

LOCATION: **SWANSEA**

LLEOLIAD: **ABERTAWE**

LEVEL **4**

LEFEL **4**

EXAMINATION PERIOD
MAY 2024

CYFNOD ARHOLIADAU
MAI 2024

SOLUTIONS

MODULE CODE: **GOEE4003**

ELECTRICAL AND ELECTRONICS PRINCIPLES

TIME: **2 HOURS**

ANSWER **ALL** QUESTIONS

Equipment or materials required – Calculator, Formula Sheet

Question One (20 Marks)

For the circuit shown in Figure 1 below: -

- Calculate the resistance of the circuit within the dashed lines designated the LOAD (i.e. R3 to R8 inclusive) [10 marks]
- Calculate the voltage at point A [3 marks]
- Calculate the **total** power dissipated. In the LOAD [2 marks]
- Calculate the value of the currents I1 and I2 [5 marks]

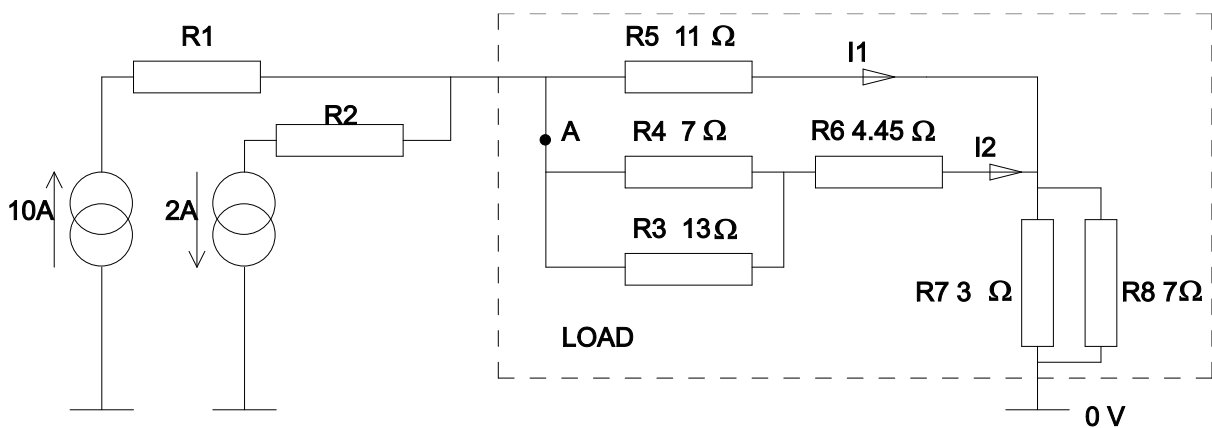


Figure 1

i.

$$R_{34} = \frac{R_3 \times R_4}{R_3 + R_4} = \frac{7 \times 13}{7 + 13} = \frac{91}{20}$$

$$R_{34} = 4.55 \, \Omega \quad [2 \text{ marks}]$$

$$R_{346} = R_{34} + R_6 = 4.55 + 4.45 = 9 \, \Omega \quad [2 \text{ marks}]$$

$$R_{3456} = \frac{R_{346} \times R_5}{R_{346} + R_5} = \frac{9 \times 11}{9 + 11} = \frac{99}{20} = 4.95 \, \Omega \quad [2 \text{ marks}]$$

$$R_{78} = \frac{R_7 \times R_8}{R_7 + R_8} = \frac{3 \times 7}{3 + 7} = \frac{21}{10} = 2.1 \, \Omega \quad [2 \text{ marks}]$$

$$R_L = R_{3456} + R_{78} = 4.95 + 2.1$$

$$R_T = 7.05 \, \Omega \quad [2 \text{ marks}]$$

ii.

$$I_T = 10A - 2A = 8A$$

$$I_T = 8A$$

$$R_L = 7.05 \, \Omega$$

$$V_A = I_T \times R_L = 8A \times 7.05 \Omega$$

$$V_A = 56.4 \text{ V} \quad [3 \text{ marks}]$$

iii.

$$P_L = I_T^2 \times R_L = 8^2 \times 7.05$$

$$P_L = 451.2 \text{ W} \quad [2 \text{ marks}]$$

iv.

$$I_1 = \left(\frac{R_{346}}{R_{346} + R_5} \right) I_T$$

$$I_1 = \left(\frac{9}{9 + 11} \right) 8 = \left(\frac{9}{20} \right) 8$$

$$I_1 = 3.6 \text{ A}$$

$$I_2 = \left(\frac{R_5}{R_{346} + R_5} \right) I_T$$

$$I_2 = \left(\frac{11}{9 + 11} \right) 8 = \left(\frac{11}{20} \right) 8$$

$$I_2 = 4.4 \text{ A} \quad [5 \text{ marks}]$$

Question Two (30 Marks)

- a) For the circuit in Figure 2, find the branch current I_1 , I_2 and I_3 using mesh analysis. [15 marks]

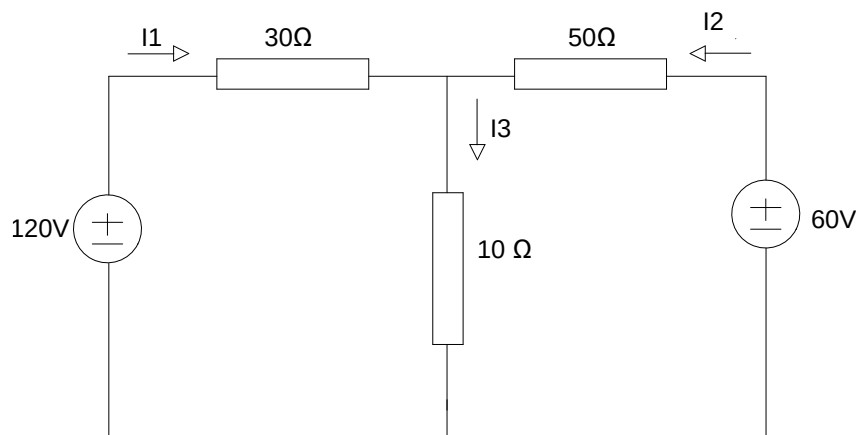


Figure 2

Solutions:

Obtain the mesh currents using KVL. For mesh 1.

$$-120 + 30I_1 + 10(I_1 + I_2) = 0$$

$$-120 + 30I_1 + 10I_1 + 10I_2 = 0$$

$$40I_1 + 10I_2 = 120$$

$$4I_1 + I_2 = 12 \quad [5 \text{ marks}]$$

For mesh 2:

$$-60 + 50I_2 + 10(I_1 + I_2) = 0$$

$$-60 + 50I_2 + 10I_1 + 10I_2 = 0$$

$$10I_1 + 60I_2 = 60$$

$$I_1 + 6I_2 = 6 \quad [5 \text{ marks}]$$

$$4I_1 + I_2 = 12 \quad (1)$$

$$I_1 + 6I_2 = 6 \quad (2)$$

$$4I_1 + I_2 = 12 \quad (1)$$

$$4I_1 + 24I_2 = 24 \quad (2)$$

$$4I_1 + I_2 = 12 \quad (1)$$

Subtract (-)

$$4I_1 + 24I_2 = 24 \quad (2)$$

$$-23I_2 = -12$$

$$I_2 = 0.522A$$

$$4I_1 + I_2 = 12 \quad (1)$$

$$4I_1 + 0.522 = 12$$

$$4I_1 = 12 - 0.522$$

$$4I_1 = 11.478$$

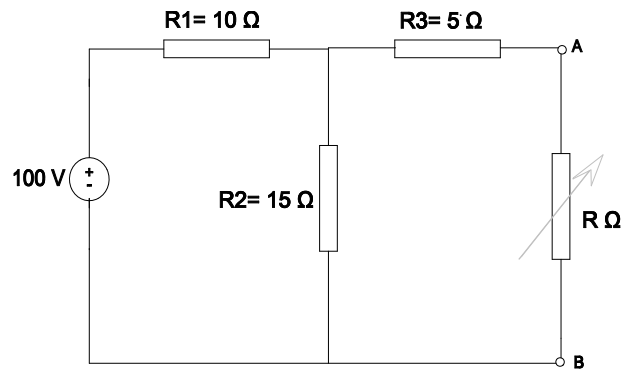
$$I_1 = 2.8695 A$$

$$I_3 = I_1 + I_2 = 2.8695 + 0.522$$

$$I_3 = 3.3915 A$$

Solution $I_1 = 2.8695 A$, $I_2 = 0.522 A$, $I_3 = 3.3915 A$ [5 marks]

- b. For the circuit shown in Figure 3, find:
- The Thevenin equivalent circuit for the network [8 marks]
 - The value of the adjustable resistance R that results in maximum power transfer across the terminals AB [2 marks]
 - The maximum power transferred in the load [2 marks]
 - Find Norton's equivalent circuit for the network. [3 marks]



Solution

Figure 3

i.

$$V_{Th} = \frac{15}{15 + 10} \times (100)$$

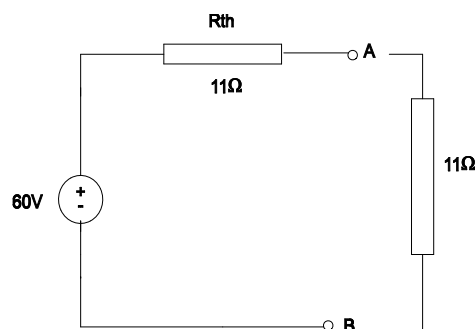
$$V_{Th} = \frac{15}{25} \times 100$$

$$V_{Th} = 60 \text{ volts}$$

$$R_{Th} = \frac{10 \times 15}{10 + 15} + 5$$

$$R_{Th} = \frac{150}{25} + 5$$

$$R_{Th} = 11 \Omega$$



[8 marks]

ii.

For maximum power transfers $R_L = R_{TH} = 11 \Omega$

$$R_L = 11 \Omega$$

[2 marks]

iii.

$$R_T = 11 \Omega$$
$$I_T = \frac{V_{TH}}{R_T} = \frac{60}{22}$$

$$I_T = 2.7 \text{ A}$$

$$P = I_T^2 R_L$$

$$P = 2.7^2 \times 11$$

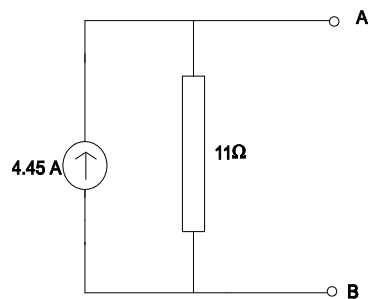
$$P = 80.2 \text{ W}$$

[2 marks]

iv.

$$R_N = R_{Th} = 11 \Omega$$

$$I_N = \frac{V_{Th}}{R_{TH}} = 5.45 \text{ A}$$

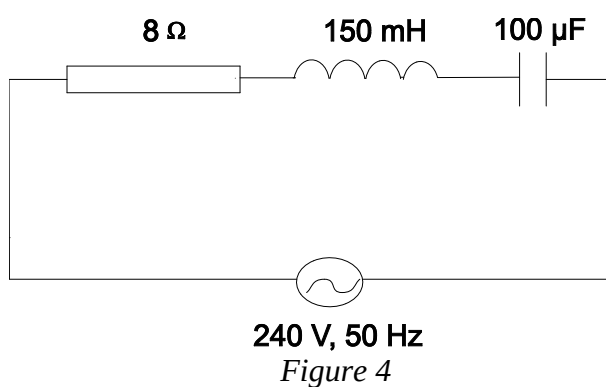


[3 marks]

Question Three (20 Marks)

A $100\mu\text{F}$ capacitor in series with a coil of resistance 8Ω and inductance 150mH is connected to a 240V , 50Hz a.c. supply as shown in Figure 4. Calculate:

- i. The circuit impedance [9 marks]
- ii. The current flowing in the circuit [2 marks]
- iii. The voltage across the coil [2 marks]
- iv. The voltage across the capacitor [2 marks]
- v. The phase angle between voltage and current [2 marks]
- vi. The real power dissipated [3 marks]



- i. The circuit impedance

$$X_L = 2\pi fL$$

$$X_L = 2\pi(50)(150 \times 10^{-3})$$

$$X_L = 47.123 \Omega$$

$$X_C = \frac{1}{2\pi fC}$$

$$X_C = \frac{1}{2\pi(50)(100 \times 10^{-6})}$$

$$X_C = 31.830 \Omega$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$Z = \sqrt{8^2 + (47.123 - 31.830)^2}$$

$$\mathbf{Z = 17.259 \, \Omega}$$

[9]

- ii. The current flowing in the circuit

$$I = \frac{V}{Z}$$

$$I = \frac{240}{17.259}$$

$$\mathbf{I = 13.905 \, A}$$

[2]

- iii. The voltage across the coil

$$Z_{coil} = \sqrt{R^2 + (X_L)^2}$$

$$Z_{coil} = \sqrt{8^2 + (47.123)^2}$$

$$\mathbf{Z_{coil} = 47.797 \, \Omega}$$

$$V_{coil} = I \times Z_{coil} \dots \dots \dots V_{coil} = 13.905 \times 47.797$$

$$\mathbf{V_{coil} = 664.617 \, V}$$

[2]

- iv. The voltage across the capacitor

$$V_C = I \times X_C \dots \dots \dots V_C = 13.905 \times 31.830$$

$$\mathbf{V_C = 442.596 \, V}$$

[2]

- v. The phase angle between voltage and current

$$\varphi = \cos^{-1} \frac{R}{Z}$$

$$\varphi = \cos^{-1} \frac{8}{17.259}$$

$$\mathbf{\varphi = 62.39^\circ}$$

[2]

vi. The real power dissipated

$$P = I^2 \times R$$

$$P = 13.905^2 \times 8$$

$$P = 1546.79 \text{ W}$$

[3]

Question Four (30 Marks)

a. Figure 4 below shows a coupled two stage amplifier circuit. Calculate:

- i. The DC current through R_1 and R_2 . [2 mark]
- ii. The DC voltage across R_1 and R_2 . [2 mark]
- iii. The DC voltage at the emitter for first stage. [1 mark]
- iv. The DC emitter and collector currents for first stage. [1 mark]
- v. The DC voltage at the collector for first stage. [1 mark]
- vi. The DC emitter voltage for the second stage. [1 mark]
- vii. The DC emitter current for the second stage. [1 mark]
- viii. The DC voltage at collector for the second stage. [1 mark]

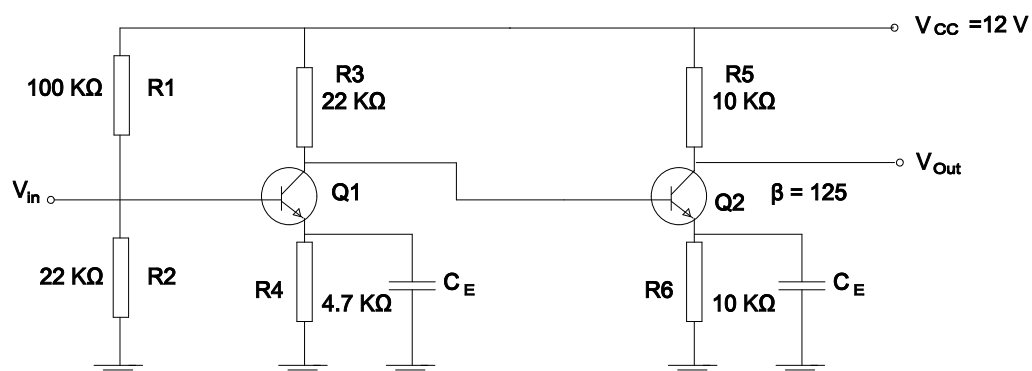


Figure 4

Solutions

i.

The DC current through R_1 and R_2

$$R_{12} = R_1 + R_2$$

$$R_{12} = 100 + 22 = 122 \text{ K}\Omega$$

$$I_{R_{12}} = \frac{V_{CC}}{R_{12}} = \frac{12}{122 \times 10^3} = 0.098 \text{ mA}$$

ii.

The DC voltage across R_1 and R_2 .

$$V_{R_1} = 0.098 \times 10^{-3} \times 100 \times 10^3 = 9.8 \text{ V}$$

$$V_{R_2} = 0.098 \times 10^{-3} \times 22 \times 10^3 = 2.2 \text{ V}$$

iii.

The DC voltage at the emitter for first stage.

$$V_{E_1} = 2.2 - V_{BE} = 2.2 - 0.7 = 1.5 \text{ V}$$

iv.

The DC emitter and collector currents for first stage.

$$I_{E_1} = \frac{V_{E_1}}{R_4} = \frac{1.5}{4.7 \times 10^3} = 0.319 \text{ mA}$$

$$I_{C_1} = 0.319 \text{ mA}$$

v.

The DC voltage at the collector for first stage.

$$V_{R_3} = I_{C_1} \times R_3 = 0.319 \times 10^{-3} \times 22 \times 10^3$$

$$V_{R_3} = 7 \text{ V}$$

$$V_{C_1} = V_{CC} - V_{R_3} = 12 - 7 = 5 \text{ V}$$

vi.

The DC emitter voltage for the second stage.

$$V_{E_2} = V_{C_1} - V_{BE} = 5 - 0.7 = 4.3 \text{ V}$$

vii.

The DC emitter current for the second stage.

$$I_{E_2} = \frac{V_{E_2}}{R_6} = \frac{4.3}{10 \times 10^3} = 0.43 \text{ mA}$$

viii.

The DC voltage at collector for the second stage.

$$V_{R_5} = I_{C_2} \times R_5$$

$$I_{C_2} = I_{E_2} = 0.43 \text{ mA}$$

$$V_{R_5} = I_{C_2} \times R_5 = 0.43 \times 10^{-3} \times 10 \times 10^3$$

$$V_{R_5} = 4.3 \text{ V}$$

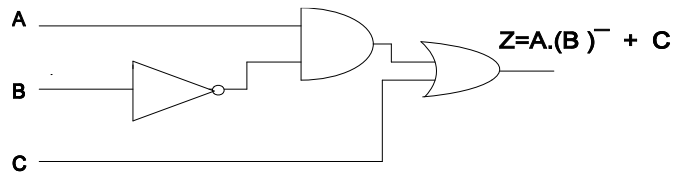
$$V_{C_2} = V_{CC} - V_{R_5} = 12 - 4.3 = 7.7 \text{ V}$$

b. Draw the logic circuit design for the following Boolean equations below.

[9 marks]

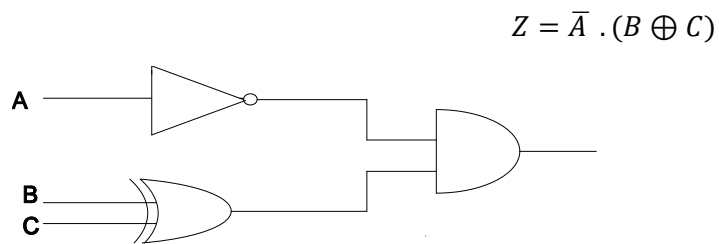
i. $Z = A.\bar{B} + C$

Solution



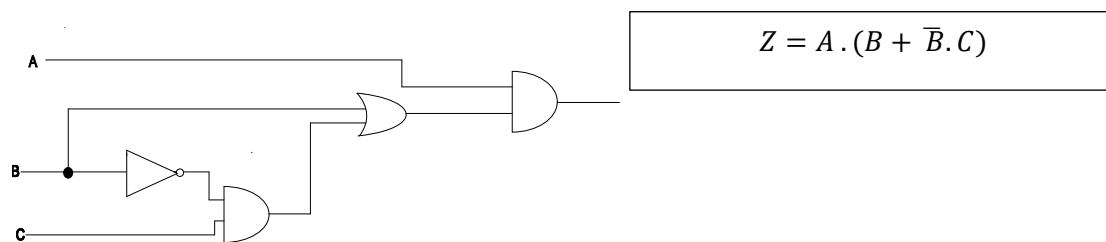
ii. $Z = \bar{A} . (B \oplus C)$

Solution



iii. $Z = A . (B + \bar{B}.C)$

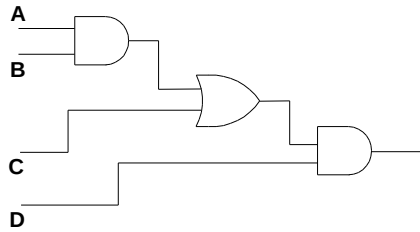
Solution



c. Write Boolean algebraic expressions for the circuits below.

[6 marks]

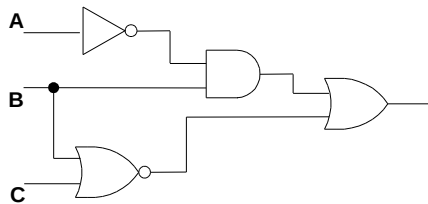
i.



Solution

$$\text{output} = (A.B + C)D$$

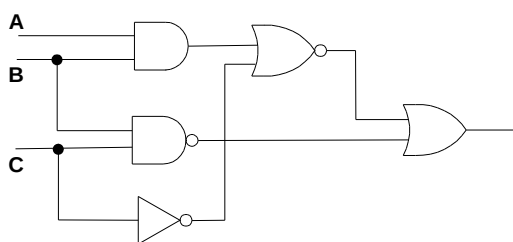
ii.



Solution

$$\text{output} = (\bar{A}.B + \overline{(B + C)})$$

iii.



Solution

$$\text{output} = \overline{(B.C)} + \overline{(AB + \bar{C})}$$

- d. Simplify the output function X using DeMorgan's theorem.

[5 marks]

$$X = \overline{(\overline{A.B})(\bar{A} + C)}$$

$$X = \overline{(\overline{A.B})(\bar{A} + C)} = \overline{(\overline{A.B})} + \overline{(\bar{A} + C)}$$

$$X = (A.B) + (\bar{\bar{A}} . \bar{C})$$

$$X = (A.B) + (A . \bar{C})$$

$$X = AB + A\bar{C}$$

End