OUC All-in-One Photovoltaic Sensor

Group 5

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Sponsored by the Orlando Utility Commission

Project Narrative

Statement of Motivation

Solar farms are structured with strings of solar panels which share the same current and produce a shared voltage known as a string voltage. Similar to christmas lights, this arrangement produces some issues when one or more solar panels in a string become defective in producing the desired voltage output. The overall string voltage drop is not proportional to the amount of solar panels which are defective in a string. For example, if a string of 100 solar panels were to have one panel become defective, the string voltage drop could be much greater than 1% of the overall string voltage (these numbers are simply illustrative, and not meant to be taken as real measurements). As such, we are motivated to design a device which can affordably and reliably measure voltage, current, and possibly temperature and irradiance to be able to quickly identify defective panels in a string.

The sensors will be uniformly distributed throughout a string of solar panels. This layout would allow a solar farm maintainer to determine the relative location of a faulty panel. As a result, on-site technicians would have a much easier time locating a defective panel, and could instead spend more time resolving the issue with the defective panel. Besides the benefits of easier repair, the sensor devices would reveal some other benefits. The array's average performance should increase, providing more consistent power generation due to faster repairs or replacements. In addition, energy producers gain a more refined monitoring process and avoid surrendering fines to distribution partners when they cannot meet the agreed upon energy generation goals. Energy producers would also have access to more technical data regarding their solar panels, which would enable further insight as to the strengths and shortcomings of the manufacturer's product.

Note that this kind of monitoring system already exists, but is not available to utility commissions. DC optimizers are commonly used to enhance performance operations, but these devices still lack the ability to translate the performance data to utility commissions. Rubin York explained that while OUC's solar arrays are already monitored, none of the performance data is readily available for study by OUC. Therefore, Rubin York devised a plan where an affordable sensor could be created.

Goals and Objectives

Our primary goal is to create several prototypes of a photovoltaic sensor usable in small- to medium-scale solar arrays that measure the voltage and amperage of the panels in order to determine panel health.

Our secondary goal is to incorporate two supplementary measuring instruments to our original sensor design: a thermocouple capable of tracking [internal] temperature and a pyranometer that can detect incident light irradiance.

Together, these devices will transmit data down the string to a local collector node that is hardwired to the producer's database. The producer can then monitor panel health and performance, optimizing the longevity and consistency of the array's generation.

Function

The function of this 'all-in-one' sensor is to detect deviation in a panel's performance. Due to the string configuration of the solar array, sensors would need to be implemented at calculated and uniform positions down the line. These positions should be configurable, as to be able to uniformly distribute the sensors through a string of panels regardless of the number of available sensors or the number of panels in the string.

Panel performance metrics will be sampled from the sensors in regular intervals, and the sensors will relay the information to a collector node which will communicate wirelessly with a database. From the database, the panel performance metrics can be analyzed and compared against either baseline numbers when the panels were installed, or comparatively against measurements from other panels in the string. Deviations in a panel's or set of panel's performance will then be traceable to a specific sensor, allowing the defective panel or panels to be located.

Requirement Specifications	Priority
Must be able to withstand 700 V [DC]	High
Must be able to carry 30 A [DC]	High
Must be rated for up to 15 kW power	High
Must contain port connections for thermocouple and pyranometer instruments	Low
Must use MC4 port connections to integrate into solar panel string	High
Enclosure must be NEMA 4X or 4R certified	High
Must last more than a year in use	Moderate
Must filter out noise with capacitive loads	High
Must be removable and transportable	Moderate
Must connect between panels	High
Must transfer data wirelessly to database	Low
Must be under $20/sensor	Low
Must be reproducible	High
Must comply with all relevant FCC standards	High

Block Diagrams

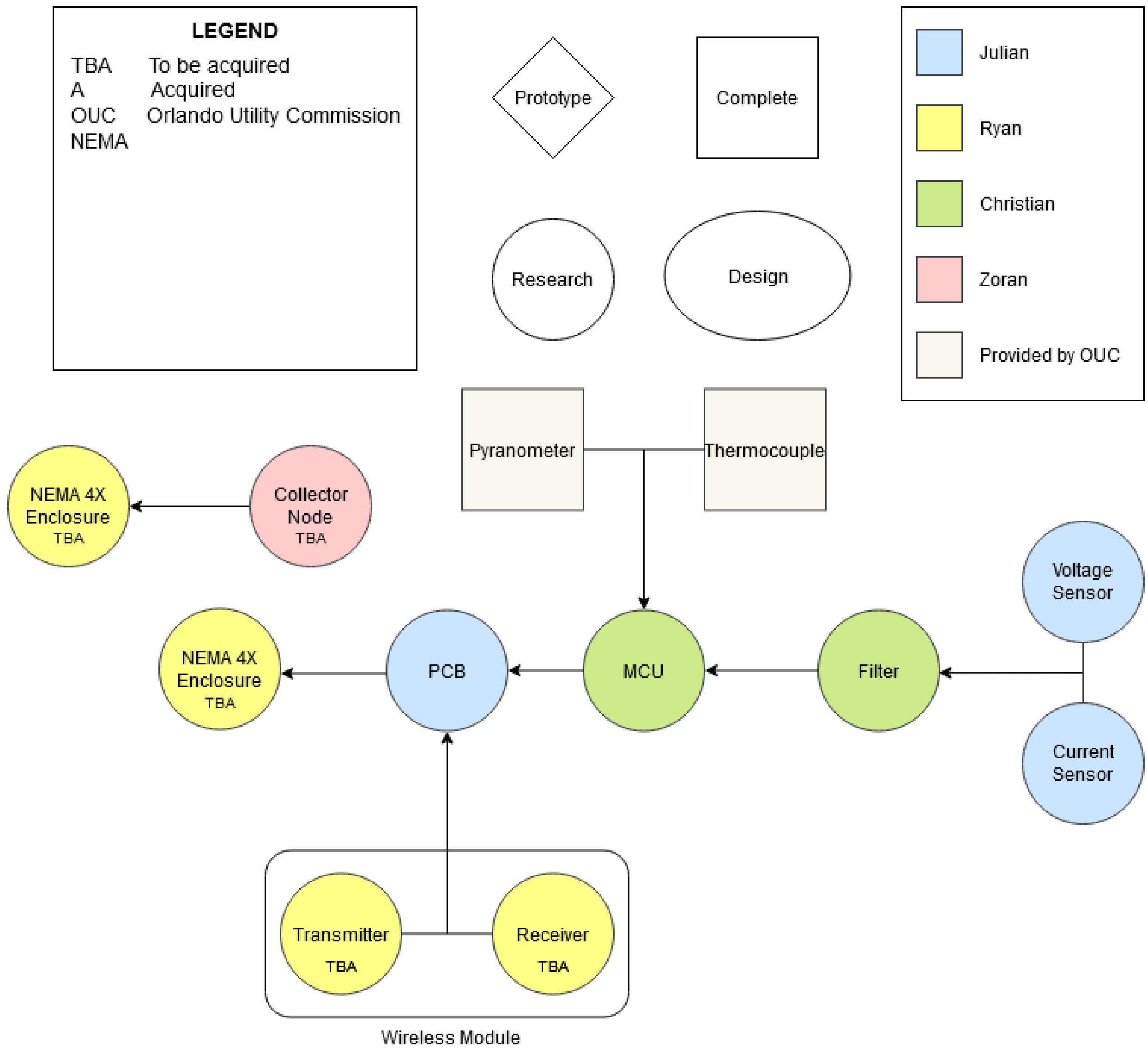

Figure 1: Hardware Block Diagram

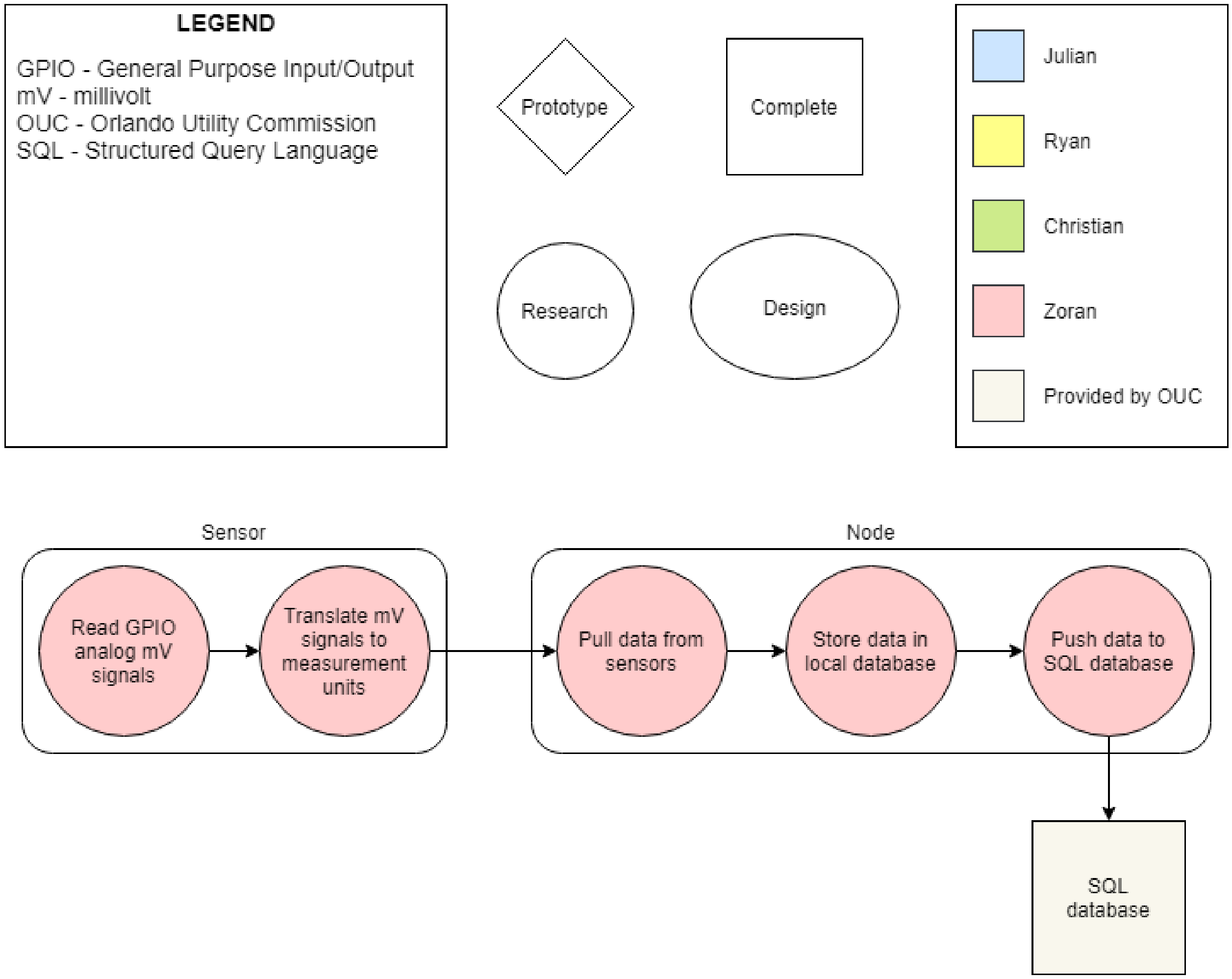

Figure 2: Software Block Diagram

Visualized Prototype

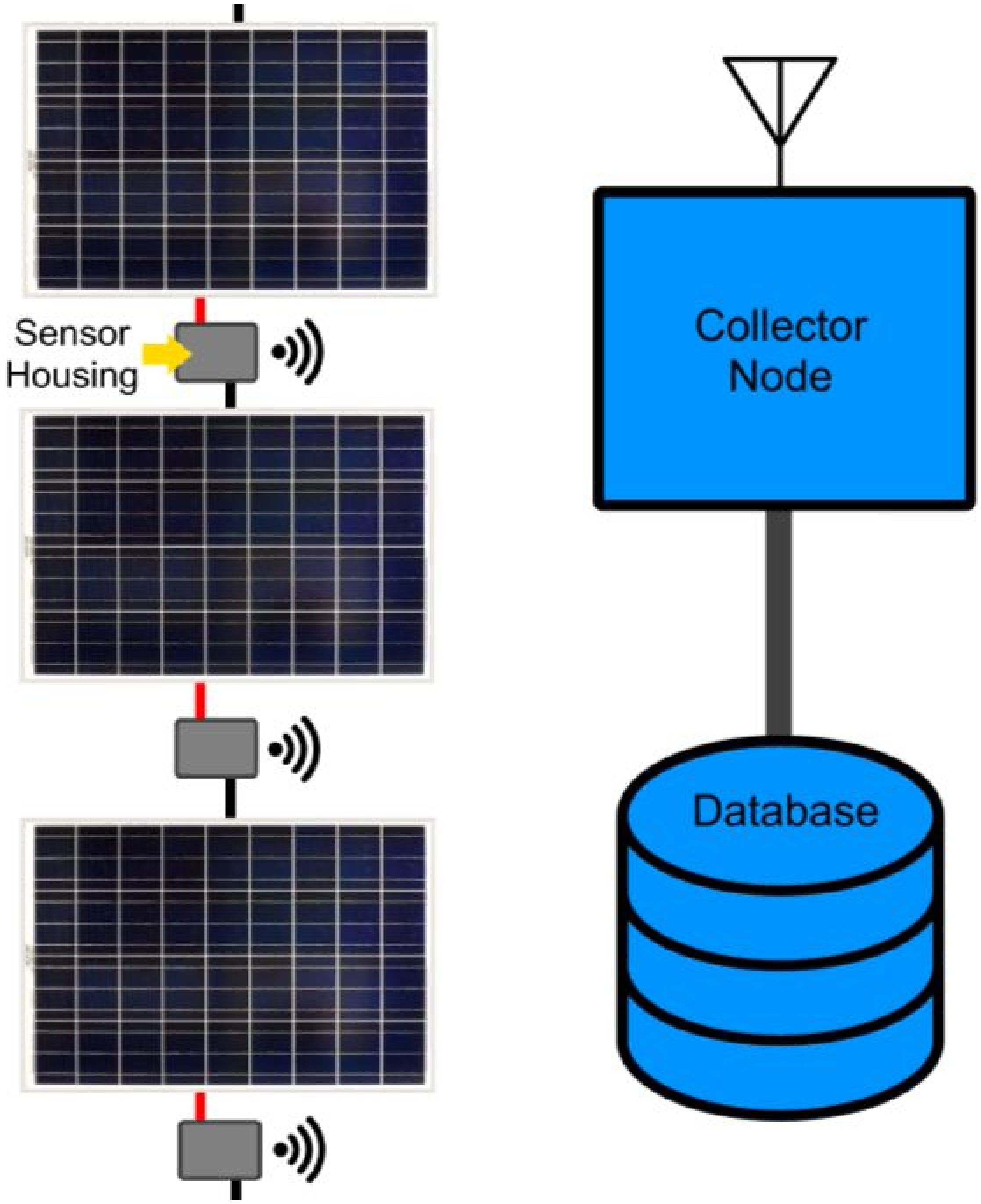

Figure 3: Visualization of Our Prototype Design

Budget

Component	Quantity	Cost per Each	Estimated Cost
NEMA 4X Enclosure	4	TBD	TBD
Pyranometer	3	$223	Provided by OUC
T-type Thermocouple	3	TBD	Provided by OUC
PCB	3	TBD	TBD
Wireless TX/RX Module	3	$20.00	$60.00
Node	1	$40.00	$40.00
Extra Hardware	Varies	TBD	TBD
Processor	3	TBD	TBD
Total			

Milestones

<u>Senior Design I</u>

Milestone	**Tasked to:**	**Start Date**	**End Date**	**Status**
Introductions				
Familiarize with the project	Group 5	1/11/2021	1/29/2021	Completed
Role Assignments	Group 5	1/11/2021	1/29/2021	In Progress
Identify Parts	Group 5	1/18/2021	1/29/2021	In Progress
Project Reports				
Initial Divide-and-Conquer	Group 5	1/11/2021	1/29/2021	Completed
Divide-and-Conquer 2.0	Group 5	1/29/2021	2/12/2021	In Progress
Final Report (1st Draft)	Group 5	2/12/2021	4/2/2021	Pending
Final Report (2nd Draft)	Group 5	4/2/2021	4/16/2021	Pending
Final Report (Final)	Group 5	4/16/2021	4/27/2021	Pending
Research and Investigation				
PCB Configuration	Julian	1/29/2021	3/31/2021	In Progress
Processor	Zoran	1/29/2021	3/31/2021	In Progress
Filter Circuit	Christian	1/29/2021	3/30/2021	In Progress
Communication Ability (wireless v wired)	Zoran	1/29/2021	3/30/2021	In Progress
Pyranometer	OUC	1/29/2021	3/31/2021	In Progress
Thermocouple	OUC	1/29/2021	3/31/2021	In Progress
Voltage Sensor	Julian	1/29/2021	3/30/2021	In Progress
Current Sensor	Julian	1/29/2021	3/30/2021	In Progress
Enclosure Design	Ryan	1/29/2021	3/31/2021	In Progress

Senior Design II

Milestone	**Tasked to:**	**Start Date**	**End Date**	**Status**
Construct First Prototypes	Group 5	4/27/2021	5/30/2021	Pending
Tinker	Group 5	5/30/2021	6/30/2021	Pending
Establish Final Product	Group 5	6/30/2021	TBD	Pending
Final Peer Presentation	Group 5	TBD	TBD	Pending
Final Report	Group 5	TBD	TBD	Pending
Final Presentation	Group 5	TBD	TBD	Pending

Resources

[1] “SP-110-SS: Self-Powered Pyranometer,” Apogee Instruments, Inc. [Online]. Available: https://www.apogeeinstruments.com/sp-110-ss-self-powered-pyranometer/#product-tab-information. [Accessed: 28-Jan-2021].

[2] “Thermocouple types,” https://www.omega.com/en-us/, 14-Oct-2020. [Online]. Available: https://www.omega.com/en-us/resources/thermocouple-types. [Accessed: 28-Jan-2021].

[3] “Raspberry Pi 1 Model B+,” Raspberry Pi. [Online]. Available: https://www.raspberrypi.org/products/raspberry-pi-1-model-b-plus/. [Accessed: 28-Jan-2021].

[4] “Raspberry Pi Zero W,” Raspberry Pi. [Online]. Available: https://www.raspberrypi.org/products/raspberry-pi-zero-w/. [Accessed: 28-Jan-2021].