15EI304L-PROCESS CONTROL LAB MANUAL

Department of Electronics and Instrumentation Engineering

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Tamil Nadu

CONTENTS

1. MARK ASSESSMENT DETAILS

ALLOTMENT OF MARKS:

Internal assessment = 60 marks

Practical examination = 40 marks

Total = 100 marks

INTERNAL ASSESSMENT (60 MARKS)

Split up of internal marks

Record	5 marks
Model exam	10 marks
Quiz/Viva	5 marks
Experiments	40 marks
Total	60 marks

PRACTICAL EXAMINATION (40MARKS)

Split up of practical examination marks

Aim and Procedure	25 marks
Panel Diagram	30 marks
Tabulation & graph	30 marks
Result	05 marks
Viva voce	10 marks
Total	100 marks

2. GENERAL INSTRUCTIONS FOR LABORATORY CLASSES

1. Enter the Lab with CLOSED TOE SHOES.
2. Students should wear lab coat.
3. The HAIR should be protected, let it not be loose.
4. TOOLS, APPARATUS and COMPONENT sets are to be returned before leaving the lab.
5. HEADINGS and DETAILS should be neatly written
    i. Aim of the experiment
    ii. Apparatus / Tools / Instruments required
    iii. Theory
    iv. Procedure
    v. Model Calculations/ Design calculations
    vi. Panel Diagram / Block diagram
    vii. Tabulations/ Graph
    viii. Result / discussions
6. Experiment number and date should be written in the appropriate place.
7. After completing the experiment, the answer to pre lab viva-voce questions should be neatly written in the workbook.
8. Be REGULAR, SYSTEMATIC, PATIENT, AND STEADY.

3. SYLLABUS

15EI304L	Process Control Laboratory	L	T	P	C
		0	0	2	1
Co-requisite:	15EI304				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	P	PROFESSIONAL CORE	CONTROL ENGINEERING		
Course designed by	Department of Electronics and Instrumentation Engineering				
Approval	32nd Academic Council Meeting held on 23rd July, 2016				

PURPOSE	To enable the students to understand the fundamentals of process control, types of processes, characteristics of different types of controllers for controlling a process and process automation

INSTRUCTIONAL OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Explain the characteristics and significance of Final Control Element	a	b					
2.	Design and implement controllers for various processes	a	b	c	e	k		
3.	Tune the controller and improve the performance of the process	a	b	c	e	k		
4.	Design and control complex systems	a	b	c	e	k		

Session	**Description of experiments**	**Contact hours**	**C-D-I-O**	**IOs**	**Reference**
1.	Characteristic of I/P and P/I converters	3	C,I,O	1	1,2,3
2.	Characteristic of various type of control valves	3	C,I,O	1	1,3
3.	Characteristic of control valve with and without positioner	3	C,I,O	1	1,2,3
4.	Design of ON/OFF, PI and PID controller for the pressure process	3	C,D,I,O	2	1,2,3
5.	Design of ON/OFF, PI and PID controller for the level process	3	C,D,I,O	2	1,2,3
6.	Design of ON/OFF, PI and PID controller for the flow process	3	C,D,I,O	2	1,2,3
7.	Design of ON/OFF, PI and PID controller for the temperature process	3	C,D,I,O	2	1,2,3
8.	Tuning of controllers	3	C,D,I,O	3	1,2,3

9.	Study of complex control system	3	C,D,I,O	4	1,2,3
10.	Responses of different order processes with and without transportation lag	3	C,D,I,O	4	1,2,3
	Total contact hours	**30**			

LEARNING RESOURCES	
Sl. No.	**REFERENCES**
1.	Laboratory Manual
2.	Johnson .C.D, "*Process Control Instrument Technology*", Prentice Hall Inc., 2004.
3.	Bequette. B.W, "*Process Control Modeling, Design and Simulation*", Prentice Hall ofIndia, 2004.

Course nature						**Practical**
Assessment Method (Weightage 100%)						
In-semester	**Assessment tool**	Experiments	Record	MCQ/Quiz/Viva Voce	Model examination	**Total**
	Weightage	**40%**	**5%**	**5%**	**10%**	**60%**
					End semester examination Weightage :	**40%**

STUDENT OUTCOMES:

a. An ability to apply engineering science and mathematical knowledge of to designing and conducting experiments as well as to analyze and interpret data.

b. An ability to design process control system components to meet desired needs within realistic constraints.

c. An ability to use the techniques, skills and tools to identify formulate and solve engineering problems.

4.INTRODUCTION TO THE LABORATORY

The purpose of this lab is to provide understanding of fundamental concepts and principles in process control. We will also get acquainted with the different types of control valves and types of controllers used in industries.

What is Good Control?

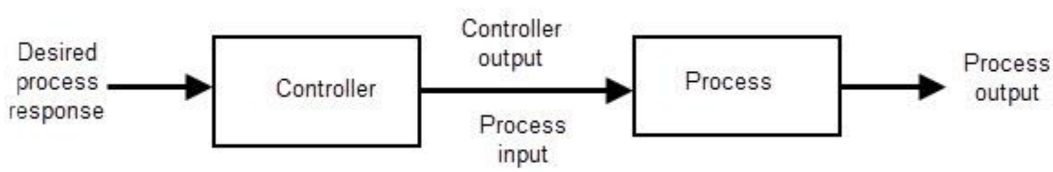
The reason one wishes to control a process is to have it behave in a desired way. This may involve the process becoming more accurate, more reliable or more economic.In some cases the uncontrolled process is unstable and good control is necessary in order not to damage it (which sometimes can cause extensive damage). Hence, good control can mean different things in different applications.

Types of control loops:

- Open loop
- Closed loop

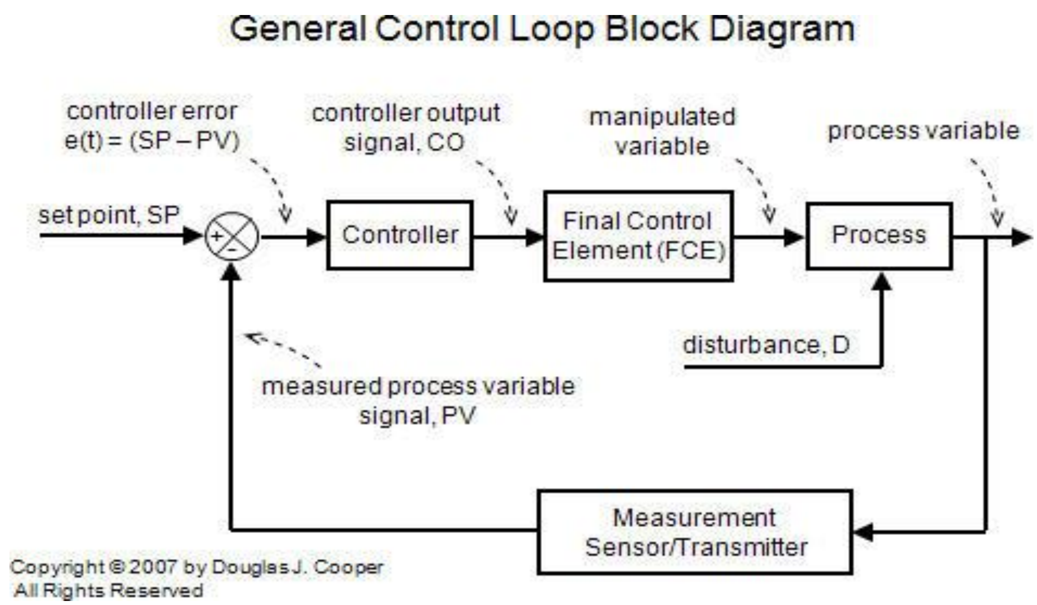
Open loop:

An **Open-loop system**, also referred to as *non-feedback system*, is a type of continuous control system in which the output has no influence or effect on the control action of the input signal. In other words, in an open-loop control system the output is neither measured nor “fed back” for comparison with input. An open-loop system is expected to faithfully follow its input command or set point.



Closed loop:

A **Closed-loop Control System**, also known as a *feedback control system* is a control system which uses the concept of an open loop system as its forward path but has one or more feedback loops (hence its name) or paths between its output and its input. The reference to “feedback”, simply means that some portion of the output is returned “back” to the input to form part of the systems excitation.



PV = Process Value/Controlled Variable
SV = Setpoint/Desired Value
MV = Manipulated Value/Controller Output
Error = Deviation/Offset
LV=Load Variables-all other variables that cause upset and affect control (e.g: input flow rate, output flow rate, environment, heater power variation)

Industrial Standards:

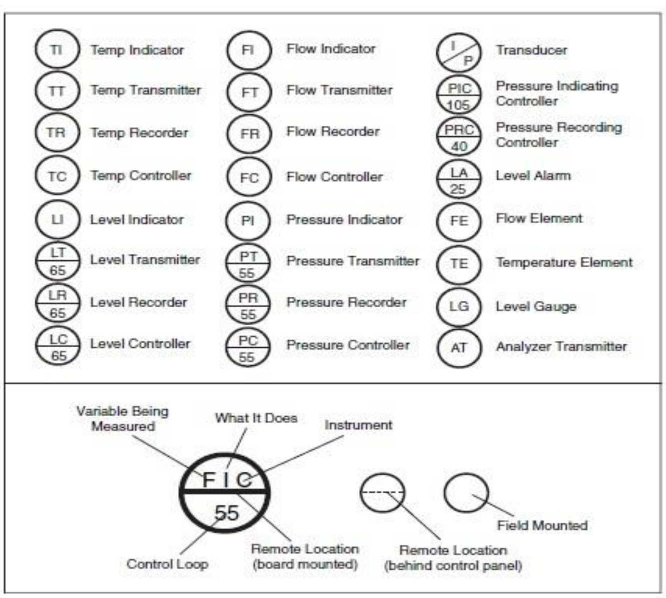
Prior to the widespread adoption of electrical and electronic controls, buildings often used pneumatic control systems. Large and powerful compressors drove 3psi to 15psi pneumatic signals throughout a plant and these pneumatic lines connected to pneumatically controlled valves and pneumatically controlling valves in order to drive proportional controls and actuators throughout the building, all powered from compressed air.

Air pressure at 3psi served as the “live-zero” and 15psi represented 100%. In this way, the more modern 4-20mA signal standard emulated the earlier 3-15psi pneumatic controls. Any pressure below 3psi was considered “dead zero” and an alarm condition. Some installations still use pneumatic control today. Modern I/P converters (current-to-pressure transducers) are available to convert the 4-20mA control loops to common pneumatic ranges, such as 3-15psi. In two-wire 4-20mA control loops, we use 2-wire transmitters to convert various process signals representing flow, speed, position, level, temperature, pressure, strain, pH, etc., to 4-20mA DC for the purpose of transmitting the signal over some distance with little or no loss of signal. its advantages, in particular as it relates to two-wire transmitters and the associated 4-20mA current loop.

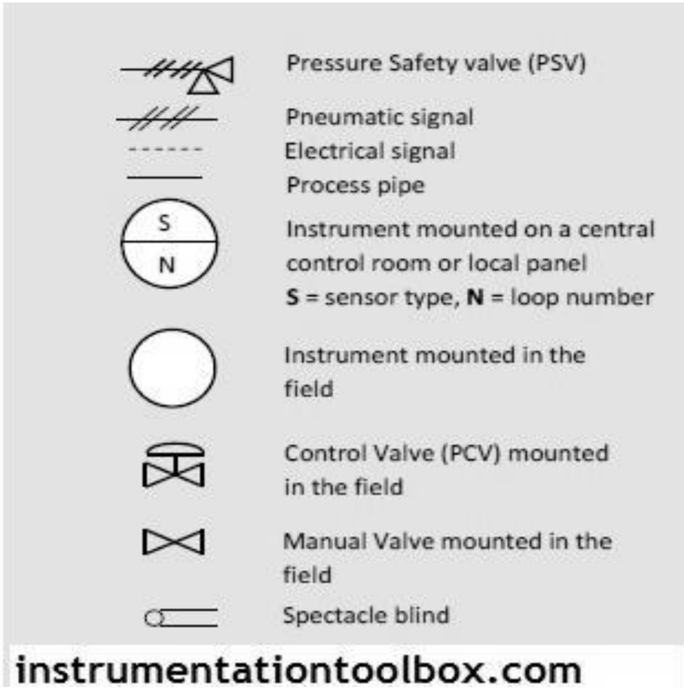
P& I Diagram:

Piping and Instrumentation diagram (**P&ID**) is a detailed diagram in the process industry which shows the piping and vessels in the process flow, together with the instrumentation and control devices. They usually contain the following information:

- Process piping, sizes and identification, including:
  - Pipe classes or piping line numbers
  - Flow directions
  - Interconnections references
  - Permanent start-up, flush and bypass lines
- Mechanical equipment and process control instrumentation and designation (names, numbers, unique tag identifiers), including:
  - Valves and their identifications (e.g. isolation, shutoff, relief and safety valves)
  - Control inputs and outputs (sensors and final elements, interlocks)
  - Miscellaneous - vents, drains, flanges, special fittings, sampling lines, reducers and increasers
- Computer control system



P&ID Symbols

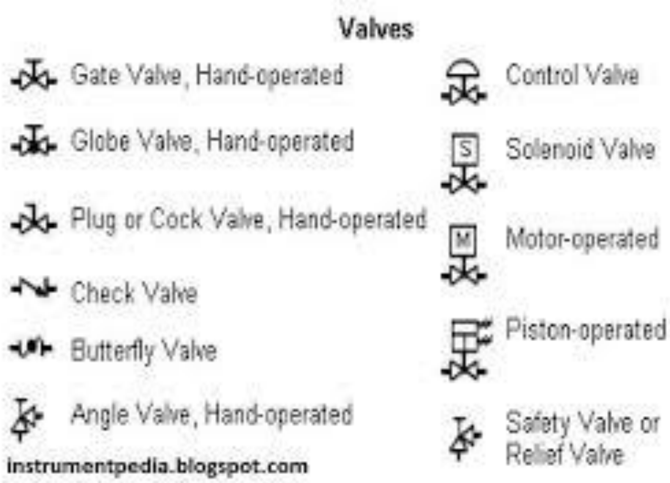


P&ID Symbols

The instrumentation panel diagrams are designed in such a way that block diagrams of the stages of process instrumentation system are clearly pictured on them. This makes the instrumentation tutor self explanatory and also the best teaching aid for engineering students.

Different types of Control valves symbols:

Following are the symbols of different types of control valves used in process industries.



Exercise Number: 1a

CURRENT TO PRESSURE CONVERTER

1.1 Aim:

To determine the characteristics of I/P converter.

1.2 Apparatus Required:

1.2.1 Hardware Required:

1. Compressor
2. VPI – 01

1.3 Preparation:

1.3.1 Theory:

Flapper nozzle method is used for current to pressure conversion. The schematic arrangement of the system is shown in figure 1. When the flapper moves to the left about its pivot, less air will leak out and a larger pressure will be developed between the fixed restriction and nozzle.

Regulated air supply enters through restriction and comes out through the nozzle. In front of the nozzle, a flapper is placed. The mid point of the flapper is fixed on a pilot. So that the flapper is placed to move freely to and fro. One end of the flapper is placed near the nozzle and the other end is placed near the current carrying coil. This operating coil energized by current flowing through it. As the current in the coil is increased, one of the flapper moves towards the coil and hence the other end moves towards the nozzle.

When the flapper moves towards the nozzle, there is increase in back pressure. When the flapper moves away, there will be a decrease back pressure. So, the back pressure is directly proportional to the distance (X) between the nozzle and the flapper. This relation is given by

$$\mathbf{P_0} \quad \frac{\mathbf{P_s}}{\mathbf{1+16(x/d)^2}}$$

Where P_0 = Back Pressure, psi

x = Distance between nozzle and flapper, mm

d = Diameter of the restriction and the nozzle.

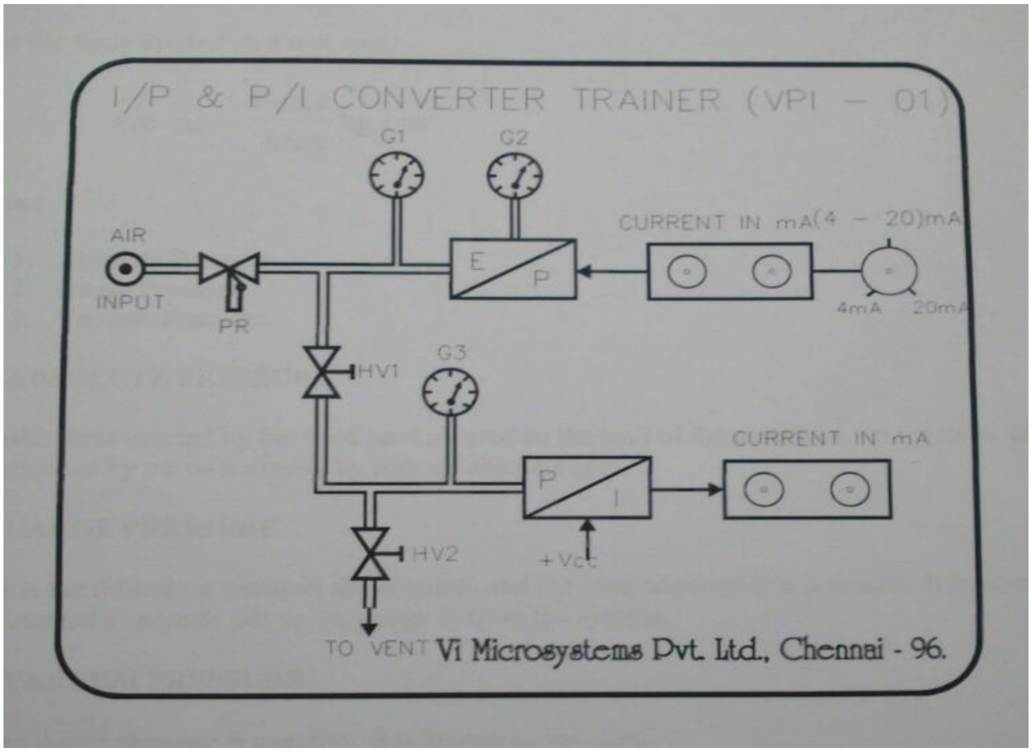
1.3.2 Pre lab Question:

1.Name some pressure transducer.
2.What is the range of current if the pressure is 3 – 15 PSI?
3.What is LVDT/
4.Why span adjustment is needed/
5.What is the need of I/P converter?

1.4 Procedure:

1. Switch ‘ON’ the compressor.
2. Set ‘G1’ to 20psi by adjusting air regulator.
3. Switch ON the unit.
4. Connect multimeter (in mA mode) to the I to P input terminals.
5. Gradually, increase the current (4 to 20mA) by adjusting knob and note down the corresponding pressure readings (G2).
6. Tabulate the readings.

1.4.1 Panel Diagram:



1.5 Observation:

Regularly open and close HV_2 to ensure excess air removal.

S.No	Input Current (mA)	I/P Converter Output G_2(psi)

1.6 Post Lab Question:

1.What is flapper and nozzle?

2. What are the standard ranges of current and pressure?

3. Where will you use I/P and P/I converters?

4. What is the principle of Bourdon guage?

5.What is live zero and dead zero?

1.7 Inference:

1.8 Result:

Thus the characteristic of Current to Pressure Converter is studied.

Exercise Number: 1b

PRESSURE TO CURRENT CONVERTER

1.1Aim:

To study the characteristics of P/I converter.

1.2Apparatus Required

1.2.1 Hardware Required:

1. Compressor
2. VPI – 01

Preparation:

1.3.1Theory:

PRESSURE MEASUREMENT

Pressure to be measured is applied to the pressure cell. Diaphragm is used as a seal and pressure gathering number. Due to this applied pressure, there will be change in resistance of the strain gauge. This change in resistance is very small. For measuring this resistance, strain gauge are fixed on the diaphragm to form wheat stone bridge.

This change in resistance causes the unbalance in the wheat stone bridge. This gives voltage output. This output voltage is proportional to the change in resistance. The change in resistance is proportional to the pressure applied. So, the output voltage is proportional to the pressure applied. This voltage is converted into the current using voltage to current converter.

When the pressure is applied, the resistance of the strain gauge changed from R to $R \pm \Delta R$, then

$$V_0=\left(\frac{\Delta R}{4R+2.\Delta R}\right).V_i$$

But 4R >> 2.ΔR

$$V_0=\left(\frac{\Delta R}{4R}\right)V_i$$

Hence, the change in resistance is directly proportional to the pressure applied.

This output voltage is converted into current signal for transmitting over long distance.

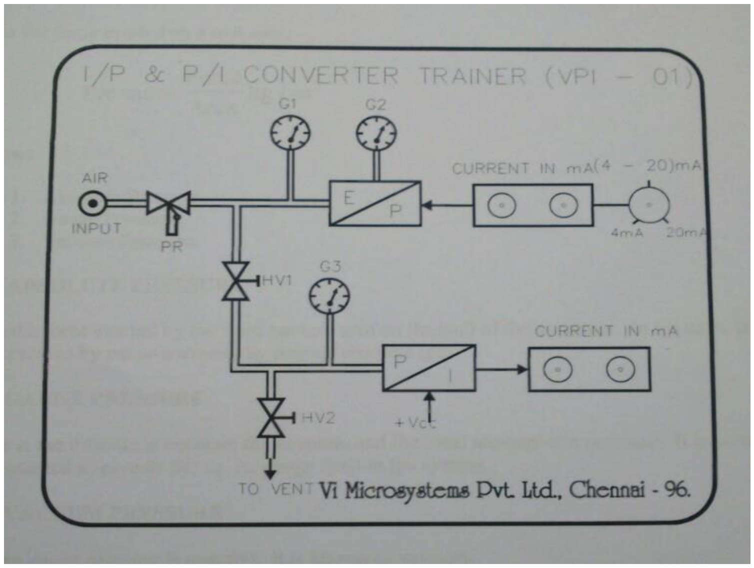
1.3.2 Pre lab Question:

1.Name some pressure transducer.
2.What is the range of pressure if the current is 4-20 mA?
3.What is LVDT?
4.Why span adjustment is needed?
5.What is the need of P /Iconverter?

a. Procedure:

7. Switch 'ON' the compressor.
8. Set 'G1' to 20psi by adjusting air regulator.
9. Switch ON the unit.
10. Connect multimeter (in mA mode) to the P to I output terminals.
11. Gradually, increase the pressure (G3) from 0 to 20psi by opening HV1.
12. Measure the output current (mA) for different pressures and tabulate them.

i. **Circuit Diagram:**



1.4 Observation:

Regularly open and close HV2 to ensure excess air removal.

S.No	Input Pressure G3 (psi)	Output Current (mA)

1.5 Post Lab Question:

1.What is flapper and nozzle?
2. What are the standard ranges of current and pressure?
3. Where will you use I/P and P/I converters?
4. What is the principle of Bourdon guage?
5.What is live zero and dead zero?

1.6 Inference:

1.7 Result:

Thus the characteristics of Pressure to Current Converter is studied

.

Exercise Number: 2

CONTROL VALVE CHARACTERISTICS

1.1 Aim :

To obtain the characteristics of control valve.

1.2 Apparatus Required :

1.2.1 Hardware Required :

control valve set up

1.3 Preparation :

1.3.1 Theory :

The setup is designed to understand the control valve operation and its flow characteristics. It consists of pneumatic control valves of linear, equal %(&quick opening for product 318B) type, stainless steel water tank with pump for continuous water circulation and rotameter for flow measurement. An arrangement is made to measure pressure at the valve inlet in terms of mm of water. An air regulator and pressure gauge is provided for the control valve actuation. In case of additional optional requirement a valve positioned is fitted on linear valve. The setup is stand-alone type.

Types of control valves: -

Valve is essentially a variable orifice. Control valve is a valve with a pneumatic, hydraulic, electric (excluding solenoids) or other externally powered actuator that automatically, fully or partially opens or closes the valve to a position dictated by signals transmitted from controlling instruments. Control valves are used primarily to throttle energy in a fluid system and not for shut off purpose. The figure shows basic elements and internal parts of typical pneumatic control valve. Depending upon the valve plug design the control valves can be classified as quick opening, linear and equal percent type.

Linear: -

Flow is directly proportional to valve lift.

$$Q = ky$$

Where

Q = flow at constant pressure drop

y = valve opening

k = constant

Equal%:-

Flow changes by a constant percentage of its instantaneous value for each unit of valve lift

$$Q = b \times e^{ay}$$

Where

Q = flow at constant pressure drop

y = valve opening

e = base of natural logarithms

a and b = constants

Constants a and b can be evaluated to give more convenient form

$$Q = Q_O \times e^{\{(\log R/ymax) \times y\}}$$

Where

Qo = flow at constant drop at zero stroke

R = flow range of valve, maximum to minimum at constant drop.

y max = maximum rated valve opening

Quick opening: -

Flow increases rapidly with initial travel reaching near its maximum at a low lift. It is generally not defined mathematically.

Valve actions and actuator mechanism:

Different types of actuators are used to control the stem travel of the valve, like electrical actuators, pneumatic actuators, hydraulic actuators etc.

In this product pneumatic actuators are used for control valves.
Spring opposed diaphragm actuator positions the valve plug in response to the controller signals.Mostly the controller signals are in the range of 3-15 psig.

Direct acting actuator (air to close):

Direct acting actuators basically consist of a pressure tight housing sealed by a flexible fabric reinforced elastomer diaphragm. A diaphragm plate is held against the diaphragm by a heavy compression spring. Signal air pressure is applied to upper diaphragm case that exerts force on the diaphragm and the actuator assembly. By selecting proper spring rate or stiffness, load carrying capacity, an initial compression, desired stem displacement can be obtained for any given input signal.

Reverse acting actuator (air to open)

In case of reverse acting actuators the stem gets retracted with increase in pressure.

Control valve flow coefficient:

A control valve regulates the flow rate in a fluid delivery system. In general a close relation exists between the pressure along the pipe and the flow rate so that if pressure is changed, then the flow rate is also changed. A control valve changes the flow rate by changing the pressure in the flow system because it introduces the constriction in the delivery system so we can say that the flow rate through the constriction is given by

$$\mathbf{Q = K\sqrt{\Delta P}} \quad \text{--} \quad \mathbf{(1)}$$

The correction factor K in the above equation allows selection of proper size of valve to accommodate the rate of flow that the system must support. This correction factor is called as valve coefficient and is used in valve sizing.

Valve coefficient:

$$C_v = 1.16 \times Q \times \sqrt{G/\Delta P} \quad \text{(in SI units)}$$

Where G is specific gravity of liquid , Q flow in m^3/h , ΔP pressure drop in bar.

Valve characteristics:

The amount of fluid passing through a valve at any time depends upon the opening between the plug and seat. Hence there is relationship between stem position, plug position and the rate of flow, which is described in terms of flow characteristics of a valve.

Inherent and install are two types of valve characteristics.

Inherent characteristics:

The inherent flow characteristic of control valve is the relation between the flow and the valve travel at constant pressure drop across the valve. Following are the inherent characteristics for different types of valves.

1.3.2 Pre-lab questions:

1.What is FCE?
2.What is control valve?
3. What are the types of control valve?
4.Define valve coefficient.
5.What are the classification of manually operated valves?

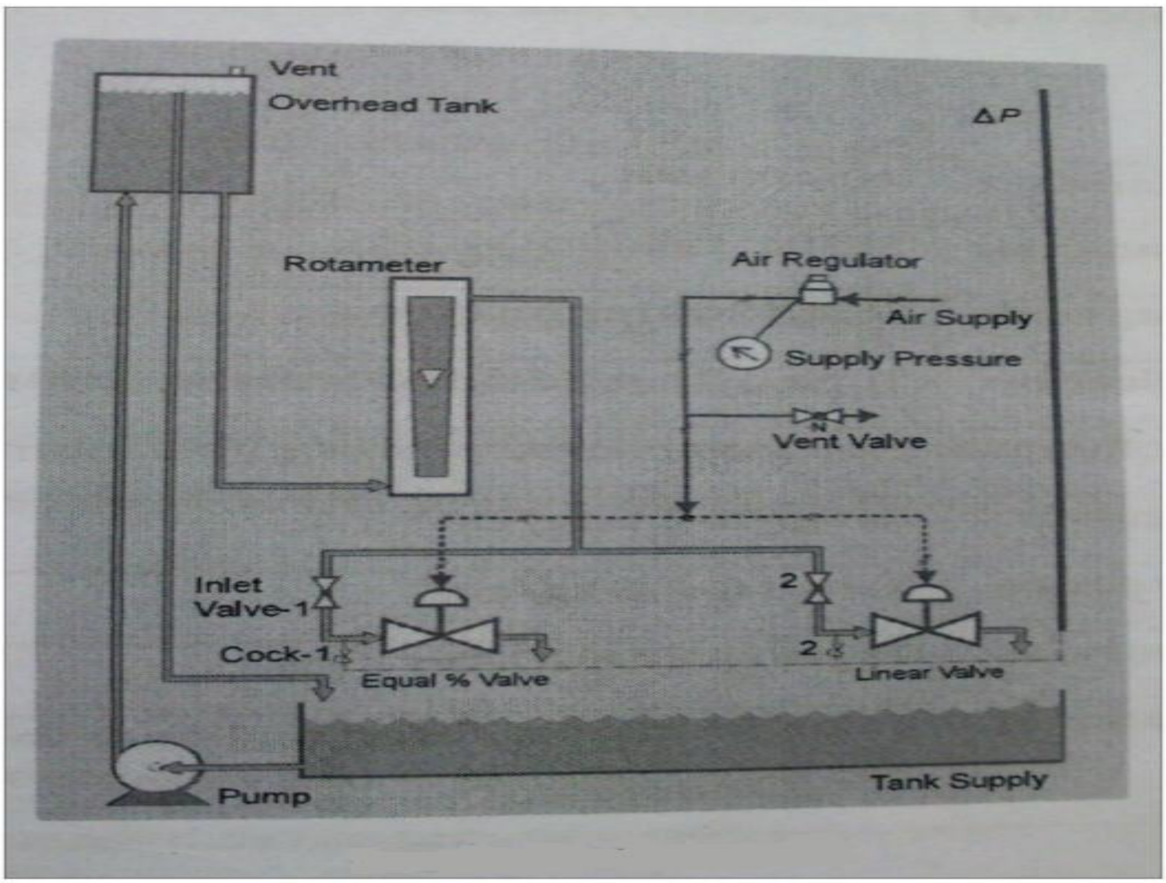
1.4 Procedure:

1) Start up the setup. Open the flow regulating valve of the control valve to be studied (linear / equal% / quick opening). Open the respective hose cock for pressure indication. (Close the flow regulating valves and hose cocks of other control valves).

2) Ensure that pressure regulator outlet is connected to the valve actuator of the control valve under study. Keep the control valve fully open by adjusting air regulator.

3) Adjust the regulating valve and set the flow rate. (Set 400 LPH flow for linear / equal% valve or 600 LPH for quick opening valve). Note for measuring flow rates below rotameter minimum range use measuring jar.

1.4.1 Circuit diagram:



1.5 Observation:

Sl.No	Inlet Pressure	Flow Rate		Change in pressure ΔP		C_v
		LPH	m^3/hr	Mm of H_2O	bar	

1.6 Post lab questions:

1.What is air to close and air to open?

2. What is quick opening?

3.What is direct acting and reverse acting?

4. What are inherent charecteristics/

5. What type of valves are used in equal percentage charecteristics?

1.7 Inference:

1.8 Result:

The characteristics of control valve was studied.

Exercise Number: 3

CONTROL VALVE CHARACTERISTICS WITH & WITHOUT POSITIONER

1.1 Aim:

To study the characteristics of a control valve with and without positioner.

1.2 Apparatus Required:

Control valve positioner trainer.

1.2.1 Hardware Required:

1. Flow Control Valve with positioner.
2. Current source (0-20)mA
3. Air regulator (20 PSI)
4. Pressure gauge (0-150 PSI)
5. E/P Converter

1.3 Preparation:

1.3.1 Theory:

A valve positioner is used to precisely position a control valve and ensure a quick and exact valve-stem positioning irrespective of variation in inlet. It helps to improve the speed of response and to overcome friction effects. The ‘Input Converter’ output is given to input bellow. This causes change in the baffle plate of the trainer. A back pressure is thus created which in turn causes the movement of a pitot valve. An air supply of 20 PSI produces a 3-15 PSI pressure signal necessary to operate the control valve.

1.3.2 Pre-Lab Questions:

1.What is the need for valve positioned?

2.What is final control element?

3.What are the types of valve positioned?

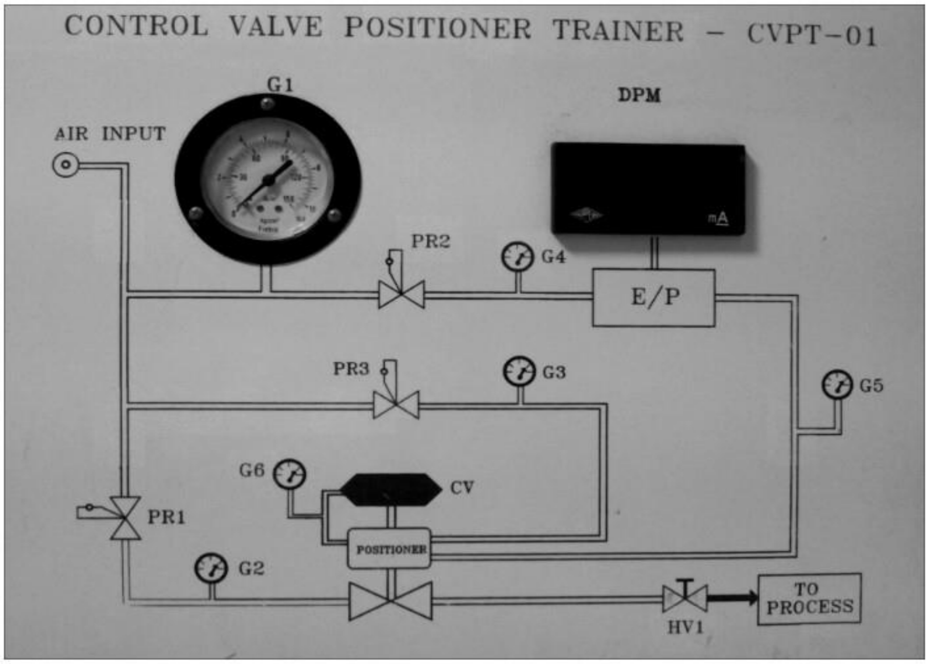
4. What is the function of control valve?

5.What is the principle of flapper and nozzle?

1.4 Procedure:

1. Switch ON the compressor and note the pressure at gauge G1.
2. Ensure that gauges G3 and G4 are at 20 PSI.
3. Switch the power switch to “ON” position.
4. When the switch is at “fixed” position the output will be constant (4 mA), change the position of the switch to variable to vary the current from 4-20 mA.
5. Select the bypass mode without the positioner and give 20mA to E/P.
6. Increase the stem movement by one mm from 0-12.5mm.
7. For each mm note the respective current reading.
8. Change the mode to “AUTO” with the positioner and give 20mA to E/P.
9. Repeat steps 6 and 7
10. Tabulate the values.

1.4.1 Circuit Diagram:



1.5 Observation:

S.No.	By Pass Mode		Auto Mode	
	Stem movement (mm)	Current (mA)	Stem movement (mm)	Current (mA)

1.6 Post Lab Questions:

1.What are the types of control valves based on inherent characteristics?

2.What type of plugs are used in equal percentage,linear and quick opening control valves?

3.Differentiate between inherent and installed chatacteristics?

4.List out some of the situations where we need positioned.

5.What is byepass and auto mode?

1.7 Inference:

1.8 Result:

Thus the control valve with and without valve positioner was studied and readings were verified.

Exercise Number: 4

PRESSURE PROCESS CONTROLLER

1.1Aim:

To study the performance of ON-OFF/P/PI/PD/PID controllers on Pressure process..

1.2Apparatus Required:

1.2.1Hardware Required:

1. VPPA-401CE
2. Data Acquisition card with cable.
3. PC with process control software.
4. Patch chords

1.3 Preparation:

1.3.1Theory:

Types of control:

ON/OFF Control:

One of the most widely used type of control is the ON/PFF control. ON/OFF control is also referred as "TWO POSITION" control or "OPEN AND CLOSE" control. Two position control is a position type controller action in which the manipulated variable is quickly changed to either a maximum or minimum value depending upon the controlled variable is greater or less than the set point.

Proportional control:

Two position control applied to a process results in a continuous oscillation in the quantity to be controlled. This drawback was overcome by a continuous control action which could maintain a continuous balance of the input and output. A mode of control which will accomplish this is known as ‘PROPORTIONAL CONTROL”.

Proportional + Integral (P + I):

The proportional control mode provides a stabilizing influence while the integral mode will help to overcome OFFSET. Integral controller will provide corrective action as long as there is a deviation in the controlled variable from the set point value.

Proportional + Derivative (P + D):

Derivative control action combined with proportional gives a controller which is good on process containing appreciable lag. Because the process lag can be compensated be the anticipatory nature of derivative action (i.e.) derivative action provides the boost necessary to counter act the time delay associated with such control by 90°.

Proportional + integral + Derivative (P + I + D):

This controller offers the benefit of each control action and moreover the effect duplicated the action of a good human operator on the process. A three mode controller contains the “stability” of proportional control and the ability to eliminate offset. Because the reset control has the ability to provide an immediate correction for the magnitude of a disturbance.

Working principle:

Pressure process controller is used to perform the control action on pressure process. In this unit pressure is the process variable and is sensed and given to controller. A Piezo electric pressure transmitter is used to measure and transmit the pressure developed in the process tank.

In thus unit, pressure is developed from a compressor and is given to the unit. Every internal transaction is in voltages. Here a PC acts as error detector and controller. According to the error signal, computer develops a control signal

This control signal is given to I/P converter which operates the control valve. Control valve acts here as final control element which controls the pressure inside the process tank by varying its plug opening according to controller output.

Data acquisition card has ADC and DAC, so that it acts an effective link between the process and the controller.

Relief valve is being used for safety purpose by which excess pressure developed in the process tank can be removed.

1.3.2 Prelab Question:

1.Name some pressure transducer.

2.Define PB.

3.What is two position control/

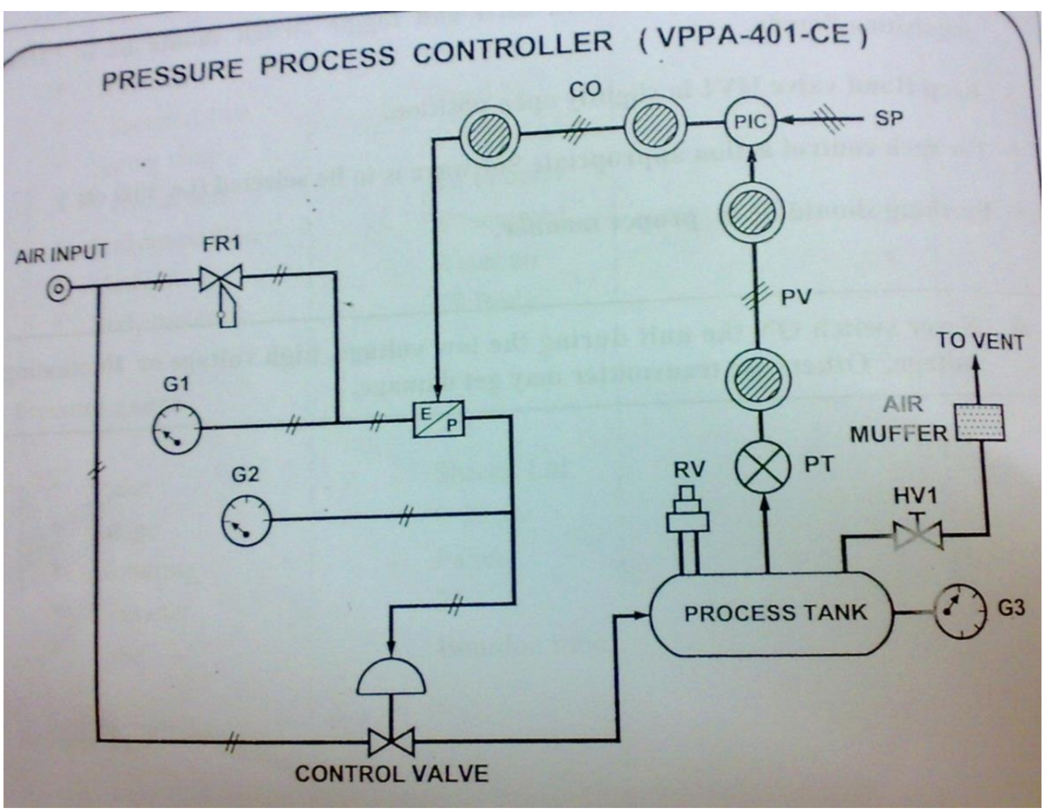
4. Define offset.

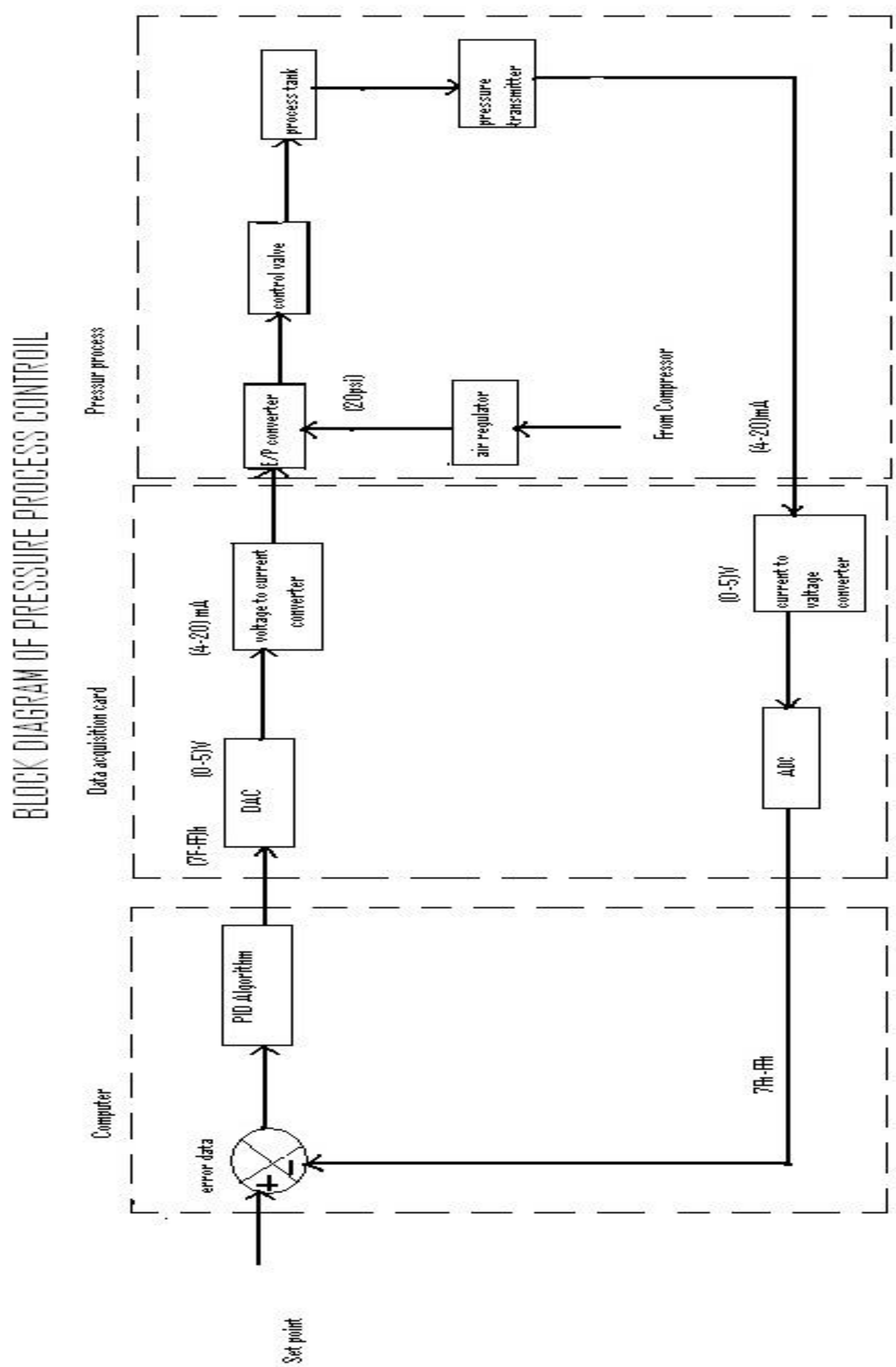
5.What is integral windup?

1.4Procedure:

1. Ensure the availability of Air.
2. Interface the PC with processes and Data acquisition card.
3. Maintain Gauge(G1) pressure at 20 PSI by using air regulator knob.
4. Position the Hand Valve HV1 in slightly open position.
5. Patch CO and PV terminals using patch chords.
6. Switch ON the Unit and Data Acquisition card with PC.
7. Invoke Process control software.
8. Select “pressure >> control >> ON-OFF/P/PI/PD/PID”.
9. Enter the parameters and observe the responses of various controllers.
10. Save the response and conclude the behavior of pressure process.

1.4.1Panel Diagram:




BLOCK DIAGRAM OF PRESSURE PROCESS CONTROIL
Computer
Data acquisition card
Pressur process
Set point
error data
+
-
PID Algorithm
(7F-FF)h
DAC
(0-5)V
(4-20) mA
voltage to current converter
E/P converter
control valve
process tank
(20psi)
air regulator
From Compressor
pressure transmitter
(4-20)mA
(0-5)V
current to valtage converter
ADC
7Fh-FFh

1.5Observation:

Sl.No	Time (sec)	PV(pressure)	Controller o/p in %

1.6 Post Lab Questions:

1. Why derivative mode is nor used alone?
2. What are the advantages of pi controller?
3. What are the drawbacks of p controller?
4. Comment on the responsed of P, PI, PID controllers.
5. What is differential gap?

1.7 Inference:

1.8Result:

Thus the performance of ON-OFF/P/PI/PD/PID controllers on pressure process was studied.

Exercise Number: 5

LEVEL PROCESS CONTROLLER

1.1 Aim:

To study the performance of ON –OFF/P/PI/PD/PID controllers on level process

1.2 Apparatus required:

1.2.1 Hardware required:

1. VLPA-101-CE.

2. Data Acquisition card and loop cable.

3. Ammeter (0-200)mA

4. Process control software with PC

1.3 Preparation:

1.3.1 Theory:

The level process controller is used to perform the control action of level process and study the characteristics of I/P converter. The RF capacitance level transmitter is used to measure the level of the process tank.

In level control action, a pump sucks the air from reservoir and gives it to control valve. Every internal transaction is in voltage. Here, IBM-PC acts as error detector and controller. According to error signal, corresponding control signal is given to the I/P converter. It controls the flow of the liquid in pipeline by varying stem position of the control valve. For maintaining the level of the process tank, flow is manipulated level signal is given to the data acquisition card. By pass line is provided to avoid the pump overloading.

From this controller also study the characteristics of the level transmitter, I/P converter, control valve and justify the various control actions.

Data Acquisition card has ADC and DAC , so that it acts an effective link between the process and the controller .

Types of control:

ON/OFF Control:

One of the most widely used type of control is the ON/OFF control. ON/OFF control is also referred as "TWO POSITION" control or "OPEN AND CLOSE "control. Two position control is a position type of controller action in which the manipulated variable is quickly changed to either a maximum or minimum value depending on the control variable is greater than or less than the set point.

If the control variable is below the set point, the controller is 100 percent (i.e. control valve is fully closed) .if the control variable is above the set point, the controller output is 0 percent (i.e. control valve is fully opened), when the differential gap is zero. The turning parameters for ON/OFF control are differential gap and time delay.

Differential Gap:

Differential gap is the region in which the control causes the manipulated variable to maintain its previous until the controlled variable has moved slightly beyond the set point. Small differential gap is not preferred. Because, it introduces oscillations and reduces the life of the final control element.

Proportional Control:

Two position control applied to a process results in a continuous oscillations in the quantity to be controlled .This drawback was overcome by a continuous control action which could maintain a continuous balance of the input and output .A mode of control which will accomplish this is known as "PROPORTIONAL CONTROL".

Proportional control:

"It is a controller action is which there is a continuous linear relationship between value of the controlled variable and position of the final control element within the proportional band" .

The tuning parameters for proportional control are,

Proportional Gain K_p

Time Delay T_d

Proportional Band P_b:

Proportional band is defined as the percent deviation in measurement of its full scale required to give 100%valve deviation. Narrow band proportional control gives a comparatively large corrective action to the value for the small change in the measurement. For wide band proportional the corrective action to the valve is small land therefore the offset will be large. Usually, narrow proportional band is preferred. If proportional band is zero, the controller behaves as two position control.

Time Delay:

Time required to take the successive sample of process variable.

Proportional +Integral(P+I):

The proportional control mode provides a stabilizing influence while the integral mode will help to overcome OFFSET. Integral controller will provide corrective action as long as there is a deviation in the controlled variable from the set point value.

Integral control has a phase lag of 90 degree over proportional control. This lagging feature of reset will result in a slow response and oscillation will come into picture.

This is suitable for flow control and pressure control where the process has little lag. But require a wide proportional band for stability. The small process lag permits the use of large amounts of integral action.

Proportional + Derivative(P+D):

Derivative control action combined with proportional gives a controller which is good on process containing appreciable lag. Because the process lab can be compensated by the anticipatory nature of derivative(i.e)derivative action provides the boost necessary to counteract the time delay associated by 90 degree.

Since this controller combination is most affected where the system lags are high, lit could be used on most multi capacity process applications. Where the process lag is short, this combination could not be used. This controller combination does not eliminate OFFSET after a sustained load disturbance. It does reduce the magnitude of the OFFSET. Because of narrow proportional band.

A proportional plus derivative controller properly fitted and adjusted to a process acts to prevent the controlled variable from deviating excessively and reduces the time required to stabilize.

Proportional +Integral+Derivative(P+I+D):

This controller offers the benefit of each control action and moreover the effect duplicates the action of a good human operator on the process. A three mode controller contains the “stability” of proportional control and the ability to eliminate the offset. Because of reset control and the ability to provide an immediate correction for the magnitude of disturbance because of rate control.

1.3.2 Pre-Lab Questions:

1.Name some level transducer.

2.Define PB.

3.What is two position control/

4. Define offset.

5.What is integral windup?

1.4 Procedure:

1. Air pressure regulator input should be more than 25psi and maintain the air regulator output pressure (G1) to 20psi by varying the air regulator knob, which supplies a constant pneumatic input to the electro-pneumatic converter.

2. Keep hand valve HV_1, HV_2 partially open.

3. Invoke “Level process control” software In PC.

4. Select “Control>>ON-OFF/P/PI/PD/PID”.

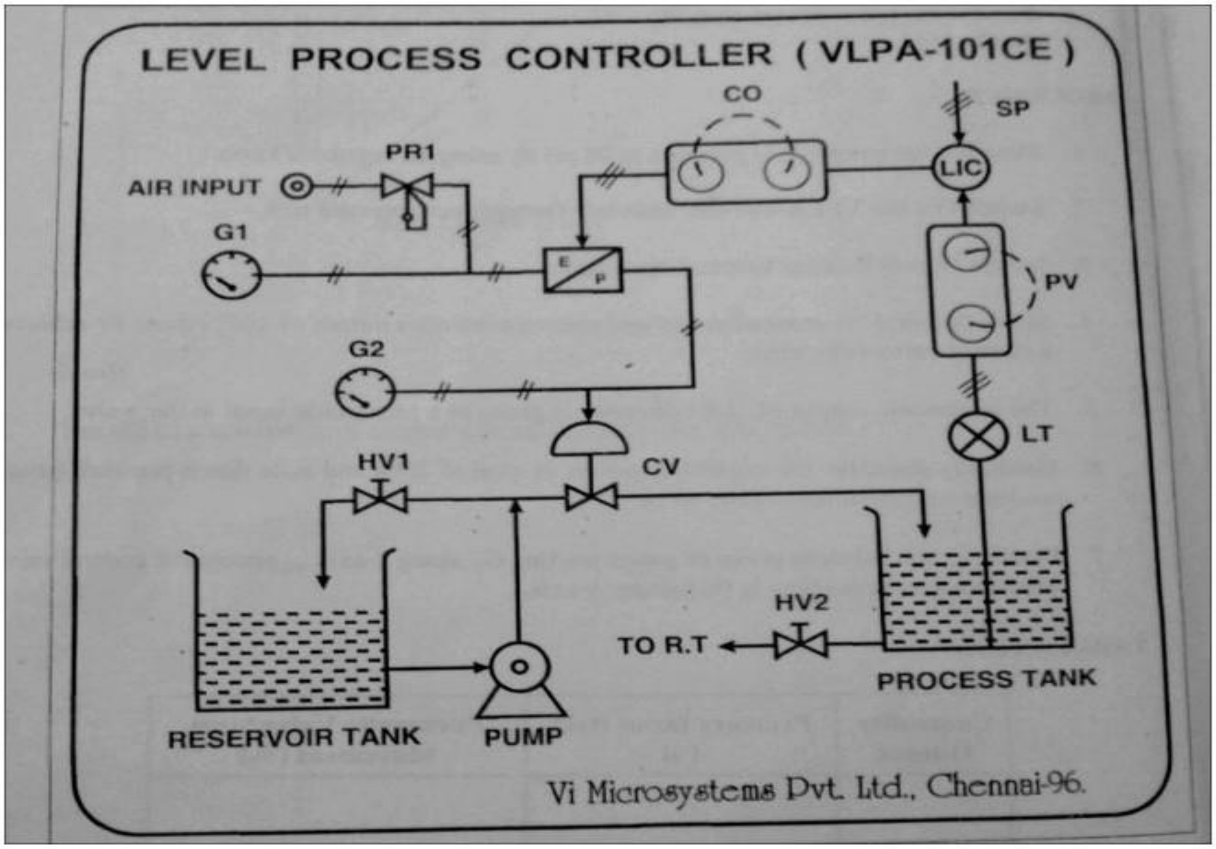
5. Select”settings>>parameters” and enter values for each parameters (i.eKp, Ki,Kd,dead band).

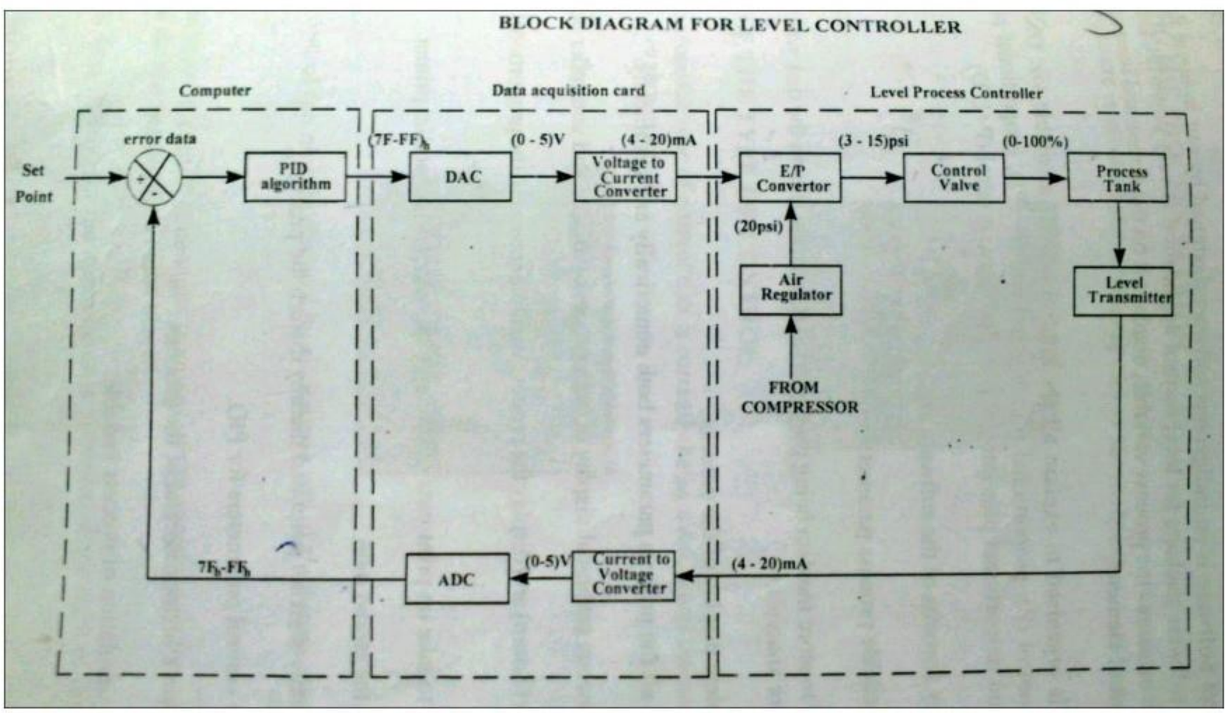
6. Switch ON the pump and to run the pump in desired speed by using variable speed control knob

7. For getting a desired response, tune the process parameter to optimum values.

8. Now, study the response of ON-OFF/P/PI/PD/PID control action for various values of set point, K_p,K_i,K_d.

1.4.1 Panel Diagram:

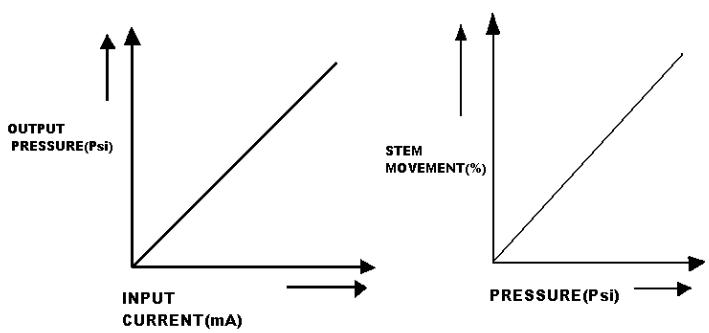

LEVEL PROCESS CONTROLLER (VLPA-101CE)
CO
SP
PR1
AIR INPUT
LIC
G1
E
P
PV
G2
LT
HV1
CV
HV2
TO R.T
PROCESS TANK
RESERVOIR TANK
PUMP
Vi Microsystems Pvt. Ltd., Chennai-96.


BLOCK DIAGRAM FOR LEVEL CONTROLLER
Computer
Data acquisition card
Level Process Controller
error data
Set Point
PID algorithm
(7F-FF)h
DAC
(0 - 5)V
(4 - 20)mA
Voltage to Current Converter
E/P Convertor
(3 - 15)psi
Control Valve
(0-100%)
Process Tank
(20psi)
Air Regulator
Level Transmitter
FROM COMPRESSOR
7Fh-FFh
ADC
(0-5)V
Current to Voltage Converter
(4 - 20)mA

1.5 Observation:

Sl.No	Time (sec)	PV(level)	Controller o/p in %

Model Graph:



1.6 Post Lab Questions:

1. Why derivative mode is nor used alone?

2. What are the advantages of pi controller?

3. What are the drawbacks of p controller?

4. Comment on the responsed of P, PI, PID controllers.

5. What is differential gap?

1.7 Inference:

1.8 Result:

Thus the performance of ON-OFF P/PI/PD/PID controllers on Level Process was studied.

Exercise Number: 6

FLOW PROCESS CONTROLLER

1.1 Aim:

To study the performance of ON –OFF/P/PI/PD/PID controllers on flow process

1.2 Apparatus required:

1.2.1 Hardware required:

1. VFPA-201CE.

2. Data Acquisition card with cable.

3. PC with Process control software.

4. Patch chords.

1.3 Preparation:

1.3.1 Theory:

Flow process controller is used to perform the control action on Flow process .In this unit flow is the process variable and is sensed and given to controller. A Differential Pressure Transmitter is used to measure the Flow of the fluid through orifice plate.

In this unit , pump sucks the water from the reservoir tank and gives it to the control valve .Every internal transaction are in voltage .Here, PC acts as error detector and controller .According to the error signal, computer develops a control signal .

This control signal is given to I/P Converter which operates the control valve .Control valves act here as final control element which controls the flow of the fluid in pipe line by varying stem position of the control valve .

Flow is the manipulated level signal here and is given to the Data acquisition card .By pass line is provided to avoid the pump over loading .

Data Acquisition card has ADC and DAC , so that it acts an effective link between the process and the controller .

Types of control:

ON/OFF Control:

One of the most widely used type of control is the ON/OFF control. ON/OFF control is also referred as “TWO POSITION” control or “OPEN AND CLOSE “control. Two position control is a position type of controller action in which the manipulated variable is quickly changed to either a maximum or minimum value depending on the control variable is greater than or less than the set point.

If the control variable is below the set point, the controller is 100 percent (i.e. control valve is fully closed) .if the control variable is above the set point, the controller output is 0 percent (i.e. control valve is fully opened), when the differential gap is zero. The turning parameters for ON/OFF control are differential gap and time delay.

Differential Gap:

Differential gap is the region in which the control causes the manipulated variable to maintain its previous until the controlled variable has moved slightly beyond the set point. Small differential gap is not preferred. Because, it introduces oscillations and reduces the life of the final control element.

Proportional Control:

Two position control applied to a process results in a continuous oscillations in the quantity to be controlled .This drawback was overcome by a continuous control action which could maintain a continuous balance of the input and output .A mode of control which will accomplish this is known as “PROPORTIONAL CONTROL”.

“It is a controller action is which there is a continuous linear relationship between value of the controlled variable and position of the final control element within the proportional band” .

The tuning parameters for proportional control are,

Proportional Gain K_p

Time Delay T_d

Proportional band P_b:

Proportional band is defined as the percent deviation in measurement of its full scale required to give 100%valve deviation. Narrow band proportional control gives a comparatively large corrective action to the value for the small change in the measurement. For wide band proportional the corrective action to the valve is small land therefore the offset will be large. Usually, narrow proportional band is preferred. If proportional band is zero, the controller behaves as two position control.

Time Delay:

Time required to take the successive sample of process variable.

Proportional +Integral(P+I)

The proportional control mode provides a stabilizing influence while the integral mode will help to overcome OFFSET. Integral controller will provide corrective action as long as there is a deviation in the controlled variable from the set point value.

Integral control has a phase lag of 90 degree over proportional control. This lagging feature of reset will result in a slow response and oscillation will come into picture.

This is suitable for flow control and pressure control where the process has little lag. But require a wide proportional band for stability. The small process lag permits the use of large amounts of integral action.

Proportional + Derivative(P+D)

Derivative control action combined with proportional gives a controller which is good on process containing appreciable lag. Because the process lab can be compensated by the anticipatory nature of derivative(i.e)derivative action provides the boost necessary to counteract the time delay associated by 90 degree.

Since this controller combination is most affected where the system lags are high, lit could be used on most multi capacity process applications. Where the process lag is short, this combination could not be used. This controller combination does not eliminate OFFSET after a sustained load disturbance. It does reduce the magnitude of the OFFSET because of narrow proportional band.

A proportional plus derivative controller properly fitted and adjusted to a process acts to prevent the controlled variable from deviating excessively and reduces the time required to stabilize.

Proportional +Integral+Derivative(P+I+D)

This controller offers the benefit of each control action and moreover the effect duplicates the action of a good human operator on the process. A three mode controller contains the “stability” of proportional control and the ability to eliminate the offset. Because of reset control and the ability to provide an immediate correction for the magnitude of disturbance because of rate control.

1.3.2 Pre-Lab Questions:

1.Name some flow transducer.

2.Define PB.

3.What is two position control/

4. Define offset.

5.What is integral windup?

1.4 Procedure:

1. Ensure the availability of air and water.

2. Interface the PC with the process and data acquisition card.

3. Maintain gauge(G1) pressure at 20PSI by using air regulator knob.

4. Position the Hand valve HV1 in slightly open position.

5. Patch CO and PV terminals through Patch cords.

6. Switch ON the unit and Data Acquisition card with PC.

7. Invoke Process Control Software

8. Select “flow<<control<<ON-OFF/P/PD/PI/PID

9. Switch ON the pump and select desired speed of pump by varying speed control knob.

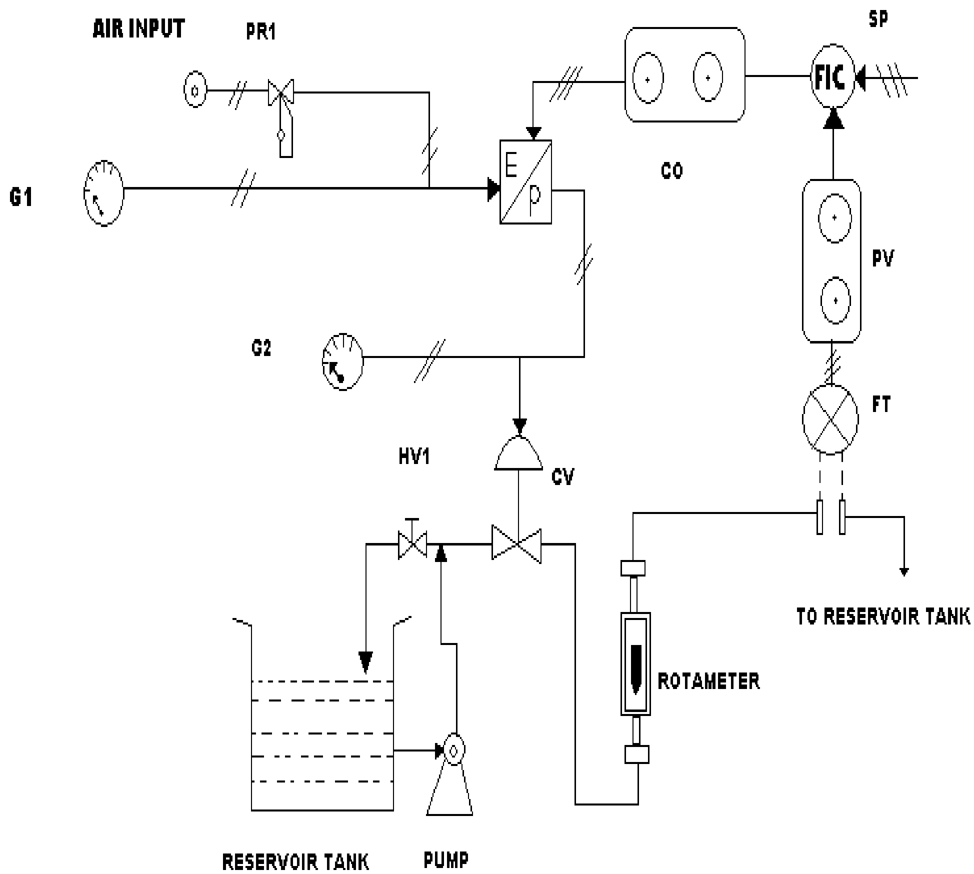
10. Enter the parameters and observe the responses of various controllers.

11. Switch OFF the pump.

12. Save the response and conclude the behavior of Flow Process.

1.4.1 Panel Diagram:

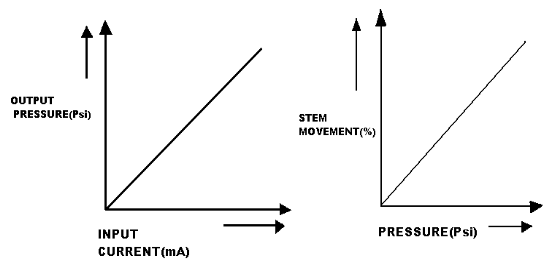
FLOW PROCESS CONTROLLER(VFPA-201CE)



1.5 Observation:

Sl.No	Time (sec)	PV(flow)	Controller o/p in %

Model Graph:



1.6 Post Lab Questions:

1. Why derivative mode is nor used alone?

2. What are the advantages of pi controller?

3. What are the drawbacks of p controller?

4. Comment on the responsed of P, PI, PID controllers.

5. What is differential gap?

1.7 Inference

1.8 Result

Thus the performance of ON-OFF P/PI/PD/PID controllers on Flow Process was studied.

Exercise Number: 7

TEMPERATURE PROCESS CONTROLLER

1.1 Aim

To study the performance of ON-OFF/P/PI/PD/PID controllers on temperature process.

1.2 Apparatus required

1. VTPA-W-321CE.
2. Data Acquisition card with cable.
3. PC with process control software.
4. Patch chords.

1.2.1 Hardware Requirement

1.3 Preparation

1.3.1 Theory

Temperature process controller is used to perform the control action on temperature process. In this unit, temperature is the process variable. An RTD sensor is being used to measure the temperature of the process and is transmitted by RTD transmitter.

In this unit, water is stored up in the over head tank by pumping water from reservoir tank through pump. Water from over head tank is allowed to heater through a rota meter.

Rota meter is being provided for giving disturbance to the process and for operational safety of the heater. For conducting experiment flow rate in minimum value (say 30 Lph). In the outlet of heater, an RTD is provided for sensing the temperature and is transmitted by RTD transmitter.

Every internal transaction are ion voltage. Here PC acts as error detector and controller .According to the error signal, computer develops a control signal.

This control signal is given to the SCR power driver circuit by which firing angle varies.Accordingly, the supply delivered to heater varies and thus process gets controlled.

Data acquisition card has the ADC and DAC so that it acts as an effective link between the process and controller.

TYPES OF CONTROL

ON/OFF Control

One of the most widely used type of control is the ON/OFF control. ON/OFF control is also referred as “TWO POSITION” control or “OPEN AND CLOSE” control. Two position controls is a position type of controller action in which the manipulated variable is quickly changed to either a maximum or minimum value depending upon the controlled variable is greater or less than the set point.

If the controlled variable is below the set point, the controller output is 100% (i.e. control valve is fully closed).If the controlled variable is above the set point, the controller output is 0% (i.e. control valve is fully opened), when the differential gap is zero. The tuning parameter for ON/OFF control are differential gap and time delay.

Differential Gap

Differential gap is the region in which the control causes the manipulated variable to maintain its previous until the controlled variable has moved slightly beyond the set point. Small differential gap is not preffered.Because it introduces oscillations and reduces the life of final control element.

Proportional Control

Two position control applied to a process results in a continous oscillations in the quantity to be controlled.This drawback was overcome by a continous control action which could maintain the continous balance of input and output mode of control which will accomplish this is known as “PROPORTIONAL CONTROL”

Proportional control is defined as follows.

"It is a controller action is which there is a continuous linear relationship between value of the controlled variable and position of the final control element within the proportional band".

The tuning parameters for proportional control are,

Proportional Gain [Kg]

Time Delay [Td]

Proportional Band [Pb]

Proportional band is defined as the percent deviation in measurement of its full scale required to give 100% valve deviation. Narrow band proportional control gives a comparatively large corrective action to the valve for a small change in the measurement. For wide band proportional the corrective action to the valve is small band therefore the offset will be large.Usually,narrow proportional band is preferred. If proportional band is zero, the controller behaves as two position control.

ii. Time Delay

Time required to take the successive samples of process variable.

Proportional + Integral (P+I)

The proportional control mode provides a stabilizing influence while the integral mode will help to overcome OFFSET. Integral controller will provide corrective action as long as there is deviation in the controlled variable from the set point value.

Integral control has a phase lag of 90degree over proportional control .This lagging feature of reset will result in a slow response and oscillation will come into picture.

This is suitable for flow control and pressure control where the process has little lag. But a wide proportional band is required for stability. The small process lag permits the use of a large amount of integral action.

Proportional derivative (P+D)

Derivative control action combined with proportional gives a controller which is good on process containing appreciable lag. Because the process lag can be compensated by the anticipatory nature of derivative action (i.e.) derivative action provides the boost necessary to counter at the time delay associated with such control by 90degree.

Since this controller combination is most effective where the system lags are high, lit could be used on most muilticapacity process applications. Where the process lag is short, this combination could not be used. This controller combination does not eliminate OFFSET after a sustained load disturbance. It does reduce the magnitude of OFFSET because of narrow proportional band.

A Proportional plus derivative controller properly fitted and adjusted to the process acts to prevent the controlled variable from deviating excessively and reduces time required to stabilize.

Proportional + Integral derivative (P+I+D)

This controller offers the benefit of each control action and moreover the effect duplicates the action of good human operator of the process. A three mode controller contains the “stability”of ability to provide an immediate correction for the magnitude of a disturbance because of rate control.

1.3.2 Pre-Lab Questions:

1.List out some temperature transducers.

2.What is the principleofRTD**?**

3.Write the equation of RTD.

4.What are the different types of RTD?

5.Mention some of the safety factors to be followed before starting the experiment?

1.4 Procedure

1. Ensure the availability of water.

2. Interface the PC with the Unit and Data Acquisition card.

3. Connect the pump plug and heater plug to the respective sockets provided at the back panel.

4. Connect the sensor terminals and level switch terminals to the respective connectors provided at the back panel.

5. Keep the switch ‘S2’ in left position (towards 1).

6. Patch R1-R2, A1-A2, B1-B2, using patch chords.

7. Switch on the unit with PC and data Acquisition card.

8. Switch in the pump.

9. Set rotameter at some minimum flow rate (say 40Lph).

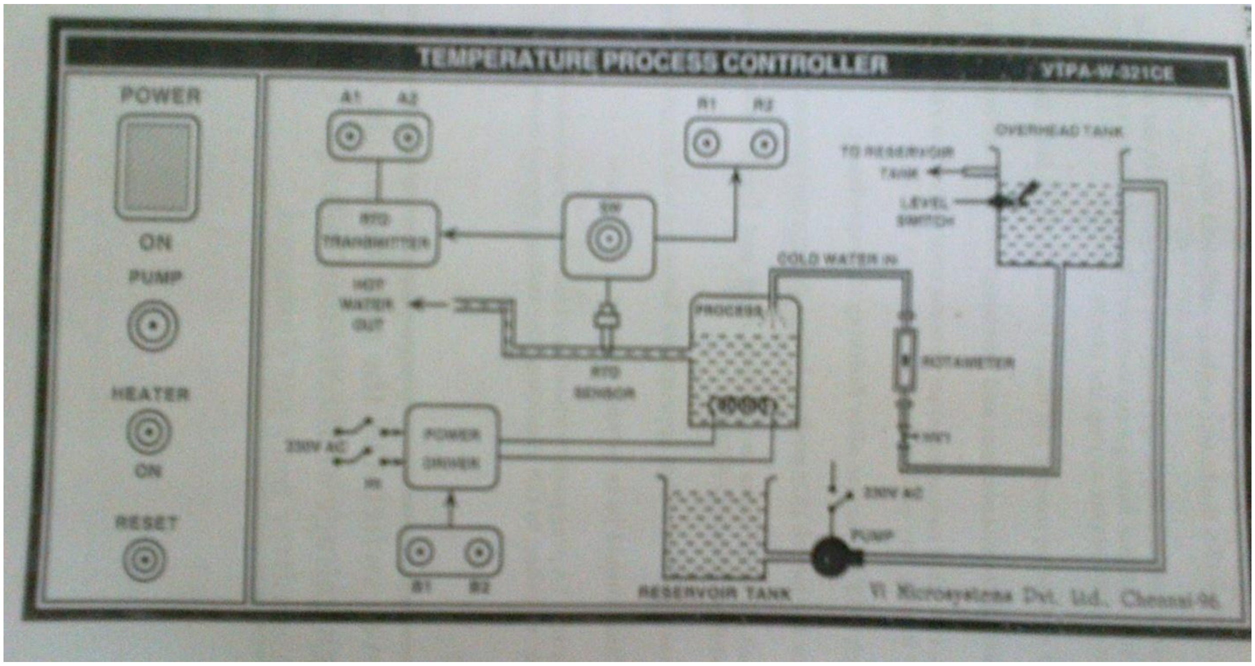
10. Select “Temperature << control << ON/OFF/P/PI/PD/PID”.

11. Switch on the heater.

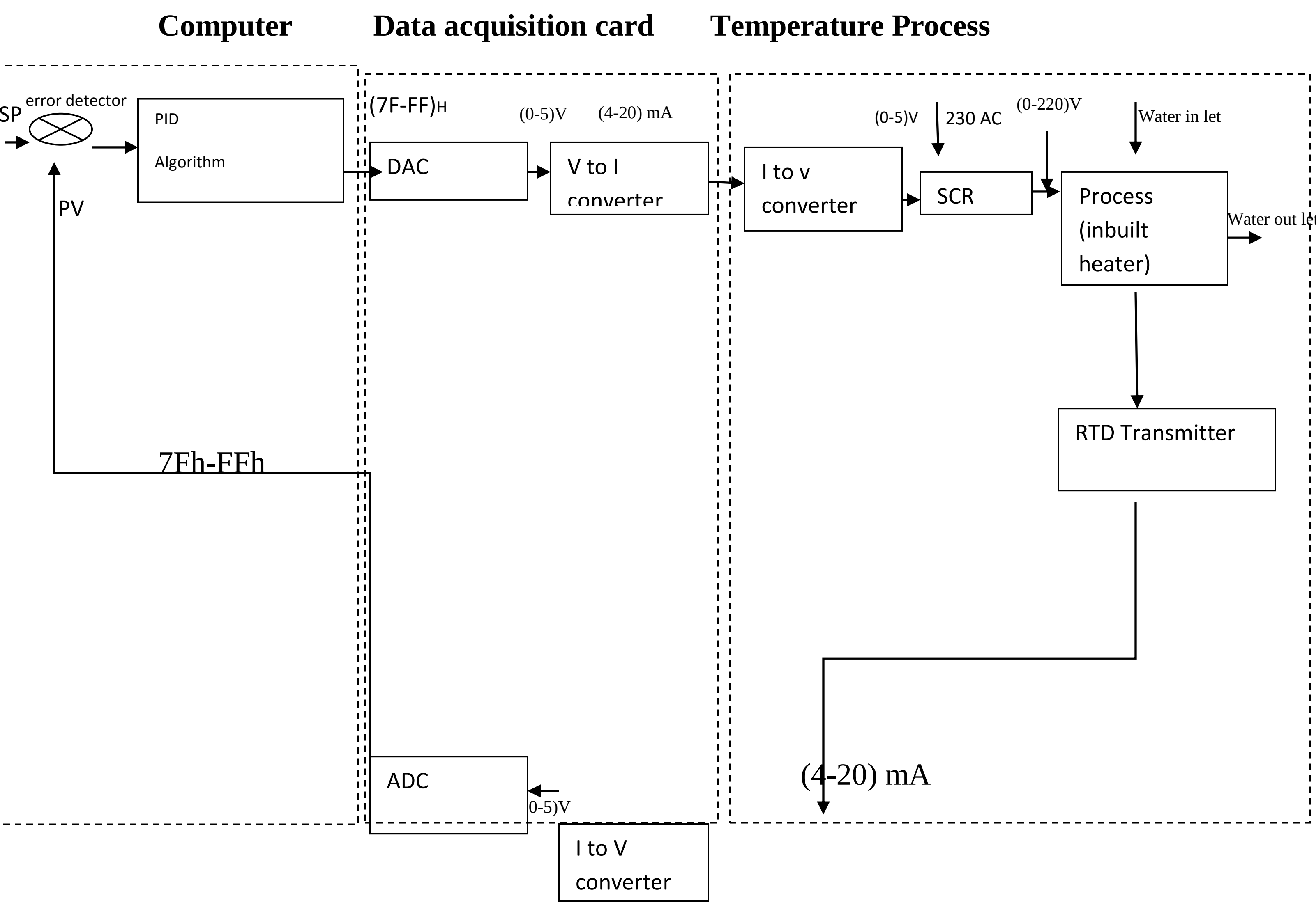
12. Enter desired parameters and observe the response by saving the graph.

13. Switch OFF the heater and pump.

1.4.1 Panel Diagram



BLOCK DIAGRAM OF TEMPERATURE PROCESS CONTROLLER



1.5 Observation:

Sl.No	Time (sec)	PV(temp)	Controller o/p in %

1.6Post Lab question:

1.What is the purpose of using rotameter?

2.Which component is used as FCE in this process?

3.What is controller tuning?

4.What are the different tuning methods of controller?

5.What is the principle of SCR?

1.7Inference:

1.8Result:

Thus the performance of ON-OFF/P/PI/PD/PID controllers on temperature process was studied.

Exercise Number: 8

CONTROLLER TUNING USING MATLAB

1.1 Aim

To obtain the open and closed loop response of a higher order system using SIMULINK software.

Given transfer function = G(s) =1/(s+1)^3

1.2 Apparatus required:

1.2.1 Hardware required :

1.PC with MATLAB

1.3 Preparation:

1.3.1 Theory:

The Ziegler–Nichols tuning method is a heuristic method of tuning a PID controller. It was developed by John G. Zieglerand Nathaniel B. Nichols. It is performed by setting the *I* (integral) and *D* (derivative) gains to zero. The "P" (proportional) gain, $K_p$is then increased (from zero) until it reaches the ultimate gain K_u, at which the output of the control loop oscillates with a constant amplitude. $K_u$and the oscillation period $T_u$are used to set the P, I, and D gains depending on the type of controller used.

1.3.2 Pre-Lab Questions:

1. What is controller tuning?

2.What is the need for tuning?

3. What are the different types of tuning of controllers?

4.List out the tuning methods based on semi empirical rules.

5. What is process reaction curve?

1.4 Procedure:

Open a new model in MATLAB.

1. Create the step input, transfer function blocks and scope as shown in figure.
2. Double click on the scope and obtain the open loop response of the given system.
3. Approximate the higher order system into a first order system with dead time by determining the values of Kp, I and t_d from response.
4. The approximated response = $K_p(e^{-tds})/(\tau s + 1)$
5. Create a PID controller block and draw the closed loop block diagram as shown in the figure
6. Calculate the values of K_p, K_i and K_d enter them in the controller block and verify the response.

ZIEGLER-NICHOLAS TUNING :-

From closed loop response, values of K_u and P_u are noted

a) K_u- Gain of the open loop system at which maximum oscillations are incurred is noted.

K_u=8

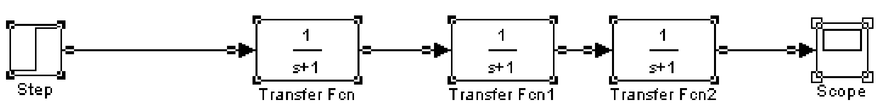
b) P_u-Ultimate time period of one complete oscillation .from graph

W_{co}= 4 s (time period of one complete oscillation)

$P_u=2\pi/W_{co} = 1.73$

1.4.1 Block Diagram:

Open loop response:



PI CONTROLLER SETTINGS:

Proportional gain $K_c = 0.9\tau/t_d.K_p$

$=0.9(2)/1.2=1.5$

Integral gain= $K_i=K_c/\ \tau_i$ and $\tau_i=3.3\ t_d$

[i=0.375 s => $K_i=1.5/0.375=4$]

PID CONTROLLER SETTINGS:

Proportional gain = $K_c= 1.2\tau/K_p\ t_d = 1.2(2)/1.2=2$

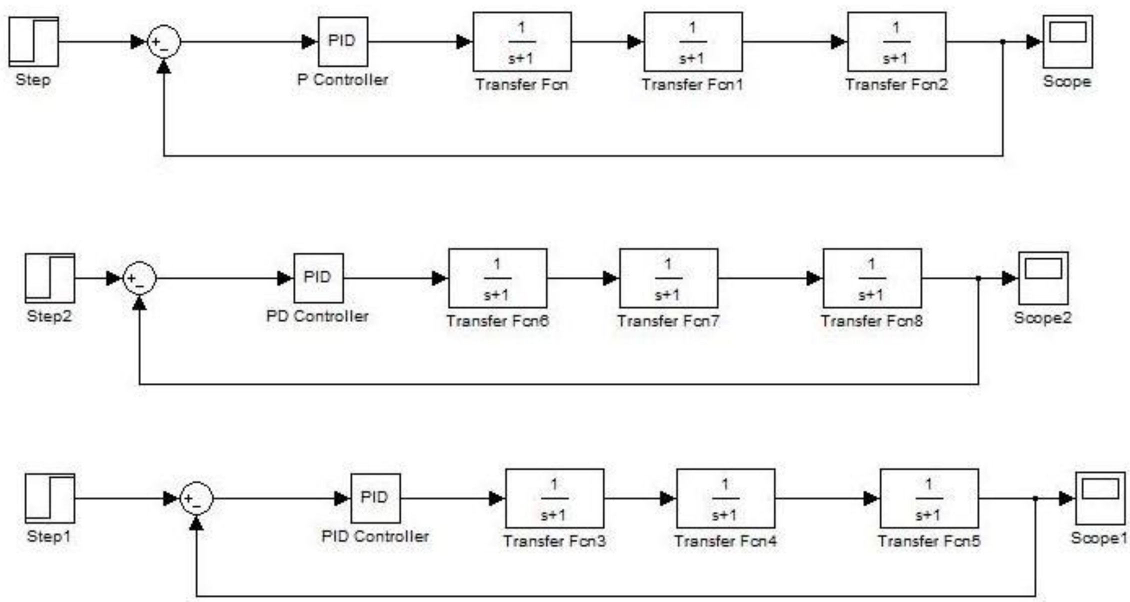
Integral time = $\tau_i= 0.5(t_d)=0.6$ s

Derivative time = $\tau_d = 2(t_d)=2.4$ s

Integral gain= $K_i=K_c/\ \tau_i=2/0.6=3.3$

Derivative gain = $K_d=K_c t_d=2(2.4)=4.8$

Closed loop response:



P-CONTROLLER

i. $K_p = K_u / 2 = 8/2 = 4$

PI CONTROLLER

$K_p = K_u / 2.2 = 8/2.2 = 3.63$
$K_i = P_u / 1.2 = 4/1.2 = 1.818$

PID CONTROLLER

$K_p = K_u / 1.7 = 4.7$

$K_i = P_u / 2 = 4/2 = 2$

$K_d = P_u / 8 = 4/8 = 0.5$

After entering these values, the response was verified.

1.5 Post Lab Questions:

1.What is an ultimate gain and ultimate period?

2.Why is ZN closed loop method called continuous cycling method?

3.What are the drawbacks of ZNclosed loop method?

4. Compare and comment on the responses of ZNclosed loop and open loop method.

5.What is decay ratio?

1.6 Inference:

1.7 Result:

Thus open and closed loop response of the given transfer function for a unit step input was obtained and graphs were verified.

Exercise Number: 9

STUDY OF COMPLEX CONTROL SYSTEM USING MATLAB

1.1 Aim:

To study the complex control system using matlab and to compare the response of simple and cascade loop.

1.2Apparatus Required:

1.2.1 Hardware Required:

1) Personal computer
2) MATLAB Software

1.3.Preparation:

1.3.1Theory:

Cascade control configuration we have one manipulated variable and more than one measurement. It is clear that with a single manipulation we can control only one output. Consider a process consisting of two parts as shown in process 1&2 processes; 1 has an output the variable we want to control process 2 has an output that we are not interested in controlling but which affect the output which we want to control. The two controllers of a cascade control system are standard feedback controllers. Generally, a proportional controller is used for a secondary loop, although a pi controller with small integral action is not unusual any offset caused by a p control in the secondary loop is not important since we are not interested in controlling the output of the secondary loop are much faster than those of the primary loop, consequently the phase lag of the closed secondary loop will be less than that of the primary loop. This feature leads to the following important result which constitutes the rationales behind the use of cascade control.

1.4 Procedure:

1. **Cascade loop.**

I. For cascade control open loop transfer function Gc(S) by Block diagram reduction technique

Ii.Find value of W and Kc for Cascade Loop Transfer Function Gc(S)

Iii. Determine block diagram Of Cascade Conrol Loop in by substituting Gain Ku For Proportional Controller

Iv. View Response Using Scope

2. **Simple Loop**

I. Find Simple Loop Transfer Function Gc(S) By Block Diagram Reduction

Ii. Repeat Steps from 2 to 4 of Cascade Control Loop

3. To Find W:

I. Write the Phase Angle ϕωfor Above Gc(S)

Ii.Equate It To -180^{o}

Iii Find Ω Value

4. To Find Ku

I. Write Amplitude Ratio Expression for Gc(S)

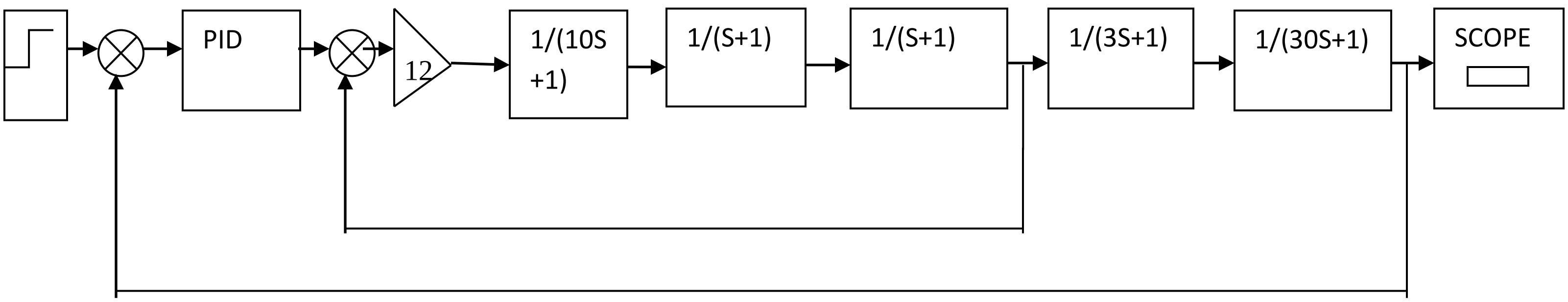
Ii.Equate It to “1”

Iii. Find Kc Value

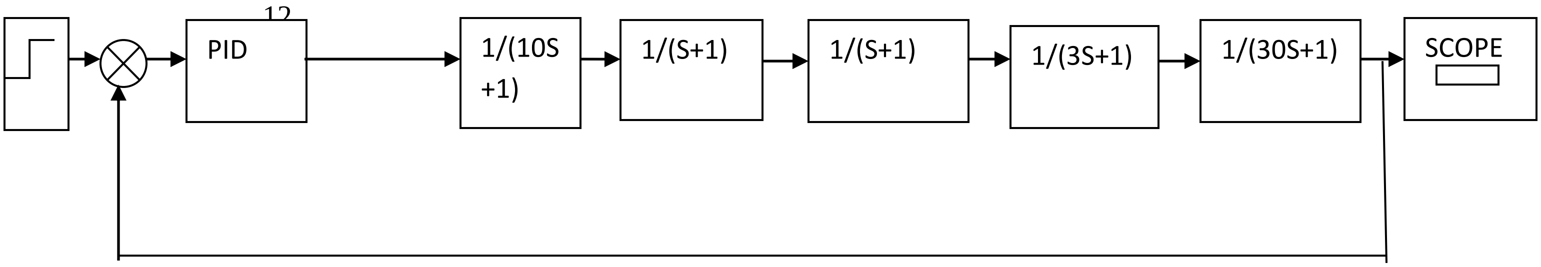
Iv.Find Ku Value, Ku=Kc /2

BLOCK DIAGRAM:

1. CASCADE CONTROL LOOP



2. SIMPLE CONTROL LOOP



CALCULATIONS:

CASCADE CONTROL LOOP:

$$\frac{G(s)}{1+G(s)H(s)} = \frac{\left[\frac{12}{(s+1)(s+1)(10s+1)}\right]}{\left[1+\frac{12}{(s+1)(s+1)(10s+1)}\right]}$$

$$= (s+1)^2 \frac{10s+1}{[(s+1)^2(10s+1)+12]} * \frac{12}{(s+1^2)(10s+1)}$$

$$= \frac{12}{[10s^3+21s^2+12s+13]}$$

$$G(s) = \frac{12}{[10s^3+21s^2+12s+13]}\left[\frac{1}{(3s+1)(30s+1)}\right]$$

$$\emptyset = \tan^{-1}\left[\frac{-10w^3+12w}{-21w^2+13}\right] - \tan^{-1}3w - \tan^{-1}30w$$

$w = 0.54;\ \emptyset = -180.02$

$$Ar = [\frac{12Ku}{\sqrt{\left((-21w^2+13)+(-10w^3+12w^2)\right)(9w^2+1)(900w^2+1)}}$$

$$= \frac{12Ku}{8.446 * 1.9 * 16.23} \approx 1$$

$Ku = 21.7$

$$Pu = 2\pi/w$$

=11.6

SIMPLE CONTROL LOOP:

$G(s)/(1+G(s)H(s)$

$$= [\frac{1}{(s+1)(s+1)(10s+1)(3s+1)(30s+1)}][\frac{(s+1)(s+1)(10s+1)(3s+1)(30s+1)}{1+(s+1)(s+1)(10s+1)(3s+1)(30s+1)}]$$

$$\emptyset = 1/(jw+1)(jw+1)(10jw+1)(3jw+1)(30jw+1)$$

$$\emptyset = -2\tan^{-1} w - \tan^{-1} 10w - \tan^{-1} 30w - \tan^{-1} 3w$$

$$w = 0.16;\ \emptyset = -180.04$$

$$Ar = \frac{Ku}{\left[\sqrt{(9w^2+1)(900w^2+1)(100w^2+1)(w^4+2w^2+1)}\right]}$$

$$Ku = 10.47$$

$$Pu = \frac{2\pi}{w} = 39.26$$

CONCLUSION:

The cascade control is much faster than simple control loop and thus settling time of simple control is more compared to cascade control loop

RESULT:

Thus the complex control system using matlab is studied and the response of cascade and simple loop is compared

Exercise Number: 10

RESPONSE OF PROCESS WITH AND WITHOUT TRANSPORTATION LAG

1.1 Aim:

To study the response of process with and without transportation lag.

1.2 Apparatus required:

1.2.1 Hardware required:

MATLAB Software

1.3 Preparation:

1.3.1 Theory:

All the dynamic components of the loop may exhibit significant time delays in their response. They are

1. The main process may involve transportation of fluids over long distances
2. The measuring device may require long periods of time for completing the sampling and the analysis of the measured output.
3. Final control element may need sometime to develop the actuating signal.
4. A human controller may need significant time to think and take the proper control action. In all of the situation quoted above conventional feedback controller would provide unsatisfactory closed loop response. As a result significant dead time is a significant source of instability for closed loop response. Increase in dead time has introduced significant additional phase lag which reduces the crossover frequency and the maximum allowable gain. Increase in dead time has made the closed loop response more sensitive to periodic disturbances and has brought the system closer to the point of instability.

1.3.2 Pre-Lab Questions:

1.Define transportation delay.

2.What is crossover frequency?

3.What is the general form of second order system?

4. How will you approximate the higher order system?

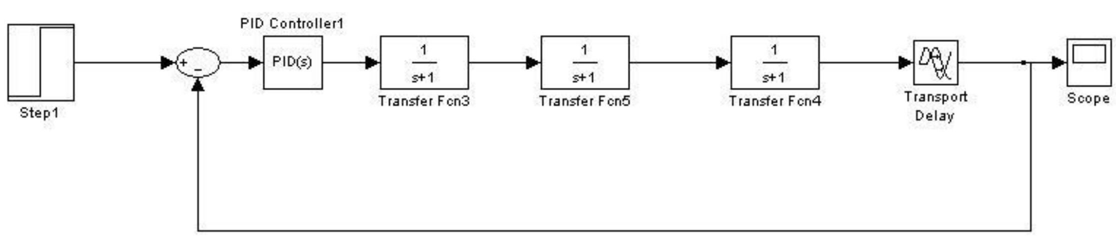
5.Define time constant.

1.4 Procedure:

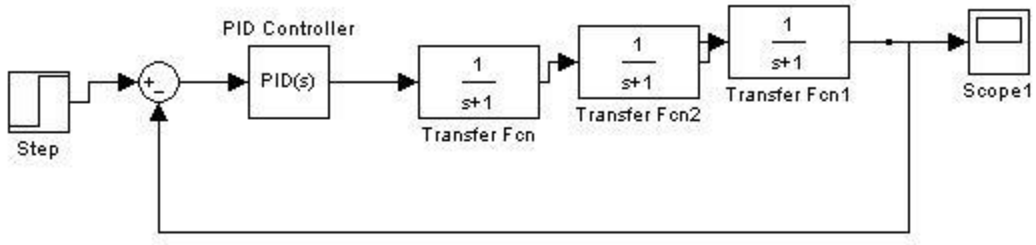
1. Find the original gain kc for the given transfer function.
2. Use k_c as controller transfer function.
3. Build the blocks of the closed loop feedback control system for the given transfer function using SIMULINK tools.
4. Plot the response of the process with the dead time.
5. Repeat the above procedure for the process without dead time.
6. Compare the two calculations.

1.4.1 Block Diagram:

With delay



Without delay



1.6 Post Lab Questions:

1.What is the significance of dead time?

2. Comment on the effect of increase in dead time.

3. Compare ZN open and closed loop tuning.

4.What is the difference between dead time and time delay.

5.Define amplitude ratio.

1.7 Inference:

1.8 Result:

Thus the response of the process with and without transportation lag is studied