FIJI NATIONAL UNIVERSITY

COLLEGE OF ENGINEERING, SCIENCE AND TECHNOLOGY

School of Electrical & Electronics Engineering

Trade Diploma in Electronics Engineering

EEE574 – Power Control Electronics

FINAL EXAMINATION (Resit/SA)

Trimester 3, 2016

Date: As per Exam Time Table

Time: As per Exam Time Table

Venue: As per Exam Timetable

Instructions to Students

1. You are allowed an extra ten (10) minutes of reading time during which you are NOT allowed to write.
2. Attempt ALL questions in this examination booklet
3. Write your answers in the answer booklet provided.
4. Write your Student ID number on each page used.
5. Begin each Section on a fresh page and use both sides of the answer sheet.
6. You may use calculators provided they are non-programmable.
7. Clearly number the questions in your answer paper in their correct sequence and write legibly. Show all working.
8. Attach any extra sheets used to your answer booklet securely with the string provided.

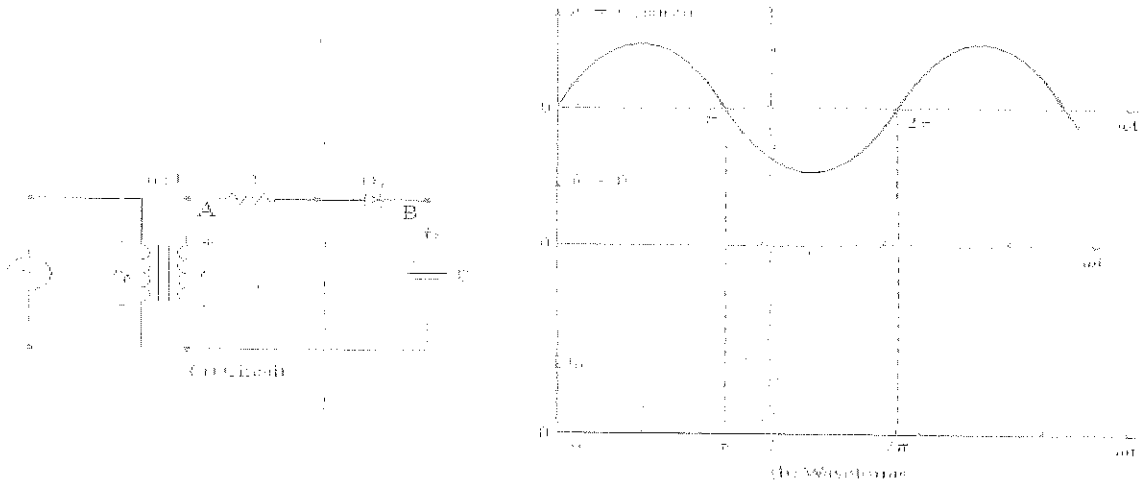
****

Part I: Power Control Devices (20 marks)

a) Draw the switching characteristics curve for SCR and describe its characteristics. **(3 marks)**
b) Draw the structure of *BJT* power transistor (npn type) and sketch the curves for switching operation of the power transistor. **(3 marks)**
c) Define secondary breakdown phenomenon in relation to power transistors. **(3 marks)**
d) Describe the characteristics of IGBT (Insulated Gate Bipolar Transistor). **(3 marks)**
e) Discuss the advantage and disadvantage of using GTO (gate-turn-of) thyristor. **(3 marks)**
f) Draw the Safe Operation Area (SOA) of the BJT power transistors and label the 4 regions. **(3 marks)**
g) Define two characteristics of an ideal switch. **(2 marks)**

Part II: Rectifiers (20 marks)

a) Define rectifier recovery time. **(2 marks)**
b) Name five important parameters used to measure the performance of rectifier circuits. **(4 marks)**
c) The battery voltage in Figure below is E=20V and its capacity is 100WH, the average charging current should be I_{DC} = 5A. The primary input voltage V_p = 120V 60Hz and the transformer turns ratio n=2:1.
   i) Draw the waveforms for current i_o and voltage between points A and B. (label the peak amplitudes) **(5 marks)**
   ii) Find the conduction angle α of the circuit. **(4 marks)**
   iii) Drive the formula for average charging current and find the value of current limiting resistor R. **(5 marks)**



Please Turn Over

Part III: Control Rectifiers (20 marks)

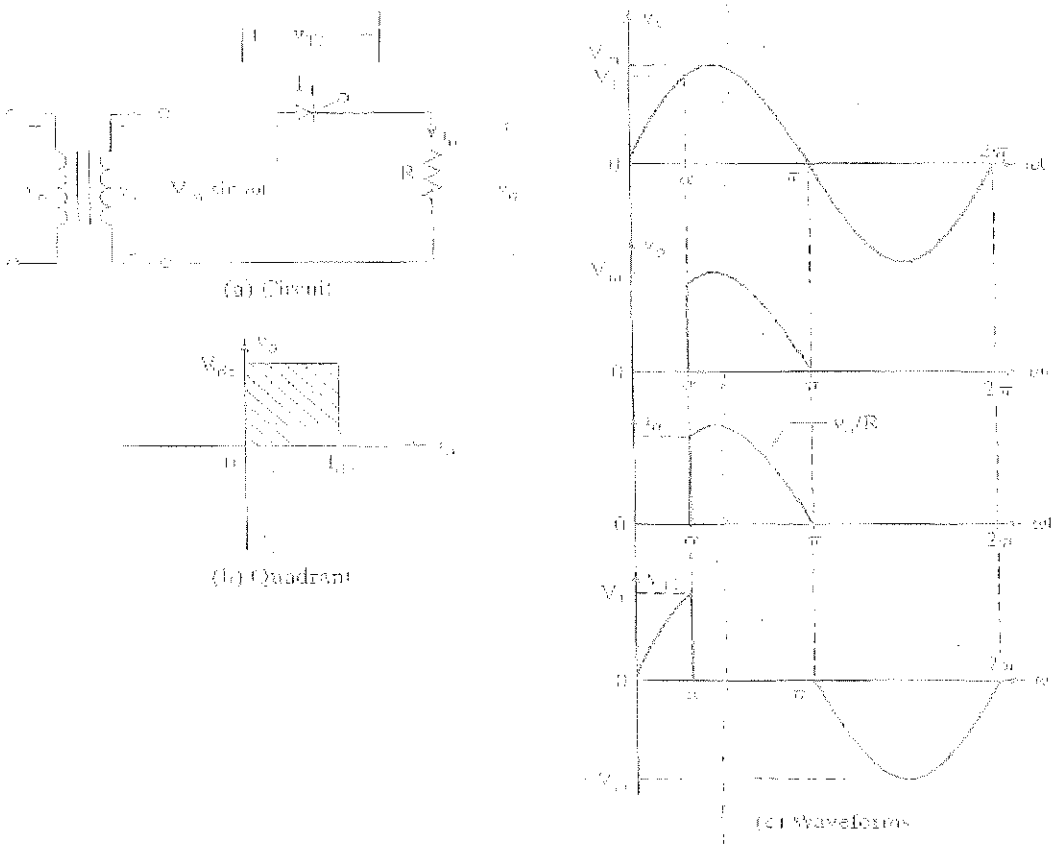
a) Explain the principles of phase control rectifiers. **(4 marks)**

b) Draw the resistance firing circuit and explain how triggering angle can be varied. **(3 marks)**

c) A single-phase half-wave converter given below is operated from a 120V, 60Hz supply. If the resistive load R is 10 ohms and the delay is $\alpha = \pi/3$, determine:

i) The efficiency **(4 marks)**

ii) The transformer utilization factor **(2 marks)**



d) A single-phase half-wave converter given in part c is operated from 120V, 60Hz supply and the resistive load R= 10 ohms. If the output voltage is 25% of the maximum possible average output voltage, calculate:

i) The delay angle **(4 marks)**

ii) The rms and average output currents **(3 marks)**

Please Turn Over

Part IV: Choppers and Inverters (20 marks)

a) Describe the principle of operation of a step-down dc-dc converter (chopper). **(4 marks)**

b) Describe pulse-width-modulation control of a convertor. **(3 marks)**

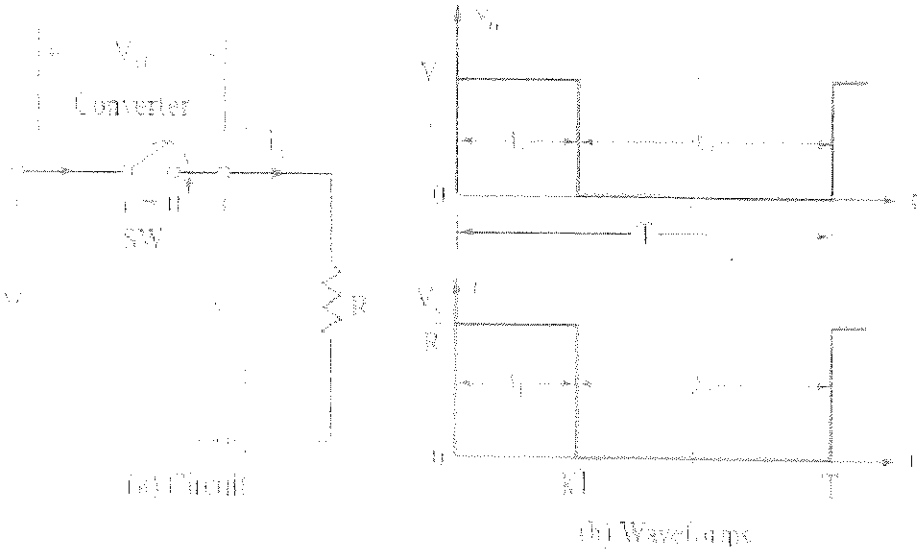
c) What are the advantages and disadvantages of circulating current mode of operation of dual converters. **(3 marks)**

d) A dc converter shown below has a resistive load of R =10 ohms and the input voltage V_s = 220V. When the converter switch remains on, its voltage drop is v_{ch}= 2 V and the chopping frequency is f = 1kHz. If the duty cycle is 50%, determine: **(5 marks)**

i) The average output voltage.

ii) The rms output voltage.

iii) The effective input resistances Ri of the converter.



e) Draw the circuit of single-phase half-bridge inverter circuit and state the principle of its operation. **(5 marks)**

Please Turn Over

Part V: Power Electronics Applications (Process Control and Motor Speed Control)
(20 marks)

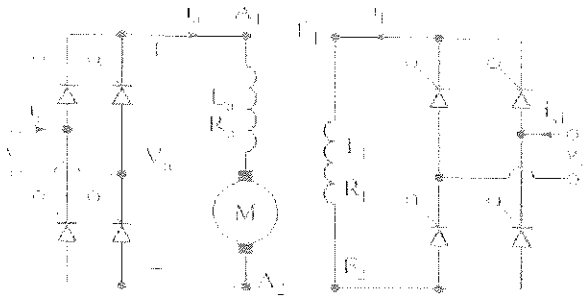
a) State and discuss the various methods of speed control of dc motors. **(4 marks)**

b) State and discuss the various methods of speed control of ac induction motors. **(4 marks)**

c) Speed of induction motors can be varied by stator voltage control. Draw and explain how ac voltage controllers can be used to control speed of three-phase induction motor. **(3 marks)**

d) Draw and explain the close-loop control block diagram of electrical drives. **(3 marks)**

e) A dc separately excited motor drives a constant toque load of 18 NM. The motor is driven by a full-wave convector through a 120 V ac supply as shown below. Assume that $K_{IF} = 2.5$ and the armature resistance is 2 ohms. Calculate the triggering angle α_a for the motor to operate at 200 rev/min. The motor current is continuous. **(6 marks)**



$$V_a = \frac{2V_{max}}{\pi}\cos\alpha_a$$

$$V_f = \frac{2V_{max}}{\pi}\cos\alpha_f$$

$$V_a = E_a + R_a I_a$$

$$E_a = KI_f\omega = KI_f * (2\pi\frac{n}{60})$$

THE END

ALL THE BEST FOR THE EXAMINATION