Introduction

This subject places a particular emphasis on the practical, hands-on aspects of electronics. In-depth understanding and mastery of electronics can be gained by practicing the analysis, design, building and testing of some fundamental electronic circuits.

These laboratory experiments will help you acquire key testing, troubleshooting and measuring skills, vital for any electrical or electronic engineer.

The laboratory experiments concentrate on characteristics and applications of the basic circuit elements – voltage sources, current source, resistors, capacitors and inductors. The topics selected for the experiments are relevant not only for future electrical and electronic engineers, but also for information and communication technology engineers and mechatronic engineers, because the experiments refer to fundamental signal responses, devices and circuits used in all electronic systems.

Computer simulation of electronic devices and circuits can produce meaningful results only if the user is aware of the physical characteristics, limitations and real-life interactions of the devices and circuits the user is attempting to simulate. The lab experiments should give you a better understanding and knowledge of these characteristics, limitations and interactions.

We hope that you will enjoy the laboratory experience, and benefit from it for the entire duration of your professional life!

Layout Plan

a) Simplify the schematic and layout as much as possible for initial testing. Fine-tuning, zeroing, and additional stages can easily be added after you have the basic circuit working.

b) Be sure to include IC number, package type suffix, and pin numbers on each IC on the schematic diagram.

c) Make the layout look as much as possible like the schematic. Refer to the schematic whenever you debug your circuit.

d) Locate inputs, outputs and the circuit in general as physically close to the binding posts as possible. (Long leads, connecting to remotely located resistors, pick up noise. This noise is then coupled into the rest of the circuit.)

e) Keep the inputs well separated from the outputs.

Circuit Breadboarding I

Once a circuit has been designed, it must be tested. To do this quickly and reliably, a good breadboarding system is needed. It should allow for the easy interconnection and removal of integrated circuits (ICs), discrete components, power supplies, and test equipment. It is absolutely critical that connections between the breadboard, the components, the power supplies and the test equipment be mechanically and electrically sound. Most beginners spend more time running down poor or wrong breadboarding connections than they spend actually evaluating the circuit they have built. In this section you will find breadboarding hints that will help you minimize problems and errors in building your circuit for testing.

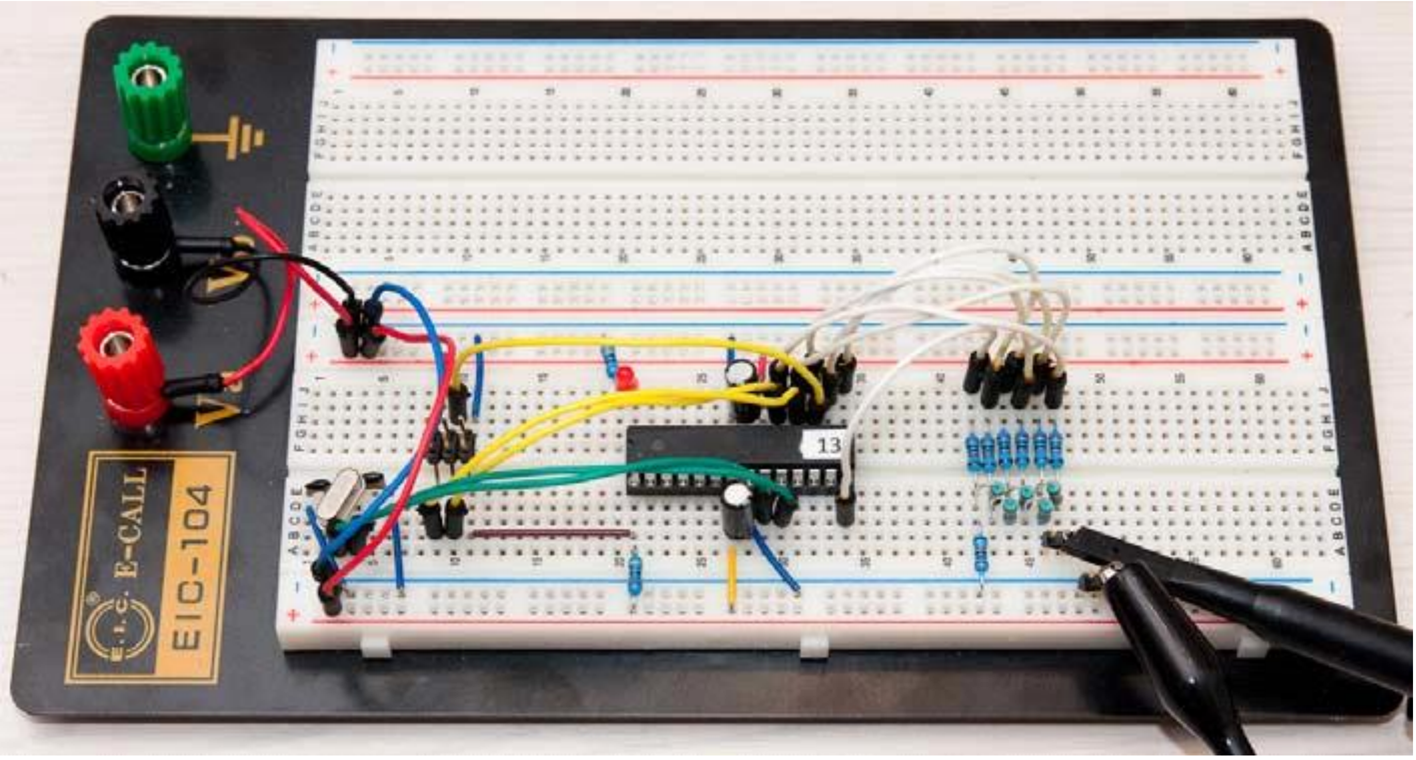

Figure 1 – Breadboard with ICs and other components inserted

The universal breadboard illustrated in Figure 1 provides a popular and convenient technique for circuit prototyping. Typically they give two to four busses (rails) for power supplies and ground, running along the edges. The body provides an array of solderless connections properly spaced and sized for most analog and digital ICs, transistors, diodes, small capacitors, 1/4 W resistors, and 22 AWG solid hook-up wire. Using it, you can construct circuits quickly, compactly, and reliably. These breadboards are available in a variety of styles and qualities from most electronic component suppliers.

Circuit Breadboarding II

The connection diagram of a typical breadboard is shown below:

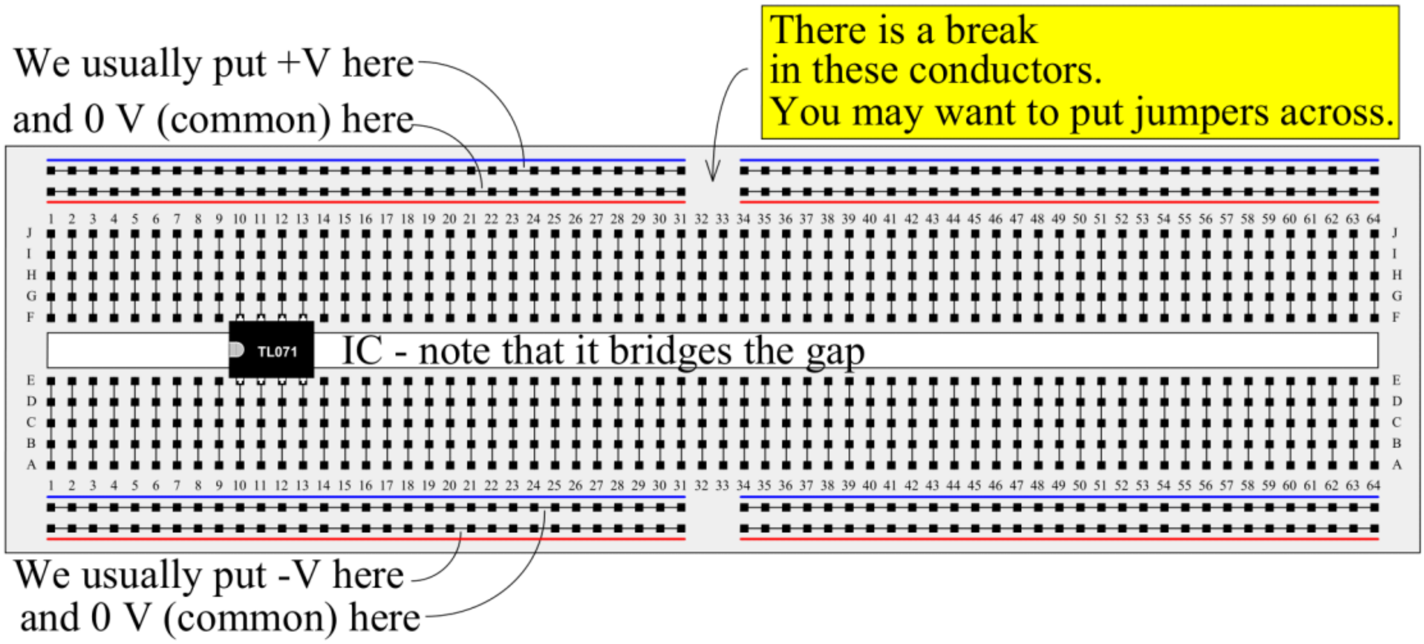

Figure 2 – Connection diagram of wire sockets (holes) on a breadboard

The breadboard consists of two regions – rows and columns:

- There are two sets of 64 columns each of 5 interconnected holes (A-E and F-J), to plug in components and connection wires.
- There are four sets of 2 rows each of 31 interconnected holes, called 'rails'. The two rails on each side are for connecting the power supply(ies). Typically, the rails are for the positive supply +V, the negative supply -V and for 0 V (common).

The universal breadboard provides a good interface between the components of the circuit, but care must be taken when you connect it to power supplies and test equipment. The breadboard is usually mounted on some larger, sturdier base (an aluminium plate).

Just as a chain is only as good as its weakest link, test equipment can perform no better than the technique used to connect it to the circuit under test. Excellent standard leads supplied with banana plugs, BNC connectors, or probes are common. Use them.

Hours of careful design and breadboarding can literally go up in smoke because of a shorted or open wire to a power supply or from two alligator clips which accidentally touch, or jump off at just the wrong time. Alligator clips are a major source of trouble. They are often too large for use on a breadboard, short together, or fail to hold adequately.

Instead of connecting test equipment to the breadboard with alligator clips, we use binding posts (that have a socket for 4mm banana plugs) mounted on the side of the base plate. There are 5 binding posts: three for a dual power supply: +V, 0 (common) and –V, and the other two for the input and output signals.

Connect signals and supply sources from the test instrument to the breadboarding system, and from breadboard to instruments using standard leads with 4mm banana plugs. Then wire from the binding posts to the breadboard with 22 AWG wire, inserting the wire into the desired connector. This technique will provide an electrically and mechanically sound and professional way to build circuits, eliminating the cause of most breadboarding headaches - bad connections.

Use only standard connectors to connect test equipment to the breadboard. Never use alligator clips.

Circuit Breadboarding III

Find a suitable box to contain the breadboard with its base and the components you have plugged into it, to enable you to carry the breadboard around from home to the Lab without unplugging components and disturbing the assembled circuit.

An example of a properly assembled breadboard is shown below:

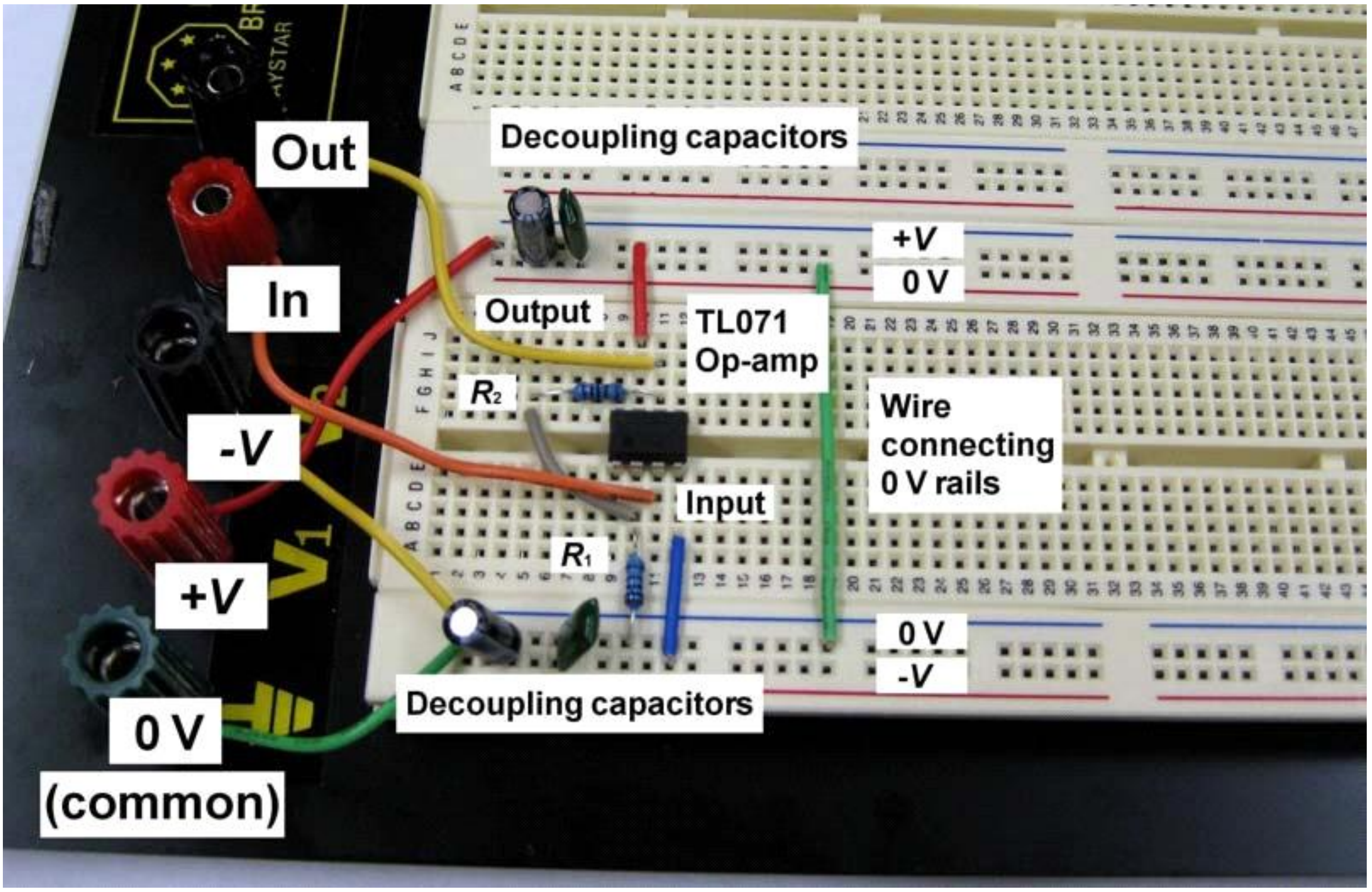

Figure 3 – Neatly and correctly assembled circuit on breadboard

Observe the upper and lower ground rails are interconnected with a wire strap.

Probes must also be used carefully. It is far too easy, when you are trying to touch a pin on an IC, for the probe to slip between two pins, shorting them together. This could damage the IC or supporting equipment. Instead of probing IC pins directly, you should connect a wire from the point you want to probe to a vacant part of the socket, where it can be secured and safely probed.

Never probe IC pins directly.

Circuit Construction

a) Always clear the breadboard of any old circuits before beginning to build a new circuit.

b) Solder 22 A WG solid wire to the leads of components with large leads.

c) Devise and carefully follow a colour code scheme for +V, -V, 0 V (common) and signal wires. The usual colour code is:

RED:	+V
BLACK:	-V
GREEN:	0 and/or EARTH

d) Avoid jungles. Make all components lie flat. Trim and bend leads and wires to fit the layout. Neat, flat layouts work better and are far easier to troubleshoot than a jungle of components and wires.

e) Select one connector as the common point. Tie the breadboard's 0 V rail, power supply common, and all test instruments' earths to that single point.

Circuit Testing

a) Analyse the circuit before applying power to ensure that you know what to expect.

b) Double check all connections, especially power supply connections, before applying power.

c) Measure voltages with respect to circuit “common”. If you need the difference in voltage between two points, measure each with respect to common and then subtract. The common terminal of some instruments (particularly the oscilloscope) may be tied to earth and may "short out" some part of your circuit if placed at a node other than the circuit "common".

d) When using the oscilloscope to measure voltages, be aware that the accuracy of an oscilloscope, as a voltmeter, is of the order of 3%.

e) To measure voltages accurately (better than 0.5% accuracy) use the Digital Multimeter. When measuring AC voltages with the Digital Multimeter, make sure that the frequency of the signal you are measuring is within the limits specified for your Digital Multimeter.

f) Unless a suitable ammeter is available, measure current by determining the voltage across a known resistor. Then calculate the current. Ammeters are rarely sensitive enough, tend to load the circuit, and often inject noise into sensitive nodes.

g) Change components and connections with the power off.

Connecting Laboratory Power Supplies I

Most regulated DC power supplies used in the laboratories usually contain *two separate, adjustable DC power supplies, isolated from one another* and *'floating'*, i.e., *not connected to earth*. This is shown below:

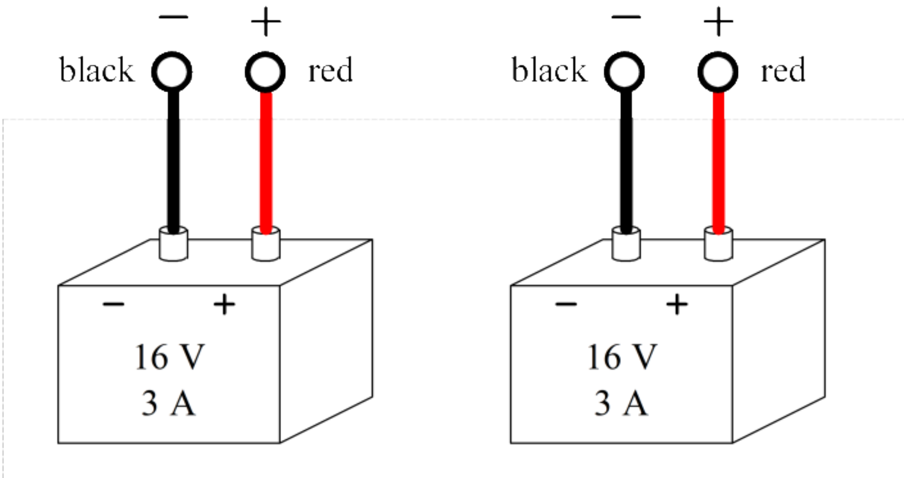

Figure 4 – Dual Independent Power Supplies

Series Connection

The *Siglent SPD3303C Series Programmable DC Power Supply* used in the Lab can be placed in a mode called *Series* in which the previously independent power supplies are internally connected in series and effectively have one common terminal, as shown below:

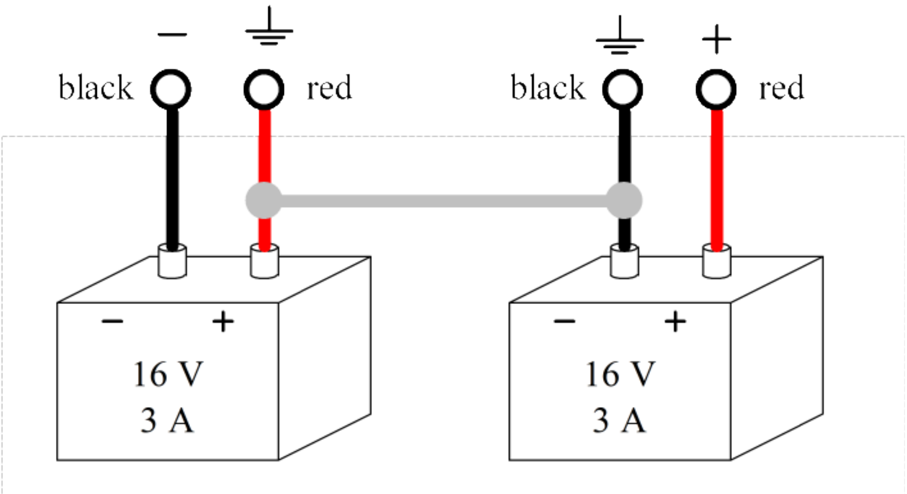

Figure 5 – Series-Connected Dual Power Supply

Connecting Laboratory Power Supplies II

There is also a third, switchable 2.5 V / 3.3 V / 5.0 V DC power supply, intended specifically for digital circuits. The Programmable DC Power Supply therefore looks like:

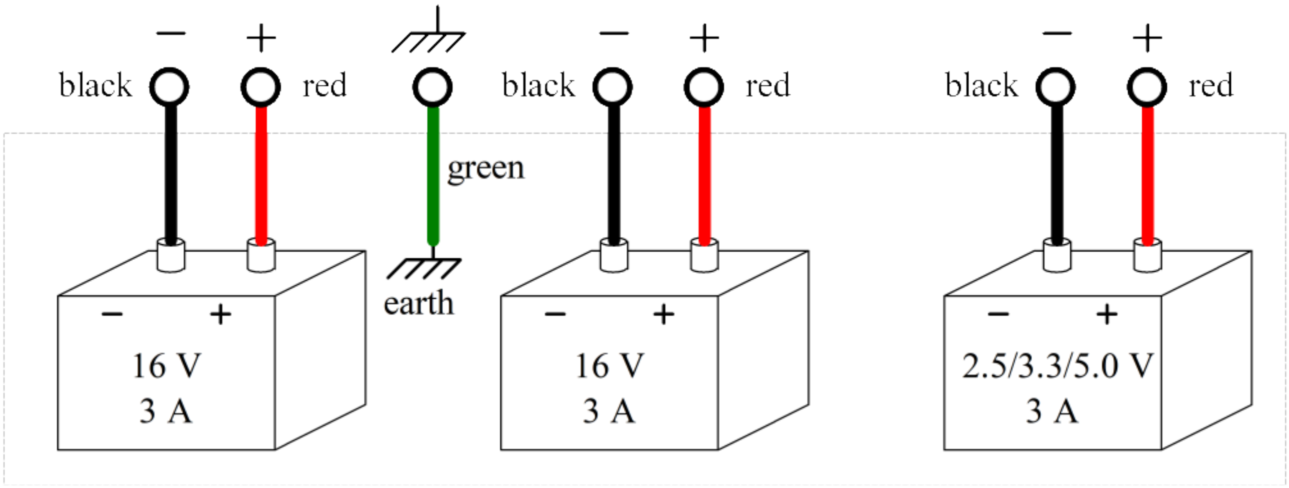

Figure 6 – Triple Independent Power Supply

For laboratory experiments, ***the 0 V "common" (wherever you decide that to be) must be connected to earth***. Otherwise, the 'floating' supplies might pick up stray DC or AC voltages that could endanger the circuit you are studying, or yourself. For example:

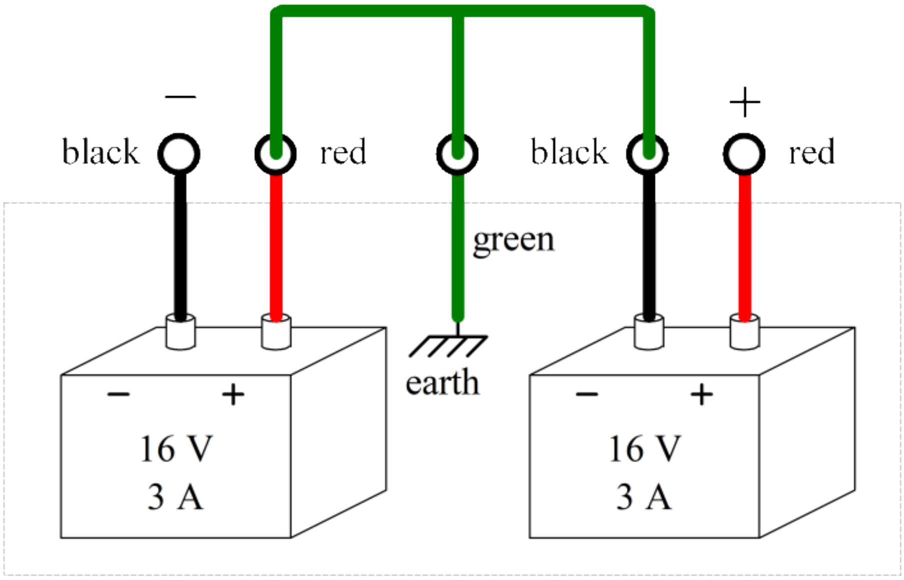

Figure 7 – Dual Power Supply with Earth

Equipment

The following four items can be found on the bench of each workstation in the laboratory environment.

Siglent SPD3303C Series Programmable DC Power Supply

Website:

https://www.siglent.eu/spd3303c-0-30v-0-3amp.html

Documentation:

http://www.siglentamerica.com/USA_website_2014/Documents/QuickStart/SPD3303C_QuickStart.pdf
http://www.siglent.com/2014EnglishWebsite/Documents/Datasheet/SPD3303C_Data%20Sheet_QS0503C-E01A.pdf

Siglent SDG1000 Series Function/Arbitrary Waveform Generators

Website:

http://www.siglent.com/ENs/generator/SDG1000

Documentation:

http://www.siglent.com/Uploadfile/file/20140925/SDG1000_QuickStart_QS02010-E02A.pdf
http://siglentna.com/wp-content/uploads/dlm_uploads/2017/10/SDG1000_DataSheet_DS02010-E08A.pdf
http://siglentna.com/wp-content/uploads/dlm_uploads/2017/10/SDG1000_UserManual_UM02010-E08B.pdf

Siglent SDM3045X Digital Multimeter

Website:

http://www.siglent.com/ENs/pdxx.aspx?id=1567&tid=37&T=2

Documentation:

http://www.siglentamerica.com/USA_website_2014/Documents/DataSheet/SDM3045x_QuickStart_QS06034-E01A.pdf
http://www.siglentamerica.com/USA_website_2014/Documents/DataSheet/SDM3045X_Datasheet_DM0545_E01A.pdf
http://www.siglentamerica.com/USA_website_2014/Documents/DataSheet/SDM3045x_UserManual_UM06034-E01A.pdf

Keysight DSOX2004A Oscilloscope: 70 MHz, 4 Analog Channels

Website:

https://www.keysight.com/en/pdx-x201829-pn-DSOX2004A/oscilloscope-70-mhz-4-analog-channels?cc=AU&lc=eng

Documentation:

https://literature.cdn.keysight.com/litweb/pdf/5990-6618EN.pdf?id=2002854&cc=AU&lc=eng