Indonesian Journal of Electrical Engineering and Computer Science
Vol. 31, No. 3, September 2023, pp. 1342~13491
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v31.i3.pp1342-1349

Development of dam controller technology water level and alert system using Arduino UNO

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Article Info

Article history:

Received Mar 16, 2023
Revised May 2, 2023
Accepted May 6, 2023

Keywords:

Arduino UNO
ATmega328P
Automatic valve
Water level control
Water level sensor

ABSTRACT

Recently, various water level detection monitoring systems integrations were implemented to various places such as rivers and reservoirs to avoid floods. Thus, it is determined to construct a project primarily focused on water level management, named dam controller technology (DCOTech). DCOTech is a system that controls the amount of water in a reservoir using a microcontroller ATMEGA328p and several functions to prevent flash floods. Water sustainability requires proper monitoring via sensors and a controller. Moreover, a buzzer is used in DCOTech to give a warning signal to the people around and the residents. The water level sensor was constructed with a metal plate attached at both the bottom and top edges of the reservoir. The results obtained met expectations; whenever the sensor detects the water level is low, the green light emitting diode (LED) is turned on; otherwise, when the sensor detects the water level is high, the drain valve is opened, and simultaneously, turned on the buzzer to alert the surrounding. The goal of this project is to integrate a control system into an autonomous water level controller. This study aims to provide a solution to unexpected floods and to notify inhabitants when the water level is dangerously high.

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1. INTRODUCTION

Every year, Malaysia will be hit by a series of floods that caused widespread damage and displacement. The floods were caused by a combination of heavy rainfall and high tides, and they affected nearly half of the country. More than 300,000 people were forced to evacuate their homes, and over 2,000 homes were destroyed. The floods also caused significant damage to infrastructure, including roads, bridges, and railways. The floods were a major blow to the Malaysian economy, and they had significant humanitarian consequences. They posed a threat to the health of millions of people who were forced to flee their homes, and they led to the displacement of thousands of people who were unable to find new accommodations [1]–[5]. The floods also disrupted the lives of many families, and they caused tremendous stress for those affected. Overall, the floods were a major disaster that caused widespread damage and loss of life.

Recently, water level monitoring systems have become a niche area in research studies. It is a crucial area that needed to be investigated since floods occurrence in residential areas kept happening and there was lack of effective methods to prevent massive loss of residents belonging. A solution is needed by providing a system to warn the residents of the incoming flood. Much research has been carried out previously related to water level monitoring systems involving Arduino UNO and ultrasonic sensor [6]–[13]. The focus of the

projects is to avoid water overflow. When sound wave is transmitted, it will return to the origin as echo after striking on any obstacle. The traveling time, the sounds of the outgoing time and returning time to the origin after striking on any obstacle is being calculated, hence the distance is obtained. Furthermore, a previous project on water level control systems has been done in [11], [14], [15]. The project's goal is to use Arduino to automatically open and close the dam's water gate based on rainfall levels, as opposed to the traditional method of manually operating the water gate at most dams. Ultrasonic sensors are used as the input value to automatically control the water gate. Servo motor is used to operate the water gate. A liquid crystal display (LCD) is mounted to show the water level and an alert sound from a buzzer will be heard for people with visual impairments (blind). It is anticipated that the prototype will be one of the beneficial contributions to the drainage system. In addition, the endeavor would reduce the likelihood of flooding.

Previously, another project on water level sensing and control was completed. The project is about monitoring and managing water levels in the context of electrical conductivity. Microcontroller-based water level detection and control in a wired and wireless environment has been investigated. The project is focusing on reducing the home water consumption as well as water overflow. The project has proposed the implementation of mobile application in providing global data and information on water level around the globe utilizing the web and cellular based monitoring system [16]. The project utilized convenient materials in its implementation such as iron rod, nozzles, resistance, and rubber. A connecting rod composed of iron and steel that connects to the earth is required, as are at least two nozzles that connect to voltage and resistance. It should be bonded together, and a rubber insulator should be placed on the wire or iron rod. When the sensor comes into contact with water, the nozzles and iron rod make an electric connection via water conductivity [16]. In a previous research project, the Arduino microcontroller was used to control the amount of water in a tank automatically. A flowchart was created from well-defined algorithms, from which codes were written and generated on the Arduino IDE [8], [9], [17]. It is similar with another research as in [6], [7], [11], Arduino is used as the main controller. As in [18], an automatic water level controller using Bluetooth wireless technology and Ultrasonic water level sensor controlled by Arduino UNO is developed.

Some previous research has been carried out related to the internet of things (IoT) implementation of water level control system. The research on water level controller has moved to the next level which could be controlled wirelessly and some could retrieved data from the system via cloud [8], [14], [19]–[21]. As in [22], the water level control system is controlled using mobile application to set its water level setpoint. A feedback control system is applied using proportional-integral-derivative control (PID) for a programmable logic controller (PLC) to actuate the motor, which fills the tank based on the designated point determined by a mobile application. Another research has also carried out using similar method by implementing PLC in the project to control the water level [23]. As in [24], the purpose of the karthoom automatic control system (KACS) is to monitor and control all pumps' operations, protect them from dry running, and then complete the sensing stage of the Rujban water supply system using a PLC, an RF transmitter/receiver, seven water flow sensors and four stage-level sensors. Using a water-level sensor, PID controller with PLC, and water pump operated by a variable-frequency drive, a closed-loop drive control system has been constructed as part of a solar water heating engineering system [25]. New residential areas are usually built over a large area and some of the developers build up a reservoir in the housing area. However, this reservoir does not give advantage to the residents as it could not help to reduce the flash flood problem. Moreover, the inclement weather with rainy season will make this residential area riskier to be hit by flood ravaged. In order to solve this common problem, an innovation from a previous project has been made that helps the resident to be more prepared and aware whenever the water level of the reservoir reaches the highest state. When the flood approaches, many residents are unaware and have little time to pack their belongings due to the lack of an alarm to warn them. Hence, it could cause the residents to lose their belongings. In conjunction, a solution is needed to ensure the residents to be more prepared to face these problems and perhaps with this project to be invented, the problems can be encountered at an early stage. In conjunction, a project focusing on addressing this problem to reduce the number of victims who suffered from floods that occur every year. Furthermore, the statistics show that areas frequently flooded mostly are in open area like village or river, meanwhile, the dam controller technology (DCOTech) is only focusing in residential area because this project only works in small area like water reservoir areas. The main objectives of this project are to develop a water level control system by using Arduino UNO and to implement it at a dam or reservoir nearby residential areas to prevent floods. The second objective is to utilize the water detector or sensor to operate the system automatically and to provide water level alarm systems for nearby residents and surroundings without human supervision.

2. PROPOSED DAM CONTROLLER TECHNOLOGY

DCOTech is designed to prevent horrendous floods in planned cities, such as residential areas. However, the implementation of the project is about producing a prototype that resembles a residential area with a water reservoir using the DCOTech adaptation. The residential area and the reservoir area were placed

in an aquarium tank to mimic the real-life situation faced by the residents. Next, the process of this project is limited until the water in the reservoir flows out through the stream to other places. This project does not provide or show where the water will be flowed out until the water has run through the stream and will automatically stop once the tank reaches the halfway point. The project starts with the LED turning red, showing that the water level is at a dangerous level and triggering the valve to open, allowing the water to flow out of the tank. Lastly, this project is limited to sound, as only a buzzer will be used in this project as a warning alarm showing that the water level is at the highest level. The application of Arduino UNO in this project is about constructing the circuit from scratch and mounting it on a printed circuit board (PCB). No Arduino UNO module is used in this project.

3. METHOD

The flowchart of DCOTech is shown in Figure 1. At first, after the system is activated, the water detector will determine if the water level is low, average, or high. If the water level is identified as low, the green LED will illuminate; otherwise, the water detector will check the water level again. If water is detected at an average level, a yellow LED will illuminate. If the water detector detects a high-water level, the red LED illuminates and simultaneously sends an input signal to the Arduino UNO. The Arduino UNO provides a signal to activate the valve, releasing or draining the water and preventing it from overflowing. When the red LED is turned on and the valve is opened, the buzzer sounds an alarm to inform the surrounding area.

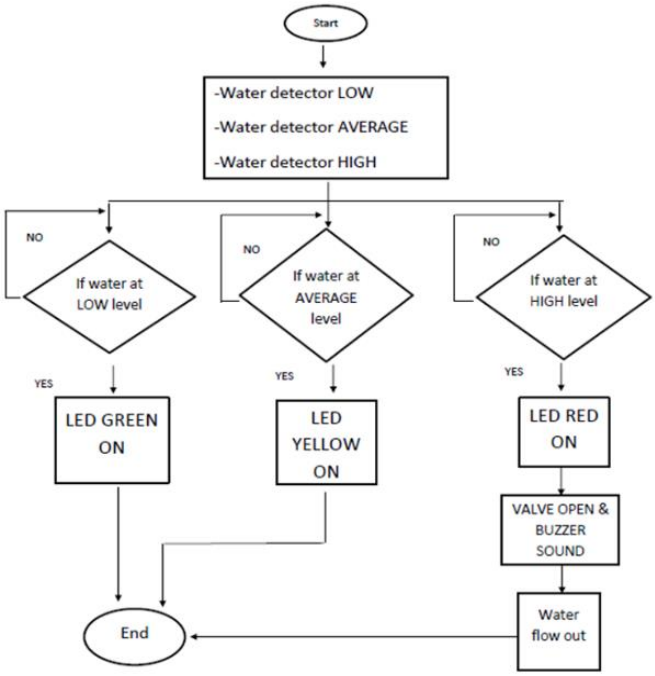

Figure 1. Flowchart of dam controller technology

3.1. Circuit construction

As shown in Figure 2, Arduino is a microcontroller (brain) that controls the complete circuit for the DCOTech project. This circuit consists of ATmega328P model program and should be uploaded using its own software. In this project the Arduino UNO circuit is being constructed from scratch and mounted the components on a PCB board as shown in the Figure 2. The supply voltage of 12 V utilized in this circuit is reduced to 5 V by using a voltage regulator. This circuit is tested with blazing LED programmed and uploaded into the Arduino, to ensure the circuit works perfectly. This circuit is also mounted with a crystal oscillator which acts as the fast metronome for the microcontroller and to perform in good accuracy. Lastly, a push button switch is also connected to control the ON/OFF the circuit and at the same time it can be a connector for the circuit due to its normally closed condition.

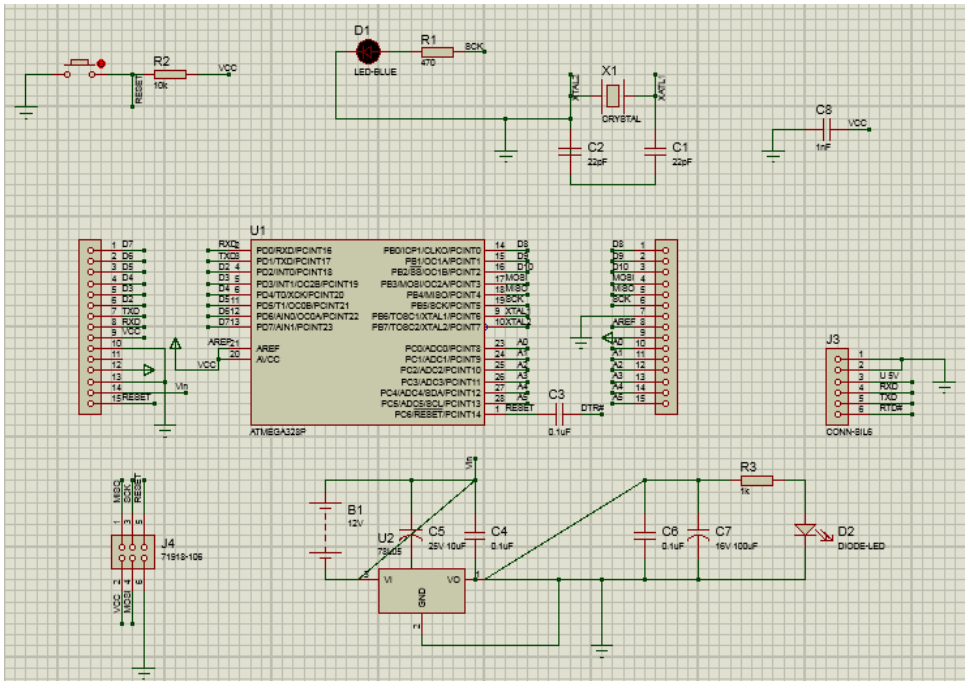

Figure 2. Arduino UNO circuit

Figure 3 depicts the project's buzzer circuit construction. In general, this circuit functions only when the water level is at its peak. When the LED turns from GREEN to RED, the probes affixed at the HIGH level generate electricity that travels across the IC timer 555. This IC will stabilize the buzzer while also rectifying it to give a better sound. The buzzer serves as the circuit's output, producing sound that alerts the surrounding area that the water level is dangerously low. The major operation in this project is the controller circuit depicted in Figure 4. There are three transistors installed at each desired level, and they will begin to function once the water level is at LOW, AVERAGE, or HIGH. When the water level reaches the HIGH level, the transistor is activated and serves as a switch, allowing current to flow through it. It will then flow to the Arduino, where the LED will display the water level. Figure 5 shows the Arduino UNO PCB layout obtained from the proteus software.

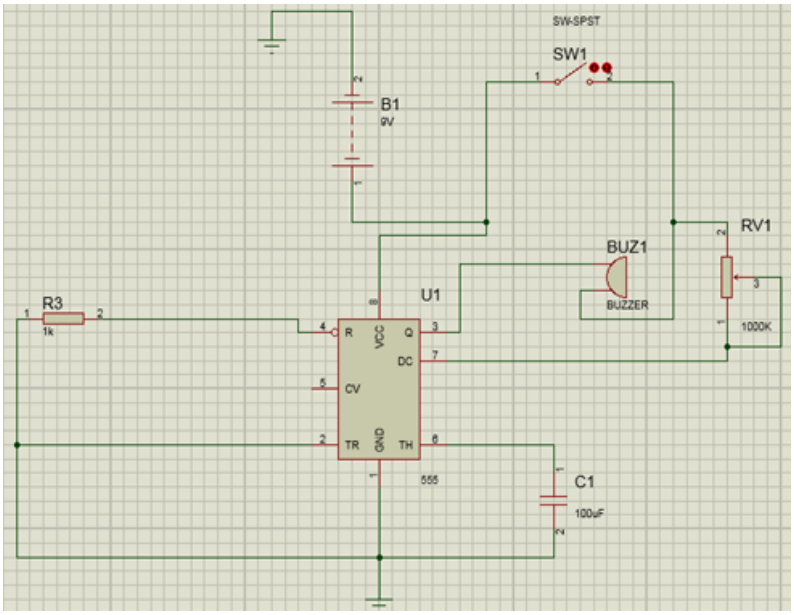

Figure 3. Buzzer circuit

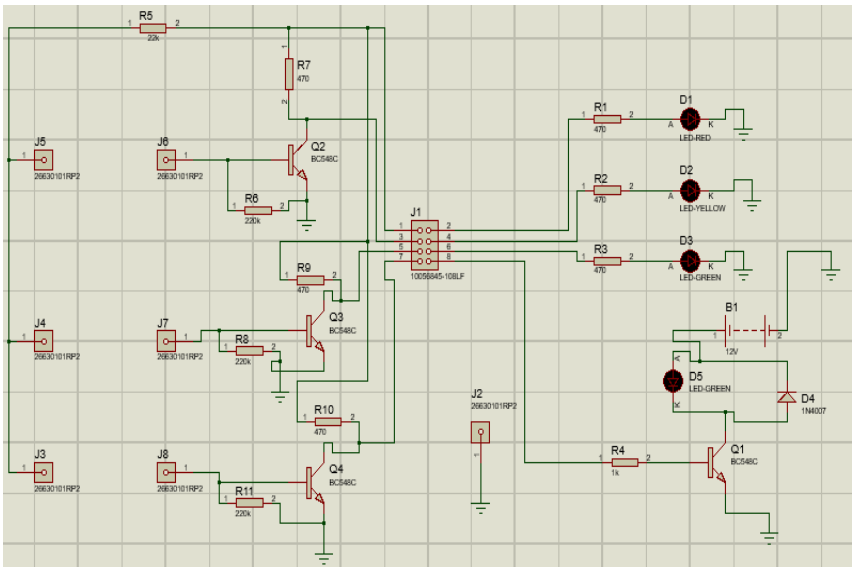

Figure 4. Controller circuit

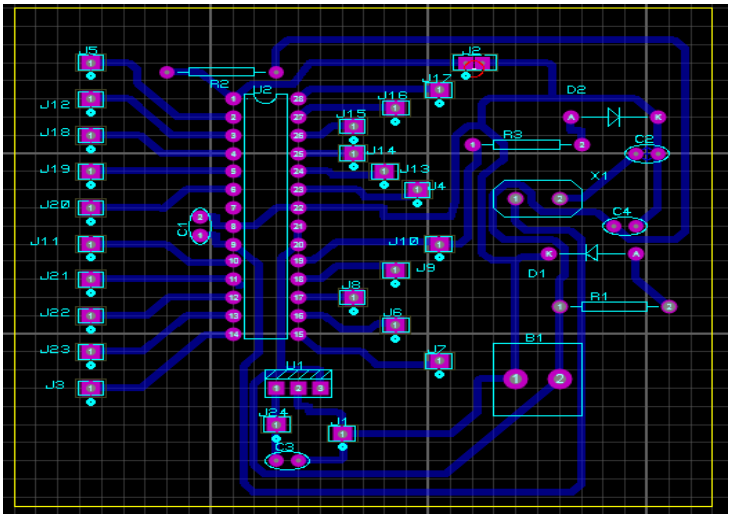

Figure 5. Arduino UNO PCB layout

3.2. Hardware implementation

Figure 6 shows the Arduino circuit and controller circuit that have been constructed on PCB board. The components are soldered on the PCB board based on the PCB layout that has been produced earlier. While Figure 7 shows the buzzer circuit on a PCB. All circuits were combined to form the prototype of DCOTech as shown in Figure 8.

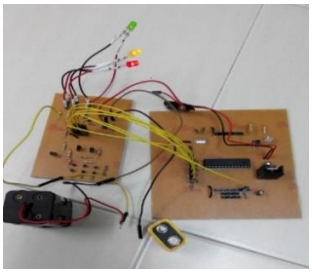

Figure 6. Arduino and controller circuit

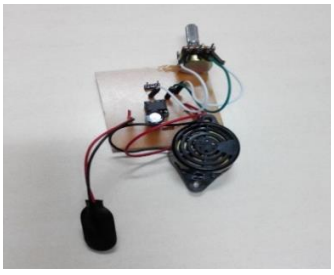

Figure 7. Buzzer circuit

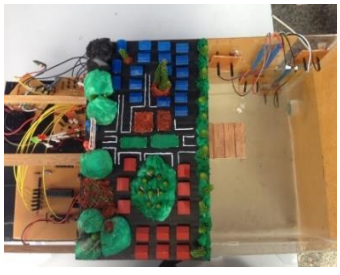

Figure 8. Prototype

4. RESULTS AND DISCUSSION

Table 1 shows that the valve of the DCOTech is opened or turned ON when the water level condition is at HIGH with output voltage of 4.877 V. The red LED simultaneously turned ON during that state. While at LOW level, the green LED turned ON and the output voltage at the valve is 0, showing that the valve is closed. A similar condition happened during AVERAGE level where the yellow LED turned ON while the valve is closed. It shows that the results obtained have met the objectives.

Table 1. Output voltage for LED and valve

Condition of water level	Red led	Yelow led	Green led	Expected value (V)	Measured value (V)	Valve output (V)
Low	0	0	1	2.213	2.119	(OFF) 0
Average	0	1	0	2.213	2.201	(OFF) 0
High	1	0	0	2.213	2.14	(ON) 4.877

Table 2 shows the output voltage of the buzzer used connected at the output of Arduino circuit. It shows that during LOW and AVERAGE water levels the output voltages at buzzer are very small, which are 0.016 mV AND 0.127 Mv. As a result, the buzzer is in OFF state. However, when the water level is at HIGH state, the output voltage measurement at the buzzer is 2.16 V, hence the buzzer is turned ON and produces an alarming sound. From the results obtained Table 2, it shows that the third objective has achieved.

Table 2. Output voltage for buzzer

Condition of water level	Buzzer	Expected value (V)	Measured value (V)
Low	Off	0	0.016m
Average	Off	0	0.127m
High	On	2.30	2.16

4.1. Future recommendations

Because it is a general project that can be implied by anyone in any location, many methods and operations can be used to improve it. There are a few suggestions that could be made in the future. First and foremost, the Arduino can be substituted with a PLC microcontroller, which accomplishes the same function. A PLC, on the other hand, is an example of a "hard" real-time system since output results must be provided in response to input conditions within a fixed time frame or else unexpected operation may occur. Following that, this project may be commercialized to the authorities so that it can be implemented in areas other than residential areas. Finally, this project can be improved and may be better if the circuit components used are water resistant and can be mounted deep within the reservoir.

5. CONCLUSION

As a conclusion, DCOTech is designed to solve the problems occurred when tremendous flood happens due to heavy rain. This project has successfully been developed to control the water level of a reservoir and prevent it from overflowing. By making this project, it can help the residents to be more prepared whenever the flood is approaching the area. It is suitable for city planners to organize their project. This also proves that it can improve human lifestyle in many ways. The utilization of water level sensors has successfully been implemented to the DCOTech to perform automatic system control operation as well as minimizing the need for human supervision. Water level microcontrollers employ the use of different technologies in their design, development, and implementation. The system used microcontroller to automate the process of water pumping in a tank storage system and could detect the level of water in a tank, open and close the valve accordingly and the LED will act as the indicator to state whether the water level is at dangerous state or not. The buzzer which acts as an alarm system attached to the DCOTech also could help the residents to be prepared and alert of the incoming flash floods. Obviously, this project is suitable to be implemented in the residential area's reservoir.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to the School of electrical engineering, Universiti Teknologi MARA, Terengganu Branch, Dungun Campus, Terengganu, Malaysia for providing the research facilities. This work is fully funded by research Nexus UiTM at Universiti Teknologi MARA Shah Alam, which is under the incentives of '*Pembiayaan Yuran Penerbitan Artikel*' (PYPA). Many thanks to all the staff

involved from the School of electrical engineering, College of engineering, Universiti Teknologi MARA (UiTM), Cawangan Terengganu, Kampus Dungun for their guidance in making this work succeed.

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