MURANG'A UNIVERSITY COLLEGE

(A Constituent College of Jomo Kenyatta University of Agriculture and Technology)

DEPARTMENT:	**ELECTRICAL ENGINEERING**
LEVEL:	**DIPLOMA**
CLASS:	**KNEC/EEP/15DJ3**
MODULE:	**III**
ACADEMIC YEAR:	**2014/15**
TERM:	**I**
UNIT:	**POWER ELECTRONICS**
UNIT CODE:	**EE1307**

DATE: 27ᵀᴴ APRIL 2015   **TIME: 2 HOURS**

Instructions to candidates

This paper contains seven (7) Questions

Attempt any five (5) questions

You should have the following for this examination;
- Drawing instruments
- Scientific calculator

➢ **NO MOBILE PHONES ARE ALLOWED WITHIN THE EXAMINATION ROOM!!!!!!!!**

QUESTION 1: (20 marks)

(a). Briefly explain the reverse recovery characteristics of a diode including the effects of reverse recovery time and the cause of the reverse recovery time in a *pn*-junction. [**4mrks**]

(b). i). Draw the typical *v-i* characteristics of thyristors   [**2mrks**]

ii). Label v, i, reverse breakdown voltage, forward break-over voltage, forward leakage current, reverse leakage current, forward voltage drop, holding current and latching current.

[4mrks]

(c).   If the converter of the figure below has a purely resistive load of R and the delay angle is α $=\pi/2$, determine the following;(i) the efficiency, (ii) the form factor FF, (iii) the ripple factor RF, (iv) the transformer utilization factor TUF and (v) the peak inverse voltage PIV.
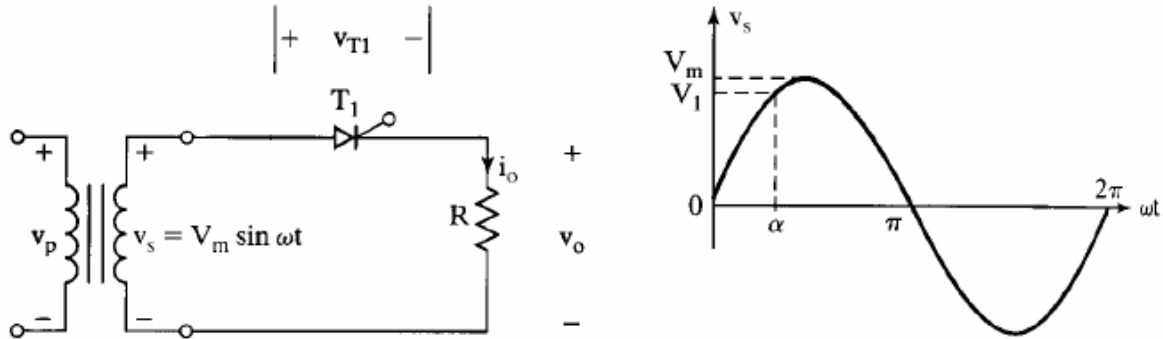
[8mrks]

Figure 1

(d).   Explain the working principle of single phase cycloconverter with circuit diagram and waveforms   **[2mrks]**

Question 2 (20 marks)

(a).   A three phase full converter bridge is connected to a 3-phase 400V, 50Hz supply having a source inductance of 5mH. The total current is constant at 20A. If the load consists of a   dc voltage source of 400V, having an internal resistance of 1Ω, calculate the firing   angle α and overlap angle μ for this condition.   **[8mrks]**

(b).   List two methods of voltage control employed in ac voltage controllers.   **[2mrks]**

(c).   Draw the power circuitry for a single-phase fully controlled converter and explain its operationwith relevant waveforms. Derive the expression for average load voltage assuming continuous current operation.   **[10mrks]**

QUESTION 3: (20 marks)

(a).   For a single phase ac voltage controller feeding a resistive load, draw the waveforms of source voltage, gating angle, output voltage, source and output currents and voltage across the SCRs. Describe its working with reference to the waveforms drawn.**[10mrks]**

(b).   An ac voltage regulator operating from 230V, 50Hz supply uses integral cycle control to control the flow of power to 10Ω load. The thyristors conduct for 18 cycles and remain   off for 32 cycles.

Find

      (i).   rms value of output voltage

      (ii).   power output to the load

      (iii).   power input to the regulator

      (iv).   input power factor

      (v).   average and rms values of SCR current (neglect losses).   **[10mrks]**

QUESTION 4: (20 marks)

(a).   Draw the circuit of a dc chopper with RL load and explain its operation with waveforms.
                 [6mrks]

(b).   A step down dc chopper is connected to a resistive load of 30Ω. The dc supply voltage is
      200V. The duty ratio of the chopper is 0.8 with a chopping frequency of 400Hz.   Determine
the average load voltage, average load current and ON time of the chopper.
                 [6mrks]

(c).   A buck-boost converter is to supply a maximum power of 75 W at −50 V from a 40 V dc
      source. The output voltage ripple must be no more than 1%. The switching frequency fs is
40kHz. Assume that the converter operates at the boundary of
      continuous/discontinuousconduction mode when 75W is supplied.
         (i).   Calculate the duty cycle D.
         (ii).   Calculate the required size of the inductance L and capacitance C.
         (iii). Determine the average, maximum and minimum inductor currents.
         (iv). Sketch the diode current waveform and find its average value.   **[8mrks]**

Question 5: (20 marks)

(a).   List the commonly used PMW technique for voltage and waveform control of inverters   and
explain any one of methods in detail.   **[6mrks]**

(b).   Draw the power circuitry for IGBT based single-phase bridge inverter and explain its
      operationwith relevant waveforms.   **[4mrks]**

(c).   A three-phase bridge inverter is fed from a dc source of 200V. if the load is star connected
      with 20Ω resistance phase obtain the value of

      (i)   rms load current

      (ii)   rms current rating of thyristors

      (iii)   The load power for 120˚ conduction and 180˚ conduction   **[10mrks]**

Question 6 (20 marks)

(a).   Highlightthe two main classification ofthyristor commutation.   **[2mrks]**

(b).   With the aid of relevant circuit diagrams and wave forms, explain the principle used in
resonant pulse commutation of SCRs.   **[6mrks]**

(c).   Explain the operation of a single-phase half controlled bridge converter with R-L load and
derivethe load voltage and load current for a firing angle, α =20˚. Draw schematic diagram
with relevant wave forms.   **[12mrks]**

Question 7 (20 marks)

(a).   A three phase half controlled converter is operated from a 3 phase star connected 220V 50Hz
supply and the load is 10Ω. If the average output voltage is 25% of the maximum possible
average output voltage, calculate:

        i) Output d.c. voltage

        ii) Output d.c. current

        iii) Rectifier efficiency

        iv) Transformer utilization factor (TUF)   **[8mrks]**

(b).   With the aid of a circuit and waveforms diagrams, explain the principles of a cycloconverter
with and intergroup reactor working in the circulating current mode
                                                                                         [10**mrks**]

(c).   List any two power electronic circuits that use source voltage for thyristor commutation
                                                                                         [2mrks]