UNIVERSITY OF SWAZILAND

SUPPLEMENTARY EXAMINATION - JULY 2016

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	POWER ELECTRONICS
COURSE CODE:	EE422
TIME ALLOWED:	THREE HOURS

INSTRUCTIONS:

1. There are FOUR questions in this paper. Answer all FOUR questions. Each question carries 25 marks.
2. If you think not enough data has been given in any question you may assume any reasonable values.

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THIS PAPER CONTAINS FIVE (5) PAGES INCLUDING THIS PAGE

QUESTION ONE (25 marks)

(a) An inductive load is switched by a BJT and some of the data related are as follows.

$t_{ri} = t_{fi} = 225ns$ $t_{rv} = t_{fv} = 200ns$ $t_{d(on)} = t_{d(off)} = 100ns$

$V_{CE(sat)} = 1.5V$ $Supply\ voltage = 125V$ $Load\ current = 25A$

$Duty\ cycle = 50\%$

You may assume usual notation.

(i) If the maximum power dissipation in the BJT is to be limited to $85W$, find the usable switching frequency range.

(10 marks)

(ii) Calculate the power dissipation in the switch if the switching frequency is $45kHz$.

(5 marks)

(b) Consider the circuit shown in Figure-Q1.

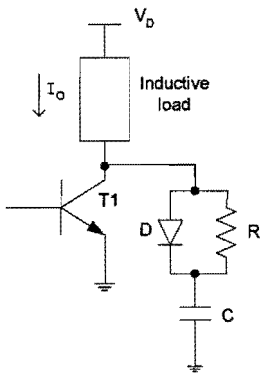

FIGURE-Q1

The inductive load consists with an inductor and a free wheel diode, in the conventional way. T_1 is a BJT used to switch the inductive load at a 50% duty cycle. You may consider the following data.

$V_D = 150V$ $I_o = 25A$ $f_S = 60kHz$ $R = 100\Omega$ $C = 20nF$

$t_{fi} = 240ns$

(i) Identify the function of the circuit section with D, R and C.

(2 marks)

(ii) Calculate the power dissipation in T_1 and in R.

(8 marks)

QUESTION TWO *(25 marks)*

(a) An ac supply of 230Vrms, 50Hz is connected to a resistive load of 5Ω through a single thyristor. The delay angle is α.

(i) Sketch on your answer book, the waveforms of load voltage and the voltage across the thyristor (V_{AK}) with reference to the supply voltage.

(3 marks)

(ii) Show that the average value and the rms value of the load voltage is given by $\frac{V_m}{2\pi}(1+cos\alpha)$ and $\frac{V_m}{2}\sqrt{1-\frac{\alpha}{\pi}+\frac{sin2\alpha}{2\pi}}$ respectively.

(6 marks)

(iii) If $\alpha = 45^0$, calculate the average load voltage, load power and the power factor.

(6 marks)

(b) The steady state power dissipation of a switching device is $50W$. You may assume the following data with usual notation.

$$T_{j(\max)} = 175^0C \qquad \theta_{jc} = 2.1^0\frac{C}{W} \qquad \theta_{ch} = 0.2^0\frac{C}{W} \qquad T_a = 40^0C$$

(i) Find the thermal specification of a suitable heat sink.

(6 marks)

(ii) Calculate the temperature of the case of the device and of the heat sink.

(4 marks)

QUESTION THREE *(25 marks)*

A single phase fully controlled bridge rectifier is shown in Figure-Q3.

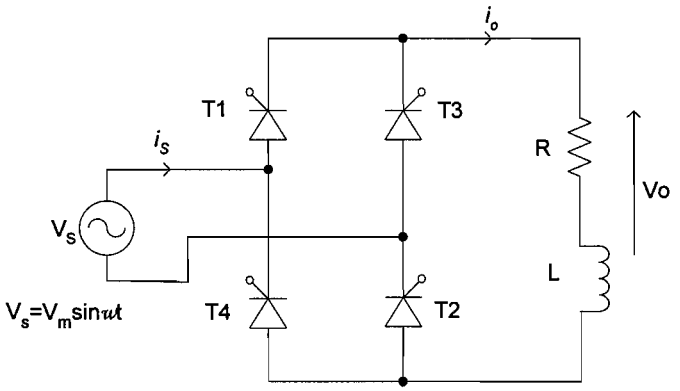

Figure - Q3

$V_s = 230V_{rms}$ at $50Hz$, $R = 10\Omega$, $L = 100mH$ and the delay angle $\alpha = 45^0$.

(a) Show that the load current is continuous.

(2 marks)

(b) Draw the following waveforms on your answer book with reference to V_S.

(i) Load current i_O. (ii) Load voltage v_O.

(iii) Currents in the thyristors T_1 and T_4.

(6 marks)

(c) Show that the average load voltage is given by $V_{dc} = \frac{2V_m}{\pi} cos\alpha$.

(5 marks)

(d) Calculate the average load voltage and average load current.

(3 marks)

(e) Find the power absorbed by the load and the power factor at the source. You may use the normalized harmonic amplitudes $\left(\frac{V_n}{V_m}\right)$ given below, where n is the harmonic order.

(9 marks)

n	2	4	6
$\left(\frac{V_n}{V_m}\right)$	0.67	0.25	0.16

QUESTION FOUR (*25 marks*)

(a) The buck converter shown in Figure-Q4, operates with a switching frequency f and a duty ratio D.

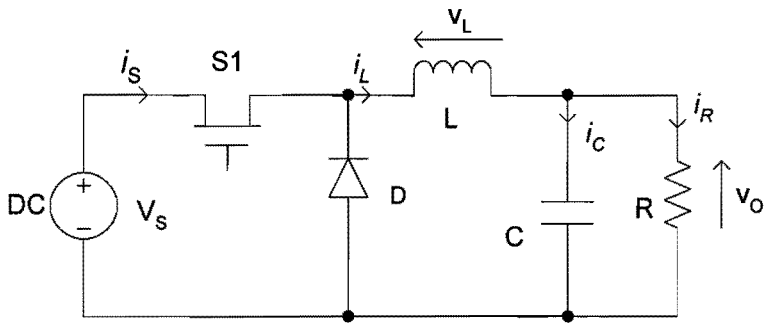

Figure-Q4

(i) Draw the waveforms of i_L and i_C, assuming that the C is large.

(2 marks)

(ii) If the C is large, show that the peak to peak variation of the inductor current is given by $\frac{V_O(1-D)}{Lf}$.

(5 marks)

(iii) Find an expression for the amplitude of the ripple voltage at the output.

(5 marks)

(iv) Consider the following data for this converter.

$V_S = 50V$ $D = 0.4$ $L = 500\mu H$ $C = 100\mu F$

$f = 40KHz$ $R = 20\Omega$

Calculate the following using the above data.

(i) The output voltage.

(ii) Maximum and Minimum inductor currents.

(iii) The output ripple amplitude.

(8 marks)

(b) In a dc to dc boost converter, the supply voltage is $15V$. If the required output voltage is $48V$ for a load resistance of 5Ω,

(i) calculate the required duty ratio,

(ii) find the average current supplied from the dc power supply.

(5 marks)