

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY DEPARTMENT OF ELECTRONIC ENGINEERING BACHELOR OF ENGINEERING (HONS) DEGREE

Final Examination May 2011

TEE 2202 ELECTRONIC DRIVES

Duration of Examination – 3 Hours

INSTRUCTIONS TO CANDIDATES

1. Answer any FIVE questions.
 2. Each question carries 20 marks.
 3. Show all your steps clearly in any calculations.
 4. Start each new question on a fresh page.
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Question 1

- a) State how the following power devices are turned on and off
- | | |
|---------------|-----------|
| i. Thyristor | [4 marks] |
| ii. Power BJT | [2 marks] |
| iii. Diode | [2 marks] |
- b) A converter application employs a single thyristor operated in switching mode. The switching frequency is 250Hz. The thyristor has a turn on time of $3\mu\text{s}$, a turn off time of $5\mu\text{s}$, and leakage current of $10\mu\text{A}$. During a phase of operation, the thyristor conducts for half the cycle carrying a current of 200A with an associated voltage drop of 2V. The supply voltage is 550V. Calculate the total losses in a cycle and the converter efficiency.
- [12 marks]

Question 2

A three phase dual converter is used to control the speed of a 75kW, 600V, 1800rpm separately excited dc motor. The dual converter is operated from a three phase, 480V, 60Hz supply and is lossless. The motor parameters are $R_a = 0.1\Omega$, $L_a = 5\text{mH}$, $k\Phi = 0.3\text{V/rpm}$ ($E_a = k\Phi n$). The rated armature current is 130A.

- a) Using circuit diagrams showing current directions in each mode of operation, describe how a dual converter is operated in the motoring and generating modes.
- [6 marks]

- b) For motoring operation, at a firing angle of $\alpha = 60^\circ$ and rated motor current (assumed to be ripple-free), determine:
- the speed of the motor. [4 marks]
 - the power from the supply source [3 marks]
- c) The motor is put into the regenerative braking operation mode. Determine:
- the firing angle for rated motor current. [3 marks]
 - the power fed back to the supply source. [4 marks]

Question 3

A two quadrant chopper is used to control the speed of a dc motor and also for regenerative braking of the motor. The motor constant is $k\Phi = 0.1 \text{ V/rpm}$ ($E_a = K\Phi n$). The chopping frequency is $f = 250 \text{ Hz}$ and the motor armature resistance is $R_a = 0.2 \Omega$. The inductance is sufficiently large so that the motor current i_o can be assumed to be ripple-free. The supply voltage is 120 V .

- a) The chopper is operated to control the speed of the motor. At $n = 400 \text{ rpm}$ and $i_o = 100 \text{ A}$.
- Determine the turn on time t_{on} of the chopper [3 marks]
 - Determine the power from the source. [4 marks]
- b) The chopper is operated for regenerative braking of the motor. At $n = 350 \text{ rpm}$ and $i_o = -100$,
- Draw waveforms for v_o , i_o and i_s . [6 marks]
 - Determine the turn on time t_{on} of the chopper [3 marks]
- c) Describe a typical application of a two quadrant chopper. [4 marks]

Question 4

- a) Why do inverters that use thyristors as switches need commutation circuits? [4 marks]
- b) Discuss the significance of pulse width modulated inverters. [3 marks]
- c) Discuss the significance of multiple pulses in each half cycle of pulse with modulated inverter. [3 marks]
- d) In a three phase bridge inverter, the dc supply voltage is 380 V .
- Sketch the waveforms of voltages of two of the phases and, hence of the load line voltage. [6 marks]
 - Determine the angle by which firing of the thyristors has to be shifted to get an rms line voltage of 280 V [4 marks]

Question 5

A three phase delta connected ac voltage controller is used to control the speed of a three phase, 5hp (1hp = 746W), 208V, 60Hz induction motor. At full load output, the motor current is sinusoidal, the power factor is 0.85 lagging, and the efficiency is 90%.

- a) Determine the minimum current rating of the thyristors. [6 marks]
- b) Determine the minimum voltage rating of the thyristors. [3 marks]
- c) What is the range of firing angles for the full load condition? [3 marks]
- d) For operation of the ac voltage controller within the control range, draw waveforms of the supply voltage, output current and output voltage for one of the phases. [6 marks]
- e) Qualitatively discuss the variation of firing angle if the ac voltage controller is also used to start up the ac motor. [2 marks]

Question 6

In a single phase cycloconverter, the input supply voltage is 120V, 60Hz. The load is a pure resistance and the output frequency is 15Hz.

- a) Draw waveforms for input voltage, control voltage and output voltage for firing angles of 0° and 90° . In each case, clearly show the relationship between the waveforms. [14 marks]
- b) Determine rms values of output voltage at firing angles of 0° and 90° . [6 marks]

END OF PAPER