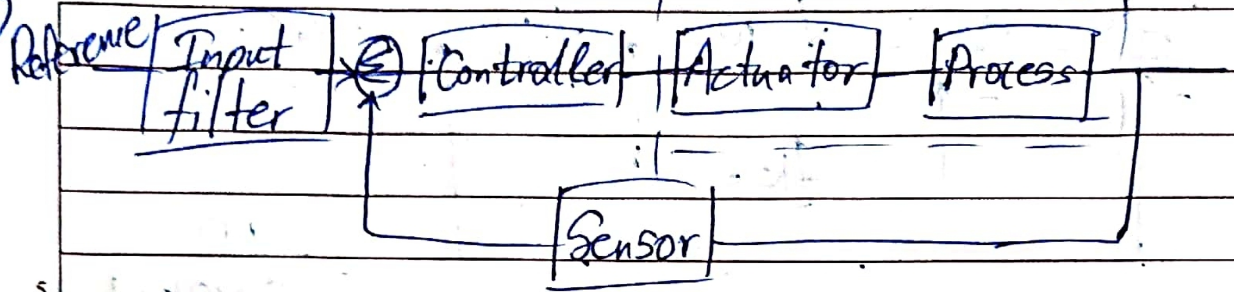
2020 - Control.

ප්‍රශ්න අංකය : / வினா எண் : Q1.   විභාග අංකය : / பரீட்சைச் சுட்டெண் :   පිටු අංකය : / பக்க எண் :

a) (i)



(ii) Controller : According to the diffrence between Reference and output (error) controller computes the suitable control signal

Actuator : According to the control signal actuator adjusts the process to get desired output.

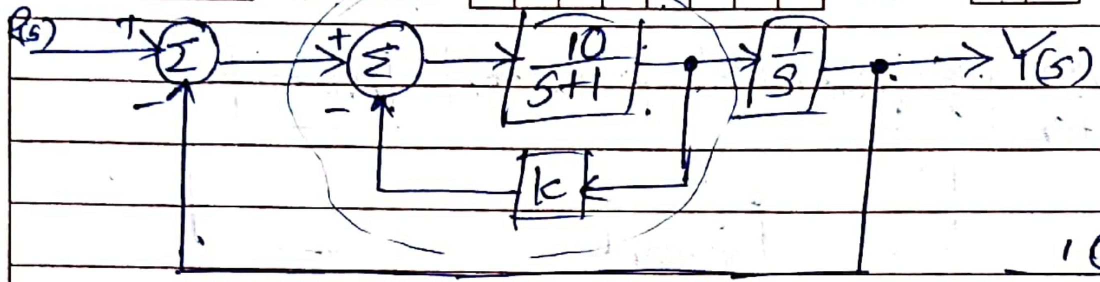
Sensor : Converts a physical value to a electrical signal

(iii) Disturbance :

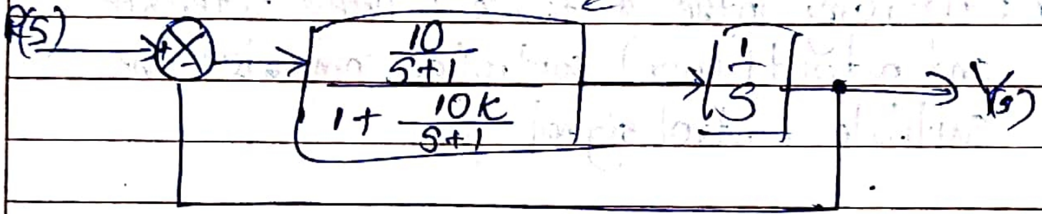
සෑම ප්‍රශ්නයක් සඳහා ම පිළිතුරු අලුත් පිටුවකින් ආරම්භ කරන්න./
ஒவ்வொரு வினாவுக்குமான விடையைப் புதிய பக்கத்தில் ஆரம்பிக்க.

ප්‍රශ්න අංකය : / வினா எண் : | විභාග අංකය : / பரீட்சைச் சுட்டெண் : | පිටු අංකය : / பக்க எண் :

b)



$$= \frac{10}{s+10k+1}$$



$$G(s) = \frac{\frac{10}{s(s+10k+1)}}{1+\frac{10}{s(s+10k+1)}}$$

$$= \frac{10}{s(s+10k+1)+10}$$

$$G(s) = \frac{10}{s^2+(10k+1)s+10}$$

General $G(s) = \cancel{\frac{10\omega_n^2}{s^2+(10k+1)s}}$ $\frac{\omega_n^2}{s^2+2\zeta\omega_n s+\omega_n^2}$

$\omega_n^2 = 10$ $\qquad 10k+1 = 2\zeta\omega_n$

$\omega_n = \sqrt{10}$ $\qquad 10k+1 = 2\times 0.5\times\sqrt{10}$

$$k = \frac{\sqrt{10}-1}{10}$$

$$= 0.216$$

Now $G(s) = \frac{10}{s^2+3.16s+10}$

poles : $s^2+3.16s+10 = 0$

$s = -1.58 \pm j2.739$

පරීක්ෂකවරයාගේ ප්‍රයෝජනය සඳහා පමණි.

பரீட்சகரின் உபயோகத்திற்கு மாத்திரம்

2020 Control.

සෑම ප්‍රශ්නයක් සඳහා ම පිළිතුරු අලුත් පිටුවකින් ආරම්භ කරන්න./
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ප්‍රශ්න අංකය : / வினா எண் : Q9   විභාග අංකය : / பரீட்சைச் சுட்டெண் :   පිටු අංකය : / பக்க எண் :

a) (i) In terms of characteristic equation, in order to have a stable system, the roots of the characteristic equation must lie in the left half plane of the s-plane

(ii) Consider a characteristic eq^n

$$s^n + a_1 s^{n-1} + a_2 s^{n-2} + \dots + a_n = 0$$

Necessary condition:

All the coefficients of the characteristic equation must be positive $a_1, a_2, \dots a_n > 0$

Sufficient condition.

all elements in the first column of Ruth array must be positive

$$s^4 + 2s^3 + (4+k)s^2 + 9s + 25 = 0$$

~~1   4+k   25~~
~~2   9   0~~
~~$-\left[\frac{9-2(4+k)}{2}\right]$ $-[0-2\times 25]$~~

1	4+k	25
2	9	0
$-\left[\frac{9-2(4+k)}{2}\right]$	$-[0-2\times 25]$	0
		0
		0

පරීක්ෂකවරුන්ගේ ප්‍රයෝජනය සඳහා පමණි. / பரீட்சகர்களின் உபயோகத்திற்கு மாத்திரம்

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සෑම ප්‍රශ්නයක් සඳහා ම පිළිතුරු අලුත් පිටුවකින් ආරම්භ කරන්න./
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ප්‍රශ්න අංකය / வினா எண் : Q3 | විභාග අංකය / பரீட்சை சுட்டெண் : | පිටු අංකය / பக்க எண் :

a) (i) Reliablity and accuracy
faster recovery
Continuos improvement

(ii) $G(s) = \frac{1}{(s+\tau_1)(s+\tau_2)} = 1$

By adding a proportional controller with gain k. the transiant response will improved by reducing the max. over shoot as well as settling time.

Max overshoot, $M_p = e^{-\zeta\pi/\sqrt{1-\zeta^2}} \times 100\%$

(iii) Root locous is the graphical representation of the CL poles in the S-plane as a system parameter varied.

සෑම ප්‍රශ්නයක් සඳහා ම පිළිතුරු අලුත් පිටුවකින් ආරම්භ කරන්න./
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ප්‍රශ්න අංකය : வினா எண் : | විභාග අංකය : பரீட்சைச் சுட்டெண் : | පිටු අංකය : பக்க எண் :

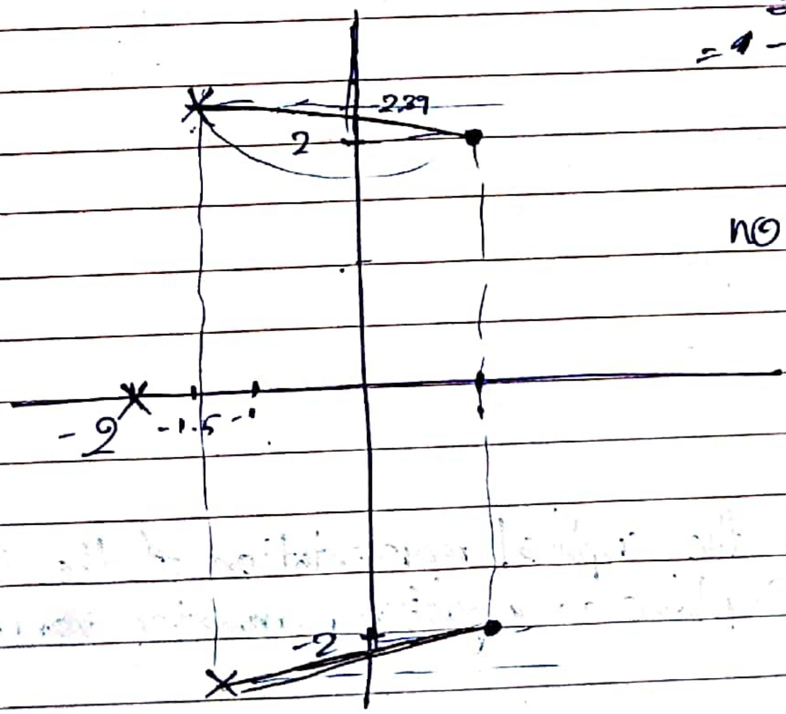
b) $G(s) = \dfrac{s^2-2s+5}{(s+2)(s^2+3s+8)}$

OL zeros, $s^2-2s+5=0$

$$s = \frac{+2 \pm \sqrt{4-4\times 5}}{2\times 1}$$
$$= 1 \pm j2.$$

OL poles, $s = -2$, $s^2+3s+8=0$

$$s = \frac{-3 \pm \sqrt{9-4\times 8}}{2}$$
$$= -\frac{3}{2} \pm \sqrt{23}\, i$$
$$= -1.5 \pm j2.3979$$



no real axis segments.

Behavior at infinity, $\sigma_a = \dfrac{\sum p_i - \sum z_i}{n-m}$

$= \cancel{\dfrac{-2 - 1.5 + j2.3979 + -1.5 - j2.3979 - [1+j2+1-j2]}{}}$

$= \cancel{7}$

One branch reaches infinity

jω axis crossings.

Root locous $1 + kG(s) = 0$

$$1 + k\frac{(s^2-2s+5)}{(s+2)(s^2+3s+8)} = 0$$

$$s^3 + (5+k)s^2 + (14-k)s + 16 + 5k = 0$$

at jω axis, $s = j\omega$.

$$(j\omega)^3 + (5+k)(j\omega)^2 + (14-2k)j\omega + 16 + 5k = 0$$

$$-j\omega^3 - (5+k)\omega^2 + (14-2k)j\omega + 16 + 5k = 0$$

~~Root~~ Real parts : $-(5+k)\omega^2 + 16 + 5k = 0 \quad -(1)$

img parts $\quad -j\omega^3 + (14-k)j\omega = 0$

$$\omega[\omega^2 + 2k - 14] = 0$$

$$\omega^2 = 14 - 2k \quad -(2)$$

$(1) \Rightarrow \; -(5+k)(14-2k) + 16 + 5k = 0$

$$-(70 + 4k - 2k^2) + 16 + 5k = 0$$

$$2k^2 + k - 54 = 0$$

$$k = 4.9522 \;,\; -5.4522$$

gain must be positive, $\therefore k = 4.9522$

$(2) \Rightarrow \quad \omega^2 = 14 - 2 \times 4.9522$

$$\omega = \pm 2.0238$$

Root locus design

සෑම ප්‍රශ්නයක් සඳහා ම පිළිතුරු අලුත් පිටුවකින් ආරම්භ කරන්න./
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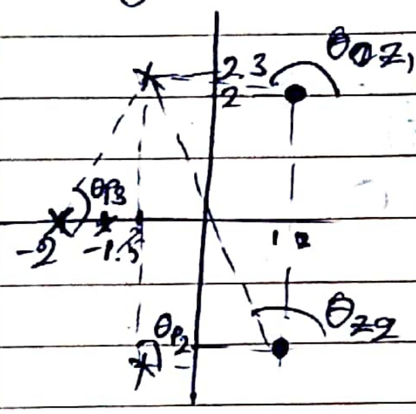
ප්‍රශ්න අංකය / வினா எண் : | විභාග අංකය / பரீட்சை சுட்டெண் : | පිටු අංකය / பக்க எண் :

NETS National Evaluation and Testing Service

Angle of departure.



$\theta_{z1} = \cancel{\tan^{-1}}\ 180 - \tan^{-1}\left(\frac{0.3979}{2.5}\right)$

$=$

$\theta_{z2} = 180 - \tan^{-1}\left(\frac{4.3979}{2.5}\right)$

$=$

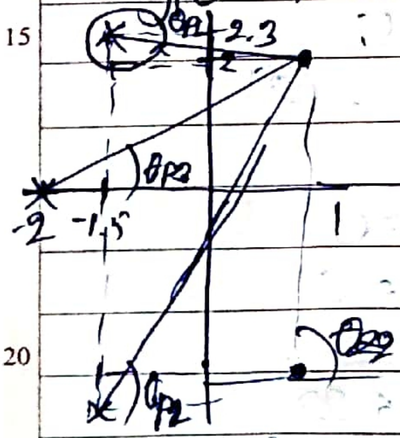
$\theta_{p2} = 90$

$\theta_{p3} = \tan^{-1}\left(\frac{0.3979}{0.25}\right)$

$\theta_{z1} + \theta_{z2} - \theta_{p1} - \theta_{p2} - \theta_{p3} = 180$

$\theta_{p1} = -57.6488^\circ$

Angle of arrival:



$\theta_{z2} = 90$

$\theta_{p1} = 360 - \tan^{-1}\left(\frac{0.3979}{2.5}\right)$

$\theta_{p2} = \tan^{-1}\left(\frac{4.3979}{2.5}\right)$

$\theta_{p3} = \tan^{-1}\left(\frac{2}{3}\right)$

$\theta_{z1} + \theta_{z2} - \theta_{p1} - \theta_{p2} - \theta_{p3} = 180$

$\theta_{z1} = +535.0305$

$= +175.0305$

(iii) from ~~0 to~~ $k=0$ to $k = 4.9522$, system is stable

(iv) $e_{ss} = \frac{\cancel{kG(0)}}{\cancel{k}1 + \cancel{kG(0)}} = 1 - \frac{kG_0}{1+kG_0} = 1 - \frac{2 \times \frac{5}{8\times 2}}{1 + \frac{2\times 5}{8\times 2}}$

$= 0.615$

සෑම ප්‍රශ්නයක් සඳහා ම පිළිතුරු අලුත් පිටුවකින් ආරම්භ කරන්න./
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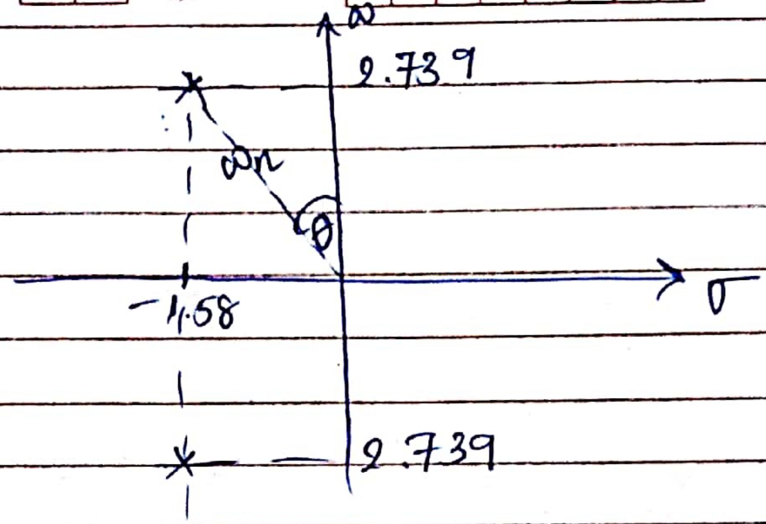
ප්‍රශ්න අංකය : / வினா எண் : විභාග අංකය : / பரீட்சைச் சுட்டெண் : පිටු අංකය : / பக்க எண் :



b)(iii) $Y(s) = R(s)\,G(s)$

$$= \frac{1}{s} \times \frac{10}{(s^2+3.16s+10)}$$

$$= \frac{10}{s(s+1.58+j2.739)(s+1.58-j2.739)}$$

$$= \frac{A}{s} + \frac{B}{s+1.58+j2.739} + \frac{C}{s+1.58-j2.739}$$

$A = 1$, $B = -0.5-j0.3$, $C = -0.5+j0.3$

$$Y_s = \frac{1}{s} - \frac{0.5+j0.3}{s+1.58+j2.739} + \frac{(-0.5+j0.3)}{s+1.58-j2.739}$$

$$= 1(t) - (0.5+j0.3)e^{(1.58-j2.739)t} + (-0.5+j0.3)e^{(-1.58+j27.39)t}$$

2020 - Control

සෑම ප්‍රශ්නයක් සඳහා ම පිළිතුරු අලුත් පිටුවකින් ආරම්භ කරන්න./
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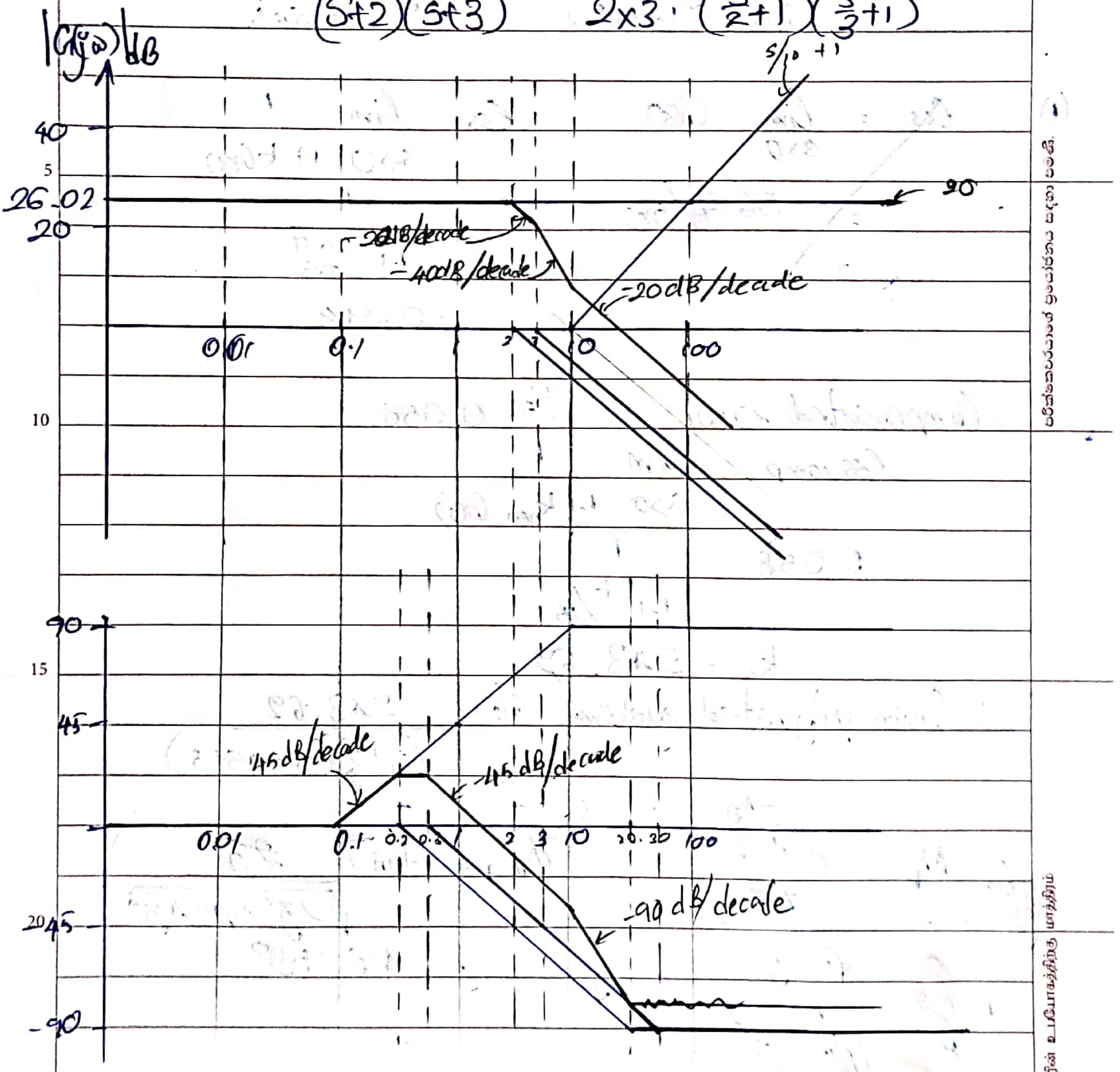
ප්‍රශ්න අංකය : / வினா எண் : Q5 | විභාග අංකය : / பரீட்சைச் சுட்டெண்: | පිටු අංකය : / பக்க எண் :

a)(i) $$G(s) = \frac{12(s+10)}{(s+2)(s+3)} = \frac{12\times 10}{2\times 3}\cdot\frac{\frac{s}{10}+1}{\left(\frac{s}{2}+1\right)\left(\frac{s}{3}+1\right)}$$



If the magnitude freq response of the system has less than 0dB value when phase freq response is 180° then an stable open loop system is stable in closed loop system.

පරීක්ෂකවරයාගේ ප්‍රයෝජනය සඳහා පමණි.
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b) $G(s) = \dfrac{36.7}{(s+3)(s^2+4s+5)} = \dfrac{36.7}{s^3+7s^2+17s+5}$

(i) $\cancel{e_{ss} = \lim_{s\to 0} G(s)}$

$\cancel{= 36.7/5\times3}$

$=$

$e_{ss} = \lim_{s\to 0} \dfrac{1}{1+kG(s)}$

$= \dfrac{1}{1+\frac{36.7}{5\times3}}$

$= 0.29$

Compensated error $= 0.29/5 = 0.058$

$e_{ss,comp} = \lim_{s\to 0} \dfrac{1}{1+k_{new}G(s)}$

$0.058 = \dfrac{1}{1+k/15}$

$k = 243.62$

$\therefore$ Gain adjusted system $G(s) = \dfrac{243.62}{(s+3)(s^2+4s+5)}$

$M_p = e^{\frac{-\pi\zeta}{\sqrt{1-\zeta^2}}}$

$\ln 0.2 = \dfrac{-\pi\zeta}{\sqrt{1-\zeta^2}}$

$1-\zeta^2 = \dfrac{\pi^2}{(\ln 0.2)^2}\zeta^2$

$\zeta = 0.456$

$\phi_{m,req} = \tan^{-1}\left(\dfrac{2\zeta}{\sqrt{-2\zeta^2+\sqrt{1+4\zeta^4}}}\right)$

$= 48.152^\circ$

$\phi_m = \phi_{m,req} + \phi_{comp}$

$= 48.152^\circ + 10^\circ$

$= 58.152^\circ$

සෑම ප්‍රශ්නයක් සඳහා ම පිළිතුරු අලුත් පිටුවකින් ආරම්භ කරන්න./
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ප්‍රශ්න අංකය : வினா எண் : | විභාග අංකය : பரீட்சைச் சுட்டெண்: | පිටු අංකය : பக்க எண் :

$$G(j\omega) = \frac{243.62}{\cancel{8} - j\omega^3 - 7\omega^2 + j17\omega + 15} = \frac{243.62}{(-7\omega^2+15) + j(-\omega^3+17\omega)}$$

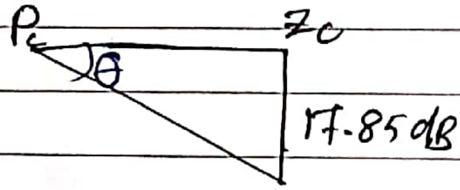
$$\tan^{-1}\frac{\omega^3 - 17\omega}{-7\omega^2+15} = -180^\circ + 58.152^\circ$$

$$\omega^3 - 17\omega = -7\times1.61\omega^2 + 15\times1.61$$

$$\omega = -12.48,\ 2.12,\ -0.91$$

$$|G(j\omega)|_{\omega=2.0} = 7.81$$

$$|G(j\omega)|\,dB = 17.85\,dB$$



$$Z_c = \cancel{\frac{17.85}{8}}\ \frac{\omega_M}{10} = 0.212$$

$$\tan\theta = \frac{17.85}{\log Z_c - \log P_c}$$

$$20 = \cancel{\frac{17.85}{0.2\ 0.6}}\ \frac{17.85}{\log 0.212 - \log P_c}$$

$$\log 0.212 - \frac{17.85}{20} = \log P_c$$

$$P_c = 0.027.$$

$$|G_{lag}(s)|_{s=0} = \gamma\left(\frac{s+0.212}{s+0.027}\right)\Bigg|_{s=0} = 1$$

$$\gamma = 0.127.$$

$$G_{OL\,comp}(s) = 0.127\left(\frac{s+0.212}{s+0.027}\right)\times\frac{1}{(s+3)(s^2+4s+5)}$$

පරීක්ෂකවරුන්ගේ ප්‍රයෝජනය සඳහා පමණි.
பரீட்சகரின் உபயோகத்திற்கு மாத்திரம்

2020

සෑම ප්‍රශ්නයක් සඳහා ම පිළිතුරු අලුත් පිටුවකින් ආරම්භ කරන්න./
ஒவ்வொரு வினாவுக்குமான விடையைப் புதிய பக்கத்தில் ஆரம்பிக்க.

ප්‍රශ්න අංකය : / வினா எண் : Q4

විභාග අංකය : / பரீட்சைச் சுட்டெண்:

පිටු අංකය : / பக்க எண் :

a) (i) I PI controller

II PD

III PD

IV PID

(ii) $G_c(s) = k_p + \frac{k_i}{s}$.

$$G_{CL}(s) = \frac{\left(k_p + \frac{k_i}{s}\right) G(s)}{1 + \left(k_p + \frac{k_i}{s}\right) G(s)}$$

$$e_{ss} = \lim_{s \to 0} \frac{1}{1 + \left(k_p + \frac{k_i}{s}\right) G(s)}$$

$$= \lim_{s \to 0} \frac{s}{s + (k_p s + k_i)\, G(s)}$$

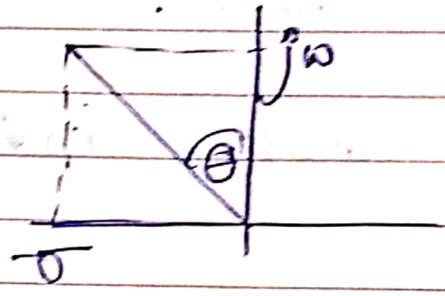
Since $G(s)$ does not have ~~a~~ zeoros

$e_{ss} = 0$

b) $G(s) = \dfrac{k}{(s+10)(s^2+4s+2)}$

$Z = \sin\theta = 0.456$

$\theta = 27.129^\circ$



$\sigma = \omega\tan\theta$

$=$

$M_p = e^{-\pi z/\sqrt{1-z^2}}$

$\ln 0.2 = \dfrac{-\pi z}{\sqrt{1-z^2}}$

$z = 0.456$

$S_1 = \omega(j - 0.\cancel{456}\,512)$

$1 + kG(s) = 0$

$1 + \dfrac{k}{(s+10)(s^2+4s+2)} = 0$

$s^3 + 14s^2 + 42s + \cancel{4}2\,0 + k = 0$

$\omega^3(j - 0.512)^3 + 14\omega^2(j - 0.512)^2 + 42\omega(j - 0.512) + 20 + k = 0$

$\omega^3(1.4 - j0.214) + 14\omega^2(-0.738 - j1.024) + 42\omega(j - 0.512) + 20 + k = 0$

img: $-0.214\omega^3 - 14\times1.024\omega^2 + 42\omega = 0$

Real: $1.4\omega^3 \cancel{+14\omega} - 14\times0.738\,\omega^2 - 42\times0.512\omega + 20 + k = 0$

$\omega = \cancel{0.214}, 2.812, -69.8, 0$

$k = +91.038, 524826, -10$

$\alpha = \cancel{36.397, 26890.23}$, 1.44.

ii) To achieve a 20% over shoot, $k = 91.038$.

Second order approximation.

root locus, $1 + \dfrac{91.038}{(S+10)(S^2+4S+2)} = 0$

$S^3 + 14S^2 + 42S + 20 + 91.038 = 0$

$S = -1.44 \pm j2.812$, -11.121

Third pole is located 5 times away from the dominant poles. ∴ Second order approximation is true.

a transfer of the 2nd order approximated system.

$$G(s) = \frac{1}{(S+1.44+j2.812)(S+1.44-j2.812)}$$

$$= \frac{1}{S^2 + 2.88S + 9.981}$$

$\omega_n = \sqrt{9.981}$
$= 3.16$

$2\zeta\omega_n = 2.88$
$\zeta = 0.4556$

Peak time $= \dfrac{\pi}{\omega_n\sqrt{1-\zeta^2}} = 1.117s$

settling time $= \dfrac{4}{\zeta\omega_n} = 2.776s$.