MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

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: 23/8/2022 **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 (COMPULSORY) (30 MARKS)

a) Define the following quantities and state their SI units

i. Propagation constant (2 marks)

ii. Characteristic impedance (2 marks)

b) 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 γ, and (5 marks)

ii. the characteristic impedance Z_0. (4 marks)

c) If the current in a series RL circuit is given by $I = 10\sin\ (1.0 \times 10^3 t - 25^0)$ ampere and the applied e.m.f is given by $V = 400\sin\ (1.0 \times 10^3 t + 20^0)$ 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,

i. Power taken by each branch (4 marks)

ii. Power factor for the combination (3 marks)

iii. Draw the circuit vector diagram. (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 1 calculate the reflection coefficient at the load for a 100-MHz signal. (3 marks)

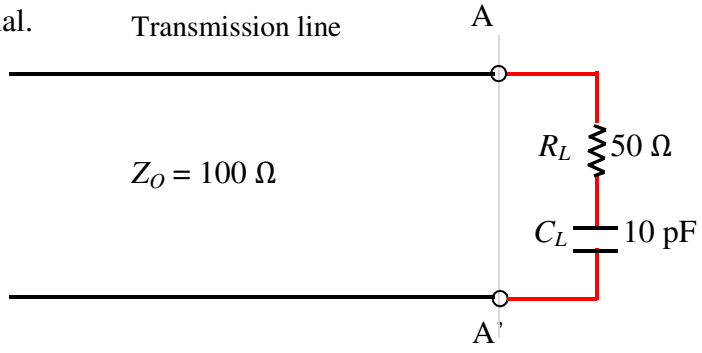

Figure 1

QUESTION TWO (20 MARKS)

a) Define the following terms as used in transmission lines

i. Impedance (2 marks)

ii. Susceptance (2 marks)

b) A transmission line has the propagation constant $\gamma = 0.1 + j10$ /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.

(4 marks)

c) A series *RLC* circuit consists of a 100 Ω resistor, an inductor of 0.318 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

i. the value of capacitor in microfarads. (3 marks)

ii. the voltage across the inductor. (3 marks)

d) If a variable frequency e.m.f. is applied to a series RLC circuit consisting of $R = 5\ \Omega$, $L = 200$ mH and $C = 0.05$ μF, determine the values of angular frequency ω for which the current will

i. be in-phase with applied voltage (3 marks)

ii. lead the applied voltage by 30^o (3 marks)

QUESTION THREE (20 MARKS)

a) Define the following

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 k Ω 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) Two admittances, $Y_1 = (0.167 - j0.167)$ S/m, and $Y_2 = (0.1 + j0.05)$ S/m are connected across a 100 V, 50 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)

QUESTION FOUR (20 MARKS)

a) Define the following terms for series AC circuits

i. Resonance (2 marks)

ii. Q-factor (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) 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)

d) 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)

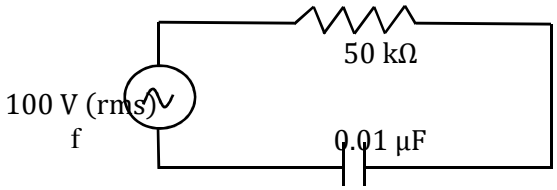

Figure 2

e) 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)

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

i. the attenuation constant α, (4 marks)

ii. the phase constant β, (3 marks)

iii. the characteristic impedance Z_0 (3 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)