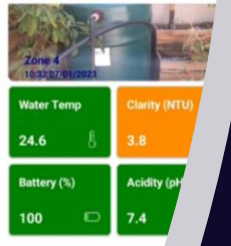


devconf;

Create the sustainable home farm of your dreams!

Email: adpead@gmail.com Twitter: @adpead

- Twitter: @adpead
- About.me: https://about.me/allan_pead
- Linkedin: https://www.linkedin.com/in/adpead/

- Blog: https://explorationspace.co.za

- Raspberry Pi South Africa
- https://www.facebook.com/groups/1493503984198019

- Cape Town MS Developer User Group
- https://www.meetup.com/Cape-Town-Ms-Dev-User-Group/

Microsoft Internet of Things Most Valuable Professional
Microsoft Azure Most Valuable Professional
Microsoft Developer Technologies Most Valuable Professional

Allan Pead

What is this talk about?

- My Journey to building a sustainable farm in my home and garden
- Hope to inspire more home growing
- Index to items you may need
- Having fun and building cool things at a low hobbyist cost


I will not have 100 things plugged in
I will not have 100 things plugged in
I will not have 100 things plugged in
I will not have 100 things plugged in

My Journey...

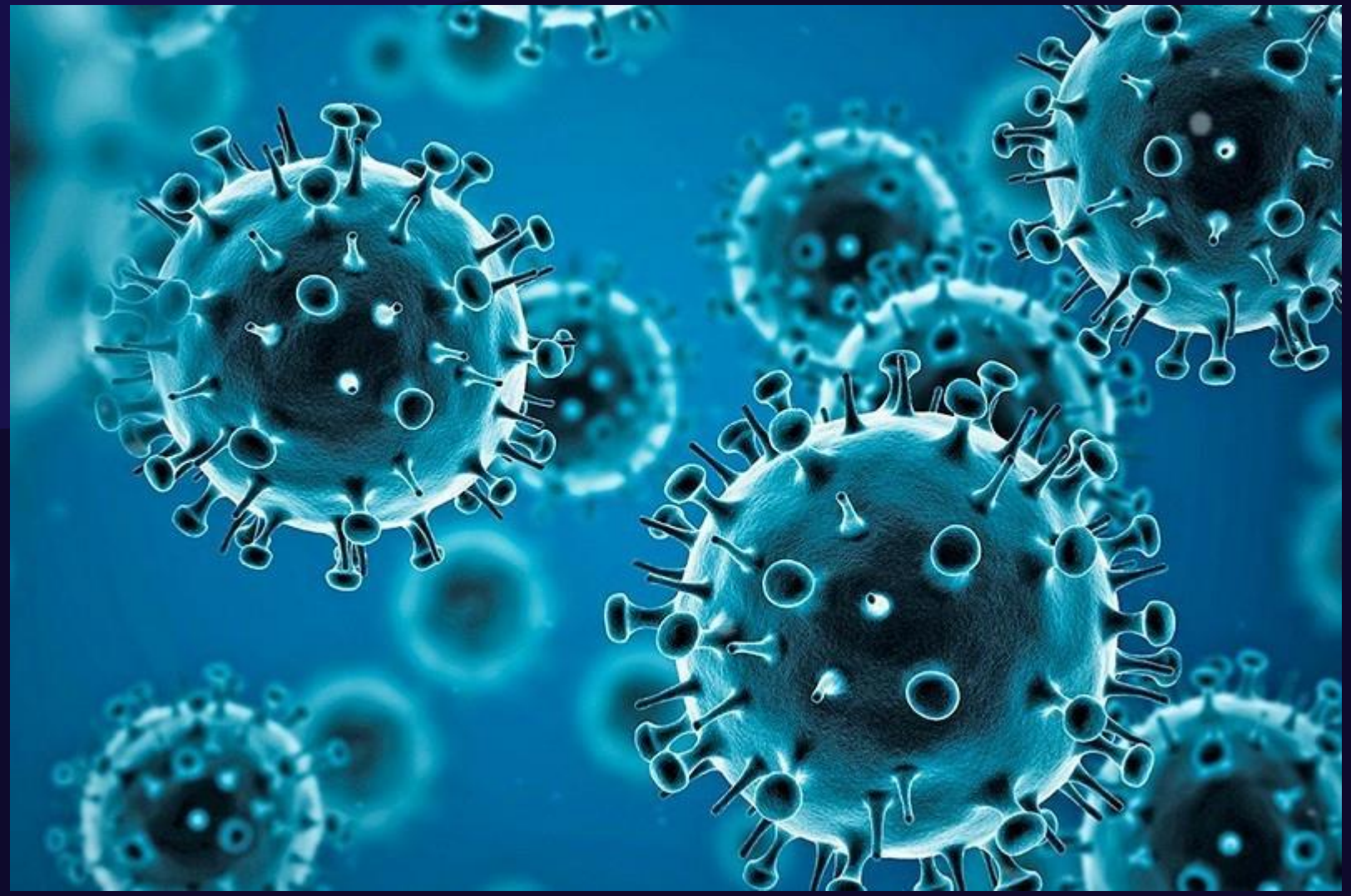
We were doing things like this for Day Zero

Problem 1: Moving Water to the “Edge”

Problem 2: This may make me die. 🤔

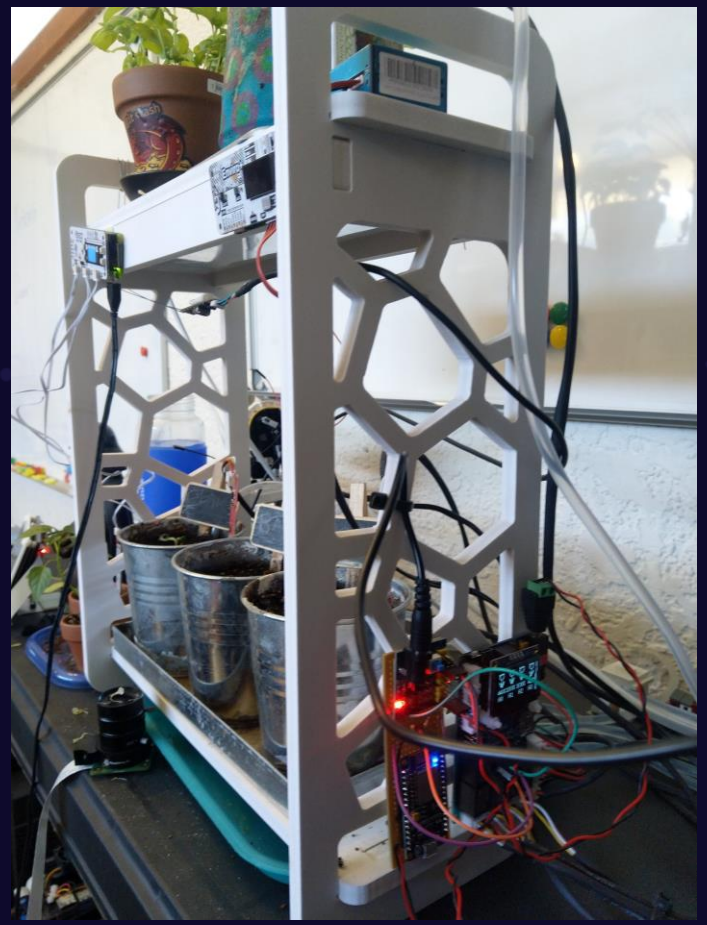
Water is now my problem 😮

Then there was this…

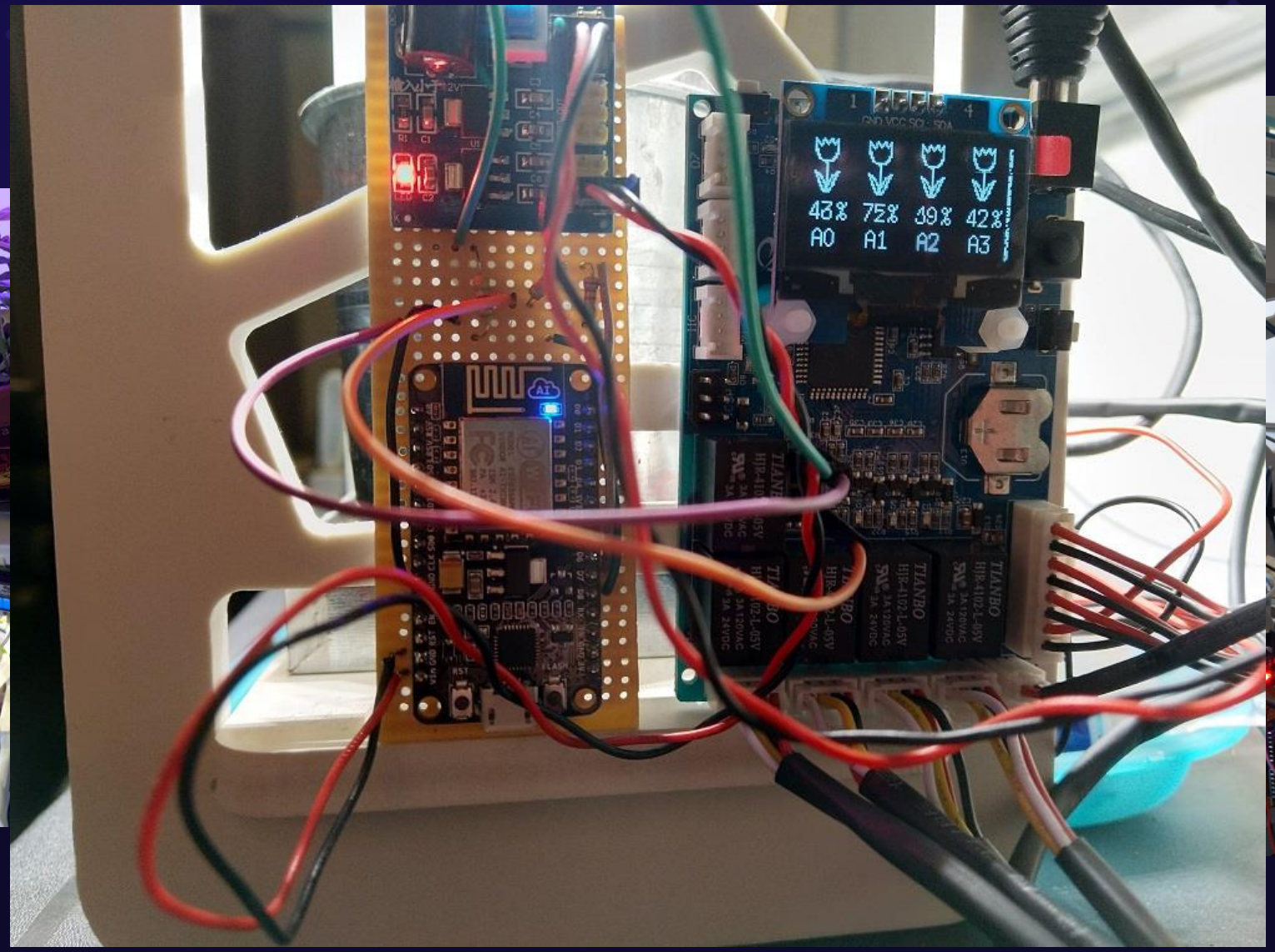


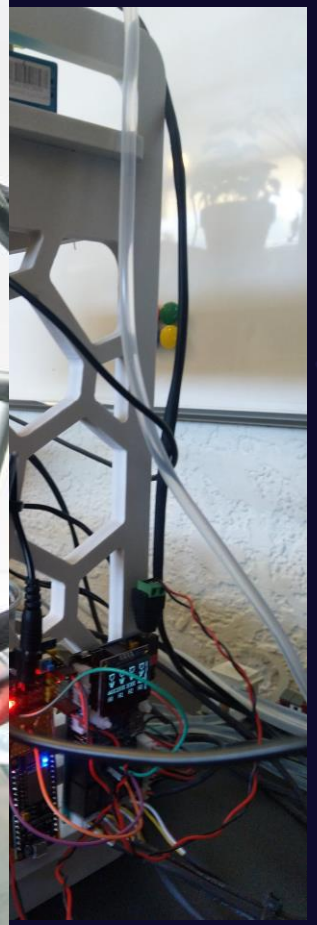
Who did things like this during lockdown?

My Plant Growing Journey

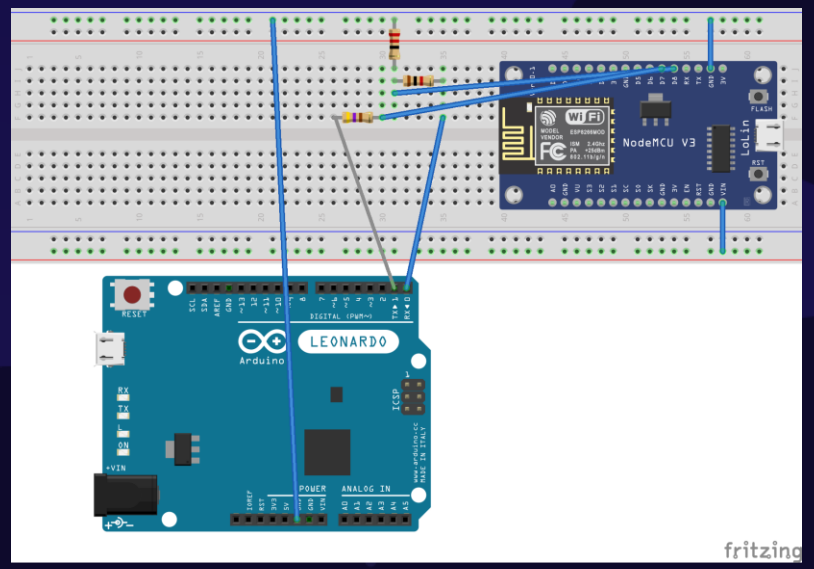


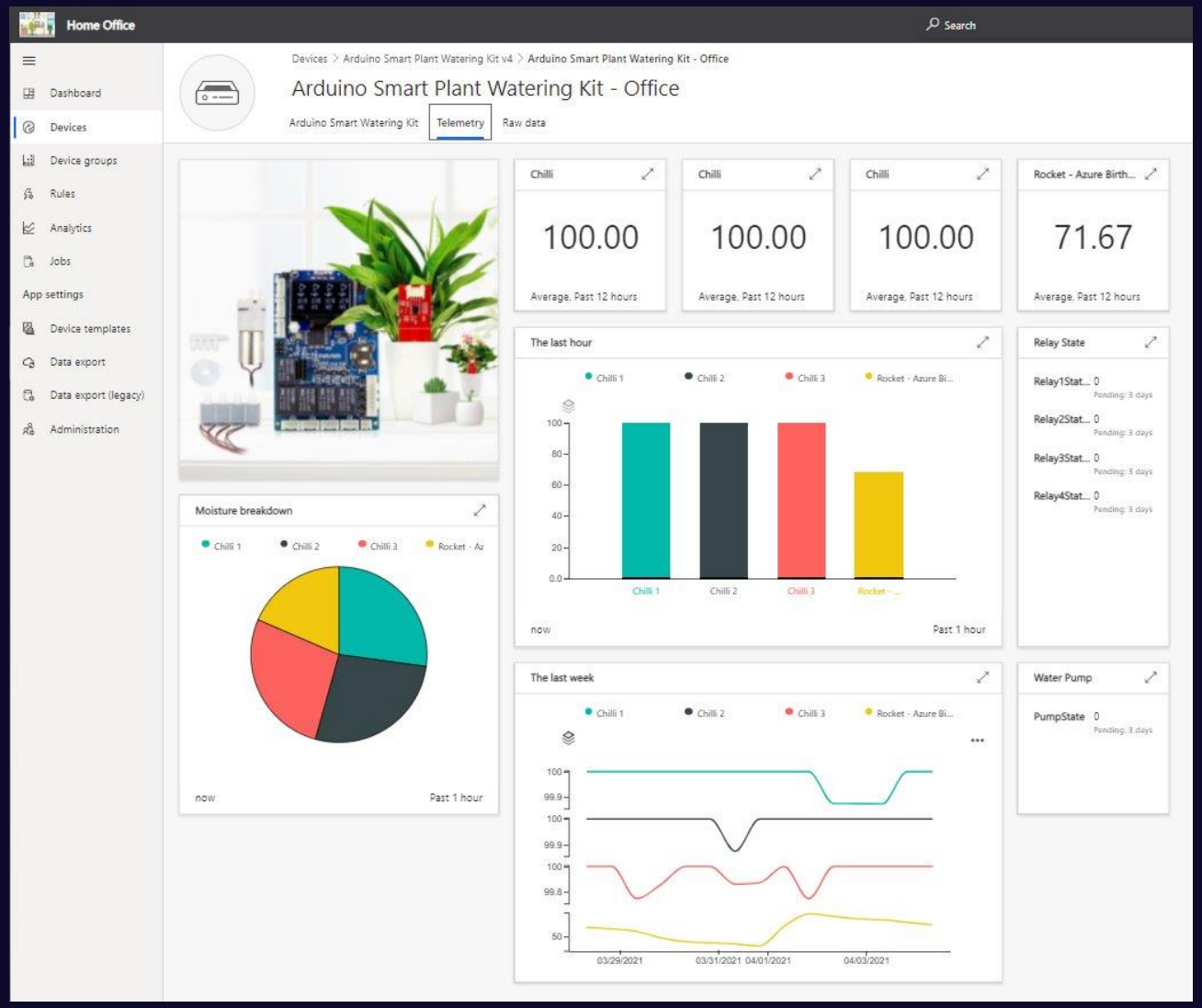
My Plant Growing Journey





Arduino Smart Waterer + IoT Central

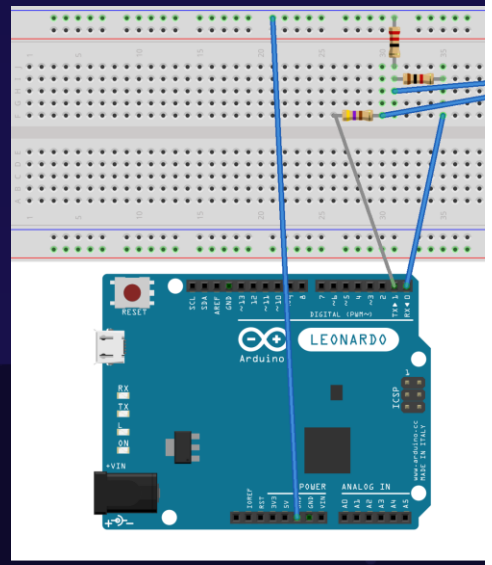


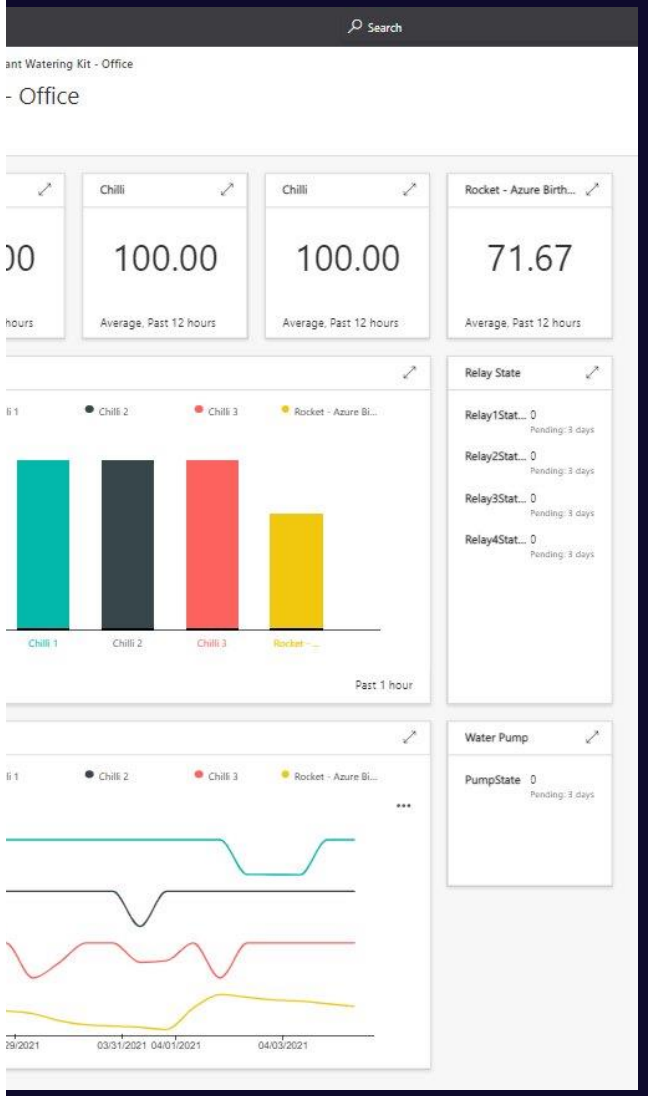


https://github.com/apead/SmartWateringKit

https://explorationspace.co.za/2021/02/07/arduino-smart-watering-kit-with-azure-iot-central/

Arduino





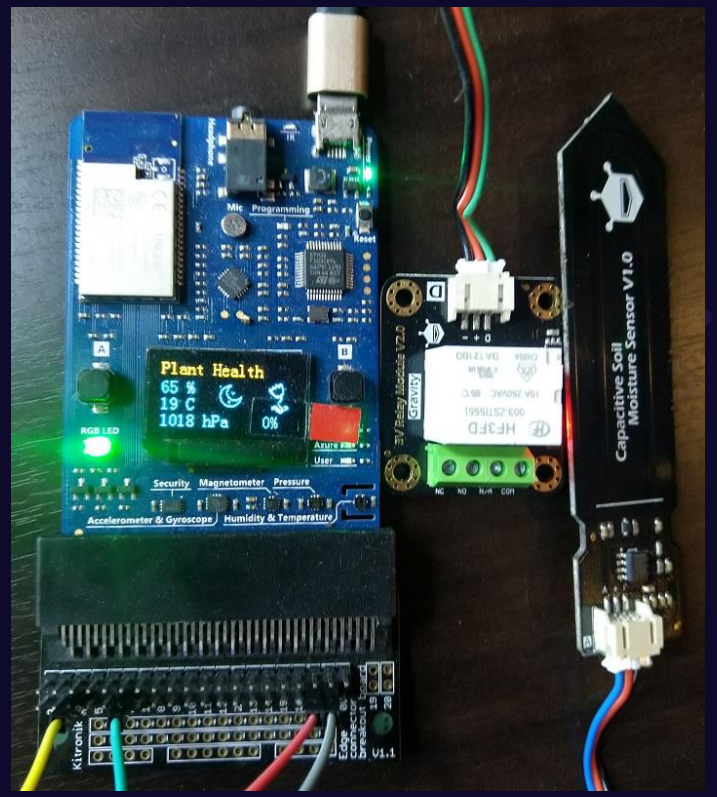
https://github.com/ape

https://explorationspace.co.za/2021/02/07/arduino-smart-watering-kit-with-azure-iot-central/

Other Grower Stations

M5 Stack – ESP32

https://github.com/apead/m5stackgrower



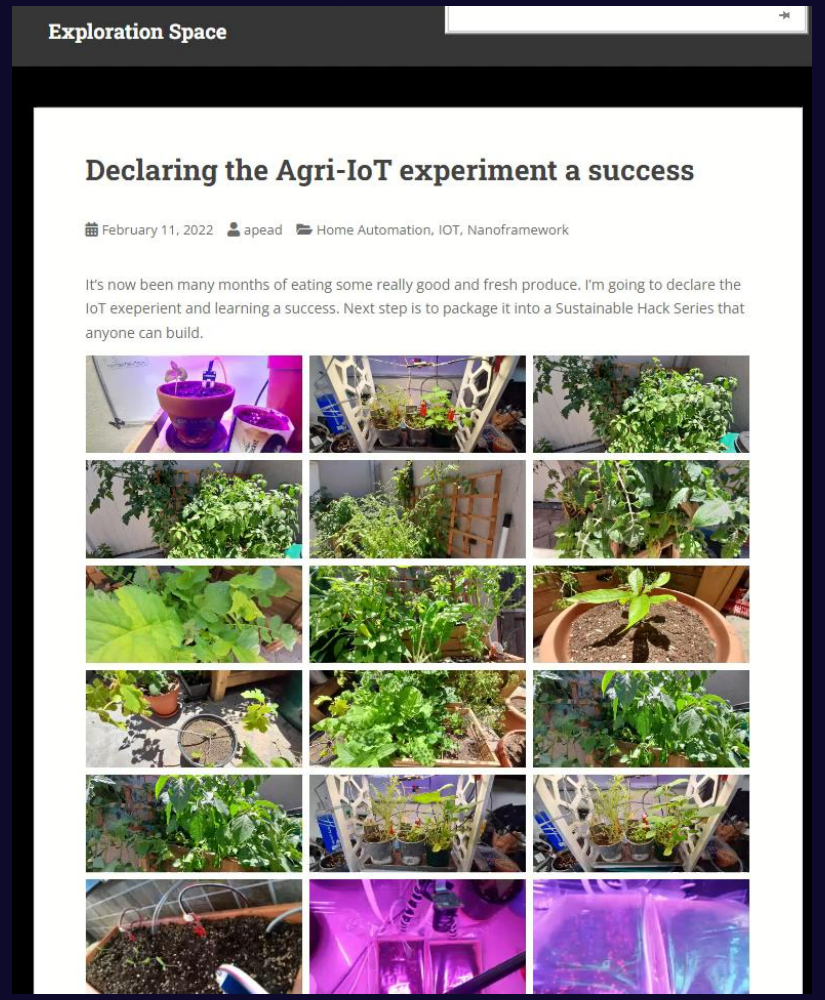
Azure IoT Dev Kit – STM32

https://github.com/apead/az3166arduinogrower

Things escalated..

Things needed to be BIGGER!

Project Success..



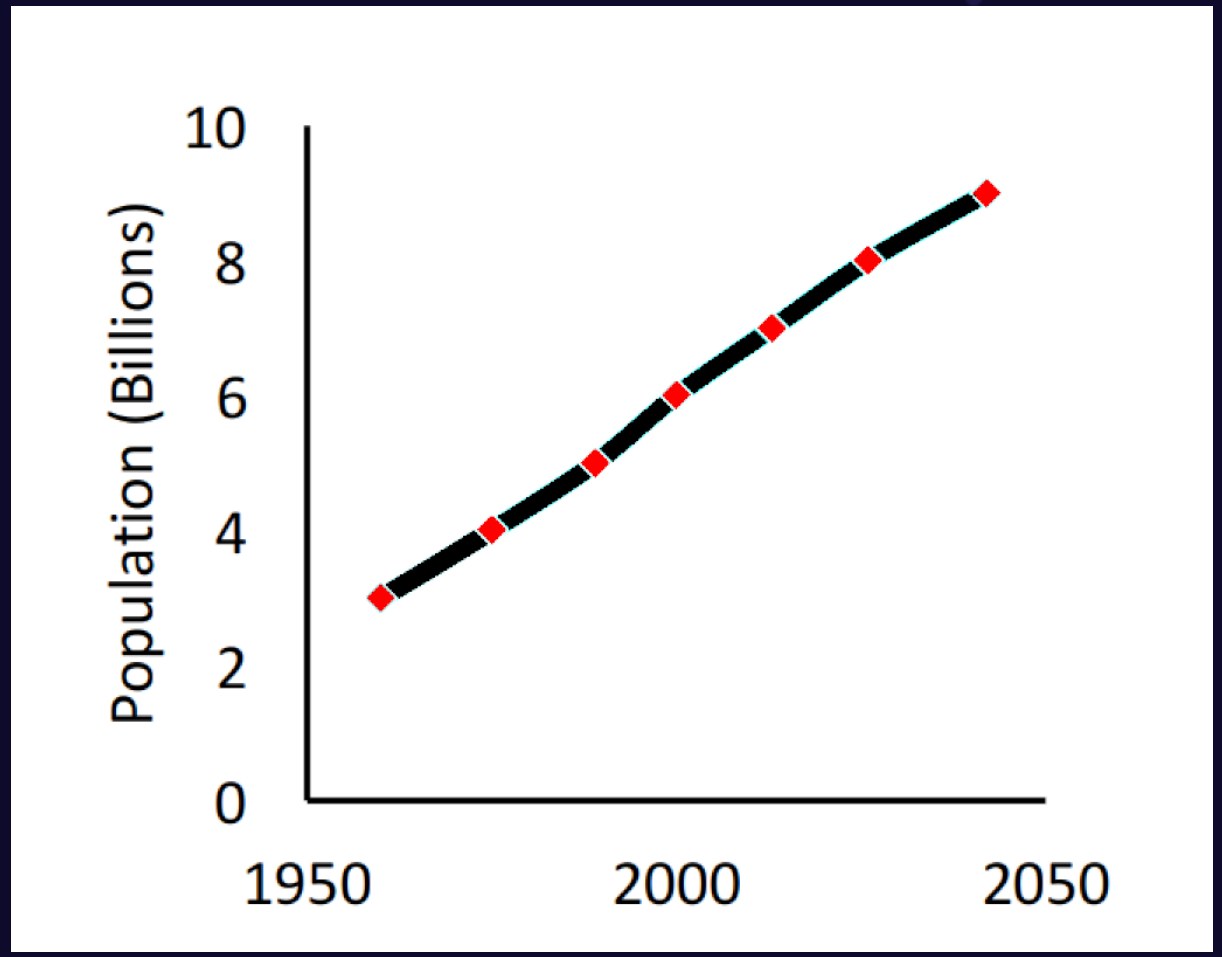
https://explorationspace.co.za/2022/02/11/declaring-the-agri-iot-experiment-a-success/

OfferZen Basil FTW

But why really do this?

Agricultural output needs to double by 2050 to meet the demands – United Nations

However..
Available water is getting less
Available land is shrinking
Climate Change



United Nations Second Committee (Economic & Financial), 2009

Basic Premise of Smart Growing

Input

Soil Moisture

Moisture < 30 %

Actuator

Water Pump

Switch Pump On

Basic Premise of Smart Growing

Input

Soil Moisture

Moisture > 70 %

Actuator

Water Pump

Switch Pump Off

Soil Moisture

- Moisture Percentage
- Different crops require different soil moisture levels to maximize yield
- Too much water can lead to root damage or “water logging” / rot
- Too little water causes wilting.

Refer to each crop type datasheet for correct insights

pH (power of hydrogen)

- Water
  - pH level of drinking water should be between 6-8.5

- Soil
  - For optimal yield and growth depends on the crop

  - Berries more acidic (4.0 -5.0)
  - Legumes more alkaline (7.5)

Refer to each crop type datasheet for correct insights

Turbidity

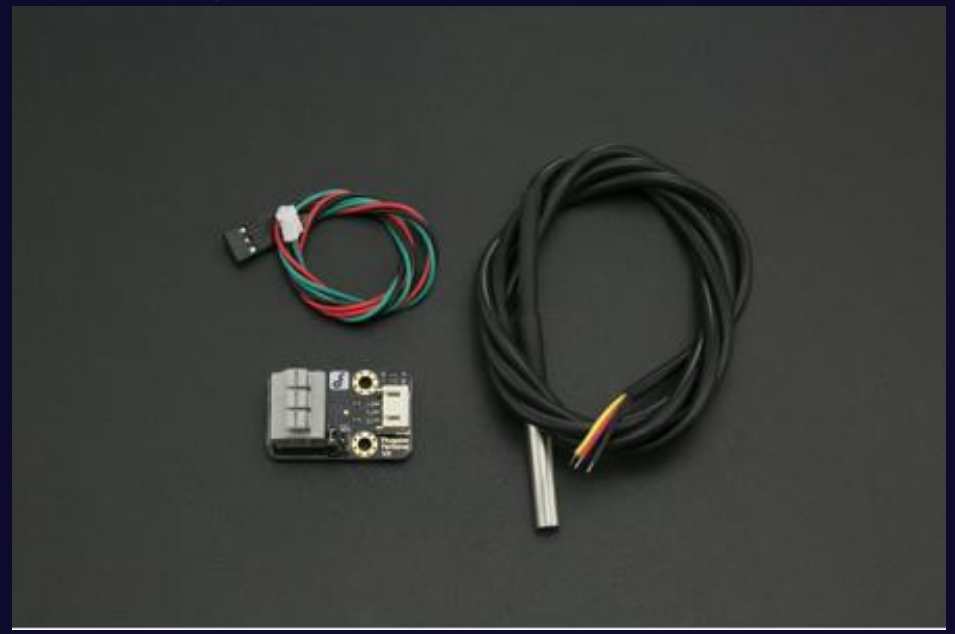
- Caused by particles suspended or dissolved in water that scatter light making the water appear cloudy or murky.
- Measured in NTU's
- High turbidity may cause crop / fruit discoloration
- High Turbidity may cause plants to have difficulty "breathing" if leaves are covered.

Salt Content (Nutrient Content)

- Electrical Conductivity (milliSiemens)
- Water
  - EC of drinking water should not exceed 1.4 mS/cm
  - Green water
- Soil
  - High soil salinity can cause root water absorption problems

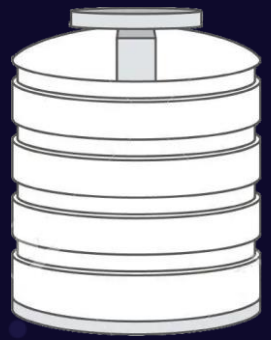
Temperature

- Degrees Celsius
- Water
  - High water temperature promotes algae growth
  - High Temperature can attract pests
  - High Temperature can reduce oxygen levels
  - Very cold water can slow down germination
- Soil
  - Soil temperature effects seed germination
  - Warmer temperatures stimulate soil microbes

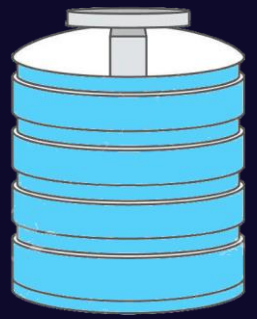


Water Pressure

- Pressure - Pascal
  - Water pipe pressure
    - Detect leaks
    - Detect blocked pipes
    - Detect Water pump efficiency
  - Water Tanks
    - Downward pressure used for Tank Volume



Minimum Pressure

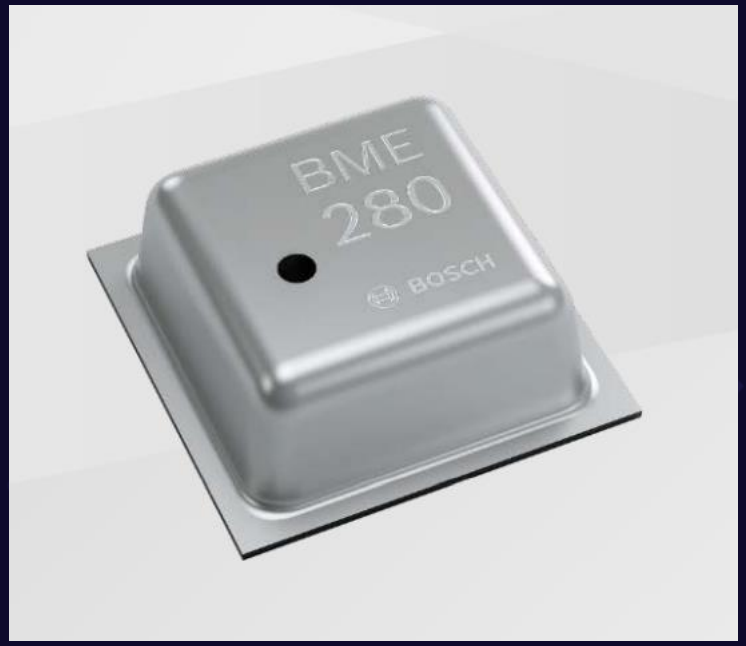


Maximum Pressure

Calibrate between minimum reading and maximum analog voltage reading

Atmospheric Conditions

- Chipset example: BME280



- Air Temperature
- Humidity
- Air Pressure

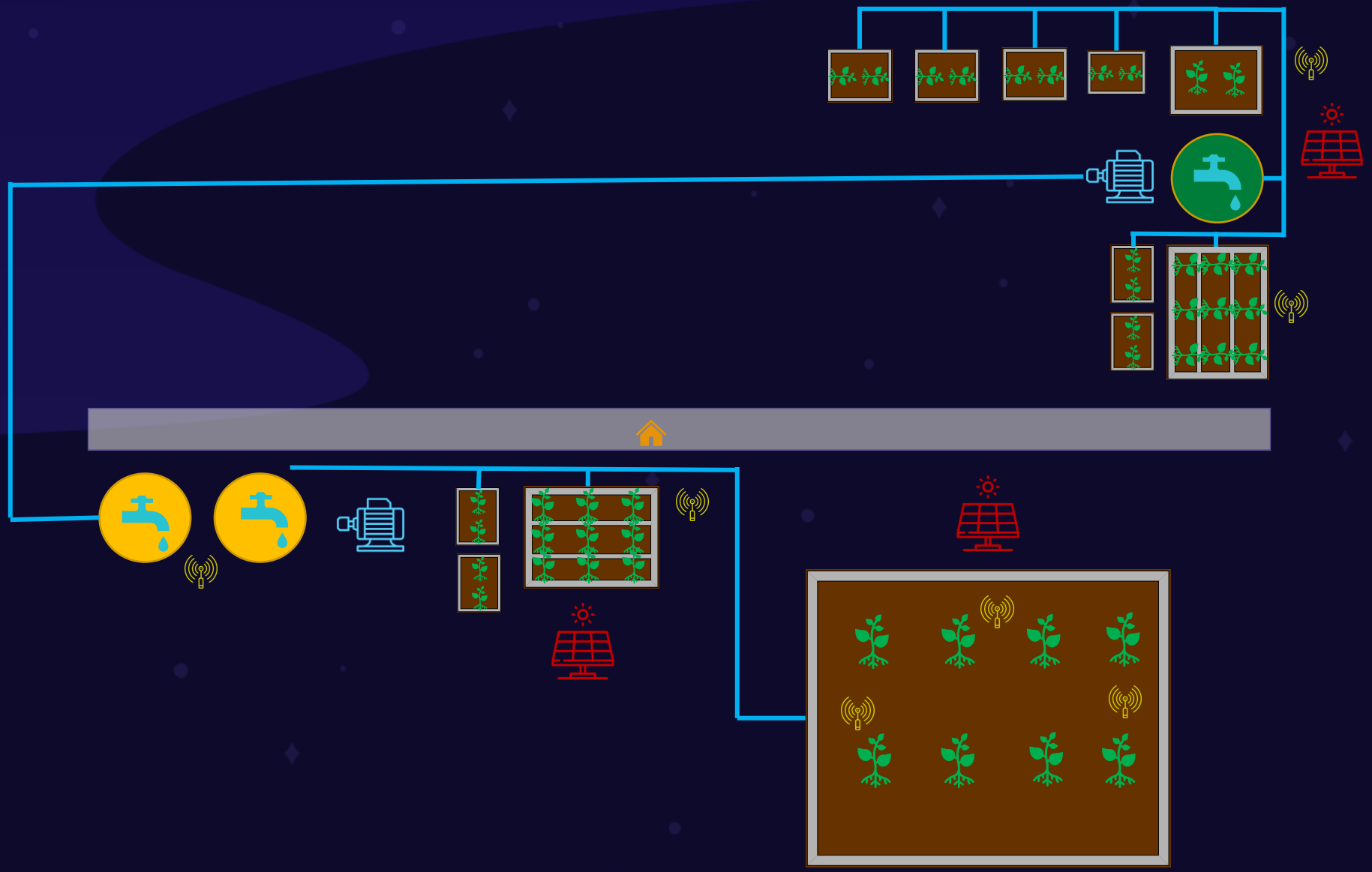
- Weather Pattern Monitoring
- Water loss rates

Actuator Actions

- Pump
  - Distribute Liquids
  - Controlled by relays (on/off)

- Solenoids
  - Control flow of liquids

Building the Home Farm



IoT Device and Power Unit

Sensor

Pump

Rainwater Tank

Building the Home Farm

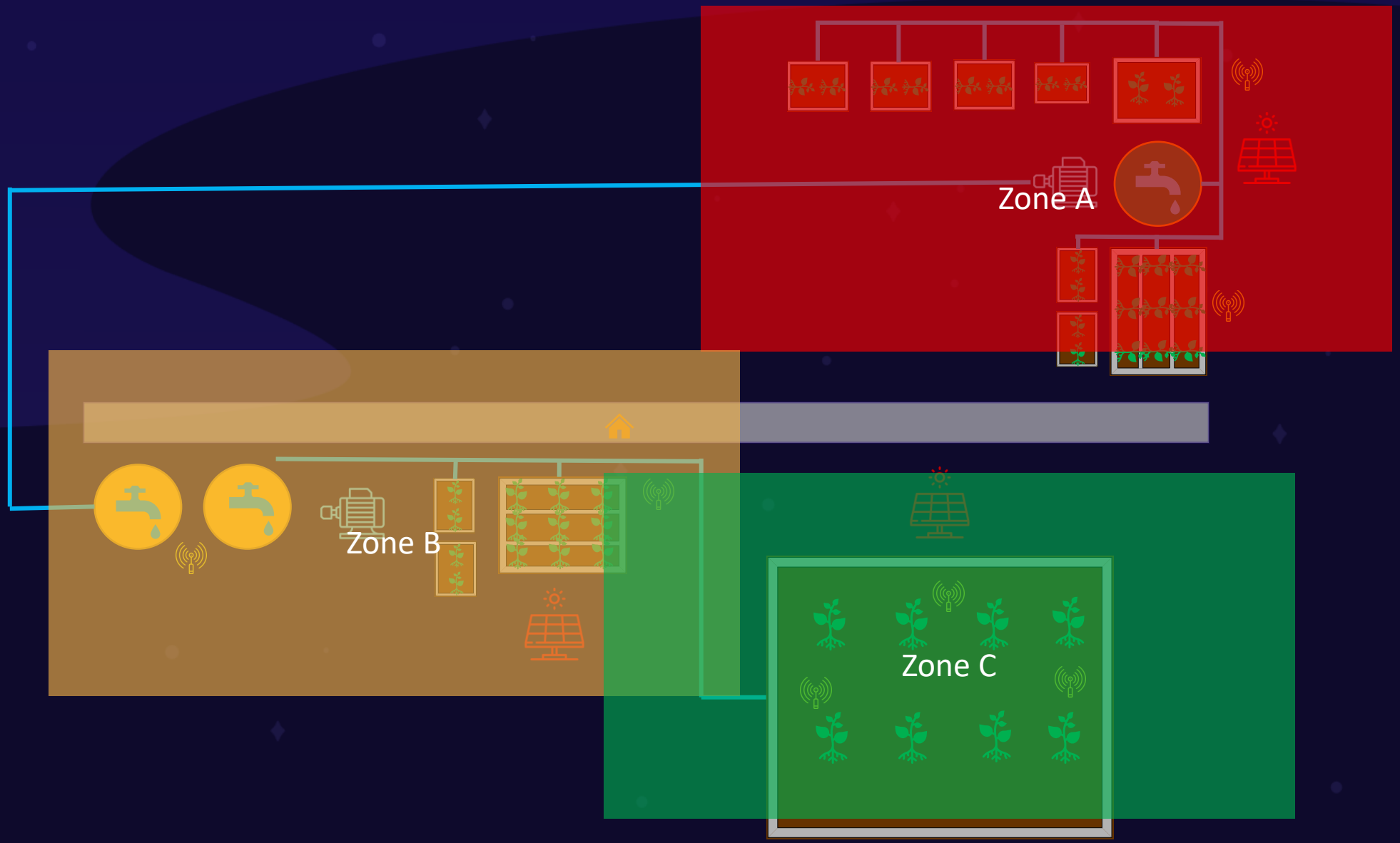
IoT Device and Power Unit

Sensor

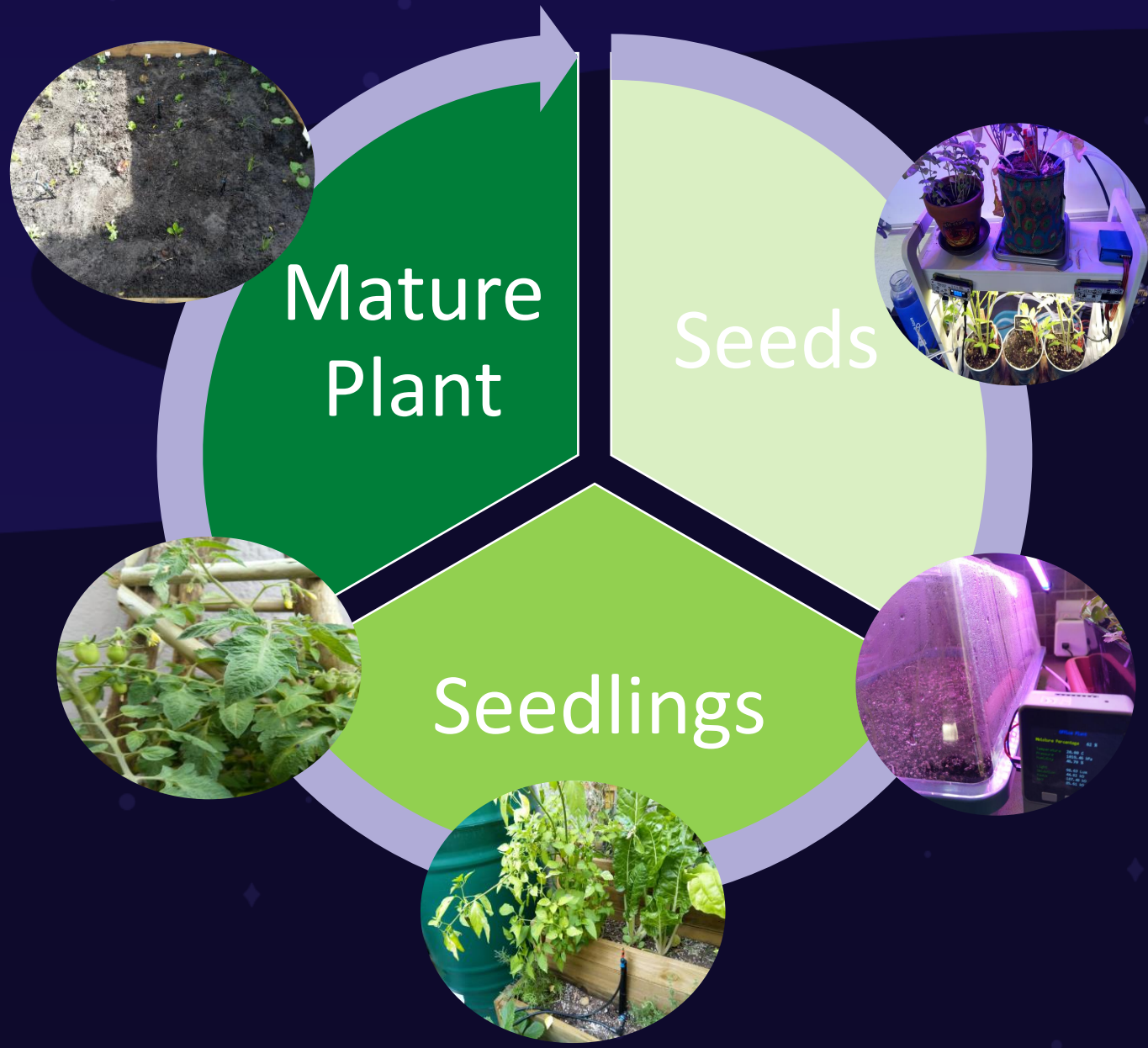
Pump

Rainwater Tank

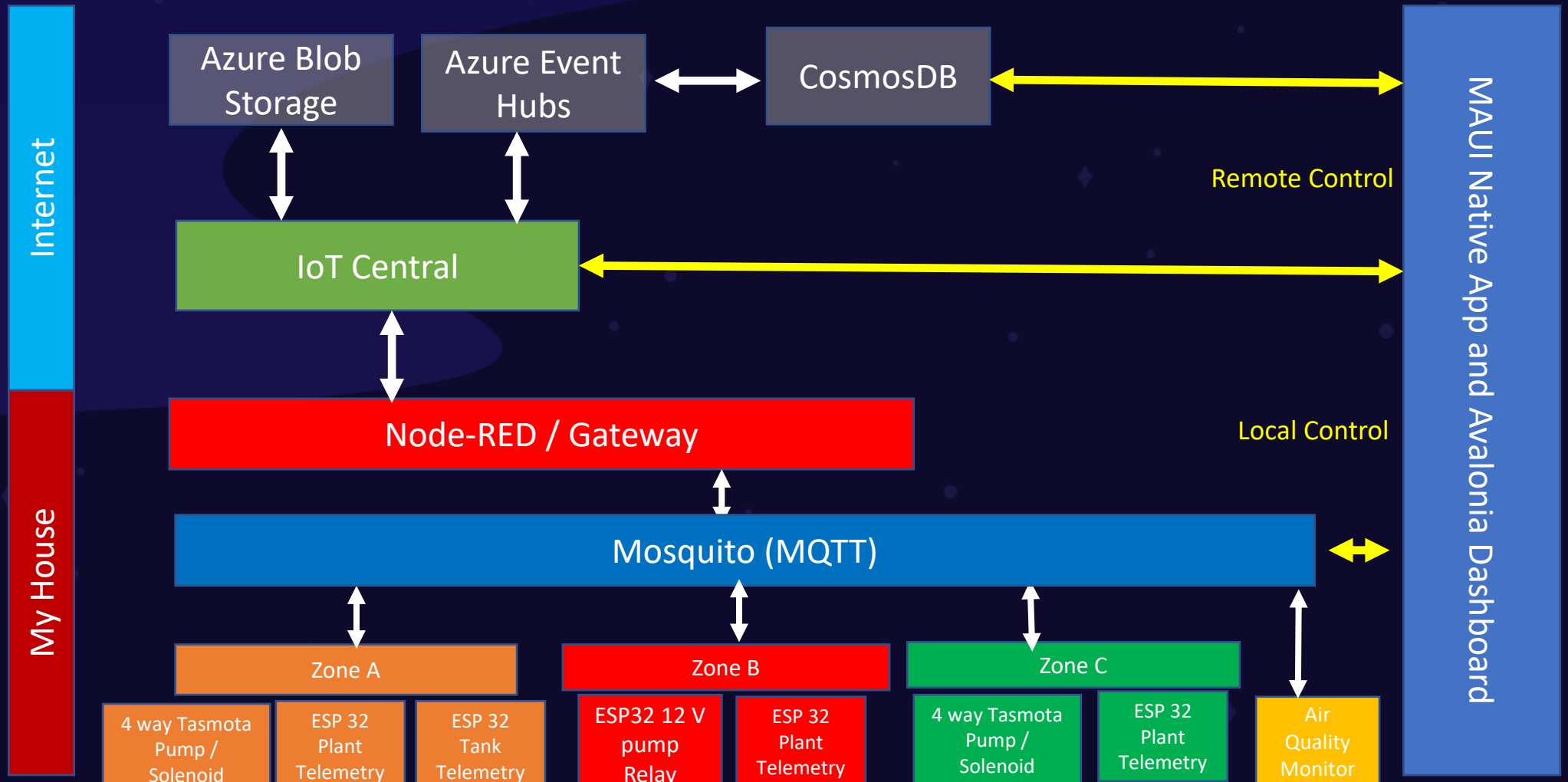
Telemetry Zones



Circle of Life

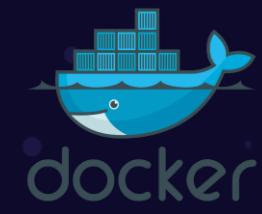


Architecture – Home Farm



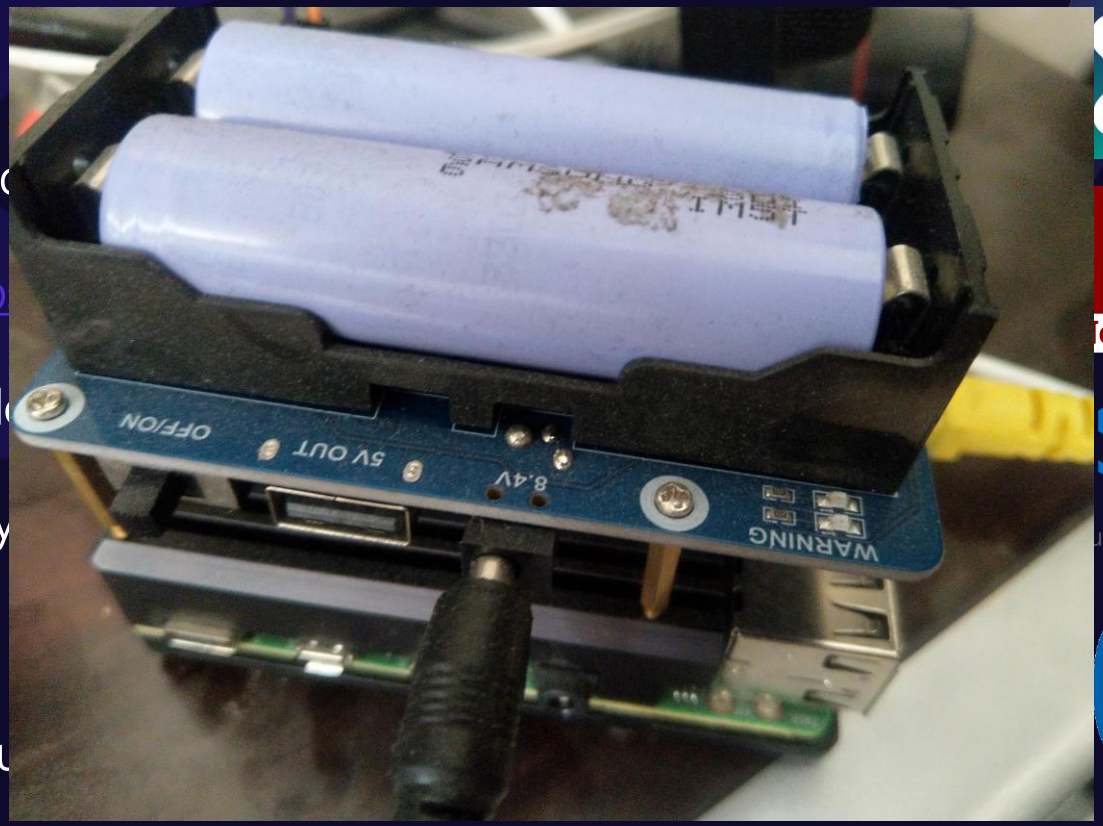
The Farm Tech Stack

- .NET Nanoframework (https://www.nanoframework.net/)
- NodeRed (https://nodered.org/)
- Mosquito MQTT (https://mosquitto.org/)
- Docker (https://www.docker.com/)
- Tasmota - Sonoff Relays (https://tasmota.github.io/docs/)
- Bluetooth Low Energy (BLE)
- IoT Central (https://azure.microsoft.com/en-us/products/iot-central/)
- AvaloniaUI (https://avaloniaui.net/)
- .NET MAUI (Multi Application User Interface) https://learn.microsoft.com/en-us/dotnet/maui/what-is-maui



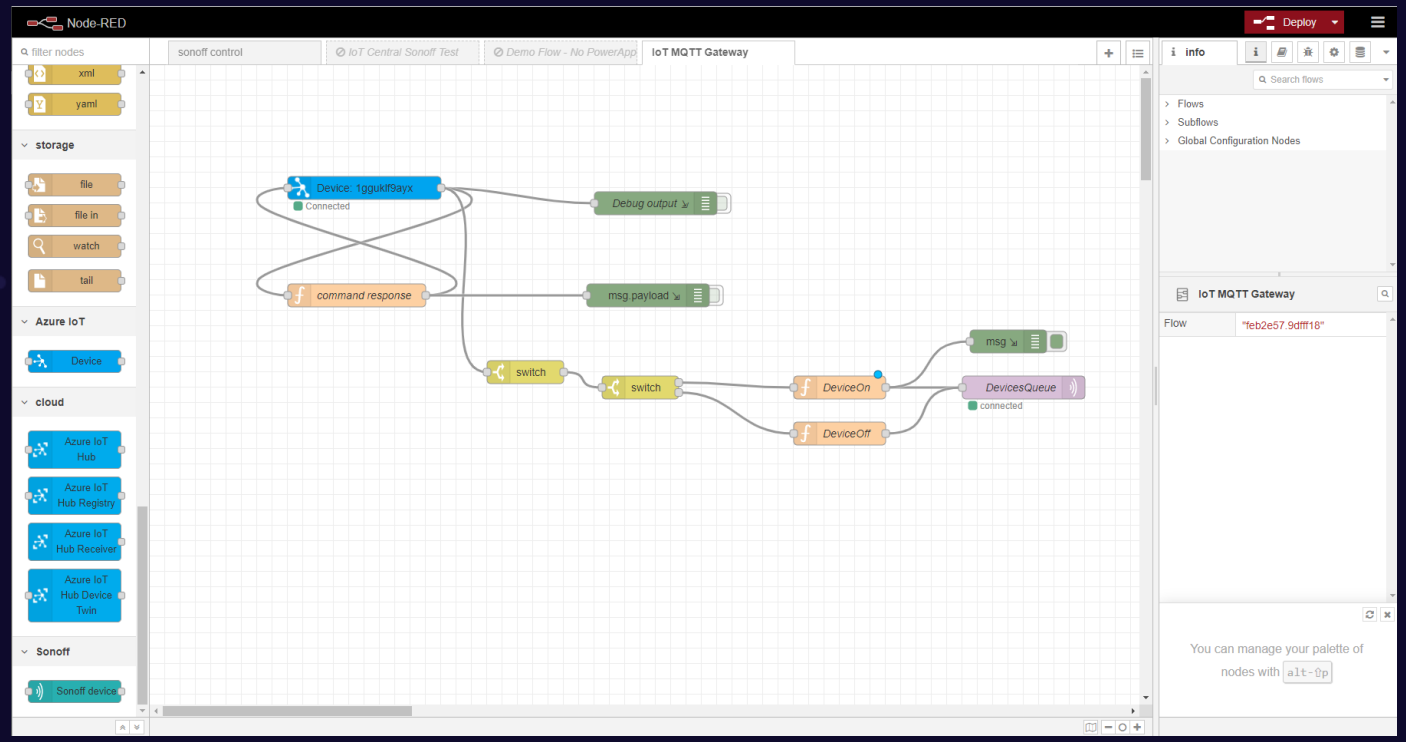
The Farm Tech Stack

- .NET Nanoframework
- NodeRed (https://noc
- Mosquito MQTT (http
- Docker (https://www.d
- Tasmota - Sonoff Relay
- Bluetooth Low Energy
- IoT Central (https://azu
- AvaloniaUI (https://avaloniaui.net/)
- .NET MAUI (Multi Application User Interface)
  https://learn.microsoft.com/en-us/dotnet/maui/what-is-maui



Node-Red

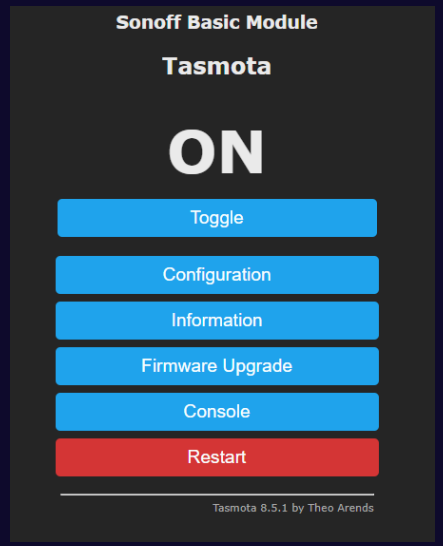
- Drag and Drop Flow Designer
- MQTT Support
- Message Transformation
- AWS IoT + Azure IoT Support
- Tasmota Support



Node-RED

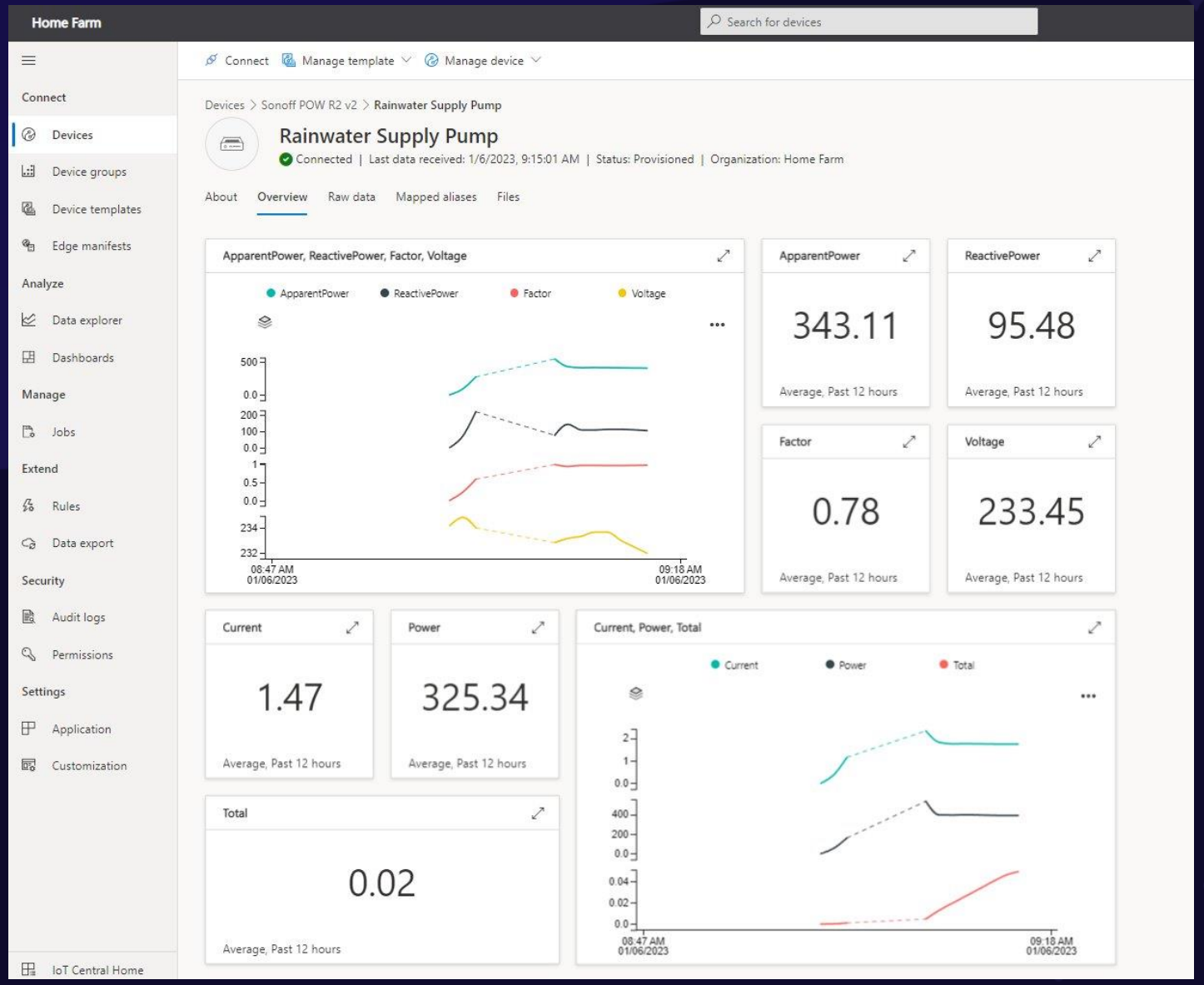
Tasmota

- Sonoff Off-the-shelf Home Automation devices (ESP8266)
- Built in Relays to Switch on 220 V Things
- Support MQTT Locally via Tasmota firmware



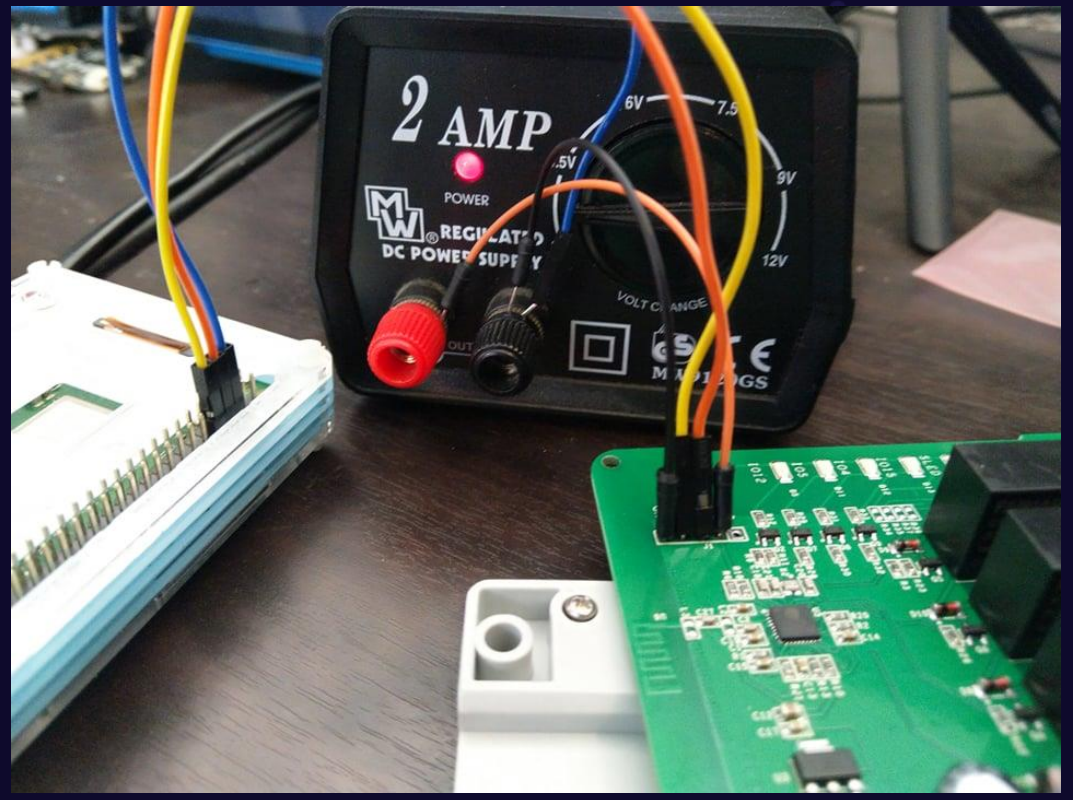
Sonoff POW R2

TASMOTA



Azure IoT Central

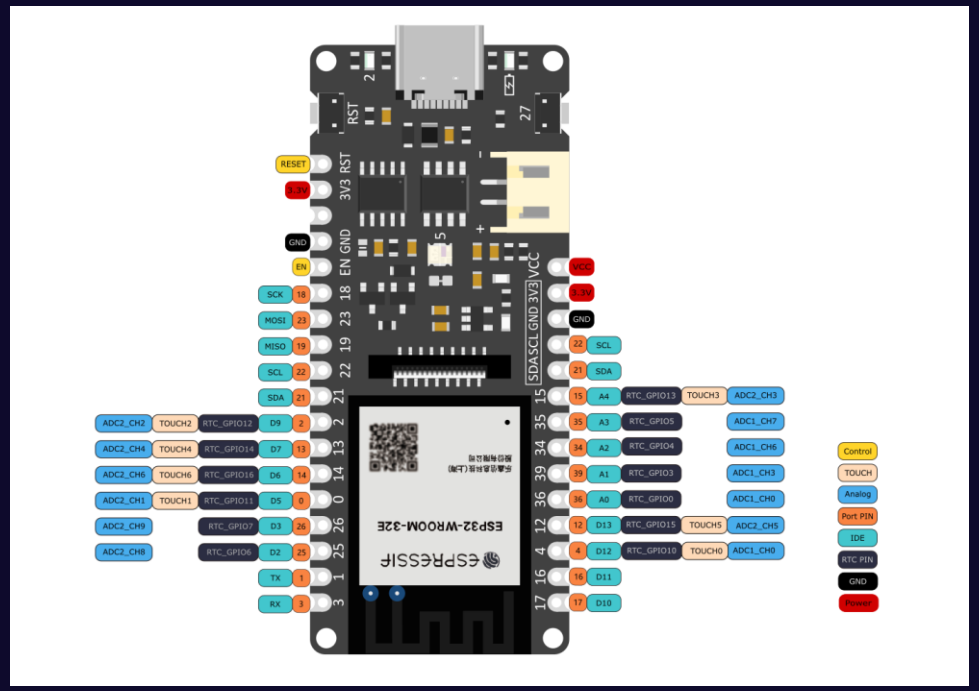
Tasmota

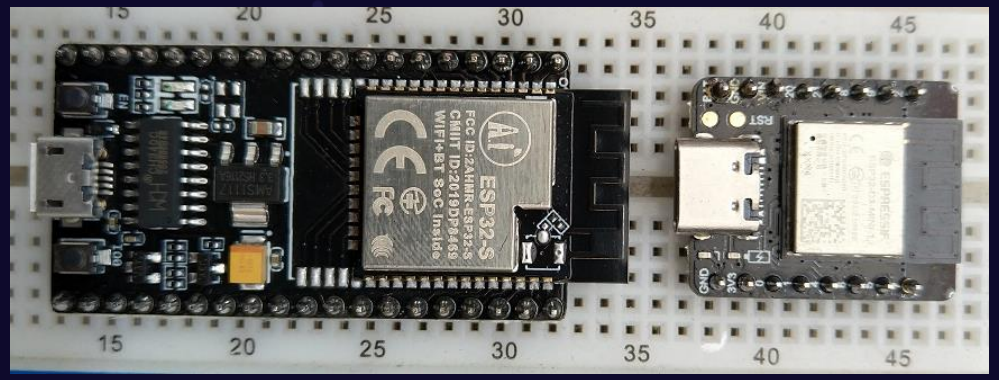


https://siytek.com/how-to-flash-esp-devices-with-tasmota-using-raspberry-pi/

Microcontrollers – ESP32

- Extremely low cost
- Long battery life
- Interact with hardware and electronics
- Wifi and BLE
- Onboard Analog to Digital





https://www.robotics.org.za/index.php?route=product/search&search=esp32

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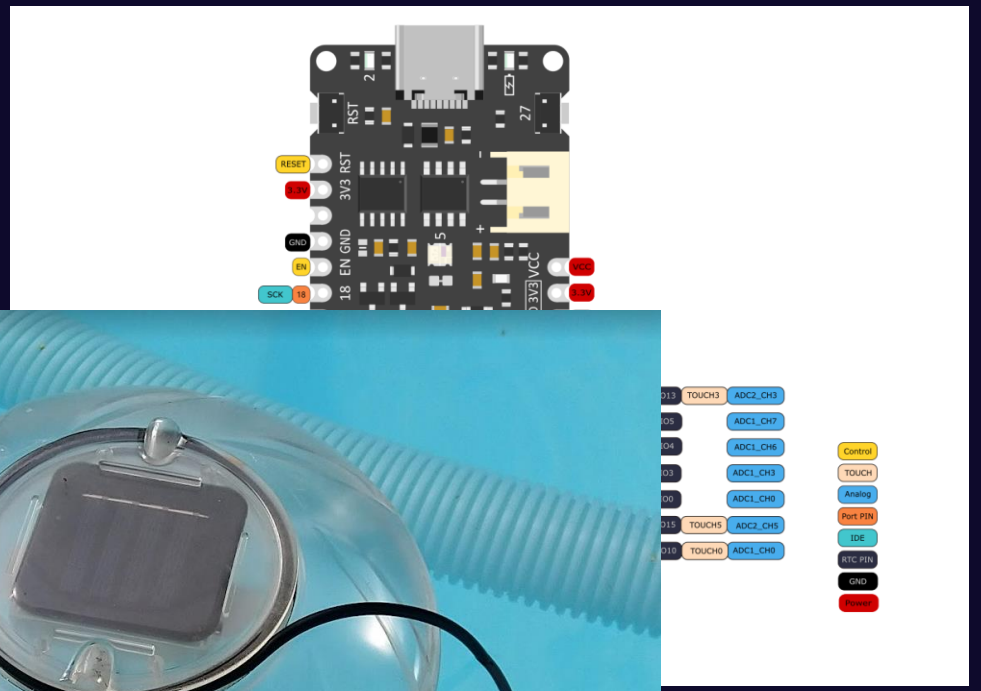

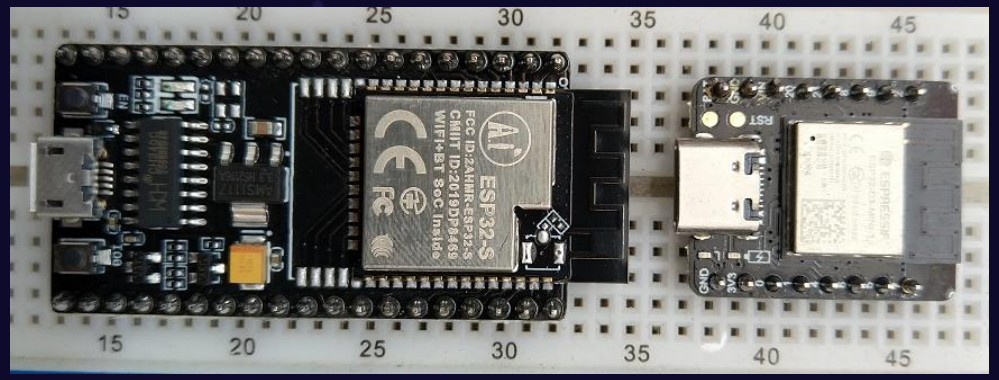

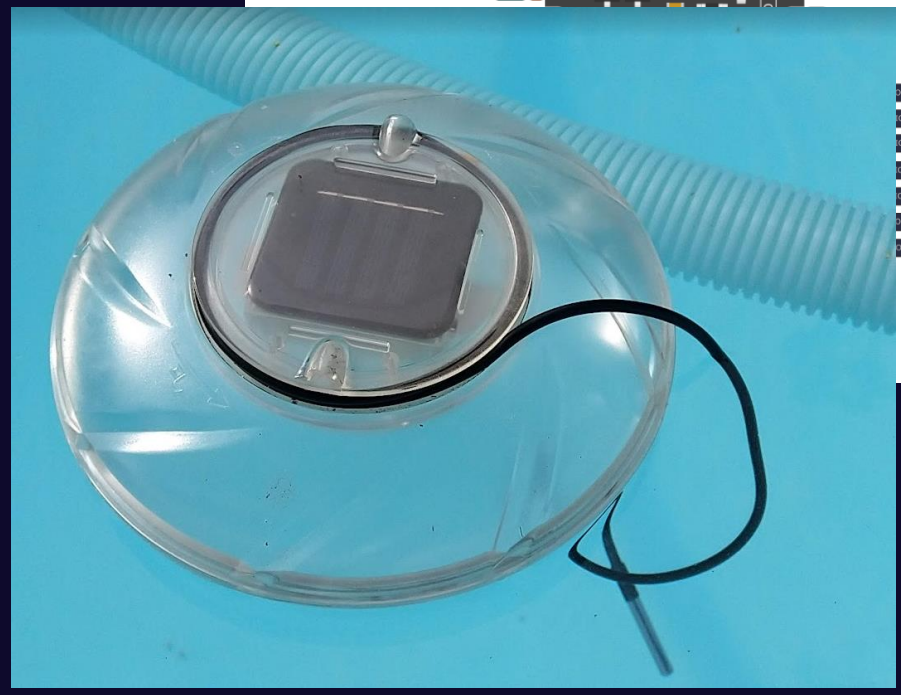

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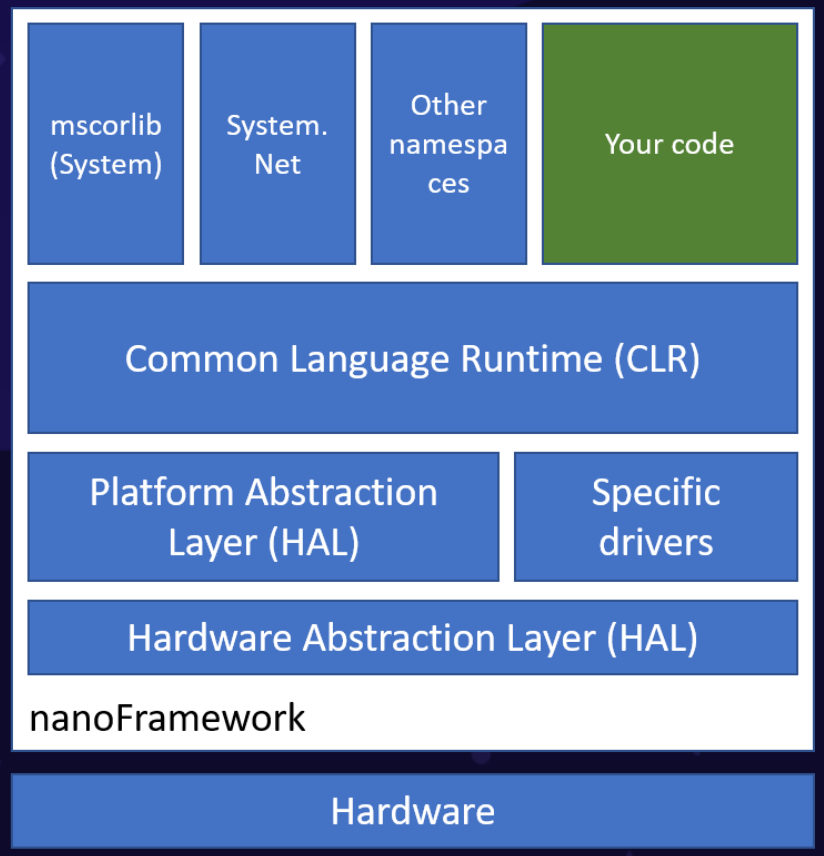
.NET Nanoframework



Reduced version of the .NET Common Language Runtime (CLR)

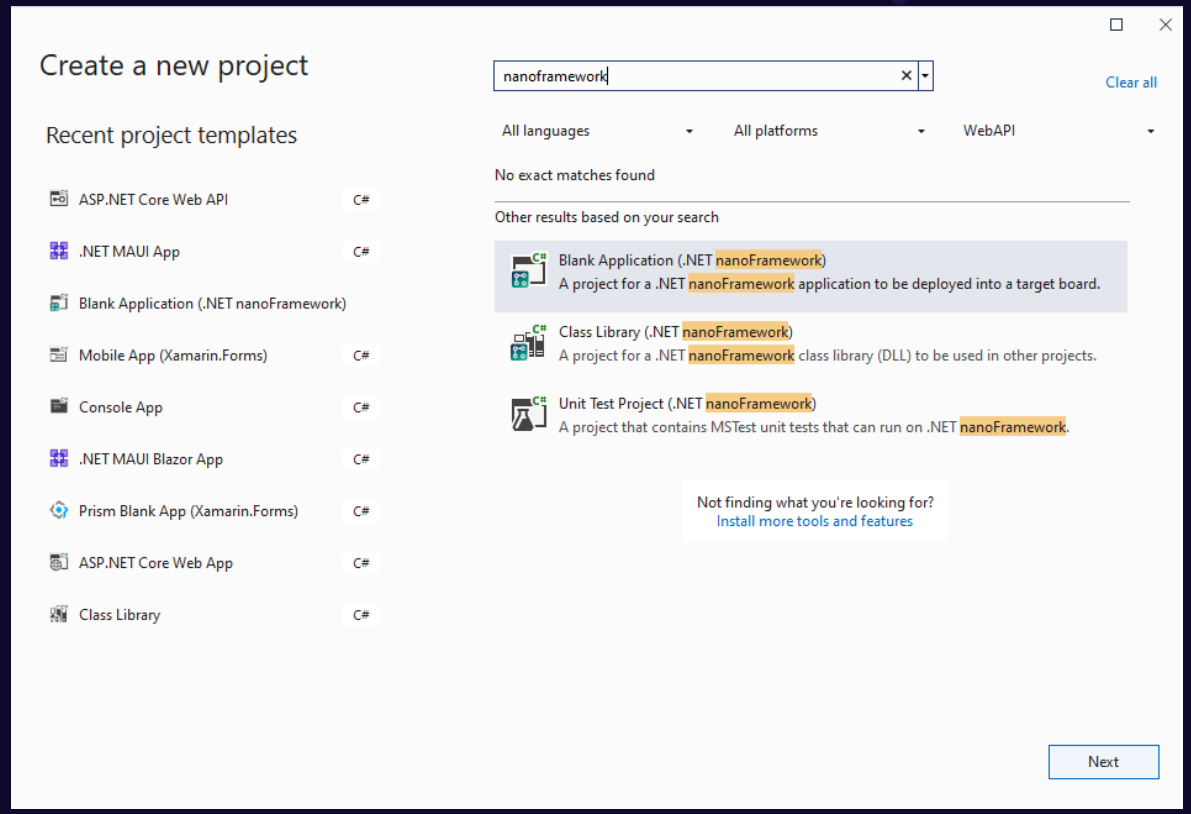
Resource-constrained devices with as low as **256kB** of flash and **64kB** of RAM

Works on ESP 32

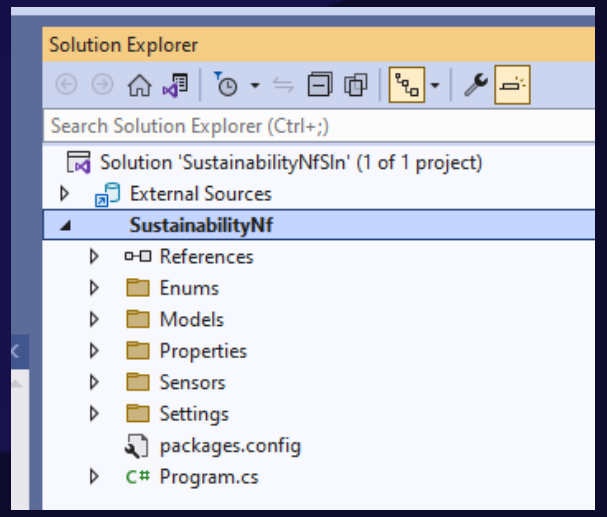
https://docs.nanoframework.net/

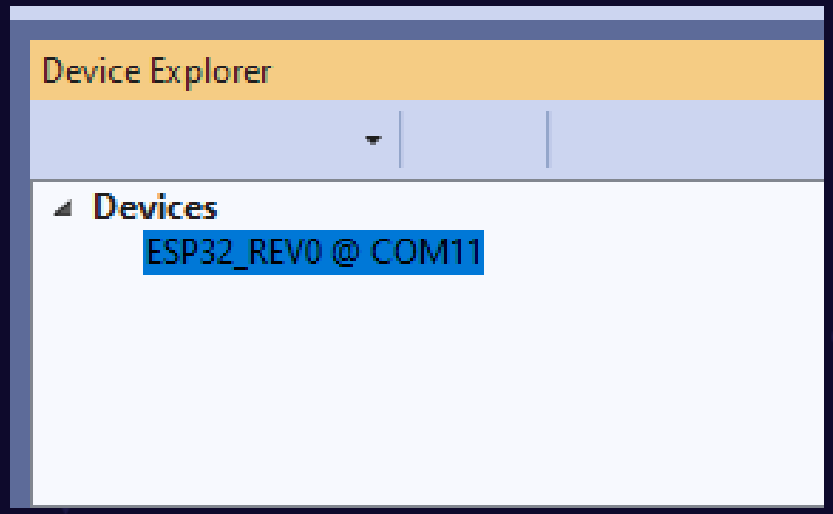
Nanoframework & .NET

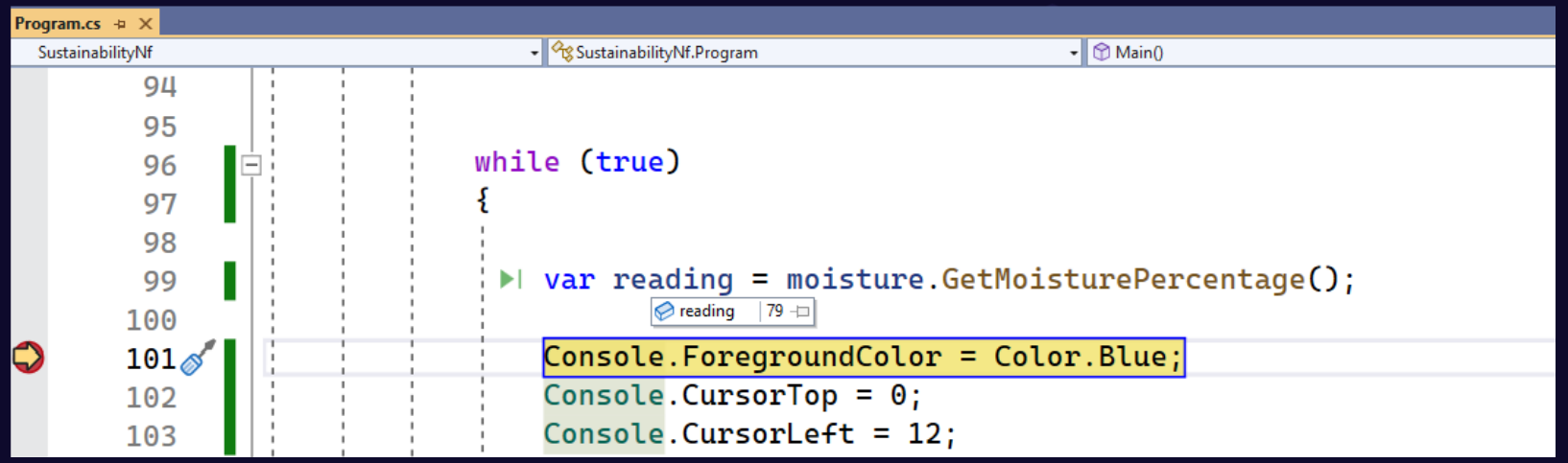
```
using nanoFramework.Json;
using nanoFramework.M2Mqtt;
using nanoFramework.M2Mqtt.Messages;
using nanoFramework.M5Stack;
using nanoFramework.Networking;
using nanoFramework.Presentation.Media;
using System;
using System.Device.Adc;
using System.Device.Gpio;
using System.Diagnostics;
using System.Text;
using System.Threading;
```



Nanoframework & .NET







Reading a Moisture Sensor in C#

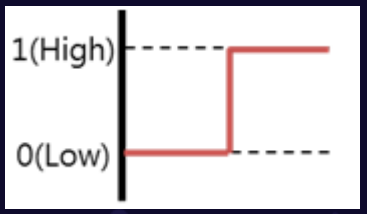
```
// Initialize Analog to Digital Converter
AdcController adc = new AdcController();


// Open Analog Channel
AdcChannel moistureAnalog = adc.OpenChannel(7);


// Read Value from Pin
moistureAnalog.ReadValue();
```

Switching on a Relay

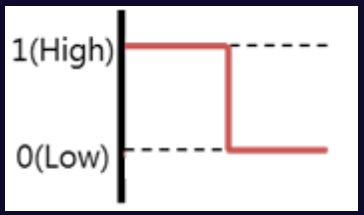
```
// Initialize Gpio Controller
 GpioController gpioController = new GpioController();


// Open Digital Pin Channel
GpioPin pin = gpioController.OpenPin(2);

 // Set Mode for Digital Pin (Input or Output)
gpioController.SetPinMode(2, PinMode.Output);

// Switch relay on
pin.Write(PinValue.High);
```

C# Event Handling Electronics

```
// Initialize GpioPin or Button
GpioPin userButton = gpioController.OpenPin(15, PinMode.Input);

// Assign event if pin state changes
userButton.ValueChanged += UserButton_ValueChanged;


        private void UserButton_ValueChanged
                (object sender, PinValueChangedEventArgs e)
         {
             if (e.ChangeType ==  PinEventTypes.Rising)
                        _greenLED.Write(PinValue.High);
               else
                        _greenLED.Write(PinValue.Low);
          }
```



Rising Edge



Falling Edge

MQTT

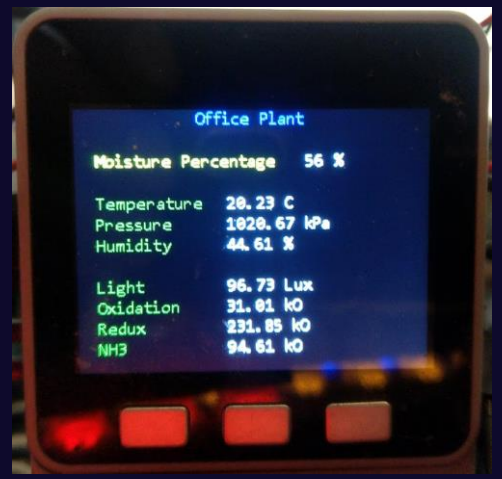
```
// Initialize Wifi with router ssid and password
 bool success = WifiNetworkHelper.ConnectDhcp(Ssid,Password,  true, token: cs.Token);

// Initialize Mqtt Client with connection information
MqttClient mqttc = new MqttClient(MQTTBrokerAddress);

// Assign Event Handler for code to be called on a message publish
mqttc.MqttMsgPublishReceived += Mqttc_MqttMsgPublishReceived;

// Subscribe to specific topics only
mqttc.Subscribe(
                    new[] {
                    “garden/zonea/tele",
                     "house/enviro-monitor/tele"
                    },
                    new[] {
                        MqttQoSLevel.AtLeastOnce,
                        MqttQoSLevel.AtLeastOnce
                    }
                    );
```

MQTT

```
private static void Mqttc_MqttMsgPublishReceived(object sender,
MqttMsgPublishEventArgs e)
{
        if (e.Topic.Contains("enviro-monitor"))
        {
                var message = Encoding.UTF8.GetString(e.Message, 0,
                e.Message.Length);
        EnvironmentalData env = JsonConvert.DeserializeObject(message,
        typeof(EnvironmentalData)) as EnvironmentalData;
        }
}
```

MQTT

```
M5Core.ButtonCenter.Press += (sender, e) =>
{
    if (mqttc.IsConnected)
    {
        mqttc.Publish(“garden/sonoff-zonea/cmnd/power1",
         Encoding.UTF8.GetBytes("off"));
    }
                    };

M5Core.ButtonRight.Press += (sender, e) =>
{
     if (mqttc.IsConnected)
     {
       mqttc.Publish("house/sonoff-zonea/cmnd/power1",
        Encoding.UTF8.GetBytes("on"));
     }
};
```

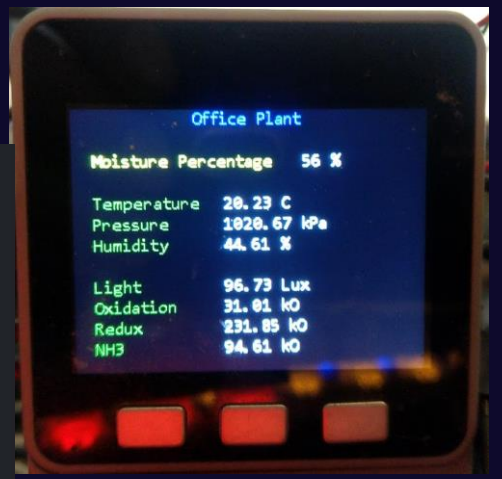


MQTT

```
M5Core.ButtonCenter.Press += (sender, e) =>
{
    if (mqttc.IsConnected)
    {
```

```
Output
Show output from: Debug
Moisture Percentage 56 %
Moisture Percentage 57 %
Moisture Percentage 55 %
Moisture Percentage 57 %
Moisture Percentage 56 %
Moisture Percentage 55 %
Moisture Percentage 54 %
Moisture Percentage 56 %
Moisture Percentage 57 %
{     "temperature": 20.3952287385,     "pressure": 1020.69664244,
20.39 C
1020.70 kPa
44.34 %
96.73 Lux
29.20 kO
234.57 kO
92.43 kO
Moisture Percentage 54 %
Moisture Percentage 54 %
Moisture Percentage 54 %
Moisture Percentage 54 %
Moisture Percentage 54 %
```

```
2023-05-21 16:24:09.139 INFO     oxid: 28.6 kO
2023-05-21 16:24:09.142 INFO     redu: 231.9 kO
2023-05-21 16:24:09.145 INFO     nh3: 91.4 kO
2023-05-21 16:24:09.150 INFO     pm1: 1.0 ug/m3
2023-05-21 16:24:09.154 INFO     pm25: 2.0 ug/m3
2023-05-21 16:24:09.157 INFO     pm10: 4.0 ug/m3
Sending telemetry..
2023-05-21 16:24:28.264 INFO     temp: 20.4 C
2023-05-21 16:24:28.275 INFO     pres: 1020.7 hPa
2023-05-21 16:24:28.286 INFO     humi: 44.3 %
2023-05-21 16:24:28.299 INFO     ligh: 96.7 Lux
2023-05-21 16:24:28.366 INFO     oxid: 29.2 kO
2023-05-21 16:24:28.369 INFO     redu: 234.6 kO
2023-05-21 16:24:28.373 INFO     nh3: 92.4 kO
2023-05-21 16:24:28.380 INFO     pm1: 1.0 ug/m3
2023-05-21 16:24:28.383 INFO     pm25: 2.0 ug/m3
2023-05-21 16:24:28.387 INFO     pm10: 4.0 ug/m3
Sending telemetry..
```




```
};
```

ESP32 Deep Sleep

```
// Deep Sleep by time
 Sleep.EnableWakeupByTimer(new TimeSpan(0, 0,
minutesToGoToSleep, 0));
   Sleep.StartDeepSleep();


// Wake up on Pin Changes
Sleep.EnableWakeupByMultiPins(Sleep.WakeupGpioPin.Pin32,
Sleep.WakeupMode.AnyHigh);
Sleep.StartDeepSleep();
```

Can use as little as 0.01 mA

Messaging

- DeviceId
- SensorStatus
- SensorType
- TimeStamp
- SensorValue
- SensorUnit
- Location

Publish / Subscribe

Input

Soil Moisture

Moisture < 30 %

Subscribe to “zone sensor” topic

Actuator

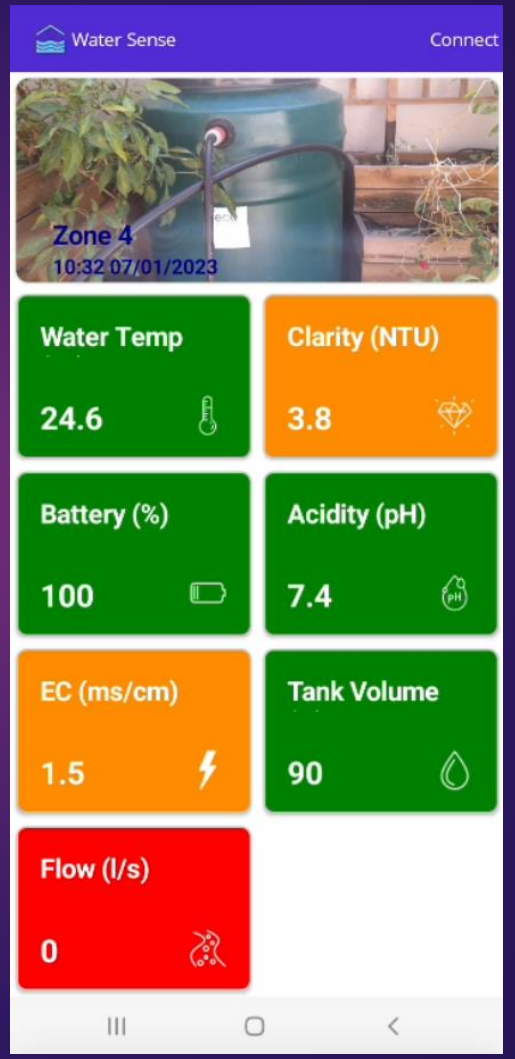
Water Pump

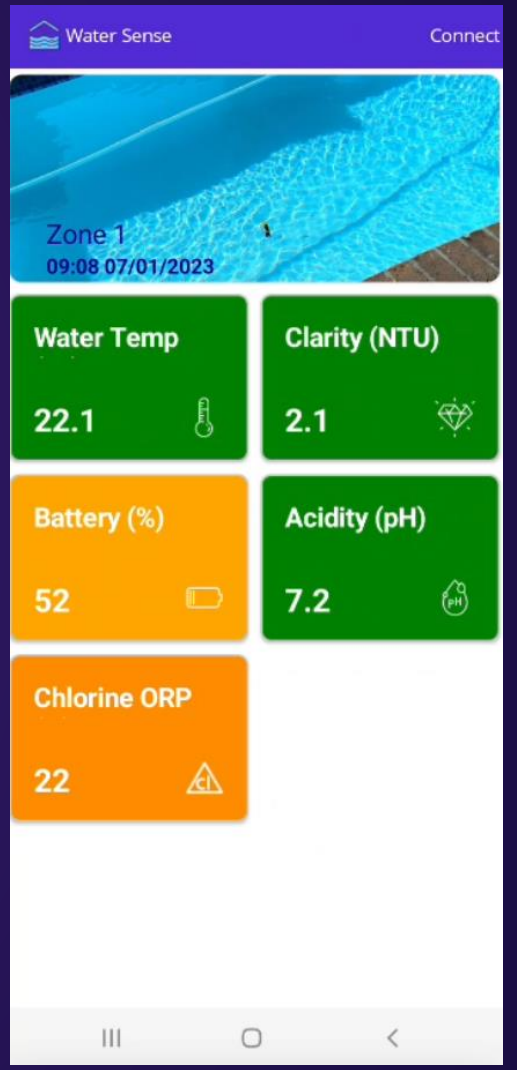
Switch Pump On

Publish to “zone pump” topic

Mobile and BLE

- Zone Devices Advertising
- Telemetry Service
  - Water Temp Characteristic
  - Ph Characteristic
  - Ec Characteristic
  - Clarity Characteristic
  - Orp Characteristic
- Battery Service
  - Battery Level Characteristic
- Implemented for Zone Devices that are not set to deep sleep

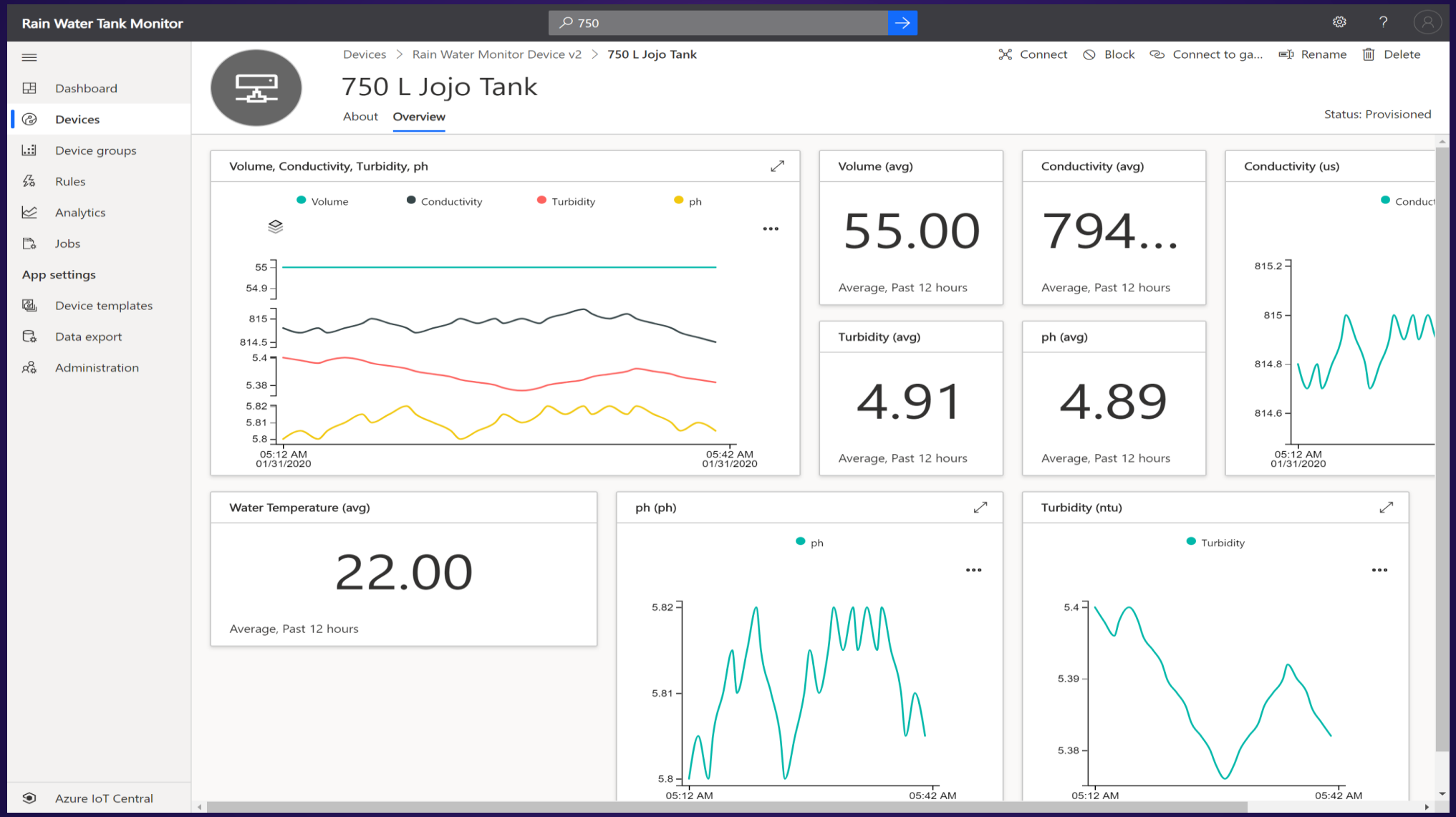




Bluetooth

```
// Event Handler for External BLE Read Request to IoT Device
void TemperatureCharacteristic_ReadRequested(GattLocalCharacteristic sender,
GattReadRequestedEventArgs ReadRequestEventArgs)
        {
            GattReadRequest request = ReadRequestEventArgs.GetRequest();
            request.RespondWithValue(GetTemperatureBuffer());
        }

        private static Buffer GetTemperatureBuffer()
        {
              // Read from Ds18b20 Sensor using One Wire Protocol
            Temperature temperature = ReadingFromOneSensor();

            DataWriter dw = new DataWriter();
            dw.WriteString(temperature.DegreesCelsius.ToString("F"));

            return dw.DetachBuffer();
        }
```

Telemetry pushed to Azure IoT Central (Wifi)



Farm Squares

- 3 m x 3 m

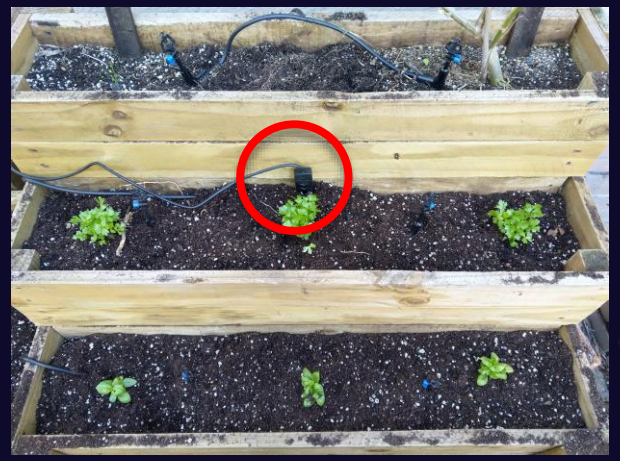
- Grounding sheets
  - 3 x 10 m Rolls

Farm Squares

- Irrigated
- Wired for Sensors

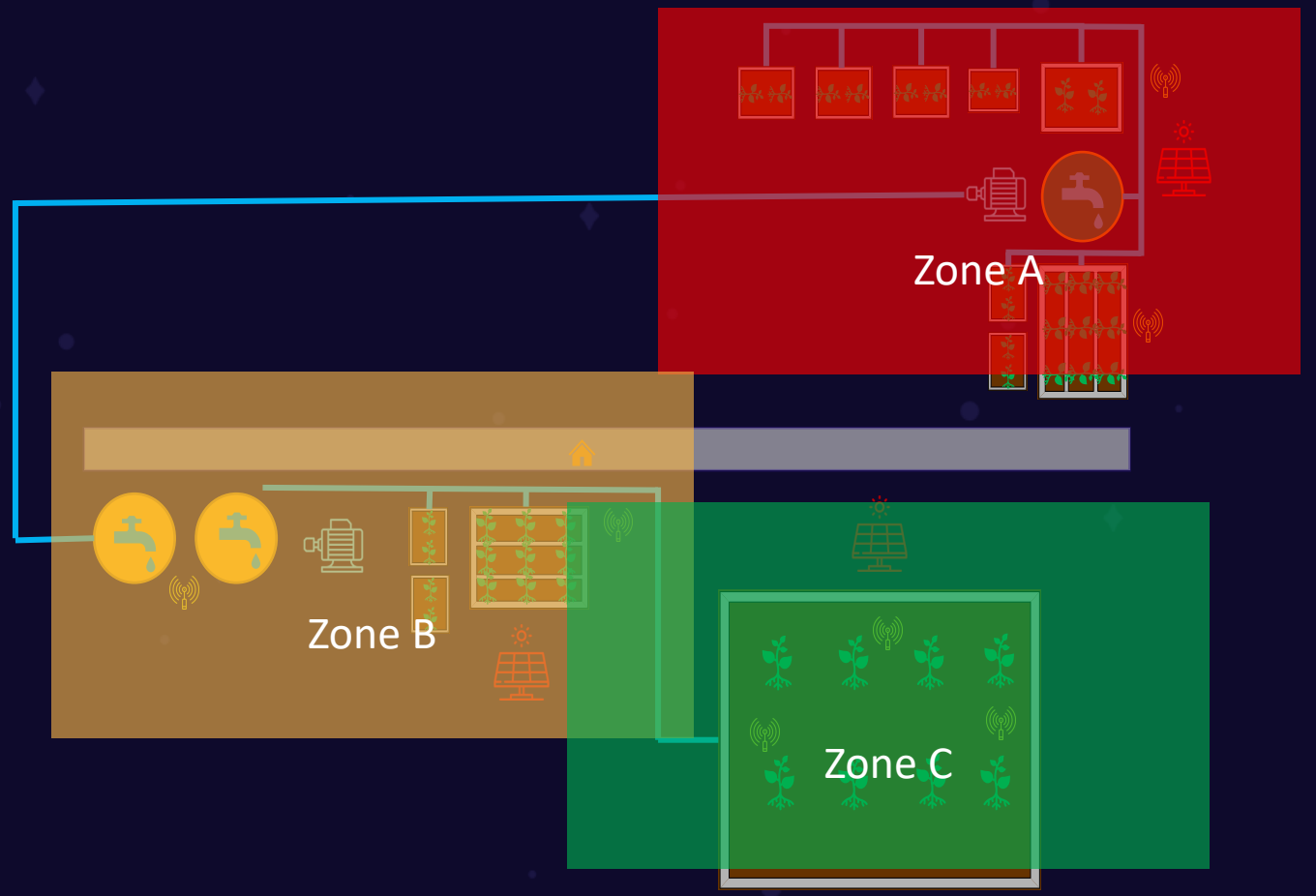
Ground based sensors

- Waterproofed Sensors
- Place Moisture Sensors in gaps where least likely to have sprinkler reach



Powering the farm

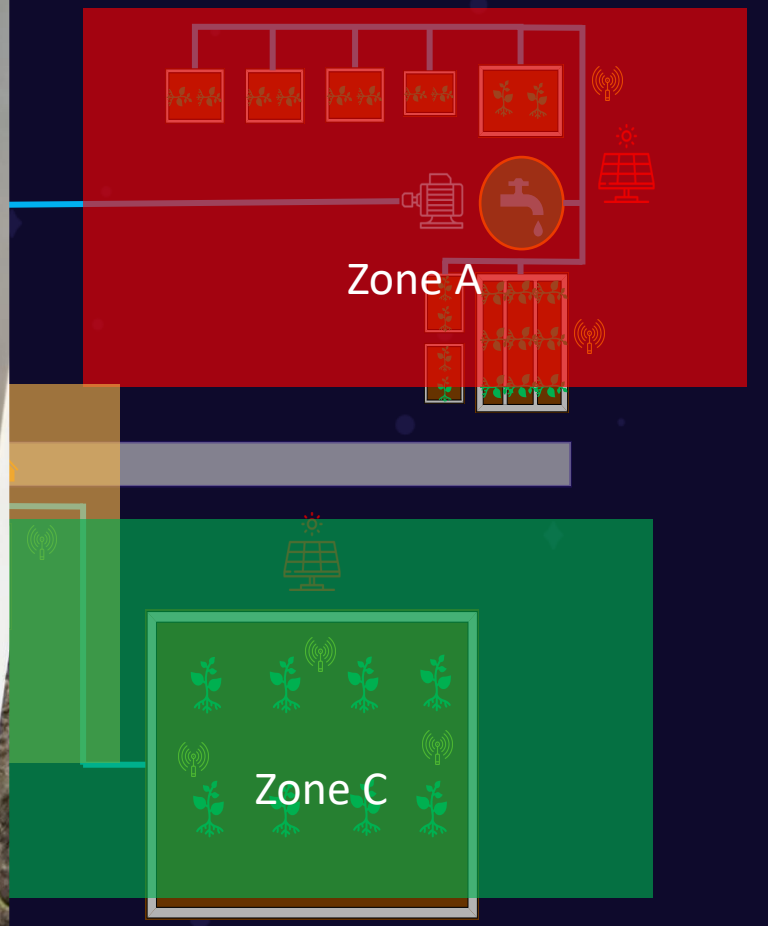
- 12 V DC per Zone
- 10 W, 30W, 50 W, 100 W Solar Panels
- Solar Charge Controller



https://www.communica.co.za/pages/search-results-page?q=cinco

Powering the

- 12 V DC per Zone
- 10 W, 30W, 50 W, 100 W S
- Solar Charge Controller



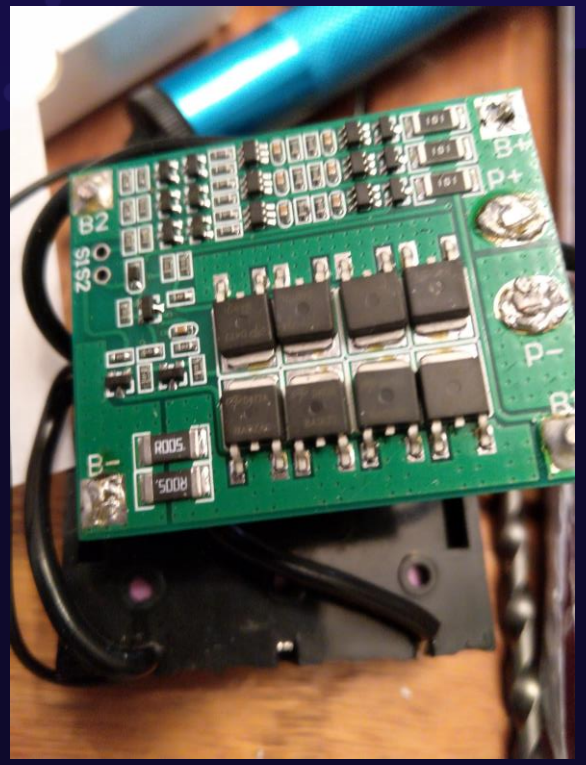
https://www.communica.co.za/pages/search-results-page?q=cinco

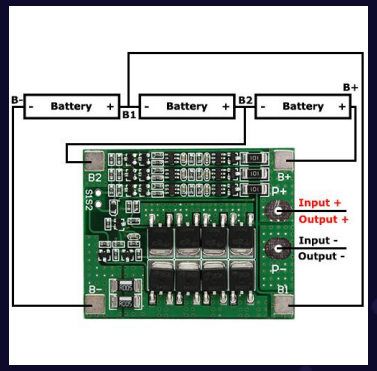
Batteries

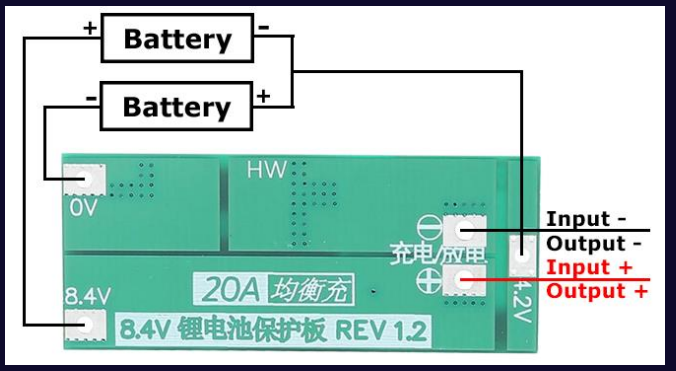
- 12 V 7aH Lead Acid
- Works directly with Charge Controllers and Solar Controllers
- Reuse your gate or fence batteries

Batteries

- 18650 Lithium
- Use BMS (Battery Management Systems)







https://www.robotics.org.za/BMS-20A

https://www.robotics.org.za/HX-3S-FL25A

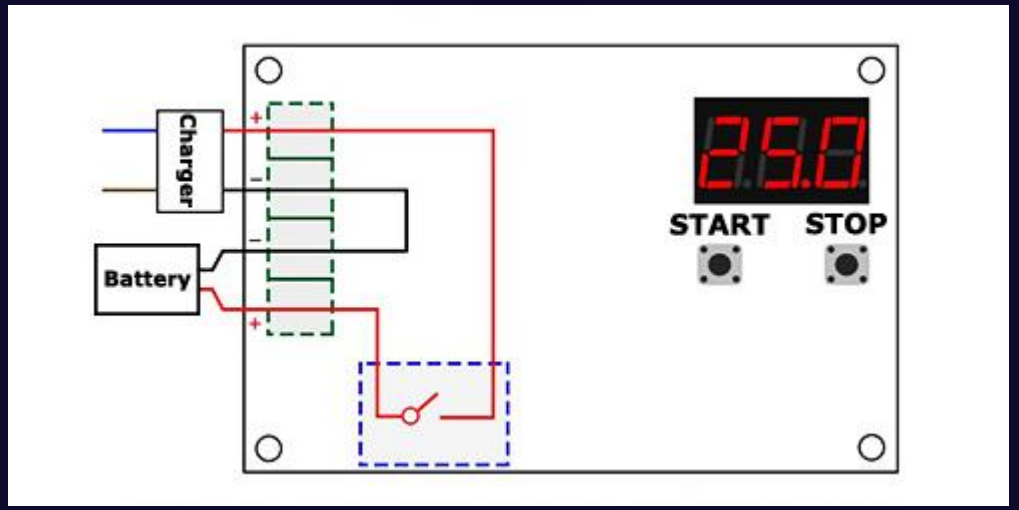
Solar Controllers

- 12 V / 24 V DC
- Max. Input Voltage of Solar Panel : 55V
- USB Ports
- Waterproof IP22 (Large Solids and Water Droplets vertically)

https://www.robotics.org.za/KWD1220

Charge Controllers

- 12 V – 24 V DC
- 10 V - 30 V DC Input
- Variable Charge Start and End

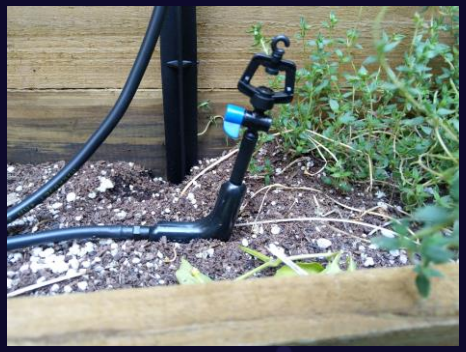


https://www.robotics.org.za/XH-M603

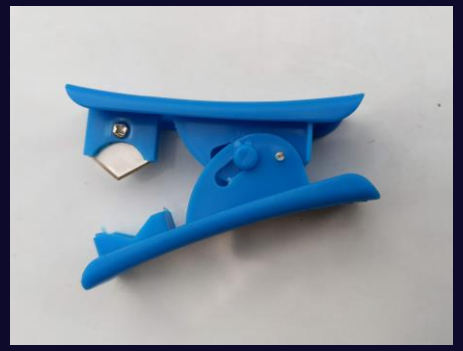
Irrigation Piping

- 15 mm piping
- Microjet sprinklers
- 5 mm sprinkler pipes










Irrigation with Water Tanks

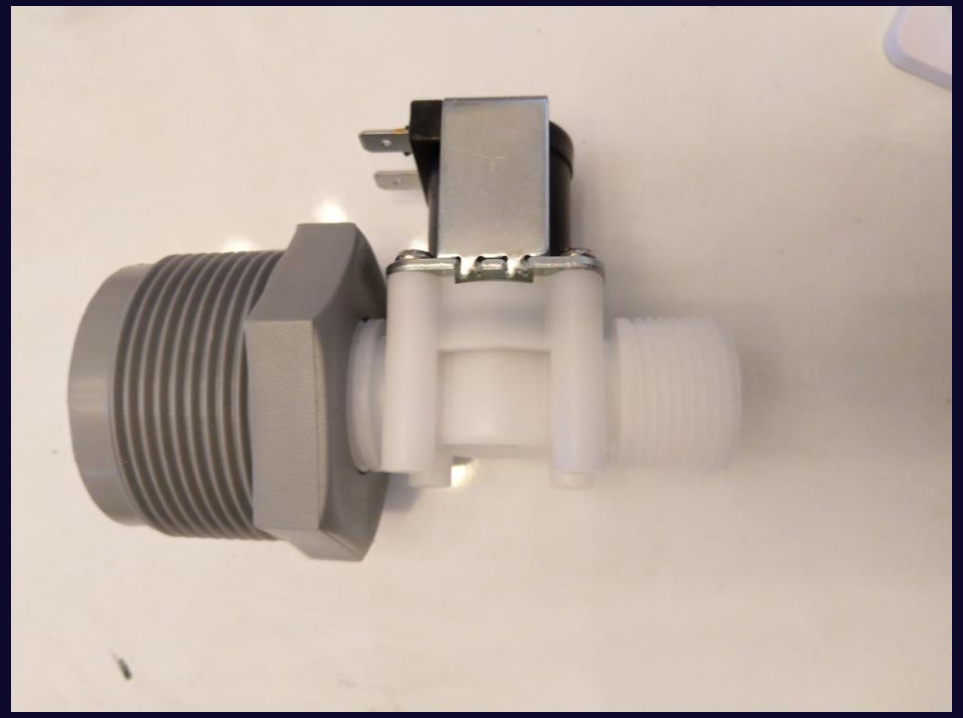
- Main Pump – JoJo Pump
  - Switch with 220V Relay

- Secondary 12 V DC Pumps
  - Switched with 12 V Relay

https://www.communica.co.za/products/cmu-high-pressu-water-pump-12vdc

Irrigation with Water Tanks

- Always use a Solenoid to switch Water sources on and off



12 V Solenoid

https://www.communica.co.za/products/hkd-g1-2in-water-flow-solenoid?variant=39345739595849

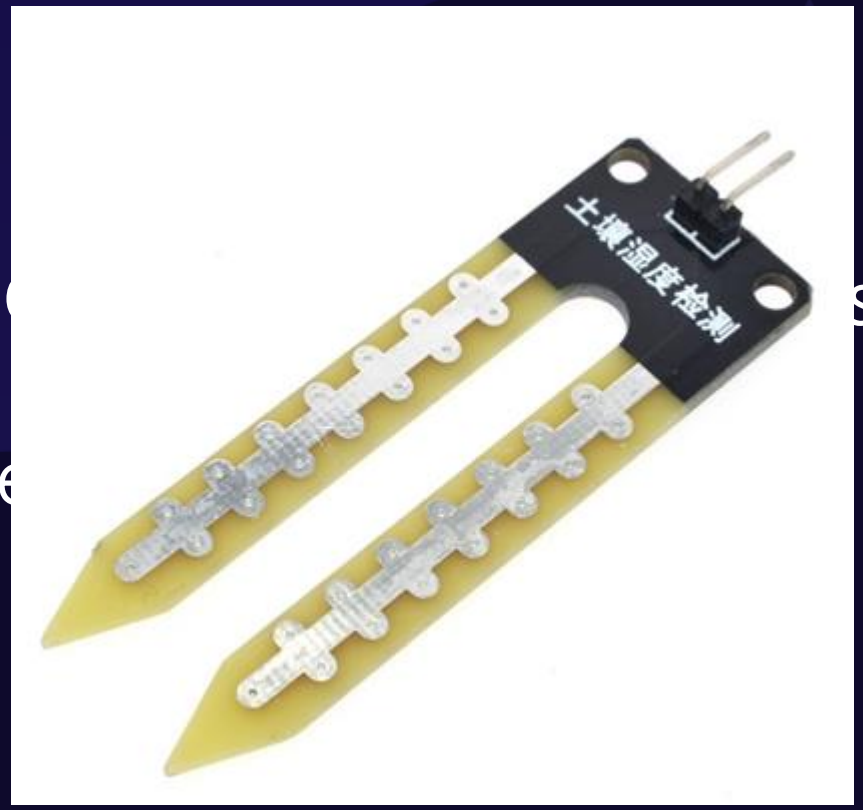
Ruggedizing the Farm - Sensors

- Use Capacitive Moisture Sensors
- Protect any exposed electronics

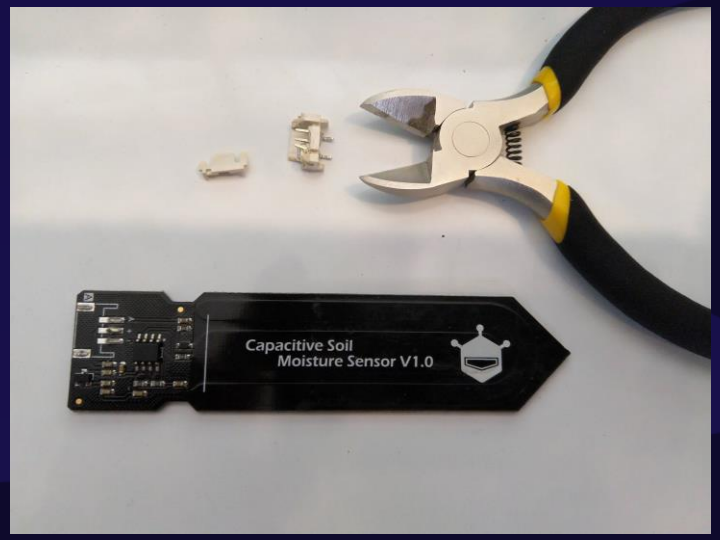
Ruggedizing the Farm - Sensors

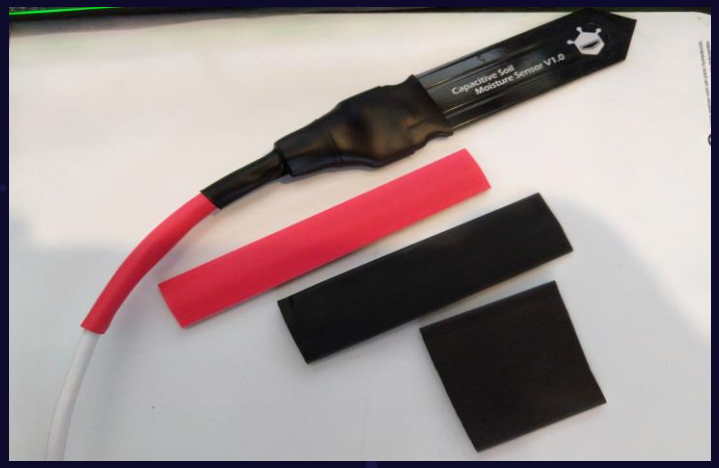
- Use (
- Prote

s



Ruggedizing the Farm - Sensors





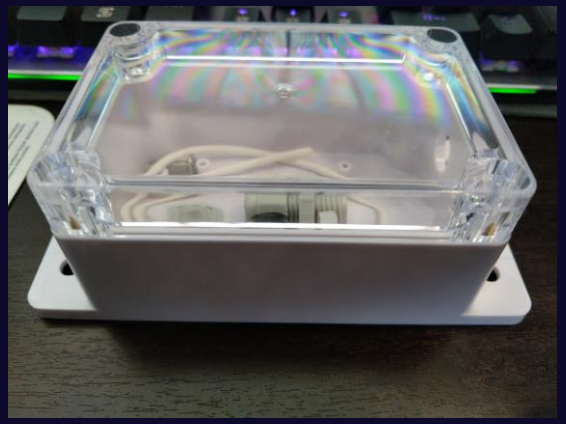
Ruggedizing the Farm - Sensors

- Or use waterproof capacitive moisture sensors

https://wiki.dfrobot.com/Waterproof_Capacitive_Soil_Moisture_Sensor_SKU_SEN0308

Ruggedizing the Farm - Enclosures

- Use waterproof enclosures
- Improve seals with rubber grommets



https://www.communica.co.za/products/sonoff-w-proof-enclosur-ip66?variant=18949716508745

Ruggedizing the Farm - Wood

- Treat all wood surfaces
- Try not to use anything harmful
- Linseed Oil

https://www.builders.co.za/Paint-%26-Adhesives/Woodfinish/Linseed-Oil/Smith-and-Co-Boiled-Linseed-Oil---Amber-%28750ml%29/p/0000000000000642933

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- Raspberry Pi South Africa
- https://www.facebook.com/groups/1493503984198019
- Cape Town MS Developer User Group
- https://www.meetup.com/Cape-Town-Ms-Dev-User-Group/

Thank you!!