Laboratory Project 1a: Pre-Amp Circuits

THE UNIVERSITY OF UTAH

***Abstract*-You will construct and test two LED power-indicator circuits and two pre-amp circuits that will be used later to amplify tiny voltages picked up by electrodes placed on the biceps muscle of the upper arm. The pre-amp circuits will output the same voltage they receive as input but with a higher current-driving capability. You will test the pre-amps with a function generator to verify that their output voltage is the same as their input voltage.**

I. Preparation

For Lab 1a, which will last about one week, you will need the parts listed in Table I. You may purchase these parts from the stockroom next to the lab or purchase them elsewhere.

TABLE I
Parts List

Item	Qnty	Description
1	1	Breadboard
2	1	Breadboard Wire Kit
3	2	1 kΩ Resistor
4	2	Red LED
5	1	Green LED
6	1	LF353 Operational Amplifier

II. Learning Objectives

1) Learn about Kirchhoff's Laws and Ohm's Law
2) Learn how to build and circuits: LED power indicators and pre-amps
3) Understand voltage dividers and output resistance

III. Introduction

In Lab 1 you will build an electromyogram circuit to measure the tiny voltages produced by muscles. The gross muscle groups (e.g., biceps) in the human body are composed of a large number of parallel fiber bundles functionally arranged into individual motor units. When each motor unit is activated by nerve commands (action potentials) from the central nervous system, electrical impulses propagate down the length of the fibers that make up the unit. The electrical impulses can be picked up by electrodes and converted to voltages. A plot of the voltages from the muscles is called an *electromyogram*, or EMG ("myo" is a root meaning "muscle"). Fig. 1 shows the system for measuring an EMG.

For the first part of Lab 1, which we call Lab 1a, you will be given fairly explicit directions describing how to build circuits that will be part of the final electromyogram circuit. For now, you are hooking up power indicators and amplifiers that will be connected to electrodes that you will put on your biceps later on

Your first task in Lab 1a is to build simple LED (Light Emitting Diode) circuits that indicate when power is on in your circuit. A red LED will light up when +12V is turned on, and a green LED will light up when −12V is turned on. These two voltages are needed for the pre-amps you will build this week. A power supply in the lab will produce the +12V and −12V power. The power supply is equivalent to two 12V batteries, such as those used in cameras. After constructing the LED circuits, you will make measurements to find current-versus-voltage characteristics of the LED's.

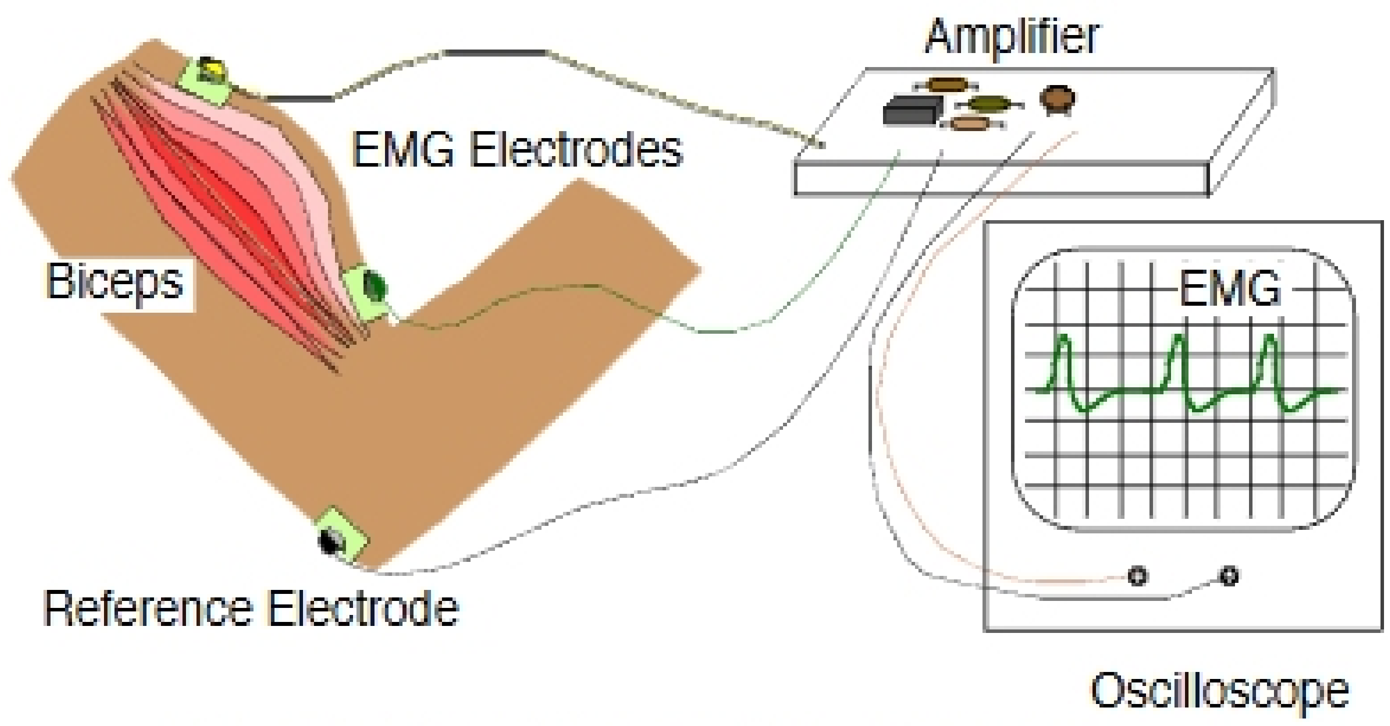


Figure 1. System for measuring an electromyogram.

In Lab 1a, you will also build and test amplifier circuits based on an op-amp (short for operational amplifier) integrated circuit (IC or "chip"). The op-amp IC comes in a small black plastic package with 8 pins. Inside the package are many transistors, which you will learn about in later courses. For Lab 1a, we may treat the op-amp as a basic circuit component whose function is to measure a voltage drop at its inputs and output a voltage that is about 100,000 (or 100k) times the input voltage drop. Fig. 2, below, illustrates the op-amp as it appears in a circuit diagram and how it is connected to the pins on the package. Note that the op-amp IC actually contains two op-amps, allowing us to build two amplifier circuits with one chip.

Just as cell phones and mp3 players require batteries, an op-amp requires power supplies. We connect +12V and −12V to the pins labeled V+ and V−, respectively. Power supplies in the lab can produce these voltages, allowing us to avoid wasting batteries.

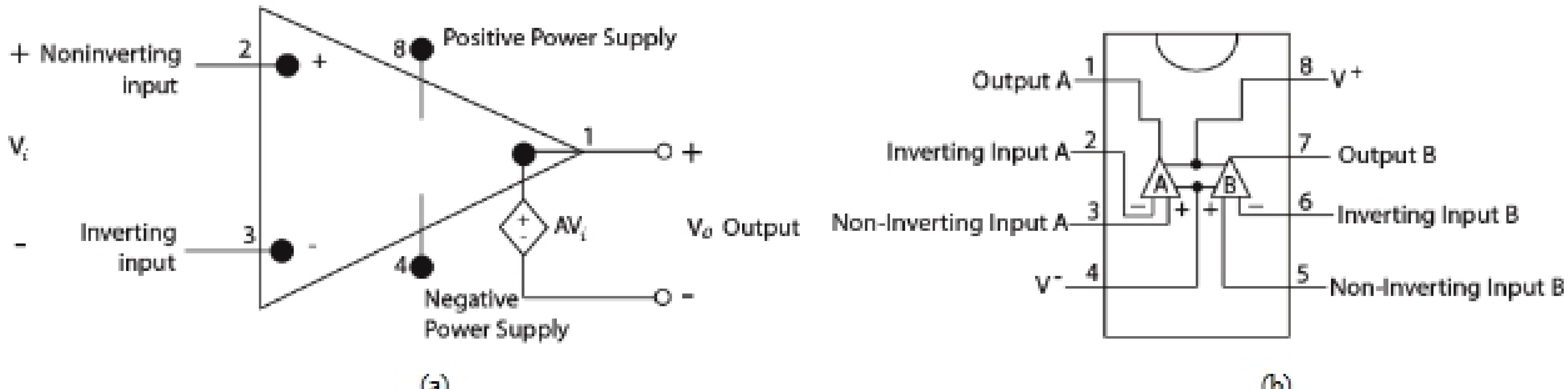
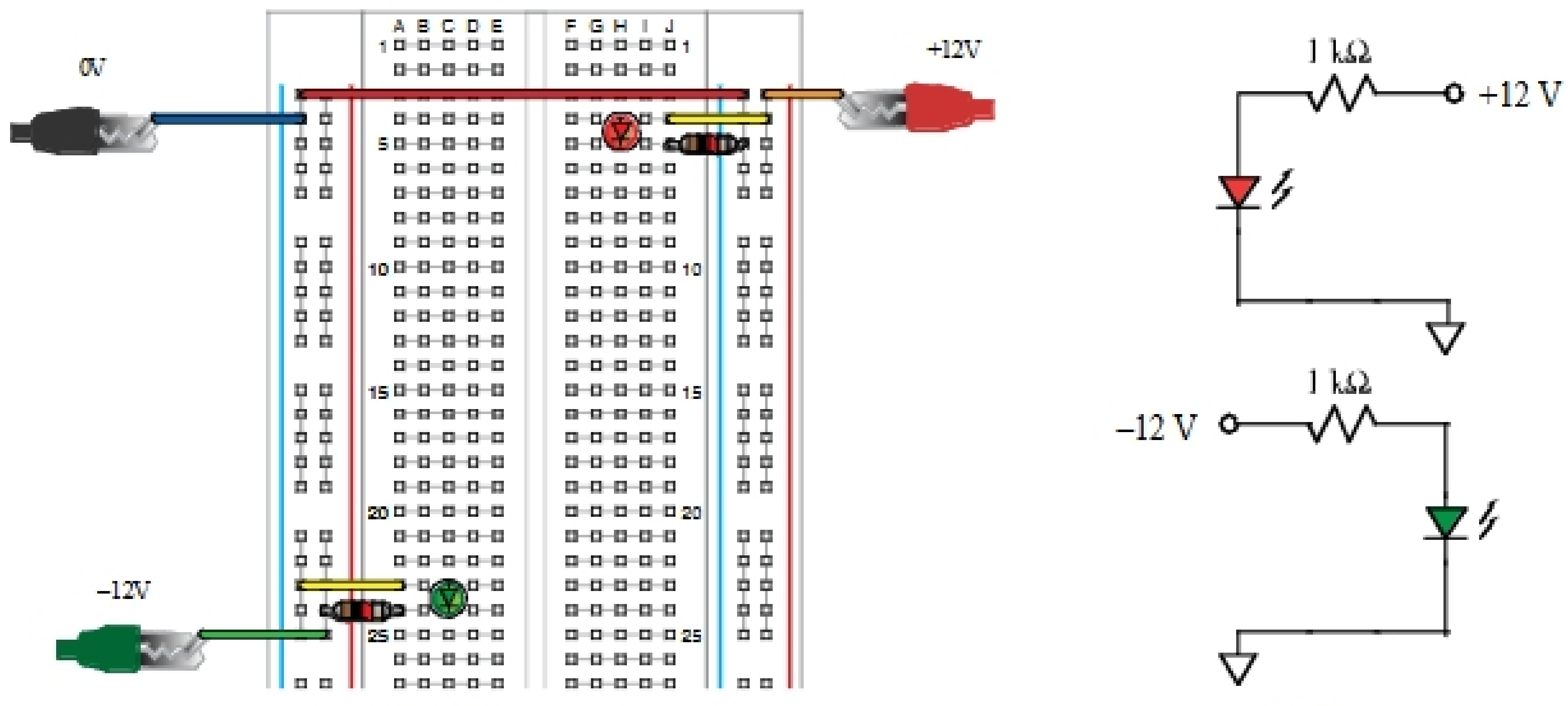


Figure 2. LF353 operational amplifier: (a) Model, (b) Pins on package.

IV. Construction of LED Power Indicators

Fig. 3a shows how to put the components on the breadboard to build the LED power indicators. The red circle in Fig. 3a is a red LED, and the green circle in Fig. 3b is a green LED. One side of the LED goes in row 4, and the other side of the LED goes in row 5. Also shown is a 1 kΩ resistor with brown, black, and red stripes. The wire colors indicate the lengths of wires using the same color code as resistors. Ignore the alligator clips at present; you will connect them after you build the circuit. Note that the breadboard has metal clips inside that connect certain holes to each other so that components inserted into those holes are automatically connected to one another. The gray line segments between holes in Fig. 3a show which holes are connected together. If you follow the wires, you can show that you obtain the schematic shown in Fig. 3b.

Build the circuit shown in Fig. 3a. You will connect power later.



(a) (b)

Figure 3. LED power indicator circuit.: (a) Breadboard layout, (b) Schematic diagram.

Fig. 4 shows how to hook up leads to the power supply. The power supply has so-called "banana plugs" to which cables with a banana plug at one end (and alligator clips at the other end) are connected. Whenever possible, we use certain cable colors to represent certain voltages. In the present case, we use red for +12V, black for 0V, and green for −12V. Unfortunately, the banana-plug cables in the lab are available only in red and black. Furthermore, the cables are in pairs connected with cable ties. The photo shows how one black cable lies unused on the left side, and a red cable is connected to a green alligator clip on the right side.

Before connecting the alligator clips to the breadboard circuit, turn on the power supply and adjust the outputs of the +25 V and −25 V supplies to +12 V and −12V. Note the power supply is equivalent to three adjustable batteries. One "battery" is adjustable from 0V to 6V, a second battery is adjustable from 0V to +25V, and a third battery is adjustable from 0V to −25V. (A negative voltage is the same as using a battery backwards.) To adjust the three different batteries, you must turn on the power supply output (using a button on the front panel) and then tell the power supply which voltage you wish to adjust. Press the button on the front panel corresponding to the voltage you wish to change, and you will see that the display shows that voltage. The gray knob and the > and < buttons below it allow you to adjust the output voltages. Adjust the +25 V and −25 V supplies to +12 V and −12V and turn the output off again. (Be sure the alligator clips for the outputs do not touch one another. If they touch, no harm will probably be done, but the output voltage will drop to zero and you will be unable to adjust the voltage as desired.)

Now connect the three alligator clips from the power supply to the breadboard as indicated in Fig. 3a and press the button on the power supply to turn on the +12V and −12V signals. If either of your LEDs fail to light, try reversing the direction of the LED in the circuit. If the LEDs still fail to light, use a voltmeter on the DCV setting to measure the voltages across pairs of power supply leads. You should get ±12V or ±24V, depending on which pair of power supply leads you measure. If this also fails, try disconnecting the power leads from your circuit and measuring again. If the voltages are now present, you have probably made a wiring mistake that shorted out the power. If so, look at your circuit very carefully and verify that it matches Fig. 3a exactly.

If you are still having trouble, consult with your TA to get more trouble-shooting tips.