UNIVERSITY OF LOUISIANA AT LAFAYETTE

MEASUREMENTS AND INSTRUMENTATION

MCHE 357

Lab 3

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Contents

List of Figures

List of Symbols

V_o = Output Voltage (Volts)
V_i = Input Voltage (Volts)
R_1 = Input Resistance (Ohms)
R_2 = Output Resistance (Ohms)
Ω = Ohms

Introduction

This lab was conducted by utilizing Multisim in order to analyze operational amplifiers, or op amps. The types of op arm configurations analyzed are the inverting, non-inverting, and follower configurations. These devices were then created in the lab physically, and theoretical calculated output voltages were compared to the voltages measured.

Theory

An op amp utilizes an amplifier with input and output resistors in order to change the input signal by a factor, called gain. An inverting amplifier changes the input signal?s sign, as well as scales the signal by the gain. The equation for an inverting amplifier?s gain is shown in Equation 1. The sign of a signal can be changed if desired without altering the signal voltage by running the signal through an inverting amp with a gain of 1.

A non-inverting amplifier does not change the sign of a signal, but does scale the signal by the gain. The gain equation for a non-inverting amplifier is shown in Equation 2. A non-inverting amplifier can be turned into a follower by shorting the output resistor, which results in the gain of the amplifier being 1. While the voltage supplied to any subsequent devices in the circuit is unchanged, a follower will isolate these devices by acting as a signal buffer. Notice that by setting the resistor R2 = 0, the gain is 1, as discussed above.

$$\frac{V_o}{V_i} = -\frac{R_2}{R_1} \tag{1}$$

$$\frac{V_o}{V_i} = 1 + \frac{R_2}{R_1} \tag{2}$$

Procedure & Analysis

First, an inverting amplifier was created in Multisim with $R_1 = 1M\Omega$ and $R_2 = 1k\Omega$, resulting in a gain of -0.002 by Equation 1. This can be seen in Figure 1. Note that the output voltage is as expected by solving for V_o in Equation 1. A non-inverting amplifier was then created with $R_1 = 1k\Omega$ and $R_2 = 2k\Omega$, resulting in a gain of 3 by Equation 2. The output voltage is again as expected by solving for V_o in Equation 2.

The non-inverting amplifier is then changed to a follower by shorting R_2, shown in Figure 3. Note that the gain is simply 1, as discussed in the Theory section.

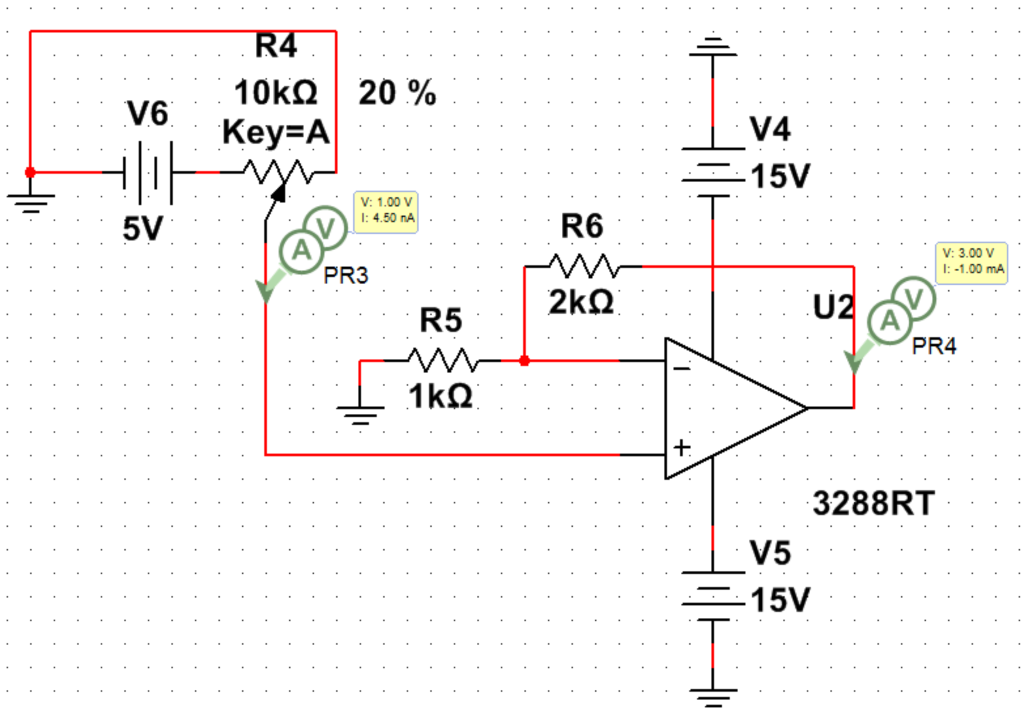


Figure 1: Non-Inverting Amplifier (Multisim)

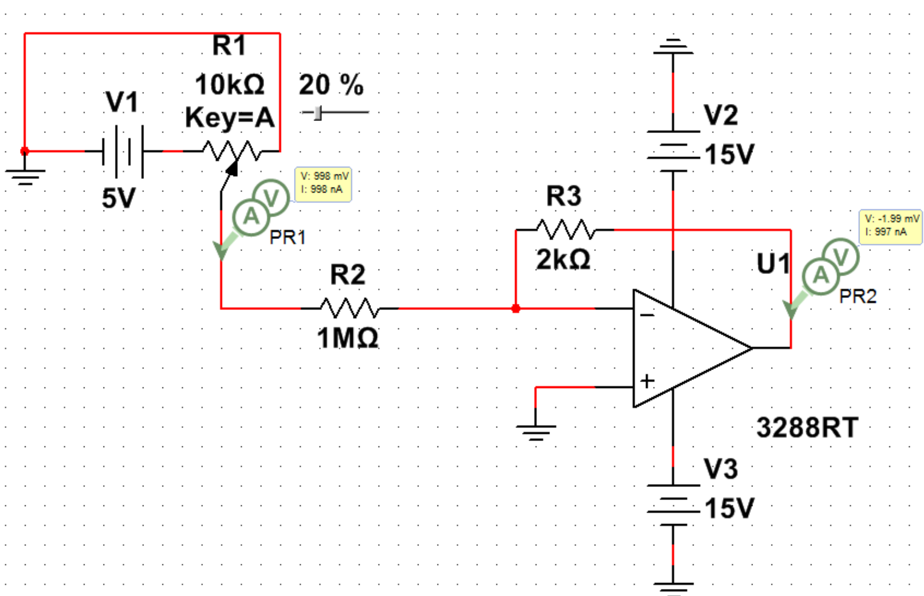


Figure 2: Inverting Amplifier (Multisim)

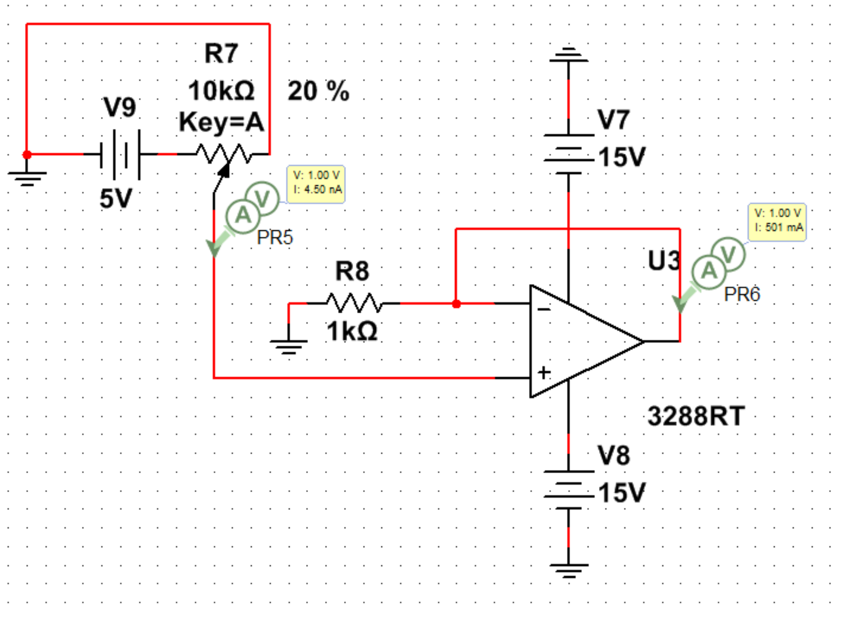


Figure 3: Follower Device (Signal Buffer) (Multisim)

These circuits were then recreated physically in the lab. The input voltage to the circuit was measured and tabulated, as well as the resistances R_1 and R_2. The gain for each circuit was calculated using the nominal and measured resistance values with Equations 1 and 2. The predicted output voltages were also calculated using Equations 1 and 2. The physical implementations of the inverting, non-inverting, and follower circuits can be seen in Figures 4 - 6. The tabulated and calculated data is shown in Figure 7.

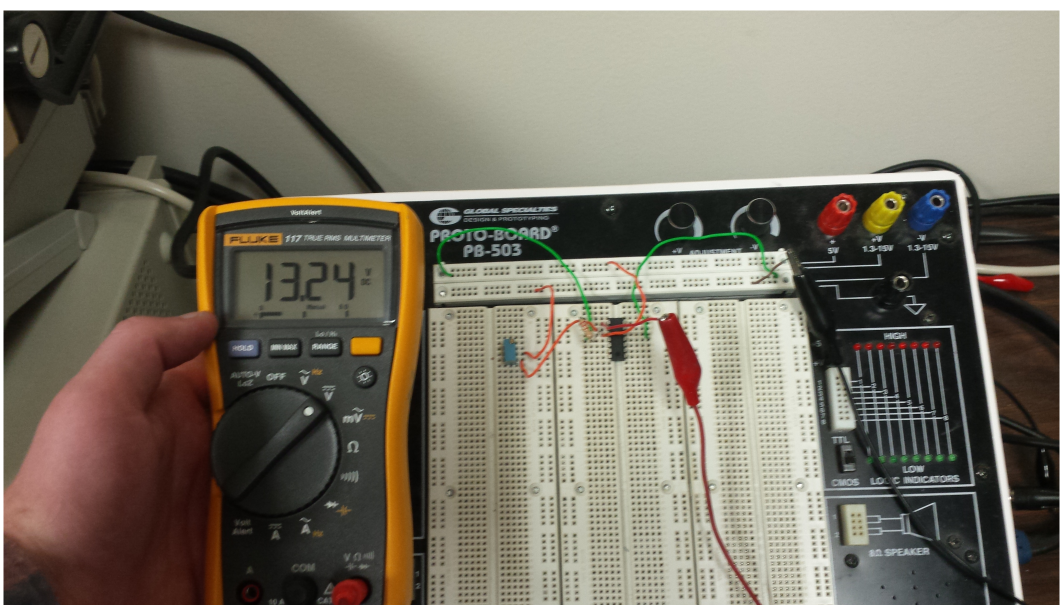


Figure 4: Non-Inverting Amplifier (Physical)

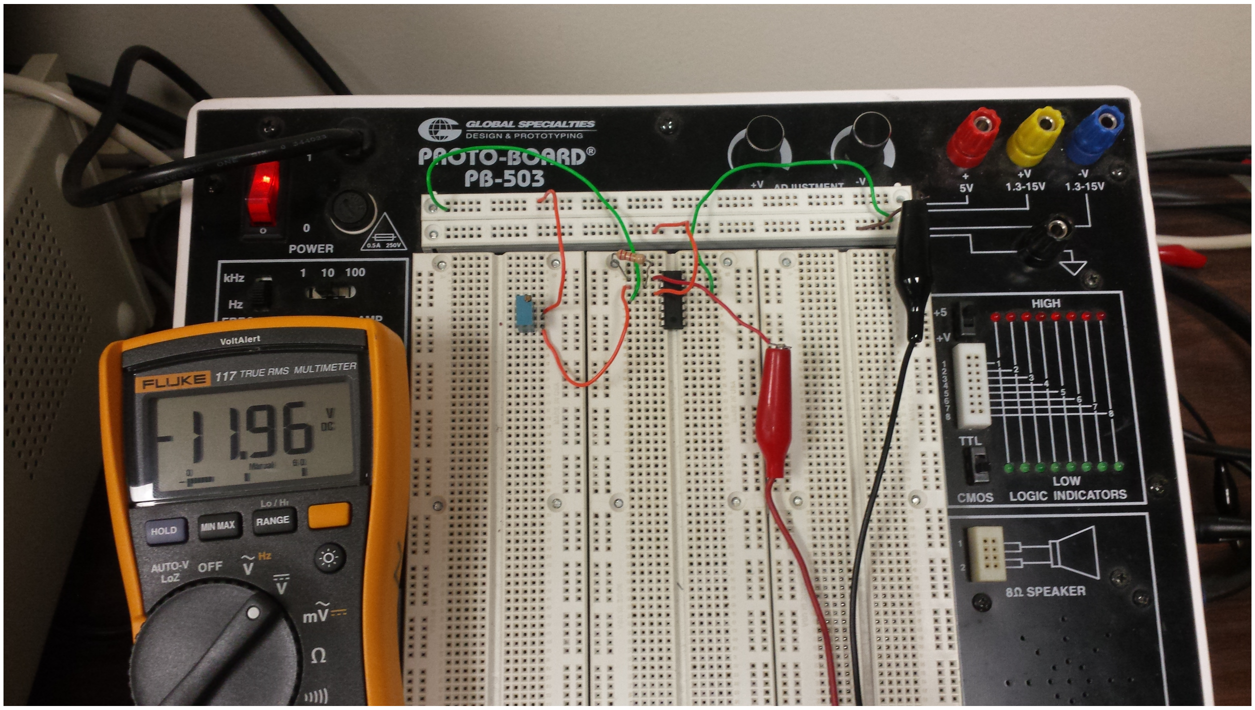


Figure 5: Inverting Amplifier (Physical)

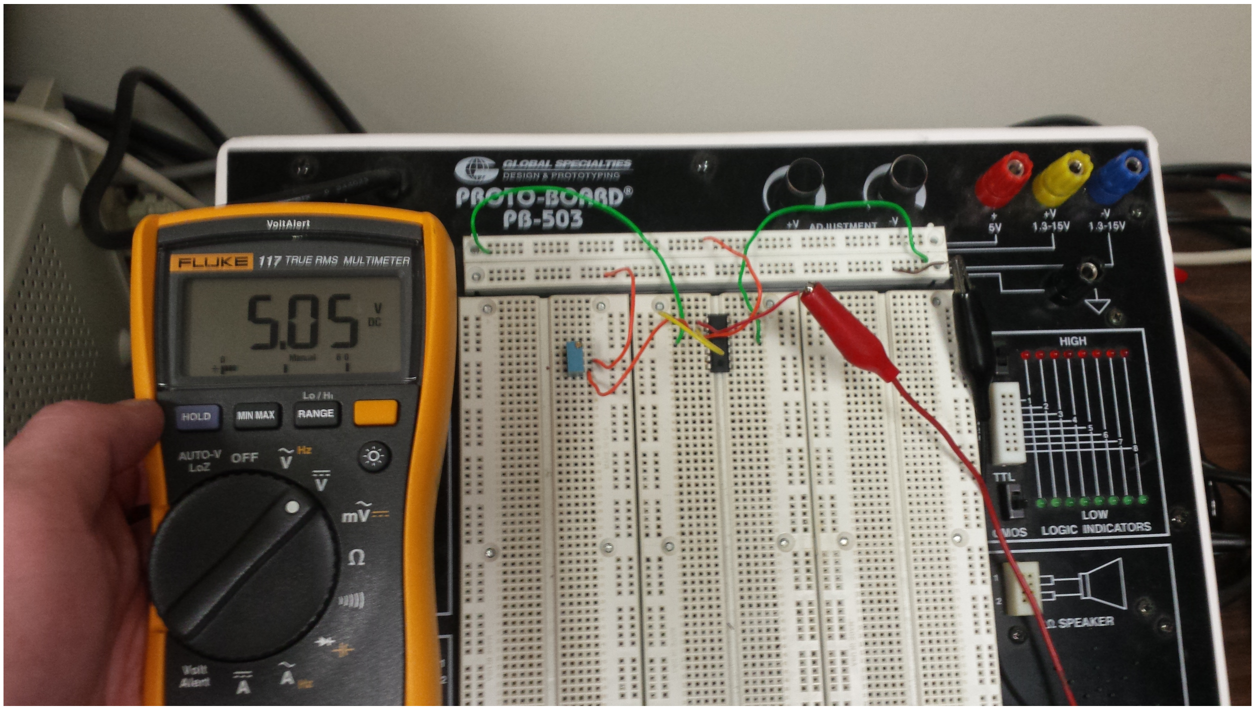
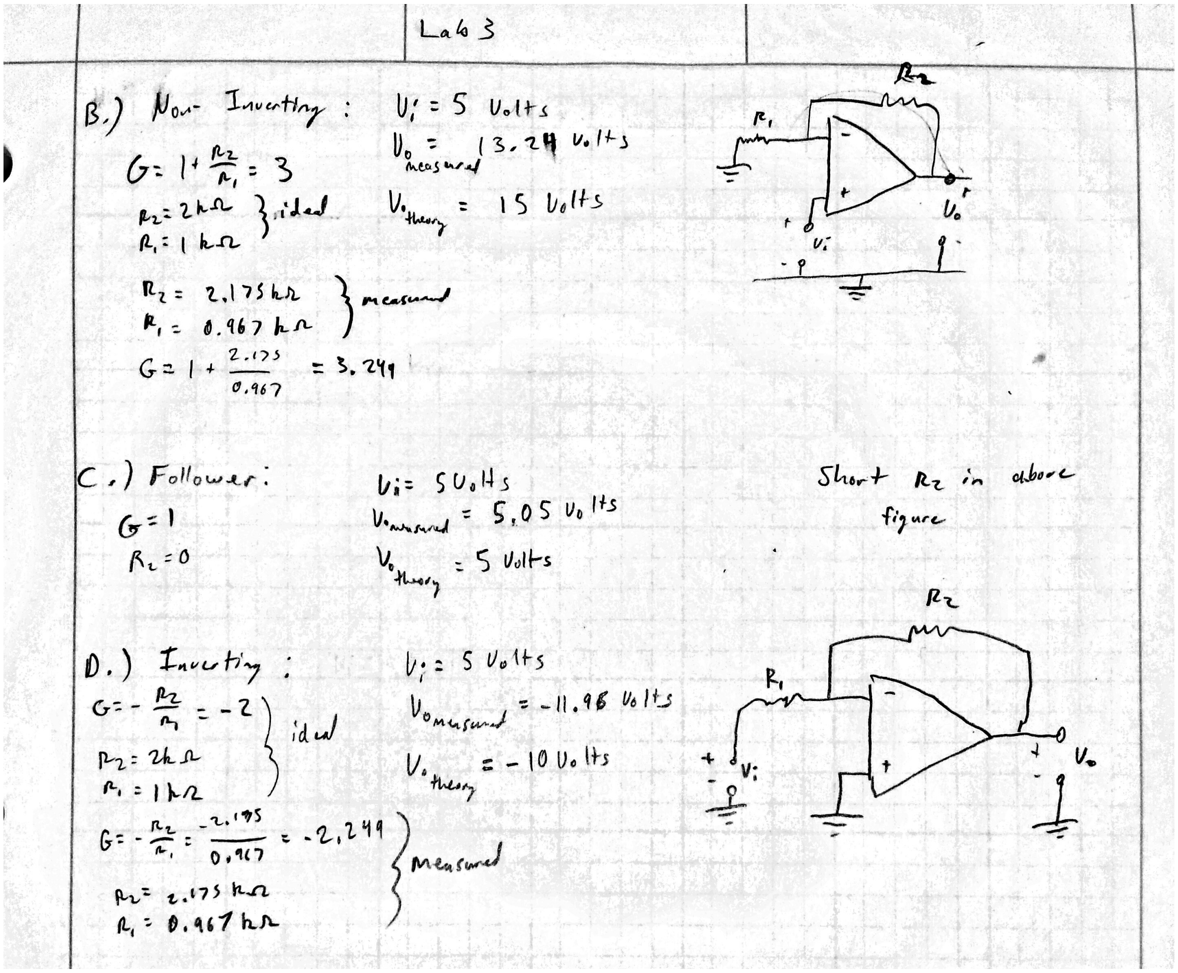


Figure 6: Follower Device (Signal Buffer) (Physical)



Lab 3

B.) Non-Inverting:

$G = 1 + \frac{R_2}{R_1} = 3$

$R_2 = 2k\Omega$
$R_1 = 1k\Omega$ } ideal

$R_2 = 2.175 k\Omega$
$R_1 = 0.967 k\Omega$ } measured

$G = 1 + \frac{2.175}{0.967} = 3.249$

$V_i = 5$ Volts

$V_{o_{measured}} = 13.24$ Volts

$V_{o_{theory}} = 15$ Volts

C.) Follower:

$G = 1$

$R_2 = 0$

$V_i = 5$ Volts

$V_{o_{measured}} = 5.05$ Volts

$V_{o_{theory}} = 5$ Volts

Short R_2 in above figure

D.) Inverting:

$G = -\frac{R_2}{R_1} = -2$

$R_2 = 2k\Omega$
$R_1 = 1k\Omega$ } ideal

$G = -\frac{R_2}{R_1} = \frac{-2.175}{0.967} = -2.249$

$R_2 = 2.175 k\Omega$
$R_1 = 0.967 k\Omega$ } measured

$V_i = 5$ Volts

$V_{o_{measured}} = -11.96$ Volts

$V_{o_{theory}} = -10$ Volts

Figure 7: Tabulated Data & Calculations (Physical)

Conclusion

The exercises conducted in this lab reinforce the theory learned in the classroom. It is shown that electric circuits can be modeled and analyzed in Multisim. The circuits created in this lab are commonplace in electronic circuits, and the creation of these circuits in Multisim helps the student to further understand what is really happening in these circuits. The first hand experience physically building these circuits in the lab supplements the information previously learned about amplifiers, and is very beneficial.