(3 Hours)   [Total Marks: 80]

Note:
- Question No. 1 is compulsory.
- Answer any **three** from the remaining five questions.
- Assume suitable data if necessary and justify the same.
- Figures to the right indicate the marks.

1   Each question carry five marks   20

   a   Given a point on the z-plane, how can one determine the associated settling time and peak time?

   b   Under what conditions would you use an observer in your state space design? Which plant representation lends itself to easier design of an observer? Why?

   c   Draw the bode plot of a typical lag compensator. Why it is called as a lag compensator?

   d   Explain the scan cycle of PLC.

2   a   Use frequency response methods to design a lead compensator for a unity feedback   10
system where $G(s) = \frac{K(s+7)}{s(s+5)(s+15)}$ and the following specifications are to be met:
percent overshoot=15%, Settling time=0.1sec, and Kv=1000.

   b   Explain the memory unit of PLC.   10

3   a   Consider the following transfer function: $G(s) = \frac{(s+6)}{(s+3)(s+8)(s+10)}$. If the system is   15
represented in parallel form design a controller to yield a closed loop response of
10% overshoot with a settling time of 1 sec. Design the controller by first
transforming the plant to phase variables. Draw the plant representation in parallel
form with the controller gains.

   b   Draw the implementation for the digital compensator defined by   05
$Gc(z) = \frac{(z+0.5)}{z^2-0.5z+0.7}$

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4   a   Design an integral controller to yield a 10% overshoot, 0.5 sec. settling time and   10
zero steady state error for a step input for the following plant.

$$x^{\cdot} = \begin{bmatrix} -2 & 1 \\ 0 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u; \qquad y = \begin{bmatrix} 1 & 1 \end{bmatrix} x$$

     b   Compare Timer ON, Timer OFF and Retentive Timer instructions of PLC with   10
timing diagrams. Explain the significance of cascade timer with an example.

5   a   Given $T(z) = \dfrac{N(z)}{D(z)}$ where $D(z) = z^4 + z^3 - 2z + 0.5$, use the Routh-Hurwitz   10
criterion to find the number of z-plane poles of $T(z)$ inside, outside and on the unit
circle. Is the system stable?

     b   What is meant by Integral wind-up? How it will affect the performance of the   10
system? Explain a simple anti wind up circuit with block diagrams to mitigate the
wind-up effect.

6   a   Explain four types of arithmetic functions performed by PLC.   10

     b   Explain Input/Output addressing formats in PLC. Also explain the relationship   10
between the number assigned to the data files in memory and the number used by
the I/O terminal using suitable diagrams.