Remotely Accessible Portable Solar Charging Evaluation System

Department of Electrical and Computer Engineering, Lafayette College

SCAN ME

SENIOR DESIGN 2023 LAFAYETTE COLLEGE ECE

LAFAYETTE ENGINEERING

Overview

Our team built a remotely accessible portable solar charging evaluation system. The main objective of the proposed system is to collect environmental, directional, and performance data and transmit them wirelessly to a remote computer. The proposed system attempts an electrically equivalent output of the Honda EU2200i portable generator with the help of solar panels to power recreational applications and provides a more environmentally friendly alternative. The system consists of solar panels, housing for internal electronics, a steerable panel mount, a 12V battery, an inverter, a solar tracking mechanism, wireless data transmission, and environmental and performance sensors.

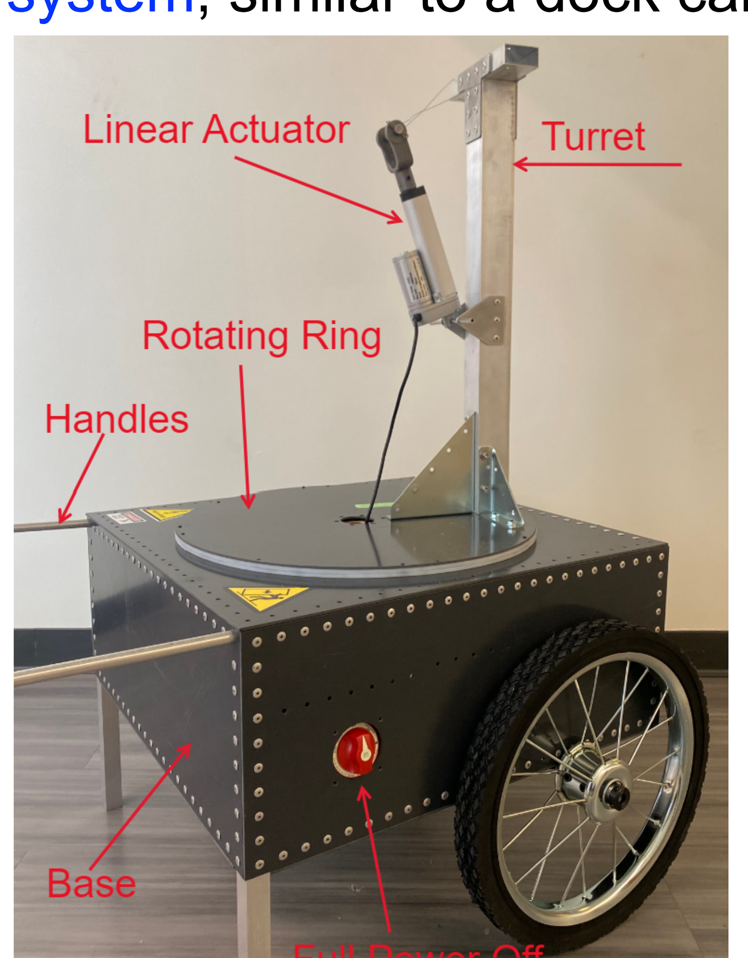
Design Specifications

- Power/Electrical: should provide a standard AC 110V 60Hz output voltage with a load capability meeting or exceeding nominal 20 Amps.
- Battery: solar charge storage should be a 12V battery.
- Mechanical Structure: the system should be portable and accommodate various but reasonable terrain.
- Data Collection: should acquire temperature, pressure, humidity, battery temperature, and solar intensity data and transmit it to a remote computer.
- Solar Tracking: should be set at a fixed angle, run in a user defined path mode, and a solar feedback tracking mode.

Mechanical Design

- We have elected to design a base and a turret, with the solar panel and its elevation mechanism mounted on the turret, which rotates on the base.

- There is also a requirement for unpowered movement; thus, we have elected to mount the base on a wheel system, similar to a dock cart/wheelbarrow.



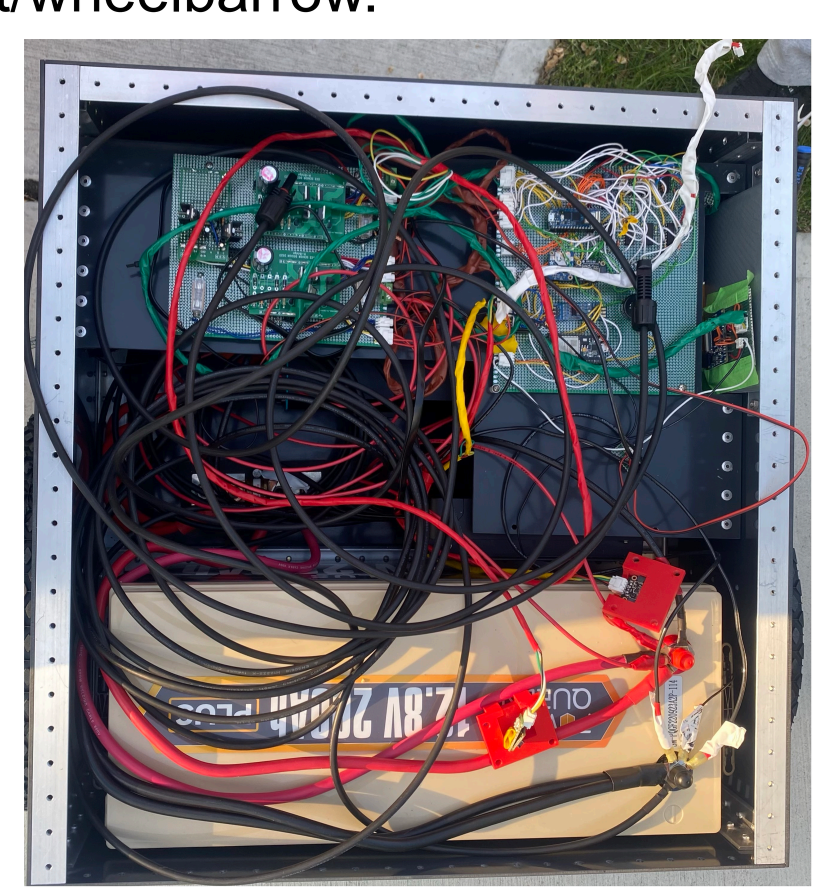


Fig. 1. Outer (left) and inner (right) sections of the mechanical structure.

Power Electronics

H-Bridges: implemented by two power P-channel MOSFETs, two power N-channel MOSFETs, and two regular N-channel MOSFETs to move the motors.

Step-down circuit: step-downs stage from 12.8V to 6V using an LM2596 buck converter, followed by a regulation stage to 5V using two Low Dropout Regulators.

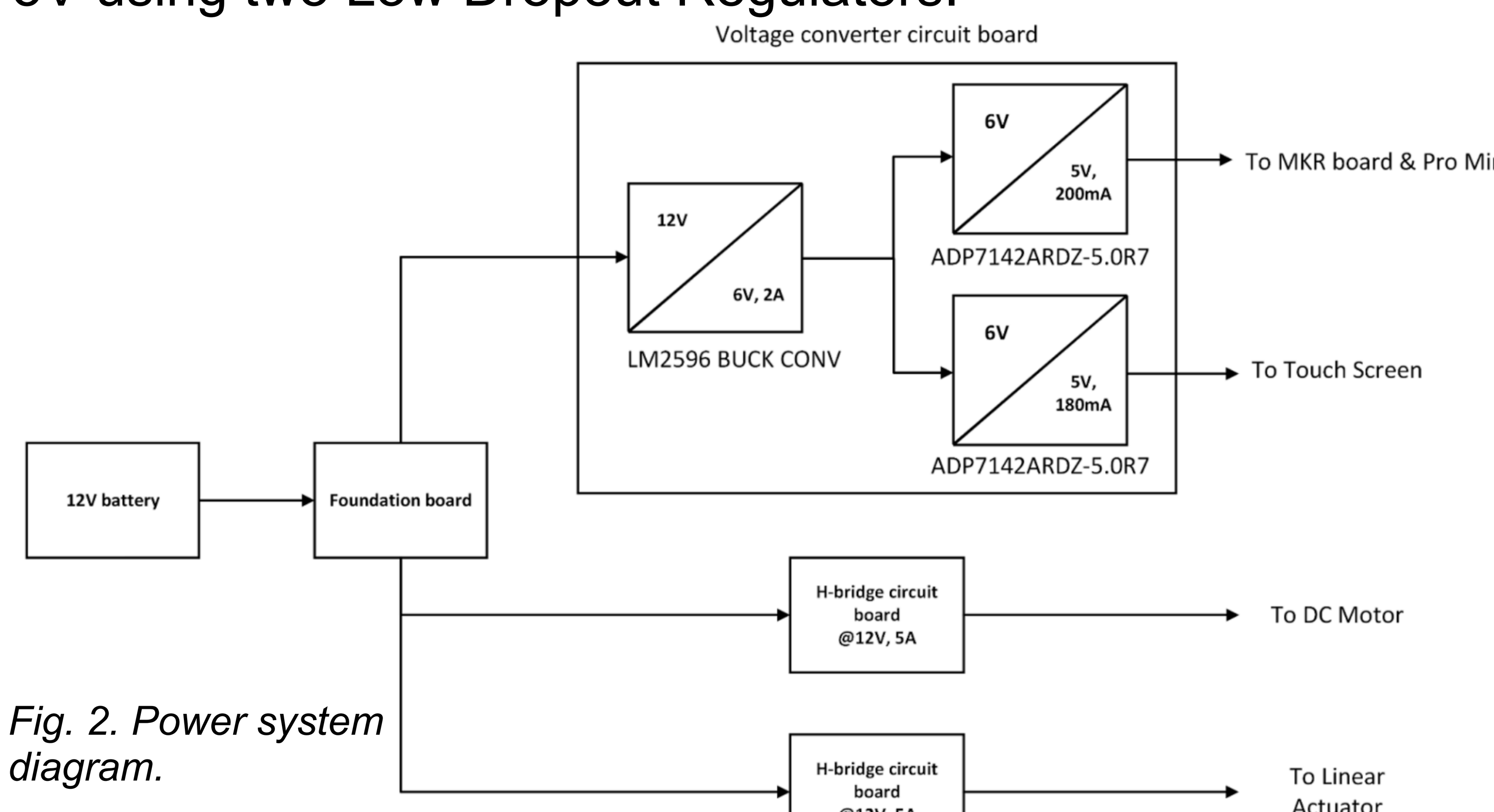


Fig. 2. Power system diagram.

The control of H-bridge is accomplished by four signal inputs with each controlling one MOSFET.

Two-step voltage regulation system provides higher efficiency, reduced power dissipation, and lower voltage drops.

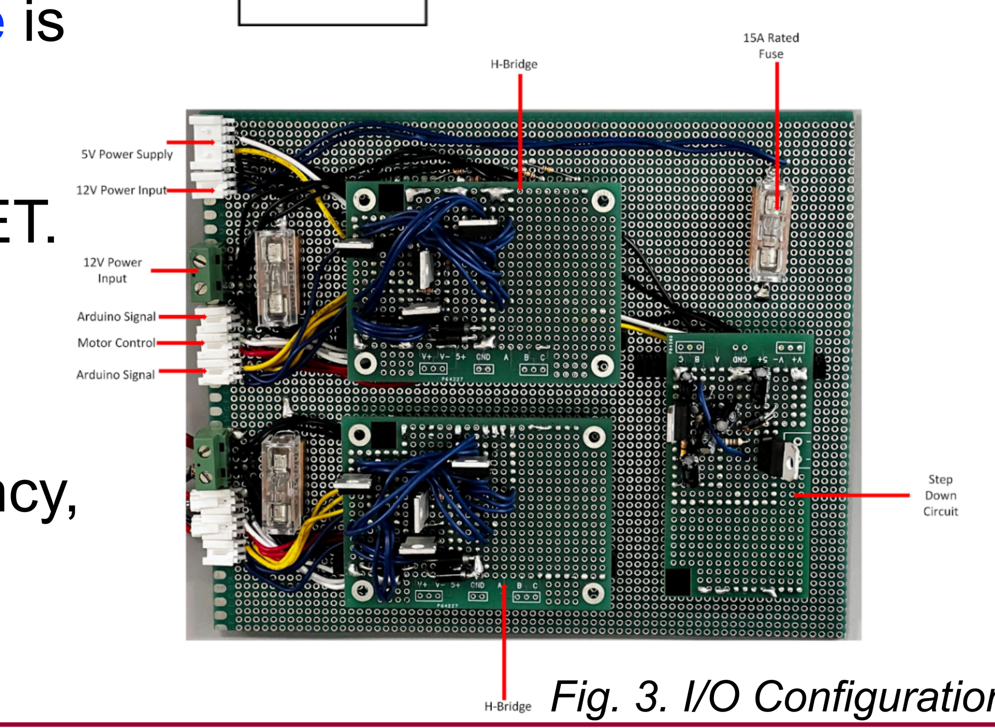


Fig. 3. I/O Configuration.

Digital Design

Sensors are wired across two MCU's:

- The first MCU is the Arduino Nano RP2040 which controls the functionality of the system as well as Wi-Fi connectivity.
- The second MCU interfaces with the charge controller and transmits the relevant data to the other Arduino.

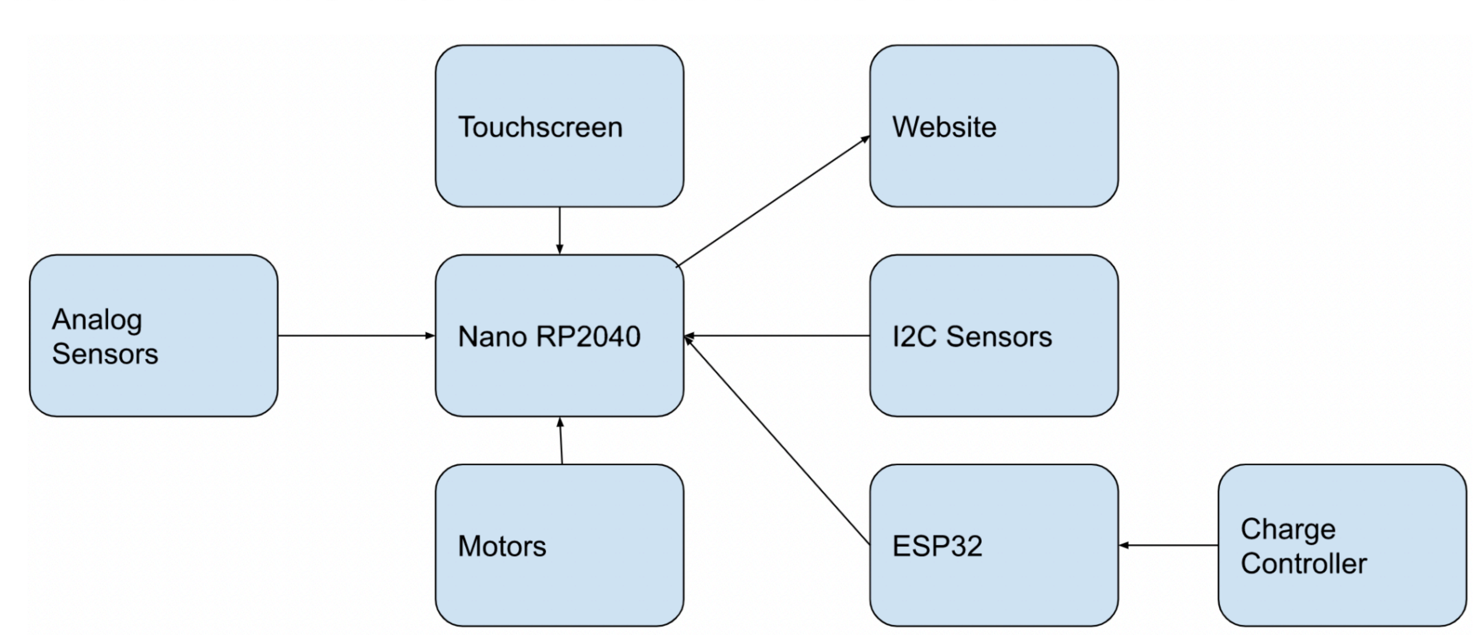


Fig. 4. High Level Overview of a Digital Design.

Sensors

AC Current - confirm the correct output from the inverter
AC Voltage - confirms the correct output from the inverter
DC Voltage - monitors car battery voltage and battery levels
Battery Temp - for safety purposes so system can shut off
Temp/Humidity/Pressure - monitors environmental data
LDR Photoresistors - for closed-loop solar tracking
Compass & Accelerometer - detect orientation of the solar panels for solar tracking
Real time clock - keeps track of time for the closed-loop solar tracking
Charge Controller Interface - pulls relevant information from the charge controller using an FTDI converter

Solar Tracking

Open-loop: Values of the different starting azimuth and altitude angles for each morning and every hourly change afterwards until dawn are stored as an array.

Closed-loop: photoresistors are placed in the four slots. Wheatstone bridge with instrumentation amplifier are used to determine the direction in which to move the panel in order to track the sun.

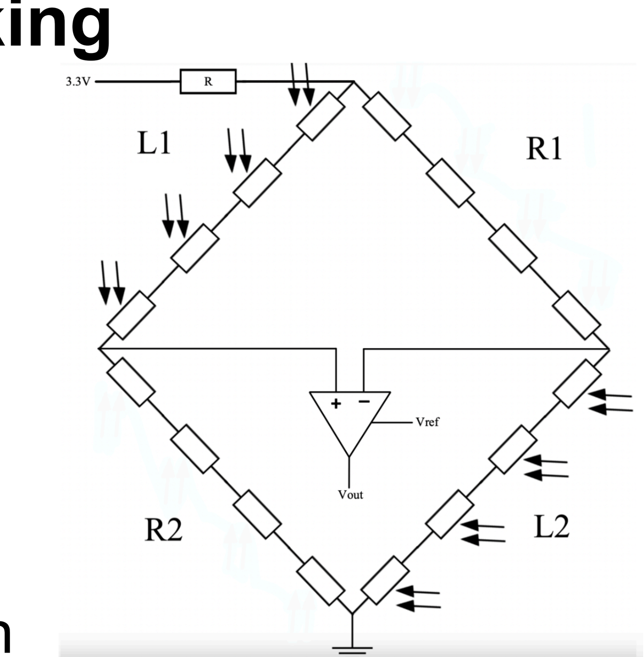


Fig. 5. Wheatstone bridge for closed loop solar tracking.

Wireless Data Transmission

The remote dashboard is a web application which communicates with the system to transmit environmental data over WiFi. The user can also choose what tracking algorithm they would like the system to use remotely.

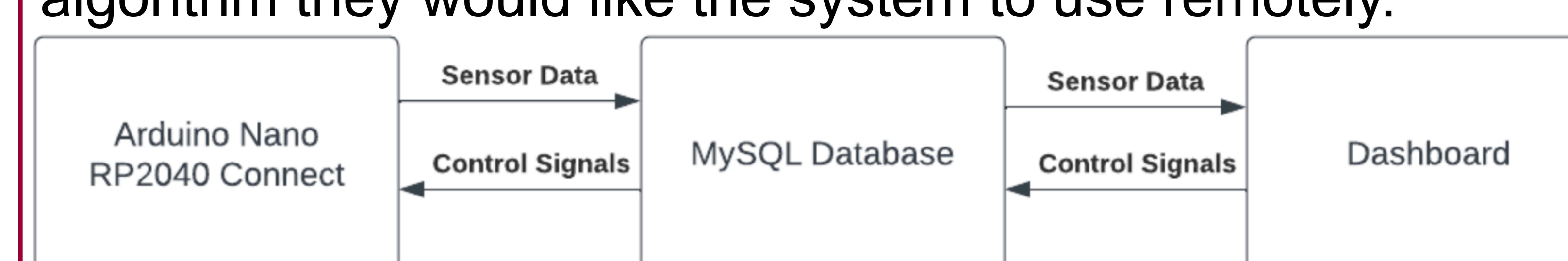


Fig. 6. Sensor data flow from the Arduino to the dashboard.

Results

- Mechanical Structure: allows for easier transportation and the detachability allows for the user to replace any parts if needed without a hassle.
- Power System: ensures safe, error-free, and modular implementation of power conversion and motor control.
- Digital Design: designed a touch screen interface with a network of the MCUs that communicate with each other, read sensors, and subsequently drive motors.
- Solar Tracking: provides an option for user-defined path tracking, open-loop tracking based on azimuth and altitude angles, and closed-loop tracking using photoresistors.