<u>**Experiment 1: DC Circuit Analysis**</u>

**Goal:** To construct and test a simple circuit with resistive elements and a DC power supply.

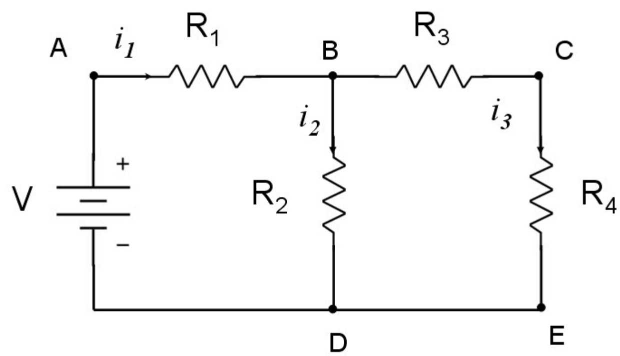
**Experimental tests to be carried out:**

**1.** Verification of Kirchhoff's voltage law: the sum of potential differences around a closed circuit loop is zero.

**2.** Verification of Kirchhoff's current law: the net current flowing into a junction is equal to the net current flowing out of the junction.

**3**. Test of Ohm's law for a resistor network: the current flowing through a resistive element is proportional to the potential difference across the resistor.

**Circuit to be analyzed:**




**Pre-Lab exercises:**

a) Draw a sketch of the circuit and work out the effective resistance $R_{eff}$ between points A and D in terms of the individual component resistances $R_1 - R_4$. Keep your expression as simple as possible so that you can use it to calculate $R_{eff}$ with the actual component values used during the lab.

b) Find an expression for the uncertainty in $R_{eff}$ based on the uncertainties in the individual resistors. Using the nominal resistor values provided below, and assuming the uncertainty in each is 0.25 %, what is the percent uncertainty in $R_{eff}$?

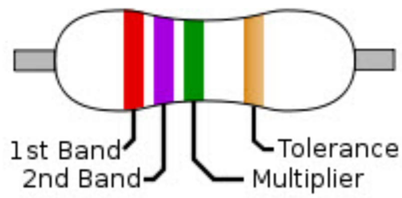
c) Find expressions for the branch currents $i_1$, $i_2$, and $i_3$ in terms of the applied voltage $V$ and the individual resistor component values.

**Equipment:**

- DC power supply (0 – 10 V)
- Digital multimeters (DMM)
- Breadboard circuit platform
- Assorted resistors

**Resistor Color code:**
Read the bands from left to right. Colors correspond to digits from 0 to 9. The first 2 digits are significant, and the third sets the power of 10 multiplier. The tolerance is indicated by the color of the isolated stripe on the far end.

**0: black** | **5: green**
**1: brown** | **6: blue**
**2: red** | **7: violet**
**3: orange** | **8: grey**
**4: yellow** | **9: white**

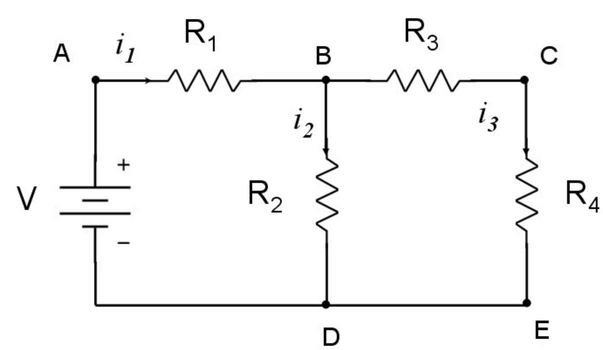



Reading the colored bands from left to right and assigning digits a, b, c to the 3 colors in turn, the resistance is determined as: $R = a\,b \times 10^{c}$. *E.g.*, a 1 $k\Omega$ resistor would have the color bands: (brown, black, red) corresponding to $10 \times 10^{2}\ \Omega$. A silver tolerance band indicates that the actual resistance will be within 10% of the coded value; gold indicates that it will be within 5%.

**Preparation and component data:**

- Select resistors as follows: $R_1 = 1\,k\Omega$, $R_2 = 3.3\,k\Omega$, $R_3 = 2.2\,k\Omega$, $R_4 = 10\,k\Omega$, and use the DMM to measure their individual values. Also, configure the resistors on the bench as shown in the circuit diagram and measure $R_{eff}$ directly with the DMM. Does the measured value of $R_{eff}$ agree with your prediction from the component values within the % error determined in exercise b?

- Assemble the circuit using the breadboard, DC power supply, and leads. Connect one DMM in DC V mode to monitor the power supply EMF, $V_{AD}$. Set the power supply to establish $V_{AD}$= 10.0 V.




**1. Voltage law test**:

- Use a DMM to measure the potential differences $V_{AB}$, $V_{AC}$, $V_{BC}$, $V_{CE}$, $V_{AD}$, $V_{BD}$, where $V_{AB} = V_A - V_B$, etc. An efficient way to record data is to note the values on a copy of the circuit diagram in your notebook.

- Check the predictions of Kirchhoff's voltage law, i.e. test whether the relations: $V_{BD} = V_{BC} + V_{CE} = V_{AD} - V_{AB}$ hold to within the approximate accuracy of the DVM – a fraction of a %.

**2. Current law test:**

- Insert the DMM sequentially in series with the components in branches 1, 2 and 3 of the circuit in order to measure the currents $i_1$, $i_2$, and $i_3$.

- Test the predictions of Kirchhoff's current law, i.e. test whether the relation $i_1 = i_2 + i_3$ holds. Does $i_1$ agree with your prediction in terms of $V_{AD}$ and $R_{eff}$ ?

**3. Ohm's law test:**

In principle, to test whether $V_{AD} = i_1 R_{eff}$, one would like to record a set of measured values $(V_{AD},\ i_1)$ for the circuit under investigation. However, voltage measurement is generally more accurate (and also easier) than current measurement, particularly for small currents. Since $i_1 = V_{AB}/R_1$, Ohm's law can be tested by measuring a set of values for ($V_{AD}$, $V_{AB}$). A plot of $V_{AB}$ versus $V_{AD}$ should be linear with a slope of $R_1 / R_{eff}$ if Ohm's law is valid.

- Record the measured values $(V_{AD},\ V_{AB})$ for 5-10 settings of the DC supply in the range 0 – 10 V. Suggested values: (1, 2, 4, 6, 8, 10)

- Plot a graph of $V_{AB}$ versus $V_{AD}$ using Origin. Use the least squares fitting program in Origin to determine the slope and intercept, and draw this line on your graph.

- A copy of the graph should be included with the report, suitably labeled.

Does the best fit line pass through (0,0)? Compare the fitted value of $R_1 / R_{eff}$ to your calculation from the component resistor values. The fitting program can also provide uncertainties based on the values themselves, or more confidently if some measure of the individual uncertainties is provided. Because this determination of $R_1 / R_{eff}$ is based on a series of measurements, it represents better accuracy.