Exam Date & Time: 07-Dec-2023 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

Elements of Mechatronics System

Elements of Mechatronics Systems [MME 4066]

Marks: 50   **Duration: 180 mins.**

END EXAM

Answer all the questions.   Section Duration: 180 mins

Draw relevant graphs on a seperate graph sheet provided.

1A)   Discuss the construction and working of an RVDT and provide a schematic illustration of how to use it to measure the angular displacement of a robotic arm.   (4)

1B)   A waste-management company requires the implementation of a waste-management strategy to optimize the time and resource utilization. As a part of this initiative, a smart thrash bin needs to be developed. For detecting the thrash level in the waste bin, an ultrasonic sensor is recommended. This sensor gives an indication of the level of thrash collected and based on this, the decision would be made whether to empty it or not. For the above stated problem, discuss how the ultrasonic sensor can be employed and schematically represent the measurement system.   (3)

1C)   A pressure transducer is used measure the pressure from a source in terms of psi. The linear range of sensor depends on the sensitive element, which detect the changes in pressure from 10 psi to 100 psi. The corresponding output voltage vary from 0 to 5V. However, the data from the sensor is measured through a 16-bit data acquisition system that can detect only a current output. A 100-ohm resistor is connected to convert the voltage reading into current. Find

(i) Sensitivity of the pressure transducer   (3)

(ii) What is the value of output measured through the data acquisition system corresponding to the pressure reading of 50 psi.

(iii) For the measurement of 40 psi pressure, if the sensor measured the values are 41.0, 41.1, and 41.0 psi at an interval of 1 min, what static characteristics is responsible for this typical response of sensor. Justify your answer.

2A)   The circuit for static AC circuit breaker is shown in figure.   (3)
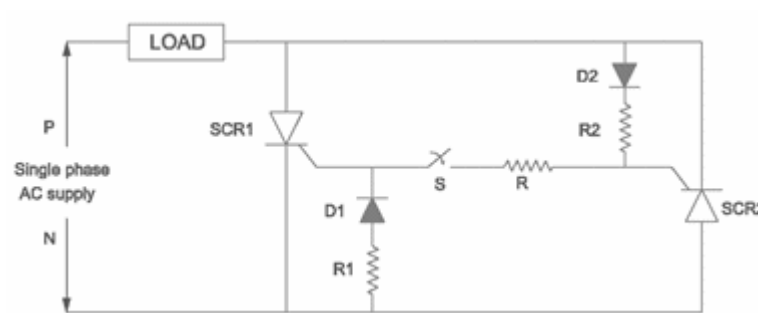
(i) Briefly discuss the functioning of circuit element SCR1, SCR2, D1 and D2

(ii) What changes in the circuit can be expected if the SCR1 is replaced by a PNP BJT and TRIAC

(iii) How a PNP and NPN transistors are connected to the power supply.

2B) Select an appropriate actuator to control the angular motion of the robotic arm, which could rotate at a rate of 200 steps per revolution. (*The serve motor cannot be used as it increases the cost significantly*). Justify your selection and discuss its construction and working.   (3)

2C) With respect to the construction and application point of view, differentiate between

(i) Variable reluctance stepper motor and BLDC motor
                                                                                                                                  (4)
(ii) AC Three phase synchronous motor and three phase induction motor.

3A) A pressure gauge is used to measure the pressure of a diaphragm. The frequency range of the measured signal is between 0-200 Hz. It was observed that the pressure readings were inaccurate. To identify the root cause for erroneous measurement, the frequency-domain of the measured signal was analyzed. Frequency domain plots indicated that a dominant signal at 50 Hz is contributing significantly to the measurement, resulting error in the measured output. This signal is associated with the electromagnetic interference caused by the AC supply. It could not be avoided until a proper electrical isolation is provided. However, as a temporary measure, a passive filter can be incorporated in the measurement circuit. For the above stated problem, suggest a suitable passive filter to resolve the issues associated with the present measurement set up and also draw the associated circuit diagram and derive the transfer function.   (3)

3B) The Coriolis acceleration of the slotted lever is expressed as **2vw**. The **v** represents the velocity of the slider and the **w** is the angular velocity of the link. Since the velocity could not be measured directly, it has been planned to measure the velocity indirectly from the acceleration. Similarly, the angular velocity is measured from the angular displacement measurement from a rotary type potentiometer.

For the given measurement scheme, suggest a suitable amplifier for the signal conditioning unit to acquire   (4)

(a) Velocity (**v**) of the slider from the acceleration signal

(b)Angular velocity (**w**)of the link from the angular displacement measurement.

Also, draw the circuit diagram and derive the expression for the amplifier gain

3C) Explain the signal overlapping in a multi-actuator pneumatic circuit. Briefly discuss how it can be eliminated by using cascade method.   (3)

4A) A 4-bit SAR type ADC is used to convert the analog signals from an LVDT to digital. The resolution of DAC is 0.5 V. What is the digital output from the ADC for the input voltage of 4 V.   (3)

4B) Explain R-2R type DAC. What would be the analog output from the DAC corresponding to a digital input of 1010. The reference voltage V_{ref} to the DAC is 5 V and the feedback resistor R_f is100 Ω and precision resistor R is 100 Ω   (4)

4C)   Discuss how a Hall effect sensor can be used to monitor the fuel level in a fuel tank

(3)

5A)   The forward and the return motion of a double acting cylinder is controlled by a solenoid operated spring return direction control valve (refer figure shown below). LSF and LSR are the limit switches to detect the forward and the return position of the cylinder respectively. The forward and return position are indicted by green (G) and Yellow (Y) lamps respectively. Initially the cylinder is in retracted position. When pushbutton 1 (PB1) is pressed, the cylinder should move forward. The cylinder should remain in extended position for 10 s. This operation should continue until pushbutton 2 (PB 2) is pressed. Construct the ladder logic circuit to represent above the requirement.
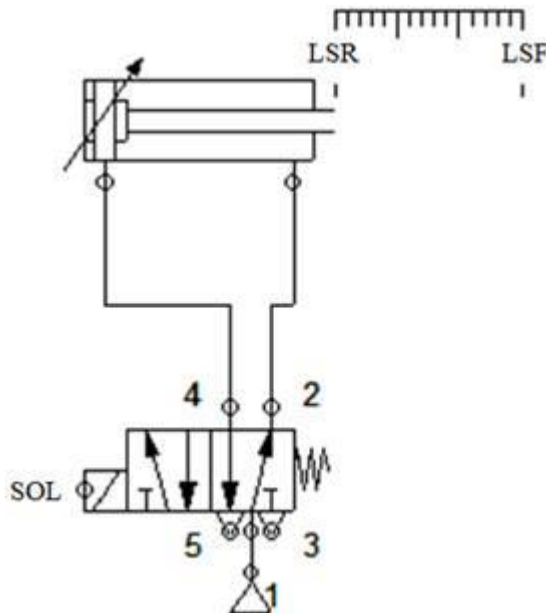
(5)

5B)   Write a note on registers in a 8085 microprocessor

(3)

5C)   With the suitable examples, discuss the following terminologies with respect to the ladder logic circuit.

(i) Latching

(2)

(ii) Signal Interlocking

-----End-----