AEMC® INSTRUMENTS
CHAUVIN ARNOUX GROUP

Chauvin Arnoux® Inc.
15 Faraday Drive • Dover, NH 03820 USA • (603) 749-6434 • Fax (603) 742-2346 • www.aemc.com

Issue 04 **"WATTS CURRENT" BULLETIN** *Winter 2015*

Tower Ground Testing with the AEMC® GroundFlex® Field Kit

TECHNICAL BULLETIN

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Featured Product:

Tower Ground Testing with the AEMC® GroundFlex® Field Kit

Proper grounding is critical to power line transmission towers. These towers are highly susceptible to lightning strikes, which can result in a dangerous “back flashover” condition resulting in progressive or instantaneous destruction of the insulators. This in turn can lead to damage to the tower and/or conductors. The results can be catastrophic.

To ensure your transmission lines are adequately protected from this risk, it’s essential to be able to accurately measure how well each tower is grounded, as well as test the quality of the overhead ground conductor connection.

AEMC’s GroundFlex® Field Kit is a robust and versatile system for testing the grounding of power line towers. At the core of this kit is the Model 6472 Ground Resistance Tester, operating in conjunction with the GroundFlex® High Gain Amplifier Adapter Model 6474. Other kit components include sensors, electrodes, and all required leads, connectors, and wiring.

AEMC GroundFlex® Field Kit

A critical advantage provided by the GroundFlex® Field Kit tower testing system is that you do not need to disconnect the overhead ground conductor to obtain accurate and meaningful results. This saves considerable time and money.

In this article, we briefly describe how to use the GroundFlex® Field Kit to test a tower. We start by explaining how to set up the kit to obtain static readings such as passive resistance and leakage current. We then dynamically test the total tower resistance/impedance, initially at a baseline frequency and then via a “sweep” from low to high frequencies.

Our test subject in this article is a four-legged lattice tower. However, the GroundFlex® Field Kit can also test monopoles, H-frames, and tri-leg towers.

Setting Up the GroundFlex® Field Kit

The first step is to set up the kit’s test environment. This involves:

1. Installing the GroundFlex® sensors on the tower’s legs
2. Attaching the voltage and current probes
3. Placing the grounding electrodes
4. Connecting all components to the GroundFlex® Field Kit

Start by connecting the Model 6472 and Model 6474 together, using the multi-pin cable supplied with the kit.

Connecting the Models 6472 and 6474

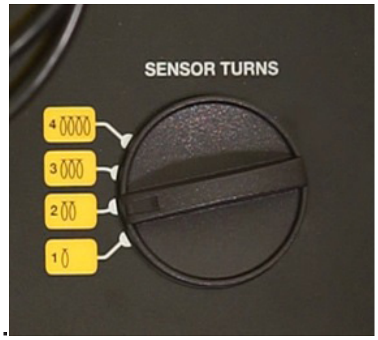
The Model 6474, which operates on power supplied by the Model 6472, serves as the primary interface for the four GroundFlex® sensors used in this test. These sensors are Rogowski type coils.

GroundFlex® probes (note the directional arrows)

Next, install the GroundFlex® sensors around each leg of the tower.

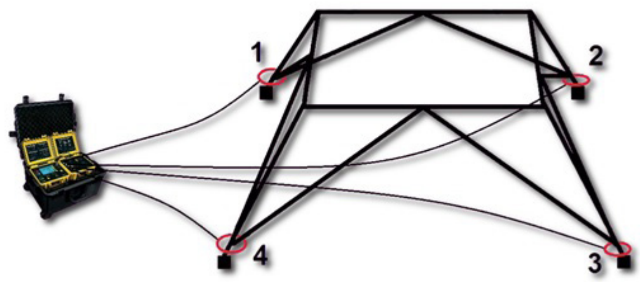
Installing the GroundFlex® probes (in this illustration, the probes are looped twice around the tower leg)

A sensor can be looped around a leg up to four times. The more loops used, the more precise the measurement can be in poor soil conditions. All sensors used in the test must be looped the same number of times. Note that each sensor is labelled with arrows. For all sensors, these arrows must be pointing in the same rotational direction on each tower leg. In this test, we will loop each sensor twice, counterclockwise. We then connect each sensor to the Model 6474, and turn the SENSOR TURNS dial on the instrument to 2.



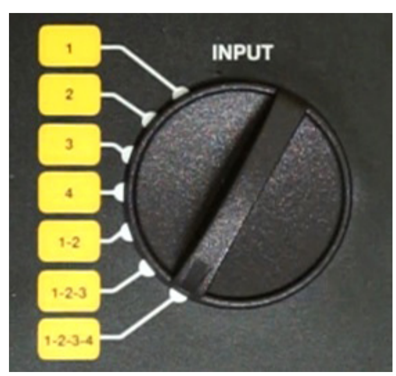
SENSOR TURNS dial on the Model 6474, set to 2 loops

Be sure that the sensors are connected to the instrument in sequence. For example, in the diagram below we have designated the sensor in the upper left as number 1, with numbers 2 through 4 following a clockwise sequence. Also, you must connect each sensor to the corresponding channel on the Model 6474. The sensors are shipped pre-calibrated to a specific channel and are marked 1, 2, 3, and 4 to match.



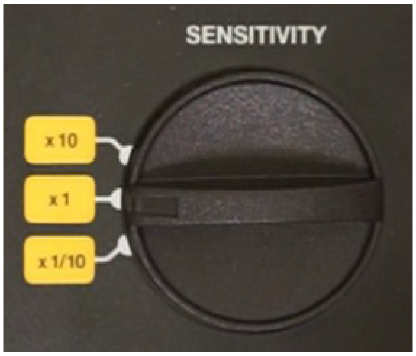
Example sensor connection sequence

Next set the INPUT dial on the Model 6474. This setting indicates which tower leg or legs you want to test. In this instance, we will test all four legs together, so turn the dial to the 1-2-3-4 setting.



INPUT dial on the Model 6474, set to 1-2-3-4 (all four legs tested together)

Finally, turn the SENSITIVITY dial on the instrument to x1, to establish measurement sensitivity.



SENSITIVITY dial on the Model 6474, set to x1

Locate the green and black test leads. The green lead is used to inject current into our test setup. The black lead is used for voltage measurement.

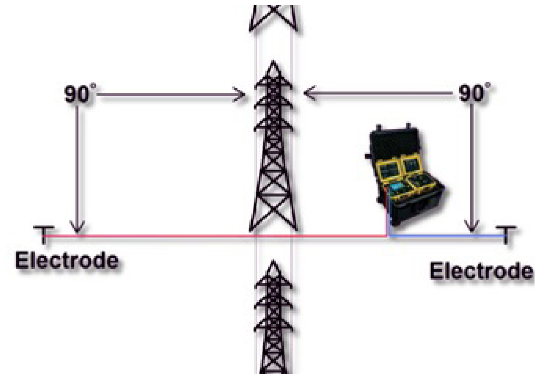
Output leads

Both leads must be attached to a tower leg, next to each other at a point higher than the GroundFlex® sensor to measure the effective tower-to-earth resistance. This can be any leg, as long as both probes are connected to the same leg.

Output leads installed on a tower leg

Connect the green lead to the Model 6472 by inserting it into the connector labeled E. Insert the black lead into the connector labeled ES.

Next, install the auxiliary ground electrodes H and S. The electrodes are placed on opposite sides of power lines, ideally at a 90° perpendicular angle to the direction of the lines, as shown below.



Electrode positioning

If this is not possible, be sure to locate the probes at least 30° out of parallel with the lines. Each electrode should be placed at least 50 meters, or approximately 150 feet, from the lines. If local conditions require that both the H and S electrodes be placed on the same side of the tower, place the S electrode 67% (two-thirds) of the distance that the H electrode is from the tower.

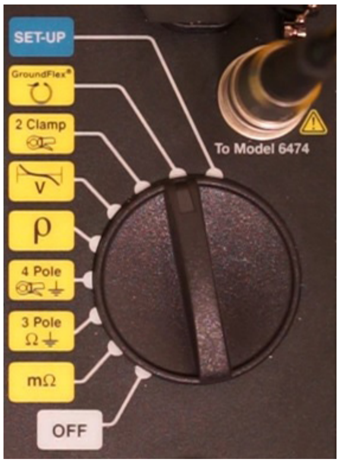
Installing an electrode

Connect the electrodes to the Model 6472 using the red and blue leads that come with the kit. Insert these leads into the corresponding red and blue terminals on the Model 6472. Ideally the lead wires should be rolled out completely, to avoid any inductance generated in the coils by the proximity of the transmission lines.

Taking Static Measurements

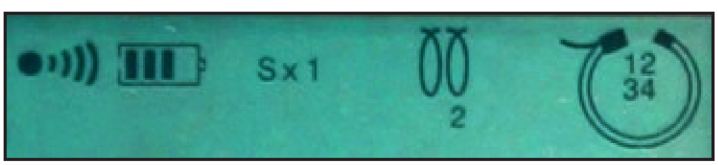
We are now ready to take measurements. We'll start by obtaining static data that does not require an output current to be generated by the Model 6472. This static data will help identify whether or not we need to make any adjustments to our setup before performing dynamic tests.

Turn the dial on the Model 6472 to the GroundFlex® setting.



Model 6472 dial set to GroundFlex

The instrument performs a series of self-calibration tests, during which the Red OVERLOAD LED light on the Model 6474 may light up briefly. When this is finished, check the row of icons at the top of the display screen, and ensure they match your test configuration.

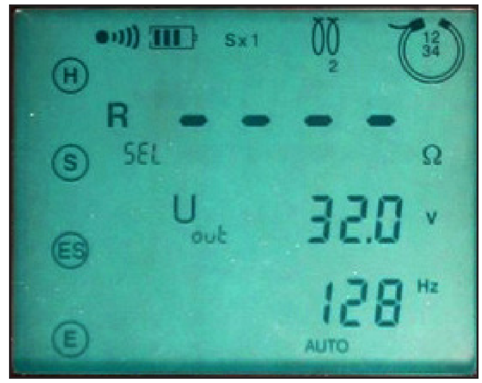


Icons

In the upper right corner is the icon indicating the number of tower legs we're testing. In this case, we're testing the vector sum of all four, as indicated by the dial on the Model 6474. This should also be reflected by the icon. The next icon to the left indicates the number of times we looped our GroundFlex® sensors, which in this example is 2. The next icon to the left indicates measurement sensitivity. In our example this is x1, as we set earlier via the SENSITIVITY dial on the Model 6474. If any of these icons indicate a setup discrepancy, make the appropriate adjustments now.

Note that if the red OVERLOAD light flashes continuously and the Model 6472 buzzer beeps, this indicates that the current in the GroundFlex® sensors is too high for the selected sensitivity. If this happens, turn the SENSITIVITY dial to x1/10. If the condition persists remove one loop from each sensor wrapped around the tower legs.

Press the Display button once on the Model 6472 to display the following:



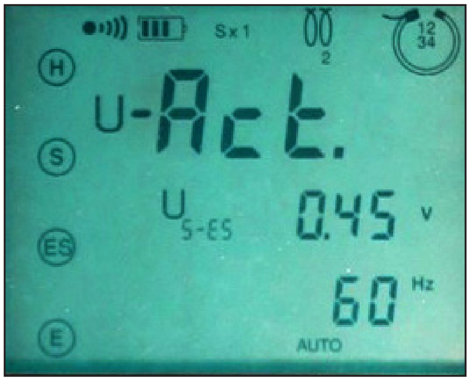
Output voltage and baseline frequency

The preceding screen shows two important values. The first is labelled U_{out}. This is the output or injector voltage we will use to perform our tests, which in this case is 32V. The second is the baseline frequency that will be used. In our demonstration this is 128Hz.

A second press of the Display button provides us with our first measurement, the actual passive resistance (R_{PASS}) of the four tower legs in combination. As shown below, this is slightly over 3Ω.

Passive resistance of tower legs (measured in combination)

Another press of the Display button shows the voltage between the black output terminal, attached to the instrument via the ES connector, and the electrode connected to the instrument via the blue S connector.



U_{S-ES} voltage

This value is labeled U_{S-ES}, and in our demonstration is around 0.45V. If the measured voltage exceeds 0.1V, as our measurement does, this screen also shows the frequency of the detected voltage. This is the same as the frequency of the transmission lines, which in North America is usually 60Hz. (It is also common under some conditions for this to be 180Hz in a three-phase system.)

Pressing the Display button again shows the voltage between the green E output terminal and the electrode connected to the instrument via the red H connector.

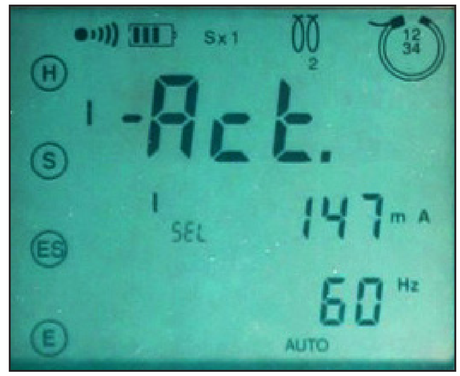
U_{H-E} voltage

This voltage, labeled U_{H-E}, should be within a volt of the U_{S-ES} reading, as is the case here. This indicates that both electrodes are placed far enough away from the tower so they are not affected by the tower legs' potential shells of influence.

If the voltage readings are below 0.1V, this likely indicates that the tower's transmission lines are not in service, or that the overhead ground conductor is completely corroded or not connected. In this case, the total tower voltage will also be close to zero.

If the difference between the readings exceeds 1V, move the electrode with the lower reading further out from the tower and take a new reading. Too large a voltage difference between the electrodes may invalidate any results we obtain from our subsequent testing.

Another press of the Display button shows the leakage current flowing through the tower to the ground.

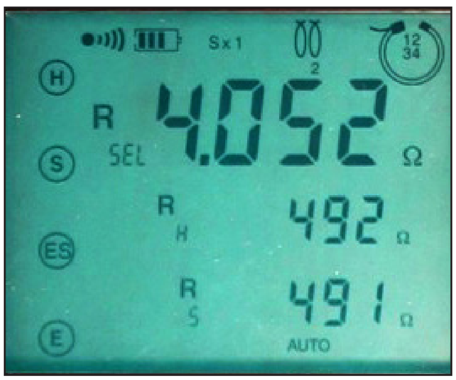


Leakage current

In our example (measuring the leakage current for all four tower legs) this is 147mA. You can also measure the leakage current for each tower leg individually by turning the INPUT dial on the Model 6474. The sum of the individual leakage currents for the legs should approximately equal the leakage current measured for all four legs simultaneously. If this is not the case – for example, if the measurement of the combined legs is near zero while the sum of the individual legs is significantly higher -- the overhead ground conductor may be disconnected from the tower, perhaps due to corrosion, and should be inspected.

Running Dynamic Tests

Now that we have obtained static measurements, we can perform a dynamic test. To do this, press the Display button to return to the main display screen. Then press and hold down the START/STOP button on the Model 6472. When you do, the instrument will beep once. Continue to hold down the button until the instrument beeps a second time, and then release the button. The instrument now performs the test, using a test voltage of 32V and a frequency of 128Hz. During this process, an indicator consisting of three rotating arrows appears. This remains on the screen until the instrument completes its measurements and calculations, and displays the results. When this process is complete, three values are displayed (see below):



Tower and Ground Resistance Measurements

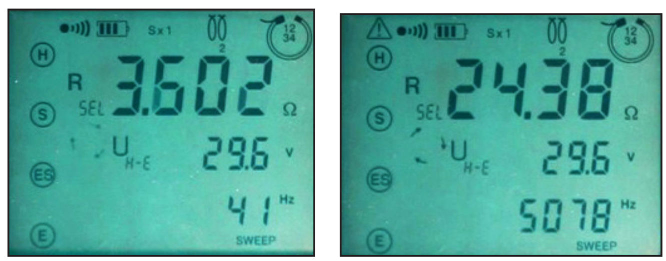
At the top of the screen is the total tower resistance. In our test, this is the resistance for the combined four tower legs, which is around 4Ω. A properly grounded tower should produce a measurement below 15Ω, and ideally below 5Ω as typically required by utility companies.

Note that this screen also shows the resistance measured between our injector and potential auxiliary electrodes to ground. For each electrode, resistance should be below 1000Ω, as is the case here. Resistance higher than 1000Ω can call into question the integrity of the measurement results. This is because resistance determines the test current, and too low a current makes obtaining reliable results difficult. In this situation, an indicator consisting of greater than and less than symbols may flash, informing you that the measurement may be unreliable.

If the resistance for either electrode exceeds 1000Ω, you can moisten the soil around the electrodes by pouring water (if possible, salt water) on it, and then re-testing. You can also connect additional auxiliary electrodes to each test electrode. These auxiliary electrodes should be placed in parallel with the primary electrodes, at a distance of approximately two to four times the depth of the primary electrodes.

We will now perform a sweep test. As noted earlier, our initial test was at 128Hz. In the sweep test, a range of frequencies will be used, from 41Hz up to 5078Hz. To set up a sweep test, press the button labeled Hz/Options. Then press the right-arrow button until the word SWEEP appears in the display.

To start the test, press the START/STOP button once. Unlike the earlier test, you do not need to hold the button down until the instrument beeps a second time. To establish a baseline, the Model 6472 initially performs a measurement at 128Hz. It then cycles through its range of frequencies, from lowest to highest.



Sweep Test Results (low frequency [41Hz] on left, high frequency [5078Hz] on right)

Note that since we are measuring impedance rather than resistance, the measurement increases as the frequency does. For instance, in the preceding illustration we see the impedance in our test rising from around 3.6Ω at 41Hz (the lowest sweep frequency) to over 24Ω at 5078Hz (the highest sweep frequency). The results appear on the display screen and are stored in the Model 6472's Flash memory.

This concludes our quick demonstration of how to use the GroundFlex® Field Kit. Note that the testing described in this article represents just a few of the many features and capabilities of this kit. For additional information about the GroundFlex® Field Kit, consult the AEMC® web site (**www.aemc.com**).

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.

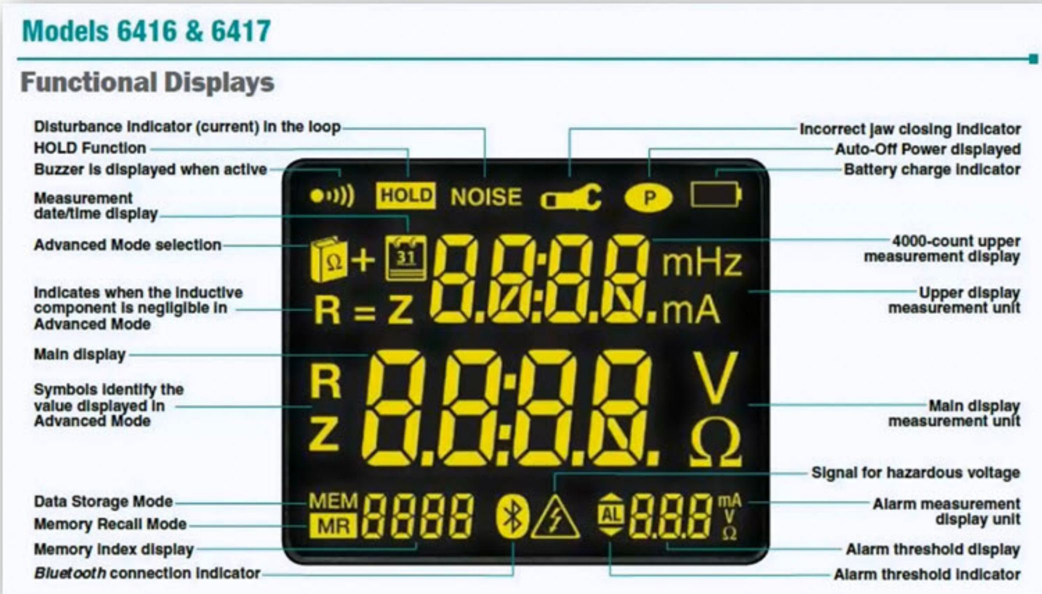
The instrument’s high sensitivity also enables measurements of leakage current flowing to ground or circulating in ground loops from 0.2mA to 40A and resistances from 10mΩ to 1500Ω.

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**.

About the Author:

Guy Belliveau is a Technical Support Specialist for AEMC® Instruments, Dover NH.

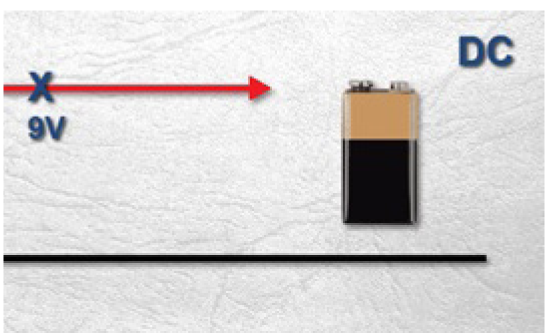
Root Mean Square (RMS) Primer

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

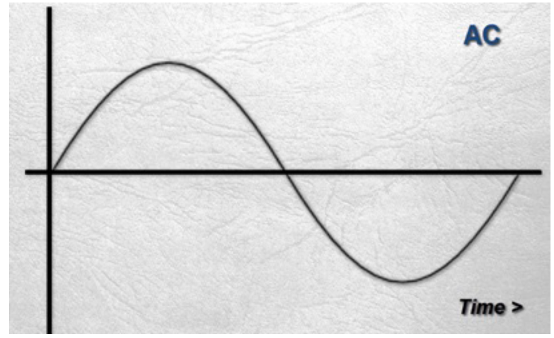
RMS is a mathematical concept used to derive the average of a constantly varying value. In electronics, RMS provides a way to calculate effective AC power. Phrased another way, RMS determines the heating value of AC power in a way that allows us to compare it to the equivalent heating value of a DC system.

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.

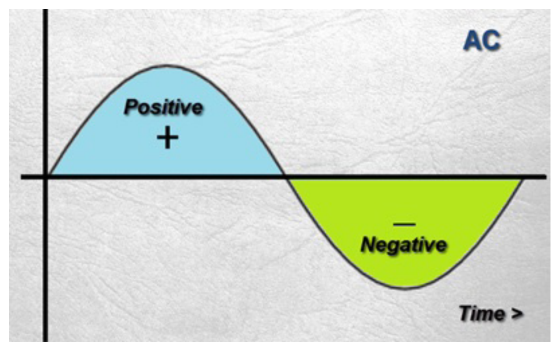


Note that our straight line graph is somewhat idealized. In a system with an actual load, the voltage would gradually slope downward over time. But our central point remains the same: all we need to do to determine the voltage is to simply take a measurement at any moment.

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.

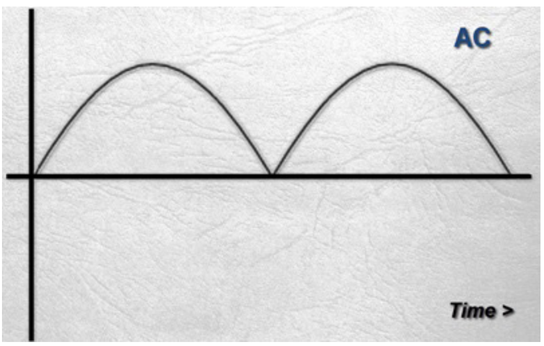


So no matter how high our peak power is, the average power for the classic AC system would always be zero, the same as if we had no power source at all. Obviously such a result tells us nothing about the true power flow in this system, so we need another way to derive the effective AC voltage or current.

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.

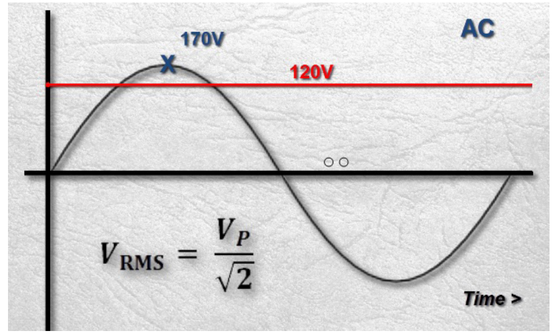
The first step is to square the AC power values. This produces a graph similar to the one below.



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:

$$V_{\mathrm{RMS}} = V_p \times 0.707$$

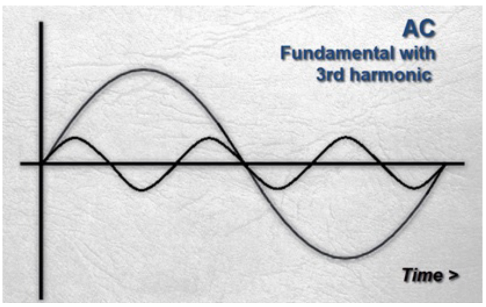
True RMS

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.

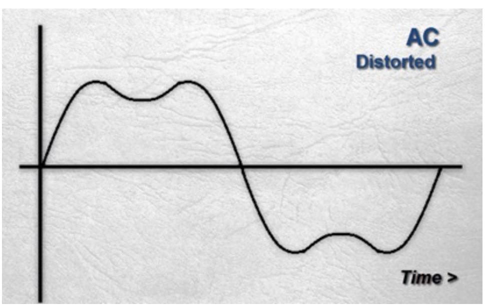
In these cases, we need to apply a method known as “true RMS.” This involves a more generalized mathematical calculation that takes into consideration all irregularities and asymmetries that may be present in the AC waveform:

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

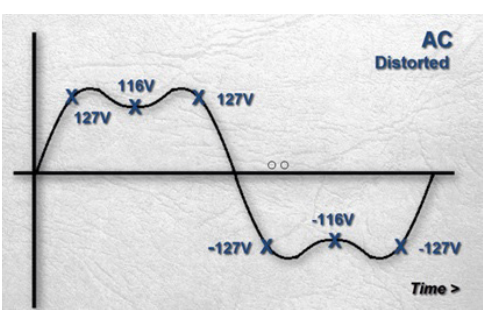
…where *n* equals the number of measurements made during one complete cycle of the waveform. For AEMC's instruments, this is always a multiple of 2 (typically 64, 128, or 256 depending on the instrument). The higher this number is, the more accurate the RMS calculation will be. This is because the higher 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:

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

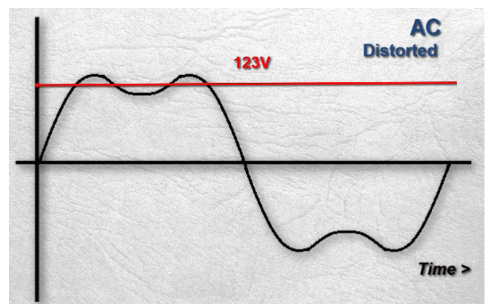
$$V_{\mathrm{RMS}} = \sqrt{\frac{16129 + 13456 + 16129 + 16129 + 13456 + 16129}{6}}$$

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

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

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

…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

AEMC® Interview:

Ray Brady, Technical Support

Over the past 9 years, Ray Brady has handled countless AEMC technical service calls, covering a wide variety of instruments, issues, and situations. In this interview, Ray shares some of his experiences and insights.

Q. What previous experiences helped prepare you for answering electronics-related customer questions?

A. I hold a Journeyman and Master Electrician license, which helps with my technical background. In addition, I've taught vocational and apprentice electrical programs, which has given me good experience explaining things to people. I try to apply both – technical background and teaching experience – when answering customer questions at AEMC.

Q. How do you prepare for customer calls?

A. One thing I've found over the years is that Technical Support needs to know at least a little about pretty much everything. For instance, I have cabinets full of AEMC's instruments, so I can get my hands on the instrument the customer may have a question about.

At the same time, I recognize it's important to remain humble, and not be reluctant to contact people with the expertise that can help me better understand the customer's question and provide me with the information I need so I can pass it along.

Q. What are some of the resources you have available to you to help answer questions?

A. I frequently consult documentation, including the user manuals that come with the product, as well as service manuals designed for a more AEMC-internal audience. And as I mentioned, I find that hands-on experience with AEMC's instruments is an excellent resource, as is talking with other AEMC personnel, including design engineers.

Q. Are there subjects about which customers frequently ask?

A. One question I get frequently is how to use a particular instrument. Many companies send their people out in the field without the proper training, and now that person is contacting AEMC because they don't know how to use the instrument to perform the test they've been assigned to do – and they need answers immediately so they can get the job done now.

Another common situation is customers contacting us for advice in selecting the AEMC instrument that best meets their specific needs and requirements.

Q. Which questions can be answered relatively quickly?

A. In most instances, it doesn't take a lot of time to explain to a customer how to perform a particular test with the instrument. Over the years I've written step-by-step instructions for a number of different types of tests. So often I can just quickly email the customer the written instructions.

Q. What have you learned about customers since joining AEMC?

A. One important thing I've learned is that interacting with customers requires good listening skills and the ability to ask probing questions. As Charles Kettering, former head of research for GM, once said, "A problem well-stated is half solved." You have to get to the stage where the problem is well-stated.

I've also learned that a positive attitude, sense of humor, and patience pay off in terms of how the customer perceives the overall technical support experience.

Q. Do your calls generally come from the U.S., or do people also call in from other countries?

A. Usually the calls I receive come from the U.S. Although some email questions do arrive from other countries, and even in other languages. When this happens I contact multi-lingual AEMC people to help with the translation so I can answer the customer's question.

Q. Other than calling on the phone, what other support resources would you recommend to AEMC customers?

A. I have found our website [**www.aemc.com**] to be a very user friendly place where the customer can gain access to a wealth of valuable information, including user manuals, technical documents, and the company online store. In addition, the **AEMC YouTube channel** is a good place to find instructional videos on AEMC products.

Q. What general piece of advice would you offer to all AEMC customers?

A. What took you so long to call me?

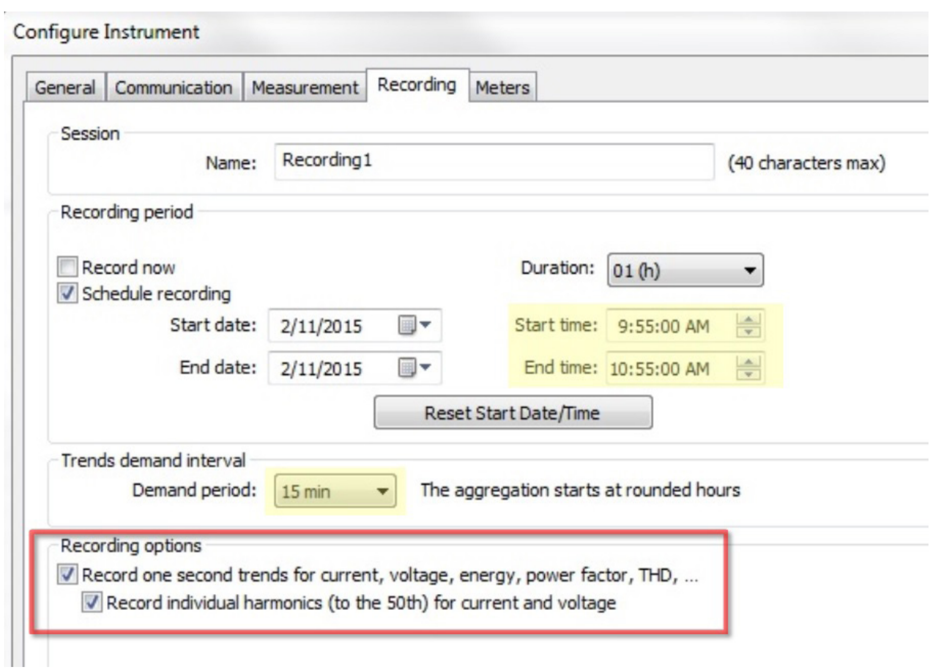
Customer Support Tip:

Understanding Aggregated Data in DataView® PEL Control Panel Reports

When working with DataView® PEL Control Panel reports, inexperienced users may misinterpret the displayed aggregated data. This confusion may lead to the user believing that some data from the original recording made by the Model PEL 100 Series instrument is missing from the report. A better understanding of how the PEL Control Panel handles factors such as recording starting time, aggregation period, and 1-second trends can help avoid this misperception.

To begin, let’s consider how the PEL records and aggregates data. The PEL starts the aggregation period (also called the “demand interval” or “trend demand interval”) on so-called “rounded hours.” In other words, whichever demand interval period is chosen for the recording, the aggregation for this period begins on an equal division of this period into one hour. For example, if the demand period is 30 minutes, the PEL aggregates data at the “top” of each hour (9:00 AM, 10:00 AM, 11:00, AM, and so on) as well as half-past each hour (9:30 AM, 10:30 AM, and so on). This results in two aggregation data points per hour.

For instance, suppose we configure our PEL to begin a 1-hour recording at 9:55 AM and end at 10:55 AM, with a 15-minute demand interval, expecting to record four data points during this hour with the first 15-minute aggregation starting at 9:55 AM and the fourth concluding at 10:55 AM. We also choose to record 1-second trends and harmonics, as shown below:

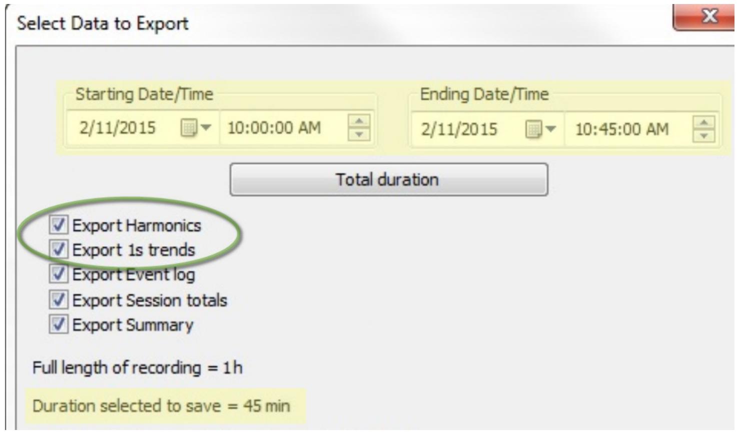


After the recording session completes, we download the recording in the PEL Control Panel and verify the recording in the Recorded Sessions dialog box:

Recorded Sessions

Folder	Session name	Starting Date/Time	Ending Date/Time	Aggregation period	Size
Ses00001	Recording1	2/11/2015 - 9:55:00 AM	2/11/2015 - 10:55:00 AM	15 min	50

We now decide to create a DataView® report by clicking the Create DataView Report icon and completing the Select Data to Export dialog box. During this process we click the “Total duration” button and notice what appear to be some discrepancies between the displayed information and our original configuration:



As shown in the yellow highlighting above, the start and end times displayed for the recording (10:00 AM and 10:45 AM respectively) do not match the times we specified when configuring the recording (9:55 AM to 10:55 AM). In addition, the displayed duration for the recording (45 minutes) is shorter than the one hour duration we selected earlier. This may lead users to mistakenly conclude that some error has occurred that either lost some of the recorded data, or prevented the recording from completing as expected.

In reality, this is normal and expected behavior. Due to the way the PEL aggregates data on “rounded hours,” only three aggregation points have been recorded for this recording: for the periods 10:00 to 10:15 AM, 10:15 to 10:30 AM, and 10:30 to 10:45 AM. Aggregation is not performed for the period 9:55 to 10:00 AM, nor for the period 10:45 to 10:55 AM, since neither period both starts and ends at a “rounded” 15-minute interval. Further, only the three full 15-minute aggregation periods are included in the aggregation data, accounting for the displayed 45-minute “duration” for this report.

Bear in mind, however, that we can in fact view the full one-hour data recorded during this session due to the fact we chose to include 1-second trends when configuring the recording, as shown in the circled portion of the preceding illustration. One-second trend data is recorded throughout the recording period, not just within the 15-minute aggregation periods. This enables us to analyze the full hour of recorded data, since it will be included in the DataView report generated from this data.

To see this data, we complete the report generation process. At the bottom of the report are a series of tabs. These include a number of tabs that display 1-second data, identified by the prefix “1 s.”

Clicking any of these tabs displays a worksheet that includes all the data recorded during the session, starting at 9:55 AM up to the stop time of 10:55 AM.

Note that recording 1-second data consumes significantly more storage space than recordings that do not include 1-second data. Therefore, we recommend the following maximum recording duration periods:

- One week when recording aggregations, 1s trends and 1s harmonics
- One month when recording without 1s harmonics
- One year when recording without 1s trends or harmonics

Chauvin Arnoux®, Inc. d.b.a. AEMC® Instruments
15 Faraday Drive • Dover, NH 03820 USA
Tel: (800) 343-1391 • (603) 749-6434 • Fax: (603) 742-2346
www.aemc.com • techsupport@aemc.com

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