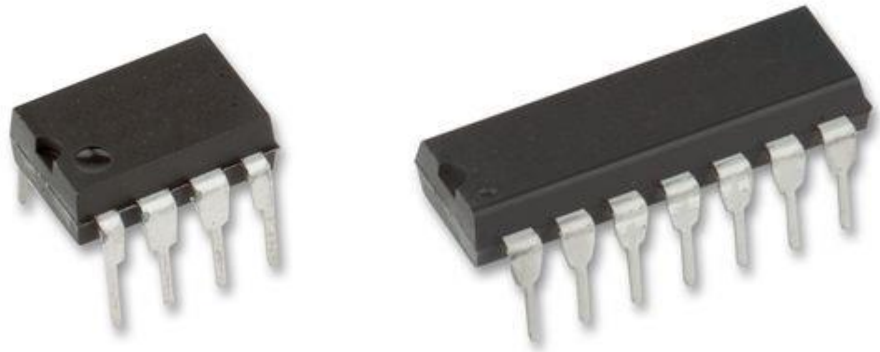
OPERATIONAL AMPLIFIERS

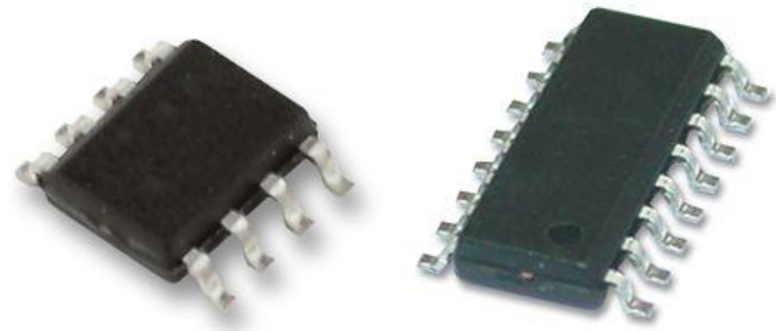
Integrated Circuits (IC)

Through-hole technology

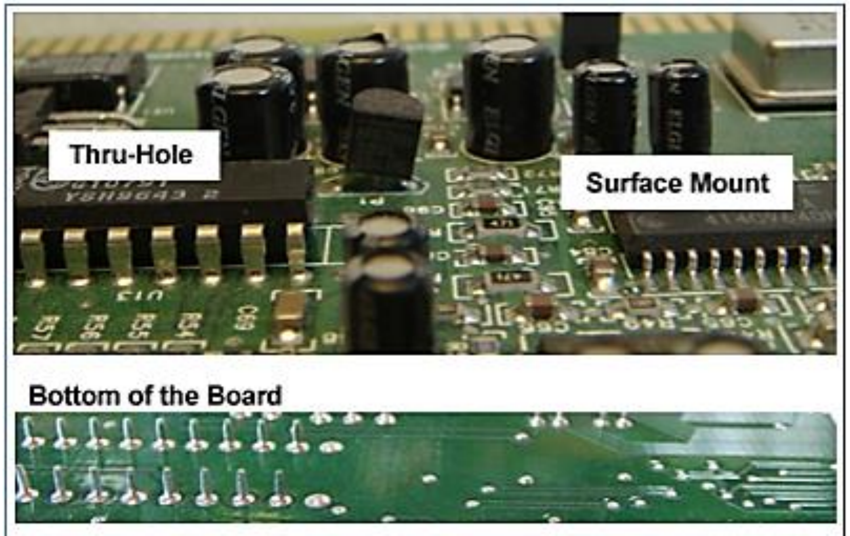


Mounting scheme used for electronic components that involves the use of leads on the components that are inserted into holes drilled in printed circuit boards (PCB) and soldered to pads on the opposite side.

Surface-mount technology
SMT;   SMD



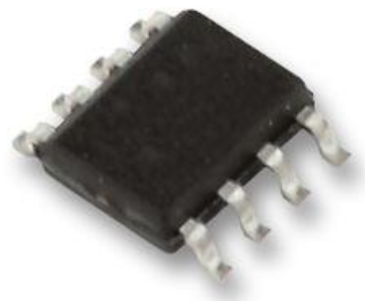
The components are mounted or placed directly onto the surface of printed circuit boards (PCBs). An electronic device so made is called a surface-mount device (SMD).



Integrated Circuits (IC) - cont.

Through-hole technology

Surface-mount technology
SMT; SMD



Both technologies can be used on the same board.

A SMT component is usually smaller than its through-hole counterpart because it has either smaller leads or no leads at all.

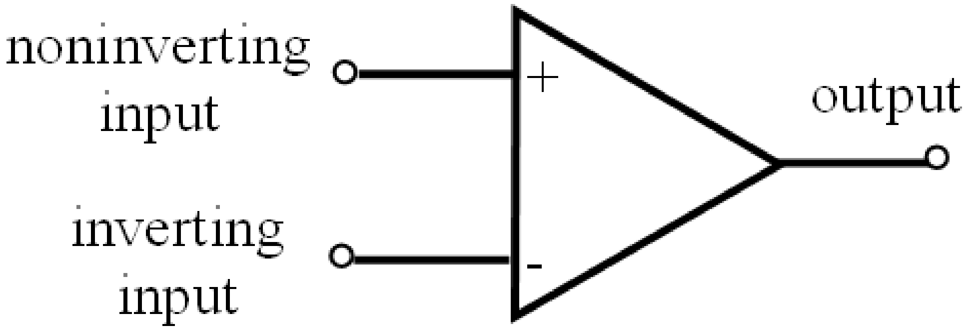
It may have short pins or leads of various styles, flat contacts, a matrix of solder balls (BGAs – **Ball Grid Arrays**), or terminations on the body of the component

Operational amplifiers (op-amp)

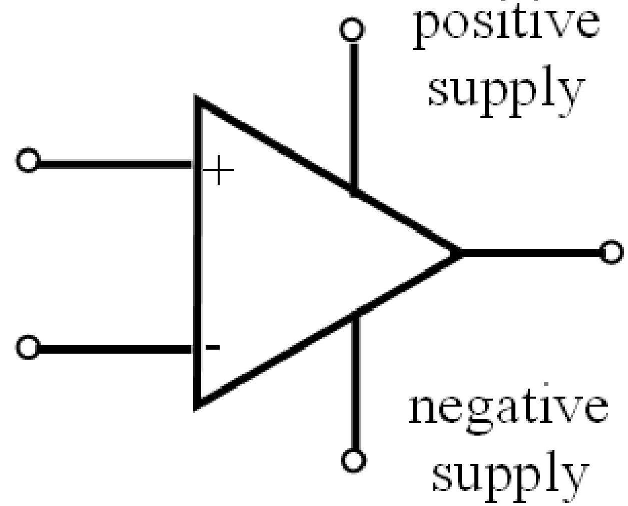
- IC consisting of a relatively large number of **interconnected transistors** and passive components on the same silicon chip (eg. the popular 741 op-amp contains 24 transistors, 12 resistors and a capacitor)
- Very popular due to their **versatility** and easy to use
- Op-amps have characteristics to the terminals that leads to a behavior very close to an **ideal amplifier**
- **Optimized for**: speed, low noise, precision, low power, high gain, maximum output swing (rail-to-rail), versatility, easy to use, low cost, thermal stability, low supply voltages, etc.
- Study from the point of view of **terminal characteristics** and main applications

Op-amp Terminals

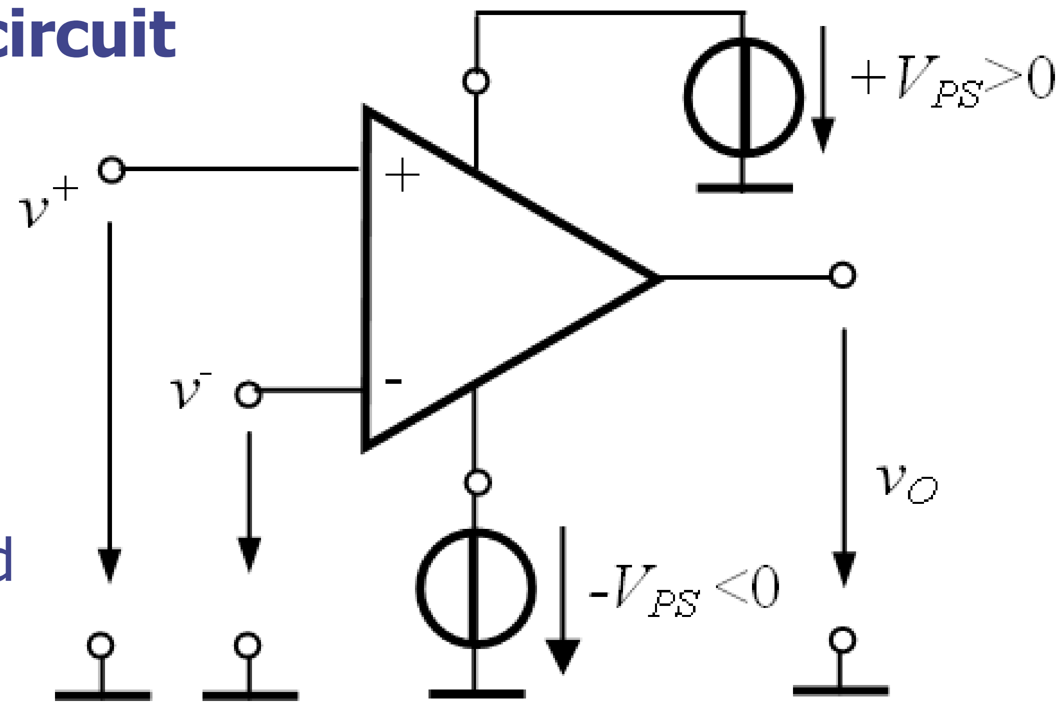
Signal terminals



Signal and supply terminals



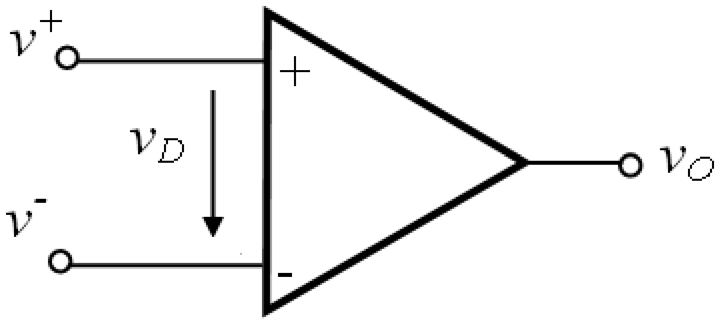
Op-amp connection in a circuit



Remark:

In many circuits the op-amp power supply terminals are not explicitly shown, considering that a correct supply is provided

Op-Amp Operation

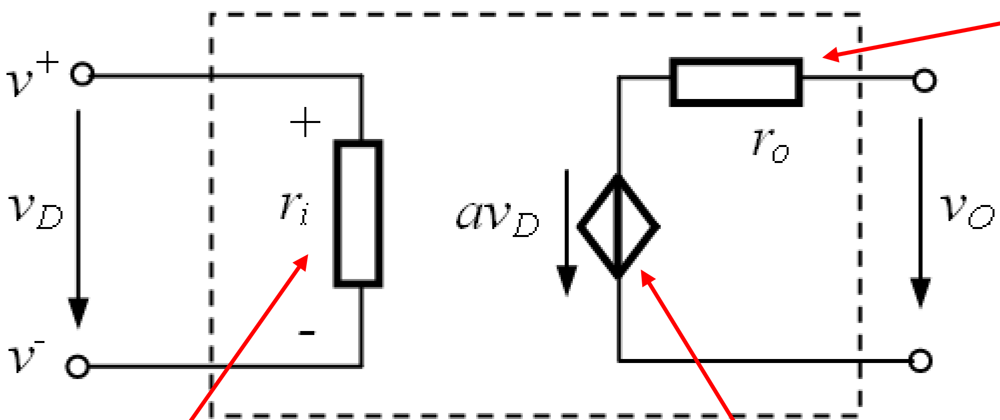


$$v_D = v^+ - v^-$$

$$v_O = a v_D$$

a – op-amp gain

The op-amp model



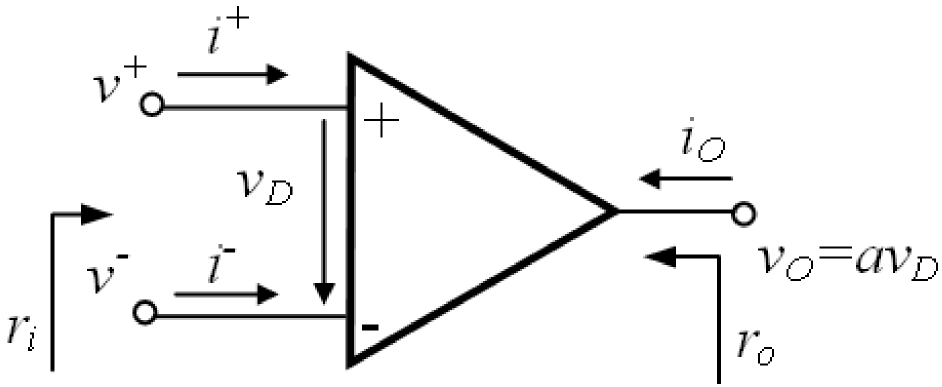
output resistance

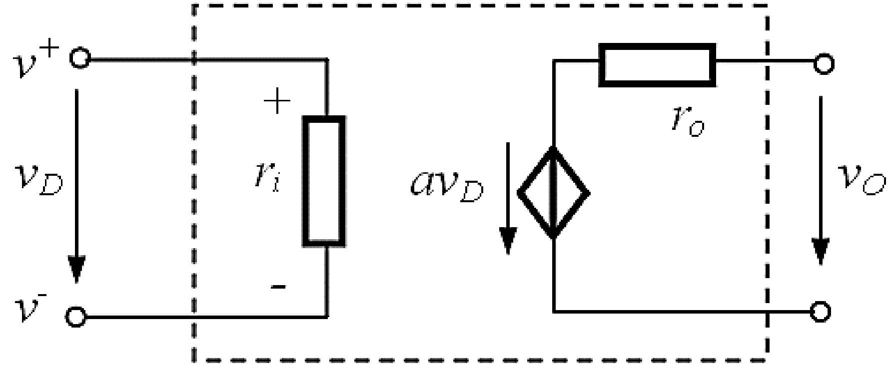
input resistance

voltage-controlled voltage source
(*pseudo -source*)

- input voltage v_D
- if none of the inputs is connected to the ground, there is no common terminal for input and for output

Ideal op-amp





- **Input resistance** $\boldsymbol{r_i = \infty}$**.** As a consequence, the op-amp doesn't draw any input current: $\boldsymbol{i^+ = i^- = 0}$
- **Output resistance** $\boldsymbol{r_o = 0}$. v_O is independent of the current that may be drawn from the output pin into a load impedance
- Infinite **bandwidth**, the gain *a* is constant in the entire frequency range, even in the dc.
- Infinite **gain**: $\boldsymbol{a = \infty}$

What is the value of the **output voltage**, considering the fundamental op-amp equation, that becomes: $v_O = a v_D = \infty \cdot v_D$?

I. Utilization as comparator, in switching mode.

$v_D > 0$; $v_O \rightarrow +\infty$, v_O limited by the positive supply $v_O = V_{OH} \approx +V_{PS.}$

$v_D < 0$, $v_O \rightarrow -\infty$, v_O limited by the negative supply $v_O = V_{OL} \approx -V_{PS.}$

v_O takes only two extreme values. $v_O \in \{V_{OL} ; V_{OH}\}$

II. Utilization as amplifier

$$v_O \in (V_{OL}; V_{OH})$$

it is necessary that $v_D = 0$. So we have an indetermination:

$$v_O = a \cdot v_D = \infty \cdot 0$$

v_D can be kept to 0 by connecting some external resistors in a ***negative feedback*** configuration. These resistors together with the op-amp maintain v_D to zero and set the value of the output voltage $\Rightarrow$ **op-amp amplifiers**