00044

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: **DMX3574/MEX3274**
	Electronics, Sensors and Actuators
Academic Year	: 2019/20
Date	: 30th September 2020
Time	: 1330hr – 1630hr
Duration	: **3 hours**

WRITE YOUR REGISTRATION NUMBER CLEARLY WITHIN THE SPACE PROVIDED

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (8)** questions in **Eight (8)** pages.
3. Answer **Five (5)** questions only, selecting **at least two questions each from part A and part B.** All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. This is a Closed Book Test (CBT).
6. Answers should be in clear hand writing.
7. Do not use Red color pen.

Part A

Question 01

a) In the operational amplifier circuit shown in Figure Q1(a), the input voltage V_i is 0.4V. Calculate the Output voltage V_0 in Volts.

[3 Marks]

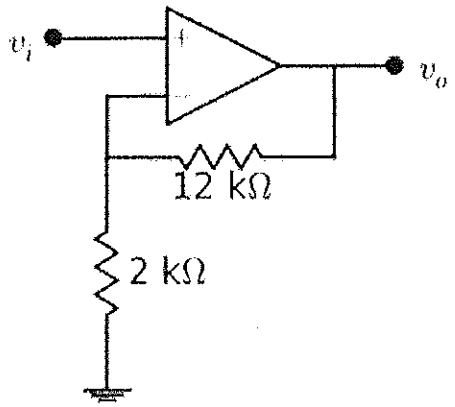

Figure Q1(a)

b) Determine the Output voltage V_0 in Volts, for the Operational amplifier circuit given in the Figure Q1(b). The input voltages are $V_1 = -5V$ and $V_2 = 2V$.

[7 Marks]

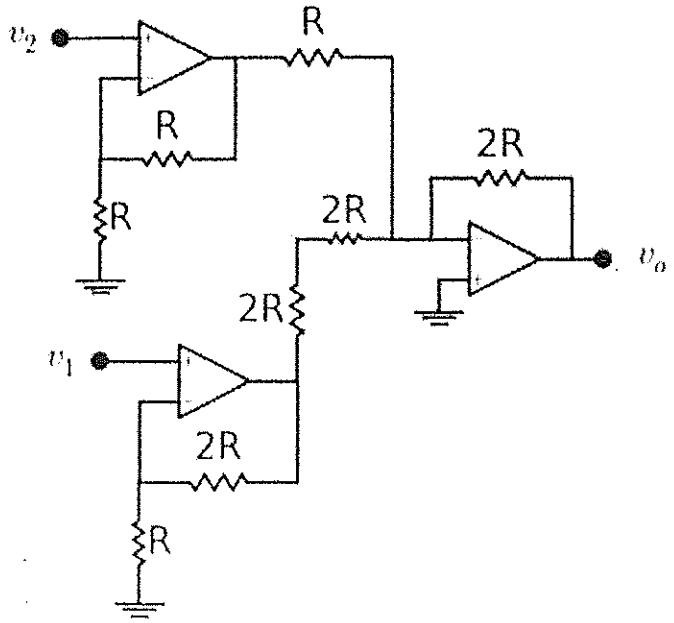

Figure Q1(b)

c) Find the Thévenin and Norton equivalent circuits for the circuit shown in Figure Q1(c).
[10 Marks]

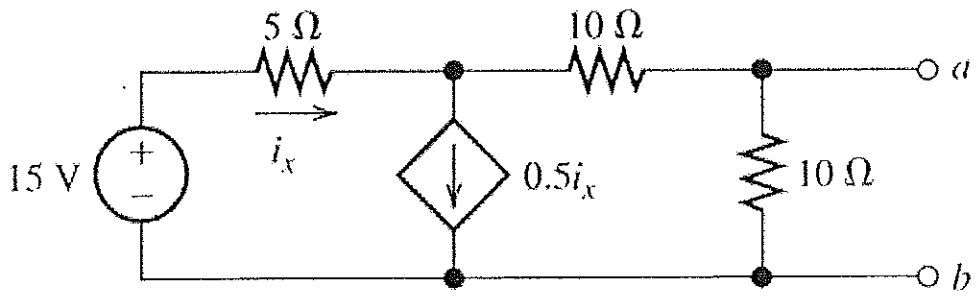

Figure Q1(c)

Question 02

a) What are the main advantages of Hexadecimal numbering system?
[3 Marks]

b) Perform the following conversions between number systems clearly showing necessary steps.

i. Convert the Hexadecimal **12EFB35C**$_{16}$ to Binary representation.
[3 Marks]

ii. Convert the Binary number **00011111**$_2$ to Decimal representation.
[3 Marks]

c) State the De' Morgan's theorem.
[3 Marks]

d) Simplify the following Function.
[4 Marks]

$$G(A, B, C) = (A + B)(\overline{A} + B + C)(\overline{A} + B + \overline{C})$$

e) Draw a logic diagram for the following function using NAND and inverter gates.
[4 Marks]

$$G(A, B, C) = (A\overline{B} + \overline{A}C + \overline{A}B\overline{C})$$

Question 03

a) State three advantages of using the Zener diode.

[3 Marks]

b) For the BJT circuit shown in Figure Q3(b),

$V_{cc} = 10V$, $V_{BB} = 4V$, $R_B = 125\ k\Omega$, $R_E = 2\ k\Omega$, and $\beta = 200$

i. Sketch the transistor small-signal equivalent circuit (r_e model)

[2 Marks]

ii. Determine:

1. r_e [Let, V_T =26mV (Thermal voltage)]

[2 Marks]

2. Input and output Impedance (Z_i and Z_o)

[3 Marks]

3. voltage gain (A_v)

[3 Marks]

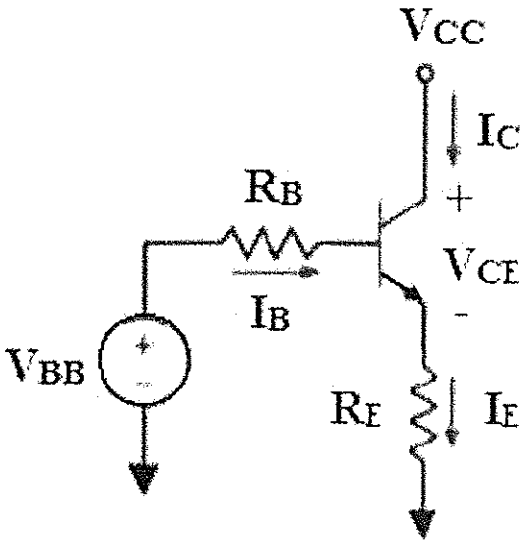

Figure Q3(b)

c) A Zener diode voltage regulator is shown in Figure Q3(c). The Zener diode is characterized by forward conducting threshold voltage ($V_{th} = 0.75$), reverse conducting threshold voltage ($V_z = -3.3$ V) and small-signal resistance ($R_z = 50\ \Omega$).
$V_S = 5$ V, $R_S = 250\ \Omega$, $R_L = 2\ k\Omega$.

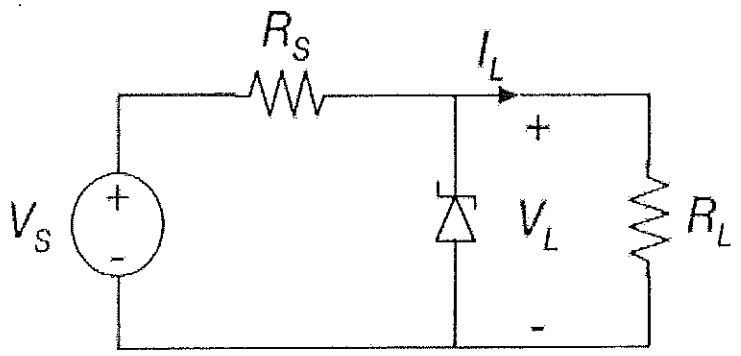

Figure Q3(c)

i. Draw the equivalent circuit of the regulator when the Zener is forward and reverse conducting.

[5 Marks]

ii. Calculate the voltage V_L across the load R_L.

[3 Marks]

iii. Calculate the power dissipated in the load R_L.

[2 Marks]

Question 04

a) A 3-phase, 60Hz, 200hp, 2400V, 8 pole, Y-connected synchronous motor has a phase synchronous reactance of 12Ω per phase and negligible resistance. The motor draws 150kW at a power angle of 18 degrees.

Determine;

i. Excitation voltage

[3 Marks]

ii. Line current

[2 Marks]

iii. Power factor

[2 Marks]

iv. Under maximum power condition determine the torque

[3 Marks]

b) A 3-phase induction motor is wound for four poles and is supplied from a 50Hz supply. Calculate;

i. The synchronous Speed

[3 Marks]

ii. The speed of the rotor when slip is 3%

[3 Marks]

iii. The rotor frequency when speed of rotor is 900rpm

[4 Marks]

Part B

Question 05

a) Briefly explain what is a sensor. Give an example of a sensor and describe its function.

[4 Marks]

b) List the factors that need to be taken into consideration when selecting a sensor for a particular application.

[4 Marks]

c) Briefly explain what is a displacement sensor and name three sensors which are used for displacement measurement.

[4 Marks]

d) Calculate the number of bits an Analog to Digital Converter (ADC) must have in order to handle a signal with a 96dB dynamic range.

[8 Marks]

Question 06

a) Discuss the differences between incremental and absolute rotary encoder.

[5 Marks]

b) A 10-bit Gray code optical encoder is outputting the number 0011100101. Determine the indicated angle.

[5 Marks]

c) State three main advantages of Gray code.

[4 Marks]

d) An absolute optical rotary encoder in a certain application must have a resolution of 3°. Determine the number of tracks of this encoder.

[6 Marks]

Question 07

a) List the three common types of stepper motors. Briefly explain each type.
[5 Marks]

b) Determine the basic step angle for the following stepper motors.

i. 6 stator phases - 4 rotor teeth, 3-phase, single stack variable reluctance motor
[2 Marks]

ii. 4 stator phases - 6 rotor teeth, 2-phase, permanent magnet motor
[2 Marks]

iii. 4 stator phases - 5 rotor teeth, 2-phase, hybrid motor
[2 Marks]

c) Consider the Single-stack, 3-phase variable reluctance stepper motor shown in Figure Q07. Find the step angle for the following phase-switching sequences.
[9 Marks]

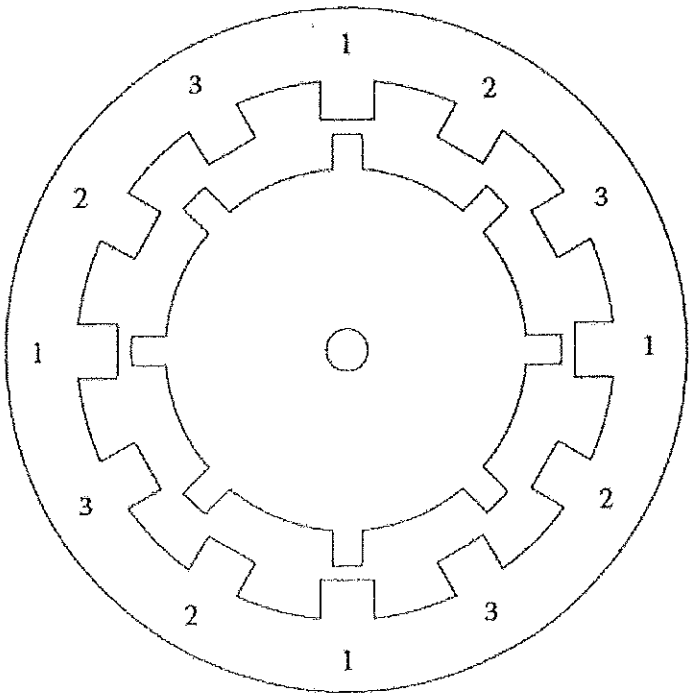

Figure: Q07

Question 08

a) State three main functions of the pneumatic air service unit.

[3 Marks]

b) Draw the graphical symbol and label the ports for a pneumatic four-way, two-position Directional control valve (DCV) with pushbutton actuation.

[7 Marks]

c) Design a Pneumatic circuit diagram consisting of a 3/2-way, lever operated, spring return directional control valve to extend a single acting spring return cylinder. The air flow of the cylinder should be controlled and the diagram should include the FRL unit, compressor and other necessary controls.

[10 Marks]

END