University of KwaZulu-Natal
Electrical, Electronic and Computer Engineering
Main Exam: 13 November 2025, 09:00 – 11:00

DURATION:	**2 HOURS**	**TOTAL MARKS: 75**
Examiners:	Mr M. Brown	(Internal)
	Dr M. Khan	(Moderator)

INSTRUCTIONS:
- Only non-programmable calculators may be used.
- This is closed book exam so no additional information may be taken into the exam room.
- Answer all questions, show all working and include all necessary comments (it is your reasoning that is being assessed, not the numerical answer).
- Marks will be deducted where no or incorrect units are used, where figures and plots are labelled incorrectly and where writing is illegible.

Question 1 [15]

a) Define power electronics, providing examples of its applications. **[2]**
b) Draw (and label) the generic power electronics converter. **[3]**
c) Discuss the ideal switch. Figures may aid your discussion. **[3]**
d) In a single-phase full wave diode bridge rectifier, the diodes have a reverse recovery time of 40μsec. For an ac input voltage of 230V, determine the effect of reverse recovery time on the average output voltage for a supply frequency of 50 Hz and 2.5 kHz. **[7]**

Question 2 [20]

A full-wave controlled bridge rectifier has an AC input of 220 V rms at 50 Hz and a 30 Ω load resistor. Determine:

a) Derive the equations for a full-wave controlled rectifier with a resistive load and with a resistive-inductive load. **[5]**
b) The delay angle required to obtain an average load current of 6A. **[2]**
c) The power factor of the circuit. **[5]**
d) The ripple factor of the rectifier. **[3]**
e) Discuss the benefits offered by a three-phase full-wave controlled rectifier, draw the circuit and determine the output ripple frequency. **[5]**

Question 3 [20]

a) A 48 V, 100 Ah, LiFePO4 is charged from a DC source that varies between 20 V and 30 V with a maximum power rating of 300 W. Select the appropriate converter to charge the battery, discuss the assumptions made to analyse the converter, derive the output voltage in terms of the input voltage and draw the appropriate waveforms. **[12]**
b) b) A buck-boost converter has parameters: Vs = 20 V, D = 0.4, R = 6 Ω, L = 200 μH, C = 90 μF and f = 125 kHz. Determine the average inductor current and the output voltage ripple. **[3]**
c) A DC chopper (with ideal components) has an output voltage of 15 V, a switching frequency of 20 kHz, an inductance of 1 mH and a filter capacitance of 670 μF. Calculate the output voltage ripple (ΔV_o) if the input voltage is 4 V and the output current is 300 mA. **[5]**

Question 4 [5]

a) Discuss the principal of integral cycle control in AC-AC converters and where it would be appropriate to utilise. **[2]**

b) Discuss whether it is possible to vary the output voltage of an AC-AC converter from 0% to 100% of the input and why. **[3]**

Question 5 [15]

a) Briefly discuss the difference between the package limit current of a MOSFET and its silicon limit current. **[2]**

b) Explain why and when a MOSFET driver is needed in a circuit. Your answer must include the necessary figures. **[3]**

c) Discuss how heat sinks improve the reliability of power electronic systems? **[3]**

d) A MOSFET's datasheet lists the junction-to-ambient thermal resistance as 65°C/W. The designer wishes for the junction temperature not to exceed 180°C. If the ambient temperature is 20°C determine the maximum power the MOSFET can absorb. **[2]**

e) If a MOSFET in a power converter is getting damaged due to electrical stresses discuss what options are available and how to selection an appropriate solution. **[5]**

END OF PAPER

Formula Sheet

Average

$$V_o = \frac{1}{T_s}\int_0^{T_s} v(t)\,dt$$

Root mean Square

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^{T} v^2(t)\,dt}$$

If $v = v_1 + v_2 + v_3 + \cdots$

then

$$V_{rms} = \sqrt{V_{1\,rms}^1 + V_{2\,rms}^2 + V_{3\,rms}^2 + \cdots}$$

Harmonics

$$THD = \frac{\sqrt{\sum_{n=2}^{\infty} I_n^2}}{I_1}$$

Transformer (Ideal)

$$\frac{V_p}{N_p} = \frac{V_s}{N_s}$$

Trig Identities

$$sin(\alpha \pm \beta) = sin\,\alpha\,cos\,\beta \pm cos\,\alpha\,sin\,\beta$$

$$cos(\alpha \pm \beta) = cos\,\alpha\,cos\,\beta \mp sin\alpha\ \ sin\,\beta$$

$$tan(\alpha \pm \beta) = \frac{tan\,\alpha \pm tan\,\beta}{tan\,\alpha\,tan\,\beta}$$

$$sin\,(2\theta) = 2\,sin\,\theta\,cos\,\theta$$

$$cos\,(2\theta) = cos^2\theta - sin^2\theta$$

$$cos\,(2\theta) = 2cos^2\theta - 1$$

$$cos\,(2\theta) = 1 - 2\,sin^2\theta$$

$$tan(2\theta) = \frac{2\,tan\,\theta}{1 - tan^2\,\theta}$$