Mazen HossamEldeen Hassan MBD_Diploma

Applied Learning Project: Designing PID Controller for 2nd Order System (RC Circuit) Using Root Locus Method

التاريخ: / /

الموضوع:

بسم الله الرحمن الرحيم

Lab project

G_p (Plant) T.F =

$R_1 = R_2 = 1e6$

$C_1 = C_2 = 1e-7$

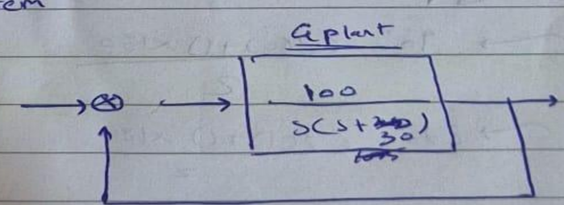
open loop second order $T.F = \dfrac{w_n^2}{s(s+2\zeta w_n)}$

$$\zeta = \frac{3 \cdot R \cdot C}{2 \cdot w_n \cdot (R^2 \cdot C^2)} \rightarrow \frac{3(1000000)(1\times10^{-7})}{2(10)(1\times10^{6})^2(1\times10^{-7})^2} = 1.5$$

$$w_n = \frac{1}{R*C} = \frac{1}{1000000 \times (1\times10^{-7})} = 10$$

$$\text{open loop} \rightarrow \frac{100}{s(s+2(1.5)(10))} \rightarrow \frac{100}{s(s+30)}$$

system



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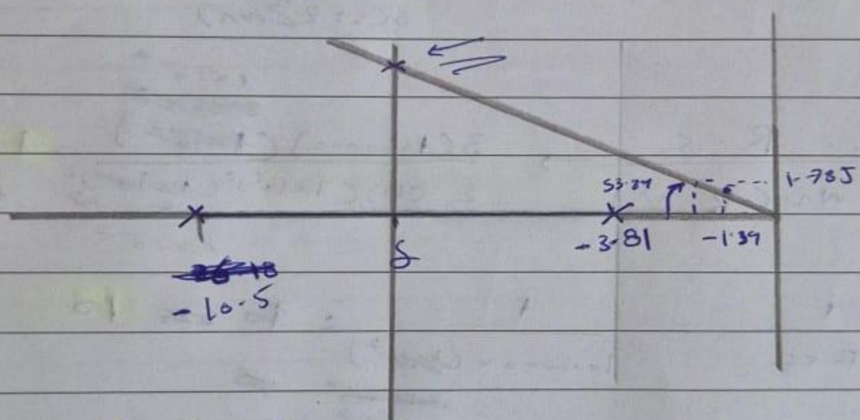
2 → **Draw root Locus**

$G_{p\,\text{openloop}} = \dfrac{100}{S(S+\cancel{10})}$ (30) → $G_{p\,\text{closed loop}} = \dfrac{100}{s^2 + \cancel{30}s + 100}$ (300)

Number of Zeros = 0

Number of poles = 2 $S_1 = -3.81$ $S_2 = -26.18$



$P - Z = 2$

$\sigma = \dfrac{(-30)}{2} = -15$ $\theta = \tan^{-1}\left(\dfrac{\sqrt{1-\zeta^2}}{2}\right)$

$\theta_\zeta =$

$q \to 0 \to 1$

$q = 0 \to 90^\circ$ $\dfrac{(2(0)+1)\times 180}{2}$

$q = 1 \to 270^\circ$ $\dfrac{(2(1)+1)\times 180}{2}$

الموضوع:

2 → requirements

$MOS < \frac{15}{100} \rightarrow \zeta$, $15 = e^{\frac{-\pi\zeta}{\sqrt{1-\zeta^2}}} \times 100$

$\zeta = 0.516$

since Less than 15%
so I will chose 10%

$10 = e^{\frac{-\pi\zeta}{\sqrt{1-\zeta^2}}} \times 100$

$\zeta = 0.59$ #

5% ess

$T_s < 3$ seconds

Assume 2% tolerance

$T_s = \frac{3.91}{\zeta \cdot w_n}$

$3 = \frac{3.91}{0.59\, w_n}$

$w_n = 2.21$ #

$\theta = \tan^{-1}\left(\frac{\sqrt{1-\zeta^2}}{\zeta}\right)$

$\theta = \tan^{-1}\left(\frac{\sqrt{1-0.59^2}}{0.59}\right)$

$\theta = 53.84$

$s_{1,2} = -\zeta w_n \pm w_n\sqrt{1-\zeta^2}$

$s_{1,2} = -1.39 \pm 1.78\, J$

$s_{1,2}$ = real ± imaginary

we will Take $\sigma = -15$ in order to achieve the requirements

$\sigma = \zeta w_n$

$15 = 0.59\, w_n$

$w_n = 25.423$

$w_d = w_n\sqrt{1-\zeta^2}$

$= 25.423\sqrt{1-0.59^2}$

$w_d = 20.523$

will achieve the requirements

$s_{1,2} = -15 \pm 20.523\, J$

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2 → Actual point you will design $s_{1,2} = -15 \pm 20.5235$

$$1 + L(s) = 0$$

$$\cancel{\boxed{\frac{K_p + K_d s + K_i}{s}} \boxed{100}}$$

$$K_p + K_d s + \frac{K_i}{s}$$

$$\cancel{1 + \left[\frac{sK_p + K_d s^2 + K_i}{s} \times \frac{100}{s^2 + 30s + 100}\right] = 0}$$

$$\cancel{1 + \frac{100 K_p s + 100 K_d s^2 + 100 K_i}{s(s^2 + 30s + 100)} = 0}$$

$$\cancel{s^3 + 30s^2 + 100s + 100K_p s + 100K_d s^2 + 100K_i = 0}$$

$$\cancel{s^3 + [30 + 100K_d]s^2 + [100K_p + 100]s + 100K_i = 0}$$

$$1 + \left[\frac{sK_p + K_d s^2 + K_i}{s} \times \frac{100}{s(s+30)}\right] = 0$$

$$1 + \frac{100K_p s + 100K_d s^2 + 100K_i}{s^2(s+30)} = 0$$

$$s^3 + 30s^2 + 100K_p s + 100K_d s^2 + 100K_i = 0$$

$$s^3 + (30 + 100K_d)s^2 + (100K_p)s + 100K_i = 0$$

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General form

$$(S+a)(S^2+2\zeta\omega_n S+\omega_n^2)=0$$

assume $a = 35$

$$(S+35)(S^2+2.61S+4.8841)=0$$

$$S^3+2.61S^2+4.8841S+35S^2+91.35S+170.9435=0$$

$$S^3+[37.61]S^2+[96.23]S+170.9435=0$$

Equatting coefficiants

$$S^3+(30+100K_d)S^2+(100K_p)S+100K_i=0$$

$\cancel{100K_i = 832683}$

$\cancel{K_i = 0.64 \text{ or } 0.636}$ #

$\cancel{100K_p = 38.9141}$

$\cancel{K_p = 0.3891}$ #

$\cancel{30+100K_d = 45.649}$

$100K_i = 170.9435$

$K_i = 1.71$ #

$100K_p = 96.23$

$K_p = 0.9623$ #

$30+100K_d = 37.61$

$100K_d = 7.61$

$K_d = 0.0761$ #

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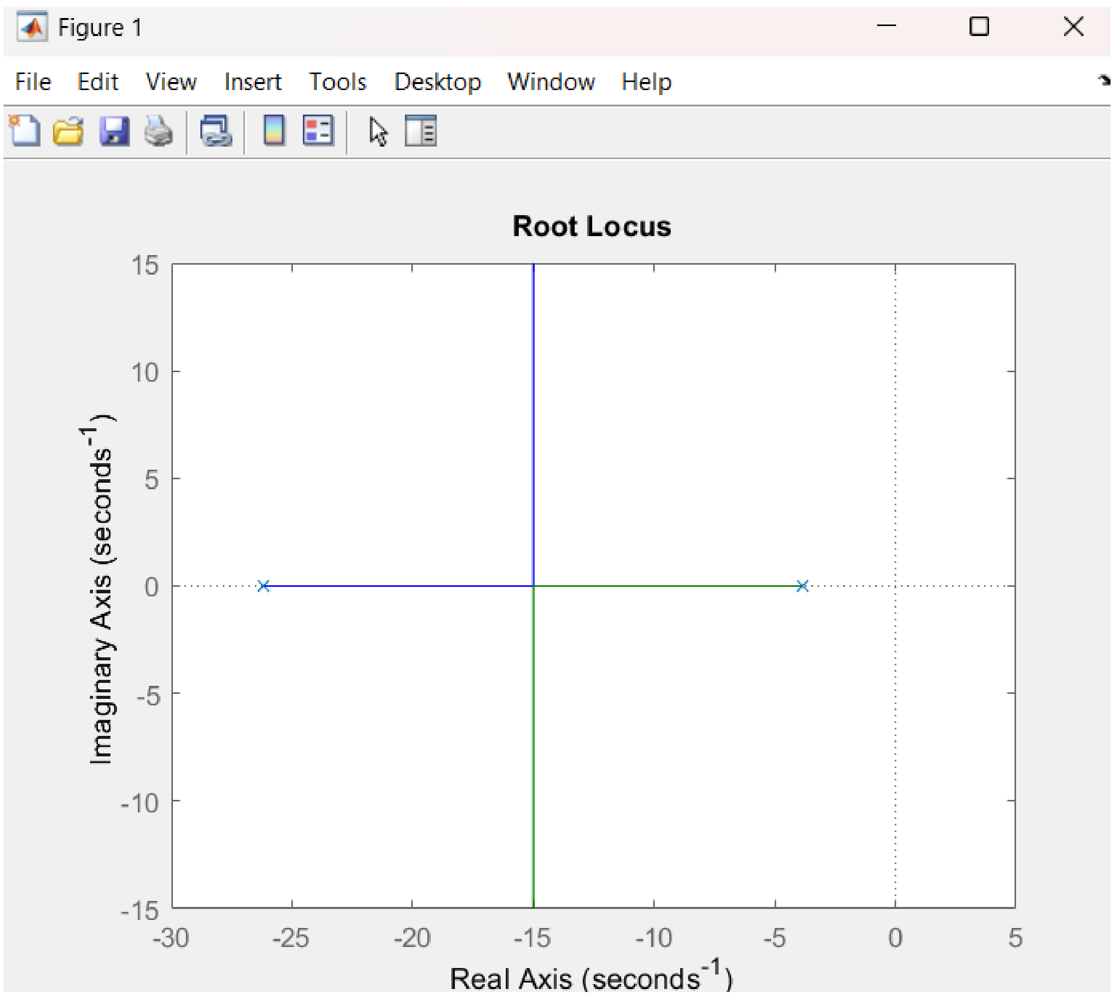
Script_root_locus

```
R1 = 1e6;
R2 = 1e6;
C1 = 1e-7;
C2 = 1e-7;
num = [1/(R1*R2*C1*C2)];
den = [1 (R1*C1+R2*C2+R1*C2)/(R1*R2*C1*C2) (1/(R1*R2*C1*C2))];
G=tf(num,den)
rlocus(G)
```



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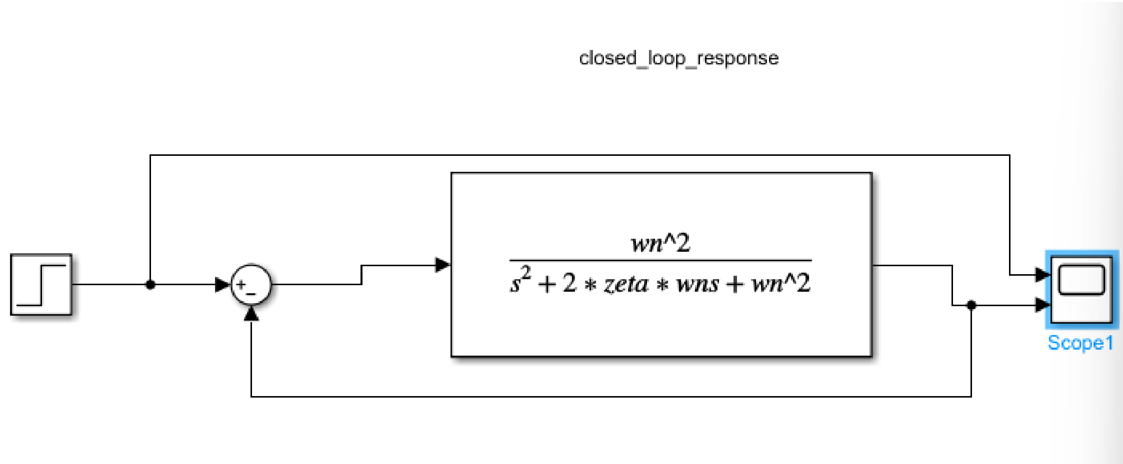
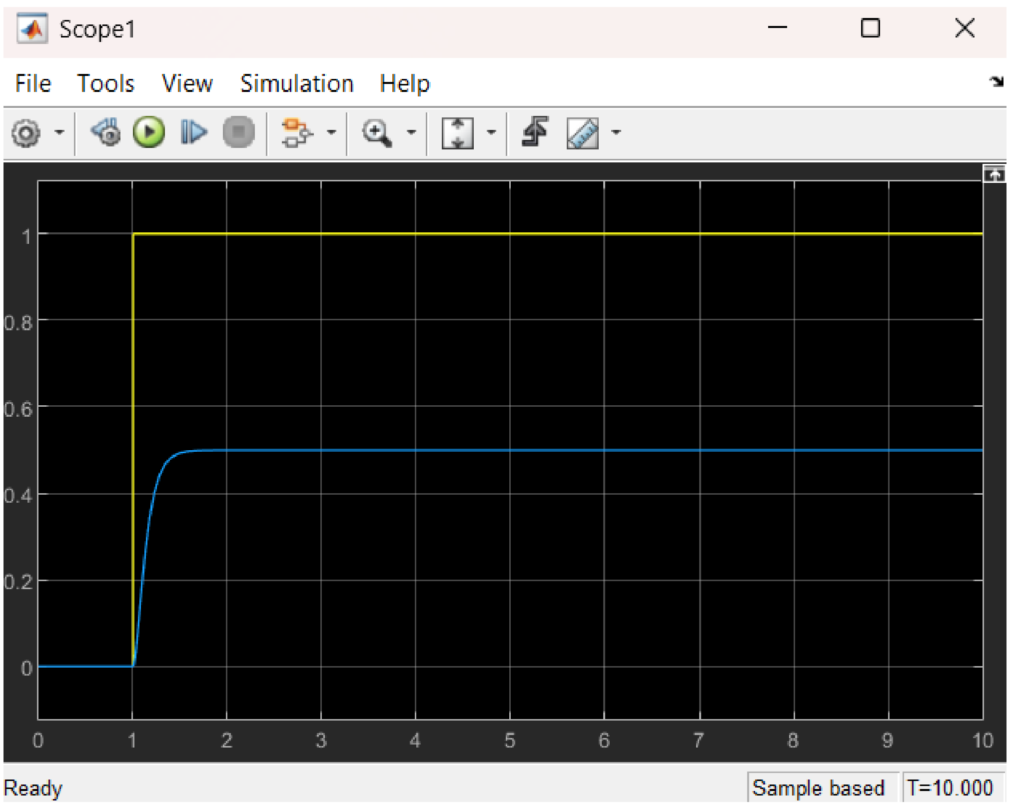
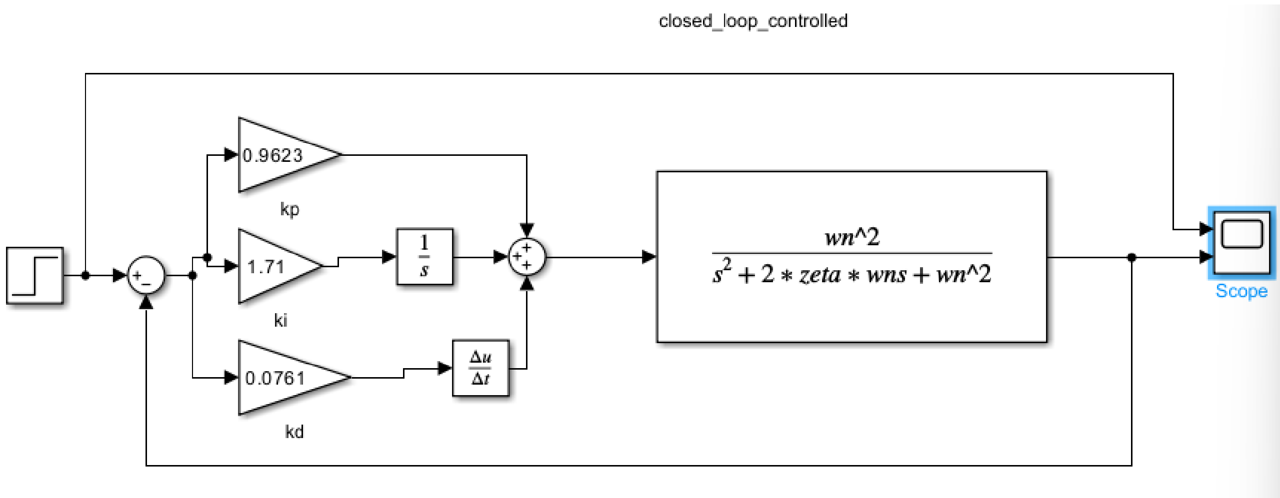
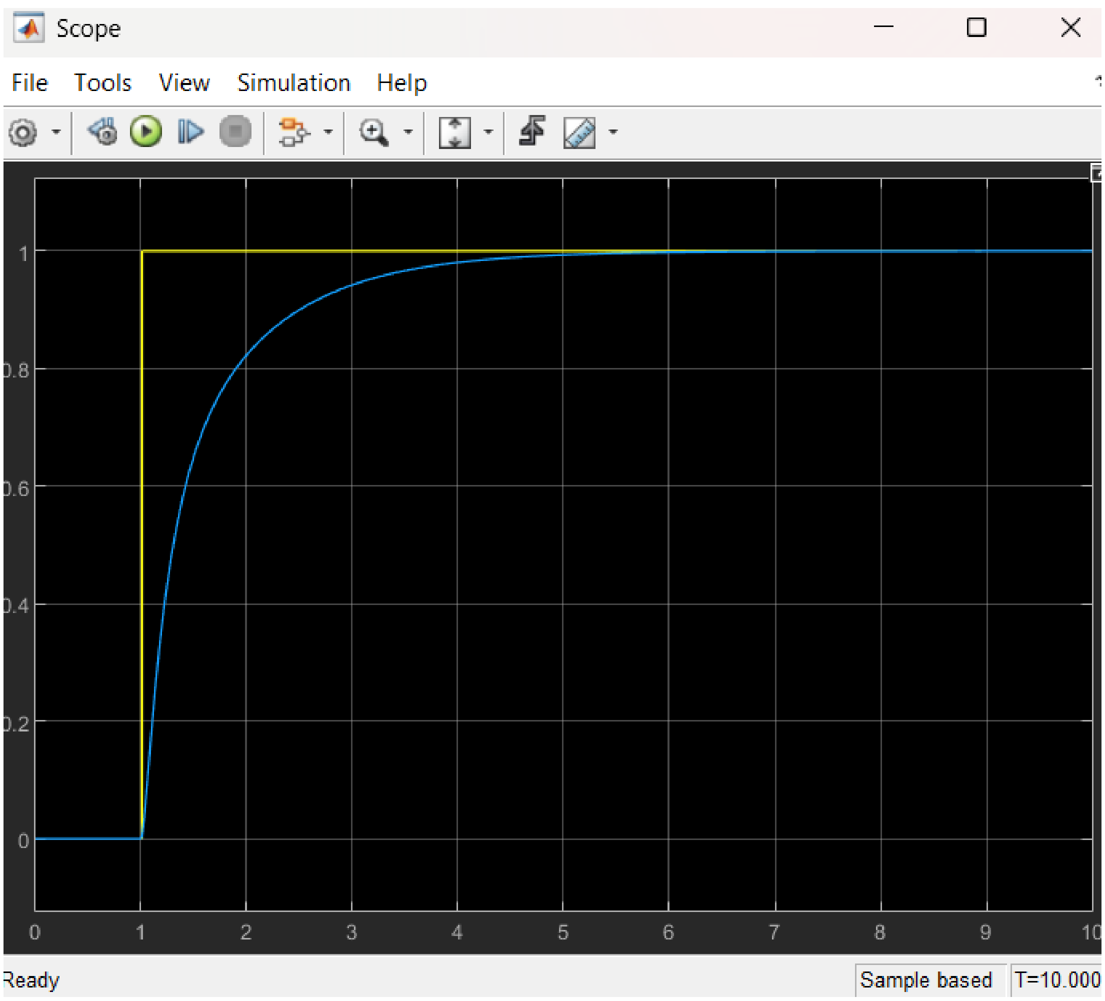





closed_loop_controlled
0.9623
kp
1.71
ki
1/s
0.0761
kd
Δu/Δt
wn^2
s^2 + 2 * zeta * wns + wn^2
Scope


Scope
File
Tools
View
Simulation
Help
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
7
8
9
10
Ready
Sample based
T=10.000