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Comparison of Control System Using PLC & PID

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Abstract— **A control system is an interconnection of components forming a system configuration that will provide a desired system response. Due to the increasing complexity of the system under control and the interest in achieving optimum performance, the importance of control system engineering has grown in the past decade. This paper proposes the development of a robust soft-hardware interfacing based advance control where linearize the input-output data is obtained. A proportional–integral–derivative controller (PID controller) is a generic control loop control Feedback mechanism widely used in industrial control system. A PID controller attempts to correct the error between a measured process variable and a desired set-point by calculating and then outputting a corrective action that can adjust the process accordingly. PID controller is designed using MATLAB functions to generate a set of coefficients associated with a desired controller's characteristics. A MATLAB program is used to activate the PID controller, calculate and plot the time response of the control system. Although, PID based controller have particularly been successfully applied in modern control engineering in the last decade, this paper deals with the feasibility of employing advanced control technique of Programmable Logic Controllers (PLC) to linearize the input-output characteristics of control system. In machining, packaging, material handling, automated assembly or countless other industries applications the PLC is more efficient considering money and time than any other control. The effectiveness of proposed control system of water tank liquid level control is amply demonstrated by the significantly low error in discrete response testing.**

Keywords— PLC Controller, PID Controller, Level Control, Water level.

I. INTRODUCTION

A feedback control system often uses a function of a prescribed relationship between the output and reference input to control the process. Often the difference between the output of the process under control and the reference input is amplified and used to control the process so that the difference is continually reduced. The feedback concept has been the foundation for control system analysis and design. Mathematical modeling of liquid level system treats of step response analyses of dynamic system. MATLAB is extensively used step response analysis and Routh's stability criteria for the stability for higher order closed loop systems. A PID controller is designed using MATLAB functions to generate a set of coefficients associated with a desired controller's characteristics. A MATLAB program is used to activate the PID controller, calculate and plot the time response of the control system. When the MATLAB program is run, it plots the time response of the system. Industries need a sophisticated, smooth and easy handling controller. When production requirements changed so did the control system. This becomes very expensive when the change is frequent. Since relays are mechanical devices they also have a limited life time which required strict adhesion to maintenance schedules. Troubleshooting was also quite tedious when so many relays are involved. These relays would be individually wired together in a manner that would yield the desired outcome. The present challenge to control engineers is the modeling and control of modern, complex, interrelated systems such as traffic control systems, chemical process and robotic systems. Perhaps the most characteristic quality of control engineering is the opportunity to control machines and industrial and economic process for the benefit of society. PLC provides above all the term we need. PLCs are used in almost every aspect of industry to expand and enhance production [1]. Where older automated systems would use hundreds or thousands of electromechanical relays, a single PLC can be programmed as an efficient replacement [2, 3, 4]. It uses a programmable memory to store instructions and execute functions including on/off control, timing, counting, sequencing, arithmetic, and data handling [5]. The functionality of the PLCs has evolved over the years to include capabilities beyond typical relay control. Sophisticated motion control, process control, distributive control systems, and complex networking have now been added to the PLC's functions [6]. Therefore, PLCs provide many advantages over conventional relay type of control, including increased reliability, more flexibility, lower cost, communication capability, faster response time and convenience to troubleshoot [7]. The importance of PLC is easy programming with ladder diagram [8] for control and the Industrial applications are the main motivation of this thesis.

II. PID IN CONTROL SYSTEM

A PID controller is a generic control loop control Feedback mechanism widely used in industrial control system.

A PID controller attempts to correct the error between a measured process variable and a desired set-point by calculating and then outputting a corrective action that can adjust the process accordingly. The PID controller calculation involves three separate parameters; the proportional, the integral and derivative values. The proportional value determines the reaction to the current error, the integral determines the reaction based on the sum of recent errors and the derivative determines the reaction to the rate at which the error has been changing [9]. By "tuning" the three constants in the PID controller algorithm the PID can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the set-point and the degree of system oscillation. In PID control action is defined by,

$$u(t) = K_p * e(t) + \frac{K_p}{T_i}\int_0^t e(t)dt + K_p * T_d \frac{de(t)}{dt}$$

In Laplace transform quantities,

$$\frac{U(s)}{E(s)} = K_p\left(1 + \frac{1}{T_i * s} + T_d * s\right)$$

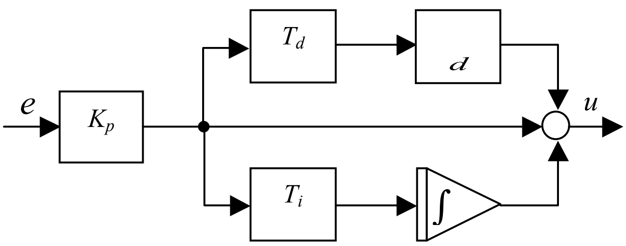

Figure 1: Proportional- Integral-Derivative controller schematic diagram.

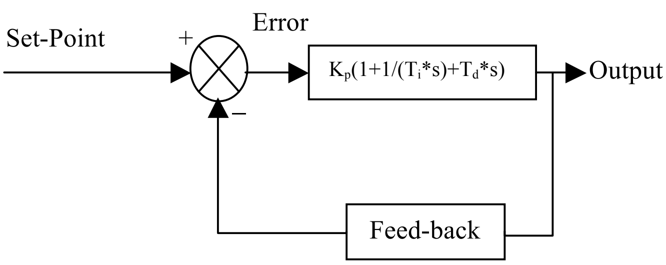

Figure 2: Block diagram of Proportional- Integral-Derivative control action.

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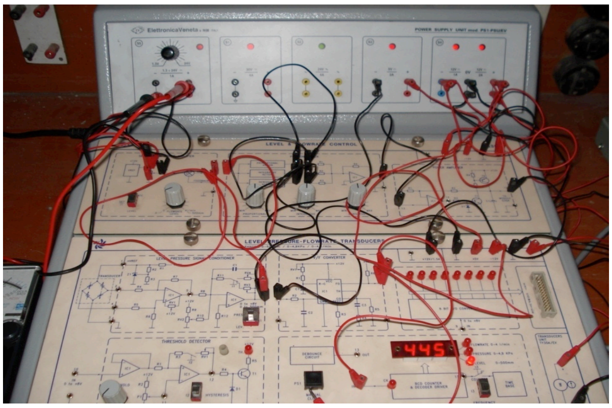

Figure 3: Pictorial view Experimental kit of PID (mod. G30B/EV).

III. PLC IN CONTROL SYSTEM

A Programmable Logic Controller (PLC) is a device that was invented to replace the necessary sequential relay circuits for machine control. The basic elements of a PLC include input modules, a central processing unit (CPU), output modules and a programming device.

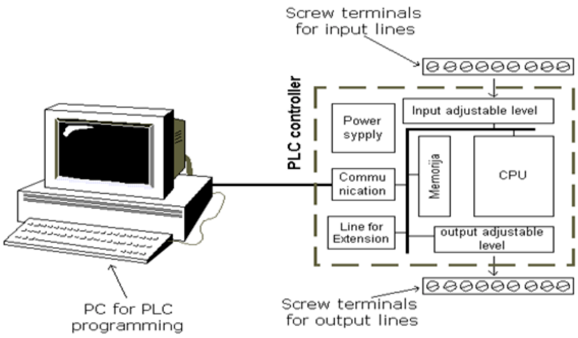

Figure 4: Basic elements of PLC controller [1]

The PLC works by looking at its inputs and depending upon their state, turning on/off its outputs. The user enters a program, usually via software, that gives the desired results. The Programmable Logic Controller (PLC) has become an essential aspect of any automated manufacturing process. PLC's are a very useful control solution for a variety of exhibit and interactive applications. These general purpose control devices can accept a number of inputs from such devices as pushbuttons, motion detectors, joysticks, etc. They can have multiple relay, analog and serial outputs to control lights, motors, sound effects, etc. In between the inputs and outputs is a control program that determines which outputs are activated when certain combinations of inputs are received. Ladder logic is the main programming method used for PLCs. Ladder logic has been developed to mimic relay logic. The decision to use the relay logic diagrams was a strategic one. By selecting ladder logic as the main programming method, the amount of retraining needed for engineers and trades people was greatly reduced [10].

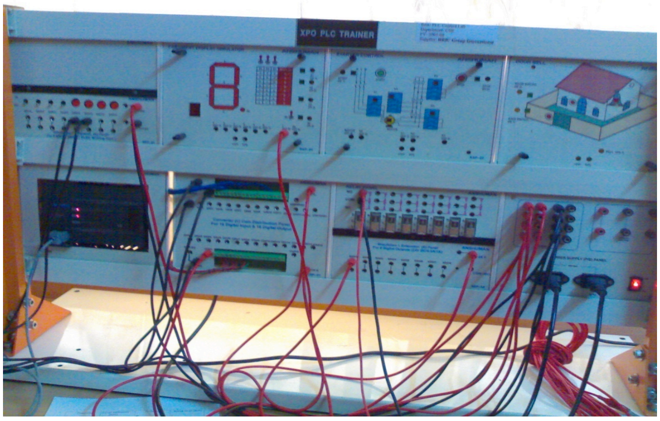

Figure 5: Pictorial view of K7M-DR20UE PLC & wiring.

The whole implementation process is done in K7M-DR20UE and complied with MASTER-K120S (KGL-WIN for Windows Version 3.64). MASTER-K120S series is extremely compact, to fit a wide range of applications and have excellent features. Using the graphical user interface a ladder diagram has developed that can interface the CPU of the PLC. The input-output ports of the CPU of the PLC set the input-output port of a panel and connect the external relay which operates on 24V dc. The control loop is a continuous cycle of the PLC reading inputs, solving the ladder logic, and then changing the outputs. After the inputs values are stored in memory the ladder logic will be scanned using the stored values not the current values. This is done to prevent logic problems when inputs change during the ladder logic scan. When the ladder logic scan is complete the outputs will be scanned (the output values will be changed). After this the system goes back to do a sanity check, and the loop continues indefinitely. So the working condition will be more desirable.

IV. Experimental Results of PID & PLC

At first different types of control actions like proportional, proportional-derivative, and proportional-integral control action are performed but not get the desired output.

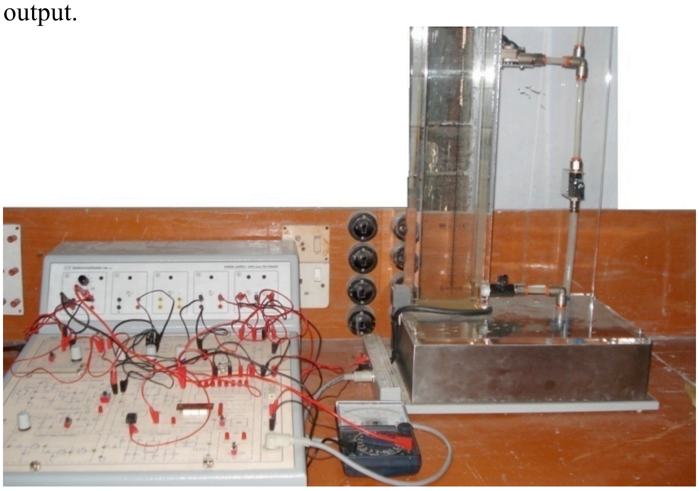

Figure 6: Water tank liquid level control with PID.

After then proportional-integral-derivative control action is performed and gets the comparably less error then the above controller. Different types of control actions like proportional, proportional-derivative, proportional-integral control demonstrate different result. The output of these different control is not desireable. A high proportional gain results in a large change in the output for a given change in the error. If the proportional gain is too high, the system can become unstable tuning. In contrast, a small gain results in a small output response to a large input error, and a less responsive controller. Magnitude of the overshoot produced by the integral component and improves the combined controller-process stability. However, differentiation of a signal amplifies noise and thus this term in the controller is highly sensitive to noise in the error term, and can cause a process to become unstable if the noise and the derivative gain are sufficiently large. The contribution from the integral term is proportional to both the magnitude of the error and the duration of the error. Summing the instantaneous error over time gives the accumulated offset that should have been corrected previously. The accumulated error is then multiplied by the integral gain and added to the controller output. In the derivative contoller the output is the derivate of the input function and so it has a high influence on the signals which rapidly vary. While the process evolves, the derivative action decades and integrative one takes its place to reduce the regulations error to zero in respect to the steady state value.

The PI controller put together the proportional and integrative actions, in order to exploit the advantages of both regulations and reduce the oscillations. In PI controller the error is remain about unity, so the oscillations remain. To remove the oscillations the derivative action is added together with proportional-integrative one: the effectiveness of the derivative action depends largely on the controlled variable.

Figure below shows the Set-point versus level, Set-point versus feed-back and Set-point versus error curves of different control action for water lavel control.

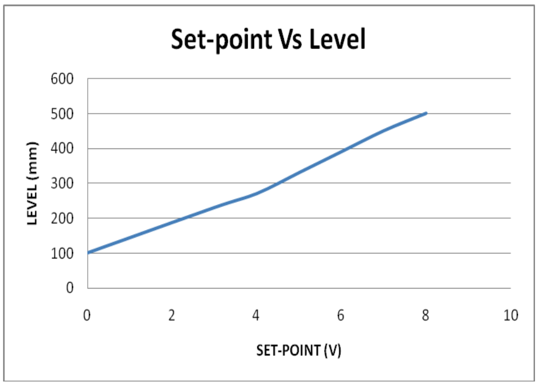

Figure 7: Set-point Vs Level of Proportional Controller.

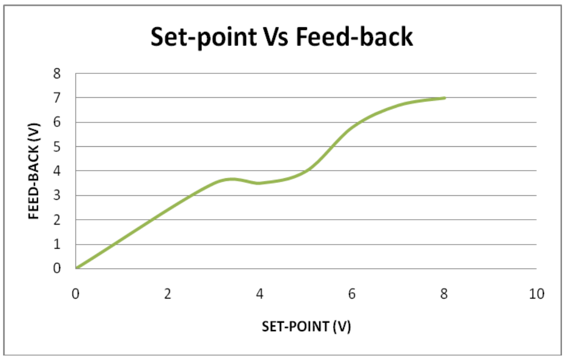

Figure 8: Set-point Vs Feed-back of Proportional Controller.

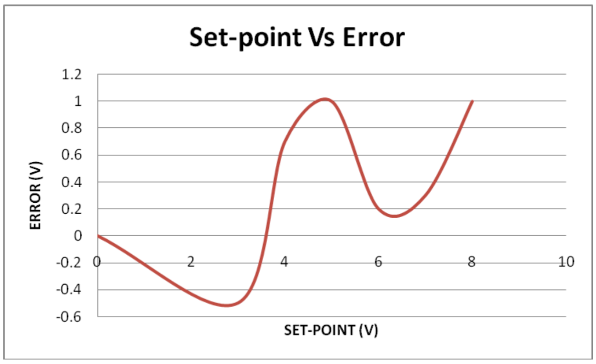

Figure 9: Set-point Vs Error of Proportional Controller.

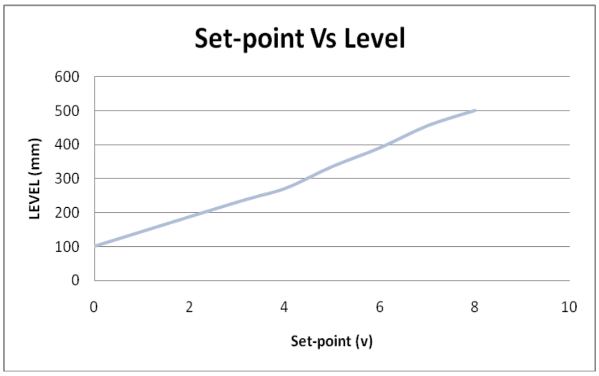

Figure 10: Set-point versus level of PD Controller.

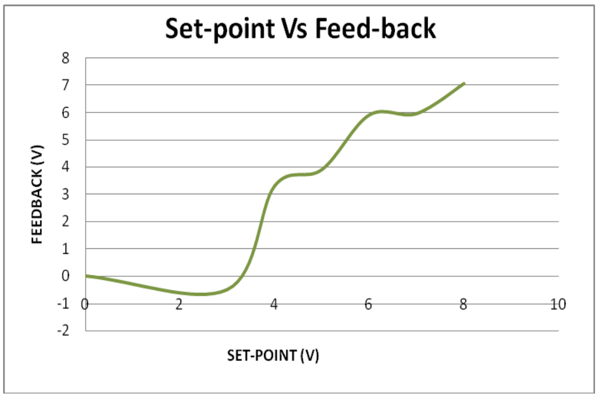

Figure 11: Set-point versus feed-back of PD Controller.

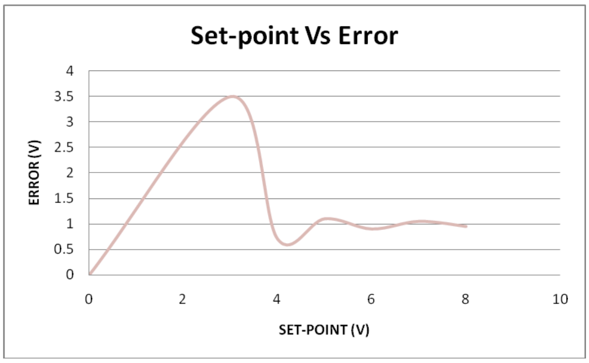

Figure 12: Set-point versus error of PD Controller.

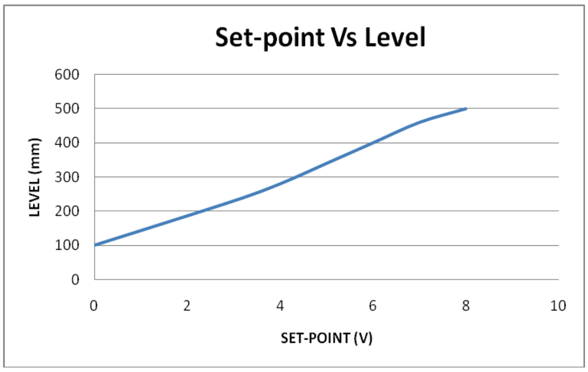

Figure 13: Set-point versus level of PI Controller.

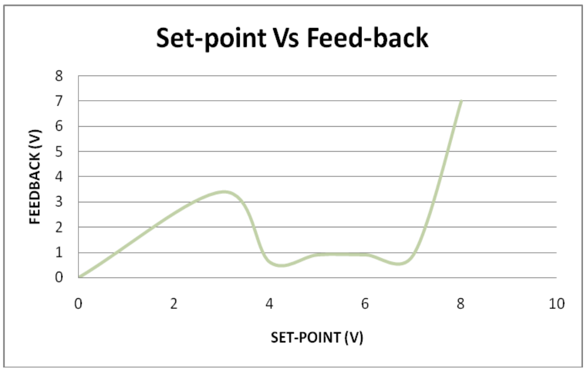

Figure 14: Set-point versus feed-back of PI Controller.

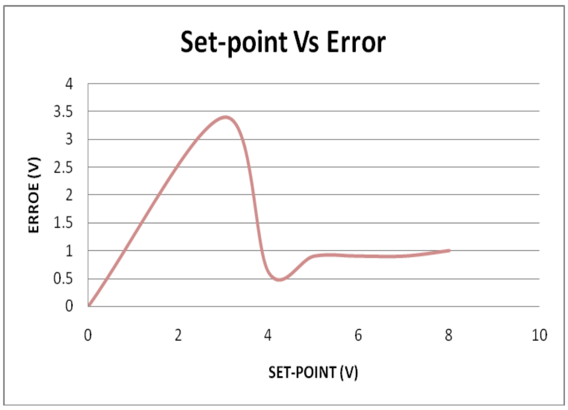

Figure 15: Set-point versus error of PI Controller.

The same experiment is done using both PID & PLC. By "tuning" the three constants in the PID controller algorithm the PID can provide control action designed for specific process requirements. In water level control water level height and change of height in different time is recorded.

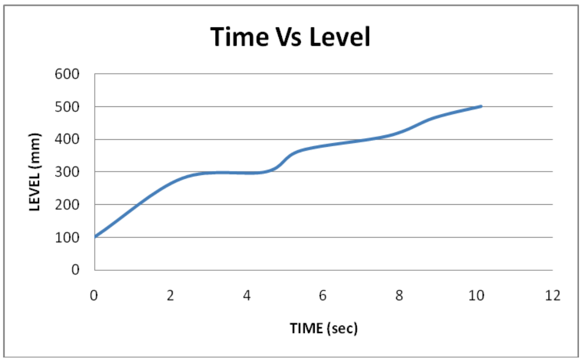

Figure 16: Time versus water level of PID Controller.

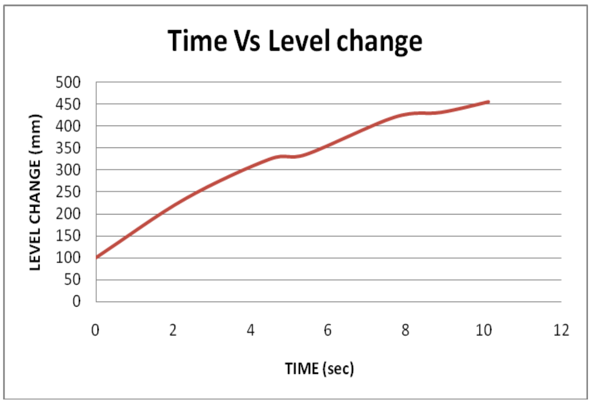

Figure 17: Time versus water level change of PID Controller.

To done this experiment using PLC MK_S 120S type of PLC is chosen and devolving a ladder diagram, next interfacing with the XPO PLC TRAINER and connected with water level kit.

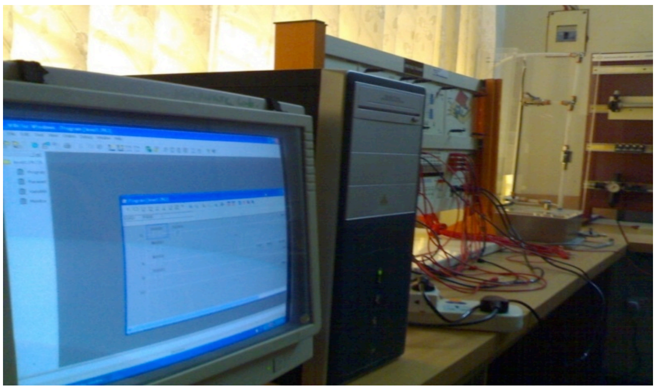

Figure 18: Soft-hardware interfacing with PLC for water level control.

The experimental output curve is given below.

Figure 19: Time versus level of PLC.

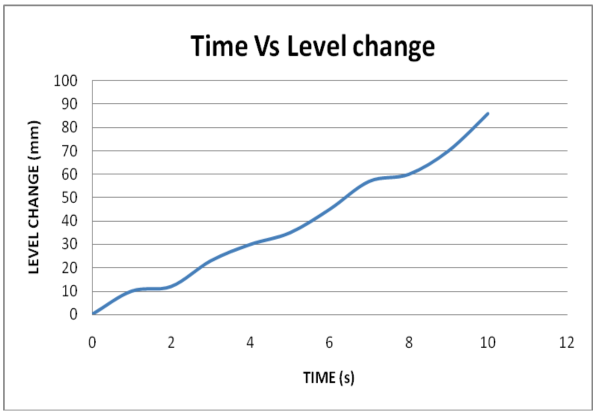

Figure 20: Time versus level change of PLC.

The actual comparison can understand from time vs error output curve of PID and PLC. After performing the PID control action it shows some error but the PLC control system gives better performance.

Figure 21: Time versus error of PID.

Figure 22: Time versus error of PLC.

From the experimental result it is depicted that In control system PLC is better than PID. Some other additional advantages of PLC is Cost effectiveness, flexibility, reliability and computational abilities allow more sophisticated control.

V. FUTURE WORK

The present work has done successfully for controlling the single tank water level by using one motor. As PID is used for controlling and monitoring for a particular motor/machine, but PLC is used for controlling of many motors as required also can monitor through SCADA. So, the future work will be to control total process/system by using more than one motor, which can save both power and time.

VI. CONCLUSION

The development of a robust soft-hardware interfacing based advance control technique which gives linear input output curve is depicted in this paper. Different control actions are performed and chose the better one Programmable Logic Controller which gives reliable control. For speed position control, the test results showed that with the PID controller added, the steady state error is minimized. Actual system outputs also agreed with theoretical results, indicating the accuracy of the system transfer functions. At the present time the PLC controller parameters have to be set in the ladder diagram and can be adjusted in real-time. We have taken experimental values of PLC which is superior to other controller because of its discrete low error response characteristics.

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