Automatic Level Control for Cascaded Water Tanks using PLC

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ABSTRACT: *This paper proposes an optimized automatic control technology using a programmable Logic controller through a communication network. A Programmable Logic Controller is a digital computer used to control the industrial process automatically. They are designed to replace hard-wired relays, timers and sequencers. They make the process flexible, easy programmable and have the ability to work under adverse condition. First, a prototype system is designed and built. Second, the remote control algorithm is applied via Remote Modules. The power consumption and cost is minimized for the proposed implemented technology. We have used ROCKWELL plc and electronic devices such as sensors, valves and controllers. To program our project we used the ladder logic language in RSLINX software. The process control is successfully tested and evaluated to demonstrate the reliable, robust and accuracy of the proposed method. This remote control process verifies the use of control network in industrial type Environment.*

Keywords: Automatic Control, Programmable Logic Controller, Manual control.

I. INTRODUCTION

Technology has been always the goal for automation industry and control systems worldwide because of many remote industrial control applications. Control networking concept had difficulties to pave its pathway into replacing the conventional control networks. The control system would have been the optimum solution that is able to reduce the cost substantially by simply replacing the running cables, wires and required infrastructure. Today, the control network is undergoing extensive studies and piloting to address the issues in order to mitigate the risk. Overall, the industrial control system standards require a level of robustness in terms of reliability and availability as a challenge for the remote control. For that reason, manufacturers are working thoroughly to improve and to develop the needed technology.

With a rapid increasing industrial growth, an efficient and effective method is needed to control the process. So the very first programmable logic controller PLC is explored in 1960s. In simpler words we can say that automatic control means assigning a human job to a device. Automation has been widely used in different areas such as traffic light control, food manufacturing industries, car parking, waste water treatment, oil and gas purification, chemical, pulp and paper production and so on.PLC has gained its importance as it helps in achieving high productivity with accuracy, reduces labor cost, ensures safety, reduces complexity.

The experiment performed uses the PLC as control platform. The level was controlled through an ON/OFF solenoid valve, they used the digital input/output pins to control the level by either fully open the valve or completely closed. Water level control is achieved by using different components such as motor, valves, sensors and PLC. In this project limiting switch is used as level sensor in order to set lower threshold and higher threshold in each tank. The sensors sense the level of water and give signal to PLC. The PLC responds accordingly. If the water level is low PLC send a control signal to start motor and if the water level is at higher threshold the PLC produce a signal to stop the motor.

Currently, there are many types of PLC in the market. One can choose the PLC depending on the required size, cost, and functions to satisfy different requirements of different system specifications. This project requires less number of inputs and outputs terminals, so we have used ROCKWELL 1600. It is a small PLC with fixed number of inbuilt inputs and outputs terminals. Since ROCKWELL is used as a controller so RSLINX software is used to program the system. Ladder logic is used to control the system.

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It uses as modules with low power consumption and capable of providing a robust control network with the most feasible and efficient way. The project illustrates how devices are compatible with industrial control applications. This is a crucial point for many controlling devices that require Special software or complex hardware to establish their interface.

In this project, a stereotype model of two tanks connected in series is designed and built to represent a small scale of a process or a plant for the proposed control network experiment. The tank's level controlled by RSLogix1600 PLC is manufactured by Rockwell automation. The tanks' levels communicate with the controller remotely using low power consumption devices produced from Allen- Bradly. Modules, the base model receive the data from the field and connect it directly to the PLC through the IOs cards. PLC includes a ladder logic control automatic control loops. Developed to emulate the control panel and to monitor the tanks' control valves as well as the pumps. The next following chapters will go in details, starting from the technical background for the major components, design and implementation and eventually with the results and conclusion.

II. SYSTEM SETUP

The system is simply recognized. The system consists of three tanks, four valves and a pump located at a basin. The upper two tanks as shown in below figure are working tanks and the third tank is taken as a swamp or a reservoir. The pump feeds the tank 1and tank 2 with a constant flow rate. The output from tank 1and tank 2 will go to a basin (tank 3) where the water is circulated to tank 2 and tank 1 again. This setup is to simply build a reasonable model to test the wireless control network performance. We represent Solenoid valve as S.V. The lower S.V3 and S.V4 are the outlets of tank 1 and tank 2. The upper S.V1 and S.V2 are the inlets of tank 1 and tank 2.

III. DELINEATION OF PROPOUND EQUIPMENTS AND SOFTWARE

A cascaded tank system is built and set up for in order to demonstrate the Automatic control concept. The HMI can be developed using the Factory Talk Studio package from Rockwell Automation creates a user interface control panel window to be used for controlling the plant. The setup illustrated is developed using three tanks, two proportional solenoid valves and one extra pump to return the water back to tank 1 from basin or tank 3. RSLogix 1600 controls the level of the tanks 1 and 2 remotely; the signals are transmitted and received using plc IOs modules.

Therefore, major components of the plc control systems are listed as follows:

1) RSLogix1600 PLC System
2) Operational Solenoid Valve
3) Level transmitter
4) Submersible pump

Pumps, PLC modules operate on different voltage ranges. In order to make these modules compatible, electronic interface modules are designed and implemented to overcome voltage range differences. Details of the system components along with designed interface boards are described in the next section.

RSlogix1600 PLC Configuration

This system is equipped with 2 Analog inputs, 2 Analog outputs and built-in 16-Digital inputs/outputs. One Analog input card is using 0-10 VDC connection and the other is using the regular 4-20mA, the same for the Analog output card as well. The well-known Allen Bradley PLC 1600 Compact Logix, as shown, is used in this project. The controller has the advantage of the size it has compact I/O modules as well as the controller with the power supply. The system is preferred for applications where size and space matter.

Operational Solenoid Valve

A Solenoid valve is an electromagnetic control unit used to control the flow of liquid automatically. It consist of a solenoid through which when electric current passes gets energized , a magnetic field builds up which pulls a plunger or pivoted armature against the action of a spring thereby allowing the flow of liquid. When power is off it gets de-energized and the plunger or pivoted armature is returned to its original position by the spring action thereby shut off the flow of liquid. Although that the valve would work better in higher velocity or pressure flow, it works with very reasonable and satisfactory performance even at low velocity flow. Due to very high frequency in signal output, the valves operate smoothly and constantly. The current sensor will maintain the output of the current no matter what the voltage or coil current variations are.

Level Transmitter

Measuring the water level in the tank is another challenge, however, level transmitter, as shown in; produced by *MiltoneTech* company is used for this set up. The level transmitter resistance output is a variable resistance. It gets converted to voltage using a linear resistor-to-voltage module. The module is a circuit consists of a differential Op-Amp which generates an output voltage signal proportional to the measured tank level. A level switch also can be called float switch is used to detect the level of liquid in a container. They used magnetic reed switches to complete the circuit. Once the float reaches its lowest point when the tank is empty the magnet would connect thereby completing the circuit. The magnet would cut off once the water reaches the ample level again, opening the circuit back up. Basically, a magnetic field is moved into the propinquity of a reed switch due to rising or falling liquid, causing its actuation.

Water Return Pump Connection and Wiring

A pump has been added to the third tank as part of the system to have a constant flow going to the first tank. It is a submersible pump. It is submerged in the liquid to be pumped. It has an airtight sealed motor close-coupled to the pump body. They push fluid upside to the surface. The main advantage of this type of pump is that it prevents pump cavitations. The pump requires 12Vdc to operate, for that we will be using EMR relay to control the pump operation. Provides the control signal to the relay, and the relay starts and stops the pump accordingly.

IV. EXPERIMENT RSULTS

Shows the overall system built for receiving the data from field through wired directly to the PLC system. It is very important to develop a procedure that serves the objectives defined for this project. Therefore, the following procedure is developed where the control performance of the tanks

level control can be tested.

The following steps are required to be applied in order to generate the results of the experiment depicted

- Powering up The system
- Starting the Pump to fill the tank 1 and tank 2 to reach 80
- Shutting off the pump when level at tank 1and tank 2 reached 80

It is noted that when the pump is turned on, depending on the water level the level switches operate. When the pump is on water is filled in both tanks till it reaches the threshold valve that is 80% of the tank. The control valve went wide open to compensate the level increment. The level switch detects the level is at 80% and sends a signal to PLC.PLC in return send respond back to stop the pump.

While defiling the tank 1 and tank 2, when water level decreases up to lower threshold value 30%of the tank the lower level switches send signal to PLC which in return turns on the pump again to fill the tanks again.

It is noticed that the tank is quite small compared to the velocity of the flow rate coming out of the valve, however, that explains the time been taken to reach the set point which took around 3 minutes. It was observed that there was the fluctuation of the level reading which is common and normal occurs due to hydrostatic shocks created by the valve's reaction towards the water. The effect of the flow-in is observed clearly when the pump is ON causing water level instability. The input flow causes the level or the process disturbed or to be unstable. Once the pump is OFF the level settled in both tanks and the reading was steady again. As the previous test, almost the time required to reach the set point is approximately around 3 minutes which is a reasonable time when compared to the output flow with respect to the tank volumes.

V. CONCLUSION

This paper proposed an optimized automatic control technology using a programmable logic controller. The remote control platform was designed and implemented for level control of a cascaded tanks system by programmable logic controllers.

A prototype system is designed and built. The power consumption and cost is minimized for the proposed implemented technology. The process control is successfully tested and evaluated to demonstrate the reliable, robust and accuracy of the proposed method. This remote control process verifies the use of plc control in industrial type environment.

The proposed set up helps realize and impose a drastic improvement in the automation and control industry. Conducting a full and thorough feasibility study at least for such a small scale process helps advance and accelerate the implementation of remote control system in wider and broader ranges. This model is a potential to develop many control strategies such as optimum control, predictable control, multi-variable control and etc., as a milestone targets for future research on plc control.

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