No. of Printed Pages : 8 **MINE-045**

M.Tech. IN ADVANCED INFORMATION TECHNOLOGY – EMBEDDED SYSTEM DESIGN (MTECHSD)

00274

Term-End Examination

December, 2014

MINE-045 : EMBEDDED INSTRUMENTATION AND CONTROL

Time : 3 hours *Maximum Marks : 100*

Note :

(i) Section I is ***compulsory****.*

(ii) Answer any ***five*** *questions from Section II.*

(iii) Assume suitable data wherever required.

(iv) Draw suitable sketches wherever required.

(v) Italicized figures to the right indicate maximum marks.

(vi) Use of calculator is allowed.

SECTION I

1. One of the applications of an automotive control system is the active control of the suspension system. One feedback control system uses a shock absorber consisting of a cylinder filled with a compressible fluid that provides both spring and damping forces. The cylinder has a plunger activated by a gear motor, a displacement measuring sensor and a piston. Spring force is generated by piston displacement, which compresses the fluid. During piston displacement, the pressure imbalance across the piston is used to control damping. The plunger varies the internal volume of the cylinder. This feedback system is shown in Figure 1.

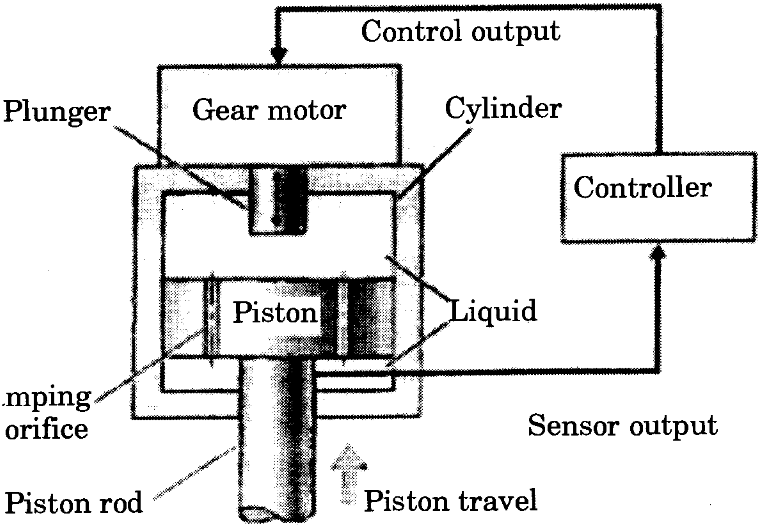

Figure 1 : Shock absorber

Develop a block diagram model of the device. *15*

2. Answer the following short answer questions : *5×3=15*

(a) What does the order signify in any difference and differential equation of the system ?

(b) Why does sampling of analog signal at equality (sampling rate = 2 max. i/p freq.) result in aliasing ?

(c) What is the characteristic equation of a system ?

(d) Is filling a glass with water an example of closed loop or open-loop system ?

(e) Why cannot derivative controller be used alone ?

SECTION II

3. In many applications, such as reading product codes in supermarkets, in printing and manufacturing, an optical scanner is utilised to read codes, as shown in Figure 2. As the mirror rotates, a friction force is developed that is proportional to its angular speed. The friction constant is equal to 0·06 Ns/rad and the moment of inertia is equal to 0·1 kg-m^2. The output variable is the velocity $\omega(t)$.

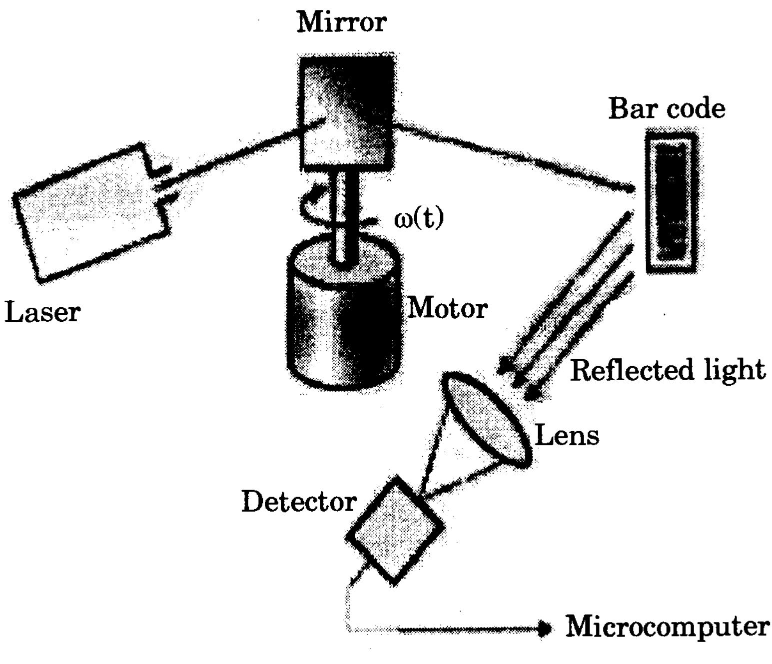

Figure 2 : Optical Scanner

(a) Obtain the differential equation for the motor.

(b) Find the response of the system when input motor torque is a unit step and initial velocity at t = 0 is equal to 0·7. 7+7

4. For the control system, giving the open-loop Bode plot of Figure 3, we have a phase margin of 10°. By how much should the gain of the system be changed if a gain margin of 40° is required ? *14*

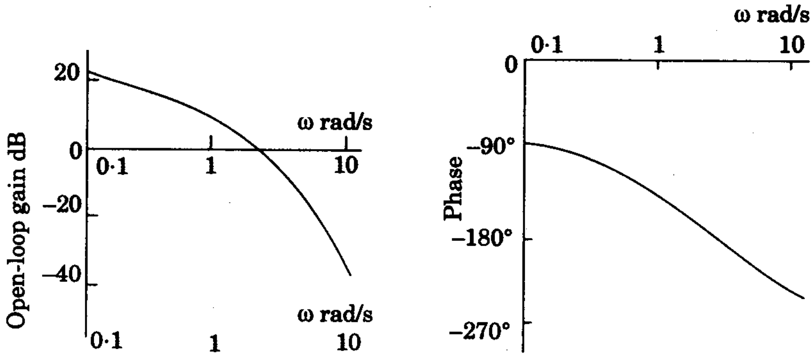

Figure 3 : Open-loop Bode plot for control system

5. A robot gripper, shown in part (a) of Figure 4, is to be controlled so that it closes to an angle θ by using a DC motor control system, as shown in part (b). The model of the control system is shown in part (c), where $K_m = 30$, $R_f = 1\ \Omega$, $K_f = K_i = 1$, $J = 0{\cdot}1$ and $b = 1$.

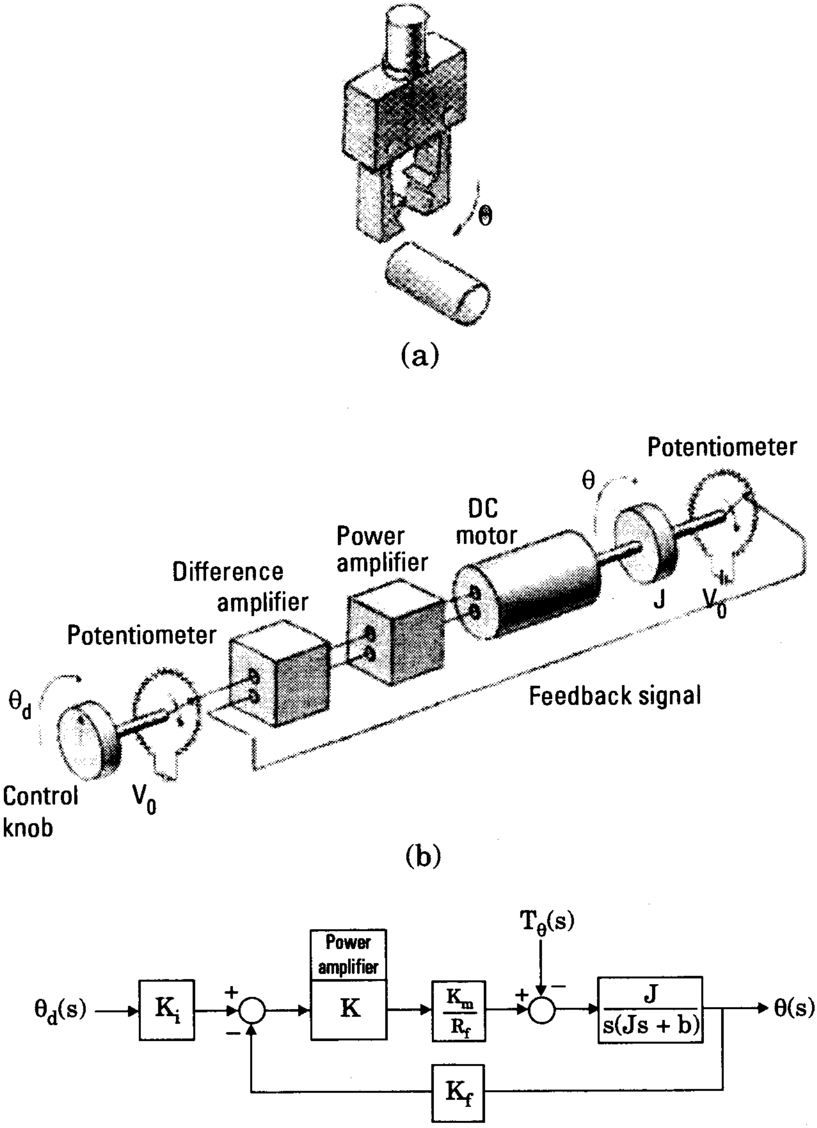

Figure 4 : Robot gripper control

(a) Determine the response $\theta(t)$ of the system to a step change in $\theta_d(t)$ when $K = 20$.

(b) Assuming $\theta_d(t) = 0$, find the effect of a load disturbance $T_d(s) = A/s$.

(c) Determine the steady-state error e_{ss}, when the input is $r(t) = t$, $t > 0$. (Assume that $T_d(s) = 0$) *5+5+4*

6. Answer the following questions : *7+7*

(a) What is the importance of Virtual Instrument concept in Embedded System ? What all are the possible domains of Embedded System where the concept of Virtual Instrument can be used ? Explain with examples.

(b) How do you differentiate Fuzziness from Uncertainty ? Also discuss in detail some applications of fuzzy logic in Embedded Instrumentation and Control System.

7. Given $T(s) = \dfrac{1}{s^2 - 3s + 2}$. Find the system poles, damping factor, natural frequency and stability of the system T(s), by plotting them on S-plane. *14*

8. Answer the following questions : *10+4*

(a) Implement a parallel PID controller with the help of operational amplifier for proportional controller gain of 2, integral coefficient of 0·2 and derivative coefficient of 0·8.

(b) Define controllability and observability of the system.

9. Many systems are piecewise linear; that is, over a large range of variable values, the system can be described linearly. A system with amplifier saturation is one such example. Given the differential equation $\frac{d^2x}{dt^2} + 15\frac{dx}{dt} + 50x = f(x)$, where f(x) is shown below. Write the differential equation for each of the following ranges of x :

(a) $-\infty < x < -2$, (b) $-2 < x < 2$, (c) $2 < x < -\infty$ *14*