EE407
Experiment 2

Prelimary Work

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Monday Morning Group 2

Part 3)

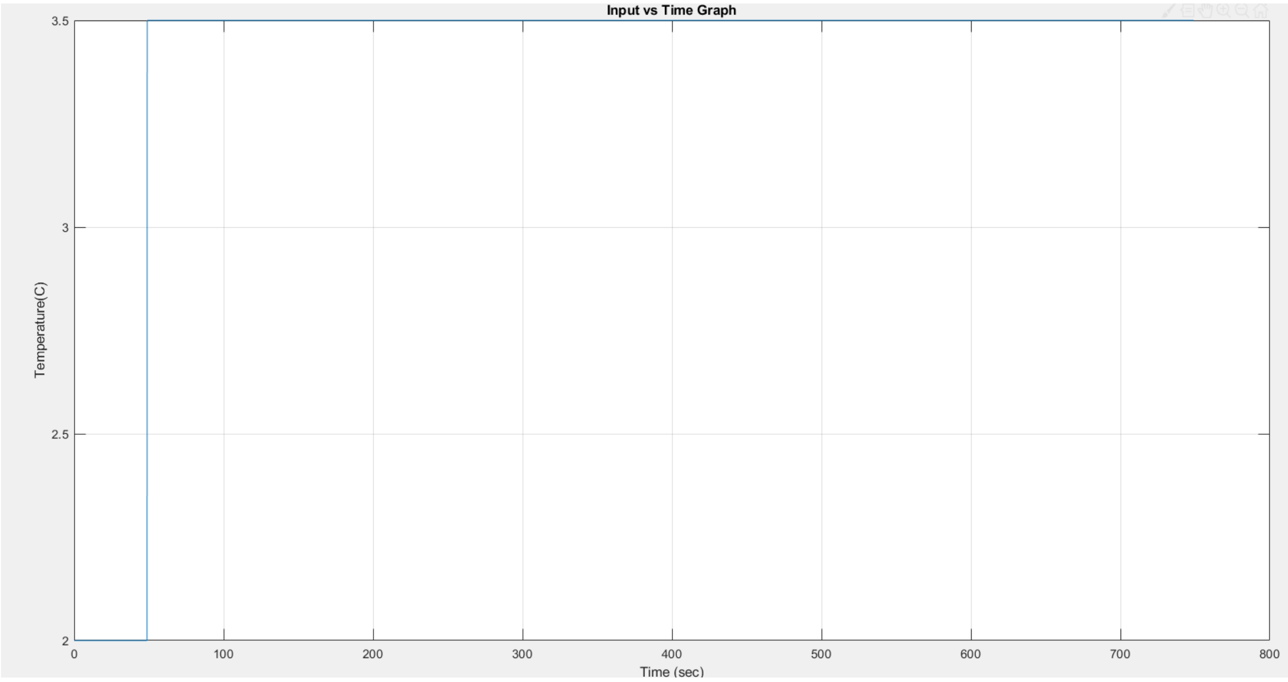

Figure 1:Input vs Time Graph for given SysldDataExp2.mat

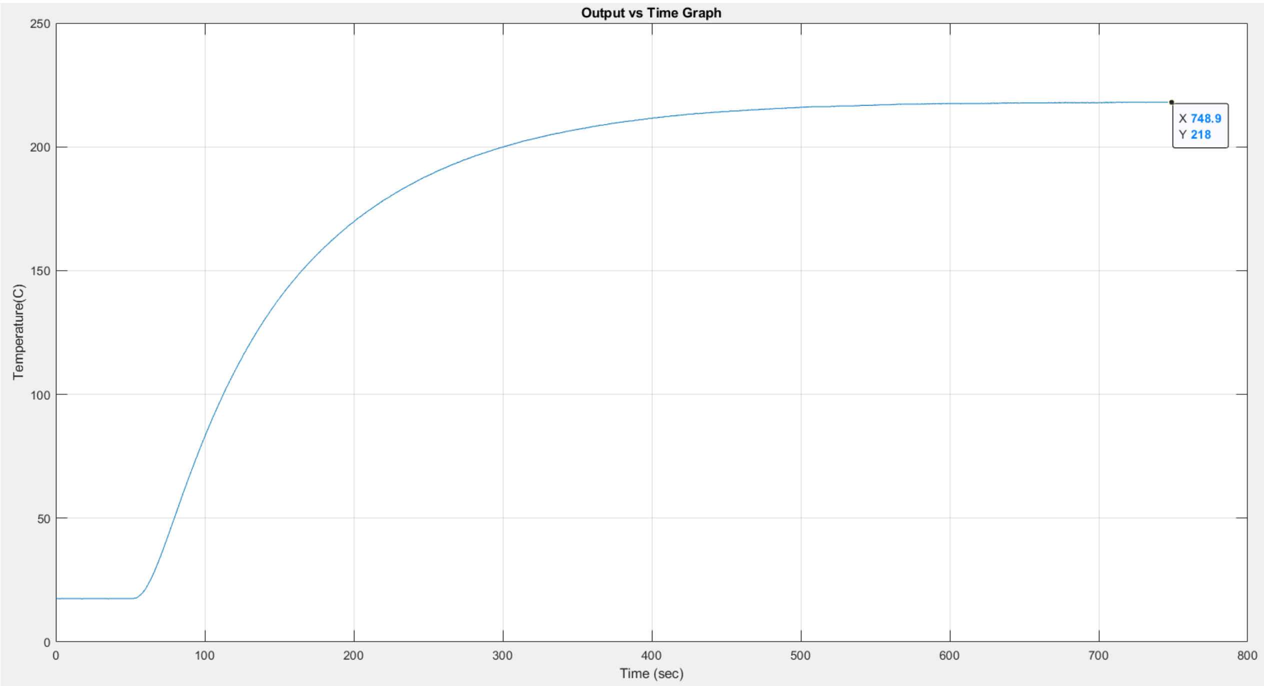

Figure 2:Output vs Time Graph for given SysldDataExp2.mat

FOPDT parameters of the system determined by using the formulas provided by Afşar Saranlı in EE407 course.The formulas that are utilized is provided below.

$$K_p = \frac{\Delta y}{\Delta u}$$

$$\tau_p = \frac{1}{0.7}(t_{\frac{2}{3}} - t_{\frac{1}{3}})$$

$$\theta_p = t_{\frac{1}{3}} - 0.4\tau_p \text{-Input Bump time}$$

FOPDT parameters for this question calculated by using Output vs Time plot in Matlab.

Δy =218-17.5=200.5 , $\Delta u = 3.5 - 2 = 1.5$ $K_p = 133.667$

$\frac{2}{3}\Delta y$ +17.5=151.1667 hence $t_{\frac{2}{3}}$=167.2 seconds $\tau_p = 94.5714$

$\frac{1}{3}\Delta y$ +17.5=84.333 hence $t_{\frac{1}{3}}$=101 seconds θ_p=101-0.4*94.5714-48.9=14.27

According to the formulas in the lecture the results for θ_p=14.27, however when the data points in input and output arrays are investigated dead time delay found as θ_p=54.4-48.9=5.5

(Bonus) Part 4)

Initial steady state input value =2 Initial steady state output value=17.5

After removing initial steady state values for input and output , System Identification Application of Matlab is used to Estimate Process Model

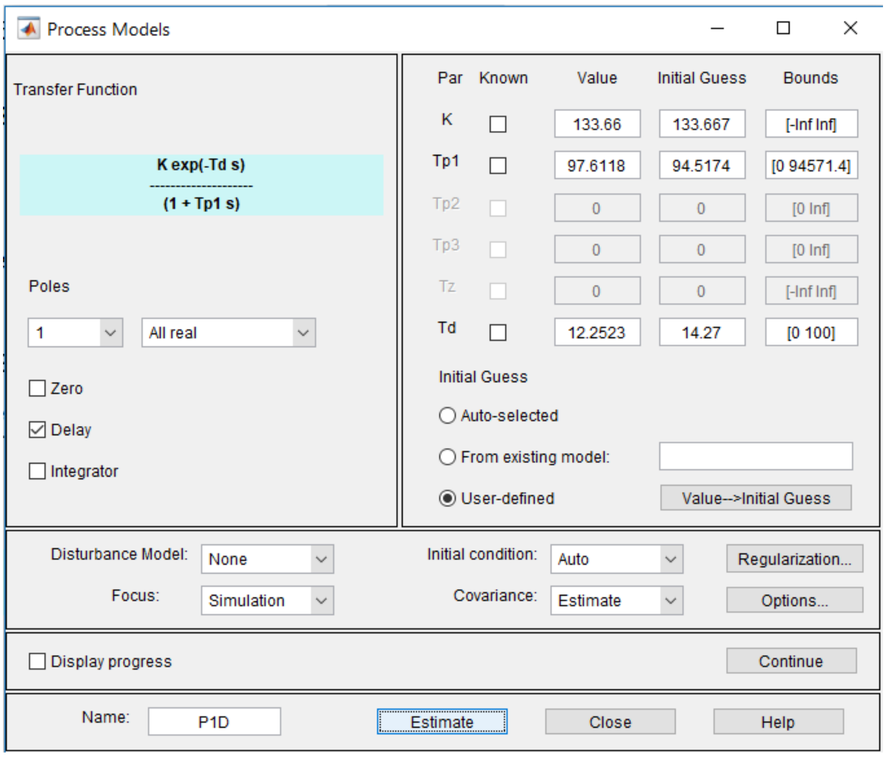

Figure 3:Estimation of FOPDT Parameters by using Matlab

Part 5)

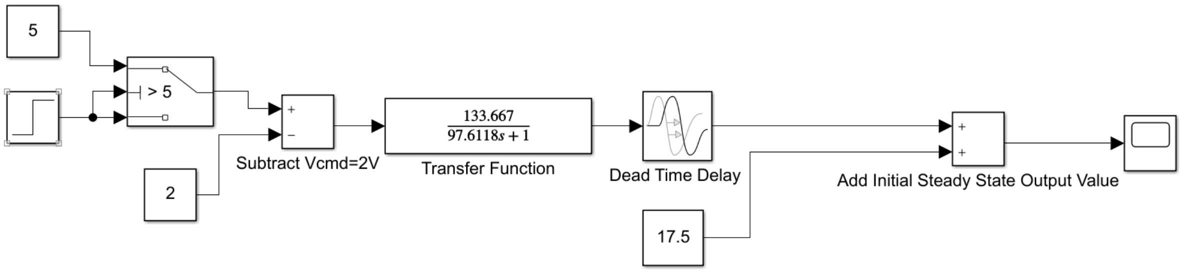

Figure 4: Simulink Block Diagram for Part 5

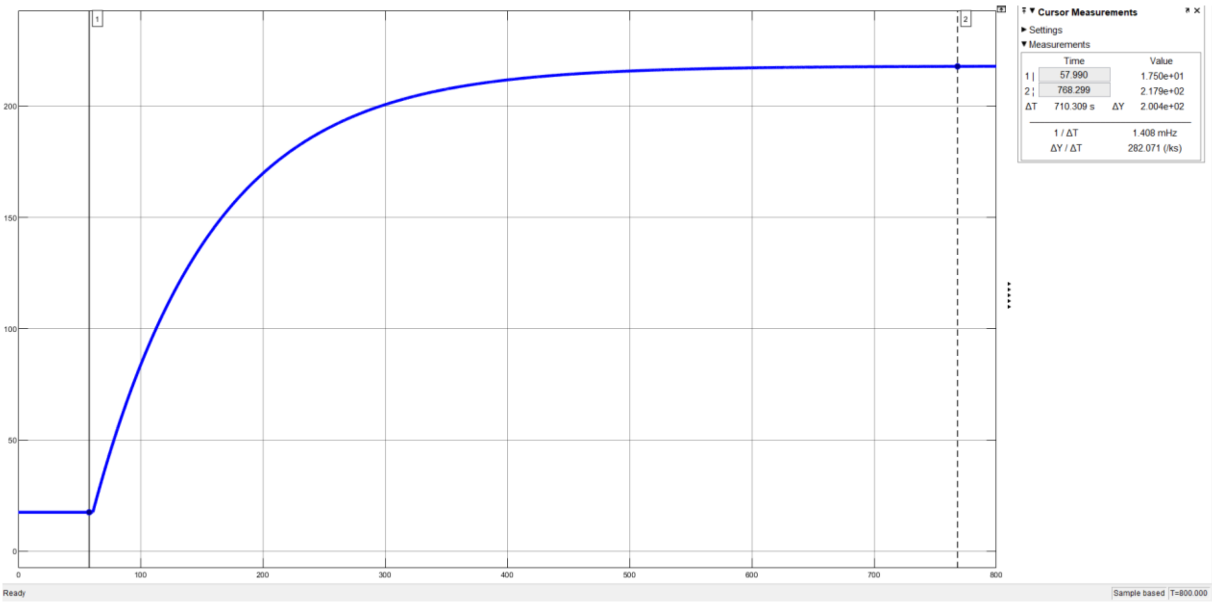

Figure 5:Simulation Results for Plant Identified with FOPDT parameters obtained with MATLAB System Identification with Estimation of Process Models

Part 6

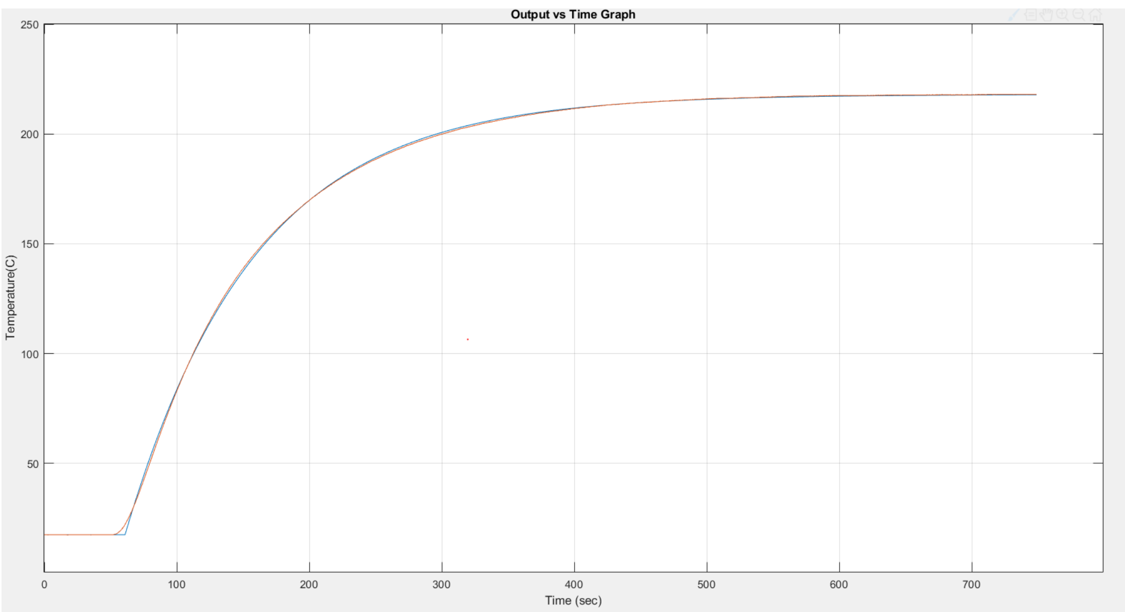

Figure 6:Simulated Data for Estimated Parameters and Experimental Data on the same plot.

As can be seen from Figure 6, estimated parameters for FOPDT model simulated data and the experimental data has nearly the same Output vs Time Plot as expected.

Part 7)

Matlab Codes generated for Table 1 in Experiment 2 PDF.

```
kcp=((0.2)/(kp))*((taop/tetap)^(1.22))
kcpi=((0.586)/(kp))*((taop/tetap)^(0.916))
tipi=(taop)/(1.03-(0.165)*(tetap/taop))
```

for Kp=133.667 Taop=97.6118 and θ_p=5.5 (Estimation of Dead Time from Data Arrays)

For P Controller

Kc=0.05

For PI Contoller

Kc=0.0611
Ti=95.6319

for Kp=133.667 Taop=97.6118 and θ_p=12.2523(MATLAB System Identification Estimation Process Models)

For P Controller

Kc=0.0188

For PI Contoller

Kc=0.0293
Ti=96.7134

Part 8)

For Kc=Kc Optimal found for P controller for Kc=0.5 PID Controller Block is created and the feedback is taken as temperature from the output .Desired temperature is entered sequentially by using clock blocks and switches ; hence, desired temperature is setted as 220, 200 and 240 degrees sequentially.As can be seen in the explanation part of the experiment
Vcmd(t) is

$$V_{cmd}(t) = K_c\left(1 + \frac{1}{T_i}\int e(t)dt + T_d\frac{de(t)}{dt}\right) + CO_{bias}$$

Hence it has a part which is not multiplied with error signal.Experimentally I found this Controller Output Bias as 27.Then I obtain the simulation results As can be seen from the simulation results results are very close to desired temperature values.

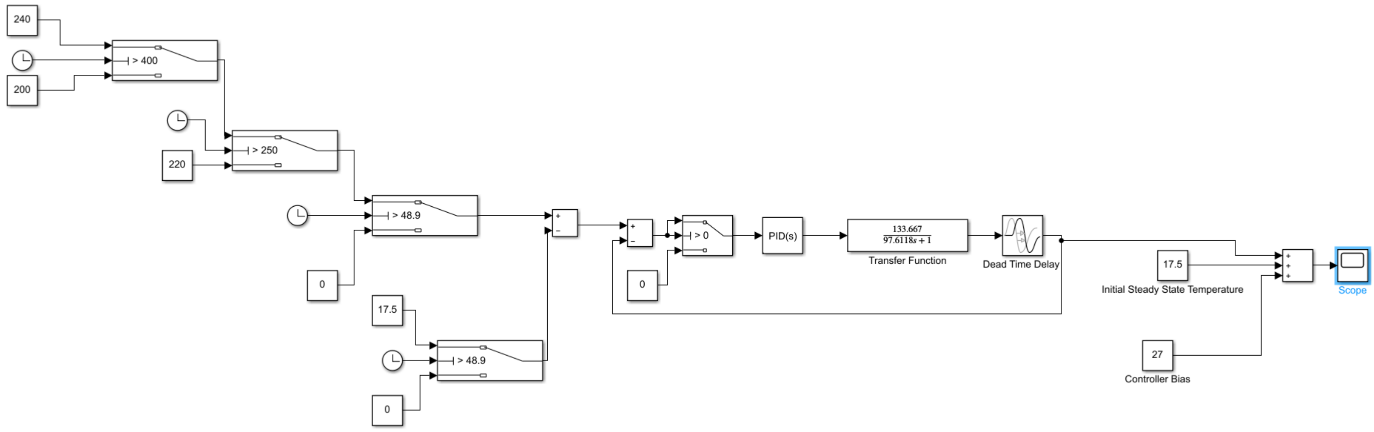

Figure 7: Simulink Block Diagram for Part 8

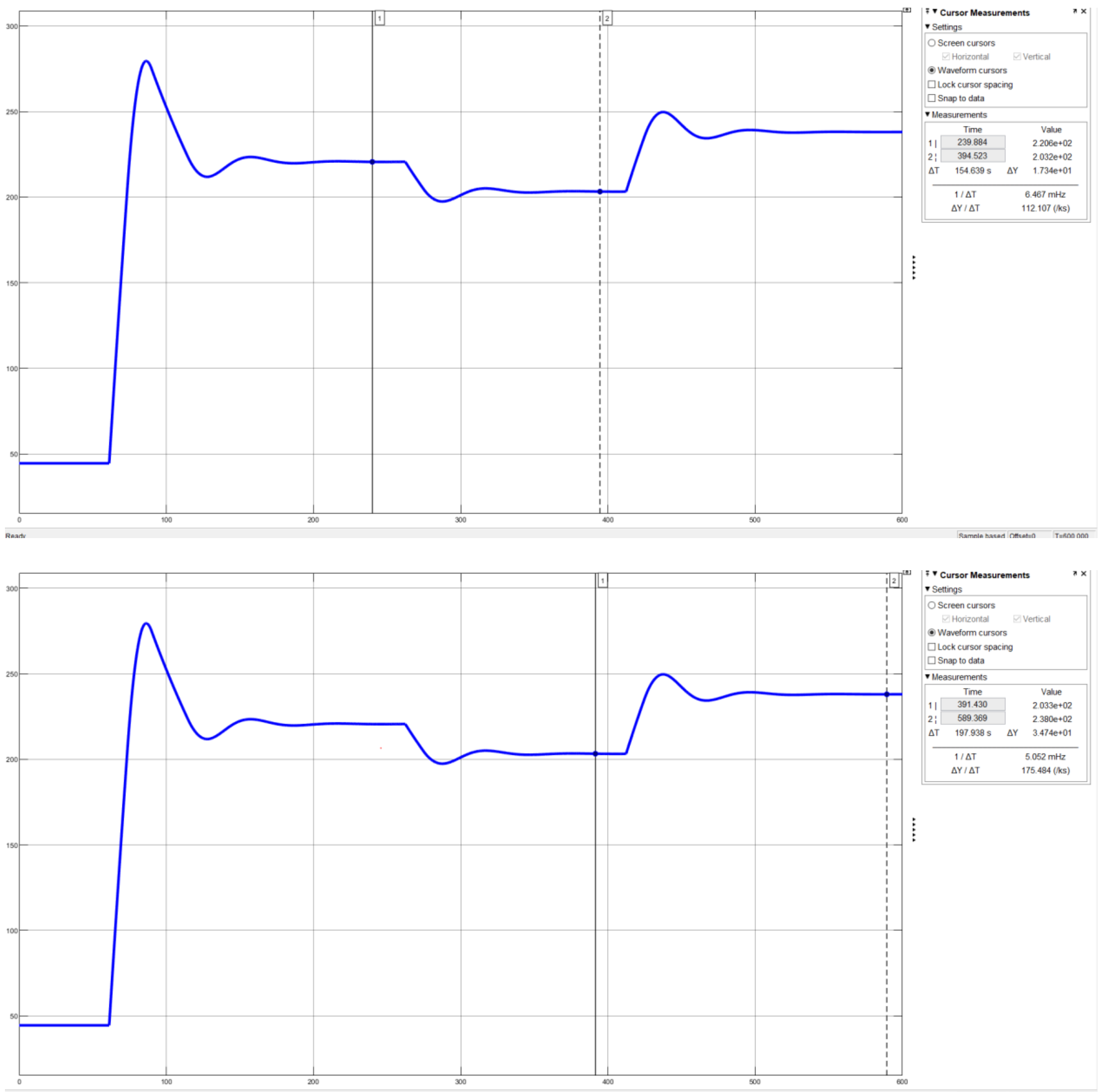

Figure 8:Simulation Results for Part 8 (All 3 Steady State Output is shown)

Part 9)

System became more oscillatory for Kc=2KcOptimal=0.1.More oscillatory output is observed therefore I had to increase clock boundaries to change desired input temperature .

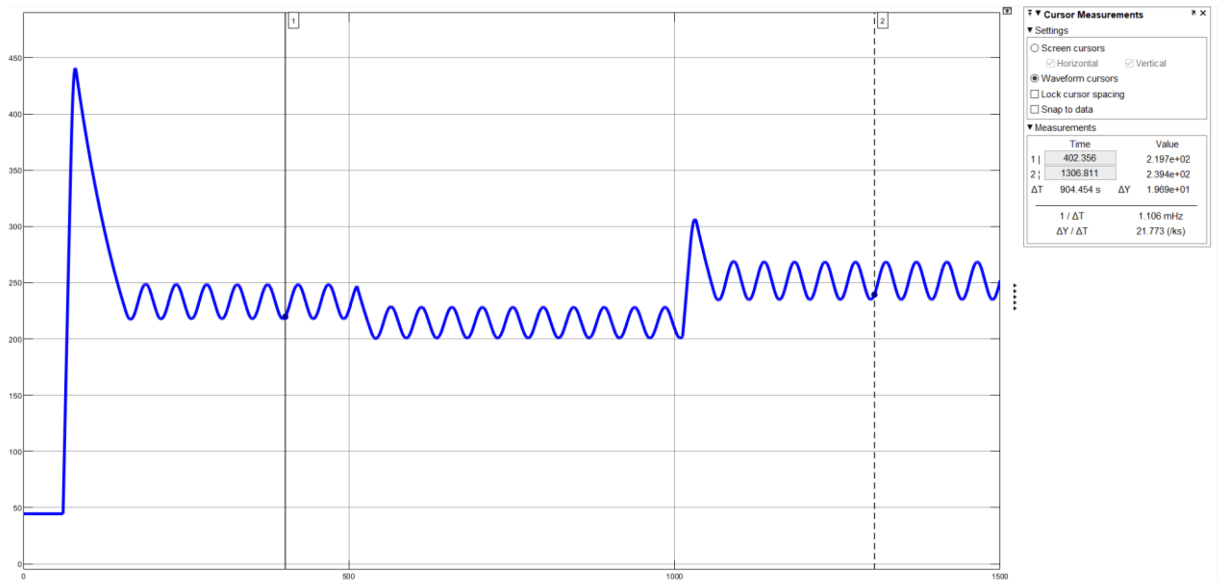

Figure 9:Simulation Results for Kc=2cKoptimal

Part 10)

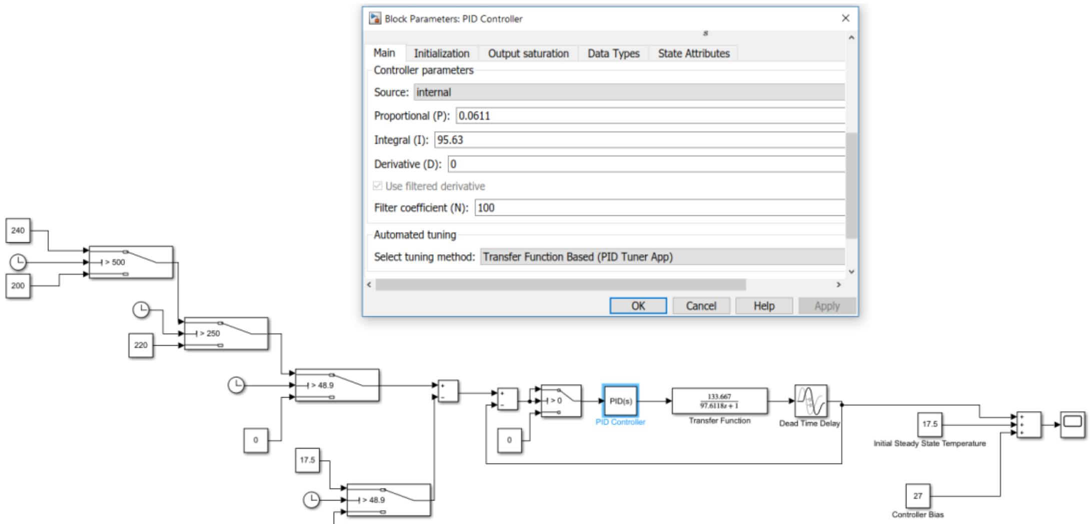

Figure 10:Simulink Block Diagram for Part 10 Configuring PID Block is shown

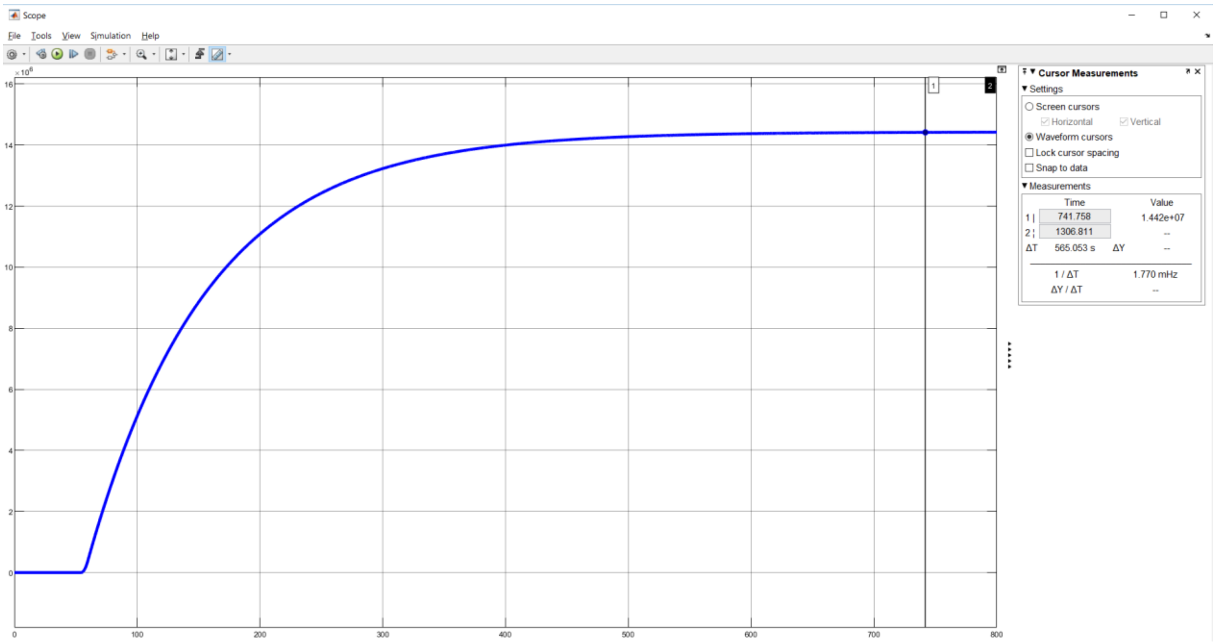

Figure 11:Simulation Results for PI Controller for Kc=Kc,optimal Ti=Ti,optimal

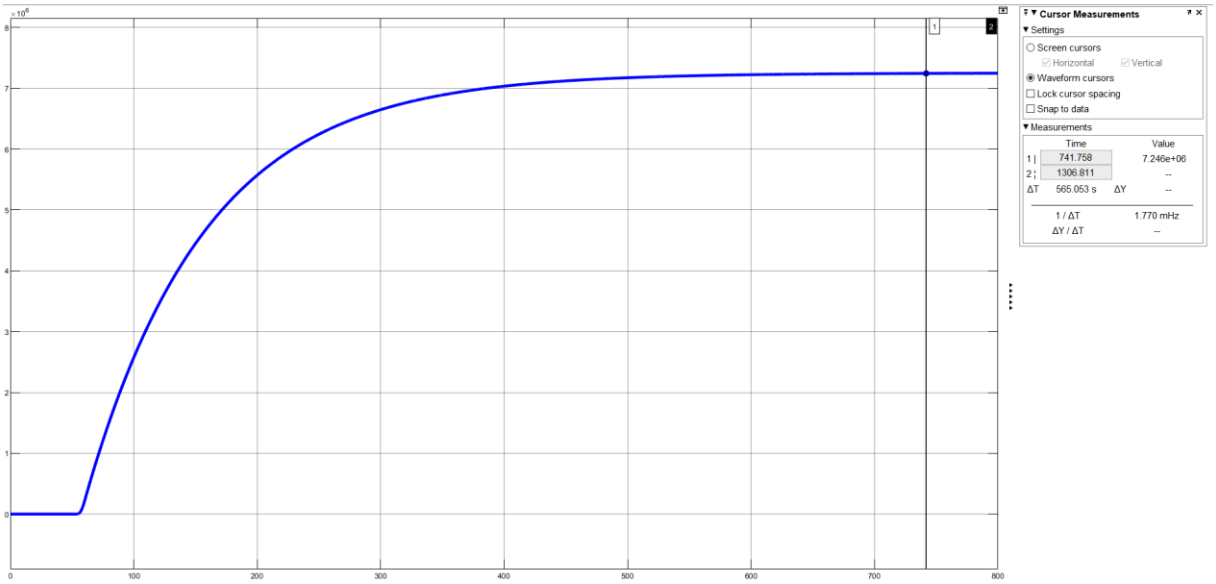

Figure 12:Simulation Results for PI Controller for Kc=Kc,optimal Ti=0.5 Ti,optimal

I am not sure for the results of part 10.As can be seen from above plots heating process becomes an integrating process .I believe that this is due to integral term in PI controller.Output is shows accumulated integral sum . According to the theorotical knowledge usage of PI controller must results in less steady state error.However this is not the case here.Therefore, I have tried different configurations and playing with the PID block options. Even though I tried meticuluously and diligently , I could not obtain a simulation results with smaller steady state error .