Benha University

Mechanical Eng. Dept. **4^{th} Year Mechanics**
Subject :Automatic Control **Date 17/5/2014**

Model Answer of The Final Corrective Exam

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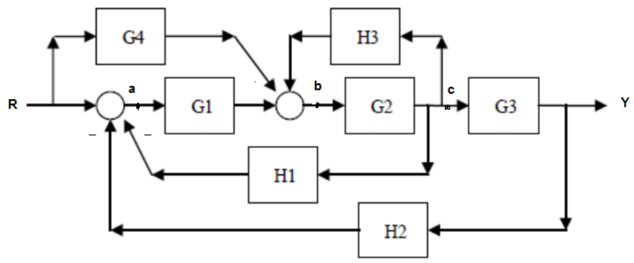
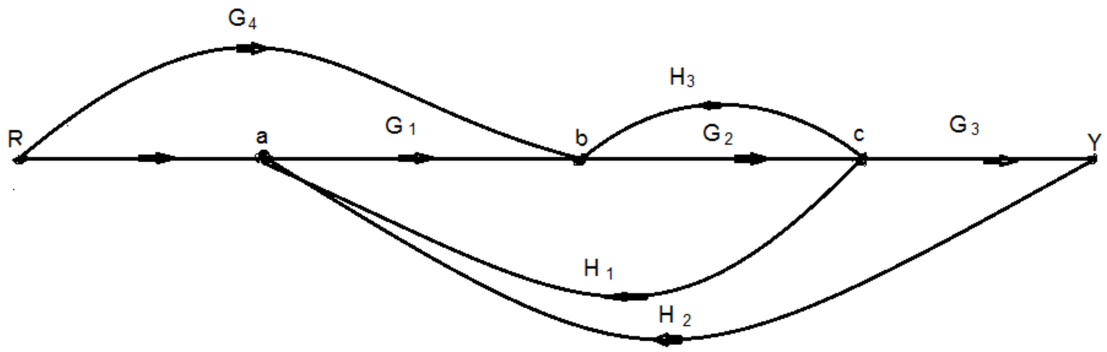
المادة : التحكم الآلى م ٤٨٢ نموذج الاجابة

التاريخ السبت 17مايو ٢٠١٤

أستاذ المادة : د. محمد عبد اللطيف الشرنوبى

1-a)





Loops

$L_1 = -G_1G_2H_1$ $L_2 = - G_1G_2G_3H_2$ $L_3 = - G_2H_3$

Paths

$M_1 = G_1G_2G_3$ $M_2 = G_4G_2G_3$

$\Delta = 1 + G_1G_2H_1 + G_1G_2G_3H_2 + G_2H_3$

$\Delta_1 = 1$

$\Delta_2 = 1$

$TF = (M_1\ \Delta_1 + M_2\ \Delta_2)/\ \Delta = (G_1G_2G_3+ G_4G_2G_3)/(1 + G_1G_2H_1 + G_1G_2G_3H_2 + G_2H_3)$

1-b)

FOR P=0, the characteristic equation is given by:

$S^2(S^2+2S+8) + K(S+Z) = 0$

$S^4+2S^3+8S^2+KS+KZ=0$

Construct the Huwarth array

s^4	1	8	KZ
s^3	2	K	0
s^2	(16-k)/2	KZ	0
s	$\frac{(16k-k^2-2kz)(2)}{16-k}$	0	
s^0	kz		

For stable systen

16 > K > 0, Z>0

$\frac{(16k-k^2-2kz)(2)}{16-k} > 0$

16-K-2z > 0

16 > k + 2z

ii For marginally stable system

Put S = jω

$\omega^4 - 2j\omega^3 - 8\omega^2 + jk\omega + kz = 0$

$-2\omega^3 + k\omega = 0$ $\qquad k = 2\omega^2$

$\omega^4 - 8\omega^2 + kz = 0$

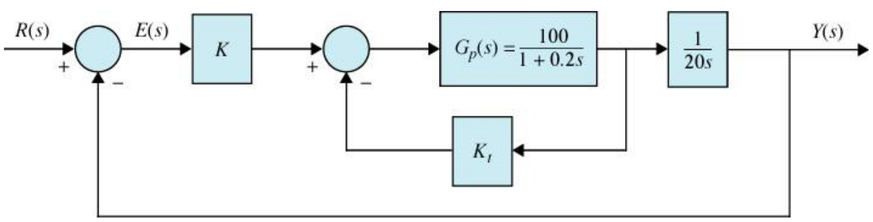
$\omega^4 + (2z-8)\omega^2 + = 0$

$\omega^4 + (2z-8)\omega^2 + = 0$ $\quad \omega = 0.$ $\quad \omega = \pm (8-2z)^{1/2}$ $\quad$, K = 16-4z

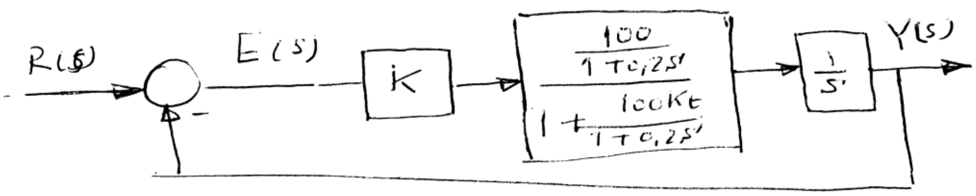
4 > z > 0 , 16 > k > 0

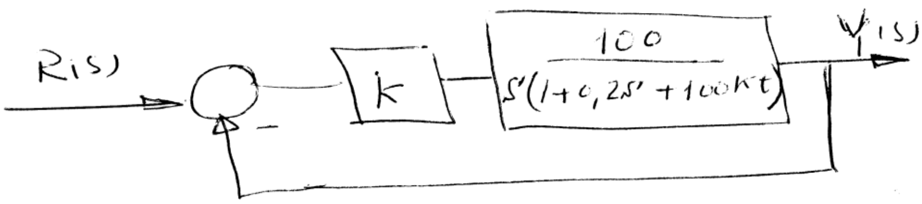
2-a)

For the system given below in figure 5, estimate the values of K and K_t so that a maximum percentage overshoot of 9.6% and a settling time of 0.05 sec for a tolerance band of 1% are achieved.



The system is reduced to





$$R(s) \longrightarrow \boxed{\dfrac{100K}{0.2s^2 + (1+100K_t)s + 100K}} \longrightarrow Y(s)$$

$$R(s) \longrightarrow \boxed{\dfrac{500K}{s^2 + 5(1+100K_t)s + 500K}} \longrightarrow Y(s)$$

$$\omega_n^2 = 500K$$

$$2\zeta\omega_n = (5 + 500K_t)$$

for 1% settling time we know

$$t_s = \frac{4.6}{\zeta\omega_n} = 0,05$$

$$\therefore \zeta\omega_n = 92$$

$$\boxed{\therefore K_t = 0,358}$$

$$M_P = \frac{1}{2\zeta\sqrt{1-\zeta^2}} = 0.096$$

$$= e^{-\pi\zeta/\sqrt{1-\zeta^2}} = 0,096$$

$$\zeta = 0,5979 \implies \omega_n = 153.87$$

$$\boxed{K = \frac{\omega_n^2}{500} = 47.35}$$

٢-b Determine the step, ramp, and parabolic error constants of the following unity-feedback control systems. The forward-path transfer functions are given. Assume the closed loop systems are stable. State the type of each system.

i) $G(s) = \dfrac{50}{(1+s)(1+20s)}$ Type Zero

K_p= 50, K_v= 0, K_a = 0

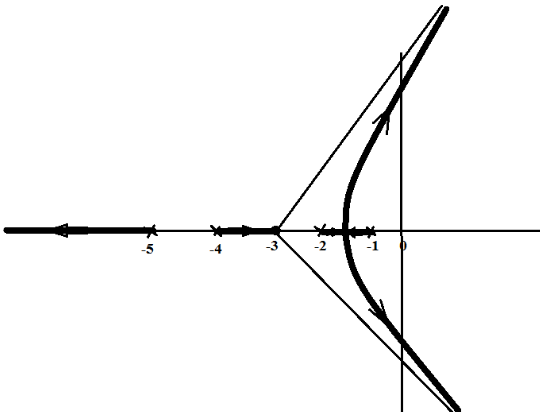
ii) $G(s) = \dfrac{2}{s(s+1)(s+2)}$ Type one

K_p= ∞, K_v= 1, K_a = 0

iii) $G(s) = \dfrac{5s+1}{s^2(s^2+5s+6)}$ Type 2

K_p= ∞ , K_v= ∞ , K_a = 1/6

3-a



The asymptotes intesect the real line at -3
There is a break point between -1 and -1
The intervals on the real line that lie on the root locus are (-1,-2), (-4,-3), (-5,-∞)
Find K that the system start to be unstable where the root locus intersect the imaginary axis

4-a)

1	**5**	**10k**
k	**10**	
$\mathbf{\dfrac{5k-10}{k}}$	**10k**	
$\mathbf{10 - \dfrac{10k^3}{5k-10}}$	**0**	
10k		

For

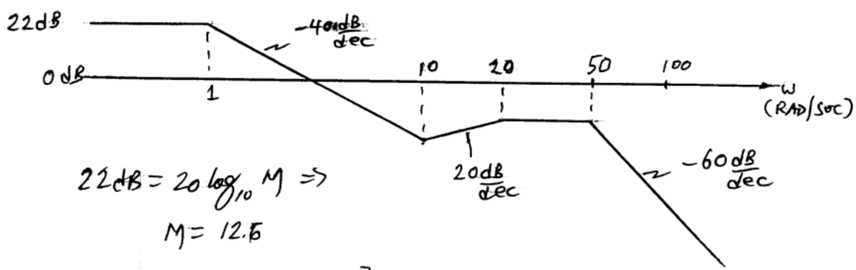
$$\mathbf{10 - \frac{10k^3}{5k-10}}$$

greater than zero k is less than 2 so the system ism unstable for any k

4-a)

$$\mathbf{Sin\ \phi = \frac{a\ \ -1}{a+1}}$$, $\omega_n^2 = aT^2$ find a and T

4-b)



$22dB = 20 \log_{10} M \Rightarrow$

$M = 12.6$

$$\frac{12.6\ (1+\frac{s}{10})^3}{(1+\frac{s}{1})^2\ (1+\frac{s}{20})(1+\frac{s}{50})^3}$$