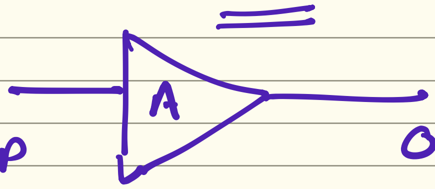
Analog Elep

05/01/24

L2

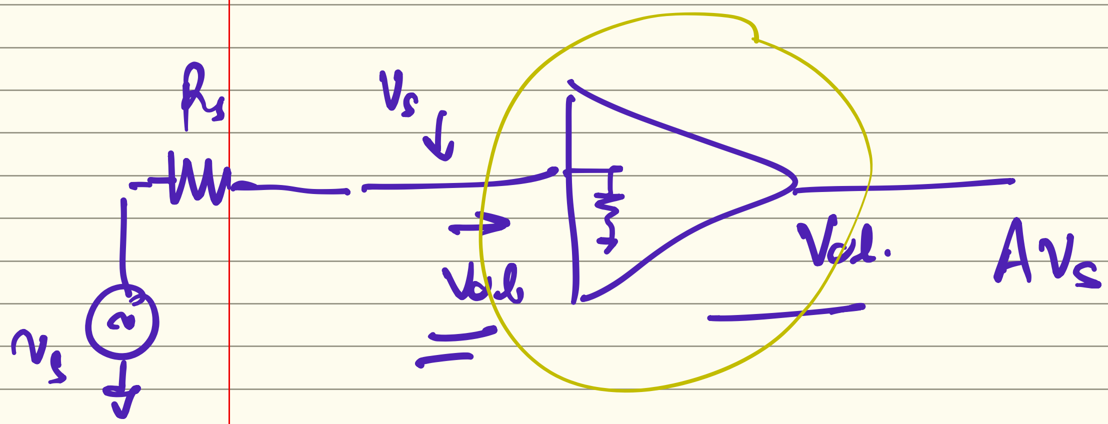
⇒

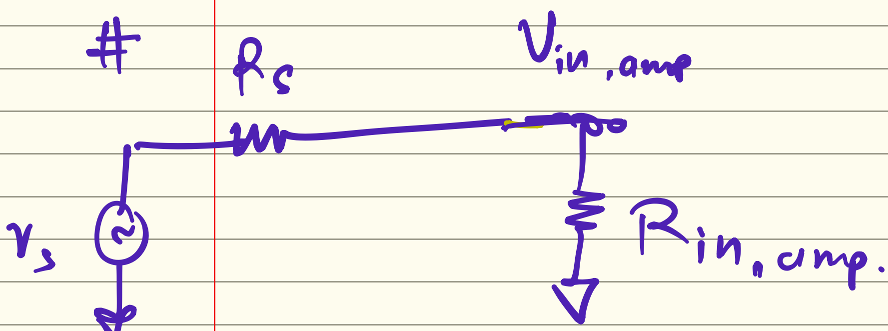


$x \to A \to A \cdot x$

Linearity

#	i/p	o/p
① :	Vol.	Vol
② :	Vol.	current
③ :	current	Vol
④ :	current	current





$$\boxed{V_{in,amp} = V_s}$$

⇒

$V_{in\,amp} \downarrow$

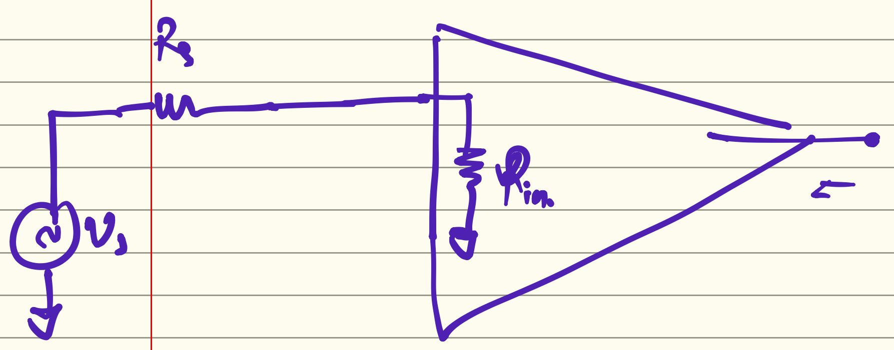
Either ⇒ $R_s = 0$

or $R_{in,amp} = \infty$

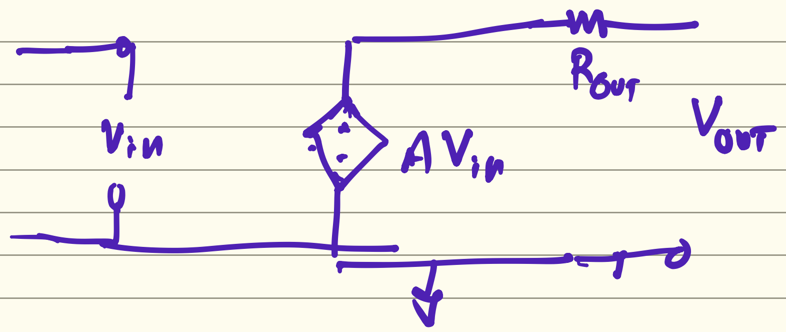
① To sense Vol at i/p

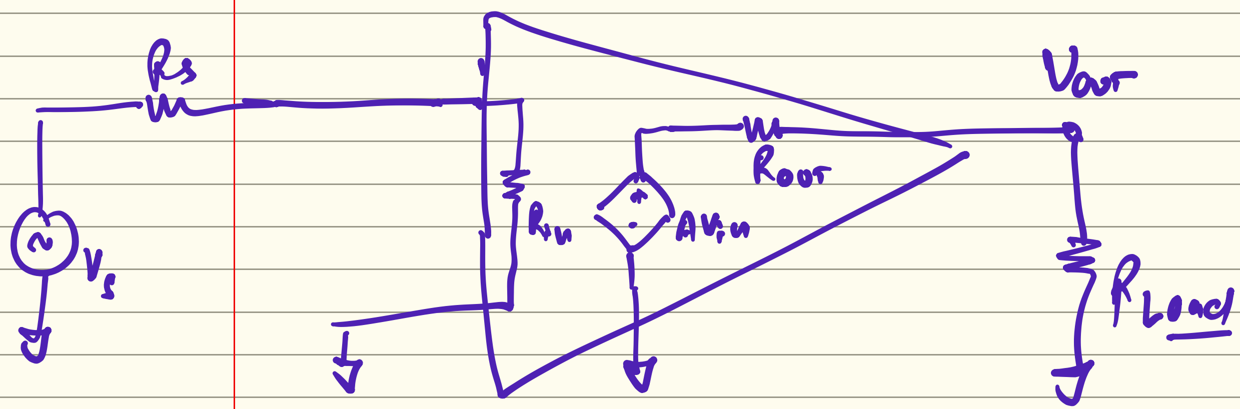
$R_{in} \Rightarrow \infty$ (or very high)

$R_{in} \ggg \underline{R_s}$



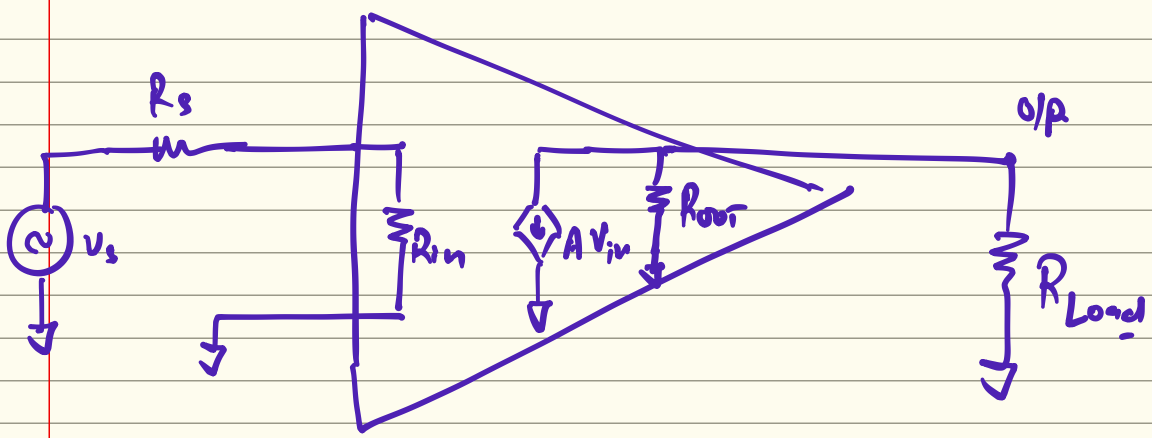
Vol amp.





$R_{in} \to \infty$ $R_{OUT} \to$ as low as possible or 0

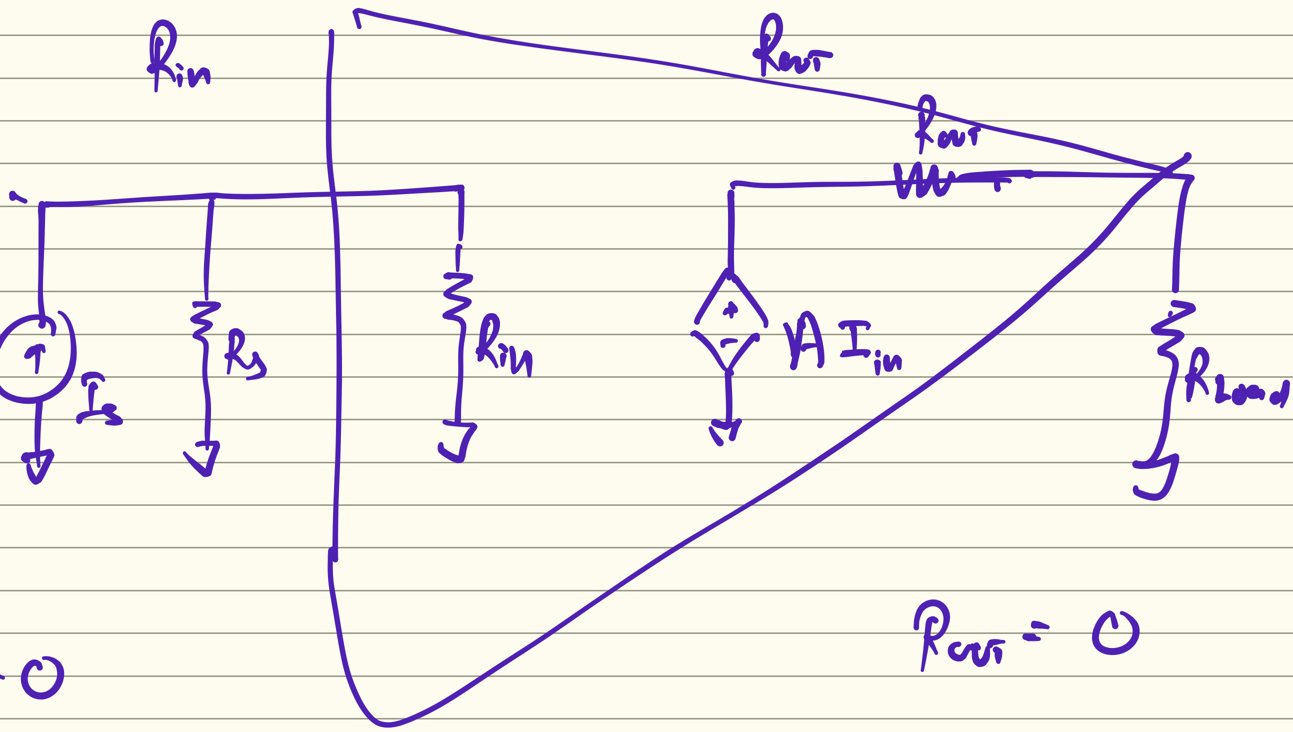
(2) → Vol Current



Vol Current

$R_{in} \Rightarrow \infty$ $R_{out} \Rightarrow \infty$

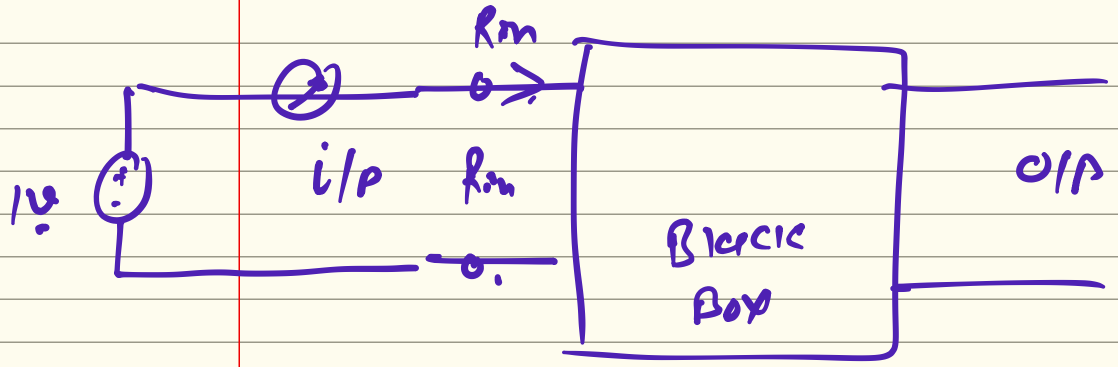
(3) → Current Vol.

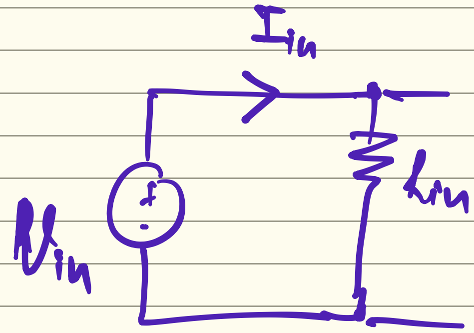


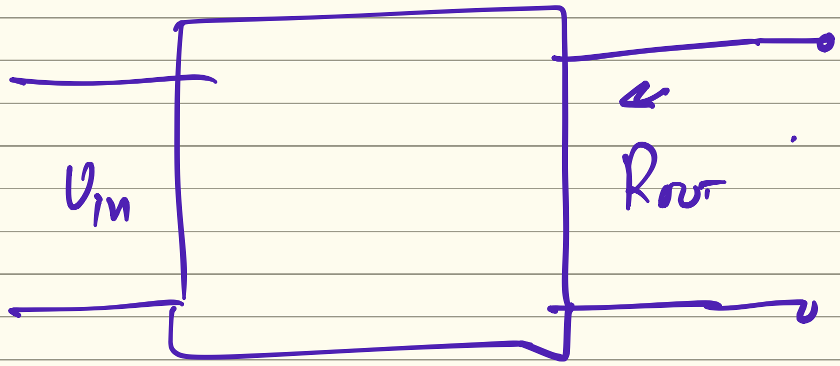
$R_{in} = 0$ $R_{out} = 0$

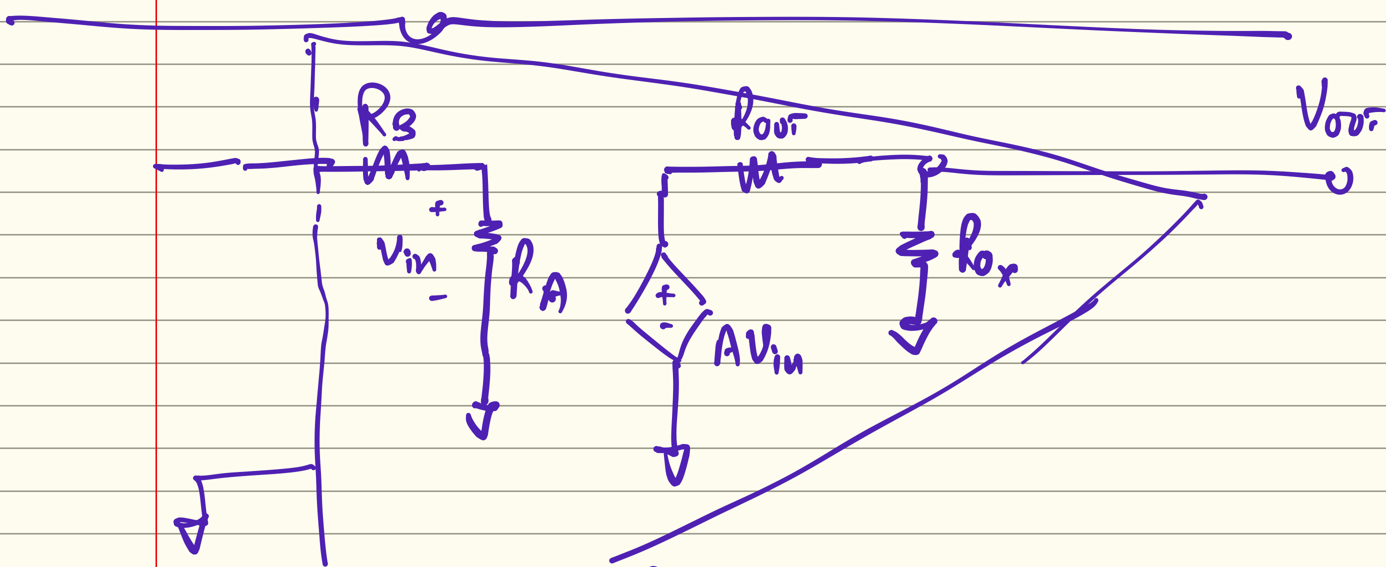
(4) Current Current

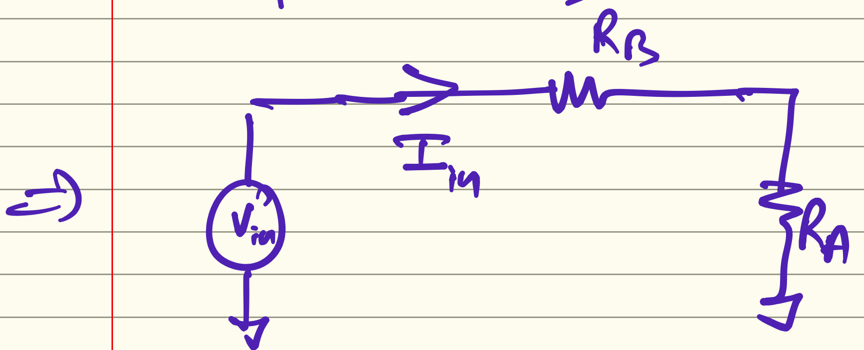
$R_{in} = 0$ $R_{out} = \infty$





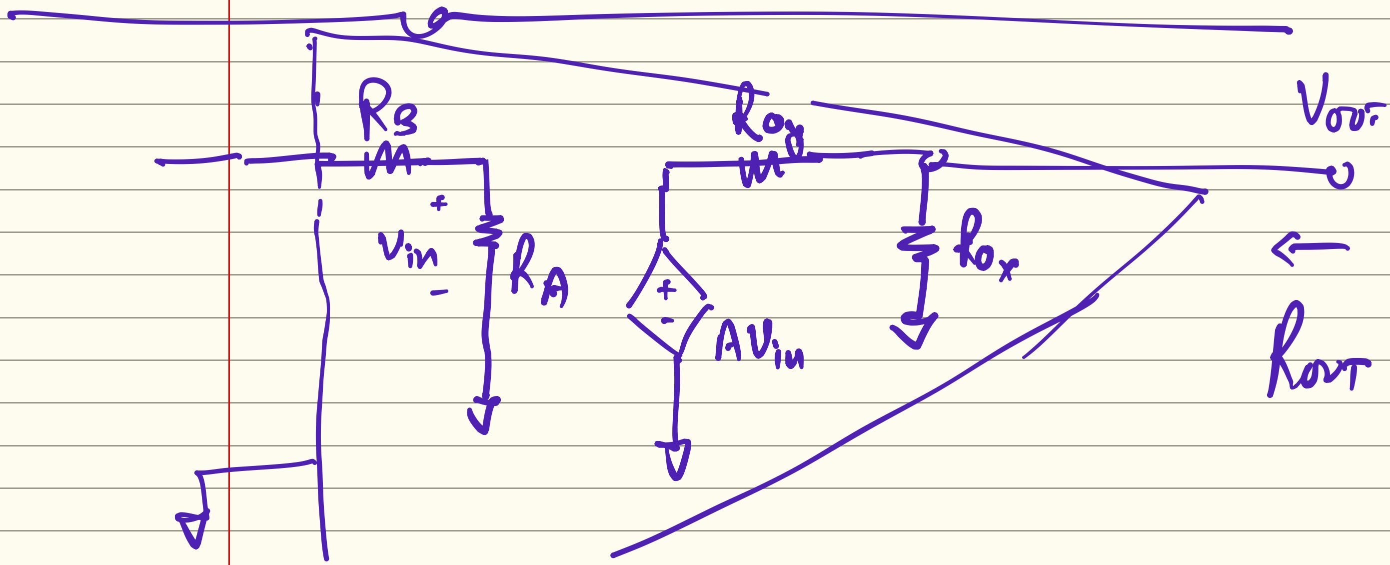


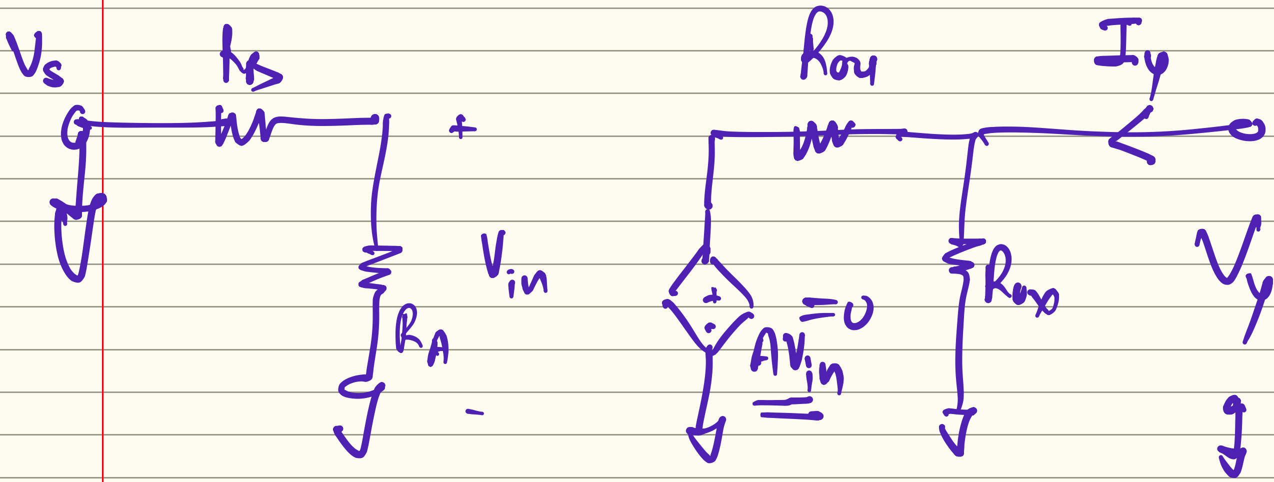


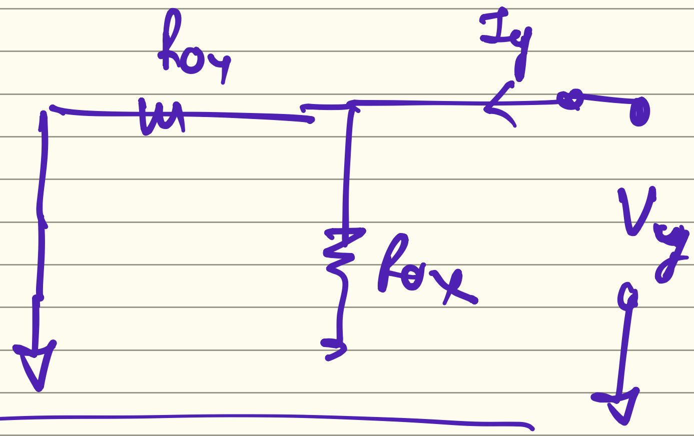


$$R_{in} = \frac{V_{in}}{I_{in}}$$

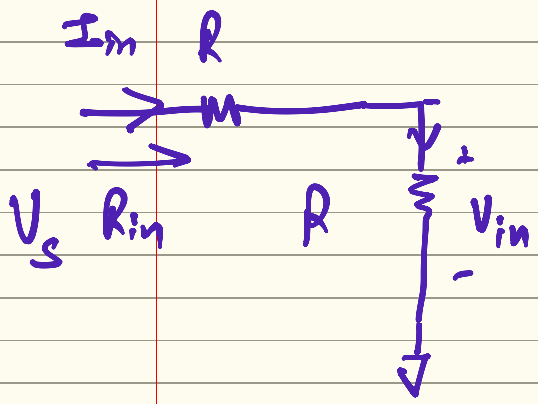
$$= \boxed{R_B + R_A}$$

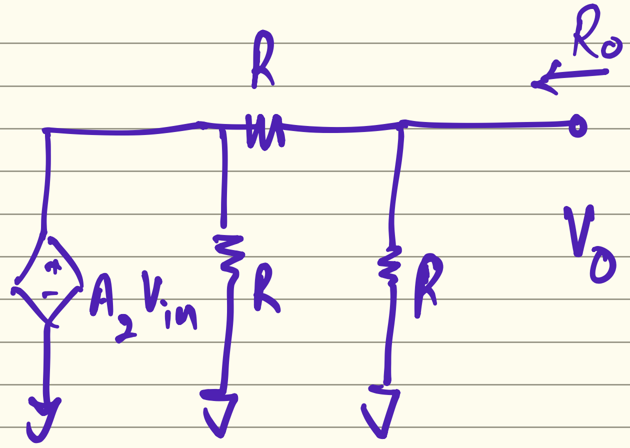






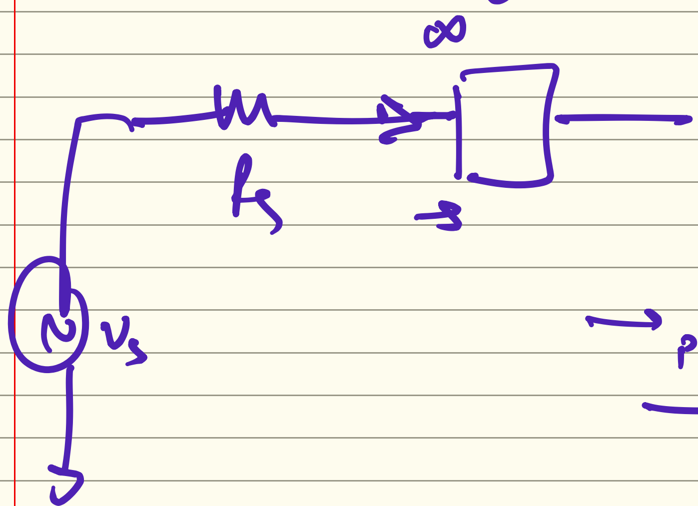
$$\boxed{\frac{V_y}{I_y} = R_{ox} \,\|\, R_{oy} = R_{OUT}}$$





$\Rightarrow$ $R_{in} = \dfrac{V_s}{I_{in}}$ $I_{in} =$

#



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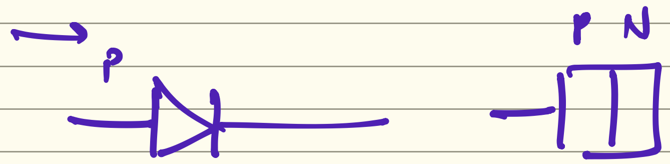

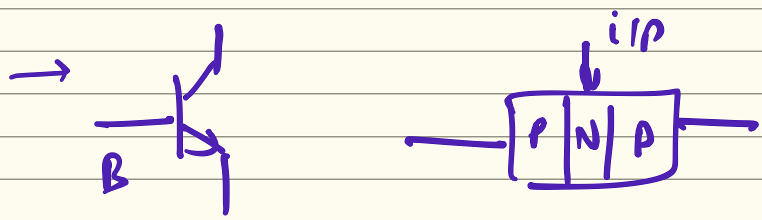

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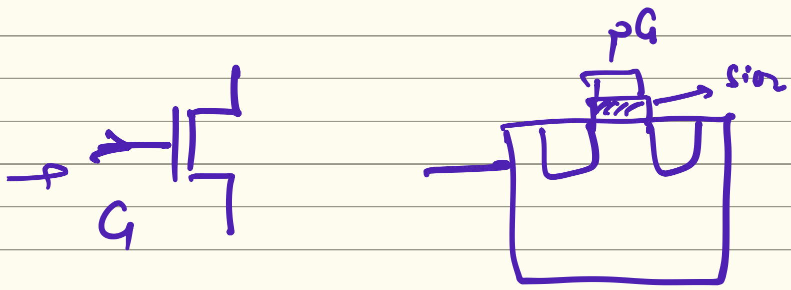
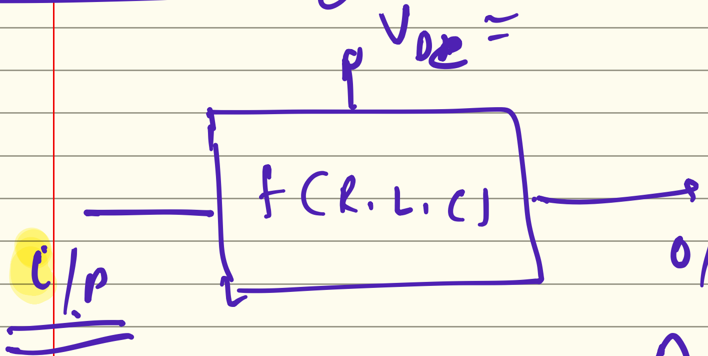


R , L , C : Diode

BJT , MOS

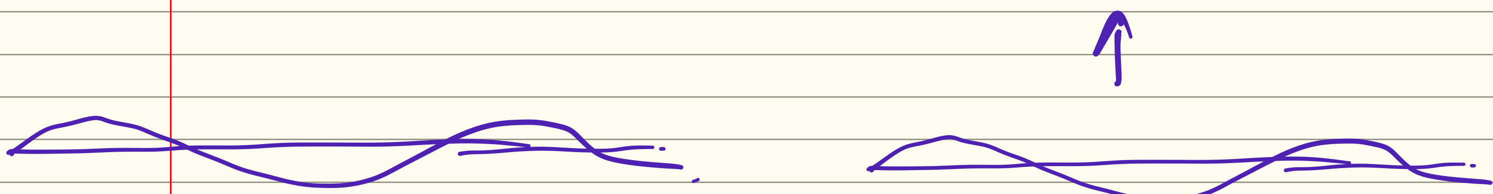
#



O/P + O/P_{DC}

A · i/p

A > 1



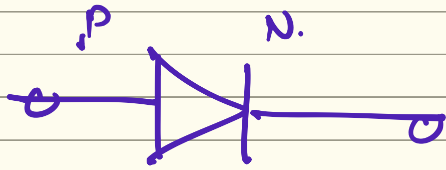
+ V_{DD}

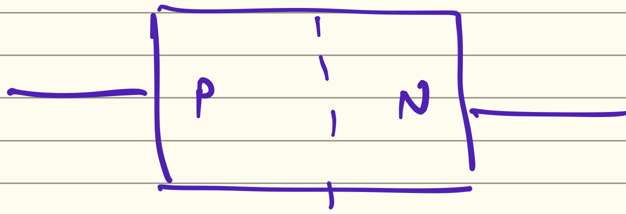
Non Linear Elements

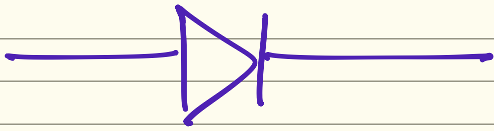
Transistor

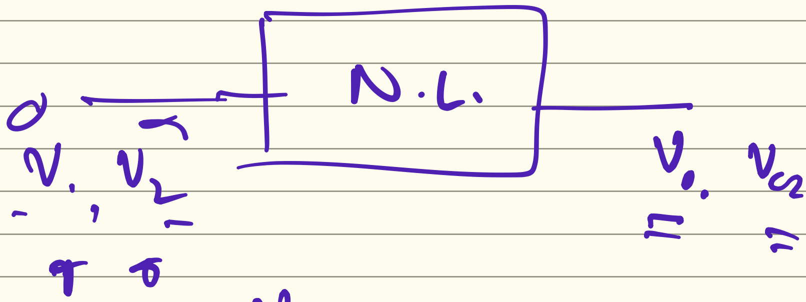
Transistor

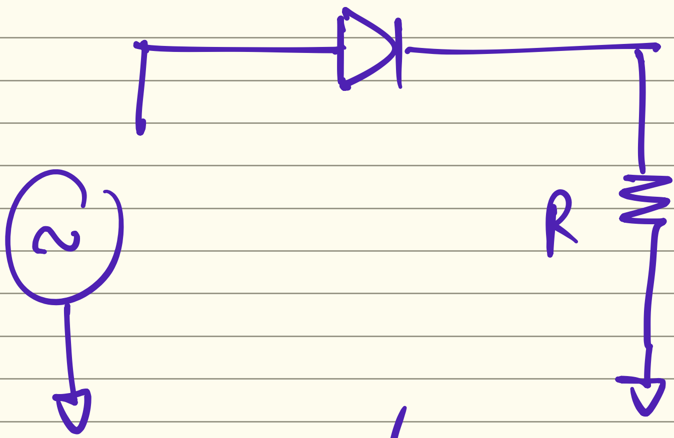
↳ **Diode**

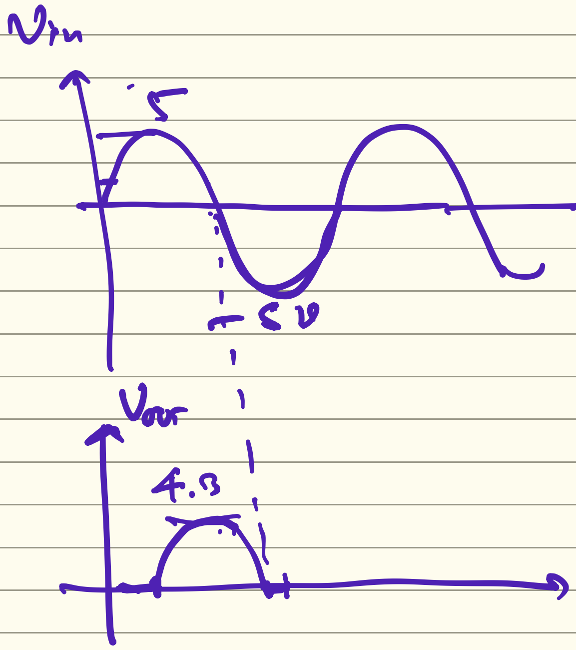


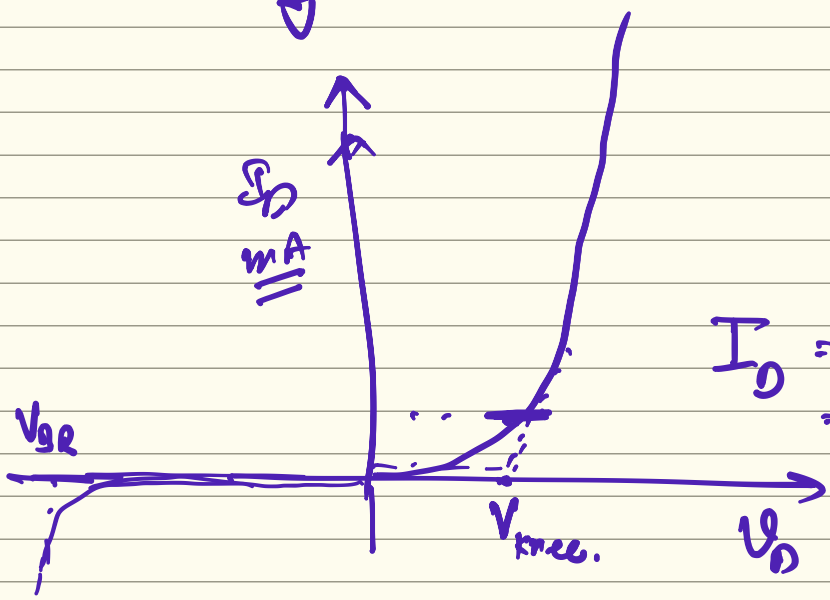












$$I_D = I_0\left(e^{V_D/V_T \cdot n} - 1\right)$$

$$I_D = I_0\left(e^{V_D/V_T} - 1\right)$$

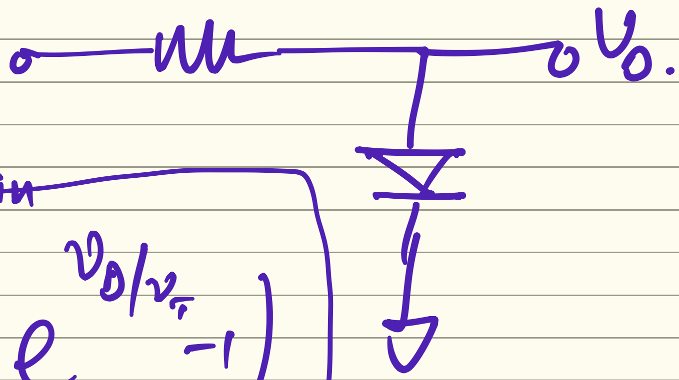
$$1\,mA = I_0\left(e^{0.7/26mV} - 1\right)$$

$$10^{-3} = I_0\left(e\right.$$

$$\frac{10^{-3}}{e}$$

$$\boxed{I_0 = 2\,fA}$$

#



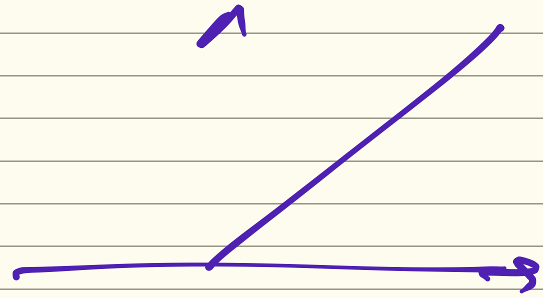
V_{in}

$$\boxed{\frac{V_{in} - V_D}{R} = I_0\left(e^{V_D/V_T} - 1\right)}$$

R = given ; $\cancel{V_{in}}$ =

V_T = 26mV

$\Rightarrow$



$$\frac{V_{in} - V_D}{R} = I_0 \left(e^{V_D / V_T} - 1\right)$$

$$\frac{V_{in} - V_D}{R} = f(V_D)$$

$$\frac{V_{in} + \Delta V_{in}}{R} - \left(\frac{V_D + \partial V_d}{R}\right) = f(V_D + \partial V_d)$$

$$f(V_D + \partial V_d) = f(V_D) + \partial V_d f'(V_D) + (\partial V_d)^2 \frac{f''(V_D)}{\lfloor 2} + \frac{(\partial V_d)^3 f'''(V_D)}{\lfloor 3} + \dots$$

(1)

H.O.T

when ∂V_d is very small

hence, $\partial V_d >> (\partial V_d)^2 >> (\partial V_d)^3 \dots$

higher order terms can be neglected

$$f(V_D + \partial V_d) = f(V_D) + \underbrace{\partial V_d f'(V_D)}_{\text{II}}$$

if II term is a linear one the whole equation becomes linear.

i.e. →

$$\frac{v_{in}+\partial v_{in}}{R}-\frac{V_D+\partial v_d}{R}=I_o\left(e^{(V_D+\partial v_d)/v_T\cdot n}-1\right)$$

$$\approx \frac{V_{in}-V_D}{R}+\frac{\partial v_{in}-\partial v_d}{R}=I_o\left(e^{V_D/n\cdot v_T}-1\right)+\frac{I_o e^{V_D/v_T\cdot n}}{v_T}\cdot\partial v_d$$

$+$ H.O.T.

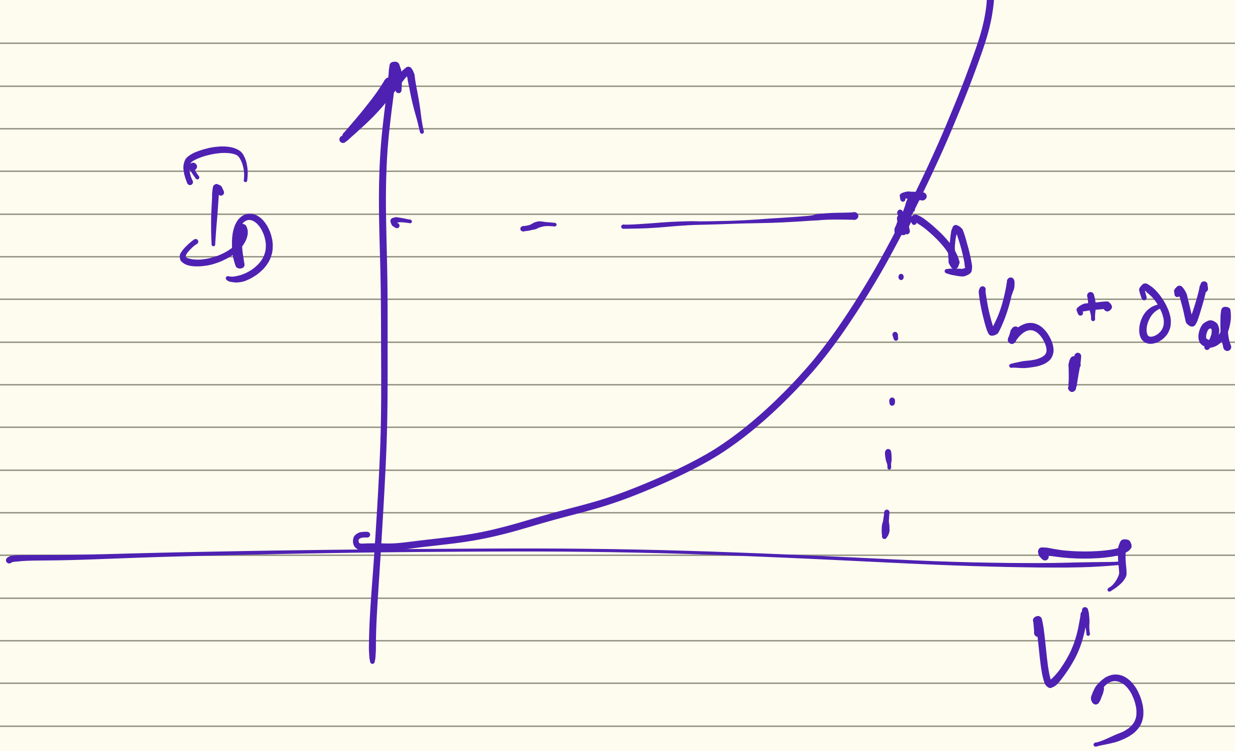
if ∂v_d is very small ⇒ H.O.T.s could be ignored.

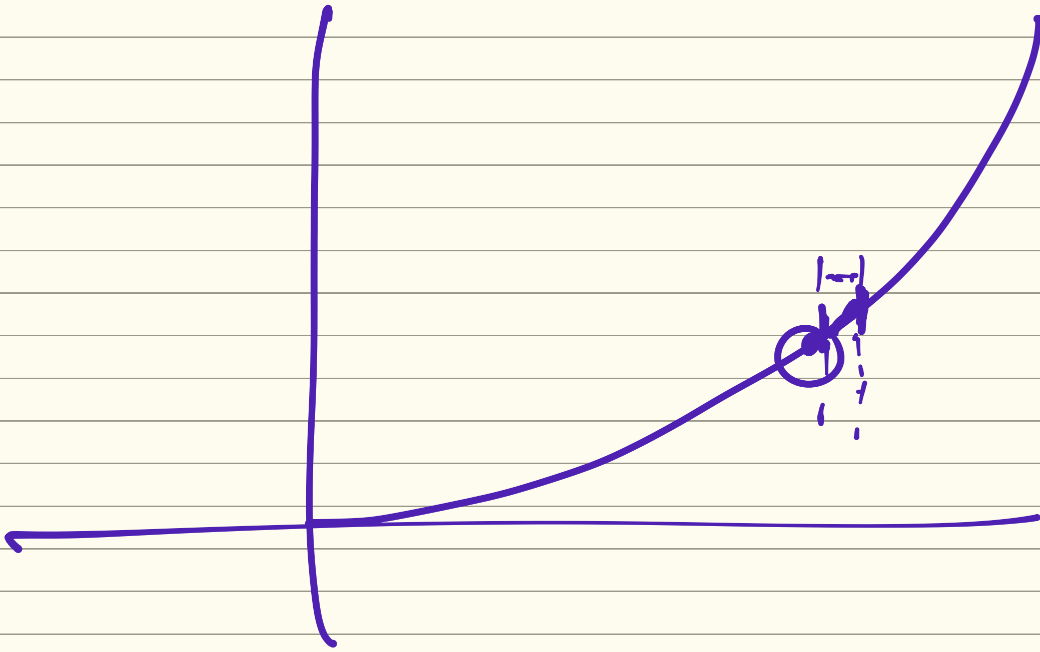
$$\Rightarrow \cancel{\frac{V_{in}-V_D}{R}}+\frac{\partial v_{in}-\partial v_d}{R}=\cancel{I_D}\Big|_{V_D}+\frac{I_D\big|_{V_D}}{v_T}\cdot\partial v_d$$

$$\Rightarrow \frac{\partial v_{in}-\partial v_d}{R}=\frac{I_D\big|_{V_D}}{v_T}\cdot\partial v_d$$

Now this is a linear equ^n

⇒ Hence, if we set ↳ Val. (V_{in}, V_D) & current $(I_D|_{V_D})$ for a non linear device & then apply small incremental change $(\partial v_{in}, \partial v_d)$ then system could be treated as linear for small range of those small incremental changes for them H.O. non linear terms are negligible. For this range of small signal i/p a non linear system could be consider as a linear only.

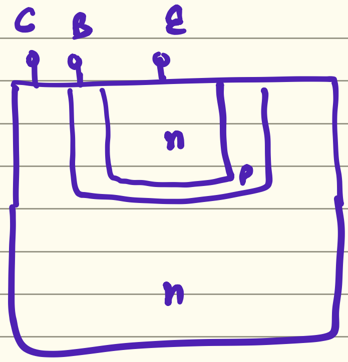

I_D
$V_{D_1} + \partial V_d$
V_D

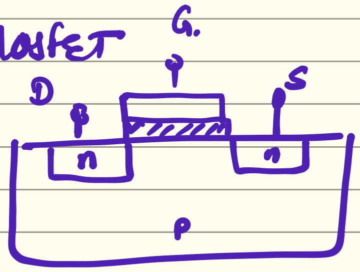


Transistors

BJTs → PNP, NPN

FETs → JFET → MOSFET





$$I_{mos} = \frac{\mu C_{ox}}{2}\frac{W}{L}(V_{GS}-V_{th})^2$$

$$\frac{\partial I_o}{\partial V_{in}} = \frac{\partial I_{mos}}{\partial V_{GS}} = G_{m_{mos}} = \mu C_{ox}\frac{W}{L}(V_{GS}-V_{th})$$

$$G_{m\,mos} = \frac{2 I_{mos}}{V_{GS}-V_{th}}$$

$$V_{GS}-V_{th} = 150-250\,mV$$

$$I_{BJT} = I_o\left(e^{V_{in}/V_T}-1\right)$$

$$\frac{\partial I_{in}}{\partial V_{in}} = \frac{\partial I_{BJT}}{\partial V_{in}} = G_{m,BJT}$$

$$= \frac{I_o}{V_T}e^{V_{in}/V_T}$$

$$\simeq \frac{I_{BJT}}{V_T}$$

$V_T = 26\,mV$ @ 27°C

Hence, for same I

$$G_{m,BJT} > G_{m\,mos}$$

Which makes BJT a better vol. amplifier as vol. amplification is directly proportional to the transconductance of an amplifier.

MOS	BJT
⇒ More Junctions → more parasitic Cap → lesser intrinsic cutoff freq (f_T) → less speed.	→ only 2 Junctions → better f_T → Better speed.
⇒ Base current is non zero (in μA) hence, i/p power is significant.	⇒ Gate current is zero (almost) hence i/p power (at gate) is zero.
⇒ Not so compatible for IC fabrication steps hence, Not a suitable candidate for VLSI Tech.	⇒ Fabrication steps are compatible for IC design. A good candidate for VLSI tech.