Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	SWITCHBOARD MAINTENANCE AND CALIBRATION
COURSE CODE	:	BBJ 10505
PROGRAMME CODE	:	BBJ
EXAMINATION DATE	:	JULY / AUGUST 2023
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTIONS	:	1. ANSWER **ALL** QUESTIONS. 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK**. 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

THIS QUESTION PAPER CONSISTS OF **ELEVEN (11)** PAGES

TERBUKA

Q1. (a) Explain what is the important of circuit breaker like fuse, Air Circuit Breaker (ACB) and Moulded Case Circuit Breaker (MCCB) in a switchboard panel.

(2 marks)

(b) **Figure Q1(b)** in Appendix shows General Arrangement (GA) of Main Switch Board (MSB) panel with components used for the operation of the panel.

(i) With reference to the **Figure Q1(b)**, state which protection relay trips the ACB and which protection relay trips the MCCB.

(3 marks)

(ii) Describe the operation of Earth Leakage Relay (ELR) including the type of Current Transformer (CT) used in its application.

(5 marks)

(c) Explain the process of arc quenching in Air Circuit Breaker (ACB).

(8 marks)

(d) The total load of a Low Voltage (LV) switchboard panel is 35 kW. Considering Power Factor (PF) of 0.86 and Safety Factor (SF) of 125%,

(i) calculate sizing of an Air Circuit Breaker (ACB) installed on the panel. The available ACB sizes in the market are 40 A, 60 A, 80 A and 100 A.

(5 marks)

(ii) Justify your selection on the ACB size in **Q1(d)(i)**.

(2 marks)

TERBUKA

Q2. Question 2 is referring to **Figure Q2(i)** and **Figure Q2(ii)** in Appendix.

(a) State **two (2)** types of fault that this relay protects the switchboard panel from.

(1 mark)

(b) **Figure Q2(i)** shows the class of the Current Transformer (CT) used for the Over Current Earth Fault (OCEF) relay is 10P10. Explain what do both 10s and P mean in the CT class.

(3 marks)

(c) **Figure Q2(i)** shows the connection of the OCEF relay in a switchboard panel with reference to the relay terminal diagram as shown in **Figure Q2(ii).** Binary Output (BO) contact of the OCEF relay that is connected to the Air Circuit Breaker (ACB) is using Normally Open (NO) contact (terminal A-C).

What would happen if the BO contact of the relay is wrongly terminated at terminal B-C (or b-c). Discuss your answer.

(3 marks)

(d) Based on the relay schematic drawing in **Figure Q2(i),**

(i) explain all the wiring connections that are involved in the protection relaying scheme.

(9 marks)

(ii) demonstrate the OCEF relay operation process starting from primary current measurement on the line until it trips the ACB.

(5 marks)

(e) The relay is tested well on all of its function and is energized since then. However, it is not maintained at all and it does not have any connection to SCADA control to be monitored its status from remote e.g., control room.

After 3 years in operation, power supply of the relay is faulty causing the relay is dead (not powered up) and nobody is noticing it. Predict what would happen to the system in this situation.

(4 marks)

TERBUKA

Q3. (a) From **Figure Q3(a)** in Appendix, identify which one is busbar. Write your answer as either A, B, C or D.

(2 marks)

(b) Explain **four (4)** functions of busbar in substation.

(4 marks)

(c) Sketch Single Line Diagram (SLD) of single busbar in substation with correct labelling of busbar, incoming panel, outgoing panel and bus coupler panel.

(5 marks)

(d) Sketch Single Line Diagram (SLD) of double busbar in substation with correct labelling of busbar, incoming panel, outgoing panel and bus coupler panel.

(6 marks)

(e) A busbar is to be installed at a Low Voltage (LV) switchboard panel. The total load of the panel is 290 kW with Power Factor (PF) of 0.87 and short circuit current (I_{sc}) 17.9 kA. Considering Safety Factor (SF) of 125%, calculate the appropriate busbar size. Please take note that the tripping time of Air Circuit Breaker (ACB) for the panel is 1 second.

(8 marks)

TERBUKA

Q4. (a) List **three (3)** types of load with an example for each type.

(3 marks)

(b) Sketch a power triangle to show active power, reactive power and apparent power, together with its units.

(4 marks)

(c) **Figure Q4(c)** shows a pure resistive load of 120 kW connected with a 600 V generator, supplying 200 A.

(i) Predict what will happen if a lagging inductive load with value of 200 kVar is added to the resistive load.

(3 marks)

(ii) Using **Figure Q4(c),** sketch how a capacitor is connected to the installation and calculate the value of capacitor that need to be used in order to raise up the power factor back to value 1.0 (unity). (Formula in Appendix).

(6 marks)

(d) A load with 100 kW and power factor 0.75 (lagging) needs to be connected to a Low Voltage (LV) switchboard panel. A power factor correction scheme that uses capacitor bank is designed to improve the value of the power factor to 0.9. With the aid of power triangle diagram, calculate the value of capacitor that is to be installed (formula in Appendix). Available capacitor sizes in the market are 20 kVar, 25 kVar and 30 kVar.

(9 marks)

-END OF QUESTIONS –

TERBUKA

FINAL EXAMINATION

SEMESTER / SESSION	:	SEM II 2022/2023	PROGRAMME CODE	:	BBJ
COURSE NAME	:	SWITCHBOARD MAINTENANCE AND CALIBRATION	COURSE CODE	:	BBJ 10505

APPENDIX (FIGURE)

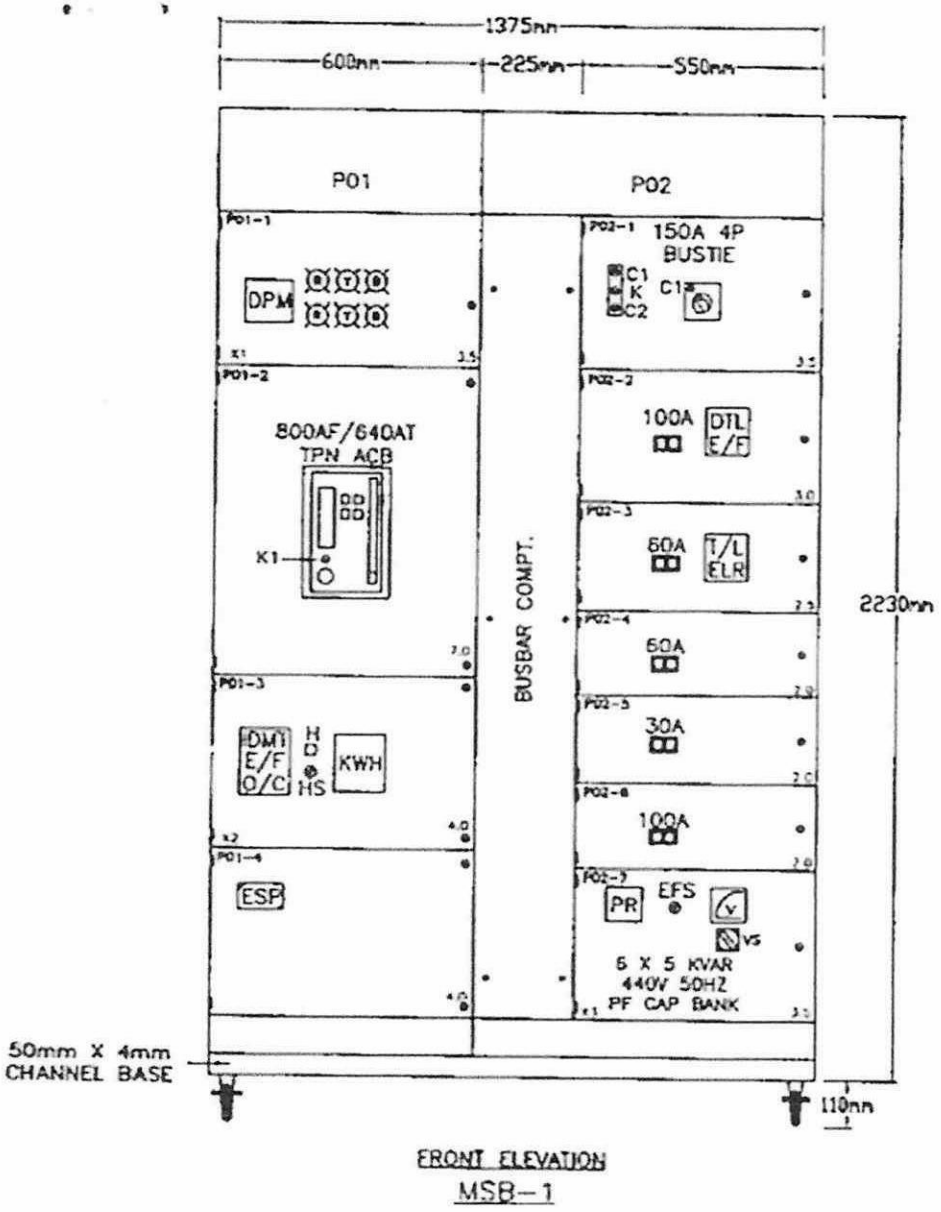

Figure Q1(b) Main Switch Board (MSB) Panel

TERBUKA

FINAL EXAMINATION

SEMESTER / SESSION	:	SEM II 2022/2023	PROGRAMME CODE	:	BBJ
COURSE NAME	:	SWITCHBOARD MAINTENANCE AND CALIBRATION	COURSE CODE	:	BBJ 10505

APPENDIX (FIGURE)

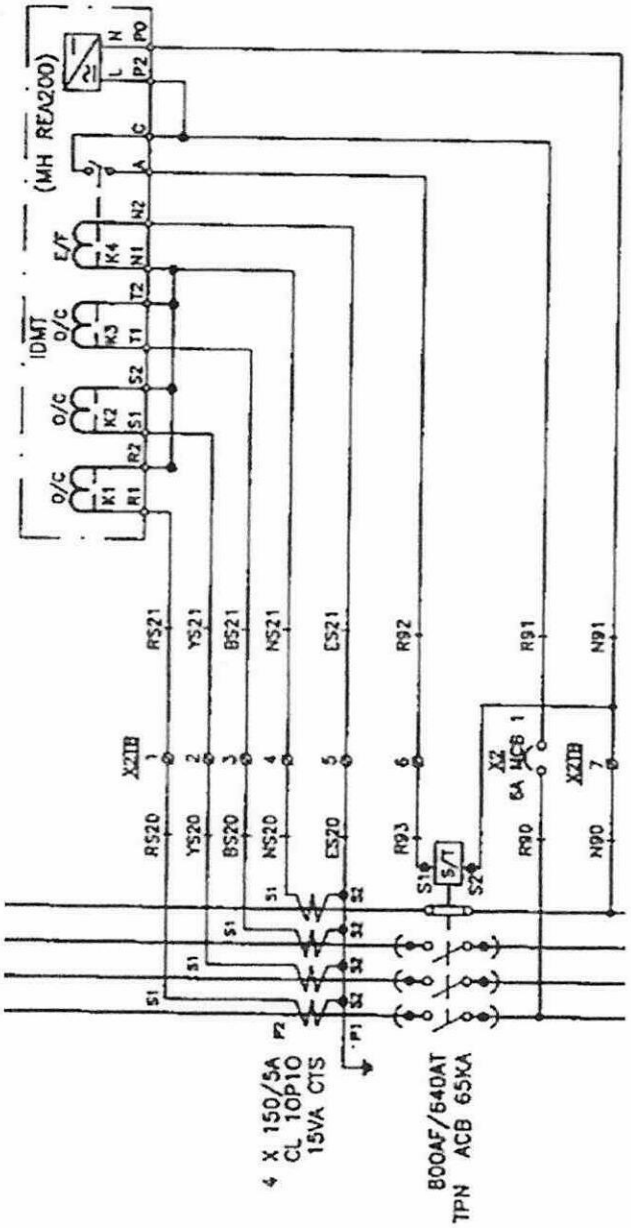

Figure Q2(i) Schematic Drawing of OCEF Relay in Switchboard Panel

TERBUKA

FINAL EXAMINATION

SEMESTER / SESSION	:	SEM II 2022/2023	PROGRAMME CODE	: BBJ
COURSE NAME	:	SWITCHBOARD MAINTENANCE AND CALIBRATION	COURSE CODE	: BBJ 10505

APPENDIX (FIGURE)

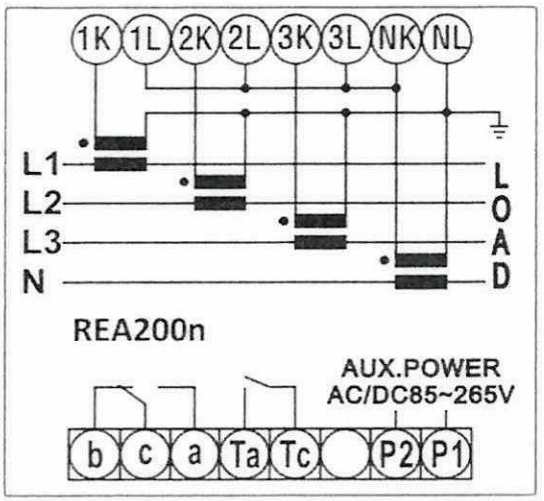

Figure Q2(ii) Terminal Diagram of OCEF relay model REA200

TERBUKA

FINAL EXAMINATION

SEMESTER / SESSION	:	SEM II 2022/2023	PROGRAMME CODE	:	BBJ
COURSE NAME	:	SWITCHBOARD MAINTENANCE AND CALIBRATION	COURSE CODE	:	BBJ 10505

APPENDIX (FIGURE)

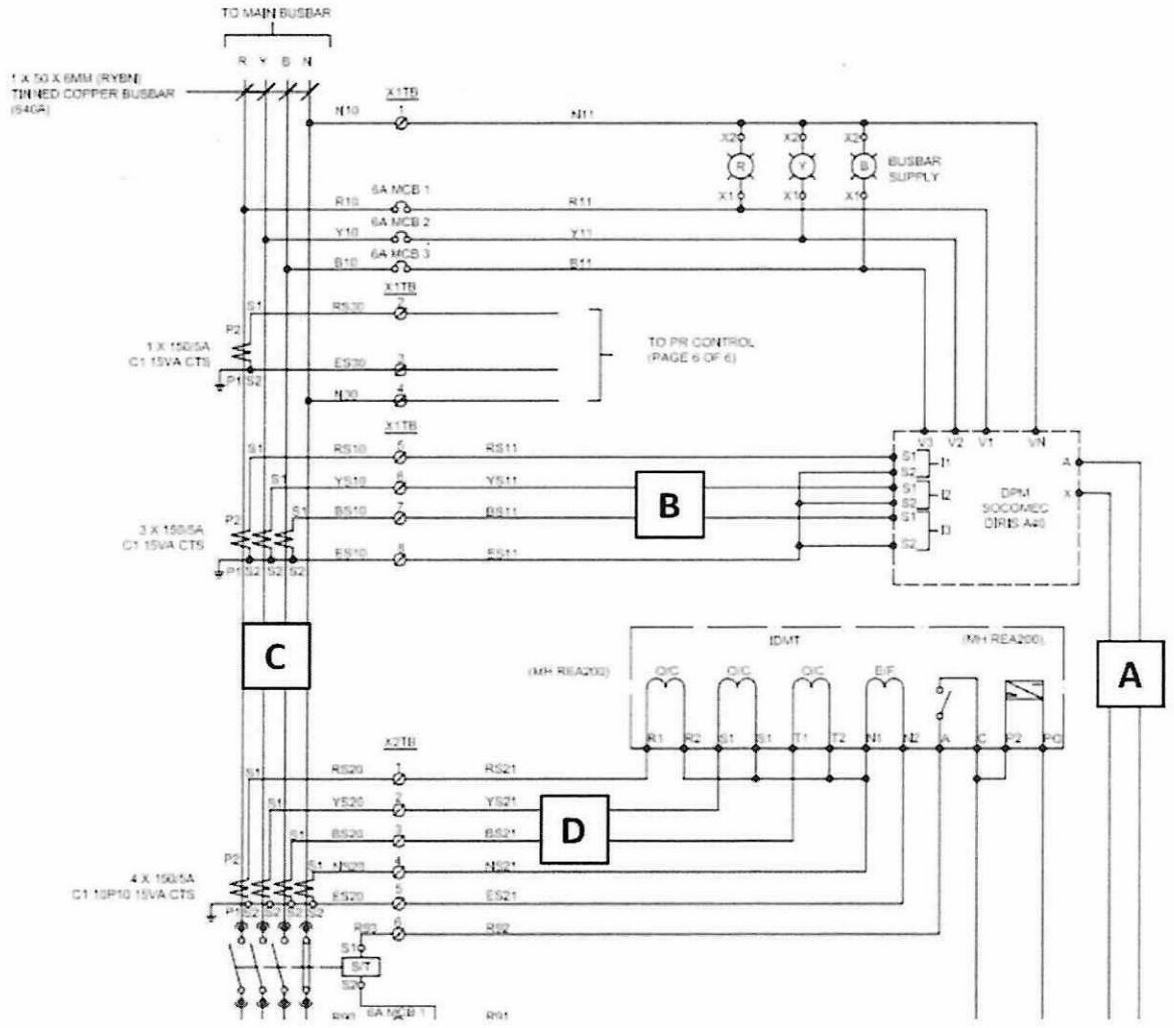

Figure Q3(a) Schematic Drawing of Low Voltage (LV) Switchboard Panel

TERBUKA

FINAL EXAMINATION

SEMESTER / SESSION	:	SEM II 2022/2023	PROGRAMME CODE	: BBJ
COURSE NAME	:	SWITCHBOARD MAINTENANCE AND CALIBRATION	COURSE CODE	: BBJ 10505

APPENDIX (FIGURE)

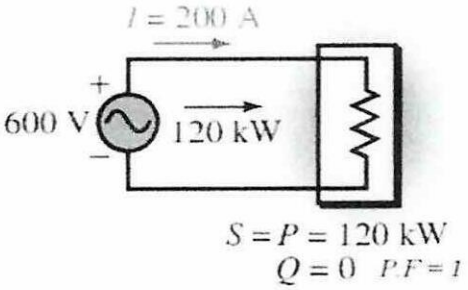

Figure Q4(c)

TERBUKA

FINAL EXAMINATION

SEMESTER / SESSION	:	SEM II 2022/2023	PROGRAMME CODE	: BBJ
COURSE NAME	:	SWITCHBOARD MAINTENANCE AND CALIBRATION	COURSE CODE	: BBJ 10505

APPENDIX (FORMULA)

Ohm's Law

$P = VI$

$P = \sqrt{3}\ VI\cos\phi$

PF correction capacitor value

$$Q_c = \frac{V^2}{X_c}$$

$$C = \frac{1}{2\pi f X_c}$$

Cross Sectional Area of Busbar

$$A_{min} = \frac{\sqrt{t_{trip}} \times I_{sc}}{0.08}$$

Table 2: Busbar current rating

Size of Bus bar (mm x mm)	Sectional Area (mm^2)	Approx. Rating (Amp) for Copper Busbar
25 x 6	150	450
40 x 6	240	660
50 x 6	300	792
60 x 6	360	915
80 x 6	480	1162
100 x 6	600	1395
125 x 6	750	1671
150 x 6	900	1915
50 x 10	500	1060
80 x 10	800	1525
100 x 10	1000	1800
125 x 10	1250	2150
150 x 10	1500	2456

TERBUKA