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NATIONAL UNIVERSITY OF IRELAND, GALWAY

SUMMER EXAMINATIONS, 1999

B.E. DEGREE (ELECTRONIC)

POWER ELECTRONICS

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Duration of examination: *Three* Hours

Instructions: Answer *five* questions.

1. Figure 1 shows a light dimmer circuit with phase controlled rectification. Explain in detail the operation of the unijunction transistor in this circuit.

Calculate the minimum and maximum values of the resistor R_f.
Assume the following parameters for the unijunction transistor: intrinsic stand-off ratio 0.69, valley point current = 5 mA, valley point voltage=2 V, peak point current=1 μA and the forward voltage drop = 0.5 V.

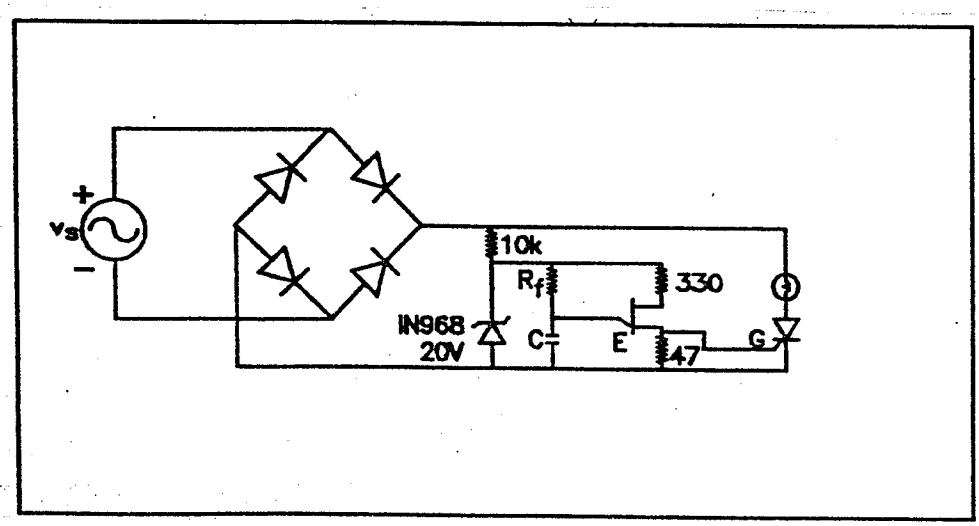

Figure 1 Phase controlled light dimmer

2. (a) Explain briefly the role of a transformer in a switching mode power supply.

(b) Draw the circuit for a push pull converter and explain its operation with the aid of current and voltage waveforms.

A 300W push-pull converter operates with a nominal input voltage of 36 V and output voltage is 24 V. Calculate the VA rating of each winding in the push-pull transformer. Assume transformer efficiency is 90%.

3. Design a buck converter to produce an output voltage of 18 V across a 10 Ω load. The output voltage ripple must not exceed 0.5% and the output current ripple must not exceed 15%. The dc supply is 48 V and the switching frequency is 40 kHz. Specify:

   (a) The duty ratio
   (b) The size of the output inductor
   (c) The size of the output capacitor

4. (a) Figure 2 shows the circuit diagram of a current fed bridge inverter with the load voltage and current waveforms. Label the operation of the switches to give the correct output current waveform.
   (b) What value of δ would eliminate the third harmonic completely.
   (c) Describe a method whereby the fifth harmonic could be eliminated.
   (d) For I_{dc}=100 A, V_{ac}=100 V, θ =10°, δ=30° calculate the average power delivered to the load.

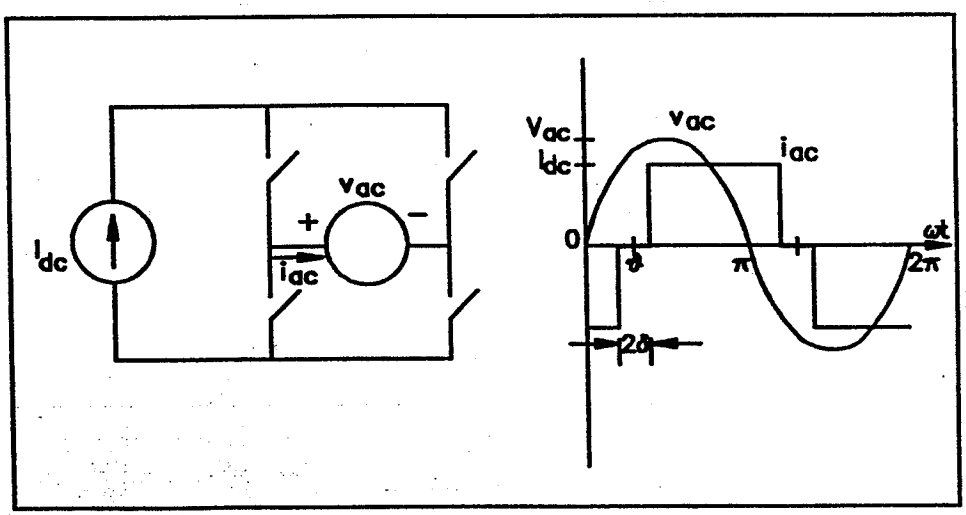

Figure 2 Current source inverter

5. Show that the average output voltage in a phase controlled q-pulse converter is

$$< v_d >= V_{do}\cos\alpha$$

$$V_{do} = \sqrt{2}V_o \frac{q}{\pi}\sin\frac{\pi}{q}$$

where V_o is the RMS value of the pulsed waveform and α is the firing angle.

A 1hp 250 R.P.M. dc motor has rated torque at 40 Nm. The motor constants are: armature resistance = 5 Ω and motor constant 7.5 V.s/r. The motor is operating at 40% of rated torque in a single phase half wave phase controlled converter. The firing angle is 90° and the extinction angle is 210°. The RMS value of the line voltage is 240 V, find the average speed of the motor
1 hp = 746 W

6. Derive an expression for the commutation angle in a half wave rectifier with a highly inductive load and a free wheeling diode in terms of the source reactance.

A half-wave rectifier with free wheeling diode has a 240 V rms 50 Hz ac source. The source inductance is 1.3 mH and the load current is constant at 5 A. Determine

(a) The commutation angle
(b) The output voltage

7. Write a short note on two of the following power semiconductor devices under the following headings:

- Circuit symbol
- Device Physics
- Device characteristics
- Device applications

(a) IGBT
(b) Power MOSFET
(c) Schottky diode