UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: July 2022

Module Number: EE3301 **Module Name: Analog Electronics (N/C)**

[Three Hours]

[Answer **all questions**, each question carries **10** marks]

Q1 a) Figure Q1.1 shows a fixed biased N-channel JFET. Here, V_{DD} = 16V, V_{GS} = -1.5 V and R_D = 2 kΩ.

i) Find the Q point (I_D, V_{DS}) of the circuit I_{DSS} = 10 mA and V_P = -4V.

ii) Find the Q point (I_D, V_{DS}) of the circuit if I_{DSS} and V_P are changed to 12 mA and -4.2V, respectively.

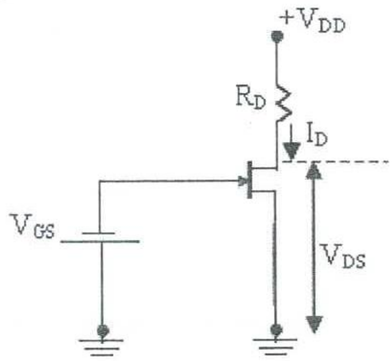

Figure Q1.1

[4.0 Marks]

b) Figure Q1.2 shows a self-biased N-channel JFET. Here, V_{DD} = 16 V, R_S = 375Ω and R_D = 2 kΩ.

i) Find the Q point (I_D, V_{DS}) of the circuit, when I_{DSS} = 10 mA and V_P = -4V.

ii) Find the Q point (I_D, V_{DS}) of the circuit, if I_{DSS} and V_P are changed to 12 mA and -4.2V, respectively.

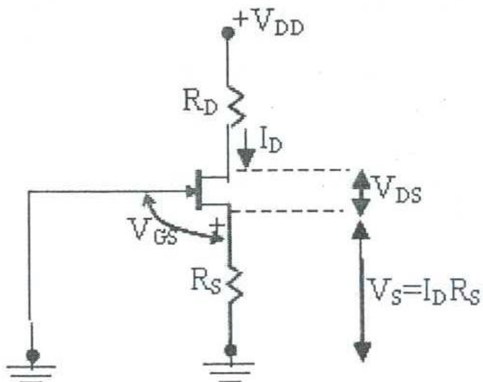

Figure Q1.2

[4.0 Marks]

c) Explain the advantage of self-biasing over fixed biasing based on the answers obtained for Q1. a) and Q1. b).

[2.0 Marks]

Q2 a) Briefly explain the importance of current mirrors in analog IC design.

[2.0 Marks]

b) Figure Q2 shows a current mirroring circuit for three transistors, namely, Q1, Q2, and Q3.

i) Approximate the Q points (I_C,V_{CE}) of Q1, Q2, and Q3.

ii) Find the exact (rounded to 2 decimal places) Q points (I_C,V_{CE}) of Q1, Q2, and Q3. Note that $\beta = 150$.

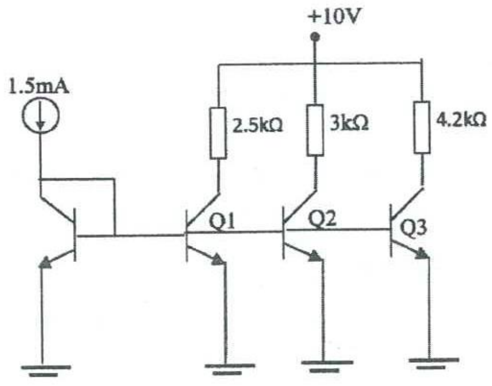

Figure Q2

[6.0 Marks]

c) Briefly explaing the role of differential amplifiers in noise filtering [2.0 Marks]

Q3 a) Briefly explain the DC offset of an operational amplifier.

[2.0 Marks]

b) Figure Q3 shows an integrating amplifier.

i) Derive an expression for the output v_o of the integrating circuit in time(t) domain assuming the ideal conditions of the operational amplifier.

ii) Derive an expression for the output v_o of the integrating circuit in time(t) domain considering the DC offset as v_{os}, where $v_s = 0$.

iii) Briefly explain why the circuit shown in Figure Q3 is incapable of delivering the expected output with the DC off-set.

iv) Propose a modified circuit for the integrating amplifier that will compansate the DC offset's effect.

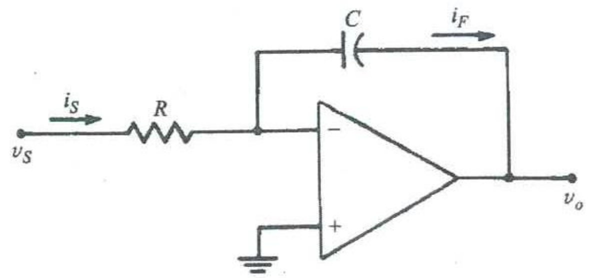

Figure Q3

[8.0 marks]

Q4 a) Answer the following questions based on Figure Q4.1.

i. Derive an expression for the output v_o of the amplifier circuit.

ii. Identify the mathematical operation performed by the circuit.

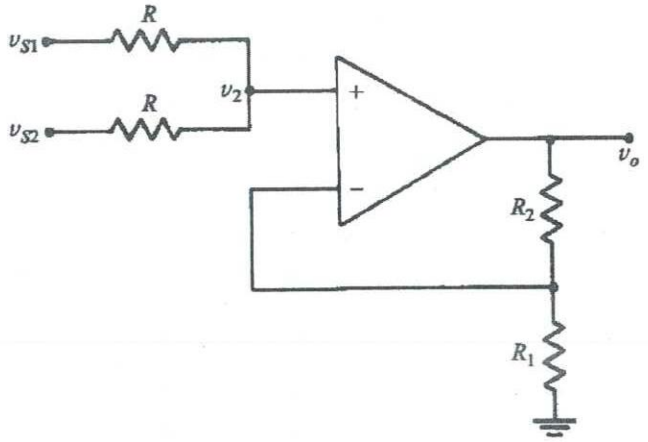

Figure Q4.1

[4.0 Marks]

b) A musician wants to mix sounds of three music instruments electrically.

i) Propose a basic circuit using opamps to conduct the above mentioned task

ii) Explain how ratios of mixing will be controlled.

[6.0 Marks]

Q5 a) Explain two methods in which the stability of a filter can be determined in the design stage.

[2.0 Marks]

b) Draw a circuit of a simple high pass filter and explain how the output is being controlled by the components in the circuit

[3.0 Marks]

c) Design a second-order VCVS low-pass Butterworth filter with cut-off frequency 2.5 kHz. The gain in the pass band should be 2. The VCVS design or Sallen-Key circuit is given is Figure Q5.1. You may use any of the charts given in Figure Q5.2.

You may use C = 0.05 μF (If this result in impractical values revise the choice).

[5.0 Marks]

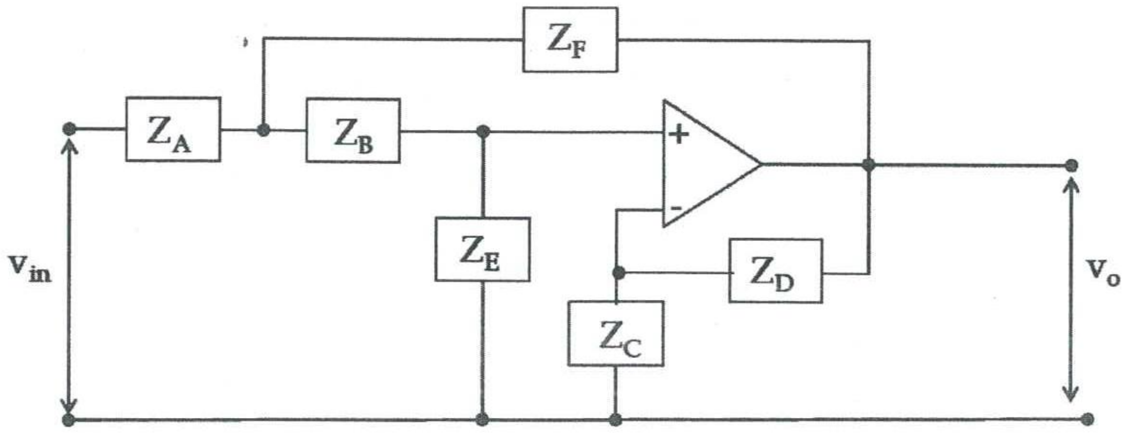

Figure Q5.1

Table 14–1
VCVS Filter Components

	Z_A	Z_B	Z_C	Z_D	Z_E	Z_F
Low-Pass Filter	R_1	R_2	R_3	R_4	C_1	C
High-Pass Filter	C	C	R_3	R_4	R_2	R_1

Table 14–2
Second-Order Low-Pass Butterworth VCVS Filter Designs

	Circuit Element Values[a]					
Gain	**1**	**2**	**4**	**6**	**8**	**10**
R_1	1.422	1.126	0.824	0.617	0.521	0.462
R_2	5.399	2.250	1.537	2.051	2.429	2.742
R_3	Open	6.752	3.148	3.203	3.372	3.560
R_4	0	6.752	9.444	16.012	23.602	32.038
C_1	$0.33C$	C	$2C$	$2C$	$2C$	$2C$

[a] Resistances in kilohms for a *K* parameter of 1.

Table 14–3
Second-Order Low-Pass Chebyshev VCVS Filter Designs (2 dB)

	Circuit Element Values[a]					
Gain	**1**	**2**	**4**	**6**	**8**	**10**
R_1	2.328	1.980	1.141	0.786	0.644	0.561
R_2	13.220	1.555	1.348	1.957	2.388	2.742
R_3	Open	7.069	3.320	3.292	3.466	3.670
R_4	0	7.069	9.959	16.460	24.261	33.031
C_1	$0.1C$	C	$2C$	$2C$	$2C$	$2C$

[a] Resistances in kilohms for a *K* parameter of 1.

Table 14–4
Second-Order High-Pass Chebyshev VCVS Filter Designs (2 dB)

	Circuit Element Values[a]					
Gain	**1**	**2**	**4**	**6**	**8**	**10**
R_1	0.640	1.390	2.117	2.625	3.040	3.399
R_2	3.259	1.500	0.985	0.794	0.686	0.613
R_3	Open	3.000	1.313	0.953	0.784	0.681
R_4	0	3.000	3.939	4.765	5.486	6.133

[a] Resistances in kilohms for a *K* parameter of 1.

Source: Reprinted from *Rapid Practical Designs of Active Filters*, D. Johnson and J. Hilburn.

Figure Q5.2