Q2 (a) In reference to control system engineering define the following terms:

(i) plant **(ii) reference input**

(iii) actuating signal **(iv) forward path**

Answer: 2.3 From Text book

Q2 (b) Draw the block diagram for whose dynamics is represented by the following equation $y = ax_1 + bx_2 + cx_3$ **

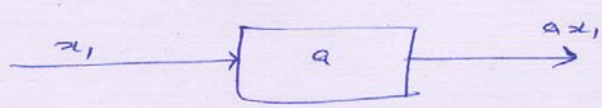
Answer:

The given equation is

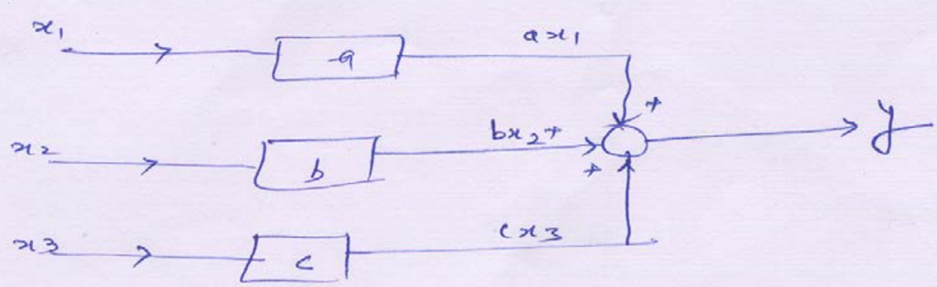
$$y = ax_1 + bx_2 + cx_3 \quad \text{—— (2)}$$

Now, it is clear that the system output is represented by y, where as x_1, x_2 and x_3 are the inputs to the system.

Let us consider the first term on RHS of the given equation. It can be represented as



Similarly, other two terms can also be represented and the resulting block diagram to represent the given equation would be



Q3 (a) Explain the meaning of steady state responses and transient response.

Answer: 3.15 from text book

Q3 (b) Determine the partial fraction expansion of the rational function given below

$$F(s) = \frac{1}{(s+1)^2(s+2)}$$

Answer:

The given function is

$$F(s) = \frac{1}{(s+1)^2(s+2)}$$

The partial fraction can be written as

$$F(s) = b_3 + \frac{c_{11}}{(s+1)} + \frac{c_{12}}{(s+1)^2} + \frac{c_{21}}{s+2}$$

The coefficients can be calculated as follows

$$b_3 = 0$$

$$c_{11} = \frac{d}{ds}(s+1)^2 F(s)\Big|_{s=-1} = \frac{d}{ds} \cdot \frac{1}{s+2}\Big|_{s=-1} = -1$$

$$c_{12} = \cancel{\frac{d}{d}}\,(s+1)^2 F(s)\Big|_{s=-1} = \frac{1}{s+2}\Big|_{s=-1} = 1$$

$$c_{21} = (s+2)\,F(s)\Big|_{s=-2} = 1$$

Thus the partial fraction can be written as

$$F(s) = -\frac{1}{s+1} + \frac{1}{(s+1)^2} + \frac{1}{s+2}$$

Ans.

Q4 (a) Explain the concepts of stability and relative stability of control systems.

Answer: 5.1 from text book

Q4 (b) Reduce the following block diagram to unity feedback form and find the system characteristic equation.

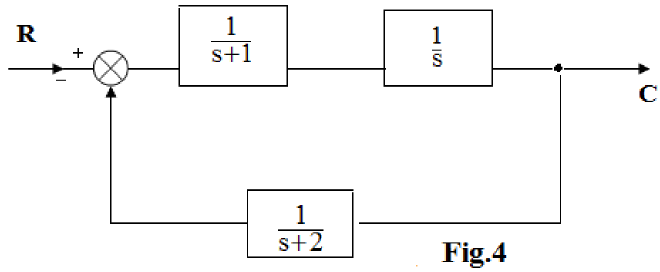
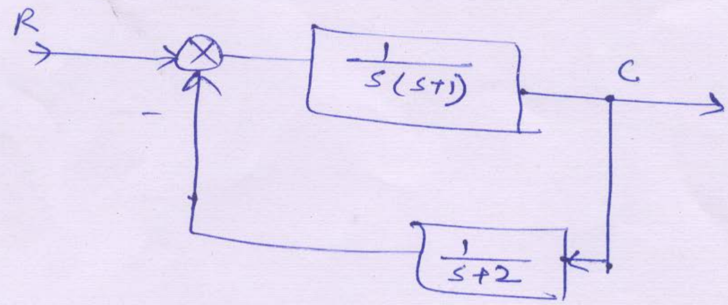


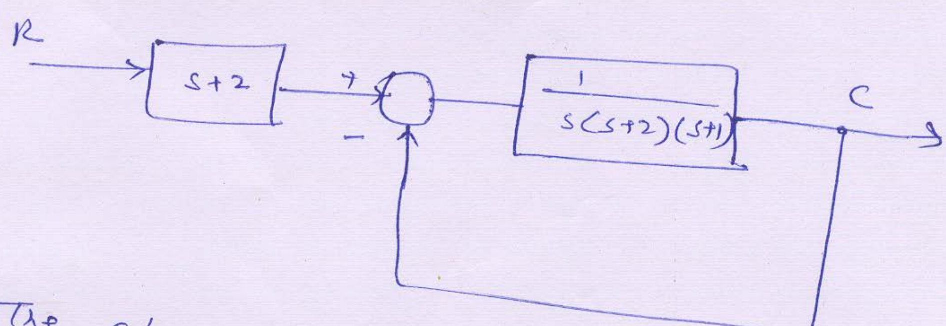
Fig.4

Answer:

Combining the blocks in the forward path, we obtain



This can be redrawn to make it a unity feedback system as follows



The characteristic equation for this system is

$$s(s+1)(s+2)+1 = 0$$

$$\equiv \quad s^3+3s^2+2s+1 = 0$$

Q5 (a) Explain the general input-output Gain formula for applied to signal flow graphs for control systems.

Answer: 8.6 from text book

Q5 (b) Determine the ratio $\frac{C(s)}{V(s)}$ for a system whose signal flow graph is shown in Fig.5.

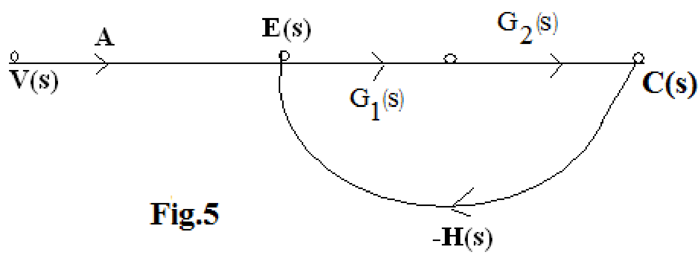


Fig.5

Answer:

b There is only one forward path

There is one loop. Therefore,

$T_1 = A\, G_1(s)\, G_2(s)$ $\quad L_1 = -G_1(s)\, G_2(s)\, H(s)$

The determinant of the graph can be written as

$$\Delta = 1 - L_1 = 1 + G_1(s)\, G_2(s)\, H(s)$$

Since the loop L_1 touches the forward path T_1

Therefore $\Delta_1 = 1$

now, we can write

$$\frac{C(s)}{V(s)} = \frac{T_1 \Delta_1}{\Delta} = \frac{A\, G_1(s)\, G_2(s)}{1 + G_1(s)\, G_2(s)\, H(s)} \quad \text{Ans.}$$

Q6 (a) Define the various types of error constants in reference to control system engineering.

Answer: 9.3 from text book

Q6 (b) Determine the resonance peak M_p and the resonant frequency ω_p for the system whose transfer function is $\dfrac{C(s)}{R(s)} = \dfrac{5}{s^2 + 2s + 5}$

Answer:

$$\left|\frac{C}{R}(j\omega)\right| = \frac{5}{|-\omega^2 + 2j\omega + 5|} = \frac{5}{\sqrt{\omega^4 - 6\omega^2 + 25}}$$

Setting the derivative of $\left|\frac{C}{R}(j\omega)\right|$ equal to zero, we get

$\omega_p = \pm\sqrt{3}$, Therefore Ans.

$$M_p = \max_{\omega}\left|\frac{C}{R}(j\omega)\right| = \frac{C}{R}(i\sqrt{3})\Big| = \frac{5}{3} \quad \text{Ans}$$

Q7 (a) In reference to linear control systems analysis explain what do you understand by polar plot. Also, explain its merits and limitation as compared to Bode plot method for control system analysis.

Answer: 11.5 from text book

Q7 (b) What do you understand by the term 'Relative Stability' of a system? Explain the terms gain margin and phase margin with the help of Nyquist plot.

Answer: 11.11 from text book

Q8 (a) The pole zero plot of a second – order control system is given in Fig.6. Draw the root- loci for this system.

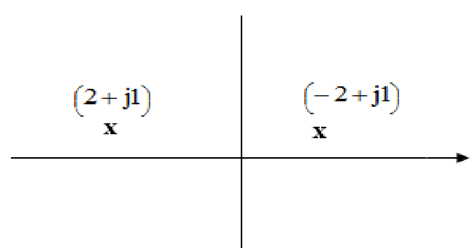


Fig.6

Answer: 13.10 from text book

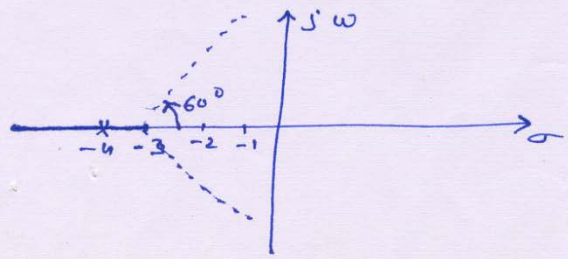
Q8 (b) In reference to root- locus method, find the angles and centre of, and sketch the asymptotes for

Answer:

b. The centre of asymptotes is

$$\sigma_c = \frac{1+3+j+3-j+4-2}{4-1} = -3$$

There are three asymptotes located at angles of $\beta = 60^0, 180^0$ and 300^0. The sketch is given below



Q9 (a) Explain the following in reference to Bode plots.

(i) Why do we plot frequency on logarithmic scale in Bode plots?
(ii) Why do we plot gain magnitude on logarithmic scale in Bode plots?
(iii) Why don't we plot phase angle on logarithmic scale on Bode plots?

Answer: 15.2 from text book

Q9 (b) Give a step-wise procedure for drawing the Bode plots for general linear control system. Illustrate with the help of an example.

Answer: 15.4, 15.5 form text book

Text Book

Feedback and Control Systems (Schaum`s Outlines), Joseph J Distefano III, Allen R. Stubberud and Ivan J. williams, 2nd Edition, 2007, Tata McGraw-Hill Publishing Company Ltd.