The Chinese University of Hong Kong
Department of Computer Science and Engineering
CENG2030 Fundamentals of Embedded System Design

Lab 5: Operational Amplifier

Submission Instructions:

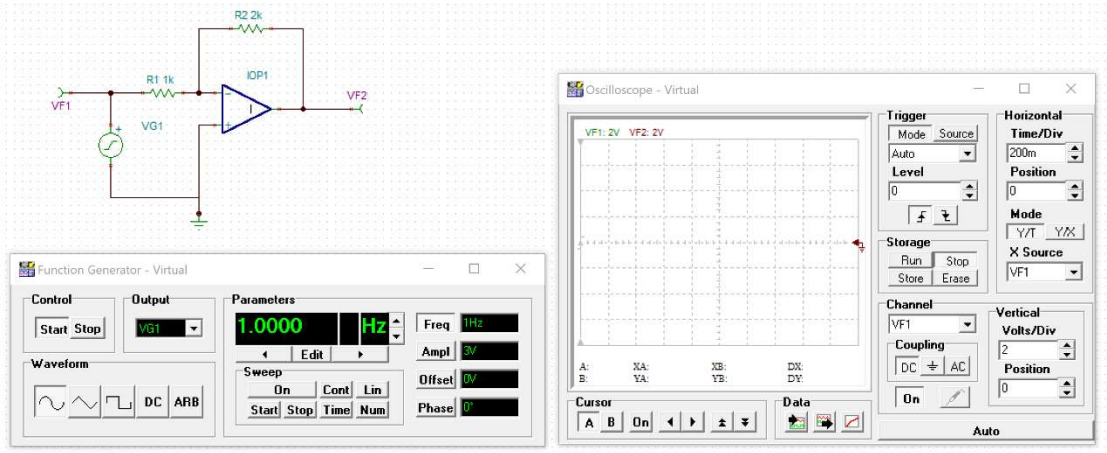
- Save all the circuit files in .TSC, which you created in the lab
- Answer all the questions in the .docx answer sheet
- Compress all the above files to one single .zip file
- Upload the .zip file **before the deadline stated in Blackboard**
- Marks will be deducted for late submission, deduct 10 marks per every 10-minute interval (e.g. deduct 20 marks for 11 minutes late).

List of components and equipment

- IC: 1x LM741
- Resistors: 1x 1.1kΩ, 1x 2.2kΩ
- Capacitors: 1x 100nF

1. Inverting Amplifier

Construct the following Inverting Amplifier using IC LM741 which is an operational amplifier. For the details of LM741, please search the datasheet on the web, such as http://www.mit.edu/~6.301/LM741.pdf



a. Analysis of Inverting Amplifier

i. Build the inverting amplifier circuit, and set up the **Function Generator** and **Oscilloscope** as shown above using TINA.

ii. Function Generator settings: Output VG1 with a 3V (i.e. 6Vpp), 1Hz, sine wave

iii. Oscilloscope settings: Set **both** VF1 and VF2 channels **ON**, with horizontal scale as 200m s./Div, and vertical scale as 2 V/Div, and press **Run**

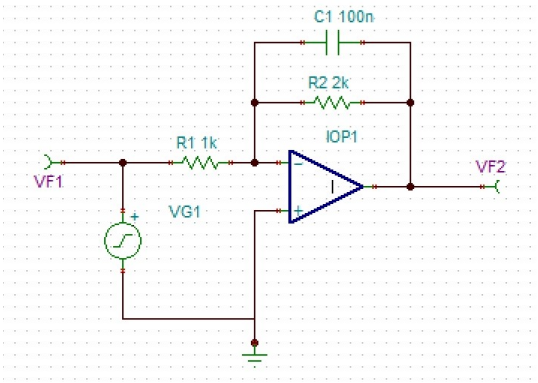
iv. With these settings, you should be able to see **both** input and output signals displayed on the screen simultaneously.

v. Write down the following measurement on the answer sheet

1. Measure the peak-to-peak output voltage of VF2
2. What is the gain of the circuit?
3. By checking the waveforms at the VF1 & VF2 of the oscilloscope, when VF1 is positive, what is the sign of VF2 (Positive or Negative)?
4. Measure the voltages of the inverting input V-, and the non-inverting input V+ of the OpAmp by using **Analysis: AC Analysis: Table of AC results**
5. What is the voltage difference between V- and V+ (i.e. V_{DIFF})?
6. Measure the currents I_{R1} (Input Current) and I_{R2} (Feedback Current)
7. Write an equation of I_{R1} in terms of I_{R2} (Please take the **directions** of the current flow into account)

2. Active Low Pass Filter

Modify the circuit in Section 1 to the following Active Low Pass Filter by adding only one capacitor, C1=100nF, at the feedback path.



a. Analysis of Active LPF

i. To observe the frequency response of the circuit, inject a sine wave at input VF1, and check the output VF2 step-by-step below.

1. Use the function generator to generate an 3V (i.e. 6Vpp), 50Hz, sine wave to VF1
2. Check and monitor the sine waves using an oscilloscope
3. Measure the peak-to-peak voltage of the output VF2
4. By changing the frequency of input VF1 according to the table in the answer sheet, and measuring the peak-to-peak voltage of VF2, we can plot a graph of the frequency response of the circuit

ii. Cut-off Frequency

1. By calculation, what is the cut-off frequency, fc, of the active LPF?
2. Based on the graph in part iii below, what is the peak-to-peak voltage of output VF2 at fc? **[Plot the graph before you answer this question]**

iii. Write down the collected data, and plot the frequency response of the circuit on the answer sheet

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Answer Sheet

Student Name:_____ SID:_____

1. Inverting Amplifier **[55%]**

a. Create and upload your TSC circuit file. [10%]

b. Analysis of Inverting Amplifier (Please state the **unit** clearly for each parameter)

Output Voltage VF2 (Vpp): _____ [5%]

Gain in dB: $A = 20log\frac{Vout}{Vin}$ = _____ [5%]

When Vin is positive, Vout is _____ [5%]

V-: _____ [5%]

V+: _____ [5%]

V_{DIFF}: _____ [5%]

I_{R1}: _____ [5%]

I_{R2}: _____ [5%]

Equation: I_{R1} = _____ [5%]

2. Active Low Pass Filter **[45%]**

a. Create and upload your TSC circuit file. [10%]

b. Analysis of Active LPF

i. Collected Data [12%]

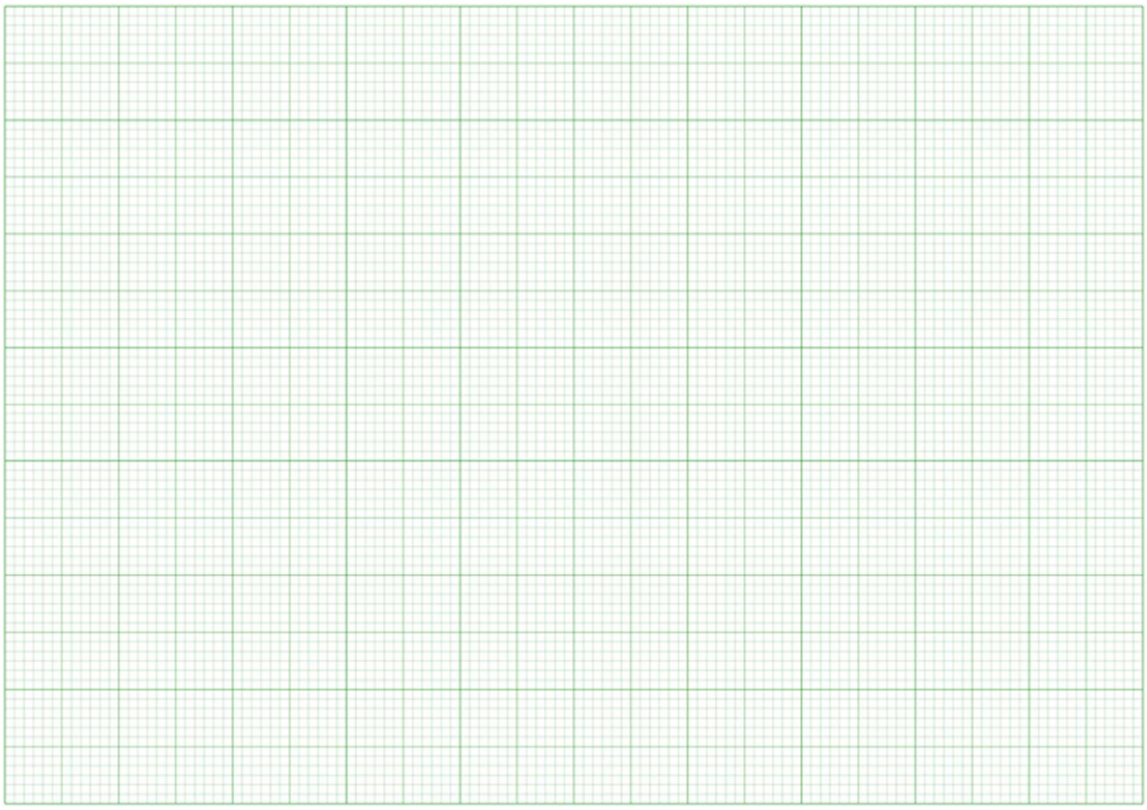
Frequency of VF1 (Hz)	50	100	200	500	1k	2k	5k	10k	20k	50k	100k	200k
Vpp of VF2 (V)												

ii. Cut-off Frequency

fc: $fc = \frac{1}{2\pi CR_2}$ = _____ [5%]

Vout at fc: _____ [5%]

iii. Graph Plotting [13%]



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