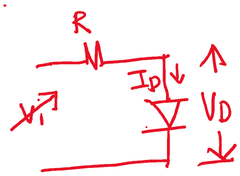
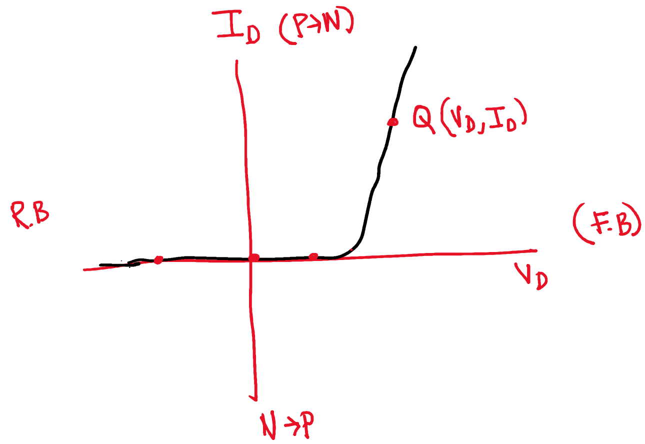
Monday, June 30, 2025 12:34 PM





$$I_D = I_s\left[e^{V_D/nV_T} - 1\right]$$

$$I_D = I_s\left[e^{\frac{V_D}{nV_T}} - 1\right]$$: diode equation

I_D: Current through the diode

V_D: Voltage across the diode

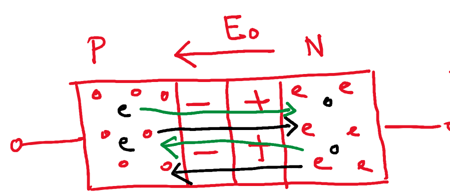
I_s: Reverse saturation current (minority carrier current)

$V_T = \frac{KT}{e}$, k: Boltzmann const.
e: charge of electron

T = 300K. $V_T \approx 25mV$ [thermal voltage]

n: Ideality factor: 1~2. (Si)

I_{Diff} (P→N) [Majority carrier]



$I_D = I_{Diff} - I_{Drift}$
(P→N) (N→P)
(Maj) (min)

I_{Drift} [Minority carrier]
(N→P)

$I_s = I_{Drift}$

$$I_D = I_s\left[e^{\frac{V_D}{nV_T}} - 1\right] = I_s e^{\frac{V_D}{nV_T}} - \cancel{I_s}$$

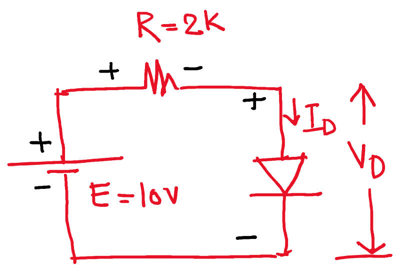
$I_D = I_{Diff} - I_{Drift}$
(P→N) (N→P)
$\sim 10^{-3}$ A $\sim 10^{-9} - 10^{-12}$ -10
(nA – pA)

$I_{Diff} = I_s e^{V_D/nV_T}$

$I_{Diff} = I_s e^{V_D/nV_T}$ ~10^{-3} A ~10^{-1} – 10 (nA – pA)

$I_{Diff} >>> I_{Drift}$ ($\times 10^{6/7}$)

$I_D \approx I_s e^{V_D/nV_T}$



Unknowns/Variables: I_D & V_D

Assume all the other parameters are known except I_D & V_D

$+E - I_D R - V_D = 0$

$I_D = \frac{E - V_D}{R}$ — (I)

$I_D \approx I_s e^{V_D/nV_T}$ — (II)

Non-linear

$I_s e^{\frac{V_D}{nV_T}} = \frac{E - V_D}{R}$ — (III)

linear

- trial & Error method
- EEE 282 (Numerial ~~tec~~ technique)

$V_D = 0.51V, 0.53V, 0.55V$ → Solution → [exact/Accurate]

18.83 19.35

19.08 19.15

19.11 19.11

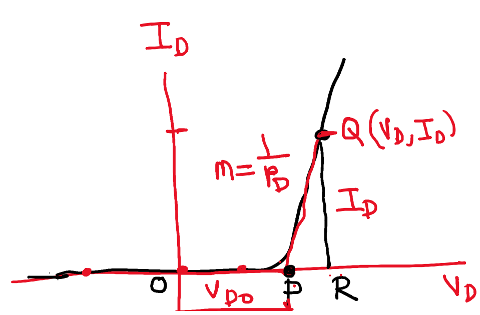
$V_D = 0.25V$

$V_D = V_D + 0.001V$

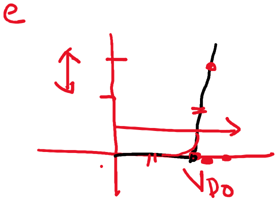
Simpler way even we have to compromise on the accuracy. find

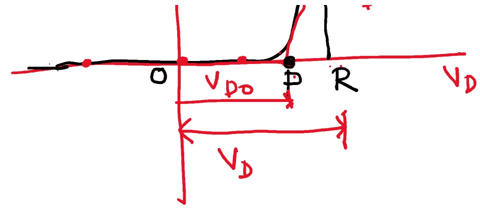
- 1.13 PM → slow/correct
- 1.15 PM → Fast/not accurate

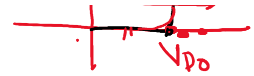
1.52 / 1.50



$I_D = I_s e^{V_D/nV_T}$







$OR = OP + PR$

$V_D = V_{D0} + PR$, ΔPQR

$m = \frac{1}{r_D} = \frac{QR}{PR}$

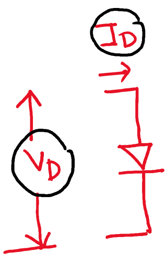
$\Rightarrow PR = QR \cdot r_D = I_D r_D$

$V_D = V_{D0} + PR = V_{D0} + I_D r_D$

$V_D = V_{D0} + I_D r_D$: Approximation

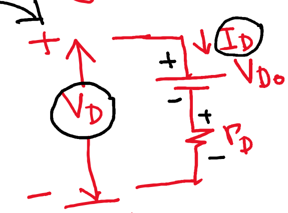
$I_D \approx I_s e^{V_D/nV_T}$: Real characteristics

A



$\rightarrow$ $V_D = V_{D0} + I_D r_D$ $\rightarrow$

KVL equation



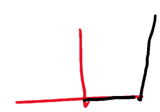
B

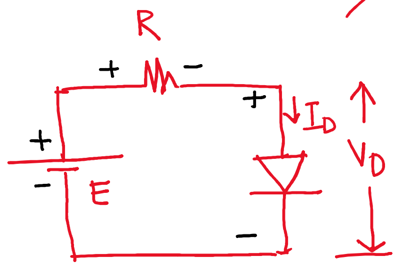
$+V_D - V_{D0} - I_D r_D = 0$

$\Rightarrow V_D = V_{D0} + I_D r_D$

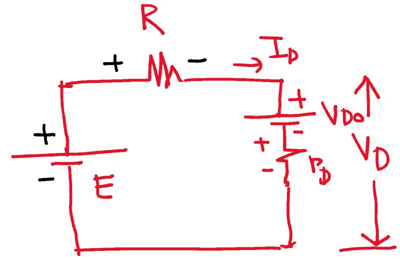
$A \Leftrightarrow B$

If two isolated systems have identical outwards behaviour, then they are said to be equivalent to each other.





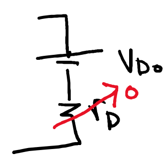
$\rightarrow$



Piecewise linear approximation

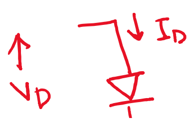
$I_D = \frac{E - V_{D0}}{R + r_D}$

$V_D = V_{D0} + \cancel{I_D r_D}^{\,0}$

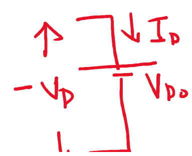


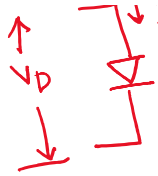
r_D : 10−20Ω ≪ R = 2K

$\cancel{r_D} \rightarrow 0$

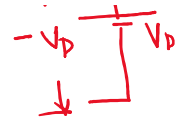


$\rightarrow V_D = V_{D0} + \cancel{I_D r_D}^{\,0}$

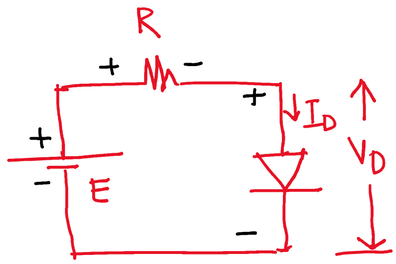


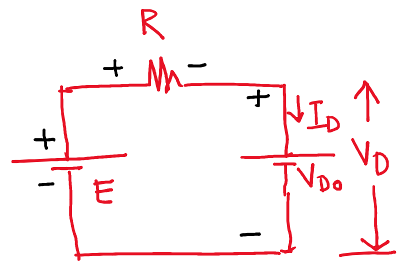


$\rightarrow V_D = V_{D0} + I_D r_D$



Constant voltage drop model/Approx.





$V_D = V_{D0} = 0.7V$ (Si)

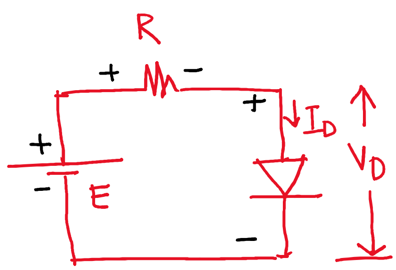
$= 0.3V$ (Ge)

$I_D = \dfrac{E - V_{D0}}{R}$

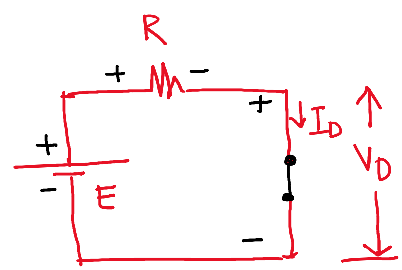
③ Ideal diode model.

$V_D = \cancel{V_{D0}}^{0} + I_D \cancel{r_D}^{0}$

$V_D = V_{D0} = 0V$



$\rightarrow$



$V_D = V_{D0} = 0V$

F.B

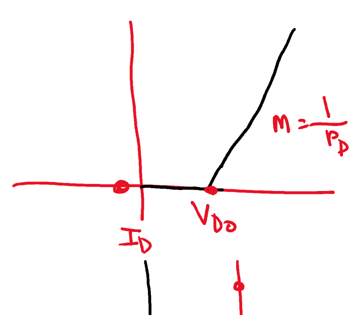
$I_D = \dfrac{E - V_{D0}}{R + r_D}$.

$I_D = \dfrac{E - V_{D0}}{R}$

$I_D = \dfrac{E}{R}$.

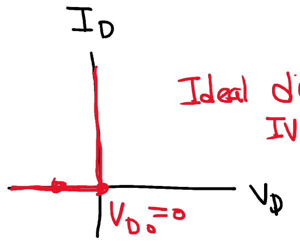
$I_D = \dfrac{E}{R}$

$I_D = \dfrac{E}{R}$



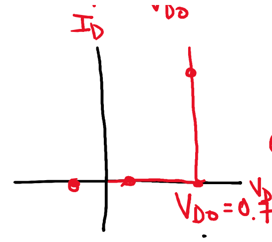
$\underline{\underline{r_D = 0}}, \quad m = \dfrac{1}{r_D} = \infty$

I_D



Ideal diode
IV characteristics

$V_{D_0} = 0V$



Const. voltage drop

$\underline{\underline{r_D = 0}}, \quad m = \frac{1}{r_D} = \infty$

R.B → diode OFF