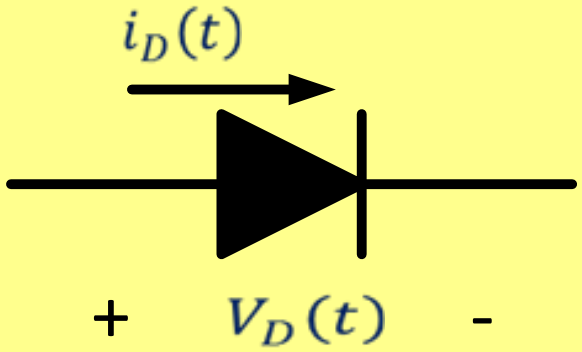
Diode Equation

$$i_D(t) = I_S(e^{\frac{V_D(t)}{\eta V_T}} - 1)$$



Is: Revers saturation current

$Is = 10^{-12}, 10^{-14}$A

η : eta

$$\eta = \begin{Bmatrix} 1\ for\ Ge \\ 2\ for\ Si\ (small\ current) \\ 1\ for\ Si\ (large\ current) \end{Bmatrix}$$

V_T= Thermal Voltage

$$V_T = \frac{T}{11600} \quad ;T \text{ in kelvin}$$

At Room Temp. T=300k

$\therefore$ V_T = 25.69 mv at Room Temp.

$$i_D(t) = I_S(e^{\frac{V_D(t)}{\eta V_T}} - 1)$$

- The equation is a non linear equation

$\therefore$ The Diode is non linear Device

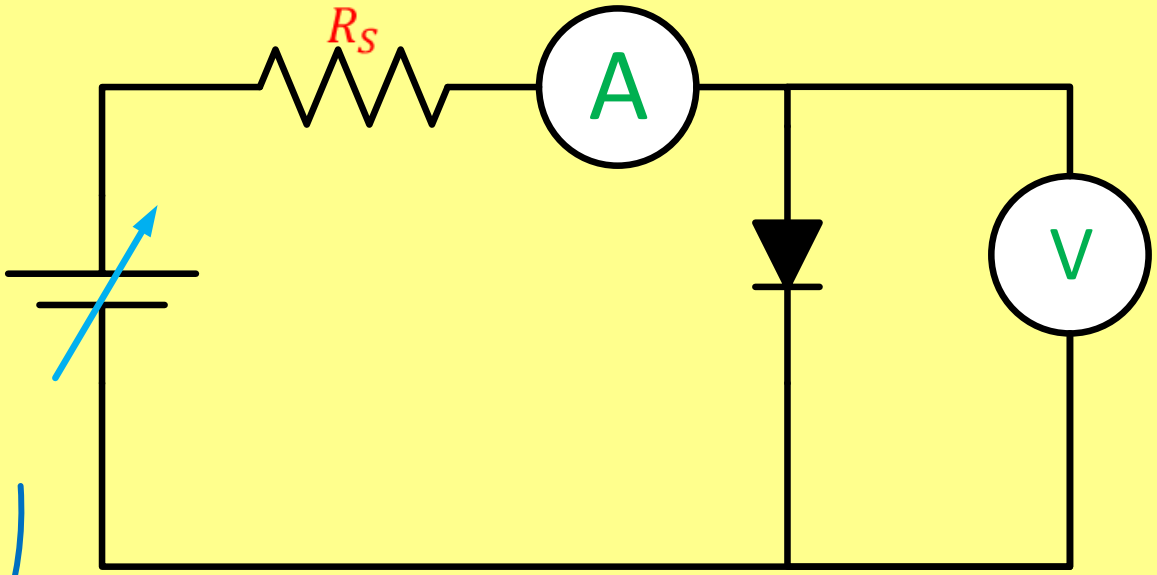
- For positive $V_D(t)$

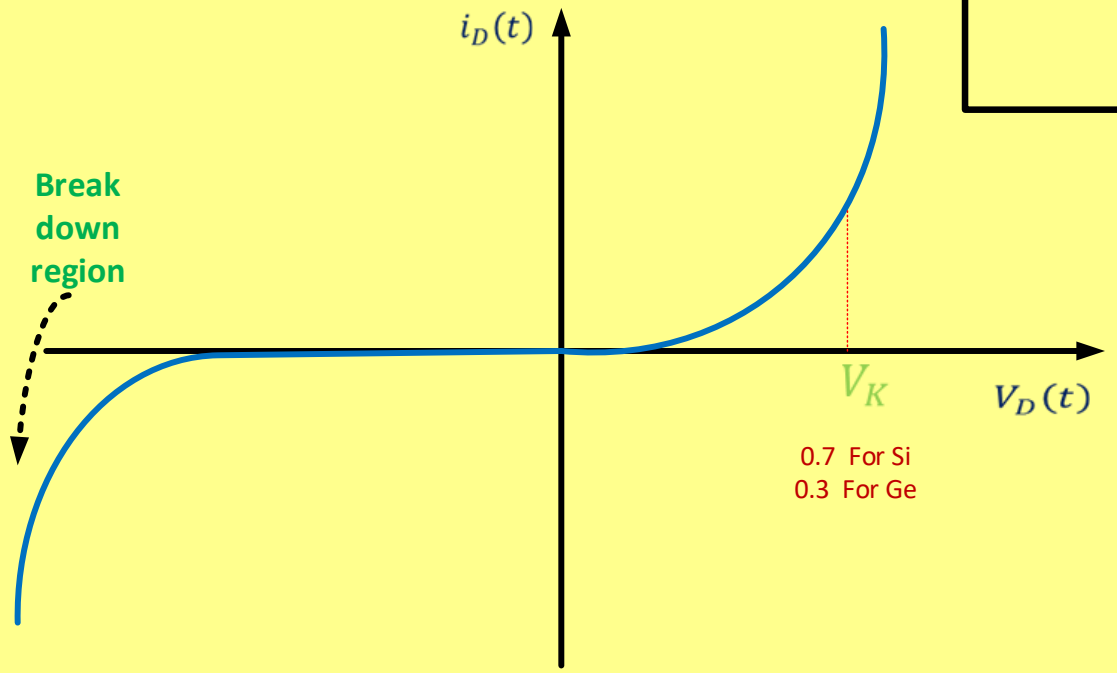
$$i_D(t) = I_S(e^{\frac{V_D(t)}{\eta V_T}})$$

- For negative $V_D(t)$

$$i_D(t) = -I_S$$

Diode V-I Characteristic curve





Approaches to Diode Circuit Analysis

The rectifier diode is a non linear device .

There are essentially three basic approaches to the solution of such problem :

1- The use of non linear mathematics

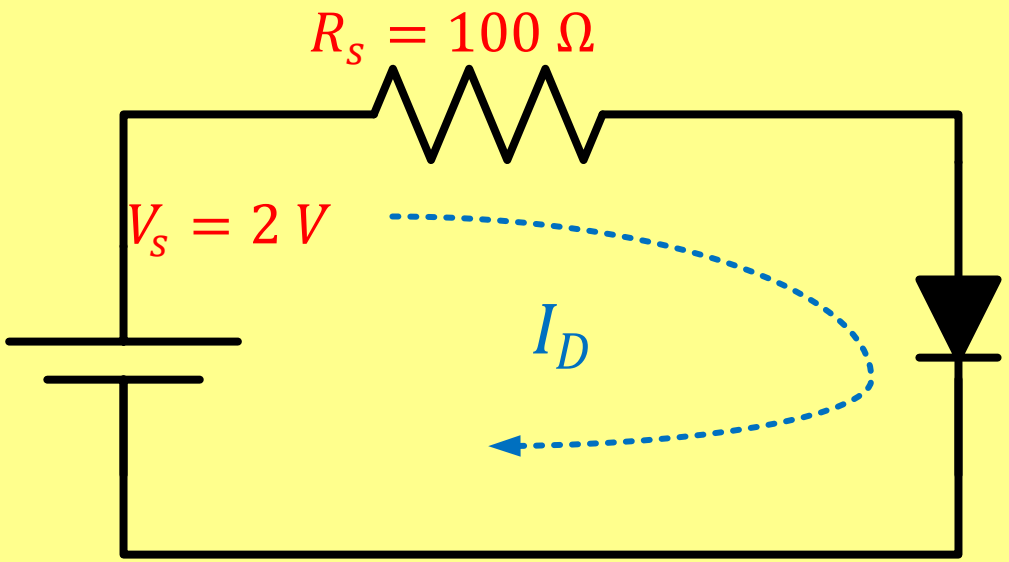
2- The use of graphical techniques

3- The use of equivalent circuit (models)

- Piece wise linear models

1)The use of non linear mathematic

- For the circuit shown, find I_D and V_D



Silicon:
η=1.1
I_S= 10^{-14} A

- KVL : $V_S = R_S I_D + V_D$

$$I_D = I_S(e^{\frac{V_D}{\eta V_T}} - 1)$$

- Since the diode is forward biased , we could approximate

$$I_D = I_S(e^{\frac{V_D}{\eta V_T}})$$

- Solving for $V_D = \eta\, V_T \ln \frac{I_D}{I_S}$

∴ We have two equations and two unknowns

$V_S = R_S I_D + V_D$ 1

$V_D = \eta V_T \ln \frac{I_D}{I_S}$ 2

$$\therefore \quad V_S = R_S I_D + \eta V_T \ln \frac{I_D}{I_S}$$

- non linear equation

Iterative Analysis

$$I_D = \frac{V_S - V_D}{R_S}$$

$$V_D = \eta V_T \ln \frac{I_D}{I_S}$$

1) Let $V_D = 0.7\text{V}$

$I_D = \frac{2-0.7}{0.1k} = 13\ \text{mA}$

$V_D = 0.7882392\text{V}$ The error is large

2) Let $V_D = 0.7882392\text{V}$

$I_D = 12.117608\ \text{mA}$

$V_D = 0.7862529\text{V}$ The error is small

3) Let $V_D = 0.7862529\text{V}$

$I_D = 12.137471\ \text{mA}$

$V_D = 0.7862991\text{V}$ The error getting smaller

4) Let $V_D = 0.7862991\text{V}$

$I_D = 12.137009\text{mA}$

$V_D = 0.786298066\text{V}$

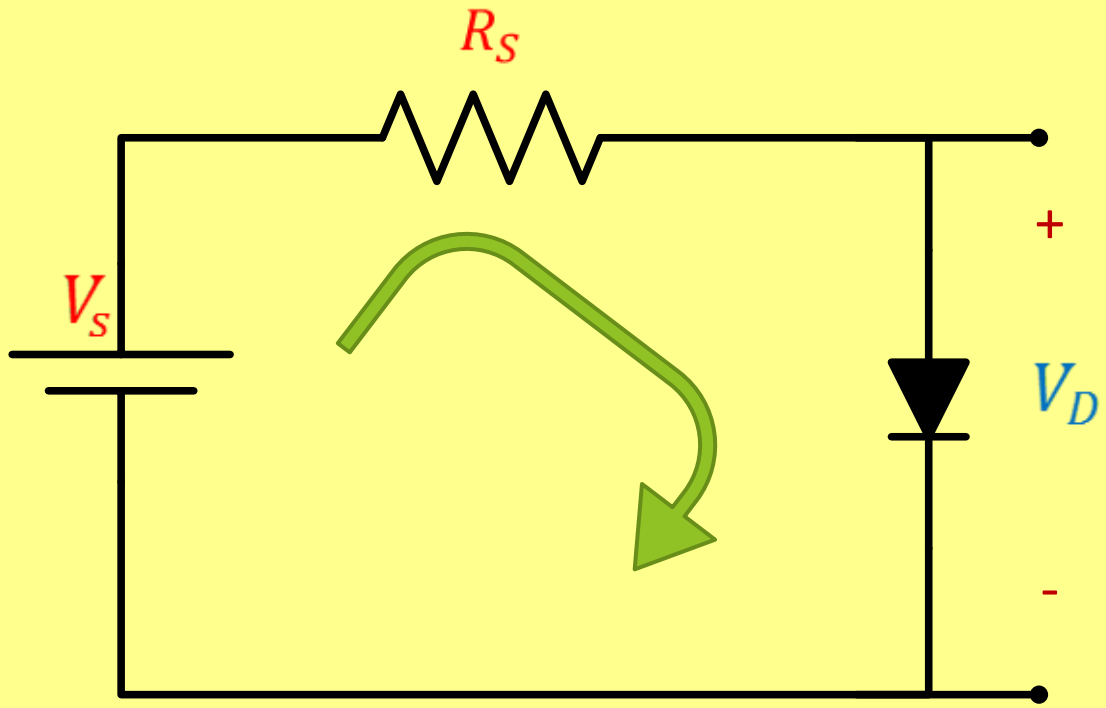
$I_D = 12.137\ \text{mA}$

$V_D = 0.7863\text{V}$

2) The use of graphical techniques

$$V_S = R_S I_D + V_D \qquad \text{.....1}$$

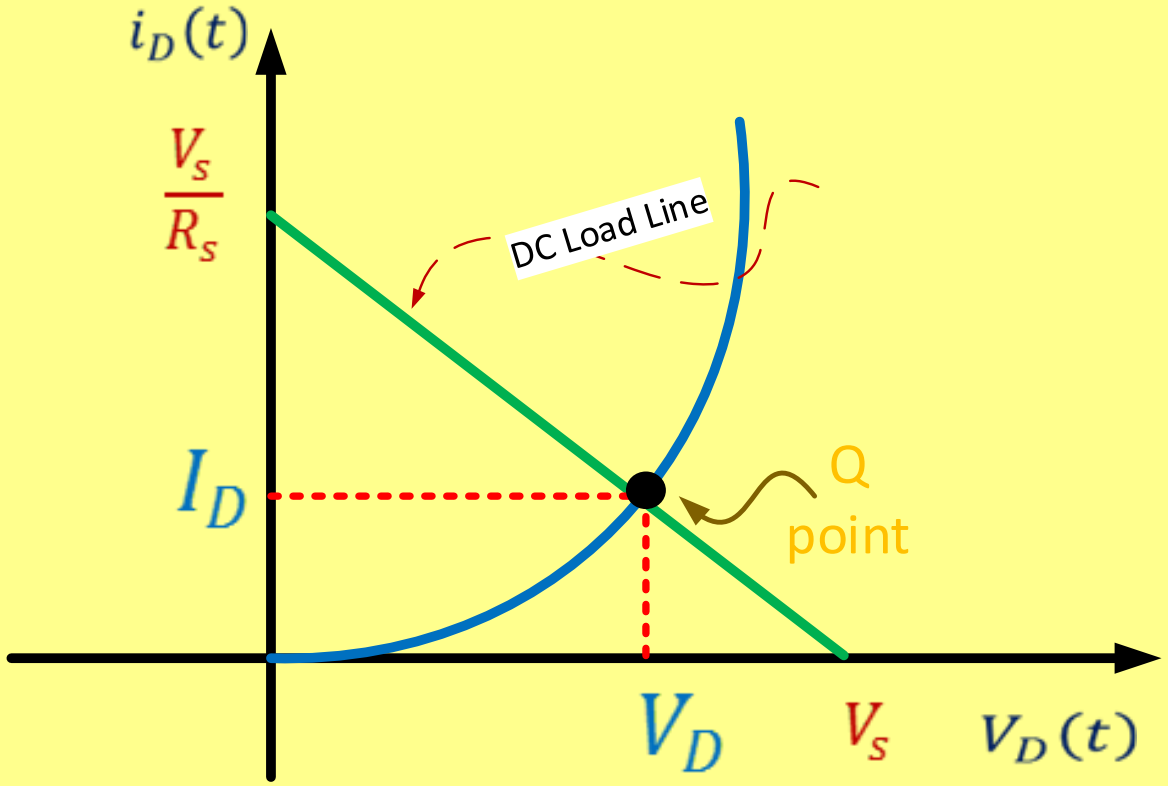
$$I_D = I_S \left(e^{\frac{V_D}{\eta V_T}} - 1 \right) \qquad \text{.....2}$$



- Using equation 1

$$I_D = -\frac{1}{R_S} V_D + \frac{V_S}{R_S}$$

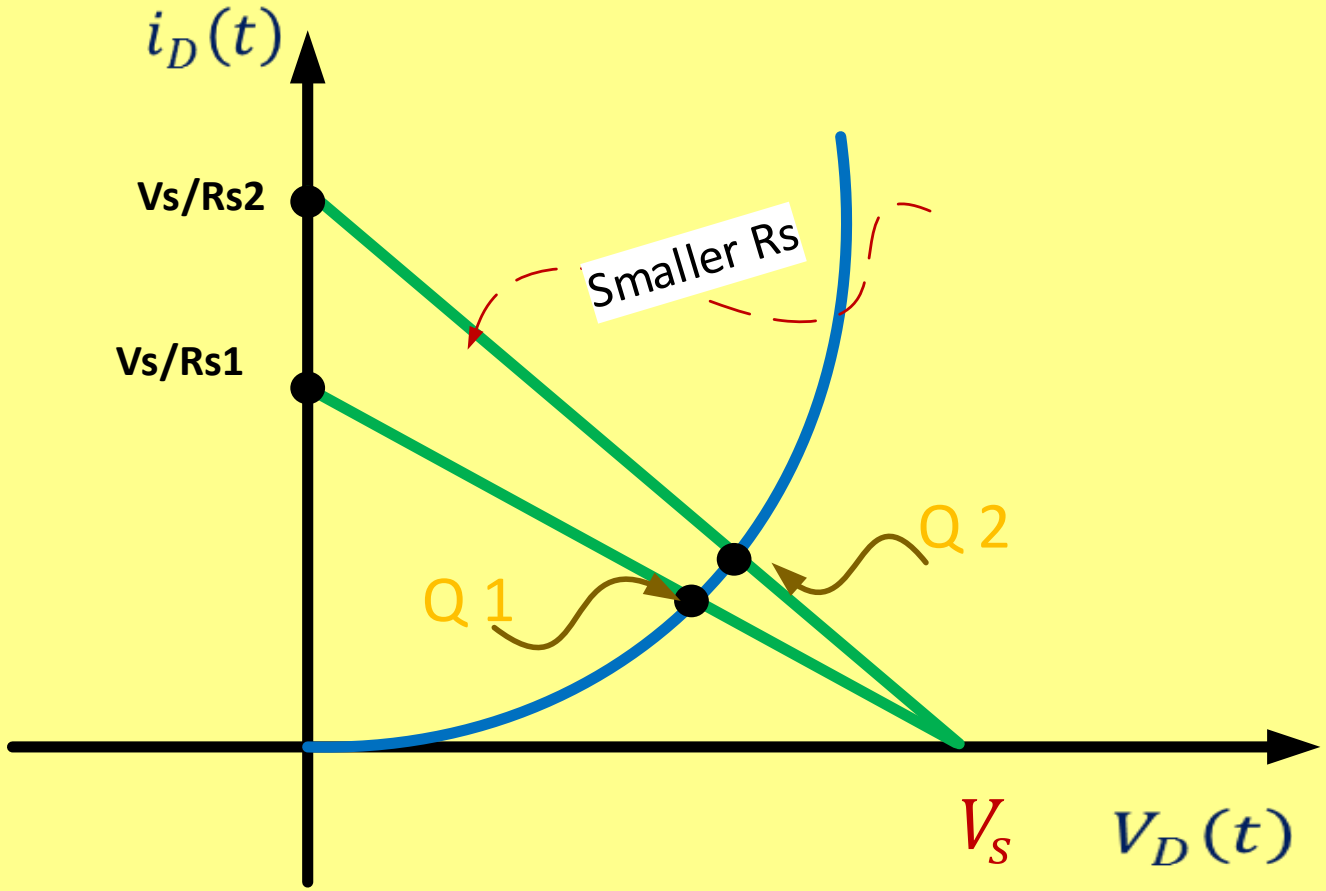
Drawing the two equations



$$I_D = -\frac{1}{R_S} V_D + \frac{V_S}{R_S}$$

- Q point = $(I_{DQ}\ ,\ V_{DQ}\ )$ = Quiescent point

The effect of Rs on the Qpoint



The effect of Vs on Qpoint