Analyzing Op-Amp circuits

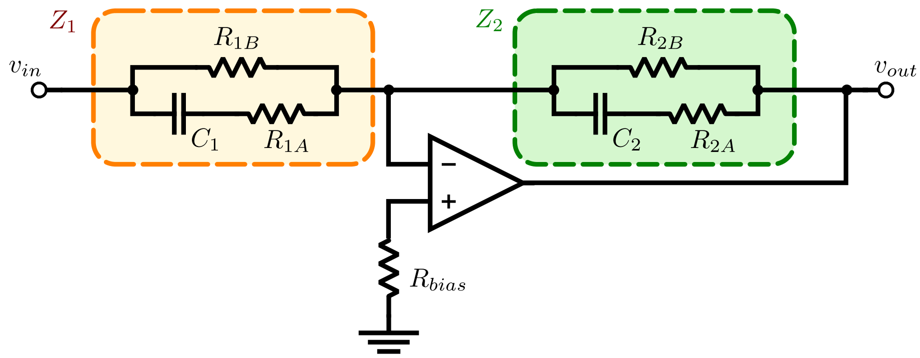

Figure 1: Inverting amplifier configuration

The inverting amplifier configuration is shown in Figure 1. The transfer function of this circuit is

$$H \equiv \frac{v_{out}}{v_{in}} = -\frac{Z_2}{Z_1}$$

. By choosing the (frequency-dependent) impedances $Z_1$and Z_2 we can determine the transfer function of the filter. A simple configuration of two resistors and a capacitor, as shown, allows one to implement two poles and two zeros. The functionality is easy to understand intuitively: The path containing a single resistor sets the impedance at DC. The parallel path containing a resistor and a capacitor in series becomes active at high frequency.

The transfer function is:

$$H(s) = \frac{R_{2B}}{R_{1B}} \frac{\omega_{p1}\omega_{p2}}{\omega_{z1}\omega_{z2}} \frac{(s-\omega_{z1})(s-\omega_{z2})}{(s-\omega_{p1})(s-\omega_{p2})}$$

where the poles and zeros are given by:

$$\begin{aligned} \omega_{z1} &= ((R_{1A}+R_{1B})\,C_1)^{-1} & \qquad w_{z2} &= (R_{2A}C_2)^{-1} \\ w_{p1} &= (R_{1A}C_1)^{-1} & \qquad \omega_{z2} &= ((R_{2A}+R_{2B})\,C_2)^{-1} \end{aligned}$$

For an ideal op-amp, R_{bias} would do nothing, since no current flows into the ideal op-amp's input. A real op-amp has some bias current i_B going into the inputs. The resistor R_{bias} is chosen to be equal to the DC source impedance $(R_{1B}||R_{2B})$ seen by the other input in order to turn this bias current into a common-mode voltage.

Noise

In front-end electronics, we care not just about the transfer function of the active filter, but also the noise performance. The purpose of the first active filter in a readout chain is to boost the signal above the noise level of all downstream electronics while itself adding negligible noise.

Although noise is added at many points within a sequence of amplifiers, it is often most convenient to quote noise as “input-referred noise”.