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Reliable Electrical Services for Critical Data Systems

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How long can you hold your breath and still answer questions? That's what it feels like to run a critical data system without a reliable electrical supply.

A reliable source of electricity is fundamental to maintaining data systems in critical environments around the clock. These critical data system environments are typically found in data centers, hospitals, banking facilities, call centers or Internet service providers. Proper design and specification of both the standby generator and the uninterruptible power supply (UPS) components are essential, and will ensure the desired level of power quality and system uptime and availability.

A UPS is typically the link between the power supply (utility source or standby generator) and the critical data equipment. The function of a UPS is to prevent undesirable characteristics of the power supply from affecting the critical data infrastructure. These undesirable power characteristics include harmonics, blackouts, sags, outages, surges, brownouts and transients.

Several types of UPS systems can be utilized including off line UPS systems and online double conversion UPS systems.

(Continued on page 10)

President's Message, page 3
Election Results, page 4
Follow the Money: Accelerate Adoption of the MasterFormat™, page 6
Telecom in Ten Winners, page 13
New Courses, Class Updates, page 18

Reliable Electrical Services for Critical Data Systems

(continued from page 1)

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Off Line UPS System

With an off line UPS system, the voltage sensing transfer switch will alter positions, and the battery powered inverter turns on to supply power to the critical data equipment only after a loss of voltage from the utility or generator. When power is available from the utility or standby generator, the batteries are charged (see Figure 1.)

Switchover time refers to the interval required for the UPS to switch to the inverter. The time required for the inverter to turn on varies with each UPS unit. Actual switching time will differ, but some server developers indicate that their power supplies can withstand a switchover time of up to 100 ms. The ITI (CBEMA) curve indicates that switch mode power supplies must withstand zero voltage for up to 20 ms. Some off line UPS systems indicate a transfer time to battery/ inverter of about 4 ms (¼ of a cycle). The 4 ms time is within the (ITI) CBEMA curve (see Figure 2).

Because critical data equipment connected to an off line UPS is usually connected directly to the power supply (utility or standby generator), off line UPS systems provide inadequate protection from frequency variations, line spikes, line noise, and sags or brownouts.

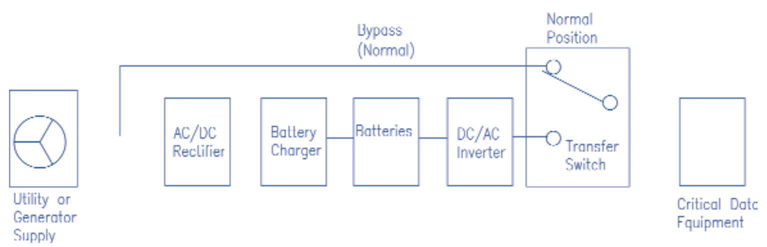

Figure1. *The diagram illustrates an off line UPS system. During a standard condition, current moves through the bypass switch around the rectifier, battery charger, battery and the inverter. When the voltage falls below a preset point, the UPS will switch to battery/ inverter operation. During typical operating conditions, there is no electrical separation from the power supply and the critical data equipment. Power system anomalies can flow straight to the critical servers.*

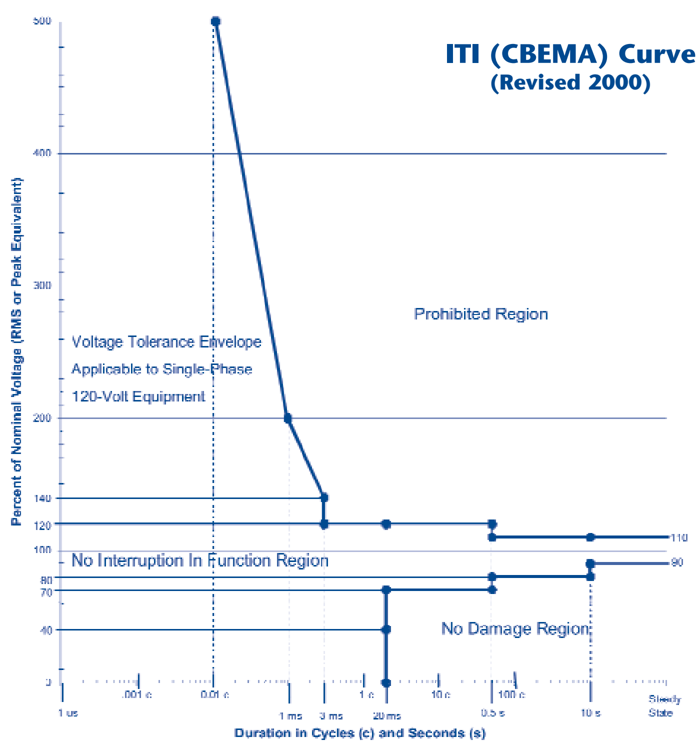

Figure2. *The ITI (Information Technology Industry Council) CBEMA (Computer Business Equipment Manufacturers Association) Curve indicates that a ½ cycle (8 ms) of zero voltage is acceptable for sensitive electronic equipment. This diagram was established in the 1978 as a susceptibility curve for power supply engineers and manufacturers. This curve has subsequently been updated in 2000 to indicate a tolerance of a 20 ms of zero voltage.*

Online Double Conversion UPS Systems

Online double conversion UPS systems are typically utilized in critical systems where availability is essential for operations and economic feasibility. These systems offer the maximum level of power quality protection for the majority of critical environments. Double conversion UPS systems provide protection and electrical isolation from all types of power problems including frequency variation, switching transients, power surges, high voltage spikes, power sags, electrical line noise, brownouts and blackouts.

These UPS systems modify the incoming alternating current (AC) power into direct current (DC) power through a rectifier and inverts the power back to regulated AC power through an inverter. This double conversion (AC to DC to AC) continuously supplies conditioned power to the critical data equipment and provides protection from power outages. The batteries on the DC bus are float charged when in normal operation.

Increased cost, power consumption from the losses in the rectifier and inverter and heat production are the negative issues involved with double conversion UPS systems.

It has been my experience that a majority of power outages in critical environments are caused

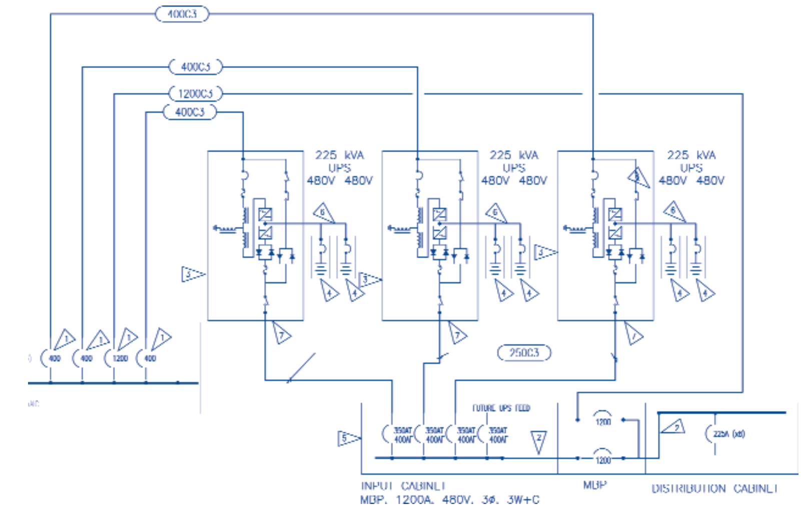

Figure 3. *This diagram illustrates three paralleled UPS modules with both internal static switch and external maintenance bypass. If the data infrastructure can be served with two of the UPS modules, this system represents N+1 redundancy.*

by interruptions between the UPS and the critical data equipment. A UPS system with redundant modules coupled together through a static switch that allows for seamless bypass to utility power can provide a considerable increase in system reliability. If the system is designed to be N+1 redundant, a failure of a single UPS module will not affect the critical data equipment (see Figure 3).

Some critical system designs will utilize a dual bus UPS system downstream of standby generators to provide a redundant UPS supply. In a topology utilizing static transfer switches between UPS systems and 120/208 volt transformers, out of phase transferring can cause residual magnetization in a transformer's core at the time of transfer. Electrical syncing between UPS modules in a dual bus topology is essential to maintain system uptime. Leftover magnetization from an out-of-phase transfer can intensify a transformer inrush problem and produce a significant inrush current. This inrush current can cause a UPS to shutdown when in battery mode or at least produce a voltage distortion. Properly locating critical pieces of electrical distribution equipment is vital.

Generator sets have an important function in the reliability of electrical distribution systems used in critical environments. Standby generators can supply life safety equipment as well as optional loads as illustrated in the *National Electrical Code®* *(NEC®)*, Article 700. Generators can be paralleled together for capacity or redundancy. Additionally, generators can be paralleled together to the utility source in either a closed transition (make before break) or an open transition (break before make) scenario.

Tiered Classifications

Critical electrical systems can be described using tiered classifications developed by the Uptime Institute. See http://www.upsite.com/TUIpages/whitepapers/tuitiers.html for more information on the tiered classification of critical environments.

In this classification, Tier 4 is the most sophisticated, offers the most uptime, reliability and redundancy and is the most expensive. Tier 1 is the simplest and provides the minimum amount of reliability, redundancy and uptime. Tier 1 or 2 is utilized for simple small data centers or server rooms. Banking and financial data centers and Internet service providers are typically Tier 3 or 4 because they are necessary for service continuity and availability and must have a higher level of redundancy and reliability. With the deployment of the Tier 3 and 4 critical environment in 1985 and 1995, engineers were utilizing generator paralleling systems to increase the redundancy of the generators to N+1 and greater as necessary for these higher tiered critical environments.

Paralleled Systems

An electrical distribution can provide the required redundancy from the generator system through conventional automatic transfer switches (ATS) and the

Figure 4. *This photo depicts a closed transition utility and generator paralleling switchgear control panel. The system can incorporate up to two medium voltage utility feeders and several medium voltage large kW generators. The paralleling gear also contains all control functions including system load analysis, generator starting, generator shedding based on actual load, generator use rotation, load shed if more than the redundant generator fails as well as other control functions.*

application of downstream dual cord servers or with the use of a closed transition paralleled utility and generator system. A paralleled system can offer many advantages with regard to total redundancy, maintenance, load bank testing and soft retransfer, and can allow for multiple utility feeders.

By paralleling two smaller generators to serve the load that a larger generator would serve, paralleling switchgear can be utilized to provide added generator capacity. This arrangement is called isolated bus, and does not incorporate the utility feeder into the system. The generator distribution is connected to the utility power downstream at an ATS.

Closed transition paralleled generator systems can provide a number of advantages, particularly for large and high power systems (see Figure 4). There is a reasonable apprehension in the industry with regard to the single point of failure that the utility and generator closed transition paralleling gear can produce. This concern can be minimized by providing a tie breaker between generator systems that will permit one of the generator systems paralleling switchboards to feed through the other generator systems paralleling switchboard in the occurrence of a single generator system switchboard failure.

Additionally, there is typically added cost involved in the engineering/design and extra relay protection that is often necessary when utilizing a closed transition paralleling system.

Studies have indicated that 70% or more of the outages in critical environments are the result of human error. Electrical system commissioning and training of maintenance personnel is an important element in achieving maximum system availability. It is imperative to verify that the complete standby electrical distribution system functions properly as a whole. As electrical distribution systems get more sophisticated, the commissioning process becomes more important. Many functions of the standby system controls must be accurately set during startup commissioning. The commissioning agent or the engineer of record must determine these settings. Most high end ATSs have multiple time settings which may include; exercise clock, time delay start, time delay transfer, time delay retransfer, program transition and time delay cool down. Many of the settings will be specific to an installation. Other parameters such as size and number of motors in the distribution system, reliability of the utility service and exercise requirements will all play a part into the actual settings of a specific ATS. Additionally, generator paralleling systems utilized in critical environments can have a much more sophisticated operation that requires greater expertise and knowledge for long term reliable operation.

Proper engineering of the electrical systems serving critical environments is required to ensure system reliability. The UPS and standby generator systems are key components in these critical electrical systems. Many potential combinations of these components can be engineered, but an experienced team will help guide the owner to the right combination of system reliability and cost, and will reduce the risk of miss applications and gaps in the electrical design. ■

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