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Automatic Flood Barrier Monitoring System using Programmable Logic Controller

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Abstract: Every year, there are so many regions across the world facing flood problems. The severity of the flood can destroy the area around the house and the destruction caused many flood victims homeless. Flood barriers exemplify the automation of flood control solutions for the sake of quick but efficient response. Thus, the flood barrier based on Programmable Logic Controller (PLC) was proposed in this project. With the capabilities of self-activating and self-closing floodgates, these flood barriers can rise automatically with the rising flood waters keeping some regions less affected by the flood. Three different water levels are set to 1 cm, 2.5 cm and 4 cm for the prototype and the angle for the DC motor to rotate are $30°, 60°,$ and $90°$ respectively. There is also a monitoring system that can be observed in real time and activated remotely by pressing a button using a cell phone. Water pump act as removal of water from inside the house yard to the outside of the house.

Keywords: Flood Barrier, PLC, Self-Activating Gate, Self-Closing Gate.

1. Introduction

Floods are hydrological events caused by abnormally high amount of water input and insufficient discharge capacity [1]. A flood takes place because of an immoderate downpour and the absence of a proper drainage system. The severity of floods may also range from area to area, and the destruction induced by them varies accordingly. Local authorities must play an important role in minimizing the impact of floods, specifically in regions that are recognized to be at risk of flooding. In Malaysia, various flood disasters happened around East Coast states such as Kelantan. Besides, Perak and Northern states such as Kedah and Perlis also face this natural disaster once a year [2].

Flood risk management as a process has been discussed in detail in [3][4] without considering the actors involved in the process. In other words, flood risk management is the process of managing an existing flood risk situation. In a broader sense, it refers to the planning of a system to reduce flood risk. These two aspects of flood risk management are considered separately, beginning with the management

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of an existing system, which consists of the processes in [5]. Risk management for the operation of an existing flood control system is the sum of actions for a rational approach to mitigating flood disasters [3].

Based on the previous researches, there are different types of flood protection walls or gates. In [6], Shrinivas et al. developed an automatic flood barrier using Arduino as a flood control system [6]. In [7], Gareeyasee *et al.* have developed an automated sluice gate using the AC500PM554 PLC. This project system can be implemented on the upcoming dams with different sizes and capacities [7]. In [8], a PLC-based dam monitoring system was developed using fuzzy logic to monitor the water filling and discharge process and the sluice control system [8]. Moreover, in [9], Linganagouda *et al*. developed a flood gate for a drainage system that can detect the water level and discharge water from the drain. The system can detect the discharge water and the tidal water [9]. Saifur Rahman Faisal *et al*. conducted a similar study in [10]. They designed and developed an autonomous flood gate using an Arduino Uno and a motor driver controller [10].

2. Materials and Methods

The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study. This project aims to develop an anti-flood system with an automatic flood barrier that rises depending on the flood level in preventing water from entering the houses as well as to monitor the flood barrier situation remotely. This project consists of several stages of the process for the flood barrier to rising. The following subsections will discuss the flow chart of overall project implementation as well as the proposed project operation.

2.1 Project block diagram

In general, the block diagram as shown in Figure 1 gives an overview of proposed system that consists of PLC as the brain of the system. The water level sensor, push button, and eWelink module will act as input to control the flood barrier (12V DC motor). The buzzer and LED functions as an alarm to warning the activation of flood barrier which located as the output of system. The water pump also act as output to remove water inside the house's yard. The camera which connected online with the mobile phone can be observed the exact situation of the flood barrier.

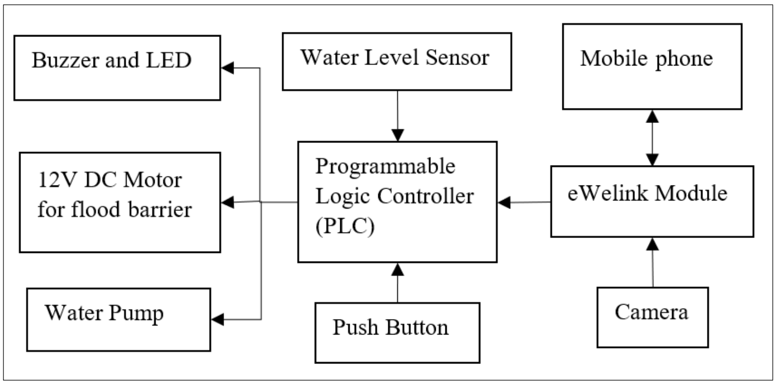


Figure 1: Block diagram of the system

2.2 System flowchart

In Figure 2, the system starts with the water level sensor that detects the water level on the road. If the sensor senses the water level is not exceed the limit, then the alarm is in off condition, and the gate is also in the closed position. Otherwise, if the water level increases beyond the limit, the buzzer and LED start to give an alarm. Then, the gate starts to increase. Next, the water pump will start running to remove the water inside the house yard. It will stop once the water level inside the house yard is low. Basically, the system can be activated manually by pushing a button and remotely by using handphone.

The system also comes with a monitoring device which is camera that will show the actual condition of the gate through the owner mobile phone.

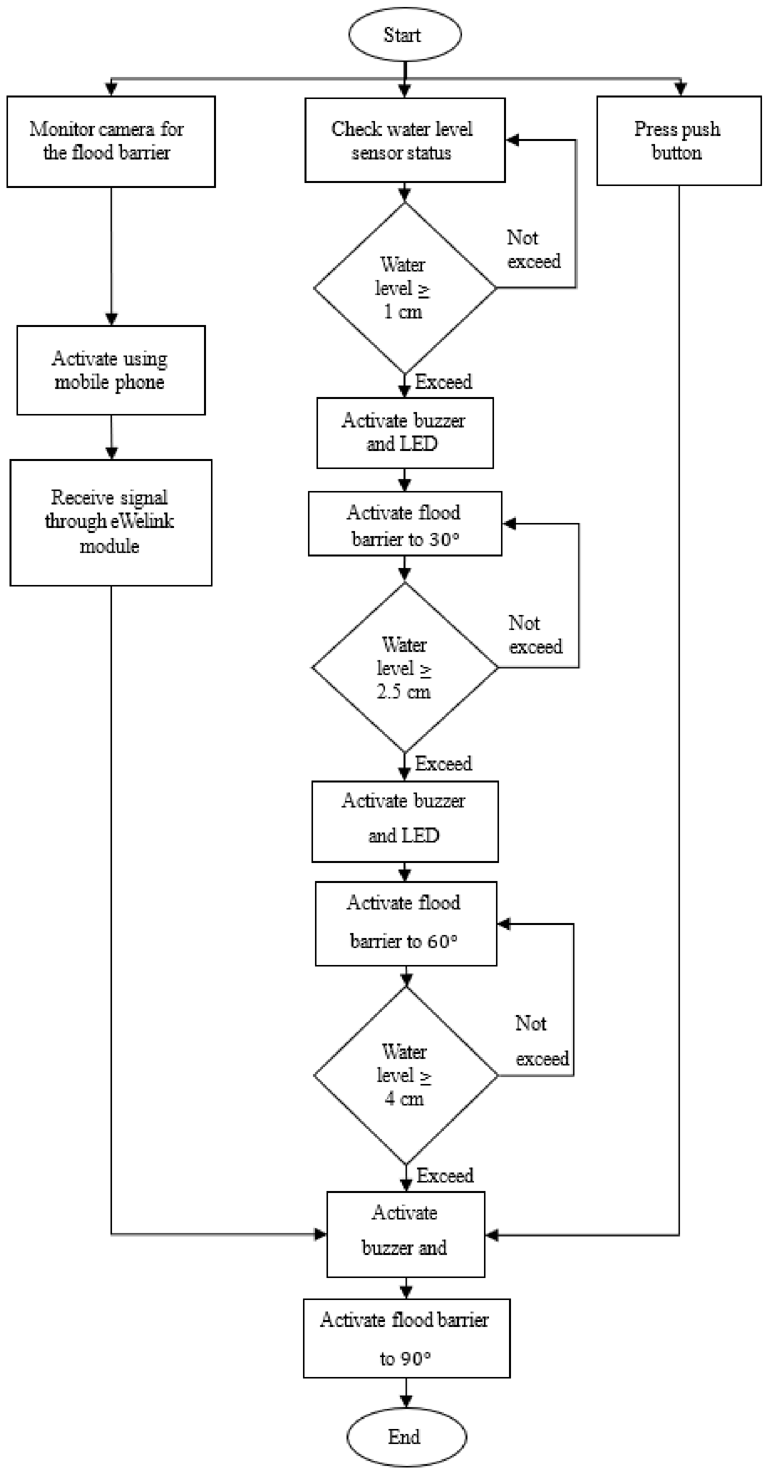


Figure 2: The flowchart of the automated flood barrier with monitoring system for home

2.3 Ladder diagram setup

This project begins with the creation of the coding for the PLC. To code the PLC, CX-Programmer software is used to create the ladder diagram that will be used as the coding in the PLC. Then the prototype is tested and analyzed whether the flood barrier or the motor runs according to the parameters or not. If any error occurs, the project is fixed until it runs smoothly and successfully. Figure 3 (a) shows the ladder diagram of the pushbutton operation.

Figure 3 (b) shows the ladder diagram for the outdoor water level sensor operation. Figure 3 (c) shows the ladder diagram of the gate control for flood control. Figure 3 (d) shows the ladder diagram for the water pump control.

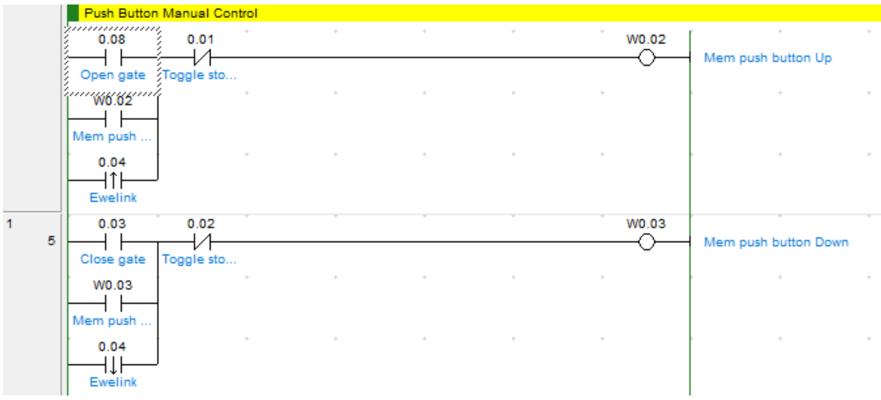


Figure 3 (a): Push button operation ladder diagram

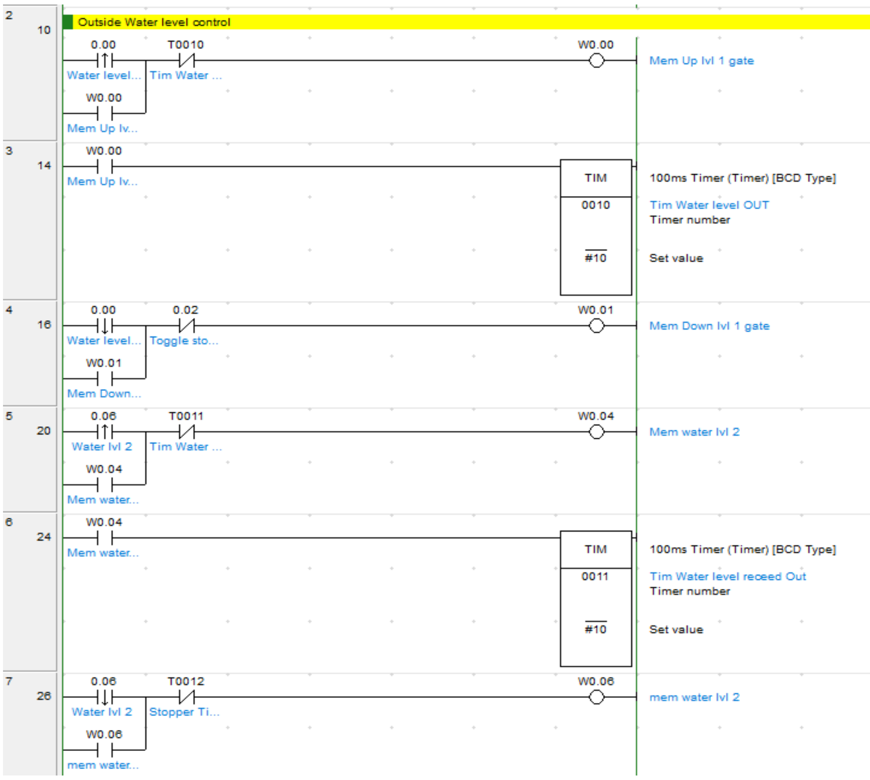


Figure 3 (b): Outside water level sensor operation ladder diagram

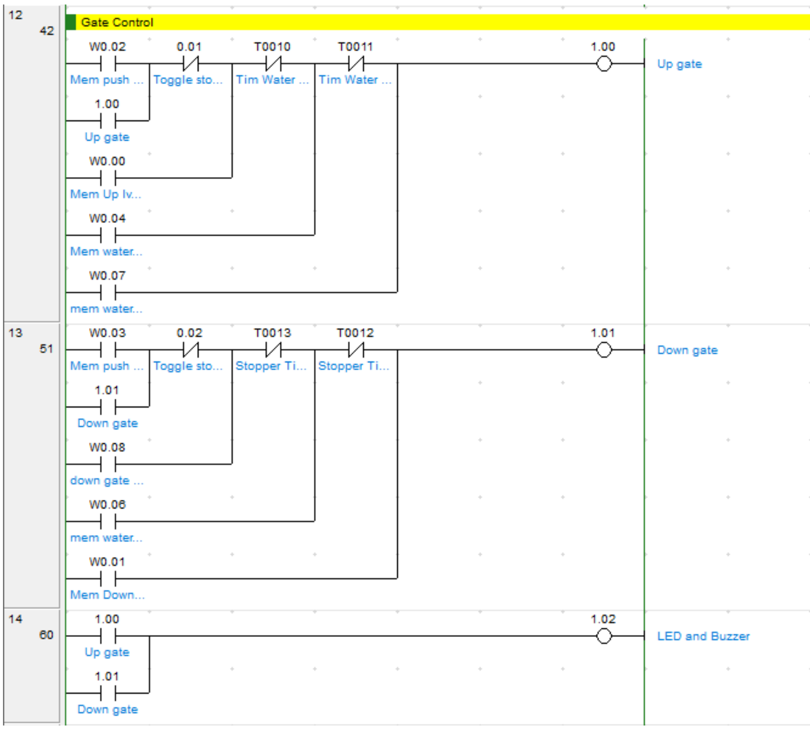


Figure 3 (c): Gate control ladder diagram

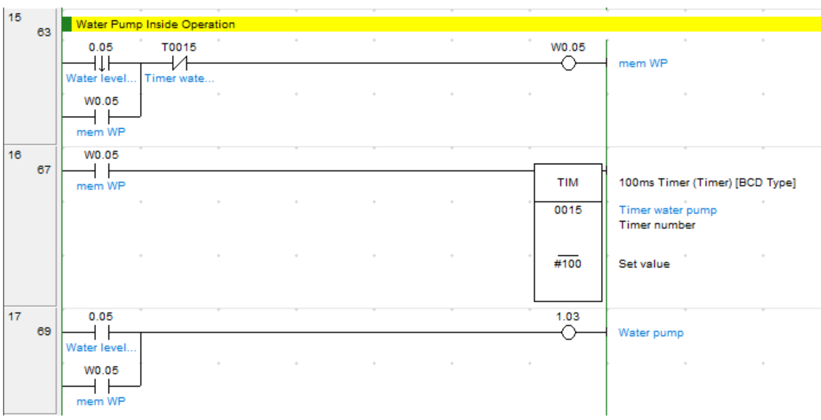


Figure 3 (d): Water pump operation ladder diagram

2.4 Parameter

In this project, water level sensor was used to detect three different water levels. The DC motor operates according to these three levels of water rising. The angles for DC motor were calculated based on the developed prototype.

The three different water levels are set to be 1 cm, 2.5 cm and 4 cm and the angle for the DC motor to rotate 30°, 60°, and 90° respectively. Table 1 shows the water level rise and angle for motor to rotate.

Table 1: Water level rise and angle for DC motor to rotate

Water level (cm), x	Angle rotation of flood barrier (θ°)
1 cm ≤ x < 2.5 cm	30°
2.5 cm ≤ x < 4 cm	60°
4 cm ≤ x	90°

3. Results and Discussion

This section presents and discusses the results based on the developed prototype. The discussion of this chapter starts with the developed prototype of the flood barrier, the designed circuit, the development of the PLC coding using CX-Programmer software, and various analyses of the prototype.

3.1 Analysis of Electronic setup

In this section, the result of the proposed prototype is presented. Figure 4 (a) shows the top view of the prototype. Figure 4 (b) shows the components inside the wiring box. In the developed prototype, acrylic sheets were used for the system and plywood for the wiring box.

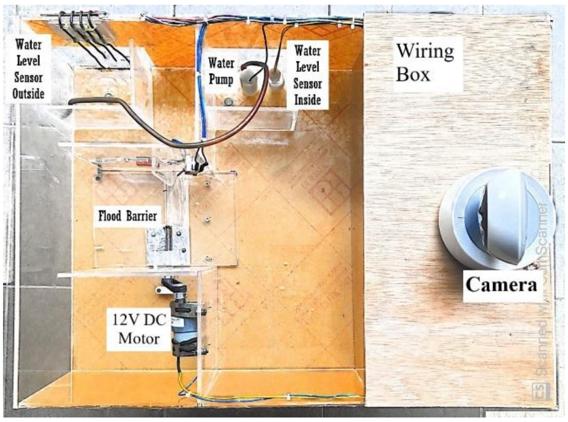


Figure 4 (a): Top view of proposed prototype

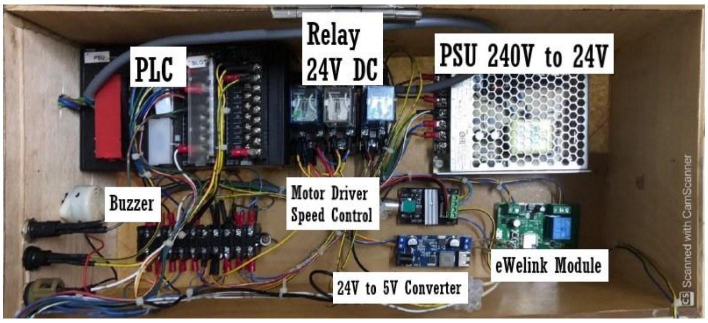
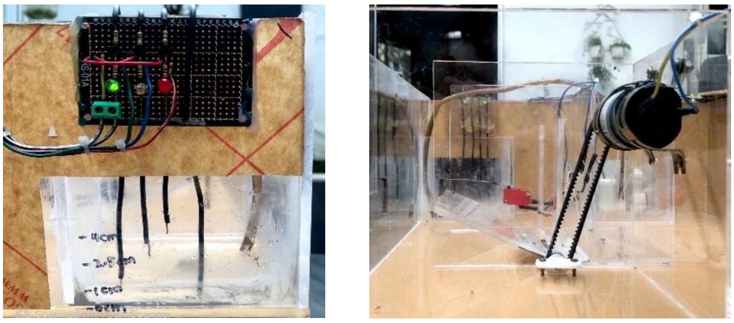


Figure 4 (b): Components inside the wiring box

3.2 Water level sensor operation

There are two water level sensors in this project. Figure 4 (a) shows the location of the water level sensors.

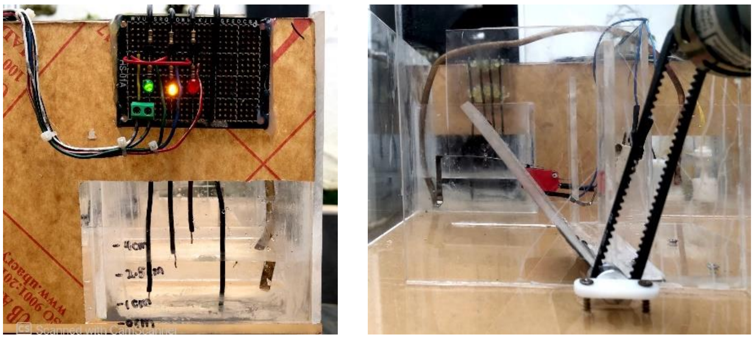
For outdoor water level sensor operation, the sensor starts detecting three water levels, namely 1 cm, 2.5 cm, and 4 cm. Then the flood barrier automatically raises at an angle of 30°, 60°, and 90°, respectively. Figure 5 (a) shows that the water level (x) rises between 1 cm < x < 2.5 cm, which activates the barrier and lights up the green LED. Figure 5 (b) shows the flood barrier rotating 30°. As the barrier rises, the buzzer and LED turn on to warn people to stay away from the barrier.



(a) (b)

Figure 5: (a) Water level (x) rises between 1 cm < x < 2.5 cm (b) Flood Barrier rises to the angle of 30°

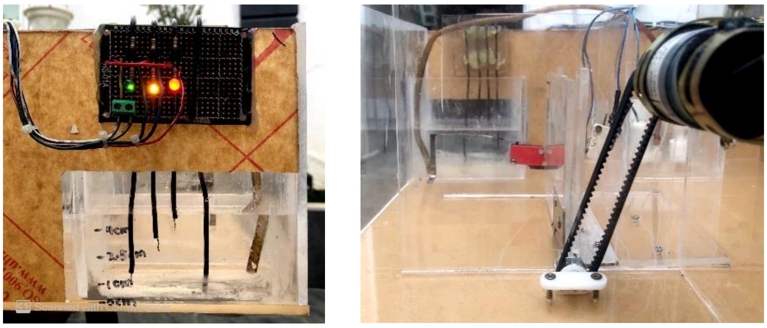
The second water level (x) is between 2.5 cm < x < 4 cm, raising the barrier to an angle of 60°. Figure 6 (a) shows that the water level (x) rises between 2.5 cm < x < 4 cm, activating the barrier and illuminating the yellow LED. Figure 6 (b) shows the flood barrier rotating 60°. As the barrier rises, the buzzer and LED turn on to warn people to stay away from the barrier.



(a) (b)

Figure 6: (a) Water level (x) rises between 2.5 cm < x < 4 cm (b) Flood Barrier rises to the angle of 60°

Finally, the third water level (x) is 4 cm < x, at which the barrier rises to an angle of 90° or is completely opened. Figure 7 (a) shows that the water level (x) rises to 4 cm < x, activating the barrier and illuminating the red LED. Figure 7 (b) shows the flood barrier rotating 90°. As the barrier rises, the buzzer and LED turn on to warn people to stay away from the barrier.



(a) (b)

Figure 7: (a) Water level (x) rises to 4 cm ≤ x (b) Flood Barrier is rises to 90° or fully open.

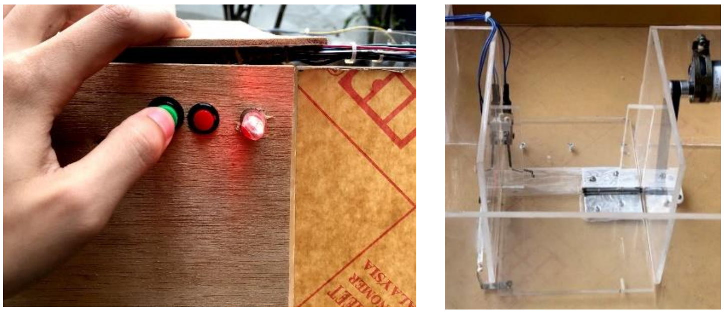
For the operation of the water level inside, the water pump turns on when the water level (x) exceeds 2.5 cm < x and turns off when 2.5 cm > x is exceeded. Figure 8 (a) shows that the water level (x) exceeds 2.5 cm < x, while Figure 8 (b) shows that the water pump turns on and moves the water outside.

(a) (b)

Figure 8: (a) Water level (x) exceeds 2.5 cm < x (b) The water pump is turned on and directs the water to the outside of the house

3.3 Push button operation

Push button activation can also be used to manually open or close the barrier. This activation option is used to open or close the barrier faster than activation by the water level sensor, as this process can save more lives or valuables in emergency situations. Figure 9 (a) shows the push button and the LED alarm. The green button opens the barrier completely, as shown in Figure 7 (b), while the red button closes the barrier completely, as shown in Figure 9 (b). The LED alarm and buzzer will turn on when the barrier is in motion.



(a) (b)

Figure 9: (a) The push button and LED alarm is turn on (b) Fully closed flood barrier

3.4 Mobile phone operation

To activate the flood barrier with a cell phone, the eWelink application must be downloaded and set up. The eWelink application can be downloaded from the App Store or the Play Store. To control and monitor the floodwall via the eWelink application, the cell phone must have an internet connection to function. Figure 10 shows the application set up on the cell phone to open or close the barrier and monitor the situation remotely.

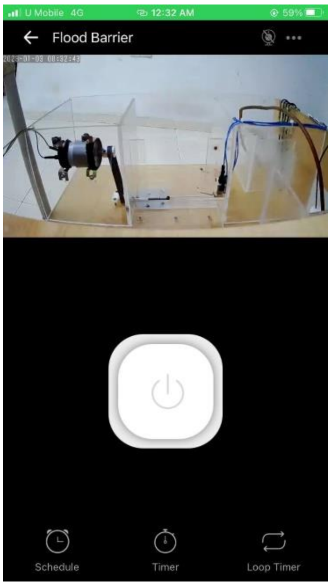


Figure 10: Flood monitoring system using eWelink application

As shown in Figure 10, the flood barrier can be observed in real time and activated remotely by pressing a button. Figure 11 shows that the flood barrier is fully open or activated when the button is pressed. So, with this system, the barrier can be monitored and also remotely controlled when the user is outside the house. There are additional benefits that it can also monitor not only the barrier, but also as a security camera monitoring that can record and take pictures when there is theft.

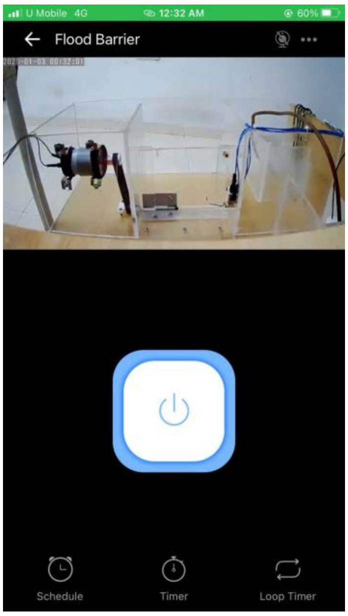


Figure 11: The flood barrier is activated

4. Conclusion

In summary, all objectives of this project have been achieved. The proposed PLC based flood barrier provides a lot of benefits to the user. Basically, this project is about a flood barrier that rises according to the water level of the flood. The flood barrier can be activated by three methods, and a monitoring system is included to know the exact situation of the barrier. The flood barrier plays an important role in this project because it can protect not only people's lives but also their houses, cars, valuables, and documents. In this project, the flood barrier can be activated by three different methods. First, by using a water level sensor that automatically activates the barrier by detecting the water level. Second, by manually activating it with the push button. The green button fully opens the barrier, while the red button fully closes the barrier. And finally, remote control via a cell phone. The last method allows the owner to monitor and control the flood barrier remotely.

Acknowledgement

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