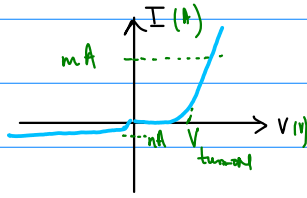
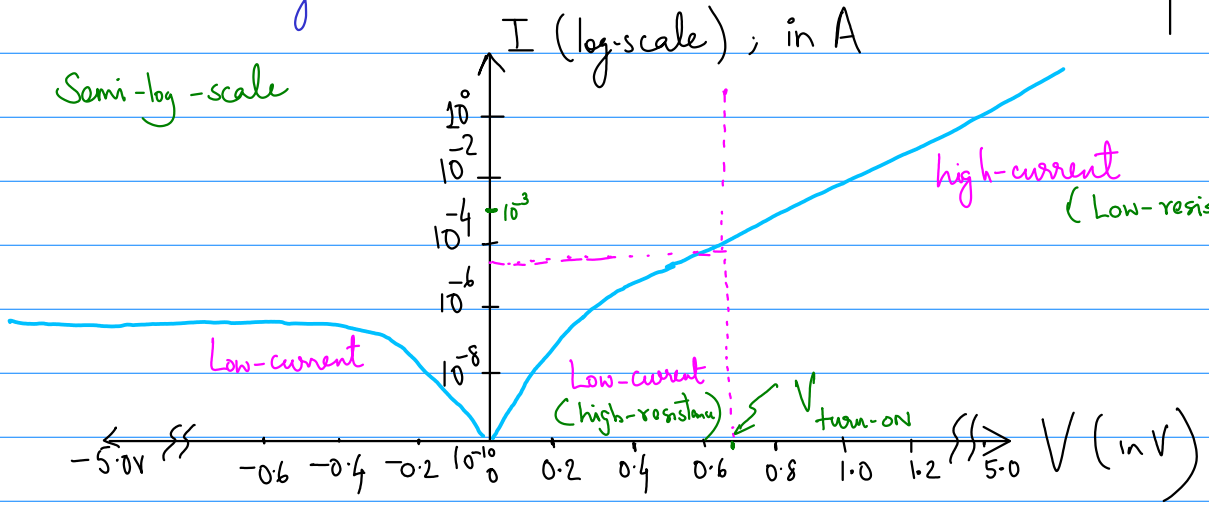
21.01.2022

p-n Diode : Circuit Models



1. Current-Voltage Characteristics :

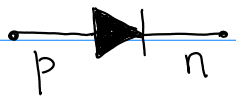


Conclusion: The current-voltage characteristics show two current levels :

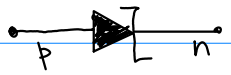
(i) Low when $V \leq V_{turn-on}$

(ii) high when $V > V_{turn-ON}$.

2) Circuit Model of a p-n diode :



Ckt symbol of a p-n diode

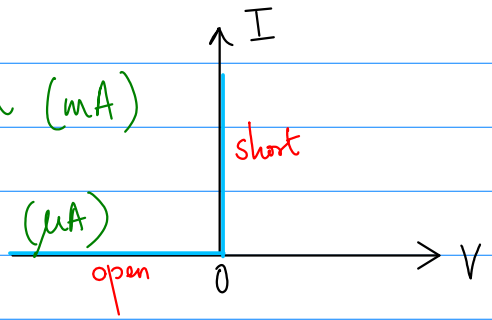


Zener-diode

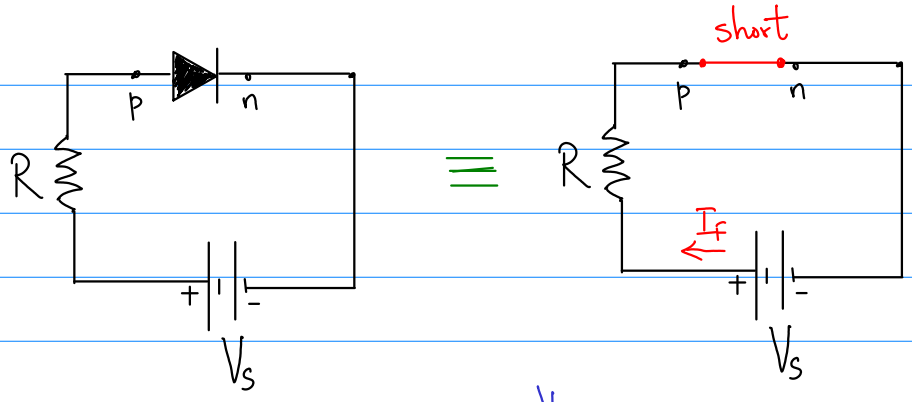
a) Ideal diode Model :

$V > 0$; $I \rightarrow$ high (mA)

$V < 0$; $I \rightarrow$ Low (μA)

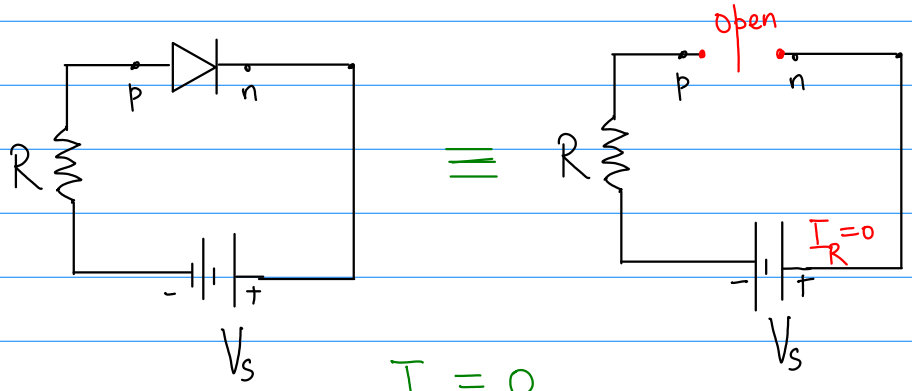


(i) Forward bias



$$I_F = \frac{V_s}{R}$$

(ii) Reverse-bias:

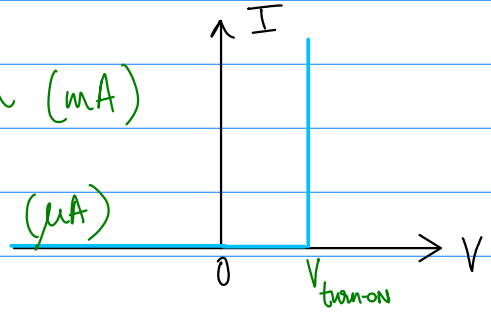


$I_R = 0$

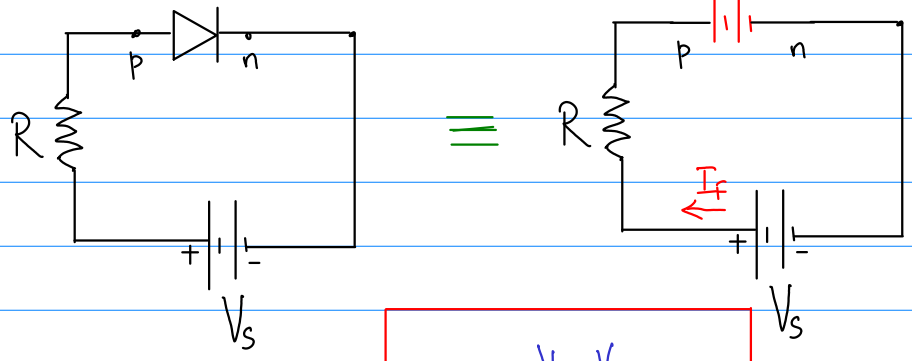
b) Modified Ideal Diode Model (Practical Model):

$V > V_{turn\text{-}on}$; $I \rightarrow$ high (mA)

$V < V_{turn\text{-}on}$; $I \rightarrow$ Low (μA)



(i) Forward bias

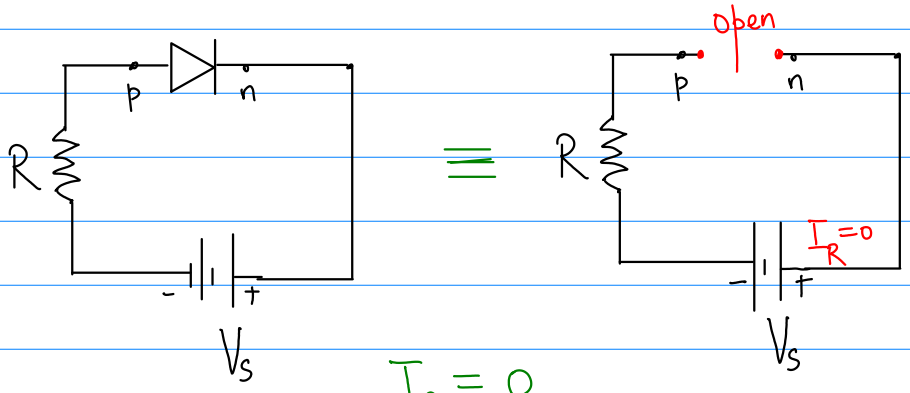


$$I_F = \frac{V_S - V_{turn\text{-}ON}}{R}$$

typically, for Silicon diode, $V_{turn\text{-}ON} \sim 0.7\,V$

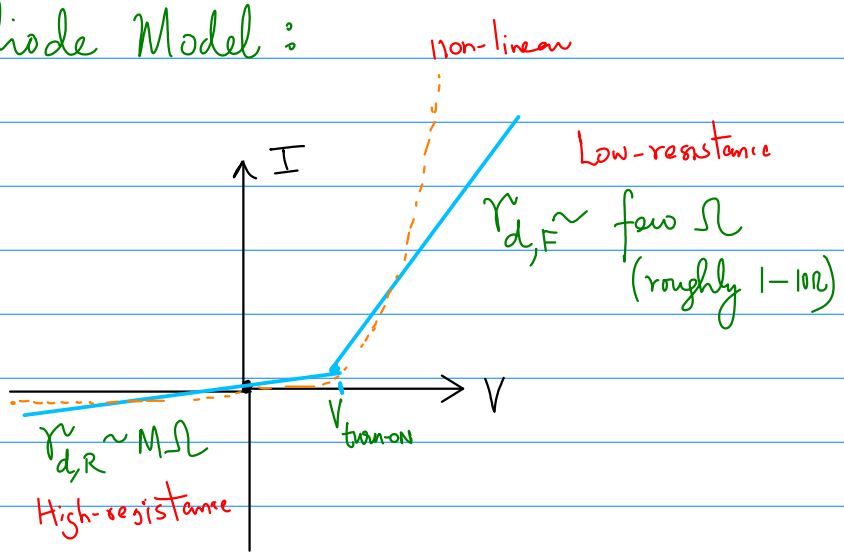
$$I_F = \frac{V_S - 0.7V}{R}$$

(ii) Reverse-bias:

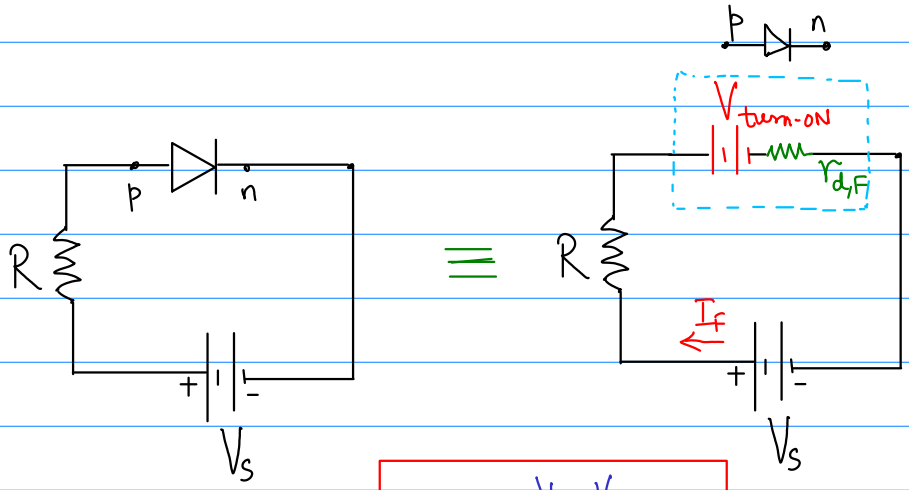


$I_R = 0$

3) Complete (Real) diode Model:

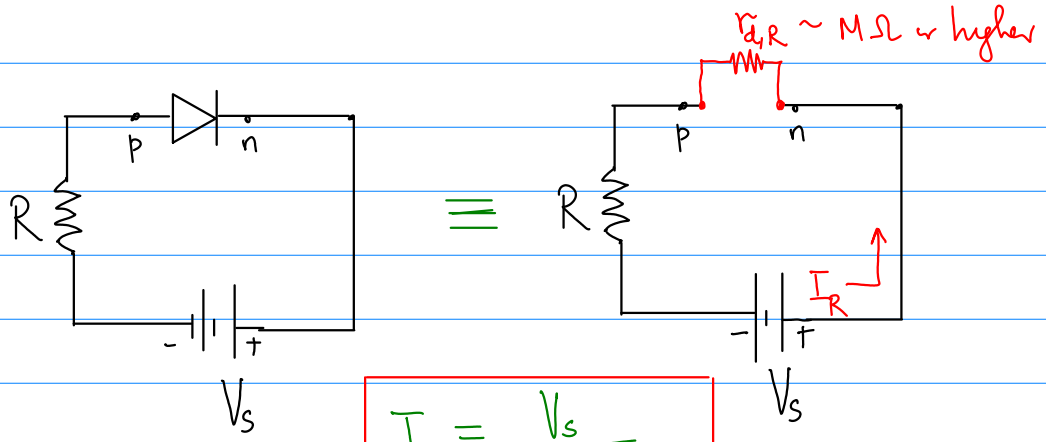


(i) Forward bias



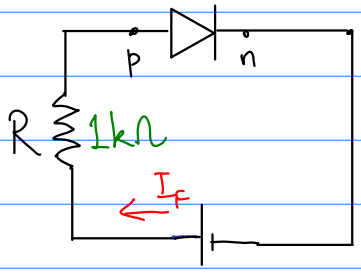
$$I_F = \frac{V_S - V_{turn\text{-}ON}}{R + r_{d,F}}$$

(ii) Reverse-bias:



$$I_R = \frac{V_S}{R + r_{d,R}}$$

Example Problem:



$V_S = 10V$

Specification of the diode

$V_{turn\text{-}on} = 0.6V$

$r_{d,F} = 10\Omega$

$r_{d,R} = 100k\Omega$

Let see forward-current (I_F) assuming the three models:

(i) Ideal model: Diode is replaced with "short".

$$I_F = \frac{V_S}{R} = \frac{10V}{1k\Omega} = 10mA$$

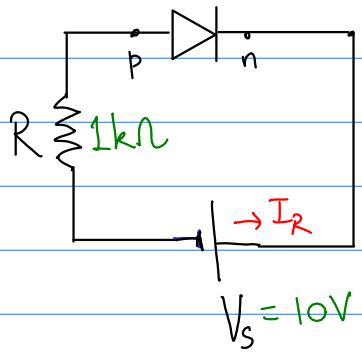
(ii) Modified Ideal Model: Diode is replaced with a "Voltage source" $= V_{turn\text{-}on}$

$$I_F = \frac{V_S - V_{turn\text{-}on}}{R} = \frac{10V - 0.6V}{1k\Omega} = 9.4mA$$

(iii) Real diode model: Diode is replaced with a voltage-source and a resistor $r_{d,F}$

$$I_F = \frac{V_S - V_{turn\text{-}on}}{R + r_{d,F}} = \frac{10V - 0.6V}{1k\Omega + 10\Omega}$$

$$I_F = 9.3mA$$



(i) Ideal Model : $I_R = 0$ (diode ≡ open)

(ii) M.I.M. : $I_R = 0$ (open)

(iii) Real Model :

Diode is replaced with a resistor '$r_{d,R}$'

$$I_R = \frac{V_S}{R + r_{d,R}} = \frac{10\,V}{1k\Omega + 100k\Omega}$$

$$I_R = 100\mu A$$