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Measuring 10 to 2000 amps with a DMM

Application Note

DMMs have many useful functions like min/max capture, true-rms and data logging, but, in some areas they may appear to be lacking the capability you need. Like measuring amps for instance. Most DMMs measure only up to 10 amps through their current jacks, so what do you do if you need to measure more than 10 amps, maybe as much as 2000 amps?

The answer, of course, is to get a current clamp accessory for the DMM. It's relatively simple to use a current clamp accessory, but researching which clamp is the best match for your needs can leave you with more questions than answers. After all, the selection of current clamps seem endless. How do you choose the right current clamp to go with your DMM and make the measurement you need within the accuracy you need?

Current clamp types

The first decision you are faced with is which type of current clamp to use. The simplest clamp is the current transformer type. This clamp has no active components and its function is based on the same principles as those found in power transformers. The clamp, or the transformer core, is placed around a conductor carrying ac current, and the varying magnetic field setup by the current passing through the conductor is coupled into the core of the clamp. The conductor serves as the primary winding in this special transformer application. The secondary windings around the clamps core picks up the current and passes it to the current input jacks of the DMM, but at a much lower current. The clamps secondary winding is constructed in such a way as to deliver a stepped down current to the DMM. Most clamps are stepped down 1000:1. In other words, a 1 amp current through the conductor of the circuit being measured will cause 1 milliamp to flow in the secondary winding of the clamp. The current inputs of the DMM are connected to the secondary and therefore indicate the lower current in that circuit. The 1000:1 ratio makes reading the DMM real easy. Although the range is set to mA, you think amps as you read the DMM display. For example, 46.9 mA on the DMM is really 46.9 **amps** in the primary winding or conductor being measured in this case.

Transformer type current clamps are limited to measuring ac current only. They are fairly rugged and work with non-sinusoidal waveforms. You will find their price at the low end of the current clamp price range.

Another type of clamp is one that uses active components to not only step down the current, but output a voltage signal proportional to the measured current. Active clamps measure both ac and dc current using a technique based on the "Hall effect." Active clamps are useful for measuring dc current or with a DMM or scope that doesn't have current input jacks.

Active clamps require batteries to power their internal circuitry, and unless specifically designed for it, do not provide an accurate output of non-sinusoidal signals. Another feature found in some active clamps is a selectable step down ratio. e.g. 1000:1, 100:1, 10:1, etc.

Specifications

While looking for a current clamp, you will note that each has its own set of specifications. The accuracy of measurements made with a DMM and current clamp accessory require combining the specifications of the two. For reference, this article will refer to this combination as a "system specification." For example take a look at two common current clamps and how they would work with a Fluke 179 multimeter.

One of Fluke's transformer type clamps is the 80i-400. It has a step-down ratio of 1000:1 and a current measurement range from 1 to 400 amps. Its reading accuracy is ± (3 % + 0.4 A). Because it is a transformer type clamp, you will need a DMM that measures current. The Fluke 179 Digital Multimeter has four current ranges: 60 mA, 400 mA, 6 A and 10 A.

To get a system accuracy specification first note that the Fluke 179's current ranges have an accuracy specification of 1.5 % + 3 digits. So the only difference in specification across the DMM's current ranges will be the + 3 digits. For measurements up to 60 amps, the three digits represent 0.03 amps. Measurements between 60 and 400 amps make the three digits equal to 0.3 amps. Therefore, the total system accuracy of the Fluke 80i-400 and the Fluke 179 will be 4.5 % + 0.43 amps for measurements up to 60 amps, and 4.5 % + 0.7 amps between 60 and 400 amps.

The Fluke i410 is an active current clamp. It too has a step-down ratio of 1000:1, but it converts amps to volts. (i.e. 1 amp produces a proportional 1 mV reading on the DMM). This clamp measures current from 0.5 to 400 amps with an accuracy of 3.5 % + 0.5 A. With the clamp's output varying between 0.5 and 400 mV, only the 600 mV range of the Fluke 179 will be used for all measurements. The DMM's specification for this range is 1.0 % + 3 digits. Combining the two specifications will produce a system specification of 4.5 % + 0.8 A.

Applying these specifications to a DMM reading of 47.6 mA, means you can safely say the actual current flowing in the measured circuit is from 45.03 to 50.17 amps using the 80i-400 and from 44.66 to 50.54 amps using the i410. As you can see, there is not much difference between these two clamps. The difference is even smaller as the measured current goes above 60 amps. But what is the result when measured currents are much lower?

The overlooked specification

Another specification of the DMM that is often overlooked is the DMM's "floor spec." Generally found in DMMs that measure true-rms, it's an often overlooked specification that is typically only found as a footnote in the specification table. However, it's a specification that needs your full attention when looking at which current clamp accessory to use with the DMM.

Let's say you need to monitor circuits that carry between 10 and 30 amps, a fairly common measurement need. Using the system accuracy calculated for the two clamp examples above, we would be led to believe that a reading of 15 mA with the 80i-400 meant between 13.89 and 16.105 amps is actually flowing in the circuit. On the other hand, the i410 would lead us to conclude between 13.52 and 16.48 is flowing in the circuit. So which one is right?

A footnote in the Fluke 179 specification table reads: "All ac voltage and ac current ranges are specified from 5 % of range to 100 % of range." This specification limitation is due to the noise level inherent in rms converters. When the measured signal gets so low that the noise level out of the converter becomes a significant part of the measurement, the accuracy of the real reading becomes distorted by the converter noise. This only affects the low readings and is therefore called the "floor specification."

Trying to measure 15 amps with the 80i-400 on the Fluke 179 requires using the 60 mA current range, which, according to the floor specification (5 % of the 60 mA range) would provide an accurate reading for 3 mA (3 amps at the clamp) and above. For the i410, 15 amps requires the use of the ac 600 mV range of the 179. Based on the 5 % of range specification, the reading would have to be above 30 mV (30 amps at the clamp). It doesn't appear the combination of the i410 and the Fluke 179 could make any measurements below 30 amps with any reasonable accuracy. However, a more accurate DMM, like those in the Fluke 180 series of meters that have a 50 mV ac voltage range, could make that measurement with the i410 clamp accessory.

Frequency bandwidth

Another specification commonly overlooked is the DMM's frequency bandwidth. As DMMs have evolved over the years, there has been a change in the frequency response of the DMM. It's not uncommon to find multimeters today that can measure signals between 40 Hz and 200 kHz. This trend has been good for electronics technicians that deal with a wide range of signals. However, the electrician using the same meter may get mislead by readings that seem to change when different DMMs are used on the same circuit.

One example involves taking current measurements on motors that are controlled by variable frequency drives (VFD). An engineer who has been taking readings on a VFD controlled motor for years with a DMM and clamp, decides to upgrade to a higher performance DMM. The engineer may find the readings with the new DMM very confusing when they indicate higher values.

The older DMM probably had a narrower bandwidth than the new DMM and is therefore sensing less of the harmonics in the VFD signal to the motor. The motor and the engineer don't really care about the additional harmonics. The inductance of the motor filters out signals that aren't close to 60 Hz. It's not that the new DMM is inaccurate, it's just that the DMM is showing more of the signal present on the motors input leads. Readings could be 10 % - 20 % higher depending on the bandwidth of the DMM. A way around this is to make these measurements with a tool specifically designed for reading current or VFD controlled motors like Fluke's 337 Clamp Meter.

In conclusion

Finding the right current clamp accessory for your application requires a little bit of research and an understanding of how the two interact with each other. Make sure you consider **all** the specifications that can affect the "system" accuracy of your clamp and DMM. Accuracy, ranges, frequency bandwidth of both clamp and DMM affect the ability of the system to take the measurements you need for your particular application. Choosing between an "active" vs. "transformer" type clamp could also make a big difference in the measurement capability.

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