Ex/BESUS/EE-603/07

B.E. (EE) Part-III 6th Semester Examination, 2007

Control System-I

(EE-603)

Time : 3 hours **Full Marks : 100**

Use separate answerscript for each half.

Answer SIX questions, taking THREE from each half.

Two marks are reserved for neatness in each half.

FIRST HALF

1. Answer all parts :

a) A system with zero initial conditions has a closed loop transfer function

$$T(s) = \frac{s^2 + 4}{(s+1)(s+4)}.$$

At which frequency is the output zero?

b) A system, whose output is $x(t)$, is characterized by the following equation :

$$\frac{d^2x}{dt^2} + 3\frac{dx}{dt} + 2x(t) = 5.$$

As 't' approaches infinity, what would be the value of $x(t)$?

c) The transfer function of a system is given as : $T(s) = \frac{s}{s+1}$.

If this system is excited with an excitation, $x(t) = sin(t)$, find the expression of the output $y(t)$ at steady state.

d) The impulse response of a second order under-damped system having zero initial conditions is given by :

$c(t) = 12e^{-31} \sin 4t$ (for $t \geq 0$). What are the damping ratio and natural frequency of oscillation of the system? **[3+3+6+4]**

2. Answer all parts :

a) What is meant by a S.I.S.O. system? A physical S.I.S.O. system is characterized by the following equation :

$c(t)\frac{d^2c(t)}{dt} + \frac{dc(t)}{dt} = 5u(t)$; where $c(t)$ stands for response and $u(t)$ is unit step excitation. Comment on what type of system it is, with reasons. Find the transfer function of the system.

b) A physical S.I.S.O. system is characterized by the following equation : $t\frac{d^3c(t)}{dt^2}+5\frac{d^2c(t)}{dt^2}+4\frac{dc(t)}{dt}+\cos 4t = 10u(t)$; where $c(t)$ stands for response and $u(t)$ is unit step excitation. Comment on what type of system it is, with reasons.

c) Define transfer function of a system. What are meant by "pole-zero" form representation and "time-constant" form representation of a system transfer function? [5+3+8]

3. Find the transfer function of the system whose *s-domain* block diagram is given in Fig.-1 (Consider $V_{ref}(s)$ as input and $\Omega(s)$ as output of the system). [16]

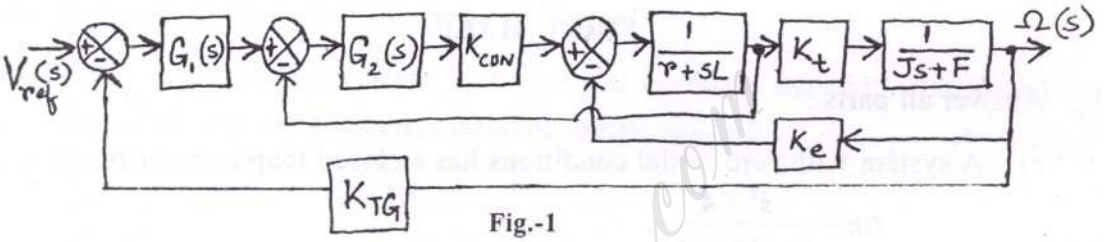

Fig.-1

4. Answer all parts :

a) Mention and explain the time domain specifications with reference to a second order system.

b) A mechanical vibratory mass-spring-dashpot system is shown in Fig.-2(a). When a 2 unit of force is suddenly applied to the system, the mass M oscillates, as shown in Fig.-2(b). Determine the numerical values of M, B and K of the system from the response curve. The displacement, x, is measured from the equilibrium position. Assume all variables are expressed in the same system of unit. [10+6]

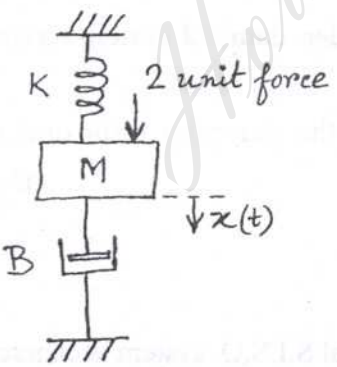

Fig.-2(a)

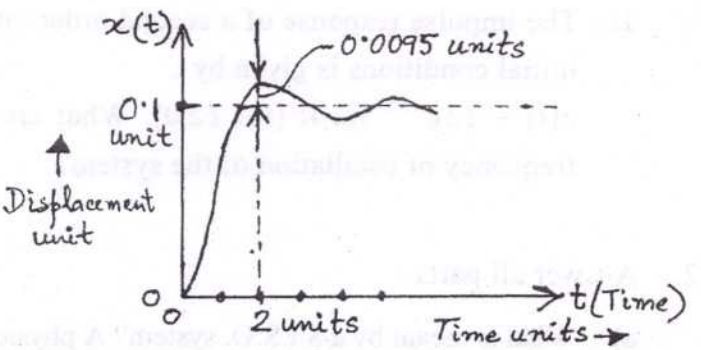

Fig.-2(b)

5. Answer all parts :

a) Develop the transfer function of an armature-controlled DC servomotor with position as output and armature voltage as input. State all assumptions made.

b) Explain, why in a servomotor, a negative slope of the speed-torque characteristics is required.

c) What will be the steady state error of the closed loop system shown in Fig.-3. [8+3+5]

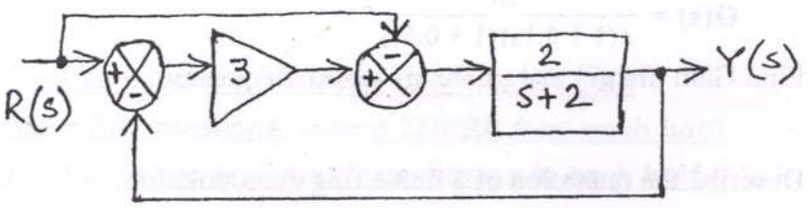

Fig.-3

SECOND HALF

6. a) Compare a closed loop system with an open loop one with examples.

b) Find range of K for stability for the unity feedback system with open loop transfer function :

$$G(s) = \frac{K\,s(s+2)}{(s^3 + 2s^2 + 10)}$$

Determine the value of K that will cause sustained constant amplitude oscillations and also the frequency of oscillations.

c) Consider the unity feedback system with open loop transfer function :

$$G(s) = \frac{K}{s\,(s+6.54)} \quad \text{with } K = 5$$

find the resonance frequency and the resonance peak. [4+8+4]

7. a) How does the synchro operate as an error detector? Derive expressions if necessary.

b) Draw the Bode plots of :

$$G(s) = \frac{1000}{s(s^2 + 105\,s + 600)}$$

Also find the gain margin and phase margin. [6+10]

8. a) When is a transfer function proper? When is it minimum phase?

b) Draw the complete root locus as $0 \le \alpha \le \infty$ for the unity feedback system with

$$G(s) = \frac{10(s+\alpha)(s+3)}{s(s^2 - 1)}$$

Suitably assume positions of break-away point, exact location need not be found. [2+14]

9. a) How can you characterise relative stability?

   b) Use Nyquist stability criterion to infer about closed loop stability of the unity feedback system with open loop transfer function :

$$G(s) = \frac{20}{s(1 + 0.1s)(1 + 0.5s)}$$

   c) Find Gain margin and phase crossover frequency. [4+10+2]

10. a) Describe the operation of a diode ring demodulation.

   b) Explain which parts of the real axis in s-plane contain a root locus.

   c) Draw the polar plot of the system given in 9(b).

   d) For a second order system how can you correlate between time domain specifications and frequency domain specifications? [4+4+4+4]

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