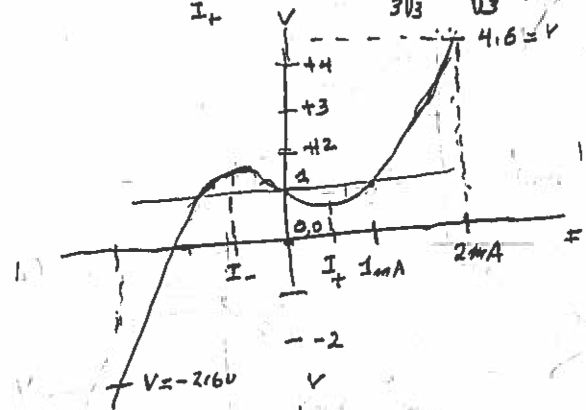
## Solution 303H Midterm, Spring 16

11/08/16

a) First find local max/min: $\frac{dV}{dI} = R_d(3I^2 - 10^{-6}) = 0 \Rightarrow I_{\pm} = \pm 10^{-3}/\sqrt{3}$

$$\Rightarrow V_{max} = V\Big|_{I_-} = 1 + 6\times10^{8}\left(-\frac{10^{-9}}{3\sqrt{3}} + \frac{10^{-9}}{\sqrt{3}}\right) = 1 + \frac{6}{3\sqrt{3}}\times10^{-1}(-1+3) = 1 + \frac{4}{\sqrt{3}}\times10^{-1} =$$

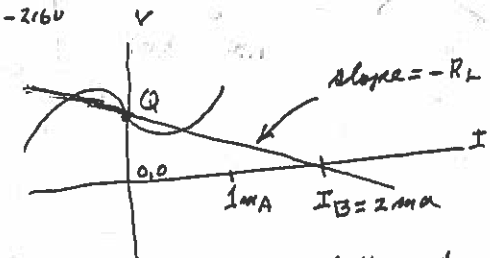
$$V_{min} = V\Big|_{I_+} = 1 + 6\times10^{8}\left(\frac{10^{-9}}{3\sqrt{3}} - \frac{10^{-9}}{\sqrt{3}}\right) = 1 + \frac{6}{3\sqrt{3}}\times10^{-1}(1-3) = 1 - \frac{4}{\sqrt{3}}\times10^{-1}$$




$$V\Big|_{I_B} = 1 + 6\times10^{8}(8\times10^{-9} - 2\times10^{-9}) = 1 + 36\times10^{-1} = 4.6\ V$$

$$V_{-I_B} = 1 + 6\times10^{8}(-8\times10^{-9} + 2\times10^{-9}) = 1 - 36\times10^{-1} = -2.6$$

b)




$I_B = I_{diode} + \frac{1}{R_L}V_{diode}$, $V_{diode} = V$, $I_{diode} = I$

$\Rightarrow V = R_L(I_B - I)$

slope load $= -R_L$

c) $V\Big|_{I=0} = 1$, $V\Big|_{I=I_B} = 0 \Rightarrow$ slope $= \left(V\big|_{I=0} - V\big|_{I=I_B}\right)/(I=0 - I=I_B)$

$= (1-0)/(0-2mA) = -\frac{1}{2}\times10^{3}\,\Omega = -R_L \Rightarrow R_L = 500\,\Omega$

$G_L = \frac{1}{500} = 2\times10^{-3}$

d) $r_d = \frac{dV}{dI}\Big|_Q = R_d(3I_Q^2 - 10^{-6}) = -R_d\times10^{-6} = -6\,\Omega$ ; $g_d = -\frac{1}{6} = -167\times10^{-3}$

e) by KCL $i_{in}' = \frac{1}{r_d}v_{out} + C\frac{dv_{out}}{dt} + \frac{1}{R_L}v_{out} \Rightarrow C\frac{dv_{out}}{dt} + (g_d + G_L)v_{out} = i_{in}'$

$\Rightarrow 2\times10^{-8}\frac{dv_{out}}{dt} + (-167+2)\times10^{-3}v_{out} = i_{in}' \Rightarrow 2\times10^{-8}\frac{dv_{out}}{dt} - 165\times10^{-3}v_{out} = i_{in}'$

f) Let $s = d/dt \Rightarrow [Cs + (g_d + G_L)]V_{out} = I_{in} \Rightarrow T(s) = \frac{V_{out}}{I_{in}} = \frac{1}{Cs + (g_d+G_L)} = \frac{1}{2\times10^{-8}s - 165\times10^{-3}}$

$$= \frac{5\times10^{7}}{s - 87.5\times10^{5}}$$

g) Here $s = j\omega$, $\omega = 2\pi\times10^{10}$

so as a phasor $\frac{V_{out}}{I_{in}} = \frac{5\times10^{7}}{j2\pi\times10^{10} + 87.5\times10^{5}} \approx -j\frac{2.5}{\pi}\times10^{-3}$ ($\angle -90°$)

$$\Rightarrow v_{out} = \frac{2.5}{\pi}\times10^{-3}\times10^{-3}\cos(2\pi\times10^{10}t - \pi/2) \approx 0.709\times10^{-6}\cos(2\pi\times10^{10}t - \tfrac{\pi}{2})$$