[ESS28]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BENG (HONS) ELECTRICAL & ELECTRONICS ENGINEERING

SEMESTER ONE EXAMINATION 2019/2020

INTERMEDIATE ELECTRICAL PRINCIPLES & ENABLING POWER ELECTRONICS

MODULE NO: EEE5013

Date: Monday 13th January 2020 **Time: 10:00 – 12:00**

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) For the differentiator shown in **Figure Q1a**, derive the equation for the output waveform if the input signal is; $Vs = 10mVsin1000t$. **[5 marks]**

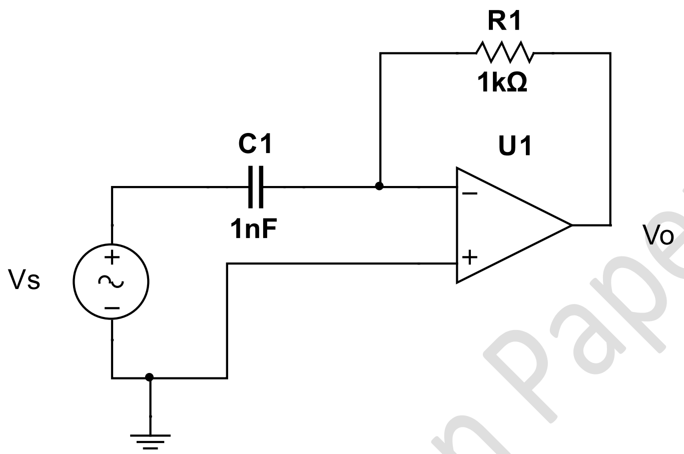


Figure Q1a An Inverting Operational amplifier

b) Sketch the input and output waveforms labelling period and amplitudes. **[6 marks]**

c) If a signal processing circuit is shown in **Figure Q1b**, calculate the output voltage. **[14 marks]**

Question 1 continues over the page….

PLEASE TURN THE PAGE….

Question 1 continued….

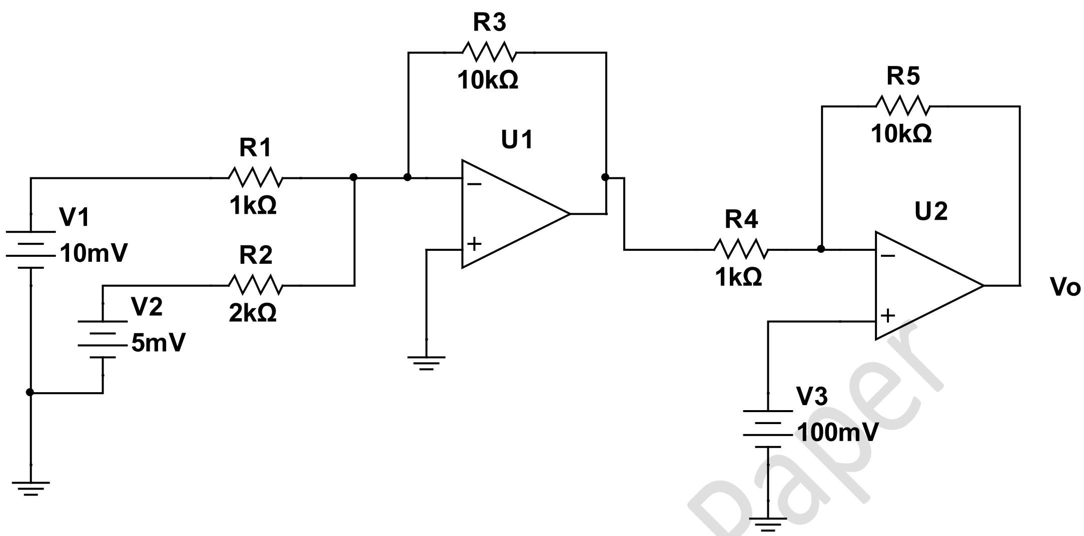


Figure Q1b a signal processing circuit

Total 25 marks

Question 2

(a) A half-wave rectifier circuit is used to charge a 150 V battery as shown in **figure Q2a** below. Calculate **[10 marks]** and plot the current i **[5 marks]** along with v_s if V_s=120 V , f=60 Hz, and L=10 mH.

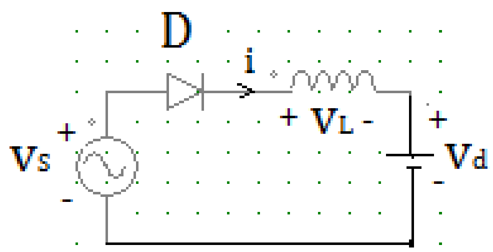


Figure Q2a A half-wave rectifier circuit

Question 2 continues over the page….

PLEASE TURN THE PAGE….

Question 2 continued….

(b) Explain the basic operation of a square-wave inverter as shown in **figure Q2b** below **[5 marks]** and illustrate the concept of AC waveform generation **[5 marks]**. Draw the waveform across the load and the diodes.

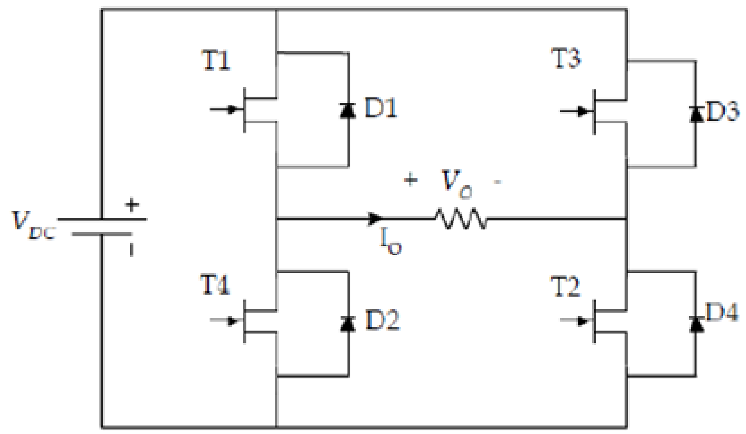


Figure Q2b A square-wave inverter

Total 25 marks

PLEASE TURN THE PAGE….

Question 3

(a) Draw a circuit diagram for a boost converter **[5 marks]** and derive an expression for $\frac{V_{out}}{V_{in}}$ defining all parameters used in this circuit **[7 marks]**.

(b) Enumerate the basic grounding system then explain what is meant by static grounding. **[4 marks]**

(c) For a single-phase inductive load (with parallel resistance and inductance).

i. Prove that the active power is always positive, has an average value of $\frac{V.I}{2}\,cos\theta$ and zero average reactive power both pulsating at double supply frequency (2ω) where V and I are the peak values of the voltage and current and θ is the power factor angle of the load. **[5 marks]**

ii. Draw the relevant waveforms for $v, i, and\ p$.

[4 marks]

Total 25 marks

Question 4

(a) Calculate the line voltages **[6 marks]** and the line currents **[6 marks]** of a Y-Y Connection. Given: V_{an} = 120 ∠60° and V_{bn}=120 ∠-60° . The system is balanced three-phase system. The system impedances are given as follows: Z_{source}=0.4+j0.3 Ω , Z_{line}=0.6+j0.7 Ω, Z_{load}=24+j19 Ω.

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.

[8 marks]

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

[5 marks]

Total 25 marks

Question 5

a) List two reasons for cooling silicon amplifier devices. **[2 marks]**

b) A silicon transistor having a T_{JMAX} rating of 170 ^{0}C will dissipate 30W when its case temperature is 80 ^{0}C, calculate its thermal resistance. **[5 marks]**

c) If this silicon transistor (part b) is mounted to a heatsink of thermal resistance 3.5 ^{0}C/W, calculate the maximum collector dissipation, if the transistor and heatsink is operated at an ambient temperature of 25 ^{0}C.

[5 marks]

d) If a mica washer of thermal resistance of 0.65 ^{0}C/W is inserted between, the transistor and heatsink calculate the collector temperature. **[5 marks]**

e) A pipe of 25mm 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 1000kg/m^3, calculate;

i) Calculate the volumetric flow rate and the average velocity of the water in the 25 mm pipe. **[5 marks]**

ii) Calculate the average velocity of the water in the 10 mm pipe. **[3 marks]**

Total 25 marks

END OF QUESTIONS

FORMULA SHEET OVER THE PAGE….

PLEASE TURN THE PAGE….

School of Engineering
B.Eng (Hons) Electrical & Electronics Engineering
Semester One Examination 2019/2020
Intermediate Electrical Principles & Enabling Power Electronics
Module No. EEE5013

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:

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

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

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

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

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

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

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

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

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

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

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

PLEASE TURN THE PAGE….

School of Engineering
B.Eng (Hons) Electrical & Electronics Engineering
Semester One Examination 2019/2020
Intermediate Electrical Principles & Enabling Power Electronics
Module No. EEE5013

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

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

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

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

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

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

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

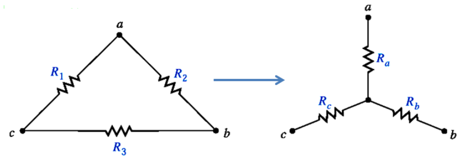
$V_{ph} = \frac{V}{\sqrt{3}}$, $I_{ph} = I$ *for star connection*, $V_{ph} = V$, $I_{ph} = \frac{I}{\sqrt{3}}$ *for delta connection*

$S = \sqrt{3}VI\ \ V.A,\ P = \sqrt{3}VI\cos\theta\ \ W.,\ Q = \sqrt{3}VI\sin\theta\ \ V.A.r$

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

PLEASE TURN THE PAGE….

Three-phase systems

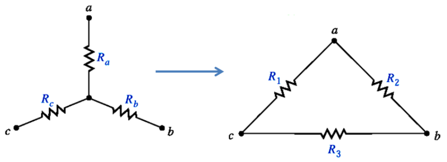


Delta to Star conversion:

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

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

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



Star to Delta conversion:

$$R_1 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_b}$$

$$R_2 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_c}$$

$$R_3 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_a}$$

Gravity: 9.81 m/s

Thermal resistance of the interface material:

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

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:

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

PLEASE TURN THE PAGE….

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:

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

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:

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

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 $\mathbf{I}_a = \dfrac{V_p\angle -30^\circ}{\sqrt{3}\mathbf{Z}_Y}$ $\mathbf{I}_b = \mathbf{I}_a\angle -120^\circ$ $\mathbf{I}_c = \mathbf{I}_a\angle +120^\circ$

END OF PAPER