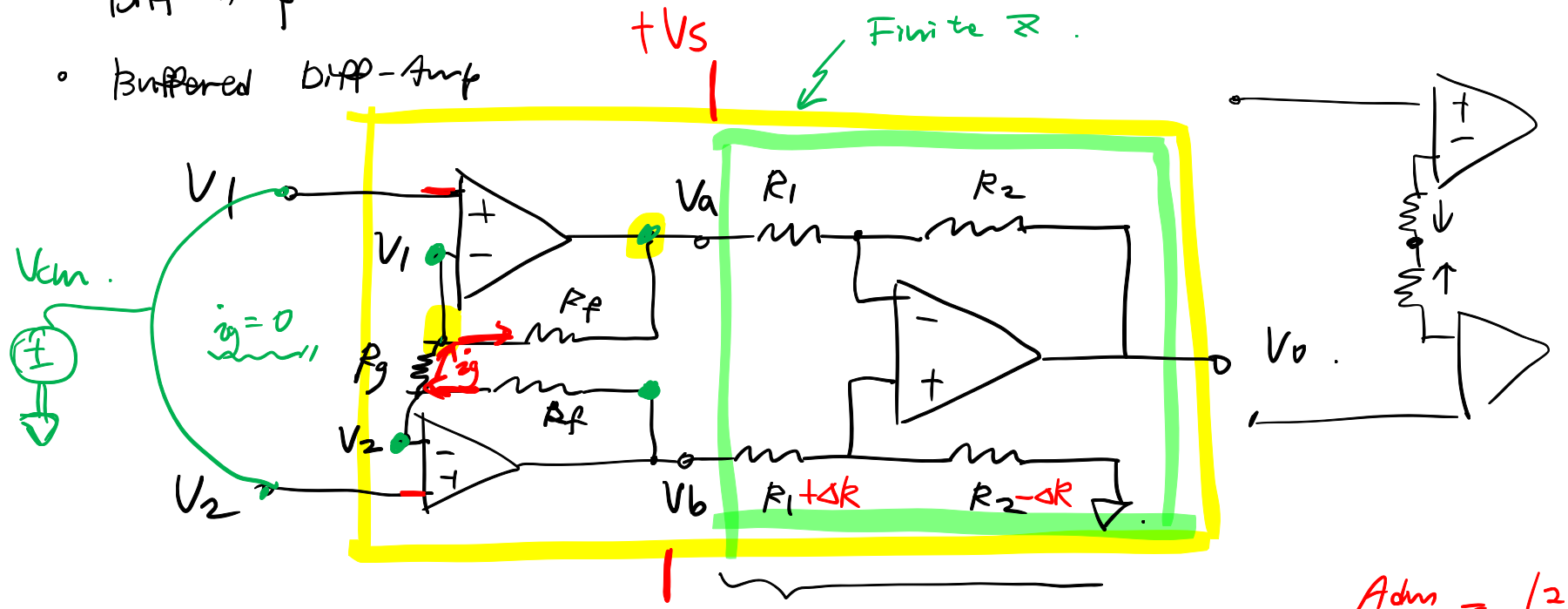
L12 – In-Amp/op-amp non-idealities

- Diff-Amp
- Buffered Diff-Amp



$A_{dm} \doteq \frac{R_2}{R_1}$ $\quad A_{cm} \neq 0$

$\left(A_{dm} \approx \frac{R_2}{R_1} \quad A_{cm} \approx 0\right)$

$\frac{A_{dm}}{A_{cm}} = 120\,dB$

10^6

- $i_g = \frac{V_2 - V_2}{R_g}$
- $V_a = V_1 - R_f i_g = V_1 - \frac{R_f}{R_g}(V_2 - V_1) = \left(\frac{R_g + R_f}{R_g}\right) V_1 - \frac{R_f}{R_g} V_2$
- $V_b = V_2 + R_f i_g = V_2 + \frac{R_f}{R_g}(V_2 - V_1) = -\frac{R_f}{R_g} V_1 + \left(\frac{R_g + R_f}{R_g}\right) V_2$

$$\Rightarrow \quad V_o = A_{dm}(V_b - V_a) + A_{cm}\left(\frac{V_b + V_a}{2}\right)$$

1.

$$= A_{dm}\left(\frac{R_g + 2R_f}{R_g}\right)(V_2 - V_1) + A_{cm}\left(\frac{R_g}{R_g}\right)\left(\frac{V_2 + V_1}{2}\right)$$

< In-Amp >

< Diff - Amp >

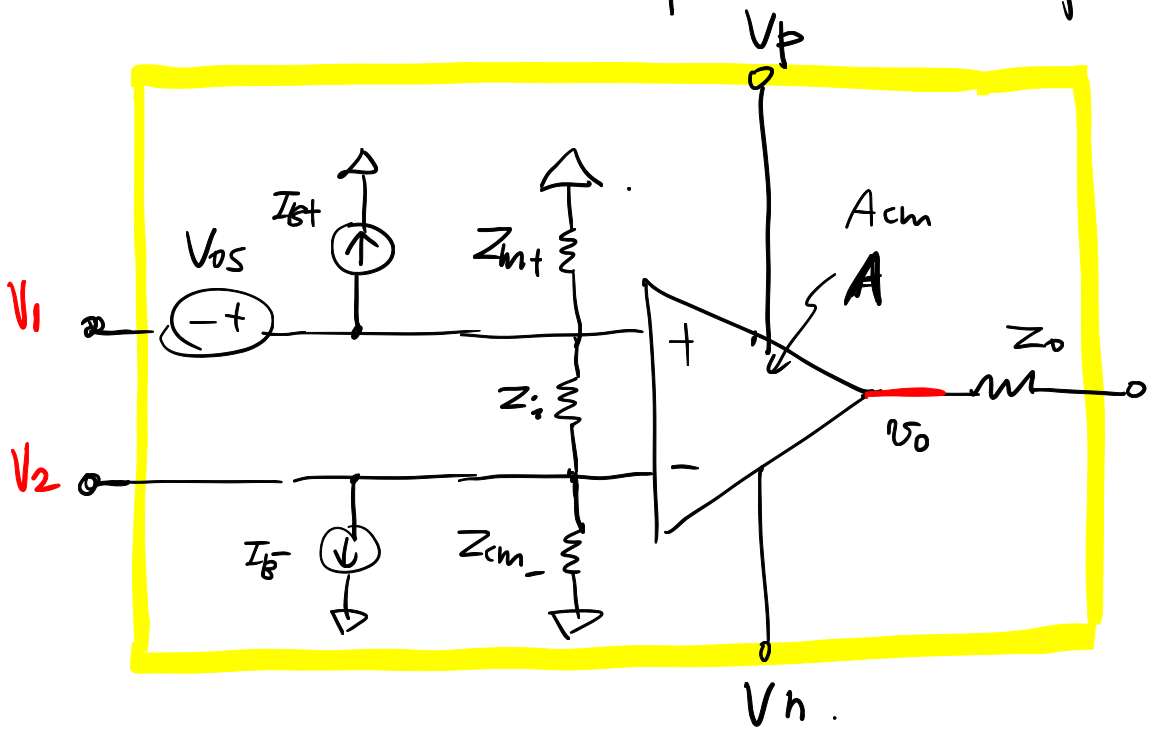
$$CMRR = \frac{A_{dm}}{A_{cm}} = \frac{A_{dm}}{A_{cm}}\left(\frac{R_g + 2R_f}{R_g}\right) \quad \underline{Vs.} \quad CMRR = \frac{A_{dm}}{A_{cm}}$$

R_g : Gain resistor. $R_g \to \infty$.

1

- There exist single-chip in-amp., $R_1 = R_2$.
- $\underline{R_g}$ for gain tuning.
- $\underline{Vs}$. Diff-Amp. { Benefit : High input Z.
  Downside : V_{cm} should < Vs

< Non Idealities of op-Amp / In-Amp >.



① Voltage Gains.

$$v_o = A(v_+ - v_-) + A_{cm}\left(\frac{v_+ + v_-}{2}\right) + A_p \Delta V_p + A_n \Delta V_n .$$

- $CMRR = \frac{A}{A_{cm}}$.
- $PSRR_+ = \frac{A}{A_p}$ $\quad PSRR_- = \frac{A}{A_n}$.

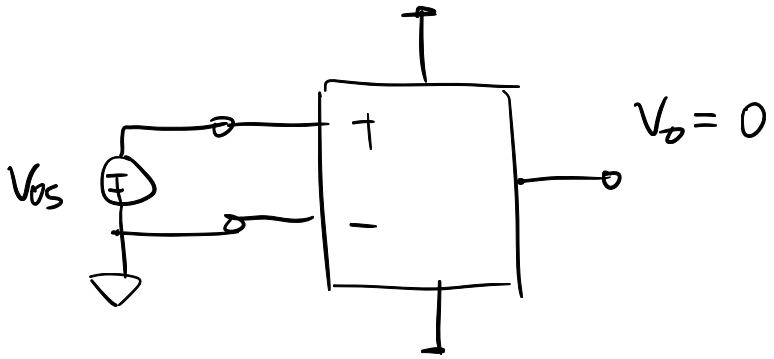
② Input Voltage Range : $V_{min} < V_{1,2} < V_{max}$.

$\simeq V_n + \Delta$ $\simeq V_p - \Delta$

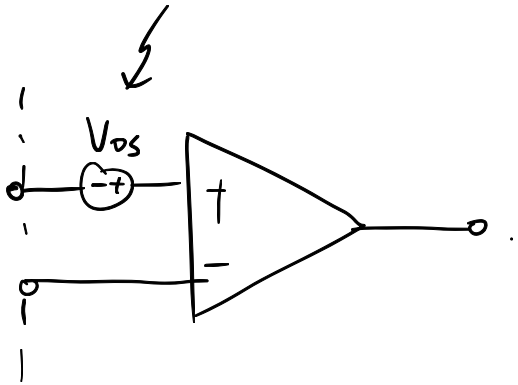
$\Rightarrow$ "Clipping"

Output : $V_{min} < V_o < V_{max}$.

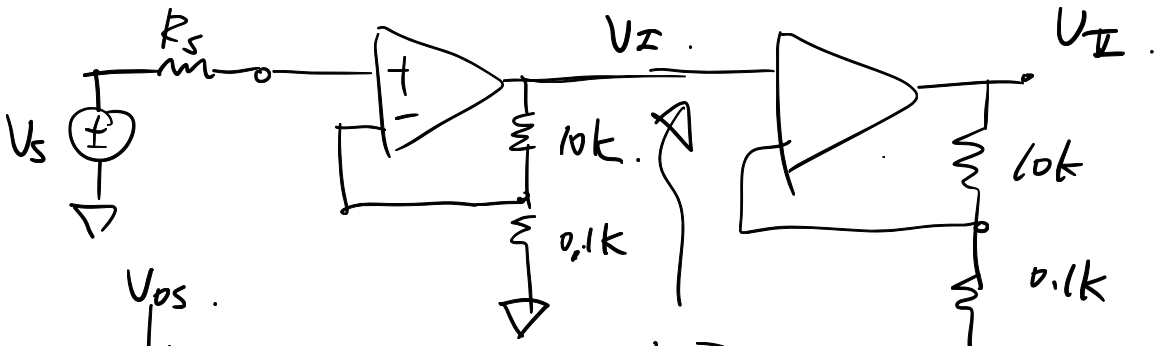
③ Input offset Voltage.

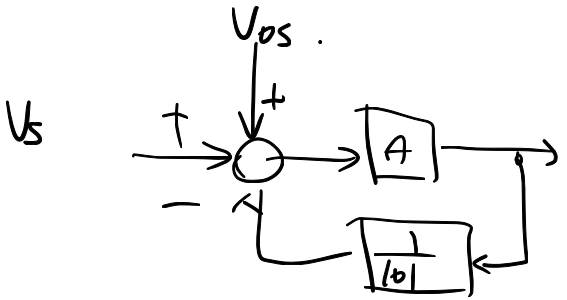


$\Rightarrow$

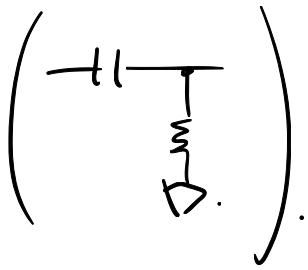


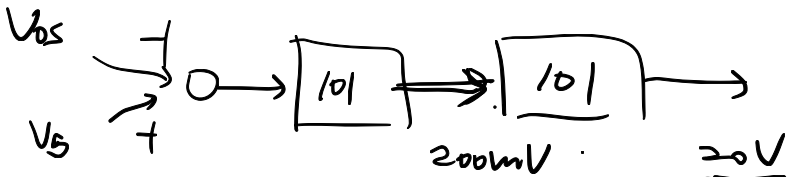
Example. Microphone Amp.





H.F "Ac-coupling"





$V_{OS} \simeq 2mV$