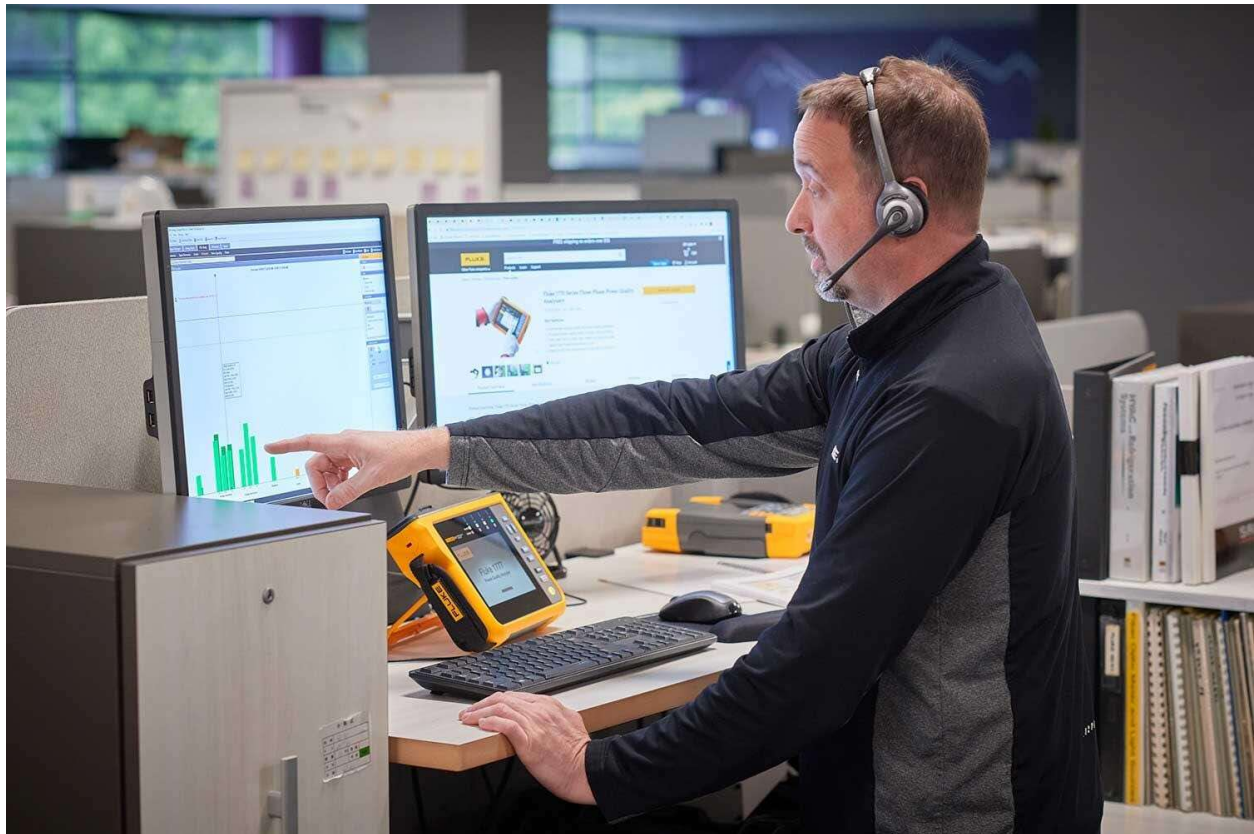


What Harmonics Really Do to Data Center Uptime

By Jason Axelson, Fluke Subject Matter Expert, Power Quality

Uptime is the lifeblood of data centers, whose customers depend on them to deliver 100% availability. Facility disruptions carry extreme consequences, including costly service-level agreement (SLA) penalties. Even though data centers are full of complex machines and systems, the most frequent cause of disruptions in data centers isn't hardware or software. Instead, the number one cause of facility disruptions is power issues, which account for over 40% of data center disruptions.



Data centers run nonlinear power loads twenty-four hours a day, seven days a week, as they power servers, uninterruptible power supplies (UPS), and variable frequency drives (VFDs). Fluctuating demands can cause damaging harmonic currents, which often go undiagnosed until overheating, shutdowns, or equipment degradation happen.

What Are Harmonics, Really?

In electrical systems, harmonics are voltage or current waveforms at frequencies that are integer multiples of the fundamental frequency (60 Hz in North America, 50 Hz in Europe). For example, in North America, the 2nd harmonic is 120 Hz, the 3rd is 180 Hz, and so on.

Data center harmonics are caused by nonlinear loads which distort the ideal sinusoidal waveform. Total Harmonic Distortion (THD) quantifies how much a waveform changes from its ideal shape due to harmonics. It's a key indicator of power quality issues, with higher values signaling more severe distortion.

How Harmonics Affect Data Center Uptime

Harmonics and data center power don't mix. Left unchecked, they can compromise reliability, reduce efficiency, and put critical systems at risk. High total harmonic distortion levels in data centers can degrade the performance and lifespan of equipment and lead to downtime caused by:

- Overloaded neutral conductors: Harmonics from non-linear loads can cause neutral conductor overload, leading to excessive heat and increasing the risk of fire or insulation damage.
- Overheating transformers or UPS systems: Harmonics raise operating temperatures in transformers and UPS systems, accelerating wear and potentially leading to unexpected failures.
- Nuisance tripping of breakers: Distorted current waveforms can cause breakers to trip unnecessarily, disrupting power to critical systems without an actual fault.
- Reduced efficiency: Harmonics lower power factor and increase wasted energy, which leads to higher utility costs and unnecessary power losses.
- Electronic equipment malfunction or instability: Voltage distortion from harmonics can disrupt sensitive electronics, leading to crashes, reboots, or erratic system behavior.

In the short term, data center harmonics can cause costly power interruptions. The long-term, damaging effects of data center harmonics on IT equipment are often invisible until the damage has already occurred.

Where Harmonics Hide in Data Centers

There are four main culprits causing data center harmonics:

1. UPS Output: UPSs often use inverter-based technology to deliver AC power. These inverters switch at high frequencies to simulate a sine wave, but the output can contain significant harmonic distortion, especially if not properly filtered. The distortion can affect downstream equipment or interact with other non-linear loads to compound harmonic issues.
2. Power Distribution Units (PDUs): While facility PDUs themselves don't create harmonics, they serve as aggregation points for many non-linear loads like servers, routers, and storage devices. The cumulative effect of these loads draws distorted current from the PDU, which can reflect harmonics back into the distribution system and amplify the total harmonic distortion in the data center.
3. Cooling Systems: Computer Room Air Conditioners (CRACs) and Air Handlers (CRAHs) often use VFDs to control motor speeds and improve energy efficiency as they move liquids through the facility to control temperatures. VFDs are known sources of harmonics because they convert AC to DC and back to variable-frequency AC using high-speed switching. This process distorts current waveforms and can inject significant harmonics into the electrical system, causing heat buildup and equipment damage.
4. LED Lighting and Newer IT Loads: Modern LED lighting and IT equipment often use switch-mode power supplies (SMPS), which draw current in short, sharp pulses rather than smooth sine waves. These pulses introduce high-frequency harmonics into the system, and although the

individual devices may be low power, their widespread use across a data center can lead to considerable aggregate distortion.

Reducing harmonics in your data center is critical to ensure electrical reliability, and harmonics can be mitigated by solutions like harmonic filters. But first, you need the right tools to identify harmonics.

How to Identify Harmonics Before They Hurt Uptime

Harmonics are usually an invisible problem until they cause equipment damage or downtime but monitoring them as part of your preventive maintenance program can equip you to identify damaging harmonics and take steps to mitigate them before they lead to further damage. Power quality and uptime are closely linked, and harmonic effects on IT equipment can have severe consequences over time.

Power quality analyzers like the Fluke 1777 are the essential tool for measuring and monitoring harmonics. These analyzers provide detailed insights including measuring and monitoring voltage, current, THD, and specific order harmonics (such as 3rd, 5th, etc.) present in your system. By tracking this data over time, you can spot problematic trends before they cause overheating, breaker trips, or equipment instability or damage.

Harmonics change over time, depending on the load being drawn, so it's critical to begin by setting a baseline for incoming power quality. The incoming power should align with standards such as IEEE 519 and using an analyzer like the Fluke 1777 for measurements at the PCC can capture and report to such standards to help facilitate a discussion with the responsible utility.

Want to learn how to set up and use these tools in your facility? Read this [How to Monitor Harmonics in a Data Center Power System](#) article, next.

When to Troubleshoot, and What to Do About It

Even without specialized tools, harmonics often leave behind clues. Excessive heat in electrical panels or transformers, frequent breaker trips, and a declining power factor are all signs it's time to troubleshoot and reduce the harmonics in your data center.

Troubleshooting starts with identifying the source, whether it's a UPS, VFD, or a cluster of high-density IT loads. From there, steps like balancing loads across phases, re-routing non-linear devices, or installing harmonic filters can significantly reduce harmonic distortion in data centers and restore system stability.

Need more details about how to troubleshoot data center harmonics? Read this [How to Troubleshoot Harmonic Distortion in Data Centers](#) article, next.

Uptime Is Electrical Health

Fluke tools give you the visibility others miss. With the Fluke 1777 Power Quality Analyzer and Fluke 1738 Advanced Power Logger, you can make harmonic monitoring a routine part of your maintenance strategy instead of just a reactive fix. These tools aren't just nice to have; they're a smart investment that helps you avoid the much higher costs of unplanned outages and equipment failure.

About the Author

Jason is a subject matter expert at Fluke specializing in power quality, electrical test equipment, and product applications. With deep experience supporting both customers and distribution partners, he helps professionals select, operate, and troubleshoot a wide range of diagnostic tools—including power quality analyzers, battery testers, acoustic imagers, and thermal imagers. Jason regularly leads application-based training sessions, drawing on his hands-on knowledge to bridge the gap between technical challenges and practical solutions across industries. Connect with Jason on [LinkedIn](#).