Automated Rotating Solar Plant Rack with Self-Care Capabilities

Group 23

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Our Team

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Introduction

- Gardening is a wonderful hobby that not only provides comfort and food to billions but also enriches the Earth by reducing carbon output.
- However, plant maintenance can be time-consuming and easy to blunder. Those with a busy schedule and/or lack of a green thumb may avoid gardening because of this.
- All those setbacks can be eliminated with an automated plant care tools! Sensors, water pump and soil piping, shading, rotation, and plant settings application will allow one to have plants without worrying about maintenance.

Project Goals & Objectives

- To create a system that will autonomously provide water and sunlight to a plant
- To create a system that can assure its plant grows straight up rather than towards the light source
- To provide a method for caring for a plant when one cannot be present
- To create an easy-to-use interface that can be leaned in a short period of time

Motivation

- Interest in Smart Home Technology
- Previous Experience with Plants

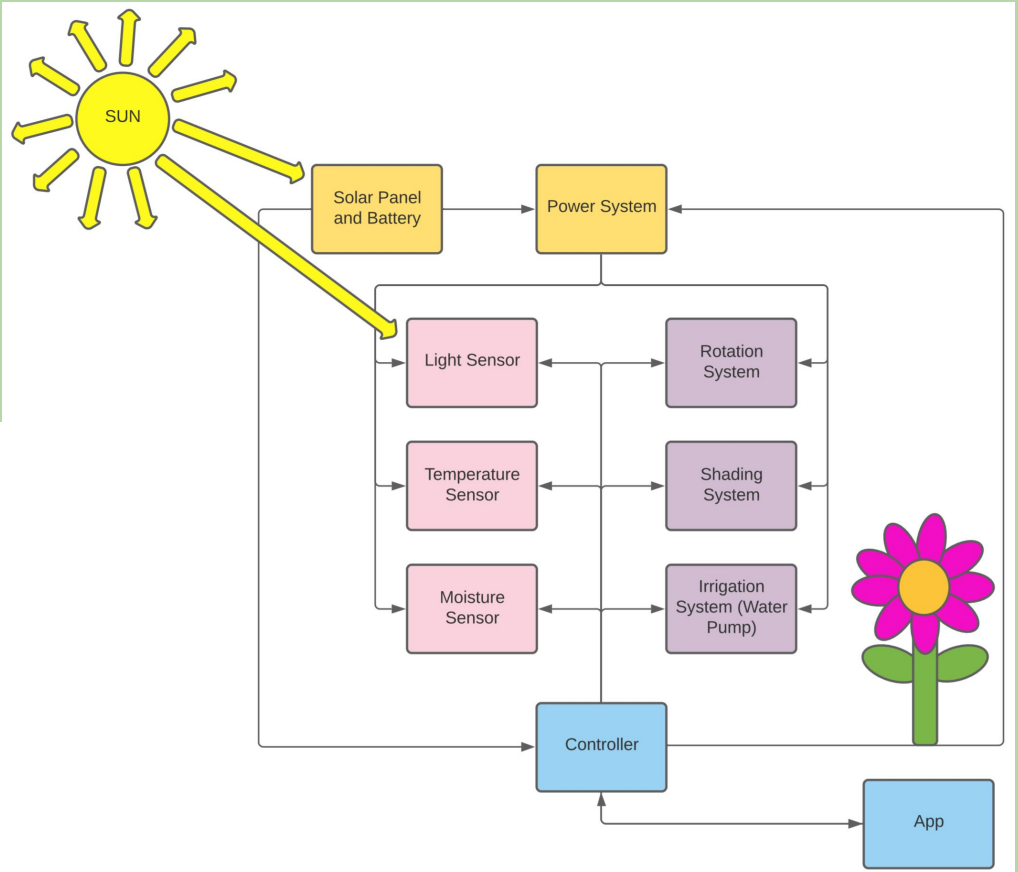
Similar Project

- EasyHerb
  - Spring 2020 - Summer 2020
  - A remote access hydroponic herb growing system.

- Similarities
  - Irrigation system
  - Light, temperature, and moisture sensor
  - Wi-Fi Module
  - App for remote access

- Differences
  - Grow herbs
  - Power from wall outlet
  - Lightning System
  - Nutrient Pump
  - Lack of rotation
  - Lack of shading

Block Diagram



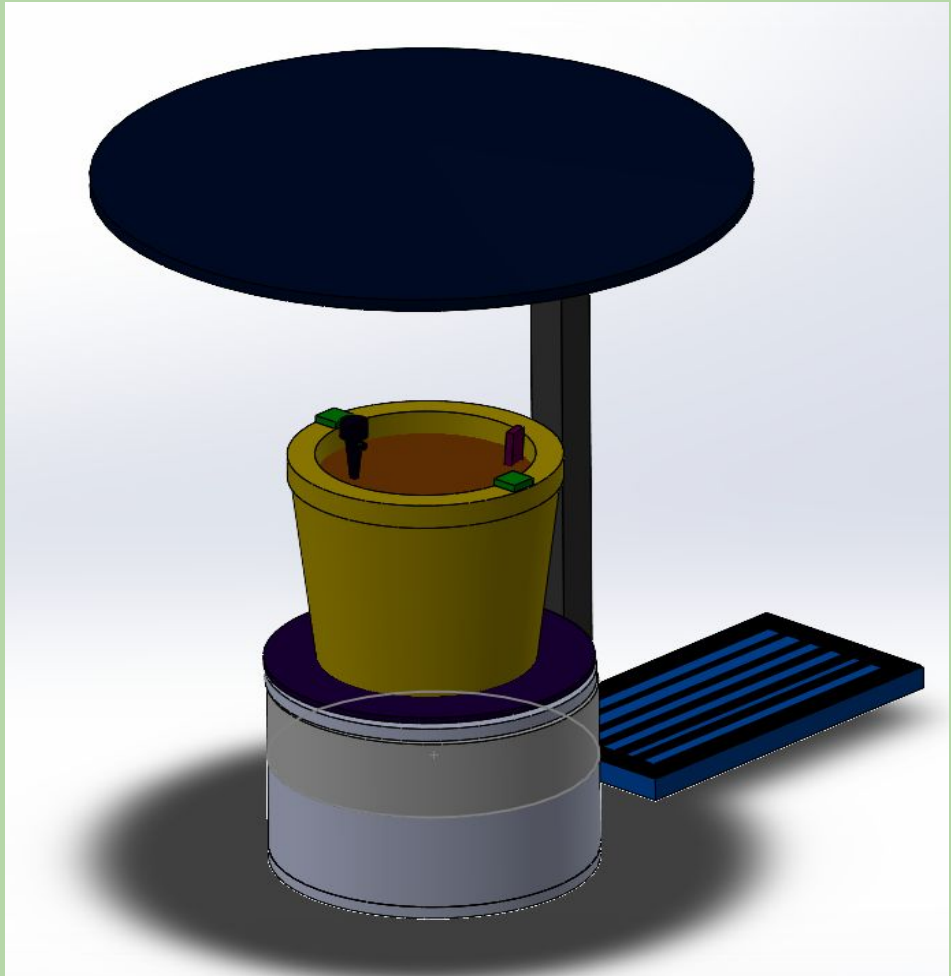
Brian Geibig - Electromechanical Output Systems

Abigail Michael - Application and Software Development

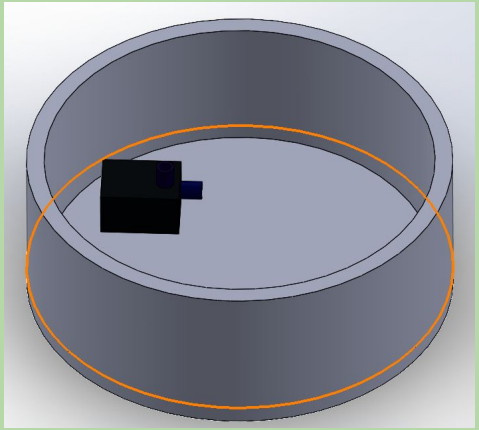
Christina Quinones - Power System and Electromechanical Input Systems

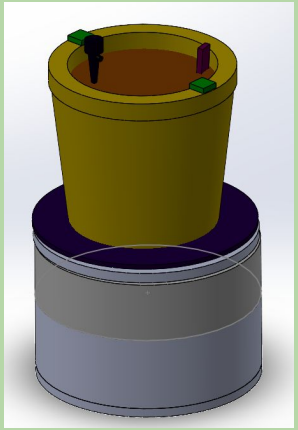
Melissa Rose - Sensors and Controller/Application Development

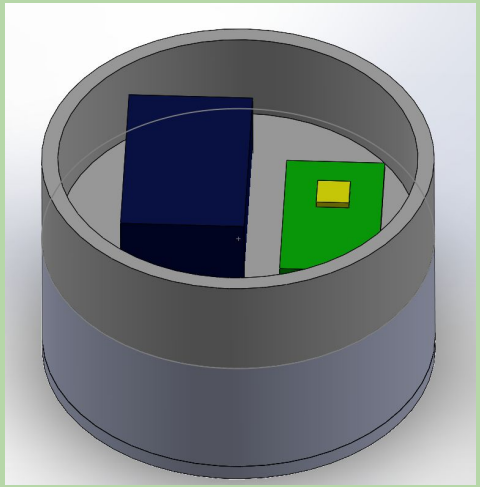
Physical Design

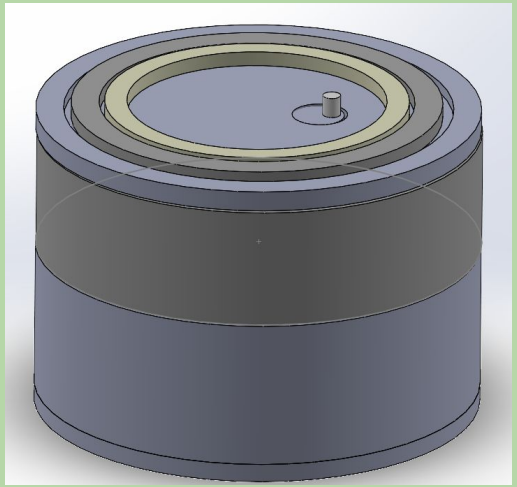


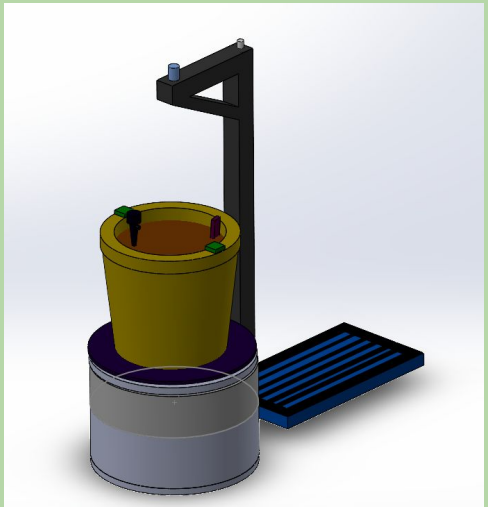
Physical Design





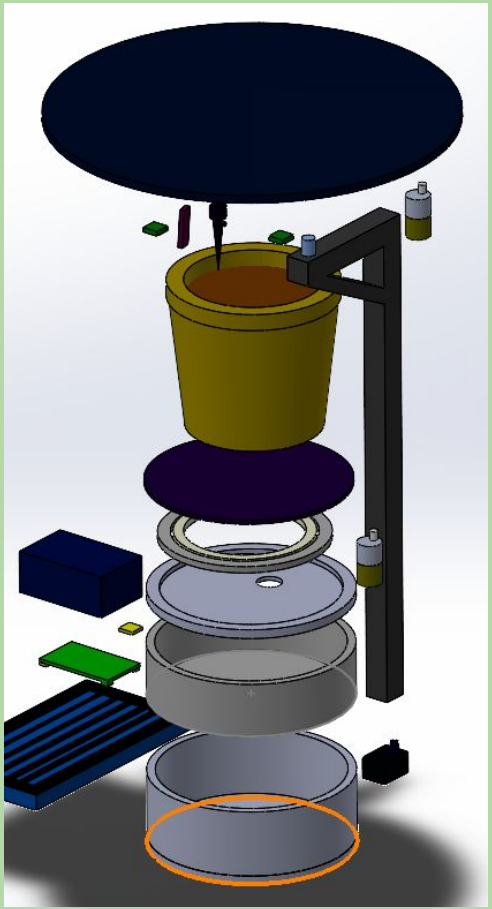


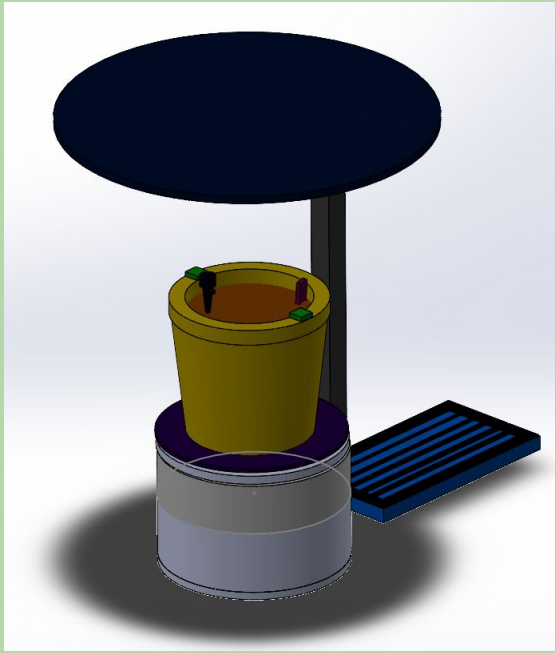




Physical Design

Height: 30”
Base diameter: 12”





Requirement Specifications Table - Power

Part	Requirement	Justification
Power System	Output Power > 20W	To provide power to all sensors and systems while remaining power efficient
Battery	Capacity ≥ 5 Ah	To provide a sufficient power supply to all components
Solar Charge Controllers	Output Voltage 12.6 - 13.7V	To have overcharge protection
Voltage Regulators	Output Voltage Tolerance: ±4%	To accurately regulate 3.3V and 5V

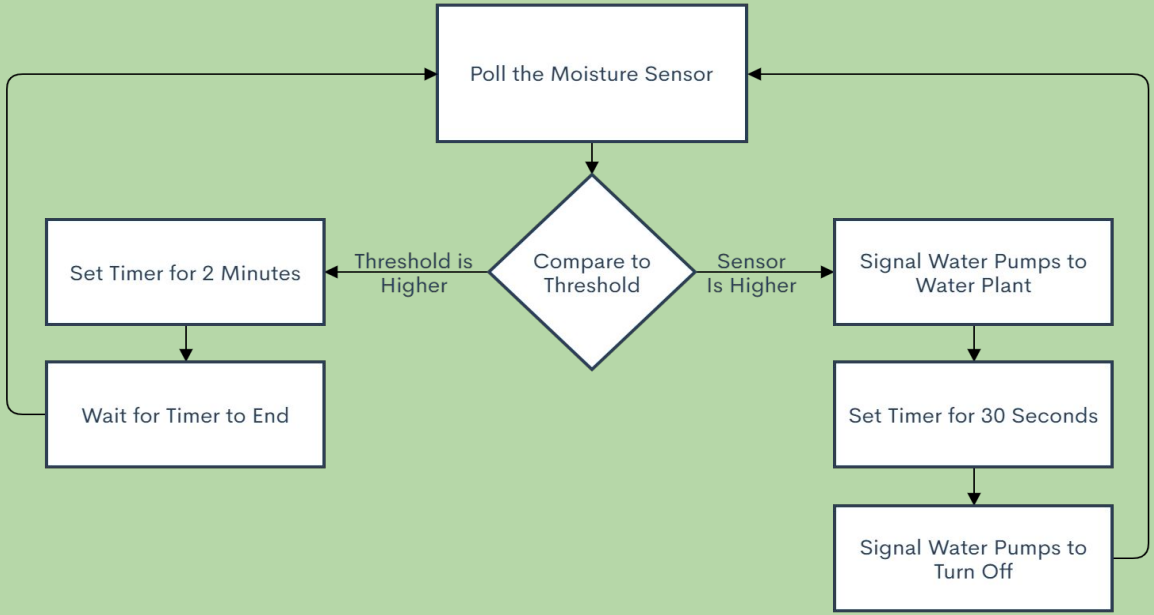
Requirement Specifications Table - Hardware

Part	Requirement	Justification
Irrigation System	Operating Voltage < 12V Response Time Upon Input < 10 sec	So the water can fill the pot when requested while remaining power efficient
Light Sensor	Detects >7000 lux Displays Measurement < 1 sec	To accurately measure the intensity of the Sun
Moisture Sensor	Displays Measurement < 1 sec	So the sensor provides accurate soil water detection
Rotation System	Completes rotation < 30 seconds	To provide a more efficient system

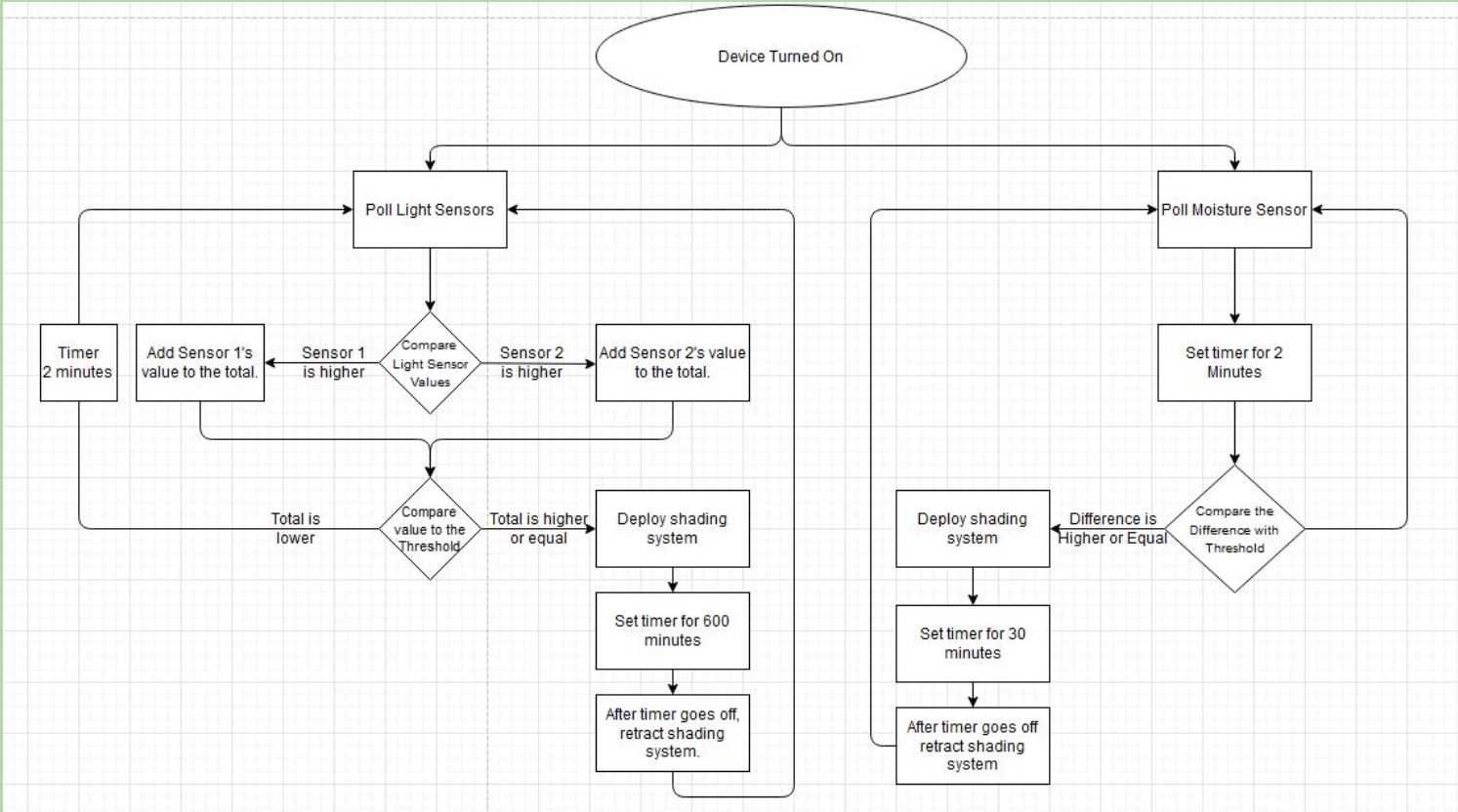
Requirements Specifications - Software

Part	Requirement	Justification
Wi-Fi Module	Max Current < 250 mA Response Time < 3 sec	To provide a more power efficient system and successfully communicate with Arduino microcontroller
Microcontroller	Current: < 50 mA Operating Voltage: 5V	So the microcontroller can sufficiently control the system while remaining power efficient
Application	Pull Data from Database < 1 sec Update Status Page < 5 sec Access Time < 3 seconds	To provide a more user friendly and efficient experience

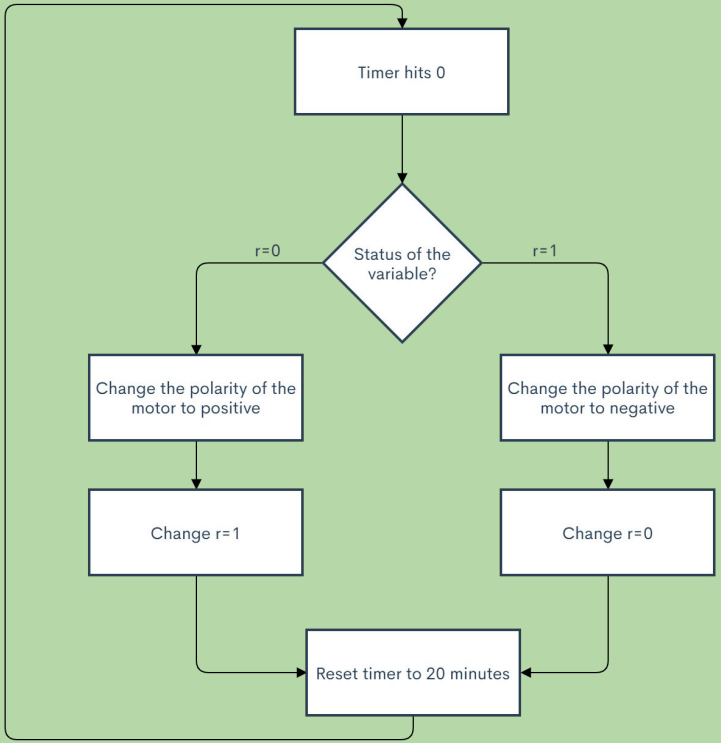
Irrigation System



Shading System

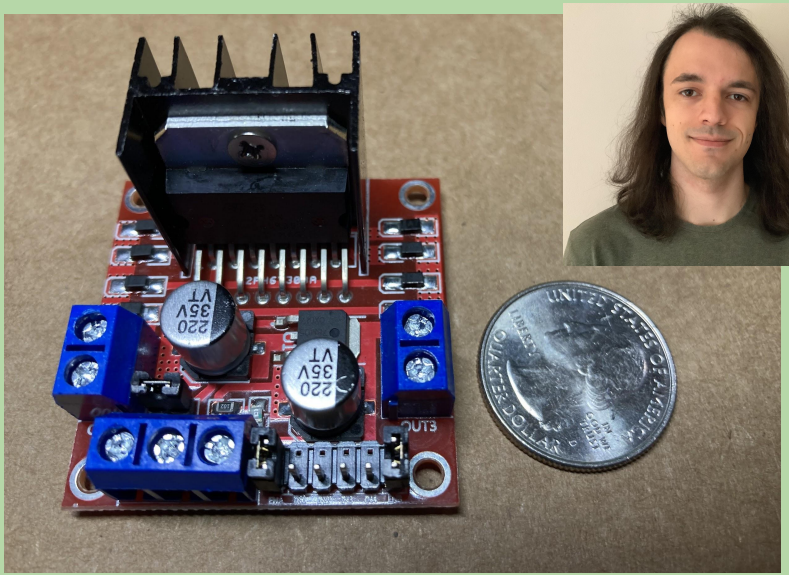


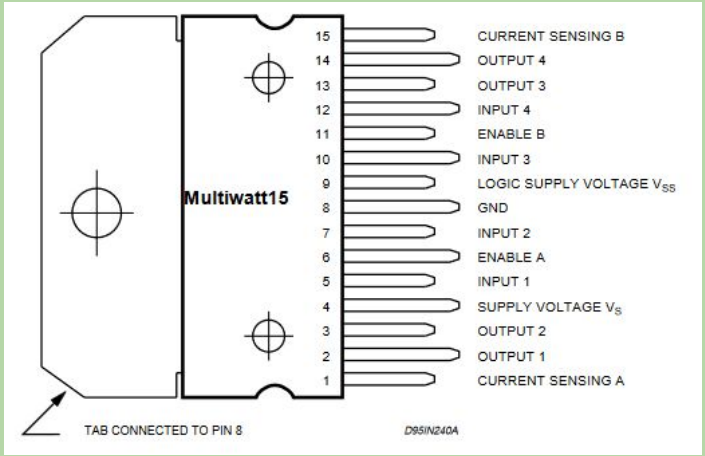
Rotational System

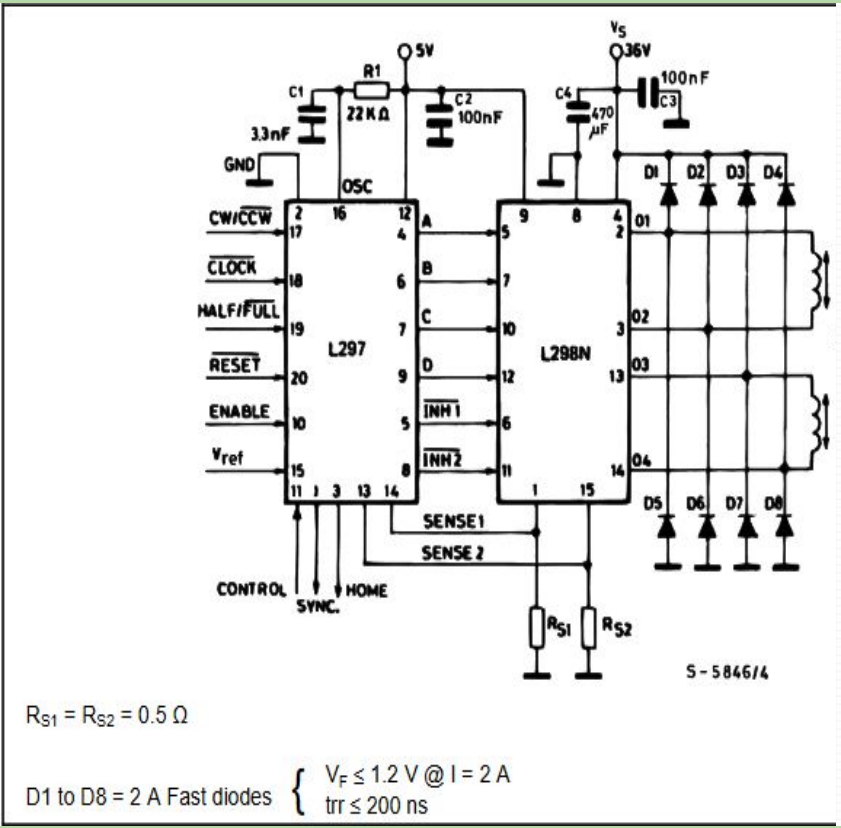


Motor Drive Controller

L298N Dual Full-Bridge Driver

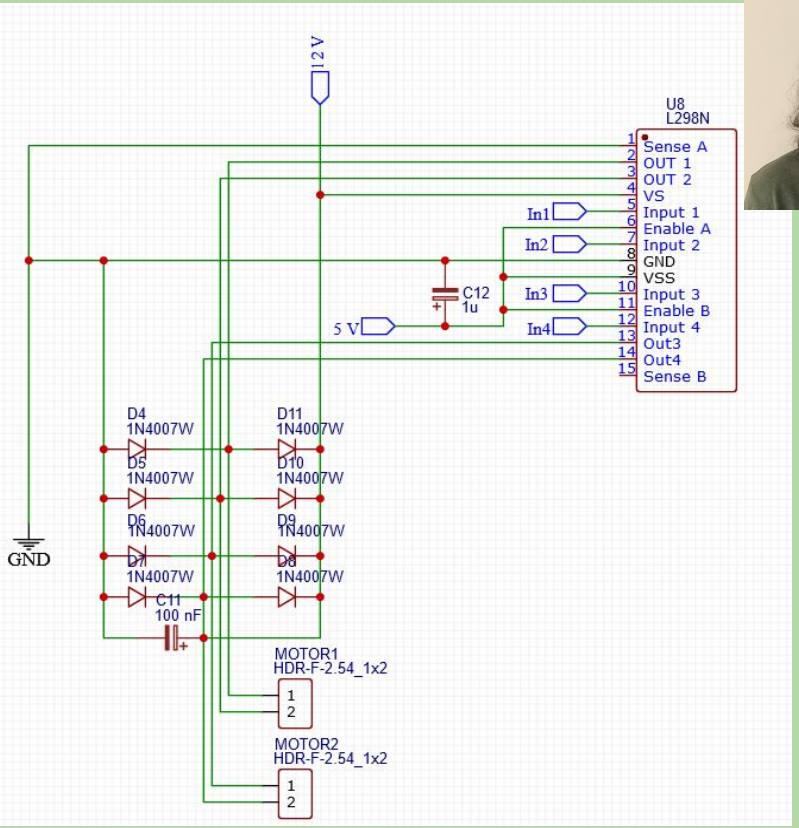




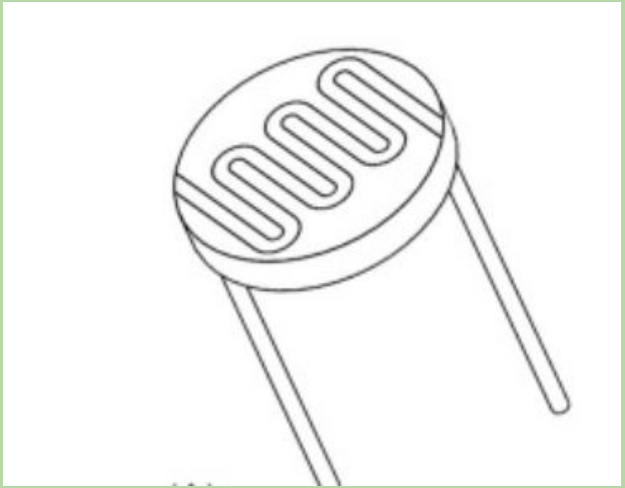


$R_{S1} = R_{S2} = 0.5\ \Omega$

D1 to D8 = 2 A Fast diodes { $V_F \leq 1.2$ V @ I = 2 A; trr ≤ 200 ns



Light Sensor Comparison



Light Sensor Comparison

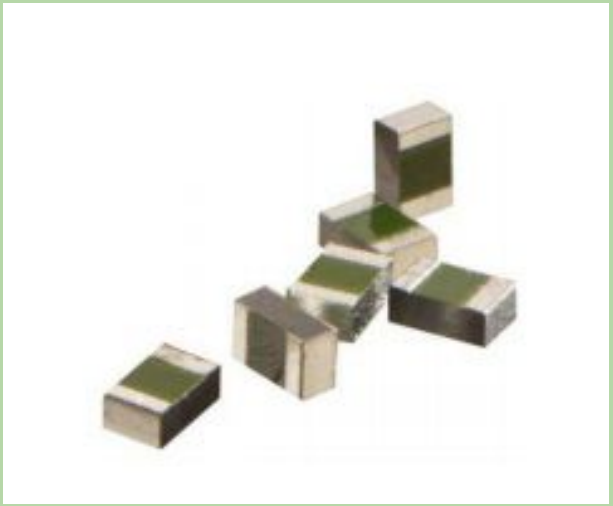
Photocell

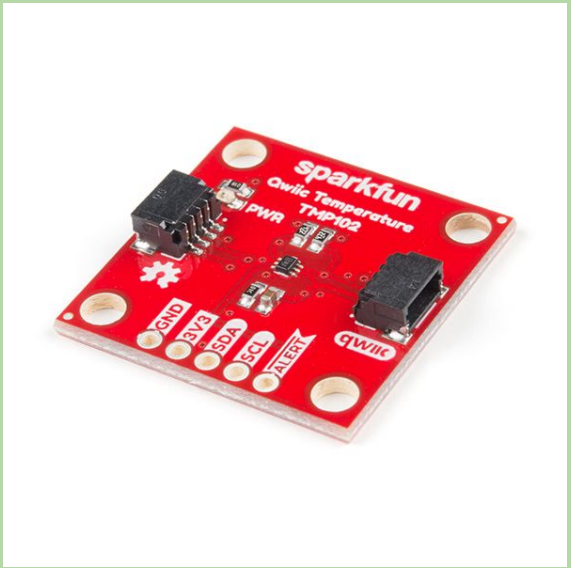
- Purpose: Sunlight Detection for Shading System
- Product: Multiple Vendors (SparkFun, Adafruit, etc)
- Core Element: Photoresistor
- Output: Analog
- Light Detection Range: 0 - 10000 lux
- Operating Voltage: <100 V
- Communication: Analog
- PCB Connection: Throughhole
- Price: $1.00

SparkFun Ambient Light Sensor - VEML6030

- Purpose: Sunlight Detection for Shading System
- Product: SparkFun Ambient Light Sensor with Qwiic Ports
- Core Element: Photodiode (VEML6030)
- Output: Digital
- Light Detection Range: 0 - 120000 lux
- Operating Voltage: 3.3 V
- Communication: I^2C
- PCB Connection: Attached to Surface-Mounted Qwiic Port
- Price: $5.25

Temperature Sensor Comparison





Temperature Sensor Comparison

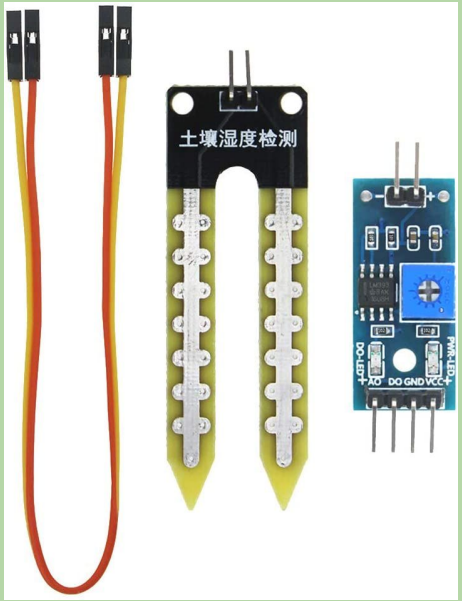
TE Connectivity NTC 10k Thermistor 0603

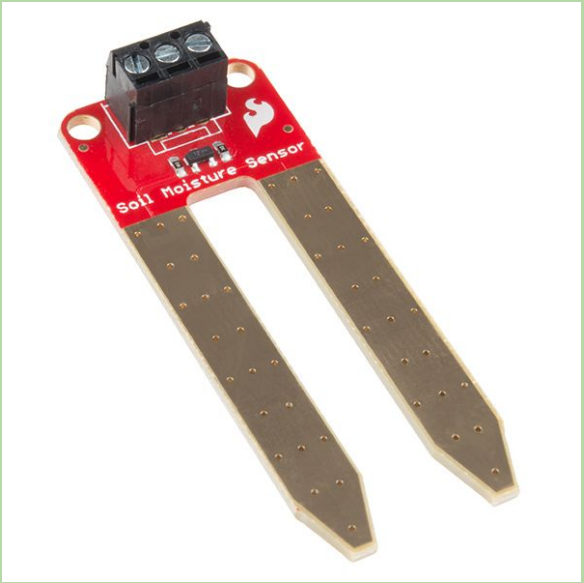
- Purpose: Temperature Measurement for the Shading System
- Product: SparkFun Temperature Sensor with Qwiic Ports
- Core Element: Thermistor
- Output: Analog
- Temperature Detection Range: -40°C - 125°C with accuracy of 0.3°C
- Operating Voltage: 3.3 V
- Communication Feature: Analog
- PCB Connection: Directly Surface-Mounted
- Price: $0.83

SparkFun TMP102 Temperature Sensor

- Purpose: Temperature Measurement for the Shading System
- Product: SparkFun Temperature Sensor with Qwiic Ports
- Core Element: Digital Temperature Sensor (TMP102)
- Output: Digital
- Temperature Detection Range: -40°C - 125°C with accuracy of 0.3°C
- Operating Voltage: 3.3 V
- Communication Feature: I^2C
- PCB Connection: Attached to Surface-Mounted Qwiic Port
- Price: $6.50

Moisture Sensor Comparison





Moisture Sensor Comparison

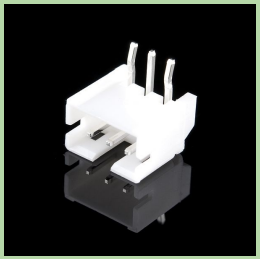
KeeYees Soil Moisture Sensor

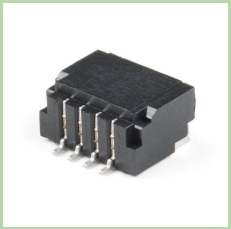
- Purpose: Soil Moisture Measurement for the Irrigation System
- Vendor: KeeYees
- Output: Analog and Digital
- Plating: Nickel
- Supporting Element: Comparator (LM393), potentiometer
- Operating Voltage: 3.3 - 5 V
- Price: $7.99 for 5

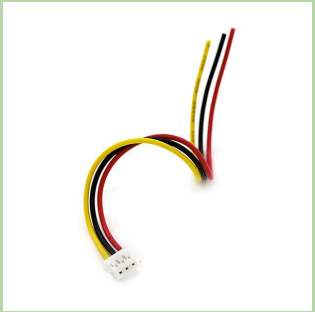
SparkFun Soil Moisture Sensor

- Purpose: Soil Moisture Measurement for the Irrigation System
- Vendor: SparkFun
- Output: Analog
- Plating: Gold
- Operating Voltage: 3.3 - 5 V
- Price: $5.95 for 3

Sensor Connectors







- The JST/Qwiic connectors will go from the sensors on the plant's pot to the PCB.
- Ports will be soldered on to the PCB for the wire connections.
- Benefits: Modularity and Ease of Access

Microcontroller Requirements

- Must consist of multiple GPIO pins
- Must be compatible with the chosen sensors
- Must be able to conduct I2C communication
- Must have a high clock speed
- Must be small enough to fit on the PCB
- Must be cost effective

Microcontroller Selection

MSP430FR6989

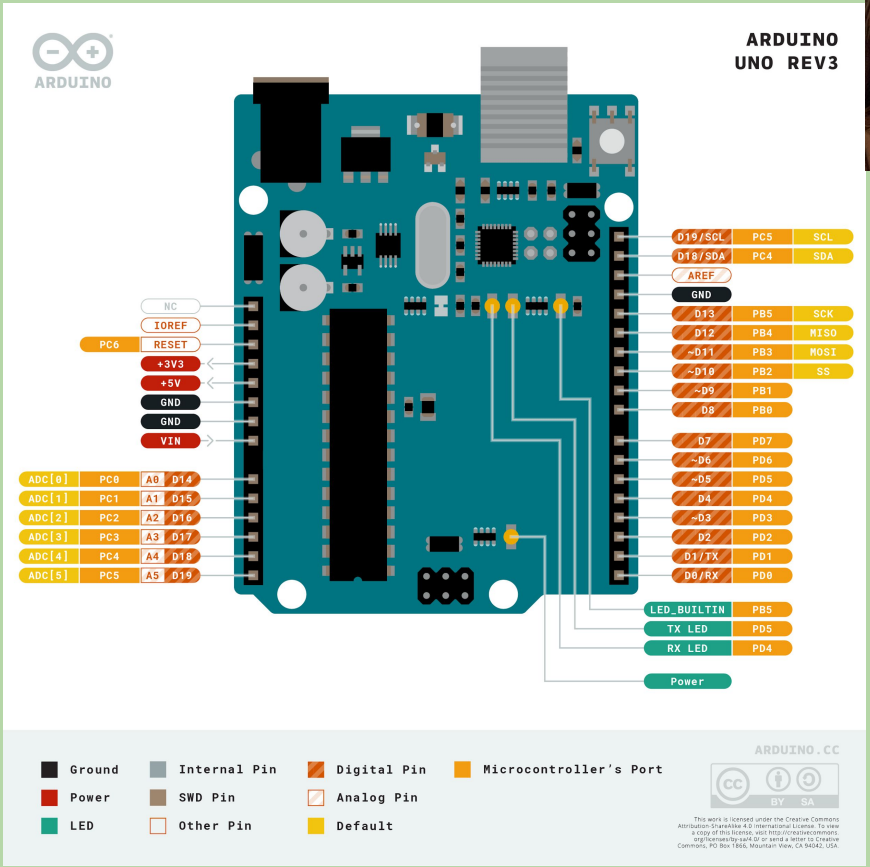
- Chip: MSP430
- SRAM: 2 KB
- Clock Rate: 16 MHz
- GPIO Ports: 83
- Cost: $20.00
- Operating Voltage: 3V
- Manufacturer: Texas Instruments
- Size: 76.2 x 50.8 mm

Arduino Uno

- Chip: ATmega328
- SRAM: 2 KB
- Clock Rate: 16 MHz
- GPIO Ports: 14
- Cost: $23.00
- Operating Voltage: 5V
- Manufacturer: Arduino
- Size: 68.6 x 53.4 mm

Arduino Uno

- 2 KB SRAM & 16 MHz clock rate
- 14 GPIO Ports
- Capable of both 5V and 3.3V
- Price: $23.00
- Arduino open source
- Availability of tutorials



Communication Systems Comparison

WiFi

- Better user security
- Range: 100 meters
- Purpose: Internet access
- Power Consumption: High
- Frequency Range: 2.4 & 5 GHz

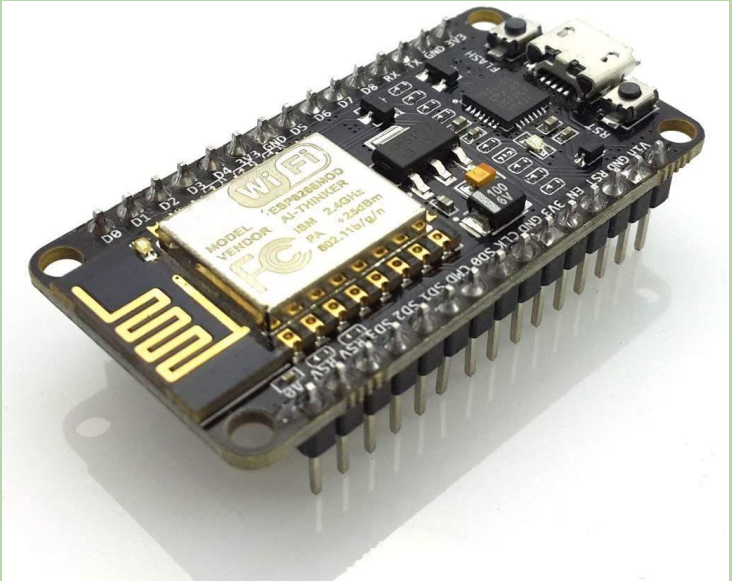
https://techdifferences.com/difference-between-bluetooth-and-wifi.html

Bluetooth

- Lesser user security
- Range: 10 meters
- Purpose: Personal interconnectivity
- Power Consumption: Low
- Frequency Range: 2.4 - 2.483 GHz

Wi-Fi Module


ESP-01S
5 Series


Wi Fi
MODEL ESP8266MOD
VENDOR AI-THINKER
ISM 2.4GHz
PA +25dBm
802.11b/g/n

WiFi Module Comparison

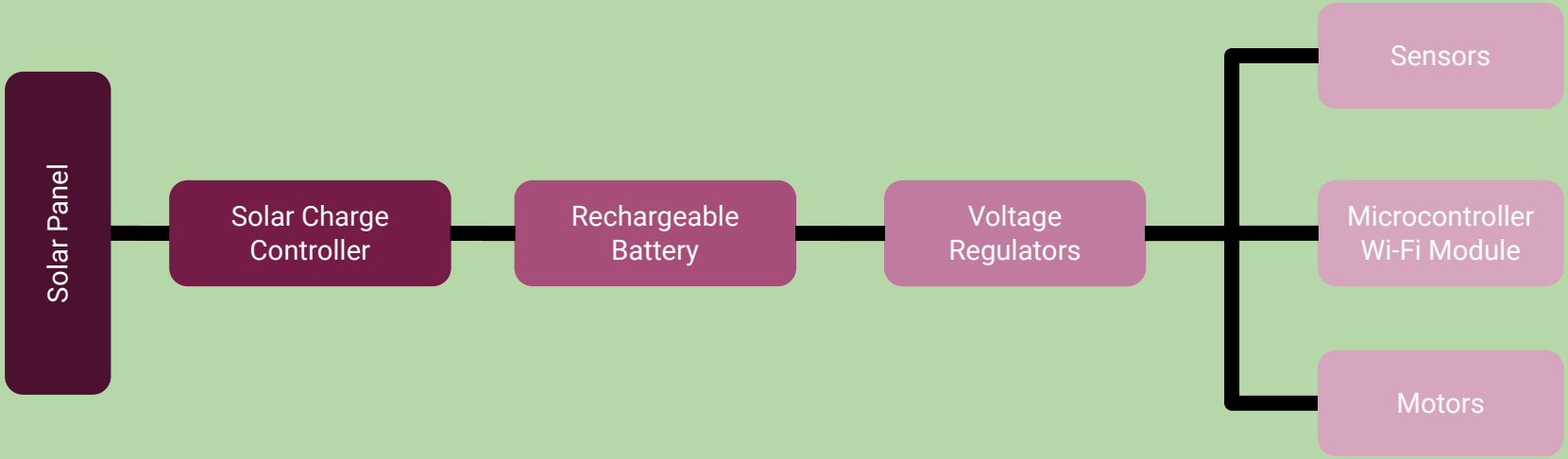
ESP-01

- Chip: ESP8266
- Operating Voltage: 3.3 V
- WiFi Modes: 802.11b/g/n
- 2.4 GHz
- GPIO Ports: 2
- Price: $12.99 for Quantity of 4
- PCB Placement: Board On Top

NodeMCU

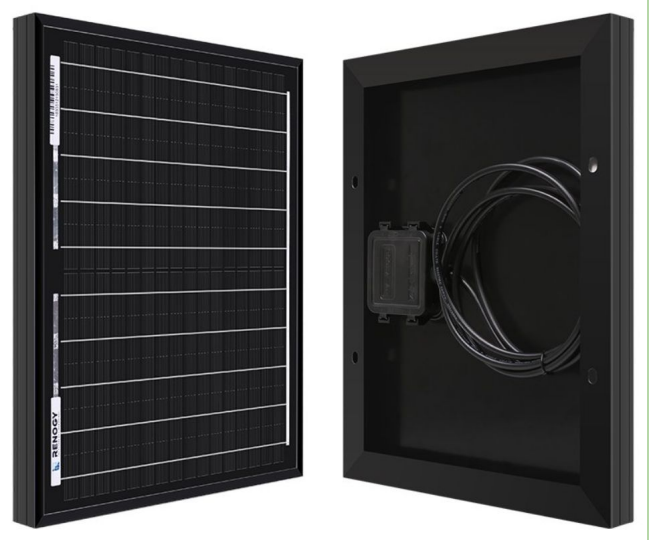
- Chip: ESP8266 (ESP-12F)
- Operating Voltage: 3.3 V
- WiFi Modes: 802.11b/g/n
- 2.4 GHz
- GPIO Ports: 16
- I2C
- Price: $13.99 for Quantity of 3
- PCB Placement: Chip Only

Power System



Solar Panel

Renogy



Newpowa

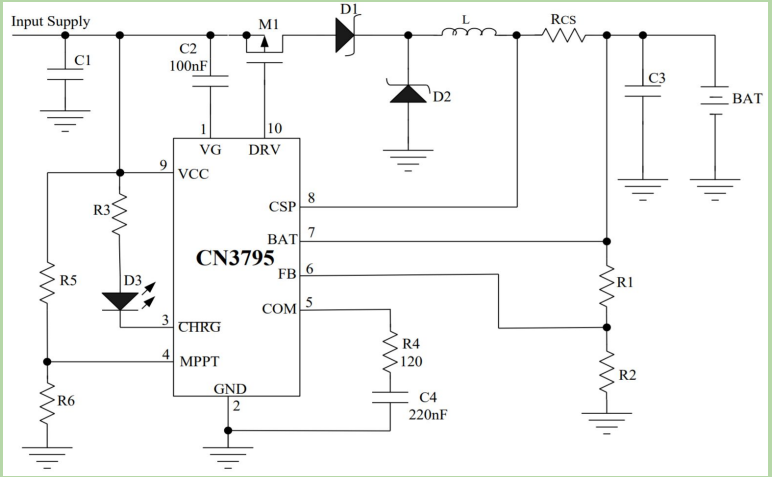
Solar Panel Comparison

- Renogy 10W 12V
- Monocrystalline
- Corrosion-Resistant
- Multi-layered Sheet Laminations
- Bypass Diodes
- Operating Temperature: -40°C to 90°C
- Efficiency 95%
- Dimensions: 10.6”x13.4”x1.0”
- Weight: 1.2 pounds
- Price: $33.99

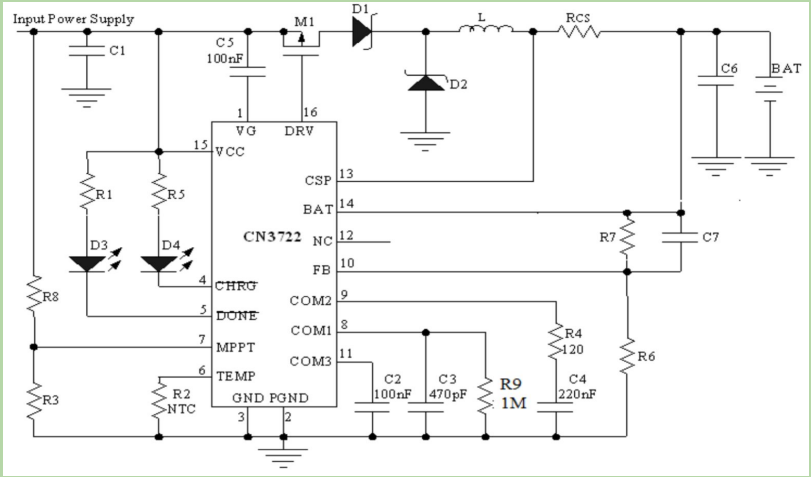
- Newpowa 10W 12V
- Monocrystalline
- Corrosion-Resistant
- Multi-layered Sheet Laminations
- Operating Temperature: -40°C to 85°C
- Efficiency 95%
- Dimensions: 14.37”x7.68”x0.91”
- Weight: 2 pounds
- Price: $27.70

Solar Charge Controller

CN3795



CN3722



Solar Charge Controller Comparison

CN3795

- Wide Input Voltage: 6.6V to 30V
- Maximum Continuous Charge Current: 4A
- Maximum Power Point Tracking Function
- Step-down PWM Charge Controller
- Regulation Voltage can be adjusted
- CC and CV Charging Mode
- Charging Indication
- Works for Single- and Multi-cell Lithium ion, LiFePO4, or Lithium Titanate Batteries
- Automatic Recharge

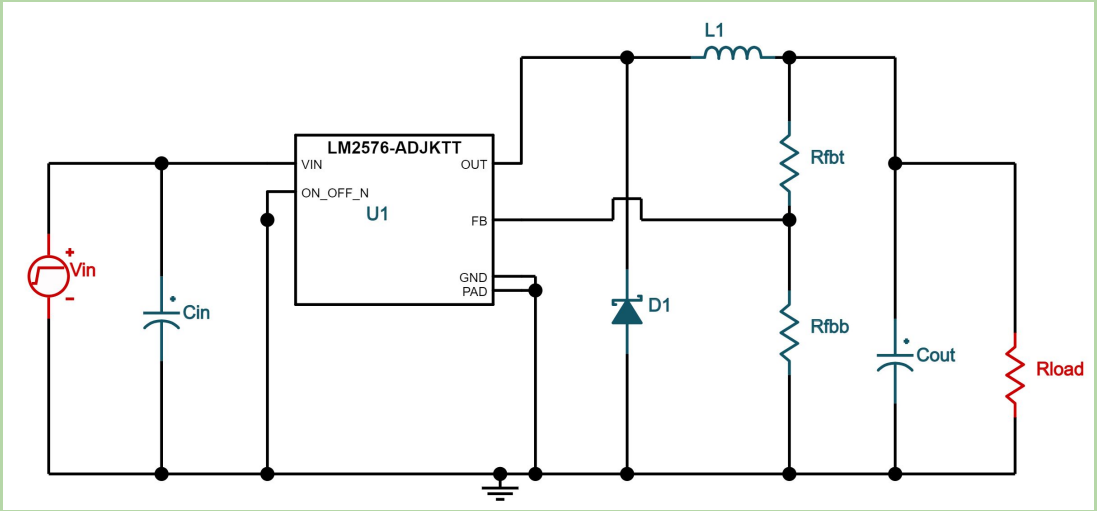
CN3722

- Wide Input Voltage: 7.5V to 28V
- Maximum Continuous Charge Current: 5A
- Maximum Power Point Tracking Function
- Step-down PWM Charge Controller
- Regulation Voltage can be adjusted
- CC and CV Charging Mode
- Charging and Termination Indication
- Works for Single- and Multi-cell Lithium ion or LiFePO4 Batteries

Rechargeable Battery

- ExpertPower 12V 5Ah Lithium LiFePO4
- 2500-7000 Life Cycles
- Built-in BMS
- Low Self-Discharge (2%/month)
- Dimensions: 3.54”x2.76”x3.98”
- Weight: 1.7 pounds
- Price: $39.99

Voltage Regulators



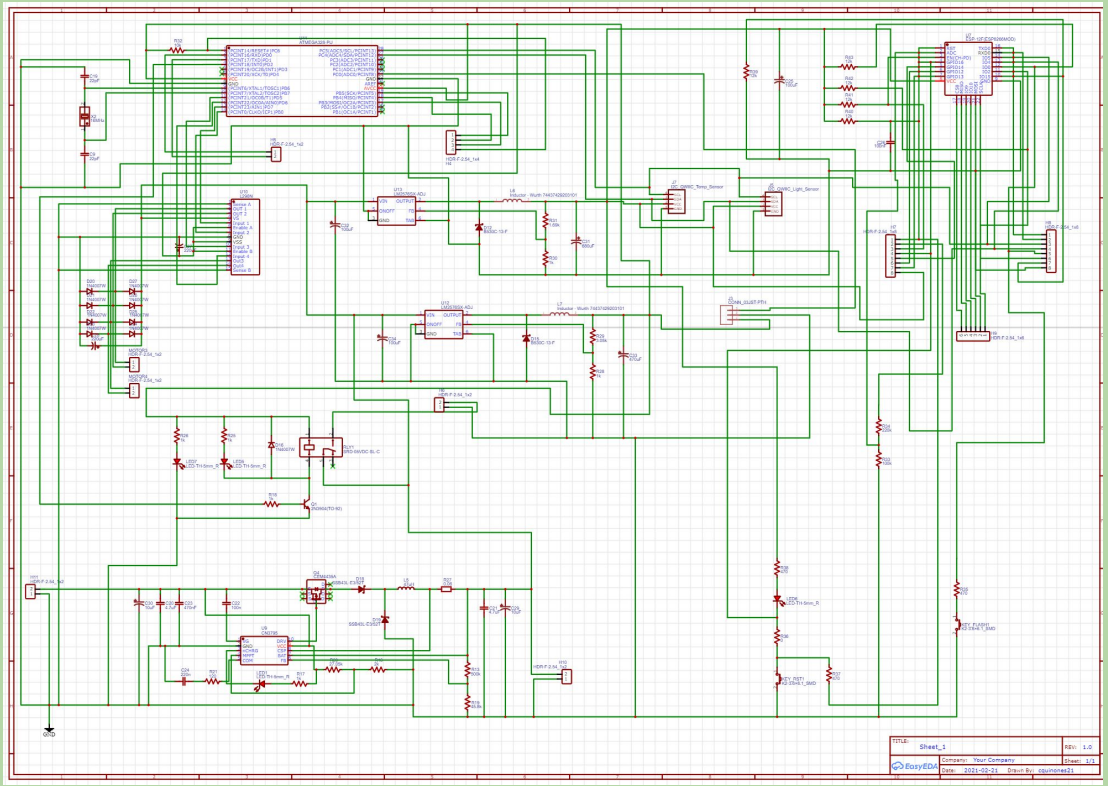
- LM2576 Switching Regulator
- Efficiency ~80-85%
- Output Current - 3A
- Output Voltage
  - 3.3V
  - 5V
- BOM Count - 7
- Experience

Application

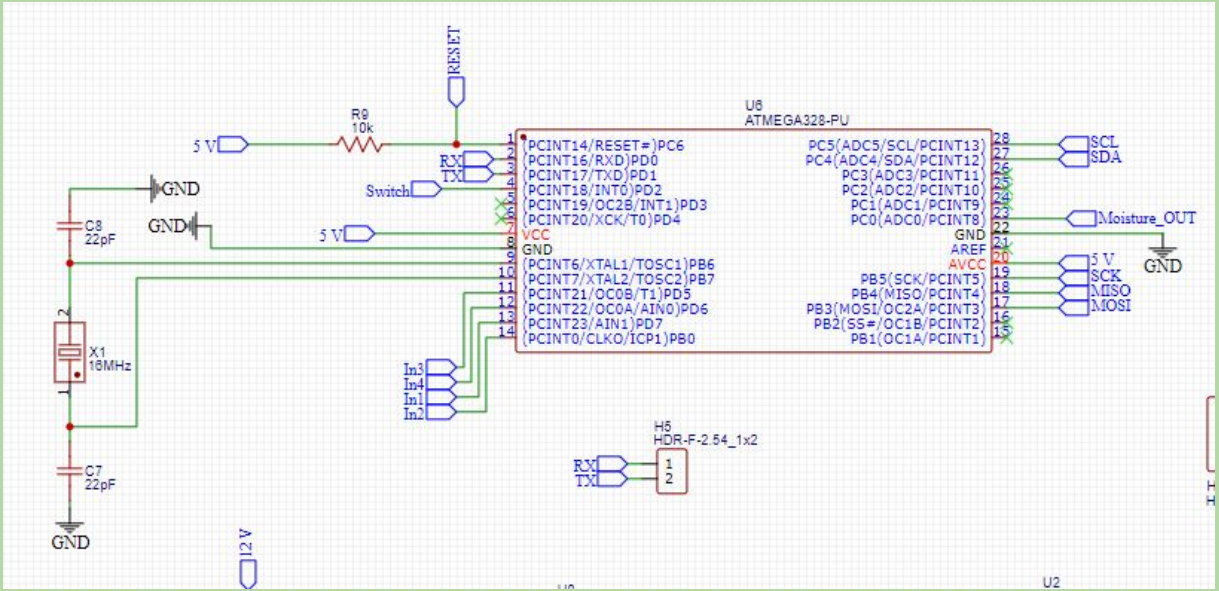
- To allow the user to insert data about the plant as well as manually control the system

- Developed with Dreamweaver
- Designed for the web (accessible on both desktop and mobile)
- Capabilities:
  - Selecting the plant
  - Manual input of care
  - View updates of the plant

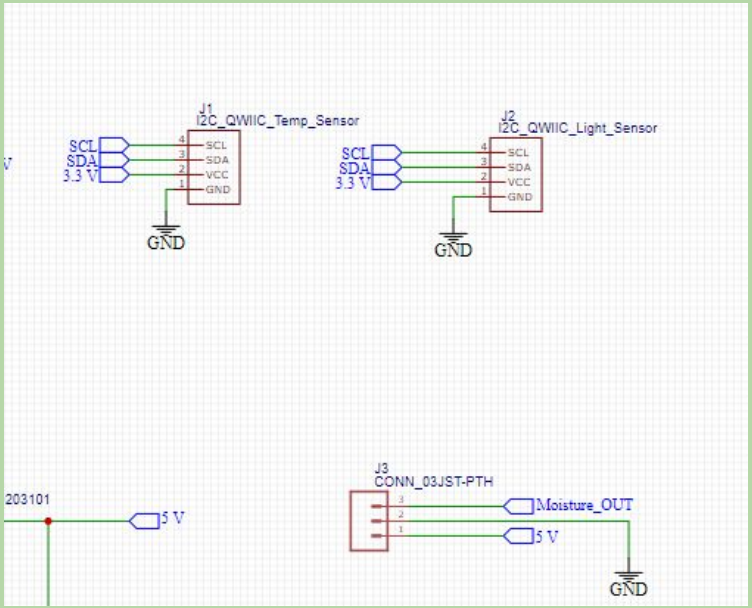
PCB Schematic



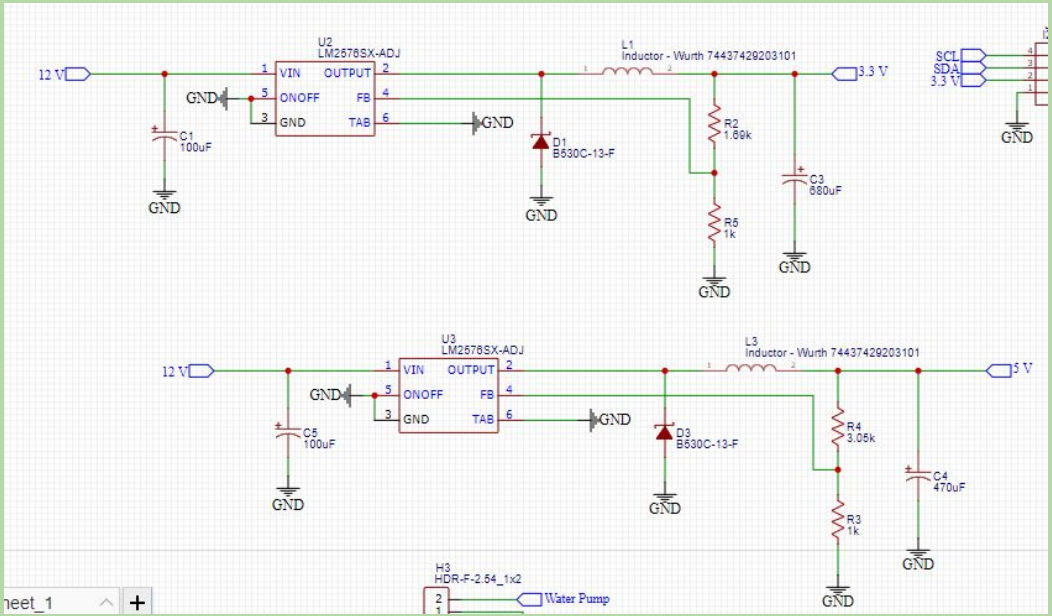
PCB Layout: Arduino Uno (ATMega328)



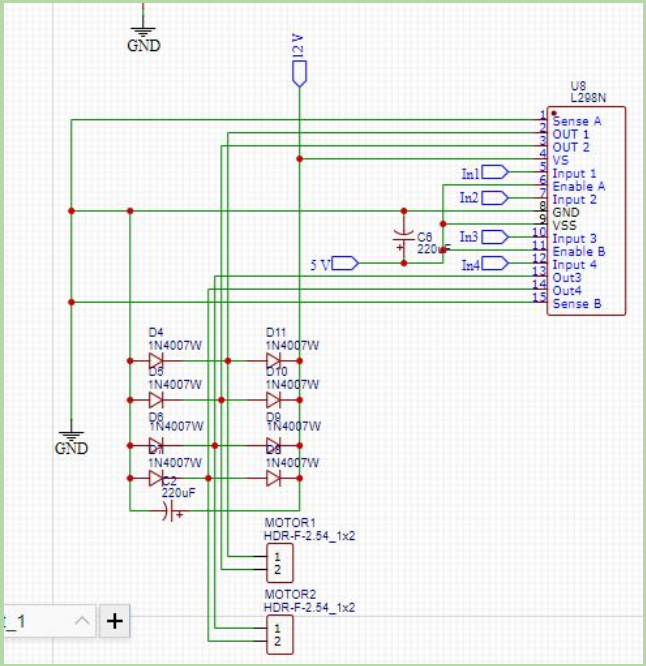
PCB Layout: Sensor Ports and Other Connectors



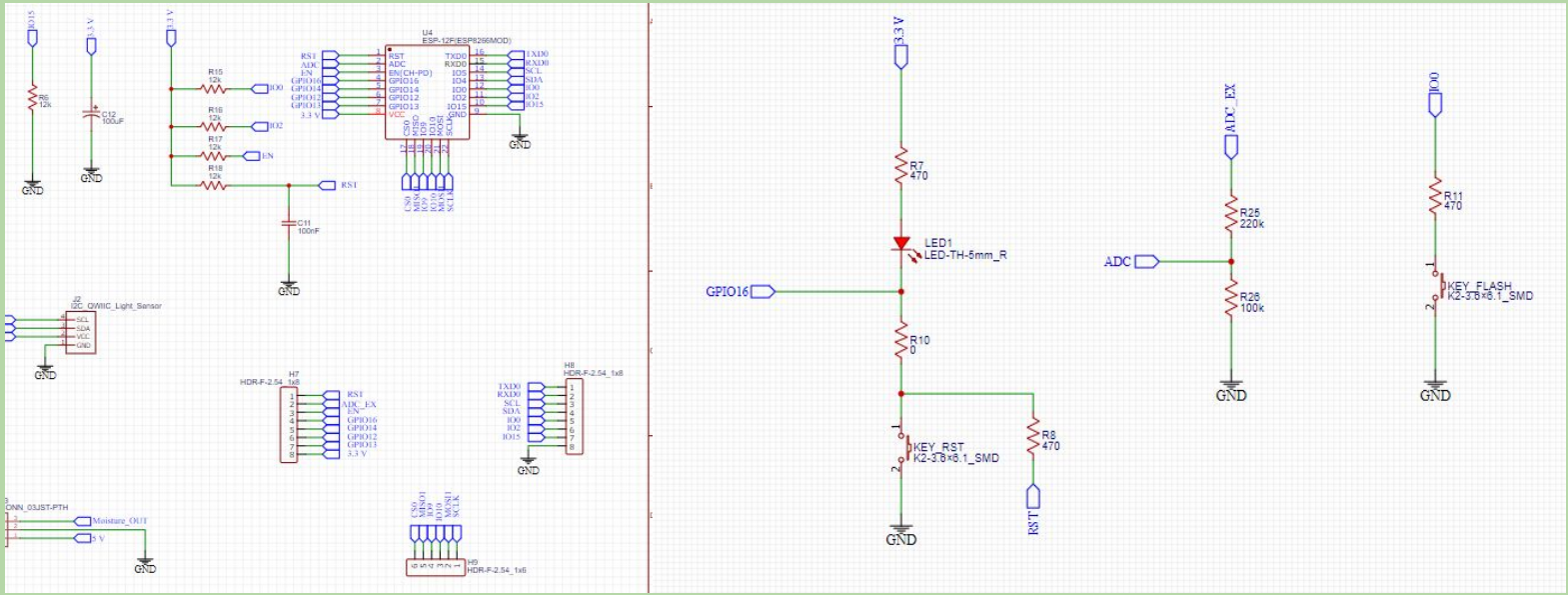
PCB Layout: Voltage Regulators



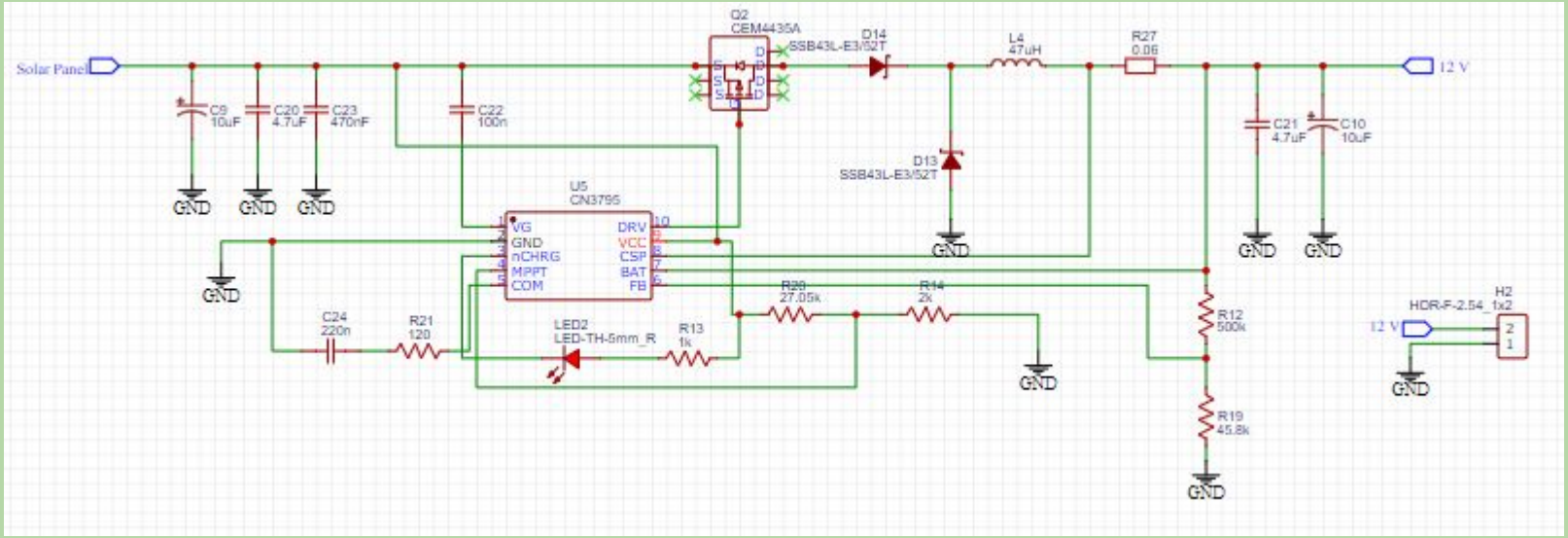
PCB Layout: Motor Driver



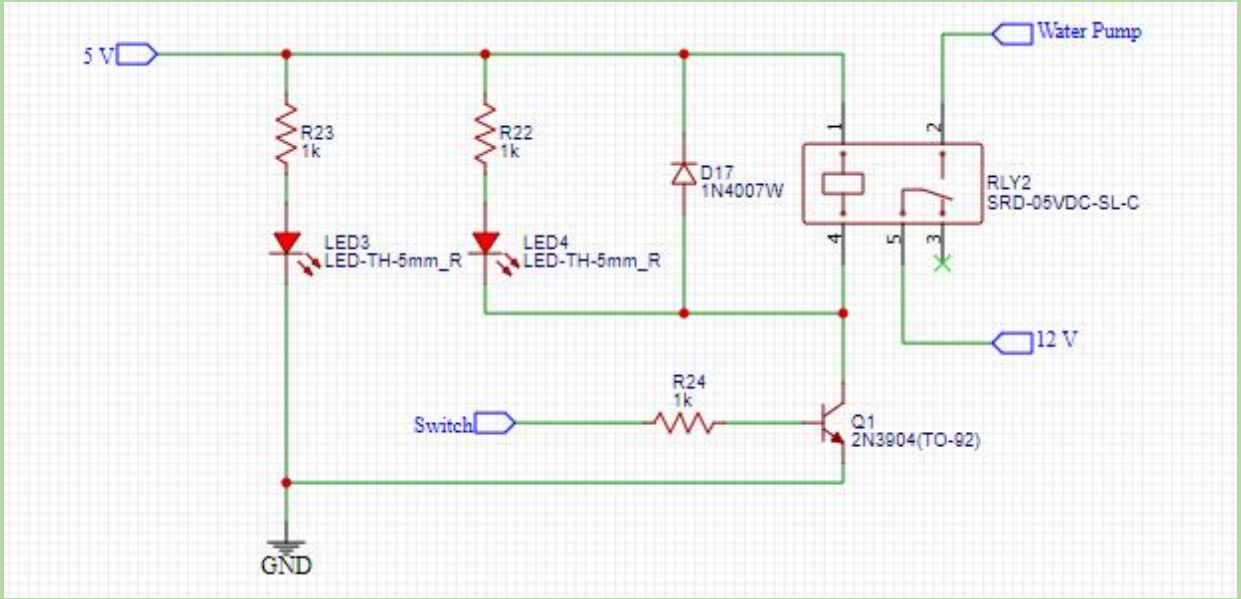
PCB Layout: WiFi Module



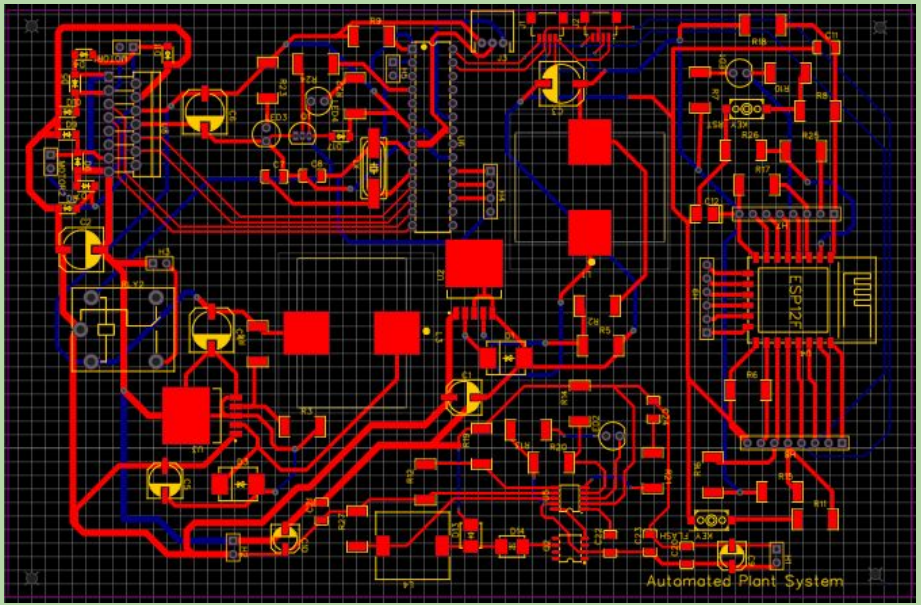
PCB Layout: Solar Power Controller

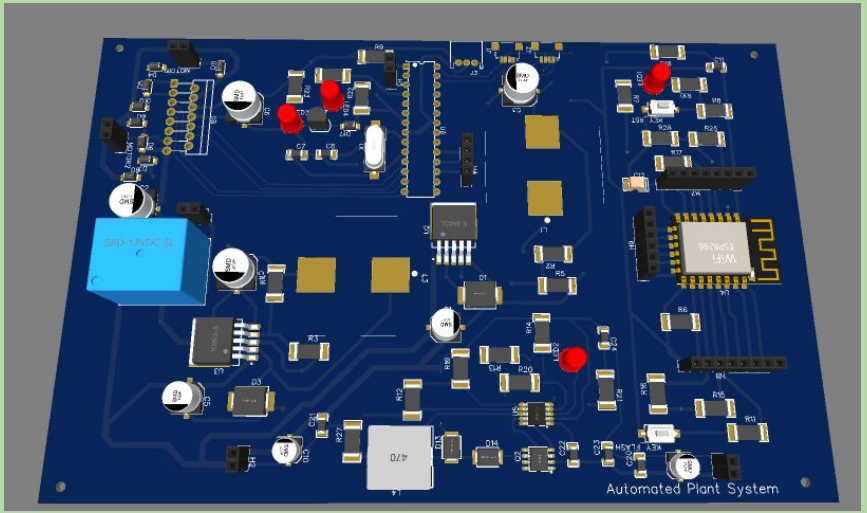


PCB Relay Circuit



PCB Layout - 2D and 3D





Realistic Design Constraints

Economic Constraints

- Self-sponsored
- Time limit of two semesters

Environmental Constraints

- Solar power can only be generated when the Sun is out
- High temperatures
- Rain

Realistic Design Constraints

Manufacturability

- Electromechanical Systems
  - Shading System
  - Irrigation System
  - Rotational System
- Equipment Availability
- Components Selection
- Experience

Sustainability

- Climate Changes
- Corrosion Resistant
- High/Low Temperatures
- Operational Levels
- Storage of Electrical Components

Realistic Design Constraints

Health & Safety

- Water Safety
- Rotation
- Materials
- Potential Fire
- Potential Shock

Social

- Affordable
- Easy to Use
- Product Size

Realistic Design Constraints

Ethical Constraints

- Academic Integrity
- Product Honesty

Political Constraints

- No Political Constraints for this Project

Related Standards

Battery Standards

- UN/DOT 38.3
- IEC 62133
- UL 2054
- UL 1642
- UL 1973
- ANSI C18.2M

Solar Panel

- IEC 61215
- IEC 61730
- IEC 62716
- IEC 61701
- IEC 60068-2-68
- UL 1703
- UL 61730

Related Standards

Programming Language

- IEEE 1178-1990
- ISO/IEC 9899
- ISO/IEC 9899: 2011
- ISO/IEC 9899: 2018

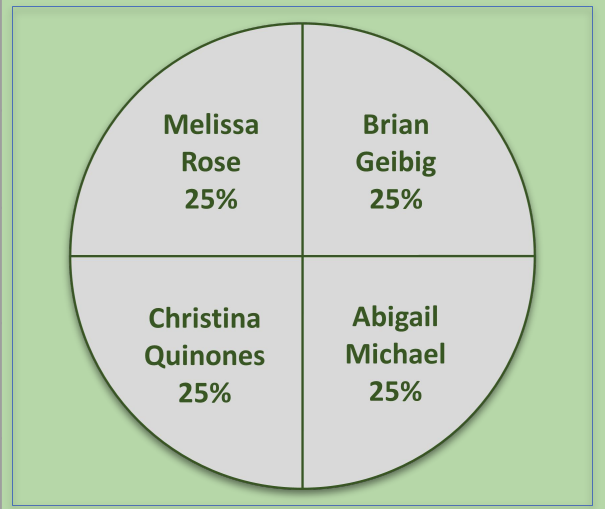
WiFi Standards

- 802.11a/b/c/g/n

RoHS Standards

Workload Distribution

	Electromechanical Output Systems	Application & Software Development	Power Systems & Electromechanical Input Systems	Sensors, Modules, & Control
Brian Geibig	Primary		Secondary	
Abigail Michael		Primary		Secondary
Christina Quinones	Secondary		Primary	
Melissa Rose		Secondary		Primary



Budget

Part	Cost
Plant	$10
Irrigation System	$60
Light Sensor	$15
Moisture Sensor	$20
Temperature Sensor	$17
Wi-Fi Module	$20
Rotational System	$30

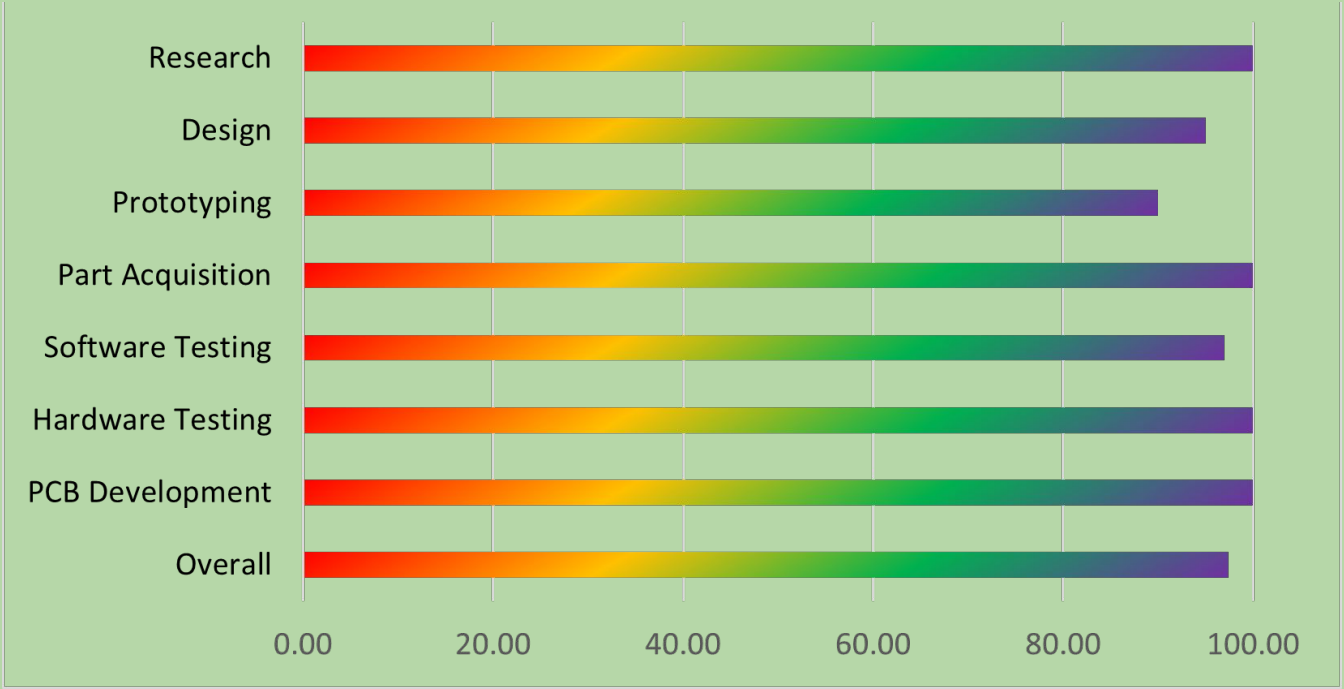
Part	Cost
Shading System	$50
Microcontroller Kit	$80
Power System	$50
Solar Panel	$34
Software Development	$0
PCB	$20
Total	**$406**

Testing

- Motors
- Water pump
- Microcontroller
- Light sensor
- Moisture sensor
- Temperature sensor
- Wi-Fi module

- Irrigation system
- Rotational system
- Shading system

Progress


Research
Design
Prototyping
Part Acquisition
Software Testing
Hardware Testing
PCB Development
Overall
0.00
20.00
40.00
60.00
80.00
100.00

Future Improvements

- Plastic/Metal Housing (3D Printing)
- Plant Care Settings for Different Types of Plants
- Alternate Shading System Mechanism
- Multiple User Application Authentication

Thank You!

Questions?