Lab 6: Operational Amplifiers

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Objective: The purpose of this lab is to experimentally verify the functions of the various circuits that are built with operational amplifiers (op-amps). In this lab exercise we will investigate the following circuits: (1) inverting amplifier, (2) non-inverting amplifier, (3) summation amplifier, (4) differentiator, (5) integrator.

1. Inverting Amplifier

- Construct the circuit in Figure 1 below using the 741 op-amp. Connect channel 1 probe of the oscilloscope at V_{in} and channel 2 at V_{out}. Keep both probes at DC measurement. Choose R_1 = 1k and R_2 = 10k.

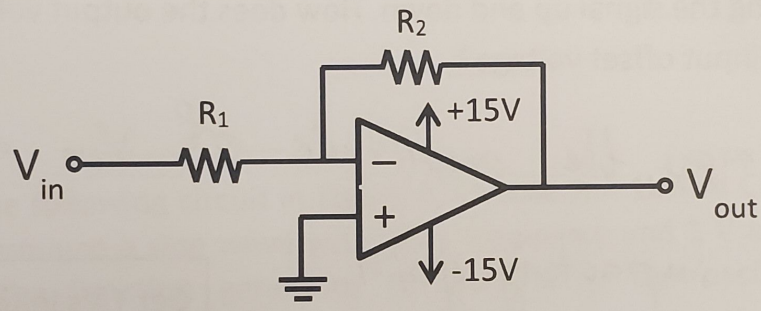


Figure 1

- Using a function generator, produce a sine wave with 1kHz frequency and 1 V amplitude and connect the output of the function generator to V_{in}.

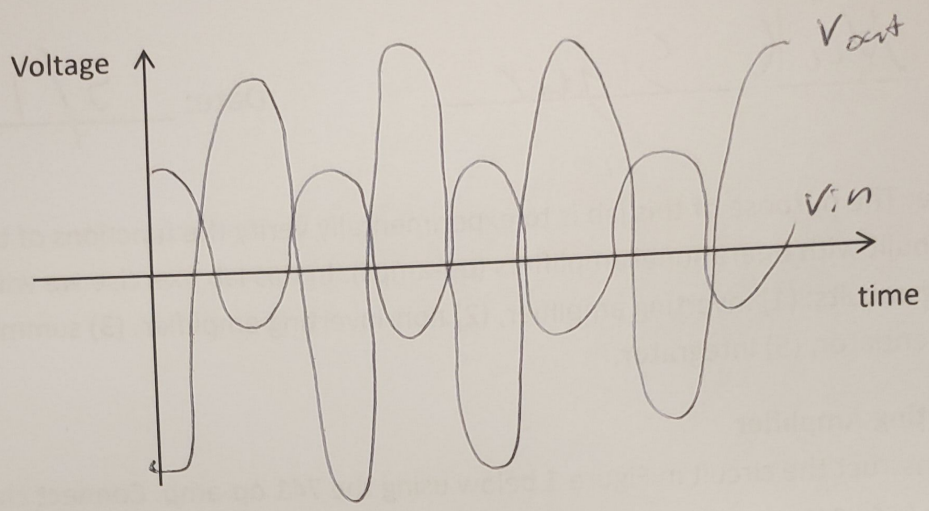
- What is the amplitude of V_{out}?

9.52 V

- What is the measured closed loop gain $\left(G = \frac{V_{out}}{V_{in}}\right)$ of the inverting amplifier?

$$G = \frac{-R_2}{R_1} = \frac{10{,}000}{1{,}000} = -10$$

- Reduce the DC voltage supply to +/- 10 V. Draw the waveform of Vout in the graph below. Does the waveform appear distorted? Explain how it looks compared to the input voltage.



- Using the offset knob in the function generator, change the DC component of the input waveform by moving the signal up and down. How does the output voltage respond to the changes in the input offset voltage?

it changes the amplitude of Vin and Vout without impacting gain

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2. Non-Inverting Amplifier

- Construct the circuit shown in Figure 2. Choose R_1 = 10k and R_2 = 1k. Using a function generator, produce a sine wave with 1kHz frequency and 1 V amplitude and connect the output of the function generator to V_{in}.

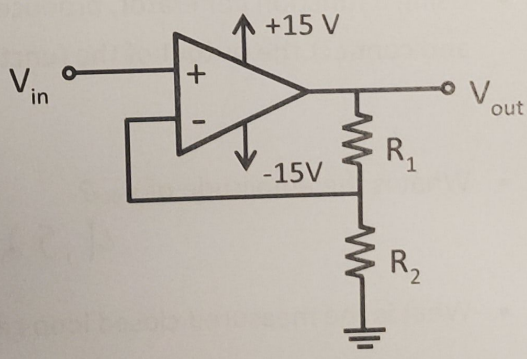

Figure 2

- What is the measured closed loop gain (G) of this amplifier?

$G = \frac{R_1 + R_2}{R_1} = \frac{11{,}000}{10{,}000} = 1.1$

$\frac{V_{out}}{V_{in}} = \frac{1.12}{1} = 1.12$

- Using the DMM measure the voltages at the positive and negative input terminals of the op-amp.

V_positive (RMS): 1.11, V_negative (RMS): -1.12

- How do the voltages at the positive input and the negative input compare?

Very close to each other

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3. Differentiator

- Construct the following circuit in Figure 3. Choose R = 1k and C = 0.1 µF. Using a function generator, produce a sine wave with 1kHz frequency and 1 V amplitude and connect the output of the function generator to V_{in}. Switch the oscilloscope channels to AC measurement.

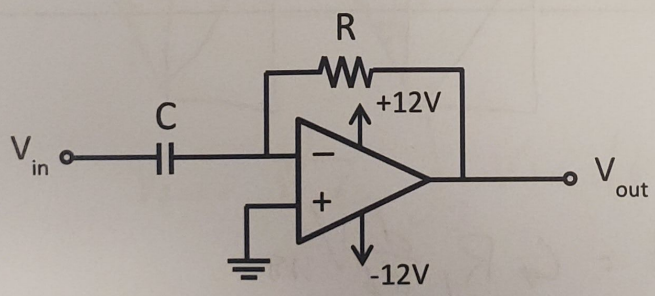
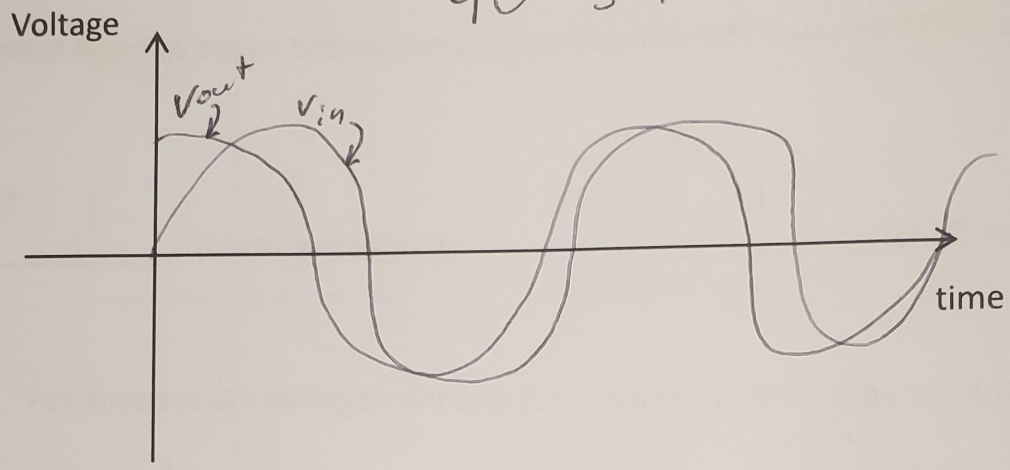


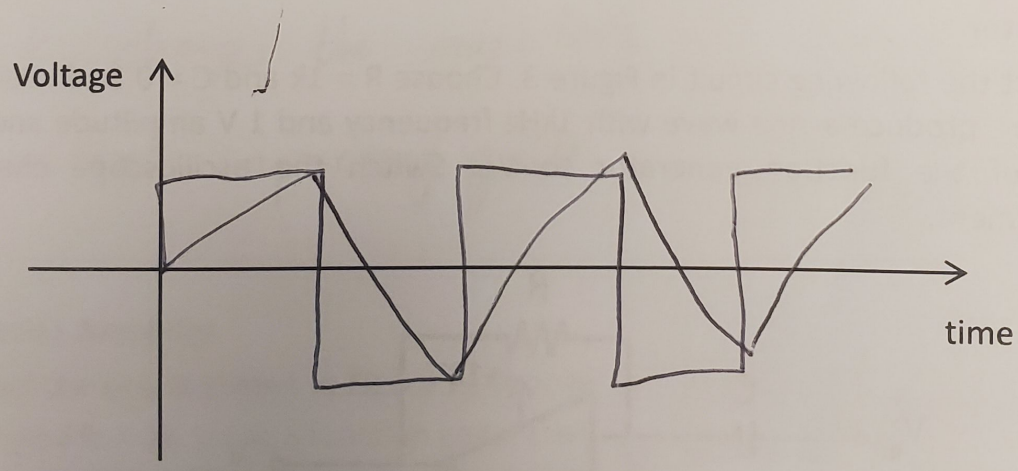
Figure 3

- Draw the waveforms of both Vin and Vout in the graph below. What is the phase shift (in degrees) between input and output?

90° shift



- Switch the waveform from the generator to a triangular wave and draw the waveforms of both Vin and Vout in the graph below. What is the input/output relationship?



$$V_{out} = C_1 R_1 \frac{d}{dt} V_{in}$$

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4. Integrator

- Construct the following circuit in Figure 4. Choose R = 1k and C = 0.1 μF. Using a function generator, produce a square wave with 1kHz frequency and 1 V amplitude and connect the output of the function generator to V_{in}. Use AC measurements for each channel.

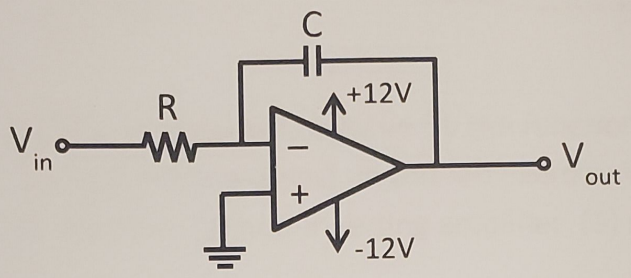
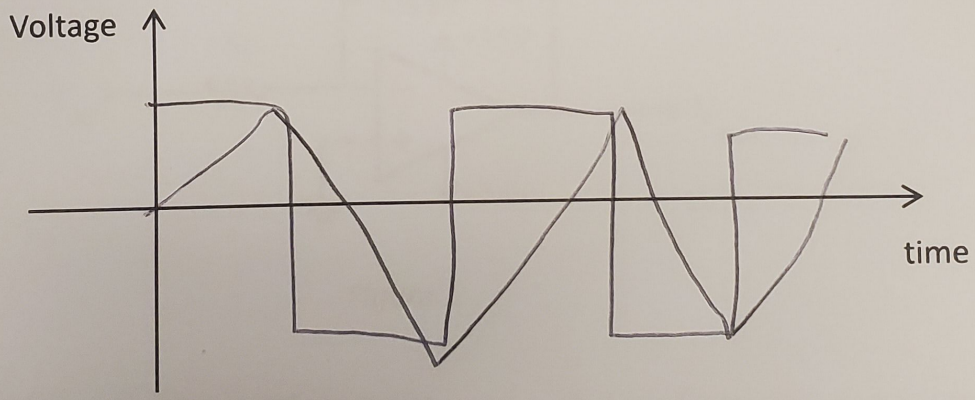


Figure 4

- Draw the waveforms of both Vin and Vout in the graph below. What is the input/output relationship?



$$V_{out} = \frac{1}{R_1 C_f} \int_0^t V_{in}\, dt$$

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