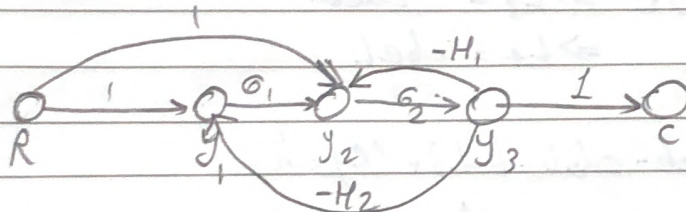


$$y_1 = R - y_3 H_2$$

$$y_2 = y_1 G_1 + R - y_3 H_1$$

$$y_3 = y_2 G_2$$



• Forward paths :-

$$R \rightarrow y_1 \rightarrow y_2 \rightarrow y_3 \rightarrow C \Rightarrow M_1 = G_1 G_2$$

$$R \rightarrow y_2 \rightarrow y_3 \rightarrow C \Rightarrow M_2 = G_2$$

• Loops :-

$$y_2 \rightarrow y_3 \rightarrow y_2 \Rightarrow L_1 = -G_2 H_1$$

$$y_1 \rightarrow y_2 \rightarrow y_3 \rightarrow y_1 \Rightarrow L_2 = -G_1 G_2 H_2$$

$$\Delta = 1 - (-G_2 H_1 - G_1 G_2 H_2) + 0 = 1 + G_2 H_1 + G_1 G_2 H_2$$

$$\Delta_1 = 1 - 0$$

$$\Delta_2 = 1 - 0 = 1$$

$$\frac{C}{R} = \frac{M_1 \Delta_1 + M_2 \Delta_2}{\Delta} = \frac{G_1 G_2 + G_2}{1 + G_2 H_1 + G_1 G_2 H_2}$$

② • $\frac{y_6}{y_1}$

NOTES

Forward Paths:

• $y_1 y_2 y_3 y_4 y_5 y_6 \Rightarrow M_1 = acdef$

• $y_1 y_2 y_4 y_5 y_6 \Rightarrow M_2 = abef$

Loops:

• $y_2 y_3 y_2 \Rightarrow L_1 = -cg$

• $y_4 y_5 y_4 \Rightarrow L_2 = -eh$

• $y_2 y_3 y_4 y_5 y_2 \Rightarrow L_3 = -cdeh$

• $y_2 y_4 y_5 y_2 \Rightarrow L_4 = -bel$

$\Delta = 1 - (-cg - eh - cdeh - bel) + (cg eh)$

$\Delta_1 = 1 - 0 = 1$

$\Delta_2 = 1 - 0 = 1$

$\frac{y_6}{y_1} = \frac{M_1 \Delta_1 + M_2 \Delta_2}{\Delta} = \frac{acdef + abef}{1 + cg + eh + cdeh + bel + cgeh}$

• $\frac{y_3}{y_1}$ | Forward: $y_1 y_2 y_3 \Rightarrow M_1 = ac$
~~Loop is None: $y_1 y_4 y_5 y_4$~~

$\Delta_1 = 1 + eh$

$\frac{y_3}{y_1} = \frac{ac(1+eh)}{1 + cgeh + cdeh + bel + cgeh}$

$$\text{for } \frac{y_5}{y_2} = \frac{y_5}{y_1} \times \frac{y_1}{y_2}$$

NOTES

$$\frac{y_5}{y_1} = \frac{abce + acde}{\Delta}$$

$$\frac{y_2}{y_1} = \frac{a(1+eh)}{\Delta}$$

$$\frac{y_5}{2} = \frac{abce + acde}{a(1+eh)} \quad \#$$

③ Forward Passes:-

$$y_1 y_2 y_3 y_4 y_5 \Rightarrow M_1 = 1 \times 5 \times 10 \times 2 = 100$$

$$y_1 y_2 y_6 y_5 \Rightarrow M_2 = 1 \times 10 \times 2 = 20$$

Loops:-

$$y_6 y_6 \Rightarrow L_1 = -1$$

$$y_3 y_4 y_3 \Rightarrow L_2 = 10 \times -1 = -10$$

$$y_4 y_5 y_4 \Rightarrow L_3 = 2 \times -2 = -4$$

$$y_2 y_3 y_4 y_5 y_2 \Rightarrow L_4 = 5 \times 10 \times 2 \times -1 = -100$$

$$y_2 y_6 y_5 y_2 \Rightarrow L_5 = 10 \times 2 \times -1 = -20$$

$$\Delta = 1 - (L_1 + L_2 + L_3 + L_4 + L_5) + (L_1 L_2 + L_1 L_3 + L_1 L_4 + L_1 L_5) \\ = 1 + 135 + 314 = 450$$

$$\Delta = 450$$

$$\Delta_1 = 1 - L_1 = 1 + 1 = 2$$

$$\Delta_2 = 1 - L_2 = 11$$

$$\frac{y_5}{y_1} = \frac{M_1 \Delta_1 + M_2 \Delta_2}{\Delta}$$

$$= \frac{420}{450}$$

$$= \frac{14}{15} \quad \#$$

(3)

④

$$x_1 = R - C$$

$$x_2 = x_1 - x_5 H_1$$

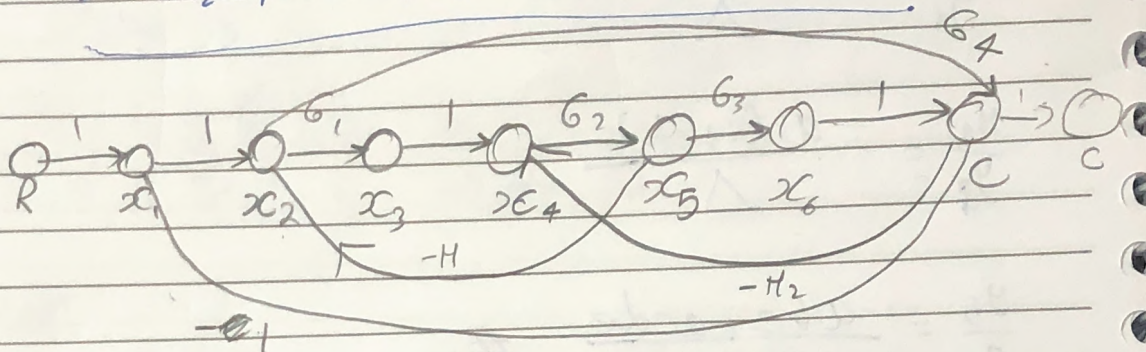
$$x_3 = x_2 G_1$$

$$x_4 = x_3 - CH_2$$

$$x_5 = x_4 G_2$$

$$x_6 = x_5 G_3$$

$$C = x_6 + x_2 G_4$$



Forward:-

$$R x_1 x_2 x_3 x_4 x_5 x_6 C \Rightarrow M_1 = G_1 G_2 G_3$$

$$R x_1 x_2 C \Rightarrow M_2 = G_4$$

Loops:-

$$x_2 x_3 x_4 x_5 x_2 \Rightarrow L_1 = -G_1 G_2 H_1$$

$$x_4 x_5 x_6 x_4 \Rightarrow L_2 = \cancel{G_1 G_2 G_3} - G_2 G_3 H_2$$

$$x_2 x_3 x_4 x_5 x_2 \Rightarrow L_3 = -G_4 G_2 G_3$$

$$x_1 x_2 C \Rightarrow L_4 = -G_4$$

$$x_2 C x_4 x_5 x_2 \Rightarrow L_5 = -G_2 G_4 H_1 H_2$$

$$\Delta = 1 - (L_1 + L_2 + L_3 + L_4 + L_5)$$

$$\Delta_1 = 1, \Delta_2 = 1$$

$$\frac{C}{R} = \frac{G_1 G_2 G_3 + G_4}{1 + G_1 G_2 H_1 + G_2 G_3 H_2 + G_1 G_2 G_3 + G_4 + G_2 G_4 H_1 H_2}$$

⑤ Forward Path:-

NOTES

- $y_1 y_2 y_3 y_4 y_5 y_6 y_7 y_8 \Rightarrow M_1 = G_1 G_2 G_3 G_4 G_5 G_6$
- $y_1 y_2 y_3 y_4 y_7 y_8 \Rightarrow M_2 = G_1 G_2 G_7 G_6$
- $y_1 y_2 y_3 y_4 y_5 y_6 y_8 \Rightarrow M_3 = G_1 G_2 G_3 G_4 G_6$

Loops

- $y_5 y_6 y_5 \Rightarrow L_1 = -G_4 H_4$
- $y_8 y_7 y_8 y_6 \Rightarrow L_2 = -G_5 G_6 H_1$
- $y_6 y_8 y_6 \Rightarrow L_3 = -G_8 H_1$
- $y_3 y_4 y_5 y_6 y_7 y_3 \Rightarrow L_4 = -G_2 G_3 G_4 G_5 H_2$
- $y_3 y_4 y_7 y_3 \Rightarrow L_5 = -G_2 G_7 H_2$
- $y_2 y_3 y_4 y_7 y_8 y_2 \Rightarrow L_6 = -G_1 G_2 G_7 G_8 H_3$
- ~~$y_2 y_3 y_4 y_5 y_6 y_7 y_8 y_2$~~
- $y_2 y_3 y_4 y_5 y_6 y_8 y_2 \Rightarrow L_7 = -G_1 G_2 G_3 G_4 G_6 H_3$
- $y_2 y_3 y_4 y_5 y_6 y_7 y_8 y_2 \Rightarrow L_8 = -G_1 G_2 G_3 G_4 G_5 G_6 H_3$

$$\Delta = 1 - (L_1 + L_2 + L_3 + L_4 + L_5 + L_6 + L_7 + L_8) + (L_1 L_5 + L_1 L_6 + L_3 L_5)$$

$$\Delta_1 = 1 \quad \Delta_3 = 1$$

$$\Delta_2 = 1 - L_1$$

$$\frac{y_8}{y_1} = \frac{M_1 \Delta_1 + M_2 \Delta_2 + M_3 \Delta_3}{\Delta}$$

#

⑥ a) $s^4 + 22s^3 + 10s^2 + 2s + k = 0$

NOTES

s^4	1	10	k
s^3	22	2	
s^2	$\frac{218}{11}$	$\frac{22k}{11}$	
s^1	A		
s^0	k		

$$A = \frac{\frac{218}{11} \cdot 2 - 22k}{\frac{218}{11}}$$

$$s^0 \Rightarrow k > 0$$

$$s^1 \Rightarrow A > 0$$

$$\frac{\frac{218}{11} \cdot 2 - 22k}{11} > 0 \quad / \quad 0 < k < \frac{109}{121}$$

$$k < \frac{109}{121}$$

b) $s^4 + 20ks^3 + 5s^2 + (10+k)s + 15 = 0$

s^4	1	5	15
s^3	20k	10+k	
s^2	A	15	
s^1	B		
s^0	15		

$$A = \frac{20k \times 5 - (10+k)}{20k} = \frac{99k - 10}{20k}$$

$$B = \frac{A(10+k) - 300k}{A}$$

$$s^3 \Rightarrow 20k > 0 \Rightarrow k > 0$$

$$s^2 = A > 0$$

$$k > \frac{10}{99}$$

$$S^1 \Rightarrow B > 0 \Rightarrow A(10+k) - 300k$$

NOTES

$$\frac{99k-10}{20k} (10+k) - 300k > 0$$

$$(99k-10)(10+k) - 600k^2 > 0$$

$$5901k^2 - 980k + 100 < 0$$

No possible k value in this system

$$c) s^3 + (k+0.5)s^2 + 4ks + 50 = 0$$

s^3	1	$4k$
s^2	$k+0.5$	50
s^1	A	
s^0	50	

$$A = \frac{4k(k+0.5) - 50}{k+0.5}$$

$$S^2 \Rightarrow k > -0.5$$

$$S^1 = A > 0$$

$$4k^2 + 2k - 50 > 0$$

$$k - 3.3 > 0 \quad ; \quad k \neq 3.8 \leq 0$$

$$k > 3.3 \quad ; \quad k \leq -3.8$$

$k > 3.3$

~~$k \leq -3.8$~~

8

C/Cs $1 + GH = 0$

NOTES

$$1 + \frac{K(s+1)}{s(1+Ts)(1+2s)} = 0$$

$$2Ts^3 + (T+2)s^2 + (K+1)s + K = 0$$

s^3	$2T$	$K+1$
s^2	$T+2$	K
s^1	A	
s^0	K	

$$A = \frac{(T+2)(K+1) - 2TK}{T+2}$$

$$s^3 \Rightarrow 2T > 0 \Rightarrow T > 0$$

$$s^2 \Rightarrow T > -2$$

$$s^1 \Rightarrow A > 0$$

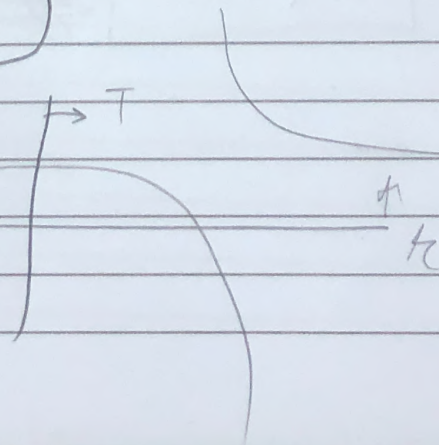
$$(T+2)(K+1) - 2TK > 0$$

$$(T-2)(1-K) > -4$$

$$s^0: K > 0$$

$$(T-2)(1-K) = \frac{-4}{1-K}$$

$$T-2 = \frac{4}{K-1}$$



⑦

$$Ts^2 + s + k = 0$$

NOTES

$$T(s_1 - A)^2 + (s_1 - A) + k = 0$$

$$Ts_1^2 + (-2TA + 1)s_1 + (A^2T - A + k) = 0$$

$$s^2 \mid T \quad A^2T - A + k$$

$$s^1 \mid 1 - 2AT$$

$$s^0 \mid A^2T - A + k$$

if all +ve

$$s^2 : T > 0$$

$$s^1 : 1 - 2AT > 0 \rightarrow T < \frac{1}{2A}$$

$$s^0 : A^2T - A + k > 0$$

$$k > A - A^2T$$

$$k > A(1 - AT)$$

if all -ve

$$s^2 : T < 0$$

$$s^1 : T > \frac{1}{2A}$$

$$s^0 : k < A(1 - AT)$$

$$\textcircled{9} s^4 + s^3 + 2s^2 + 2s + 4 = 0$$

$$\begin{array}{c|ccc} s^4 & 1 & 2 & 4 \\ s^3 & 1 & 2 & \\ s^2 & 0 & 4 & \\ s^1 & 4 & & \\ s^0 & 4 & & \end{array}$$

$$A = \frac{2s - 4}{s} = 2 - \frac{4}{s}$$

$$\lim_{s \rightarrow 0} A = 2 - \infty = -\infty < 0$$

unstable

Assume $S = S_1 + x$

$$S_1^4 + (4x+1)S_1^3 + (6x^2+3x+2)S_1^2 + (4x^3+3x^2+4x+2)S_1 + (x^4+x^3+2x^2+2x+4) = 0$$

S^4	I	B	D
S^3	A	C	
S^2	M	D	
S^1	N		
S^0	D		

$S^3: A, 4x+1 > 0$

$S^0: D > 0, x^4+x^3+2x^2+2x+4 > 0$

$$N = \frac{20x^3 + 15x^2 + 7x}{4x+1}$$

$$N = \frac{M(C) - AD}{M}$$

$$0 < A \leq \frac{1}{2}$$

#