



CINEC Campus

Faculty of Engineering & Technology

Department of Electrical and Electronic Engineering

BSc Hons in Engineering in Mechatronics Engineering – Batch 06
Semester 03 - First Sit – End Semester Examination
February 2025

Module Code	:	EE2319
Module Title	:	Sensors & Signal Conditioning
Date	:	2025 - 02 - 22
Examiner	:	MGJP Fernando
Time Allowed	:	03 Hrs

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of **FIVE** (05) questions. Answer **ALL** questions.
- Write clearly and legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains Five pages.

MATERIALS REQUIRED

- CINEC answering Booklet & Extra answering paper
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.

QUESTION 01 [20 MARKS]

- [a] Illustrate and describe the main difference between an Open loop system and a Closed loop system using a flow chart, and state why a sensor is a key factor for this difference. [04]
- [b] Using a suitable scenario, describe how a thermal sensor can be used to automate a manual process. [04]
- [c] State the difference between a sensor and a transducer. [02]
- [d] State **three** Conversion Phenomena which can be used to convert a measurand to an electrical signal. [03]
- [e] Describe how sensors can be classified as active and passive with suitable examples. [04]
- [f] With a suitable example, describe why non-contact sensors can be useful in certain situations compared to contact sensors to measure the same measurand. [03]

QUESTION 02 [20 MARKS]

- [a] If you are designing a smart mobile device, state **five** types of sensors you would integrate in your device and the purposes of integration. [05]
- [b] State the definition of the phrase 'Process Instrumentation' related to an industrial setting. [02]
- [c] Provide **three** reasons to justify the statement "Calibration is a necessity for sensors used in any application" with appropriate examples for each reason. [03]
- [d] Compare 'Known' and 'Unknown' Uncertainties which can affect a measurement. [02]
- [e] State the main **four** types of characteristics that describe sensor performance [04]
- [f] ▪ Transfer function of a thermocouple linking its voltage output V and temperature input is provided as [04]

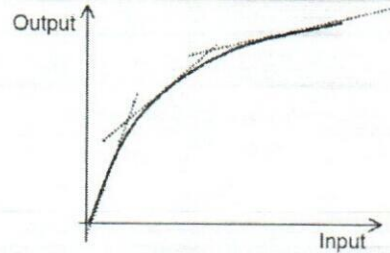
$$G(s) = \frac{30 \times 10^{-6} \text{ V}}{10s + 1} \frac{\text{V}}{^{\circ}\text{C}}$$

- Determine the response of the system in time domain when subject to a step input of size 100°C .

<i>Laplace transform</i>	<i>Function of time</i>
$\frac{1}{s + a}$	e^{-at}
$\frac{a}{s(s + a)}$	$(1 - e^{-at})$

QUESTION 03 [20 MARKS]

- [a]** Define 'Sensitivity of a Sensor'. Redraw the provided input-output graph in **Figure 3.1** in your answer script and describe how the sensitivity varies along the curve. **[04]**

**Figure 3.1**

- [b]**
- The sensitivity of a particular displacement sensor with voltage output is specified as 20 mV/mm. **[02]**
 - Its specified temperature sensitivity is 0.2 mV/K.
 - What is the displacement to cause a temperature rise of 10°K?
- [c]** Describe the difference between Accuracy and Precision an appropriate illustration. **[04]**
- [d]** What is the resolution of a 1024 PPR (pulse per revolution) incremental encoder? **[02]**
- [e]**
- An ultrasonic range sensor is used to continuously monitor a stationary object every 3 seconds. **[04]**
 - The voltage to distance conversion function of the sensor is given as
- $$d(\text{cm}) = 2 \times v(\text{V}) + 0.1$$
- If output voltage values recorded during a 30 seconds window are shown as below, what could be the most accurate distance between the sensor and the object? Provide a justification for your voltage value selection.

Time (s)	Voltage (V)	Time (s)	Voltage (V)
3	3.85	18	3.72
6	3.72	21	3.70
9	3.61	24	3.71
12	3.81	27	3.68
15	3.69	30	3.72

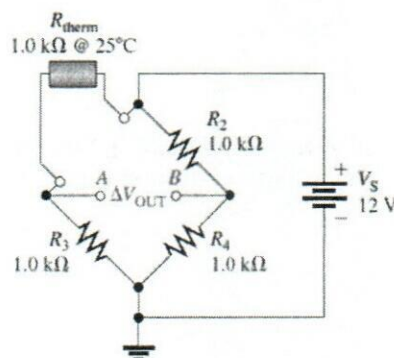
- [f]** Describe what is Hysteresis in a sensor using an appropriate diagram and how hysteresis can occur in a sensor when measuring a parameter. **[04]**

QUESTION 04 [20 MARKS]

- [a] ▪ A strain gauge is bonded to a beam which is 2 m long and has a rectangular cross-sectional area of 6 cm $\times$ 10 cm. [06]
- The strain gauge has an unrestricted resistance of 120 Ω and a gauge factor of +1.8.
- When a load is applied, the resistance of the gauge changes by 32 m Ω .
- (i) Calculate the change in length of the beam
- (ii) Calculate the stress applied on the beam cross section [Young's modulus for the material is given as 207 GN/m²]
- (iii) Calculate the force applied on the beam
- [b] Illustrate and describe through-beam, diffuse-reflective, and retro-reflective optical sensing methods. [03]
- [c] Derive equations which express the relationship between capacitance of a parallel plate capacitor and displacement of an object, if the capacitance is changed by, [03]
- (i) Changing the distance between plates
- (ii) Changing the surface area of the plates
- [d] Discuss Environmental Errors and Observational errors that can affect a sensor reading. [04]
- [e] State **five** applications where flow and level sensing are required in household, commercial, or industrial environments. [04]

QUESTION 05 [20 MARKS]

- [a] Describe the difference between NTC and PTC Thermistors. [02]
- [b] ▪ A thermistor is connected to a leg of the temperature-measuring bridge circuit shown in **Figure 5.1**. [04]
- Thermistor's resistance at 25°C is 1 k Ω .
- Determine the output voltage of the thermistor if it exposed to a temperature of 50°C.
- Assume the resistance of the thermistor decreases to 900 Ω at 50°C and
- $$V_{out} = \Delta R_{Thermal} \left(\frac{V_s}{4R} \right)$$

**Figure 5.1**

- [c] Illustrate and describe the difference between Amplification and Attenuation of a voltage signal. [02]
- [d] An Operational Amplifier circuit used to amplify the voltage output of a sensor is shown in **Figure 5.2**. [04]
- Determine the closed loop voltage gain of the Op-Amp circuit.
 - If sensor output is 43.6 mV, what is the amplifier's voltage output?

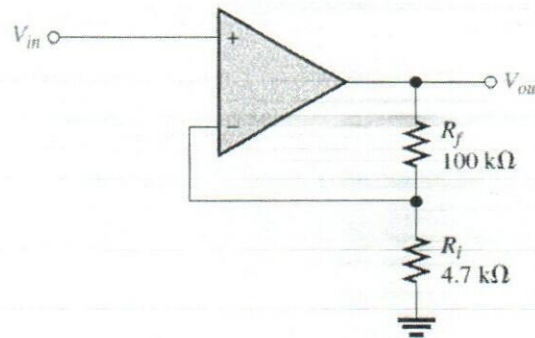


Figure 5.2

- [e] Describe why 'Isolation' and 'Excitation' are necessary for some sensor applications. [03]
- [f] Describe how the AC signal is converted to a DC signal through the consequent sections of the circuit given in **Figure 5.3** by illustrating the waveforms. [05]

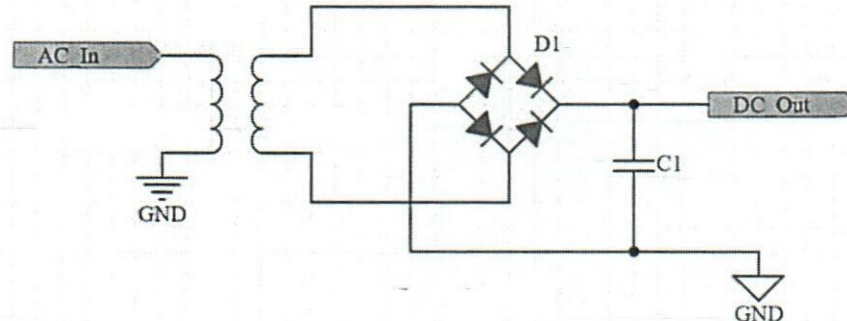


Figure 5.3



CINEC Campus
Faculty of Engineering and Technology
Department of Electrical and Electronics Engineering
BSc Hons (Eng) Mechatronic Engineering
Semester 05 First-Sit Examination 2025

Module Code : EE3316
Module Title : Embedded Systems Design
Date : 30th January 2025
Examiners : Mr. Randeera Liyanage
Time Allowed : 9.00AM – 12.00PM; 03hrs

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of 2 Parts. Part A contains 15 MCQ questions and Part B contains 4 essay type questions. You should answer **ALL** questions.
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper consists of 10 pages.

MATERIALS REQUIRED

- CINEC answering booklet; Extra answering paper.
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- MCQ answer sheet. (Attached in Annex I)
- Pinout diagrams. (Attached in Annex II)

PART A - MCQ**Instructions**

- You are required to answer all 15 MCQ questions given below.
 - You must indicate the correct answer on the MCQ answer sheet given in Annex I and attach to your answer script.
 - Each question carries 2 marks.
1. Which of the following is a key challenge in the design of embedded systems, particularly for applications like medical devices and autonomous vehicles?
 - (a) Lack of compatibility with modern programming languages.
 - (b) Limited computational resources and real-time performance requirements.
 - (c) Excessive power consumption due to reliance on cloud-based operations.
 - (d) Difficulty in integrating multiple sensors due to hardware limitations.
 2. Which of the following is a primary advantage of deploying embedded machine learning models directly on edge devices instead of using cloud-based systems?
 - (a) Enhanced privacy and reduced latency for real-time decision-making.
 - (b) Increased computational power and larger model capacity.
 - (c) Simplified model development and reduced hardware requirements.
 - (d) Elimination of data collection and labeling challenges
 3. Why is an anti-aliasing filter essential in analog-to-digital conversion (ADC)?
 - (a) To enhance the amplitude of high-frequency components above the Nyquist frequency.
 - (b) To reduce noise in the sampled signal by eliminating low-frequency components.
 - (c) To remove high-frequency components above the Nyquist frequency, preventing distortion in the digital signal.
 - (d) To ensure the output signal of the ADC remains continuous and smooth.
 4. Which of the following is a key advantage of using an R/2R ladder DAC compared to a binary-weighted DAC?
 - (a) Higher resolution due to increased quantization levels.
 - (b) Reduced power consumption, making it ideal for portable applications.
 - (c) Lower output impedance, ensuring better performance at high frequencies.
 - (d) Simplicity and scalability, requiring only two resistor values regardless of resolution.

5. A successive approximation ADC is chosen for an embedded system requiring moderate speed and fixed conversion time. Which of the following best explains its operating principle?
- (a) It uses a ramp generator to linearly approximate the input voltage over time.
 - (b) It uses a comparator to test each bit sequentially, starting with the most significant bit (MSB).
 - (c) It converts the input signal to a binary value using parallel comparators and a priority encoder.
 - (d) It integrates the input signal over a fixed time period to calculate the binary value.
6. What is the decimal equivalent of the binary number 11010101_2 ?
- (a) 213_{10}
 - (b) 197_{10}
 - (c) 229_{10}
 - (d) 181_{10}
7. What is the decimal equivalent of the hexadecimal number $2F_{16}$?
- (a) 47_2
 - (b) 48_2
 - (c) 49_2
 - (d) 50_2
8. What is the Binary Coded Decimal (BCD) equivalent of the decimal number 356_{10} ?
- (a) 0010 0101 0110
 - (b) 0001 0101 0110
 - (c) 0010 0101 0111
 - (d) 0010 1010 0110
9. In a scenario where multiple sensors need to communicate with a microcontroller over a shared bus, ensuring low power consumption and scalability, which protocol is the most appropriate?
- (a) SPI (Serial Peripheral Interface)
 - (b) UART (Universal Asynchronous Receiver-Transmitter)
 - (c) I2C (Inter-Integrated Circuit)
 - (d) RS-232

10. Which of the following accurately describes a key difference between synchronous and asynchronous communication in embedded systems?
- (a) Synchronous communication uses start and stop bits for synchronization, while asynchronous communication shares a clock signal.
 - (b) Synchronous communication is always slower than asynchronous communication.
 - (c) Asynchronous communication protocol is used for high-speed data transfer, while synchronous communication is suitable for low-speed communication.
 - (d) Asynchronous communication allows independent clocks for transmitter and receiver, while synchronous communication relies on a shared clock.
11. In a communication protocol like RS-232, which mechanism is commonly used to detect single-bit errors during data transmission?
- (a) Checksum
 - (b) Parity Bit
 - (c) CRC (Cyclic Redundancy Check)
 - (d) ACK/NACK Signals
12. What is the primary role of the Control Unit (CU) during the fetch-decode-execute cycle in a microcomputer system?
- (a) To perform arithmetic and logic operations on data.
 - (b) To store temporary data and addresses required for execution.
 - (c) To coordinate and direct the flow of data and instructions between the CPU and other components.
 - (d) To increase the clock speed of the system for faster execution.
13. Which of the following best describes a fundamental difference between RISC and CISC architectures in microcomputer systems?
- (a) RISC focuses on minimizing power consumption, while CISC focuses on simplifying hardware design.
 - (b) RISC uses variable-length instructions, while CISC uses fixed-length instructions.
 - (c) RISC simplifies hardware design by using a smaller instruction set, while CISC supports complex operations within a single instruction.
 - (d) RISC requires fewer registers than CISC due to its simplified architecture.
14. Which of the following is a key advantage of the Harvard architecture over the Von Neumann architecture in microcontroller systems?
- (a) Higher performance through simultaneous access to program and data memory.
 - (b) Simpler hardware design due to fewer buses.
 - (c) Greater flexibility in dynamically allocating memory between program and data.
 - (d) Reduced cost due to shared address and data buses.

15. Which operation is performed when using the bitwise AND operator with a mask to isolate specific bits in a binary number?
- (a) Setting the desired bits to 1 while leaving others unchanged.
 - (b) Clearing the desired bits to 0 while leaving others unchanged.
 - (c) Toggling the bits at specific positions.
 - (d) Checking whether the specific bits in the binary number are set to 1.

[Total - 30 Marks]

PART B - ESSAY

Question 01

- (a) Describe three basic components of a small embedded system and provide specific examples of how each component contributes to the system's functionality. *(Use two sentences to describe each component.)*

(04 Marks)
- (b) Discuss three primary design challenges of embedded systems and provide examples of how these challenges are addressed in hardware and software design. *(Use two sentences to describe each design challenge.)*

(04 Marks)
- (c) Explain the key benefits of edge computing systems compared to traditional cloud computing systems. *(Use at least 3 sentences in your answer.)*

(03 Marks)
- (d) A microcontroller in an embedded system uses an 8-bit register to store unsigned integer values. If the system is required to represent values ranging from 0 to 500, explain why the current register size is insufficient and propose an alternative. Include how many bits would be required to store the full range of values in your answer. *(Justify your answer with calculations.)*

(04 Marks)

[Total - 15 Marks]

Question 02

- (a) Explain the role of an anti-aliasing filter in an Analog-to-Digital Conversion (ADC) system. Discuss how it prevents aliasing and ensures accurate signal sampling. *(Use at least 3 sentences in your answer)* (03 Marks)
- (b) Consider a 3-bit flash ADC with reference voltage set to 8V. Determine the binary code output of the 3-bit flash ADC for the input signal and the encoder enable pulses given in Figure 1 and the resulting digital output waveform. (06 Marks)
- (c) In a data acquisition system, the resolution of the ADC determines the smallest measurable signal change. Discuss the significance of ADC resolution and explain how increasing the number of bits impacts signal accuracy and system performance. *(Use at least 3 sentences in your answer)* (03 Marks)
- (d) Compare the I2C and SPI communication protocols in terms of their speed, complexity, scalability, and application areas in embedded systems. Provide at least 4 distinct points in your comparison. *(Use at least 4 sentences in your answer to provide a clear comparison.)* (04 Marks)
- (e) Consider a microcontroller interfacing with multiple sensors and an actuator in an industrial automation system. Propose a communication architecture using SPI or I2C and justify your choice based on system requirements such as speed, complexity, and scalability. *(Use at least 4 bullet points in your answer to provide a clear justification.)* (04 Marks)

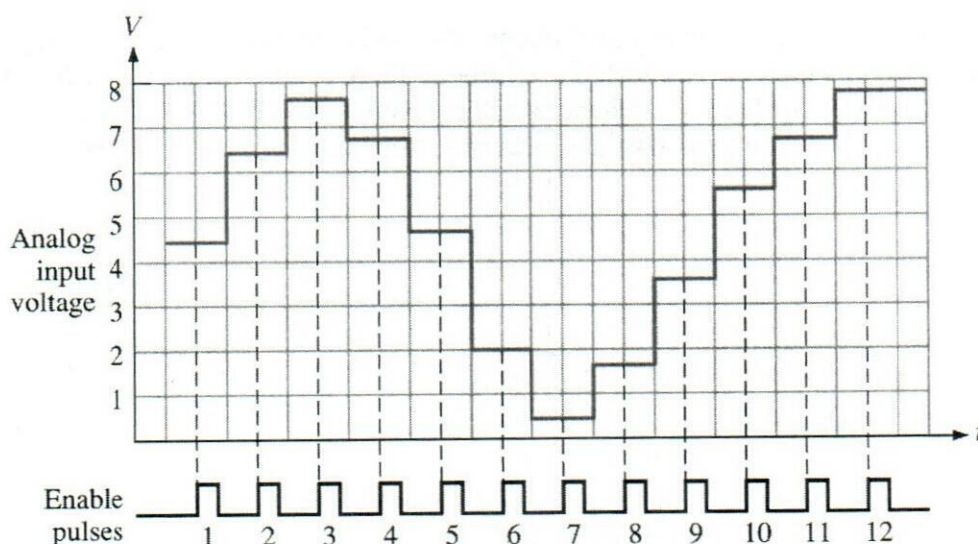


Figure 1: ADC Input Waveform

[Total - 20 Marks]

Question 03

- (a) Compare RISC (Reduced Instruction Set Computer) and CISC (Complex Instruction Set Computer) architectures with respect to their design philosophy, instruction set characteristics, execution efficiency, and hardware complexity. In your answer, clearly describe how each architecture handles instruction execution and discuss their suitability for embedded systems. *(Use at least 4 detailed bullet points.)*
(04 Marks)
- (b) Explain the specific advantages of using the Harvard architecture in microcontroller design compared to the Von Neumann architecture with respect to the impact of separate data and instruction memory on system performance and instruction execution speed. *Use at least 4 sentences in your answer to provide a clear comparison.*
(04 Marks)
- (c) Describe the role of the Control Unit (CU) in managing the fetch-decode-execute cycle of a microcontroller. Include specific details about how the CU generates control signals, coordinates with system buses, ensures accurate execution of instructions and impact on overall system reliability. *(Use at least 4 detailed bullet points.)*
(04 Marks)
- (d) Compare the programmer's model and the hardware model of a microcontroller and explain how each model influences the programming and design of embedded systems. *(Use at least 3 sentences in your answer.)*
(03 Marks)

[Total - 15 Marks]

Question 04

You are working as an embedded systems engineer; an STM32F103 microcontroller is given to be used for an upcoming project.

- (a) With reference to the pinout diagram in Annex II Figure 2, identify and explain 2 communication protocols supported by this microcontroller (Do not use Abbreviations) and compare the advantages and disadvantages of each. *(Use four sentences for the explanation.)*
(04 Marks)
- (b) You are given an OLED display module with I2C communication in Annex II Figure 3a to be integrated during prototype stages. Explain how you will integrate this hardware. *(You must show the connections in Annex II and attach it your answer script.)*
(08 Marks)
- (c) The project now requires you to add a temperature monitoring feature using a digital sensor that communicates via I2C as illustrated in Annex II Figure 3b. Explain how to connect the sensor to the microcontroller and ensure proper communication with the aid of a diagram. *(Specify the pins with justification and show the connections in Annex II and attach it your answer script)*
(08 Marks)

[Total - 20 Marks]

-END OF EXAMINATION PAPER-



PAST PAPERS

Faculty	Department / Section/Division
Not Applicable	Learning Resource Centre

Past Papers

Faculty of Engineering and Technology

BSc Hons in Eng. in Mechatronics Engineering

Document Control & Approving Authority	Senior Director – Quality Management & Administration
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1 st Issue Date: 2017.01.30	Revision No.00	Revision Date: 27.9.2024	Validated by: Librarian
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CINEC Campus
Faculty of Engineering & Technology
Department of Electrical and Electronic Engineering

BSc Hons in Eng. in Mechatronics Engineering
Batch 05 - Semester 04 - First Sit – End Semester Examination
July 2024

Module Code : EE2329
Module Title : Electrical Machines and Actuators
Date : 2024 - 07 - 15
Examiners : MGJP Fernando
Time Allowed : 03 Hrs

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of 06 questions in two Parts.
- **Answer All FOUR (04) questions in PART A. (Q1, Q2, Q3, Q4)**
- **Answer only ONE (01) question from PART B. (Either Q5 or Q6)**
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains 07 pages.

MATERIALS REQUIRED

- CINEC answering Booklet & Extra answering paper
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.

PART A

Question 01 [20 Marks]

[A] [i] Derive the equations which describes the torque-speed ($T-\omega$) characteristics of armature-control and field control methodologies for a DC motor.

[06]

[ii] Redraw the block diagrams in **Figures 1.1 & 1.2** in your answer scripts and complete them using the relevant derived terms.

[04]

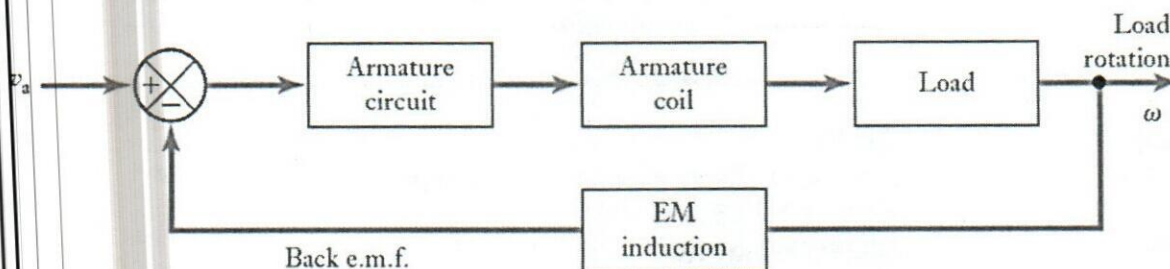


Figure 1.1

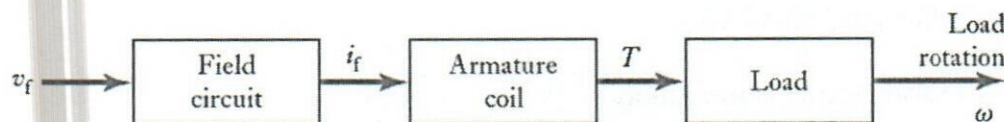


Figure 1.2

[B] Explain what are armature-control and field-control of a DC motor and how the rated $T-\omega$ characteristics curve is drawn.

[04]

[C] A separately-excited (Sep-ex) DC motor at rated voltage conditions of **300V** runs at **2200 rpm** on no load condition. When a load is connected, speed drops down to **1950 rpm**. Determine the combination of armature voltage (v_a) and field voltage (v_f) values to

[i] To change the speed to **650 rpm** if the load torque is constant,

[ii] To change the speed to **900 rpm** if the load torque varies as the square of the speed.

[06]

Question 02 [20 Marks]

[A] Describe how Series, Sep-ex, and Compound DC motors differ from each other using their equivalent representations.

[06]

[B] Explain why a DC motor starter is required and state 3 types of DC motor starters.

[04]

[C] Illustrate and describe the operation of a 3-Point Starter.

[03]

[D] Discuss the differences among the types of electrical braking.

[E] Illustrate and explain how the voltage supply and the waveform vary in the diagram shown by **Figure 2.1**. [03]

[04]

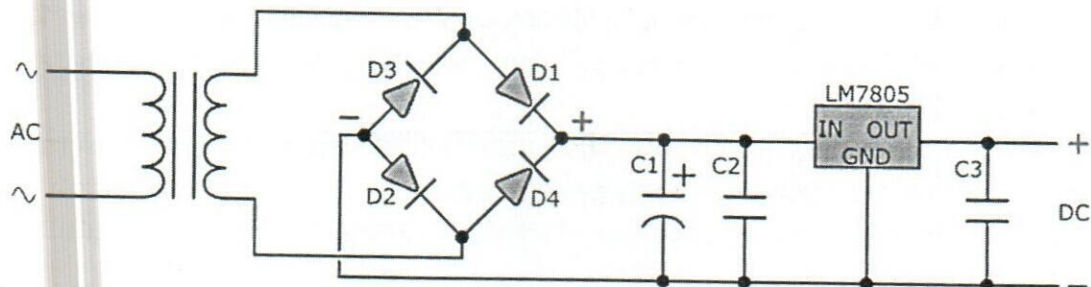


Figure 2.1

Question 03 [20 Marks]

[A] The linear dc machine shown in **Figure 3.1(a)** has a DC supply voltage of **150 V**, an internal resistance of **0.2 Ω** , and a magnetic flux density of **0.5 T**.

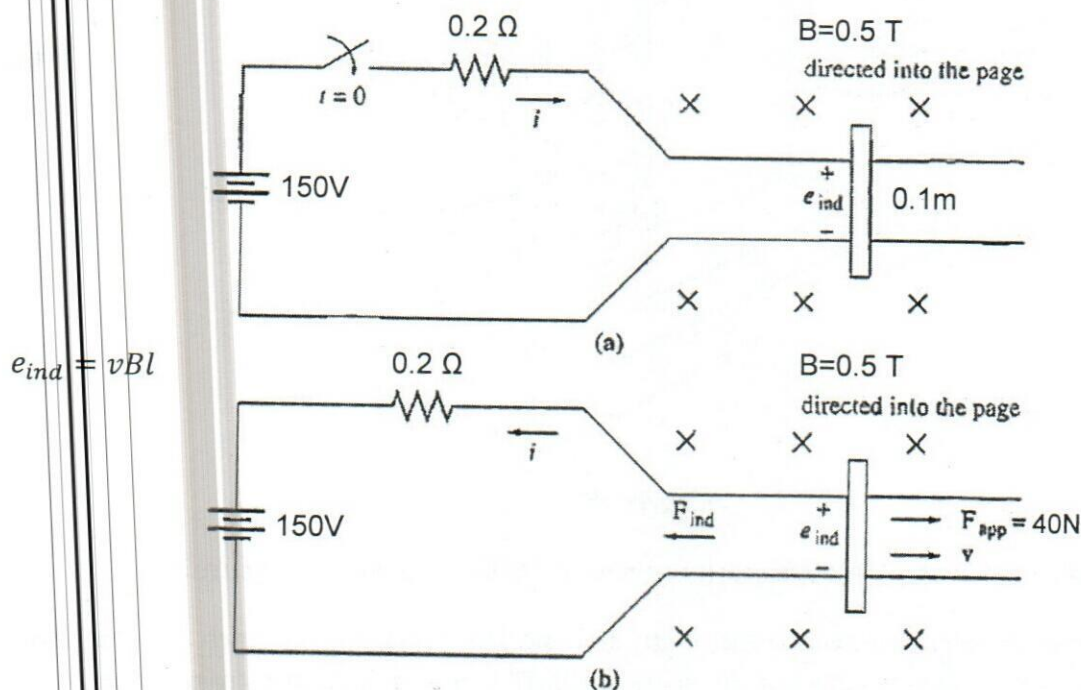


Figure 3.1

- [i] What is this machine's maximum starting current?
- [ii] What is its steady-state velocity at no load?
- [iii] If a **40 N** force pointing to the right was applied to the bar as shown in **Figure 3.1 (b)**, what would the steady-state speed be?

- [iv] Under the same force, how much power would the bar be producing or consuming and how much power would the supply be producing or consuming?
- [v] Is this machine acting as a motor or as a generator?

[06]

[B] Figure 3.2 shows a simplified rotor and stator for a DC motor.

- The mean path length of the stator is **50 cm**, and its cross-sectional area is **12 cm²**.
- The mean path length of the rotor is **5 cm**, and its cross-sectional area also may be assumed as **12 cm²**.
- Each air gap between the rotor and the stator is **0.05 cm** wide, and the cross-sectional area of each air gap (including fringing) is **14 cm²**.
- The iron of the core has a relative permeability of **2000**, and there are **200** turns of wire on the core.
- Considering permeability of free space as $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$, if the current in the wire is adjusted to be **1 A**, what will be the resulting flux density in the air gaps?

[07]

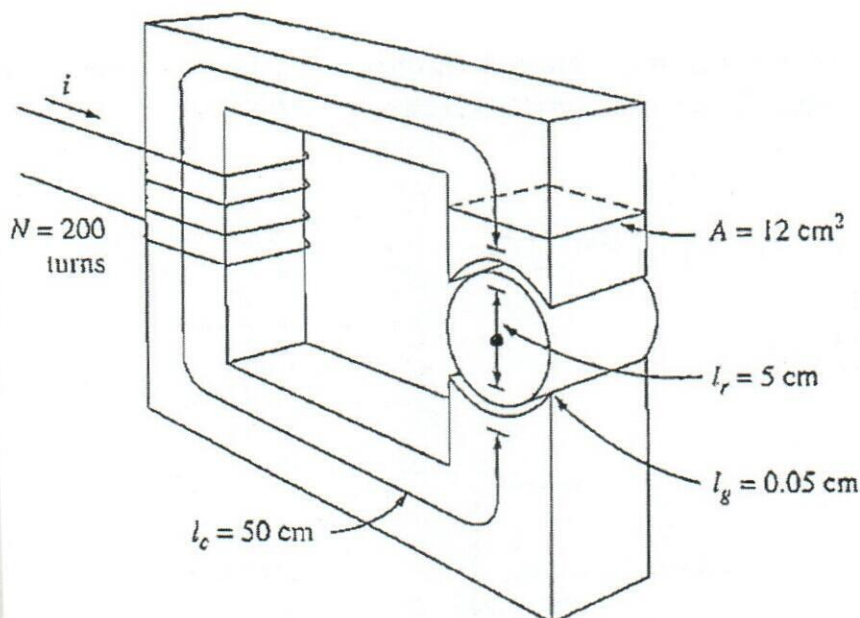


Figure 3.2

[C] A ferromagnetic core with a relative permeability of **1500** is shown in Figure 3.3.

- The dimensions are as shown in the diagram, and the depth of the core is **7 cm**. The air gaps on the left and right sides of the core are **0.07 cm** and **0.09 cm**, respectively.
- Because of fringing effects, the effective area of the air gaps is **5 percent** larger than their physical size.
- If there are **600** turns in the coil wrapped around the centre leg of the core and if the current in the coil is **2 A**, what is the total flux in the core?

[07]

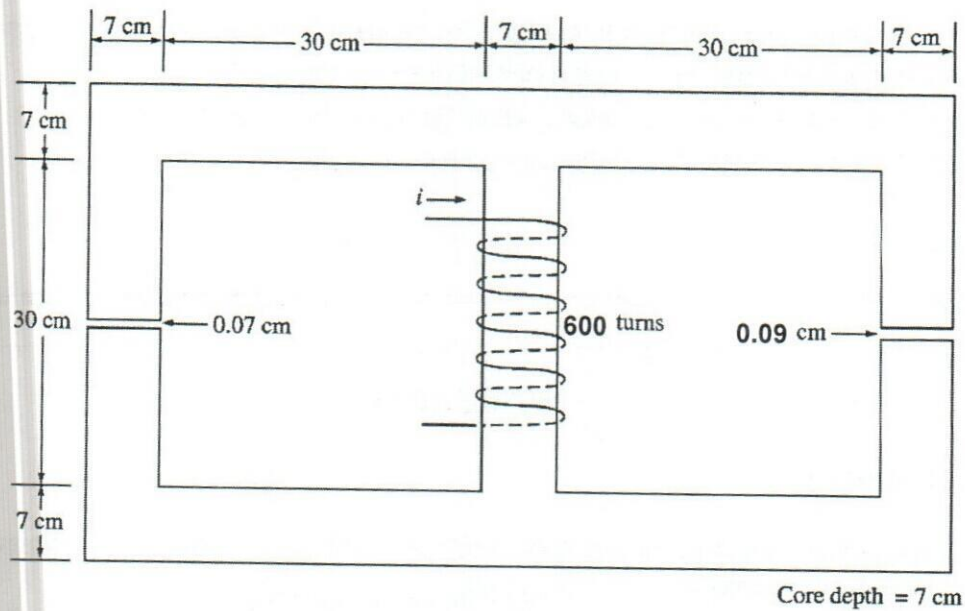


Figure 3.3

Question 04 [20 Marks]

[A] What are the differences between an ideal transformer and a real transformer?

[02]

[B] A single-phase transformer provided the following test results for the core losses shown in Table 4.1.

Table 4.1

Applied Voltage - V_{rms} (V)	Frequency (Hz)	Core losses ($P_h + P_e$) (W)
300	50	200
350	60	280

- If the cross-sectional area of the core is uniform, and the no load current and the flux leakage can be ignored, estimate the core losses when the applied voltage is 300V at 70 Hz frequency.
- P_h and P_e can be obtained using following equations.
- $P_h = k_1 B_m^{1.6} f v$
- $P_e = k_2 B_m^2 f^2 t^2 v$
- $V_{rms} = f n \Phi_m$

Φ_m – Peak instantaneous flux
 B_m – Peak flux density
 f – Frequency of the voltage
 v – Volume of the iron core
 t – Thickness of the laminations
 k_1, k_2 – Test constants
 n – Number of turns

[C] Illustrate the 3 types of 3-Phase transformer core configurations.

[08]

[06]

[D] Primary and the secondary windings of a 3-phase transformer is connected in delta configurations.

- When the primary is connected to a **600V** 3-phase AC system, the secondary develops a **800V** line-to-line voltage on an open circuit connection.
- Assuming the transformer is ideal, what will be the line-to-line voltage values if the secondary is reconnected as following configurations?

[i] Star

[ii] Zig-zag

[04]

PART B

Question 05 [20 Marks]

[A] A **6-pole, 60Hz**, 3 phase induction motor runs at **1120 rpm**. What is the operating slip and the frequency of the rotor current?

$$N_s = \frac{60 f_s}{P}, N_s - N_r = \frac{60 f_r}{P}, \frac{f_r}{f_s} = S$$

f_s – Stator current frequency

f_r – Rotor current frequency

N_r – Rotor Speed

N_s – Stator Speed

S – Slip

P – Pairs of Poles

[04]

[B] Redraw and complete the given Power flow diagram for an induction motor shown in Figure 5.1.

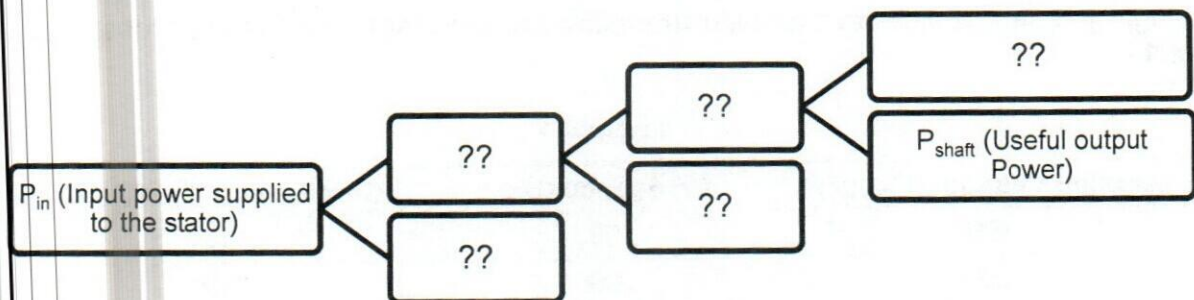


Figure 5.1

[05]

[C] A **4-pole, 3-phase** induction motor operating at **50Hz**, delivers a power output of **20kW** to the shaft rotating at **1300 rpm**.

- Rotational losses of the motor can be considered as a constant value of **500W**.
- Stator is star connected and the stator resistance is **0.5Ω/phase**.
- The line current at input is **15 A**.
- Calculate the following

[i] Air-gap power

[ii] Copper losses of the Rotor

[iii] Input Power

[iv] Efficiency of the motor

$$P_{Cu(Stator)} = I^2 R \text{ (Per Phase)}$$

$$P_{Cu(Rotor)} = S \cdot P_g$$

$$P_m = (1 - S) \cdot P_g$$

$$\eta = \frac{P_{Shaft}}{P_{in}}$$

[08]

[D] State three factors which need to be considered when selecting a motor for an application. [03]

.....

Question 06 [20 Marks]

[A] State Faraday's First and Second Laws of Electro-Magnetic Induction. [04]

[B] Illustrate and describe the operation of an electromagnetic relay. [05]

[C] Describe the operation of a DC Servomotor and how it differs from other types of DC motors. [03]

[D] Name 3 solid-state devices which can be used as electronic switches. [03]

[E] Compare electrical actuators with pneumatic actuators. [05]

* * *

End of Examination Paper



CINEC Campus
Faculty of Engineering & Technology
Department of Electrical and Electronics Engineering
BSc Hons (Eng) Mechatronics Engineering
Semester 04 First Sit Examination 2024

Module Code	:	EE2328
Module Title	:	Microcontroller Engineering
Date	:	24 th July 2024
Examiners	:	Dr. Sampath Edirisinghe
Time Allowed	:	3 hrs

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of **FOUR (4)** questions. You Should Answer **ALL** questions.
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains 08 pages.

MATERIALS REQUIRED

- CINEC answering Booklet; Extra answering paper
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.
- You may use additional data provided at the end of this examination paper

Total 25 marks
4 marks

Q1

- (i) Consider a 4-bit two's complement binary number system. Convert the following decimal numbers to the respective binary representation.
- 6
 - 10
 - 5
 - 1
- (ii) Tabulate the whole binary number space against the decimal values for the 4-bit two's complement binary number system. 4 marks
- (iii) Calculate the fixed-point binary representation of the following decimal numbers. 4 marks
- 3.75
 - 6.8
- (iv) Convert the following decimal numbers to IEEE 32-bit single precision floating point numbers. Clearly mark the sign bit, exponent and mantissa. 4 marks
- 3.5
 - 1.5
- (v) Following bit field representation is used in a microcontroller for sensor data inputs. Write the three masking bit patterns to extract the sensor data. 3 marks
- | | | | | | | | |
|------------------|---|---|------------------|---|------------------|---|---|
| 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| Data of sensor 1 | | | Data of sensor 2 | | Data of sensor 3 | | |
- (vi) Implement a 4-bit logic circuit using a ripple carry adder and shift operator to execute the following expression. There must be an input to select between addition and subtraction. 4 marks
- $$2 \times (A \pm B)$$
- (vii) Explain the advantages of carry-select and carry-look-ahead adders. 2 marks

Q2

Refer Appendix 1 in answering the following questions.

Total 25 marks

- (i) Explain the different between Harvard and Von Neumann architectures. 2 marks
- (ii) Explain the purpose of the following components of PIC16F877A microcontroller. 8 marks
- Program counter
 - Flash program memory

- c. Instruction register
- d. W register

(iii) What is the purpose of the stack? 3 marks

(iv) What is meant by the 'd' and 'f' letters in the last column of Fig. 2 in Appendix 1. 4 marks

Add W and f	1	00	0111	dfff	ffff
AND W with f	1	00	0101	dfff	ffff

(v) Explain the operation of the following instructions. 6 marks

- a. ADDWF f,d
- b. DECFSZ f,d

(vi) What is the purpose of having four memory banks instead of one in PIC16F877A? 2 marks

Q3 Refer Appendix 1 in answering the following questions. **Total 25 marks**

(i) Assume that a microcontroller has a per pin current limit of 20 mA. Calculate the resistor needed to drive an LED assuming that the pin voltage is 5 V. 2 marks

(ii) Explain how TRIS and PORT registers are used to configure the pin input and output. 2 marks

(iii) Refer to Fig. 3 in Appendix 1 and explain how the TRIS register affects the pin input and output mode 3 marks

(iv) Draw a circuit of a push button connection to make a pin go to digital '1' when pressed. 2 marks

(v) What is the purpose of the analog-to-digital converter (ADC) module in microcontrollers? 2 marks

(vi) Explain the following operations related to ADCs. 4 marks

- a. Quantization
- b. Sampling

(vii) Calculate the ADC output for the following configuration. 2 marks

Analog voltage = 2 V
Reference voltage = 5 V
ADC resolution = 10 bits
Sampling rate = 30 kHz

- (viii) Refer the Fig. 4 in Appendix 1 and state the register ADCON0 value for the following configuration. 2 marks

Conversion rate = $1/32 \times$ oscillator frequency

Input pin = AN5

ADC state = on

- (ix) Explain the purpose of interrupts in microcontrollers. 2 marks
- (x) State an external interrupt and an internal interrupt of PIC16F877A microcontroller. 2 marks
- (xi) What would happen if an interrupt were triggered when the microcontroller is servicing another interrupt. 2 marks

Q4 Refer Appendix 1 in answering the following questions. **Total 25 marks**

- (i) Draw the Universal asynchronous receiver-transmitter (UART) transmission sequence for the following bit pattern. State the assumptions you have made. 4 marks

11001010

- (ii) Calculate the SPBRG register value for a baud rate of 9,600 bps for asynchronous, low-speed communication with a 20 MHz oscillator. Refer Appendix 1 for required equations. 3 marks
- (iii) State the difference between baud rate and bit rate. 2 marks
- (iv) Draw a diagram to show the connectivity of serial peripheral interface (SPI) for 2 secondary devices and one primary device. Label all connections and entities. 4 marks
- (v) Inter-Integrated Circuit (I2C) communication uses less wires than SPI. How does it address a particular secondary device without chip select lines? 2 marks
- (vi) Assume a four-wheeled robot is used in a factory environment. Two of the rear wheels are powered by two separate motors. The two motors are equipped with rotary encoders. How can you use them to measure the distance travelled with a microcontroller? 3 marks
- (vii) If one of the wheels are stuck (stationary) how could that be detected using a microcontroller? 3 marks
- (viii) If the robot is overloaded the current draw of the motors become higher than normal. Draw a circuit to detect robot overloading with necessary circuit components. 4 marks

Appendix 1

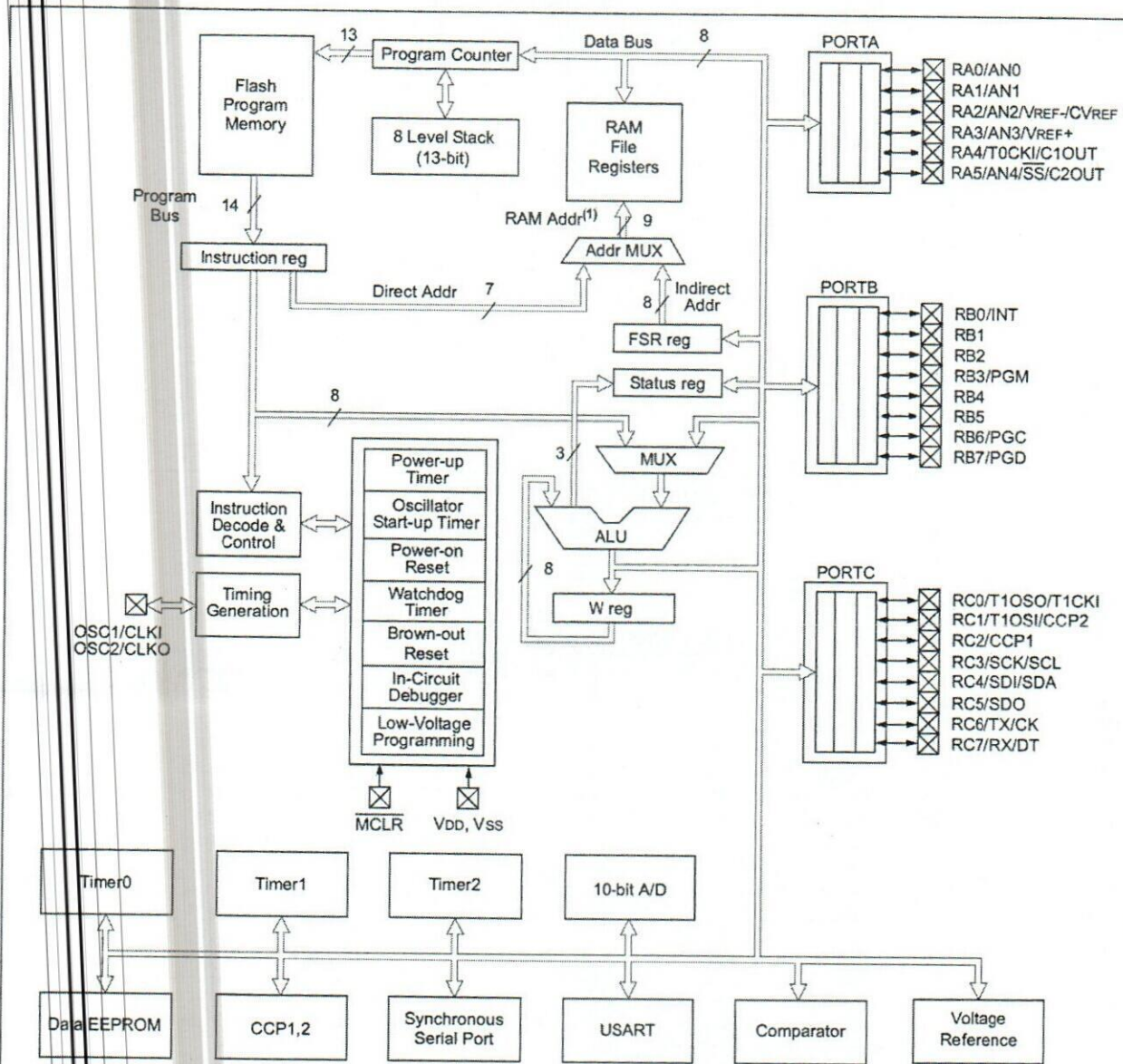


Figure 1: Block Diagram of PIC16F877A

Mnemonic, Operands	Description	Cycles	14-Bit Opcode		Status Affected	Notes
			MSb	LSb		
BYTE-ORIENTED FILE REGISTER OPERATIONS						
ADDWF	f, d	Add W and f	1	00 0111 dfff ffff	C,DC,Z	1,2
ANDWF	f, d	AND W with f	1	00 0101 dfff ffff	Z	1,2
CLRF	f	Clear f	1	00 0001 1fff ffff	Z	2
CLRW	-	Clear W	1	00 0001 0xxx xxxx	Z	
COMF	f, d	Complement f	1	00 1001 dfff ffff	Z	1,2
DECF	f, d	Decrement f	1	00 0011 dfff ffff	Z	1,2
DECFSZ	f, d	Decrement f, Skip if 0	1(2)	00 1011 dfff ffff		1,2,3
INCF	f, d	Increment f	1	00 1010 dfff ffff	Z	1,2
INCFSZ	f, d	Increment f, Skip if 0	1(2)	00 1111 dfff ffff		1,2,3
IORWF	f, d	Inclusive OR W with f	1	00 0100 dfff ffff	Z	1,2
MOVF	f, d	Move f	1	00 1000 dfff ffff	Z	1,2
MOVWF	f	Move W to f	1	00 0000 1fff ffff		
NOP	-	No Operation	1	00 0000 0xx0 0000		
RLF	f, d	Rotate Left f through Carry	1	00 1101 dfff ffff	C	1,2
RRF	f, d	Rotate Right f through Carry	1	00 1100 dfff ffff	C	1,2
SUBWF	f, d	Subtract W from f	1	00 0010 dfff ffff	C,DC,Z	1,2
SWAPF	f, d	Swap nibbles in f	1	00 1110 dfff ffff		1,2
XORWF	f, d	Exclusive OR W with f	1	00 0110 dfff ffff	Z	1,2
BIT-ORIENTED FILE REGISTER OPERATIONS						
BCF	f, b	Bit Clear f	1	01 00bb bfff ffff		1,2
BSF	f, b	Bit Set f	1	01 01bb bfff ffff		1,2
BTFSZ	f, b	Bit Test f, Skip if Clear	1 (2)	01 10bb bfff ffff		3
BTFSZ	f, b	Bit Test f, Skip if Set	1 (2)	01 11bb bfff ffff		3
LITERAL AND CONTROL OPERATIONS						
ADDLW	k	Add Literal and W	1	11 111x kkkk kkkk	C,DC,Z	
ANDLW	k	AND Literal with W	1	11 1001 kkkk kkkk	Z	
CALL	k	Call Subroutine	2	10 0kkk kkkk kkkk		
CLRWDZ	-	Clear Watchdog Timer	1	00 0000 0110 0100	TO,PD	
GOTO	k	Go to Address	2	10 1kkk kkkk kkkk		
IORLW	k	Inclusive OR Literal with W	1	11 1000 kkkk kkkk	Z	
MOVLW	k	Move Literal to W	1	11 00xx kkkk kkkk		
RETFIE	-	Return from Interrupt	2	00 0000 0000 1001		
RETLW	k	Return with Literal in W	2	11 01xx kkkk kkkk		
RETURN	-	Return from Subroutine	2	00 0000 0000 1000		
SLEEP	-	Go into Standby mode	1	00 0000 0110 0011	TO,PD	
SUBLW	k	Subtract W from Literal	1	11 110x kkkk kkkk	C,DC,Z	
XORLW	k	Exclusive OR Literal with W	1	11 1010 kkkk kkkk	Z	

- Note 1:** When an I/O register is modified as a function of itself (e.g., MOVF PORTB, 1), the value used will be that value present on the pins themselves. For example, if the data latch is '1' for a pin configured as input and is driven low by an external device, the data will be written back with a '0'.
- 2:** If this instruction is executed on the TMR0 register (and where applicable, d = 1), the prescaler will be cleared if assigned to the Timer0 module.
- 3:** If Program Counter (PC) is modified, or a conditional test is true, the instruction requires two cycles. The second cycle is executed as a NOP.

Figure 2: Instruction Set of PIC16F877A

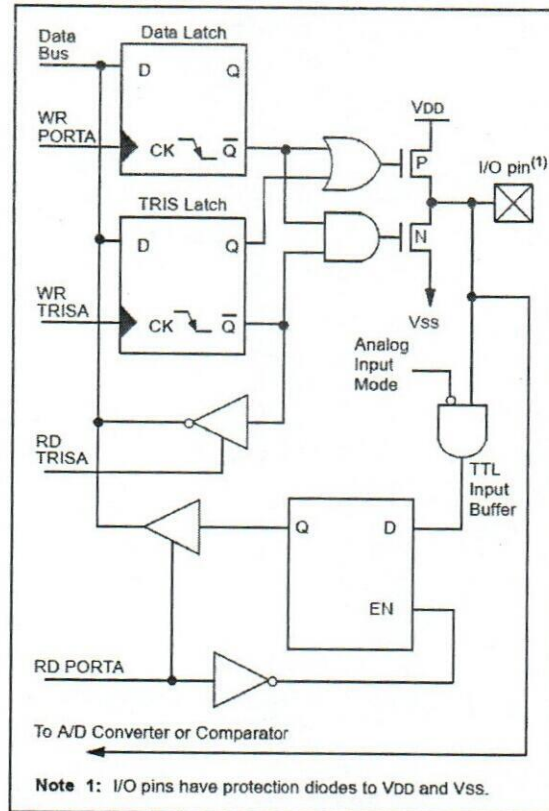


Figure 3: Block Diagram of I/O Pins

REGISTER 11-1: ADCON0 REGISTER (ADDRESS 1Fh)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0
ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/DONE	—	ADON
bit 7							bit 0

bit 7-6 **ADCS1:ADCS0**: A/D Conversion Clock Select bits (ADCON0 bits in **bold**)

ADCON1 <ADCS2>	ADCON0 <ADCS1:ADCS0>	Clock Conversion
0	00	Fosc/2
0	01	Fosc/8
0	10	Fosc/32
0	11	FRC (clock derived from the internal A/D RC oscillator)
1	00	Fosc/4
1	01	Fosc/16
1	10	Fosc/64
1	11	FRC (clock derived from the internal A/D RC oscillator)

bit 5-3 **CHS2:CHS0**: Analog Channel Select bits

000 = Channel 0 (AN0)
 001 = Channel 1 (AN1)
 010 = Channel 2 (AN2)
 011 = Channel 3 (AN3)
 100 = Channel 4 (AN4)
 101 = Channel 5 (AN5)
 110 = Channel 6 (AN6)
 111 = Channel 7 (AN7)

Note: The PIC16F873A/876A devices only implement A/D channels 0 through 4; the unimplemented selections are reserved. Do not select any unimplemented channels with these devices.

bit 2 **GO/DONE**: A/D Conversion Status bit

When ADON = 1:

1 = A/D conversion in progress (setting this bit starts the A/D conversion which is automatically cleared by hardware when the A/D conversion is complete)
 0 = A/D conversion not in progress

bit 1 **Unimplemented**: Read as '0'

bit 0 **ADON**: A/D On bit

1 = A/D converter module is powered up
 0 = A/D converter module is shut-off and consumes no operating current

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'
 - n = Value at POR '1' = Bit is set '0' = Bit is cleared x = Bit is unknown

Figure 4: ADCON0 Register of PIC16F877A

SYNC	BRGH = 0 (Low Speed)	BRGH = 1 (High Speed)
0	(Asynchronous) Baud Rate = $F_{osc}/(64 (X + 1))$	Baud Rate = $F_{osc}/(16 (X + 1))$
1	(Synchronous) Baud Rate = $F_{osc}/(4 (X + 1))$	N/A

Legend: X = value in SPBRG (0 to 255)

Figure 5: Baud Rate Formula for UART Communication



CINEC Campus
Faculty of Engineering & Technology
Department of Electrical and Electronic Engineering

BSc Hons in Eng. in Mechatronics Engineering
Semester 03 – Re-Sit Examination
September 2024

Module Code	:	EE2319
Module Title	:	Sensors and Signal Conditioning
Date	:	2024 – 09 – 03
Examiners	:	MGJP Fernando
Time Allowed	:	03 Hrs

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of 05 questions. You Should Answer **ALL** questions.
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains 05 pages.

MATERIALS REQUIRED

- CINEC answering Booklet & Extra answering paper
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.

Question 01 [20 Marks]

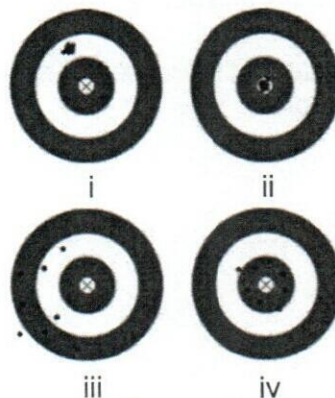
- [a] Describe the difference between 'desired input' and 'input' given to a system. [02]
- [b] Explain the purpose of calibrating a sensing instrument. Also, provide a brief explanation of the calibration process for a weighing scale. [04]
- [c] Explain what is 'feedback' to a system and how it can be used to control a system's output. [03]
- [d] Explain the following statement. "All sensors are transducers but not all transducers are sensors." [03]
- [e] State the conversion phenomena of the following sensors.
 [i] Reed Switch
 [ii] Thermocouple
 [iii] LDR
 [iv] Piezoelectric sensor [04]
- [f] What are the differences between 'active sensors' and 'passive sensors'? Describe with suitable examples. [04]

Question 02 [20 Marks]

- [a] Explain the difference between a contact sensor and a non-contact sensor using suitable examples. [02]
- [b] Illustrate and describe through-beam, diffuse-reflective, and retro-reflective optical sensing methods. [06]
- [c] State four characteristics which can describe the behaviour of the sensor. [04]
- [d] Describe the difference between a 'known uncertainty' and an 'unknown uncertainty'. [02]
- [e] Describe the purpose of the 'transfer function' of a sensor. [02]
- [f] In a linear distance measurement system, for a movement of 0.02m distance, a voltage of 0.03V is induced.
 [i] What is the sensitivity of this sensor?
 [ii] If the system output (induced voltage) changes from 0.09V to 0.63V, what is the change in distance? [04]

Question 03 [20 Marks]

- [a] Using **Figure 3.1**, explain how precision and accuracy of a sensor readings can be changed.

**Figure 3.1**

[06]

[b] Describe the operating principle and applications of the sensing element shown in **Figure 3.2**.

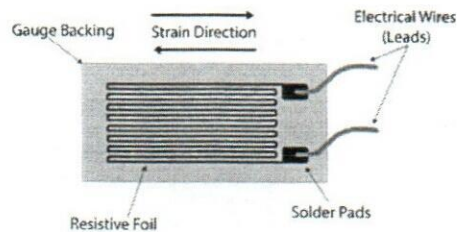


Figure 3.2

[c] A strain gauge is bonded to metal shaft as shown in **Figure 3.3**. Young's modulus for the material is given as 200 GN/m^2 . The strain gauge has an unrestricted resistance of 330Ω and a gauge factor of 3.7. [04]

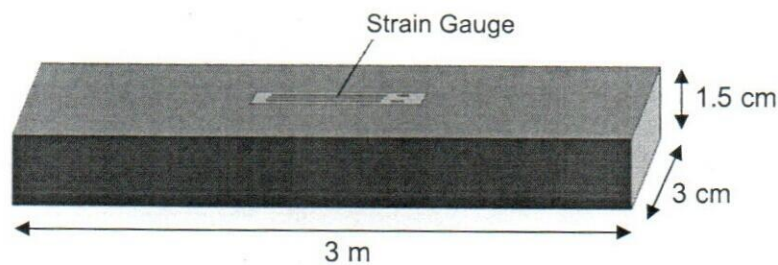


Figure 3.3

When the shaft loaded, the resistance of the gauge changes by 0.028Ω .

- [i] Calculate the change in length of the beam
- [ii] Calculate the stress applied on the beam cross section
- [iii] Calculate the force applied on the beam

[d] A voltmeter displays 100V on its 0-150V scale when connected across an unknown resistor in series with an ammeter. If the voltmeter has a sensitivity of $1000 \frac{\Omega}{V}$, find the following when the ammeter reads 5 mA. [06]

- [i] Apparent resistance of the unknown resistor
- [ii] Actual resistance of the unknown resistor

[04]

Question 04 [20 Marks]

[a] Derive mathematical expressions which describes the relationship between capacitance and distance for a parallel plate capacitor, when following parameters are changed.

- [i] Changing the distance between plates
- [ii] Changing the surface area of the plates
- [iii] Changing the dielectric material

[08]

[b] A capacitive displacement measuring sensor developed using changing the dielectric material principles is shown in **Figure 4.1**.

Considering ϵ_{r1} as 2.7 and ϵ_{r2} as absolute permittivity (8.854×10^{-12} F/m), find the change in capacitance (ΔC) if the displacement changes (Δx) 0.25 mm forward as shown in **Figure 4.1 (b)**.

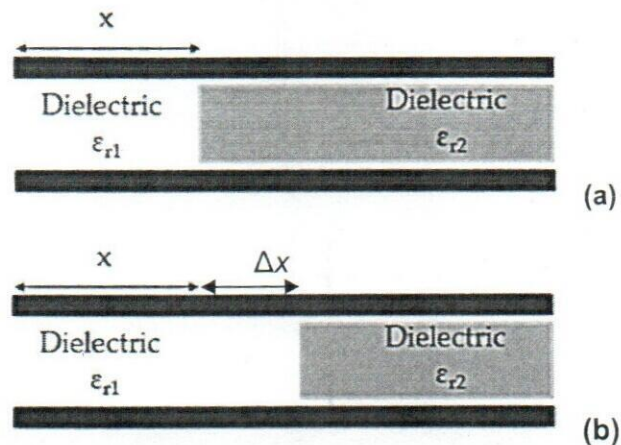


Figure 4.1

[c] State three parameters which can be measured using ultrasonic sensors.

[02]

[d] State three applications where flow & level sensing is required.

[03]

[e] Briefly explain what are the suitable sensors to automate the process shown in **Figure 4.2** as well as to measure the fluid temperature of the inlet and outlet. State the reasons for your selections.

[03]

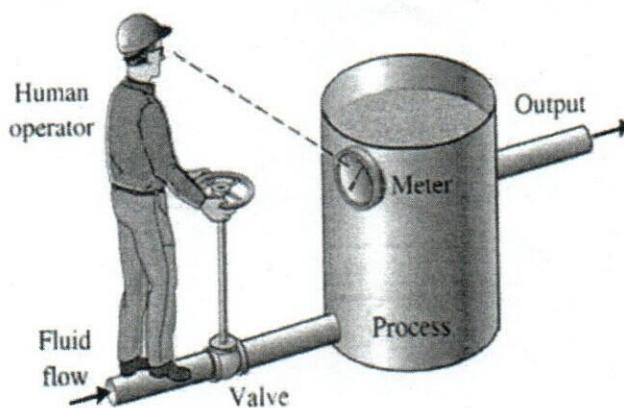


Figure 4.2

[04]

Question 05 [20 Marks]

[a] State three environmental errors and two observational errors that can occur when obtaining a sensor reading.

[05]

[b] To amplify the output signal of a proximity sensor, a non-inverting op-amp is used as shown in **Figure 5.1**. If the sensor output is 0.6 mV, find the closed-loop gain and the value of the amplifier output.

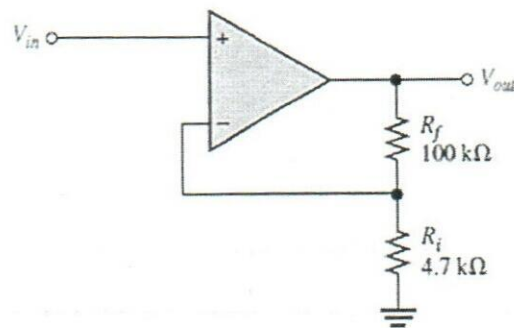


Figure 5.1

[05]

[c] Describe how the Alternating voltage signal changes to DC signal in the given Figure 5.2.

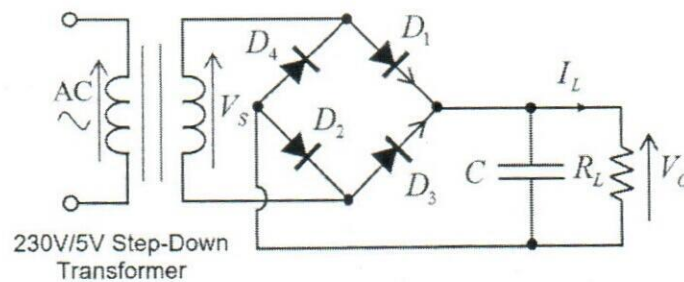


Figure 5.2

[05]

[d] The ultrasonic distance measuring sensor shown in Figure 5.3 outputs 1 mV, if the time difference between input and output waves is $2 \mu\text{s}$. If the sensor output is 249 mV, determine the distance (d) between the sensor and the object. Consider the speed of sound as 340m/s.

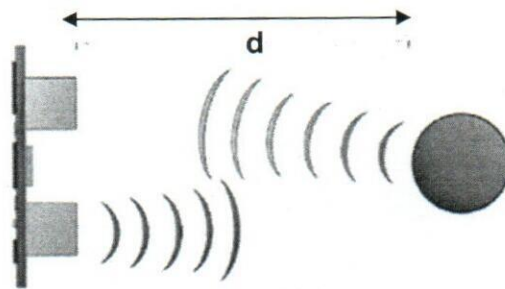


Figure 5.3

[05]

End of Examination Paper



**Faculty of Engineering & Technology
Department of Electrical and Electronic Engineering**

**BSc Hons in Engineering in Mechatronics Engineering
Semester 03 – Re-Sit Examination
August 2024**

Module Code : EE2318
Module Title : Applied Mechatronic Systems
Date : 2024 – 08 – 30
Examiners : MGJP Fernando
Time Allowed : 03 Hrs

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of 05 questions. Answer **ALL** questions.
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains 03 pages.

MATERIALS REQUIRED

- CINEC answering Booklet & Extra answering paper
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.

Question 01 [20 Marks]

- [a] Describe the term "system" with relation to control engineering. [3]
- [b] Describe the difference between open loop and closed loop system using an example. [4]
- [c] What are the key elements of a mechatronic system? [4]
- [d] State three objectives of designing a mechatronic system. [3]
- [e] Explain 3 challenges that may arise when converting an existing mechanical system to a mechatronic system. [6]

Question 02 [20 Marks]

- [a] Classify the following actuators in a table form under the electromechanical, electromagnetic, and pneumatic categories. [6]
- | | |
|-----------------------------|--------------------|
| ▪ Permanent magnet DC motor | ▪ Servo motor |
| ▪ Piston cylinder | ▪ Relay |
| ▪ Solenoid valve | ▪ Linear guide |
| ▪ Induction motor | ▪ Rodless cylinder |
- [b] Name three coupling mechanism that can be used to couple a motor to a controlled system or a load. [3]
- [c] Describe two methods of energy/motion conversion that can be obtained using mechanical actuators. [2]
- [d] Illustrate and explain the operation of a basic NO/NC relay. [5]
- [e] Describe the purpose of the feedback system of a servo motor. [4]

Question 03 [20 Marks]

- [a] Discuss the advantages and disadvantages of pneumatic actuators in contrast with hydraulic actuators. [4]
- [b] What are the selection considerations for a Pneumatic Actuator? [3]
- [c] Name three positive characteristics and three negative characteristics of pneumatics. [6]
- [d] What are the types of controllers which can be used in a mechatronic system? [3]
- [e] Describe four technical considerations which must be taken into account when selecting a microcontroller for an embedded system. [4]

*** Question 04 and 05 are essay type questions. Refer the given considerations and justify your selections accordingly.

[i] Breakdown of tasks and How to select the most ideal elements these task/s

- Most ideal sensors – measured parameters/phenomenon, their ranges
- Most ideal actuators – required output work/motion types, range/frequency of actuation
- Most ideal controller
- Most ideal user-interface devices – input devices, indicators

[8]

[ii] Design Considerations

- Redundancy and Reliability
- Ergonomics & Robustness according to the working environment
- Comparison of the Safety vs Cost
- Level of automation and intelligence

[8]

[iii] Feasible Suggestions for improvement

[4]

Question 04 [20 Marks]

Develop a conceptual design for an intelligent - automated Railway crossing system

Question 05 [20 Marks]

Develop a conceptual design for a smart building with automated security systems, automated fire protection, automated HVAC systems, automated lightning systems, and an automated parking system.



CINEC Campus
Faculty of Engineering & Technology
Department of Electrical and electronics engineering
BSc Hons (Eng) Mechatronics Engineering
Semester 3 Re-Sit Final examination 2024

Module Code	:	EE2317
Module Title	:	Data Structures and Soft Computing
Date	:	2024.08.28
Examiners	:	Ms. Anuththara Dikovita
Time Allowed	:	1.30pm – 4.30pm

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of 5 questions. You Should Answer **ALL** questions.
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains 6 pages.

MATERIALS REQUIRED

- CINEC answering Booklet; Extra answering paper
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.

Question 01:**(20 Marks)**

Suppose you are going to create a computer program to store a set of numbers which use first in last out technology. You are advised to store data using Stacks.

1. Define a suitable data type to represent a stack. (04 Marks)
2. Define a function called IsStackFull to check whether a stack is full or not. (04 Marks)
3. Your supervisor advised you to use a list instead of a stack. Differentiate the two methodologies. (02 Marks)
4. Define all suitable data types to represent a Queue and write a function IsQueueEmpty to check whether the Queue is empty or not. (10 Marks)

Question 02**(20 Marks)**

1. Draw 2 examples for the graphs that are not binary trees. (02 Marks)
2. An **expression tree** is built up from the simple operands and operators of an (arithmetic and logical) expression by placing the simple operands as the leaves of a binary tree and the operators as the interior nodes. Draw an expression tree for the following equation. Hint : ignore the brackets.

$$(2a + 3b)/(c+5) = d/7-e$$

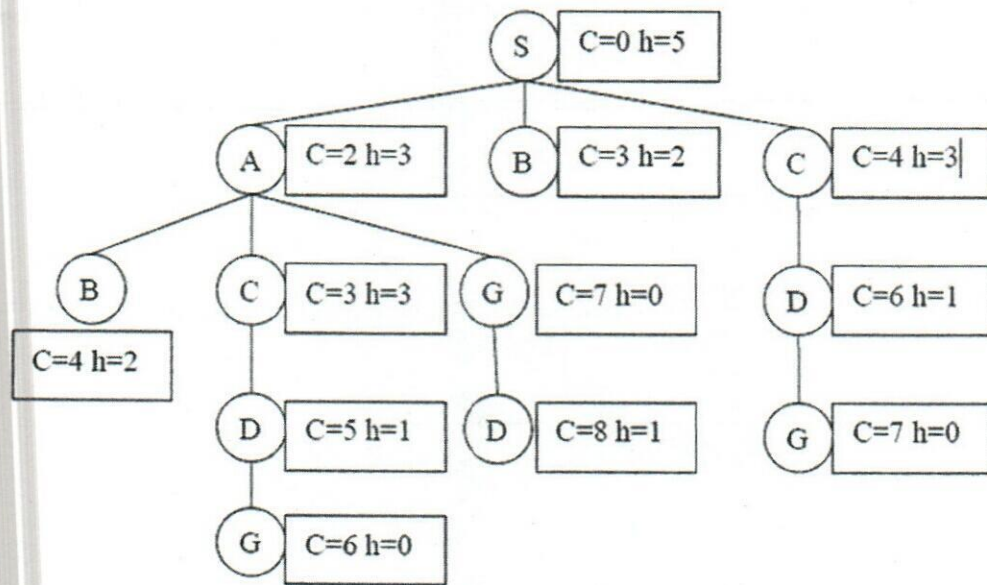
(04 Marks)

3. Here given is an unsorted array. Clearly show all the iterations with diagrams and demonstrate how an insertion sort works.

3	1	5	4	7	2
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(06 Marks)

4. Using the following search tree, perform the searches indicated below (always from S to G). Each node shows both the total path cost to the node as well as the heuristic value for the corresponding state.



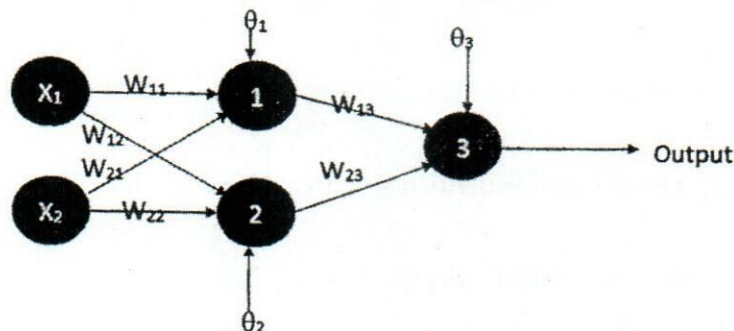
- Breadth first search
- Depth first search
- Greedy best first search
- A* search

(08 Marks)

Question 03

(20 Marks)

- Consider the following neural network.



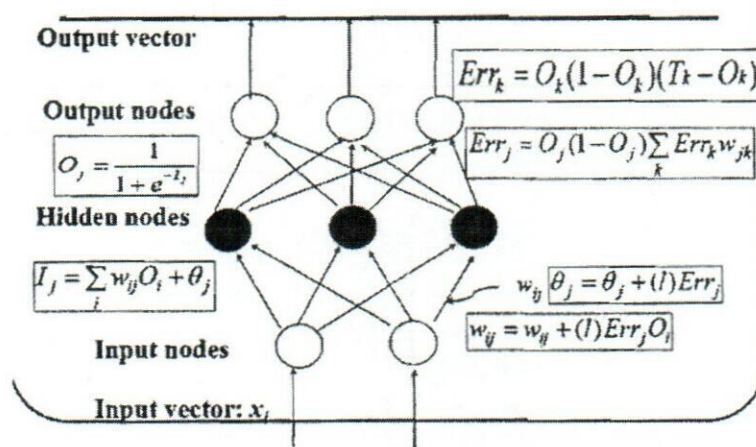
- Using the initial weights provided below, compute the total output at each neuron 1, 2 & 3 after forward propagation. Show all necessary steps in your calculation. Input values for X_1 and X_2 are 2, 0.5 accordingly.

Weight	θ_1	W_{11}	W_{12}	W_{13}	θ_2	W_{21}	W_{22}	W_{23}	θ_3
Value	0.5	1	1	0.5	0.5	1	1	0.25	0.5

(10 Marks)

- b. Using the learning rate of 1 and a desired output of 0, back propagate the error and update all the weights in above neural network. Show all necessary steps in your calculation.

(10 Marks)

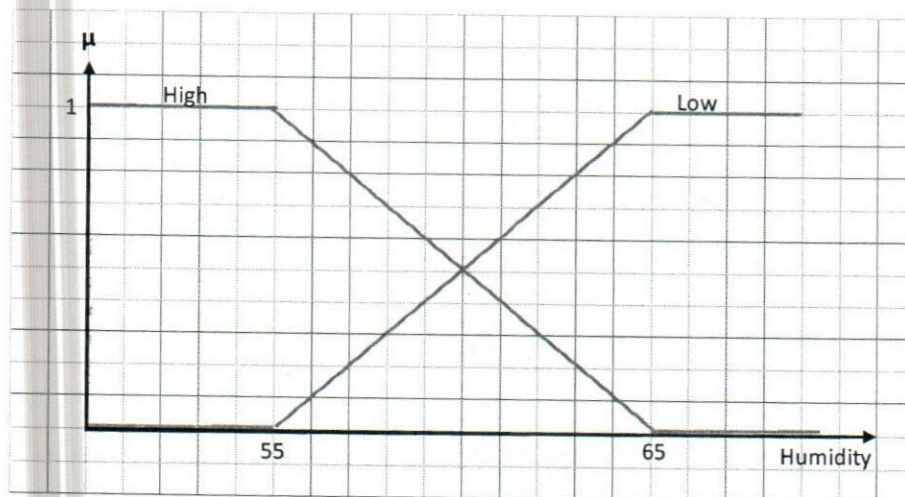
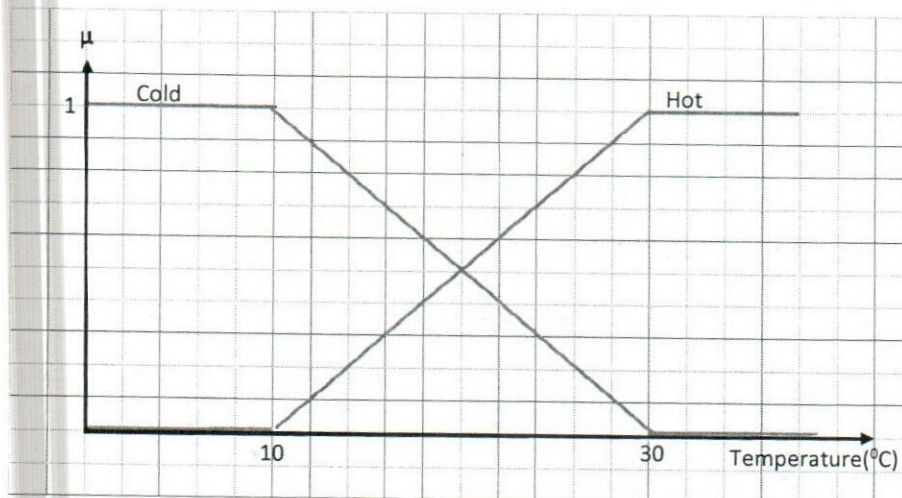


Question 4

(20 Marks)

- The following scenario is consist of controlling a car's air conditioning system based on the temperature (t) and humidity (h). The temperature can be "Cold," and "Hot" While the humidity can be "Low," and "High." The **Air Conditioning Power** (a) has the values of "Low," and "High."
 - If temperature is hot and humidity is low, then $A_1 = 6t - h$
 - If temperature is hot and humidity is high, then $A_2 = h+1$
 - If temperature is cold and humidity is low, then $A_3 = 33-t$
 - If temperature is cold and humidity is high, then $A_4 = 4t - h+2$
- If the membership functions are as below, find the fuzzy values of air conditioning power according to the given rules at temperature is 14°C and Humidity is 62.

(08 Marks)



- b. Find the crisp values of air conditioning power according to the given rules at temperature is 18°C and Humidity is 58.

(08 Marks)

- c. Calculate the actual air conditioning power when temperature is 18°C and Humidity is 58.

(04 marks)

Question 05

(20 Marks)

1. List 05 types of knowledge.
2. Consider the following statements.

Statement A: "If it is raining, then the ground is wet."

Statement B: "The ground is not wet if it is not raining."

(05 Marks)

- a. Translate above statements in to logic in terms of P and Q. (04 Marks)
b. Prove those statements are logically equivalent. (06 marks)
3. Crossover and the mutation are two types of operators for chromosome modification. Perform below mentioned modifications to the given chromosomes.

A:

0	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---

B:

9	0	8	1	7	2	6	3	5	4
---	---	---	---	---	---	---	---	---	---

- a. One point crossover from 7rd position.
b. Multipoint crossover from 3rd and 6th positions.
c. 3st position bit-flip mutation for A.
d. Swap mutation for B with 2rd and 5th positions.
e. Inversion mutation to A from 3th position to 5th position.

(05 Marks)

-----END OF THE QUESTION PAPER-----



CINEC Campus
Faculty of Engineering & Technology
Department of Electrical and Electronic Engineering
BSc Hons in Eng. in Mechatronics Engineering
Semester 03 - First Sit – End Semester Examination
February 2024

Module Code	:	EE2319
Module Title	:	Sensors and Signal Conditioning
Date	:	2024 - 02 - 14
Examiners	:	MGJP Fernando
Time Allowed	:	03 Hrs

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- This paper consists of 05 questions. You Should Answer **ALL** questions.
- Write clearly legibly with a blue or black pen.
- Use only the **CINEC Answering Booklet**. Additional sheets may be requested from the invigilators.
- This paper contains 04 pages.

MATERIALS REQUIRED

- CINEC answering Booklet & Extra answering paper
- You may use a scientific calculator. This must not be programmable. This may be examined during the examination.

Question 01 [20 Marks]

- [a] Define 'measurement' and state the two conditions which must be met to obtain an accurate measurement. [4]
- [b] Explain what is 'feedback' to a system and how negative feedback affects system output. [4]
- [c] Explain the difference between a sensor and a transducer. [2]
- [d] Name 3 conversion phenomenon that can be used for sensing a physical parameter. [3]
- [e] Compare active and passive sensors with examples. [3]
- [f] Classify the following sensors into given categories.

Sensors: Strain Gauge, Hall Effect Sensor, Thermocouple, Capacitive Touch Sensor, Load Cell, PIR Sensor, Bimetallic Strip, Optical Encoder, Ultrasonic Sensor, Piezoresistive Sensor, Reed Switch, Inductive Sensor, Capacitive Sensor, Thermistor

Categories: Distance & Displacement, Proximity, Temperature, Force

[4]

Question 02 [20 Marks]

- [a] Describe the operation of a strain gauge. [4]
- [b] A strain gauge is bonded to a beam 1 m long and has a cross sectional area of 0.33 m^2 .
▪ Young's modulus for the material is given as 207 GN/m^2 .
▪ The strain gauge has an unrestricted resistance of 240Ω and a gauge factor of 2.2.
▪ When a load is applied, the resistance of the gauge changes by 0.013Ω .
(i) Calculate the change in length of the beam
(ii) Calculate the stress applied on the beam cross section
(iii) Calculate the force applied on the beam [6]
- [c] Discuss the advantages and disadvantages of Load Cells. [2]
- [d] Explain the difference between contact and non-contact sensors and how each type can be applied for proximity sensing with examples. [2]
- [e] Illustrate and describe through-beam, diffuse-reflective, and retro-reflective optical sensing methods. [6]

Question 03 [20 Marks]

[a] Derive equations to measure distance using parallel plate capacitors, when the following parameters are manipulated.

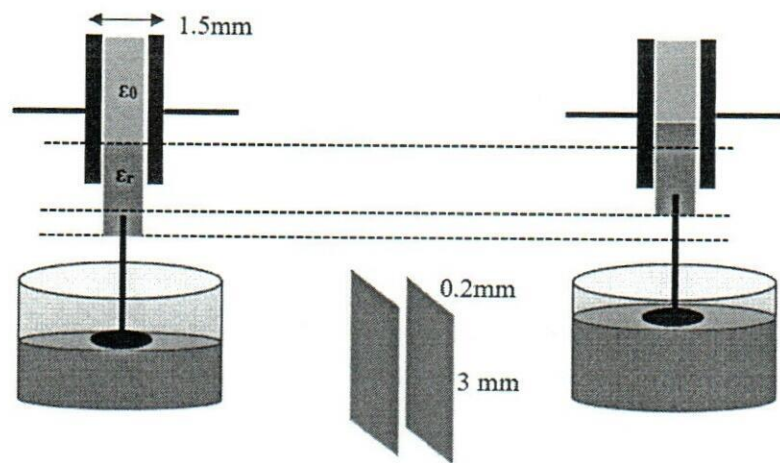
- (i) Changing the distance between plates
- (ii) Changing the surface area of the plates
- (iii) Changing the dielectric material

[6]

[b] Describe how a capacitive level sensor can be developed using the **part [a] [iii]** principle for a thin vertical fluid container.

[4]

[c] A fluid level measuring sensor developed using capacitive sensing principles (changing the capacitance by changing the dielectric constant) is shown in Figure 3.1. Considering ϵ_r as 2.7 and absolute permittivity as 8.854×10^{-12} F/m, find the change in capacitance if the fluid level rises 0.25 mm.

**Figure 3.1****[4]**

[d] State 3 parameters which can be measured using ultrasonic sensors.

[3]

[e] State 5 applications where flow & level sensing is required.

[3]**Question 04 [20 Marks]**

[a] What is a measurement uncertainty?

[2]

[b] Define 'Sensitivity' of a sensor.

[2]

[c] In a linear electrical based distance measurement system, for a movement of 0.001m distance, a voltage of 0.02V is induced.

(i) What is the sensitivity?

(ii) The induced voltage changes from 0.02V to 0.035V for a displacement. What is the change in distance?

[4]

[d] Illustrate and explain the difference between accuracy and precision.

[4]

[e] Discuss Environmental Errors and Observational errors that can affect a sensor reading.

[4]

[f] A voltmeter having sensitivity of $1000 \frac{\Omega}{V}$ reads 100V on its 150V scale when connected across an unknown resistor in series with an ammeter. When the ammeter reading is 5mA, calculate,

[i] Apparent resistance of the unknown resistor

[ii] Actual resistance of the unknown resistor

[4]

Question 05 [20 Marks]

[a] A multi-output voltage supply used to supply power to a sensor array is shown in **Figure 5.1**. Calculate the no load voltage output for each tapping point of the in the supply circuit, if the series-connected resistive network is connected to a 24V DC supply.

[6]

[b] To amplify the output signal of a proximity sensor, a non-inverting op-amp is used as shown in **Figure 5.2**. If the sensor output is 0.2 mV, find the amplifier output.

[4]

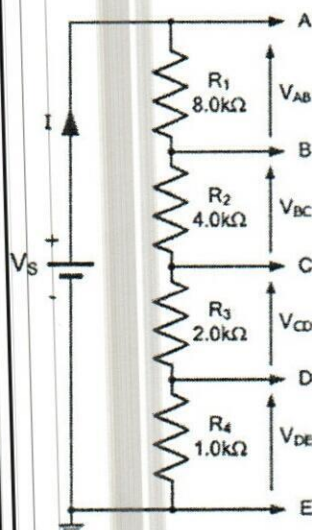


Figure 5.1

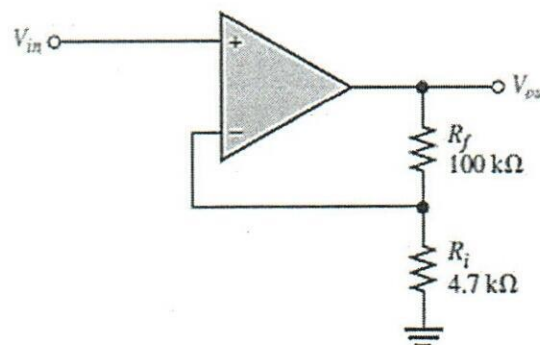


Figure 5.2

[c] Illustrate and explain the operation of a Full Wave Bridge Rectifiers (with smoothing).

[5]

[d] Explain how a 'Sun Tracking system' could be developed for a solar panel using four LDRs.

[5]