Class Test No. 12 Monday 07th Oct 2019 Duration: 10 Minutes Closed notes

Name: ________________________ Roll No. ________________

Choose only one option which is the most appropriate for questions 1 - 5.

1. For a benchmark 2nd order closed loop transfer function, following quantity is infinite.

(a) GM
(b) PM
(c) GCO
(d) ω_d

2. For a stable minimum phase proper plant whose phase never reaches 180°, phase margin in general, is

(a) 180° for all gain values
(b) a minimum positive number for some gain value
(c) infinite for all gain values
(d) not defined

3. Approximate settling time for a benchmark 2nd order closed loop system under step input, for a 5% ripple, is

(a) $5/\sigma$
(b) $3/\sigma$
(c) $4/\sigma$
(d) $2/\sigma$

4. Benchmark 2nd order closed loop transfer function assumes that the resultant plant is

(a) 1st order type 2 system
(b) 2nd order type 1 system
(c) 2nd order type 0 system
(d) 2nd order type 2 system

5. Expression for peak overshoot for a benchmark 2nd order closed loop system under step input is

(a) $\ln M_p = -(\pi\sigma)/\omega_d$
(b) $\ln M_p = -(\pi\omega_n)/\omega_n$
(c) $\ln M_p = -(\pi\omega_d)/\sigma$
(d) $\ln M_p = -(\pi\omega_n)/\sigma$

Give short (1 - 2 lines) answer to the questions 6-10

6. What is the connection between the stability margins and closed loop dominant response?

Both stability margins and dominant closed loop response depend on dominant poles.

..... 2 (PTO)

7. Give the approximate expression for, ζ in terms of, γ when it is expressed in radians. (Hint: You may use the relation given alongside, as necessary).

$$\tan\gamma = \frac{2\zeta}{\sqrt{\sqrt{1+4\zeta^4}-2\zeta^2}}; \quad 0<\zeta<0.6$$

$$\gamma \approx \frac{2\zeta}{\sqrt{1-2\zeta^2}} \approx 2\zeta\left(1+\zeta^2\right)$$

8. Give the expression for rise time, T_r, of a benchmark 2nd order closed loop transfer function under unit step input. Use the time response given alongside.

$$c(t) = 1 - \frac{\omega_n}{\omega_d} e^{-\sigma t} \sin\left(\omega_d t + \tan^{-1}\frac{\omega_d}{\sigma}\right)$$

$$c(t) = 1 - \frac{\omega_n}{\omega_d} e^{-\sigma t} \sin\left(\omega_d t + \tan^{-1}\frac{\omega_d}{\sigma}\right) = 1 \rightarrow \sin\left(\omega_d t_r + \tan^{-1}\frac{\omega_d}{\sigma}\right) = 0$$

$$\omega_d t_r + \tan^{-1}\frac{\omega_d}{\sigma} = 0 \rightarrow t_r = -\frac{1}{\omega_d}\tan^{-1}\left(\frac{\omega_d}{\sigma}\right) = \frac{1}{\omega_d}\tan^{-1}\left(\frac{\omega_d}{-\sigma}\right)$$

9. Why is the assumption of benchmark closed loop transfer function to be of 2nd order, unity DC gain type practically justified?

The assumption is practically justified as exact tracking is required only for a step input and 2nd order behaviour provides small rise time and settling time, for small overshoot.

10. Give the expression for peak time of a benchmark 2nd order closed loop system subject to unit step input, in terms of damped natural frequency.

$$t_p = \frac{\pi}{\omega_d}$$