# Informational Document from Harmonics Limited IDHL-11

**Subject: Harmonic Suppression Systems and Voltage Distortion**

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## ESTIMATING MEAN TIME BETWEEN FAILURE (MTBF) FOR HARMONIC SUPPRESSION SYSTEMS

VOLTAGE DISTORTION

"When high levels of non-sinusoidal current flow through building wiring, the voltage at the point of use can be distorted by nonlinear or frequency-dependent drops in voltage." Thus begins a brief sidebar discussion of harmonic voltage and distortion in, PQTN Commentary No. 1, December 1996, published by EPRI Power Electronics Application Center. This discussion points out that high harmonic currents drawn by computer power supplies cause voltage flat-topping at outlets in the system and that voltage distortion may be as much as 10% from this alone.

The chief effect of flat-topping is to reduce ride-through capability of the computer power supply. The effect of this peak lowering on ride through is shown in the article, and illustrations are used to demonstrate the change in ride through time caused by flat- topping, (Monitoring studies of many systems show that a 198 millisecond interruption is statistically most likely.) The conclusion is that a computer, either with or without flat topping will not ride through an outage of this length.

Installation of a Harmonics Limited Harmonic Suppression System (HSS) completely eliminates high 3rd harmonic current flow throughout the distribution system, but causes 3rd harmonic voltage distortion and flat topping of the voltage wave. This distortion, which is exactly the same as that caused by high harmonic currents, can range from 10- 20%. This flat topping similarly reduces ride through time of the power supplies.
Several studies have been carried out to examine the numerical effect of flat-topping on " power supplies.

RIDE THROUGH

PQTN brief No. 11, March 1993, published by the EPRI Power Electronics Application Center, has as its objective, "…to identify and investigate key ride-through performance characteristics of a typical PC switch-mode power supply during typical ac low voltages." A typical computer power supply was investigated using carefully created and controlled low voltage events and outages. "Test events covered a range from 0-120 Vac and from 0.5 to 20 cycles (8-320 ms)."

For a complete power outage, the computer circuit operating voltage remained steady for ~ 7 cycles and then dropped until ~ 10.5 cycles, after which the voltage was too low to sustain operation. The low voltage ride-through time was determined both by the energy storage capacity and the margin of the computer logic circuits to operate at a reduced voltage. For a voltage sag it was

discovered that the PC could operate properly and continuously with a 50% decrease in voltage (60 volts.)

The amount of storage in the capacitors is only one of the parameters that determines ride-through for a computer. The design of the power supply regulators is equally important. Since, “the most common severe low voltages last only 5-10 cycles” it is reasonable to conclude computer power supplies are capable of riding through short outages and many brownouts. Application of an HSS does not significantly change this capability. Recent improvements in power supplies and lower operating voltages for computer logic chips, all accomplished by the industry since *Brief 11* was published twelve years ago, have decreased the likelihood that short voltage outages will cause problems in computer operation.

**ENERGY USE**

*PQTN Brief No. 20, May, 1994, published by the EPRI Power Electronics Applications Center*, has as its objective, “…to characterize the efficiency of a personal computer during 1) nominal conditions, 2) a range of steady-state loading conditions, and 3) unregulated and distorted voltage conditions.” Power supply efficiencies were measured with: voltage varying from 104 to 127 volts; 120 volts with 10% 3rd, 5th, and 7th harmonic distortion; 25 and 60% loading.

The results are tabulated. At the lower voltage limit, 104 volts, the computer power supply efficiency was improved 3.2% at 25% loading and 0.6% at 60% loading.
Efficiencies were decreased slightly at the high voltage limit. Perhaps the most unexpected result was that the maximum increase in efficiency resulted from the introduction of 3rd harmonic distortion. When operated on a distorted voltage containing 10% 3rd harmonic distortion (flat topped) the efficiency improved by 5.6% at 25% loading and by 6.1% at 60% loading.

This result was explained as a function of the relative proportion of real and reactive power drawn by the power supplies. A power supply operating on a flat-topped waveform draws more real power relative to the reactive power and thus is more efficient. Rather than harming the computer power supply, 3rd harmonic voltage distortion seems to improve its operation.

**COMPUTER POWER SUPPLIES**

A modeling study carried out by Professor Alexander Emanuel, Professor of Electrical and Computer Engineering at Worcester Polytechnic Institute and a Fellow of the IEEE, indicates that the lifetime of computer power supplies should be increased by application of an HSS. Reduction in peak current passed by the power supply rectifiers results in lower I2R losses in these rectifiers and peak junction temperatures are lowered. Since the current peak is spread out over time, the ripple voltage on the power supply capacitors is lower and capacitor lifetime should be increased. These effects, coupled with the
reduction of reactive currents shown in PQTN Brief No 20, should result in increased reliability of the computer power supply.

**UPS**

The question arises, “If computers can ride through short (5-10 cycle) outages, why use a UPS?” The

answer, of course, is that 24x7 facilities must also operate during long-period outages caused by distribution system failures. The typical UPS switches to battery in less than 50 milliseconds (~3 cycles) when a power outage is sensed. Thus all computers, whether or not an HSS is installed on the power system, will remain operational on a UPS.

## CONCLUSIONS

Ample independently published evidence exists to show that the application of an HSS has no harmful effects on operation or lifetime of computer power supplies. Further, the slight reduction in ride-through time caused by voltage flat topping, is not significant enough to result in operational problems with computers. Today there are several million computers operating with the benefit of the HSS and there have been no instances reported of power supply failure or ride through problems.

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