Embedded Electronics in Solar Material (20-211)

Team:

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Faculty Sponsored:

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Sponsor:

Glenn Weinreb (Manhattan 2)

Introduction

The U.S Government predicts sea level rise within the next 60-200 years

This sample image of a sea level rise courtesy of Sea Level Rise Viewer [1]

This sample image of a sea level rise courtesy of Sea Level Rise Viewer [2]

Client Background

Manhattan 2

R&D To Create A Low-Carbon Society

Glenn Weinreb
(Founder/CTO)

All work done is 100% open source and free

The organization has an emphasis on renewable energy sources

Non-profit corporation aimed to reduce CO2 emissions

MA2

Logo and Profile picture courtesy of Manhattan 2 [5]

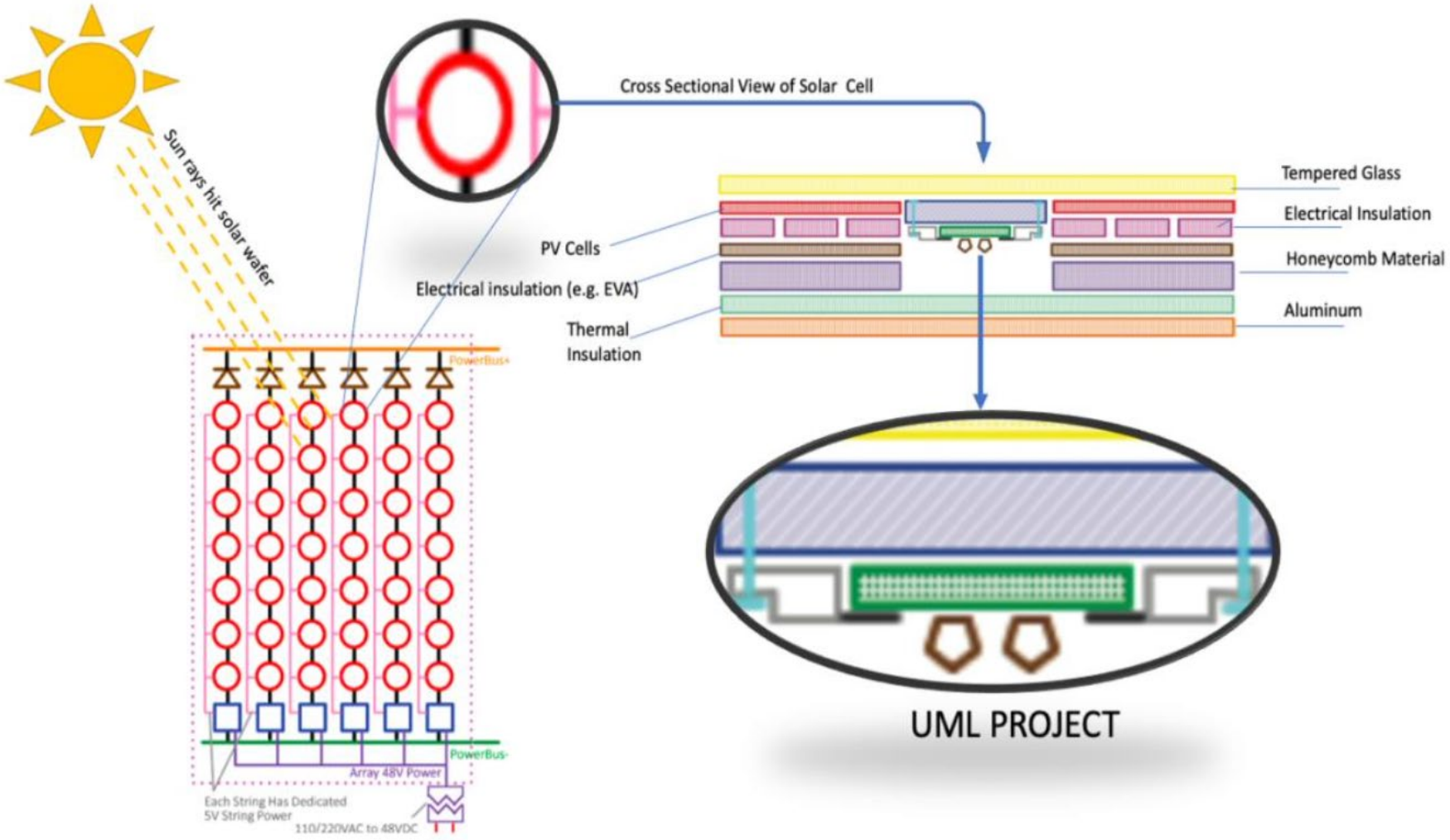
Problem

Solar panels can be an efficient solution to the energy crisis, but panels that are currently on the market can be bulky and expensive

The above image of solar cell courtesy of expgreen [3]

The above image of solar cell courtesy of Energis Melbourne [4]

Project Description



Project Objective

S The team will prototype, test, and improve the design of schematics provided by Manhattan 2 as well as develop a program that will combine to create a 300 W DC to DC converter for a flexible PV solar cell model by the end of May 2021.

M

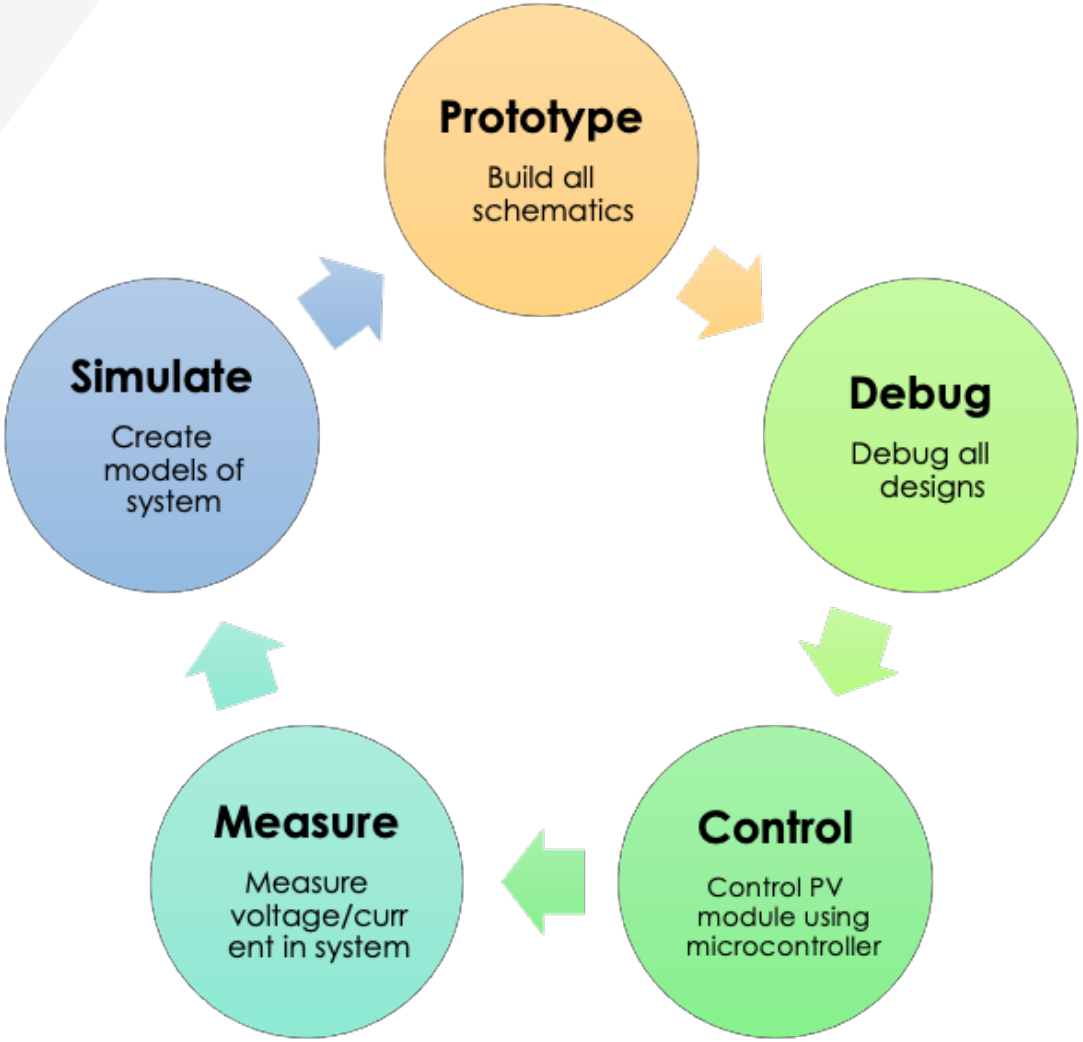
A

R

T

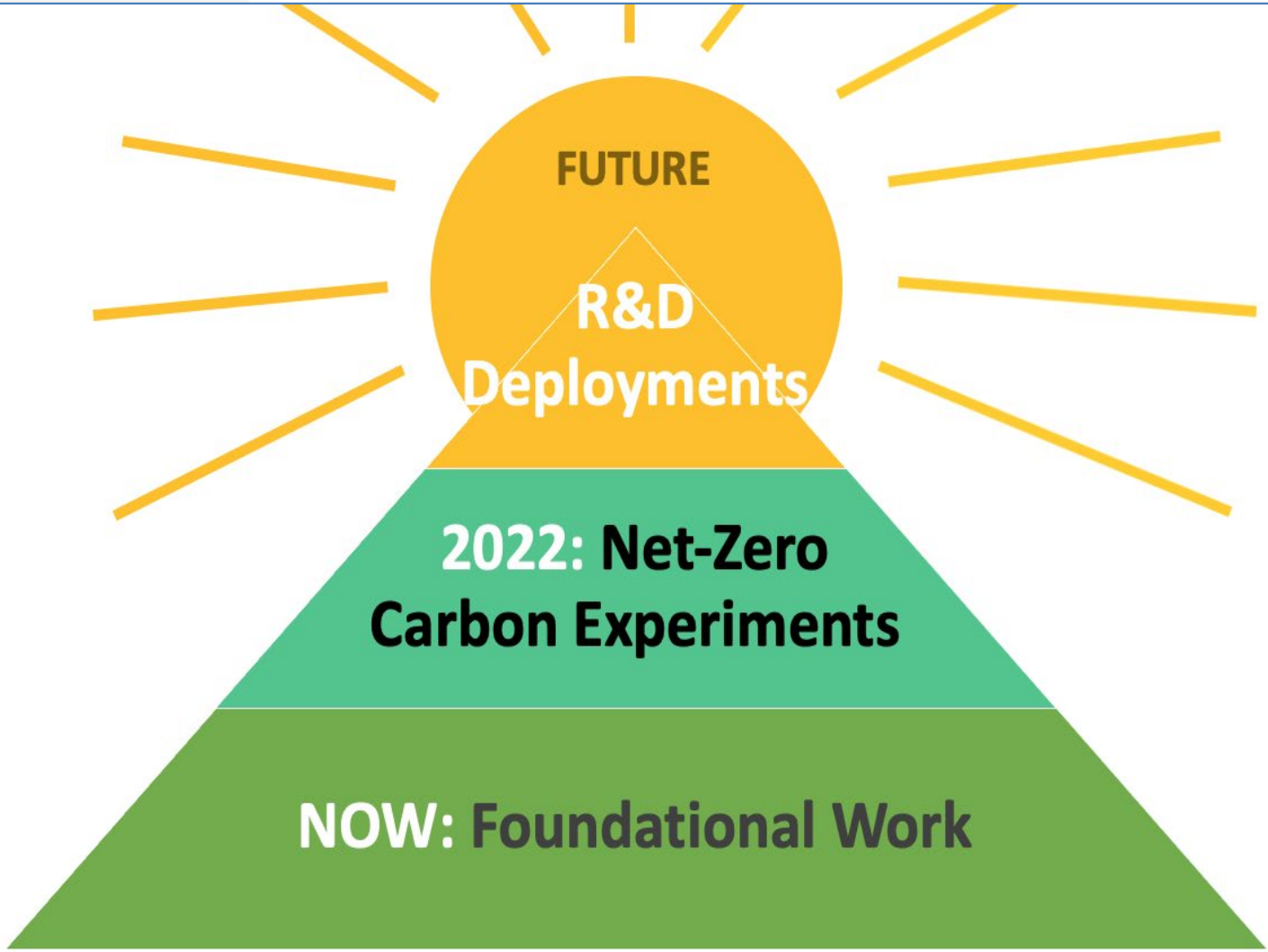
Proposed Solution

Manhattan 2
R&D To Create A Low-Carbon Society



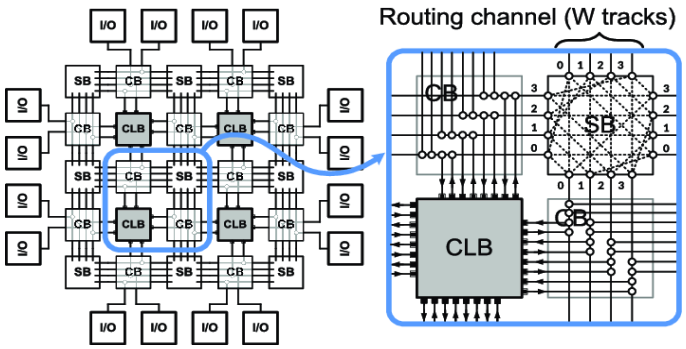
These sample images courtesy of Manhattan 2 [5]

Benefits


FUTURE
R&D
Deployments
2022: Net-Zero
Carbon Experiments
NOW: Foundational Work

Deliverables: Summary

- FPGA SPI communication system
- Breadboards:
  - Power supplies
  - Voltage Reference
  - Voltage Measurement
  - Power Conversion
- 16-bit A/D conversion system
- Photovoltaic simulation models



These sample images courtesy of Manhattan 2 [5]

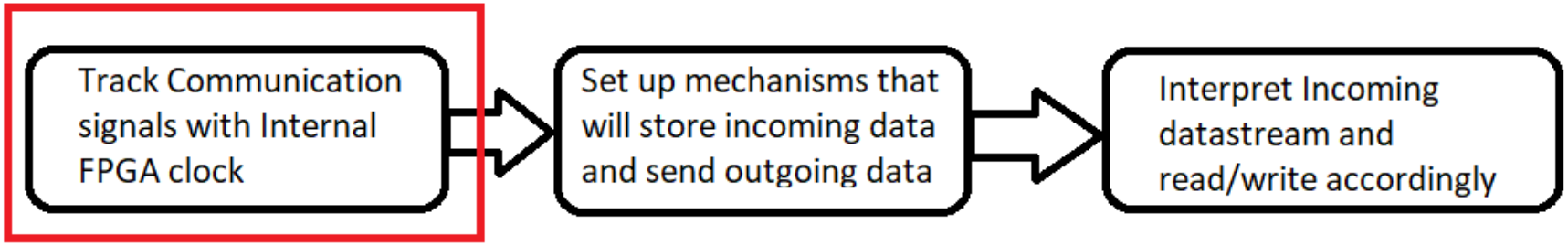
Design: FPGA SPI System

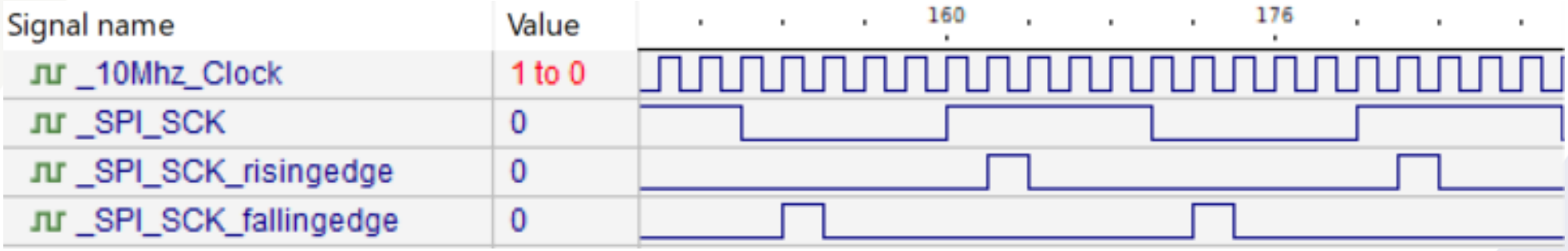
Communication System

- Because Covid restrictions limited the ability to have all portions of the project in the same physical area, the communication system operation had to be confirmed using simulation software

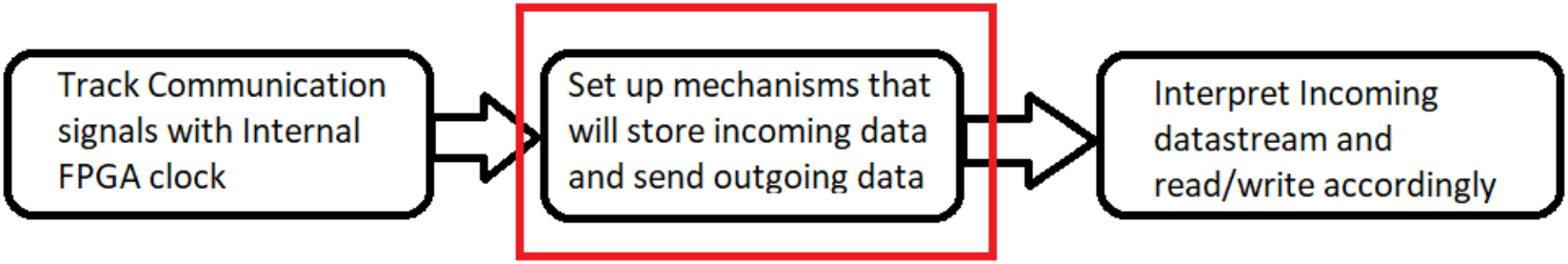
- ActiveHDL was used to simulate the SPI communication Verilog code

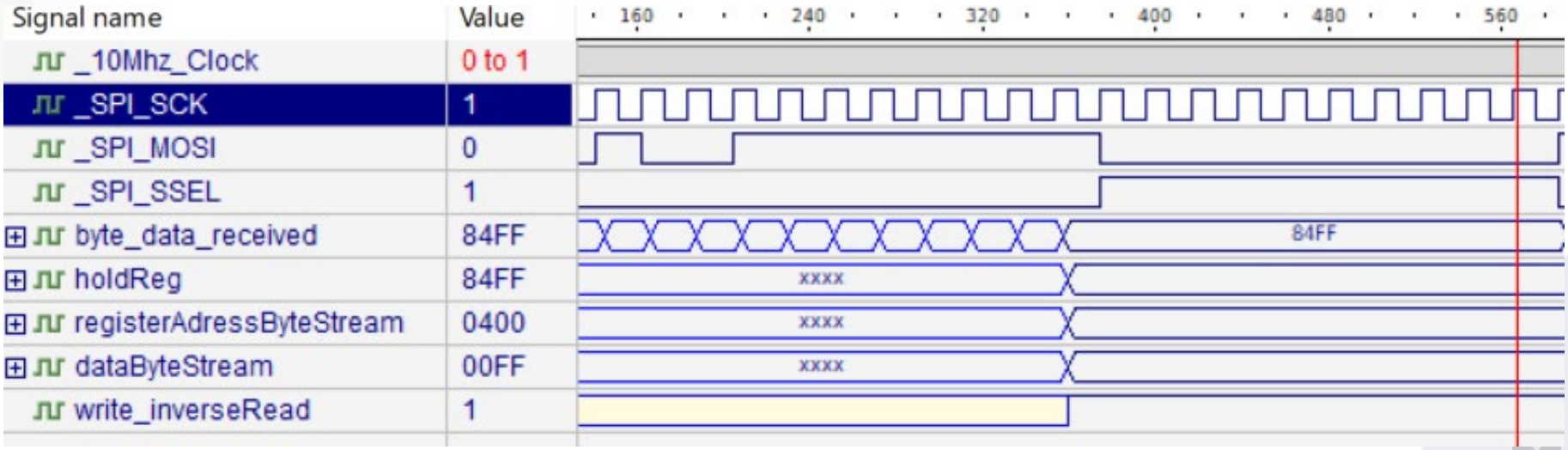
Analysis: FPGA SPI System



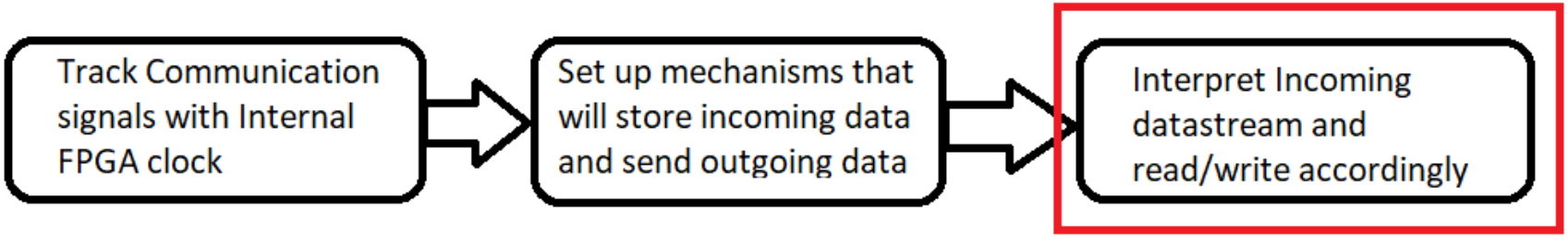


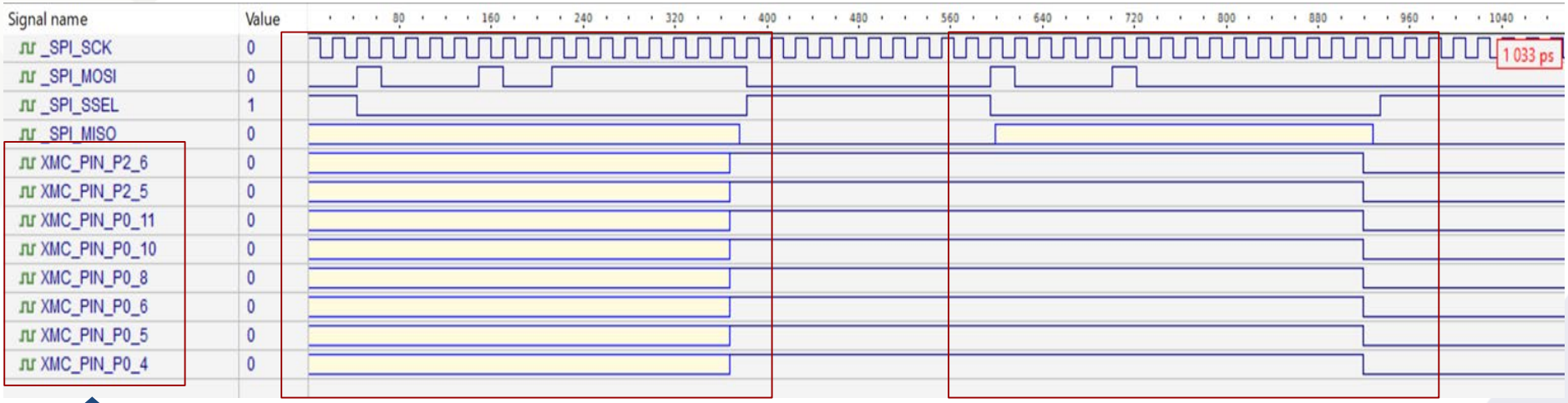
Analysis: FPGA SPI System





Analysis: FPGA SPI System



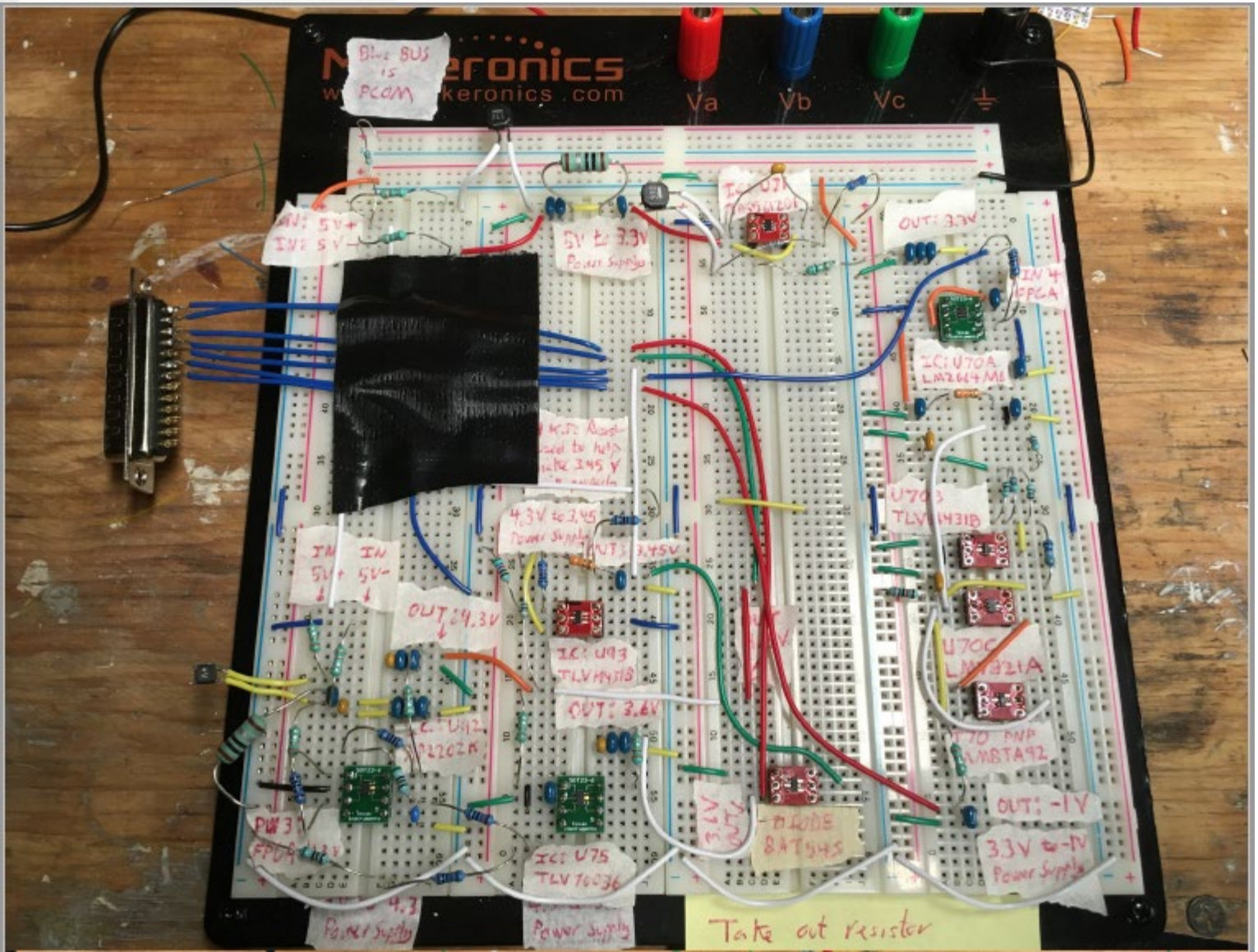


Register 4

Message 1: Write all 1's to Register 4

Message 2: Write all 0's to Register 4

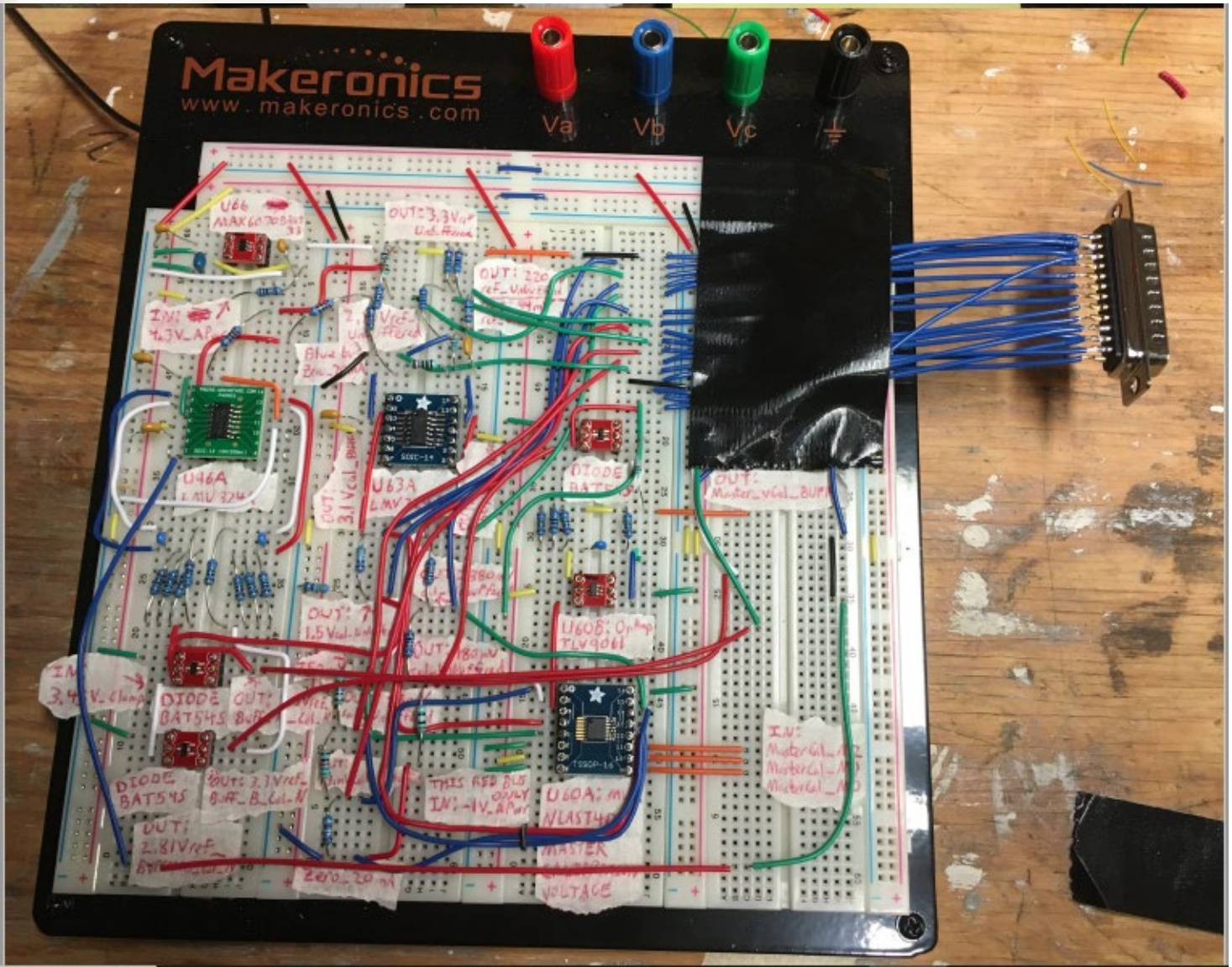
Design: Prototype Power Supplies



Power Supplies Breadboard with connector attaching to Vectorboard

- connector used to hook up between boards

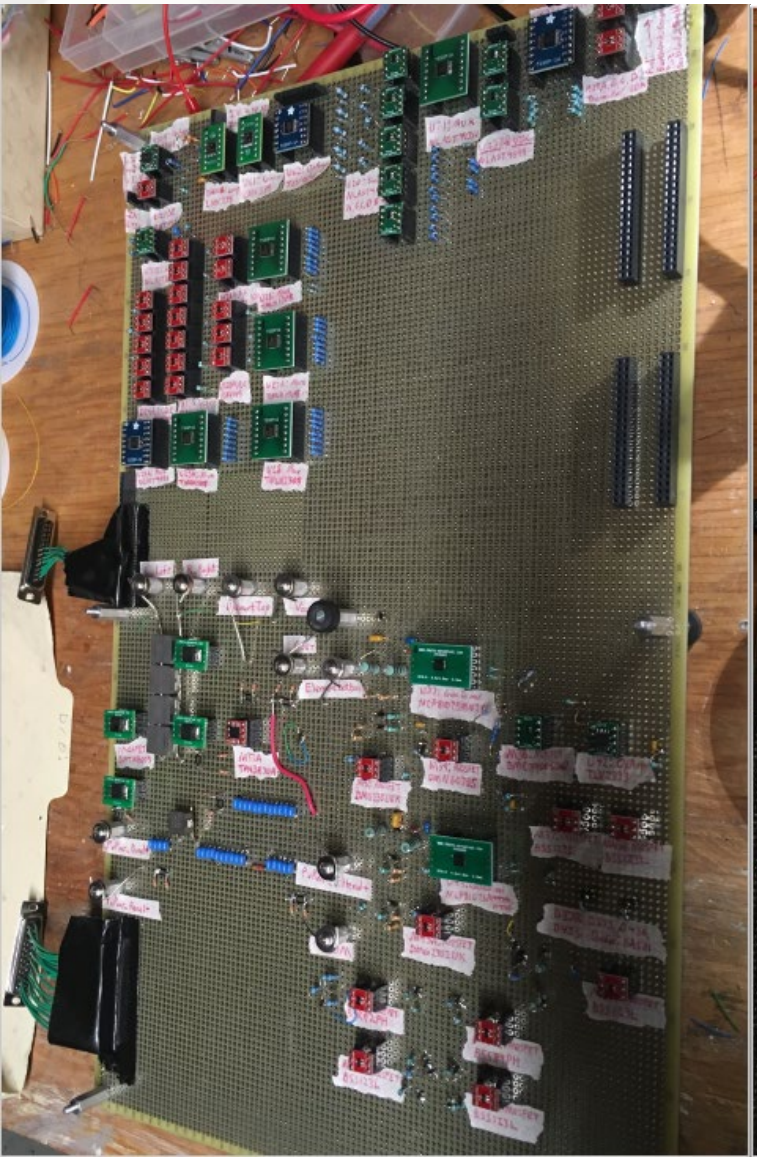
Design: Prototype Voltage References

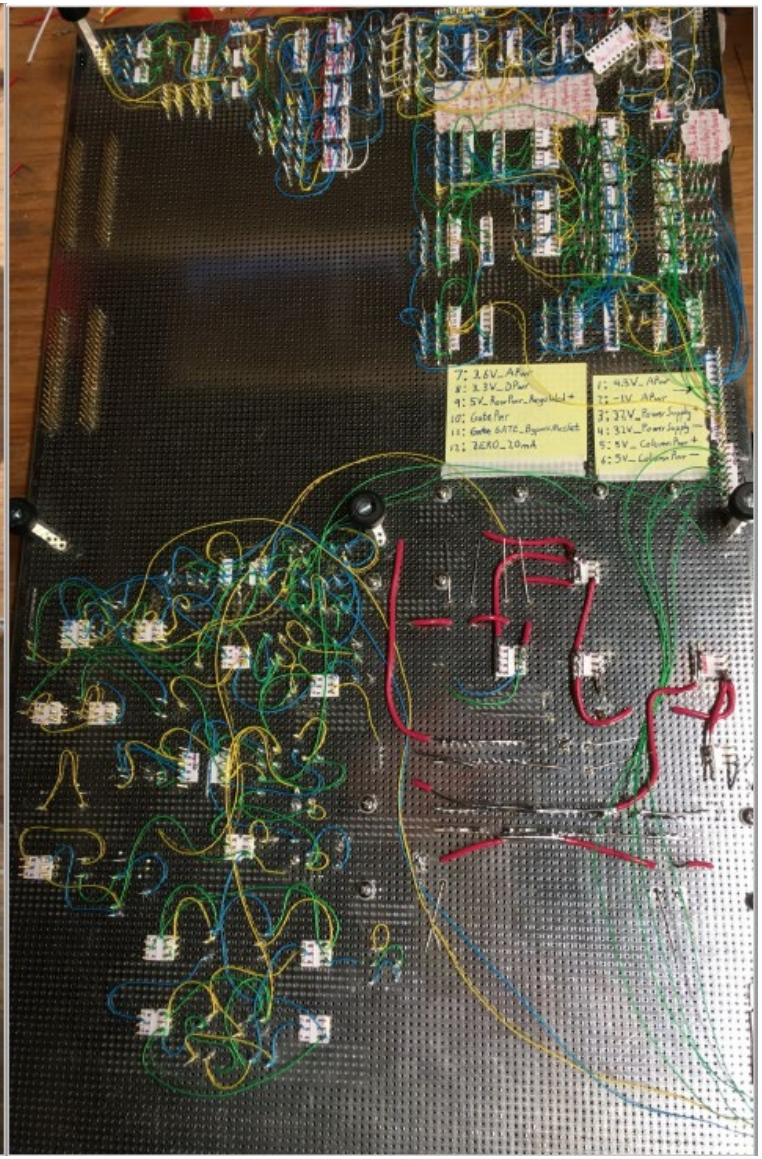


Voltage Reference Breadboard with connector attaching to Vectorboard

- connector used to hook up between boards

Design: Prototype Power Conversion & FPGA connectors & more

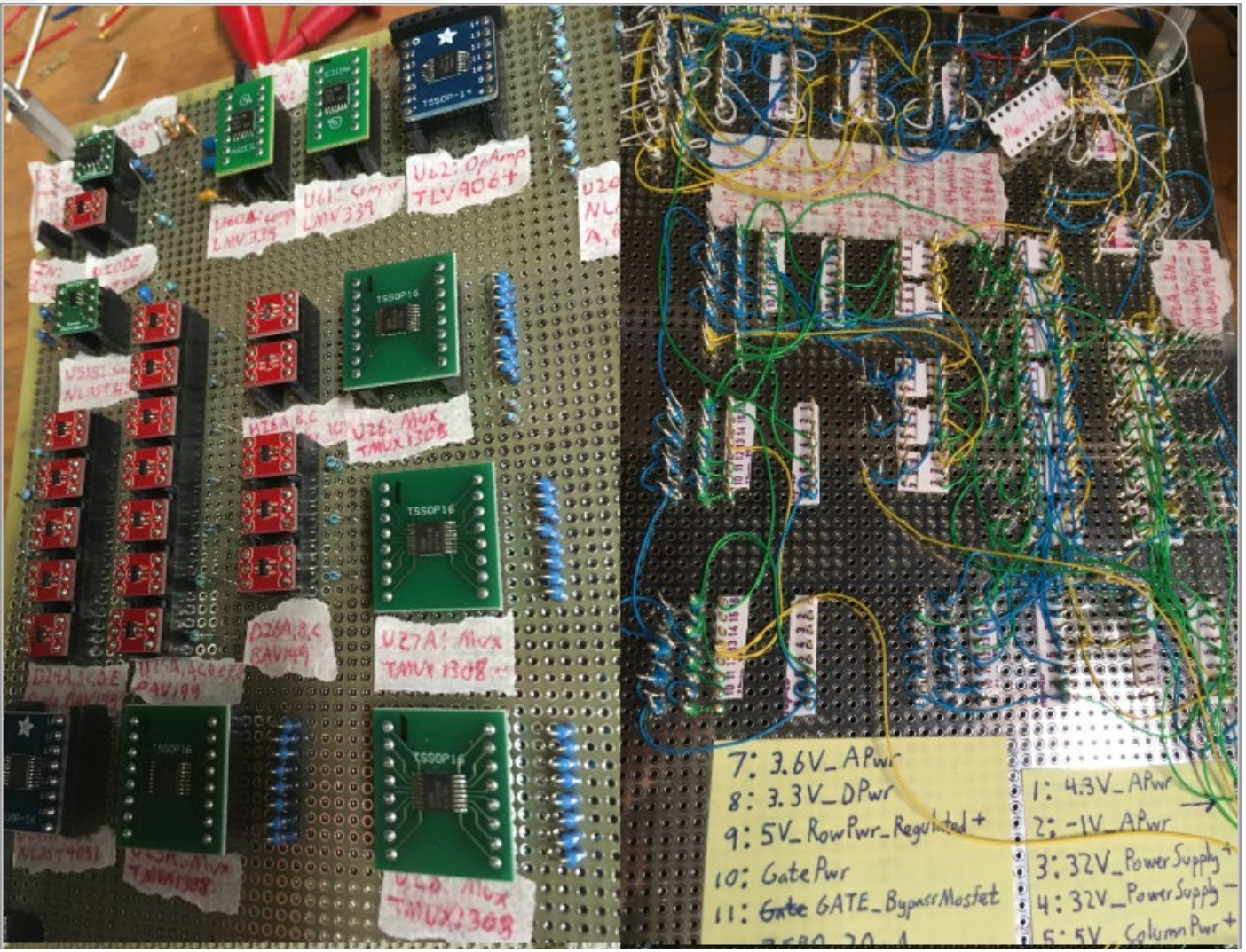




Vectorboard containing voltage measurement and power conversion schematics, connectors to breadboards, and connectors to FPGA

- wire wrapping
- soldering

Design: Prototype Voltage Measurement



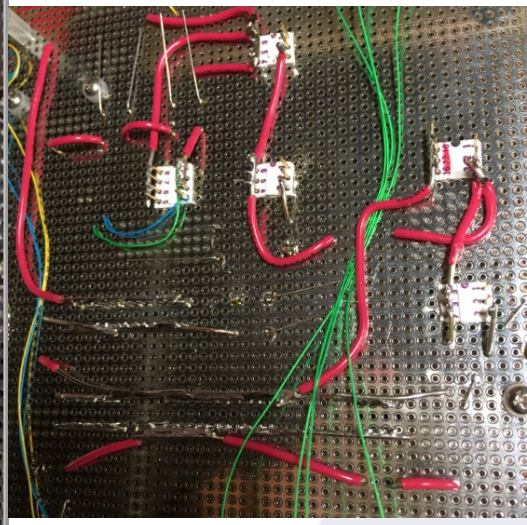
Voltage Measurement schematics on the vectorboard

- wire wrapping
- soldering

Design: Power Conversion (cont'd)

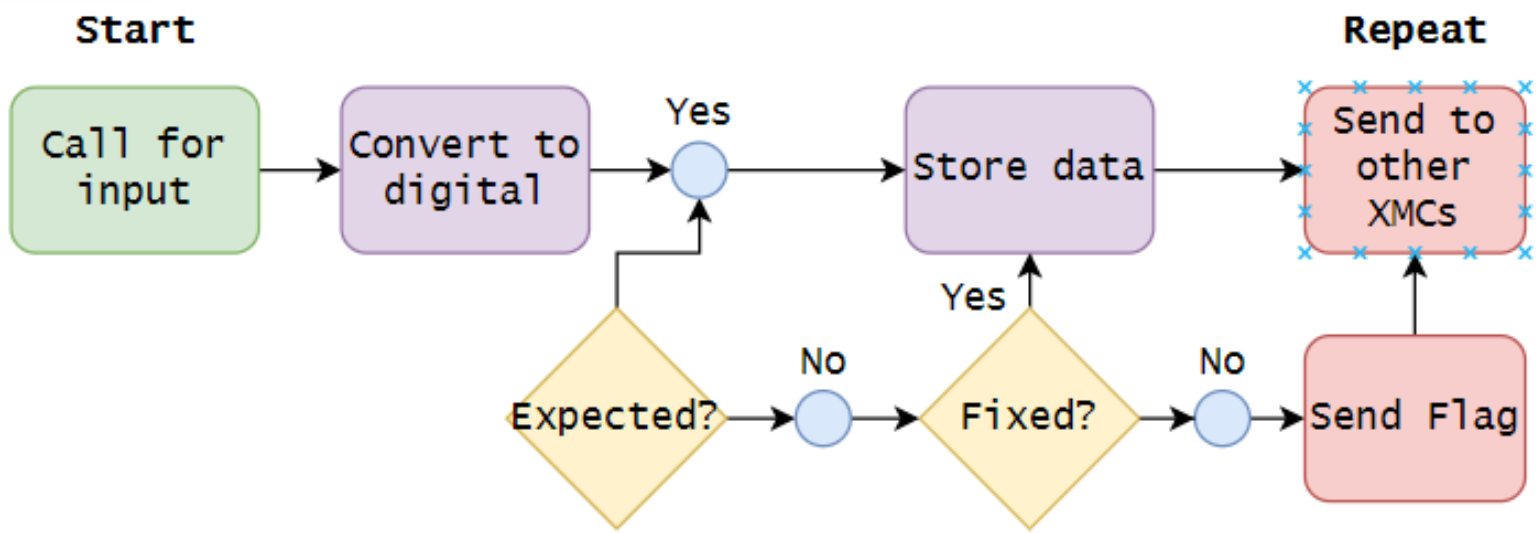
Power Conversion schematics on the vectorboard

- wire wrapping
- soldering

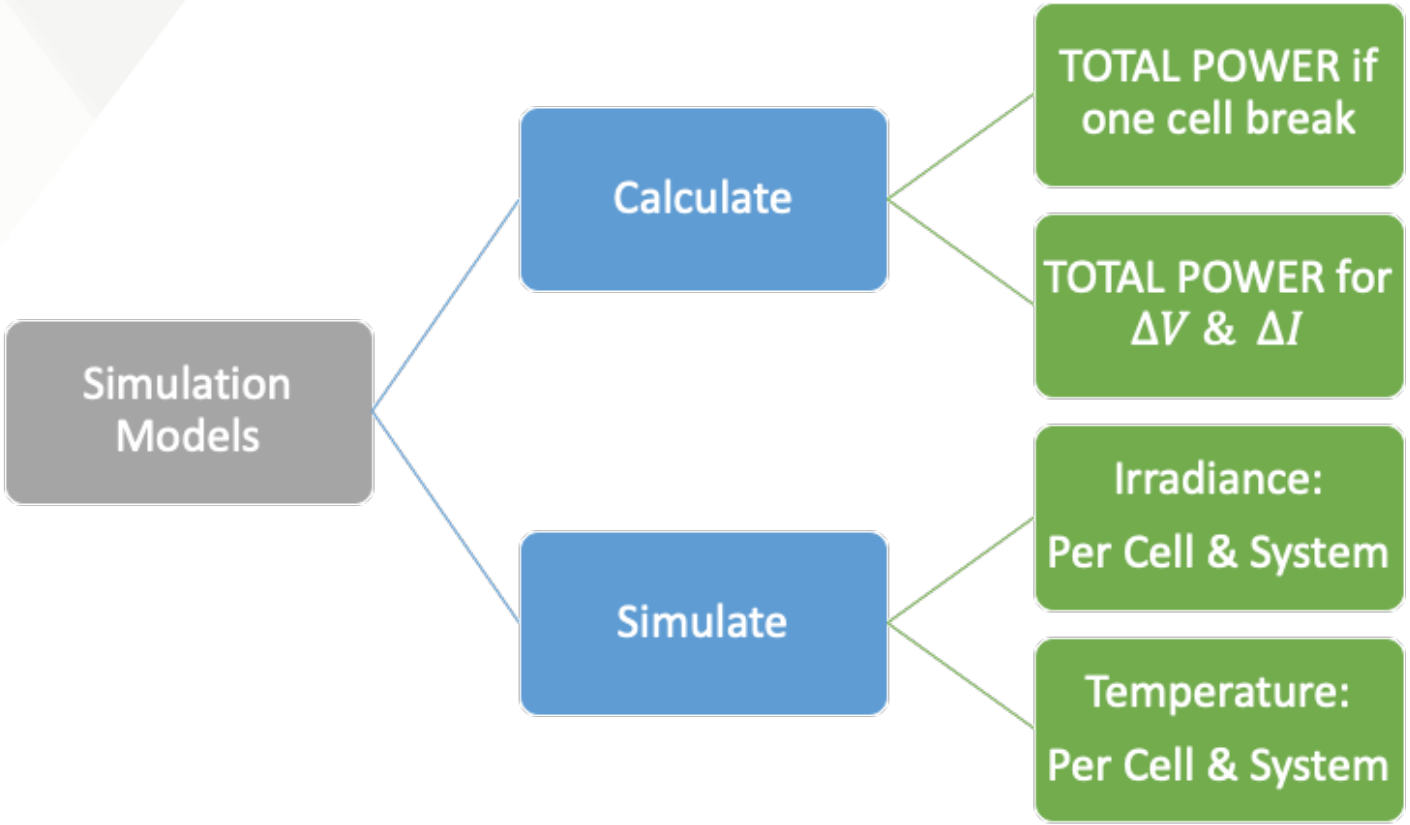


Work Area

A/D Design

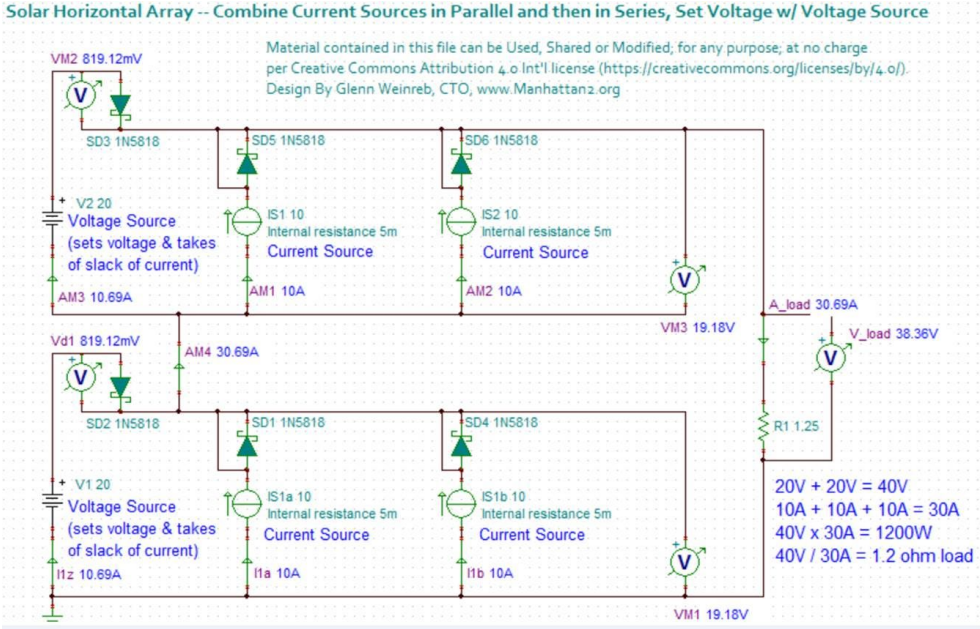

Start
Repeat
Call for input
Convert to digital
Yes
Store data
Send to other XMCs
Yes
No
No
Expected?
Fixed?
Send Flag

Design: Simulations & Calculators



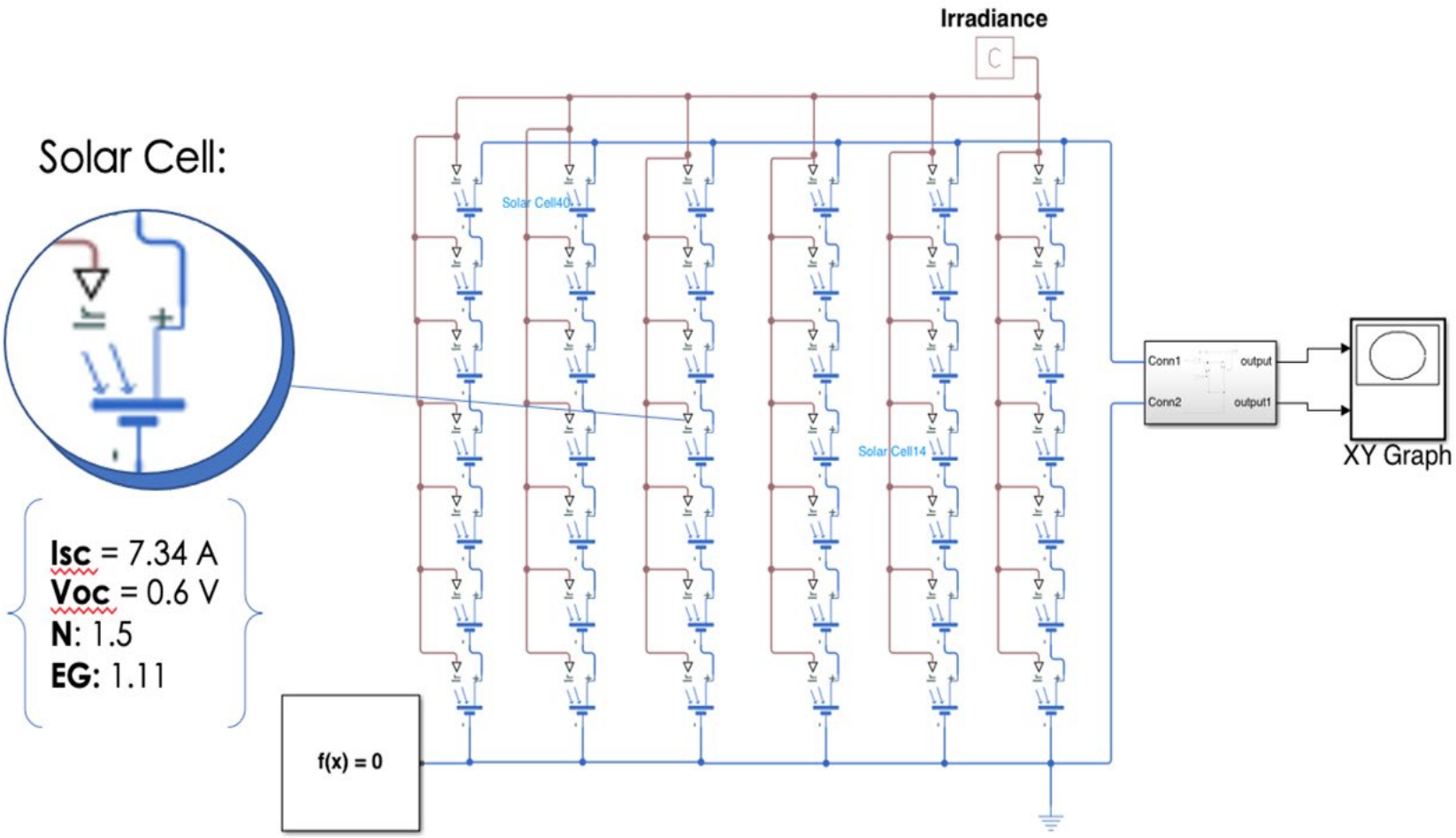
Design: Solar Array

- The array used can be used in a larger scale when developing larger solar panels
- Each array contains 2 layer of variable components
  - One voltage source
  - Two current sources
- The array can be expanded into many different layers



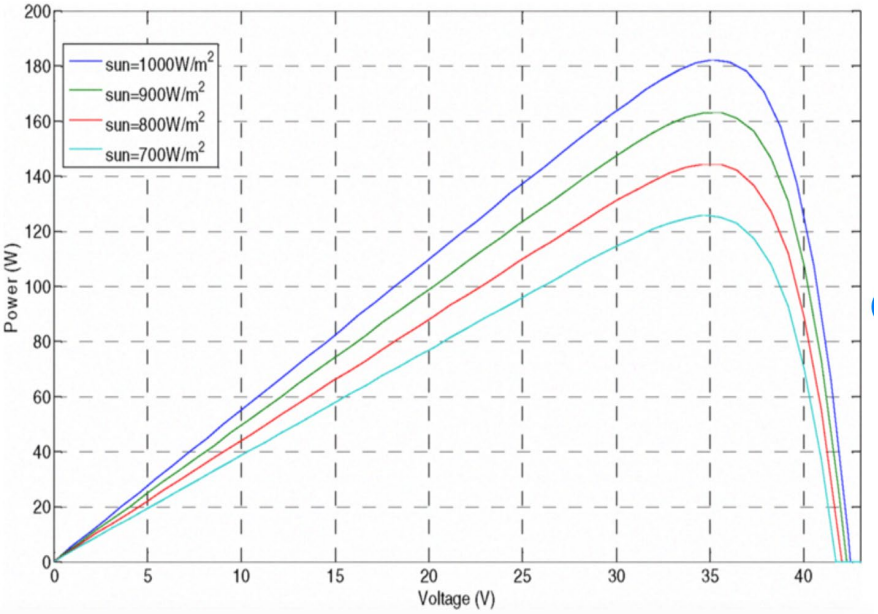
[9] Courtesy of Manhattan2

Design: Irradiance Model



[8] Image courtesy of Coastal Climate Control

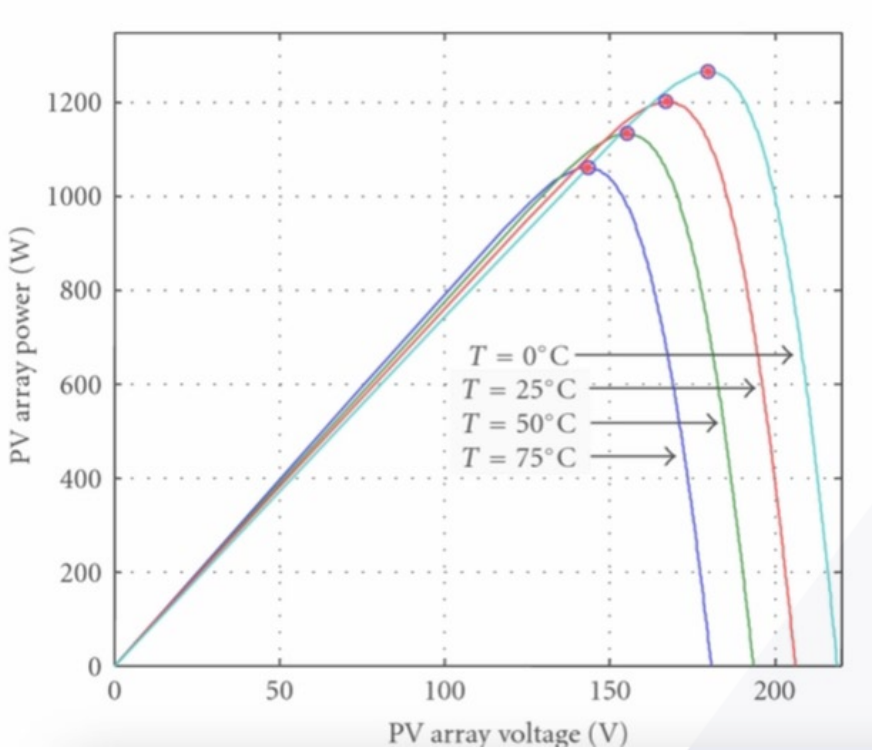
Analysis: Irradiance & Temperature



Factors for lower power yield:

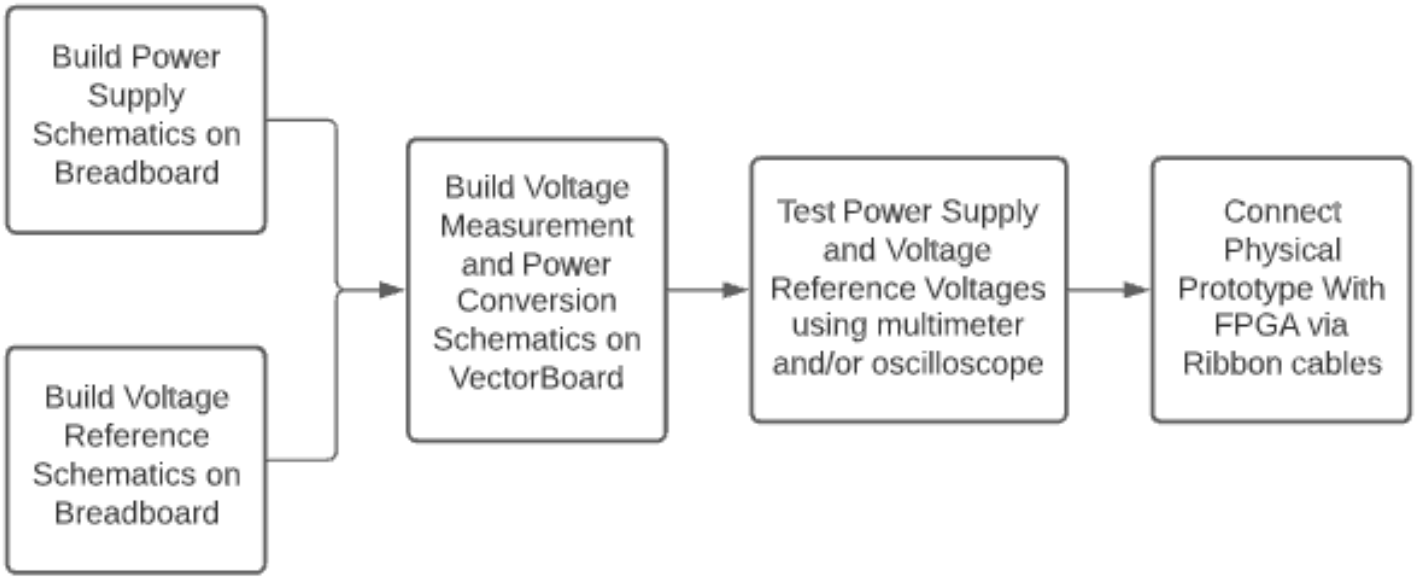
- Cloud Cover
- Air Pollution
- Time of Year
- Location Latitude

Nominal operating solar cell temperature is critical to solar cell performance



Evaluation: Prototyping Schematics

- One of the objectives was to physically prototype the circuit.



Evaluation: A/D Converter and Data Handling

- Successfully tested A/D converter.
- Measurement interval was timed
- Program tests for unwanted spikes and removes them from data.
- The system is ready to be used on the larger schematic.

Evaluation: FPGA SPI Communication

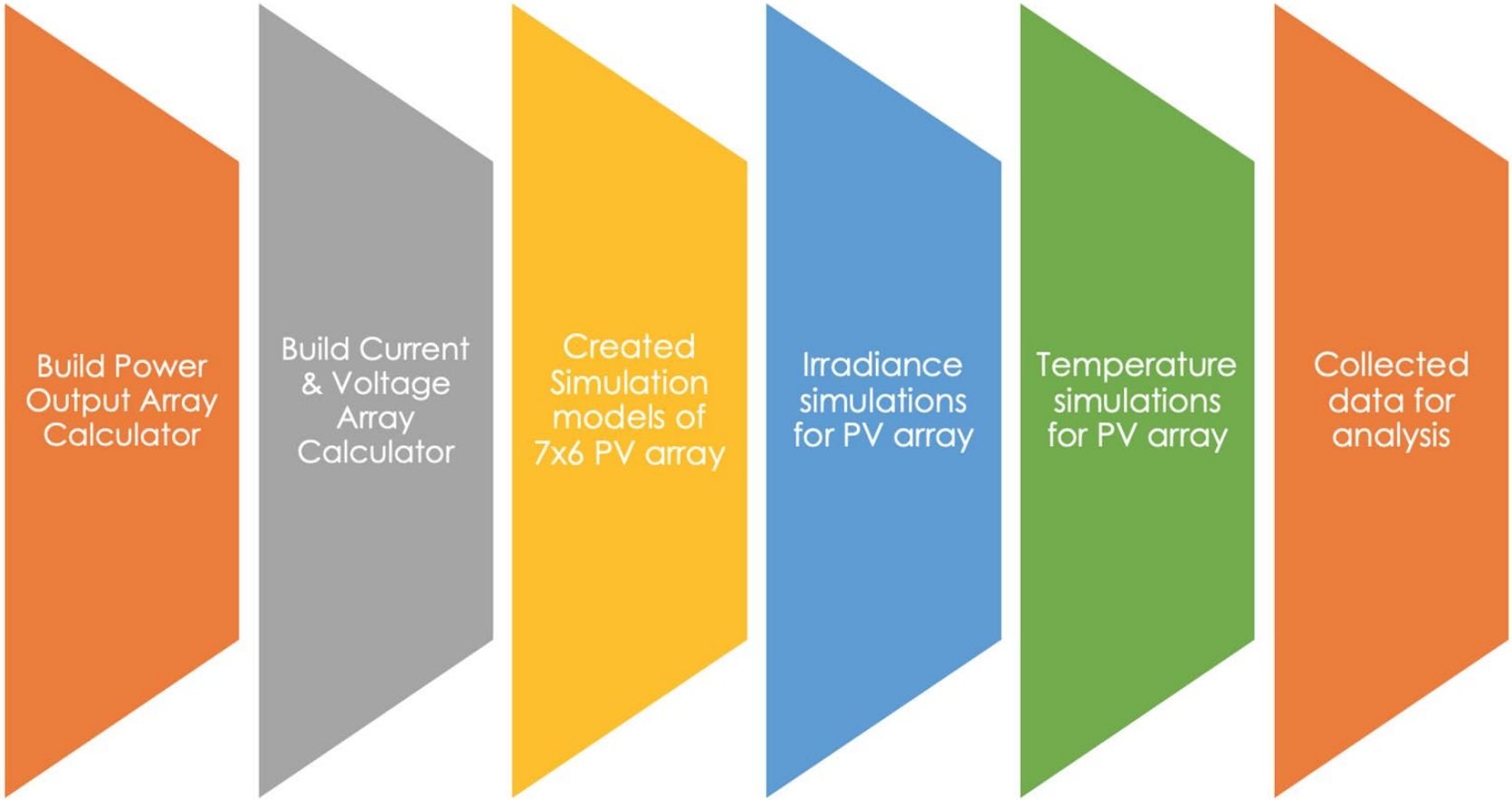
- Successful created SPI code for the FPGA that will enable communication with the microcontroller
- Allows for read/write operations as needed to each circuit input that is located on the Manhattan 2 solar cell schematic
- Simulation software was used to verify the correct operation of all communication elements
- This satisfies the requirements for this section of the project as defined in our original deliverables

Evaluation: Solar Array

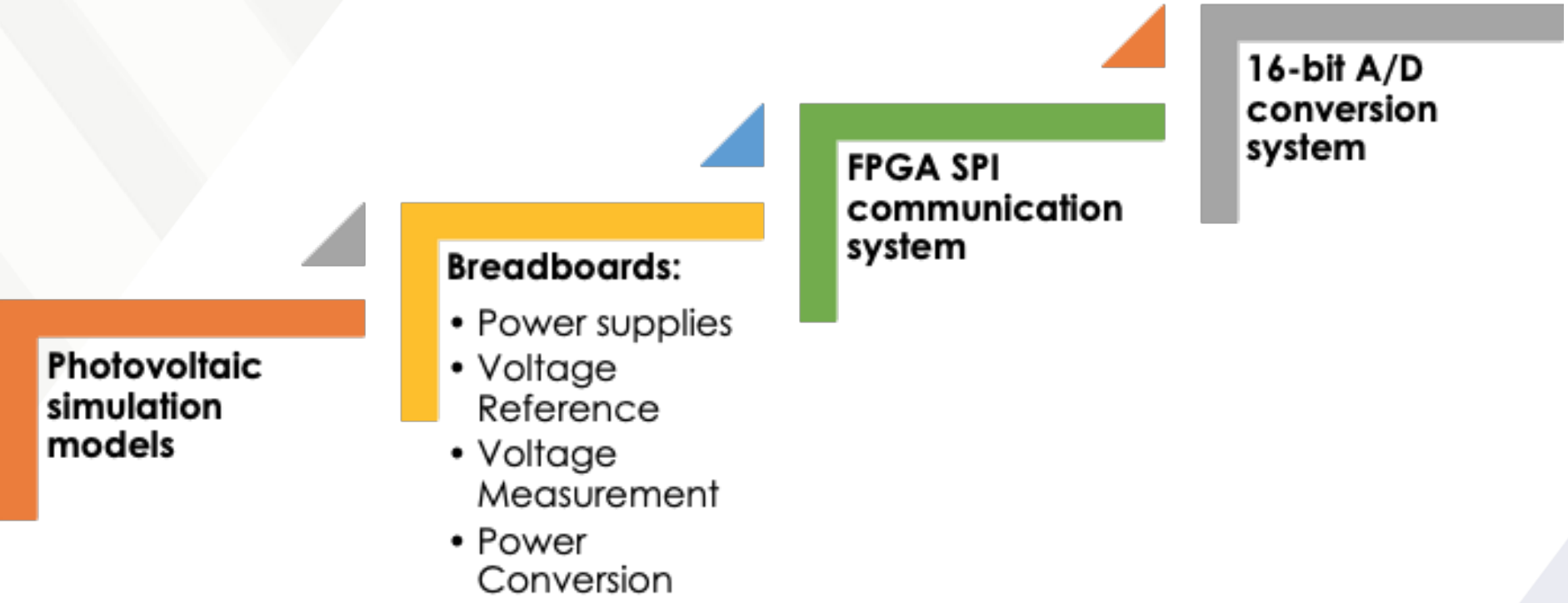
- The objective was to create a simulated array circuit using Excel
- The Excel sheet was able to calculate total current, voltage, and power for each layer based on input values

Layer	Voltage Sources (V)	Curren A (A)	Current B (A)	Total Current (A)	Total Power (W)
L1	10.0	3.0	0.5	3.5	35.0
L2	9.8	3.3	0.8	4.1	40.2
L3	9.4	3.5	0.9	4.4	41.4
L4	9.1	3.8	1.3	5.1	46.4
L5	8.6	4.0	1.5	5.5	47.3
L6	8.6	4.2	1.7	5.9	50.7
L7	7.9	4.5	2.0	6.5	51.4
L8	7.3	4.8	2.2	7.0	51.1
L9	7.0	2.4	2.6	5.0	35.0
L10	6.5	0.0	0.0	0.0	0.0

Evaluation: Simulation Models



Evaluation: Summary of all Parts



Share with future capstone team

Future Work (2021)

Finish the following schematics:

- Communication Network
- Fully connected circuit

Complete the following parts:

- CANbus omnidirectional communication
- Test for complete circuit operation and faults
- Print fully tested circuit board
- Plot voltage fluctuations
- Test power optimization

SUMMARY & ACKNOWLEDGEMENT

SUMMARY:

- 20-211 Team delivered critical foundational starting point of the proposed Manhattan2 project

- While challenges existed, the team overcome them and executed required deliverables with satisfactory outcome

ACKNOWLEDGEMENT:

THANK YOU TEAM MANHATTAN2 AND PROF. SCHMID!

Thank You