

ELG 2138 LAB

DIRECT CURRENT MEASUREMENTS

OBJECTIVES

1. To become familiar with the three analog measuring instruments: ammeters, voltmeters, and ohmmeters.
2. To learn typical errors in measurement and their correction methods.
3. To verify experimentally Kirchhoff's Laws and the Power Balance Equation.

PREPARATIONS

1. Reference sections in your text by Dorf and Svoboda: Sections 1.3, 1.4, 1.5 and 2.4, 2.5, 2.6.
2. Read and understand the notes on "Measurements and Their Errors".
3. Understand the color code of resistors given at the end of this lab.
4. Read and understand the experiment procedure below.
5. Answer the preparation questions. As discussed in the lab seminar, there is a penalty for not getting the preparation questions done before your lab.

PARTS AND EQUIPMENT

- 1 D.C. source.
- 2 analog multimeters.
- 3 resistors: one each of 2.7 k Ω , 33 k Ω , 330 k Ω .
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PROCEDURE

When placing a voltmeter in a circuit, we should remember the following rules.

- a) Use the correct terminal polarity so that the pointer does not deflect the wrong way.
- b) Always connect the voltmeter in parallel to the circuit to be measured. On the other hand, you have to break the circuit to connect an ammeter in series.
- c) When using a voltmeter/ammeter with scale selection, start at the highest possible scale and then decrease the setting (increase the sensitivity) to achieve as close as possible a full scale deflection; this would give the minimum relative instrumental error.
- d) Take necessary steps to correct the systematic error of the instrument.

A. Measurements of Resistance

Preparation Question:

Q1: For $R_x=2.7$ k Ω , what is the maximum value of the source voltage so that the power dissipated in the resistor does not exceed the limit (use 250mW) given by the manufacturer?

Q2: Why do we prefer to use analog instead of digital meters in this lab?

Q3: What is a multimeter?

Measurement Steps:

1. Familiar yourselves with the analog ammeters and voltmeters by measuring different power

sources (batteries .. etc) with known values.

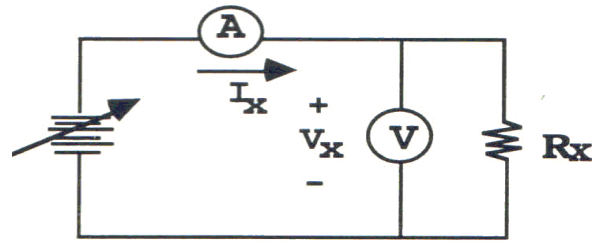


Fig. 1: Measuring Voltage and Current at the same time.

2. Set up the circuit of Fig. 1 with $R_x=2.7\text{ k}\Omega$. Take a habit of using the red terminal/wires for the positive voltage. This will help you to track down connection errors in more complicated circuits.
3. The power rating of the $2.7\text{ k}\Omega$ resistor given to you in the lab may have a different power rating. Check it out. If it is different, repeat the procedure given in the Preparation Question.
4. Adjust the source voltage to some desired value less than the maximum value allowed by the power rating. (say some nice numerical value about 70% of the maximum value you obtained, e.g. if you obtain 6.72 V , you can try 6.5V or 7.0V).
5. Obtain a proper range of the voltmeter and the ammeter to give the biggest deflection. Record the chosen ranges and the measurement reading of the voltmeter and the ammeter in Table 1 provided below.

Table 1: Measurements and Computation using Fig. 1

Nominal Value R_x	Measured Value $V_x[\text{v}]$	Measuring Range [V/div]	Measured Value $I_x [\text{mA}]$	Measuring Range [mA/div]	Computed Value by Ohm's Law	Corrected Value $R'_x[\Omega]$	Ohmmeter Reading $R_o[\Omega]$
2.7 k Ω							
33 k Ω							
330 k Ω							

6. Repeat step 5 for $R_x=33\text{ k}\Omega$ and $330\text{ k}\Omega$. Use the same voltage in step 4 every time, but decrease the source voltage to zero before each repetition.
7. Calculate the values of the different resistors by a simple application of Ohm's Law and record them in Table 1. Then correct the values by taking into account the current flowing through the voltmeter and the voltage drop across the ammeter.
8. Measure the resistors with the analog ohmmeter. Use a range that gives you the largest deflection.
9. Evaluate and compare the errors for the two methods (the corrected value from Fig. 1 and ohmmeter reading),

Questions for Lab Report

Q4:

- a) Give another configuration of setting up the voltmeter and ammeter to measure the voltages and currents. (Hint: it is just a simple variation of Fig.1)
- b) Explain the difference in measurements and correction based on this new configuration.

- c) Which one (the proposed and the Fig.1 configurations) is more appropriate for measuring big resistance values and for small resistance values? Explain in terms of the loading effects of the meters. (Hint: you can assume that voltmeter usually has a higher internal resistance than the ammeter.)

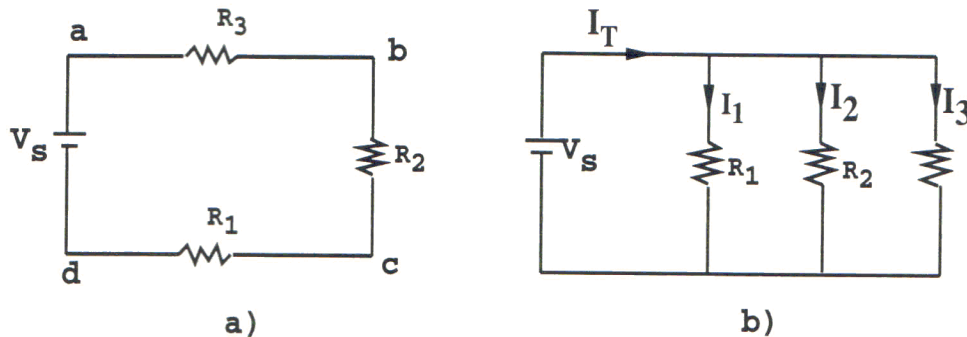


Fig.2: Resistors in Series (a) and in Parallel (b)

B. Kirchoff's Voltage Law

For the experiment below, use $R_1=2.7\text{ k}\Omega$, $R_2=33\text{ k}\Omega$ and $R_3=330\text{ k}\Omega$

1. Set up the circuit shown in Fig. 2a with a voltage supply and the three resistors provided in this lab. Adjust V_s for 10V with a voltmeter and leave it connected.
2. Use a second voltmeter to measure the voltages V_{ad} , V_{bc} , V_{cd} and V_{ab} . While making each measurement, observe any change in the reading of the first meter.
3. Make any necessary steps to correct the measurement values due to loading effect of the meters. Comment on any difficulties you encounter and make appropriate assumptions.
4. Confirm whether the corrected measurements verify Kirchoff's Voltage Law. Justify and explain any discrepancies from theory (e.g, in terms of various types of error).

C. Kirchoff's Current Law

For the experiment below, use $R_1=2.7\text{ k}\Omega$, $R_2=33\text{ k}\Omega$ and $R_3=330\text{ k}\Omega$

1. Set up the circuit shown in Fig. 2b with the same V_s (i.e., 10V as the last step) and the three resistors provided in this lab. Use an ammeter to measure I_T and leave it connected for the remainder of the experiment.
2. Use a second ammeter to measure the currents I_1 , I_2 and I_3 . While making each measurement, observe any change in the reading of the first meter.
3. Make any necessary steps to correct the measurement values due to loading effect of the meters. Comment on any difficulties you encounter and make appropriate assumptions.
4. Confirm whether the corrected measurements verify Kirchoff's Current Law. Justify and explain any discrepancies from theory (e.g, in terms of various types of error).

D. Power Balance Equation

The power balance equation says that the instantaneous power supplied by some elements (e.g., power source) of the circuit must be equal to the instantaneous power absorbed by the rest of the circuit.

Use configuration 2b and the corrected measurement results from Part C to demonstrate (or invalidate?) this.

STANDARD RESISTOR COLOR CODE

Low-power resistors have a standard set of values and color-band codes as well as a tolerance. The most common types of resistors are the carbon composition and carbon film resistors.

The color code for the resistor value utilizes two digits and a multiplier digit in that order as shown in Figure F-1. A fourth band designates the tolerance. Standard values for the first two digits are listed in Table F-1.

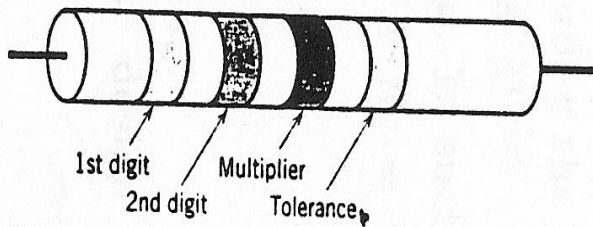


Figure F-1 Resistor with 4 color bands.

Table F-1

Standard Values for First Two Digits for 2% and 5% Tolerance Resistors

10	16	27	43	68
11	18	30	47	75
12	20	33	51	82
13	22	36	56	91
15	24	39	62	100

Table F-2
Color Code

0	black
1	brown
2	red
3	orange
4	yellow
5	green
6	blue
7	violet
8	gray
9	white

The resistance of a resistor with the four bands of color may be written as

$$R = (a \times 10 + b)m \pm \text{tolerance}$$

where a and b are the values of the first and second bands, respectively, and m is a multiplier. These resistance values are for 2% and 5% tolerance resistors as listed in Table F-1. The color code is listed in Table F-2. The multiplier and tolerance color codes are listed in Table F-3 and F-4 respectively. Consider a resistor with the four bands yellow, violet, orange, and gold. We write the resistance as

$$\begin{aligned} R &= (4 \times 10 + 7) \text{ k}\Omega \pm 5\% \\ &= 47 \text{ k}\Omega \pm 5\% \end{aligned}$$

Table F-3
Multiplier Color Code

silver	0.01
gold	0.1
black	1
brown	10
red	100
orange	1 k
yellow	10 k
green	100 k
blue	1 M
violet	10 M
gray	100 M

Table F-4
Tolerance Band Code

red	2%
gold	5%
silver	10%
none	20%