

# Inrush current

## Application Note

### Introduction

Energy shortages around the country, especially in California, have increased the urgency for plants to install, or replace with, high efficiency motors. While they consume less electricity than their older, less efficient counterparts, they draw considerably more at startup than the older motors. Startup or inrush current in these high efficiency motors can run as high as 11 times the running current as compared to a multiplier of seven to eight times for earlier motors. While this is usually not a serious problem, the installer must be aware of changes to over current protection devices (OCPDs) to support these inrush current increases.

Since motors make up 40 % or more of the electrical load in most plants, it is not surprising that plant electrical personnel spend 20 % of their time either installing or troubleshooting them. Regardless of the job at hand, it is useful and often necessary, to know what the value of the starting or inrush current is. This can help to identify where a starting problem is located, either in the motor or somewhere in the starting circuit. This measurement may also be recorded in a preventative maintenance log.

Previously, digital clamp meters have had various features that were supposed to capture and display the starting current of motors. These features have been called peak, peak hold, min/max, min/max hold, etc. While all of these features provide a reading that is higher than the

running current, they tend not to be repeatable over several start cycles. Part of the reason they do not give an accurate picture is that they don't always start taking measurements synchronously with the start of the motor inrush current.

### Inrush

To provide repeatable motor inrush measurements, the new Fluke 370 series of clamp meters utilizes a "triggered" mode that allows synchronizing of the measurement with the actual starting current. The technician first "arms" the inrush function of the clamp meter. The meter is then triggered by the inrush current. Once triggered, it takes a large number of samples during a

100 millisecond period and then digitally filters and processes the samples to calculate the actual starting current. The result is a more accurate, synchronous indication of the start current not previously available in a clamp meter.

### Peak, min/max, and inrush

It's important to understand that different brands of clamp meters will use different terms to describe the same measurement. In addition, the actual operation of the feature may be significantly different from what the name would imply. While there is too wide a variation across brands to detail in this space, the following are the terms Fluke uses:

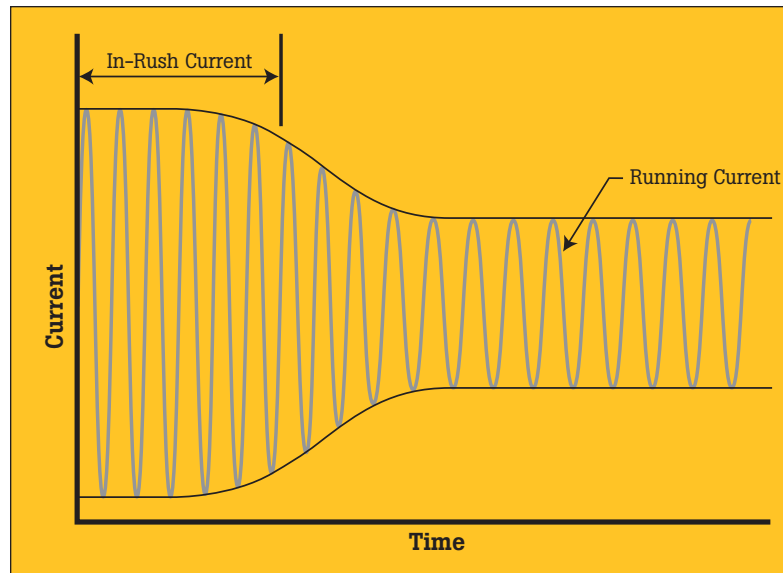


Figure 1. Motor starting current.

**Analog peak**

The earliest Fluke handheld instrument to have a highest value capture feature was the 8024A digital multimeter (DMM). It had an analog peak hold circuit (labeled “Peak Hold”), which captured the highest peak value that lasted for ten milliseconds or longer, regardless of when it happened in time. From a strict definition point of view, this was a correctly labeled feature since it did capture the actual peak value, but it didn’t necessarily measure the inrush current.

**Digital min/max**

Newer generations of Fluke DMMs, like the Fluke 27, had a min/max function (more correctly labeled digital min/max). It looks at a portion of the a to d cycle to obtain its value, which happened at a fixed rate based on the system clock. However, it made its measurements when it wanted to, which in many cases did not coincide with the startup event, so it could miss the event partially or completely. The Fluke 87 was the first handheld instrument to have both a one

millisecond analog peak and 100 millisecond digital min/max, allowing for measuring of relatively short or medium long events. Again, the 100 millisecond min/max suffered the same limitations as the earlier model 27; the measurements were not synchronous with the occurrence of an event. The first Fluke clamp meter to have a max hold feature was the Fluke 36. Although this was implemented as an analog track and hold, in ac the Fluke 36 looked at the output of the ac analog rms converter. That significantly slowed the response rate so the 36 was only useful for events that lasted several hundred milliseconds or longer. Unfortunately this was too slow for short-term events, like inrush current. Min/max on the Fluke 376 Clamp Meter is a digital min/max—similar to the one on the Fluke 27—and it is updated every time the display updates. Its sampling window opens for about 100 milliseconds every 400 milliseconds and takes a number of readings, and updates the min or max registers as appropriate. This

type of min/max is most useful for longer term events, such as those occurring on heavily loaded or long wire run circuits, to record more regular voltage drops or load increases, but is not ideal for inrush measurements.

**Inrush on the Fluke 43B vs. the Fluke 370 Series**

Fluke has inrush functions on other products, such as the Fluke 43B Power Quality Analyzer, but while they share the same name, they are different. The 370 Series takes a large number of samples precisely at the beginning of the starting current for a 100 millisecond period and then digitally filters and processes the samples to calculate the actual starting current. In contrast, when “inrush” is selected from the Fluke 43B menu, it digitally captures the current (amps) waveform. A cursor can then be used to pick out the instantaneous amps value at any point of the sampled amps waveform and the duration of that value. This capability is ideal for examining reduced voltage (a two stage) starter waveform.

**Why does the display show a value higher than the rating of the circuit breaker?**

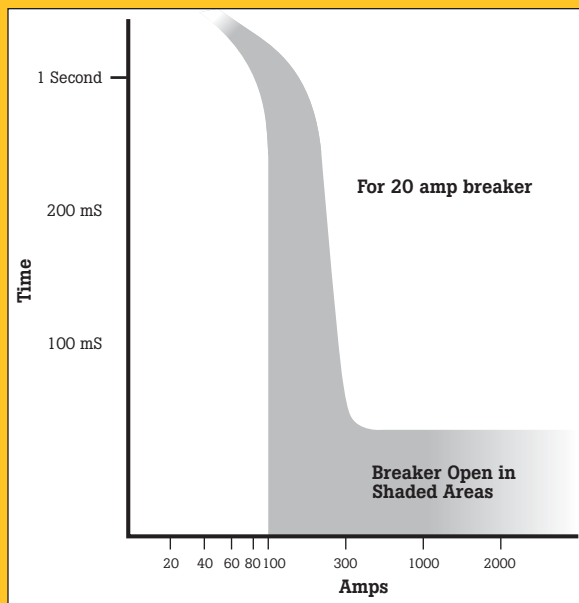


Figure 2. Breaker clearing time for 20 amp breaker.

Inrush current can be four-to-eleven times the normal running current depending on the type of motor. For example, if the running current of a motor is eight amperes and the starting current multiplier is five times the running current, the Fluke 370 Series clamp meter displays a reading of about 40 amperes, even though the circuit breaker is rated for 20 amperes. The reason the breaker or overload unit does not trip is because both of these devices operate on a time versus current curve. This indicates how much current passes through the breaker and for how long a time period without opening the circuit.

## The right tool for the job

New high efficiency motors require better tools to evaluate and fix the consequences of their high inrush current. The Fluke 370 Series of clamp meters is designed to capture inrush current accurately and, most importantly, synchronously, providing readings that accurately depict what the circuit protector experiences.

Using the right tool for the job allows you to protect your plant's equipment investment and avoid some of the annoying problems inherent with installing new motors.

## Additional resources

**Fluke Corporation**  
www.fluke.com

**IEEE**  
www.ieee.org

## Glossary of terms

### a to d converter

Analog to digital converter. An electronic hardware device that converts analog signals to digital signals.

### Analog peak

The highest peak value measured that lasted some specified time period, usually measured in milliseconds.

### Circuit breaker

An electrical device configured to supply overload and short circuit protection to an electrical circuit. They range in complexity from the common and simple thermal overload/magnetic trip devices to complex electronic units that allow the adjusting of several trip parameters.

### Digital min/max

The measurement of the minimum and maximum values (e.g., voltage, current or resistance) over a specific period of time.

### Inrush current

A transient condition, generally lasting 100 milliseconds or more that occurs during motor start-up.

### Overload units

Devices in motor start control units, such as heater coils, overload trips, thermals, etc. that protect the motor while its running. There are a number of different phrases used worldwide to refer to these devices.

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