DEPARTMENT OF ELECTRICAL ENGINEERING

LABORATORY MANUAL

PROCESS INSTRUMENTATION LAB (EE 436)

FOR

B.E IV/IV (I- SEM) E.I.E

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List of Experiments

Process Instrumentation Lab (EE436)

1. Calibration of Voltage to Current and Current to Voltage Converter
2. Calibration of Current to Pressure and Pressure to current Converter
3. Study of Control Valve Characteristics
4. Study of Interacting and Non- interacting system
5. Calibration of Pneumatic Amplifier
6. Calibration of Temperature Control loop
7. Calibration of Pressure Control loop
8. Calibration of Level Control loop
9. Calibration of Flow Control loop
10. Implementation of AND,OR,NOT,NAND,NOR Gates by using PLC
11. Application of Programmable Logic Controller
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ELECTRONICS AND INSTRUMENTATION ENGINEERING

EE 436-PROCESS INSTRUMENTATION LAB

INDEX

EXPERIMENT:1

I/V AND V/I CONVERTER

Aim:

To study the linearity of V /I and I/ V converter

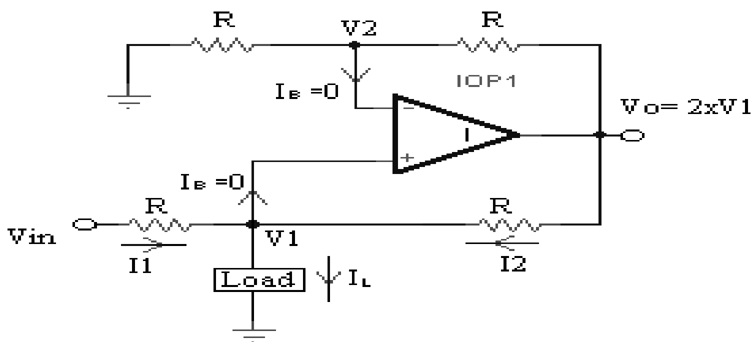
Apparatus:

V/I and I/V converter setup.

Theory

voltage to current converter

The configuration of voltage to current converter is that in which one terminal of load is grounded and the load current is controlled be an input voltage. The circuit is as shown in fig.



According to Kirchhoff's Voltage law,

$I_1 + I_2 = I_L$

$$\frac{Vin - V_1}{R} + \frac{V_O - V_1}{R} = I_L$$

$Vin + VO - 2V1 = I_L R$

Therefore,

$$V1 = \frac{Vin + VO - I_L R}{2}$$

Since op-amp is connected in non-inverting mode, the gain of the circuit will be 2. then the output voltage is

$V_O = 2V_1$

$= V_{in} + V_O - I_L R$

$V_{in} = I_L \times R$

$$I_L = \frac{Vin(\text{r.m.s. value})}{R}$$

Current to Voltage Converter :

Op-amp circuit working as current to voltage converter is as shown in fig.3a. Here the input current which is to be converted into output equivalent voltage is applied to the inverting input terminal of op-amp and hence the circuit will work as inverting amplifier. As we know the gain of inverting amplifier is given by,

$$A_v = \frac{V_{out}}{V_{in}} = -\frac{R_F}{R_1}$$

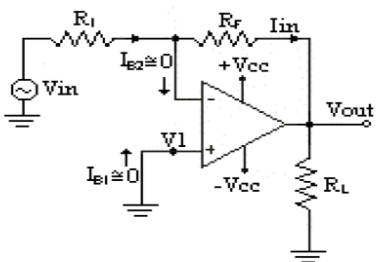
Therefore,

$$V_{out} = \frac{-V_{in} \times R_F}{R_1}$$

However, since $V_1 = 0V$ and $V_1 = V_2$

$$I_{in} = V_{in} / R_1$$

And $$V_{out} = -I_{in} \times R_F \qquad \text{.................(3)}$$



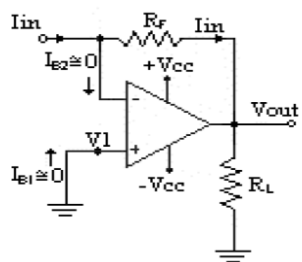
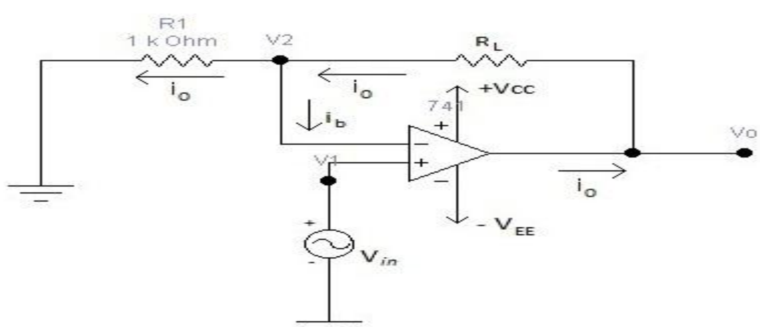


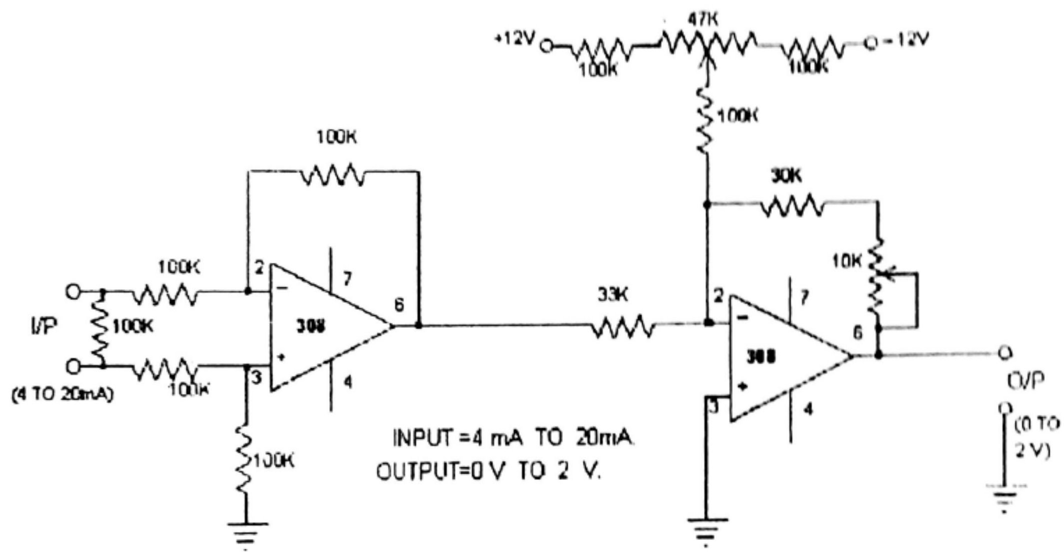
Fig.3a **I-V Converter** **Fig.3b**

Circuit diagram

Voltage to current Converter



Current to Voltage converter



I TO V CONVERTER. FIG.NO.(3)

Procedure

1. Control voltage of 0-2 volts is available across the terminals on the rear side of the set up.
2. Establish connections across the front panel observing polarity with load resistance of typically 100 ohms to 330 ohms.
3. Also establish connections on the rear side of the panels for both the instruments.
4. With switch SW3on front panel of I/V converter in test position. Measure the control voltage applied to V/I converter on the DPM in the range of 0 to 2 volts and check the results.
5. The switch SW3 in normal position the output voltage of I/V converter is measured and indicated on the DPM of I/V converter.
6. The DPM of V/I converter indicates current in the range of 4 to 20 mA

Tabular column

Current to Voltage converter

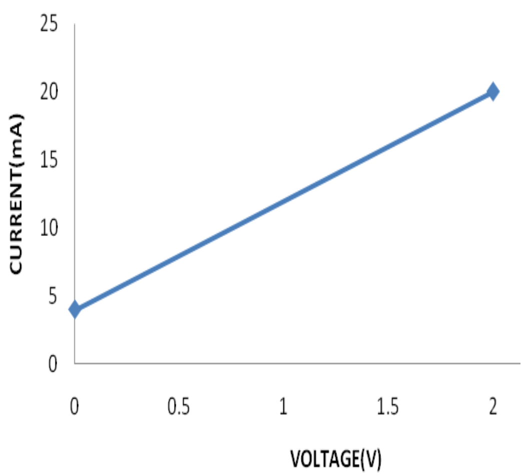
S.No	Current (mA)	Voltage (volts)		%Error
		Theoretical	Practical	

Voltage to Current converter

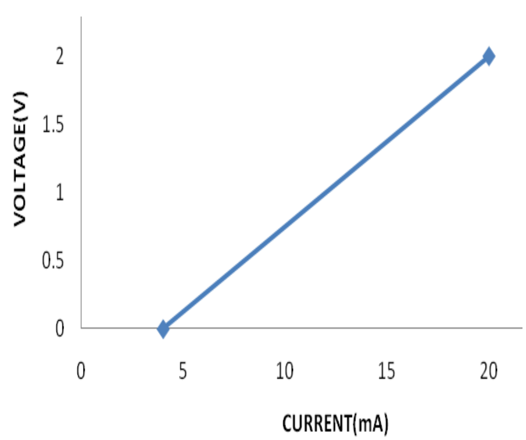
S.No	Voltage(volts)	Current(mA)		%Error
		Theoretical	Practical	

Expected Graph

Voltage to Current converter



Current to Voltage converter



Discuission of Result:

Students may observe some deviation in actual linearity of V /I and I/ V converter

EXPERIMENT:2

I/P AND P/I CONVERTER

Aim

To study linearity of I/P converter and linearity of P/I converter

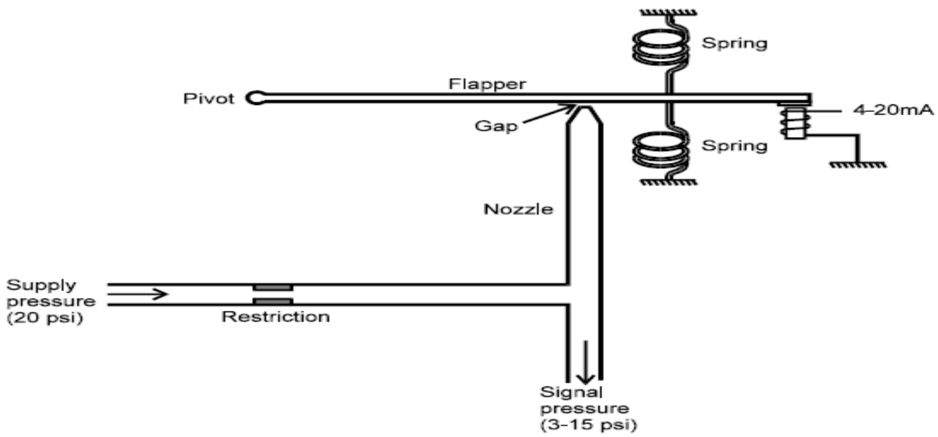
Theory

The I/P converter is a force balance device in which a coil is suspended in he fieldof a magnet by a flexure. Current flowing through coil generates axial movementof the coil and flexure. The flexure moves towards the nozzle and creates backpressure, which acts as a pilot pressure to an integral booster relay. Inputsignal increases (or decreases for reverse acting) cause proportional output pressure increases.The current to pressure (I/P) converter, is very important element in process control. Often, when we want to use the low-level electric current signal to dowork, it is much easier to let the work be done by a pneumatic signal. The I/P converter gives us a linear way of translating the 4-20 mA current into 3-15-psig signals. There are many designs for these converters, but the basic principle almost always involves the use of a flapper/nozzle system. Refer Fig. below.The current through coil produces a force that will tend to pull the flapper down and close off the gap. A high current produces a high pressure so that the deviceis direct acting. Adjustment of the springs and perhaps the position relative to the pivot to which they are attached allows the unit to calibrated so that 4 mA corresponds to 3 psig and 20 mA corresponds to 15 psig. Current to pneumatic converters are two-wire precision instruments designed to convert standard industrial electrical input signals into proportional pneumatic output signal. They are force balance instruments using a coil suspended in a magnetic field to operate a flapper valve against an air nozzle to create backpressure on the control diaphragm of a booster relay. They are compact robust instruments suitable for panel or field mounting applications.

Input signal: 4-20 mA DC.

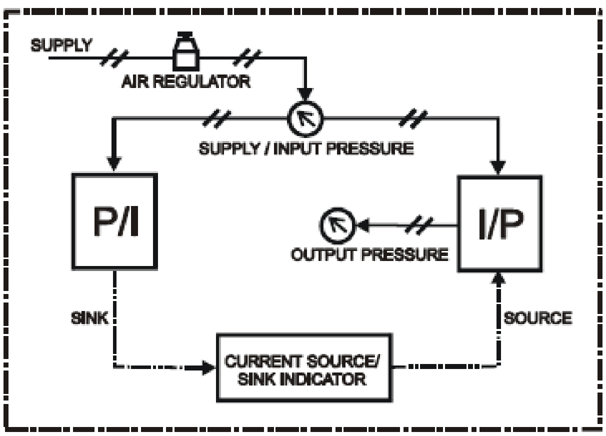
Output signal: 3-15 psi

Supply pressure: 20 psig



Principles of a current-to-pressure converter

Experiment setup



Calibration of I/P converter

1. Generally I/P converter is calibrated for standard industrial signals as 4-20 mA
2. input and 3-15 psig output. These are standard factory settings and need not to be changed.
3. Refer following steps to calibrate I/P converter:
4. Open protective covers to expose zero and span adjustment screws.
5. Connect 20 psi supply pressure and connect input signal i.e. 4-20 mA.
6. Set the input signal to 4 mA and check the output pressure on gauge as 3psig.
7. If necessary adjust zero screw until reaching 3 psig. Turn zero screw counter clockwise to increase pressure, clockwise to decrease pressure. (Note: If unable to achieve output

during calibration process, turn zero adjustment screw counter clockwise for up to 30 revolutions, until output pressure rises)

8. Set the input current signal to 20 mA and check the output pressure on gauge as 15 psig.
9. If necessary adjust the span screw until reaching 15-psig pressures. Turn span screw counter clockwise to increase pressure, clockwise to decrease pressure.
10. Repeat step 3 to check that the desired low value (4 mA ~ 3 psig) has not changed after adjusting the span. If necessary repeat steps 4 through 6 to fine-tune the unit.

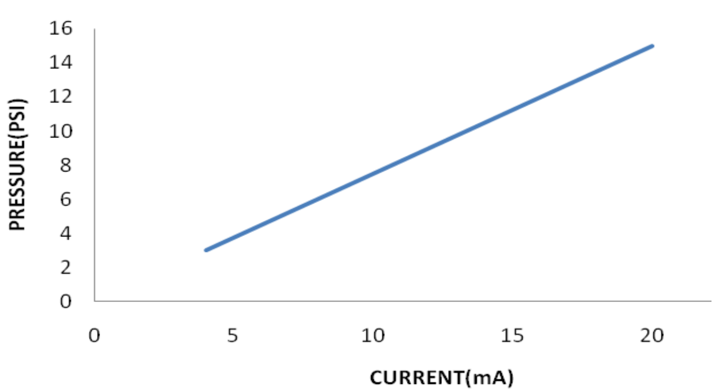
Procedure (for I/P converter)

1. Now put current source/sink indicator source mode by pressing push button and confirm source LED is glowing.
2. Give current input in the step of 4 mA from 4 to 20 mA by slowly rotating the knob of source indicator.
3. Note down corresponding pressure on output pressure gauge in psig.
4. Tabulate above readings in the observation table given below.

Tabular column

S. no	Input Current (mA)	Standard Output Pressure (psig)	Actual Output Pressure (Psig)	error

Expected Graph:



Calibration of P/I converter

Generally P/I converter is calibrated for standard industrial signals as 3-15 psig input corresponds to 4-20 mA DC output. These are standard factory settings and need not to be changed.

1. To adjust the zero and span settings proceed as follows:
2. Two adjustments for zero and span are provided in front face of unit.
3. Set current source/sink indicator on sink mode and ensure sink LED is glowing.
4. Connect input signal i.e. 3-15 psig.
5. Set the input signal to 3 psig and check the output current as 4 mA.
6. If the current is showing more or less than 4 mA then adjust zero. Turn zero adjustment screw slowly by very small turn to obtain 4 mA current. More turning of zero adjustment may damage the P/I converter.
7. Set the input pressure signal to 15 psig and check the output current 20 mA.
8. Turn the span adjustment potentiometer very slowly by small turn to obtain 20 mA current. More turning of span adjustment may damage the P/Iconverter.
9. Repeat step 3 to check that the desired low value (3 psig ~ 4mA) has not changed after adjusting the span. If necessary repeat steps 3 through 4 to fine-tune the unit.

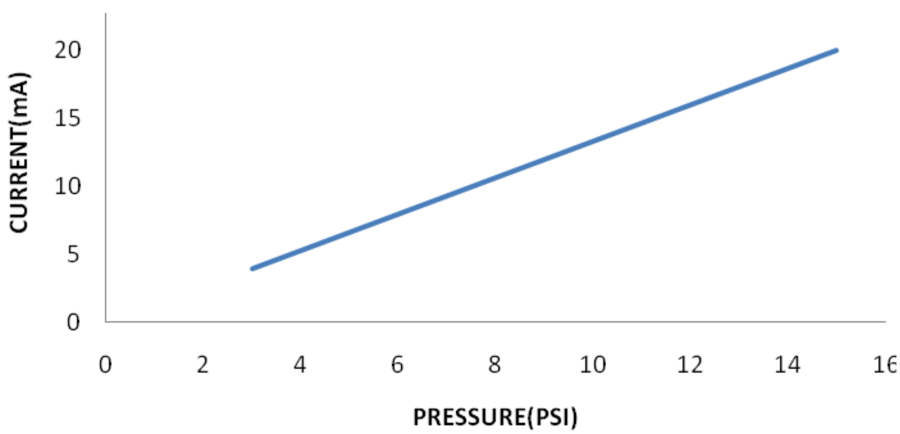
Procedure(P/I converter)

1. Now put current source/sink indicator on source mode and confirm source LED is glowing.
2. Give current input in the step 4 mA from 4 to 20 mA by slowly rotating the adjust knob on current source/sink indicator.
3. Note down corresponding output pressure on output pressure gauge in psi.
4. Now repeat the above steps for more trials.
5. Tabulate above readings in the observation table given below.

Tabular column

S.no	Input Pressure (psi)	Standard input current (mA)	Output current(mA)	error

Expected Graph



Discussion of result:

1. Students may observe some deviation in actual linearity of I/P converter from manufacturer's specification, as it depends upon accuracy of pressure gauges used, accuracy of current indicator and visual error in recording the readings.

2. Student may observe some deviation in actual linearity of P/I converter from manufacturer's specification, as it depends upon accuracy of pressure gauges used, accuracy of current indicator and visual error in recording the readings.

EXPERIMENT: 3

STUDY OF CONTROL VALVE CHARACTERISTICS

Aim:

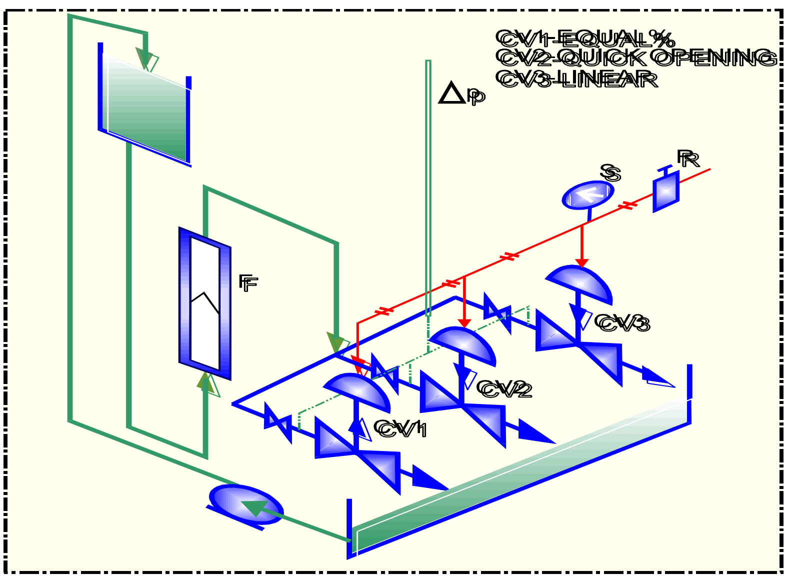
To study inherent characteristic of control valve

Experiment setup

F: Rotameter, CV1: Equal %(air to close), CV2: Quick opening(air to open)

CV3: Linear(air to open)

R: Pressure regulator ,S: Supply pressure gauge ,ΔP: Pressure indication tube



Theory:

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

$Q = be^{ay}$

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

$Q = Q_o\, e^{\{(\log R/y_{max}) * y\}}$

Where

Q_o = Flow at constant drop at zero stroke

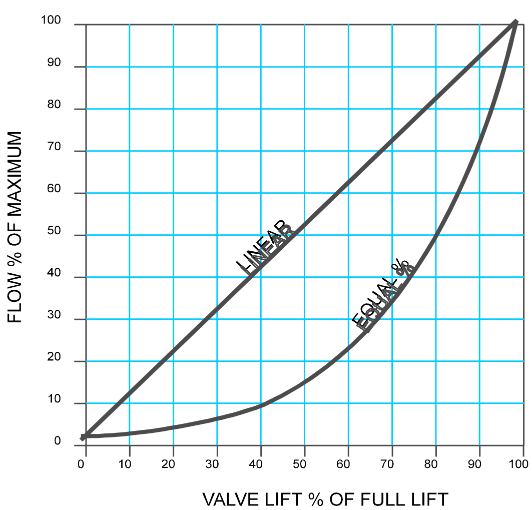
R = Flow range of valve, maximum to minimum at constant drop.

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.

Direct acting actuator (air to close): Direct acting actuators basically consist of a pressure tight housing sealed by a flexible fabric reinforced 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, and 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



Procedure:

1. Keep the control valve fully open by adjusting air regulator to correct pressure.
2. Adjust the regulating valve and set the flow rate. (Set 400 LPH flow for linear/equal percent valve or 600 LPH for quick opening valve).
3. Note the pressure drop at control valve at full open condition.
4. Slowly increase/decrease air pressure by regulator and close the control valve to travel the stem by 2 mm. Note the pressure drop at control valve and flow.
5. Repeat above step and take the readings at each 2mm stem travel till the valve is fully closed.

Observation table:

Sr. No	Pressure	Lift (mm)	Flow (LPH)
1			
2			
3			
4			
5			
6			
7			

Discussion of Result

Students will be able to study inherent characteristic of control valves

EXPERIMENT: 4

Interacting and Non-Interacting system

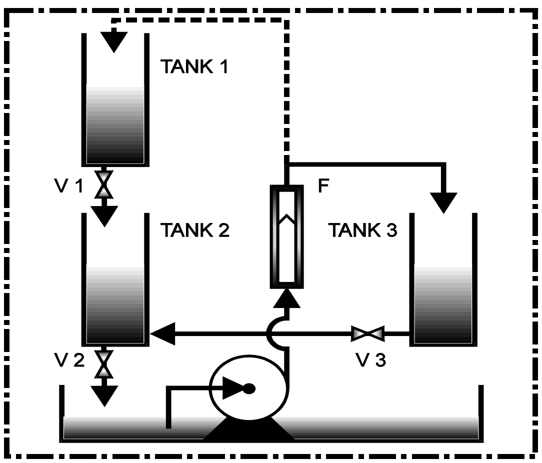
Aim:

To study the response of interacting and non-interacting system.

Apparatus:

Tank1, tank2,tank3(each 200mm level),rotameter, pump.

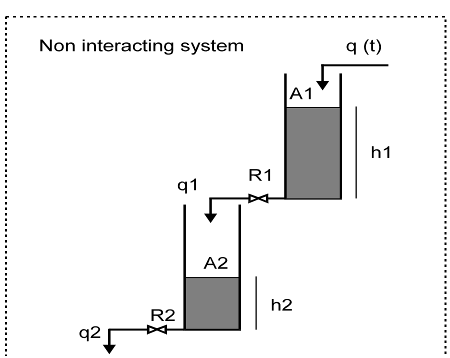
Experiment setup

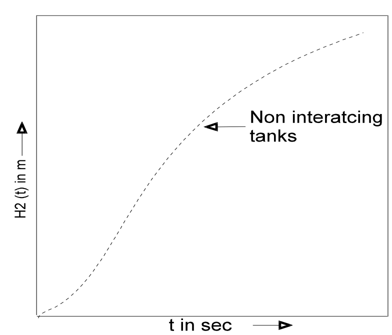


Theory:

NON INTERACTING SYSTEM:

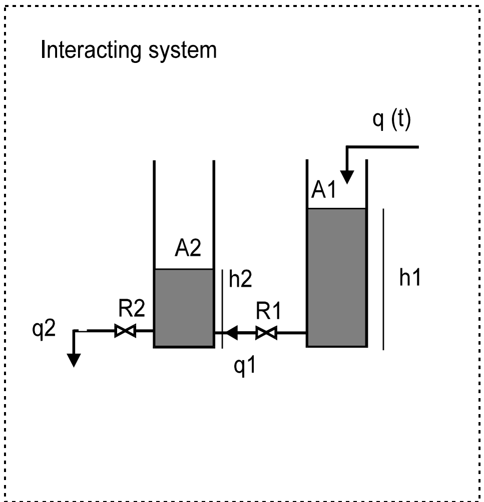
Consider two tanks 1 and 2 connected as shown in the figure. Any change in level h1 of tank1 will change the level of that of tank2,h2. But the converse is not possible i.e, any change in level h2 of tank2 does not effect the level in tank1. This type of system is referred to as Non-Interacting system.

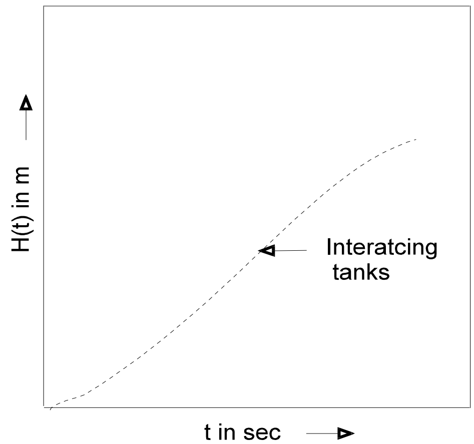




Transient response of non-interacting system

Interacting system





Transient response of interacting system

Procedure(Non-Interacting system)

1. Start up the setup as mentioned in commissioning part.
2. A flexible pipe is provided at rotameter inlet and outlet rotameter will be used to adjust flow rate in the tank.
3. Ensure that initially valve v1,v2,v3 are closed,
4. Now switch on the pump and adjust rotameter to 50LPH and fill the tank to 150mm.
5. While continuously allowing water in tank 1 to maintain 150mm level in tank1 to open valve v1.
6. Water will flow from tank 1 to 2. Record the level in tank2 at an interval of 5 or 10 seconds until the level in tank2 reaches 150mm.
7. Draw a graph between time v/s level of tank 2.

Procedure(Interacting system)

1. Initially the valve v2 is closed.
2. From above procedure for non-interactng system level in the tank t2 is 150mm.
3. While maintaining the levels in tanks 1 and 2 at 150mm, open the valve v3 to allow water to flow from tank2 to tank3.
4. Observe the level of tank3 at interval of 5 or 10 seconds until the level reaches 150mm.
5. Draw the graph between time v/s level of tank3.

6. Switch off the pump and open the valve v2 to completely drain out water from tank3.

Tabular column (for non-interacting system and interacting systems)

S.NO	TIME(sec)	LEVEL(mm)

Discussion of result

1. Based on the characteristics of Non-Interacting system, students may observe Non-Interacting system acts as a critically damped system
2. Based on the characteristics of Interacting system, students may observe Interacting system acts as a critically damped system

EXPERIMENT: 5

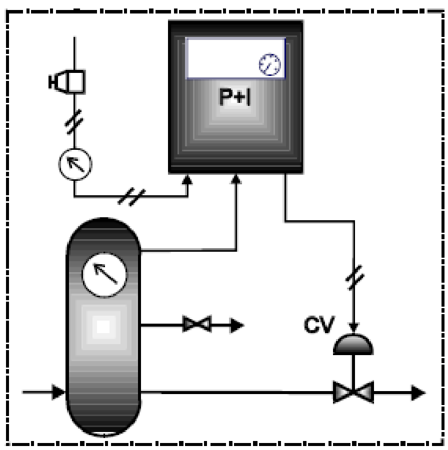
Calibration of Pneumatic P+I controller

Aim:
To study P+I pneumatic controller

Apparatus:

P+I pneumatic controller set up.

Experiment Set-up:



Procedure:

1. Adjust the set point approximately at mid scale of the operating range say 2Kg/cm^2
2. Switch the controller to Auto mode.
3. Start from gain 1 and each time give step change to the system, observe the process response for oscillations. Note the offset at higher proportional band(lower gain).
4. Gradually increase gain (reduce the proportional band) and give disturbance to the system by changing set point. Observe the reduction in offset and faster response of the system for step changes. As the gain increased (proportional band is decreased) the system may show small oscillations. Note the gain.
5. Gradually add reset setting and give disturbance to the system by changing set point. Observe the faster response of the system for step changes. As the reset value is decreased the system may show small oscillations. Note the reset value.
6. Observe working of controller by changing the set point or by operating vent valve for load changes.

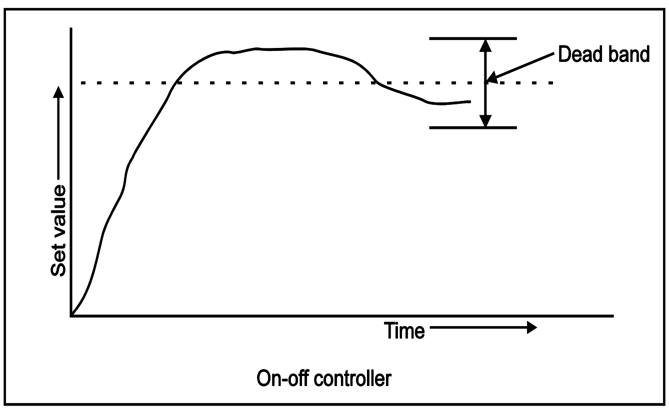
7. For our system following values gives the best control: Gain=10, Reset (repeats per minute)= 5

K_P = K_i =

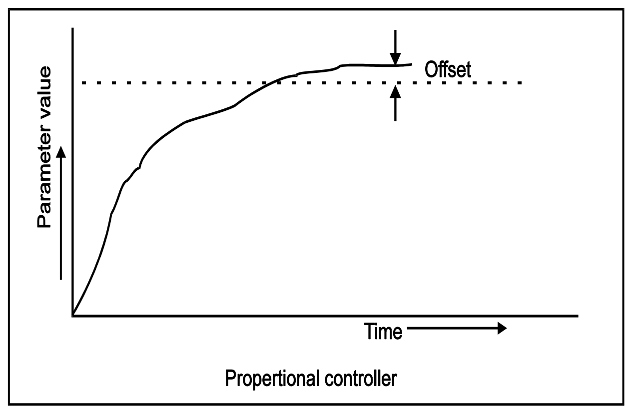
S.NO	Setpoint	Time	Pressure inside the vessel	Remarks

Expected Graphs

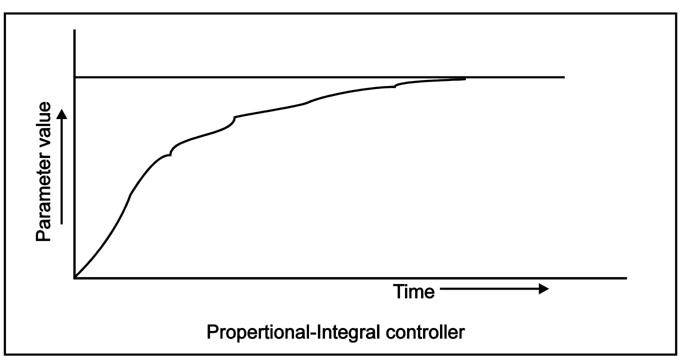
Kp=high   Ki=min



Kp=10   Ki=min



Kp=10   Ki=5



Discussion of result:

Student may observe that:

1. With gain at 'H' position (Proportional band low) & integral at below 0.05 (integral action cut), the system works as ON-OFF controller.
2. Now putting gain at 10, observe process response. There is some offset (deviation in set point & process value).
3. Now add reset to above gain and see that the deviation is minimized. See at gain 10 & reset at 5 the process gives the best response.

EXPERIMENT: 6

CALIBRATION OF TEMPERATURE CONTROL LOOP

Aim

Study of On/Off ,P,P+I,P+I+D for Calibration Temperature control loop

Apparatus: Temperature control trainer

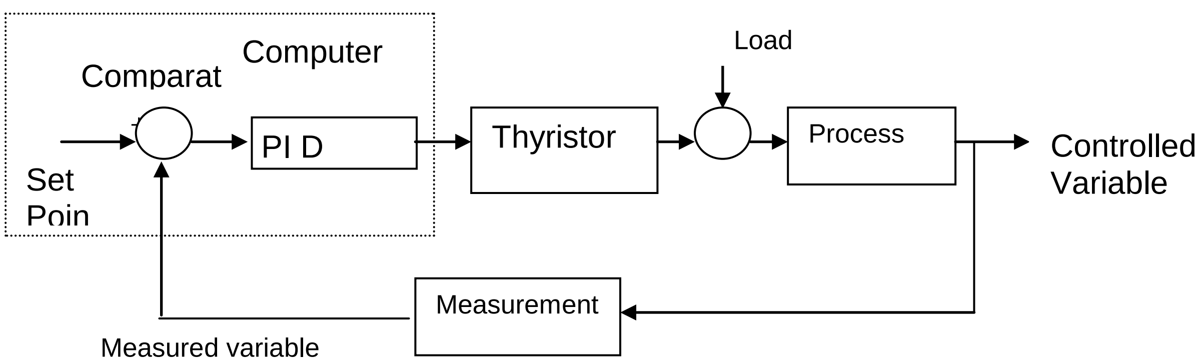
Theory

Direct Digital Control (DDC):

The method of process control described by the term DDC (Direct Digital Control) applies to those cases in which digital logic circuits or a computer are an integral part of the loop.

The control function, setpoint and deviation about the nominal are all defined by the software program. Direct digital control has the capacity to control multivariable processes with interaction between elements.

This is most economically developed process control system basically used for laboratory scale application. In this system the process signals are transmitted to computer through interfacing unit. The software is used to change the control variables to control the process. Software also performs the function of data acquisition. The signals are displayed on the computer. This system requires Computer for interfacing with trainer.



Supervisory Control And Data Acquisition (SCADA):

SCADA systems are used in central part of the operations of many industry e.g. offshore oil & gas platforms, petrochemical complexes, pulp & paper work. In this system the process signals are transmitted the controller & the same signals are transmitted to the computer through RS 232 communication. Software performs the function of data acquisition. The signals are displayed on computer. The controller variables can be changed from software. This model requires computer for interfacing with trainer.

ON-OFF CONTROL

A special case of proportional control is On-Off controller. If the gain (Kc) of controller is made very high (Proportional band is made very low) controller output will move from one extreme position to other for slight deviation of process value from the set point. This very sensitive action is called On - Off control because final control element is either open (on) or close (Off) i.e. operates like a switch.

Hysteresis is a value set in the vicinity of on-off operating point. Upper hysteresis is value or band in which process value is allowed to operate above the set point and lower hysteresis is value or band in which process value is allowed to operate below the set point.

P-CONTROL

The method by which a controller counteracts a deviation from set point is called the control mode. The three most commonly used modes of feedback control are the Proportional, Integral and Derivative modes.The control algorithm that generates a linear control output proportional to deviation is called proportional action. In proportional action the amount of change in the measured value (or deviation) is expressed in percent of span that is required to cause the control output to change from 0 to 100 % is called the proportional band.The equation of the Proportional controller out put is

$P = K_p[SP-PV] + P_0$

Kp = Proportional gain. = Inverse of proportional band (=100/PB)

P_0 = Bias (The value of the controller at zero error.)

In this experiment we observe the performance of proportional feed back control. In this set up we compare the measured process value (PV) with a desired set point (SP). The measured temperature is process value for the controller while manipulated variable is the voltage from the thyrister from to heater. The output of the controller is proportional to the resulting error signals.

Proportional + Integral Controller (PI)

This mode of control is described by the relationship

Error e = (SP - PV)

Kc = (1/Proportional Band) x 100

$P = K_c e + K_c / T_i \int e\, dt + P_s.$

Where

Ti is integral time

Kc is proportional gain

This controller is also called as reset controller. In this case the proportional term Kc e is added by another term that is proportional to the integral of the error. The values of Kc and the Integral time (I) in terms of sec can be changed.The offset in the proportional controller is removed by addition of integral action.A small reset time corresponds to an increase in integral action.For most of the controller proportional band term is used instead of proportional gain where relation is Proportional band = 1/ Proportional gain.With P action the measured value will not necessarily become equal to the set point, and a deviation will usually be present. The control algorithm that applies changes in output as long as a deviation exits, so as to bring the deviation to zero, is called integral action. When integral action is used, the parameter that determines how fast the output will change in correspondence to some amount of deviation is referred to as the integral time, and shorter the integral time, stronger the integral action (the greater the output rate of change). I action is usually used together with P action as PI action, and the integral time (I) is the time required, after application of a step input, for the output change due only to I action to become equal to that due only to P action.

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

This mode of control is described by the relationship

$P = Kc\ e + Kc / Ti \int e\,dt + Kc\ T_d\ de/dt + Ps.$

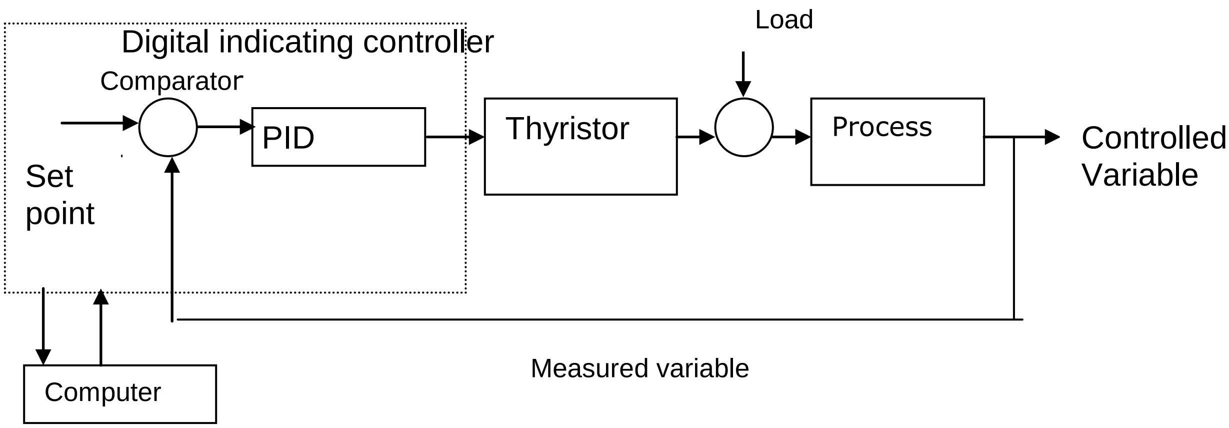
Where

Error e = (SP - PV)

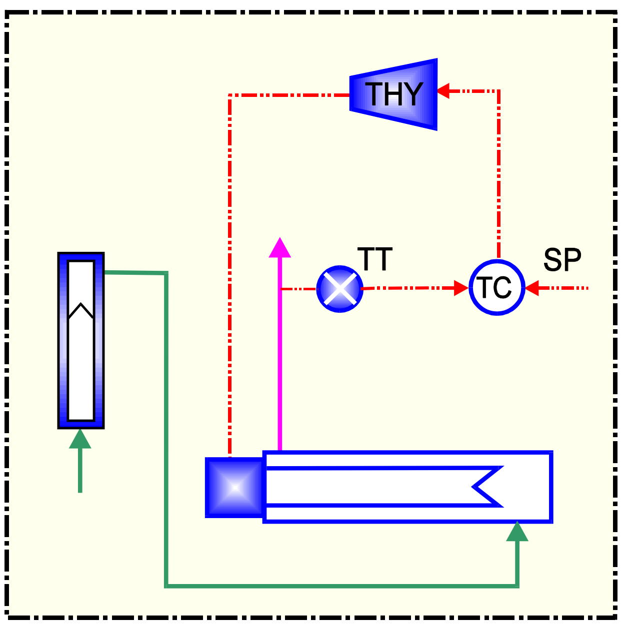
Kc = (1/Proportional Band) x 100

Where ꚍd is derivative time and ꚍi is integral time and Kc = Proportional gain

Block diagram:



Experiment Set-up



TT	Temperature transmitter
THY	Thyrister
SP	Set point
TC	Temperature controller

Tabular column (for ON-OFF,P.P+I,P+I+D)

S.NO	TIME	PROCESS VARIBALE(Temperature)	CONTROLLER OUTPUT

Procedure(ON-OFF Controller)

1. Set the controller to **On/Off** mode.
2. Press Tune & set the upper and lower hysteresis of the controller.
3. Change the values of the set point and observe the control operation.
4. Proceed further to next experiment otherwise shut down the set up

Procedure(P-Controller)

1. Start up the set up as mentioned
2. Select **close loop** option for control.
3. Switch on the thyrister supply.
4. Set the controller to proportional control (P) mode.
5. Switch the controller to auto mode. Apply step change to set point Step change should be of 2 to 3 %.
6. Switch the controller to auto mode and Decrease proportional band value. With each decrease, obtain a new response of the step change. Ensure that the set point changes are around the same operating point.
7. Using trail and error approach find a value of proportional band so that the response to a step change has at most one overshoot and one undershoot.
8. Set the controller to the settings obtained in the above step and wait for the system to reach at steady state.

Procedure (Proportional+integral controller)

1. Start the set up as mentioned in start up.
2. Select **close loop** option for control.

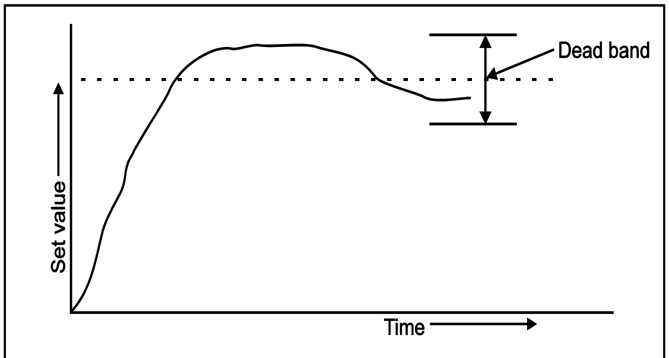
3. Adjust the process value by changing controller to auto mode to a particular temperature Select PID controller. Set the proportional band estimated from Proportional control (P only, from previous experiment) Start with derivative time to 0 and integral time 6000 sec., which will cut off the derivative action and widen the effect of integral action.
4. Set the set point to desired temperature. Start data storing in file. Allow the process to reach at steady state. Record the steady state error.
5. Change the integral time and apply step change to the set point by 2 to 3%. Record the transient response to the system.
6. Reduce the integral time from the half of the previous and repeat the above steps.
7. Using trial and error, select a set of reset time, which gives satisfactory response to the step change in set point.
8. Apply step change to the system (+/- 2 %) and observe the response.
9. After experimentation, shut down the set up

Procedure(Proportional+Integral+Derivative (PID) controller)

1. Select PID controller. Start with largest integral time and derivative time 0.
2. Switch the controller to auto mode.
3. Change the proportional band to the value that estimated in proportional controller.
4. Set the set point to @ 50 %. Start data logging. Switch the controller to manual mode. Allow the process to reach steady state.
5. Apply the step change of 10%. Observe the transient response. Record the data in computer. Measure new steady state error
6. Change the integral time and observe the response of the process and repeat the above step.
7. Using trail and error, select the proportional band and integral time, which gives a satisfactory response to step change in set point.
8. Take the process value at 50% with P and I parameters obtained in the above steps. Set the derivative time to a non-zero value and carry out the above steps for different derivative time values.
9. After experimentation shut down the set up.

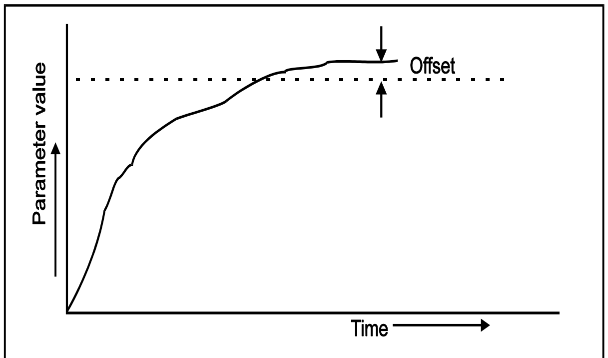
Expected Graph

ON-OFF Controller



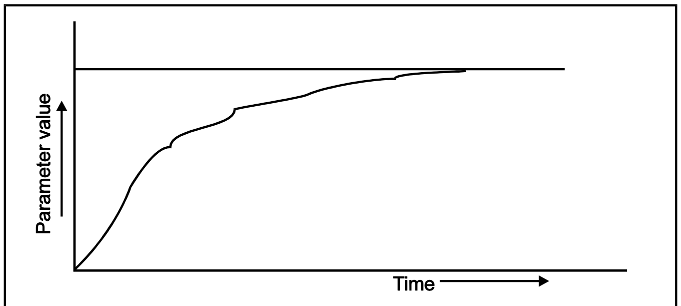
On-off controller

P-Controller



Propertional controller

P+I Controller



Propertional-Integral controller

Discussion of result:

ON-OFF Controller

Student may Observe that if process value exceeds the set point and increases than the value of upper hysteresis, controller switches off the thyrister and if process value decreases than the set point, thyrister switches on i.e. the controller operates like on off switch

P-Controller

1. Students may Observe that ,state error decreases as proportional band decreases.
2. Students may Observe that ,of very low proportional band values system works as on-off control

Proportional +integral controller

1. Students may Observe that, at any value of integral time the steady state error to a set point change is zero.
2. Students may Observe that, the transient response to set point change when the integral time is reduced to very low value.
3. Student may observe that the system is sluggish because of integral action

Proportional + Integral+ derivative controller

Students may Observe that, the transient response steady state response of the PID controller and note that the response system response is fast compare to P+I Controller.

EXPERIMENT: 7

CALIBRATION OF PRESSURE CONTROL LOOP

Aim

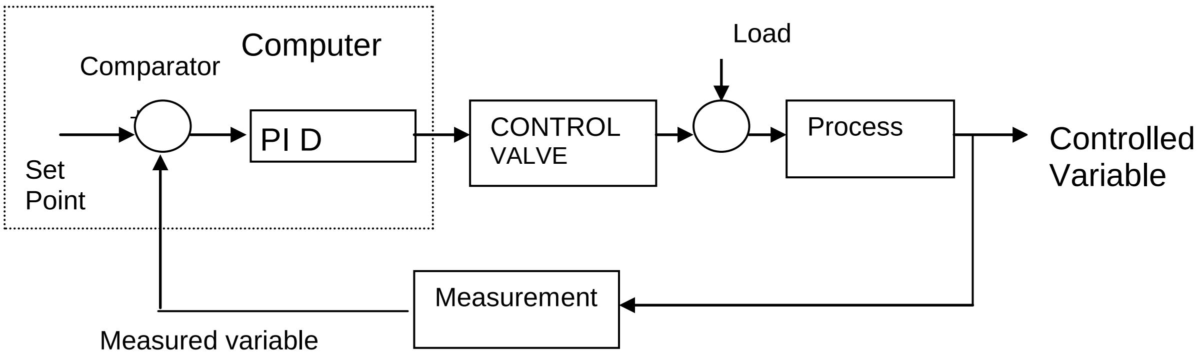
To study On/Off ,P,P+I,P+I+D for Calibrate Pressure control loop

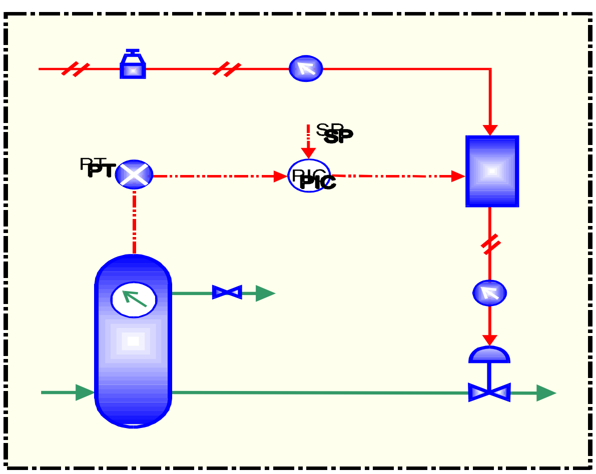
Apparatus: Pressure control trainer

Theory

(Refer page numbers 19,20,21)

Experiment Set-up:





LT	Pressure transmitter
E/P	Current to pressure converter
CV	Control Valve
SP	Set point
LIC	Pressure indicating controller

Tabular column (for ON-OFF,P.P+I,P+I+D)

S.NO	TIME	PROCESS VARIBALE(PRESSURE)	CONTROLLER OUTPUT

<u>Procedure (ON-OFF Controller)</u>

1. Set the controller to **On/Off** mode.
2. Press Tune & set the upper and lower hysteresis of the controller.
3. Change the values of the set point and observe the control operation.
4. Proceed further to next experiment otherwise shut down the set up

.***Procedure (for P-Controller)***

1. Select **close loop** option for control.
2. Set the controller to proportional control **(P)** mode.
3. Switch the controller to auto mode. Start data logging.
4. Apply step change of 10% to set point.
5. Decrease proportional band and With each decrease, obtain a new response of the step change. Ensure that the set point changes are around the same operating point (Say 50%).
6. Using trial and error approach find a value of proportional band so that the response to a step change has at most one overshoot and one undershoot.
7. Set the controller to the settings obtained in the above step and wait for the system to reach steady state.
8. Stop data logging.
9. Proceed further to next experiment otherwise shut down the set up

Procedure (Proportional+ integral (P+I) controller)

1. Select **close loop** option for control.

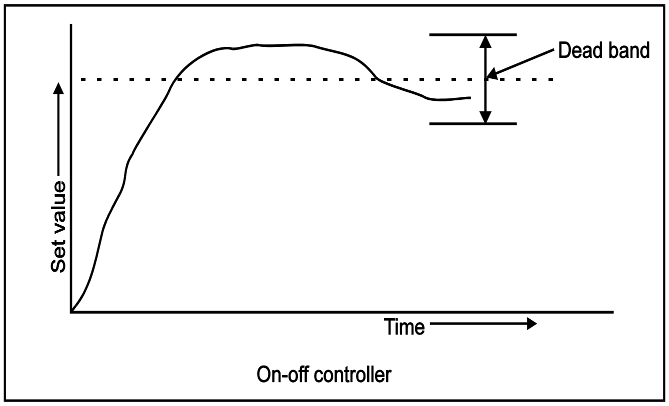
2. Select PID controller. Set the proportional band estimated in Proportional control. Set derivative time to 0 and integral time 6000 sec, which will cut off the derivative action and widen the effect of integral action.
3. Start data logging. Allow the process to reach at steady state. Record the steady state error.
4. Change the integral time and apply step change to the set point. Record the transient response to the system.
5. Reduce the integral time and repeat the above steps.
6. Using trial and error, select a set of proportional band and reset time, which gives satisfactory response to the step change in set point.
7. Apply step change to the system (+/- 10%) and observe the response.
8. Stop data logging.
9. Proceed further to next experiment otherwise shut down the set up

Procedure(Proportional+Integral+Derivative (PID) controller)

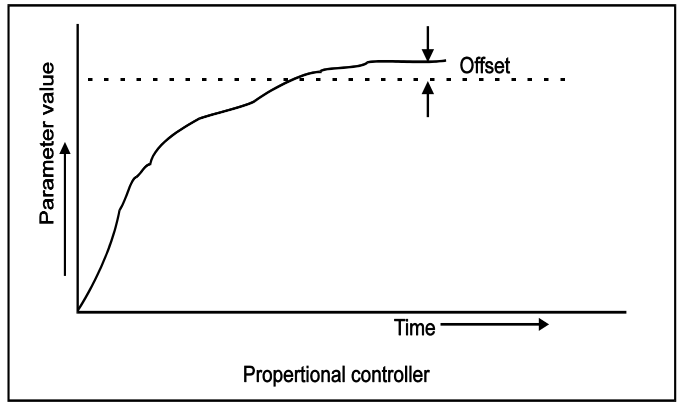
1. Select PID controller. Start with largest integral time and derivative time 0.
2. Switch the controller to Auto mode.
3. Change the proportional band to the value that estimated in proportional controller.
4. Set the set point to @ 50 %. Start data logging. Allow the process to reach steady state.
5. Apply the step change of 10%. Observe the transient response. Record the data in computer. Measure new steady state error
6. Change the integral time and observe the response of the process and repeat the above step.
7. Using trail and error, select the proportional band and integral time, which gives a satisfactory response to step change in set point.
8. Take the process value at 50% with P and I parameters obtained in the above steps. Set the derivative time to a non-zero value and carry out the above steps for different derivative time values.
9. Stop data logging.
10. Proceed further to next experiment otherwise shut down the set up

<u>Expected Graph</u>

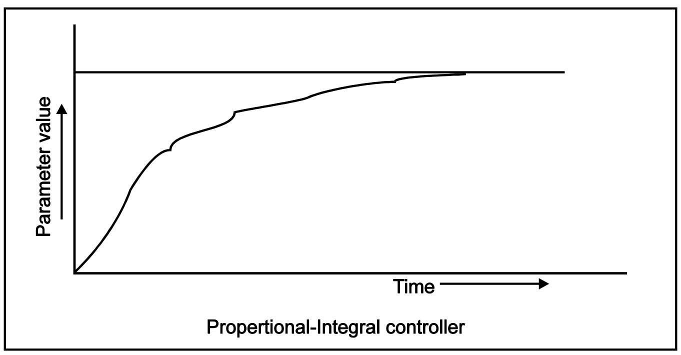
ON-OFF Controller



P-Controller



P+I Controller



<u>Discussion of result:</u>

ON-OFF Controller

Student may Observe that if process value exceeds the set point and increases than the value of upper hysteresis controller closes the valve and if process value decreases than the set point and lower hysteresis, control valve opens. I.e. the process operates as on off switch.

P-Controller

1. Students may Observe that ,state error decreases as proportional band decreases.
2. Students may Observe that ,of very low proportional band values system works as on-off control

Proportional +integral controller

1. Students may Observe that, at any value of integral time the steady state error to a set point change is zero.
2. Students may Observe that, the transient response to set point change when the integral time is reduced to very low value.
3. Student may observe that the system is sluggish because of integral action

Proportional + Integral+ derivative controller

Students may Observe that, the transient response steady state response of the PID controller and note that the response system response is fast compare to P+I Controller.

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EXPERIMENT: 8

CALIBRATION OF LEVEL CONTROL LOOP

Aim

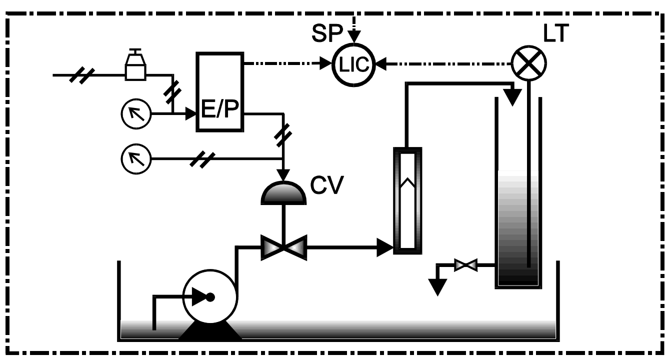
To study On/Off ,P,P+I,P+I+D for calibration level control loop

Apparatus: Level control trainer

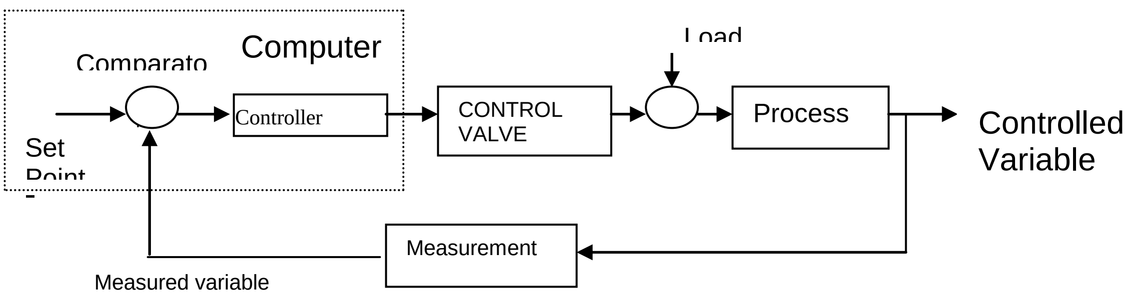
Theory

(Refer page numbers 19,20,21)

Experiment Set-up



Block diagram:



LT	Level transmitter
E/P	Current to pressure converter
CV	Control Valve
SP	Set point
LIC	Level indicating controller

Tabular column (for ON-OFF,P.P+I,P+I+D)

S.NO	TIME	PROCESS VARIBALE(LEVEL)	CONTROLLER OUTPUT

Procedure (ON-OFF Controller)

1. Set the controller to **On/Off** mode.
2. Press Tune & set the upper and lower hysteresis of the controller.
3. Change the values of the set point and observe the control operation.
4. Proceed further to next experiment otherwise shut down the set up

Procedure (for P-Controller)

1. Select **close loop** option for control.
2. Set the controller to proportional control **(P)** mode.
3. Switch the controller to auto mode. Start data logging.
4. Apply step change of 10% to set point.
5. Decrease proportional band and With each decrease, obtain a new response of the step change. Ensure that the set point changes are around the same operating point (Say 50%).
6. Using trial and error approach find a value of proportional band so that the response to a step change has at most one overshoot and one undershoot.
7. Set the controller to the settings obtained in the above step and wait for the system to reach steady state.
8. Stop data logging.
9. Proceed further to next experiment otherwise shut down the set up

Procedure (Proportional+ integral (P+I) controller)

1. Select **close loop** option for control.

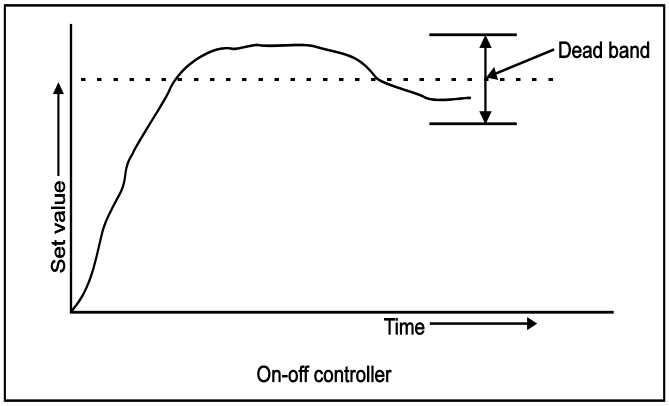
2. Select PID controller. Set the proportional band estimated in Proportional control. Set derivative time to 0 and integral time 6000 sec, which will cut off the derivative action and widen the effect of integral action.
3. Start data logging. Allow the process to reach at steady state. Record the steady state error.
4. Change the integral time and apply step change to the set point. Record the transient response to the system.
5. Reduce the integral time and repeat the above steps.
6. Using trial and error, select a set of proportional band and reset time, which gives satisfactory response to the step change in set point.
7. Apply step change to the system (+/- 10%) and observe the response.
8. Stop data logging.
9. Proceed further to next experiment otherwise shut down the set up

Procedure (Proportional+Integral+Derivative (PID) controller)

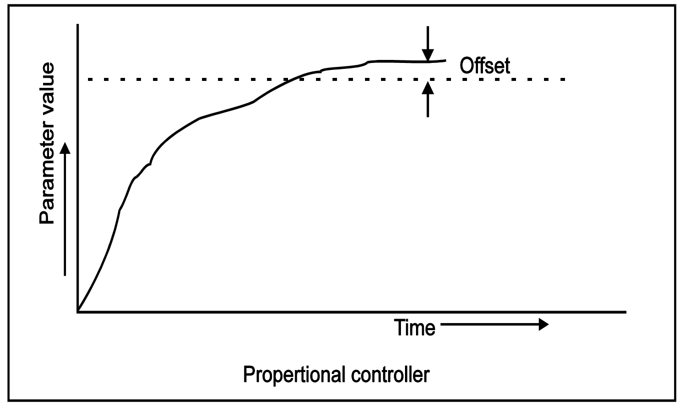
1. Select PID controller. Start with largest integral time and derivative time 0.
2. Switch the controller to Auto mode.
3. Change the proportional band to the value that estimated in proportional controller.
4. Set the set point to @ 50 %. Start data logging. Allow the process to reach steady state.
5. Apply the step change of 10%. Observe the transient response. Record the data in computer. Measure new steady state error
6. Change the integral time and observe the response of the process and repeat the above step.
7. Using trail and error, select the proportional band and integral time, which gives a satisfactory response to step change in set point.
8. Take the process value at 50% with P and I parameters obtained in the above steps. Set the derivative time to a non-zero value and carry out the above steps for different derivative time values.
9. Stop data logging.
10. Proceed further to next experiment otherwise shut down the set up

Expected Graph

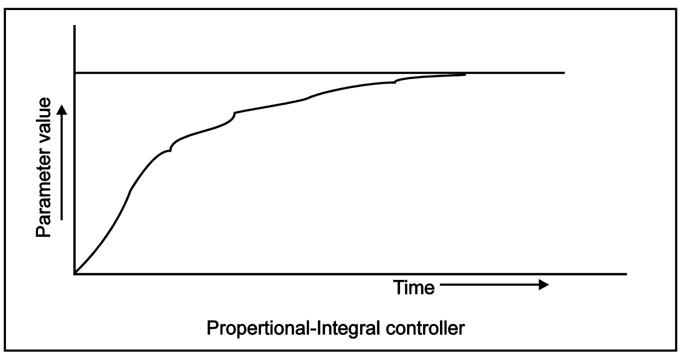
ON-OFF Controller



P-Controller



P+I Controller



Discussion of result:

ON-OFF Controller

Student may Observe that if process value exceeds the set point and increases than the value of upper hysteresis controller closes the valve and if process value decreases than the set point and lower hysteresis, control valve opens. I.e. the process operates as on off switch.

P-Controller

1. Students may Observe that ,state error decreases as proportional band decreases.
2. Students may Observe that ,of very low proportional band values system works as on-off control

Proportional +integral controller

1. Students may Observe that, at any value of integral time the steady state error to a set point change is zero.
2. Students may Observe that, the transient response to set point change when the integral time is reduced to very low value.
3. Student may observe that the system is sluggish because of integral action

Proportional + Integral+ derivative controller

Students may Observe that, the transient response steady state response of the PID controller and note that the response system response is fast compare to P+I Controller.

EXPERIMENT : 9

CALIBRATION OF FLOW CONTROL LOOP

Aim

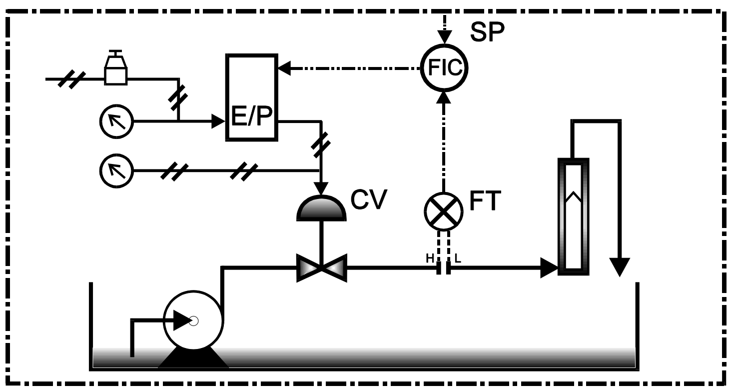
To study On/Off ,P,P+I,P+I+D for calibration flow control loop

Apparatus: Level control trainer

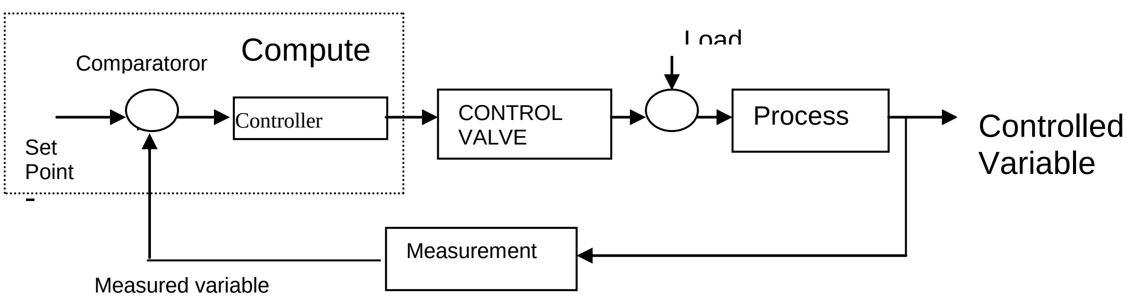
Theory

(Refer page numbers 19,20,21)

Experiment Set-up



Block diagram:



FT	Flow transmitter
E/P	Current to pressure converter
CV	Control Valve
H	High pressure tapping
L	Low pressure tapping
SP	Set point
FIC	Flow indicating controller

Tabular column (for ON-OFF,P.P+I,P+I+D)

S.NO	TIME	PROCESS VARIBALE(FLOW)	CONTROLLER OUTPUT

Procedure (ON-OFF Controller)

1. Set the controller to **On/Off** mode.
2. Press Tune & set the upper and lower hysteresis of the controller.
3. Change the values of the set point and observe the control operation.
4. Proceed further to next experiment otherwise shut down the set up

Procedure (for P-Controller)

1. Select **close loop** option for control.
2. Set the controller to proportional control **(P)** mode.
3. Switch the controller to auto mode. Start data logging.
4. Apply step change of 10% to set point.
5. Decrease proportional band and With each decrease, obtain a new response of the step change. Ensure that the set point changes are around the same operating point (Say 50%).
6. Using trial and error approach find a value of proportional band so that the response to a step change has at most one overshoot and one undershoot.
7. Set the controller to the settings obtained in the above step and wait for the system to reach steady state.
8. Stop data logging.
9. Proceed further to next experiment otherwise shut down the set up

Procedure (Proportional+ integral (P+I) controller)

1. Select **close loop** option for control.

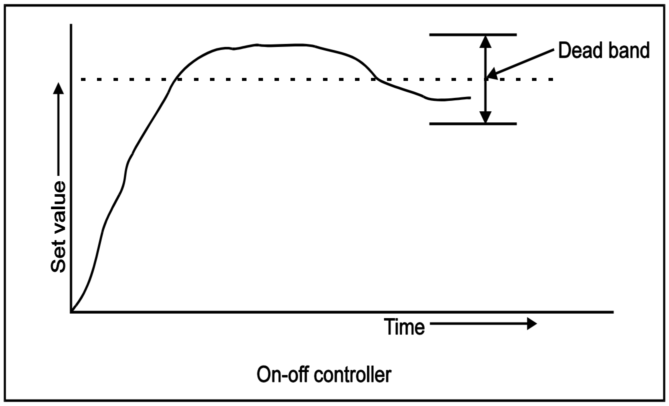
2. Select PID controller. Set the proportional band estimated in Proportional control. Set derivative time to 0 and integral time 6000 sec, which will cut off the derivative action and widen the effect of integral action.
3. Start data logging. Allow the process to reach at steady state. Record the steady state error.
4. Change the integral time and apply step change to the set point. Record the transient response to the system.
5. Reduce the integral time and repeat the above steps.
6. Using trial and error, select a set of proportional band and reset time, which gives satisfactory response to the step change in set point.
7. Apply step change to the system (+/- 10%) and observe the response.
8. Stop data logging.
9. Proceed further to next experiment otherwise shut down the set up

Procedure (Proportional+Integral+Derivative (PID) controller)

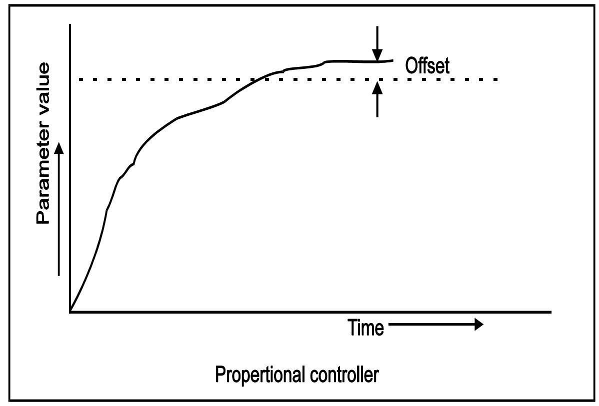
1. Select PID controller. Start with largest integral time and derivative time 0.
2. Switch the controller to Auto mode.
3. Change the proportional band to the value that estimated in proportional controller.
4. Set the set point to @ 50 %. Start data logging. Allow the process to reach steady state.
5. Apply the step change of 10%. Observe the transient response. Record the data in computer. Measure new steady state error
6. Change the integral time and observe the response of the process and repeat the above step.
7. Using trail and error, select the proportional band and integral time, which gives a satisfactory response to step change in set point.
8. Take the process value at 50% with P and I parameters obtained in the above steps. Set the derivative time to a non-zero value and carry out the above steps for different derivative time values.
9. Stop data logging.
10. Proceed further to next experiment otherwise shut down the set up

Expected Graph

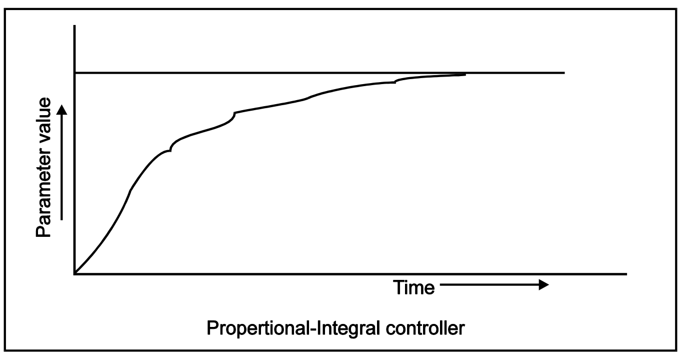
ON-OFF Controller



P-Controller



P+I Controller



Discussion of result:

ON-OFF Controller

Student may Observe that if process value exceeds the set point and increases than the value of upper hysteresis controller closes the valve and if process value decreases than the set point and lower hysteresis, control valve opens. I.e. the process operates as on off switch.

P-Controller

1. Students may Observe that ,state error decreases as proportional band decreases.
2. Students may Observe that ,of very low proportional band values system works as on-off control

Proportional +integral controller

1. Students may Observe that, at any value of integral time the steady state error to a set point change is zero.
2. Students may Observe that, the transient response to set point change when the integral time is reduced to very low value.
3. Student may observe that the system is sluggish because of integral action

Proportional + Integral+ derivative controller

Students may Observe that, the transient response steady state response of the PID controller and note that the response system response is fast compare to P+I Controller.

EXPERIMENT: 10

IMPLEMENTATION OF LOGIC GATES USING PLC

Aim:

To Study and execute ladder logic ladder program for basic gates using PLC

Apparatus:

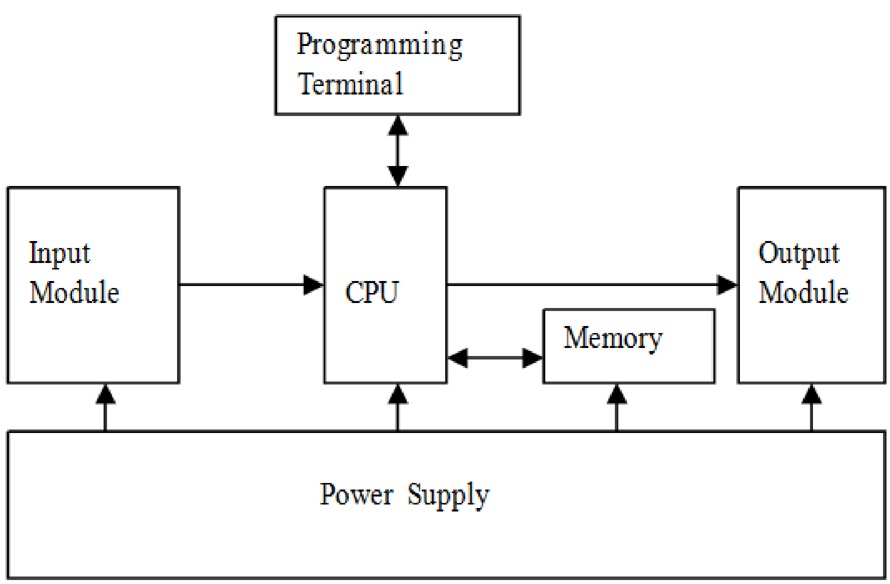
PLC set up, Codesys software

Theory:

A Programmable logic controller consist is shown figure. the programming terminal is not part of the PLC, but it is essential to have a terminal for programming or monitoring a PLC. In the diagram , the arrow between blocks indicate the information and power flowing direction.

A programmable logic controller consist of the following components

- Central processing unit
- Memory
- Input module
- Output module



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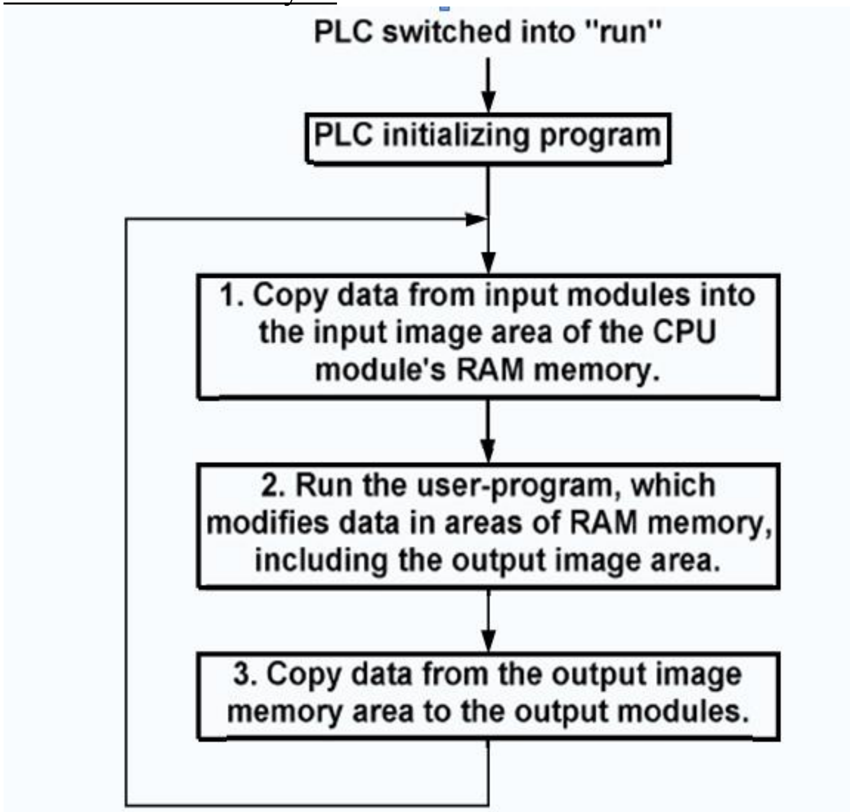
Standard PLC Scan Cycle



Procedure

1. **To Create a New Project**
   - To open the software

     Start ⟶ Programs ⟶ Messung systems ⟶ CoDeSys V2.3
   - Close project that is displayed (if any) like file menu⟶close.
   - To create new project, select file ⟶ New.
   - A dialog box of target settings is displayed, select 'Nexgen 2213A T1.00' and press OK.
   - In the next dialog box don't make any changes and press OK.
   - Name of the new POU is PLC_PRG, it is default don't change it. Select type of POU as program, select language of the POU as LD (Ladder diagram) and press OK.
   - A window is displayed contains empty rung,

- You can insert input i.e. contacts, coils and function blocks whatever you want in your program.
- Next to that is set your PLC configuration in resources menu and select PLC configuration → Nexgen 2000 → 4-IO Base Rack [SLOT].
- Right click on the 0 Pt input+output module[SLOT].
- Select replace element→16 Pt input module for one and other as 16 Pt outputmodule.

2.To give addressing for inputs and outputs

Input is called as 'CONTACT' .It is normally open (⊣ ⊢) or normally closed (⊣/⊢) respectively. It is addressed as %IX0.x. The Input address ranges from: %IX0.0 to %IX0.7 for first 8 inputs. %IX1.0 to % IX1.7 for next 8 inputs.Output is called as 'COIL'. It is normally open or normally closed respectively. It is addressed as %QX0.x. The output address ranges from: %QX0.0 to %QX0.7 for first 8 outputs. %QX1.0 to %QX1.7 for next 8 outputs.Flags are temporary storage bits. They are addressed as: %MX0.0 to %MX0.9 and %MX1.0 to %MX1.9 so on

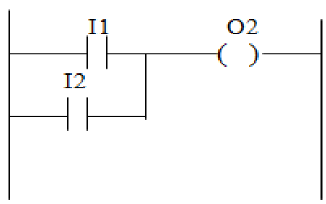
3.To Download the Project:

- After completion of editing your program, you have to download the program into PLC for executing it. For downloading the program, follow the below steps:
- First, build your project by using 'build' option in project menu.
- If errors are not there, you are ready to download the program. For this select: online menu and select login.
- Then you have a prompt for asking to download the program, and then press yes.
- Next prompt is for to flash the program, press yes.
- Now the download is completed.

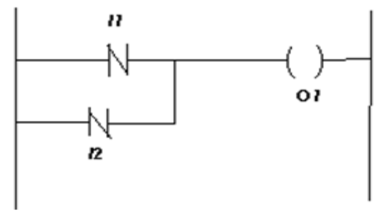
- Next to see the output of your program put PLC in run mode by selecting 'Run' in online menu.
- Now check your program through PLC.
- To stop run mode, press stop in online menu.
- To exit the execution mode, press logout in online menu.

<u>LOGIC DIAGRAM OF GATES</u>

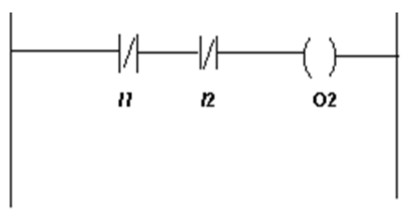
Ladder diagram for OR gate



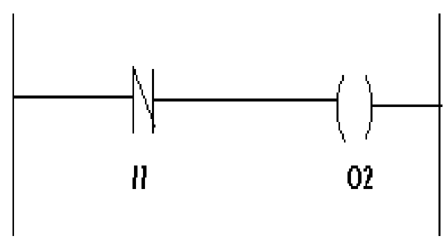
Ladder diagram of NAND gate



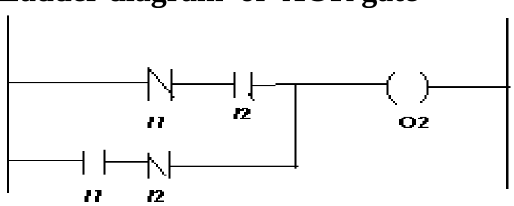
Ladder diagram of NOR gate



Ladder diagram of NOR gate



Ladder diagram of XOR gate



Result:
Using PLC , Student will able to Implement and execute Ladder diagrams for basic gates

EXPERIMENT: 11

SEQUENTIAL CONTROL OF MOTOR USING PLC

Aim:

To implement and execute ladder diagram logic for Sequential control of motors

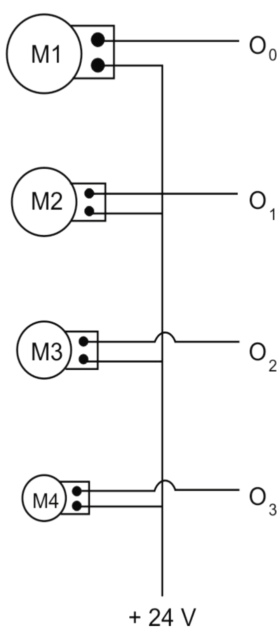
Apparatus:

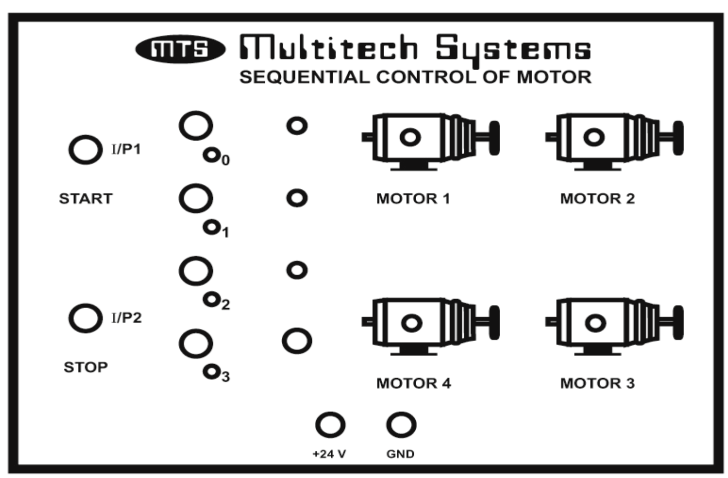
Messung PLC, Codesys Software

Application Module

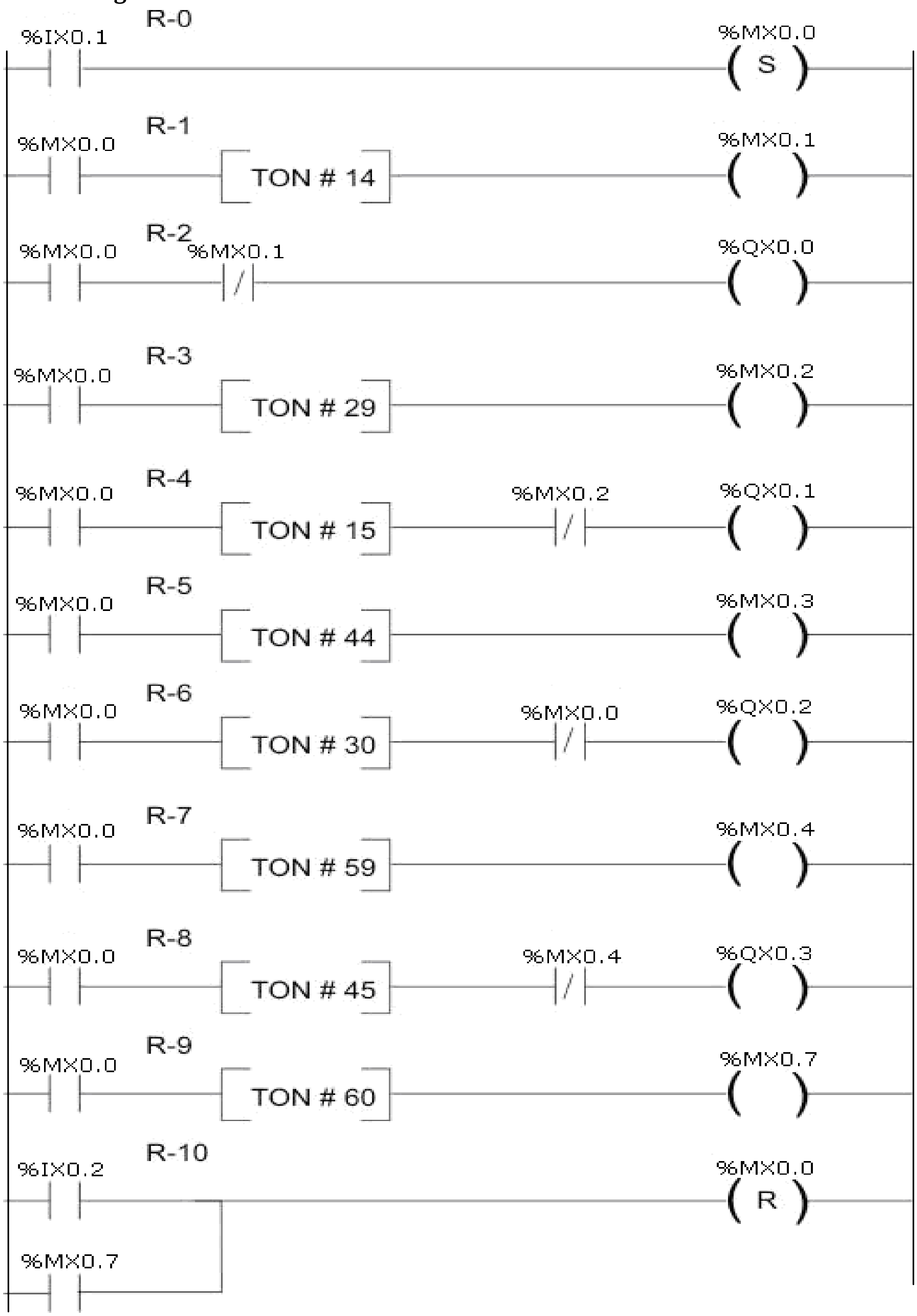
When I_1 is high 'M1' rotates with selectable time delay, when motor 'M1' rotating all other (M2, M3, M4) must be in OFF condition. When next motor 'M2' rotates with selectable time delay, all other motors (M1, M3, M4) are OFF. When next motor 'M3' rotates with selectable time delay, all other motors (M1, M2, M4) are OFF. When next motor 'M4' rotates with selectable time delay, all other motors (M1, M2, M3) are OFF. When I_2 is high rotating of motors will be OFF.

We have to switch I1 high and the motors start rotating one by one with the time delay as specified. The motors activate alternately one by one without giving any inputs.





Ladder Diagram:



Procedure

1. Using codesys software, develop ladder diagram for sequential motor control
2. Connect the patch cords of PLC input sockets I_1 & I_2 to sequential control of motor input sockets START(I/P1) & STOP(I/P2)
3. Connect PLC output sockets O_0, O_1, O_2 & O_3 to sequential control of motor output sockets O_0, O_1, O_2 & O_3
4. Connect+24V & GND respectively to PLC and sequential control of motor.
5. Load program into PLC For this select online menu → login

Discussion of Result:

Student will be able Implement and execute ladder diagram logic for sequential control of motors

EXPERIMENT: 12

RATIO CONTROL SYSTEM

Aim:

1.To Study ratio Control system

2. To Set and Control The ratio of controlled variable (Flow1) to wild variable (Flow2)

Theory:

Ratio control systems are feed forward systems wherein one variable is controlled in ratio to another to satisfy some higher-level objective. In ratio control systems, the true controlled variable is controlled in the ratio of controllable flow F1 to wild flow F2. R = F1 /F2.In the above system the ratio set is multiplied by the wild flow and the value is given as a set point to flow controller FIC. The controllable flow F1 and the wild flow F2 is measured with orifice meters and DP transmitters.

Ratio Station: The ratio station is the calculation box where the set point is generated for FIC. Calculations to be carried out in the ratio station block:

SP= F2 X Rs

Where

SP: Set point for controllable flow loop F1

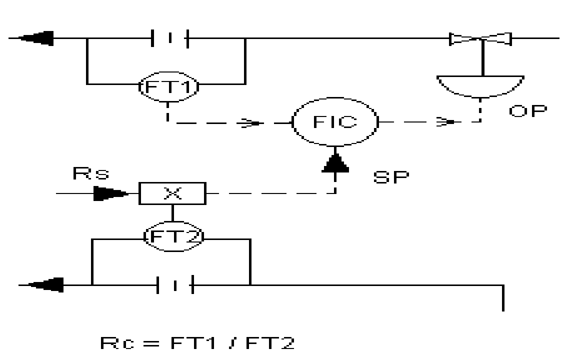
F1: Controllable flow displayed in %.

F2: Wild flow displayed in %. (Flow values displayed are square rooted values obtained from respective DP transmitter)

Rs: Ratio set. (Range 0.5 – 2)

Rc: Current ratio = Ratio of current flow values (**F1** / **F2**).

Fundamental diagram of Ratio control system



Procedure

1. If the tapings of orifice placed in the second inlet flow line to the process tank are short circuited by a PU tube loop, remove the loop. Connect pressure signal tappings of this orifice to FT2 with proper polarity.
2. Short circuit the pressure tappings of orifice placed in the outlet line of the process tank. (i.e. at the inlet of the left rotameter).
3. Start up the set up and adjust the Rotameter no. 3 (middle) and Rotameter-1(extreme right) to 100LPH. Remove air entrapped, if any,from the FT2. For removing air open the vent valves on the DP transmitter.
4. Provide air supply to the regulator and adjust it to 2 kg/cm^2
5. Switch on the computer and ensure MODBUS communication is initialized by executing Wonderware FactorySuite | IO Servers | Modicon Modbus)
6. Execute Programs | Wonderware | InTouch for *"*Multi Process trainerADAM-4022T*"* Select all in Windows to open and Click "Runtime".
7. For selecting Ratio Control: Click "Experiment On"; Click "Experiment off". Then Click " Ratio Control"
8. Adjust Rotameter no.3 to @ 75 LPH.
9. From the default values of PB=75, IT=8, DI=2, Ratio Set (RS)=1, observe that the flow in rotameter no.1 is automatically adjusted and become equal to that of rotameter no.3.
10. Manipulate the flow in Rotameter no. 3 and observe the effect on Rotameter no.1.
11. Change the ratio (range 0.5-2) and observe the effect.

Tabular column

S.no	**Time**	**Set point (ratio)**	**Flow1**	**Flow2**	**Measured ratio**

Observations

The ratio of controlled variable (Flow1) to wild variable (Flow2) can be set and Controlled

Discussion of result:

1. Student able to understand concept ratio control system
2. Student can be set and Control The ratio of controlled variable (Flow1) to wild variable (Flow2)