MACHAKOS UNIVERSITY

University Examinations 2023/2024

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SPH 304: AC CIRCUIT THEORY

DATE: **TIME:**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

QUESTION ONE (30 marks)

a) Explain what you understand by the following terms

i. Electrical filter circuits (2 marks)

ii. Cut-off frequency of a filter circuit (2 marks)

b) If an ideal generator of e.m.f $e = 400 \sin 1000t$ V is applied to a series circuit consisting of a pure inductor, inductance 100 mH, and a capacitor, capacitance 5 μF, determine the instantaneous current flowing in the circuit. (4 marks)

c) The RLC circuit shown in Figure 1 is at resonance. Calculate

i. The resonant frequency (3 marks)

ii. The Q-factor (3 marks)

iii. The p.d across the inductor (3 marks)

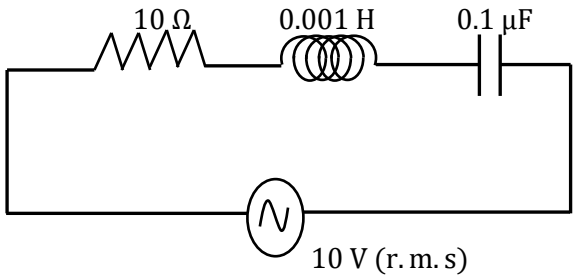

Figure 1

d) Two circuits with impedances of $Z_1 = 10 + j15\ \Omega$ and $Z_2 = 6 - j8\ \Omega$ are connected in parallel. If the total current supplied is 15A, determine,

(i) Calculate the total impedance (in polar form) (4 marks)

(ii) Draw the circuit Phasor diagram showing all currents. (4 marks)

(iii) Calculate the power factor for the whole circuit. (2 marks)

e) A 100- Ω transmission line is connected to a load consisting of a 50-Ω resistor in series with a 10-pFcapacitor as shown in Figure 2 calculate the reflection coefficient at the load for a 100-MHz signal. (3 marks)

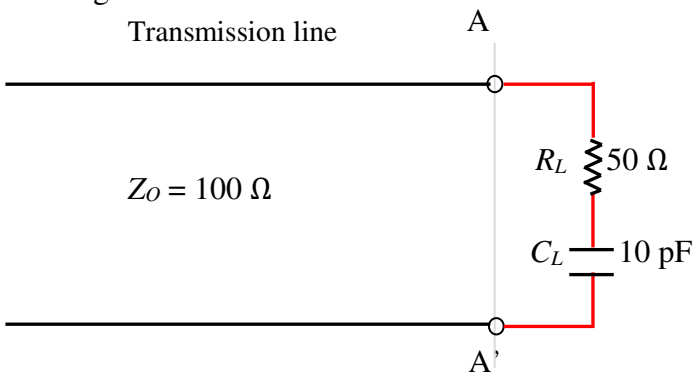

Figure 2

QUESTION TWO (20 MARKS)

a) Define the following terms as used in transmission lines

i. Propagation constant (2 marks)

ii. Characteristic impedance (2 marks)

b) A 15 mH inductor is in series with a parallel combination of an 80 Ω resistor and a 20 μF capacitor. If the angular frequency of the applied voltage is ω =1000 rad/s, calculate the admittance of the network. (3 marks)

c) For the RC series circuit shown in Figure 3, determine the frequency *f* of the ideal generator, if the current flowing in the circuit is 1 mA (r.m.s). (3 marks)

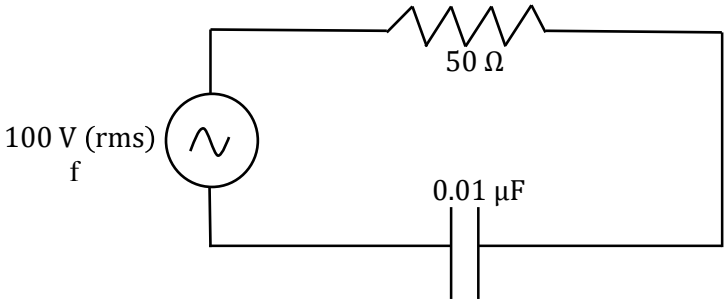

Figure 3

d) A 32 V, 1000 Hz supply voltage is applied across a 100 ohm resistor, 400 mH inductor, and 20 uF capacitor connected in series. Calculate

i. the rms current in the circuit. (3 marks)

ii. the phase angle between the voltage E and current I (3 marks)

e) A generator whose internal resistance is 1 Ω furnishes an e.m.f of 10 V at a frequency of $\frac{10{,}000}{\pi}$ Hz. Design a series RLC circuit so that a potential difference of 1000 V may be developed across the capacitor. (4 marks)

QUESTION THREE (20 marks)

a) Define the following terms for series AC circuits

i. Resonance (2 marks)

ii. Q-factor (2 marks)

b) A transmission line has the propagation constant $\gamma = 0.1 + j10\ /\text{m}$, and characteristic impedance $Z_0 = 50 + j5\ \Omega$. The line is terminated with impedance $100 - j30\ \Omega$. Determine the impedance at a distance of 1.5 m from the load. (5 marks)

c) If a variable frequency e.m.f. is applied to a series RLC circuit consisting of $R = 5\ \Omega$, $L = 200$ mH and $C = 0.05$ μF, determine the values of angular frequency ω for which the current will lead the applied voltage by 30^o (3 marks)

d) A transmission line operating at $f =$ 500 MHz has $Z_0 = 80\ \Omega$, $\alpha = 0.04$ Np/m $\beta = 1.5$ rad/m, where symbols have their usual meaning. Calculate the line parameters R, L, G, and C. (8 marks)

QUESTION FOUR (20 MARKS)

a) Define the following quantities and state their SI units

(i) Impedance (2 marks)

(ii) Susceptance (2 marks)

b) A two-wire air-line has the following line parameters: $R = 0.404$ (m Ω /m), $L = 2.0$ (μH/m), $G = 0$, and $C = 5.56$ (pF/m). For operation at 5 kHz, determine

i. the complex propagation constant γ (5 marks)

ii. the characteristic impedance Z_0 (5 marks)

c) If the current in a series RC circuit is given by $i = 2\cos\ (1000t + 10^0)$ ampere and the applied voltage is given by $e = 100\cos\ (1000t + 55^0)$ volts, calculate the values of R and C. (6 marks)

QUESTION FIVE (20 MARKS)

a) With the aid of diagrams, distinguish between the following types of transmission lines
   i. Co-axial line (2 marks)
   ii. Open line wire (2 marks)

b) A high-pass RC filter consists of a 100 kΩ resistor and a 50 pF capacitor. Calculate
   i. the cut-off frequency f_c of the filter (2 marks)
   ii. the ratio of the peak output voltage and peak input voltage at frequency of 0.1 f_c (2 marks)
   iii. At what frequency is the peak output voltage one half the peak input voltage? (3 marks)

c) The circuit shown in Figure 4 is made up of two parallel branches (a) and (b). Branch (a) consists of a resistance of 60 Ω, branch (b) consists of a resistance of 20 Ω in series with a capacitor of capacitance 80 μF. An emf of 250 V (r.m.s) at 50 Hz is applied to the circuit. Determine
   i. the scalar admittance of the circuit. (3 marks)
   ii. the total r.m.s current I_t (2 marks)
   iii. the r.m.s current in each branch. (4 marks)

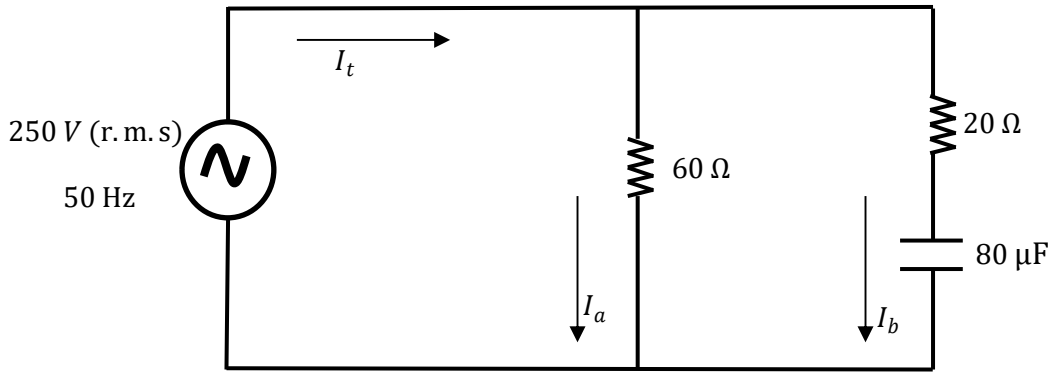

Figure 4