EXAMINATION FOR AUTHORISATION B

Paper 2

Date: 4th July 2024

Time: 16:00 – 19:00 (Three hours)

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.

Write <u>only</u> your Index Number in the space provided in the booklet.

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) With the aid of diagrams explain how to measure the power of a three phase **STAR** connected load, when:
    (i)   the three-phase load is either balanced or unbalanced, using one wattmeter,   **(10 marks)**
    (ii) the power is measured, using two-wattmeter simultaneously.   **(7 marks)**

    (b) List THREE advantages of measuring power using the two-wattmeter method.   **(3 marks)**
    (20 marks)

2. Three branches, possessing a resistance of 50 Ω, an inductance of 0.15 H and a capacitance of 100 μF respectively, are connected in parallel across a 100 V, 50 Hz supply.
    (a) Sketch the RLC circuit.   **(2 marks)**
    (b) Calculate**:**
        (i)   the current in each branch   **(6 marks)**
        (ii) the supply current   **(5 marks)**
        (iii) the circuit impedance   **(3 marks)**
        (iv) the phase angle between the supply current and the supply voltage.   **(4 marks)**
        (20 marks)

3. (a) What is the difference between a steel wire armoured and a steel tape armoured cable?   **(2 marks)**
    (b) What is the main difference between a copper and an aluminium conductor used as current carrying conductor?   **(3 marks)**
    (c) With the aid of a diagram draw a soldered type of cable lug and crimp type cable lug.   **(2 marks)**
    (d) Briefly explain why it is not recommended to use a steel wire armour of a cable as an earth conductor.   **(3 marks)**
    (e) An electrical contractor stores two types of cables.
        1) PILSWA cable.
        2) XLPE armoured cable.

    The contractor is to provide a temporary three-phase and neutral electrical supply to a tent which is to be used for an upcoming exhibition event. The contractor has assigned you the works to select the required cable from the stores and to terminate the cable to the metal clad main switch board using a cable gland.
        (i)   What type of cable do you select for the tent supply?   **(3 marks)**
        (ii) With the aid of a diagram draw the cable gland terminated to the selected cable and clearly show how the cable gland is earthed.   **(7 Marks)**
        (20 marks)

4. (a) Briefly, explain **THREE** types of earth electrodes used for the TT-system and according to the IET BS7671 regulation 542.2.2.   **(6 marks)**
    (b) With the aid of a diagram draw and explain the testing of two electrodes which are connected together and used for a three-phase installation.   **(5 marks)**
    (c) The design of the protective conductor common for one or more circuits can be calculated by using the equation given in IET BS7671 regulation 543.1.3:

$$S = \frac{\sqrt{I^2 \times t}}{K}$$

    (i)   Calculate the earth fault current if the earth fault impedance is Zs = 0.68 ohms. Assume single phase supply   **(1 mark)**
    (ii) Using the above equation, calculate the cross-sectional area (CSA) S. The operating current of the 32A MCB is 0.1 seconds. Assume the K factor is 115 and use the calculated earth fault current.   **(8 marks)**
    (20 marks)

5. (a) A three phase 4 pole MCCB is equipped with these protection elements,
   (i) Thermal overcurrent element and
   (ii) Instantaneous or magnetic element.

   On the booklet provided draw Figure 5.1 and on it label the respective zones for:
   (i) thermal part **(1 mark)**
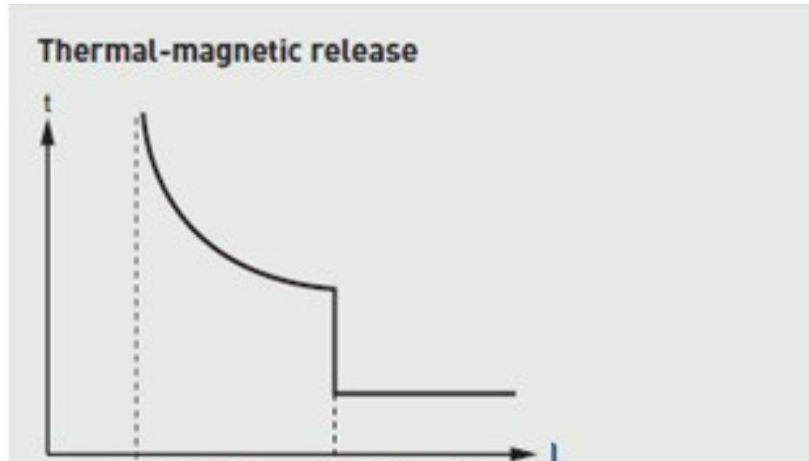   (ii) magnetic part. **(1 mark)**

Figure 5.1

(b) The diagram given in Figure 5.2, shows a 4-pole MCCB equipped with a core balance current transformer, CBCT.
   (i) What is the purpose of the CBCT? **(4 marks)**
   (ii) What is the function of the Earth Leakage Relay? **(4 marks)**
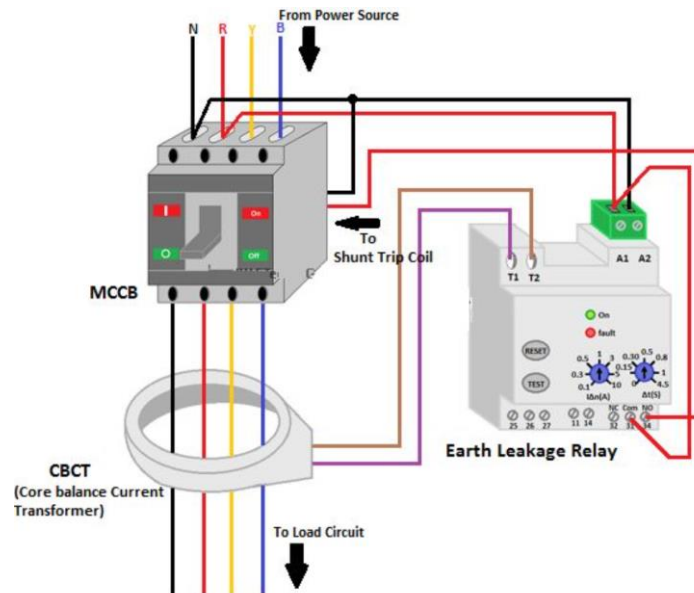   (iii) What is the purpose of the shunt trip? **(4 marks)**

Figure 5.2

(c) If the CT ratio is 10/1 and the earth fault loop impedance, Ze, at the point of fault is 100 ohms, calculate the earth fault current, if the phase conductor comes in contact directly with earth. (assume that all the fault current is affecting one phase, and other phases are unaffected by the fault). **(3 marks)**

(d) Calculate the resultant magnitude of the secondary current generated by the core balance current transformer. **(3 marks)**
(20 marks)

6. (a) (i) A three-phase star connected motor develops a fault and is tripping the machine.
Draw up a list of activities that an electrical authorised person is requested to conduct in order to diagnose the problem, keeping in mind the safety requirements. **(4 marks)**

(b) A digital power meter is going to be installed to monitor the power of a system consisting of a pump driven by a three-phase motor rated 7.5 kW at 400 V, 0.92 pf.
Figure 6.1, shows the motor power wiring setup with three Current Transformers and voltage terminations, and the Power meter (PM) with the terminals. (Assume that the power meter voltage terminals are rated at 400 V).
On the answer booklet draw Figure 6.1 and show clearly how you would connect the terminations from the current transformers and the motor main terminals to the Power meter (PM). **(6 marks)**
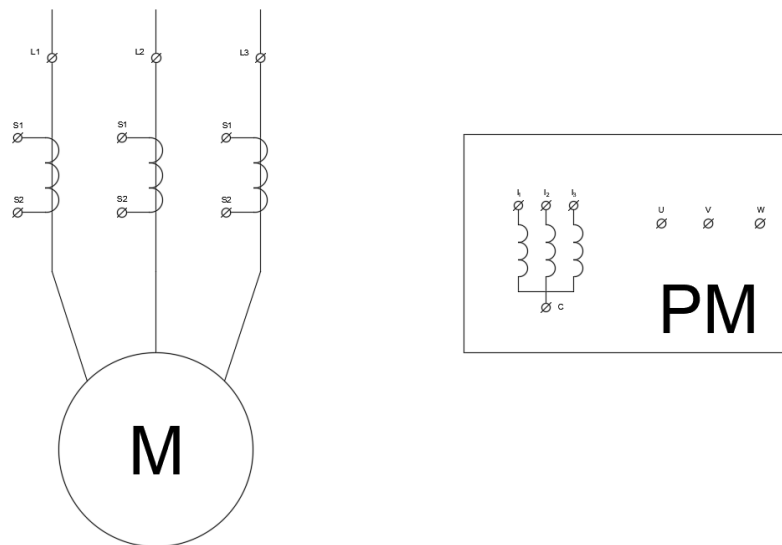

Figure 6.1

(c) Calculate the current of the motor at maximum load. **(2 marks)**

(d) If the CT ratio is 15:1 calculate the secondary CT current flowing into the power meter. **(2 marks)**

(e) The power meter is also an Energy meter measuring the energy in unit's kwh. If the accumulated energy value reads 680 units, what is the new expected value 24 hours later, if machine runs at full load for 24 hrs. **(2 marks)**

(f) If the power meter measures the kVAh what will be then the daily kVAh consumption assuming machine runs at full load for the whole 24 hrs? **(2 marks)**

(g) If the customer is charged for the kVAh and the cost per kVAh is 15 euro cents, calculate the gain in one year if he improves the power factor of his system to approx. 1.0.
(Assume plant runs on a 24x7 basis) **(2 marks)**

END OF EXAMINATION PAPER