

True RMS in Input Current Monitoring: Data Center and Facilities Managers at Risk without Accurate Values

Server Technology, Inc. Advances Current Measurement Technology in Sentry Power Distribution Units

Introduction

Today's data centers face extreme power demands and tight constraints, and tomorrow's data centers will be even greater due to the increasing power requirements of new computing technology. For data center and facilities managers, this makes identifying new methods for accurately monitoring and forecasting power utilization critical.

Monitoring the current into a data center's power circuits provides important & relevant data for power planning and management. Recently a few leading manufacturers of cabinet-level power distribution units have introduced input current monitoring to measure each circuit. The method of *how* they calculate input current values, however, is the center of an important subject matter detailed in this text.

Server Technology, Inc. provides Input Current Monitoring in its Sentry Power Tower products so that data center managers can obtain the data they need to plan their power requirements and to monitor power to their IT equipment. In this document, Server Technology describes its state-of-the-art technology used to accurately compute the RMS value of input current. This method is performed by an integrated circuit using switched capacitor technology to incorporate the best of both analog & digital methods.

Unlike the prior generation of RMS converters and other manufacturers' methods, Server Technology provides Input Current Monitoring attained from an accurate RMS value. It has inherent benefits:

- This method accurately reflects the current drawn by today's switch power supplies.
- This method is not sensitive to temperature drift.
- It is accurate to a Crest Factor of four.
- The sampling rate is not limited by a supplementary processor's power.

Understanding Input Current

If the power feeds in the data center are DC (direct current), then measuring and monitoring the input current is straightforward and simple. If, however, the data center is powered by AC (alternating current), then measurement and monitoring of the input current is more complicated.

Since the purpose of measuring and monitoring the input current is to determine the power used by the data center equipment (i.e., wattage) it is required to measure the *effective* current.

Of the methods used to obtain an input current value (the total effective current being drawn), the most reliable and acceptable method is to determine the Root-Mean-Square (RMS) value because the RMS value may be determined mathematically for any periodic wave shape that can be described by a known function of time.

Due to the many erroneous methods of estimating RMS, industry has coined the term "True RMS" to indicate state of the art technology is used to determine the RMS value.

When calculating RMS, it is important to note the difference between RMS and "True RMS."

RMS Methodology in Application

There are a number of methods used in industry to estimate or calculate the RMS value of current amplitude that varies in time. Common ways to quantify dynamic waveforms include peak detection and calculation of the RMS with the assumption that the waveform is sinusoidal (*See Figure 1*). The result is a calculated value, which will be inaccurate if the waveform is not a true sinusoid.

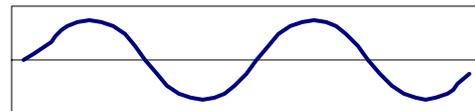


Figure 1: A sinusoidal waveform (a sine wave)

An inherent problem exists with this type of RMS calculation, however, due to the nature of the power supplies found in today's servers and other networking devices. Most data center equipment converts AC to DC using *switching* power supplies. Switching power supplies do not produce a sinusoidal current waveform.

Measuring RMS – the “Old” Method

Typically, measuring average current and using an analog multiply/divide calculation has been used to calculate an RMS value. This method is only accurate for a sine wave. Using a set of equations for a sine wave, average current amplitude can be converted to RMS, and doing this allows the input current monitor to display an RMS value.

Trying to use this type of method with any waveform other than a sine wave results in erroneous RMS readings. This flawed method uses a snapshot of the current, without understanding the shape of the waveform, the height of the waveform’s peak, or at what point in the waveform the sample was taken.

Unfortunately, the assumption that a power supply’s current waveform is sinusoidal is a common mistake. In today’s world of switching power supplies, the currents drawn by the equipment with switching power supplies are not sinusoidal. (See figure 2). Additionally, the peak current amplitude required by these power supplies may reach much higher values than is required if the current waveform is sinusoidal.

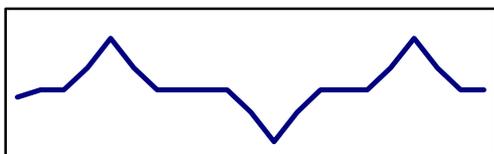


Figure 2: Example of a non-sinusoidal waveform

For a non-sinusoidal wave (i.e, a square wave or triangle wave) these equations do not apply and the resulting measurement is inaccurate.

Application Tip

When taking readings with a typical RMS reading meter, a 120-volt sine wave will indicate 120 volts RMS. This is because the meter uses the mathematical relationships to calculate the RMS value for a sine wave. However, if used to measure a non-sinusoidal wave these meters will indicate meaningless values.

Improper measurement can easily lead a data center manager to believe that a modified sine wave – such as those found in a switching power supply -- is not operating at its rated power. This is extremely important as improper measurements could potentially lead to serious power shortages and failures in the data center.

Some modern high-end meters with the latest technology will convert measurement to RMS with good accuracy if the ratio of the peak value to the to the RMS value is less than four (4.0). This ratio is known as Crest Factor. (The Crest Factor for a sinusoidal wave is 1.414).

True RMS for Today’s Power Supplies

Server Technology, Inc. uses state-of-the-art technology to accurately compute the RMS value of input current. This method is performed by an integrated circuit that uses switched capacitor technology to incorporate the best of both analog & digital methods.

Unlike the prior generation of RMS converters:

- This method applies to both sine waves and non-sine waves.
- This method is not sensitive to temperature drift.
- It is accurate to a Crest Factor of four.
- The sampling rate is not limited by the processor’s power.

Accurate RMS

Using a pioneering approach to RMS measurement, Server Technology incorporates the world’s first monolithic Delta Sigma RMS solution. It is not just extremely accurate (0.25% untrimmed total error from 50Hz to 1kHz), it also features high linearity over a wide input voltage range (0.02% from 50mV to 350mV). High linearity is key to obtaining RMS.

While RMS cannot be computed without some averaging to obtain the *mean* function, Server Technology’s methodology takes a best approach. The averaging takes place over a sufficiently long interval – rather than the “snapshot” approach used in previous methods.

The waveform’s Crest factor, obviously, also affects the RMS value. With a higher crest factor, more of the energy in the signal is concentrated into a smaller portion of the waveform, and the averaging has to ride out the long lull in signal activity. Server Technology’s Delta Sigma methodology captures each amplitude to a Crest Factor value of four.

Additionally, nothing about the Delta Sigma circuitry is temperature sensitive. So the RMS result is not susceptible to distortion by signal-driven thermal fluctuations like a log-analog circuit output is.

Conclusion

When faced with calculating and forecasting power for each cabinet in the data center, True RMS of the input current supplies the data center manager with the information they need to allocate appropriate power. Because of the severe fluctuations in the wave forms of today’s switching power supplies, a “traditional” method of calculating RMS for a sine wave will most assuredly produce erratic and inaccurate results. To prevent power measurement miscalculations, data center managers need to deploy a solution that uses modern technology that accurately reflects True RMS values, regardless of the wave form’s shape.