[ESS22]

UNIVERSITY OF BOLTON

ENGINEERING, SPORTS AND SCIENCES ACADEMIC GROUP

B.ENG (HONS) BIOMEDICAL ENGINEERING

SEMESTER TWO EXAMINATION 2018/2019

MEDICAL SENSORY DEVICES & MEASUREMENT

MODULE NO: BME4004

Date: Wednesday 22nd May 2019 **Time: 14:00 – 16:00**

INSTRUCTIONS TO CANDIDATES:

There are FIVE questions.

Answer ANY FOUR questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

Electronic calculators may be used provided that data and program storage memory is cleared prior to the examination.

CANDIDATES REQUIRE: **Formula Sheet (attached).**

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Question 1

(a) A resistive circuit is shown in Fig. Q_{1a}

(i) Why do we need to use the Thévenin's and Norton's Theorems?

[4 marks]

(ii) Determine Thévenin and Norton equivalent circuits of the circuit in Fig. Q_{1a}

[6 marks]

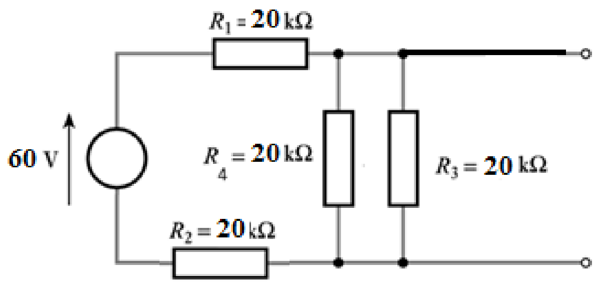

Fig. Q_{1a}

(b) For the circuit shown in Fig. Q_{1b} below, Find:

(i) the voltage across R_{Load} using the superposition method **[9 marks]**

(ii) the current flowing through the R_2 resistor **[6 marks]**

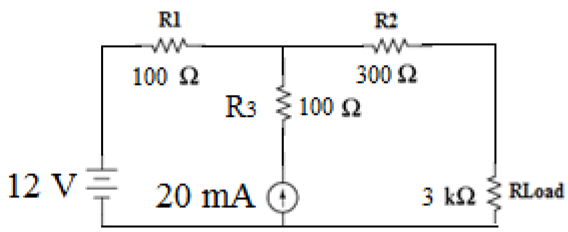

Fig. Q_{1b}

Total 25 marks

Question 2

a) A 180 μC charge is available in a 30 V capacitor. What is its capacitance value in $\mu Farads$ and what is the stored energy in joule? **[5 marks]**

b) A straight wire carries a current of 10 A. positioned at the centre of a 200 mm diameter. What is the magnetic field strength H at the circumference of this circle? **[5 marks]**

c) What is the inductive reactance of a 20 mH inductor working on a 50 Hz frequency and what is the stored energy in joules if the voltage across the inductor is 240 V? **[5 marks]**

d) A 2 A. current flows through a coil and produce mmf of a 400 A.T .

i) What is the number of turns of this coil?

[3 marks]

ii) What is the inductance of this coil with air core? **[5 marks]**

iii) What is its inductance with iron core of relative permeability=1200?

Assume the ratio of coil length to its cross-sectional area is 1/4. **[2 marks]**

Total 25 marks

Question 3

Fig.Q3 shows an RLC parallel circuit.

(a) Determine the values of:

i. The current in each branch **[4 marks]**
ii. The total current I_T **[4 marks]**
iii. total impedance Z **[3 marks]**
iv. The phase difference between the supply voltage and the circuit current θ

[3 marks]

(b) Determine whether the circuit is inductive or capacitive? Illustrate your answer with the aid of the phasor diagram. **[4 marks]**

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Q3 continued….

(c) Calculate the resonant frequency of the circuit and the peak current flowing in the circuit at the resonant frequency **[7 marks]**

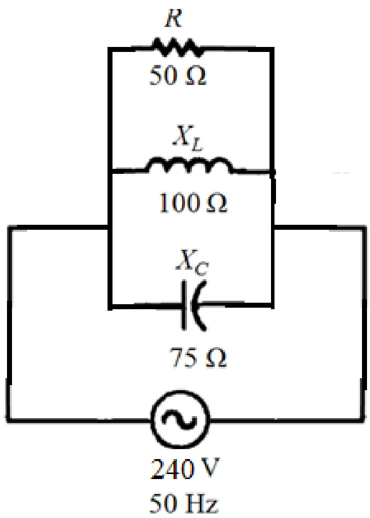

Fig. Q3 RLC parallel circuit

Total 25 marks

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Question 4

(a) For a single-phase transformer of rated power of 500 V.A, what would be:

(i) its secondary voltage **[3 marks]**

(ii) its primary and secondary currents **[4 marks]**

If it has a turns ratio ($\frac{N_1}{N_2}$) of 10:1(step down) and when it is connected to a supply mains of 250 V, 50 Hz.

(b) Design the clock signal frequency of a stepper motor to rotate at 750 rpm(+/- 15 rpm). Given that the stepper motor has the accuracy of 5 degree per step.

[10 marks]

(c) Fig.4 shows a single-loop Direct Current machine. Is it a generator or a motor? Explain briefly with the aid of diagrams its operation. **[4 marks]**

(d) If we replace the DC voltage source by a load resistor and rotate the loop anticlockwise, draw the direction of generated EMF and current in the loop as well as the output voltage waveform. **[4 marks]**

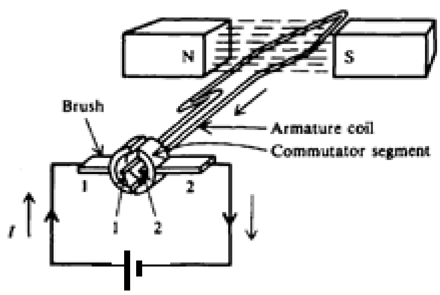

Fig.4 A single-loop DC machine

Total 25 marks

Question 5

(a) Explain the biomedical instrumentation modes of operation in terms of the source of power. **[6 marks]**

(b) Describe the compensation techniques used in biomedical sensory devices. **[7 marks]**

(c) Enumerate four of static characteristics of the biomedical sensory devices. **[4 marks]**

(d) Explain the operation of a full-wave rectifier used to produce low ripple DC output voltage in a biomedical instrument.

Illustrate your answer with the aid of diagrams **[8 marks]**

Total 25 marks

END OF QUESTIONS

Formula sheets over the page….

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Formula sheet

These equations are given to save short-term memorisation of details of derived equations and are given without any explanation or definition of symbols; the student is expected to know the meanings and usage.

Ohm's law: $V = IR$, Power: $P = IV$, Magnetic flux: $\Phi = BA$, Induced voltage: $V = N.\,\Delta\Phi/\Delta t$

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

$H = \frac{N.I}{l}$

MMF=N.I

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

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

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

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

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

Transformer voltage ratio: $\frac{V_1}{V_2} = \frac{N_1}{N_2}$, $P = V_1.I_1 = V_2.I_2$

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

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

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

Tangent function: $\tan\theta$=opposite/adjacent

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

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

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

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