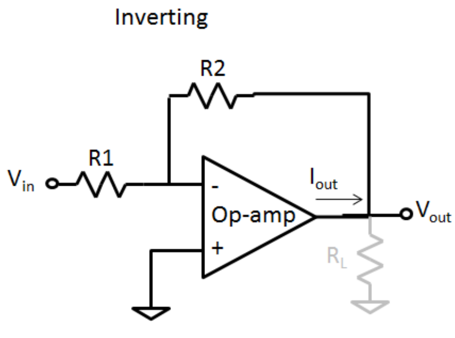
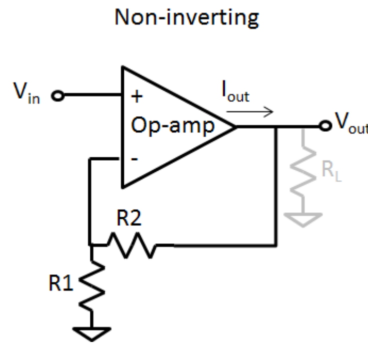
Prelab Problem 3.1: Inverting and non-inverting amplifiers

Consider the inverting and non-inverting amplifiers shown below.





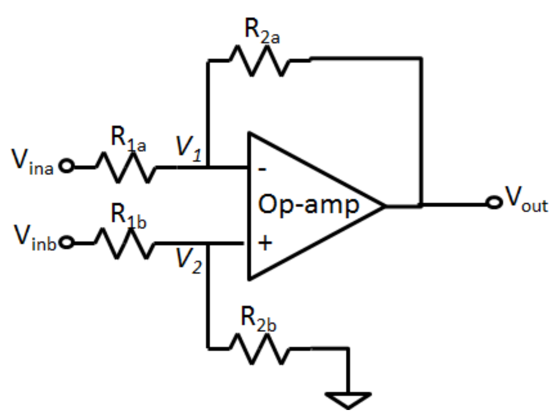
(a) Assume that the op-amp has infinite input resistance ($R_I \to \infty$) and zero output resistance ($R_O = 0$), but finite gain A. Write equations for the amplifier gain G ($\equiv V_{out}/V_{in}$), and its input resistance R_{in} as a function of A, R_1 and R_2. As A gets very large, what do these converge to in each amplifier? (Assume, the load resistor R_L is not present).

(b) In each case, (for A very large) and fixed $R_1 = 500\ \Omega$, what is the gain when $R_2 = 0$? When $R_2 = 2\ k\Omega$? (Assume, R_L is not present).

(c) Op-amps generally have a limited range of output voltages, and also a limited range of output currents. For an amplifier with $5\ V > V_{out} > -5\ V$, and $30\ mA > I_{out} > -30\ mA$, what is the range of output voltages possible when the amplifier is loaded by $R_L = 100\ \Omega$?

Prelab Problem 3.2: Differential amplifier

Consider the differential amplifier shown to the right, and assume an ideal op-amp.



(a) In terms of V_{ina}, V_{inb}, R_{1a}, R_{1b}, R_{2a}, and R_{2b}, find V_2, V_1 and V_{out}.

(b) If $R_{1a} = R_{1b} = R_1$, and $R_{2a} = R_{2b} = R_2$, what is V_{out}, in terms of R_1, R_2, V_{ina}, and V_{inb}?

(c) Now, redefine the inputs as a common-mode signal $V_{inc} = (V_{ina} + V_{inb})/2$ and a differential mode signal $V_{ind} = (V_{ina} - V_{inb})$. Rewrite V_{ina} and V_{inb} each in terms of V_{inc} and V_{ind}.

(d) Compute the differential mode gain G_d, and common mode gain G_c, where $G_d \equiv V_{out}/V_{ind}$ when $V_{inc} = 0$, and $G_c \equiv V_{out}/V_{inc}$ when $V_{ind} = 0$.

(e) Now, compute G_d and G_c for imperfectly matched resistors, i.e., when $R_{1b} = R_{1a}(1 + \Delta_1)$, $R_{2b} = R_{2a}(1 + \Delta_2)$, and $R_{2a} = 10 \cdot R_{1a}$ for the following four cases:

(i.) $\Delta_1 = 0.05, \Delta_2 = 0.05$

(ii.) $\Delta_1 = 0.05, \Delta_2 = -0.05$

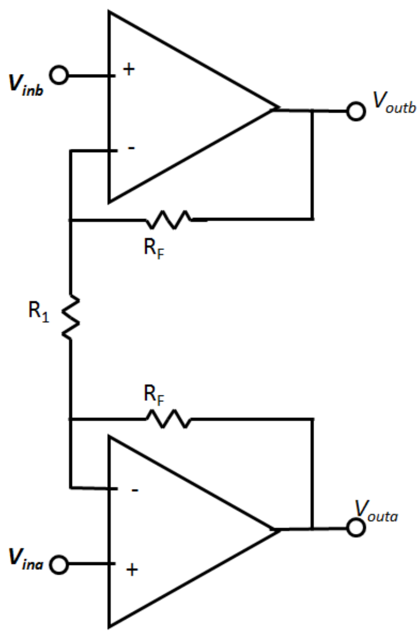
(iii.) $\Delta_1 = -0.05, \Delta_2 = 0.05$

(iv.) $\Delta_1 = -0.05, \Delta_2 = -0.05$

Which cases have the worst Common Mode Rejection Ratio (CMRR $\equiv G_d/G_c$) and what is it in those cases?

Prelab Problem 3.3: Fully differential amplifier

Consider the fully differential amplifier shown below. Assume the op-amp is ideal.



Compute V_{outa} and V_{outb} in terms of R_1 and R_F.

(a) Determine the differential mode gain $G_d = (V_{outa} - V_{outb})/(V_{ina} - V_{inb})$ and the common mode gain $G_c = (V_{outa} + V_{outb})/(V_{ina} + V_{inb})$.

(b) What is the CMRR ($\equiv G_d/G_c$)?