PRESSURE CONTROL TRAINER

Product Code 314A

(PCT version)
(With Ethernet / USB communication)

Instruction manual

Contents

Apex Innovations

Documents to be referred

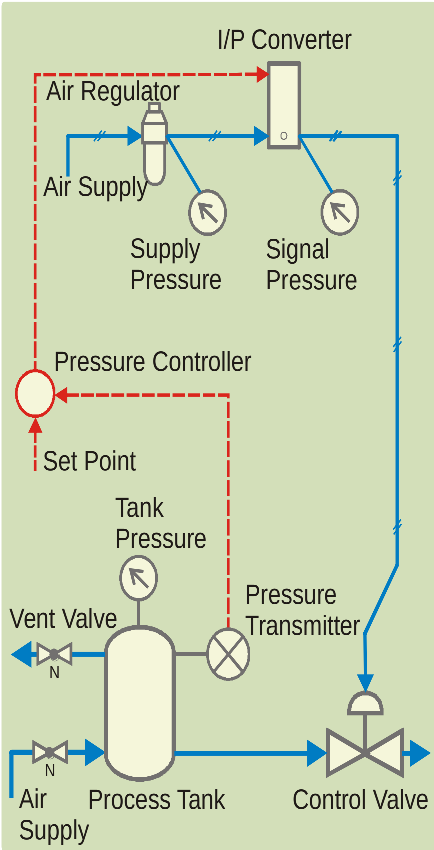
Following table lists various documents available in **PCTSoft** CD which needs to be referred while working with the product.

File name	Document description
Theory Process Control.pdf	Describes theoretical aspects of process control study
Components.pdf	Additional details of the components used

Description

Pressure control trainer is designed for understanding the basic principles of pressure control. The process set up consists of pressure vessel fitted with pneumatic control valve. Pressure transmitter is used for pressure sensing. The process parameter (Pressure) is controlled by microprocessor based digital indicating controller which manipulates pneumatic control valve fitted at outlet of pressure tank outlet through I/P converter. These units along with necessary piping are fitted on support housing designed for tabletop mounting.

The controller can be connected to computer through Ethernet /USB port for monitoring the process in SCADA mode.



Specifications

Product	Pressure control trainer
Product code	314A
Type of control	SCADA
Control unit	Digital indicating controller with Ethernet communication
Communication	Ethernet / USB
Pressure Transmitter	Type Two wire, Range 0–2.5 bar, Output 4–20 mA
I/P converter	Input 4-20mA, Output 3-15 psig
Control valve	Type: Pneumatic; Size: 1/4", Input: 3–15 psig, Air to close, Characteristics: linear
Process tank	Pressure vessel, MS
Air filter regulator	Range 0-2.5 kg/cm^2
Pressure gauge	Range 0-2.5 kg/cm^2(1No), Range 0-7 kg/cm^2(2Nos)
Overall dimensions	550Wx480Dx525H mm
Optional	Compressor

Packing slip

Box No.1/1	Size W575xD500xH525 mm; Vol:0.15m^3	Gross weight: 34 kg Net weight:21 kg
1	Set up assembly	1 No
2	Piping set (1 Pieces)	1 No
3	Male stud 2Nos (4*6tube 1/4 thr, 4*6tube1/2thr)	1 No
4	Communication cable	1 No
5	Tool kit	1 No
6	Set of instruction manuals consisting of: “PCTSoft” CD (Apex Innovations) User’s manual Yokogawa User’s manual reference CD (Yokogawa)	1 No

Installation requirements

Installation requirements

Electric supply

Provide 230 VAC single phase electric supply with proper earthing. (Neutral – Earth voltage less than 5 VAC)

- 5A, three pin socket with switch (1 No.)

Air supply

Clean, oil and moisture free air, pressure 3 Bar, Air consumption 7.0 m^3/hr

Computer

Computer with standard configuration

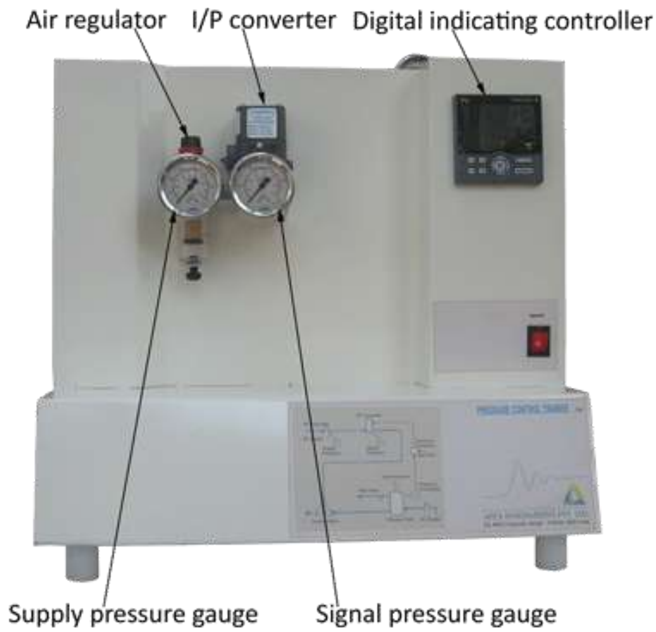
Support table

Size: 800Wx800Dx750H in mm

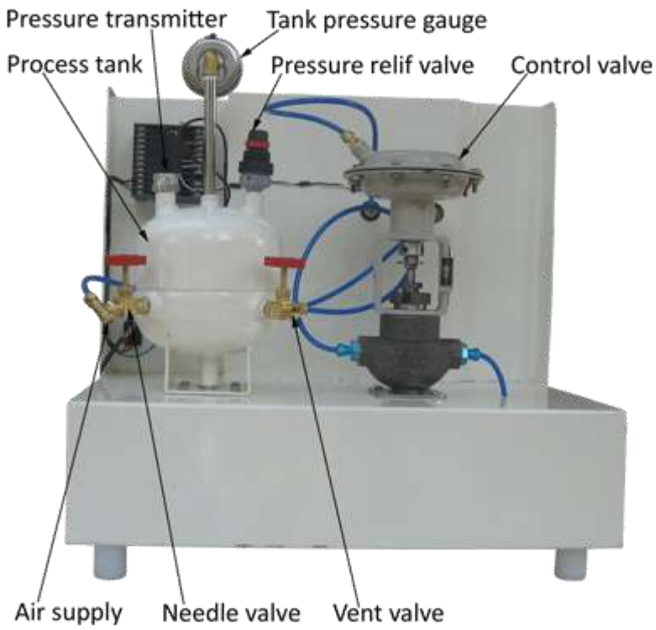
Installation Commissioning

Installation (Ethernet port equipment)

Front view:

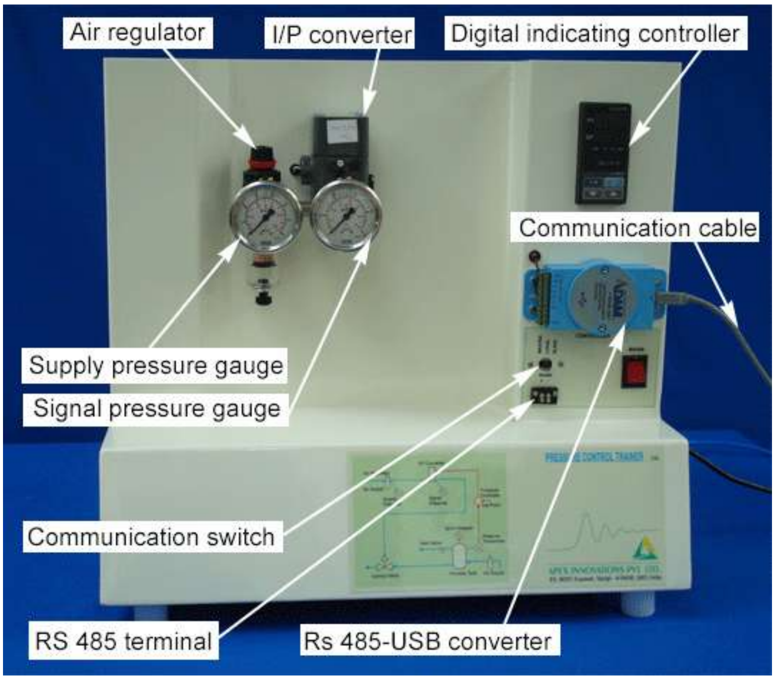


Back view:

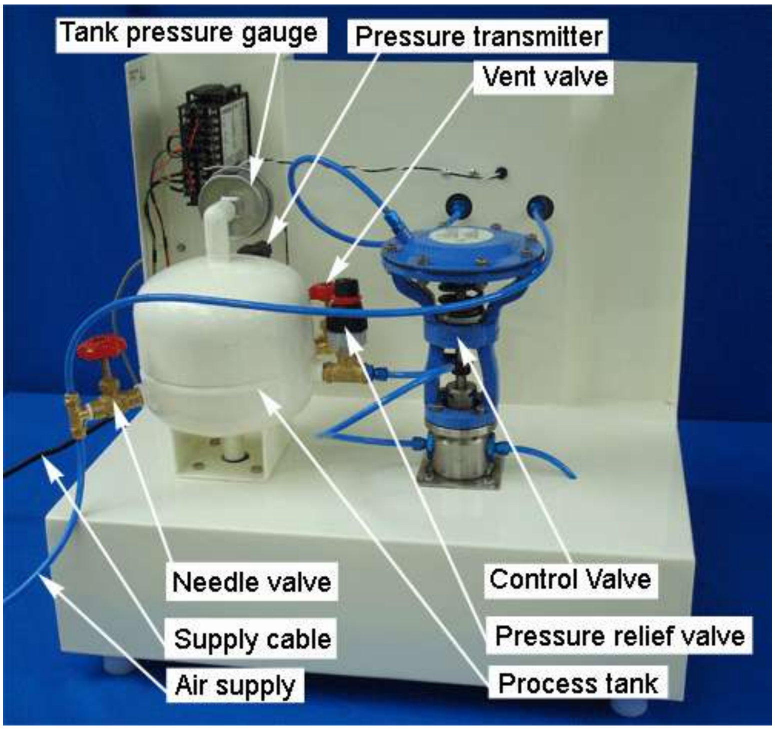


Installation (USB port equipment)

Front View:



Back view:



- Unpack the box(es) received and ensure that all material is received as per packing slip (provided in instruction manual). In case of short supply or breakage contact Apex Innovations / your supplier for further actions.
- Place the set up on table
- Air supply: Ensure that clean and oil free air is received from compressed air source (compressor / mini compressor) by venting out the air for few minutes. Then connect air supply to the set up.

Commissioning

- Connect electric supply. Switch on Mains.
- Switch on the compressed air source and adjust the ***Air regulator*** to set supply air pressure at @ 2 kg/cm^2.
- Set the ***Digital indicating controller*** to manual mode by pressing the A/M key and increase output to 100%
- Open the needle valve at the inlet of the pressure tank and adjust the ***Pressure relief valve*** to 2.5 kg/cm^2.
- Decrease output of controller from 100% to 0% in steps of 25%. Check the pressure on pressure gauge at the output of I/P converter is varying from 15-3 psig and ensure that control valve operates from full close to full open position.
- Switch on the computer and install "MCRInstaller " provided on PCTSoft CD
- Copy the file "Apex_Process_Trainers" at any drive/ folder.
- Create the desktop icon for the "Apex _Process_Trainers" for further use.
- **For Ethernet port equipment**

  Set computer IP address as **192.168.1.2**

  For USB port Equipment

  Install ADAM-4561 USB Drivers provided on ADAM Driver CD / PCT Soft CD
    - Note to which port ADAM-4561 is connected
    - Click Start | Right Click on Computer | Click Manage | Click Device Managaer |
    - Click Ports and Note the COM port Number to which the ADAM is connected.
    - Following screen shows it is connected to COM4
- Execute the software and ensure correct signals are displayed on computer.

NOTE: Do not disturb the pressure relief valve once set at 2.5 kg/cm^2.

Troubleshooting

Note: For component specific problems refer components' manual

Problems	Possible causes / remedies
Control valve does not operate	• Faulty I/P converter • No output from Controller
I/P converter does not work	• Insufficient supply air pressure • Faulty electrical input signal
No communication with computer	**For Ethernet port equipment** • Check communication settings for IP addresses of computer and controller. Default setting computer 192.168.1.2 and controller 192.168.1.14 **For USB port equipment** • Improper USB port connection • Computer USB port not configured. • Ensure that the communication switch position is "Local" • Check communication settings P.SL, bPS, PrI, StP, dLn, Adr setting of the controller (Refer "Parameter setting sheet" provided in "Software Process control")

Components used

Product	Pressure control trainer
Product code	314A
Pressure Transmitter	Make Wika, model Eco, Output 4-20mA (2 wire), Supply 24VDC, range 0-2.5 bar, process conn. 1/4"BSP(male)
Digital indicating controller	Make Yokogawa, Model UT35A-002-11-00 with Ethernet communication Make Yokogawa, Model UT321/UT32A(with RS 485 communication)+ RS485-USB converter, Model ADAM 4561 Make Advantech
I/P converter	Make Control air inc, Type T500-AC, Input 4-20 mA DC, output 3-15 psig, end connection 1/4 NPT
Control valve	Make Pneucon, Type globe 2 way, Model 119, size 1/2"x1/8", Screwed end(F), Body CCS, Trim SS, Travel 14.3, CV=0.1, Air to CLOSE, Spring range 0.2-1, actuator 12 sq inch.
Air filter regulator	Make Airmatic, Model MB10-02-1-PAP-PD (Alu body, Polycarbonate bowl, G1/4 BSP, Range 0-2 Kg/cm^2, Relieving, 25M Plastic element, Bunan diaphragm.
Pressure relief valve	Make Airmatic, Model MRV-022, Range 0-3.5Kg/cm^2, Size G1/4, Alluminium.
Pressure gauge	Make Wika, Dia.2.5", Gly. filled, Brass internls, S.S. casing, Range 0-2.5 Kg/cm^2 and 0-35 PSI, 1/4"BSP (M) back connection without bracket.
Pressure gauge	Make Wika, Dia.2.5", Gly. filled, Brass internls, S.S. casing, Range 0-7 Kg/cm^2 and 0-100PSI, 1/4"BSP (M) back connection without bracket.

Warranty

This product is warranted for a period of 12 months from the date of supply against manufacturing defects. You shall inform us in writing any defect in the system noticed during the warranty period. On receipt of your written notice, Apex at its option either repairs or replaces the product if proved to be defective as stated above. You shall not return any part of the system to us before receiving our confirmation to this effect.

The foregoing warranty shall not apply to defects resulting from:

- Buyer/ User shall not have subjected the system to unauthorized alterations/ additions/ modifications.
- Unauthorized use of external software/ interfacing.
- Unauthorized maintenance by third party not authorized by Apex.
- Improper site utilities and/or maintenance.

We do not take any responsibility for accidental injuries caused while working with the set up.

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Experiments

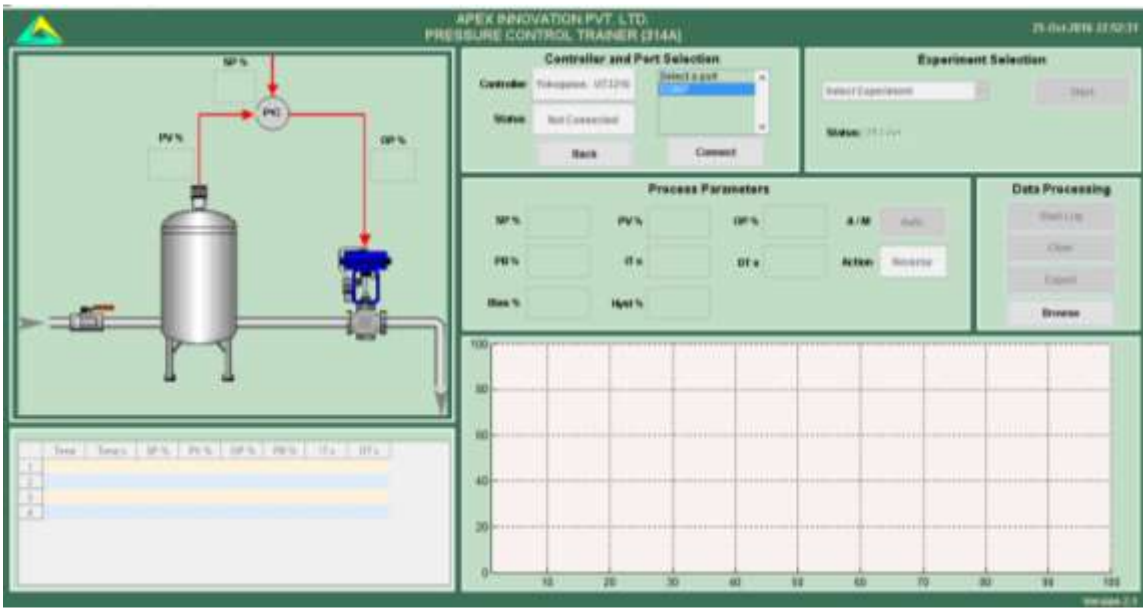
General Instructions

1 The experiment nos 1 thr 6 are to get feel of the process and PID settings.

2 Startup Setup

- Switch on Mains.
- Switch on the compressed air source and adjust the ***Air regulator*** to set supply air pressure at @ 2 kg/cm^2.
- Switch on computer
- Double click on Apex_Process_Trainers icon on the desktop

- Select product Pressure Control Trainer (312A), select Controller Yokogawa (UT35A or UT321E or UT32A whichever available with you) and Click Continue



- For Ethernet port equipment Click Connect
- For USB port equipment select Port to which ADAM 4561 is connected and Click Connect

1 Study of open loop response (Manual control)

- **Start up** set up as explained in general instructions.
- Click Select Experiment, select **Open Loop** and click Start
- Close the control valve by increasing the controller output to 100%. Note down steady state process value.
- Apply the step change by 10% to controller output and wait for the process value to reach the steady state value. Note down the process value.
- Repeat the above step until the controller output reaches to minimum 0%.

Observations

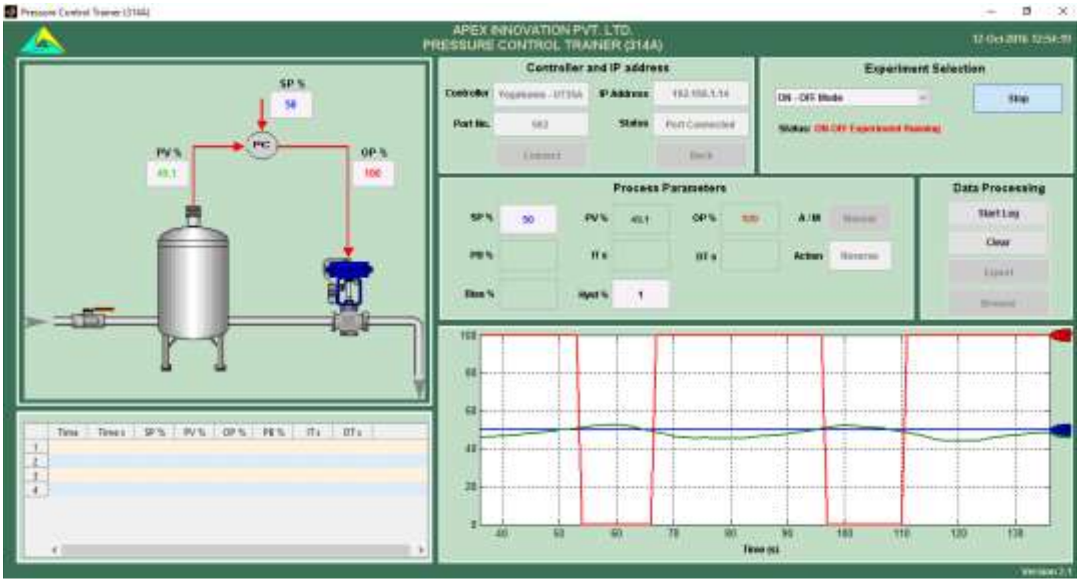
Tabulate the observations as follows

Controller output in %	Process Value in %
100	
90	
80	
…	
0	

- From the above data, note the output required for maintaining the process at desired set points. (for particular vent valve opening).
- Set the output of the controller to the noted value and at steady state apply the load change to the process. Load change can be given by slightly varying the vent valve. Observe new steady state process value.

2 Study of on/off controller

- **Start up** set up as explained in general instructions.
- Click Select Experiment, select **On-Off Mode** and click Start
- Change Hystresis value to 1%.(Range 0.1-10%)
- Change the values of the set point and observe the On-Off control operation.

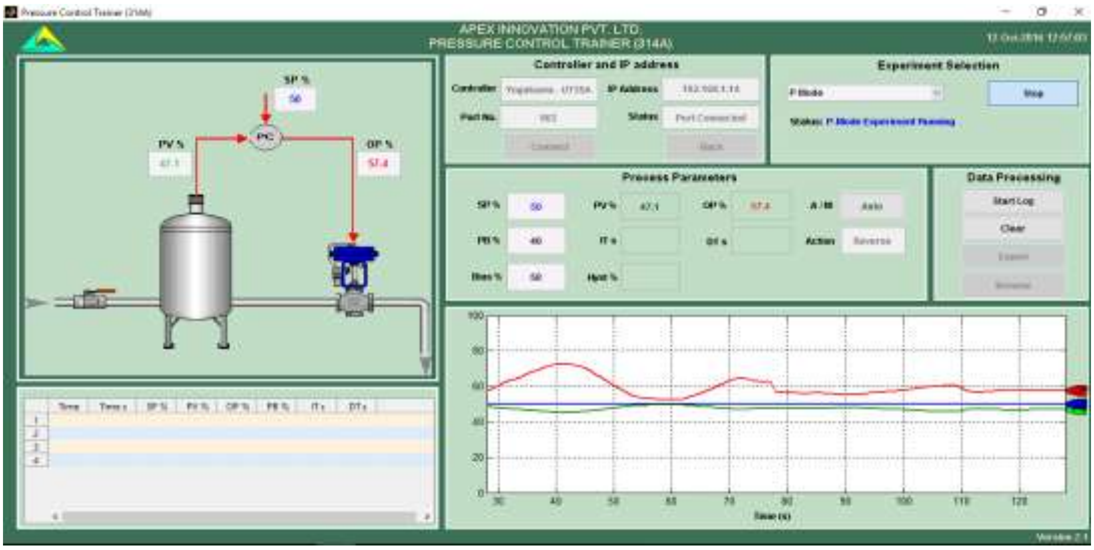


Observations

- Observe that if process value exceeds the set point and increases above the value of (0.5x Hysteresis), control valve is full open and if process value decreases below the set point by (0.5 x Hysteresis), the control valve closes fully i.e. controller operates like On/Off switch.

3 Study of proportional controller

- **Start up** set up as explained in general instructions.
- Click Select Experiment, select **P Mode** and click Start
- Keep the set point to 60%. Change output mode to Manual. Adjust output value so as to match the process value with set point and apply this output value as bias value to the controller. Adjust the proportional band to 50%.
- Switch the controller to Auto mode.
- Apply step change of 10% to set point and observe the response.
- Switch the controller to Manual mode. Decrease proportional band to half of the previous value & then shift controller to Auto mode. With each decrease, obtain a new response of the step change. Ensure that the set point changes are around the same operating point (@ 5-10% only).
- 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.
- Set the controller to the settings obtained in the above step and wait for the system to reach at steady state.

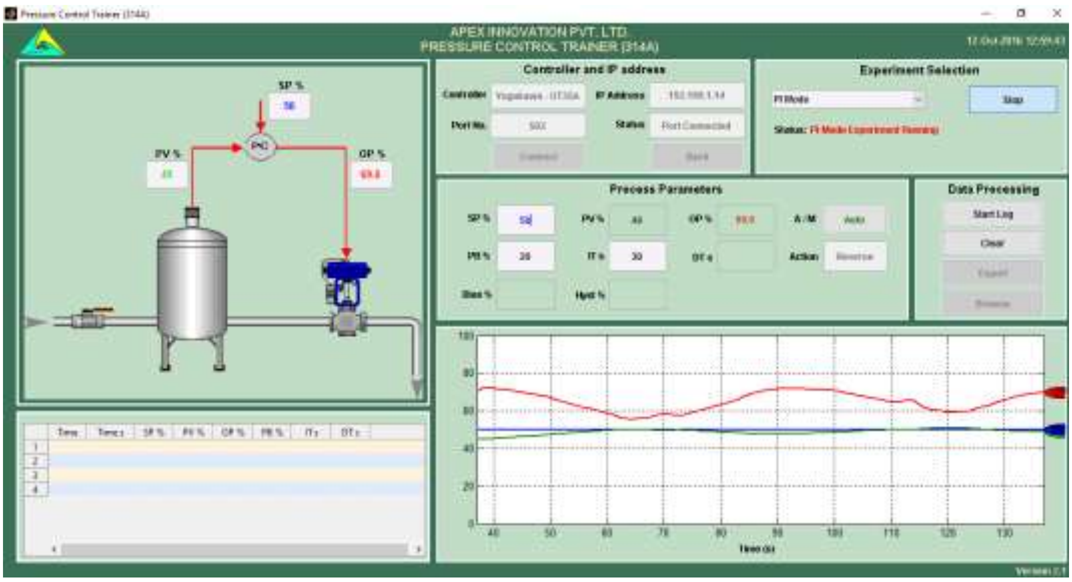


Observations

- Observe steady state error decreases as proportional band decreases.
- Observe the effect of very low proportional band values (system works in oscillatory mode).
- Observe the response of the system at load change. Load change can be given by slightly manipulating the vent valve of the tank.
- Study of proportional integral controller

4 Study of proportional integral controller

- **Start up** set up as explained in general instructions.
- Click Select Experiment, select **PI Mode** and click Start
- Adjust the process value by changing the output of controller in manual mode to a particular pressure (set point =60%).
- Set the proportional band estimated from Proportional control (from previous experiment). Start with derivative time=0 and integral time=1000 sec., which will cut off the derivative action and widen the effect of integral action.
- Set the set point to desired pressure (@60%). Allow the process to reach at steady state. Record the steady state error.
- Switch on the controller to manual mode. Reduce the integral time to half of the previous value. Switch to Auto mode and apply step change to the set point by 2 to 3%. Note the response of the system.
- Using trial and error, find out an integral time, which gives satisfactory response to the step change in set point.

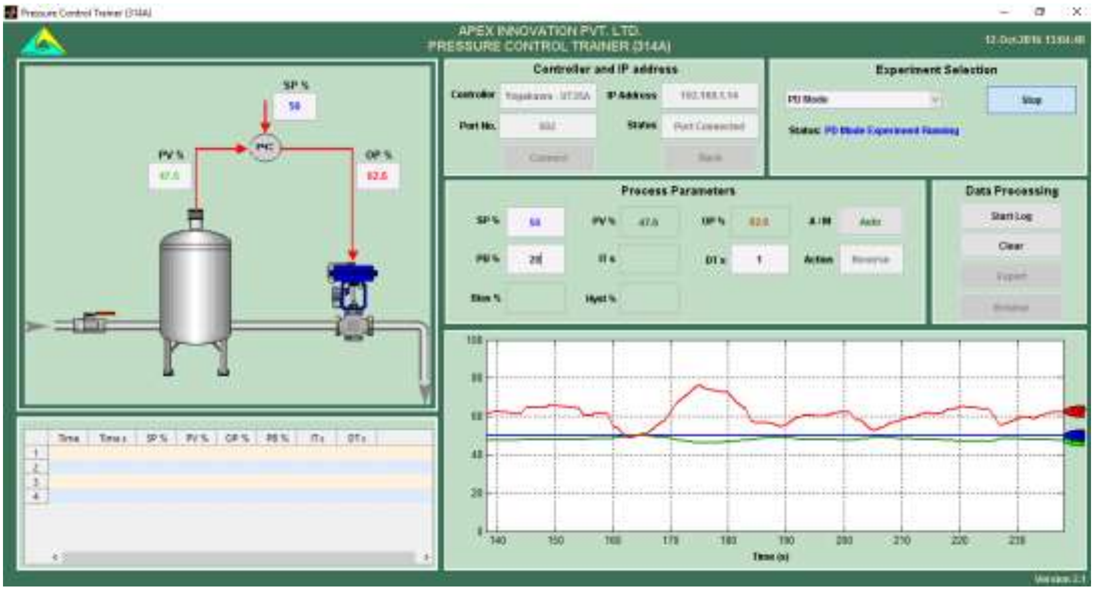


Observations

- Observe the effect of reducing integral time on offset and on the response of the process.

5 Study of proportional derivative controller

- **Start up** set up as explained in general instructions.
- Click Select Experiment, select **PD Mode** and click Start
- Select PD controller. Set the proportional band estimated from Proportional control (P only). Start with derivative time=0 and integral time=6000 sec., which will cut off the derivative action and widen the effect of integral action.
- Set the set point to desired pressure (@60%). Allow the process to reach at steady state. Note the response of the system.
- Switch on the controller to manual mode. Increase the derivative time by 1 sec. Switch to Auto mode and apply step change to the set point by 2 to 3%. Note the response of the system.
- Increase the derivative time gradually and observe the process response for step change.

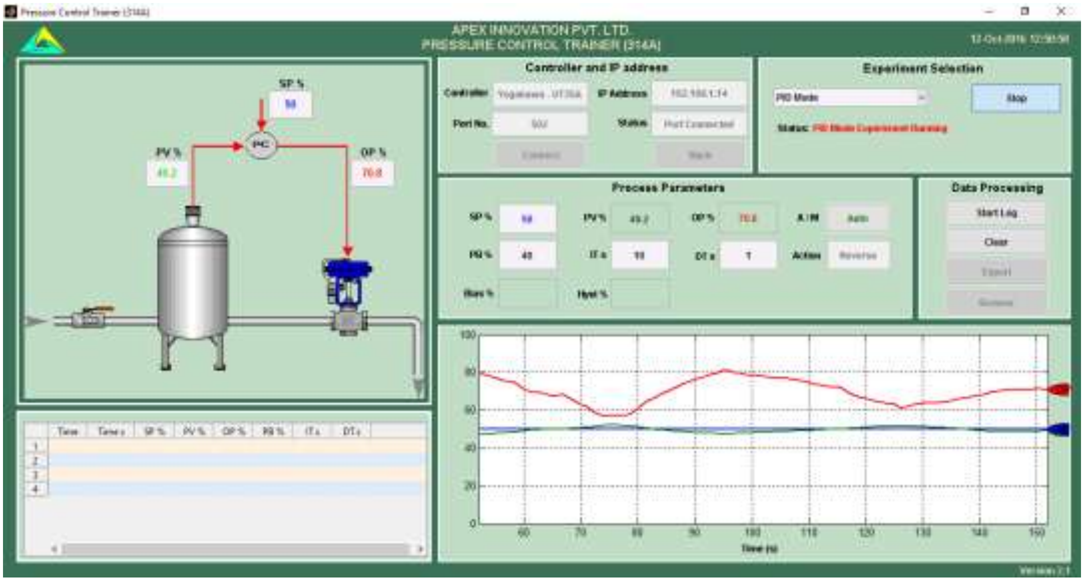


Observations

- Observe the effect of increasing derivative time. Also note that the process may show offset as effect of integral action is cut off.

6 Study of proportional integral derivative controller

- **Start up** set up as explained in general instructions.
- Click Select Experiment, select **PID mode** and click Start
- Switch the controller to manual mode.
- Change the proportional band to the value that estimated in proportional controller. Set integral time and derivative time based on the responses in previous experiments.
- Change the controller to Auto mode. Apply step change by 2 to 3% to the set point and observe the response of the process.
- Change the proportional band, integral time, derivative time and observe the response of the process for step change for each change in setting.



Observations

- Compare the steady state response of the PID controller with P, PI and PD controller obtained in the previous experiments.

7 Tuning of controller (Open loop method)

- **Start up** set up as explained in general instructions.
- Click Select Experiment, select **Process Reaction** and click Start
- Adjust controller output, so that the process value is maintained at 60%.
- Start data logging.
- With the controller still in manual mode impose a step change apply a 20 - 30 % change to controller output. (Open the control valve) Record the step response. Wait for the steady state.
- Stop data logging.
- Plot the step response (Process reaction curve) from stored data. Find out the value of slope at the point of inflection and time lag.
- Calculate P I D settings for different modes.
- Select **PID Mode** option for control from software. (Click on "Change Expt." Button, click on "Change", Click on "PID Mode" button.) Switch on the controller to manual mode and Keep the set point to 60%. Adjust output value so as to match the process value to set point.
- Set the PID values obtained from the calculations. Switch on the controller to Auto mode. Apply the step change & observe the response of the system. Allow the system to reach steady state.

Observations

(Refer Theory process control for formula.)

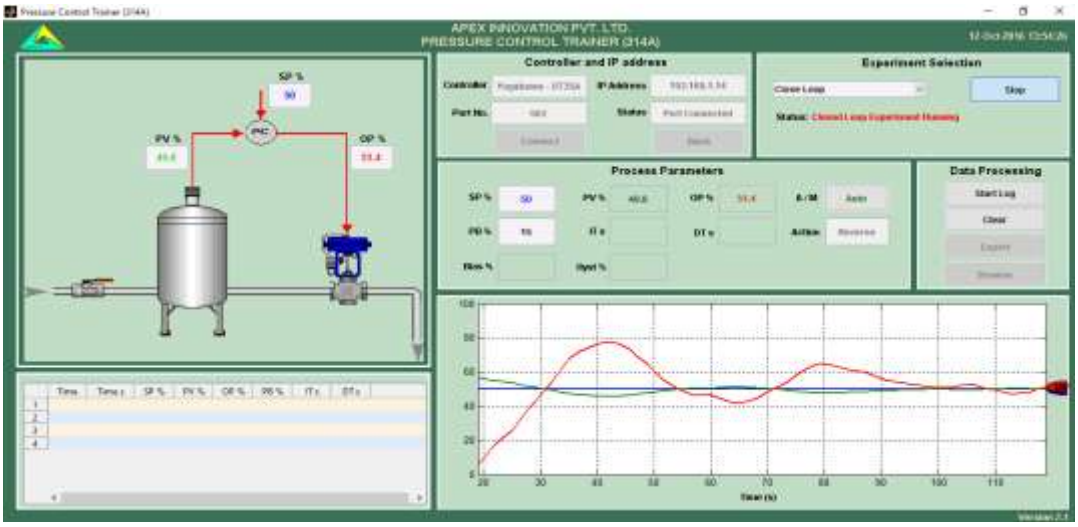
- Step change to the system P = Initial output - Final output of the controller.
- Plot the graph of process value Vs Time on a graph paper.
- From process reaction curve:

  Slope of the process reaction curve R =

  Time lag L=
- Calculate P, PI, PID setting from above values.
- Observe response of the system for different PID settings.

8 Tuning of controller (Closed loop method)

- **Start up** set up as explained in general instructions.
- Click Select Experiment, select **Close Loop** and click Start
- Set the proportional band value to maximum (Say 100). Set the controller to manual mode and adjust the output so that the process is nearly at set point (60%).
- Set controller to auto mode and impose step on the process by moving the set point for a few seconds & then return to its original value (or apply the step change to the set point of 5%). Wait for some time & observe the response.
- Decrease the proportional band to the half of previous and impose step on the process as mentioned above. Wait for some time & observe the response.
- Repeat the above procedure and find out correct value of proportional band for which the system just goes unstable i.e. continuous oscillations are observed in the output of controller.
- Record the ultimate proportional band and ultimate period from the response.
- Calculate the PID values from the table. Select the PID controller and apply the parameter values obtained from the above steps. Observe the response of the process to a step change with these settings.

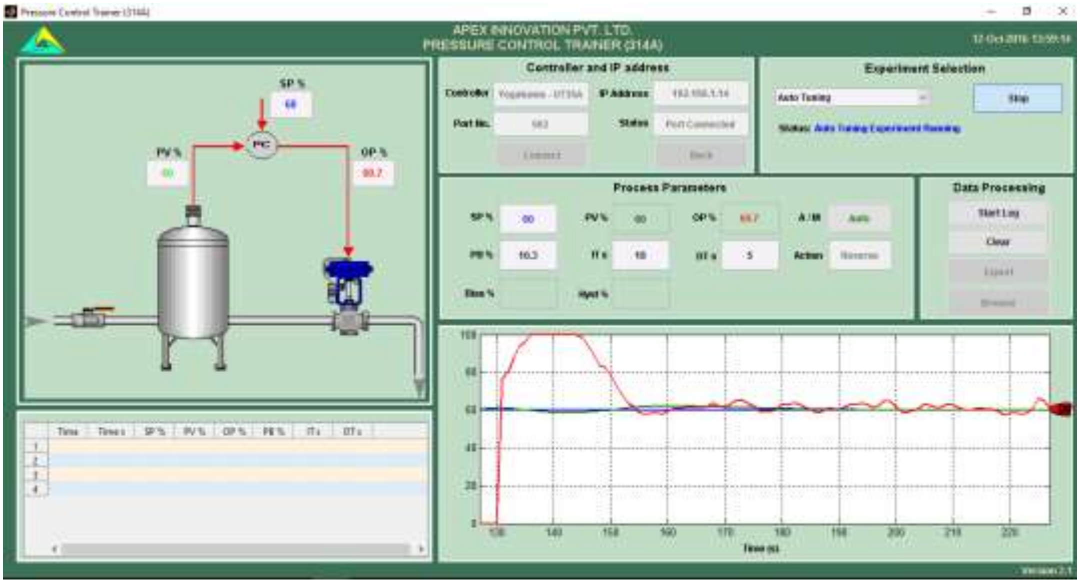


Observations

- Record the ultimate proportional band (Pbu) and ultimate period (Tu) from above experiment.
- Calculate PID values by referring theory part for different control actions.
- Observe the process response for these settings.
- Compare the values obtained with open loop response method.

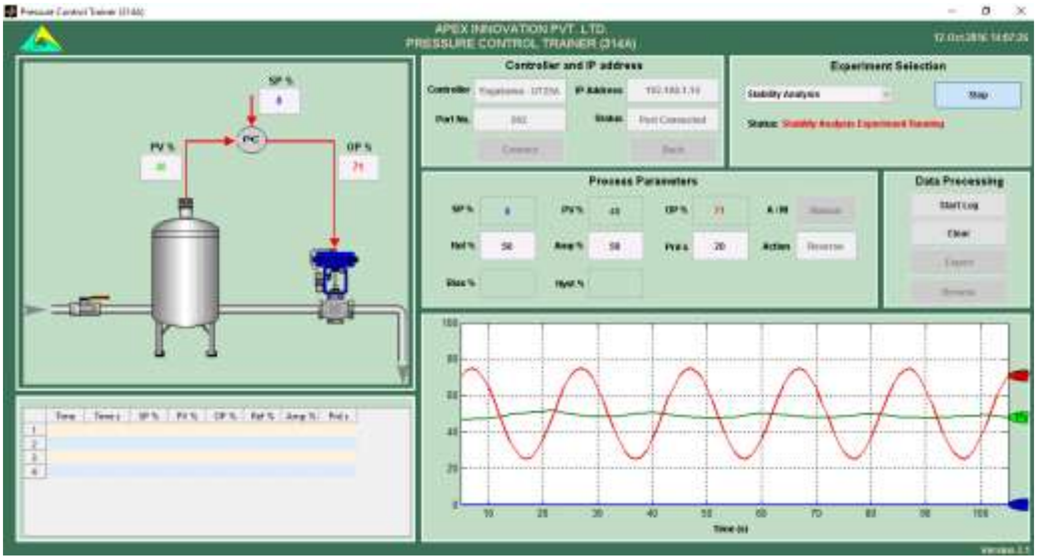
9 Tuning of controller (Using Auto Tuning method)

- **Start up** set up as explained in general instructions.
- Click Select Experiment, select **Autotune** and click Start
- Wait Till Autotune is complete. (Blinking of green LED stops).
- Controller automatically finds the PB, IT & DT values.
- Find out PID values at different set points /vent valve positions rates.



10 To study stability of the system (Bode plot)

- **Start up** set up as explained in general instructions.
- Click Select Experiment, select **Stability analysis** and click Start
- Select function generator to apply the sinusoidal input to the output of the controller.
- Enter Reference point, Amplitude and Period.
- Observe the sinusoidal output of the controller and sinusoidal response of the process.
- Log the data for records.
- Change the period and repeat the observation for 3-4 different values of the period.



Observations

- Form the data file stored note down the
- Observe the output response of the process and note down the output amplitude. Measure output wave period and note down as T sec. Measure the phase lag x and note down in sec.

Obs. No.	Input amplitude A1 %	Output amplitude A2 %	Output Period T in sec	Lag X In sec	Frequency

Calculations

- Calculate for each observation

  Magnitude ratio as M = A2/A1

  Phase angle = (X/T) x 360

  Frequency = 1/T cycles / sec.
- Draw the graphs of:

Magnitude Vs frequency on log - log scale

Phase angle Vs frequency on semi-log coordinates.

- Study the graph for stability conditions mentioned in theory.