Lab#2 Operational Amplifier

Leonardo Fusser (1946995)

Objectives:

- Design a non-inverting voltage amplifier
- Take voltage and current measures on the amplifier
- Test the limits of the amplifier

Material: Simulated on Mindi

To hand in to Team Assignment

1- This document with the answers and measures. Copy-paste screenshots when required.
2- You provide comments to all screenshots
3- Upload the wxsch project file

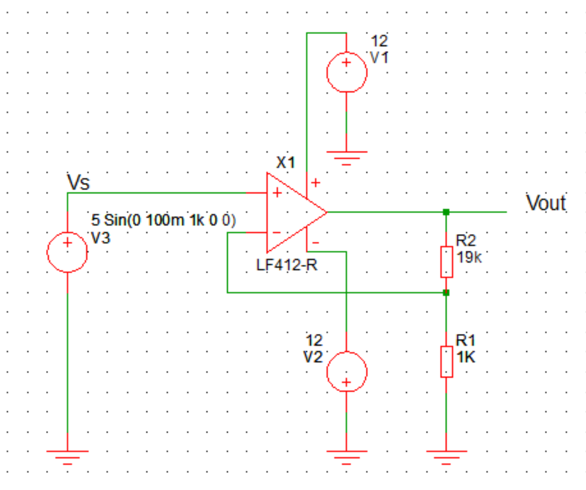
Lab preparation: Fill in the calculate column for all tables

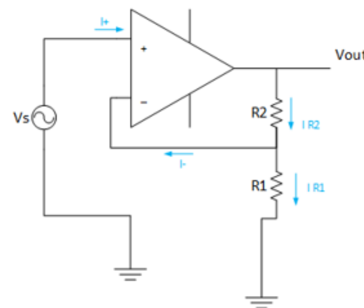
<u>Lab work</u>

Part 1: Non-inverting amplifier

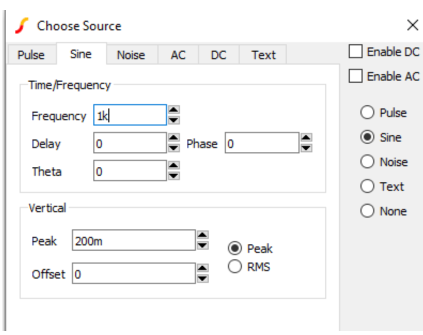
In this part of the lab, you are going to build a non-inverting op-amp based amplifier to amplify an AC signal.

Wire the following circuit:

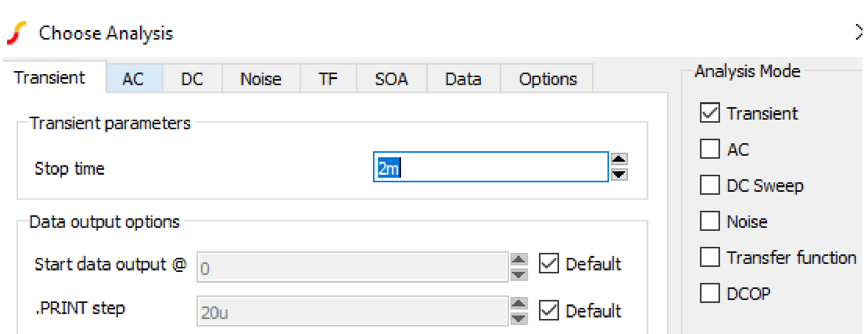




Set Vs to 200mV peak:



Run the simulator for at least 2 cycles:



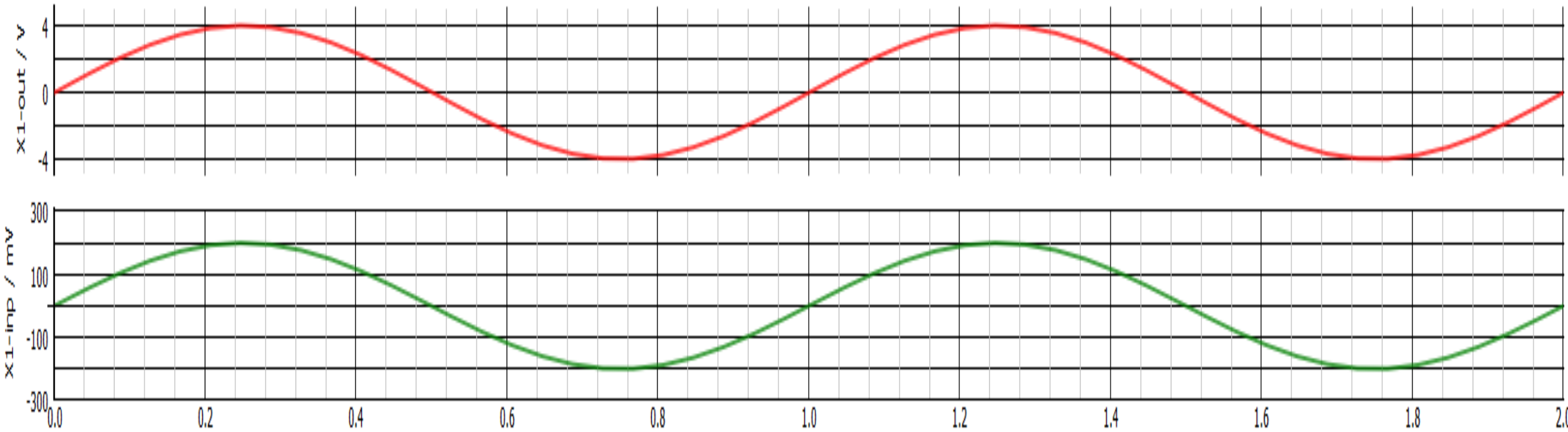
Fill up the following table. The grey area should be calculated.

To measure peak values:

1. Undock the Waveform Viewer
2. Waveform Viewer -> Measure -> Maximum
3. Select all measures

	Measures	**Calculations**
V_S peak	199.96771mV	200mV
V_{out} peak	3.9983515V	VR1(p) + VR2(p) = 3.79843399V + 199.91751mV
V_{R1} peak	199.91751mV	IR2(p) * R2 = 198.9782uA * 1K = 198.9782mV
V_{R2} peak	3.79843399V	Vout(p) – VR2(p) = 3.9983515V - 199.91751mV
Acl	~20	Vout(p) / Vs(p) = 3.9983515V / 199.96771mV
I_{R2} peak	198.97804uA	VR1(p) / R1 = 3.79843399V / 19KΩ = 199.917uA
I_{R1} peak	198.9782uA	VR2(p) / R2 = 199.91751mV / 1KΩ = 199.917uA
I- peak	4.5141708nA	N/A

Take a screenshot of Vs and Vout waveforms stacked on top of one another.



Red waveform: Vout & Green waveform: Vs. Vout = ~4Vp & Vs = ~200mVp

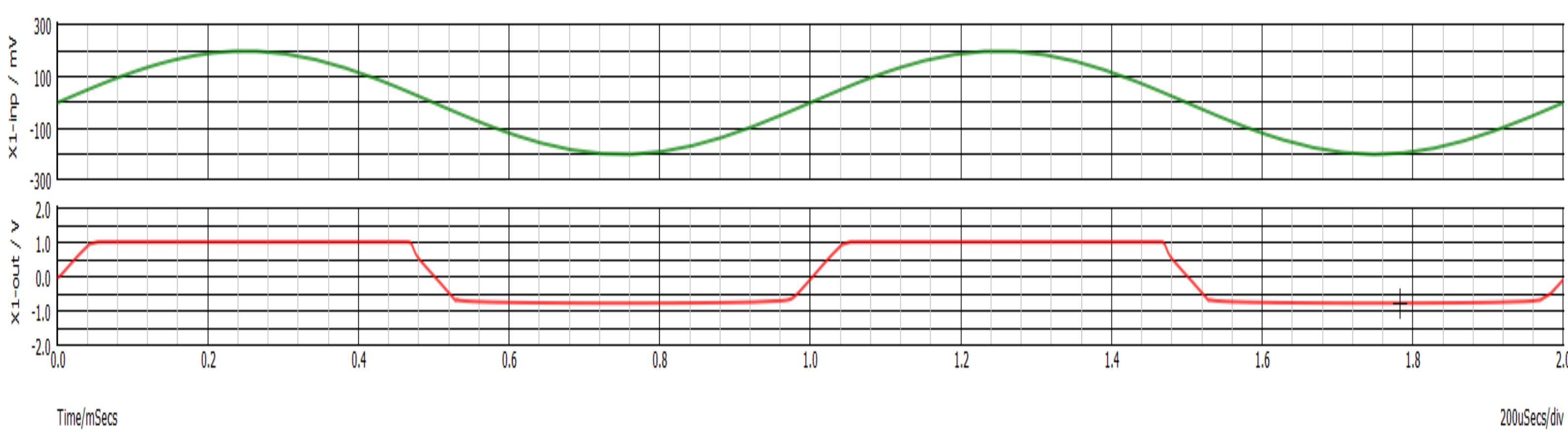
Part 2: Vout max

In this section you will look at the effect of connecting a load to the circuit.
Then you are going to increase Vs and see whether Vout reaches its maximum value.

Keeping Vs at 200mV peak, load the output with a 30 Ohm value.

Run the simulator and take a screenshot of Vs and Vout waveforms on top of one another.

Explain the Vout waveform.



Red waveform: Vout & Green waveform: Vs. Vout = ~1Vp & Vs = ~200mVp. Above is a good example when the Op-Amp is in "protection mode". The load connected to the Op-Amp is too much to handle causing the Vout signal to look saturated. The Op-Amp is limiting the load to 1Vp to prevent damage to the Op-Amp itself. Below are calculations for further explanation.

From that waveform find Io max in source mode for this Op-Amp? Explain

We can observe the maximum tolerable output current of the Op-Amp by calculating as follows:

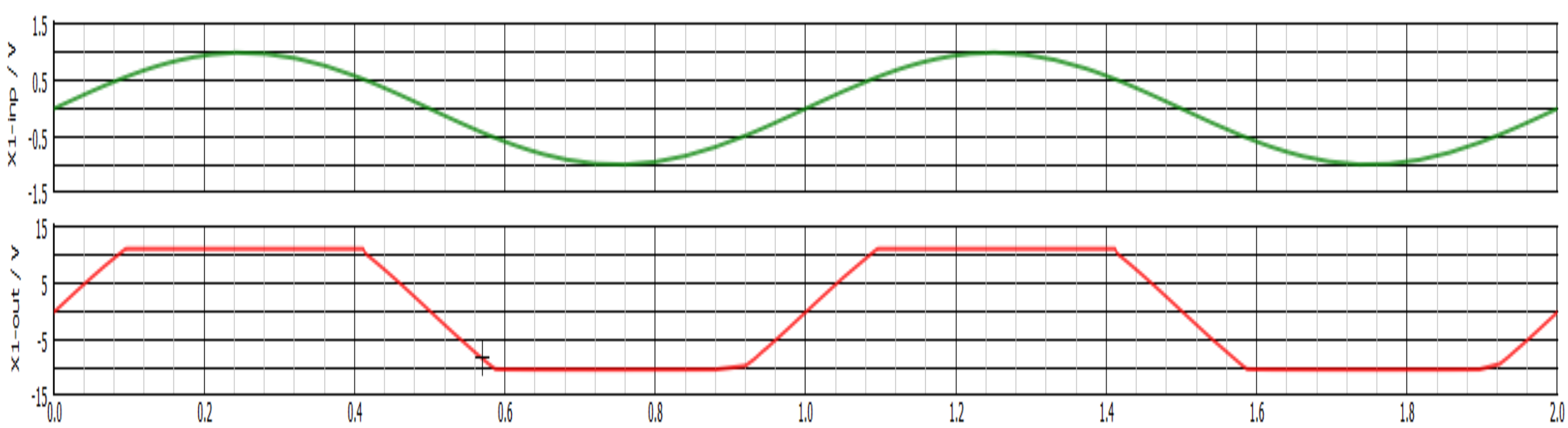
$$I_{O(MAX)} = \frac{1V_P}{30\Omega} = \sim 33.3mA$$

From the calculation above, we can see that the maximum amount of current that the Op-Amp can source is around 33mA. Any possible increase in current can possibly damage the Op-Amp or any other components in the circuit. "Source mode" is the opposite term to "sink/sink mode" where the Op-Amp is providing the power to power the load connected to the output of the Op-Amp.

Now, remove the load from the circuit. Then increase Vin to 1 Volt peak.

Run the simulator and take a screenshot of Vs and Vout waveforms stacked on top of one another.

Explain the Vout waveform.



Red waveform: Vout & Green waveform: Vs. Vout = ~10Vp & Vs = ~1Vp. Above is a good example when there is no load connected to the output of the Op-Amp. The output of the Op-Amp looks saturated because the Op-Amp is limiting the output from exceeding it's supply voltage. This phenomenon can be expressed as follows:

$$+V_{OUT(MAX)} = V_{CC} - 2V$$
$$-V_{OUT(MAX)} = -V_{CC} + 2V$$

Substituting for our values yields:

$$+V_{OUT(MAX)} = 12V - 2V = +10V_P$$
$$-V_{OUT(MAX)} = -12V + 2V = -10V_P$$

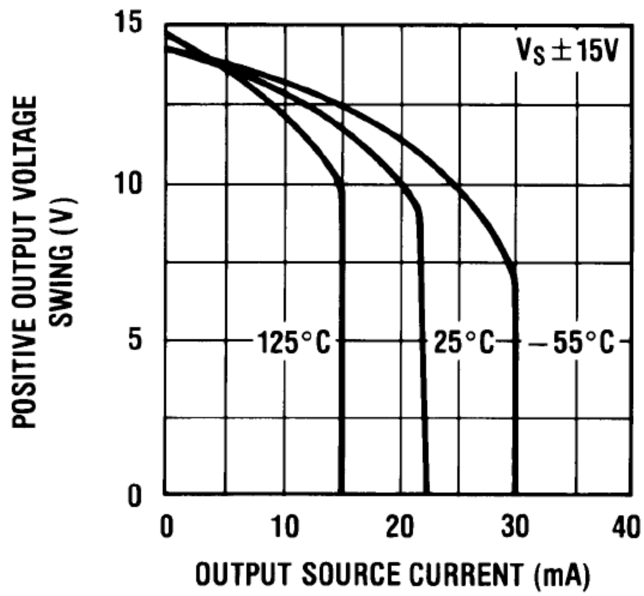
These values can be seen in the above screenshot.

You must give a demo before leaving the classroom.

After lab questions

Compare Io max measured with the datasheets. Data LF412 datasheets are uploaded in Teams.

The maximum output current that was calculated from above shows that the Op-Amp can tolerate loads up to around 33mA. Looking at the LF412's datasheet, we can see the suggested maximum tolerable output current:



Based on the information provided from the datasheet above, the suggested maximum output current this Op-Amp can handle is anywhere from 0mA to 30mA depending on ambient environment.