UNIVERSITY OF SWAZILAND

FIRST SEMESTER EXAMINATION 2006/2007

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRONIC ENGINEERING

TITLE OF PAPER: POWER ELECTRONICS AND DRIVES

COURSE NUMBER: EIN510

TIME ALLOWED: THREE HOURS

INSTRUCTIONS:

1. **Answer any FOUR (4) of the following six questions.**
2. **Each question carries 25 marks.**
3. **If you think not enough data has been given in any question you may assume reasonable values.**

THIS PAPER SHOULD NOT BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR

THIS PAPER CONTAINS FIVE (5) PAGES INCLUDING THIS PAGE

QUESTION 1

(a) The data sheets of a switching device specify the following switching times corresponding to the linearized characteristics shown in Fig. Q1a for clamped inductive switchings:

$t_{d(on)} = 40$ ns $t_{ri} = 80$ ns $t_{fv} = 40$ ns $t_{rv} = 80$ ns $t_{fi} = 160$ ns $t_{d(off)} = 100$ ns

Calculate the switching device power loss if the switch is operated at 100 kHz, assuming $V_d = 400$ V, $I_o = 10$ A, $V_{on} = 2.5$ V and 50% duty ratio.

[15 MARKS]

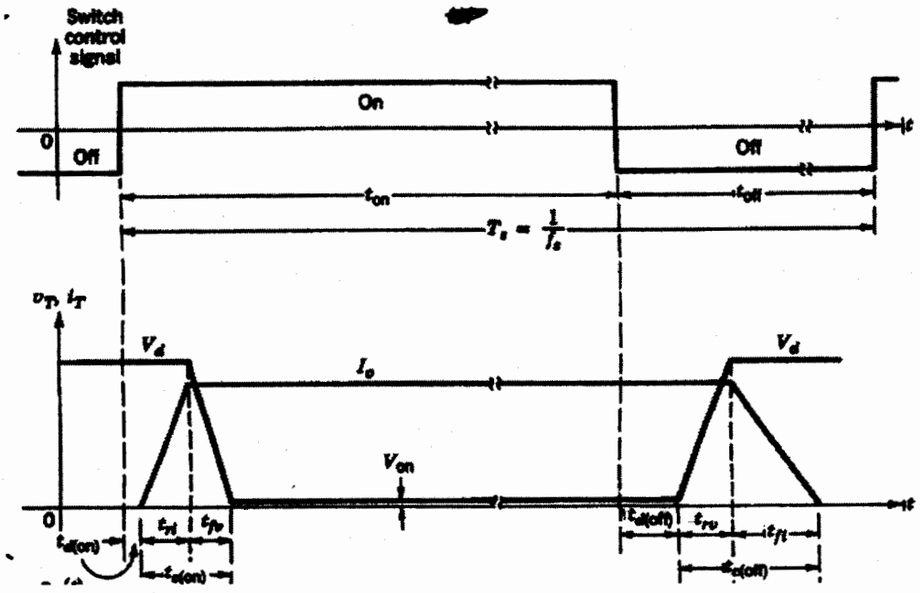

Fig. Q1a

(b) Select the components of the snubber circuit of Fig. Q1b. The supply voltage V_s = a step of dc voltage 350 V. The thyristor powers a 10-Ω resistive load R. R_s should limit the maximum current through the capacitor to 50 A. The maximum permitted values of di_T/dt and dv_T/dt are 100 A/μs and 350 V/μs respectively. Ignore the switching times.

[10 MARKS]

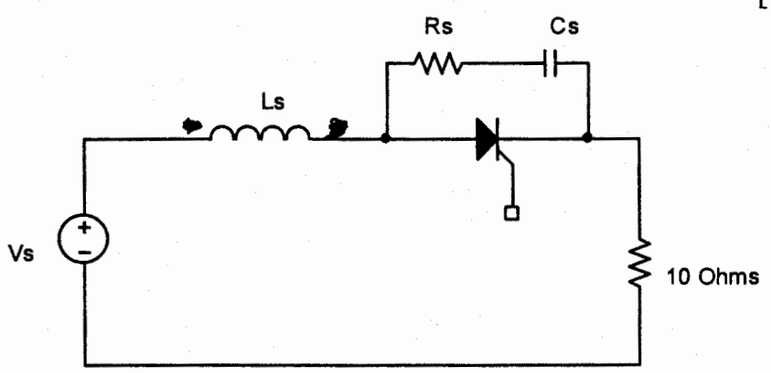

Fig Q1b

QUESTION 2

Design a power converter for the following specifications:

$V_s = 20\ V \sim 30\ V$ $V_o = 48\ V$ $f_s = 100\ kHz$ $R_L = 8\ \Omega$

(a) Draw the circuit diagram of a suitable power converter.

[5 MARKS]

(b) Select values for L and C such that

(i) the input current ripple Δi_L is 20 mA and

(ii) the peak output voltage ripple Δv_o is 2% of V_o.

[20 MARKS]

QUESTION 3

(a) In a full-bridge converter, the duty ratio is adjusted to regulate the output voltage to 15 V. The input dc voltage varies in the range 20 V to 30 V. The converter is switched at 100 kHz. Find the range of pulse width of the switching waveform applied at the switch.

[9 MARKS]

(b) In a single-phase full-bridge SPWM inverter, the input dc voltage varies in a range of 283 to 325 V.

(i) What is the highest V_{o1} (rms) that can be obtained and stamped on its nameplate as its voltage rating?

(ii) Find the range of maximum duty cycle of the SPWM switching waveform.

[16 MARKS]

QUESTION 4

(a) The full-bridge converter shown in Fig. Q4a is fed with an input voltage of 230 V at 50 Hz. It is required to provide a dc current of 20 A to a coil of inductance 0.5 H and resistance 3 Ω.

(i) Find the phase delay angle α.

(ii) If transistors replace the SCRs in the full-bridge circuit and PWM control is used, determine the pulse width δ.

[9 MARKS]

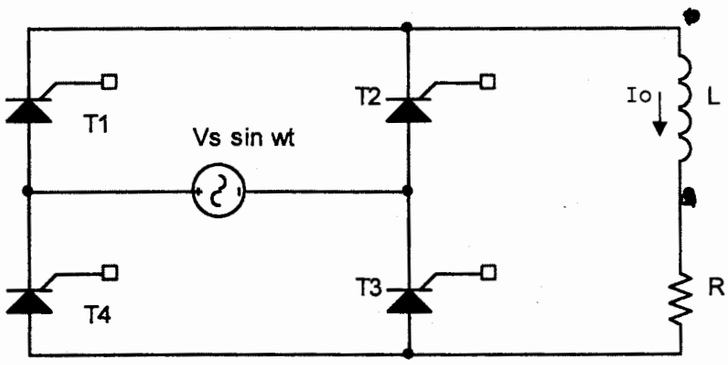

Fig. Q4a

(b) A 400 V three-phase full-bridge converter is connected to a 400 V DC grid. Find the firing angle α.

[16 MARKS]

QUESTION 5

(a) Develop the averaged model and obtain the transfer function for a dc-dc Buck converter in which the source voltage is 48 Vdc and the output voltage is 24 Vdc operating in the continuous conduction mode. Other components are L = 1 mH and C = 220 μF.

[10 MARKS]

(b) For the Buck converter in (a), determine the transient response of the output voltage when the duty ratio undergoes a step change to 0.7 (in the next switching period) with output current I_o = 5 A.

[15 MARKS]

QUESTION 6

(a) A dc motor with a voltage rating of 400 V for both armature and field is used as a separately excited motor. The field is supplied at the rated voltage. The armature is supplied by a thyristor bridge from a three-phase, 400 V, 50 Hz ac bus. The inductance per phase of the ac bus is 200 μH. The armature is rated for 100 A and has a resistance of 0.2 Ω. The no-load speed is 1200 RPM. Determine the delay angle required to achieve a speed of 800 RPM at the rated current in the armature. [Hint: For a 3-phase full-bridge converter with source inductances,

$$V_o = \frac{3\sqrt{2}}{\pi} V_{LL} \cos\alpha - \frac{3\omega L_s}{\pi} I_o \qquad]$$

[14 MARKS]

(b) A three-phase, 50 Hz induction motor is rated 400 V, 1460 RPM. How much dc voltage should a variable-frequency drive provide to the motor at 35 Hz?

[11 MARKS]