SwitchDoc Labs

The Smart Garden System
4 Plant Extender
Assembly and Operation Manual

October 2018

Version 1.2

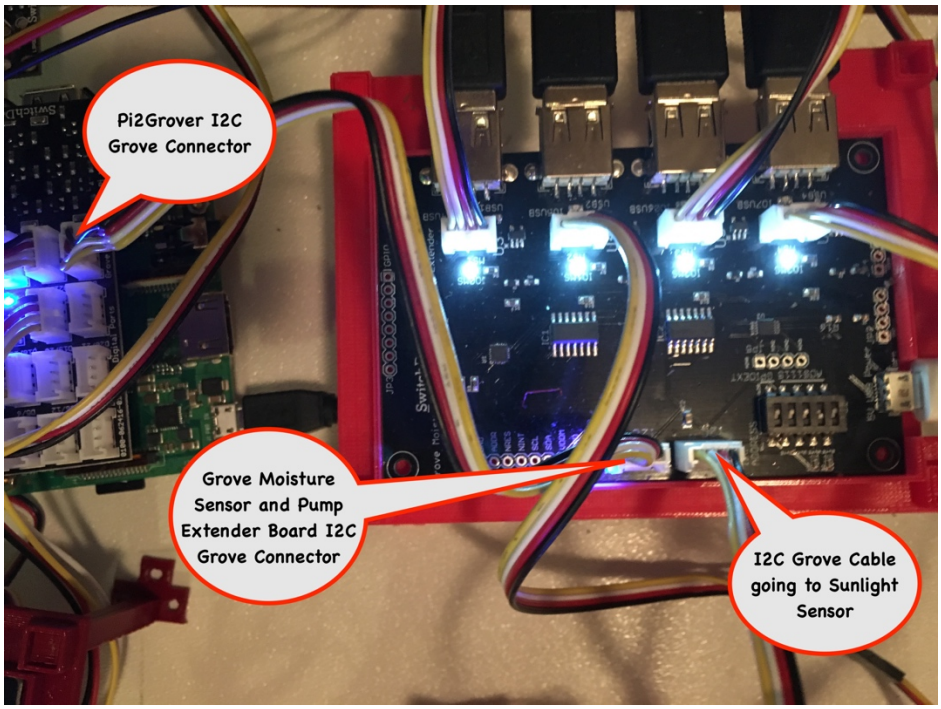


Table of Contents

Cautions when building and using The Smart Garden System 1

What is The Smart Garden System? 2

The Smart Garden System Features 2

The First Step 2

What is in the The Smart Garden System 4 Plant Extender Kit? 3

DIP Switch Programming 4

Parts List 5

Step by Step Assembly 7

Preparing the Tubes 14

Setting up the Raspberry Pi 16

Initial Testing 17

Calibrating your Water Tank 21

The Smart Garden System Operations 24

What does the LED Strip Display? 24

What About Blynk? 26

The Science and Education Goals Behind The Smart Garden System 28

How the 4 Plant Extender Board Works 28

Support 30

Disclaimer 31

Cautions when building and using The Smart Garden System

1) **Keep all water away from the electronics and power supply at all times!**
2) **The Smart Garden System is designed for indoor use only and should be placed in a dry environment where no water or rain can reach to avoid short circuiting the electronics**
3) **Insert the moisture sensor into the CENTER of the flower pot, and keep it near the center of the plant and away from the water coming out of the holes cut in the watering pipe.**
4) **This is not a toy! Keep it out of reach of young children and pets.**
5) **SwitchDoc Labs assumes no liabilities in the use of this kit, beyond the refund of the purchase price.**

What is The Smart Garden System?

This is a perfect project kit for kids with some help from the adults and for adults trying to learn some new things. We have done this before with our successful OurWeather KickStarter so we know what we are talking about. People all over the world have built the OurWeather weather station with great success. This project has **no soldering** involved and uses Grove connectors to wire everything up! You can't reverse them and blow things up. Here is our tutorial on the Grove system.

The Smart Garden System Features

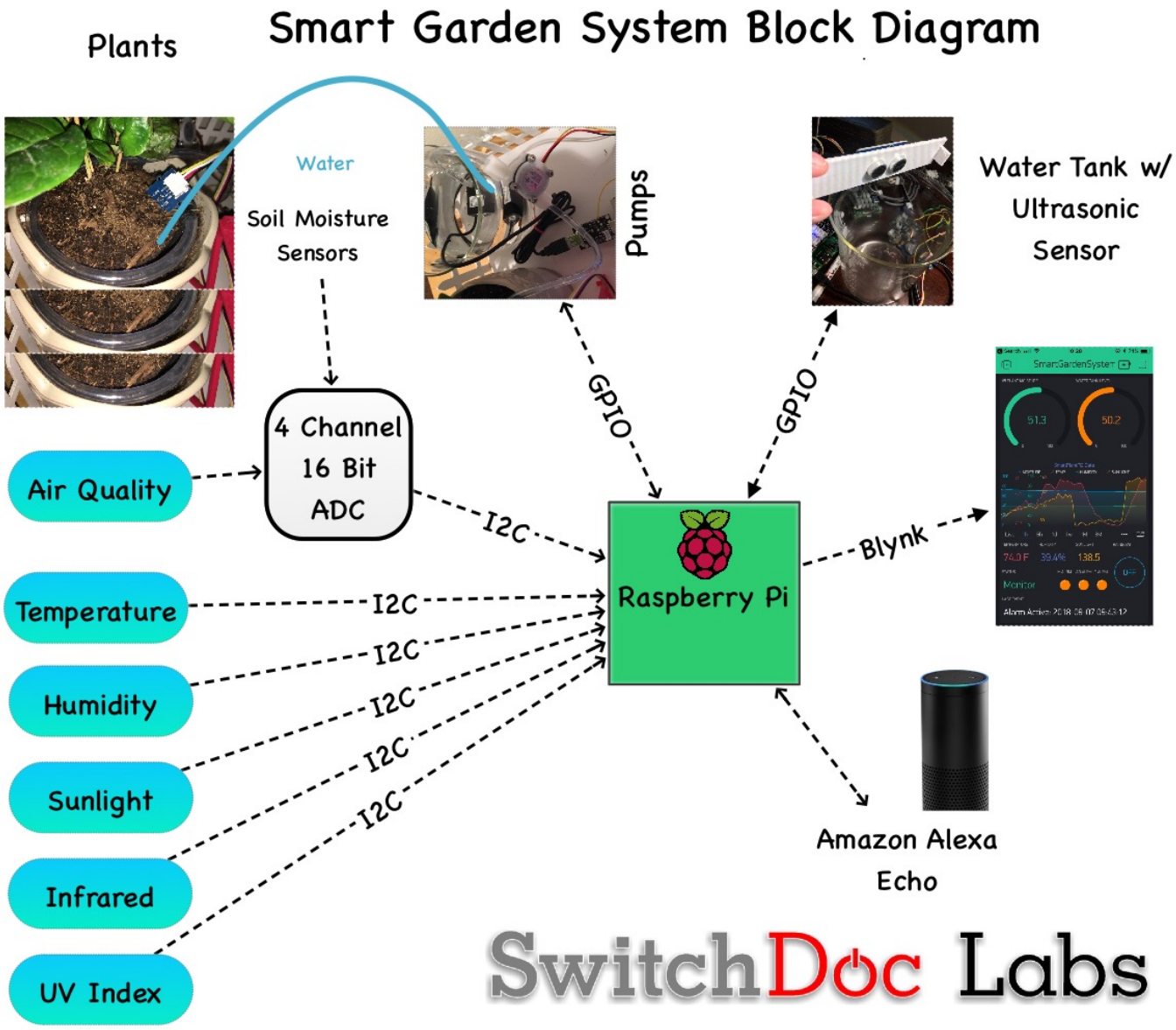
- Measure your Temperature
- Measure your Soil Moisture
- Measure your Sunlight
- Measure your Air Quality
- Show your results on the Internet and your Phone
- Even connect your plant to the Amazon Echo/Alexa

Easy to build. Easy to learn about the IOT (Internet Of Things) and the Raspberry Pi.

SwitchDoc Labs is building on the strength and reception of our last successful No Soldering Kickstarter Project - OurWeather.

The First Step

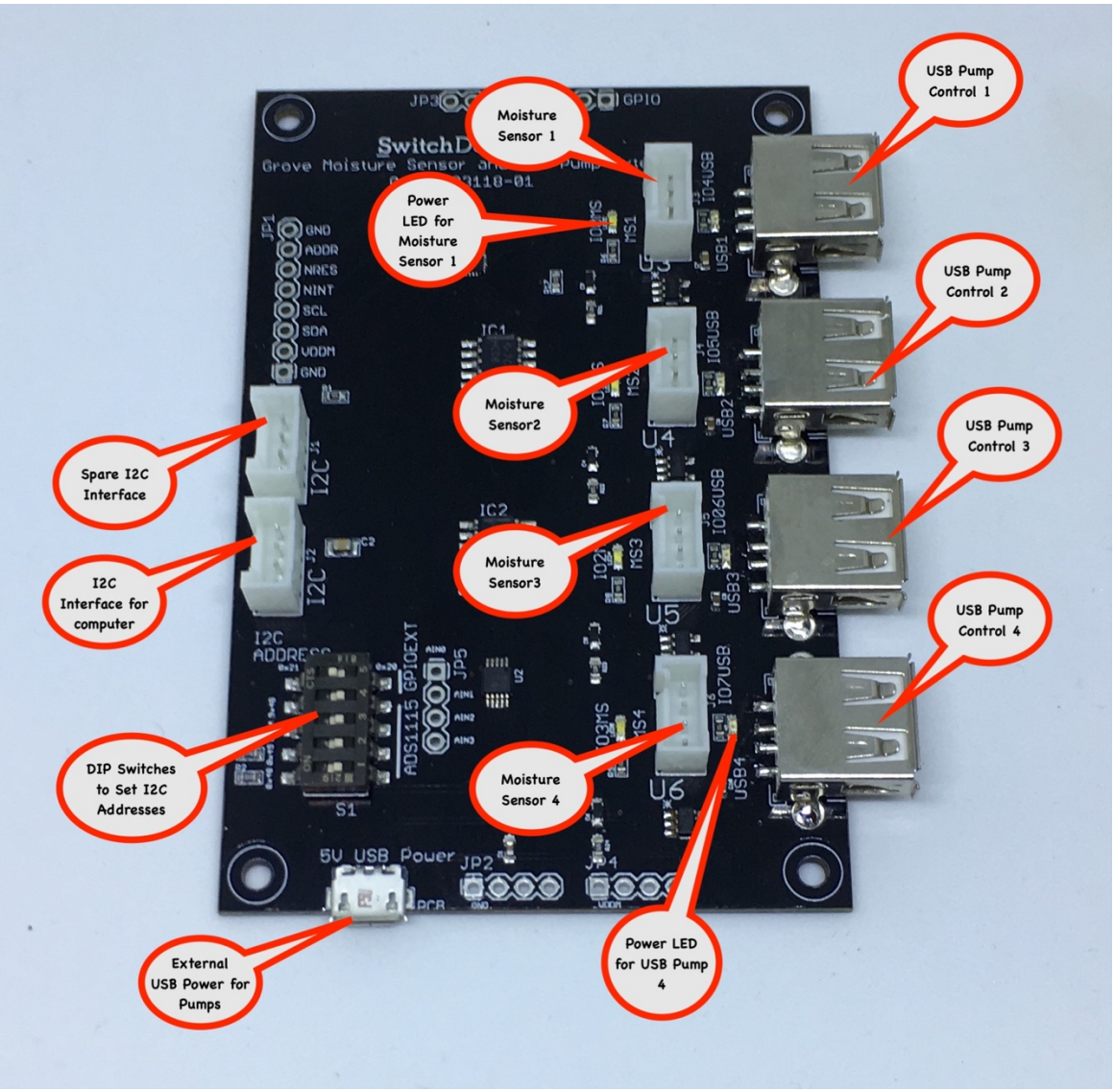
Set up and get running the Smart Garden System as shown in the Smart Garden System Assembly and Operations manual. After you have that running, shut your Raspberry Pi Smart Garden System off and proceed with this manual.



What is in the The Smart Garden System 4 Plant Extender Kit?

The SGS 4 Plant Extended is designed to add an additional 4 sensed and controlled plants to the Smart Garden System base unit. The first extender board added supports plants 2-5 and the second board supports plants 6 - 9. It includes:

- SGS 4 Plant Extender Board (with built in USB Pump Controls and Analog to Digital Converter)
- Four USB Controlled Pumps
- Four Capacitive Moisture Sensors
- 5V Power Supply for pumps
- 5 50cm Grove to Gravity Cables
- 800mm Hose, 4 Hose Clips
- 4 Hose Plugs
- 3D Printed SGS Extender Stand



This board contains most of the electronics for the I2C SGS Extender board. It has an GPIO Extender on the board, a 4 channel 16 bit Analog to Digital Converter and four USB Port controls. Note that this is not an USB Hub as the data lines are not connected. These are power only ports. There are 9 LEDs on the board. One for power, 4 for moisture detector sensing (1 per sensor) and four showing if the pumps are on or not.

DIP Switch Programming

An I2C bus is often used to communicate with chips or sensors that are on the same board or located physically close to the CPU. It stands for standard Inter-IC device bus. I2C was first developed by Phillips (now NXP Semiconductors). To get around hardware licensing issues, sometimes the bus will be called TWI (Two Wire Interface). SMBus, developed by Intel, is a subset of I2C that defines the protocols more strictly.

I2C provides good support for slow, close peripheral devices that only need be addressed occasionally. For example, a temperate measuring device will generally only change very slowly and so is a good candidate for the use of I2C, where a camera will generate lots of data quickly and potentially changes often.

I2C uses only two bi-directional open-drain lines, SCL (Serial Clock) and SDA (Serial Data). Kind of like two serial data lines next to each other. Open-drain means the I2C device can pull a level down to ground ("0"), but cannot pull the line up to VDD ("1"). Hence the name open-drain. You put a resistor on the line to pull it up to a "1" between "0" serial pulses. Very much like a dance between SDA and SCL.

I2C devices are addressed by using a 7 bit address (0-127 in decimal) so you can have many devices on the same I2C bus, which is a very cool feature.

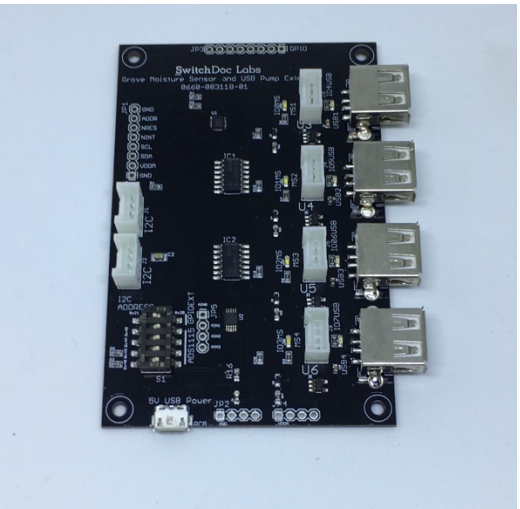
The DIP Switch on the I2C SGS Extender Board is used to set the I2C addresses for the two I2C devices on the board (the ADS1115 ADC and the 8 Pin GPIO Extender). Switches 1-4 are used to set the ADS1115 address and Switch 5 is used to select the address for the 8 Pin GPIO Extender. How you set these switches is explained in the Step-By-Step instructions.

For your information, here are the addresses for Plants 2-5 and if you have a second extender Plants 6-9.

Extender #	ADS1115 ADC I2C Address	GPIO Extender I2C Address
#1 (Plants 2-5)	0x49	0x20
#2 (Plants 6-9)	0x4A	0x21

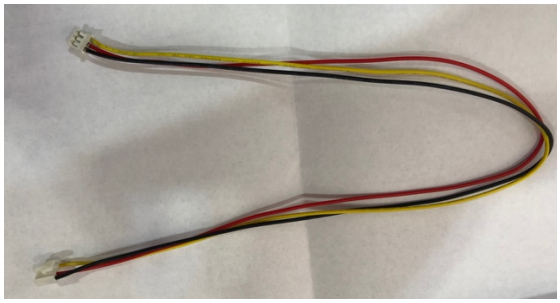
Parts List

Part A – Grove Moisture Sensor and Pump Extender Board



Part B – Grove Capacitive Moisture Sensors (4)

Part C - Grove to Capacitive Moisture Sensor Cables (4)

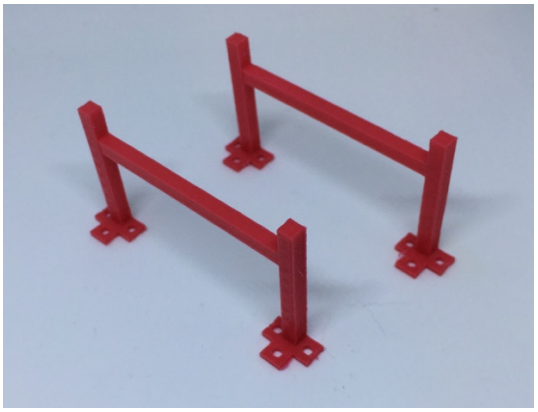


Part D – USB Submersible Pump (4)

Part E– Stakes (4)

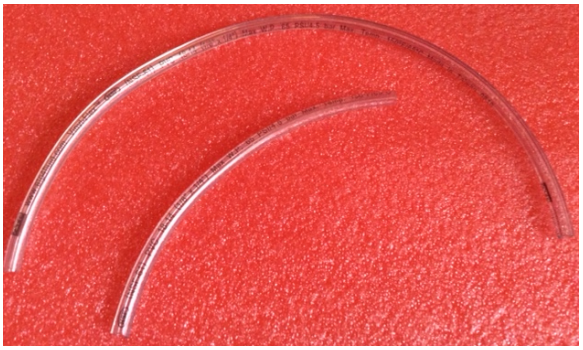
Part F – 3D Printed Top

Part G – 3D Printed Stands (two)

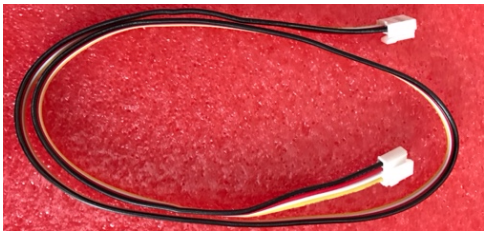


Part H - Long (800mm) ¼” Plastic Pipe

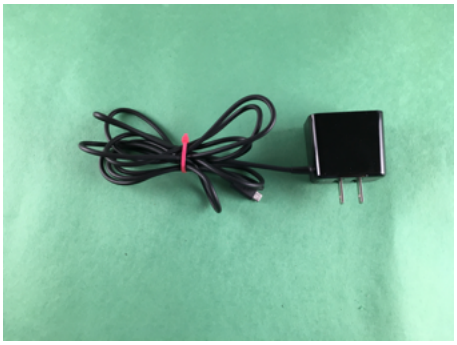
Part I – Plastic Pipe Plug (4)



Part J– 50cm Grove to Grove Cable



Part K– MicroUSB Plug AC Power Supply



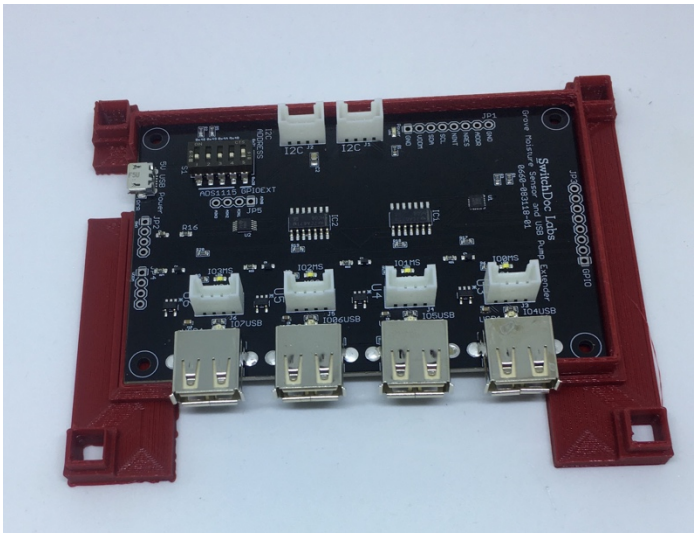
Step by Step Assembly

Cautions: Keep your static charge to a minimum during your assembly and operation. Touch metal before handling parts. Avoid shuffling your feet. Before starting assembly, layout all the parts above and familiarize yourself with the various parts.

Step 0) Make sure you have powered OFF your Raspberry Pi and you have not plugged in the micro USB Power Supply on the Grove Moisture Sensor and Pump Extender Board (Part A).

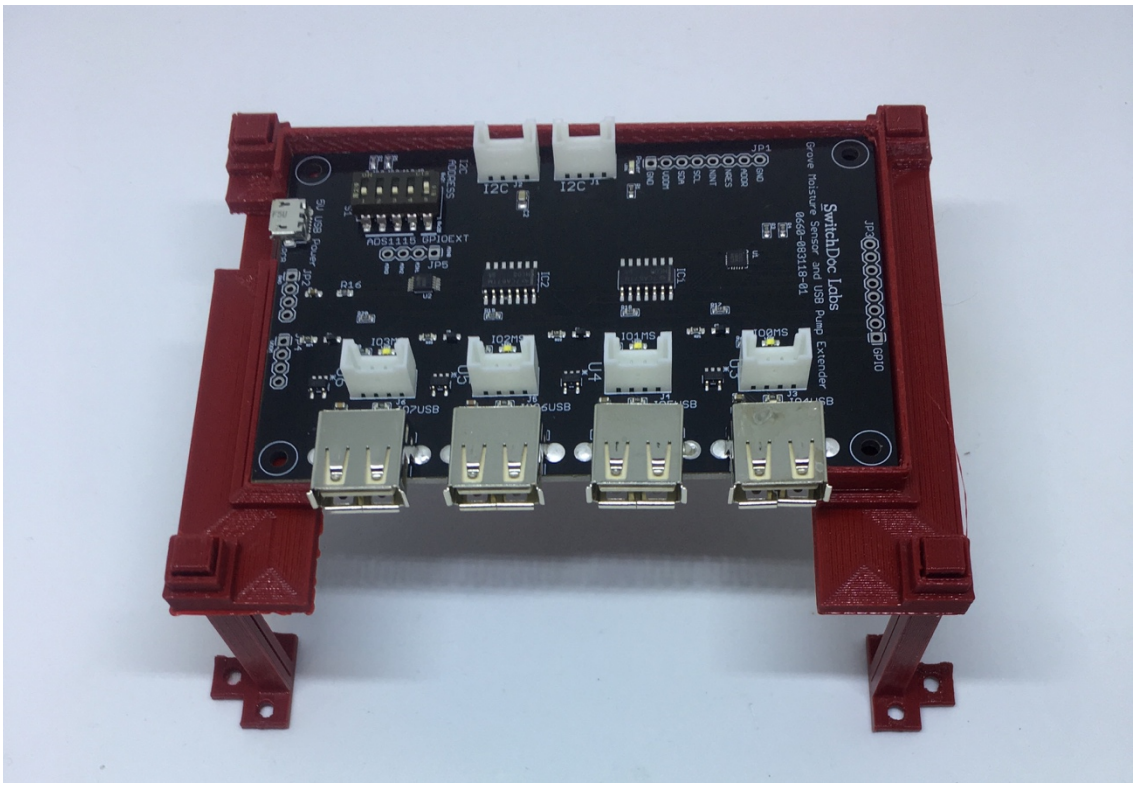
Step 1) Take the 3D Printed Top (Part F) and lay it on a flat surface.

Step 2) Take the SGS Extender Board (Part A) and snap it into the 3D Printed top as below.

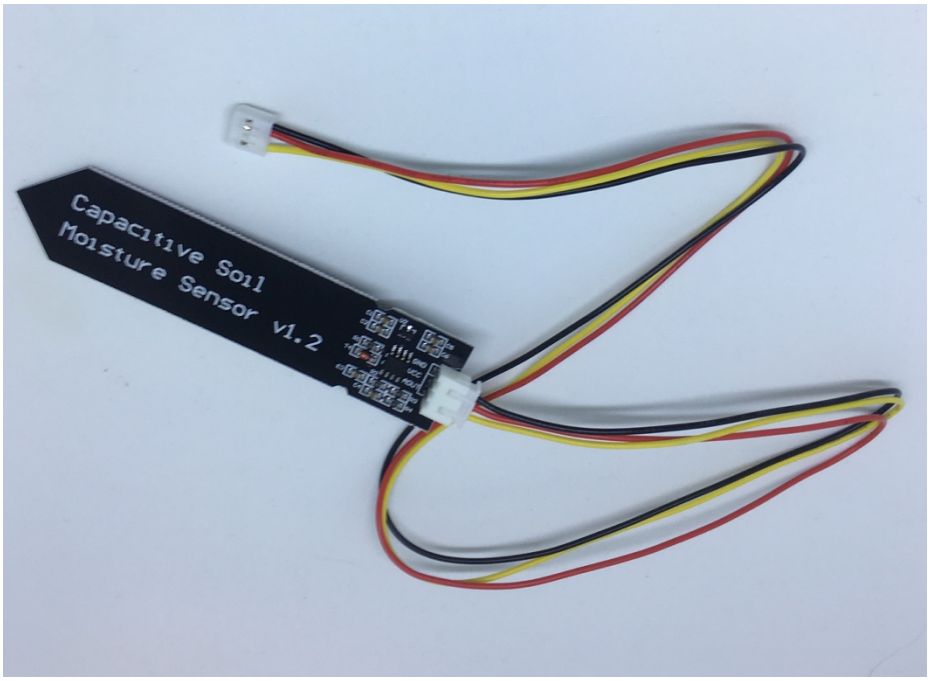


Step 3) Take the two 3D Printed Stands (Part G) and insert them in the holes at each end of the 3D Printed Top (Part F). If the stands are tight, take a nail file and sand the ends down slightly so they fit through the

holes in the 3D Printed top. Insert the stands so the flanges with the screw holes face out from the 3D Printed Top as shown.



Step 4) Take the 50cm Grove to Capacitive Moisture Board Cable (Part C) and plug the other end into the Grove Capacitive Moisture Sensor (Part B). Repeat for all four sensors (Parts B). You may discard the other cables packaged with the Grove Capacitive Moisture Sensors (Part B). Set these sensors aside.

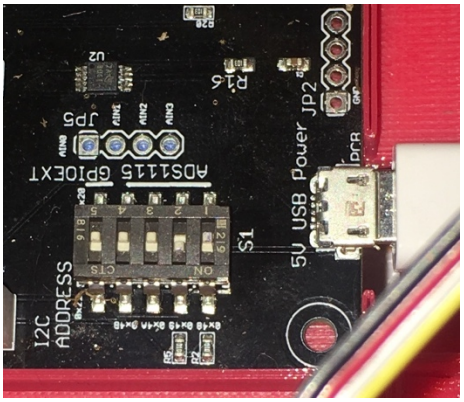


Step 5) If this is the first SGS 4 Plant Extender you are adding to your Smart Garden System, set the DIP switches on the SGS Extender Board (Part A) to the following. You can use a small screw driver to set the switches

Plants #1-5 – First Extender Kit

```
Switch 1 – Off
Switch 2 – On (Sets ADS1115 to I2C Address 0x49)
Switch 3 – Off
Switch 4 – Off
Switch 5 – Off (Sets GPIO Extender to I2C Address 0x20)
```

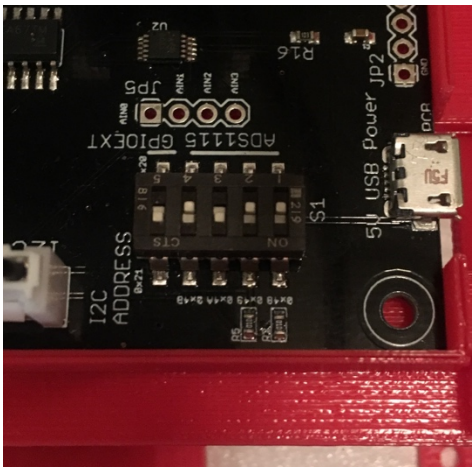
Your switches will look like this:



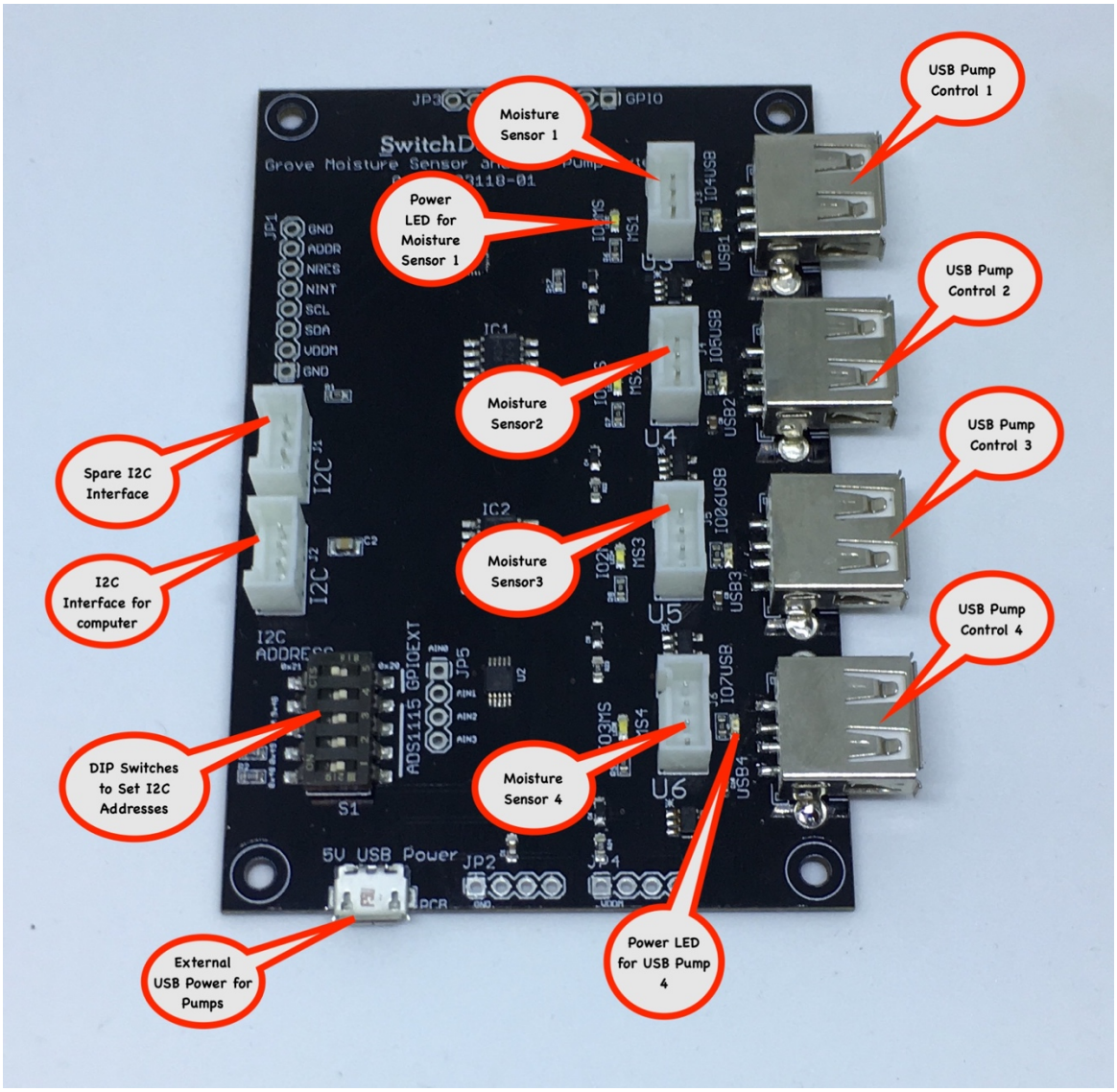
Plants #6-9 –Second Extender Kit

```
Switch 1 – Off
Switch 2 – Off
Switch 3 – On (Sets ADS1115 to I2C Address 0x4A)
Switch 4 – Off
Switch 5 – On (Sets GPIO Extender to I2C Address 0x21)
```

Your switches will look like this:



Now we are ready to start plugging in the moisture sensors and the pumps.



Step 6) Take your four USB Submersible pumps (Part D) and plug them into the Four USB plugs on the left side of the Grove Moisture Sensor and Pump Extender Board (Part A).

Step 7) Label each of the pumps or their cables with the Plant number. Since the Smart Garden Base system comes with one plant (Plant #1) start with Plant #2 and continue to Plant #5 (If this is your second Extender

kit, then go from Plant #6 – Plant #9). **This is important.** You don't want mix up Plant pumps #'s with the corresponding moisture sensor. If you do, then the SGS has no idea if it has watered your plant enough!

Step 8) Now take the four capacitive moisture sensors you wired up in Step 4 and plub them into the four right side Grove connectors on the Grove Moisture Sensor and Pump Extender Board (Part A). The Grove cables are keyed so you can't plug them in backwards! Label each Capacitive Moisture Sensor with the Plant number. Since the Smart Garden Base system comes with one plant (Plant #1) start with Plant #2 and continue to Plant #5 (If this is your second Extender kit, then go from Plant #6 – Plant #9).

This is important. You don't want mix up Plant pumps #'s with the corresponding moisture sensor. If you do, then the SGS has no idea if it has watered your plant enough!

Now you have wired up all the moisture sensors and their corresponding pumps.

Step 9) Check your wiring and labeling and make sure that the pumps and moisture sensors match.

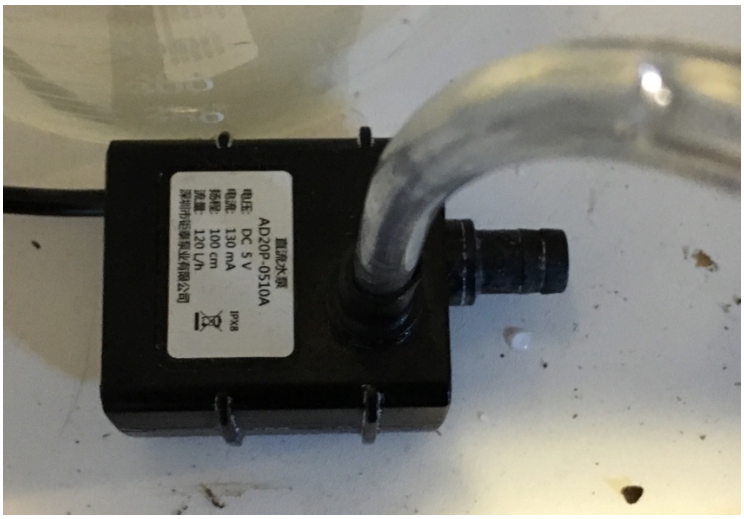
Preparing the Tubes

Step 10) There is one length (800mm) of ¼" plastic pipe (Part H) included. Cut this tube into four equal lengths or whatever your requirements are.

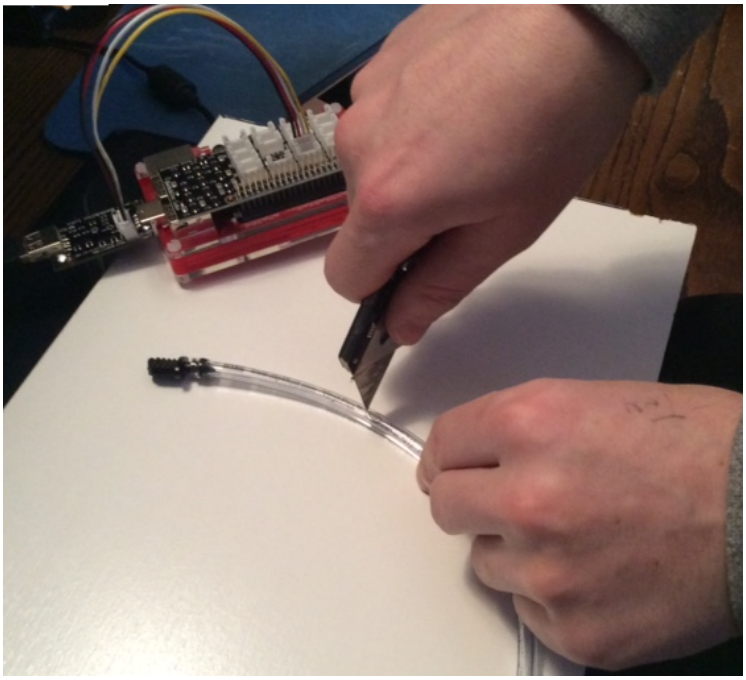
Note: If your length requirements are different than the tubes supply, any ¼" irrigation plastic pipe will work for this project. Available at any major hardware store.

Step 11) Take the pipe you cut in Step 10 and push it onto the nipple of the USB Submersible Pump (Part D). If you are having a hard time pushing it in, soak the end of the pipe in hot water for a few minutes to soften it. Then try again. Plug the other end of the pipe with the Plastic Plug Pipe (Part I).

The pump output is on the side of the pump (Part D) next to the label as show below.

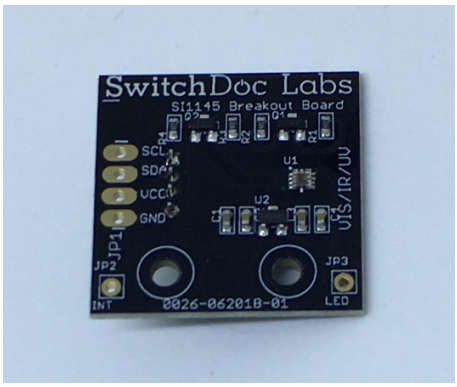


Step 12) With an Xacto knife or sharp blade (be careful!) make at least three evenly spaced holes around the pipe that will circle the plant.

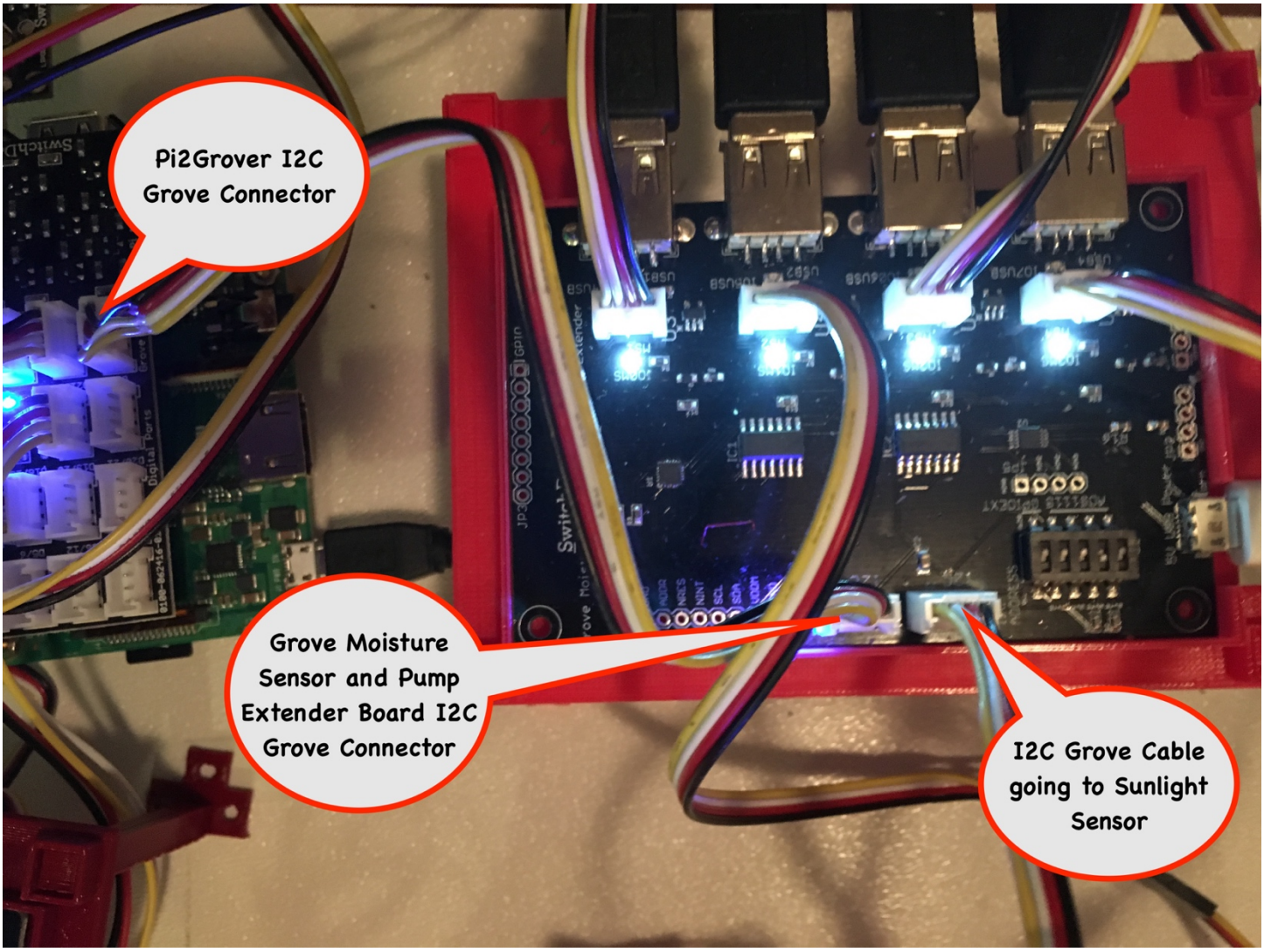


Step 13) With the included plant Stakes (Part E) secure the pipe to the plant pot circling the plant. Cut the Stakes with a pair of scissors if the stakes are too tall for your plant.

Step 14) Check one more time that you have the correct moisture sensor paired with the correct USB Pump!



Step 15) On your Smart Garden System, unplug the Grove Cable (on the Pi2Grover side) between the Pi2Grover I2C Plug and the Sunlight Sensor on the Smart Garden System. Then Plug the free end of the Grove Cable into the I2C Grove Plug on the left of the Grove Moisture Sensor and Pump Extender Board (Part A).



Step 16) Plug in the Micro USB Connector into the 5V USB Power connector (Part K) on the Grove Moisture Sensor and Pump Extender Board (Part A). Plug the other end into a AC Power plug.

Now you are completely wired up. Check your connections (and the plant numbering!) and it is time to power on the Raspberry Pi.

Setting up the Raspberry Pi

Before we start the Smart Garden System (Check out the Smart Garden System and Operations Manual for more information), we need to set a couple of parameters in the software on the Raspberry Pi.

Step 1) Power up your Raspberry Pi and let it boot up. You should see a couple of LEDs on the Raspberry Pi and you will see the Power LED on the Grove Moisture Sensor and Pump Extender Board (Part A) glow blue.

If you don't see any lights on the Pi2Grover board or the Grove Moisture Sensor and Pump Extender Board (Part A), power down immediately and check your wiring.

Step 2) Open up a terminal window on your Raspberry Pi display or ssh into the Raspberry Pi.

```
cd /home/SDL_Pi_SmartGardenSystem
```

Now edit the conflocal.py configuration file. If this file does not exist then copy config.py to conflocal.py (*cp config.py conflocal.py*) before continuing. Use nano or vi, your editor of choice:

```
nano conflocal.py
```

Scroll down until you see the following:

```
############
# Moisture Sensor and Pump Count
############

plant_number = 1
moisture_sensor_count = plant_number
USB_pump_count = plant_number
```

Change the "1" above to "5" ("9" if this is your second extender)

```
############
# Moisture Sensor and Pump Count
############

plant_number = 5
moisture_sensor_count = plant_number
USB_pump_count = plant_number
```

Save the file.

Initial Testing

Step 1) I2C Test - Now we can run the first major test.

Type this into a terminal window:

i2cdetect –y 1

Here is what you should see:

```
pi@RPi3-62:~/SDL_Pi_The Smart Garden System $ i2cdetect -y 1

     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
```

```
00:          -- -- -- -- -- -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: 20 -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- 3c -- -- --
40: 40 -- -- -- -- -- -- -- 48 49 -- -- -- -- -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: 60 -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --


pi@RPi3-62:~/ SDL_Pi_SmartGardenSystem $
```

This is a list of all the devices present on your I2C Bus.

0x20 – 4 Plant Extender Board

0x3c – OLED Display

0x40 – HDC1010 Temperature / Humidity Device

0x48 – 4 Channel ADC Board

0x49 – 4 Channel ADC Board on the 4 Plant Extender Board

0x60 – Sunlight Sensor

If you are missing any of the above devices, carefully check your wiring. You probably have made a mistake above in wiring.

Note: If this is your second board you should see these two devices also:

0x21 – second 4 Plant Extender Board

0x4A– 4 Channel ADC Board on the second 4 Plant Extender Board

If this looks good, move to the next step.

Step 7) Run the testALL.py program – this tests a number of the other devices on The Smart Garden System

```
cd SDL_Pi_The Smart Garden System
sudo python testAll.py
pi@RPi3BP-70:~/SDL_Pi_SmartGardenSystem $ sudo python testAllSensors.py
[Errno 121] Remote I/O error
[Errno 121] Remote I/O error
Error accessing 0x49: Check your I2C address
Error accessing 0x49: Check your I2C address

Test All SGS Devices Version 1.0 - SwitchDoc Labs

Program Started at:2018-10-17 19:02:22

Temp             = 22.227 deg C
```

```
Humidity         = 39.11 %
-----------------
 Sunlight Vi/IR/UV Sensor
-----------------
Sunlight Visible:  392
Sunlight IR:       3635
Sunlight UV Index: 0.72
376.580357143
Moisture Humidity = 53.80
------------------------------
Sensor Value=250 --> Fresh Air  | 0
Ultrasonic Level
Grove Ultrasonic get level and print
4.633cm
4.612cm
4.612cm
4.596cm
4.612cm
4.629cm
4.510cm
4.612cm
4.596cm
4.510cm
----------------------
Main Sensors
----------------------
ADS1115:          Present
OLED:             Present
Sunlight Sensor:              Present
hdc1000 Sensor:               Present
Ultrasonic Level Sensor:            Present

----------------------
Plant / Sensor Counts
----------------------
Sensor Count:  1
Pump Count:  1

----------------------
Extender Devices
----------------------
ADS1115_Ext1:           Present
ADS1115_Ext2:           Not Present
GPIO Extender 1:              Present
GPIO Extender 1:              Not Present

----------------------
Future Smart Garden System Expansions
----------------------
SunAirPlus:             Not Present
Lightning Mode:               Not Present
Solar Power Mode:             Not Present
MySQL Logging Mode:           Not Present

done with testAll
pi@RPi3BP-70:~/SDL_Pi_SmartGardenSystem $
```

You can ignore the first four lines of errors. They are a result of the testing process.

If this is your second 4 Plant Extender you should see this:

```
ADS1115_Ext1:           Present
ADS1115_Ext2:           Present
GPIO Extender 1:              Present
GPIO Extender 1:              Present
```

If every thing looks good then we are ready to proceed to the next step.

Note: YOU SHOULD HAVE NO WATER IN THE SYSTEM AT THIS POINT. If your tank has water in it, drain it at this time.

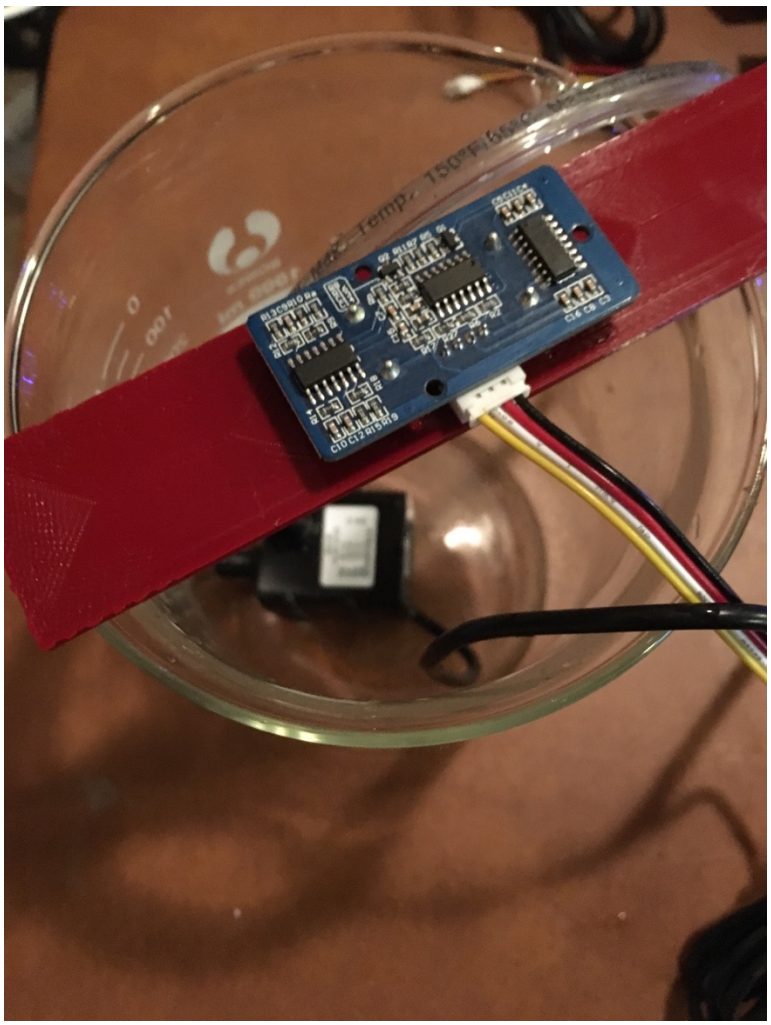
Next we need to recalibrate the water tank since you have a bunch more pumps in the tank!

Calibrating your Water Tank

Once you have done all the above steps and tests, it is time to add water and start The Smart Garden System (SGS) running for real. We have one more step before starting the software. We need to calibrate the ultrasonic sensor so the SGS will know how much water is in the tank. You already have the plant connected, so it is time to get a beaker, bucket or glass and add the USB Submersible Pump into the vessel.

Step 1) Take a glass (we used a beaker) and place all five (4 from this kit) of the USB Submersible Pumps inside the glass, making sure not to crimp the pipe coming out. Do NOT Add water at this time. These pictures only show one.

Step 2) Place the Ultrasonic sensor over the top of the tank with the sensor facing down. If your tank is larger than the 3D printed Ultrasonic Holder, take a piece of wood or plastic of the appropriate size and cut two holes to fit the sensor inside.



Step 3) In the SDL_Pi_SmartGardenSystem directory run the following CalibrateWaterTank program and following the on screen directions. Do NOT get the Ultrasonic Sensor wet and don't fill the tank so full that the sensors will be in the water! This program writes a calibration file containing these full and empty measurement numbers. If you change the tank size or depth, just re-run this calibration program.

```
pi@RPi3BP-70:~/SDL_Pi_SmartGardenSystem $ sudo python CalibrateWaterTank.py
############################
Ultrasonic Tank Calibration
SwitchDoc Labs
Software Version: 001
############################

Step 1) Empty Water Tank
Step 2) Put Ultrasonic Sensor in place on top of tank

hit return to continue:
Measuring Empty Level
11.265cm
11.355cm
11.265cm
11.318cm
11.269cm
11.285cm
11.249cm
11.285cm
11.285cm
11.285cm
calibrated EMPTY Level=   11.3

Step 3) Fill Water Tank
Step 4) Put Ultrasonic Sensor in place on top of tank

hit return to continue:
Measuring Full Level
2.314cm
2.314cm
2.314cm
2.179cm
2.331cm
2.351cm
2.196cm
2.196cm
2.196cm
2.196cm
calibrated FULL Level=    2.3

############################
Values written to TankCalibration File
############################
Calibration Complete
############################
pi@RPi3BP-70:~/SDL_Pi_SmartGardenSystem $
```

You have now completed the initial assembly and calibration of the 4 plant extender for The Smart Garden System.

Now proceed to the Smart Garden System Assembly and Usage Manual and start the SGS software running.

The Smart Garden System Operations

Before we discuss the various controls and their usage, let's talk about a few important things about The Smart Garden System.

1) **Keep all water away from the electronics and power supply at all times!**
2) **The Smart Garden System is designed for indoor use only and should be placed in a dry environment where no water or rain can reach to avoid short circuiting the electronics**
3) **Insert the moisture sensor into the CENTER of the flower pot, and keep it near the center of the plant and way from the water coming out of the holes cut in the watering pipe.**
4) **This is not a toy! Keep it out of reach of young children and pets.**
5) **SwitchDoc Labs assumes no liabilities in the use of this kit, beyond the refund of the purchase price.**

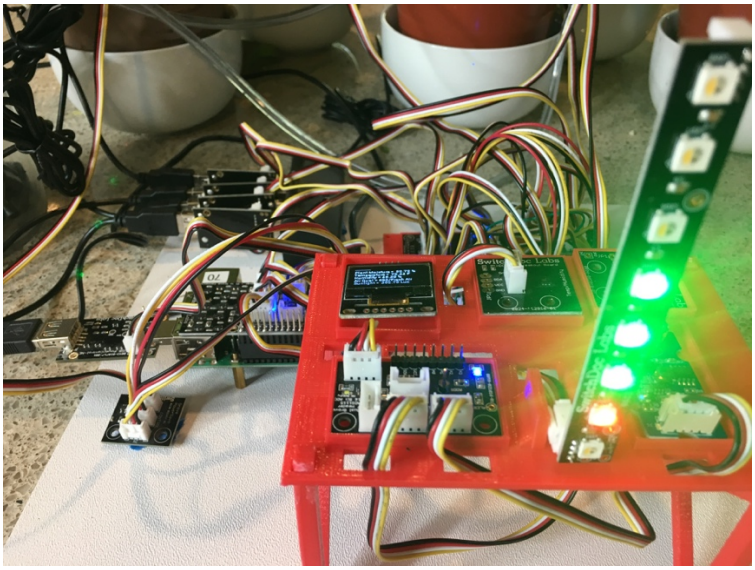
OK, now that we have that out of the way, let's talk about the software and how things work.

While the the Smart Garden System system is pretty simple, the architecture of the software is pretty sophisticated. The Smart Garden System is a real-time system. What we mean by "real time" is that the program has to monitor environmental variables and then do certain actions at certain times. In a nutshell, we used a scheduler to build and run a set of tasks to check the moisture content of the plant and then turn the pump on if applicable. We detect that we are out of water by monitoring level of the tank using an ultrasonic sensor. No water pumped? We are out of water.

So, we have a task to check the water, update all the environmental sensors and a variety of other tasks. All source included, all open source. Feel free to add sensors, more pumps or anything you want to do!

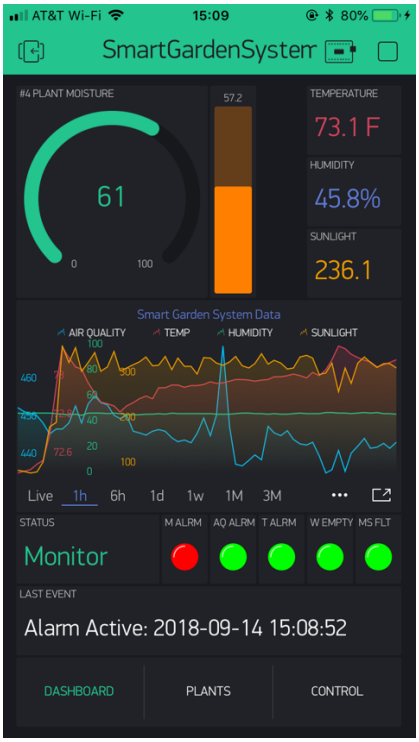
What does the LED Strip Display?

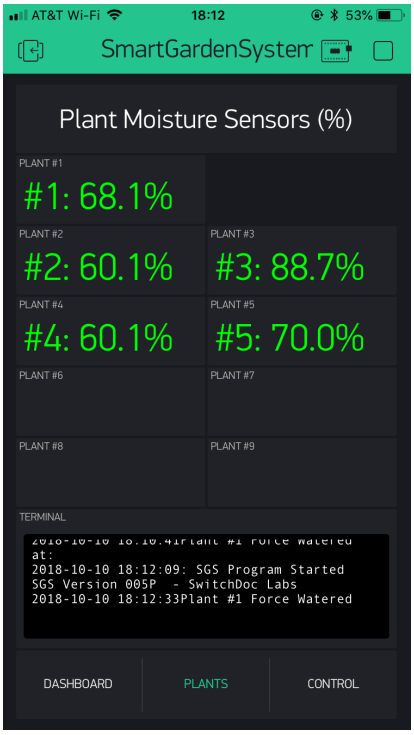
The 8 Pixel RGBW (NeoPixels) strip shows three things. The bottom-most LED blinks to show you that the system is still running and the program and Pi has not bombed. The other 7 LEDs alternate between displaying the water tank level and the moisture readings from plant #1.



What About Blynk?

Please see the manual “Installing Blynk for the Smart Garden System”.





The Science and Education Goals Behind The Smart Garden System

Everything we build for the Maker market is designed for education and learning. Making is education. Making is learning. Building your own projects allows you to innovate around a framework and do wonderful things that we have never thought of.

The educational goals for Smart Plant are:

- Learn about the Raspberry Pi and installing software on the Pi
- Connecting up sensors to the Raspberry Pi
- Learning about Feedback loops and regulating water to plants
- Understand your indoor environment and what affects it
- Learn about the new technology called the Internet of Things

Just a few words about the theory behind The Smart Garden System. This was a great project to design and build. It was really an interesting process learning about the sensors, how to interconnect them and then learning about flow meters, USB Pumps and especially the software bringing them all together.

Where is the science and engineering in this project? All through it from the bottom to the top. The most interesting points? One, we are using feedback in the system. Negative feedback to be exact. We aren't just watering on a timer, we are looking at the soil moisture and if it is high enough, we don't water. We don't water unless we need to. Very cool.

Secondly, the sensors we have in this project are amazing. For example, the Air Quality sensor is very, very sensitive. We can detect hairspray from 50 feet away.

Thirdly, We got a lot out of learning how to display the data from Smart Plant on the Blynk App.

The Amazon Alexa was fascinating and although very complex (we are releasing a tutorial on how to do it) we learned a lot about designing voice interfaces. We can use Alexa [https://youtu.be/q141lM3S05s] but it is not released to the general public. That will take a bunch more work to do that so it will be easy to use by our customers.

How the 4 Plant Extender Board Works

The 4 Plant Extender Board contains an additional 4 channel 16 bit ADC (Analog to Digital Converter) to read the moisture sensors as well as 4 chanels of USB Power Control to switch the pumps on and off. There are LEDs that show the state of the pumps and when the moisture sensors are being read. While we ship the SGS system with capacitive sensors, you can also use resistive sensor by modifying the software. We will be posting the modifications necessary in our blog in the not too distant future.

The 4 Plant Extender will only support a total of two devices (for a total of 9 plants) in the Smart Garden System. A different version of the 4 Plant Extender will support many, many more plants using WiFi. Stay tuned.

Support

As with all SwitchDoc Labs products, technical support is given through the forums on Forum.switchdoc.com

If you have issues that can be solved by our fabulous customer service department, please go to www.switchdoc.com and send your issues through our Contact page on the top menu.

Disclaimer

SwitchDoc Labs, LLC takes no responsibility for any physical injuries and possession loss caused by those reasons which are not related to product quality, such as operating without following the operating manual and cautions, natural disasters or force majeure.

SwitchDoc Labs, LLC has compiled and published this manual which covers the latest product description and specification. The contents of this manual are subject to change without notice.