Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2011-12 (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.**

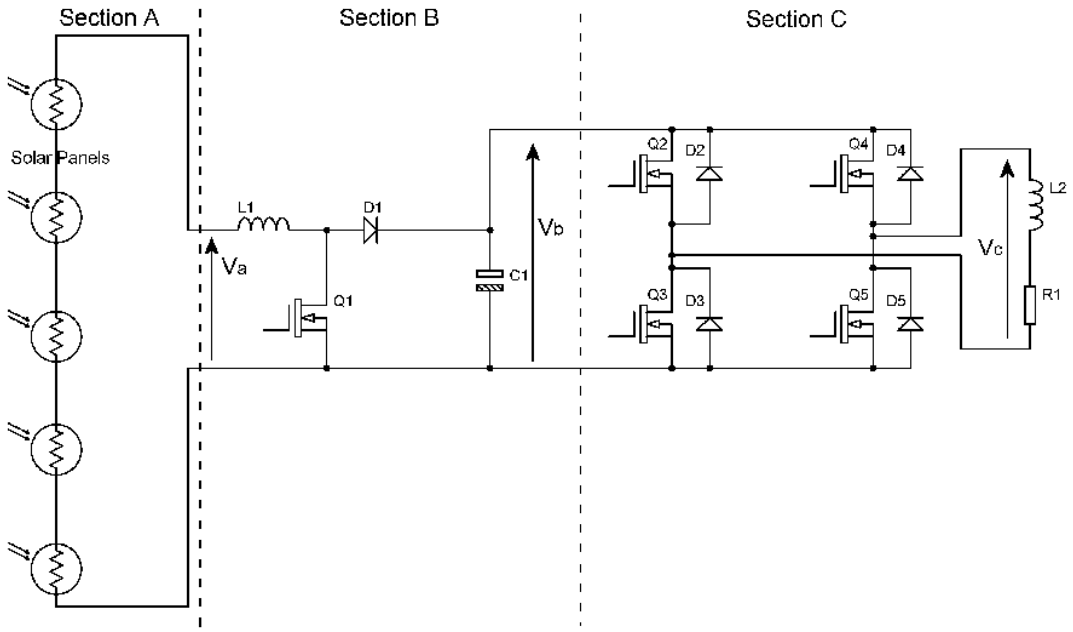

Figure 1 – Standalone solar power supply.

1. **a.** The circuit diagram of a standalone solar power supply shown in figure 1 is divided into 3 sections, A, B & C by the vertical dotted lines. Explain with the aid of circuit diagrams, and voltage and current waveforms, the operation of the dc-dc converter circuit contained in section B. **(8)**

b. If the total voltage output, V_a, of the solar panels in section A of figure 1 varies between 90V and 250V, and the voltage output ,V_b, of section B needs to be 400V and supply between 0.1A and 6A, find the values of the inductor and capacitor in the converter (L1 and C1), and suggest ratings for the switch and diode in the converter (Q1 and D1). Assume the converter operates at 50kHz and the output voltage of section B should have less than a 5% ripple. **(8)**

c. Highlight and explain the key features of components D1 and C1 in the converter circuit. **(4)**

2. **a.** The circuit diagram of a standalone solar power supply shown in figure 1 is divided into 3 sections, A, B & C by the vertical dotted lines. Explain with the aid of circuit diagrams, and voltage and current waveforms, the operation of the circuit contained in section C when operating with a quasi square wave output. **(8)**

b Given that the load resistor, R1 = 40Ω, and the load inductor, L2 = 0 in figure 1, calculate the total loss in the semiconductor devices in section C of figure 1. Also calculate the size of the heatsink required to maintain the devices below 80^{o}C in an ambient temperature of 20^{o}C if all of the semiconductor devices on section C of figure 1 were mounted on the same heatsink. Assume that the input voltage to section C is 400V dc, and the circuit is giving a square wave output across the load with a 50% duty cycle. The device ratings are given at the end of the question. **(6)**

c. Show how pulse width modulation (PWM) may be used to give an output voltage which is a closer approximation to a sine wave when driving an inductive load. **(6)**

Device ratings:

MOSFETS			***Diodes***		
$R_{ds(on)}$	=	*0.05Ω*	V_{fwd}	=	*0.3V*
V_{max}	=	*600V*	I_{max}	=	*15A*
I_{max}	=	*15A*	V_{max}	=	*600V*
t_{on}	=	*250ns*			
t_{off}	=	*250ns*			

3. **a.** Show that for the general case of a phase controlled rectifier circuit, the commutation overlap angle ,μ, during which two phases will conduct simultaneously is given by the following expression.

$$\mu = \left(\cos^{-1}\left(\cos(\alpha) - \frac{2\omega L_s I_0}{\sqrt{2} V_{LINE}} \right) \right) - \alpha$$

where the symbols have their usual meaning. **(7)**

b. Given that the circuit in figure 2 is used in a welding supply, and that the 12V (50Hz) supply is derived from the secondary of a transformer having a leakage inductance, Ls, of 100μH, calculate the required firing angle for the thyristors given that the load resistance, R=0.05Ω, and the output current is required to be 150A. (Assume the load inductance is sufficient to keep the output current continuous).

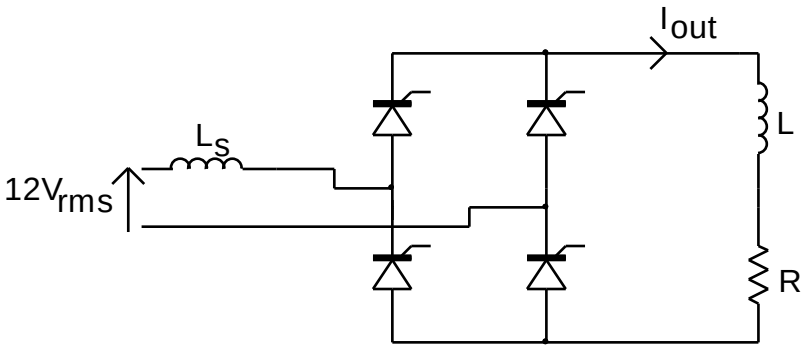

Figure 2. **(7)**

c. Calculate the output voltage and current if all of the thyristors in figure 2 were replaced by diodes. **(6)**

4. **a.** With the aid of voltage and current waveforms explain the operation of a turn on snubber circuit when applied to a BJT switching a constant current source load across a dc supply. **(8)**

b. Calculate values for the snubber inductance and resistance to ensure that the transistor is not subject to more than 20% overvoltage given a supply rail voltage of 200V dc, when switching a load current (Ic) of 10A. If the minimum time which the transistor will be in the off-state is 2μs, give a suitable power rating for the resistor. **(6)**

c. Would the switching device shown be suitable if the circuit was to be operated at 40kHz? Would any alternative device which you may suggest require the use of the snubber circuit? Justify your answer. **(6)**

DAS