

NORTHERN PHOTOVOLTAIC ENERGY SYSTEM

Office of Undergraduate Research and Creative Activity

Northern Arizona University, Flagstaff, AZ

MOTIVATION

In recent years, the utility-scale solar installations have grown at a high average rate. In case of that, the photovoltaic market has a great need of the large central inverter. Our project is to develop the next generation large-scale PV system interfaces with integrated energy storage for improved energy efficiency, reduced manufacturing cost, enhanced system reliability, and grid code compliance with proper control.

- The sunlight is the most important condition that can affect output power of photovoltaic system. Due to the non-uniform radiation of sunlight, there are some of PV cells in the PV array are exposed to lower radiation than the rest of the PV array the partial shading occurs.
- The Modular Multilevel Converter (MMC) has good output performance, flexibility in control and its modular and scalable design allow it to directly connect to high voltage networks. The converter's isolated DC links also allow for the connection of many individual PV arrays.



SOLUTION

Maximum power point tracking (MPPT)

- Open circuit voltage Voc
- Short-circuit current Isc
- The fill factor FF
- Power P=FF*Voc*Isc.

When derivative dI/dV of the I-V curve is equal and opposite the I/V ratio (where dP/dV=0), the output power is maximum value.

Three phase MMC

Our Modular Multilevel Converter is made of 3 phases, control unit in the middle with a primary purpose of sending the signals, with a sensing unit to measure the current and voltage throughout the circuit, and at the bottom, we have the switching unit, input from the solar panel and the output to the grid.

- Insulated-Gate Bipolar Transistor (IGBT)
- Capacitors
- Inductor
- Interface Board
- Gate Drivers
- Relay board





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MATLAB/SIMULINK MODEL



RESULTS

Three phase line PWM voltages and phase currents in MMC with sub-modules.





MMC ADVANTAGES & DISADVANTAGES

Advantages:

- Low THD
- Low dv/dt on devices and good voltage sharing for semiconductors.
- Modular structure with identical modules which has redundancy and allows to substitute failed modules.
- Scalable and no DC link voltage limitation.
- Simple mechanical construction
- No need for bulk filters on AC side
- Lower losses

Disadvantages:

- Extra controller required for balancing of capacitor voltages
- Need for monitoring all capacitor voltages
- Circulating current consisting double fundamental frequency component and increases device losses if not suppressed

REFERENCES

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