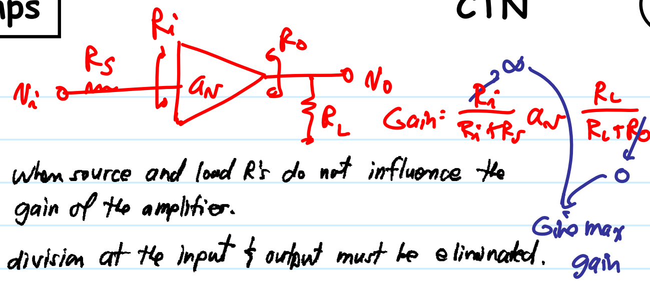
EE 140 | **Ideal Op Amps** | CTN | 1



Ideal Voltage Amplifier

→ ideal when $\frac{v_o}{v_s} = A_v$; i.e., when source and load R's do not influence the gain of the amplifier.

For this to occur, the voltage division at the input & output must be eliminated.
This happens when:

$R_i = \infty$, $R_o = 0$ } These resistance values define an ideal voltage amplifier.

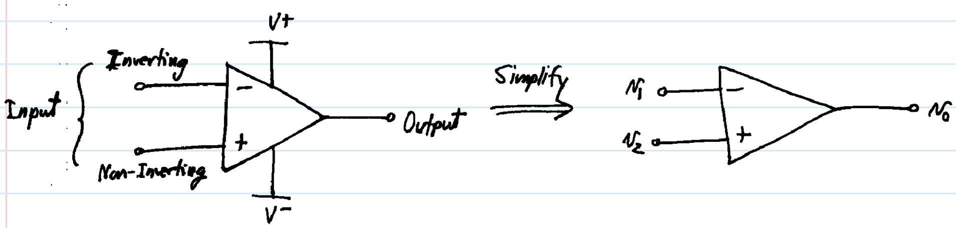
We'll look at other amplifier types later.

→ This, then, naturally leads us to:

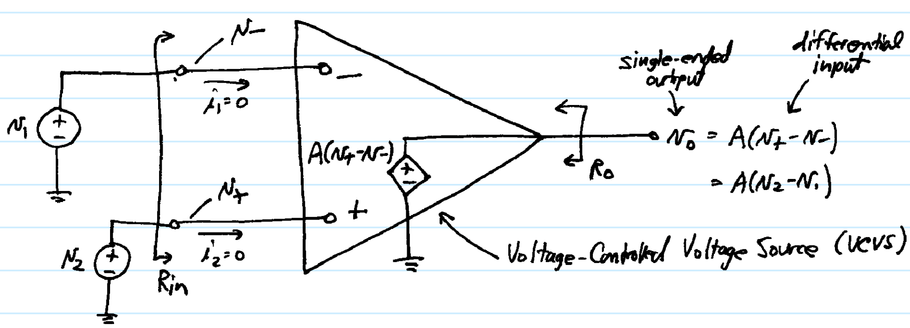
Ideal Operational Amplifiers (Op Amps)

→ The work horse of analog electronics → combinations of op amps w/ feedback components allow the implementation of analog computers, sampled-data systems, analog filters, A/D Converters, DAC's, instrumentation amplifiers

In general, have a minimum of 5 terminals:



Perhaps the best way to define an op amp is thru its equivalent ckt:
Equivalent Ckt. of an Ideal Op Amp:



EE 140 | Ideal Op Amps

CTN ②

Properties of Ideal Op Amps:

① $R_{in} = \infty$ —leads to→ ④ $i_+ = i_- = 0$

② $R_o = 0$

③ $A = \infty$ —leads to→ ⑤ $v_+ = v_-$, assuming v_o = finite

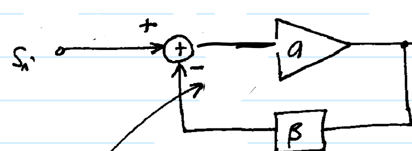
↳ Why? Because for $\infty(v_+ - v_-) = v_o$ = finite

$\therefore \underbrace{v_+ - v_-}_{= v_o/\infty} = 0 \rightarrow v_+ = v_-$ ⇒ virtual short ckt. (virtual ground)

Big assumption! (v_o = finite)

How can we assume this? ⟹ only when there is an appropriate negative feedback path!

Negative Feedback



where S could be a current, voltage, displacement, etc., …

Negative feedback acts to oppose or subtract from input.

$$\left.\begin{aligned} S_o &= a S_\varepsilon \\ S_\varepsilon &= S_i - \beta S_o \end{aligned}\right\} \Rightarrow \begin{aligned} S_o &= a(S_i - \beta S_o) \\ S_o(1 + a\beta) &= a S_i \rightarrow \boxed{\frac{S_o}{S_i} = \frac{a}{1 + a\beta}} \end{aligned}$$

← overall transfer function

$$[a \rightarrow \infty] \Rightarrow \frac{S_o}{S_i} \approx \frac{a}{a\beta} = \frac{1}{\beta} = \text{finite!}$$

$$\therefore S_o = \frac{1}{\beta} S_i = \text{finite} \checkmark$$

(when there is neg. FB around the amplifier)

In Summary:

① Neg. FB can insure S_o = finite even with $a = \infty$.

② Overall Gain dependent (or overall T.F.) dependent only on external components. (e.g., β)

③ Overall (closed-loop) gain $\frac{S_o}{S_i}$ is independent of amplifier gain a.

↖ very important! ⇒ as you'll see, when designing amplifiers using transistors, it's easy to get large gain, but it's hard to get an exact gain. i.e., if you're shooting for a = 50,000, you might get 47,000 or 60,000 instead.