THE KENYA POLYTECHNIC

ELECTRICAL/ELECTRONICS ENGINEERING

DEPARTMENT

HIGHER DIPLOMA IN ELECTRICAL ENGINEERING

END OF YEAR II EXAMINATIONS

NOVEMBER 2006

POWER ELECTRONICS

3 HOURS

INSTRUCTIONS TO CANDIDATES:

You should have the following for this examination:

Answer booklet

Calculator/Mathematical tables

Answer any FIVE of the following EIGHT questions.

All questions carry equal marks and the maximum marks for each part of a question are as shown.

This paper consists of 5 printed pages.

1. (a) Describe with the aid of a diagram and appropriate waveforms, the operation of a single-phase, half-wave, fully-controlled rectifier with a resistive load. (9 marks)

   (b) Derive an expression for the r.m.s value of the output voltage of circuit 1(a) above. (4 marks)

   (c) A semi-conductor diode, the forward and reverse characteristics of which can be considered ideal, is used in a half-wave rectifier circuit supplying a resistive load of 1000Ω. If the r.m.s value of the sinusoidal supply voltage is 230v, calculate:

   (i) The peak diode current

   (ii) The mean diode current

   (iii) The r.m.s diode current

   (iv) The power dissipated in the load (7 marks)

2. (a) State the advantages of:

   (i) Connecting a free-wheeling diode across an R-L load in converter circuits.

   (ii) Phase-controlled converters (4 marks)

   (b) (i) An R-L load is fed from a 250v, 50Hz, single phase, half-wave, fully controlled converter. Derive an expression for the load current, Io, as a function of time given the following information:

   R = 10Ω, L = 1.2H

   Firing angle of the thyristor α = 40^0.

   (ii) If the extinction angle B = 200^0, calculate the mean voltage of the load. (16 marks)

3. (a)

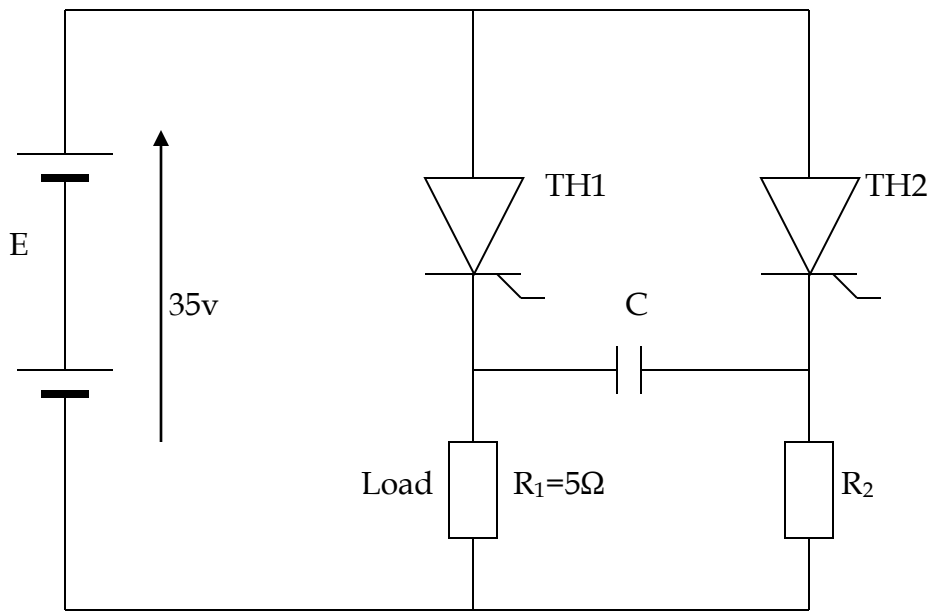

Figure 2

For the simple parallel capacitor chopper shown in figure 1 above:-

(i) Explain the operation of the circuit

(ii) State the disadvantage of the circuit

(iii) Calculate the size of the capacitor C when the load is 5Ω supplied from a 35v battery, the required turn-off time for thyristor TH1 being 80μs.

(iv) If R_2=5R, determine the approximate minimum on-time for thyristor TH1. Neglect thyristor losses. (13 marks)

(b) Describe with the aid of a diagram and appropriate waveforms the operation of the single-phase, full-bridge inverter. (7 marks)

4. (a) (i) State the advantages of three-phase converters compared to single phase converters.

(ii) Explain, with the aid of a diagram and corresponding waveforms, the operation of a three-phase, full-wave, fully-controlled converter. (9 marks)

(b) Derive an expression for the d.c value of the output voltage of a three-phase, half wave, fully-controlled converter. (5 marks)

(c) A three-phase, fully controlled converter is connected to a 415v (line) supply. Calculate the mean load voltage of 40^0 given that the thyristors have a forward volt drop of 1.5v. (4 marks)

5. (a) State:

(i) TWO advantages of using pulse transformers in triggering semi-conductor devices.

(ii) THREE reasons as to why the trigger pulses applied between the gate and cathode of a thyristor are preferred to be in the form of a waveform with high peak and narrow width. (5 marks)

(b) With the aid of circuit and waveform diagrams describe the operation of a synchronized U.J.T SCR triggering. (15 marks)

6. (a) Explain what is meant by the following:

(i) Chopper (ii) A.C. link (4 marks)

(b) State any:

(i) TWO disadvantages of an "a.c link chopper."

(ii) THREE industrial applications of choppers. (5 marks)

(c) An ideal chopper operating at frequency of 300Hz supplies a load of 15Ω, having an inductance of 12mH from a 60v battery. Assuming the load is shunted by a perfect commutating diode, and the battery to be lossless, draw the output voltage and current waveforms and derive expressions for the maximum and minimum load currents for the maximum and minimum load currents for the ON/OFF ratio 3:1. For the same ratio, calculate the maximum load current. (11 marks)

7. (a)

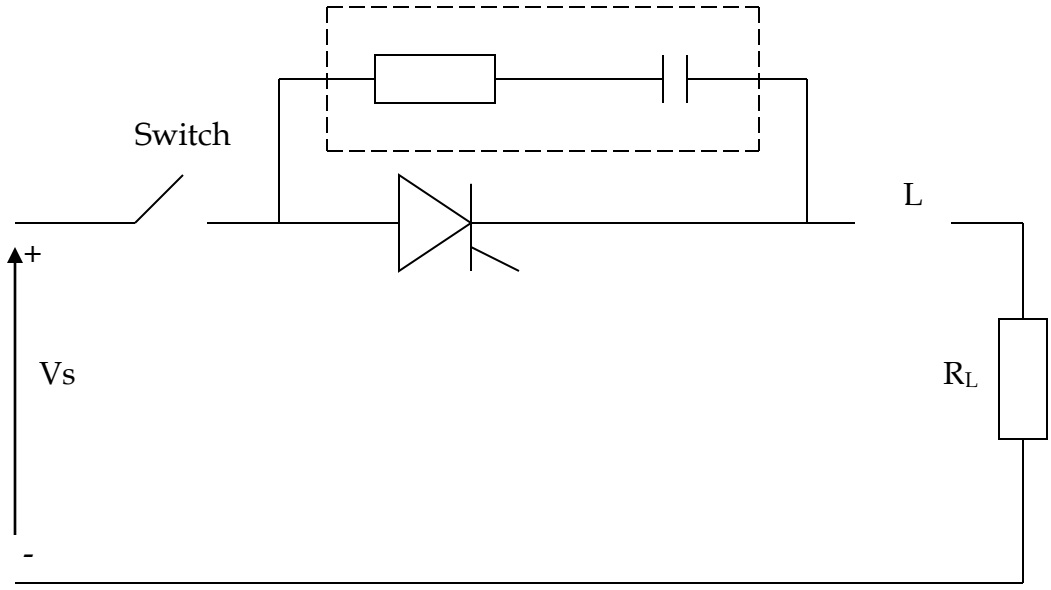

Figure 2

Figure 2 shows thyristor protection with L and Rs and Cs forming the snubber circuit. The supply voltage, Vs, is 400v d.c and the specified limits for $\frac{di}{dt}$ and $\frac{dv}{dt}$ for the thyristor are 50A/μs and 300v/μs respectively.

(i) Draw the equivalent circuit for figure 2 at the instant the switch is closed.

(ii) Calculate the values of the $\frac{di}{dt}$ inductance and the snubber circuit parameters Rs and Cs. (14 marks)

(b) Explain the following with regards to overvoltage protection of a thyristor.

(i) Internal overvoltages (ii) External overvoltages (6 marks)

8. (a) With reference to dynamic characteristics of thyristors:

(i) Define the following terms:

I. Rise time, tr II. Spread time, tp
III. Turn-off time, tq (6 marks)

(ii) Describe with the aid of a diagram the technique of gate triggering. (4 marks)

(b) Draw appropriate waveforms during thyristor turn-on and turn-off processes for a resistance load and label the various parts. (10 marks)