GOVERNMENT OF MALTA
MINISTRY FOR EDUCATION, SPORT, YOUTH
RESEARCH AND INNOVATION
DEPARTMENT OF EXAMINATIONS

EXAMINATION FOR AUTHORISATION B

Paper 2

Date: **Friday 4th July 2025**

Time: **09.00 – 12:00 (Three hours)**

Write only your Index Number in the space provided in the booklet.

This examination paper includes six questions. Candidates are requested to choose and answer any FIVE questions clearly indicating the question number of the answered questions.

Candidates are requested to answer ALL FIVE questions in the booklet correctly listing the answered question number in the space provided on the booklet's front sheet.

Answers should be written in Blue/Black Ink. Diagrams can be drawn in pencil.

All answers should include the necessary workings, diagrams and formulae.

Use a separate page for each different question.

Each question carries 20 marks.

1(a) There are different types of three-phase AC motors. Explain briefly the following characteristics found in AC motors:

(i) stator losses (2 marks)
(ii) rotor losses (2 marks)
(iii) friction and winding losses (2 marks)
(iv) slip speed. (2 marks)

(b) Explain the construction of the following AC motors:

(i) synchronous induction motor (2 marks)
(ii) squirrel-cage induction motor (2 marks)
(iii) wound rotor induction motor. (2 marks)

(c) A conveyor is used to deliver boxes from the warehouse to the delivery truck. The conveyor is powered by 12kW, 3 phase wound-rotor induction motor. The motor develops a fault and needs to be replaced with a new motor ***without reversing*** the conveyor motion. Explain the necessary precautions and the instrument used to replace the motor. (6 marks)

2 A workshop is using a tank filled with non-hazardous chemicals to clean the equipment. The tank is required to be heated with three-phase electrical star connected heating elements. The tank is equipped with an overhead beam crane supplied from a 200A three-phase moulded case circuit breaker to a copper conductor busbar chamber installed alongside the longitudinal travel motion of the crane.

(a) The chemical tank catches fire from a continuous scatter of copper particles produced by a short-circuit between the busbars' copper conductors. List the 10 necessary actions to control or eliminate the danger, fire and fumes. (10 marks)

(b) If the supply voltage is a three-phase 400V, 50Hz, determine the short circuit current flowing between the copper conductors if the impedance was found to be 0.01Ω. (2 marks)

(c) Explain briefly whether the 200A three-phase moulded case circuit breaker was in operation or not. (4 marks)

(d) Describe the first aid procedure to be carried out whenever a person gets injured by cutting one's arm. (4 marks)

3 The Figure below (Figure 1) shows an equivalent circuit of a TT connected network which includes the secondary side of a three-phase transformer. The transformer secondary winding is star connected with its star point directly connected to earth. There is also a load connecting cable with its represented impedance.

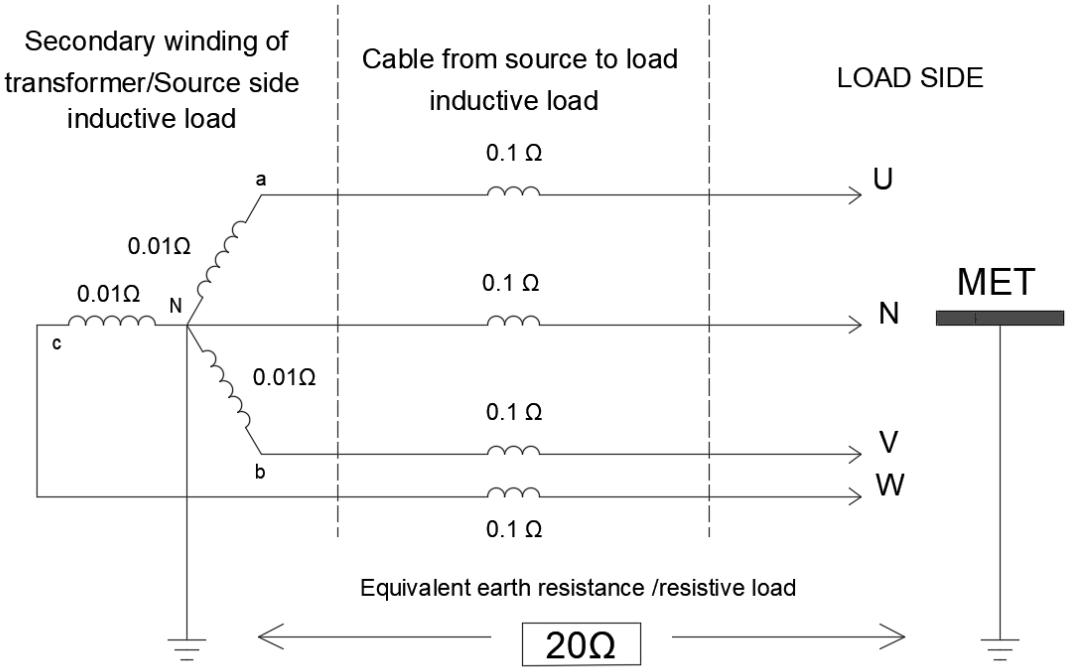

Figure 1 Equivalent Circuit

(a) Assuming that during fault the nominal RMS voltages are sustained by the system. Calculate the fault short circuit current in the following two cases (case A and case B).

Case A: fault short circuit current between 2 phases at the load end side i.e. short circuit between U and V.

Case B: fault short circuit current to earth at load end side. Assume an earth loop impedance of 20Ω (resistive) between earth electrode and main neutral connection of transformer.

(8 marks)

(b) A sensitive load is connected on a final circuit using BS 88 20A fuse. State if the fuse operates for case A and case B. (2 marks)

(c) The engineer wants to install a device as shown in Figure 2 that is triggered by overall unbalanced current (between phases and neutral) or earth leakage value of more than 5A. The diagram below shows the required related items.

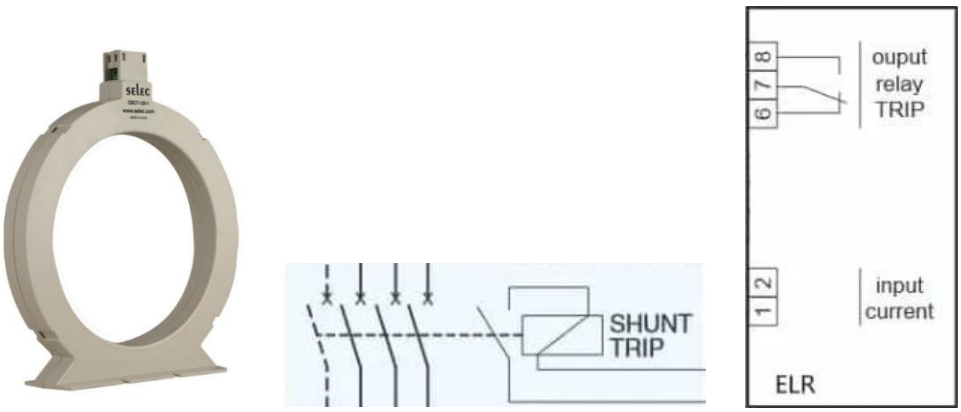

Figure 2 Core balance current transformer, MCCB with shunt trip element and Earth Leakage Relay (ELR)

(i) Draw a diagram to show how the devices are installed and wired with respect to the main power cables and the control wiring. Give a small description of how this works and what is the protection device that needs to be tripped when fault current is exceeded. (7 marks)

(ii) Given that the CT ratio of the concentric earth leakage CT is 50/1A, calculate the secondary current setting of the triggering (tripping) device. (3 marks)

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4 A 20kW, 0.8 pf three-phase cold room has suffered a severe power cut with potential long days of supply absence from the supplier.

The owner decides to install a portable three-phase generator. An equivalent circuit of the generator set is shown in Figure 3 together with the load side mains terminations.

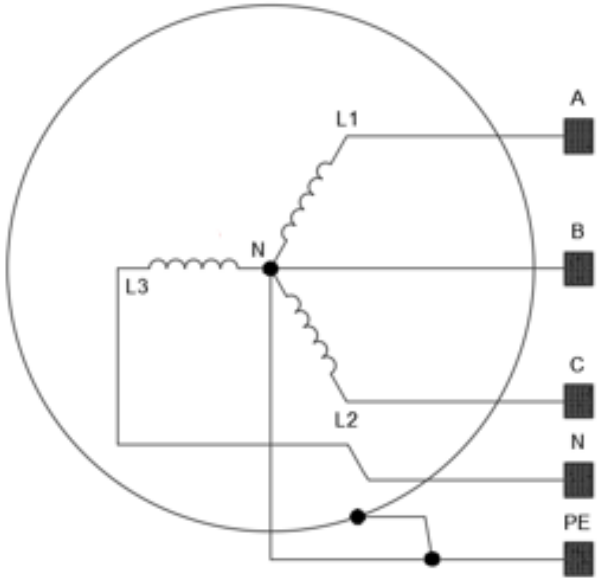

Figure 3 Generator Terminals

(a) Calculate the load current. (3 marks)

(b) From the list below, choose a suitable generator and state the socket outlet connection for this load if the load consists of multiple refrigeration machines with Direct-On-Line starters. (2 marks)

15 kVA generator equipped with 2 x 5 pin 16 A 3 phase Socket outlets
25 kVA generator equipped with 4 x 16 A 5 pin socket outlets
60 kVA generator equipped with 2x 16 A, 2 x 32 A and 1 x 63 A 5 pin socket outlets
200 kVA generator equipped with 4 x 16 A, 4 x 32A and 2 x 63A 5 pin socket outlets

(c)(i) The Figure below (Figure 4) shows the load end (Factory side) terminals at the distribution board. With the aid of a diagram clearly indicate how you would set up the connectivity between the Generator Terminals shown in Figure 3 and the Terminals at Load End of Figure 4, showing clearly the required protection devices that one is obliged to install. (9 marks)

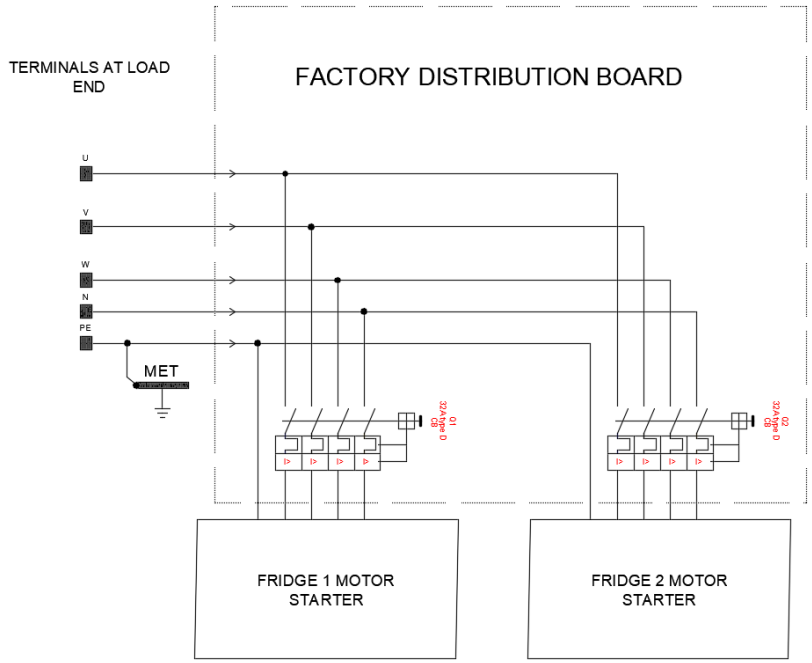

Figure 4 Factory Terminals

(ii) Since there are motors involved on the load side what other important test is required by the electrician at commissioning stage? (3 marks)

(iii) It is recommended that a separate Earth conductor is laid from MET to Genset earth connection. Explain why. (3 marks)

5 (a) What is meant by an automatic recloser in both single-phase and three-phase high-voltage power? (6 marks)

(b) List four typical temporary faults that are the common causes in a three-phase power failure. (8 marks)

(c) Name the abnormal current conditions that activate a circuit breaker. (3 marks)

(d) The circuit breaker has internal sensing mechanisms to enable operation under faulty conditions. Name three circuit breaker mechanisms commonly used. (3 marks)

6 (a) Distinguish between “linear” load and a “non-linear” load in harmonic’s generation. (6 marks)

(b) List three loads for each of the following:
(i) Linear Loads
(ii) Non-linear Loads. (6 marks)

(c) With the aid of a diagram define the term discrimination. (3 marks)

(d) Calculate the correct overload relay setting for a 3-phase induction motor with the specifications listed in the box below.

Rated Power (P): 15kW
Voltage (V): 400V (Line-to-Line)
Frequency (f): 50Hz
Efficiency (η): 90%
Motor power factor (PF): 0.85

(5 marks)

END OF EXAMINATION PAPER

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