# True InRush® and AEMC Power Clamp-On Meters

When an electrical system or device is turned on, voltage and current initially spike before settling down to steady-state operation. For example, when a 3-phase motor powers up, its initial current draw can peak at up to 12x its normal current for a period of 75 to 150 msec. This phenomenon is known as ***inrush***, and it can be an important consideration when monitoring your electrical network for events that could affect the performance of your facility. Inrush is also a critical factor in determining the proper design and sizing of your network.

In addition to motors, transformers are also susceptible to inrush currents. When a transformer is powered up, there is an inrush of approximately 25x its rated current for approximately 10 ms.

Electronically-controlled power supplies are another source of overcurrents, due to their energy-storage capacitors. This also applies to many mass-consumer electronic appliances that incorporate a switching power supply. These devices may cause very strong current surges, which in severe cases can create a spark when they are powered up

Inrush currents can also be produced by solid-state components such as computers and copiers, as well as heaters and filament lamps.

## Inrush Protection

Circuits generally have some form of overcurrent protection, such as fuses and circuit-breakers. These devices trip in the presence of currents that exceed their specified limits, thereby protecting delicate electrical components. The overcurrent protection must be able to react quickly to any overload or short-circuit, but ideally will not trip in the event of a high overcurrent caused by normal use rather than from a fault.

To help prevent this, power supplies often incorporate an internal system known as an Inrush Current Limiter (ICL). This can protect electrical components from overheating due to inrush. Without an ICL in place, inrush is often only limited by factors such as line impedance. ICLs are designed with different specifications and performance characteristics to meet the requirements of a variety of circuits and applications.

When selecting a protection system for a circuit, you must take inrush into consideration to prevent the system from tripping in response to the normal short-lived spikes produced by events such as a motor powering up. In addition to causing needless system downtime, the constant tripping of protection devices by inrush current can significantly shorten their lives – and in extreme cases, can produce pitting and welding in switches, causing them to malfunction and fail to work when actual dangerous currents are present.

## Measuring Inrush (and why it's difficult)

An accurate measurement of inrush current is critical for circuit design and maintenance. Instruments used for measuring inrush include clamp meters, digital multimeters, and power quality analyzers. These products use different methods for detecting, measuring, and calculating inrush. They also vary widely in price.


Unfortunately, determining inrush with precision and repeatability can be challenging. **Most instruments can only measure inrush in systems that are initially powered off**. Basically, these instruments measure current and voltage starting with the original powered-down state, through power-up and finally steady-state operation. This usually occurs within the first few seconds after start-up. The instrument then compares the power-up peak to steady-state and, depending on the threshold criteria used, displays the inrush reading.

One limitation with this method is that inrush currents frequently occur on circuits that are already powered on. For example, a circuit can have multiple components capable of inducing inrush currents at different times. 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®

AEMC's True Inrush® function provides the unique ability to measure power-up events from devices on a network that is already energized. In addition to the initial power-up event, True InRush can also detect subsequent power-up inrush events that meet user-defined threshold criteria. True InRush captures these overcurrents, making it simpler and easier to size complex installations correctly. The basic steps in the True InRush process are as follows:

1. When turned on, the instrument acquires the steady-state current for the installation.

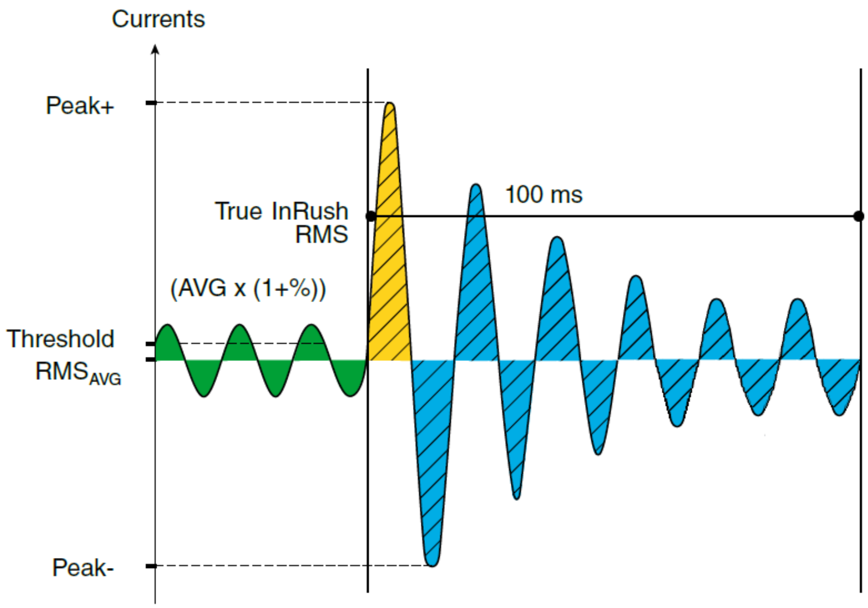
2. The instrument processes this signal to filter out normal operational variations.

3. When the base RMS current has been calculated, the instrument performs half-period monitoring on the circuit.

4. 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 session during which the instrument takes a measurement every 1 ms.

5. At the end of the 100 ms period (which encompasses 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 actual inrush RMS current for the period. This value is then displayed along with the peak instantaneous maximum and minimum.

   This process is shown below for a 60 Hz network:




AEMC provides power clamp-on meters that provide True InRush capability. 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. They include the 400 Series and 600 Series families of clamp-on meters. AEMC also offers other 3 phase analyzers, including the Model 8333 and Model 8336, that provide True InRush detection and storage.

## Measuring True InRush with the AEMC Model 607


To demonstrate, we'll explain how to set up the AEMC Power Clamp-On Meter Model 607 for True InRush detection and measurement. The Model 607 is a 10,000-count professional electrical measuring instrument that combines the following functions:

- Current and voltage measurement
- Frequency measurement
- Harmonic distortion (THD) measurement
- Continuity testing (with audible alarm buzzer)
- Resistance measurement
- Power (W, VA, var and PF) and Energy measurements
- Crest Factor (CF), Displacement Power Factor (DPF) and RIPPLE measurement

Measurements can be recorded and stored in the Model 607 memory. The instrument then can be connected via Bluetooth to a computer running DataView software, for data download and report generation.

In addition to these features, the Model 607 can perform True InRush detection and measurement.

**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 RMC current must exceed the steady-state current in order to trigger an inrush event.

1. With the Model 607's rotary selection switch in the OFF position, press and hold down the MAX/MIN PEAK button. (Note this button is also labeled "Inrush.") While holding this button down, turn the switch to the A≈ setting.

   After a few moments the instrument beeps, and the symbol **Inrh** appears on the LCD. 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, press the instrument's yellow button. Each press displays a different value.

   We suggest initially setting the threshold at or near the default 10%, and conducting 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 few 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.

**Step 2: Recording True InRush Current**
With the threshold percentage set, we are ready to conduct an inrush recording session.

1. Before making the actual inrush measurement, we need to "zero" the DC component. First, ensure the instrument is not clamped around a conductor. Turn the rotary switch to A≂ and observe the instrument's mode indication, which appears blinking in the upper right corner of the LCD. If this does not indicate **DC**, press the yellow button until **DC** is displayed.

2. Press the HOLD button until the instrument emits a double beep and displays a value at or near zero. The correction value is stored until the clamp is powered OFF.

3. Clamp the Model 607's jaws around the conductor to be measured. Then press the MAX/MIN PEAK button for two seconds, until a beep sounds and the symbol **Inrh** appears on the LCD. The backlight blinks, indicating the instrument is acquiring the steady-state RMS current. When complete, the triggering threshold appears on the screen.

   The Model 607 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.

4. When the instrument measures a half-cycle with an RMS current exceeding the triggering threshold, it initiates a 100 ms session during which it makes a series of 1 ms measurements. When complete, the LCD calculates and displays the True InRush current.

5. Press the MAX/MIN PEAK button to display the minimum and maximum peak instantaneous current values measured during the 100 ms session. (Note that this step can only be performed if an inrush event has been detected; otherwise pressing MAX/MIN PEAK has no effect.)

6. Press and hold down the MAX/MIN PEAK button (or turn the rotary switch to a different setting) to exit True InRush mode.

## True InRush: An Important Tool for Circuit Design

As we've seen, determining the magnitude of a circuit's inrush events is critical to its design, particularly when choosing protection devices such as circuit breakers, fuses, switches, and Inrush Current Limiters. Correctly selecting and sizing these systems 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 designers an important tool for accomplishing this goal, by providing a method for measuring inrush during normal operation, **without powering down the network**. And once the circuit is designed and put into operation, True InRush offers an easy way to monitor the network, identifying potential problem areas. It also enables you to determine the effects of adding or removing system devices, and making modifications as appropriate.

For more information on AEMC Power Clamp-On Meters with True InRush capabilities, including the Models 400 and 600 Series of instruments, please visit the AEMC web site.