Frequency Response Analysis (Part - I)

1. A system has fourteen poles and two zeros. Its high frequency asymptote in its magnitude plot having a slope of:

(a) – 40 dB/decade
(b) – 240 dB/decade
(c) – 280 dB/decade
(d) – 320 dB/decade

[GATE 1987: 2 Marks]

Soln.

Poles (P) = 14
Zeros (z) = 2
P – Z = 14 – 2 = 12
$\lim_{\omega\to\infty} slope = (P - Z)(-20 dB/dec)$
$= -240 dB/decade$

Ans: Option (b)

2. The polar plot of $(s) = \frac{10}{s(s+1)^2}$ intercepts real axis at $\omega = \omega_0$. Then, the real part and ω_0 are respectively given by:

(a) – 2.5, 1
(b) – 5, 0.5
(c) – 5, 1
(d) – 5, 2

[GATE 1987: 2 Marks]

Soln.

$$(s) = \frac{10}{s(s+1)^2} = \frac{10}{s(s+1)(s+1)}$$

$$\angle(j\omega) = -90^0 - 2\tan^{-1}\omega$$

ω_{pc} is the phase cross over frequency where

$\angle(j\omega) = -180^0$

$so,\ -180^0 = -90^0 - 2\tan^{-1}\omega pc$

$2\tan^{-1}\omega_{pc} = 90^0 \Rightarrow \omega_{pc} = \tan 45^0$

$\boldsymbol{\omega pc = 1\ rad/sec}$

$$|G|_{\omega=\omega pc} = \frac{10}{\omega\sqrt{1+\omega^2}\sqrt{1+\omega^2}}$$

$$= \frac{10}{1\sqrt{2}\sqrt{2}} = \frac{10}{2} = 5$$

At $\omega = \omega_{pc}$ the polar plot crosses the negative real axis at – 5

Ans: Option (c)

3. From the Nicholas chart one can determine the following quantities pertaining to a closed loop system:

(a) Magnitude and phase (b) Band width

(c) Only magnitude (d) only phase

[GATE 1989: 2 Marks]

Soln. Nicholas chart is magnitude versus phase plot

Ans: Option (a)

4. The open-loop transfer function of a feedback control system is $(s).H(s)=\frac{1}{(s+1)^3}$ The gain margin of the system is

(a) 2 (b) 4 (c) 8 (d) 16

[GATE 1991: 2 Marks]

Soln. $(s).(s)= \frac{1}{(s+1)^3}$

$$GM=\frac{1}{|G(j\omega pc)\,H(j\omega pc)|}=\frac{1}{M}$$

ω_p is the phase cross over frequency where

$\angle(s)H(s)=-180^0$

$$G(s)H(s)=\frac{1}{(s+1)(s+1)(s+1)}$$

$$-3tan^{-1}\omega_{pc}=-180^0$$

$$tan^{-1}\omega_{pc}=60^0 \Rightarrow \omega_{pc}=ta(60^0)$$

$$\omega_{pc}=3\ rad/sec$$

$$M=|(j\omega_{pc})\ H(j\omega_{pc})|=\frac{1}{(\sqrt{1+\omega pc^2})^3}=\frac{1}{8}$$

$$GM=\frac{1}{M}=8$$

Ans: Option (c)

5. Non-minimum phase transfer function is defined as the transfer function

(a) which has zero in the right-half s-plane

(b) which has zero only in the left-half s-plane

(c) which has poles in the right-half s-plane

(d) which has poles in the left-half s-plane

[GATE 1995: 1 Mark]

Soln. Non minimum phase transfer function is defined as the transfer function which has one or more zeros in the right half of s – plane and remaining poles and zeros in the left half of s – plane.

Ans: Option (a)

6. The Nyquist plot of a loop transfer function $(j\omega)\ (j\omega)$ of a system encloses the $(-1, j0)$ point. The gain margin of the system is

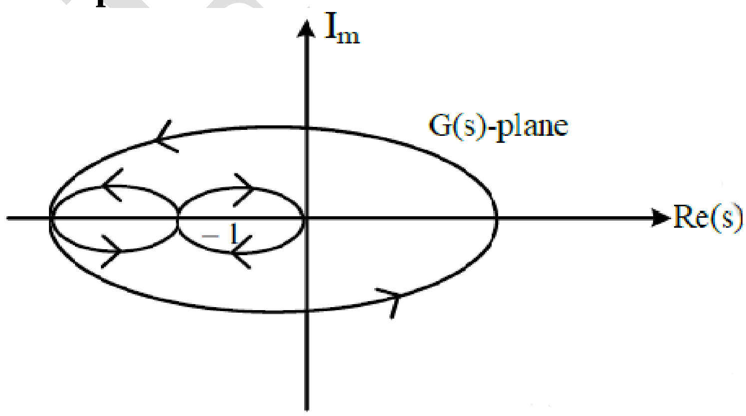
(a) less than zero (b) zero (c) greater than zero (d) infinity

[GATE 1998: 1 Mark]

Soln. A system is unstable when Nyquist plot of $(j\omega)\ (j\omega)$ enclosed the point (-1, j 0). Gain margin of unstable system is less than zero

Ans: Option (a)

7. The Nyquist plot for the open-loop transfer function G(s) of a unity negative feedback system is shown in the figure, if G(s) has no pole in the right-half of s-plane, the number of roots of the system characteristic equation in the right-half of s-plane is



(a) 0 (b) 1 (c) 2 (d) 3

[GATE 2001: 1 Mark]

Soln.

N = P – Z

One encirclement in clockwise direction and one in anticlockwise direction house

N = 0

Given that number of poles of $(s)(s)$ in the right half s – plane, p = 0

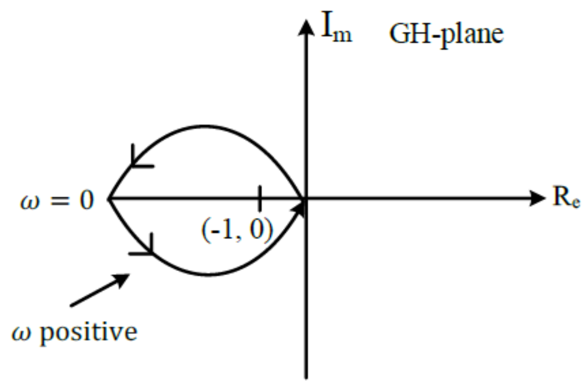
N = P – Z

Or Z = P – N = 0

So No roots of the characteristic equation or poles of the closed loop system lie in RH of s – plane

Ans: Option (a)

8. In the figure, the Nyquist pole of the open-loop transfer function $(s)(s)$ of a system is shown. If $(s)H(s)$ has one right-hand pole, the closed-loop system is



(a) always stable

(b) unstable with one closed-loop right hand pole

(c) unstable with two closed-loop right hand poles

(d) unstable with three closed-loop right hand poles

[GATE 2003: 1 Mark]

Soln.

N = P – Z

The encirclement of critical point (-1, j 0) is in the anticlockwise direction hence N = 1, P = 1 (given)

Z = P – N = 0

Hence no poles of closed loop system lie in the RH of s – plane therefore system is always stable.

Ans: Option (a)

9. A system has poles at 0.01 Hz, 1 Hz and 80 Hz; zero at 5 Hz, 100 Hz and 200 Hz. The approximate phase of the system response at 20 Hz is

(a) – 90^0 (b) 0^0 (c) 90^0 (d) – 180^0

[GATE 2004: 2 Marks]

Soln.
Phase shift are
Due to Pole at 0.01 Hz = – 90^0
Due to Pole at 1 Hz = – 90^0
Due to Pole at 80 Hz = 0
Not to be considered as the system response at 20 Hz is to be considered
Zero at 5 Hz = 90^0
Zero at 100 Hz = not be considered
Zero at 200 Hz = not be considered
Thus approximate total phase shift = – 90 – 90 + 90 = - 90^0

Ans: Option (a)

10. The Nyquist plot of $(j\omega)(j\omega)$ for a closed loop control system, passed through (-1, j 0) point in GH plane. The gain margin of the system in dB is equal to

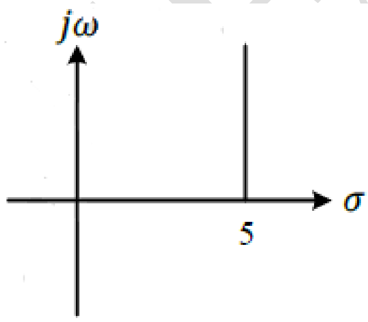
(a) infinite (b) greater than zero (c) less than zero (d) zero

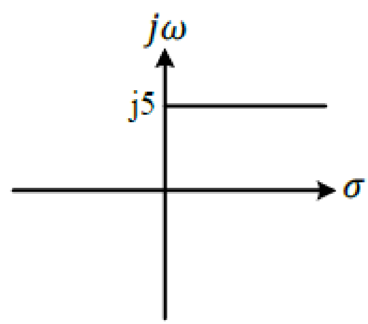
[GATE 2006: 2 Marks]

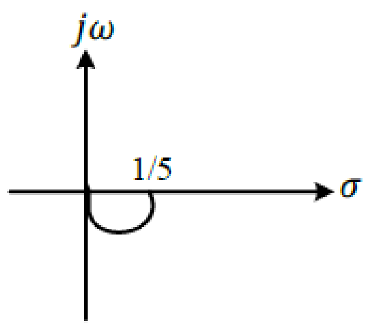
Soln. The gain margin of system is negative i.e. less than zero

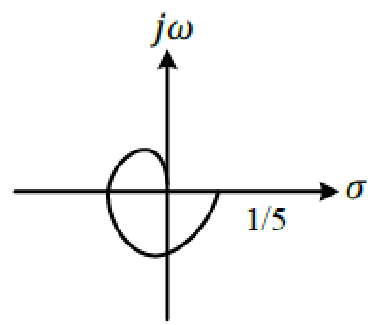
Ans: Option (c)

11. For the transfer function $(j\omega) = 5 + j\omega$, the corresponding Nyquist plot for positive frequency has the form

(a)


(b)


(c)


(d)


Soln. The transfer function $(j\omega) = 5 + j\omega$

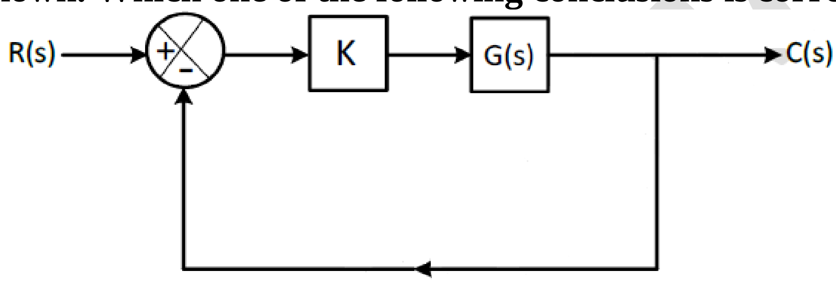
$|(j\omega)| = \sqrt{25 + \omega^2}$

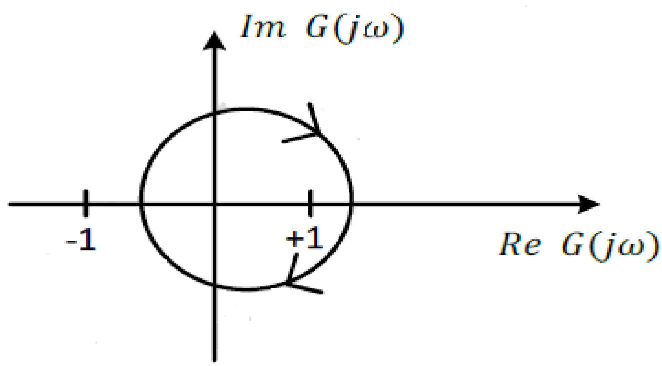
At $\omega = 0$, $|(0)| = 5$

At $\omega = \infty$, $|(\infty)| = \infty$

Ans: Option (a)

12. Consider the feedback system shown in the figure. The Nyquist plot of G(s) is also shown. Which one of the following conclusions is correct?





(a) G(s) is an all-pass filter

(b) G(s) is strictly proper transfer function

(c) G(s) is a stable and minimum-phase transfer function

(d) The closed-loop system is unstable for sufficiently large and positive K.

Soln. Nyquist plot is not enclosed critical point (-1, j 0), hence the system is stable. If the value of gain K is increased, then intersection point moves towards $-\infty$ on the negative real axis which makes system unstable.

Ans: Option (d)