



**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**FACULTY OF ENGINEERING**

**DEPARTMENT OF ELECTRONIC ENGINEERING**

**INDUSTRIAL CONTROL**

**EEE 5241**

**Final Examination Paper**

**March 2025**

This examination paper consists of 3 pages

**Time Allowed: 3 hours**

**Total Marks: 100**

**Special Requirements: None**

**INSTRUCTIONS AND INFORMATION**

1. This question paper comprises of two sections. Section A carries a total of 40 marks and each question in Section B carries 30 marks.
  2. Answer **all** questions in **Section A** and **any 2** questions from **Section B**.
  3. Show your steps clearly in any calculation.
  4. Start the answers for each question on a fresh page.
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## **SECTION A (Answer all questions in this section)**

### **Question A1**

Using a diagram, describe and explain how a 3-wire sourcing connection between a sensor and a controller such as a PLC works. [8 marks]

### **Question A2**

Differentiate between discrete and continuous operation of an actuator. Describe how an electric motor can be controlled in discrete mode. Describe also, how an electric motor can be controlled in continuous mode. [8 marks]

### **Question A3**

Using a diagram, describe and explain how a double acting hydraulic or pneumatic cylinder operates. [8 marks]

### **Question A4**

Outline the different types of interface modules (input and output signal types) found in a PLC. [8 marks]

### **Question A5**

Outline the functions of the major components of a SCADA system [8 marks]

## **SECTION B (Answer any TWO questions from this section)**

For each of the questions in this section the distribution of marks is as follows:

- a) Block diagram showing sensors and actuators needed in the system as well as any necessary diagrams and accounts of how the system will operate to achieve the functionality. Clearly indicate the allocation of I/O points to the sensors and actuators. [9 marks]
- b) Diagrams and any necessary notes detailing how each type of sensor and actuator is connected to the PLC. [6 marks]
- c) Ladder program for the PLC. Clearly indicate the allocation of I/O and memory addresses to sensors, actuators and memory based variables. [15 marks]

### **Question B1**

A machine has been built for filling barrels. The operations of the system are listed below:

1. The process begins in an idle state.
2. If the fluid pressure is high enough and the barrel is present, the system will open a flow valve for 2 seconds.

3. The flow valve is turned off for 10 seconds.
4. The flow valve is then turned on until the barrel is full.
5. The system goes into the idle state.

Develop a PLC based solution for the system.

[30 marks]

## Question B2

In an industrial process, an oven is used to bake production units placed on a turn table. The stages of operations are as follows:

1. The oven begins in an idle state in which it will be waiting for an item to arrive.
2. When an item arrives (sensed by an optical sensor), an alarm in the form of an audio is turned on and maintained for 1 minute.
3. The alarm is turned off and a heater is turned on for 3 minutes to allow the temperature to rise to the acceptable range.
4. The heater is maintained on whilst the turntable is being rotated.
5. When the item has been baked, the heater is turned off, but the turntable is kept rotating for two minutes. End of baking is detected by a suitable discrete sensor on the turntable. After this stage, the oven returns to idle state.
6. At any time, if an emergency push button is pressed, the machine goes into emergency stop mode which can only be cleared by pressing a reset switch after which the machine goes into the idle state.

Develop a PLC based solution for the baking system.

[30 marks]

## Question B3

A PLC-based conveyor control system that will operate as follows is required:

- The conveyor has an optical sensor **S1** that detects boxes entering a work cell
- There is also an optical sensor **S2** that detects boxes leaving the work cell
- The boxes enter the work cell on a conveyor controlled by output **C1**
- The boxes exit the work cell on a conveyor controlled by output **C2**
- The controller must keep a running count of boxes using the entry and exit sensors
- If there are more than five boxes in the work cell the entry conveyor will stop
- If there are no boxes in the work cell the exit conveyor will be turned off
- If the entry conveyor has been stopped for more than 30 seconds the count will be reset to zero, assuming that the boxes in the work cell were scrapped.

Design a PLC based system to control the process.

[30 marks]

**End of Paper**