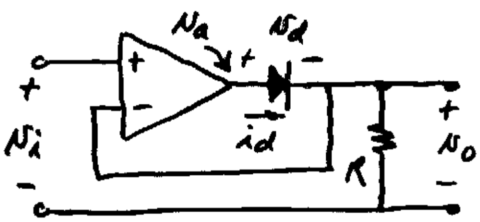
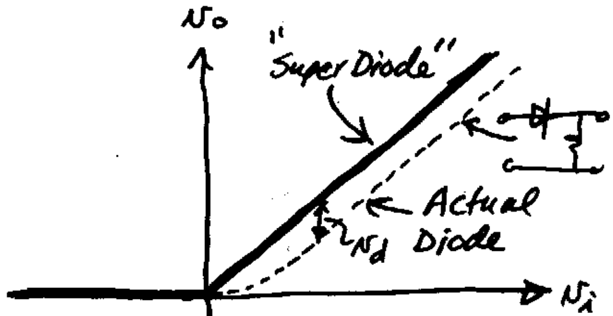
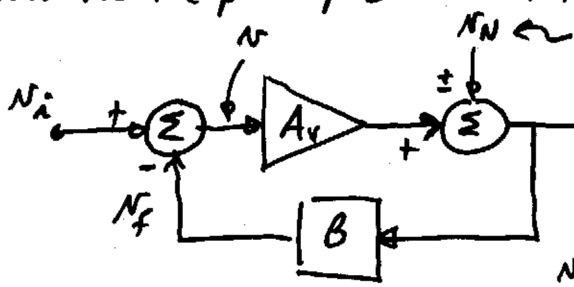
Nonlinear Circuits using the Op Amp

"Super Diode"





What is the principle behind this circuit which makes it work?



$$v_o = \pm v_N + A_v(v_i - v_f)$$

$$v_o = A_v(v_i - B v_o) \pm v_N$$

$$v_o(1 + A_v B) = A_v v_i \pm v_N$$

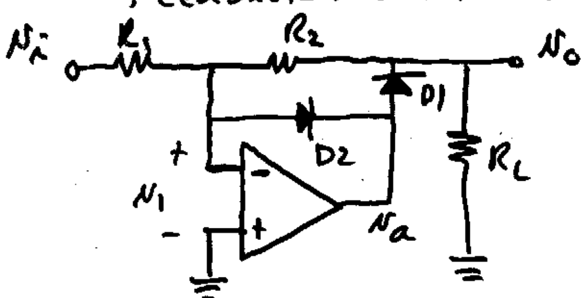
$$v_o = \frac{A_v}{1+BA_v} v_i \pm \frac{v_N}{1+BA_v}$$

As $A_v B >> 1$,

$$v_o \simeq \frac{v_i}{B} \pm \frac{v_N}{1+BA_v} = \frac{v_i}{B}$$

In the "superdiode" $B = 1$ so $v_o = v_i$

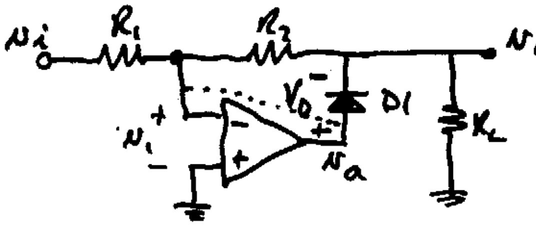
Practical Application of the above ideas –
(Problem is in the "super diode", the op amp doesn't have feedback when the diode is off.)



Note that D1 and D2 cannot both be ON.

$v_1 < 0$

$\therefore v_a > 0 \Rightarrow$ D1 ON & D2 OFF

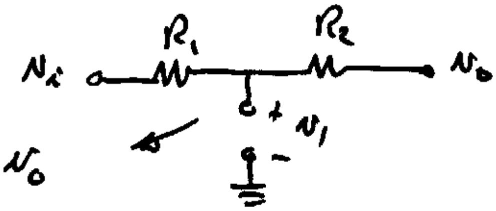


Cont'd

$$v_O = v_a - V_D = -A_N v_1 - V_D$$

$v_1 = ?$

$$v_1 = \frac{R_2}{R_1+R_2} v_i + \frac{R_1}{R_1+R_2} v_O$$



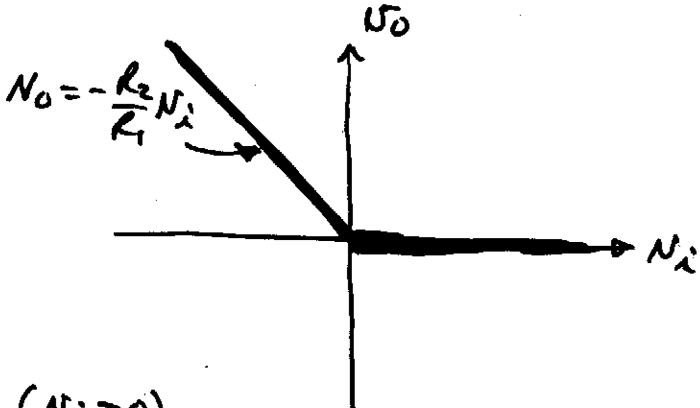
$$v_O = -A_N \left[\frac{R_2}{R_1+R_2} v_i + \frac{R_1}{R_1+R_2} v_O\right] - V_D$$

$$v_O \left[1 + \frac{A_N R_1}{R_1+R_2}\right] = -A_N \frac{R_2}{R_1+R_2} v_i - V_D$$

$$A_N \frac{R_1}{R_1+R_2} >> 1$$

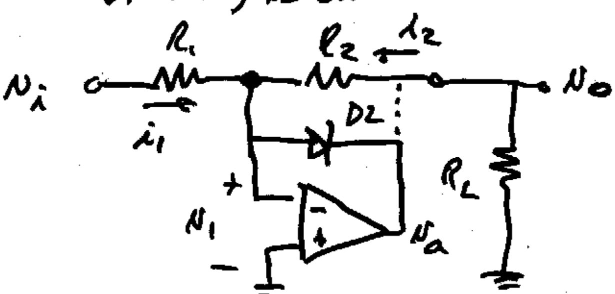
$$v_O = \left(-\frac{R_2}{R_1}\right) \frac{A_N \frac{R_1}{R_1+R_2}}{1 + A_N \frac{R_1}{R_1+R_2}} - \frac{V_D}{1 + A_N \frac{R_1}{R_1+R_2}} \longrightarrow v_O = -\frac{R_2}{R_1} v_i - \frac{V_D}{1 + A_N \frac{R_1}{R_1+R_2}}$$

$$\underline{\underline{v_O \approx -\frac{R_2}{R_1} v_i}}$$



$\underline{v_1 > 0 \; (v_i > 0)}$

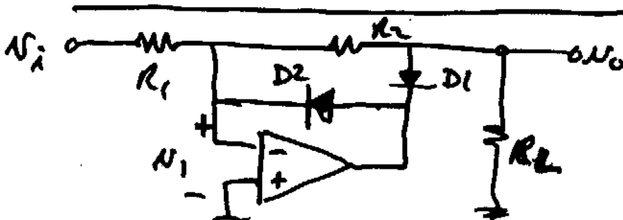
D1 OFF, D2 ON

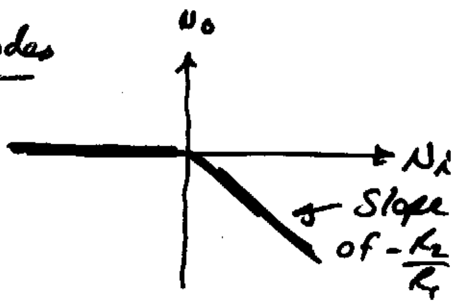


$$i_1 = \frac{v_i}{R_1}, \quad i_2 = \frac{v_O}{R_2} = 0$$

$$v_O = 0$$

Reverse the Direction of the Diodes





Example

Design an op amp circuit which gives $v_o = -|v_{in}|$ using the previous practical op amp diode circuits