

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S4 (R) (FT/WP) Examinations April 2026 (2024 Scheme)

Course Code: PCEET403

Course Name: Power Electronics and Drives

Max. Marks: 60

Duration: 2 hours 30 minutes

## PART A

*(Answer all questions. Each question carries 3 marks)*

		CO	Marks
1	A mobile phone manufacturer intends to design a compact 100 W charger with very high power density. For the DC–DC converter stage inside the charger, the design team is considering three types of power semiconductor devices: MOSFETs, IGBTs, and GaN HEMTs. Which device should the manufacturer select to achieve the highest possible power density, and why?	CO1	(3)
2	A thyristor (SCR) is used as a static switch to energize a series $RL$ circuit from a DC voltage source. Explain the requirements for the magnitude and duration of the gate pulse to ensure reliable turn-on of the SCR in this application.	CO1	(3)
3	What are the effects of non-idealities such as capacitor ESR and inductor resistance on a boost converter.	CO2	(3)
4	A single-phase full-wave AC voltage controller is used to regulate the power supplied to a resistive heating element. The supply voltage is a sinusoidal voltage of 230 V (rms), and the resistance of the heating element is 10 ohms. Draw the voltage waveform across the heating element and calculate the average power consumed by the heating element for a firing angle of 90 degrees.	CO2	(3)
5	Draw the circuit of a full-bridge inverter feeding a series $RL$ load using IGBTs and diodes. Draw and explain how the output voltage differs in bipolar and unipolar PWM.	CO3, CO4	(3)
6	Explain why dead time is necessary between the gate pulses of the top and bottom switches of a half-bridge voltage source inverter. Draw the complementary gate signals with dead time for a half-bridge inverter operating in square-wave mode.	CO3, CO4	(3)



- 7 The torque–speed characteristics of the motor  $T_e$  (solid curve) and the load  $T_l$  (dotted curve) are shown in Figure 1. Determine which operating point, A or B, is stable, and explain why. CO5 (3)

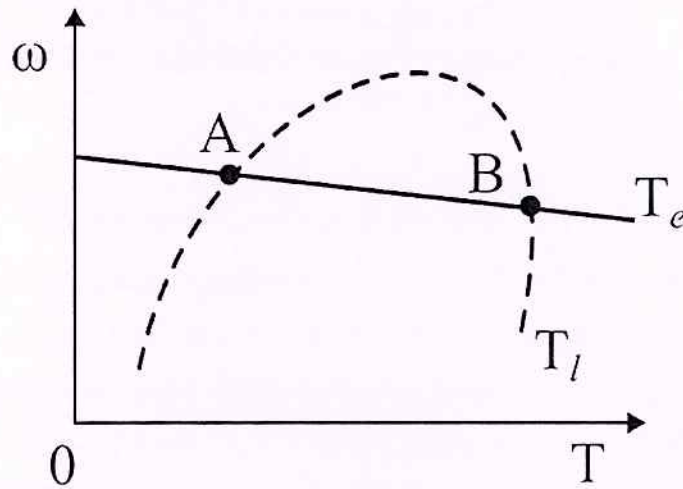


Figure 1

- 8 An inductor motor drive is connected to a constant torque load. Explain using torque speed characteristics how the speed of the drive can be changed by stator voltage adjustment. CO5 (3)

### PART B

*(Answer any one full question from each module, each question carries 9 marks)*

#### Module -1

- 9 a) Draw the structure of a n-channel power MOSFET and explain the current path from drain to source when sufficient gate-to-source voltage is applied. Also, show the path for the current from source to drain when zero gate-to-source voltage is applied. CO1 (5)
- b) A power diode in the ON state can be represented by a voltage source of magnitude 0.8 V in series with a resistance of 0.01 ohm. If the average current through the diode is 5 A and the RMS current is 7.07 A, determine the average power loss in the diode. CO1 (4)
- 10 a) Draw the reverse recovery characteristics of a power diode and explain the effects of the reverse recovery transient. Why do Schottky diodes have a lower reverse recovery time? CO1 (5)
- b) Draw the equivalent steady-state thermal circuit for a power semiconductor switch mounted on a heat sink. Explain the calculation for junction CO1 (4)

temperature in terms of power dissipation, ambient temperature, and thermal resistances.

### Module -2

- 11 a) A fully controlled three-phase thyristor converter has an AC input line-to-line voltage of 400 V RMS at 50 Hz. It delivers 2700 W to a highly inductive load with a firing angle of 60 degrees. Neglecting losses and assuming the DC-side current is ripple-free, determine the DC-side voltage and the total harmonic distortion (THD) of the input AC current. CO2 (5)
- b) Derive the expression for the input power factor of a single-phase semi-converter feeding a constant current load. CO2 (4)
- 12 a) A single-phase fully controlled converter is connected to a constant current load, as shown in Figure 2. The converter is supplied by a sinusoidal AC voltage source with a series source inductor. Draw the instantaneous output voltage  $v(t)$  and derive the expression for the average voltage in terms of given parameters when the converter is operated at a firing angle  $\alpha$ . CO2 (5)

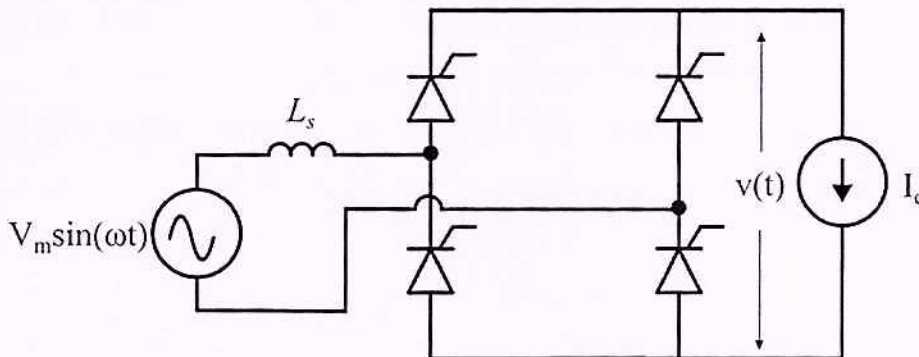


Figure 2

- b) A boost converter is operated in continuous conduction mode with an output voltage of 20 V. The load resistance is 20 ohms, and the average input current is 2 A. Calculate the input voltage and the duty cycle of the converter, neglecting the ripple in the output voltage. CO2 (4)

### Module -3

- 13 a) Explain, with modulation waveforms and relevant equations, how third-harmonic injection PWM increases the output phase voltages of a three-phase voltage source inverter while remaining in the linear modulation range. CO3, CO4 (5)

- b) A single-phase voltage source inverter has a DC link voltage of 400 V and supplies a series  $RL$  load with  $R = 10$  ohms and  $L = 1$  mH. The inverter is operated using bi-polar sinusoidal pulse width modulation (SPWM), with the frequency of the modulating signal equal to 50 Hz and a modulation index of 0.8. Determine the RMS value of the 50 Hz (fundamental) component of the load current. CO3, (4)  
CO4
- 14 a) Draw the circuit diagram of a single-phase front-end boost converter and the block diagram of the control scheme. Also, draw the waveform of the current through the inductor of the above boost converter. CO3, (4)  
CO4
- b) A three-phase voltage source inverter has a DC link voltage of 600 V and is connected to a balanced star-connected load. Determine the RMS value of the fundamental load-to-neutral voltage for (a) square-wave mode and (b) sine PWM mode with a modulation index of 0.9. CO3, (5)  
CO4

#### Module -4

- 15 a) A single-phase fully controlled converter is used for the electrical braking of a separately excited DC motor. The DC motor load is represented by an equivalent circuit, as shown in Figure 3. Assume that the motor inductance is sufficient to maintain a continuous, ripple-free load current. Determine the firing angle of the converter for a load current of  $I_o = 10$  A. CO5 (3)

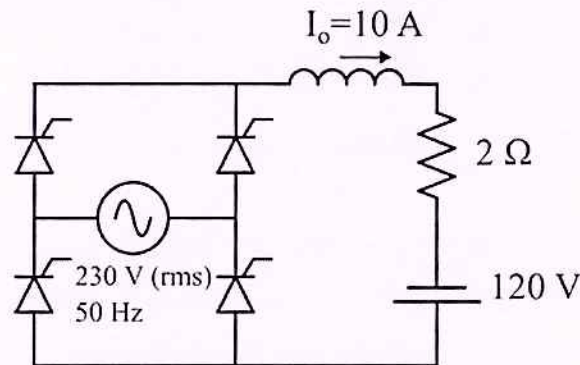


Figure 3

- b) What are the advantages of V/f control for an induction motor drive compared to stator voltage control? In V/f control, how is the speed of an induction motor controlled below and above the base speed? CO5 (4)
- c) Explain how regenerative braking is achieved in induction motor drives. CO5 (2)

- 16 a) Draw the circuit diagram of a circulating-current type, single-phase dual CO5 (5)  
converter feeding a separately excited DC motor. Plot the voltage waveforms  
on the DC side of the two converters for a firing angle  $\alpha$ .
- b) A separately excited dc motor has a rated armature current of 20 A and a CO5 (4)  
rated armature voltage of 150 V. An ideal chopper connected to a 200 V DC  
source is used to control the armature voltage. The armature resistance is 1  
ohm. Neglecting the armature reaction, determine the duty ratio of the  
chopper to obtain 50% of the rated torque at the rated speed and the rated  
field current.

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