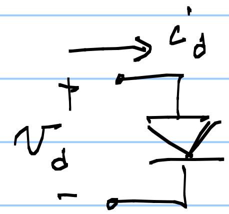
EE302

Note Title 2/10/2004

p. 153 = forward current of diodes (pn)



Power into diode = $v_d i_d$

voltage control

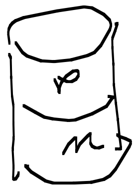
$$i_d = I_S\left(e^{v_d/(nV_T)} - 1\right) = \begin{cases} -I_S & \text{for } v_d < 0 \\ I_S e^{v_d/V_T} & \text{for } v_d > 0 \end{cases}$$

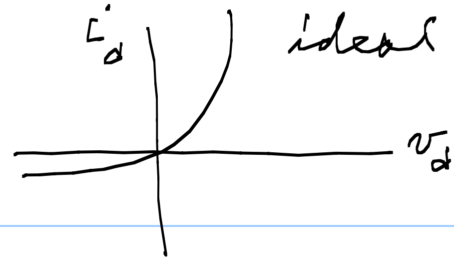
V_T = thermal voltage = $\dfrac{kT}{|q|_{electron}}$; k = Boltzmann's constant

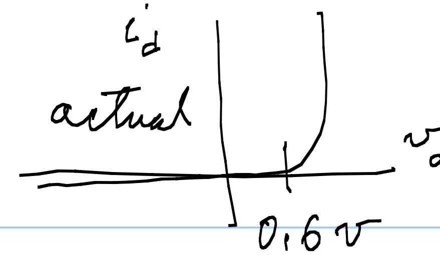
$\approx 0.026\,v$ at room T

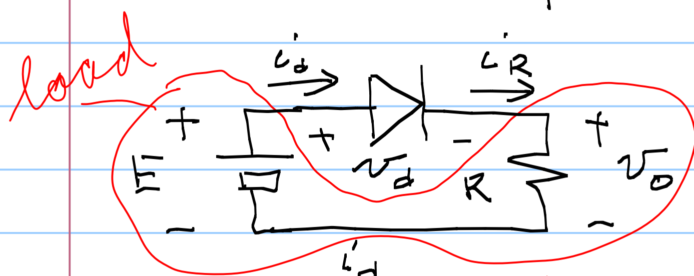
T = Temperature °K

n = constant ≈ 1









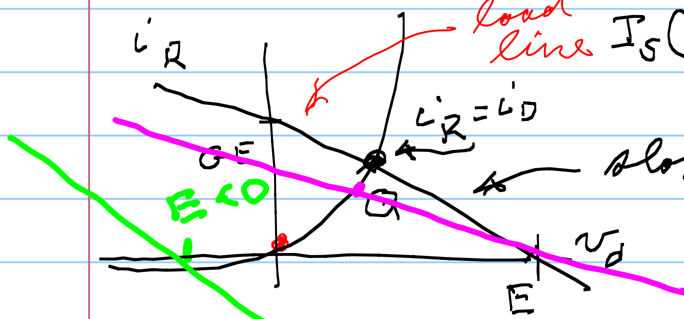
$0 = -E + v_d + v_o$

$v_o = E - v_d$

$i_d = i_R$

$I_S(e^{v_d/V_T} - 1)$ " " $= v_o/R = G v_o$; $G = 1/R$

$= GE - G v_d$



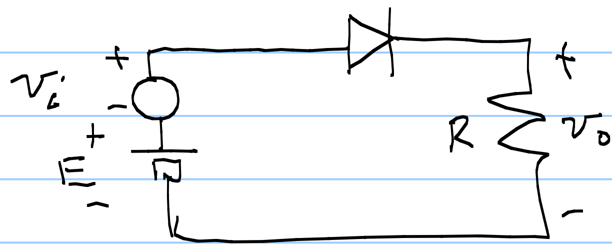
slope = − G

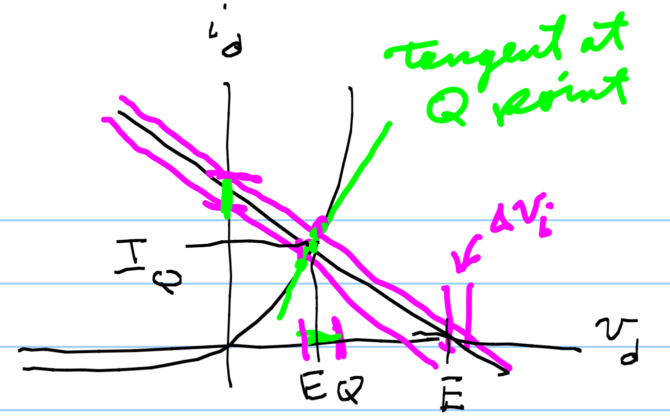
= − 1/R

Q = quiescent point

= operating point

biasing if E is fixed = bias point



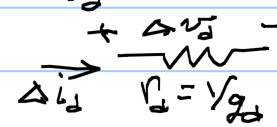


$$i_d = f(v_d) = f(E_Q) + \left.\frac{\partial f}{\partial v_d}\right|_Q \underbrace{\Delta v_d}_{(v_d - E_Q)} + \frac{\partial^2 f}{\partial v_d^2}(\Delta v_d)^2 + \dots$$

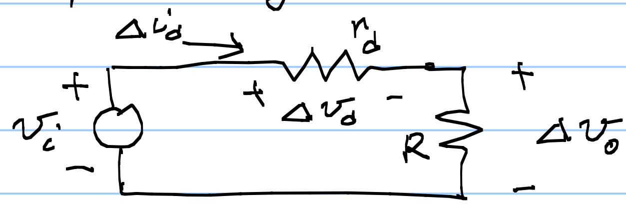
if $|v_i|$ is small $|\Delta v_d|$ is small so

$$i_d = f(E_Q) + \frac{\partial f}{\partial v_d}\cdot \Delta v_d = I_Q + g_d \cdot \Delta v_d$$

$$\Delta i_d = i_d - I_Q = g_d \cdot \Delta v_d \Rightarrow$$



replace by a "small signal" circuit



$$\Delta v_o = \frac{R}{R + r_d} \cdot v_i$$

$$\text{gain} = \frac{\Delta v_o}{v_i} = \frac{R}{R + r_d}$$

have linearized around the bias point

for forward bias

$$r_d = \frac{1}{g_d} \ , \quad g_d = \frac{\partial i_d}{\partial v_d} = \frac{\partial \left[e^{v_d/V_T} - 1 \right] I_S}{\partial v_d} = \frac{I_S}{V_T} \cdot e^{v_d/V_T} \Big|_Q$$

$$\approx \frac{I_d}{V_T} \quad ; \quad I_d = \text{bias diode current} = I_Q$$