UNIVERSITÀ DEGLI STUDI DI PAVIA

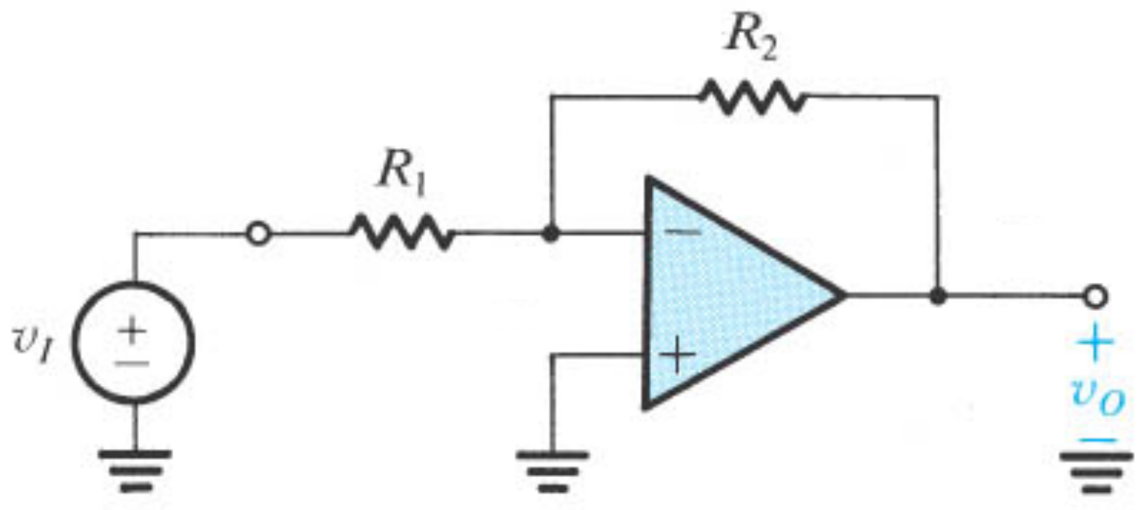
Dept. of Electrical, Computer and
Biomedical Engineering

Inverting and non inverting amplifier

Purpose of this lab

- Build an inverting and a non inverting amplifier based on a TL081 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

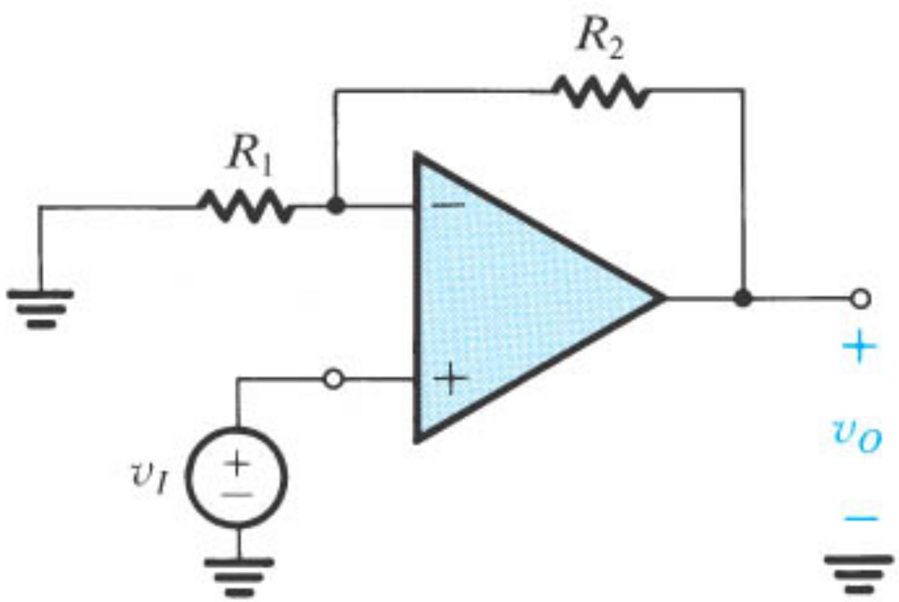
Inverting amplifier



$$\frac{V_o}{V_I} = -\frac{R_2}{R_1}$$

- 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=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



$$\frac{v_o}{v_I} = 1 + \frac{R_2}{R_1}$$

- 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?)

TL081 JFET input op amp

National Semiconductor

December 1995

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™ 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.

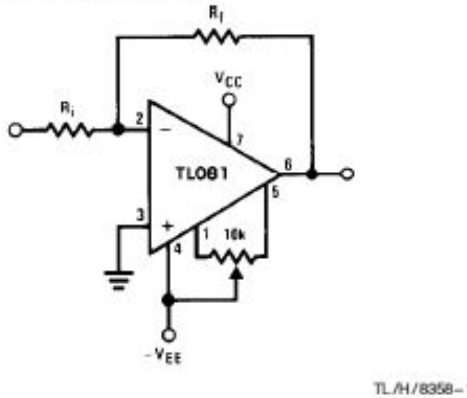
The TL081 may be used in applications such as high speed integrators, fast D/A converters, sample-and-hold circuits and many other circuits requiring low input offset voltage, low input bias current, high input impedance, high slew rate and wide bandwidth. The devices has low noise and offset voltage 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

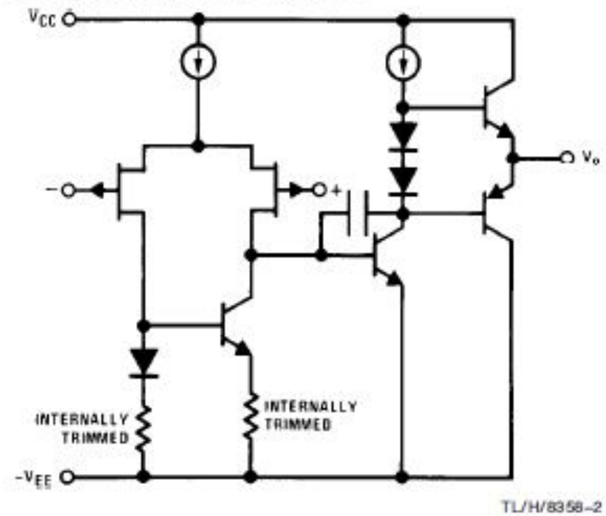
- Internally trimmed offset voltage — 15 mV
- Low input bias current — 50 pA
- Low input noise voltage — 25 nV/$\sqrt{Hz}$
- Low input noise current — 0.01 pA/$\sqrt{Hz}$
- Wide gain bandwidth — 4 MHz
- High slew rate — 13 V/µs
- Low supply current — 1.8 mA
- High input impedance — $10^{12}\Omega$
- 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

TL081 JFET input op amp

Typical Connection

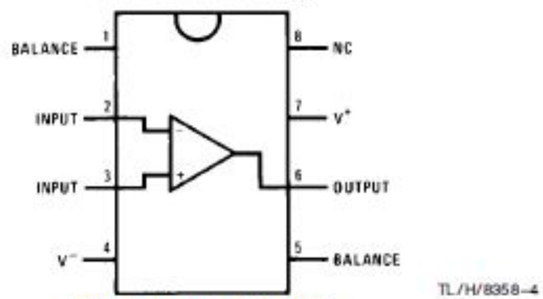


Simplified Schematic



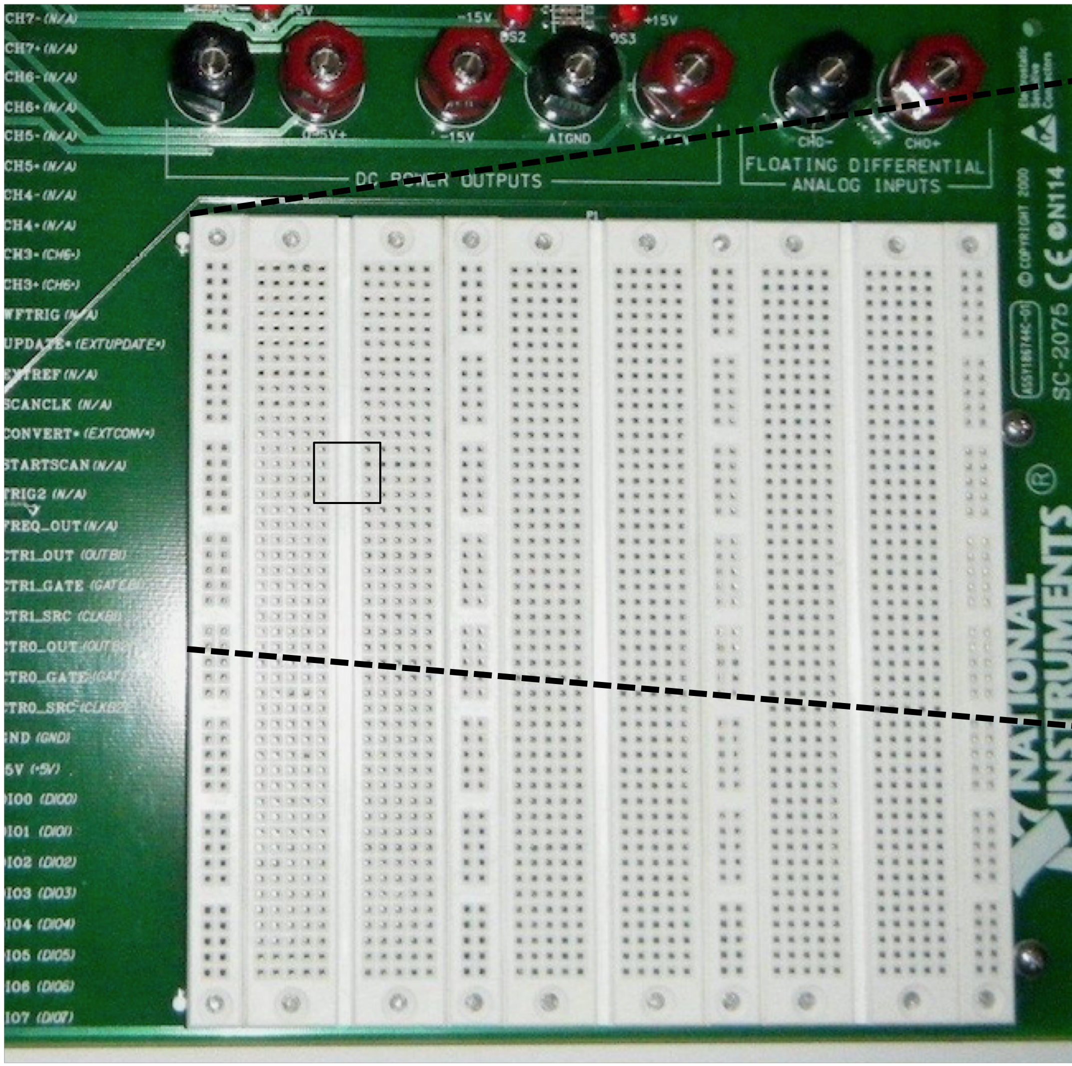
Connection Diagram

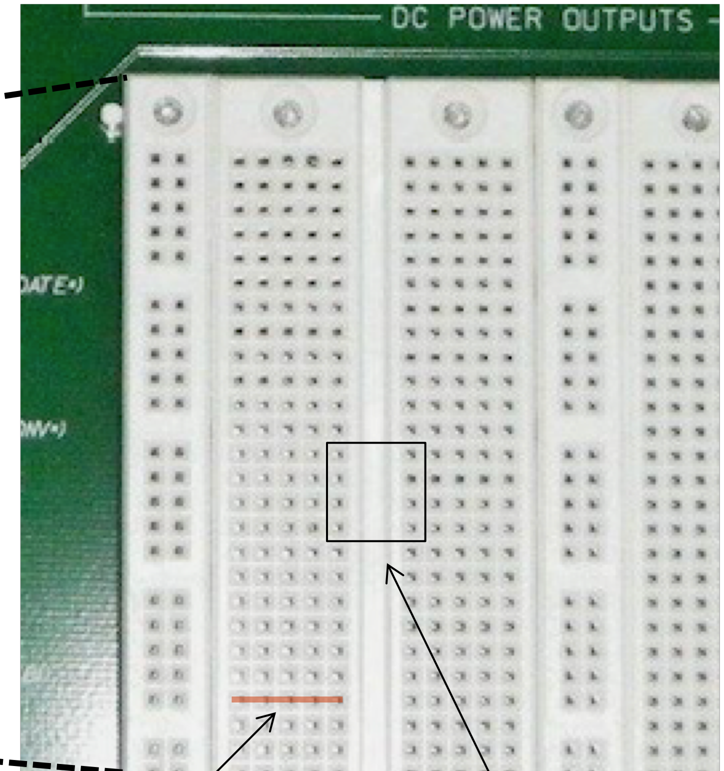
Dual-In-Line Package



Order Number TL081CP
See NS Package Number N08E

Suggestions on how to build the circuit





Remember: all the holes in a 5 hole row are short circuited

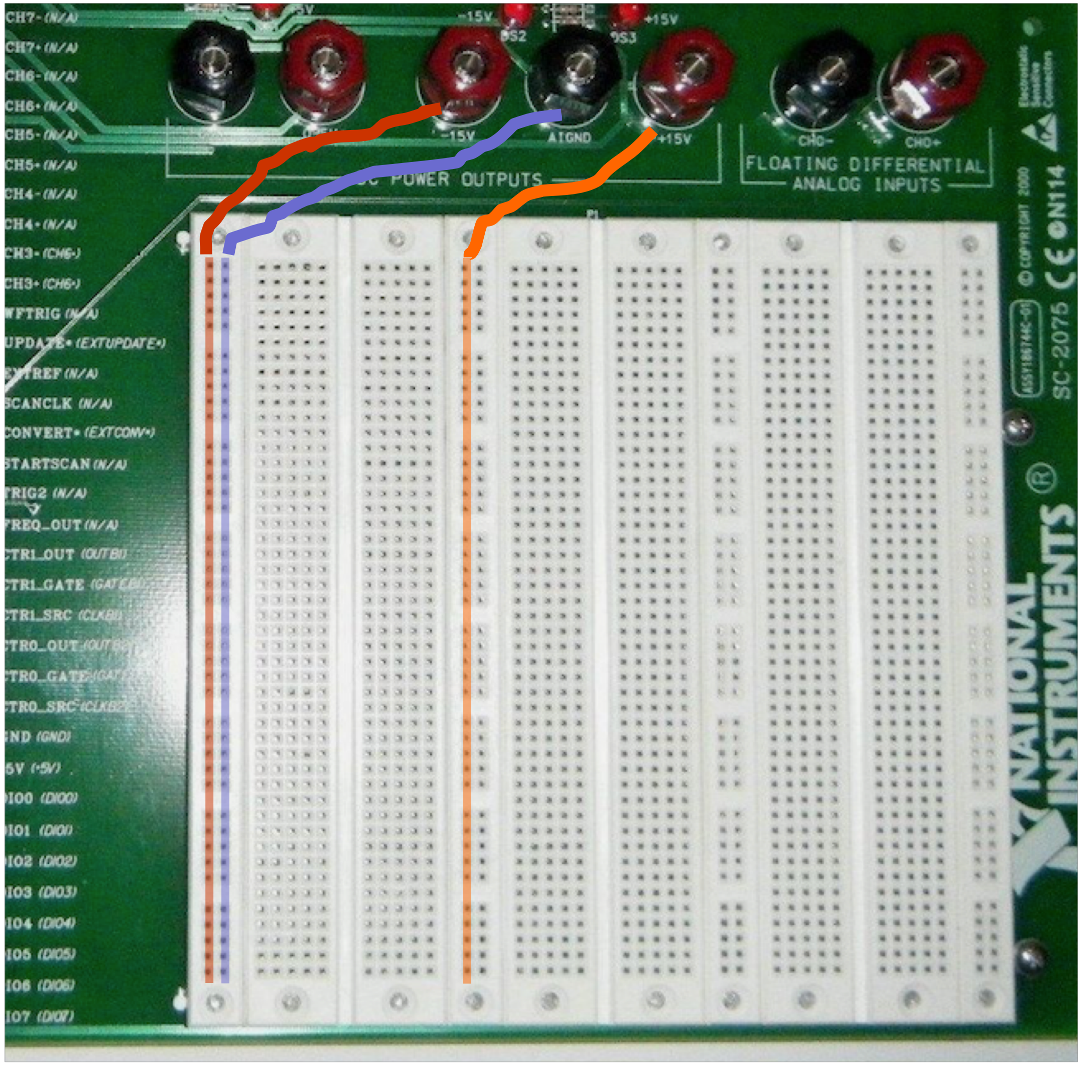
TL081 – 4 leads on the left, 4 on the right side of the package

Suggestions on how to build the circuit

Use the red column to distribute the -15 V power supply

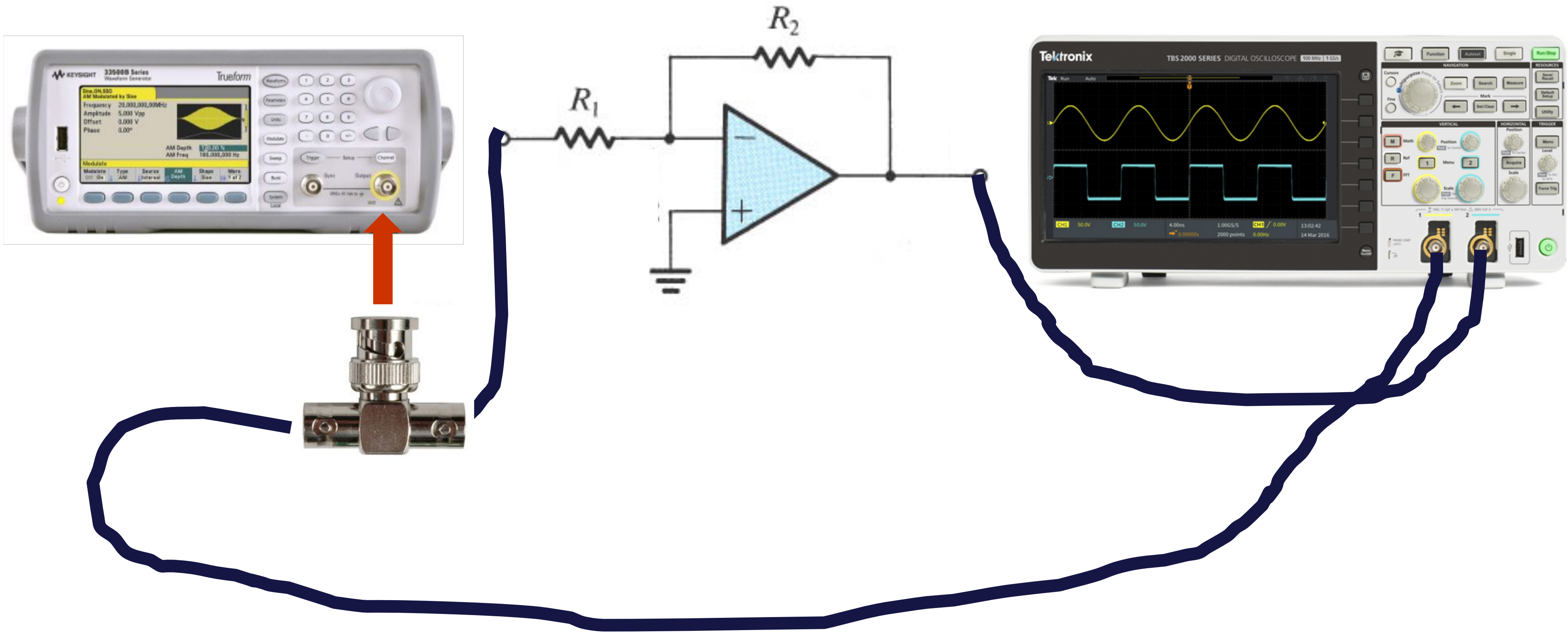
Use the purple column to distribute ground

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



Remember: all of the holes in each of the three columns are short circuited → 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

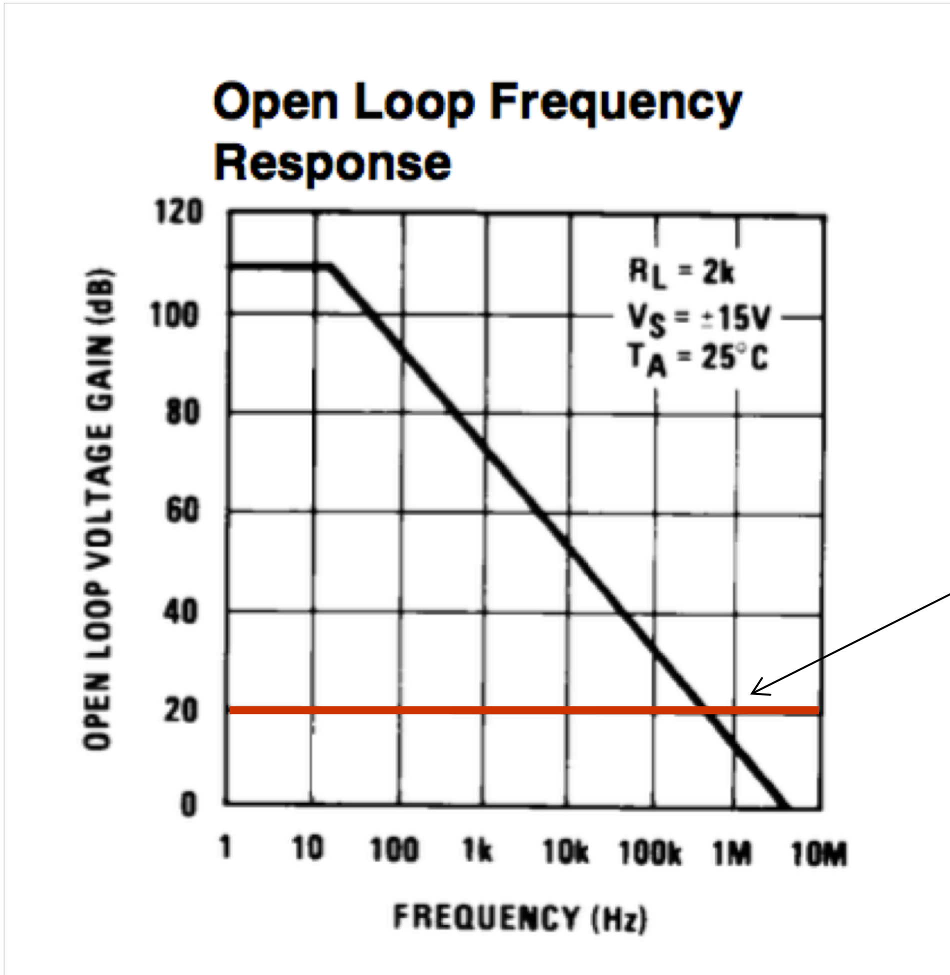
Setup for measuring the time response of the circuit



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?

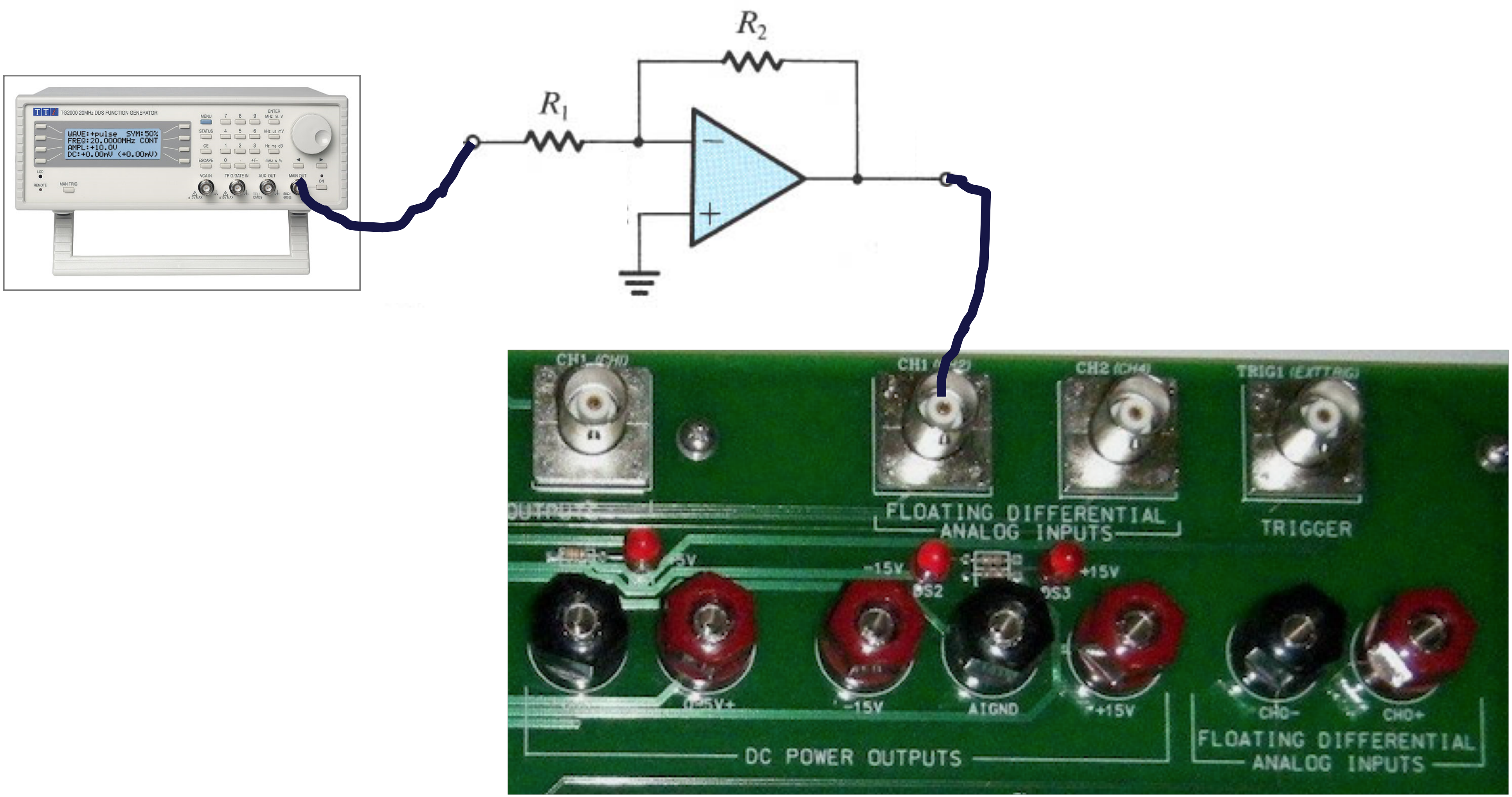
Open loop gain of the TL081 op amp



Remember that the gain-bandwidth product is conserved → 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

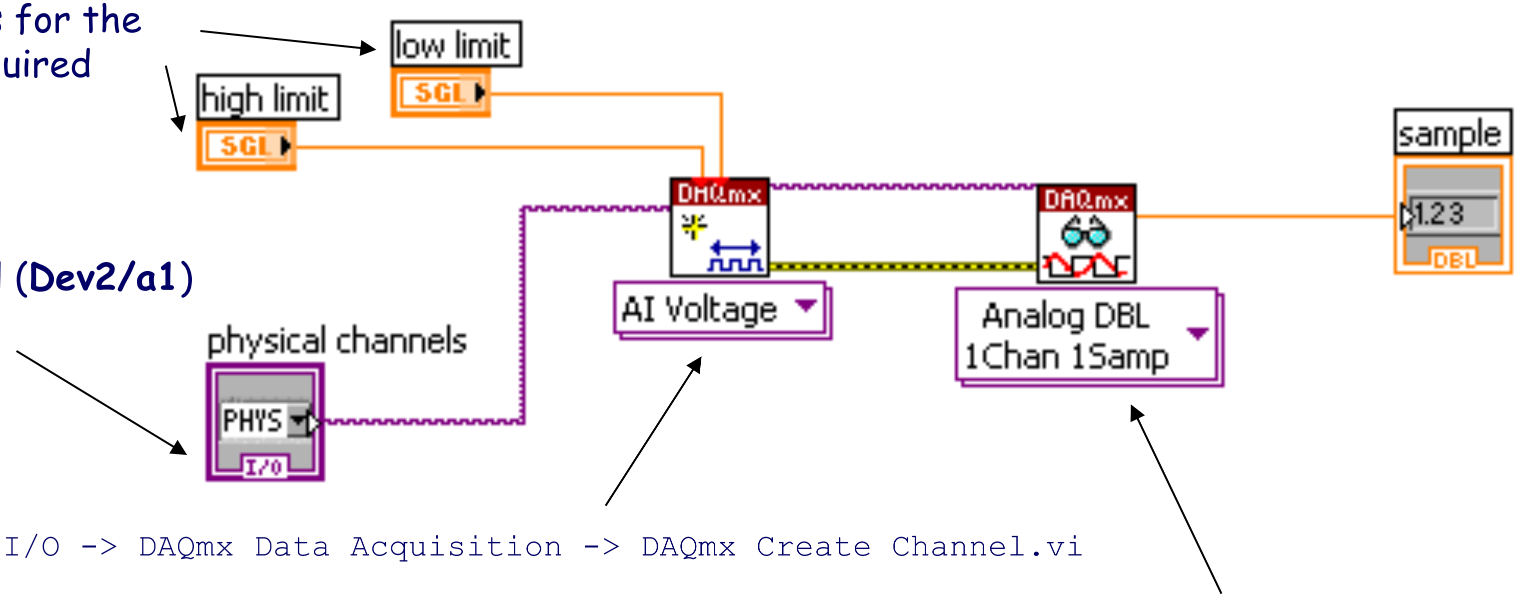


DAQmx Create Channel.vi and DAQmx Read.vi

- 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

expected limits for the signal to be acquired

input channel (**Dev2/a1**)

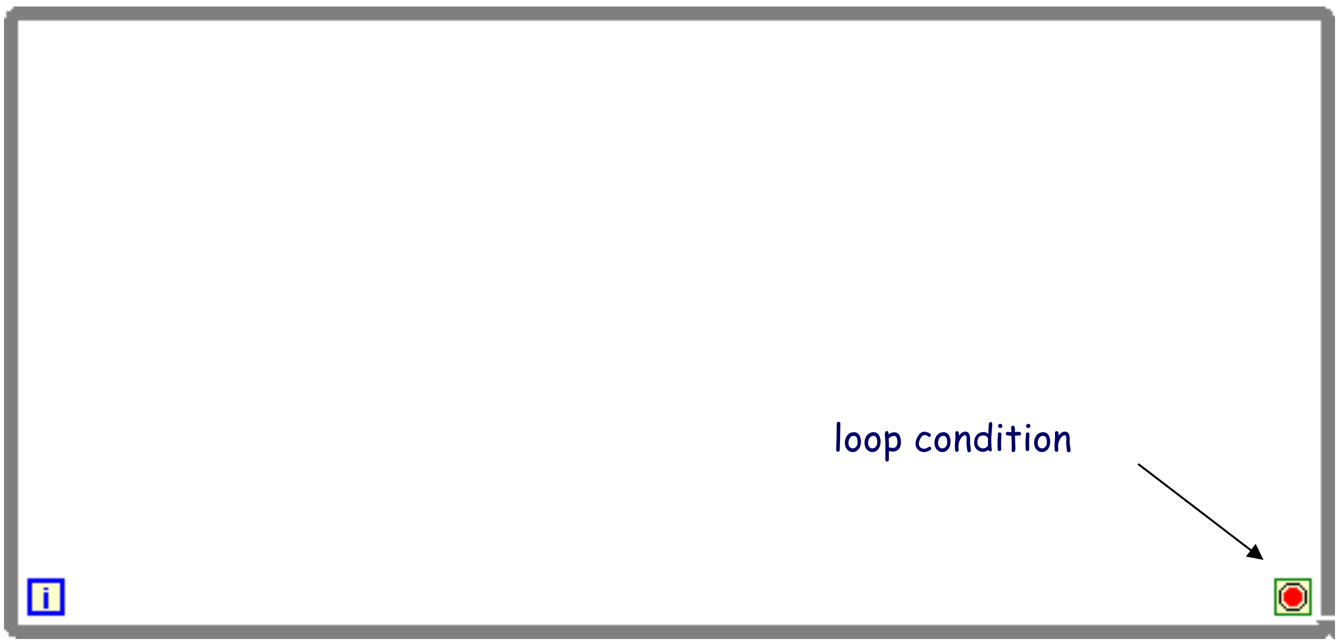


Measurement I/O -> DAQmx Data Acquisition -> DAQmx Create Channel.vi

Measurement I/O -> DAQmx Data Acquisition -> DAQmx Read.vi

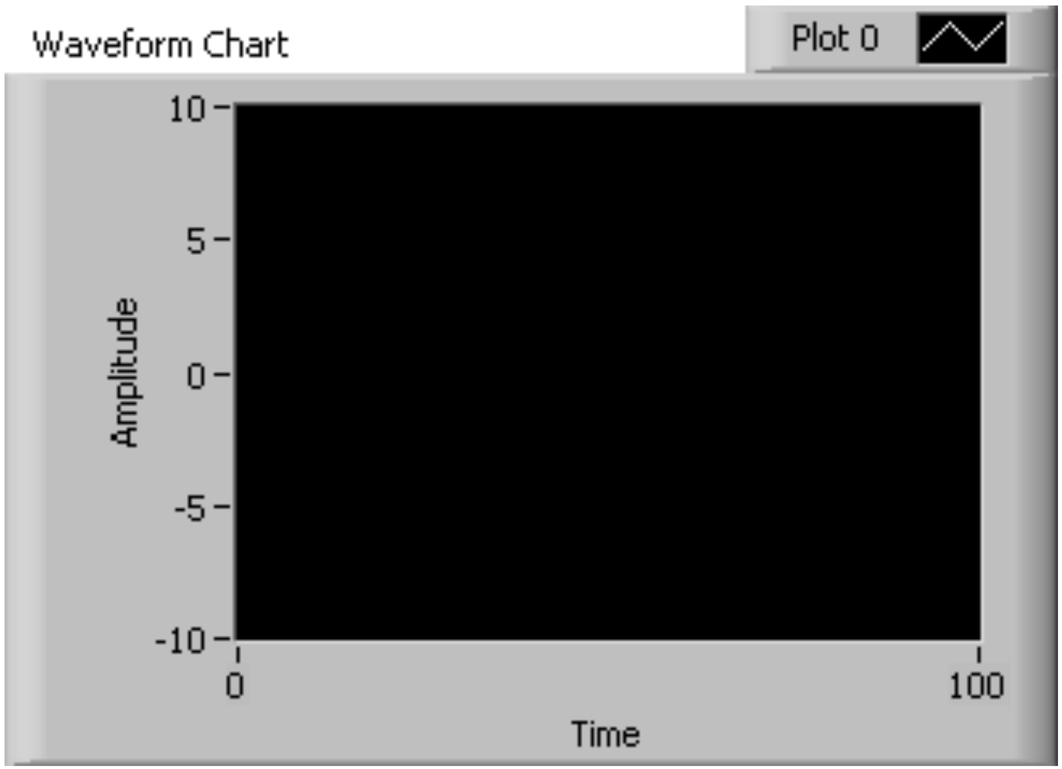
While loop

- 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_{rms}x sqrt(2))