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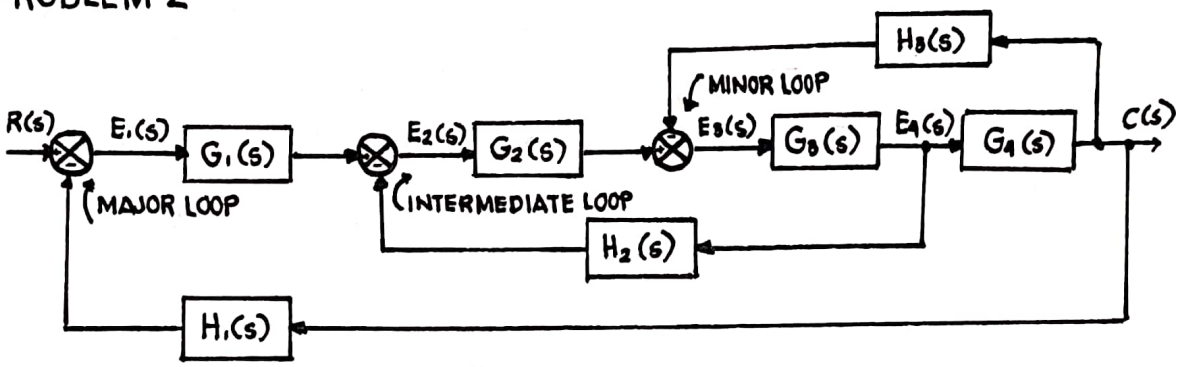
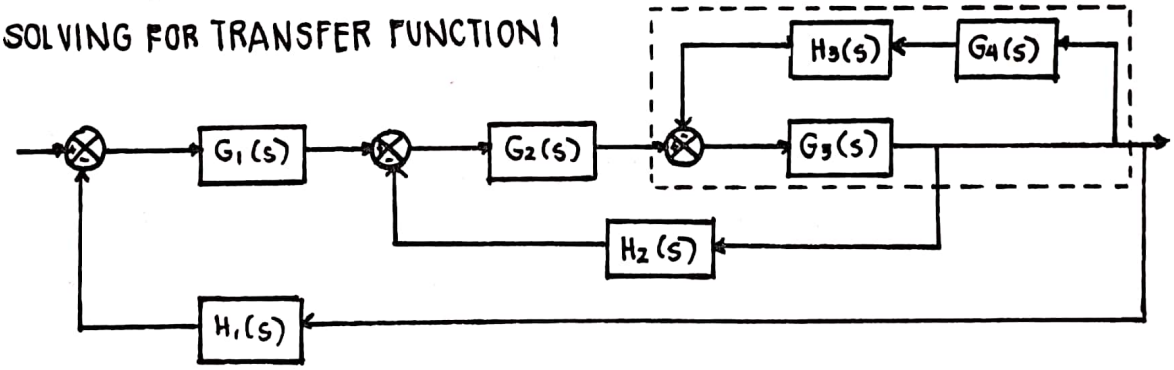
PROBLEM 2



$G_1(s) = 1/s^2$
$G_2(s) = 1/(s+1)$
$G_3(s) = 1/s$
$G_4(s) = 1/2s$

$H_1(s) = 1/s$
$H_2(s) = 1/s-1)$
$H_3(s) = 1/(s-2)$

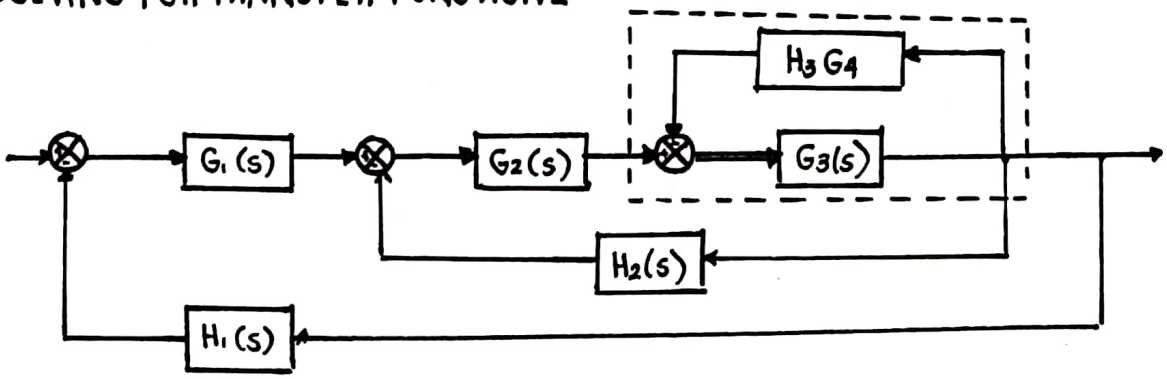
SOLVING FOR TRANSFER FUNCTION 1



SERIES : $H_3 - G_4$

$TF_1 = H_3 G_4 = \frac{1}{s-2}\left(\frac{1}{2s}\right) = \frac{1}{2s^2-4s}$

SOLVING FOR TRANSFER FUNCTION 2

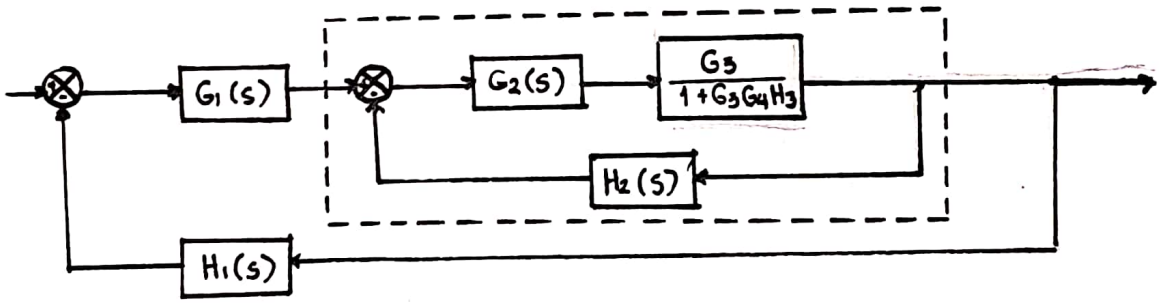


PARALLEL : $G_3 - H_3G_4$

$TF_2 = \frac{G_3}{1 + G_3G_4H_3}$; $G_3G_4H_3 = \frac{1}{s}\left(\frac{1}{2s^2 - 4s}\right)$

$= \frac{1/s}{1 + \frac{1}{2s^3 - 4s^2}} = \frac{1}{s} \cdot \frac{2s^3 - 4s^2}{2s^3 - 4s^2 + 1} = \frac{2s^3 - 4s^2}{2s^4 - 4s^3 + s} = TF_2$

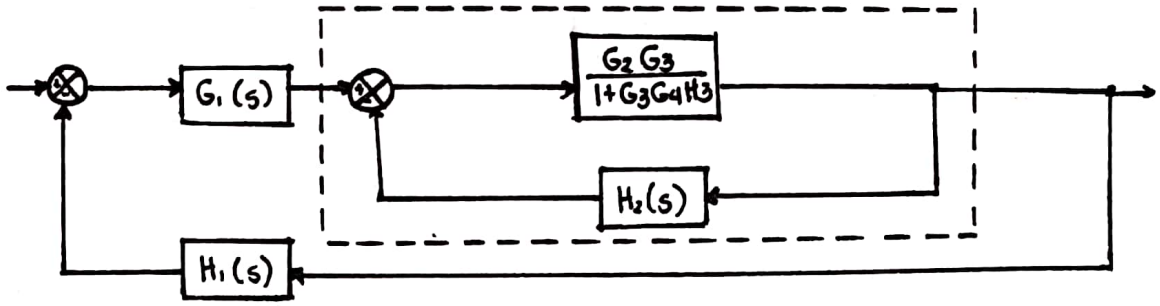
SOLVING FOR TRANSFER FUNCTION 3



SERIES: $G_2 \cdot \frac{G_3}{1 + G_3G_4H_3} = \frac{G_2G_3}{1 + G_3G_4H_3}$

$\frac{G_2G_3}{1 + G_3G_4H_3} = \frac{1}{s+1}\left(\frac{2s^3 - 4s^2}{2s^4 - 4s^3 + s}\right) = \frac{2s^3 - 4s^2}{2s^5 - 2s^4 - 4s^3 + s^2 + s}$

SOLVING FOR TRANSFER FUNCTION 4



PARALLEL : $H_2 - \frac{G_2G_3}{1+G_3G_4H_3}$

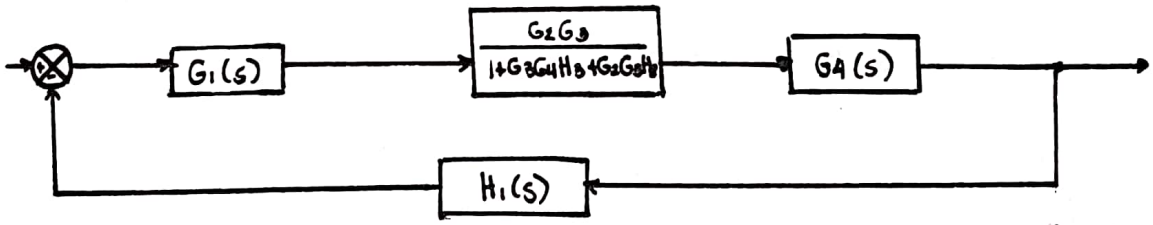
$$\frac{\frac{G_2G_3}{1+G_3G_4H_3}}{1+\left[\frac{G_2G_3}{1+G_3G_4H_3}(H_2)\right]} = \frac{1+G_3G_4H_3}{1+G_3G_4H_3} = \frac{G_2G_3}{1+G_3G_4H_3+G_2G_3H_2} =$$

$G_2G_3 = \frac{1}{s+1}\left(\frac{1}{s}\right) = \frac{1}{s^2+s}$ g, h | $G_2G_3H_2 = \frac{1}{s^2+s}\left(\frac{1}{s-1}\right) = \frac{1}{s^3-s}$ i, j

$$\frac{G_2G_3}{1+G_3G_4H_3+G_2G_3H_2} = \frac{g/h}{1+\frac{g}{h}+\frac{i}{j}} = \frac{1/s^2+s}{1+\frac{1}{2s^3+6^2}+\frac{1}{s^3-s}} = \frac{(2s^3-4s^2)(s^3-s)}{s^2+s[(2s^3-4s^2)(s^3-s)+(s^3-s)+2s^3-4s^2)]}$$

$$= \frac{2s^6-4s^5-2s^4+4s^3}{s^2+s(2s^6-4s^5-2s^4+7s^3-4s^2-s)} = \left[\frac{2s^6-4s^5-2s^4+4s^3}{2s^8-2s^7-6s^6+5s^5+3s^4-5s^3-s^2}\right] k, l$$

SOLVING FOR TRANSFER FUNCTION 5



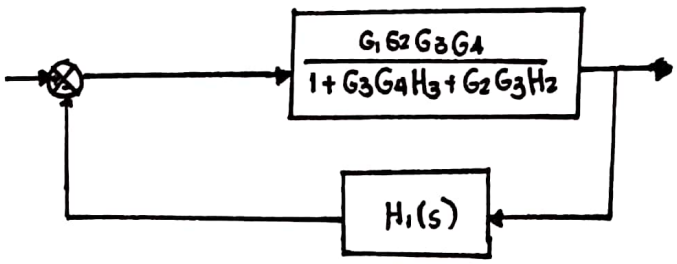
SERIES $G_1(s) - \frac{G_2G_3}{1+G_3G_4H_3+G_2G_3H_4} - G_4$:

$G_1G_4 = \frac{1}{s+1}\left(\frac{1}{2s}\right) = \frac{1}{2s^2+2s}$ m, n

$$TF_5 = \frac{G_1G_2G_3G_4}{1+G_3G_4H_3+G_2G_3H_2} = \frac{1}{2s^2+2s}\left(\frac{2s^6-4s^5-2s^4+4s^3}{2s^8-2s^7-6s^6+5s^5+3s^4-5s^3-s^2}\right)$$

$$= \frac{2s^6-4s^5-2s^4+4s^3}{4s^{10}-16s^9-7s^7+10s^6-4s^5-12s^4-2s^3}$$

SOLVING FOR TRANSFER FUNCTION G



PARALLEL: $\frac{G_1G_2G_3G_4}{1+G_3G_4H_3+G_2G_3H_2} - H_1 =$

$$\frac{\frac{G_1G_2G_3G_4}{1+G_3G_4H_3+G_2G_3H_2}}{1+\frac{G_1G_2G_3G_4}{1+G_3G_4H_3+G_2G_3H_2}(H_1)} \times \frac{1+G_3G_4H_3+G_2G_3H_2}{1+G_3G_4H_3+G_2G_3H_2}$$

$$TF_6 = \frac{G_1G_2G_3G_4}{1+G_3G_4H_3+G_2G_3H_2+G_1G_2G_3G_4H_1}$$

$G_1G_2G_3G_4 = \frac{1}{s^2+s}\left(\frac{1}{2s^2+2s}\right) = \frac{1}{2s^4+4s^3+2s^2}$ ⁴

$G_1G_2G_3G_4H_1 = \frac{1}{2s^4+4s^3+2s^2}\left(\frac{1}{s}\right) = \frac{1}{2s^5+4s^4+2s^3}$ ⁵

$$\frac{G_1G_2G_3G_4}{1+G_3G_4H_3+G_2G_3H_2+G_1G_2G_3G_4H_1} = \frac{\frac{1}{2s^4+4s^3+2s^2}}{1+\frac{1}{2s^3+4s^2}+\frac{1}{s^2+s}+\frac{1}{2s^5+4s^4+2s^3}}$$

$$= \frac{(2s^3+4s^2)(s^3+s)(2s^5+4s^4+2s^3)}{2s^4+4s^3+2s^2[(2s^3+4s^2)(s^3+s)(2s^5+4s^4+2s^3)+(s^3+s)(2s^5+4s^4+2s^3)+(2s^3+4s^2)(2s^3+4s^4+2s^3)+(2s^3+4s^2)(s^2+s)]}$$

$$= \frac{4s^{11}+16s^{10}+8s^9+12s^8+8s^7}{2s^4+4s^3+2s^2(4s^{11}+16s^{10}+2s^9+16s^8+2s^7+16s^6+4s^5+4s^4)}$$

$$= \boxed{\frac{4s^{11}+16s^{10}+8s^9+12s^8+8s^7}{8s^{15}+16s^{14}+24s^{13}+68s^{12}+8s^{11}+56s^{10}+8s^9+76s^8+40s^7+8s^6+8s^5}}$$

TF_6 FINAL REDUCED