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1 . Learning outcome

In this module

- We shall learn the, what is Operational Amplifier?
- We shall learn the block diagram of operational amplifier.
- We shall learn the different characteristics of operational amplifier.

2. Introduction

The term OP-AMP was first used by John R Ragazzini in 1947. He used it to denote an amplifier which could be configured to perform variety of operations such as amplification, addition, subtraction, differentiation and integration.

The OP-AMP is basically a voltage amplifier with extremely high voltage gain. For example, the popular 741 OP-AMP has a typical gain of 2×10^5 or 10^6 dB. A careful look at the circuit symbol of OP-AMP (Refer Fig. 1.1) reveals following things :

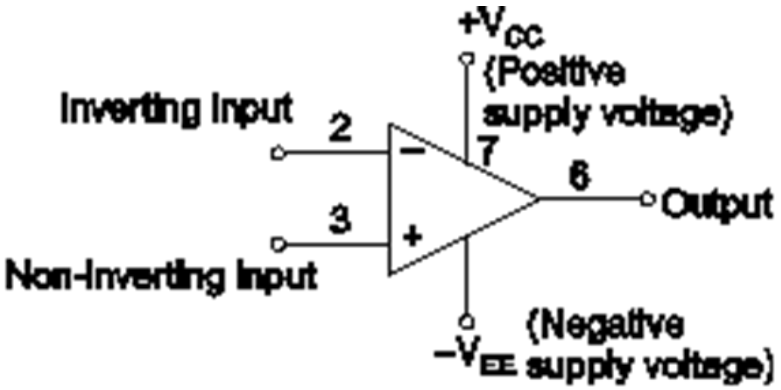

Fig. 1.1 : OP-AMP symbol and terminals

(1) An OP-AMP has two input terminals : one output terminal and two supply voltage terminals.

(2) We can apply the input voltage which is to be amplified to any of these input pins connecting the other pin to ground or the input signal can be connected "between" the two input pins differentially.

(3) The input terminal marked with negative (-) sign is called as "inverting" terminal. If we connect the input signal to this terminal then amplified output signal is 180° out of phase with respect to input as shown in Fig. 1.2 (a).

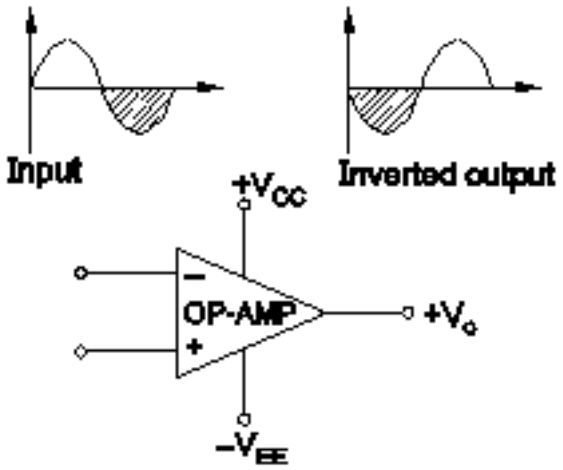

Fig. 1.2 (a)

(4) The input terminal labelled with a positive (+) sign is called "non-inverting" terminal. If we connect the input signal to this terminal then the amplified output signal is in phase with the input signal as shown in Fig. 1.2 (b).

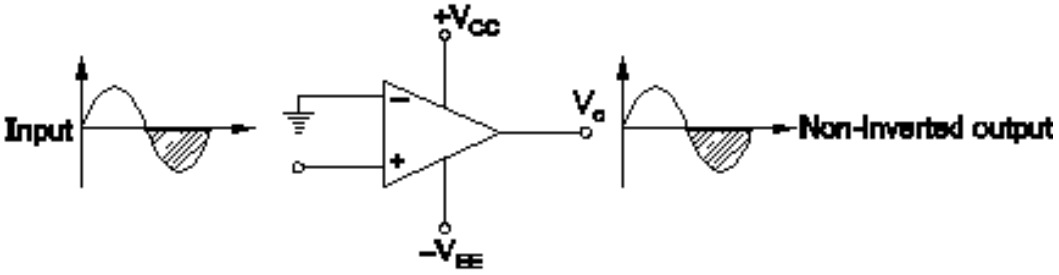

Fig. 1.2 (b) : Non-inverted output

3. Block diagram of operational amplifier

The block diagram of a typical OP-AMP is shown in Fig. 1.3.

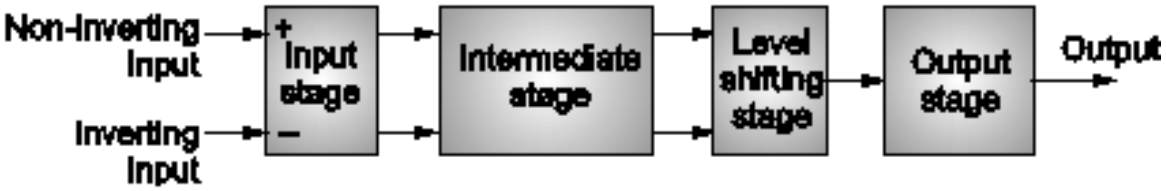

Fig. 1.3 : Block diagram of OP-AMP

The OP-AMP is basically differential amplifier i.e. it will amplify the voltage which is differentially present between its input terminals.

It consists of four stages.

1. Input stage :

The input is a dual-input, balanced output differential amplifier. The two inputs are inverting and non-inverting input terminals. The stage provides high CMRR and most of the voltage gain of the OP-AMP and decides the input resistance value R_i.

2. Intermediate stage :

This is usually another differential amplifier. It is driven by the output of the input stage. This stage is dual-input, unbalanced output (single ended output) differential amplifier. This stage increases the voltage gain and CMRR.

3. Level shifting stage :

Due to direct coupling between the first two stages, the input of level shifting stage is an amplified signal with some non-zero dc level. The level shifting stage is used to bring this dc level to zero volts with respect to ground.

4. Output stage :

This stage is normally a complementary output stage. It increases the magnitude of voltage and raises the current supplying capability of the OP-AMP. It also provides a low output resistance.

4. Characteristics of Operational Amplifier

The important characteristics of an ideal OP-AMP are as follows :

- **It has infinite open loop gain ($A_v = \infty$) :**

The open loop (without any feedback) gain of ideal OP-AMP is denoted by A_v. It is the differential voltage gain and its value for ideal OP-AMP is ∞. As $A_v = \infty$, the differential voltage V_d required to obtain maximum output voltage will be negligible.

- **The input impedance is infinite ($R_i = \infty$) :**

The total impedance measured between the two input terminals of OP-AMP is called input impedance. Due to its infinite value, the current flowing through each input terminal will be zero i.e. $I_{B_1} = I_{B_2} = 0$.

- **The output impedance is zero ($R_o = 0$) :**

Due to zero output impedance, the ideal OP-AMP can drive infinite number of other devices. Further there will not be any change in its output voltage due to change in load current.

- **It has infinite bandwidth :**

Due to infinite bandwidth, ideal OP-AMP can amplify any frequency signal from 0 to ∞ Hz. Thus the gain of an ideal OP-AMP is constant from 0 frequency (dc signal) to ∞ Hz.

- **It has infinite CMRR.**
- **It has infinite slew rate ($S = \infty$).**

5. Summary

I. Operational amplifier is high gain diff. amp.

II. Operational amplifier consists of two input and one output terminal.

III. IC 741 is Operational amplifier.

IV. Operational amplifier is used as an amplifier as well as for doing mathematical operation.

V. Studded important characteristics of an ideal OP-AMP.

6 . Video

1. https://youtu.be/kiiA6WTCQn0
2. https://youtu.be/YBl5qJaO-Mw
3. https://youtu.be/I8tbRibujcY

7 . Assessment

1.https://forms.gle/xCQK68MftyqtM3TM9