NAU
NORTHERN ARIZONA UNIVERSITY

PHOTOVOLTAIC INVERTER

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Project Mentor: Han Peng

AMPERE
Advanced Motors, Power Electronics, and Renewable Energy Laboratory

SOLAR HERO

Client

Dr. Yaramasu

Assistant Professor at NAU

Office location: SICCS

Research Interests:

- Renewable energy
- High power converters
- Variable-speed drives

Introduction

PV System:

- Converts solar energy directly into electrical energy
- Reliable, Modular, durable

Power Conversion Systems:

Converter

- Connected to solar panels.
- Converts the input to AC

Controlling Unit

- Controls the activity of the converter
- Adjust the current on the output side

Problem Definition

Problem

- Currently there's no laboratory scale modular multilevel converter available in the market.
- Building such a converter will help our client to study and develop new topologies and test controlling schemes.

Goal

- Build a modular multilevel converter for laboratory use and test it using predictive current control.
- Can handle power level 5 kW.

Challenges and Constraints

Technical:

- Partial shading
- High voltage and High power
- Control system

Hardware:

- Soldering
- Complex wiring
- Installation

Budget:

$500

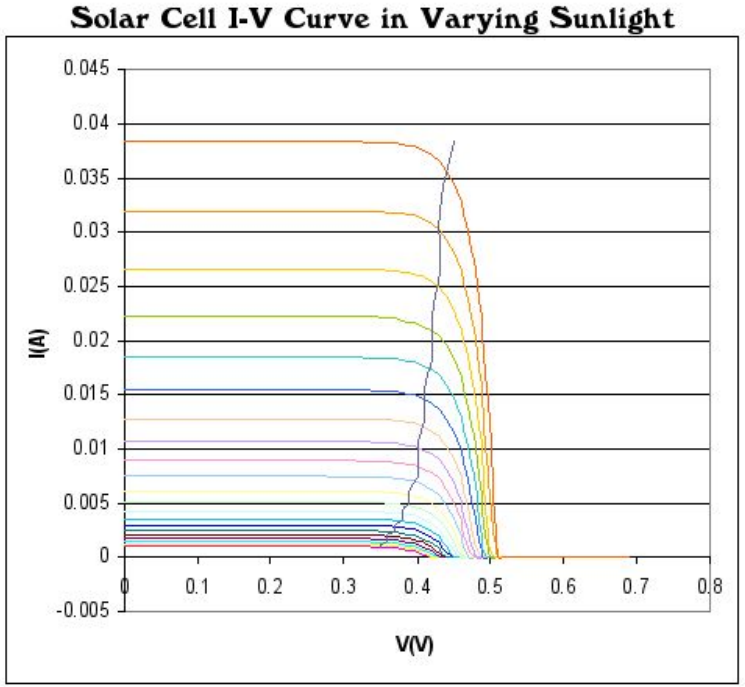
Maximum Power Point Tracking

Explanation:

- Open circuit voltage Voc
- Short-circuit current Isc
- The fill factor FF
- Power P=FF*Voc*Isc.
- dP/dV=0

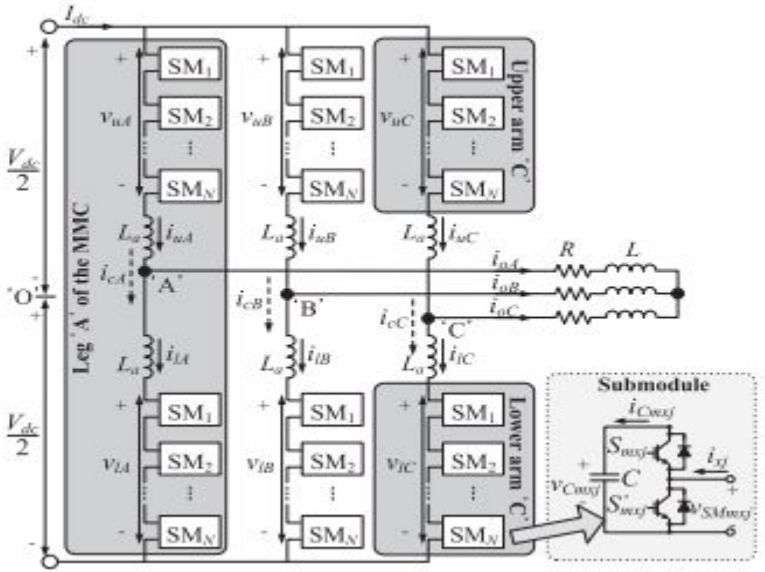
Advantages:

- Improve efficiency
- Easy to develop
- Strong applicability



Solution: Modular Multilevel Converter

Modular Multilevel Schematic [1]



Advantages:

- Reach higher voltage and power level
- Scalable and no DC link voltage limitation.
- Low total harmonic distortion(THD)
- Modular structure with identical modules
- Simple mechanical construction

Disadvantages:

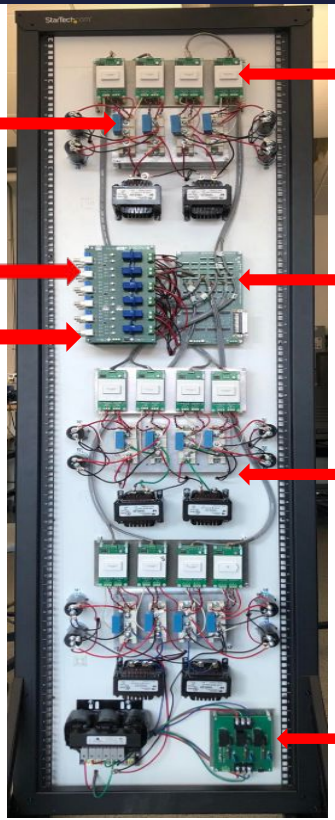
- Extra controller required for balancing of capacitor voltages
- Need for monitoring all capacitor voltages
- Increases device losses

OVERALL DESIGN

IGBT: Primarily used as an electronic switch, which will provide high efficiency and fast switching.

Current Sensor: send current measurements to the Oscilloscope.

Voltage Sensor: send Voltage measurements to the Oscilloscope.



Gate Drivers: Turn on/off electrical devices.

dSpace Interface Board: Converts TTL logic signals to CMOS logic

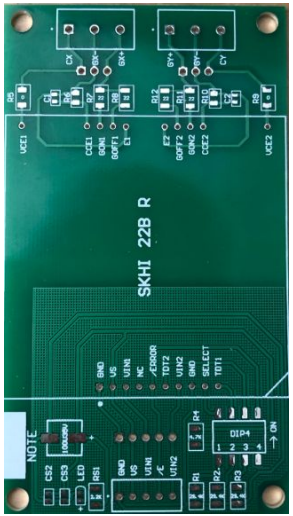
Heat Sink: Used as a cooling device for the IGBT's

Relay Board: works as a safety switch for our Inverter.

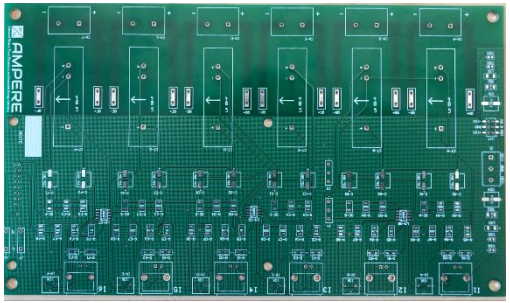
Khaled Albannai

Hardware Implementation: Soldering

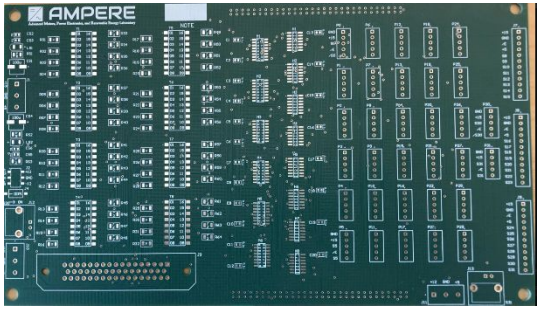
Gate Driver



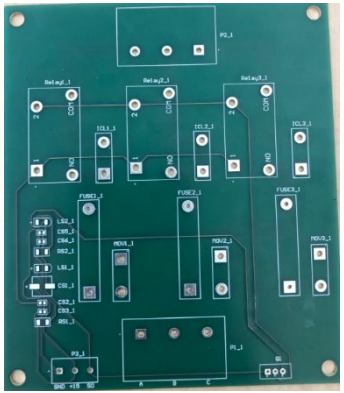
Current Sensor



Interface Board



Relay Board



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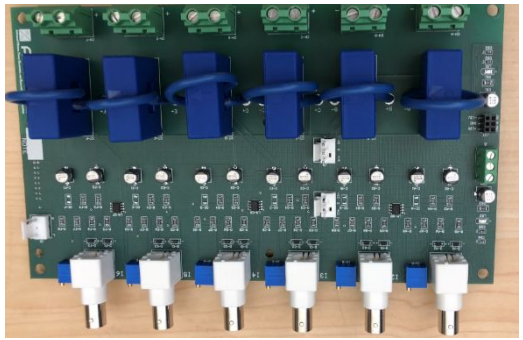
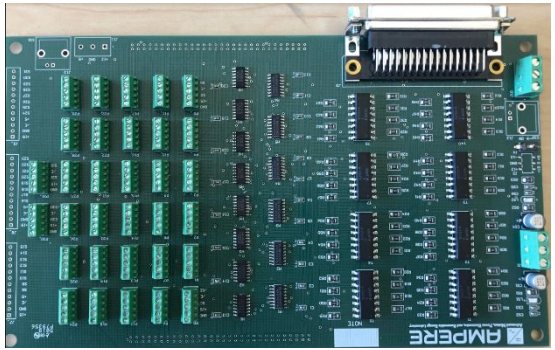
Hardware Implementation: Soldering

Gate Driver

Current Sensor



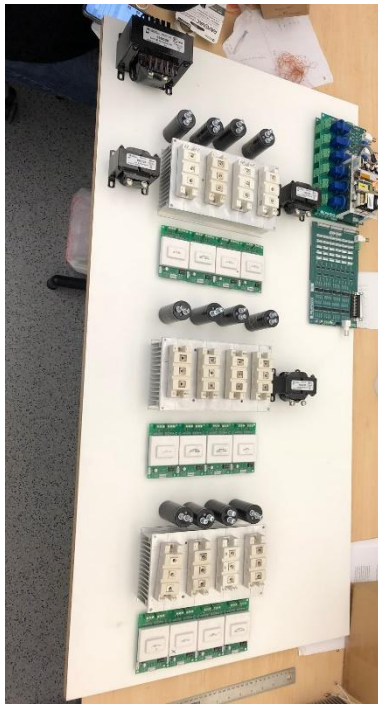
Interface Board



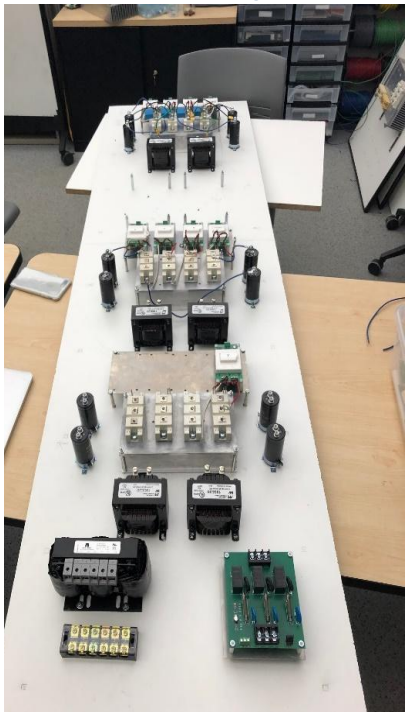
Relay Board

Hardware Implementation: Design Layout

First Design

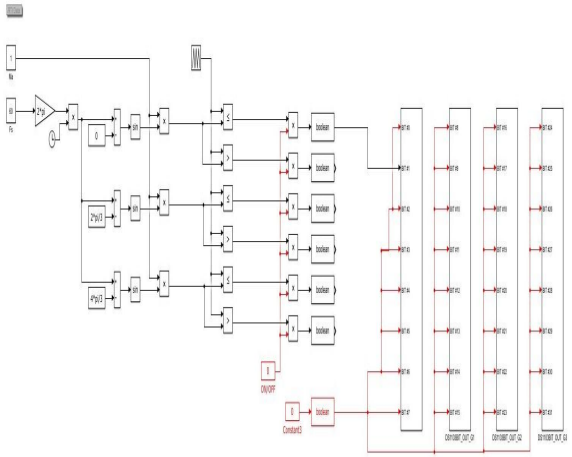


Final Design



Hardware Implementation: Gate Drivers, Interface Board and IGBT Testing

Matlab/Simulink



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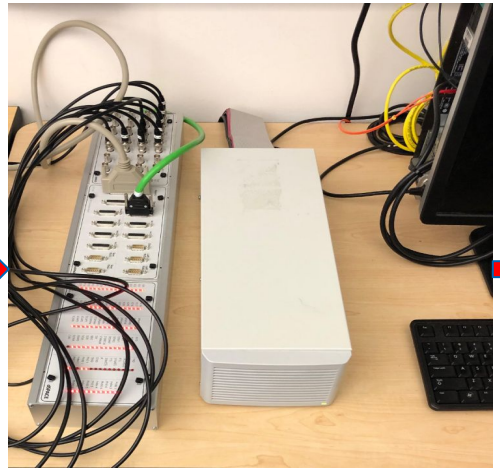
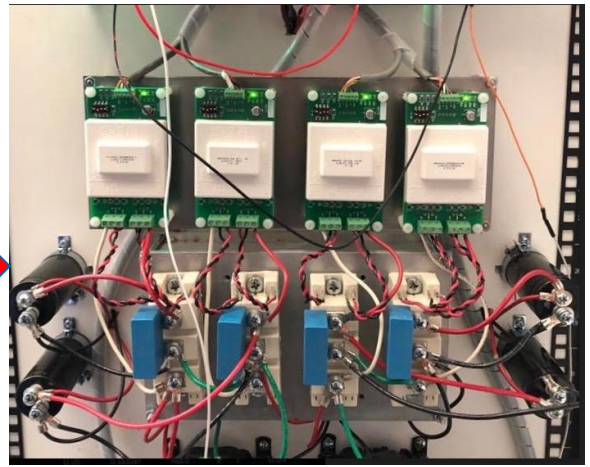
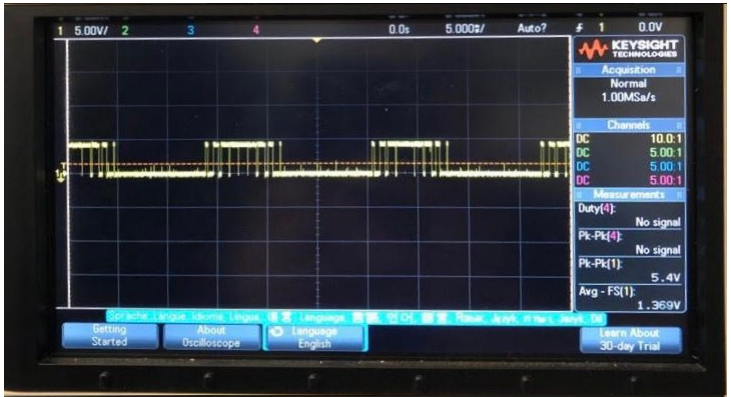


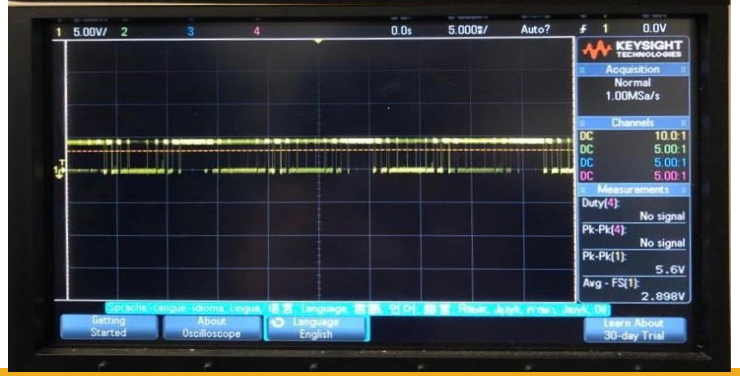
Gate Drivers



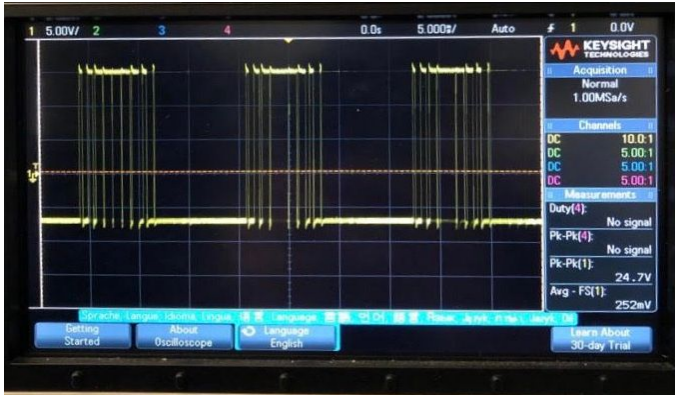
Hardware Implementation: Results

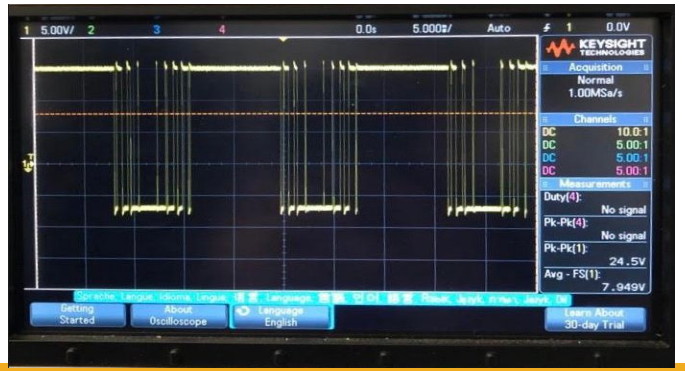
Input Side





Output Side





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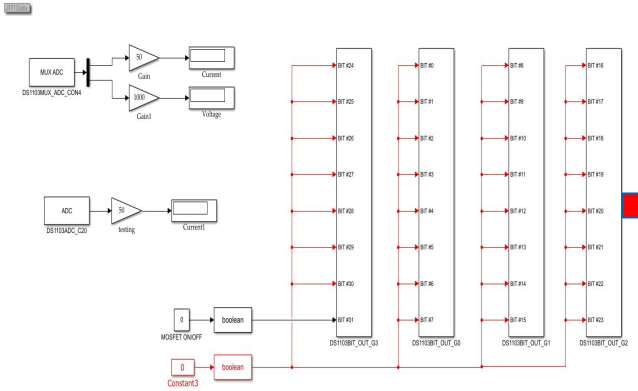
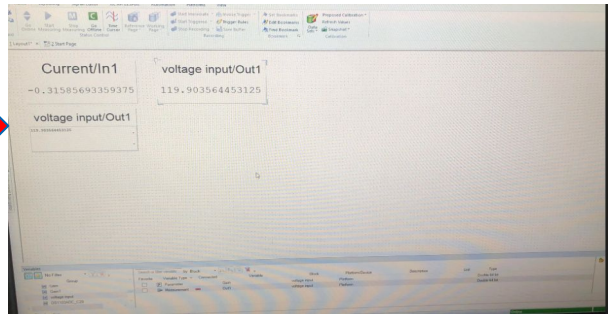
Hardware Implementation: Voltage\Current Sensors Testing

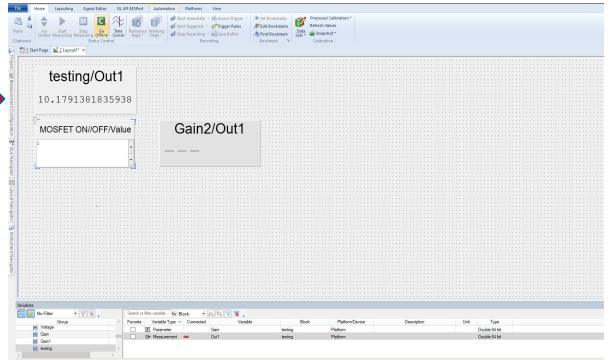
Simulink



Voltage\Current Sensors

dSpace





PV Emulator

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Conclusion

- Modular Multilevel Converter has met our client needs.
- Converter has similar design as manufacturer standards.
- The team finished building the Converter before the due date.
- Dealing with the project challenges and limitations very well.
- The team is still testing the converter.

References

[1] B. Gutierrez and S.-S. Kwak, “Modular Multilevel Converters (MMCs) Controlled by Model Predictive Control With Reduced Calculation Burden,” Jan. 2018.

[2] Svarc, “Home solar battery systems,” CLEAN ENERGY REVIEWS, 29-Nov-2018. [Online]. Available: https://www.cleanenergyreviews.info/blog/home-solar-battery-systems. [Accessed: 18-Apr-2019]

[3]"Maximum power point tracking", En.wikipedia.org, 2019. [Online]. Available: https://en.wikipedia.org/wiki/Maximum_power_point_tracking. [Accessed: 26- Apr- 2019].

THANK YOU!

Any Questions?

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