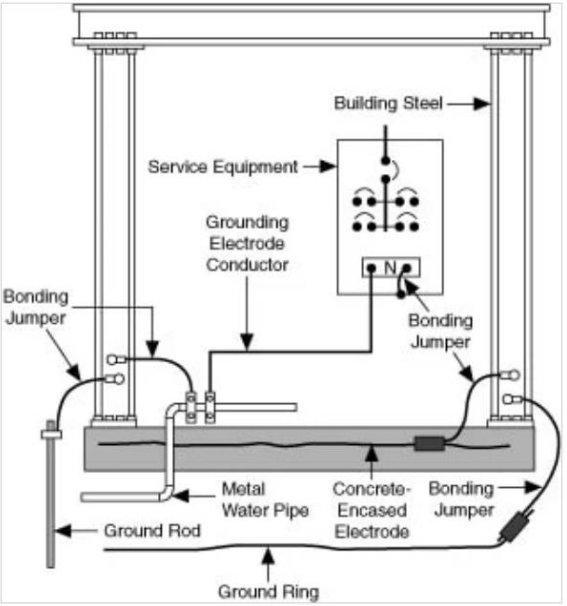
IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

SAFETY MOMENT



Proper Fence and Equipment Grounding

- Substations have an electrode grounding system
- Energized equipment over 150 volts with no insulating cover need to be grounded unless they have significant clearance
- Fences within 16 feet of exposed equipment need to be grounded and bonded at corners or 160 feet intervals; also if conductors cross the fence, the crossing need to be bonded
- Step, Touch, and Transfer voltages pose the biggest threat for workers



| Andrew Chizek

| 02/03/2025

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

NEW TECHNOLOGY

- AI-Powered Substation Automation
  - AI is being implemented in substations to improve fault detection and grid optimization
  - AI can be integrated into SCADA systems to improve efficiency and reliability.

https://electricity-today.com/electrical-substation/ai-powered-substation-automation-revolutionizing-grid-operations

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

ACCESS TO ETAP

- ETAP has been installed in Senior Design Lab
- Will have access to the Lab room this week

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

GANTT CHART SPRING 2025

- Updated Gantt Chart to reflect this semesters work in designing the Substation

	A	B	C	D	E	F	G
1	**Project:**	115/34.5 kV Solar Power Plant & Substation	**Company Name**	Black & Veatch			
2	**Project manager**	Adam Schroeder, Eli Schaffer, Utsavee Desai					
3							
4							
5		**TASK TITLE**	**TASK OWNER**	**START DATE**	**DUE DATE**	**DURATION**	**TASK COMPLETE**
6							
7		SUBSTATION					
8	**1**	**Documentation**					
9		Weekly Agenda	All	1/27/2025	5/16/2025	109	☐
10		Meeting Minutes	All	1/27/2025	5/16/2025	109	☐
11		Weekly Report	All	1/27/2025	5/16/2025	109	☐
12		Presentation Slides	All	1/27/2025	5/16/2025	109	☐
13		Project Design Document	All	1/27/2025	5/16/2025	109	☐
14		Final Report	All	1/27/2025	5/16/2025	109	☐
15		Final Presentation	All	1/27/2025	5/16/2025	109	☐
16	**2**	**Research**					
17		Substation Components - Transformers	David & Ben	1/27/2025	2/3/2025	7	☐
18		Substation Components - Disconnect Switches	David	1/27/2025	2/3/2025	7	☐
19		Substation Components - Circuit Breakers	Mohamed & Ben	1/27/2025	2/3/2025	7	☐
20		Substation Components - CCVTs	Sergio & Andrew	1/27/2025	2/3/2025	7	☐
21		Bus Configuration	All	2/3/2025	2/24/2025	21	☐
22		One-Line Plan	All	2/3/2025	2/24/2025	21	☐
23		Design Standards	All	2/3/2025	2/24/2025	21	☐
24	**3**	**Component Selection**					
25		Circuit Breakers	All	2/3/2025	2/24/2025	21	☐
26		Transformer	All	2/3/2025	2/24/2025	21	☐
27		Switches	All	2/3/2025	2/24/2025	21	☐

	H	I	J	K	L	M	N	O	P	Q	R
4	Week 1							Wee			
5	1/27/2025							2/3/2			
6	M	T	W	R	F	S	Su	M	T	W	R

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

TRANSFORMERS

Overview of transformers:

- Essential for voltage step-up and step-down in power systems.
- Improve efficiency, reliability, and safety in transmission and distribution.

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

TRANSFORMERS

Types of Substation transformer:

- **Power Transformers** – High efficiency load at 100%, used to step up or step down the voltage.
- **Distribution Transformers** – High efficiency load at 50-70%, used for local power distribution.
- **Instrument Transformers** – CTs for current measurement, PTs for voltage measurement.

https://eepower.com/technical-articles/substation-transformers-explained

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

DISCONNECT SWITCHES

Overview of disconnect switches:

- Used for isolating electrical equipment in substations.
- Provides a visible break for maintenance and safety.
- Cannot interrupt load current (requires circuit breakers for that)

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

DISCONNECT SWITCHES

Types of disconnect switches:

- **Air-Break Disconnect Switch** – Most common, uses air as insulation.
- **Gas-Insulated (SF_6) Disconnect Switch** – Compact, high-voltage applications.
- **Vacuum Disconnect Switch** – Used in medium-voltage systems.
- **Center-Break Disconnect** – Two arms open outward for isolation.
- **Vertical-Break Disconnect** – Moves in a vertical plane, space-efficient.
- **Pantograph Disconnect** – Reduces phase-to-phase clearance in high-voltage substations.

https://savree.com/en/encyclopedia/high-voltage-disconnectors

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

CIRCUIT BREAKERS

Types of Circuit Breakers for 115/34.5kV Substations:

based on voltage levels, arc extinction methods, and insulation types. For our project, the most suitable options are:

- Gas-Insulated (SF_6) Circuit Breakers – Best for 115 kV
- Vacuum Circuit Breakers (VCB) – Best for 34.5 kV
- Oil Circuit Breakers (OCB) – Older technology, less preferred
- Air Circuit Breakers (ACB) – Limited to lower voltages

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

CIRCUIT BREAKERS

115 kV Side: SF_6 Dead Tank Circuit Breaker (GE LW24-126)

- Uses SF_6 gas for arc extinction (high insulation & reliability).
- Compact, low maintenance, and handles high fault currents.
- Disadvantage: SF_6 gas has environmental impact (greenhouse gas).

https://www.gevernova.com/grid-solutions/products/brochures/primaryequip/dtcb_725_800kv_xdge_en_print.pdf

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

CIRCUIT BREAKERS

34.5 kV Side: Vacuum Circuit Breaker (VCB) (Mitsubishi EDD 38kV)

- Uses vacuum for arc extinction (no SF_6 gas, environmentally friendly).
- Very low maintenance, long life (20,000+ operations) and Lower cost

https://0aab1c21-cdn.agilitycms.cloud/Attachments/EDD%2038kV%20VCB%20Overview.pdf

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

CCVTs - Coupling Capacitor Voltage Transformers

Comparison between:

- GE: www.gevernova.com/grid-solutions/products/brochures/primaryequip/cvt_iec_xdge_en_web.pdf
- Ritz: https://ritzusa.com/wp-content/uploads/2020/11/CVO.pdf
- Arteche: https://mindcoretech.com/cvt.pdf

Criteria:

- Electrical Ratings: such as Voltage, Insulation levels..
- Frequency response & Transient Behavior
- Construction & Materials
- Specifications
- Standards
- …

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

CCVTs - Coupling Capacitor Voltage Transformers

Arteche DDB-170

- Lacks digital connectivity
- Best for extreme temperatures.
- Reliability in harsh conditions.
- Maintenance-free operation with stable capacitance over time.
- Ideal for time-sensitive projects.
- Compliance IEEE, ANSI, IEC.
- Environmentally friendly design.
- Low cost.

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

CCVTs - Coupling Capacitor Voltage Transformers

Arteche DDB-170 (Characteristics)

- Electrical Ratings: Nominal Voltage (170 kV), Standard output voltage (115 V), Burden capacity (100 VA).
- Construction & Materials: Oil-paper insulation capacitors, inductive voltage transformer with ferroresonance suppression circuit, oil-filled with hermetically sealed design insulation type, standard grounding with shielding for electrical safety, certified for high seismic withstand.
- 50/60 Hz Operating frequency | stable transient response | low partial discharge level.
- Good operating temperature range (-55°C to +55°C).
- Compliance IEEE C57.13. | IEC 61869-5 | ANSI/NEMA Standard
- Extremely steady capacitance => accuracy

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

THANK YOU

| Senior Design Team 41

| 02/03/2025