Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	ELECTRONIC CIRCUIT ANALYSIS AND DESIGN
COURSE CODE	:	BEL 30403
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	DECEMBER 2019/JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **TWELVE (12)** PAGES

Q1 (a) The circuit in **Figure Q1(a)** is used to drive an LED with a voltage source. The circuit can also be thought of as a current amplifier with a proper design where $I_D > I_I$.

(i) Based on the circuit given, derive the expression for I_D in terms of I_I and the resistors.

(7 marks)

(ii) Design the circuit to have $I_D = 8$ mA, and $I_I = 1.2$ mA for $V_I = 7$ V. Use $R_F = 56$ kΩ.

(4 marks)

(b) A Schmitt Trigger circuit is shown in **Figure Q1(b)**.

(i) Determine the upper threshold voltage, V_{UT}, and lower threshold voltage, V_{LT}, of the circuit.

(4 marks)

(ii) Sketch the output waveform if the input waveform V_{in} is as shown in **Figure Q1(b)(ii)**. Label clearly the output waveform.

(5 marks)

Q2 (a) (i) Design an active filter using non-inverting amplifier that will produce a frequency response as shown in **Figure Q2(a)**. The bandwidth of the filter is 30 kHz. Use a capacitor value of 10 nF.

(9 marks)

(ii) Draw the circuit and clearly label it.

(5 marks)

(b) Derive the transfer function of the filter in **Q2(b)**.

(6 marks)

Q3 (a) **Figure Q3(a)** is a block diagram of an amplifier (dotted box) utilizing a negative feedback. For this figure:

(i) Determine the type of the amplifier and the feedback topology used.
(2 marks)

(ii) Derive the relationship between the output impedance without feedback (Z_O) and the output impedance with feedback (Z_{OF}).
(8 marks)

(iii) Discuss how the negative feedback can improved the output impedance of the amplifier.
(2 marks)

(b) An amplifier system without feedback has the following specifications:

Open loop gain: 120
Input impedance: 60kΩ
Output impedance: 3kΩ

(i) If the amplifier system employs a negative feedback and the close loop gain is 9.2, calculate the with system feedback factor, β.
(2 marks)

(ii) Suppose the negative feedback topology used for the amplifier system in **Q3(b)(i)** is a current shunt feedback, determine the amplifier, input impedance and output impedance of the amplifier with feedback.
(6 marks)

Q4 (a) Explain a Barkhusen criteria that must be fulfilled by an oscillator.
(4 marks)

(b) Refer to the circuit shown in **Figure Q4(b)**.

(i) Calculate the period, frequency of oscillation and duty cycle for the output waveform (V_O).
(6 marks)

(ii) Draw and clearly label the output waveform (V_O).
(4 marks)

(c) Design the oscillator shown in **Figure Q4(c)** by finding the value of the capacitors C_D and C_F to achieve a gain of 20 and oscillating frequency of 20 Hz. Assume the inductor $L = 10\ mH$.
(6 marks)

Q5 (a) A centre-tapped rectifier with transformer coupled is supplied by *200 sin ωt* V input voltage. The turn ratio of the transformer used is 4:1. The diodes used are silicon IN4001 and connected to a load resistor of 100 Ω at the output.

(i) Determine the voltage at secondary winding parallel with primary winding and the dc voltage across the load resistor.

(4 marks)

(ii) A capacitor filter is connected to the circuit in **Q5(a)(i)** to eliminate the fluctuations in the output voltage of the centre-tapped rectifier. Draw the new circuit from the input section at the primary up until the load resistor. Sketch and label the ripple of the output voltage and show clearly the dc voltage level. Determine the values if f = 120 Hz and capacitor of 1000 μF is used. Show all calculations.

(8 marks)

(iii) Find the ripple factor for the circuit in **Q5(a)(ii)**.

(3 marks)

(b) For the circuit in **Figure Q5(b)**, calculate the approximate values of output voltage V_O, input current I_{R2}, load current I_L and collector current I_{SH}. Given: R_2 = 10Ω, V_Z = 6.8V, R_3 = 2.5 kΩ, R_4 = 7.5 kΩ and R_L = 50 Ω.

(5 marks)

– **END OF QUESTIONS** –

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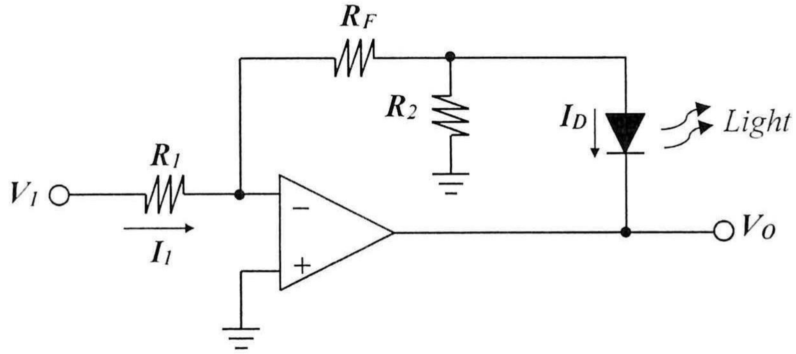

Figure Q1(a)

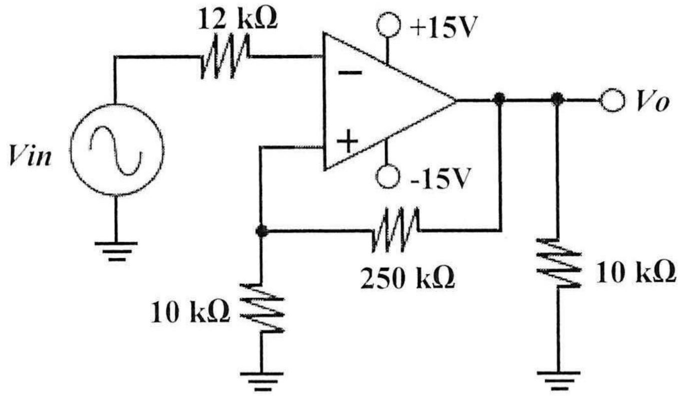

Figure Q1(b)

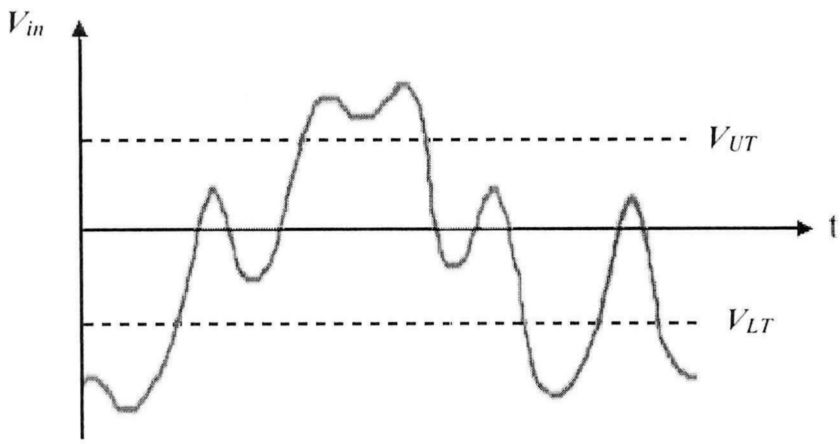

Figure Q1(b)(ii)

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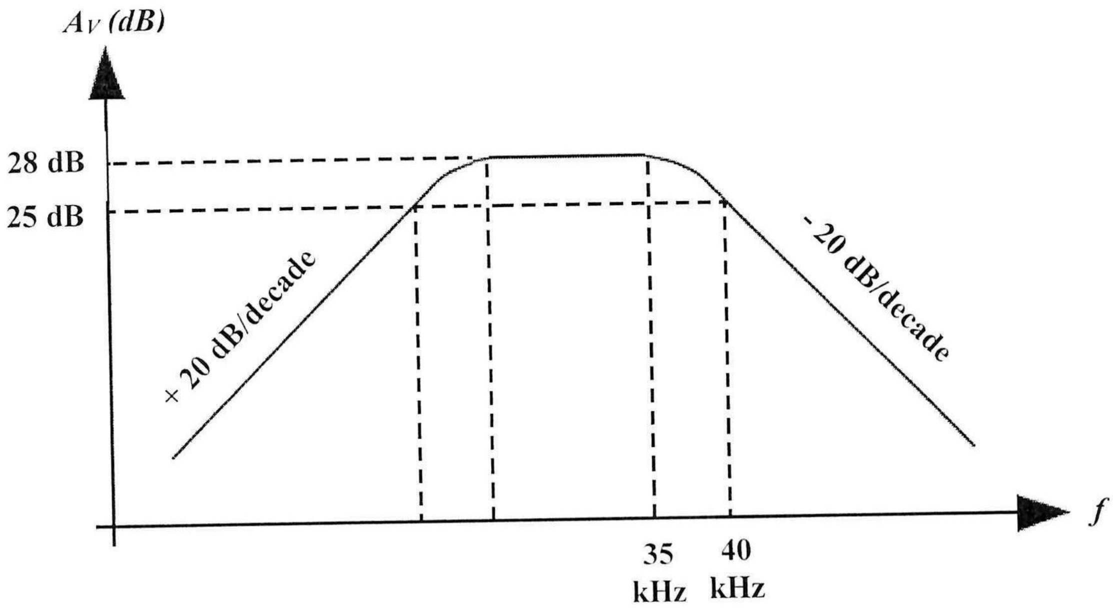

Figure Q2(a)

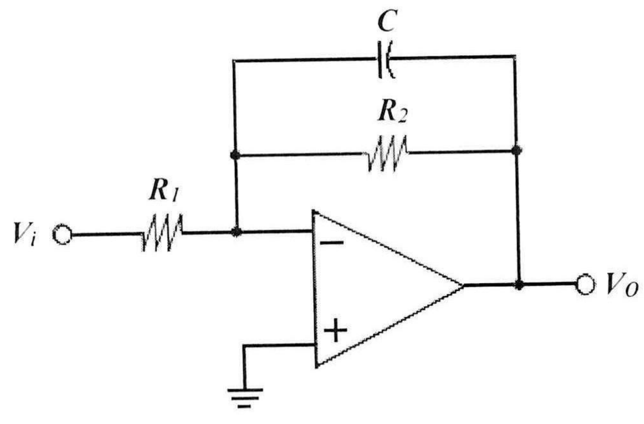

Figure Q2(b)

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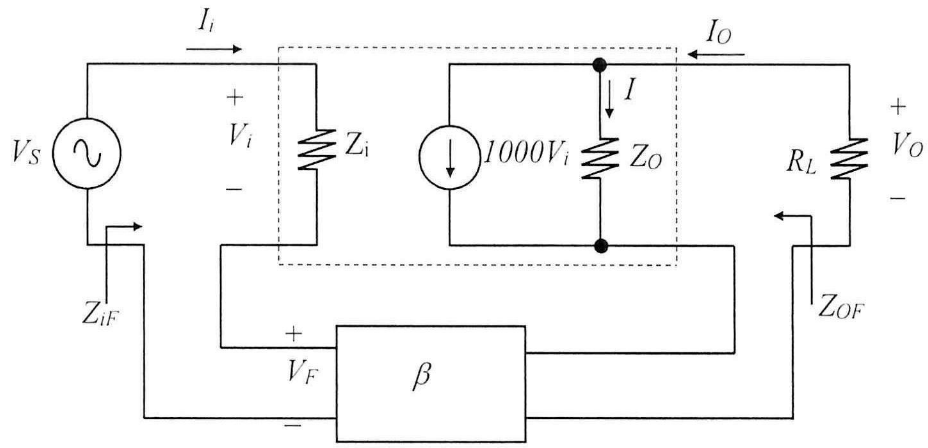

Figure Q3(a)

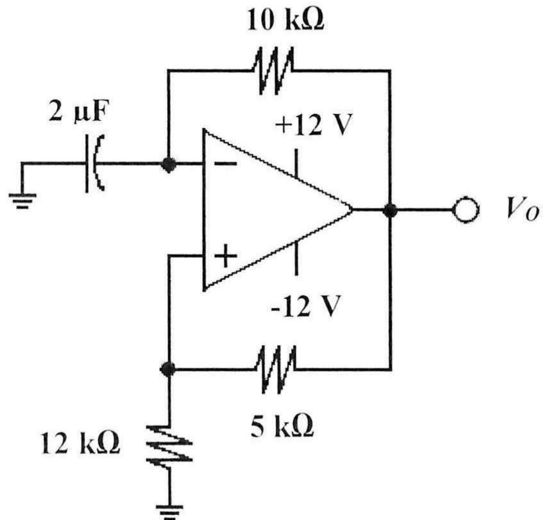

Figure Q4(b)

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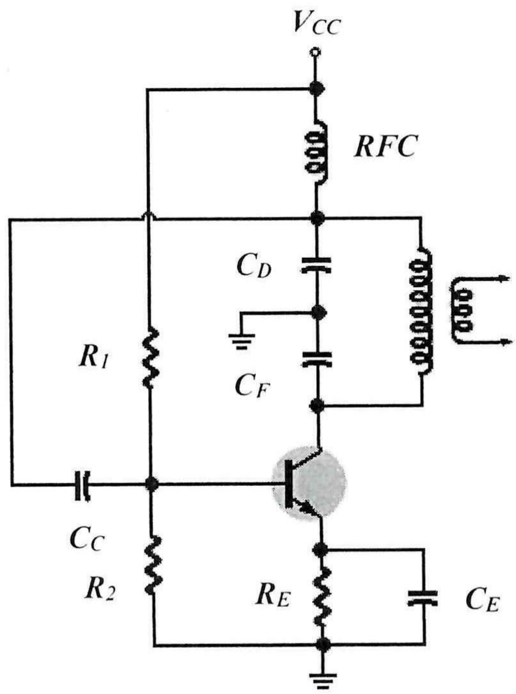

Figure Q4(c)

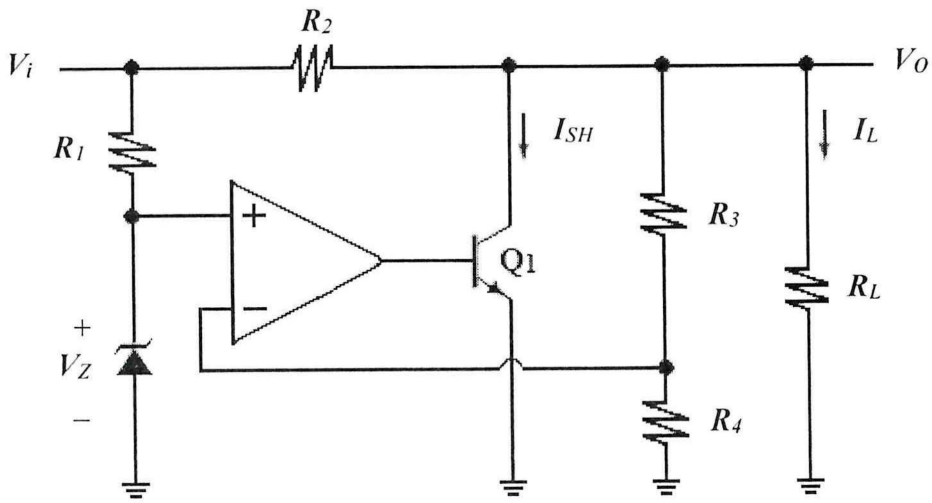

Figure Q5(b)

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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	$A_V = A_1 A_2 = \frac{v_o}{v_{in}} = \left(1 + \frac{2R}{R_x}\right)\left(\frac{R_4}{R_3}\right)$
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	$f_o = \frac{1}{R_T C_T \ln\left[1\ (1-\eta)\right]}$
Triangular-wave Oscillator	$f = \frac{1}{4R_1 C}\frac{R_2}{R_3}$

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Table 1 : List of formula (cont.)

Square-wave Oscillator	$f=\frac{1}{T}=\frac{1}{2RC\ln\left(\frac{1+\beta}{1-\beta}\right)}$ $\beta=\frac{R_3}{R_3+R_2}$
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	$T_m=t_1=\tau_2\ln 2=0.693(R_1+R_2)C_1$ $T_s=t_2=\tau_2\ln 2=0.693R_2C_1$ $T=T_m+T_s$ $f=\frac{1.44}{(R_1+2R_2)C_1}$ $D=\frac{T_m}{T_m+T_s}\times 100\%=\frac{R_1+R_2}{R_1+2R_2}\times 100\%$
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	$V_{r(rms)}=\frac{V_{r(p-p)}}{2\sqrt{3}}\approx\frac{V_{o(p)}}{2\sqrt{3}fCR_L}$ $V_{o(DC)}=V_{o(p)}-\frac{V_{r(p-p)}}{2}$ $V_{r(p-p)}\approx\frac{V_{o(p)}}{fCR_L}=\frac{I_{o(DC)}}{fC}$ $r=\frac{V_{r(rms)}}{V_{DC}}\approx\frac{1}{2\sqrt{3}fCR_L}$ $I_{o(DC)}=\frac{V_{o(DC)}}{R_L}\approx\frac{V_{o(p)}}{R_L}$

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Table 1 : List of formula (cont.)

Full-wave rectifier with a filter	$V_{r(rms)} = \frac{V_{r(p-p)}}{2\sqrt{3}} \approx \frac{V_{o(p)}}{4\sqrt{3}fCR_L} = \frac{I_{o(DC)}}{4\sqrt{3}fC}$ $V_{o(DC)} = V_{o(p)} - \frac{V_{r(p-p)}}{2}$ $V_{r(p-p)} = \frac{I_{o(DC)}}{2fC} \approx \frac{V_{o(p)}}{2fCR_L}$ $r = \frac{V_{r(rms)}}{V_{DC}} \approx \frac{1}{4\sqrt{3}fCR_L}$ $\quad I_{o(DC)} = \frac{V_{o(DC)}}{R_L} \approx \frac{V_{o(p)}}{R_L}$
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	$V_o \cong V_B \left(\frac{R_1 + R_2}{R_2}\right)$ $\quad V_B = V_Z + V_{BE}$ $V_o \cong \left(\frac{R_1 + R_2}{R_2}\right)(V_Z)$
Series regulator	$V_o = \frac{R_1 + R_2}{R_1}(V_Z + V_{BE})$ $\quad V_o = V_Z \left(\frac{R_1 + R_2}{R_1}\right)$
Adjustable IC regulator	$V_o = V_{ref}\left(1 + \frac{R_2}{R_1}\right) + I_{adj} R_2$