Selecting a Multimeter for E-bike work

By Dave Rumsey

There are hundreds of multimeters available, with a variety of features and at prices from $5 to over $1,000, so selecting one can be confusing if you aren't sure what features etc you need.

Here's a few I have at my house:

Prices from left to right: $5, $25, $80, $120.

All of these meters have all of the ranges we need for our purposes, so how do you decide which to buy?

Measurement ranges needed for Ebike work:

DC Voltage (the unit of Voltage is the Volt, abbreviation V. for DC Voltage, Vdc).

Ebikes run off batteries, so we need to be able to measure DC Voltages, both for checking the state of charge of batteries, and checking whether electricity is reaching certain places where it should be reaching.
Our batteries are "36 Volt" batteries.. that is the average (half charged) voltage: the actual voltages range from 32V when fully discharged to 42V fully charged.
We have sold at least one bike with a "48V" battery.. the range for those is 41.6V discharged to 54.6V fully charged.

Our lights and throttles work at around 5V DC.

So we need a meter that will give accurate results in those Voltage ranges.
Many meters have a 20V range, then a 200V range, and that is a good progression: the Voltages we need to measure are at least 15% of the maximum value in the range we would use, so could expect accurate results.
One meter I saw recently jumped from a 20V range to 600V, so we would be reading 32V on a 600V range.. it would work, but probably be less accurate.

AC Voltage (Vac)
Our Ebikes don't use AC power (except between the controller and motor) but this can still be useful.
For example: The battery charger is plugged in but the light doesn't come on… is that because there is no mains power reaching the charger, or because the charger is broken?

With a Multimeter you can check whether mains power is live in the wall socket or at the mains plug of the charger power lead, which helps answer that question.

NZ Mains power is nominally 230V, so we need an AC Voltage range higher than that.. typically 500 or 600V.
You need to be safe while testing this level of Voltage: **Please read the "Safety" section below!**

Continuity
A major use for a multimeter is to check continuity: to see if one part of a circuit is connected with low resistance to another part, allowing easy flow of electrons.
Most multimeters have a special range for checking this, with an audible "Beep" which sounds when the two probes are connected to each other through a low resistance (low resistance implies easy passage of electricity, or "a good connection").
Using this we can check whether a wire is broken or good, whether a connection is good or has high resistance due to corrosion, whether a fuse is blown or good, whether a motor winding is ok or blown etc.

Even meters without the Beep function can be used by measuring resistance, but the Beep is really useful and ideally you should choose a meter with that function.

Resistance (Unit of resistance: Ohms, symbol Ω)

-Electricity is basically a flow of electrons through a conductor.
-Resistance is a measure of "how hard it is to push electrons through" a component.
-If an electric current passes through a resistance, some energy is lost, and that energy will appear as heat in the component.
-Wires, connectors etc need to have low resistance to allow easy flow of electricity with minimal losses.

When a multimeter is switched to a Resistance scale, it applies a small voltage across the probes.

When the probes are touched to the ends of a component, the meter measures how much current flows in a component because of that voltage. The higher the current flow, the lower the resistance.
It is perfectly safe to touch the probes, and to connect the probes together.

For our work we will usually be using low resistance ranges, no higher than 200 Ohms. Almost every multimeter will come with a wide range of resistance ranges so almost any meter will be fine for our purposes.

Current (The unit of current is Amps, abbreviation A)

Electrical current is a measure of how many electrons are moving in a circuit per second.

For the meter to measure the current, the electrons must also flow through the meter, so the circuit will have to be "broken" at some point and the meter added to the circuit.

Although it can be useful, it is harder to measure current than voltage or resistance, and current measurements are not as often used for faultfinding.
Most multimeters have a maximum current range of 10 Amps, and our bikes draw 20A or more from the battery, so most meters will not be useful for measuring that current draw.

One important thing is to get a meter with a fuse on the current input (See "Safety" section below), and I have a personal preference for meters where you have to shift the probe lead into a different socket to measure current.

Other Ranges and features

The above measurement ranges are the basic requirements, and a meter that only has those ranges would do virtually everything we need. Almost every multimeter on the market will have suitable ranges, although some may not have the audible Beep for continuity.

Many multimeters have other ranges or functions that may occasionally be useful. Specialty automotive meters may have Tachometer and Dwell ranges, meters designed for electronics use might have Capacitance, Frequency, diode test, transistor test etc.

These extra ranges require understanding of what is being measured.. so may be of limited benefit.

Other features include:
-Backlight (for using the meter in poor light);
-Hold (for capturing a reading at a particular time so you don't have to remember it);
-Max / Min (for capturing the maximum and minimum values seen during the measurement);

-NCV (Non-Contact Voltage.. indicates mains AC voltage without contact when held near a live mains wire);
-Thermometer (a temperature probe is supplied with the meter and can be plugged in to the probe sockets to allow the meter to display the temperature)

None of these features are absolutely necessary, but might be helpful at times, so it might be worth paying a bit more to get them. Obviously, having extra ranges and features that you will never use is not a disadvantage unless it makes the meter more expensive.

Manual or Automatic Range Selection.

Most cheaper multimeters have a rotary switch to select what measurement type and what maximum measurement value will be used.
For example, when measuring the Voltage of an Ebike battery we expect between 30 and 50V, so would select the lowest DCV range with a higher maximum: 20V is too low, so go to the next higher range, probably 200VDC, then do the measurement.

Some more advanced meters have “Autorange”.. you just select **V, A or Resistance** and do the measurement, and the meter sorts out whether it is AC or DC and what range to use.
This is quick and convenient, but it does require you to check what units are being displayed as well as the numerical value.
For example, a battery with a blown fuse might still have a 40 millivolt reading because there is still a very high resistance path through the fuse.
On a manual range meter set to 200V, this will show as 0V or maybe 0.004V, so you will see that it is not a good reading.
On an Autorange meter, you would see the numbers “40” but may not notice that the unit is mV instead of V, and assume it is ok.

So my preference for occasional use / beginner level meters is manual range selection, but either works fine if used correctly, and you get used to whatever meter you have.

Clamp meters

If you look at the right-hand meter in the first photo you will see that it has a split “loop” at the top. This is to allow it to be “clamped” around a single wire (hence the name Clamp meter) to measure the current flowing in it by measuring the strength of the magnetic field created.
Most clamp meters only work with AC current, so are of limited benefit for our purposes, but recently clamp meters have come on the market that can measure DC as well as AC through the clamp.
This is a potentially useful feature for convenience and safety, but the meters are expensive.

SAFETY

The voltages we are typically dealing with on Ebikes are generally below 50V, which is termed “Safety Extra Low Voltage”… in other words, accidental contact is not likely to lead to injury or electrocution. However there is a lot of energy stored in the batteries and care is needed not to short-circuit the output.

The meter should have a Fused current measurement circuit.
If you try to measure a current in excess of what the meter and leads can safely handle, it could damage the meter or test leads, so it is a good idea to have a fuse built into the meter.
Also, if you forget the leads are in the “current” position and / or that current (Amps) range is selected, and go to measure voltage, you will create a short circuit across the supply, whether it is a battery or the mains. A fuse blowing in your meter is a minor inconvenience, but not having a fuse could cause the probe leads to melt or blow a fuse or cause damage in the circuit being tested.

Quality:
Have a look at the two meters on the left in my photo above.. then check out this photo:

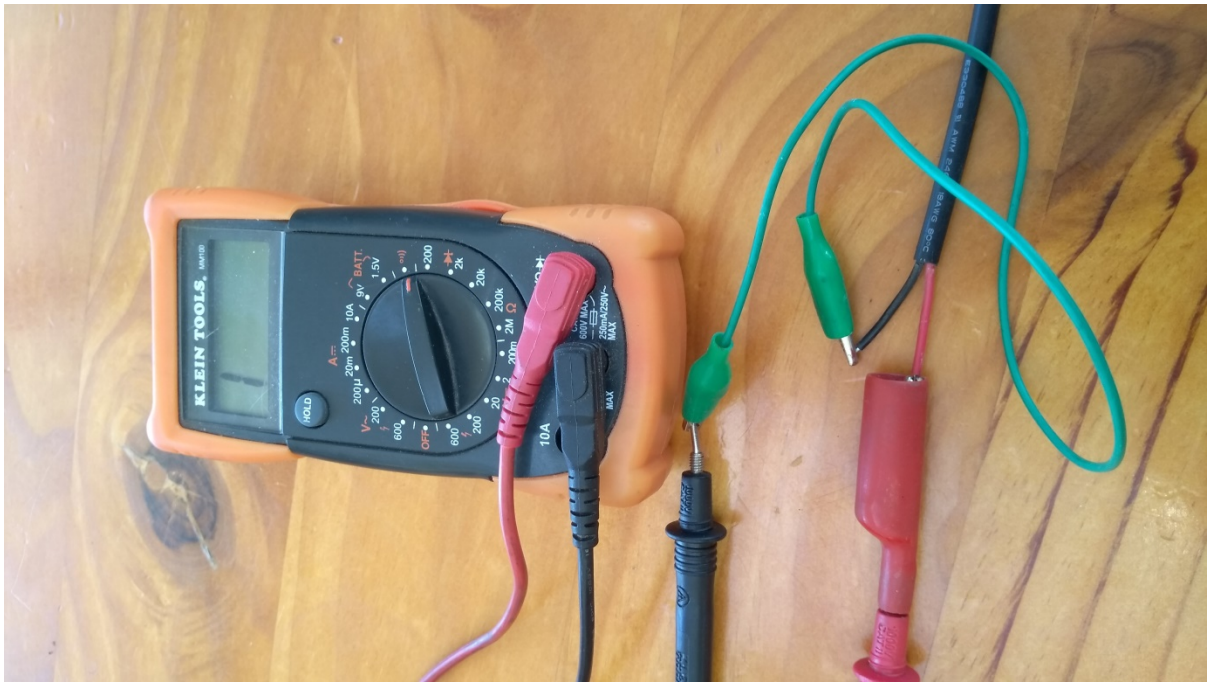
This clearly illustrates one of the main reasons that you shouldn’t buy a cheap multimeter. To keep the cost down, cheap materials are used, and this type of failure is common.
The little black meter has probably been used less than 10 times, and the yellow one not much more, but the probe wire insulation is broken on the black meter and both probes have fallen off the leads of the yellow one.
Not a huge issue if testing the voltage of a torch battery but potentially fatal if measuring mains voltage…
(I have seen meters that look like the little black one .. sometimes coloured yellow.. advertised from $5 up to $38.. they are probably identical.. avoid them!).

By contrast, the orange Klein meter has been carried around in tool boxes with spanners, hammers etc, dropped, hosed, splashed with chemicals and generally abused for years, and is showing no signs of damage beyond scuff marks. The leads are still in great condition.

IEC Category ratings
Good meters will probably have been tested to an IEC rating and state what that rating is: Category 1; Cat 2; Cat 3; or Cat 4.
Cat 1 is all we need for the low voltages of Ebikes, Cat 2 for testing mains Voltage appliances.
Electricians would typically use a Cat 3 meter for domestic installations and Linesmen would use Cat 4.

If the meter has a Cat 1 or 2 rating (or higher) it is an indication that it has been tested for quality and safety. If the leads have a Cat number or a voltage and current rating on them, that (hopefully) gives an indication of better quality than unmarked leads.

Accessories:
Multimeters are very useful by themselves, but sometimes you don't have enough hands to hold both probes plus do whatever else you need to do (switch something on, operate the throttle or whatever) so a very useful accessory is alligator clips that attach to the probes, or Clip leads.. wires with an alligator clip on each end, so the meter probe can be connected to the circuit without holding it.



Obviously be aware of any exposed metal carrying voltage when using probes or clip leads, and ensure they cannot touch each other or any conductive component (or the meter user!).

Summary:
Ranges: At least the following:
DCV;
ACV;
Resistance;
DC Current (Amps);
Continuity “Beep”;
Preferably manual range selection;
Preferably separate sockets for the red test lead for current measurement.

Safety:
Cat1 minimum (Cat 2 or higher preferred);
Check the test leads for soft, flexible, tough insulation and Cat or V&A markings;
Fused Current input.