MACHAKOS UNIVERSITY

University Examinations 2019/2020 academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SPH 304: AC CIRCUIT THEORY

DATE: 22/1/2021 **TIME:2.00-4.00 PM**

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)

a) State the advantages of the AC over DC. (3 marks)

b) Calculate the phasor current through a $100\,\Omega$ resistor assuming a voltage of $V_{rms}\angle 0^0$ applied across it. (2 marks)

c) Define impedance, and write down the mathematical expression in a series RLC circuit. With the help of a diagrammatic representation, show the relationship between z, X_L and X_C. (5 marks)

d) Define resonance in a series RLC circuit. Write down the mathematical expression for resonant frequency. State the sufficient conditions for the phenomenon of resonance to occur. (3 marks)

e) Sketch a plot for the average power as function of the driving angular frequency ω in a driven RLC circuit. (3 marks)

f) Compute the power factor for each of the following cases;

i. $z = 100\angle -30^0$ (1 mark)

ii. $100 + i50\Omega$ (2 marks)

g) An inductor is connected to an AC voltage source. The inductor has an inductance of 1 H and is connected to a 120 V 60 Hz line. Determine the current flow in this circuit. (3 marks)

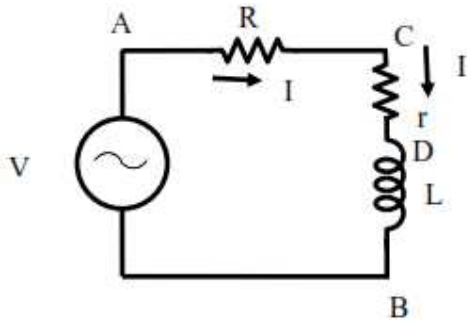
h) Write down the mathematical expression for Inductance, L. State the factors the inductance of an inductor is dependent on. (3 marks)

i) Write down the transformer equation. Distinguish between a step-up and a step-down transformer. (3 marks)

j) Distinguish between the RL high-pass filter and the low-pass filter. (2 marks)

QUESTION TWO

a) A resistor, *R* is connected in series with an iron-cored choke coil, *L*. The circuit draws a current of 5A at 240 V, 50 Hz. The voltages across the resistor and the coil are 120 V and 200 V respectively.



Calculate,

i. The resistance, reactance and impedance of the coil (6 marks)

ii. The power absorbed by the coil, and (2 marks)

iii. The power factor (pf) of the input current (2 marks)

iv. Solution

b) Using phasor diagrams, show the relationships between current and voltage in a series RLC circuit. Using the phasor representation, write down the expression for the voltage supplied by the AC source. (3 marks)

c) An RL high-pass filter, represented by the circuit shown in figure 1 has an inductor with internal resistance *R*.

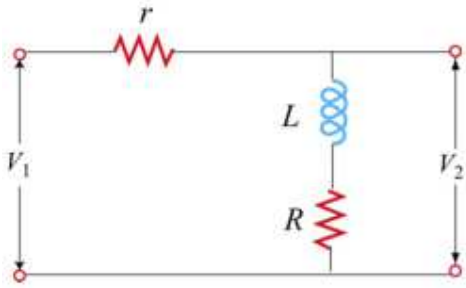


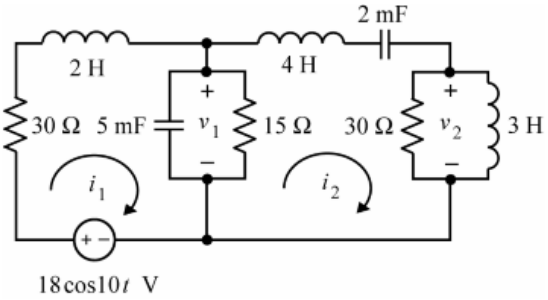
Figure 1.

i. Find V_{20}/V_{10}, the ratio of the maximum output voltage V_{20} to the maximum voltage V_{10}. (4 marks)

ii. Suppose $r = 15.0\Omega, R = 10.0\Omega$ and $L = 250\,mH$. Determine the frequency at which $V_{20}/V_{10} = 1/2$. (3 marks)

QUESTION THREE

a) Determine the nodes voltages, $v_1(t)$ and $v_2(t)$, and the mesh currents, $i_1(t)$ and $i_2(t)$, for the circuit shown. (10 marks)



b) If you built a Full-wave bridge rectifier (without using a transformer) with a $1\,k\Omega$ resistor and a $4.7\,\mu F$ capacitor to convert an AC input voltage of 30 volts peak-to-peak at 1 kHz to a DC voltage.

i. Determine the approximate DC voltage across the load resistor. (2 marks)

ii. Determine the peak Revers voltage across each of the 4-diodes in the circuit (3 marks)

c) Compute the reactance of a $10\,\mu F$ capacitor at a frequency of;

i. 10 kHz (1 mark)

ii. 1 MHz (1 mark)

d) Draw the phasor diagram of the following signal. $V = 300V_{rms} - i150V_{rms}$. (Use a scale of 1cm = 100 V_{rms}). (3 marks)

QUESTION FOUR

a) (i) Define a phasor and state its properties. (3 marks)

(ii) Sketch a phasor diagram for a purely resistive circuit. (3 marks)

b) Define a transformer and discuss briefly how it operates. (6 marks)

c) A sinusoidal voltage $V(t) = 200V \sin \omega t$ is applied to series RLC circuit with $L = 10.0\,mh, C = 100\,nF$ and $R = 20.0\,\Omega$. Determine the following quantities.

i. The resonant frequency. (2 marks)

ii. The amplitude of the current at resonance. (2 marks)

iii. The quality factor Q of the circuit, and (2 marks)

iv. The amplitude of the voltage across the inductor at the resonant frequency. (2 marks)

QUESTION FIVE

a) A series RLC circuit with $L = 160\,\text{mH}, \text{C} = 100\,\mu\text{F}, \text{and R} = 40.0\Omega$ is connected to a sinusoidal voltage $V(t) = 40.0V \sin \omega t$, with $\omega = 200 rad/s$.

i. Determine the impedance of the circuit. (4 marks)

ii. Let the current at any instant in the circuit be $I(t) = I_0 \sin(\omega t - \phi)$. Find I_0.

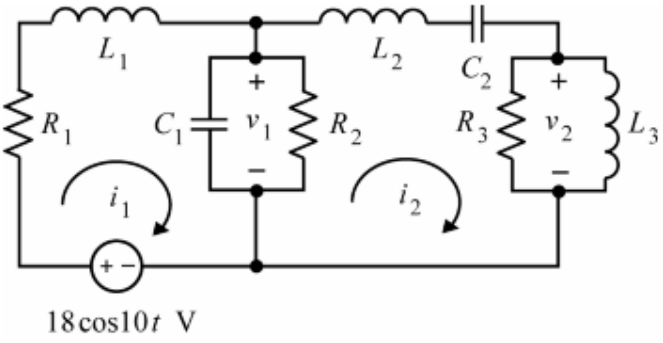
(2 marks)

iii. Determine the phase ϕ. (4 marks)

b) In this circuit, the node voltages are;

$v_1(t) = 3.318\cos(10t - 39.3^0)V$ and $v_2(t) = 4.452\cos(10t - 12.7^0)V$, and the mesh currents are;

$i_1(t) = 0.439\cos(10t - 25.9^0)A$ and $i_2(t) = 0.2099\cos(10t - 57.7^0)A$.



Determine the values of the resistances, inductances and capacitances.(10 marks)