UNIVERSITY OF GREATER MANCHESTER

SCHOOL OF ENGINEERING AND BUILT ENVIRONMENT

BENG (HONS) ELECTRICAL & ELECTRONIC ENGINEERING

SEMESTER ONE EXAMINATIONS 2025/2026

INTERMEDIATE ELECTRICAL PRINCIPLES & ENABLING POWER ELECTRONICS

MODULE NO: EEE5013

Date: Wednesday 14th January 2026 **Time: 10am – 12:30pm**

INSTRUCTIONS TO CANDIDATES:

There are Five questions.

Answer ANY FOUR questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

Electronic calculators may be used provided that data and program storage memory is cleared prior to the examination.

CANDIDATES REQUIRE: **Formula Sheet (attached).**

Question 1

a) Sketch an equivalent circuit of an ideal operational amplifier.

[7 marks]

b) Using Figure Q1, derive an expression for the output V_o of the following circuit in terms of the input voltages V_1 and V_2.

[14 marks]

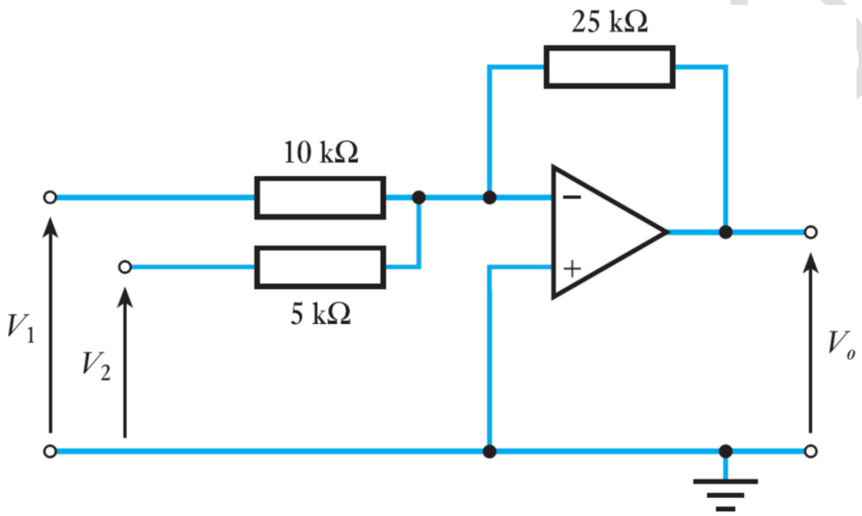

Figure Q1

c) Also, determine the output voltage if V_1 = 1 V and V_2 = 0.5 V.

[4 marks]

[**Total 25 marks]**

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Question 2

a) State three methods of cooling and explain each one briefly.

[6 marks]

b) Consider a laptop CPU operated without a heatsink. The thermal resistance from Junction-Ambient is 58°C/W and maximum junction temperature is 98°C with junction to case thermal resistance of 8°C/W, assuming a room temperature of 25^{o}C .

i. Determine the maximum power dissipated.
ii. the power derating factor.

[4 marks]

c) Assume the CPU in part (b) operated with a heatsink. The thermal resistivity of the heatsink is 188.58×10^{-2} °Cm/W, thickness is 3.22×10^{-6} m and contact area is 44.78×10^{-6} m^2. Determine, the thermal resistance from sink-to-ambient.

[5 marks]

d) A pipe of 20mm diameter is carrying 0.3 kg/s of water the flow then passes into a pipe of 10mm diameter if the density of water is $1000 kg/m^3$.

i. Calculate the volumetric flow rate and the average velocity of the water in the 20 mm pipe.
ii. Calculate the average velocity of the water in the 10 mm pipe.

[10 marks]

[Total 25 marks]

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Question 3

Explain with the aids of diagrams the operation of a single-phase half-wave rectifier with inductive load.

[10 marks]

(a) A half-wave single-phase rectifier circuit is shown in figure Q3 below. The following are given:

Vs=220 V, f=50 Hz, diode forward voltage drop is assumed to be zero. Determine:

i. The load mean voltage and current for resistive load of 8 Ohms

[4 marks]

ii. The load current ac component and shape for

1. A pure resistive load of 8 Ω resistor and

[7 marks]

2. An inductive load of 0.1 H inductance in series with the 8 Ω resistor

[4 marks]

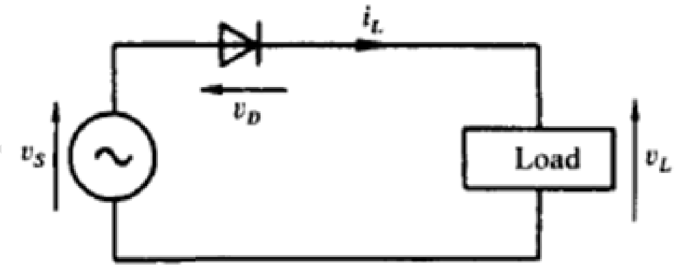

Fig. Q3 A single-phase half-wave rectifier circuit

[Total 25 marks]

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Question 4

(a) Draw a circuit diagram for a buck converter and derive an expression for $\frac{V_{out}}{V_{in}}$ defining all parameters used in this circuit.

[15 marks]

(b) Enumerate the basic grounding system then explain what is meant by static grounding.

[10 marks]

[Total 25 marks]

Question 5

(a) Calculate the line voltages and the line currents of a Y-Y source-load Connection. Given: $V_{an} = 120 \angle 60^o$ V . The system is balanced three-phase system. The system impedances per phase are given as follows:

$Z_{source}=0.4+j0.3\ \Omega$, $Z_{line}=0.6+j0.7\ \Omega$, $Z_{load}=24+j19\ \Omega$.

[12 Marks]

b) Assume a delta-connected load, with each leg Z = 100<80° Ω, is supplied from a 3-phase supply with voltage of 13.8 kV (L-L) source. Find:

i. The complex power of the source and load.

[6 marks]

ii. The power factor at the load and the value of a shunt capacitor that brings the power factor to unity.

[3 marks]

iii. The value of a shunt capacitor that brings the power factor of the load to unity. Assume system frequency is 50 Hz.

[4 marks]

[Total 25 marks]

END OF QUESTIONS

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Formula sheet

These equations are given to save short-term memorisation of details of derived equations and are given without any explanation or definition of symbols; the student is expected to know the meanings and usage.

Converters:

$$\%\mathrm{THD}_i = 100 \times \frac{I_{\mathrm{dis}}}{I_{s1}} = 100 \times \frac{\sqrt{I_s^2 - I_{s1}^2}}{I_{s1}} = 100 \times \sqrt{\sum_{h \neq 1}\left(\frac{I_{sh}}{I_{s1}}\right)^2}$$

$$\mathrm{PF} = \frac{V_s I_{s1} \cos\phi_1}{V_s I_s} = \frac{I_{s1}}{I_s}\cos\phi_1$$

$$\mathrm{DPF} = \cos\phi_1$$

$$\mathrm{PF} = \frac{I_{s1}}{I_s}\,\mathrm{DPF}$$

$$\mathrm{PF} = \frac{1}{\sqrt{1+\mathrm{THD}_i^2}}\,\mathrm{DPF}$$

$$A_u = \sqrt{2}V_s(1-\cos u) = \omega L_s I_d$$

$$\cos u = 1 - \frac{\omega L_s I_d}{\sqrt{2}V_s}$$

$$V_d = 0.45V_s - \frac{\text{area } A_u}{2\pi} = 0.45V_s - \frac{\omega L_s}{2\pi} I_d$$

$$V_d = 1.35\, V_{LL} cos\alpha - 3\frac{\omega L_s}{\pi} I_d$$

$$\cos(\alpha+u) = cos\ \alpha - 2\frac{\omega L_s}{\sqrt{2}V_{LL}}\, I_d$$

$$\gamma = 180 - (\alpha + u)$$

$$V_L = \left[\frac{1}{T}\int_0^T v_L^2(t)dt\right]^{1/2}$$

$$V_{dc} = \frac{1}{T}\int_0^T v_L(t)\,dt$$

$$\mathrm{TUF} = \frac{P_{dc}}{V_s I_s} = \frac{V_{dc} I_{dc}}{V_s I_s}$$

$$\mathrm{RF} = \frac{V_{ac}}{V_{dc}}$$

$$\left(V_{peak} - V_{min}\right) = \frac{2P\Delta t}{(V_{peak} + V_{min})C}$$

$$\frac{di_L}{dt} = \frac{V_{in} - V_{out}}{L}$$

$$\sigma = \frac{P_{dc}}{P_L} = \frac{V_{dc} I_{dc}}{V_L I_L}$$

$$\mathrm{FF} = \frac{V_L}{V_{dc}} \quad \text{or} \quad \frac{I_L}{I_{dc}}$$

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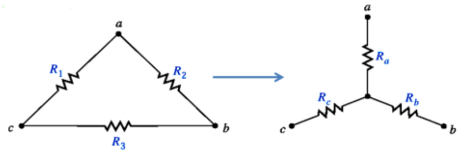
$$V_{d\alpha} = \frac{1}{2\pi}\int_{\alpha}^{\pi} V_{max}\sin(\omega t)d(\omega t) = \frac{V_{max}}{2\pi}(1+\cos\alpha)$$

$$V_{ph} = \frac{V}{\sqrt{3}}\ , I_{ph} = I \quad for\ star\ connection,\ V_{ph} = V,\quad I_{ph} = \frac{I}{\sqrt{3}} \quad for\ delta\ connection$$

$$S = \sqrt{3}VI \quad V.A,\ P = \sqrt{3}VIcos\theta\ \ W.,Q = \sqrt{3}VIsin\theta\ \ V.A.r$$

$$Q_C = \sqrt{3}VI_C\ \ V.A.r,\ \ X_C = \frac{V}{\sqrt{3}I_C}\ \ \Omega$$

Three-phase systems

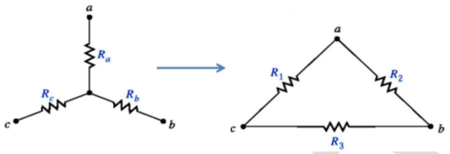


Delta to Star conversion:

$$R_a = \frac{R_1R_2}{R_1 + R_2 + R_3}$$

$$R_b = \frac{R_2R_3}{R_1 + R_2 + R_3}$$

$$R_c = \frac{R_3R_1}{R_1 + R_2 + R_3}$$



$$R_1 = \frac{R_aR_b + R_bR_c + R_cR_a}{R_b}$$

$$R_2 = \frac{R_aR_b + R_bR_c + R_cR_a}{R_c}$$

$$R_3 = \frac{R_aR_b + R_bR_c + R_cR_a}{R_a}$$

Star to Delta conversion:

Gravity: 9.81 m/s

Thermal resistance of the interface material:

$$\theta_{cs} = \frac{(\rho)(t)}{A}$$

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Output voltage of a differentiator circuit:

$$v_0 = -R_2 C_1 \frac{dv_I}{dt}$$

Compressibility relationship:

$$K = -V \frac{dP}{dV}$$

General manometer:

$$\Delta P = | \Delta \rho \, g \, \Delta h |$$

Venturi meter:

$$v_{\text{in}} = C_D \sqrt{\frac{2\,\Delta P}{\rho_f \left[\left(\frac{d_{\text{large}}}{d_{\text{small}}} \right)^4 - 1 \right]}}$$

Force on a submerged wall:

$$F = \frac{\rho g a h^2}{2}$$

Drag coefficient:

$$C_{Drag} = \frac{F_D}{\frac{1}{2} \rho v^2 A}$$

Flow through a small hole:

$$Q = C_D \sqrt{\frac{2\,\Delta P}{\rho}}\, A$$

Flow through a rectangular slit:

$$Q = \frac{2}{3} C_D \, W \sqrt{2g} \left[(Ho + L)^{\frac{3}{2}} - Ho^{\frac{3}{2}} \right]$$

Tank draining:

$$h^{\frac{1}{2}} = h_0^{\frac{1}{2}} - \frac{C_D a \sqrt{2g}}{2A} t$$

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Flow over a rectangular weir:

$$Q = \frac{2}{3} C_D W \sqrt{2g}\ H^{\frac{3}{2}}$$

Flow over a V-notch weir:

$$Q = \frac{8}{15} C_D \tan\left(\theta/2\right) (2g)^{\frac{1}{2}}\ H^{\frac{5}{2}}$$

Poisseuille's Law:

$$Q = -\frac{\pi}{128\mu} \frac{dP}{dx} D^4$$

Darcy's Law:

$$\Delta P = \frac{2f L \rho \bar{u}^2}{D}$$

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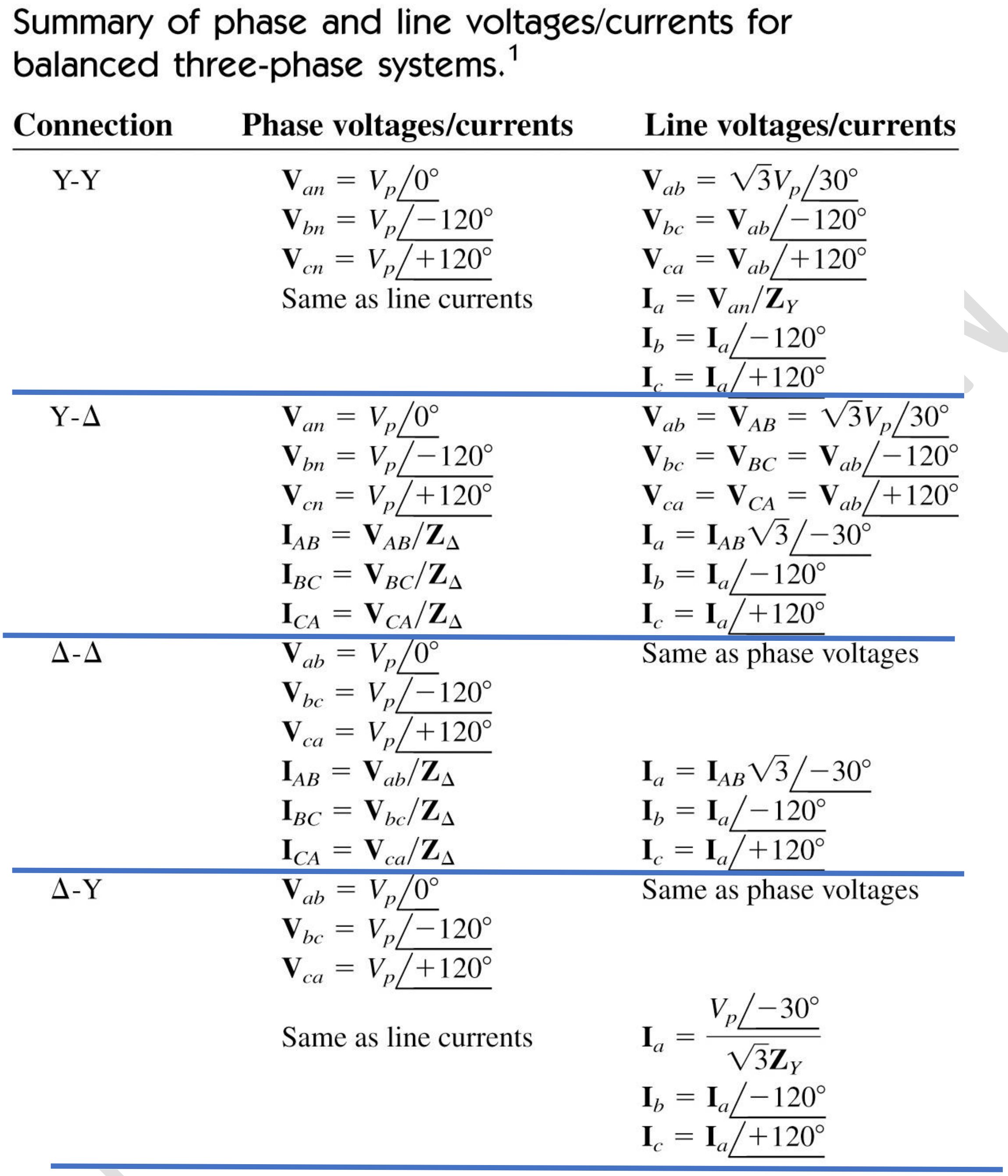

Summary of phase and line voltages/currents for balanced three-phase systems.[1]

Connection	Phase voltages/currents	Line voltages/currents
Y-Y	$\mathbf{V}_{an} = V_p\angle 0^\circ$ $\mathbf{V}_{bn} = V_p\angle -120^\circ$ $\mathbf{V}_{cn} = V_p\angle +120^\circ$ Same as line currents	$\mathbf{V}_{ab} = \sqrt{3}V_p\angle 30^\circ$ $\mathbf{V}_{bc} = \mathbf{V}_{ab}\angle -120^\circ$ $\mathbf{V}_{ca} = \mathbf{V}_{ab}\angle +120^\circ$ $\mathbf{I}_a = \mathbf{V}_{an}/\mathbf{Z}_Y$ $\mathbf{I}_b = \mathbf{I}_a\angle -120^\circ$ $\mathbf{I}_c = \mathbf{I}_a\angle +120^\circ$
Y-Δ	$\mathbf{V}_{an} = V_p\angle 0^\circ$ $\mathbf{V}_{bn} = V_p\angle -120^\circ$ $\mathbf{V}_{cn} = V_p\angle +120^\circ$ $\mathbf{I}_{AB} = \mathbf{V}_{AB}/\mathbf{Z}_\Delta$ $\mathbf{I}_{BC} = \mathbf{V}_{BC}/\mathbf{Z}_\Delta$ $\mathbf{I}_{CA} = \mathbf{V}_{CA}/\mathbf{Z}_\Delta$	$\mathbf{V}_{ab} = \mathbf{V}_{AB} = \sqrt{3}V_p\angle 30^\circ$ $\mathbf{V}_{bc} = \mathbf{V}_{BC} = \mathbf{V}_{ab}\angle -120^\circ$ $\mathbf{V}_{ca} = \mathbf{V}_{CA} = \mathbf{V}_{ab}\angle +120^\circ$ $\mathbf{I}_a = \mathbf{I}_{AB}\sqrt{3}\angle -30^\circ$ $\mathbf{I}_b = \mathbf{I}_a\angle -120^\circ$ $\mathbf{I}_c = \mathbf{I}_a\angle +120^\circ$
Δ-Δ	$\mathbf{V}_{ab} = V_p\angle 0^\circ$ $\mathbf{V}_{bc} = V_p\angle -120^\circ$ $\mathbf{V}_{ca} = V_p\angle +120^\circ$ $\mathbf{I}_{AB} = \mathbf{V}_{ab}/\mathbf{Z}_\Delta$ $\mathbf{I}_{BC} = \mathbf{V}_{bc}/\mathbf{Z}_\Delta$ $\mathbf{I}_{CA} = \mathbf{V}_{ca}/\mathbf{Z}_\Delta$	Same as phase voltages $\mathbf{I}_a = \mathbf{I}_{AB}\sqrt{3}\angle -30^\circ$ $\mathbf{I}_b = \mathbf{I}_a\angle -120^\circ$ $\mathbf{I}_c = \mathbf{I}_a\angle +120^\circ$
Δ-Y	$\mathbf{V}_{ab} = V_p\angle 0^\circ$ $\mathbf{V}_{bc} = V_p\angle -120^\circ$ $\mathbf{V}_{ca} = V_p\angle +120^\circ$ Same as line currents	Same as phase voltages $\mathbf{I}_a = \dfrac{V_p\angle -30^\circ}{\sqrt{3}\mathbf{Z}_Y}$ $\mathbf{I}_b = \mathbf{I}_a\angle -120^\circ$ $\mathbf{I}_c = \mathbf{I}_a\angle +120^\circ$

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