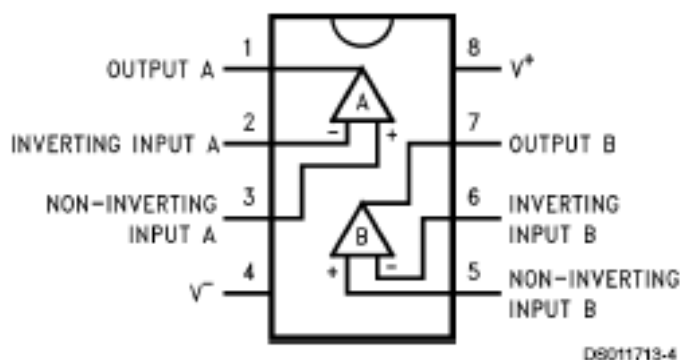


## Op-Amps: Experiment Guide

In this lab, we are going to study operational amplifiers and circuits with op-amps. The op-amp chip that we are going to use is LMC 6482 from National Instrument. The configuration of the chip is shown below. It has two amplifiers in one chip with 8 pins. The pin configuration is also shown in the same figure (There is a node on the chip indicating pin 1). The power supply to the chip is -4 V for  $V^-$  and +6 V for  $V^+$  in this lab (Maximum  $V^+ - V^-$  is 30V). For more information, please refer to the device specification.



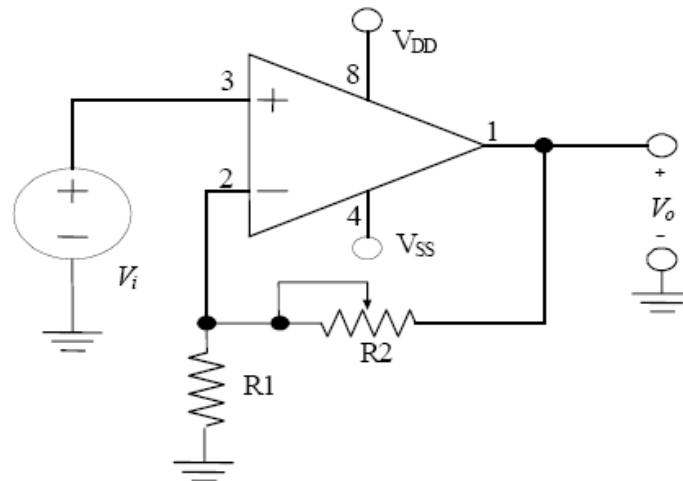
### Part 1: Noninverting Amplifier

#### (a) DC measurements:

- (1) Build up the noninverting amplifier as shown in Fig 1. Use +25V channel and -25V channel of the DC power supply for the  $V_{DD}$  and  $V_{SS}$ , the +25V should be set up to +6V and -25V channel should be set up to -4V. Use 6V channel of the DC power supply for  $V_{in}$ , and measure both input and output using oscilloscope.  $R_1$  is 5k and  $R_2$  is 5k. Change  $V_{in}$  from -2V to 3V to verify the proper amplification range of DC inputs.
- (2) Fix the DC input 0.5V, measure the amplifier gain ( $V_{out}/V_{in}$ ) for  $R_2 = 2\text{ k}, 5\text{ k}, 10\text{ k}\Omega$  (turn  $R_2$ ) and compare with the calculated gain. (You need to take out the pot from the circuit to measure its value.)

#### (b) AC measurement:

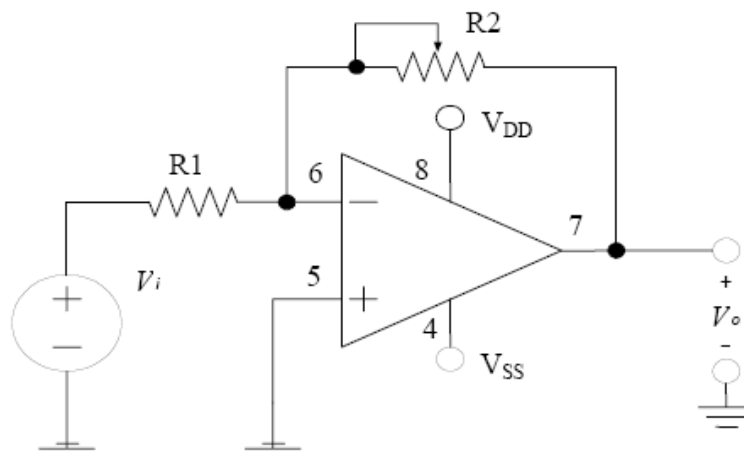
- (1) Now, set the input signal to a 1 kHz, 0.5 V<sub>pp</sub>, 0 VDC offset (on the function generator display) Sine wave from the function generator. Use a 10k $\Omega$  potentiometer as  $R_2$ . Adjust  $R_2$  to see the gain change. Can you get a gain less than unity by turning  $R_2$ ? Why?
- (2) Turn the potentiometer  $R_2$  until the gain is 2 and then adjust the V<sub>pp</sub> and DC offset to the input signal. Observe the input and output waveforms as you vary the DC offset for large V<sub>pp</sub> (say 2.5V). Draw the input and output for a case that gives clipping, label all the axes and indicate the amplitude, and DC offset value.



**Fig 1: Non-inverting Amplifier**

### Part 2: Inverting Amplifier

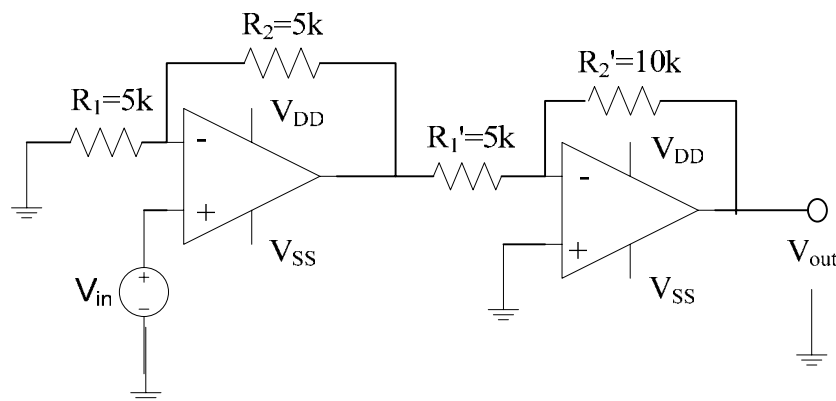
Using the unused op-amp of the chip, build the inverting amplifier as shown in Fig 2 (please use the unused op-amp now).  $R_1$  is 5k and  $R_2$  is the 10k pot. While you are building a circuit, it is safer for the circuits if you turn the DC power supply OUTPUT OFF. Let the input signal be a 1 kHz, 2.5V<sub>PP</sub> sine wave, 0 VDC offset, turn  $R_2$  to max. What's happening to the output signal as you change  $R_2$ ? Adjust the input offset to make the output more complete. Now adjust the potentiometer and observe the resulting change in the amplitude and offset of the output. Adjust these two parameters until the gain is at its maximum and there's no clipping. What range of output voltage do you have in this circuit? Verify the correct amplification (range of the output signal) of both AC and DC signals. What is the phase difference between  $V_{out}$  and  $V_{in}$  and where is it from?



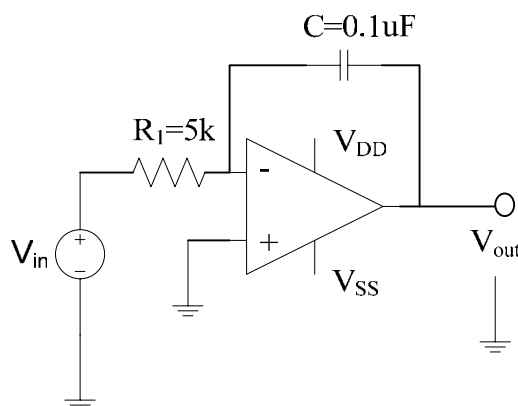
**Fig 2 Inverting Amplifier**

**Part 3: Cascaded connection**

Now we will study a cascade connection of two amplifiers. Connect the output of the inverting amp to act as the input voltage for the non-inverting amp. Use  $R_2 = 10k$  in the inverting circuit and  $R_2' = 5k$  in the noninverting circuit. The input signal should be a 1 kHz, 50mV<sub>pp</sub> (on the function generator display) sine wave and you have to pick the correct offset for the circuit to amplify linearly. Adjust the input signal to make sure there is no clipping in the circuit. Measure the gain of each stage separately and then the overall gain of this cascaded circuit.

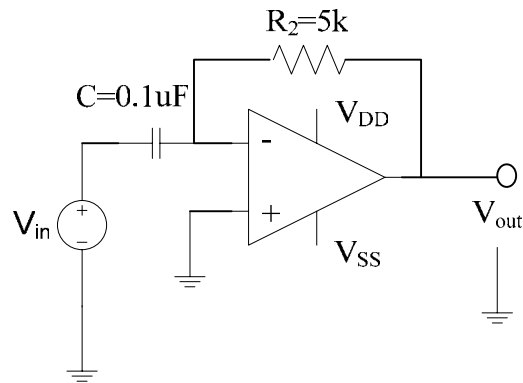
**Fig 3 Cascade amplifier structure****Part 4: Integrator**

Put a 0.1  $\mu$ F capacitor instead of  $R_2$  in a new inverting amplifier (Fig 3) and measure the time constant. Use a 60 Hz, 500mV<sub>pp</sub> square wave as input. After getting the waveforms and triggering correct, measure time constant RC (how will you measure it? Hint: you prelab question 4). Compare measured time constant with theory. Now change the function generator back to a sine wave input, sweep frequency from 1Hz to 100kHz and observe the change of the gain.

**Fig 4 Integrator**

**Part 5: Differentiator**

Build the inverting amplifier but put 0.1  $\mu\text{F}$  capacitor in stead of  $R_1$  as shown in Fig 4. Use  $R_2=5\text{k}$ . Input a 500 Hz 500 mVpp triangle wave. Zoom into the waveform to measure time constant  $RC$  (Hint: prelab question 5). Compare measured time constant with theory. Add DC offset to the input signal, is there any change on the output signal? Why?

**Fig 5 Differentiator**