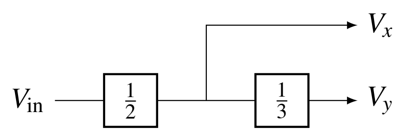
EECS 16A Designing Information Devices and Systems I
Fall 2022 Discussion 11A

1. Modular Circuit Buffer

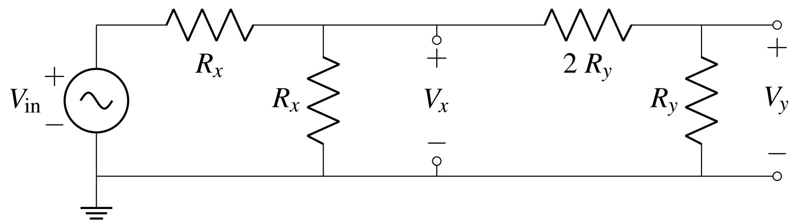
Let's try designing circuits that perform a set of mathematical operations using op-amps. While voltage dividers on their own cannot be combined without altering their behavior, op-amps can preserve their behavior when combined and thus are a perfect tool for modular circuit design. We would like to implement the block diagram shown below:



In other words, create a circuit with two outputs V_x and V_y, where $V_x = \frac{1}{2}V_{\text{in}}$ and $V_y = \frac{1}{3}V_x = \frac{1}{6}V_{\text{in}}$.

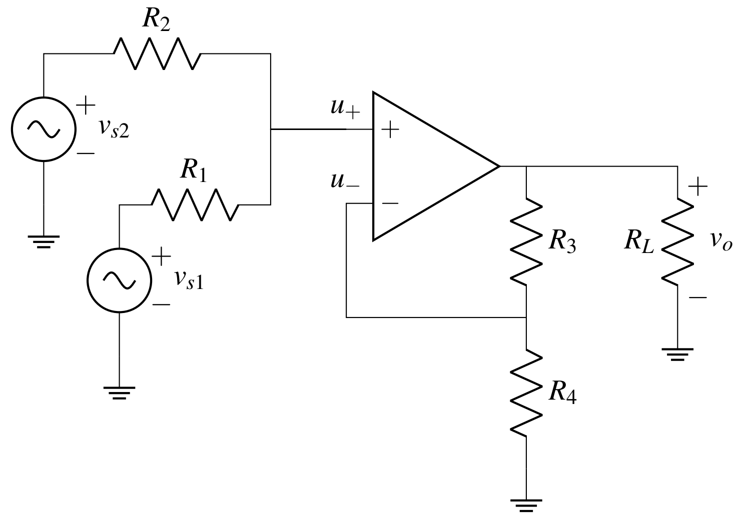
(a) Draw two voltage dividers, one for each operation (the $1/2$ and $1/3$ scalings). What relationships hold for the resistor values for the $1/2$ divider, and for the resistor values for the $1/3$ divider?

(b) If you combine the voltage dividers, made in part (a), as shown by the block diagram (output of the $1/2$ voltage divider becomes the source for the $1/3$ voltage divider circuit), do they behave as we hope (meaning $V_{\text{in}} = 2V_x = 6V_y$)?



(c) Perhaps we could use an op-amp (in negative-feedback) to achieve our desired behavior.
Modify the implementation you tried in part (b) using a negative feedback op-amp in order to achieve the desired V_x, V_y relations $V_x = \frac{V_{\text{in}}}{2}$ and $V_y = \frac{V_x}{3} = \frac{V_{\text{in}}}{6}$.
HINT: Place the op-amp in between the dividers such that the V_x node is an input into the op-amp, while the source of the 2nd divider is the output of the op-amp!

2. Multiple Inputs To One Op-Amp



(a) First, let's focus on the left part of the circuit containing the voltage sources v_{s1} and v_{s2}, and resistances R_1 and R_2. Solve for u_+ in the circuit above. *(Hint: Use superposition.)*

(b) How would you choose R_1 and R_2 that produces a voltage $u_+ = \frac{1}{2}V_{s1} + \frac{1}{2}V_{s2}$? Could you also achieve $u_+ = \frac{1}{3}V_{s1} + \frac{2}{3}V_{s2}$

(c) Now, for the whole circuit, find an expression for v_o.

(d) How could you use this circuit to find the sum of different signals, i.e. $V_{s1} + V_{s2}$? What about taking the sum and multiplying by 2, i.e. $2(V_{s1} + V_{s2})$?

3. (Optional) Designing current divider

(a) You have two current sources I_1 and I_2. You also have a load resistor $R_L = 6\,\mathrm{k\Omega}$. You can use whatever resistors you want (as long as they are finite integer multiples of $1\,\mathrm{k\Omega}$). How would you design a circuit such that the current running through R_L is $I_L = \frac{2}{5}(I_1 + I_2)$?