Plant Nanny: The Automated Plant Growth System

- GROUP 8
- AJAY EMMANUEL – COMPUTE ENGINEER
- CHRISTOPHER JORDAN – ELECTRICAL ENGINEER
- GABRIEL RODRIGUEZ – ELECTRICAL ENGINEER
- CLAYTON SZOKE – COMPUTER ENGINEER

Project Motivation

To build and create an aesthetically pleasing home automated, self-sustaining plant system.

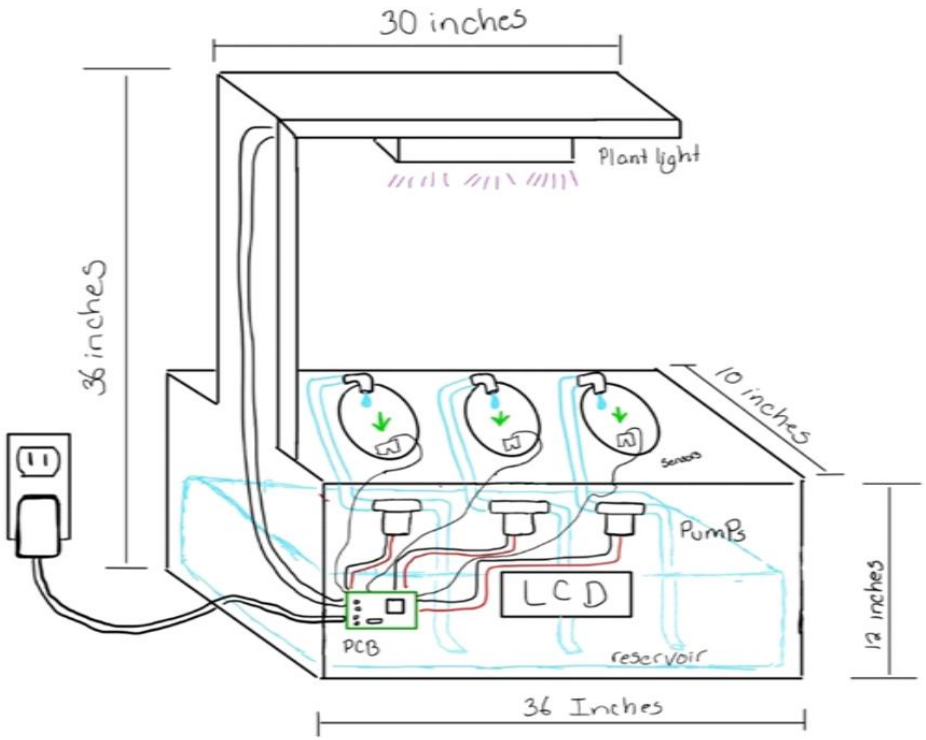
The Plant Nanny aims to minimize the user need to constantly water and monitor home plants such as herbs, vegetables, and other small plants.

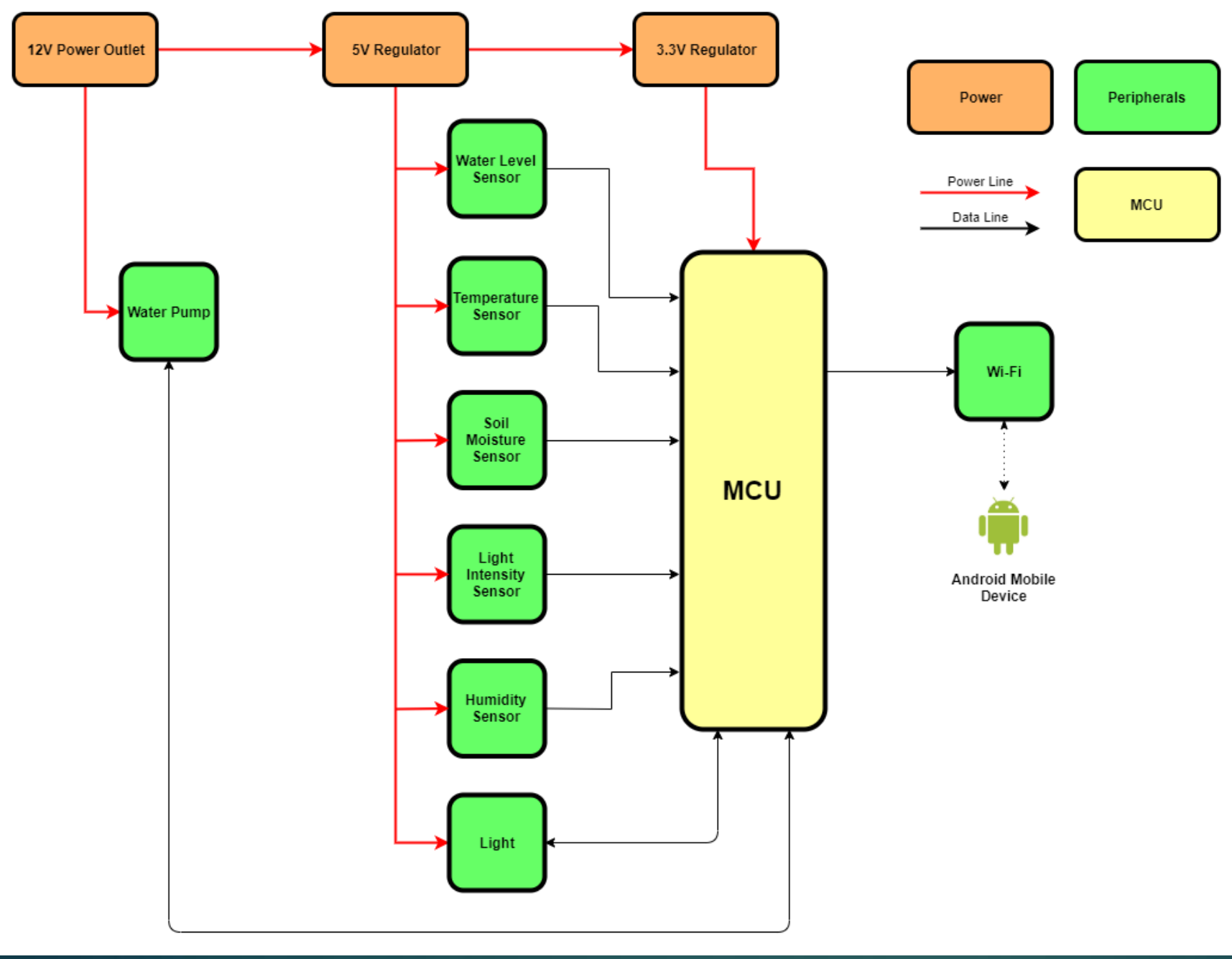
Goals and Objectives

Specifications
To be able to water the plant automatically from sensor readings when moisture dips below 60%.
To be able to detect when the water reservoir needs to be refilled with levels of 25, 50, 75, and 100.
To be able to set the plant light on a timer based on times from 5 to 10 hours of sunlight.
To be able to display sensor data such as temperature and humidity through the application.
To be able to have a direct connection between the plant and the application with near 0 latency.

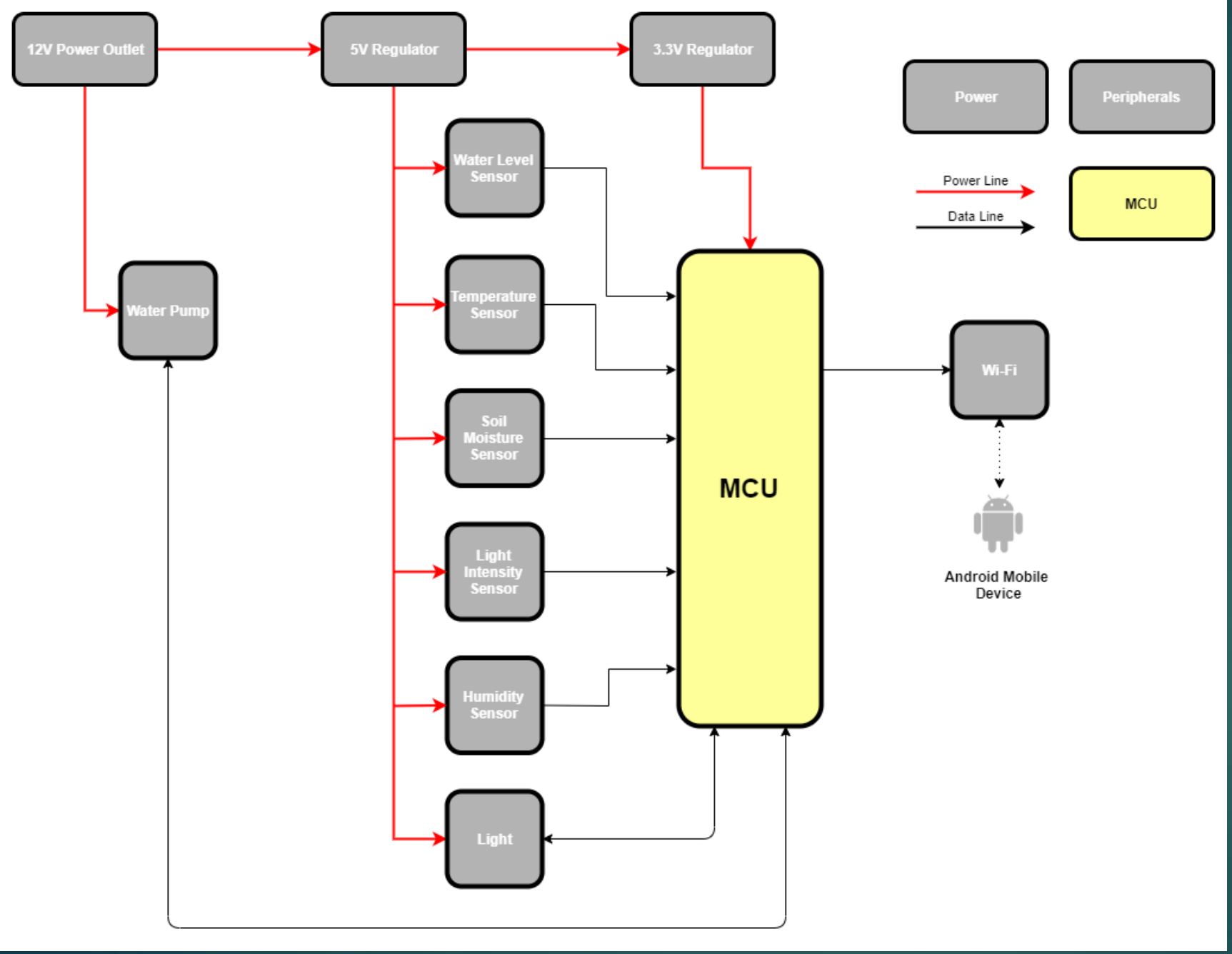
Sketch Draft Design

- Original design involved the care of three individual plants.
- Dimensions were based on the size of our expected plants such as herbs.
- The design was to be powered by a wall socket.





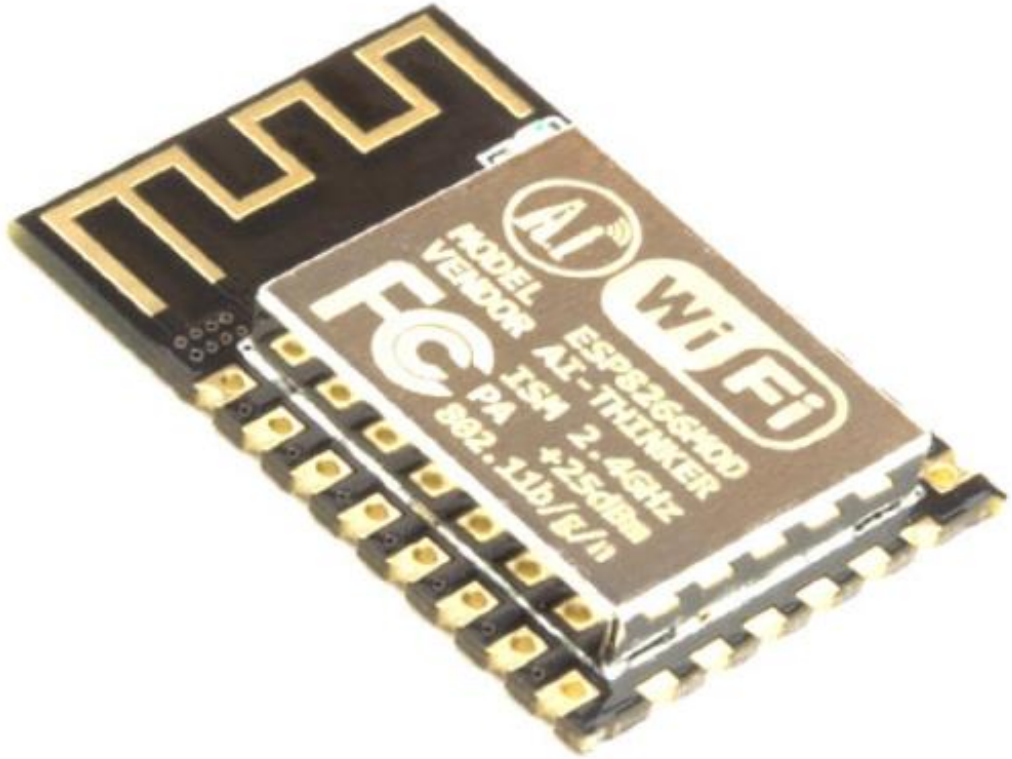
Overall Block Diagram


12V Power Outlet
5V Regulator
3.3V Regulator
Power
Peripherals
Water Level Sensor
Power Line
Data Line
MCU
Water Pump
Temperature Sensor
Wi-Fi
Soil Moisture Sensor
MCU
Light Intensity Sensor
Android Mobile Device
Humidity Sensor
Light

MCU

ESP8266-12E

- Broad Online Community
- 11 available GPIO pins
- Built-in WIFI capabilities
- Functions as a standalone application
- Maximum current allowed to draw per pin: 15mA
- Operating voltage and current: 3.3V, 80mA

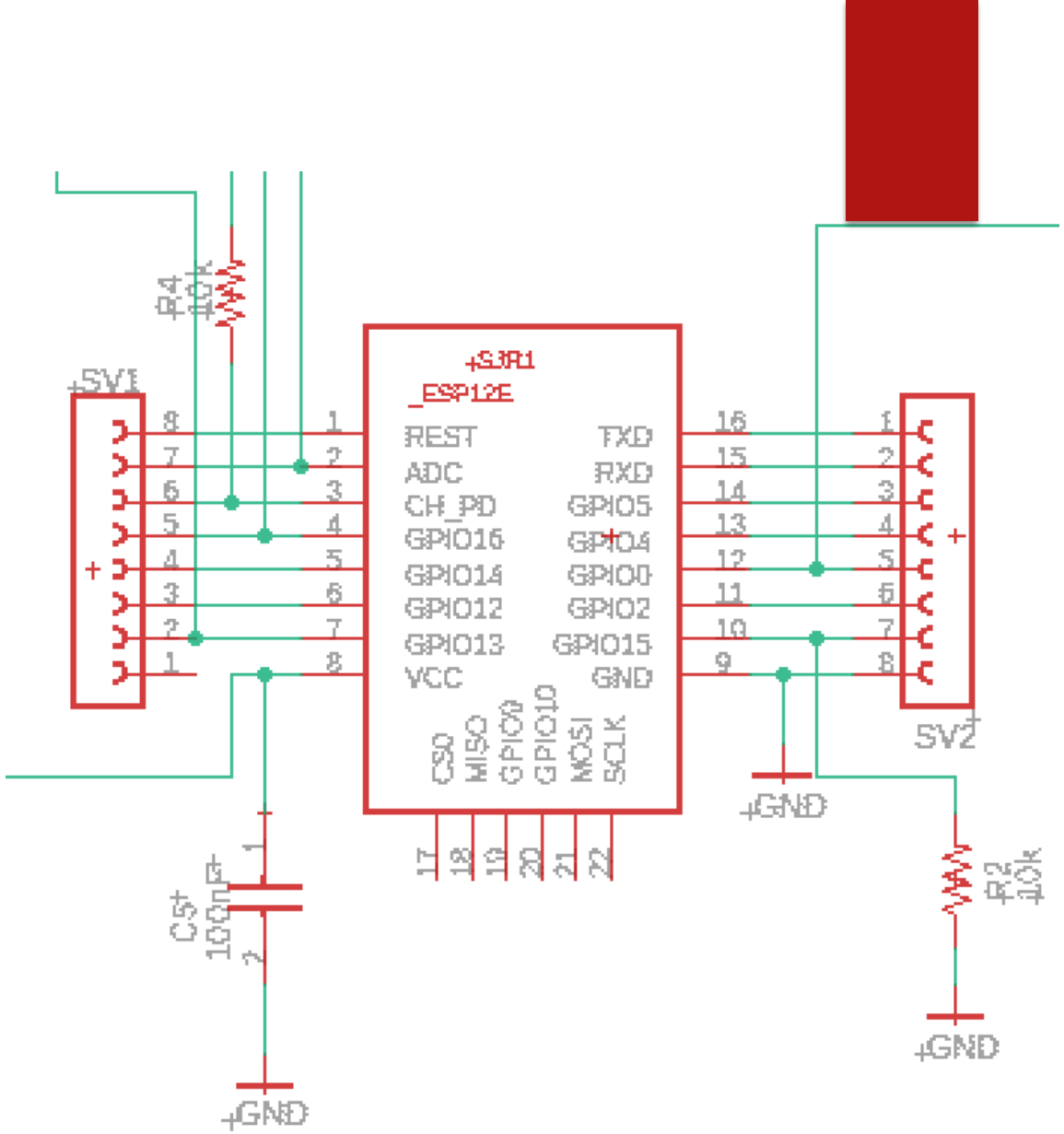


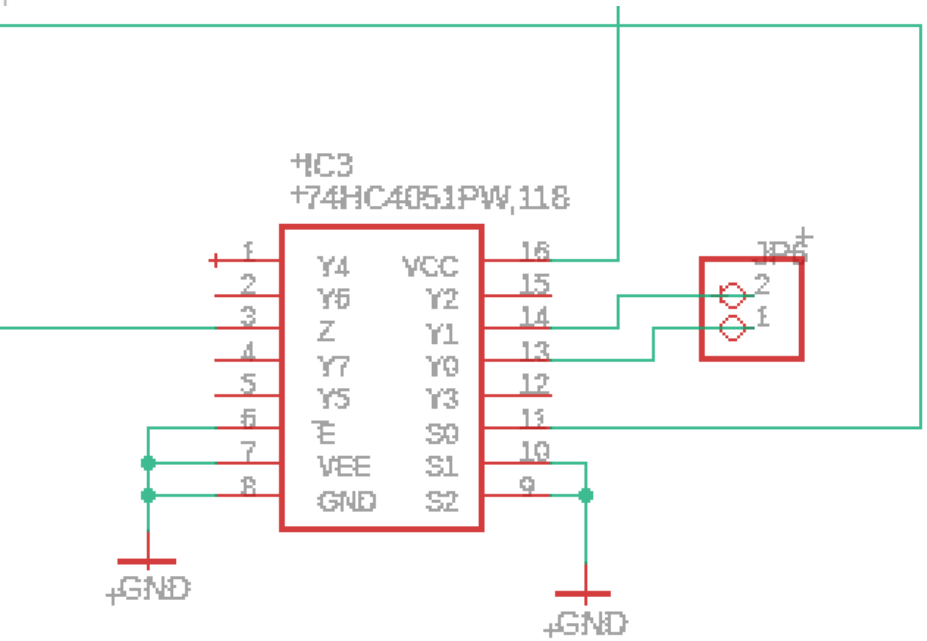
Schematic & PCB Design

- Originally was going to use KiCAD or EasyEDA
- Use of EAGLE Cad Software chosen instead
- Free for UCF students
- Relatively Simple to learn and readily available libraries for components
- Online tutorials available

ESP8266-12E Schematic

- Bottom pins not available to do to Flash Memory error known to community
- Fixes for error out of scope for project
- Limited to 11 GPIO lines
- Pull-up & Pull-down resistors needed
- Female headers to left & right for ease of connectivity to sensors



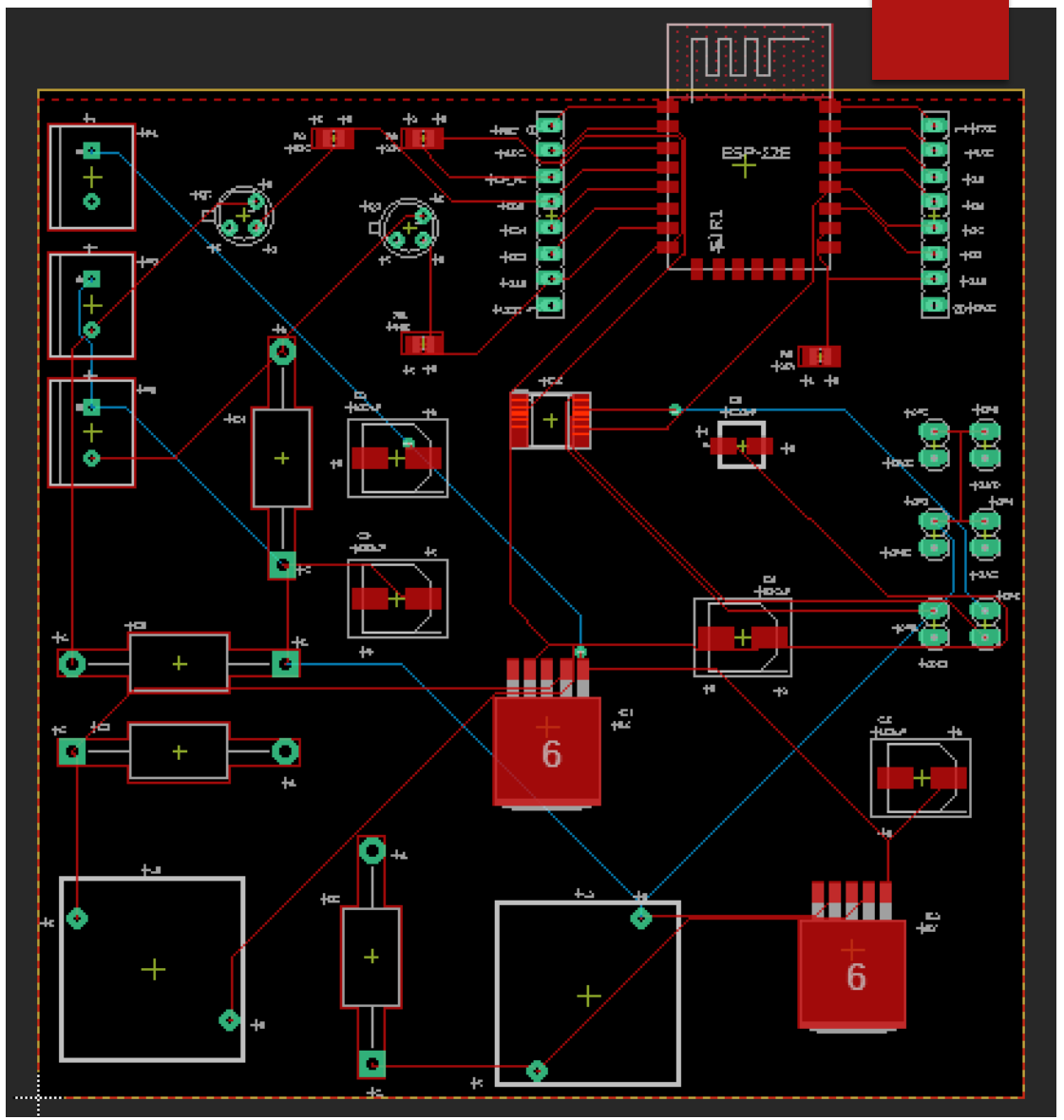


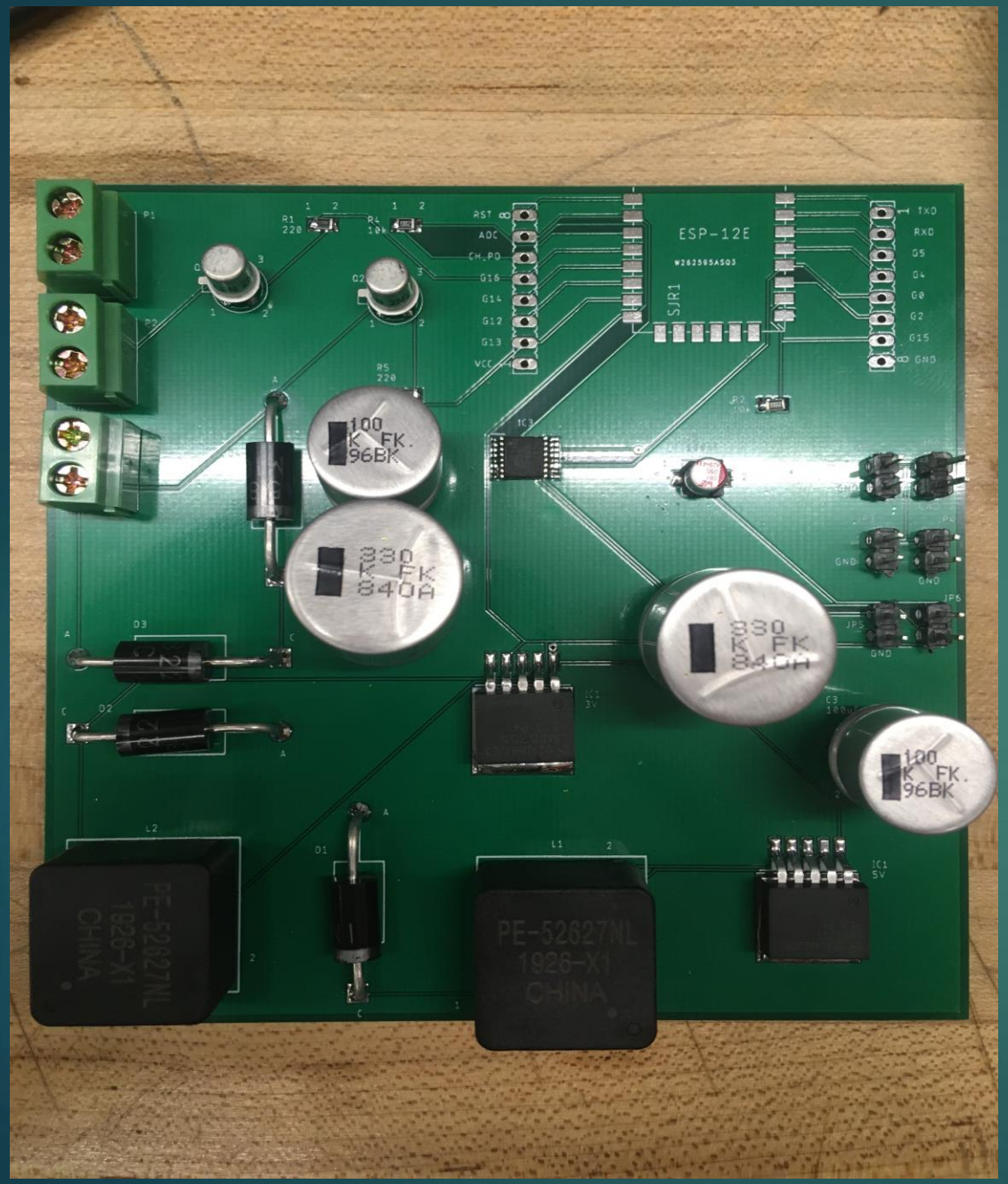
Moisture Sensor MUX

- Needed for multiple plants
- 'Z' connected to ADC
- VCC powered by 5V output
- Y1 & Y0 to switch between Plant 1 & Plant 2
- Mobile App able to switch between plants for different readouts

Final PCB Design

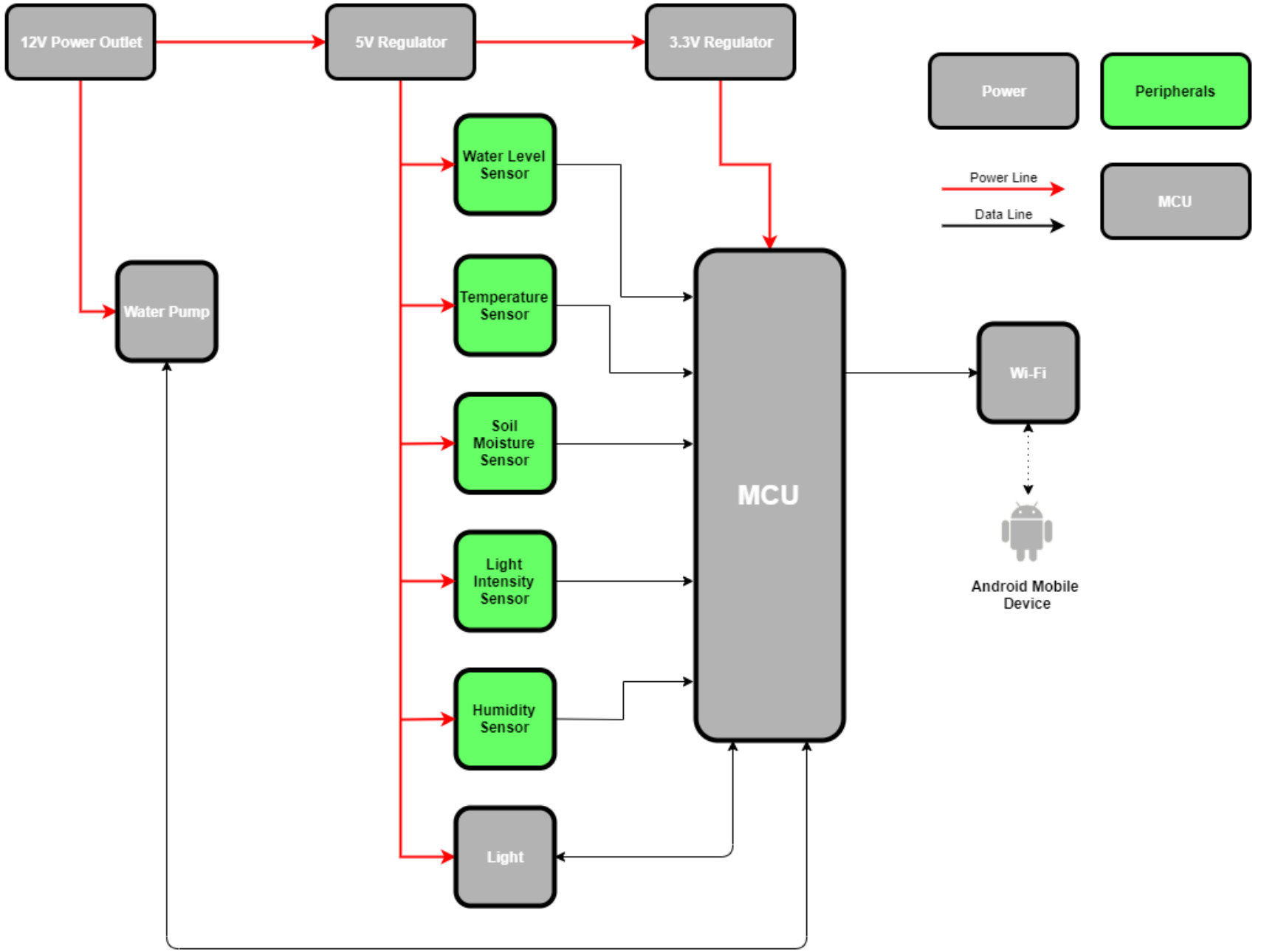
- Copper pour used for GND
- ESP Antenna sticking out board to avoid issues with copper
- Auto-route was used due to lack of experience with software
- Had to re-position components due to mis-connected air wires
- Was sent out to PCBWay





- Re-designed because of ceramic capacitors were initially chosen
- Aluminum Electric Capacitors are shown on final design
- First PCB attempted solder ourselves
- MUX was too small
- Connections were bridged
- Taken to Quality Manufacturing Services, Inc (Sanford, FL)
- Fully soldered (minus MCU)
- All voltages tested with multi-meter and proved to be correct

Final PCB Design


12V Power Outlet
5V Regulator
3.3V Regulator
Water Pump
Water Level Sensor
Temperature Sensor
Soil Moisture Sensor
Light Intensity Sensor
Humidity Sensor
Light
MCU
Wi-Fi
Android Mobile Device
Power
Peripherals
Power Line
Data Line
MCU

Sensors

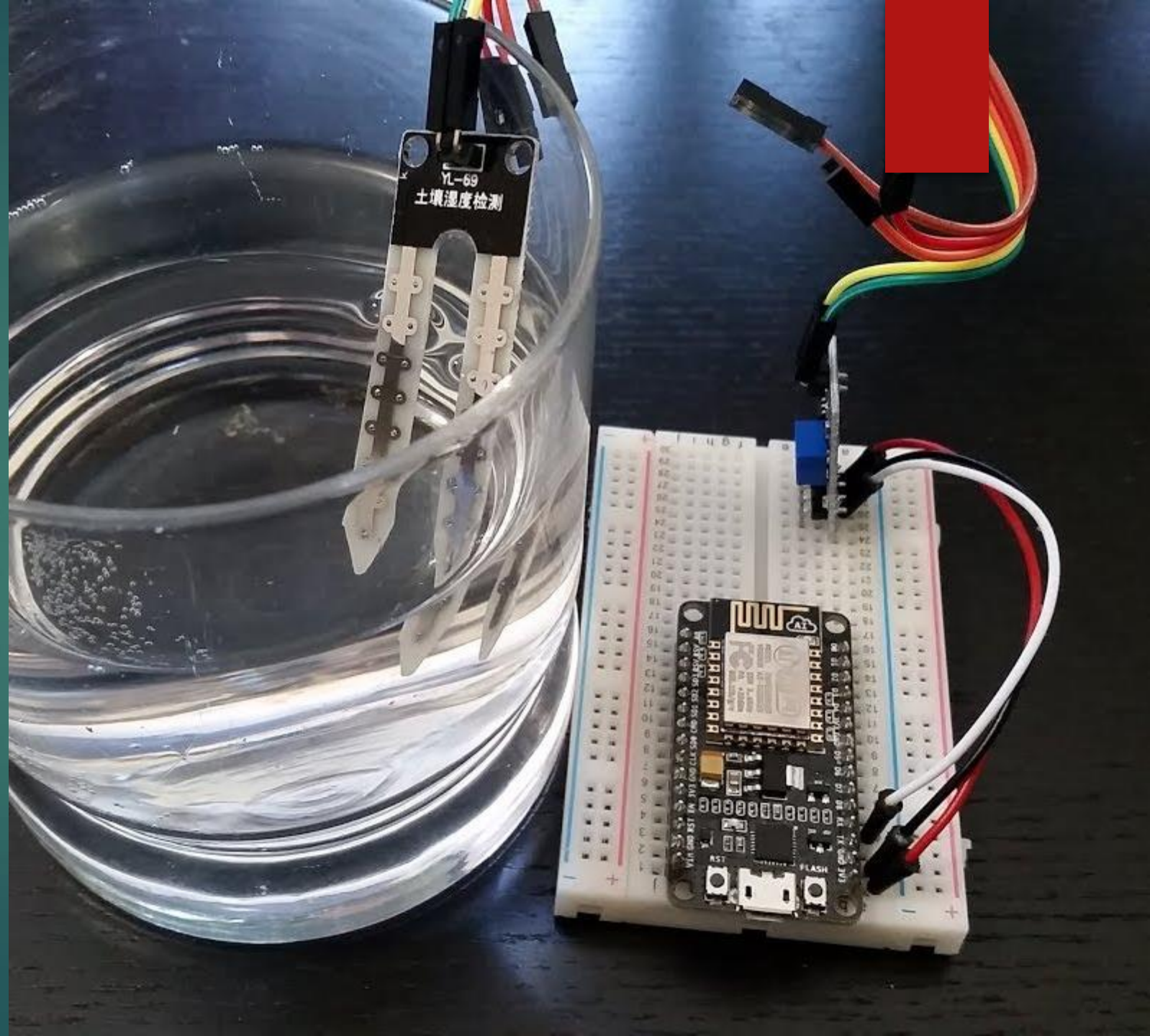
Sensors

Various sensors needed in order to track the plants environment/condition in order to ensure a hospitable environment and relay this data to the MCU for adjustments if necessary.

- 5 different sensor types
  - Soil Moisture
  - Temperature
  - Humidity
  - Light Intensity
  - Water Level

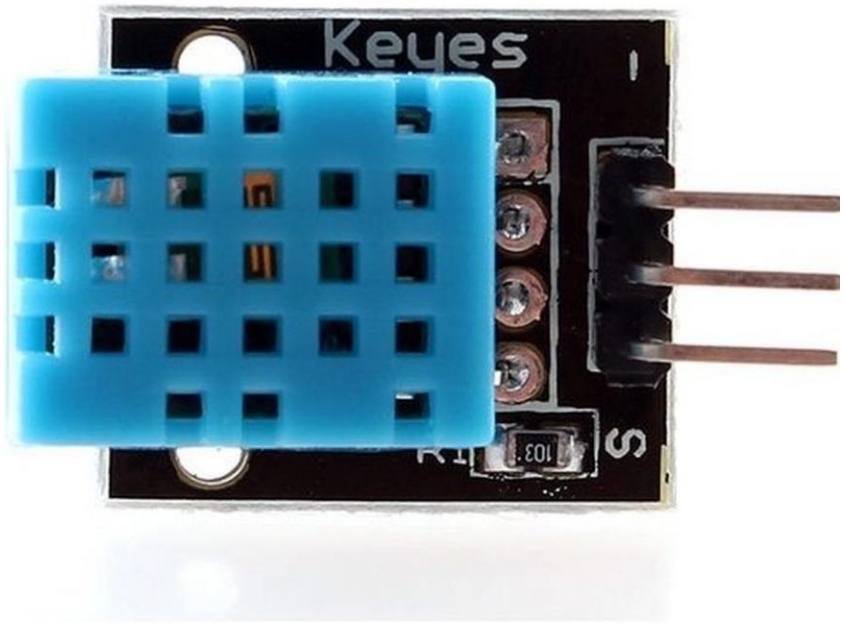
Soil Moisture Sensor

- We used the TE215 soil moisture sensor
- Operates at 3.3-5V
- Analog output for greater precision
- High sensitivity
- Programmed to turn on certain thresholds unless water reservoir is running low



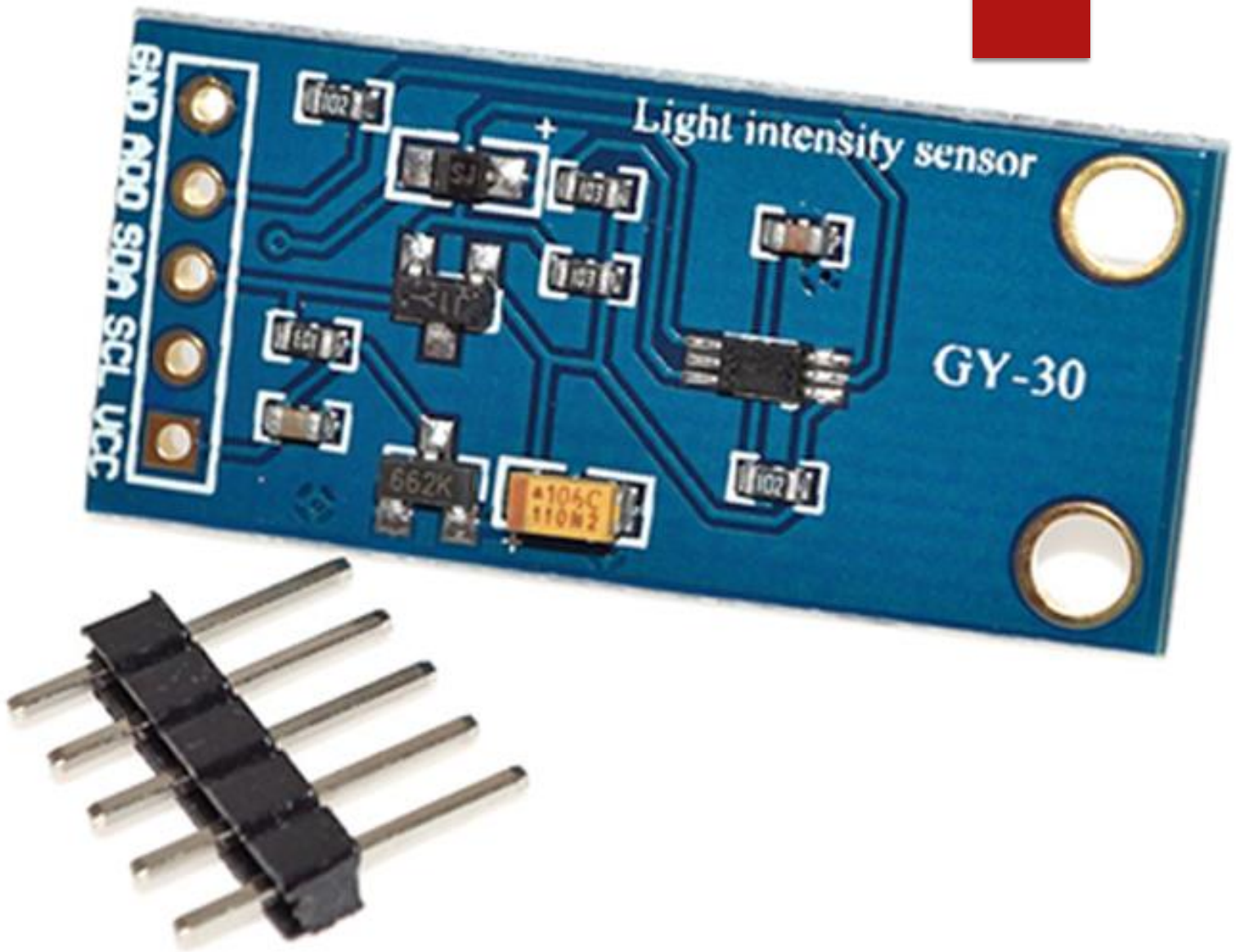
Temperature/Humidity Sensor

- The DHT11 combines temperature and humidity
- Provides 9-12 bit measurements
- Cheap and easy to code
- Shares a single I/O pin
- Low accuracy but that is acceptable for indoor use
- Can discretely position in design due to small size
- Readily available



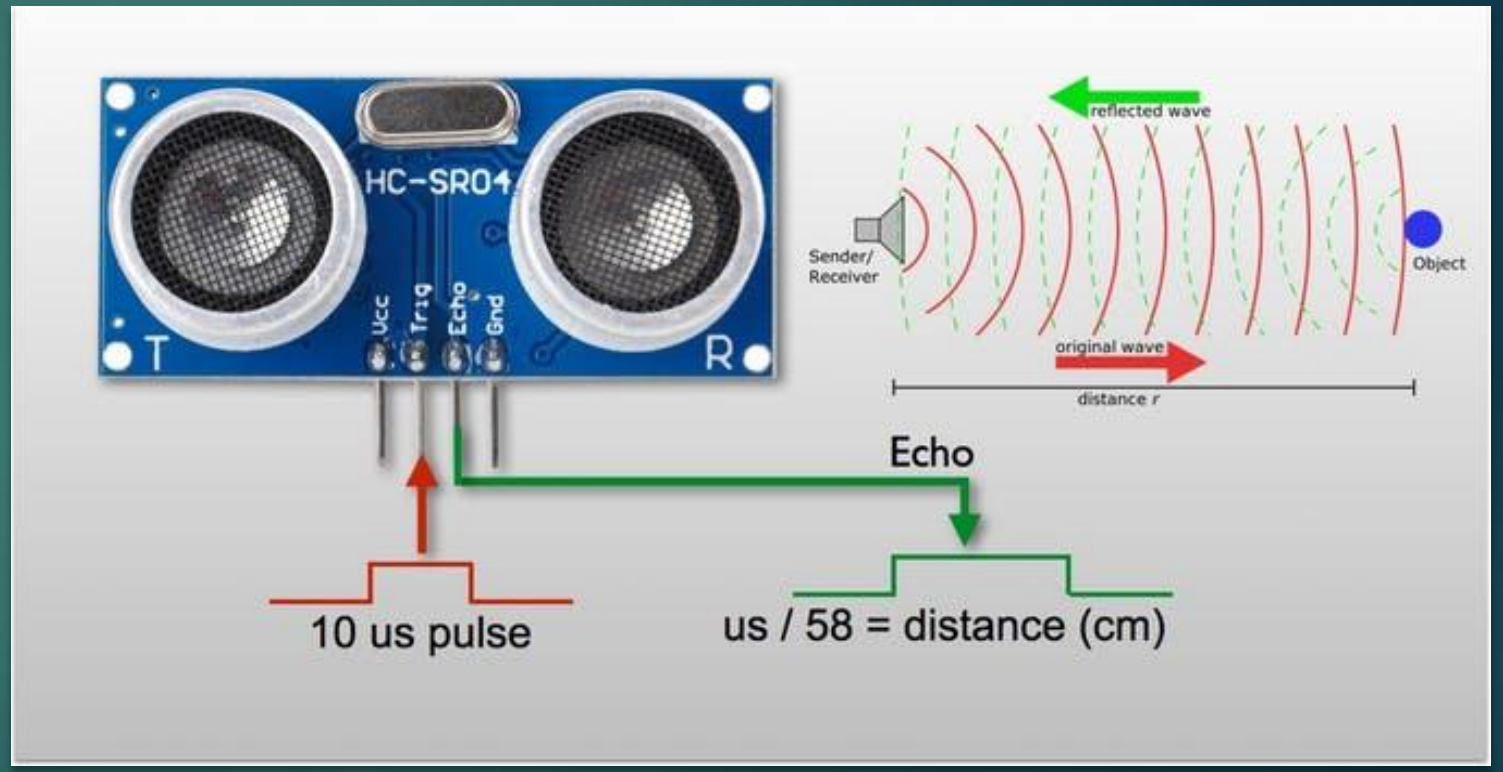
Light Intensity Sensor

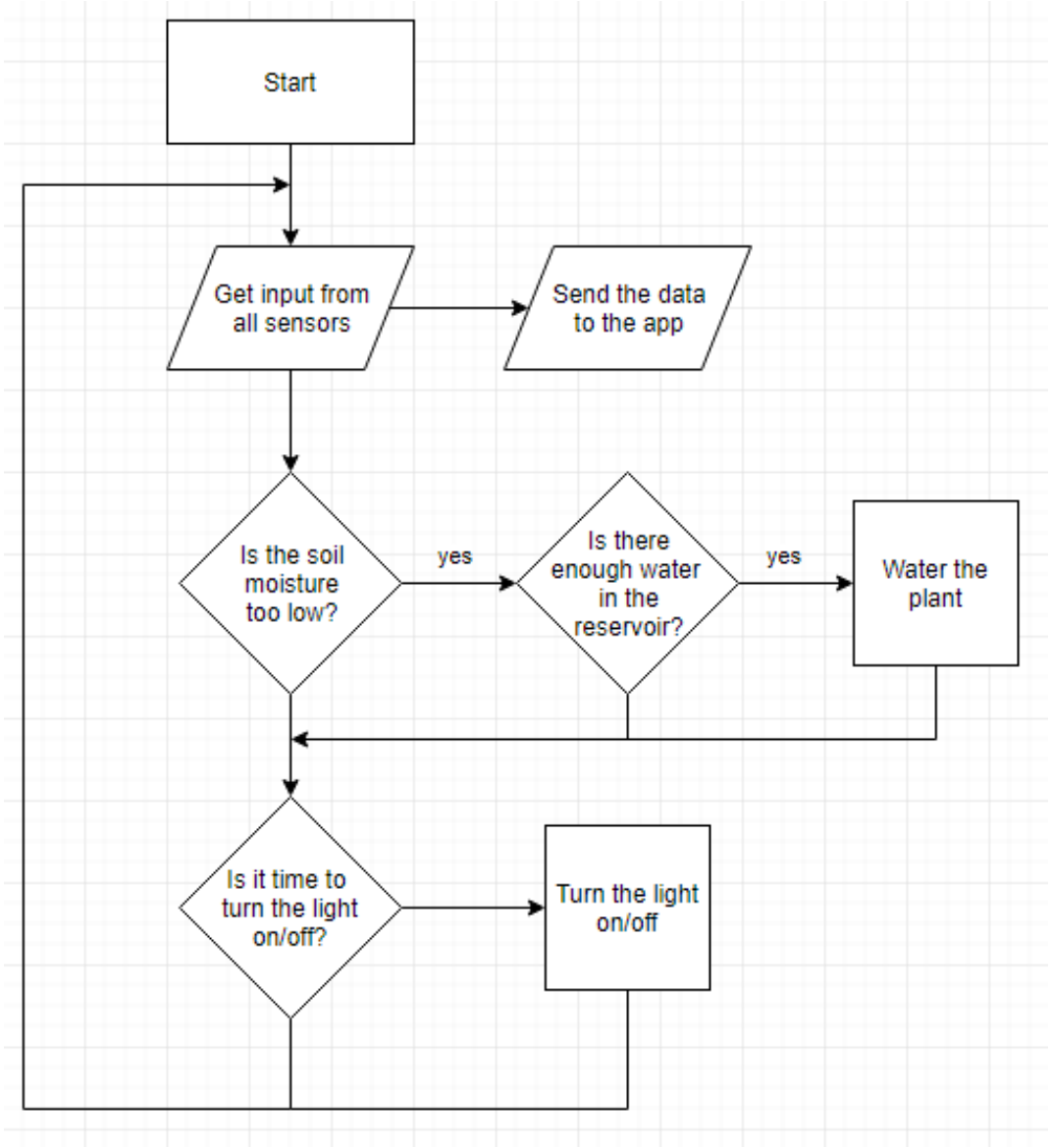
- GY-30 Light Intensity Sensor
- Small Footprint, won't obstruct sleekness of design
- Can operate from 3-5V, perfect for low power use
- Built-in 16 bit Analog to Digital Converter (provides a digital output)



Water Level Sensor

- HC-SR04 ultrasonic water level sensor
- Positioned away from water so it won't corrode
- Can detect from 2cm to 4m
- Operates at 5V and 15mA (low power)
- Small footprint for design
- Other options considered, but due to cost of more sophisticated sensors and lack of GPIO pins, the HC-SR04 was chosen.

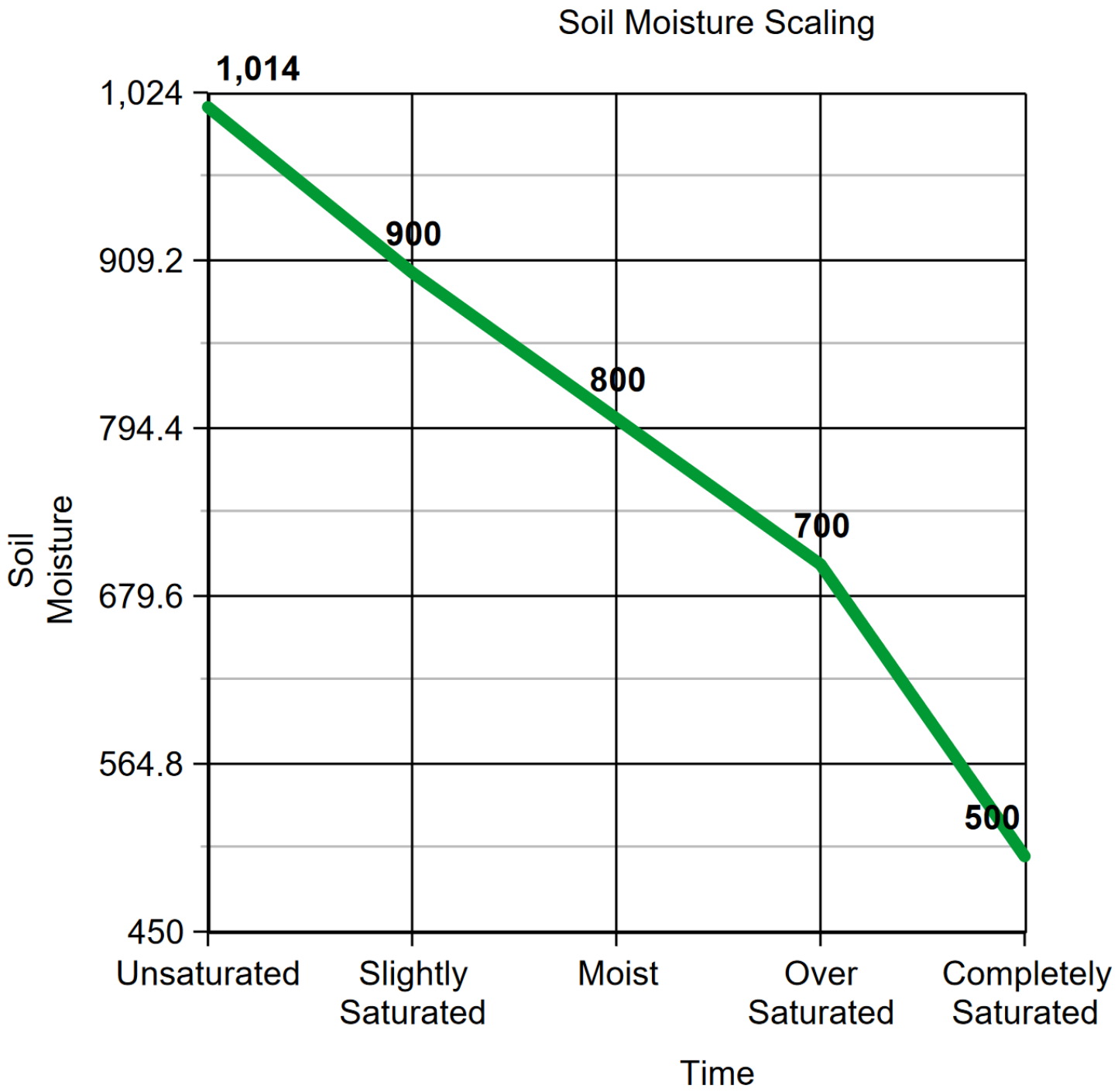




MCU Software Diagram

MCU Software Functionality

- Created a feature for turning the water pump on when moisture levels are low.
- Timer intervals for how long the light is on per 24 hours.
- Collecting sensor data and converting it into readable values.
- Managing thresholds of water saturation and water levels.
- Creating a static IP for correct Wi-Fi connection commands.



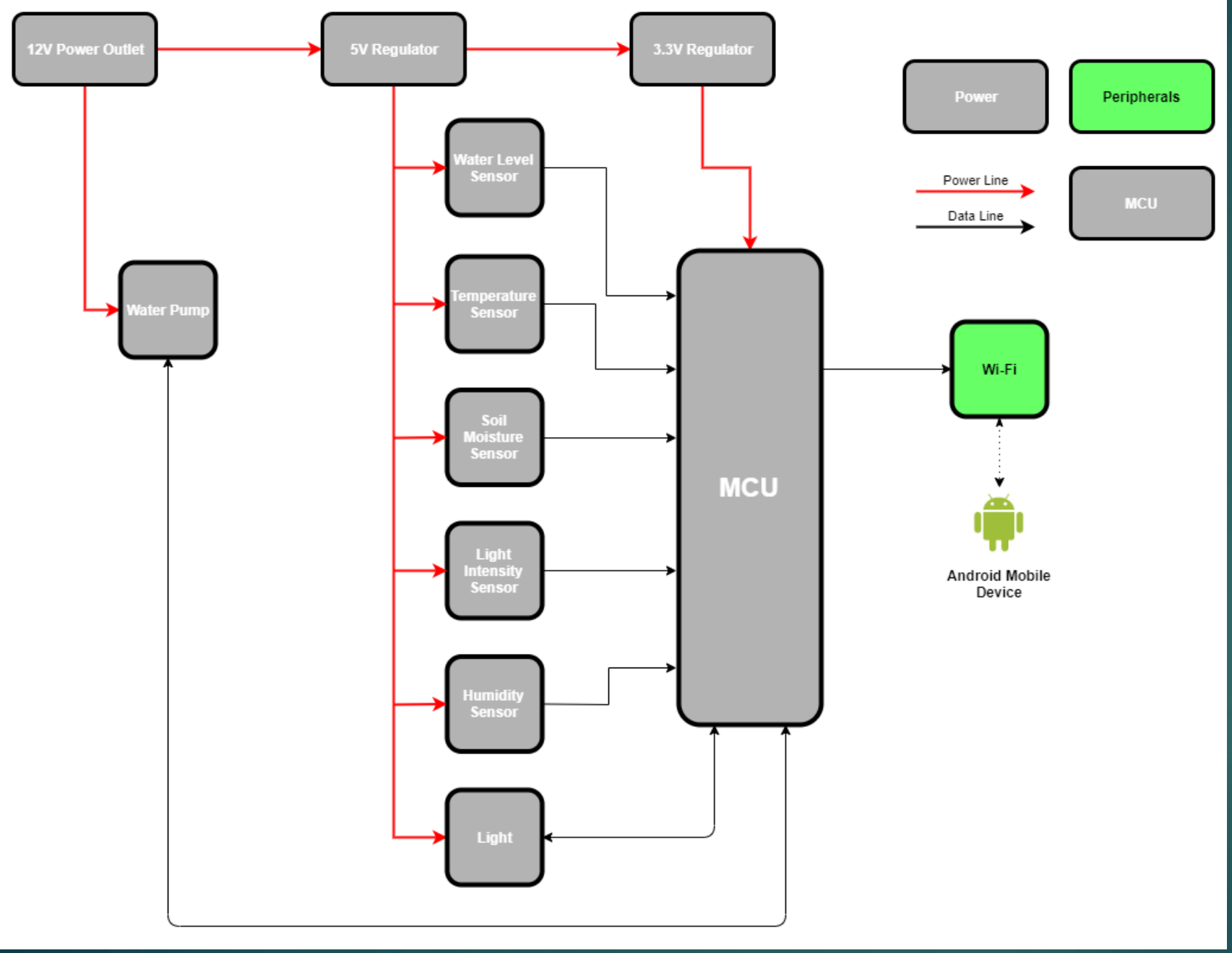
- As the pump runs in short intervals the soil becomes more saturated.
- The maximum and minimum were found by having the sensor completely submerged in water and having the sensor in open air.
- A safe level for soil moisture is between 700-900.

Wireless Technology

- Wireless communication to connect the user to the device.
- The user can interact with elements of the system to control plant environment.
- Through Wi-Fi emulation of the microcontroller, the phone is able to connect and directly send commands that can be processed.
- The commands are sent through a web address containing the microcontrollers static IP appended to a "/" command
- Example: "http://192.167.1.12/lighton"

Wireless Technology

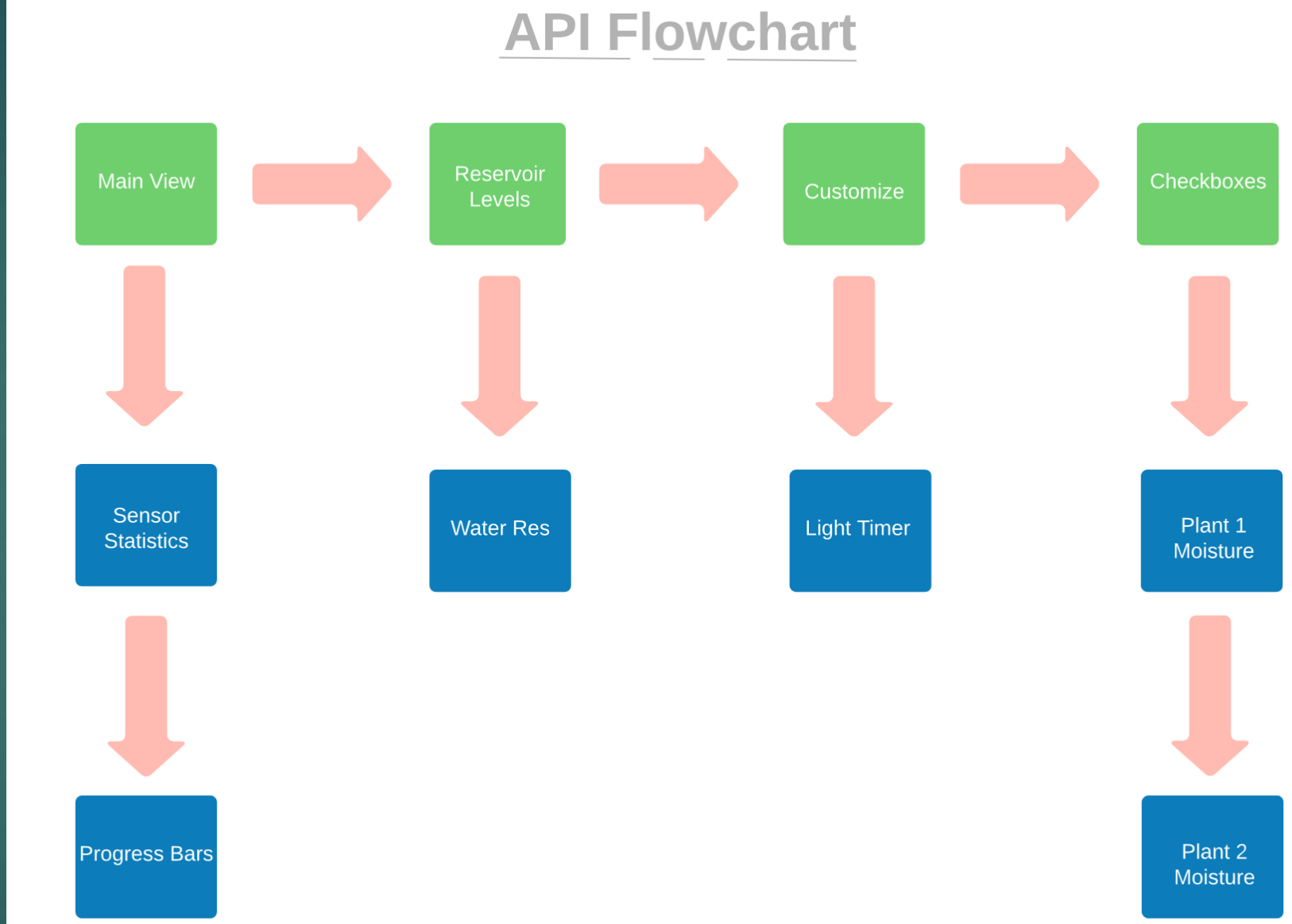
Technology	Advantage	Disadvantage
Wi-Fi	• Can be operated anywhere in the world through the internet • High speed communication of 144 MBPS 802.11n • Baud rate usage of 115200 bits/second • Long range	• Hard to setup • Easy to maintain with static IPs
Bluetooth V3.0	• Easy to setup • Low energy consumption • Data transfer rates of 24 MBPS	• Extremely limited signal range of 10 meters • Cannot connect to the internet
Zigbee	• Low cost • Low power • Secure communication over encrypted network	• Limited signal range 15 – 30 meters • Low transmission rate



Android Mobile Communication

Plan of Attack

- Obtained the basic statistics and displayed them
- Created a progress bar to show the water level
- Small QoL features such as a lighting timer
- Checkboxes to let application know soil moisture is satisfactory



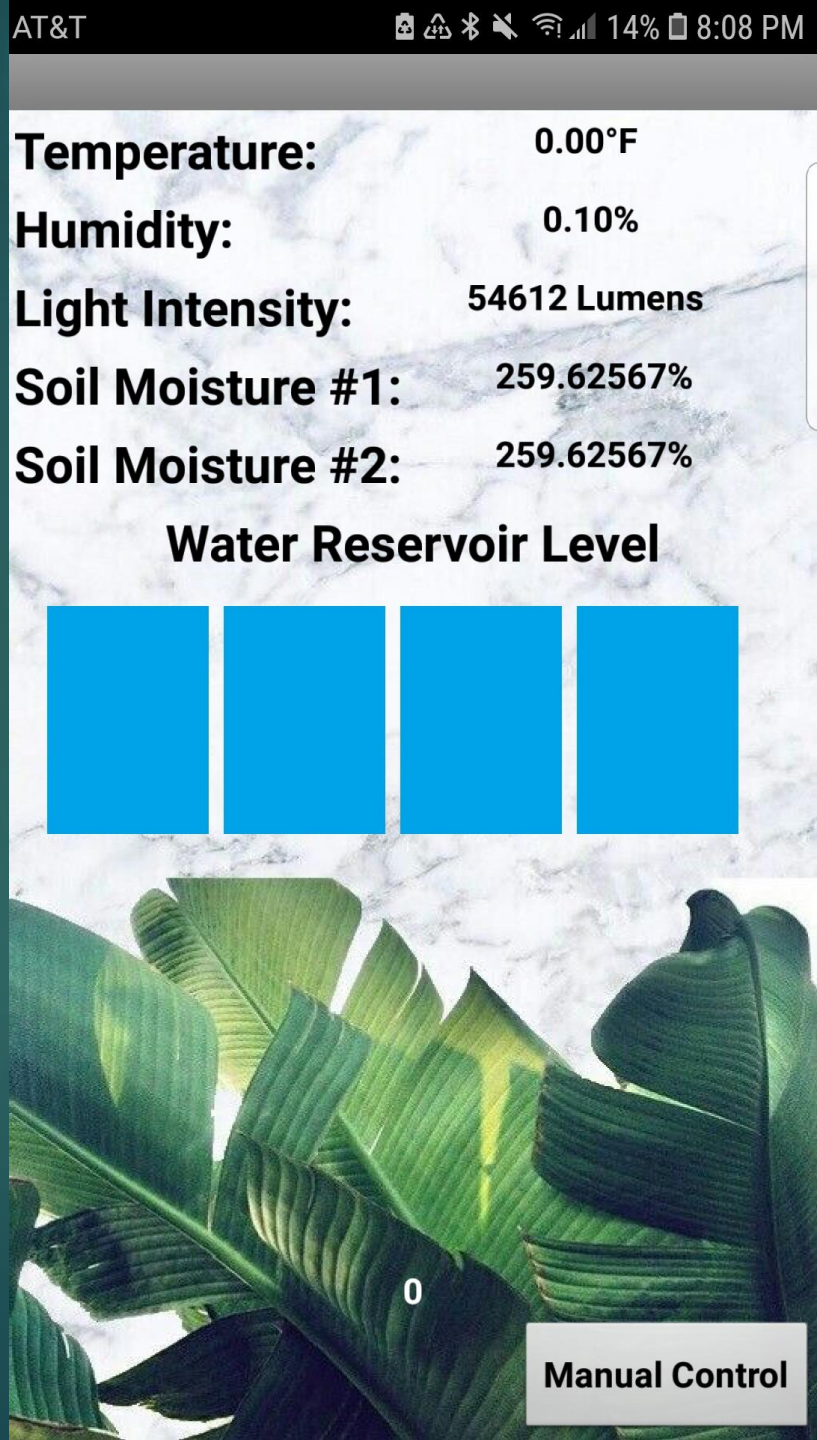
Android Application Software Design

Remote statistic viewing

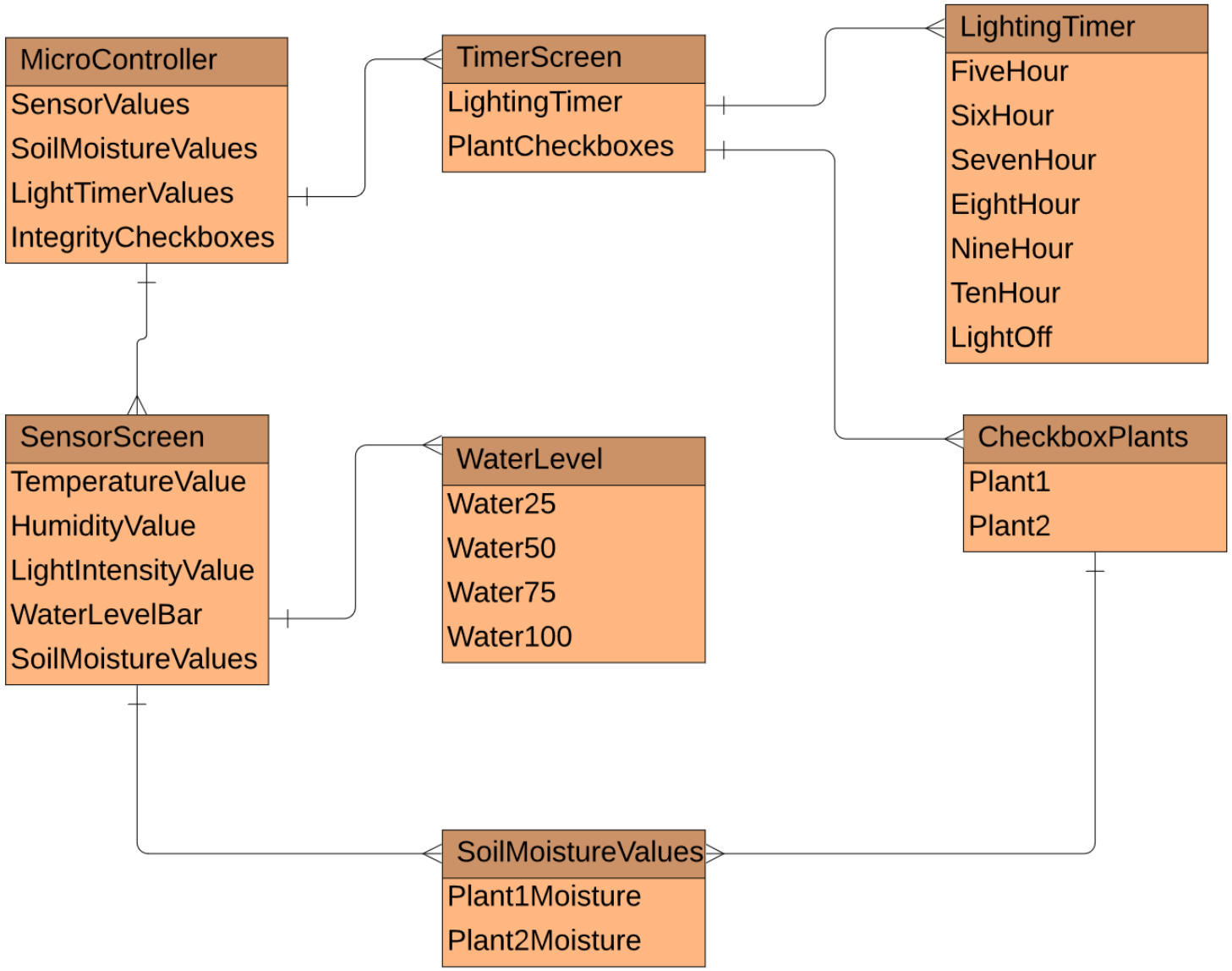
- Control over the environment and power consumption
- Detailed data on the sensor output
- Lighting timer for how long your plant is in sunlight
- Direct viewing of when the water reservoir requires a refill

Environmental Statistics

- Sensors transmit information to the microcontroller
  - Microcontroller sends information to your phone
- These statistics will be displayed and constantly updated
- Certain statistics have updates when appropriate
  - Water level has increments such as 25 and 50 percent



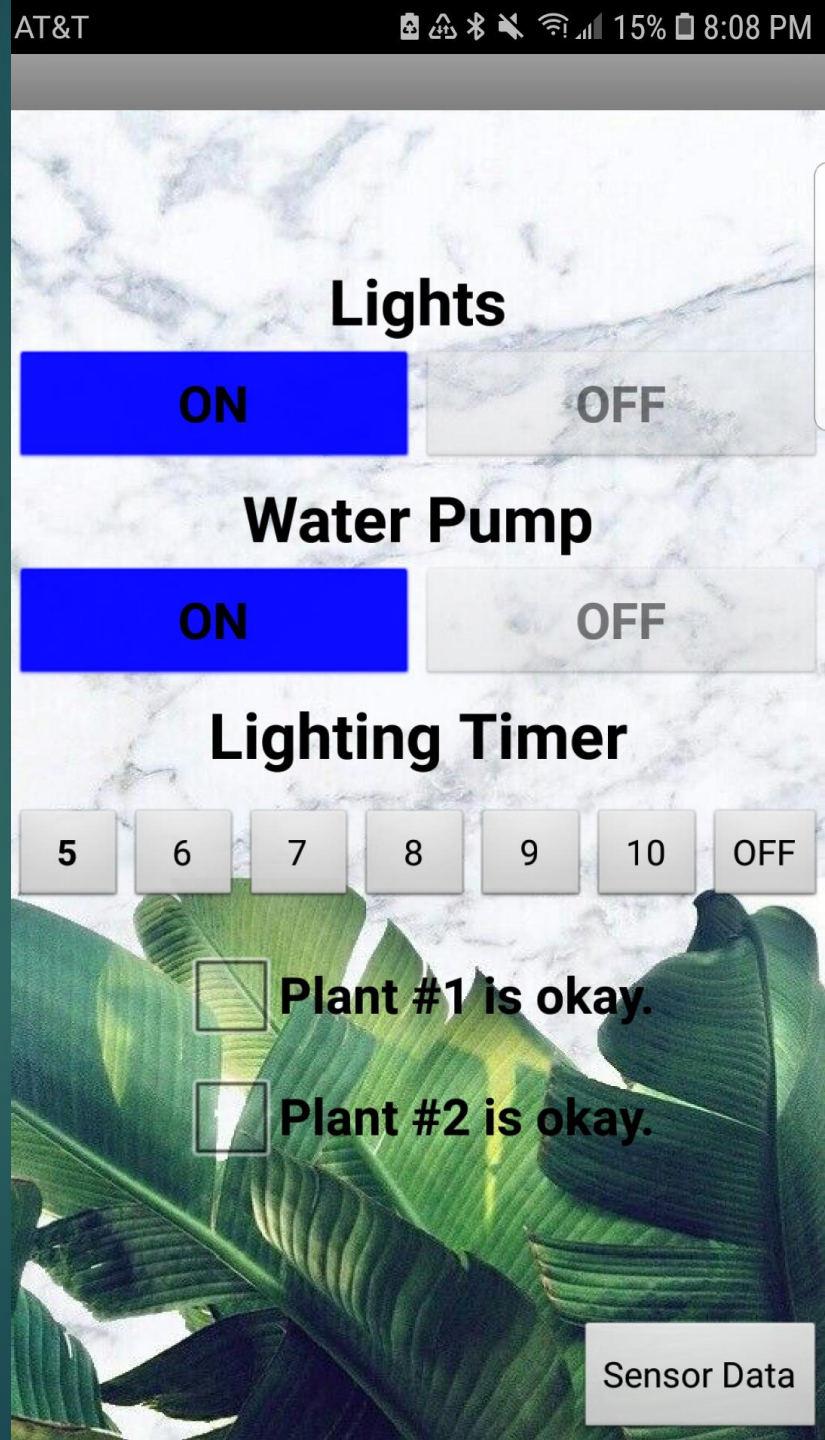
Entity Relationship Diagram Example (UML Notation)



- The app communicates with the microcontroller through IP address web commands.
- Sensor data is automatically pulled and displayed.
- Lighting timer will have button functionality to turn the light on for a specified time.
- Checkboxes for pump and soil moisture interaction.

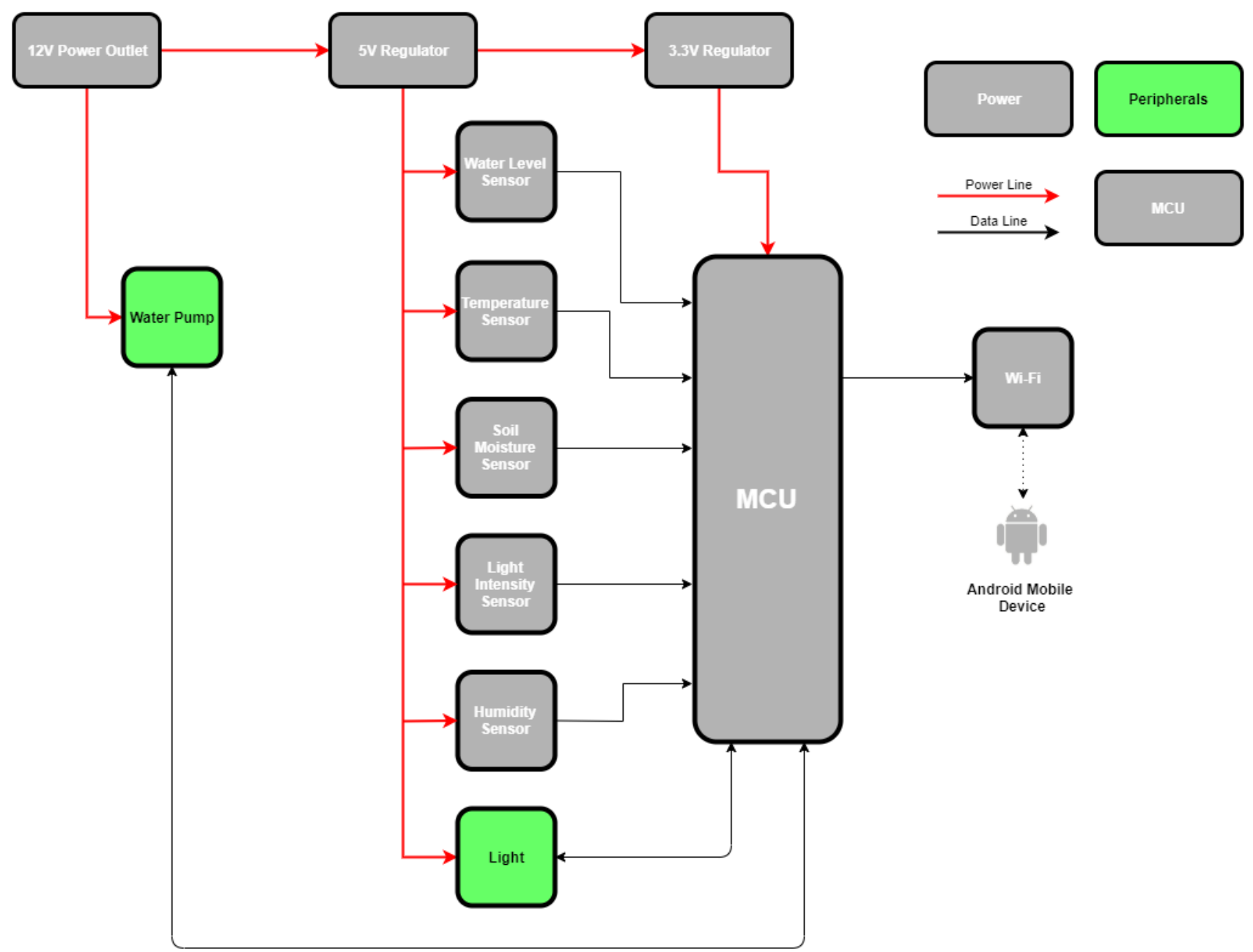
Button Functionality

- How it works:
- For setting specified times for the light timer.
  - Button sends IP address of the microcontroller linked with a command for it to recognize.
    - Timer has commands for each individual timer.
    - Times range from 5 – 10 hours of sunlight.
    - Off button will cancel any active timer.
- Manual commands for testing your electronics.



Why Android based?

- Familiarity with Java
- Basic understanding of MIT App Inventor 2
- Freeware
- Widely used and known
- Easy connection-based commands to the microcontroller
- Ability to install the app through a QR code as a third-party application



Peripherals

Peripherals

- Water Pump(s) - Originally going to be 3.
- Controlled via BJT as a switch and GPIO line
- Needed to water plants from the reservoir

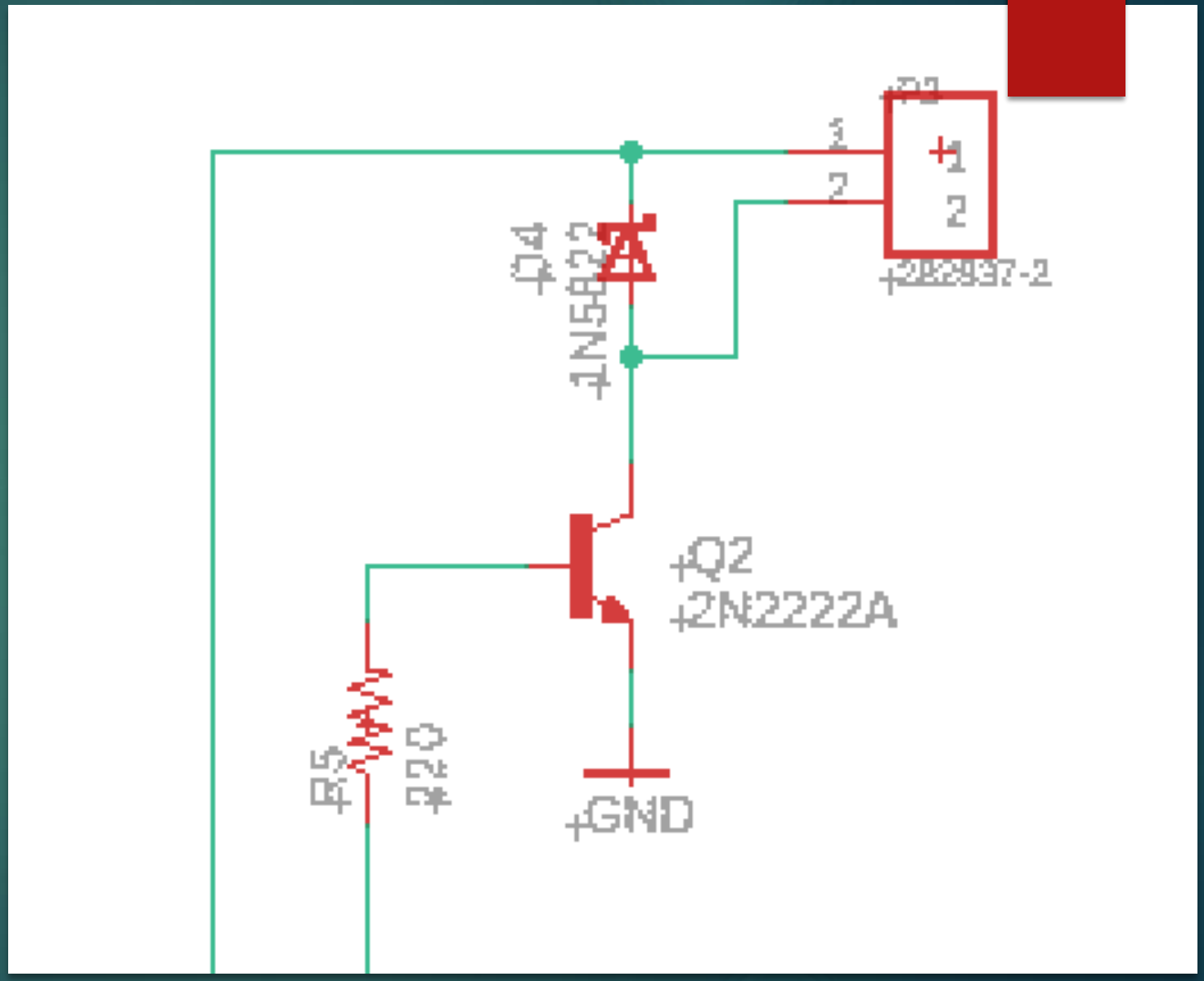
- Grow Light – Needed in order to provide plants a light source
- Can be set via timer on the mobile app or manually switched on/off
- Opted for one big light to cover area of all plants

Water Pump

- Gikfun Fully submersible water pump
- Rated 5V DC
- Load rated current of 0.18 A
- Cheap and readily available on Amazon (fast shipping)
- Small and fits in our water resevoir tube

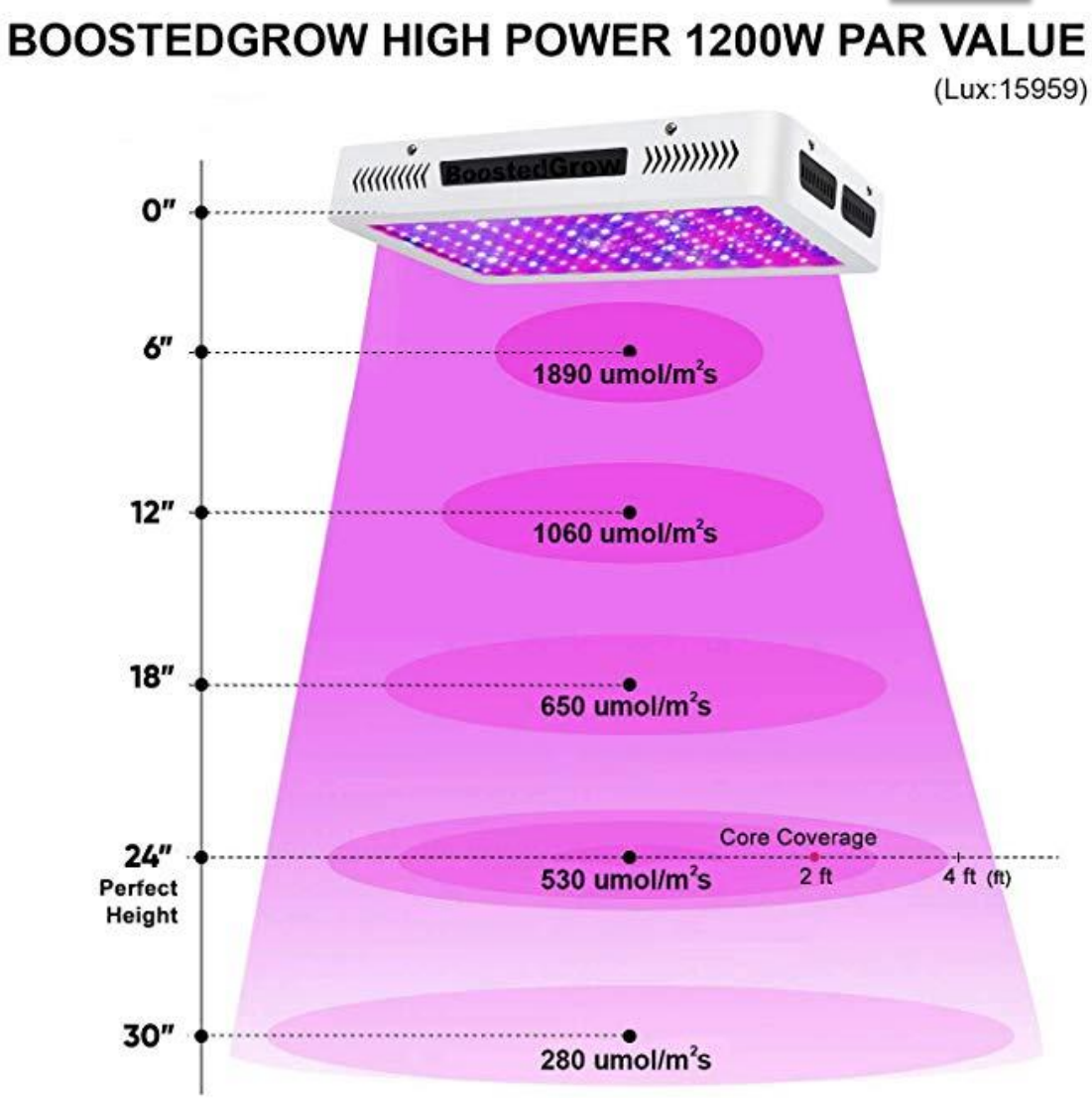
Pump Design

- Connected to 5V Output for power
- Connected via GPIO line and a BJT (2N2222A) to act as a switch
- Repeated 2 times for 2 pumps/plants
- Supposed to be 3 total but time and space constraints have limited us



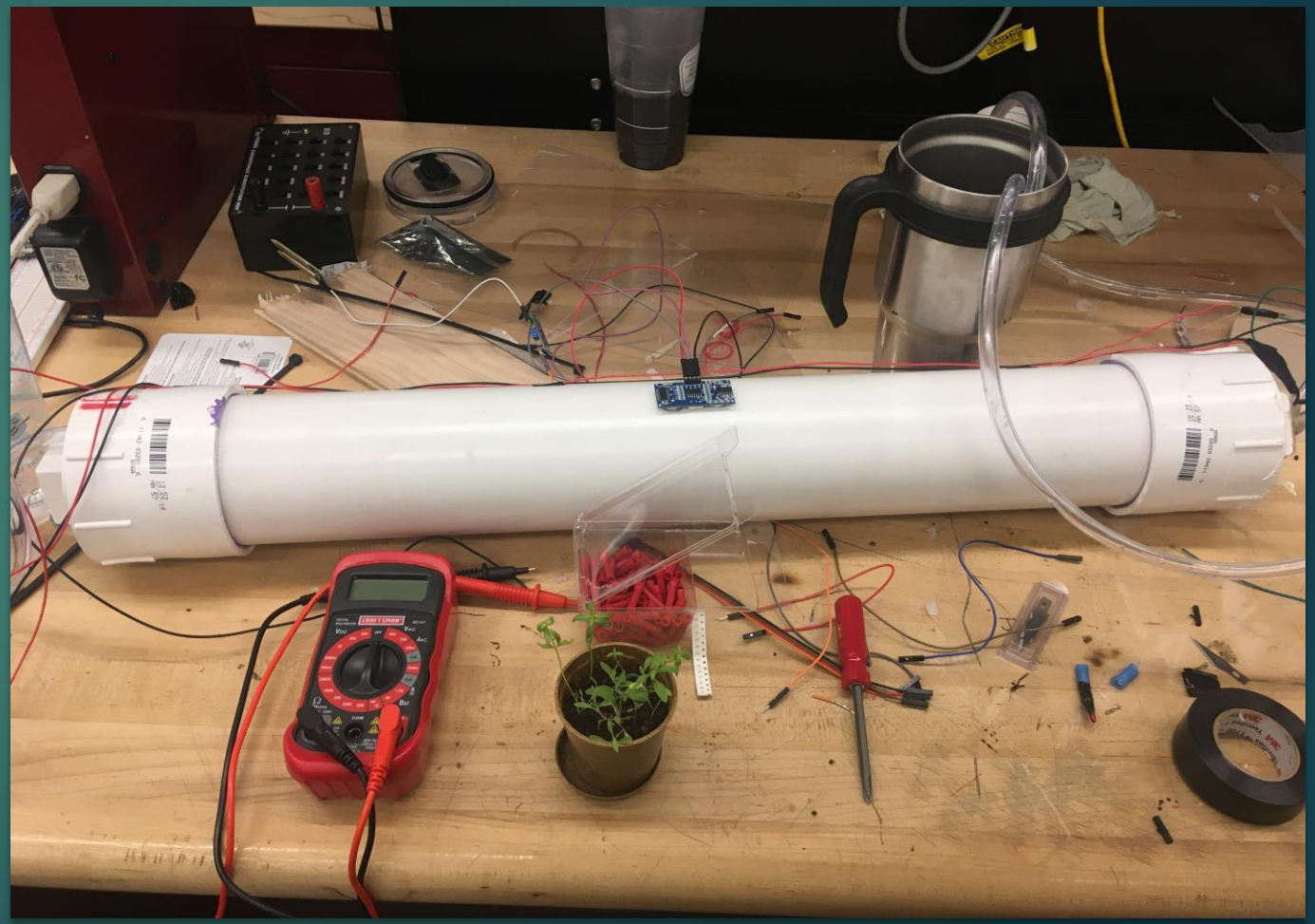
Grow Light

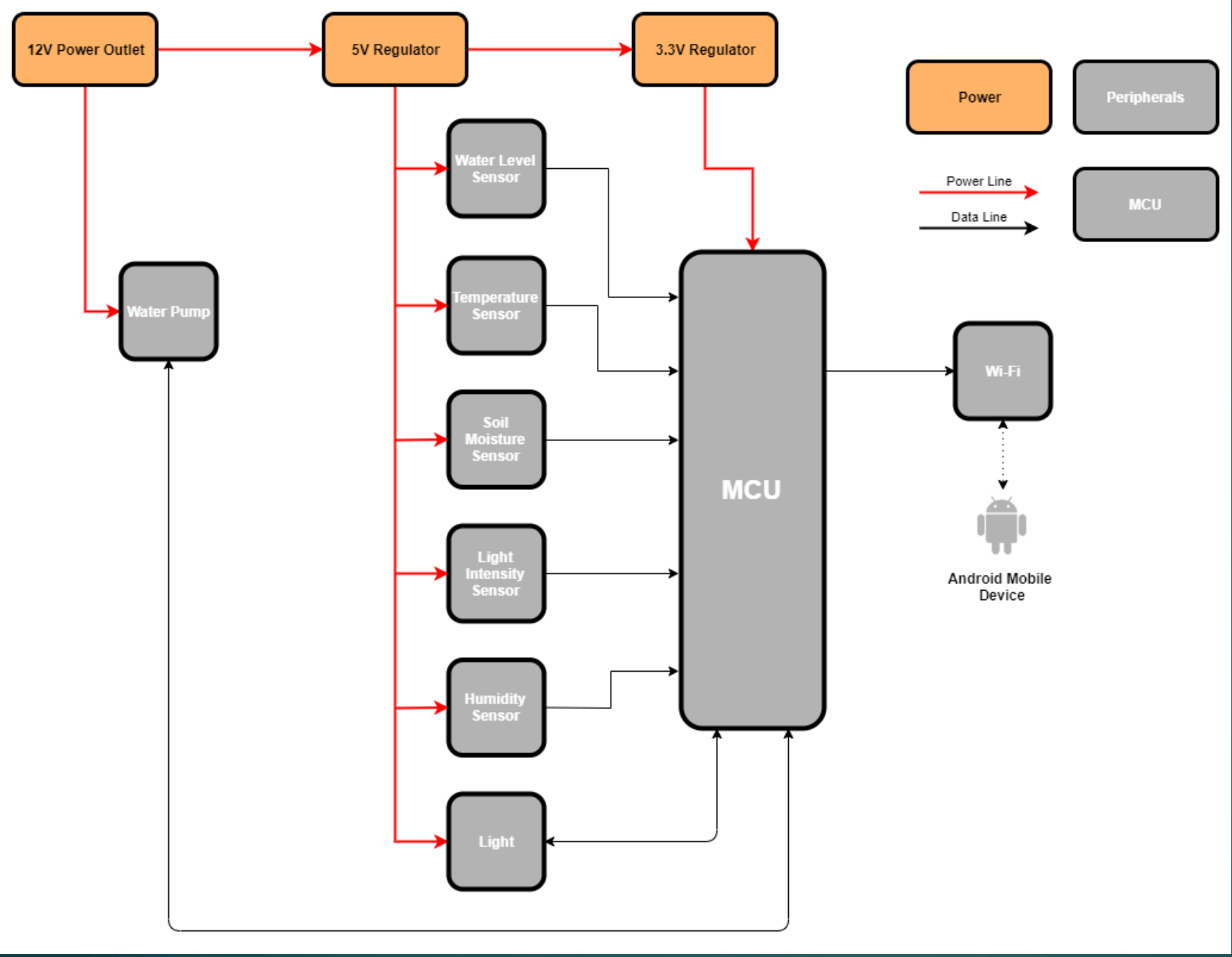
- Double chips 10W scientifically engineered to keep the balance of the Lumen Output and coverage
- Provides cooling system
- Every LED has a resistance to allow them to work separately
- Available light: white, red, blue, yellow, UV, and IR (similar to natural light & perfect for a variety of indoor plants)



Water Level Reservoir

- Tubing System with cutouts for ultrasonic to safely be positioned
- Fits snugly in display unit
- Pumps also reside inside of tube
- When empty, a pump is used to bring water back into the tube system

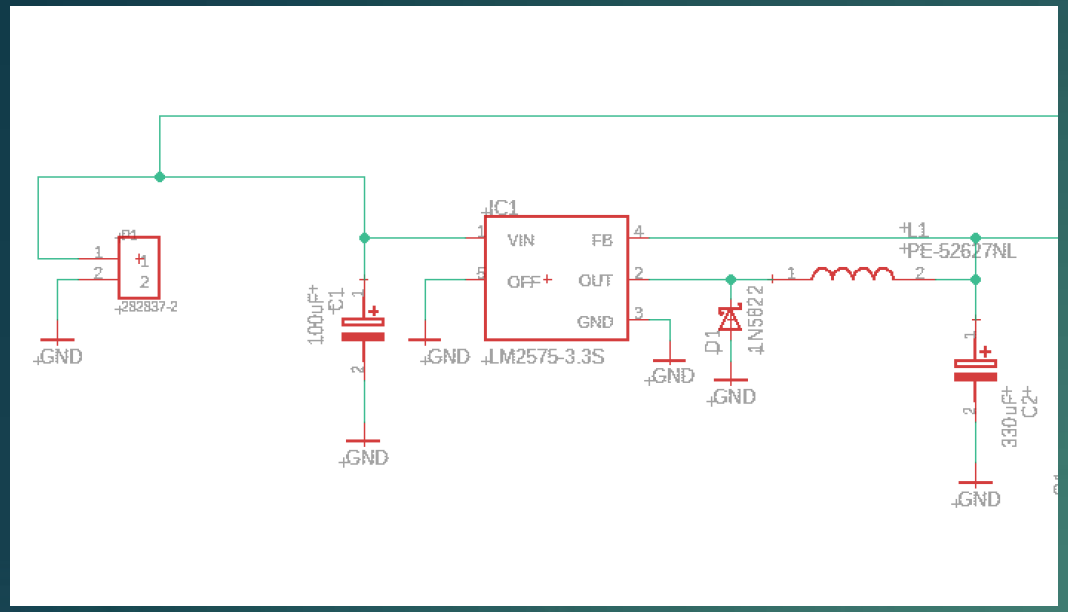


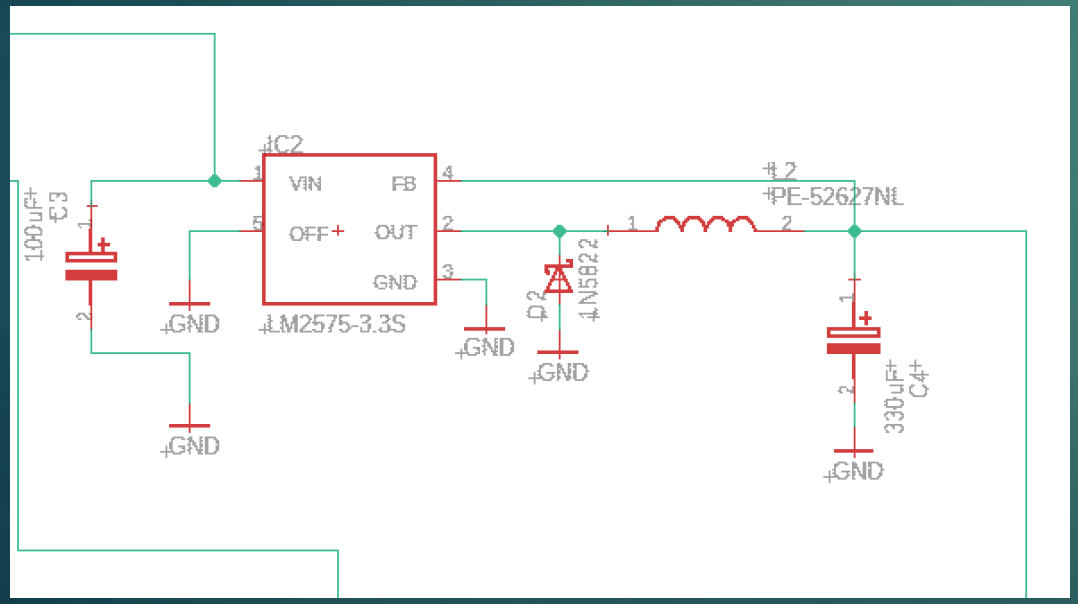

12V Power Outlet
5V Regulator
3.3V Regulator
Power
Peripherals
Water Level Sensor
Power Line
Data Line
MCU
Water Pump
Temperature Sensor
Wi-Fi
Soil Moisture Sensor
MCU
Light Intensity Sensor
Android Mobile Device
Humidity Sensor
Light

Power

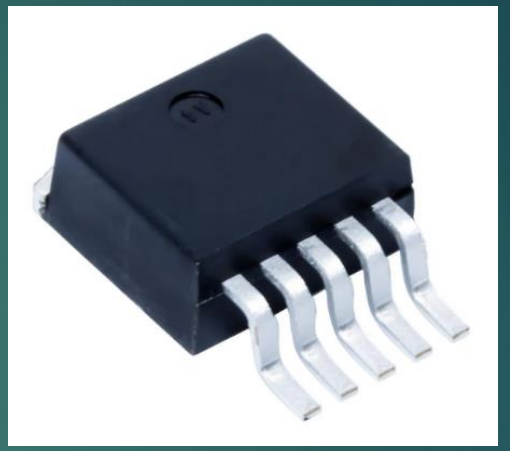
Power

- Power provided from home outlet
- Conversion of AC to DC via rectification to an output of 24V DC 2A
- Use of switching regulators to transform the voltage to 5V and 3V
- 5V powers: water pumps, grow light, and all sensors
- The 3.3V output powers the ESP8266-12E MCU





LM2575 Switching Voltage Regulator



- Available in 5V & 3.3V Output
- Switching Regulation
- 1A Output
- 58 kHz Switching Frequency
- Aluminum Electric Output Capacitors Required

Voltage Regulation

Work Distribution

	Ajay Emmanuel	Christopher Jordan	Clayton Szoke	Gabriel Rodriguez
MCU Software	X			X
PCB Design		X		
Mobile App			X	
PCB Testing		X	X	X
Software Testing	X		X	X

Cost

Item	Cost
Multiplexer	7.99
Water Pumps	11.98
Headers	7.99
LCD + Screen	38.75
Terminal Blocks	6.99
Grow Light	45.00
Resistors	14.99
Diodes	10.00
Capacitors	10.00
Development Board	27.00
Power Jacks	7.50
Power Adaptor	9.00
Ultrasonic Sensor	10.00
ESP MCU	13.00
Tubing	5.00
Moisture Sensor	9.00
Voltage Regulators	56.00
PCB	66.00
Total	**~360.00**

Questions???