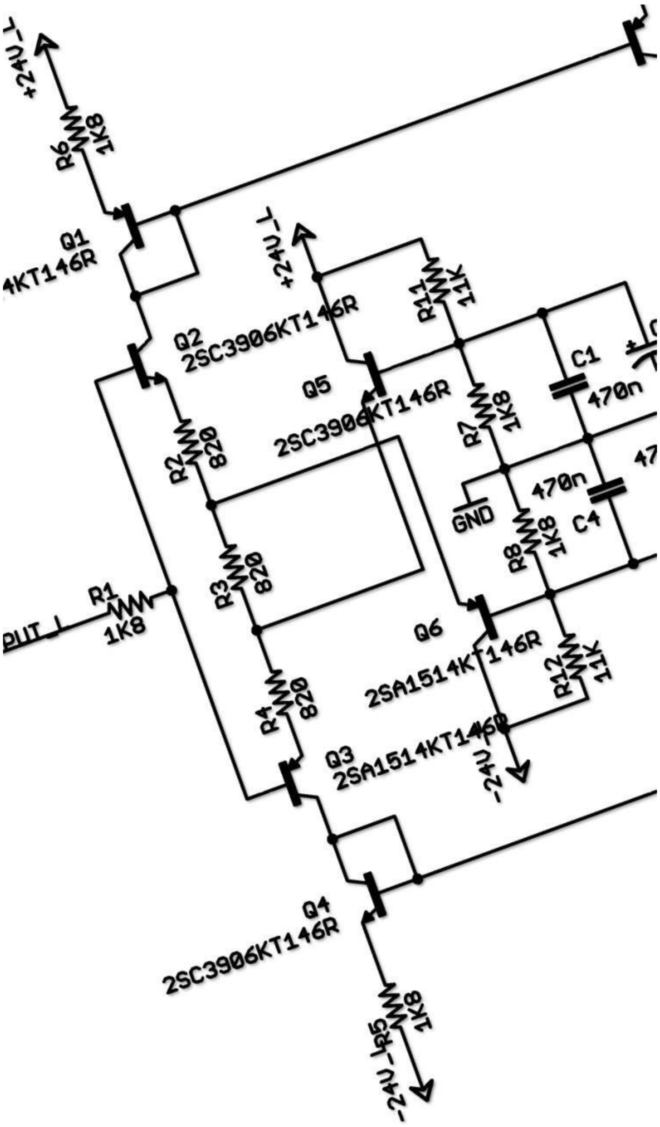
MONASH University
Engineering

ECE2131

Electrical Circuits

Laboratory Notes



2022 Edition

Name:	Student ID:	Email:

Electrical and Computer Systems Engineering, Monash University

2022

9 Operational Amplifier Applications II

9.1 Learning Objectives and Introduction

Another useful application of an opamp is as a source of oscillations. This laboratory explores two different sides of oscillation – hysteresis effects and the design of multivibrators.

The first part of this lab involves exploring the operation of a Schmitt trigger, a device which uses a positive feedback comparator to control the amount of certain types of noise (for example, from a switch bouncing) in a signal. It can also be used to generate a square wave from a sinusoidal input. This device relies on hysteresis to operate – the circuit has a sense of 'memory' of its state. This is a bi-stable multivibrator.

The second part of this lab involves the exploration of a relaxation oscillator, which is an astable multivibrator. This circuit has applications as a source of non-sinusoidal oscillations in electronic circuits (for example – making a turn light on a car flash).

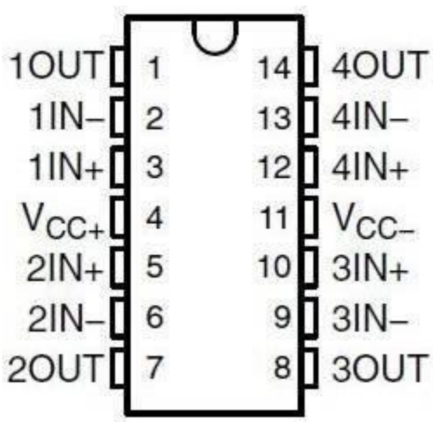
By the end of this lab you should:

- Build and characterise op-amp circuits with positive feedback.
- Understand the fundamental differences in operation for op-amp circuits in positive or negative feedback.
- Build a Schmitt trigger comparator, and understand the causes of differences between theory and lab outcomes
- Build an oscillator with a set frequency, based on knowledge of RC time constants and comparators.

9.2 Equipment and Components

- Breadboard.
- Opamp TL074.
- Resistors: 1 kOhm, 10 kOhm.
- Capacitors: 100 nF, 100 pF.

TL074 Connection Diagram



9.3 IMPORTANT NOTES

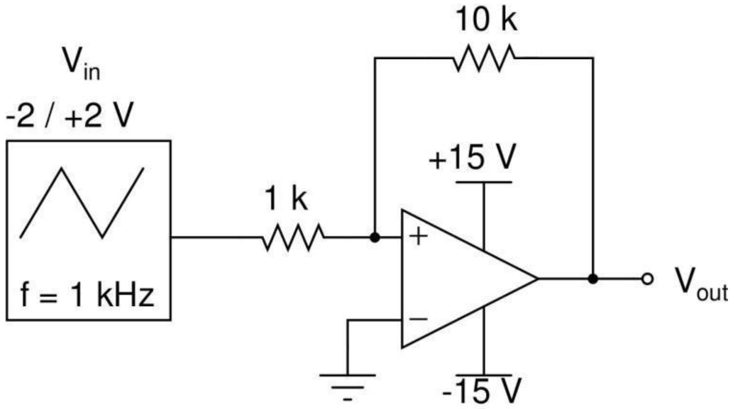
Remember that the components have tolerances (resistors 1%, ceramic and polyester capacitors 10%, electrolytic capacitors up to 40%). It is not critical that your circuit meet the required specifications exactly; but you should take account of component tolerances, their effect on your design and the performance variations that you can expect from the circuits as a consequence.
The operational amplifier used as a comparator in this experiment is the TL074. Note that the performance of this op amp as a comparator is poor, since the op amp slew rate limit significantly reduces the transition switching times.

Make sure you include 0.1uF ceramic decoupling capacitors between the supply voltages and ground close to the circuit/power supply pins of the op-amp. These capacitors provide transient high-frequency current to the circuit during switching transitions, and are critical for reliable operation.

9.4 EXPERIMENTAL WORK

9.4.1 PART A – SCHMITT TRIGGER (HYSTERESIS) COMPARATOR

Construct the following comparator circuit on the prototype board.



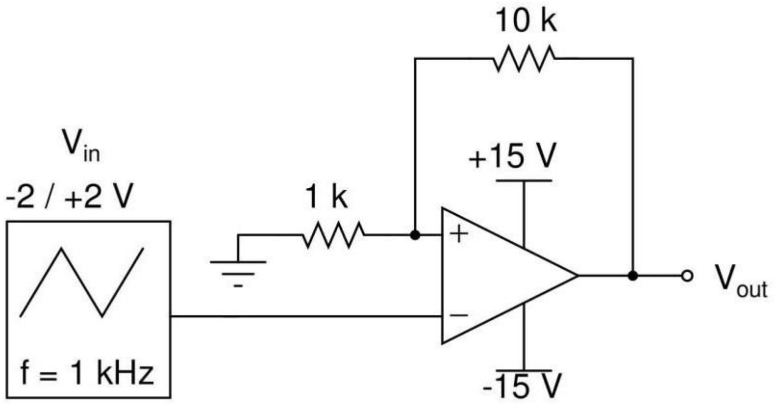
9.4.1.1 Set the signal generator to a 1 kHz $4V_{p\text{-}p}$ (+2V and -2V peaks) triangular waveform, with zero DC offset. If you are using ADAML2000, you can reduce the power supply to +5V and -5V respectively.

Using this arrangement, measure and record the circuit hysteresis offset (i.e. the input voltage difference between the comparator output switching high and switching low), $V_{hys} = V_{PH} - V_{PL}$

Compare each of these experimental values to the theorical values. Explain any discrepancies/similarities.

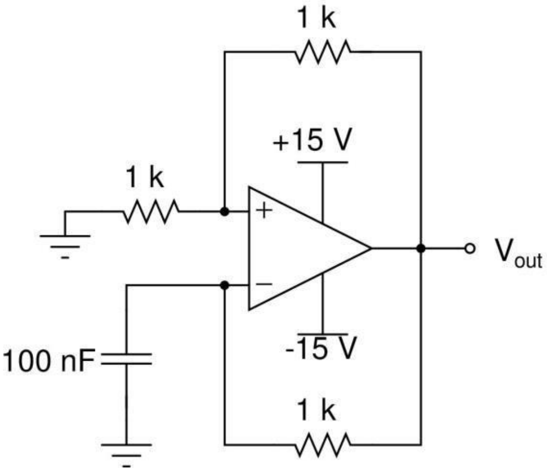
9.4.1.2 Increase the signal generator frequency to 2kHz, 5kHz, 10kHz, 50kHz, 100kHz, and then to 200 kHz. Explain any changes observed when frequency increases. Do not use a network analyzer for this question.

9.4.1.3 Construct the following circuit. Measure the hysteresis levels and compare with the previous measurements in 9.4.1.1. Explain the differences to the previous circuit. Explain any comments/discrepancies against theoretical values also.



9.4.2 PART B – ASTABLE RELAXATION OSCILLATOR

Construct the following astable multivibrator circuit on the prototype breadboard.



9.4.2.1 Investigate the comparator output (V_{out}) and the voltage across the 100nF capacitor (V_C). Explain your observations. What is the measured frequency observed at V_C? Does the oscillation frequency match theoretical expectations? Explain.

9.4.2.2 Comment on the magnitude limits of the capacitor peak voltages and the comparator switched output compared to ideal theory. What is the theoretical peak voltages across the capacitor?

9.4.2.3 Change the capacitor to 100pF. What is the oscillation frequency now? Does the circuit still operate correctly? If not, why not?

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: ________