



**AEMC**<sup>®</sup>  
INSTRUMENTS

Chauvin Arnoux<sup>®</sup> Inc.

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Issue 11

“WATTS CURRENT” TECHNICAL BULLETIN

Winter 2017

# A Brief Introduction to Harmonics

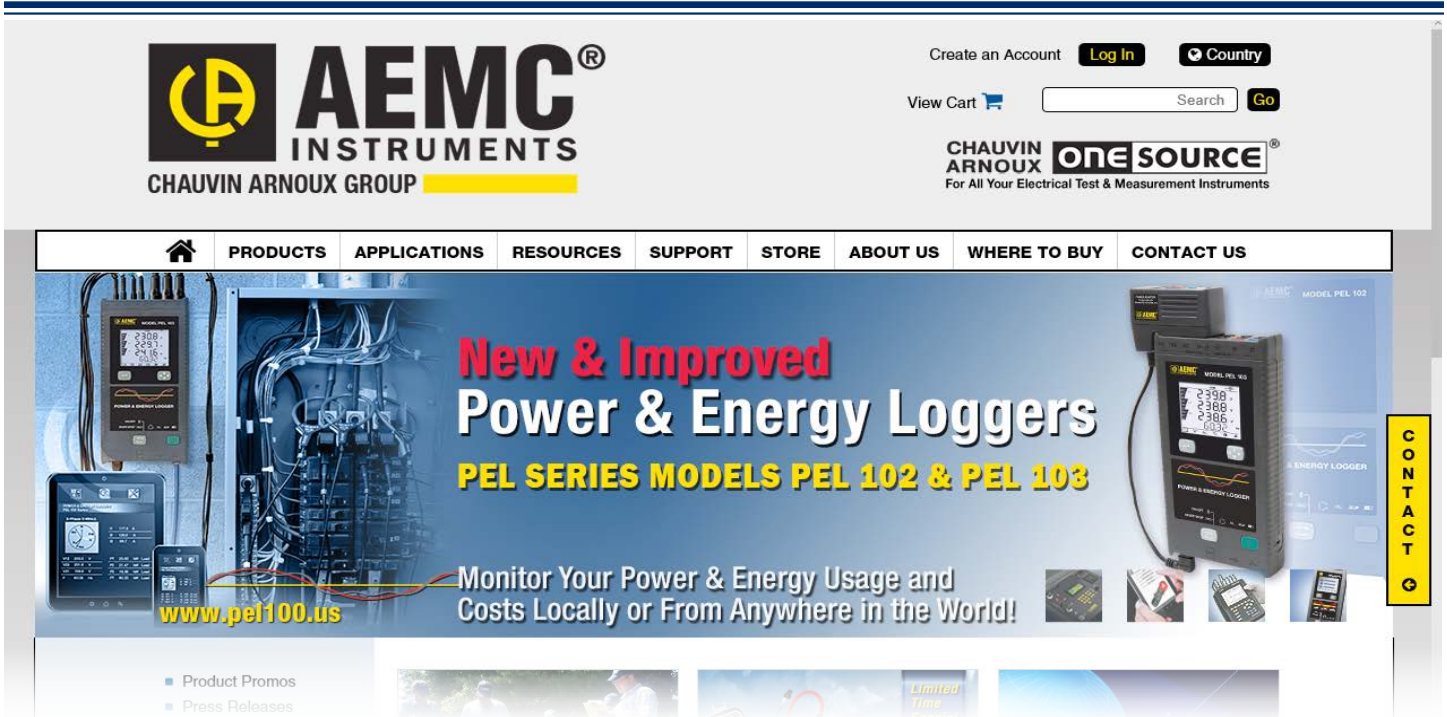


## Also Inside This Issue:

- Special Announcement:  
New AEMC WebSite Coming in 2017.
- Featured Product: New Features in DataView 3.50
- Rogowski Coil Primer
- Megohmmeter Calibration Checker and Ground Resistance Checker
- AEMC Interview: John Olobri, Director of Sales and Marketing
- New AEMC Product: CAmReport Software for the Infrared Camera Model 1950

Special Announcement:

# New AEMC Website Coming in 2017



AEMC Instruments is proud to announce the upcoming launch of our redesigned website. The new site, scheduled to go online in 2017, is a critical component of our ongoing efforts to provide AEMC customers with the best possible user experience.

In addition to updating site aesthetics and layout, the main goals of the redesign include:

- Faster, more intuitive navigation.
- Improved search capabilities for finding the right product to match your requirements.
- Enhanced eCommerce features for ordering online directly from AEMC.
- Easier access to content resources (user documentation, technical notes, bulletins, instructional videos, and more).
- Responsive, mobile-friendly design.

These and other new features will be described in more detail in an upcoming issue of the AEMC Technical Bulletin. Stay tuned!

## Featured Product:

# Whats New in DataView 3.5

DataView enables a computer to connect to, and interact with, a variety of AEMC instruments. DataView includes a core set of features for viewing data, and for opening, creating, and saving DataView reports. DataView also includes product-specific Control Panels for connecting to the instrument, viewing measurements data in real time, configuring settings from the computer, and other actions.

Experienced DataView users will notice several new features introduced in DataView 3.50, released in early 2017. This includes updates to core DataView functionality, as well as enhancements to a number of DataView Control Panels.

### New Navigation Frame in Reports

For example, navigation through DataView report worksheets has been significantly enhanced. In previous versions, you opened worksheets by clicking tabs at the bottom of the screen.

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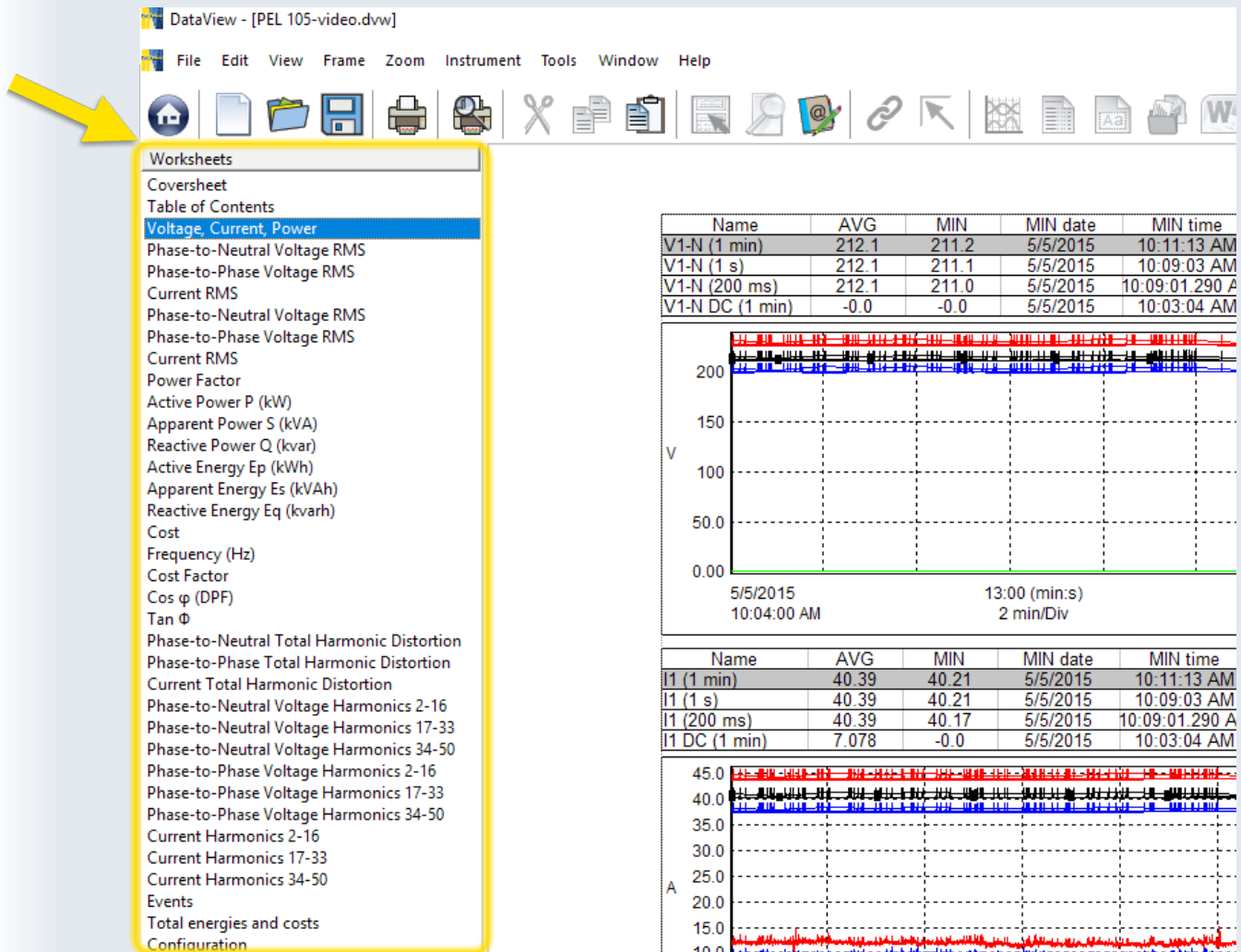
Value

- 50.00m — Ep (WH) \$ (1 min) (\$)
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Date	Time	Val	Units
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5/5/2015	10:06:00.000 AM	0.140	\$
5/5/2015	10:07:00.000 AM	0.180	\$
5/5/2015	10:08:00.000 AM	0.230	\$

Navigation bar: (h) | Es (kVAh) | Eq (kvarh) | Cost | F (Hz) | CF | Cos φ (DPF) | Tan φ | Vφ-N-THD (%) | Vφ-φ-THD (%) | I-THD (%) | Vφ-N h 2-16 | Vφ-N h 17-33 | Vφ-N h 17-33 | Vφ-N h 17-33

DataView 3.50 includes a new left navigation frame, similar to the navigation frames in Control Panels.



This provides several advantages. In addition to easier navigation, more worksheets can be listed and viewed in a single place. Worksheet names can be longer and more descriptive without affecting how many names can appear at the same time, since they are no longer displayed horizontally. As a result, you can usually move from any worksheet to another with a single click. You can also quickly see a list of all the content contained within the report from any worksheet, without having to return to the Table of Contents.

Note that the new navigation feature does not require any redesign of existing reports created with previous versions of DataView. All worksheets in the report will be listed in the navigation frame without modification -- although you may want to take advantage of this feature and rename worksheets to more descriptive names.

## Redesigned Toolbar Icons

Another readily visible enhancement is the DataView toolbar. Icons are now larger and have been redesigned so their functions are more intuitive and easier to identify.



**New Icons**



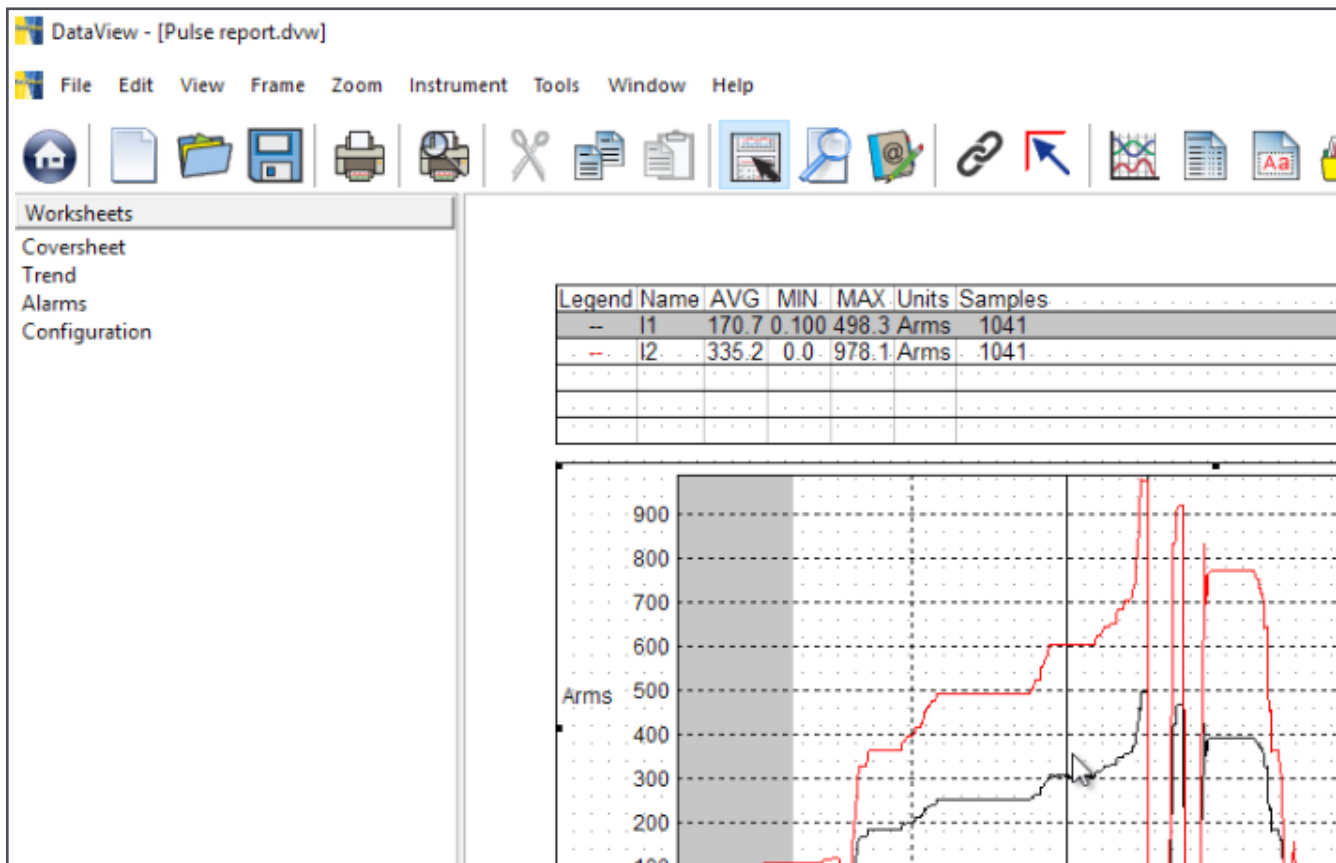
**Old Icons**

## Enhanced Zoom In/Out

Zoom functionality for closer inspection of data has been improved. In addition to expanding a single selected frame, the Zoom In and Zoom Out tools can also be used to expand and reduce the entire worksheet.

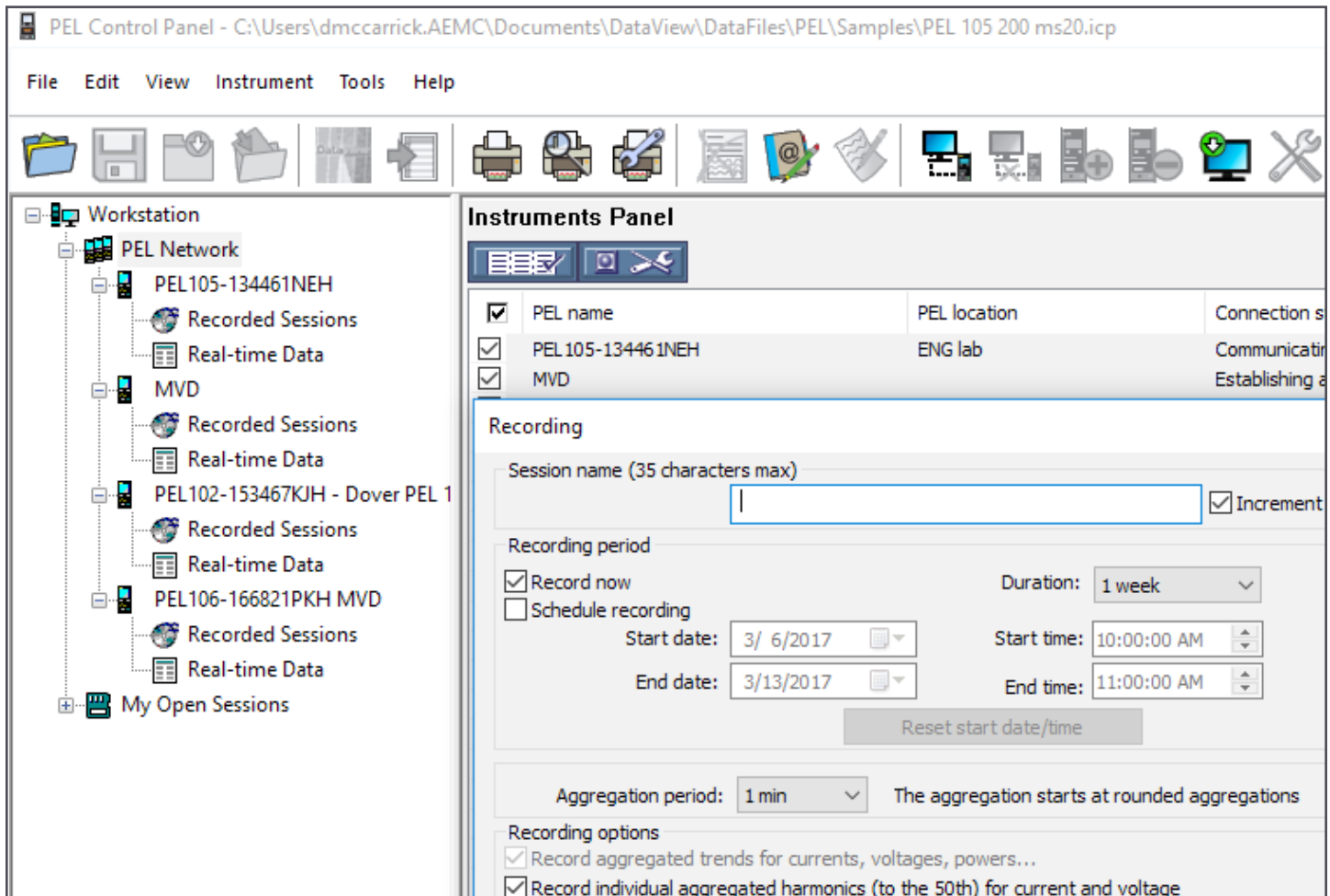
## DataView Templates

A number of DataView report templates have been modified for usability. We have also added a new template for viewing and analyzing pulse data recorded by AEMC data logger instruments.



## Control Panel Updates

In addition, several DataView Control Panels have been enhanced in Version 3.50. For example, the PEL Control Panel can now configure recording sessions to run simultaneously on multiple instruments. This and other new Control Panel features are described in the separate Help systems that come with each Control Panel.



## Downloading DataView 3.50

You can download Version 3.50 from within DataView or a Control Panel. To do this, click Help in the menu bar and select Update. The software checks whether or not your current version of DataView is the latest. If not, you are directed to the DataView download page on the AEMC website. Follow the instructions listed on the page for downloading DataView.

Note that you can also open the DataView download page directly by visiting the AEMC website and clicking Software and Firmware Updates to open the Software Downloads page. Then click the DataView link in the list of available updates.

This concludes our brief review of new features in DataView 3.50. For more information, consult DataView Help. And be sure to check our YouTube channel for instructional videos about other topics in electronics, including the many products offered by AEMC.

# Harmonics: A Brief Introduction

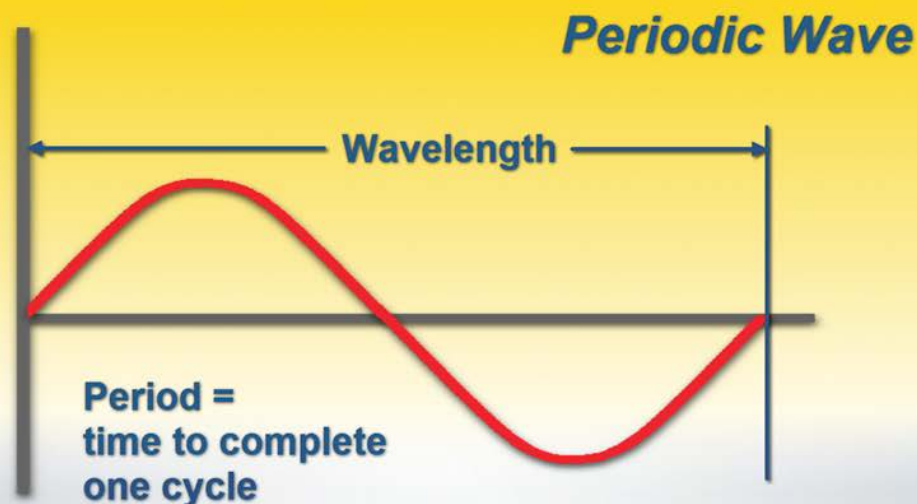
**H**armonics is a critically important concept in electronics. Harmonics affect the quality of AC electricity delivered to industrial, commercial, and residential facilities, and the performance of equipment that uses the electricity in these facilities. Harmonics can increase energy costs and reduce the lifespan of hardware. In some cases, harmonics can overheat electrical conductors, creating a fire risk.

In this article, we briefly explain what harmonics are, and why you should care about them.

## Periodic Waves, Clean and Distorted

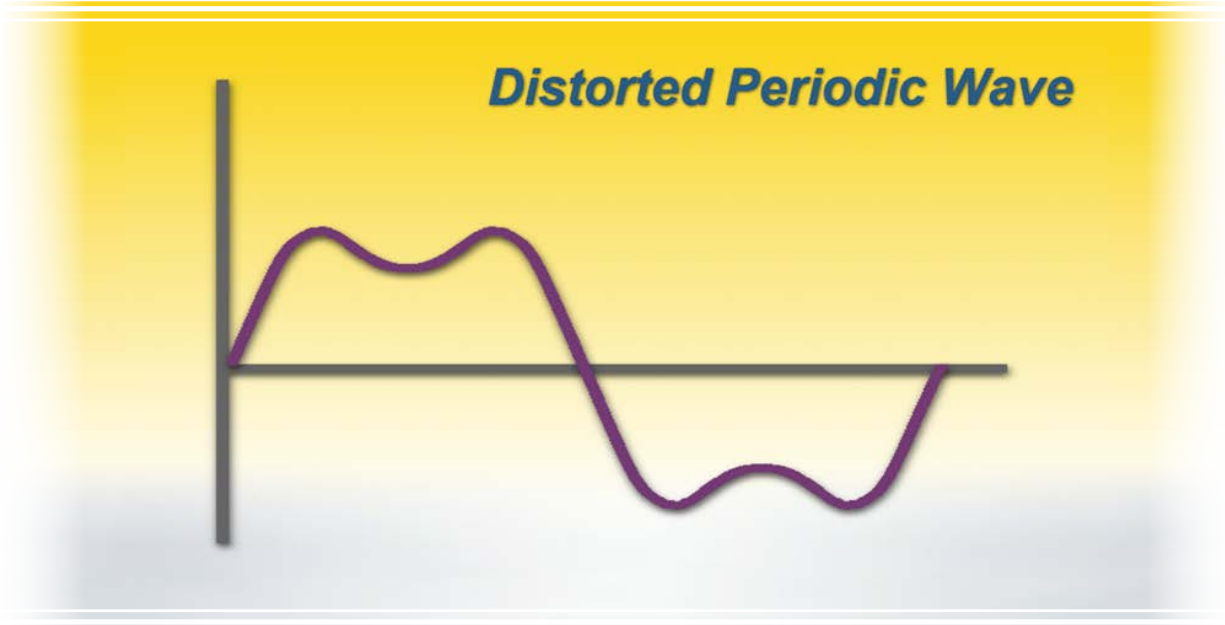
To begin, let's consider a mathematical concept called the periodic wave. This is a graphical representation of a constantly changing variable whose values follow a repeated sequence.

A familiar example is the sine wave shown below:



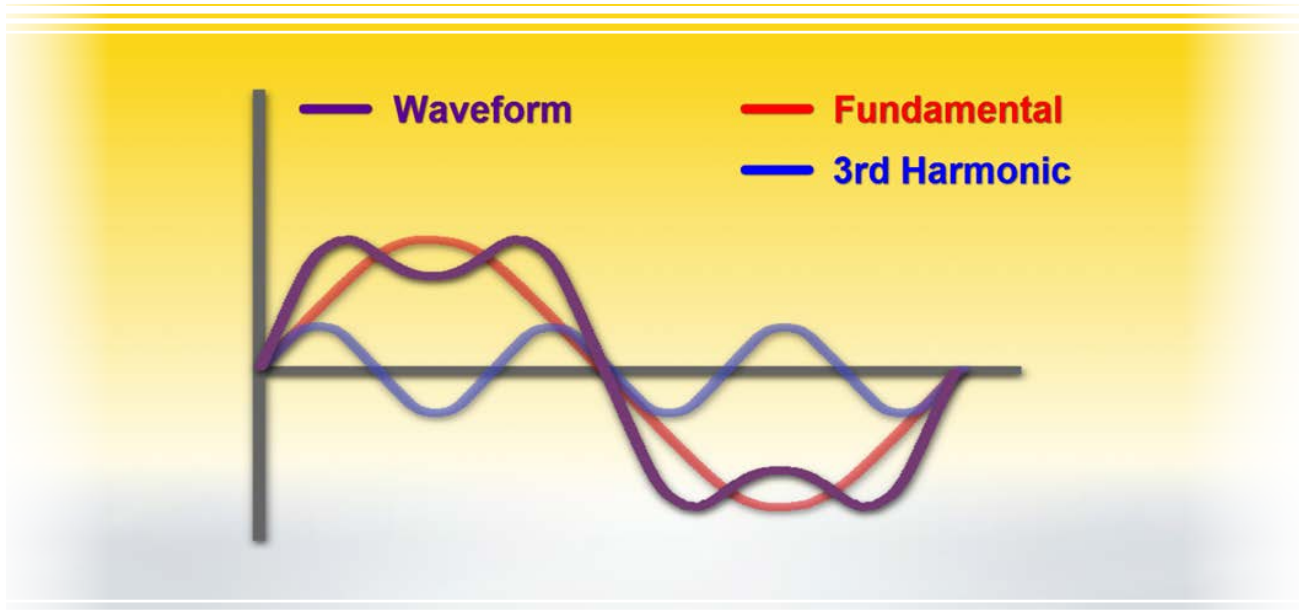
When we examine a sine wave, one of the first things we notice is that it follows a very symmetrical and repeated pattern. Each full wave has a certain length, called its wavelength. The time required for one wavelength to complete its cycle is called its period, from which we derive the term "periodic wave." Periodic waves are found in a wide variety of natural phenomena, including ocean waves, sound, and light. Electricity transmitted over the public power grid can also be graphed as periodic waves.

A perfectly regular and symmetrical sine wave represents a very simple and “clean” example of a periodic wave. In the real world, however, periodic waves are subject to numerous influences that affect their shapes. These can produce waves that display distortions and asymmetries, as shown below.



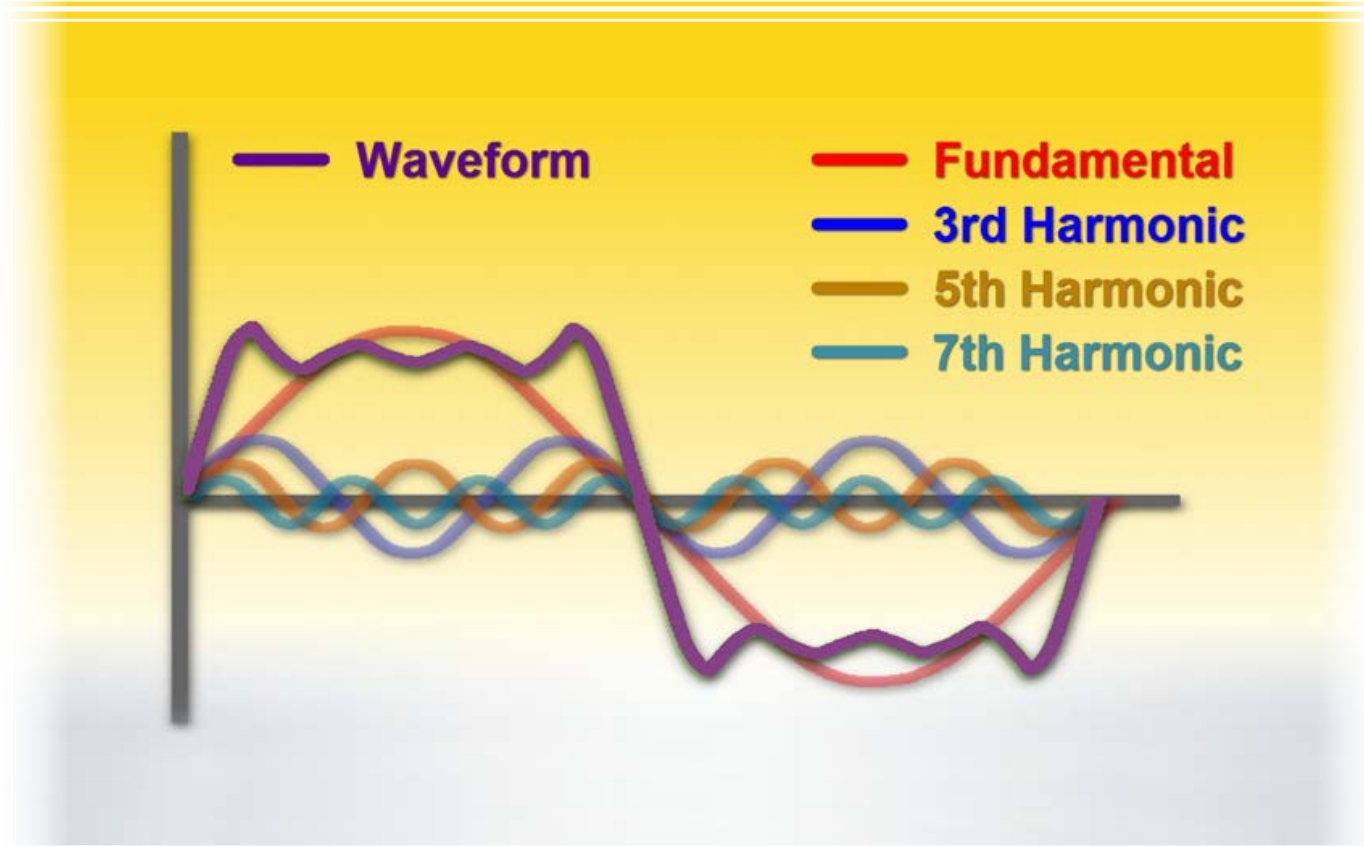
### Deconstructing Distorted Waves

To understand how this happens, it might be useful to work backwards and deconstruct this wave into its individual components. A periodic wave, no matter how distorted, can be defined as the composite of a single primary or fundamental wave, and one or more so-called harmonic waves of varying wavelengths. For example, our illustration can be deconstructed into two waves, the fundamental wave and a harmonic wave whose wavelength is one-third the fundamental. This second wave is therefore called the 3rd harmonic.





The combination of these two waves – the fundamental and the third harmonic – produces the distorted wave shown in our example. Adding additional harmonics results in further distortion in the waveform.



The presence of all these individual harmonics can be expressed as total harmonic distortion, or THD. The mathematical formulas for calculating THD are shown below.

$$THD_F = \frac{\sqrt{\sum_{n=2}^{n=\infty} V_n^2}}{V_1}$$

$$THD_R = \frac{THD_F}{\sqrt{1 + THD_F^2}}$$

Fortunately, modern test instruments designed for measuring harmonics can perform these calculations automatically and display the results, greatly simplifying the process for monitoring THD in a facility.

## Harmonics in Electrical Power Lines

In an electrical power line, a number of factors can create harmonic distortion. These include currents introduced into the line by users of non-linear loads, environmental causes such as lightning, electromagnetic interference, and others. As a result, the AC electricity delivered to a facility can include a significant percentage of THD in addition to the fundamental sinusoidal electricity produced by the power generation plant. The higher the THD, the more distorted the electricity’s waveform.

This can be a problem for electrical equipment designed to operate optimally when provided with clean, undistorted AC power. A high percentage of THD can stress electrical infrastructure and equipment, resulting in a significant amount of electricity dissipated as excess heat. Left unaddressed, harmonic distortion can produce numerous issues such as system underperformance, shortened hardware life, wasted energy, and increased electrical costs. In extreme cases, THD can increase the risk of personal injury to operators and damage to facilities.

THD can also raise regulatory considerations. A number of guidelines exist, such as IEEE 519-2014, that define how much harmonic distortion is allowed for certain types of facilities (see the excerpt below). Strict adherence to these specifications can be an essential business requirement for many organizations.

**Table 1 – Voltage Distortion Limits**

<b>Bus Voltage V at PCC</b>	<b>Individual Harmonic (%)</b>	<b>Total Harmonic Distortion THD (%)</b>
$V \leq 1.0 \text{ kV}$	5.0	8.0
$1 \text{ kV} < V \leq 69 \text{ kV}$	3.0	5.0
$69 \text{ kV} < V \leq 161 \text{ kV}$	1.5	2.5
$161 \text{ kV} < V$	1.0	1.5*

*\*High-voltage systems can have up to 2.0% THD where the cause is an HDVC terminal whose effects will have attenuated at points in the network where future users may be connected.*

## Harmonics Mitigation and AEMC Power Quality Instruments

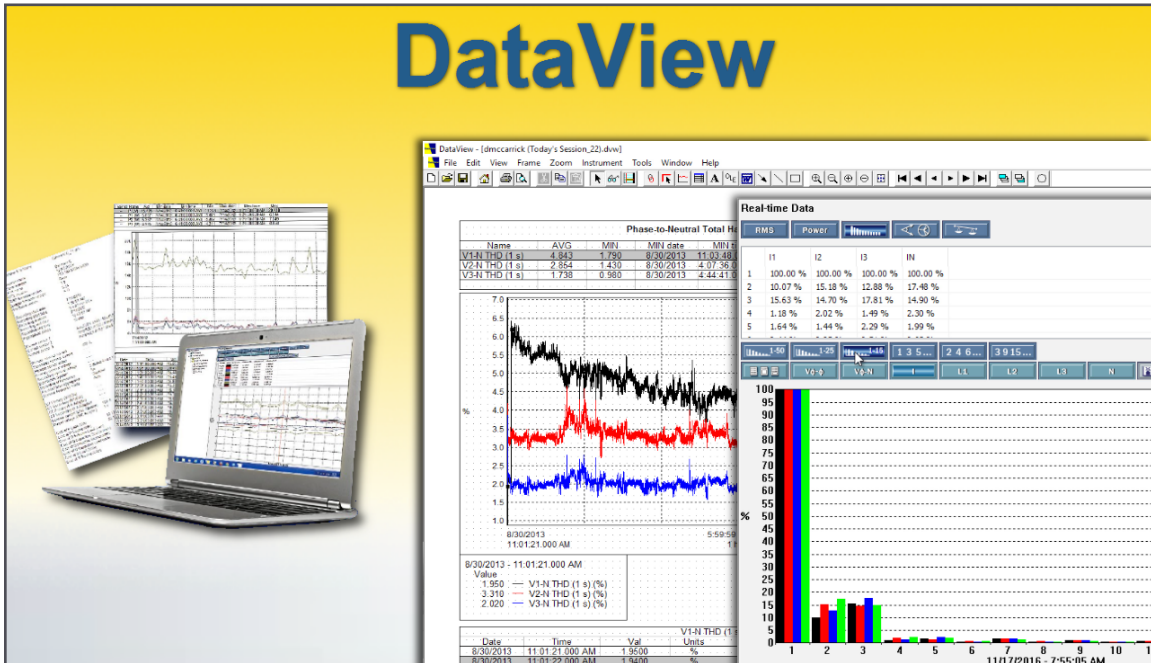
Fortunately, there are several mitigation techniques that can minimize and even eliminate the impact of harmonic distortion. A first step in this process is to analyze the quality of the power in your facility. This will help you assess how significant a problem THD is at your location, and which measures will likely be the most effective for addressing it.

AEMC offers a full line of power quality analyzers, loggers, and meters that incorporate the most up-to-date measurement technology and communication options.



These include the Power Quality Analyzers Models 8333, 8336, and 8435, as well as the Power and Energy Loggers Models PEL 102, 103, and 105. These and other AEMC instruments (including the Clamp-on Meters 407 and 607) can help you quickly and accurately perform harmonic analysis, with some models capable of automatically measuring and displaying up to the 50th harmonic.

Many of these instruments are supported by DataView, AEMC’s data analysis software. You can connect the instrument to a computer running DataView and view its measurement data in real-time. You can also download recorded data from the instrument, and format it into reports that can be analyzed and shared.



This data can then form the basis for a comprehensive harmonics mitigation strategy. And once this strategy is implemented, AEMC power quality instruments can help determine how effective these measures are, and whether they require fine-tuning. In addition, these instruments can also measure numerous other factors that can degrade power quality.

## Conclusion

Let’s review some of the points we’ve covered in this article:

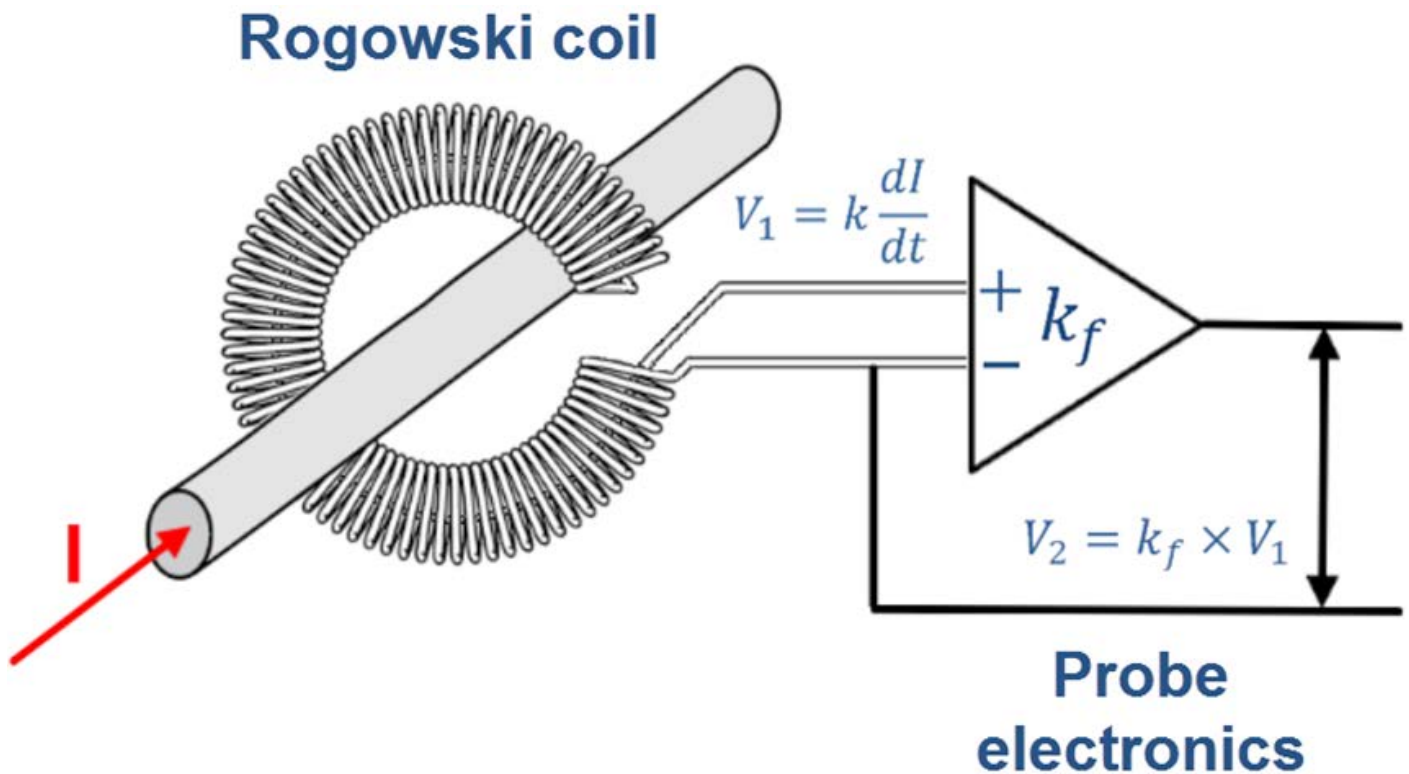
- AC electricity produced by power plants is generated as clean, sinusoidal periodic waves.
- A number of causes, both natural and man-made, can result in harmonics being added to electricity as it is transmitted over power lines. These harmonics distort the electricity’s original waveform.
- Total harmonic distortion, or THD, can have a significant impact on the operation of electrical equipment, affecting its efficiency, reliability, safety, and cost.
- And finally, AEMC offers a wide range of instruments for measuring and analyzing harmonic distortion in your facility, helping to provide the data on which an effective THD mitigation strategy can be based.

For more information about AEMC power quality measurement instruments, please visit us at: [www.aemc.com](http://www.aemc.com).

# Rogowski Coil Primer

A Rogowski coil is a device for measuring AC current. The coil is a helical winding of wire resembling a large spring, with one end of the wire passed back through the center of the coil (see the illustration below). When the coil is wrapped around a conductor through which current is flowing, voltage directly proportional to the current is induced in the coil.

The AEMC AmpFlex® and MiniFlex® families of AC current probes incorporate Rogowski coils. Some of these probes include electronics to provide a stronger and linearized output signal. The following simplified diagram illustrates how these probes function:



In the preceding diagram, the probe’s Rogowski coil has been placed around a conductor. As current ( $I$ ) flows through the conductor, it induces a voltage ( $V_1$ ) within the coil.  $V_1$  varies in proportion to two variables:

- Amount of current in the conductor
- AC frequency of the current

Calculating instantaneous current from  $V_1$  requires the following formula:

$$V_1 = k \frac{dI}{dt}$$

...where

- $k$  is a value derived from the physical characteristics of the coil (loop size, number of turns, length of winding)
- $dI/dt$  is the change in current over time (this is dependent on the current's frequency).

To convert  $V_1$  to a linear, frequency-independent output voltage ( $V_2$ ), the probe electronics remove the time/frequency variable from the equation. To do this, the probe electronics automatically adjust the gain in accordance with the current's frequency:

$$V_2 = k_f \times V_1$$

...where  $k_f$  is a value derived from the physical characteristics of the coil for a given frequency.

$V_2$  can then be used to calculate the associated current by applying a scale factor that is independent of frequency, such as  $1A = 1mV$ . For example, the probe can be connected to a digital multimeter or similar measurement instrument to calculate and display the current reading, based on the input voltage and scale factor.

Rogowski coils offer a number of advantages over iron core, Hall effect, and flux gate probes:

- High resistance to electromagnetic interference.
- No saturation when measuring high currents (and therefore little heating).
- Lightweight and flexible.
- Can be wrapped multiple times around a conductor to amplify sensitivity.
- Can be left unterminated without damage or developing hazardous voltage levels

## AmpFlex and MiniFlex

The AEMC AmpFlex® and MiniFlex® families of AC current probes enable measurements on conductors where standard clamp-on probes cannot be used.

The AmpFlex Shape Memory feature allows you to pre-shape the sensor before inserting it between or around conductors. This feature facilitates positioning the sensor around the conductor, enhances user safety by eliminating the need to reach in to position the sensor, and alleviates the drooping effect associated with other flexible sensors.

AmpFlex and MiniFlex probes are lightweight and can be installed in tight spaces, around cable bundles, around wide or large bus bars, or even wrapped around irregular shapes. Probes create virtually no load to the system under test, have a low phase shift and excellent frequency response, and cannot be damaged by overloads. Probes are insensitive to DC currents; only the AC component of the measured signal is displayed.

These probes have a mV output proportional to the current measured for direct readings on digital multimeters, loggers, and power or harmonic meters. (Models specifically designed with a 1 MHz bandwidth are ideal for oscilloscope use.) Each probe’s sensor assembly is insulated for 1000V CAT III (600V CAT IV), meets EN 61010, and is CE marked. Probes come in variety of lengths.

AmpFlex and MiniFlex probes can be used in a wide range of applications, including:

- power measurements
- measurements on switchboards
- measurements on thyristors
- switching measurements (disconnecting switch, etc.)
- display of control signals

For more information about AmpFlex and MiniFlex probes, visit us at: [www.aemc.com](http://www.aemc.com).



**Digital FlexProbe**  
(AmpFlex Family of Products)



**MF 300-10-2-10 HF Probe**  
(MiniFlex Family of Products)

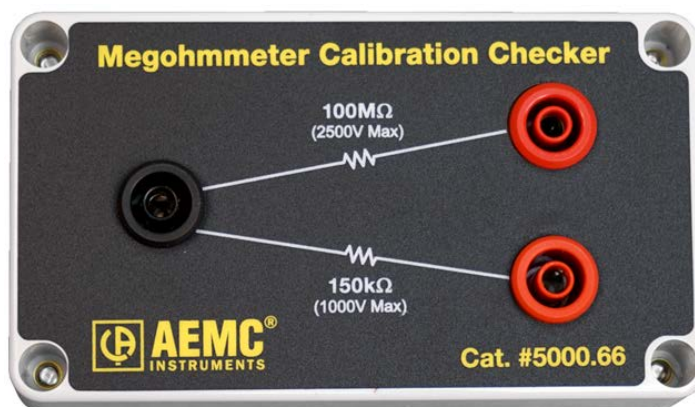
# Megohmmeter Calibration Checker and Ground Resistance Checker

All electronic measurement instruments should be checked regularly for accuracy. Over time, an instrument's measurements may drift from their original factory settings. Periodically checking the readings against a known value can identify whether or not the instrument is still producing accurate results, or whether it may need to be sent to an authorized facility for recalibration.

In this article, we look at two handy tools provided by AEMC for checking the accuracy of resistance measurement instruments. One is the Megohmmeter Calibration Checker and the other is the Ground Resistance Checker. Both let you quickly and easily verify whether or not your instrument is performing within its measurement specifications. (Note that these tools are not designed to calibrate instruments.)

## Megohmmeter Calibration Checker

The Megohmmeter Calibration Checker provides two known resistances, 150k $\Omega$  and 100M $\Omega$ . The k $\Omega$  terminal accepts test voltages up to 1000V, while the M $\Omega$  terminal accepts inputs up to 2500V.



To run a test with the Megohmmeter Calibration Checker:

1. Use the leads supplied with your megohmmeter to connect the Checker's black terminal to the megohmmeter's negative terminal, and the red 150k $\Omega$  terminal to its positive terminal.
2. Turn the megohmmeter's dial to the k $\Omega$  setting and perform a test, as instructed by the instrument's User Manual. The resistance reading appears on the instrument's display screen. This should be close to 150k $\Omega$ .
3. Next, disconnect the lead from the 150k $\Omega$  terminal and insert it into the 100M $\Omega$  terminal.
4. Turn the megohmmeter's dial to a 100M $\Omega$  setting. Any voltage setting at or below 2500V will work. Perform a test. The reading should be close to 100M $\Omega$ .

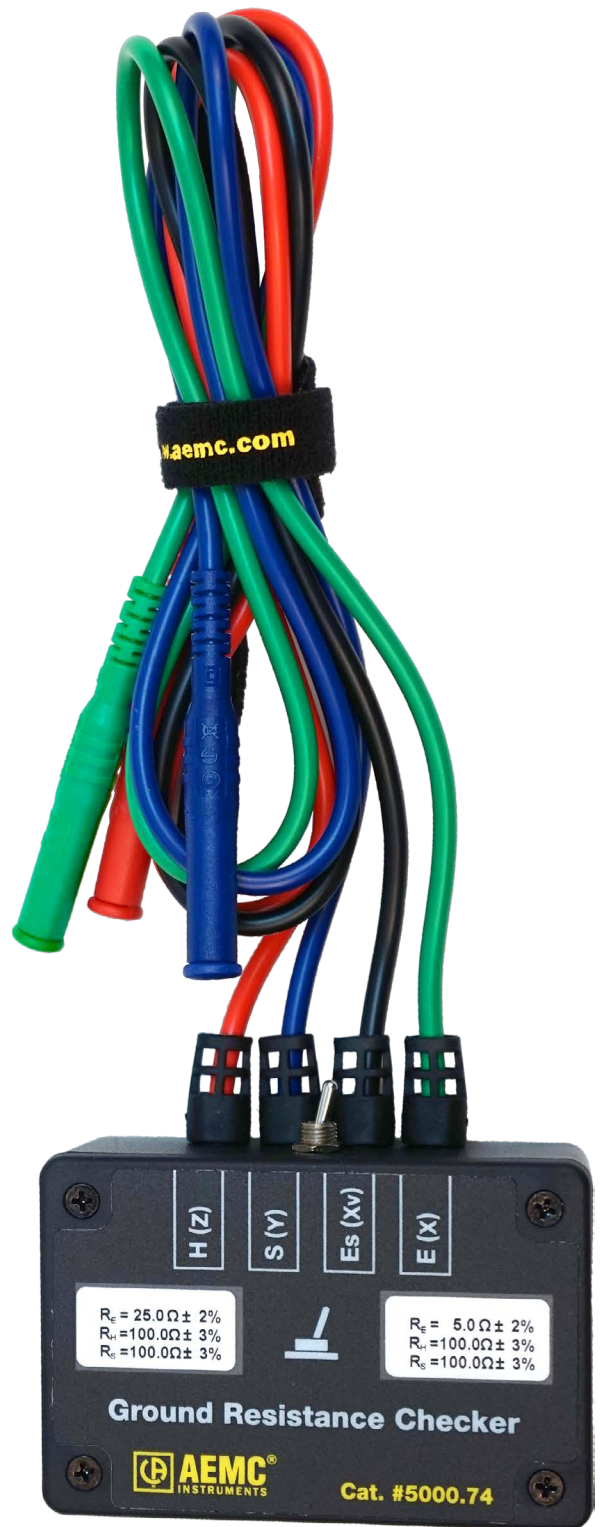


## Ground Resistance Checker

Now we'll demonstrate the Ground Resistance Checker. This provides test resistances for the measurements RE (X), RH (Z), and RS (Y). The RE resistance is 5Ω or 25Ω, depending on switch position. The RH and RS resistances are both 100Ω.

To perform a test:

1. Connect the Ground Resistance Checker to the instrument. The leads are color-coded to match the terminals on AEMC's ground resistance testers; match each lead's color to the appropriate instrument terminal color. If required by your instrument's terminals, use the four fork terminals supplied with the Ground Resistance Checker to facilitate connection to binding posts.
2. Turn the Ground Resistance Checker's switch to the left to set the RE resistance to 25Ω. Then turn the instrument's dial to a setting that displays RE, RH, and RS. For some instruments this is the 4 Pole setting, for others, such as the Model 6472, this is the 3+1 Pole setting.
3. Hold down the START button for two seconds. After a few moments the RE, RH, and RS readings appear on the display screen. The RE reading should be within ±2% of 25Ω. The RH and RS readings should be within ±3% of 100Ω.
4. Turn the switch on the Ground Resistance Checker to the right to set the RE resistance to 5Ω. Hold down the START button and take a measurement. The RE reading should be within ±2% of 5Ω.



Note that you can also use the Ground Resistance Checker to perform a 4-Pole milliohm test.

## AEMC Interview:

# John Olobri

## Director of Sales and Marketing

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*Even the best products need to be carefully positioned and promoted to ensure commercial success. In this interview, John Olobri, AEMC's Director of Sales and Marketing, explains how we develop and market the right products for all our customers' needs.*



### ***Q. What are your primary responsibilities with AEMC?***

In my position there are two key areas I need to focus on, marketing and sales. The marketing side includes identifying new product needs, creating a promotion strategy to ensure market visibility for these products, and developing training materials. In the sales arena, my responsibilities include developing, managing, and motivating the selling organization.

### ***Q. How does AEMC ensure the products it develops match up with customer needs?***

We pride ourselves with our "Voice of the Customer" approach. We ask customers what they need to do their jobs, and carefully listen to what they say. We look to find what issues and problems they have with their existing test equipment. We observe how they actually use the equipment, with the intent to improve the operator interface and efficiency with new instruments.

We then discuss this feedback with our development team – staffed with the right mix of technical skills and experience -- to ensure we design and develop products that are functional, reliable, and cost effective.

### ***Q. What are the ways AEMC informs customers of new products?***

AEMC employs all the marketing communication tools that are available to ensure that our potential and existing customers and distributors are aware of new products and their features and benefits. We start off with a comprehensive launch package that includes datasheets, brochures, selling guides (that summarize the key features benefits and product advantages), press releases, ad reprints, PowerPoint presentations, user manuals, and digital files. This launch package is sent to our entire selling organization, including our distribution network.

We schedule ads in trade publications that fit the customer focus for the product, and we employ digital banners with the publisher's electronic media and our distributor's websites. Our own website is updated coincident with the launch package mailings.

In addition, our field selling organization is trained via webinar and hands on application case studies designed to ensure they can properly demonstrate the product to the customer, and point out the strategic advantages and feature/benefit proposition.

***Q. What training and other resources are available for AEMC customers to learn about their instruments?***

Our internal technical writing staff and application engineers produce application notes, step by step "how to" guides, and YouTube videos that are very effective for helping our customers understand how to use the products correctly for the applications they are designed for. The AEMC selling organization is a technically competent unit that is capable and enthusiastic to demonstrate a product to a potential customer.

We also teach day-long accredited technical programs designed help customers with the theory of operation and proper test procedures to employ to obtain reliable results.

***Q. Are there any unique aspects or challenges to marketing for AEMC?***

As with many products today, software is a key element. The challenge is to present software in a way that ensures the customer has a clear understanding of the tools and reports available, without being threatened by complexity.

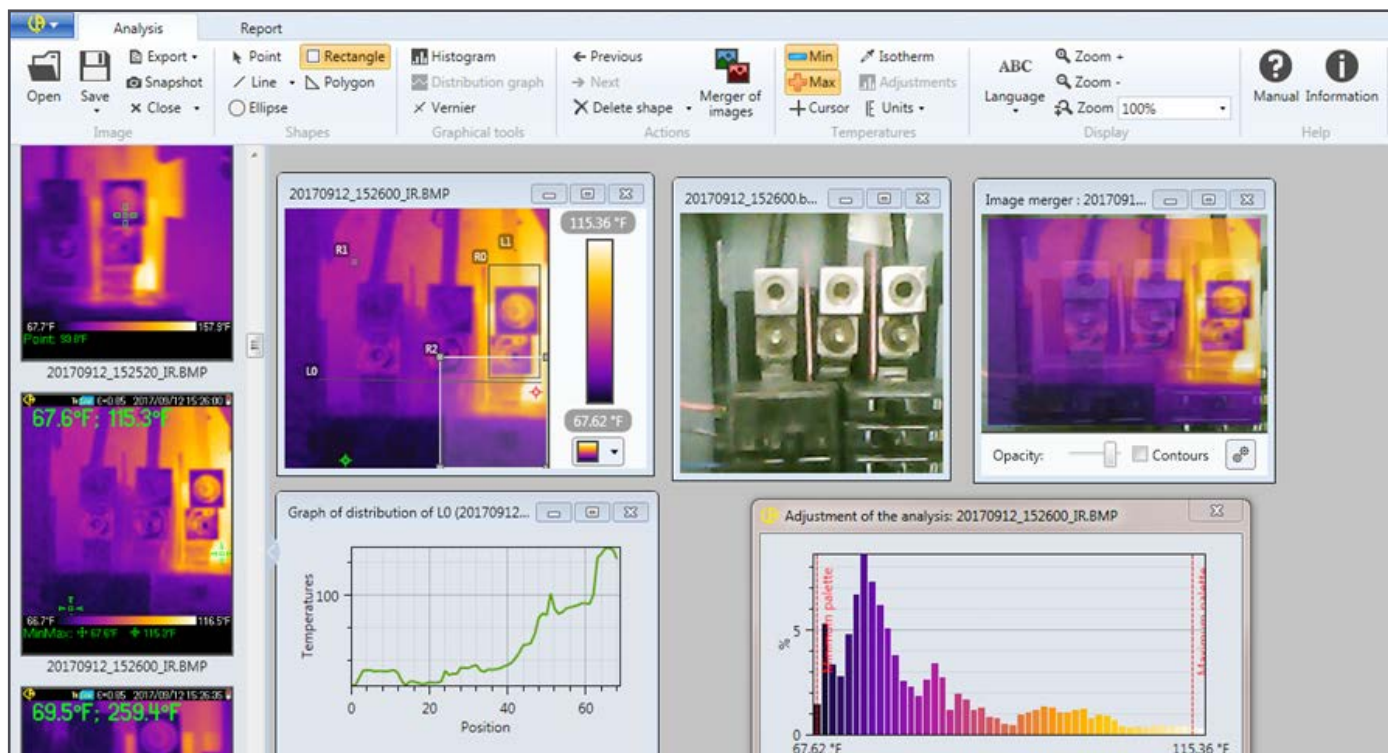
***Q. Any final "words of wisdom" you'd like to share?***

AEMC prides itself for providing reliable, high quality products backed by conscientious customer service and solid technical support. The customer's needs are our highest priority. We welcome all customer feedback; it's a tremendous help with product improvement.

New Product:

# CAmReport Software for the IR Camera Model 1950

The AEMC IR Thermal Camera Model 1950 camera comes with free CAmReport analysis software. This enables you to perform data analysis on images taken with the camera and downloaded to the computer. The application also lets you create reports from the downloaded data.



The CAmReport interface consists of two main tabs:

- **Analysis** lets you download and display images recorded by the Model 1950. You can then perform a variety of analytical tasks with the image, including changing the color pallet used for the thermogram, create temperature distribution graphs for the entire image or a user-defined shape within it, view measurement data in tabular format, merge the thermogram with its visible light image, and others.
- **Report** generates reports from image measurement and analytical data. You can enter general information about the report (title, business, operator, and so on), select images to include in the report along with their associated analysis data, and preview, print, and export the report.

For more information about the IR Thermal Camera Model 1950, visit its [product page](#).



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