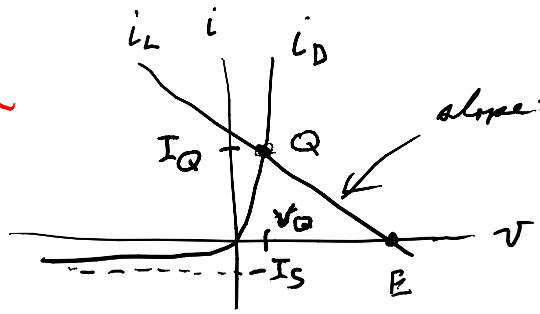
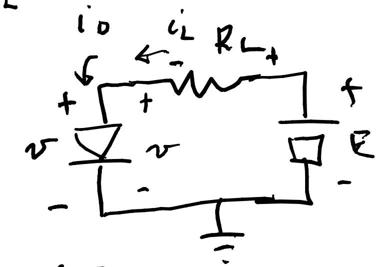
EE 303H
02/03/09

P. 212





$$i_D = I_S\left(e^{v/V_T} - 1\right)$$

$$V_T = \frac{kT}{|q|} \approx 26\,mV \text{ @ room } T$$

$$i_L = G_L(E - v)$$

$$v = E - R_L i_L$$

$$i_L = \frac{E - v}{R_L} = G_L(E - v)$$

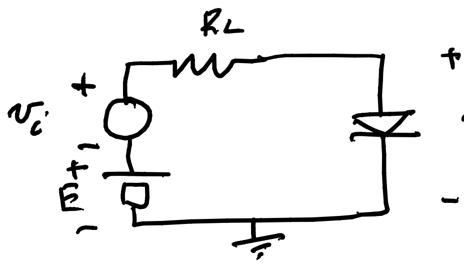
V_Q solves this equation

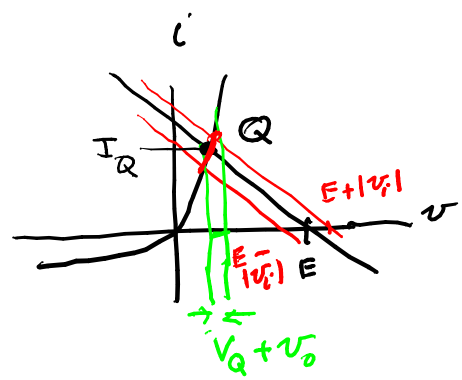
$$i_L = i_D = I_S\left(e^{v/V_T} - 1\right) = G_L E - G_L v$$

$$= e^{v/V_T} + \frac{G_L}{I_S} v = 1 + \frac{G_L}{I_S} E$$

a transcendental we use a computer

Now put signal on





If v_i is small, $v_i(t)$, to find v_o

use a series expansion

$$i_D = i_D(t) = i_D(V_Q) + \left.\frac{\partial i_D}{\partial v_D}\right|_{@\, v_D = V_Q} \left(v_D(t) - V_Q\right) + \cdots$$

$$i_D(t) - i_D(V_Q) = i_D(t) - I_D = i_d = \text{signal part of diode current}$$

I_D = bias value of diode current

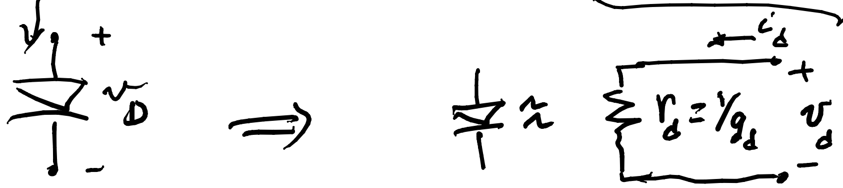
i_D = total current in the diode

$$i_d = \frac{\partial i_D}{\partial v_D}\Big|_Q \cdot \underbrace{(v_D - V_Q)}_{\text{signal } v_d} \Rightarrow i_d(t) = \underbrace{\frac{\partial i_D}{\partial v_D}\Big|_Q}_{g_d} \cdot v_d(t)$$

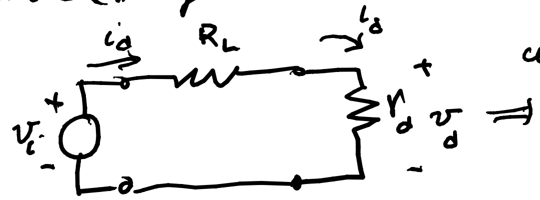
$\Rightarrow$ linear equation for the diode operating at the Q point for small signals.

g_d { diode conductance

$$i_D = I_S(e^{v_D/V_T} - 1)$$



∴ for small signal



$\Rightarrow$ can analyze using linear theory

$$v_i = i_d \cdot R_L + i_d r_d = (R_L + r_d) \cdot i_d = (R_L + r_d) \cdot g_d \cdot v_d$$

here: $$\frac{v_d}{v_i}(t) = \frac{1}{(R_L + r_d) \cdot g_d} = \frac{1}{1 + R_L \cdot g_d}$$

for g_d: $$g_d = \frac{\partial i_D}{\partial v_D}\Big|_Q \Rightarrow \frac{\partial i_D}{\partial v_D}\Big|_Q = \frac{\partial (I_S[e^{v_d/V_T} - 1])}{\partial v_D}\Big|_Q = \frac{I_S e^{v_d/V_T}}{V_T}\Big|_Q$$

$$= \frac{I_S e^{V_Q/V_T}}{V_T}$$

If bias in forward region, $V_Q > 0$ $\quad (e^{V_Q/V_T} - 1) \approx e^{V_Q/V_T}$

$$I_D = I_S(e^{V_Q/V_T} - 1) \approx I_S e^{V_Q/V_T}$$

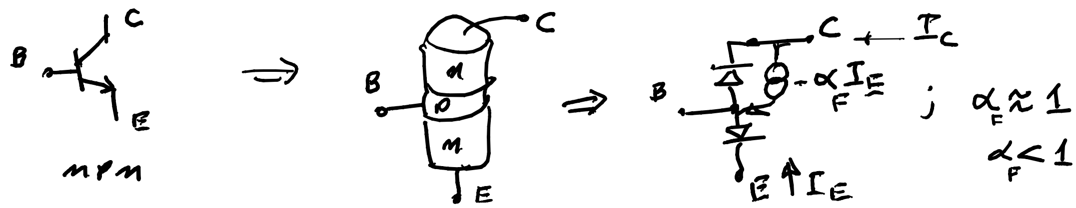
$$\Rightarrow g_d = \frac{I_D}{V_T}$$

if $I_D = 1mA = 10^{-3}$

& $V_T = 26mV \Rightarrow$

$g_d = \frac{1}{26}$; $r_d = 26\Omega$

BJT



but n portion is very thin