University of Ruhuna- Faculty of Technology

Bachelor of Engineering Technology Honours Degree
Level 4 (Semester II) Examination, November/December 2025
Academic year 2023/2024

Course Unit: ENT4223 Power electronics and applications (Written) Duration: 3hours

- Closed-book examination in English.
- Five (05) questions on four (04) pages, all carry equal marks. Answer all questions.
- All symbols have their usual meanings.
- Calculators permitted.

1)

a) Briefly explain the primary function of power electronics in electrical systems?

(2 marks)

b) List two (02) advantages of using power electronic systems.

(2 marks)

c) List two (02) differences between power electronics and linear electronics.

(4 marks)

d) Explain two (02) reasons for using switching power supplies instead of linear power supplies.

(4 marks)

e) Explain two requirements of power electronics in High Voltage Direct Current (HVDC) transmission systems.

(4 marks)

f) Draw the block diagram of an Uninterruptible Power Supply (UPS) and explain the reason for using power electronics in its operation.

(4 marks)

2)

a) A single-phase uncontrolled full-wave bridge rectifier is supplied by a sinusoidal AC voltage of 150 V (RMS) at 50 Hz, connected to a purely resistive load $R = 40\ \Omega$.

i) Draw the circuit diagram and the output voltage waveform.

ii) Calculate the mean value of the output voltage and voltage ripple frequency.

iii) Calculate the displacement factor and explain how to determine the displacement angle.

(8 marks)

b) A three-phase uncontrolled full-bridge diode rectifier is connected to a balanced three-phase supply with phase voltage of 230 V (RMS) at 50 Hz. The load is purely resistive with R = 30 Ω.

i) Draw the circuit diagram and show the output voltage waveform.

ii) Calculate the following parameters including assumptions you made,

a. Mean value of the output voltage.

b. Output voltage ripple frequency.

c. Peak-to-peak ripple voltage.

d. Displacement factor.

iii) The three-phase rectifier in supplies a constant load current of 10 A. Each diode has a forward voltage drop of 0.8 V. Calculate rectifier efficiency assuming the output DC power remains the same as in part (i).

(12 marks)

3)

a) List sown two (02) types of DC–AC inverters according to their operating source, and specify the operating source for each type.

(2 marks)

b) State the equations for the depth of modulation and the carrier ratio, clearly defining all parameters used.

(4 marks)

c) A single-phase voltage source inverter (VSI) is supplied by a DC voltage of 300 V, connected to a purely resistive load of 60 Ω.

i) Draw the circuit diagram

ii) Assuming inverter operates with square wave switching,

a. Draw the output voltage and current waveforms.

b. Calculate the RMS value of the fundamental component of output voltage.

iii) Assuming the inverter operates with unipolar sinusoidal PWM switching, with a carrier frequency 3 kHz and a depth of modulation of 80 %,

a. Draw the unipolar PWM modulator circuit, define symbols.

b. Draw the output voltage waveform.

c. Calculate the RMS value of the fundamental component of output voltage.

(14 marks)

4)

a) A three-phase fully controlled thyristor bridge rectifier is supplied with a sinusoidal AC voltage of 400 V (RMS) at 50 Hz and connected to a purely resistive load.

   i) Draw the circuit diagram of the three-phase fully controlled thyristor bridge rectifier.

   ii) Explain the method of generating gate triggering signals for the thyristor, using waveforms or a block diagram.

(6 marks)

b) A three-phase voltage source inverter (VSI) is supplied by a DC voltage of 300 V, connected to a purely resistive load.

   i) Assuming inverter operates with square wave switching,

      a. Draw the circuit diagram

      b. Draw waveforms of the output **line voltages** (V_{AB}, V_{BC}, V_{CA})

   ii) Assuming inverter operates with unipolar square wave PWM switching, with depth of modulation of 0.8 and carrier ration 9,

      a. Draw the unipolar PWM modulator circuit, define symbols.

      b. Draw the output voltage waveform V_{AB} and V_{AN}, including pulse high and low angles.

(14 marks)

5) A grid connected solar photovoltaic (PV) system is designed to supply power to a remote DC load and an AC load through an inverter. The system consists of a PV array, a DC–DC converter with MPPT control, a battery bank, and a single-phase inverter. The specifications of the PV module and battery module are given in Table 01.

a) Draw the block diagram of the standalone solar PV system, showing all major components and power flow paths.

(3 marks)

b) Design a solar-powered battery charging and inverter system to deliver a total load power of 1700 W using the data in Table 01.

   i) Determine the number of PV panels required to meet the total power demand.

   ii) When connecting three (03) panels in series, calculate the number of parallel strings required.

iii) Calculate the total output voltage and current of the PV array when the panels are connected in series–parallel combination

iv) Calculate the total maximum power output from the solar panel.

v) Find the number of battery modules required in series to form a 48 V battery bank.

vi) Determine the number of parallel battery string for the battery bank.

(9 marks)

c) The PV array is connected to a buck–boost converter controlled by a Maximum Power Point Tracking (MPPT) algorithm.

i) Draw the circuit diagram for buck–boost converter.

ii) Write down the relationship between input and output voltage of the buck–boost converter in terms of the duty cycle D.

iii) If the PV voltage at maximum power is 36 V and the required charging voltage is 48 V, compute the duty cycle (D) for the converter.

iv) Determine the input and output currents at full load, assuming a converter efficiency of 90%.

(8 marks)

Table 01: Parameters of Solar Module and Battery Module Datasheet

Solar module Datasheet	
Maximum power output of the panel	300 W
Voltage at Maximum power	36 V
Current at Maximum power	8.33 A
Open circuit voltage	44 V
Short circuit Current	8.8 A
Li-ion battery module Datasheet	
Nominal Voltage	12 V
Maximum charging Voltage	14.4 V
Minimum charging Voltage	11 V
Maximum charging current	10 A