MACHAKOS UNIVERSITY

University Examinations 2019/2020Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SPH 304: A.C. CIRCUIT THEORY

DATE: 4/12/2019 **TIME: 2.00-4.00 PM**

INSTRUCTIONS TO CANDIDATES

*This paper consists of **FIVE** questions in **FIVE** printed pages. Answer **Question One** (compulsory) and any **TWO questions** from the rest of the questions.*

QUESTION ONE (30 MARKS)

a) Define the following quantities and state their SI units

i. Admittance (2 marks)

ii. Susceptance (2 marks)

b) 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 $e = 400\sin\ (1.0 \times 10^3 t + 20^0)$ volts, what are the values of R and L? (5 marks)

c) 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 (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)

d) 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 Fig. 1.1. Find the reflection coefficient at the load for a 100-MHz signal. (3 marks)

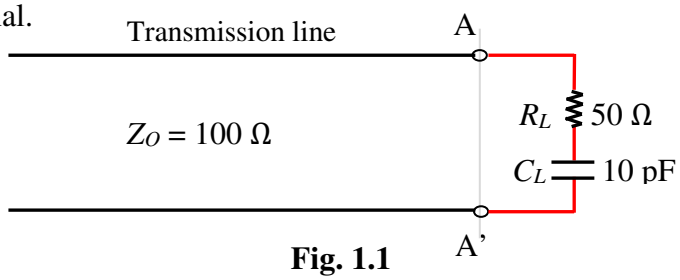

Fig. 1.1

e) 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)

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 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 $100 - j30\ \Omega$. Find 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 $2.3\sqrt{2}\sin 100\pi t$. Find:

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

ii. Voltage across the inductor. (2 marks)

iii. The total power consumed. (2 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 ω for which the current will

i. be in-phase with applied voltage (2 marks)

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

QUESTION THREE (20 MARKS)

a) Define the following terms as used in RLC circuits

i. Resonance (2 marks)

ii. Q-Factor (2 marks)

b) Figure 3.1 shows a transmission line with voltage input $v(x,t)$ and lumped components as functions of time and distance (x,t): resistance R, inductance L, conductance G and capacitance C per unit length. Derive the second derivative of current wave motion $i(x,t)$ with respect to the distance, in terms of the propagation constant γ. (8 marks)

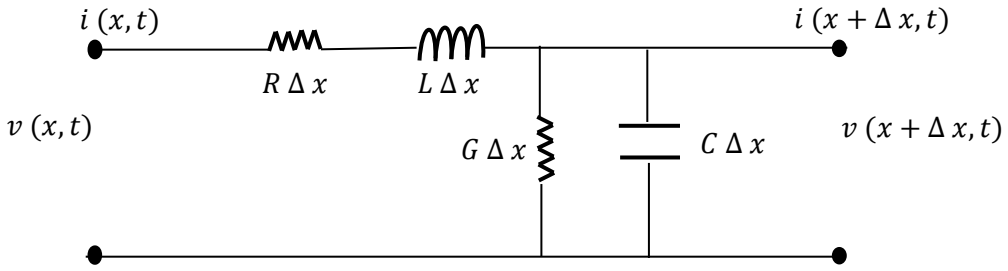

Fig. 3.1 1

c) One resistor R_1 is connected in parallel with an inductor *L*, this connection is in series with another parallel connection of resistor R_2 and capacitor *C* as shown in Fig 3.1 2. The entire connection is in resonance. Determine the resonance frequency f of the network in terms of R_1, R_2, L and *C*. (8 marks)

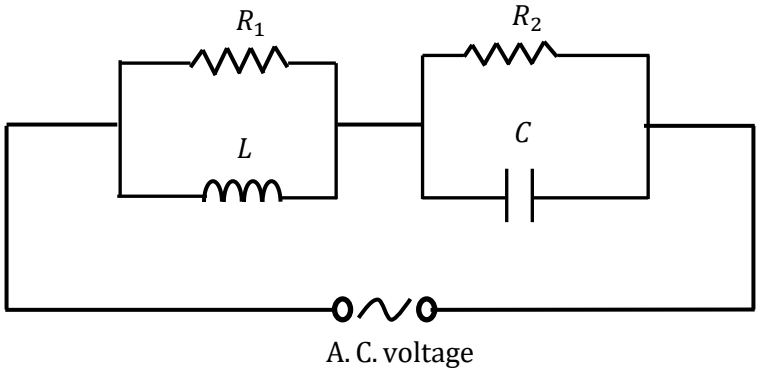

Fig. 3.1 2

QUESTION FOUR (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 vole mf is given by $e = 100\cos\ (1000t + 55^0)$ volts, what are the values of R and C? (6 marks)

QUESTION FIVE (20 MARKS)

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 k Ω resistor and a 50-pF capacitor.

i. What is the cut-off frequency f_c of the filter? (2 marks)

ii. What is 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. Find

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)