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What is true-RMS?

Electrical (/en-us/learn/blog/electrical), 101 Learning (/en-us/learn/blog/fundamentals)

A **true-RMS** device (RMS = root mean square) is one of three tools that can measure alternating current (ac) or ac voltage:

1. True-RMS digital multimeters (https://www.fluke.com/en-us/product/electrical-testing/digital-multimeters/fluke-279-fc) (or clamp meter)
2. Average-responding digital multimeter (https://www.fluke.com/en-us/products/electrical-testing/digital-multimeters) (or clamp meter (https://www.fluke.com/en-us/products/electrical-testing/clamp-meters))
3. Oscilloscope (/en-us/products/electrical-testing/portable-oscilloscopes)

Only the first two tools are commonly used, and both can accurately measure standard (pure ac) sinusoidal waveforms.

Yet a true-RMS meter is widely preferred because it is the only one that can accurately measure both sinusoidal and non-sinusoidal ac waveforms.

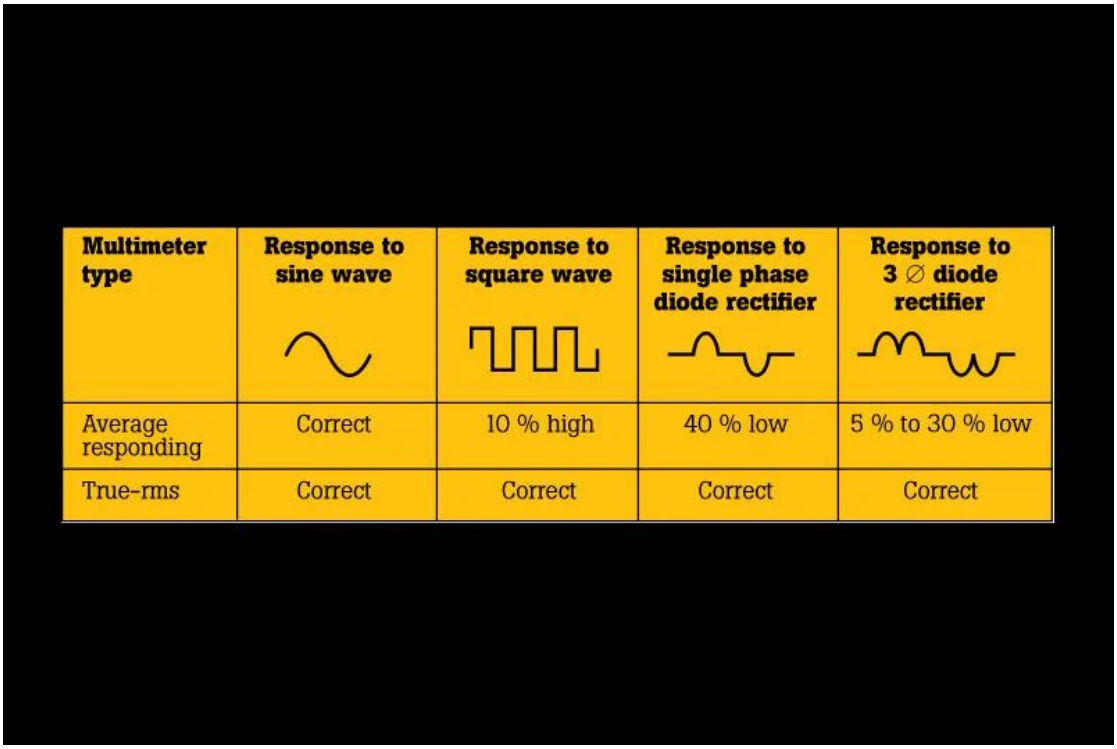
- **Sinusoidal (sine) waves**: Pure, without distortion, with symmetrical transitions between peaks and valleys.
- **Nonsinusoidal waves:** Waves with distorted, irregular patterns—spikes, pulse trains, squares, triangles, sawtooth and any other ragged or angular waves.

How to calculate RMS

As mentioned previously, **RMS = root mean square.** Though its formula can be challenging to grasp, RMS essentially **calculates the equivalent direct current (dc) value of an ac waveform**. More technically, it determines the "effective," or dc heating value, of any ac wave shape.

An **average-responding meter** uses averaging mathematical formulas to accurately measure pure sinusoidal waves. It can measure non-sinusoidal waves, but with uncertain accuracy.

A more sophisticated **true-RMS meter** can accurately measure both pure waves and the more complex non-sinusoidal waves. Waveforms can be distorted by nonlinear loads such as variable speed drives or computers. An averaging meter attempting to measure distorted waves can be up to 40% low or 10% high in its calculations.



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 % to 30 % low
True-rms	Correct	Correct	Correct	Correct

Where to measure true-RMS

The need for true-RMS meters has grown as the possibility of non-sinusoidal waves in circuits has greatly increased in recent years. Some examples:

- Variable-speed motor drives
- Electronic ballasts
- Computers
- HVAC
- Solid-state environments

In these environments, current occurs in short pulses rather than the smooth sine wave drawn by a standard induction motor. The current wave shape can have a dramatic effect on a current clamp reading. In addition, a true-RMS meter is the better choice for taking measurements on power lines where ac characteristics are unknown.

Reference: Digital Multimeter Principles by Glen A. Mazur, American Technical Publishers.

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