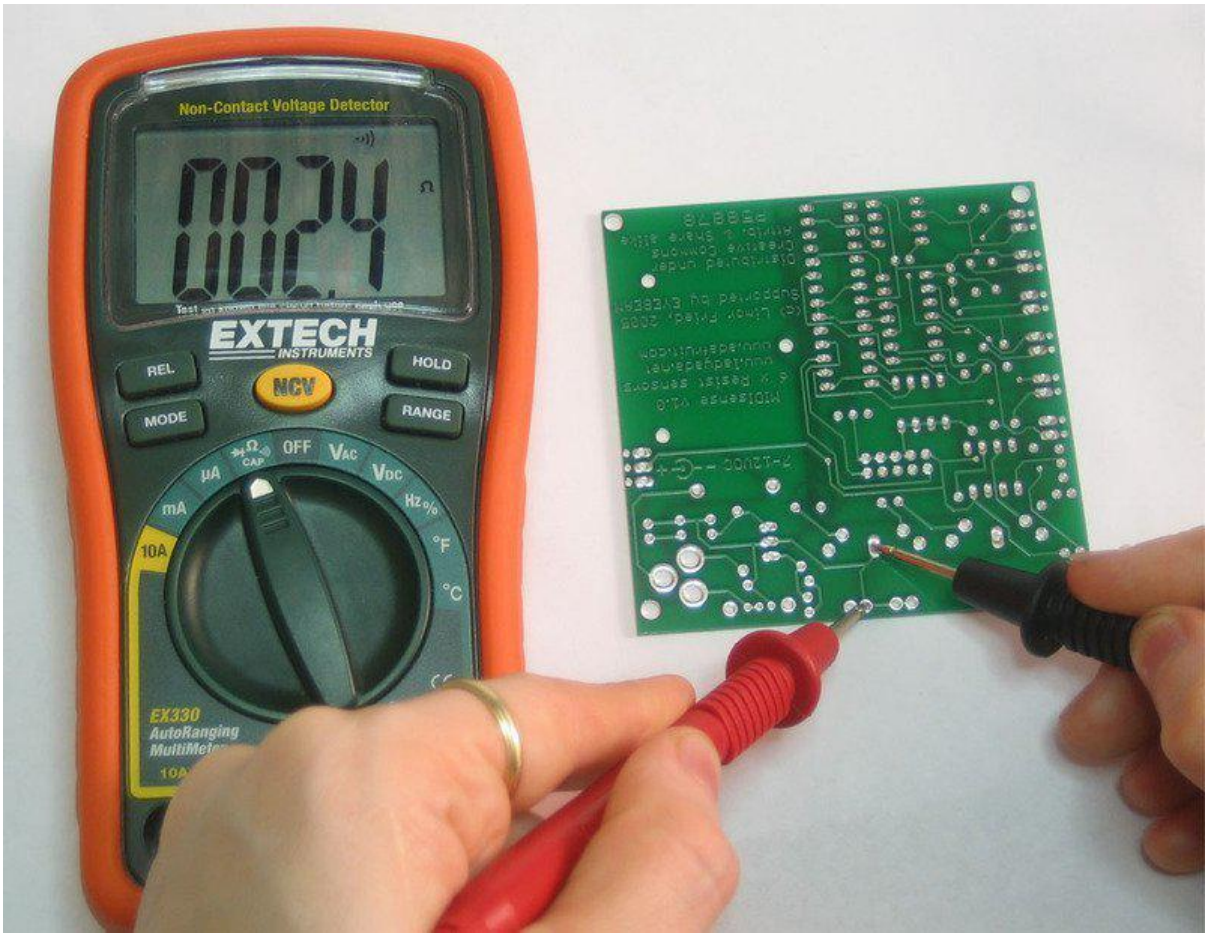
Multimeters

Created by lady ada



https://learn.adafruit.com/multimeters

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Overview

The most important debugging tool in any E.E.'s toolbox is a trusty multimeter. A multimeter can measure continuity, resistance, voltage and sometimes even current, capacitance, temperature, etc. It's a swiss army knife for geeks!

What to look for?

Everyone always asks, "What multimeter should I get?"

Well, since they're rather commodified (there are dozens of manufacturers) it is hard to make everyone use the same model, even though it would make things easier.

These are the necessities:

- Continuity testing with piezo buzzer
- Resistance test down to 10 ohm (or lower) and up to 1 Megaohm (or higher)
- DC voltage test down to 100mV (or lower) and up to 50V
- AC voltage test down to 1V and up to 400V (or 200V in the US/Canada/Japan)
- Diode testing

Here are nice things to have in your meter

- Auto-off - to keep from draining the batteries
- AC and DC current test, from 10mA to maybe 200mA and then also a 10A one as well
- Stand - a thing that flips out and keeps it upright on your table
- Auto-ranging - note: some people don't like auto-ranging because its slower and not as precise
- Hold - keep the maximum value on the screen so you can probe without looking at the meter.
- Common battery - such as 9V or AA's, pocket meters use hard-to-replace coin cells

These are things that I rarely (if ever) use, in descending order

- Frequency counter - before I had a scope this was surprisingly useful!
- Capacitance testing - usually to check random SMT caps
- Inductance testing - how often do you really use an inductor?
- Duty cycle - never used this

- Transistor beta meter - people don't really work with transistors anymore
- Temperature probe - I use the "Pease temperature test": a finger

Other Useful Resources

- TangentSoft's half-hour video tutorial ()
- Make Magazine's Bre & Joey Grand on how to use a multimeter ()
- Robot Platform tutorial on using digital multimeter ()

Continuity

What is Continuity?

You might be asking, "What is continuity?" But don't worry, it's quite simple! Continuity means, are two things electrically connected. So if two electronic parts are connected with a wire, they are continuous. If they are connected with cotton string, they are not: while they are connected, the cotton string is not conductive.

You can always use a resistance-tester (ohmmeter) to figure out if something is connected because the resistance of wires is very small, less than 100 ohms, usually. However, continuity testers usually have a piezo buzzer which beeps. This makes them very useful when you want to poke at a circuit and need to focus on where the probes are instead of staring at the meter display.

For some basic circuits you can just look to see where the wires go to determine continuity but it's always wise to use a multimeter. Sometimes wires break or you're tired and can't easily follow all the PCB traces. I use continuity check all the time!

What is it good for?

Continuity is one of the most important tests. Here are some things it is good for

- Determine if your soldering is good. If your solder joint it is a cold solder connection it will appear connected but in actually it is not! This can be really frustrating if you are not experienced in visually detecting cold solder joints
- Determine if a wire is broken in the middle. Power cords and headphone cables are notorious for breaking inside the shielding, it appears as if the cable is fine but inside the wires have been bent so much they eventually broke.
- Making sure something isn't connected. Sometimes a solder joint will short two connections. Or maybe your PCB has mistakes on it and some traces were shorted by accident. ()

- Reverse-engineering or verifying a design back to a schematic

Remember!

You can only test continuity when the device you're testing is not powered. Continuity works by poking a little voltage into the circuit and seeing how much current flows, its perfectly safe for your device but if its powered there is already voltage in the circuit, and you will get incorrect readings

Always test to make sure your meter is working before starting the test by brushing the two tips together, and verifying you hear the beep. Maybe the battery is low or its not in the right mode.

Continuity is non-directional, you can switch probes and it will be the same.

If you are testing two points in a circuit and there is a (big) capacitor between those points you may hear a quick beep and then quiet. That's because the voltage the meter is applying to the circuit is charging up the capacitor and during that time the meter 'thinks' its continuous (essentially)

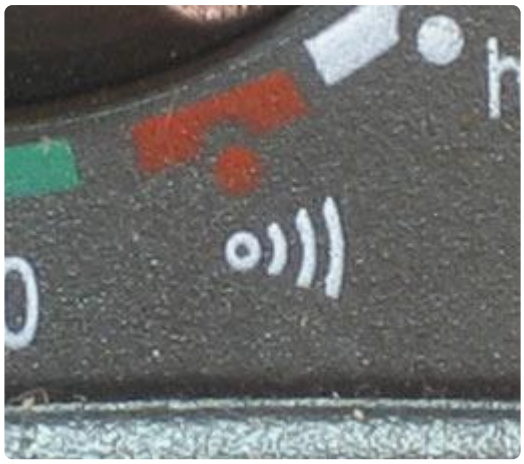
Small resistors (under 100 ohms or so) and also all inductors will seem like short circuits to a multimeter because they are very much like wires.

Likewise, continuity doesn't mean "short" it just means very very low resistance. For example, if you have a circuit that draws an Amp from a 5V supply, it will appear to be a 5Ω resistor. If you measure that with your meter it will think its a short circuit, but really its just a high-drain circuit.

Get Into the Mode

First step is to get your multimeter into the correct mode. Look for the icon that looks sort of like a 'sound wave'

Here are three examples. Note that sometimes the mode is "dual" (or possibly more) usage,



Turn the multimeter knob so that it points to this symbol.

Touch and Go

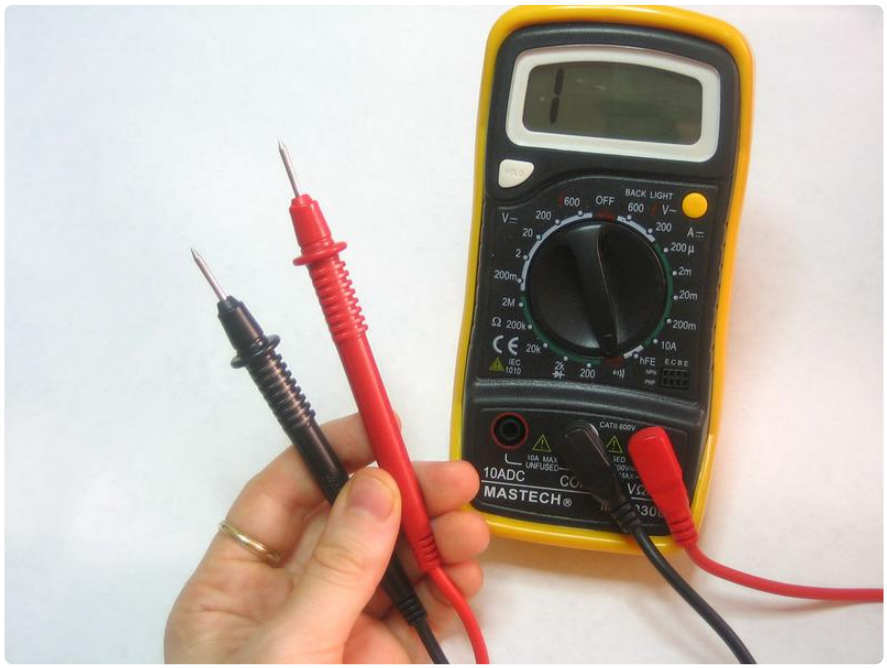
For a majority of multimeters, you're ready to go, just touch the tips of the probes together so that they make a beeping sound!

Here's a video demonstration:

Here are some examples covering a couple of different multimeters:

Example 1

This meter is very simple. When the probes are not touching, the display shows "1"



When you touch the tips together, the display changes to a three digit mode (it's displaying resistance, which we will cover later) It also emits a beep.

Example 2

This meter is dual-mode but still very easy to use. Turn the dial to the symbol. When the probes are not touching the display shows "OL" which stands for Open Loop. (Open loop is another way of saying there is no continuity).

When you touch the probes, the soundwave icon shows up in the display (upper right) and it also shows a number. The number is not the resistance, actually...its the voltage (look for the V in the right hand side for Volts). This is because this mode is also a Dio de Test (which will be discussed later).

Example 3

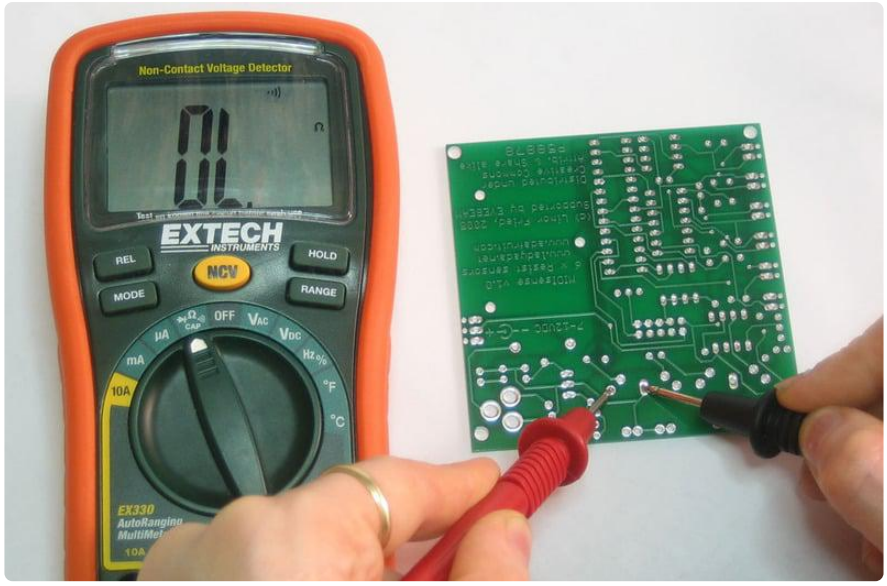
This meter is triple-mode and requires an extra step to get to the continuity function. Click on the image to get a closer view of the triple-mode. After you dial to this mode you must press the Mode button, the wave icon will then appear in the display.

You can see the wave icon in the top right as expected. This meter also displays OL (I've noticed that nicer meters do this).

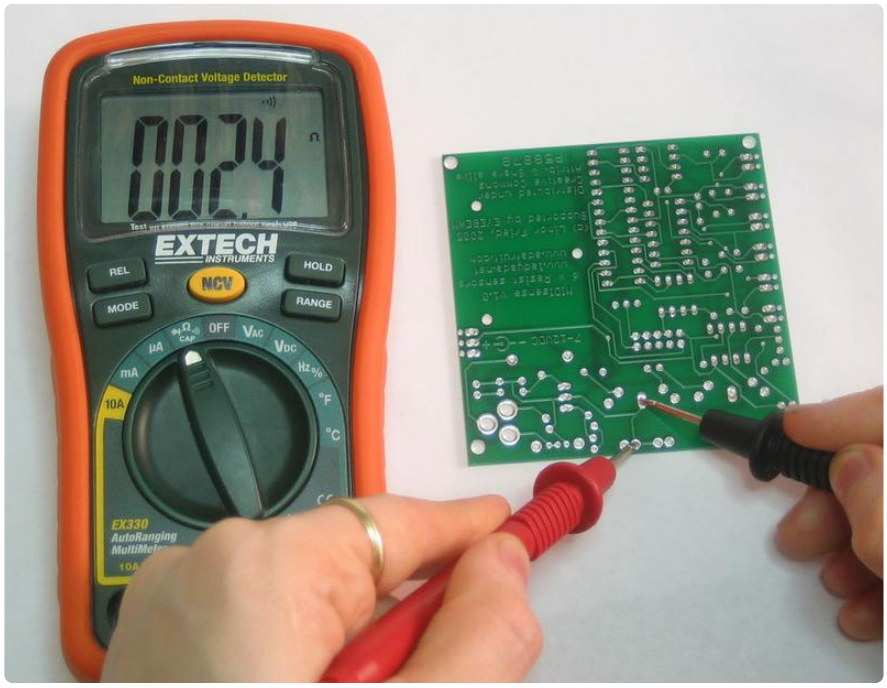
Unlike the other meter, this one displays Ohms (see the symbol on the right of the display). The resistance is low (4.7Ohms) but not 0 (the ideal value) because the probes and wires act as resistors. Usually with these sorts of meters they will beep whenever resistance is under 100 ohms or so.

Probing a PCB

Here is an example of testing a PCB for continuity.The first test shows that the two points are not connected.



The second test shows that these two points are connected.



Resistance

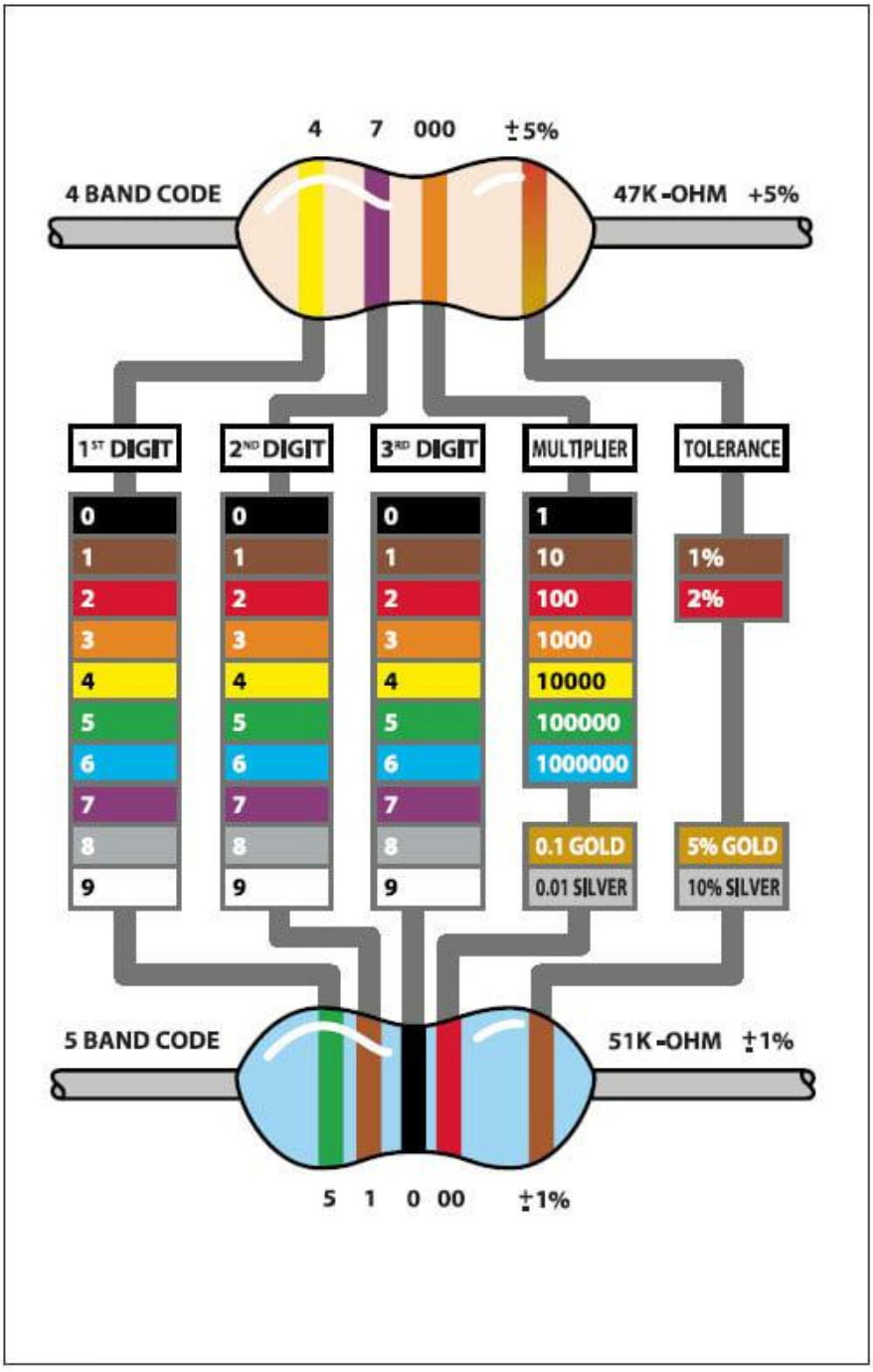
What is Resistance?

Resistance is just what it sounds like, its the characteristic that makes a component fight current flow. The bigger the resistance value (in ohms **Ω**) the more it fights. Most resistors () you'll see range between 1 ohm and 1 megaohm (1.0 MΩ) they often have 5% tolerance but you can buy 1% or even 0.1% accuracy resistors.

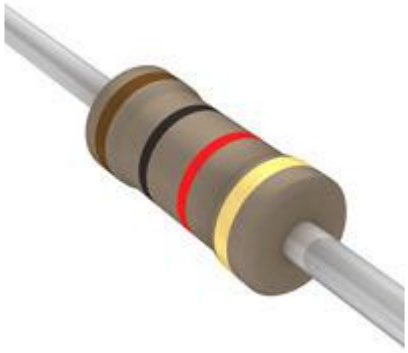
In general, resistence testing is best for measuring resistors, but you may find yourself measuring the resistance of other things, such as sensors and speakers.

Resistor Coding

Resistors are color coded, at first it seems like a bad way to print the values but with a little time it becomes faster because you dont have to read any numbers and the stripes are visible no matter how it is rotated. You can use this calculator to play around with resistor color codes ().



Resistor color code chart courtesy of Make Magazine ()



Resistor image courtesy of Digikey ()

This image shows a 1.0 kΩ 5% resistor (brown black red gold).

What is resistance testing good for?

Resistance-testing is very useful

- If you don't have a continuity tester, it can double as one
- Check resistors whose values are not clear, if you aren't good at reading color codes () or if the marking has come off
- Measure input and output resistance of circuits
- Test and characterize sensors () and potentiometers () (see below)

Remember!

You can only test resistance when the device you're testing is not powered. Resistance testing works by poking a little voltage into the circuit and seeing how much current flows, its perfectly safe for any component but if its powered there is already voltage in the circuit, and you will get incorrect readings

You can only test a resistor before it has been soldered/inserted into a circuit. If you measure it in the circuit you will also be measuring everything connected to it. In some instances this is OK but I would say that in the vast majority it is not. If you try, you will get incorrect readings and that's worse than no reading at all.

You can make sure your meter is working well by having a 'reference resistor' to test against. A 1% 1KΩ or 10KΩ resistor is perfect! Low batteries can make your multimeter wonky.

Resistance is non-directional, you can switch probes and the reading will be the same.

If you have a ranging meter (as most inexpensive ones are), you'll need to keep track of what range you are in. Otherwise, you will get strange readings, like OL or similar, or you may think you're in KΩ when really you're in MΩ. This is a big problem for beginners so be careful!

Get into the mode.

Look for an ohm (Ω) symbol, if its a ranging meter there will be a bunch of subdivided modes. If its auto-ranging there will be only one.

This meter has the Ω symbol and then 7 submodes, ranging from 200Ω to 2000MΩ (wow!)

This meter has the Ω symbol and then 5 submodes, ranging from 200Ω to 2MΩ

This meter has a multi-mode (you need to press a seperate MODE button to change between capacitor sense, diode test, resistor test and continuity!) It does not, however, have any numbered submodes, as it is auto-ranging.

Ranging vs. Auto-Ranging

As long as it works, it doesn't matter which type you have. But auto-ranging meters are a little slower.
Compare these two videos as I measure a 1KΩ resistor with an autoranging meter:

Which takes about 4 seconds to settle on a final value, and a 10KΩ resistor with a ranging meter:

Which gets the first significant digit instantly, the second digit after 1 second and the final digit after 2.

Expensive autoranging meters, like Fluke 73s, will be super fast so it's not a big deal, but if you have a $200 meter you're probably not reading this tutorial.

Ranges will almost always be something like 200Ω, 2KΩ, 20KΩ, 200KΩ, 2MΩ, etc.
Why the 2s instead of 100, 1K, 10K etc.? Well, here's my guess.
Because the vast majority of resistors are 5%, the resistor values are 5% apart (or so).
For example, the "standard" 5% values between 1K and 10K are:

1.0K, 1.1K, 1.2K, 1.3K, 1.5K, 1.6K, 1.8K, 2.0K, 2.2K, 2.4K, 2.7K, 3.0K, 3.3K, 3.6K, 3.9K, 4.3K, 4.7K, 5.1K, 5.6K, 6.2K, 6.8K, 7.5K, 8.2K, 9.1K

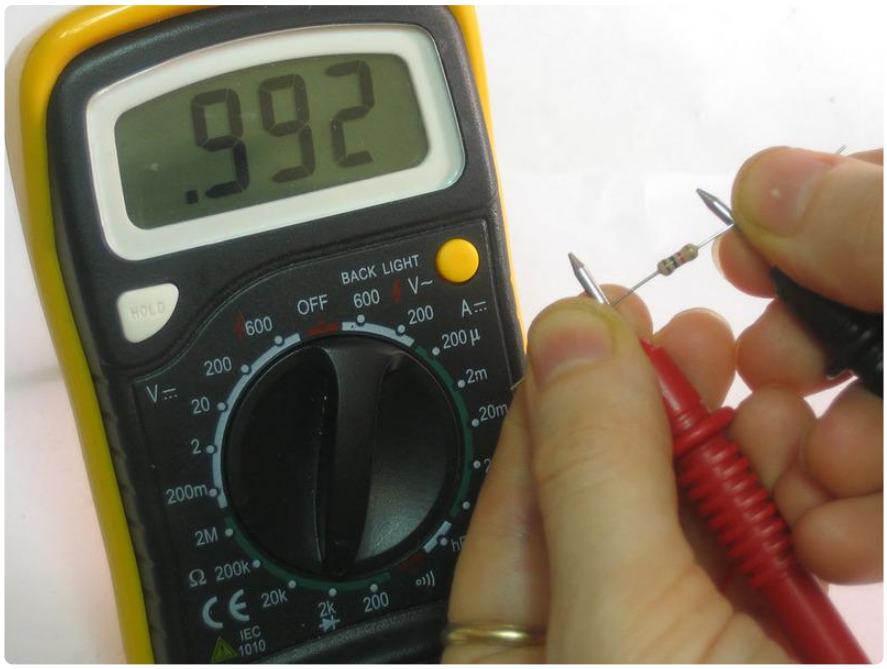
There are way more values between 1KΩ and 2KΩ than between 2KΩ and 3KΩ, etc.
By picking 2KΩ as your max range, you get the best precision for the most probable values.

Example 1: Testing a Resistor

With an auto-ranging meter, its easy, just put the two probes across the resistor and read the number. For example, this 1KΩ 5% resistor is actually 0.988 Kohm.

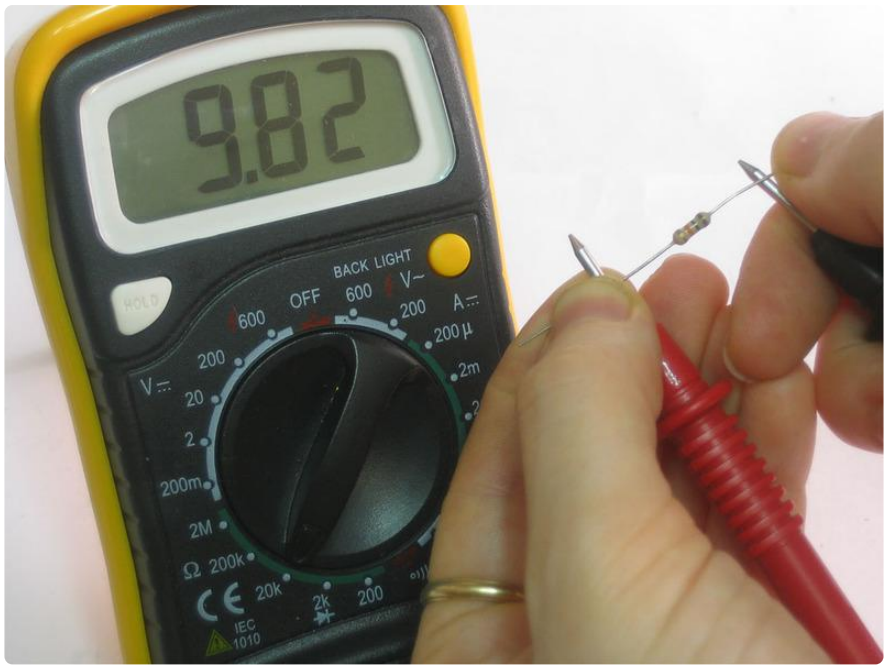
And this 10KΩ is really 9.80KΩ. Note that the numbers look similar but the decimal point has moved.

This ranged meter requires that you dial in the range. We'll guess that this resistor is under 2KΩ then measure it. We get 0.992 which means its 0.992 KΩ (or, a 1KΩ resistor).



Now testing a different resistor, we will again guess its under 2KΩ. However, this time we get a strange response, a 1. which means out of range. Some meters will display an OL which you may remember from the continuity secion as meaning "open loop" here it means "the measurement is higher than the range".

We try again, changing the range to 20KΩ

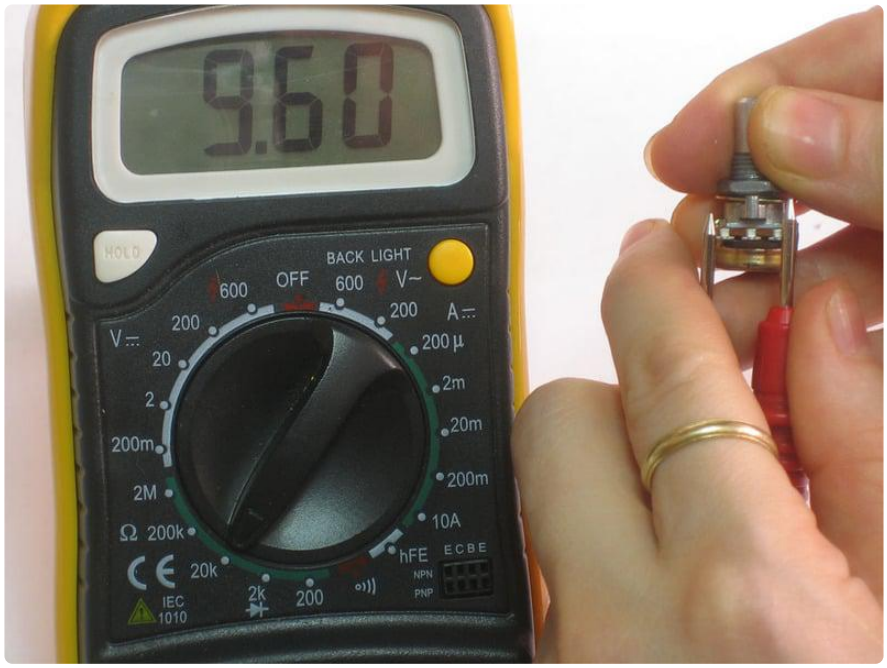


Aha! It is a 9.82 KΩ resistor (10KΩ)

Its a little clumsier than auto-ranging but if you are pretty sure you know about how big the resistance you are expecting is, its very speedy.

Example 2: Testing a Potentiometer

You can test the max-value of a potentiometer by measuring across the two 'ends' as shown here with a rotational 10KΩ pot. To find the 'range' look at the dial.



You can also use a multimeter to tell whether the potentiometer is a linear or logarithmic (audio) pot. When the pot is centered, if the resistance between the wiper and one end is half of the total value, its linear. (I used clips instead of probles to make it easier to take these photos).

This is a 10KΩ linear potentiometer.

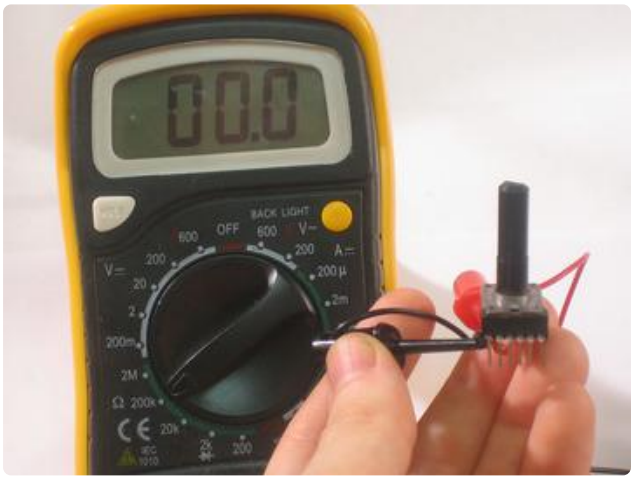
The minimum resistance of the pot, 0Ω (a short) as expected.

Potentiometer centered, about 5KΩ

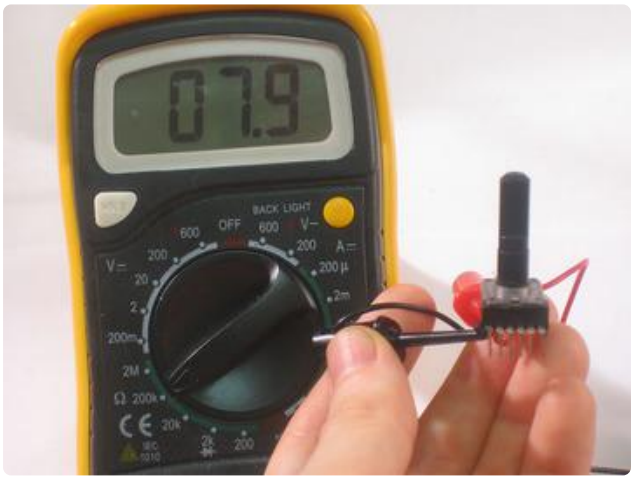
Maximum value is 9.5KΩ (it should be around 10KΩ)

This video shows the resistance of a 10KΩ linear pot as it is adjusted. At the end it is set to approximately the midd, which is measured at 4.7KΩ, pretty close to the 'ideal' of 5KΩ.

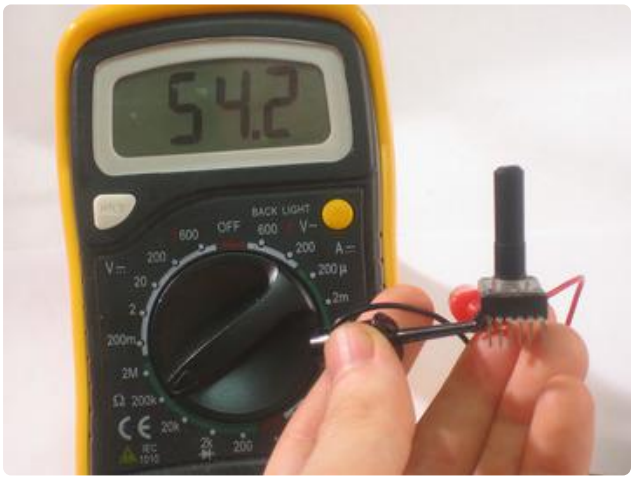
Here are photos of a 50KΩ audio potentiometer:



Minimum is 0Ω as expected



Middle is 8KΩ



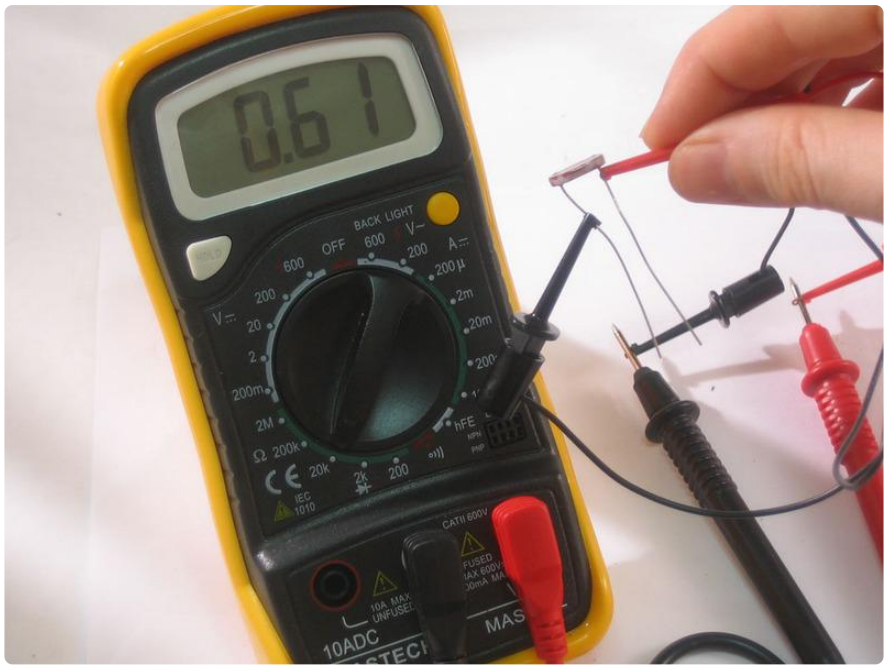
Maximum is 54.2KΩ, close to the ideal 50KΩ

If, when centered, the resistance is more like 85% or 15% of the total resistance, then its a log pot. This is a 50KΩ analog potentiometer. When centered, the resistance is about 8KΩ.

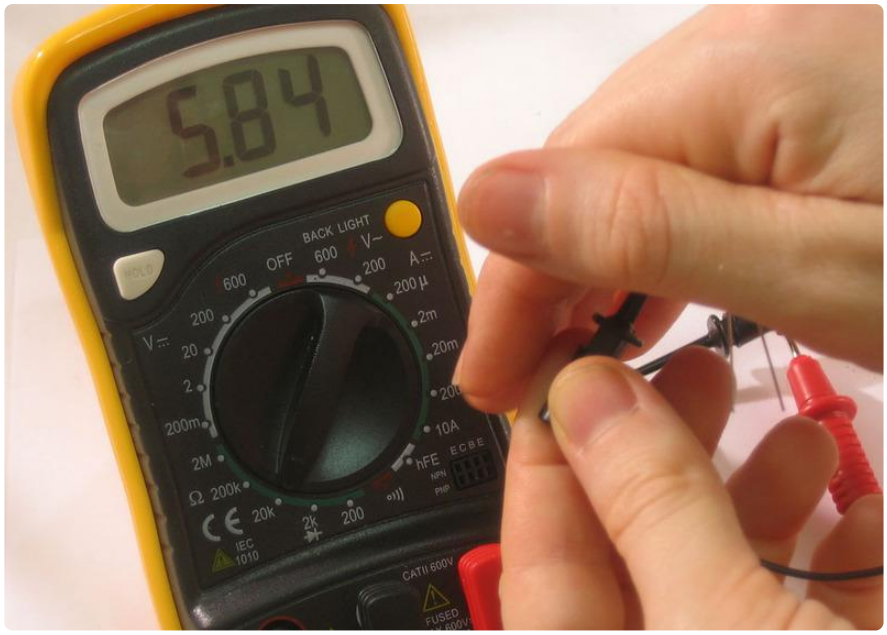
Example 3: Testing a Sensor

Potentiometers are resistors that change value when they are moved. A Light Dependent Resistor (LDR) () is a resistor that changes value with the amount of light it receives. This one has a range of about 20K max.

First, set the range, in this case 20KΩ seems pretty good. In bright light, it measures about 610 Ω



Slightly shaded it's 5.84KΩ (remember this is still a well-lit photo)



After setting the range, I experiment with shading it on video:

Voltage

What is Voltage?

So what is voltage anyhow? Well, its a pretty abstract term but a lot of people like to use the term "potential energy" which is that thing you heard about in high school physics and then forgot immediately.

Some people like to draw an analogy to water () to describe voltage. A water pump is like a voltage supply ()(also known as a battery).
The pump pushes water through a hydraulic system, and the voltage supply pushes electrons through an electronic system.
The higher the rated pressure of the pump, the more 'work' the water can do.
Likewise, the higher the voltage the more 'work' (Watts) the electrons can do.

Voltage is used to provide power (via a battery or wall plug) and its also used as a way of transmitting data. For example, music is recorded from a microphone as an analog voltage signal, if that voltage waveform is applied to a speaker the voltage performs the work of making air move and produces sound.
Voltage is also used to in digital circuits to talk back and forth in binary, usually 5V or 3.3V is a "1" and 0V is a "0", by alternating the 1's and 0's millions of times a second, data can be moved around rather quickly.

AC/DC

Not just an 80's hair metal band! Voltage comes in two flavors (yum): Alternating Current (AC) and Direct Current (DC). Here is a quick tour of the differences.

Direct current voltage is what comes out of batteries. The battery is at 9V, and it pretty much keeps that voltage constant, until it dies. The chemical reactions inside the battery creates DC voltage.
Electronic circuits really like DC voltage.

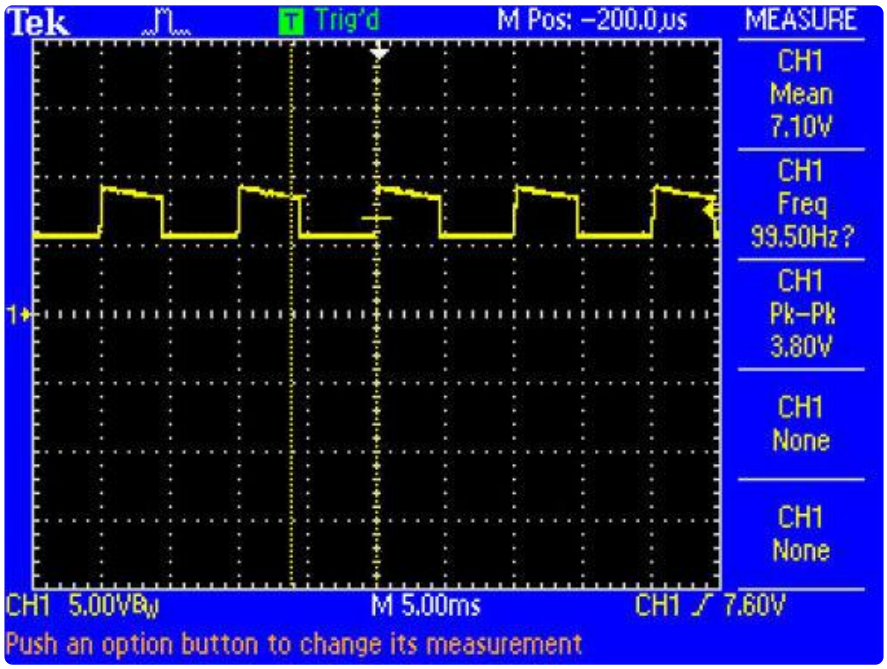
Alternating current voltage is what comes out of the wall. We call it 120 VAC (Volts Alternating Current) because the generator at the US power plant creates a voltage that oscillates (alternates). At the outlet in your home, the voltage is not constant but goes from about -120V to 0 to +120V to 0 again, 60 times a second. In Europe, it's referred to as 240VAC because the voltage goes from about -240V to +240V at 50 times a second.
Technically the voltage is truly +170V to -170V in the US, which would make 120VAC we're mentioning -> 340Volts peak to peak. Since multimeters tend to show RMS

voltages, its easier to just refer to it as 120VAC and remember that the peak postive and negative voltage are each ~1.5x the RMS voltage and the peak-to-peak is going to be ~3x as what the multimeter is displaying for sinusoidal/wall outlet waveforms! You can read all about peak to peak vs RMS voltages here ()

AC voltage is great for power plants because its easy to transform AC voltages (using a transformer ()) up to 50KVAC for long distance travel and then down to 240VAC or 120VAC to safely power your home. Those big honking grey things that you see next to buildings that hum are the huge transformers.
Motors (like your washing machine and refrigerator compressor pump) also like running off of AC voltage.

You can turn AC voltage into DC voltage very easily by using a very small transformer to bring the 120VAC down to a reasonable level like say 16VAC and then rectify it ().
This is basically what's inside a wall wart plug () or your laptop power supply.
Its much harder to turn DC into AC, you will need an inverter which are more expensive than transformers/rectifiers.

Batteries only supply DC voltage and wall plugs only supply AC voltage. However, it is totally possible to have both AC and DC voltage at a certain point:
If an AC voltage is oscillating between -60V and +60V it has 120Vpp AC and 0V DC because the average voltage of -60V and +60V is 0V.
If an AC voltage is oscilating between 0V and 120V then it has 120Vpp AC and 60V DC because the average voltage of 0V and 120V is 60V.



In the above oscilloscope image, the dashed horizontal line in the center is ground (0V) and each dashed division is 5V. The scope is displaying a signal that has both AC

and DC components. There is an alternating voltage (a square wave) that is about 4V high at about 100Hz and a DC (mean average) voltage that is around 7V. Use the dashed divisions to verify for yourself that this is so.

What is voltage testing good for?

Voltage testing is very common, you'll use it a lot

- Test if your power supply is working, are you getting 5V out of that 7805 regulator?
- Verify that your circuit is getting enough power: when all of the blinky lights are on, is the power supply drooping too low?
- Verify signals to and from chips to make sure they are what you expect once the circuit is up and running
- Testing batteries, solar cells, wall plugs, and power outlets (carefully!)
- With a current sense resistor you can perform current testing on a project without possibly damaging your meter.

Remember!

You can only test voltage when the ciruit is powered If there is no voltage coming in (power supply) then there will be no voltage in the circuit to test! It must be plugged in (even if it doesn't seem to be working)

Voltage is always measured between two points There is no way to measure voltage with only one probe, it is like trying to check continuity with only one probe. You must have two probes in the circuit. If you are told to test at a point or read the voltage at this or that location what it really means is that you should put the negative (reference, ground, black) probe at ground (which you must determine by a schematic or somewhere else in the instructions) and the positive (red) probe at the point you would like to measure.

If you're getting odd readings, use a reference voltage (even a 9V battery is a reasonable one) to check your voltage readings. Old meter batteries and wonky meters are the bane of your existence but they will eventually strike! Good places to take reference voltages are regulated wall plugs such as those for cell phones. Two meters might also be good :)

Voltage is directional If you measure a battery with the red/positive probe on the black/negative contact and the black probe on the positive contact you will read a negative voltage. If you are reading a negative voltage in your ciruit and you're nearly positive (ha!) that this cannot be, then make sure you are putting the black probe on the reference voltage (usually ground)

DC voltage and AC voltage are very different Make sure you are testing the right kind of voltage. This may require pressing a mode button or changing the dial.

Unless otherwise indicated, assume DC voltages

Multimeters have different input impedences that affect readings of high impedence circuits For example, measuring a sensor that has 1Mohm impedence with a 1Mohm impedence meter will give you only half the correct reading

Get into the right mode.

There are often two seperate modes for AC and DC voltage. Both will have a V but one will have two lines, one dashed and one solid (DC) and one with have a wave next to it (AC).

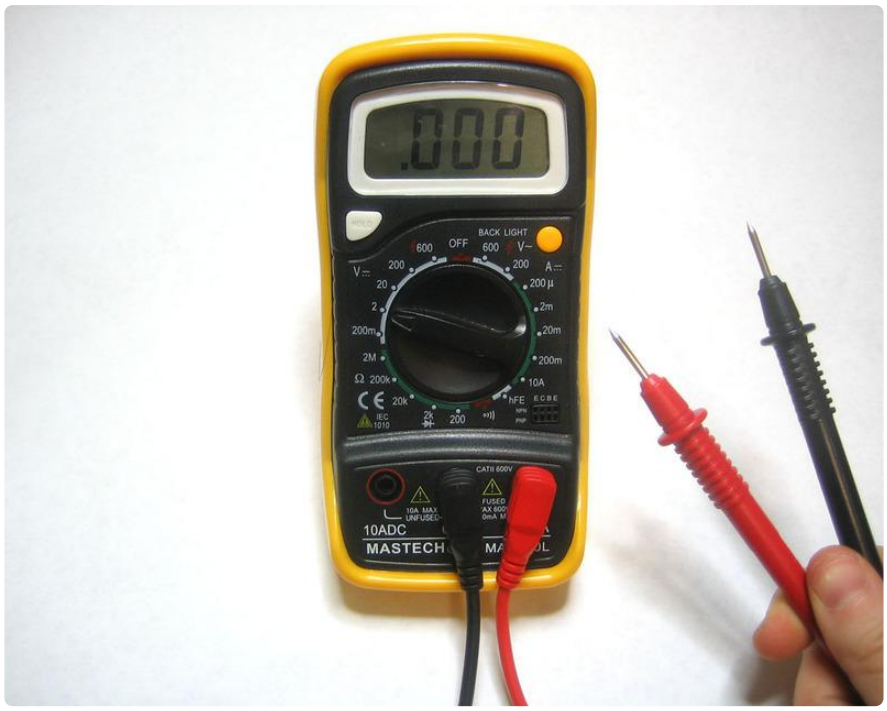
This meter has the double line for DC voltage, and 5 ranges, from 200mV to 600V. The lightning bolt symbol is a gentle reminder that this voltage is extremely dangerous.

There is also the V-wave symbol for AC, and two ranges since most AC voltages that are measured are power voltages and are pretty big. (For small AC waveforms, a scope is best since you will be able to see the waveform itself).

This autoranging meter makes it pretty clear which mode you want to be in.

This ranged meter has 5 ranges, the top range is 750 VAC or 1000 VDC, to switch between DC and AC you need to press the DC/AC button on the upper right.

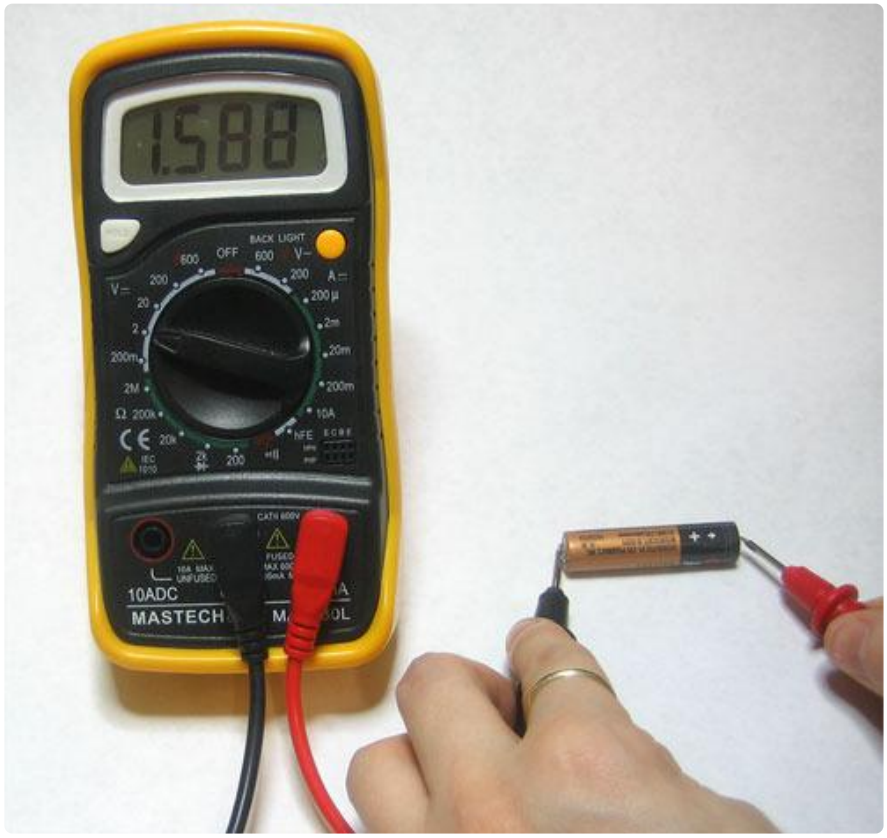
When the probes are not connected to anything, they should display 0V. They might flicker a bit if they pick up ambient voltage (your home is a big radiator of 60Hz voltage which can couple into your meter probes).



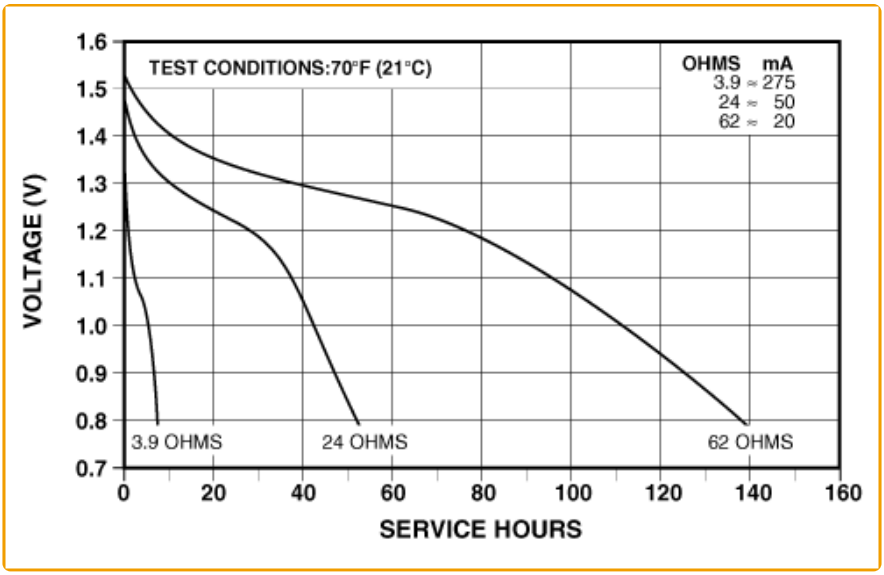
Example 1: Testing Batteries

Testing batteries is a super useful skill and is one of the best ways to practice with your multimeter

The first battery we'll test is a new 1.5V alkaline. This one is a AAA but a AA, C or D cell will be the same voltage. Set the range to 2V DC.



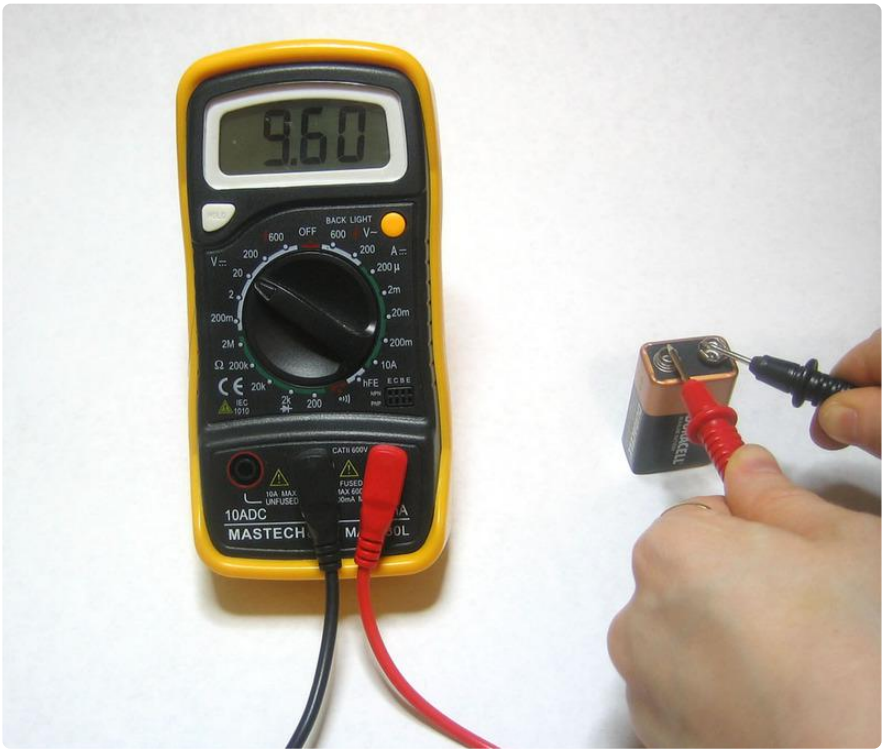
We read 1.588V, which you may think is a mistake, after all its a 1.5V battery so shouldn't it be 1.5V? Not quite, the 1.5V written on the side is just a nominal voltage, or the "average" you may expect from the battery.In reality, an alkaline battery starts out higher, and then slowly drifts down to 1.3V and then finally to 1.0V and even lower. Check out this graph from Duracell's page about alkaline battery voltage ().



Using this graph you can easy tell how fresh your battery is and how long you can expect it to last.

Next, we measure a 9V alkaline battery. If we still have the range set to 2VDC we will get a mysterious "1. " display, indicating is it over-range.

Fix the range so that it's 20V, and try again.

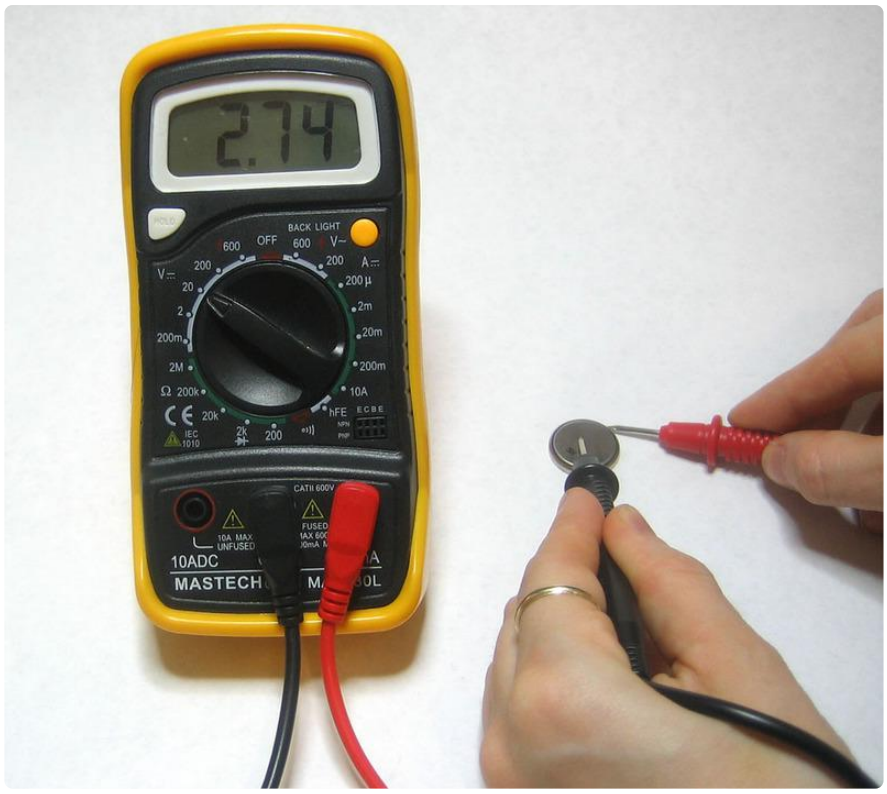


For this new battery we get 9.6V. Remember that battery voltage is nominal, which means that the "9V" is just the average voltage of the battery. In reality, it starts out as high as 9.5V and then drops down to 9 and then slowly drifts to 7V. You can check out the discharge curve in the Duracell 9V datasheet ()

If we want to check a rechargeable AA battery, and it's set to a 20VDC range, we will read 1.3V, which is about what a fully charged NiMH battery will measure.

If we fix the range so it's 2VDC, we can get an extra digit of precision. This meter probably isnt more than 0.5% accurate so the precision may not mean much.

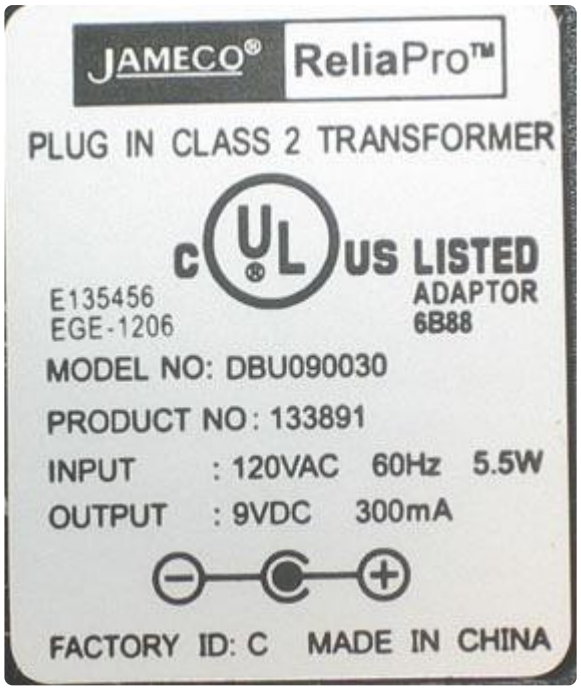
Finally, I test a lithium 3V coin cell, its at 2.7V which means it's getting near the end of it's life.



Example 2: Testing wall wart (adapter) plugs

Testing wall adapters is also very handy, especially when you build your own circuits.

The first kind we will test is a transformer-based adapter.



Note that the label says Transformer, its also blocky and heavy which indicates a transformer as well. It requires 120VAC input, US power only. The nominal output is 9VDC at 300mA. The polarity symbol shows that the middle is positive, the outside is negative, thus we place the ground (black) probe on the outside and the positive (red) probe on the inside.

Yow! 14V? That's not anything like the 9V on the package, is this a broken wall wart? Turns out, its totally normal. Transformer-based wall adaptors are (almost always) unre gulated, which means that the output is not guaranteed to be a particular value, only that it will be at least what is printed on the box. For example, with this adapter it means that when drawing 300mA, the voltage is guaranteed to be higher than 9V.

Since the output is unregulated, the voltage supplied will droop as more current is pulled from it, which means that open-circuit (connected to nothing) the measured output can be as high as 14V. Our power supply tutorial on transformer-based wall adapters covers this in detail ()

Next, lets check out a Switch-mode adapter.

Notice that it's not square, its much thinner and although you cant feel it, its quite light for its size: There is no big honking transformer inside!

Note that it says Switching (not Transformer) on the label, and you can input US or European power. Like the transformer adapter, it is center-positive polarity.

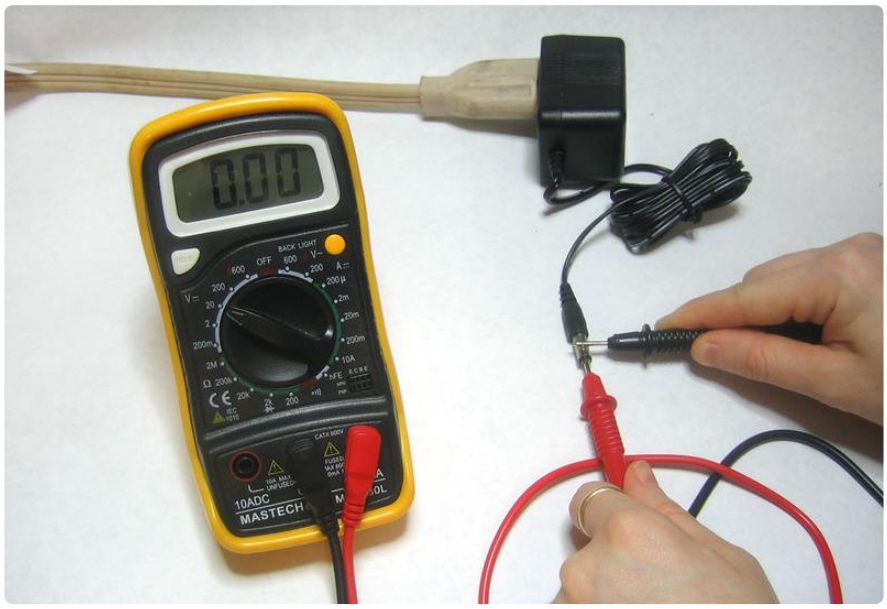
Switch-mode wall adapters are regulated which means that the output doesn't droop from open-circuit to full load. Its not an ultra-high quality supply, the voltage is 12.2V which is less than 5% error. Still, its much better than the transformer's 50% error!

Lastly, we'll test a 9VAC adaptor, which outputs AC voltage instead of DC. Basically this means that there's still a transformer inside, but no rectifier. This is also an unregulated supply.

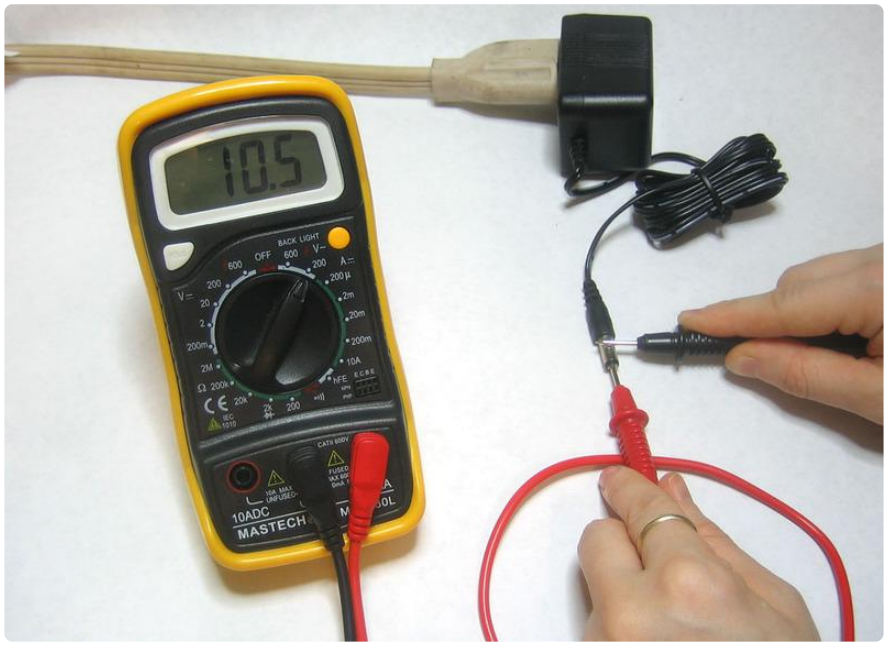
Note that is is similar to the transformer-based DC supply we checked out first.

Note again that the label says transformer. It requires 120VAC input, US power only. The nominal output is 9VAC at 300mA. The output is indicated twice, once at the top "AC/AC" and then again in the output designator "9V AC"
There is no polarity because AC adaptors are not polarized: AC power oscillates between positive and negative voltages.

We test the output, but get 0V! That's when we remember that the multimeter has to be in AC voltage mode.



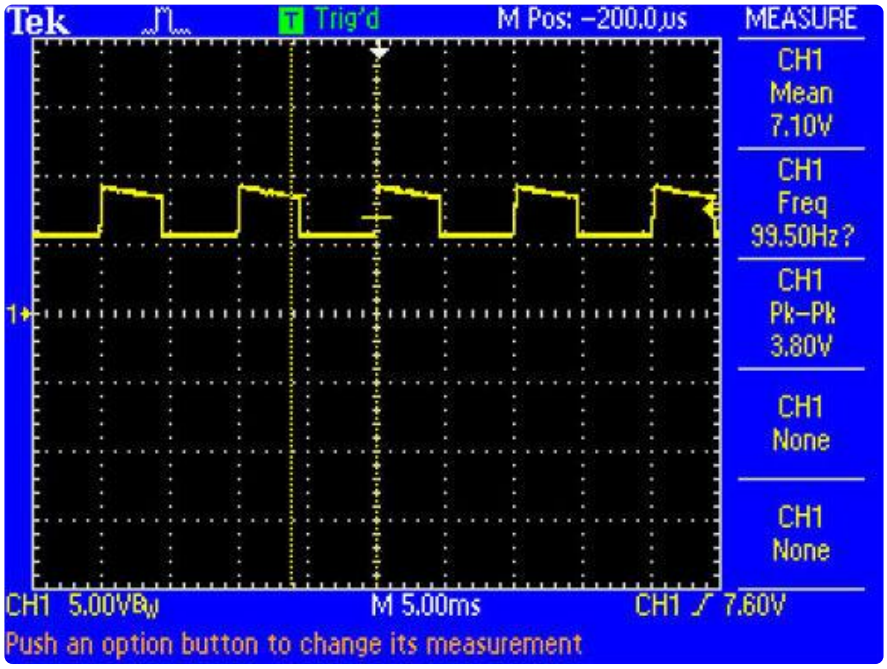
Switching over to AC, we get a good reading, 10.5VAC. This is an unregulated supply so again we are going to get a voltage higher than 9V.



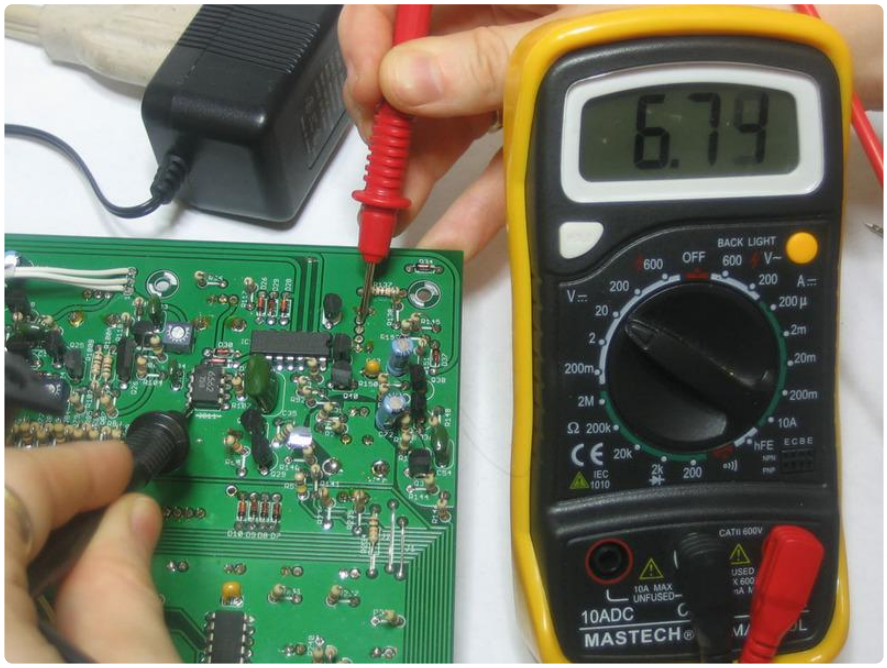
Bonus Example: Testing a circuit with AC and DC

If you're trying to measure something that is just DC or just AC its very easy, just get into the right mode and measure away! The hardest thing to do is measure a circuit with both AC and DC voltages.

For example, here is a few attempts to measure the VCO output of a x0xb0x as seen in the oscilloscope output shown here (its the same one from above).

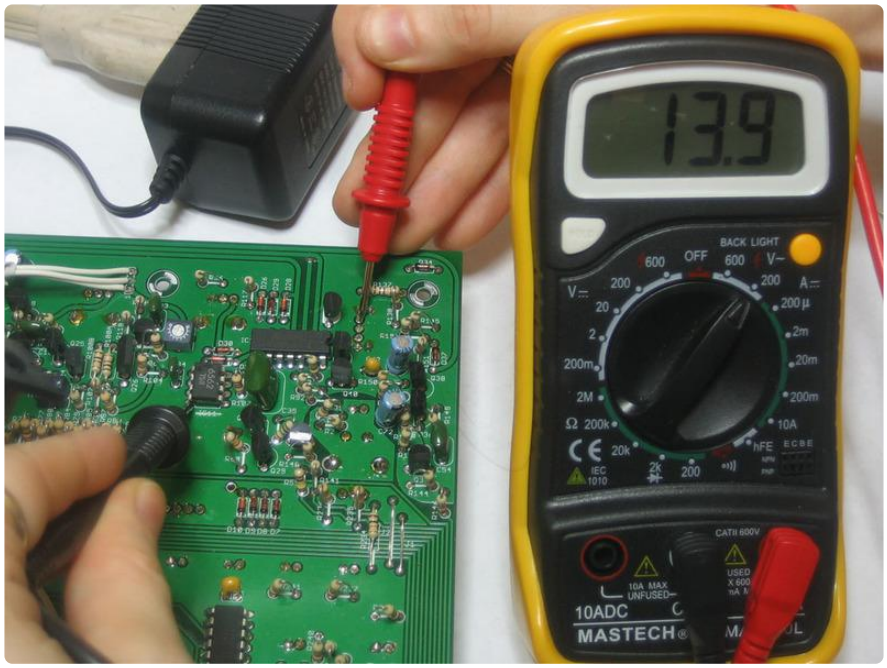


The DC portion is the easy part to measure, most multimeters just average out the input measurement.

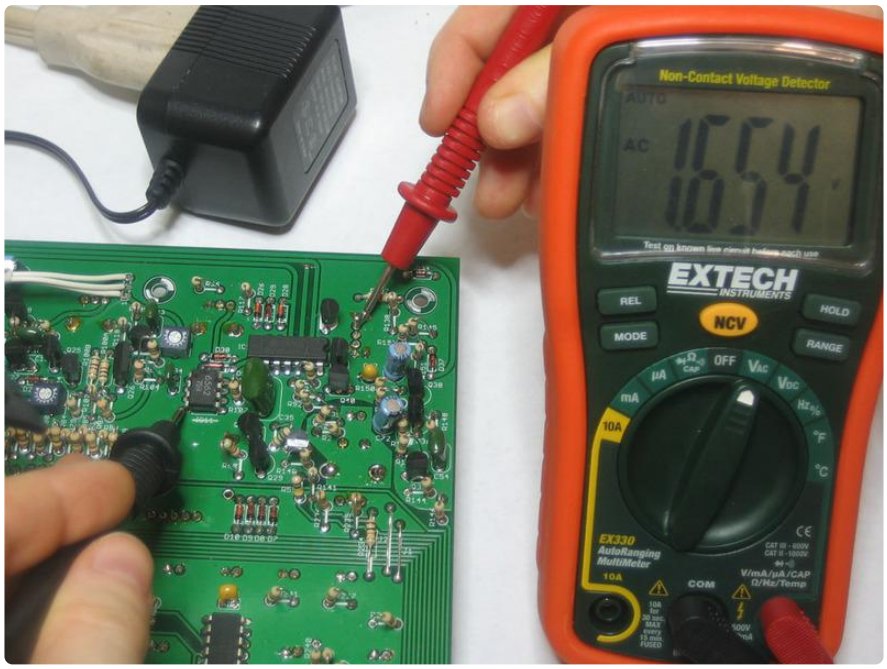


We read 6.75V DC, which is about right.

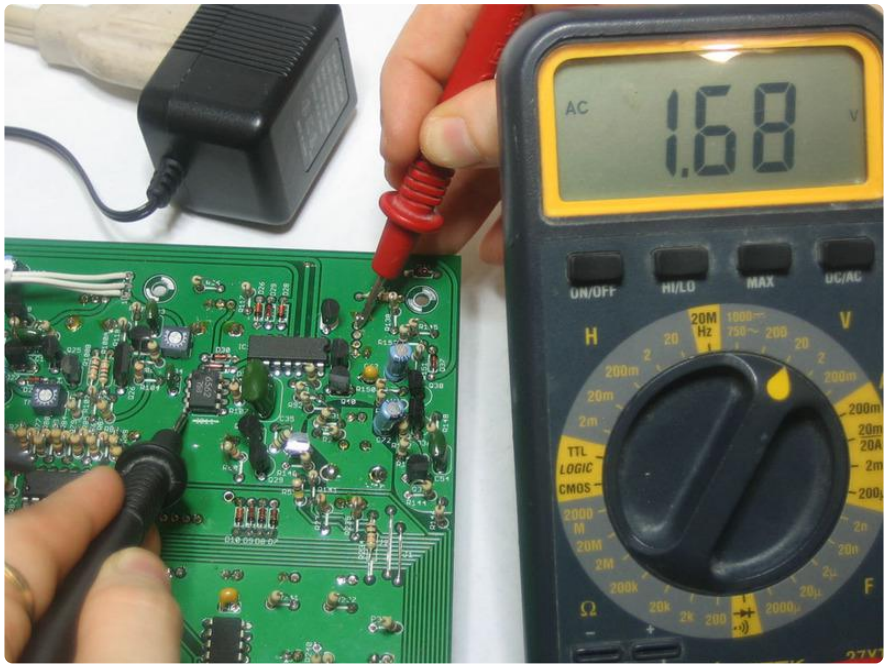
However, when trying to measure AC, this multimeter gives us a seemingly random number. (Maybe the DC voltage * 2 ?).



The Extech meter reads 1.65V



The Wavetek does the same



The lesson? You can't depend on your multimeter to measure AC voltages when there is a DC component!

Current

What is current?

Current is the rate of electricity flow in a circuit. Using the same water analogy as before, higher pressure (voltage) and a bigger pipe (lower resistance) means a

greater volume of water per second (current) will flow. This simple relationship is represented by the equation known as "Ohm's Law":

$$I = V/R$$

Where: 'I' is current, 'V' is voltage and 'R' is resistance.

Another important equation is the one for power.

$$P = I \times V$$

Where 'P' is power (measured in Watts), 'I' is current and 'V' is voltage.

Watts is a measure of work, or the conversion of electrical energy into some other form such as heat, light or motion. As the equation implies, it takes both voltage and current to do work.

Why Measure Current?

If there is not enough current, your circuit may not be able to do the work it was designed to do. Logic circuits may not function reliably, displays may be dim, motors may stall.

On the other hand, if there is too much current, things will heat up and components may be damaged. In extreme cases there may even be smoke or flames.

Reasons for measuring current in a circuit include:

- Determining circuit power requirements
- Verifying correct circuit operation
- Testing power supply performance
- Verify that batteries are charging or discharging at a safe rate
- Estimating battery life or recharge time
- Diagnosing circuit problems

DC
.000
mA
ON/OFF
HI/LO
MAX
DC/AC
20M Hz
1000
750
H
V
A
TTL
LOGIC
CMOS
Ω
F
WAVETEK
DM27XT
V Ω
COM
mA Cx Lx
20A
MAX
1000V
750V

Pick a safe range.

Most meters have several current measuring ranges. Choose one that is good for AT LEAST the maximum current you expect to be measuring. If in doubt, choose the next higher range. There is usually overlap between the ranges and you can always go back to a lower one after you have verified that it is safe to do so.

Be careful here! Measuring currents above the selected range can damage your meter!

This meter has 4 ranges from 200 microamps to 200 milliamps. In addition, the 20 milliamp setting can be used to measure up to 20 amps when used with a special high-current probe jack.

This is an 'auto-ranging' meter and has just 3 very wide range settings. It will automatically adjust the range to give you the best precision measurement within those settings:

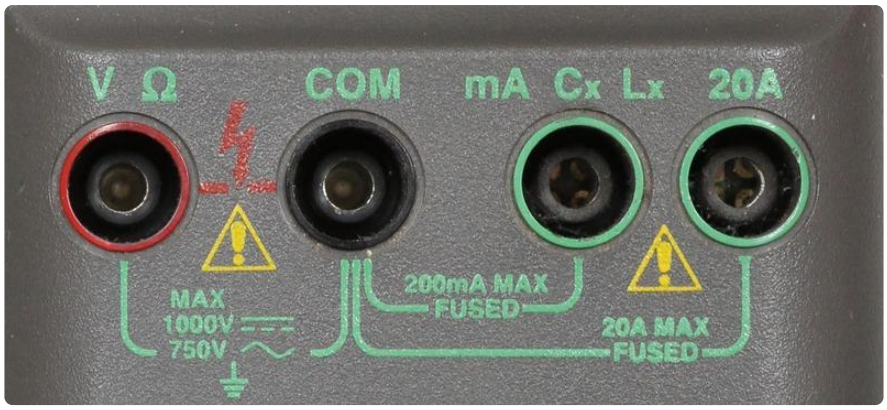
- microamps (uA)
- milliamps (mA)
- amps (A)

Choose the right connections.

Multimeters contain sensitive circuits capable of precision measurements of tiny currents and voltage. These circuits can be damaged or destroyed by high current flow. That is why most meters have a separate jack for high current measurements. This jack is fused for safety. If you are using the high-current setting, be sure to use the right jack.

Measuring current with the wrong connections can damage your meter!

Use extra caution when measuring high current levels. There is an old saying in electronics: "It is not the voltage that kills you, it is the current".



This meter has a separate jack for measuring voltage and resistance. And two jacks for different ranges of current measurement. One current measurement jack is safe for currents up to 200mA. The other can be used to measure currents up to 20 amps.

These two meters use the same jack for all measurements except high current measurements.

Here we are using the 0-200mA jack to make a measurement in the 2mA range.

This is the correct jack and range to use for measurements above 200mA on this meter.

On this meter, the correct jack and range selections for high-current measurement are clearly indicated in yellow.

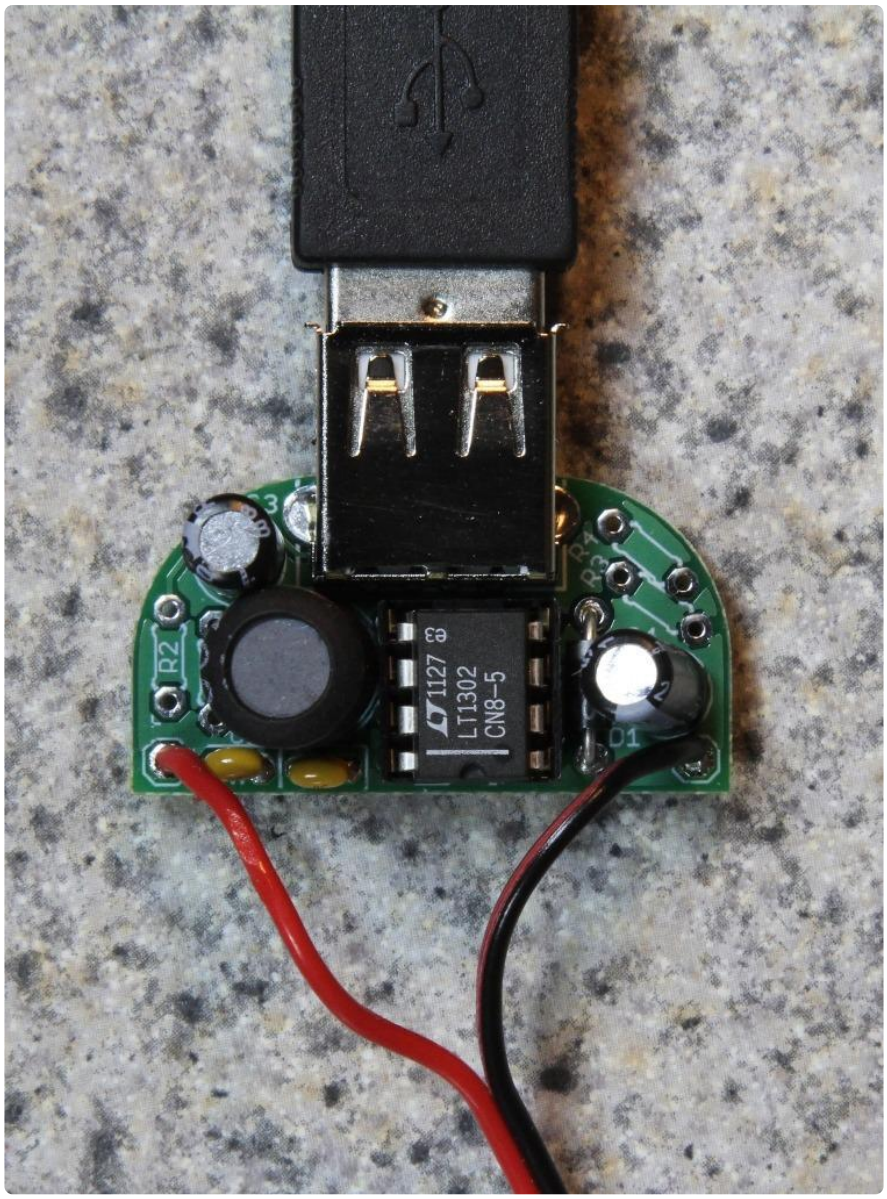
Also note the warning labels indicating maximum safe levels for each jack.

But with all meters, use care when choosing range and connections to avoid damage to the meter. Most meters have internal fuses to protect the circuitry, but they are not always readily accessible for easy replacement.

Get in the loop!

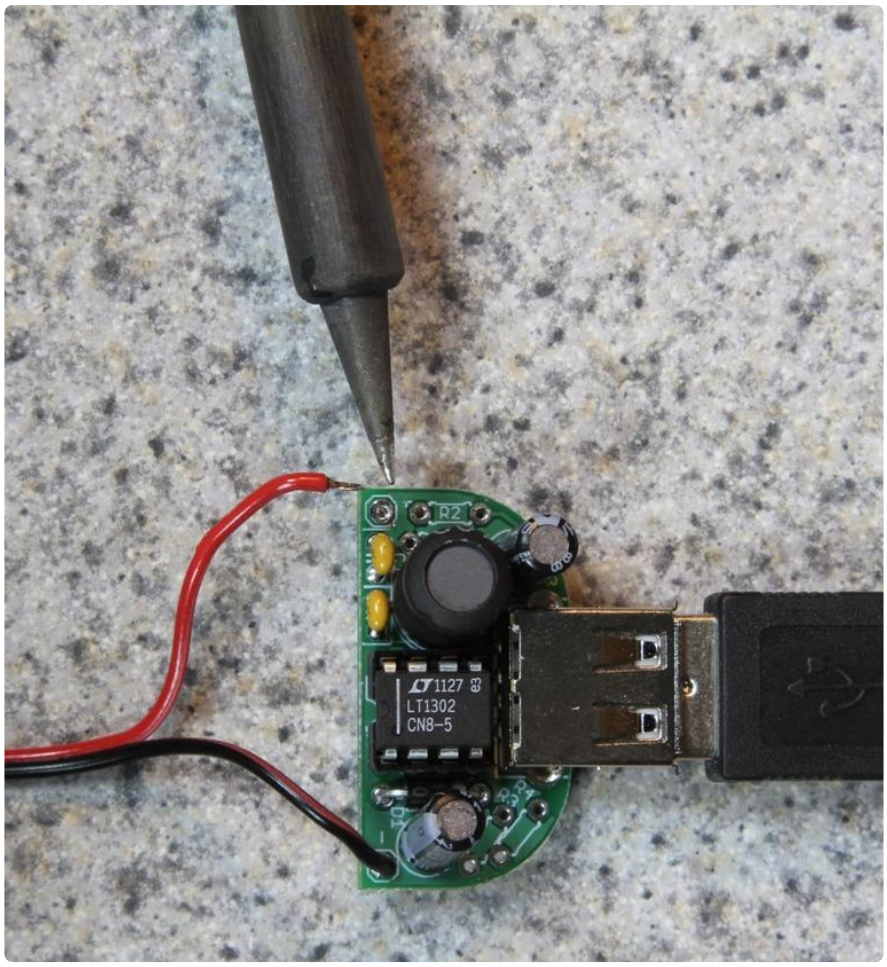
To measure the current, you have to make it flow through the meter. To do that you need to make your meter part of the circuit. You need to break the circuit at the point where you want to measure the current and insert your meter in the middle. Before connecting your meter to the circuit, double check your range and make sure you have the leads plugged into the right jacks.

For this example, we are going to measure the battery supply current going into a MintyBoost:

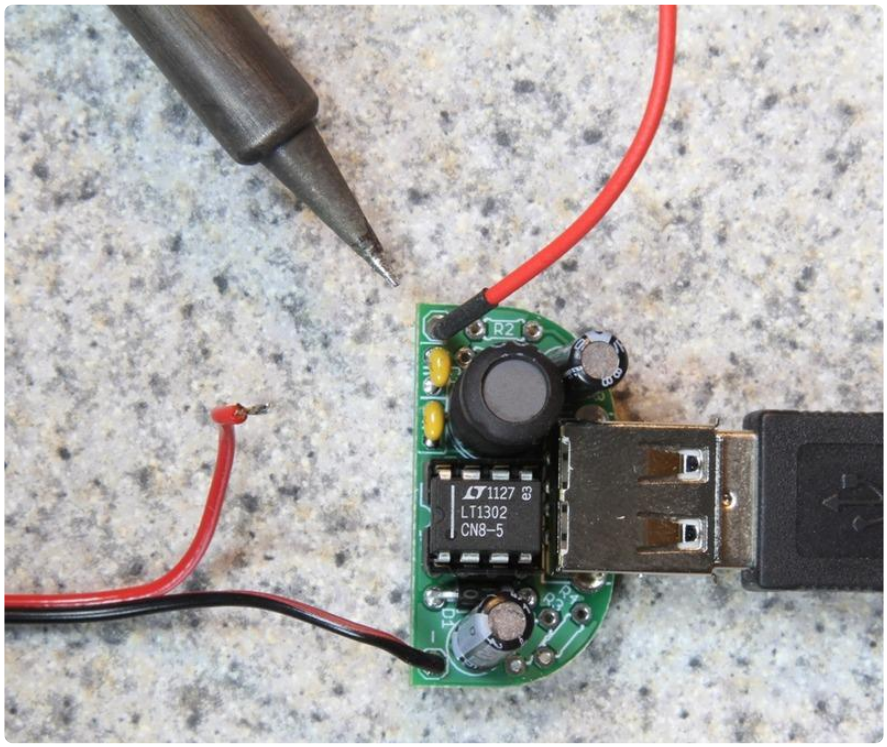


Breaking the circuit:

First we need to break the circuit so we can insert our meter. In this case we will just unsolder the battery wire from the Mintyboost circuit board



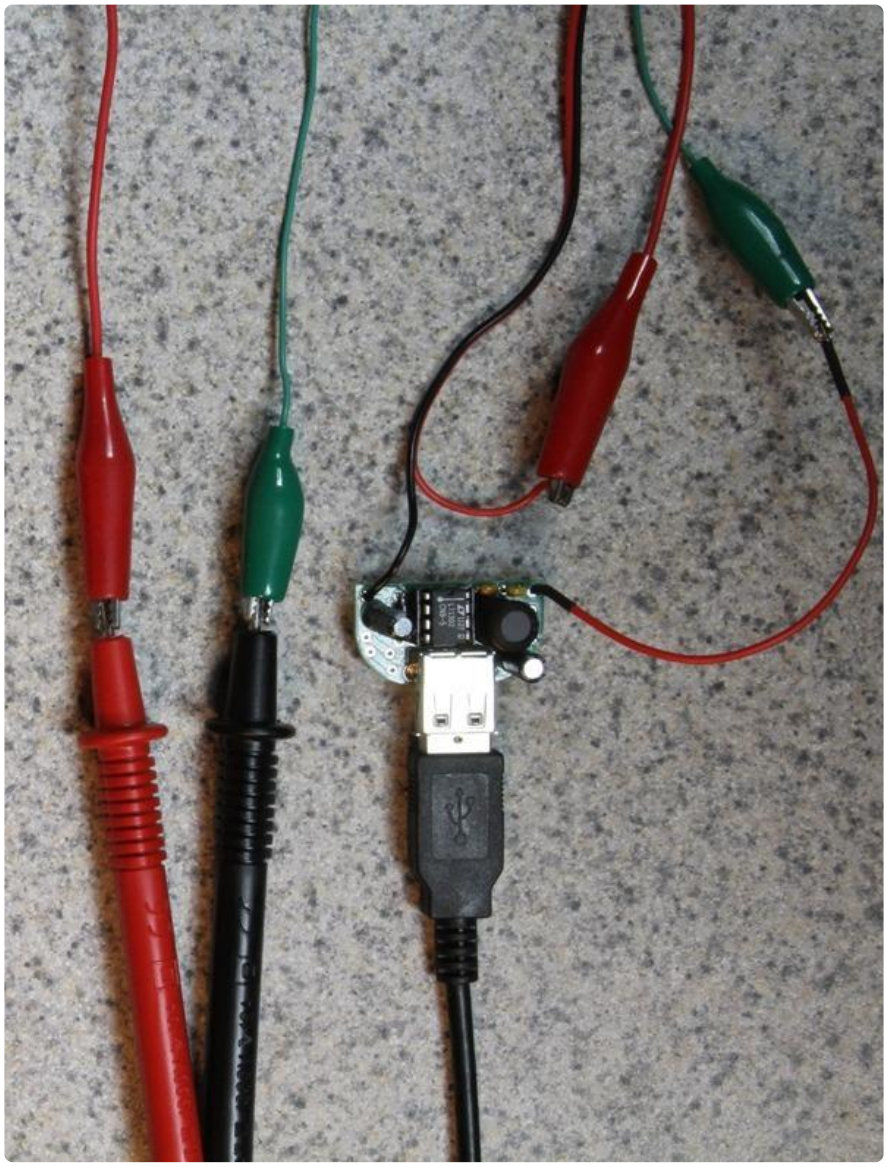
Then we will attach a temporary lead to make it easier to connect the meter.



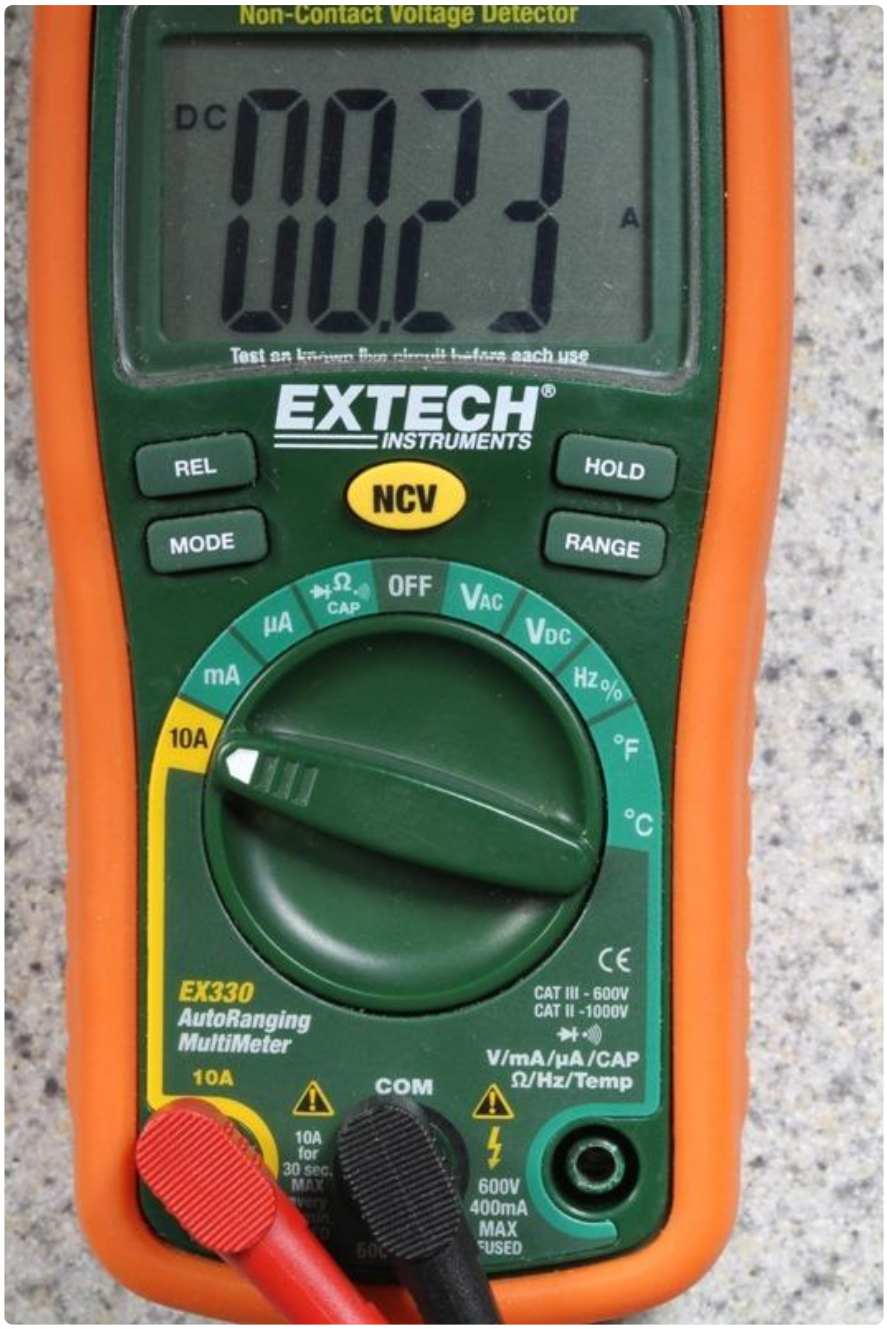
Closing the loop

Now we connect the meter between the battery lead and our temporary lead. We'll use some alligator clips to hold it all together.

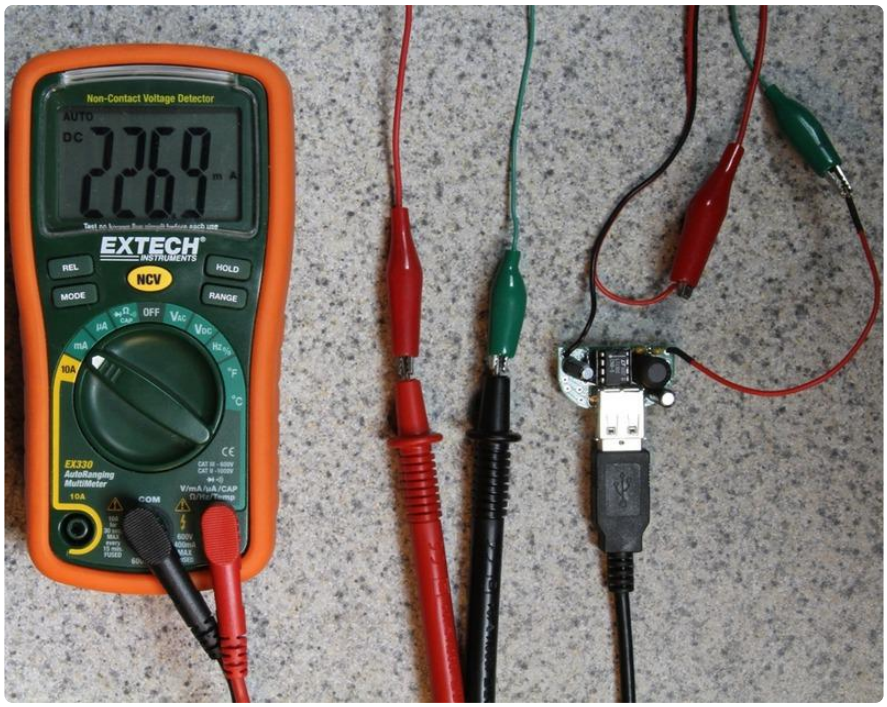
The positive meter probe is connected to the positive battery lead. The negative probe connects to the temporary lead we soldered to the Mintyboost circuit board. This closes the loop and makes the battery current flow through the meter.



We'll start with the high-current range and probe connection to be safe:



We see that the current is 0.23A (230mA). This is well within the 400mA safe limit for the low-current probe jack, so we set the meter to the milliamp range and use the low current jack for a more precise measurement.



Using the milliamp range, we can see that there is 226.9 mA of current going from the battery to the mintyboost.

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