A Review on Automation of Floodgates of Water Reservoir by Programmable Logic Controller (PLC)

Vandana Sahu*, Dr. (Mr.) Nagendra Tripathi**

*M.Tech Scholar, Department of EE, Bhilai Institute of Technology, Durg, India,

sahuvandana55@gmail.com

**Professor, Department of EE, Bhilai Institute of Technology, Durg, India,

ntripathi@bitdurg.ac.in

Abstract-This paper is intended as an overview of water reservoir automation. Water reservoir are crucial to country's economy as they are the resources of power generation, irrigation, water conservation and so on. This paper is focused on controlling the floodgates of reservoir and the process variable parameters like level and flow of water with real time implementation using programmable logic controller. In this paper, a programmable logic controller is act as an industrial computer, playing role of a control device and push buttons, level and flow sensors provide incoming signals to the control unit. The prototype model is provided with five levels and depending on the level sensor outputs, ladder logic is actuated. This work uses PLC of Semeins-Simatic S7300 with 32 digital I/O and 8 analog I/O.

Keywords: Automation, Ladder logic, PLC, Level Sensor, Reservoir Gate Control

1. Introduction

Water constitutes 75% of Earth resources and has been harnessed by human beings for various purposes, one of them is to generate electricity through reservoir. It nearly contributes 17% of India's electricity and thus act as an integral part of our daily lives.[Shah T.,2008,[3]]. Reservoir may be built of any size to serve the purpose that they had been intended for. But without sufficient planning and allocation of resource, any dam could give result that are unsatisfactorily or in extreme cases, even harmful to human welfare.

It not only provides electricity but also used for irrigation, domestic water supply and for flood control. It also serves as great places of conserving local flora and fauna and attract a great number of tourist but unfortunately the current operations of these reservoir may put these tourists lives under-risk.

While the total power generated by hydroelectric sources is about 36GW. Another major aspects of these dams is that they supply water to a number of irrigation canals that feed their way to agricultural plots in places that face a dearth of rainfall or other natural resources of irrigation. Currently there are 13 irrigation canals from dams in India. A function of reservoir with revenue potential is that they serve as great places of conserving local flora and fauna and attracting tourists.

Until now around 8,00,000 dams have been constructed world wide for different purposes. V.Rajeswari et.all,[2012][4], represents an automatic/remote controlling of an hydroelectric power plant using PLC and SCADA. The prototype model is provided with five levels in the upper tank and two levels in the lower tank and depending on the sensor output, logic is actuated. This research work uses PLC of ABB MICROLOGIX 1200 inbuilt with 24 digital inputs and provides 16 outputs to control the miniaturized process depicted in the work. Thus by using PLC and SCADA, the level of water is effectively controlled, by opening the gates of the dam whenever the level changes.

The automation Canal Gate control project proposed by Mahesh Nandaniya,[2013][1], describes a new canal automation system that has an integrated hardware and software system from gate control to a commercially available supervisory control system and focuses mainly on irrigation. A 3-phase induction motor with two gear boxes are used with conjunction of a PLC that controls the rpm of the induction motor for gate control. PLCs and variable frequency drives (VFD) are used to control and monitor Canal Gate at the field.

Although various automated floodgates system exist that make use of supervisory control and simulation of dam safety. We propose a system that eliminates the need of manual supervisory control to a good extent in ensuring safety from the released spillway water. Our implementation of automatic floodgates delivers into installation of a floodgates system that focuses on three major aspects- power generation, irrigation and human safety consideration.

2. Methodology

The input signals are given to the PLC. The input devices can be pushbutton, level switches, limit switches, sensor etc. The output of the PLC is given to the final control element. The output elements can be valves, motor, control relays, alarms, and siren. They control the opening of the gates and the feedback signal provide continuous monitoring of the exact water level in the reservoir. The feedback signals are compared with threshold values of the main program which is used to open / close gate of reservoir for flood control.

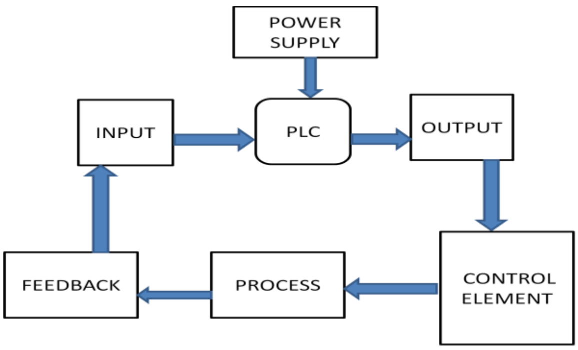


Figure 1. Block Diagram

Describing this system starting with the components that may be best suited for practical implementation, followed by a brief description of our proposed solution and lastly, the detailed process description.

a) Programmable Logic Controllers: A PLC is used for the control operation of manufacturing process and machinery. It uses a programmable memory to store instructions and execute functions including counting, on/off control, timing, sequencing, arithmetic, and data handling. For this, we use the PLC SIMATIC S7-300 of SIEMENS in Simulation Mode, as this particular PLC is flexible, fast, offers good memory capacity and various networking options through CAN, Ethernet, Ether Cat, etc.

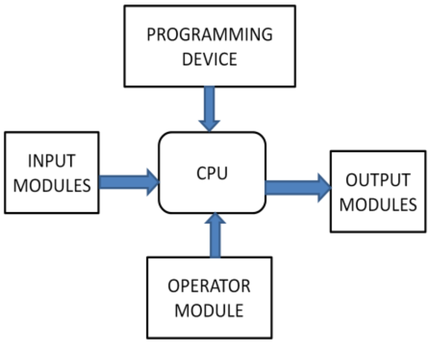


Figure 2. Block diagram of PLC

b) Ladder Logic Programming: Ladder programs are used in large, complex systems that control industrial automation, process control, manufacturing and assembly lines. Programming in ladder logic provides ease of use, easy functionalities, flexibility and helps in incorporating changes better. PLC programming through ladder programming is thus a suitable, less-cumbersome way of operating large systems, like floodgates of dams.

c) Floodgates actuation: Floodgates are adjustable gates used to control water flow in flood barriers and reservoirs. Floodgates generally enclose the water in the reservoir, giving them a one-way, open/close passage to the spillways. Once freed, the water drops from the height dictated by the dam construction and allowed to fall on the turbines; thereby converting the potential energy (mgh) of falling water with mass m at a height h, into rotation al energy through the turbines. The rotation of the turbines is then responsible for generating DC (dynamos) or AC (alternators) power through the principle of electromagnetic induction.

The actuation of floodgates is implemented with PLCs, wherein the ladder program takes care of controlling the opening and closing of the floodgates as and when needed, or following interrupts that may occur in the program operation sequence. This is beneficial also because the response time of the system controlled by PLCs usually range within microseconds to milliseconds. For practical implementation of this project, we intend to use gate actuators, interfaced with the PLC.

d) Level sensors: Standard level sensors that can be interfaced with PLCs are used to sense the level of a liquid. Mechanical float level sensors are the most widely used type of sensors for automation purposes. The sensor consists of a lightweight float suspended at the liquid level that moves vertically with changing water levels. The raising of the float -that is mechanically attached to a level switch on the other end- above a certain height, trips the level switch. Thus, when the water level rises above preset height, the level switch trips to give logic 0 and when the level is below the preset height, the circuit is complete and results in logic 1 which is the default state of the sensor. Using such mechanical float sensors allows quick response of the level switches that are represented in the ladder program, in response to changing water levels in the reservoir.

Process Description

The primary goal of this research work is to meet power generation requirements of a small hydroelectric dam and also serve irrigation needs without compromising the safety of tourists or personnel involved in the dam operation who maybe approaching the dam or its vicinity. The dam consists of two level sensors at the entry point of the water from the reservoir to the floodgates- LS 1 and LS2. These two levels designate the low and high levels of the water in the reservoir. When water is below the low level, it is evident that there is not sufficient water in the reservoir and at this stage the turbines are not desired to be operated. These levels are specific to different dams. On the other hand, the second sensor designates the upper level of the reservoir water. When water level rises above this level, there may be elevated risk of flooding and dam breach failures. Thus it is desirable for the water to flow through the floodgates onto the spillways when this happens. When water level in the reservoir is between the two levels discussed above, normal functioning of the dam ensues. At a stipulated time of the day, say 10 p.m., the gates are opened to turn the turbines for a limited time period (4 hour).

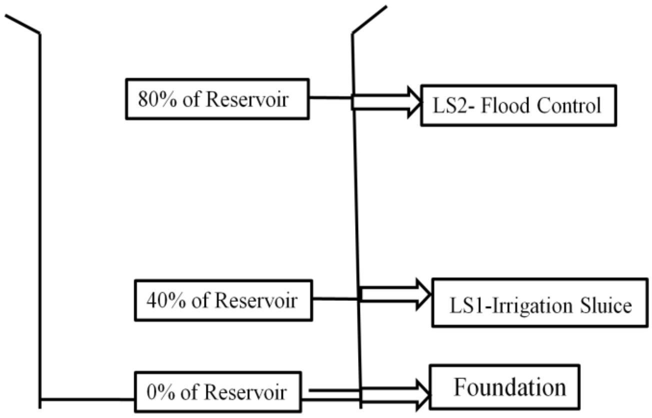


Figure 3. Layout of Water Reservoir

3. Ladder Program Implementation

A. Algorithm

To model the system, we implement a ladder program based on the following steps:

• Initially, we consider that the water in the reservoir is below the lower level (LSl); this implies that water in the reservoir is below the minimum level, therefore we require all the gates to be closed, irrespective of the presence or absence of humans in the tourist area.

• Next, when water in the reservoir rises above Level 1, and it is the operation time of the dam, we open Gates so that water fills the canal and flows down to the turbines for power generation.

• When the water is above Level 2, a siren rings to alert them to open the gates of reservoir. At the same time, the floodgates are open to direct water from Gate channel, thereby minimizing the risks of flooding near the banks of the reservoir. The need for opening of gate is detected by the water level sensor LS2. Thus, when water level goes above LS2, Gate is opened to allow water flow to the spillway. It remains open until water lower down to the level of water in the reservoir.

• Lastly, in case water level goes below LS2, they are detected by the sensors and floodgates are close so that water level is maintained for its multipurpose uses in the reservoir.

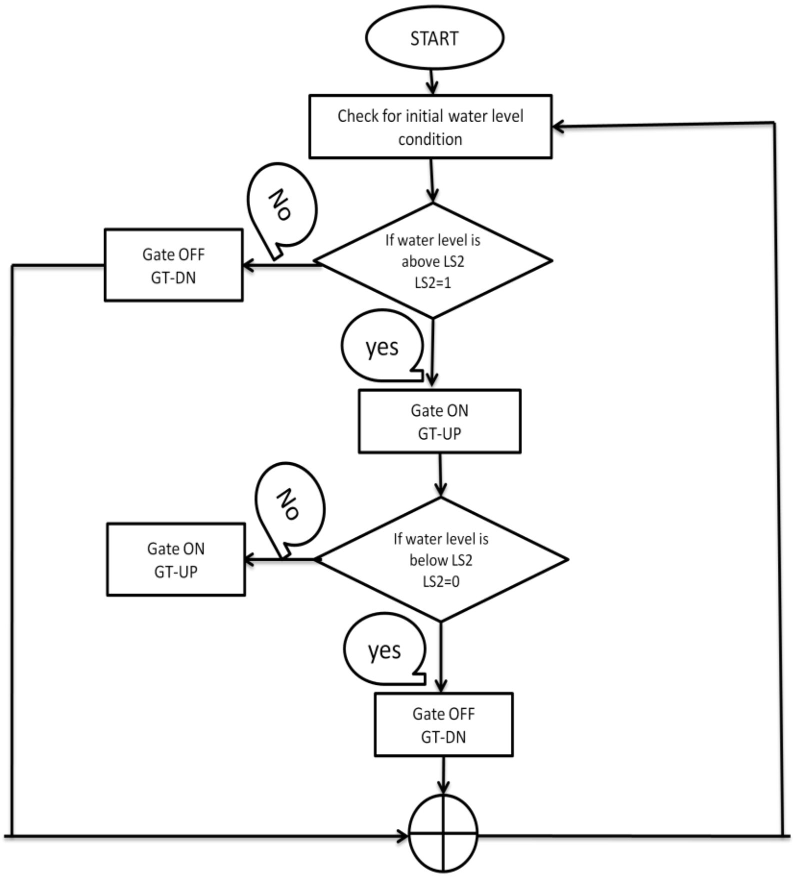
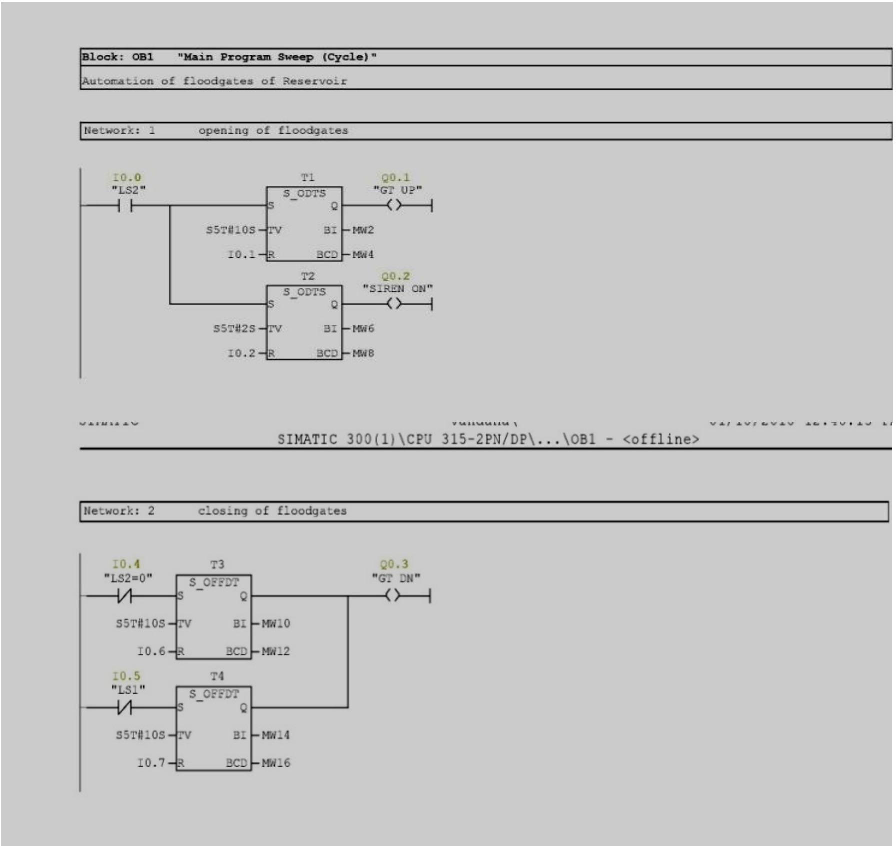


Figure 4. Flowchart of algorithm implemented

B. Ladder Program As illustrated in the flowchart (Figure 4), the various I/O described here are.



LS1 = 1 when water in reservoir reaches the dead level.

LS2 = 1 when water in reservoir reaches the higher level; needs to be released.

Each set of gate actuator is represented by two limit switches- up and down. For example, GT up= 1 motions Gate 1 to move up, thereby opening Gate 1. At the same time GT Dn must be = 0 to ensure that Gate 1 does not come down before indicated in the ladder program. The same holds true for all the other gate actuators.

Network -1: Once LS2 = 1, Timer T1 counts down to the set time and energizes an intermediate output after 10 sec and Gate is opened. Siren goes on if LS2=1 and Timer T2 operates after 2sec.

Network-2: Gate should be immediately closed, if LS2=0 and the Timer T3 counts down to the time for dam operation. Gate should also be closed when LS1=1.

4. Results

Using minimal inputs and corresponding outputs, the system has been realized on SIEMENS-SIMATIC- S7300 in Simulation mode. The use of Ladder programming goes in line with its usage in controlling the operations of existing large-scale systems like dams. The algorithm for this program is a nobel initiative for upcoming plans of large or small hydro-electricity generation projects, that does not compromise on safety of nearby people on account of normal dam functions like power generation and irrigation.

5. Conclusion

The automation of floodgates has been implemented in Simulation Mode using PLC SIEMENS-S7300 V5.5 As can be seen, the system is automated keeping in mind several factors such as level of water in reservoir, irrigation, time of the day and also of human beings near the floodgates. The added features of this system are water storage, servicing as a tourist destination, meeting irrigation demands while minimizing the potential dangers of such hydroelectric systems. This system is capable of fulfilling the described goals of the project with the added focus on human safety.

6. Future Scope

The use of PLC makes the system both power and cost- effective and also easy to be operated and maintained. Further extensions can be made on the system by:

a) The system can be implemented on a full-scale SCADA computer for easier operation and visualization of a single operator at the control station.

b) Direct gate control using weather forecasts and satellite implications can be done. This would help make the system a lot more efficient and robust by upgrading its response to sudden situations like cloudbursts or floods.

7. References

[1] Mahesh Nandaniya (2013) "A Review Paper of Automatic Canal Gate Control of 3- Induction Motor with PLC and VFD, Powered by Solar System and Monitoring by SCADA." International Journal of Emerging Trends in Electrical and Electronics (IJETEE), Vol.1, Issue. 1,March-2013.

[2] Rajat R.Sorte,Rahul R.Sonwane,Nikhil L.Thaku,Swapnil A.Akhade, Shashwat N.Kawale,Nikhil R.Dusawar,Kapil K.Lalwani,2015 “PLC Based Dam Automation System”,IJERECE,Vol.2,Issue 3, March 2015.

[3] Shah, T. and Verma, S. 2008. "Co-management of Electricity and Groundwater" Economic and Political Weekly, Vol.43 (7).

[4] V.Rajeswari, Prof.Y.Rajeshwari, Dr.L.Padma Suresh, (2012)”Real- Time Implementation of Hydroelectric Power Plant Using PLC and SCADA” International Journal of Engineering Research and Applications (IJERA),Vol. 2, Issue 3, May-Jun 2012.

[5] Petrezuella :Programmable Controllers :Principles & Applications, Merryl Publishing Co.

[6] Bobat, A., Gezgin, T., Aslan, H. (2014),”The use of SCADA system in dam management”, EWaS-MED International Conference, April 2012.

[7] Gareeyasee Saha,Anjana Parua,Sushmitha R,Shilpa Bhat, (2015) “Automatic Floodgates Control Using PLC With Added Focus On Human Safety”,IEEE,International Conference on Control Instrumentation, Communication and Computational Technologies(ICCICCT),Issued on 2015.

[8] Prashant Bhardwaj,Yogendra Singh Rajawat,Satyaprakash Rajput, Satyaveer Singh Narvariya,Laxmi Narayan(2014) “Automatic Dam Shutter Senses The Water Level And Control The Dam Door Using Servo Motor” 4^{th} SARC-IRF International Conference,New Delhi,India.,Issued on 27^{th} April,2014.