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 Copper Ground Copper Ground Copper Ground



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.







ANNEX

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.

PARAMETER	UNIT			CLASS		
		-	IIA/IIB	111*	IV	V
Al	mg/l			(0.06)	0.5	
As	mg/l	I T	0.05	0.4 (0.05)	0.1	I T
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	1 1	0.02		0.2	
Hardness	mg/l		250			
Ca	mg/l	1 1	-			
Mg	mg/l					
Na	mg/l				3 SAR	· ·
K		· ·			3 SAR	
	mg/l	1				L
Fe Pb	mg/l	N	1	1	1 (Leaf) 5 (Others) 5	Ē
	mg/l	Ä	0.05	0.02* (0.01)	-	V
Mn	mg/l	Ť	0.1	0.1	0.2	E
Hg	mg/l	u	0.001	0.004 (0.0001)	0.002	L
		R				s
Ni	mg/l	A	0.05	0.9*	0.2	
Se	mg/l	L	0.01	0.25 (0.04)	0.02	A
Ag	mg/l	1	0.05	0.0002	-	в
Sn	mg/l	L		0.004	-	ō
U	mg/l	Ē			-	V
Zn	mg/l	EV	5	0.4*	2	E
В	mg/l	E	1	(3.4)	0.8	
a	mg/l	Ē	200	(0)	80	N
G ₂	mg/l	s	-	(0.02)	-	IV
CN	mg/l		0.02	0.06 (0.02)		
F	mg/l	R	1.5	10	1	
NO ₂		R	0.4	0.4 (0.03)		
	mg/l	A		0.4 (0.03)		
NO ₃	mg/l	B	7		5	1
P	mg/l	s	0.2	0.1	-	
Silica	mg/l	E	50		-	
SO4	mg/l	N	250		-	
S	mg/l	т	0.05	(0.001)	-	
CO ₂	mg/l	1			-	
Gross-a	Bq/I	1	0.1		-	
Gross-ß	Bq/I	1	1		-	+
Ra-226	Bq/I	1	< 0.1			
Sr-90	Bq/I	1	< 1			
CCE	µg/1	1	500			
MBAS/BAS	µg/1		500	5000 (200)		-
O & G (Mineral)	/10/1	1 1	40; N	N		
O & G (Emulsified Edible)			7000; N	Ň	-	
PCB	µ9/1		0.1		-	
	µ9/1			6 (0.05)		-
Phenol	µ9/1	1 1	10			-
Aldrin/Dieldrin	<i>µ</i> 91		0.02	0.2 (0.01)		-
BHC	µ9/1		2	9 (0.1)		-
Chlordane	/g/l	1 1	0.08	2 (0.02)		
t-DDT	/g/l		0.1	(1)		-
Endosulfan	/g/l		10			
Heptachlor/Epoxide			0.05	0.9 (0.06)	-	
	µ91					
Lindane	µ9/1		2	3 (0.4)		-
2,4-D	<i>µ</i> 91	•	70	450		-
2,4,5-T	/ _{P01}	1	10	160		-
2,4,5-TP	/g/l	1	4	850		
Paraguat	//9/1	1	10	1800		

Notes :

* = At hardness 50 mg/l CaCO₃

= 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							
			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	۰Č	-	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 AO)

• 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.



□ ThingSpeak ™	Channels -	Apps 🗸	Devices -	Support -	Commercial Use How to Buy 🚾
My Channel	S				Help
New Channel	Sear	ch by tag			QCollect data in a ThingSpeak channel from a device, from another channel, or from the web.

- 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 megaAVRBoards to Arduino IDE inBoard Manager. The boardmanager can be found in Tools> Boards.

🚥 Boards Mai	nager		×
Type All	~	negaAVR	
Arduino mega Boards include Arduino Uno W <u>Online help</u> <u>More info</u>	ed in this pa		1.8.1 V Install

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.

Blink		Auto Format Archive Sketch Fix Encoding & Reload	Ctrl+T		
1 /* 2	Blin}	Serial Monitor Serial Plotter	Ctrl+Shift+M Ctrl+Shift+L		
3 4	Turns	WiFi101 Firmware Updater Board: "Arduino Uno WiFi F)	Boards Manager	atedly.
5	Most	Port Get Board Info	>	Arduino megaAVR Boards Arduino Uno WiFi Rev2	IO, MEGA a
	it is the c If ya-	Programmer: "Arduino as I: Burn Bootloader	SP" >	Arduino AVR Boards Arduino Yún Arduino/Genuino Uno	VILTIN is
	model,	check the Techni //www.arduino.cc/	- 10- 10 - 10 - 10 - 10 - 10 - 10 - 10	Arduino Duemilanove or Diecimila Arduino Nano Arduino/Genuino Mega or Mega 2560) on your
		ed 8 May 2014 tt Fitzgerald		Arduino Mega ADK Arduino Leonardo Arduino Leonardo ETH	

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

sketch_aug19a | Arduino 1.8.15 (Windows Store 1.8.49.0)

File Edit Sketch Tools Help

sketch_aug19	Auto Format Archive Sketch Fix Encoding & Reload	Ctrl+T		
void setup(Manage Libraries	Ctrl+Shift+I		
// put yo	Serial Monitor	Ctrl+Shift+M		
	Serial Plotter	Ctrl+Shift+L		
}	WiFi101 / WiFiNINA Firmware Updater			
<pre>void loop()</pre>	Board: "Arduino Uno WiFi Rev2"	;		
// put yo	Registers emulation: "None (ATMEGA4809)"	>		ATMEGA328
	Port: "COM7 (Arduino Uno WiFi Rev2)"	>	•	None (ATMEGA4809)
}	Get Board Info			
	Programmer	;	>	
	Burn Bootloader			

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

		C WiFi101 / WiFiNINA Firmware/Certificates Updater	
		1. Select port of the WIFI module	
		If the port is not listed click "Refresh list" button to regenerat	te the list
eius_rest_rinai Aruunio 1.0.15 (win	UUWS SILIE 1.0.45.0)	Arduino Uno WIFI Rev2 (COM7)	Open Updater ske
ools Help			Refresh list
Auto Format	Ctrl+T	2. Update firmware	Test connection
Archive Sketch		Select the firmware from the dropdown box below	
Fix Encoding & Reload		NBNA firmware (1.4.5) (Arduino Uno WIFi Rev2)	
Manage Libraries	Ctrl+Shift+I	Update Firmware	
Serial Monitor	Ctrl+Shift+M		
		3. Update SSL root certificates	
Serial Plotter	Ctrl+Shift+L	Add domains in the list below using "Add domain" button arduino.cc:443	
WiFi101 / WiFiNINA Firmware U	odater	and the second	Add domain
WiFi101 / WiFiNINA Firmware Up	odater		Add domain
	odater		
	odater .	Upload Certificates to WiFi n	Remove dom
	odater	Upload Certificates to WiFi n	Remove doma
			Remove dom
	ESP32BootROM.cpp ESP32BootROM		Add domain Remove doma
FirmwareUpdater /* FirmwareUpdate	ESP32BootROM.cpp ESP32BootROM r - Firmware Updater for the	.h Endianess	Remove dom
FirmwareUpdater /* FirmwareUpdate	ESP32BootROM.cpp ESP32BootROM r - Firmware Updater for the	.h Endianess	Remove doma
FirmwareUpdater /* FirmwareUpdate Arduino MKR Wi	ESP32BootROM.cpp ESP32BootROM r - Firmware Updater for the	h Endianess	Remove doma
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FirmwareUpdater /* FirmwareUpdate Arduino MKR Wi Copyright (c) This library i modify it unde License as pub version 2.1 of	ESP32BootROM.cpp ESP32BootROM r - Firmware Updater for the Fi 1010, Arduino MKR Vidor 4 2018 Arduino SA. All rights s free software; you can red r the terms of the GNU Lesse lished by the Free Software	h Endianess 0000, and Arduino UNO WiFi Rev.2. reserved. Mistribute it and/or rr General Public Foundation; either tion) any later version.	Remove doma
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```
typedef struct __attribute__((__packed__)) {
  uint8_t command;
  uint32_t address;
  uint32_t arg1;
```

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

WiFi101 / WiFiNINA Firmware/Certificates Updater		_	-		×
1. Select port of the WiFi module					
If the port is not listed click "Refresh list" button to regenerate the list	st				
Arduino Uno WiFi Rev2 (COM7)		0	pen U	pdater sk	(etch
				fresh list connectio	
2. Update firmware Select the firmware from the dropdown box below					
NINA firmware (1.4.5) (Arduino Uno WiFi Rev2)					\sim
Update Firmware					
3. Update SSL root certificates Add domains in the list below using "Add domain" button					
arduino.cc:443					
			A	Add doma	ain
			Rei	move dor	main
Upload Certificates to WiFi module					
Programming 1133568 bytes					
Done uploading		_	_	_	_

1)

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

WiFi101 / WiFiNINA Firmware/Certificates Updater	—		×
1. Select port of the WiFi module			
If the port is not listed click "Refresh list" button to regenerate the list			
Arduino Uno WiFi Rev2 (COM7)		n Updater sk	etch
		Refresh list	
	Te	est connectio	n
2. Update firmware			
Select the firmware from the dropdown box below			
NINA firmware (1.4.5) (Arduino Uno WiFi Rev2)			\sim
Update Firmware			
3. Update SSL root certificates			
Add domains in the list below using "Add domain" button			
arduino.cc:443			
		Add doma	in
		Remove don	nain
Upload Certificates to WiFi module			
Downloading certificate from arduino.cc:443			

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

Library Manager

Type All V Topic All V Thingspeak

ThingSpeak

by MathWorks Version 2.0.1 INSTALLED

ThingSpeak Communication Library for Arduino, ESP8266 & EPS32 ThingSpeak (https://www.thingspeak.com) is an analytic IoT platform service that allows you to aggregate, visualize and analyze live data streams in the cloud. <u>More info</u>

Setup for the codes

 Coding for the IoT system: <u>https://studentusm-</u> my.sharepoint.com/:f:/g/personal/tayyingkeat_student_usm_my/En2R2o5u 6bJCms2wRYPQeYUB-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



ThingShow -ThingSpeak visualizer

devinterestdev

Contains ads • In-app purchases



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

ThingShow



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.

Adding a new channel Private channel Channel... API Key 1476504 PVPCOWMAC7L77UKH Server https://thingspeak.com

Name

Water quality monitoring system

Description

Measures the water level and turbidity of the water

Fields

Water Level

2. Turbidity

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



