OLED Display for the AEMC® Clamp-on Ground Resistance Tester Models 6416 & 6417

By Guy Belliveau

The Clamp-on Ground Resistance Testers Model 6416 and Model 6417 enable you to measure grounding electrodes and grid resistance without the use of auxiliary ground rods. These instruments can be used in multi-grounded systems without disconnecting the ground system under test. With onboard memory, measurements can be stored for later analysis. The Model 6417 also features Bluetooth to communicate with our DataView® software and our Model 6417 Android™ App **(available through Google Play)**.

As you can see in the photo to the right, the Model 6416/6417 simply clamps around the ground conductor or rod and measures the resistance/impedance to ground.

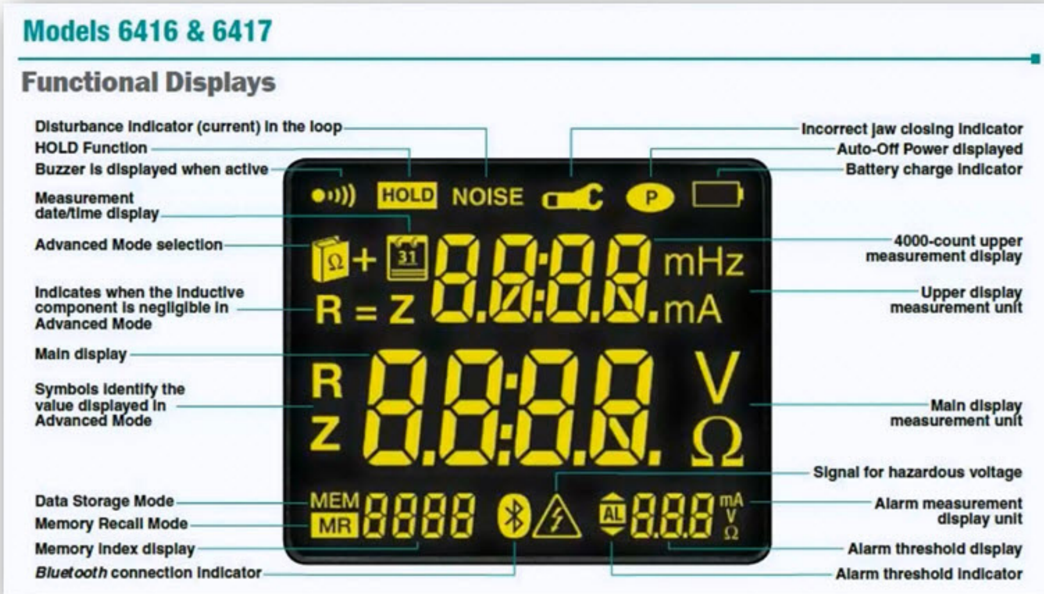
The instrument’s high sensitivity also enables measurements of leakage current flowing to ground or circulating in ground loops from 0.2mA to 40A and resistances from 10mΩ to 1500Ω.

Safety checks of voltage and current are automatically performed to help ensure conditions are safe and noise-free for valid measurements.

In the example measurement shown in the photo, the instrument indicates that there is approximately 1.66mA of current on the ground rod and the ground resistance is approximately 27.5 Ohms.

An important feature of this instrument is the large multi-function display. This is a 152 segment Organic Light Emitting Diode (OLED) screen. OLED technology results in a thinner, lighter, sharper, higher contrast display when compared to LCD screens. The OLED display also consumes less power than traditional screens and helps to maximize battery life.

The display provides up to 22 parameters and informational icons that can be activated during configuration testing and analysis of results, either in real-time or from stored memory.



OLED technology renders the screen visible through a wide 170-degree viewing angle. This ensures the displayed data remains viewable from many different viewing positions.

The OLED display is also ideal for bright ambient conditions. For example, when viewing outdoors in sunny conditions, press the brightness ☀ button on the instrument’s front panel to enhance the contrast on the screen. With the display contrast set to high the screen is now easily visible even in the brightest natural conditions.

This concludes our quick introduction to the Models 6416 and 6417 with OLED display screen. For more information about these and other AEMC instruments please visit our website at **www.aemc.com**, or subscribe to our **You Tube Channel**.

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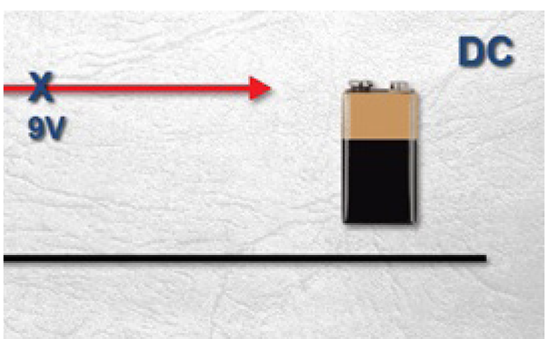
Root Mean Square (RMS) Primer

Root mean square, commonly called RMS, is an important concept in electronics. It's also one that can cause a bit of confusion at first. In this short article, we define RMS, why it is needed, and how it is used. We also explain the difference between "averaging" RMS and "true" RMS.

RMS Defined

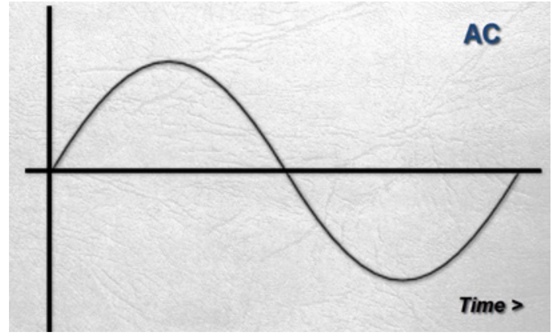
RMS is a mathematical concept used to derive the average of a constantly varying value. In electronics, RMS provides a way to calculate effective AC power. Phrased another way, RMS determines the heating value of AC power in a way that allows us to compare it to the equivalent heating value of a DC system.

To help understand this, let's consider a DC power source, such as a 9V battery. If we plot the voltage from this battery (without a load) on a graph with time as the horizontal axis, we end up with a straight line. The graph starts at 9V, and remains more or less constant for the useable life of the battery. In this case, measuring the voltage is straightforward: we simply pick any instantaneous point on the graph, and that gives us the value.

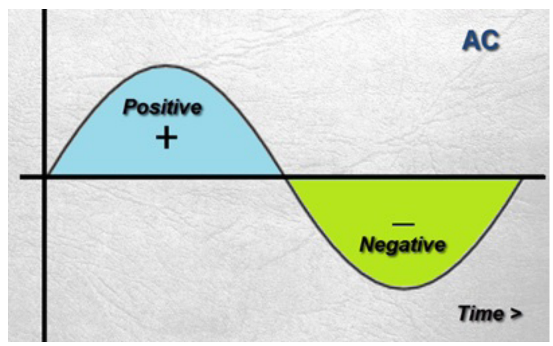


Note that our straight line graph is somewhat idealized. In a system with an actual load, the voltage would gradually slope downward over time. But our central point remains the same: all we need to do to determine the voltage is to simply take a measurement at any moment.

For AC power, it's considerably more complicated. When we plot clean and undistorted AC power against time, we see the familiar sine wave graph, due to its constant cycling from positive to negative values and then back again.



If we measure the voltage or current at random times on this graph, we get different values, depending on which points we choose. At first glance, it may seem logical to simply take the average of these measurements to calculate the effective power for this source. However, if we do so, we'd end up with a voltage or current of zero. By definition, the pure sinusoidal AC power wave cycle spends as much time below zero as above, therefore the negative values will cancel out the positive ones.

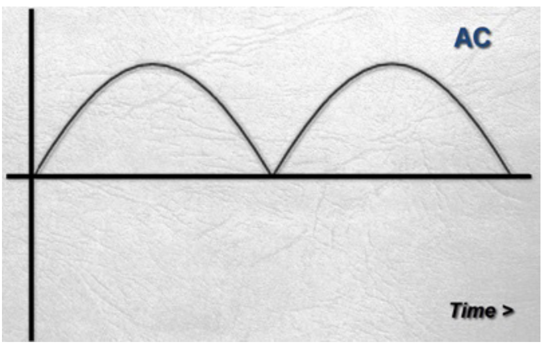


So no matter how high our peak power is, the average power for the classic AC system would always be zero, the same as if we had no power source at all. Obviously such a result tells us nothing about the true power flow in this system, so we need another way to derive the effective AC voltage or current.

Calculating RMS

We can do this by applying the RMS method. For demonstration purposes, we will consider the simplest and “cleanest” AC waveform, an undistorted sine wave such as the one shown above. In real life an AC system can display waveform asymmetries due to factors such as non-linear loads. We will return to this point a little later in this article. But for now, let’s discuss how to find RMS for a regular sine wave.

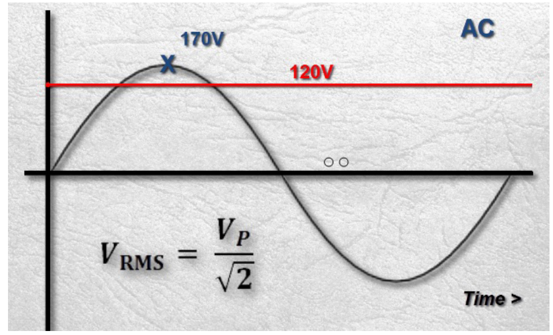
The first step is to square the AC power values. This produces a graph similar to the one below.



As you can see, all points on the graph are at or above zero, so we no longer have to deal with negative values. We can now use these positive numbers to calculate the effective power of this AC system. A step-by-step derivation of these calculations requires a moderate amount of math; so for the sake of brevity we’ll cut to the chase and show the final formula, which for sinusoidal voltage is as follows:

$$V_{\mathrm{RMS}} = \frac{V_P}{\sqrt{2}}$$

In this equation, RMS voltage (V_{RMS}) equals the peak AC voltage (VP) divided by √2. For example, suppose we have an AC system in which the peak voltage is 170V. Applying the formula shown above, we derive a V_{RMS} value of approximately 120V. In other words, the effective voltage of this AC system is 120V, the same as household outlet voltage in the U.S.A.



This formula can also be applied to calculate effective AC current:

$$I_{\mathrm{RMS}} = \frac{I_P}{\sqrt{2}}$$

And for a quick approximation, you can calculate effective voltage or current by simply multiplying the peak value by 0.707, which represents the decimal form of 1/√2:

$$V_{\mathrm{RMS}} = V_p \text{ x } 0.707$$

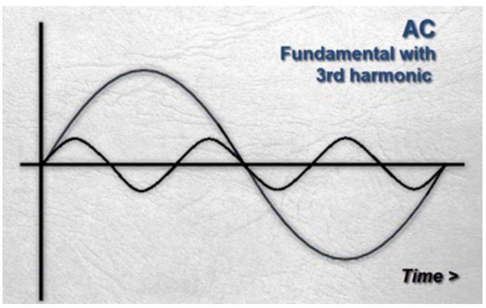
True RMS

This simple RMS equation forms the basis of so-called “averaging” RMS instruments. For electrical systems where the AC cycle is sinusoidal and reasonably undistorted, these products can produce accurate and reliable results. Unfortunately, for other AC waveforms, such as square waves, this calculation can introduce significant inaccuracies. The equation can also be problematic when the AC wave is irregular, as would be found in systems where the original or fundamental wave is distorted by one or more harmonic waves.

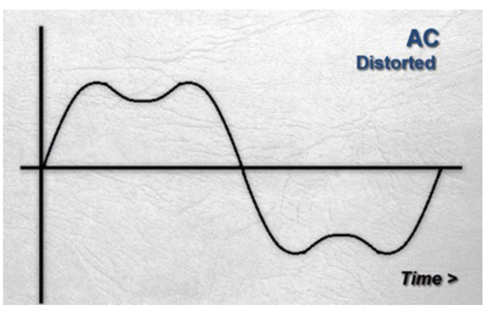
In these cases, we need to apply a method known as “true RMS.” This involves a more generalized mathematical calculation that takes into consideration all irregularities and asymmetries that may be present in the AC waveform:

$$V_{\mathrm{RMS}} = \sqrt{\frac{x1^2 + x2^2 + \cdots + xn^2}{n}}$$

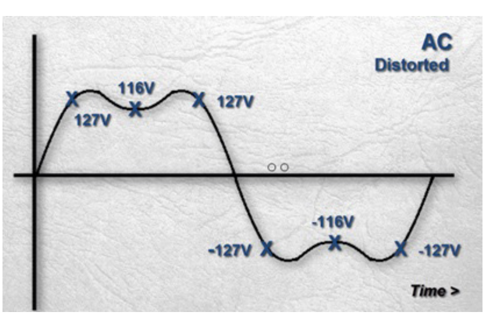
…where *n* equals the number of measurements made during one complete cycle of the waveform. For AEMC's instruments, this is always a multiple of 2 (typically 64, 128, or 256 depending on the instrument). The higher this number is, the more accurate the RMS calculation will be. This is because the higher the value of n, the higher the order of harmonics the preceding formula can accommodate. To understand why this is so, let's consider the following example. Suppose we added a 3rd harmonic wave to our fundamental wave, as follows:



The combination of these two waves produces the following distorted waveform:



As you can see, the greatest distortion to the fundamental occurs when the 3rd harmonic reaches either its positive or negative peak. By definition, this occurs 6 times per cycle of the fundamental. Therefore to accommodate the effect of the 3rd harmonic, we will take 6 measurements, timed to correspond with the positive and negative peaks of the third harmonic:



Since in this example we have 6 measurements, the value of n is 6. Plugging this number and the measurement values into the formula, we derive the following:

$$V_{\mathrm{RMS}} = \sqrt{\frac{127^2 + 116^2 + 127^2 + -127^2 + -116^2 + -127^2}{6}}$$

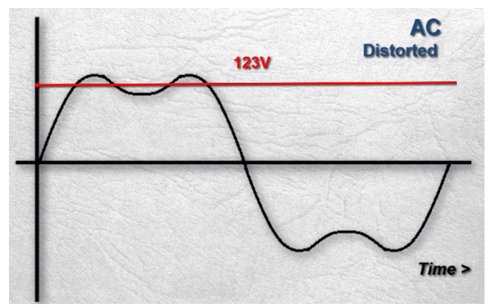
$$V_{\mathrm{RMS}} = \sqrt{\frac{16129 + 13456 + 16129 + 16129 + 13456 + 16129}{6}}$$

$$V_{\mathrm{RMS}} = \sqrt{\frac{91428}{6}}$$

$$V_{\mathrm{RMS}} = \sqrt{15238}$$

$$V_{\mathrm{RMS}} = 123.4\mathrm{V}$$

…or approximately 123V:



In other words, the harmonic distortion introduced in the waveform shown above has changed the V_{RMS} from 120V in its pure sinusoidal form to approximately 123V in its distorted form.

Note that this is a very simple example. In the real world, we would likely need to take into consideration many other orders of harmonics, (5th, 7th, 9th, 11th, and so on), in which case the number of measurements per cycle, and correspondingly the value of n, would be much higher. But for the purposes of demonstration, our example should provide some insight into how true RMS instruments perform their calculations.

We hope you have found this brief explanation of root mean square helpful. If you have further questions about this topic, or have topic suggestions for future articles, please email us at:
technicalsupport@aemc.com