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## Spring 2004

Due to the continued increase in capabilities of computers, we are finding that very critical operations are being housed in non-hardened buildings. What is more troubling is that in many instances the owner is not aware that the facility housing these operations is not properly designed. Some of these data centers with a very small footprint have sufficient computing capability for managing the entire operation of a company including all business functions, accounts payable, accounts receivable, payroll, internet access, web hosting, inventory control, point-of-sale interface and manufacturing resource planning. We have performed numerous failure analyses on small data centers of this type and found that the original design team did not apply mission critical design concepts. If the desire is to have a mission critical operation, it must receive special attention during the design process to insure that it meets the owner's "Business Objective".

## Third Party Review

by Leo P. Soucy, Jr., P.E.

Based on our extensive experience in the design of mission critical facilities, **FEA** has been asked numerous times to provide "third party review" of a proposed design to insure that it meets the requirements necessary for a mission critical facility. While we totally endorse design review, we are reluctant to provide this service as we have had problems in the past and we feel it could compromise the project.

First, I must explain this concept. Normally, if a client wants "Third Party Review" of a mission critical project, he wants to commission a design firm with no mission critical design experience and have it reviewed by a design firm knowledgeable in mission critical design concepts. The hope is that any design deficiencies will be identified and corrected by the knowledgeable mission critical design firm.

Unfortunately, "Third Party Review" by a design firm experienced in mission critical design puts the owner in a difficult position. It has let the primary design engineer know that they are not totally responsible for all aspects of the project as there is a third party responsible for review of portions of the project. The primary design professional does not know the necessary design concepts and may feel that he can be lax in these areas as the third party engineer is essentially responsible for identifying any design deficiencies. In this arrangement, the third party engineer is not responsible for the detailed engineering

aspects of the design so they cannot be held liable and may request a "no liability" clause relieving them of any responsibility for the system design. As you can see, this becomes a very convoluted arrangement with the owner having the potential of getting an inferior design with no recourse to either party.

On one project a client made certain assumptions that were incorrect, much to his detriment. It was assumed that **FEA**, as the third party mission critical design review professional, was providing in-depth design review rather than review of the overall design concept. The Agreement between **FEA** and the client had a "no liability" clause and a requirement that the owner request in writing if he wanted **FEA** to provide detailed design review of specific design features. We included this provision as we were concerned that we might get caught in the middle if there were problems. There were problems with aspects of the mission critical detail design that resulted in costing the client \$1.5 million to upgrade that portion of the system to provide true 7x24xForever capability. There were also detailed engineering design issues that resulted in system capacities being grossly inadequate which resulted in an \$8 million add to the project.

The bottom line is that if 7x24 design is required, it is in the client's best interest to hire a mission critical design firm that is thoroughly familiar with mission critical design. For information on selecting a competent 7x24 design firm, please refer to our Fall 2002 article "Choosing a Mission Critical Design Firm".

## Transformer Inrush - STS and UPS Systems

By Rafiq G. Bulsara, P.E.

In our Spring 2003 newsletter we discussed the pros and cons of the STS (Static Transfer Switch) being on the primary side or the secondary side of the PDU (Power Distribution Unit) transformers. This article discusses additional interesting facts and developments that are based on experiences we have had and testing we recently witnessed. Keeping the STS on the secondary side of the PDU transformer alleviates most problems caused by the transformer inrush (magnetizing) currents even though it is more expensive than the STS being on the primary side of the transformer.

A common belief in the case of an STS being on the primary side of transformers is that if the two sources to the STS inputs are in sync with each other, there will be no inrush currents caused when the STS transfers from one source to another. This, however, is not always true as we observed during testing of an STS feeding two transformers. During the test, one of the sources was the utility supply and the other source was generator power. When both sources were available and both were 'good' (within acceptable voltage and frequency range) and a manual transfer was initiated, the output voltage appeared virtually seamless and there was observed no inrush current. However, when one of the sources was abruptly turned off and even if the automatic transfer occurred within  $\frac{1}{4}$  cycle to  $\frac{1}{2}$  cycle (4ms to 8 ms) there was significant inrush current observed. We also performed several out-of-phase transfers and it was interesting to find that transfers at 60 degrees out of phase created far

greater inrush currents than those with 180 degrees out of phase transfers. Also 15 degrees out of phase transfers, a normally accepted window, caused significant inrush currents. This is because the magnitude of inrush current depends greatly on at which instant the voltage is re-applied after the original voltage is taken away and not as much on the phase angle difference.

Among other factors such as size, core material properties, transformer construction and source impedance, the moment at which the voltage is re-applied and the sign and value of the residual flux, etc., play very important roles in determining the resultant inrush current. The highest value of inrush (magnetizing) current occurs when the transformer is switched at zero transition of the winding voltage and when the new forced flux assumes the same direction as the flux left in the core from previous energization.

This is not a new revelation to the people in the know but it is not well understood by all data center users and consulting engineers. In fact, there are special purpose relays in use that deal with the inrush current issues in high voltage power transformers in utility power systems. It is interesting to note that more than one STS manufacturer is working on perfecting an algorithm in the STS logic that will calculate the time delay based on the phase angle difference and instant of loss of primary source and applying the alternate source voltage at such an 'instant' that it will virtually eliminate or drastically minimize the inrush.

Some beta type testing showed that even 60 and 180 degrees out-of-phase transfers with up to 8ms to 12 ms delay (break) did not cause any transformer inrush currents. This would be a very helpful feature to incorporate in mission critical power system designs using STSs and

UPSs.

Static UPS systems, being a weak source of power, do not handle heavy transformer inrush well. Although they are designed to go to static bypass upon seeing a large load current, they do not transfer to the bypass cleanly all the time. We have seen cases of inverter fuses being blown when a UPS transferred to the static bypass due to heavy inrush currents and the UPS output voltage sagging beyond acceptable levels for the STS input. In some cases where the STS is connected between two separate UPS outputs (2N design), the deterioration of a UPS output during such transients has caused the STS to transfer to the alternate UPS source, simply causing the alternate UPS also to fail and in the process dropping the critical load. An STS would 'ungate' (turning off SCRs and the output) when it sees both sources out of acceptable parameters.

Inrush can also occur upon reenergizing of the PDUs after a catastrophic power outage to the PDUs. In order to minimize the impact of inrush currents on the UPSs, many users choose to automatically open (shunt trip) the PDU main breakers upon a power loss and sequentially reenergize them manually when the power is restored. Some users see the shunt trips as a source of nuisance trips and do not choose this method. The power system design and user's objective play important roles in the final strategy.

## Meeting of the New York Chapter 7x24 Exchange

By William H. Flaherty, Jr., P.E.

In late February, **FEA** attended a meeting hosted by the New York Chapter of the 7x24 Exchange held in New York City. The meeting was

well attended with approximately 125 people representing consulting engineers, manufacturers representatives, IT professionals, facilities planners and facility operators. An excellent program covering various aspects of cooling high density IT loads was presented. We thought it would be interesting to our readers to pass along some of the information presented in the hope that it will foster further thought and increased awareness of problems and some solutions being used to handle high density IT cooling loads.

A highlight of the meeting was a discussion of the new ASHRAE Standard "Thermal Guidelines for Data Processing Environments". This standard is available from ASHRAE and is a must read for anyone involved in cooling IT spaces. It is the first attempt at standardizing many of the principles of cooling IT equipment such as hot and cold aisles, cooling issues when using a raised floor, standardization of inlet and outlet air flow from IT equipment, and recommendations for marking of IT equipment concerning BTU output and CFM requirements.

Additional information gleaned from the meeting is as follows:

- ♦ Equipment electrical nameplate ratings are now approaching the actual thermal output, i.e. nameplate watts are closely equal to heat when converted to BTUs.
- ♦ Watts per sq.ft. is becoming an irrelevant term. Watts per cabinet is a better design parameter.
- ♦ When cooling high density loads with a raised floor, it may be advisable to power the fans of the cooling equipment with UPS power. This technique could allow the system to take advantage of any thermal mass under the raised floor and lessen the spiking of aisle temperature while

generators are coming on line.

- ♦ It is important to seal all openings in raised floors that are not necessary for cooling. This increases static pressure below the floor and allows air to flow from the perforated floor tiles to where cooling is needed.
- ♦ As loads increase above 3.0 kW per cabinet, special cabinets are advisable which provide internal fans to direct air through the equipment or other means to cool these concentrated loads. This entails close cooperation between IT, equipment manufacturers, facilities personnel and engineers.
- ♦ It is a good idea to distribute 3-phase power to all cabinets. As the kW per cabinet increases, having enough power is becoming a problem.
- ♦ Increasing the load density of a data center does not necessarily mean reduced construction cost. As load density increases, the equipment needed to cool the high density loads increases in cost beyond square foot construction costs.
- ♦ Savings in cost of data center ownership are more likely to be realized in the reduction of electrical energy rather than smaller footprints.
- ♦ As load density increases and proper airflow becomes a critical factor, it is increasingly important to use computer modeling or Computational Fluid Dynamics (CFD) techniques to study airflow before committing to a final design.

The above information is offered as "food for thought". **FEA** would like to thank the 7x24 Exchange for providing a forum for the discussion of these issues. We welcome the opportunity to discuss these issues and others, as needed, with clients and potential clients.

## Food for Thought

Just to give you an idea of the challenge facing anyone trying to design, construct and operate a mission critical facility, the following is very humbling.

NASA, which is the premier mission critical operation, recently issued a contract for replacement of gears in the space shuttle braking system. The contract was issued because the gears showed signs of corrosion as they had been installed backwards. This condition has existed since 1981!!!!

### Policy

**designPLUS Newsletter** is published to keep the readers current with the latest trends in mission critical systems.

### Correspondence

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