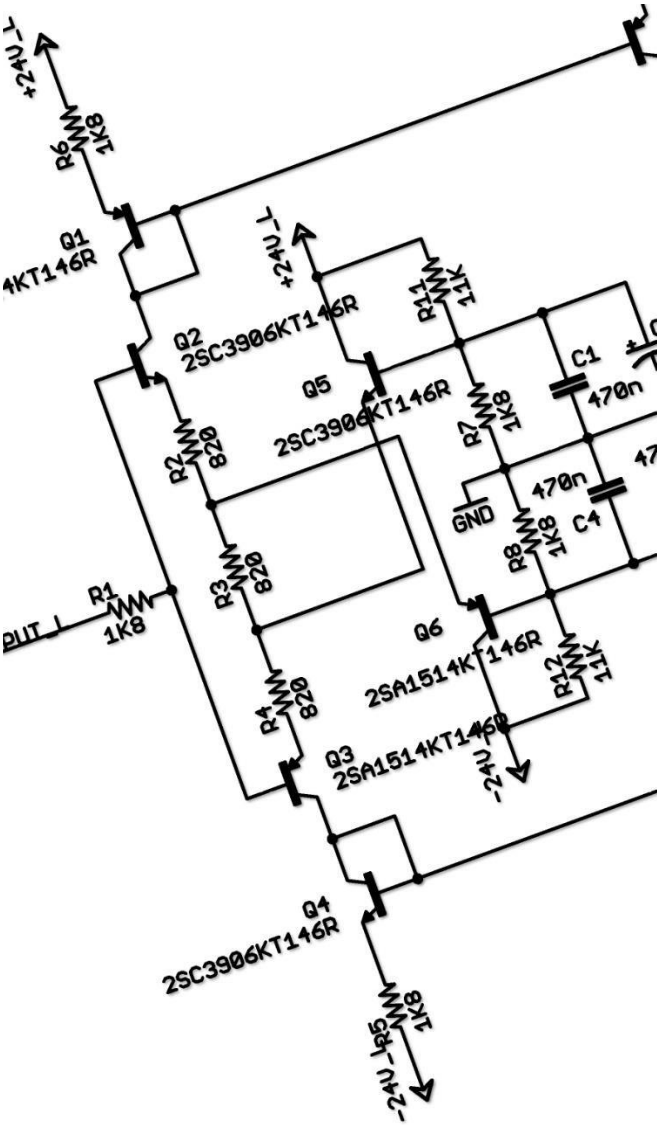
MONASH University
Engineering

ECE2131

Electrical Circuits

Laboratory Notes



2022 Edition

Name:	Student ID:	Email:

Electrical and Computer Systems Engineering, Monash University

2022

8 Operational Amplifier Applications I

8.1 Learning Objectives and Introduction

One of the useful applications of an opamp is in processing an incoming analogue signal. This laboratory explores two types of processing – integration and differentiation. The circuits covered in this lab can also be used as active high and low pass filters (compare and contrast with the passive equivalents explored in Lab 5). These devices are also extremely useful in analogue control design and in analogue computing. The aim of this lab is to gain some familiarity with designs that implement these functions, and to investigate the characteristics of these more complicated opamp circuits.

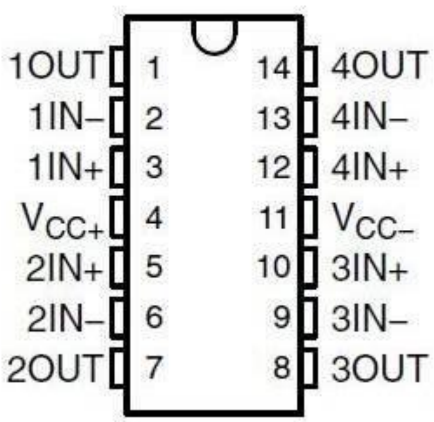
By the end of this lab you should:

- Build and characterise op-amp circuits with frequency dependent feedback.
- Link the concepts of integration and differentiation with 'active' high-pass and low-pass filter
- Use concepts related to the Fourier transform to understand the difference between characterization with a single sinusoid and a square wave input, and the effect of filtering on output waveforms.

8.2 Equipment and Components

- Breadboard.
- Opamp TL074.
- Resistors: 1 kOhm, 1000 kOhm (i.e. 1 MOhm).
- Capacitors: 100 nF, 100 pF.

TL074 Connection Diagram



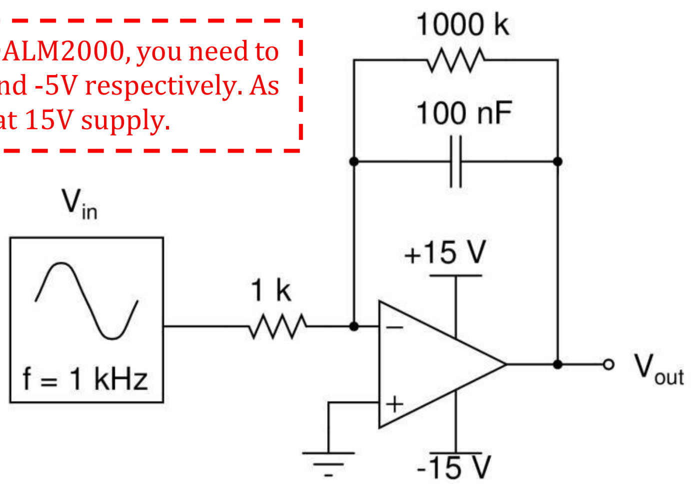
8.3 EXPERIMENTAL WORK

8.3.1 PART A – INTEGRATING OPERATIONAL AMPLIFIER

8.3.1.1 Construct the following inverting amplifier circuit on the prototype breadboard. NOTE: The 1000k resistor in parallel with the integrating capacitor is required to ensure the DC stability of the circuit. Explore the operation of the circuit without this resistor. Is the circuit DC stable?

DC stable means the circuit is ready to function at very low frequencies, or very close to DC inputs. Test your circuit according to the description above and see whether it works at **very low frequency** and then with a **DC input**.

Similarly, if you're using ADALM2000, you need to change the supply to +5V and -5V respectively. As usual, LTSpice can remain at 15V supply.



8.3.1.2 Restore the resistor and change the DC offset of the input signal away from zero (non-zero DC offset), with any suitable frequency and amplitude. Explain the circuit response when the DC offset is non-zero, compared to when the input is zero DC offset.

8.3.1.3 Set the signal generator DC offset to 0V, and adjust the signal generator to produce $2V_{p\text{-}p}$ ($\pm 1V_{peak}$) SINE wave at a frequency of 1 kHz. Verify the basic integration operation of the circuit for this input signal. How does the gain relationship of the circuit compare with your expectations from the preliminary quiz? Show your theoretical analysis of this op-amp circuit.

As the name of the op-amp circuit suggests, it suppose to "integrate" the input and the output is the integration of the input (Yes! The mathematics integration).

For e.g., if your input is a cos, your output is a sine. If your input is a triangle (gradient), then your output is exponential, whereas if your input is a square wave, then your output is a ________ ?

8.3.1.4 What is the phase shift between the signal generator output and the op-amp output? Comment if this matches your theoretical analysis.

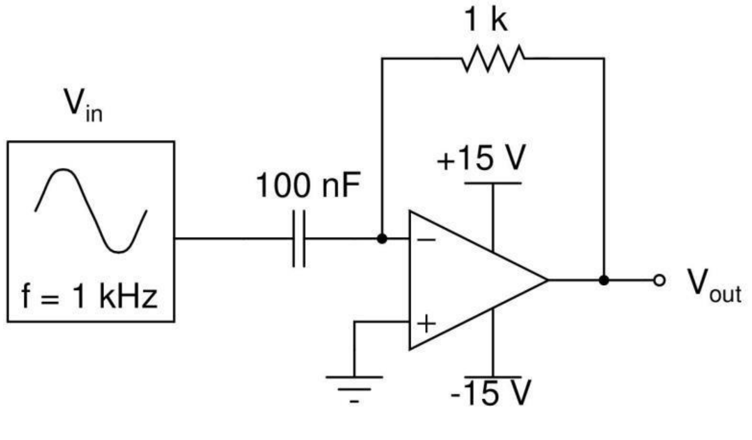
8.3.1.5 Increase the signal generator frequency to 10 kHz and then to 100 kHz. Explore the circuit operation. Compare the circuit gain and phase shift at EACH of these higher signal generator frequencies with the previous results. For better understanding, you should use theoretical analysis to verify your results.

8.3.1.6 Change the signal generator to a 1kHz $2V_{p-p}$ ($\pm 1V_{peak}$) SQUARE wave. Record and describe the circuit response for this input signal. Comment and explain if this is expected.

8.3.1.7 Change the frequency of the SQUARE wave to 10 kHz, and explain any changes that occur in the integrator output.

8.3.2 PART B – DIFFERENTIATING OPERATIONAL AMPLIFIER

Construct the following differentiating amplifier circuit on the prototype board.



8.3.2.1 Set the signal generator DC offset to 0V, and adjust the signal generator to produce $2V_{p\text{-}p}$ ($\pm 1V_{peak}$) SINE wave at a frequency of 1 kHz. Verify the basic differentiating operation of the circuit for this input signal. How does the gain relationship of the circuit compare with the theoretical analysis? Show your theoretical analysis.

and now we perform a "mathematical differentiation" of your input. The op-amp output will be the differentiation of your input. For example, if your input is x^2, then your output is $2x$.

8.3.2.2 What is the phase shift between the signal generator and the op-amp output?

8.3.2.3 Increase the signal generator frequency to 10 kHz and then 100 kHz, and explore the circuit operation. Compare and comment on the circuit gain and phase shift at EACH of these higher signal generator frequencies. For better understanding, you should use theoretical analysis to verify your results.

8.3.2.4 Change the signal generator to a 1kHz $2V_{p\text{-}p}$ ($\pm 1V_{peak}$) TRIANGULAR wave. Record and describe the circuit response for this input signal. Comment and explain if this is expected.

8.3.2.5 Change the frequency to 10kHz. Explain on the differences of the output between 1kHz and 10kHz.

ASSESSMENT

Student Statement:

I have read the university's statement on cheating and plagiarism, as described in the *Student Resource Guide*. This work is original and has not previously been submitted as part of another unit/subject/course. I have taken proper care safeguarding this work and made all reasonable effort to make sure it could not be copied. I understand the consequences for engaging in plagiarism as described in *Statue 4.1 Part III – Academic Misconduct*. **I certify that I have not plagiarized the work of others or engaged in collusion when preparing this submission.**

Student signature:________________________________Date:____/____/____

TOTAL: ________(/7)

ASSESSOR: ________