

9210-223

Level 7 Post Graduate Diploma in Engineering

Mechatronics

GLA d`Y`DUdYf

You should have the following for this examination

No additional data is attached

- one answer book
- calculator (programmable calculators are not allowed)
- pen pencil and eraser
- drawing instruments

General instructions

- This paper consists of **nine** questions.
- Answer only **five** questions.
- Each question carries twenty (20) marks. Marks allocated to a part of a question are indicated against that part.
- You may use drawing instruments to draw sketches, where necessary.

Section A

- 1 a) i) What is a Rotary Variable Differential Transformer (RVDT)? (1 mark)
 ii) Describe briefly how a RVDT works. (2 marks)
 iii) Draw the output wave form of the RVDT. (2 marks)
 - b) In an RVDT, 1° angular displacement of core corresponds to 10 mV produced at the output.
 i) What will be the voltage produced when core moves 350 clockwise direction? (5 marks)
 ii) What is the range of RVDT output voltage if core can move to a maximum of 1800 anticlockwise direction? (5 marks)
 - c) Explain the necessary steps to be taken when a RVDT is connected to a microcontroller. (5 marks)
- 2 a) Explain the construction and operation of absolute position encoder and incremental position encoder. (4 marks)
 - b) Find the angular resolution of

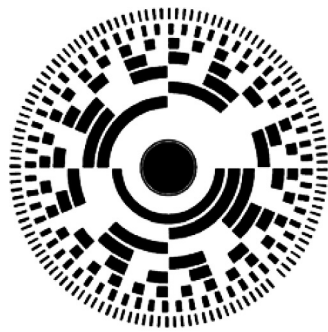


Figure Q2 (i)

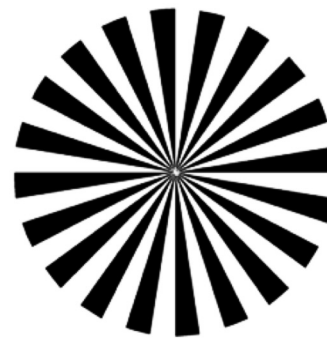


Figure Q2 (ii)

- i) the optical shaft encoder shown in Figure Q2 (i). (4 marks)
 - ii) the sectored disk encoder with 40 divisions shown in Figure Q2 (ii). (4 marks)
- c) i) Explain how the angular resolution of the optical shaft encoder can be improved. (4 marks)
 - ii) Sketch and explain interfacing of each slotted disk encoder and optical shaft encoder to a microcontroller. (4 marks)

- 3 a) A car is fitted with an alarm which sounds a buzzer when the outside temperature falls below 10°C. The sensor is a thermistor, buzzer control circuit shown in Figure Q3.

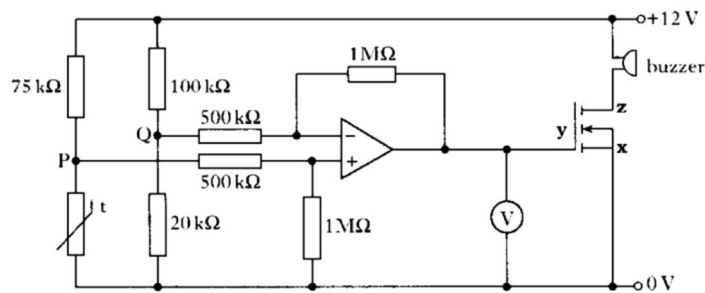


Figure Q3

- Identify with relevant names the terminals labelled by the letters **x**, **y** and **z** of the MOSFET. (3 marks)
- b) The buzzer sounds when the reading on the voltmeter is greater than or equal to +3.0V.
- i) Calculate the minimum potential difference between points P and Q to sound the buzzer. (12 marks)
- ii) Calculate the resistance of the thermistor when the buzzer sounds. (5 marks)
- 4 a) Find the minimum sum of products form and product of minimum sums form of the following function using the Karnaugh map. (8 marks)
- $$F(A,B,C,D) = \sum(5,7,8,9,10) + dc_terms(0,1,13,15)$$
- b) i) A building has four floors and stair case, which link the floors. The stair case is provided with illumination lights and these lights are required to switch on and off from any of the floors. Design a logic circuit for this application using the minimum number of gates. Show the design steps clearly. (6 marks)
- ii) If the lights are controlled through a relay, design a suitable circuit which fulfills this requirement and draw the circuit diagram. (6 marks)

Section B

- 5 a) i) What is a first-order system? Sketch a graph showing how a first-order system responds to a step change of input. (6 marks)
- ii) Give an example which illustrates in each application in each mechanical engineering and electronics engineering, where it can be represented by a first-order system. (4 marks)
- b) A spring-damper system is shown in Figure Q5 (i). The spring stiffness is 200 Nm^{-1} and the damping coefficient is 600 Nsm^{-1} .

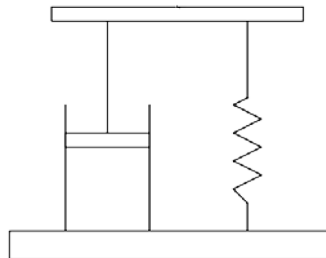


Figure Q5 (i)

- i) Calculate the system time constant. (2 marks)

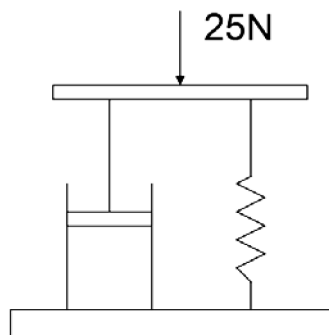


Figure Q5 (ii)

- ii) A force of 25 N is applied downwards to the upper beam as shown in Figure Q5 (ii). The force is then suddenly removed. Calculate the time taken for the system to move 50 mm from its initial starting point and the time taken for the system to return very closely to its original length. (8 marks)
- 6 a) Distinguish variable reluctance stepper motor from permanent magnet stepper motor. (4 marks)
- b) Explain the operation of different types of stepper motor drive modes using switching sequence table. (hint: drive modes consist with half step drive modes and full step drive modes) (8 marks)
- c) A stepper motor with $15^\circ/\text{step}$ is given 64 step clockwise and 12 step anti clockwise. Assuming it starts at 0° , find the final position of the rotor. (4 marks)
- d) Briefly explain the operation of micro-step drive of stepper motor. (4 marks)

- 7 a) Draw the symbols for the following pneumatic components
- i) a pressure relief valve (2 marks)
 - ii) a 4/2 valve which has actuators of a push-button and spring (2 marks)
 - iii) a 5/3 valve. (2 marks)
- b) i) Name all the components given by symbolic representations in Figure Q8. (8 marks)

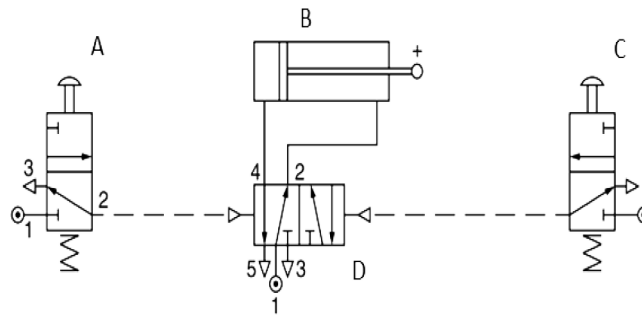


Figure Q8

- ii) Describe the operation of the pneumatic circuit given in Figure Q8. (6 marks)
- 8 a) Draw a schematic symbol for a solenoid controlled pneumatic valve and explain how the valve operates. (6 marks)
- b) Draw a simple hydraulic system that will advance and retract a double acting cylinder using PLC outputs. (Sketches should include details from the PLC output card to the hydraulic cylinder). (7 marks)
- c) A system contains a pneumatic cylinder with two inductive proximity sensors that will detect when the cylinder is fully advanced or retracted positions. The cylinder is controlled by a solenoid controlled valve. Draw electrical and pneumatic schematics for the system. (7 marks)
- 9 a) i) Write ladder logic for a motor starter that has a start and stop button and uses latches. (4 marks)
- ii) Write the same ladder logic without latches. (4 marks)
- b) A conveyor that conveys items from one location to another is operated by an electric motor, which can be switched on or off. Items to be conveyed are detected by an optical detector. When the optical sensor detects an item on the conveyor, the system needs to wait for 1.5 seconds requiring to stop the conveyor. After a delay of 2 seconds from the instant it stops the conveyor starts again. System needs to use a start and stop button, and indicator bulb to burn when the system is active. Write the ladder logic for above operation. (12 marks)