



#### Dept. of Electrical, Computer and Biomedical Engineering

# Inverting and non inverting amplifier



# Purpose of this lab

Build an inverting and a non inverting amplifier based on a TLO81 op amp use the NI SC-2075 breadboard as your building platform

Find out what the circuit response is to a sinusoidal and a square (periodic) signal for different frequencies; use the waveform generator to provide the input signal and the oscilloscope to look at the amplifier output signal

Acquire the signal using a virtual instrument developed in the LabVIEW environment

Perform some measurements on the acquired signal: amplitude, average value, rms or effective value



#### Inverting amplifier



Choose R<sub>1</sub> and R<sub>2</sub> in such a way to have a gain of -10 (for instance, R<sub>1</sub>=1 kOhm and R<sub>2</sub>=10 kOhm)

You may want to use a resistor at the non-inverting input to compensate for the input bias current (what's the value you need?)



### Non-inverting amplifier



- Choose  $R_1$  and  $R_2$  in such a way to have a gain of 10 (for instance,  $R_1$ =1 kOhm and  $R_2$ =9 kOhm)
- You may want to use a resistor at the non-inverting input to compensate for the input bias current (what's the value you need?)

### TLO81 JFET input op amp

December 1995

# **National** Semiconductor **TL081 Wide Bandwidth JFET**

### Input Operational Amplifier

#### **General Description**

The TL081 is a low cost high speed JFET input operational amplifier with an internally trimmed input offset voltage (BI-FET II<sup>TM</sup> technology). The device requires a low supply current and yet maintains a large gain bandwidth product and a fast slew rate. In addition, well matched high voltage JFET input devices provide very low input bias and offset currents. The TL081 is pin compatible with the standard LM741 and uses the same offset voltage adjustment circuitry. This feature allows designers to immediately upgrade the overall performance of existing LM741 designs.

The TL081 may be used in applications such as high speed integrators, fast D/A converters, sample-and-hold circuits and many other circuits requiring low input offset voltage, low input bias current, high input impedance, high slew rate and wide bandwidth. The devices has low noise and offset voltage drift, but for applications where these requirements are critical, the LF356 is recommended. If maximum supply current is important, however, the TL081C is the better choice.

#### Features

Internally trimmed offset voltage	15 mV
Low input bias current	50 pA
Low input noise voltage	25 nV/√Hz
Low input noise current	0.01 pA/ <sub>v</sub> Hz
Wide gain bandwidth	4 MHz
High slew rate	13 V/μs
Low supply current	1.8 mA
High input impedance	10 <sup>12</sup> Ω
■ Low total harmonic distortion $A_V = 10$ , $R_L = 10k$ , $V_O = 20$ Vp-p, BW = 20 Hz-20 kHz	<0.02%
Low 1/f noise corner	50 Hz
Fast settling time to 0.01 %	2 µs

#### TLO81 JFET input op amp



#### Suggestions on how to build the circuit

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#### Suggestions on how to build the circuit

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Use the purple column to distribute ground

Use the orange column to distribute the +15 V power supply

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Remember: all of the holes in each of the three columns are short circuited  $\rightarrow$  you just need to connect one of the holes to -15 V, GND or +15 V to have the same voltage available in all the other holes in the same column

#### Setup for measuring the time response of the circuit



# Time response of the amplifier

#### Send a sinusoidal signal to the input of the amplifier

- Measure the amplitude of the output signal when the input signal has a frequency of 10 kHz and an amplitude of 0.5 V and 1 V. Verify that the amplifier gain is -10 for the inverting configuration and 10 for the non-inverting one.
- Measure the amplitude of the output signal when the input signal has a frequency of 10 kHz and an amplitude of 1.5 V and 2 V. What happens? Can you explain it?
- Measure the amplitude of the output signal when the input signal has an amplitude of 1 V and a frequency of 10 kHz, 100 kHz, 1 MHz and 10 MHz. What happens when the frequency of the input signal is equal to or larger than 1 MHz? Can you explain it?
- Send a square signal with a 1 V amplitude to the input of the amplifier
  - Look at the output signal when the frequency is 10 kHz, 100 kHz, 1 MHz and 10 MHz. Does the signal change shape when the frequency increases? Can you explain why?
- Can you think of a way to extract the offset voltage? After having a look at the data sheet, do you think that the bias current can have a significant effect on the output?

# Open loop gain of the TLO81 op amp



Remember that the gain-bandwidth product is conserved  $\rightarrow$  when the gain changes, the cut-off frequency of the circuit changes accordingly (if the gain is reduced by a factor of x, the cut-off frequency is increased by a factor of x)

gain of the closed loop configuration



### Signal acquisition



## DAQmx Create Channel.vi and DAQmx Read.vi

- DAQmx Create Channel.vi provides the acquisition board with information about the type and range of the signals to be acquired and about the input channel
- DAQmx Read.vi samples the signal from the specified channel and yield the measured value



# While loop

Needed for continuous acquisition of the signal coming from the amplifier output (use a low frequency for the input signal, 100 Hz) - a "stop" button should be included in the virtual instrument to stop the acquisition



### Waveform chart

You can use a waveform chart for a graphical representation of the acquired data ('Graph' menu of the Controls palette, from the front panel window) – the acquired sample can be directly fed to the waveform chart



### Measurements on the acquired data

Send a sinusoidal signal with an amplitude of 1 V and a frequency of 100 Hz to the input of the amplifier

- Measure the amplitude of the acquired signal
- Measure the average value of the acquired signal change the DC value of the signal from the waveform generator and check that the measured average value is the one you expect
- Measure the rms (effective) value of the acquired signal you can use the rms value of the acquired waveform to obtain the amplitude (amplitude=V<sub>rms</sub>x sqrt(2))