Lab4 Guide Operational Amplifier

Objectives

The purpose of this lab is to familiarize you with the properties and operations of operational amplifiers. In this lab we will use the LF347N operational amplifier to implement several different practical configurations of the operational amplifier, such as inverting and non- inverting. In the pre-lab, you will first simulate the different configurations for the operational amplifier. During the lab, you will build the circuits that you simulated in the pre-lab and explore the non-idealities of real world implementations. Corresponding calculated and measured circuit response values will be compared.

Operational Amplifier Introduction

Integrated operational amplifier, or opamp for short is a versatile circuit building block. An opamp can sum signals, amplify a signal, integrate it, or differentiate it. The ability of the opamp to perform these mathematical operations is the reason it is called an operational amplifier. An opamp is usually a voltage amplifier with very high gain. An opamp may also be regarded as a "black box", a differential amplifier with double-ended input and single-ended output, it is usually represented by the circuit symbol shown in figure 1. The terminals of primary interest are:

1. Noninverting input:V+
2. Inverting input:V-
3. Output:Vout
4. Positive power supply: Vcc
5. Negative power supply: -Vcc

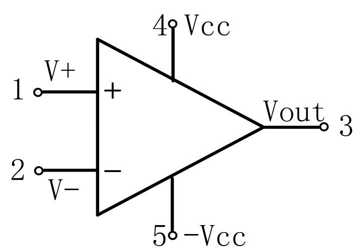


Fig.1 The circuit symbol for an operational amplifier (op amp)

The inputs are marked with minus (-) and plus (+) to specify inverting and non-inverting inputs, respectively. An input applied to the non-inverting terminal will appear with the same polarity at the output, while an input applied to the inverting terminal will appear inverted at the output. **Although the power supplies are often ignored in op amp circuit diagrams for the sake of simplicity, the power supply must not be overlooked in an experiment.**

Negative feedback configuration

Figure 2 illustrates the typical input-output characteristic tor an operational amplifier used with and without feedback. The voltage transfer characteristic describes how the output voltage varies as a function of the input voltages; that is, how voltage is transferred from the input to the output.

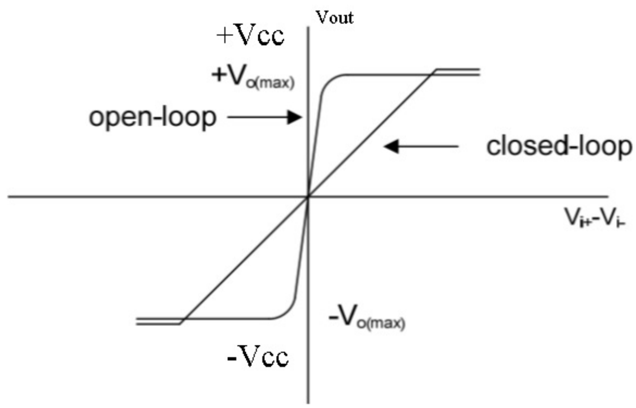


Fig.2 Input-Output Characteristic for an Opamp

Due to the opamp's high gain, the linear region of an opamp is very narrow, so the opamp is commonly used in a **negative feedback** configuration. The application of feedback reduces the non- linearity, but also reduces the voltage gain. The feedback involves connecting the output back to the inverting input of the op-amp, which will keep the differential input voltage ($v_+ – v_-$) close to zero. With feedback, the overall gain is called the closed-loop gain. A major advantage of using feedback is that the gain is now a function of the resistors only and is independent of the op-amp open-loop gain Av.

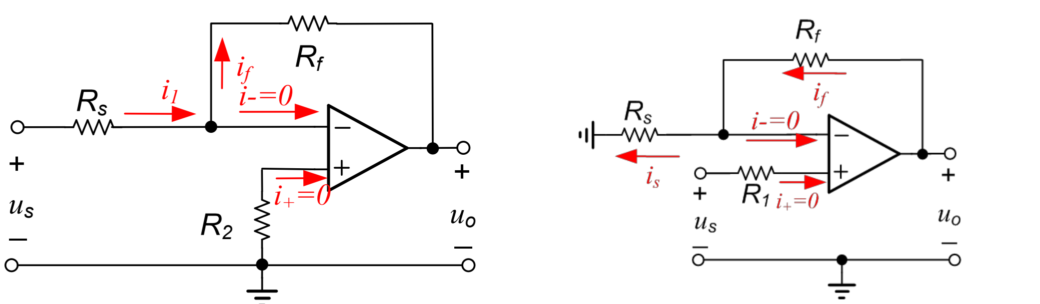


Figure3 (a) Inverting op-amp

Figure3 (b) non-inverting op-amp circuit.

Two popular feedback configurations are the inverting and non-inverting op-amp circuits as shown in Figure 3. Notice that in both cases the output voltage is feedback to the negative input terminal. The only difference is the connection of the input voltage to the inverting or non-inverting input terminal.

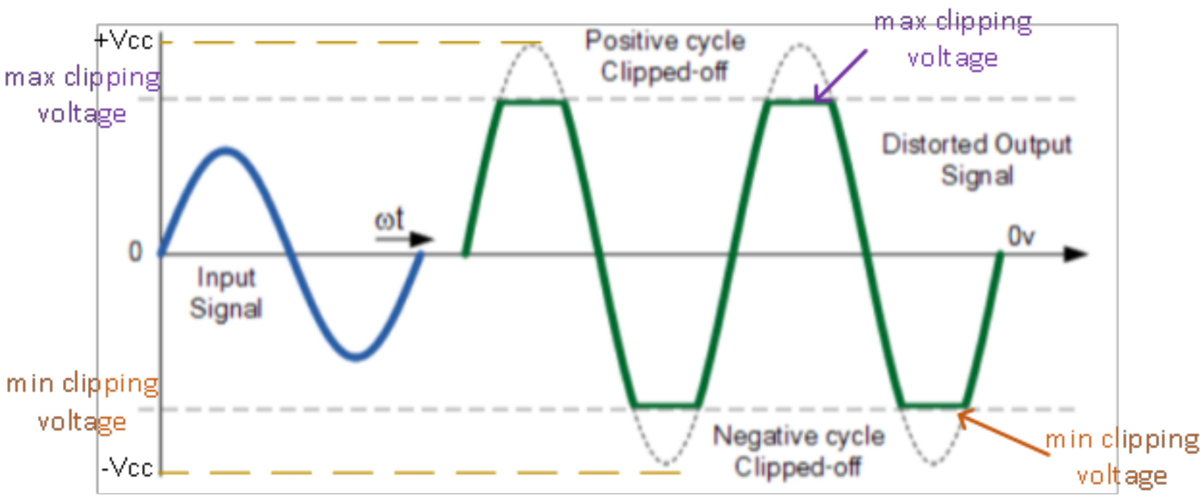
For the Negative feedback application, Figure 2 illustrates that the op amp can operate in three modes, depending on the differential input voltage v_+-v_-:

1. Positive saturation, $V_{out} = V_{o(max)} <+V_{CC}$
2. Linear region, $-V_{o(max)}\le V_{out}\le V_{o(max)}$

3. Negative saturation, vout=- V_{CC}

Clipping Distortion

It was pointed out earlier that the output of an amplifier cannot increase indefinitely. **It is limited by the power supply voltages used to power the amplifier.** In most cases, the output saturates before it reaches the power supply voltages. How close it gets to the power supply voltage depends on the op-amp used。



The graph above shows the effect of saturation. Here, an amplifier in theory produces an output voltage that peaks at ±VCC V. But in practice, the output of this amplifier does not saturate at ±VCC V. Instead of the waveform increasing all the way to ±VCC V, it 'clips' at "max clipping voltage" or "min clipping voltage". The result is known as 'clipping distortion', which should be avoided in practical application

Generally speaking, there are three ways to reduce clipping distortion:

1. To increase the power supply voltage and, hence, the saturation voltages of the amplifier;
2. To reduce the voltage gain of the amplifier by adjusting the resistor values so that saturation does not occur for that input signal;
3. To reduce the amplitude of the input signal and hence the amplitude of the output signal so that saturation does not occur.

Integrated Amplifier module and Schematic Conventions

The op amp is available in several different packages (the outward appearance of the pin), such as dual in-line package (DIP), Pin Grid Array Package (PGA) and Ball Grid Array (BGA). In this lab, op amp LF347N with 14-lead DIP configuration will be used whose top view of the package and pin configuration is shown in figure 4.

It is very important that the leads (or pins) of op amp are connected correctly to other circuit components to ensure that the overall circuit operates properly to avoid damage to the Op Amp. Before using the chip, we must carefully check the identification of the integrated circuit pin, confirm the power, ground, input, output pin number, so as not to damage the device due to wrong connection.

Fig.4 (a). The LF347 14-lead DIP package

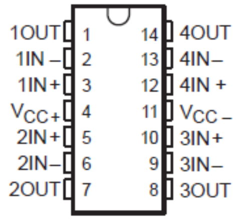


Fig.4(b).The LF347 pin configuration

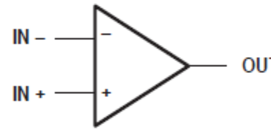


Fig.4(c) symbol (each amplifier)

As for the double-in-line packaging (DIP), their positioning marks are usually a half-moon or a dot at one end of the top side as shown in figure4, which is important for pin number determination. The pin numbers do not appear on the package, but must be determined from the location of the pins with respect to the positioning marks. For this determination, the LF347N package should be held with the letters and code upwards facing the person, and with the pins extending underneath the package. Then the pin at the bottom of the left is the first pin, and then count the pin counterclockwise, which is the second, third and so on. As a chip with 14 pins, the bottom row of pins is 1-7 (from left to right), and the top row is 8-14 (from right to left).

Note that the breadboard channel is designed so that the op amp neatly straddles the channel as shown in Fig.6. By convention, a DIP is always oriented like Fig.6. Many of you will be tempted to randomly orienting the op amps, it will lead you to much confusion; better to get in the habit of orienting them properly from the beginning. Furthermore, orienting the circuits properly will make it much easier to debug.

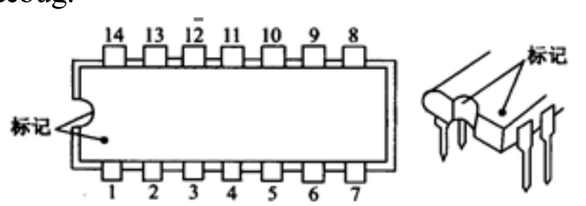


Fig.5 positioning marks

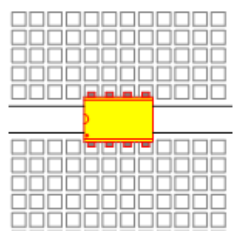


Fig.6 breadboard