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LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 4

LEFEL 4

EXAMINATION PERIOD
MAY 2020

CYFNOD ARHOLIADAU
MAI 2020

SOLUTIONS

MODULE CODE: M4X00935

ELECTRICAL AND ELECTRONIC PRINCIPLES

TIME: 2 HOURS

ANSWER ALL QUESTIONS

Equipment or materials required – Calculator

Question One (25marks)

- a) For the parallel-series circuit shown in Figure 1, where $R_1 = 6\Omega$, $R_2 = 12\Omega$, $R_3 = 4\Omega$, $R_4 = 3\Omega$, $R_5 = 5\Omega$. Determine:
- i. The equivalent resistance of the circuit [4]
 - ii. The total current of the circuit [1]
 - iii. The power dissipated by the circuit [1]
 - iv. The current through the 3Ω resistor [2]
 - v. The voltage across the 5Ω resistor [1]
 - vi. The voltage across the 6Ω resistor [2]
 - vii. The current through the 12Ω resistor [2]

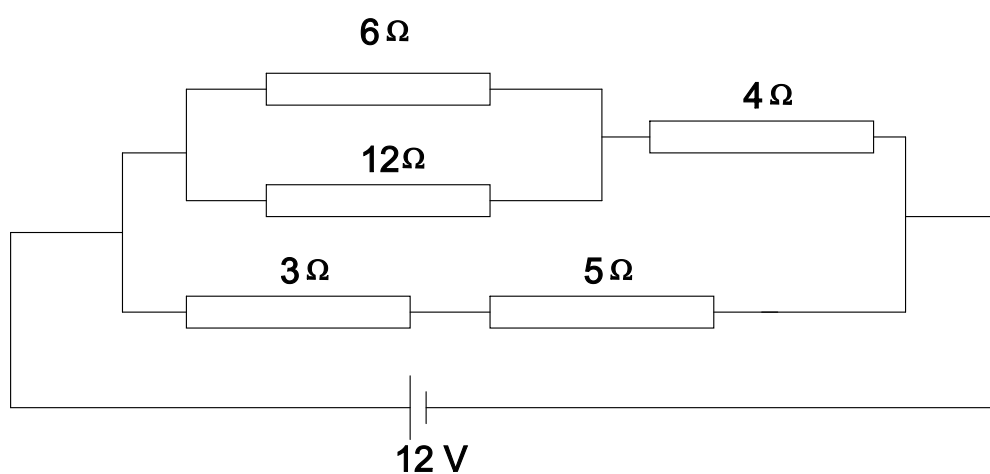


Figure 1

The equivalent resistance of the circuit

$$R_{12} = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{6 \times 12}{6 + 12}$$

$$R_{12} = 4\Omega$$

$$R_{123} = 4 + 4 = 8\Omega$$

$$R_{45} = 3 + 5 = 8\Omega$$

$$R_{12345} = \frac{R_{123} \times R_{45}}{R_{123} + R_{45}} = \frac{8 \times 8}{8 + 8}$$

$$R_{12345} = 4\Omega$$

[4]

The total current of the circuit

$$I = \frac{V}{R_T} = \frac{12}{4}$$

$$I = 3 \text{ A}$$

[1]

The power dissipated by the circuit

$$P = I^2 R = (3^2)(4)$$

$$P = 36 \text{ W}$$

[1]

The current through the 3Ω resistor

The current through the 3Ω resistor is $\frac{12}{8} = 1.5 \text{ A}$

[2]

The voltage across the 5Ω resistor

The current through the 5Ω resistor = the current through the 3Ω resistor

The current through the 5Ω resistor is $= \frac{12}{8} = 1.5 \text{ A}$

So the voltage across the 5Ω resistor is $= 1.5 \times 5 = 7.5 \text{ V}$

[1]

The voltage across the 6Ω resistor

The voltage across the 4Ω resistor is $1.5 \times 4 = 6 \text{ volts}$

So the voltage across the 6Ω resistor = 6 volts

[2]

The current through the 12Ω resistor $\frac{6}{12} = 0.5 \text{ A}$

[2]

- b) Figure 2 shows a circuit containing two voltage sources with their internal resistance; determine the current in each branch of the network by using Kirchhoff's Laws.

[12]

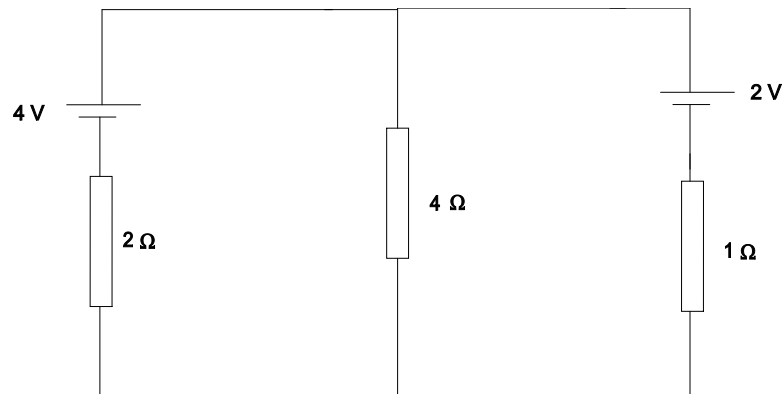
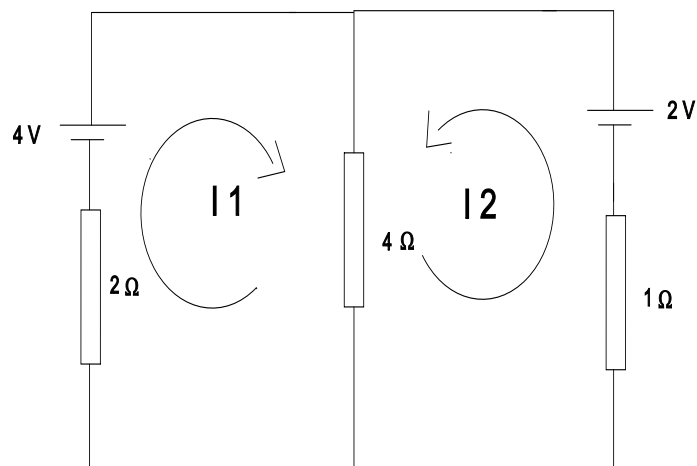


Figure 2



Loop 1:

$$2I_1 - 4 + 4(I_1 + I_2) = 0$$

$$2I_1 - 4 + 4I_1 + 4I_2 = 0$$

$$6I_1 + 4I_2 = 4 \dots \dots \dots (1)$$

[2.5]

Loop 2:

$$1I_2 - 2 + 4(I_1 + I_2) = 0$$

$$1I_2 - 2 + 4I_1 + 4I_2 = 0$$

$$4I_1 + 5I_2 = 2 \dots\dots\dots(2)$$

[2.5]

$$6I_1 + 4I_2 = 4 \dots\dots\dots(1) \quad \times 4$$

$$4I_1 + 5I_2 = 2 \dots\dots\dots(2) \quad \times 6$$

$$24I_1 + 16I_2 = 16 \dots\dots\dots(1)$$

$$24I_1 + 30I_2 = 12 \dots\dots\dots(2)$$

$$-14I_2 = 4$$

$$I_2 = -0.286 \text{ A}$$

[3]

$$6I_1 + 4(-0.286) = 4$$

$$6I_1 = 1.144 + 4$$

$$I_1 = \frac{5.144}{6}$$

$$I_1 = 0.857 \text{ A}$$

[2]

The current through the 4Ω resistor = $I_1 + I_2$

The current through the 4Ω resistor = 0.57 A

[2]

Question Two (25marks)

For the circuit shown in Figure 3, find:

- i. The Thevenin equivalent circuit for the network [8]
- ii. The value of R_L to provide maximum power to the load [4]
- iii. The maximum power transferred in the load [8]
- iv. The current through R_L when $R_L = 100\Omega$ [5]

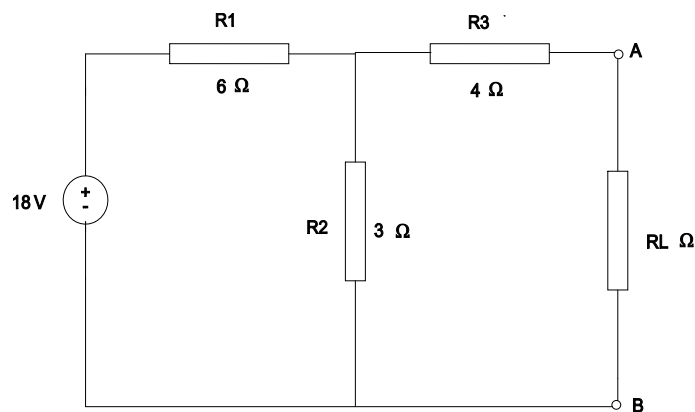


Figure 3

$$V_{Th} = \frac{3}{6+3} \times (18)$$

$$V_{Th} = \frac{3}{9} \times 18$$

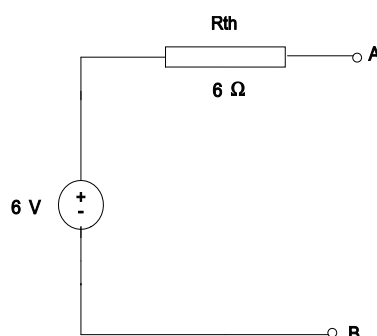
$$V_{Th} = 6 \text{ volts}$$

$$R_{Th} = \frac{6 \times 3}{6+3} + 4$$

$$R_{Th} = \frac{18}{9} + 4$$

$$R_{Th} = 6 \Omega$$

[8]

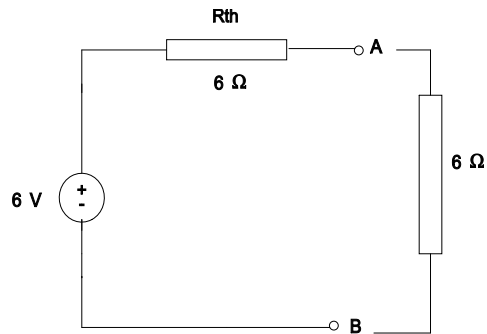


For maximum power transfers $R_L = R_{TH} = 6 \Omega$

$$R_L = 6 \Omega$$

[4]

The maximum power transferred in the load



$$R_T = 12 \Omega$$

$$I_T = \frac{V_{TH}}{R_T} = \frac{6}{12}$$

$$I_T = 0.5 A$$

$$P = I_T^2 R_L$$

$$P = 0.5^2 \times 6$$

$$P = 1.5 W$$

[8]

When $R_L = 100 \Omega$

$$R_T = 106 \Omega$$

$$I_T = \frac{V_{TH}}{R_T} = \frac{6}{106}$$

$$I_T = 0.057 A$$

[5]

Question three (25marks)

- a) A 40 μF capacitor in series with a coil of resistance 8Ω and inductance 80mH is connected to a 200V, 100 Hz supply as shown in Figure 4. Calculate:
- i. The circuit impedance [7]
 - ii. The current flowing in the circuit [2]
 - iii. The voltage across the coil [2]
 - iv. The voltage across the capacitor [2]
 - v. The phase angle between voltage and current [2]

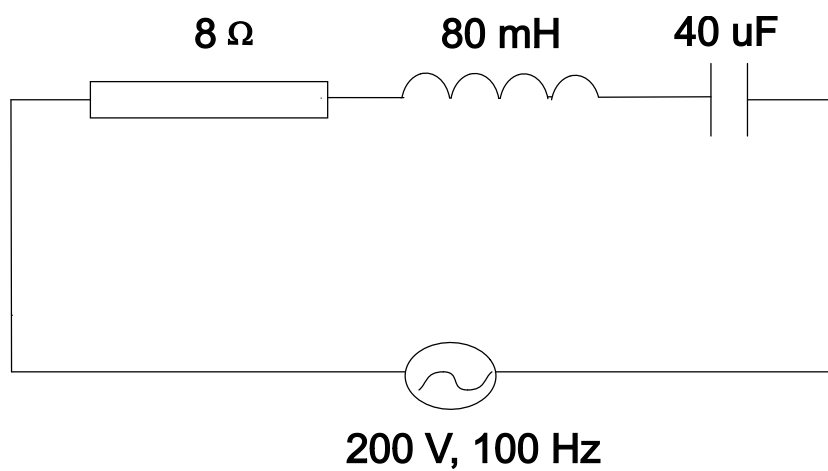


Figure 4

The circuit impedance

$$X_L = 2\pi fL$$

$$X_L = 2\pi(100)(80 \times 10^{-3})$$

$$X_L = 50.27 \Omega$$

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

$$X_C = \frac{1}{2\pi(100)(40 \times 10^{-6})}$$

$$X_C = 39.79 \Omega$$

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

$$Z = \sqrt{8^2 + (50.27 - 39.79)^2}$$

$$\mathbf{Z = 13.18 \, \Omega}$$

[7]

The current flowing in the circuit

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

$$I = \frac{200}{13.18}$$

$$\mathbf{I = 15.17 \, A}$$

[2]

The voltage across the coil

$$V_L = I \times X_L \dots\dots\dots V_L = 15.17 \times 50.27$$

$$\mathbf{V_L = 762.6 \, V}$$

[2]

The voltage across the capacitor

$$V_C = I \times X_C \dots\dots\dots V_C = 15.17 \times 39.79$$

$$\mathbf{V_C = 603.6 \, V}$$

[2]

The phase angle between voltage and current

$$\varphi = \frac{(X_L - X_C)}{R}$$

$$\varphi = \tan^{-1} \frac{(50.27 - 39.79)}{8}$$

$$\varphi = \tan^{-1} 1.31$$

$$\mathbf{\varphi = 52.64^\circ}$$

[2]

b) A coil of resistance 25Ω and inductance 100mH is connected in series with a capacitance of $12\mu\text{F}$ across a 200V , variable frequency supply as shown in figure 5. Calculate;

- i. The resonant frequency [2]
- ii. The inductive reactance X_L at resonance [1]
- iii. The capacitive reactance X_C at resonance [1]
- iv. The current at resonance [2]
- v. The voltage across the capacitor at resonance [1]
- vi. The voltage across the inductor at resonance [1]
- vii. The factor by which the voltage across the reactance is greater than the supply voltage. [2]

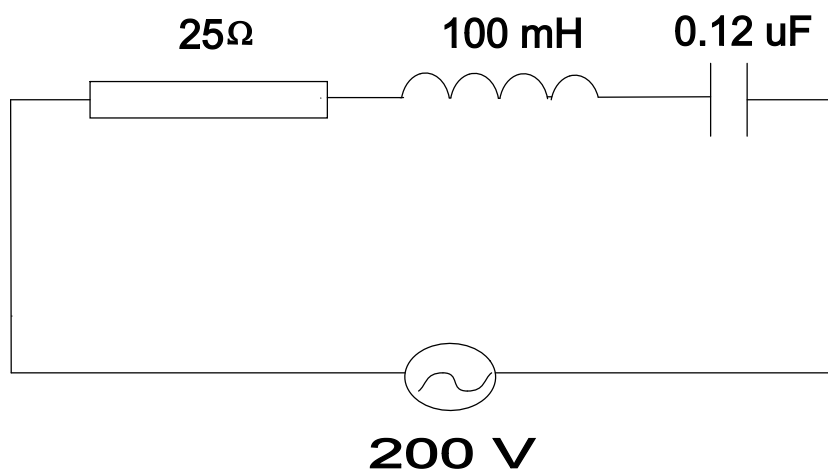


Figure 5

The resonant frequency

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$f = \frac{1}{2\pi\sqrt{(100 \times 10^{-3})(0.12 \times 10^{-6})}}$$

$$f = 1452.88 \text{ Hz}$$

[2]

The inductive reactance X_L

$$X_L = 2\pi fL \dots\dots X_L = 2\pi(1452.88)(100 \times 10^{-3})$$

$$X_L = 912.87 \Omega$$

[1]

The capacitive reactance X_C

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

$$X_C = \frac{1}{2\pi(1452.88)(0.12 \times 10^{-6})}$$

$$X_C = \mathbf{912.87 \, \Omega}$$

[1]

The current at resonance

$$Z = R \text{ since } X_L = X_C$$

$$I = \frac{V}{R} = \frac{200}{25} \dots \dots \dots I = \mathbf{8 \, A \text{ the current at resonance}}$$

[2]

The voltage across the capacitor

$$V_C = I \times X_C$$

$$V_C = 7302.96 \text{ Volts}$$

[1]

The voltage across the inductor

$$V_L = I \times X_L$$

$$V_L = 7302.96 \text{ Volts}$$

[1]

The factor by which the voltage across the reactance is greater than the supply voltage

$$\frac{\text{voltage across the reactance}}{\text{supply voltage}} = \frac{\mathbf{7302.96}}{\mathbf{200}} = \mathbf{36.51}$$

[2]

Question Four (10marks)

- a) Assume the diode in Figure 6 is ideal. Determine:
- The value of the current through the diode if the supply voltage (5) volts. [2]
 - The value of the current through the diode if the supply voltage (-5) volts. [2]

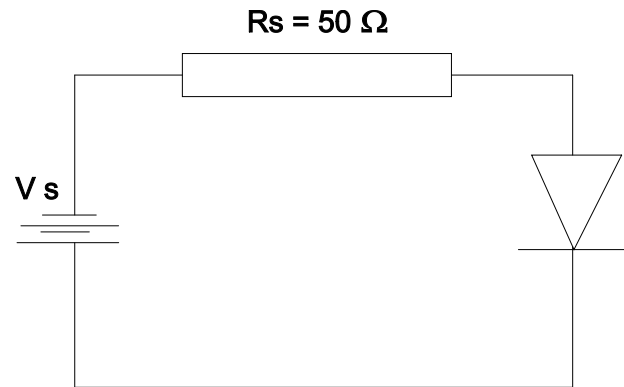


Figure 6

Solution

- i) With $V_A > 0$ the diode is in forward bias and is acting like a perfect conductor ($V_D=0$) so:

$$I_D = \frac{V_s}{R_s}$$

$$I_D = \frac{5\text{ V}}{50\ \Omega}$$

$$I_D = 100\text{ mA}$$

- ii) With $V_A < 0$ the diode is in reverse bias and is acting like a perfect insulator, therefore no current can flow and $I_D = 0$ ($V_A = V_D$).

$$I_D = 0\text{ A}$$

- b) The circuit in Figure 7 is a common emitter amplifier, If $R_1 = 27\text{k}\Omega$, $R_2 = 7.8\text{k}\Omega$, $R_C = 2.2\text{k}\Omega$, $R_E = 1.0\text{k}\Omega$, $V_{CC} = 15\text{V}$, $V_{BE} = 0.7\text{V}$ and $I_{R1} = 0.44\text{mA}$. Determine:
- The current through R_2 [3]
 - The current through R_E , and [2]
 - The gain of the amplifier. [1]

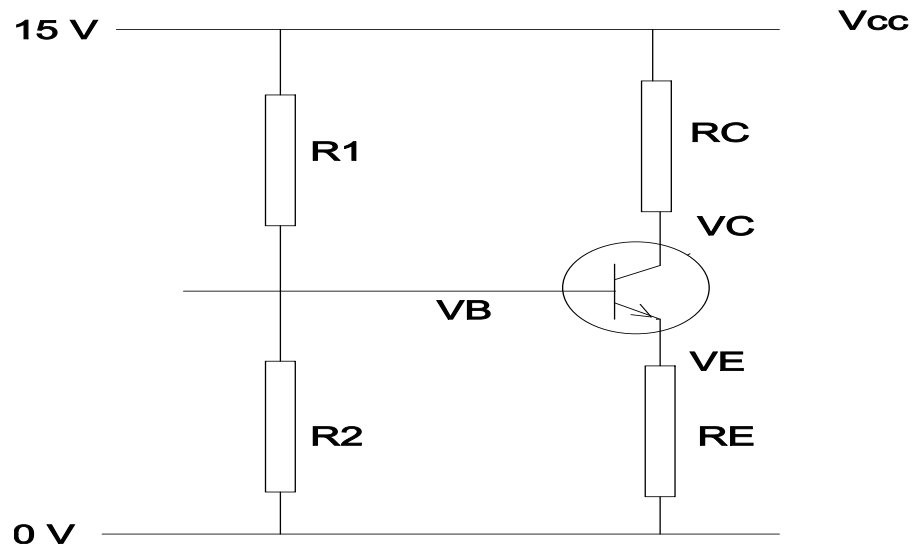


Figure 7

The current through R_2

$$V_{R1} = I_{R1} \times R_1$$

$$V_{R1} = 0.44 \times 10^{-3} \times 27 \times 10^3$$

$$V_{R1} = 11.88 \text{ V}$$

$$V_{R2} = 15 - V_{R1}$$

$$V_{R2} = 15 - 11.88$$

$$V_{R2} = 3.12 \text{ V}$$

$$I_{R2} = \frac{V_{R2}}{R_2} = \frac{3.12}{7.8 \times 10^3}$$

$$I_{R2} = 0.4 \text{ mA}$$

[3]

The current through R_E

$$V_{RE} = V_{R2} - V_{BE}$$

$$V_{RE} = 3.12 - 0.7$$

$$V_{RE} = 2.42 \text{ V}$$

$$I_{RE} = \frac{V_{RE}}{R_E} = \frac{2.42}{1 \times 10^3}$$

$$\mathbf{I_{RE} = 2.42 \text{ mA}}$$

[2]

The gain of the amplifier

$$\mathbf{Gain = \frac{R_C}{R_E} = \frac{2.2}{1}}$$

$$\mathbf{Gain = 2.2}$$

[1]