WATER LEVEL CONTROLLER

MOHD FIRDAUS BIN ABD GHANI

MAY 2006

"I hereby certify that I have read and understood the following project thesis. To my opinion this thesis is sufficient in term of scope and quality to achieve partial fulfillment of requirement for the Degree of Bachelor in Electrical Engineering (Industrial Power)."

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"I hereby declared that this report, of my own, except for the excerpts that have been cited clearly in the references"

Signature : ....

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Date : 4 MAY 2006

"Dedicated to for those supporting me, for my parents, thank you Allah for giving me a chance"

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ABSTRACT

In life today the study of Programmable Logic Controllers (PLC) becomes one of the most important things in all fields. Programmable Logic Controllers were developed to provide a replacement for large relay based control panels. These systems were inflexible requiring major rewiring or replacement whenever the control sequence was to be changed The purpose of using this PLC is to control the water's level in tank and when it come to the set point of desired level it will automatically stop or on the pump and also it will give a signal to user so that the user know either the pump is on or off and the level of water. So as the input of the PLC we need the sensor to determine the level of the water in tank empty, half empty or full. When it comes to the set point, the pump will on or off. This process using PID controller to determine the level of the water .We using this type of control because we need to do it continuously to control the water without any shortage that's why we using PID controller. We improve the transient response then we improve the steady state error. Then the monitor of the level will monitor by the touch screen and design it by NS – Designer.

ABSTRAK

Dalam kehidupan masa kini PLC merupakan alatan yang terpenting dalam industri , PLC yang di cipta berdasarkan lgik geganti merupakan satu gantian kepada pengunaan geganti yang banyak dan menyusahkan. Dan pengunaan geganti mendatangkan masalah sekiranya berlaku sebarang kerosakkan , jadi PLC adalah pengganti kepada geganti , tetapi kita harus memproggramkan PLC mengikut yang kita kehendaki bagi memprogramkan PLC , salah satu cara yang digunakan ialah pengunaan 'Ladder Diagram ' . Bahasa Program ini yang menentukan bagaimana sesuatu ouput itu beropearsai sebagaimana yang kita kehendaki.Ia digunakan untuk menetukan takat akhir bagi air dalam tangki , mengawal perjalanan pam dan valve, serta memastikan bahawa air berada dalam takat yang di kehendaki dengan pengunaan skrin sentuh , yang mana kita program mengikut 'software' NS-Designer.Sebagai input kepada PCL sensor digunakan iaitu 'ultrasonic sensor ' yang lebih baik yang mana tidak terganggu oelh warna dan keadaan air.Pengunaan PID controller adalah untuk memastikan bahawa process ini dpt berjalan secara berterusan.Dan pengunaan PID juga mampu meningkatkan 'transient response'.

CONTENTS

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CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

For this project, the PLC is used to monitor the level of the water and to control the level of the water. By using the PLC, the level of the water could be determined because the using of the ultrasonic sensor which is has been interfaced with the PLC. For this project the hardware is, tank, sensor, PLC, monitoring device. All of them are interfaced with PLC. The user at first will be key in the level of the water that they want, and from the monitoring devices the level of the water that the user key in will be appeared then the user will switch on the controller by pressing the touch screen, after the desired level is reach the pump will off than the last level will displayed at the touch screen.

For doing all these process, the programs for the PLC is needed and the touch screen have to program and interfaced will PLC , to program the PLC , CX-Programmer is used and for the touch screen the NS-Designer is required.

This project also need to understand the principal of the PLC, how to operates the PLC and how to interfaces the PLC with all the devices and hardware. Because of them is need to make the system complete.

1.2 PROJECT OBJECTIVES

In this project there so many objectives to design this water level controller The objectives are:

1. Design a water level controller using PLC

2. Implementing the application of PLC in this project.
3. By using the PLC we also design an output that can receive a signal from PLC. So that the user can know the level of the water in tank and also either pump is on or off.
4. Display circuit also been designed as the output for the PLC so this water level controller can display a level of the water and the pump is on or not.
5. Make an interfacing of the PLC and the output. Because in PLC the interfacing is the hardest section to do. Because sometime we need to trouble shoot the problem so many time. In the process sometime it causes the error in PLC.

First in the proposal, the objective is wanted to design the transceiver circuit as the monitoring devices. But because of time constrain, I'm choosing another monitoring devices called touch screen, which more easy to use and to program.

1.3 SCOPE OF PROJECT

Scope of the project will determine how is the project will be conducted. And the literature review will be implemented in the design. This is the scope of the project:

1. In this project we need to study the operation and application of the PLC. The operation of the PLC, how they works and how to program is the important thing in this project. We need to understand it because there are so many type of PLC and so many type of programming the PLC. So we have to study the suitable program for the PLC in this project. Because there are so many type of programming for PLC. Such as Boolean algebra, Ladder Diagram and so on.
2. We using the different type of method and make a comparison of the method that the other person use before this. Because before this the other method is using a complex component. So in this project it uses the PLC as the controller. And we have to make an interfacing between PLC and output.
3. The output of the PLC that we choose is display panel of the level of the water. And the devices that can receive a signal from PLC so that

the users can know pump is on or not and the level of the water in tank.

4. We also use the CX-Programmer to program the PLC. The CX-Programmer is used in the CQM1H PLC model. It's a program that we build the ladder diagram to implement in PLC.
5. In literature review covers the operation of PLC and the type of controller that being use in this project. So by know the type of controller that suitable for the design of water level controller we will get the appropriate solution for the problem.

1.4 PROBLEM STATEMENT

In water industry, the water is stored in OHT (Over Head Tank). This is located so far from the WTP (Water Treatment Plant) .This also not so convenience to the user to look after the tank, in order to control the level of the water in the tank. As shown in Figure 1.0

Sometimes the user doesn't know the level of the pump empty, half empty or full. And the circuit that commonly use as a indicator circuit is so complicated to use. It contains so many components which is sometimes can be damage when the fault happens at the circuit. By using this complicated circuit we also have to switch on or off the pump manually. It's difficult to the human to go up to the hill because the tank usually located at the hill and sometimes there so difficult to trouble shoots the fault happen at the circuit.

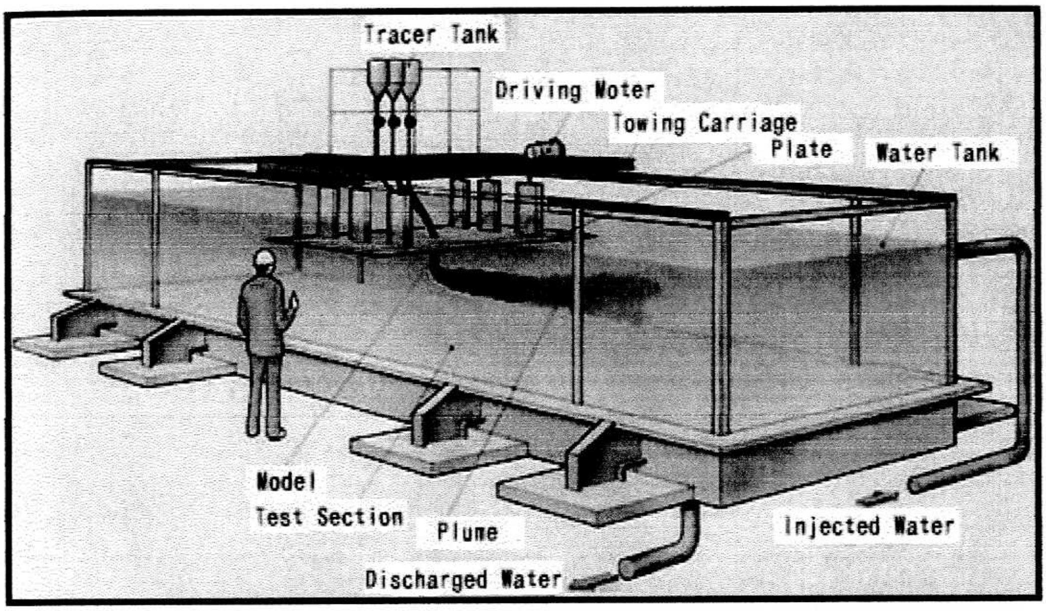

Figure 1.1: A Traditional Water Tank.

This circuit also not mentions or indicates the pump is on or not because it's only using a simple connection between them or so called contact point. So when the level is come to full the contact point will contact to each other so the pump will stop. The problem here is, when the contact point is not working properly so it will cause overflowing to the water tank when the pump is non stop running. It's also so expensive to produce. Actually for one water tank we need to design for each water tank, by using PLC we can use it to all water tank. The circuit also can't be reusable because it's only use for the purpose of the level indicator and controlling the water level of the tank. The wiring of the circuit also make more complicated to us.

So the PLC is the solution for this because it only needs a program language such as ladder diagram or other language which is mention before. So the type of controller can be changed. Before this we always use the mechanical connector to control the level of water. But this is not so practical to use because the connection doesn't know when to stop or on the pump. So once again the water will overflow when using this traditional type of water level control.

CHAPTER 2

LITERATURE REVIEW

2.1 BACKGROUND

Before this there are so many methods to control the level of water tank. But none of them are using PLC as a controller of the water tank level. Actually there are using a complicated component in the circuit. Below are some of the methods that we all study before this.

2.2 THEORETICAL STUDY AND BACKGROUND

2.2.1 METHOD NO 1

The simple circuit presented here as shown in Figure 2.1, makes this system automatic, i.e. it switches on the pump when the water level in the overhead tank goes low and switches it off as soon as the water level reaches a pre-determined level. It also prevents 'dry run' of the pump in case the level in the underground tank goes below the suction level. In the figure, the common probes connecting the underground tank and the overhead tank to +9V supply are marked 'C'. The other probe in underground tank, which is slightly above the 'dry run' level, is marked 'S'.

The low-level and high-level probes in the overhead tank are marked 'L' and 'H', respectively. When there is enough water in the underground tank, probes C and S are connected through water. As a result, transistor T1 gets forward biased and starts conducting. This, in turn, switches transistor T2 on. Initially, when the overhead tank is empty, transistors T3 and T5 are in cut-off state and hence pnp transistors T4 and T6 get forward biased via resistors R5 and R6, respectively. As all series-connected transistors T2, T4, and T6 are forward biased, they conduct to energize relay RL1 (which is also connected in series with transistors T2, T4, and T6). Thus the supply to the pump motor gets completed via the lower set of relay contacts (assuming that switch S2 is on) and the pump starts filling the overhead tank.

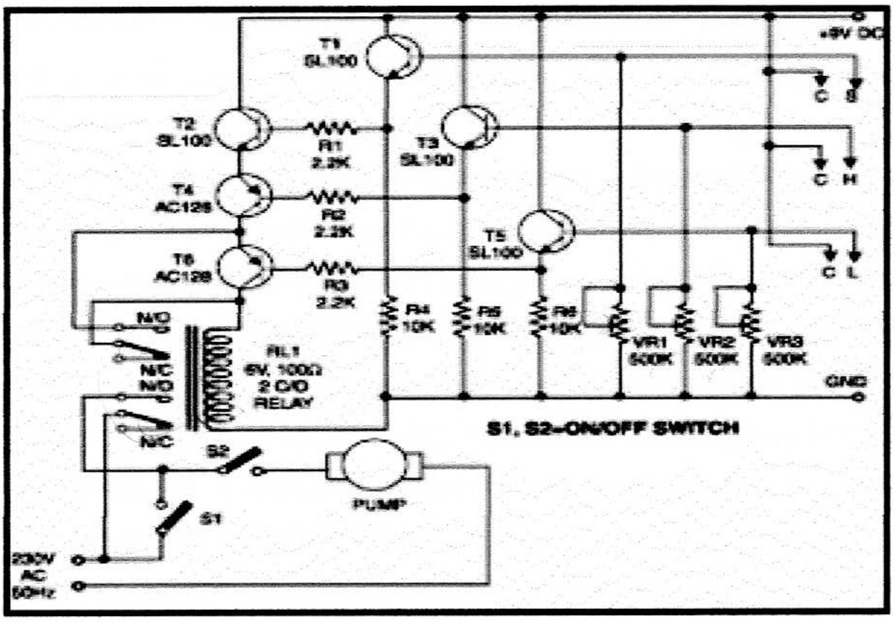

Figure 2.1: A Circuit for a water level controller

Once the relay has energized, transistor T6 is bypassed via the upper set of contacts of the relay. As soon as the water level touches probe L in the overhead tank, transistor T5 gets forward biased and starts conducting. This, in turn, reverse biases transistor T6, which then cuts off. But since transistor T6 is bypassed through the relay contacts, the pump continues to run. The level of water continues to rise. When the water level touches probe H, transistor T3 gets forward biased and starts conducting. These causes reverse biasing of transistor T4 and it gets cut off. As a result, the relay de-energizes and the pump stops. Transistors T4 and T6 will be turned on again only when the water level drops below the position of L probe.

2.2.2 METHOD NO 2

Here is a simple, versatile circuit which indicates the level of water in a tank as shown in Figure 2.2. This circuit produces alarm when water level is below the lowest level L1 and also when water just touches the highest level L12. The circuit is designed to display 12 different levels. However, these display levels can be increased or decreased depending upon the level resolution required. This can be done by increasing or decreasing the number of level detector metal strips (L1 to L12) and their associated components. In the circuit, diodes D1, D2 and D13 form half-wave rectifiers.

The rectified output is filtered using capacitors C1 through C3 respectively. Initially, when water level is below strip L1, the mains supply frequency oscillations are not transferred to diode D1. Thus its output is low and LED1 does not glow. Also, since base voltage of transistor T1 is low, it is in cut-off state and its collector voltage is high, which enables tone generating IC1 (UM66) and alarm is sounded. When water just touches level detector strip L1, the supply frequency oscillations are transferred to diode D1. It rectifies the supply voltage and a positive DC voltage develops across capacitor C1, which lights up LED1.

At the same time base voltage for transistor T1 becomes high, which makes it forward biased and its collector voltage falls to near-ground potential. This disables IC1 (UM66) and alarm cannot be sounded. Depending upon quantity of water present in the tank, corresponding level indicating LEDs glow. It thus displays intermediate water levels in the tank in bar-graph style. When water in the tank just touches the highest level detector strip L12, the DC voltage is developed across capacitor C2. This enables tone generating IC1 (UM66) and alarm is again sounded.

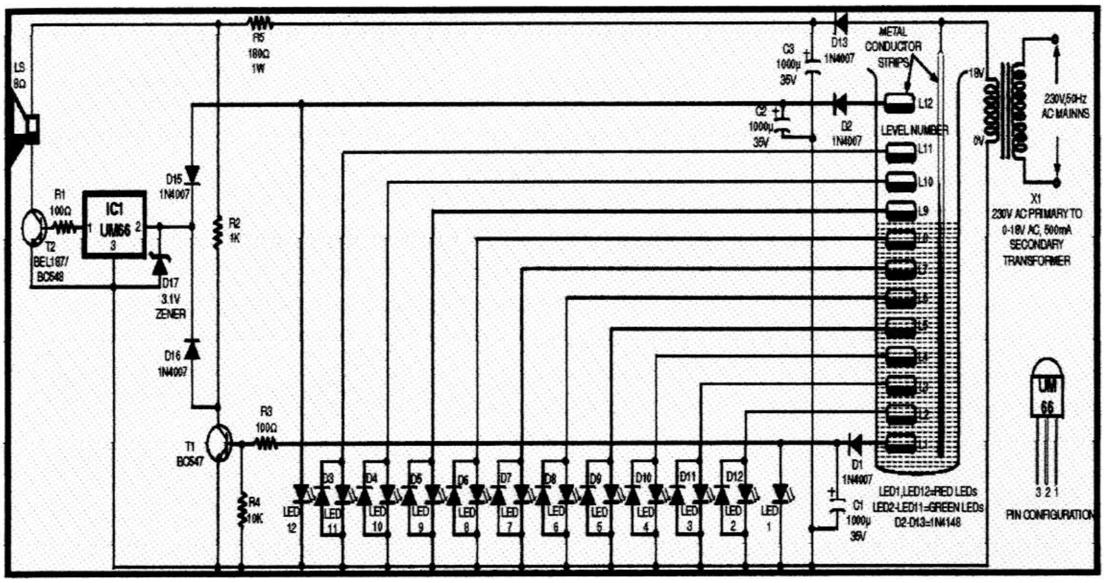

Figure 2.2: A circuit of water level indicator.

2.3 PROJECT BACKGROUND

From both of the method mention above we have make some modification of level controller and indicator, which is we are using the PLC as a controller .This is because PLC is more suitable than the method mentioned above. In PLC the PID controller is the suitable controller. PID or known as Proportional Integral Derivative .The PLC will be conducted the logic of the operation so if the level is reaching the set point, the pump will off but if not it will be on the pump until the desired level is reach. The PID is used because of two main reasons:

1. The steady state error will be improve without changing the transient response
2. The response is slower than the other controller

The characteristics of the PID are:

1. Lag zero and pole origin improve steady state error.
2. Lead zero improves transient response.
3. Lag zero is close to the left and to the origin.
4. Active circuit is required to implement.

The PLC will be program using the ladder diagram language or the software is CX-Programmer .The software will be constructs the ladder diagram, then ladder diagram will be implemented to the PLC and interfacing between the hardware (output) will be done. So there are no more the electronic components will be need except for the display panel. So it will less cost and easy to use.

2.3.1 FUNDAMENTALS OF PLC

A programmable logic controller, PLC, or programmable controller is a small computer used for automation of real-world processes, such as control of machinery on factory assembly lines. The PLC usually uses a microprocessor. The program is usually created by a skilled technician at an industrial site, rather than a professional computer programmer. The program is stored in battery-backed memory. The main difference from other computers is the special input/output arrangements. These connect the PLC to a process's sensors and actuators. PLCs read limit switches, dual-level devices, temperature indicators and the positions of complex positioning systems. Some even use machine vision.

On the actuator side, PLCs drive any kind of electric motor, pneumatic or hydraulic cylinders or diaphragms, magnetic relays or solenoids the input/output arrangements may be built into a simple PLC, or the PLC may have external I/O modules attached to a proprietary computer network that plugs into the PLC.
PLC actually a microprocessor base and memory store of instruction and implement logic. The simple explanation as shown below:

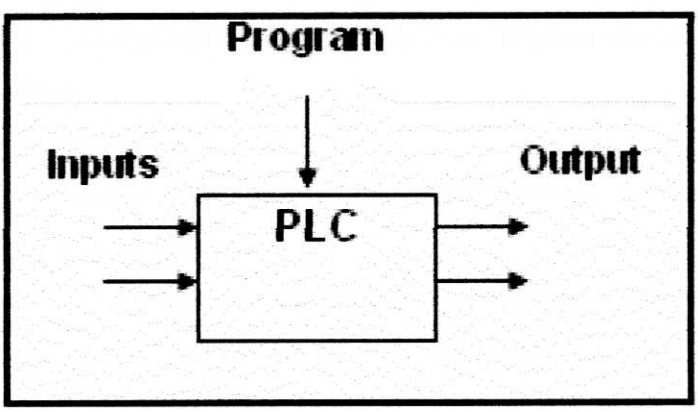

Figure 2.3: A simple block diagram of PLC [2]

Inputs to, and outputs from a PLC are necessary to monitor and control a process. Both inputs and outputs can be categorized into two basic types:

1. Logical
2. Continuous

Consider the example of light bulb. If can be only turned on or off it is logical control. If the light can be dimmed into different level, it is continuous. Continuous values seem more intuitive but logical values are preferred because they allowed more certainly and simplify control .As results most control application (and PLC) use logical inputs and outputs for most application. Outputs actuators allow PLC to cause something happen in a process. A short list of popular actuators is given in below:

1. Solenoid Valves – logical outputs that can switch a hydraulic flow
2. Light – logical outputs that can be often be powered directly from PLC boards.
3. Motor Starters – motor s often draw large amount of current when started, so they required motors starter which basically large relays.
4. Servo Motors – A continuous output from the PLC can be command a variable speed or position

Outputs form PLC are often relays but they also can be solid states electronic such as transistors for Dc outputs or Triacs for AC outputs .Continuous output required special cards with digital analog converters .Inputs come form sensors that translate phenomena into electrical signals. Typical example of sensor as listed below:

1. Proximity Switch – Use inductance ,capacitance or light detect to detect object logically
2. Switches – mechanical mechanism will open or close electrical contact for logical signal

In PLC there are consist of:

1. CPU - Unit that contain microprocessor , interprets the input signal to carry out control actions
2. Programmer – The software that will drive how the PLC will operate

Memory Unit – Program will save here and will be perform.

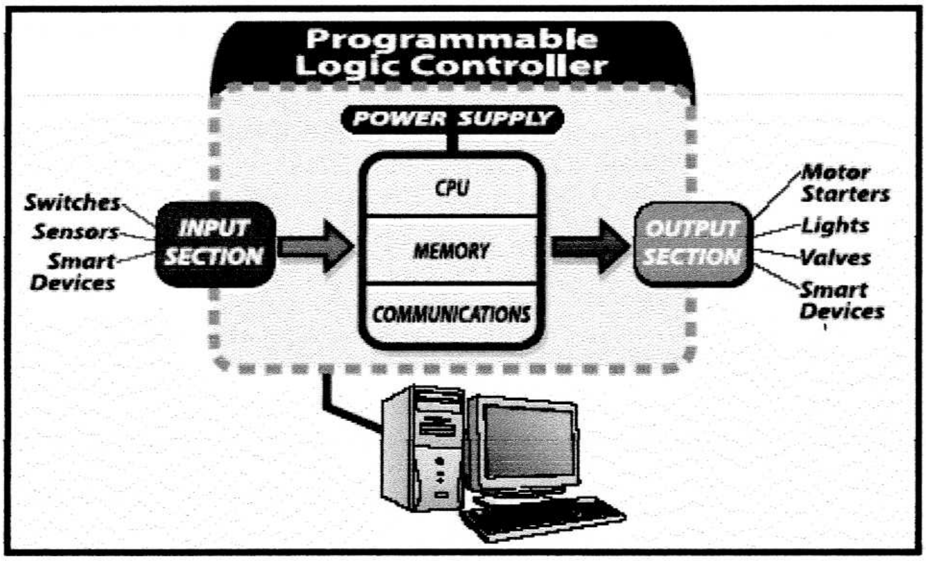

Figure 2.4: Figure show a PLC hardware [3]

The PLC's from Omron can be connected to various peripheral equipment each device requires its own cable layout. Only the more common cables are shown here.

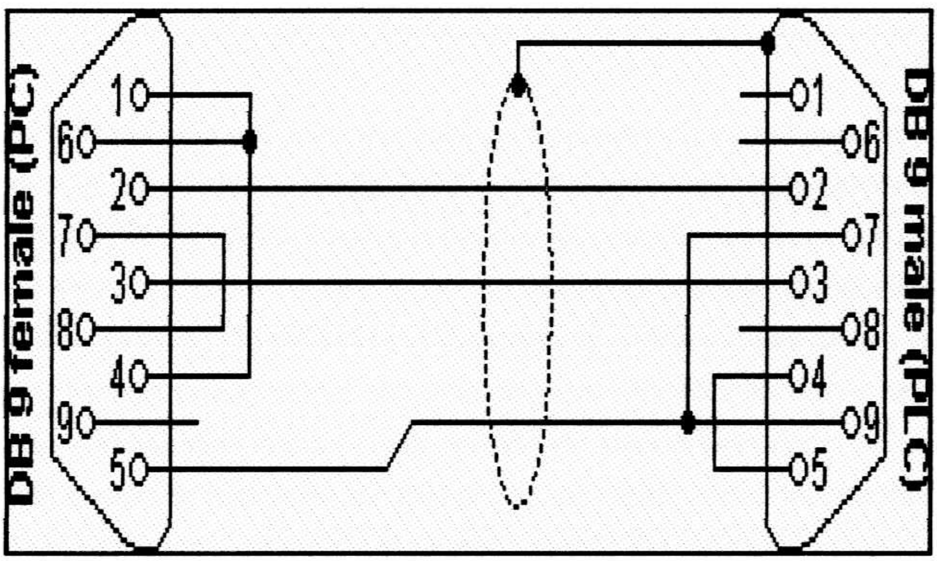

Figure 2.5: CJ1 programming cable [9]

2.3.2 PID CONTROLLER

PID CONTROL OF CONTINUOUS PROCESS

A PID controller transfer function is:

$$G_s(s) = K_1 + (K_2 / s) + K_3 s \tag{2.1}$$

Proportional Integral Derivative (PID) controller are most common controller choice .The basic controller equation is shown below:

$$u = K_c e + K_i \int e\, dt + K_d\, (de/dt) \tag{2.2}$$

where the

$\left.\begin{matrix} K_c \\ K_i \\ K_d \end{matrix}\right\}$ Relative weight of components

The equation uses three terms, the proportional term K_p will push the system in the right direction. The integral term K_i will response to long term errors. The values of Ki, K_c, K_p can be selected or tuned to get desired system response[1].

PID is an effective control system for continuous processes that performs two control tasks. First, PID control keeps the output at a set level even though varying process parameters may tend to cause the output to vary from the desired set point. Second, PID promptly and accurately changes the process level from one set point level to another set point level. For background, we briefly discuss the characteristics of each of the PID control components: proportional, integral, and derivative. Proportional control, also known as ratio control, is a control system that corrects the deviation of a process from the set level back toward the set point. The correction is proportional to the amount of error.