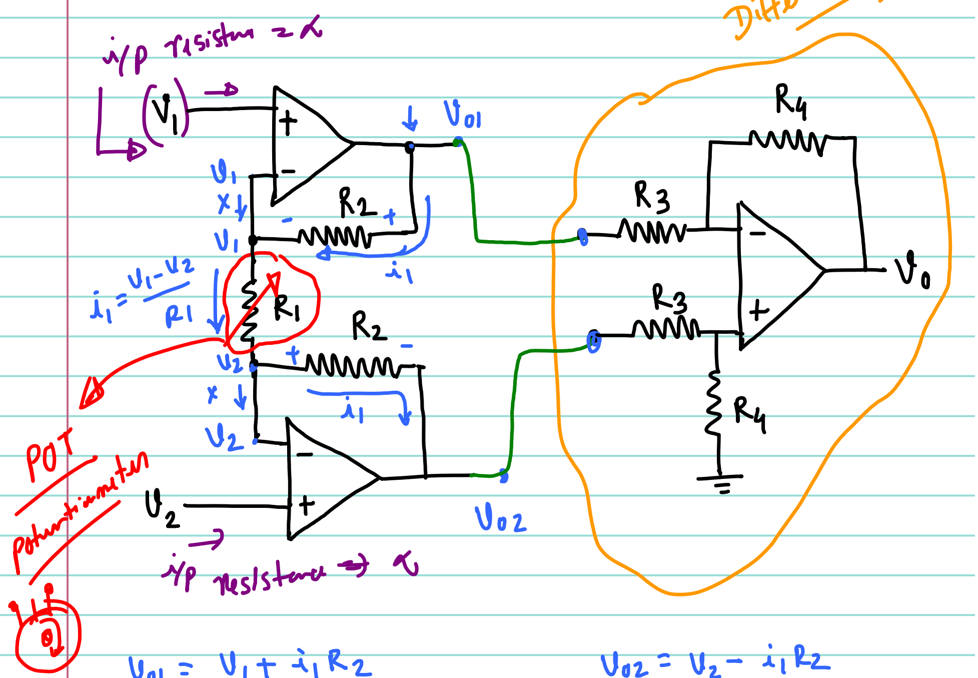
Lec-27

Instrumentation Amplifier:



$V_{o1} = V_1 + i_1 R_2$

$V_{o1} = V_1 + \frac{V_1 - V_2}{R_1} \cdot R_2$

$V_{o2} = V_2 - i_1 R_2$

$V_{o2} = V_2 - \frac{V_1 - V_2}{R_1} \cdot R_2$

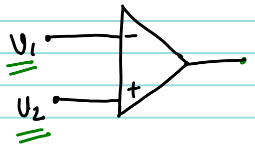
$$V_o = \frac{R_4}{R_3}\left(V_{o2} - V_{o1}\right) = \frac{R_4}{R_3}\left(V_2 - \frac{V_1 - V_2}{R_1} \cdot R_2 - V_1 - \frac{V_1 - V_2}{R_1} \cdot R_2\right)$$

$$\Rightarrow V_o = \underbrace{\frac{R_4}{R_3}\left[V_2 - V_1\right]}\ \underbrace{\left[1 + \frac{2R_2}{R_1}\right]}$$

by changing only this R_1, you can change the overall gain.

i/p resistance is also '∞' (very high.)

Common mode rejection ratio: (CMRR)

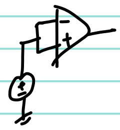


differential gain

$V_o = A_{od}(V_2 - V_1) = A_{od}\, V_{id}$

if, $V_1 = V_2$, o/p will be '0'

$A_{cm} \rightarrow$ common mode gain.



Common mode signal is generally defined as $= \left(\frac{V_1+V_2}{2}\right)$

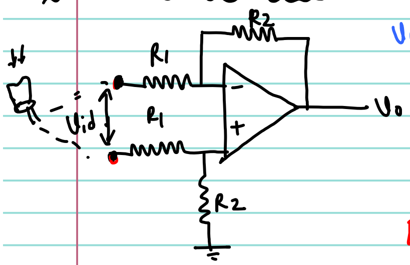
CMRR value is quite high., so it is expressed in 'dB'

$$CMRR = \left|\frac{A_d}{A_{cm}}\right| \quad ; \text{ ideally, } A_{cm} = 0$$

$$CMRR \text{ in dB} = 20 \log \left|\frac{A_d}{A_{cm}}\right|$$

Example

for a Diffrence Amp:



$V_o = \frac{R_2}{R_1}(V_2 - V_1) = \frac{R_2}{R_1} V_{id} \qquad \left(\frac{V_o}{V_{id}} = \frac{R_2}{R_1}\right)$

$V_{id} = 50\,mV$

$R_2 = 10 R_1$

$CMRR = 90\,dB$

50 Hz Noise (common to both i/ps)

Amplitude = 5 mV

Find out common mode o/p voltage.

$$CMRR = 90\,dB = 20 \log_{10}\left(\frac{A_d}{A_{cm}}\right) dB$$

$$\frac{A_d}{A_{cm}} = 10^{4.5} \cong 31{,}622$$

$\rightarrow A_d = 31{,}622 \times A_{cm}$; $A_{cm} = \frac{A_d}{31{,}622}$

$A_d = \frac{R_2}{R_1} = 10$, $\qquad A_{cm} = \frac{10}{31{,}622}$

Common mode o/p signal $= A_{cm} \times 5\,mV$

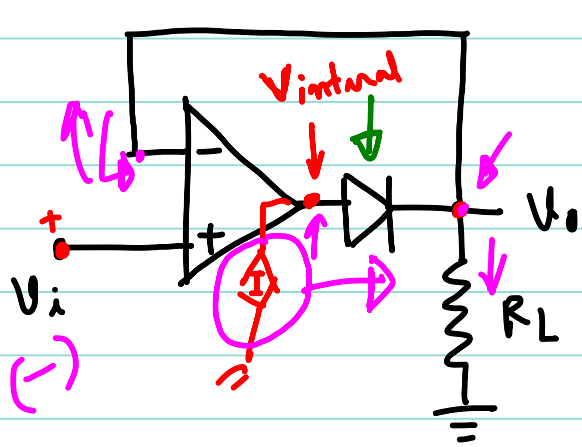
$= \frac{10}{31{,}622} \times 5\,mV$

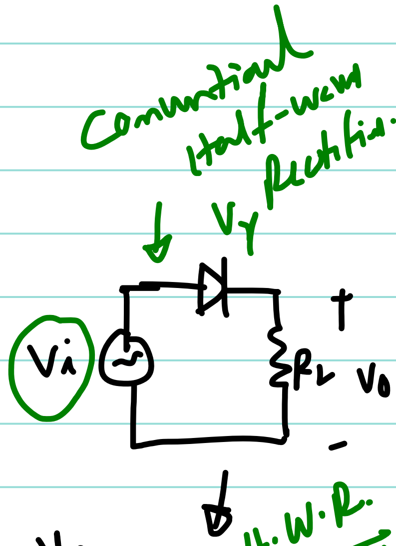
common-mode input = 5 mV

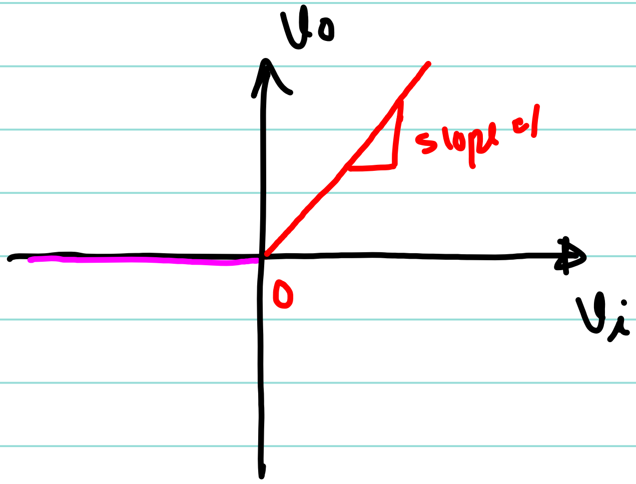
$= 1.58\,\mu V.$

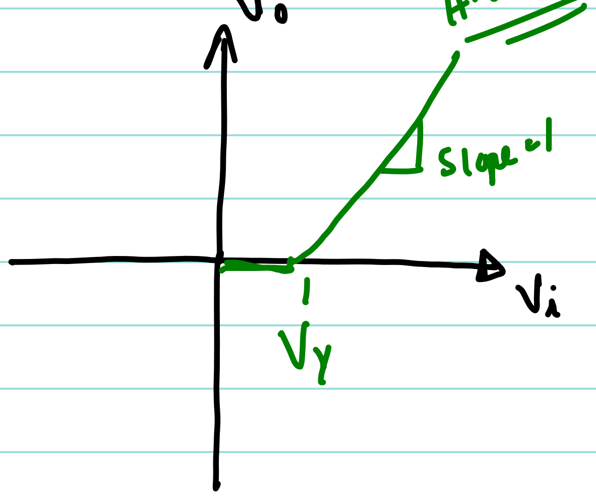
Typical values of CMRR $\rightarrow$ 70 – 100 dB.

Precision Half-Wave Rectifier:



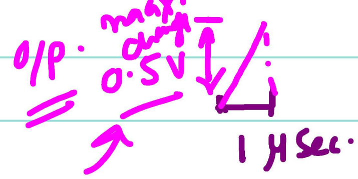




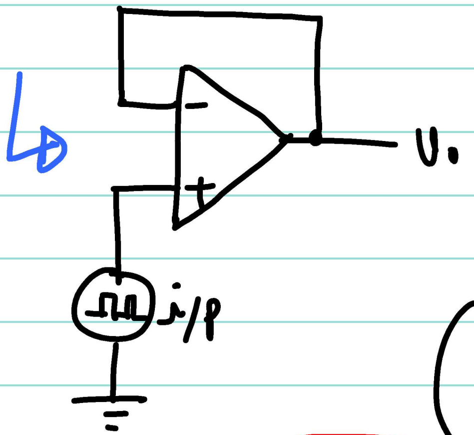


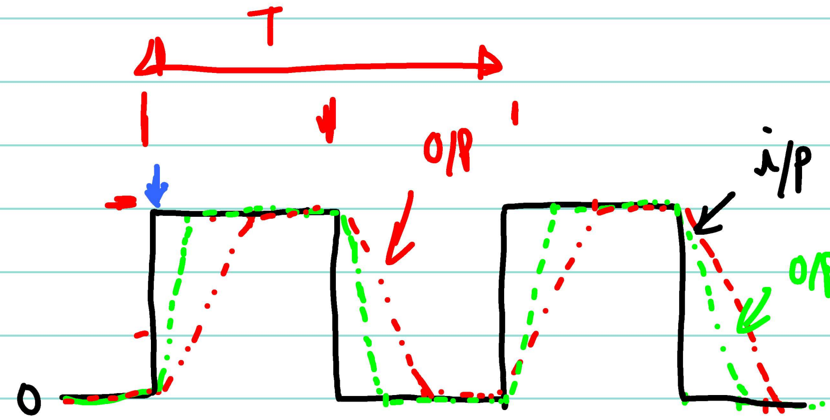
Slew Rate: Maximum rate of change in o/p voltage of an Op-Amp.

unit → V/time, V/μSec.

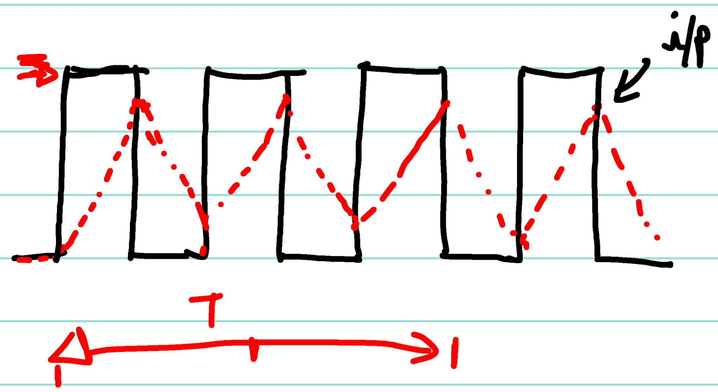


for μA 741, slew rate = 0.5 V/μSec.

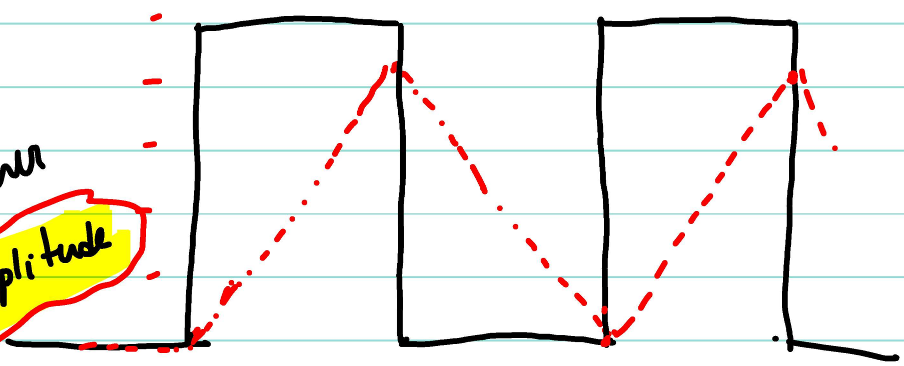


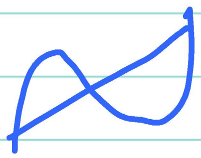


frequency of the signal increased

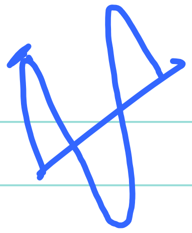


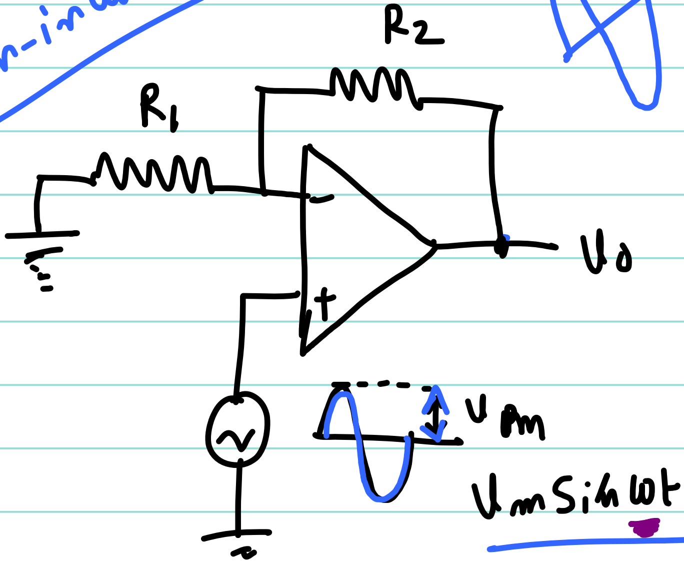
Higher Amplitude





Non-inverting Amp.





o/p

i/p signal

$$V_o = \left(1+\frac{R_2}{R_1}\right) V_m \sin \omega t$$

$$V_o = V_p \sin \omega t$$

$= V_p$

$$V_p = \left(1+\frac{R_2}{R_1}\right) V_m$$

$V_m \sin \omega_1 t$

$V_m \sin \omega_2 t$

$\omega_2 > \omega_1 > \omega$

$$V_o = V_p \sin \omega t$$

$$\frac{dV_o}{dt} = V_p \omega \cos \omega t$$

↳ rate of change of o/p. $\leq$ Slew rate (S.R.)

$$\omega V_p \cos \omega t \leq S.R.$$

$\cos \omega t$ → max. value

$\omega = 2\pi f_{max}$

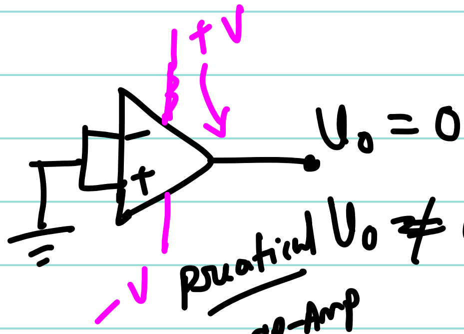
$$\omega V_p \leq S.R.$$

$$2\pi f_{max} \cdot V_p \leq S.R.$$

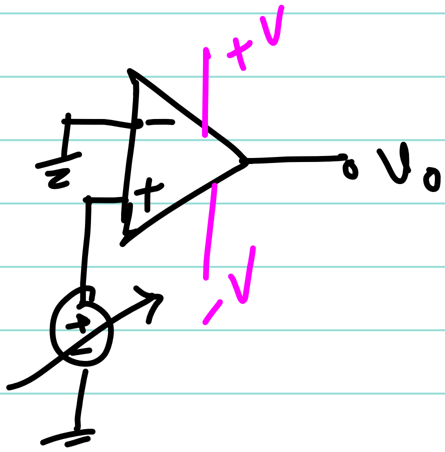
f_{max} = Full power bandwidth freq.

$$f_{max} \leq \frac{SR}{2\pi V_p}$$

OFF- Set Voltages!



practical op-Amp $V_o \neq 0$, → output dc offset voltage.



input dc offset voltage