Q 2 (a) Discuss the computer controlled systems with the help of its block diagram.

Answer Page Number 2.8 of Text Book

Q 2 (b) Differentiate the following:
(i) Continuous & discrete control systems
(ii) Open loop & closed loop control system

Answer
(i) Page Number 1.6 of Text Book
(ii) Page Number 1.4 of Text Book

Q 3 (a) A closed loop servo system is represented by the differential equation.

$$\frac{d^2c}{dt^2} + 8\frac{dc}{dt} = 64e$$

Where c is the displacement of the output shaft, r is the displacement of the input shaft and e = r - c. Determine.
(i) Damping ratio
(ii) Damped natural frequency
(iii) % M_p for unit step input

Answer

$$\frac{d^2c}{dt^2} + 8\frac{dc}{dt} = 64e$$

Putting value of e = r-c in above of equation.

$$\frac{d^2c}{dt^2} + 8\frac{dc}{dt} = 64(r - c)$$

Taking Laplace transform of above equation, we get

$$s^2C(s) + 8sC(s) = 64[R(s) - C(s)]$$

$$[(s]^2 + 8s + 64)C(s) = 64\,R(s)$$

$$\frac{C(s)}{R(s)} = \frac{64}{s^2 + 8s + 64}$$

Comparing above equation with second order equation

$$\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\varepsilon\omega s + \omega_n^2}$$

We get

$\omega_n = 5$

$\varepsilon = 0.5$

Putting values of

$\omega_n = 5$

$\varepsilon = 0.5$

In equation

$$\%M = e^{\frac{-\pi x 0.5}{\sqrt{1-0.5^2}}} \times 100$$

We get,

%M=16.11%

Q 3 (b) Derive the unit step response to a second order system.

Answer Page Number 3.15 of Text Book

Q 4 (a) Determine the transfer function of a control system shown in Fig. 2:

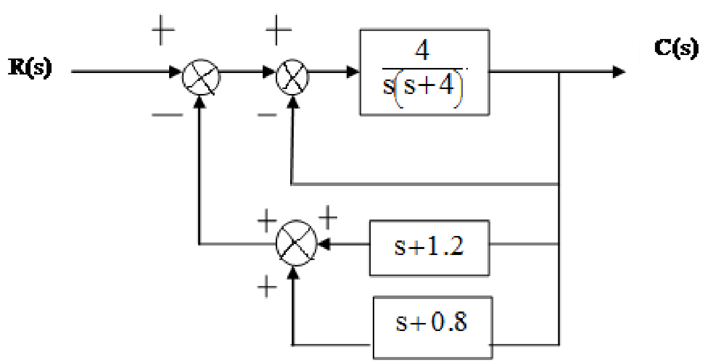


Fig.2

Answer $\frac{C}{R} = \frac{4}{(s+2)(s+6)}$

Q 5 (a) Draw the signal flow graph for the block diagram in given Fig. 3 and obtain the transfer function C(s)/R(s).

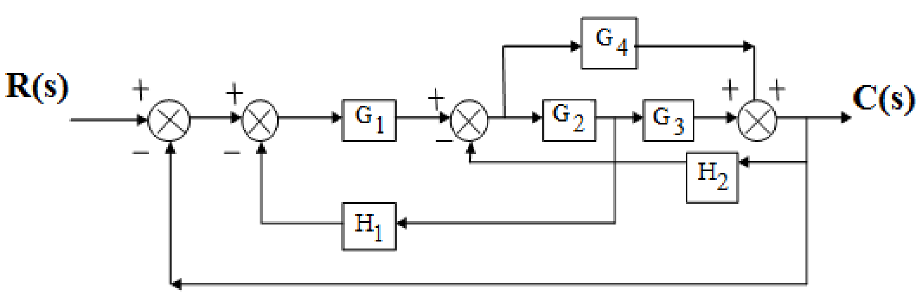


Fig.3

Answer

Transfer function = $\dfrac{G_1G_4 + G_1G_2G_3}{1 + G_4H_2 + G_4G_1 + G_2G_3H_2 + G_1G_2G_3 + G_1G_2H_1}$

Q 5 (b) Write down Mason's gain formula and explain each term therein.

Answer

The gain formula is as follows:

$$M = \frac{y_{out}}{y_{in}} = \sum_{k=1}^{N} \frac{M_k \Delta_k}{\Delta}$$

where:

- Δ = the determinant of the graph.
- y_{in} = input-node variable
- y_{out} = output-node variable
- G = complete gain between y_{in} and y_{out}
- N = total number of forward paths between y_{in} and y_{out}
- G_k = gain of the kth forward path between y_{in} and y_{out}
- L_i = loop gain of each closed loop in the system
- L_iL_j = product of the loop gains of any two non-touching loops (no common nodes)
- $L_iL_jL_k$ = product of the loop gains of any three pairwise nontouching loops
- Δ_k = the cofactor value of Δ for the k^{th} forward path, with the loops touching the k^{th} forward path removed. *

Q 6 (a) Explain various time domain specifications used for design of feedback control system.

Answer Page Number 10.6 of Text Book

Q 8 (a) Draw the root locus plot for a unity feedback control system having open loop transfer function as $G(s) = \dfrac{k(s+2)}{s(s+1)(s+4)}$.

Determine:
(i) Centroid
(ii) Angles of a asymptotes
(iii) Breakaway point, if any

Answer

(i) Centroid: = $\dfrac{-3}{2}$

(ii) Angle of asymptotes: 90° and 270°

(iii) break away s= -0.55

Q 8 (b) Write the method for finding the angle of departure from a complex pole in a root locus plot.

Answer Page Number 13.7 of Text Book

Q 9 (a) Obtain Bode Plots for the system: $G(s)=\dfrac{1000}{(0.1s+1)(0.001s+1)}$

Also obtain GM and PM. Comment on stability.

Answer Put s= jw

$$G(jw)=\frac{1000}{(0.1jw+1)(0.001jw+1)}$$

The given transfer function is of type'0' system. Therefore the initial slope of the bode plot is 0db/decade. The starting point is given by

$$20\log_{10} K = 20\log_{10} 1000 = 60 \text{ db}$$

Corner frequencies $w_1 = \dfrac{1}{0.1} = 10$ rad/sec.

$$w_2 = \frac{1}{0.001} = 100 \text{ rad/sec.}$$

Mark the starting point 60db on y-axis and draw a line of slope 0db/decade up to first corner frequency

From first corner frequency to second corner frequency draw a line with slope (0-20 = -20 db/decade)

From second corner frequency to next corner frequency draw a line having the slope -20 + (-20) = -40 db/decade.

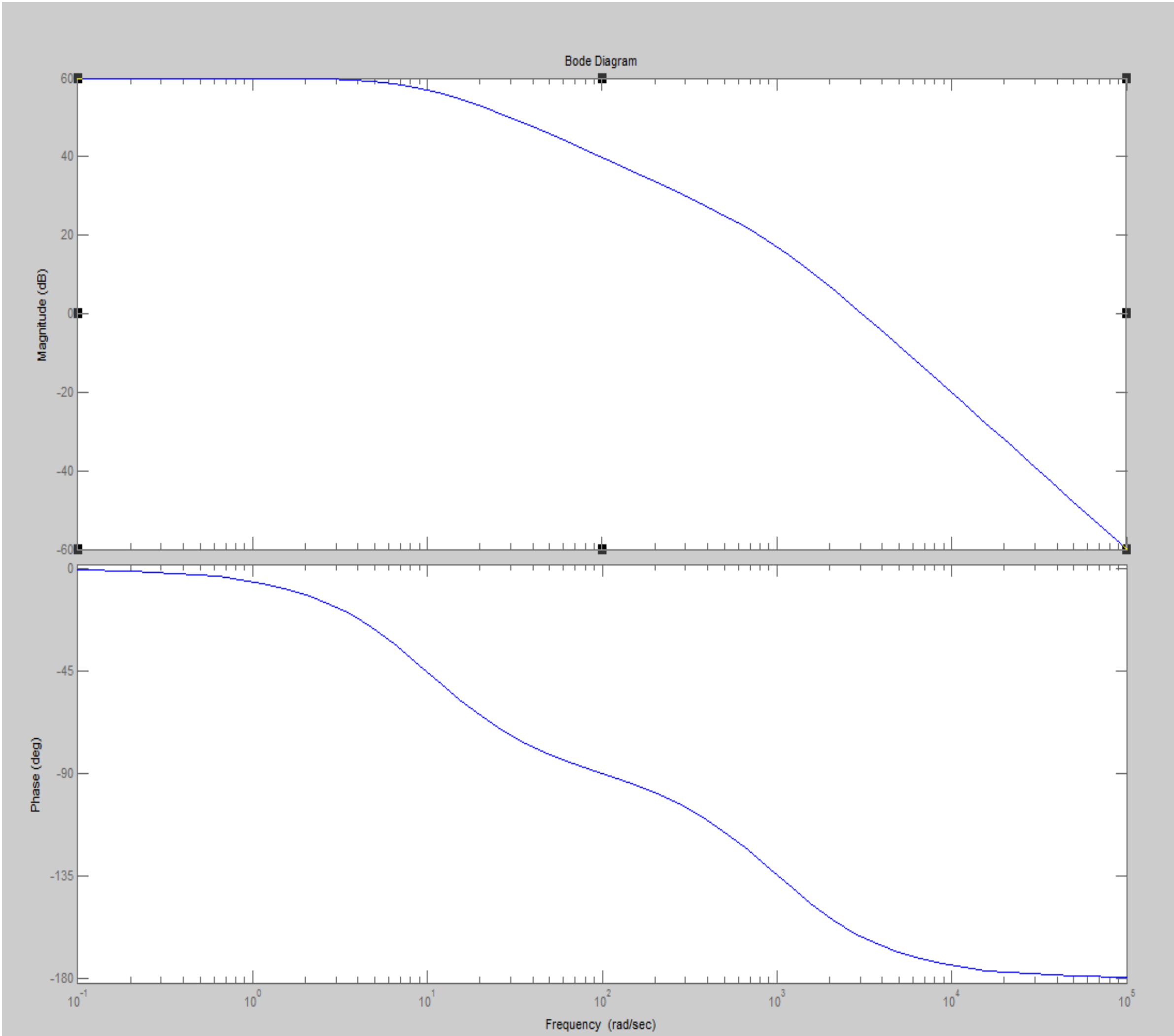
The magnitude plots are complete and now draw the phase plot by calculating the phase at different frequencies

From the bode plot

From the point of intersection of magnitude curve with 0 db axis draw a line on phase curve. This line cuts the phase curve at -154°

Therefore **P.M = - 154 - (-180) = +26°** , **Gain Margin G.M =** ∞

Since, P.M = + 26 and gain margin = ∞ , the system is inherently stable.



Q 9 (b) Discuss the general procedure of determination of transfer function from bode plot

Answer Page Number 15.17 of 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.