Digital Flood Control Model as a Digital Practical Learning Module

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Abstract— Teaching aids are one of the learning media that can be used in the learning process in the classroom or laboratory. The purpose of this media is to facilitate the understanding of the material being studied. In laboratory learning, in addition to practical modules, the development of teaching aids is needed as a case study for solving problems in the field. The teaching aid being researched is a learning module as the development of digital engineering practicals in the laboratory, specifically a digital flood control module. The module designed and created aims to teach how a flood control process can be created using digital circuits, thereby providing insights and understanding to students about the control process. The controller module reads the water level sensors set at high and low levels. When the water touches the high-level water sensor, the control output activates the relay to turn on the pump, so the water in a specific location is pumped elsewhere. When the control system reads the low-level sensor, the output deactivates the relay and the pump stops working. The water level sensor is set at a distance of 10 cm between the lower and upper limits. The volume of water pumped is 0.006 m3 or 6 liters in 30 seconds using a 12v DC water pump with a power of 25 watts.

Keywords— Teaching aids, control process, digital circuits

1. Introduction

The learning process, whether in the classroom or in the laboratory, must be able to create ease in the learning process, especially when the teaching material is considered quite difficult in certain fields of science. Learning that is still conventional, such as using books or lectures, or teaching materials presented by instructors, does not sufficiently utilize media like PowerPoint or in practical sessions that are still mediated by lecturers, indicating that it is not yet effective enough. The learning process is very important in achieving the success of students in understanding the knowledge being studied. Learning, especially in practical activities, is still conducted using computer simulations, which less effectively develop students' psychomotor skills [3].

Efforts that need to be made to improve learning abilities and pay attention to the competencies of students include adding forms of teaching media, which are one of the components in the learning process, so that the material or teaching materials are easier to understand both in terms of process and outcome, and can become concrete experiences in learning[4]. Technology has become one of the main means in developing products and learning content[5], including developing practical modules[6].

The learning process does not only focus on the materials or teaching aids that are the main needs in education. Learning in the classroom or laboratory needs to address specific case studies and their solutions. Like in the case of flood management. One of the flood mitigation measures is using pumps to accelerate the reduction of flood depth[7]. To describe and understand the process, it is necessary to create a learning medium in the form of teaching aids that can be studied in the laboratory.

2. Method

To complete this research, the research stages were carried out starting from planning the system design, planning the digital circuit design, planning the mechanical system, and creating the prototype product.

2.1. Design Planning

The digital flood control demonstration tool is a practical module in the form of a system. In this system, there are three parts: input, process, and output.

The input section is the part that reads data using a water level sensor. In the process section, there is a main system that processes the water level sensor data to determine whether to proceed with an action or not.

In the process, there is a simple algorithm, if the upper level sensor input data is detected, the controller takes action to send a command to the output section to perform the desired action, which is to turn on the pump. However, if the upper level sensor input is not detected, the controller does not issue any commands to the output section to take action. The control of the lower water level is carried out; if the water has started to be pumped and the water level reaches the lower water level sensor limit, the controller instructs the output section to turn off the pump.

In the output section, there is a relay driver connected to a water pump. The pump will operate if the command to turn on the pump is given by the controller. On the contrary, the pump is turned off when it receives a command from the control panel to turn off the pump. Figure 1 shows the flow diagram of the pump working and Figure 2 shows the pump not working.

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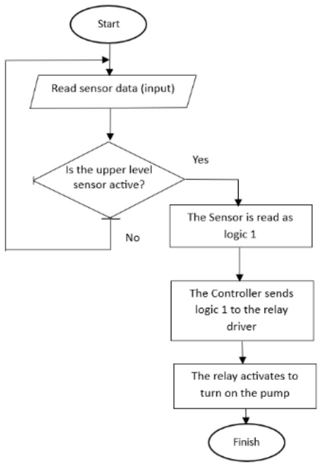

Fig. 1. The flow diagram of the pump working

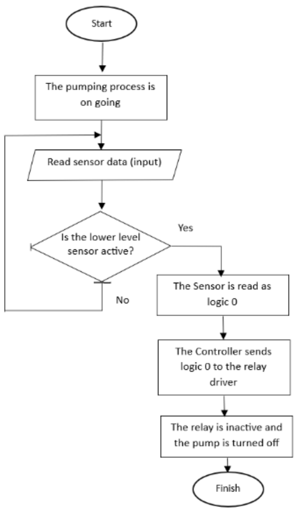

Fig. 2. The flow diagram of the pump not working.

The module design system describes the processing from input to output. In the design of the teaching aid, it is equipped with a +5v power supply to power the control circuit and clock generator, and a +12v power supply as the voltage source for the water pump.

There are two sensors as inputs, namely the upper level sensor and the lower level sensor. Both sensors produce data of logic 1 or logic 0 depending on the water level that touches them. Considering that this prop is a flood control regulator, when the water level touches the upper level sensor, it indicates that the flood height threshold has been detected. The controller processes the sensor data and produces a logic output of 1 to control the relay actuator and turn on the water pump. The stagnant or flood water is pumped until it reaches the lower level sensor limit. This condition causes the sensor to send a logic 1 to the controller, which then sends a logic 0 to turn off the water pump. Figure 3 shows the block diagram of the flood control system design.

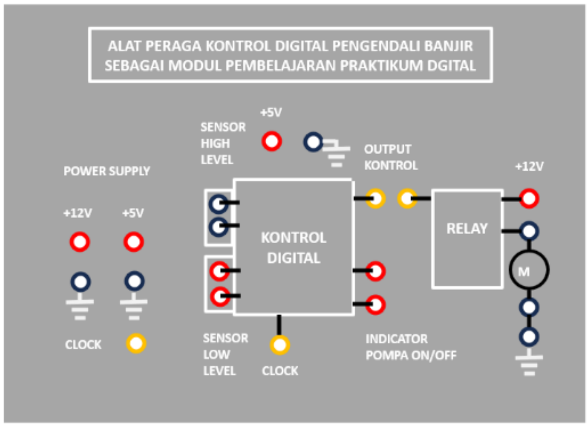

Fig. 3. the block diagram system design.

2.2. Digital Circuit Planning

This stage involves designing the digital circuit layout from the block diagram that has been created. The designed circuit requires two mechanical sensors that function as float switches. The switch is placed at two different locations (top and bottom) with the distance between the sensors adjustable as needed. the distance between the two sensors increases, causing the pump to run longer. Conversely, if the distance between the two sensors decreases, the pump runs for a shorter duration.This floating switch can open and close whether it is in water or in free air. Therefore, the placement of this sensor is very crucial as either a closed or open position.

If it is desired for the sensor to close when the water decreases and open when the water increases, then the switch position is set to normally closed. Conversely, if the sensor closes when the water increases and opens when the water decreases, then the switch position is set to normally open.

In addition to using the two water level sensors, this teaching aid design requires a main component, namely the JK flip flop. The JK flip flop was chosen because it has the characteristics needed in the module design. The JK flip flop has two inputs, J and K, and an output Q that is needed as the control output. The two inputs J and K receive input from the float switch sensor. The characteristics of the JK flip-flop are shown in Table 1.

The output of the JK flip flop is connected to a relay driver circuit, and the normally open relay output functions as a switch that connects the +12V power supply to the water pump. The digital circuit design can be simulated for both water level sensors using push button switches. The clock generator circuit is designed using a 74LS14 IC, which is a Schmitt trigger IC, connected with a resistor and a capacitor. The clock pulse or wave generator circuit does not require accuracy or precise duty cycle adjustment because its function is as a trigger that continuously operates as a clock input for the JK flip flop. circuit design as shown in Figure 4.

Table 1. characteristics/ operational functions

Input			Output
J	K	Clock	Q
0	0	↓	No change
0	1	↓	0
1	0	↓	1
1	1	↓	toggle

**toggle is a condition that changes from the previous output*

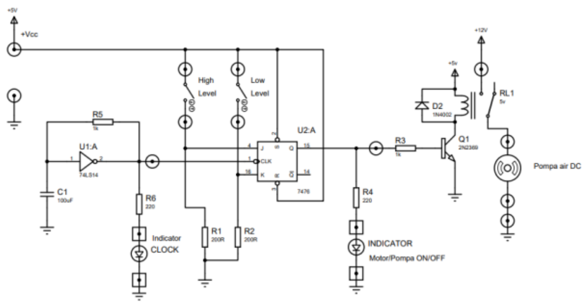

Fig. 4. Circuit Design

The principle of the JK flip flop is that when the clock input receives a clock trigger from the clock generator. When the input J=1, K=0 receives a clock trigger, the flip flop produces an output Q=1. When J and K are both 0, the flip flop output Q does not change.

With those characteristics, the circuit design as shown in Figure 4 can produce a flood control function. If input J connected to the sensor is in the upper position with a normally open installation, then when water touches the sensor/switch, it will close. This state is represented as logic 1 or in the circuit simulation replaced by a pressed push button switch. On the other side, input K receives input from the low-level sensor in a normally closed position. When the water continues to rise and reaches the upper level, it means the switch is open or K=0. According to the operation function of the JK flip flop, in the state of J=1 and K=0 with the given clock trigger, the output Q is logic 1.

The output condition Q=1 is used to trigger the relay driver circuit to activate the relay lever to close. When the lever is closed, the +12v voltage source supplies the water pump to operate.

When the pump works to pump water, the water level decreases. The change that occurs in the reduction of water flow causes the upper level sensor to open or become logic 0. This condition results in input J becoming logic 0. The change that occurs in the pumping process makes input J=0 and K=0. This condition does not change the output of the JK flip flop, which means the pump continues to operate.

The continuous decrease in water level will reach the lower level sensor point (input K), and this sensor will change to produce logical data 1. When J=0 and K=1, the flip flop output Q=0. This logic 0 output affects the relay driver, causing the pump to stop working. (off). The pump will continue to stop as long as there is no volume of water in that place. When water enters that place, the volume of water increases but the pump still does not work. This is because when the water increases, sensor K becomes open or logic 0. The change in input J=0 and K=0 is the condition where the output is the same as the previous output, which is that the pump does not work.

When the water reaches the upper level sensor, input J receives a logic 1 and the pump starts working again. This cycle continues to occur as the water process in that location undergoes the same cycle. Figure 5 is a graph illustrating the pump working and not working.

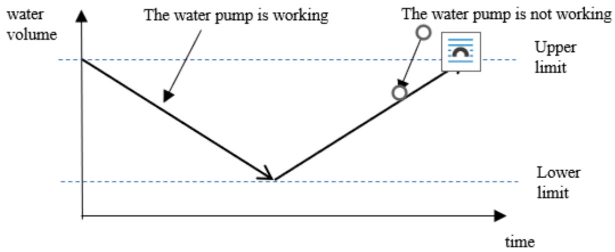

Fig. 5. Illustrating the pump working and not working.

2.3. Mechanical Module Planning

The stage of designing the mechanical module is the stage of designing the box as a teaching aid module. In this design, the box is made of acrylic and the cover is made of aluminum. The size of the box is 33x22x7cm with a partition width of 10 cm. The box design is as shown in figure 6. Figure 7 shows the acrylic material used as the module box and Figure 8 shows the result of the module box production.

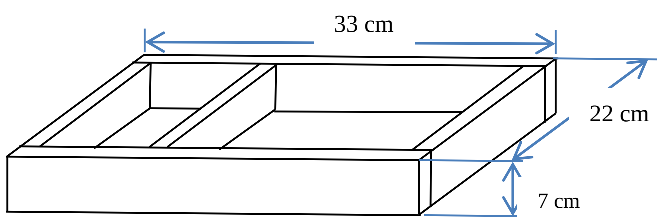

Fig. 6. Box Design.

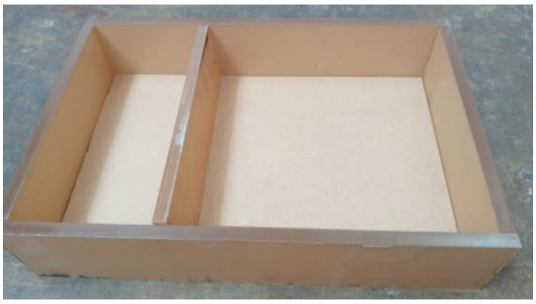

Fig. 7. The acrylic module box

Fig. 8. Module box production

2.4. Creating Prototype module

Creating a prototype module is the process of making a module that includes the creation of control circuits, boxes, and installation. The completed box is equipped with a cover.

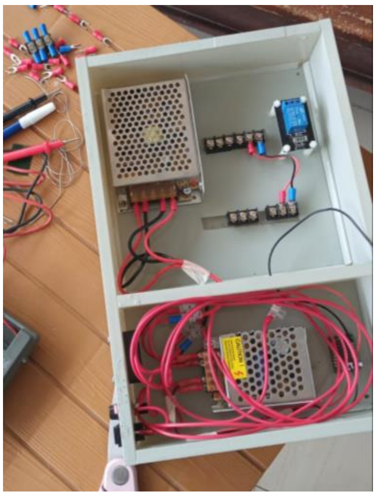

Fig. 9. The wiring installation process

The box cover is made according to the design, starting with measuring the aluminum material, followed by the drilling process for the connector holes. The next process is painting the cover and labeling each part. In the box section, it includes the process of installing components/circuits, power supply, and wiring installation from each connector point. Figure 9 shows the wiring installation process and figure 10 shows the module results.

The wiring installation process begins with placing the components and circuits (PCB) into the box. This placement is very important because it must facilitate the installation of each part. Next, measure the cable requirements used to connect each component part to the connectors on the box cover. The final step is the installation of the cables on each part.

Fig. 10. Prototype module

3. Result and Discussion

To produce the module according to the plan, a series of tests were conducted, including circuit testing using the Proteus application and breadboard, testing the functionality of the control circuit on the module, and overall module testing.

3.1. Circuit testing using a breadboard and Proteus

This test is to evaluate the circuit design that has been created. The first test used the Proteus software application to ensure the system could function. The next step is the physical testing of the circuit. Physical testing is conducted by assembling the components according to the circuit design on a breadboard. The purpose of the testing is to ensure that the circuit operates according to its intended function. Testing was conducted in stages starting from input, process, to output. The results of the testing using a breadboard showed that the circuit functions as intended and works well. Figures 11 and 12 show circuit testing using the Proteus application and physical circuit testing using a breadboard.

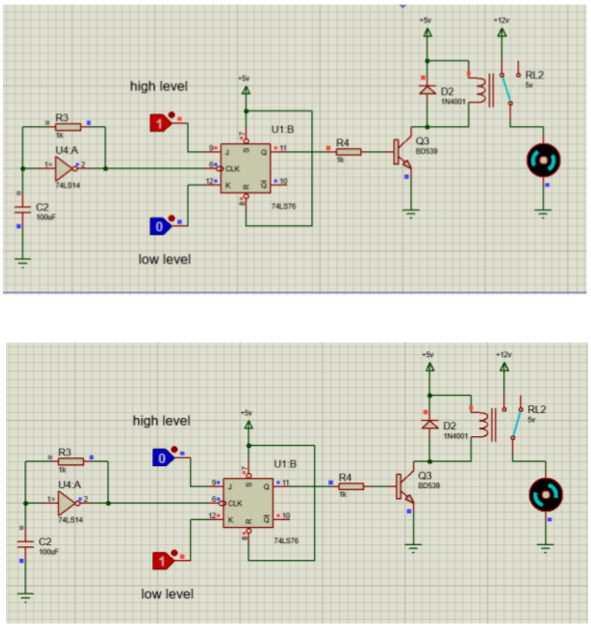

Fig. 11. Circuit testing using Proteus

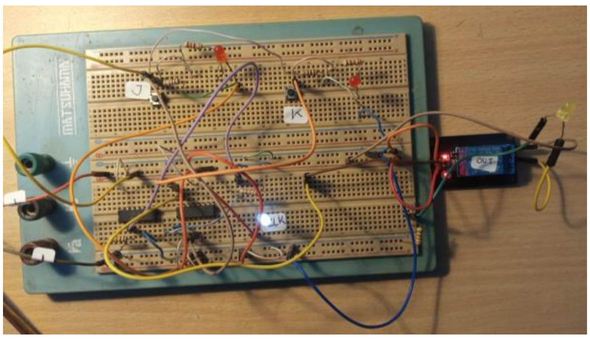

Fig. 12. Circuit testing using a breadboard

3.2. Testing the functionality of the control circuit

This test aims to ensure that the control section of the produced module can function and work properly. This test is divided between the control section and the pump output section. The testing stages include the installation of jumper cables from the power supply to the control section. The installation of the clock generator output to the control section clock input. After all the jumper cable installations are complete, proceed by turning on the power supply. There are two power supplies, namely +5v to power the circuit and +12v to power the DC water pump.

To replace the sensor input, in this test, it is sufficient to short-circuit both terminals/connectors of the sensors. The short-circuit means that the sensor is in the "on" position or logic 1.

The results of this test show that the control output can function well. When the high-level sensor input connector is connected, the control output operates, indicated by the LED indicator lighting up. On the other hand, when the low-level sensor input connector is connected, the control output is low logic, indicated by the LED indicator not lighting up. Figure 13 shows the module testing on the control system.

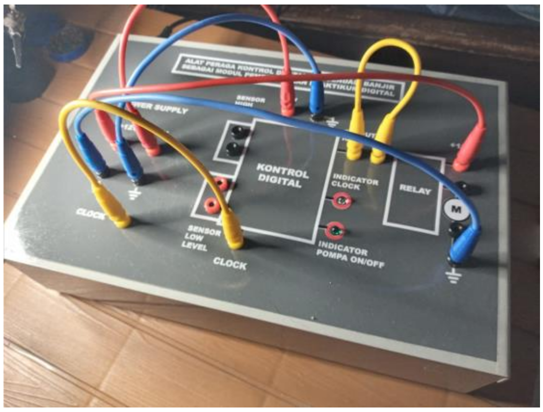

Fig. 13. The module testing on the control system

3.3. Overall module testing

Overall module testing is testing the entire module, including testing the relationship between the controller part and the relay driver and pump. The mechanism is similar to testing the function of a control circuit. After everything is connected starting from the input (sensor switches), the control section output is connected to the relay driver and the relay output is connected to the water pump. The test installation is as shown in Figure 14.

There are two water places, the first one as a simulation of pumped water and the second one as a disposal place. The sensors (float switches) are installed at the first water location with a distance of 10 cm between the sensors. The upper limit is equipped with an upper level sensor, and the lower limit is equipped with a lower level sensor.

The volume of water being pumped is approximately 6 (six) liters with dimensions of 20x30x10 cm. The water pump used is a 12v dc pump with a power of 25 watts and a flow capacity of 800 L/H.

From the test results, it shows that the control section is capable of receiving input data from both the upper and lower level sensors. This is demonstrated by the control output functioning according to the control circuit's purpose. The relay driver works well and is able to turn on the pump when the upper level sensor is detected or touches the water surface. The pump continues to operate until the water level drops to the lower limit, and the pump stops. To pump a volume of water of 6 liters takes about 30 seconds. The water flow rate is 0.2 L/second. The graph in Figure 15 shows the change in the volume of water pumped over 30 seconds.

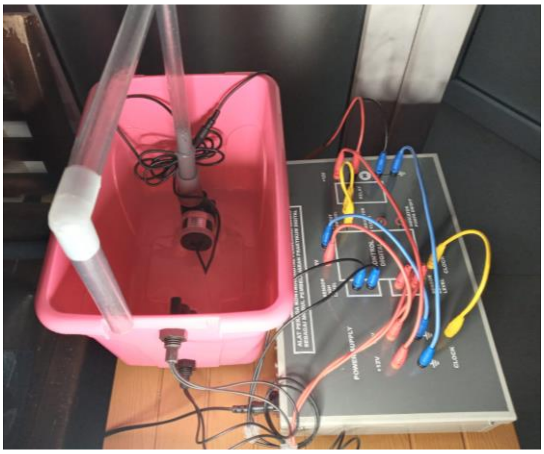

Fig. 14. Overall module testing

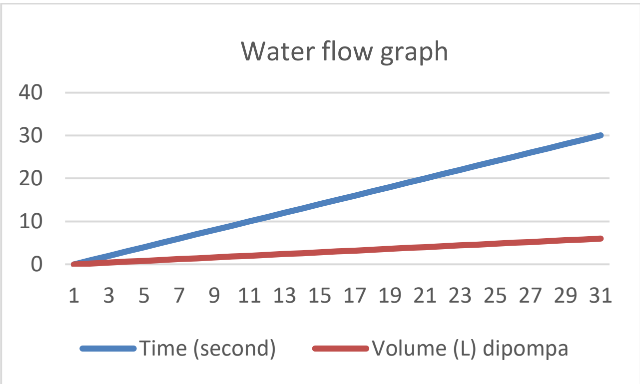

Fig. 15. Water flow 0,2 L/s

4. Conclusion

The test results show that the teaching aid works well, capable of reading the sensor data (float switch) for the upper and lower levels, which serve as inputs for the JK flip flop. The logical changes in the flip flop inputs are responded to well and produce outputs according to the characteristics of the JK flip flop. This teaching aid in the form of a module can be used in digital practical case studies in the laboratory to provide students with an understanding of digital control, which is a control system built using digital components. The teaching aid created is a simple simulation related to a flood control system where the control system is tasked with controlling the water pump when the water level in a certain place reaches the pumping limit and turning off the pump when the water level is at the lower limit.

This research fully utilizes digital components capable of functioning as flood control controllers, so this module can be used as a learning medium in digital engineering laboratories.

Module testing shows that a volume of 6 (six) liters of water can be pumped in 30 seconds using a 12v dc water pump with a capacity of 25 watts and a pump flow rate of 800 L/s. With a pumping time of 30 seconds for a volume of 6 (six) liters of water, this indicates a pumping rate of 0.2 liters/second.

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