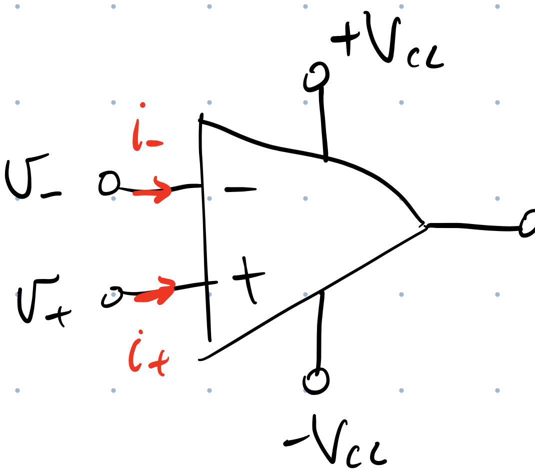
PHYS 231 Oct. 23, 2024

Last Time:

Op Amps:



$v_{out} = A_{OL}(v_+ - v_-)$

$A_{OL} \approx 2 \times 10^5$ for LM741

Op Amp Golden Rules:

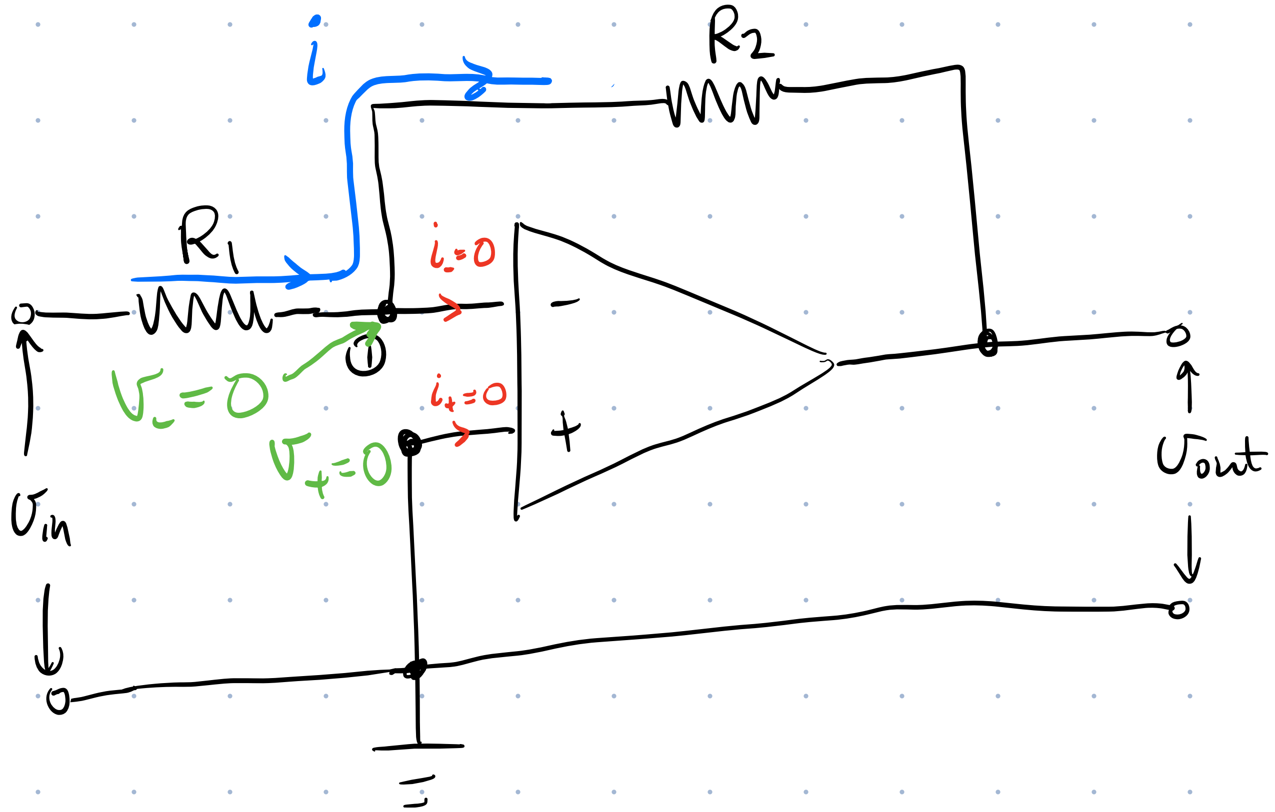
① $i_- = i_+ = 0$

No current into or out of op amp inputs

② When using negative feedback,

$v_- = v_+$

Inverting Amplifier



G.R. #1: $i_- = i_+ = 0$

Jcn Rule @ ①.

$$i_1 = \cancel{i_-}^{\,0} + i_2 = i_1 = i_2 \equiv i$$

G.R. #2: $v_- = v_+$

B/c v_+ has a direct connect to gnd, $\boxed{v_+ = 0.}$ ∴ By G.R. #2 $\boxed{v_- = 0}$

① Track changes in volt. from V_{in} to V_-

$$V_{in} - iR_1 = \cancel{V_-} \rightarrow 0$$

Solve for $i = \boxed{\frac{V_{in}}{R_1}}$

② Track changes in voltage from V_- to V_{out}

$$\cancel{V_-} \rightarrow 0 \quad - iR_2 = V_{out}$$

$$V_{out} = -iR_2 = -\frac{V_{in}}{R_1}R_2$$

$$\boxed{V_{out} = -\frac{R_2}{R_1}V_{in}}$$

"inverting"

$$\therefore \frac{V_{out}}{V_{in}} = G = -\frac{R_2}{R_1}$$

gain

In Lab # 5, you will use $R_2 = 100\,k\Omega$
$R_1 = 1\,k\Omega$

$\Rightarrow G = -100$

Recall that the opamp can output a maximum of

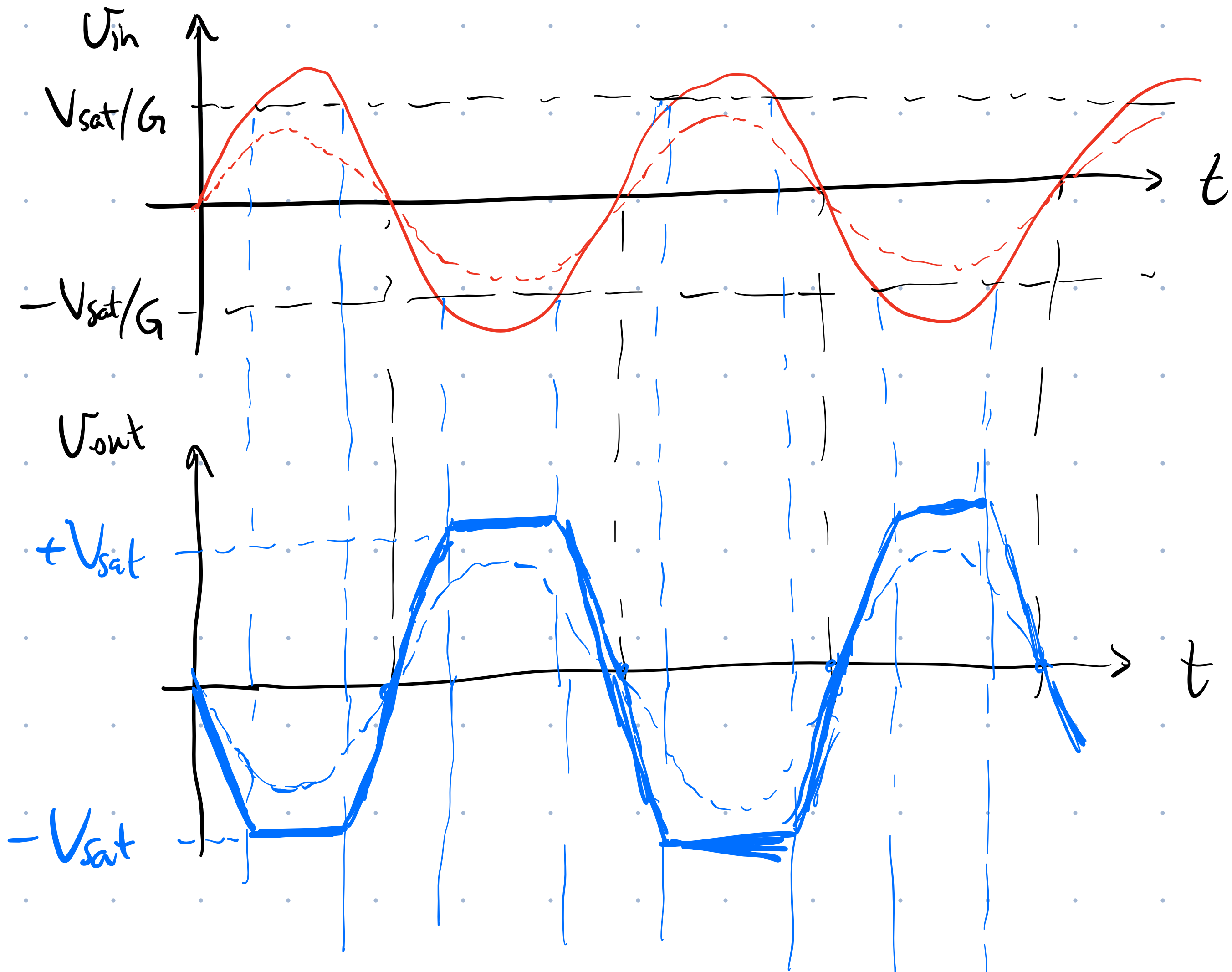
$\pm V_{sat} \approx \pm 14\,V$ if $V_{cc} = \pm 15\,V$.

$v_{out,max} = \pm V_{sat}$

$v_{out} = -G\,v_{in}$

$\therefore$ require $G\,v_{in} \leq V_{sat}$

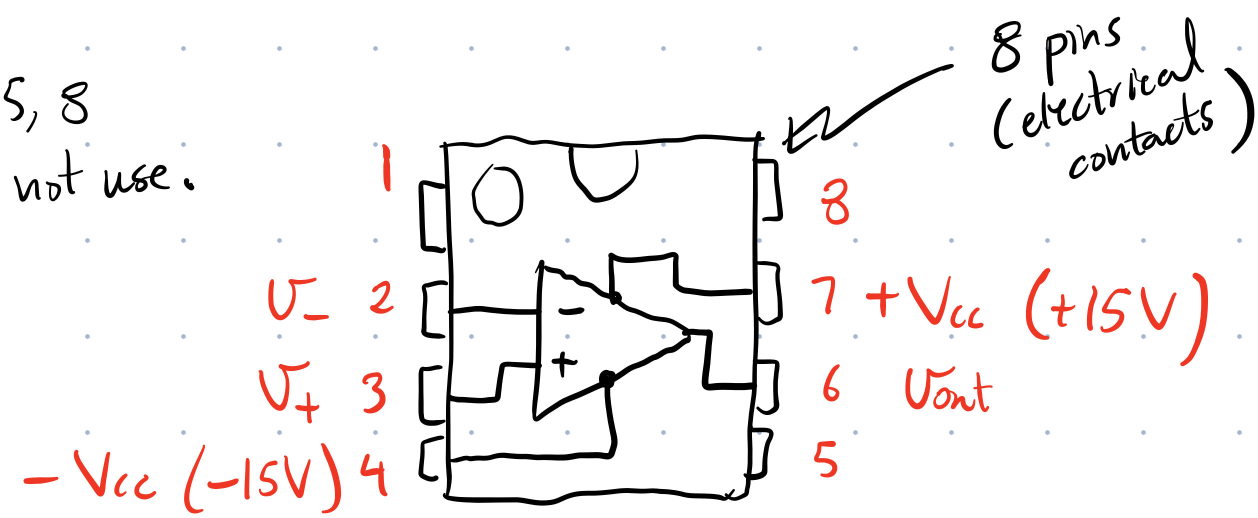
$$\boxed{v_{in} \leq \frac{V_{sat}}{G}}$$



saturation of op amp output
"clipping".

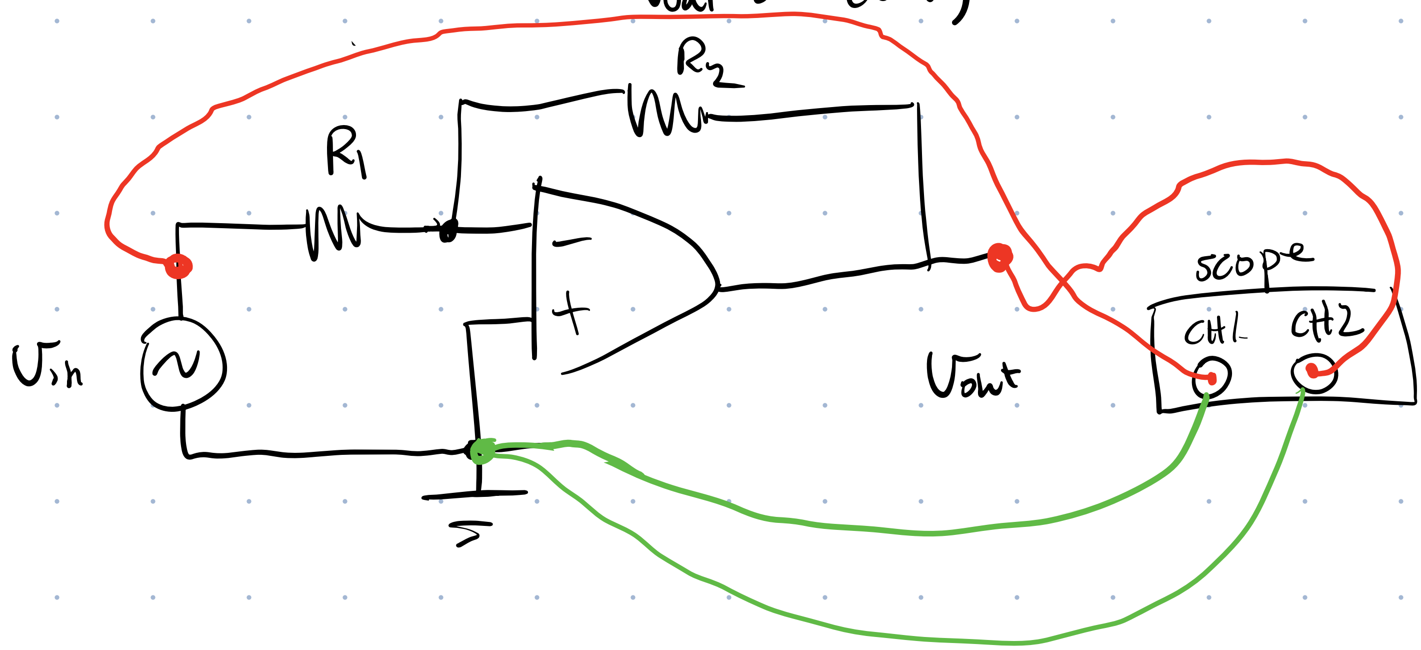
Op Amps come packaged as a chip.

Pins 1, 5, 8
we will not use.



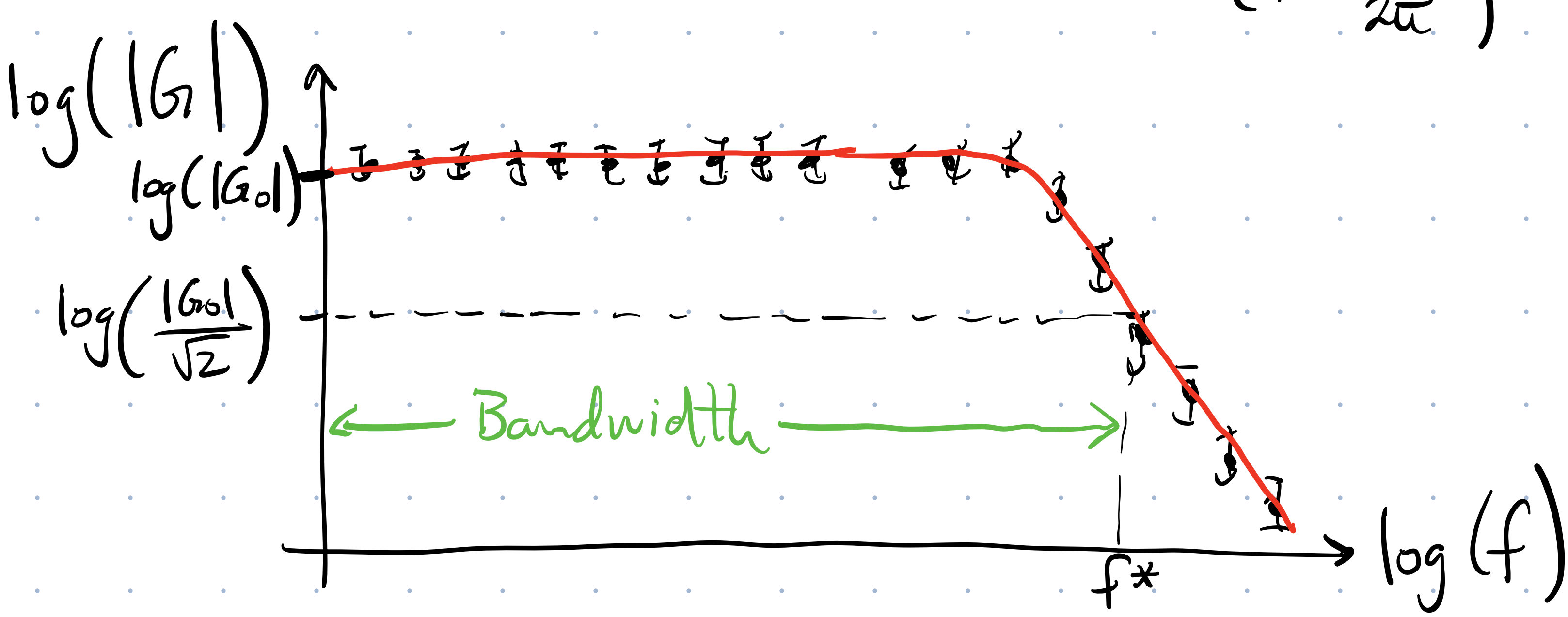
In Lab # 5, we will use a fcn gen. to provide
$v_{in} = V_{in} \sin(\omega t)$.

Meas. v_{in} & $v_{out} = -V_{out} \sin(\omega t)$



Meas. amplitude of v_{in} (V_{in}) and amp. of v_{out} (V_{out}) as a fcn of frequency f.

$$\left(f = \frac{\omega}{2\pi}\right)$$



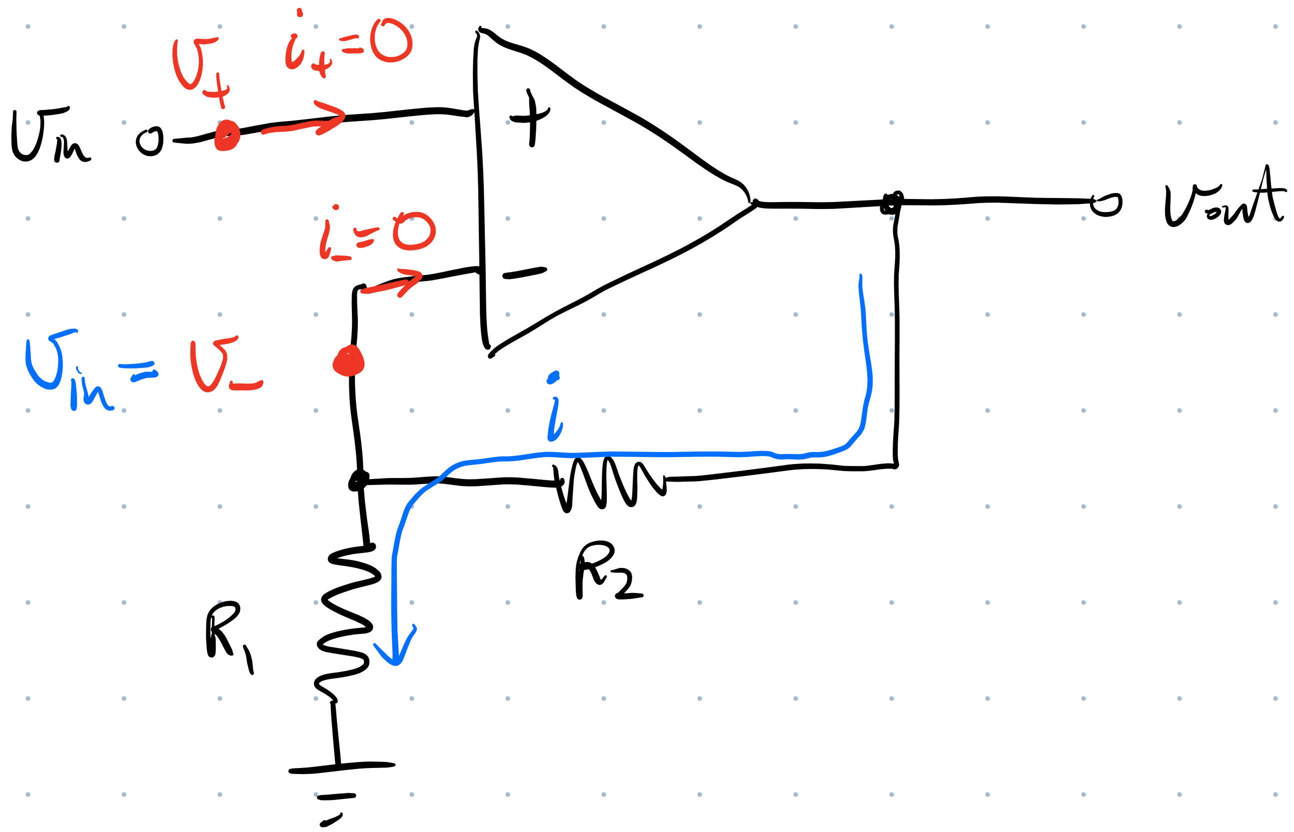
At low enough freq. the $|G| = \frac{V_{out}}{V_{in}}$ is const. (indep. of f).

However, as freq is increased, eventually reach a point at which the gain decreases.

We define the "bandwidth" of the amplifier as the freq. f^* at which the gain falls to $\frac{1}{\sqrt{2}}$ of the low-freq. value.

The bandwidth (BW) $0 < BW < f^*$ defines the useful freq. range over which the amplifier behaves well.

Another Op amp Application



GR#1. $i_- = i_+ = 0 \Rightarrow R_1$ & R_2 have same current i.

GR #2. $v_- = v_+$

$$v_+ = v_{in} \quad \therefore \quad v_- = v_{in}$$

Track volt. changes from v_- to gnd.

$$v_{in} - iR_1 = 0 \Rightarrow \boxed{i = \frac{v_{in}}{R_1}}$$

Track volt. changes from v_{out} to gnd.

$$v_{out} - iR_1 - iR_2 = 0$$

$$\therefore v_{out} = i(R_1 + R_2)$$

$$\therefore v_{out} = \frac{v_{in}}{R_1}(R_1 + R_2)$$

$$\therefore v_{out} = \left(1 + \frac{R_2}{R_1}\right) v_{in}$$

Another amplifier w/ gain $G = 1 + \frac{R_2}{R_1}$

b/c v_{out} & v_{in} have the same sign, this is a non-inverting amplifier.

Min. possible gain of non inverting amp. is +1.