MSMF GATE CENTRE

Subject: Control Systems

Frequency Response Analysis

Time: 30 min **Marks= 15**

1. With respect to frequency response the true statement(s) is/are

   (a)is the steady state output to the sinusoidal input
   (b)input is sinusoidal and output is also sinusoidal
   (c)output amplitude and phase depends on the system
   (d)all the above

2. If the transportation lag is introduced into the system, stability of the system

   (a) remains same
   (b) increases
   (c) decreases
   (d) increases and then decreases

3. The gain of the system is made half gain margin

   (a) reduces by 6dB
   (b) increases by 2
   (c) increases by 2dB
   (d) decreases by 2

4. TF of a unity feedback system is $\frac{1}{s^2+s+1}$ the magnitude of the system at 0.1591Hertzs is approximately

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

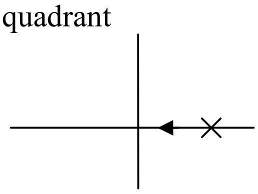
5. The peak overshoot of a 2^{nd} order protype system to a step input is zero, the resonant peak of the system is

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

6. The system is stable for $0<k<20$,the gain margin of the system for k=10 is

   (a) 10dB (b) 6dB
   (c) 12dB (d) 3dB

7. The RLD is shown below, the polar plot lies in __ quadrant

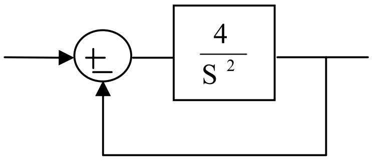


   (a) 1^{st} (b) 2^{nd}
   (c) 3^{rd} (d) 4^{th}

8. The initial and final slopes of a bode plot of a certain 2^{nd} order all pole minimum phase system is -20dB/dec and -40dB/dec, the system is stable for

   (a) $-\infty<k<\infty$ (b) $-\infty<k<0$
   (c) $0<k<\infty$ (d) can't say

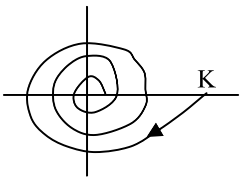
9.



Gain and phase margins of the above system are respectively

(a) -1,180^0 (b) 1,-90^0
(c) -1,180^0 (d) 1, 0^0

10. The TF of a system whose polar plot is given below is



(a) $\frac{Ke^{-ST_D}}{(1+ST)}$

(b) $\frac{Ke^{-sT_D}}{S(1+ST)}$

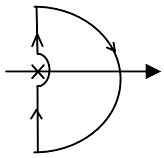
(c) $\frac{Ke^{-sT_D}}{S^2(1+ST)}$

(d) $\frac{Ke^{-sT_D}}{S}$

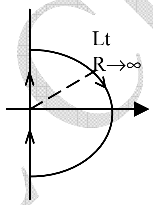
11. OLTF G(s)H(s)= $\frac{K(S+2)}{S(S^2+4)}$

The Nyquist contour is

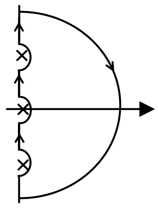
(a)



(b)



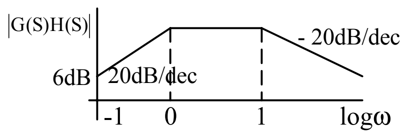
(c)



(d) All the above

Linked data questions 12 and 13

The Bode plot of a system is given below



12. The TF G(s)H(s) is

(a) $\frac{20s}{(1+s)(s+10)}$

(b) $\frac{200s}{(1+s)(1+0.1s)}$

(c) $\frac{10s}{(1+s)(s+10)}$

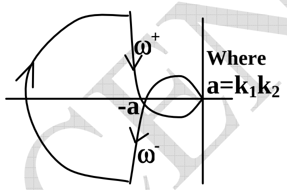
(d) $\frac{20s}{(1+s)(1+0.1s)}$

13. The gain of the closed loop system at ω=0 is

(a) 0dB (b) 0
(c) 1dB (d) none

Common data questions 14 and 15

The Nyquist plot of G(s)H(s) which has one right hand pole is given below



14. The system is stable for a=

(a) 0.2 (b) 0.5
(c) 1 (d) 1.5

15. If a=10 phase margin is

(a) -45^0 (b) -90^0
(c) 45^0 (d) 90^0

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Frequency Response Analysis

(Solutions)

1. **Ans: (d)**
   Sol:
   Frequency response is the steady state output of at system to the sinusoidal input.

2. **Ans: (c)**
   Sol:
   Eg: Transportation lag = e^{-ST_D}
   It introduces the negative phase, hence Phase and Gain margins of the system decreases
   $\therefore$ Stability decreases.

3. **Ans: (b)**
   Sol:
   $$GM = \frac{1}{|G(j\omega_{pc})H(j\omega_{pc})|}$$
   It is clear from the expression the gain is decreased then GM increases,, hence if the gain is made half, GM increase by '2'.

4. **Ans:(a)**
   Sol:
   f = 0.1591 Hz
   $\omega = 2\pi f = 2\pi(0.1591) = 1$rad/sec
   $$\left|\frac{1}{(j\omega)^2 + j\omega + 1}\right| = \left.\frac{1}{\sqrt{(1-\omega^2)^2 + \omega^2}}\right|_{\omega=1} = 1$$
   (or) 20log1 = 0 dB

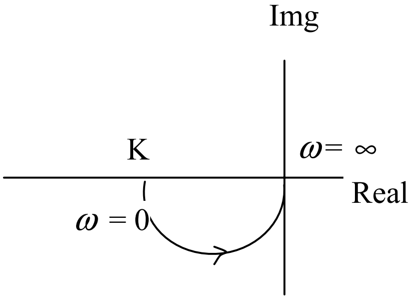
5. **Ans: (b)**
   Sol:
   If peak overshoot is zero, implies that damping ratio, $\xi \geq 1$
   Resonant peak for $\xi \geq \frac{1}{\sqrt{2}}$ is '1'

6. **Ans: (b)**
   Sol:
   Stable range of k is 0 < k < 20
   $$GM = \frac{\text{The value of k for marginal stability}}{\text{Required value of K}}$$
   $$GM = \frac{20}{10} = 2$$
   (or) GM in dB = 20log2 = 6dB

7. **Ans: (c)**
Sol:
Eg. OLTF $= \frac{K}{S-2}$

$$= \frac{K}{j\omega-2} = \frac{K}{\sqrt{\omega^2+4}} - (180\text{-}\tan^{-1}\frac{\omega}{2})$$

The Polar plot is



8. **Ans:(c)**
Sol:
Eg let us consider a system with G(S)H(S) = $\frac{K}{S(S+2)}$
This system is stable for $0 < K < \infty$

9. **Ans: (d)**
Sol:
System is marginally stable
$\therefore$ GM = 1 (or) 0 dB
& PM = 0^0

10. **Ans: (a)**
Sol:
It is a polar plot of type '0' system
$\therefore$ Option "**a**" is correct

11. **Ans: (c)**
Sol:
G(S)H(S) has a pole at the origin and poles on the jω axis
$\therefore$ option '**c**' is correct

12. **Ans: (d)**
Sol:
Corner frequencies are $= \log\omega_1 = 0$

$\omega_1 = 1$

$\therefore T_1 = \frac{1}{1}$

and $\log\omega_2 = 1$

$\omega_2 = 10$

$\therefore T_2 = \frac{1}{10}$

The starting point frequency $\log\omega = -1$

$\omega = 0.1$

Initial slope is 20 dB/dec hence portion of the TF = G(S)H(S) = Ks

At $\omega_1 = 1$ slope changes to '0' dB. i.e. -20 dB/dec is added to initial slope +20 dB/dec, implies there is a presence of real pole Hence portion of the TF G(S)H(S) = $\frac{KS}{1+ST_1}$

At $\omega_2 = 10$ slope become – 20dB/dec implies another pole is added

$$\therefore \text{Total TF } G(S)H(S) = \frac{Ks}{(1+sT_1)(1+sT_2)}$$

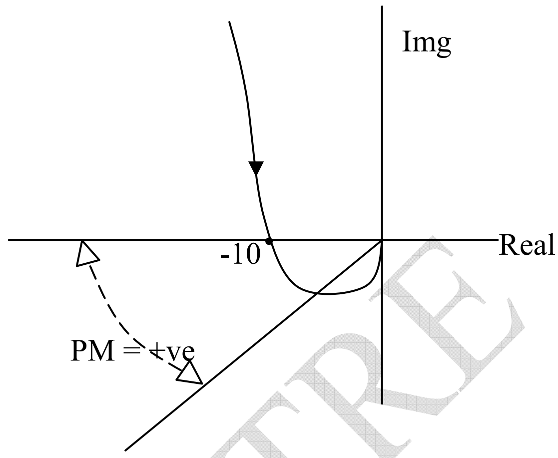
$|K| + |S| = 6\text{dB}/\ \omega = 0.1$

$(20\log K + 20\log\omega)_{\omega=0.1} = 6\text{dB}$

$K = 20$

$$\therefore \text{ TF } G(S)H(S) = \frac{20S}{(1+S)(1+S.\frac{1}{10})}$$

$$= \frac{20S}{(1+S)(1+0.1S)}$$



13. **Ans: (b)**

Sol:

$$\text{CLTF} = \frac{G(S)}{1+G(S)(H(S)}$$

$$\text{CLTF} = \frac{20S}{(1+S)(1+0.1S)+20S}$$

$$|\text{CLTF}|_{\omega=0} = 0$$

14. **Ans: (d)**

Sol:

For a > 1, (-1, j0) is enclosed once in the ccw direction

$\therefore$ N = 1, (from the plot)

& P = 1 (Given)

N = P – Z
Z = P – N
Z = 1 -1 = 0
Z = 0 System is stable
a > 1, hence a = 1.5

15. **Ans: (c)**

Sol:

For a = 10
PM is +Ve
$\therefore$ PM = 45^0