IOT Based Flood Forecasting and Prevention System

A.A.A. Wahab, S. S. N. Alhady, W. A. F. W. Othman and H. Husin
School of Electrical and Electronic Engineering , KampusKejuruteraan, UniversitiSains Malaysia, 14300, NibongTebal, Pulau Pinang, MALAYSIA.

Abstract *— This paper introduces an application system which will help in flood disaster management. The system focus on the problem that faced by most of the villagers that do not have any system to estimate the time left for the flood to occur at their respective area for them to escape the disaster with enough time and proper plan such as saving all their valuable properties. The application will help to prevent the flood from occur and delay the time of flood to occur. Countdown timer, water pump and Arduino flow meter are used in the system introduced to prevent flood. Countdown timer will display the time left before water reach emergency level of the area, which is fixed according to the size of area × emergency height. Water pump motor will pumps out the water automatically or manually to the backup reservoir system after water has passed the emergency level. Arduino flow meter is used to measure the rain flow rate (forecasting) using principle "Hall Effect".*

Index Terms *— Hall effect, water flow rate, water runoff rate*

I. INTRODUCTION

Malaysia is one of the countries that has annually frequent flood disaster occurrence. Throughout Malaysia, including Sabah and Sarawak, there is total of 189 river basins with the main channels flowing directly to the south china sea and 85 of them are prone to recurrent flooding (89 of the river basins are in Peninsula Malaysia, 78 in Sabah and 22 in Sarawak). The estimated area vulnerable to flood disaster is approximately 29,800 km2 or 9% of the total Malaysia area, and is affecting almost 4.82 million people which is around 22% of the total population of the country (DID, 2009) [1].

Figure 1.1: Map of flood disaster occurrence in Peninsular Malaysia with number of evacuees and deaths.

Figure 1.1 above shows the places affected by flood disaster in Malaysia in 2014 and the data on number of evacuees and

deaths from the disaster [2]. Nearly 110,000 people are evacuated from their homes in five states of peninsular Malaysia as the worst floods in decades hit the country [2].

This flood prevention system is proposed knowing that the flood is the most common disaster that occur in Malaysia.

II. EXISTING SOLUTIONS

For the topic selected, "Flood Prevention System", there are actually a lots of different method been carried out all around the world in dealing with this disaster.

As forecast by the United States Geological Survey Report of Investigation No.50, in the past the priority of injection wells has been reduced flood damage by disposal of excess rain water. A dry well has been built to drain water runoff and release to an underground reservoir system, which could be a buried concrete structure that allow rain water to flow out and infiltrate to groundwater. Which underground drainage system had been introduced to be used in flood controlling [4]. Other than this, flood predictive control are introduce as well. A model which simulate a flood location and calibrated/validated accordingly from local water administration, which the model consists of the clear route on water flow for a specific location as well as detail drainage system. From this model, the flood control system is actually using as algorithm which it will calculate the water runoff for a specific area and by identifying the heaviness of stormy rain, it predicting the water inflow rate for the specific location. And from the data acquired, the percentage for the flood to happen will be calculated accordingly [5]. Different kind of flood control had been study include urban flooding control which decentralized small reservoir be place in different location throughout the city to manage the water runoff during an unexpected flood [6].

In the study above, we can know that management of water runoff is essential to prevent flood, just the matter of the sustainability of different way would affect the effectiveness and productivity of the system. According to this, we came out with an idea which fulfilled the objective of the project which is control or prevent flood as in a more sustainable way.

III. FLOOD FORECASTING AND PREVENTION SYSTEM

In this project, the issue is addressed by introducing an application which will help in flood disaster management as in delaying time for flood to occur while displaying remaining time left for flood to occur. Countdown timer and water pump play significant roles in this system. Countdown timer will show remaining time left before flood occurs while water pump willautomatically or manually pump water to the backup reservoir system. Arduino flow meter is used to measure water flow rate and it works on the principle of “Hall Effect”. “Hall effect” is the generation of an electric potential perpendicular to both an electric current flowing along a conducting material and an external magnetic field applied at right angles to the current upon application of the magnetic field. Hall Effect is put to use in the flow meter using a small propeller shaped rotor which is placed in the path of the water flowing. The water will push against the fins of the rotor, causing it to rotate. The shaft of the rotor is connected to a hall effect sensor. It is a positioning of a current flowing coil and a magnet connected to the rotor shaft. Thereby, a pulse is induced as this rotor rotates. For every litre of liquid passing through it per minute it outputs certain pulses. This is due to the changing magnetic field caused by the magnet attached to the rotor shaft. The number of pulses can be determined using an Arduino. Water flow rate in Litre/hour can be calculated using a simple conversion formula:

$$Water\ flow\ rate\ \left[\frac{litre}{hour}\right] = Total\ pulse\ count \div Pulse\ count\ per\ litre\ \div 60$$

By implementing this system, flood can be prevented from happening. This system can delay the time for the flood to occur too. This precious time can be used for rescuing process and the people can plan their way out properly and safely. Finally, the reservoir system can be kept as backup water supply too [3].

IV. MATERIALS AND METHODS

MATERIALS

Before we build the proposed design *(prototype)*, there are some requirements that the design should meet which are: 1)The design must be able to function according to the variables (situations) *(solution 2 – flood prevention)* 2) User can enter input such as the area of the village and the emergency level) *(solution 1 – flood forecasting)*

There are 5 cases of real situations that taken into consideration while designing the system.

A. Arduino MEGA

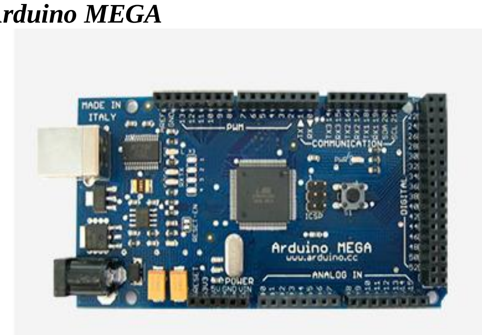

Figure 4.1 Arduino MEGA

As we know Arduino is an open-source project that created microcontroller based kits for building digital devices and interactive objects that can sense and control physical devices. Well, Arduino Mega is a microcontroller board based on the ATmega1280. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.

In this project, the microcontroller Arduino will read the data from the flow rate sensors which will work according to the principle of “Hall Effect” as explained in previous section, through the code developed in Arduino. The data acquired then will be processed by Arduino and we preset the area, the water outflow rate and the emergency depth beforehand.

B. G1/2 Water Flow Sensor Fluid Flowmeter

Figure 4.2 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.The water flow sensor is applied for water heater, and can be used as flow switch. Straight structure, nylon and glass fiber made, waterproof and explosion-proof, heat and cold resistant. Portable size and light weight, easy to install. With stainless steel ball inside of the impeller, wear-proof. Provides three wire connection: Red for positive, black for negative, yellow for pulse signal.

Data processing consists of Arduino and water flow as the input data. The microcontroller Arduino will read the data from the flow rate sensors which will work according to the principle of "Hall Effect" as explained in previous section, through the code developed in Arduino. The data acquired then will be processed by Arduino and we preset the area, the water outflow rate and the emergency depth beforehand.

C. Peristaltic Water Pump

Figure 4.3 Peristaltic Water Pump

A peristaltic pump is a type of positive displacement pump used for pumping a variety of fluids. The fluid is contained within a flexible tube fitted inside a circular pump casing (though linear peristaltic pumps have been made). A rotor with a number of "rollers", "shoes", "wipers", or "lobes" attached to the external circumference of the rotor compresses the flexible tube.

In this project, the water pump will pump the water out to the *backup reservoir system*, manually or automatically. The water pump will start pump out the water to the reservoir system 1) Manually: When the user *(villagers/area's resident)* manually change the emergency level 2)Automatically: When the water passed the emergency level of the village//residence.

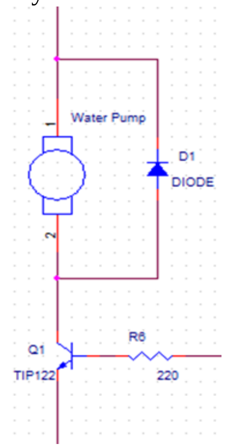

Figure 4.4 Part of the circuit (water pump)

At the switch on water pump circuit, we use the PWM port to connect with the transistor, TIP 122 that to switch on the motor when the analog output send from the PWM pin. Pulse width modulation (PWM) is to use for getting the analog results with digital means. We use the PWM, so we can change the duration of the "on" time which means the pulse width. We repeat the on-off pattern fast enough then the signal produced is steady voltage between 0V and 5V. Thus, the motor speed can be control by us. If we use the digital pin, there is always 5V to switch on the motor, then the motor speed is very fast and cannot control by us. For our project, we use the scale is 255 which is 100% of the duty cycle.

The diode that connected parallel with the motor is needed to protect the transistor again the voltage generated from the batteries when the transistor is switched off and on rapidly. The diode will short circuit the high voltage to protect the transistor.

The resistor connect at the base is to prevent when the pin of PWM short to the ground directly.

The calculations for the transistor, TTIP 122:

$$I_B = \frac{V_o - V_{BE}}{R_B}$$

$$I_C = \beta I_B$$

$V_o = 5V, V_{BE} = 0.7, R_B = 220\,\Omega, \beta = 20$

Thus,

$$I_B = 20mA$$

$$I_C = 400mA$$

D. LCD 16×2

Figure 4.5 Liquid Crystal Display

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom character (unlike in seven segments), animations and so on. A 16x2 means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

In this project, Liquid Crystal Display (LCD) is used to display the time, t left for water to reach emergency depth level.

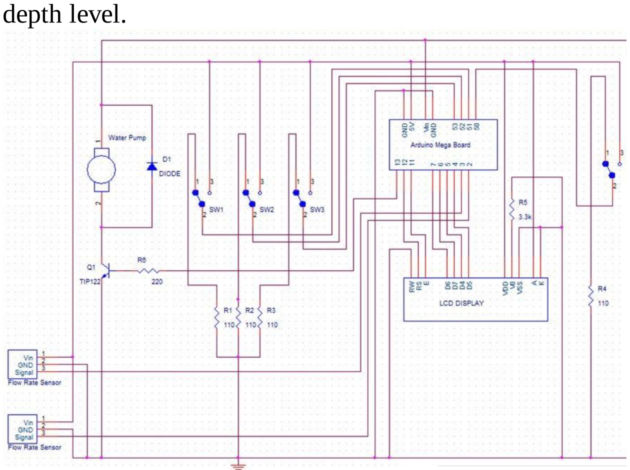

Figure 4.6

METHODS

Small rain and heavy rain are taken into consideration while designing the system along with some geographical and water drainage system study.

Figure 4.6 below shows the program flow chart.

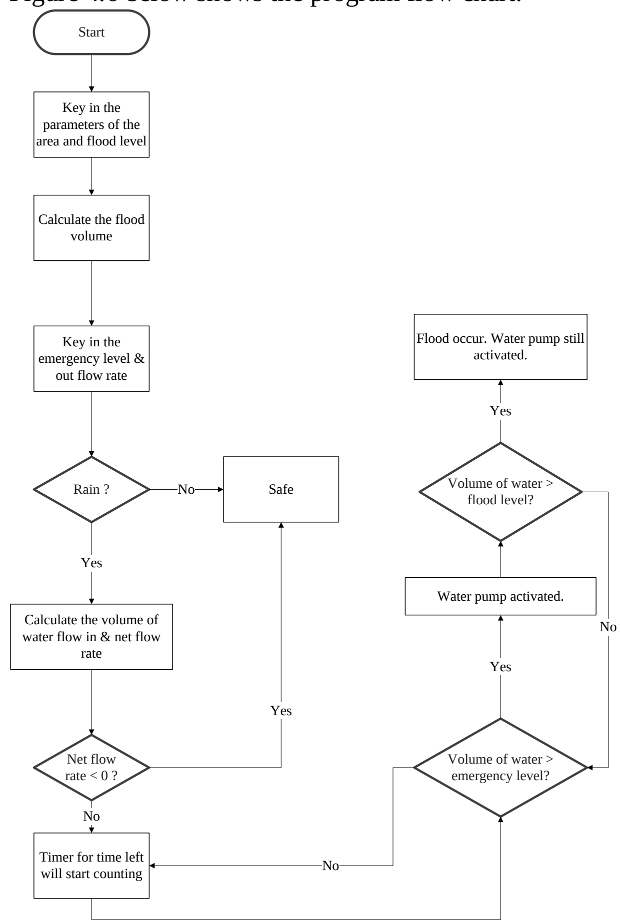

Figure 4.7 Program Flow Chart

Figure 4.8

Figure 4.9

Figure 4.10

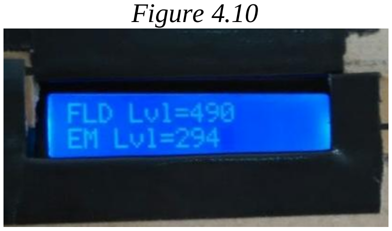

Figure 4.11

Figure 4.8, 4.9 4.10 and 4.11show the LCD display the preset data by users:

1) Length, width, flood level (height)
2) Emergency level
3) Outflow rate

Outflow rate is the flow rate of the water runoff (drainage system) of the village.

A. Flood forecasting

In this project, the flood forecasting is the early solution the system is designed to operate for. As mentioned in previous section, the system is user interactive. The user will have to enter1)the area of the village, 2)the emergency level and 3)flood level and they will be displayed on the LCD. From these inputs, through calculations in coding, we obtain the **volume(1)**of water needed to fully flood the area of the village.

From the water flow sensor, we will able to measure the heaviness of rain as in

volume (2)/time/area

From the calculation, we can obtain time left for the water to reach emergency level and flood level through the equation

Figure 4.6 Rain Water Collection Dock

Time Left = Volume 1 / {(Volume 2 /time/area) * {area[1]/area[2])}

Which

Volume (1): obtained from the inputs by user (area of the village)
Volume (2) : volume obtained from the area of water dock
Time : time calculated
Area 1 : area of the village
Area 2 : area of the water docking (fixed)

There are two cases of real situations that applied to this flood forecasting system which are:

a) *Case 1: No rain*

b) *Case 2: Small rain*

B. Flood prevention

Flood prevention is the solution for next two cases-worse than case 2 that are

a) *Case 3: Heavy Rain*

b) *Case 4: Super Heavy Rain (reached emergency level)*

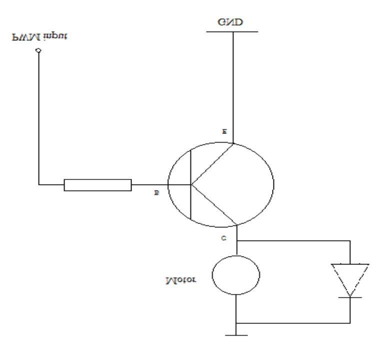

Figure 4,6 Circuit of the water pump motor

V. TESTING AND RESULTS

Water Flow Sensor

Before proceeding the project testing, we first do a calibration factor testing to decide water flow sensor flowmeter position.

Position	90°	45°	0°
Calibration factor	Volume (L)		
4.5	7.0	6.0	5.0
5.5	5.0	4.4	3.8
6.5	4.5	3.3	2.6
7.5	3.3	2.6	1.8
8.5	2.5	1.8	1.4

Table 5.1

After a few tests , the most suitable position for water flow sensor placement is at 0°. The correct location of sensor in the piping system is important to ensure a proper flow profile in the pipe. Sufficient straight pipe immediately upstream the sensor to create “fully-developed turbulent flow.” This will provide the stability required for the rotor to measure the rate of flow accurately.

Figure 5.1Location of the water flow sensor in piping system of the project (0°)

RESULTS

The results were done based on five cases of different situations for flood to occur.

Figure 5.1

Figure 5.2

For the flood and emergency level that user key in: length, L is 14cm, width, W is 7cm and height, FLD Lvl is 5cm, emergency level, “EmergrncyLvl” is 3cm and the out fkow rate of drain for village, “OutFlowRate” is 10ml/s.

Figure 5.3

System will show out the flood level and emergency level for user to see.

CASE 1 : NO RAIN

Figure 5.4

In case 1, there is no water flow through water flow sensor. In figure 4.9 above, the LCD displays the total milliliter **(TML)** in the box (village) which is initially **0**and net flowrate **(NetFR)** which is initially **-1****0** without the water runoff drainage system.

CASE 2 : SMALL RAIN

In case 2, there is only little water flow through the flow sensor and the net flow rate increased because the water runoff flow rate also increases.

Figure 5.5

CASE 3 : HEAVY RAIN

In case 3, the rain is heavier and the flow rate of the water through sensor is higher. The net flow rate is bigger than 0 and the countdown timer will appear on LCD screen. The timer will start counting for time left (in second) for water to reach the emergency level.

Figure 5.6

Figure 5.7

Figure ** show the net flow rate of water and time left for the water to reach emergency level in seconds.

CASE 4 : SUPER HEAVY RAIN

The water flow rate is higher than in case 3 and the waterpassed the emergency level. The water pump motor is activated and pumps out the water to the reservoir system.

Figure 5.8

Figure 5.9

Figure 5.10

CASE 5: FLOOD OCCUR

In case 5, the water has reached the flood level, and the water runoff (water pump out to reservoir flow rate + river/water drainage/out flow rate) is still lower than the rain water flow rate but the water pump motor is still activated.

Figure 5.11

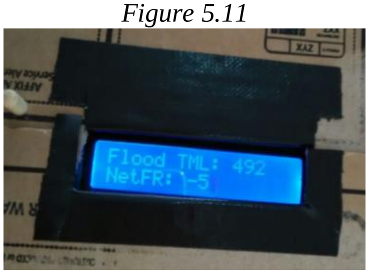

Figure 5.12

Figure 5.12 shows that even after the rain become small (the net flow rate is lower than 0), and the water level is decreasing, the motor is still activated since the water is still exceeding the flood level.

Figure 5.13

Figure 5.13 shows that even the rain stop (NetFR is -25, which mean the motor pump flow rate plus the out flow rate of village) the water level has decreased to below flood level. The motor is still activated because the water level is higher than the emergency level.

Figure 5.14

The motor will stop only after the water has reached below emergency level (Water level, TML is lower than the emergency level).

IV. CONCLUSION AND FUTURE WORKS

For this project, we chose to make a flood forecasting and prevention system. After studying about the common disaster in Malaysia, flood is the worst disaster with high number of deaths and damages, and also causes other disaster such as landslides and commonly occur in rural areas. Some of the victims that were succeed in evacuating could not save their belongings due to insufficient time. So we came up with the idea of building a system that will display the time left before flood occur for the villagers to start evacuate and save their properties. The countdown timer will alert the villagers so that the villagers will take action earlier than before we placed the timer in the area. Through this initial thought, we decided to add on an extra feature to our project. We decided to build a reservoir system to delay and prevent the flood from occurring by pump out the water from the village when the water has reached the dangerous level. This is how our ideas expand and build our project.

REFERENCES

[1] S. G. D/iya, M. B. Gasim, M. E. Toriman and M. G. Abdullahi, "Historical Reviews, Causes, Effects, and Mitigations Approach," Floods in Malaysia, vol. 2, no. 4, p. 59, 2014.

[2] A. Gartland, "Changing Times," 27 December 2014. [Online]. Available: https://time2transcend.wordpress.com/2014/12/27/mass-

evacuations-as-northern-malaysia-is-deluged-by-floods/. [Accessed 23 11 2016].

[3] G. J. Lim, K. Ramaya, H. L. Yeoh, N. H. Hashim and M. I. Mukhtar, "Flood Prevention System," 2016.

[4] N. A. Josol, "The Feasibility of Eliminating Flood Problems in Manilla Through a Flood Water Conduit," 11 March 2014. [Online]. Available: http://prezi.com/nhbhbmavazia/thesis.

[5] P. W. P.-K. C. K. C. B. D. M. a. J. B. T. Barjas Blanco, "Flood Regulation by means of Model Predictive Control," 2014. [Online]. Available: ftp://ftp.esat.kuleuven.be/sista/tbarjan/reports/CurrentChapter.pdf.

[6] L. JongSun, "Water Stops : Study on New Type of Flood Control System," 2013. [Online]. Available: http://ced.berkeley.edu/downloads/thesis/arch/ucb_ced_march_2013_lee_jongsun.pdf.