## 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				
		1	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		0.02		0.2	
Hardness	mg/l		250		-	
Ca	mg/l				-	
Mg	mg/l				-	
Na	mo/l				3 SAR	· ·
ĸ	mol					
Ee	mail		1		1 /Leaf) 5 (Others)	L
Pb	mg/l	N	0.05	0.02* (0.01)	(Lear) 5 (Others)	E
PD No.	mgn	Ä	0.00	0.02 (0.01)		v
Mn	mg/l	т	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			0.004	-	0
U	mg/l	Ē			-	v
Zn	mg/l	v	5	0.4*	2	E
B	mo/l	E	1	(3.4)	0.8	
a	mol	L	200	(	80	
G.	mail	s	200	(0.02)		IV
CN CN	mail		0.02	0.06 (0.02)		
E	mgn	8	1.6	0.00 (0.02)		
	mg/i	ĸ	1.5	10	1	
NO <sub>2</sub>	mg/i		0.4	0.4 (0.03)	-	
NO <sub>3</sub>	mg/l	B	1		5	1 1
Р	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 <sub>2</sub>	mg/l				-	
Gross-a	Bg/I		0.1		-	
Gross-6	Bg/I		1		-	↓
Ra-226	Bo/I		< 0.1			· ·
Sr-90	Bo/I		< 1			
CCE	100	1	500			-
MRAS/RAS	/ gr	I .	500	5000 (200)		
MBAarbAa	<i>µ</i> 91		500	5000 (200)	-	
O & G (Mineral)	<i>µ</i> 9/1		40; N	N	-	
O & G (Emulsified Edible)	μg/l	1 1	7000; N	N		
PCB	µg/1		0.1	6 (0.05)		-
Phenol	//g/l		10			
Aldrin/Dieldrin	ug/l		0.02	0.2 (0.01)		-
BHC	401		2	9(0.1)		
Chiordane	101		0.08	2 (0.02)		
DDT	/ gr	1 1	0.1	(1)		
Endersiden	//gn	1 1	10	0		
Endosullan	µ9/1		10			
Heptachlor/Epoxide	µg/I		0.05	0.9 (0.06)		-
Lindane	//g/l		2	3 (0.4)		-
2.4-D	ug/l	+	70	450		
2.4.5-T	ug/l		10	160		
2.4.5.TP	100	1	4	850	-	
a, a, a Th	//gn		4	600		
Paraquat	µgn		10	1800	-	

Notes :

\* = At hardness 50 mg/l CaCO<sub>3</sub>

# = 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	٥Č	-	Normal + 2 °C	-	Normal + 2 °C	-	-		
Turbidity	NTU	5	50	50	-	-	-		
Faecal Coliform**	count/100 ml	10	100	400	5000 (20000) <sup>a</sup>	5000 (20000) <sup>a</sup>	-		
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.



<b>□ ThingSpeak</b> ™	Channels <del>-</del>	Apps <del>-</del>	Devices <del>-</del>	Support <del>-</del>	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 Manag	er	×
Type All	~ megaAVR	
Arduino megaAVI Boards included ir Arduino Uno WiFi <u>Online help</u> <u>More info</u>	<b>R Boards</b> by <b>Arduino</b> n this package: Rev2, Arduino Nano Every.	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.

💿 B	Blink   Arduino	1.8.5			
File E	dit Sketch To	ools Help			
Bli	e 🗈	Auto Format Archive Sketch Fix Encoding & Reload	Ctrl+T		
1 2	/* Blin}	Serial Monitor Serial Plotter	Ctrl+Shift+M Ctrl+Shift+L		
3 4 5	Turns	WiFi101 Firmware Updater Board: "Arduino Uno WiFi Port	Rev2" >	Boards Manager      Arduino megaAVR Boards      Arduino Uno WiFi Rev2	atedly.
7 8 9	it is the c	Get Board Info Programmer: "Arduino as Burn Bootloader	ISP" >	Arduino AVR Boards Arduino Yún Arduino/Genuino Uno	HLTIN is
10 11 12 13 14	model, https: modifi by Sco	check the Techni //www.arduino.cc/ ed 8 May 2014 ott Fitzgerald	ical Specs of /en/Main/Prod	Arduino Duemilanove or Diecimila Arduino Nano Arduino/Genuino Mega or Mega 2560 Arduino Mega ADK Arduino Leonardo Arduino Leonardo ETH	y on your

#### 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

	Auto Format	Ctrl+T		
	Archive Sketch			
sketch_aug19	Fix Encoding & Reload			
void setup(	Manage Libraries	Ctrl+Shift+I		
// put vo	Serial Monitor	Ctrl+Shift+M		
,, pao 10	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	I		
	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.

		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
icius_rest_rinar   Aruunio 1.0.15 (wi	100WS Store 1.0.45.0/	Arduino Uno WiFi Rev2 (COM7)	Open Updater sket
ools Help			Refresh list
Auto Format	Ctrl+T		Test connection
Archivo Skotch		<ol> <li>Update firmware Select the firmware from the dropdown box below</li> </ol>	
Alchive Sketch		NBIA firmware (1.4.5) (Arduino Uno WIFi Rev2)	
Fix Encoding & Reload			
Manage Libraries	Ctrl+Shift+I	Update Firmware	
Serial Monitor	Ctrl+Shift+M	2 Under 22 and additions	
Serial Plotter	Ctrl+Shift+L	Add domains in the list below using "Add domain" button	
		arduino.cc:443	
WiFi101 / WiFiNINA Firmware U	pdater		Add domain
			Remove doma
		Upload Certificates to WiFi	Remove doma
		Upload Certificates to WiFi	module Remove doma
		Upload Certificates to WiFi	Remove dom
FirmwareUpdater	ESP32BootROM.cpp ESP32BootROM	Upload Certificates to WiFi	Remove dom
FirmwareUpdater	ESP32BootROM.cpp ESP32BootROM	Upload Certificates to WiFi	Remove dom
FirmwareUpdate /* FirmwareUpdate Ardwino MKR W	ESP32BootROM.cpp ESP32BootROM er - Firmware Updater for the Fi 1010, Arduino MKR Vidor 4	h Endianess	module
FirmwareUpdater /* FirmwareUpdate Arduino MKR W	ESP32BootROM.cpp ESP32BootROM er - Firmware Updater for the FFi 1010, Arduino MKR Vidor 4	h Endianess	module
FirmwareUpdater /* FirmwareUpdate Arduino MKR W: Copyright (c)	ESP32BootROM.cpp ESP32BootROM er - Firmware Updater for the Fi 1010, Arduino MKR Vidor 4 2018 Arduino SA. All rights	h Endianess 0000, and Arduino UNO WiFi Rev.2. reserved.	module
FirmwareUpdater /* FirmwareUpdate Arduino MKR W: Copyright (c) This library :	ESP32BootROM.cpp ESP32BootROM er - Firmware Updater for the Fi 1010, Arduino MKR Vidor 4 2018 Arduino SA. All rights is free software; you can red	h Endianess 0000, and Arduino UNO WiFi Rev.2. reserved.	module
FirmwareUpdater /* FirmwareUpdate Arduino MKR W: Copyright (c) This library : modify it unde License as put	ESP32BootROM cpp ESP32BootROM er - Firmware Updater for the Fi 1010, Arduino MKR Vidor 4 2018 Arduino SA. All rights is free software; you can red or the terms of the GNU Less blished by the Free Software	h Endianess 0000, and Arduino UNO WiFi Rev.2. reserved. distribute it and/or r General Public Foundation; either	module
FirmwareUpdater /* FirmwareUpdate Arduino MKR W Copyright (c) This library : modify it unde License as pu version 2.1 of	ESP32BootROM cpp ESP32BootROM er - Firmware Updater for the Fi 1010, Arduino MRR Vidor 4 2018 Arduino SA. All rights is free software; you can red er the terms of the GNU Lesse blished by the Free Software f the License, or (at your op	h Endianess 0000, and Arduino UNO WiFi Rev.2. reserved. listribute it and/or r General Public Foundation; either stion) any later version.	module
FirmwareUpdater /* FirmwareUpdate Arduino MKR W Copyright (c) This library : modify it unde License as pu version 2.1 of This library :	ESP32BootROM cpp ESP32BootROM er - Firmware Updater for the Fi 1010, Arduino MRR Vidor 4 2018 Arduino SA. All rights is free software; you can red er the terms of the GNU Lesse blished by the Free Software f the License, or (at your op is distributed in the hope th	h Endianess 0000, and Arduino UNO WiFi Rev.2. reserved. distribute it and/or r General Public Foundation; either stion) any later version.	module
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FirmwareUpdater /* FirmwareUpdate Arduino MKR W Copyright (c) This library : modify it unde License as pu version 2.1 of This library : but WITHOUT AN MERCHANTABILIT Lesser General	ESP32BootROM cpp ESP32BootROM er - Firmware Updater for the Fi 1010, Arduino MRR Vidor 4 2018 Arduino SA. All rights is free software; you can red er the terms of the GNU Lesse blished by the Free Software f the License, or (at your op is distributed in the hope th NY WARRANTY; without even the PY or FITMESS FOR A PARTICULA Public License for more det	h Endianess 0000, and Arduino UNO WiFi Rev.2. reserved. distribute it and/or or General Public Foundation; either otion) any later version. dat it will be useful, eimplied warranty of R PURPOSE. See the GNU ails.	module
FirmwareUpdater /* FirmwareUpdate Arduino MKR W: Copyright (c) This library : modify it unde License as pul version 2.1 of This library : but WITHOUT AT MERCHANTABLIT Lesser General	ESP32BootROM cpp ESP32BootROM er - Firmware Updater for the iFi 1010, Arduino MKR Vidor 4 2018 Arduino SA. All rights is free software; you can red or the terms of the GNU Lesse blished by the Free Software f the License, or (at your op is distributed in the hope th YY WARRANTY; without even the FY or FITNESS FOR A PARTICULA I Public License for more det	Lupicad Certificates to WFin Upload Certificates to WFin Dolo, and Arduino UNO WiFi Rev.2. reserved. Mistribute it and/or or General Public Foundation; either tion) any later version. Mat it will be useful, simplied warranty of R PURPOSE. See the GNU mails.	module
FirmwareUpdater /* FirmwareUpdate Arduino MKR W: Copyright (c) This library : modify it unde License as pul version 2.1 of This library : but WITHOUT AH MERCHANTABILIT Lesser General You should haw	ESP32BootROM cpp ESP32BootROM er - Firmware Updater for the iFi 1010, Arduino MKR Vidor 4 2018 Arduino SA. All rights is free software; you can red or the terms of the GNU Lesse blished by the Free Software f the License, or (at your op is distributed in the hope th YY WARRANYY; without even the FY or FITNESS FOR A PARTICULA 1 Public License for more det re received a copy of the GNU with this library; if not. w	Lupicad Certificates to WiFi Lupicad Certificates to WiFi Double Certificates to WiFi Poundation UNO WiFi Rev.2. Inserved. Mistribute it and/or or General Public Foundation; either Stion) any later version. Mat it will be useful, simplied warranty of R PURPOSE. See the GNU mails. Lesser General Public rrite to the Free Software	medule
FirmwareUpdater /* FirmwareUpdate Arduino MKR W Copyright (c) This library : modify it unde License as pul version 2.1 of This library : but WITHOUT AN MERCHANTABILIT Lesser General You should haw License along Foundation, In	ESP32BootROM cpp ESP32BootROM er - Firmware Updater for the Fi 1010, Arduino MRR Vidor 4 2018 Arduino SA. All rights is free software; you can red er the terms of the GNU Lesse blished by the Free Software f the License, or (at your op is distributed in the hope th NY WARRANTY; without even the PY or FITNESS FOR A PARTICULA I Public License for more det re received a copy of the GNU with this library; if not, w nc., 51 Franklin St, Fifth FI	Lybood Certificates to WFin Upload Certificates to WFin Doto, and Arduino UNO WiFi Rev.2. reserved. distribute it and/or or General Public Foundation; either atticn) any later version. Hat it will be useful, e implied warranty of R PURPOSE. See the GNU ails. J Lesser General Public prite to the Free Software oor, Boston, MA 02110-1301 USA	medule

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 Firm	ware/Certificates Updater	-	-		×
1. Select port of the WiFi mod	le				
If the port is not listed click "Re	efresh list" button to regenerate the list				
Arduino Uno WiFi Rev2 (COM)	7)	C	)pen U	pdater sk	etch
			Ref	fresh list connectio	n
2. Update firmware Select the firmware from the o	dropdown box below				
NINA firmware (1.4.5) (Arduir	no Uno WiFi Rev2)				$\sim$
	Update Firmware				
3. Update SSL root certificates					
Add domains in the list below	using "Add domain" button				
aruuno.cc.443					
			A	dd doma	in
			Rer	move don	nain
	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)	Оре	n Updater sk	ketch
		Refresh list	
	Т	est connection	on
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	ain
		Remove dor	main
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



