Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2012-13 (2.0 hours)

EEE6023 Power Electronics 3

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. Explain with the aid of suitable diagrams the operation of zero current switching as applied to a basic buck converter. Include waveforms and a circuit diagram. **(10)**

b. The maximum current which is to flow to the load through the inductor in the buck converter, including the peak of the inductor ripple current, is 1A, and the resonant zero current switching tank is to operate at 500kHz. Calculate suitable values for the inductor and capacitor in the resonant switching tank circuit to ensure correct zero current switching of the converter. **(6)**

c. What would be a suitable choice for the switch technology to be used in the converter above? Explain your choice. **(4)**

2. **a.** Explain the mechanism whereby two diodes connected in parallel may not share forward current equally. **(6)**

b. Give two methods in which diodes connected in parallel could be made to share forward current. What constraints need to be placed on the circuit layout to help with the current sharing of the devices? **(4)**

c. With reference to the diode characteristics below, and given that two diodes are now connected in series, calculate the values of sharing resistors needed to ensure a maximum of 10% variation in the voltage seen by the diodes. The maximum reverse voltage seen across the pair of diodes is 1000V, and the diode characteristics are as given below. Give a suitable power rating for the sharing resistors. **(5)**

d. The diodes, with the characteristics given below, are used in a circuit where they carry a constant current of 50A with a duty cycle of 0.5. Calculate the power dissipated in the diodes, and the maximum thermal resistance of the heatsink they should be mounted on to keep the diode case temperature below 50°C with an ambient temperature of 30°C (ignore any switching losses in the diodes). **(5)**

Diode Characteristics:

Maximum Reverse Voltage = 700V, *Max reverse leakage current = 400μA*

Diode Junction voltage drop = 0.7V, *Incremental on-state Resistance = 50mΩ*

3. **a.** Derive an expression for the switching loss within a semiconductor switching device operating at a frequency f with an inductive load **(8)**

b. Four MOSFET switching devices are used in a H-bridge configuration, together with 4 Schottkey diodes, to regulate the current in a near constant current load to 5A dc as shown below in figure 1. The device characteristics and ratings of the MOSFETs and diodes are given below.

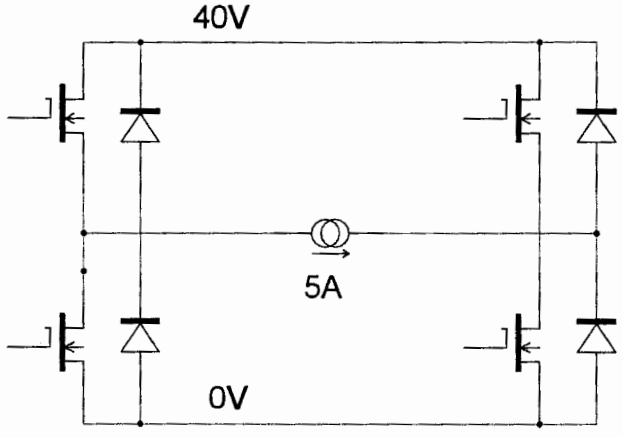

Figure 1. H-bridge inverter

Given that the duty cycle of the top-left switch is 25%, infer the duty cycles of the other devices and calculate the power dissipated in a common heatsink onto which all 8 devices are mounted. Determine the required thermal resistance for the heatsink if the devices are to be kept below 50°C in an environment where the ambient temperature is 20°C. The inverter is to operate at 30kHz. **(8)**

c. If the operating frequency of the circuit above was reduced to 200Hz, would Thyristors be a suitable choice in this circuit configuration. Justify your answer **(4)**

Device Ratings:

MOSFETS

$R_{ds(on)} = 0.5\Omega$

$V_{max} = 60V$

$I_{max} = 10A$

$t_{on} = 200ns$

$t_{off} = 300ns$

DIODES

$V_{fwd} = 0.5V$

$I_{max} = 10A$

$V_{max} = 50V$

4. **a.** With the aid of current and voltage waveforms and circuit diagrams, explain the operation of the components R, C & D in the circuit shown in figure 2 below.

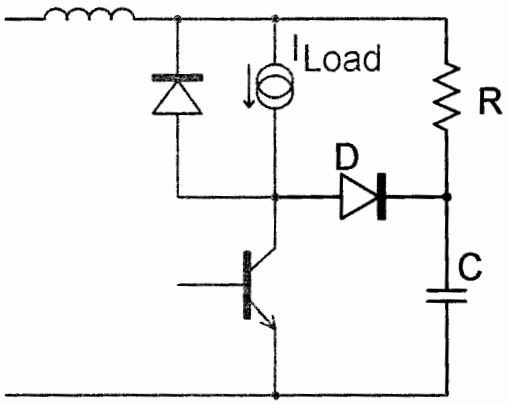

Figure 2 **(8)**

b. Given the value of the stray inductance within the circuit is 10μH (represented by the inductor in the circuit diagram above), and that the circuit is switching a square wave voltage across the load at 10kHz, calculate suitable values for the resistor and capacitor in the circuit if the maximum voltage seen by the switch is to remain below 120V. (Assume the supply voltage is 100V and the load current (I_{Load}) is a constant 5A). **(7)**

c. Briefly highlight the problems which could be faced if the switching device was actually to be formed by two BJT's in parallel, for a higher power version of the same circuit topology **(5)**

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