Mastering The Art of Measurement

User Guide for the Plusivo DM301B Multimeter

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Introduction

In this guide, you are going to learn how to measure DC voltage and AC voltage, DC current, resistance, diodes, capacitance and continuity test using DM301B 4000 Counts T-RMS Digital Multimeter. We are going to study some basic concepts like Ohm's Law and Kirchhoff's Law. Please note that product color may slightly vary due to photographic lighting sources or your monitor settings.

1. Overview

This True RMS high performance digital multimeter can be used to measure DC voltage and AC voltage, AC and DC current, resistance, diodes and do continuity tests. It can also be used to assess the battery quality, has NCV and live test functions. The new display and function layout show clearer and better user experience. It is the best choice for professional electricians, enthusiasts and families.

Please take the time and read the printed operating instructions manual that is inside the kit before use and pay attention to the safety information and retain them for future reference. Failure to follow these instructions may lead to serious injury and damage to property.

In general, if something unusual happens or if you suspect that something is wrong or has malfunctioned, do not do anything with the product and immediately contact the seller for assistance (email address: office@plusivo.com)

2. Parts

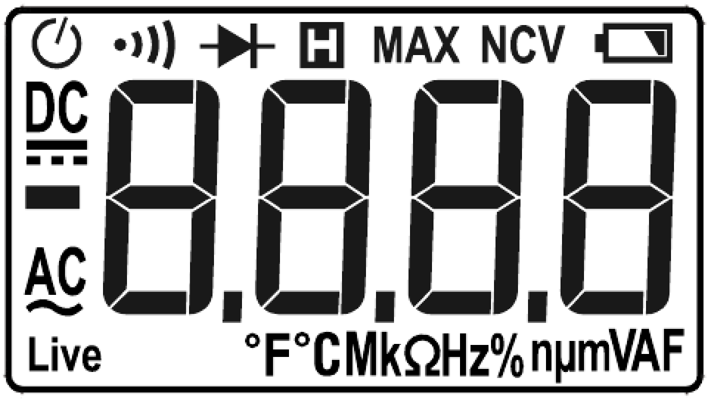
2.1 Rotary switch / Function Knob

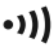
OFF	Instrument turned OFF
V⎓	DC Voltage measurement
V~	AC Voltage measurement
•))) ▶| Ω	Resistance/Diode/Continuity measurement
⊣(	Capacitance Measurement Function
1.5V 9V	Battery Test Function
µA mA A	AC/DC Current measurement
NCV Live	Non Contact Voltage measurement (NCV) / Live Test

2.2 Function keys description

FUNC	Function Key to switch between measurements
HOLD	Hold Function for data or reading retention
MAX	Maximum value measurement mode
	Flashlight / Backlight Function

2.3 LCD



AC	Alternating current measurement
DC	Direct current measurement
	Auto power off indicator
	Low battery indicator
	Hold function activated
V	Voltage measurement
A	Current measurement
MAX	Maximum value
F	Capacitance
	Continuity measurement
	Diode measurement
Live	Live Test measurement

3. Technical Specifications

- Environmental conditions of use:
  CAT. III 600 V
  Pollution level: 2
  Altitude < 2000 m
  Working environment temperature and humidity:
  0~40°C (<80% RH, <10°C non condensing)
  Storage environment temperature and humidity:
  -10~60°C (<70% RH,remove the battery)
- Temperature coefficient: 0.1 x accuracy/°C (<18°C or >28°C)
- MAX. Voltage between terminals and earth ground: 600 V
- Fuse protection: mA: F400 mA/250 V fuse, 10 A: F10 A/250 V fuse
- Sampling rate: about 3 times/second
- Display: 4000 counter readout. Automatically displays the unit symbols according to the shift of the measurement function
- Over range indication: it displays "OL"
- Low battery indication: when the battery voltage is lower than the normal working voltage, " " will be displayed
- Input polarity indication: automatically displays " - "
- Power requirement: 2 x 1.5 V AAA batteries
- Dimension: 151 mm x 75 mm x 46 mm

4. Safety Specifications

The instrument is designed according to the requirements of the international electrical safety standard IEC61010-1 for the safety requirements of the electronic testing instruments. The design and manufacture of instruments strictly comply with the requirements of IEC61010-1 CAT. 111 600V over voltage safety standards and pollution level 2.

Warning

To avoid possible electric shock, personal injury or other accidents, please follow the instructions specified in the printed DM301B manual that comes with the DM301 Multimeter kit purchase.

- Please read this manual carefully before using the instrument and pay attention to the safety information.
- Strictly observe the operating instructions in this manual before using it. Otherwise, the protective function of the device may be damaged or weakened.

Complete safety instructions can be found in the DM301B manual that is inside the DM301B Multimeter Kit.

In general, if something unusual happens or if you suspect that something is wrong or has malfunctioned, do not do anything with the product and immediately contact the seller for assistance (email address: office@plusivo.com)

5. Reference Table

5.1 Table of SI units

Quantity	SI Unit	Abbreviation
Voltage	Volts	V
Current	Ampere	A
Power	Watt	W
Energy	Joule	J
Electric charge	Coulomb	C
Resistance	Ohm	Ω
Capacitance	Farad	F
Inductance	Henry	H
Frequency	Hertz	Hz

5.2 Table of prefixes

Prefix	Power	Numeric Representation
Tera (T)	10^{12}	1 trillion
Giga (G)	10^{9}	1 billion
Mega (M)	10^{6}	1 million
Kilo (k)	10^{3}	1 thousand
No prefix	10^{0}	1 unit
Milli (m)	10^{-3}	1 thousandth
Micro (u)	10^{-6}	1 millionth
Nano (n)	10^{-9}	1 billionth
Pico (p)	10^{-12}	1 trillionth

6. Instrument Specifications

Accuracy specifications

The accuracy applies within one year after the calibration.
Reference condition: the environment temperature is 18°C to 20°C, the relative humidity is no more than 80%.
Accuracy: ± (% reading + word)

6.1 DC Voltage

Range	Resolution	Accuracy
400 mV	0.10 mV	

4 V	0.001 V	± (0.5% + 3)
40 V	0.010 V	
400 V	0.100 V	
600 V	1 V	

Input impedance: 10 MΩ
Overload protection: 600 V
Maximum input voltage: 600 V

6.2 AC Voltage

Range	Resolution	Accuracy
4 V	0.001 V	± (1.0% + 3)
40 V	0.01 V	
400 V	0.1 V	
600 V	1 V	

Input impedance: 10 MΩ
Overload protection: 600 V
Maximum input voltage: 600 V
Frequency response: 10 Hz ~ 1 kHz, TRMS

6.3 DC Current

Range	Resolution	Accuracy
400 μA	0.1 μA	±(1.2%+3)
4000 μA	1 μA	
40 mA	0.01 mA	
400 mA	0.1 mA	
4 A	0.001 A	
10 A	0.010 A	

Overload protection: μA/mA : F400 mA/250 V fuse, A: F10 A/250 V fuse
Maximum input current: uA/mA: 400 mA; A: 10 A
When measuring large current, continuous measurement should be no longer than 15 seconds.

6.4 AC Current

Range	Resolution	Accuracy
400 μA	0.1 μA	±(1.5%+3)
4000 μA	1 μA	
40 mA	0.01 mA	
400 mA	0.1 mA	
4 A	0.001 A	
10 A	0.01 A	

Overload protection: μA/mA : F400 mA/250 V fuse; A: F10 A/250 V fuse
Maximum input current: mA: 400 mA; A: 10 A

Frequency response: 10 Hz ~ 1 kHz; TRMS
When measuring large current, continuous measurement should be no longer than 15 seconds.

6.5 Resistance

Range	Resolution	Accuracy
400 Ω	0.100 Ω	±(1.0%+3)
4 kΩ	0.001 kΩ	
40 kΩ	0.010 kΩ	
400 kΩ	0.100 kΩ	
4 MΩ	0.001 MΩ	±(1.2%+3)
40 MΩ	0.01 MΩ	

Overload protection: 250 V

6.6 Capacitance

Range	Resolution	Accuracy
4 nF	0.001 nF	±(4.0%+5)
40 nF	0.010 nF	
400 nF	0.100 nF	
4 μF	0.001 μF	
40 μF	0.010 μF	
400 μF	0.100 μF	
4 mF	0.001 mF	

Overload protection: 250 V

6.7 Diode and Continuity Test

	Forward DC current is about 1 mA Reverse DC voltage is about 2.5 V Overload protection: 250 V It displays the approximate forward voltage value of the diode.
	Open circuit voltage is about 0.5 V Overload protection: 250 V The resistance is <30, the buzzer sounds and the indicator light turns green. When the resistance is >30 and <60, the buzz does not ring, the indicator light is red.

Overload Protection: 250 V DC or AC peak

7. Measurement Operation

FUNC key

When the gearbox has several measurement functions, the FUNC key switch function is used.

Data hold

Press the "HOLD" key to enter the data hold mode or cancel the data hold mode.

Maximum measurement

Press the "Max" key to enter the Maximum measurement or cancel the Maximum measurement function.

Backlight

Press " " key to turn on/off the backlight, or after 10 seconds it will automatically shut down.

Flashlight

Press and hold the " " key for 2 seconds to turn on/off the flashlight.

Auto power off

- If there is no operation in 15 minutes, the instrument will turn off automatically to save battery energy. After the automatic shutdown, press any key to restore the instrument to the working state.
- If you press the "FUNC" button and turn on the meter, the automatic shutdown function will be canceled. After turning off the meter, it opens again to restore the automatic shutdown function.

7.1 DC Voltage Measurement

1. Turn the knob to " V⎓ "
2. Insert the red probe in " ⊣⊢VΩ Live •))) ▶| mAμA " and black probe in "COM" sockets.
3. Connect the probe to the circuit to be measured (connect to the measured power source or circuit in parallel) and measure the voltage.
4. Read the measurement result.

⚠ **Warning**

- **Voltage above 600V cannot be measured; otherwise the instrument may be damaged.**
- **Pay special attention to safety when measuring high voltage to avoid electric shock or personal injury.**
- **Check the known voltage with a meter before use and make sure that the function of the meter is not damaged.**

7.2 AC Voltage Measurement

1. Turn the knob to " Ṽ "
2. Insert the red probe in " ⊣⊢VΩ Live •)))→⊢ mAµA " and black probe"COM" sockets.
3. Connect the probe to the circuit to be measured (connect to the measured power source or circuit in parallel) and measure the voltage.
4. Read the measurement result.

⚠ **Warning**

- **Voltage above 600V cannot be measured; otherwise the instrument may be damaged.**
- **Pay special attention to safety when measuring high voltage to avoid electric shock or personal injury.**
- **Check the known voltage with a meter before use and make sure that the function of the meter is not damaged.**

7.3 DC/AC Current Measurement

1. Turn the knob to "μA" or "mA" or "A" position and switch AC or DC voltage function with "FUNC" key.
2. Insert the red probe in "VΩLive mAμA" or 10 A socket and black probe in "COM" socket.
3. Disconnect the power of the tested circuit; connect the meter to the circuit under test, then turn on the circuit power supply.
4. Read the measurement result.

The example below is for measuring DC current. If you want to measure AC current, use the FUNC key to switch to AC current measurement function.

The measured current in this figure is 128.2 mA

In this set-up, the red probe is inserted in the 10A socket for measuring DC current.
The reading is 3.99 A.

⚠ Warning

- **Voltage above 600V cannot be measured; otherwise the instrument may be damaged.**
- **Pay special attention to safety when measuring high voltage to avoid electric shock or personal injury.**
- **Check the known voltage with a meter before use and make sure that the function of the meter is not damaged.**

7.4 Resistance Measurement

1. Turn the knob to " Ω▶| •)) ". Insert the red probe in " ⊣⊢VΩLive •))▶| mAµA " and black probe"COM" sockets.
2. Connect the probe to the measured circuit or resistance and measure the resistance.
3. Read the measurement result.

The resistance measured in this figure is 9.294 kΩ

The resistance measured in this figure is 6.2 Ω

⚠ **Warning**

When measuring resistance on the line, disconnect the power supply and discharge all the high-voltage capacitors. Otherwise, the instrument may be damaged and may be struck by electric shock.

7.5 Continuity Test

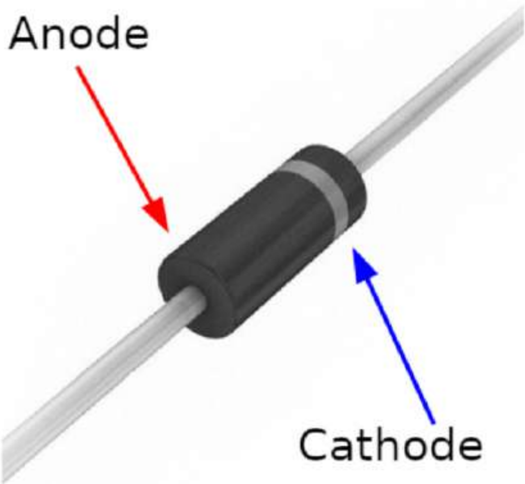
1. Turn the knob to " Ω⯈| •))) " and switch to the continuity measurement function with the "FUNC" key.
2. Insert the red probe in " ⊣⊢VΩLive •))⯈| mAµA " and black probe in "COM" sockets.
3. Connect the probe to the measured circuit or resistance and measure the resistance.
4. If the resistance or circuit of the measured resistance is less than 30Ω, the buzzer will turn on and the green indicator will light up at the same time; when the resistance is between 30Ω to 60Ω, the red indicator lights up; the screen displays the resistance of the measured circuit.

⚠ **Warning**

When measuring continuity on the line, disconnect the power supply and discharge all the high-voltage capacitors. Otherwise, the instrument may be damaged and may be struck by electric shock.

7.6 Diode Measurement

1. Turn the knob to " Ω▶| •)) " and switch to the diode measurement function with the "FUNC" key.
2. Insert the red probe in " •)) ▶| ⊣⊢VΩ Live mAμA " and black probe in "COM" sockets.
3. Connect the diode anode with the red probe, and the diode cathode with the black probe.
4. Read the measurement results



The measured forward voltage in this figure is 0.557 V

⚠ **Warning**

When measuring diode on the line, disconnect the power supply and discharge all the high-voltage capacitors. Otherwise, the instrument may be damaged and may be struck by electric shock.

7.7 Capacitance Measurement

1. Turn the knob to "⊣⊢" and switch to the capacitance measurement function with the "FUNC" key.
2. Insert the red probe in "⊣⊢VΩLive •))▶⊢mAμA" and black probe in "COM" sockets.
3. Connect the probe to the measured circuit capacitance and measure the resistance.
4. Read the measurement results.

⚠ **Warning**

When measuring capacitance on the line, disconnect the power supply and discharge all the high-voltage capacitors. Otherwise, the instrument may be damaged and may be struck by electric shock.

7.8 NCV (Non Contact Voltage) Test

1. Turn the knob to "NCV Live "
2. . Gradually approach the NCV sensor to the conductor under test.
3. When the meter detects weak AC signals, the green indicator lights up and beeps are sent in slow dips.
4. When the meter detects strong AC signals, the red indicator lights up and the beeps are sent in fast dips.

Warning

In order to avoid possible accidents such as electric shock or personal injury, please follow the safety regulations.

7.9 Live Test

1. Turn the knob to the "NCV Live" position and switch to the live test function according to the "FUNC" key. The meter will display "LIVE".

2. Insert the red probe into the "⊣⊢VΩLive •))⊢mAµA" socket, then the probe will touch the test point.

3. When the meter detects weak AC signals, the green indicator lights up and beeps are sent in slow dips.

4. When the meter detects strong AC signals, the red indicator lights up and the beeps are sent in fast dips.

⚠ **Warning**

In order to avoid possible accidents such as electric shock or personal injury, please follow the safety regulations.

7.10 Battery Test

1. Turn the probe to battery test and select the appropriate range.
2. Insert the red probe in "VΩ Live mAµA" and black probe"COM" sockets.
3. Connect the positive to the red test lead and the black test lead to the negative.
4. Read the measurement result.

Note: 1.5 V range Load resistance: 30Ω
9 V range Load resistance : 300Ω

8. Basic Concepts

8.1 Ohm's Law

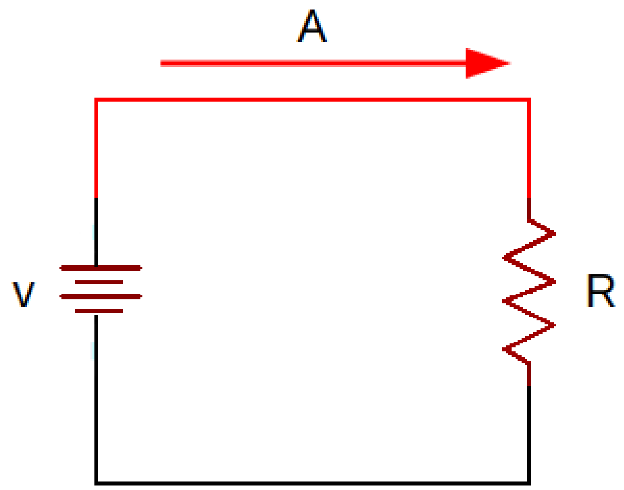
It is a law that illustrates the relationship between the voltage, the current, and the resistance.

$$V = I \cdot R$$

$$R = \frac{V}{I}$$

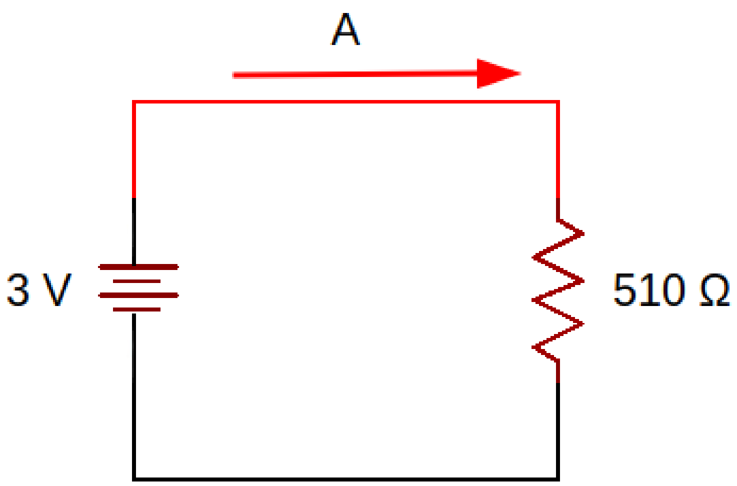
$$I = \frac{V}{R}$$

I is the current through the resistor.
V is the voltage around the resistor.
R is the resistance.



8.1.1 Example

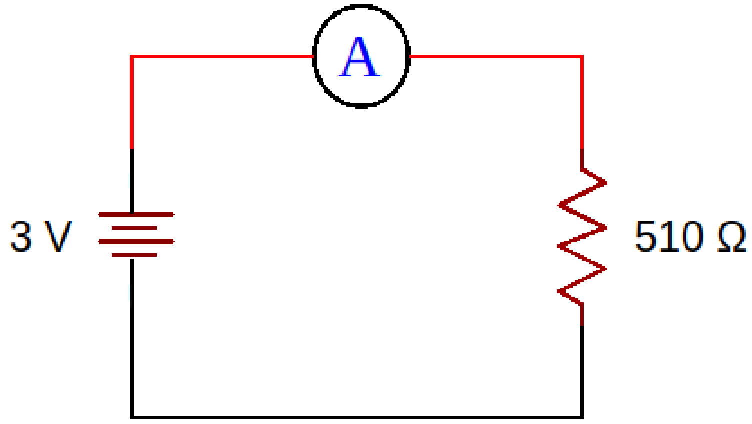
Calculate the current in this circuit.



Simply, we can use Ohm's law: $I = \frac{V}{R}$

$$\frac{3\,V}{510\,\Omega} = 0.00588\,A = 5.88\,mA$$

If we built this circuit in reality and measure the current using the multimeter as in the following schematic:



We should read on the screen of the multimeter: **5.88 mA**

But this is if we have an ideal circuit, in reality, we will not get this specific value because each component in this circuit has tolerance, for example, if we measure the resistance:

The measured resistance in this figure is 556.2 Ω.

Note:
Disconnect the battery when measuring the resistance, otherwise, the multimeter may be damaged.

If we measure the voltage around the resistor:

The measured voltage in this figure is 3.19 V DC.

If we calculate the new values: $\frac{3.19\,V}{556.2\,\Omega} = 5.74\,mA$

Based from the result of the calculation, the value is near the theoretical value of 5.88 mA

8.2 Joule's Law for Electrical Power

Electric power is the rate of the emitting power from a resistor per unit time, the unit of power is watt.

$$P = I \cdot V$$

$$P = I^2 \cdot R$$

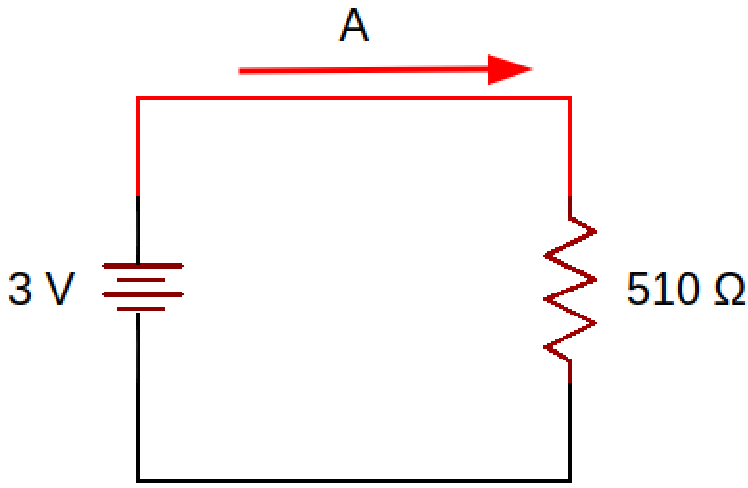
$$P = \frac{V^2}{R}$$

P is the power on the resistor.
I is the current through the resistor.
V is the voltage around the resistor.
R is the resistance.

Note: There are many types of emitting power, it may be a rotary power, light, heat, etc.

8.2.1 Example

Calculate the power on the resistor.



To calculate the power on the resistor, we need any two values of these: **Voltage**, **Current** or **Resistance**.

In our example, we have the voltage and the resistance, so we can use this formula:

$$P = \frac{V^2}{R}$$

$$\frac{(3\,V)^2}{510\,\Omega} = 0.0176\,W = 17.6\,mW$$

Let us see what we will get if we built this circuit in reality and calculate the power using the multimeter.

The measured resistance in this figure is 508.3 Ω

Note:
Disconnect the battery when measuring the resistance, otherwise, the multimeter may be damaged.

The measured voltage in this figure is 3.18 V DC.

So if we calculate the new values: $\frac{(3.18\,V)^2}{508..3\,\Omega} = 19.9\,mW$

We can count on our calculation "$\frac{(3\,V)^2}{510\,\Omega} = 0.0176\,W = 17.6\,mW$" because the theoretical value of **17.6 mW** is near the value of **19.9 mW.**

If we want to use the current to calculate the power.

The measured current in this figure is 6.2 mA

We can use the first formula which is: $P = I \cdot V$

$3.18\,V \cdot 6.2\,mA = 0.0197W = 19.7\,mW$

And the second formula which is: $P = I^2 \cdot R$

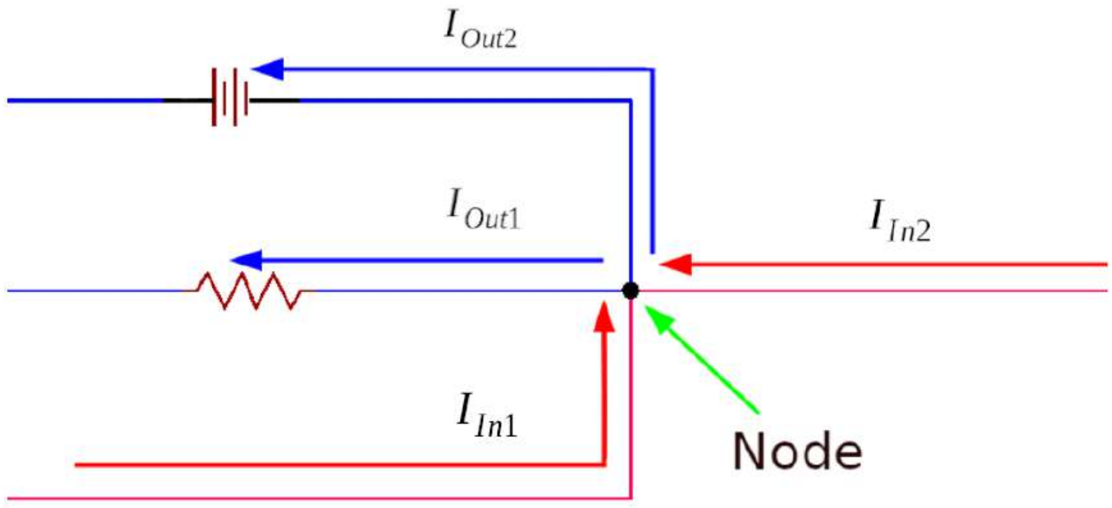
$(6.2\,mA)^2 \cdot 510\,\Omega = 0.0196\,W = 19.6\,mW$

So all the result of the calculations using the formulas above are near each other's value: **19.9 mW, 19.7 mW, 19.6 mW**

8.3 Kirchhoff's Law

8.3.1 Kirchhoff's Current Law

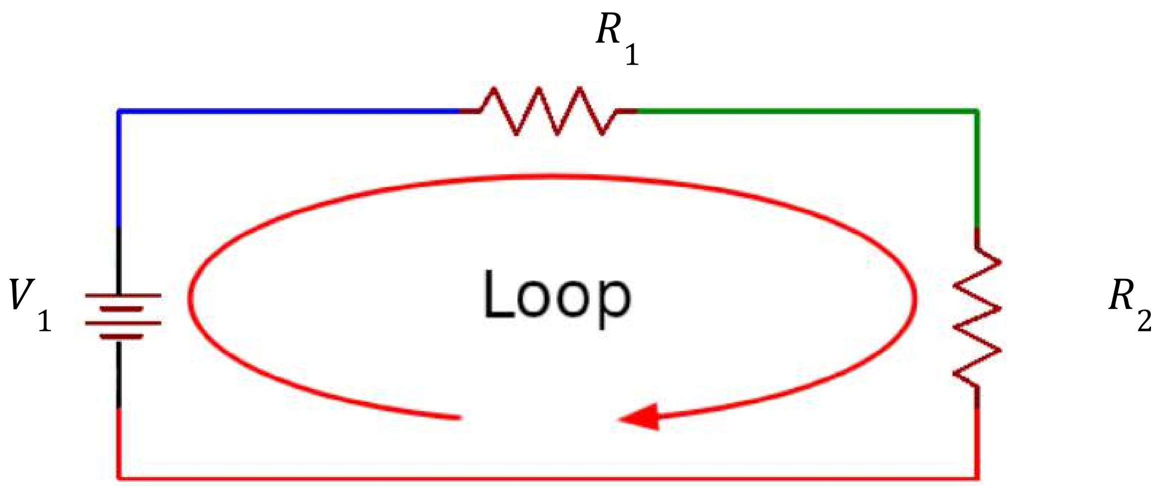
Currents entering the node equals currents leaving the node.



$$I_{In1} + I_{In2} = I_{Out1} + I_{Out2}$$

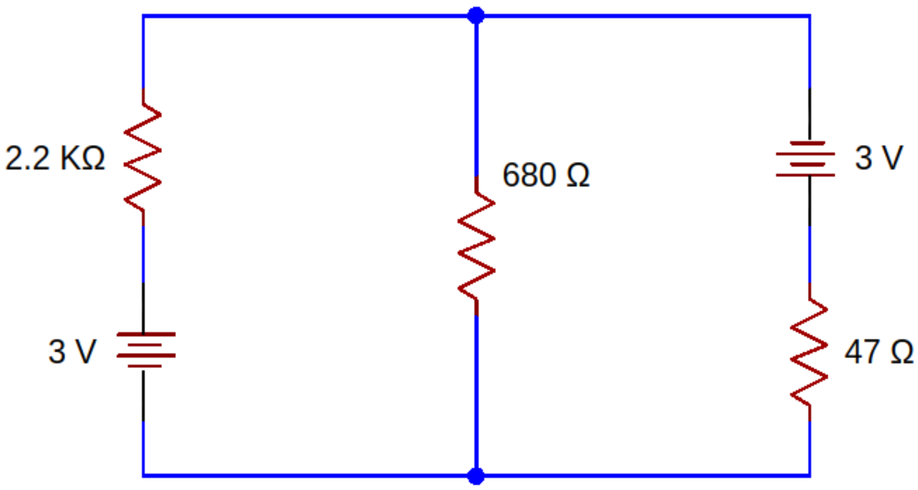
8.3.2 Kirchhoff's Voltage Law

The sum of all the voltages around the loop is equal to zero.

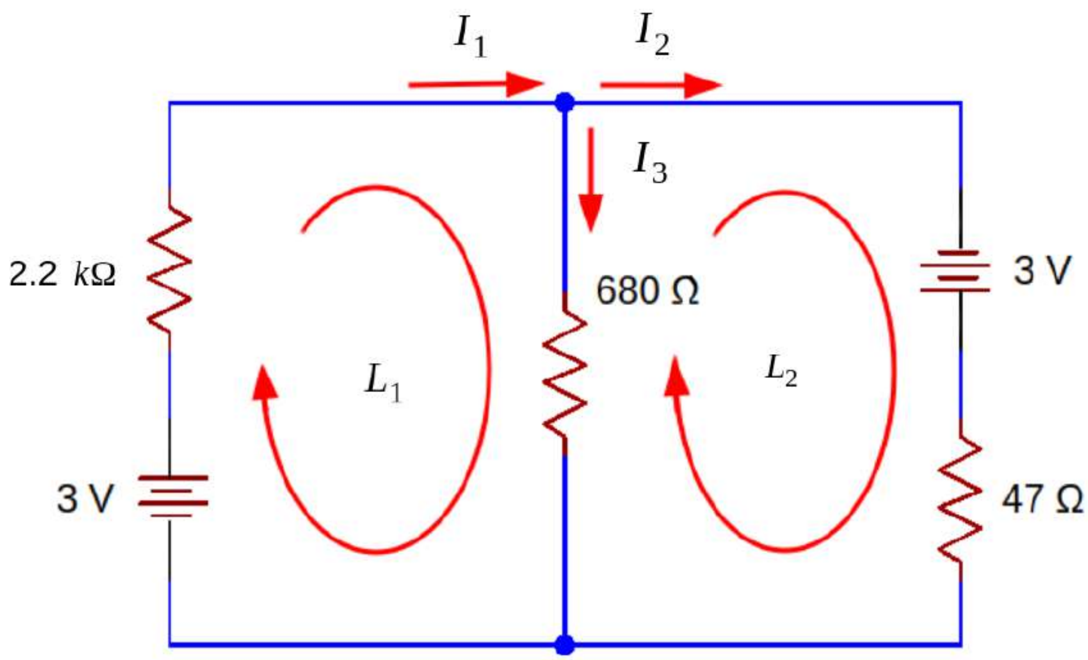


8.3.3 Example

Calculate the voltage around the resistors.



In this case, we are going to use Kirchhoff's law, we need to suppose the paths for offthe current to use Kirchhoff's current law, and we need to suppose two loops to use Kirchhoff's voltage law.



To use Kirchhoff's voltage law, we need to know some rules, for example, in L_1 if the loop passes the battery from - to + we write it in the equation (+3 V), but if the loop passes the battery from + to - we write it in the equation (-3 V). Let us take 2.2 $k\Omega$ resistor as an example, if the loop passes the resistor in the same direction with the current we write it $\left(-\ 2.2\ k\Omega\ \cdot\ I_1\right)$, but if the loop passes the resistor in the opposite direction with the current we write it $(+\ 2.2\ k\Omega \cdot I_1)$.

We get this equation from L_1.

Equation 1: $3\ V\ -\ (I_1 \cdot 2.2\ k\Omega)\ -\ (I_3 \cdot 680\ \Omega)\ =\ 0\ V$

We get this equation from L_2.

Equation 2: $(I_3 \cdot 680\ \Omega)\ +\ 3\ V\ -\ (I_2 \cdot 47\ \Omega)\ =\ 0\ V$

We get this equation from **the node**.

Equation 3: $I_1\ =\ I_2\ +\ I_3$

Now, let us do some math to calculate I_1, I_2 and I_3.

Equation 1: $3\ V\ -\ (I_1 \cdot 2.2\ k\Omega)\ -\ (I_3 \cdot 680\ \Omega)\ =\ 0\ V$

$$3\ V\ -\ (I_3 \cdot 680\ \Omega)\ =\ I_1 \cdot 2200\ \Omega$$

$$I_1 = \frac{3\ V}{2200\ \Omega} - \frac{I_3 \cdot 680\ \Omega}{2200\ \Omega}$$

$I_1\ =\ 0.001363\ A\ -\ (I_3 \cdot 0.3091)$ → This becomes equation 4

Equation 2: $(I_3 \cdot 680\ \Omega)\ +\ 3\ V\ -\ (I_2 \cdot 47\ \Omega)\ =\ 0\ V$

$$I_2 \cdot 47\ \Omega\ =\ (I_3 \cdot 680\ \Omega)\ +\ 3\ V$$

$$I_2 = \frac{I_3 \cdot 680\ \Omega}{47\ \Omega} + \frac{3\ V}{47\ \Omega}$$

$I_2\ =\ (I_3 \cdot 14.468)\ +\ 0.0638\ A$ → This becomes equation 5

Equation 4: $I_1\ =\ 0.001363\ A\ -\ (I_3 \cdot 0.3091)$

Equation 5: $I_2\ =\ (I_3 \cdot 14.468)\ +\ 0.0638\ A$

From **Equation 3:** $I_1\ =\ I_2\ +\ I_3$, we will use the derived I_1 and I_2 from previous calculation to get I_3, thus,

$$0.001363\ A\ -\ (I_3 \cdot 0.3091)\ =\ (I_3 \cdot 14.468)\ +\ 0.0638\ A\ +\ I_3$$

$$-\ I_3 \cdot 0.3091\ =\ (I_3 \cdot 14.468)\ +\ 0.0638\ A\ -\ 0.001363\ A\ +\ I_3$$

$$-\ I_3 \cdot 0.3091\ =\ (I_3 \cdot 14.468)\ +\ 0.062437\ +\ I_3$$

$$-\ 0.062437\ =\ (I_3 \cdot 0.3091)\ +\ (I_3 \cdot 14.468)\ +\ I_3$$

$$-\ 0.062437\ =\ 15.7771 \cdot I_3$$

$$I_3\ =\ -\ 0.003957\ A$$

Equation 4: $I_1\ =\ 0.001363\ A\ -\ (I_3 \cdot 0.3091)$

$$I_1\ =\ 0.001363\ A\ -\ (-\ 0.003957\ A \cdot 0.3091)$$

$$I_1\ =\ 0.001363\ A\ +\ 0.001223\ A$$

$$I_1\ =\ 0.002586\ A$$

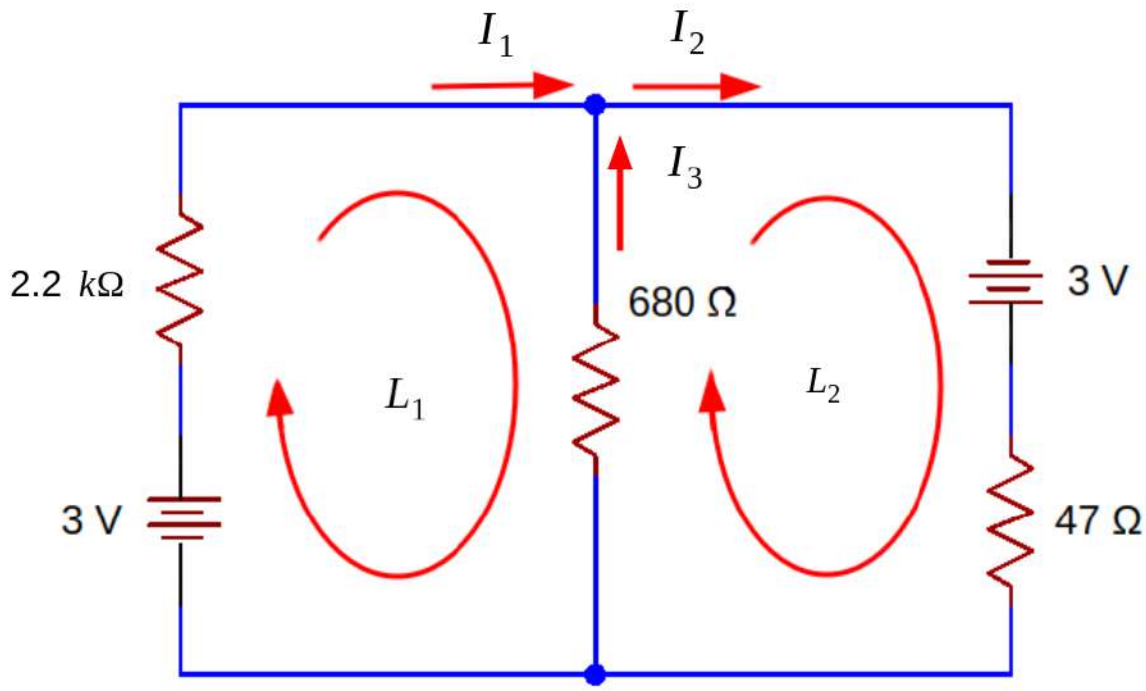
Equation 5: $I_2\ =\ (I_3 \cdot 14.468)\ +\ 0.0638\ A$

$$I_2\ =\ (-\ 0.003957\ A \cdot 14.468)\ +\ 0.0638\ A$$

$$I_2\ =\ -\ 0.05725\ A\ +\ 0.0638\ A$$

$$I_2\ =\ 0.00655\ A$$

Do not forget that we have supposed the directions of the currents, in the final answer if we get a positive answer, like I_1 and I_2 the direction we have supposed is true, but if we get a negative answer, like I_3 the direction we have supposed is wrong, so we must reverse it.



The equation $I_1 = I_2 + I_3$ will be changed to: $I_2 = I_1 + I_3$

Now, it is easy to calculate the voltage on the resistors using Ohm's law: $V = I \cdot R$

The voltage on 2.2 kΩ

$$V = I_1 \cdot 2.2\ k\Omega$$
$$V = 0.002586 \cdot 2200\ \Omega$$
$$V = 5.7\ V$$

The voltage on 680 Ω

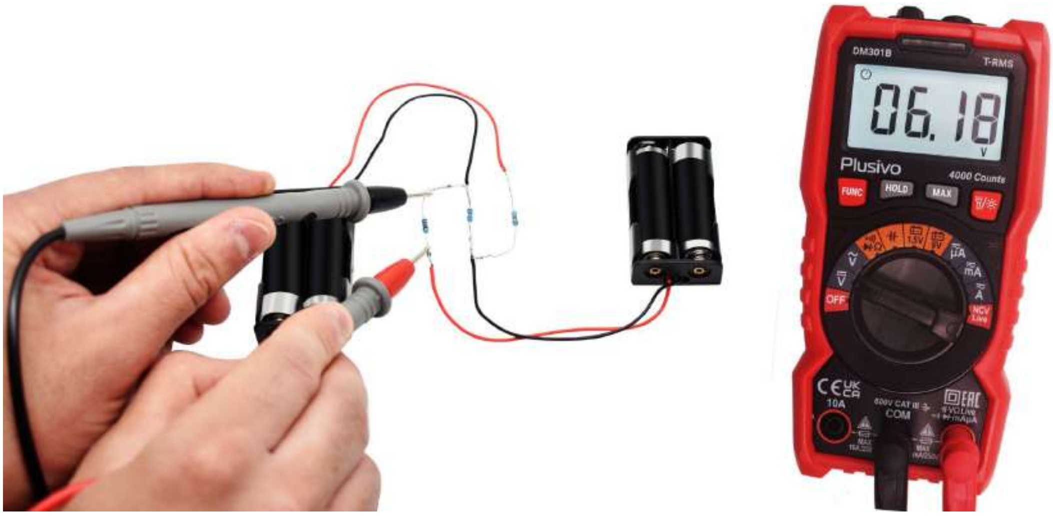
$$V = I_3 \cdot 680\ \Omega$$
$$V = 0.003957 \cdot 680\ \Omega$$
$$V = 2.7\ V$$

The voltage on 47 Ω

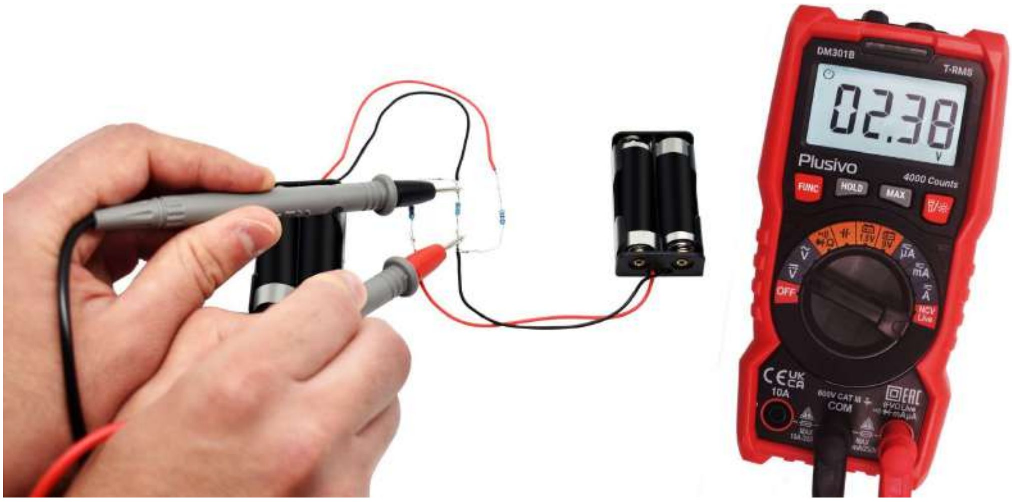
$$V = I_2 \cdot 47\ \Omega$$
$$V = 0.00655\ A \cdot 47\ \Omega$$
$$V = 0.3\ V$$

Now, let us make this circuit in reality and measure the voltage around the resistors using the multimeter.

The measured voltage around the 2.2 kΩ resistor is 6.18 V. Please see the set-up below.



The measured voltage around the 680 Ω resistor is 2.38 V. Please see the set-up below.

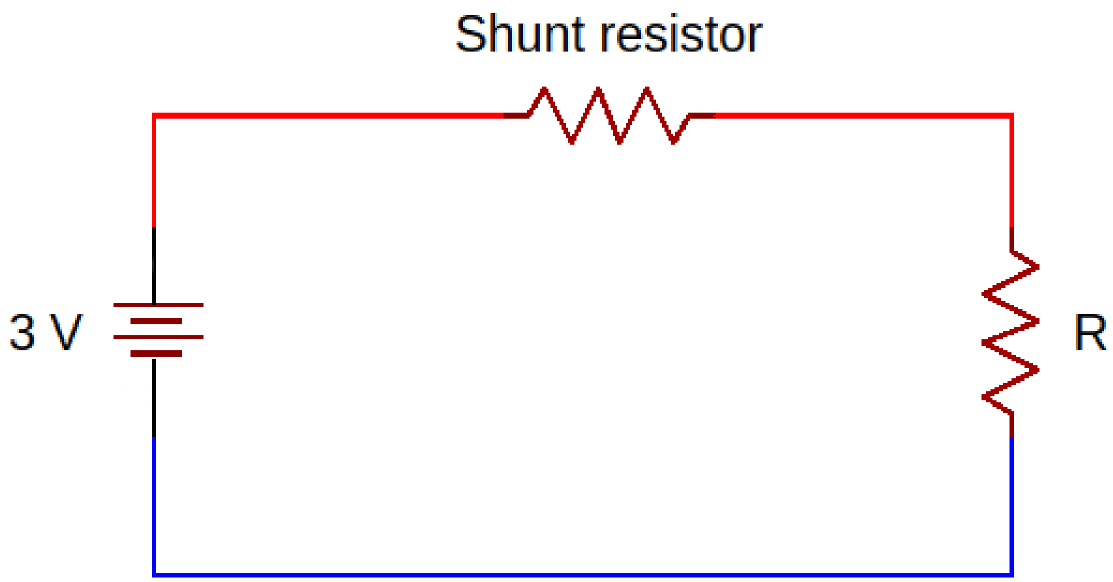


The measured voltage around the 47 Ω resistor is 0.36 V. Please see the set-up below.

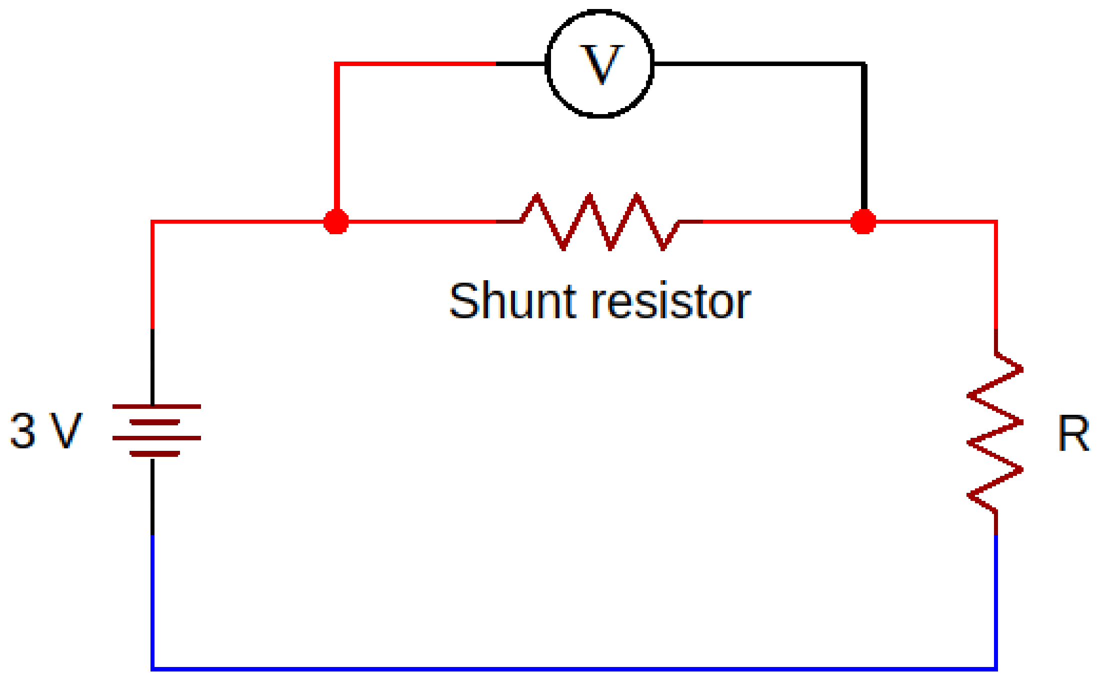
So we can count on our calculation, we will always find these small differences between the calculations and the real measurements because of the tolerance of the components.

8.4 Shunt Resistor

It is a way to measure current through a bath in the circuit using a small value resistor, we cut the circuit and connect it again using the shunt resistor. In most cases, it should be a high power resistor to handle the current passing through it.

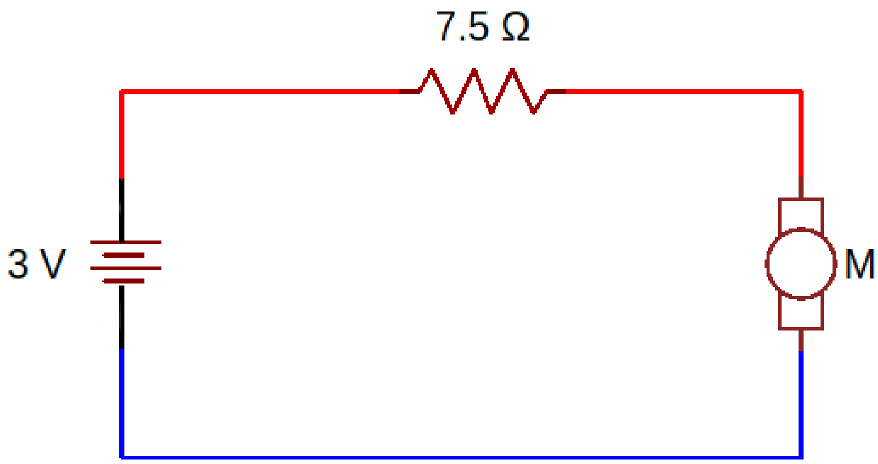


So depending on ohm's law "$V = I \cdot R$", we have a shunt resistor, and we have a current passing through it, so the voltage will be generated around it. And then we will measure this voltage using the multimeter, this way we have converted the current into voltage.



8.4.1 Example

In this circuit, we are going to use a 7.5 Ω resistor as a shunt, calculate the current using Ohm's law.



Now, we need to measure the voltage around the 7.5 Ω shunt resistor using the multimeter.

The measured voltage in this figure is 1.88 V DC.

Using Ohm's law "$V = I \cdot R$"

$1.88\,V = I \cdot 7.5\,\Omega$

$$I = \frac{1.88\,V}{7.5\,\Omega} = 0.251\,A = 251\,mA$$

Now, let us measure the current using the multimeter to compare it with our calculations.

The measured current in this figure is 242 mA.

But there is a tolerance for the resistor, let us measure the resistor.

The measured resistance in this figure is 8.2 Ω.

If we calculate it again using Ohm's law "$V = I \cdot R$"

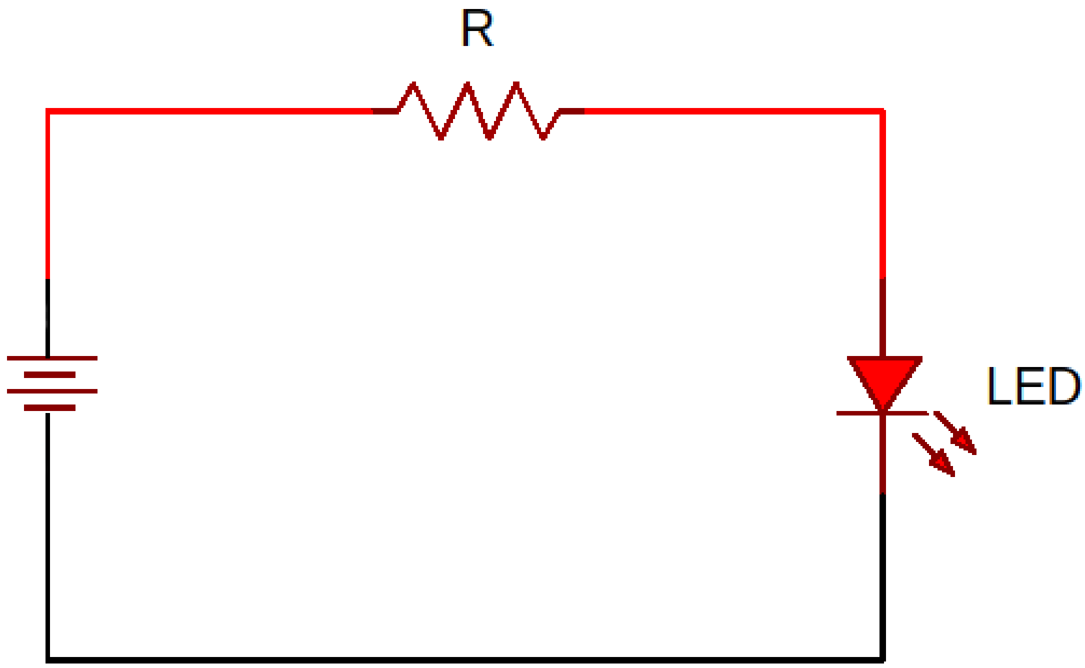
$1.88\,V = I \cdot 8.2\,\Omega$

$$I = \frac{1.88\,V}{8.2\,\Omega} = 0.229\,A = 229\,mA$$

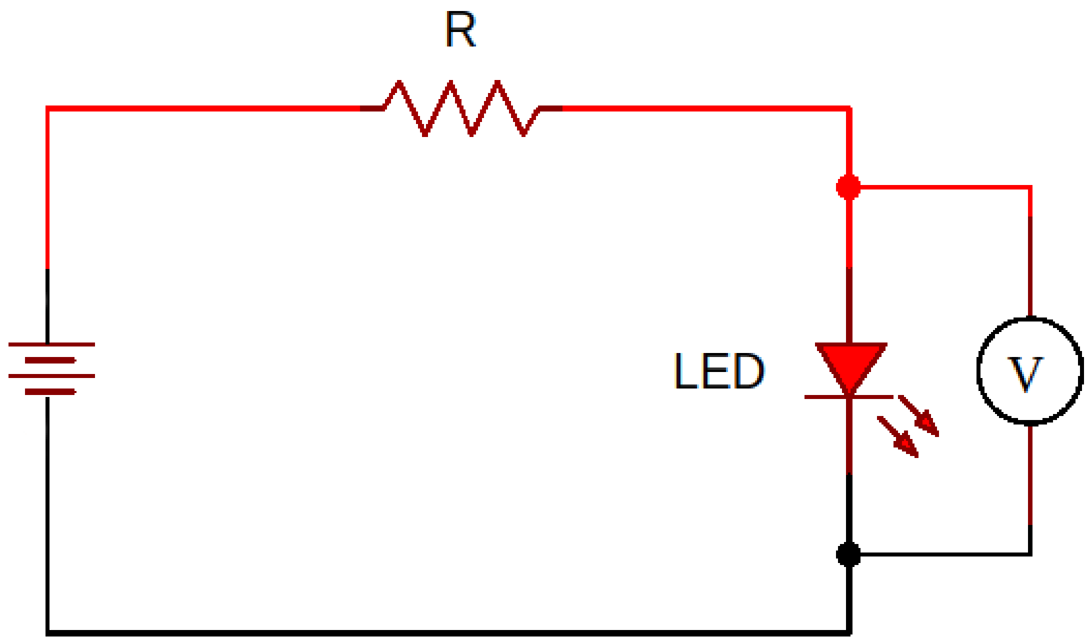
So, we can count on this way to measure the current, **229 mA** is near the value **242 mA**.

8.5 Choosing the Right Resistor for an LED

To calculate the resistor for an LED, we need to know the forward voltage for the LED, LEDs are different from the resistors, we need to limit the current passing through it because it does not work on Ohm's law.



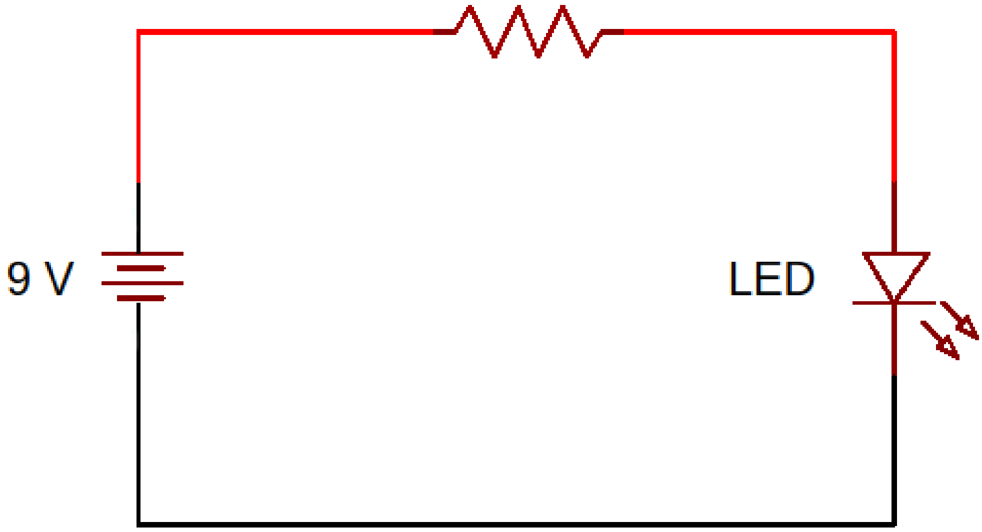
We need to know the voltage around the LED. Usually, a 5 mm LED needs 15 - 30 mA to be in good lighting. After knowing the forward voltage for the LED, it is easy to calculate the resistance.



To measure the forward voltage we connect a high value resistor, so we ensure that a low current will pass through the LED.

8.5.1 Example

Calculate the resistance in the following circuit for a red LED to make it consume around 20 mA.



Now, we need to build the circuit with a red LED, and we will use a high resistor, in our case, we will use a **2.2 kΩ** resistor and measure the forward voltage using the multimeter.

The measured voltage in this figure is 1.894 V DC

And if we measure the current in this circuit.

The measured current in this figure is 3.262 mA.

Now, let us calculate the value of the resistor. We have a **9 V** battery, the voltage on the LED is **1.894 V**, so the voltage on the resistor is: $9\,V - 1.894\,V = 7.106\,V$

Now, let us use Ohm's law: $R = \frac{V}{I}$

$$R = \frac{7.106\,V}{20\,mA} = 355.3\,\Omega$$

And the closest standard value is 330 Ω.

Now, let us build the circuit again using a 330 Ω resistor and measure the forward voltage again and the current.

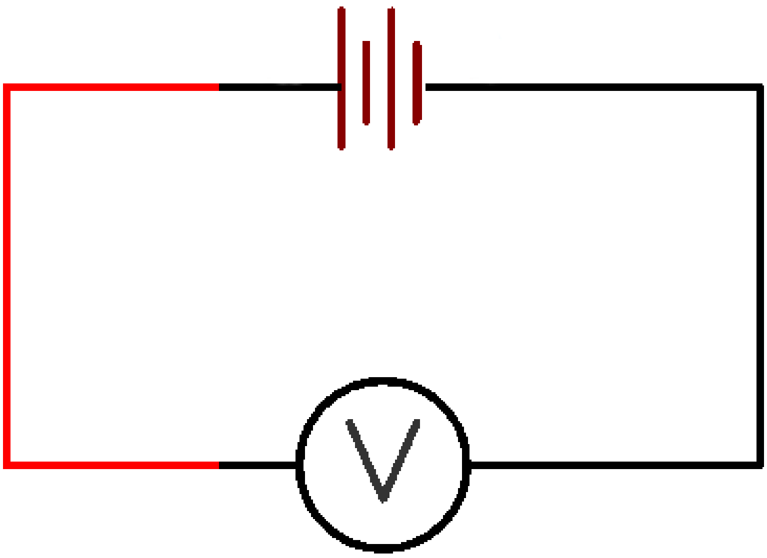
The measured voltage in this figure is 1.994 V DC

The measured current in this figure is 18.62 mA.

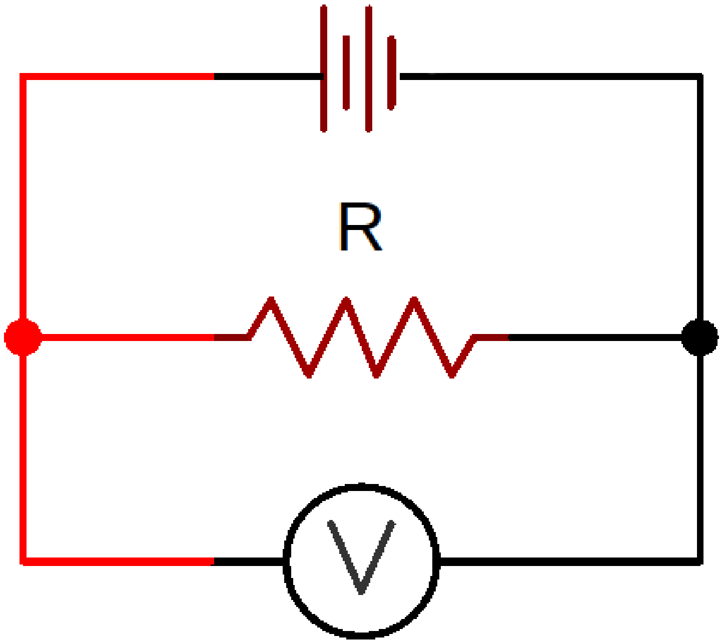
18.62 mA is so close to 20 mA.

8.6 Measuring Internal Resistance of a Battery

We need to follow these steps to measure the internal resistance of a battery using the multimeter. First, we need to measure the voltage of the battery.



Second, we connect a resistor with the battery and measure its voltage.



Third, we will do some calculations using Ohm's law.

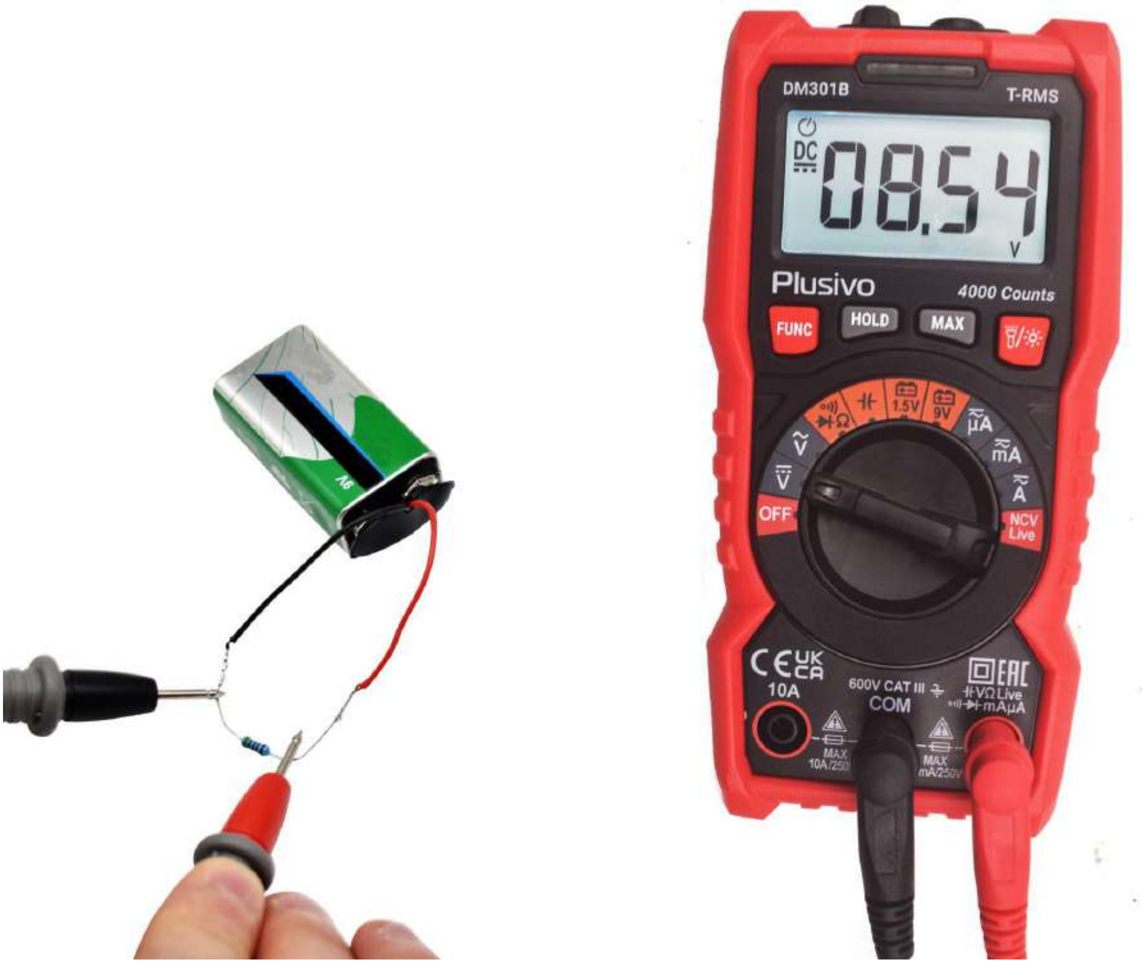
- Calculate the current passing through the resistor: $\frac{R_V}{R} = I$
- Subtract the voltage of the battery from the voltage on the resistor: $B_V - R_V = B_{RV}$
- Now, we have the current and the voltage on the internal resistance, so we can calculate the value of the internal resistor: $\frac{V}{I} = I_{BR}$

8.6.1 Example

To measure the internal resistance of a 9 V battery, we need to measure the voltage of the battery first.

The measured voltage in this figure is 8.94 V DC.

Second, we connect a resistor with the battery and measure its voltage, in our case we will connect a 510 Ω resistor.



The measured voltage in this figure is 8.54 V DC.

Third, we will do some calculations using Ohm's law.

- Calculate the current passing through the resistor: $\frac{R_V}{R} = I$

$$\frac{8.54\,V}{510\,\Omega} = 0.0167\,A = 16.7\,mA$$

- Subtract the voltage of the battery from the voltage of the resistor: $B_V - R_V = B_{RV}$

$$8.94\,V - 8.54\,V = 0.40\,V$$

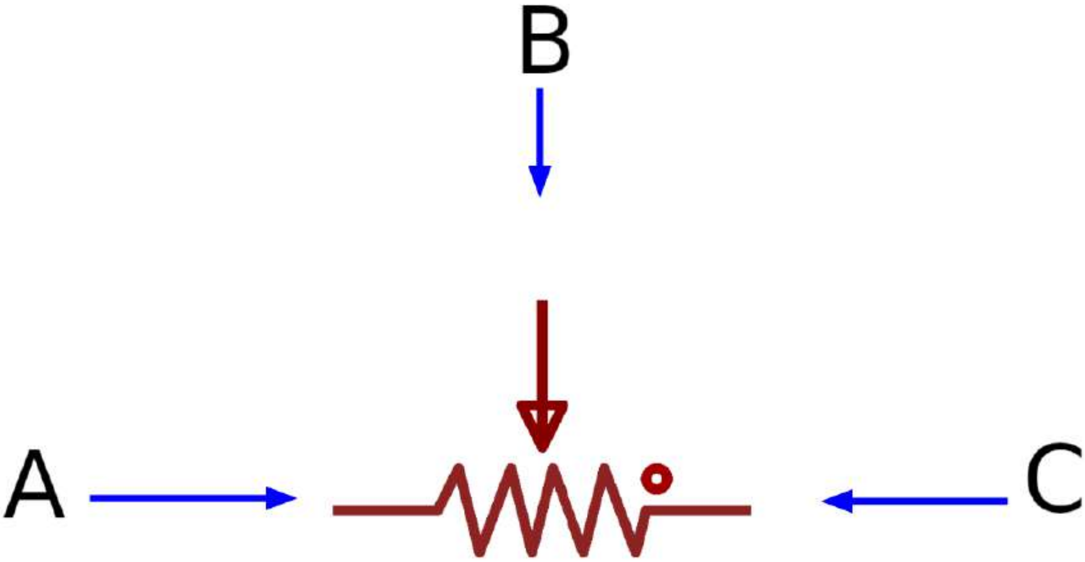
- Now, we have the current and the voltage on the internal resistance, so we can calculate the value of the internal resistor: $\frac{V}{I} = I_{BR}$

$$\frac{0.40\,V}{0.0167\,A} = 23.95\,\Omega$$

8.7 Testing Some Components Using Multimeter

In this section, we are going to test some components using a multimeter.

8.7.1 Potentiometer Test



First, we need to measure the resistance between A - C.

The measured resistance in this figure is 48.84 kΩ.

And then we measure the resistance between A - B and B - C, the sum of the two values must be equal to A - C.

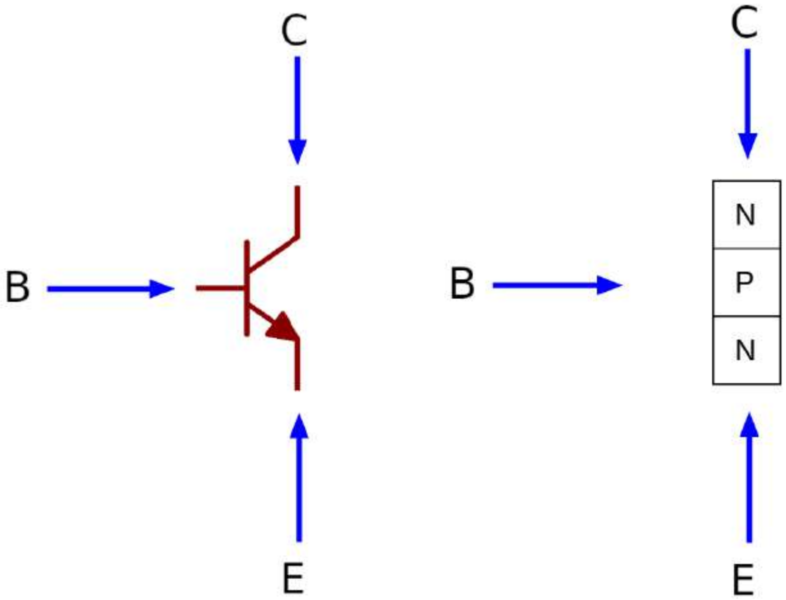
The measured resistance in this figure is 12.89 kΩ.

The measured resistance in this figure is 36.04 kΩ.

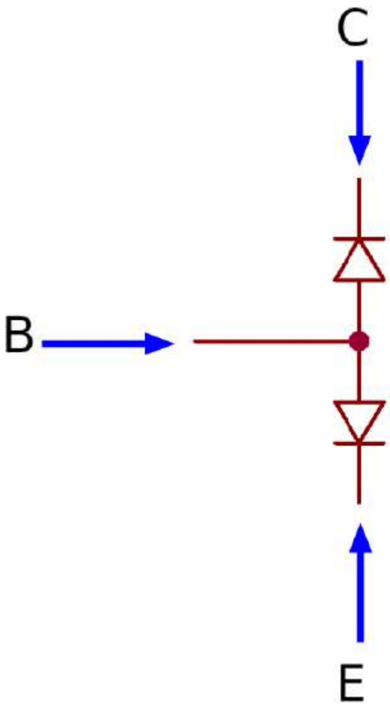
$12.89\ k\Omega\ +\ 36.04\ k\Omega\ =\ 48.93\ k\Omega$, which is almost equal to 48.84 kΩ

8.7.2 BJT Transistor Test

NPN



The NPN Type consists of two N-Regions separated by a P-Region, so we can suppose a diode between B - C and between B - E.



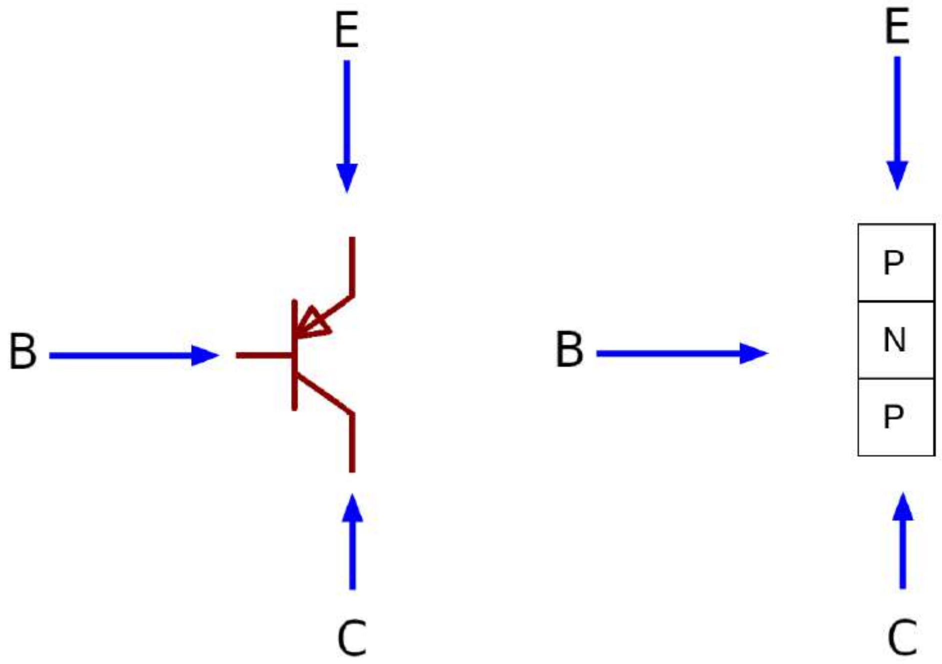
Now, we can test the NPN transistor as 2 diodes. To test the first diode (B - C), we need to connect the red probe to the anode which is the base of the transistor and connect the black probe to the cathode which is the collector of the transistor.

The measured forward voltage is 0.697 V.

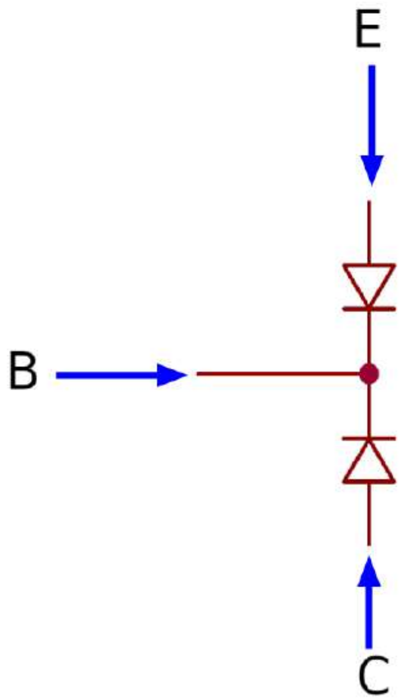
To test the second diode (B - E), we need to connect the red probe to the anode which is the base of the transistor and connect the black probe to the cathode which is the emitter of the transistor.

The measured forward voltage in this figure is 0.699 V.

PNP



The PNP type consists of two P-Regions separated by N-Region, so we can suppose a diode between B - C and between B - E.



Now, we can test the PNP transistor as 2 diodes. To test the first diode (B - E), we need to connect the black probe to the cathode which is the base of the transistor and connect the red probe to the anode which is the emitter of the transistor.

The measured forward voltage is 0.691 V.

To test the second diode (B - C), we need to connect the black probe to the cathode which is the base of the transistor and connect the red probe to the anode which is the collector of the transistor.

The measured forward voltage in this figure is 0.672 V.

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MULTIMETER AND CLAMPMETER KITS

Digital Multimeter Kit	Digital Multimeter Kit with Enhanced Bonus	DM301B Digital Multimeter Kit with Enhanced Bonus	DM401B Digital Multimeter Kit with Enhanced Bonus	DM501D Digital Multimeter Kit with Enhanced Bonus
				

AC Current Clamp Meter	AC/DC Clamp Meter	Digital Clamp Meter 1999 Counts	Digital Clamp Meter 3999 Counts
			

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[Soldering Kit Model 4]()	[Soldering Kit Model 5]()	[Solder Wire and Paste Kit]()*	[12 pcs Soldering Tips Kit]()
		 *Available in different solder weight (50g, 100g) and diameter (0.6mm, 0.8mm, 1mm)	

WIRE KITS
6 spools of different colors

Stranded Silicone Coated Wires	Gauge/No. of Strands	Length
	18 AWG / 150 strands	5 meters each color
	20 AWG / 100 strands	7 meters each color
	22 AWG / 60 strands	7 meters each color
	24 AWG / 40 strands	9 meters each color
	30 AWG / 11 strands	20 meters each color

Solid PVC Coated Wires	Gauge/No. of Strands	Length
	18 AWG	5 meters each color
	20 AWG	7 meters each color
	22 AWG	10 meters each color
	24 AWG	11 meters each color

B. 2 colors (Red and Black)

12 Gauge Silicone Wire Kit	Length / Number of Strands
	3 m each color / 680 strands
	8 m each color / 680 strands

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