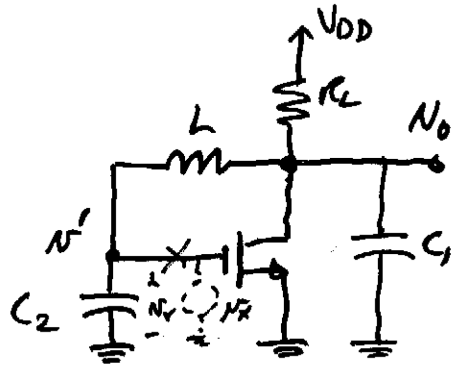
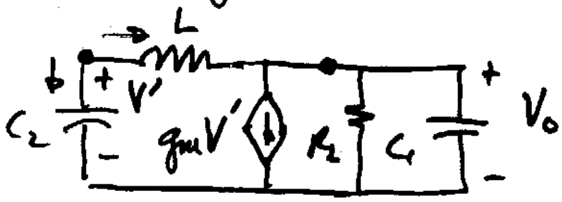
Example of an LC Oscillator

An LC oscillator is shown. Find an expression for the frequency of oscillation and the value of $g_m R_L$ necessary to oscillate. Assume that the value of $r_{ds} = \infty$.



Small-signal model – (Determinant = 0 approach)



$$g_m V' + G_L V_o + sC_1 V_o + \frac{(V_o - V')}{sL} = 0$$

$$sC_2 V' + \frac{(V' - V_o)}{sL} = 0$$

$$sC_2 V' + \frac{V'}{sL} = \frac{V_o}{sL} \rightarrow V_o = (1 + s^2 L C_2) V'$$

$$g_m V' + \left(G_L + sC_1 + \frac{1}{sL}\right)(1 + s^2 L C_2) V' - \frac{V'}{sL} = \Delta = 0$$

Assuming a non-zero value of V', then

$$g_m + \left(G_L + sC_1 + \frac{1}{sL}\right)(1 + s^2 L C_2) - \frac{1}{sL} = 0$$

$$g_m + G_L + sC_1 + \cancel{\frac{1}{sL}} + s^2 L C_2 G_L + s^3 L C_1 C_2 + sC_2 - \cancel{\frac{1}{sL}} = 0$$

$$\left[g_m + G_L - \omega^2 L C_2 G_L\right] + j\omega\left[C_1 + C_2 - \omega^2 L C_1 C_2\right] = 0$$

$$\boxed{\omega_{osc} = \sqrt{\frac{C_1 + C_2}{L C_1 C_2}} = \frac{1}{\sqrt{L \frac{C_1 C_2}{C_1 + C_2}}}}$$

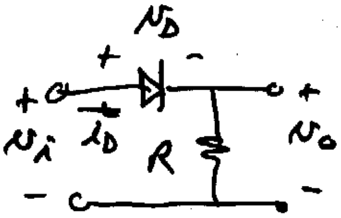
$$g_m + G_L = \omega^2 L C_2 G_L$$

$$g_m + \cancel{G_L} = \cancel{L C_2} G_L \left(\frac{C_1 + C_2}{\cancel{L} C_1 \cancel{C_2}}\right) = G_L\left(1 + \frac{C_2}{C_1}\right) = \cancel{G_L} + G_L \frac{C_2}{C_1}$$

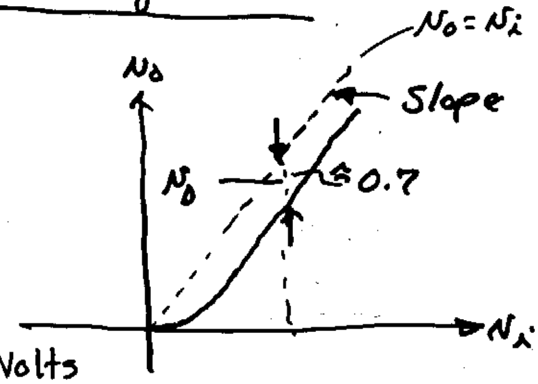
$$g_m = G_L \frac{C_2}{C_1} \rightarrow \boxed{g_m R_L = \frac{C_2}{C_1}}$$

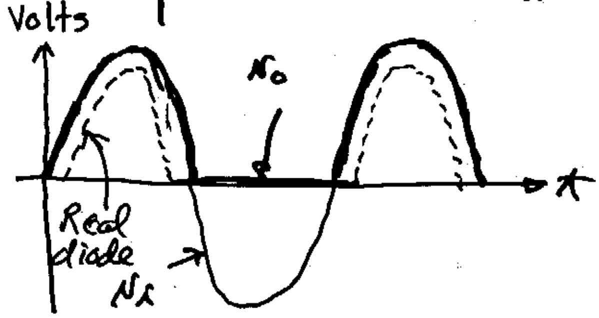
12.12 - Nonlinear Circuits using Op Amp

Rectification

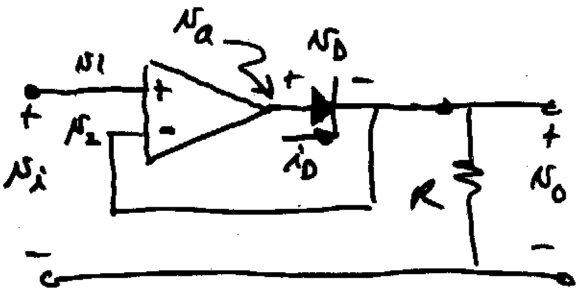


$v_o = v_i - v_D$





"Super Diode"



Assume that $A_v \gg 1$

$v_o = v_a - v_D$

$v_a = A_v (v_1 - v_2)$

$v_o = A_v (v_1 - v_2) - v_D$

$v_o = A_v (v_i - v_o) - v_D = A_v v_i - A_v v_o - v_D$

$v_o (1 + A_v) = A_v v_i - v_D$

$$v_o = \frac{A_v}{1 + A_v} v_i - \frac{v_D}{1 + A_v} \xrightarrow{A_v \to \infty} v_i$$

If $A_v \to \infty \to \underline{\underline{v_o = v_i}}$

Principle?