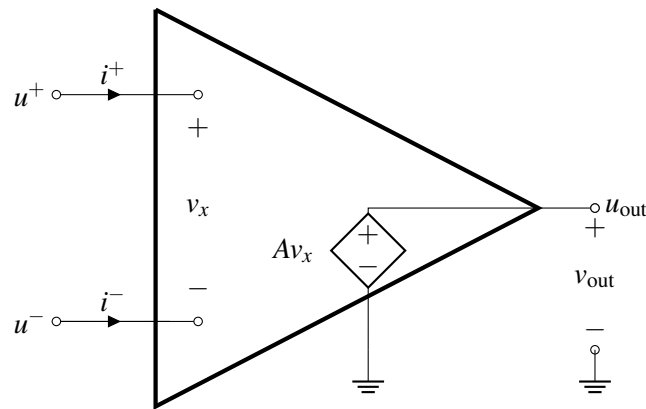

EECS 16A Designing Information Devices and Systems I

Summer 2023 Discussion 6B

1. Op-Amp Rules

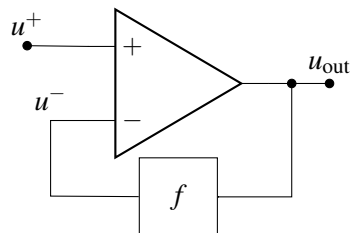
Here is an equivalent circuit of an op-amp (where we are assuming that $V_{SS} = -V_{DD}$) for reference:



- (a) What are the currents flowing into the positive and negative terminals of the op-amp (i.e., what are i^+ and i^-)? Based on this answer, what are some of the advantages of using an op-amp in your circuit designs?

- (b) Suppose we add a resistor of value R_L between u_{out} and ground. What is the value of v_{out} ? Does your answer depend on R_L ? In other words, how does R_L affect A_{v_C} ? What are the implications of this with respect to using op-amps in circuit design?

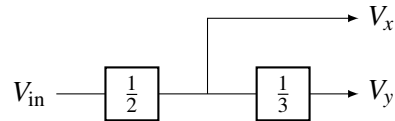
- (c) Now suppose our op-amp is connected in negative feedback.



What is the relationship between u^+ and u^- ?

2. Modular Circuit Buffer

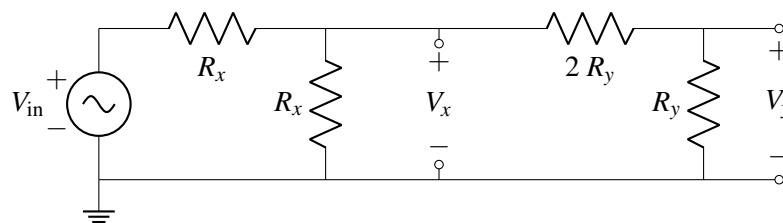
Let's try designing circuits that perform a set of mathematical operations using op-amps. While voltage dividers on their own cannot be combined without altering their behavior, op-amps can preserve their behavior when combined and thus are a perfect tool for modular circuit design. We would like to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



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

- (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 $V_{in} = 2V_x = 6V_y$)?



(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 $V_x = \frac{V_{in}}{2}$ and $V_y = \frac{V_x}{3} = \frac{V_{in}}{6}$.

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!