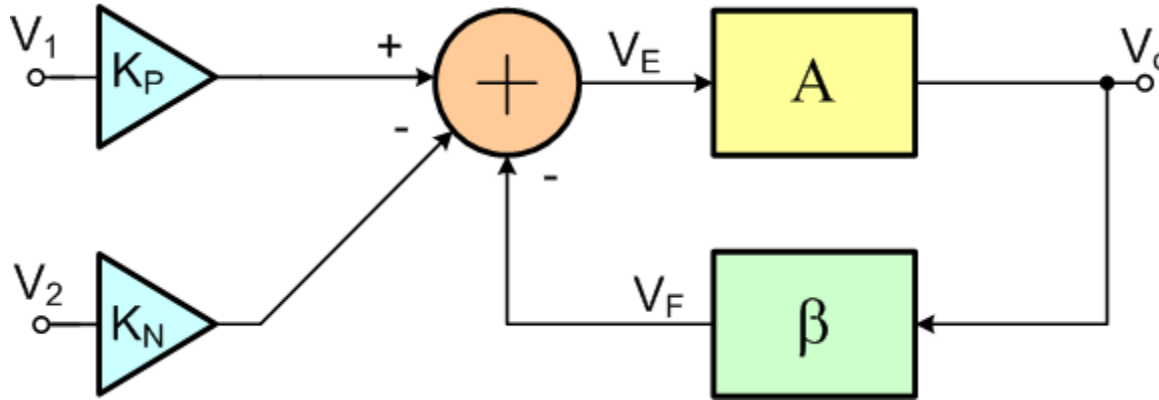


How to implement a negative feedback amplifier from a top level block diagram.



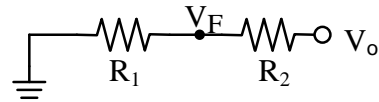
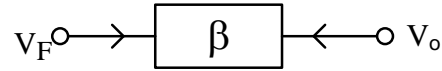
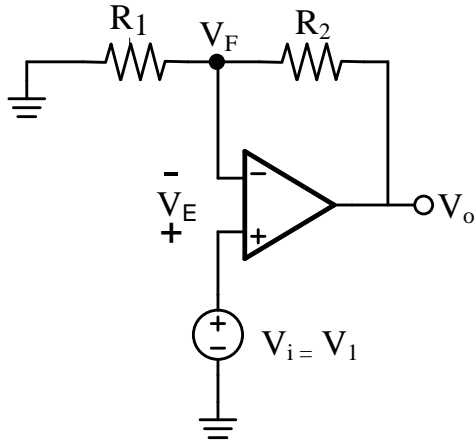
$$V_E = V_1 K_p - V_2 K_N - \beta V_o$$

$$V_o = \frac{K_p A V_1}{1 + \beta A} - \frac{K_N A V_2}{1 + \beta A} = \frac{(K_p / \beta) V_1}{1 + \frac{1}{\beta A}} - \frac{(K_N / \beta) V_2}{1 + \frac{1}{\beta A}}$$

Let us consider the corresponding implementations for K_p and K_N one at the time.

$$\beta = \frac{V_F}{V_o} \left| \begin{array}{l} V_1 = V_2 = 0 \\ \text{And disconnecting} \\ \text{A. i.e. } V_o = 0 \end{array} \right. \quad K_p = \frac{V_E}{V_1} \left| \begin{array}{l} V_2 = 0 \\ V_o = 0 \end{array} \right. \quad K_N = \frac{V_E}{V_2} \left| \begin{array}{l} V_1 = 0 \\ V_o = 0 \end{array} \right.$$

Non-Inverter Amplifier



$$V_E = -\frac{R_1 V_o}{R_1 + R_2} = -\frac{V_o}{1 + \frac{R_2}{R_1}}$$

Notice $V_F = -V_E$

$$\beta = \frac{1}{1 + \frac{R_2}{R_1}} = \frac{G_2}{G_1 + G_2}$$

From system level

$$V_E = V_1 K_p - \beta V_o$$

$$K_p = \left. \frac{V_E}{V_1} \right|_{V_o=0}$$

From circuit implementation

$$V_E = V_p - V_N = V_i - 0 = V_i$$

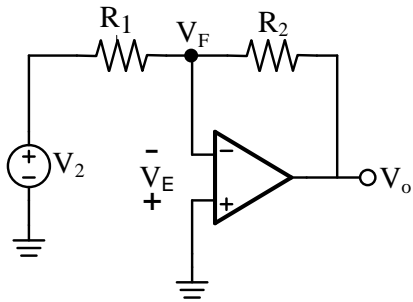
Therefore

$$K_p = 1$$

Thus

$$H_{NI} = \frac{V_o}{V_1} = \frac{\frac{1}{\beta}}{1 + \frac{1}{\beta A}} = \frac{1 + \frac{R_2}{R_1}}{1 + \frac{1}{A} \left(1 + \frac{R_2}{R_1} \right)} \Bigg|_{A \rightarrow \infty} = 1 + \frac{R_2}{R_1}$$

Inverting Amplifier



- β is obtained exactly the same way as before.

$$\beta = \frac{1}{1 + \frac{R_2}{R_1}} = \frac{G_2}{G_1 + G_2}$$

From System

$$V_E = -K_N V_2 - \beta V_o$$

From Circuit

$$V_E = -K_N V_2 \Big|_{V_o=0}$$

$$V_E = -V_2 \frac{R_2}{R_1 + R_2} = -V_2 \frac{G_1}{G_1 + G_2} = -V_2 \frac{\frac{R_2}{R_1}}{1 + \frac{R_2}{R_1}} = -V_2 \frac{R_2}{R_1} \beta$$

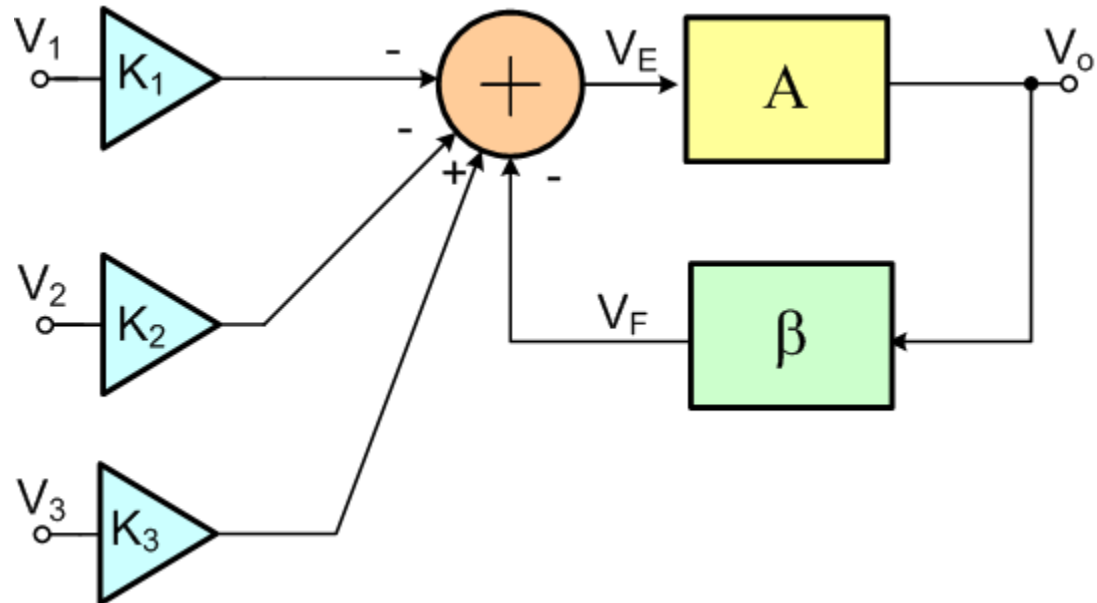
Thus

$$K_N = \frac{V_E}{V_2} = \frac{R_2}{R_1} \beta = \frac{G_1}{G_1 + G_2}$$

Therefore

$$H(s) = \frac{-K_N \frac{1}{\beta}}{1 + \frac{1}{\beta A}} = \frac{-\frac{R_2}{R_1}}{1 + \frac{1}{A} \left(1 + \frac{R_2}{R_1}\right)}$$

Let us now consider a more general case



$$V_E = -K_1 V_1 - K_2 V_2 + K_3 V_3 - \beta V_o$$

At the Op Amp

$$V_E = V_p - V_N$$

Thus

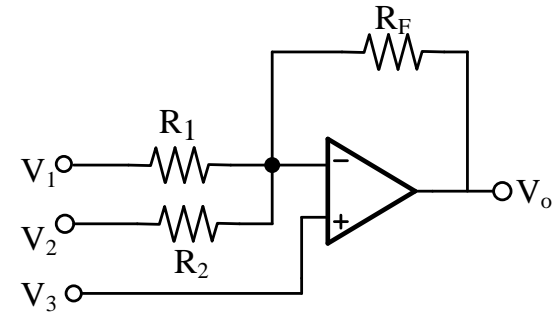
$$V_p = K_3 V_3$$

$$V_N = K_1 V_1 + K_2 V_2 + \beta V_o$$

Therefore

$$K_1 = \left. \frac{V_E}{V_1} \right|_{V_o=0, V_2=V_3=0} = \frac{R_F // R_2}{R_F // R_2 + R_1} = \frac{G_1}{G_F + G_2 + G_1}$$

$$K_2 = \left. \frac{V_E}{V_2} \right|_{V_o=V_1=V_3=0} = \frac{R_F // R_1}{R_F // R_1 + R_2} = \frac{G_2}{G_F + G_2 + G_1}$$



$$K_3 = \left. \frac{V_E}{V_3} \right|_{V_0=V_1=V_2=0} = 1$$

Furthermore β can be obtained as

$$\beta = \frac{R_1 // R_2}{R_1 // R_2 + R_F} = \frac{G_F}{G_F + G_2 + G_1}$$

Note that in the case that the Op Amp has an input impedance r_d this will load R_1 and R_2 . For example for β , this becomes

$$\beta = \frac{R_1 // R_2 // r_d}{R_1 // R_2 // r_d + R_F} = \frac{G_F}{G_F + G_2 + G_1 + G_d}$$

Also K_1 and K_2 will be modified to take into account r_d .