UNIT-3 OPERATIONAL AMPLIFIER

INTRODUCTION:

An operational amplifier is a direct-coupled high-gain amplifier usually consisting of one or more differential amplifiers and usually followed by a level translator and an output stage. An operational amplifier is available as a single integrated circuit package. The operational amplifier is a versatile device that can be used to amplify dc as well as ac input signals and was originally designed for computing such mathematical functions as addition, subtraction, multiplication, and integration. Thus the name operational amplifier stems from its original use for these mathematical operations and is abbreviated to op-amp. With the addition of suitable external feedback components, the modern day op-amp can be used for a variety of applications, such as ac and dc signal amplification, active filters, oscillators, comparators, regulators, and others.

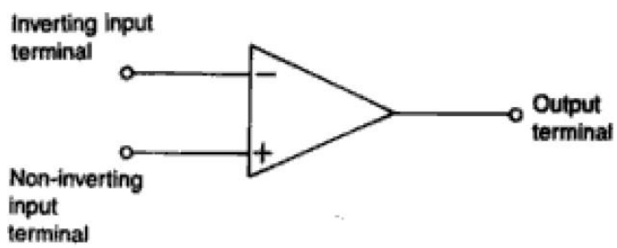
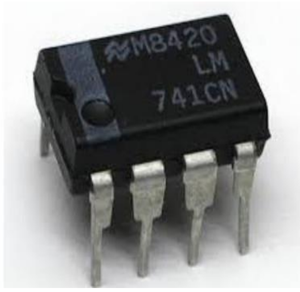


Fig. 2.1 Op-amp circuit symbol



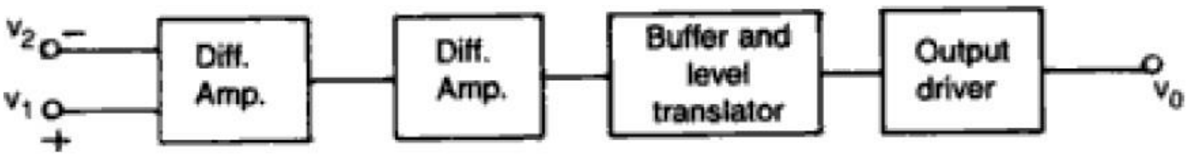


Fig. 2.10 Block schematic of an op-amp

It has two input terminals and one output terminal. The terminal with a (–) sign is called inverting input terminal and the terminal with (+) sign is called the non-inverting input terminal.

HISTORY

- *First developed by **John R. Ragazzine** in **1947** with vacuum tube.*
- *In 1960 at **FAIRCHILD SEMICONDUCTOR CORPORATION, Robert J. Widlar** fabricated op amp with the help of IC fabrication technology.*
- *In 1968 FAIRCHILD introduces the **op-amp** that was to become the industry standard.*

Op-amp pin diagram

There are 8 pins in a common Op-Amp, like the 741 which is used in many instructional courses.

- Pin 1: Offset null
- Pin 2: Inverting input terminal
- Pin 3: Non-inverting input terminal
- Pin 4: –VCC (negative voltage supply)
- Pin 5: Offset null
- Pin 6: Output voltage
- Pin 7: +VCC (positive voltage supply)
- Pin 8: No Connection

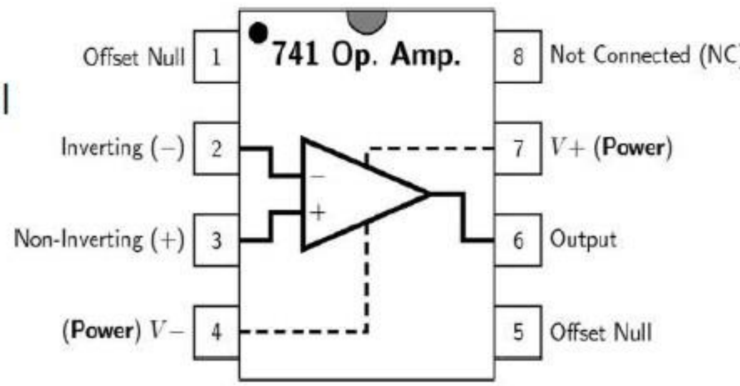
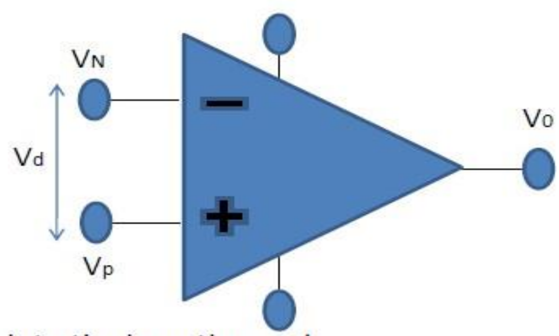


Figure : Pin connection, LM741.

Important terms and equation

a = gain of amplifiers.
V_d= difference between the voltage.
V_0= gain of voltage.
The equation :

$$V_0 = a\,(V_P - V_N)$$



Electrical parameter :

1.Input bias current(I_b): average of current that flows into the inverting and non-inverting input terminal of op-amp.

2. I/p and o/p impedance: It is the resistance offered by the inputs and the output terminals to varying voltages. The quantity is expressed in Ohms.

3. Open Loop Gain: It is the overall voltage gain or the amplification.

4. Input offset voltage : It is a voltage that must be applied between the two terminal of an op-amp to null the o/p.

5. Input offset current (I_i): The algebraic different between the current in to the inverting and Non-inverting terminal.

The basic processes used to fabricate ICs using silicon planar technology can be categorised as follows:

1. Silicon wafer (substrate) preparation
2. Epitaxial growth
3. Oxidation
4. Photolithography
5. Diffusion
6. Ion implantation
7. Isolation technique
8. Metallization
9. Assembly processing and packaging

IDEAL OPERATIONAL AMPLIFIER:

This op-amp is said to be ideal if it has the following characteristics.

Open loop voltage gain,	A_{OL}	=	∞
Input impedance,	R_i	=	∞
Output impedance	R_o	=	0
Bandwidth	BW	=	∞

Zero offset, i.e. $v_o = 0$ when $v_1 = v_2 = 0$.

(i) an ideal op-amp draws no current at both the input terminals i.e., $i_1 = i_2 = 0$. Because of infinite input impedance, any signal source can drive it and there is no loading on the preceding driver stage.

(ii) Since gain is ∞, the voltage between the inverting and non-inverting terminals, i.e., differential input voltage $v_d = (v_1 - v_2)$ is essentially zero for finite output voltage v_o.

(iii) The output voltage v_o is independent of the current drawn from the output as $R_o = 0$. The output thus can drive an infinite number of other devices.

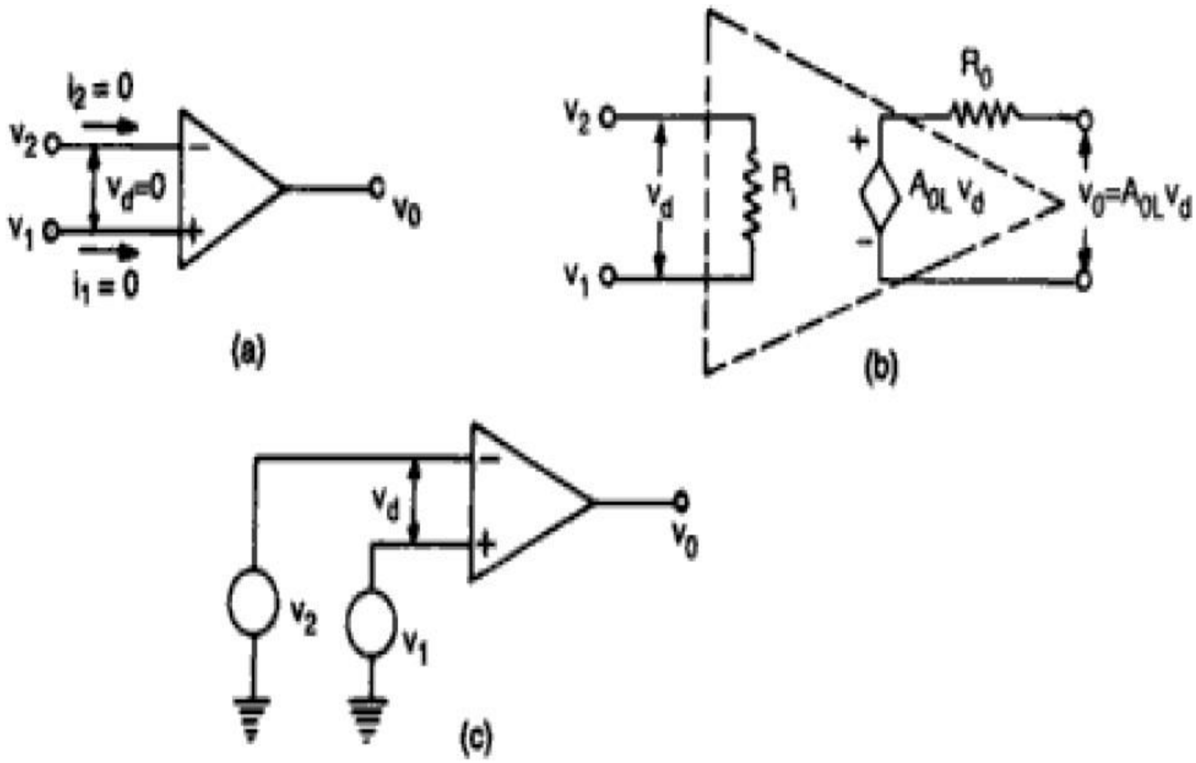
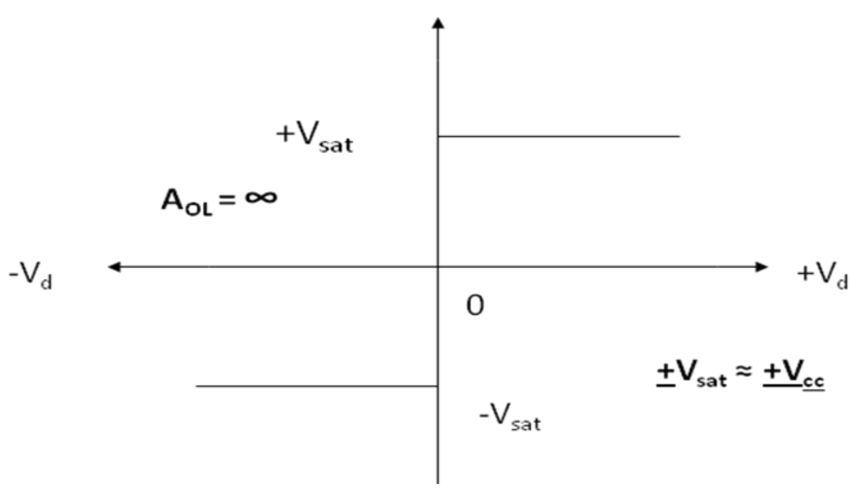


Fig. 2.4 (a) Ideal op-amp (b) Equivalent circuit of an op-amp (c) Open loop circuit

<u>Ideal Voltage transfer curve:</u>



Practical Op-Amplifier:

- The open loop gain of practical Op – Amp is around 7000.
- Practical Op – Amp has non zero offset voltage. That is, the zero output is obtained for the non – zero differential input voltage only.
- The bandwidth of practical Op – Amp is very small value. This can be increased to desired value by applying an adequate negative feedback to the Op – Amp.
- The output impedance is in the order of hundreds. This can be minimized by applying an adequate negative feedback to the Op – Amp.
- The input impedance is in the order of Mega Ohms only. (Whereas the ideal Op – Amp has infinite input impedance).

Differences between Ideal and practical Op-Amps:

Characteristics	Ideal Op-amp	PracticalOp-amp
Voltage gain	Infinite	High
Input resistance	Infinite	High
Output resistance	Zero	Low
Outputvoltagewheninputvoltageis zero	Zero	Low
Band width	Infinite	High
CMRR	Infinite	High
Slew Rate	Infinite	High