Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	ELECTRICAL MEASUREMENTS
COURSE CODE	:	BEF 23903
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	DECEMBER 2019/JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) **Figure Q1(a)** shows an AC voltmeter with full wave rectifier. Given that internal resistance of meter, R_m=500 Ω, full scale current deflection, I_{fsd} = 1 mA, shunt resistance, R_{sh}=250 Ω, average forward resistance of each diode is 35 Ω and infinite reverse resistance of each diode,

(i) Determine the value of multiplier resistance, R_s that is required to measure the input voltage, V_{in} up to 50 V_{rms}.

(5 marks)

(ii) Calculate the AC and DC sensitivity of the meter.

(2 marks)

(iii) Compare the sensitivity of half-wave and full-wave rectifier voltmeter.

(2 marks)

(b) A wheatstone bridge can be used for measuring an unkwon resistance as shown in **Figure Q1(b)**.

(i) Based on the **Figure Q1(b)**, write the equation of unknown resistance, R_x under balance condition.

(1 mark)

(ii) Find the current through the galvanometer, G if V_{DC}=10 V, R_1=1.5 kΩ, R_2=3.5 kΩ, R_3=2.5 kΩ, R_x=10.5 kΩ and R_g=200 Ω,

(7 marks)

(c) With help of a circuit diagram, describe the main working principle of a potentiometer.

(3 marks)

Q2 (a) (i) Define the **two (2)** conditions which must be fulfilled when balancing an AC bridge.

(2 marks)

(ii) Differentiate the performances of Maxwell bridge and Hay bridge for measuring inductance in terms of load quality factor.

(4 marks)

(b) Schering bridge in **Figure Q2(b)** is widely used for measuring an unknown capacitor and insulating properties.

(i) Determine the suitable type of capacitor, C_3 that can be used for general and insulation measurements.

(2 marks)

(ii) Prove that the unknown capacitor, C_x and unknown resistor, R_x under balanced condition are given as follows:

$$R_x = \frac{R_2 C_1}{C_3}; \quad C_x = \frac{R_1 C_3}{R_2}$$

(6 marks)

(iii) Calculate the quality factor and dissipation factor of the measurement if C_1=1.5 μF, C_3=1.0 μF, R_1=1.2 kΩ, R_2=2.5 kΩ and frequency, f=1 kHz under balance condition.

(4 marks)

(iv) Discuss the advantage of this bridge.

(2 marks)

Q3 (a) An instrument transformer is one of the important equipment for measuring high voltage and current in power engineering applications.

(i) State **two (2)** main functions of instrument transformer.

(2 marks)

(ii) Illustrate the circuit connections of the instrument transformers for measuring high voltage and high current in transmission line.

(2 marks)

(b) A current transformer (CT) with rating of 500/5 A is connected to an AC transmission line. The secondary side is connected to an ammeter, relays and wire with total impedance of 1.5 Ω.

(i) Determine the turn ratio and nominal ratio of the CT.

(2 marks)

(ii) Calculate the secondary current and voltage of CT if the transmission line current is 300 A.

(4 marks)

(c) The measurement range of an electrostatic voltmeter can be extended by using appropriate multiplier.

(i) Draw the circuit diagram of voltage measurement with capacitive potential divider.

(2 marks)

(ii) Derive the relationship between measured voltage and capacitance based on the circuit in **Q3(c)(i)**.

(4 marks)

(ii) An electrostatic voltmeter with full scale deflection of 10 kV and capacitor of 0.5 uF are connected in parallel with voltmeter. Calculate the value of additional capacitance in series required to perform the voltage measurement up to 33 kV.

(4 marks)

Q4 (a) Draw a basic connection of a wattmeter and explain the function of its main components.

(4 marks)

(b) In single phase system, real power and power factor can be measured by using three-voltmeter method as shown in **Figure Q4(b)**.

(i) Based on **Figure Q4(b)**, prove that the equation of real power, P and power factor, $p.f$ are as follows:

$$P = \frac{V_1^2 - V_2^2 - V_3^2}{2R} \ ; \ p.f = \frac{V_1^2 - V_2^2 - V_3^2}{2V_2V_3}$$

(Assume the current in R is same as the load current)

(4 marks)

(ii) Calculate the power factor of the load if the reading of V_1=350 V, V_2=160 V and V_3=200 V.

(2 marks)

(iii) Suggest a possible solution to improve the accuracy of this method.

(2 marks)

(c) Two wattmeters are used to measure the total power in a 3-phase system connected to a balanced load. The wattmeters read 11 kW and -3 kW, respectively at the line voltage of 400 V.

(i) Illustrate the electrical connection of the power measurement.

(2 marks)

(ii) Determine the total power and power factor.

(4 marks)

(iii) Calculate the line current.

(2 marks)

Q5 (a) The resistance of a material can be measured by using ammeter-voltmeter method as shown in **Figure Q5(a)**. The readings of voltmeter and ammeter are 3.0 V and 0.5A, respectively. The internal resistance of voltmeter and ammeter are 450 Ω and zero (0) Ω, respectively.

(i) Calculate the value of the measured resistance, $R_{measured}$.

(3 marks)

(ii) Calculate the true value of the resistance, R_{true}.

(5 marks)

(iii) Calculate the percentage of error.

(2 marks)

(b) A 30 kV supply and a micro-ammeter are used to measure the insulation resistance of a metal-sheath cable as shown in **Figure Q5(b)**. A current of 5.5 μA is measured when the components are connected without guard wire. When the circuit is connected with a guard wire, the current is 2.0 μA.

(i) Draw and label the equivalent circuit of the measurement in **Figure Q5(b)**.

(2 marks)

(ii) Discuss the function of the guard wire.

(2 marks)

(iii) Determine the volume resistance of the cable insulation.

(3 marks)

(iv) Determine the surface leakage resistance.

(3 marks)

- END OF QUESTIONS -

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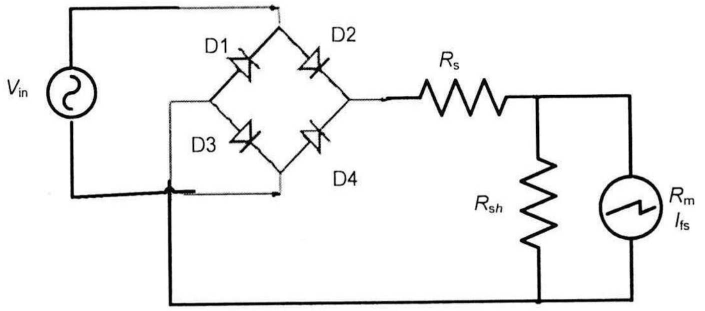

Figure Q1(a)

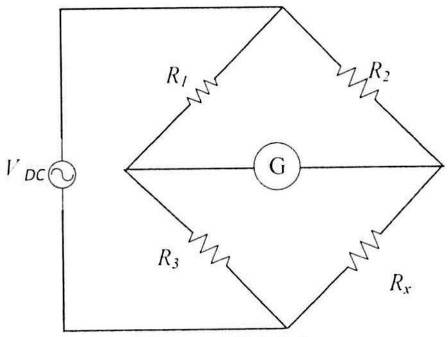

Figure Q1(b)

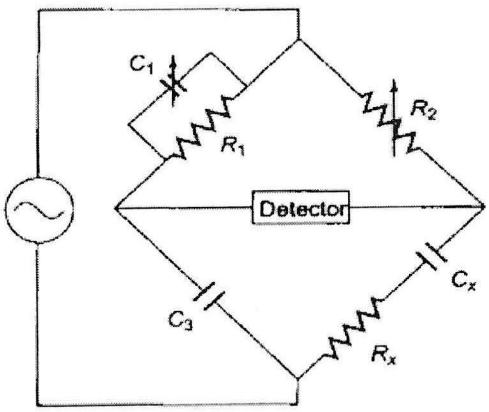

Figure Q2(b)

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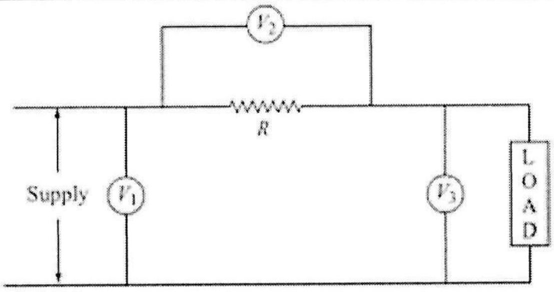

Figure Q4(b)

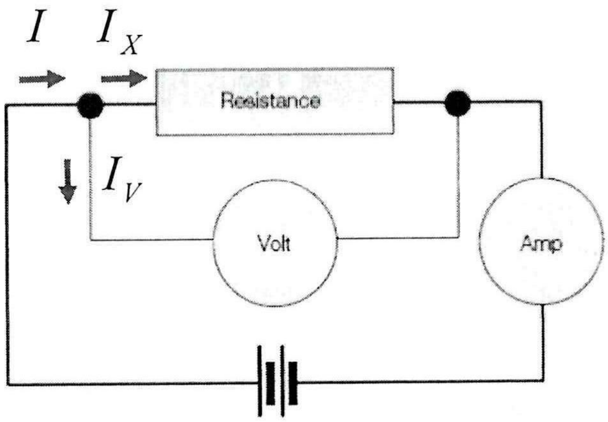

Figure Q5(a)

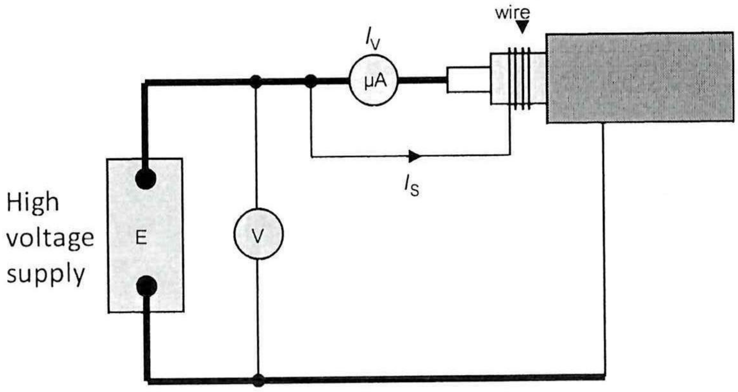

Figure Q5(b)