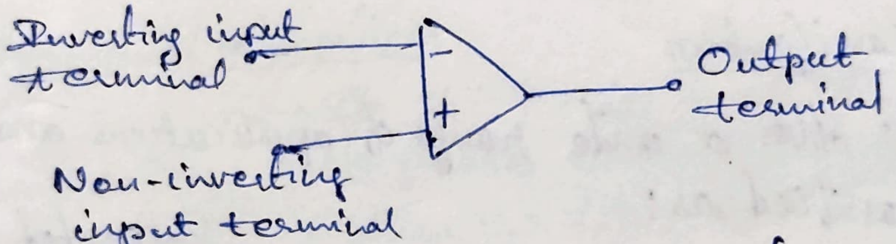
Operational Amplifier

→ Linear integrated circuits are being used in a number of electronic applications such as in fields like audio, and radio communications, medical electronics, instrumentation control, etc.

→ An important linear IC is operational amplifier

→ The operational amplifier (commonly reffered to as op-amp) is a multi-terminal device which internally is quite complex.

→ The circuit schematic of an op-amp is a triangle



→ 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.

→ There are three popular packages available:

1) The metal can (TO) package
2) The dual-in-line package (DIP)
3) The flat package of flat pack

→ Op-amps have five basic terminals, i.e: 2 i/p terminals, 1 o/p terminal and 2 power supply terminals

→ The V^+ and V^- power supply terminals are connected to the 2 dc voltage sources.

→ A number of manufacturers also produce popular ICs of the other manufacturers.

→ For example, Fairchild's original μA741 is also manufactured by other manufacturers as follows:

1) National semiconductor — LM741
2) Motorola — MC1741
3) RCA — CA3741
4) Texas Instruments — SN52741
5) Signetics — N5741

→ Some linear ICs are available in different classes such as A, C, E, S and SC. The main difference of these op-amps are:

741 — Military grade op-amp (operating temperature range −55°C to 125°C)

741C — Commercial grade op-amp (operating temperature range 0° to 70°/75°C)

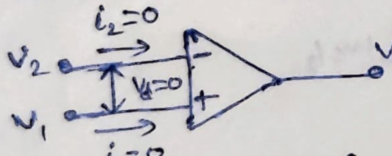
741A — Improved version of 741 } Better electrical specifications

741E — Improved version of 741C } Better electrical specifications

741S — Military grade op-amp with higher slew-rate

741SC — Commercial grade op-amp with higher slew rate

The Ideal Operational Amplifier



→ If $V_1 = 0$, o/p V_o is 180° out of phase with i/p signal V_2

→ When $V_2 = 0$, o/p V_o will be in phase with i/p signal applied at V_1.

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

Open loop voltage gain, $A_{OL} = \infty$

Input impedance, $R_i = \infty$

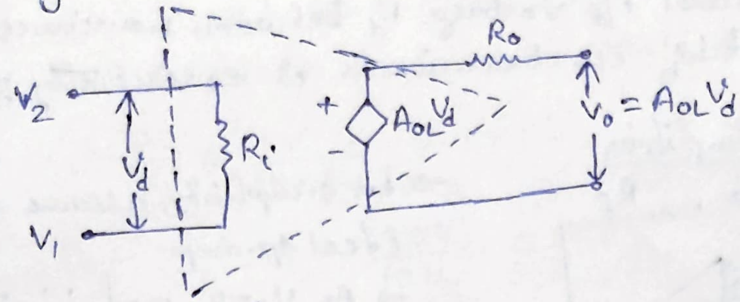
Output impedance, $R_o = 0$

Bandwidth, $BW = \infty$

Zero offset, i.e, $V_o = 0$ when $V_1 = V_2 = 0$

→ The above properties can never be realized in practice.

→ A physical amplifier is not an ideal one



→ So the equivalent circuit of an op-amp may be shown as above, where $A_{OL} \neq \infty$, $R_i \neq \infty$, and $R_o \neq 0$

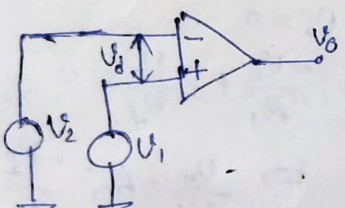
→ It can be seen that op-amp is a voltage controlled voltage source and $A_{OL} V_d$ is an equivalent Thevenin voltage source and R_o is the Thevenin equivalent resistance looking back into the o/p terminal of an op-amp.

→ The o/p voltage is $V_o = A_{OL} V_d$

$$= A_{OL}(V_1 - V_2)$$

→ The equation shows that the op-amp amplifies the difference between the 2 i/p voltages.

Open Loop Operation of Op-Amp



→ Since the gain is infinite, the o/p voltage V_o is either at its positive saturation voltage ($+V_{sat}$) for $V_1 > V_2$ or negative saturation voltage ($-V_{sat}$) for $V_2 > V_1$

→ The o/p assumes one of two possible o/p states, i.e., $+V_{sat}$ or $-V_{sat}$ and the amplifier acts a switch only.

→ This has a limited number of applications such as voltage comparator, zero crossing detector, etc.

Feedback in Ideal Op-amp

→ The utility of an op-amp can be greatly increased by providing negative feedback.

→ The o/p in this case is not driven into saturation & the circuit behaves in a linear manner

→ In order to understand the operation of feedback connections, we make two realistic simplifying assumptions

1) The current drawn by either of the i/p terminals is negligible
2) The differential i/p voltage V_d between non-inverting and inverting i/p terminals is essentially zero.