Leading Consulting Engineers Discuss Power Factor, Real Power, and UPS Overload

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Executive Summary

The purpose of this paper is to document expert opinions from leading consulting engineers regarding various power trends that are occurring in the IT industry.

Computer Power Requirements are Changing, Traditional UPS Designs Haven't

Over the past several years, electrical requirements of computer systems have changed—dramatically. Unfortunately for consulting engineers, computer users and facility engineers, many UPS system designs have not kept pace with these changes.

"The overall power factor requirements of computers today is exceeding 95, 96, even 97%, which is very high," says Peter Gross, Executive Principal and Managing Director for Mission Critical Facilities for Los Angeles and New York-based EYP. "This is almost entirely distortion power factor and very little displacement power factor. It's almost a unity power factor, as opposed to years ago when the power factor was typically .85, .86, .87."

John Stapleton, Associate at the New York City-headquartered JB&B, agrees. "Computer loads have gone up from a .8 power factor rating in recent years," he says. "I think on average now we see .92 power factor-type loads."

"Almost every new computer design today requires a unity power factor, except for some of the very small PCs," adds Al Kesterson, Principal of Boca Raton, Florida-based Kamm Consulting, an electrical/mechanical consulting firm.

Overload Potential for Outdated UPS Technologies

"A UPS is extremely unforgiving of overload," says Michael Fluegeman, Senior Project Engineer in the Los Angeles office of New York City-headquartered Syska & Hennessy. "Unlike most equipment in a data or telecommunications center, circuit breakers, transformers, wiring and especially air conditioning systems, if you overload those systems, you may trigger alarms, but you are likely to have time to deal with the problem. "If you overload a transformer, it emits more noise, it gets a little hotter, but it doesn't break, it doesn't shut itself down, at least not right away. If you overload a UPS, especially one with a double conversion design, it shuts down. It may stay on utility bypass until someone notices and corrects the problem. In the meantime, critical computing systems have no protection, no battery backup. UPS systems are very unforgiving of overload."

Fluegeman advises computer users and their consultants: "If a UPS becomes more than 90% loaded in today's dynamic computer operations, then most installed UPS systems may be in jeopardy of overloading."

kW vs. kVA – Understanding the Importance of Real Power

Kilowatts (kW) are a measure of the real power drawn by the equipment, whereas kilo volt-amps (kVA) are a measure of "apparent" power. For an easy analogy, think of a glass of draft root beer. The liquid portion is the drinkable part or "real" component, akin to the kW. The foam plus the liquid comprise the sum total, or the kVA. If a root beer is very carefully poured to result in all liquid and no foam, the drinkable portion is the entire glass of root beer (kW=kVA). In this case, the ratio of kW to kVA, known as the power factor, would be 1.0, or unity power factor.

Herein lies the crux of the problem: while computer loads have been approaching unity power factor in recent years, many UPS systems are still being manufactured with .8 or .9 power factor ratings, with some as low as .66. To complicate the issue, many UPS manufacturers market kVA as the more important capacity measurement to users and consultants who may not be keenly aware of the effects of changing computer power requirements.

"When someone buys a 100 kVA UPS designed with a .8 power factor, in reality he is buying the equivalent of an 80 kVA UPS that has unity power factor rating," says Gross. "They pay for a 100 kVA UPS, but in reality, with the load approaching unity power factor, they only get an 80 kVA system, only 80% of the UPS capacity they thought they were buying."

This isn't a simple matter of wasting the company's money, as Gross explains. It can be very dangerous if users and consultants don't understand this concept because there is a risk of overloading the UPS. It is more likely to exceed the KW rating than the kVA rating. When this happens, the UPS will need to transfer to bypass. That puts the computer load at risk.

"UPSs are designed to operate below both the kVA and the kW ratings," he says. "It's a kW overload that generates conditions for overheating the UPS. When you exceed the kW rating, you are going into a turmoil condition. Critical UPS components and assemblies can overheat and begin to degrade."

If users not familiar with this issue solely focus on UPS kVA nameplate capacity ratings, they run the risk of purchasing a UPS system that won't be able to deliver reliable UPS power, particularly as a displacement power factor rated UPS is loaded to more than 90%—even if only temporarily.

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"The reality is you're in less danger of inadvertently overloading an APC box than other designs because of the unity power factor that it can deliver," says Fluegeman. "Everyone would like to have a capacity buffer of 20-25%, but with a UPS other than APC, the UPS may not be telling you that it is as close to being overloaded as it really is."

"It's not that kVA is an unimportant rating, since it has crucial implications for wire, transformer and circuit breaker sizing, but it's not as reflective of a UPS's operational 'load limiting factor," says Fluegeman. "The kW rating typically is."

"You want to hit both limits—kW and kVA—at the same time, and APC's Delta Conversion technology design allows you to do that. With other UPS designs, you're going to max out on kW before you even get close to reaching maximum kVA. With APC's design, because kW and kVA capacities are equal, you have a far more accurate indication of the actual loading of the UPS," Fluegeman adds.

APC's Delta Conversion's Edge Over Outdated Double Conversion Designs

Fueled by double conversion UPS manufacturers, disagreement has emerged with some in the consulting engineering community as to whether Delta Conversion UPS designs are "true online" systems.

"APC's technology is absolutely online," Kesterson confirms. "There's no question about it. The fact that it's Delta Conversion doesn't change a thing."

"Legacy" UPS systems use 30-year-old double conversion technologies, which convert utility power twice (AC to DC from the utility and DC to AC to the critical load). State-of-the-art Delta Conversion technology eliminates this double conversion while providing output unity power—a significant advantage over legacy UPS systems.

Delta Conversion technology offers users and consultants other advantages:

- Installation costs are much lower than those associated with double conversion, which requires oversized generators and supplementary distortion filters to cope with the current harmonic distortion and even oversizing of the UPS itself to handle the increasing power factor of new computer loads.
- Less energy is lost and less heat is dissipated (meaning lower air conditioning costs).
- With unity power factor, Delta Conversion gives you a true measure of the real power—the real capacity—of your UPS.

The Cost of Making Double Conversion Systems do What Delta Conversion Already Does

"All the major manufacturers could build UPSs with capacity ratings like APC," says Fluegeman. "They could and they probably will…in time. But the reason they are still rated at .7, .8, .9—rather than unity— is that computer loads in the past pulled a lower power factor rating. At the same time, most engineers vastly oversized the UPS relative to the user's load anyway, which meant UPS manufacturers weren't compelled to improve their designs. Now that computer power factor requirements are approaching unity, it makes sense that the UPS power factor ratings should be higher as well. I think other UPS manufacturers haven't gotten around to adjusting to that."

"There is a lot of work being done to bring power factor ratings up," says Gross, "but it's not easy. To move a box from .8 to .9, you have to find ways to dissipate 10% additional heat, which is not easy. You have to oversize the rectifier and other internal components. The IGBTs or SCRs may also need to be larger. It's a lot of work—and a lot of money."

Kesterson agrees: "Would I like to see the bar raised to higher power factor-rated UPSs? Absolutely. But costs go up when you do that. When you're talking about improving double conversion UPS technology, you're talking about increased costs because you have to deliver more real watts and it takes more of everything to do that."

"The other manufacturers are going to have to redesign and bring their power factor ratings up," Fluegeman asserts. "Or they are going to simply have to lower the kVA rating of the same box because with today's new computer loads kVA isn't as important anymore. As computer manufacturers continue the trend to power factor-corrected loads, it will continue to bode well for Delta Conversion technologies like APC's."

Oversizing UPS Systems – A Design Option That Costs Users More Money

Before Delta Conversion technology, the only thing a prudent engineer or user could do was compensate—or overcompensate—for the disparity between newer power factor-corrected computers and older double conversion UPS technologies with costly overdesign of UPS systems.

"Engineers are always going to design very conservatively to have a cushion. For fast-growing companies, like technology or dot-com companies, for example, it's easy for a UPS to reach a load condition of 90% or higher. When that happens the UPS is maxed out," Fluegeman cautions.

"If users gave us candid answers to what their UPS needs are, there would be no problem," adds Stapleton. "What we wind up doing, however, or what people wind up causing, is wasting their organizations a lot of

money because everyone is piling on load numbers. Most people will deny that, but I see it and I can certainly take you to sites where it happens."

Dynamic Computer Room Environments Create Potential for Overload

"What you have today is a mix of old and new computer technology, which eases the problem some," says Stapleton. "But once a user puts a new installation in and the computer systems change over to the better, more efficient, power factor-corrected supplies of today, then obviously the potential for problems increases."

Most users with dynamic computer environments are going to be desperately trying to upsize their UPS capabilities "because they know the danger they're getting into," Fluegeman adds. "The person in charge of UPS reliability is challenged to deal with the entire infrastructure: the switchboard, circuit breakers and upgraded utility service, to name a few. Those upgrades could take months. Until those upgrades are made, the computers keep coming in and the watts keep going up, so they have to rush to get the new UPS upgrades done before they overload the old one. And we all know what happens when people are in a rush."

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Even in a company that isn't growing by leaps and bounds, changes and upgrades to computer and server hardware can occur on a daily, hourly and even minute-by-minute basis. Computers don't run at a constant speed or constant load draw. A computer's electrical appetite varies depending on how many users are logged on and the nature of their work.

"While 99% percent of the time computers operate at a relatively constant load," Fluegeman says, "if you happen to get a room full of computers or servers that are all going full blast at the same time or you're upgrading hardware, loads may increase and a marginally-sized UPS can overload just when you need it the most."

Advice for Consulting Engineers and UPS Users

"Engineers who know their stuff know they have to pay more attention to kilowatts," says Fluegeman.

And those engineers have a responsibility to bring that knowledge to their clients. "The reality is that most people who are making decisions on UPSs, especially in the range of 50-500 kVA, don't have a full

comprehension and tend to get misled and start looking at the kVA number when that's not the most important number to look at. They should be looking at kilowatts."

"In the past when you had a load of 400 kVA, a 450 kVA UPS was sufficient," says Gross. "That's not sufficient anymore. You need to look at the kW rating of the machine compared to the load."

If an engineer does not have a lot of experience with UPS systems or does not have a reference point based on the company's UPS needs in its existing facilities, Stapleton advises the consultant to "pick a unity system."

"You don't know what the power supplies are in a lot of systems," Kesterson adds. "The unity power solution eliminates a lot of potential problems where you can't find out what the loads are. It greatly simplifies things for a consulting engineer or facilities engineer who doesn't have a tremendous amount of experience with computer loading issues. No question about that."

Simplifying the Issue for End Users and Engineers – Select Unity Power Factor UPS Systems

"You have an awful lot of people coming into the market today who don't have vast experience with UPSs, but they're buying UPSs," says Kesterson. "They are not familiar with the requirements. A unity power factor output eliminates all those concerns. Unity power factor eliminates the need for a complete understanding of what you're dealing with."

"Operating at unity power factor is so important," says Gross. "If users and engineers don't understand that, they are going to run into problems. APC should be commended for addressing these issues.

"When all other factors are equal, unity power factor gives APC an edge over the competition. There is no question that it represents a major advantage for APC."

Stapleton is unequivocal: "The ultimate solution is just select a UPS with unity power factor."