Development of PID & it's Autotuning Function on Mitsubishi PLC

Project Report

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF TECHNOLOGY

IN

INSTRUMENTATION AND CONTROL ENGINEERING

(Control and Automation)

By

Bhakhar Rikin C.
(14MICC03)

Instrumentation and Control Engineering Section
Department of Electrical Engineering
INSTITUTE OF TECHNOLOGY
NIRMA UNIVERSITY
AHMEDABAD - 382 481

MAY 2016

Development of PID & it's Autotuning Function on Mitsubishi PLC

Project Report

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF TECHNOLOGY

IN

INSTRUMENTATION AND CONTROL ENGINEERING

(Control and Automation)

By

Bhakhar Rikin C.
(14MICC03)

Under the Guidance of

Dr. J.B.Patel

Instrumentation and Control Engineering Section

Department of Electrical Engineering

INSTITUTE OF TECHNOLOGY

NIRMA UNIVERSITY

AHMEDABAD - 382 481

MAY 2016

Declaration

This is to certify that

i. The thesis comprises my original work towards the degree of Master of Technology in Instrumentation and Control Engineering at Nirma University and has not been submitted elsewhere for degree.

ii. Due acknowledgement has been made in the text to all other material used.

- Bhakhar Rikin C.

14MICC03

Undertaking for Originality of the Work

I, **Bhakhar Rikin C.**, Roll No. **14MICC03**, give undertaking that the Major Project entitled **"Development of PID And It's Autotuning Function On Mitsubishi PLC"** submitted by me, towards the partial fulfillment of the requirements for the degree of **Master of Technology** in **Instrumentation and Control Engineering (Control and Automation)** of Nirma University, Ahmedabad, is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere it will result in severe disciplinary action.

Signature of Student

Date:

Place : NU, Ahmedabad

Endorsed by

(Signature of Guide)

Certificate

This is to certify that the Major Project entitled "**Development of PID And It's Autotuning Function On Mitsubishi PLC**" submitted by **Bhakhar Rikin C. (14MICC03)**, towards the partial fulfillment of the requirements for the degree of **Master of Technology** in **Instrumentation and Control Engineering (Control and Automation)** of Nirma University is the record of work carried out by him under our supervision and guidance. The work submitted has reached a level required for being accepted for examination. The results embodied in this major projec to the best of my knowledge have not been submitted to any other university or institution for award of any degree or diploma.

Date: Place: Ahmedabad

Internal Guide & PG Coordinator

____

Dr. J.B.Patel
Associate Professor (I & C)
Institute of Technology
Nirma University
Ahmedabad

External Guide

____

Mr. Rameshchandra Bhorania
Asst. General Manager
FA Training — FAC - FAID
Mitsubishi Electric India Private Limited
Pune

Section Head

____

Dr. D.M.Adhyaru
Instrumentation & Control Engineering Section
Department of Electrical Engineering
Institute of Technology
Nirma University
Ahmedabad

Director & Head of Department

____

Dr. P.N.Tekwani
Department of Electrical Engineering
Institute of Technology
Nirma University
Ahmedabad

Acknowledgement

I would like to thanks to my guide Dr. J. B. Patel, Associate Professor, Instrumentation and Control Engineering, Institute of Technology, Nirma University, who has help, stimulating suggestions and encouragement me during the course of my work. He never accepted less than my best efforts. His optimism, enthusiasm and time managing skill were motivational for me, even during tough times in the M.Tech persuit. Thank you sir, i could not have imagined having a better advisor and mentor for my M.Tech project. I owe my most sincere gratitude to Dr. P. N. Tekwani, HOD, Electrical Engineering Department and Dr. J. B. Patel, the PG Coordinator and Mr. Rameshchandra Bhorania, Asst. General Manager FA Training — FAC - FAID, Mitsubishi Electric India Private Limited, Pune, who gave me the opportunity to work with them and give me untiring help during my dicult moments. I am very grateful to Dr. P. N. Tekwani, the Director, Institute of Technology without whose support my research and this dissertation would not have been possible. I thank Dr. Dipak Adhyaru, Section Head, Instrumentation and Control,Nirma University, for extending all the support. For their support and direction over the year, I would like to express my heart felt gratitude to all my professors Prof. H. K. Patel, Prof. Sandip Mehta, Prof. Alpesh Patel, Prof. Harsh Kapadiya and Prof. Ankit Sharma for their motivation.I would also like to give special mention to the wonderful lab staff members Mr. Ketan Patel, Mr. Jignesh Sihora, Ms. Krupali Shah for their never ending and overwhelming support with the lab resources. They were always willing to help me out. Last but not the least, I would like to thanks God almighty, my parents, my family member and friends for their love, support and excellent co-operation to build my moral during the work.

- Bhakhar Rikin C.
14MICC03

Abstract

An implementation of PID and it's autotuning function from a simulation environment into the Mitsubishi Q - Programmable logic Controller. Development of PID and it's autotuning feature is vital for their use in a simulation environment and verification on simulation models. The real control system have to be linked to the simulation environment with a Mitsubishi Q-PLC to check the control algorithms on a real physical model.

In this project, there is implementation of PID and it's autotuning function for demanding nonlinear and time-varying processes using programmable logic controllers. Programmable Logic Controller is used with low order process as a Level Trainer System.

There is development of PID Function Block with auto tuning facility in Mitsubishi Q-PLC. PID auto tuning is generally involving the development of some form of process model and then choosing P, I, and D primarily based at the dynamic model parameters.

Contents

List of Figures

Chapter 1

Introduction

1.1 Aim

In this thesis, the development of PID and it's autotuning function for level trainer system, with programming in Mitsubishi Q-PLC using Function Block Diagram. The primary goal of this is to implement PID and it's autotuning function from a simulation environment. The reason at the back of doing that is to achieve a whole knowledge of the adjustments in the dynamics of the system and transient response characteristics related to the system.

1.2 Setup

All the principle components are shown by the arrow shown in the figure. The system has a conventional PID controller which gives slow response for set point tracking. Now whilst the process larger results of change in disturbance as well as inside the process dynamics, it becomes quite tough to tune the parameters manually.[1]

Figure 1.1: Level Trainer System

Chapter 2

Literature Review

1. Title: PID Auto tuning Using Relay Feedback

Detail of Conference: S.Levy, S.Korotkin, K.Hadad, A.Ellenbogen, M.Arad, Y, Kadmon Nuclear Research Center Negev Israel, Beer-Sheva 9001.

Abstract: PID auto tuning algorithms based on relay feedback are used to identify different points of process frequency response before performing the actual tuning procedure. These require minimal amount of priori information approximately the controlled manner, they may be also insensitive to modeling errors & disturbances.[2]

Conclusion: The PID parameters extracted within the manner can be used both for initialization of different advanced optimization algorithms or for calibrating complicated adaptive regulators.

2. Title: A Comparative Performance Study of PID Auto - Tuners

Detail of Conference: C.C. Hang & K.K. Sin, 1991 IEEE Control Systems.

Abstract: The auto-tuning performance characteristics of three controllers were evaluated the use of bench test. The Controller are two commercial Single loop PID Controller, namely, the state control Relay Feedback Auto-tuner and Foxboro Exact Self Tuning Controller and Z-N prototype PID controller auto tuned by means of cross-correlation method.[3]

Conclusion: The approach focus on comparative study to develop a set of benchmark test and to select a criteria to assess the performance of industrial PID auto-tuner.

3. Tittle: Improved Identification for PID Controllers Auto-Tuning

Detail of Conference: R. R. Pecharroman, F. L. Pagola. 1999 European Control Conference (ECC) 31 August- 3 September 1999, Karlsruhe, Germany.

Abstract: Every auto-tuning method for PID controllers has two steps: 1.) Identification of the plant and 2.) Tuning of the controller parameters. This paper provides a method for plant identification based on two points of its frequency response, namely, the ultimate and the crossover frequency. A novel technique is presented for estimating the ultimate frequency: the Amplitude Dependent Gain feedback. This method gives better results than the well-known relay feedback method. Plant identification using two points of its frequency response is better than using only one point, so improved auto-tuning of the controller can be achieved.[4]

Conclusion: A new technique for the identification of the ultimate point of a process frequency response is presented in this paper. The ADG has been analysed using describing function methods. The accuracy of the identification is much better with the ADG than with the relay feedback.

4. Tittle: Modelling and System identification of Liquid Level System

Detail of Conference: Pramod Gondaliya - PG Student, Department of Instrumentation Control Engineering, L.D. College of Engineering, Ahmedabad.
Manisha C. Patel - Assistant Professor, Department of Instrumentation Control Engineering, L.D. College of Engineering, Ahmedabad.

Abstract: The first level in the development of any control and monitoring system is the identification and modelling of the system. Therefore, system identification has been a precious tool in identifying the model of the system based on the input and output data for the design of the controller. The present work is involved with the identification of transfer function models using open loop test for liquid level system.[5]

Conclusion: The raw data used for the system identification in the paper can be collected from actual time system using LabVIEW and compatible DAQ card.

5. Tittle: PI Control of Level Control System using PLC and LabVIEW based SCADA

Detail of Conference: Pooja Panchal, Alpesh Patel, Jayesh Barve, 2015 International Conference on Industrial Instrumentation and Control (ICIC) College of Engineering Pune, India. May 28-30, 2015.

Abstract: This paper focuses on development of PID controller for a single tank level control system the usage of concepts of industrial automation. The idea in the back of this work is to replace the conventional PID controller available in the level control trainer system with a high end PLC.[6]

Conclusion: The developed platform enables the user to visualize real-time process trend. Some other features of SCADA like data logging, remote control, historical trend etc. can be incorporated easily into the system.

6. Tittle: MPC Implementation on a PLC for DC Motor Speed Control

Detail of Conference: Arief Syaichu-Rohman and Raphael Sirius, Laboratory for Control & Computer Systems, School of Electrical Engineering and Informatics Institut Teknologi Bandung, Jalan Ganesa No.10, Bandung 40132, Indonesia.

Abstract: MPC has been widely applied in numerous industrial plants, which are relatively sluggish processes. MPC application for faster processes is usually limited with the availability of faster optimization algorithms or digital processor. While it is widely employed, plc is not usually utilized as an implementation target of MPC in industry due to its low computation performance. A unique MPC processor module attached to the standard PLC is used instead. This paper gives an experiment of using Mitsubishi Electric MELSEC-Q PLC as an MPC for DC motor speed control. The algorithm involves a simple computation with a large number of iterations and may be optimized for faster convergence speed. The MPC with this QP algorithm is programmed into the PLC by standard LD program.[7]

Conclusion: The designed MPC algorithm as the quadratic program solver has been implemented on MELSEC Q-Series Mitsubishi PLC. The experiments shows that its performance is not as good as PI-AW for a SISO feedback system of DC motor speed control.

Chapter 3

Overview of Hardware and Software

This section describes the hardware used in the project. Hardware included are:

- MELSEC Q-PLC
  - GX Works2
  - MC Protocol
  - MX Sheet & MX Component
  - Programming Cables
- Level Trainer System
  - Level Transmitter
  - I/P Converter
  - Final Control Element

3.1 MELSEC Q-PLC

3.1.1 Hardware Feature

With its nano-order speed primary command processes, the next era MELSEC Q-PLC dramatically improves system and machine overall performance.

As equipment and manufacturing facilities preserve to evolve on a daily basis, the series enables excessive-speed, excessive-accuracy and huge volume data processing and machine control.[8]

- **Power Supply**
  - **Q61P** Module
  - 120-240 VAC Supply Voltage
  - +5VDC 6A

Figure 3.1: Q61P Power Supply Module

- **CPU**
  - **Q03UDE** Module
  - 30K steps Memory
  - 20ns Speed
  - 4096 Maximum I/O

Figure 3.2: Q03UDE CPU Module

- **Discrete I/O**
  - **QX81** Digital Input Module
  - 32 Points/Common
  - 24 VDC 4mA, Source Type

Figure 3.3: QX81 Digital Input Module

  - **QY41P** Digital Output Module
  - 32 Points/Common
  - 12-24 VDC 0.1mA/point, Sink Type

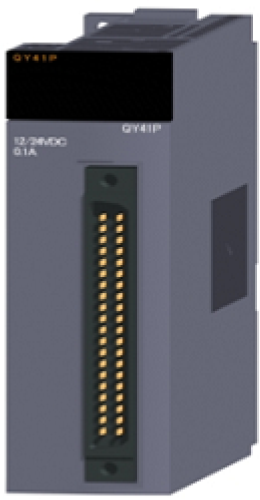

Figure 3.4: QY41P Digital Output Module

- **Analog I/O**
  - **Q64AD** Analog Input Module
  - 4-20Ma, 0-10V, -10 to +10V

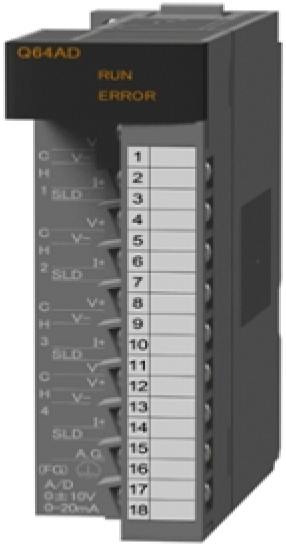

Figure 3.5: Q64AD Analog Input Module

  - **Q64DAN** Analog Output Module
  - 4-20Ma, 0-10V, -10 to +10V

Figure 3.6: Q64DAN Analog Output Module

- **High Speed Counter**
  - **QD62** Module
  - Open Collector Type
  - Transistor Output
  - Up to 4MHz

Figure 3.7: QD62 Module

- **Networking**
  - **QJ61BT11N** CC-Link Master/Local Module
  - 1 to 4 Stations Local

Figure 3.8: QJ61BT11N CC-Link Master/Local Module

3.1.2 GX Works2

GX Works2 is the next generation configuration and programming software for FX and Q Series controllers. With this program you can create your own function blocks for easy re-use or utilize pre-made function blocks. Combine the use of ladder and function blocks seamlessly to reduce programming errors and save time.[9]

3.1.3 MC Protocol

The MC protocol is used for reading or writing device data and programs of a PLC CPU from/to a personal computer via an Ethernet module or a Q series serial communication module. On the personal computer side, creating a program for data transfer with MC protocol enables an easy access to the PLC CPU. On the PLC CPU side, there is no need to create a communication program.[10]

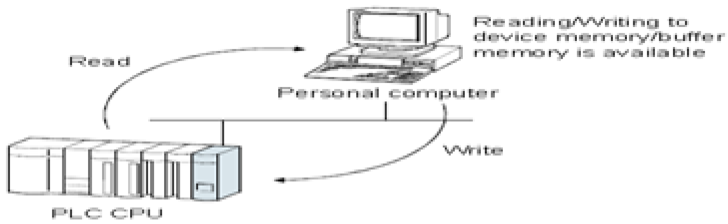

Figure 3.9: Communication Process

3.1.4 MX Sheet and MX Component

MX Sheet enables users to acquire data from the MELSEC Q-PLC and analyze it using the familiar tools and functions of Excel. MX Sheet can analyze and display real-time data in tables, graphs and charts as it happens. It additionally functions a useful automatic report function, whereby data displayed on Excel automatically saves and prints at a selected time or circumstance brought about through the MELSEC Q-PLC.[11]

MX Component provides users with effective ActiveX controls that simplify the communication between a PC and MELSEC Q-PLC. Users to not have to design complicated communication protocols and is good for implementing specific software applications requiring MELSEC Q-PLC connectivity.[12]

MX Component supports a huge variety of effective and standardized programming languages along with Visual C++, .NET, VBA and VB Script.

3.1.5 Programming Cables

MELSEC Q-Series PLC has a USB interface, making preferred programming cable. We are the use of a standard USB A Male to B Male cable for programming.[13]

Figure 3.10: Cable

3.2 Introduction to Level Trainer System

3.2.1 Level Transmitter

The level transmitter hooked up inside the trainer kit is manufactured by ABB and its working range is -1 to 0.25 bar.

- Design and Function

The level transmitter works on Hydro static pressure principle which states that the force exerted by way of any liquid on the walls of the container wherein it is placed are directly proportional to the height of the liquid.[14]

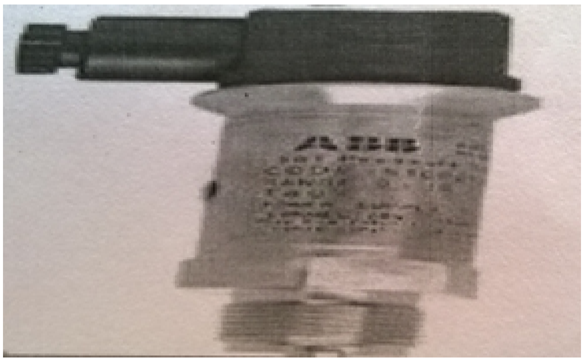

Figure 3.11: Level Transmitter

3.2.2 I/P Converter

500X I/P Transducer manufactured by Control Air Inc. The water inflow to the tank is maintained with the aid of a pneumatic control valve. The movement of pneumatic control valve is done by I/P converter. It converts a current or voltage input signal to a linearly proportional to output pressure.

Figure 3.12: 500X I/P Transducer

- Design and Function

It is also referred to as force balance device wherein a coil is moving in the field of a magnet with the assist of flexure. It generates the movement of the coil and flexure that is axial motion when the current flow through coil. The flexure moves near the nozzle and also developed a back pressure which is also called as a pilot pressure to an integral booster relay. Zero and Span are changed by adjusting the screws on the front face.[15]

3.2.3 Final Control Element

Samson Pneumatic Control Valve Type 241-1

- Design and Function

The Type 241-1 and 241-7 Pneumatic Control Valves consist of a single seated Type 241 Globe Valve and either a Type 271 or Type 277 Pneumatic Actuator. In the micro-flow valve version, a micro-trim element is installed in the valve body instead of the usual seat-plug assembly.[16]

Figure 3.13: Pneumatic Control Valve

Chapter 4

Interfacing of Components with PLC

4.1 Introduction to Process

- **Process:** It is defined as the change in the level of liquid inside the tank. The input parameter is the flow into the tank i.e. qi(t)(m3/s).
- **Transducer:** The transducer indirectly measures the level. So, pressure= density g head of liquid. It converts the guage pressure to electrical current signal in (mA).
- **Actuator:** It takes the control signal uc(t), a current in mA and applies this to a current to pressure transducer which in turn produces a valve position, (in mm). The position of the valve stem determines the flow (in m3/s).
- **Actuator Process Transducer:** The liquid level system indicates the liquid inflow as qi(t), and the outflow as qo(t). The height is given by h(t) and the constant cross sectional area of the tank by A.

4.2 Interfacing

To control the system level transmitter and I/P converter has to be interfaced with PLC. The PLC can read the level input given in phrases of current with the aid of

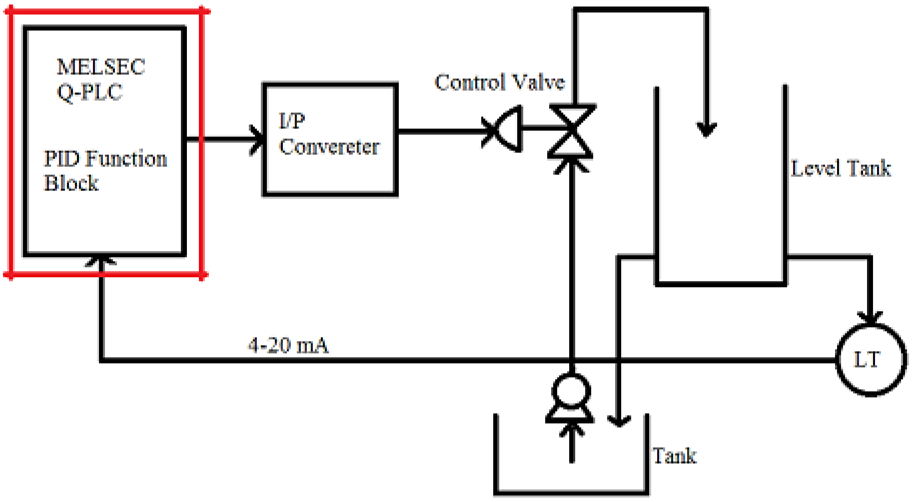

Figure 4.1: Process Block Diagram

the level transmitter. Based on the control strategy, it can decide the current output given to I/P converter.[17]

There is level transmitter calibrated in terms of current Vs level as follows:

Height(cm)	**ADC Count**	**Current(mA)**
0	75	4.30
10	225	4.90
20	380	5.52
30	530	6.13
40	685	6.75
50	842	7.37
60	998	7.98
70	1150	8.60
80	1305	9.30
90	1460	9.84
100	1620	10.46

4.2.1 Level Trainer System

Figure 4.2: Hardware Setup

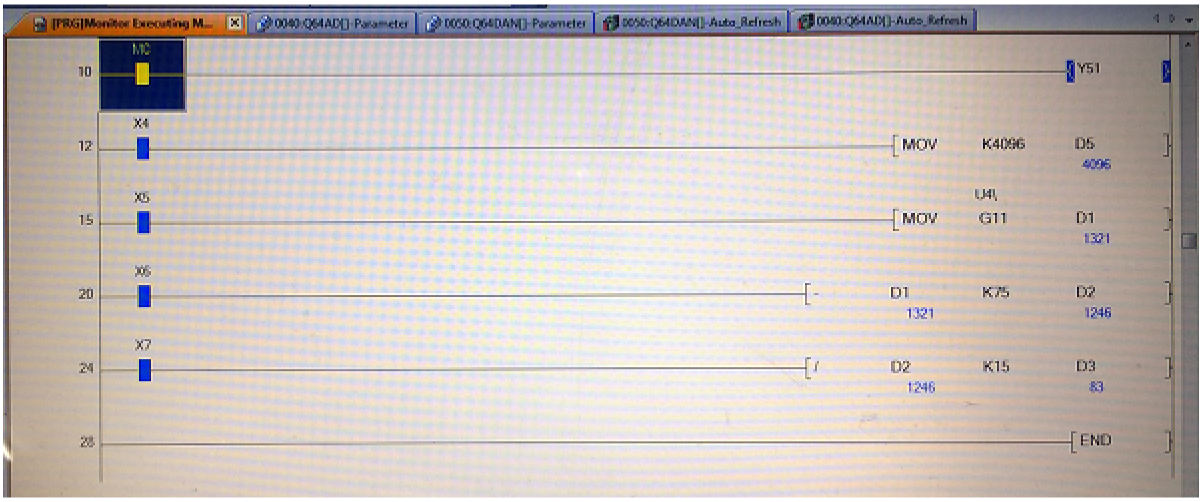

Figure 4.3: Valve On & Scaling Program

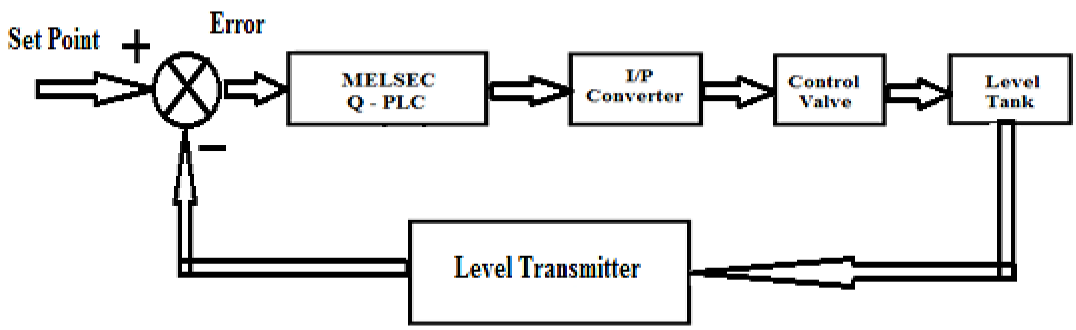

Figure 4.4: PLC Interfacing Block Diagram

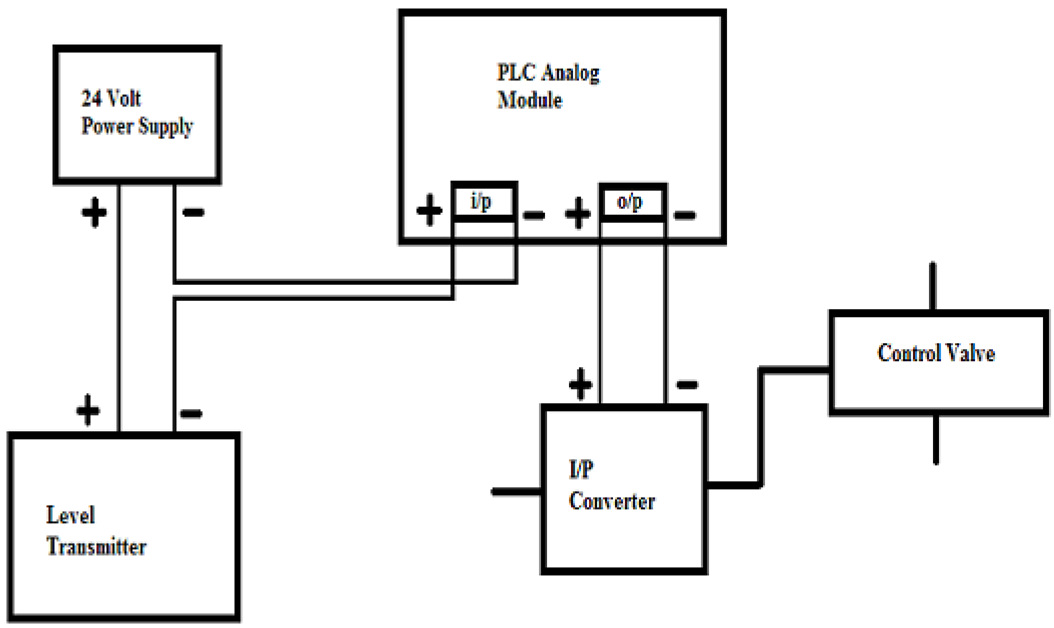

Figure 4.5: Wiring Diagram

Chapter 5

Modeling & Simulation

5.1 Modeling of Level Control System

Figure 5.1 shown the water level tank is studied right here. In such a system, water is inflow into the tank and outflow through valve. The system is a SISO type because processes have one manipulated variable: inflow rate and one controlled variable water level in the tank. Open loop is used to identify the transfer function of the process variable level. The Output is measured for given the step input.[18]

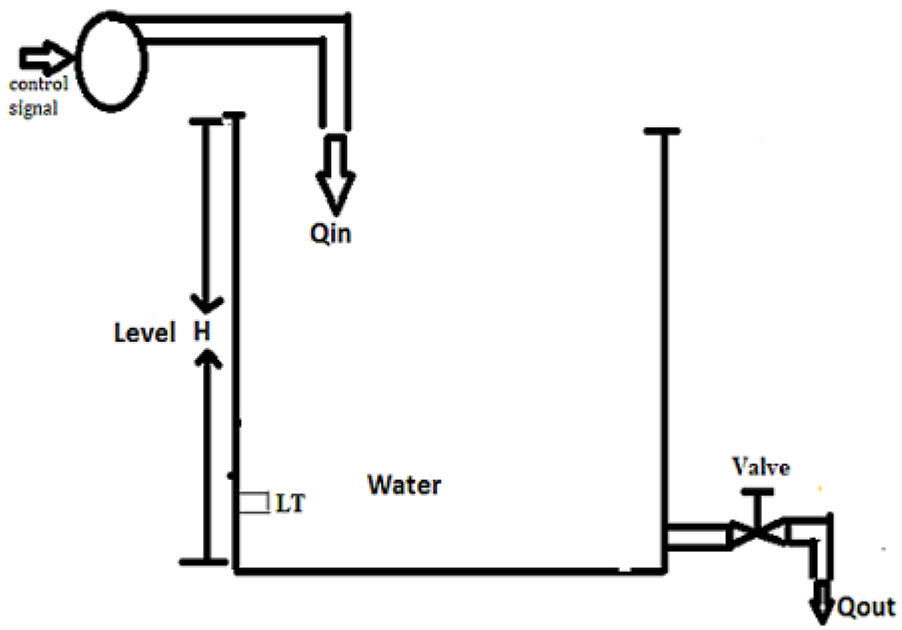

Figure 5.1: Water Level Tank

Modeling of the system will be described in open loop & close loop response. In open loop response to identify the actual behavior of the system. To generate the model of the system using system identification toolbox in MATLAB. The mathematical model can be done of actual hardware values are taken into the consideration for simulation in MATLAB. In this section be made on open loop performance of actual hardware system. Using System identification toolbox in Matlab, to generate the model of the system is shown. Transfer function is given below:

Tf = 0.809681 / 79.3545s+1

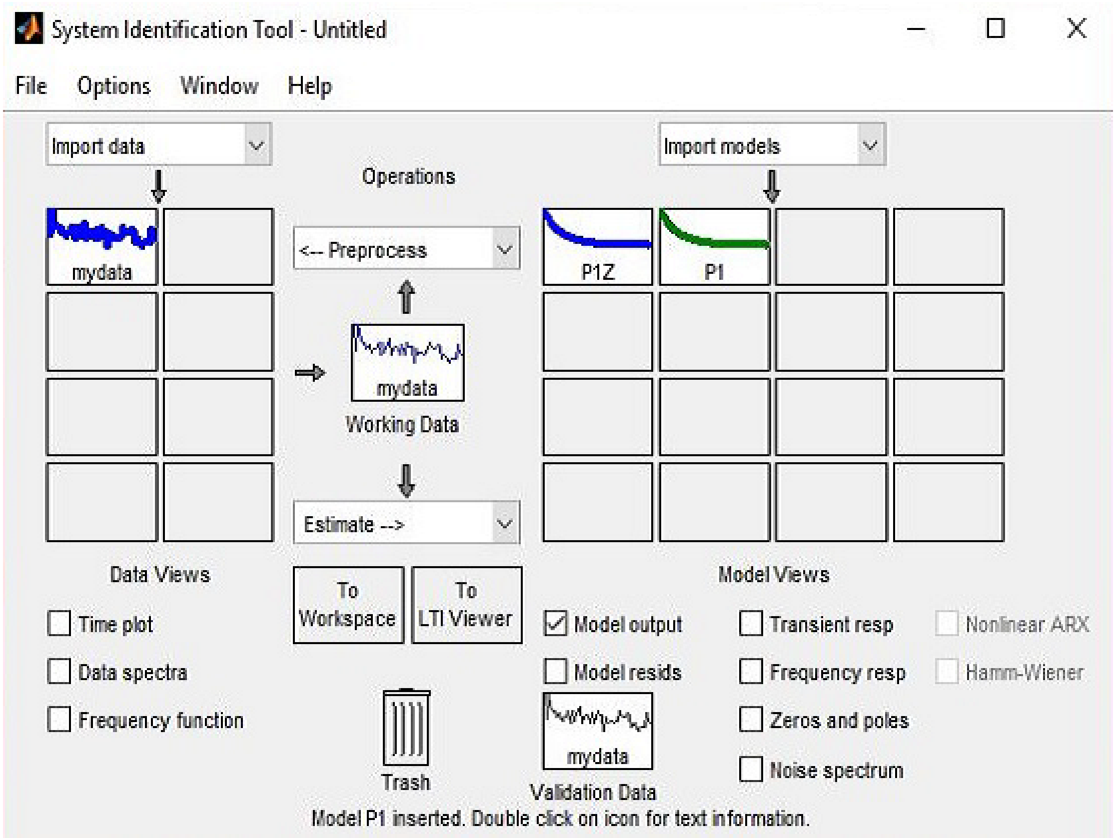

Figure 5.2: System Identification Toolbox in Matlab

5.2 Open Loop Response

Figure 5.3 shows the Simulink model made in order to obtain the open loop response. Any step are given input of the system so output will gives the response. In open loop response to identify the actual behaviour of the system.

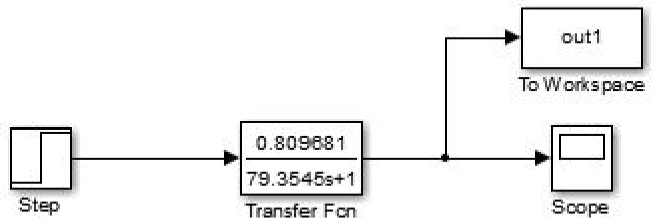

Figure 5.3: Simulink Diagram for Obtaining Open Loop Response

Simulation result shown in figure 5.4.

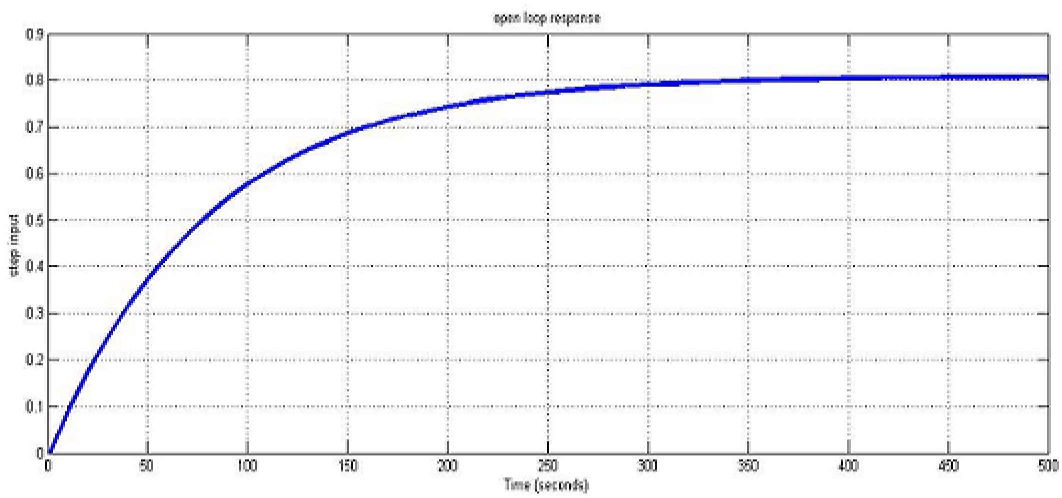

Figure 5.4: Simulation Result of Open Loop Response

In this graph analyze that both input and output are stable but not it is stable on before or after set point. Any step change in any input the output will stabilize but it is open loop response so output will not achieve the set point.

5.3 Close Loop Response

Applying close loop method and analyze the output will follow the set point and stabilize the system. In close loop performance, output will tracing the set point but some peak over shoot will be there. Mp% will be increase Ts settling time will reduced and rise time will decrease. Steady state error will reduced.[19]

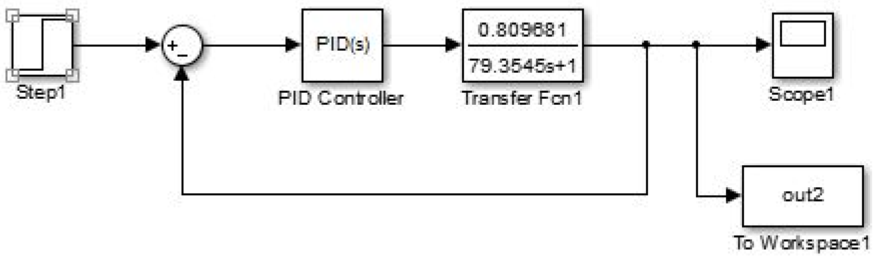

Figure 5.5: Simulink Diagram for Obtaining Close Loop Response

Simulation result shown in figure 5.6.

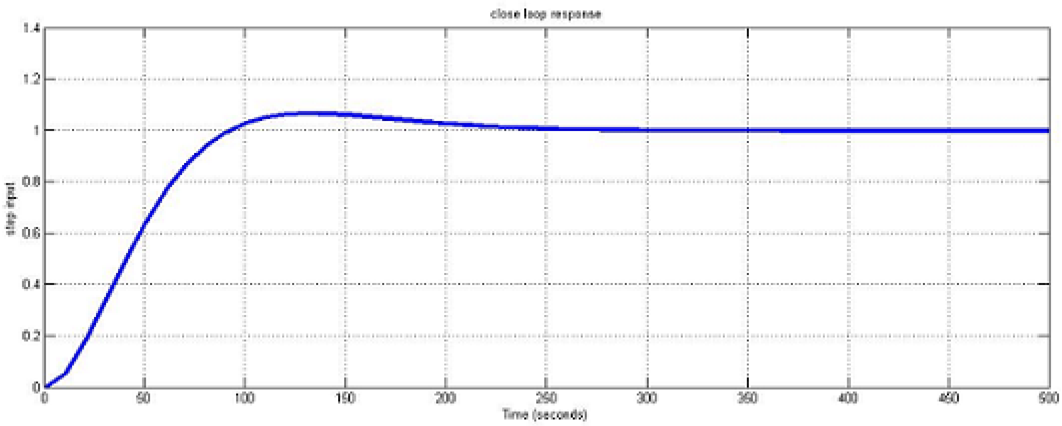

Figure 5.6: Simulation Result of Close Loop Response

Figure 5.7 analyze that both input and output are working as SISO system. Comparison of open loop and close loop response is shown in figure 5.8.

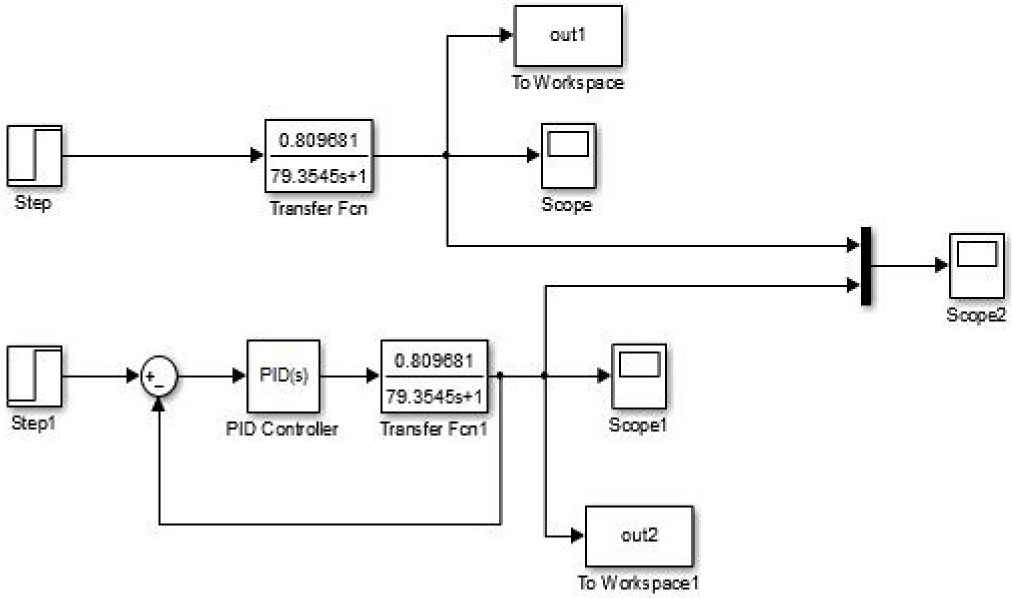

Figure 5.7: Simulink Diagram for Obtaining Open Loop Vs Close Loop Response

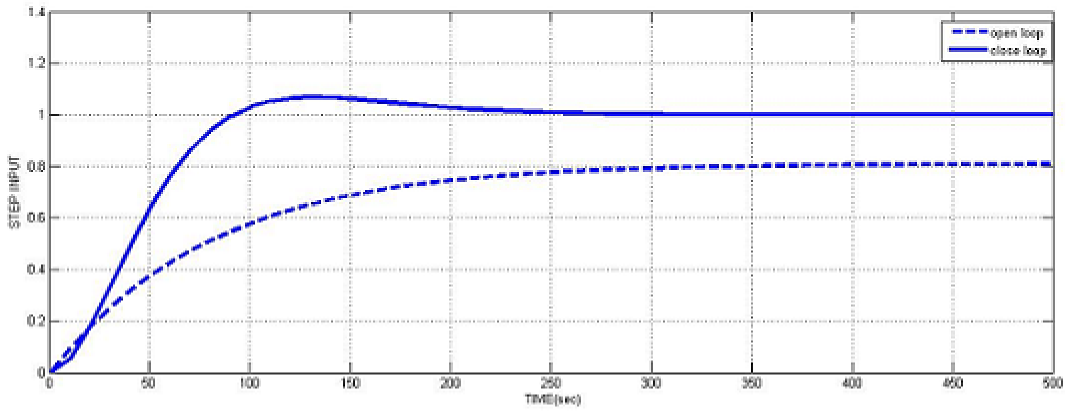

Figure 5.8: Simulation Result of Open Loop Vs Close Loop Response

Chapter 6

PID Controller Tuning

6.1 Introduction

PID Controllers are the most extensively used controllers within the chemical method industries due to their simplicity, robustness and a hit sensible application.

PID controller is a control loop comments mechanism normally used in commercial control structures. It constantly calculates an error value because the difference among a preferred setpoint and a measured process variable.[20] A controller attempts to decrease the error over time by adjustment of a control variable, together with the position of a control valve, a damper, or the power furnished to a heating element, to a new value decided by means of a weighted sum:

$\mathrm{u(t)} = \mathrm{K}_p e(t) + K_i \int_0^t e(\tau)d\tau + K_d \frac{de(t)}{dt}$

In this model,

- P accounts for present values of the error. For example, if the error is large and positive, the control output will also be large and positive.
- I accounts for past values of the error. For example, if the current output is not sufficiently strong, error will accumulate over time, and the controller will respond by applying a stronger action.
- D accounts for possible future values of the error, based on its current rate of change.

As a PID controller is predicated simplest on the measured process variable, now not on know-how of the underlying process, it's miles widely application. Through tuning the three parameters of the model, a PID controller can deal with particular process necessities. The response of the controller can be described in phrases of its responsiveness to an blunders, the degree to which the system overshoots a setpoint, and the degree of any system oscillation. The use of the PID set of rules does not guarantee most efficient manage of the system or even its stability.

Some applications might also require using most effective one or two terms to provide the perfect system control. This is performed by using setting the alternative parameters to zero. It will be called a PI, PD, P or I controller within the absence of the respective system movements. PI controllers are fairly common, because derivative action is sensitive to measurement noise, while the absence of an integral term may prevent the system from attaining its target value.[21]

6.1.1 The Proportional Term (Kp)

The relative term creates a yield esteem this is corresponding to the existing mistake esteem. The multiplying for you to correspond response may be balanced the blunder by means of a consistent Kp, known as the relative increase steady. The relative term is given by means of:

Pout = Kp e(t)

A high relative increase outcomes in an expansive alternate in the yield for a given trade inside the blunder. Apparently, a bit pick out up consequences in a bit yield response to a massive data blunder, and a less responsive or much less sensitive controller. Inside the event that the relative addition is just too low, the control interest can be too little whilst reacting to framework aggravations. Tuning speculation and cutting-edge exercise display that the relative time period have to make a contribution the primary part of the yield change. In a actual framework, corresponding just manipulate will go away a balance mistake within the remaining unfaltering state situation. Basic activty is needed to take out this mistake.[22]

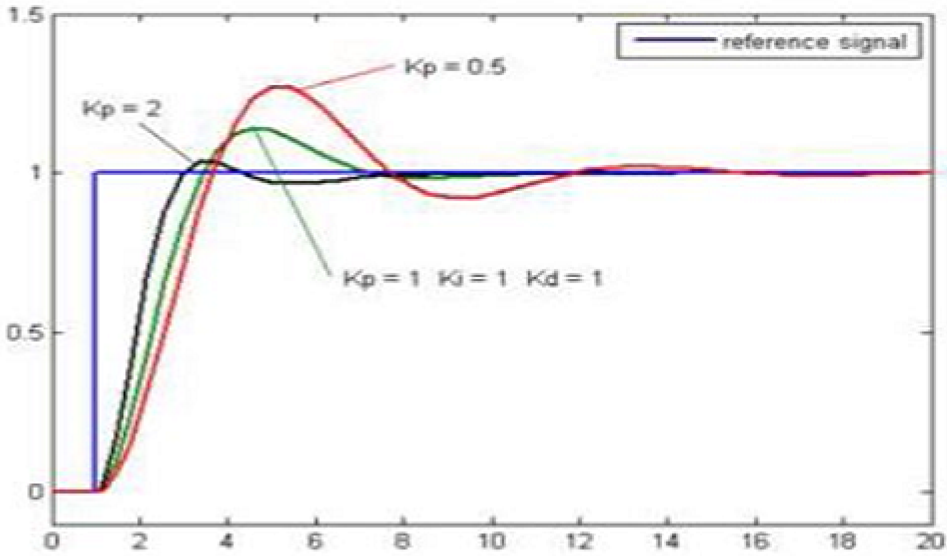

Figure 6.1: Graph showing different values of proportional control (Kp)

6.1.2 The Integral Term (Ki)

The commitment from the vital time period is relative to each the extent of the blunder and the span of the error. The crucial in a PID controller is the full of the fast mistake after some time and gives the accumulated balance that need to have been revised ahead. The accumulated mistake is then duplicated with the aid of the integral increase (Ki) and added to the controller yield.

The vital term is given with the aid of the important time period speeds up the improvement of the technique towards set point and disposes of the ultimate relentless state mistake that takes place with an immaculate corresponding controller.

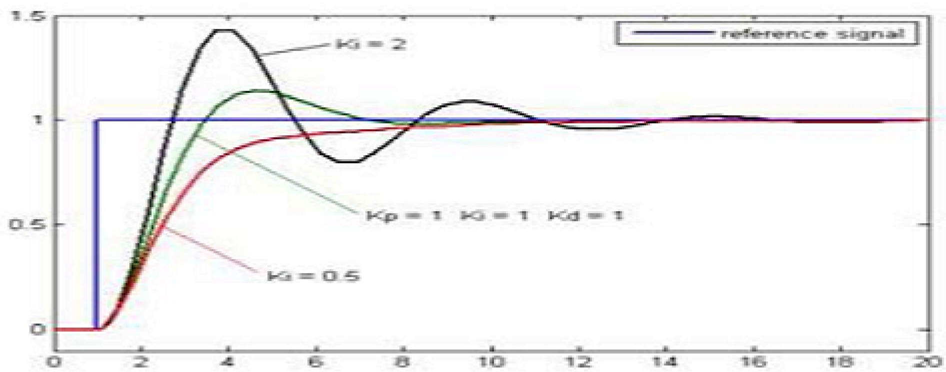

Figure 6.2: Graph showing different values of integral controller (Ki)

6.1.3 The Derivation Term (Kd)

The subsidiary of the system mistake is ascertained by using figuring out the incline of the blunder after a while and duplicating this charge of progress by the subordinate increase Kd. The greatness of the commitment of the subsidiary time period to the overall control activity is called the subordinate addition, Kd.

Subordinate activity predicts framework behavior and on this manner enhances settling time and security of the device. A really perfect subsidiary isn't causal, in order that usage of PID controllers incorporate an additional low pass keeping apart for the subsidiary term, to restrict the excessive recurrence pick up and noise.[23]

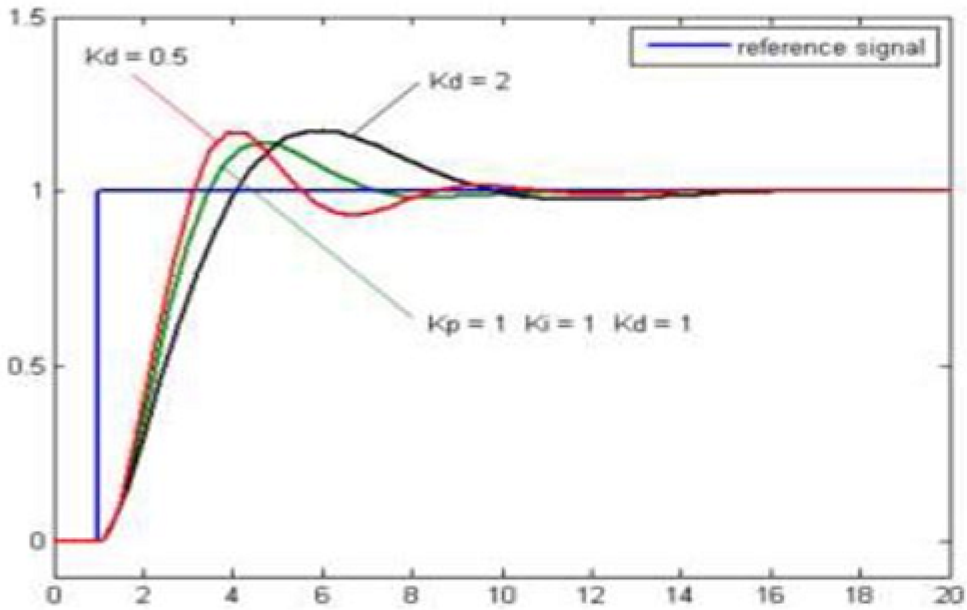

Figure 6.3: Graph showing different values of derivative controller (Kd)

A list of the instructions used to execute PID control is given below:

Instruction Name	Processing Details
PIDINIT	Sets the reference data for PID operation
PIDCONT	Executes PID operation with the SV and the PV
PIDSTOP PIDRUN	Stops or starts PID operation for the set loop No
PIDPRMW	Changes the operation parameters for the designated loop number

6.2 Relay Feedback Tuning

Consider the simple feedback system shown in figure 6.4, where for the estimation mode the controller is replaced with the aid of a perfect relay. Under certain conditions, which are not precisely definable but can be ascertained approximately by way of numerous techniques, the closed loop will own a limit cycle.

The only case, that is taken into consideration here, is when this limit cycle is a symmetrical square wave at the relay output. Whether this is the case depends upon the d.c. loop conditions, which in turn depend upon bias input signals and the location of integrators in the loop. It is then possible to obtain information about the process from this limit cycle using one of two analytical approaches.

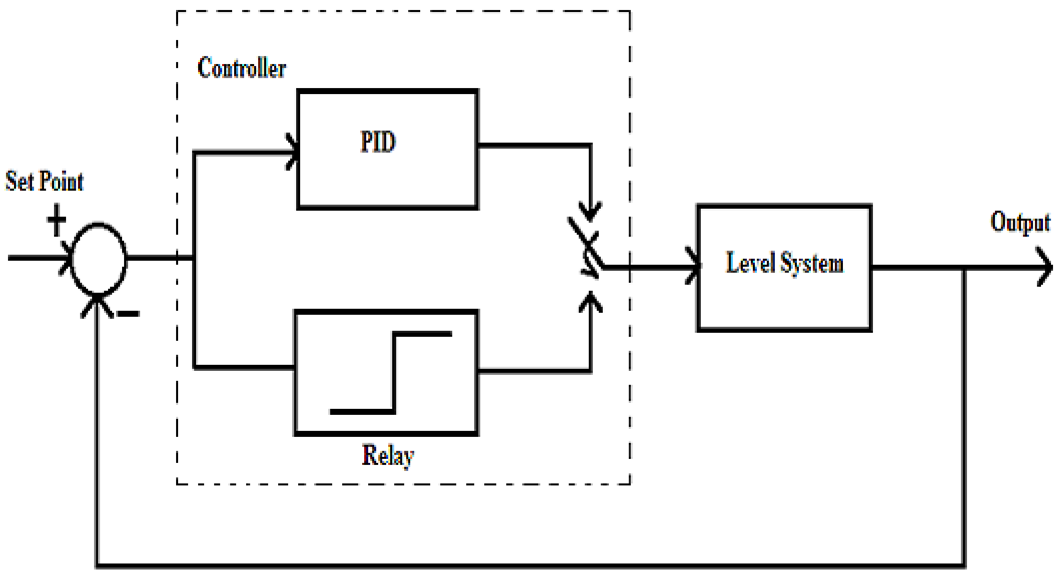

Figure 6.4: Block Diagram of Autotune Scheme

Relay Feedback auto tuning is simplest way to tuning of PID controllers that removes trial and error, and eliminates the possibility of operating the system close to the stability limit.

Astrom and Hagglund give the idea about relay feedback method to generate sustained oscillation as an alternative to the traditional non-stop cycling technique.

This is very effective in figuring out the ultimate gain and ultimate frequency. Luyben popularizes the relay feedback method and says the method ATV.[24]

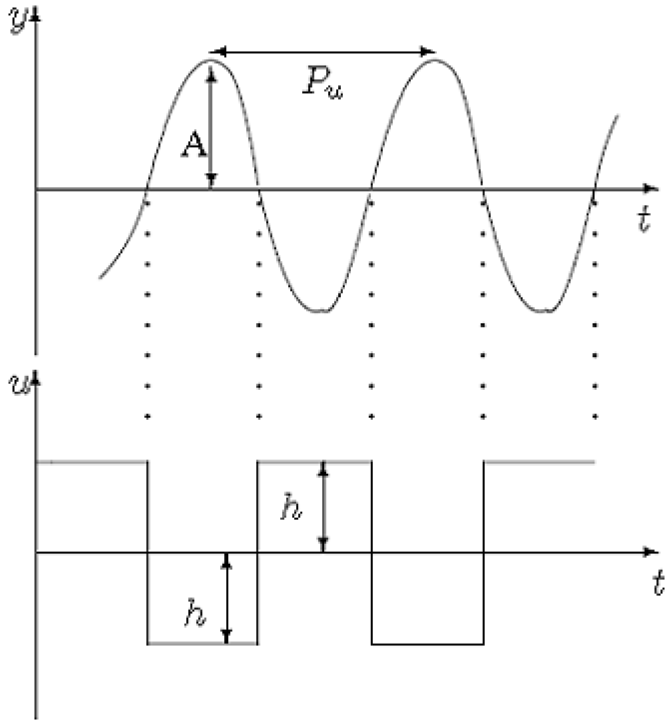

Figure 6.5: Autotune with ATV Test

As it turns out, under relay feedback method, most systems oscillate with a modest amplitude fortuitously at the critical frequency. The procedure is the following:

1. Apply a relay with amplitude d for PID controller as shown in Figure 6.5.

2. Put into action, and record the system output amplitude a and period P.

3. The ultimate period is the observed period, Pu = P, while the ultimate gain is inversely proportional to the observed amplitude,

Ku = 4d/(pi)a

To apply the relay feedback tuning method, simulation conduted for this system :

Tf = 0.809681 / 79.3545s+1

The whole procedure of inserting the relay, providing a moderate incentive for the system to oscillate, the amplitude and period measurement, and the subsequent computation of controller tuning constants can be reliably automated.

6.3 Results & Flow Chart

For checking the stability region apply the step input before the system gets stable and maintain the level constant. When proportional gain is applied to level of system then level reaches in 191 sec.

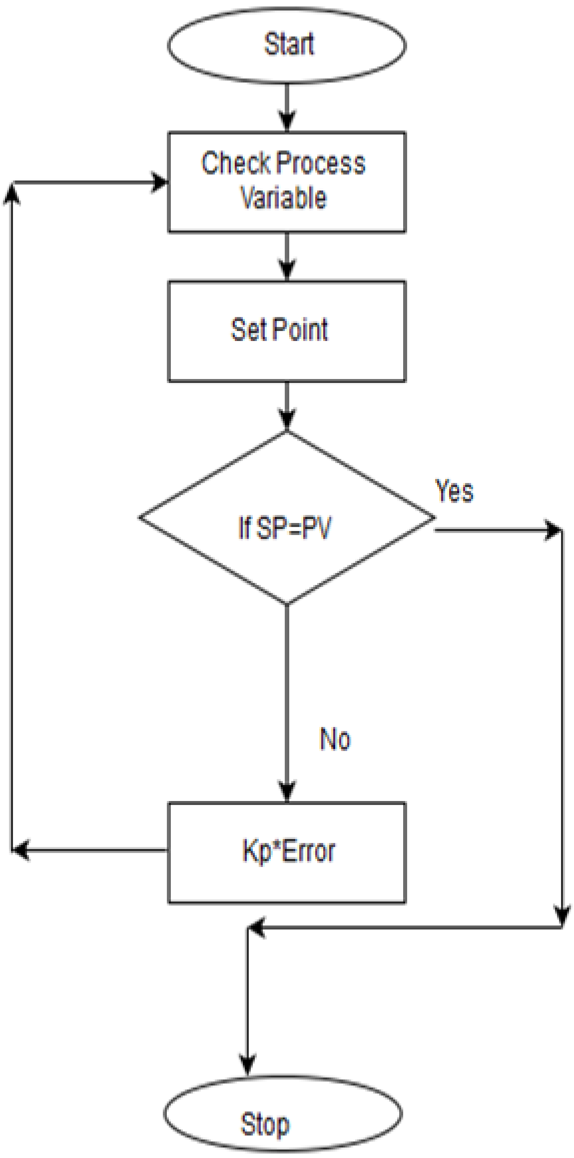

Figure 6.6: Proportional Control

When the values of proportional gain is increased then level will take much less time to settle as setpoint. When gain of level are tuned ,because of the flow rate the level will not reach the set point quickly. The system became sluggish.

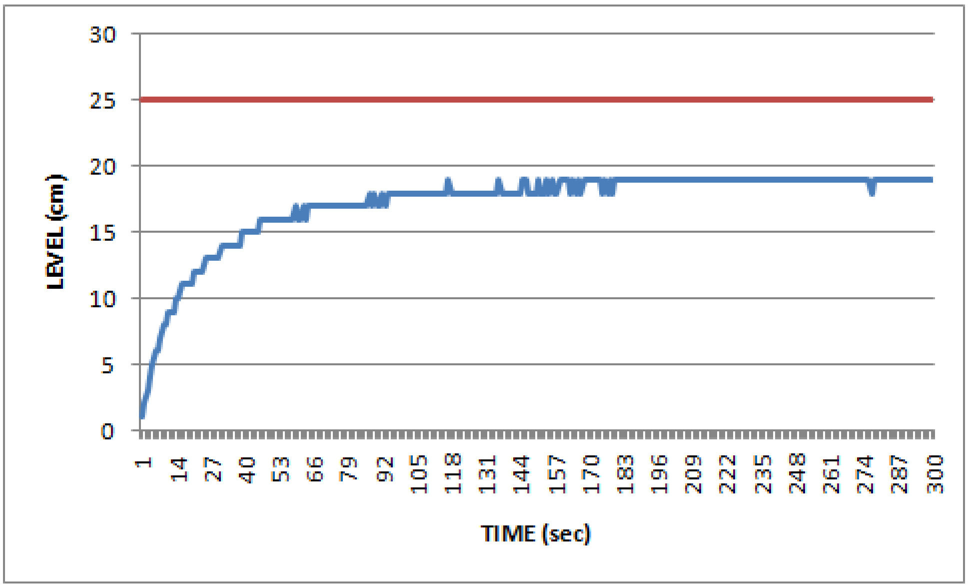

Figure 6.7: Kp=100 Step input when System is Stable

In this chaptor, Applying PID controller and take real time data and monitor all parameters in Mitsubishi Q-PLC. There is PID controller implemented in Mitsubishi Q-PLC.

Applying TRIAL AND ERROR METHOD and analyze all parameters of PID. In this method, take different gains of PID.

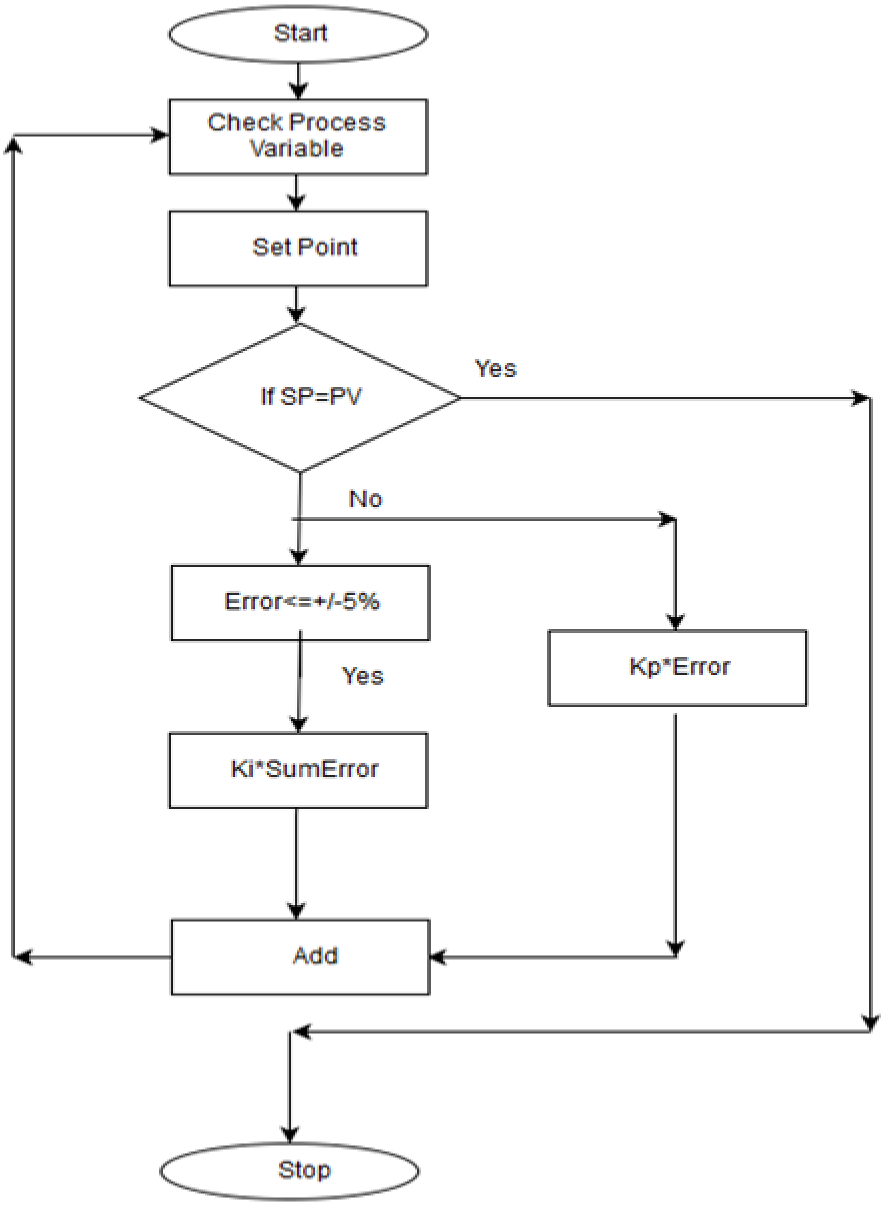

Figure 6.8: Proportional & Integral Control

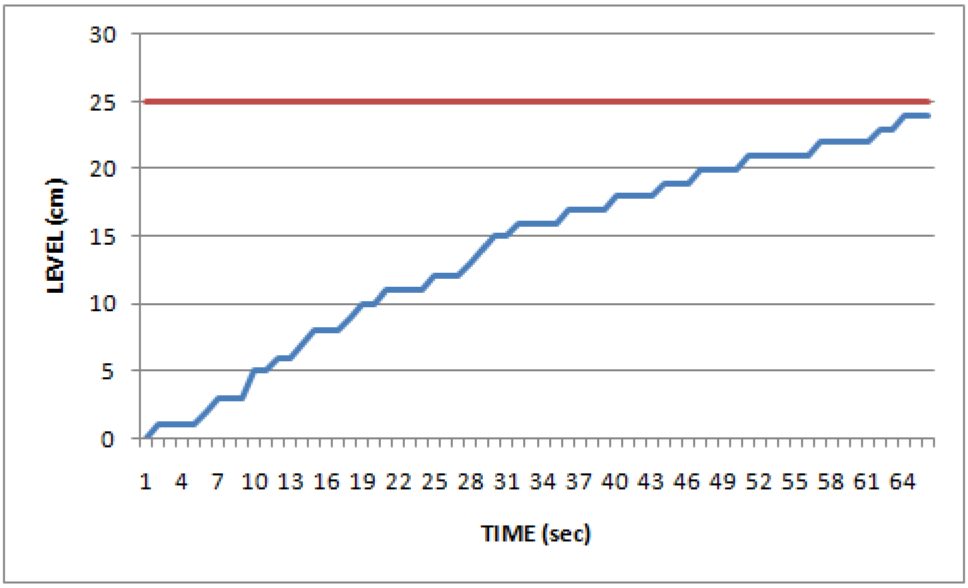

Figure 6.9: Kp=100 & Ki=0.0001

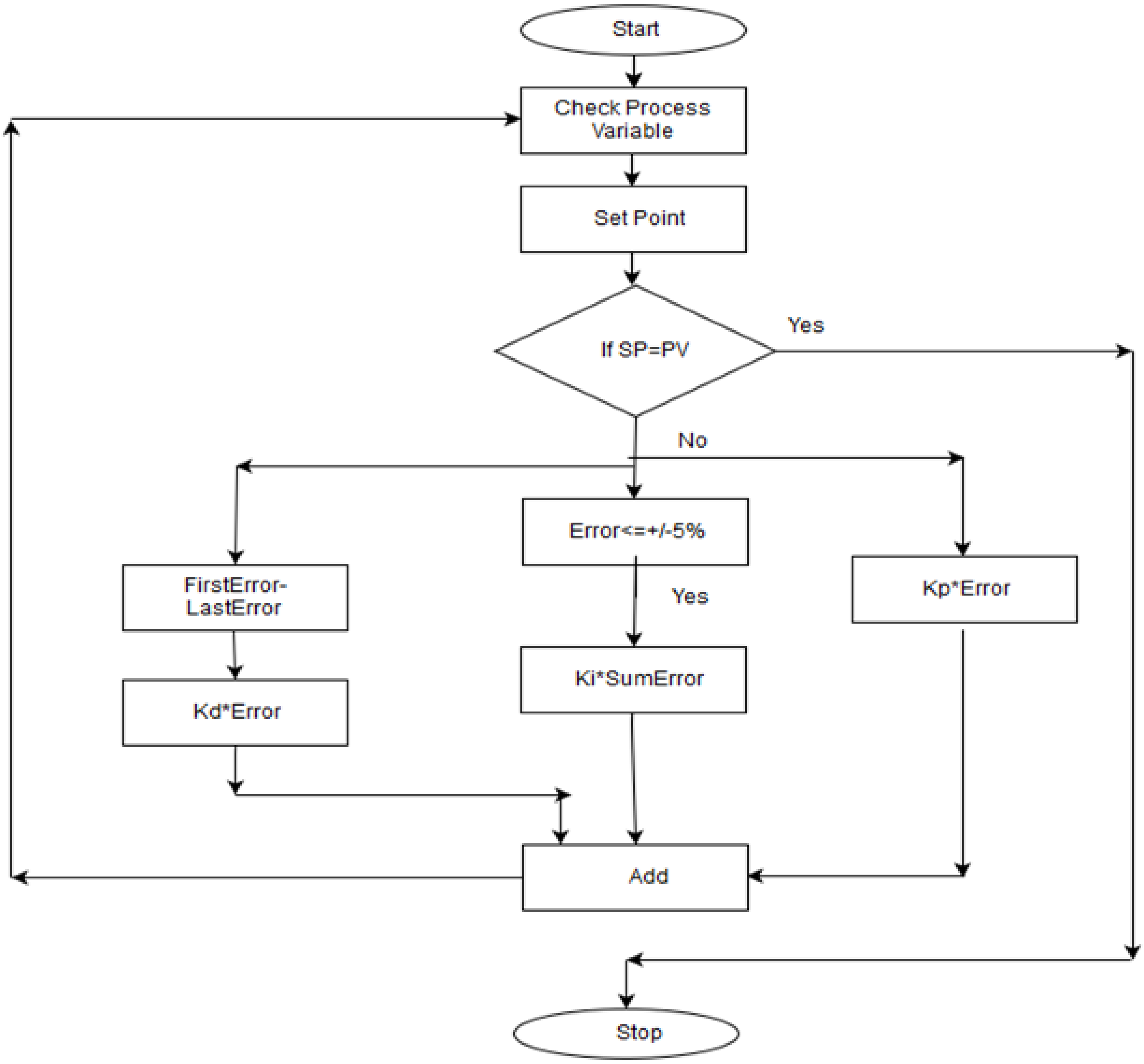

Figure 6.10: Proportional, Integral Control & Derivative Control

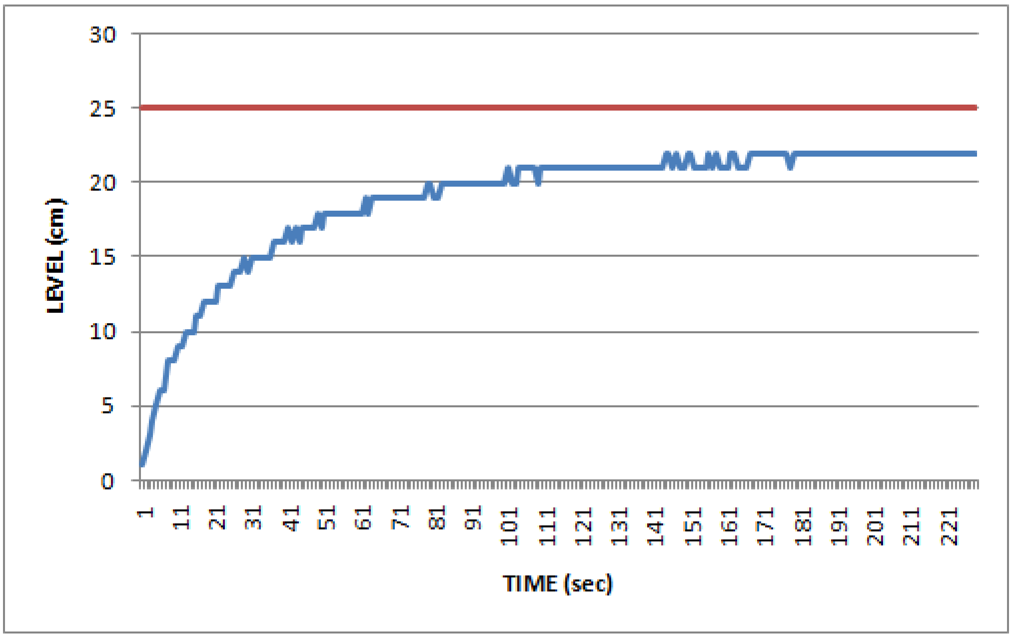

Figure 6.11: Kp=100, Ki=0.0001 Kd=1

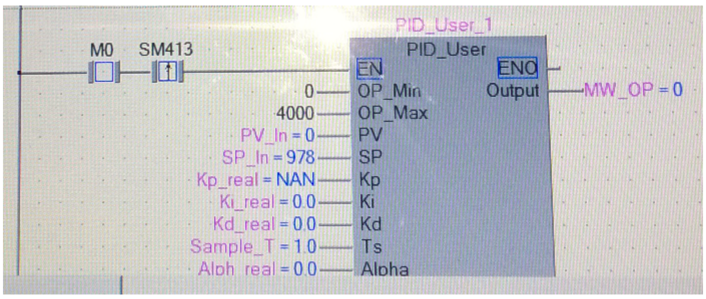

Figure 6.12: PID in FBD

Chapter 7

Conclusion & Future Scope

7.1 Conclusion

PID Control is implemented & then obtained the working response. The PID parameters can also be used for more complex optimization algorithms for improved performance, or for initializing more complex adaptive algorithms. PID autotuning algorithms based on relay feedback method are used to identify different points of the process frequency response before performing the actual tuning procedure. These algorithms require minimal amount of priori information about the controlled process, they are also insensitive to modeling errors and disturbances.

7.2 Future Scope

The developed setup can be used to analyze and implement an advance control algorithm like Systems Identification Function Block in Mitsubishi Q-PLC which may use PRBS and collect samples, does identification using some model structure like 1st order or 2nd order.

References

[1] Instruction manual, Level control trainer (313, 313A), Apex Innovations.

[2] S.Levy, S.Korotkin, K.Hadad, A.Ellenbogen, M.Arad, Y,Kadmon,"PID autotuning using relay feedback", 2012 IEEE 27th Convention of Electrical and Electronics Engineers in Israel, Beer-Sheva 9001.

[3] C.C. Hang - PHD Degree in Control Engineering from university of Warwick."A Comparative Performance Study of PID Auto - Tuners" K.K. Sin Degree in Electrical Engineering from National University of Singapore.

[4] R. R. Pecharroman, F. L. Pagola, "IMPROVED IDENTIFICATION FOR PID CONTROLLERS AUTO-TUNING",1999 European Control Conference (ECC), Karlsruhe, Germany.

[5] Pramod Gondaliya Manisha C. Patel, "Modeling and System Identification of Liquid Level System", International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 5, May 2015.

[6] Pooja Panchal, Alpesh Patel, Jayesh Barve, "PI Control of Level Control System using PLC and LabVIEW based SCADA". 2015 International Conference on Industrial Instrumentation and Control (ICIC) College of Engineering Pune, India. May 28-30, 2015.

[7] Arief Syaichu-Rohman and Raphael Sirius, "MPC Implementation on a PLC for DC Motor Speed Control", 2011 International Conference on Electrical Engineering and Informatics 17-19 July 2011, Bandung, Indonesia.

[8] MELSEC Q Series. Available at www.mitsubishielectric.com, 11 July 2015.

[9] GX Works2. Available at www.gx-works2.software.informer.com, 7 July 2015.

[10] MC Protocol. Available at www.mitsubishielectric.com, 11 July 2015.

[11] Engineering Software, MX Sheet. Available at www.mitsubishielectric.com, 15 November 2015.

[12] MX Component. Available at www.mitsubishielectric.com, 15 November 2015.

[13] Mitsubishi Q Series Programming (Training Manual). www.mitsubishielectric.com, 25 June 2015.

[14] Level transmitter ABB Manual. Available at www.abbinstrumentation.ltd, 21 July 2015.

[15] Type 500X Electropneumatic Transducer. Available at www.Controlairinc.com, 30 July 2015.

[16] Samson Valve Type 241-1Manual. Available at www.samson control.pvt.ltd,28 July 2015.

[17] P.Srinivas and K.Vijaya Lakshmi, "A Comparison of PID Controller Tuning Methods for Three Tank Level Process", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 3, Issue 1, January 2014.

[18] Seborg DE, Edgar TF, Mellichamp DA. Process dynamics and control. 2nd ed. New York: Wiley; 2004.

[19] K. Ogata, Modern Control Systems, Prentice Hall, 2005.

[20] N. S. Nise, Control Systems Engineering, Wiley, 2008.

[21]Ziegler, J. G. and N. B. Nichols (1942). "Optimum settings for automatic controllers." Trans. ASME 64, pp. 759-768.

[22] Jing-Chung Shen,"New Tuning Method for PID Controller", Proceedings of the 2001 IEEE International Conference on Control Applications, September 5-7, 2001 Mexico City, Mexico.

[23] Mohammad Shahrokhi and Alireza Zomorrodi, "Comparison of PID Controller Tuning Methods", Sharif University of Technology.

[24] Astrom, K. J. and T. Hagglund (1995). PID Control Theory, Design and Tuning, Instrument Society of America, Research Triangle Park, North Carolina, USA, second edition.