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

Study Programme	:	Bachelor of Science Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**DMX5313 Power Electronics and Motor Drives**
Academic Year	:	2024/25
Date	:	20th February 2026
Time	:	1400-1700 hrs
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Five (5)** questions in **four (4)** pages.
3. Answer **all** questions.
4. All questions carry equal marks.
5. Answer for each question should commence from a new page.
6. This is a Closed Book Test **(CBT)**.

Question 01

a. Compare the following power transistors by considering their working principles, advantages, and limitations. (09 marks)

   i.) BJT

   ii.) IGBTs

   iii.) MOSFET

   Use the corresponding V-I characteristic curve for each case to explain the working principle of each device.

b. Consider a power transistor switch with the following characteristics.

   V_{rated} = 220V and I_{rated} = 18A

   $V_{CE(sat)}$=1.5V

   $I_{leakage}$=1mA

   $t_{SW(on)}$= 1.2 µs and $t_{SW(off)}$= 4 µs

If the switching frequency is 150Hz with 50% duty cycle find:

i.) On-state and Off-state energy losses (01 marks)

ii.) Maximum power losses during On-state (01 marks)

iii.) Energy losses during Turn-on and Turn-off (01 marks)

iv.) Average power loss (01 marks)

c. According to the power transistor used in part b, the device experiences a linear fall in current in 4μs at turn off and linear fall in voltage in 1.2μs at turn on. Design a turn-on snubber circuit if the current rise time delayed to 0.8μs:

i.) Draw appropriate circuit diagram (01 marks)

ii.) Determine the value of the inductor (02 marks)

iii.) Determine the total energy loss at this condition (02 marks)

iv.) Suggest a suitable snubber resistor (02 marks)

Question 02

a. Differentiate uncontrollable rectifiers and controllable rectifiers in terms of their operations and applications. (04 marks)

b. What is the effect of firing angle delay on the output voltage of a controlled rectifier? (02 marks)

c. A single-phase half wave-controlled rectifier circuit with a **RL** load using a thyristor T1 is shown in Figure Q2.

Assume that the thyristor T1 conducts from ωt =α to β (Supply voltage $V_s=V_m \sin \omega t$).

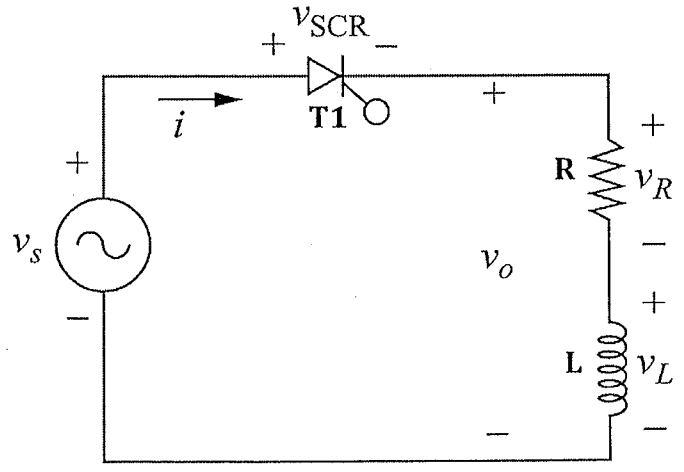

Figure Q2: Single-phase half wave-controlled rectifier circuit

i.) Identify the thyristor type used in the circuit and explain the operation of the circuit using the corresponding V-I characteristic curve (05 marks)

ii.) Draw the input supply voltage and thyristor current waveforms (03 marks)

iii.) Draw the output (load) voltage waveform (02 marks)

iv.) Derive an expression for the average load (DC) voltage (04 marks)

(Clearly mention assumptions you made and boundary conditions)

Question 03

a. Explain the purpose of using power inverters in solar power generation. (02 marks)

b. Explain the steps followed to obtain a pure sine-wave for inverter output, with the help of appropriate wave forms and circuit diagrams. (08 marks)

c. A single-phase full-bridge inverter operates with DC input voltage (V_{dc}) of 300V and supplies power to a resistive load (R_L) of 20Ω.

The inverter uses sinusoidal PWM (SPWM) with a modulation index of $\mathbf{m_a} = 0.85$.

Determine:

i.) The RMS value of the fundamental component of the output voltage (04 marks)

ii.) The RMS current through the load (02 marks)

iii.) The output power delivered to the load (02 marks)

iv.) If the switching frequency is 5 kHz and the fundamental frequency is 50 Hz, calculate the frequency modulation ratio ($\mathbf{m_f}$) (02 marks)

Question 04

a. Classify DC to DC converters based on the voltage conversion relationship. (03 marks)

b. Explain each mode of operation of a buck-converter using the corresponding circuit diagrams and waveforms. (06 marks)

c. Suppose that you are assigned to design a buck converter to produce an output voltage of 18V (V_o) from a 48V DC supply (V_s) across a 10 Ω load resistor (R_L) with switching frequency (f_s) 40kHz.

If the converter design for continuous inductor current, determine:

i.) Duty Ratio (D) (01 marks)

ii.) The minimum inductor size (L_{min}) (02 marks)

iii.) If the inductor be 25% larger than L_{min}, average inductor current (I_L), maximum inductor current (i_{L_max}), and minimum inductor current (i_{L_min}) (06 marks)

iv.) If the output voltage ripple must not exceed 0.5%, capacitor size (02 marks)

Assume ideal components.

Question 05

a. Compare the following motor drive systems in terms of their characteristics, advantages, disadvantages, and typical applications: (08 marks)

i.) DC motor drives with phase-controlled rectifiers

ii.) AC induction motor drives with voltage source inverters

b. What is VFD (Variable Frequency Drive) and why is it useful in industry applications? (04 marks)

c. Suppose that a typical variable speed drive (VFD) is built with a separately excited DC motor, rated at 220V. The motor is coupled to a pump that developed a torque proportional to the square of the speed at rated voltage conditions. Motor load system runs at 1200rpm in steady state. No load speed of the motor at rated voltage conditions is 1300 rpm. Determine the combination of armature and field voltages required to run the motor load systems at:

i.) 250 rpm (04 marks)

ii.) 1750 rpm (04 marks)

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