UNIVERSITY OF SWAZILAND

SUPPLEMENTARY EXAMINATION - JULY 2017

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 power BJT at a frequency of f_S. Draw a diagram of V_{CE} and I_C of the device for one complete switching cycle. The supply voltage and the load current are V_O and I_O respectively.

(6 marks)

(b) Assuming the following data, calculate the power loss in the transistor mentioned in (a) above. Show the steps of your calculations clearly.

$t_{ri} = t_{fi} = 150ns$ $t_{rv} = t_{fv} = 100ns$ $t_{d(on)} = t_{d(off)} = 50ns$

$V_{CE(sat)} = 1.2V$ $Supply\ voltage = 120V$ $Load\ current = 35A$

$Duty\ cycle = 50\%$ $f_S = 30kHz$

You may assume usual notation.

(9 marks)

(c) A power transistor is mounted on a heat sink having a thermal resistance of $0.3^0\frac{C}{W}$.

You may assume the following data with usual notation.

$T_{j(\max)} = 170^0C$ $\theta_{jc} = 2^0\frac{C}{W}$ $\theta_{cs} = 0.15^0\frac{C}{W}$ $T_a = 40^0C$

(i) Find the maximum possible power dissipation of the switch under steady state.

(6 marks)

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

(4 marks)

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

A resistive load of 8Ω is connected to the ac supply of 220Vrms, 50Hz through a single thyristor.

(a) If the delay angle is α, draw the waveforms of load voltage, load current and the voltage across the thyristor (V_{AK}) with reference to the supply voltage, in your answer book.

(9 marks)

(b) Show that the average value of the load voltage is given by $\frac{V_m}{2\pi}(1 + cos\alpha)$.

(8 marks)

(c) If $\alpha = 40^0$, calculate the average load voltage and the average load current.

(8 marks)

QUESTION THREE *(25 marks)*

Consider the single phase fully controlled bridge rectifier shown in Figure-Q3.

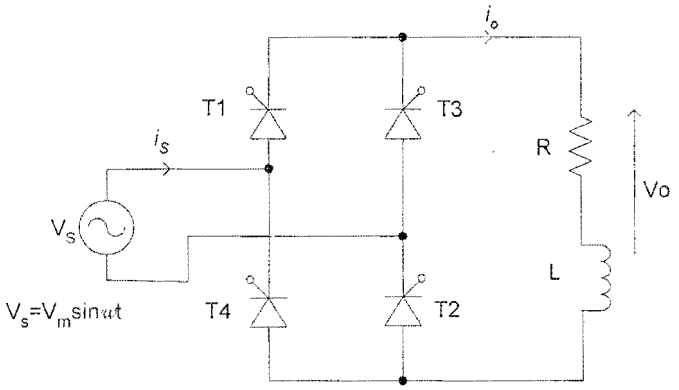


Figure - Q3

$V_s = 220V_{rms}$ at $50Hz$, $R = 8\Omega$, $L = 200mH$

(a) Calculate the maximum possible delay angle for which the load current is continuous.

(5 marks)

(b) Draw the following waveforms in your answer book with reference to V_S. Assume that the delay angle α is $0 < \alpha < \frac{\pi}{2}$.

(i) Load voltage v_O.

(ii) Currents in the thyristors T_1 and T_4.

(iii) Current of the supply i_S.

(8 marks)

(c) Derive an expression for the average load voltage if the delay angle is α.

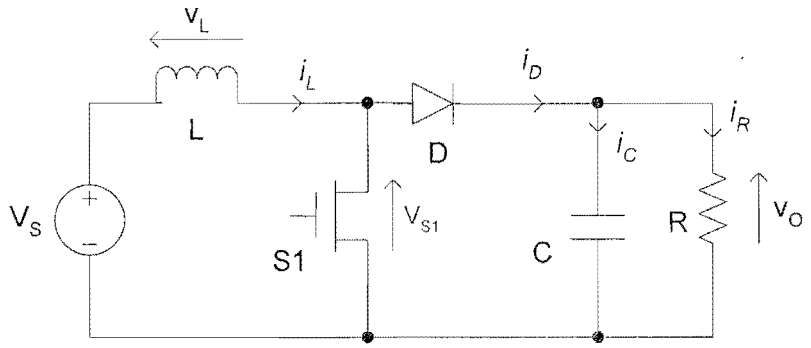
(6 marks)

(d) Calculate the average load voltage and the average load current if the delay angle $\alpha = 40^0$.

(6 marks)

QUESTION FOUR (*25 marks*)

(a) A circuit of a boost converter is shown in Figure-Q4.



You may assume that ,

$V_S = 12V$ $Duty\ cycle = 0.6$ $L = 150\mu H$

$f = 30KHz$ $R = 10\Omega$

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

(9 marks)

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

(6 marks)

(c) Calculate the following using the data shown above.

(i) The output voltage. (2 marks)

(ii) Maximum and Minimum inductor currents. (4 marks)

(iii) The output ripple amplitude if $C = 100\mu F$. (4 marks)

Note: You may use, $V_o = \frac{V_S}{1-D}$.