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Malaysia-Japan International Institute of Technology (MJIIT)

INTEGRATED DESIGN PROJECT

(SMJE 3303)

Title: Smart Masjid Water Conservation

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COURSE : 3 SMJE

GROUP : 10

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Abstract

The main objective of this project is to reduce the monthly water bill of *Masjid* (mosque) and save energy sources. The unique approach of this project is the utilization of rain as source of water supply. As known, a large amount of clean water has been wasted for daily activities such as flushing toilets and watering plants. Apparently, these daily activities do not necessarily use clean water. This project highlighted the usage of rainwater as water supply for those activities as way to reduce the usage of water from supplier and also utilize the concept of Internet of Thing (IoT) as an assistive feature to monitor the performance of the tanks afar. The level of rainwater and amount of water used from supplier can be monitor through mobile phone application as long as it is connected to Wi-Fi. In case the rainwater is insufficient, the water from water supplier can be automatically or manually flow into the rainwater tank using electronic valve controlled by phone and stop when desired water level is reached. Based on the result, 20% is set as the minimum level of water level in the main tank and 60% is set as the stopping criteria to stop water supply from water suppliers. In order to approach the aims that give awareness to the society regarding the usage of water. In other words, this project intentionally designed to display the usage of water from Water Agency and deliver the data using IoT technologies to the society who came to the mosque. It is believed that this is a good method to spread awareness within the society to save the water. Furthermore, this project is highly potential to be commercialized because of impressive features. For instance, this project use industry sensors which will give more accurate data sensing and analyze these statistical data by using mobile application. Last but not least, this project is obviously a better product with IoT system at low cost budget compared to other available product on market.

Keywords: impressive features, accurate data sensing, statistical data analysis, mobile application, low cost budget, rainwater, IoT.

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CHAPTER 1

1.0 Introduction

Malaysia is one of the countries that forging ahead with Industrial Revolution 4.0 and Malaysia has launched Industry 4.0 policy in 2018. Internet of Things (IoT) is one of the core technologies of Industrial Revolution 4.0. Not to fall behinds, students have been encouraged to design and build a project that portray a Smart City Initiative developed in Malaysia. This project focuses on developing a smart water product with IoT background.

Living in a rapid technology evolution, Malaysia should go for high quality products that could sustain the needs and coziness of their lives. Since water is a very important source to keep people comfortable and the environment clean, this sector should be look at attentively. In order to accomplish Smart City, a lot of improvement should be done on how water supply functions in Malaysia. Reduction in water supplies is a huge concern in the world. Even though Malaysia still has sufficient supply of clean water, there is significant drop of the amount of water supply nowadays by comparing it to the last 5 year [1]. There were many ideas on how to solve this issues including initiative taken to reduce the demand side to avoid any more wasted water. However, this approach could cause discomfort within people. Instead of reducing the demand, this paper suggest the approach of increase the water supply sources.

This project chose to focus its implementation on mosques since most of the activities happen in mosque required water. This paper also chose filtered rain water to be one of the water suppliers. The main reasons of choosing rain as water supplier is because it is natural resources and by collecting rain water, flood can be avoided from happening. The IoT elements are also implemented in this project to improve the system design.

1.1 Background

Mosques are the main place for Muslims community to perform religious activities and a center for community worship. Since Malaysia is a Muslim country, the frequency of people visiting mosques in a day is high. As known, Muslims must conduct ablution before most of the rituals. Abdullah Al Mamun et al. (2014) stated in his report that amount of water to be used for just for ablutions only reached up to 32 liters per day [1]. While according to IR Haji Ahmad Jamalluddin Shaaban (2016), the amount of water demand for a mosque is the second highest in Taman Melawati region which is 1,100 liter per day [2]. Referring to both statements, it can be deduced that a mosque use a huge amount of clean water to perform its daily operations. Yet, this huge amount of clean water has been wasted for its daily activities that do not necessarily need clean water such as flushing toilets and watering plants. It is also learnt that a massive usage of clean water supplied from local water agency results in a high water bill cost in which also increase the operation cost of a mosque. Commonly, water tanks will be on top of the mosque, specifically, on the roof. It such a troublesome for the committee to monitor the water tanks if there is any problem.

In order to solve these problems, this project proposed a unique approach of using filtered rain water as one of the water supply for the mosque. This project also highlighted the usage of IoT platform to monitor the water level in both main (distributor) tank and rainwater tank as an improvement of the current water supply system. Last but not least, this project included a programmed system that activate local water supply when needed.

In this project, ultrasonic sensors are used to monitor the water level in main (distributor) tank and the rain water tank. The water flow sensor is also used to monitor and track the water usage supplied from local water agency. An automatic valve is installed in the system to control the water supply from local water agency. These electronic components are connected through an IoT platform to control and monitor the performance of the system.

1.2 Problem statement

As mentioned in the earlier of the paper, mosques use a huge amount of clean water to operate daily. However, this huge amount of clean water has been wasted for daily activities that do not necessarily need clean water such as flushing toilets and watering plants. Summer (2000) stated that about 3.5 gallons of water is used per flush while a garden hose or sprinkler can use almost as much water in an hour as an average family of 4 uses in one day [3]. Since the mosques are using a large amount of water supplied by local water agencies, the operation cost become high.

1.3 Objectives

The main objective of this project is to reduce the water usage from local water agency as well as the high water bill faced by the mosque. This project also aimed to ease the mosque committee to monitor and control the water flow by using IoT platform. There would no necessity for the committee to climb up the roof to check the water tanks if there is any problems.

CHAPTER 2

2.0 Methodology

In order to build and modify the product, team's creativity is used in designing the strategy, integrate with the components used, use with the modern tool and doing some methodology and evaluation.

2.1 Design Strategy and Creativity

In this project, the team has identified the main problem to be solved and set a several objectives to be achieved with effective planning and implementation of engineering skills to complete the project. The overall process flow chart can be seen in Figure 2.1.1 below:

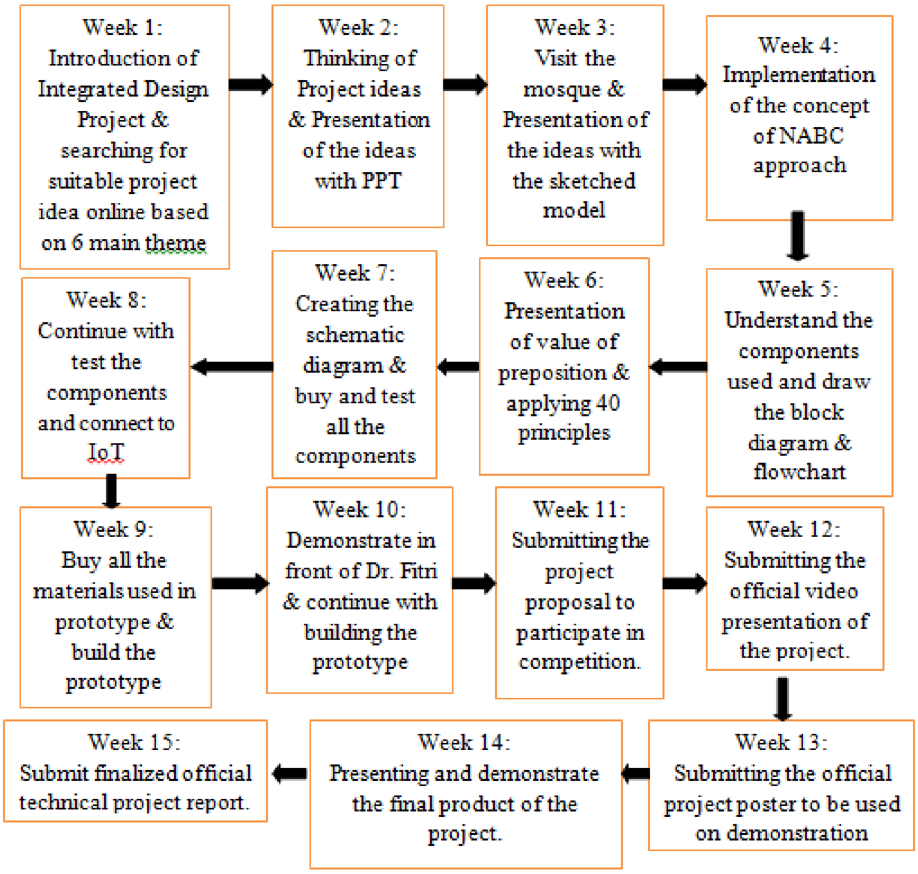


Figure 2.1.1: Overall Process Flowchart

Table 2.1.1 Activities carried out by the team members

Task	Lee	Shariffudin	Hafizuddin	Amirah
Discussion on Idea of project (smart water)	●	●	●	●
Present the idea with NABC concept	●	●	●	●
Present Flowchart and block diagram, detail on product sketch and component used	●	●	●	●
Approach company through email and update on company engagement	●	●	●	●
Presentation Value Proposition and 40 Innovation Principles	●	●	●	●
Buy the components	●	●	●	●
Circuit Assembly	●	●	●	●
Arduino Coding	●	●	●	●
Present the proposal/ abstract, update the progress and demonstrate the circuit	●	●	●	●
Make a Prototype	●	●	●	●
Poster Presentation	●	●	●	●
Demonstration of project	●	●	●	●
Report writing	●	●	●	●

As for the project management, it is divided into 2 parts, Task allocation and Gantt chart. Task allocation is where each team member performs tasks of self-responsibility in order to complete this project. Table 2.1.1 shows the summary of the activities/tasks carried out by the team members for the completion of the whole project. All members are contributing efforts in completing the task given every week.

Table 2.1.2. Gantt Chart

WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14
INITIALIZATION														
Introduction to IDP														
Group Formation														
Brainstorming Idea														
Initial Sketching														
PLANNING														
Task Distribution														
Design Consideration														
Simulation														
Material Selection														
Technical Calculation														
EXECUTION														
Conceptual Prototype														
Buying Components														
Building Prototype														
Testing Prototype														
Improve the functionality														
PERFORMANCE														
Short Video Presentation														
Poster Presentation														
Product Demonstration														
Receipt Collection														
Final Report														

The timeline and due date are arranged for every single task by developing the Gantt Chart. The Gantt Chart is shown as above.

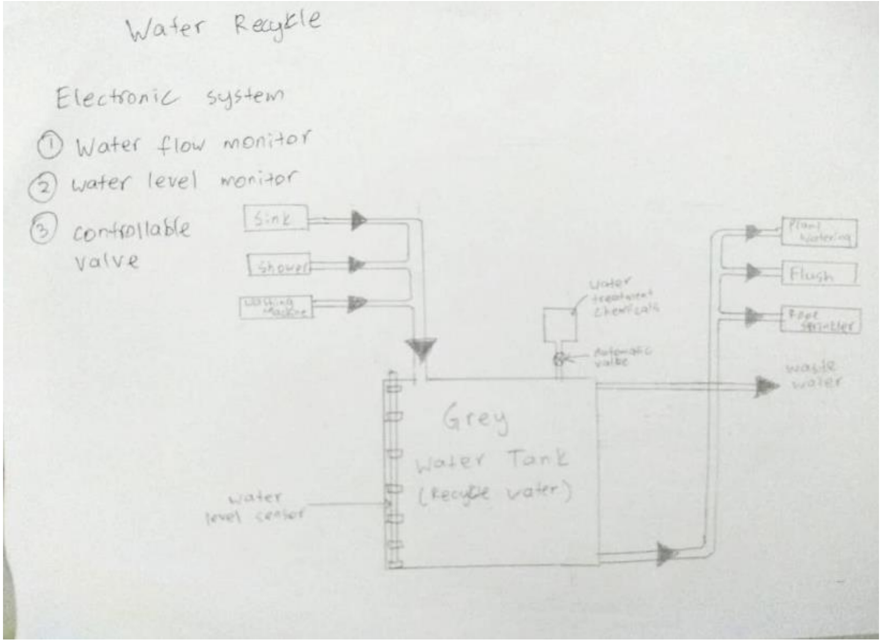


Figure 2.1.2: First design sketched at the early stage with the title of Smart Home Water Conservation

After developing the overall process flowchart and decomposition of work into subtasks, the sketch model is designed from time to time. At the early stage, the team came out with a project named, “Smart Home Water Conservation” during brainstorming session and started to design the model. This design is shown in Figure 2.1.2.

However, the project was the changed to Smart Masjid Water Conservation with the suggestions from Dr Fitri. The team then visited the mosque to learn and find out about the real water flow system in mosque to further improvement in the model designed. The real water flow system of the mosque visited is designed as Figure 2.1.3 below:

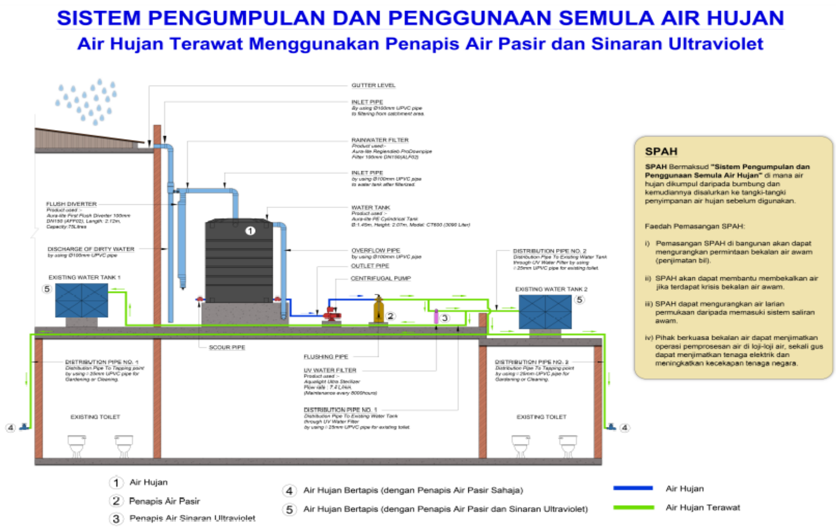


Figure 2.1.3: Water Flow System in Masjid

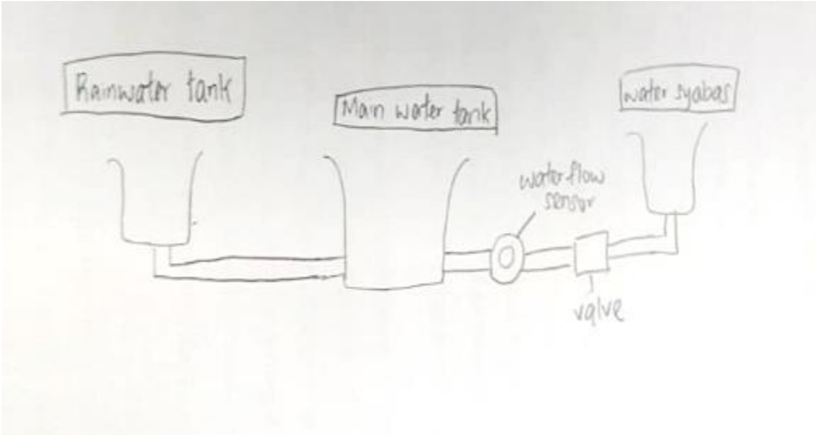


Figure 2.1.4: Second design sketched at the early stage

By referring the Figure 2.1.3 above, the second sketched was designed as Figure 2.1.4.

The second sketched model was presented to the lecturer, Dr.Fitri. Dr. Fitri suggested to add another area for rainwater catchment and monitor the water level inside the rainwater tank by using ultrasonic sensor, so that it more closer to the design of real water flow system in Masjid. Therefore, the third design is sketched as below:

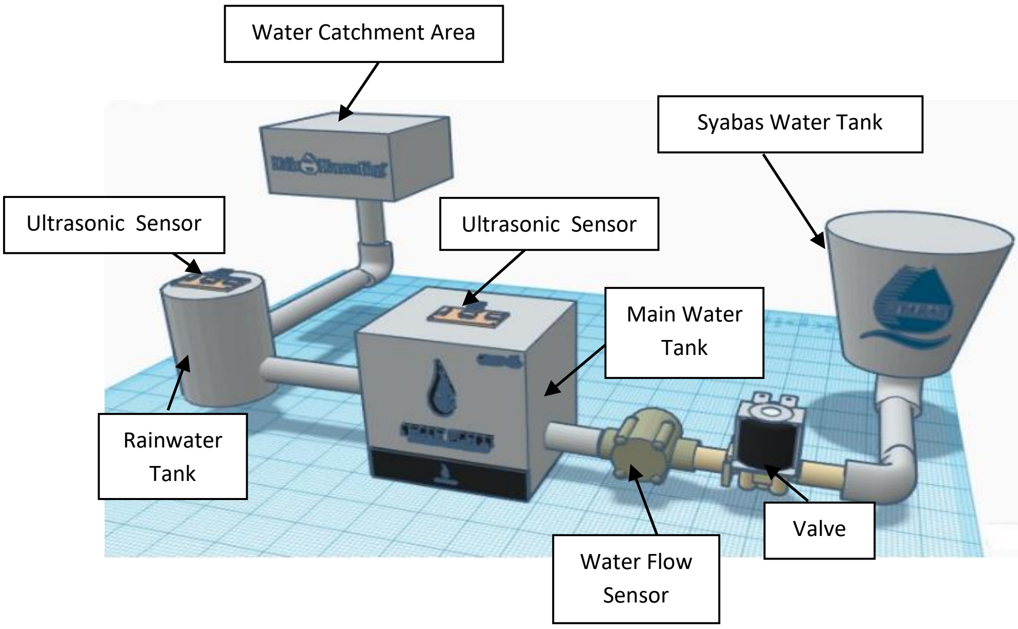


Figure 2.1.5: Third design sketched at the early stage

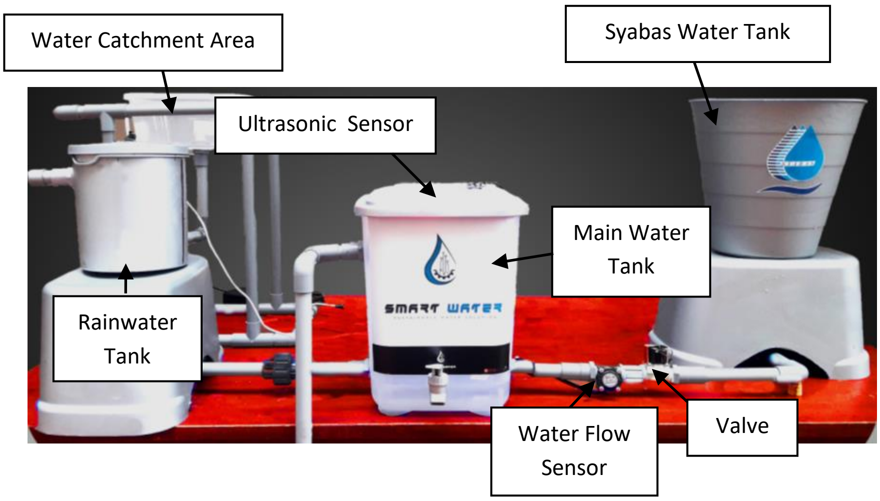


Figure 2.1.6: The full prototype designed.

At last, the third design was decided to be used as the final design. By referring to the third design sketched as above, the whole prototype was designed as in Figure 2.1.6.

2.2 Integration

The block diagram of this project is designed as below:

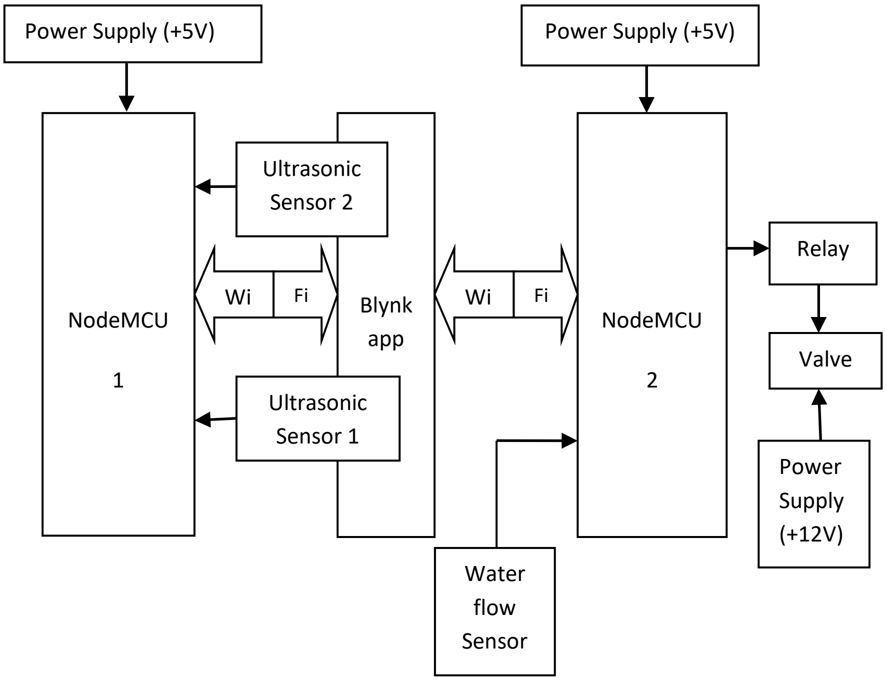


Figure 2.2: Block diagram of Smart Water Flow System

In this project, two NodeMCU are used to interface between software and hardware circuit, in which NodeMCU1 is used to connect the ultrasonic sensors (hardware) with the Blynk apps (software) in the mobile phone, while NodeMCU2 is used to connect the water flow sensor and solenoid valve (hardware) with the Blynk apps (software). Both of the NodeMCUs used have programmable Wi-Fi module and need 5V DC to operate. If there is insufficient of 5V, therefore the NodeMCUs will not operate.

For NodeMCU1, it connects both of ultrasonic sensors that used to measure the distance by using ultrasonic waves with the Blynk apps that downloadable by using mobile phone. The ultrasonic sensors head emits the ultrasonic wave and receive the wave reflected back from the target [10]. Then, the Blynk apps will receive the distance that measured by ultrasonic sensors to display on the mobile phones via Wi-Fi-module from NodeMCU1 [16]. Therefore, the mobile phone can display the result of both ultrasonic sensors in percentage respectively by using graph.

For the NodeMCU2, it connects the water flow sensor and solenoid valve with the same Blynk apps that downloadable by using mobile phone. When the water flow sensor detect that there is water flows through the rotor, rotor will rolls [12]. Its speed changes with different rate of flow. Then, the Blynk apps will receive the amount of water flow that it measured to display on the mobile phones via Wi-Fi-module from NodeMCU2. Therefore, the mobile phone can display the result of water flow sensor in liter by using line graph. In addition, a relay is used connected with the NodeMCU2 and solenoid valve, therefore the solenoid valve part does not interrupt or receive the signal from the water flow sensor part. The solenoid valve need 12V to operate and control the water flow from water supplier (SYABAS) automatically or manually [9]. The functionality of solenoid valve can be seen with the result of water flow sensor. If the solenoid valve is closed, the graph result will showed flat, while the solenoid valve is opened, the graph result will showed increased due to the design model.

NodeMCU is similar to Arduino Uno but with the added advantage of built-in Wi-Fi. Therefore the board looks and works like an UNO except this system required good line coverage to get the high speed internet [7]. Blynk app connects with the NodeMCU with the help of internet connection. Next, the wires from the Arduino connected to the circuit and to the sensors [7].

2.3 Modern Tool Usage (Engineering application)

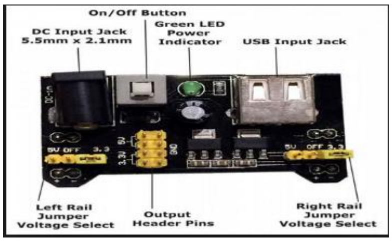
2.3.1 Selection of components

Table 2.3.1 shows the list of the components used and Table 2.3.2 shows their description as below:

Table 2.3.1: List of components that used

No.	Components	Values/Model	Quantity
1.	Breadboard Power Supply Module Board	mb102, 3.3/5V	2
2.	AC/ DC Adapter	CD-120200B (12V, 1A)	1
3.	NodeMCU module	ESP 8266	2
4.	Ultrasonic Sensor	HC SR04	2
5.	Solenoid Valve	230V	1
6.	Water Flow Sensor	-	1
7.	Relay Module	5V, DC	1
8.	LEDs	-	1

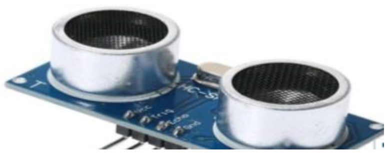
Table 2.3.2: The description of the components used

<table>
<tr><th>No</th><th>Pictures</th><th>Features</th></tr>
<tr><td>1.</td><td>

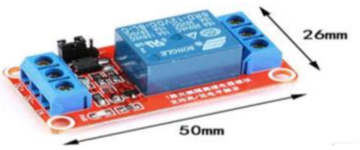
Breadboard Power Supply Module Board</td><td>

Plug directly to MB102 Standard breadboard.
Input voltage: 6.5-12 V (DC) or 5V USB power supply.
Output voltage: 3.3V and 5V can switch over.
Maximum output current: <700 mA.
External Input voltage ON/OFF switch.
USB device connector onboard for power output to external device.
Size: 5.3cm x 3.5cm.
</td></tr>
<tr><td>2.</td><td>
Power Adapter</td><td>

Switching Adaptor
Model: CD-120200B
Plug type: UK or BS1363(type G)
Input: 100-240V ~ 50/60Hz 0.4A
Output: Regulated +12VDC 2A
Wire length 1 meter
</td></tr>
<tr><td>3.</td><td>
NodeMCU</td><td>

programable Wi-Fi module.
Arduino-like (software defined) hardware IO.
Can be programmed with the simple Arduino IDE.
USB-TTL included, plug & play..
Wi-Fi networking and connect to internet to fetch or upload data.
Event-driven API for network applications.
PCB antenna.
</td></tr>
<tr><td>4.</td><td>
Ultrasonic sensor</td><td>

Operating voltage: +5V
Theoretical Measuring Distance: 2cm to 450cm
Practical Measuring Distance: 2cm to 80cm
Accuracy: 3mm
Measuring angle covered: <15°
Operating Current: <15mA
Operating Frequency: 40Hz
</td></tr>
</table>

5.	 Solenoid Valve	• A control unit which, when electrically energized or de-energized • The number of port connections or the number of flow paths ("ways").
6.	 Water Flow Sensor	• Flow Rate Range: 1～60L/min • Water Pressure: ≤1.75MPa (Max 2MPa)
7.	 Relay Module	• Operation voltage: 5V • Max current: 190mA • Trigger voltage: Off- 0V; ON- 5V • Trigger current: 2-4mA • Max load: AC250V (10A) ; DC30V (10A)

1. Breadboard Power Supply Module Board

This is a 3.3V and 5V Breadboard Power Supply Module with series diode, polarity reversal protection. In this project, the module take 12V input from AC/DC power adapter to produce 3.3V and +5V. It use power supply module to specially test/prototype electronic circuits on breadboard, in which in this project the NodeMCU that used need 5V to operate while the solenoid valve that used need 3.3V to operate. Therefore, it is suitable to be used in this project.

2. AC/ DC Adapter

The AC to DC adapter transforms the alternate current (AC) input to direct current (DC) output. For this device, it will convert the main electricity (100V-240V AC) to 12 volts (DC) that you need. In this project, this adapter is used to power up the components that need 12V input, which is the breadboard power supply. This AC/DC adapter is selected because it is safe to use, good in heat reduction, ease of replacement and configuration versatility.

3. NodeMCU

NodeMCU is an open source development board and firmware based in the widely used ESP8266 -12E Wi-Fi module [17]. In this project, it allows the users to program the ESP8266 Wi-Fi module with the simple Arduino IDE [13]. With just a few lines of code, the users can establish a Wi-Fi connection and define input/output pins according to the user's needs exactly like Arduino, turning your ESP8266 into a web server and a lot more. It is the Wi-Fi equivalent of Ethernet module. Therefore, it will have internet of things (IoT) real tool [14].

4. Ultrasonic Sensor

Ultrasonic sensors are used to measure the distance by using ultrasonic waves [11]. The sensor head emits an ultrasonic wave and receive the wave reflected back from the target. Ultrasonic sensors measure the time between the emission and reception. This enables miniaturization of the sensor head. In this project, it is used to measure the water level of a tank by measuring the distance from sensor head to the water surface of a tank and reflect back to the sensor head. The pin configurations of ultrasonic sensor are shown in Table 2.2.3:

Table 2.2.3: Ultrasonic Sensor Pin Configuration

Pin Number	**Pin Name**	**Description**
1	Vcc	The Vcc pin powers the sensor, typically with +5V
2	Trigger	Trigger pin is an Input pin. This pin has to be kept high for 10us to initialize measurement by sending US wave.
3	Echo	Echo pin is an Output pin. This pin goes high for a period of time which will be equal to the time taken for the US wave to return back to the sensor.
4	Ground	This pin is connected to the Ground of the system.

5. Solenoid Valve

Solenoid valve is a control unit which,, when electrically energized or de-energized, either shut off or allow fluid flow [15]. The actuator takes the form of an electromagnet. When energized, a magnetic field builds up which pulls a plunger or pivoted armature against the action of a spring. When de-energized, the plunger or pivoted armature is returned to its original position by the spring action. To the mode of actuation, a distinction is made between direct- valves, internally piloted valves, and externally piloted valves. By this principle, it is used to control the movement of water flow from the tank in this project.

6. Water Flow Sensor

Water flow sensor consists of a plastic valve body, a water rotor, and a hall-effect sensor. When water flows through the rotor, rotor rolls. Its speed changes with different rate of flow. The hall-effect sensor outputs the corresponding pulse signal. With the principle, it used to measure the amount of water flow from a tank in this project.

This flow sensor meter is lightweight, small and easy to install. The internal impeller has stainless steel shaft which is quite wear-resistant. Seal ring uses mechanical structure that stressed from up and down directions and will not leak. The sensor has high quality Hall-effect element and is encapsulated with glue, preventing from water entering.

7. Relay Module

This is a low voltage level trigger relay module and suitable for electronic project. In this project, it acts as a switch to connect with two circuits (NC, normally close circuit and NO, normally open circuit) and uses to separate two different working principles of the circuit, which includes the solenoid valve part and water flow sensor part. Therefore, those two components are not interrupted by each other, so that either one will remain well function even if the other one is malfunctioned.

8. LEDs

It used as an indicator for the solenoid valve, which it can controlled manually via Blynk apps (IoT) at the early stage of the testing the project implementation.

2.3.2 Arduino IDE

The Arduino Integrated Development Environment (IDE) is a cross-platform application for Windows, macOS, and Linux that is written in the programming language Java [13]. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores (Blynk app), other vendor development boards.

The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

2.3.3 Solidworks

SolidWorks is a solid modelling computer-aided design (CAD) and computer-aided engineering (CAE) computer programs that runs on Microsoft Windows [6]. Engineering and manufacturing process are enabled simultaneously from shared Solidworks data. SolidWorks has higher quality due to increased efficiency resulting from the ability to explore a greater number of design iterations during product development and lower unit costs due to reduced development and prototype expenses. Solidworks develops opportunities for the elimination of inherent inefficiencies in existing work flows and/or practices. Efficient use of Solidworks allows the production of more work while maintaining current staff levels.

2.3.4 Application of Internet of Things (IoT)

Internet of things in also known as a system that is interrelating to mechanical, digital machines and computing devices that are equipped with unique identifiers and the ability to transfer data without the need of human interaction over network [5]. In this project the same concept of the IoT is applied in the development of smart water conservation in Masjid. The data is send automatically without the needs of human to computer interaction to the mobile phone.

2.4 Methodology and evaluation

In this project, Blynk app interface is used to monitor and control the different programs wirelessly with NodeMCU.

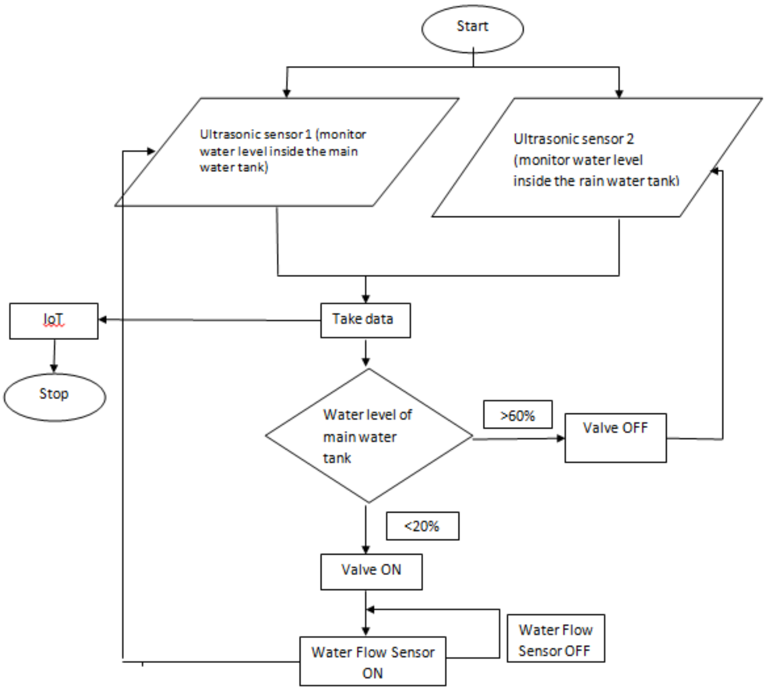


Figure 2.4.1 Flowchart of Smart Water Flow System

Water level inside the main water tank and rain water tank that monitored continuously by ultrasonic sensors, which include ultrasonic sensor 1 (monitor water level inside the main water tank), and ultrasonic sensor 2 (monitor water level inside the rain water tank) are displayed respectively via Blynk app. In this project design, if it is raining, the water level inside the rain water tank will increase, and flow directly toward the main water tank. As the water level of the main water tank is less than 20% (minimum water level set) that measured by the ultrasonic sensor, the valve will automatically on and the water flow sensor will started to receive the data of the water flow from water supplier (SYABAS) via Blynk apps. However, when the water level is more than 60% (maximum water level set), the valve automatically closed. The overall operation wil stop unless the water level of the main water tank become below than 20% again. The additional button in Blynk apps is used to manually closed valve to stop the water flow from SYABAS (water supplies) if there is pipe leakage is detected.

The schematic diagram is drawn as below based on the block diagram that used:

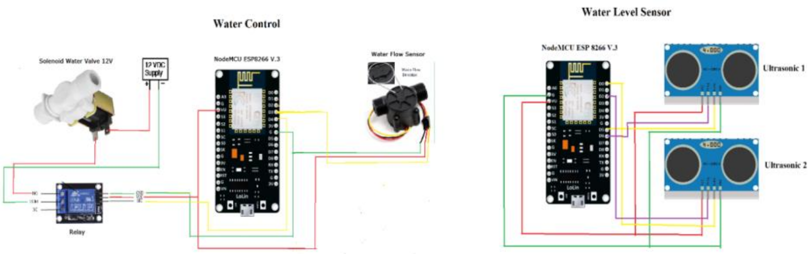


Figure 2.4.2: Schematic Diagram

Figure 2.4.3: Testing on the breadboard

The circuit build on the breadboard according to the schematic diagram is shown as above. After the circuit tested and the prototype was set up, the water is filled into the rainwater catchment area and Syabas tank to test and observe the results.

CHAPTER 3

3.0 Interface of the Blynk Application on Mobile Phone

Figure 3.0 below shows the interface of water flow system in this project.

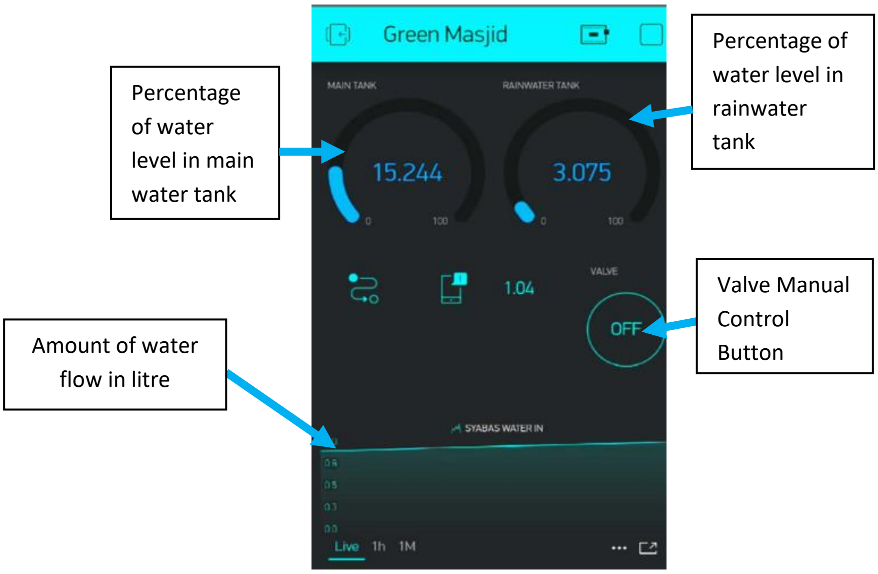


Figure 3.0: The interface of water flow system

3.1 Results

Figure 3.1.1 to Figure 3.1.6 shows the results obtained when each parameter or condition is occurred.

a) When the main water tank is below 20% (less than the desired minimum water level) that measured by the ultrasonic sensor, a notification will be triggered to alert the users and the solenoid valve will be automatically open (allow the water flows from water supplier (SYABAS) to the main water tank). Then, water flow sensor will start to receive the data of the amount of water flow from water supplier (SYABAS) with represented in line graph. Figure 3.1.1 below shows the result of the Blynk apps for this condition.

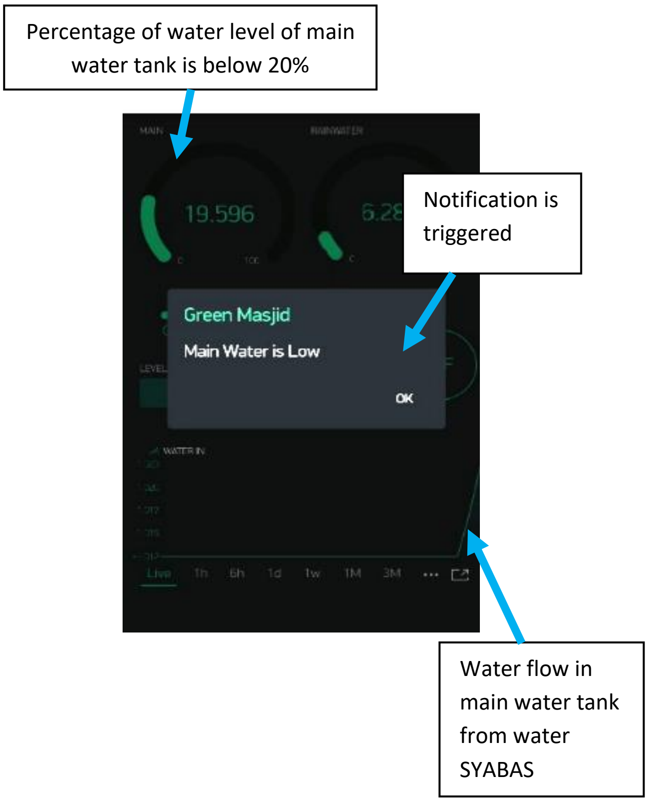


Figure 3.1.1: A notification will be triggered when the main water tank is below 20%

Table 3.1.1: Range of distance from the sensor head that indicates the water level as high or low

Water level / Distance (cm)	High (>=20%)	Low (<20%)
0	✓	X
3	✓	X
6	✓	X
9	✓	X
12	✓	X
15	X	✓
18	X	✓

Table 3.1.1 summarize the range of the distance from the sensor head that indicates the water level of main water tank as low (<20%) or high (>=20%), in which it will affect a notification will be triggered or not to the users via Blynk app.

In this project, 17cm is considered the measured height of the main water tank. Through calculation, 20% of main tank height is considered as 3.4 cm. But, the shorter distance that measured by the ultrasonic sensor, the higher water level will be observed. Therefore, 17-3.4= 13.6cm is the actual distance of 20% from the sensor head that observed.

As a result, from table above, when the distance from sensor head that is more than 13.6cm (15cm or 18cm), it will send a notification to the user, otherwise if the distances from sensor head is less than 13.6cm, it will not notify the user.

b) When the main water tank reached 60%, measured by the ultrasonic sensor, the solenoid valve will be automatically close (prevent the water flows from water supplier (SYABAS) to the main water tank). Then, water flow sensor will not receive any data of the amount of water flow from water supplier (SYABAS), represented in line graph. Figure 3.1.2 shows the result of the Blynk apps for this condition.

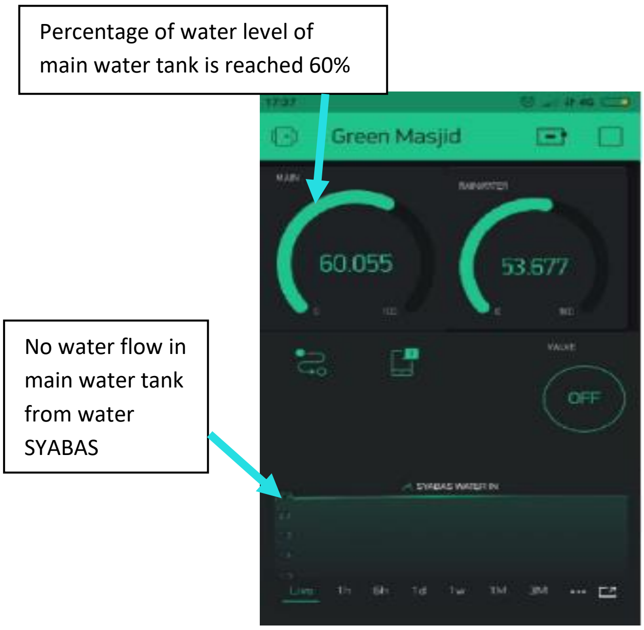


Figure 3.1.2: Percentage of water level of main water tank is reached 60%

Table 3.1.2 summarize the percentage of water level of main water tank that will affect the condition of the solenoid valve automatically (opened/closed) and the amount of the water flow from water supplier (SYABAS).

In this project, 60% of the water level of the main water tank is set using coding to automatically on/off the solenoid valve and allow/prevent the water flows from water supplier (SYABAS). Based on the table below, it shows that as the percentage in the water level of the main water tank is less than 60%, therefore the solenoid valve will automatically open and allow the water flows from water supplier (SYABAS). Its amount of water flow and graph result will be showed in Blynk app. However, the solenoid valve will automatically close and the water SYABAS cannot flow to the main water tank when the percentage in the water level of the main water tank is reached to 60%. Therefore, water flow sensor will not receive any data of the amount of water flow from water supplier (SYABAS).

Table 3.1.2: The percentage of water level of main water tank that will affect the water usage from water supplier and the condition of solenoid valve automatically.

The amount of water flow from water supplier (SYABAS) / Percentage of water level of main water tank (%)	Increased	No increased	Condition of the solenoid valve by automatically
0	✓	X	Open
20	✓	X	Open
40	✓	X	Open
60	X	✓	Closed
80	X	✓	Closed
100	X	✓	Closed

Figure 3.1.3: It is raining

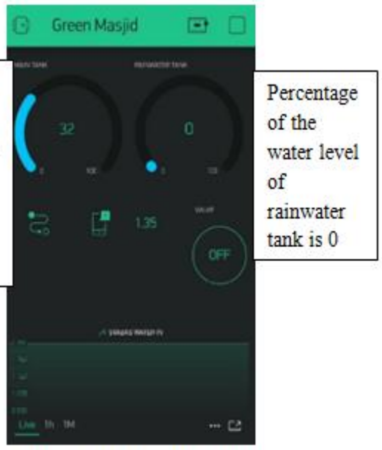


Figure 3.1.4: It is no raining

c) During raining, the rainwater will be caught into the rainwater tank, therefore the percentage of the water level of rainwater tank is increased and the rainwater in the rainwater tank will flow directly into the main water tank as shown in the Figure 3.1.1 and Figure 3.1.4 above.

d) When the user wanted to increase/decrease the water level of the main water tank, an addition button in Blynk apps that allow them to manually open/close the solenoid valve to allow or prevent the water from water SYABAS flows directly into the main water tank as shown in the Figure 3.1.6 below:

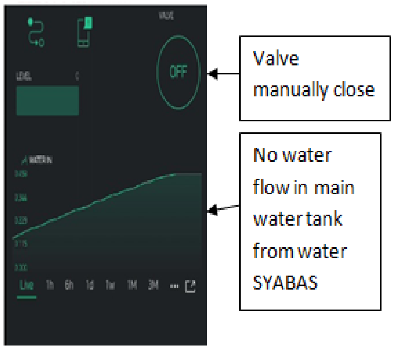


Figure 3.1.5: Valve manually close

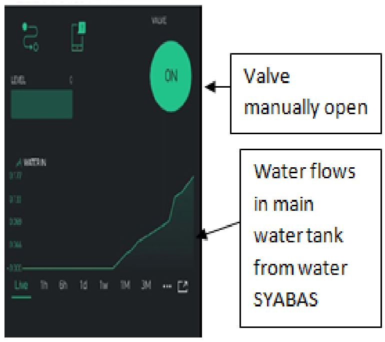


Figure 3.1.6: Valve manually open

3.2 Discussion

Based on the results obtained, it can be seen that most of the functions implemented are working well. The specialty of this project is approach IoT technology to ease the user to monitor water flow system continuously. Therefore, the user will be more concise to the water usage for main water tank. Another specialty in this project is its flexibility, in which it able to allow the user to set the minimum water level of the main water tank to allow water flows from water SYABAS into main water tank. From the results above, 20% is set as the minimum water level of the main tank in this project, as the main water tank is below than 20%, the application will notified user and the solenoid valve will automatically open to allow the water flows from water SYABAS to main water tank. 20% is chosen because it ensure sufficient water supply to be used as adding water from water SYABAS could take up sometimes. In addition, 60% of the water level in main water tank is set as the stopping criteria to stop water flow from water supplier (SYABAS), which mean the solenoid valve is automatically close, once the water level of the main water tank is reached to 60%. 60% is chosen because 60% is assumed to be sufficient for the mosque to operate in a day. Adding to that, the water supplied by SYABAS should not reach 100% water level because if it rained after supplying the water, the rainwater still can be collected instead of wasting it. Therefore, once the main tank exceeds above 90% of the water level, the water will be overflow and it purposely can be used for fill in the water pool for shower. It will prevent the wastage of the rainwater.

From the Blynk app, the line graph represented the amount of water flow from water supplier (SYABAS) in liter against time, in which the parameter for time can be changed based the demand of the user. It can be specified in second, minutes, hours, day or even month. It will update the amount of the water flow from water SYABAS according to the time taken that set. From the results above, an additional button is provided to manually on/off the valve to allow or prevent the water from SYABAS to flows directly to the main water tank is added to this project to overcome upcoming issues such as if there is insufficient water from SYABAS or the pipe leakage.

3.3 Implementation, Potential and Limitation of the project

3.3.1 Implementations

As this project falls under the smart water theme, the product is implemented for the user who faced the difficulty of high water bills, for this case is Masjid. Water usage in *Masjid* is increasing. *Masjid* faced high water bill monthly. Statistics showed that the average monthly household consumption expenditure for Malaysia increased from RM2,190 in 2009 to RM3,578 in 2014 which was 9.8 per cent per annum at the nominal value [4]. While at a real value, the annual growth rate is 7.5 per cent for the same period. Moreover, a lot of governments are legislating against the water use nowadays. Thus, the idea to use the rainwater to reduce the usage from the water suppliers (Syabas) breaks out. In addition, the implementation of IoT via Blynk app in mobile apps to monitor the currently water level and amount of water flow from SYABAS provides a lot benefits to the users in terms of economic and environmental factors:

a) **Economic**

Water bill usage can be reduced, in which the utilization of rainwater to replace the water from suppliers as the main use of the water tank in daily life. Moreover, the software of Blynk apps is free and downloadable by the users. Therefore this allow users to monitor the water flow system without wasting any money and time.

b) Environmental

This project is actually use the weather phenomenon to solve the problem faced by the users, in which the utilization of rainwater as the main water source instead of water from water suppliers (SYABAS) to reduce the water bills. In addition, this can also increase awareness on water consumption to the public.

3.3.2 Potential

It has great potential in term of safety and commercial as below:

a) Safety

The product is safe to use as it can check the water level and monitor the water flow via Blynk apps with 99% of the accuracy and can be applied in anywhere and anytime for the users who faced the difficulty of water bills. This product is also encouraged water conservation and save water resources. In addition, the software is easy to install, therefore it brings a lot of convenience to the users.

b) Commercial

This project is highly potential to be commercialized because of impressive features. For instance, this project use industry sensors which will give more accurate data sensing and analyze these statistical data by using mobile application. Last but not least, this project is obviously a better product with IoT system at low cost budget compared to other available product on market. Therefore, this product has its own market in long term.

3.3.3 Limitations

However, there are a few limitations of the product that could be improved in the near future.

a) Limitation of IoT platform

Since this product is using Blynks server to operate, it is unable to function there is any problem faced by the server. System down in Blynks will automatically affect this product’s functionality. This may result in no water supply from local water supply to main water tank since the valve can only open by connecting it to Blynks server. The same scenario could also happen if the Wi-Fi server in the mosque is malfunctioning. In simple words, this product will not able to function well without internet.

b) Limitation of the use of sensors

The sensors used may not able to function well all the time. There are possibilities of sensors to deliver inaccurate data which can affect the performance of water flow system. It will contribute to the higher water bills with the overflow of the water if the ultrasonic sensor is malfunction. This is because the solenoid valve cannot automatically close when the water level of the main water tank is exceed 60% and allow the water supplier (SYABAS) flows continuously to the main water tank..

c) Limitation of the use of the solenoid valve

For current stage, the solenoid valve used is unable to be close tightly, hence there is a little bit of water flow to the main water tank even though the solenoid valve is automatically/manually closed.

d) Limitation of the rainwater tank design

If there is any excessive rain water, this product wouldn’t be able to store it as it would be overflowed to other functionalities, such as fill in the water pool for shower.

3.4 Solutions

a) The solenoid valve works with or without IoT

In order to secure the product functionality and data, an application and server can be developed and used to control and monitor the product. This will cost more workload and this project will be requiring money invested in the project. If the server system is downed, it could be fixed immediately. A little modifying on the valve could help to solve any concern if the Wi-Fi or apps' server is downed. The alternative way to make sure the valve works with or without IoT is the valve should be design to function using IoT in normal circumstances but can be open manually once the product disconnected to the internet.

b) High quality of sensors to be used

To have a better result for real life implementation, a high quality sensor should be used to ensure accurate data are obtained from the product. This will lower the possibilities for the product to malfunction at times.

c) High quality of the solenoid valve to be used

By using high quality solenoid valve, it is more likely that it would able to be in close tight, so that there is no water will flow to the main water tank when the solenoid valve is automatically/manually closed.

d) Another tank for rainwater storage

Another tank could be developed to collect any excessive water that comes from the main tank to be used for other activities in the mosque.

3.5 Practicality

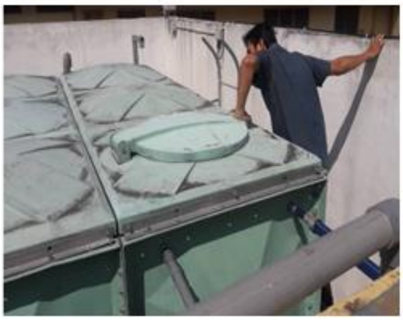


Figure 3.5.1: Water supplies (SYABAS) tank

Figure 3.5.2: Rainwater tank

Figure 3.5.3: Rainwater tank and main water tank

This product is easy to install as it is design to fit current water supply system. Looking at the design, it only required a few modifications and additional part to install this product such as the rain water catchment area, rain filter and also rain water tank. On electronic system part, the mosque should have a Wi-Fi server and also the designed circuit system to activate the product. Wi-Fi server in mosque is common nowadays, so it wouldn't be a problem for the mosque to install this product at any time. Since this product has been design to fit current water supply system, the install process wouldn't take a long time. The current water supply wouldn't be disturbed for a long time. This is a very important concern on behalf of the mosque if the current water supply stopped for a long time. This scenario will cause discomfort within visitors and the performance of mosque daily operation will be dropping. This product is also a suitable approach for any housing area or building to reduce the water bill. More studies can be done to develop this product to fit other buildings. The figures above show the actual water flow system of Masjid Al-MuttaqinWangsa Melawati.

3.6 Planning and Organizing

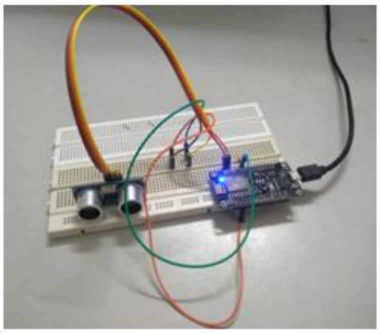


Figure 3.6.1: Testing for ultrasonic sensor

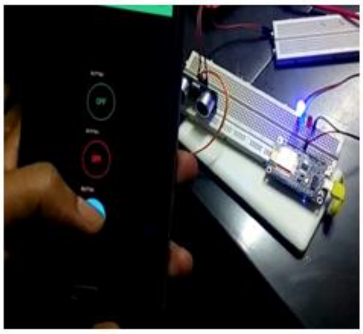


Figure 3.6.2: Testing for NodeMCU ESP8266

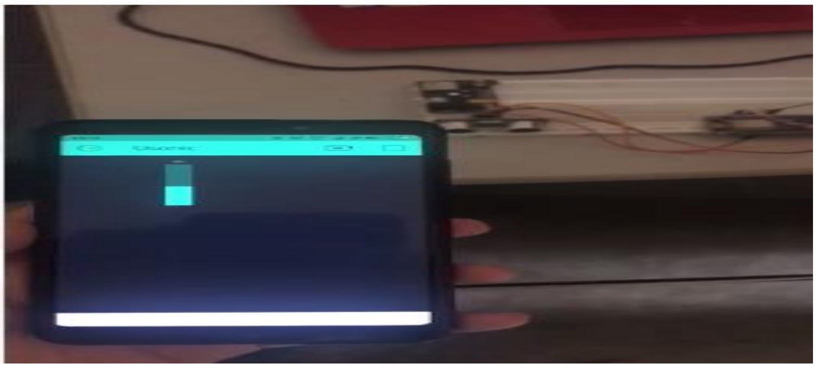


Figure 3.6.3: Use visual diagram to observe the output reading of the distance that measured by the ultrasonic sensor

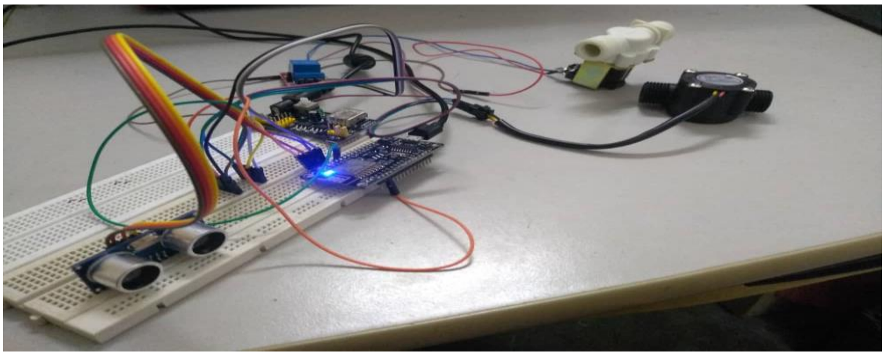


Fig 3.6.4: Implementation full project on breadboard based on the schematic diagram


Figure 3.6.5: First Prototype Design


Figure 3.6.6: Second Prototype Design

Figure 3.6.7: Final Prototype Design

In order to keep track with the arranged schedule, and completed the project before the exhibition day, the team referred to the overall project flowchart and Gantt chart. Besides, the records of team's progress are documented in the weekly report. In the weekly report, the result of meeting discussion, the progress of the product, the improvements for the product, the problems encounter during the development stage and the next plan to optimize and improved this project are explained. The figures above show the implementation of project on the breadboard and prototype design.

3.7 Cost Estimation

The cost estimation in this project is calculated as below:

Table 3.7: Estimated Cost

No	Item	Prices (RM)
1.	Mechanical Parts	250
2.	Electrical Parts	200
3.	Printing	50
Total		500

3.8 Actual costing of the project

The complete costing for the project has been tabulated in table 3.8 as below:

Table 3.8: Actual cost of project

Components and Materials Used	**Quantity**	**Prices (RM)**
Plumbing pipe & fitting	6	111.70
Canister	1	4.20
PVC 900 Elbow	4	1.88
Spray paint Silver	2	11.14
Sand paper	1	0.57
Plastic Stool	1	5.44
NodeMCU module	2	56.00
Ultrasonic Sensor (HC SR04)	2	18.00
Rectangular Stool	2	4.20
Starch compostable	1	0.20
Android USB cable	6	15.50
Nylon Twine	1	2.10
Dustbin	1	2.10
Dust Tape	1	2.10
Mamalia Square Container	1	2.10
Water Dispenser	1	17.87
GBS Foam Core Board	1	8.50
Solenoid Valve 230V	1	27.00
Relay module 5V DC	1	7.30
Ultrasonic Sensor (Waterproof)	1	56.00
Jumper Wire	6	14.00
SIRIM 13A plug top	1	2.70
3 core cable 40/0.16mm	2	5.60
AC / DC Adopter 12V 1A	1	20.50
Breadboard GL 12	1	12.00
Water Flow Sensor	1	35.00
Power Supply Board	1	8.50
LED	2	0.60
USB Male	4	4.00
Poster	1	25.00
Printing	1	11.40
Total		493.15

CHAPTER 4

4.0 Conclusion

In conclusion, this project was successfully done and completed, in which most of the results achieved as expected. Even though there are some limitations, this project did achieve the main objective as it is to ease the mosque committee to monitor and control the water flow by using IoT platform. Besides, the use of rainwater to replace water supplies (SYABAS) as the main water source could reduce the water usage from local water agency as well as the high water bill faced by the mosque. In addition, there would be no necessity for the committee to climb up the roof to check the water tanks if there is any problems. This is because this project enables the users to monitor the condition of the main water tank and rainwater tank afar continuously via Blynk app. The amount of water flow from water supplies can also be monitored according to the time set by the users. Therefore, the user will be more concise to the water usage for main water tank. Moreover, the system has its flexibility in which able to allow the user to set the minimum water level and the stopping criteria of the main water tank to allow/prevent water flows from water SYABAS into main water tank.

During the progress of the project, Smart Masjid Water Conservation Team managed to work in team, gave full commitment, abide the punctual time management planned by the team and having critical and creative thinking before presentation as well. This team also able to implement different software or tools to run every perspective of project, leads the team to become more skillful in term of circuit connection, Arduino programming, SolidWorks to develop the enclosure and even Photoshop to design the poster. To sum up, most of the tasks were performed well without major issues. In short, the overall progress is good and most of the difficulties and problems faced during the process are successfully overcome and the smart key system is working as expected.

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Appendix A

This is an attachment of the full coding with divided into two separate NodeMCU board in Arduino IDE and its explaination:

Source Code for first NodeMCU board (2 Ultrasonic sensors):

```
// Your WiFi credentials.
// Set password to "" for open networks.
char ssid[] = "huh?";
char pass[] = "qwertyuiop";


void Ultrasonic() {
  // Clears the trigPin
digitalWrite(trigPin1, LOW);
delayMicroseconds(2);
// Sets the trigPin on HIGH state for 10 micro seconds
digitalWrite(trigPin1, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin1, LOW);
// Reads the echoPin, returns the sound wave travel time in microseconds
duration1 = pulseIn(echoPin1, HIGH);
// Calculating the distance
distance1= (duration1*0.037/2)*0.909;
level1=((17.0-distance1+9)/17.0)*100;
// Prints the distance on the Serial Monitor
delay(200);

if(level1<=0){
  disp1=0;
}
else if(level1>=100){
  disp1=100;
}
```

```
else
  displ=level1;

Serial.print(" Level1: ");
Serial.println(displ);
Blynk.virtualWrite(V4, displ);

digitalWrite(trigPin2, LOW);
delayMicroseconds(2);
// Sets the trigPin on HIGH state for 10 micro seconds
digitalWrite(trigPin2, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin2, LOW);
// Reads the echoPin, returns the sound wave travel time in microseconds
duration2 = pulseIn(echoPin2, HIGH);
// Calculating the distance
distance2= (duration2*0.037/2)*0.909;
level2=((11.0-distance2+3.75)/11.0)*100;
// Prints the distance on the Serial Monitor
delay(200);

if(level2<=0){
  disp2=0;
}
else if(level2>=100){
  disp2=100;
}
else
  disp2=level2;

Serial.print(" Level2: ");
Serial.println(disp2);
Blynk.virtualWrite(V5, disp2);

  if (level1 <= 20 && flag==0) {
    Serial.println("Main Tank is Low");
    Blynk.notify("Main Tank is Low");
    flag=1;
  }
  else if (level1 >= 21)
  {
    flag=0;
  }
}

void setup() {

  // Debug console
  Serial.begin(9600);
  Blynk.begin(auth, ssid, pass);
  pinMode(trigPin1, OUTPUT);
  pinMode(echoPin1, INPUT);
  pinMode(trigPin2, OUTPUT);
  pinMode(echoPin2, INPUT);

`
void loop() {
Ultrasonic();
Blynk.run();
}
```

ESP8266WiFi Library

ESP8266 is about Wi-Fi. The Wi-Fi library for ESP8266 has been developed based on ESP8266 SDK, using overall functionality of Arduino WiFi library. By time, Wi-Fi features ported from ESP9266 SDK to ESP8266 / Arduino outgrew Arduino WiFi library and it became advanced that developer need to provide separate documentation on what is new and extra

Blynk Library

Blynk is a software that frequently used as Internet of Things (IoT) platform for connecting any hardware to the cloud, designing apps to control them and managing deployed products at scale. This library supported for board to connect to Blynk apps

Ultrasonic

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves.An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity. High-frequency sound waves reflect from boundaries to produce distinct echo patterns.Ultrasonic sound vibrates at a frequency above the range of human hearing. Transducers are the microphones used to receive and send the ultrasonic sound. Ultrasonic sensor use a single transducer to send a pulse and to receive the echo. The sensor determines the distance to a target by measuring time lapses between the sending and receiving of the ultrasonic pulse.

From this theory, source code can be calibrated by set trigger pin LOW as trigger pin does not emit sound wave at beginning. After short delay, trigger pin will emits sound wave for 10 microsecond and the echo pin will read the returns sound wave travel time to reflect back. The distance can be calculated by this delaying of returns sound wave by using formula distance = (duration x 0.037/2) x 0.909. For this project, the source code is modified to find water level base on tank size and display percentage value on how much water in the tank by using formula level = ((17 – distance + 9) / 17) x 100. The desired value display must be in percentage which range from 0 to 100. So, if else condition must be made to ensure there will no negative value or over 100.

The calibrated value for first ultrasonic can be duplicated for second ultrasonic in different tank with different size. The code is modified in level formula by using this formula: level = ((11 – distance + 3.75) / 11) x 100.

Blynk apps

The calibrated value was stored in Blynk cloud by using codeBlynk.virtualWrite(V5, disp2); for the user access to value using IoT. The Blynk apps also had extra features on giving notification on desired outcome. For this project, user will notify if first ultrasonic sensor reach value below 20 using if else condition and can be store to cloud by using code Blynk.notify("Main Tank is Low");

Source Code for second NodeMCU board (WaterFlow Sensor)

```
#define BLYNK_PRINT Serial
#define TCP_MSS whatever
#define LWIP_IPV6 whatever
#define LWIP_FEATURES whatever
#define LWIP_OPEN_SRC whatever


#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

int X;
int Y;
float TIME = 0;
float FREQUENCY = 0;
float WATER = 0;
float TOTAL = 0;
float LS = 0;
const int input = D3;

// You should get Auth Token in the Blynk App.
// Go to the Project Settings (nut icon).
char auth[] = "f45a06236ac14ade94e11f1dd8493a93";

// Your WiFi credentials.
// Set password to "" for open networks.
char ssid[] = "huh?";
char pass[] = "qwertyuiop";
void water_in(){
X = pulseIn(input, HIGH);
Y = pulseIn(input, LOW);
TIME = X + Y;
FREQUENCY = 1000000/TIME;
WATER = FREQUENCY/7.5;
LS = (WATER/360)*3.0;
if(FREQUENCY >= 0)
{
if(isinf(FREQUENCY))
{
Serial.println(TOTAL);
Blynk.virtualWrite(V6, TOTAL);
}
else
{
TOTAL = TOTAL + LS;
Serial.println(TOTAL);
Blynk.virtualWrite(V6, TOTAL);

}
}
delay(200);
}


void setup() {

Serial.begin(9600);
Blynk.begin(auth, ssid, pass);
pinMode(input,INPUT);

}

void loop() {
water_in();
Blynk.run();
}
```

Water Flow Sensor

A water flow sensor is an instrument capable of measuring the amount of water passing through a pipe. The basic working principle for this sensor is perform flow measurement through turbine rotation with a shunt, propeller, or paddle wheel design. The mechanical types of water flow meters work by measuring the speed of water flowing through the pipe that causes a piston or turbine to rotate. The volumetric flow rate of the water is proportional to the rotational speed of the blades.

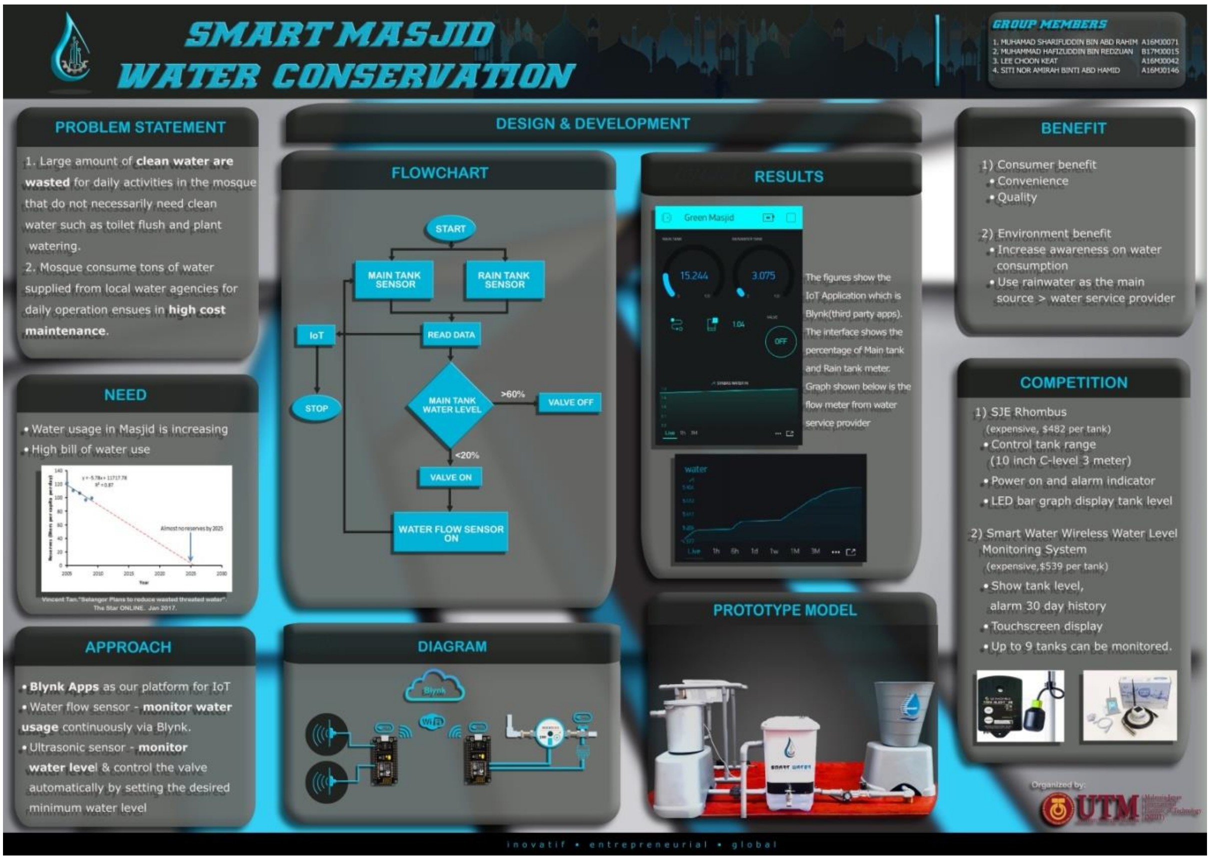
From this principle, we can calibrate the source code by using formula TIME = X + Y, FREQUENCY = 1000000/TIME, WATER = FREQUENCY/7.5, LS = (WATER/360)*3.0. Then, those value be use for next step in if else condition. For turbine in idle which is no water flow, the value should the current value without adding the water in while turbine rotate which mean there is water flow, the current volume of water will total up to get latest reading. Then this value was stored in cloud using same technique as first source code.

Appendix B

Here is the attachment of the photograph of the project development from 13 February to 16 June 2019:

Photograph for testing the components used

Photograph during the implementation of the project

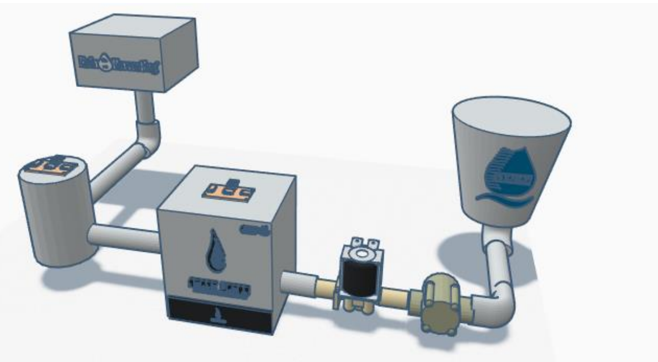


Photograph of the poster presentation

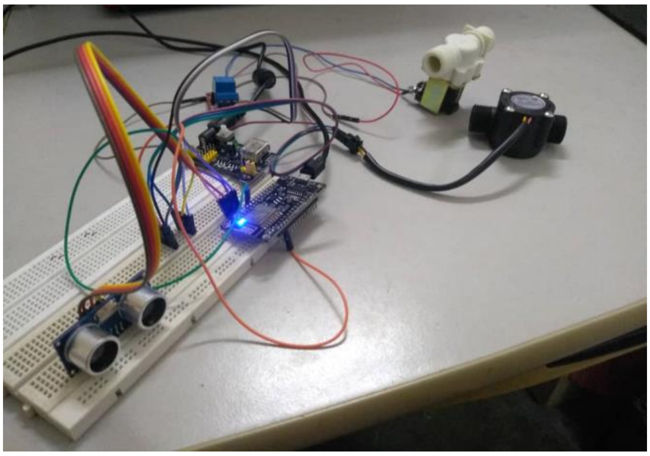
Photograph of the circuit diagram on the breadboard

Appendix C

DEVELOPMENT



Sketching



Testing

Final Product