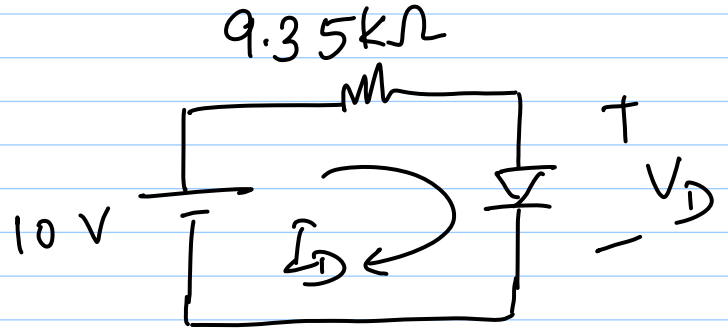
3-8-12

Lec 4

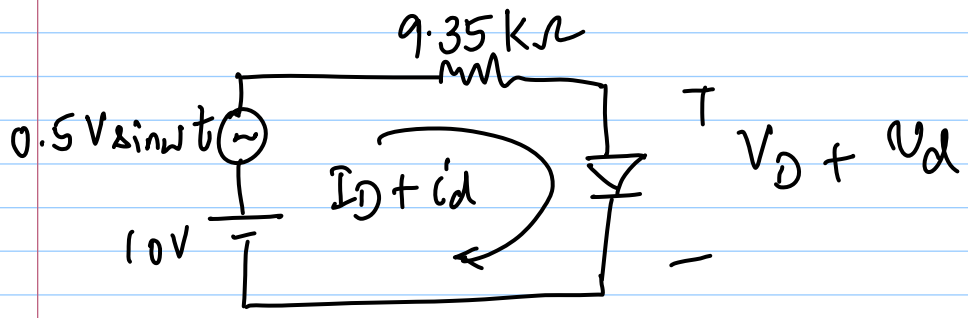


$V_D \simeq 0.65\,V$

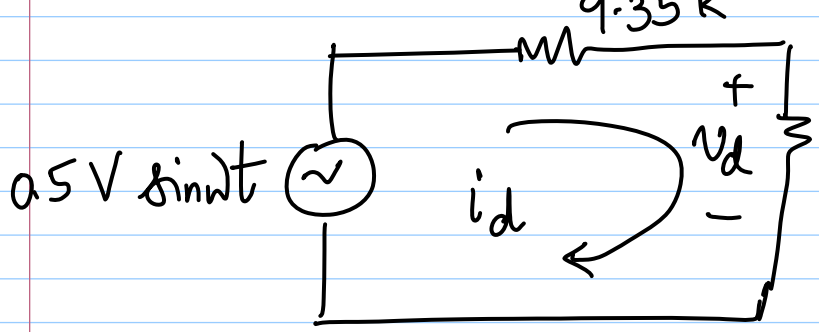
$I_D \simeq 1mA$

$r_d \simeq 25\Omega$

Say, a sinusoid is added along with the 1V source.



Incremental network



$r_d = 25\Omega$

based on earlier calculation for 1V, you can tell that

$v_d = 1.35mV \sin\omega t$

inc. network: → all elements are linear
→ no dc sources

* Inc. voltage across the diode

$$v_d = \frac{r_d}{r_d + 9.35k} \cdot 0.5V \sin\omega t$$

* Total voltage across the diode is Quiescent + Increment

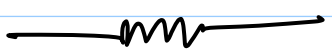
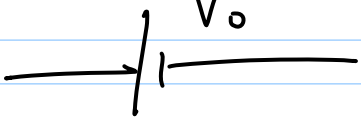
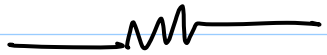
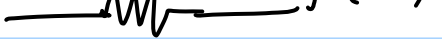
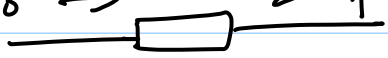
$$\simeq 0.65V + \frac{r_d}{r_d + 9.35k} \cdot 0.5V \sin\omega t$$

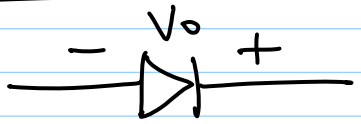
* Can be extended to network with several NL elements – replace each $r_i = \frac{1}{f_i(V_i)}$

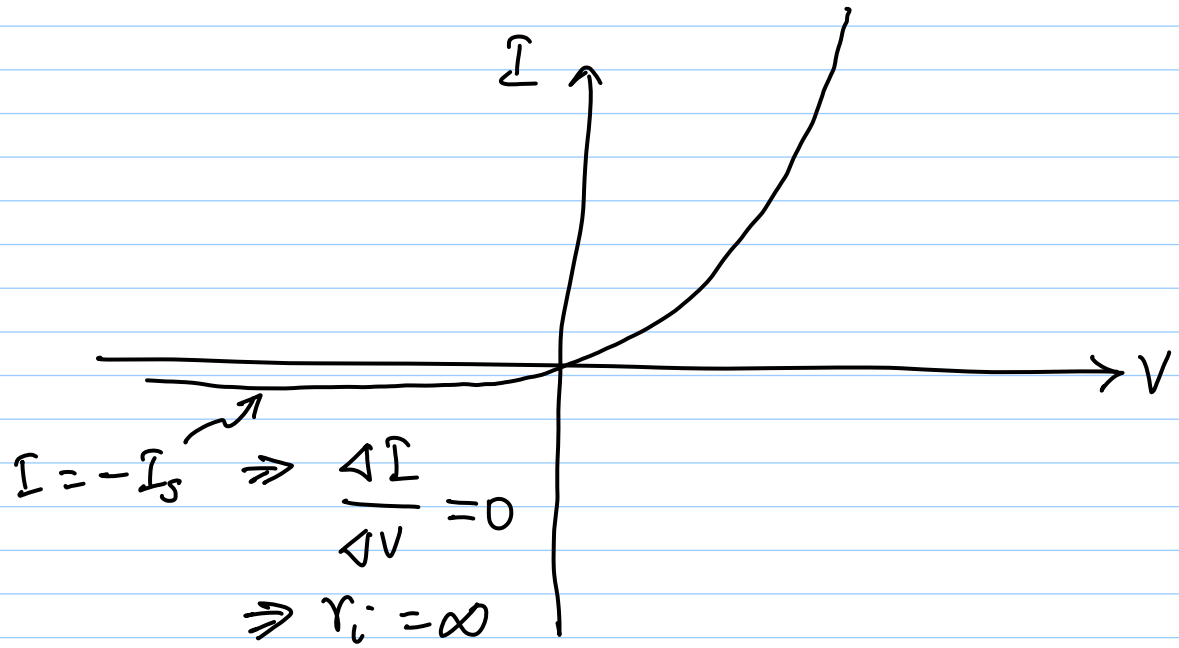
1) Find operating point
→ incremental v, i are dependent on the Q-point
→ solve non-linear equations

2) Draw the incremental equivalent circuit
→ Linear network

3) Total node voltage or branch current
= Quiescent voltage/current
+ Incremental voltage/current

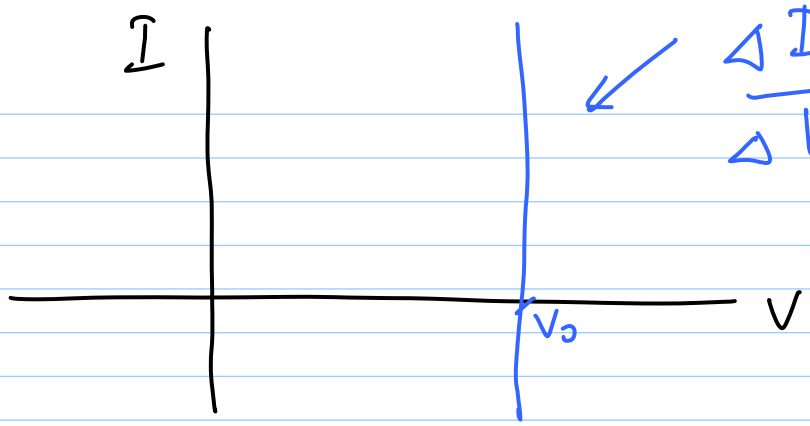
Element	Incr. eq.
R 	R 
V_0 	short ckt
I_0 	open ckt 
V_0 (+ −) 	V_t/I_0 
I_0	$r = \frac{1}{f'(V_0)}$ 
I_0 → $I = f(V)$ 	
+ V_0 − 	

Element	Inc. eq.
V_0 (− +) 	open ckt

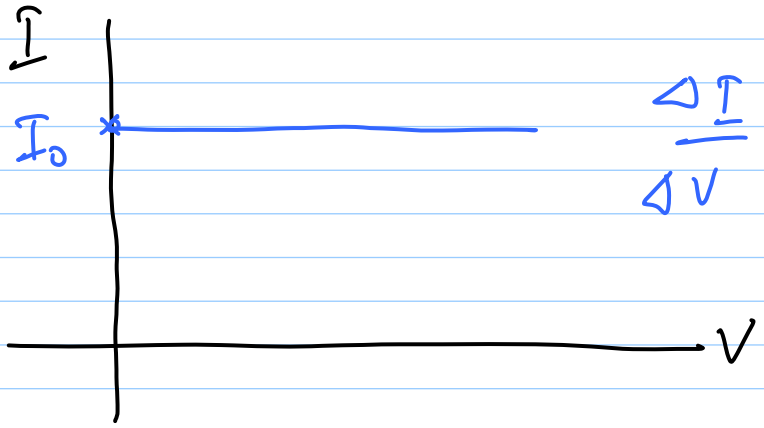


$I = -I_S \Rightarrow \frac{\Delta I}{\Delta V} = 0$

$\Rightarrow r_i = \infty$

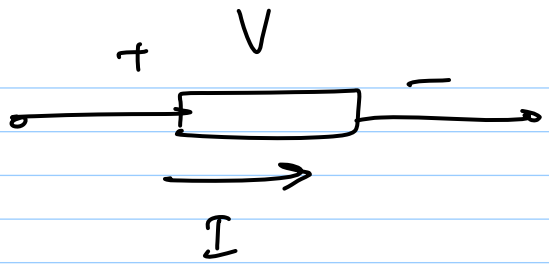


$\frac{\Delta I}{\Delta V} = \infty \Rightarrow r_i = 0$



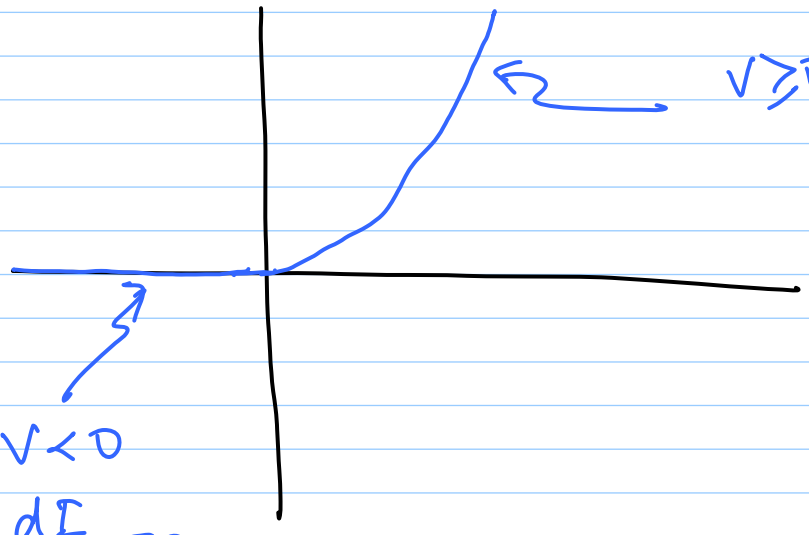
$\frac{\Delta I}{\Delta V} = 0 \Rightarrow r_i = \infty$

e.g.



$I = \alpha V^2, \quad V \geq 0$

$= 0, \quad V < 0$



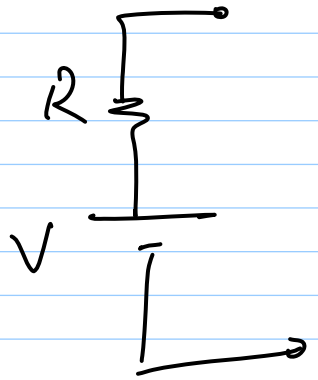
$V \geq 0 \Rightarrow \frac{dI}{dV} = 2\alpha V$

$\Rightarrow$ $\frac{1}{2\alpha V}$

$V < 0$

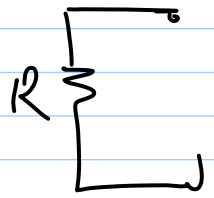
$\Rightarrow \frac{dI}{dV} = 0$

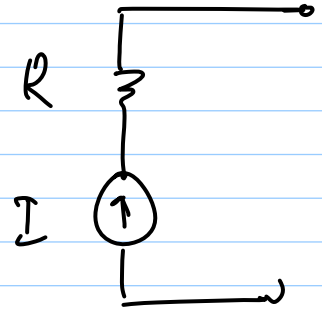
$\Rightarrow$ open ckt

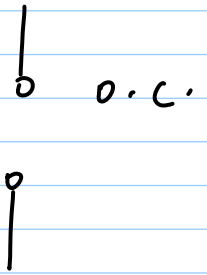


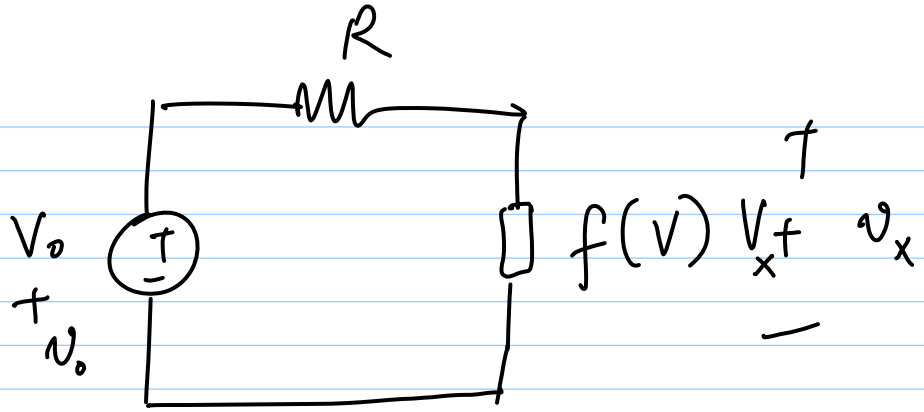
$\Rightarrow$

Inc. eqv.









* Is $v_x > v_0$ possible?

$$v_x = \frac{r_i}{R + r_i} v_0$$

Tunnel Diode

→ only if slope of $f(V)$ is negative in some region of characteristic (and O.P. is in that region)

* purely linear passive devices ⇒ Is amplification possible?

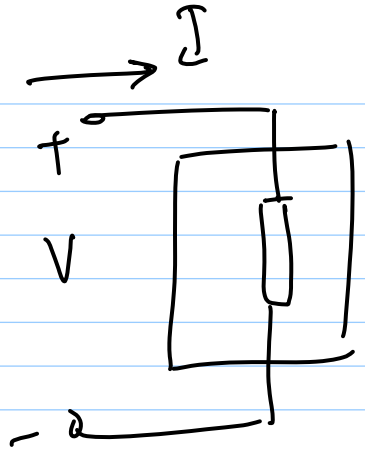
→ voltage gain – Yes (LC, transformer...)

→ power gain – no

* non-linear devices

→ incremental voltage & power gain is possible

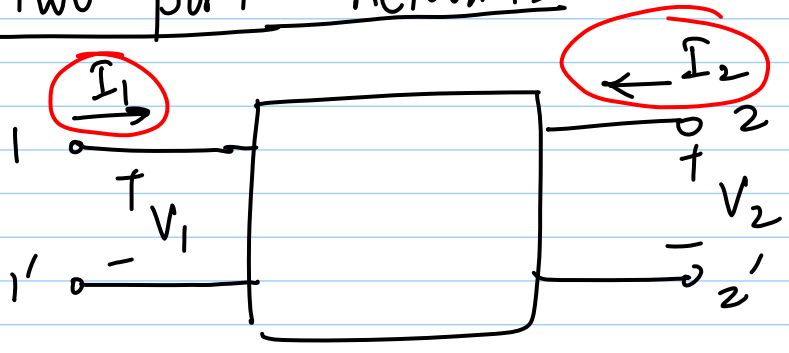
→ Battery power is still used up overall



2-Terminal
1-port

1 parameter required to describe it e.g. R

Two-port networks



4 parameters required to describe 2-port

* note current directions

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \underbrace{\begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix}}_{\text{impedance or } Z\text{-parameters}} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

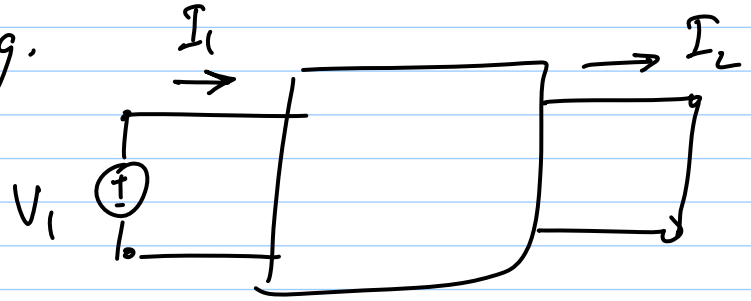
$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \underbrace{\begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix}}_{Y\text{- parameters}} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

* Other combos possible
* I_1, I_2 = Linear functions of V_1, V_2 & vice versa

$$I_1 = Y_{11} V_1 + Y_{12} V_2$$

$$I_2 = Y_{21} V_1 + Y_{22} V_2$$

e.g.



$$I_1 = Y_{11} V_1$$

$$I_2 = -Y_{21} V_1$$