THE UNIVERSITY OF BRITISH COLUMBIA

IoT Monitoring of Aquaponic and Hydroponic Food Production

INSTALLATION AND SETUP INSTRUCTIONS

UBC Electrical and Computer Engineering Capstone 121

Carson Berry
Lynes Chan
Mason Duan
Jayden Leong
Hannah Xu

for

Alison Chadwick, Nelly Leo, and Joshua Azza UBC SEEDS Sustainability Program
Bernhard Nimmervoll, UBC Mechanical Engineering

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Contents

0.1 Change Log

The change log documents changes made to the document.

Table 1: Change Log of Document

Date	Author	Sections	Change
2021-01-23	CB	1.0 - 4.0	Creation of document skeleton
2021-04-04	CB	1.0 - 5.0	Added Electronic, Hardware manufacturing steps
2021-04-08	LC	6.1-6.2	Fixed formatting, Edited Raspberry Pi setup, added Installing the Project

1 Introduction

This suite of setup instructions is designed to walk a person with some familiarity of circuits, CAD tools, and programming through the steps of setting up a monitoring and control system for their pre-existing aquaponic or hydroponic growing system.

The setup and manufacturing of this system can divided into several steps.

1. Electronic Circuit manufacturing
2. Mechanical component preparation
3. Integration and Assembly

2 Equipment Requirements

Some tools will be required for the assembly of this system. They may be seen below.

1. Screw-Driver, multi-tool
2. Adjustable Wrench
3. Soldering Iron
4. Solder, flux, and Solder paste
5. Hand-Saw
6. Power-Drill

3 Electronic Circuit Manufacturing

3.1 Printed Circuit Board

This project includes the design for a printed circuit board (PCB). This PCB is designed to be a ”hat” for the Raspberry Pi. That is, it will sit directly on the

header pins of the Raspberry Pi.

3.1.1 Ordering the PCB

The PCB will need to be ordered from a PCB manufacturing service. Several options are shown below. Each service may require a different combination of files, so please check in with their requirements.

Local PCB Manufacturers:

1. Canadian Circuits Inc., http://www.canadiancircuits.com/
2. Enigma Interconnect, https://www.enigmacorp.com/
3. Omni Circuit Boards, https://www.omnicircuitboards.com/

Local Vancouver, BC assembly services:

1. Active Electronic Manufacturing, http://activeelectronic.com/
2. Leading Edge Manufacturing, http://www.leadingedge-mfg.com/

Foreign PCB manufacturing / Assembly:

1. Advanced Circuits 4PCB (PCB & Assembly), https://www.4pcb.com/
2. JLCPCB (PCB & Assembly), https://jlcpcb.com/
3. MyRo PCB (PCB & Assembly), http://www.myropcb.com/
4. Osh Stencils, https://www.oshstencils.com/
5. PCB Cart (PCB & Assembly), https://www.pcbcart.com/
6. PCB Way (PCB & Assembly), https://www.pcbway.com/
7. SpeedyPCB (PCB), http://www.speedypcb.com/

3.1.2 Ordering components for the PCB

This PCB will act as the interface between sensors, sensor break-out boards, relays, and the Raspberry Pi.

For a complete listing of the components needed to populate the PCB please refer to table 2 below.

Designator	Description	Quantity	Link
12V_in	Power 12V in	1	https://www.digikey.ca/en/products/detail/on-shore-technology-inc/OSTVN02A150/1588862
A1_0, A1_1, A1_2, A1_3	Header, 3-pin	4	https://www.digikey.ca/en/products/detail/on-shore-technology-inc/OSTVN03A150/1588863
ADC_0, ADC_1	Analog to digital converter	2	https://www.digikey.ca/en/products/detail/adafruit-industries-llc/1085/5761229
Bat	2AA Battery Holder	1	https://www.digikey.ca/en/products/detail/hammond-manufacturing/BH2AAW/3869832
Boost_0, Boost_1	5V Boost converter	2	https://www.pololu.com/product/2562
C1 (4.7uF)	Capacitor	1	https://www.digikey.ca/en/products/detail/tdk-corporation/FA20X7S2A475KRU00/7384281
D1	Power Schottky rectifier, 60 V, 5 A	1	https://www.digikey.ca/en/products/detail/smc-diode-solutions/95SQ015/8021507
Leak Sensor Header	Header, 3-Pin	2	https://www.digikey.ca/en/products/detail/on-shore-technology-inc/OSTVN03A150/1588863
Header 20X2	GPIO shield for RPi	1	https://www.digikey.ca/en/products/detail/adafruit-industries-llc/2223/5629433

pH Sensor Header	Header, 4-Pin	1	https://www.digikey.ca/en/products/detail/on-shore-technology-inc/OSTVN04A150/1588864
Q1	2N3904 NPN General Purpose Amplifier	1	https://www.digikey.ca/en/products/detail/stmicroelectronics/2N3904/603420
R1(10k), R2(1k), R3(220), R4(900k), R5(4.7k), R6(10k), R7(3.9k)	Resistor	6	
Relay header	Relay Control	1	https://www.digikey.ca/en/products/detail/on-shore-technology-inc/OSTVN04A150/1588864
RPi_Vin	Header, 2-pin	1	https://www.digikey.ca/en/products/detail/on-shore-technology-inc/OSTVN02A150/1588862
Temp Sensor header	Header, 3-Pin	1	https://www.digikey.ca/en/products/detail/on-shore-technology-inc/OSTVN03A150/1588863
V1, V2	Header, 2-Pin	2	https://www.digikey.ca/en/products/detail/on-shore-technology-inc/OSTVN02A150/1588862
VR1, VR2	Voltage Regulator	2	https://www.digikey.ca/en/products/detail/texas-instruments/LM7805SX-NOPB/6110585
WL Sensor Header	Header, 3-Pin	1	https://www.digikey.ca/en/products/detail/on-shore-technology-inc/OSTVN03A150/1588863

Table 2: PCB Bill of Materials

To automatically purchase the required components from digikey.ca please find a shopping cart at this url: https://www.digikey.ca/short/tqvrt484. If there is any problem with that digital cart, please try uploading the saved spreadsheet *piponic_BOM_digikey_cart.xlxs* to the website. One note is that the resistors saved in this cart are not special, but were the cheapest available options in single quantities. We recommend investing in a resistor kit, but will leave that decision to the grower.

This cart does not contain everything needed to purchase the parts for this project. Some items must be purchased from other websites, such as the Polulu boost converters. The sensors are also not included in the above table.

3.1.3 Soldering

Once all the components have been purchased, and the PCB has been received from manufacturers it must be soldered together. This should be done in a well-ventilated workspace to avoid aspiration of noxious fumes.

Some of the components belong on the top of the PCB, and some on the bottom. The voltage regulators, resistors, diode, capacitor, and the analog to digital converters all belong on the bottom. In addition the header-pin for the raspberry pi should be placed with the female side on the bottom (so that the male-ends are exposed on the top side).

The most challenging component to solder on the board will likely be the voltage regulators, which are in a surface-mount package. Despite this challenge, they can still be soldered with a conventional soldering iron. When doing so, set the soldering iron to 230 C, and take care that it is fully heated before beginning. Apply solder-paste in an even layer to the exposed VR1 and VR2 footprints. Place the voltage regulators on top of the paste, and heat up the exposed leads with the iron. Try to keep the heating under 10s to avoid damaging the device.

The rest of the through-hole components can be soldered normally using solder-wire.

Once finished soldering all of the components, clean the board with a cotton swab soaked in rubbing alcohol to ensure best performance.

4 Sensors

4.1 Sensor Bill of Materials

The base array of sensors that are recommended can be seen in the table below.

Designator	Description	Quantity	Link
Temperature	DS18B20	1	https://www.digikey.ca/en/products/detail/dfrobot/DFR0198/7597054
Water Level	SEN0204	1	https://www.digikey.ca/en/products/detail/dfrobot/SEN0204/6579443?s=N4IgTCBcDaIMoFEByAGMKAsIC6BfIA
pH Sensor	SEN0161-V2	1	https://www.digikey.ca/en/products/detail/dfrobot/SEN0161-V2/9608223
Leak Sensor	Analog Leak Sensor	1	https://www.amazon.ca/gp/product/B07PV9SYLV/ref=ppx_yo_dt_b_asin_title_o03_s00?ie=UTF8&psc=1

Table 3: Sensor Bill of Materials

4.2 Control Devices Bill of Materials

Some devices will be necessary to set up the control system aspect. This includes what is seen below in the table BOM. The design currently has 2 unused relay channels that may be used in future expansion.

Designator	Description	Quantity	Link
Relay Module	4 Channel 5V controlled Relay Module	1	https://leeselectronic.com/en/product/31302-4-relay-digital-module-5v.html

Solenoid Valve	12V 3/4" solenoid for connecting with hoses	1	https://leeselectronic.com/en/product/440-44012VSOLENOIDVALVE34SMALLROB104.html
Peristaltic Pump	12V Peristaltic Pump with surgical tubing	1-2	https://www.amazon.ca/Peristaltic-Liquid-Dosing-Silicone-Tubing/dp/B075VN1QZM/ref=asc_df_B075VN1QZM/?tag=googleshopc0c-20&linkCode=df0&hvadid=292901727312&hvpos=&hvnetw=g&hvrand=16446818779147696161&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9001561&hvtargid=pla-376008502070&psc=1

Table 4: Control Devices Bill of Materials

4.3 Sensor Placement in Aquaponic or Hydroponic system

The sensors should be placed in location with water flow and minimal contaminating waste deposits. The pH sensor should be placed in the water, upstream of the peristaltic pump's effluent hose.

The temperature sensor can be placed anywhere in the water.

The leak sensor(s) should be placed out of the water wherever you don't want water to pool.

The water level sensor should be attached to the outside of the tank (if the tank is plastic) at the line where you want the minimum water level to be. It should be attached with glue or tape to a plastic wall. If your water tank is metallic, the water level sensor will provide false readings, so a plastic covering for the water level sensor should be added as seen in figure 1.

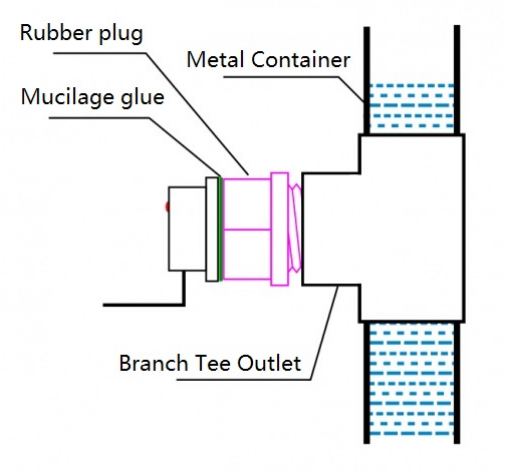

Figure 1: Metal Enclosure Water Level Sensor installation.

4.4 Enclosure Location

The main enclosure needs to be located close to a power-outlet. An extension cord could be used to extend the range of permissible locations. The main enclosure should also be located close to the aquaponic or hydroponic system so that all sensors can adequately reach. The wire length of the sensors can be adjusted for this.

4.5 Wiring

A braided, multiconductor wire is recommended to interface between the sensor break-out boards and the sensors. This wire will be clamped down with cable glands as it passes through holes drilled in the enclosure wall.

The wall-outlet power cord will also pass through the enclosure wall in this manner.

4.5.1 Cable Length

The cable length can selected based on your aquaponic or hydroponic system setup. That is, measure where you will be mounting the main enclosure, and where you want the sensors to be.

Figure 2: Waterproof Nylon Cable Gland example.

4.6 Temperature Sensor

The DS18B20 temperature sensor must be wired up correctly to the raspberry pi. This sensor utilizes the one-wire interface protocol. This is accomplished by connecting the red 5 V wire to pin 4, the black ground wire to Pin 6, and the orange data wire to pin 7. A 4.7 Ω resistor should be included between the data pin and 5V, acting as a pull-up resistor.

The one wire interface protocol should be enabled using the $sudoraspi - config$ menu, under the 3rd heading "Communication Protocols".

The temperature sensor can be examined in the raspberry pi configuration with the command $ls/sys/bus/w1/devices$. There you should see a device listed such as "$28 - 3c01b556d3de$". The output is stored in a file called "$w1\_slave$", and will be accessed automatically by the temperature polling script in the repository.

The temperature sensor connects to the labelled temperature interface on the *Piponic* PCB.

4.7 Leak Sensor

The leak sensors require minimal setup. They get connected to the ADC, 3.3V and GND labelled leak header pins on the PCB.

4.8 Water Level Sensor

The water level sensor has a breakout board with a reset button on it. This button should be set when the sensor is reading the water level as present (reset-high). This breakout board connects to the PCB with Data, 5V and GND through the pre-existing header pins.

4.9 pH Sensor

The pH sensor has a breakout board with a BNC edge-connector for the pH probe. This BNC connector must be passed through the body of the enclosure, so that the pH sensor can connect to the it on the outside of the enclosure. The breakout board needs to be connected to the PCB with female to male wires.

4.10 Chemical solution preparation and placement

The user must prepare a KOH solution. The concentration of the solution must be entered into the app. The input part of the pump must be in the KOH solution. If the setup matches what is shown in the user manual, the user has successfully passed this validation test.

5 Hardware Setup

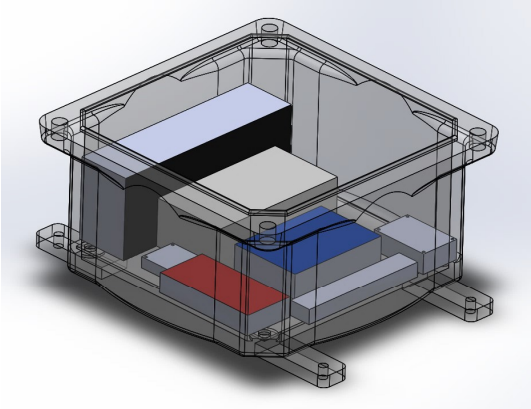

Figure 3: Enclosure elements inside enclosure: Power Supply, Breadboard, Relay Block, Terminal Block, Raspberry Pi, Water-level board, pH sensor board.

The hardware BOM can be seen in the table below.

Designator	Description	Quantity	Link
Enclosure	8x8x4' junction box	1	https://www.homedepot.ca/product/carlon-thermoplastic-junction-box-8x8x4-in/1000403713
Heatshrink	Variety Pack	1	https://leeselectronic.com/en/product/15370-kit-heatshrink-variety-pack-170pcs.html
Cable Gland	7mm	3	https://leeselectronic.com/en/product/61270-fitting-water-proof-pg-7-light-grey-csa-bi html
Cable Gland	9mm	6	https://leeselectronic.com/en/product/6125-fitting-water-proof-pg-9-black.html
Screws/Bolts	4x1/2", 6x1/2"	Box	

Table 5: Hardware BOM required for building project

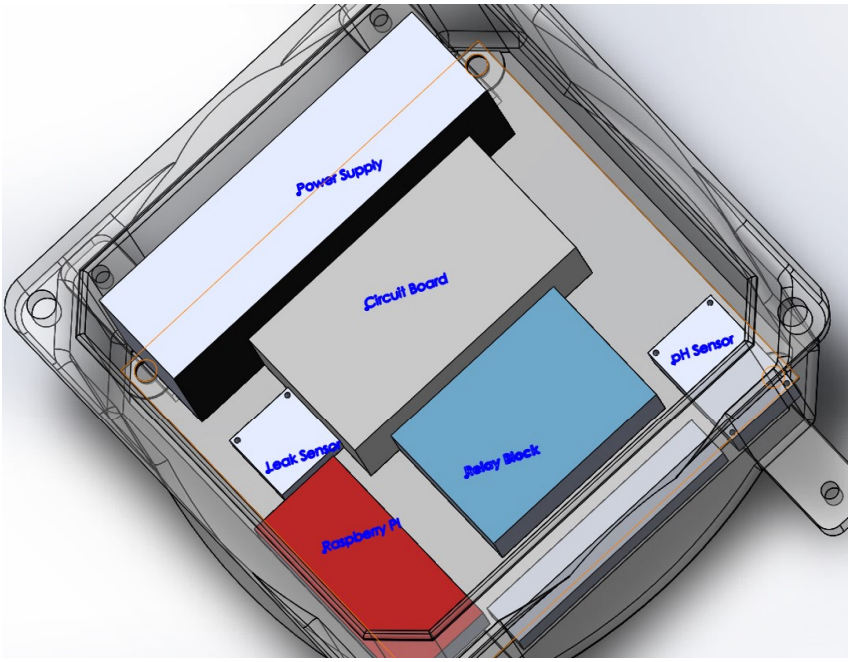

Figure 4: Labelled Enclosure elements: Power Supply, Breadboard, Relay Block, Terminal Block, Raspberry Pi, Water-level board, pH sensor board.

The components within the enclosure must be mounted onto a board that rests within the enclosure. This board can be fastened to the bottom of the enclosure with magnets, velcro, or another temporary adhesive of your choosing.

This board can be made of any non-conductive material, such as plastic or wood.

6 Software Setup

6.1 RaspberryPi setup

The user must be able to properly load the SD card with the RaspberryPi OS using the Raspberry Pi Imager. Download and install Raspberry Pi Imager, select the Raspbian OS and write it into the SD card.This process will take several minutes.

Using an SD card adapter, the user will be able to see the files that were written into the SD card. They must add/edit 4 files. Firstly, the user must add an empty text file named "ssh.txt". Secondly, the user must add a .conf file named "wpa_supplicant.conf". This file contains the following text below with the appropriate changes to ssid and psk:

```
country=CA
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1

network={
scan_ssid=1
ssid="your_wifi_ssid"
psk="your_wifi_password"
}
```

If the user is not located in Canada, they must replace "CA" with their appropriate country code.

Thirdly, the user must edit "config.txt" by adding the line *dtoverlay=dwc2* to the

very bottom of the file. Lastly, the user must edit "cmdline.txt" and insert *modules-load=dwc2,g_ether* right after the word *rootwait*.

After downloading and installing PuTTY and powering up the RaspberryPi, open PuTTY and type "raspberrypi" in the Host Name and click open. A terminal will open asking for the login credentials. If this does not open a terminal, verify that the RaspberryPi is connected to the wifi by checking the router. Under device connected, the user should be able to see the RaspberryPi if the earlier steps were done correctly. If the RaspberryPi is connected to the wifi, but the terminal still does not open, type the IP address of the RaspberryPi in the host name instead. This can be found by checking the router as well. Once the terminal is open, enter the login credential user as "pi" and the password is "raspberry". To verify the connectivity of the RaspberryPi to the internet, type "ping 8.8.8.8" in the terminal and press enter. If a signal is seen, the user has successfully passed this validation test.

6.2 Installing the Project

Before installing the project, the user must create or have a pre-existing Google Cloud Project and enable the Google Cloud IoT Core API using their Google Account. After this is finished, open the PuTTY terminal, login, and install the project by running the following code:

```
sudo ./install.sh <DEVICE-ID> <REGISTRY-ID> <PROJECT-ID>
```

Note the following parameters:

- DEVICE-ID: string name to call the device (the user chooses)
- REGISTRY-ID: string name of the Google IoT Registry ¡can be new or pre-existing)
- PROJECT-ID: string name of the Google Cloud Project

This process will take approximately 20 minutes. The install will prompt the user

to login to their Google Account that was associated with the Google Cloud Project around halfway through the installation process.