INTI International College Penang

FINAL
ALTERNATIVE ASSESSMENT

(COVER PAGE)

Session	:	**April 2021**
Programme	:	Diploma in Electrical & Electronic Engineering (DEEI)
Course	:	**EEE1109: Analogue Electronics**
Date of Examination	:	30 July 2021 (Friday)
Time	:	8.00am – 11.00am Reading Time : Nil
Duration	:	3 Hours

Special Instructions :

This paper consists of **FOUR (4)** questions. Answer **ALL FOUR (4)** questions. All questions carry equal marks.

Material permitted :

Non-Programmable Scientific Calculator

Materials provided :

Nil

Examiner(s)	:	**Dr. Su Hsiao Wei**
Chief Moderator	:	Chai Yoon Yik

*This paper consists of **9** printed pages, including the cover page*

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
EEE1109: ANALOGUE ELECTRONICS
FINAL ALTERNATIVE ASSESSMENT: APRIL 2021 SESSION

Instructions: This paper consists of **FOUR (4)** questions. Answer **ALL FOUR (4)** questions. All questions carry equal marks.

Question 1

(a) Figure 1(a) shows a single stage FET amplifier and its voltage gain frequency response.

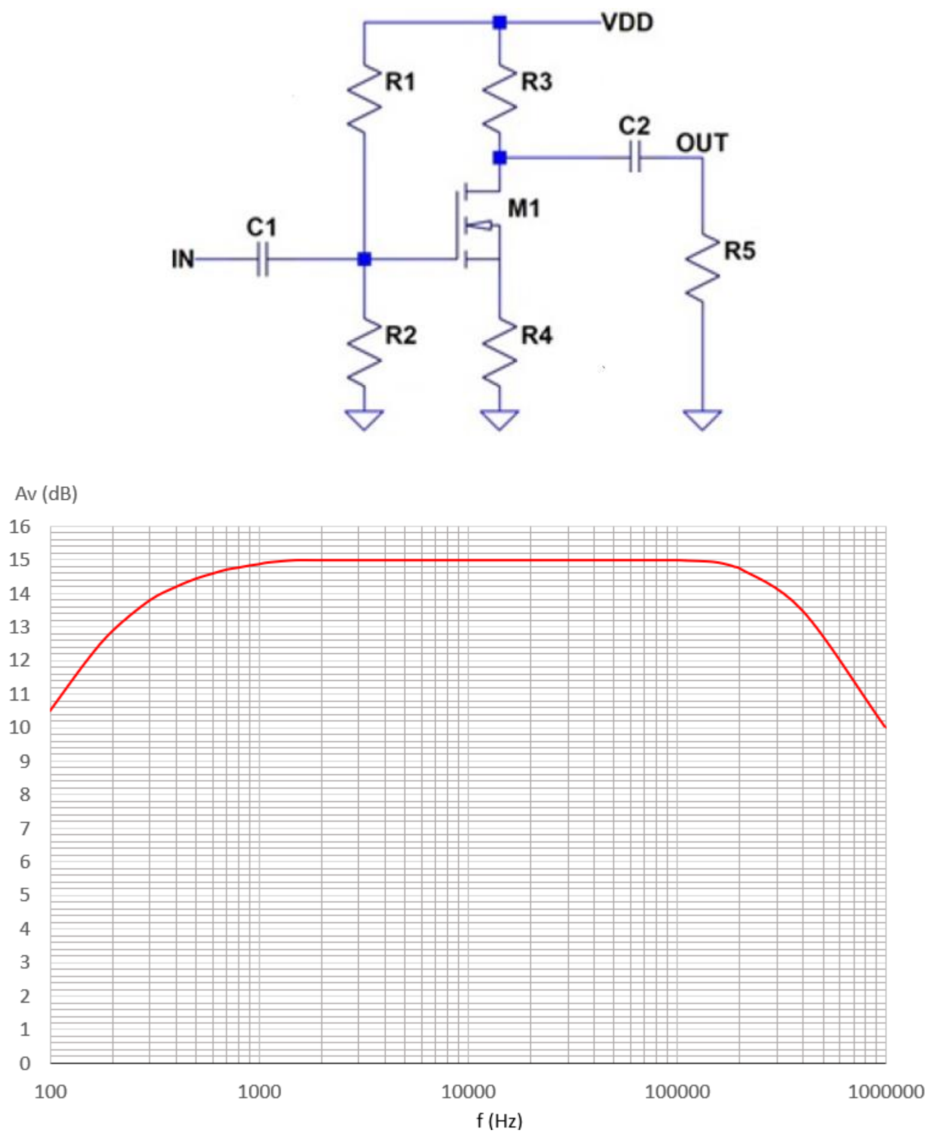

Figure 1(a)

From the amplifier's voltage gain response, do the followings:

(i) Identify the maximum amplifier gain.

(2 marks)

(ii) Find the upper and lower cutoff frequencies. Then estimate the bandwidth of the amplifier.

(3 marks)

(b) Figure 1(b) shows a single-stage E-MOSFET amplifier. The E-MOSFET has the following parameter values:
$V_{DQ} = 8V @ V_{GSQ} = 2.5V$

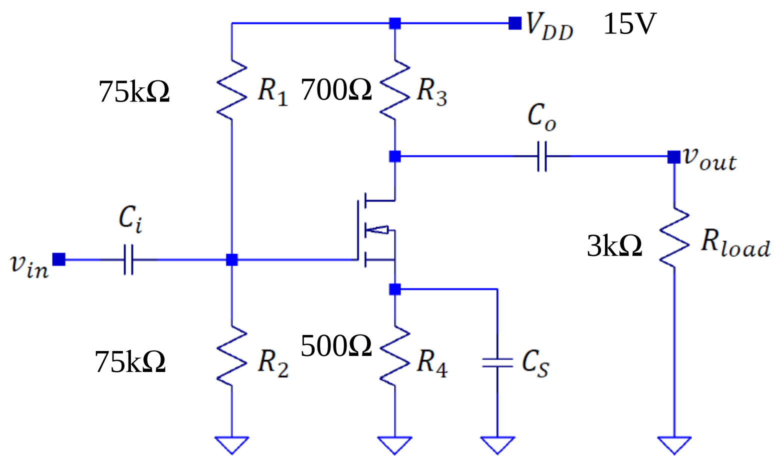

Figure 1(b)

(i) Explain the purpose of the source bypass capacitor C_s in the circuit.

(2 marks)

(ii) Calculate the quiescent voltage voltages V_{GQ} and current I_{DQ}

(2 marks)

(iii) Calculate the quiescent voltages V_{SQ} *and* V_{DSQ}.

(2 marks)

(c) Figure 1(c) shows the AC equivalent circuit model of a MOSFET.

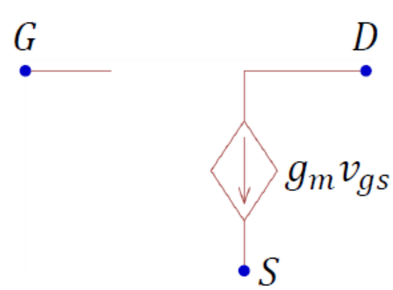

Figure 1(c)

Utilizing the MOSFET AC model in Figure 1(c), do the followings:

(i) Draw the AC equivalent circuit model for the amplifier in Figure 1(b) and then derive the expression for mid-band voltage gain (v_{out}/v_{in}).

(4 marks)

(ii) Draw the AC equivalent circuit model of the amplifier in Figure 1(b) without the source bypass capacitor and then derive the expression for the resultant mid-band voltage gain (v_{out}/v_{in}).

(8 marks)

(iii) Quantitatively compare the mid-band voltage gain expressions obtained from Q1(c)(i) and (ii) and explain the amplifier configuration which is favoured to achieve higher mid-band voltage gain.

(2 marks)

Question 2

(a)

(i) Draw the schematic diagram of an inverting amplifier which is utilizing a single op-amp, operating from a dual supply.

(2 marks)

(ii) Using relevant circuit principles or rules, derive the voltage transfer function expression of the amplifier in Q2(a)(i).

(3 marks)

(iii) Sketch the input V_{in} and output V_{out} waveforms as a function time for the amplifier in Q2(a)(i) with the closed-loop voltage gain of -10 and $V_{in} = \sin(2000\pi t)$. Show all your calculations and list down any assumption. Label your sketch clearly.

(4 marks)

(b) Figure 2(b) shows a non-inverting amplifier implemented using an op-amp with the following specifications:

$Vs(max)$ = ±12 V
$slew\ rate$ = 8 V/µs
$|V_{out(sat)}| = |Vsupply| - 1$ V

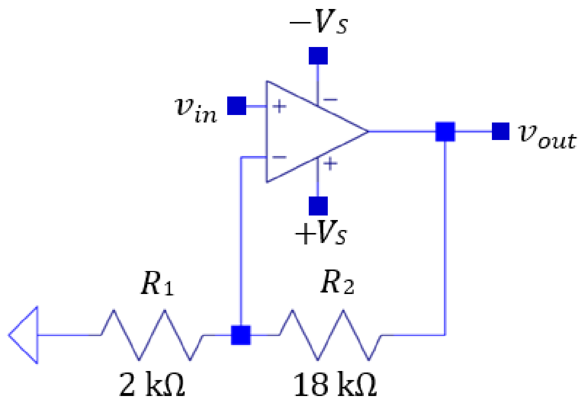

Figure 2(b)

If $v_{in} = \sin(200000\pi t)$, do the followings:

(i) Calculate the maximum output voltage V_{out} of the amplifier. Justify the suitability of the op-amp implementation from the saturation voltage point of view.

(4 marks)

(ii) Calculate the maximum rate of change of the amplifier output. Justify the suitability of the op-amp implementation from the slew-rate point of view.

(4 marks)

(c) Figure 2(c) shows a Schmitt triggered comparator with a reference voltage circuitry. Assumed that the op-amps used in the circuit have rail-to-rail output.

(i) Calculate the reference voltage, upper and lower threshold points of the circuit.

(6 marks)

(ii) Sketch the voltage transfer curve of the circuit with clear labeling of all relevant voltage levels.

(2 marks)

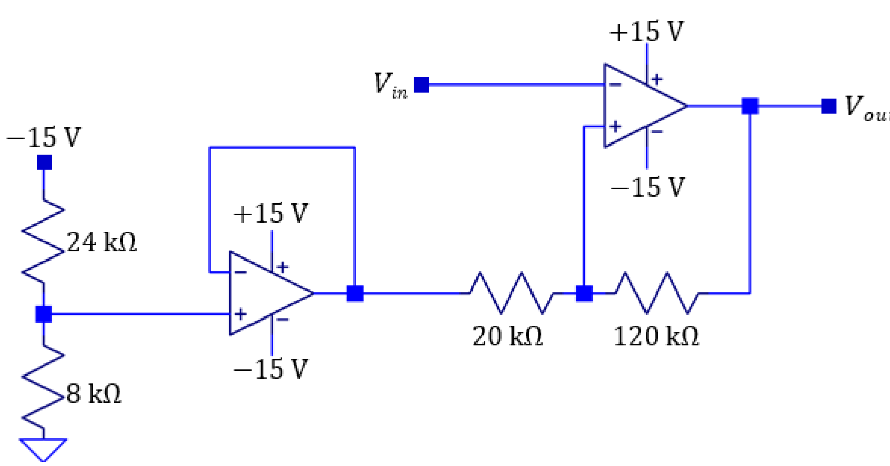

Figure 2(c)

Question 3

(a) Copy Table 3(a) into your answer script and complete the blank cells in the table by stating two pros and cons of the listed filters.

Table 3(a)

		Passive Filter	Active Filter
Pros	1		
	2		
Cons	1		
	2		

(4 marks)

(b) A filter is implemented based on the cascade of several analogue circuit building blocks, as shown in Figure 3(b).

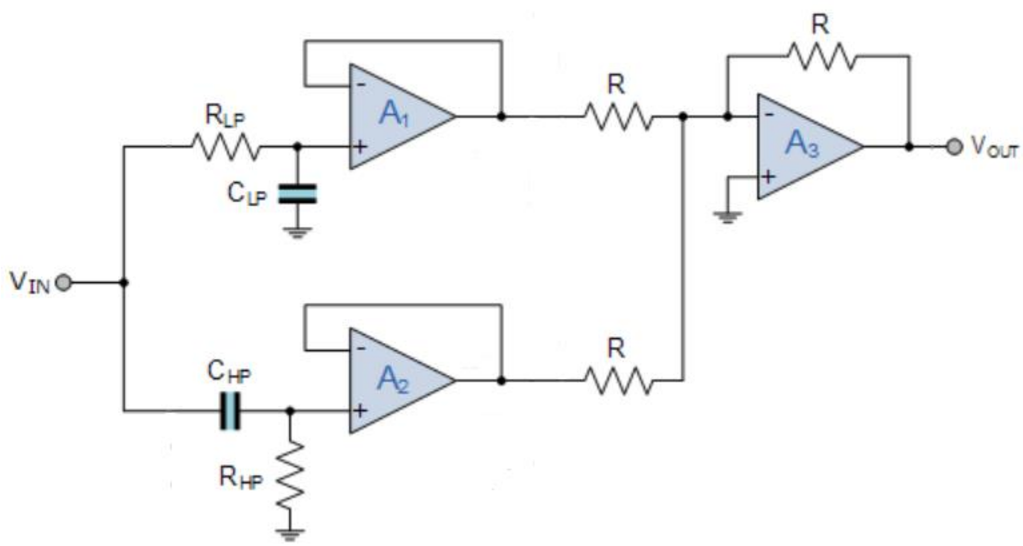

Figure 3(b)

(i) Identify the building blocks.

(2 marks)

(ii) Based on elementary filter voltage transfer functions, derive the filter voltage transfer function $(V_{out}(s)/V_{in}(s))$.

(6 marks)

(iii) Identify the type and order of the filter based on the voltage transfer function expression obtained in Q3(b)(ii).

(2 marks)

(c) A filter is realized by cascading two different filter building blocks and the overall filter transfer function is expressed as

$$T(s) = \left(\frac{2s-1}{2s+40}\right)\left(\frac{2s+1}{2s+40}\right)$$

(i) Identify the type and order of the filter. Quantitatively justify your answers.
(3 marks)

(ii) Calculate the filter cut-off frequencies (lower and upper) in rad/s.
(6 marks)

(iii) Identify the filter type (passive or active). Quantitatively justify your answer.
(2 marks)

Question 4

(a) Briefly explain the followings pertaining to an oscillator circuit.

(i) Operation.
(2 marks)

(ii) Output design requirements.
(2 marks)

(b) Figure 4(b) shows a relaxation oscillator constructed from a 555 timer IC.

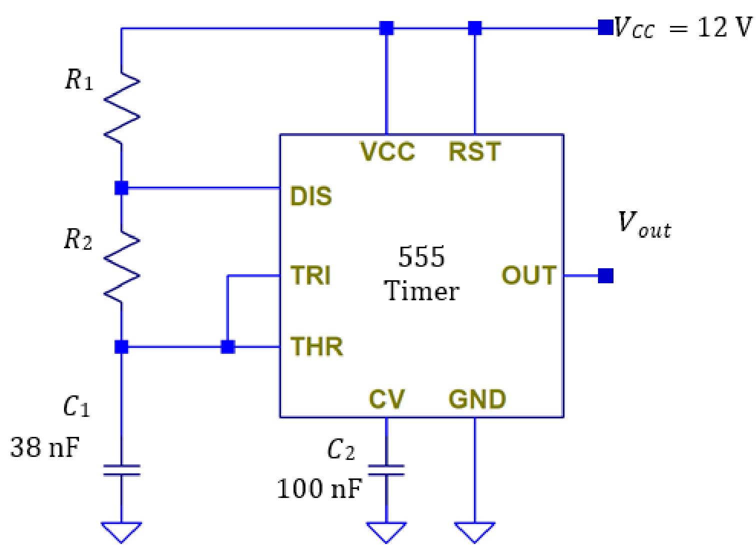

Figure 4(b)

(i) If the desired oscillation frequency of the output signal V_{out} is 863Hz, determine the design values of resistors R_1 and R_2. State any assumption made.

(3 marks)

(ii) Calculate the duty cycle of the output signal in %, based on your resistor values in Q4(b)(i).

(2 marks)

(iii) Derive the design relationship between the resistors R_1 and R_2 if duty cycle of 67% is targeted.

(2 marks)

(iv) Explain a way to increase the oscillation frequency without affecting the duty cycle.

(3 marks)

(c) Figure 4(c) shows a Wien Bridge oscillator circuit.

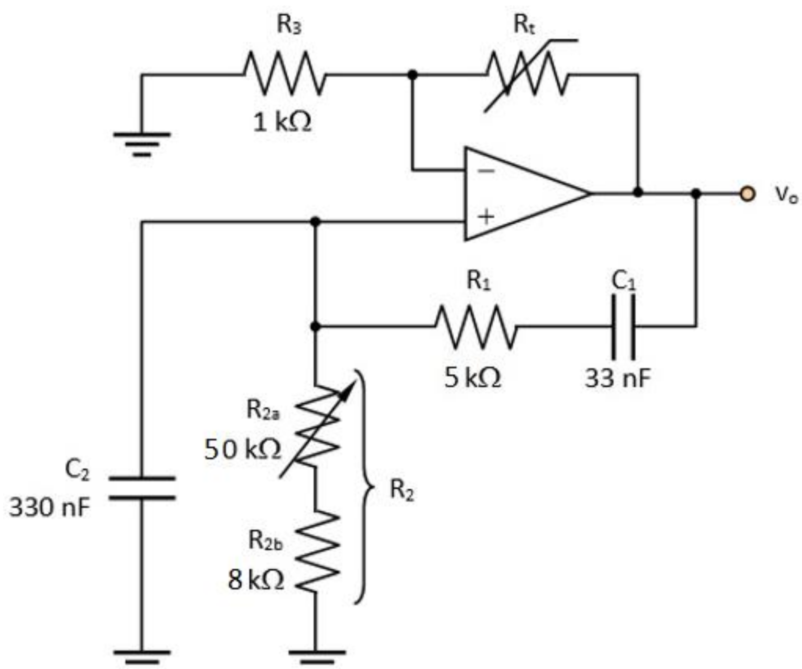

Figure 4(c)

(i) Explain the purpose of the fixed resistor R_{2b}.

(2 marks)

(ii) Explain the purpose of the thermistor R_t.

(2 marks)

(iii) The positive feedback circuit transfer function is expressed as

$$\frac{V_f}{V_O} = \frac{\omega C_1 R_2}{\omega(C_1R_1 + C_2R_2 + C_1R_2) - j(1 - \omega^2 C_1C_2R_1R_2)}$$

Find the expression for the resonant angular frequency.
Prove that for the circuit to sustain oscillation, the oscillator's amplifier gain is given by $R_t = 3R_3$. Assuming $R_2 = 2R_1$ and $C_2 = 2.5C_1$.

(5 marks)

(iv) Calculate the range of oscillation frequency when R_{2a} is adjusted between its extreme ends.

(2 marks)

~THE END~