TEXAS A&M UNIVERSITY
Engineering

EPS Booth: E19

Solar Lighting System

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Problem Definition

As renewable energy sources are becoming more widespread, a drive to incorporate Solar Panels into normal household applications led to this project. Our team has been tasked with creating a self-powered autonomous lighting system that's controlled through a mobile application.

Methodology

The solar lighting system includes 4 subsystem: the solar charge controller, the power inverter, the microcontroller unit, and the mobile application.

Mobile Application

- Developed an Android application that controls lights manually , toggles to motion sensing mode

Microcontroller

- Developed Arduino code to control relay's digital signals provided by motion and app connection

Power

- Assembled 12 - to - 5V Buck Converter, 120VAC Modified Sine Wave Inverter.

Solar Charge Controller

- MPPT (Maximum Power Point Tracking) Constant Voltage, Overvoltage Protect

Figure 1. Multiple angles of the Solar Lighting System.

Engineering Analysis

Our project is unique in the fact that it uses solar charge control to charge a battery. Furthermore, using Bluetooth to control system mode of operations and receive system data posed additional challenges:

A. The solar charge controller design verification, with large amounts of current making selection of components and trace sizes difficult.

B. Power delivery systems testing presented challenges in the DC/AC Inverter, and DC Converter regulation to constant output voltage.

C. Validation of the motion sensor's presented difficulty with sensitivity , and digital signal time delays and Arduino processing for switch control.

D. The mobile app was coded on Android Studio and connects to an Arduino Uno & HC-05 Bluetooth to complete with the wireless system.

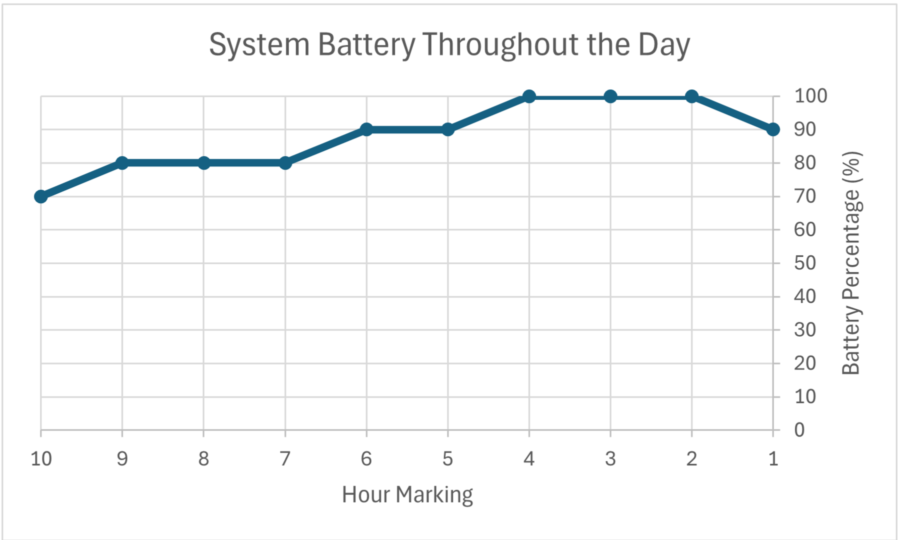


Figure 2. Battery Percentage across 10-hour history, taken from mobile app.

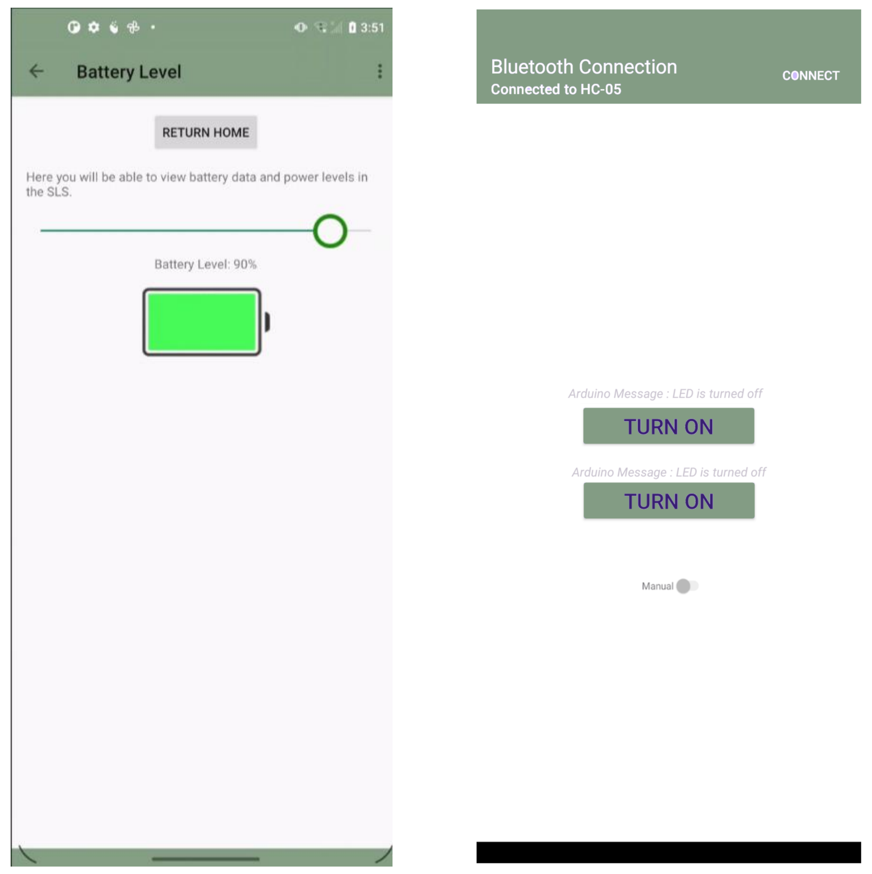


Figure 2. Battery Percentage readings and mode of operation

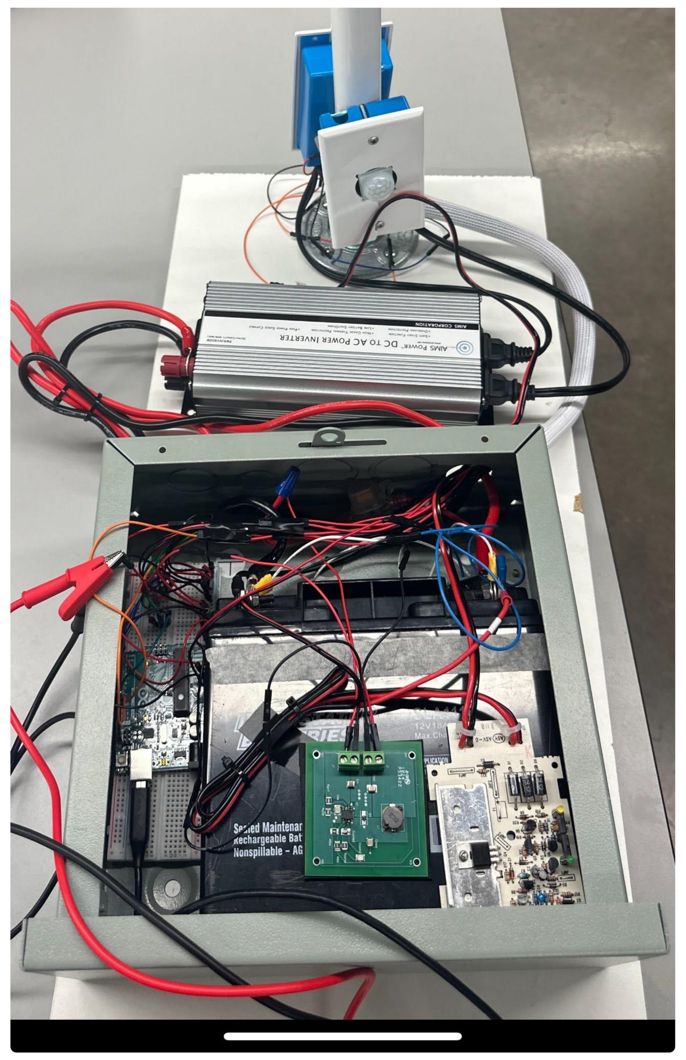
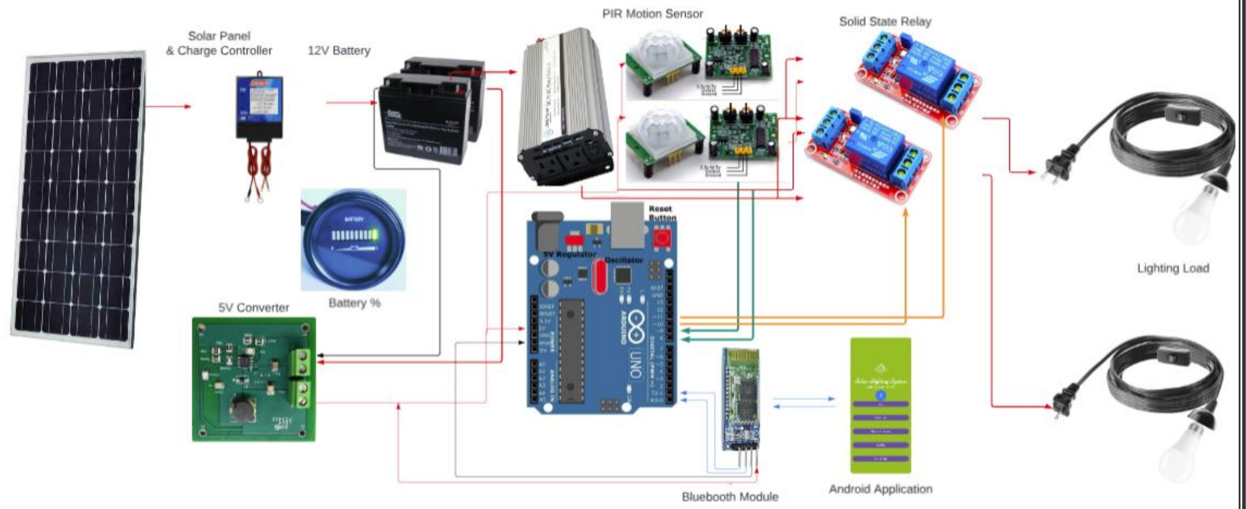


Figure 2. Integrated System Image

Functional Block Diagrams



Outcomes

Our project was able to successfully make the lights work with motion sensing control, as well as make a manual option for them. Unforeseen complications with our mobile application led to no further functions within the app. We also decided to remove the flood light from our initial design, as the power demand would be too great.

Table 1. Charge Control Requirements

Specification	Min	Nominal	Max
Solar Panel Input Voltage (V)	5	21	25
Solar Panel Input Current (A)	1	1.2	1.5
Charge Controller output current (A)	0.5	2	10
Battery Voltage (V)	2.1	12	26
Estimated Battery Life (hours)	5.4	9	27

Table 2. Power Requirements

Supply	Voltage	Current	Power
Bluetooth Module	4.91 V	40mA	185mW
Arduino	4.91 V	37-40 mA	185-200 mW
Switches	4.91 V	10mA	180mW
Sensors	4.91 V	1-2mA	4.91-9.82 mW
		DC Total	550-565 mW
AC Light Load	120V RMS	180-200 mA	21-22W
		Nom. Total	23W

Here is the data for the power requirements of the components coming out of the battery. As shown in previous graph, expected nominal lifetime with these listed power requirements is ~9 hours.

Impact

The solar lighting system allows homeowners to reduce utility expenses through renewable energy sources, and overall helps the power grid in reducing load. For our team, it helped us in learning:

- Design and implementation of power system converters.
- Detailed multi-layered PCB design for large current power systems.
- Mobile Application design and Bluetooth implementation in Arduino microcontroller.

References

1. IEEE 1562-2021 Recommended Practice for Sizing of Stand-Alone Photovoltaic
2. BQ24650 Stand-Alone Synchronous Buck Battery Charge Controller for Solar Power With Maximum Power Point Tracking
3. bq24650EVM Synchronous, Switch-Mode, Battery Charge Controller for Solar Power

Acknowledgements

Dr. Wonhyeok Jang, Dr. John Lusher, Pranav Dhulipala, Rhett Guthrie