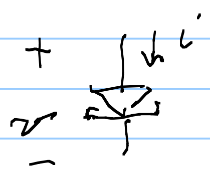
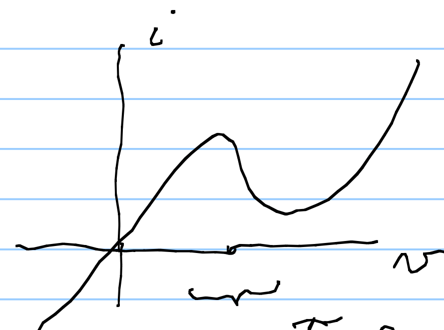
Note Title 10/6/2014

EE303H
10/07/14

Esaki diode = tunnel diode



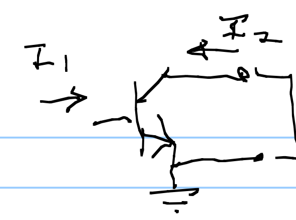


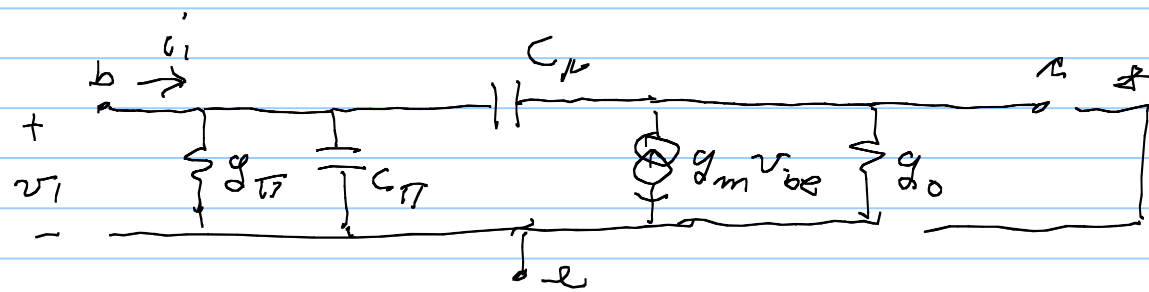
negative differential resistance

h_{fe} a BJT parameter $= h_{21}\Big|$ when e = ground forward

$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = H \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

$$h_{21} = I_2 / I_1 \Big|_{V_2 = 0}$$





$$i_2 = g_m v_1 + C_\mu (s[v_1 - \underbrace{v_2}_{=0}]$$

$$i_2 = (g_m + sC_\mu) v_1 \; ; \quad i_1 = (g_\pi + s C_\pi) v_1 + s C_\mu v_1$$
$$= (g_\pi + s[C_\pi + C_\mu]) v_1$$

$$\Rightarrow v_1 = \frac{i_1}{(g_\pi + s[C_\pi + C_\mu])} \Rightarrow \frac{i_2}{i_1} = \frac{g_m + sC_\mu}{g_\pi + s[C_\pi + C_\mu]}$$

$$\beta(\alpha) = \frac{g_m}{g_\pi}\left(\frac{1+\alpha C_\mu/g_m}{1+\alpha\frac{[C_\pi+C_\mu]}{g_\pi}}\right) = \beta_0 \cdot \frac{1+\alpha C_\mu/g_m}{1+\alpha\frac{[C_\pi+C_\mu]}{g_\pi}}$$

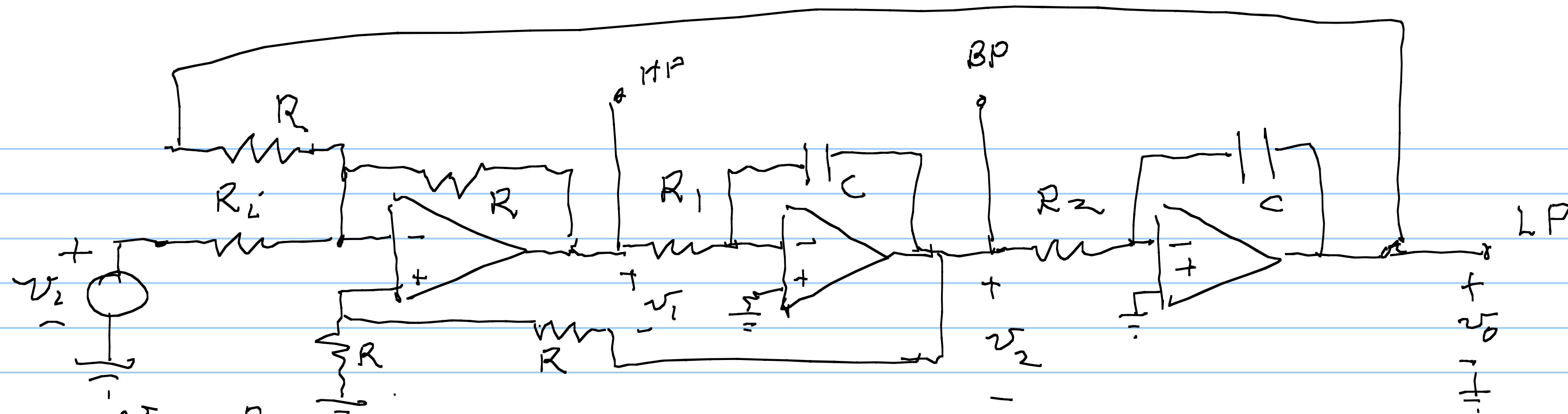
if C_μ is small

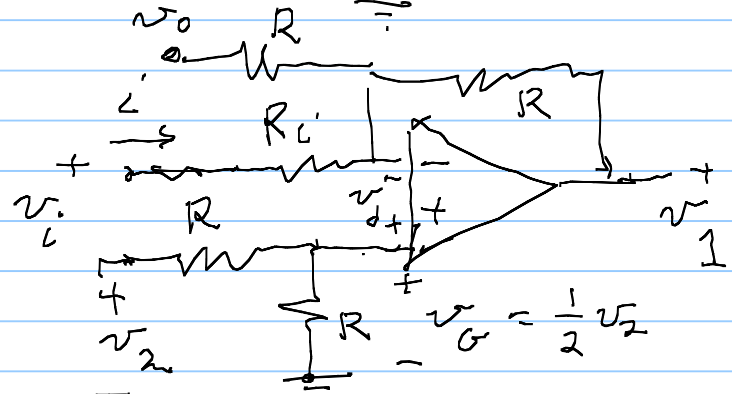
$$\Rightarrow \quad \beta = \beta_0 \frac{1}{1+\alpha/\omega_{3db}} \qquad \omega_{3db} \approx 1\Big/\frac{C_\pi}{g_\pi}$$

$$\beta(j\omega) = \frac{\beta_0}{1+j\omega/\omega_{3db}} \qquad @\ \omega = \omega\ , \quad |\beta(j\omega_T)| = \frac{\beta_0}{\sqrt{2}}$$

$\omega_{3db} =$ 3db frequency

TI design by UAF = universal analog filter





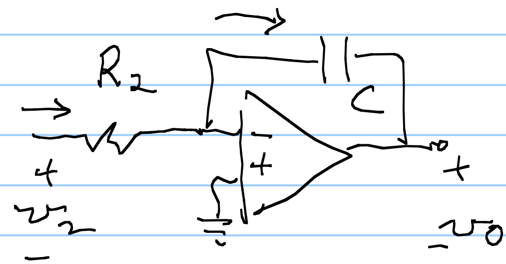
$v_d = 0$, $i_{\text{op-amp in} + \text{or} -} = 0$

$v_1 = -R_i i + \frac{1}{2} v_2$; $i = G_i (v_i - v_G)$

$+ \left(-\frac{R}{R}\right)(v_0 - v_G)$

$v_1 = -R G_i v_i + R G_i \frac{1}{2} v_2 + \frac{2}{2} v_2 - v_0$

$$v_1 = -RG_i v_i + \left(\tfrac{1}{2}\right)(2 + RG_i)v_2 - v_0$$



$$i = -sC\,v_0 = +G_2 v_2$$

$$\frac{v_0}{v_2} = -\frac{G_2}{sC} = -\frac{1}{R_2Cs} = \text{integrator}$$

$$\frac{v_2}{v_1} = -\frac{1}{R_1Cs} \Rightarrow v_2 = -\frac{1}{R_1Cs} \cdot v_1 \Rightarrow v_0 = -\frac{1}{R_2Cs} \cdot \frac{-1}{R_1Cs} v_1$$

$$v_0 = \frac{1}{R_1R_2C^2s^2} v_1 = \frac{1}{R_1R_2C^2s^2}\left[-RR_i v_i + \frac{1}{2}(2 + RG_i)(-R_2Cs)v_0 - v_0\right]$$

$$\left[1 + \frac{(2+RG_i')}{2}\left(\frac{R_2 C s}{R_1 R_2 C^2 s^2}\right) + \frac{1}{R_1 R_2 C^2 s^2}\right] = \frac{-RR_i'}{R_1 R_2 C^2 s^2}\, v_i$$

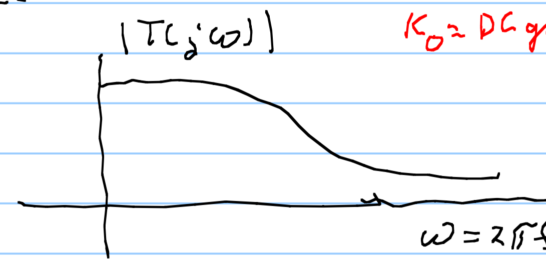
$$\left[s^2 + \frac{(2+RG_i')}{2}\,\frac{1}{R_1 C}\cdot s + \frac{1}{R_1 R_2 C^2}\right] v_o = -\frac{RR_i'}{R_1 R_2 C^2}\, v_i$$

$$\frac{v_o}{v_i} = T(s) = \frac{-\dfrac{RR_i'}{R_1 R C^2}}{s^2 + \dfrac{(2+RG_i')}{2}\,\dfrac{1}{R_1 C}\, s + \dfrac{1}{R_1 R_2 C^2}} = \frac{K_0\,\omega_0^2}{s^2 + \dfrac{\omega_0}{Q} s + \omega_0^2}$$

$K_0 =$ DC gain

$$\omega_0^2 = \frac{1}{R_1 R_2 C^2} \Rightarrow \omega_0 = \frac{1}{C}\,\frac{1}{\sqrt{R_1 R_2}}$$

$$\frac{\omega_0}{Q} \Rightarrow Q = \frac{\omega_0\, 2}{(2+RG_i)} \times R_1 C = 2\sqrt{\frac{R_1}{R_2}}\cdot\frac{1}{(2+RG_i)}$$



all-pass $= T(s) = \dfrac{s^2 - \frac{\omega_0}{Q} s + \omega_0^2}{s^2 + \frac{\omega_0}{Q} s + \omega_0^2}$; $|T(j\omega)| = 1$