

Mitigating harmonics in energy saver uninterruptible power systems

How Eaton's Energy Saver System Plus maximizes uninterruptible power system (UPS) energy efficiency while dramatically reducing the effects of harmonic distortion

Energy saver UPSs save money and enhance environmental sustainability by reducing data center energy waste up to 10 percent under typical loading conditions. Unfortunately, few such systems come with the harmonic mitigation features often available in UPSs that don't support energy saver operation. As a result, data center operators with high harmonics who wish to use eco-mode UPSs have traditionally had to choose between installing additional equipment to mitigate harmonics or exposing their facilities to the costly and disruptive effects of harmonic distortion.

The Power Xpert™ 9395 UPS from Eaton frees companies from this trade-off. When equipped with ESS Plus, Eaton's Energy Saver System (ESS) and Harmonic Reduction System (HRS), the 9395 both lowers energy expenses and eliminates low-order harmonic currents from non-linear loads. This technology brief explains how ESS Plus helps companies enjoy the efficiencies of energy saver UPS operation without accepting the potentially negative effects of harmonics.

How harmonics impact data centers

In an electrical distribution system, harmonics are the distortion of the voltage or current waveform produced by non-linear loads, such as servers, variable frequency drives, florescent lighting and other electronic devices. They appear as supplemental frequencies higher than the fundamental frequency, which is 60 Hz in the U.S. and 50 Hz in most other regions. These superimposed frequencies create a distorted signal that results in these problems:

Reduced energy efficiency: Harmonic currents increase losses on the power system conductor and transformers, adding heat to the power chain that drives up power and cooling costs.

Decreased reliability: The heat created by harmonics can increase downtime by causing premature equipment failure or malfunctions, overheated wiring and other hardware issues, including generator transfer switch and control malfunctions.

Higher capital expenses: Harmonics can reduce the lifespan of electrical equipment, forcing companies to purchase replacement devices sooner than would otherwise be necessary. They can also compel data center managers to compensate for increased heating and distortion by investing in oversized generators, neutral conductors and transformers.

Costly utility penalties: Electrical utilities must compensate for harmonic-related waste too by deploying additional generating capacity, and "harmonic pollution" at one facility can impact operations at nearby buildings that share a point of common coupling. For both reasons, many utilities penalize customers who exceed harmonic distortion limits defined by the IEEE-519 standard.

Understanding ESS Plus

Comprehensive power protection and high energy efficiency have historically been mutually exclusive UPS features. Unlike other eco mode technologies, however, Eaton's ESS Plus combines both with the following benefits under normal utility operation:

- Provides up to 99 percent energy efficiency across all load ranges
- Continually monitors load current and reduces harmonics in excess of user-defined limits
- Compensates reactive low power factor in non-linear loads
- Balances loads across phases to avoid stranded capacity
- Provides clean and continuous power during utility outages or in response to electrical disturbances

With energy costs soaring, ESS can save companies thousands of dollars a year per UPS. For example, at a typical data center load of 30 percent, replacing a legacy 90.5 percent efficient UPS supporting a 750 kW load with an Eaton UPS in ESS mode can reduce power consumption by 630 megawatt hours over three years. If power costs average \$0.10 per kilowatt hour, the end result over the same three-year period is \$63,000 in utility savings.

Unlike separately installed harmonic mitigation devices, ESS Plus is an optional feature of the 9395 UPS that:

- Does not take up valuable data center floor space
- Does not impose added installation and maintenance costs

Moreover, in addition to reducing harmonic distortion ESS Plus also enables the 9395 UPS to correct low power factor and ensure even load balancing across three-phase power systems *when operating in energy saver mode*. Power factor correction and load balancing are functions that most eco mode UPSs can perform only when running in double-conversion mode. While performing this power correction, the 9395 UPS efficiency typically remains within one percent of energy saver levels, a significant improvement over double-conversion efficiency levels.

How ESS Plus works

When an 9395 is in ESS Plus mode, the UPS continually monitors current from the critical load for harmonic distortion. If it detects harmonics in excess of pre-determined and adjustable limits, the system injects an additional current into the line that's identical to but 180 degrees opposite of the harmonic current coming from the load, effectively canceling out the electrical disturbance in much the way noise-canceling headphones cancel out sonic disturbances.

Figure 1 shows waveforms from a sample deployment. The hardware configuration is a 480V 60 Hz 550 kVA UPS supplied with a five percent source impedance 600 kVA three-wire feed. The load is 100 kVA of six-pulse rectified nonlinear load plus 175 kVA of 0.7 of resistive load. There is no voltage distortion provided by the source, so the only observed voltage distortion is the distortion reflected by the load itself.

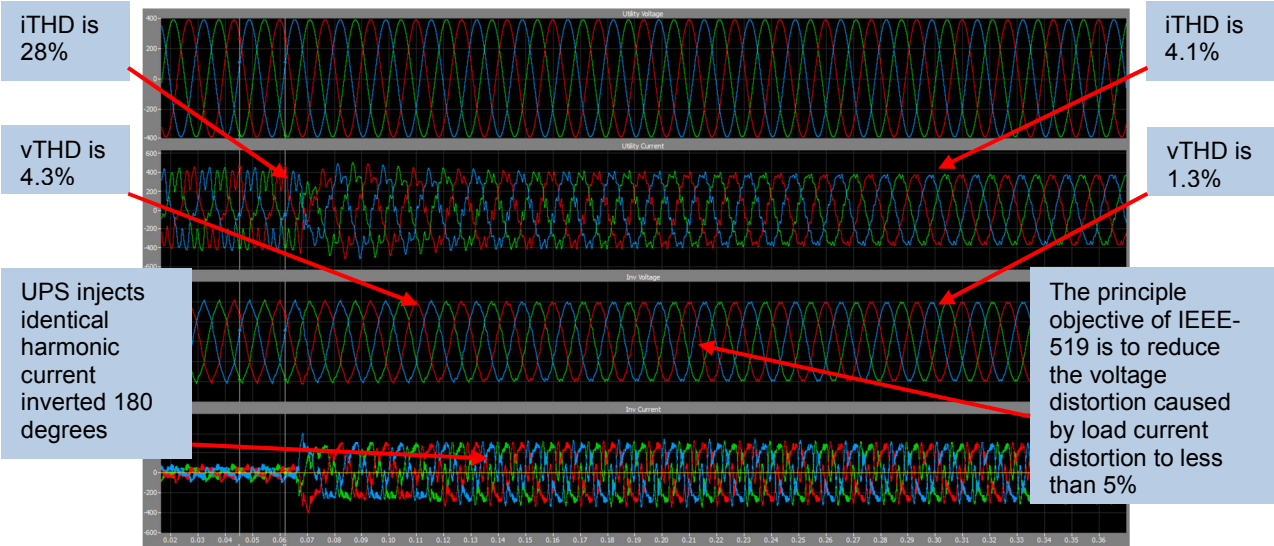


Figure 1. Sample effects of ESS Plus on a waveform with harmonic distortion.

Conclusion

Thanks to its built-in ESS and HRS technologies, the 9395 UPS enables data center operators to collect the rewards of energy saver operation without suffering the potentially negative effects and cost of harmonic distortion and low power factor. Harmonics aren't a problem at all data centers, but facilities with "harmonic-rich" loads can now maximize UPS energy efficiency and mitigate the harmful effects of harmonics simultaneously.

About Eaton

Eaton's electrical business is a global leader with expertise in power distribution and circuit protection; backup power protection; control and automation; lighting and security; structural solutions and wiring devices; solutions for harsh and hazardous environments; and engineering services. Eaton is positioned through its global solutions to answer today's most critical electrical power management challenges.

Eaton is a power management company providing energy-efficient solutions that help our customers effectively manage electrical, hydraulic and mechanical power. A global technology leader, Eaton acquired Cooper Industries plc in November 2012. The 2012 revenue of the combined companies was \$21.8 billion on a pro forma basis. Eaton has approximately 102,000 employees and sells products to customers in more than 175 countries. For more information, visit www.eaton.com.