# Self-Regulating Water Management system using Programmable Logic Controller

**[1]Yesvanthkrishna V, [2]Roshan B, [3]Kracose Nishanth J, [4]Anbarasu P and [5] Mohan Raj C**
[1,2,3,4,5]Department of Electrical and Electronics Engineering, Sri Eshwar College of Engineering, Coimbatore, India.
[1]yesvanthkrishna.v2020eee@sece.ac.in, [2] roshan.b2020eee@sece.ac.in,[3] kracose.nishanth.jeee2020@sece.ac.in,
[4]anbarasu.p@sece.ac.in, [5]mohanraj.c@sece.ac.in

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**Abstract –** This paper presents the design and implementation of a distributed control system (DCS) for water reservoir using programmable logic controllers (PLCs) and a human machine interface (HMI) for monitoring and control. The control system is designed to monitor the water levels, gates, and pumps in the water reservoir and to provide remote access to operators for better decision-making. The PLCs are programmed to control the gates and pumps according to the water level in the dam. The HMI provides a graphical user interface to monitor the water reservoir status and control the gates and pumps remotely. The system is tested and validated, and the results demonstrate the effectiveness and efficiency of the proposed control system.

**Keywords –** Programmable Logic Control, Automation, Ladder Program, Power Wiring, Control Wiring, Relay.

## I. INTRODUCTION

The integrating PL controls, numerical control, and other industrial control systems with different IT applications, industrial automation eliminates the need for human involvement [1]. In production, mechanization is followed by automation. Automation significantly reduces sensory and cerebral effort, whereas mechanization aids human operators with physical labor. Automate systems and procedures [2] through [3]. Automation has a significant impact on both the global economy and people's daily spending [4]. Engineers create complex structures for software and people using automated technologies, math, and organization. Many industrial jobs cannot be done by automation in place of people. Modern technologies and computers are incapable of producing language or pattern recognition. Human skill is necessary for strategy planning and the subjective assessment of complex sensory data, such as sound. To synchronize sensor and event data, programmable logic controllers (PLCs) are frequently employed [5].

## II. PROGRAMMABLE LOGIC CONTROLLERS

The PLC was made to meet the demands of the United State automotive industry. In 1968, the division of General Motors in charge of automatic transmissions, GM Hydrometric, requested suggestions for an electronic system that may take the place of the company's existing hard-wired relay devices. The man who has become known as the "father" of the PLC is Dickey Morley [1]-[4]. In industrial contexts, programmable controllers are a tool for managing processes. It is created using solid- state technology and allows the user to program it utilizing timer and counter operation, sequencing function, logical and arithmetic operations, and data manipulation capabilities. Similar to a computer, the controller contains of a CPU, I/O connection, memory and a programming.

## III. METHODOLOGY

The PLC, different sensors, control valves, and actuators make up the automation system for dam control described in this study [6]. The sensors are used to gauge the amount of water flowing through the dam and its level. Water flow into and out of the dam is controlled by the control valves, and the actuators regulate the movement of the control valves. Ladder logic programming is used to program the PLC to control the opening and closing of the control valves according to the dam's water level.

Dam control techniques come in many forms, such as:

- Spillway Gates: Spillway gates are used to control the flow of water in a dam [7]. These gates are normally positioned near the top of the dam and are used to release surplus water during periods of high rainfall or snowfall.
- Outlet Works: Outlet works are used to manage the flow of water out of a dam [8].

- Flood Control: Dams can also be used to control floods by retaining water during times of heavy rain and gradually releasing it to stop flooding downstream [9].
- Monitoring Systems: Current dams have monitoring systems in place to keep tabs on a number of variables, including temperature, flow rates, and water levels. Dam operators utilize this information to determine when to modify the different control strategies in order to preserve safety and peak performance [10].

## IV. AUTOMATIC DAM SHUTTER CONTROL

PLCs can be programmed to accept information from sensors and other monitoring systems, use that information to inform choices, and then use that information to manage the various dam equipment. PLCs can be programmed to keep track of how well different control mechanisms are working and to send out alerts or alarms when problems are found [11]. This enables operators to respond to issues as soon as they arise and take the necessary corrective action. To control water level in dam using PLC has advantages. Some of them are:

- quicker reaction times
- lower operating expenses
- consistent and efficient over time.

*Block Diagram*

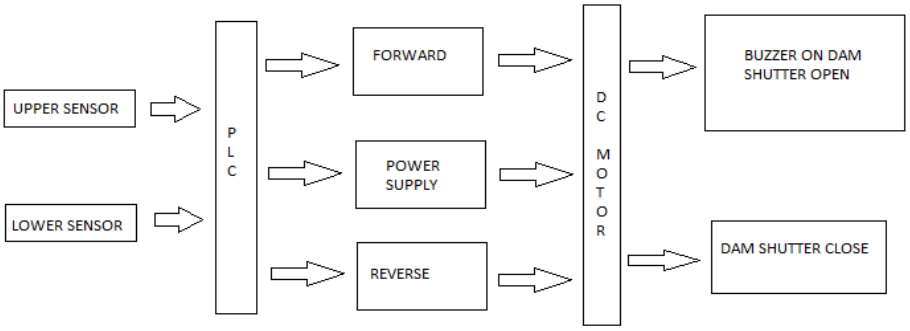


**Fig 1**. Functional Block Diagram

The **Fig 1** shows the functional block diagram of a self-regulating water repository conservancy.As shown in Fig. 1the sensor has been directly connected to the PLC's analog input pins the PLC will receive the analog input signal from it. The power supply has been connected to relay. Then according to the input signal, the PLC will trigger forward or reverse relay. The DC motor has been connected to relays. The motor has been connected to the dam shutter.

*I/O configuration*

**Table 1** Input/ Output Configuration

| Components | Type | Pin Addr. |
|---|---|---|
| FX5U PLC | controller | Nil |
| GOT1000 | Input | Nil |
| Float switch 1 | Input | $X_0$ |
| Float switch 2 | Input | $X_1$ |
| Lead screw 1 | Output | $Y_0$ |
| Lead screw 2 | Output | $Y_1$ |
| Gear motor 1 | Output | $Y_0$ |
| Gear motor 2 | Output | $Y_1$ |

Input and output components required for this system are tabulated in **Table 1**. All the I/O is digital, thus connected to the digital I/O pins of the PLC. This system consists of two float switch buttons to control the operation of the system. Each lead screw is used to operate the dam shutter [12].

*Control Wiring*

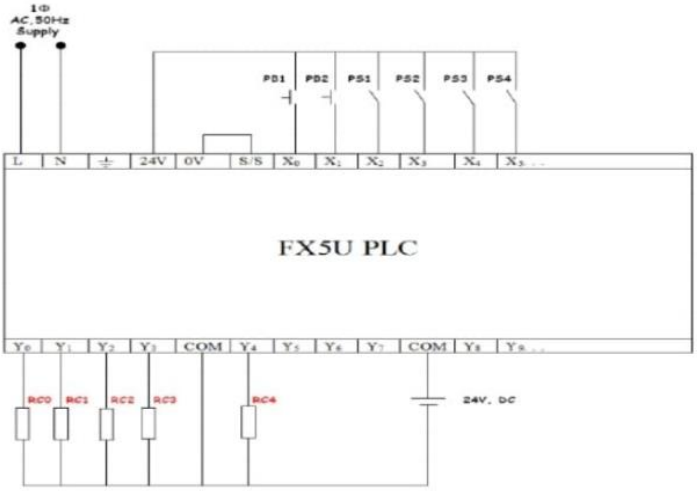


**Fig 2.** PLC Control Wiring

The FX5U PLC from Mitsubishi was used for this project. **Fig 2** shows the control wire for the self-regulating water repository conservancy. In sourcing mode, inputs are connected to the analog input pins. In sourcing mode, outputs are connected to the digital output pins. These RCs are powered by 24 volts from the PLC [13].

*Power Wiring*

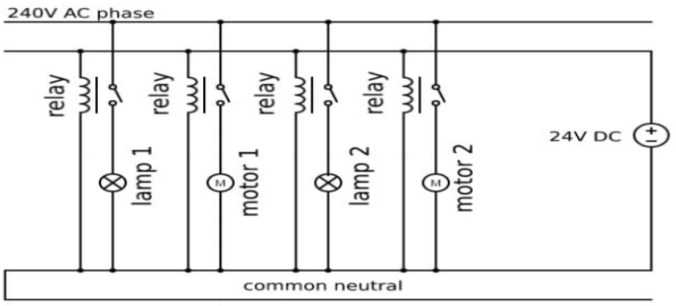


**Fig 3.** Power Wiring

The system's power wiring is shown in **Fig 3**. The external 12V DC supply is connected to all of the I/O components. From Fig. 3 the coil pins of relay have been connected to PLC, the normally open pin is connected to 24V DC and the motor has been connected to the normally open pin [14].

*A. Ladder Program*

Gxworks2 is used to program the ladder program for the self-regulating water repository conservancy. Here, it is provided as follows:

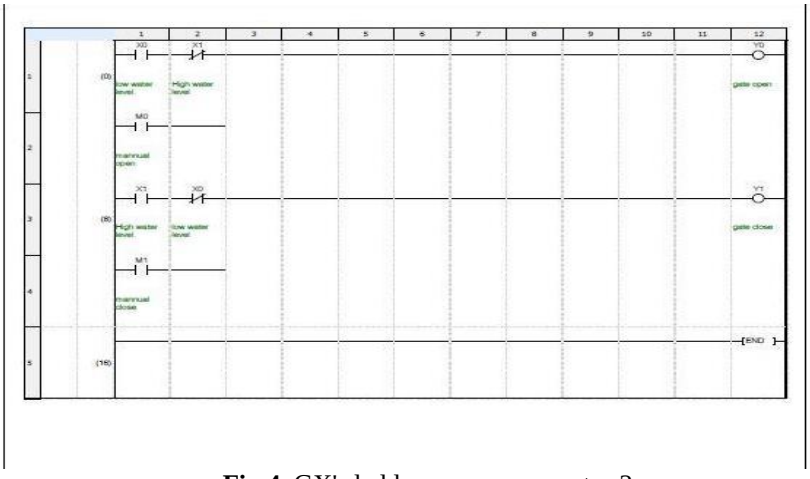

**Fig 4.** GX's ladder program operates 2

GX's ladder program operates 2 is shown in **Fig 4**. The ladder program has been programmed to control the dam shutter. The following steps are followed to program in GX Works 2 software:

- A sensor is first used to gauge the flow rate or water level. The sensor signals the PLC with the water level or flow rate that is currently present.
- Then, a ladder program can be developed to determine whether the flow rate or water level is above or below a specific threshold.
- The "rungs" of the ladder are used to define a number of conditions and activities in the ladder program. For instance, the first rung might determine whether the water level is higher than a predetermined level, and if it is, the second rung might instruct the shutter to open.
- The ladder program will send a signal to a motor or actuator that controls the shutter in order to tell it to open or close. The ladder program "coil" is used to produce this signal.

In the program, the address X0 has been assigned to the low-level sensor of the dam, and the address X1 has been assigned to the high-level sensor of the dam. The address Y0 has been connected with the gate opening mechanism, and the address Y1 has been connected with the gate closing mechanism. The address M0 has been internally assigned to the HMI to control the gates regardless of the water level [15].

The logic works on a simple basis: if both the higher and lower sensors are triggered, then the gates will open, and if the higher and lower sensors are triggered, the dam shutters will automatically close [16].

*Flow process of water level controller*

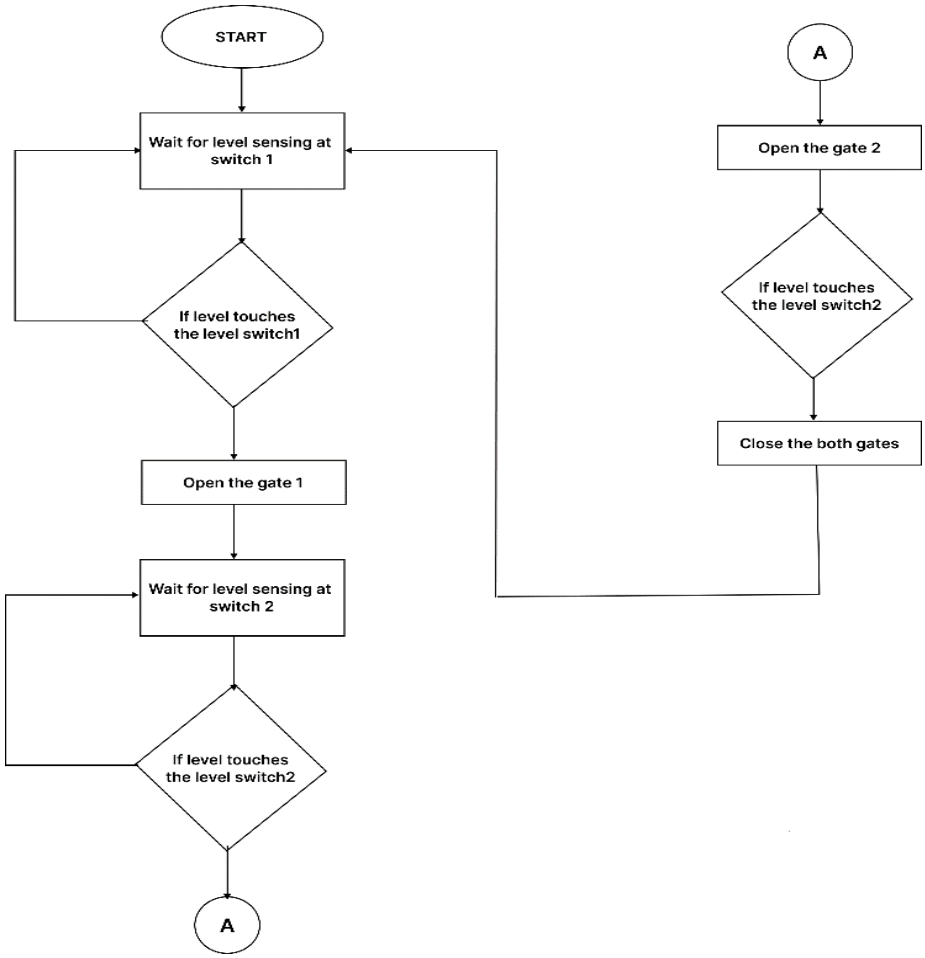


**Fig 5**. Flowchart of water level control using PLC

The flowchart of the self-regulating water repository conservancy is depicted in **Fig 5** and it depicts how the ladder program logic has been used in projects and under PLC control. **Fig 5** explains that the process starts by getting signal from level sensor, if NO it will wait for the sensor signal or if YES then it will proceed to next step by opening the gate. Then it will wait for second sensor signal, if NO it doesn't close the gate, if YES then it will close the gate and this process run repeatedly.[17] – [18].

## V. HARDWARE AND IMPLEMENTATION

Several hardware elements are needed in order to create a dam shutter control system using a PLC, including:

- Programmable Logic Controller (PLC)
- Input/output (I/O) modules
- Human Machine Interface
- Communication modules
- Power supply
- Dam shutter actuator

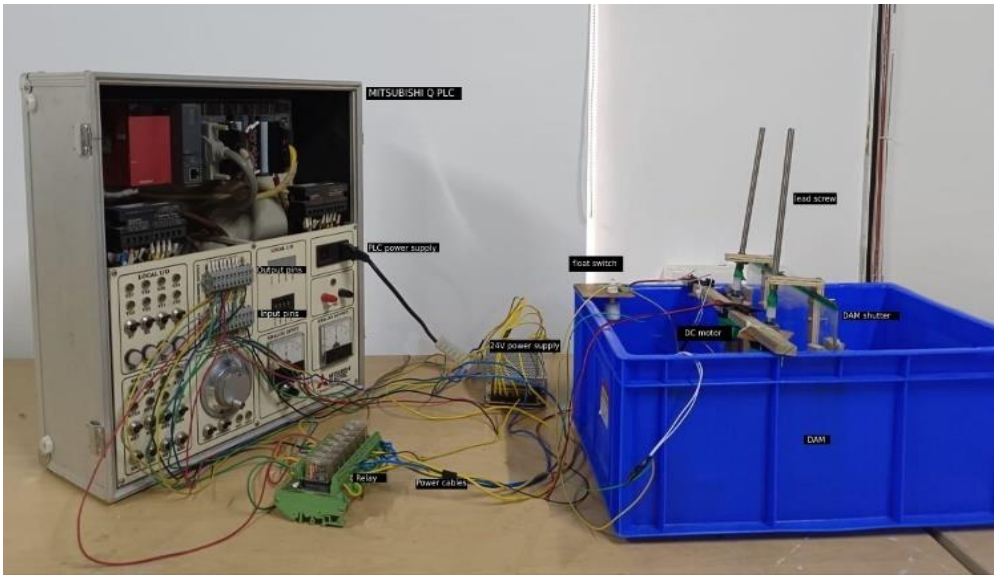


**Fig 6.** Self-RegulatingWater Repository Conservancy

**Fig 6** is the prototype model for the complete dam mechanism, which is controlled by Mitsubishi Q plc. The gate-controlled high-voltage induction motor is indirectly connected to the level sensor's output pins by a relay, with the level sensor's output serving as the plc's input. Internal memory bits have been used to connect the HMI to the PLC. Lead screws have been used to open the dam gate. The top and bottom levels of the dam are where the floating sensors are maintained.

## VI. RESULT AND DISCUSSION

Using a PLC to implement a dam control system has various benefits, including improved efficiency, precision, and safety. In this part, we will talk about the outcomes and advantages of adopting a PLC-based dam control system.

Greater efficiency: By automating the opening and closing of the dam shutter, a PLC-based dam control system can increase the effectiveness of the dam's operation. This reduces the possibility of overflow or drought by ensuring that the water level or flow rate is kept at the proper level. This can result in enhanced energy efficiency and reduced water waste. Increased safety: Automating the opening and closing of the dam shutter, which eliminates the need for manual intervention, is one way that PLC-based dam control systems can increase safety. This lessens the possibility of mishaps and injuries during the manual control of the dam.

Remote monitoring: The PLC-based dam control system can be monitored remotely with the use of communication modules. This enables operators to remotely make adjustments, receive alarms as needed, and monitor the system in real-time. As a result, fewer manual checks are required, and any problems can be addressed more quickly.

A PLC-based dam control system has various advantages, including improved effectiveness, precision, and safety. A PLC-based system can also aid in lowering operating expenses for dams because it allows for remote monitoring and requires less maintenance. Overall, using PLCs for dam management gives a dependable and efficient method of managing the water flow in dams.

## VII. CONCLUSION

Automating the dam shutter control with a programmable logic controller (PLC) has the potential to improve efficiency, productivity, and safety. The PLC can be configured to operate the dam shutter entirely. Human error can be reduced, and the washing can be done swiftly and reliably by automating the process. A PLC can also decrease the demand for manual labor, which will save operating costs. Overall, firms that wish to enhance their shutter control may find that building a self-regulating water repository conservancy using a PLC is a cost-effective alternative.

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