EECS 16A Designing Information Devices and Systems I
Spring 2023 Discussion 9B

Note to students:

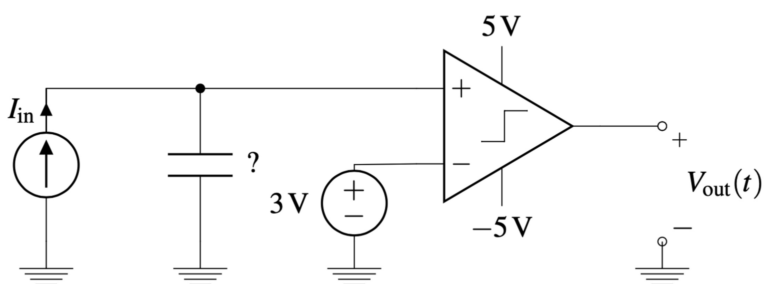
In this worksheet, we will begin exploring comparators (denoted by the little square wave within the triangle).

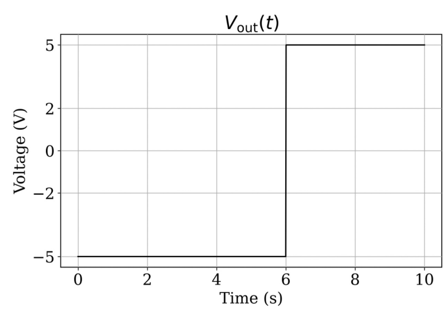
Here is the inherent logic of a comparator:

- If $V_+ > V_-$, then $V_{\text{out}} = V_{DD}$ (positive supply rail)
- If $V_+ < V_-$, then $V_{\text{out}} = V_{SS}$ (negative supply rail)

1. Comparators

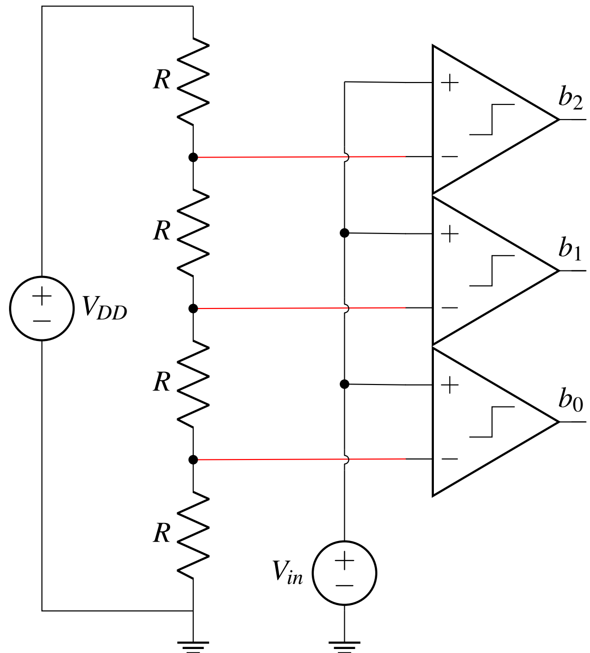
We want to find the value of an unknown capacitor using the comparator outputs. For the circuit shown below (left), $I_{\text{in1}} = 1\mu\text{A}$, $I_{\text{in2}} = 3\mu\text{A}$, and $I_{\text{in3}} = 0.5\mu\text{A}$ and the initial voltage across the capacitor is 0 when $t = 0$. The plot of $V_{\text{out}}(t)$ for time t from 0-10s is shown on the right. Note that $\mu = 10^{-6}$. What is the value of the capacitor for each value of I_{in}? *Note: the intial voltage across the capacitor at time t = 0 is 0V in all three cases.*





2. Data Conversion Circuits

(a) The dual to DAC circuits are analog-to-digital converters, or ADC circuits. Here is an example of one, called a "Flash ADC," using resistors and comparators:



Note: The red wires in the diagram are regular wires, but have been colored to show that they do not touch the crossing black wires.

The resistor ladder gives us a set of reference voltages to compare against. We use a set of comparators to compare the input voltage V_{in} against these reference levels, and we get out a corresponding digital code b_0, b_1, and b_2.

Assume that $V_{DD} = 1\,\mathrm{V}$, and that the comparators are connected to rails $V_{DD} = 1\,\mathrm{V}$ and $V_{SS} = 0\,\mathrm{V}$. If V_{in} is $0.3\,\mathrm{V}$, **what are the outputs** b_0**,** b_1**, and** b_2?