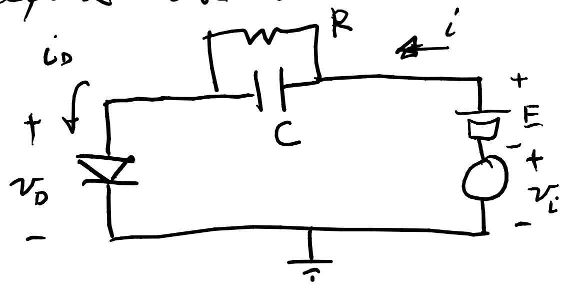
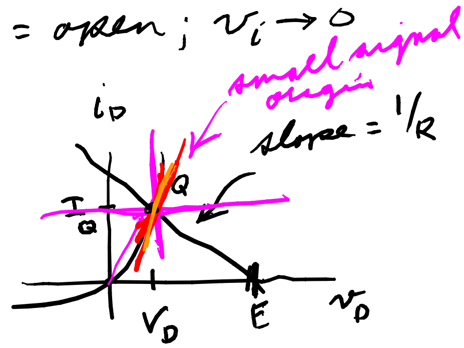
EE303
03/12/07

For exam – as on the list



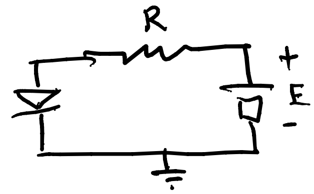
for bias work at DC

C = open ; $v_i \to 0$



$V_D = 0.63$

at DC



Ex: $i_D = 10^{-13}(e^{v_D/V_T} - 1)$

$10^{-13} = I_S$

$\approx I_S e^{v_D/V_T}$

for $V_D = 0.63v$; $E = 3v$

T = room

$V_T = 26\,mV$

$I_Q = 10^{-13} e^{0.63/0.026}$

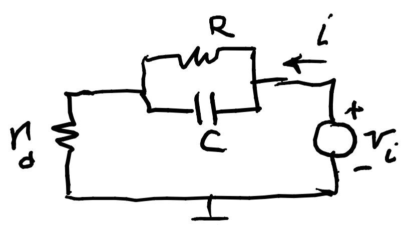
$= e^{24.23}$

$= 3.34 \times 10^{10}$

$I_Q = 3.34 \times 10^{-13} \times 10^{10} = 3.34\,mA$

Then R: $G = \dfrac{I_Q}{E - V_D} = \dfrac{3.34 \times 10^{-3}}{3 - 0.6}$; $R = \dfrac{1}{G} = \dfrac{2.4}{3.34}\,k\Omega = 719\,\Omega$

For small signals



$g_d = \dfrac{di_D}{dv_D}\Big|_Q = \dfrac{I_S}{V_T} \cdot e^{V_D/V_T} = \dfrac{I_Q}{V_T}$; $r_d = \dfrac{1}{g_d} = \dfrac{V_T}{I_Q} = \dfrac{0.026}{3.34 \times 10^{-3}}$

$= \dfrac{26}{3.34} \times 10^{-3} \times 10^{3}$

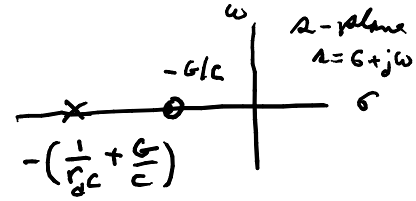
$= 7.78\,\Omega$

let $C = 0.1\,\mu fd = 0.1 \times 10^{-6}\,fd$

If desire small signal current, use admittance

$$Y(s) = \frac{I(s)}{V_i(s)} = \frac{1}{Z(s)} = \frac{1}{r_d + \frac{1}{G + Cs}} = \frac{G + Cs}{(r_d G + 1) + r_d C s}$$

$$Y(s) = \frac{C\left(s + G/C\right)}{r_d C\left(s + \frac{1+r_d G}{r_d C}\right)} = \frac{1}{r_d}\,\frac{\left(s + G/C\right)}{\left(s + \frac{1+r_d G}{r_d C}\right)}$$



$$Y(s) = \frac{1}{7.78}\left(\frac{s + z_n}{s + p_d}\right), \quad z_n = \frac{1}{719 \times 0.1 \times 10^{-6}} = \frac{1}{0.719} \times 10^{4} = 1.39 \times 10^{4}$$

$$p_d = \frac{1 + 7.78 \times \frac{1}{719}}{7.78 \times 0.1 \times 10^{-6}} = \frac{1.011}{0.778 \times 10^{-7}} = 1.30 \times 10^{+7} = 13 \times 10^{+6}$$

$$Y(s) = 0.13\left(\frac{s + 1.39 \times 10^{4}}{s + 13 \times 10^{6}}\right)$$

Choose $v_i(t) = 2 \times 10^{-6} \sin\left(2\pi \times 10^{6} \times t\right)$ $\quad f = 1\,\text{MEG Hz}$

$$Y(j\omega)\Big|_{\omega_i = 2\pi \times 10^{6}} = 0.13\left(\frac{j2\pi \times 10^{6} + 1.39 \times 10^{4}}{j2\pi \times 10^{6} + 13 \times 10^{6}}\right) = \left|Y(j\omega_i)\right| e^{j\angle Y(j\omega_i)}$$

$$\omega_i = 2\pi \times 10^{6} \qquad i(t) = \left|Y(j\omega_i)\right| \cdot \left(2 \times 10^{-6}\right) \sin\left(2\pi \times 10^{6} t + \angle Y(j\omega_i)\right)$$

$$\left|Y(j\omega)\right| = 0.13\,\frac{\left|1.39 \times 10^{4} + j2\pi \times 10^{6}\right|}{\left|13 \times 10^{6} + j2\pi \times 10^{6}\right|} = 0.13 \times 10^{-2}\,\frac{\left|1.39 + j200\pi\right|}{\left|13 + j2\pi\right|}$$

$$\approx \frac{0.13 \times 10^{-2} \times 200\pi}{\sqrt{(13)^2 + (2\pi)^2}} \approx \frac{0.13}{13.7} \times 6.28 = 0.06$$

$$\left|i(t)\right| = 2 \times 10^{-6} \times 6 \times 10^{-2} = 1.2 \times 10^{-7} = 0.12\,\mu a$$

phase = numerator $= \pi/2 = 90^\circ$, denominator $= \tan^{-1}\left(\frac{2\pi}{13}\right) = 25.8^\circ$ $\Big\}$ $(90 - 25.8)^\circ = 64.2^\circ$

$$i(t) = 0.12 \times 10^{-6} \sin\left(2\pi 10^{6} \times t + 64.2^\circ\right)$$