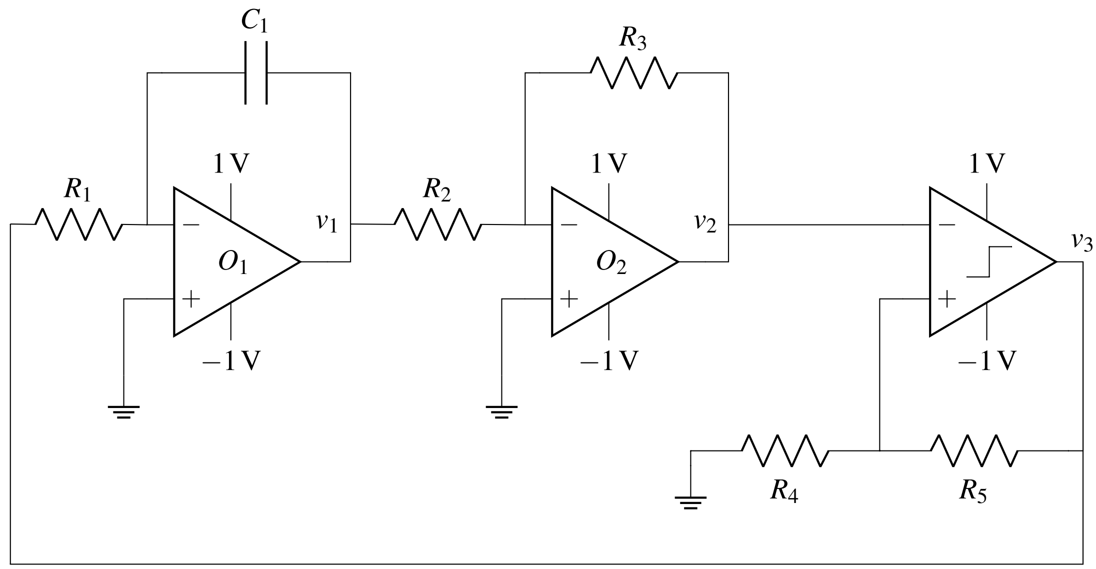
EECS 16A Designing Information Devices and Systems I
Summer 2020 Discussion 5C

1. Timer Circuit

In this problem, we will walk through another useful, real-world circuit, the timer circuit. The circuit is shown below. All resistors have a resistance of $1\,\text{k}\Omega$ and $C_1 = 1\,\mu\text{F}$.



(a) Find the current through the capacitor C_1 in terms of the voltage V_3 and the resistor R_1.

(b) Suppose that at time $t = 0$, C_1 is uncharged. Find the voltage v_1 in terms of t, v_3, and R_1. What is the maximum $|v_1|$ could be?

(c) How is v_2 related to v_1? What is the voltage v_2?

Now, let's independently analyze the circuit in the two possible outputs of the comparator, when $v_3 = 1\,\text{V}$ and when $v_3 = -1\,\text{V}$.

(d) Assume that the output of the comparator v_3 has railed to the top rail. With this value of v_3, what is v_2 as a function of time? What is the voltage at the positive input of the comparator? At what time will the two inputs of the comparator be equal?

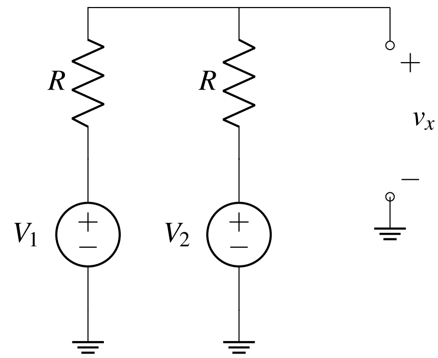
(e) Now assume that the reverse occurs, that is, the output of the comparator has railed to the bottom rail. Repeat part (d) with this value of v_3.

(f) What is v_3 as a function of time? Draw a graph of v_3 and v_2. Since the graph is periodic, find its period and frequency.

(g) Suppose that we changed the value of C_1 to be $2\,\mu\text{F}$? What is the new period? Suppose that we change R_5 to be $2\,\text{k}\Omega$. What is the new period? What if we change R_5 to be $0\,\Omega$? Will this circuit still operate?

2. Practice: Dividers for Days

(a) Solve the following circuit for v_x.



(b) You have access to two voltage sources, V_1 and V_2. You can use two resistors (as long as $0 \leq R < \infty$). How would you design a circuit that produces a voltage $v_x = \frac{1}{3}V_1 + \frac{2}{3}V_2$?

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