ENGINEERING TRIPOS PART IIA

Wednesday 10 May 2006 9 to 10.30

Module 3B3

SWITCH MODE ELECTRONICS

*Answer not more than **three** questions*

All questions carry the same number of marks

*The **approximate** percentage of marks allocated to each part of a question is indicated in the right margin.*

There are no attachments.

STATIONERY REQUIREMENTS	SPECIAL REQUIREMENTS
Single-sided script paper	Engineering Data Book
	CUED approved calculator allowed

You may not start to read the questions printed on the subsequent pages of this question paper until instructed that you may do so by the Invigilator

1 (a) A mobile phone charger uses a single phase bridge rectifier as shown in Fig. 1. The battery type in the phone is NiMH, with three 1.2V batteries connected in series. The open circuit voltage of the charger is found to be 12.9V. The charging current is estimated from the charging time to be 0.5 A . Sketch the waveform of the current in the resistor R. [15%]

Find the conduction period of the diodes and the value of the resistance R. State three reasons why this is an effective design. [30%]

(b) A second mobile phone uses a 3.7 V LiIon battery pack. The desktop charger uses a full wave bridge rectifier which is capacitively smoothed. The power adapter gives 12 V ac. The smoothing capacitor is 470 μF. The charging current is estimated to be 0.2 A. Sketch the capacitor voltage waveform assuming the charging current drawn from the capacitor is constant. [20%]

Neglecting the internal resistance of the power adapter, estimate the conduction period of the diodes and the peak diode current. [35%]

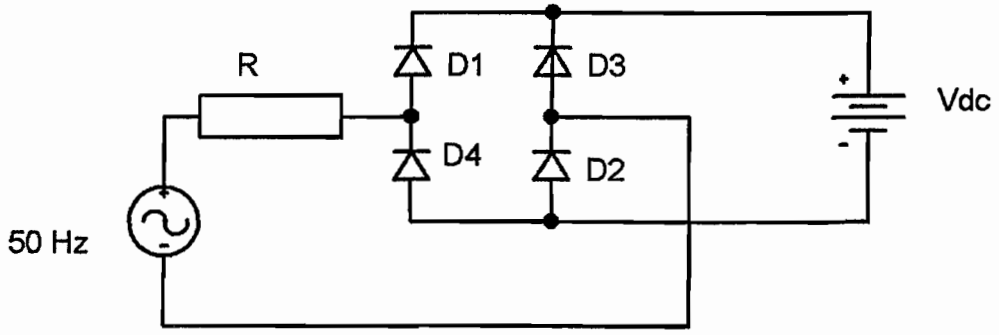


Fig. 1

2 (a) State three factors influencing the choice of switching frequency in pulse width modulation inverter systems. [15%]

(b) Explain briefly how naturally sampled pulse width modulation switching instances are obtained for the three phase full bridge inverter shown in Fig. 2. State the features in the method which avoid unnecessary harmonics appearing. [40%]

(c) For the three-phase bridge shown in Fig. 2 operated according to part b, explain carefully why the rms. line voltage output is given by

$$\frac{m\sqrt{3}\,V_{DC}}{2\sqrt{2}} \quad ,$$

where m is the modulation index.

Explain what happens to the waveform of the output voltage when m exceeds unity. [25%]

(d) The inverter may be operated using *Space Vector Modulation*. By means of sketches of the output voltage waveforms or otherwise, show that the effective value of m may then exceed unity without any increase in the harmonic content of the output waveforms. [20%]

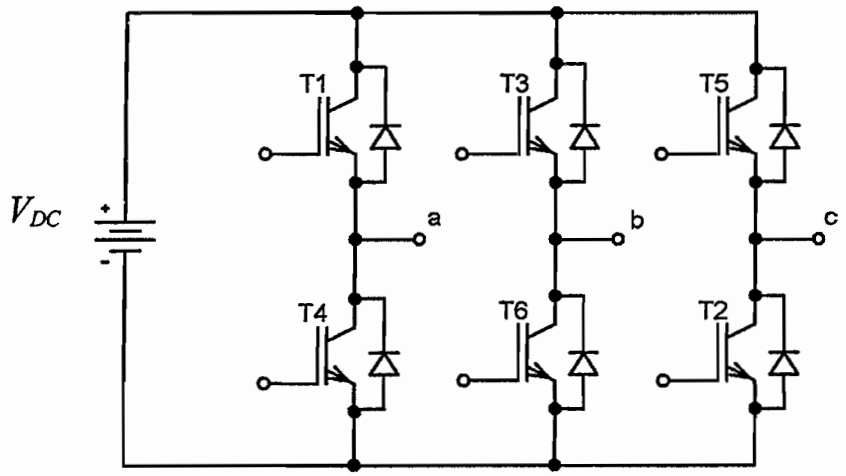


Fig. 2

3. A flyback converter is designed to be used to form 170 V dc from a 12 V battery for a 100 W inverter load, Fig. 3. The flyback transformer has a turns ratio of 1:5 . Find the maximum duty ratio for the MOSFET, if the transformer is demagnetised fully each cycle. The losses may be neglected. [20%]

Estimate the maximum current and voltage the MOSFET must withstand. Hence give one reason why 1:5 was a good choice of turns ratio for the transformer if the switching frequency is 50 kHz . [30%]

The load voltage is regulated by adjusting the MOSFET duty cycle. On one set of axes, sketch the MOSFET current for the conditions described above and for half load with a battery voltage of 14.7 V .

Estimate the new duty ratio. [50%]

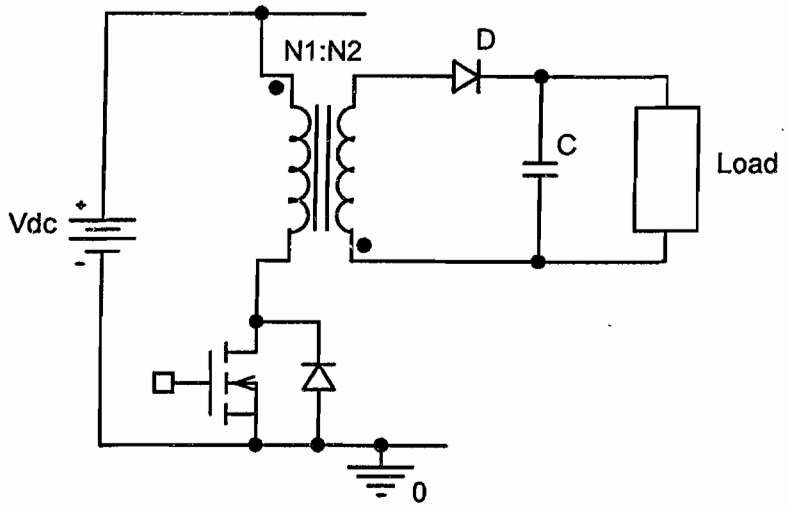


Fig. 3

4 (a) A half bridge resonant inverter is shown in Fig. 4(a). Make sketches of the current in the capacitor C, drawn with respect to the voltage at the output **A**, for three distinct modes of operation.

State one advantage and one disadvantage for each mode. [45%]

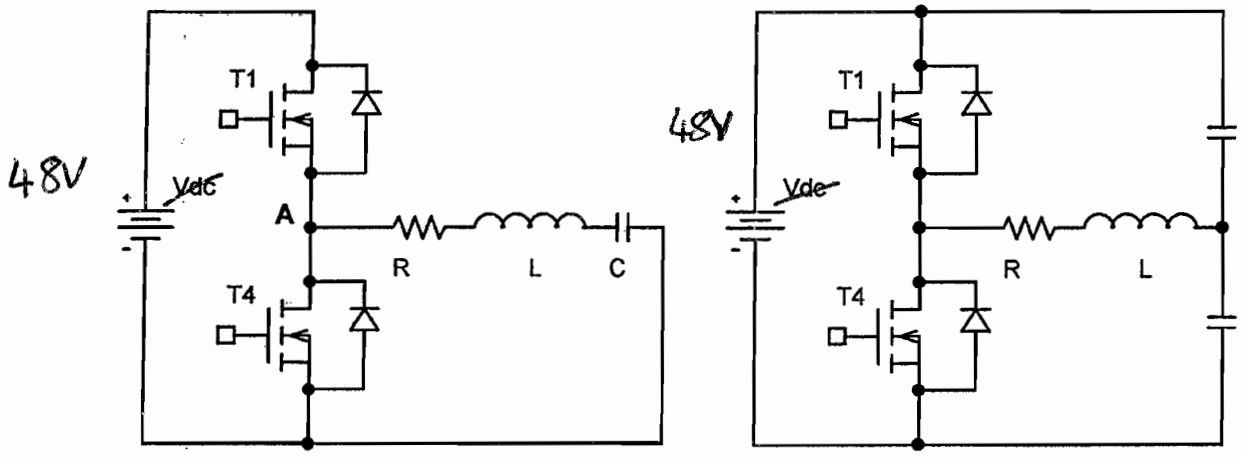
It is proposed that the circuit of Fig. 4(a) shall be operated with an additional capacitor placed across T4. State the purpose of the additional capacitor.

If $C = 0.1$ μF, $L = 1$ μH and $R = 1$ Ω, chose a value of the capacitor to be added and state your reasoning. [20%]

(b) An alternate configuration is proposed for the resonant inverter of part (a). The capacitor C is to be replaced by two capacitors connected as shown in Fig. 4(b). What value of capacitor should be used if the resonant frequency is to remain the same?

Sketch the dc supply current waveforms for Fig. 4(a) and Fig. 4(b) when operating at the same frequency.

For both cases estimate the peak supply current when operated near resonance. [35%]



(a) (b)

Fig. 4.

END OF PAPER

Pt IIA: 3B3: Switch mode electrics 2006. (Principal assessor: Dr P. R. Palmer)

ANSWERS

1.(a)	8.46 ms	17.72 Ω		
(b)	2.14 ms	1.38 A		
2.				
3.	0.739	22.55 A	46 V	0.43
4.(a)	0.01 μF			
(b)	0.05 μF	61.12 A (a)	30.56 A (b)	