# Testing Lightning Talk: 115/34.5 kVA Solar Power Plant & Substation Design

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# Project Information

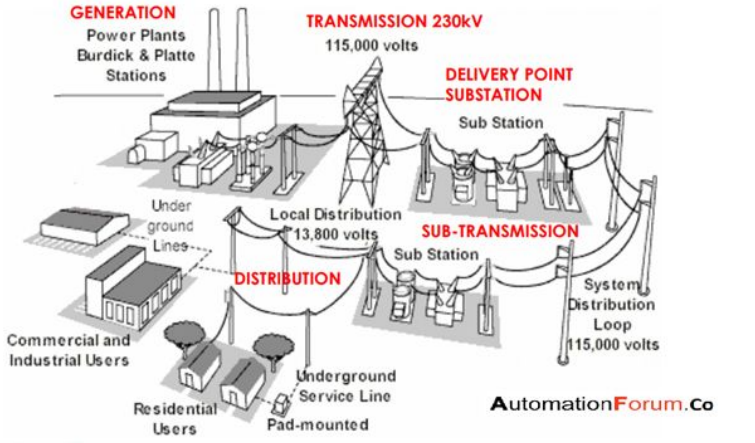
Due to increasing Renewable Energy requirements for utilities, a 34.5/115 kV distribution substation and 60 MW Solar Plant will need to be designed by Iowa State University. We as the project team are responsible for the complete design of solar layout, electrical layout, and associated construction deliverables. Our project team will also perform various calculations required of a typical substation, including load-flow analysis, short-circuit studies, system protection design, and grounding calculations.

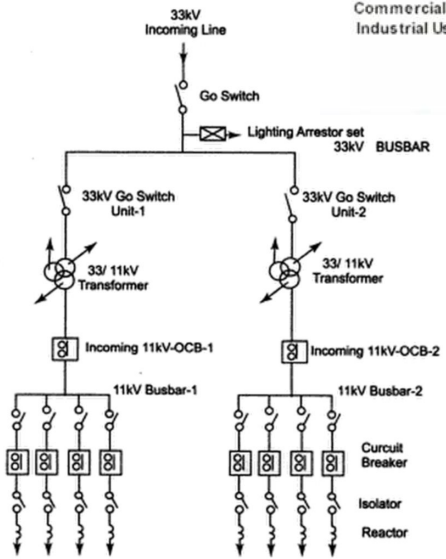
Substation Link Solar Field Link

Eli

# Substation Overview

Transmission lines come into substation at 115 kV. These lines then step down into transformers which take the voltage from 115 kV to 34.5 kV. The line then goes through a switchgear to help service in case of a disaster. After the switchgear, the lines go to bus bars which help distribute the voltage to different lines to be distributed.




Feeders -> SG -> XFMR -> SG -> Circuit Breaker -> Busbar -> Outgoing Feeders

The circuit diagram to the left shows an overview of a typical substation circuit. This shows a 33/11 kV system and transformer, but similar principles apply to our project.

Substation One-Line  Substation Picture

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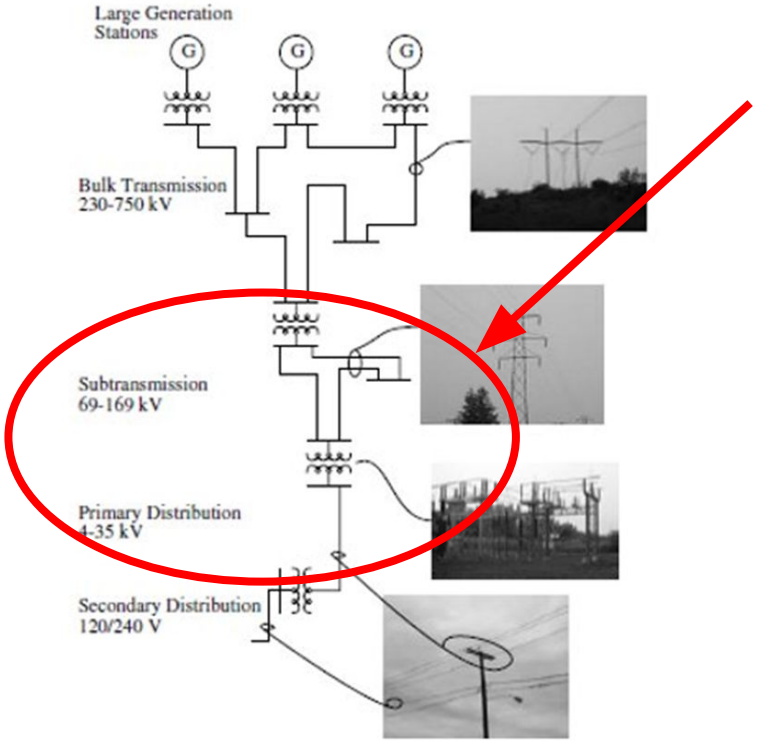
# Electricity Infrastructure – Solar Farms (PV systems)




- Solar Farms (Photovoltaic systems) are usually interconnected to the grid at either the **sub-transmission voltage** or **primary distribution level**.
- Solar systems provide a DC output that must be inverted and stepped-up before making a network (grid) interconnection.

# Safety Moment - Situational Awareness

SLAM Method

- S: Stop
  - Stop and consider the work and what it will involve.
- L: Look
  - Look for overhead or other objects that could be hazardous.
- A: Assess
  - Think about what PPE or other precautions need to be taken to mitigate hazards.
- M: Manage
  - Take steps needed to reduce or eliminate hazards.

SLAM Link  Picture Link

Eli

# TESTING TALK

# Unit Testing

What units are being tested?

- Voltage, Current, Power, Safety Systems(Circuit Breakers)

How?

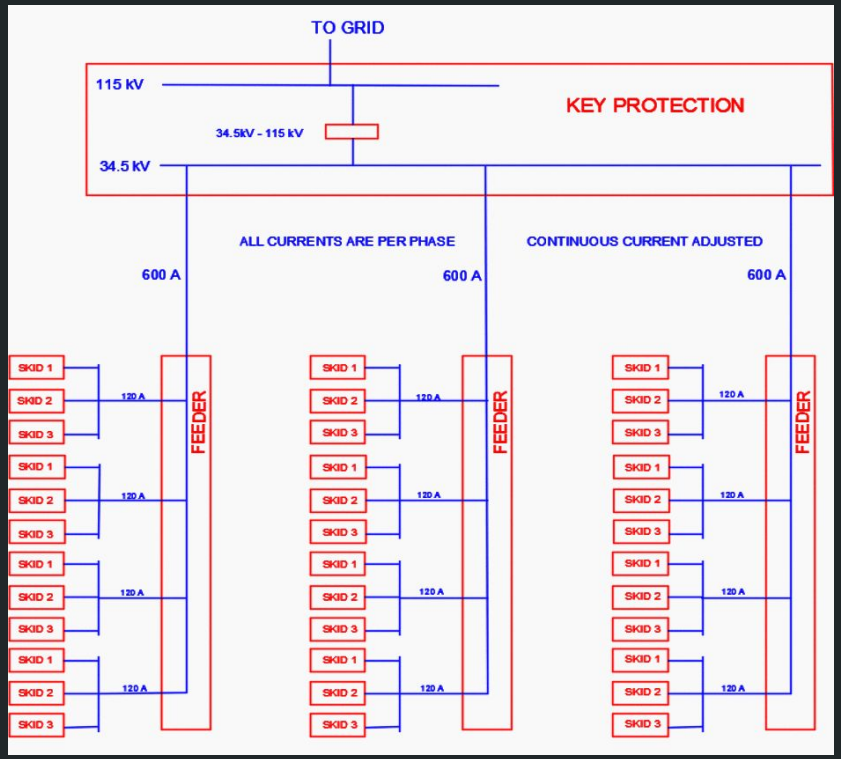
- Etap will be used to test the solar farm

Plan for testing?

- All of the testing will be done in a software called Etap that will show the output of each component to determine if the group needs to change parts of the design.

# Interface Testing

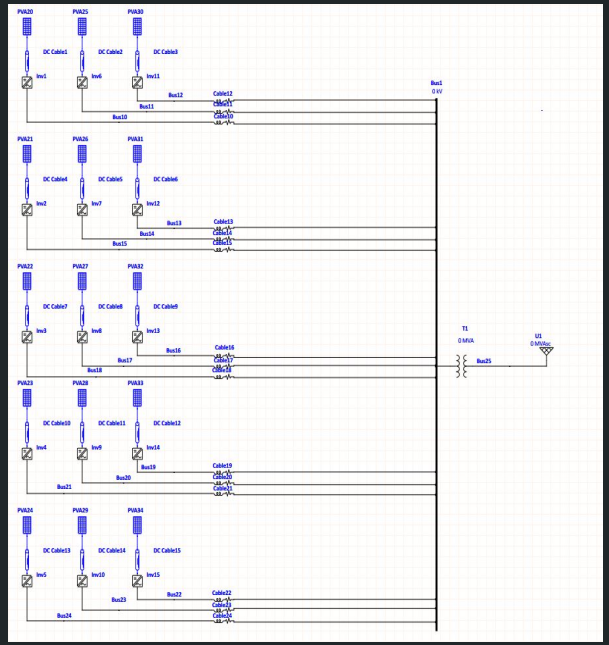
- “Interfaces” for Phase One Design
- Voltage and Power output from the solar arrays to inverters
  - Voltage drop calculations from racks to the skid inverters
- Output from Inverter to Substation
  - Using AC output from inverters voltage drop calculations from inverters to substation



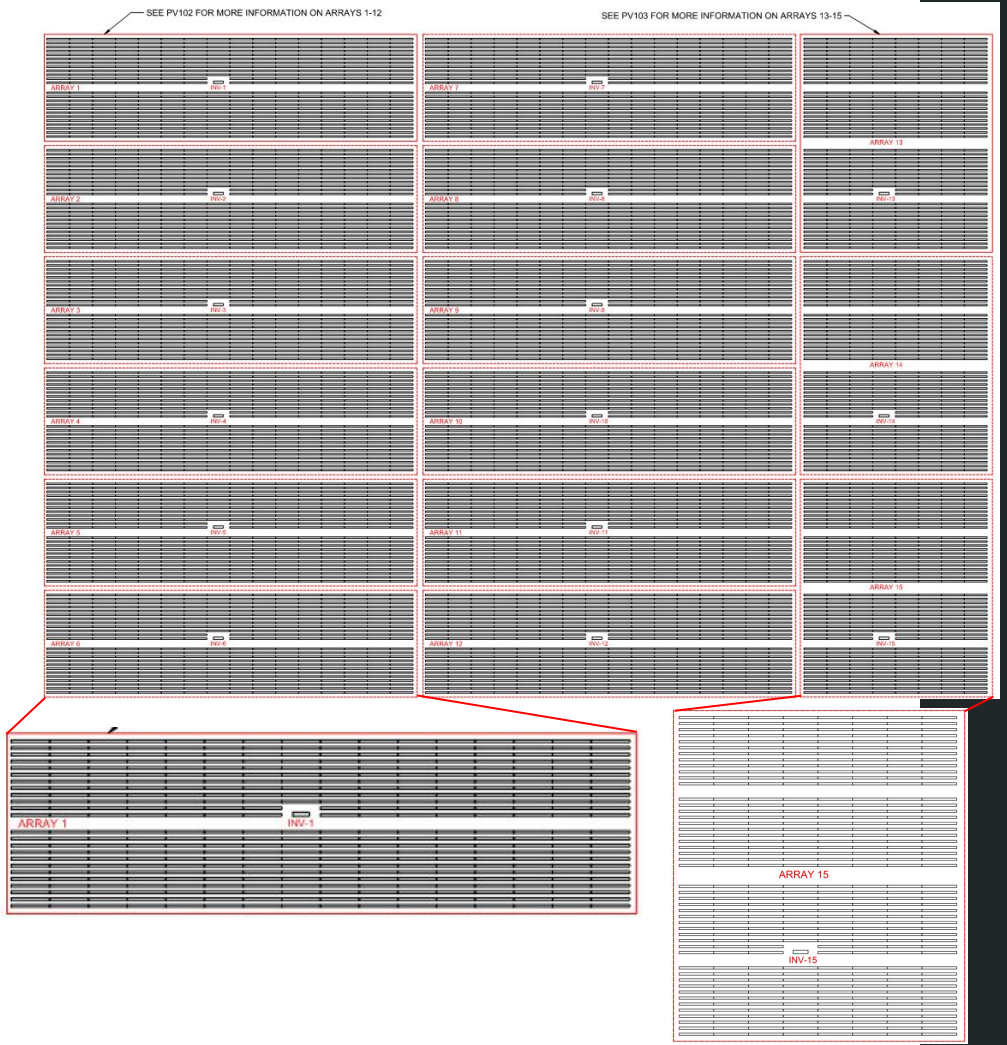

Link

# Integration Testing

- **Solar Panel to Inverter**
  - Efficiency analysis under various conditions
  - Durability tests
- **Monitoring and Control Systems**
  - Data accuracy
  - Communication reliability
- **Grid Interconnection**
  - Power quality
  - Anti-islanding protection
- **Safety and Protection Systems**
  - Grounding systems
  - Circuit breakers



etap
Powering Success
SERVICE PROVIDER

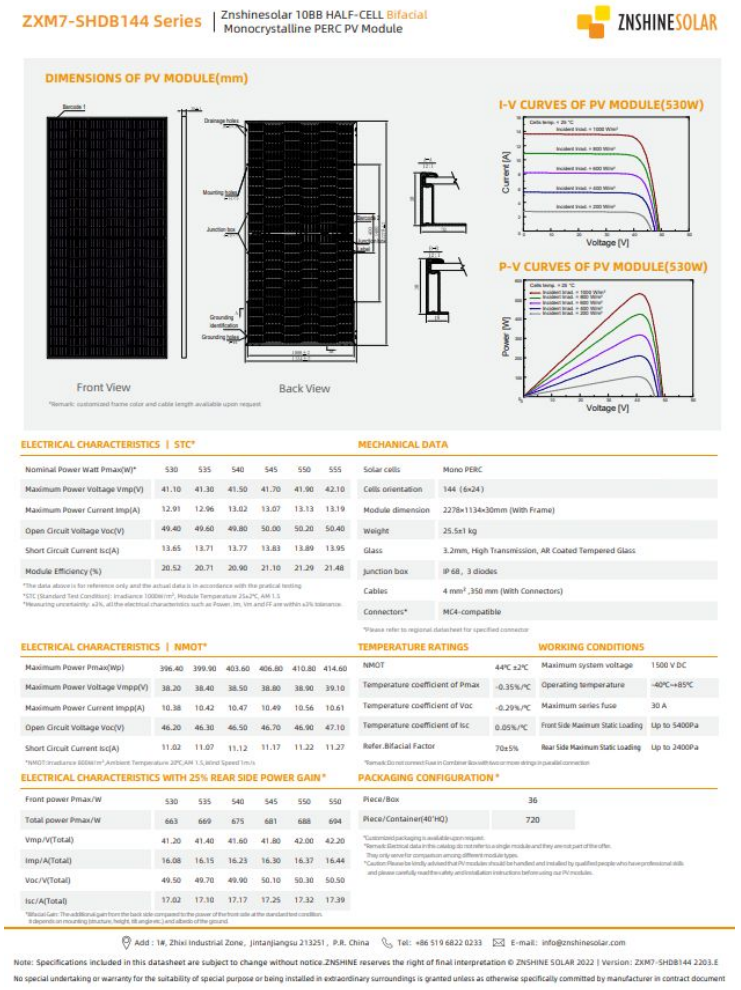



# System Testing

- Voltage Drops
  - Rows
  - Arrays
  - Substation
- Integration
  - Inverter Efficiencies
  - Panel Efficiencies

# Regression Testing

New design components are tested to ensure their compatibility with other connecting components as well as meeting the requirements of the overall project. Values such as rated voltage, current, apparent power, and number of connections are used to calculate compatibility.



ZXM7-SHDB144 Series | Znshinesolar 10BB HALF-CELL Bifacial Monocrystalline PERC PV Module

ZNSHINESOLAR

DIMENSIONS OF PV MODULE(mm)

Front View

Back View

I-V CURVES OF PV MODULE(530W)

P-V CURVES OF PV MODULE(530W)

ELECTRICAL CHARACTERISTICS | STC*

| | | | | | | |
|---|---|---|---|---|---|---|
| Nominal Power Watt Pmax(W)* | 530 | 535 | 540 | 545 | 550 | 555 |
| Maximum Power Voltage Vmp(V) | 41.10 | 41.30 | 41.50 | 41.70 | 41.90 | 42.10 |
| Maximum Power Current Imp(A) | 12.91 | 12.96 | 13.02 | 13.07 | 13.13 | 13.19 |
| Open Circuit Voltage Voc(V) | 49.40 | 49.60 | 49.80 | 50.00 | 50.20 | 50.40 |
| Short Circuit Current Isc(A) | 13.65 | 13.71 | 13.77 | 13.83 | 13.89 | 13.95 |
| Module Efficiency (%) | 20.52 | 20.71 | 20.90 | 21.10 | 21.29 | 21.48 |

*The data above is for reference only and the actual data is in accordance with the practical testing
*STC (Standard Test Condition): Irradiance 1000W/m², Module Temperature 25±2℃, AM 1.5
*Measuring uncertainty: ±3%, all the electrical characteristics such as Power, Im, Vm and FF are within ±3% tolerance.

MECHANICAL DATA

| | |
|---|---|
| Solar cells | Mono PERC |
| Cells orientation | 144 (6×24) |
| Module dimension | 2278×1134×30mm (With Frame) |
| Weight | 25.5±1 kg |
| Glass | 3.2mm, High Transmission, AR Coated Tempered Glass |
| Junction box | IP 68, 3 diodes |
| Cables | 4 mm², 350 mm (With Connectors) |
| Connectors* | MC4-compatible |

*Please refer to regional datasheet for specified connector

ELECTRICAL CHARACTERISTICS | NMOT*

| | | | | | | |
|---|---|---|---|---|---|---|
| Maximum Power Pmax(Wp) | 396.40 | 399.90 | 403.60 | 406.80 | 410.80 | 414.60 |
| Maximum Power Voltage Vmpp(V) | 38.20 | 38.40 | 38.50 | 38.80 | 38.90 | 39.10 |
| Maximum Power Current Impp(A) | 10.38 | 10.42 | 10.47 | 10.49 | 10.56 | 10.61 |
| Open Circuit Voltage Voc(V) | 46.20 | 46.30 | 46.50 | 46.70 | 46.90 | 47.10 |
| Short Circuit Current Isc(A) | 11.02 | 11.07 | 11.12 | 11.17 | 11.22 | 11.27 |

*NMOT: Irradiance 800W/m², Ambient Temperature 20℃, AM 1.5, Wind Speed 1m/s

TEMPERATURE RATINGS

| | |
|---|---|
| NMOT | 44℃ ±2℃ |
| Temperature coefficient of Pmax | -0.35%/℃ |
| Temperature coefficient of Voc | -0.29%/℃ |
| Temperature coefficient of Isc | 0.05%/℃ |
| Refer.Bifacial Factor | 70±5% |

WORKING CONDITIONS

| | |
|---|---|
| Maximum system voltage | 1500 V DC |
| Operating temperature | -40℃~+85℃ |
| Maximum series fuse | 30 A |
| Front Side Maximum Static Loading | Up to 5400Pa |
| Rear Side Maximum Static Loading | Up to 2400Pa |

*Remark:Do not connect fuse in Combiner Box with two or more strings in parallel connection

ELECTRICAL CHARACTERISTICS WITH 25% REAR SIDE POWER GAIN*

| | | | | | | |
|---|---|---|---|---|---|---|
| Front power Pmax/W | 530 | 535 | 540 | 545 | 550 | 550 |
| Total power Pmax/W | 663 | 669 | 675 | 681 | 688 | 694 |
| Vmp/V(Total) | 41.20 | 41.40 | 41.60 | 41.80 | 42.00 | 42.20 |
| Imp/A(Total) | 16.08 | 16.15 | 16.23 | 16.30 | 16.37 | 16.44 |
| Voc/V(Total) | 49.50 | 49.70 | 49.90 | 50.10 | 50.30 | 50.50 |
| Isc/A(Total) | 17.02 | 17.10 | 17.17 | 17.25 | 17.32 | 17.39 |

*Bifacial Gain: The additional gain from the back side compared to the power of the front side at the standard test conditions.
It depends on mounting (structure, height, tilt angle etc.) and albedo of the ground.

PACKAGING CONFIGURATION*

| | |
|---|---|
| Piece/Box | 36 |
| Piece/Container(40'HQ) | 720 |

*Customized packaging is available upon request.
*Remark: Electrical data in this catalog do not refer to a single module and they are not part of the offer.
They only serve for comparison among different module types.
*Caution: Please be kindly advised that PV modules should be handled and installed by qualified people who have professional skills and please carefully read the safety and installation instructions before using our PV modules.

Add : 1#, Zhixi Industrial Zone, Jintan Jiangsu 213251, P.R. China Tel: +86 519 6822 0233 E-mail: info@znshinesolar.com

Note: Specifications included in this datasheet are subject to change without notice.ZNSHINE reserves the right of final interpretation © ZNSHINE SOLAR 2022 | Version: ZXM7-SHDB144 2203.E

No special undertaking or warranty for the suitability of special purpose or being installed in extraordinary surroundings is granted unless as otherwise specifically committed by manufacturer in contract document