CMPE-242
Applied Feedback Control

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# 4 LEAD DESIGN

\[ G(s) = \frac{10}{\pi (\pi + 1)(\pi + 10)} \]

\[
\left[ \begin{array}{c}
M_p < 16\% \\
t_r < 0.4m \Rightarrow t_r = \frac{1.4}{\omega_n} < 0.4 \Rightarrow \omega_n > 4.5 \\
\varepsilon_p < 0.02
\end{array} \right] \]

\[ J = 0.5 \Rightarrow 30^\circ \]
\[ \Delta \omega_s = -2.5 \pm 4j \]
$G(s) = \frac{10}{s(s+1)(s+10)}$

$\Delta_{\text{av}} = -2.5 \pm 4j$

$\phi_{\Delta} = -180 + \tan^{-1}\left(\frac{4}{10-2.5}\right)$

$\phi_{\Delta} = -261^\circ$

$x \to 0$

$\alpha = -\frac{11}{3}$

$150 - \tan^{-1}\left(\frac{4}{2.5}\right)$

$150 - \tan^{-1}\left(\frac{4}{2.5-1}\right)$
\[ \phi_\Delta = -260.6 \rightarrow -180 \rightarrow 81^\circ \text{ at phase lead} \]

\[ \angle = 180 - (69 - 81) = 30^\circ \]

\[ \ell = \frac{4}{\tan(30^\circ)} \]

\[ D(s) = \frac{L_0 (\lambda + 1)}{(\lambda + \left(\frac{9}{L - 5}\right)^{1.5})} = \frac{L_0 (\lambda + 1)}{(\lambda + 9.1)} \]
\[ k(s) = k_0 \frac{\lambda + 1}{\lambda + 9.1} \]

\[ k_0 = \frac{\prod l_{p_i}}{\prod l_{q_j}} \]

\[ k_0 = \frac{\lambda_1 \lambda_2 \lambda_3}{10} \]

\[ \frac{\sqrt{4^2 + 2.5^2}}{\sqrt{4^2 + (6.9)^2}} \]

\[ \frac{l_1}{l_2} \]

\[ \frac{\lambda_3}{\sqrt{4^2 + (10.25)^2}} \]

\[ |GK| = 1 \]

\[ \left| \frac{10k_0}{\lambda_1 \lambda_2 \lambda_3} \right| = 1 \]
Gs = tf([10],con([1 10 0],[1 10]));
Ds = tf(ko*[1 1],[1 9.4]);

rlocus(Gs);
hold on
sgrid(0.5,4.5);

rlocus(Ds*Gs);
ko = rlocfind(Ds*Gs);

Gcl = feedback(ko*Ds*Gs,1);
step(Gcl);
\[ E_{ss} < 0.02 \]
\[ \frac{e}{r} = \frac{1}{1 + \theta k} \]

\[ \lim_{n \to 0} \left( \frac{E(n)}{R(n)} \right) R(n) = \lim_{n \to 0} \frac{1}{k} \frac{1}{n^2} \]

\[ = \frac{1}{1 + k \theta D(n) C(n)} \cdot \frac{1}{n} \]
\[
\frac{3}{n^2} = \frac{1}{1 + \frac{k_0(n+1)}{n(n+9.4)(n+10)}}
\]

As \( n \to \infty \),

\[
\frac{n(n+9.4)(n+10)}{n(n+9.4)(n+10) + 10k_0}
\]

\[
\left(\frac{1}{n}\right)^{0.8} = \frac{(9.4)(0.8)}{10k_0} < 0.02
\]

\[
\frac{9.9}{k_0} < 0.02 \quad \therefore \quad k_0 > 9.4
\]

\[
\frac{9.9}{k_0} \approx 0.7
\]
\[ D(\xi) = \frac{K_0(\xi+1)K_0 + 0.03}{(\lambda + \gamma + 0.4)(\lambda + 0.001)} \]

\[ \frac{\lambda}{\gamma} \]

\[ \frac{\lambda + 0.3}{\gamma} \]

\[ 0.02 \]

\[ 0 \]

\[ 30 \]

\[ 3 = 0.001 \]

\[ p = 3 \times 0.001 \]
\[ \frac{\Sigma}{R} = \frac{1}{1 + G_K} \]

Err = feedback(1, Ds*Gs)
2:

\[ G(s) = \frac{1}{s^2 + (1+\alpha)\sigma + (1+\alpha)} \]

\[ \frac{\zeta}{\sigma} = -1 \]

\[ (n^2 + n + 1) + \alpha (n+1) = \phi \]

\[ \frac{1 + \alpha (n+1)}{n^2 + n + 1} = \phi \]

\[ \alpha \left( \frac{n+1}{n^2 + n + 1} \right) = -1 \]
\[ \Delta_{dl}(s) \bigg|_{s=j\omega} = \omega + \omega \cdot j - \omega \cdot \alpha \]
\[ R \rightarrow \frac{1}{\text{DC gain}} \rightarrow \frac{1}{K_o} \frac{s + 10}{s - \omega_0} \rightarrow \text{Gain} \rightarrow \text{Output} \]
\[ G(s) = \frac{4 - 2s}{(s^2 + s + 9)} = \frac{-2(s + 2)}{(s^2 + s + 9)} \]

\[ \sigma = \sigma \pm \sigma_j \]
$\phi_0 = \frac{180}{\text{度}} - 90 - 90 = ?$

$\theta = 180 - 90 - 175 = ? - 180$

$\gamma = 180 - 175 = ?$
PRE-GAIN

\[
\frac{\psi}{n} = \frac{\sigma k}{1 + \sigma k} \left( \frac{1}{DC \text{ gain}} \right)
\]
Successive loop closure