Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

IV SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, MAY 2024

POWER ELECTRONICS [ELE 2222]

REVISED CREDIT SYSTEM

Time:180 Minutes **Date: 03 May 2024** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A. A half-wave uncontrolled rectifier is interfaced with a resistive load of 100Ω. The AC source is 230V rms at 50Hz. With a neat circuit,

(i). Determine the average load voltage and average load current.

(ii). Sketch the waveforms of load current and load voltage.

(iii). Subsequently, introduce a capacitor across the resistive load and redraw the above waveforms in (ii). Discuss the changes in circuit dynamics following the incorporation of the capacitor. ***(04)***

1B. A single-phase full wave-controlled bridge rectifier feeding an RL load operates from a 230 V, 50 Hz AC supply.

(i)With a neat circuit, discuss the operation of the converter with RL Load when in continuous conduction mode (CCM).

(ii)The converter provides an average load current of 10 A at a delay angle of 60° in CCM. Determine the average load voltage.

(iii)For the firing angle of 60°, sketch the steady state waveform of load voltage, load current and SCR voltage (Sketch upto one cycle) ***(04)***

1C. For the converter in Q 1B, if a freewheeling diode (FWD) is now connected across the output for the same RL load and the same firing angle, calculate the new average load voltage with the FWD. Redraw the steady state waveforms of load voltage and load current (Sketch upto one cycle) ***(02)***

2A. A single-phase full wave ac voltage controller feeds a load of R = 15 Ω with an input voltage of 120V, 60Hz. Firing angle for both the SCRs is 1.535 radians. Calculate (i) rms value of output voltage (ii) load power (iii) input power factor. (iv) rms SCR current. ***(04)***

2B. Analyse the operation of a buck dc dc converter with a neat circuit schematic and sketch the following waveforms.

(i). Inductor current and inductor voltage

(ii). Capacitor current and capacitor voltage ***(03)***

2C. An employee of a company was asked to design a power converter for the specifications shown in Table 1.

Table 1: Specifications

Input Voltage	8 V
Output Voltage	4 V
Output Current	1 A
Switching frequency	200 kHz
Inductor current ripple	40%
Output Voltage ripple	2%
Inductance (L)	12.5 µH
Capacitance (C)	15.625 uF

The employee selects a boost topology as the power converter. Hence evaluate the design and answer the following questions:

(i). Is the boost topology ideal for the design specifications mentioned in Table 1? If not, suggest a better topology.

(ii). Are the designed values of L and C in Table 1 meeting the specifications and ripple considerations? Are they underrated or overrated? Justify with appropriate calculations. ***(03)***

3A. A single-phase AC load requires a voltage of 100V rms at 50 Hz and is purely resistive. In the laboratory setting, there's a 100V DC supply. The designer's task is to select between a half bridge and a full bridge square wave inverter for connecting the DC supply to the AC load to meet the specified requirement. Justify your choice by providing a circuit diagram along with the following waveforms (Sketch upto 2 cycles):

(i) Load voltage and load current

(ii) Gating pulses ***(03)***

3B A single-phase full bridge square wave inverter has a resistive load of R =10 Ω and a DC input voltage of Vs = 100 V. The desired output frequency is 50 Hz. Determine

(i). RMS of output voltage

(ii). RMS output voltage of fundamental component

(iii). The output power

(iv). THD

(v). The Harmonic factor of the third harmonic

(vi). The peak current and peak voltage of the switch. ***(04)***

3C Discuss the advantages of PWM inverters and outline the difference between bipolar and unipolar PWM switching scheme. ***(03)***

4A A three-phase bridge inverter delivers power to a resistive load from a 450V dc source. For a star connected load of 10 ohms per phase, the inverter is operated in 180° mode of conduction. The switch used in the circuit has a peak voltage rating of 600V and peak current rating of 20A. With a neat circuit diagram, evaluate the following.

(i). Compute rms value of load phase voltage and the rms value of the load current.

(ii). Compute the power consumed by the three-phase load.

(iii) Verify if the rating of the switch is meeting the design criteria of the circuit.

(iii) Sketch the waveforms of any one phase voltage upto one cycle. ***(04)***

4B A single-phase full bridge inverter is used to produce a 50Hz voltage across a series R-L load using bipolar PWM, with R= 12Ω and X_L=16 Ω. The dc input to the bridge is 100V. The carrier signal has a frequency of 5kHz and a peak value of 1V. The control signal has a frequency of 50 Hz and a peak value of 0.8 V.

(i). Specify the amplitude modulation ratio and the frequency modulation ratio.

(ii). Calculate the peak amplitude of fundamental component of output voltage.

(iii). Calculate the peak amplitude of fundamental component of output current.

(iv). Sketch the harmonic spectrum of the load voltage ***(03)***

4C Discuss the key considerations and design aspects related to gate drivers. Categorize the various types of gate drive circuits based on their functionalities and applications ***(03)***

5A The Power MOSFET is used to switch a load of 5 Amps from 10 V supply at a duty cycle of 0.5 as shown in Figure 1. The switching frequency f_s is 100kHz and the duty cycle of operation D is 0.5. The On-state resistance $R_{DS(on)}$ of the MOSFET is 50mΩ. The turn on time and the turn off time of the MOSFET is same and is given as t_{ON}=t_{OFF}=2ns.

(i) Estimate the conduction loss and switching loss in the Power MOSFET.

(ii) Sketch the turn on and turn off switching characteristics of the Power MOSFET.

[Given: The RMS of the drain current through the MOSFET is $I_{Drms} = I_{D(ON)}\sqrt{D}$]

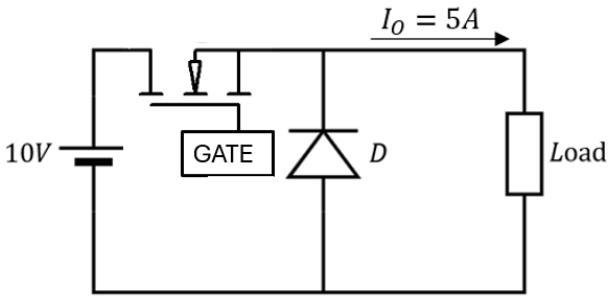

Figure 1

(05)

5B A SPV (Solar PV) system is configured with four strings having 10 modules per string. This is connected to an inverter whose input voltage is 400 V . The intermediate stage consists of a Boost DC-DC converter. The STC rated values of voltage and current of individual modules at MPP are Vm=18V and Im=8A. Assume the system is operating at STC. Analyse the system and answer the following.

(i)Determine the corresponding value of the duty cycle applied to the boost converter required to extract the maximum power from the solar modules.

(ii)Draw the block diagram of the entire system ***(03)***

5C Draw the block diagram of an electric drive and explain the role of power electronic converters in the electric drive system ***(02)***