APPLICATION NOTE

Measuring 10 amps using a digital multimeter—The pros and cons

If the work being done is in high energy ac or dc measurement environments where arc flash and arc blast are a real concern, then it is recommended to consider using multimeters without amp jacks and depend upon current clamp style measuring accessories for much safer non-intrusive measurements for current.

A century ago, virtually all dc current measurements used in-line shunts. These, and the meters they were connected to, were usually permanently wired into the circuit being measured. The standard of the day was the 50 millivolt instrument shunt. It had a 50 mV voltage drop across its voltage sense terminals when at full range, so a 10 amp shunt added about 0.005 ohms to the circuit. It was not a large burden, and it was always present, so it presented no inconvenience or safety concern to the user. These shunts are still used today, for both dc and ac (up to about 1 kHz.)

Portable analog multimeters of the 1930s presented multiple ways to connect into a circuit, using several different jacks on the front panel. Two dedicated jacks were connected to an unfused 10 A shunt, similar to the earlier instrument shunt, inside the meter. Switching allowed a user to connect the indicating meter to the shunt. The shunt itself presented low burden to the circuit, but its ultimate effect depended on the test leads used. The added resistance of the test leads could cause readings taken with the meter in circuit to be significantly lower than that which would flow when the meter was no longer in the circuit. That effect is known as burden error.

Fluke's first handheld digital multimeter (DMM), the 8020A, did not have a 10 A range. It did have a mA jack and the meter could measure up to 2000 mA. For higher current ac measurements, a clamp current transformer scaled 1000:1 was connected to the mA jack. When the transformer was clamped around a conductor carrying 10 A, the meter read 10 mA. There was a similar clamp on device that could measure dc current, but In this case, the output was in millivolts—10 A in the conductor would be read as 10 mV in a voltage measuring range of the DMM. Many such clamp-on accessories are available today.

The 3000FC True-rms Digital Multimeter

A multimeter accessory such as the Fluke i1010, 1000 A AC/DC Current Clamp will make a 10 A measurement without introducing significant burden voltage, and without breaking the circuit

Safety issues and the 10 A range

In today's electrical maintenance world, measurement technology has progressed to the point that a dedicated 10A in-line measurement range on a DMM is no longer needed, and in some cases such as explosive environments, meters with this capability are not even allowed on-site due to safety concerns.

Not only are there significant safety risks associated with open wiring to a meter being used in high energy environments, but significant measurement errors are likely due to the necessary addition of high energy fusing, requiring in-depth analysis and correction factors to be applied to measurements.

With the availability of ac and ac-dc current clamp accessories that use either the mA or mV inputs of a DMM, there is no longer a reason to have a 10 A range on a meter intended for industrial applications.

There are of course, low energy laboratory applications for such a meter, but before using that feature consider the following.

The introduction of the fused, 10 A range, and its drawbacks.

In 1983, Fluke introduced the 70 Series Digital Multimeters. The first models had an unfused 10 A range, but safety issues arising when these meters were used in high-energy electrical distribution systems prompted Fluke to introduce arc-extinguishing high energy fusing into subsequent current measuring DMM circuits.

With the introduction of these shunts and their associated fuses into the in-line circuit, the added series resistance (burden error) became significant. It's usually not a problem in the milliamp ranges, but can be very significant in the 10 A range, especially when the circuit source voltage is low—such as that from a 6 V battery. There is a specification for current measurement in this and other Fluke DMMs called "Burden Voltage." This is the voltage that will appear across the meter due to the internal burden resistance of the shunt and its associated fuse.

What has been learned over the years is that most DMM users never used the 10 A range. Their current clamp accessories measured both ac and dc, working with the mA or mV inputs, to read values scaled so that 1 mA represented 1 A, and 1 mV represented 1 A, depending on the clamp accessory used.

How does the accuracy of direct current measurements using the 10 A range compare to using one of the clamp accessories?

For this discussion, we'll use the Fluke 87-5. This digital multimeter has a fused 10 A range that can be connected directly into a working circuit. The specified Burden Voltage for this range is 0.03 V/A. That corresponds to an equivalent resistance of 0.03 ohms.

Add to that number the resistance of the test leads connecting the meter to the circuit to be measured (about 0.1 ohms), and the total added series resistance is now 0.13 ohms.

Let's suppose we want to adjust the circuit to draw 8.0 Amps from an unregulated battery. From our specification shown above, the approximate voltage drop across the meter terminals will be 0.24 volts (0.3V/A * 8.0A=0.24V). But, there is also the 0.1 Ohm test leads to be considered. That adds another 0.8 volts drop, for a total of 1.04 Volts. That's about 16% of our available voltage. What is worse is that when we remove the meter and leads from the circuit, the current will likely increase to nearly 10 Amps.

For comparison, the Fluke i1010, 1000 A AC/DC Current Clamp will make this measurement without introducing any significant burden, and without breaking the circuit. The measurement error of the clamp will be less than 7% at this low level, and the current won't change when we remove the clamp.

For those of you who must, for one reason or another, measure the current directly, we suggest adding a permanent calibrated shunt to the circuit as described

at the beginning of this article. Such shunts are still available today, and the voltage drop across them can be easily (and accurately) read with the millivolt range of your DMM.

Summing it up

For bench design engineers or technicians who troubleshoot electronic circuits that typically would consume smaller amounts of ac or dc current less than 10 amps, there is likely still a need for having a 10 A range on your multimeters and the need for making an in-line current measurements. These applications and measurements are also made in low-energy circuits and in applications where there are no concerns with arc flash or arc blast.

However, if the work being done is in high energy ac or dc measurement environments where arc flash and arc blast are a real concern, then it is recommended to consider using multimeters without amp jacks and depend upon current clamp style measuring accessories for much safer non-intrusive measurements for current.

Non-invasive current measurements reduce the risk to the user substantially over making inline current measurements. In-line current measurements in high energy electrical environments are not a safe work practice, especially when there are less invasive clamp style current accessories or standalone units that will work with multimeters with no amp inputs that make these current measurements much safer.

So, if you work in or around high energy electrical environments and you need to measure current, consider a multimeter without an amp input as there are a number of current measurement options which make the troubleshooting or testing process much safer than old style in-line current measurements.

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