

Multimeter Basics for beginners



Step By Step

by Alexander Chukhryaev

Multimeter Basics Step by Step

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Multimeter Basics Step by Step

Introduction

This eBook will help you to master the multimeter skills as this is the one of the most fundamental skills a maker should be able to do.

The information given in this book is for reference only. Always read and comply with your multimeter guide.

Whether you are building a robot or working with Arduino or Raspberry Pi, knowing how to use the multimeter will come in handy.

Have fun with your projects. Thank you for reading,
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What Is Multimeter?

A multimeter or a multimeter, 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. Analog multimeters use a microammeter with a moving pointer to display readings. Digital multimeters (DMM, DVOM) have a numeric display, and may also show a graphical bar representing the measured value. Digital multimeters are now far more common due to their lower cost and greater precision, but analog multimeters are still preferable in some cases, for example when monitoring a rapidly varying value.

A multimeter can be a hand-held device useful for basic fault finding, or a workshop instrument which can measure to a very high degree of accuracy. Multimeters are available in a wide range of features and prices. Let's have a look at 10 best multimeters in this section. We have listed them in order of price ascending, and mirrored this order in the reviews to make it easy for you to reference.



1. AstroAI Multimeter with Volt Amp & Diode Test
Resistance: to $20\text{M}\Omega \pm(1.0\%+10)$
Voltage: to 500V
Amperes: to 10A



2. Innova 3320 Autoranging Digital Multimeter
Resistance: $200\Omega - 20\text{M}\Omega \pm(1.0\%+5)$
Voltage: 200mV - 600V
Amperes: 20mA - 10A



3. Mastech MS8268 Series Digital Multimeter
Resistance: $400\Omega - 40\text{M}\Omega \pm(1.2\%+2)$
Voltage: 400mV - 1000V
Amperes: 0.4mA - 10A

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4. Tacklife DM01M Advanced Version Digital Multimeter

Resistance: $600\Omega - 60M\Omega \pm(1.2\%+3)$

Voltage: 600mV - 1000 V

Amperes: 0.06mA - 10A



5. Etekcity Digital Clamp Multimeter

Resistance: to $200M\Omega \pm(0.4\%+1)$

Voltage: to 500V

Amperes: to 10A



6. Klein Multimeter MM500

Resistance: to $4K\Omega \pm(0.8\% + 4)$

Voltage: 1V - 750 V

Amperes: N/A



7. Extech EX330 Autoranging Mini Multimeter

Resistance: $400\Omega - 40M\Omega \pm(1.2\%+2)$

Voltage: 400mV - 600V

Amperes: 0.4mA - 10A



8. Fluke 117 Electrician's True Multimeter

Resistance: $600\Omega - 40M\Omega \pm(0.9\%+3)$

Voltage: 600mV - 600V

Amperes: 1mA - 10A



9. Fluke 87-V Digital Multimeter

Resistance: to $50M\Omega \pm(0.2\% + 1)$

Voltage: 400mV - 1000V

Amperes: 0.4mA - 20A



10. Fluke 88V/A Automotive Multimeter Combo Kit

Resistance: to $50M\Omega \pm(0.4\%+1)$

Voltage: to 1000V

Amperes: to 20A

1. AstroAI Multimeter with Volt Amp & Diode Test. The price is fair enough, that you can leave on in your car and at home for easy accessibility as needed. This device does basic measurements and is easy to operate and read. If you're looking for a simple multimeter that gets the job done, this is the one for you. This meter is powered by 9V battery. The price is just \$13.

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2. Innova 3320 Autoranging Digital Multimeter. A clear display, accurate readings, and a fairly sturdy built quality makes this the best multimeter under \$20. Four corner guards protect the unit itself. This meter is powered by 2 double A batteries and has it auto off feature to help save battery power.

3. Mastech MS8268 Series Digital Multimeter. This release is the best multimeter for the money. It is basically a multi tester too. Auto powers off, blue LED black lit LCD display, auto ranging with relative measurement, AC/DC 1000 V, diode checker, and more. This meter is powered by 3 triple A batteries. The price is just \$25.

4. Tacklife DM01M Advanced Version Digital Multimeter. Better accuracy and safer testing is what Tacklife boasts with this multimeter unit. There is flashlight, which makes it easy to work with only two hands in dark places. It' also has a temperature measure, which increases safety tenfold. The DC Voltage measures up to 1000Volts, and the AC up to 750V. This meter is powered by 4 double A batteries. The price is around \$25.

5. Etekcity Digital Clamp Multimeter. The autoranging clamp multimeter makes it easy to test AC current just by opening the clamp. This small unit packs a big punch of data, by being able to hold information, let you know when you've hit a max reading point, and going into sleep mode automatically as to save batteries. This meter is powered by 2 triple A batteries. The price is around \$30.

6. Klein Multimeter MM500. The Klein MM500 Multimeter is another great option with high ratings, and at a reasonable price. This is great for basic tasks such as doing repairs on electric ranges, outlets, switches, breakers, refrigerators, etc. Furthermore if you are poking around your vehicle, trailer, or RV this would be a great unit for you. It is a great mid range multimeter with plenty of drop protection. It is auto ranging, dust and waterproof, and can handle up to 10 foot drops. The safety rating for this unit is a CAT IV for up to 600V. This wins our award for the best multimeter for electronic basics. This meter is powered by 2 triple A batteries. The price is around \$80.

7. Extech EX330 Autoranging Mini Multimeter. This is the best budget multimeter for around \$50. You can test current, capacitance, frequency, continuity, diode, duty cycle, resistance, and voltage. On top of all that you get auto-ranging, continuity tester, tilt stand, and the data readout can be set to max hold/data hold/relative. The fact that it has the capability to sense temperature makes it worth this price alone. This unit runs on 2 triple A batteries. Even though this model may be aimed at the professional market even hobbyists can afford it. The price is around \$75.

8. Fluke 117 Electrician's True Multimeter. It won our award for the best HVAC multimeter. Fluke 117 digital multimeter designed specifically for HVAC professionals. It includes built-in thermometer to measure temperature from -

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40°C to 400°C (-40°F to 752°F) and provides microamps to test flame sensors. Has features low input impedance to help prevent false readings due to ghost voltage. Presents a large white LED backlight for working in poorly lit areas. This unit runs on 1 triple A battery. The price is around \$200.

9. Fluke 87-V Digital Multimeter. If you want the best multimeter, this is the one. An analog bar readout provides the best of both digital and analog worlds. The auto ranging system is on point, but can be switched off if you want to change to manual. Arguably the best feature of this multimeter is that it will beep at you if you put the wrong thing into input jack. That makes this unit great for inexperienced technicians and will prevent them from taking the wrong measurement. Another awesome feature is that this puppy can measure up to 20A for 30 seconds at a time. Sure, it is one of the most expensive models money can buy, the price is around \$450. This unit runs on 4 double A batteries.

10. Fluke 88V/A Automotive Multimeter Combo Kit. If you're looking for the best automotive multimeter, you can't beat the Fluke 88V. The Fluke 88V is excellent for measuring signal pulse width and determining the health of an injector. The Fluke 88V has good stats: 1000V AC and DC, maximum resistance of 50 M, and withstands even the most hazardous of spikes up to 8,000 volts. This unit also has the capability to carry out diode tests on vehicles. It is extremely accurately at +/- 1.00 percent. The maximum conductance that it will measure is 60.00 nS. This unit runs on 9V battery. The price is around \$700.

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Electricity Basics

Electricity is the movement of electrons. Electrons create charge, which we can harness to do work. A circuit is a closed loop that allows charge to move from one place to another. Components in the circuit allow us to control this charge and use it to do work.

The three basic principles for this tutorial can be explained using electrons, or more specifically, the charge (measured in Coulombs) they create:

1. **Voltage** is the difference in charge between two points. It's measured in Volts (V);
2. **Current** is the rate at which charge is flowing (amount of charge flowing through the circuit over a period of time). It's measured in Amperes (A). An ampere is defined as 6.241×10^{18} electrons (1 Coulomb) per second passing through a point in a circuit.
3. **Resistance** is a material's tendency to resist the flow of charge (current). Ohm defines the unit of resistance of "1 Ohm" as the resistance between two points in a conductor where the application of 1 volt will push 1 ampere, or 6.241×10^{18} electrons. This value is usually represented in schematics with the greek letter " Ω ", which is called omega, and pronounced "ohm".

When describing voltage, current, and resistance, a common analogy is a water tank. In this analogy, charge is represented by the water amount, voltage is represented by the water pressure, and current is represented by the water flow. So for this analogy water is charge, pressure is voltage, hose width is resistance and flow is current.

Consider a water tank at a certain height above the ground. At the bottom of this tank there is a hose. The pressure at the end of the hose can represent voltage. The water in the tank represents charge.

The more water in the tank, the higher the charge, the more pressure is measured at the end of the hose. We can think of the

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amount of water flowing through the hose from the tank as current. The higher the pressure, the higher the flow, and vice-versa. With water, we would measure the volume of the water flowing through the hose over a certain period of time. The water flow through the narrower hose is less than the water flow through the wider hose. If we want the flow to be the same through both hoses, we have to increase the amount of water (charge) in the tank with the narrower hose. This increases the pressure at the end of the narrower hose, pushing more water through the tank.

The narrow hose "resists" the flow of water through it even though the water is at the same pressure as the tank with the wider hose.

Combining the elements of voltage, current, and resistance, Ohm developed the formula: $E = I \times R$, where E - Voltage in volts, I - Current in amps, R - Resistance in ohms.

Power is the rate of work being done by the movement of electrical charge. But often, power is a measurement of heat generated in an electrical component as a result of electrons moving through it. Its unit of measurement is the watt (W). It's defined as the product of voltage and current, such that $1W = 1A \times 1V$.

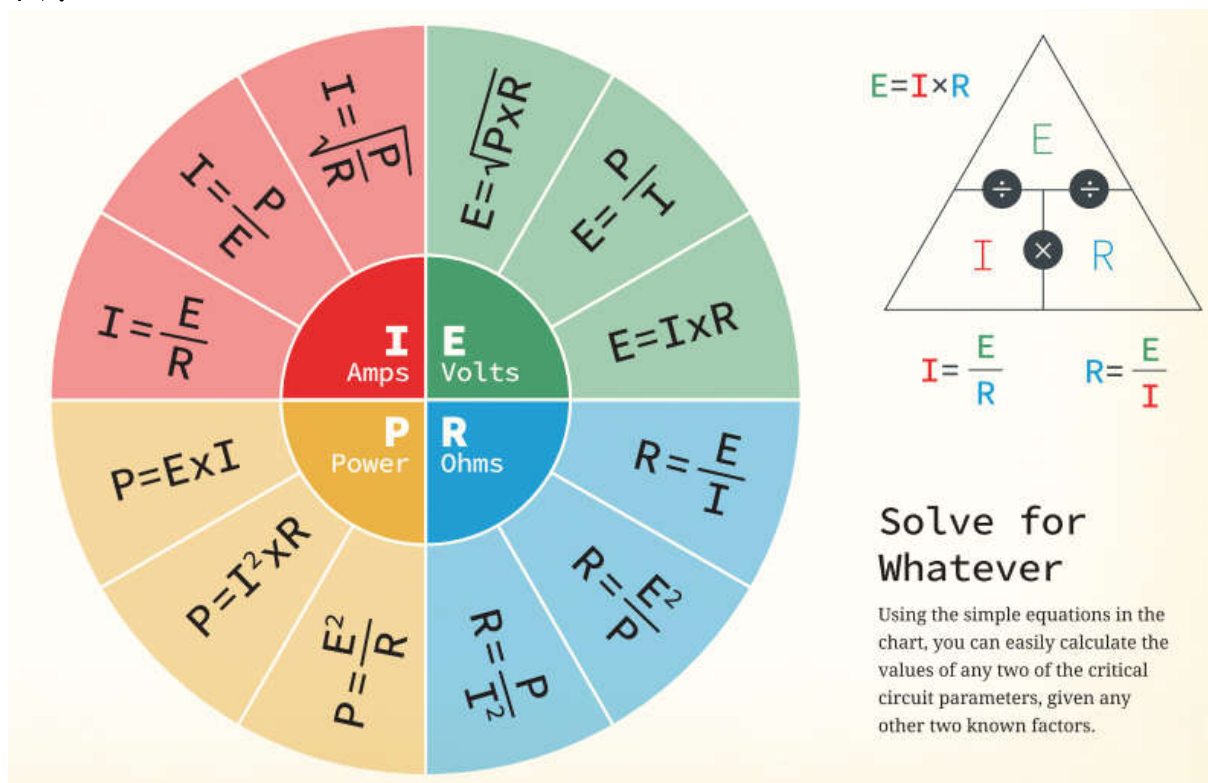


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Important terms

What is a "Load"?

The reason we want to build circuits is to make electricity do useful things for us. The way we do that is by putting things in the circuit that use the current flow to light up, make noise, run programs, etc. These things are called loads, because they "load down" the power supply, just like you are "loaded down" when you're carrying something.

Short Circuit

If you connect a wire directly from the positive to the negative side of a power supply, you'll create what is called a short circuit. This is a very bad idea. If you don't have a load, there won't be anything to slow down the current, and it will try to be infinite! Your power supply can't provide infinite current, but it will provide as much as it can, which may be a lot. This could cause your wire to burn up, damage the power supply, drain your battery, or other exciting things. Most of the time your power supply will have some sort of safety mechanism built into it to limit the maximum current in the event of a short circuit, but not always. This is the reason all homes and buildings have circuit breakers, to prevent fires from starting in the event of a short circuit somewhere in the wiring.

Open Circuit

The opposite of a short circuit is an open circuit. This is a circuit where the loop isn't fully connected (and therefore this isn't really a circuit at all). Unlike the short circuit above, nothing will get hurt by this "circuit", but your circuit won't work either. If your circuit doesn't work, the most likely cause is an open circuit. This is usually due to a broken connection or a loose wire.

Series Circuits

Components connected in series are connected along a single conductive path, so the same current flows through all of the components but voltage is dropped (lost) across each of the resistances. In a series circuit, the sum of the voltages consumed by each individual resistance is equal to the source voltage.

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Parallel Circuits

Components connected in parallel are connected along multiple paths so that the current can split up; the same voltage is applied to each component. In a parallel circuit, the voltage across each of the components is the same, and the total current is the sum of the currents flowing through each component.

Alternating Current (AC)

The current that changes its magnitude and polarity at regular intervals of time is called an alternating current (AC). The major advantage of using the alternating current instead of direct current is that the alternating current is easily transformed from higher voltage level to lower voltage level. AC is used to deliver power to houses, office buildings, etc. AC can come in a number of forms, as long as the voltage and current are alternating. If we hook up an oscilloscope to a circuit with AC and plot its voltage over time, we might see a number of different waveforms. The most common type of AC is the sine wave.

Direct Current (DC)

Direct Current (DC) is defined as the "unidirectional" flow of current; current only flows in one direction. DC provides a constant voltage or current.

What's a PCB?

Printed circuit board is the most common name but may also be called "printed wiring boards" or "printed wiring cards". PCB is an acronym for printed circuit board. It is a board that has lines and pads that connect various points together. A PCB allows signals and power to be routed between physical devices. Solder is the metal that makes the electrical connections between the surface of the PCB and the electronic components. Being metal, solder also serves as a strong mechanical adhesive.

What is Polarity?

Polarity indicates whether a circuit component is symmetric or not. A non-polarized component - a part without polarity - can be connected in any direction and still function the way it's supposed to function. A symmetric component rarely has more than two

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terminals, and every terminal on the component is equivalent. You can connect a non-polarized component in any direction, and it'll function just the same.

A polarized component -- a part with polarity -- can only be connected to a circuit in one direction. A polarized component might have two, twenty, or even two-hundred pins, and each one has a unique function and/or position. If a polarized component was connected to a circuit incorrectly, at best it won't work as intended. At worst, an incorrectly connected polarized component will smoke, spark, and be one very dead part.

Breadboard

An electronics breadboard (as opposed to the type on which sandwiches are made) is actually referring to a solderless breadboard. These are great units for making temporary circuits and prototyping, and they require absolutely no soldering.

Prototyping

Prototyping is the process of testing out an idea by creating a preliminary model from which other forms are developed or copied, and it is one of the most common uses for breadboards. If you aren't sure how a circuit will react under a given set of parameters, it's best to build a prototype and test it out.

True RMS multimeter or AR multimeter

A True RMS (Root Mean Square) multimeter is a type of multimeter that is able to accurately measure both sinusoidal and non-sinusoidal AC waveforms. Other types of multimeters – such as an Average Responding Multimeter or Oscilloscope – are only able to measure sinusoidal AC waveforms.

AC waveforms

Sinusoidal (sine) waves: Symmetrical transitions between circular peaks and valleys, without distortion. Sometimes known as Pure AC Waveforms.

Non-sinusoidal waves: Waves that have irregular patterns such as pulse trains, square waves, sawtooth waves, angular waves, and spikes. Effectively any wave that is not a sinusoidal wave.

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Common Electronics Units

We will go through some of the most commonly used units in electronics now.

There are a lot of units to describe physical quantities. For example, length can be measured by the foot, meter, fathom, and so on. In order to better communicate measurements, we needed a standardized system of units, which every scientist and measurer could use to share their findings. This standardized system has come to be called the **International System of Units**, abbreviated **SI**.

Physical SI Units is a standardized way for every scientist to share their measurements. You can find them in Table 1 below.

	SI Unit	Unit Abbreviation
Time	second	s
Length	meter	m
Mass	gram	g
Temperature	kelvin	K
Force	newton	N

Table 1. Physical SI units

The common electronics units are (see below, Table 2):

	SI Unit	Unit Abbreviation
Electric Potential Difference (Voltage)	volts	V
Electric Current	ampere	A
Power	watt	W
Energy/Work/Heat	joule	J
Electric Charge	coulomb	C
Resistance	ohm	Ω
Capacitance	farad	F
Inductance	henry	H
Frequency	hertz	Hz

Table 2. Common electronics units

Let's look at how they can be augmented with prefixes. These are what we'll consider the standard six prefixes (see below, Table 3):

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Prefix (Symbol)	Power	Numeric Representation
kilo (k)	10^3	1,000
hecto (h)	10^2	100
deka (da)	10^1	10
no prefix	10^0	1 unit
deci (d)	10^{-1}	0.1
centi (c)	10^{-2}	0.01
milli (m)	10^{-3}	0.001

Table 3. Standard prefixes

When learning about electronics, the range of prefixes well exceeds the standard six. While these prefixes cover a range of 10^{-3} to 10^3 , many electronic values can have a much larger range. The prefixes in Table 4 help to describe quantities of units in large amounts.

Prefix (Symbol)	Power	Numeric Representation
yotta (Y)	10^{24}	1 septillion
zetta (Z)	10^{21}	1 sextillion
exa (E)	10^{18}	1 quintillion
peta (P)	10^{15}	1 quadrillion
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

Table 4. Prefixes for large amounts

There are also prefixes for helping to describe a very small numbers as well (See below, Table 5).

Prefix (Symbol)	Power	Numeric Representation
no prefix	10^0	1 unit
milli (m)	10^{-3}	1 thousandth
micro (μ)	10^{-6}	1 millionth
nano (n)	10^{-9}	1 billionth
pico (p)	10^{-12}	1 trillionth
femto (f)	10^{-15}	1 quadrillionth
atto (a)	10^{-18}	1 quintillionth
zepto (z)	10^{-21}	1 sextillionth
yocto (y)	10^{-24}	1 septillionth

Table 5. Prefixes for very small amounts

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Identifying Polarized Components

Whether you're plugging parts into a breadboard, soldering them to a PCB, it's critical to be able to identify polarized components and to connect them in the correct direction.

Let's discuss which components do and don't have polarity, how to identify component polarity, and how to test some components for polarity.

Diode and LED

Diodes only allow current to flow in one direction, and they are always polarized. A diode has two terminals. The positive side is called the anode, and the negative one is called the cathode. Current through a diode can only flow from the anode to the cathode, which would explain why it's important for a diode to be connected in the correct direction. Physically, every diode should have some sort of indication for either the anode or cathode pin. Usually the diode will have a line near the cathode pin, which matches the vertical line in the diode circuit symbol.

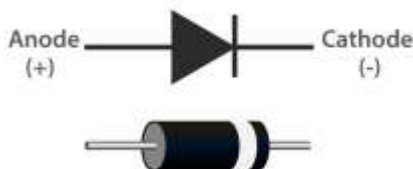


Image credit: byjus.com

LED stands for light-emitting diode, they're polarized. There are a handful of identifiers for finding the positive and negative pins on an LED. You can try to find the longer leg, which should indicate the positive, anode pin. Or, if someone's trimmed the legs, try finding the flat edge on the LED's outer casing. The pin nearest the flat edge will be the negative, cathode pin. There might be other indicators as well. SMD diodes have a range of anode/cathode identifiers. Sometimes it's easiest to just use a multimeter to test for polarity. Turn the multimeter to the diode setting (usually indicated by a diode symbol), and touch each probe to one of the LED terminals. If the LED lights up, the positive probe is touching the

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anode, and the negative probe is touching the cathode. If it doesn't light up, try swapping the probes around.

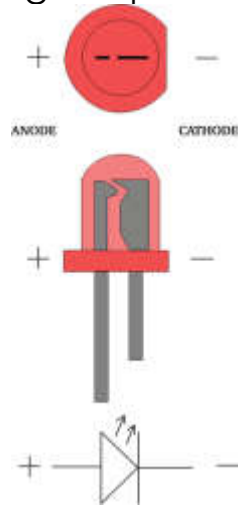


Image credit: clker.com

Integrated Circuits

Integrated circuits (ICs) might have eight pins or eighty pins, and each pin on an IC has a unique function and position. It's very important to keep polarity straight with ICs. There's a good chance they'll smoke, melt, and be ruined if connected incorrectly.

Through-hole ICs usually come in a dual-inline package (DIP) - two rows of pins, each spaced by 0.1" wide enough to straddle the center of a breadboard. DIP ICs usually have a notch to indicate which of the many pins is the first. If not a notch, the IC might have an etched dot in the casing near pin 1.

For all IC packages, pin numbers increase sequentially as you move counter-clockwise away from pin 1.

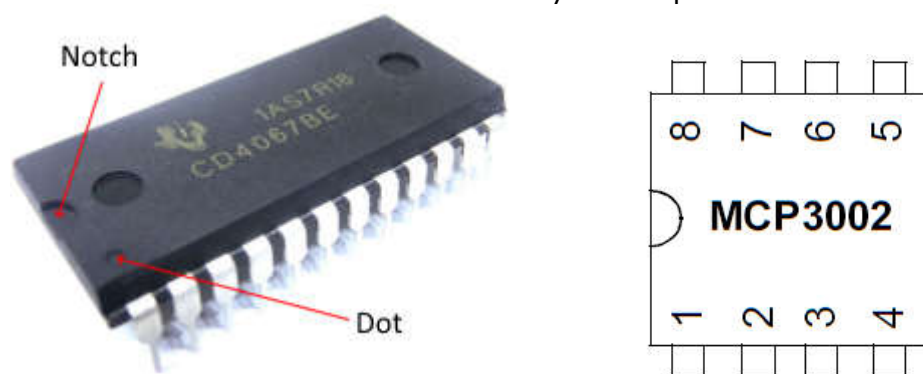
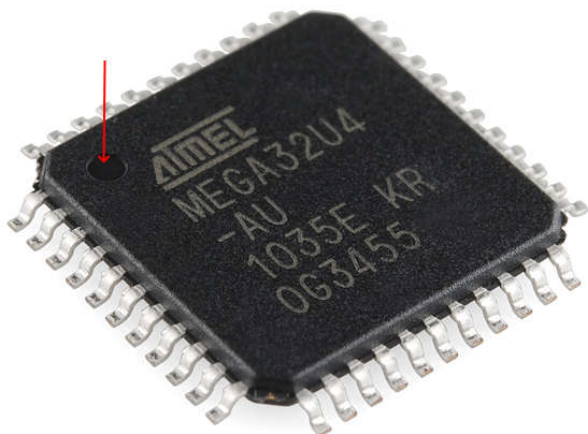


Image credit: Acoptex

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Surface-mount ICs might come in QFN, SOIC, SSOP, or a number of other form-factors. These ICs will usually have a dot near pin 1.



Electrolytic Capacitors

Not all capacitors are polarized, but when they are, it's very important not to mix their polarity up. Ceramic capacitors - the small (1 μ F and less), commonly yellow guys - are not polarized. You can stick those in either way. Electrolytic caps (they've got electrolytes), which look like little tin cans, are polarized. The negative pin of the cap is usually indicated by a "-" marking, and/or a colored strip along the can. They might also have a longer positive leg. You can see 10 μ F electrolytic capacitor (left), which has a dash symbol to mark the negative leg, as well as a longer positive leg. Applying a negative voltage for an extended period to an electrolytic capacitor results in a briefly exciting, but catastrophic, failure. They'll make a pop, and the top of the cap will either swell or burst open. From then on the cap will be as good as dead, acting like a short circuit.



Image credit: Acoptex

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Batteries and Power Supplies

Getting polarity right in your circuit all starts and ends with getting the power supply connected correctly. Anyone that's ever replaced batteries knows how to find their polarity. Most batteries will indicate the positive and negative terminals with a "+" or "-" symbol. Other times it might be red wire for positive and a black wire for negative. Power supplies usually have a standardized connector, which should usually have polarity itself. A barrel jack, for example, has two conductors: outer and inner; the inner/center conductor is usually the positive terminal. Other connectors, like a JST, are keyed so you just can't connect them backwards.

Transistors, MOSFETs, and Voltage Regulators

These (traditionally) three-terminal, polarized components are lumped together because they share similar package types. Through-hole transistors, MOSFETs, and voltage regulators commonly come in a TO-92 or TO-220 package, seen below. To find which pin is which, look for the flat edge on the TO-92 package or the metal heatsink on the TO-220, and match that up to the pin-out in the datasheet.

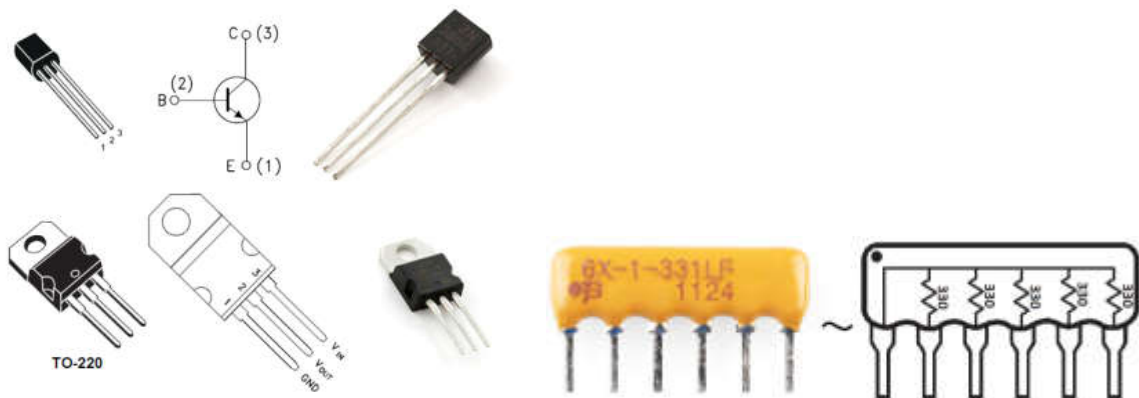


Image credit: Sparkfun

Others

This is just the tip of the polarized-component iceberg. Even non-polarized components, like resistors, can come in polarized packages. A resistor pack - a grouping of five-or-so pre-arranged resistors (330 ohm each) - is one such example (see above).

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Parts of a Multimeter



Image credit: Acoptex

A multimeter is has three parts:


1. Display
2. Selection Knob
3. Ports

The display usually has four digits and the ability to display a negative sign. A few multimeters have illuminated displays for better viewing in low light situations.

The selection knob allows the user to set the multimeter to read different things such as milliamps (mA) of current, voltage (V) and resistance (Ω).

The probes are plugged into the input ports on the front of the unit. COM stands for common and is almost always connected to Ground or '-' of a circuit. The COM probe is black but there is no difference between the red probe and black probe other than color. 10A or **20A MAX** is the special input port used when measuring large currents (more than 200mA). **mA**, **VΩmA** or **VΩ→°C°F** is the port that the red probe is plugged in to. **mA** port allows the measurement of current; **VΩmA** allows the measurement of

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current (mA), voltage (V), and resistance (Ω);  allows the measurement of voltage (V), resistance (Ω), temperature (C), temperature (F) and do diode test. The probes have a banana type connector on the end that plugs into the multimeter.

Any probe with a banana plug will work with this meter. This allows for different types of probes to be used.

There are many different types of probes available for multimeters.



Image credit: Acoptex



Image credit: Acoptex



Image credit: Acoptex



Image credit: Acoptex

1. Banana to Alligator Clips.

These are great cables for connecting to large wires or pins on a breadboard. Good for performing longer term tests where you don't have to have to hold the probes in place while you manipulate a circuit.

2. Banana to IC Hook. IC hooks work well on smaller ICs and legs of ICs.









3. Banana to Tweezers. Tweezers are handy if you are needing to test SMD components.

4. Banana to Test Probes. If you ever break a probe, they are cheap to replace.














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Multimeter Symbols' Meanings

























In this section, I am going to give you a quick rundown of how to read multimeter symbols, so you can measure and master your next project with ease!

	This button locks your meter reading/measurement into place after you've taken it. This is especially helpful if you are doing a project that requires you to keep an exact measurement at your fingertips. It's also a great feature if, during a testing of the probes, you can't read your multimeter in full.
Continuity 	The moment continuity is discovered within two points, the meter will automatically emit an audible tone. This is an excellent and great way for finding short circuits, or open circuits.
Diode test 	This function is used to test a diode, which is like a one-way valve for electricity; it only lets current flow in one direction. It will tell you if you are dealing with a good or bad diode.
Capacitance (Capacitance test) 	This is normally the shift option on your diode test button. It measures your capacitance very well.
Direct Current Voltage (DCV) 	This voltage setting allows the user to test small electronic circuits, batteries and as well indicator lights on the car. Most people come across dc voltage and it is usually under 30 volts dc.
Alternating Current Voltage (ACV) 	This setting is used to measure the voltage from alternating current sources, which is pretty much anything that plugs into an outlet, as well as the power coming from the outlet itself.
Alternating Current (AC current) 	It allows you know the amount of load an item is utilizing.
	Alternating Current (AC)


Multimeter Basics Step by Step

	<p>This button is usually based across the top of the multimeter and has a sign in form of "Lo/Hi" above it. This button will help you view through different meter ranges. A lot of multimeters have auto-ranging now.</p>
<p>Direct current amperage (DCA) (DC current)</p> 	<p>This button posses the same attributes as the alternating current button but measures direct current instead.</p>
<p>Resistance (Ω)</p> 	<p>This measures how much resistance there is in the circuit. The lower the number, the easier it is for the current to flow through, and vice versa.</p>
	<p>Direct Current (DC)</p>
	<p>Both Alternating Current (AC) and Direct Current (DC)</p>
	<p>Grounding</p>
<p>Direct Current Gain (hFE)</p> 	<p>This setting is to test transistors and their DC gain, but it's mostly useless, since most electricians and hobbyists will use the continuity check instead.</p>
<p>Hertz</p> 	<p>This is utilized to measure the frequency of your circuit or appliance. Every equipment and circuit is programmed to function at either variable or fixed frequency.</p>
<p>Brightness indicator</p> 	<p>This is an important button especially if you're working in a dimly lit area. By pressing the brightness button, light comes on which lights your screen and makes it possible for you to read results in the dark.</p>
<p>DC millivolts</p> 	<p>This is normally based right next to the AC millivolts button. It has a similar role as AC millivolts, but utilizes DC voltage.</p>
<p>AC millivolts</p> 	<p>It is used to test small circuits using AC Voltage setting that are especially low.</p>
	<p>Common jack. It is almost always connected to Ground or '-' of a circuit.</p>
	<p>This is utilized to measure the Centigrade temperature</p>

Multimeter Basics Step by Step

	This is utilized to measure the Fahrenheit temperature
	The continuity buzzer
	Conforms to European Union directives.
Min/Max button 	Save input values. The multimeter will beep when a high/low value is exceeded and the new value is saved.
Function Button 	Allows you to activate secondary functions around the dial usually indicated with yellow text or icons. Comparable to a Ctrl or Alt key on a keyboard.
Auto-V/LoZ 	Found on some models, it prevents false measurements because of ghost voltage.
	Consult user documentation.
	WARNING. RISK OF DANGER.
 	Current jack. This should only be used to measure currents with clamp attachments, or with a red lead.
	Double Insulated
  	Red jack. It measures pretty much everything except for current. That means it can help read temperature, duty cycle, frequency, resistance, and voltage, among others.
	WARNING. Risk of electric shock. HAZARDOUS VOLTAGE.
	Battery
	Conforms to relevant South Korean EMC Standards.
	Certified by TÜV SÜD Product Service.
	Certified by CSA Group to North American safety standards.
	Fuse
	Deficiency of Built-in battery
 	Square Wave output
	Duty cycle in %



Multimeter Basics Step by Step

	Used to test PNP and NPN transistors
NCV	Non Contact Voltage. Non-contact voltage detectors don't need to physically touch the measured hardware. They work by sensing the AC electric field created by live AC wires.
Fcx	Capacitance Measurement

Multimeter Basics Step by Step

DC Voltage Measurement

Let's measure voltage on a AA battery (1.5 V DC).

- Make sure the Sleep Mode is not on if you found there is no display on the LCD after turning on the Meter.
- Make sure the Low Battery Display is not on , otherwise false readings may be provided.
- Pay extra attention to the  symbol which is located besides the input terminals of the Meter before carrying out measurement.

Step by Step instruction:

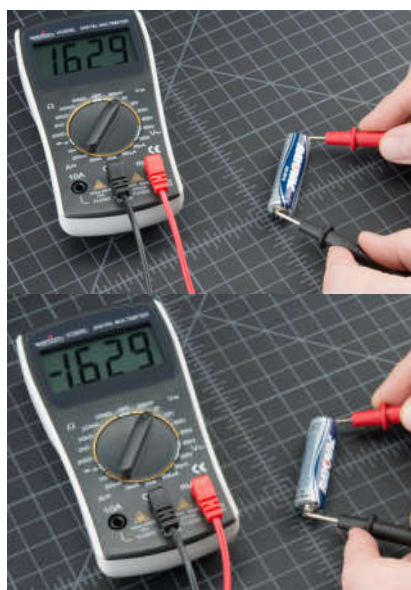


Image credit: Sparkfun

1. Insert black test probe banana plug into the **COM** input terminal.
2. Insert the red test probe banana plug into the **mAVΩ** input terminal.
3. Set the selection knob (rotary switch) to an appropriate measurement position in DCV range ("**2V**" in the DC (direct current) range. Almost all portable electronics use DC.
4. Connect the test probes across with the battery being measured - the black probe to the battery's ground or '-' and the red probe to power or '+'. Squeeze the probes with a little pressure against the positive and negative terminals of the AA battery.
5. The measured value will be shown on the display. What happens if you switch the red and black probes? The reading on the multimeter is simply negative.
6. When finished, remove the probes in reverse order: red first, then black.

Multimeter Basics Step by Step

When you are doing your DIY projects you need to be sure that your circuit is powered up correctly. If your project should be at 5V but is less than 4.5V or greater than 5.5V, this would quickly give you an indication that something is wrong and you may need to check your power connections or the wiring of your circuit.



Image credit: Sparkfun

Set the knob to "**20V**" in the DC range (the DC Voltage range has a V with a straight line next to it). Multimeters are generally not autoranging. You have to set the multimeter to a range that it can measure. For example, 2V measures voltages up to 2 volts, and 20V measures voltages up to 20 volts. So if you're measuring a 12V battery, use the 20V setting. 5V system? Use the 20V setting.



What happens if you select a voltage setting that is too low for the voltage you're trying to measure? The multimeter will simply display a **1**. This is the meter trying to tell you that it is overloaded or out-of-range. Whatever you're trying to read is too much for that particular setting. Try changing the multimeter knob to the next highest setting. If the value of voltage to be measured is unknown, use the maximum measurement position (**600V**) and reduce the range step by step until a satisfactory reading is obtained.



Image credit: Sparkfun

Multimeter Basics Step by Step

AC Voltage Measurement

- Make sure the Sleep Mode is not on if you found there is no display on the LCD after turning on the Meter.
- Make sure the Low Battery Display is not on , otherwise false readings may be provided.
-  To avoid harms to you or damages to the multimeter from electric shock, please do not attempt to measure voltages higher than the maximum readings (600V or 1000V, depends on your multimeter).

Step by Step instruction:



Image credit: Acoptex

1. Insert black test probe banana plug into the **COM** input terminal.

2. Insert the red test probe banana plug into the **mAVΩ** input terminal.

3. Set the selection knob (rotary switch) to an appropriate measurement position in ACV range.

4. Connect the test probes across with the object being measured.

5. The measured value will be shown on the display. If the value of voltage to be measured is unknown, use the maximum measurement position (**600V**) and reduce the range step by step until a satisfactory reading is obtained. What happens if you select a voltage setting that is too low for the voltage you're trying to measure? The multimeter will simply display a **1**. This is the meter trying to tell you that it is overloaded or out-of-range.

6. When AC voltage measurement has been completed, disconnect the connection between the testing leads and the circuit under test.
7. When finished, remove the probes in reverse order: red first, then black.

Multimeter Basics Step by Step

Continuity test

Continuity testing is the act of testing the resistance between two points. If there is very low resistance (less than a few Ω s), the two points are connected electrically, and a tone is emitted. If there is more than a few Ω s of resistance, then the circuit is open, and no tone is emitted.

Step by Step instruction:



Image credit: fluke.com

Image credit: Sparkfun



1. Insert black test probe banana plug into the **COM** input terminal.

2. Insert the red test probe banana plug into the **mAV Ω** input terminal.

3. Set the selection knob (rotary switch) to the **Continuity** mode position. It may vary among digital multimeters, but look for a diode symbol with propagation waves around it (like sound coming from a speaker)

4. Touch the probes together. The multimeter should emit a tone. This shows that a very small amount of current is allowed to flow without resistance (or at least a very very small resistance) between probes.

5. Turn off the power supply to your circuit before doing a continuity check. If your circuit has a power switch, you can do this by turning the switch "off." If there is no switch, you can remove the batteries.

6. Connect the test probes across the component being tested. The multimeter beeps if a complete path (is detected. If the circuit is open (the switch is in the OFF position), the multimeter will not beep and might display something on the screen such as "OL," "OVER," or "1," which all stand for "overload."

7. When finished, remove the probes in reverse order: red first, then black.

Multimeter Basics Step by Step

Diode test



To avoid damage to the multimeter or to the equipment under test, disconnect circuit power and discharge all high-voltage capacitors before measuring diodes and continuity.

Use the diode test to check diodes, transistors, and other semiconductor devices. The diode test sends a current through the semiconductor junction, and then measures the voltage drop across the junction.

Connect the test leads to the proper terminals as said below to avoid error display. The LCD will display "1" indicating open-circuit for wrong connection.

Step by Step instruction:



Image credit: Acoptex



Image credit: fluke.com

1. Insert black test probe banana plug into the **COM** input terminal.
2. Insert the red test probe banana plug into the **mAVΩ** input terminal.
3. Set the selection knob (rotary switch) to the **Diode test** mode position.
4. Turn off the power supply to your circuit before doing a diode check. If your circuit has a power switch, you can do this by turning the switch "off." If there is no switch, you can remove the batteries.
5. For forward voltage drop readings on any semiconductor component, place the red test probe on the component's anode and place the black test probe on the component's cathode.
6. The measured value shows on the display. In a circuit, a good diode should still produce a forward voltage drop reading of 0.5V to 0.8V; however; the reverse voltage drop reading can vary depending on the resistance of other pathways between the probe tips.
7. When finished, remove the probes in reverse order: red first, then black.

Multimeter Basics Step by Step

Temperature Measurement



To avoid harm to you or damages to the Meter, do not attempt to measure voltages higher than 60V in DC or 30V rms in AC although readings may be obtained.

Step by Step instruction:

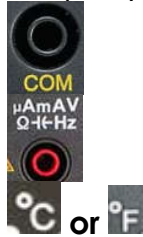


Image credit: Acoptex



Rod type temperature probe
Image credit: Protek

1. Insert black test probe banana plug into the **COM** input terminal.
2. Insert the red test probe banana plug into the **mAVΩ** input terminal.
3. Set the selection knob (rotary switch) to the **°C** or **°F** position.
4. Place the temperature probe to the object being measured.
5. The measured value shows on the display. The multimeter automatically displays the temperature value inside the multimeter when there is no temperature probe connection.
6. The temperature probe can only be measured up to 250 °C any measurement higher than that, the rod type temperature probe must be used instead. When temperature measurement has been completed, disconnect the connection between the testing probes and the circuit under test.
7. When finished, remove the probes in reverse order: red first, then black.



Temperature probe
Image credit: Acoptex

Multimeter Basics Step by Step

Capacitance Measurement

A multimeter determines capacitance by charging a capacitor with a known current, measuring the resulting voltage, then calculating the capacitance.



A good capacitor stores an electrical charge and may remain energized after power is removed. Before touching it or taking a measurement, a) turn all power OFF, b) use your multimeter to confirm that power is OFF and c) carefully discharge the capacitor by connecting a resistor across the leads. Be sure to wear appropriate personal protective equipment. Use your multimeter to confirm the capacitor is fully discharged.

Step by Step instruction:



Image credit: Acoptex



Image credit: fluke.com

1. Insert black test probe banana plug into the **mA** input terminal.
2. Insert the red test probe banana plug into the **VΩ°C°F** input terminal.
3. Set the selection knob (rotary switch) to an appropriate measurement position in **Fcx** range or select capacitance mode.
4. Visually inspect the capacitor. If leaks, cracks, bulges or other signs of deterioration are evident, replace the capacitor.
5. Connect the test probes across with the object being measured. For testing the capacitor with polarity, connect the red test lead to anode & black test lead to cathode. For a correct measurement, the capacitor will need to be removed from the circuit.
6. The measured value shows on the display. When the tested capacitor is shorted or the capacitor value is overloaded, the LCD display "1". To minimize the measurement error caused by the distributed capacitor, the testing probe or testing clip should be as short as possible. When the tested capacitor is greater than 30 F, **m** reading is for reference only. It will display OL if a) the capacitance value is higher than the measurement range or b) the capacitor is faulty.
7. It is normal to take a while for zeroing when changing over the measurement range. This process will not affect the

Multimeter Basics Step by Step

Measuring Resistance

Why measure resistance? To determine the condition of a circuit or component. The higher the resistance, the lower the current flow, and vice versa. In general, the resistance of components used to control circuits (such as switches and relay contacts) starts out very low and increases over time due to factors such as wear and dirt. Loads such as motors and solenoids decrease in resistance over time due to insulation breakdown and moisture.



To avoid damages to the multimeter or to the devices under test, disconnect circuit power and discharge all the high-voltage capacitors before measuring resistance.

Step by Step instruction:



Image credit: Acoptex



Image credit: fluke.com

1. Insert black test probe banana plug into the **COM** input terminal.

2. Insert the red test probe banana plug into the **mAVΩ** input terminal.

3. Set the selection knob (rotary switch) to an appropriate measurement position in



range.

4. Connect the test leads across with the object being measured. Make sure that contact between the test leads and circuit is good.

5. The measured value shows on the display. Best results will be achieved if the component to be tested is removed from the circuit. If the component is left in the circuit, the readings could be affected by other components in parallel with the component to be tested.

6. When finished, remove the probes in reverse order: red first, then black.

7. Remember that measuring resistance is not perfect. Temperature can affect the reading a lot. Also, measuring resistance of a device while it is physically installed in a circuit can be very tricky. The surrounding components on a circuit board can greatly affect the reading.

Multimeter Basics Step by Step

For example we will pick up a 1 k Ω resistor and set the multimeter to the 20k Ω setting. Then hold the probes against the resistor legs with the same amount of pressure you when pressing a key on a keyboard. The meter will read one of three things - 0.00, 1, or the actual resistor value. In my case, the meter reads 0.97, which means that this resistor has a value of 970 Ω , or about 1k Ω (remember you are in the 20k Ω or 20,000 Ohm mode so you need to move the decimal three places to the right or 970 Ohms). If the multimeter reads 1 or displays OL, it's overloaded.

You will need to try a higher mode such as 200k Ω mode or 2M Ω (megaohm) mode. There is no harm if this happen, it simply means the range knob needs to be adjusted. If the multimeter reads 0.00 or nearly zero, then you need to lower the mode to 2k Ω or 200 Ω .

Remember that many resistors have a 5% tolerance. This means that the color codes may indicate 10,000 Ohms (10k Ω), but because of discrepancies in the manufacturing process a 10k Ω resistor could be as low as 9.5k Ω or as high as 10.5k Ω . Don't worry, it'll work just fine as a pull-up or general resistor.



20 K Ω selected

Image credit: Sparkfun



2 K Ω selected

Image credit: Sparkfun

Let's drop the meter down to the next lowest setting, 200 Ω . Not a whole lot changed. Because this resistor (a 1K Ω) is less than 2K Ω , it still shows up on the display. However, you'll notice that there is one more digit after the decimal point giving us a slightly higher resolution in our reading. What about the next lowest setting? Now, since 1k Ω is greater than 200 Ω , we've maxed out the meter, and it is telling you that it is overloaded and that you need to try a higher value setting.



200 Ω selected. Image credit: Sparkfun

Multimeter Basics Step by Step

DC Current Measurement

Reading current is one of the trickiest and most insightful readings in the world of embedded electronics.



Never attempt an in-circuit current measurement where the open circuit voltage between terminals and ground is greater than 60V DC or 30V rms. If the fuse burns out during measurement, the multimeter may be damaged or the operator himself may be hurt. Use proper terminals, function, and range for the measurement. When the testing probes are connected to the current terminals, do not parallel them across any circuit.

Step by Step instruction:



Image credit: Acoptex

1. Turn off power to the circuit. Discharge all high-voltage capacitors.

1. Insert black test probe banana plug into the **COM** input terminal.

2. Insert the red test probe banana plug into the **mAVΩ** input terminal (current less than 200mA) or 10A input terminal (current more than 200mA).

3. Set the selection knob (rotary switch) to an appropriate measurement position in **DCA A=** range.

4. Break the current path to be tested. Connect the red test probe to the more positive side of the break and the black test probe to the more negative side of the break. I suggest to use alligator clips. When measuring current, it's often good to watch what your system does over time, for a few seconds or minutes. While you might want to stand there and hold the probes to the system, sometimes it's easier to free up your hands. These alligator clip probes can come in handy.

5. Turn on power to the circuit. The measured value shows on the display.

6. If the value of current to be measured is unknown, I use the maximum measurement position (10A) and 10A terminal, and reduce the range step by step until a satisfactory reading is obtained.

7. Turn off power to the circuit. Discharge all high-voltage capacitors.

8. When finished, remove the probes in reverse order: red first, then black.

Multimeter Basics Step by Step

Important. When you're done using the multimeter, always return the multimeter to read voltage (return the probes to the voltage port, set the multimeter to read the DC voltage range if necessary). It's common to grab a multimeter and begin to quickly measure the voltage between two pins. If you have left your multimeter in 'current' mode, you won't see the voltage on the display. Instead you'll see '0.000' indicating that there is no current between power and ground. Within that split second you will have connected power to ground through your multimeter and the fuse will blow.

AC Current Measurement



Never attempt an in-circuit current measurement where the voltage between terminals and ground is greater than 60V. If the fuse burns out during measurement, the multimeter may be damaged or the operator himself may be hurt. Use proper terminals, function, and range for the measurement. When the testing leads are connected to the current terminals, do not parallel them across any circuit.

Step by Step instruction:



Image credit: Acoptex

1. Turn off power to the circuit. Discharge all high-voltage capacitors.

1. Insert black test probe banana plug into the **COM** input terminal.

2. Insert the red test probe banana plug into the **mA** input terminal (current less than 200mA) or **20A** input terminal (current more than 200mA).

3. Set the selection knob (rotary switch) to an appropriate measurement position in **A~** range.

4. Break the current path to be tested. Connect the red test probe to the more positive side of the break and the black test probe to the more negative side of the break. I suggest to use alligator clips. When measuring current, it's often good to watch what your system does over time, for a few seconds or minutes. While you might want to stand there and hold the probes to the system, sometimes it's easier to free up your hands. These alligator clip probes can come in handy.

5. Turn on power to the circuit. The measured value shows on the display.

6. If the value of current to be measured is

Multimeter Basics Step by Step

unknown, I use the maximum measurement position (20A) and 20A terminal, and reduce the range step by step until a satisfactory reading is obtained.

7. Turn off power to the circuit. Discharge all high-voltage capacitors.

8. When finished, remove the probes in reverse order: red first, then black.

Duty Cycle Measurement

Step by Step instruction:

1. Set the selection knob (rotary switch) to measure frequency. The steps can vary by meter. Usually a multimeter's dial will be

turned to **V_~** and the **Hz** button is pressed. The multimeter is ready to measure duty cycle when a percent sign (%) appears in the right side of the multimeter's display.

2. Insert black test probe banana plug into the **COM** input terminal.

3. Insert the red test probe banana plug into the **V Ω** input terminal.

4. Connect the test leads to the circuit to be tested.

5. Read the measurement in the display. A positive symbol (+) indicates POSITIVE time percent voltage measurement. A negative symbol (-) indicates NEGATIVE time percent voltage measurement. Note: A positive reading typically indicates a circuit's ON time and a negative reading its OFF time. On occasion a negative portion of the signal can create an ON signal.

6. Press the beeper button (beeper button) to toggle between POSITIVE time and NEGATIVE time percent voltage measurement. Note: The button used varies by digital multimeter. Refer to your model's user manual for specific instructions.

7. When finished, remove the leads in reverse order: red first, then black.



Image credit: fluke.com

Multimeter Basics Step by Step

Duty cycle basics

- Duty cycle is the ratio of time a load or circuit is ON to the time a load or circuit is OFF. A load that is turned ON and OFF several times per second has a duty cycle.
- Why do this? Many loads are rapidly cycled on and off by a fast-acting electronic switch to accurately control output power at the load. Lamp brightness, heating element outputs and magnetic strength of a coil can be controlled by duty cycle.
- Duty cycle is measured in percentage of ON time. Example: A 60% duty cycle is a signal that is on 60% of the time and off 40% of the time.
- An alternate way to measure duty cycle is dwell, measured in degrees instead of percent.
- When measuring duty cycle, a digital multimeter displays the amount of time the input signal is above or below a fixed trigger level – the fixed level at which the multimeter counter is triggered to record frequency. Slope is the waveform edge on which the trigger level is selected.
- The percent of time above the trigger level is displayed if the positive trigger slope is selected. Conversely, the percent of time below the trigger level is displayed if the negative trigger slope is selected. The slope selected is indicated by a positive (+) or negative (-) symbol in the display. Most multimeters default to display the positive trigger slope; the negative trigger slope is usually selected by pressing an additional button. Refer to a your multimeter user manual for specifics.

Troubleshooting

If your multimeter isn't working there are several common mistakes that can be easily fixed:

- Make sure your multimeter has fresh batteries.
- Some multimeters have an auto power-saving feature, and will turn off after a certain period of inactivity. If this happens, turn your multimeter's dial to "off" and then turn it on again.
- Make sure you have your probes plugged into the correct ports for what you want to measure.
- Make sure you are connecting your probes to your circuit in the correct manner (series or parallel) for what you want to measure.
- Make sure you have the correct setting chosen on your multimeter selection knob for what you want to measure; for example, if you need to measure DC voltage, make sure you don't have current, resistance, or AC voltage selected.
- If your multimeter is not auto-ranging, you might need to manually adjust your range. If your multimeter screen always reads "0," this might mean the range you have selected is too high. If it reads "OL," "OVER," or "1," the range you have selected could be too low.

Multimeter Basics Step by Step

- Each multimeter is different, so you might need to read your multimeter's manual to find out what the display on the screen means. You can then adjust the range accordingly.
- For example, if you are trying to measure the voltage of a 9V battery, but have your multimeter set to 2 DCV, this range is too small and you would have to increase it to a higher value, such as 20 DCV.

Still not working? You might have blown out a fuse in your multimeter. Some multimeters have a fuse (or multiple fuses) that will "burn out" when too much current flows through them, which then prevents more electricity from flowing, and hopefully saves the rest of the multimeter from damage. In some multimeters, these fuses can be replaced if they burn out, but instructions for replacing them (and figuring out if they need to be replaced at all) will vary for different multimeter models.

You will probably need to open up your multimeter to access the fuses (**Important: Always disconnect the probes before you do this**). Some multimeters have covers that will pop or slide off, and some have screws that must be removed first. Fuses usually look like small, glass cylinders with metal caps on the end and a thin wire running down the middle.



A typical fuse. Image credit: Acoptex

If a fuse has burned out, it might be visibly blackened or charred. The wire on the inside might have completely burned away, and no longer be visible.

Instructions for changing the fuse vary with each multimeter model, so you will need to check your multimeter's manual for instructions. This tutorial from SparkFun provides directions for changing a fuse on their brand of multimeter, but remember that these directions might not apply to your model. Note that in some multimeters-especially in inexpensive ones-you might not be able to change the fuse.