POWER QUALITY INTERNATIONAL
2404 Merchant Avenue | Odessa, FL 33556

POWER QUALITY INTERNATIONAL

CASE STUDY

GTEC Corporation

Austin, TX

+ Linear Switch-Mode Power Supplies

Phase-to-phase connected, linear switch-mode power supplies, as typically found in blade-servers, are currently being supplied at 208-volts by conventional or K-Rated distribution transformers. However, virtually all switch-mode power supplies have nominal voltage ratings of 120V and 240V, with automatic switching to accommodate either possibility. Supplying switch-mode power supplies at less than their nominal voltage will normally increase their losses, reduce their efficiency, contribute to heating within the rack and increase operating costs. This is corroborated by manufacturers' published specifications, which include their efficiencies at various voltages, within their products' bandwidths, and at various loadings.

Switch-mode power supplies, in their active mode, have efficiency ratings between 60% and 75%. These efficiencies assume the devices are supplied at their nominal voltage ratings. Since virtually all switch-mode power supplies are rated 240-volts, supplying them at 208-volts will typically increase their load current by 15.4% and their I2R losses by 33.2%. This increase in losses will produce a matching increase in heat and decrease in efficiency. To confirm our calculations and preliminary 'in-house' test results, we were able to arrange for a 'beta site' at a GTECH Corporation facility.

Our test method was as follows:

1. The assigned equipment rack was reconnected to a three-phase, three-wire variable autotransformer. The transformer's output was set at 208-volts, the voltage level normally supplying the rack. With the equipment rack's internal temperature stabilized, a complete set of power measurements, including harmonic profiles, was taken and recorded.
2. On completion of the first test, the variableautotransformer's output was reset to 240-volts. With the equipment rack's internal temperature again stabilized, a new set of measurements was taken and recorded.

These 'beta site' electrical measurements confirmed our earlier calculations and preliminary test results. We understand that the IT loads in large data centers represent almost 50% of the total facility load. We have also been informed that rack cooling represents approximately 35% of the total and that more than 50% of the losses or heat within the rack are generated by the switch-mode power supplies. If these values are even close to reality, a 33.2% reduction in power supply losses and resulting heat would produce a significant financial benefit by reducing rack power and AC loading. This revision should also produce a capital cost reduction. This opportunity may be what Ken Brill, of The Uptime Institute, might call a 'Golden Nugget'.

+ Low Voltage Feeder & Branch Circuits

Operating the feeder and branch circuits at 240-volts will produce similar load current and I2R loss reductions. Although most of these circuits are outside the rack enclosures, power and AC loads would be reduced.

+ Voltage-Related Transformer Losses

If a transformer's secondary voltage is increased from 208-volts to 240-volts, the secondary current will be reduced by 13.4%.

$$I_{240} = 0.866\ I208$$

If the voltage is increased, the resistance of the secondary winding will increase due to an increase in the number of turns and the lower cross section of the conductor. The load losses in the secondary winding will decrease by the same ratio as the decrease in current.

$$P_{240} = 0.866\ P208$$

Similarly, it has been proposed that 480-volt levels, throughout the distribution system be elevated to 575-volts. With respect to the transformer, the benefit for the transformer's primary winding would be similar:

$$I_{575} = 0.834\ I480 \text{ and } P575 = 0.834\ P480$$

Increasing the primary and secondary voltages, as proposed, would decrease the transformer's losses by approximately 15%.

+ Transformer Efficiency

Much has already been presented regarding transformer losses and their measurement under linear and nonlinear loading. With the means to simultaneously measure excitation and impedance losses or calculate these losses under linear or any nonlinear load condition, PQI has developed Power and Distribution Class transformers for every application, including mission-critical facilities.

All PQI transformers meet or exceed the linear load efficiency requirements of NEMA TP1-2002 and CSA C802.2-00 under linear loading. Our Distribution TransFilter™ harmonic mitigating transformers meet these same efficiency requirements under the most severe nonlinear (≤100% THD_I) load conditions.

Ultra-efficient e-Rated® transformers exceed the efficiency requirements of the US Department of Energy's Candidate Standard Level 3. e-Rated® Distribution TransFilters™ exceed this proposed standard at 100% THD_I nonlinear loading.

All of the foregoing standards require the determination of efficiency at 35% of a transformer's full load rating. This requirement is based on average transformer loading in North America. To be competitive, manufacturers generally optimize their transformers' efficiencies at this load level.

Unlike excitation (no-load) losses, which are constant, impedance (load) losses increase rapidly with loading. As a consequence, the resulting degradation of efficiency may be unacceptable at higher load levels. To maintain energy efficiency, e-Rated® transformers can be optimized for any predicted load level above 35%.

Under no-load or light-load conditions, ultra-low excitation losses will reduce power consumption. This benefit is achieved by using higher quality grain oriented silicon core steel, reducing the number of laminations per group and by using a 'full and step-lap miter-cut core'. An example of this core design is shown above. Unlike a conventional 'buttlap-cut core' or 'scrap-less miter-cut core', the three vertical legs of the 'full and step-lap miter-cut core' are not exposed at the upper surface of the top horizontal laminations.

e-Rated® core and coil designs have been refined to achieve minimum losses and maximum energy efficiency under any specified loading conditions.

+ The Calculation of Financial Benefits

PQI was asked to calculate the benefits associated with the application of its 300kVA e-Rated® Transformers, as compared to the 300kVA transformers that had been specified by the owner of a number of very large missioncritical facilities. For the purpose of this calculation, the facility engineer specified the cost-of-power, the estimated UPS and transformer load levels and efficiencies

+ Conclusion

Supplying phase-to-phase connected 240-volt switch-mode power supplies at their nominal voltage will dramatically reduce their losses and the resultant heat within the server racks. The application of ultra-efficient distribution transformers will always provide an attractive financial benefit, particularly in 7 x 24 operations.