Masters of Mechanical & Automobile Engineering 1ˢᵗ Year 1ˢᵗ Semester Examination, 2018

Subject: Control of Mechatronic Systems

Time : Three hours   **Full Marks: 100**

Answer any **FOUR** *questions.*

1. Consider a three-land symmetric spool valve controlling the flow to and from a double-acting single-rod cylinder by activating any of the two solenoids connected at both ends of the spool. Find the expressions for steady state and transient flow forces for the extension of the cylinder at no load. What is the significance of these forces in connection to a manually-operated spool valve of similar type?   **20+5**

2. Draw a schematic of a bi-directional force motor and find the expression of the electromagnetic force generated by the motor in terms of the current in the solenoid and the air gaps on both sides of the armature. What is the role of the springs in the force motor?   **20+5**

3. Draw an intensifier circuit and explain its operation. What is the role of the pressure reducing valve in this circuit? How the spring of this valve should be designed in this circuit?   **15+5+5**

4. Consider a second order dynamic system $\ddot{e}=u+d$ and $|d|<C$, where e, u and d are the output error, input signal and the disturbance respectively and the initial state $e_o>0$, $\dot{e}_o=0$, $\ddot{e}_o=0$. With proper explanations, draw the system trajectory in the $e-\dot{e}$ phase plane with $\alpha>C$ for the input signal $u=\alpha\,\text{sgn}(\dot{x}+\beta\,\text{sgn}(x)\sqrt{|x|})$. Also determine the time of dwell on the sliding surface and state the advantage of the semi-parabolic sliding surface over the linear sliding surface.   **15+5+5**

5. The objective is to find the maximum of function $\varphi(x)=-x^4+6x^3-11x^2+6x$ for the attribute range $0\le x\le 2.5$ by employing a real-coded genetic algorithm.
   a) Select three candidate pairs from the first generation at $x=0.2$, 0.6, 1.0, 1.4, 1.8 and 2.2 and then applying 6 random numbers 0.2, 0.7, 0.4, 0.8, 0.3 and 0.9 in a sequential manner on the normalized cumulative relative fitness of the functional values of the candidates.
   b) Update the attributes x_1 to x_6 of the population by enabling the crossover for the first pair with attribute range of each pair extended by 25% on either side subject to the overall constraint of the domain and executing two interpolations in each modified domain by choosing two random numbers.

   c) Update the attribute of the population by enabling mutation for the fifth candidate only by the relation $x_5=2.5(1-m)(1-f^{1/20})$ by randomly choosing m and f as 0.8 and 0.4 respectively.   **25**