

**KIMATHI COLLEGE UNIVERSITY OF TECHNOLOGY****2010/2011 ACADEMIC YEAR**THIRD YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN  
TELECOMMUNICATION AND INFORMATION ENGINEERING**EEE 2308: POWER ELECTRONICS I**

DATE: AUGUST 2010

TIME: 2 HOURS

**INSTRUCTIONS:**

1. This paper consists of **FIVE** questions.
2. Answer question **ONE (Compulsory)** and any **TWO** of the other four questions.
3. Question **ONE** carry **30 MARKS** and the other four questions carry **20 MARKS** each.
4. All working **MUST** be clearly shown.

**QUESTION ONE (COMPULSORY) [30 MARKS]**

- (a) With a well labeled diagram describe how the traditional Ward-Leonard drive system was used to control and regulate voltage in DC machines. [4 marks]
- (b) Name and describe four types of power electronic converters. [8 marks]
- (c) i. State the advantages of power-electronics converters have over the traditional methods of power conversion. [3 marks]
- ii. Describe the effects of generated harmonics by power electronic converter circuits on the supply system and load circuit. [3 marks]
- iii. Which methods are used to reduce high harmonics in power electronics? [2 marks]
- (d) The single phase bridge rectifier is supplied from 120-V, 60-Hz source. The load resistance is  $R = 500 \Omega$ . Calculate the value of a series inductor  $L$  that limits the root-mean-square ripple current  $I_{ac}$  to less than 5% of  $I_{dc}$  [4 marks]
- (e) A single-phase full bridge diode rectifier is supplied from 230 V, 50 Hz source. The load consists of  $R = 10 \Omega$  and a large inductance so as the load current is constant.
- i. draw a circuit diagram and waveforms for  $v_s, v_o, v_{DL}$ , for a period  $\omega t = 4\pi$ ,
  - ii. determine average values of output voltage and output current,
  - iii. determine average and root-mean-square values of diode currents, [6 marks]

**QUESTION TWO [20 MARKS]**

- (a) Discuss the conditions which must be satisfied for turn on of SCR with a gate signal and basic requirement for commutating when in conduction mode. [4 marks]
- (b) Explain the operational differences between power transistors and thyristors devices [4 marks]
- (c) Sketch the circuit diagram of a single-phase full wave bridge diode rectifier supplying an RL load. With the aid of voltage and current waveform diagram explain the operation of the circuit and derive expression for average and root mean square voltage. Take that the inductance is large enough to render the load current constant. [6 marks]
- (d) A single-phase 230V, 1kW heater is connected across single-phase 230V, 50Hz supply through a diode. Calculate
- i. the power delivered to the heater element
  - ii. peak diode current.
  - iii. Input power factor [6 marks]

**QUESTION THREE [20 MARKS]**

- (a) State and explain three application of phase controlled rectifiers. [3 marks]
- (b) For a single-phase one pulse controlled rectifier system, sketch waveforms for source voltage, load voltage, load current and voltage across SCR for firing angle  $\alpha=\pi/4$  with RL load. [6 marks]
- (c) Explain the advantages of using freewheeling diode in the circuit in part (b). [3 marks]
- (d) A separately excited d.c motor is driven from a 240 V, 50 Hz supply using a fully controlled thyristor bridge. The motor has an armature resistance  $R_a$  of  $1.0\Omega$ , and an armature constant  $k_v$  of  $0.8 \text{ V/rad.s}$ . The field current is constant at its rated value. Assume the armature current is steady. For a speed of 1600rpm and firing angle of  $30^\circ$ , Determine
- i. the value of armature current
  - ii. developed Torque
  - iii. limits of the firing angle for this speed [8 marks]

**QUESTION FOUR [20 MARKS]**

- (a) Describe two types of chopper configurations with appropriate circuit diagrams. [4 marks]
- (b) Explain with appropriate waveforms, the different control strategies used for obtaining variable output voltage from a dc chopper. [4 marks]
- (c) Explain using suitable circuits the following methods used in commutating thyristor chopper circuits.
- i. Voltage-commutation chopper
  - ii. Current-commutated chopper [6 marks]

(d) A dc converter in figure 4 has a resistive load of  $10 \Omega$  and the input voltage is  $V_s = 220 \text{ V}$ . When the converter switch remains on its voltage drop is  $V_{ch} = 2 \text{ V}$  and the chopper frequency is  $f=1\text{kHz}$ . If the duty cycle is 50%, determine

- i. The average output voltage  $V_a$
- ii. The rms output voltage  $V_o$
- iii. The converter efficiency

[6 marks]

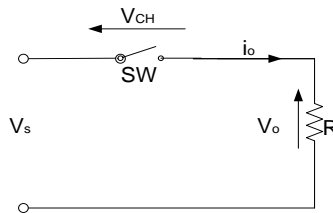


Fig. 4. Dc converter.

**QUESTION FIVE [20 MARKS]**

- (a) Define power electronics and with a suitable block diagram describe the components of a typical power electronic system? [4 marks]
- (b) Using a suitable block diagram describe the operation of static no-break UPS. [4 marks]
- (c) A single-phase half-bridge inverter in figure 5 has a load  $R=2\Omega$  and a dc source voltage  $0.5V_s = 115 \text{ V}$ .

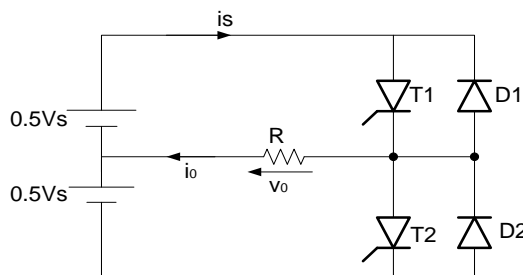


Fig. 5. Single –phase half-bridge inverter

- i. Sketch the waveforms for  $V_o$ , load current  $i_{o1}$ , current through the thyristor 1 and diode 1 and voltage across thyristor  $T_1$ . Harmonics other than the fundamental components are neglected. Indicate the devices that conduct during different intervals of one cycle.
- ii. Find the power delivered to the load due to fundamental current [12 marks]

**END OF EXAM PAPER**