SMART ALERT FLOOD SYSTEM USING GSM

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Abstract

Flood disaster is a natural phenomenon which can occur anytime and anywhere. This flood disaster is not a new thing for Malaysian since Malaysia is located near the Equator. This disaster occurs due to improper irrigation method in housing area or sudden increase of water volume in a river because of heavy rain or monsoon season. For the safety precaution, a notify message should be sent to the people at early stage to avoid any losses of property, damages and people's life. This system design of an earlier flood alert system which can detect the water level by using ultrasonic sensor. The objectives of this research are to determine the water level of flood, to send a message to people about the flood's condition, the delay time taken for a message reach to the people and to reduce the power consumption by using solar compare to other supply. The system is developed by Arduino Mega, Ultrasonic HC-SR04 Sensor and GSM modem technology. This research focuses on monitoring water level which used Global System for Mobile communication (GSM) to send Short Message Services (SMS) to communicate the data from Ultrasonic HC-SR04 sensor and then sent a warning message to the people through their mobile phone. This system had improved in the delay of sending of SMS, power consumption of solar system and detection of ultrasonic sensor.

Keywords: Flood, Ultrasonic Sensor, Global System for Mobile communication (GSM), Short Message Services (SMS), Solar System

1. INTRODUCTION

Floods are a natural phenomenon that is beyond control of the human being. This phenomenon happens almost every year in Malaysia during the monsoon season due to climate changes heavy rainfall and strong winds. The phenomenon causes an enormous effect like losses of property, damages and harm to the people who live nearby the flood area. The worst flooding caused by monsoonal rain is happened in December 2014. This flood occurred some states in Peninsular Malaysia such as Pahang, Terengganu, Kelantan, Perak, Johor, Selangor and Perlis and also affected to the Sabah state in East Malaysia. This massive flood evacuee about 235,218 people and at least 21 people dead in past flooding. The total damage of these flood disaster is about RM1 billion (Malaymail, 2015).

About 90 percent of the damage in Malaysia comes from natural disaster caused by flood [1]. These disasters cannot be eliminated, but the effect after a flood can be reduced if there have an advance warning system which could reduce the loss of people lives, damages and trauma of disaster. There is need in early stage of safety precautions to avoid problems because of the flood.

Extensive research has shown that the flood's problem can be overcome by develop a suitable alert system that can give continuous alert of flood's information before the condition becomes worst and critical. The increasing of water level at the river normally caused by the heavy rainfall at night which most of the flood victims are not aware about it. The existing early warning system technologies already available but this system still insufficient in systems in terms of basic capacities such as equipment, skills in maintaining the system and resources for the system. Although some research has been carried out on flood system, it just designed an early flood alerts that only detect one meter of water height and send a warning message with notifying the current condition of the flood (K. Endrowednes, S. Leonardy, and D. Jessie, 2010, p. 173). However, that system has been upgraded to control the water level via SMS (Izzatdin. Azyan, Nazleeni and Mazlina, 2008). Some of the research used liquid sensor as their sensor to detect the level of the water flood. This kind of sensor has their own advantages such as ability of detection for liquid substance. In this liquid sensor they used other sensor like reflective, NPN type. In Pahang, there have The Department of Irrigation and Drainage also known as InfoBanjir.

Previously published research studies, the flood have been established via internet-based National Flood Monitoring System. Over 300 wired sensor have been placed at remote site for InfoBanjir system feeds on real time data source, and this system can be accessed through the internet. This system only monitoring and forecasting for the State of Pahang by using SCADA (Ping Ultrasonic Sensor datasheet, online). This is a good monitoring and forecasting system but it should have an additional system that can give early warning to the people and flood victims in fastest way such as SMS. Using GSM because it can provide low cost of mobile and base station and it is easily compatible with other system such as Integrated services Digital Network (ISDN). GSM also covers a wider coverage of rural areas, major cities and without roaming charges. This system can be more flexible in which the water level can be customized by the people through SMS (Short Message Service) and the water height can be detected four meters. This system also can detect three types of flood level, condition: safe flood level, warning flood level and danger flood level with a maximum water level detection of four meters.

In this research, this Smart Alert System aims to create a water level device equipped with a microcontroller and a GSM which can send a message via SMS to the specified phone numbers in order to notify people when an area that are prone to flood area. The GSM can send SMS as long as the people are covered by GSM signal in that area. This system able to customize the water level boundaries with alarms.

2. METHODOLOGY OF SYSTEM

This Smart Alert Flood System can be separated into three main parts: ultrasonic sensor, Arduino Mega as the microcontroller and the GSM to send SMS to people. The solar cell is used as a voltage source for the whole system by consuming direct irradiance from the sunlight, therefore the system can easily supply the power even there is no electricity when the flood happen. This solar can be replaced on the riverside to detect the water level. This solar panel also can be used when there is no electricity in the flood area because the solar is fully charged by the sunlight and stored into the battery. The charge controller will display the battery condition. The microcontroller has to control the ultrasonic sensor that function to measure the distance of water surface and sending the water level condition data that received from the ultrasonic to the GSM through the SMS. The main design of the Smart Alert Flood System is shown in Figure 1.

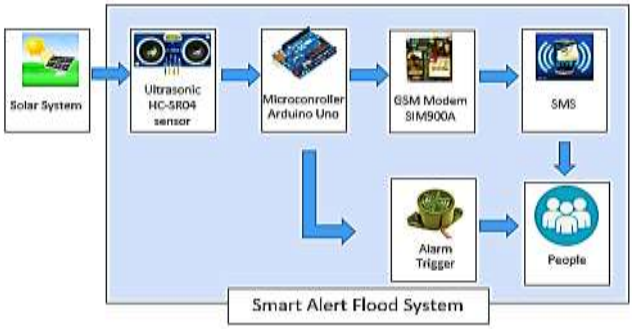

Fig. 1. Block diagram of Smart Alert Flood System

2.1. Measuring Water Level Using Ultrasonic Sensor

The ultrasonic sensor is a sensor which make easy to measure the distance of water and requires a very low-cost, this sensor can detect the distance between 2 cm to 400 cm. The ranging accuracy of ultrasonic

can reach to 3mm. It also can be used for moving and stationary objects (Ping Ultrasonic Sensor datasheet, online). This sensor, includes ultrasonic transmitter, receiver and control circuit. The sensor works by using IO trigger for at least 10μs high level signal, the sensor will automatically send eight 40 kHz and detect either there is a pulse signal back. If the signal back, through high level, time of high in IO duration is the time from sending ultrasonic to returning.

$$Distance = \frac{high\ level\ time\ X\ velocity\ of\ sound(340\ x\ t)}{2}$$

The distance of water can be calculated by the above formula, which $\frac{(340.t)}{2}$ is the distance between transmitted ultrasonic sensor to reflect and t is the time difference between transferred waves by the ultrasonic and receiver from the ultrasonic. This time period also called as cycle period which suggested not less than 50ms (Let's Make Robots, 2011).

In this system, the microcontroller Arduino Mega will process all the sensor reading. The ultrasonic sensor is placed in the PVC pipe horizontally to protect the sensor from any disturbance of the nearby area. At bottom part of the PVC pipe has a small holes to allow water flows into the PVC pipe. Then, the sensor can make the reflection of the water process. The tank is used to test the system before put it into the river. This simulation is to determine the water level precisely with the distance of one meter. The system is shown in Figure 2.

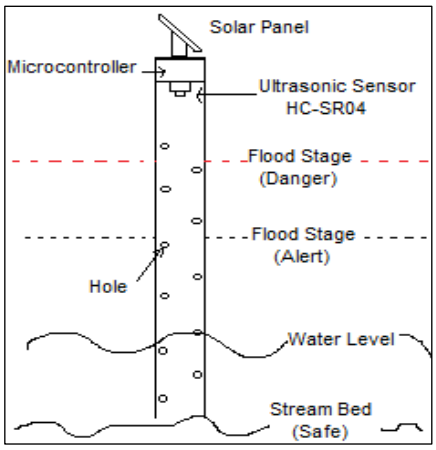

Fig. 2. Smart Alert Flood System in simulation tank

2.2. Notification Message through SMS

This Smart Alert Flood system is create to give a warning notification to the people through the SMS. The GSM and the Arduino Mega as microcontroller plays main role in the communication network in the system and people. This system can give information about the water level condition of the flood prone area through LCD display. This type of GSM SIM900A is a specific type of modem, which receives a SIM card and function same as a mobile. The function is same like mobile phone (B. Ramamurthy, S. Bhargavi, and R. ShashiKumar, 2010), which can receive, send the SMS and making or receive a call from the people. The system of SIM900A to microcontroller is shown in Figure 3.

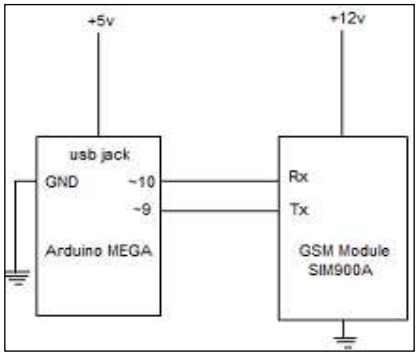

Fig. 3. Circuit diagram of GSM to Arduino Mega

GSM modem can receive and sends messages from the number that has been saved into mobile device by using radio waves (Nitika and S. Jindal, 2011, p.157-161). AT commands are used in Microcontroller and GSM modem for sending and receiving messages. The benefit using this microcontroller is a low power consumption, high performance and memory can erasable read only (Ultrasonic Sensor, online). The main controller in this system is microcontroller, which works in 3.3-5V. The SIM900A modem works at 3.5-4.5V.

2.3. Microcontroller Arduino Mega

Table 1. The specification of Arduino Mega

Data	**MEGA**
Microcontroller	Atmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

The Mega 2560 is a microcontroller board which is based on the ATmega2560. It contains of 54 digital input/output pins which 15 of them can be used as PWM output, other 16 is an analog inputs, 4 UARTs (hardware serial ports) for TTL, a 16Mhz crystal oscillator, USB connection for a simply connect it to a computer or power it with an AC-DC adapter power jack, an ICSP header and also a reset button. To configure the Arduino must use the Arduino Software (IDE) and then start doing the system coding and connect all the electronic components on the board. The board can operate on the external supply of 6 to 20 volts. The Arduino Mega board has 256 KB of flash memory for storing code which 8 KB is used for the

bootloader, 8 KB of SRAM and 4 KB of EEPROM which can be read and written with the EEPROM library compare to Arduino UNO that only have 32 KB of flash memory which 0.5 KB is used for the bootloader. The specification of Arduino Mega is shown in Table 1.

Besides, Arduino Mega has a resettable polyfuse which can protect computer's USB ports from being short and overcurrent. This fuse provides an extra layer of protection if the current more than 500mA is applied to the USB port, the fuse then will automatically cut off the connection until the overcurrent is removed. The Arduino Mega is shown as in Figure 4.

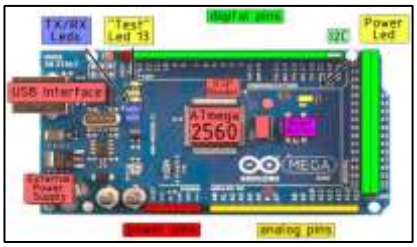

Fig. 4. The Arduino Mega 2560 board

2.4. Voltage Source from Solar System

This Smart Alert Flood System is using Solar System as a voltage source. This voltage needs solar panel, charge controller and battery. A charge controller is an essential part of nearly all power system that charge batteries. It has their own benefit such as to keep the batteries properly fed and safe for the long term. In this system, the power is being used more than watt rated output, which highly recommended to use a solar controller. This controller preventing from overcharge, prevents battery discharged at low or no light conditions, and it also can improve the charge quality of the solar system. Figure 5 below shows the connectivity of a typical solar power which including a solar panel, a solar charge controller, a battery and the Arduino Mega. The solar panel connects to the controller through the positive and negative leads, only creating a charging function when the controller is connected to the battery. The loads from Arduino Mega then responsible for discharging function from controller.

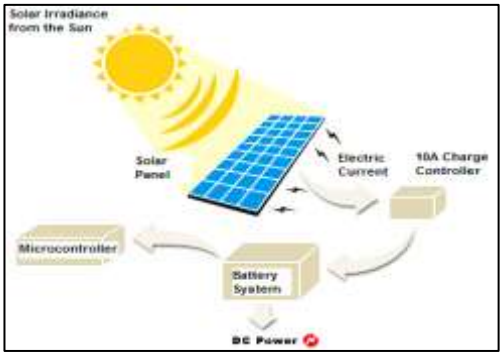

Fig. 5. Solar system

3. RESULT AND DISCUSSION

In this system, there are divided into 3 parts to be tested: the Ultrasonic Sensor, the output GSM (SIM900A module) for flood warning system that send SMS to the people, the consumption of power system and delay time of SMS delivered to people.

3.1 Ultrasonic HC-SR04 Sensor

Table 2. Flood level condition

Flood Level	**Condition**
Level 1	Safe
Level 2	Alert
Level 3	Danger

This Ultrasonic Sensor can detect a range between 2cm to 4 meters which can function through 5V supply. For this research, the sensor's function is to measure the distance between the water surface and ultrasonic sensor to get distance of water which indicates the flood condition as in Table 2. For level 1 the condition is safe which detect flood level above 100 cm, level 2 is the alert condition which detect the flood level between 50cm to 100cm and last level is danger condition which detect flood level below than 50 cm. This data from ultrasonic will be sent to microcontroller and the GSM will sent a message to the people.

Table 3. Result of ultrasonic sensor

Length (cm)	**Result (cm)**	**Error (%)**
5	5	0
10	11	-10
20	21	-4.76
30	31	-3.26
40	41	-2.44
50	52	-4
60	63	-5
70	71	-1.43
80	79	1.25
90	88	2.22
100	99	1.00
120	118	2.5

The data have been collected when the ultrasonic sensor is located in the PVC pipe compared which the

real distance detected an object is showing in average percent of error is 3.16% and result is shown in Table 3 above.

The HIGH pulse of ultrasonic sensor comes from microcontroller function as triggering the object detected. After that, the sensor will send out 8 cycle burst of ultrasound at 40 kHz and raise its echo. The ultrasonic sensor and the Arduino Mega microcontroller can directly connect without any additional circuit. Timing Diagram of Ultrasonic Sensor can be seen in Figure 6 (Nitika and S. Jindal, 2011, p.157-161).

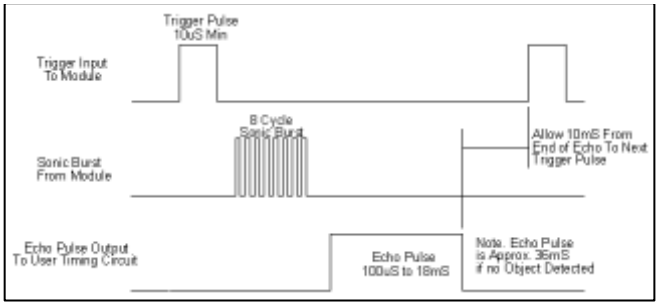

Fig. 6. Timing Diagram of Ultrasonic Distance Sensor

This sensor can works better when located inside the PVC pipe compared to outside the PVC pipe. This is due to reflection of echo occur outside the PVC pipe. Therefore, the best ultrasonic work is within a plane angle of 30°. One of the factors that affect the transmission and reflection process of the sensor is the diameter of PVC pipe that used. The angle of ultrasonic sensor is shown in Figure 7.

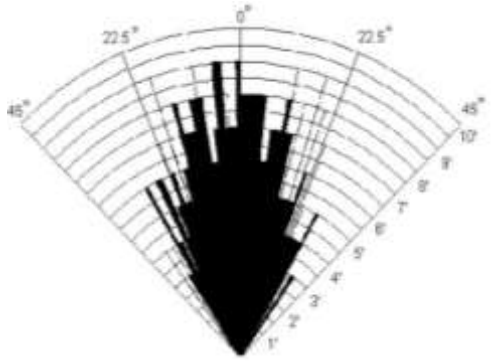

Fig. 7. Measuring angle of HC-SR04 Sensor

3.2 GSM SIM 900A

The result shows that the GSM can make a call, sending or receiving SMS and also store phone numbers into a phonebook SIM card that used. In order to send SMS to the specific numbers that has been stored in the SIM card, the microcontroller must give ATcommand to GSM. Figure 8 shows the flowchart between GSM and ultrasonic sensor.

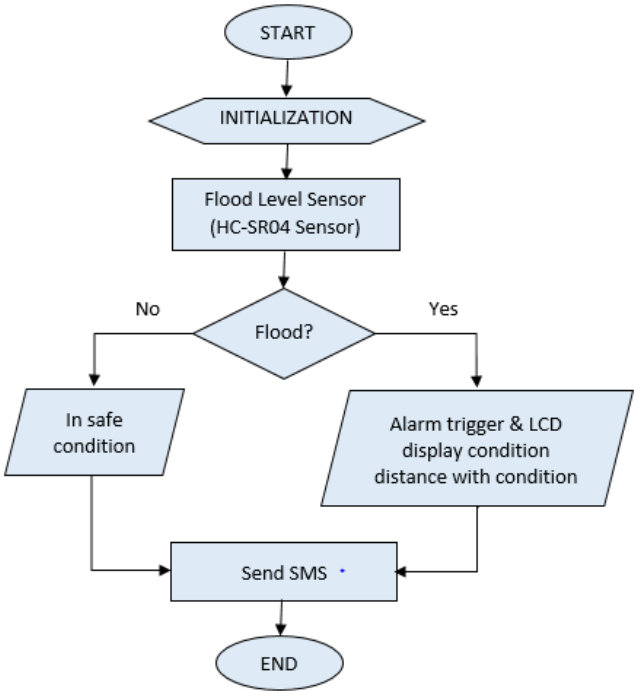

Fig. 8. Flowchart between GSM and ultrasonic sensor

This Smart Alert Flood System can send messages to two people only and that number need to be saved into the SIM card and system. That number must requires twelve digits of hand phone numbers.

When the sensor trigger the water level increase, it will send the data to microcontroller, then the system will send a SMS to the people that the water level has reached at a certain water level condition. This system can easily be placed at any river because the system is setting at zero point off water levels. Figure 9 shows the examples of SMS received from the smart alert flood system.

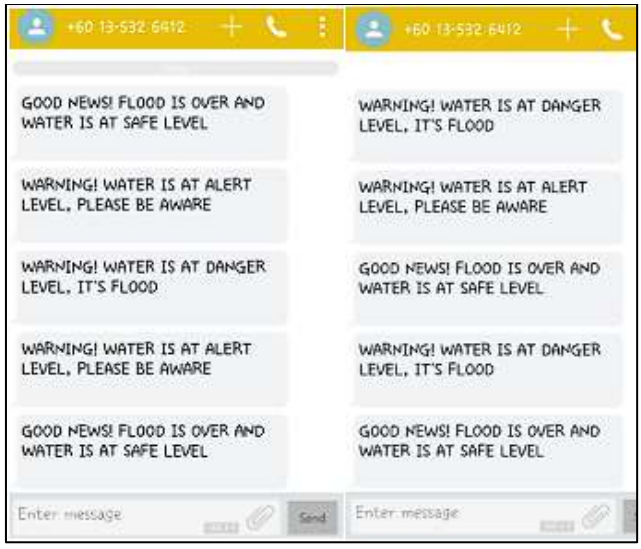

Fig. 9. Display of message notification

Table 4. Delay time of sending SMS

Type of Telco	Time, s	
	SMS 1	SMS 2

	(normal)	(busy)
Celcom - Celcom	3.00	8.25
Celcom - Umobile	5.05	9.15
Celcom - Digi	4.33	9.03
Celcom - Maxis	4.26	9.34

For this part, it will discuss about delay of SMS receive by the people. Smart Alert Flood system send the SMS when the sensor detect the water level increases to the flood level. Table 4 shows the time that have been recorded during the receiving process of SMS with different type of Telco in GSM. For the SMS 1 in table shown that the time taken to is different as time taken in SMS 2, this is because of signal in GSM is different. All type GSM have their strength and weakness signal base on certain place (N. F. Ab Aziz and N. A. Mohamad Ali, 2013, p.2319). Besides, the material and pattern building on GSM downlink signal also might cause of power losses. Normally, the signal moved from the outside to inside of building and the path loss is increase (P. Elechi and P. Otasowie, 2015, p.609). Based on the result at table 3, the best of time taken for Telco send SMS is between Celcom because it take about 3 seconds which shorter than Celcom to Maxis which take almost 5s to send the SMS to the people.

3.3. Solar System

Table 5. Lifetime of battery requires depend on current

Parameter	**Minimum current (88mA)**	**Maximum current (130mA)**
V_{system}	12 V	12 V
I_{system}	88 mA	130 mA
P_{system}	1.056 W	1.56 W
E_{req}	25.34 Wh	37. 44 Wh
C_{bat_req}	2.64 Ah	3.9 Ah
$T_{lifetime\_battery}$	3 days	2 days

The voltage source for this system is a solar system which requires of 5Watt of 12V solar cell, 10A of 12/24V solar charge controller that function to monitor the input and output between solar cell and battery that used as an energy store of solar cell direct from sunlight. The 8.2 Ah Lead Acid battery is used to store energy that penetrates the solar cell direct from sunlight. Therefore, the voltage produce by the battery is 12V and the current supply for one hour is 8.2Ah. The value of current for this system is about 88mA-130mA and the

parameter that requires for the battery is shown in Table 5.

If the system is not sending SMS to the people, the current used in this system is about 88 mA, then the lifetime of battery is about 4 days. When the system sending SMS to the people, the current slightly change to 130 mA and the battery lifetime is about 3 days. The performance of a battery can be affected due to several factors such as changes in battery temperature, the discharge of the battery, and the age of the battery.

3.4. Power Consumption

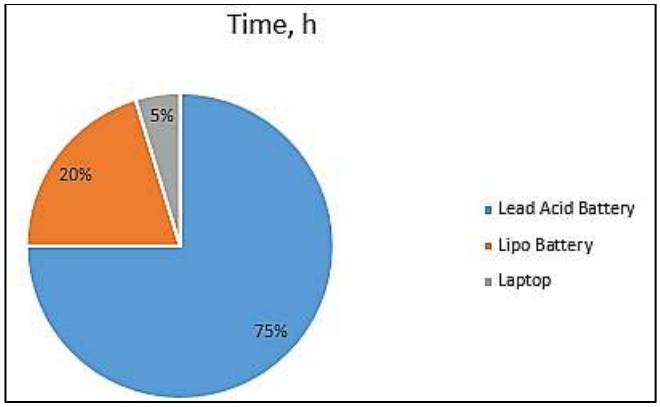

Fig. 10. Lifetime of batteries supply voltage

The Figure 10 shows the pie chart for the lifetime of battery function when apply it in the Smart Alert Flood System. For the first battery, the system used 8.2Ah Lead Acid battery which can survive about 3 days compare to the Lipo battery which can function about 26 hours. These two batteries are injected to external power supply of Arduino Mega. Moreover, for the laptop supply use USB cable to the USB interface Arduino Mega to power up the system. As shown in the pie chart above, the time taken for laptop supply last is about 6 hours.

Table 6: Comparison between lifetime and battery type

Supply	Time, h	Price, RM	Weight, g	Size, mm
Lead Acid Battery	96	58	2000	151x65x95
Lipo Battery	26	40	32	46x26.5
Laptop	6	150	327	180x32

Based on the result, the best and the suitable supply for the Smart Alert Flood System is Lead Acid battery because it can supply within 3 days, large capacity to store the energy and the price is affordable as shown in Table 6 above.

4. CONCLUSION

This Smart Alert Flood System using GSM are successfully well designed and function. This system will be continued to be refined so that it has the reliability and small error rate. This research have been achieved the objectives this system to notify the water level of flood then the water is increasing at the river. The best and effective alert communication tools for this system are SMS because it can spread the information to flood victim in the particular area also to rural area. It is designed to send the SMS to two people which number have been saved and will send a warning SMS for each warning condition. This system also will

automatically notify the people if the flood is in safe condition. The ultrasonic sensor as the water level sensor work well in the PVC pipe. It can measure the maximum distance of 4 meters from ultrasonic and water surface, but in the PVC pipe, the ideal distance or measuring the water height is 3 meters with a minimum PVC diameter of 8 inches. This system has alarm that can be beneficial to the people that prone to flood area as a precautionary action before the flood happened to avoid loss of lives, trauma from disaster cause by flooding and property damage. In addition, this system can reduce the power consumption about 30% when using solar system that stored energy in the lead acid battery.

5. RECOMMENDATION

Further studies is on the wireless sensor that can give precise and accurate detection of water level thus will improve the data get from the system for future monitoring and controlling station. Furthermore, the display of information could be upgraded to LED display boards for the road user and should be placed at strategic area for safety reason. The current power supply is powered by solar cell, this solar system is easy to install and maintain. This solar system can be improved by combine with other power source such as micro hydro system near the river. The combination of these kind of renewable energy could save the waste of electricity.

6. ACKNOWLEDGMENT

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