

# Tutorial – Using a multimeter

## The multimeter

You might have already seen or worked with a multimeter. It is an electronic measuring device that combines several instruments such as the voltmeter (to measure the voltage) or the ammeter (to measure the current) in one apparatus. The multimeter is usually a standalone instrument that you can carry around to do measurements. You will be working with one of these standalone multimeters during your physics labs (like the one shown in [Figure 1](#)) but you will also work with a slightly different device that needs to be connected to a computer to work.

This second multimeter is part of a small portable data acquisition device called myDAQ (from National Instrument, see [Figure 2](#)) that features eight commonly used plug-and-play computer-based lab instruments including a digital multimeter, an oscilloscope, and a function generator. These instruments are controlled using software interfaces such as the one presented in [Figure 3](#) (the multimeter). In the following sections, we will show you how to make simple measurements with this multimeter.



Figure 1 – The Fluke digital standalone multimeter used during the physics labs



Figure 2 – The myDAQ from National Instrument.

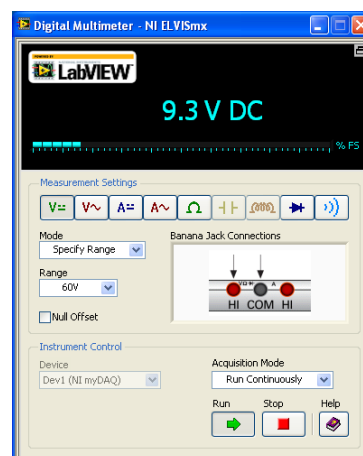
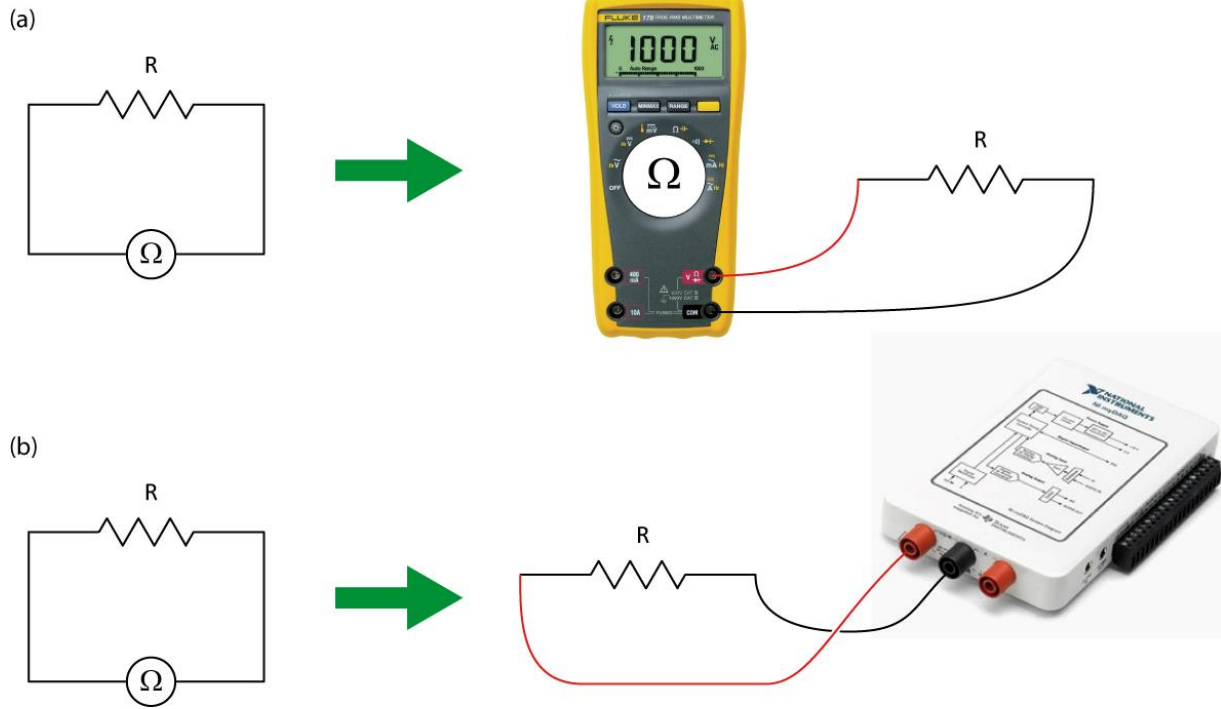


Figure 3 – Screenshot of the virtual digital multimeter of the myDAQ

## Measuring the resistance

[Figure 4](#) presents the circuit diagram for measuring the resistance value of a resistor using an ohmmeter. To use the ohmmeter, you need to select it from the list of instruments in the Digital Multimeter window (see [Figure 3](#), it is represented by the  $\Omega$  symbol).



**Figure 4 - Using the Fluke multimeter (a) and the myDAQ multimeter (b) as an ohmmeter**

In order to correctly report value measured using the ohmmeter, you need to know the uncertainty on the measurement you are making. This uncertainty will depend on the value you measure and the scale of the instrument for that given measurement. All multimeters have different specifications regarding their uncertainties. The specifications of the Fluke and myDAQ multimeters are available in the [Appendix 1 – Fluke multimeter specifications](#) and [Appendix 2 - myDAQ multimeter specifications](#) at the end of this tutorial.

### Calculation example:

Your myDAQ ohmmeter has a reading of 12.06 k $\Omega$  (set on the 20.00 k $\Omega$  range).

From the [Appendix 2 - myDAQ multimeter specifications](#), you know that the accuracy of that reading is  $\pm (0.8\% + 30 \Omega)$ . The percentage part is a percentage of the reading value to which you have to add a constant value of 30  $\Omega$  whatever the reading is. This translates as:

$$\pm (0.8\% + 30 \Omega) = \pm (0.008 \times 12.06 + 0.03)\text{k}\Omega = \pm 0.12648 \text{ k}\Omega.$$

Consequently, your final reading is (12.1  $\pm$  0.1) k $\Omega$ .

## The resistor colour code

The resistance value of a resistor can be usually indicated on the resistor itself by the manufacturer. It is either indicated as a number (that you can directly read) or using a colour code (that you have to interpret). The resistor colour code uses four bands. Make sure you read the bands on the resistor from the correct side. In most cases the resistor will have either a gold or silver band, which should be the right most band when reading the colors on the resistors. If no such bands exist then you should arrange the resistor in such a way that the right most color band is the widest.

The first two bands represent the significant figures while the third colour band represents the multiplier and the fourth colour band is for the tolerance (uncertainty on the resistance's value specified by the manufacturer). The table below summarizes the resistor colour code.

Table 1 - Resistor colour chart

	1 <sup>st</sup> band	2 <sup>nd</sup> band	3 <sup>rd</sup> band	4 <sup>th</sup> band
	1 <sup>st</sup> significant figure	2 <sup>nd</sup> significant figure	Multiplier	Tolerance
<b>Silver</b>	-	-	$10^{-2}$	10%
<b>Gold</b>	-	-	$10^{-1}$	5%
<b>Black</b>	-	0	1	-
<b>Brown</b>	1	1	10	1%
<b>Red</b>	2	2	$10^2$	2%
<b>Orange</b>	3	3	$10^3$	-
<b>Yellow</b>	4	4	$10^4$	-
<b>Green</b>	5	5	$10^5$	0.5%
<b>Blue</b>	6	6	$10^6$	0.25%
<b>Violet</b>	7	7	$10^7$	0.1%
<b>Grey</b>	8	8	$10^8$	-
<b>White</b>	9	9	$10^9$	-

### Calculation example:

You have a resistor with the four following bands: red, black, orange and gold.

The first and second significant figures are 2 (red) and 0 (black).

The multiplier is  $10^3$  (orange) and the tolerance is 5% (gold).

The resistance value is thus  $20 \times 10^3 \Omega \pm 5\% = (20 \pm 1) \text{ k}\Omega$ .

## Measuring the voltage

[Figure 5](#) presents the circuit diagram for measuring the voltage value in a simple circuit using a voltmeter. To use the voltmeter from the myDAQ, you need to select it from the list of instruments in the Digital Multimeter window (it is represented by the V symbols). The first one is for direct current and the second one is for alternating currents.

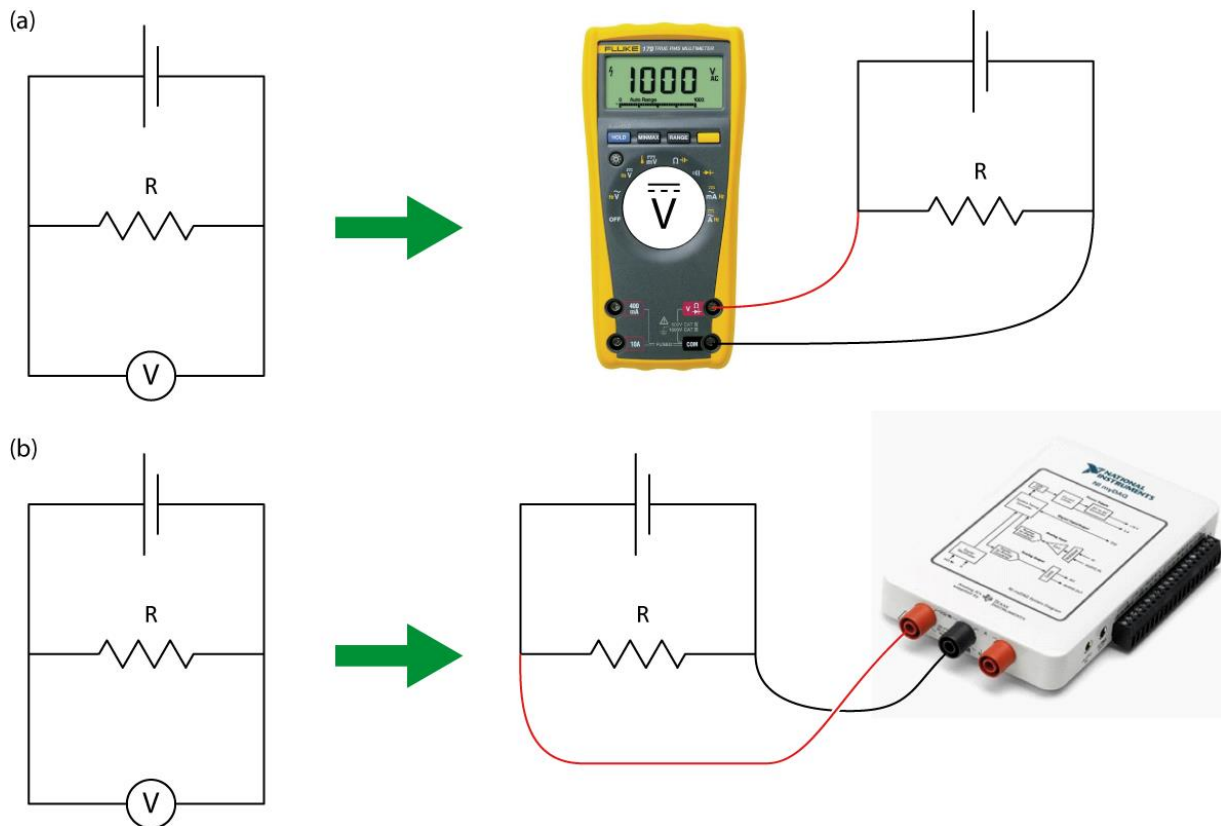


Figure 5 - Using the Fluke multimeter (a) and the myDAQ multimeter (b) as a voltmeter

### Calculation example:

Your Fluke voltmeter has a reading of 1.276 V (set on the 4.000 V range).

From the [Appendix 1 – Fluke multimeter specifications](#) at the end of this tutorial, you know that the accuracy of that reading is  $\pm (0.3\% + 0.001 \text{ V})$ . The percentage part is a percentage of the reading value to which you have to add a constant value of 0.001 V whatever the reading is. This translates as:

$$\pm (0.3\% + 0.001 \text{ V}) = \pm (0.003 \times 1.276 + 0.001) \text{ V} = \pm 0.004828 \text{ V.}$$

Consequently, your final reading is  $(1.276 \pm 0.005) \text{ V}$ .

## Measuring the current

[Figure 6](#) presents the circuit diagram for measuring the current passing through a simple circuit using an ammeter. To use the ammeter from the myDAQ, you need to select it from the list of instruments in the Digital Multimeter window (it is represented by the A symbols). The first one is for direct current and the second one is for alternating currents.

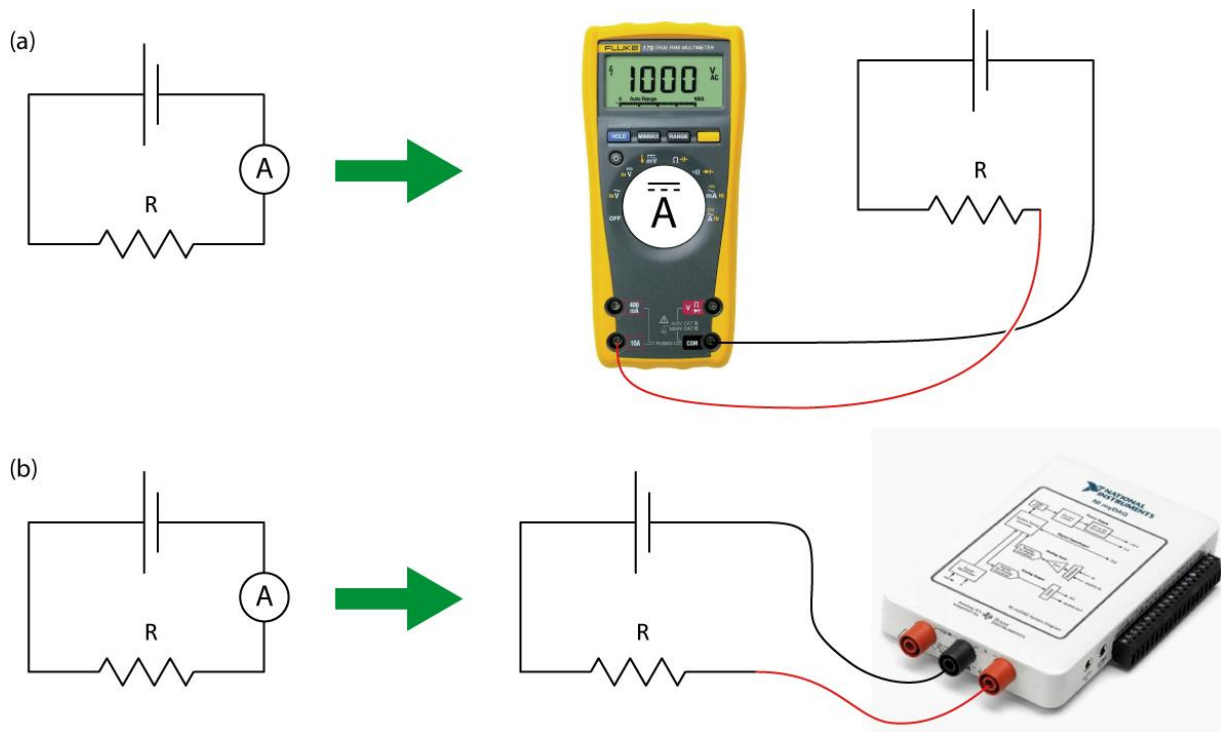


Figure 6 - Using the Fluke multimeter (a) and the myDAQ multimeter (b) as an ammeter

### Calculation example:

Your myDAQ ammeter has a reading of 0.057 A (set on the 1.000 A range).

From the [Appendix 2 - myDAQ multimeter specifications](#) at the end of this tutorial, you know that the accuracy of that reading is  $\pm (0.5\% + 2 \text{ mA})$ . The percentage part is a percentage of the reading value to which you have to add a constant value of 2 mA whatever the reading is. This translates as:

$$\pm (0.5\% + 2 \text{ mA}) = \pm (0.005 \times 0.057 + 0.002) \text{ A} = \pm 0.002285 \text{ A.}$$

Consequently, your final reading is  $(0.057 \pm 0.002) \text{ A}$ .

## Measuring the capacitance

[Figure 7](#) presents the circuit diagram for measuring the capacitance value of a capacitor using a ohmmeter. To use the ohmmeter, you need to select it from the list of instruments (see [Figure 7](#) below).

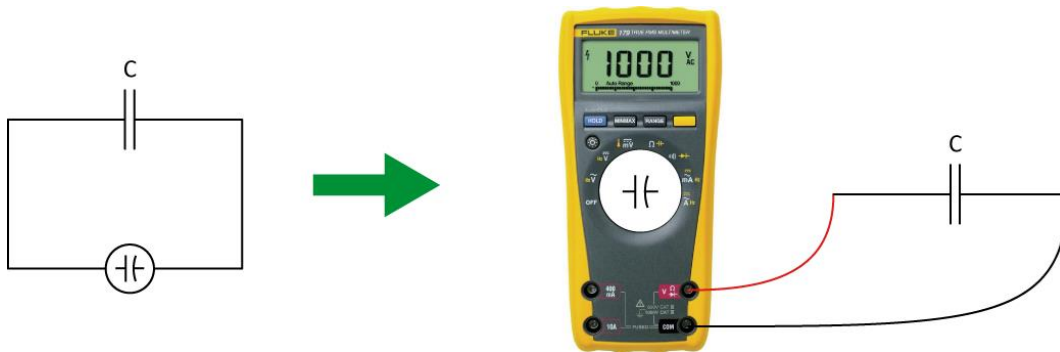


Figure 7 - Using the Fluke multimeter as a Faradmeter

### Calculation example:

Your Fluke Faradmeter has a reading of 81.55 nF (set on the 100.00 nF range).

From the [Appendix 1 – Fluke multimeter specifications](#) at the end of this tutorial, you know that the accuracy of that reading is  $\pm (1.9\% + 0.02 \text{ nF})$ . The percentage part is a percentage of the reading value to which you have to add a constant value of 0.02 nF whatever the reading is. This translates as:

$$\pm (1.9\% + 0.02 \text{ nF}) = \pm (0.019 \times 81.55 + 0.02) \text{ nF} = \pm 1.57 \text{ nF}.$$

Consequently, your final reading is  $(82 \pm 2) \text{ nF}$ .

## Appendix 1 – Fluke multimeter specifications



### Resistance measurement

Range	Resolution	Accuracy ± ([% of reading] + offset)
400.0 Ω	0.1 Ω	0.4% + 0.2 Ω
4.000 kΩ	0.001 kΩ	0.4% + 1 Ω
40.00 kΩ	0.01 kΩ	0.4% + 10 Ω
400.0 kΩ	0.1 kΩ	0.6% + 100 Ω
4.000 MΩ	0.001 MΩ	0.4% + 1 kΩ
40.00 MΩ	0.01 MΩ	1% + 30 kΩ

### Voltage measurement (DC)

Range	Resolution	Accuracy ± ([% of reading] + offset)
40.00 mV	0.01 mV	0.3% + 0.05 mV
400.0 mV	0.1 V	0.3% + 0.1 mV
4.000 V	0.001 V	0.3% + 0.001 V
40.00 V	0.01 V	0.3% + 0.01 V
400.0 V	0.1 V	0.3% + 0.1 V
1000 V	1 V	0.3% + 1 V

### Current measurement (DC)

Range	Resolution	Accuracy ± ([% of reading] + offset)
4.000 A	0.001 A	0.5% + 0.005 A
10.00 A	0.01 A	0.5% + 0.02 A

### Capacitance measurement

Range	Resolution	Accuracy ± ([% of reading] + offset)
100.00 nF	0.01 nF	1.9% + 0.02 nF
1000.0 nF	0.1 nF	1.9% + 0.2 nF
10.000 μF	0.001 μF	1.9% + 0.002 μF
100.00 μF	0.01 μF	1.9% + 0.02 μF
1000.0 μF	0.1 μF	1.9% + 0.2 μF
10.000 mF	0.001 mF	10%

## Appendix 2 - myDAQ multimeter specifications



### Resistance measurement

Range	Resolution	Accuracy ± ([% of reading] + offset)
200.0 Ω	0.1 Ω	0.8% + 0.3 Ω
2.000 kΩ	0.001 kΩ	0.8% + 3 Ω
20.00 kΩ	0.01 kΩ	0.8% + 30 Ω
200.0 kΩ	0.1 kΩ	0.8% + 300 Ω
2.000 MΩ	0.001 MΩ	0.8% + 3 kΩ
20.00 MΩ	0.01 MΩ	1.5% + 50 kΩ

### Voltage measurement (DC)

Range	Resolution	Accuracy ± ([% of reading] + offset)
200.0 mV	0.1 mV	0.5% + 0.2 mV
2.000 V	0.001 V	0.5% + 2 mV
20.00 V	0.01 V	0.5% + 20 mV
60.0 V	0.1 V	0.5% + 200 mV

### Current measurement (DC)

Range	Resolution	Accuracy ± ([% of reading] + offset)
20.00 mA	0.01 mA	1% + 0.02 mA
200.0 mA	0.1 mA	0.5% + 0.2 mA
1.000 A	0.001 A	0.5% + 2 mA