

ELE2EMI 2007

Laboratory 2: Interfacing Techniques

July 30, 2007

1 Components and Equipment

1. Stationery
2. Breadboard
3. Op-amp (e.g. LM 324 or LM 741)
4. $2 \times 560 \Omega$ resistors
5. $1 \text{ M}\Omega$ resistor
6. AC signal generator
7. Oscilloscope
8. 5V dc supply
9. Leads
10. Single strand hookup wire

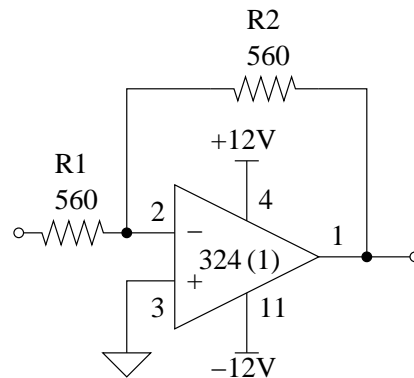
2 Experiment

We saw in the laboratory on Meter Insertion Errors that instruments for voltage measurement have finite input impedance and therefore cause **loading**, that is they draw current from voltage sources. Since real voltage sources have nonzero output impedance, their output voltage is decreased when they are loaded.

2.1 Loading of Signal Generator by Amplifier

Switch on the signal generator. **Measure** its output voltage; **adjust** it to be 1 Volt peak-to-peak.

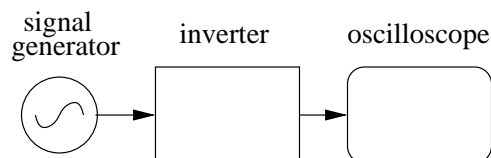
Build this inverter:



Calculate the expected gain of this inverter, in sign and magnitude.

Expected Gain of Inverter

Connect the inverter to the signal generator, then connect the oscilloscope to the inverter's output.



Measure the output voltage of the inverter. **Calculate** the gain of the inverter, both magnitude and sign.

Input Voltage	Output Voltage	Gain (V/V)
1Vp-p		

Is the gain what you were expecting?

Measure the voltage of the signal generator with the inverter still attached, and **recalculate** the gain of the inverter.

Sig. Gen. Voltage	Inverter Output Voltage	Gain (V/V)

The *signal generator's voltage* has decreased, because the *inverter* has **loaded** it down. If the signal generator were an ideal voltage source, it would have zero output impedance, but it hasn't. Find out what the output impedance of the signal generator is, and **record** it here:

Z_o (sig. gen.)

Despite the nonzero signal generator output impedance, loading still wouldn't occur *if* the inverter had infinite input impedance, but it has $560\ \Omega$ instead. This is in series with the signal generator's output impedance, so they combine by addition.

Draw a complete diagram of the effective circuit: it includes an ideal oscillator (representing the AC voltage source of the signal generator) and a modified representation of the inverter with the $560\ \Omega$ replaced by the combined resistance.

You can sketch the circuit diagram here.

What is the value of the ideal AC voltage source in the diagram above? **Why?**

Calculate the expected gain of the inverter in this circuit.

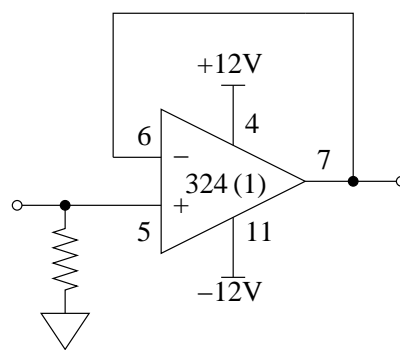
Ideal AC Source Voltage	Expected Gain of Inverter	Expected Output Voltage of Inverter

Compare this new expected output voltage with the measurement you took earlier.

LEAVE THIS CIRCUIT INTACT FOR USE IN THE NEXT SECTION!

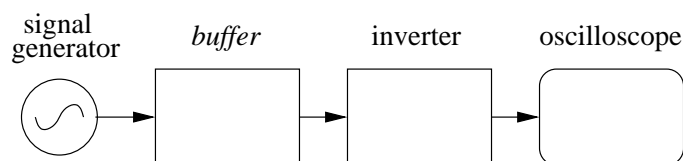
2.2 Buffering

The above investigation shows that joining non-ideal circuits causes loading. We can salvage the situation by intervening with a nearly ideal circuit (a kind of ‘adaptor’ if you like). Between voltage sources and voltage-input loads we can place a **unit gain buffer**.



The principle of the buffer is that it has a large input resistance so it won't load the signal generator, and a small output resistance so it can drive low resistance loads. We use the buffer to **isolate** the signal generator from the inverter.

Incorporate the unit gain buffer into your existing circuit, in accordance with this block diagram.



Temporarily **separate** the signal generator, and **remeasure** its (unloaded) AC voltage. **Make sure** it's **1Vp-p**.

Connect the signal generator to the input of the buffer. **Measure** the voltage at the *buffer's* input, *buffer's* output, and *inverter's* output. Calculate the gain of the overall

circuit as the ratio of inverter output voltage to the 1Vp-p unloaded signal generator voltage.

Unloaded Sig. Gen. Voltage	Buffer Input	Buffer output	Inverter Output	Overall Gain (V/V)
1Vp-p				

Compare this measured gain to the original expected gain of the inverter.

VERY IMPORTANT: LEAVE THIS CIRCUIT INTACT FOR LATER USE!