**Lab 2: DC Test Equipment**

**Objective:**

To introduce the fundamental test equipment and procedures used for verifying the operations of electrical circuits.

**Equipment and Components:**

* Multimeter
* Power Supply
* Breadboard/ Protoboard
* Resistors: 4.7 kΩ, 10 kΩ, 10 MΩ

**Preliminary:**

1. From online, copy into your lab book a resistor color code and tolerance table. Include a mnemonic you can use to remember the color code.
2. Calculate the resistance value and tolerance of a resistor with the following color bands:
3. BROWN-BLACK-BLACK-GOLD
4. YELLOW-VIOLET-ORANGE-SILVER
5. BLUE-GREEN-GOLD-GOLD
6. BROWN-BLACK-GREEN-SILVER
7. GRAY-RED-RED-SILVER
8. Calculate the equivalent resistance for:
9. 4.7 kΩ and 10 kΩ connected in series.
10. 4.7 kΩ and 10 kΩ connected in parallel.
11. For the circuit shown in Fig. 2.1, calculate the voltage drop across each resistor and the current flowing through them.
12. For the circuit shown in Fig. 2.2, calculate the current flowing through each resistor and the voltage drop across them.
13. The appendix includes a short tutorial for the lab equipment. Document in your lab book your own key notes and observations about them.

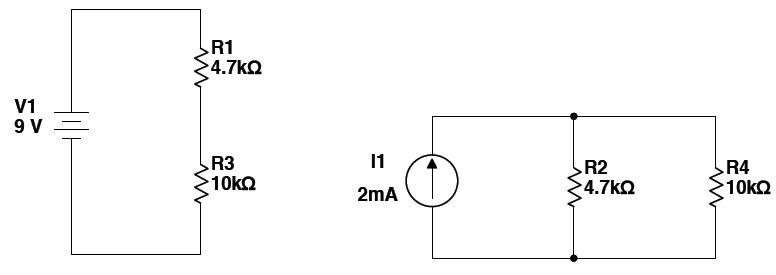


Figure 2.1: Series circuit Figure 2.2: Parallel circuit

**Procedure:**

1. Set the multimeter to measure resistance. Hold the 10 MΩ resistor between your fingers and measure its resistance. Record the value in your lab book.
2. Insert the resistor in your breadboard such that the two leads are not shorted and re-measure the resistance of the 10 MΩ resistor. Record the value in your lab book. Compare the value from Procedure parts 1 and 2, explain your thoughts behind the discrepancies, if any.
3. Connect the 4.7 kΩ and the 10 kΩ resistors in series and measure the total resistance of the combination. Repeat with the two resistors in parallel. Compare the values to the calculated values in Preliminary 3 and discuss any discrepancies. The discrepancy comes from the resistor tolerance values and bread-board’s own parasitic resistance as well as the resistance in the leads.
4. Set the power supply to 9 V DC and set the multimeter as a voltmeter and measure the voltage difference between the “-“ and “+” terminals. Record the error between the voltage shown on the power supply and the multimeter readings, if any.
5. Connect the 9V DC power supply to the series combination of resistors (see Fig. 2.1). Make sure that the “-“ and “+” terminals do not touch each other.
6. Measure the voltage drop across the 4.7 kΩ and the 10 kΩ resistor. How do they compare to the calculated values in Preliminary 4?
7. Set the multimeter to milliammeter (mA). DO NOT forget to relocate the leads to the ammeter terminals.

Note: *It is very easy to destroy the multimeter by connecting a voltage source directly to the ammeter terminals. It is best to turn down the power supply every time you work on your circuit.*

Separate one lead of the resistor from the power supply and insert the ammeter in series with the source and resistors.

1. Measure the current flowing through the resistors. Record the value in your lab book. How does this compare with the calculated value of Preliminary 4?
2. With the 4.7 kΩ and the 10 kΩ resistors connected in parallel (see Fig. 1b, also see the note below), measure the voltage and current of each elements and compare them to the calculated values of Preliminary 5.

Note: *To convert the power supply into a current supply, connect the ammeter between the power supply and the resistors. Then decrease the current control until the supply becomes current limited. DO NOT connect the ammeter directly across the power supply as this will allow large amounts of current to flow through the ammeter burning it out.*

**Conclusion:**

Provide a summary table of your results. Explain your findings in at least a half page write up. Include in your summary the following information:

1. What discrepancy occurred between Procedure 1 and 2 and why?
2. Display final calculated and measured data from Preliminary 4 and 5 and Procedure 5 and 6 in a table. Calculate the % error between measured and calculated values.
3. What are some of the key things to remember when performing electrical measurements?
4. From Procedure 1 and 2, estimate the resistance of the human body and the voltage required to cause 10 mA current to flow through the body.
5. What is meant by a “Floating Power Supply” and why would you want to use one?

**Appendix B: Lab Equipment**

**Power Supplies:**

Standard laboratory power supplies can act as both constant current or constant voltage depending upon the settings. Good laboratory power supplies have the ability to float with respect to a common reference point. This enables a single power supply to act like both a +V (with the ‘-‘ terminal connected to the common point) or a –V (with the ‘+’ terminal connected to the common point) without harming the internal circuitry. This also allows sets of power supplies to be connected together in parallel or series combinations, similar to battery cells, in order to provide + V, or scaled V’s or I’s.

The power supplies in the lab have a current-limiting knob and a voltage limiting knob. There is also a corresponding light to identify whither the current is limited (i.e. a current source) or the voltage is limited (i.e. a voltage source). To convert the supply from one source to the other just increase the value that is limiting the device until the other begins to limit the system.

Be careful however of operating the power supplies with a high current limit as it is typically current that kills. By keeping the current limit below 10 mA it may be “safe” to operate on a live circuit. However, keep in mind that when working on live circuits it is very common to short out resistors or other devices. These instantaneous shorts commonly destroy integrated circuits.

 **When in doubt, power it down! Never work on a circuit while it is powered. Power the circuit only when you are taking measurements.**

**Multimeter:**

Multimeters are used to measure Voltages, Currents, and Resistance. Depending upon the construction of the multimeter, each measurement type may require probes to be placed in different “jacks” as well as different settings/modes selected at the user interface.

Voltage is always measured across a device (between two points). Because of this fact, the voltage sensing part of the multimeters is designed to present a high resistance between the terminals so as not to load down the circuit under test. It is also common to place the negative (black) probe at ground and measure all other connections with respect to that reference point.

Current is always measured thru a device. Because of this fact, the current sensing part of the multimeter is designed to present a low resistance between the terminals so as not to modify the circuit under test. To measure current the physical circuit must be broken and the multimeter must be inserted into the break. In order to address the various levels of current that may flow through the meter, multimeters often have one port for measurements less than 1 Amp and a second for measurements between 1 Amp and 10 Amps. If more current is passes through a specific port, high quality multimeters will have a fuse that will blow to protect the remaining circuitry.

**Measurements:**

Resistance is typically measured using the same method as the voltage, except that all power must be removed from the component. If any external power supply is attached the reading on the multimeter will be incorrect.

Finally, many multimeters are capable of measuring DC (constant voltage), AC (RMS), AC (peak), and AC (instantaneous) depending upon the settings.

* *RMS* – Root Mean Square is the effective DC voltage value that will dissipate the same amount of power in the circuit.
* *Peak* – Commonly also a peak hold, will record the largest value measured over a fixed amount of time.
* *Instantaneous* – Will constantly vary as the AC signal varies.

**Protoboard (Breadboard):**

In many cases it is very desirable to construct prototypes or test circuits before a printed circuit board is manufactured. There are many techniques that have been developed to aid in the construction of test circuits: terminal strips, wire wraps, or protoboard/breadboard.

The breadboard is designed such that solderless connections can be made, by inserting component leads into adjacent rows or columns, depending upon the location, see Fig. 2.3.



Figure 2.3: Connections on a breadboard/protoboard