Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2016/2017

COURSE NAME	:	ELECTRONIC CIRCUITS ANALYSIS AND DESIGN
COURSE CODE	:	BEL 30403
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JUNE 2017
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWERS **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

Q1 (a) A voltage detector circuit is required to have the following features:

- identifies -3V as the minimum input limit and produces output of 15V,
- identifies 3V the maximum input limit and produces output of -15V

(i) Show a possible circuit design to satisfy the requirements in **Q1(a)**.

(6 marks)

(ii) Prove that the circuit in **Q1(a)(i)** could achieve the requirements set in **Q1(a)** by showing input-output relationship diagram.

(4 marks)

(b) Next, the circuit in **Q1(a)** is modified such that it meets these conditions:

- identifies -2.5V as the minimum input limit and produces output of -10V,
- identifies 2.5V the maximum input limit and produces output of 10V

(i) Show a possible circuit design to satisfy the requirements in **Q1(b)**.

(6 marks)

(ii) Show the input-output waveform to prove that the circuit design in **Q1(b)(i)** could achieve condition mentioned in **Q1(b)**.

(4 marks)

Q2 (a) Suppose a 4G-LTE service provider operates their services in a band spectrum between 1830 MHz and 1880 MHz. As a system engineer, design an active filter that possesses these criteria:

- has maximally flat response,
- has a maximum roll-off of 40 dB/decade, and
- has a maximum gain of 72 dB.

(12 marks)

(b) Verify that the filter design in **Q2(a)** meets the requirement by calculating quality factor of the filter, and the corresponding frequency response.

(8 marks)

Q3 A new system has been proposed to reduce call drop rate in the Ayer Hitam region. The system consists of a circuit block diagram as shown in **Figure Q3** that has the following features:

- amplify the input current with attenuation factor of 2×10^{-4}
- the open-loop gain, A, is not less than 20,000.

(a) Design a feedback circuit that satisfies the requirements by determining the circuit configuration and its closed-loop gain value.

(6 marks)

(b) Determine the following:

(i) ratio $\frac{A_f}{A}$

(ii) ratio $\frac{Z_{if}}{Z_i}$

(iii) ratio $\frac{Z_{of}}{Z_o}$

(iv) ratio $\frac{BW_f}{BW}$

(10 marks)

(c) Analyse if there is improvement in received signal by implementing the circuit design shown in **Figure Q3**.

(4 marks)

Q4 As part of a team project, you are assigned to design an oscillator circuit features the following requirements:

- the output signal has 180° phase shift
- frequency of oscillation at 4 kHz

(a) Propose a circuit design that meets all the requirements by showing:
- values of all required components
- a complete circuit configuration

(12 marks)

(b) Predict the possible output waveform by showing input-output waveform and the corresponding gain.

(8 marks)

Q5 (a) Design a regulator circuit that meets these requirements:

- it regulates output voltage at 5.6V from a 12V input voltage
- voltage regulation by drawing current from load
- contains only passive elements

Show a complete circuit configuration with values of all required components.

(12 marks)

(b) Analyse **TWO (2)** possibilities that cease voltage regulation mechanism in the circuit designed in **Q5(a)**. Support your analysis with the appropriate examples.

(8 marks)

- END OF QUESTIONS –

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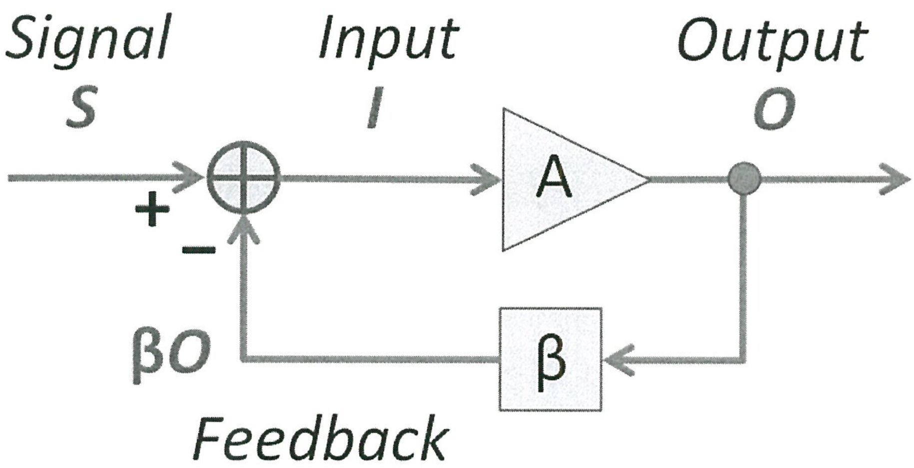

Figure Q3

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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	$f_o = \frac{1}{R_T C_T \ln[1/(1-\eta)]}$
Square-wave Oscillator	$f = \frac{1}{T} = \frac{1}{2RC \ln\left(\frac{1+\beta}{1-\beta}\right)}$ $\beta = \frac{R_3}{R_3 + R_2}$

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Table 1 List of formula (Cont..)

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	$T_m = t_1 = \tau_2 \ln 2 = 0.693\left(R_1 + R_2\right)C_1$ $T_s = t_2 = \tau_2 \ln 2 = 0.693 R_2 C_1$ $T = T_m + T_s$ $f = \frac{1.44}{(R_1 + 2R_2)C_1}$ $D = \frac{T_m}{T_m + T_s} \times 100\% = \frac{R_1 + R_2}{R_1 + 2R_2} \times 100\%$
Monostable Multivibrator	$T = 1.1\, R_1 C_1$
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	$V_{r(rms)} = \frac{V_{r(p-p)}}{2\sqrt{3}} \approx \frac{V_{o(p)}}{2\sqrt{3} fCR_L}$ $V_{o(DC)} = V_{o(p)} - \frac{V_{r(p\text{-}p)}}{2}$ $\quad V_{r(p\text{-}p)} \approx \frac{V_{o(p)}}{fCR_L} = \frac{I_{o(DC)}}{fC}$ $r = \frac{V_{r(rms)}}{V_{DC}} \approx \frac{1}{2\sqrt{3} fCR_L}$
Full-wave rectifier with a filter	$V_{r(rms)} = \frac{V_{r(p-p)}}{2\sqrt{3}} \approx \frac{V_{o(p)}}{4\sqrt{3} fCR_L} = \frac{I_{DC}}{4\sqrt{3} fC}$ $V_{o(DC)} = V_{o(p)} - \frac{V_{r(p\text{-}p)}}{2}$ $V_{r(p\text{-}p)} = \frac{I_{o(DC)}}{2fC} \approx \frac{V_{o(p)}}{2fCR_L}$

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	$r = \frac{V_{r(rms)}}{V_{DC}} \approx \frac{1}{4\sqrt{3} f C R_L}$
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	$V_o \cong V_B \left(\frac{R_1 + R_2}{R_2} \right)$ $V_B = V_Z + V_{BE}$ $V_o \cong \left(\frac{R_1 + R_2}{R_2} \right)(V_Z)$
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	$V_o = V_{ref} \left(1 + \frac{R_2}{R_1} \right) + I_{adj} R_2$