UNIVERSITY OF SWAZILAND

FIRST SEMESTER EXAMINATION DECEMBER, 2008

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRONIC ENGINEERING

TITLE OF PAPER:	POWER ELECTRONICS AND DRIVES
COURSE CODE:	EIN510
TIME ALLOWED:	THREE HOURS

INSTRUCTIONS:

1. **Answer any FOUR (4) of the following five 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**

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THIS PAPER CONTAINS SIX (6) PAGES INCLUDING THIS PAGE

QUESTION ONE ***(25 marks)***

The buck converter shown in Fig.Q1 is required to give an output voltage of 12 V with a maximum peak-to-peak ripple of 100 mV into a 100 W resistive load. The input voltage is 40 V dc and the converter operates with a minimum load current of 0.3 A. The switching frequency is 50 kHz. Assuming that all devices used are ideal, determine

(a) The duty cycle of switching *(1 mark)*

(b) The values of

(i) L, and *(5 marks)*

(ii) C *(5 mark)*

(c) The minimum and maximum value of the inductor current *(4 marks)*

(d) Sketch the waveforms of the following and determine their minimum and maximum values:

(i) The voltage across the inductor *(2 marks)*

(ii) The voltage across the BJT *(2 marks)*

(iii) The current in the BJT *(3 marks)*

(iv) The current in the diode *(3 marks)*

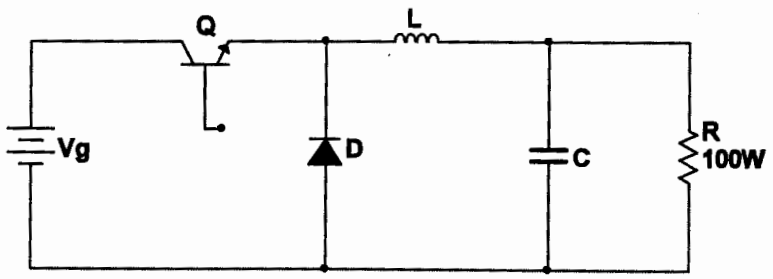

Fig.Q1

QUESTION TWO **(25 *marks*)**

The circuit in Fig.Q2 is used to control power in an 8 Ω, 5 mH load. The free-wheel path includes a 5.1 V zever diode. The switch is operated at 25 kHz with a duty cycle of 0.3. Assume that the switch and diode each has a voltage drop of 0.8 V.

(a) Sketch the waveform of the voltage across the load, specifying the key amplitude levels and time scales. *(3 marks)*

(b) Repeat (a) for the voltage across the switch. *(3 marks)*

(c) Calculate the average load current. *(3 marks)*

(d) Estimate the peak-to-peak magnitude of the ripple in the load current. *(5 marks)*

(e) Estimate the power dissipated in the free-wheel path. *(3 marks)*

(f) Estimate the power dissipation in the MOSFET *(2 marks)*

(g) Calculate the rate of decay of current in the inductor. *(4 marks)*

(h) What is the effect of the zener diode on the rating of the MOSFET switch? *(2 marks*

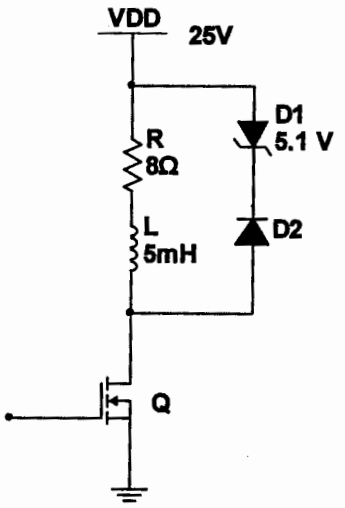

Fig.Q2

QUESTION THREE **(25 *marks*)**

(a) A three-phase fully-controlled thyristor ac to dc converter is operating from a 400 V, 50 Hz supply. The load is a 12 Ω highly inductive load.

(i) If the average output voltage is 50% of the maximum possible output voltage, determine:

1. The delay (firing) angle. *(1 mark)*
2. The output voltage. *(3 marks)*
3. The average load current. *(2 marks)*
4. The r.m.s. thyristor current *(2 marks)*
5. The r.m.s. supply current *(2 marks)*
6. The average thyristor current. *(2 marks)*

(ii) If the thyristors have a forward voltage drop of 1.2 V when conducting, calculate the thyristor firing angle required to produce an output voltage of 300 V. *(5 marks)*

(b) Design a base drive circuit for a power BJT operating as a switch with a peak base drive current limit of 0.6 A. A base current of 0.25 A is required to ensure saturation over all load conditions. The switching frequency is 10 kHz and the switching voltage is 0 V and 15 V. You may assume that peaking network time constant is about 5% of the switching period. *(8 marks)*

QUESTION FOUR **(25 *marks*)**

(a) Determine the power factor in a three-phase fully controlled converter operating with a firing angle of 45° and feeding a d.c. current of 200 A into an inductive load. The supply voltage is 400 V, 50 Hz. *(9 marks)*

(b) A diode in a power switching converter has a forward voltage drop of 0.8 V when conducting pulses of amplitude 10 A. The pulses have a duration of 40 μs and a repetition rate of 100 μs. The diode's thermal resistance between junction and case is 2°C/W and it is mounted on a heatsink of thermal resistance 4°C/W in air with an ambient temperature of 30°C. If the diode switching losses and off state losses are negligible, calculate the diode junction temperature. *(8 marks)*

(c) A 1200 rpm dc motor is rated at 3 kW, 230 V is fed from a 400 V, 3-phase 50 Hz supply using a thyristor converter. The armature resistance of the motor is 0.6 Ω and the full load current is 15 A. Determine the thyristor firing angle required for the motor to develop its full rated torque is 600 rpm. *(8 marks)*

QUESTION FIVE **(25 *marks*)**

The Fig.Q5 shows a dc series motor is controlled under regeneration by a dc chopper from a 400 V supply. The armature resistance is R_a =0.02 Ω and the field resistance R_f = 0.03 Ω. The back e.m.f. constant of the motor is K_v = 15 mV/A-rad/s. The average armature current is 250 A and can be considered to be continuous with negligible ripple. If the MOSFET switch has a duty cycle of 0.6, determine:

(a) The equivalent input resistance of the switch. *(2 marks)*

(b) The voltage across the switch. *(2 marks)*

(c) The power being returned to the supply. *(3 marks)*

(d) The torque of the motor. *(4 marks)*

(e) The maximum possible braking speed. *(7 marks)*

(f) The motor speed when the duty cycle is reduced to 0.4 *(7 marks)*

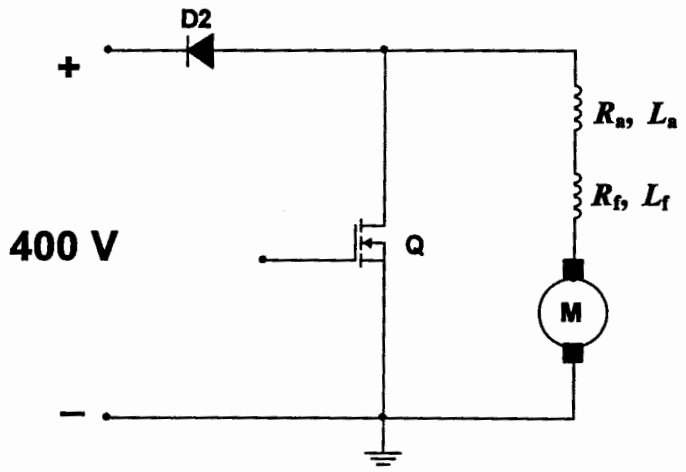

Fig.Q5