

Instructions to candidates

Duration : Two (02) hours
 Number of Questions : Four (04) Essay questions
 Mark Allocation : 100 marks
 Scientific calculators are allowed.
 Answer **all** questions.

1.
 - a. Write down two ways that thyristor could turn on accidentally in forward blocking state. Sketch a snubber circuit to prevent this.

(06 marks)
 - b. Sketch the output characteristics curves for the MOSFET. Explain the operational regions of the power MOSFET as a switching device.

(06 marks)
 - c. The diode shown in the following circuit in figure 01 has following ratings. Calculate the reverse recovery current of the diode and hence calculate the peak repetitive forward current rating of the Q transistor.
 - i. Forward voltage drop, $V_{FO} = 0.8\text{ V}$
 - ii. Maximum RMS forward current, $I_{FRMS} = 40\text{ A}$
 - iii. maximum $\frac{di}{dt}$ rating = 10^7 A/s
 - iv. reverse recovery charge = $10\text{ }\mu\text{C}$

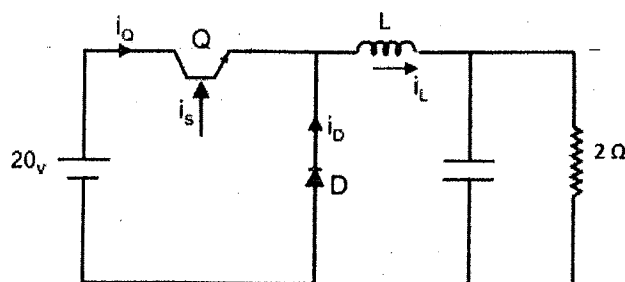


Figure 01

- d. Calculate the maximum power dissipation rating of the diode and hence calculate the maximum frequency the above circuit can operate.

(08 marks)
- (04 marks)



2.

- a. Sketch the circuit diagram and input/output voltage waveforms for 3 phase full wave bridge rectifier with 240 V 60 Hz input line voltage and 15 Ω output load resistance. Clearly state each diode's forward biased time duration in output voltage waveform.

(06 marks)

- b. Draw the voltage waveform across a diode and hence calculate V_{RRM} rating for the diode.

(05 marks)

- c. Calculate the following parameters for the above 3 phase full wave bridge rectifier

i. Rectification ratio

ii. Form factor

iii. Ripple factor

(06 marks)

- d. Following figure 02 shows a fully controlled single phase full bridge rectifier circuit which is used to drive a dc motor. Show that the average dc voltage is given by

$$V_d = \frac{2V_m \cos\alpha}{\pi} \text{ where, } V_m \text{ is the peak input voltage and } \alpha \text{ is the thyristor firing angle.}$$

Hence explain how rectifier circuit can be used to control the dc motor speed and the rotation direction.

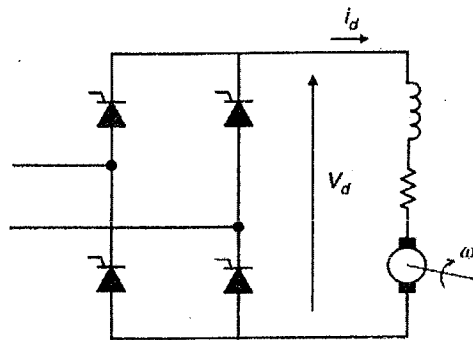


Figure 02

(08 marks)

3.

- a. Sketch the circuit diagram for Buck converter using a power MOSFET as the switching device. Take a resistive load as the output load.

(02 marks)

- b. Draw the voltage and current waveforms for the
- Inductor
 - Capacitor
 - Output load resistor
 - Free-wheeling Diode
- (04 marks)

- c. Hence derive the equations for
- DC voltage transfer function, m_v
 - Minimum inductance for CCM operation
 - Minimum capacitance to limit ripple voltage (V_r)
- (09 marks)

- d. Design a Buck converter with following specifications. Calculate the minimum switching frequency in order to operate in CCM mode and the minimum capacitor value for ripple filtering. Consider both cases of minimum and maximum input voltage for the calculations.

- Input voltage 3-5 V
- Output voltage 2.5 V
- Output current 500mA
- Voltage ripple 1%
- Inductance 10uH

(10 marks)

4.

Following figure 03 shows a full bridge voltage source inverter circuit.

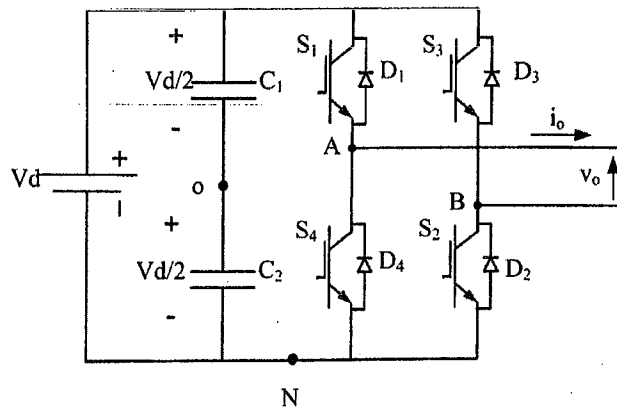


Figure 03

- a. Write down the operational states of the full bridge inverter and associated output voltage



(06 marks)

- b. In order to generate 8 V (rms) 60Hz AC output using unipolar PWM technique, calculate m_a (modulation index) and hence draw waveforms for V_c (desired ac output) and V_{Δ} (carrier signal) indicating amplitude and frequency. (Take $V_d = 12$ V, frequency modulation ratio (m_f) = 8)

(07 marks)

- c. Write down the selection criteria for operational state depending on V_c and V_{Δ} and draw the waveforms for each operational state clearly indicating relevant time duration in V_c and V_{Δ} graphs.

(07 marks)

- d. Hence draw the output waveform (V_o)

(05 marks)