# 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

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

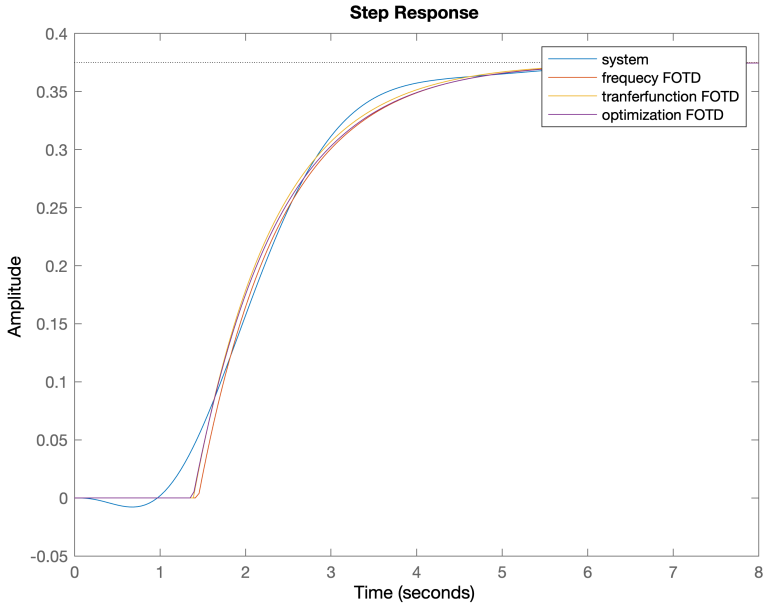
- transfer function

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

- optimum

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

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.

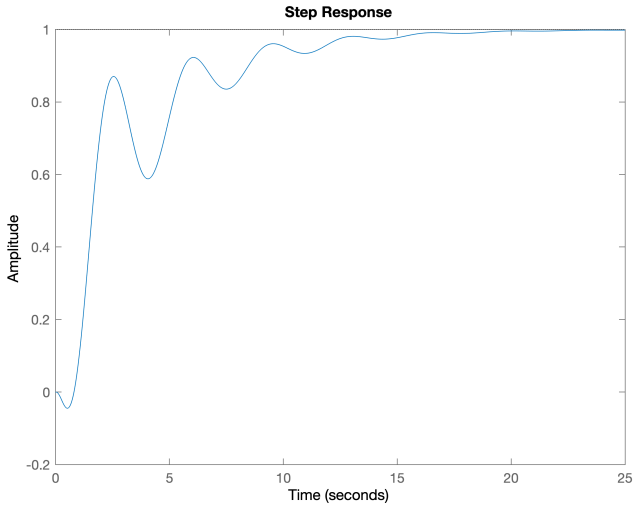
## 1.2 part b

Now design PID controller with following methods.

- ziegler nichols

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

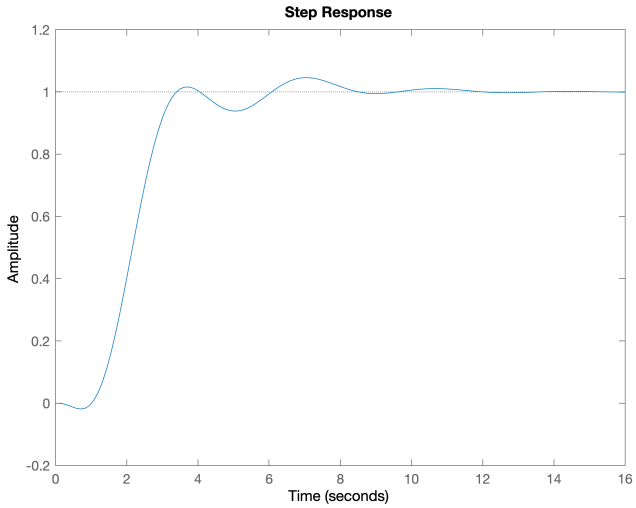
Figure 2: step responde with ziegler nichols PID controller




- refined ziegler nichols

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

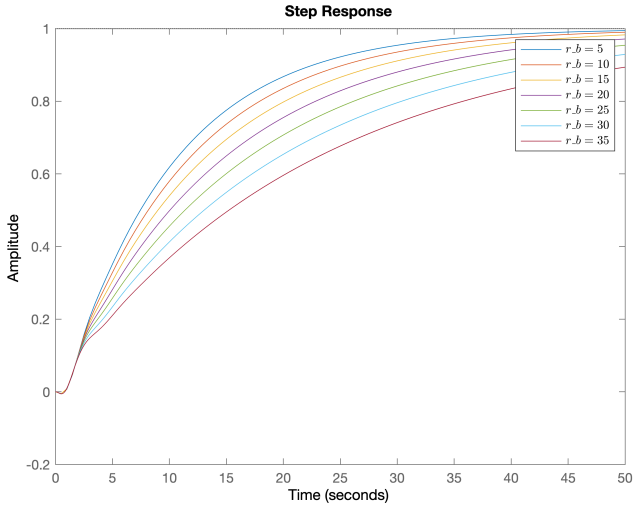
Figure 3: step responde with refined ziegler nichols PID controller



- modified ziegler nichols

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

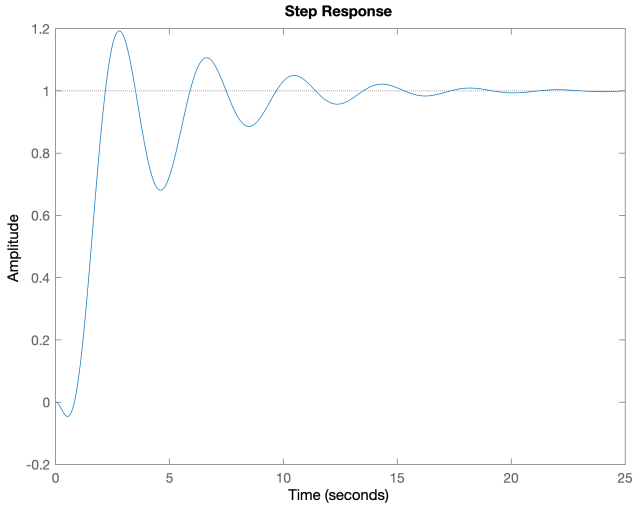
Figure 4: step responde with modified ziegler nichols PID controller




- Cohen Coon

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

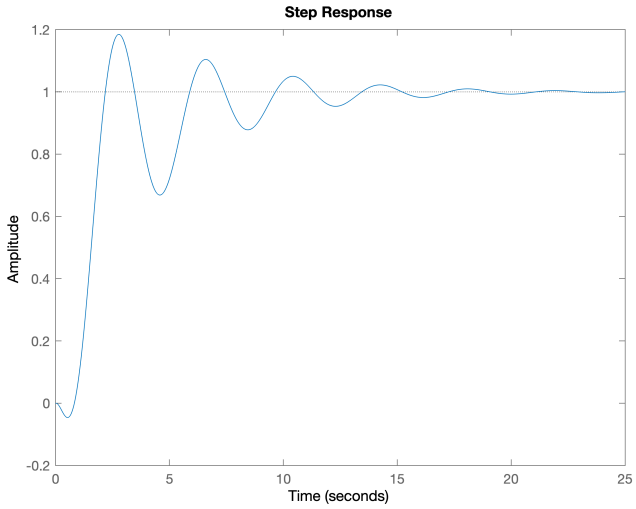
Figure 5: step responde with Cohen Coon PID controller



- Cohen Coon revisited

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

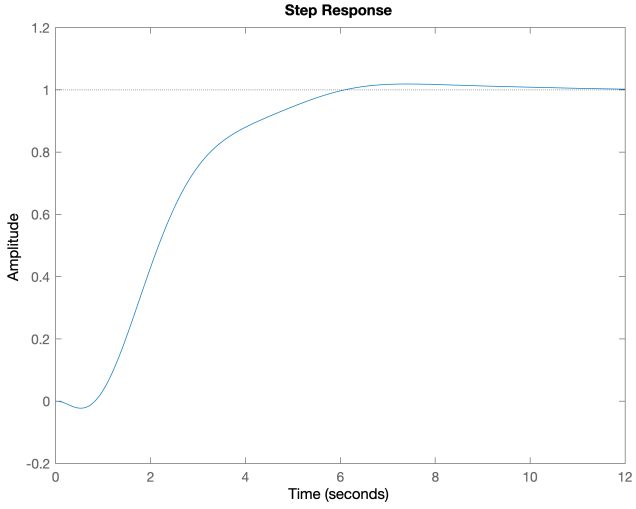
Figure 6: step responde with Cohen Coon revisited PID controller




- Astrom Hagglund

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

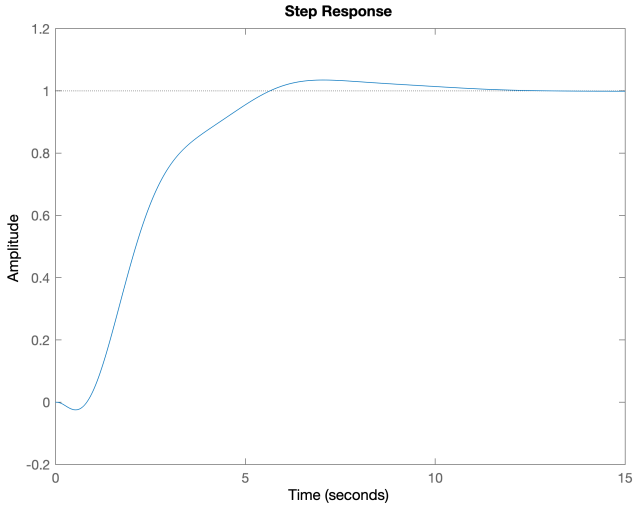
Figure 7: step responde with Astrom Hagglund PID controller



- Frequency based Astrom Hagglund

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

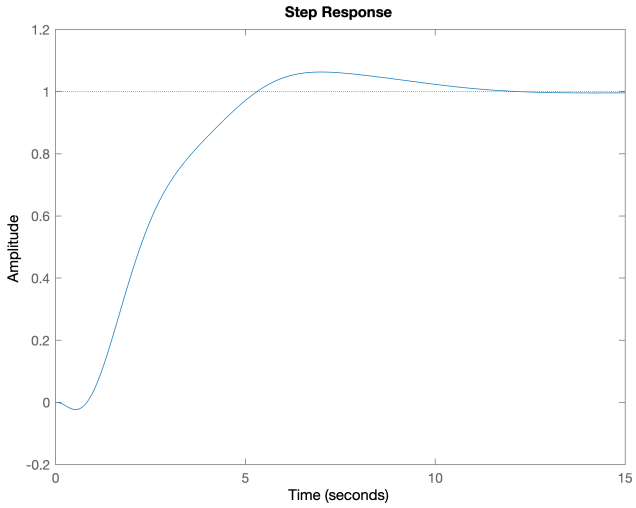
Figure 8: step responde with Frequency based Astrom Hagglund PID controller




- CHR set point 0% overshoot

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

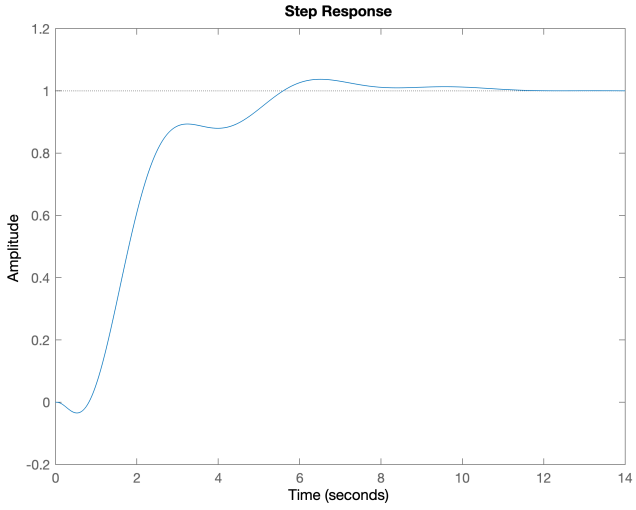
Figure 9: step responde with CHR set point 0% overshoot PID controller



- CHR set point 2% overshoot

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

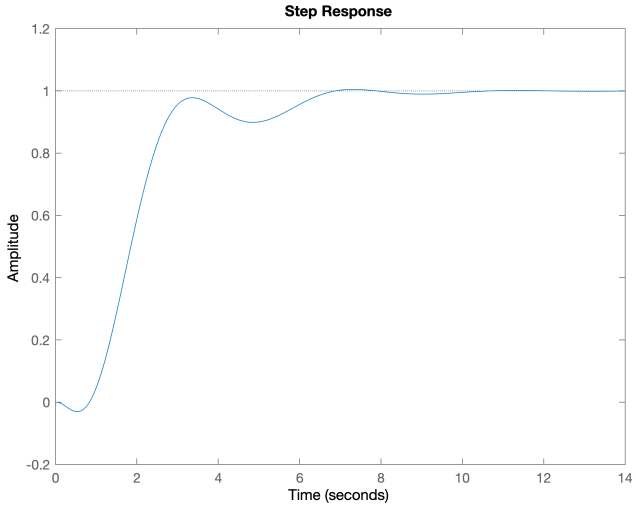
Figure 10: step responde with CHR set point 2% overshoot PID controller




- WJC

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

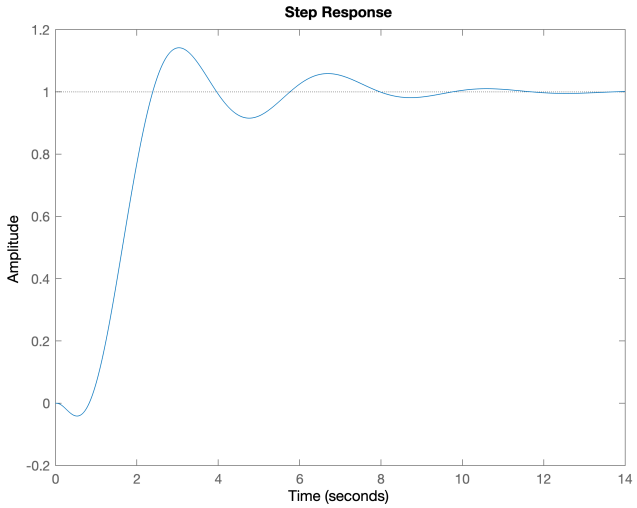
Figure 11: step responde with WJC PID controller



- optimum set point PID ISTE

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

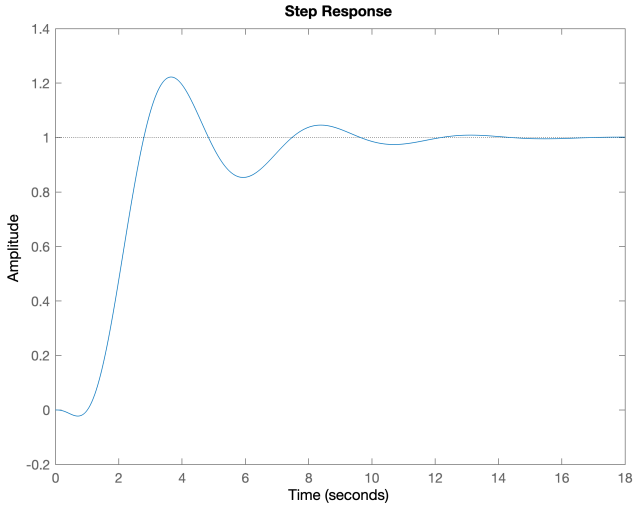
Figure 12: step responde with optimum PID controller




- 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



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