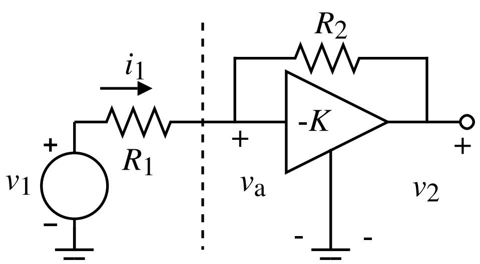
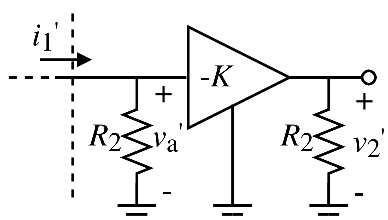
## SHUNT INPUT FEEDBACK VERSUS A THEVINEN AND NORTON INPUT SOURCE

This example illustrates how to apply shunt-input feedback with either a Thevinen or Norton input source. The inverting voltage amplifier with a gain of $K$ and infinite input and zero output resistance is shown in a shunt-shunt configuration but all results of this example are also applicable to shunt-series.

In the following, we will find the voltage gain, $v_2/v_1$, and the input resistance defined as $v_1/i_1$. The results for either case will be shown to be the same. The vertical dotted line illustrates the boundary for the feedback analysis method for either case.



Thevinen Input Source



Open-Loop Thevinen Input Source

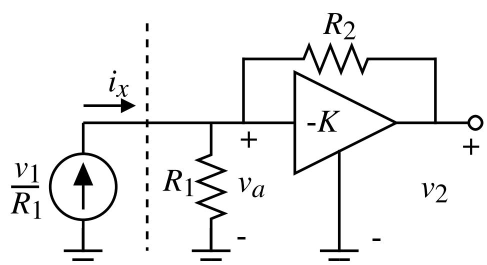
$$\beta = \frac{-1}{R_2}$$

$$v_2' = -KR_2 i_1' \Rightarrow \frac{v_2'}{i_1'} = R_T = -KR_2$$

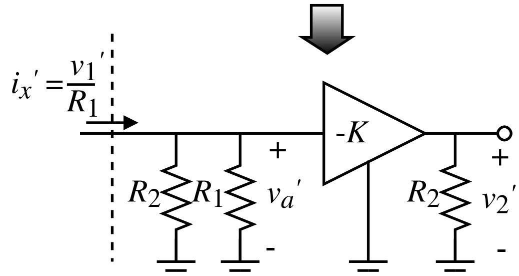
$$\frac{v_2}{i_1} = \frac{-KR_2}{1+(-KR_2)\left(\frac{-1}{R_2}\right)} = \frac{-KR_2}{1+K}$$

$$\frac{v_a}{i_1} = R_{inF} = \frac{R_2}{1+K}$$

$$\boxed{\frac{v_1}{i_1} = R_1 + R_{inF} = R_1 + \frac{R_2}{1+K}}$$



Norton Input



Open-Loop Norton Input

$$\beta = \frac{-1}{R_2}$$

$$v_2' = -K(R_1 \| R_2) i_x' \Rightarrow \frac{v_2'}{i_x'} = R_T = -K(R_1 \| R_2)$$

$$\frac{v_2}{i_1} = \frac{-K(R_1 \| R_2)}{1+(-K(R_1 \| R_2))\left(\frac{-1}{R_2}\right)} = \frac{-K\frac{R_1R_2}{R_1+R_2}}{1+K\frac{R_1}{R_1+R_2}}$$

$$\frac{v_a}{i_x} = R_{inF} = \frac{\frac{R_1R_2}{R_1+R_2}}{1+K\frac{R_1}{R_1+R_2}}$$

$$\frac{v_a}{i_x} = \frac{v_a R_1}{v_1} \text{ which gives,}$$

$$\frac{v_2}{v_1} = \frac{v_2}{i_1}\frac{i_1}{v_1} = \left(\frac{-KR_2}{1+K}\right)\left(\frac{1}{R_1 + \frac{R_2}{1+K}}\right)$$

$$= \frac{-KR_2}{R_1(1+K) + R_2} = \frac{-KR_2}{R_1 + R_2 + KR_1}$$

$$\boxed{\frac{v_2}{v_1} = -\frac{R_2}{R_1}\frac{\frac{KR_1}{R_1+R_2}}{1+\frac{KR_1}{R_2+R_1}}}$$

$$v_a = \frac{\frac{R_2}{R_1+R_2}}{1+K\frac{R_1}{R_1+R_2}}\ v_1$$

$i_1$ can be expressed from the Thevinen form as,

$$i_1 = \frac{v_1}{R_1} - \frac{v_a}{R_1} = \frac{v_1}{R_1} - \frac{\frac{R_2}{R_1+R_2}}{1+K\frac{R_1}{R_1+R_2}}\frac{v_1}{R_1}$$

$$\therefore\ \frac{i_1}{v_1} = \frac{1}{R_1}\left(1 - \frac{\frac{R_2}{R_1+R_2}}{1+K\frac{R_1}{R_1+R_2}}\right)$$

$$= \frac{1}{R_1}\left(\frac{1+K\frac{R_1}{R_1+R_2} - \frac{R_2}{R_1+R_2}}{1+K\frac{R_1}{R_1+R_2}}\right) = \frac{1+K}{R_1+R_2+KR_1}$$

Finally,

$$\boxed{\frac{v_1}{i_1} = R_1 + \frac{R_2}{1+K}}$$

Lastly,

$$\frac{v_2}{v_1} = \frac{v_2}{i_x}\frac{i_x}{v_1} = \frac{\frac{R_1R_2}{R_1+R_2}}{1+K\frac{R_1}{R_1+R_2}}\left(\frac{1}{R_1}\right)$$

$$\boxed{\frac{v_2}{v_1} = -\frac{R_2}{R_1}\frac{\frac{KR_1}{R_1+R_2}}{1+\frac{KR_1}{R_2+R_1}}}$$

So the results are identical although one method is a lot more work than the other.