IIT-Delhi Dept. of Electrical Engineering

EEL301: Control Engineering-1

May 2009 *Instructor: M. Nabi*

Major: Part-1

1. (a) The Fig.1 below shows a mass-spring system with a nonlinear viscous damping proportional to square of velocity. Obtain a linearised state-space system of the system, clearly showing the Jacobian, linearising about a general point state-point (x^*, v^*)

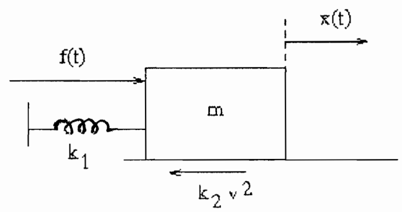


Figure 1: Mass-spring system

(b) Find its natural frequency, damped or damped as the case may be.

(c) Now the above system is connected to an overall motion-control system in the manner shown in Fig. 2. The details of the other components are:

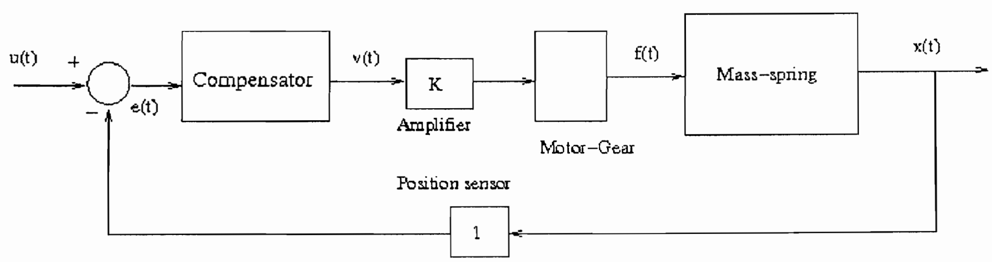


Figure 2: Layout of Assembly

- Amplifier: A constant gain K
- Motor-gear mechanism: A *constant* gain of P N/v, where P is the last digit of your entry number. (in case it is zero, take P=1).
- Position sensor: A constant gain of 1 v/m
- Compensator: A circuit as shown in Fig. 3, with $R_1 = 200, C = 0.01$ and R_2 to be determined.

For this system, proceeding from the linearised model obtained in a), find the value of R_2 required so that the overall system has a damping coefficient $1/\sqrt{2}$, and an *undamped* natural frequency of $\sqrt{2}/2\pi$ Hz

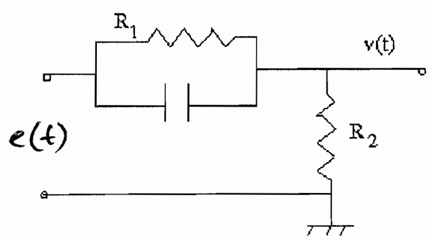


Figure 3: The Compensator

5+3+12=15

2. For the system given in Fig. 4, with

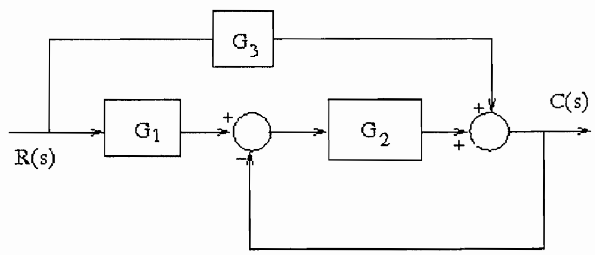


Figure 4: Block Duagram

$$G_1(s) = 2 \ ; \ G_2(s) = K/(s^4 + 5s^3 + 10s^2 + 5s) \ ; \ G_3(s) = 5$$

find the range of values of the gain K suct that the system remains stable. 15

MAJOR; PART-2

FIGURES.

Fig 1

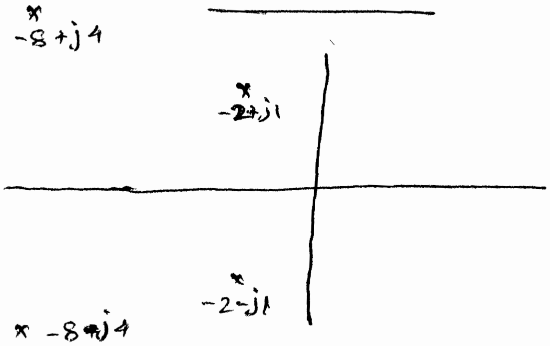


Fig 2.

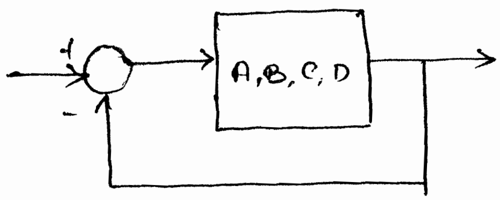


Fig 3.

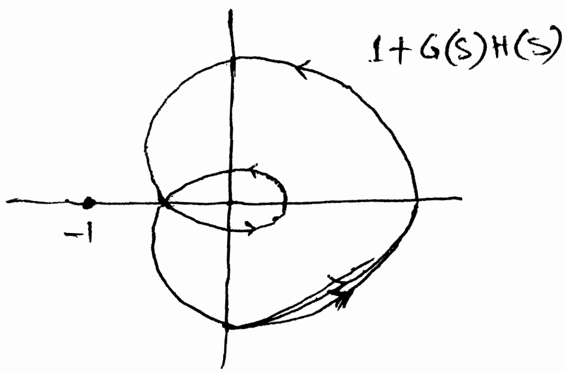


Fig 4.

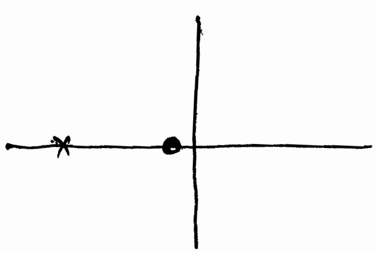


Fig 5.

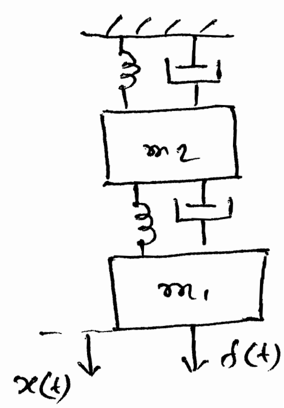
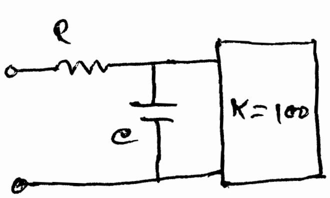


Fig 6.



$R = 10\ \Omega$.
$C = 10^{-4}$ F

IIT-Delhi Dept. of Electrical Engineering
EEL301: Control Engineering-1

May 2009 *Instructor: M. Nabi*

Major: Part-2

1. For a standard feedback system with forward T.F. $G(s)$, the Nyquist-plot of $1+G(s)H(s)$ is shown in Fig. 3. If the C.L.T.F. is know to have two right-half zeroes, is the C.L. system stable ?
   (a) No
   (b) Yes
   (c) Can be either
   (d) Can not be said

2. For the system shown in fig. 5, the order of the T.F from $F(s)$ to $X(s)$ is
   (a) 1
   (b) 2
   (c) 3
   (d) 4

3. The right-most segment of an asymptotic Magnitude bode plot for an open-loop T. F. $G(s)$ is a straight line with a downward slope of 60 db/dec. If the root-locus of the correspoding unity-feedback system is drawn, the angles of the asymptotes if any would be
   (a) 60, -60, 180
   (b) 90, -90
   (c) No such asymptote
   (d) Can not be said in any way from this

4. The settling time of the system with pole-zeros shown in fig.1 is
   (a) 2 sec
   (b) 1/2 sec
   (c) 1/8 sec
   (d) It never settles (unstable)

5. For the system shown in fig. 6 the amplifier simply passes on the voltage from left-right thrugh a scaling of K=100, without "loading". Then upto which frequency will the overall system maintain a constant magnitude gain, and with what magnitude ?
   (a) 1000 rad/sec and 40 dB
   (b) 1000 rad/sec and 20 dB
   (c) 10 rad/sec and 100 dB
   (d) 100 rad/sec and 10 dB

6. A compensator has a pole-zero configuration as given in Fig 4. Which of the following is true ?

(a) It would improve stability performance but not affect transient respose.

(b) Improve stability and also affect transient response.

(c) Not afect stability performance at all, but affect transient response.

(d) Affect neither of the above to any significant degree, but may improve steady-state response

7. For the system shown in the Fig. 2, the forward path block is given in state-space form as A, B, C, D, with $A = diag[k_1 \ , \ k_2]$ where k_1 is the last digit of your entry number, and and k_2 the next integer. in addition, $B = [1 \quad -1]^T$, $C = [1 \ \ 0]$ and $D = 3$. For this, how many branches of the corresponding unity-feedback Root-locus go to infinity ?

   (a) None

   (b) 1 sec

   (c) 3 sec

   (d) Can not be said at all

8. If somebody for some reason considers the two poles at $-2 \pm j1$ as the dominant ones, and proceeds to calculate settling time T_s and rise time T_r using these only, which of these two parameters thus computed is more relaible ?

   (a) T_s

   (b) T_r

   (c) Both equally

   (d) Can not be said at all

9. Use of a PD controller may

   (a) Improve transient response but deteriorate signal quality

   (b) Improve transient response and have no effect on signal quality

   (c) Improve steady-state response and have no effect on transient response

   (d) None of the above is true

10. The compensator $G_c(s) = (s + 0.1)/(s + 0.01)$ will

    (a) Reduce a finite nonzero steady state error by some factor, but deteriorate stabilty slightly

    (b) Reduce a finite nonzero steady state error to zero

    (c) Have no effect on steady-state error but modify transient-response.

    (d) Will just improve stability, nothing else can be definitely said.
