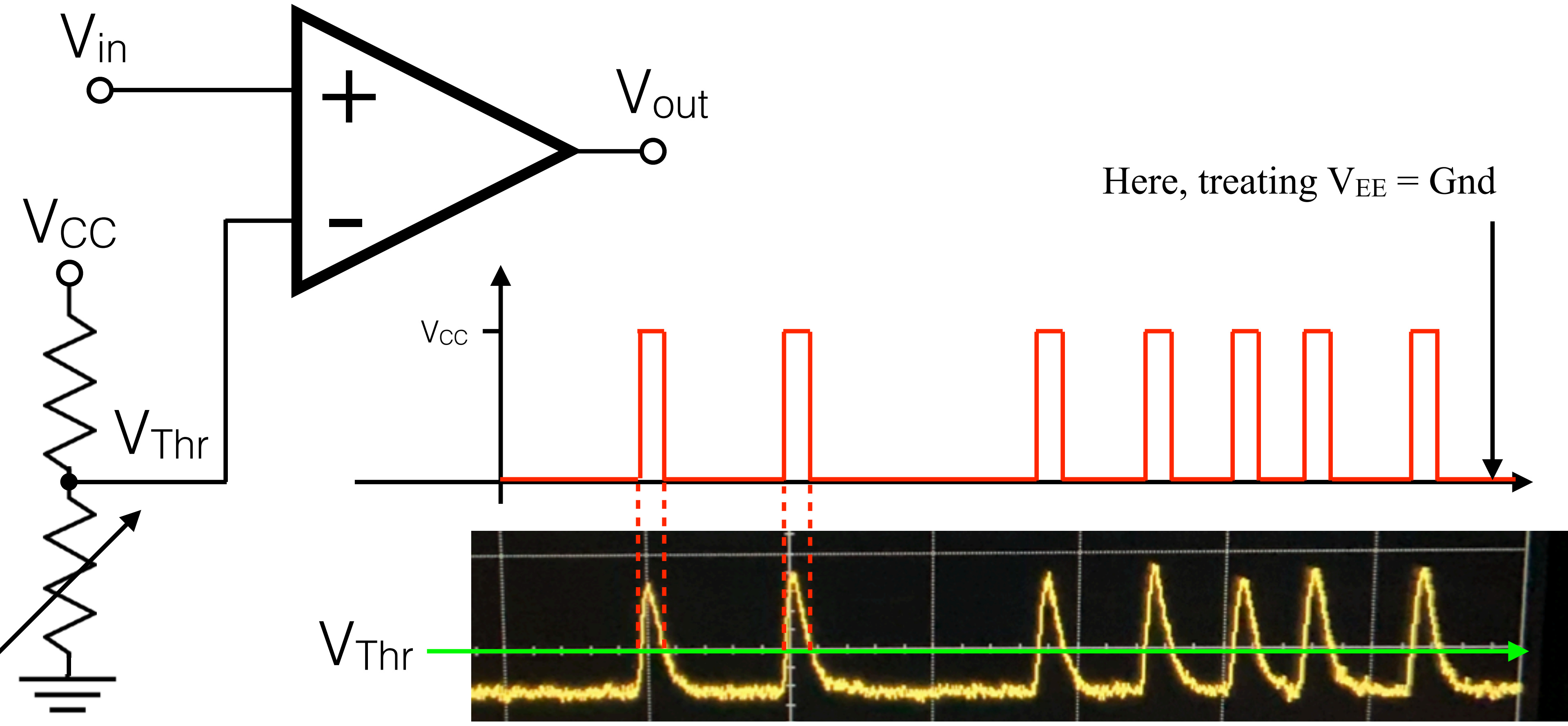
PHYS127AL Lecture 12

David Stuart, UC Santa Barbara, Nov 2, 2021

An application and oscillators

Comparator

If $V_A > V_B$ then $V_{out} = V_{CC}$, otherwise $V_{out} = V_{EE}$.
Can use this to "trigger" at a threshold, similar to your scope.



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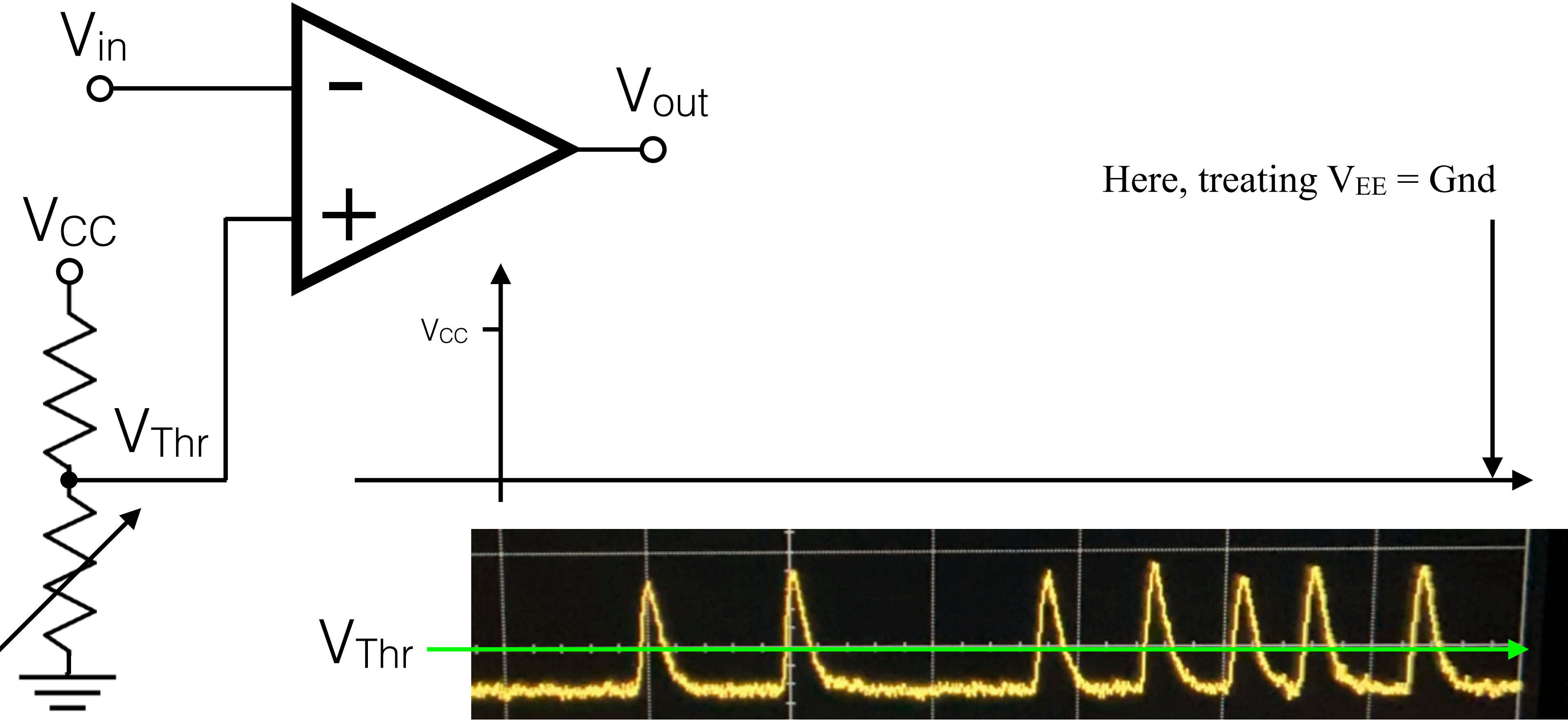

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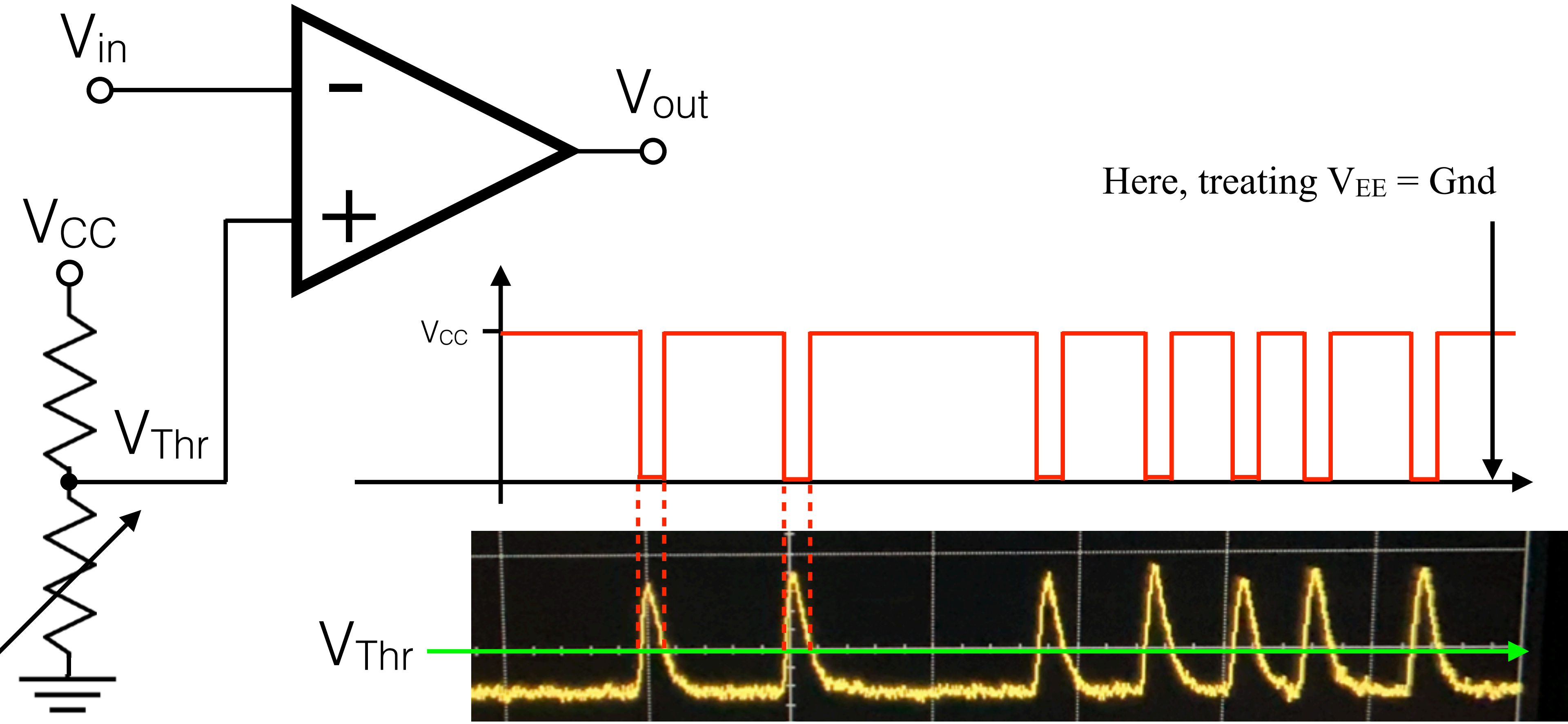


Design of a smoke alarm

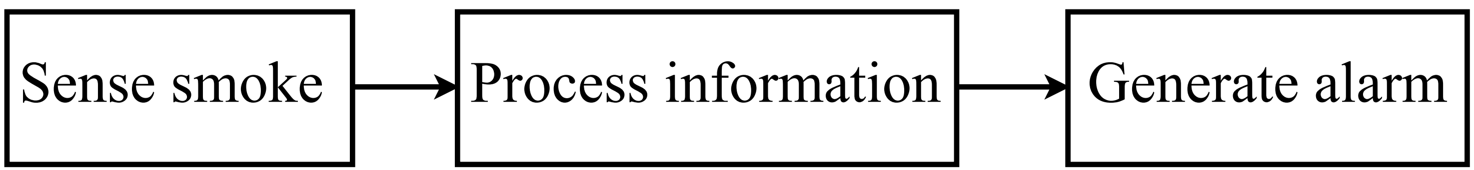
We have enough tools to start *designing* things.

Learning the electronics design process is part of our goal here.

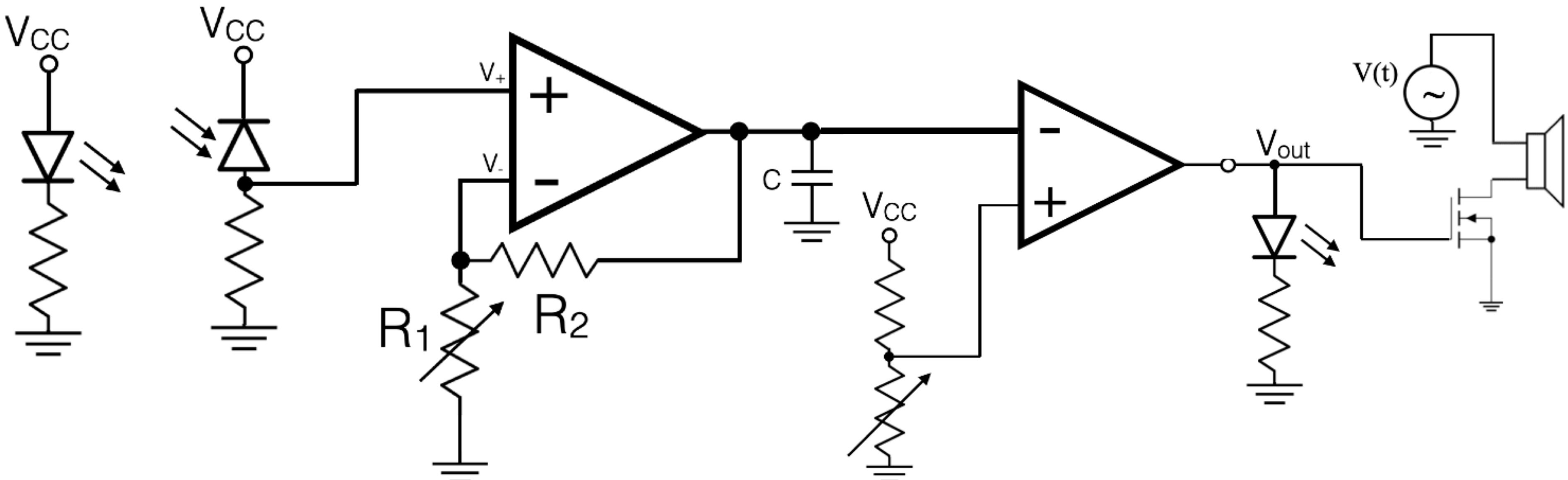
As we design, we might need to learn some new tools.

So, let's go through the design of a smoke alarm.
In lab next week you will make a "burglar alarm".

Start with an overview of the required stages:



Smoke alarm

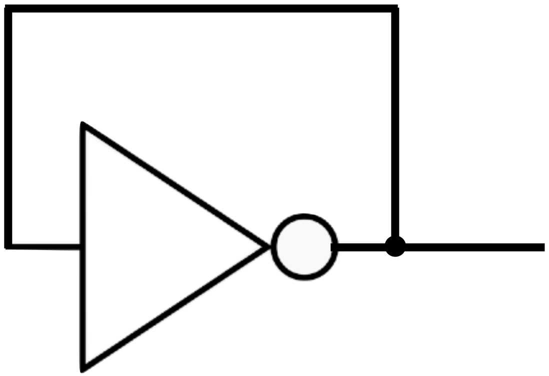


Safety checks:

- Battery warning
- Test feature

Oscillator

We can make an oscillator with any positive feedback



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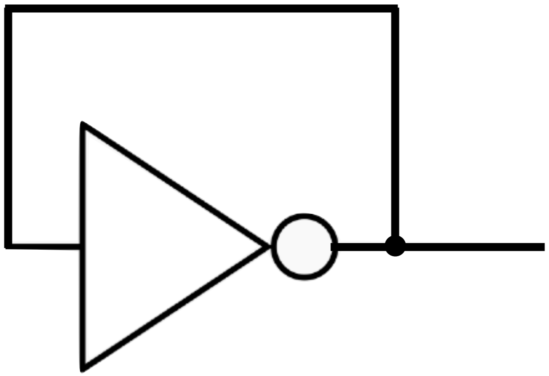
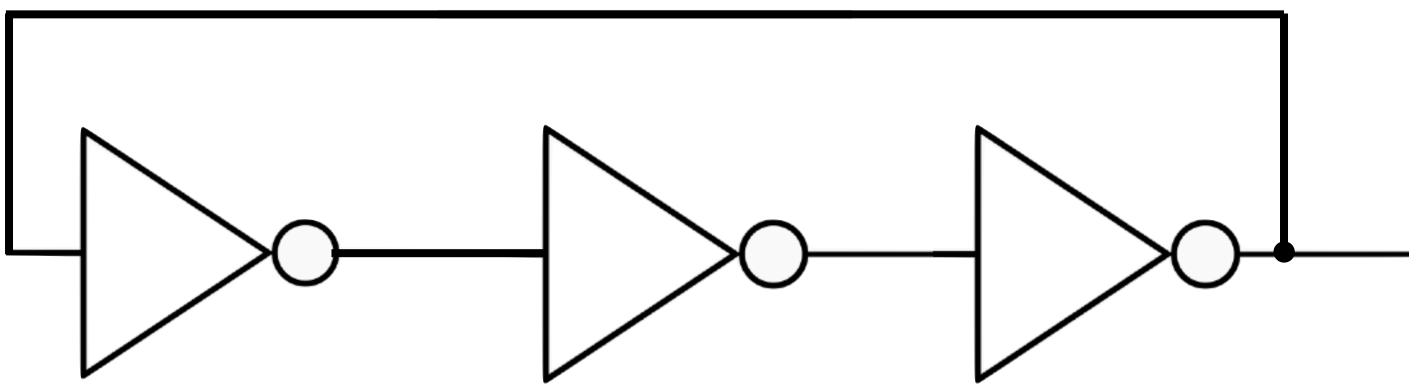
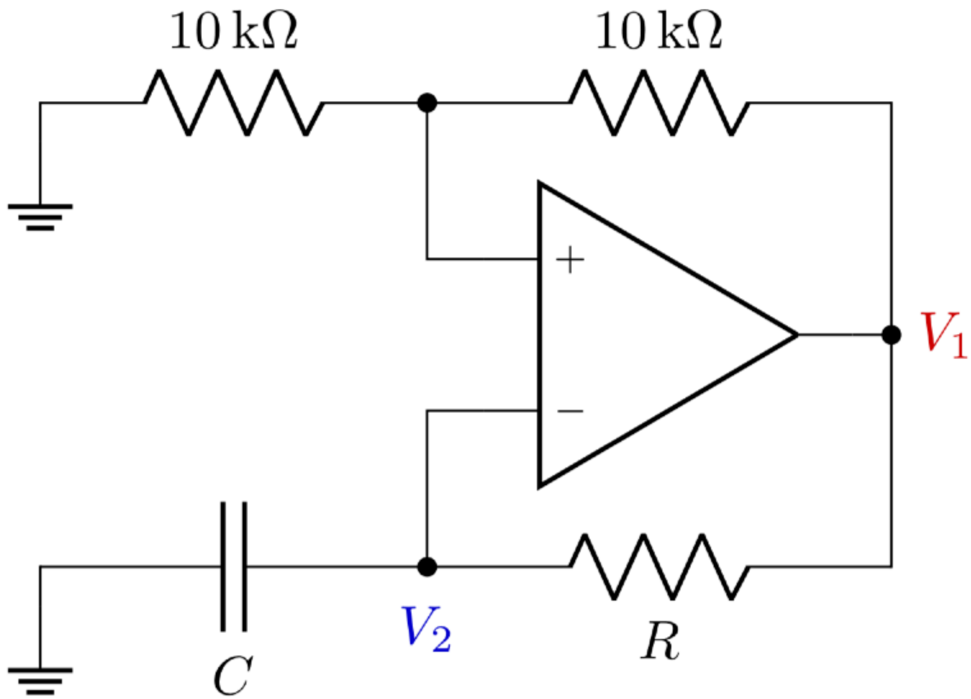




Oscillator

We can make an oscillator with an op-amp



The $I_+ = I_- = 0$ golden rule means we can calculate V_+ and V_- in terms of V_1.

$V_+ = ?$

$V_2 = V_- = ?$

Oscillator

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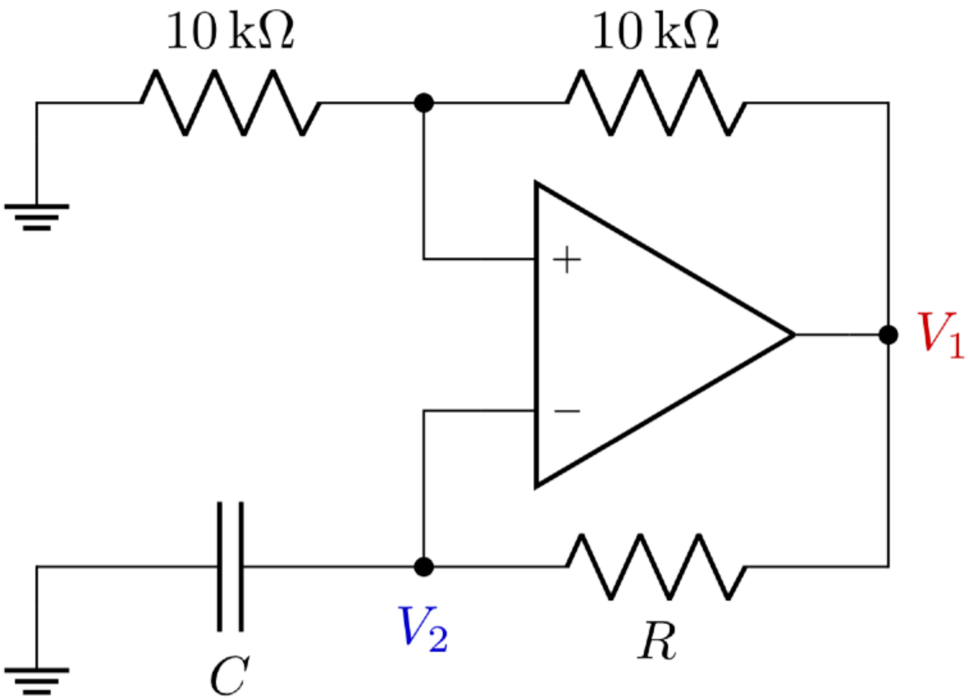

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$$V_2 = V_- = V_1 - I\,R$$

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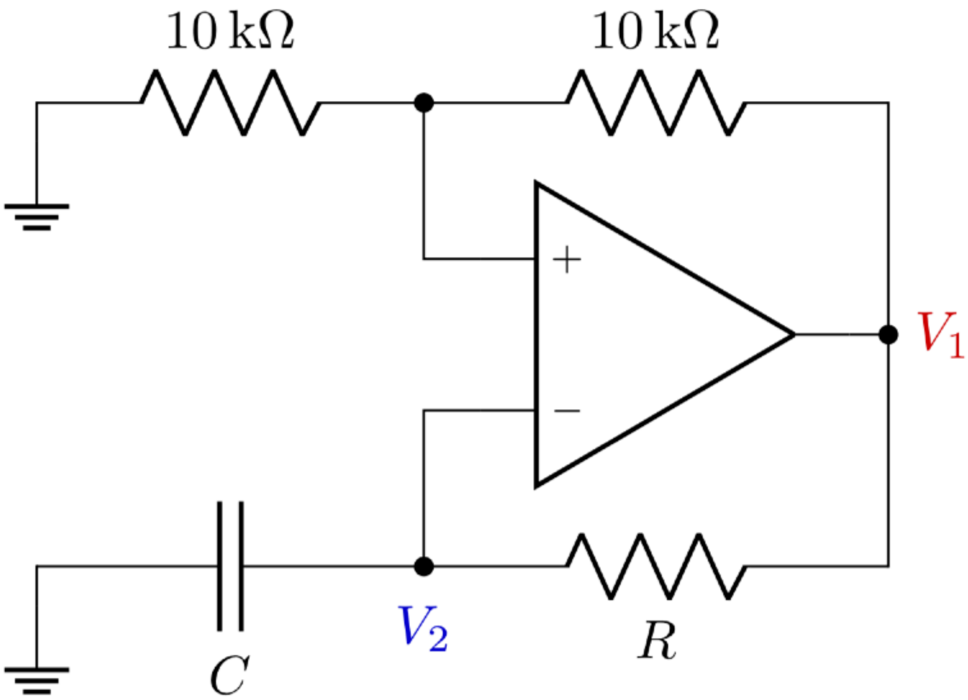

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where $I = C\,dV_2/dt$

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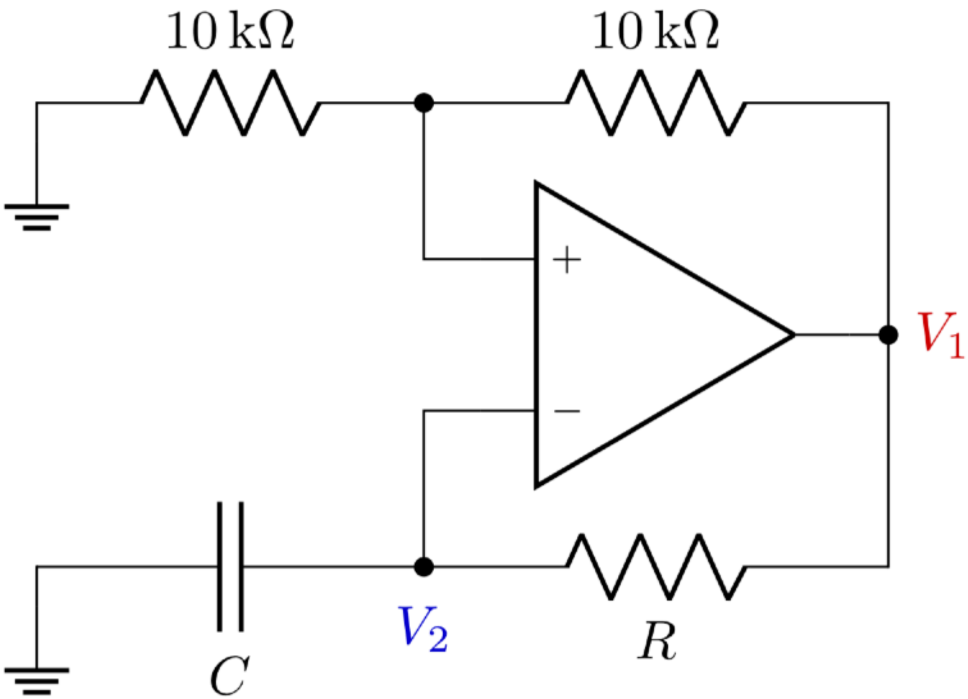

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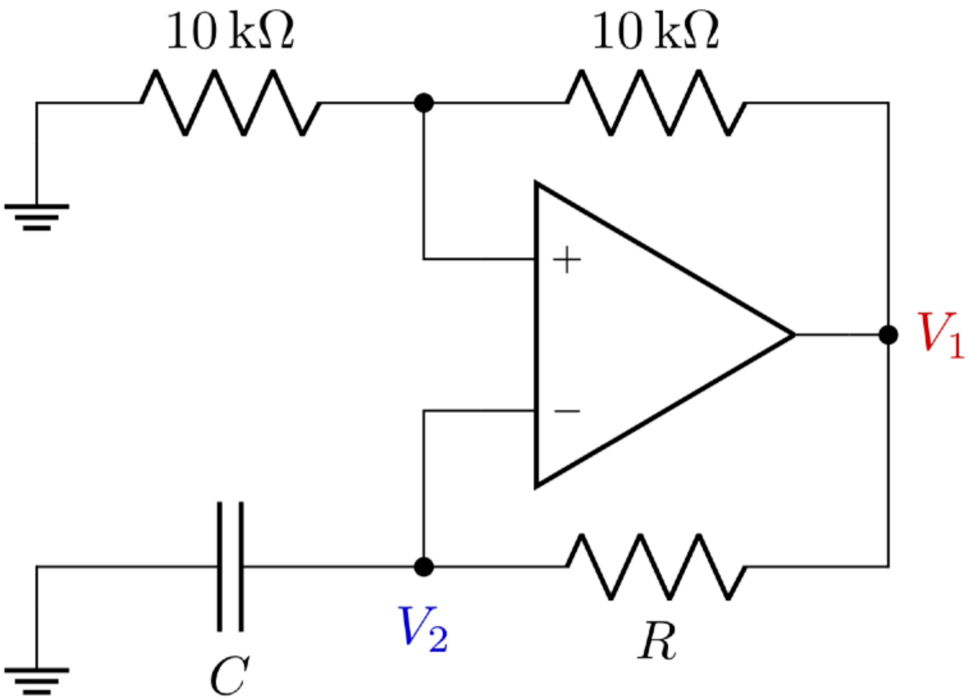

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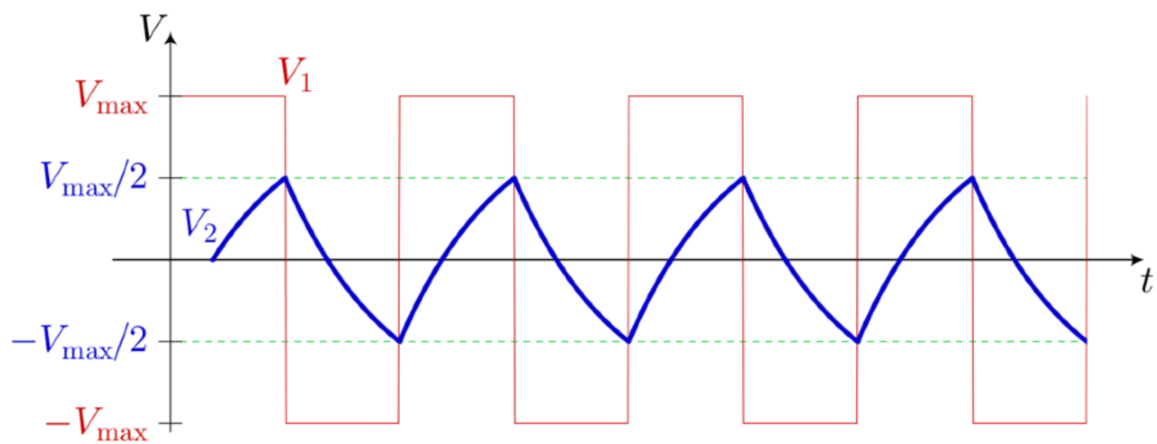

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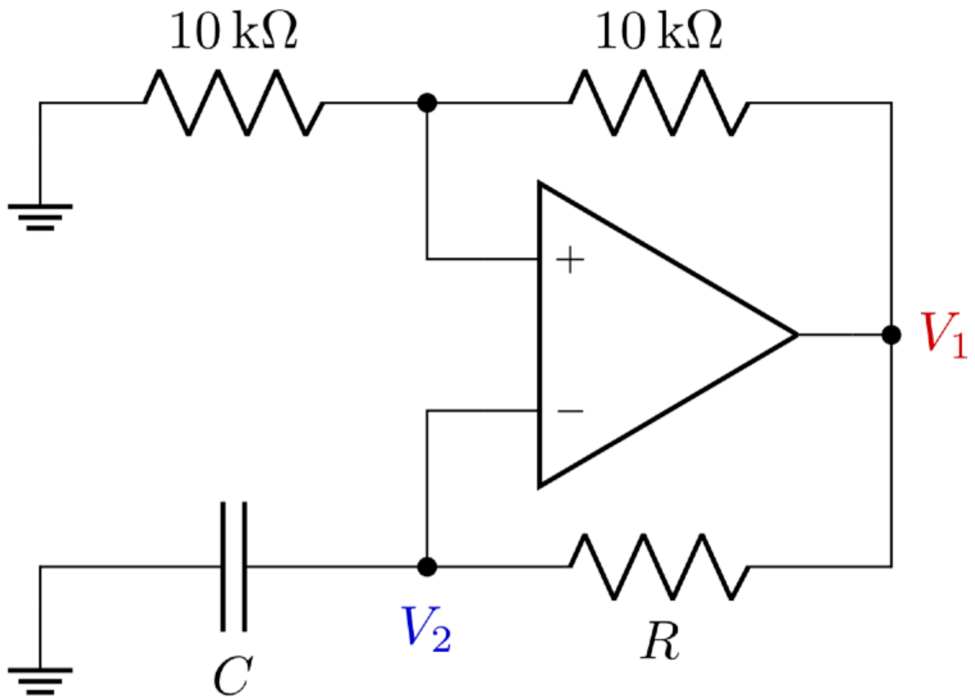

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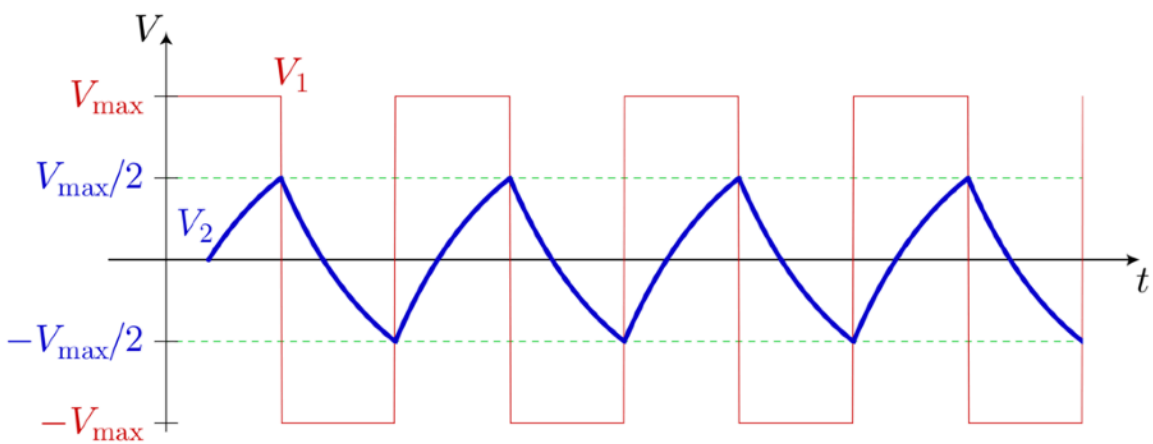
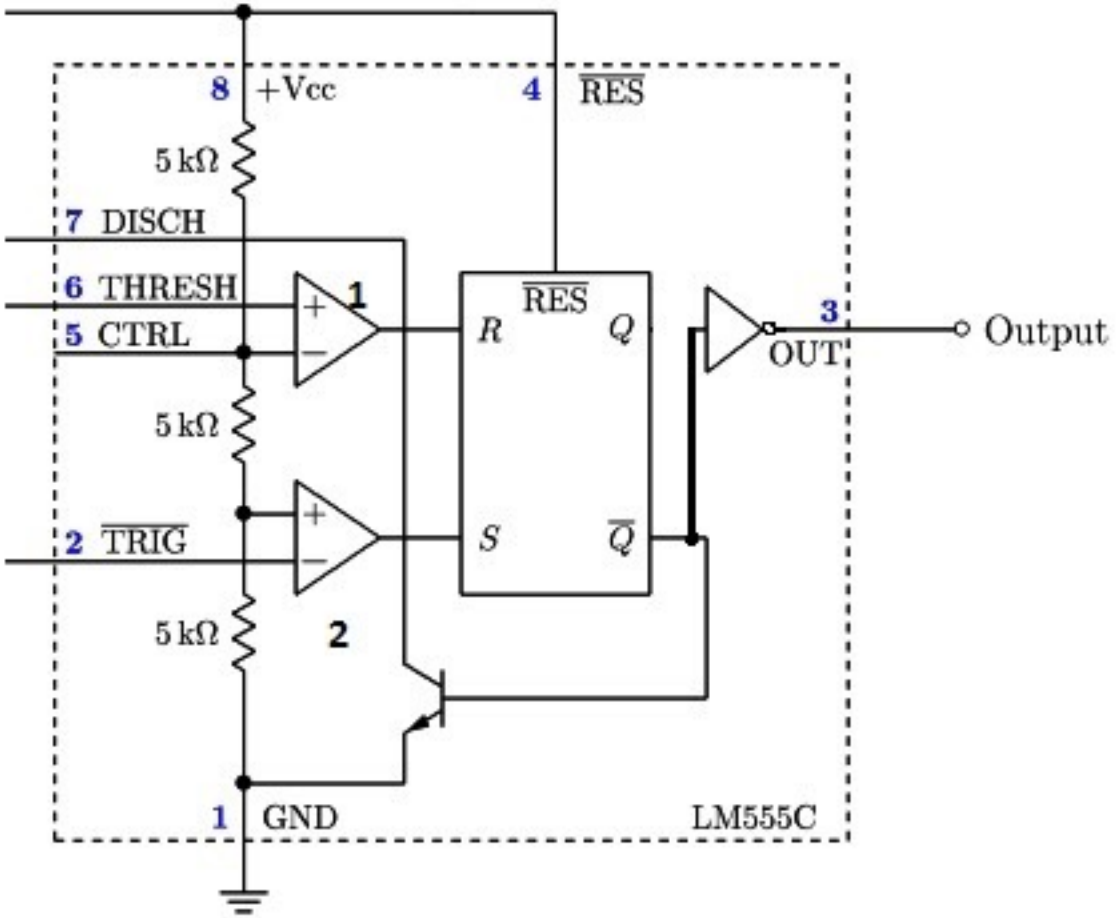
$$T \approx 2.2RC$$



555 timer

Oscillators and other timing applications are common, so there is a timer chip



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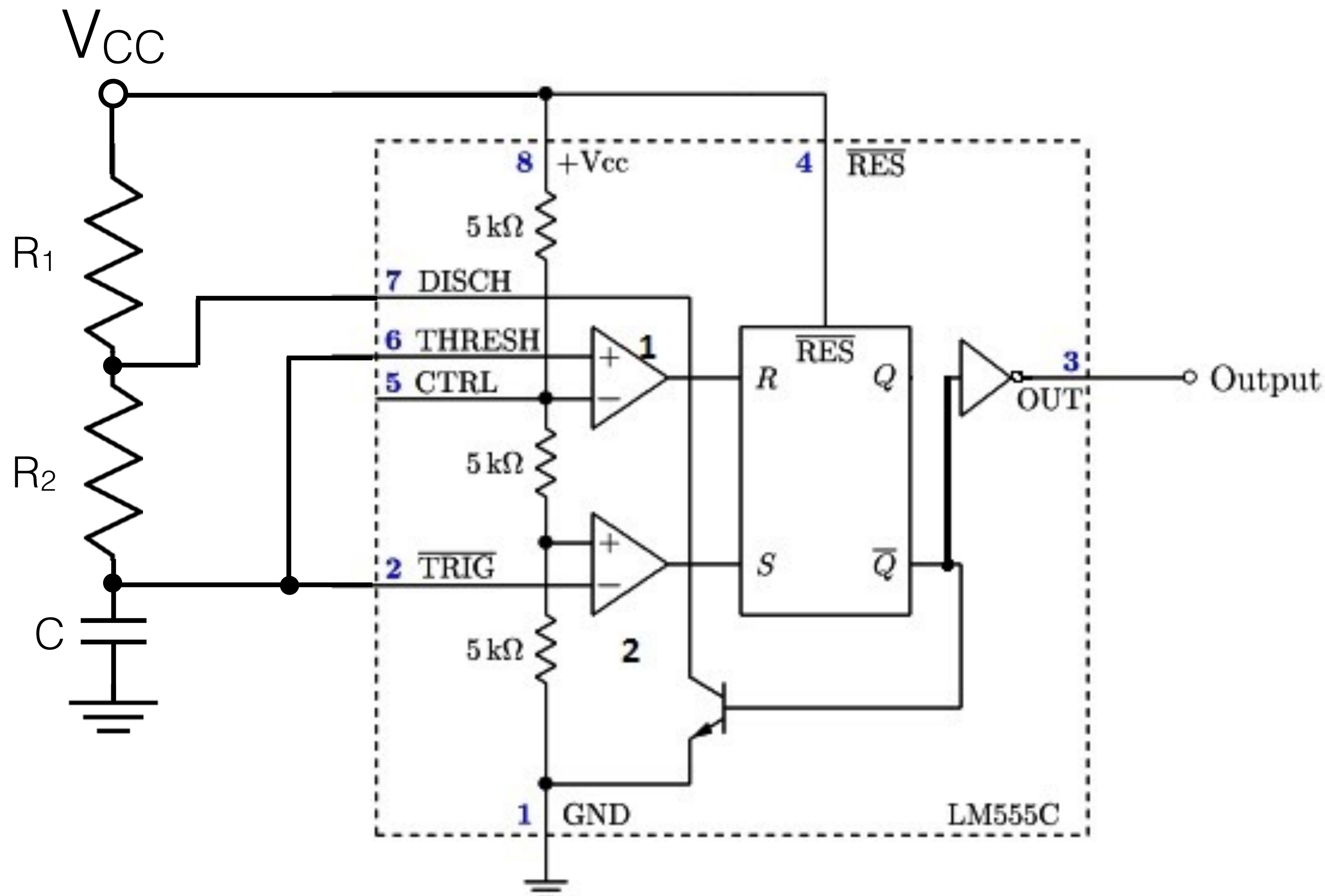

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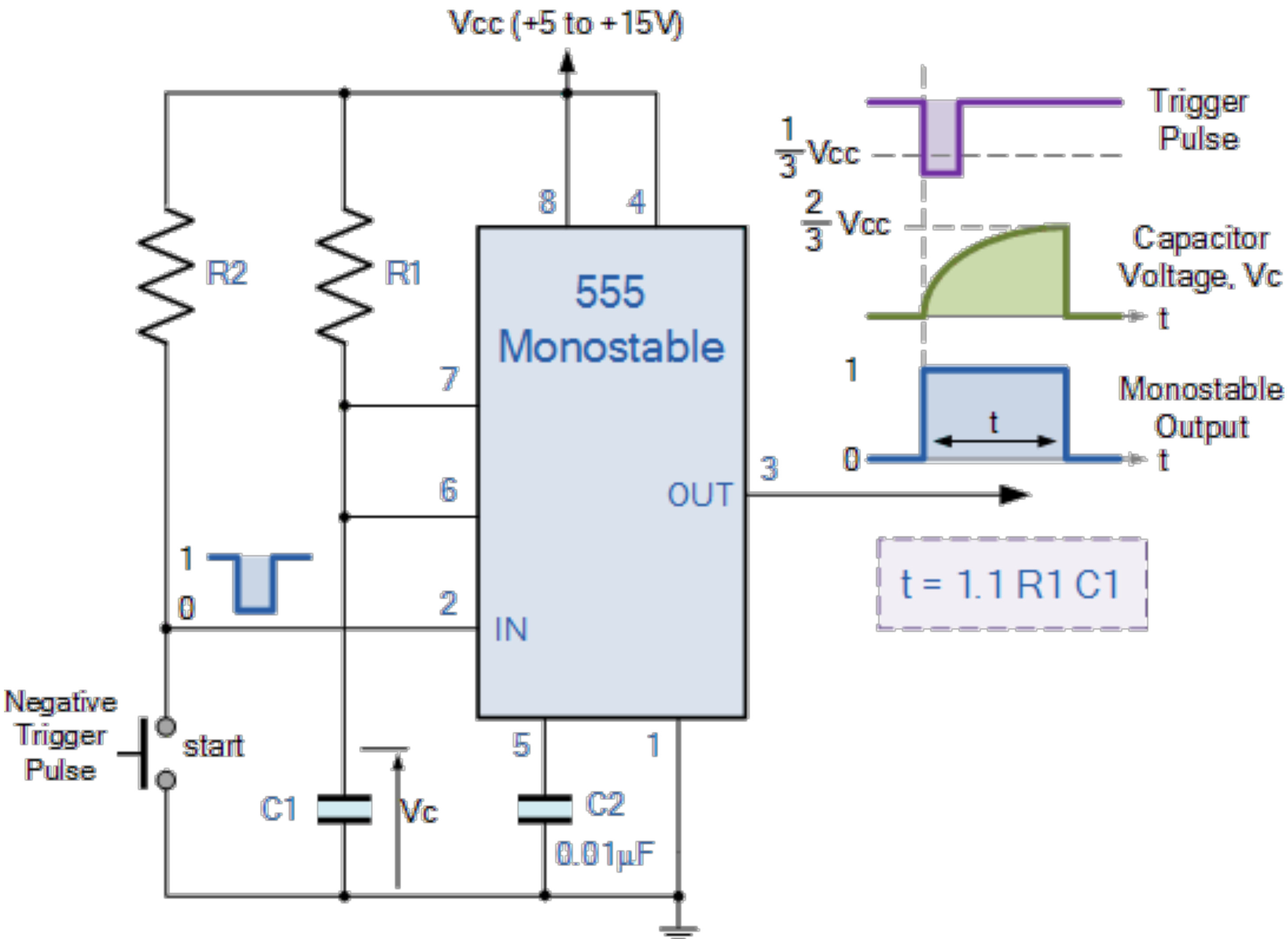

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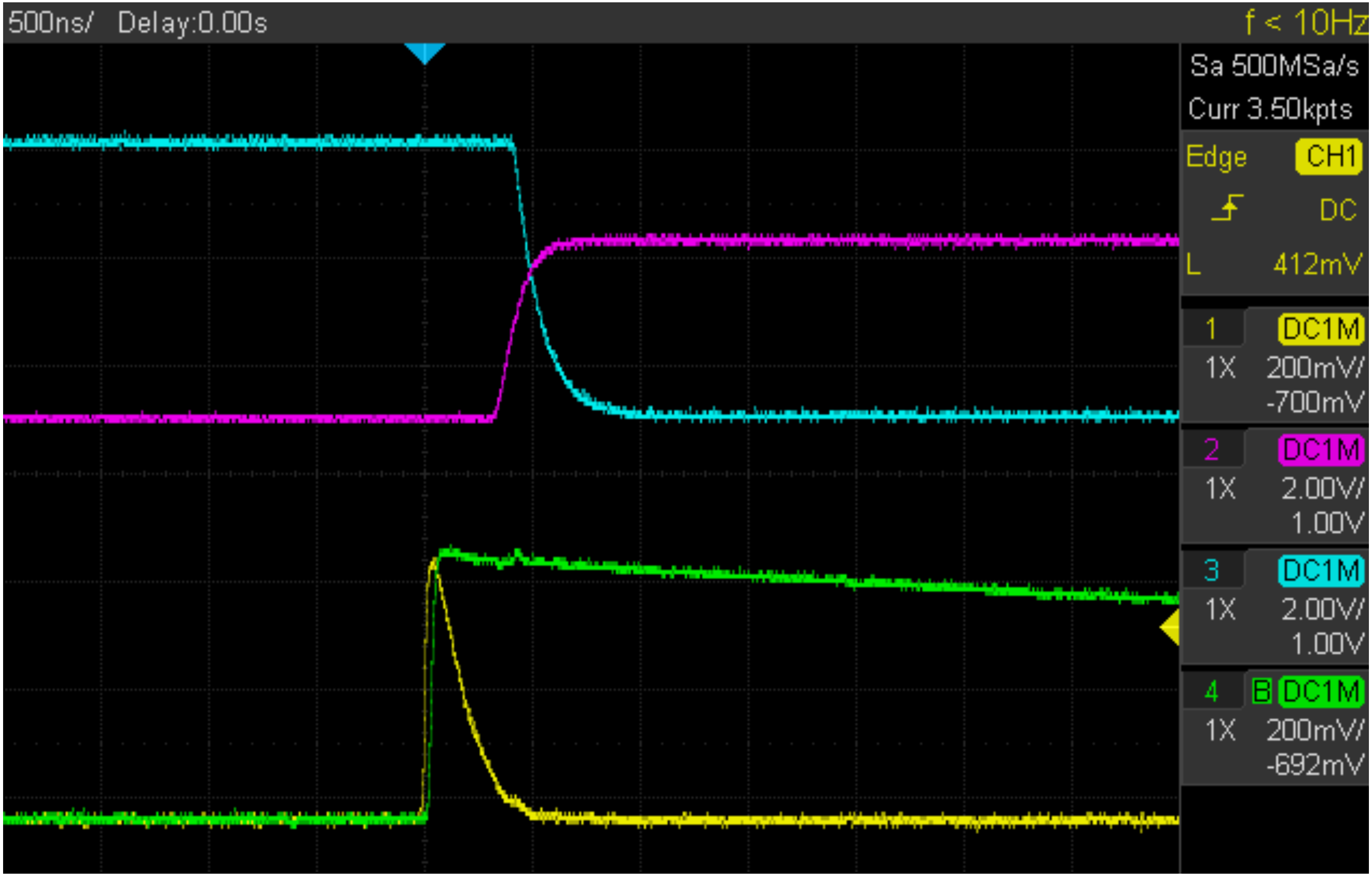
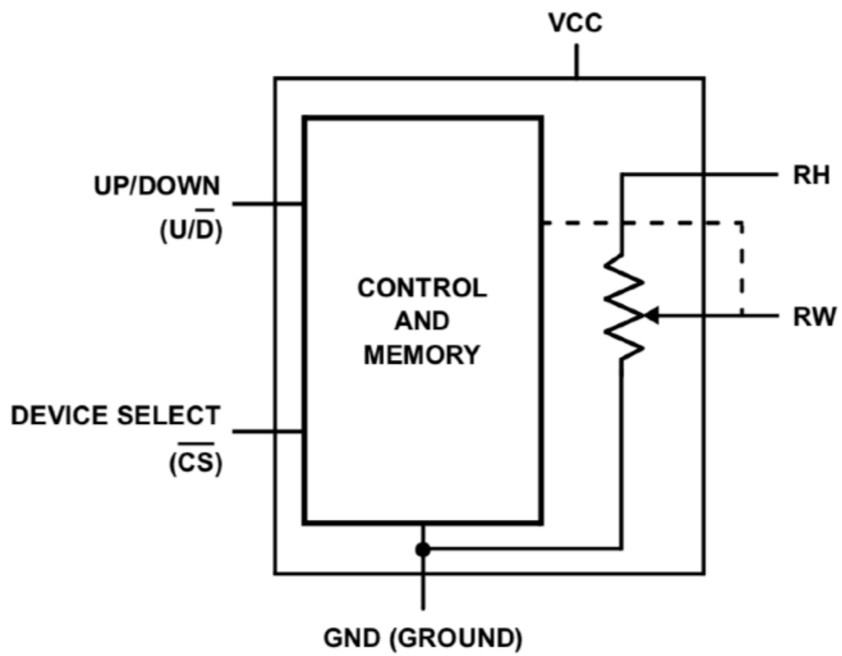
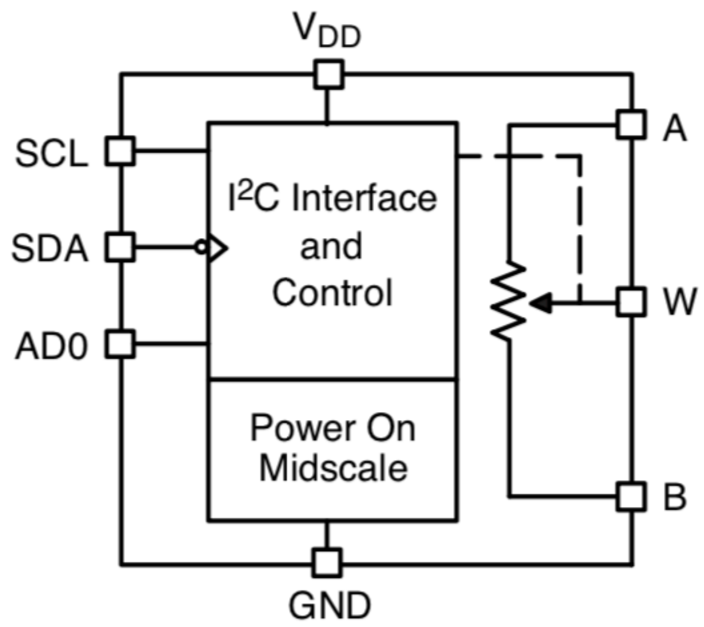
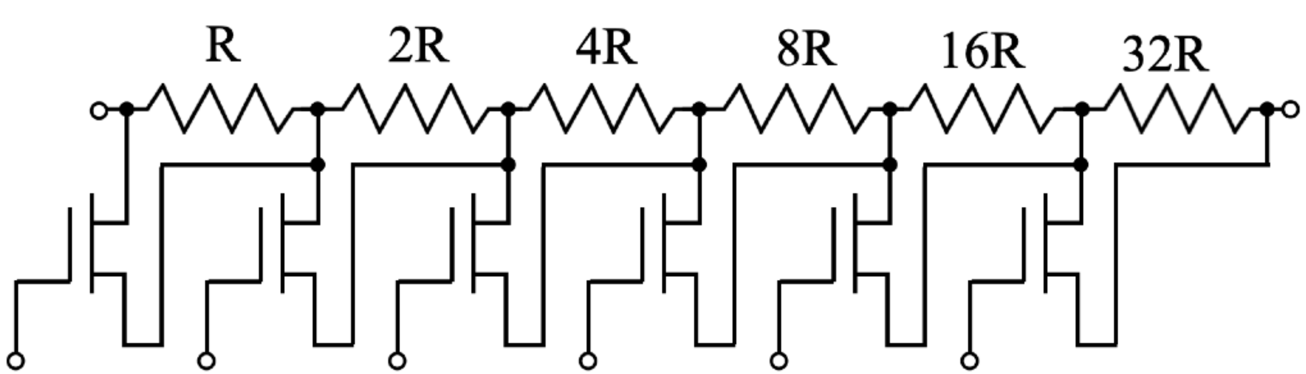


Digital potentiometer

We can adjust the frequency by changing the resistance with a potentiometer.
It is more common now to use a “digital potentiometer” (cheaper than trimpot).

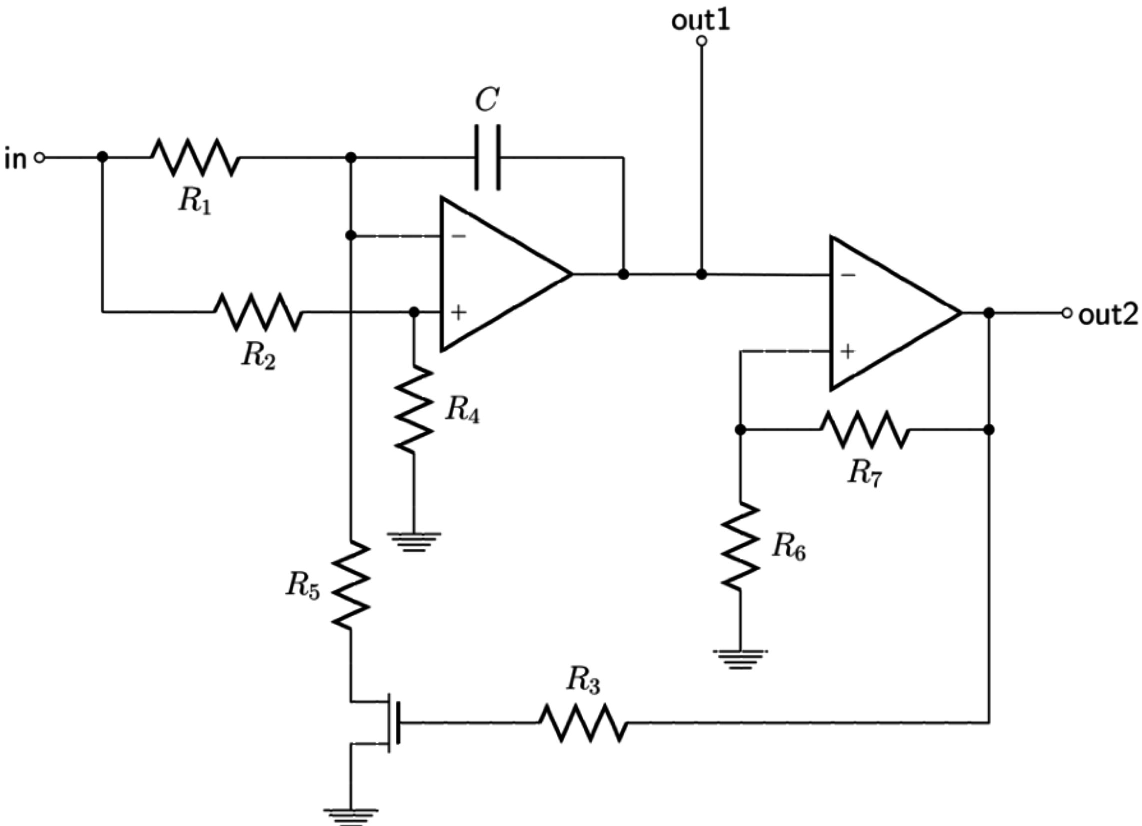


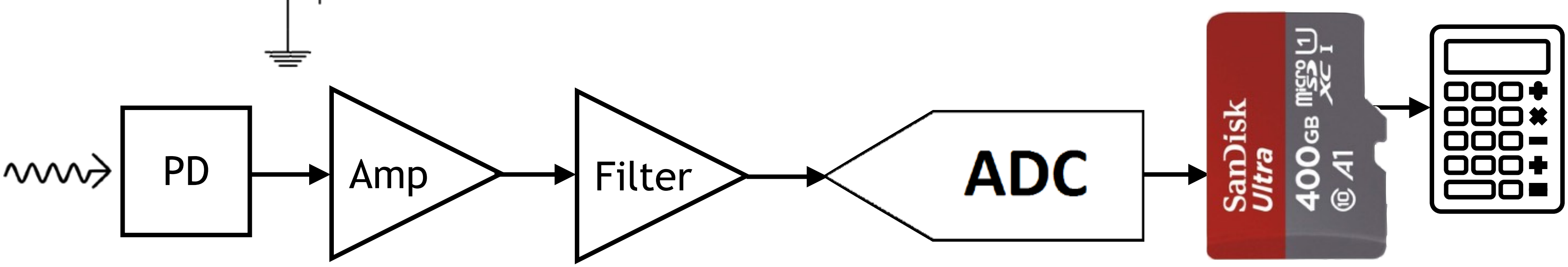




Voltage controlled oscillator

It is sometimes useful to control an oscillator with a voltage, or to encode a voltage as a frequency.





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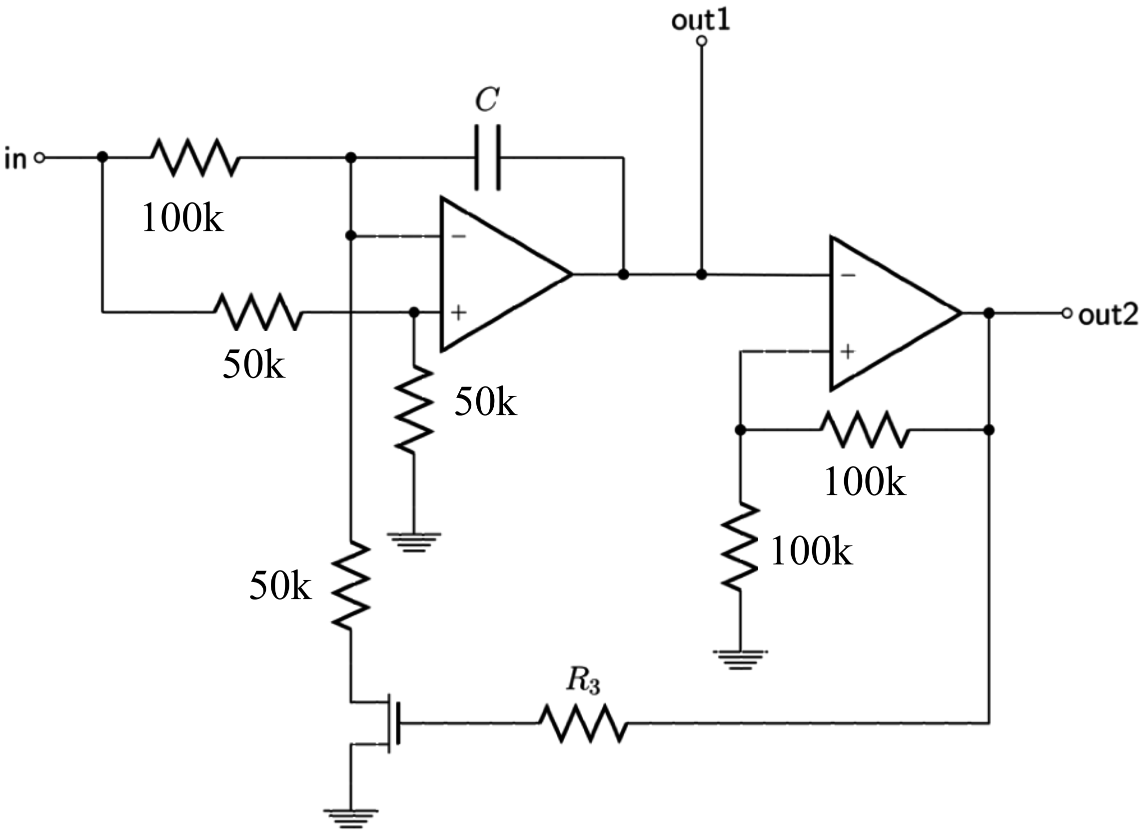

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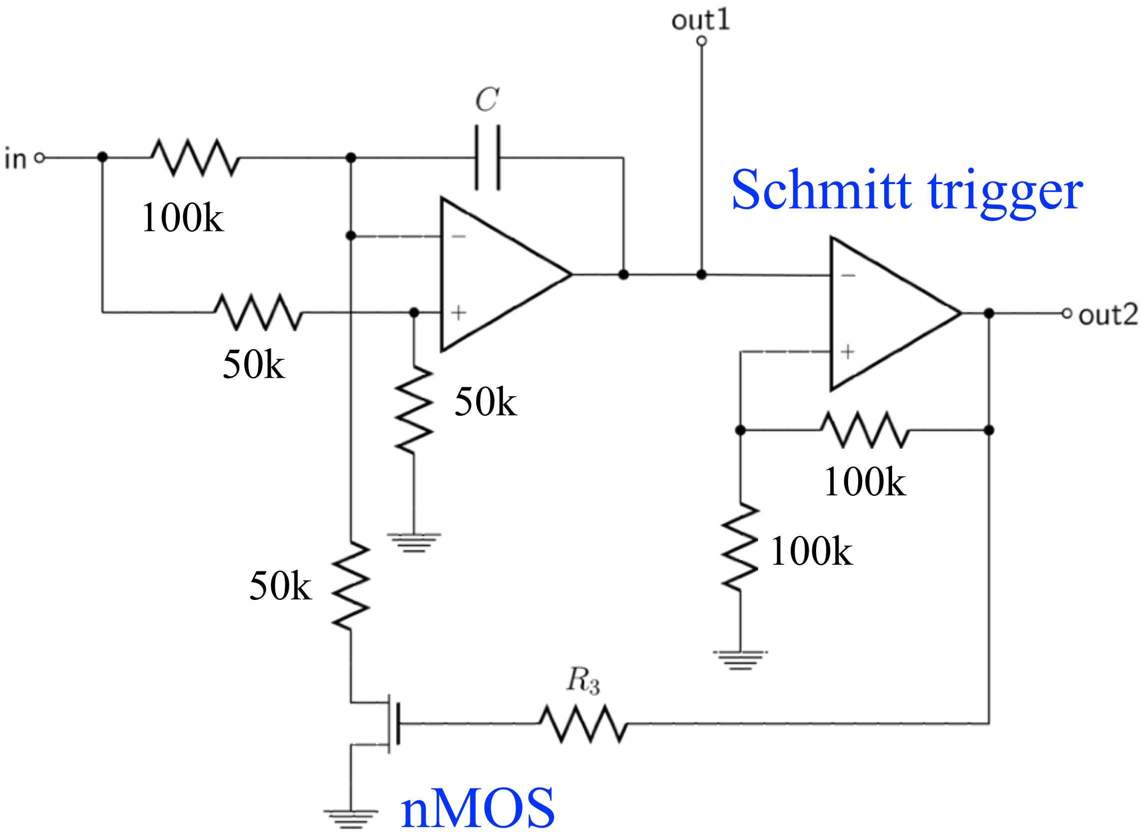
Out2 is either high or low as output of comparator.



Out1 linearly ramps down until $V_{EE}/2$, then Out2 flips to V_{CC}.
Ramp rate proportional to V_{in}.

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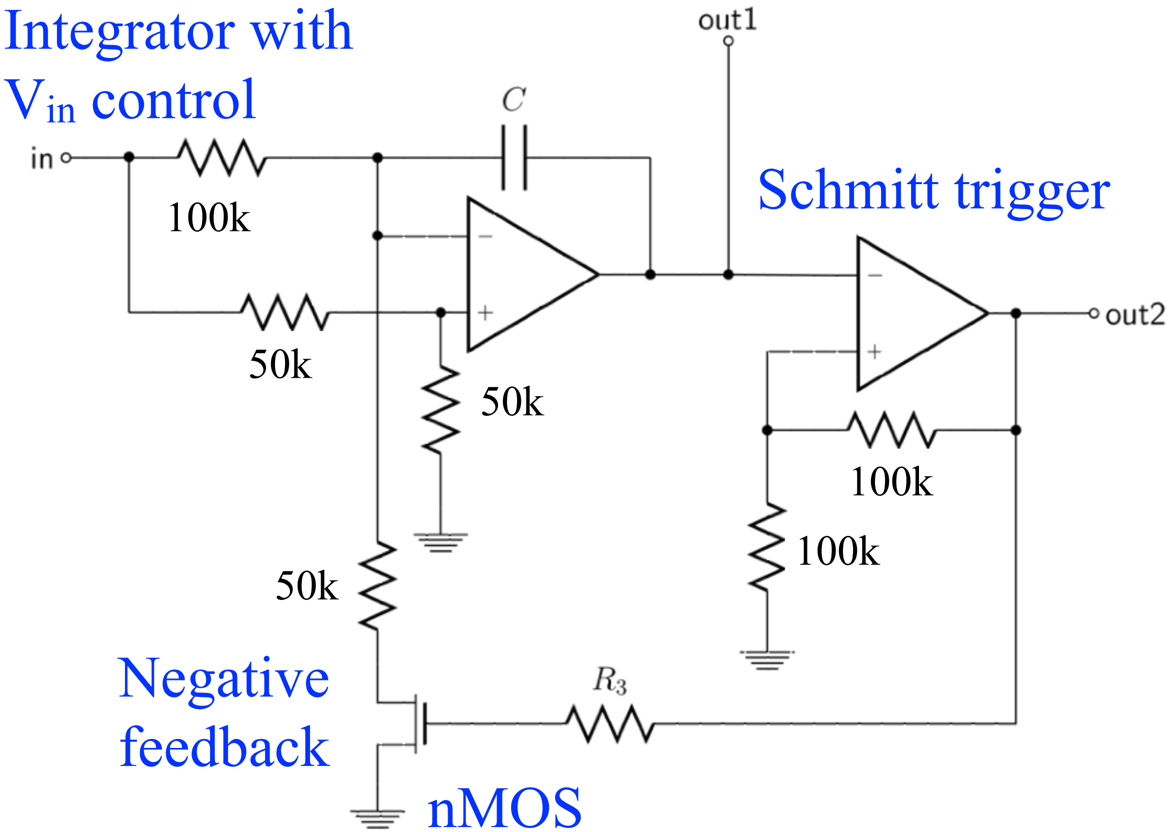

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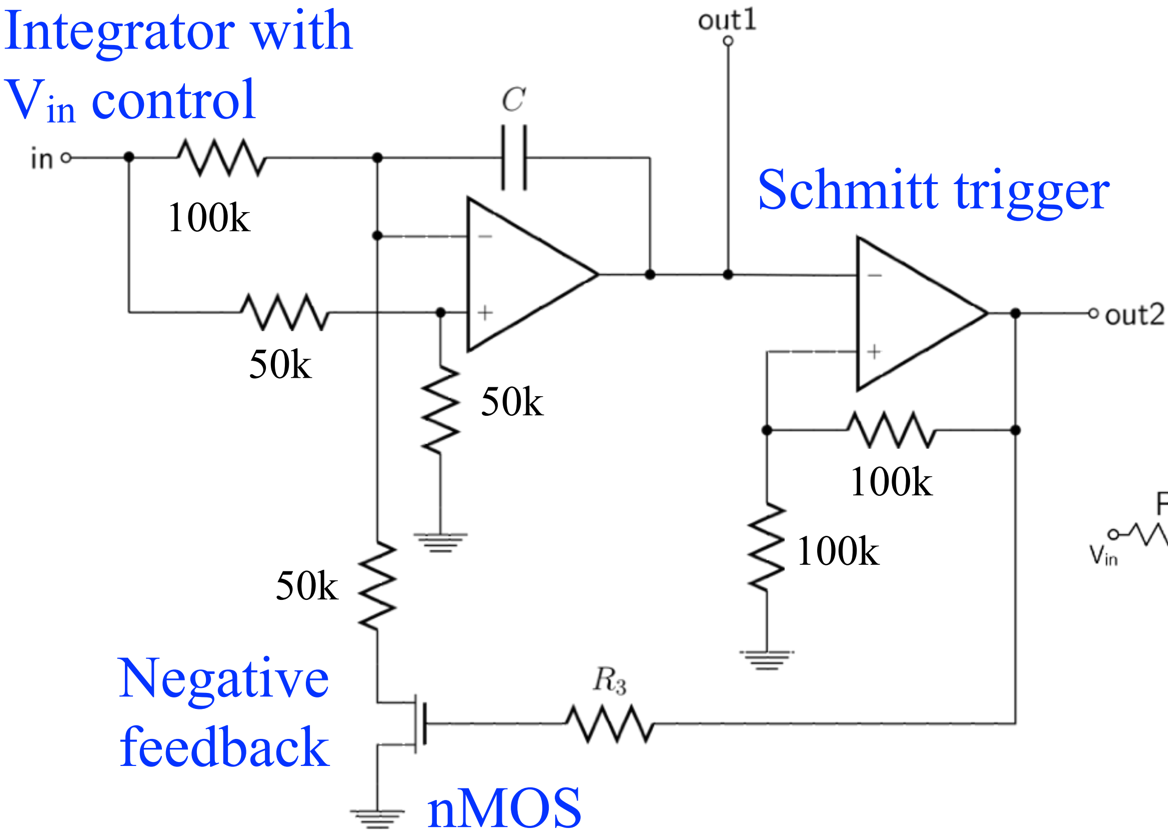
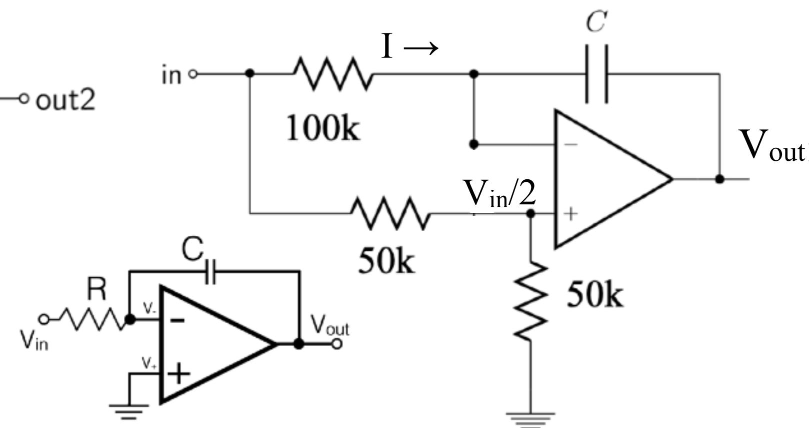


If Out1>0 & Out2=V_{EE},
then nMOS=off.
C charges as an integrator



$I = (V_{in}-V_{in}/2) / 100k = V_{in} / 200k$

$I = C\ dV/dt = V_{in} / 200k$

$C\ d(V_{in}/2-V_{out1})/dt = V_{in} / 200k$

$C\ dV_{out1}/dt = -V_{in} / 200k$

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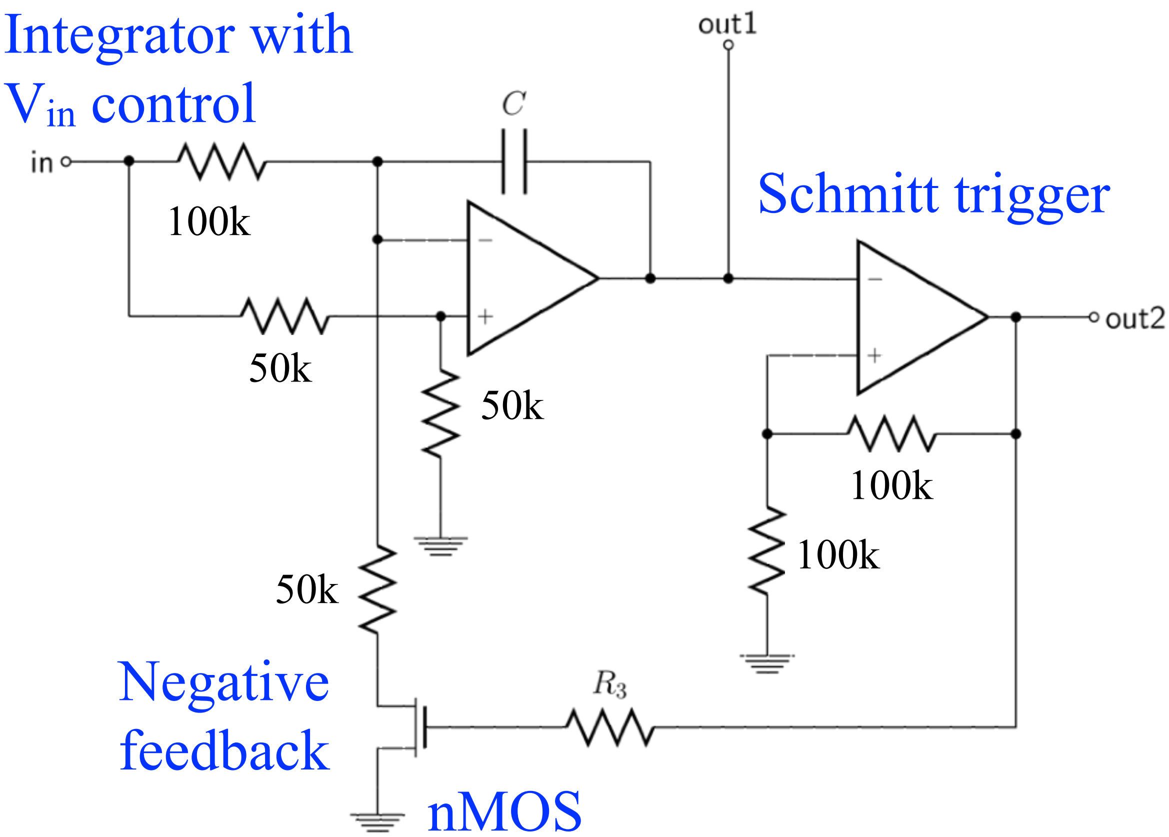
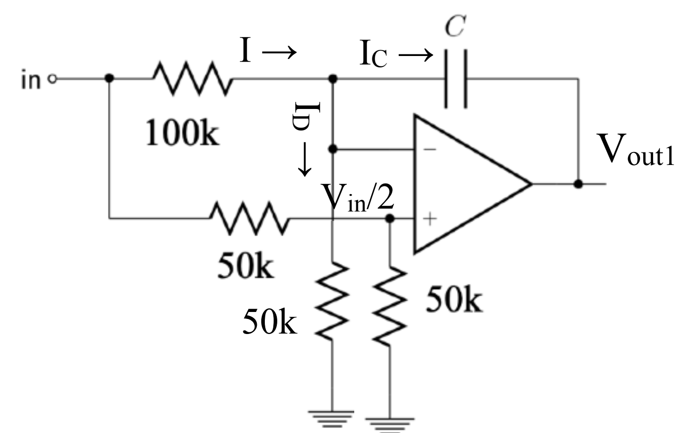


If $Out1<0$ & $Out2=V_{CC}$, then nMOS=on.
C charges as an integrator



Out1 linearly ramps up until $V_{CC}/2$, then Out2 flips to V_{EE}.
Ramp rate proportional to V_{in}.

$I = (V_{in}-V_{in}/2)/100k = V_{in}/200k$

$I_D = (V_{in} / 2) / 50k = V_{in} / 100k$

$I_C = I-I_D = V_{in} (1/200k - 1/100k)$

$I_C = I-I_D = -V_{in}/200k$

$C\, d(V_{in}/2-V_{out1})/dt = -V_{in} / 200k$

$C\, dV_{out1}/dt = V_{in} / 200k$

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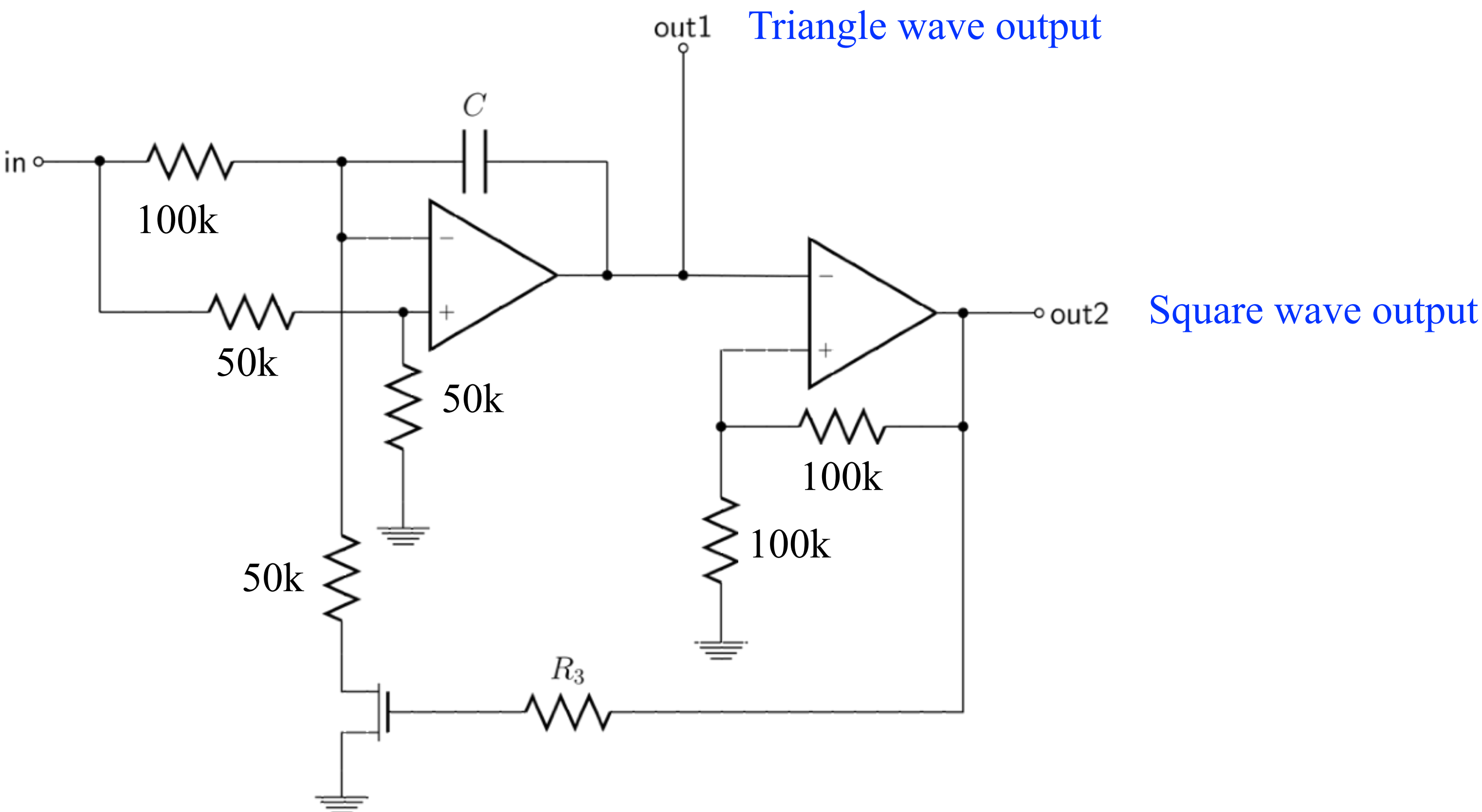
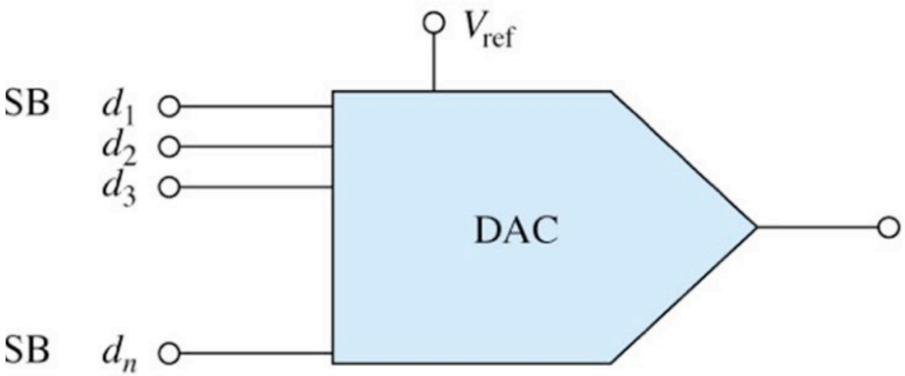
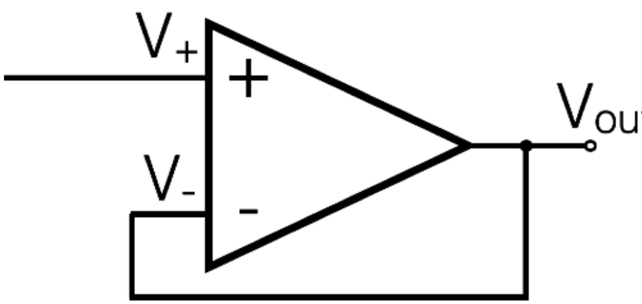


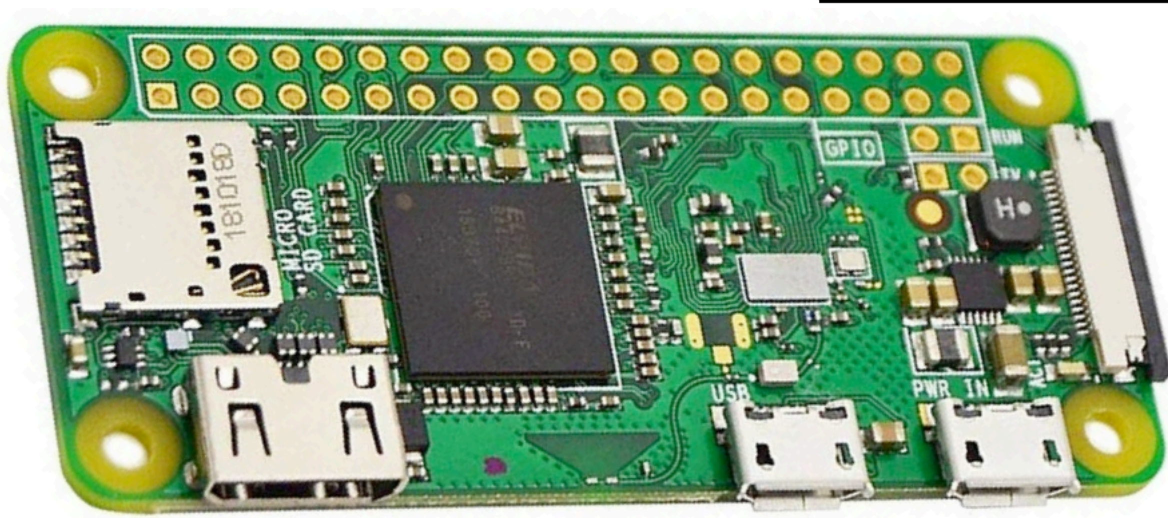
Sine wave oscillator

We could get a sine wave oscillator in a few ways:

0). Use a computer to rapidly change the resistance in a digital potentiometer used in a voltage divider







Quiz

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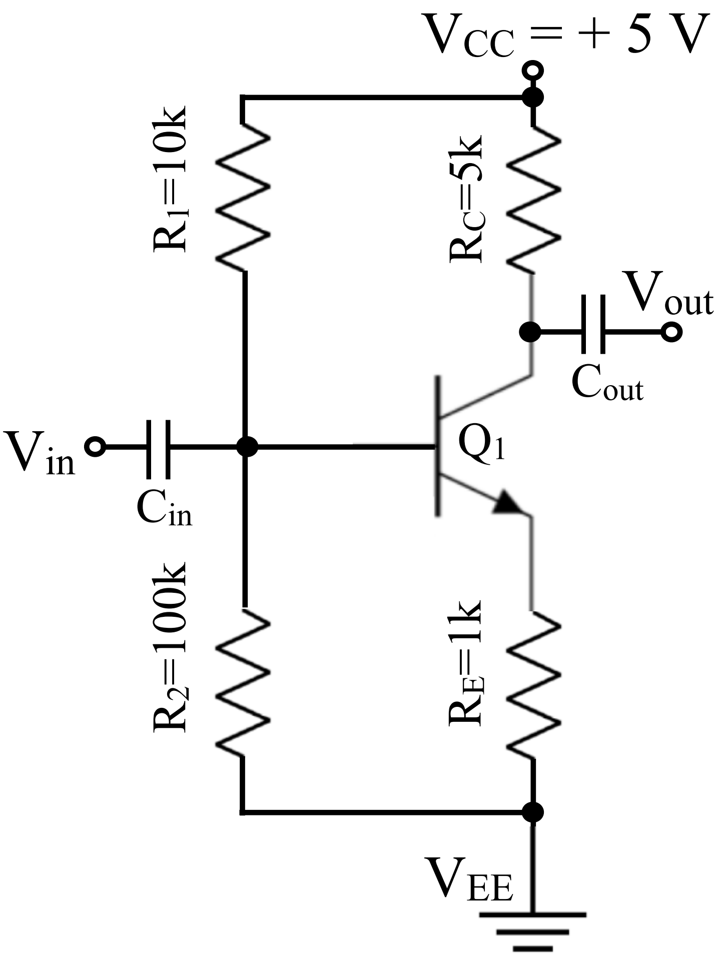
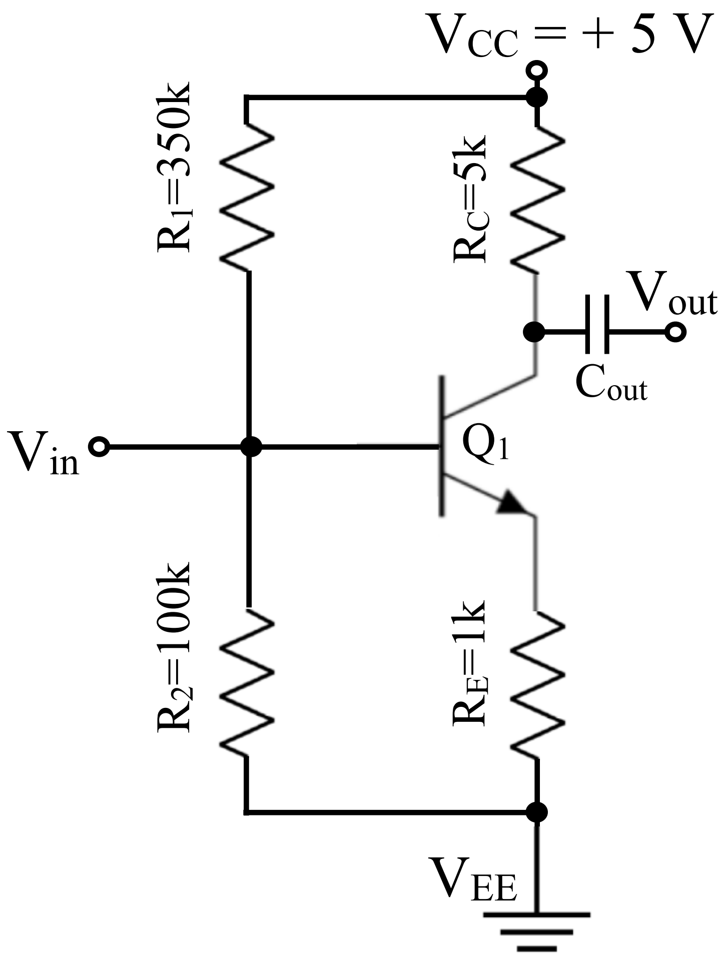
What is wrong with these circuits?





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