UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	ELECTRONIC CIRCUITS ANALYSIS AND DESIGN
COURSE CODE	:	BEJ 30403
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY / AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTION		1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK** 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

Q1 Consider a series-connected of amplifiers shown in **Figure Q1**. Given $V_1 = 0.5\ sin2t\ V$, $V_2 = 0.2\ sin2t\ V$ and $V_3 = 0.3\ sin2t\ V$.

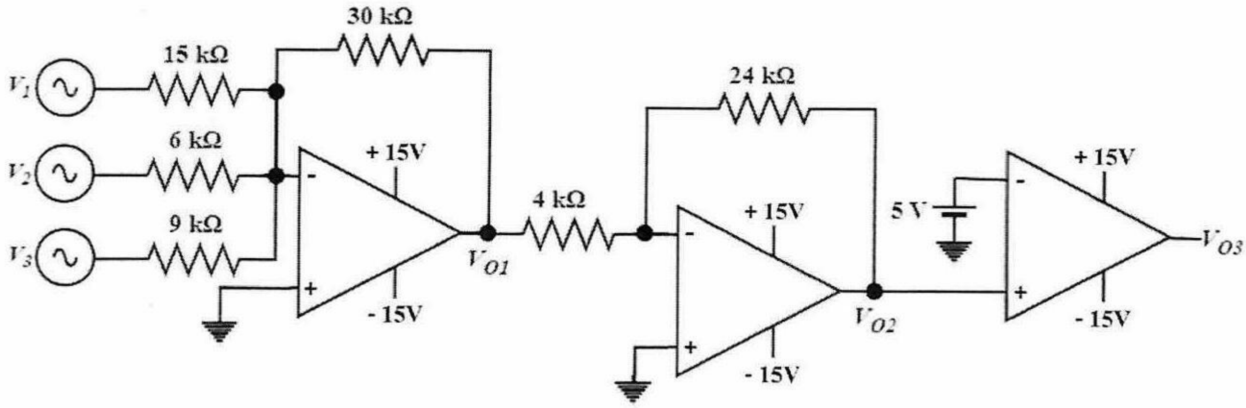

Figure Q1

(a) Determine all the outputs of V_{O1}, V_{O2} and V_{O3} by showing the calculation steps clearly.

(9 marks)

(b) Draw the waveforms of V_{O1}, V_{O2} and V_{O3} in the same time scale.

(6 marks)

(c) Analyse the output of V_{O3} if all input voltages are changed into DC voltage.

(5 marks)

Q2 (a) Explain the function of the following active filters;

(i) Low pass filter

(2 marks)

(ii) Band pass filter

(2 marks)

(b) A filter circuit is given in **Figure Q2(b)**.

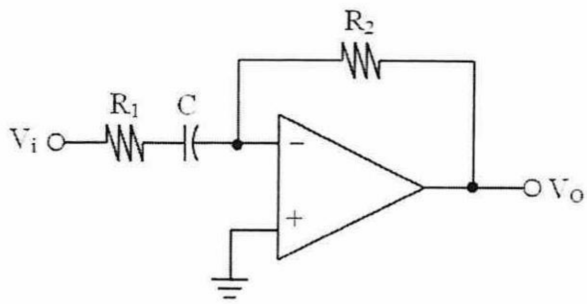

Figure Q2(b)

(i) Derive the gain transfer function of the circuit in **Figure Q2(b)**.

$$H(\omega) = A(\omega) = \frac{V_o\ (\omega)}{V_i\ (\omega)}$$

(6 marks)

(ii) Find the gain of the circuit at the frequency of $\omega = 0$ and $\omega = \infty$.

(4 marks)

(iii) Draw the frequency response graph of the circuit.

(3 marks)

(iv) Determine the type of the filter.

(1 mark)

(v) Calculate the cut-off frequency if given, $R_1 = 2.2$ kΩ, $R_2 = 15$ kΩ and $C = 0.068$ μF.

(2 marks)

Q3 (a) Consider an operational amplifier circuit in current-series feedback configuration with these parameters:

$$A_f = 500, Z_o = 40\ \Omega, Z_{of} = 6k\Omega$$

Determine the amplifier type, gain without feedback (A) and attenuation (β) of this circuit.

(5 marks)

(b) Derive the amplifier attenuation (β) and gain (A_v) in term of R for an amplifier circuit shown in **Figure Q3(b)**.

(10 marks)

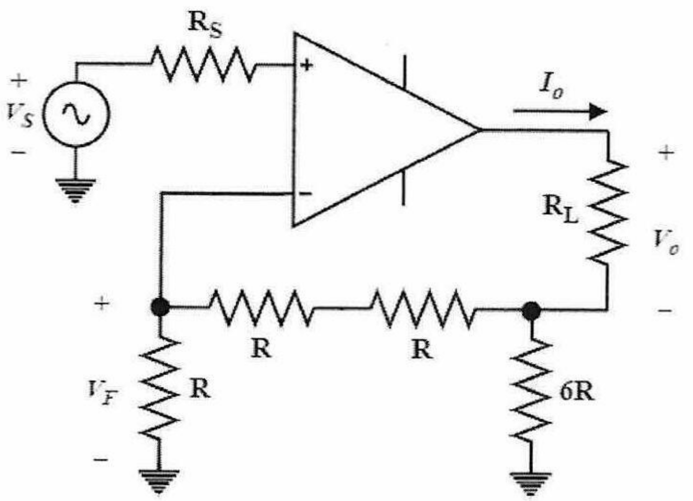

Figure Q3(b)

(c) Analyse any change in value of β if the resistor across V_f is doubled.

(5 marks)

Q4 (a) List **TWO (2)** types of oscillator circuit that produces sinusoidal waveform.

(2 marks)

(b) In the Op-Amp oscillator circuit, analyse the oscillator conditions at the different effects of $A_v\beta$ as following;

(i) $A_v\beta < 1$ operation

(5 marks)

(ii) $A_v\beta = 1$ operation

(5 marks)

(c) An inverting amplifier circuit using Op-Amp 741 IC, a feedback resistor, R_F and input resistance, $R_A = 5\ k\Omega$ is used in a feedback oscillator circuit. The output pin of the amplifier is connected to the three RC network that can generate frequency of oscillation, $f_o = 20$ kHz. Assume that $R_1 = R_2 = R_3 = R$ and $C_1 = C_2 = C_3 = C$.

(i) Name the oscillator circuit.

(1 mark)

(ii) Draw the oscillator circuit.

(3 marks)

(iii) Using a capacitor value of 0.001 μF, determine all other component values.

(4 marks)

Q5 (a) **Figure Q5(a)** is a full wave bridge circuit with a capacitor filter. Assume all the diodes in the circuit have a forward voltage of 0.7 V. Sketch the waveform of A, B, C and D.

(8 marks)

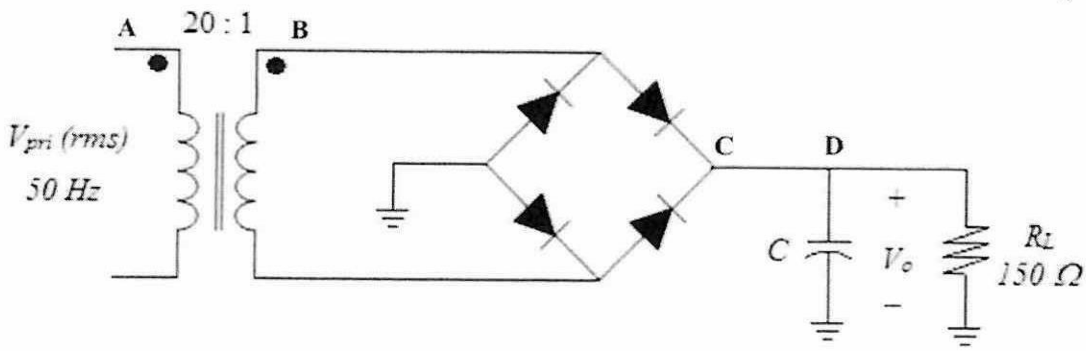

Figure Q5(a)

(b) **Figure Q5(b)** shows the output waveform produces from the circuit in **Figure Q5(a)**. By analysing **Figure Q5(b)**, Determine;

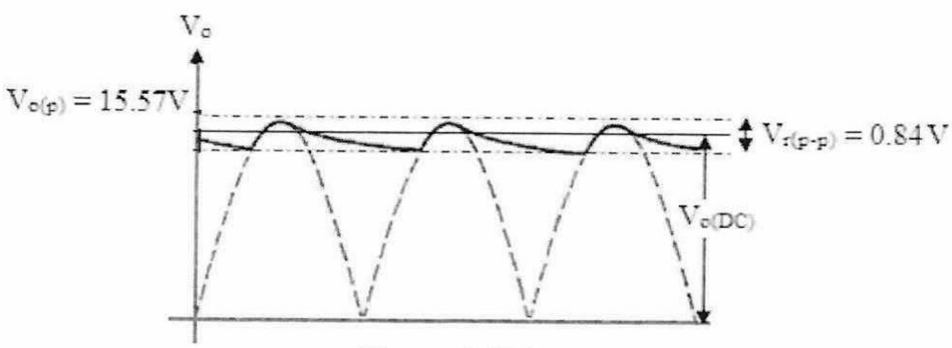

Figure Q5(b)

(i) DC voltage, $V_{o(\mathrm{DC})}$

(2 marks)

(ii) AC ripple voltage, $V_{r(\mathrm{rms})}$

(2 marks)

(iii) Capacitor, C

(2 marks)

(iv) Secondary voltage, $V_{sec(p)}$

(2 marks)

(v) Primary voltage, $V_{pri(rms)}$

(2 marks)

(c) Calculate the ripple factor, $\%r$ for the circuit in **Figure Q5(a)**.

(2 marks)

– END OF QUESTIONS –

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Table 1 List of formula

Inverting Amplifier	$A_V = \frac{V_o}{V_i} = -\frac{R_f}{R_1}$
Non-Inverting Amplifier	$A_V = \frac{V_o}{V_i} = 1 + \frac{R_f}{R_1}$
Inverting Summing Amplifier	$V_o = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right)$
Non-Inverting Summing Amplifier	$V_o = \left(1 + \frac{R_f}{R_1}\right)\left(\frac{R_B}{R_A + R_B}V_A + \frac{R_A}{R_A + R_B}V_B\right)$
Subtracting Amplifier	$V_o = \left(1 + \frac{R_f}{R_1}\right)\left(\frac{R_3}{R_2 + R_3}V_2 - \frac{R_f}{R_1 + R_f}V_1\right)$
Instrumentation Amplifier	$A_T = A_1 A_2 = \frac{v_o}{v_{in}} = \left(1 + \frac{2R}{R_x}\right)\left(\frac{R_4}{R_3}\right)$
Integrator	$V_o(t) = -\frac{1}{RC}\int_{t_0}^{t_1} V_i(t)\,dt + V_o(t_0)$
Differentiator	$V_o(t) = -RC\frac{dV_i(t)}{dt}$
Schmitt Trigger	$V_{UTP \text{ or } LTP} = \frac{R_2}{R_1 + R_2}(\pm V_{out(\max)}) + \frac{R_1}{R_1 + R_2}(V_{REF})$
Cut-off frequency for a filter	$f_c = \frac{1}{2\pi RC}$
1st order Low Pass Filter	$A_V(s) = \frac{V_o}{V_i} = \left(1 + \frac{R_F}{R_1}\right)\left(\frac{1}{1 + sRC}\right)$
2nd order Low pass filter	$A_V(s) = \frac{V_o}{V_i}(s) = \frac{A_{VO}}{(RCs)^2 + (3 - A_{VO})RCs + 1}$
1st order High Pass Filter	$A_V(s) = \frac{V_o}{V_i} = \left(1 + \frac{R_F}{R_1}\right)\left(\frac{1}{1 + \frac{1}{sRC}}\right)$

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Table 1 List of formula (Cont..)

2nd order High Pass Filter	$A_V(s) = \frac{V_O}{V_i}(s) = \frac{A_{VO}}{\frac{1}{(sRC)^2} + \frac{3 - A_{VO}}{sRC} + 1}$
Negative feedback – Gain	$A_f = \frac{V_o}{V_S} = \frac{A}{1 + \beta A}$
Positive feedback – Gain	$A_f = \frac{A}{1 - \beta A}$
Phase shift oscillator	$\beta = \frac{V_F}{V_o} = \frac{1}{\left(1 - \frac{5}{\omega^2 R^2 C^2}\right) + j\left(\frac{1}{\omega^3 R^3 C^3} - \frac{6}{\omega RC}\right)}$ or $\beta = \frac{V_F}{V_o} = \frac{1}{\left(1 - 5\omega^2 R^2 C^2\right) + j\left(6\omega RC - \omega^3 R^3 C^3\right)}$ $f_o = \frac{1}{2\pi RC\sqrt{6}}$ or $f_o = \frac{\sqrt{6}}{2\pi RC}$
Wien bridge oscillator	$f_o = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$
Colpitts Oscillator	$f_o = \frac{1}{2\pi\sqrt{LC_{eq}}}$ $C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$
Hartley Oscillator	$f_o = \frac{1}{2\pi\sqrt{CL_{eq}}}$ $L_{eq} = L_1 + L_2$
UJT relaxation oscillator	$f_o = \frac{1}{R_T C_T \ln\left[1/(1-\eta)\right]}$

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Table 1 List of formula (Cont..)

Square-wave Oscillator	$f=\frac{1}{T}=\frac{1}{2RC\ln\left(\frac{1+\beta}{1-\beta}\right)}$ $\beta=\frac{R_3}{R_3+R_2}$
Triangular-wave Oscillator	$f=\frac{1}{4R_1C}\frac{R_2}{R_3}$
Capacitor voltage	$v_c(t)=v_c(0)+\left(v_c(\infty)-v_c(0)\right)\left(1-e^{-t/\tau}\right)$ $=v_c(\infty)+\left(v_c(0)-v_c(\infty)\right)e^{-t/\tau}$
Astable Multivibrator	$T_m=t_1=\tau_2\ln 2=0.693\left(R_1+R_2\right)C_1$ $T_s=t_2=\tau_2\ln 2=0.693R_2C_1$ $T=T_m+T_s$ $f=\frac{1.44}{(R_1+2R_2)C_1}$ $D=\frac{T_m}{T_m+T_s}\times 100\%=\frac{R_1+R_2}{R_1+2R_2}\times 100\%$
Monostable Multivibrator	$T=1.1\,R_1C_1$
Ripple Factor	$\%\,r=\frac{\text{ripple voltage (rms)}}{\text{dc voltage}}=\frac{V_{r(rms)}}{V_{dc}}\times 100$
Half-wave rectifier with a filter	$V_{r(rms)}=\frac{V_{r(p-p)}}{2\sqrt{3}}\approx\frac{V_{o(p)}}{2\sqrt{3}\,fCR_L}$ $V_{o(DC)}=V_{o(p)}-\frac{V_{r(p-p)}}{2}$ $V_{r(p-p)}\approx\frac{V_{o(p)}}{fCR_L}=\frac{I_{o(DC)}}{fC}$ $r=\frac{V_{r(rms)}}{V_{DC}}\approx\frac{1}{2\sqrt{3}\,fCR_L}$

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Table 1 List of formula (Cont..)

Full-wave rectifier with a filter	$V_{r(rms)} = \frac{V_{r(p-p)}}{2\sqrt{3}} \approx \frac{V_{o(p)}}{4\sqrt{3} fCR_L} = \frac{I_{DC}}{4\sqrt{3} fC}$ $V_{o(DC)} = V_{o(p)} - \frac{V_{r(p-p)}}{2}$ $V_{r(p-p)} = \frac{I_{o(DC)}}{2fC} \approx \frac{V_{o(p)}}{2fCR_L}$ $r = \frac{V_{r(rms)}}{V_{DC}} \approx \frac{1}{4\sqrt{3} fCR_L}$
Rectifier with Additional RC filter	$V'_{r(rms)} \approx \frac{X_C}{R} V_{r(rms)}$
Inductor Filter	$r = \frac{R_L}{3\sqrt{2}\omega L}$
Shunt regulator	$V_o \cong V_B \left(\frac{R_1 + R_2}{R_2} \right)$ $V_B = V_Z + V_{BE}$ $V_o \cong \left(\frac{R_1 + R_2}{R_2} \right) (V_Z)$
Series regulator	$V_o = \frac{R_1 + R_2}{R_1} (V_Z + V_{BE})$ $V_o = V_Z \left(\frac{R_1 + R_2}{R_1} \right)$
Adjustable IC regulator	$V_o = V_{ref} \left(1 + \frac{R_2}{R_1} \right) + I_{adj} R_2$