

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

EXAMINATION PERIOD
MAY 2025

CYFNOD ARHOLIADAU
MAI 2025

MODULE CODE: GOEE5001

ELECTRICAL PRINCIPLES THEORY

TIME: 2 HOURS

ANSWER ALL QUESTIONS

SHOW ALL CALCULATIONS AND WORKINGS CLEARLY

Equipment or materials required – Calculator, Formula Sheet

Question One (30 marks)

- a. A series RLC circuit has the following total impedance in the Laplace domain:

$$Z(s) = 2s + \frac{1000}{s} + 6$$

Determine the values of the resistor R, inductor L and the capacitor C in the circuit.

[5 marks]

- b. Compute the Laplace transform of the given functions:

[10 marks]

i. $3e^{3t} \cos(2t) + t^2 + 0.75$

ii. $\sin(4t) e^t + 5e^{-3t}$

iii. $e^{2t}(3 - t^2) + \frac{3\pi}{2}$

iv. $t \cosh(2t) + e^{-2t}$

v. $e^2 e^{-4t} t^3 - 3e^t \sin(e^2 t)$

- c. A series RL circuit, as shown in Figure 1, is connected to an exponential voltage source $v(t) = 80e^{-10t}$ volts for $t \geq 0$. The circuit contains a resistance $R = 4\Omega$ and an inductance $L = 0.5H$.

The switch is closed at $t = 0$. The circuit is described by the following differential equation:

$$L \frac{di}{dt} + Ri = v(t)$$

Using the Laplace transform method, determine the current $i(t)$ for $t \geq 0$, assuming $i(0) = 0$.

[15 marks]

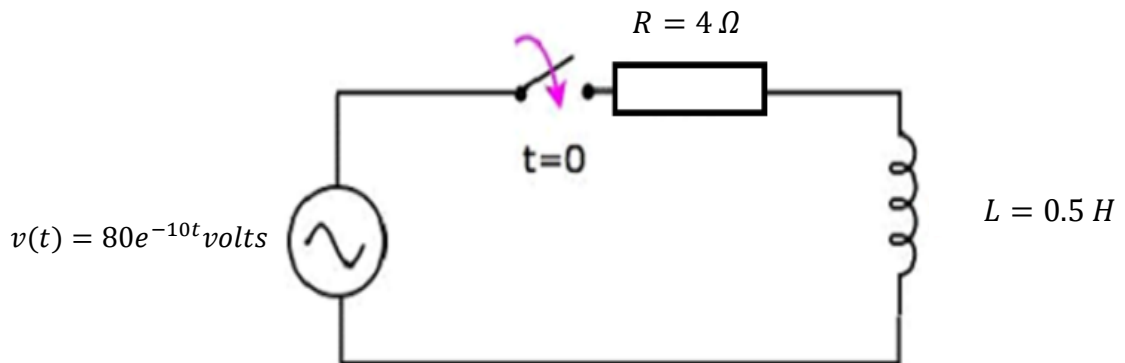


Figure 1

Question Two (30 marks)

a. Determine the fundamental frequency of the following signals:

i. $x(t) = 2 + 3 \cos(0.2t) + \cos(0.25t + \frac{\pi}{2}) + 4 \cos(0.3t - \pi)$

[3 marks]

ii. $x(t) = 1 + 10 \cos\left(2\pi(60)t + \frac{\pi}{8}\right) + 2 \cos(2\pi(300)t + \frac{\pi}{4})$

[2 marks]

b. Figure 2 below shows the waveform graph of a periodic square wave $f(x)$, defined by the following piecewise function:

$$f(x) = \begin{cases} 1 & \text{if } -\pi \leq x < 0 \\ 0 & \text{if } 0 \leq x < \pi \end{cases}$$

And the function is periodic with $f(x + 2\pi) = f(x)$.

Write down the real Fourier series expression for $f(x)$, explicitly including the first five non-zero terms.

[25 marks]

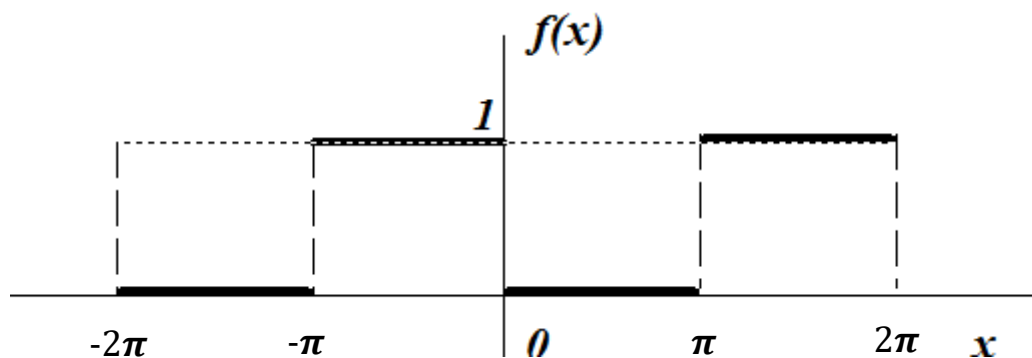


Figure 2

Question Three (20 marks)

For the circuit shown in Figure 3, determine:

- a. The Thevenin equivalent circuit with respect to terminals A and B. [10 marks]
- b. The load impedance Z_L that maximizes the power drawn. [3 marks]
- c. The maximum average power. [7 marks]

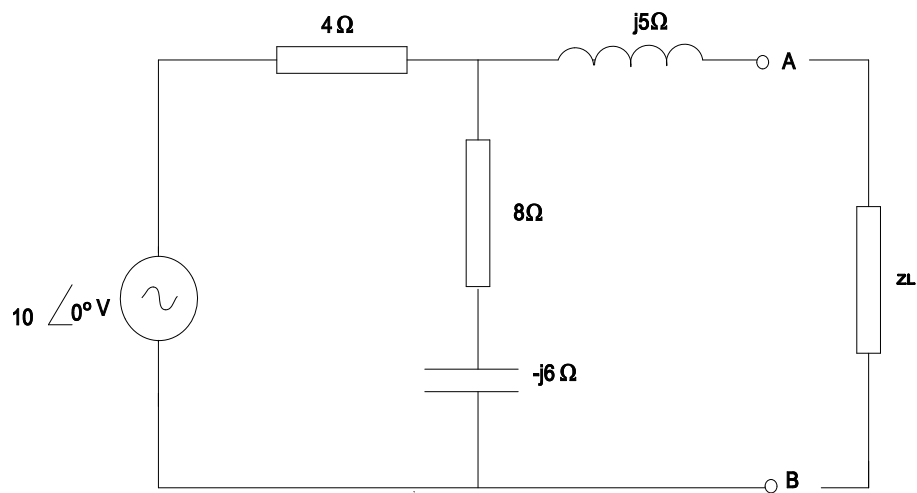


Figure 3

Question Four (20 marks)

- a. In the UK, three-phase systems are often configured as either star (Y) or delta (Δ). When dealing with motor loads, it is common for the motor to start in star configuration and then be switched to delta configuration after reaching a specific speed to provide higher torque.

Consider the star-connected load in Figure 4 below with the following impedance:

$$Z_A = 10 + j6 \, \Omega$$

$$Z_B = 8 + j4 \, \Omega$$

$$Z_C = 12 + j8 \, \Omega$$

Provide the equivalent delta network impedance in both Polar and Cartesian (Rectangular) forms.

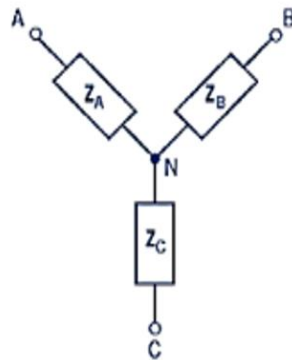


Figure 4

[10 marks]

- b. A periodic voltage source is represented by the waveform:

$$v(t) = 300 \cos(2\pi 120t) + 100 \cos(4\pi 120t) \, V,$$

and is applied across a circuit. The resulting current through the circuit is given by the Fourier series:

$$i(t) = 15 \cos(2\pi 120t - 30^\circ) + 5 \cos(6\pi 120t + 60^\circ) \, A$$

Determine:

- The rms values of both the voltage and the current.
[4 marks]
- The real (average) power delivered to the circuit and the power factor of the circuit.
[6 marks]

End