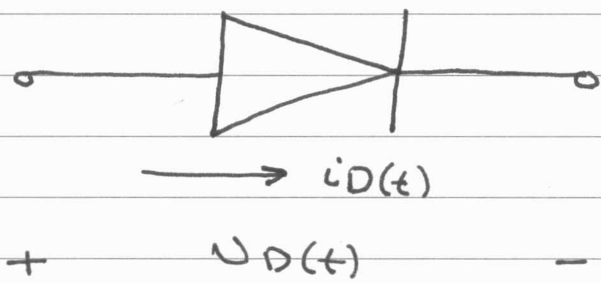
Diode Equation



$$i_D(t) = I_s \left(e^{\frac{v_D(t)}{\eta V_T}} - 1 \right)$$

$I_s \equiv$ Reverse Saturation Current

$I_s \approx 10^{-12}\,A\,,\ 10^{-14}\,A$

$\eta \equiv$ eta

$$\eta = \begin{cases} 1 & \text{for Ge} \\ 2 & \text{for Si (small current)} \\ 1 & \text{for Si (Large Current)} \end{cases}$$

$V_T \equiv$ Thermal Voltage

$V_T = \dfrac{T}{11600}$; T in Kelvin

at Room Temp. $T \equiv 300\,K$

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

$$i_D(t) = I_s \left(e^{\frac{v_D(t)}{\eta V_T}} - 1 \right)$$

- The equation is a non Linear equation

∴ The Diode is non Linear Device

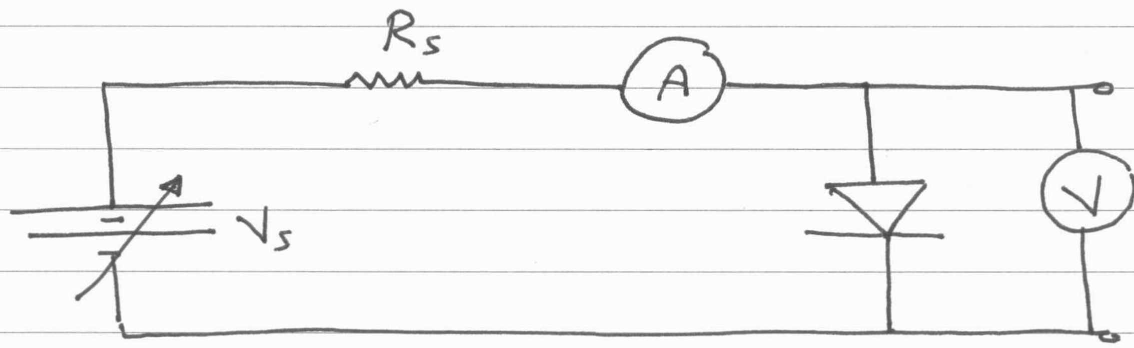
- For positive $v_D(t)$

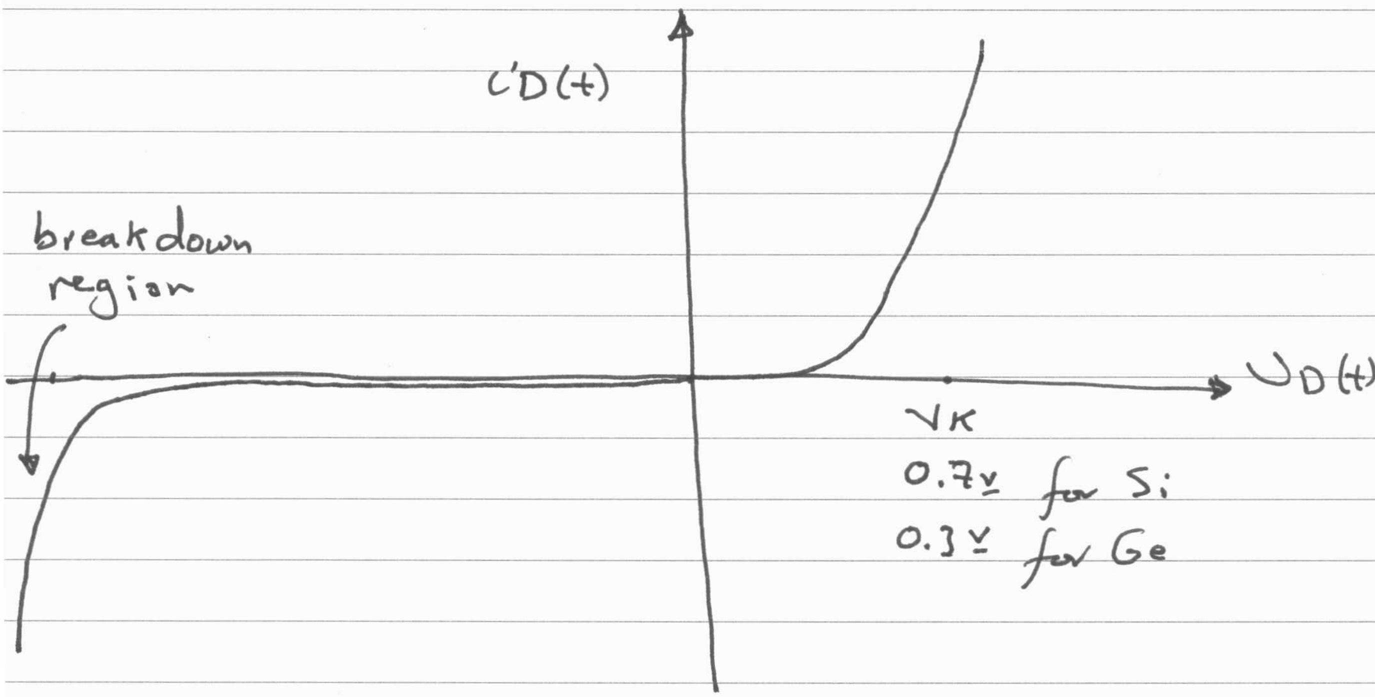
$$i_D(t) \approx I_s \, e^{\frac{v_D(t)}{\eta V_T}}$$

- For negative $v_D(t)$

$$i_D(t) = -I_s$$

Diode V-I Characteristic Curve





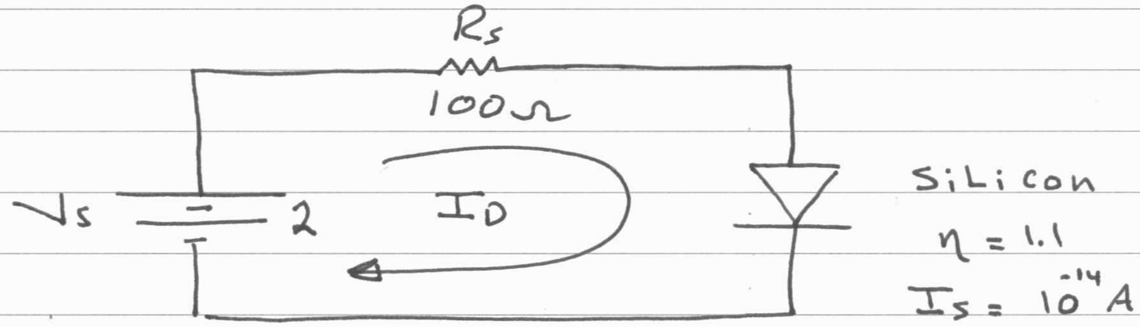
Approaches to Diode Circuit Analysis

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

KVL : $V_s = R_s I_D + V_D$

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

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

$$V_s = R_s I_D + V_D \quad \text{—— (1)}$$

$$V_D = \eta V_T \ln \frac{I_D}{I_s} \quad \text{—— (2)}$$

$$\therefore \quad V_s = R_s I_D + \eta V_T \ln \frac{I_D}{I_s}$$

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 $V_D = 0.7\,V$

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

$$V_D = 0.7882392\,V$$

The error is Large

2) let $V_D = 0.7882392\,V$

$$I_D = 12.117608\,mA$$

$$V_D = 0.7862529\,V$$

The error is small

3) let $V_D = 0.7862529\,V$

$$I_D = 12.137471\,mA$$

$$V_D = 0.7862991\,V$$

The error getting smaller

4) let $V_D = 0.7862991\,V$

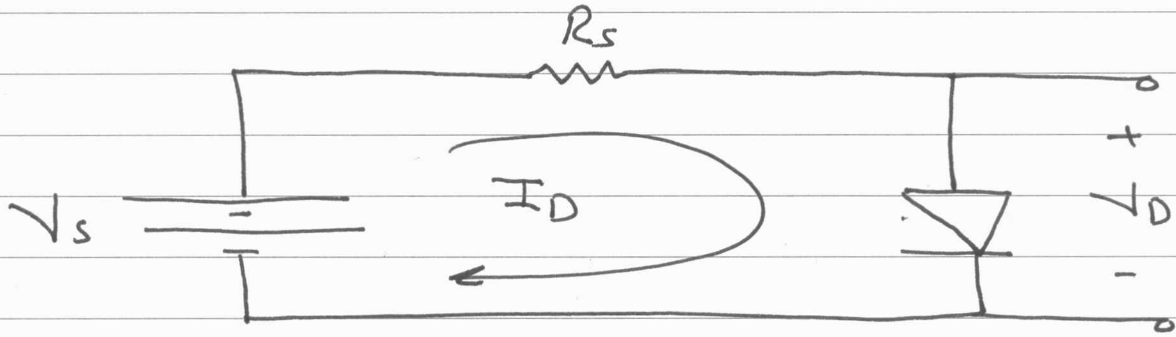
$$I_D = 12.137009\,mA$$

$$V_D = 0.786298066\,V$$

$\therefore$ $I_D = 12.137\,mA$

$V_D = 0.7863\,V$

2) The use of graphical techniques



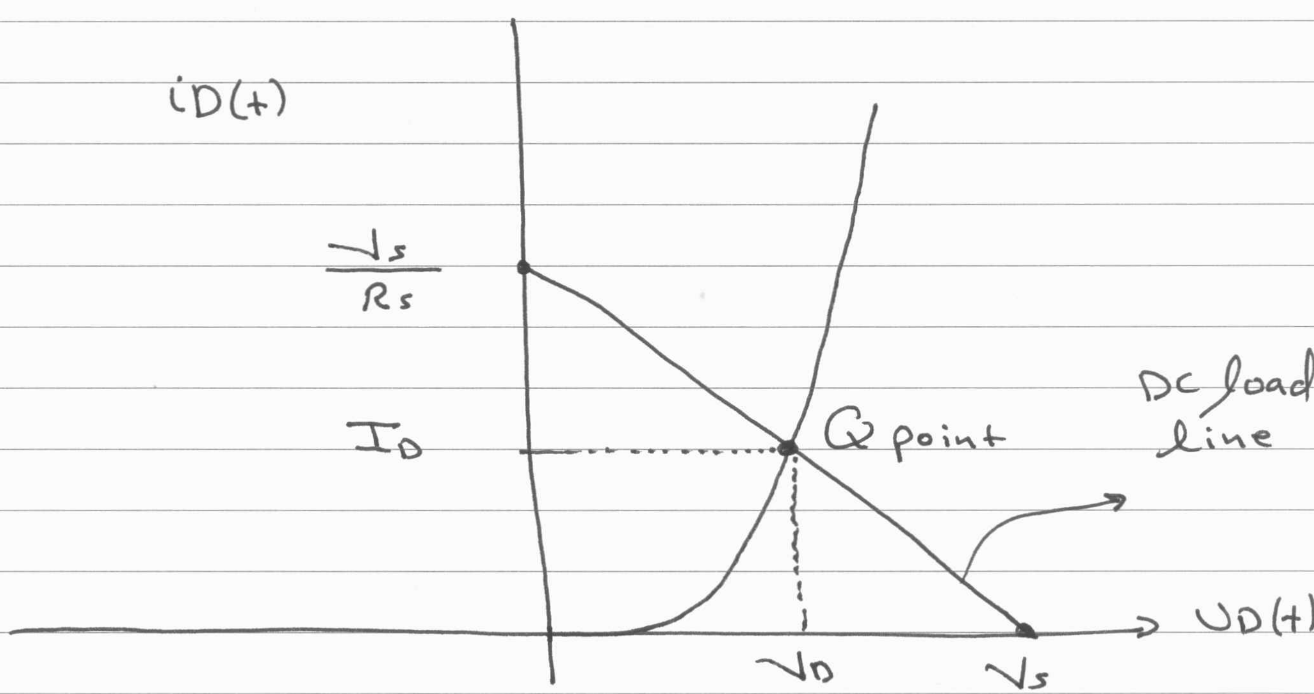
KVL : $V_s = R_s I_D + V_D$ — ①

$$I_D = I_s \left(e^{\frac{V_D}{\eta V_T}} - 1 \right) \quad — ②$$

using equation ①

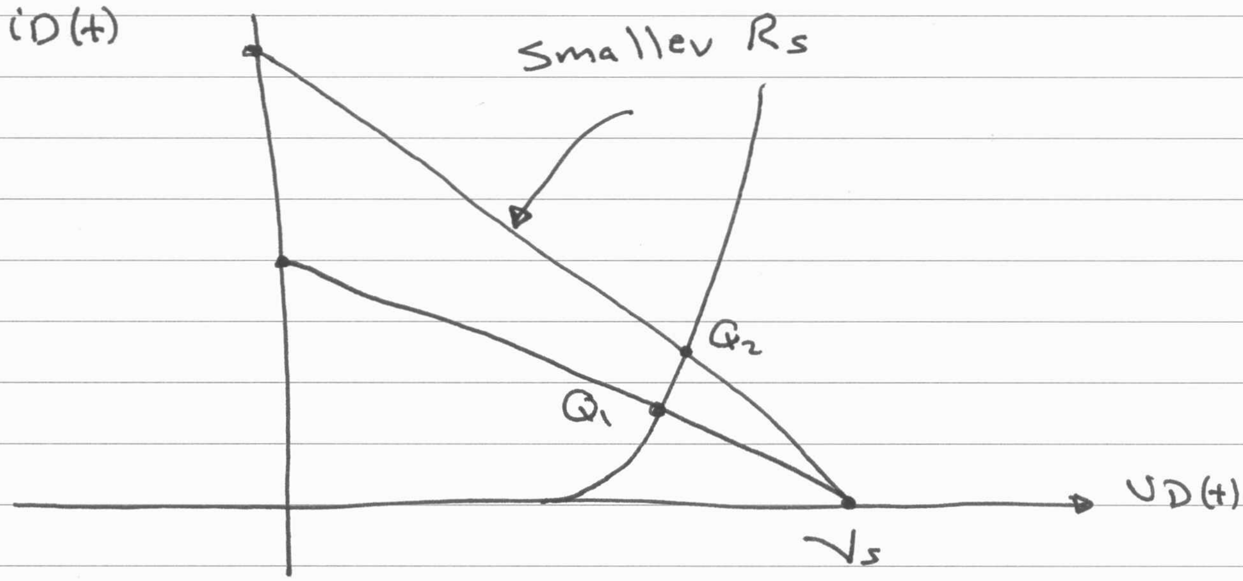
$$I_D = -\frac{1}{R_s} V_D + \frac{V_s}{R_s}$$

Drawing the two equations



Q point = (I_{DQ}, V_{DQ}) ≡ Quiescent point

The effect of R_s on the Q point



The effect of V_s on the Q point