Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER I
## SESSION 2022/2023

| | | |
|---|---|---|
| COURSE NAME | : | ELECTRICAL MEASUREMENT AND INSTRUMENTATION |
| COURSE CODE | : | BEV 20103 |
| PROGRAMME CODE | : | BEV |
| EXAMINATION DATE | : | FEBRUARY 2023 |
| DURATION | : | 3 HOURS |
| INSTRUCTION | : | 1.ANSWER **ALL** QUESTIONS<br>2.THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSE BOOK**<br>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 **EIGHT (8)** PAGES

**Q1** (a) Differentiate between digital and analog multimeter in term of its construction and measuring capability.

(4 marks)

(b) **Figure Q1(b)** shows a bipolar junction transistor (BJT) voltmeter with the following specifications:

| | |
|---|---|
| Common collector voltage, $V_{CC}$ | : 12 V |
| Meter internal resistance, $R_m$ | : 2.5 kΩ |
| Full scale deflection current, $I_m$ | : 1.5 mA |
| Base-emitter junction voltage, $V_{BE}$ | : 0.7 V |
| Current gain, β | : 50 |

(i) Determine the multiplier resistance ($R_s$) and input resistance of the voltmeter ($R_{in}$) such that the voltmeter can give full scale deflection when a voltage source ($V_{in}$) of 5 V is applied to it.

(6 marks)

(ii) The voltage drop across the base emitter junction causes an error during measurements. Propose a solution to eliminate the error by illustrated the modified circuit of the BJT voltmeter.

(4 marks)

(c) **Figure Q1(c)** shows an operational amplifier (op-amp) voltmeter with a maximum input voltage of 20 mV. The circuit has a meter circuit with full scale deflection current ($I_m$) of 2 mA and meter internal resistance ($R_m$) of 500 Ω. Consider that the current gain value of 200 and the op-amp input current ($I_B$) of 20 μA requires to switch the resistive load of the current $I_4$, recommend suitable values for the resistors $R_3$ and $R_4$.

(6 marks)

**Q2** (a) Differentiate between analog and digital oscilloscopes in term of its mode of operation.

(4 marks)

(b) **Figure Q2(b)** shows the voltage waveforms observed in an analog oscilloscope. Given that the time/div knob is set to 0.2 ms,

(i) determine the frequency of waveform A and waveform B.

(2 marks)

(ii) determine the phase difference between the two waveforms.

(2 marks)

(c) **Figure Q2(c)(i)** shows a circuit for an attenuator probe of an oscilloscope with $C_{osc}$, $C_w$, $R_s$ and $R_{osc}$ represent input capacitance of the oscilloscope, input capacitance of co-axial cable, source resistance and input resistance, respectively. Its equivalent circuit is shown in **Figure Q2(c)(ii)** in which the $C_2$ is the sum of capacitance $C_{osc}$ and $C_w$.

(i) Derive an equation of the oscilloscope input voltage ($V_i$) when the capacitive impedances are not effective using the equivalent circuit.

(4 marks)

(ii) Derive and equation of the oscilloscope input voltage ($V_i$) when the capacitive impedances are acting alone neglecting the resistive components using the equivalent circuit.

(4 marks)

(iii) Determine the required capacitance ($C_1$) and the input capacitance of the probe seen from the source end ($C_T$) when $C_{osc}$ = 20 pF, $C_w$ = 80 pF, $R_{osc}$ = 1 MΩ and $R_1$ = 9 MΩ for the signal attenuation by capacitive and resistive networks in equal condition.

(4 marks)

**Q3** (a) Explain a difference between current and potential transformers in term of its circuit configuration.

(2 marks)

(b) A potential transformer with ratio of 1000/100 V has the following specifications:

| | |
|---|---|
| Primary resistance, $r_p$ | : 94.5 Ω |
| Primary reactance, $x_p$ | : 66.2 Ω |
| Secondary resistance, $r_s$ | : 0.86 Ω |
| Total equivalent reactance, $X_P$ | : 110 Ω |
| Excitation current, $I_o$ | : 0.6 A |
| Power factor, cos α | : 0.4 |

Determine the following:

(i) The magnetizing component ($I_m$) and the core loss component ($I_e$) of excitation current.

(6 marks)

(ii) The phase angle error at no load.

(4 marks)

(c) A current transformer having a 1 turn primary and a 200 turns secondary winding. The secondary supplies a current of 5 A to a non-inductive burden of 1 Ω resistance. The requisite flux is set up in the core by an mmf of 80 A. The frequency is 50 Hz. Neglecting the effects of losses and magnetic leakage, determine the following:

(i) The voltage induced in the secondary winding ($V_S$), the magnetizing component of exciting current ($I_m$), the reflected secondary current, the primary current ($I_p$) and actual transformation ratio.

(6 marks)

(ii) Illustrate the phasor diagram of the current components in **Q3(c)(i)**.

(2 marks)

**Q4** (a) There are two alternate methods of connecting a wattmeter in a circuit. Illustrate the difference between the two connections with the help of circuit configurations.

(4 marks)

(b) A wattmeter has a current coil of 0.1 Ω resistance and a pressure coil of 6.5 kΩ resistance. Determine the following:

(i) The true power when load specified as 12 A at 250 V with 0.4 power factor.

(2 marks)

(ii) The power loss and percentage error when current coil and pressure coil on the load side, respectively.

(8 marks)

(c) Blondel's theorem is used to specify the number of wattmeters for power measurement in a system of electrical conductors. Discuss the **three (3)** arrangements of a wattmeter method.

(6 marks)

**Q5** (a) The ammeter-voltmeter method with a voltmeter resistance ($R_V$) of 600 Ω and the ammeter resistance ($R_A$) of 0.8 Ω is used to measure the unknown low or high resistance ($R_x$) in a laboratory. If the voltmeter and the ammeter readings are 40 V and 120 mA, respectively, determine the real value of $R_x$ when,

(i) the voltmeter is connected across the unknown resistance and the ammeter connected in series with power supply.

(4 marks)

(ii) the voltmeter is connected across the power supply and ammeter connected directly in series with the unknown resistance.

(3 marks)

(iii) Discuss the measurement results of the unknown resistance by both cases based on **Q5(a)(i) and (ii)** above.

(3 marks)

(b) A technician tests a cable conductor for insulation resistance using loss of charge method. From the testing, a capacitance of 300 pF was recorded between the conductor and earth. It was observed that after charging the cable with a voltage supply of 300 V for sufficiently long time, when the voltage supply is withdrawn, the voltage drops down to 100 V in 2 minutes. Determine the insulation resistance of the cable.

(4 marks)

(c) The insulation of a three-core insulated electric cable is tested using a 11 kV voltage supply and a micro-ammeter. A current of 3.0 μA is measured when the cable is connected using a circuit configuration, as shown in **Figure Q5(c)(i)**. When the circuit is reconfigured using guard-wire method as in **Figure Q5(c)(ii)**, the current is 0.9 μA. Determine the volume resistance of the cable insulation ($r_V$) and the surface leakage resistance ($r_S$).

(6 marks)

**- END OF QUESTIONS -**

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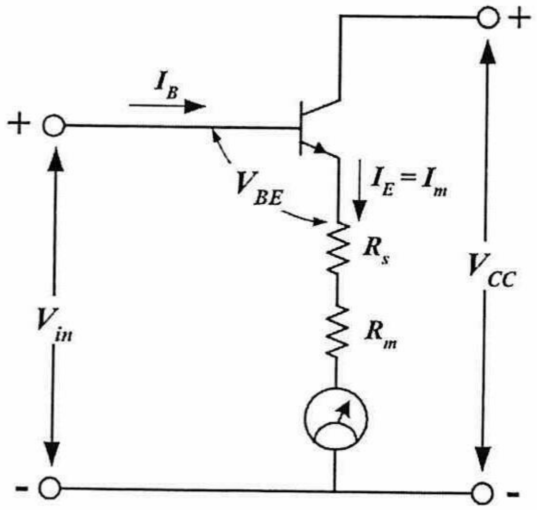


**Figure Q1(b)**

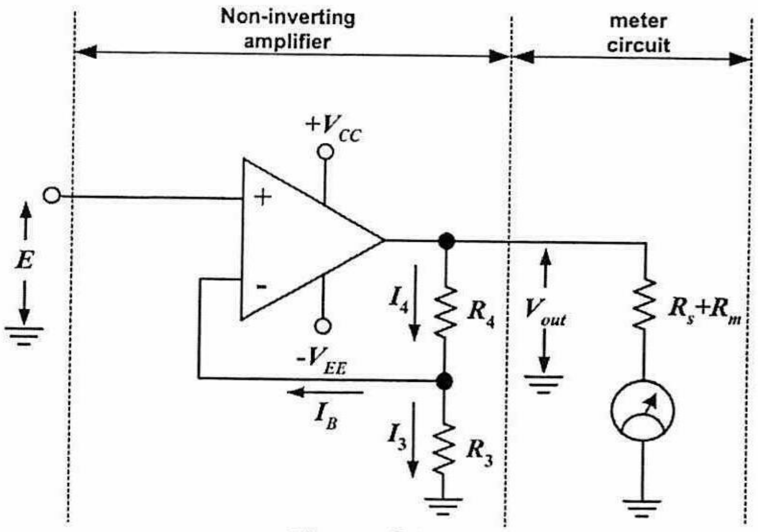


**Figure Q1(c)**

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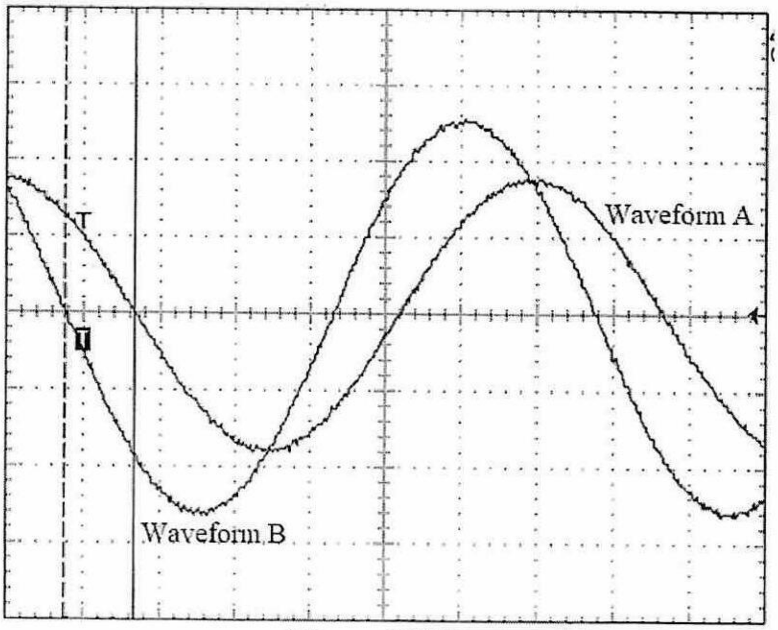
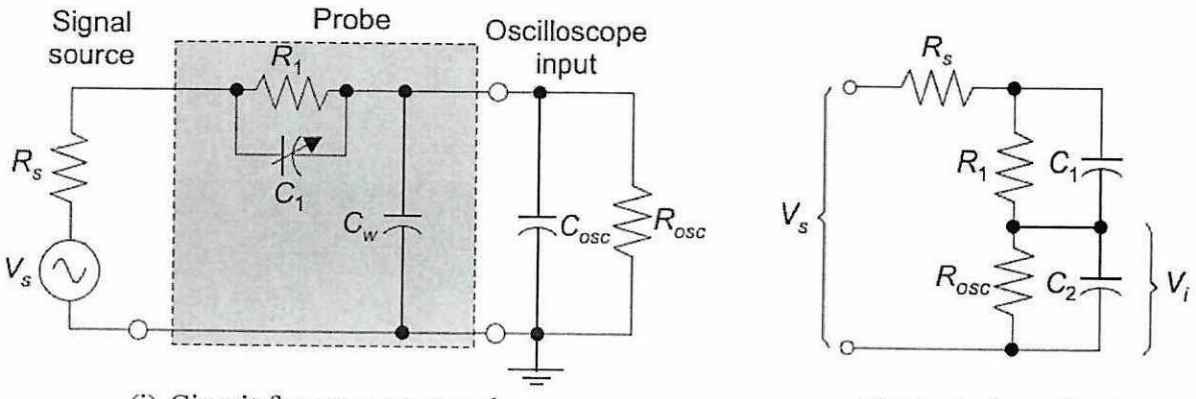



**Figure Q2(b)**




(i) Circuit for attenuator probe (ii) Equivalent circuit

**Figure Q2(c)**

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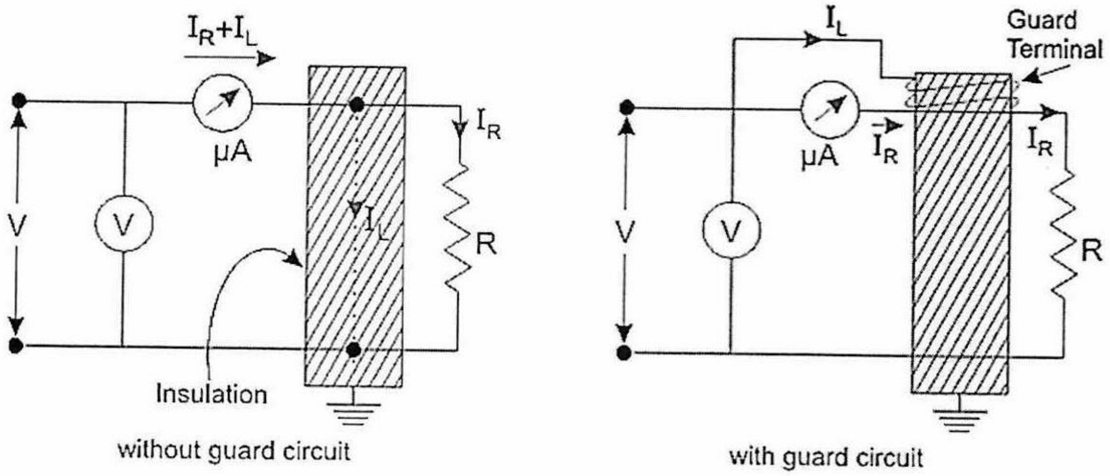


(i) (ii)

**Figure Q5(c)**