PROCESS INSTRUMENTATION

Course Project Report

Name of Topic: Tuning of PID controller for pressure control application

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Problem Statement

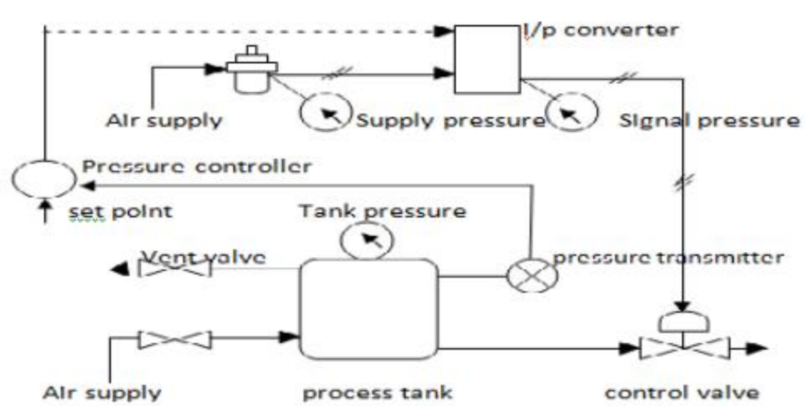
Measurement of Pressure is one of the very essential parameter in a process station which needs to be controlled. So PID controller plays an important role in measurement and controlling the process parameter. On the other hand, Poor pressure control can cause major safety, quality, and productivity problems. On addition to this high pressure inside a closed system can cause an explosion. Therefore, it is highly preferable to keep the pressure inside the closed loop system in control and to maintain it within its safety limits which becomes the prerequisite of pressure control.

So Our course project is giving solution for this problem by providing different method of PID controller tuning due to that we will get correct output result in pressure measurement

Methodology

A. Experimental setup of pressure process

In this setup the process tank is connected with an air supply valve and vent valve for safety purpose, in order to indicate the process tank, pressure an indicator is fixed over the tank. The pressure transmitter used here is a two wire type, (range 0- 5 bar, output 4-20 mA) the transmitter is connected to the controller which is LabVIEW. The controller is also fed with the set point, the control signal is fed to the I/P converter of (Input 4-20mA, output 3-15 psig) I/P is also connected with air filter regulator (range0-2.5 kg/cm2). The output from I/P converter is given to the control valve (pneumatic; size: ¼", Input:3-15 psig, air to close, characteristic: linear) from which the pressure of the process tank is maintained



B. System transfer function

Model validation is done by using two-point method the basic formulae for calculating time constant and delay time is given below Two-point method:

T=1.5(t63.2% - t28.3%)

Ʈ= t32.2% - T

From the process we obtain a transfer function which is a first order plus dead time (FOPDT) of the form given below

$$G(s) = \frac{k_p e^{-\tau_d (s)}}{\tau s + 1}$$

Where, K - Steady state gain of the process

Ɵs - dead time of the process

Ʈ- time constant of the process

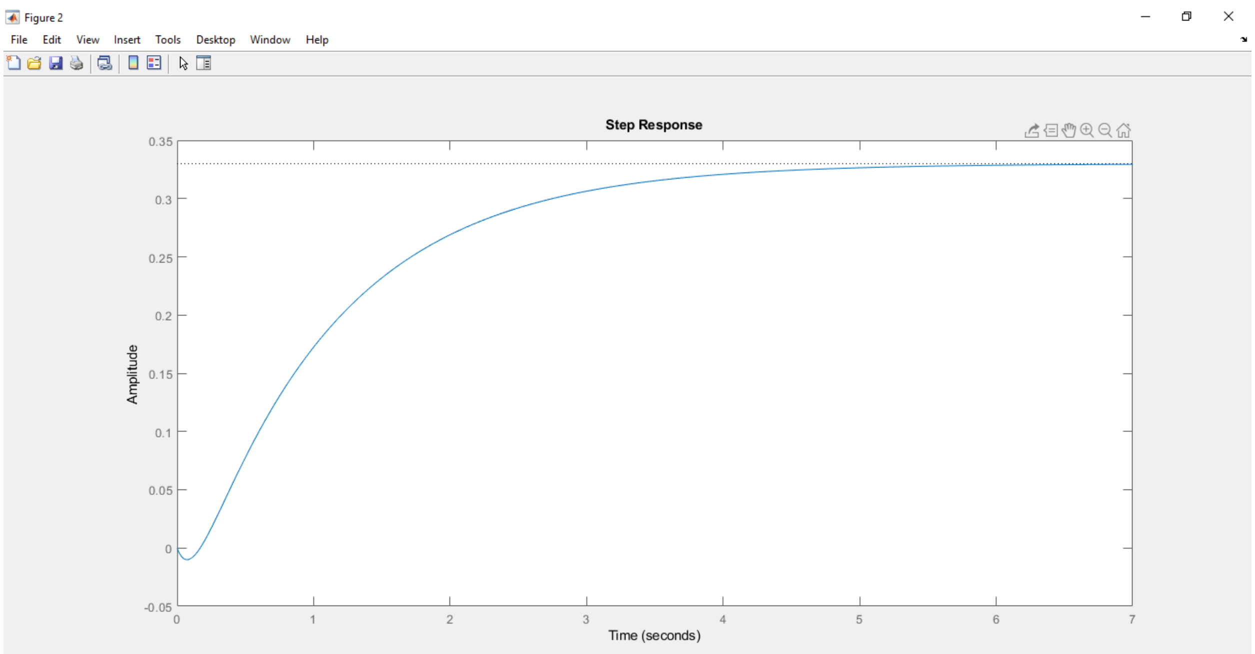
Actual values get by calculation

$$G(s) = \frac{0.33e^{-0.2197s}}{1.055s + 1}$$

Continuous time response obtained in Matlab using pade () function

$$G(s) = \frac{-0.33\, s + 3.004}{1.055\, s^2 + 10.6\, s + 9.103}$$

System Step response

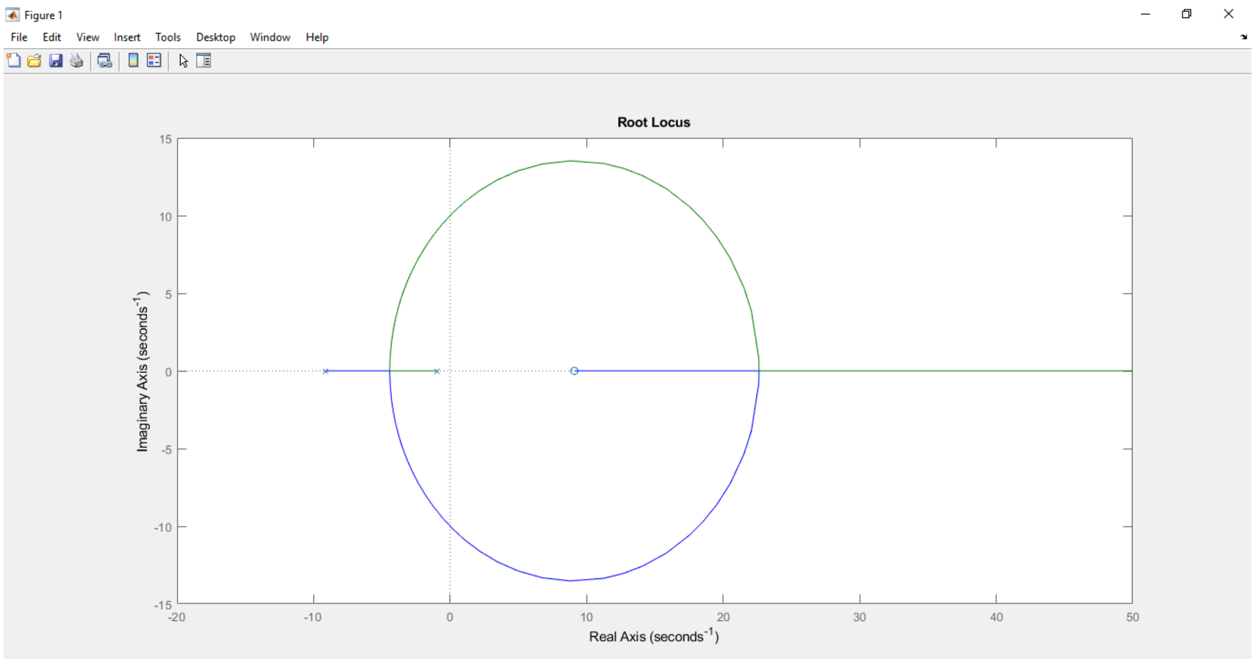


Rise time=2.32s

Settling time= 4.35s

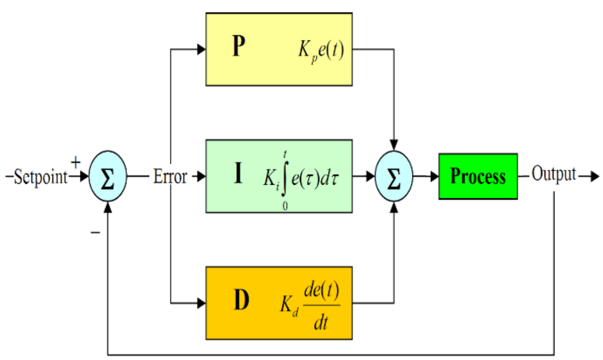
Final value=0.33

System root locus



Implementation of PID Controller

Continuously calculates the error between measured value and set-point. Applies correction based on proportional, integral and derivative actions.



$$u(t) = K_p e(t) + K_i \int e(t)dt + K_p \frac{de}{dt}$$

- P - Proportional term. Changes output linearly with error. Gives faster response. Constant is Kp.
- I - Integral term. Output keeps changing till error is zero. Removes offset error. Constant is Ki.
- D - Derivative term. Anticipates future error. Gives output if error is changing. Constant is Kd.

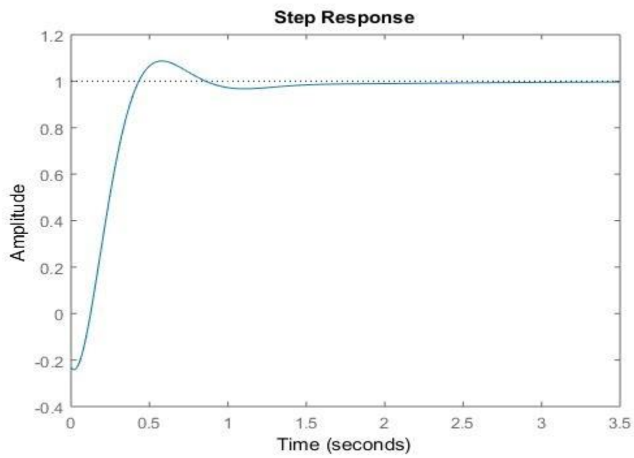
PID tuning methods and output of improved step response:

1. Manual tuning

In manual method we use below table for calculation of Kp, ki, kd

Parameter	Rise time	Overshoot	Settling time	Steady-state error	Stability
K_p	Decrease	Increase	Small change	Decrease	Degrade
K_i	Decrease	Increase	Increase	Eliminate	Degrade
K_d	Minor change	Decrease	Decrease	No effect in theory	Improve if K_d small

Output step response of manual method



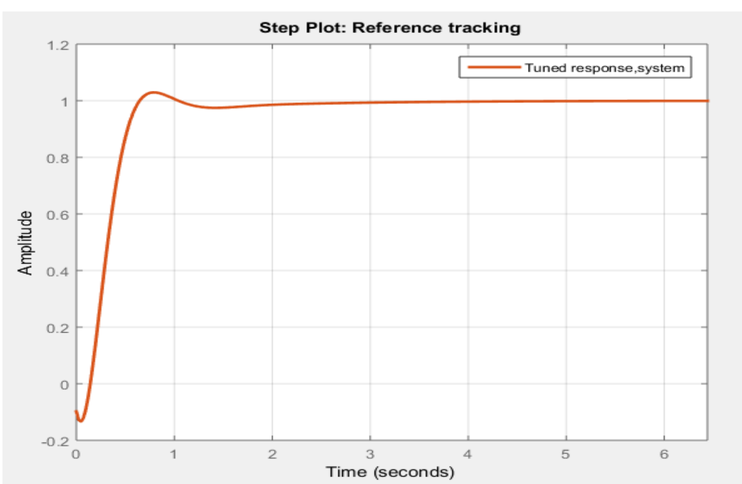
- Set Ki, kd to zero
- Increase Kp till system oscillates
- Increase Ki to eliminate offset, Increase Kd to reduce overshoot

Kp = 14, Ki = 10.5, Kd = 0.6

Rise time = 0.27 s
Settling time = 1.3 s
Overshoot = 8.69%

2. Using Matlab PID tuner:

Output Step response



Kp = 10.2, Ki = 7.9, Kd = 0.28

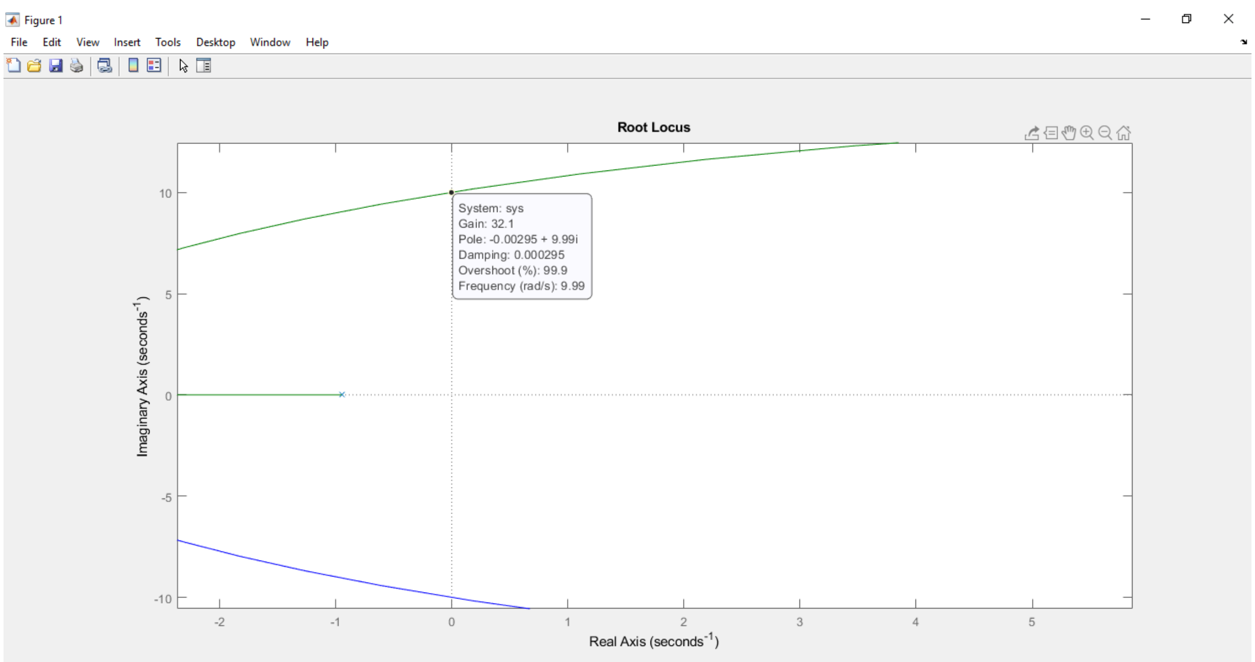
Rise time = 0.3 s
Settling time = 1.6 s
Overshoot = 2.94%

3. Zeigler-Nichols method

Controller Type	From step response			From frequency response		
	Kp	Ti	Td	Kp	Ti	Td
P	1/a			0.5Kc		
PI	0.9/a	3L		0.4Kc	0.8Tc	
PID	1.2/a	2L	L/2	0.6Kc	0.5Tc	0.12Tc

A. By root locus (frequency response method)

When we zoom the root locus plot and click at the points where our poles are lies on jw axis because till jw axis to left system plot is stable then we get proper information of system gain and frequency and from that we can calculates kp, ki and kd



After getting values of gain=32.1 and frequency =9.99 we can find period 2*3.14/Frequency

Editor - E:\pi_cp_25C.m

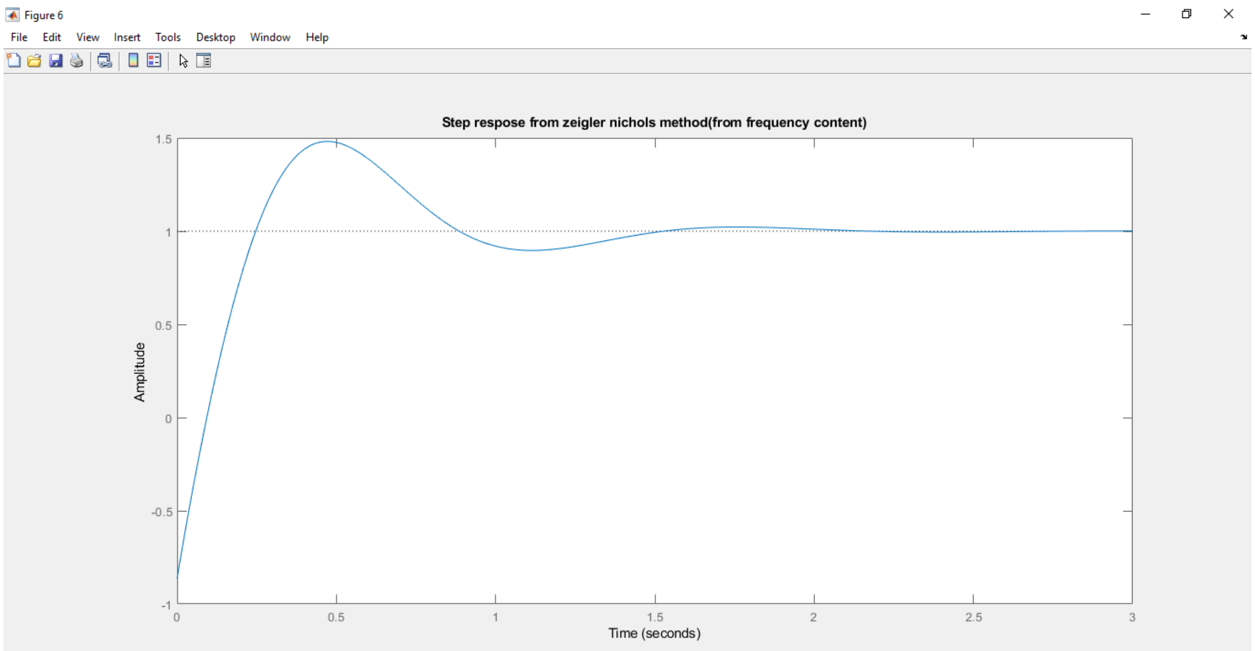
pi_cp_25C.m | pi_cp.m

```
s=tf('s');
sys1 = (0.33*exp(-0.2197*s))/(1.055*s+1);
pade(sys1);
sys=(-0.33*s + 3.004)/ (1.055*s^2 + 10.6*s + 9.103)
figure;
rlocus(sys);
figure;
step(sys);

ku=32.1;
wu=10;
pu=2*3.14/wu;
```

We get values for kp, ki, kd by using zeigler-nichol table

Kp = 18.9, Ki = 60.1, Kd = 1.48

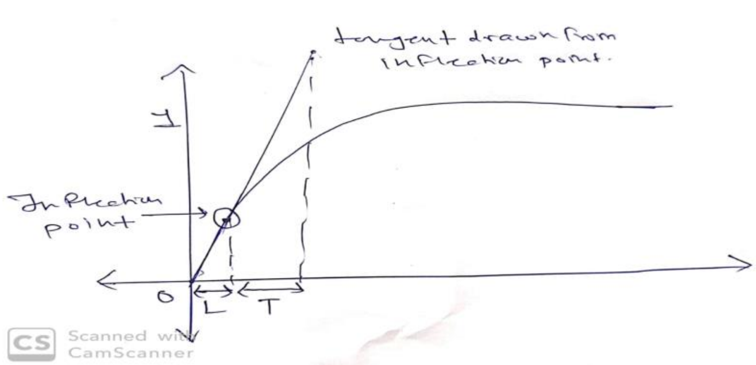
Output step response



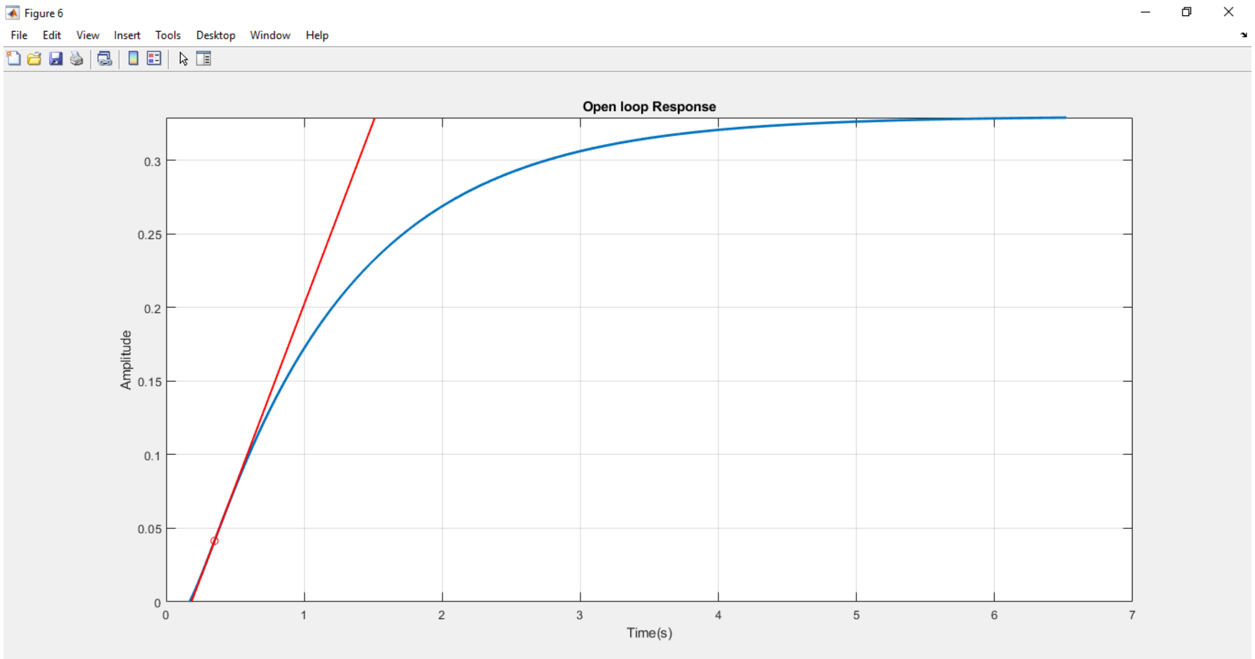
B. By step response method

Algorithm steps:

1. Take first and second derivative of system transfer function
2. Mark the point at which second derivative crosses the zero line as inflection point
3. Point at which inflection point draws a perpendicular line to time axis mark that as T
4. Draw tangent at inflection point
5. Then draw a perpendicular to the time axis from maximum point value of tangent then distance from 0 to point is called as L and after from L to point of intersection of tangent to time axis is value of T
6. By obtaining T and L we can get gain as a=L/T
7. From a, L, T we can find out Kp, Ti and Td



Calculation of inflection point

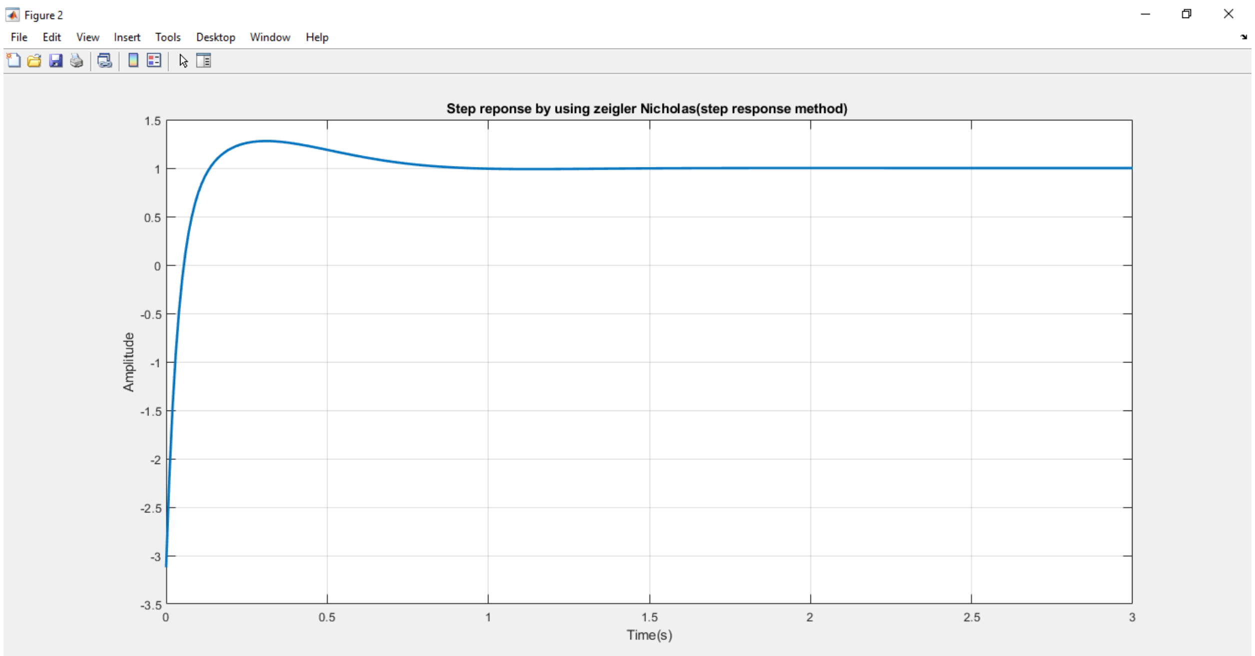


From inflection point and tangent to that point we get values of L and T

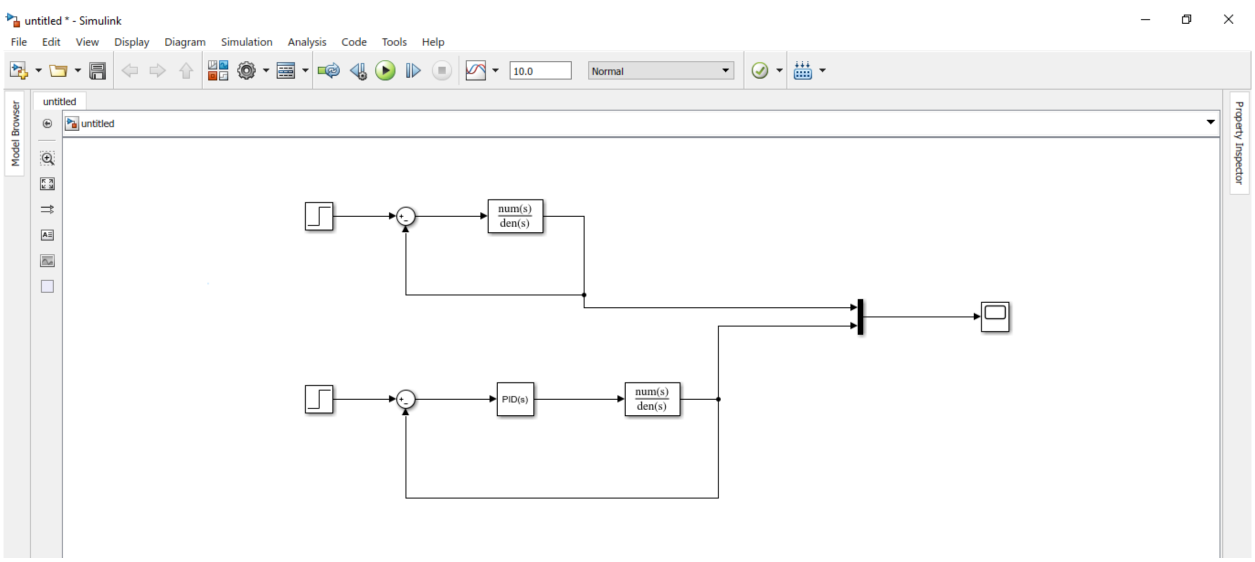
```
%% finding T and L
L = tv(1);
T = tv(2) - tv(1);

% PID parameters
a = L/T;
Kp = 1.2/a;
Ti = 2*L;
Td = L/2;

% cont = Kp(1 + 1/(s*Ti) + s*Td);
cont = Kp + Kp/(s*Ti) + Kp*Td*s;
```

Kp = 26.4079, Ti= 0.3667, Td = 0.0917

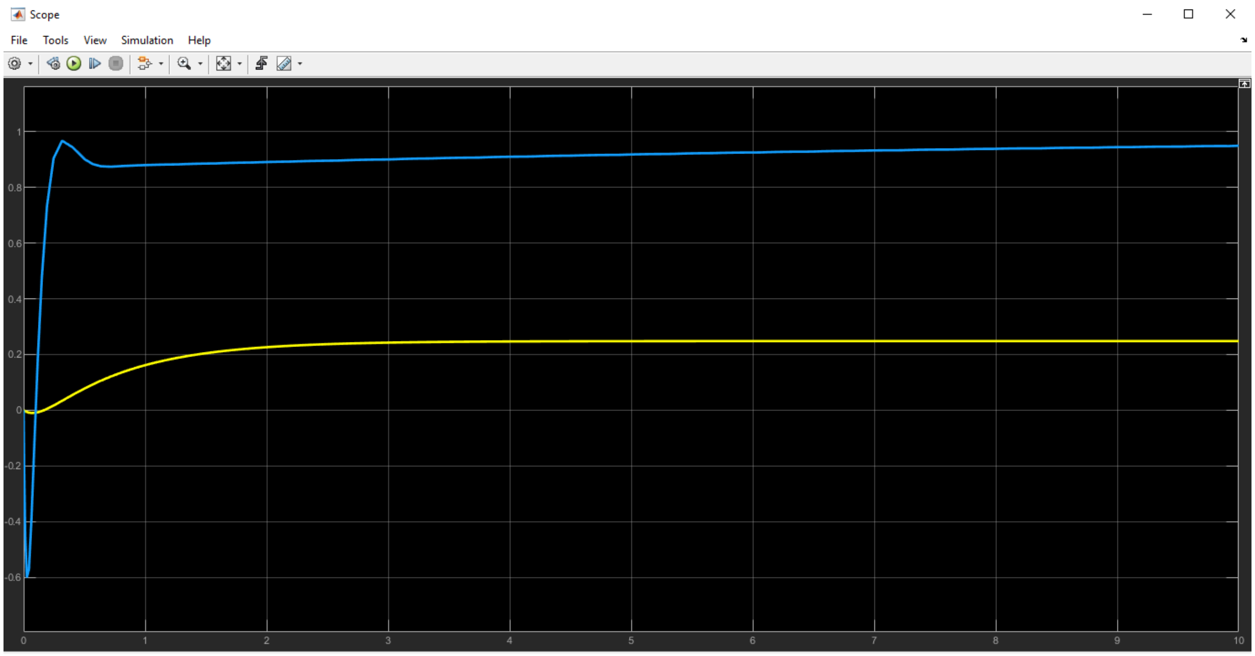
Output step response



Result obtain in Simulink:



Final output



Conclusion:

In this course project we have find out the proper values of kp, ki, kd to get accurate tuning for pressure measurement system using PID controller. Here we have used three basic methods of PID tuning like manual method, PID tuner method and Ziegler-Nichols method. In zeigler-Nichol method there are two types like using root locus and using step response but our observation by using both process is we get ideal values of kp, ki, kd using step response method.

References:

Design of Model Based PID Controller Tuning for Pressure Process by A. Kanchana1, G.Lavanya2 , R.Nivethidha3 , S.Subasree4 , P.Aravind5