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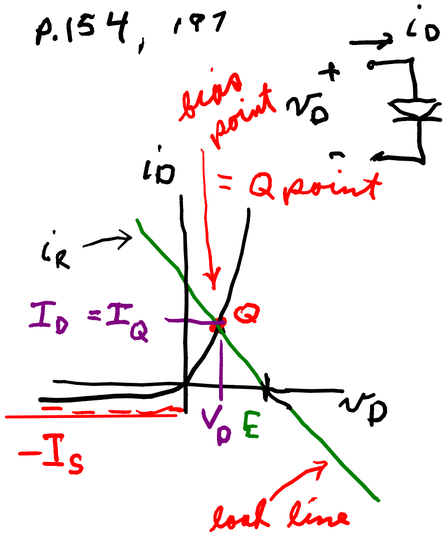
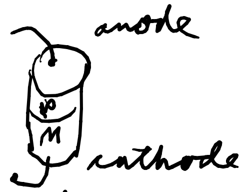
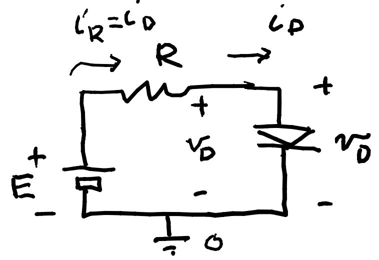




$i_D = I_S\left(e^{v_D/nV_T} - 1\right)$; $V_T = \dfrac{kT}{|q|} \approx 26\ mV$

$n \approx 1$



device: $i_D = I_S e^{v_D/V_T}$

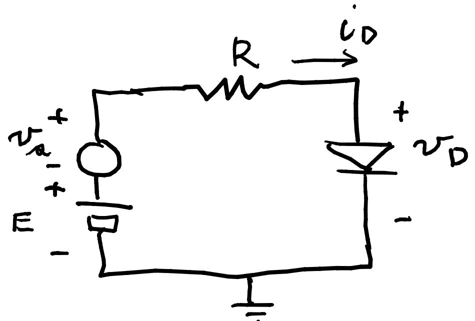
load: $v_D = -R i_D + E$

or $i_D = -\frac{1}{R}(v_D - E)$

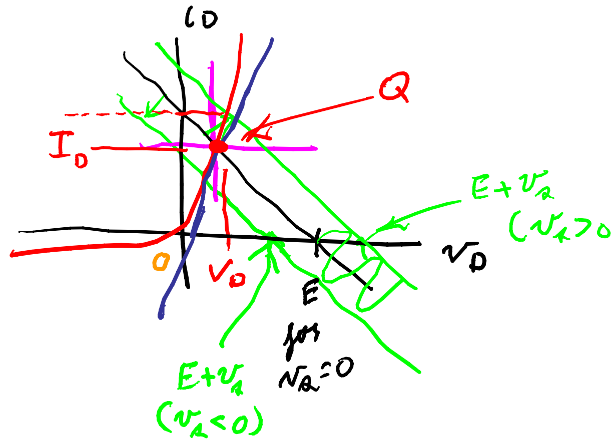
$= -G(v_D - E) = i_R$

Q = quiescent

with signal v_a



load: $i_D = i_R = -G(v_D - E - v_a)$



here

$v_D = V_D + v_d \Rightarrow v_d = v_D - V_D$

$\underbrace{i_D}_{\text{total}} = \underbrace{I_D}_{\text{bias}} + \underbrace{i_d}_{\text{signal}} \Rightarrow i_d = i_D - I_D$

Next expand the device law equation

$$i_D = I_S\left(e^{v_D/V_T} - 1\right) = \underbrace{I_S\left[\left(e^{V_D/V_T} - 1\right)\right.}_{I_D} + \underbrace{\frac{1}{V_T} e^{v_D/V_T}\Big|_{v_D = V_D}(v_D - V_D)}_{i_d} + \cdots$$

$= I_D + i_d$; $i_d =$

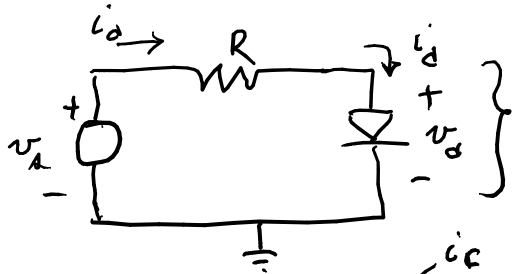
if ignore higher order terms $\Rightarrow (v_D - V_D) = v_d$

has $|v_d| \ll E$

in the circuit

$$E + v_a = -R i_D + v_D = -R(I_D + i_d) + V_D + v_d$$

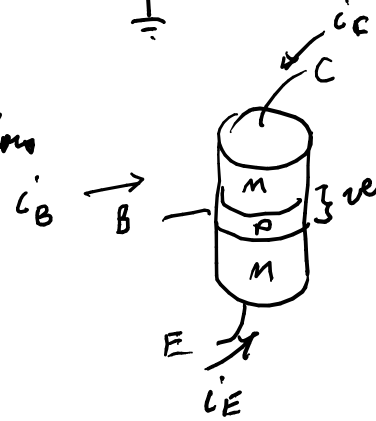
but $E = -R I_D + V_D \Rightarrow v_a = -R i_d + v_d$



} signal

$$i_d = \underbrace{\frac{I_S}{V_T} \cdot e^{V_D/V_T}}_{\text{diode conductance}} \cdot (v_d)$$

Transistor



} very thin so $i_C \approx -i_E$ use $i_C = -\alpha i_E$

$\alpha \approx 1$

by KCL: $i_B + i_E + i_C = 0$

$$\Rightarrow i_B + \left(-\frac{1}{\alpha} i_C\right) + i_C = 0$$

$$\Rightarrow i_C = \frac{1}{\left(-1 + \frac{1}{\alpha}\right)} i_B = \frac{\alpha}{1-\alpha} i_B$$

$$= \beta i_B$$