# Portable Watering Device
# Group 9

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# Project Motivation

- Growing plants as a hobby
- Learning from a bad personal experience
- Finding the right solution

# Purpose

- For those who like to grow plants
- Benefits of owning a home vs. apartment
- Suitable for apartment residents who like growing their plants in balconies
- This system will let the user water their plants remotely, set a timer to water their plants consistently, or use an algorithm to water their plants efficiently

# Main Requirements

The system should be

- Efficient : High performance, low power consumption
- Portable : Small in size and lightweight, since apartment renters tend to move more often
- Smart : Show sensor data and let the user operate the system from a smartphone app

# Power Source

- It is important to find a power source that doesn’t require any wall outlet to operate
- A power bank or battery pack is a good option

# Battery

- Power the MCU, thus the whole system
- This battery is small size and lightweight
- Specifications: 12,000 mAh capacity, 2 USB ports, 5V output

- What if the battery runs out of charge?

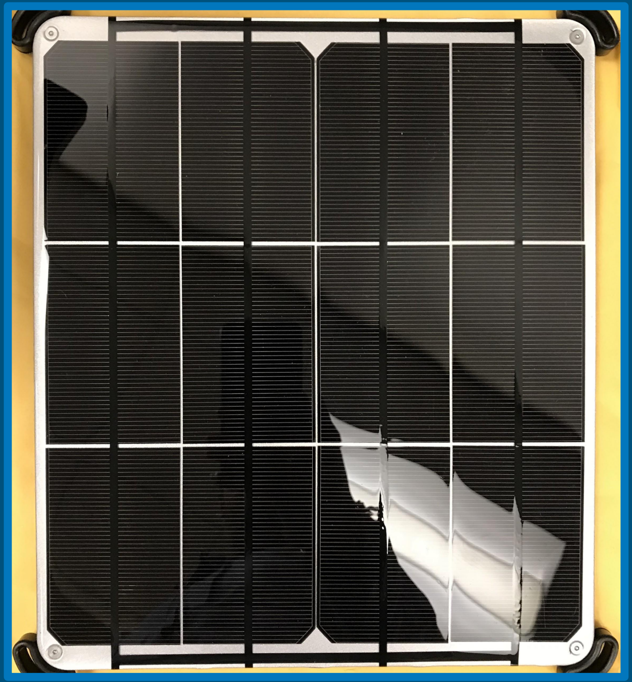
# Solar Panel

Comparison of 3 solar cell technologies

- **Monocrystalline Cells - Small in size, highest efficiency, very portable**
- Polycrystalline Cells - Large in size (heavy), less efficient, not portable
- Thin-Film Cells - Large in size, less efficient, not portable

Specifications

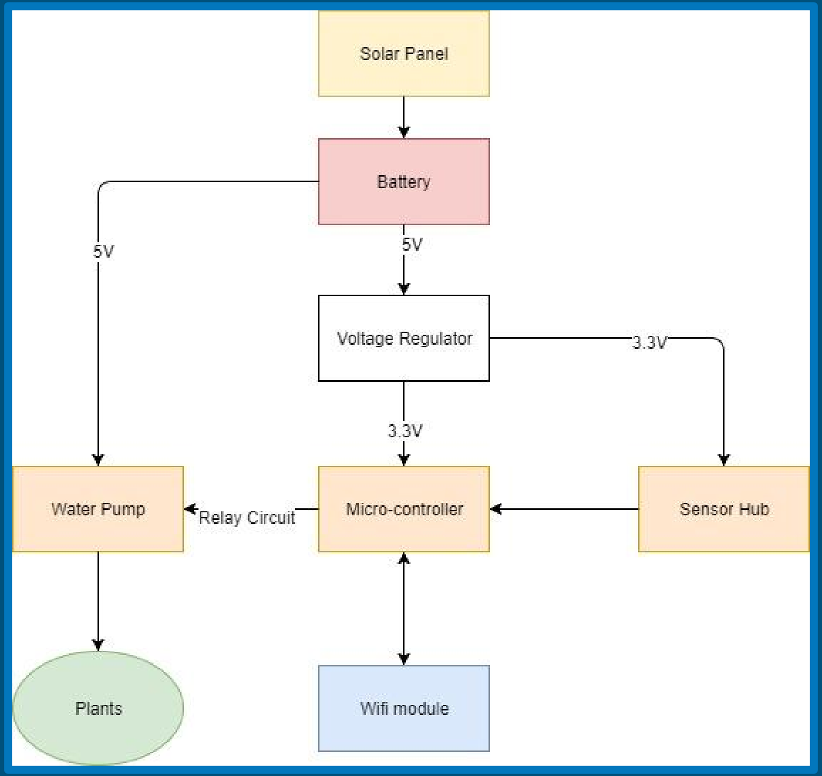
- 19% efficiency, 6V output, peak current of 1.5A, and peak power of 9W
- Provides a DC input to charge the battery, LED indicators to show charge



# Battery and Solar Panel Testing

- Battery was tested by simply trying to charge a phone with it
- LED indicators were tested by checking if they turned off as the battery was losing charge
- Solar panel was tested by connecting the battery and checking whether it charges the battery when under the sun

# Hardware Diagram



# Sensors

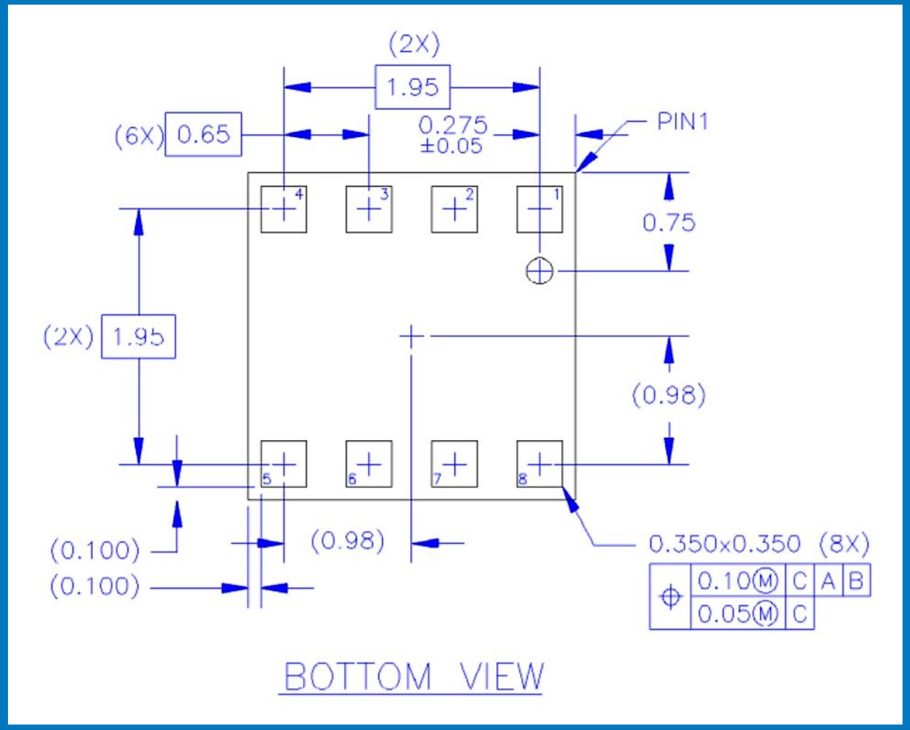
- Need to be able to measure relative humidity (RH), temperature, and the pressure of air surrounding the plant
    - Nice for users to see these values when looking at the application
    - We will be using this data to determine suitable times to automatically water plants
- Also need to monitor the water level in the tank
- While researching, we valued size, power consumption, and accuracy
    - Didn’t want components to fail prematurely when operating outside for extended periods
- Had to decide between analog and digital sensors

# Bosch BME280

- Combines temperature, pressure, and humidity sensing into one discrete package
  - Saves physical space on PCB, only 2.5 x 2.5 x 0.93 mm
- $7.58 per unit
  - Performance-to-price ratio was hard to ignore
  - Purchased from Digi-Key
- Operates between 1.7V to 3.6V, drawing 1.8μA to 3.6μA
- Operates from -40°C to 85°C, 0% to 100% relative humidity, and handles between 300 to 1100 hPa of pressure

# Soldering Sections, BME280 (in mm)

- We realized it was too small once it was delivered
- Precision required for soldering was too much for us
- Would have no way to test



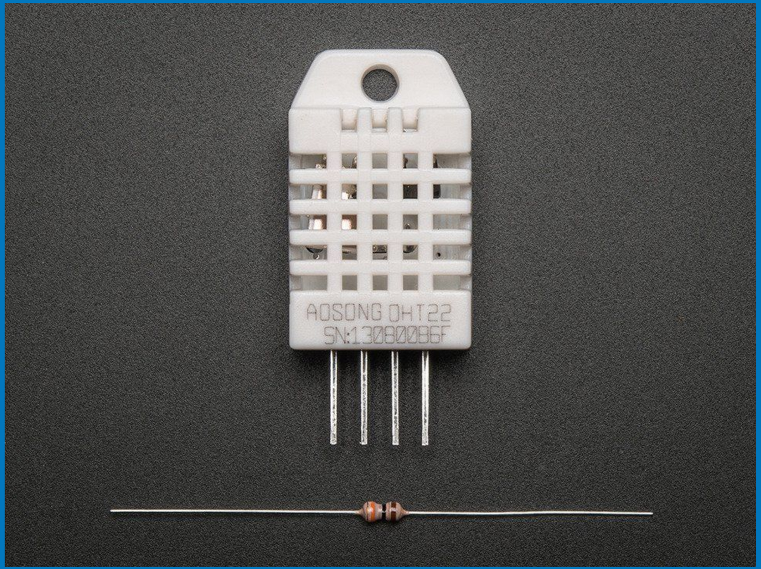
# Humidity Sensor

| Sensor | RH Range | Temperature Range | Accuracy | Current Consumption | Cost |
|---|---|---|---|---|---|
| **DHT22** | 0% to 100% | -40°C to 85°C | ±2% RH | 1.25mA | $9.95 |
| **HTU21D** | 0% to 100% | -40°C to 125°C | ±2% RH | 0.45mA | $1.33 |

- HTU21D has the DHT22 beat, but it requires a minimum order quantity
- DHT22 combines temperature and RH sensing

# Temperature Sensor

- DHT22 comes with built-in temperature sensor
- Sensor provides 9- to 12-bit measurements
- We'll do an analog to digital conversion to grab the voltage across the sensor, giving the digital sensor a usable value

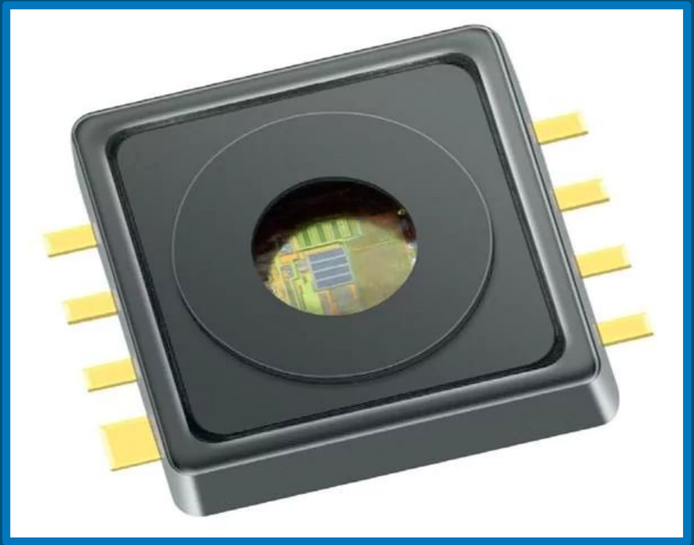


# Temperature Sensor Comparison

| Sensor | Resolution | Temperature Range | Accuracy | Current Consumption | Cost |
| --- | --- | --- | --- | --- | --- |
| **DFRobot DS18B20** | 0.5°C to 0.0625°C | -55°C to 125° C | ±0.5°C within -10°C to 80°C | 1mA | $6.90 |
| **DHT22 DS18B20** | 0.5°C to 0.0625°C | -40°C to 85°C | < ±0.2°C | 1.25mA | $9.95 |
| **TDK Thermistor** | Analog | -55°C to 125° C | Translate voltage through lookup table | - | $0.14 |

# Barometric Pressure Sensor

- KP235 pressure sensor from Digi-Key
- Converts pressure between 40kPa to 115kPa into a voltage between 0.5V and 4.5V
- Typical atmospheric pressure is around 101kPa
- Accurate within 1.2kPa
- -40°C to 125°C operating range



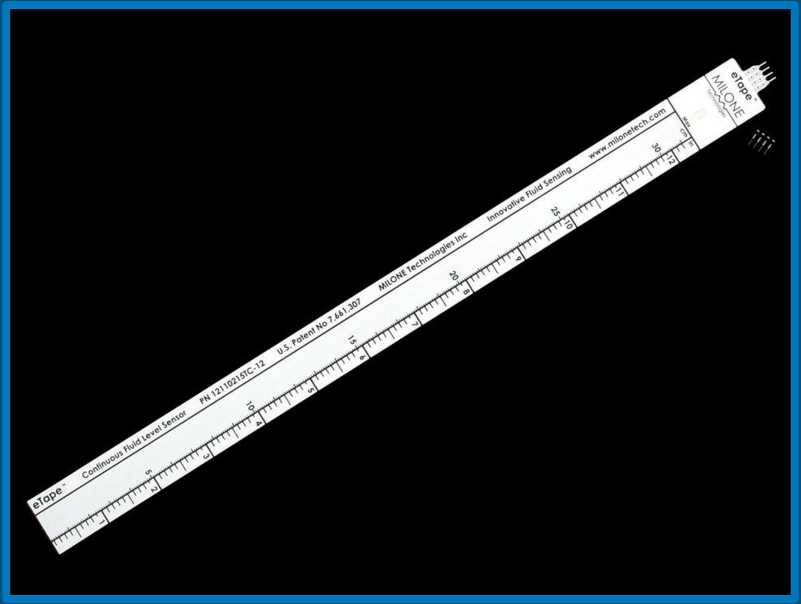
# Water Level Sensor Comparison

| Sensor | Sensing Range | Temperature Range | Current Consumption | Cost |
|---|---|---|---|---|
| **HC-SR04** | 2cm to 4m | - | 15mA | $3.95 |
| **Resistive Strip** | 31.5cm | -9°C to 65°C | 50mA | $39.99 |

- As long as the strip sensor fits in the tank, it will measure any amount of liquid
- Ultrasonic sensor requires a minimum distance

# Water Level Sensor

- We felt, despite the cost, the strip sensor benefits the project
- More accurate than ultrasonic sensor
- Easier to set up for users
- Keeping the ultrasonic sensor as backup



# MCU Needs

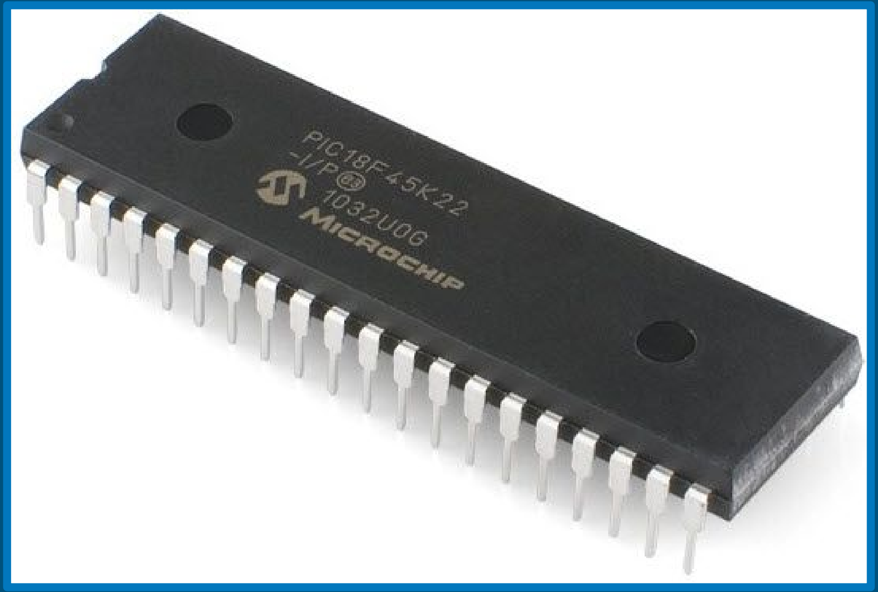
Size:
- Small to reduce size of PCB

Price:
- Cheap to reduce overall cost

Ease of Use:
- Easy to Solder onto board

Control:
- Enough Memory for Code
- Enough GPIO pins for sensors(5+)

Low Power:
- Reduce the amount of drain on battery for a longer lasting device

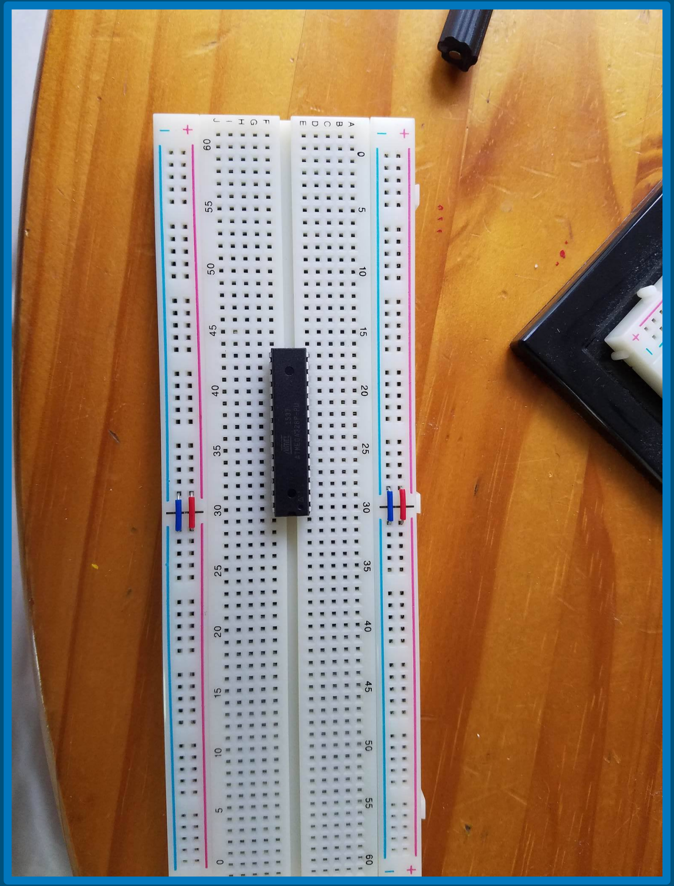


# Microcontroller Comparison

| | AT32UC3L0128 | MSP430FR6989 | MSP430F6659 | ATmega328P | ATSAMG51 |
|---|---|---|---|---|---|
| **Clock Rate** | 50 MHz | 16 MHz | 20 MHz | 20MHz | 48 MHz |
| **Low Power Mode** | 165 uA/MHz | 101.25 uA/MHZ | 295 uA/MHz | .75 uA/MHz | 103 uA/MHz |
| **Cost** | $6.39 | $9.64 | $12.25 | $2.18 | $3.14 |
| **Memory** | 128 KB | 128 KB | 512 KB | 32 KB | 256 KB |
| **GPIO** | 36 | 83 | 74 | 23 | 38 |
| **Communication Types** | UART,SPI,I2C | UART,SPI,I2C | UART,SPI,I2C | UART,SPI,I2C | UART,SPI,I2C |
| **Package Type** | 18  x 18 pin surface mount | 18 x 18 pin surface mount | 18 x 18 pin surface mount | DIP | 18 x 18 pin surface mount |

# Atmega 328p

- Arduino bootloader
- Small DIP based chip
- Low power
- Fast clock rate
- Enough GPIO pins



# Pump Needs

Size:
- Small to reduce size of project Design

Price:
- Cheap to reduce overall cost

Voltage & Power Consumption:
- Low voltage to eliminate the need of a booster circuit
- Low power consumption to increase battery life

Flow Rate:
- High flow rate means better water distribution

# Pump Comparison

| | Voltage | Cost | Size | Gallons Per Hour | Power Consumption |
|---|---|---|---|---|---|
| **Lightobject EWP-7L9** | 6-9V | $8.95 | 30 x 78.3 x 10 mm | 65 G/H | 12W |
| **Mavel Star 12 volt** | 12V | $10.99 | 10 x 6 x 8.8 cm | 63 G/H | 6W |
| **Anself Ultra-quiet Mini** | 12V | $10.35 | 5.2 x 4.6 x 5.5 cm | 63 G/H | 4.8W |
| **Uniclife 80 GPH Submersible Water Pump** | 110-120V AC | $7.99 | 53.3 x 43.2 x 33.02 mm | 80 G/H | 4W |
| **3M Water Circulation Micro Brushless Water Pump** | 5-12V | $12.00 | 50.8 x 45.7 x 55.9 cm | 63 G/H | 2W |
| **FORTIRIC ZKWP01 60GPH DC 12V** | 12 V | $10.99 | 51 x 34 x 42.7 mm | 60 G/H | 4.2W |

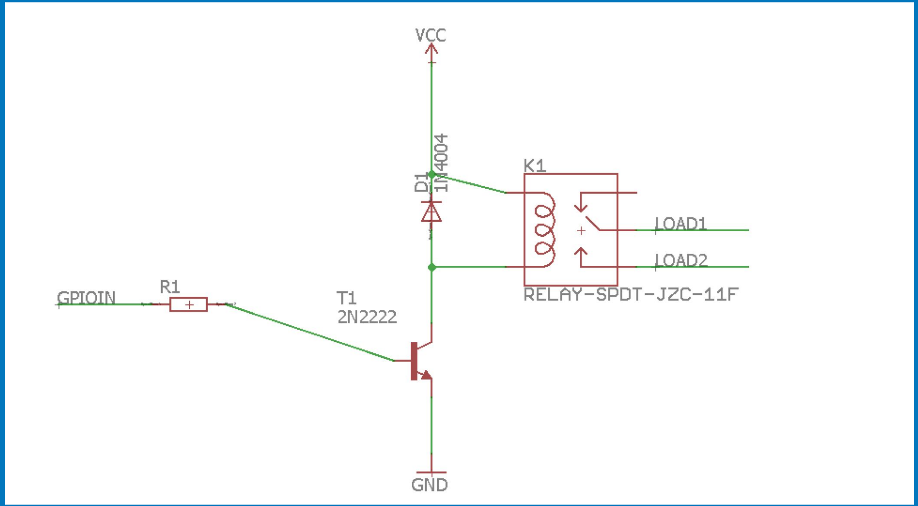
# Pump Selection

- Works with 5V
- 2W power consumption during operation
- No boost circuit needed
- Small and cheap
- Easy to install with screw brackets

# Relay Circuit

Voltage & Power Consumption:

- Reduces power consumption with switching capabilities
- Uses 5V from battery to drive pump
- Uses 3.3V burst from GPIO to turn on
- Allows for a more efficient pump
- All current from second port of the battery goes directly to the pump



# Printed Circuit Board (PCB)

Speed:
- Fast turnover in case an error occurs

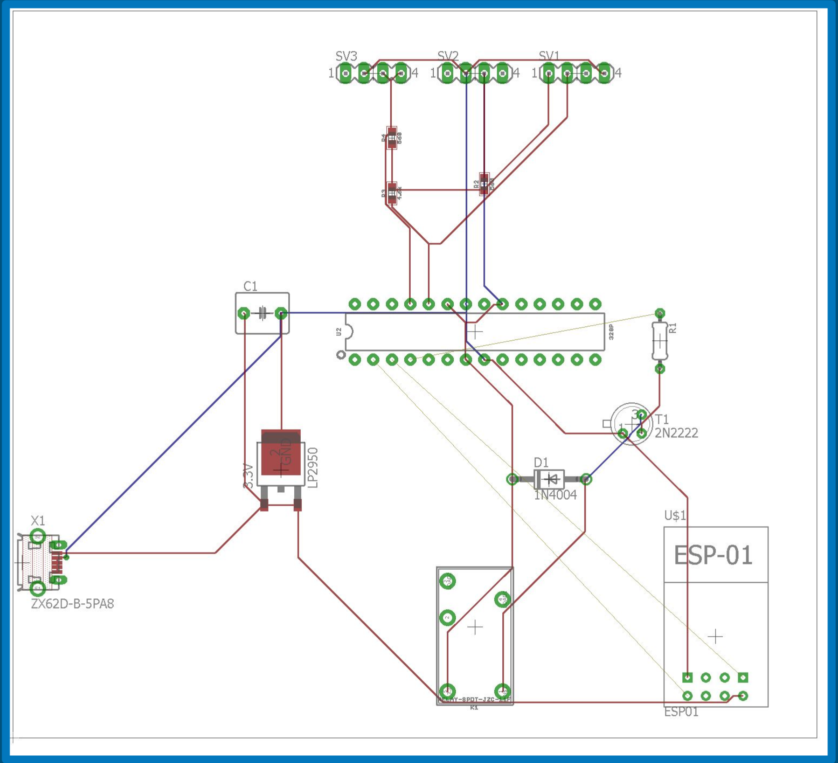
Layers:
- 2 or more to help with wire routing

Price:
- Cheap to reduce project cost

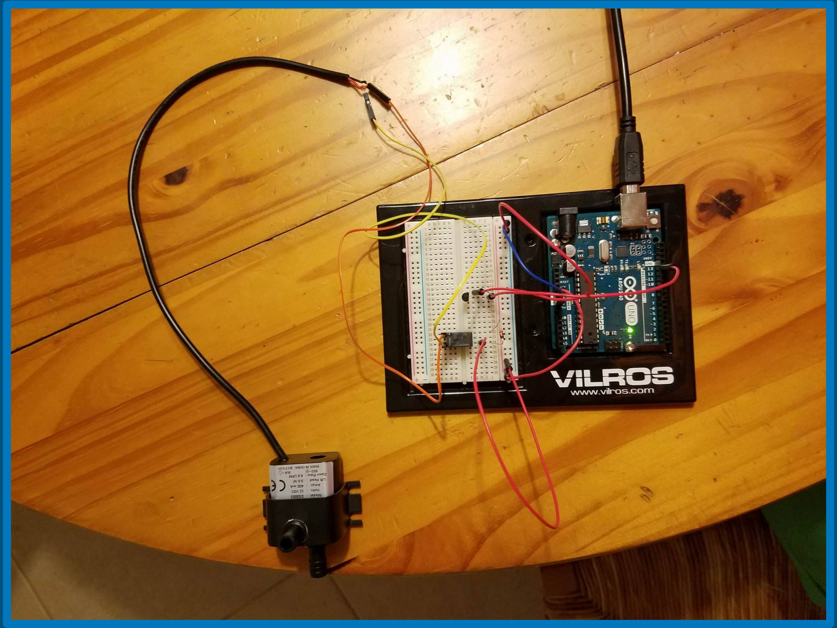
Customer Service:
- High rated in case we need faster shipment or damaged board comes in

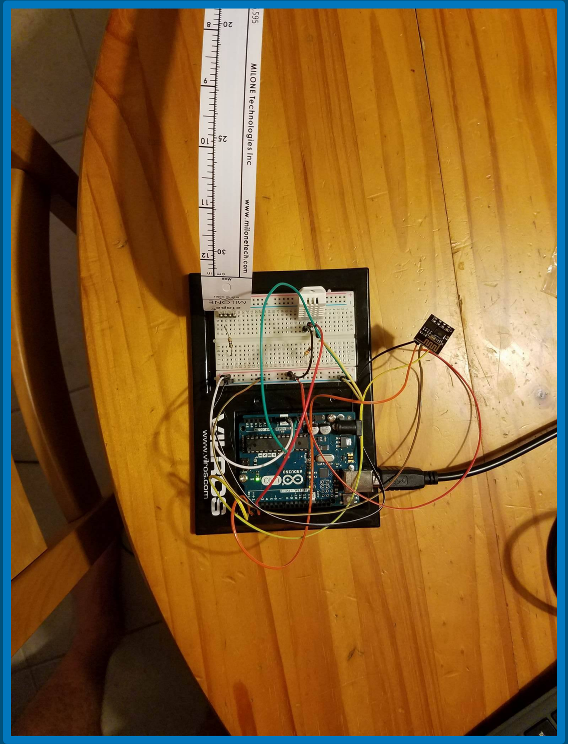
| | Price | Manufacturing Speed | Layers | Rating |
|---|---|---|---|---|
| **4PCB** | $33 | 5 days | 2 | 5 stars |
| **PCBCart** | quoted | 1-5 day build + shipping | 10 | 5 stars |
| **Seeed Studio** | quoted | 1 day build + shipping | 16 | 5 stars |

# PCB Schematic



# Hardware Testing



# Wireless Communication

In order for the project to work, the device and its application must be able to communicate wirelessly

| Technology | Advantage | Disadvantage |
|---|---|---|
| Wi-Fi | - Provides high-speed access to the internet<br>- Long signal range<br>- Once device is connected to internet it can be operated from anywhere in the world | - Harder to setup<br>- Walls and other obstacles interfere with signal strength |
| Bluetooth | - Easy to connect devices<br>- Easier to implement in microcontroller environment | - Only works over short distances (< 30 ft)<br>- Cannot connect a device to the internet |
| ZigBee | - Low cost<br>- Low power<br>- Encrypted network | - Mainly works over short distances<br>- Slow transmission speed |

# Wi-Fi Module Comparison

| | Arduino Wi-Fi 101 Shield | ESP8266 Wi-Fi Module |
|---|---|---|
| **Operating Voltage** | 3.3V and 5V | 3.3V |
| **Wi-Fi Standards Supported** | IEEE 802.11 b/g/n | IEEE 802.11 b/g/n |
| **PCB Connection** | SPI Port | SDIO 1.1/2.0, SPI, UART |
| **Size** | 2.1" x 2.5" x 0.93" | 1.0" x 0.6" x 0.04" |
| **Price** | $49.95 | $6.95 |

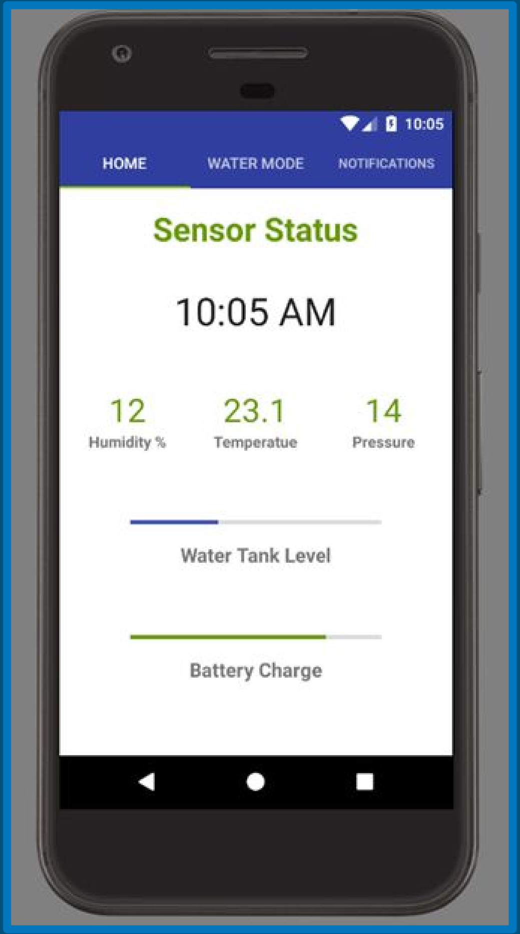
Although the Arduino Wi-Fi Shield had many more features and was a little easier to set-up, the ESP8266 had all the features we needed and was considerably cheaper

# Smartphone Application

- Helps the user communicate with the device through Wi-Fi
  - Read sensor data and status
  - Modify settings
- Operating System: Android
  - iPhone platform was also considered but developing an application for iOS requires Xcode which is only available on Mac
- Application development software: Android Studio
- Initial testing conducted on Google Pixel Emulator

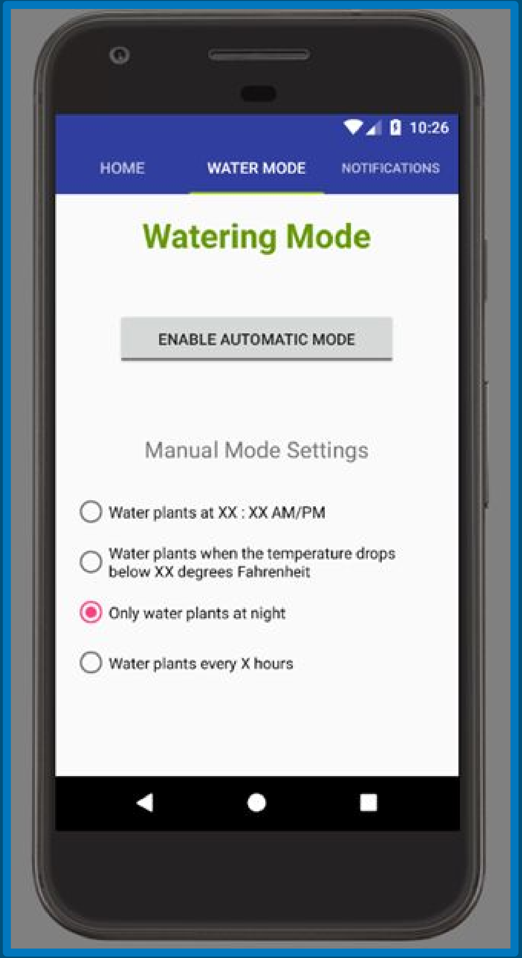
# Home Screen

- Default screen when application is launched
- Displays all relevant sensor data in one page
    - Humidity
    - Temperature
    - Pressure
    - Water Tank Level
    - Battery Charge
- Easy way to determine if sensors are working properly
- Overall quick overview of the entire system



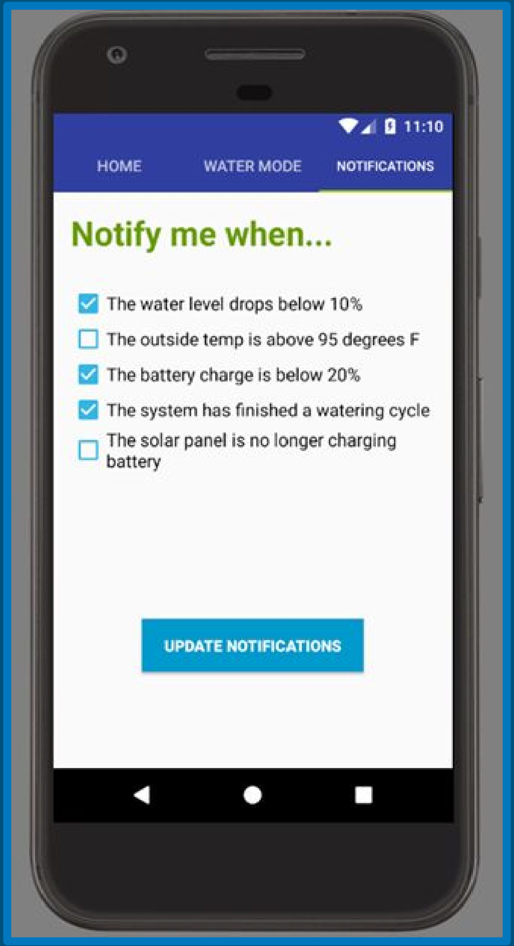
# Watering Mode Screen

- Enable /disable automatic watering mode
  - Uses all the onboard sensors to determine the best time to water the plants
- When automatic mode is disabled, manual mode settings become available to the user
- In manual mode, users have the option to water plants:
  - At a certain time
  - At a certain temperature
  - Every X amount of hours
  - And more…

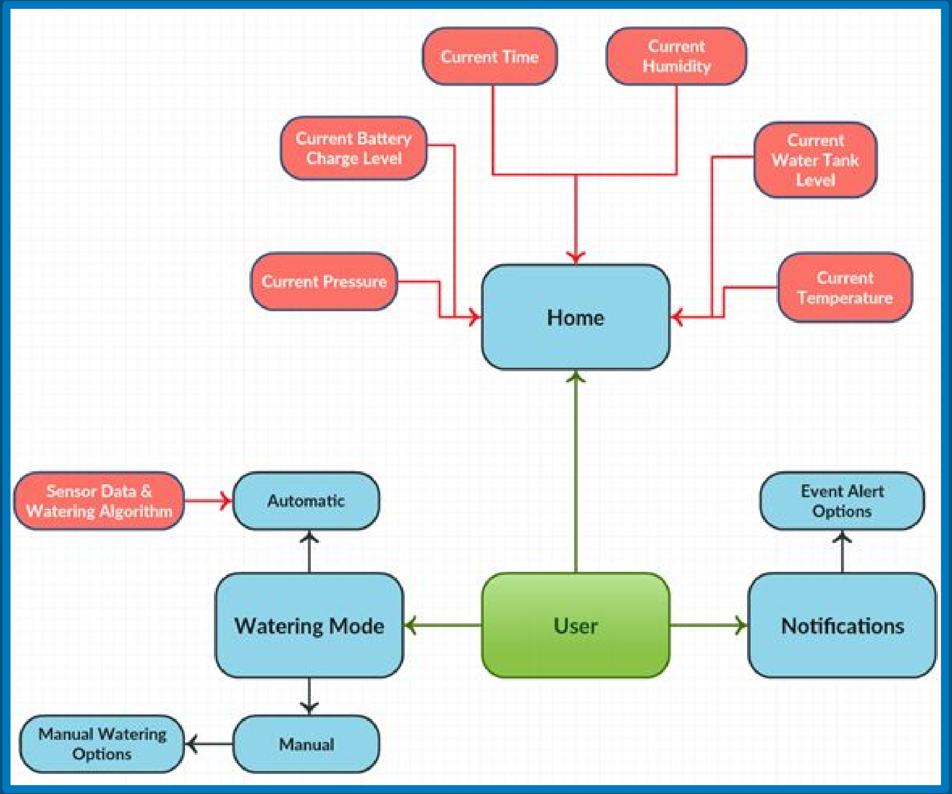


# Notifications Screen

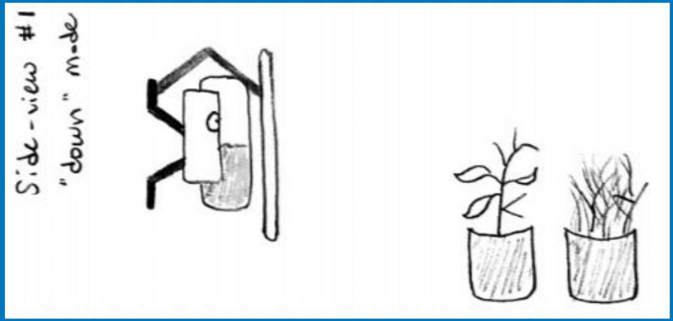
- Allows user to set up notifications for certain events
- Events include:
  - The water level drops below X %
  - Outside temperature is above X degrees F
  - Battery charge is below X %
  - The system has finished a watering cycle
  - And a few more…
- Still in development
  - More events will be added as the system gets closer to its final stage

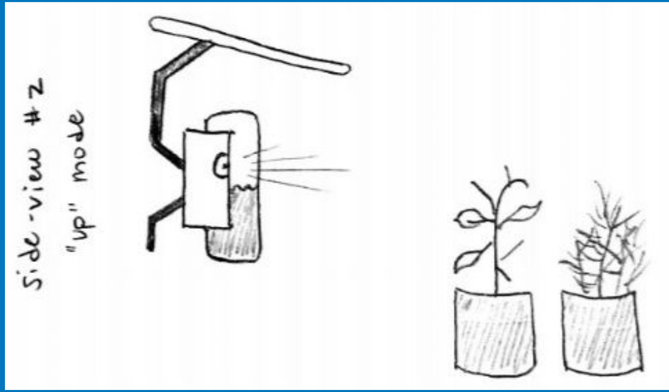


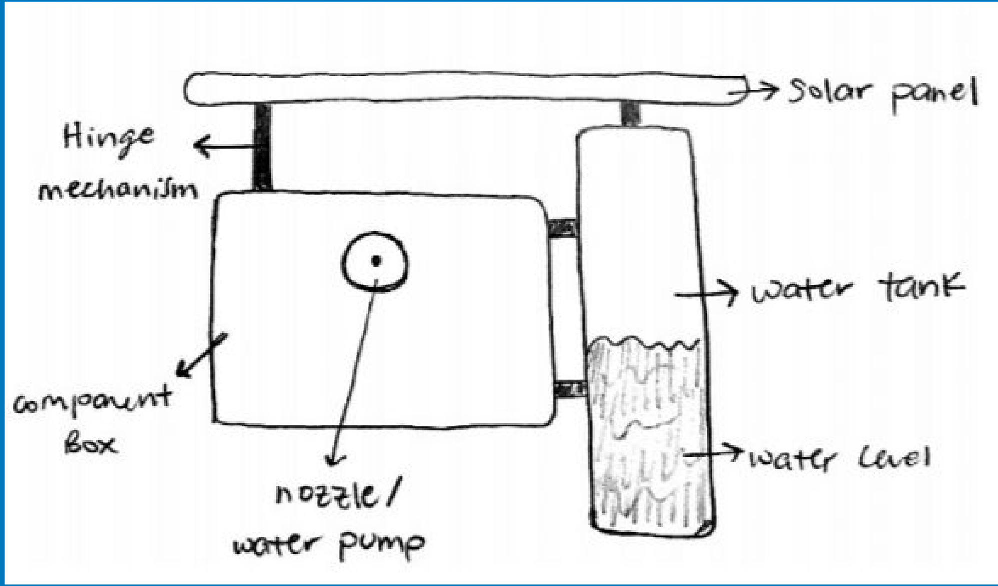
# Use Case Diagram



# Device Prototype Sketch



# Current Issues

- Physical Design
  - Directing the solar panel to get enough sunlight
  - Placing the device in desired location
- PCB Design
  - Proper Routing

# Budget & Funding

- Price per unit is going to be around $ **310.50**
  - Price of final PCB could change this amount
- Total amount spent so far is $ **385.84**, which includes:
  - Needed components
  - Backup parts
  - Miscellaneous parts (resistors, capacitors, etc.)
  - Testing equipment
- This is not a sponsored project
  - Project funded entirely by the team
  - Total cost split evenly across the four team members

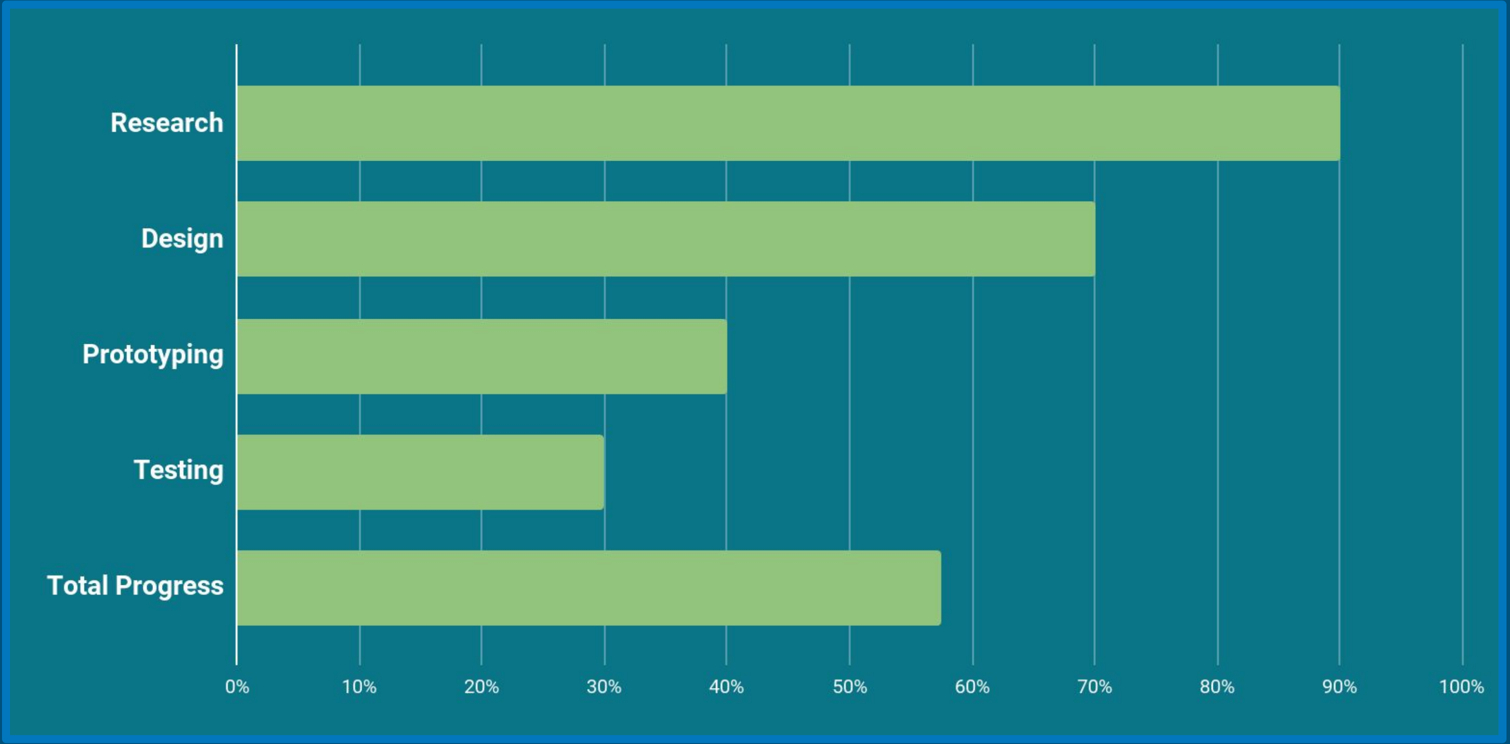
# Budget & Funding

| Component Name | Price | Source | Quantity Purchased | Amount Spent |
|---|---|---|---|---|
| **Water Pump** | $12 | Amazon | 1 | $12 |
| **Solar Panel & Battery** | $159 | Voltaic Systems | 1 | $159 |
| **PCB** | $50 | 4PCB | 1 | $50 |
| **ATmega328P Microcontroller** | $2.18 | Adafruit | 1 | $2.18 |
| **Temperature & Humidity Sensor** | $9.95 | Adafruit | 2 | $19.90 |
| **Barometric Sensor** | $8.43 | Digi-Key | 3 | $25.29 |
| **ESP8266 Wi-Fi Module** | $6.95 | SparkFun | 3 | $20.85 |
| **Water Level Strip Sensor** | $39.99 | Adafruit | 1 | $39.99 |
| **Water Tank** | $2 | Walmart | 1 | $2 |
| **Miscellaneous Parts** | $20 | Amazon | 1 | $20 |
| | | | | |
| **MSP430 Chip** | $1.33 | Adafruit | 3 | $3.99 |
| **3-in-1 Sensors** | $7.58 | Digi-Key | 3 | $22.74 |
| **Ultrasonic Sensor** | $7.90 | SparkFun | 2 | $15.80 |

# Work Distribution

| Team Member | Power | PCB | Sensors | Application |
|---|---|---|---|---|
| Chris | | | X | |
| Joan | | | | X |
| Peter | | X | | |
| Ronak | X | | | |

# Progress


Research
Design
Prototyping
Testing
Total Progress
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

# Any Questions?