PS7: Op-Amps

Wednesday, April 7, 2021 9:59 PM

PS7-OpAmps

PSet: Foundational Op-Amp Circuits

Goals: Learn how op-amps can be used to perform math operations on their inputs.

Learning objectives

- Apply the operational principles of op-amps to a feedback circuit;
- Derive mathematical relationships between V_{out} and V_{in} for simple op-amp feedback circuits;
- Formulate a name for the op-amp circuit blocks, based on your derived equations;
- Investigate the difference in V_{out} when tying the op-amp input reference to 2.5V v. 0V;
- Critique the benefit of using 2.5V v. 0V as an op-amp input reference.

Turn in these pages when you're done.

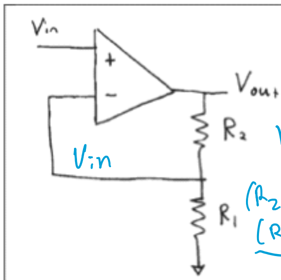
The following op-amp circuits function. We invite you to determine how each circuit functions and formulate a name for the function.

As an example, an *integrator* would produce a mathematical function that integrates the input:

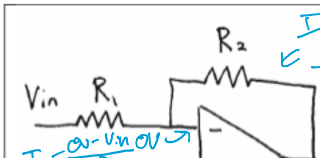
$$\frac{-1}{RC}\int_0^T V_{in}\cdot dt = V_{out}$$

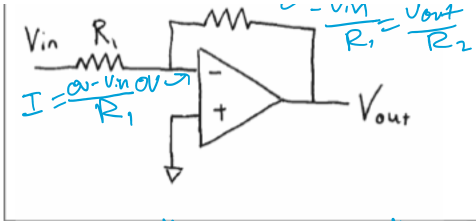
Your goal is to derive an equation that relates the inputs to the output. To get started, apply the rules for op-amps in feedback and use Ohm's law to figure out the current flow through each resistor.

- Inputs to the op-amp have zero current.
- V+=V- when we have negative feedback.

 $V_{in} = V_{out}\frac{R_2}{R_2+R_1}$ $(R_2+R_1)V_{in} = V_{out}R_2$ $\frac{(R_2+R_1)}{R_2}V_{in} = V_{out}$	$V_{out} = V_{in}\frac{R_2+R_1}{R_2}$ **Name:** Scalar

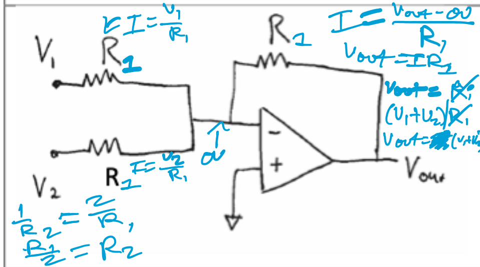
$I = \frac{\Delta V}{R}$

 $I = \frac{V_{out} - 0V}{R_2}$ $\frac{0 - V_{in}}{R_1} = \frac{V_{out}}{R_2}$ $I = 0V - V_{in}\ 0V$	$V_{out} = -\frac{R_2}{R_1}V_{in}$



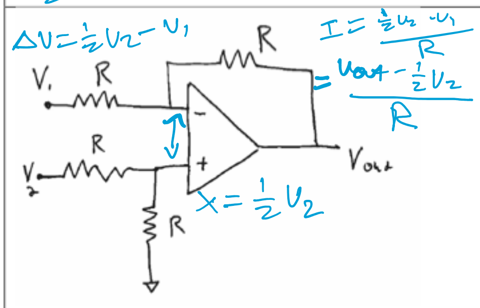
$V_{out} = \frac{\quad}{R_1} V_{in}$

Name: Scaler - Inverter



$V_{out} = V_1 + V_2$

Name: Adder

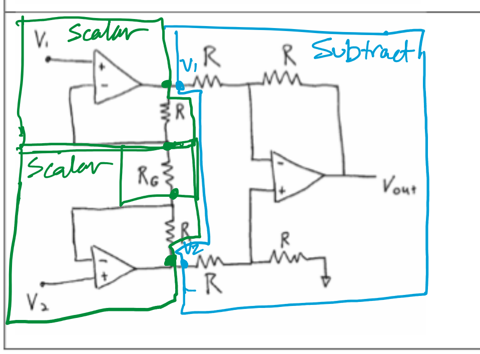


$V_{out} = V_2 - V_1$

$$\frac{\frac{1}{2}V_2 - V_1}{R} = \frac{V_{out} - \frac{1}{2}V_2}{R}$$

$$\frac{1}{2}V_2 + \frac{1}{2}V_2 - V_1 = V_{out}$$

Name Subtracter

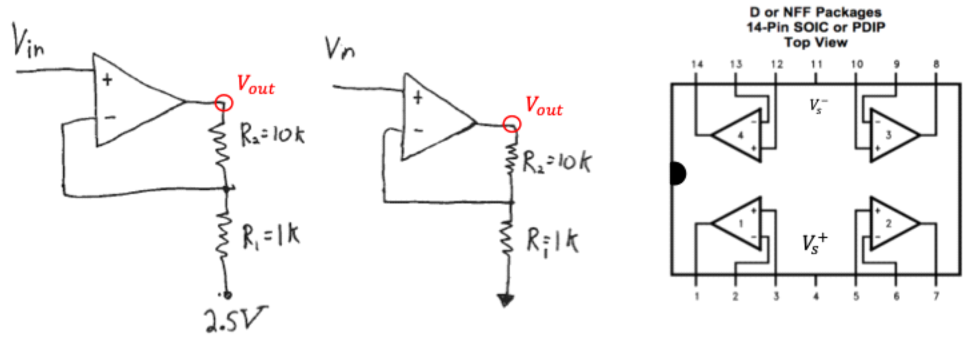


This is the challenge circuit

$V_{out} = \left(\frac{R+R_G}{R}\right)(V_2 - V_1)$

Name: Instrumentation amplifier

Now we ask you to **evaluate** two different op-amp configurations as shown in the figure below through measurements. You'll need a LMC6484 chip and an O-scope. Build both circuits.



Set up the **Scope** to monitor V_{in} with Channel 1 and V_{out} with Channel 2.

> *Make sure you have configured your circuit and hardware so that your computer, your breadboard and the Analog Discovery share a 0V reference.*

For the **input**, we suggest you use **Wavegen** to produce a ~100mV sinusoidal voltage of 1kHz, offset by a) 2.5V and then b) offset by 0V.

Work to understand how the reference point (2.5V or ground) changes the V_{out} response to the a) or b) input.

Explain any advantage of using 2.5V over 0V for these circuit configurations. There is no need to provide plots, just your thoughts.

Centering @ 2.5V ensures the wave @0V
isn't cut off @0V