

EECS 16A Designing Information Devices and Systems I

Spring 2023 Discussion 9B

Note to students:

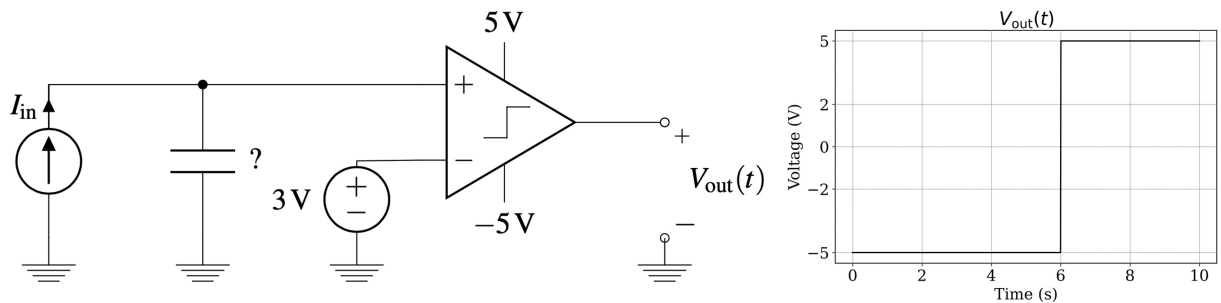
In this worksheet, we are using comparators (denoted by the little square wave within the op-amp symbol), which are distinct from op-amps that we will be covering in the coming weeks. While it is true op-amps can be used as comparators, this is not practical since comparators are faster than op amps, consume less power, and occupy smaller area. Op-amps are designed for signal amplifications whereas comparators are specifically dedicated to signal comparison (more on this later).

Here is the inherent logic of a comparator:

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

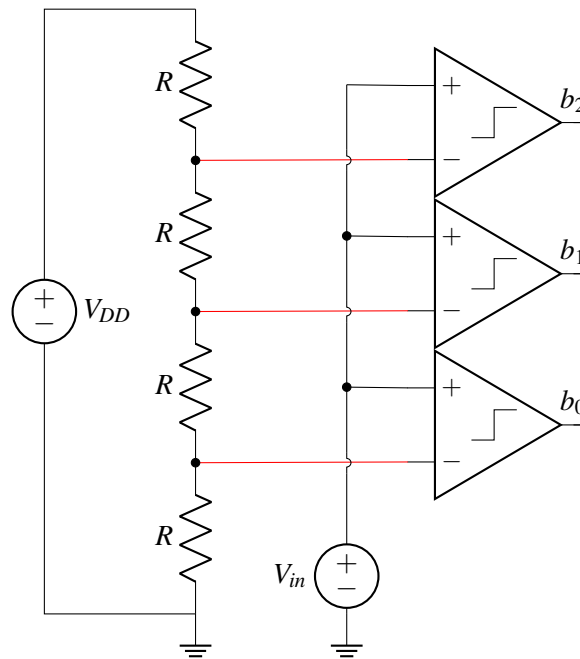
1. Comparators

We want to find the value of an unknown capacitor using the comparator outputs. For the circuit shown below (left), $I_{in1} = 1\mu A$, $I_{in2} = 3\mu A$, and $I_{in3} = 0.5\mu A$ and the initial voltage across the capacitor is 0 when $t = 0$. The plot of $V_{out}(t)$ 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 initial 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 $V_{DD} = 1\text{ V}$, and that the comparators are connected to rails $V_{DD} = 1\text{ V}$ and $V_{SS} = 0\text{ V}$. If V_{in} is 0.3 V , **what are the outputs b_0 , b_1 , and b_2 ?**