

Proper use of clamp meters in commercial and residential settings

Application Note

There's nothing so annoying as a breaker that keeps tripping, usually at the most inopportune times. More annoying yet is not being able to figure out why as the production line stands silent waiting for you to work your magic. The pressure's on! In this application note, we'll discuss how to utilize all the capabilities of your clamp meter so you can keep your world up and running.

We all know that clamp meters are used to measure circuit loading. But, with a bit of ingenuity, you can also use clamps to tell you which breaker controls which outlets, as well as to measure individual loads (for both load and ground currents, if any). This can help you solve load problems quickly and preserve your reputation as an ace troubleshooter.

Clamp meters measure current by determining the magnetic field around a current-carrying conductor. There is simply no other practical way to measure current on electrical wiring systems. Breaking these circuits open to make a series circuit measurement is impractical and may even be a career ending move if you inadvertently take critical loads offline. Usually, measurements are taken at the panel and include loading and balance on three-phase feeders. With the prevalence of harmonic loads, neutral measurements at panelboards are also mandatory. Current measurements can also be used to diagnose motor health.



Beyond these basic measurements that clamps were specifically designed for, modern digital clamp meters have voltage and resistance measurement capability as well. That means it's possible to make most, if not all, of the common, everyday measurements using a clamp meter. If an electrician could take just one test tool on the job, it would make sense for him to choose his clamp meter. Furthermore, that clamp meter should be a true-rms model. The alternative is an average-sensing model, which costs less, but will not measure the

current accurately. Whenever there are electronic loads (computers, TVs, lighting, motor drives, etc.) on a circuit, the average-sensing meter could be inaccurate. The greater the electronic load, the greater the inaccuracy. True-rms clamps will always be accurate (assuming of course that you've kept it calibrated). So unless you feel comfortable saying that you're not likely to run into those kind of loads, get a true-rms clamp. That way you can think about the job, not the test tool. In commercial sites especially, accurate true-rms clamps are mandatory.

Clamp meters in residential applications

For residential electricians, clamps are a necessity to measure loads on individual branch circuits at the service panel. While a spot check of current is often sufficient, sometimes it doesn't provide the full picture as loads are switching on and off, going through cycles, etc. Voltage should be stable in an electrical system, but current can be very dynamic. To check the peak or worst-case loading on a circuit, use a clamp with a min/max function which is designed to catch high currents that exist for longer than 100 ms, or about eight cycles. These currents lead to intermittent overload conditions which can cause nuisance tripping of circuit breakers.

Take measurements on the load side of the circuit breaker or fuse. The breaker will open the circuit in the event of an accidental short circuit. This is especially important with any kind of direct-contact voltage measurement. Even though clamp jaws are insulated and therefore have a level of protection that doesn't exist with direct-contact voltage measurement, it's still a good idea to be cautious.

A common problem in residential electrical work is mapping outlets to breakers. A clamp can be useful in identifying which circuit a particular outlet is on. First take a baseline reading, at the service panel, of the existing current on the circuit. Then put the clamp in min/max mode. Go to the outlet in question, plug in a load—a hair dryer is ideal—and turn it on for a second or two. Check the clamp to see if the max current reading has changed. A hair dryer will typically draw 10–13 amps, so there should be a noticeable difference. If the reading is the same, you've got the wrong breaker.

Clamp meters in commercial environments

Clamp meters are used at the panelboard to measure circuit loading on feeders as well as on branch circuits. Measurements on branch circuits should always be made at the load side of the breaker or fuse.

- Feeder cables should be checked for balance as well as loading: current on all three phases should be more or less the same, to minimize the return current on the neutral.
- The neutral should also be checked for overloading. With harmonic loads, it's possible for the neutral to be carrying more current than a feeder—even if the feeders are balanced.
- Each branch circuit should also be checked for possible overloading.
- Finally, the grounding circuit should be checked. There should be minimal current on the ground.

Testing for leakage currents

To check if there is leakage current on a branch circuit, put both the hot and neutral wires in the jaws of the clamp. Any current that is measured is leakage current, i.e., current returning on the ground circuit. The supply (black wire) and return (white wire) currents generate opposing magnetic fields. The currents should be equal (and opposite) and the opposing fields should cancel each other out. If they don't, that means that some current, called leakage current, is returning on another path, and the only other available path is the ground.

If you do detect a net current between the supply and return, consider the nature of the load and the circuit. A mis-wired circuit can have up

to half of the total load current straying through the ground system. If the measured current is very high, you probably have a wiring problem. Leakage current may also be caused by leaky loads or poor insulation. Motors with worn windings or moisture in fixtures are common culprits. If you suspect excessive leakage, a de-energized test using a megohmmeter will help evaluate the integrity of the circuit's insulation and help identify if and where a problem exists.

Measuring individual loads

To measure individual loads, you can use a break-out cord at the receptacle. This is simply an extension-type cable where the outer insulation is stripped so that the black, white and green wires are exposed. It's a lot easier than taking the receptacle out to get at a wire. Plug the load into the cable and the cable into the outlet. To measure load current, clamp the black wire. Make the ground current check directly on the green cable or on the black and white wire together.

Motors and motor control circuits

One of the most challenging places to make current measurements is in a control circuit cabinet, especially if it uses IEC-style components. European-originated IEC-style components are much more compact than the equivalent NEMA parts, and the wiring can be packed pretty tight. The tapered jaw and "backlight" function of the Fluke 370 Series clamp meters are well suited to this measurement task.

Three-phase induction motors are commonly used in commercial buildings to drive fan and pump loads. Motors can either be controlled by electromechanical starters or by electronic variable speed drives.



Variable speed drives are more and more common, since they save considerable energy.

The Fluke 376 is the ideal clamp to make these motor and drive measurements:

- **Loading:** The current draw of the motor, measured as an average of the three phases, should not exceed the full load amperes rating of the motor (times the service factor). On the other hand, a motor that is loaded below 60 percent of full load amperes—and many of them are—is less and less efficient, and the power factor decreases as well.
- **Current balance:** Current imbalance can be an indication of problems with the motor windings (for example, different resistances on field windings due to internal shorts). Generally speaking, imbalance should be under 10 percent. (To calculate imbalance, first calculate the average of the three phase readings; then find the highest deviation from the average and divide by

the average.) The extreme of current imbalance is single phasing, when there is no current on one of the three phases. This is usually caused by an open fuse.

- **Inrush current:** Motors started across the line (by mechanical starters) will have an inrush current (variable speed drives do not have inrush current). The inrush current is approximately 500 percent on older motors to as high as 1,200 percent on energy-efficient motors. This inrush current, if it is too high, is a common cause of voltage sags as well as nuisance tripping. The “inrush” function of the Fluke 376 clamp meter is a unique capability, designed to trigger on the inrush current and capture its true value.
- **Peak loading (shock loads):** Some motors are subject to shock loads, which can cause enough of a current surge to trip the overload circuit in the motor controller. Think of a saw running into a knot. The min/max function can be used to record the worst-case current drawn by shock loads.

Whether in residential or commercial settings, the clamp meter is the electrician’s indispensable test tool.

Work safely

The high voltage and currents present in electrical power systems can cause serious injury or death by electrocution and burns. Consequently, only trained, experienced electricians who have knowledge of electrical systems in general and the equipment under test should perform testing and modification of electrical systems.

Fluke cannot anticipate all possible precautions that you must take when performing the measurements described here. At a minimum, however, you should:

- Use appropriate safety equipment such as safety glasses, insulated gloves, insulating mats, etc.
- Be sure that all power has been turned off, locked out, and tagged in any situation where you will be in direct contact with circuit components. Be certain that the power can’t be turned on by anyone but you.
- Read and understand all of the applicable manuals before applying the information in this application note. Take special note of all safety precautions and warnings in the instruction manuals.
- Do not use instruments on applications for which they are not intended, and always be aware that if the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

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