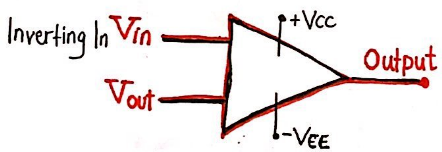
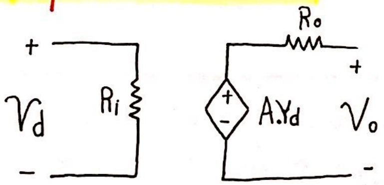
Electronics 236 → L18 Part1 op-amp1

- Operational Amplifier
  - Integrated Circuit.
  - Used for different Applications
    - Math operations
    - Comparison
    - Filters
    - Communications Eng.
    - Control systems
    - Instrumentation

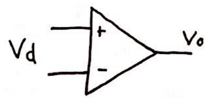
OP_ Amp "Not design but how to use the op amp as a device.



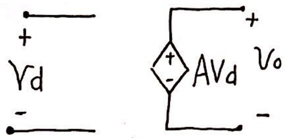
Equivalent Circuit :



- A very high (A > 100000)
- R_i very high (MΩ's)
- R_o very small (Ω's)



Ideal op-amp : "Equivalent Circuit" Considering ↑↑ R_i "open Circuit" and ↓↓ R_o "Short Circuit"

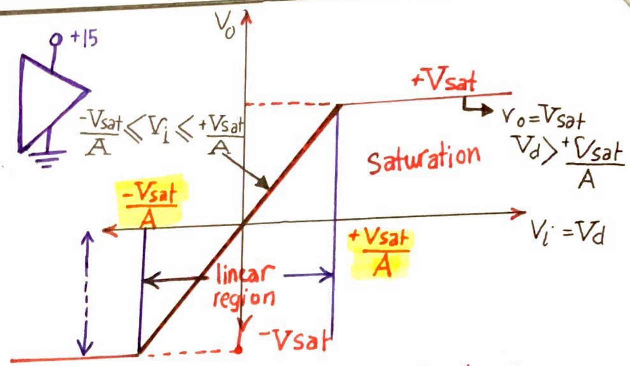


Op-amp characteristic

$^{+}V_{sat} \cong {}^{+}V_{cc} - 2$

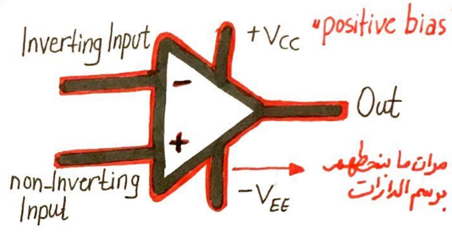
$^{-}V_{sat} \cong {}^{-}V_{cc} + 2$

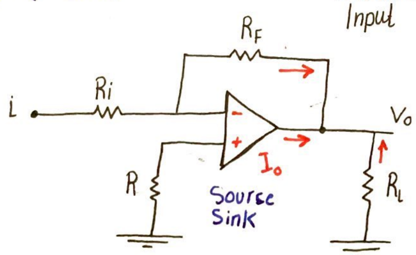
"For calculation Purpos" in this course

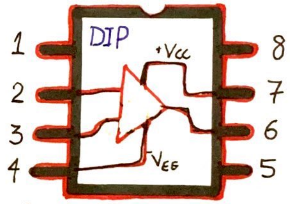


Op-Amp Ratings

1. $^{-}V_{sat} \leqslant V_o \leqslant {}^{+}V_{sat}$
2. $I_o \leqslant I_{o\,max}$

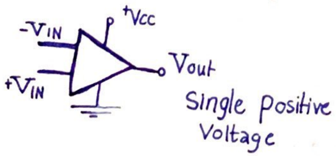


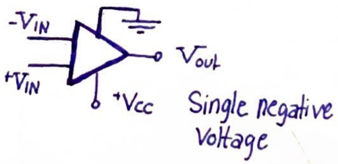




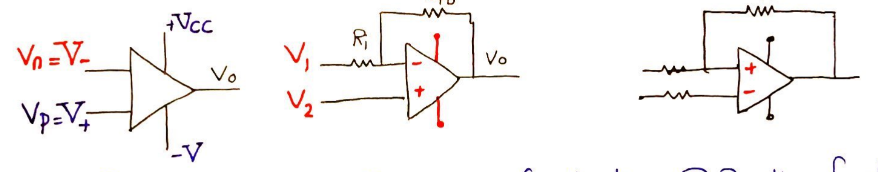
Dual in-ling Pack

Most OP Amps require dual power supply with Common Ground & Some Op Amps require single Supply "with some restriction"





OP-Amp Configuration



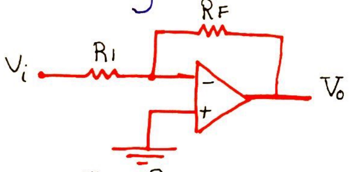
① no feedback
- used as Comparator
$V_o = \pm V_{sat}$

② Negative feedback
- used as an Amplifier
$-V_{sat} < V_o < +V_{sat}$

③ Positive feedback
- Comparator with Hyst.
$V_o = \mp V_{sat}$

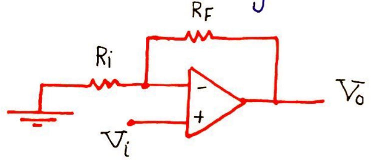
Op-Amp as an Amplifier

Inverting



$$V_o = \frac{-R_F}{R_i} V_i$$

Non-Inverting



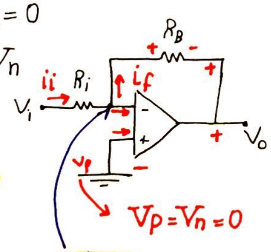
$$V_o = \left(1 + \frac{R_F}{R_i}\right) V_i$$

L18_Part 2 — Inverting Amp. Analysis

Using ideal op-amp Model

$$\begin{cases} i_p = i_n = 0 \\ V_p = V_n \end{cases}$$

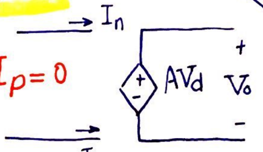
only for Amp. with negative feedback



$$i_i = i_f + \overset{0}{\cancel{i_n}}$$

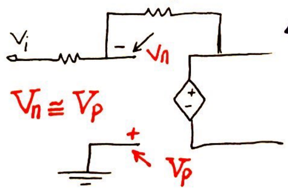
$$i_i = \frac{V_i - \overset{0}{\cancel{V_n}}}{R_i} = \frac{V_i}{R_i} = i_f$$

① $I_n = I_p = 0$



Negative feedback

② $V_n \cong V_p$

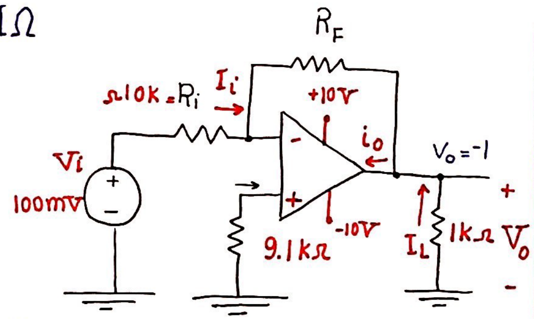


$$V_o = -i_f R_F = \frac{-V_i}{R_i} \cdot R_F = \frac{-R_F}{R_i} V_i$$

Example

Find the Value of V_o and I_o and Verify if the opamp is in linear or saturation mode for two values of feedback resistor; assume $I_{o(max)} = 20\,mA$

[1] $R_f = 100\,k\Omega$ [2] If $R_F = 2M\Omega$



$V_p = 0$

$-10+2=-8$ $\quad$ $10-2=8$

$$-V_{sat} \leq V_o = \frac{-R_F}{R_i} \cdot V_i \leq +V_{sat}$$

$$I_o \leq I_{o(max)} = 25\,mA$$

$$V_o = \frac{-100K}{10K} \cdot V_i = -10 \times 100\,mV = -1 \quad \text{ضمن الرينج}$$

$$i_i = i_f = \frac{100\,mV}{10\,K} = 10\,\mu A \qquad i_L = \frac{1}{1K} = 1\,mA$$

$$i_o = i_f + i_L = 10\,\mu A + 1\,mA$$

$$= 1.01\,mA < 20\,mA \checkmark$$

op Amp is a low current device

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[2] $R_F = 2M\Omega$ ($\Rightarrow 2000\,k$)

$$V_o = \frac{-2M}{10K} * 100\,mV$$

$$= -20\,V$$

, $-V_{sat} \leq V_o \leq +V_{sat}$, but V_o not In the range

V_o is Limited to $-8V$

$$I_o = 10\,\mu + \frac{8}{1K} = 8\,mA \checkmark$$

Assume $R_L = 200\Omega$

$$I_o = 10\,\mu + \frac{8}{200} = 40.01\,mA > I_{o(max)}$$, I_o is limited to 20 mA

$$V_o = -20\,mA \times 200 = -4V$$