PRACTICE 2. ERRORS ON MEASUREMENT REPORT

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GROUP 1E

TABLE 0

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1. Theoretical background

Ohm's law states that the quotient between the voltage on terminals of a resistor (V) and the intensity of current flowing along it (I) are related through the equation $R=\frac{V}{I}$. R is a characteristic parameter of resistor, called resistance.

On the other hand, in order to better understand the results of this practice, the equivalent resistance of two resistors associated in parallel must be known; if two resistors R_1 and R_2 are associated in parallel, their equivalent resistance comes from: $\frac{1}{R_{eq}}=\frac{1}{R_1}+\frac{1}{R_2}$. A particular case occurs when both resistors in parallel are equal (R_1=R_2=R); then, the equivalent resistance is a half of each: $R_{eq}=\frac{R}{2}$

2. Experimental

In this practice, we'll compare the measurements of a resistor R done in three different ways:

a) Nominal value of resistor, from the color code.

Colors: Brown, Green, Orange, Gold

R=15*10^3=15000 Ω = 15 KΩ ΔR=5*15/100=0,75≈0,8 KΩ

R = 15,0 ± 0,8 KΩ

b) Directly measuring its resistance with an ohmmeter.

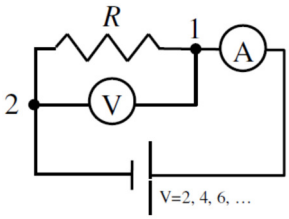
A Fluke 45 on ohmmeter mode was used.

R = 14,850 KΩ Accuracy: 0,05 % Reading error: 2 d

ΔR=14,850*0,05/100+0,002=0,0074+0,002=0,0094≈0,009

R = 14,850 ± 0,009 KΩ

c) Indirectly measuring its resistance, measuring the voltage V on terminals of resistor and the intensity I flowing along it on the shown electric circuit.



An analog Demestres was used as voltmeter:

Class: 2 Reading error: 0,5 V Full scale: 15 V

A digital Fluke 45 on ammeter mode was used as ammeter:

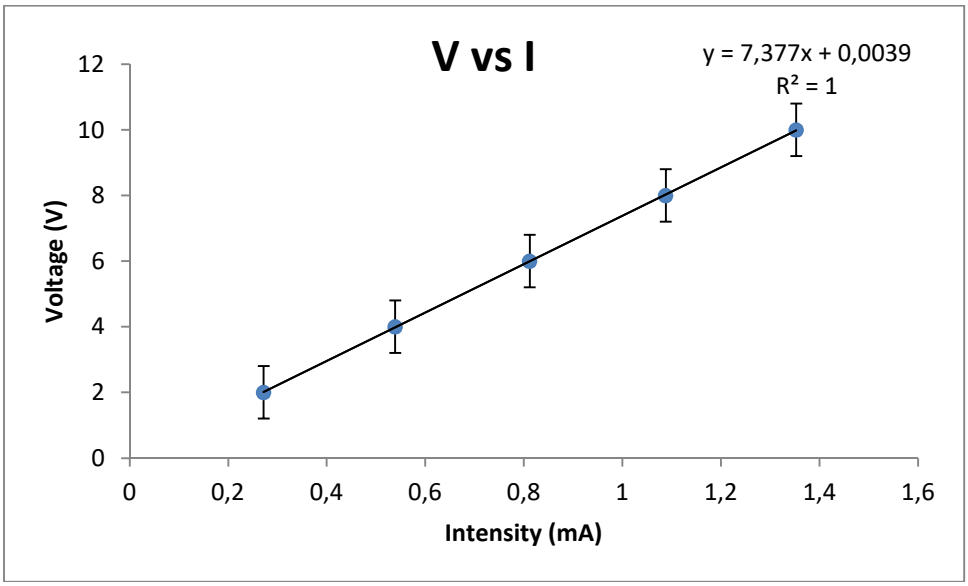
Accuracy: 0,05 % Reading error: 3 d

After adjusting five different voltages on power supply, the results are summarized on next table:

Vs (V)	V (V)	ΔV* (V)	I (mA)	ΔI& (mA)
2	2,0	0,8	0,272	0,003
4	4,0	0,8	0,539	0,003
6	6,0	0,8	0,812	0,003
8	8,0	0,8	1,088	0,004
10	10,0	0,8	1,353	0,004

* ΔV=Class*Full Scale/100+Reading error
& ΔI=I*Accuracy/100+0,001*Reading error

Drawing a graph of V against I, with the error bars, and performing a linear fitting, it comes:



The slope of linear fitting give us 7,377 KΩ for R. Results after using command ESTIMACION.LINEAL are:

7,37704338	0,00393914
0,02752716	0,02473833
0,99995823	0,02359935

Correlation coefficient (R^2) equals 0,9999≈1, revealing a very good adjustment between experimental points and fitted straight line.

The error of slope of linear fitting is 0,0275≈0,03 KΩ. So, **R = 7,38 ± 0,03 KΩ**

Also from results of ESTIMACION.LINEAL, the ordinate on origin results 0,00±0,02 V revealing that the fitted line goes through the origin of coordinates.

Discussion of results: From the three different methods, we can stay (first method) that the manufacturer can assure that the studied resistor is on range 15,0 ± 0,8 KΩ, it is, between 14,2 and 15,8 KΩ.

From second method, we see that this resistor is 14,85 KΩ sized (inside the before range corresponding to the first method). Besides, this is the more accurate method, with an absolute error of only 9 Ω.

The result from third method, 7,38 KΩ is very far from other methods, with an error of 30 Ω. ¿Why it happens?. The reason can be understood after measuring the internal resistance of analog Demestres voltmeter (R_v), using the Fluke 45 on ohmmeter mode:

$$R_v = 14{,}977 \pm 0{,}009\ K\Omega$$

This measured value is almost identical to the resistor we want to measure, and then, if we analyze the used circuit, on such circuit, voltmeter and resistor to be measured are associated in parallel. The equivalent resistance of such association is around 7,5 KΩ, as we have got. If the internal resistance of voltmeter was very high, then the equivalent resistance of both elements would be almost that of resistor, and the measurement would be most accurate. It could be got if we has used a second Fluke 45 measurement device as voltmeter instead the analog Demestres. If we look at the data sheet of Fluke 45 and we look for the Input Impedance on DC voltage mode, we'll find an Input Impedance (Internal resistance) of 10 MΩ, high enough to consider that the equivalent resistance of resistor and voltmeter in parallel is almost equal to that of resistor.

The error introduced by the low resistance of voltmeter is a systematic error, because it is inherent to this measurement method with this voltmeter, whereas the errors computed on measurement devices, ΔV and ΔI are random errors (we suppose that all these measurement devices are well adjusted and calibrated).

3. Conclussions

- On the studied case, direct measurement with ohmmeter is the measurement method with a lower random error.
- Indirect measurement with the shown circuit introduces a higher random error, even though the measurements lead to a very good linear fitting ($R^2 \approx 1$ and y intercept = 0). Linear fitting can cancel random errors.
- On second method, a voltmeter with a low internal resistance introduces a high systematic error on measurement. A "good" voltmeter should show so high internal resistance (Input Impedance) as possible.
- Linear fitting doesn't cancel systematic errors.