Distortion

$+V_{cc} = +5\text{V}$

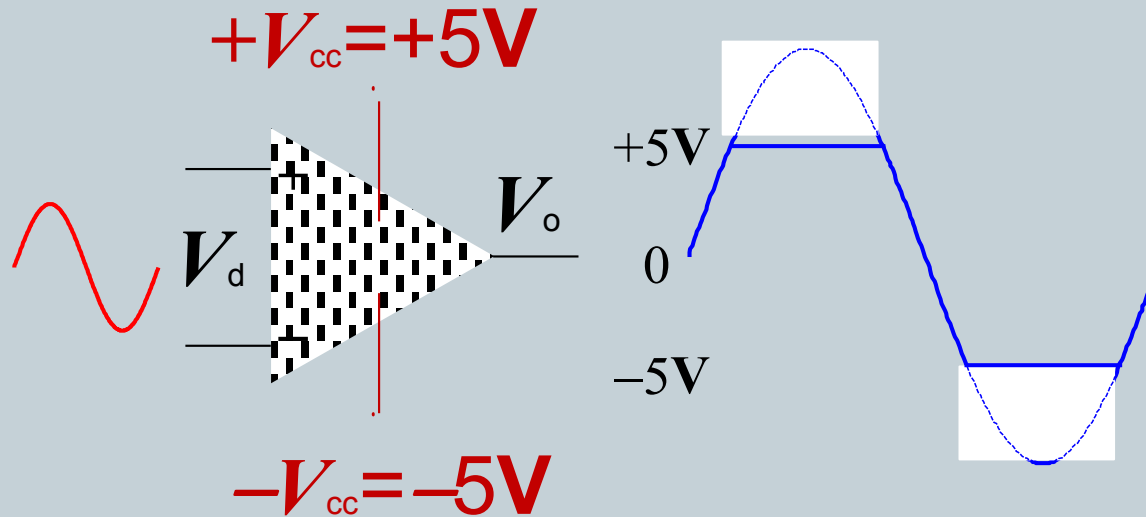V_d

V_o

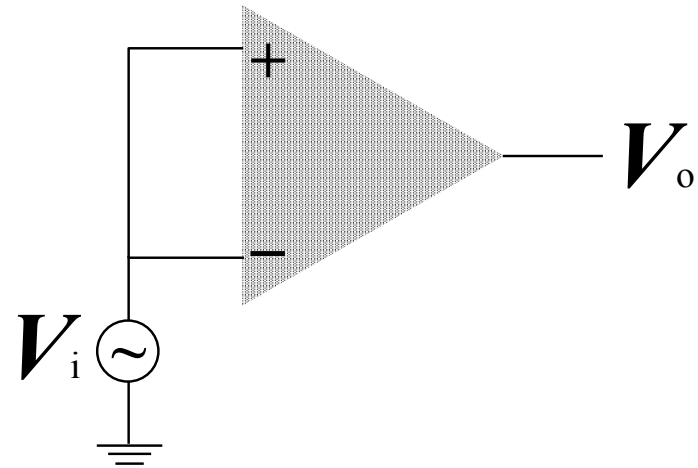$-V_{cc} = -5\text{V}$

$+5\text{V}$

0

-5V

The output voltage never excess the DC voltage supply of the Op-Amp

Common-Mode Operation

- Same voltage source is applied at both terminals

- Ideally, two input are equally amplified

- Output voltage is ideally zero due to differential voltage is zero

- Practically, a small output signal can still be measured

V_i ⊗

V_o

Note for differential circuits:
Opposite inputs : highly amplified
Common inputs : slightly amplified

$\Rightarrow$ Common-Mode Rejection

Common-Mode Rejection Ratio (CMRR)

Differential voltage input :

$$V_d = V_+ - V_-$$

Common voltage input :

$$V_c = \frac{1}{2}(V_+ + V_-)$$
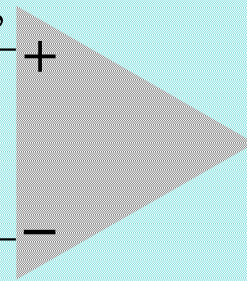
Output voltage :

$$V_o = G_d V_d + G_c V_c$$

G_d : Differential gain
G_c : Common mode gain

Noninverting
Input $\quad$ +

$\quad$ Output

Inverting $\quad$ −
Input

Common-mode rejection ratio:

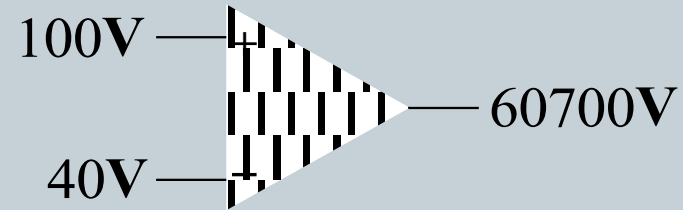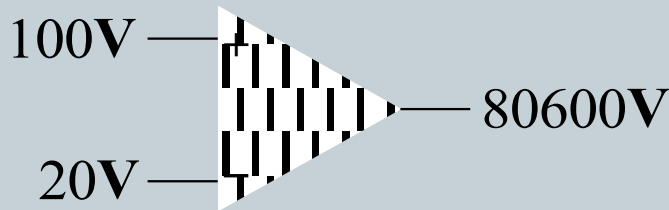$$\text{CMRR} = \frac{G_d}{G_c} = 20\log_{10}\frac{G_d}{G_c}\,(\text{dB})$$

Note:
When $G_d \gg G_c$ or $\text{CMRR} \to \infty$
$\Rightarrow V_o = G_d V_d$

CMRR Example

What is the CMRR?

100V ——[▷]—— 80600V
20V ——[▷]

100V ——[▷]—— 60700V
40V ——[▷]

Solution :

$$\left.\begin{array}{l} V_{d1} = 100 - 20 = 80\textbf{V} \\ V_{c1} = \dfrac{100 + 20}{2} = 60\textbf{V} \end{array}\right\} \text{(1)}$$

$$\left.\begin{array}{l} V_{d2} = 100 - 40 = 60\textbf{V} \\ V_{c2} = \dfrac{100 + 40}{2} = 70\textbf{V} \end{array}\right\} \text{(2)}$$

From (1) $V_o = 80G_d + 60G_c = 80600\textbf{V}$

From (2) $V_o = 60G_d + 70G_c = 60700\textbf{V}$

$G_d = 1000$ **and** $G_c = 10$ $\Rightarrow$ **CMRR** $= 20\log(1000/10) = 40\textbf{dB}$

NB: This method is Not work! Why?