Summary Report-Week1

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1. Introduction

The overall objective of week 1 was to analyse the basic operating principles of non-inverting Op-Amps and observing the effects of the following arrangements on the non-inverting Op-Amp:

- Open Loop Configuration
- Closed Loop Configuration
- Differential Amplifier with two Op-Amps.

2. Simulation Details

- Environment: LTspiceXVII
- Important Component(s): LM741 Op-Amp IC
- Reference Book: OpAmps and Integrated Circuits by Ramakant Gayakwad

2.1 Introduction

The basic role of an operational amplifier is to amplify weak electric signals and output the voltage difference between two input terminals. These two input terminals can be arranged accordingly to generate the two basic types of connections of the operational amplifier:

- Inverting
- Non-Inverting

Note that we will restrict our discussion to analysis of non-inverting Op-Amps under different arrangements.

One of the most popular Op-Amp is the LM741 type which has been produced by several manufacturers over the years. For our analysis, we will consider the LM741C Op-Amp specifications.

2.2 Open Loop Configuration

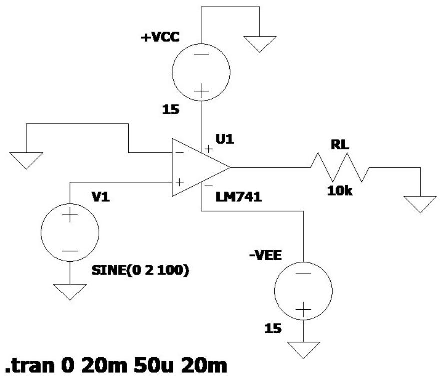
A. Theory

In the open loop configuration of non-inverting Op-Amps, the input is applied to the non-inverting terminal.
We know that the output voltage of Op-Amp is given by,

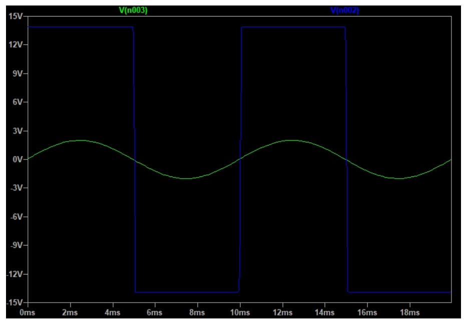
$$v_0 = Av_{id} = A(v_1 - v_2)$$

where
A=large-signal voltage gain.
v_{id}= difference input voltage
v_1= voltage at the non-inverting input terminal with respect to ground.
v_2= voltage at the inverting terminal with respect to the ground.

In the circuit of non-inverting amplifier in open loop configuration in fig[1], $v_1 = v_{in}$ and v_2= 0. Therefore, the output voltage is given by $v_0 = Av_{in}$.

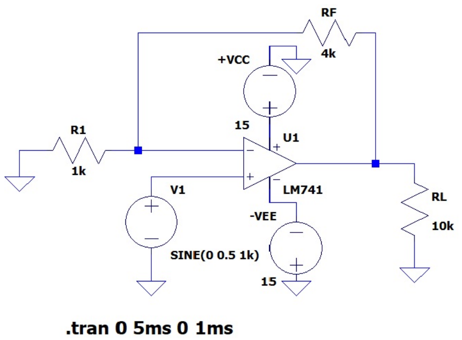


(a) Circuit

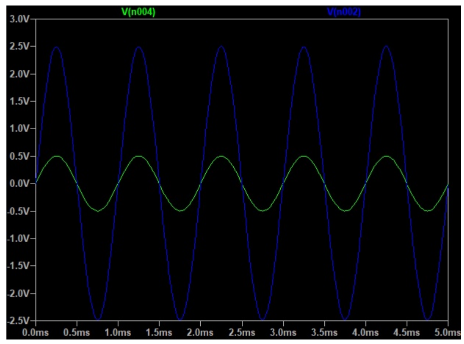


(b) Waveform

Figure 1: Open Loop configuration of Non-inverting Op-Amp



(a) Circuit



(b) Waveform

Figure 2: Closed Loop configuration of Non-inverting Op-Amp

B. Schematic and Waveform

Fig [1] shows that the output voltage is larger than the input voltage by gain A and is in phase with the input signal.

2.3 Closed Loop Configuration

A. Theory

The non-inverting amplifier with feedback(or closed loop non-inverting amplifier) uses feedback circuitry and the input signal is applied to the non-inverting input terminal of the Op-Amp. The non-inverting terminal with feedback is also known as voltage series feedback amplifier.

The closed loop voltage gain with feedback is given by

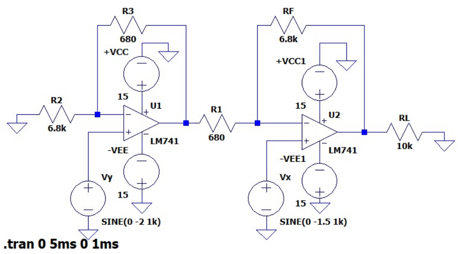
$$A_F = v_0/v_{in} = 1 + R_F/R_1$$

This equation makes it obvious that the magnitude of the output voltage can be controlled by properly selecting the values for resistors R_F and R_1.

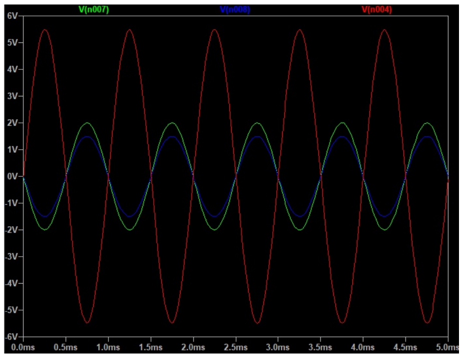
In fig [2], the Op-Amp is working in non-inverting mode and there is a single external input signal $v_1 = v_{in}$ that is applied to the $+ve$ pin of Op-Amp. A signal is also made to appear at the -ve input terminal, but this is derived from the resistors R_1 and R_F. The connection of junction point of R_F and R_1. to the negative input pin causes no effect in the circuit involving R_1. and R_F because of the assumption of infinite resistance of Op-Amp.

B. Schematics and Waveform

Fig [2] shows that the output voltage is larger than the input voltage by gain A and is in phase with the input signal.



(a) Circuit



(b) Waveform

Figure 3: Differential Amplifier with two Op-Amps

2.4 Differential Amplifier with Two Op-Amps

A. Theory

Differential amplifiers with negative feedback can be evaluated with two different arrangements depending on the number of Op-Amps used:

- Differential Amplifier with One Op-Amp
- Differential Amplifier with two Op-Amps

Note that in this report,we will strictly stick to analysis of Differential Op-Amp with two Op-Amps since the advantage of using two Op-Amps in differential Amplifiers is that the gain of the differential amplifier as well as the input resistance R_{if} can be increased.The characteristic of this amplifier are identical to those of the non-inverting amplifier.

Fig [3] shows that the circuit is composed of two stages:

1. the non-inverting amplifier
2. the differential amplifier with unequal gains.

By finding the gain of these two stages we can find the gain of the circuit as follows:

$$A_D = 1 + R_F/R_1$$

B. Schematics and Waveform

Fig [3] shows that the output voltage is larger than the input voltage by gain A and is in phase with the input signal.