Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2013-14 (2.0 hours)

EEE6023 Power Electronics

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1. a. With reference to suitable voltage and current waveforms, explain the operation of the circuit shown in figure 1 below. Derive an expression for the average output voltage (across the resistor and inductor) for the circuit. **(8)**

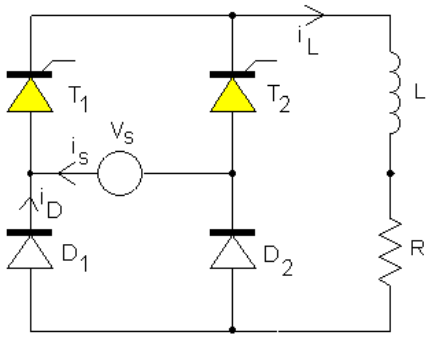

Figure 1

b. The circuit in figure 1 is to supply a load in an electroplating tank with 400A dc from the low voltage secondary output of a 50Hz single phase transformer rated at 12Vrms. Calculate the firing angle for the devices given that the circuit needs to develop 8Vdc across the load to give the rated load current. **(4)**

c. If the diodes were to be replaced by thyristors in the above circuit, what firing angle would be required to maintain the output conditions, assuming continuous current in the load? **(4)**

d. What is the minimum value of load inductance which would ensure the continuous load current conditions to be met for the converter in part 'c'? **(4)**

2. **a.** Derive from first principles a relationship between the input and output voltage for the converter shown in figure 2 below. You should include all steps taken, and show graphs of voltage and / or current, as necessary, to explain the operation for the circuit. **(8)**

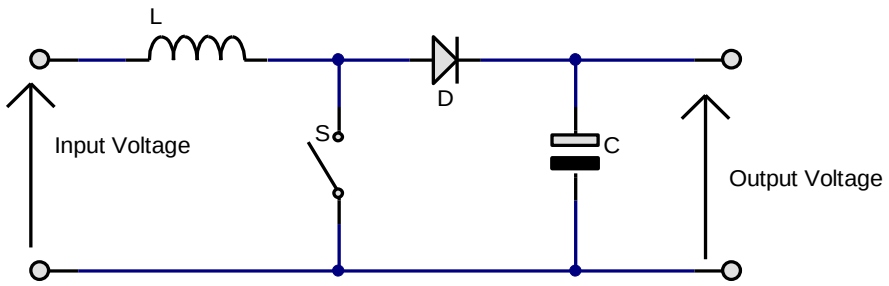

Figure 2

b. Given that the above circuit has an input voltage of 5V, and would be operated with a duty cycle (δ) of 2/3, calculate the output voltage. **(2)**

c. If the circuit was to supply a load current between 50mA and 200mA, and operate at 40kHz, give a suitable inductor value for the circuit **(3)**

d. Calculate the required capacitor value necessary to ensure the output voltage ripple doesn't exceed 1%. **(3)**

e. Justify your choice of switching device for the circuit, giving the necessary device voltage and current ratings **(2)**

f. What factors affect the choice of diode for the circuit in figure 2 above **(2)**

3. **a.** Given the state-space equations for the inductor current and capacitor voltage, averaged over the duty cycle, for a Buck converter are below:

$$\dot{i}_L = \frac{dv_i}{L} - \frac{Ri_L}{L} + \frac{CR\dot{v}_o}{L} \qquad \dot{v}_o = \frac{i_L}{C} - \frac{v_o}{CR}$$

where $\dot{i}_L$ and $\dot{v}_o$ denote the derivative s with respect to time

Prove the following small signal Audio Susceptibility transfer function for the converter.

$$\frac{v_o}{v_i} = \frac{d}{LC\left(s^2 + \frac{s}{CR} + \frac{1}{LC}\right)}$$

(12)

b. Calculate the values of capacitor and inductor required for use in a Buck converter that generates a regulated 12V dc output from a 36 to 48V input. The circuit is to supply an output current ranging from a minimum of 0.5A to a maximum of 5A. The output voltage ripple for the converter should be less than 2%. Ignore switch and diode voltage drops, and assume the converter is to operate at a frequency of 30kHz **(8)**

4. **a.** Explain the problems encountered in the connection of BJTs in parallel, and show how the devices may be made to share current. **(6)**

b. With reference to voltage and current waveforms, derive an expression for the switching loss in a BJT when switching current in an inductive load. **(8)**

c. Explain with the aid of a circuit diagram the problems encountered in designing the base drive circuits for an H-bridge inverter. **(6)**

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