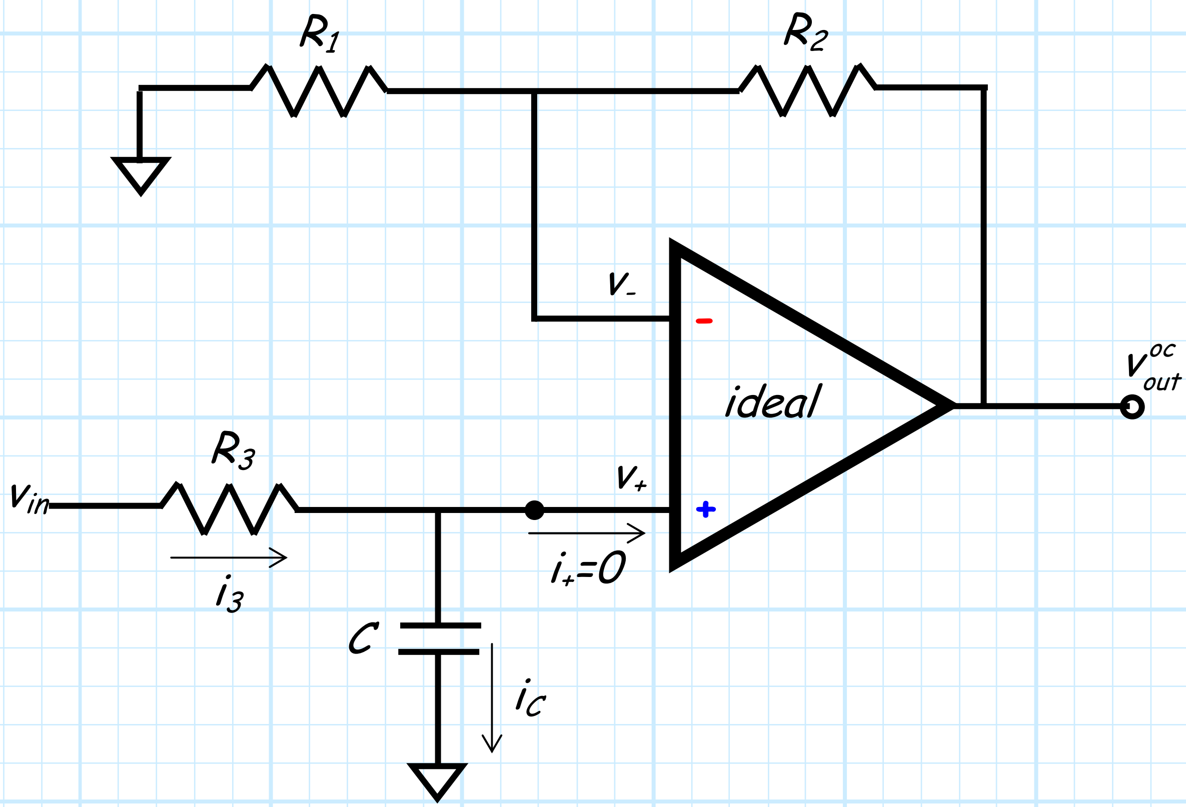
Example: A Non-Inverting Network

Let's determine the **transfer function** $G(\omega) = v_{out}^{oc}(\omega) / v_{in}(\omega)$ for the following circuit:



Some enjoyable circuit analysis

From **KCL**, we know:

$$i_3(\omega) = i_C(\omega) + i_+(\omega) = i_C(\omega) + 0 = i_C(\omega)$$

where:

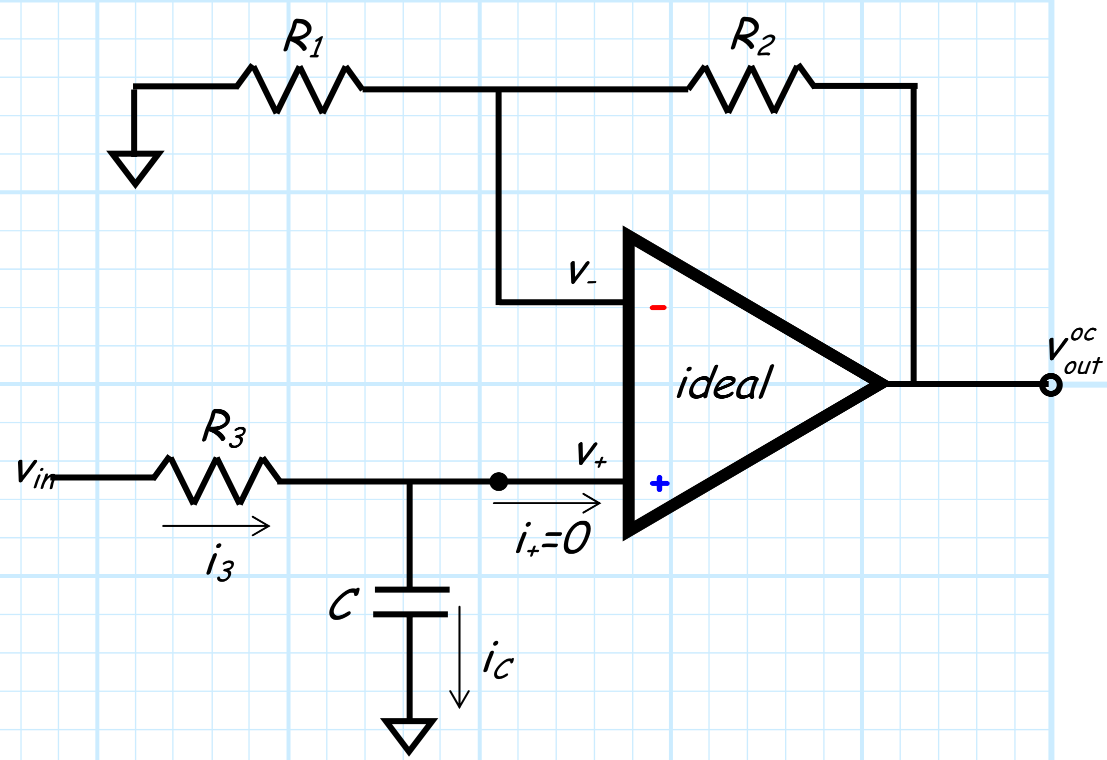
$$i_3(\omega) = \frac{v_{in}(\omega) - v_+(\omega)}{R_3} \qquad \text{and} \qquad i_C(\omega) = \frac{v_+(\omega) - 0}{\left(1/j\omega C\right)} = j\omega C\, v_+(\omega)$$

Equating, we find an expression involving $v_{in}(\omega)$ and $v_2(\omega)$ only:

$$\frac{v_{in}(\omega) - v_+(\omega)}{R_3} = j\omega C\, v_+(\omega)$$

and performing a little **algebra**, we find:

$$v_2(\omega) = \frac{v_{in}(\omega)}{1 + j\omega R_3 C}$$

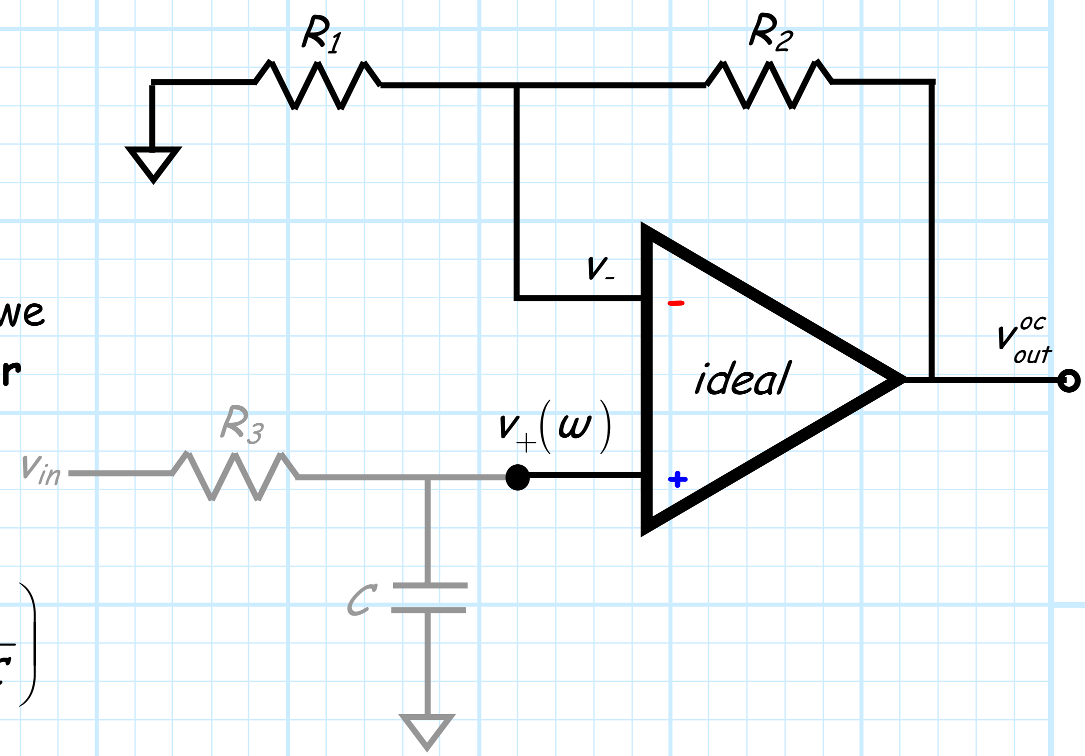


No need to go further: we have a template!

The remainder of the circuit is simply the **non-inverting amplifier** that we studied earlier.

We know that:

$$v_{out}^{oc}(\omega) = \left(1 + \frac{R_2}{R_1}\right) v_+(\omega)$$



Combining these two relationships, we can determine the **complex transfer function** for this circuit:

$$G(\omega) = \frac{v_{out}(\omega)}{v_{in}(\omega)} = \left(1 + \frac{R_2}{R_1}\right)\left(\frac{1}{1 + j\omega R_3 C}\right)$$

It's a low-pass filter!!!

The **magnitude** of this transfer function is therefore:

$$|G(\omega)|^2 = \left(1 + \frac{R_2}{R_1}\right)^2 \frac{1}{1 + \left(\omega/\omega_0\right)^2}$$

where:

$$\omega_0 = \frac{1}{R_3 C}$$

This is a **low-pass filter**—one with **pass-band gain**!