Building filters with op-amps

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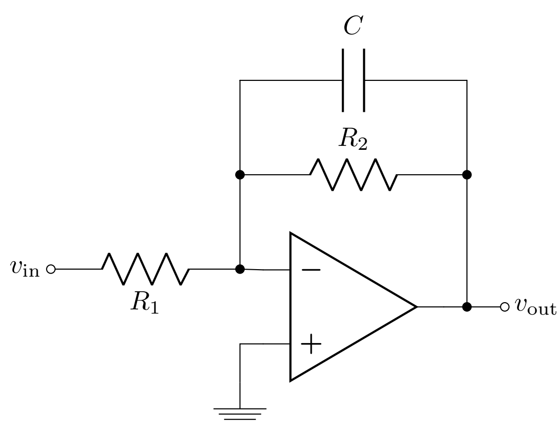
There's nothing new about building filters with op-amps. It's just a combination of what we did in the last two lectures: Apply the *golden rules of ideal op-amps in negative feedback*, using impedance for capacitors or inductors, to derive an expression for gain as a function of frequency.

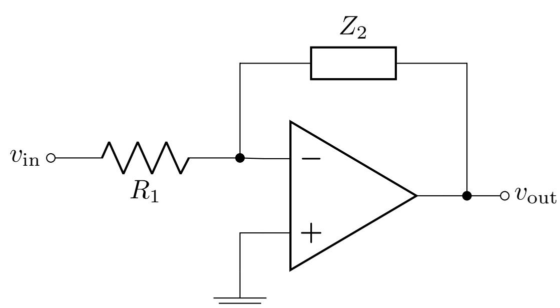
In many cases, you might be able to use the results for the inverting and non-inverting amplifiers (Examples 1 and 2 of last lecture) as a shortcut, after combining resistors, capacitors and/or inductors into a single impedance.

Example

Example 1. Consider the circuit below.



Using impedance, we can combine R_2 and C, as follows:



where

$$Z_2 = \left(\frac{1}{R_2} + \frac{1}{Z_C}\right)^{-1} = \frac{R_2}{1 + j2\pi f C R_2}.$$

Then this is just an inverting amplifier, as in Example 1 of last lecture, where

$$\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{Z_2}{R_1} = -\frac{R_2/R_1}{1 + j2\pi f C R_2}.$$

Note that this a first-order low-pass filter of the form $\frac{V_{\text{out}}}{V_{\text{in}}} = \frac{A}{1+jBf}$, where

$$A = -\frac{R_2}{R_1}, \qquad B = 2\pi C R_2,$$

So to draw the Bode magnitude plot, we can just use our general method, using the DC gain A and corner frequency $\frac{1}{B}$. That negative sign doesn't affect the magnitude, so the DC gain is just $|A|$, and the rest of the plot works as usual.