[ENG22]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BSc(Hons) MECHATRONICS

SEMESTER ONE EXAMINATION 2021-22

ELECTRONIC ENGINEERING FOR MECHATRONICS

MODULE NO: MEC6005

Date: Thursday 13th January 2022 **Time: 14:00 – 16:00**

INSTRUCTIONS TO CANDIDATES:

There are SIX questions.

Answer any FOUR questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 100 marks.

Formulae sheet is attached at the end of the paper.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

Question 1

a) Define the following terms (**1.5 marks for each definition**):

i. Frequency
ii. Period
iii. Phase angle
iv. Peak to peak value
v. RMS value
vi. Internal resistance
vii. Current
viii. Resistance

[12 marks]

b) An AC ammeter reads 11A rms current through a resistive load, and a voltmeter reads 360V rms drop across the load.

(i) What are the peak values and the average values of the alternating current and voltage? **[6 marks]**

(ii) Calculate the load resistance. **[2 marks]**

c) Find the Thevenin equivalent of the circuit given in Figure Q1 below. **[5 marks]**

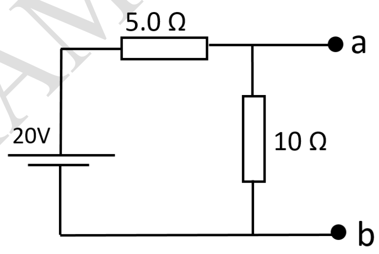


Fig.Q1

Total: 25 marks

PLEASE TURN THE PAGE….

Question 2

a) For the circuit shown below (Figure Q2a), considering the RLoad as the load resistance

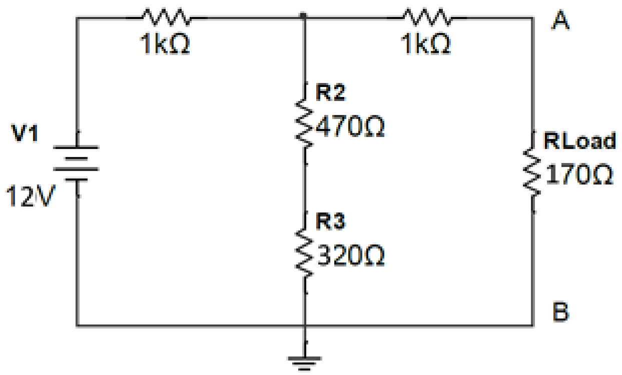


Figure Q2a

(i) Derive the equivalent Thevenin circuit between points “A” and “B” **[10 marks]**

(ii) Derive the equivalent Norton circuit between points “A” and “B” **[5 marks]**

b) For the following circuit (Figure Q2b), using superposition theorem or otherwise, find out the current flowing through the 10 Ω resistor.

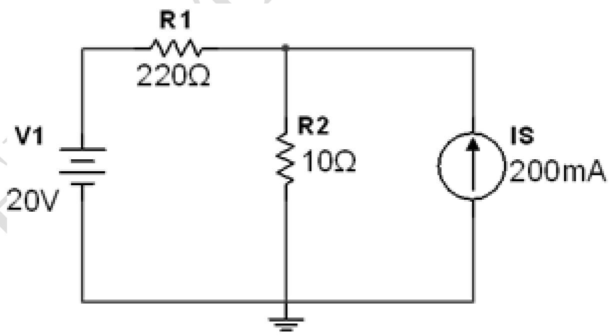


Figure Q2b **[10 marks]**

Total: 25 marks

PLEASE TURN THE PAGE….

Question 3

a) A 13 μF capacitor has 12 V across it. What quantity of charge is stored in it? **[5 marks]**

b) Draw a diagram of a parallel plate capacitor showing the charge on the plates and the **E** field in the region between the plates. **[5 marks]**

c) Explain what is meant by the dielectric strength $\mathbf{E_m}$ of an insulator? **[5 marks]**

d) For the capacitor **charging** circuit shown in Figure Q3d below, where the capacitor is initially discharged, sketch two separate graphs for the current I versus time and the capacitor voltage V_c versus time. **[5 marks]**

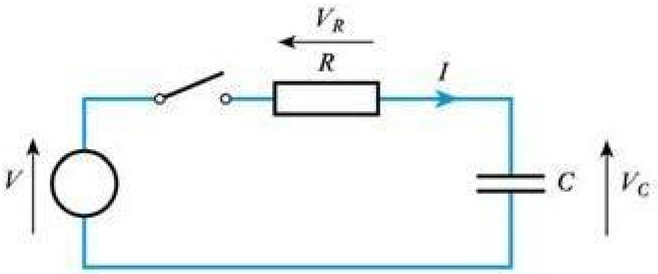


Figure Q3d - An initially uncharged capacitor being charged through a resistor.

e) Explain with the assistance of a diagram what happens to the structure of the curves for I versus time and V_c versus time if the time constant □ = RC for the circuit increases? **[5 marks]**

Total: 25 marks

PLEASE TURN THE PAGE….

Question 4

For the circuit shown in figure Q4, calculate:

a) Currents I1, I2, and I3 **[9 marks]**

b) Voltages across R1, R2, and R3 **[6 marks]**

c) Powers P1, P2, and P3 **[3 marks]**

d) Draw the complete voltages and currents phasor diagram **[3 marks]**

e) The peak I3 current at resonance frequency **[4 marks]**

Where $v = 17cos314t$, $R_1 = R_2 = 2\Omega$, $R_3 = 4\Omega$, $X_{L2} = j2\Omega$, $X_{L3} = j6\Omega$, $X_C = -j4\Omega$

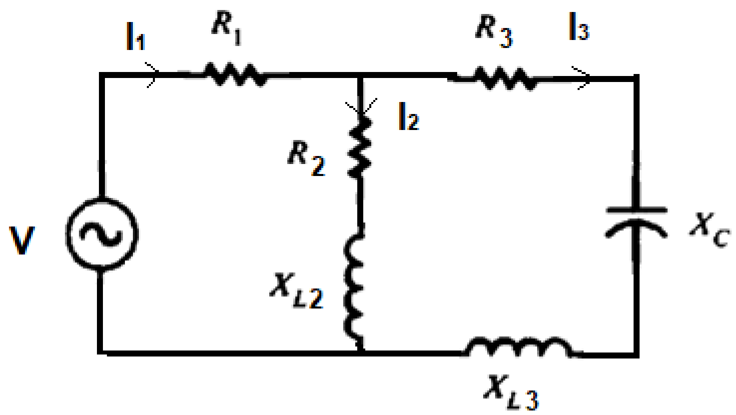


Figure Q4

Total: 25 marks

PLEASE TURN THE PAGE….

Question 5

a) For the combinational digital circuit shown below in Figure. Q5a:

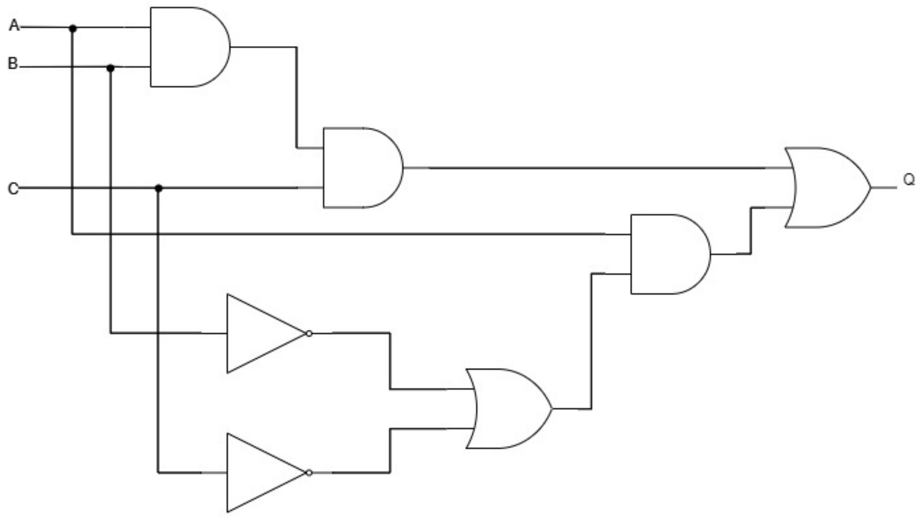


Figure Q5a Digital Circuit

i) Find out the Boolean expressions at output Q. **[7 marks]**

ii) Complete the following truth table for this digital circuit: **[10 marks]**

b) Fill in the blanks by converting the following numbers into their respective missing decimal and binary equivalents:

i) 11000_2 = ________$_{10}$

ii) 100010_2 = ________$_{10}$

iii) $A2_{16}$ = ________$_{10}$

iv) _______$_{16}$ = 1306_{10}

v) _______$_{16}$ = 26_{10}

[5 marks]

c) What does adding redundant information into numeric and alphabetic codes provide? **[3 marks]**

Total: 25 marks

PLEASE TURN THE PAGE….

Question 6

a) In a Wheatstone bridge ABCD, a galvanometer is connected between B & D, and a battery of 5V emf and 3Ω internal resistance is connected between A & C. A resistor of unknown voltage is connected between A & B. When the bridge is balanced, the resistance between B&C is 50Ω, between C&D is 5Ω and between D&A is 100Ω. Calculate:

(i) the value of unknown resistance between point A & B and **[7 marks]**

(ii) the total current supplied by the battery. **[7 marks]**

b) Use network conversion to find the total current of the circuit in figure 6b

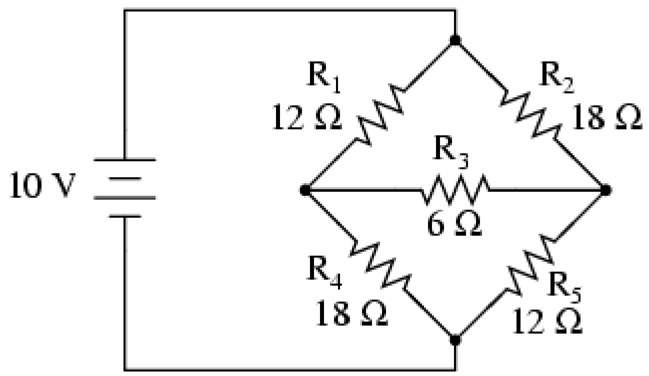


Figure 6b

[11 marks]

Total: 25 marks

END OF QUESTIONS

Formula sheet follows on next page….

PLEASE TURN THE PAGE….

APPENDIX: Formula Sheet

The following symbols in the formulae have their standard meaning:

Ohm's law: $V = IR$

Power: $P = IV$

Magnetic flux: $\Phi = BA$

Induced voltage: $V = \Delta\Phi/\Delta t$

Force experienced by charged particle = $qvBsin\theta$

Motional emf: $E = Blv \quad f = \frac{pn}{120}$

Magnitude of the Reactance of Inductor L: $X_L = 2\pi fL$

Magnitude of the Reactance of Capacitor C: $X_C = \frac{1}{2\pi fC}$

Pythagorean theorem: $c^2 = a^2 + b^2$

Tangent function: tanA=opposite/adjacent

$\mu_o = 4\pi X10^{-7} H/m$, $\epsilon_o = 8.85X10^{-12} F/m$

$H = \frac{N.I}{l}$, $\quad B=uH$

MMF=N.I

$L = \frac{\mu_o \mu_r A N^2}{l}$, $\quad E = \frac{1}{2}LI^2$

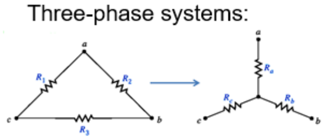
C=Q/V , $\quad C=\frac{\epsilon A}{d}$, $\quad E=\frac{1}{2}CV^2$

$v_L = L.\frac{di_L}{dt}$

$i_C = C\frac{dv_C}{dt}$

$f = \frac{pn}{120}$

Three-phase systems:

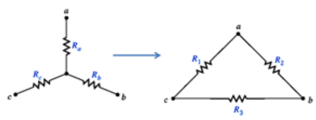


Delta to Star conversion:

$$R_a = \frac{R_1 R_2}{R_1 + R_2 + R_3}$$

$$R_b = \frac{R_2 R_3}{R_1 + R_2 + R_3}$$

$$R_c = \frac{R_3 R_1}{R_1 + R_2 + R_3}$$



Star to Delta conversion:

$$R_1 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_b}$$

$$R_2 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_c}$$

$$R_3 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_a}$$

PLEASE TURN THE PAGE….

Multiply the Value	By	To Get the Value
Peak	2	Peak-to-peak
Peak-to-peak	0.5	Peak
Peak	0.637	Average
Average	1.570	Peak
Peak	0.707	RMS (effective)
RMS (effective)	1.414	Peak
Average	1.110	RMS (effective)
RMS (effective)	0.901	Average

Summary Table for Series and Parallel *RL* Circuits

X_L and R in Series	X_L and R in Parallel
I the same in X_L and R $V_T = \sqrt{V_R^2 + V_L^2}$ $Z = \sqrt{R^2 + X_L^2} = \dfrac{V_T}{I}$ V_R lags V_L by 90° $\theta = \arctan \dfrac{X_L}{R}$	V_T the same across X_L and R $I_T = \sqrt{I_R^2 + I_L^2}$ $Z_T = \dfrac{V_T}{I_T}$ I_L lags I_R by 90° $\theta = \arctan \left(-\dfrac{I_L}{I_R}\right)$

Summary Table for Series and Parallel *RC* Circuits

X_C and R in Series	X_C and R in Parallel
I the same in X_C and R $V_T = \sqrt{V_R^2 + V_C^2}$ $Z = \sqrt{R^2 + X_C^2} = \dfrac{V_T}{I}$ V_C lags V_R by 90° $\theta = \arctan \left(-\dfrac{X_C}{R}\right)$	V_T the same across X_C and R $I_T = \sqrt{I_R^2 + I_C^2}$ $Z_T = \dfrac{V_T}{I_T}$ I_C leads I_R by 90° $\theta = \arctan \dfrac{I_C}{I_R}$

END OF PAPER