.

EE1101: Circuits and Network Analysis

Lecture 14: Operational Amplifier

August 29, 2025

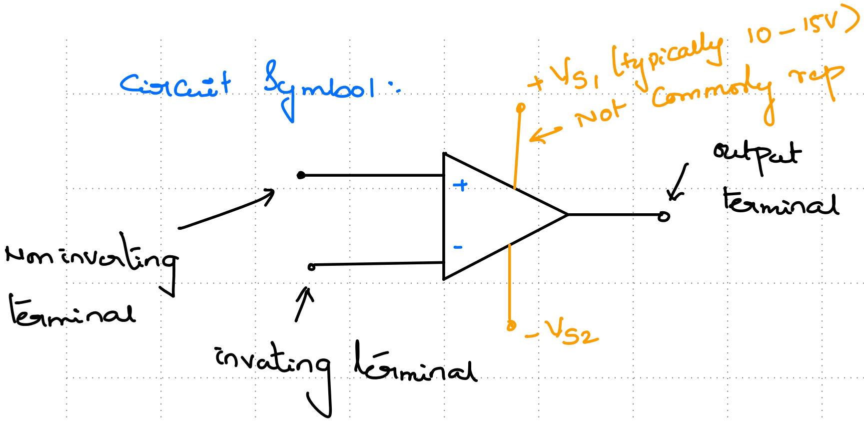
Topics :

1. Operational Amplifier (Op-Amp)

2. Virtual Short Principle

Operational Amplifier from a Circuit Perspective

Circuit Symbol:



only operates as an amplifier

& not as a switch.

Characteristic Eqn $\Big\}$ $v_{out} = A(V_+ - V_-)$

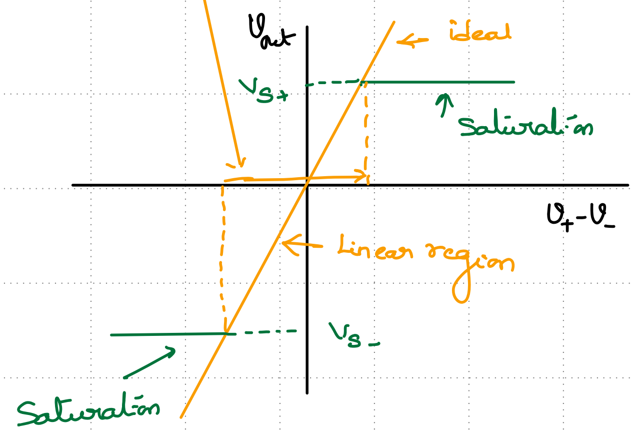
$\uparrow$ gain V/V is typically very large.

when $V_- = 0 \Rightarrow v_{out} = AV_+$

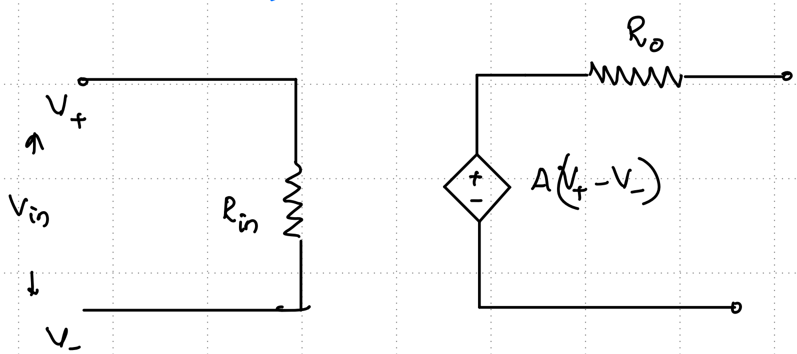
when $V_+ = 0 \Rightarrow v_{out} = -AV_-$

circuits to be analyzed in this course.

In Practice



Equivalent Circuit. (Non-ideal)

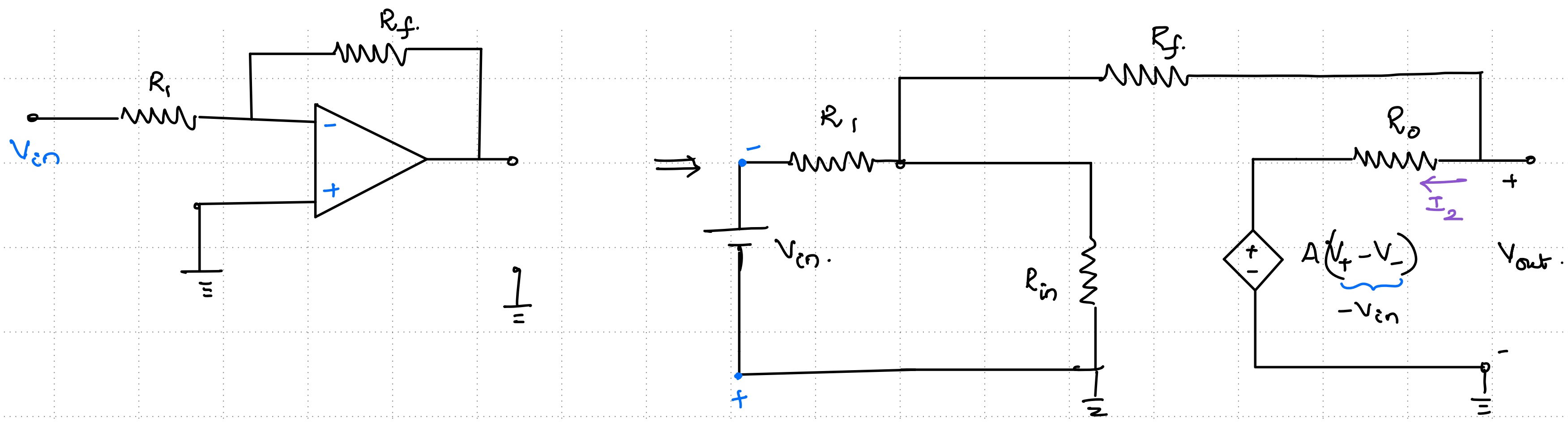


$R_{in} \longrightarrow$ typically very large

$A \longrightarrow$ very high

$R_o \longrightarrow$ typically low

Example



$$V_{out} = -A V_{in} + I_2 R_o$$

$\uparrow$ Compute I_2 ?

Complete by choosing Numerical Values

$R_{in} \rightarrow$ large

$R_o \rightarrow$ small

$\frac{R_f}{R_1} \approx 10$

Virtual Short Concept

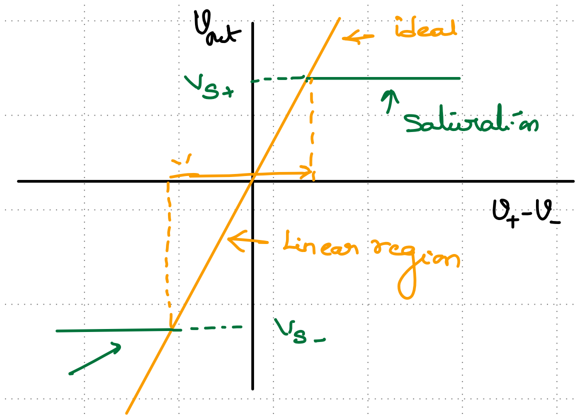
① given that V_s = 10 – 15 (range) and gain is high

range of linear operation is very small (typically mV)

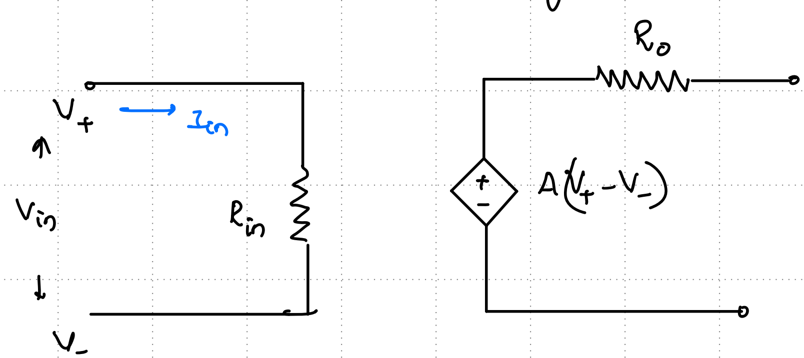
$\Downarrow$

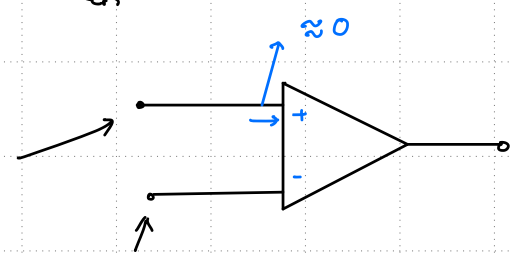
$V_+ - V_- \approx 0 \Rightarrow$ Virtual short

i.e. $V_+ \approx V_-$.



② Since $R_{in} \to$ large & $V_+ - V_-$ is very small, $I_{in} = \dfrac{V_+ - V_-}{R_{in}} \to$ neg. small

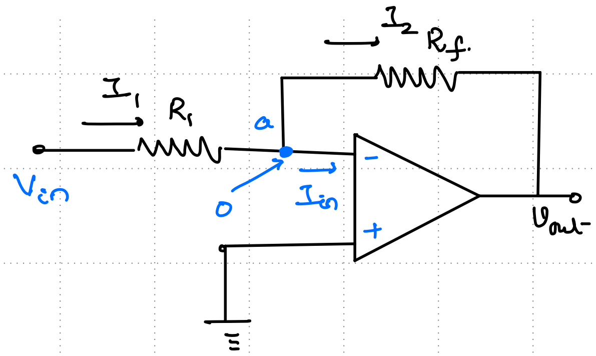




③ Caution: Not all ckts can be analyzed using virtual short

Majority of the ckts can be analyzed using Virtual short.

Example (using Virtual Short)



Step 1: by Virtual Short $V_a = 0$

Step 2: Since $V_a = 0 \Rightarrow I_1 = \dfrac{V_{in}}{R_1}$

Step 3: by virtual Short, $I_{in} = 0$

$\Rightarrow I_2 = I_1$

Step 4: $V_{out} = V_a - I_2 R_f$

$$= 0 - \frac{V_{in}}{R_1} R_f = \underbrace{-\frac{R_f}{R_1}}_{G} V_{in}$$

$G \leftarrow$ adjusted by choosing R_f & R_1

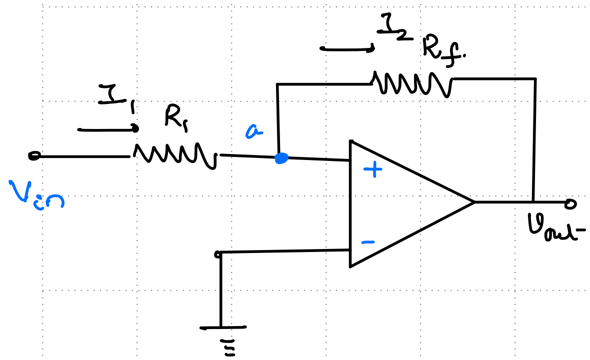
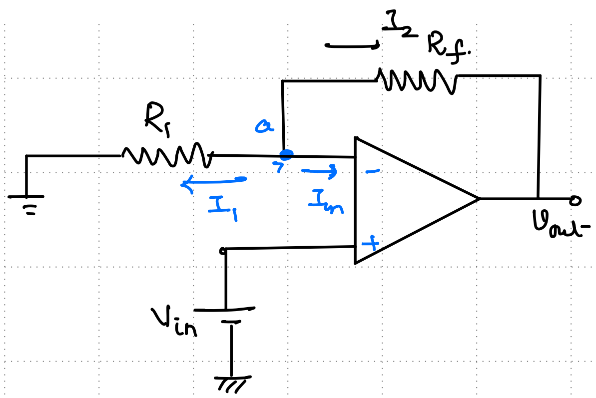


figure out if Virtual Short Concept can be applied to this Circuit.

Examples



Step 1 :- by VS : $V_a = V_{in}$

Step 2: $I_1 = \frac{V_{in}}{R_1}$

Step 3 :- by VS : $I_{in} = 0 \implies I_2 = -I_1 = -\frac{V_{in}}{R_1}$

Step 4 :- $V_{out} = V_a - I_2 R_f$

$= V_{in} + V_{in} \frac{R_f}{R_1}$

$= \left(1 + \frac{R_f}{R_1}\right) V_{in}$