Home Work #6

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1 Question 1

System is:

$$G(s) = \frac{-s+3}{(s+1)(s+2)(s^2+2s+4)}$$

1.1 part a

We used get_fog and opt_app to find first order time delay transfer function (FOTF).

- frequency

$$G(s) = e^{-1.45s}\frac{0.375}{0.9587s+1}$$

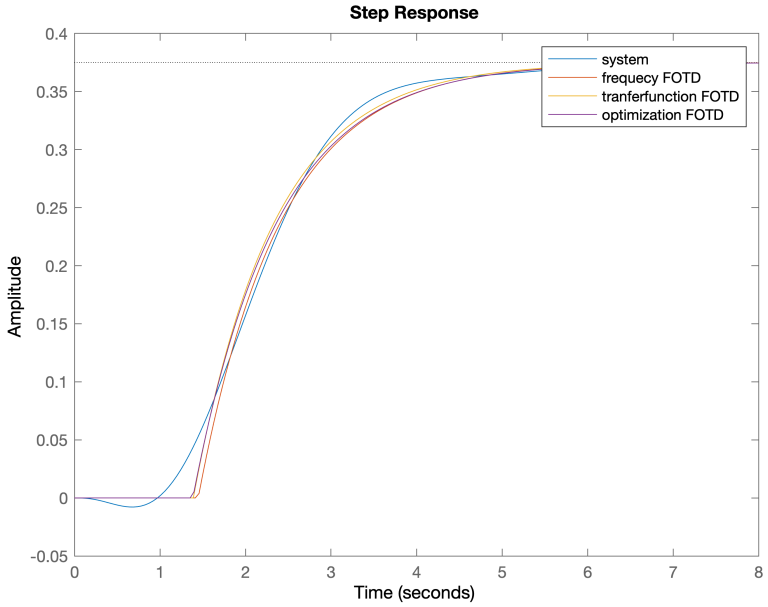
- transfer function

$$G(s) = e^{-1.39s}\frac{0.375}{0.9428s+1}$$

- optimum

$$G(s) = e^{-1.38s}\frac{0.383}{s+1.021}$$

Figure 1: system and FOTD step responde



I used below cost function to see witch one fits better.

$$\text{Cost} = \int_0^8 |G(t) - G'(t)|dt, \qquad G' \text{ is FOTD transfer function}$$

- frequency
  Cost = 1.5949
- transfer function
  Cost = 1.3208
- optimum
  Cost = 1.0345

Optimum hase minimum cost so we choise FOTD that used optimum function.

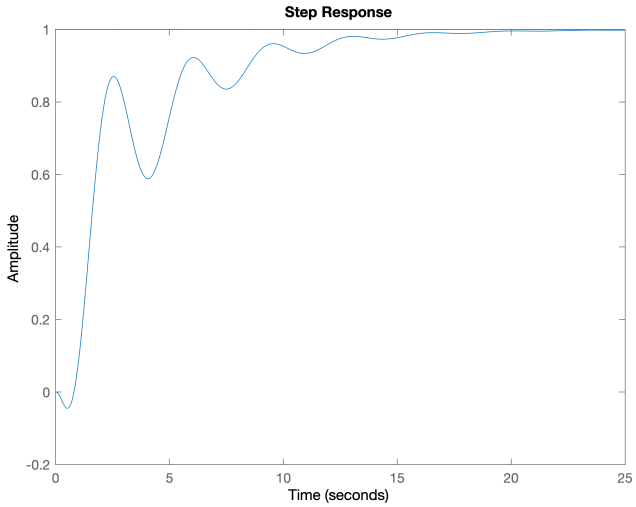
1.2 part b

Now design PID controller with following methods.

- ziegler nichols

$$G_c = \frac{4.756s^2 + 6.423s + 2.27}{0.1904s^2 + 2.76s}$$

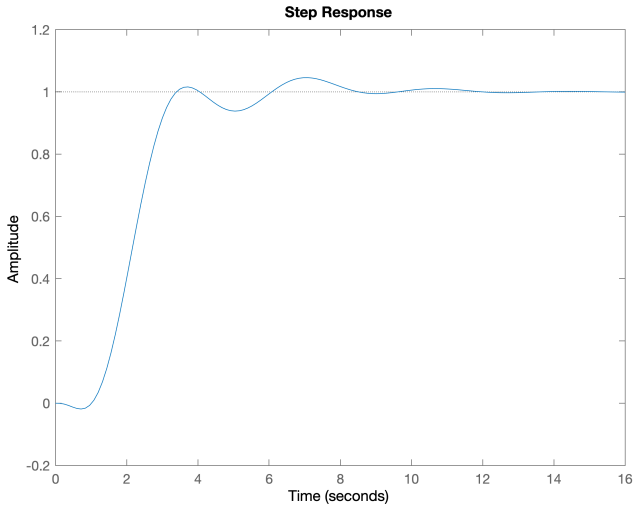
Figure 2: step responde with ziegler nichols PID controller



- refined ziegler nichols

$$G_c = \frac{3.099s + 2.27}{1.629s}, \qquad H = \frac{1.051s^2 + 1.698s + 1}{0.09418s^2 + 1.434s + 1}$$

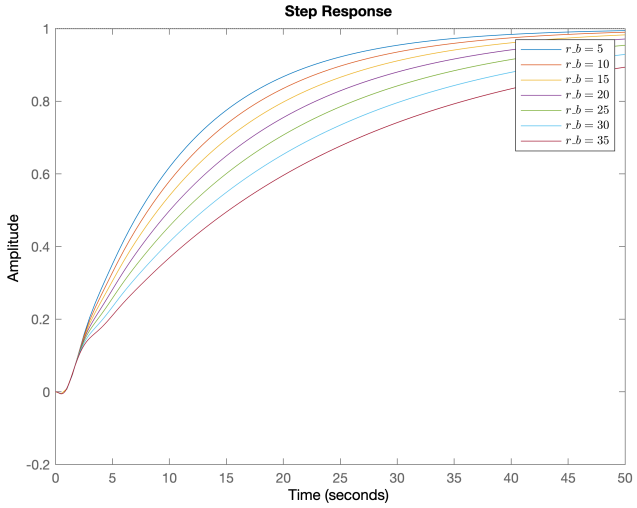
Figure 3: step responde with refined ziegler nichols PID controller



- modified ziegler nichols

$$r_1 = 1.0, \qquad p_b = 5 : 5 : 35$$

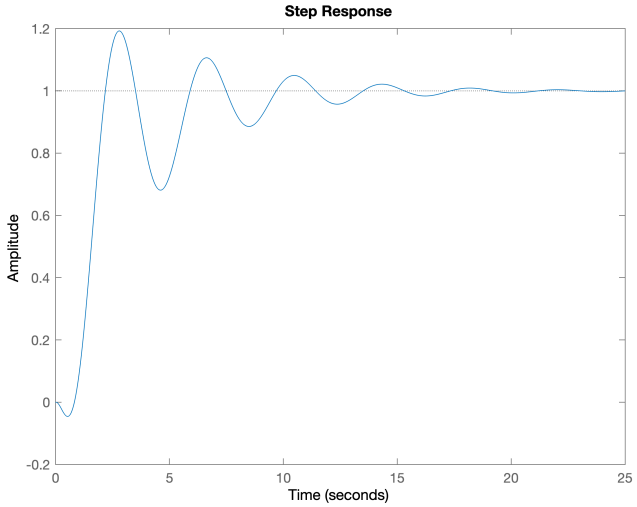
Figure 4: step responde with modified ziegler nichols PID controller



- Cohen Coon

$$G_c = \frac{3.223s^2 + 7.463s + 3.189}{0.09188s^2 + 2.3s}$$

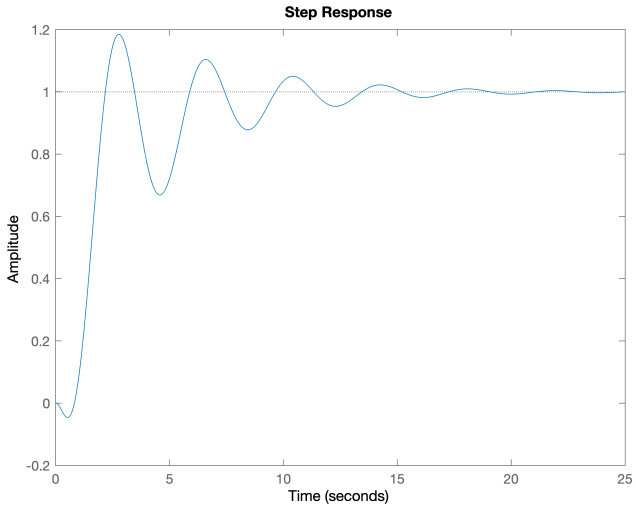
Figure 5: step responde with Cohen Coon PID controller



- Cohen Coon revisited

$$G_c = \frac{3.374s^2 + 7.744s + 3.202}{0.09579s^2 + 2.378s}$$

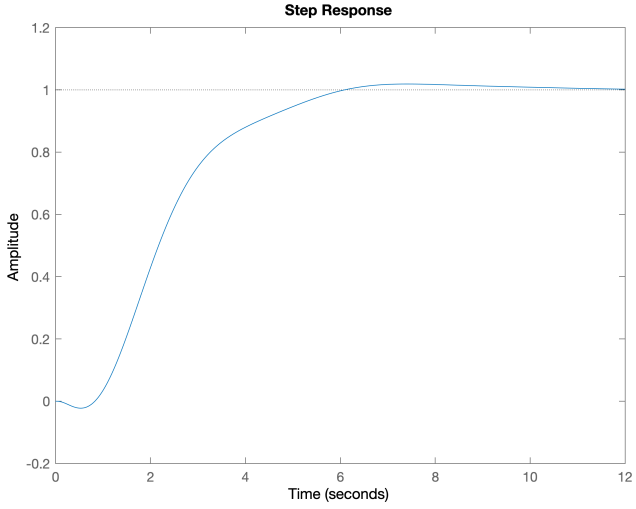
Figure 6: step responde with Cohen Coon revisited PID controller



- Astrom Hagglund

$$G_c = \frac{0.9211s^2 + 1.794s + 1.385}{0.06048s^2 + 1.247s}$$

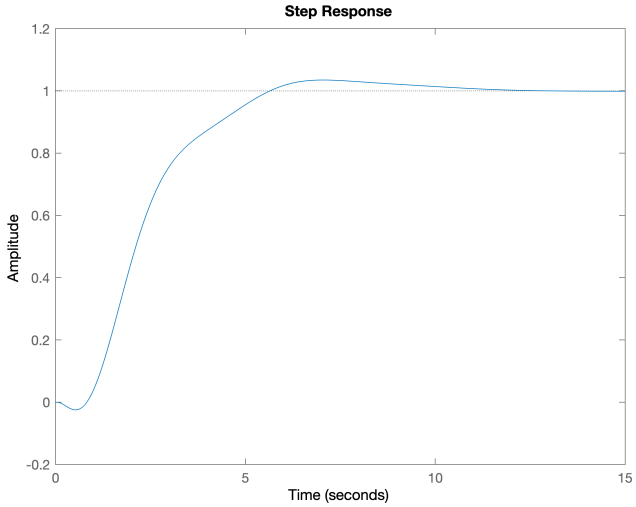
Figure 7: step responde with Astrom Hagglund PID controller



- Frequency based Astrom Hagglund

$$G_c = \frac{1.025s^2 + 1.666s + 1.355}{0.0688s^2 + 1.171s}$$

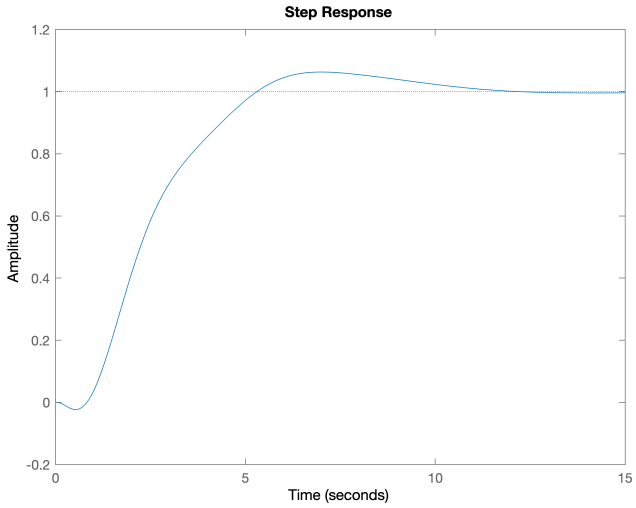
Figure 8: step responde with Frequency based Astrom Hagglund PID controller



- CHR set point 0% overshoot

$$G_c = \frac{0.8439s^2 + 1.19s + 1.135}{0.06758s^2 + 0.9794s}$$

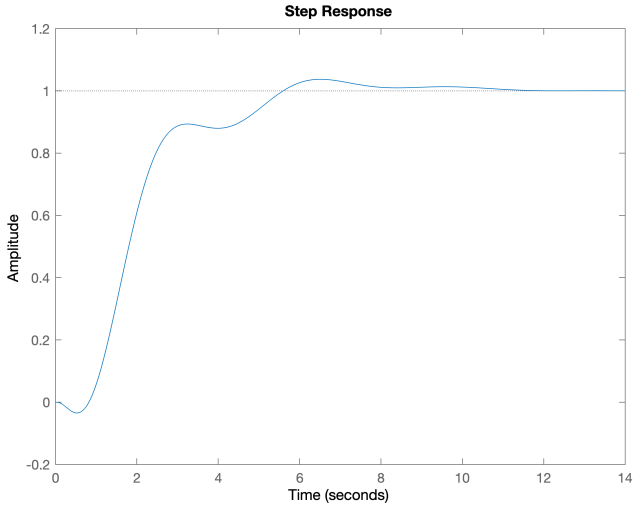
Figure 9: step responde with CHR set point 0% overshoot PID controller



- CHR set point 20% overshoot

$$G_c = \frac{1.758s^2 + 2.581s + 1.797}{0.08893s^2 + 1.371s}$$

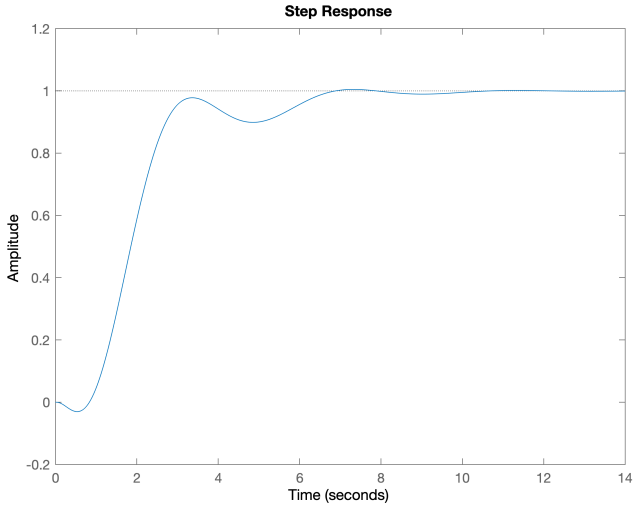
Figure 10: step responde with CHR set point 20% overshoot PID controller



- WJC

$$G_c = \frac{9.298s^2 + 21.39s + 12.51}{0.4048s^2 + 10s}$$

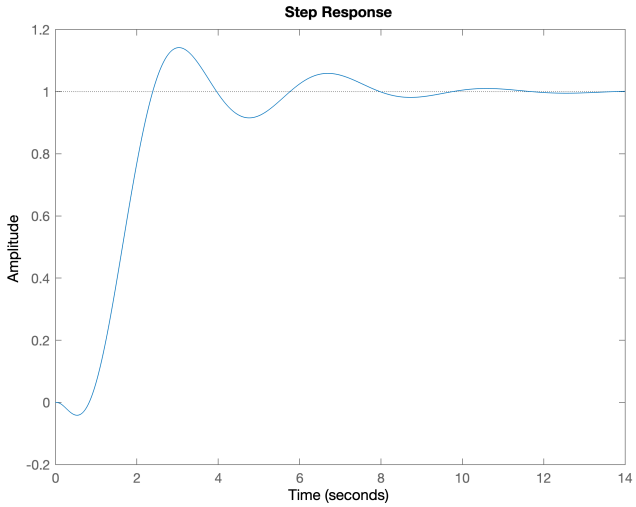
Figure 11: step responde with WJC PID controller



- optimum set point PID ISTE

$$G_c = \frac{1.993s^2 + 3.738s + 2.496}{0.07258s^2 + 1.447s}$$

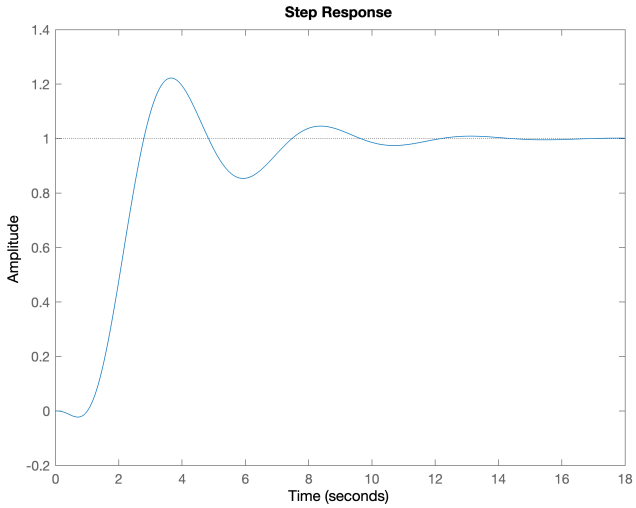
Figure 12: step responde with optimum PID controller



- optimum set point PI-D ISTE

$$G_c = \frac{4.219s + 2.41}{1.751s} \qquad H = \frac{0.9836s^2 + 4.328s + 2.41}{0.191s^2 + 4.328s + 2.41}$$

Figure 13: step responde with optimum PI-D controller



1.3 conclusion

ziegler nichols is very slow but refined ziegler nichols is better ans faster. modified ziegler nichols is very slow. Cohen coon is slow and has hight overshoot but cohen coon revisited is faster. Astromm hagglund is very good in doesn't have overshoot and system is fast but Frequency is a little slow. CHR is fast but overshoot method work strange. Zero overshoot has overshoot but 20% overshoot has lower overshoot. WJC work fast and have very small overshoot. Optimum PID work well but PI-D is a little slow. We don't what the system is so we can't select best controller it depends on our plant.

2 Question 2

System is:

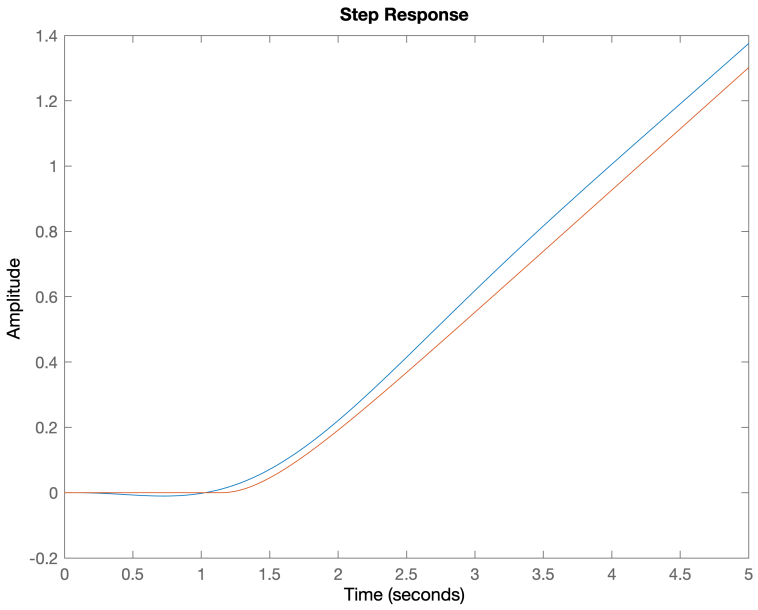
$$G(s) = \frac{-s+3}{s(s+2)(s^2+2s+4)}$$

2.1 part a

Integral plus Time Delay:

$$G = e^{-1.15s}\frac{0.375}{s(0.378s+1)}$$

Figure 14: system and ITD step responde



Now we use foipdt function.

Figure 15: step responde with foipdt PD controller

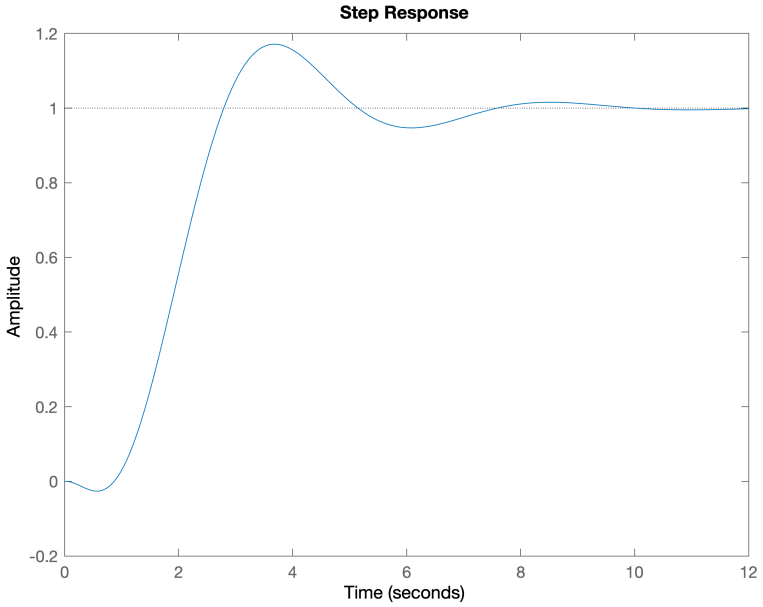
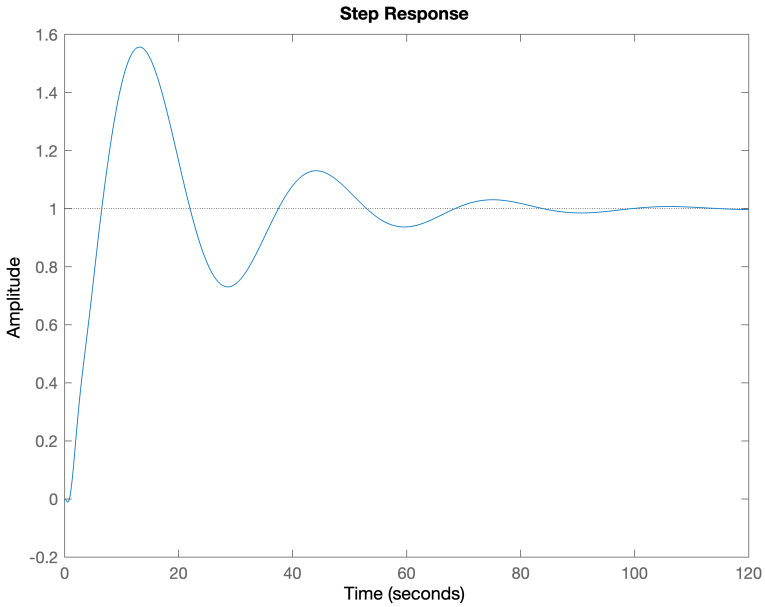


Figure 16: step responde with foipdt PID controller

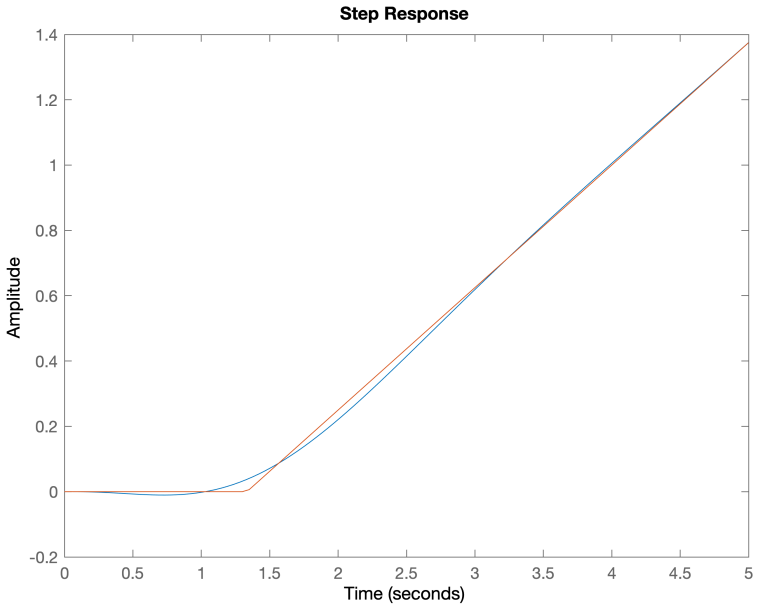


2.2 part b

Integral plus Time Delay:

$$G = e^{-1.33s}\frac{0.375}{s}$$

Figure 17: system and ITD step responde



Now we use ipdtctrl function.

Figure 18: step responde with ipdtctrl for ISE PD controller

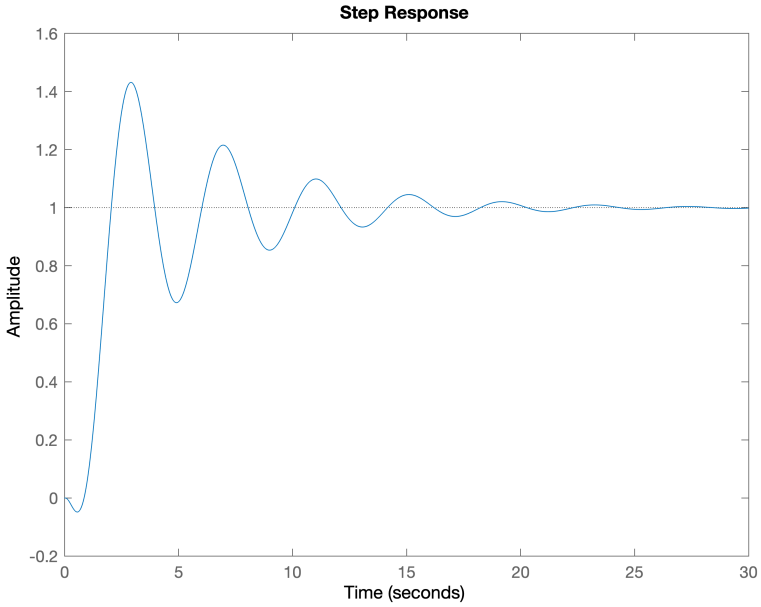


Figure 19: step responde with ipdtctrl for ITSE PD controller

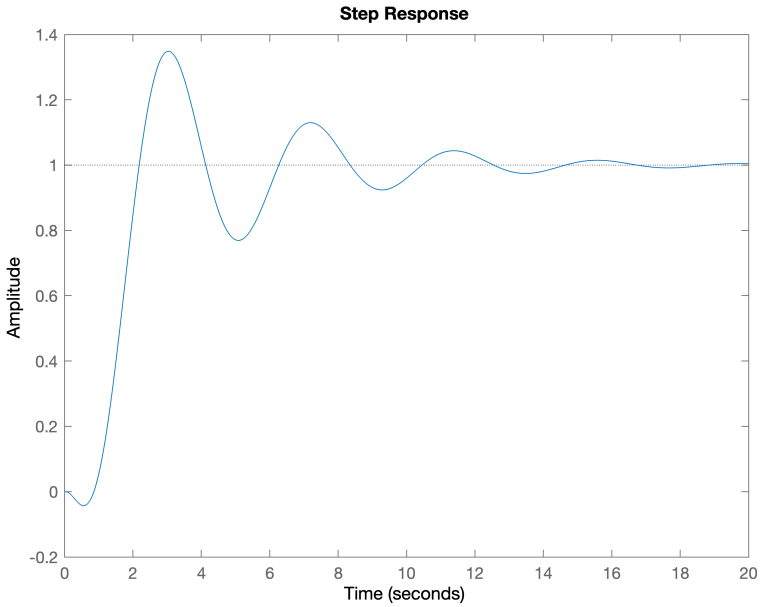


Figure 20: step responde with ipdtctrl for ISTSE PD controller

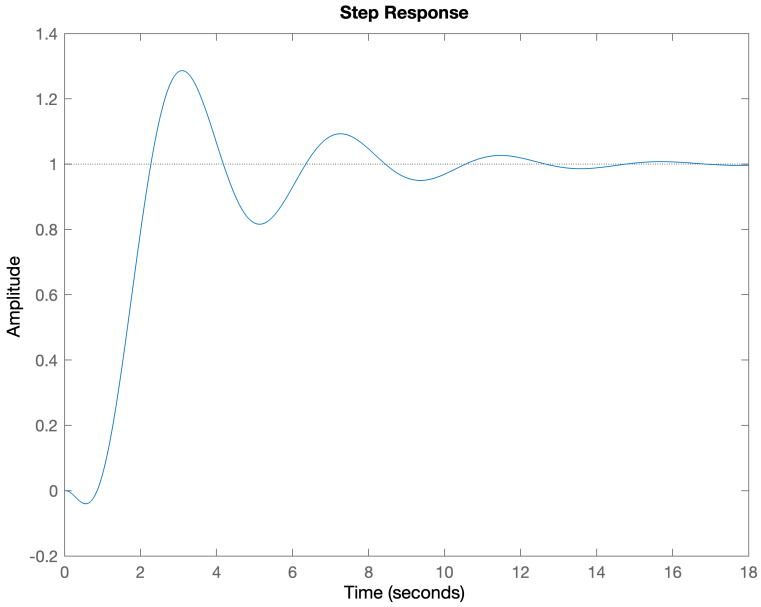


Figure 21: step responde with ipdtctrl for ISE PID controller

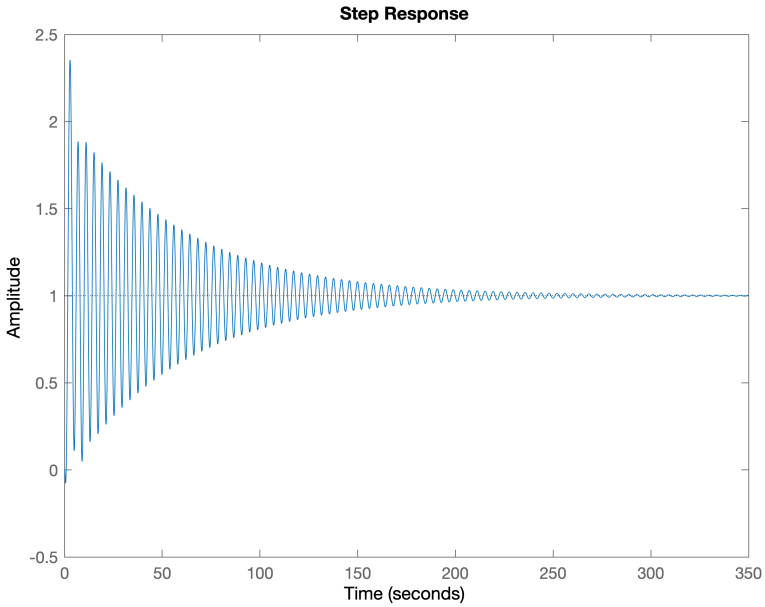


Figure 22: step responde with ipdtctrl for ITSE PID controller

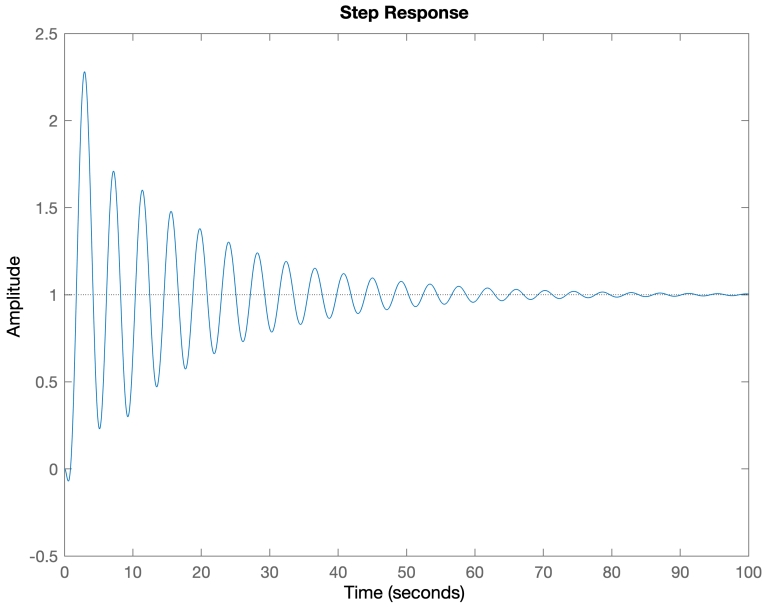
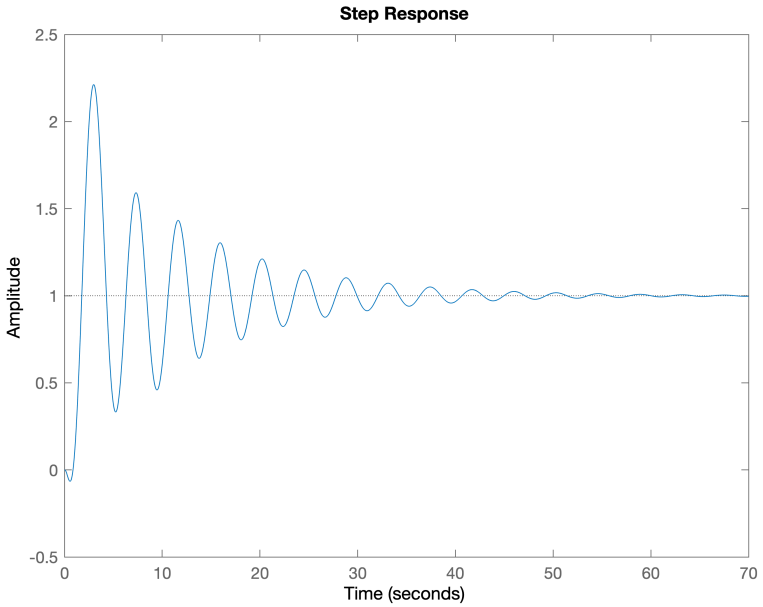


Figure 23: step responde with ipdtctrl for ISTSE PID controller



2.3 conclusion

Firt ITD function doesn't fit well but PD controller work very good but PID controller work very bad too slow for setteling time and has a high overshoot. system has integrator so we don't need to have integrator in controller and just make system slow and pendulous. Second ITD fits very good bad PD and PID controller don't work well. PD is far better than PID and PID is too slow and pendulous. In final PD controller used first method is the best fot this system.

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