87.1%

LAB REPORT :EXPERIMENT 1

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Introduction:

The objective of this experiment is to make students familiar and measure accurate results with multimeter. Multimeter has several applications in an electrical circuit. It is use to measure multiple properties of an electrical circuit such as resistance(Ohms Ω/MΩ/KΩ),Voltage(V/mA) and current (A/mA) and can also be use to troubleshoot any issue in the circuit.

We conducted three experiment in the lab .In these experiments first we noticed the change in the readings as we change the voltage range of the multimeter.Then we noticed the effect of resistance on the voltage.In the last part we observe the current using different settings of voltmeter.

Theory:

Important definataions for this experiment.

Ohm's Law: states that the current through a conductor between two points is directly proportional to the voltage across the two points.

Kirchhoff's Current Law: This law states that, for any node (junction) in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node or equivalently.

Kirchhoff's Voltage Law: It states that the algebraic sum of total voltage around a loop is always equal to zero i.e. Voltage Drop = Voltage Gain

How to connect?

Ameteter: an instrument for measuring electric current in amperes .

Voltmeter: A voltmeter is an instrument used for measuring electrical potential difference between two points in an electric circuit .

Multimeter: A **multimeter** or a multitester, also known as a VOM (volt-ohm-milliammeter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical **multimeter** can measure voltage, current, and resistance.

Error:

Absolute Error: These are usually the instrument errors. It gives the range of inconsistency of the measured value to the actual value. The absolute errors of the instruments used in lab are as follows:

That's only for one range!!

- Tenma Multimeter ΔE = ±(0.06% rdg + 3 dig) – Δ E in [V]
- Elabo Multimeter ΔE = ±(0.03% f.Value + 0.01% f.Range) – Δ E in [V]

Relative Error: It is the error with respect to the measured value. It may be expressed in percentage or not. It is calculated as follows:

What is the general form for calculating the rel. error?

$E\% = Emax/rdg * 100\%$

Error Propagation: The individual errors that happen during measurement will increase while calculating something with a formula which will cause the overall error to increase. The

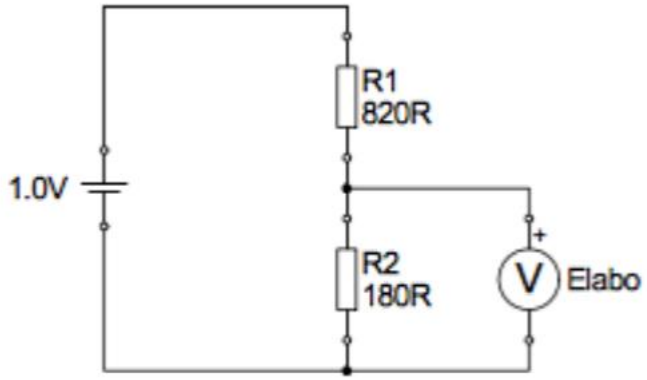
absolute errors add up while adding and subtracting, and the relative errors add up for multiplication and division.

Experimental Set-up and Results

Experiment (5.3 Part 1A): Used tools and instruments:

- Resistors
- Elabo Multimeter
- Power supply
- Breadboard, Tools box from workbench
- Cables We set up the circuit as follows.

The circuit we set up as follows:



We Set up the apparatus using powersupply,R1(8K20R) and R2(1K20R) in series as shown in the diagram. Then we connected Elabo volt meter in parallel with 180R .We switch on elabo multimeter and sets its reading range to 2000V.Now we turn on the power supply and set it to 9 V.Now we took the reading from the multimeter. We record this Value and change the Voltage range of the Elabo Multimeter to 200V and then again we record the value of the voltage being shown by the Elabo Multimeter. We drop the voltage range of the Elabo Multimeter every time and record its value till the lowest possible range. We get the following DATA:

Supply Voltage	Range	Voltage Measured
9	2000	-001.5
9	200	-01.62
9	20	-1.63
9	2	-1.6309
9	0.2	0.0000

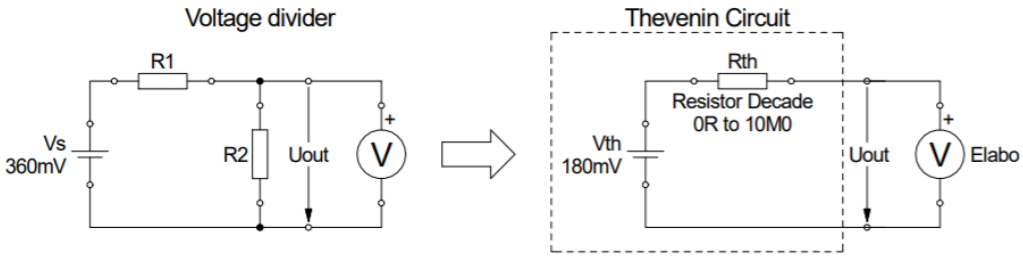
Experiment (5.4 Part 1B):

Used tools and instruments:

- Variable resistor
- Elabo multimeter
- Power supply
- Breadboard, Tools box from workbench

We set up the circuit as follows:

We set up the circuit by putting voltage source,resistor-decade,and voltmeter in series to check the instrument error. For this we see how the reading in the voltmeter changes with the resistance using the resistor decade and the power supply of 180mV .We set the elabo power range to 2000V. We change the



resistance from 0R to 10M R and record values of the displayed Voltage in the Elabo Multimeter into the table. We get the following results:

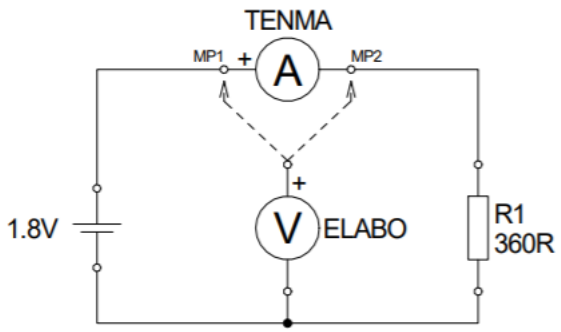
Resistance(Ω)	Voltage (V)
0	0.1830
10	0.1830
100	0.1830
1K	0.1830
10K	0.1828
100K	0.1812
1M	0.1665
10M	0.0920

Experiment (5.5 Part 2):

Used tools and instruments:

- TENMA ammeter
- Elabo multimeter
- Power supply
- Breadboard, Tools box from workbench

We set up the circuit as follows.



This experiment is to demonstrate the methodical erors.This experiment can be divided in two parts.First we set up the above circuit by first putting voltage source(1.8V),Ammeter(plug A and switch mA/A) and resistor (360Ω) in series then we voltmeter parallel to the resistor R1 and ammeter(at point MP1) . We take down the reading voltmeter and ammeter.Then Chang the plug of ammeter to uA-mA and then took the readings for volmeter and ammeter.After that we changed the switch of ammeter to uA and then took the reading of both meters. For the second time we kept the same arrangement except this time we put the voltmeter parallel to resistor only.And then repeat the steps in first part.The values are taken down in the table below:

Plug	Switch	Vmp1/[V]	Vmp2/[V]	Current
A	mA/A	1.856	~~1.45~~	0.005
uA-mA	mA/A	1.856	~~1.451~~	5.14
uA-mA	uA	1.856	1.45	4037

Vmp2 in range A and mA are wrong!

Evaluation:

5.6.1 Part 1A

Question 1:

The absolute error for measurements taken by ELABO multimeter is calculated by the following formula:

$$\Delta E = \pm(0.03\%\text{f.Value} + 0.01\%\text{f.Range})$$

The relative error for measurements taken by ELABO multimeter is calculated by the following formula:

$$E\% = \frac{\Delta E}{\text{rdg}} \times 100$$

- Absolute error for 2000V range:

$$\Delta E = \pm\left(\frac{0.03}{100} * 1.5 + \frac{0.01}{100} * 2000 = 0.20045\text{V} \approx 0.2\text{ V}\right)$$

- Relative error for 2000V range:

$E\% = \frac{0.2045}{1.5} \times 100 = 13.633 \approx 13.6\ \%$

RANGE OF ELABO (V)	2000V	200V	20V	2V	0.2V
ABSOLUTE ERROR (V)	0.200	0.0205	0.0025	0.00069	0.0002
RELATIVE ERROR (%)	13.6	1.26	0.15	0.042	undefined

unusal table - put range and error in columns

Question 2:

The most accurate range for this experiment is 2V.because the vales greater than 2V has higher percentage relative error and absolute error were larger and below 2V the absolute error turns to undefined. We can say that the smaller the range the more accurate result you get(if the voltage supply fits in the range).

OK

Question 3:

To determine the relation between relative errors in voltage measured for the 2 V range, the value of voltage has to be varied. The following table summarizes the values varied and their corresponding relative errors (calculated by the stated formula in Question 1) for the 2 V range.

Voltages	Relative Errors(%)
0.1	0.23
0.2	0.13
0.5	0.07
1	0.05
3	0.037
5	0.034

Note:Although it is possible to calculate error of value greater than 2V with 2V range in theory.In practicle the multimeter would not show any reading bigger than its range value.

To show the effect you need smaller values than 0.1V.
Where is the diagram??

5.6.1 Part 1B

Question 1 :

The relative error of Uth for all Rth is calculated by first finding the absolute errors for all readings. The formulas used for error calculations are the same as before. The following table summarizes the results:

RESISTANCE	0	10	100	1000	10K	100K	1M	10M
ABSOLUTE ERROR (V)	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
RELATIVE ERROR (%)	109.32	109.32	109.32	109.32	109.44	109.44	120.15	217.42

change the table line and columns
the rel. errors are wrong! Its ~0.15% check formula and calculation

Question 2:

The relative error shows that how accurate are the readings. Theoretically, the value should be approximately the same as the Thevenin voltage. The change happens because of the methodical error occurring. ~~The change happens because of the methodical error occurring~~. The methodical error occurs because the circuit configuration is altered by increasing the Thevenin resistance. This happens because as the Thevenin resistance approaches near the internal resistance of the ELABO multimeter, the circuit behaves as a voltage divider.

The formula for relative methodical error is as follows:

$$\mathbf{E\%} = (\mathbf{Valmeas - Valtrue/Valtrue}) * \mathbf{100}\ \%$$

At R=0 the voltmeter shows the true value i.e 0.18300V.

The following table summarizes the relative methodical error of Uth for all Rth:

RESISTANCE (Ω)	0	10	100	1K	10K	100K	1M	10M
RELATIVE METHODICAL ERROR (%)	0	0	0	0	0.11	0.98	9.02	49.73

OK

Question 3:

The internal resistance of voltmeter is $10^7 \Omega$.For methodical error to be 0 the internal resistance must be infinity.

OK

5.6 Evaluation Experiment Part 2

Question 1

The absolute error of the TENMA multimeter is calculated by:

$\Delta E = \pm(0.2\%rdg + 3dgt)$

The relative error is given by: OK

$E\% = \Delta \mathbf{E\ rdg\ x\ 1}00$

The results are displayed in the table below:

PLUG	SWITCH	VMP1/[V]	VMP2/[V]	CURRENT	ABSOLUTE ERROR	RELATIVE ERROR (%)
A	mA/A	1.856	~~1.45~~	0.005	0.00301 A	60.2
UA-MA	mA/A	1.856	~~1.451~~ ?	5.14 mA	0.01328mA	0.26
UA-MA	uA	1.856	1.45	4037 uA	8.077uA	0.20

Question 2

Theoretical current value:

I = V/R

I=0.00518A

Relative Methodical Error formula:

$\mathbf{E\%} = |\mathbf{Valmeas} - \mathbf{Valtrue}|/\ \mathbf{Valtrue}*100$

Plug	Switch	Vmp1/[V]	Vmp2/[V]	Current	Relative Methodical Error (%)
A	mA/A	1.856	~~1.45~~	0.005A	61.
uA-mA	mA/A	1.856	~~1.451~~	5.14mA	0.014
uA-mA	uA	1.856	1.45	4037uA	0.11

wrong values!

Question 3:

We will use the uA-mA and mA/A as we see in the previous question that this setting has the least relative methodical error.

there is only one usefull range

Question 4:

Ri = VMP1 − VMP2 /I (1) and Ri = VMP1/ I − R1 (2)

PLUG	SWITCH	VMP1/[V]	VMP2/[V]	CURRENT	FORMULA 1 (Ω)	FORMULA 2 (Ω)
A	mA/A	1.856	1.45	0.005A	81.2	11.2
UA-MA	mA/A	1.856	1.451	5.14mA	78.79	1.09
UA-MA	uA	1.856	1.45	4037uA	100.56	99.74

OK

Question 5

Error propagation is found as follows: If two or more quantities add or subtract then their absolute errors add up. If two or more quantities multiply or divide then their relative errors add up. Error propagation for formula 1 was calculated as follows:

- Absolute errors of Vmp1 & Vmp2 were added
- Relative error of Vmp1-Vmp2 was found.
- Relative errors of Vmp1-Vmp2 & I was added

Error propagation for formula 2 was calculated as follows:

- Relative error of Vmp1 was found
- Relative error of Vmp1 & I was added
- Absolute error of Vmp1/I was found
- Absolute error of Vmp1/I & R1 was added.

Conclusion:

The theoretical results and practical result can vary a lot from each other due to the errors in the instruments.This is why we need to be careful using the instruments so that we get minimum error as we cant eliminate the error completely. There are examples of the readings being accurate but the result being wrong in account of the methodical errors induced due to the inappropriate use of the multimeter or the usage of too many wires which may lead to an increased resistance all of which results in a change of the function of a circuit.One way to minimize errors is use minimum wires and try to use the minimum range of volt meter as we have shown in the first experiment.

References:

Lab Manual

Error Booklet

Data sheet of ELABO & TENMA multimeters

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https://en.wikipedia.org/wiki/Kirchhoff%27s_circuit_laws

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