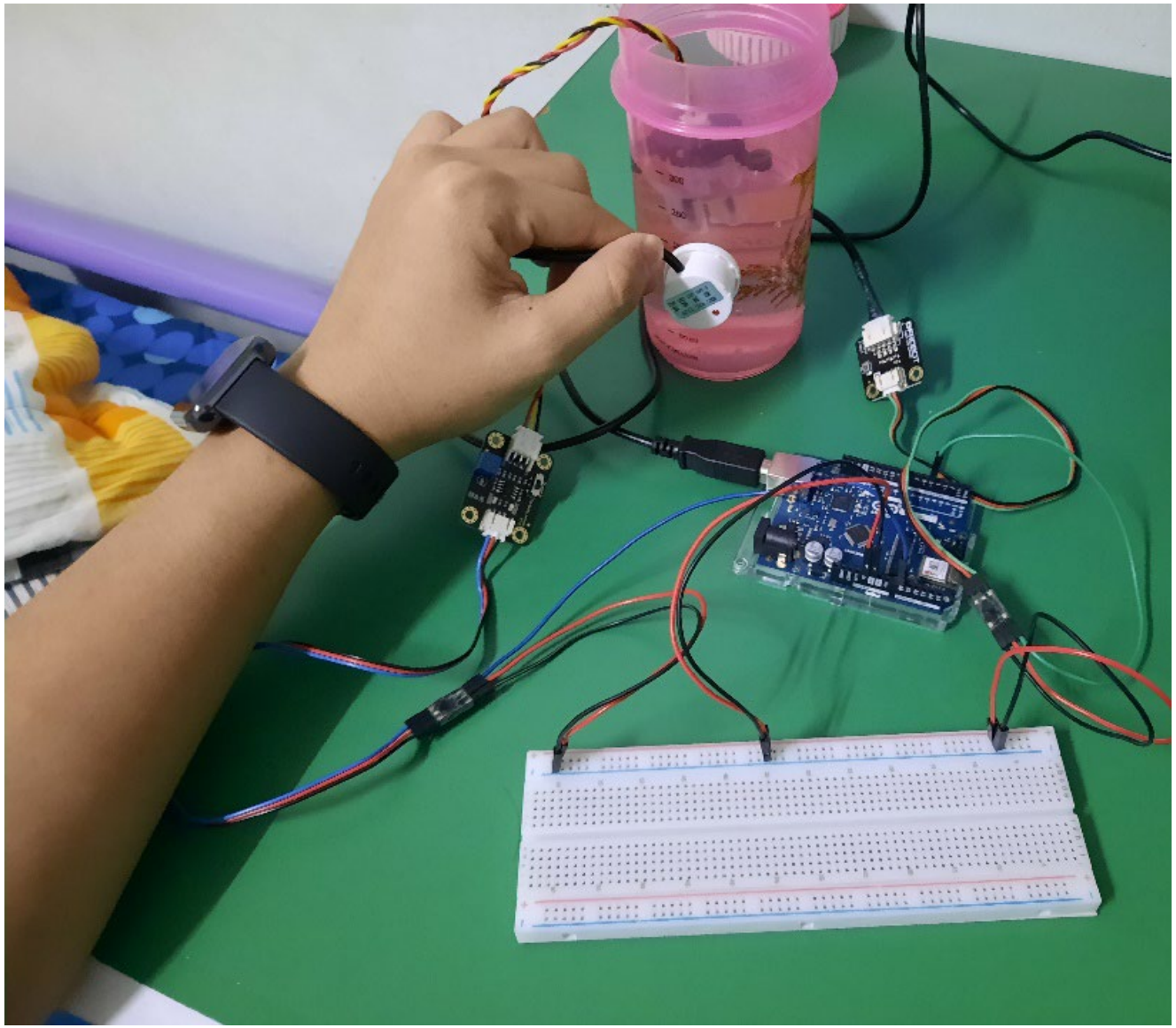
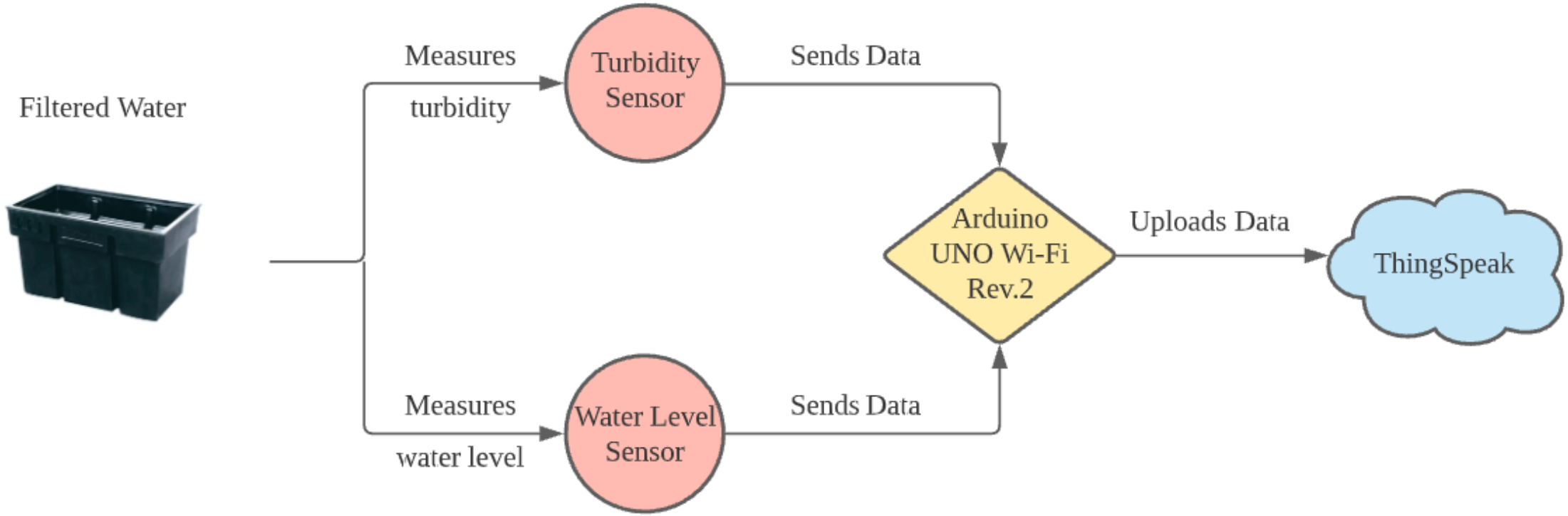
IoT Water Quality Monitoring System

Univerisiti Sains Malaysia

Overview of the IoT Water Quality Monitoring System

- The IoT water quality monitoring system consists of water level sensor and turbidity sensor.
- All these sensors are connected and controlled by the microcontroller which is Arduino UNO Wi-Fi Rev.2 board.





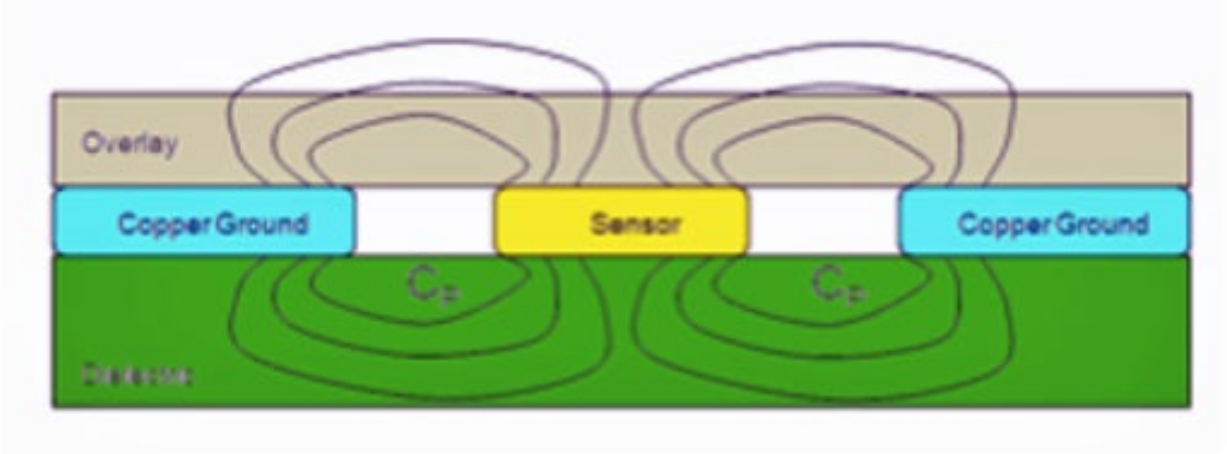
Working Mechanism of the IoT Water Monitoring System

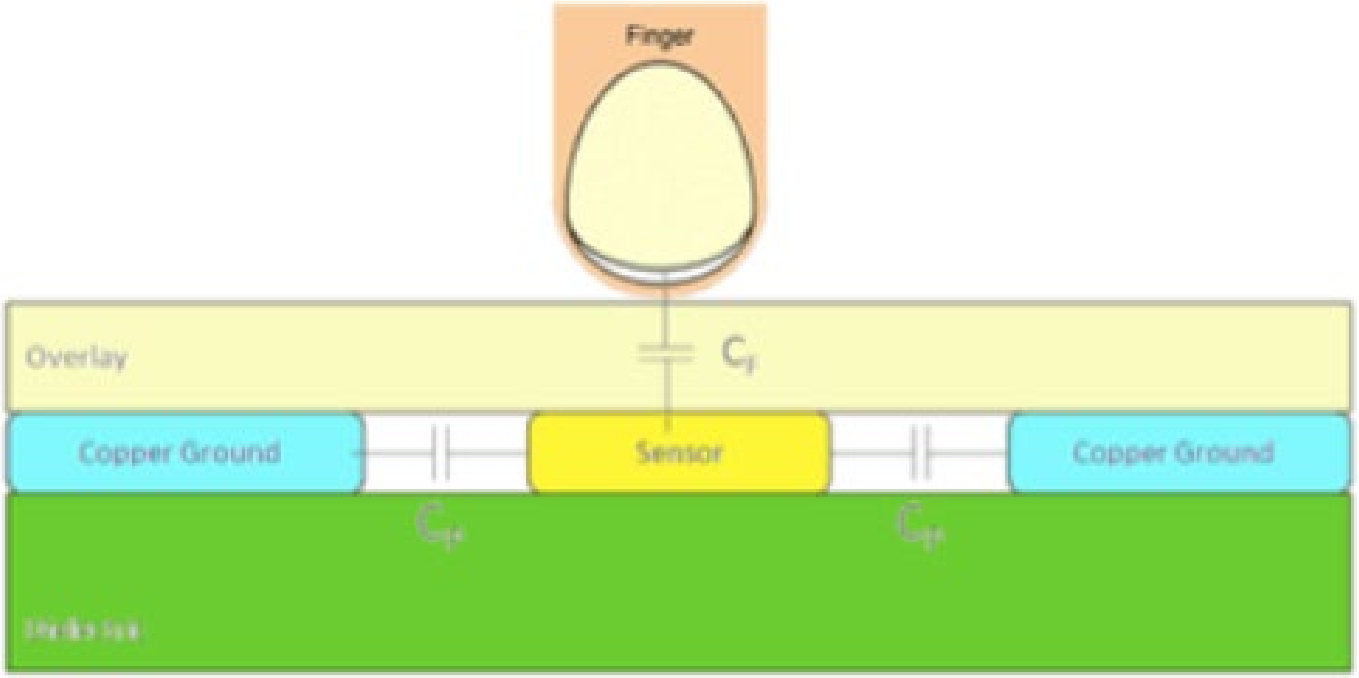
- The sensors will continuously measure the quality of the filtered water (for now, turbidity and water level) and the data will be read and uploaded by Arduino to a cloud server which is ThingSpeak.
- Since it is stored in cloud server, the data can be easily accessed anytime, anywhere.

Type of Sensors Used

1. DFRobot Non-contact Liquid Level Sensor

- Uses water sensing capacitor to detect the liquid level.
- Without water, there will be a presence of distributed capacitance. This results certain amounts of static capacitance to ground on the sensor.
- When there is liquid near the sensor, the parasitic capacitance of the liquid will be coupled to the static capacitance so that the final capacitance value of the sensor becomes larger and the changed capacitance signal is then input to the control IC for electrical signal conversion.

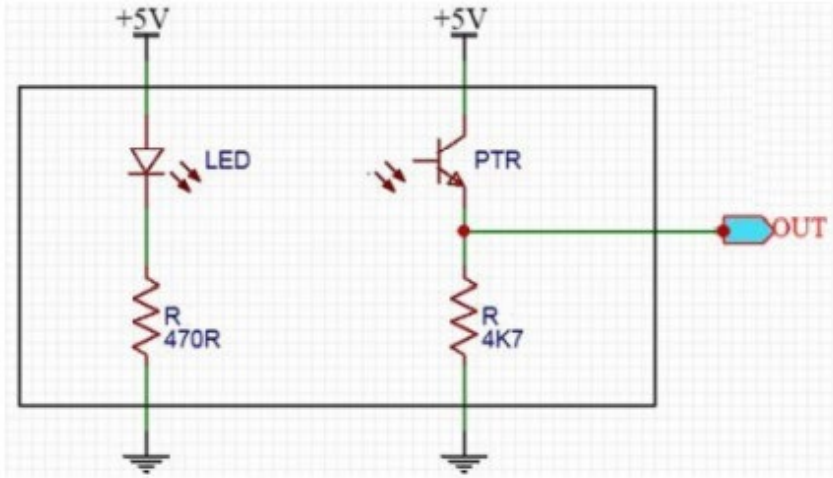

Overlay
Copper Ground
Sensor
Copper Ground
C_p
C_p

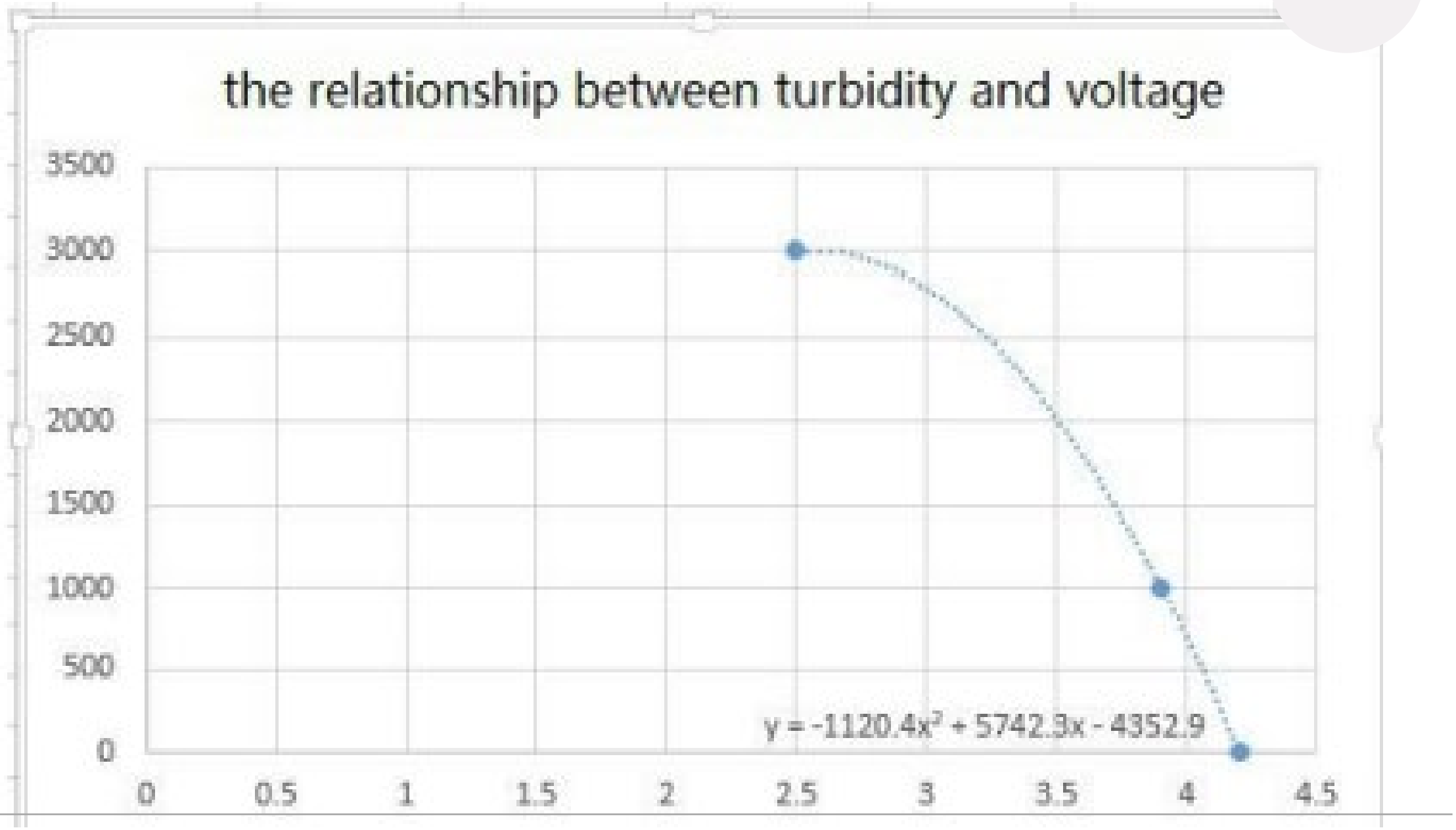

Finger
Overlay
C_f
Copper Ground
Sensor
Copper Ground
C_p
C_p

Type of Sensors Used

2. DFRobot Turbidity Sensor

- Uses light to detect suspended particles in water
- Beams of light will be produced from the photoemitter and it needs to pass through the water before it reaches the phototransistor.
- The cloudiness of the water will affect the amount of light received at the phototransistor. It will then affect the voltage that is allowed to pass through. Voltage value is converted to NTU in the coding.
- The higher the voltage produced, the lower the NTU, the clearer the water.




the relationship between turbidity and voltage
3500
3000
2500
2000
1500
1000
500
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
y = -1120.4x² + 5742.3x - 4352.9

Water Quality Standard in Malaysia

- From the Department of Environment of Malaysia, there are 5 classes for the water quality standard which are Class I, Class IIA/IIB, Class III, Class IV and Class V established. Each class is split based on the tolerance for each of the water parameter. Each class has different standard and usages.

ANNEX

NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA

PARAMETER	UNIT	CLASS				
		I	IIA/IIB	III#	IV	V
Al	mg/l		-	(0.06)	0.5	
As	mg/l		0.05	0.4 (0.05)	0.1	
Ba	mg/l		1	-	-	
Cd	mg/l		0.01	0.01* (0.001)	0.01	
Cr (VI)	mg/l		0.05	1.4 (0.05)	0.1	
Cr (III)	mg/l		-	2.5	-	
Cu	mg/l		0.02	-	0.2	
Hardness	mg/l		250	-	-	
Ca	mg/l		-	-	-	
Mg	mg/l		-	-	-	
Na	mg/l		-	-	3 SAR	
K	mg/l		-	-	-	
Fe	mg/l		1	1	1 (Leaf) 5 (Others)	
Pb	mg/l	NATURAL	0.05	0.02* (0.01)	5	LEVELS
Mn	mg/l		0.1	0.1	0.2	
Hg	mg/l		0.001	0.004 (0.0001)	0.002	
Ni	mg/l		0.05	0.9*	0.2	
Se	mg/l	LEVELS	0.01	0.25 (0.04)	0.02	ABOVE
Ag	mg/l		0.05	0.0002	-	
Sn	mg/l		-	0.004	-	
U	mg/l	OR	-	-	-	
Zn	mg/l		5	0.4*	2	
B	mg/l		1	(3.4)	0.8	
Cl	mg/l	ABSENT	200	-	80	IV
Cl_2	mg/l		-	(0.02)	-	
CN	mg/l		0.02	0.06 (0.02)	-	
F	mg/l		1.5	10	1	
NO_2	mg/l		0.4	0.4 (0.03)	-	
NO_3	mg/l		7	-	5	
P	mg/l		0.2	0.1	-	
Silica	mg/l		50	-	-	
SO_4	mg/l		250	-	-	
S	mg/l		0.05	(0.001)	-	
CO_2	mg/l		-	-	-	
Gross-α	Bq/l		0.1	-	-	
Gross-β	Bq/l		1	-	-	
Ra-226	Bq/l		< 0.1	-	-	
Sr-90	Bq/l		< 1	-	-	
CCE	μg/l		500	-	-	-
MBAS/BAS	μg/l		500	5000 (200)	-	-
O & G (Mineral)	μg/l		40; N	N	-	-
O & G (Emulsified Edible)	μg/l		7000; N	N	-	-
PCB	μg/l		0.1	6 (0.05)	-	-
Phenol	μg/l		10	-	-	-
Aldrin/Dieldrin	μg/l		0.02	0.2 (0.01)	-	-
BHC	μg/l		2	9 (0.1)	-	-
Chlordane	μg/l		0.08	2 (0.02)	-	-
t-DDT	μg/l		0.1	(1)	-	-
Endosulfan	μg/l		10	-	-	-
Heptachlor/Epoxide	μg/l		0.05	0.9 (0.06)	-	-
Lindane	μg/l		2	3 (0.4)	-	-
2,4-D	μg/l		70	450	-	-
2,4,5-T	μg/l		10	160	-	-
2,4,5-TP	μg/l		4	850	-	-
Paraquat	μg/l		10	1800	-	-

Notes :
* = At hardness 50 mg/l $CaCO_3$
# = Maximum (unbracketed) and 24-hour average (bracketed) concentrations
N = Free from visible film sheen, discolouration and deposits

NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA (cont.)

PARAMETER	UNIT	CLASS					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
Biochemical Oxygen Demand	mg/l	1	3	3	6	12	> 12
Chemical Oxygen Demand	mg/l	10	25	25	50	100	> 100
Dissolved Oxygen	mg/l	7	5 - 7	5 - 7	3 - 5	< 3	< 1
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Electrical Conductivity*	μS/cm	1000	1000	-	-	6000	-
Floatables	-	N	N	N	-	-	-
Odour	-	N	N	N	-	-	-
Salinity	ppt	0.5	1	-	-	2	-
Taste	-	N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Turbidity	NTU	5	50	50	-	-	-
Faecal Coliform**	count/100 ml	10	100	400	5000 (20000)[a]	5000 (20000)[a]	-
Total Coliform	count/100 ml	100	5000	5000	50000	50000	> 50000

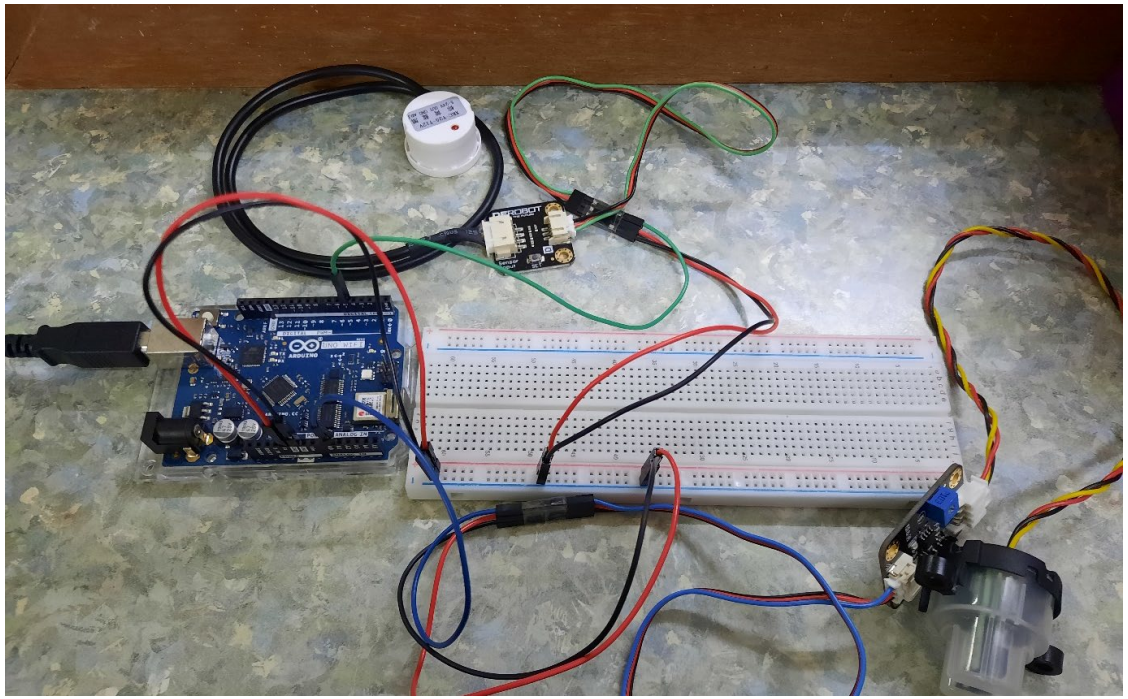
Notes :

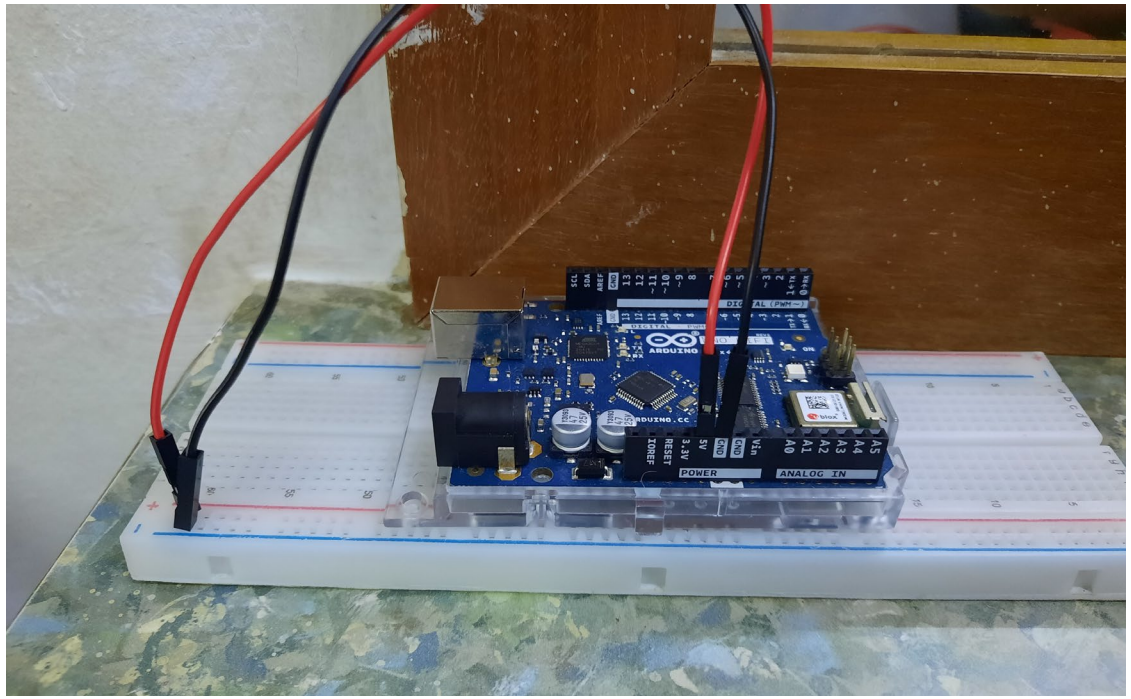
N : No visible floatable materials or debris, no objectional odour or no objectional taste
* : Related parameters, only one recommended for use
** : Geometric mean
a : Maximum not to be exceeded

Demonstration on IoT Water Monitoring System

List of Materials

1. Turbidity sensor – 1
2. Water level sensor – 1
3. Arduino UNO Wi-Fi Rev.2 Board – 1
4. Male to male jumper cable – 6
5. Breadboard – 1
6. Plastic cup with water – 1
7. Cloth – 1

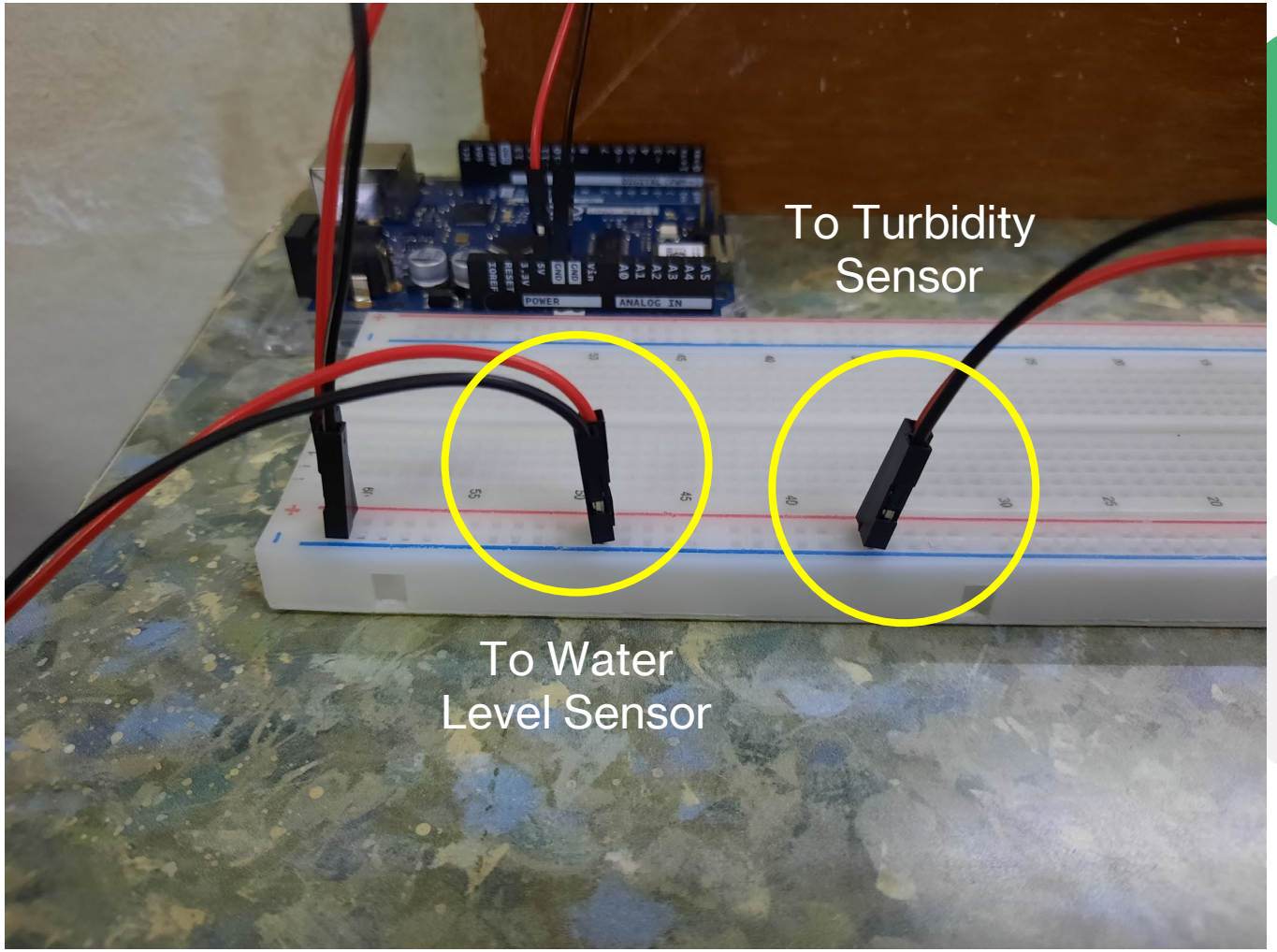




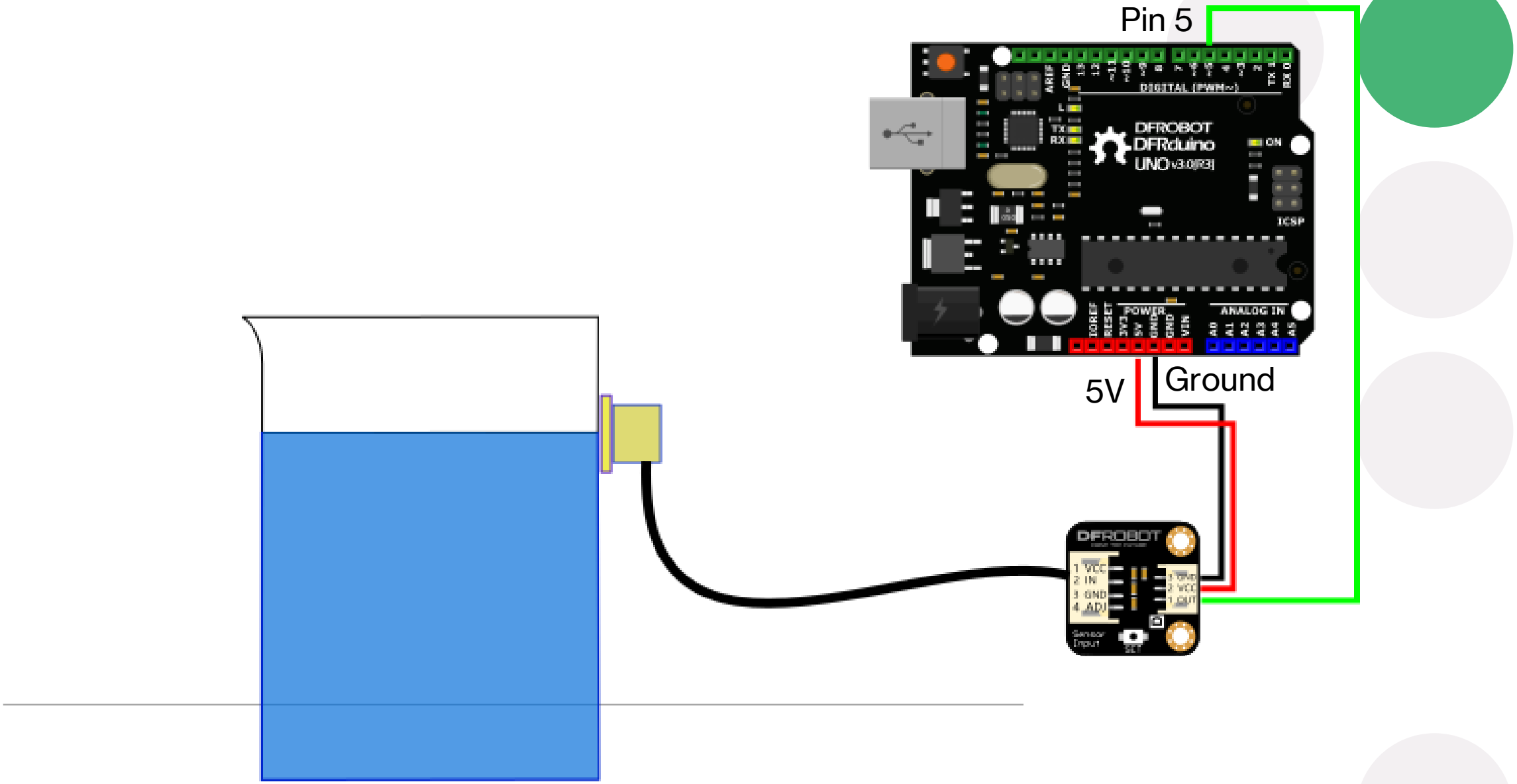
Overall Wiring for the IoT Water Monitoring System

- For water level sensor: Red wire (5V), Black wire (Ground), Green wire (Digital Pin 5)
- For turbidity sensor: Red wire (5V), Black wire (Ground), Blue wire (Analog Pin A0)
- Since there is only one 5V pin on the Arduino board, a bread board is used to extend the connection for the 5V and ground as shown in the diagram on the right.

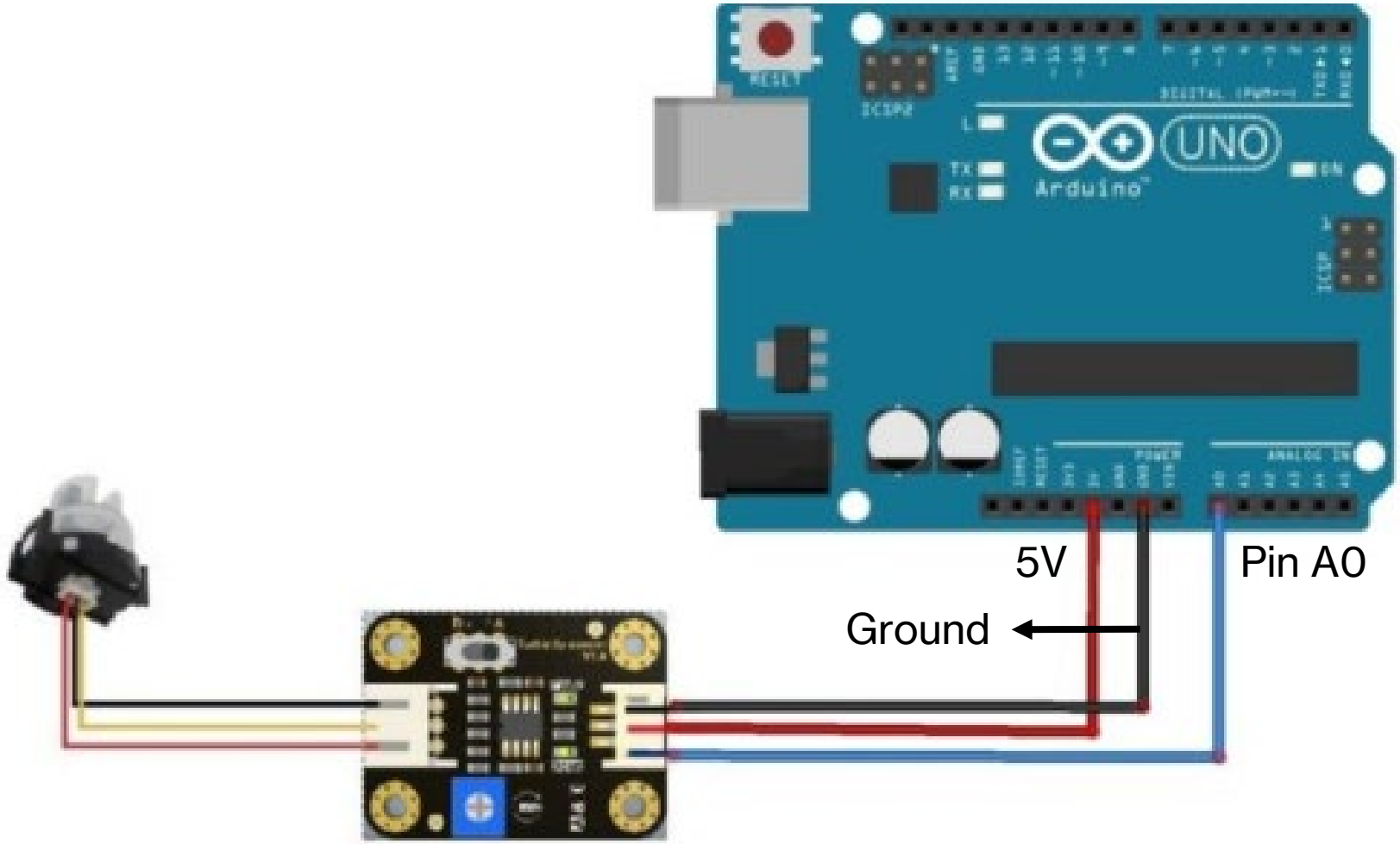
- Then the power cable for the sensors are connected as shown in the diagram.



Connecting the Water Level Sensor to Arduino Board



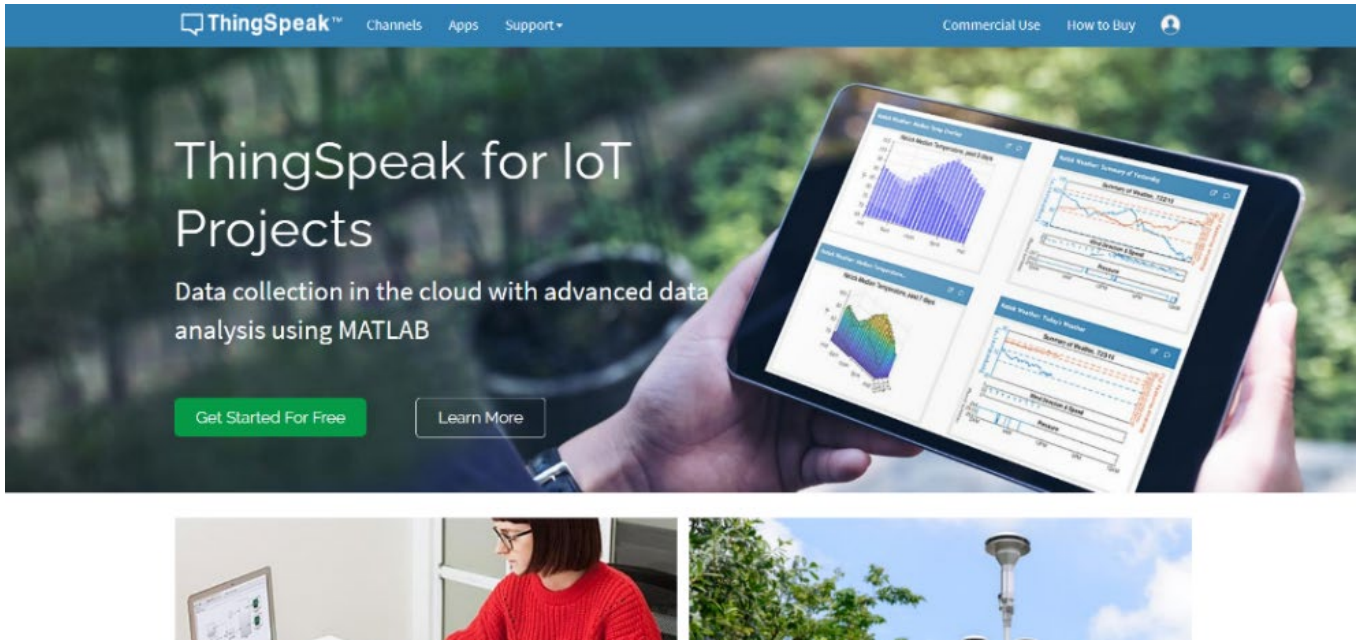
Connecting the Turbidity Sensor to Arduino Board

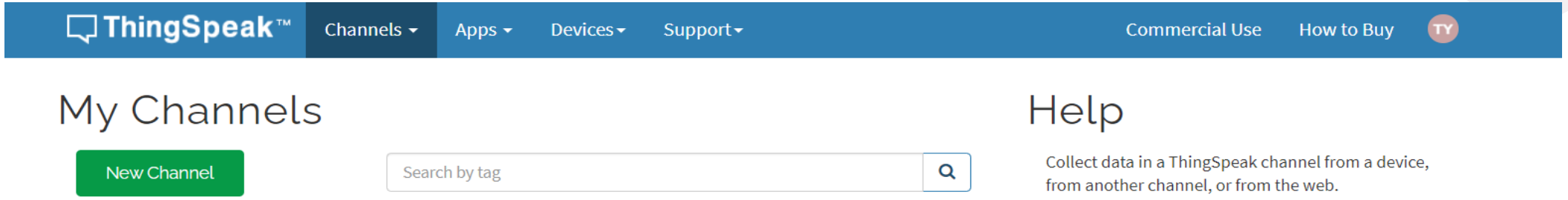


Setup for ThingSpeak Channel

1. Signup for ThingSpeak

- Before creating a channel on ThingSpeak, the user must sign up an account on ThingSpeak or sign in using MATLAB account or existing account.



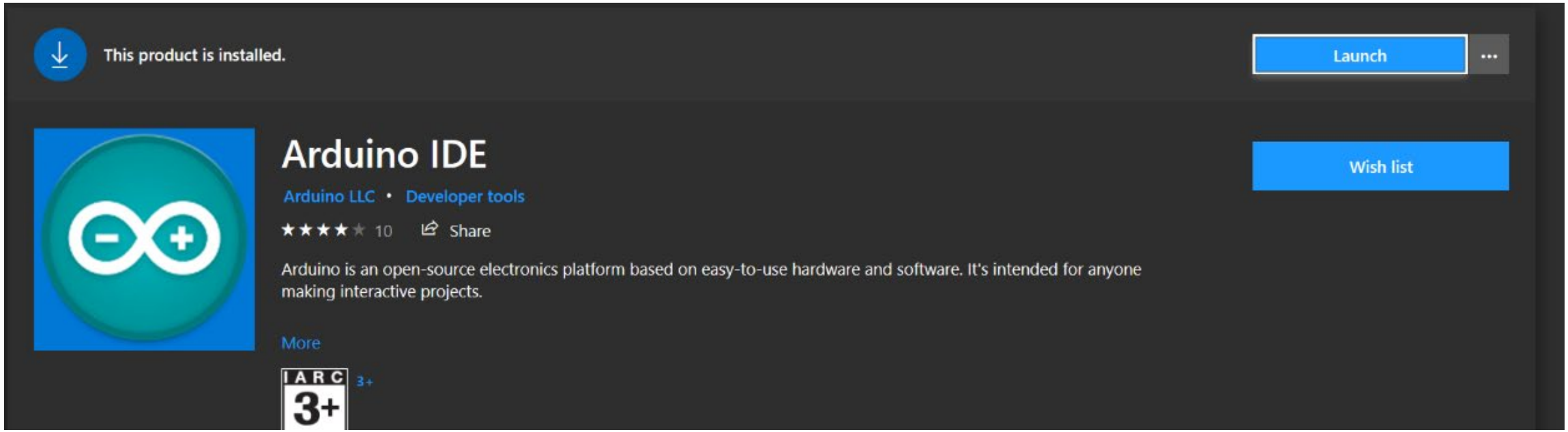


2. Create a Channel for the data

- Once signed in, the user can create a new channel by clicking on “New Channel” button.
- After clicking on “New Channel”, the name and description of the data that they want to upload on this channel can be entered.
- Then, “save channel” button is clicked to save the details.

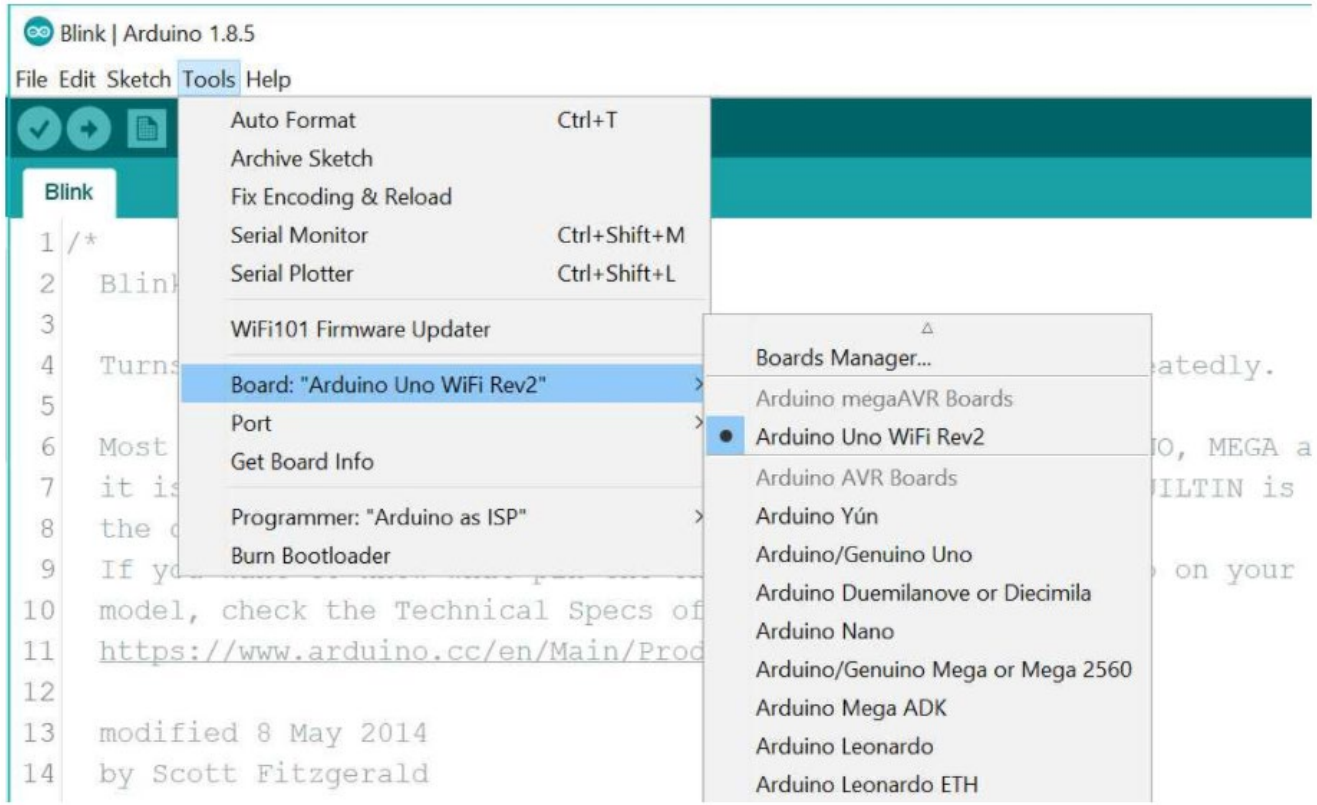
Setup for Arduino UNO Wi-Fi Rev.2 board

1. Plug in the Arduino Board to the Pc and install the Arduino IDE from Windows Store

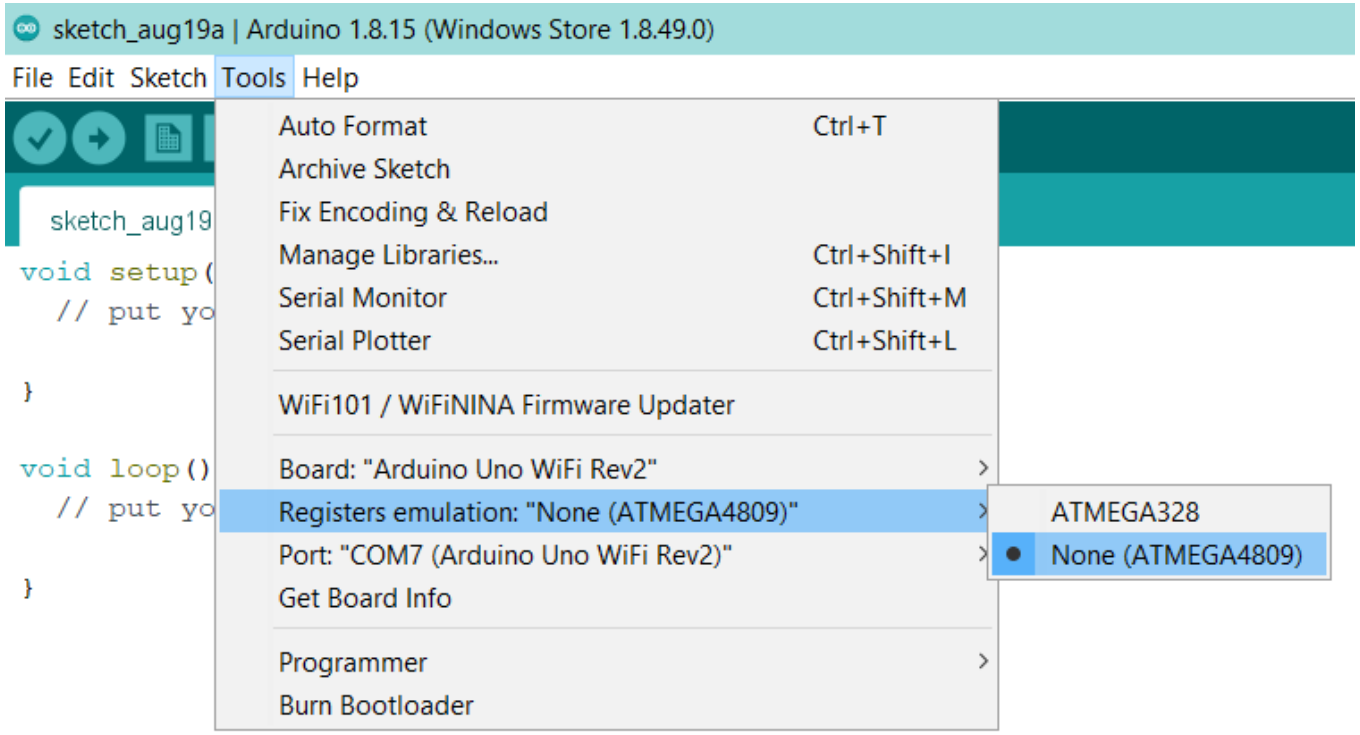


2. Install Arduino megaAVR Boards to Arduino IDE in Board Manager. The board manager can be found in Tools > Boards.

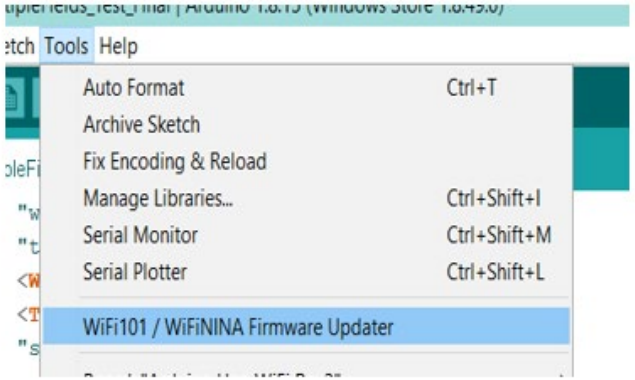
3. The Arduino board should be recognized by the IDE now. If not, select the entry in the Tools > Board menu that corresponds to the Arduino UNO Wi-Fi Rev.2 board.

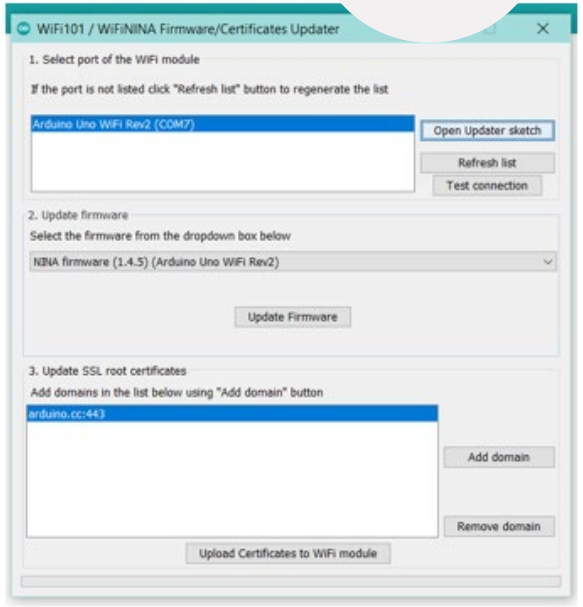


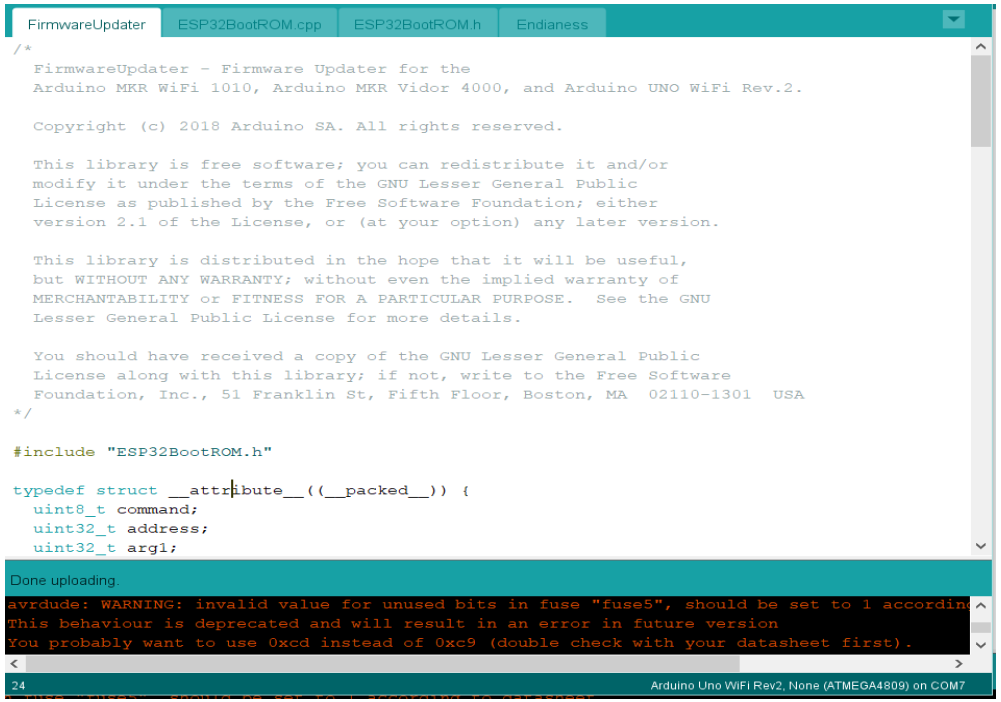
4. Select None (ATMEGA 4809) for the Registers Emulation



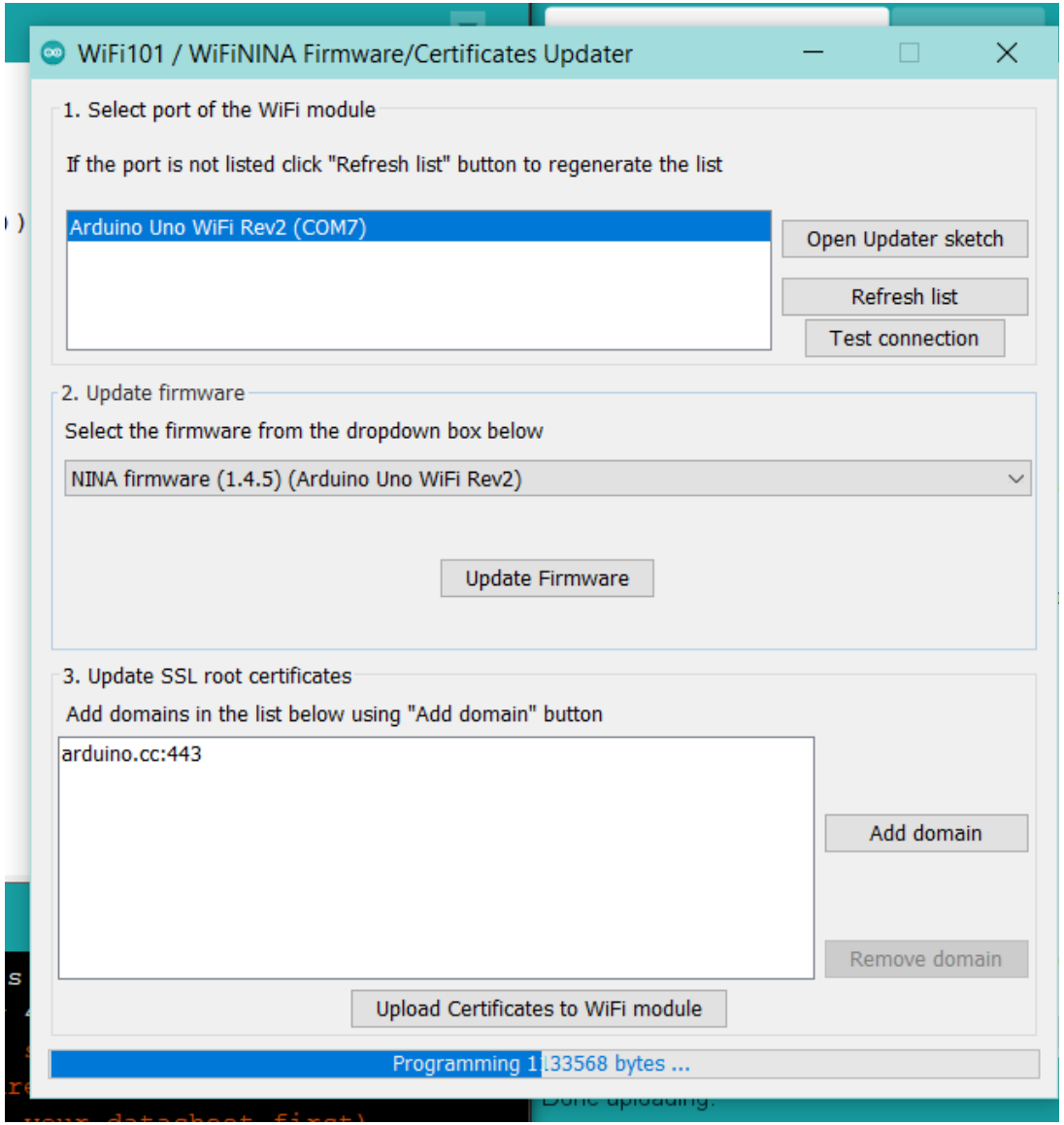
5. Open the WiFiNINA updater which can be found in Tools.
6. By selecting the Arduino UNO Wi-Fi Rev.2, open and upload the updater sketch.



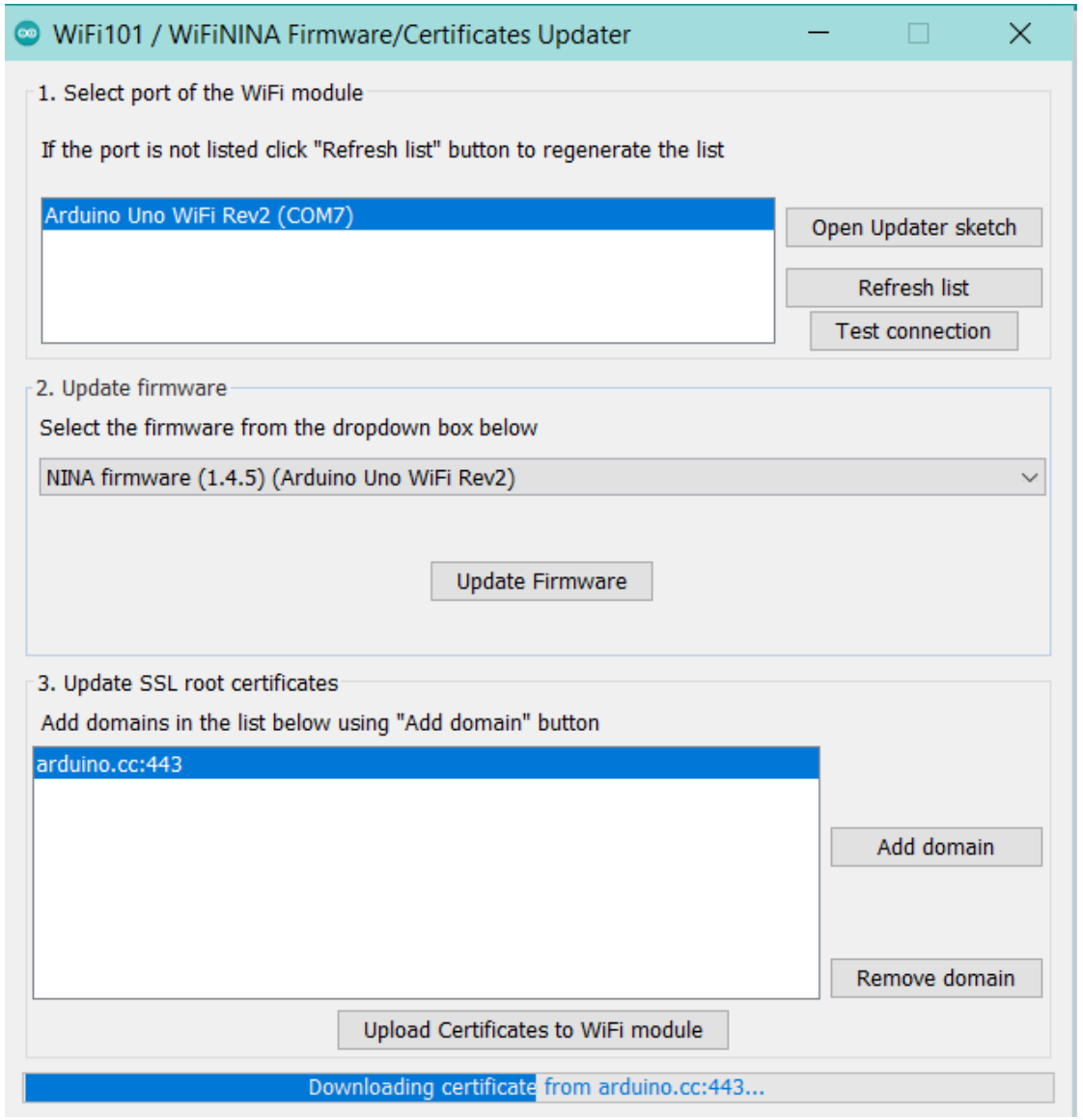




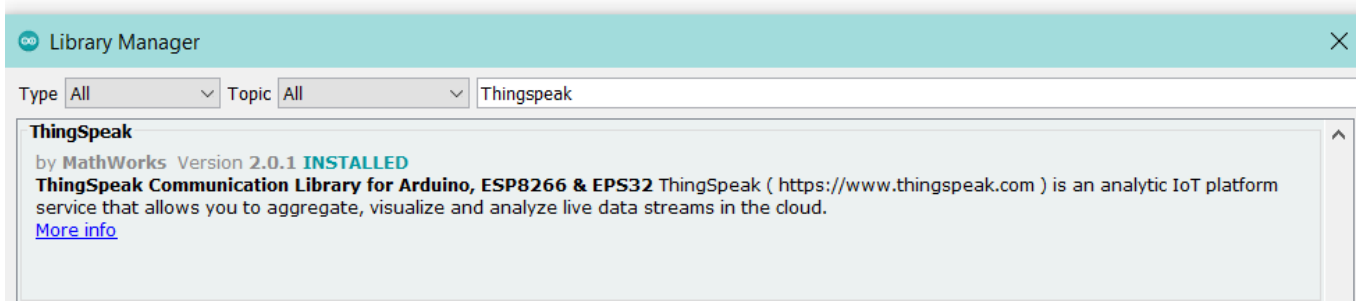
7. After the updater sketch is uploaded, the firmware is updated by clicking “Update Firmware”.



8. Then, upload the certificates to the Wi-Fi module on the Arduino board.

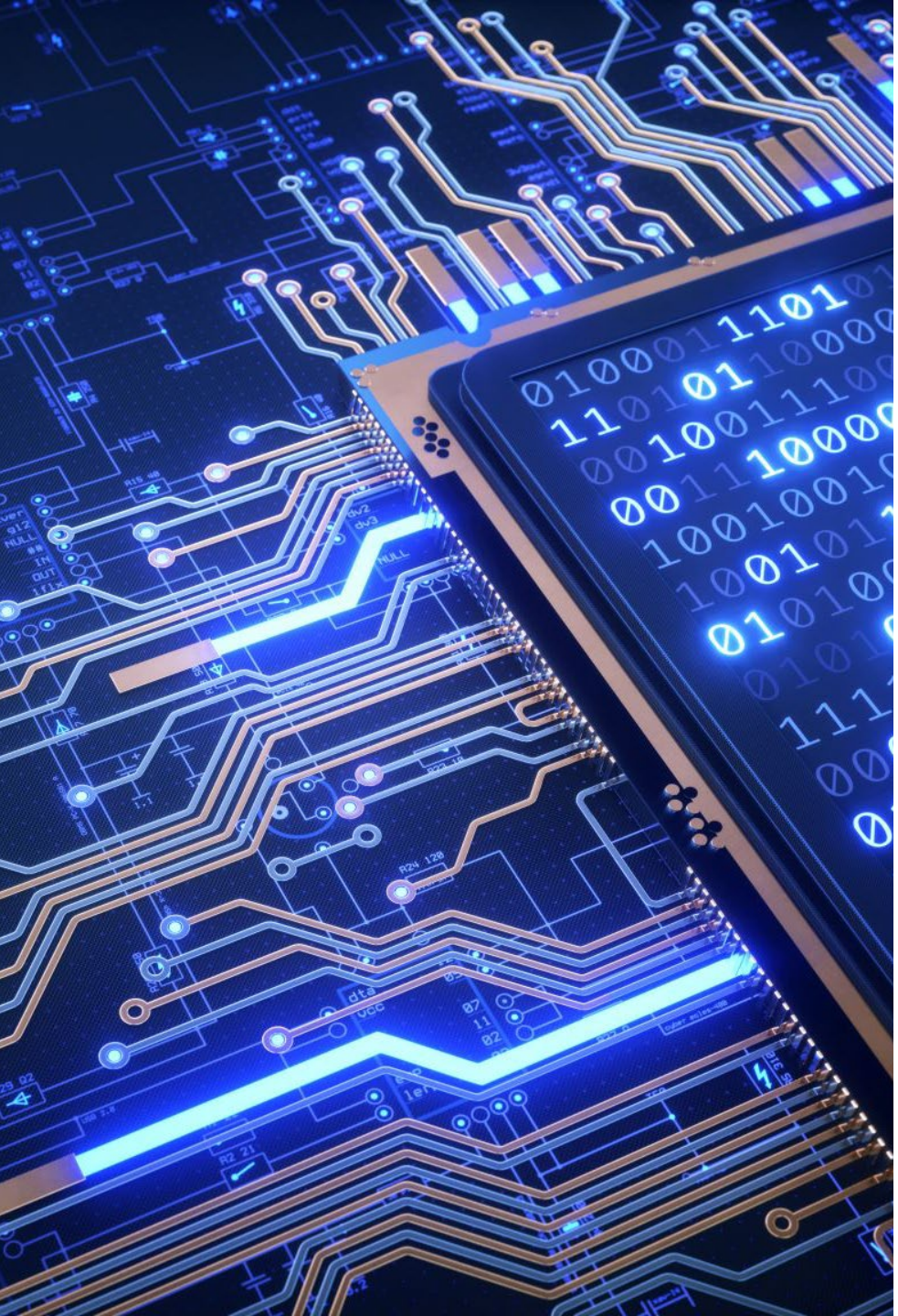


9. Install the ThingSpeak library in the Arduino IDE from the library manager in “Sketch” tab.



Setup for the codes

- Coding for the IoT system: https://studentusm-my.sharepoint.com/:f:/g/personal/tayyingkeat_student_usm_my/En2R2o5u6bJCms2wRYPQeYUB-kDA3mVurHh9ae47SAeKlg?e=vo6KRm

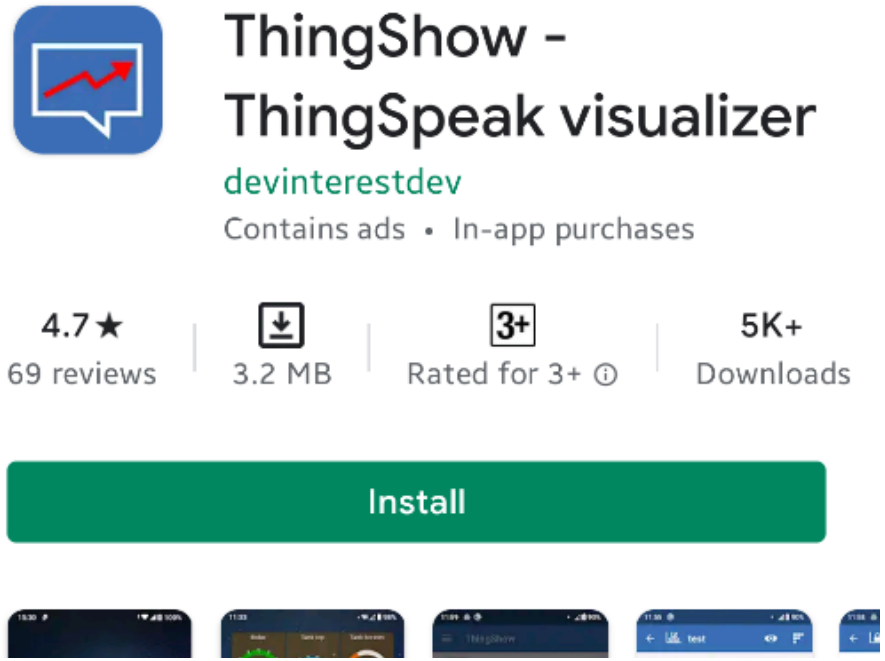


How to run the IoT Water Quality Monitoring System?

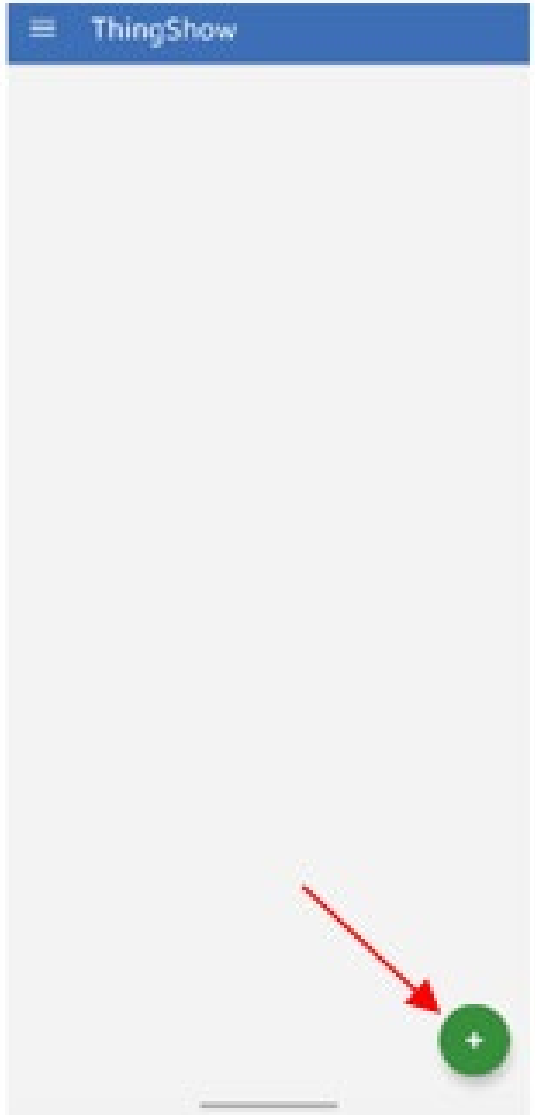
1. Setup the Wi-Fi that Arduino is connecting to and make sure it is in 2.4GHz.
2. Define the SSID, password of the Wi-Fi and write API key for the ThingSpeak channel in secret.h tab of the “WriteMultipleFields_Test_Final” sketch ino file.
3. Upload the “WriteMultipleFields_Test_Final” sketch ino file to the board.
4. Open serial monitor to see the program logs.
5. Open ThingSpeak channel to see the data uploaded.

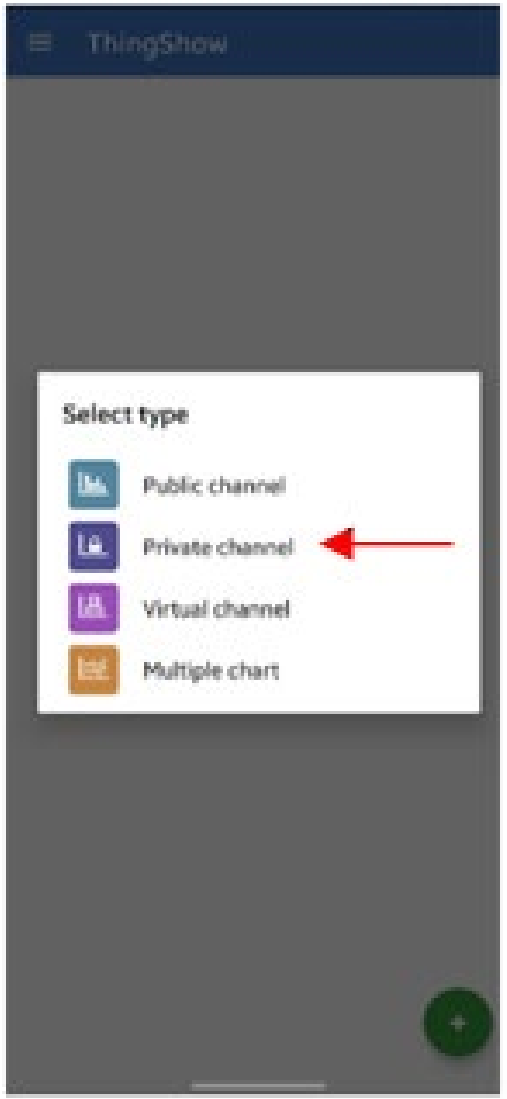
Setup for Visualizing ThingSpeak in Mobile Phone

1. Install ThingShow on mobile phone

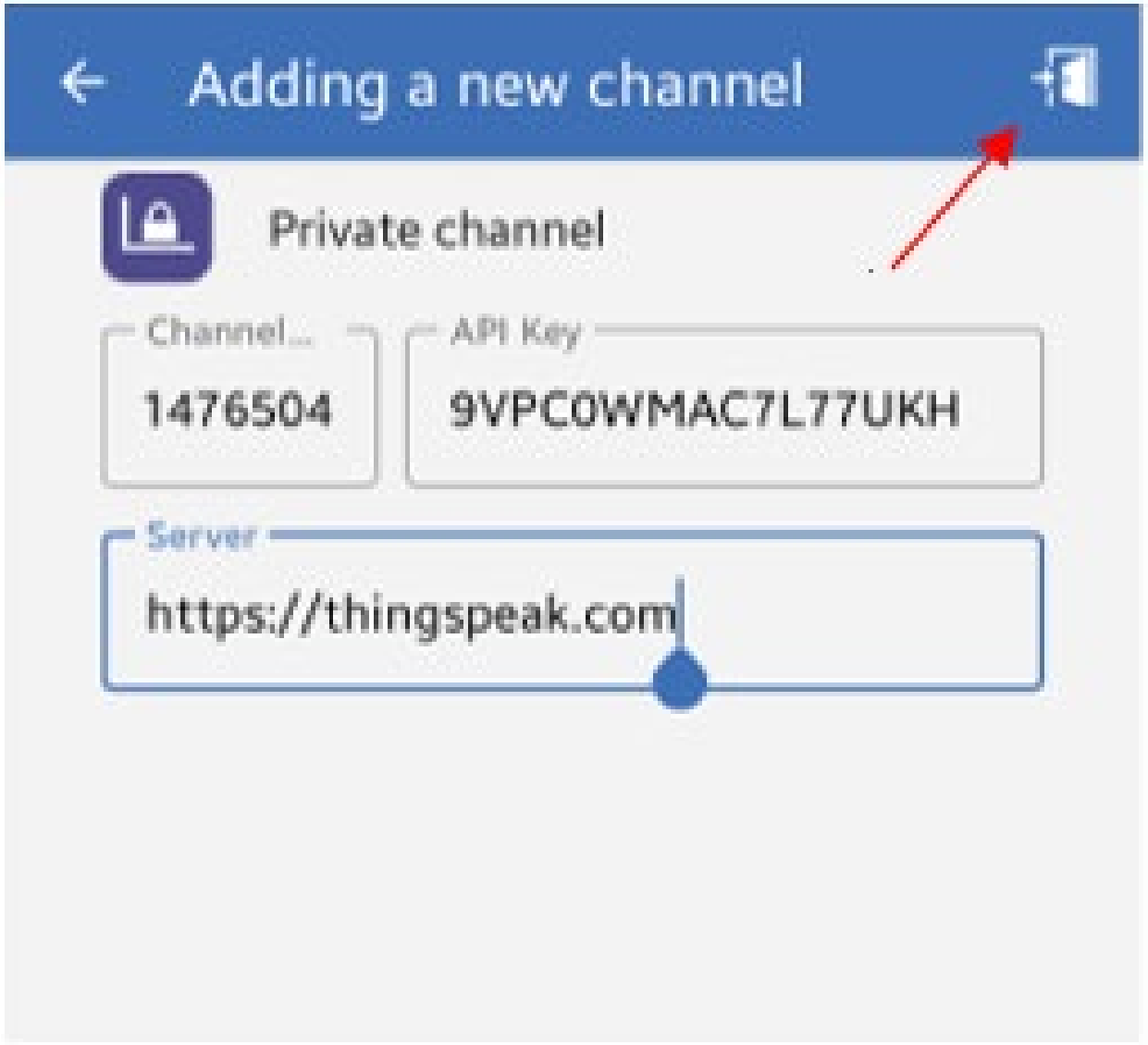


2. Open ThingShow and add a channel. Since the channel used currently is private channel, thus private channel is selected.

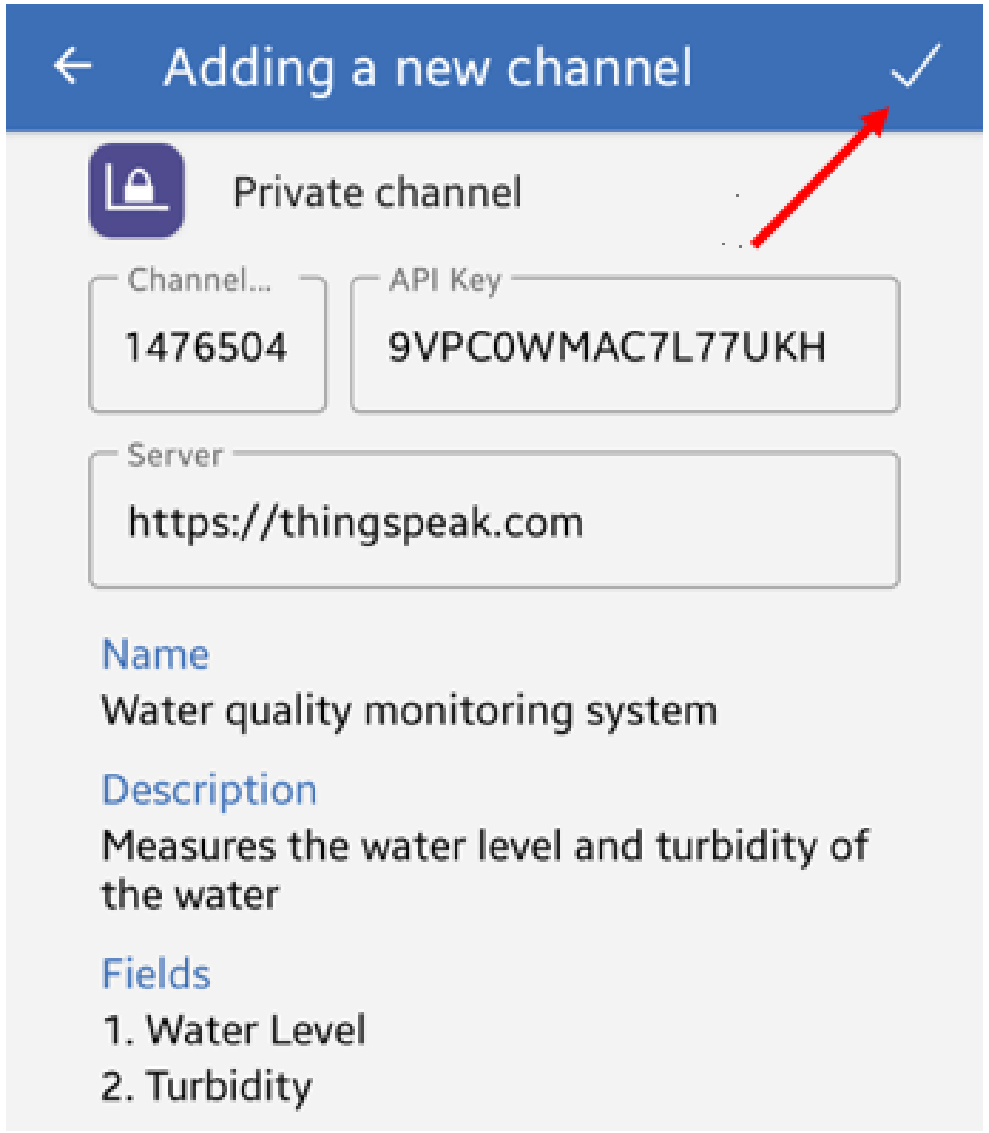




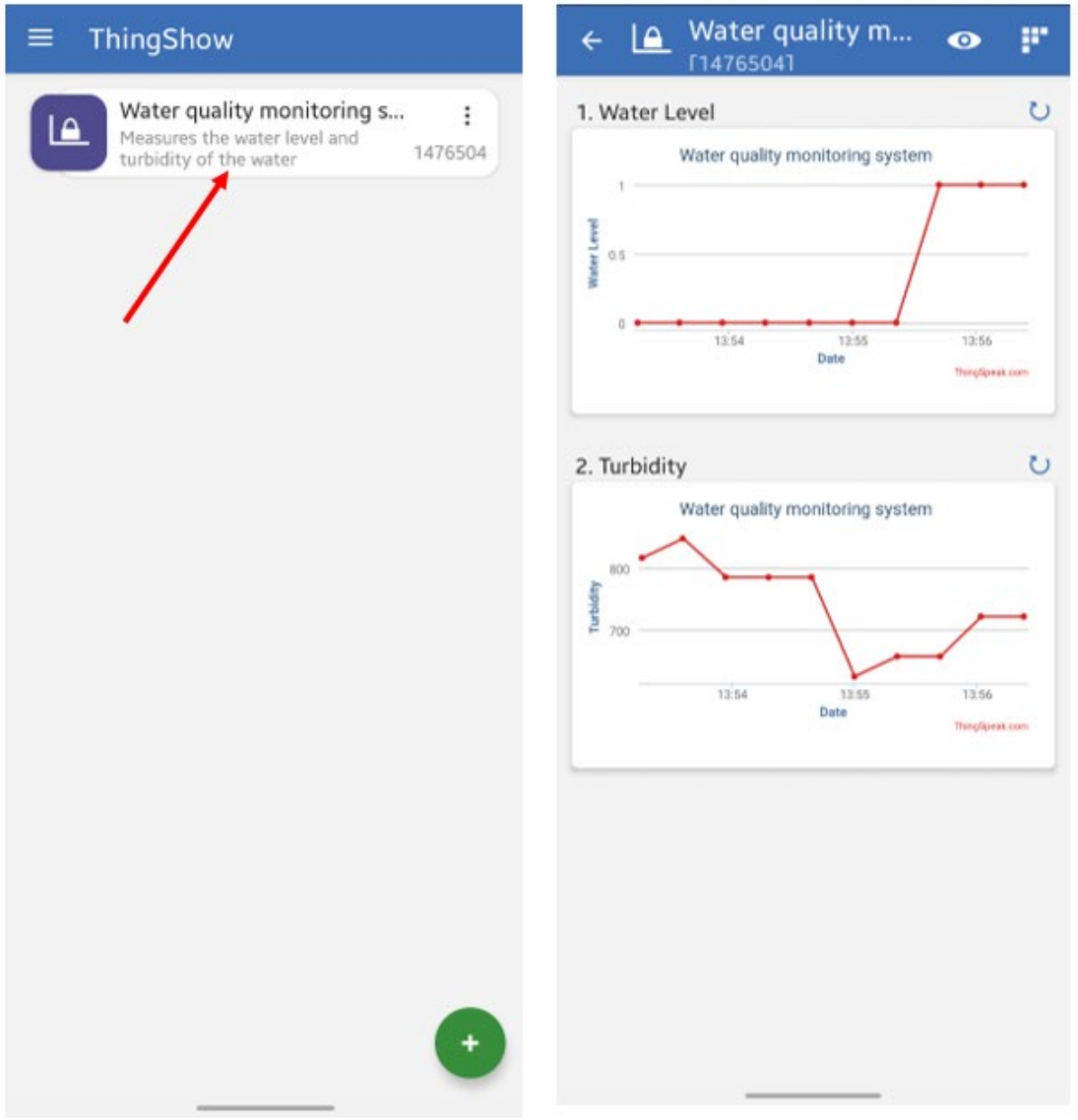
3. Key in the channel ID and read API key. The read API key can be obtained from ThingSpeak. The server is prefilled by default thus no change needs to be made. After that, click the enter button on the top right of the screen.



4. Double check the channel name, description and the fields. If there is no problem, click the tick button on the top right of the screen.



5. Once the channel is successfully created, it will show up in the front page of the app. By clicking the channel created, the users can now view their channel from ThingShow.



Thank you