Experiment 40: OP Amps

Saturday, December 4, 2021 1:22 PM

Objectives:
- Examine the specifications of an IC op amp
- Build and demonstrate the operations and characteristics of common op-amp circuits

(no pre-lab)

Modifications:
- Use LF411 or LM741 op amp (we used LF411)
- Define terms for Procedure 2
- For procedure 5b, read note 2. Vary input voltage to observe saturation
- At least 4 scope images: 1 of each circuit, 1 showing clipping

LF411 Specifications:
- Max DC Power: 18 V
- Max Input Voltage: +-15 V
- Unity Gain Bandwidth: 3 MHz
- Input Impedance: 10^{12} Ω
- Slewrate: 13 $\frac{V}{\mu s}$

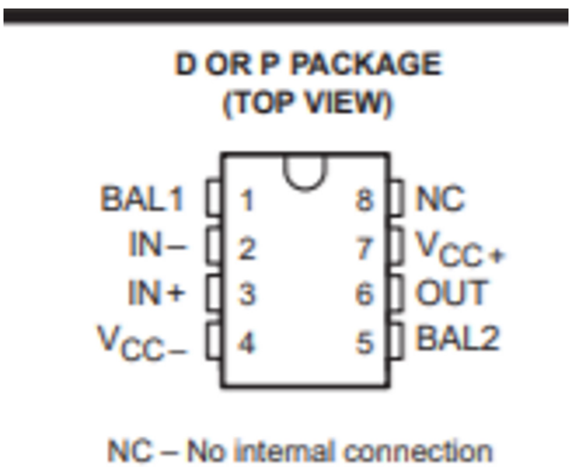

Figure 1: LF411 op amp pins(Texas Instruments Datasheet LF411CD)

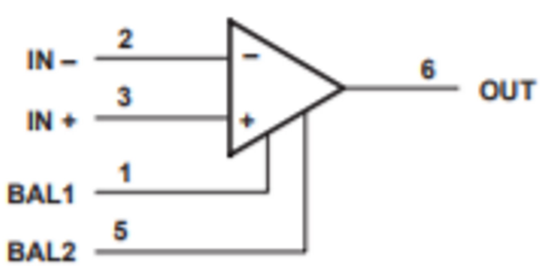

Figure 2: LF411 Circuit Diagram(Texas Instruments Datasheet LF411CD)

<u>**NOTE:**</u> CH1 = Vin, CH2 = Vout

Circuit 1:

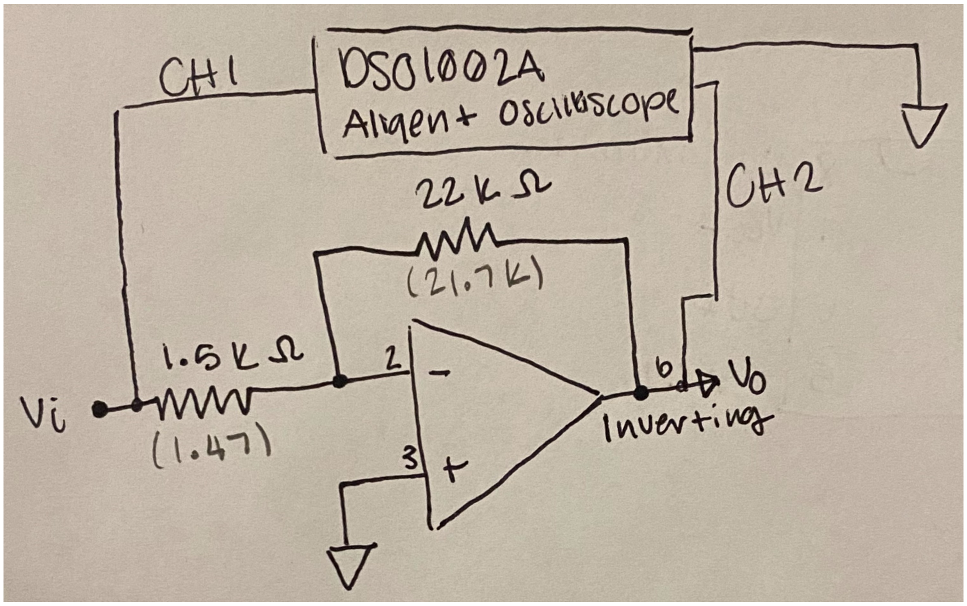

Figure 3: Circuit 1 Schematic - Inverting OP-Amp

Circuit 1 is an inverting op-amp. The equation for the gain is:

$$Av = \frac{Vout}{Vin} = -\frac{Rf}{Rin}$$

<u>AC Voltage:</u>

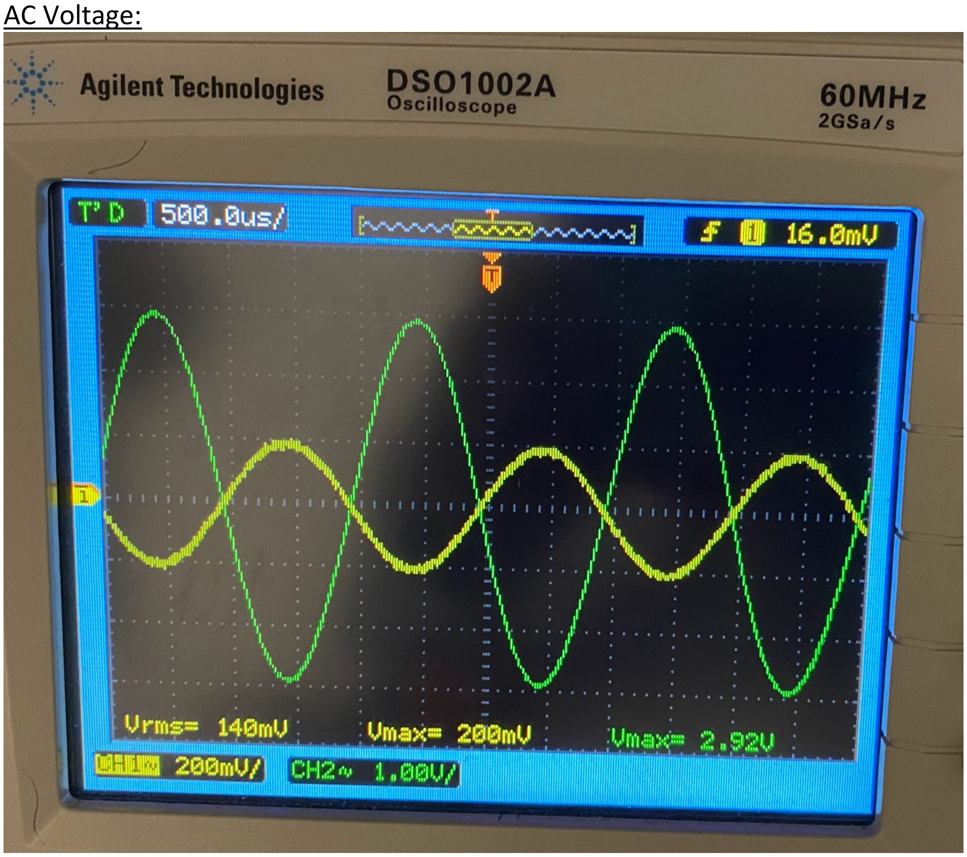

Figure 4: Circuit 1, Vi = 200 mVpp 500 Hz with full Vout

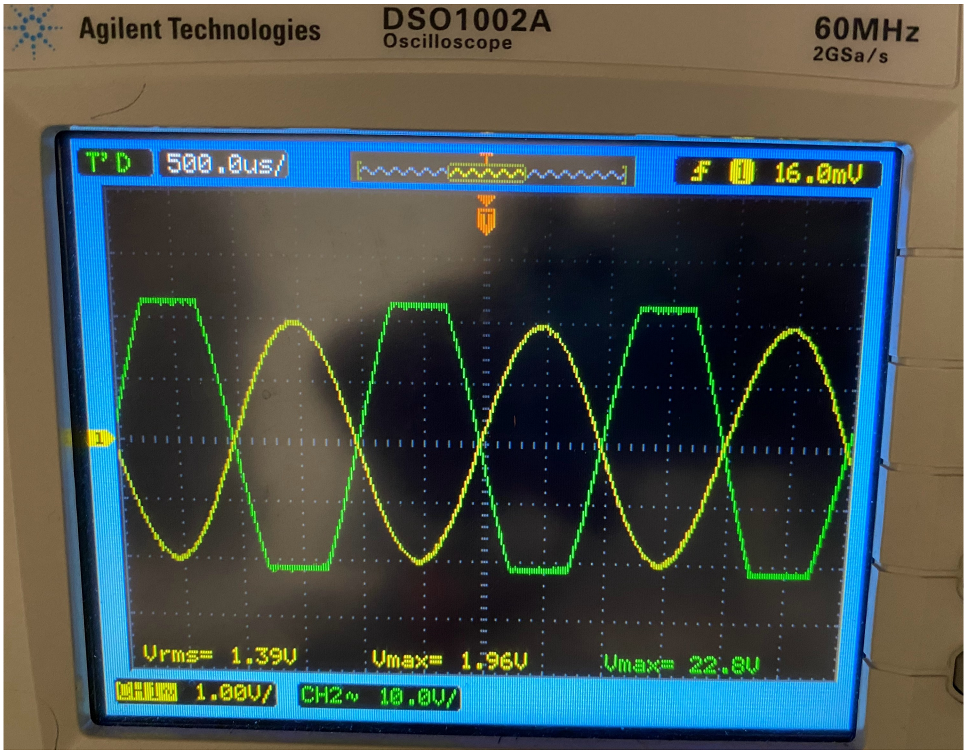

Figure 5: Circuit 1, Vi = 2 Vpp 500 Hz with Vout Clipping

Table 1: Vi: 200 mVpp, 500 Hz

	Calculated	Measured
Gain	14.76	14.6
Vout	2.952 V	2.92 V

To determine the saturation of this inverting op-amp, we started at 200 mVpp input voltage and increased the Vpp in 200 mV increments until we saw clipping at the maximums and minimums of the sinusoid. At 2 Vpp input voltage, we no longer had a full sinusoidal graph and had a wave with clippings at the maximums and minimums of the sinusoid. Looking at the oscilloscope graph, the output voltage clips at the value of 22.8 Vpp. Therefore the output saturation level is 22.8 Vpp and cannot surpass that output in this circuit.

<u>DC Voltage:</u>

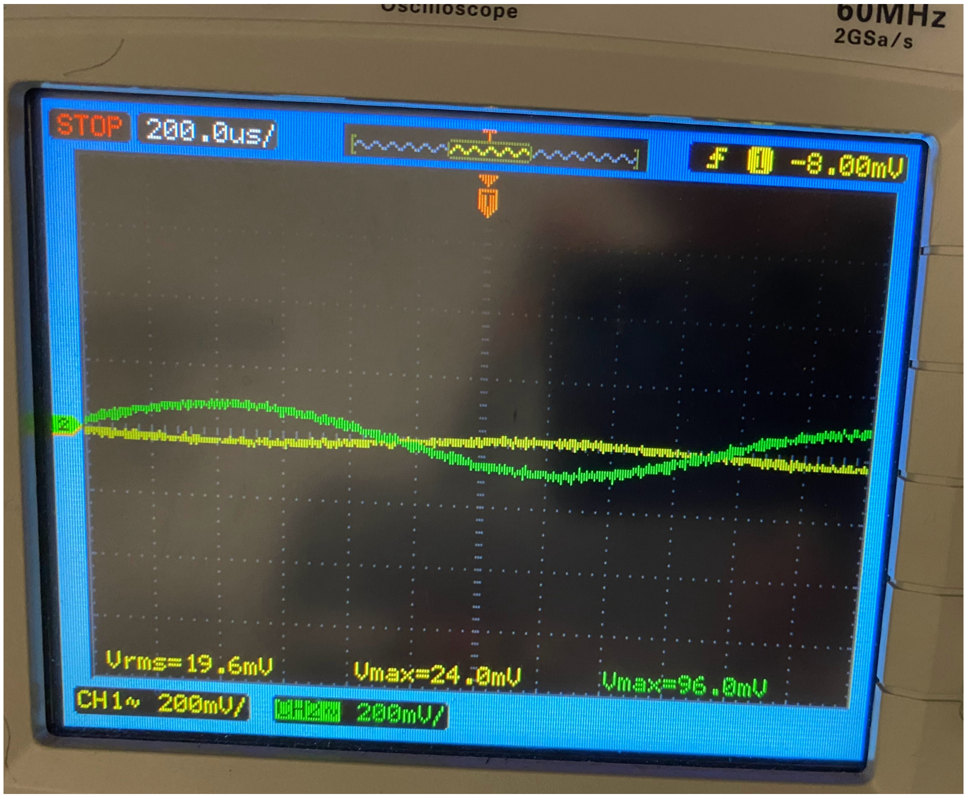

Figure 6: Circuit 1, Vi = -0.5 V (DC Power)

For the DC power, we used the oscilloscope to supply this power. Because of this, we had to have a minimum of 2 mVpp and would not allow us to only supply DC power. This means our results is not as close to ideal as we wanted.

Table 2: Vi: -0.5 V

Vin	Vout	Gain
24 mV	96 mV	4

Circuit 2:

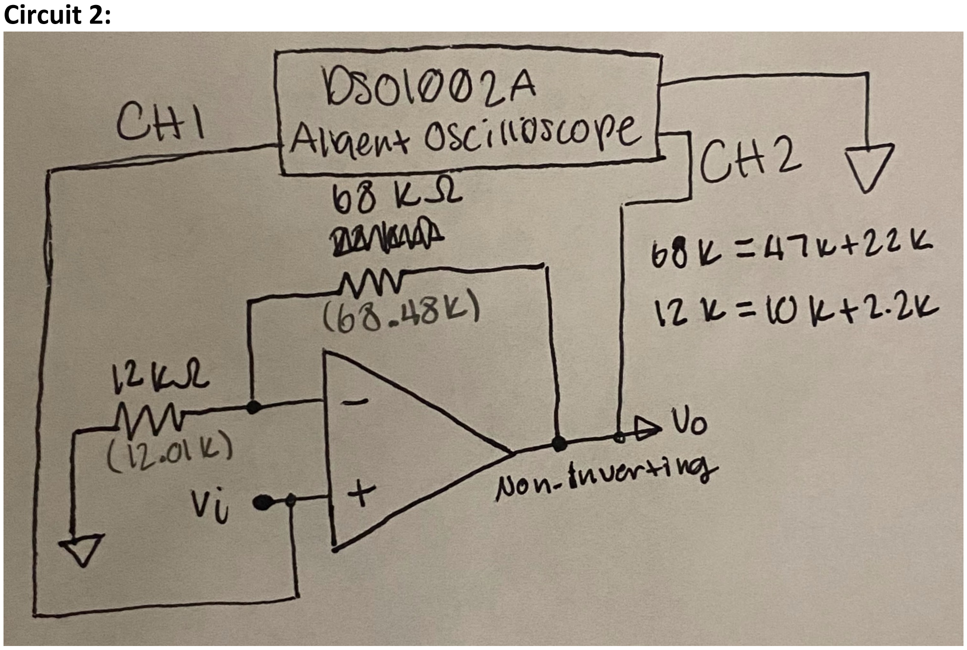

Figure 7: Circuit 2 Schematic - Non-Inverting OP-Amp

Circuit 2 is a non-inverting op-amp. The equation for the gain is:

$$Av = \frac{Vout}{Vin} = 1 + \frac{Rf}{R2}$$

AC Voltage:

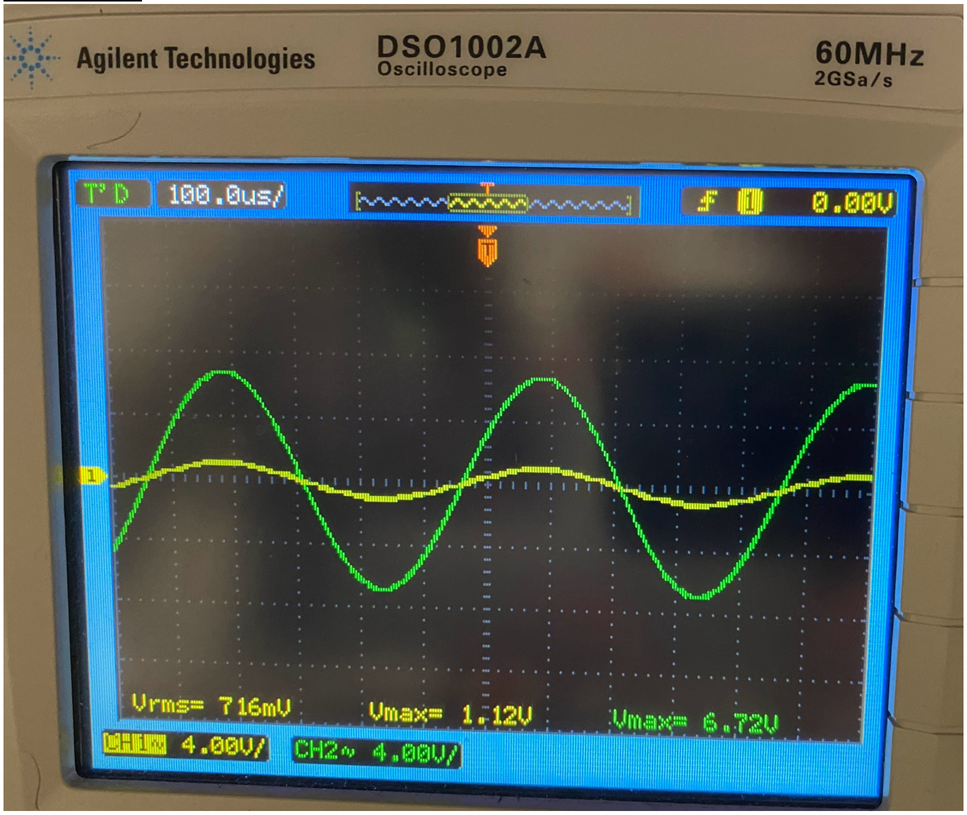

Figure 8: Circuit 2, Vi = 1 Vpp 2 KHz with full Vout

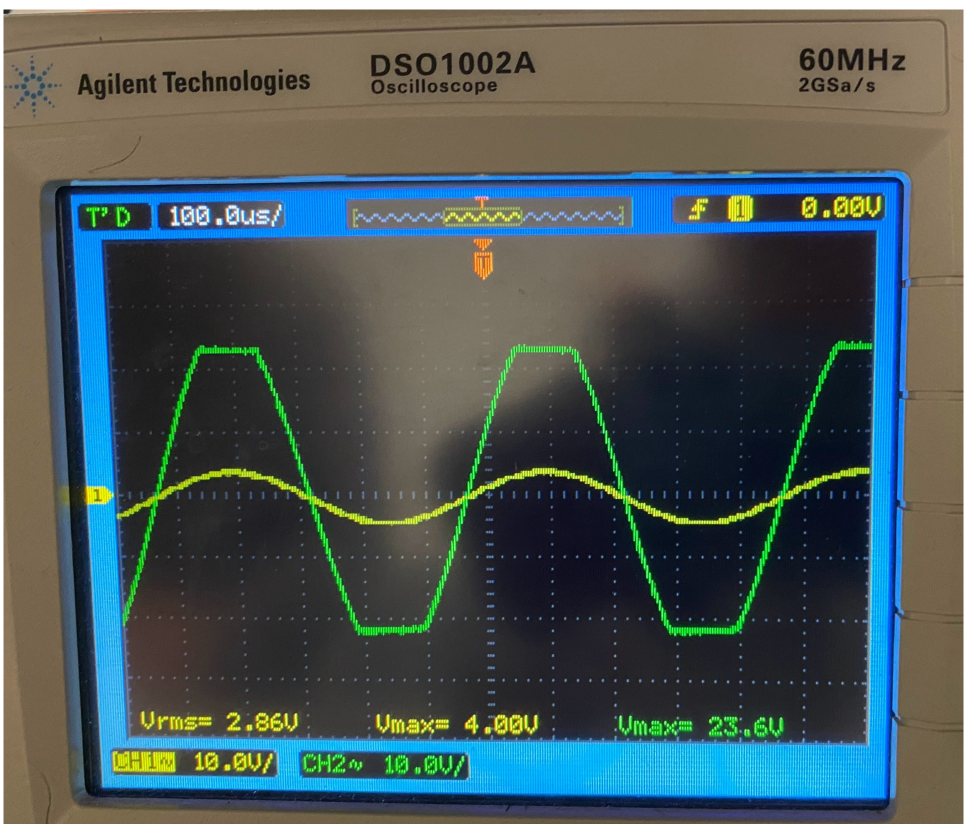

Figure 9: Circuit 2, Vi = 4 Vpp 2 KHz with Vout Clipping

Table 3: Vi - 1 Vpp, 2 KHz

	Calculated	Measured
Gain	6.67	6
Vout	6.67 V	6 V

To determine the saturation of this non-inverting op-amp, we started at 1 Vpp input voltage and increased the Vpp in 0.5 V increments until we saw clipping at the maximums and minimums of the sinusoid. At 4 Vpp input voltage, we no longer had a full sinusoidal graph and had a wave with clippings at the maximums and minimums of the sinusoid. Looking at the oscilloscope graph, the output voltage clips at the value of 23.6 Vpp. Therefore the output saturation level is 23.6 Vpp and cannot surpass that output in this circuit.

<u>DC Voltage:</u>

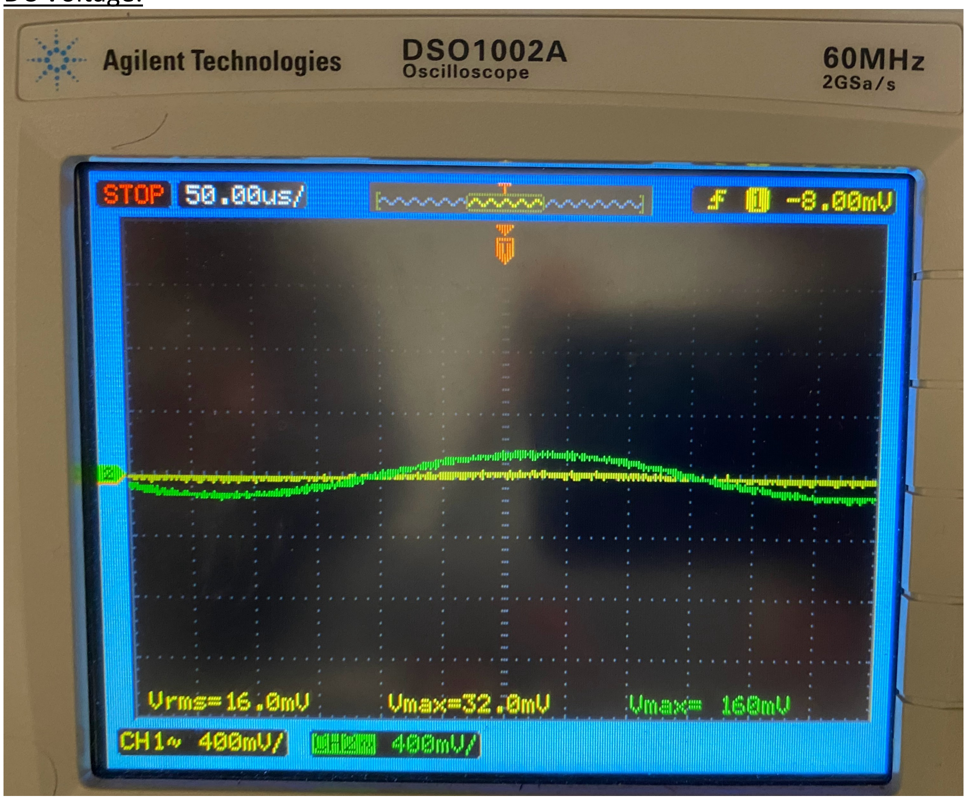

Figure 10: Circuit 2, Vi = +1.5 V (DC Power)

For the DC power, we used the oscilloscope to supply this power. Because of this, we had to have a minimum of 2 mVpp and would not allow us to only supply DC power. This means our results is not as close to ideal as we wanted.

Table 4: Vi: +1.5 V

Vin	Vout	Gain
32 mV	160 mV	5

Questions:

1. Op amps amplify both DC and AC signals
   - True

2. An op-amp circuit could be made to have a gain of less than 1
   - True

3. What type of transistors are used to build the op-amp?

- For the LF411 op-amp, it includes a JFET (Junction Field Effect Transistor) input operational amplifier