# Cork Institute of Technology

## Bachelor of Engineering in Mechanical Engineering - Award

Bachelor of Engineering in Manufacturing Engineering - Award

(National Diploma in Engineering in Mechanical/Manufacturing Engineering – Award)

(NFQ – Level 7)

## Summer 2005

# **Industrial Electronics and Control**

(Time: 3 Hours)

INSTRUCTIONS:	Examiners:	Mr. R. Simpson
Answer Five Questions, at least Two from each section.		Mr. J. Connolly
All formula and calculations must be shown.		Mr. R. Daly
		Mr. M. Murray
		Mr. N. Mulcahy

## Section A (Industrial Electronics) - Please Use Answer Book A

- Q1 The following single-phase 400V loads are connected across a 3-phase, 3-wire, 400V supply:
  - (i) Between Brown and Red lines 12 kW at 0.86 p.f. lagging;
  - (ii) Between Red and Yellow lines 9 kW at 0.82 p.f. lagging;
  - (iii) Between Yellow and Brown lines 15 kW at 0.84 p.f. lagging.
  - (a) Draw a circuit diagram showing the loads above as seen by a 3-phase supply and calculate each phase current and its phase angle. <u>6 marks</u>
  - (b) Draw a vector diagram showing the supply voltages and the phase currents drawn to scale. <u>6 marks</u>
  - (c) Calculate, or determine by means of a vector diagram, the current in each supply line.

8 marks

- Q2 (a) A 3-phase, 11kW, 400V, 50Hz, 4-pole, delta connected squirrel cage induction motor has a full-load; efficiency of 88%, power factor of 0.84, and running speed of 1460 r.p.m. Calculate for full-load conditions, the motor's:
  - (i) Input power;
  - (ii) Supply current;
  - (iii) Phase (winding) current;
  - (iv) Full-load torque.
  - (b) Explain the terms; *synchronous-speed, slip-speed, and slip* of a 3-phase motor. Calculate for the motor in (a):
    - (i) synchronous speed;
    - (ii) % slip;

4 Marks

12marks

- (c) Electronic controllers are the modern method of speed control for 3-phase induction motors. Explain using an appropriate formula, the principle on which the control of the motor speed is implemented.
- Q3 (a) The Mitsubishi FXo30MR-ES PLC contains 512 Memories of two general types, General and Retentive Memories. Detail the difference between these two memories. (4 marks)
  - (b) Give an example address of both types of memories detailed above. (2 marks)
  - (c) Two contactors (KM1 and KM2) connected to outputs Y12 and Y13 on a Mitsubishi FXo30MR-ES PLC are used to start a motor by means of three push-buttons; PB1, PB2, and PB3 connected to inputs X10, X11 and X12 respectively. Also connected to the PLC are two indicator lamps, L1and L2 and these are connected to Y1and Y2. The circuit will operate as follow:

When PB1 is operated, contactor KM1 will energise and start the motor in forward direction. Indicator light L1 must also light to indicate motor running forward direction;
When PB2 is operated, contactor KM2 will energise and start the motor in reverse direction. Indicator light L2 will light to indicate motor running in reverse direction;
PB3 when operated will stop the output currently on;

• The outputs for both contactors must not be on simultaneously.

Devise an instruction list to carry out the control outlined above. Show network titles and any other information that makes the program clear. (14 marks)

- Q4 (a) Explain by examples, the effect of low power-factor on the supply system and the need to improve the power factor of an installation. <u>4 marks</u>
  - (b) How is a consumer with low power factor encouraged by the supply authority to improve low power-factor? How might the consumer suffer by ignoring the request to carry out this undertaking? <u>4 marks</u>
  - (c) An industrial installation with a total load of 1.5MW and a power-factor of 0.8 is to have a six-step automatic power factor correction unit installed. Determine or calculate the capacitive kVAr required to improve the power to the required 0.95. Suggest a suitable arrangement for switching in the capacitors given that capacitors are available in 30, 60, 100, 150, and 200 kVAr ratings.

(Assume that the load never falls below 40% of total load value). <u>6 marks</u>

(d) A charge for low power factor will be applied as follows: For each 0.01 the power factor falls below 0.95, there will be an additional charge of 2.5% per kW of max demand. Given that the max demand for the billing period is 1.2MW and the cost per kW of max demand is  $\in$ 15, calculate the extra cost for low power factor, if correction equipment is not installed. <u>6 marks</u>

#### Section B (Control Technology)

### Please Use Answer Book B

Q5. (a) Explain the operation of the following circuit. Use a timing diagram and truth table, as appropriate, to support your answer. (8 marks)



(b) The switching function below is expressed as a sum of its minterms. Reduce the function to its simplest form using a Karnaugh map.
 (6 marks)

$$F_1 = (W, X, Y, Z) = \sum_{i=1}^{1} (0, 1, 4, 6, 8, 9, 12, 14) + \sum_{i=1}^{3} (5, 13)$$

- (c) Sketch an H Bridge circuit that may be used to control the direction of motion in a DC motor. Briefly explain its operation. (6 marks)
- Q6. (a) Draw a block diagram of a typical gas/oil central heating system. Include a brief description of each block (8 marks)
  - (b) List the factors that contribute to the response delay of a closed-loop system. Suggest an alternative strategy for dealing with a system where response time is critical
  - (c) A thermocouple gives an output of 0.5 mV/°C. Determine the minimum word length required when its output passes through an analogue-to-digital converter if temperatures from 0 to 200°C are to be measured with a resolution of 0.5°C?

(6 marks)

Q7. (a) In terms of Industrial Control systems explain what is meant by:

- (i) On/Off control
- (ii) Proportional control
- (iii) Integral control
- (iv) Derivative control

In each case sketch the controllers' output in response to an error signal. (12 marks)

(b) Describe the Central Processing Unit of a computer and its contents. (8 marks)