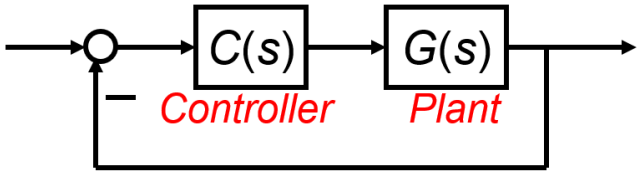
Assignment 15 (ELEC 341 L15_RLPID)

Problem 1:

Determine the Ziegler-Nichols tuning parameters for a PID controller, with the given plant transfer function:

$$G(s) = \left(\frac{5}{2s+1}\right)\left(\frac{0.4}{5s+1}\right)\left(\frac{2}{s+1}\right)$$



Assume that the time constants have units of minutes and the controller transfer function *C*(*s*) is as follows:

$$C(s) = K_p\left(1 + \frac{1}{T_I s} + T_D s\right)$$

Use Matlab to graph the step response.

Solution:

$$1+\left(\frac{5}{2s+1}\right)\left(\frac{0.4}{5s+1}\right)\left(\frac{2}{s+1}\right)(K_c)=0$$

$\longrightarrow (2s+1)(5s+1)(s+1)+4K_c=0 \rightarrow 10s^3+17s^2+8s+1+4K_c=0$

Let $s=j\omega \rightarrow 10(j\omega)^3+17(j\omega)^2+8(j\omega)+1+4K_c=0 \longrightarrow$

$10(-j)\omega^3+17(-1)\omega^2+8j\omega+1+4K_c=0$; $\begin{cases} a+jb=0 \\ a=0 \ \& \ b=0 \end{cases}$

Real coef: $-17\omega^2+1+4K_c=0$ (1)

Im " : $-10\omega^3+8\omega=0$ (2) $\rightarrow -10\omega^2+8=0 \longrightarrow$ (ignore $\omega=0$)

$\rightarrow \omega = 0.894$ rad/min $\xrightarrow[(1)]{\text{sub in}} -17(0.894)^2+1+4K_c=0 \rightarrow$

$\rightarrow K_c = 3.146$; $\omega=\frac{2\pi}{T_c} \rightarrow T_c=\frac{2\pi}{0.894} \rightarrow T_c=7.028$ min

$$\begin{cases} K_p=0.6K_c=0.6\times3.146 \\ T_I=0.5T_c=0.5\times7.028 \\ T_D=0.125T_c=0.125\times7.028 \end{cases} \Rightarrow$$

$K_p=1.887$

$T_I=3.514$ min

$T_D=0.878$ min

Step response:

$$OLTF = C(s) \cdot G(s) \longrightarrow$$

$$OLTF = 1.887\left(1 + \frac{1}{3.514s} + 0.878s\right) \cdot \frac{4}{(2s+1)(5s+1)(s+1)}$$

Data Browser

Controllers and Fixed Blocks

G

H

Designs

Responses

LoopTransfer_C

IOTransfer_r2y

Preview

```
Fixed Block
Name: G
Sample Time: 0
Value:
          23.29 s^2 + 26.52 s + 7.548
  ---------------------------------------------
  35.14 s^4 + 59.74 s^3 + 28.11 s^2 + 3.514 s
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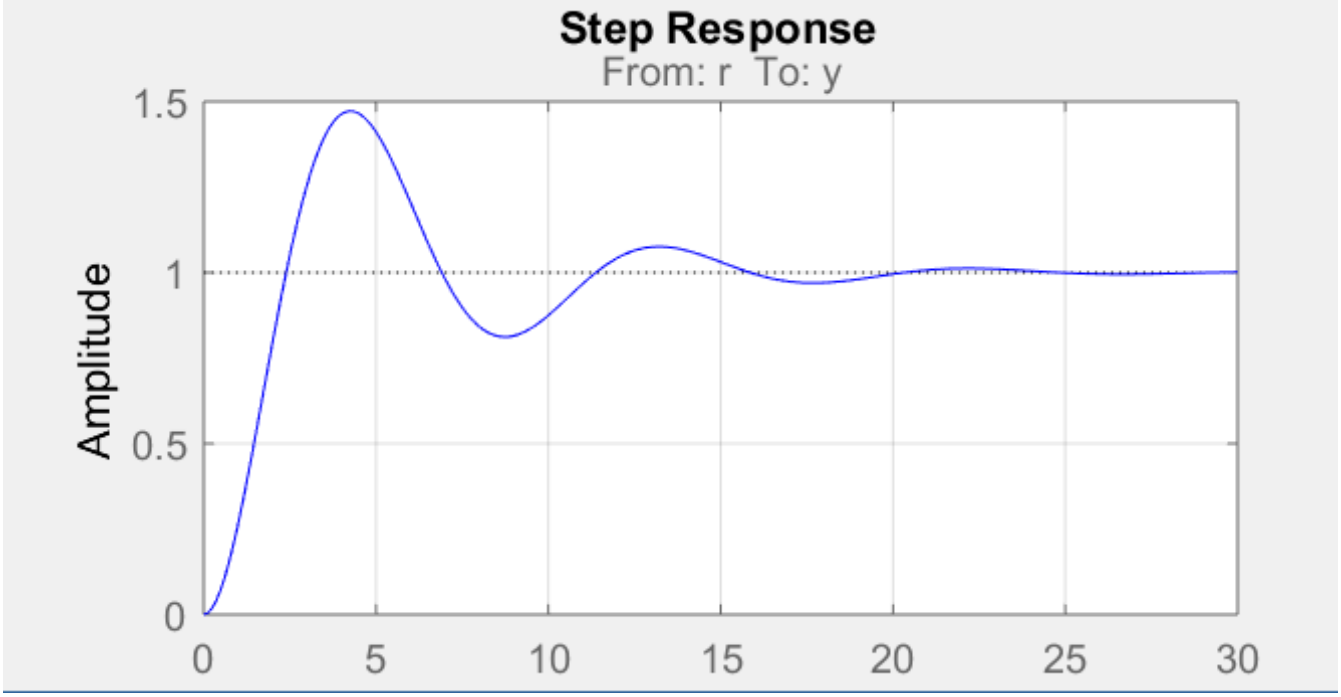
Step Response
From: r To: y
Amplitude
1.5
1
0.5
0
0
5
10
15
20
25
30