APPLICATION NOTE

True RMS, True InRush® and True Megohmmeter®

Technical Hotline: (800) 343-1391

www.aemc.com

AEMC® INSTRUMENTS

CHAUVIN ARNOUX GROUP

If you use AEMC® Instruments, you may have come across the terms **True RMS, True InRush®** or **True Megohmmeter®**.

The most well-known of these is **True RMS**, an industry term for a method to calculate Root Mean Square.

The terms **True InRush®** and **True Megohmmeter®** may be less familiar, but they are exclusive to AEMC® Instruments and signify advanced capabilities that set our products apart from the competition.

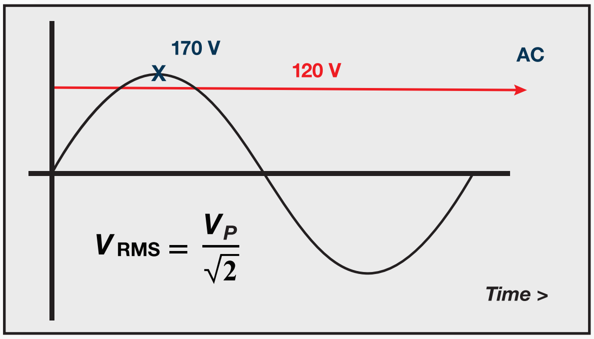
In this article, we'll briefly define what these terms mean and why they are important to you.

RMS Measurements

An alternating current (AC) source periodically reverses both the direction of current and the polarity of voltage, with neither staying constant over time. When measured, the oscillation of current and voltage presents a challenge for measurements, as the value is constantly and, often, rapidly changing. When RMS (Root Mean Square) measurements are displayed, they represent hundreds or thousands of measurements taken rapidly over a period of time allowing for an effective steady-state measurement of an alternating source. RMS is a basic mathematical concept used to find the average of a continuously varying value.

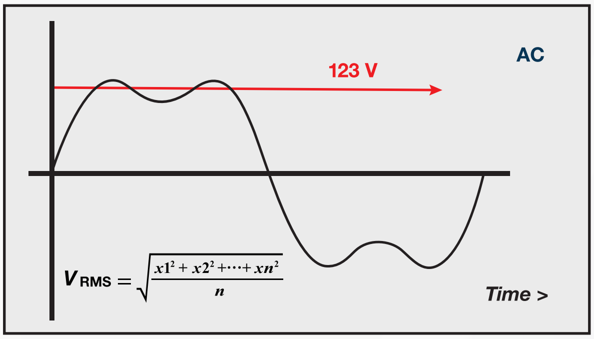
Using RMS for Electrical Measurements

When applied to a voltage or current measurement, RMS measures effective AC values equivalent to a DC system. Some low-end instruments use a technique known as 'average sensing,' sometimes referred to as 'average RMS.' This method involves multiplying the peak AC voltage or current by 0.707, which is the decimal representation of one over the square root of two, allowing the instantaneous voltage or current to be calculated over one complete frequency cycle.



Undistorted 60 Hz supply voltage waveform

Averaging RMS is accurate for a **sinusoidal** waveform supplies, which rises and falls in smooth, equally spaced periods. Unfortunately, RMS averaging calculations can also be problematic in real-world applications as supply voltages encountered in non-linear loads, like the rectifier circuitry of a variable frequency drive or an electric arc furnace. The presence of these loads creates a non-sinusoidal waveform. In this scenario, average RMS values can only achieve an accuracy of 90% or less. **True RMS accounts for the variability of a power source, and precisely measures both sinusoidal and non-sinusoidal AC voltage and current.**



Voltage waveform from a 60 Hz supply with 3rd and 5th order harmonic content

True RMS

In these cases, we need to apply a method known as 'true' RMS. This involves a more complex mathematical calculation that takes into consideration all irregularities and asymmetries created by the introduction of harmonics that may be present in the AC waveform:

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

In this equation, ***n*** equals the number of measurements ***x*** made during one complete cycle of the waveform. 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 this formula can accommodate.

True RMS involves a comprehensive mathematical calculation that considers all waveform asymmetries and irregularities, improving accuracy, especially in systems with harmonic distortions.

Instruments featuring True RMS

Clamp-On Meters

205
TRMS
AC/DC
AC+DC
Power

404
TRMS
AC/DC

606
TRMS
AC/DC
AC+DC
Power

407
TRMS
AC/DC
AC+DC
Power, Energy,
Harmonics,
Recording

607
TRMS
AC/DC
AC+DC
Power, Energy,
Harmonics,
Recording

505
TRMS
AC/DC

514
TRMS
AC/DC

566
TRMS
AC
Leakage
Current

Digital Multimeters

5212

5217

5231

5233

MTX 3290

MTX 3291

MTX 3292B / 3292B-BT

MTX 3293B / 3293B-BT

Power Quality Analyzers: PowerPad® Series

TRMS Voltage AC/DC
TRMS Current AC/DC

POWERPAD IV
Class A

8345

8333

8336

8436

True *InRush*®

To troubleshoot nuisance trips caused by rapid over currents, AEMC® Instruments has the solution: ***True InRush® function!***

Understanding the Inrush Phenomenon

When an electrical device is energized, the current momentarily surges due to the load's low impedance. This initial surge saturates the devices windings or capacitor components, reducing current demand within a few cycles after energization. However, the effects of this starting current can impact other parts of an electrical system for many subsequent cycles. This phenomenon is known as inrush current.

Inrush is important when troubleshooting your electrical system for events that could affect your facility's performance. It is also critical in determining the proper design and sizing of your electrical system's protective devices, such as relays, breakers, fuses, and specialty inrush-limiting devices.

In essence, inrush current can be compared to the initial force required to overcome the inertia of a stationary load. Inrush current can be observed on a small scale, such as when household appliances like a vacuum or refrigerator are initially turned on, causing the lights to dim briefly.

Rotating Machines and Transformers

When power is applied to a machine, the stator quickly magnetizes, generating a magnetic field that induces current into the rotor. Without controlling the machine's start-up with a drive or soft starter, this inrush current can measure up to twenty times the motor's full load current (FLC), potentially tripping protective devices or damaging the motor's internal components.

Transformers, like motors, are also prone to inrush currents. When a transformer is first energized, the primary winding in the transformer's core creates magnetic flux, creating an inrush. Currents can exceed twenty-five times the transformer's full current rating for 10 ms or less. Transformer inrush can overload the upstream supply, causing voltage instability across a system.

Power Supplies

Electronically controlled power supplies are another potential source of overload due to the inrush current needed to saturate their input power capacitors initially. The installation of LED lighting has introduced inrush issues where they were not previously found. When several LED drivers are installed in parallel, inrush currents can exceed normal operating limits by as much as ten times, causing unexpected issues after LED lighting retrofits. These devices can produce significant current surges. Inrush currents can also be generated by solid-state transformers, relays, and power supplies in data centers and process control systems.

Inrush Protection

Circuits should have multiple types of overcurrent protection, such as fuses and circuit breakers. These devices trip when currents exceed their specified limits, protecting delicate electrical components. Overcurrent protection must respond quickly to any overload or ground fault, but ideally, it should not trip due to an expected inrush current.

Power supplies, motors, and other critical loads often use thermistor devices known as Inrush Current Limiters (ICL) to mitigate this. These devices effectively prevent damage in electrical components due to inrush. Without an ICL, inrush is often limited only by factors such as line impedance.

When selecting a protection scheme for a circuit, inrush current must be considered to prevent the system from tripping in response to tolerable inrush events, such as motor loads energizing. Constant tripping of protection devices due to inrush can lead to unnecessary system downtime and significantly reduce the lifespan of those devices. In extreme cases, it can result in pitting and welding in contactors, breakers, and other protective devices, causing them to malfunction and potentially fail during fault conditions.

Measuring Inrush

(and why it's difficult)

Accurately measuring inrush current is crucial for troubleshooting and maintenance. Unfortunately, determining inrush with precision and repeatability can be challenging. **Most conventional instruments can only measure inrush on circuits that are initially powered off.** This limitation prevents conventional instruments from measuring inrush on energized branch circuits, making it difficult for technicians to identify the specific loads causing inrush issues, such as voltage sags. Powering down the circuit each time you want to measure inrush produced by a single component is inconvenient, and obviously cannot be used for monitoring a system in operation.

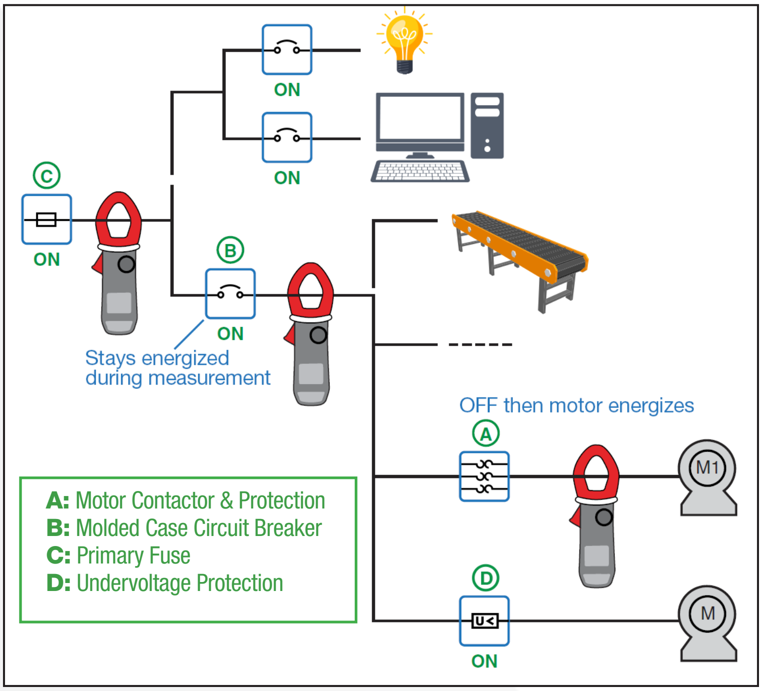
True InRush® Function

(and why it's different)

AEMC® Instruments True InRush® function provides the unique ability to capture the inrush current demanded by a load while the circuit remains energized. In addition to the initial starting current, True InRush® can also detect subsequent inrush events that meet user-defined threshold criteria. True InRush® captures these overcurrents, making it easier to troubleshoot nuisance trips or other trouble conditions caused by inrush issues.

Inrush current peaks occur for a fraction of a cycle, while conventional measurements are sampled at the meters sample frequency and then displayed as RMS values at the meters refresh rate. In contrast, inrush measurements are triggered when current exceeds a preset threshold, sampling at 1 ms intervals over 100 ms. These readings are stored for review, providing both the 100 ms RMS value and the peak instantaneous current during the inrush event.

DC inrush can also be captured and sampled over a 100 ms period. DC inrush can be problematic in battery storage systems, DC fast chargers, and DC motors, especially during frequent start-stop cycles, which may stress or damage components if inrush protection fails or is inadequate. DC-powered devices with long cable runs or high capacitance may also experience high inrush currents, leading to premature failure if not properly managed

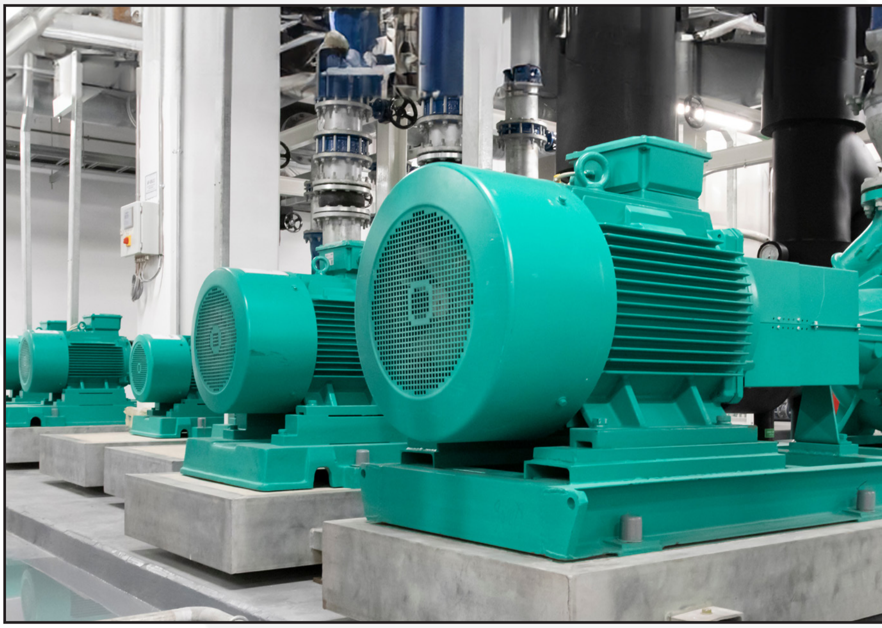


When the motor **M1** starts up:

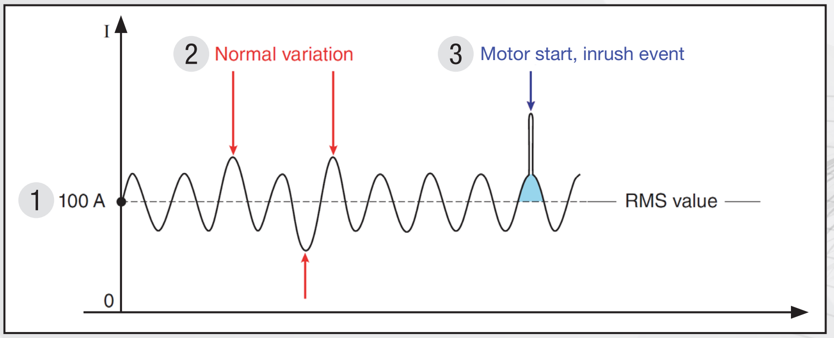
- Protection **A** may be activated and may be tripped
- Protection **B** may be activated
- Protection **C** may be activated

To prevent tripping of protections **B** and **C**, it is not enough simply to find out the inrush current of motor **M1.**

Most instruments on the market can only measure the inrush currents caused by powering up an installation or machine. **Only the True InRush® function allows you to capture an overcurrent event on an energized system in operation, as is the case with B and C.**



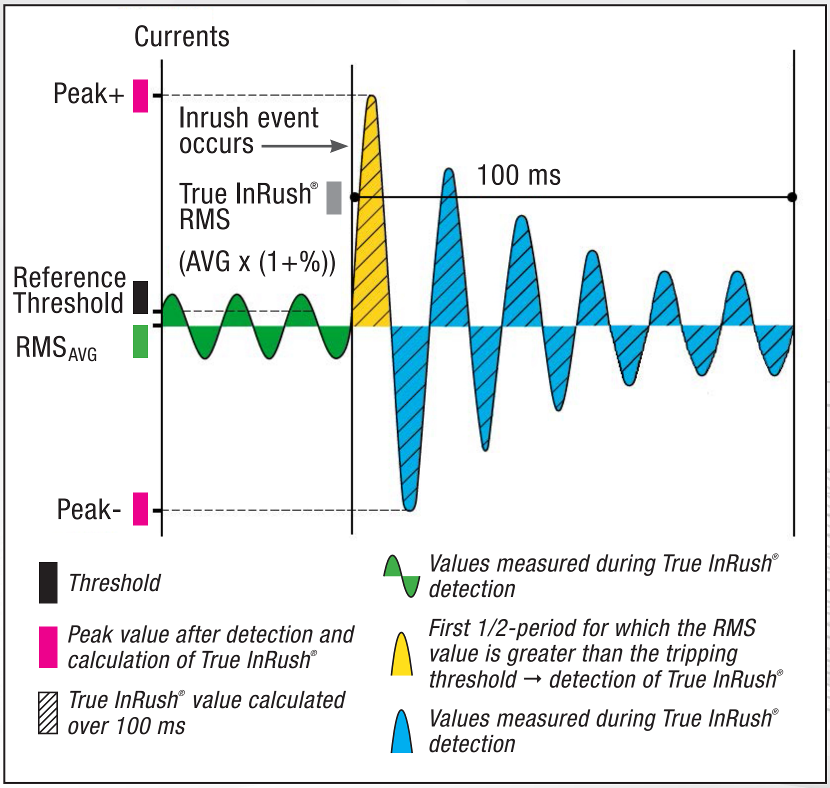
The Clamp-On Method of the True InRush® function involves:



1. When the Inrush function is enabled, the user sets the current threshold % for Inrush detection.
2. The instrument establishes a reference value by sampling the current on the circuit being measured.
3. When the reference RMS current has been calculated, the instrument performs half-cycle monitoring on the circuit. If the instrument measures a half-period with an RMS current that exceeds the user-defined overcurrent threshold *(indicating an inrush event has occurred)*, it triggers a 100 ms capture during which the instrument takes a measurement every 1 ms.

   At the end of the 100 ms period *(6 cycles on a 60 Hz network and 5 cycles on a 50 Hz network)*, the instrument digitally filters and processes the samples to calculate the inrush RMS current for the period. This value is then displayed along with the peak instantaneous maximum and minimum currents.

This process is shown below for a 60 Hz network:



True *InRush*®

205 407 607 404 606

Instruments featuring True InRush®

Our Clamp-On Meters in the 200, 400, and 600 Series are equipped with True InRush® so you can confidently tackle the problems of untimely tripping of protective devices. These instruments feature high-speed, digital signal processing to filter out electrical noise and capture inrush current to a high level of precision and repeatability.

We also offer other 3-phase analyzers, including our Power Quality Analyzers, the PowerPad® Models 8336, 8345 and 8436 that provide True InRush® detection and storage.

8336

8345

POWERPAD IV Class A

8436

True InRush®:
Measure inrush current without de-energizing!

Measuring True InRush® with the Model 606

To demonstrate, we'll explain how to set up the Power Clamp-On Meter Model 606 for True InRush® detection and measurement. The Model 606 is a 10,000-count professional electrical measuring instrument that combines the following functions:

- Current and voltage measurement
- Frequency measurement
- Harmonic distortion measurement
- Continuity testing *(with audible alarm buzzer)*
- 1700 VDC / 1200 VAC measurements
- Measures W, VA, var and PF for single- and three-phase balanced systems
- True InRush® current measurement with 100 mS capture

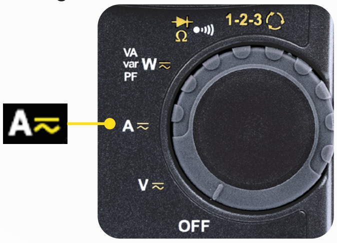
With a boost in AC voltage and DC voltage capability of up to 1200 VAC and 1700 VDC, the Model 606 offers enhanced functionality for solar and photovoltaic (PV) purposes. With its safety rating of 1000 V CAT IV and 1500 V CAT III, you can operate confidently in even the most demanding electrical environments.

Step 1: Setting the Inrush Threshold %

To get started, we'll set the inrush threshold percentage. This is the percentage by which the half-cycle RMS current must exceed the steady-state current in order to trigger an inrush event.

1. With the Model 606 rotary selection switch in the ***OFF*** position, press and hold down the ***MAX/MIN PEAK*** button. This button is also labeled ***Inrush***.

While holding this button down, turn the rotary switch to the ***A*** setting.



After a few moments, the instrument beeps and the symbol ***%*** flashes on the screen.

The inrush threshold also appears on the display, blinking to indicate it is in edit mode.

By default, this is set to 10%, representing 110% of the measured steady-state current. Possible values are 5%, 10%, 20%, 50%, 70%, 100%, 150%, and 200%.

2. To change the threshold percentage, press the **yellow button**. Each press scrolls to the next preset %.

We suggest initially setting the threshold at steps in 5%, 10%, 20% and conduct a recording session. If the threshold results in a high number of inrush events being recorded, you can reset this to a higher value. Conversely, if any events are recorded, you can change this setting to 5% to capture smaller overcurrents.

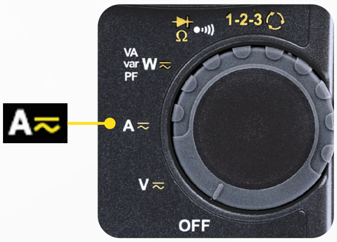
3. When the desired threshold is displayed, turn the switch to another setting. The chosen threshold is stored and a double beep is emitted.

*The **True InRush®** function empowers technical staff to monitor, locate, and troubleshoot rapid overcurrent events responsible for unstable voltages, nuisance trips, and other abnormal operations.*

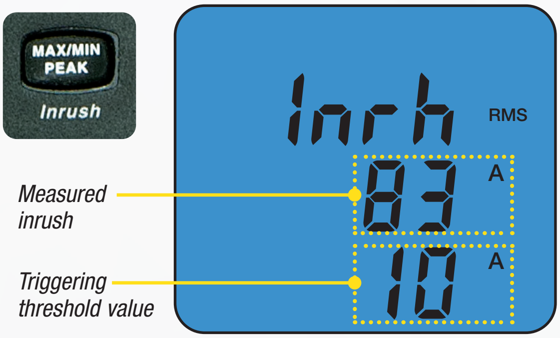
Step 2: Recording True InRush® Current

With the threshold percentage set, we are ready to conduct an inrush recording session.

1. Turn the meter to the ***A*** measurement mode, then clamp the meter around the conductor to be measured. The meter will automatically detect the presence of AC or DC. If DC is being measured, use the DC zero function found in the manual for a more accurate inrush measurement.

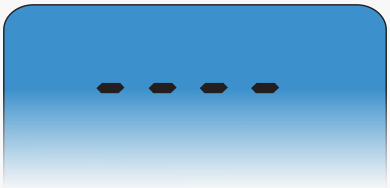


2. Press the ***MAX/MIN PEAK*** button for two seconds, until a beep sounds and the symbol ***Inrh*** appears on the screen.



The backlight blinks, indicating the instrument is acquiring the reference RMS current. When complete, the triggering threshold appears on the screen.

The Model 606 then begins monitoring the circuit for an inrush event. During this process the mode indicator ***A*** blinks and a series of dashes appears in the measurement area of the screen.



True InRush®: An Important Tool for Troubleshooting

As we've seen, determining the magnitude of a circuit's inrush events is critical to its troubleshooting, particularly when locating faulty protection devices such as circuit breakers, fuses, switches, and Inrush Current Limiters.

Correctly selecting and sizing these devices can help prevent them from interrupting circuit operation in response to normal inrush currents – while still preventing dangerous overcurrents from damaging sensitive components.

True InRush® gives electrical technicians an important tool for accomplishing this goal, by providing a method for measuring inrush even on an energized circuit, **without powering down the system.**

Once the circuit is designed and put into operation, True InRush® offers an easy way to monitor branch circuits or individual loads, identifying potential problem areas. It also enables you to determine the effects of adding or removing system devices, and making modifications as appropriate.

True InRush® simplifies the process of troubleshooting complex installations, ultimately saving you time!

For more information about AEMC® Instruments Clamp-On Meters with True InRush® capabilities, visit our website at **www.aemc.com**.

True Megohmmeter®

Another term unique to the AEMC® Instruments world is True Megohmmeter.® To fully appreciate its significance, it is important to understand the general principle behind megohmmeters. These instruments work by applying high voltage across a motor, transformer or cable insulation system with a limited test current to prevent creating unwanted stress to the insulation. Current 'leaks' across the insulation layer(s), returning back to the instrument. The meter then calculates the resistance according to Ohm's Law using the applied voltage and leaked current values.

Maintaining a constant voltage during testing can be challenging, especially at lower resistance levels. Many megohmmeters address this by lowering the voltage as needed during the test. However, this adjustment can introduce uncertainty, as ideally, all measurements should be made at a consistent test voltage to ensure accurate comparisons of similar devices or for long term trending data.

The True Megohmmeter® addresses this issue by ensuring that the test voltage remains constant throughout the entire measurement process, regardless of the resistance level. If the instrument is unable to maintain a constant voltage, the True Megohmmeter® function will terminate the test. This feature guarantees complete voltage consistency for all measurements, allowing for highly reliable comparisons and confident data interpretation.

Instruments featuring True Megohmmeter®

All of our digital Megohmmeters are equipped with the True Megohmmeter® function so you can test with confidence no matter which model you select.

Hand-held Megohmmeters

6536
Up to 100 V

6534
Up to 500 V

6529
Up to 1 kV

SEE OUR WEBSITE FOR ALL MODELS

Hard Case Megohmmeters

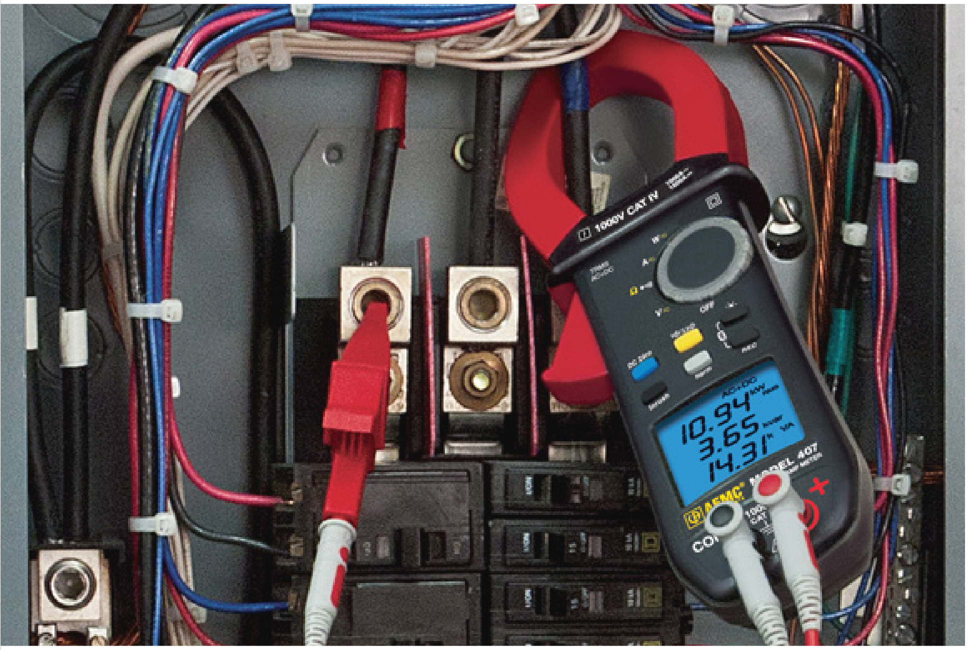
5070
Up to 5 kV

6550
Up to 10 kV

6555
Up to 15 kV

TRUE MegOhmmeter®

ensures accurate measurements by applying a constant test voltage to the sample under test.



True RMS, True InRush®, and True Megohmmeter® all speak to AEMC® Instruments commitment to delivering the most reliable and accurate data.

To summarize:

True RMS refers to our instruments' ability to accurately measure the root mean square (RMS) value of an AC signal, regardless of waveform distortion. This ensures precise measurements for both pure sine waves and complex waveforms, which is crucial for accurate troubleshooting and analysis.

True InRush® measures power-up events from devices on an energized network, detecting both the initial and subsequent inrush currents that meet user-defined thresholds. This capability simplifies and enhances the process of correctly sizing complex installations.

True Megohmmeter® ensures that the test voltage applied during insulation resistance testing remains constant, regardless of the resistance level. This consistency is vital for obtaining accurate measurements.

Choose AEMC® Instruments to deliver exceptional performance for effective troubleshooting, system analysis, and overall electrical safety.

United States & Canada

Chauvin Arnoux®, Inc.
d.b.a. AEMC® Instruments
15 Faraday Drive
Dover, NH 03820 USA
Tel (603) 749-6434
Fax (603) 742-2346

Customer Support
Place orders, obtain prices
and delivery options
(800) 343-1391
customerservice@aemc.com

Sales & Marketing Department
sales@aemc.com
marketing@aemc.com

United States & Canada (continued)

Repair & Calibration Service
repair@aemc.com

Technical & Product
Application Support
(800) 343-1391
techsupport@aemc.com

South America, Central America, Mexico & the Caribbean

Chauvin Arnoux®, Inc.
d.b.a. AEMC® Instruments
15 Faraday Drive
Dover, NH 03820 USA
export@aemc.com

Australia & New Zealand

Chauvin Arnoux®, Inc.
d.b.a. AEMC® Instruments
15 Faraday Drive
Dover, NH 03820 USA
export@aemc.com

All other countries

Chauvin Arnoux®
12-16 Rue Sarah Bernhardt
92600 Asnières-Sur-Seine, FR
Tel +1 33 1 44 85 45 85
Fax +1 33 1 46 27 73 89
info@chauvin-arnoux.com
www.chauvin-arnoux.com

Family of Products

Measure Up
WITH AEMC INSTRUMENTS®

To learn more, visit www.aemc.com

Call the AEMC® Instruments Technical Assistance Hotline for immediate consultation with an applications engineer: (800) 343-1391

AEMC® Instruments • 15 Faraday Dr. • Dover, NH 03820 USA • (800) 343-1391 • Fax (603) 742-2346 • E-mail: sales@aemc.com
Export Department: +1 (603) 749-6434 x520 • Fax +1 (603) 742-2346 • E-mail: export@aemc.com
950.APP-TRUE-RMS-INRUSH-MEGOHMMETER_1124 • Printed in the USA