FLUKE®

Why true-rms?

Non-linear loads need a true-rms current clamp for accurate readings

Application Note

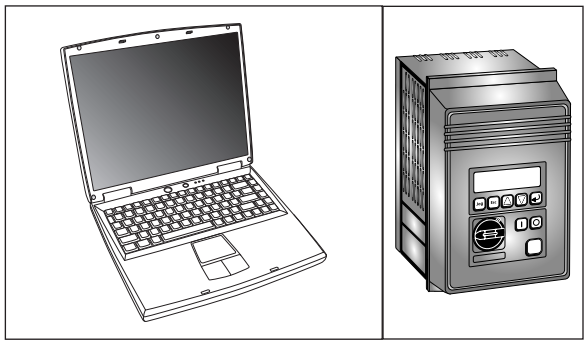
Troubleshooting the electrical service feeding adjustable speed motor loads can be difficult if you don't have the right tools. New solid state motor drives and heating controls often conduct non-sinusoidal (distorted) current. In other words, the current occurs in short pulses rather than the smooth sine wave drawn by a standard induction motor. The current wave shape can have a drastic effect on a current clamp reading.

One current—two readings. Which do you trust? The branch circuit above feeds a non-linear load with distorted current. The true-rms clamp reads correctly but the average responding clamp reads low by 32 percent.

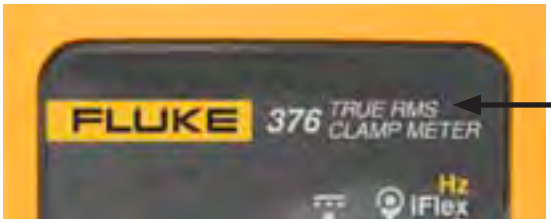
Basically, there are two types of current clamps commonly available: "average responding" and "true-rms." The average responding units are widely used and are usually lower cost. They give correct readings for linear loads such as standard induction motors, resistance heaters, and incandescent lights. But when loads are non-linear, containing semiconductors, the average responding meters typically read low. Worst case non-linear loads include three-phase adjustable speed drives (5 horsepower or less) connected line to line across two phases of a 480 volt (V, three-phase system, solid state heater controls connected single phase to 240 V, or computers connected to 120 V. When troubleshooting a branch circuit that suffers from circuit breaker tripping (or fuse blowing), the cause of the trouble can usually be separated into one of three categories:

1. Too much current.
2. Too much heat in the electrical enclosure.
3. Faulty circuit breaker (or fuse).

Your first instinct will probably be to measure the current with a current clamp while the load is on. If the current is within the circuit rating, you may be tempted to replace the circuit breaker.



Non-linear loads that cause measurement errors include computer loads and adjustable speed motor load.



The true-rms clamp is labeled on the front panel.

Before you do that, make two other observations: First, analyze the load. If the load contains power semiconductors, rectifiers, SCRs, etc., be suspicious of the current clamp reading. Second, look at the front panel of your current clamp—does it say true-rms? If you can't find the words true-rms on the front panel, then you probably have an average responding current clamp.

Current clamps come in two physical styles. The most common type is the integral clamp, which has the jaws, readout, and measured circuit built into a stand-alone unit. Examples include Fluke models 373, 374, 375, 376, 381, and 902. Look for the words true-rms on the front panel.

The second style consists of a current transformer (CT)-type accessory that works with a digital multimeter. Examples include Fluke models i200, i400, or i800. The jaws of the clamp enclose the conductor being measured, which acts as a transformer primary of one turn. The secondary coil has 1,000 turns, which divides the measured current by 1,000. That is, the measured current is converted from amps to milliamps. When the clamp's output leads are plugged into the DMM's ac milliamp jacks, the displayed reading in milliamps reads correctly for amps in the jaws.

If you are trying to measure current drawn by a non-linear load containing semiconductors, without a true-rms meter, you are likely to make the wrong conclusion—that the problem is a faulty circuit breaker. Replacing the breaker won't help. You'll get a call-back with some unpleasant words from your customer. To avoid this, read the sidebar about true-rms, find your local Fluke distributor and get yourself a true-rms current clamp or meter that will give correct readings regardless of the type of load or current wave shape. If your reputation depends on accurate current readings then it won't take you long to decide that a true-rms multimeter or current clamp is the only reasonable choice. For additional information call 1-800-443-5853 (US) or your Fluke distributor.

What is true-rms?

"RMS" stands for root-mean-square. It comes from a mathematical formula that calculates the "effective" value (or heating value) of any ac wave shape. In electrical terms, the ac rms value is equivalent to the dc heating value of a particular waveform—voltage or current. For example, if a resistive heating element in an electric furnace is rated at 15 kilowatts (kW) of heat at 240 V ac rms, then we would get the same amount of heat if we applied 240 V of dc instead of ac.

Electrical power system components such as fuses, bus bars, conductors, and thermal elements of circuit breakers are rated in rms current because their main limitation has to do with heat dissipation. If we want to check an electrical circuit for overloading, we need to measure the rms current and compare the measured value to the rated value for the component in question.

If a current clamp is labeled and specified to respond to the true-rms value of current, it means that the clamp's internal circuit calculates the heating value according to the rms formula. This method will give the correct heating value regardless of the current wave shape.

Certain low-cost current clamps, which don't have true-rms circuitry, use a short cut method to find the rms value. These meters are specified to be "average responding-rms indicating." These meters capture the rectified average of an ac waveform and scale the number by 1.1 to calculate the rms value. In other words, the value they display is not a true value, but rather is a calculated value based on an assumption about the wave shape. The average responding method works for pure sine waves but can lead to large reading errors up to 40 percent, when a waveform is distorted by nonlinear loads such as adjustable speed drives or computers. The table below gives some examples of the way the two different types of meters respond to different wave shapes.

Some true-rms clamp meters are ac coupled, which gives the rms value of only the ac component of a waveform. (This dates from the time when a majority of measurements in the electrical industry were predominately sinusoidal with no dc offset.) To measure the rms with an ac-coupled clamp meter, first measure the rms value of the ac component. Then measure the waveform on the dc scale. Combine the ac and dc components by squaring each, adding the results, and then extracting the square root. The function AC+DC in Fluke true-rms clamp meters essentially does the calculation for you.

Multimeter type	Response to sine wave	Response to square wave	Response to single phase diode rectifier	Response to 3 ∅ diode rectifier
Average responding	Correct	10 % high	40 % low	5-30 % low
True-rms	Correct	Correct	Correct	Correct

A comparison of average responding and true-rms units

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