PS6: Op-Amps

Thursday, April 1, 2021 4:28 PM

PS6-OpAmp
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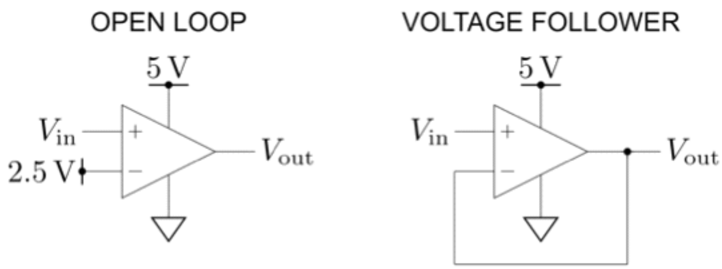
Problem set: Op-amps

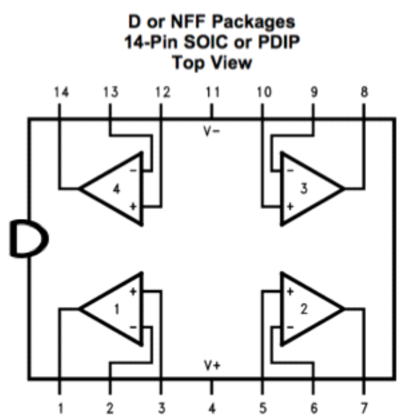
<u>Goal:</u> Experience how the operational amplifier ("Op-amp") functions and how it can be used to get more accurate voltage measurements. *Why? The reason is in the puzzle, page 2.*

Overview

In this problem set, you're going to use an op-amp in two configurations that are schematically represented below, OPEN LOOP and with negative feedback, as a VOLTAGE FOLLOWER:



You'll be using the LMC6484 chip which has the pin configuration pictured below.

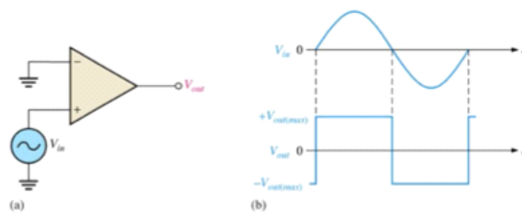


V^- and V^+ are source or "rail" voltages that supply all the op-amps.

To use this chip as indicated in the above schematic, As you work through this problem set, you'll need to recall the **behavior of op-amps**:

1. $I_+ = I_- = 0$
2. $When\ V_{in}^+ > V_{in}^-,\ V_{out} = V_s^+,\ When\ V_{in}^+ < V_{in}^-,\ V_{out} = V_s^-$
3. For $V_s^- < V_{out} < V_s^+$, $V_{in}^+ = V_{in}^-$,

4. It takes time for V_{out} to switch states from $V_s^- \rightarrow V_s^+$



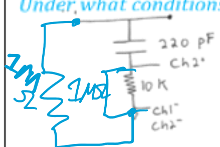
Source: Anastasia Armstrong, https://slideplayer.com/slide/11113908/

First, a puzzle...

In general, we want our decisions to be based on objective facts. But sometimes, the act of *observing* distorts what's being *observed*.

In ISIM, the O-scope has been our *observer.*

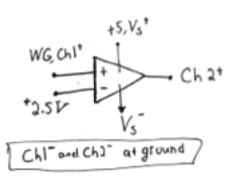
Under what conditions are the observations distorted by the observer?

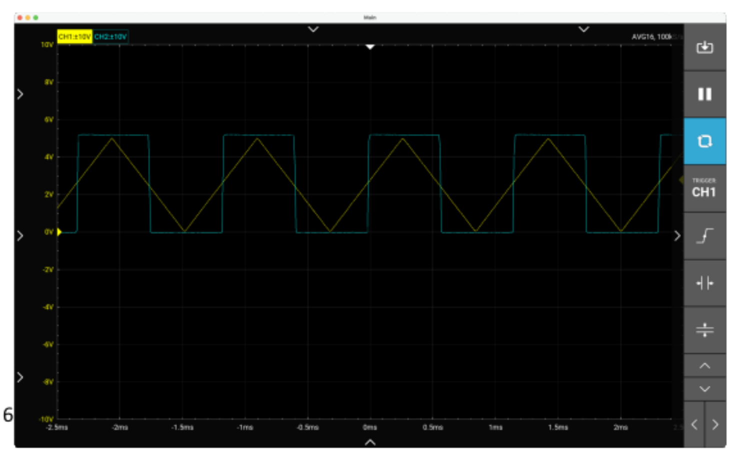


The O-Scope has a 1 MΩ resistor in series.

I. Open loop behavior

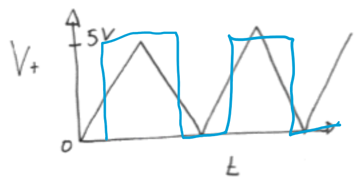
1. Create the circuit below using any op-amp within the LMC6484 chip.





2. Connect the O-scope

3. Set the WAVEGEN conditions (+2.5V offset, ±2.5V amplitude triangle wave) and run.



Given the input, what are you expecting for ?

*[**Hint**: See **behavior of op-amps,** page 1]*

Sketch the expected on the v. time graph, left.

4. Observe the V_{in} and $V_{out}(t)$

Confirm that you get Figure 5.3 in book (**note**: $V_- = 3.5$ V in Fig. 5.3, *not* 2.5V).

Save a screenshot to turn in.

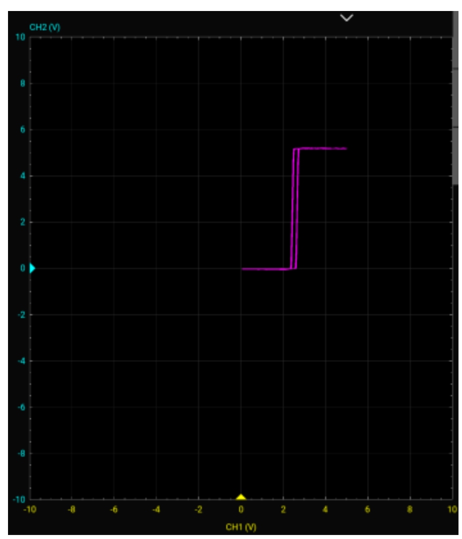
5. Use the X-Y plot pull out to see how $V_{out}(t)$ changes with $V_{in}(t)$.

*Of and , which is the **independent** variable that you would assign to the x-axis?* Vin

That is, which of the two can you vary, independently of the other?

See for yourself that you get Figure 5.4 (p. 65).

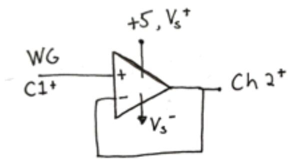
Save this x-y plot to turn in.



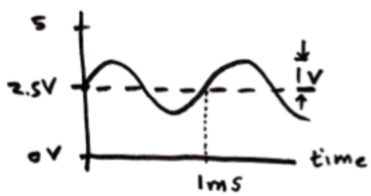
II. Op-amp voltage follower

One of the simplest and most useful op-amp circuits is called a voltage follower, described in section 5.3 of the book. The circuit consists of simply wiring the op-amp's output to the negative input.

1. Alter your circuit from the **open loop** observations to create a voltage follower.



2. Change the input signal to 2.5 V offset sine wave of 1V amplitude,



Given the input, what are you expecting for ?

*[**Hint**: See **behavior of op-amps,** page 1]*

Sketch the expected on the v. time graph, left.

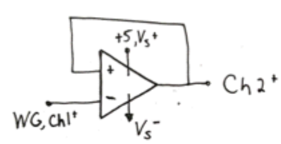
3. Use the O-scope to monitor V_{out} (t). It does, the input equals the output

   Does the follower work as expected? Record your observations on the last page.

   You don't need a figure to turn in.

4. Maximize the input signal frequency. Notice that the output signal is the same size, but lags behind the input signal? Quantify the size of this effect; what is your theory of this effect? ~750ms, opamp latency
5. Set the input frequency back to 1 kHz. Amplitude = 1 V, centered about 0 V. What do you notice about both input and output signals. Explain what is happening.

   Both are clipped at V=0, because you can't have negative voltage
6. Just for fun, reconfigure the circuit as shown:



Does it work as a follower? What happens?

There is no need to turn in any plots.

Nothing: V_out = 0

III. Follower as a buffer

This follower circuit is useful since the input to the op amp draws no current, the follower can be added between components of a system in order to isolate the components from each other. A simple example is found in the difference between the two circuits shown in Figures 1a and 1b.

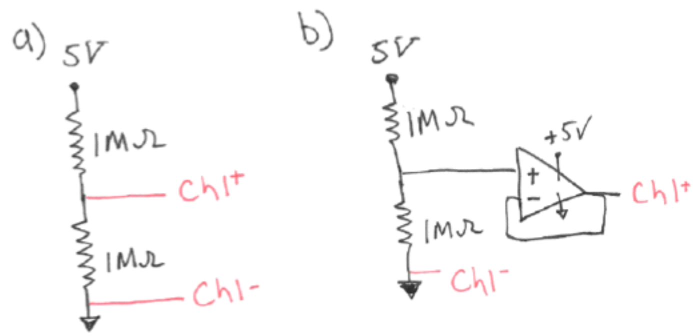


Figure 1. a) Voltage divider; b) Voltage divider with voltage follower.

Test the measurement of a simple voltage divider as shown in Figure 1 and see the difference between the circuit Figure 1a and 1b.

How do you expect the results to be different?

Why? The o-scope has an internal resistor, so less voltage drop in (a)

*[**Hint**: Consider your answer to **the puzzle**]*

Report the value of V_{out} for circuits a and b.

A: 2.25V
B: 2.58V