



# MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR SUPPLEMENTARY/SPECIAL EXAMINATION FOR  
BACHELOR OF EDUCATION (SCIENCE)

SPH 304: AC CIRCUIT THEORY

DATE: 16/3/2022

TIME: 8:30 – 10:30 AM

## 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

(a) A transmission line has the following per-unit-length parameters:  $L = 0.5 \mu\text{H/m}$ ,  $C = 200 \text{ pF/m}$ ,  $R = 4.0 \Omega/\text{m}$ , and  $G = 0.02 \text{ S/m}$ . Calculate the following parameters of the line at 800 MHz:

- (i) the propagation constant  $\gamma$ , and (3 marks)
- (ii) the characteristic impedance  $Z_0$ . (3 marks)
- (iii) If the line is 30 cm long, what is the attenuation in dB? (3 marks)

(b) Define the following quantities and state their SI units

- (i) Impedance (2 marks)
- (ii) Susceptance (2 marks)

(c) If the current in a series  $RL$  circuit is given by  $i = 10 \sin (1.0 \times 10^3 t - 25^\circ)$  ampere and the applied e.m.f is given by  $e = 400 \sin (1.0 \times 10^3 t + 20^\circ)$  volts, calculate the values of  $R$  and  $L$ . (5 marks)

- (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,
- Power taken by each branch (4 marks)
  - Power factor for the combination (3 marks)
  - Draw the circuit vector diagram. (2 marks)
- (e) A 100- $\Omega$  transmission line is connected to a load consisting of a 50- $\Omega$  resistor in series with a 10-pF capacitor as shown in Figure 1 calculate the reflection coefficient at the load for a 100-MHz signal. (3 marks)

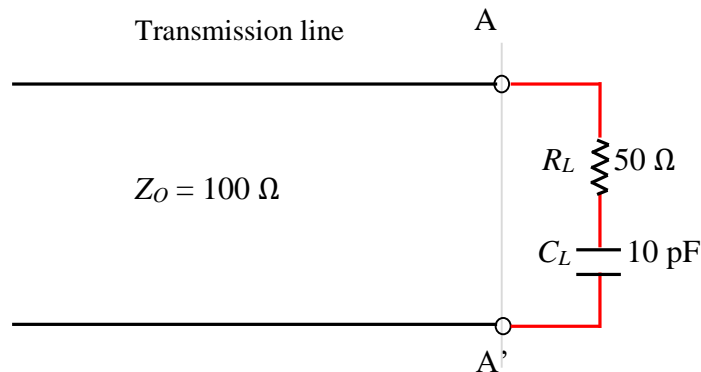


Figure 1

## QUESTION TWO

- Define the following terms for series AC circuits
  - Resonance (2 marks)
  - Q-factor (2 marks)
- A 15 mH inductor is in series with a parallel combination of an 80  $\Omega$  resistor and a 20  $\mu\text{F}$  capacitor. If the angular frequency of the applied voltage is  $\omega = 1000 \text{ rad/s}$ , calculate the admittance of the network. (3 marks)
- For the RC series circuit shown in Figure 2, determine the frequency of the ideal generator, if the current flowing in the circuit is 1 mA (r.m.s). (3 marks)



- A 321V (r.m.s) voltage is applied across a 100-ohm resistor, 400 mH inductor, and 20 uF capacitor connected in series. Calculate
  - the rms current in the circuit? (3 marks)
  - the phase angle between the voltage E and current I (3 marks)

Figure 2

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

### QUESTION THREE

- a) Define the following terms as used in transmission lines
- Propagation constant (2 marks)
  - Characteristic impedance (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  $1.5 \text{ m}$  from the load. (4 marks)
- c) A series RLC circuit consists of a  $100 \Omega$  resistor, an inductor of  $0.318 \text{ H}$  and a capacitor of unknown value. When this circuit is energized by  $230\sqrt{2} \sin 100\pi t$  volts a.c. supply, the current is found to be  $2.3\sqrt{2} \sin 100\pi t$ . Calculate
- the value of capacitor in microfarads. (3 marks)
  - the voltage across the inductor. (3 marks)
- d) If a variable frequency e.m.f. is applied to a series RLC circuit consisting of  $R = 5 \Omega$ ,  $L = 200 \text{ mH}$  and  $C = 0.05 \mu\text{F}$ , determine the values of angular frequency  $\omega$  for which the current will
- be in-phase with applied voltage (3 marks)
  - lead the applied voltage by  $30^\circ$  (3 marks)

### QUESTION FOUR

- a) With the aid of diagrams, distinguish between the following types of transmission lines
- Co-axial line (2 marks)
  - Open line wire (2 marks)
- b) A two-wire air-line has the following line parameters:  $R = 0.404 \text{ (m}\Omega / \text{m)}$ ,  $L = 2.0 \text{ (}\mu\text{H/m)}$ ,  $G = 0$ , and  $C = 5.56 \text{ (pF/m)}$ . For operation at  $5 \text{ kHz}$ , determine
- the attenuation constant  $\alpha$ , (4 marks)
  - the phase constant  $\beta$ , (3 marks)
  - the characteristic impedance  $Z_0$  (3 marks)

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

### QUESTION FIVE

- a) What do you understand by the following terms?
- i. Electrical filter circuits (2 marks)
  - ii. Cut-off frequency of a filter circuit (2 marks)
- b) A high-pass RC filter consists of a  $100 \text{ k}\Omega$  resistor and a  $50\text{-pF}$  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) Two admittances,  $Y_1 = (0.167 - j0.167) \text{ S/m}$ , and  $Y_2 = (0.1 + j0.05) \text{ S/m}$  are connected across a  $100 \text{ V}$ ,  $50 \text{ Hz}$  single-phase supply. Determine
- i. the current in each branch and the total current. (4 marks)
  - ii. the power factor of the combination. (3 marks)
  - iii. Sketch a neat phasor diagram. (2 marks)