The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX 5270 Power electronics and motor drives**
Academic Year	:	2014/2015
Date	:	**12th September 2015**
Time	:	09.30am – 12.30pm
Duration	:	3 hours

General instructions

1. Read the question carefully before answering the questions.
2. This question paper consists of 8 questions. All questions carry equal marks.
3. Answer any 5 questions only.

Q1. **(i)** What is meant by Electrical Drives? Discuss the different factors for the selection of electrical drives?

(ii) What is the difference between a thyristor and a TRIAC ?

(iii) Discuss at least four applications of power electronic converters.

(iv) Sketch a turn-off snubber circuit configuration which could be used to reduce turn-off switching loss in a power semiconductor switch feeding a constant current load.

Q2. **(i)** Assume that the current and voltage variations in the power semiconductor switch, S as shown in Fig. Q2, are linear during switching transitions. The on-state voltage drop across the switch is V_D.

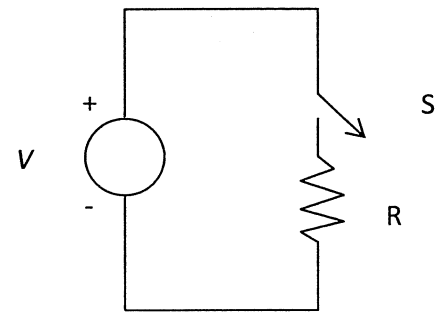


Fig. Q2

Derive an expression for the average switching power loss across the switch and show that

$$P_{SW} = \left(\frac{VI}{6} + \frac{V_D I}{3}\right)\left(t_{sw(on)} + t_{sw(off)}\right) f_s$$

Where, V is the off state voltage across the switch, I is the on state current through the switch, $t_{sw(on)}$ and $t_{sw(off)}$ are the switching transition time and f_s is the switching frequency.

(ii) For the circuit as shown in Fig. Q2 the following data are given :

V = 100 V, R = 5Ω, $t_{sw(on)}$ =2 μs, $t_{sw(off)}$ = 3 μs, D (duty cycle) 0.3 and f_s = 20 kHz.

(a) The switch is assumed to be non-ideal with a forward characteristics given by

$V_D = 1.5 + 0.05i$

where, i is the instantaneous current through the switch. Determine the on-state current, I, through the switch.

(b) Determine the average switching power loss and also the average on-state loss of the switch. The off-state loss is assumed to be negligible.

(c) With no heat sink used, the power semiconductor device exhibits a thermal resistance, $R_{\theta(ja)}$ = 4.5° C/W. Determine whether it is feasible for the power semiconductor switch to operate reliably and dissipate the total power loss as obtained in part (b) (ii).

It may be assumed that the ambient temperature is 50° C and the maximum junction temperature allowed for the switch is 150° C.

Q3 **(i)** Design a half-wave controlled rectifier circuit to produce an average voltage of 40 V across a 100 Ω load resistance from 120 V rms, 60 Hz ac source. Determine the power absorbed by the resistance and the power factor.

(ii) A full-wave controlled Bridge rectifier has an AC source of 240V rms at 60Hz, V_{dc} = 100V, R = 5 Ω and an inductor large enough to cause continuous current.

Determine

(a) the delay angle, α such that power absorbed by the dc source is 1000 W.
(b) the valve of L which will limit the pack-to-pack variation in the load current to 2 A.

Q4. **(i)** What is the principle of operation of a step-down converter?

(ii) A buck converter has an input voltage, V_d = 15 V. The required average output voltage V_o = 5 V and the pack-to-pack output ripple voltage is 10 mV.The switching frequency is 20 kHz. The pack-to-pack ripple current of the inductor is limited to 1 A. The converter is operating in continuous current mode.

Determine,

(a) the duty cycle D,
(b) the filter inductor L,
(c) the filter capacitor C,
and (d) the boundary current I_{LB}.

Q5. **(i)** Design a boost converter that will have an output of 30 V from a source of 12 V.

Design for continuous inductor current and an output voltage of ripple less than 1 %. The load consists of a resistance of 50 Ω. Assume ideal components for the design.

(ii) A one quadrant chopper is feeding RL load with input voltage V_d = 220 V. The load R = 5 Ω, L = 15.5mH. The switching frequency is 1 kHz. The duty cycle is 40 % calculate :

(a) the minimum instantaneous load current.
(b) the pack instantaneous load current.
(c) the pack-to-pack ripple load current.
(d) the average load current and average load voltage.

Q6. **(i)** For single-phase ac voltage regulator feeding a resistive load, draw the wave forms of source voltage, gating signals, output voltage, source and output currents and voltage across SCRs. Describe its working with reference to the waveforms drawn.

(ii) Propose and design a power converter circuit to deliver power in the range of 750 W to 1500 W to a 30 Ω resistive load from a 230 V at 50 Hz source. Determine the corresponding maximum firing angle of the device, rms and average currents of the device and the corresponding worst case power factor on the supply side.

Q7. **(i)** With the help of neat circuit diagram and associated waveforms, explain the operation of single phase half bridge MOSFET based voltage-source inverter with.

(a) Resistive load and
(b) Inductive load

(ii) The full-bridge inverter has a switching sequence which produces a square-wave voltage across a series $R - L$ load. The switching frequency is 50 Hz, V_{dc} = 100 V, R = 10 Ω and L = 25 mH.

Determine,

(a) an expression for the load current,
(b) power absorbed by the load,
(c) average current drawn from the dc source.

Q8. **(i)** What is a rectifier?

(ii) What is the difference between a rectifier and a converter?

(iii) Show that the power factor for the controlled full-wave bridged rectifier with a resistive load is

$$pf = \sqrt{1 - \frac{\alpha}{\pi} + \frac{Sin(2\alpha)}{2\pi}}$$

where α = firing delay angle.

End