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White Paper and Case Study on Data Center application

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Until some time ago, the power quality in the data center is mainly related to the continuous supply of energy to the load. However, with the addition of nonlinear loads in the data center, the power quality is more than "continuous support of electrical power to the load. The power quality in the data center is redefined as, providing a noise-free sinusoidal current and voltage to the load. A data center is not just servers; it requires the support of sophisticated infrastructure that includes a power supply, cooling system, and maintenance. Power supply constitutes UPS, generators, and PDUs. Cooling system and maintenance include fans, motors, chillers and other air movement equipment.

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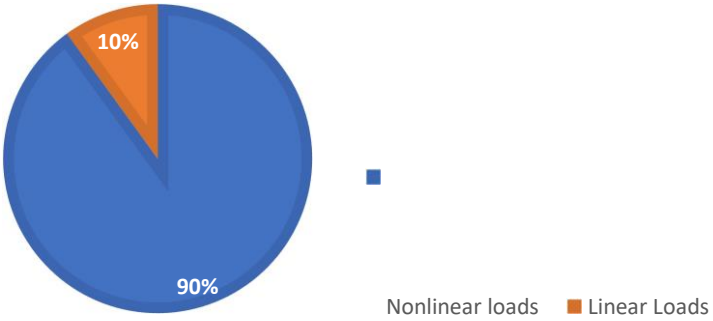
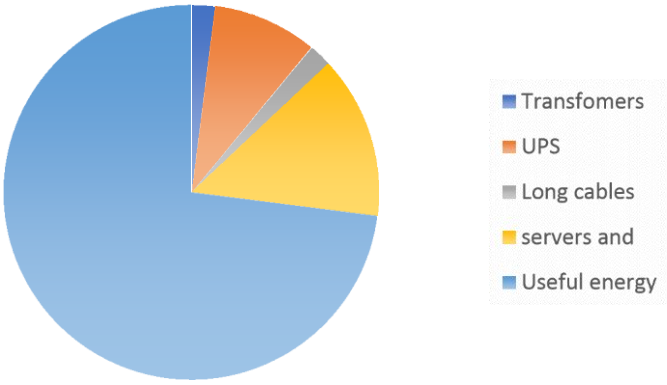
Source of Noise: More than 90% of the electrical load in the data center is nonlinear. Nonlinear loads such as UPS, fluorescent ballasts, servers, PLC, VFDs, the computerized equipment works on the principle of power conversion (AC-DC and then DC- AC). During this process of power conversion, the device must need to generate and draw transients and high-frequency noise (other words, nonsinusoidal waveform) from mains. The compound effect of nonlinear waveforms in the facility will cause significant power quality issues.



Effect of noise: The generated high-frequency noise along with transients could cause detrimental effects on the facility. The transients could puncture holes on the electrolytic capacitors, increase junction temperature of semiconductor devices, increase ohmic losses on motors and transformers, cause improper triggering of FET's and thyristors, and corrupt the data (noise overriding on 5v could false signal 0's and 1's). Thus, the noise causes erratic behavior of the load or reduce meantime between failures (MTBF) and premature failure of the equipment. Electrical noise is also one of the causes for server restarts/reboots.

Electrical noise increases the ohmic losses (heat) in the wire, transformer, and motors. On an average, transformer contributes towards 2% of power losses, UPS about 6-12%, and the wire about 13%. Total power losses in a typical infrastructure can add up to 27%. The generated heat is the biggest enemy towards sensitive electronic equipment such as servers for their operation. Apparently, more energy is used in the form of cooling, to remove the excessive heat in the system.



Cost of the noise: When the noise is not addressed properly in the data center, it could cost the significant amount of capital cost on maintenance and repair/or replacement of the equipment. Data center has costly electronics loads that could not afford down time, due to its nature. The average downtime of data center equipment in the

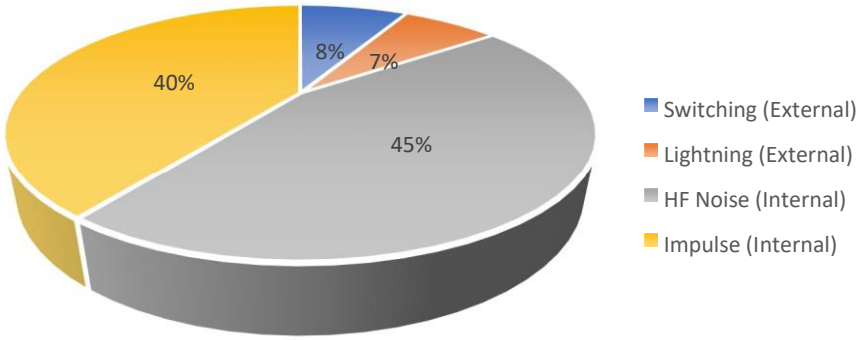
US is 86 minutes, resulting in an average cost per incident of about $690,200. This dollar amount did not include the loss of reputation and confidence.

Excessive heat generated in the data center is one of the most expensive maintenance costs. It is reported that each one degree raised on the thermostat would cost as much as 2% of the air conditioning costs. "10°C – twice law" states that the life of equipment decreases by half for every 100C rise in temperature. Arrhenius law says that failure rate at a temperature below 30°C is very less however at 40°C temperature, the failure rate is 1. It increases 10 times to close to 30 times when the temperature becomes 60°C, and at 80°C, it rapidly increases 100 times to 300 times. Therefore, excessive heat in the system is not only your power bill but also the repair/replacement cost of the expensive equipment.

Abnormal Operation mode: Abnormal operation mode is when the generator and UPS are switched over at mains to supply power for the data center. This Switch over (using ATS – Automatic Transfer Switch) can cause very strong transients which a conventional TVSS cannot suppress. These transients are high-frequency noise that interferes with the normal operation of sensitive equipment such as servers, UPS, data banks, instrumentation and alike. Even transient signal as low as 0.5V is capable of damaging sensitive components by electrical overstress (EOS) per IPC-A-610.

Solution: The electrical noise along with the transients need to be removed from the electrical system to 1) protect the expensive IT equipment 2) decrease the electrical losses in the system 3) increase the life of the equipment. Environmental Potentials, Inc. (EP) manufactures patented waveform correction devices, that is the combination of TVSS and low pass filters. TVSS with inbuilt tank circuit will quickly absorb the voltage transients in the system, while the low pass filter absorbs and remove the higher frequency noise in the system. EP units are widely installed in data centers and have shown significant improvement in power quality.

Conclusion: 85% of the electrical noise is generated inside the facility, while the rest of 15% comes from external sources such as lightning and power grid switching. Therefore, extra attention is needed on electrical equipment used inside the facility, in removing the noise generated by them. An SPD installed at the main entrance of the building, or an isolation transformer is not a perfect solution to remove the internal electrical noise. It is necessarily required to protect all the loads at the sub panel level. There is a myth that UPS is a power quality device – it is not. UPS is an excellent invention to back up the power, but it's a typical nonlinear device, generating the nonlinear waveform in the facility. US data centers consume about 2% of the US total electricity usage and are expected to grow at 4% by 2020. About only 50% of the energy is spent on IT equipment while the rest is consumed by the maintenance of the IT equipment. The Electric Power Research Institute (EPRI) has determined that U.S. businesses lose between $119 billion and $188 billion per year because of poor power quality. Taking all this into account, to protect and improve the efficiency of a data center, each subpanel should be covered with low pass filters that remove the high-frequency noise.



Case Study: Taipei MRT

Taipei MRT – Metro Railway Transit station has a data center that reported frequent failures on their VFD's, excessive heat generation and erratic behavior of their security system. EP performed the complete power quality study on the facility and had examined that the facility encounters severe highfrequency noise on their power line. Two units of EP2500 (waveform correction devices) were installed on the problematic sub panel, and the measurements were taken before and after installing the EP units. Figure 1 and 3 shows the high-frequency noise before the EP units are installed, while Figure 2 and 4 shows the high-frequency noise measurements after the EP units are installed.

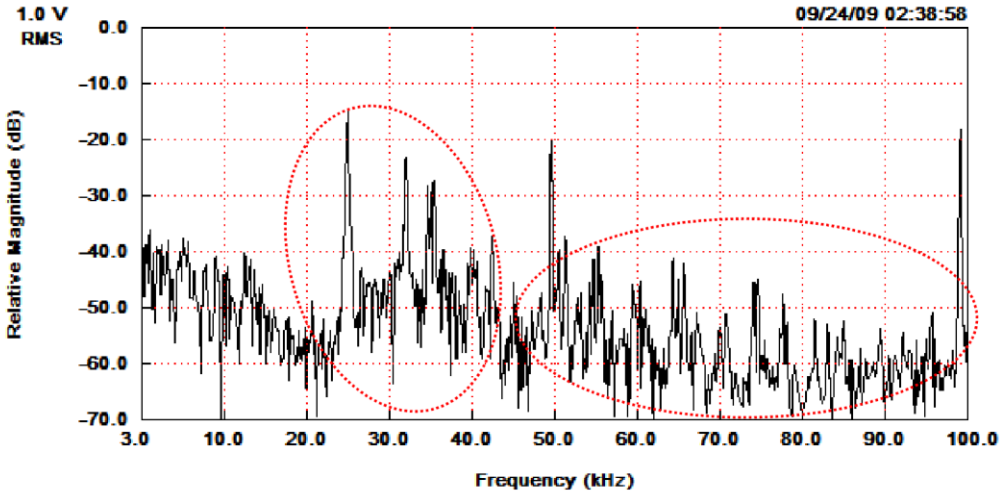


Figure 1: High frequency noise from 3-100kHz between the phases **before** installing the EP units

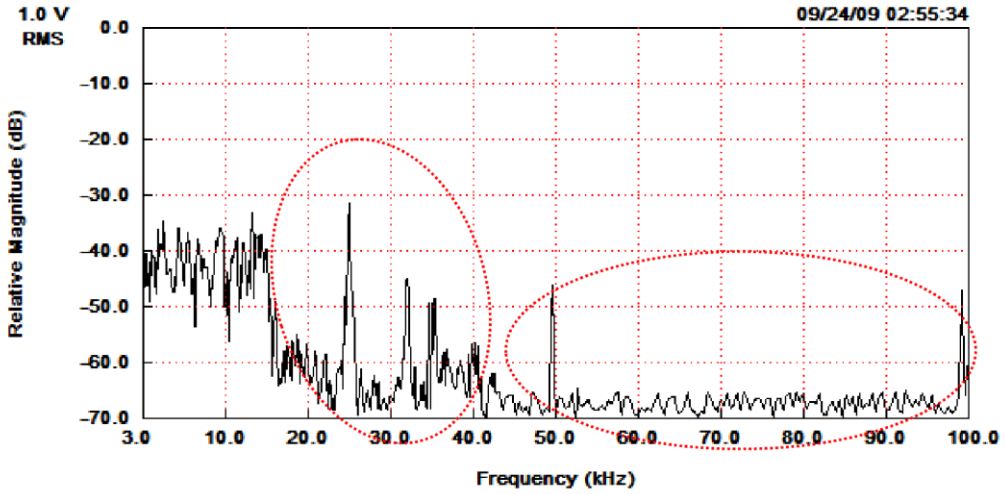


Figure 2: High frequency noise from 3-100kHz between the phases **after** installing the EP units

Similarly, the frequency noise at another subpanel before and after EP installation is shown in Figure 3 and 4.

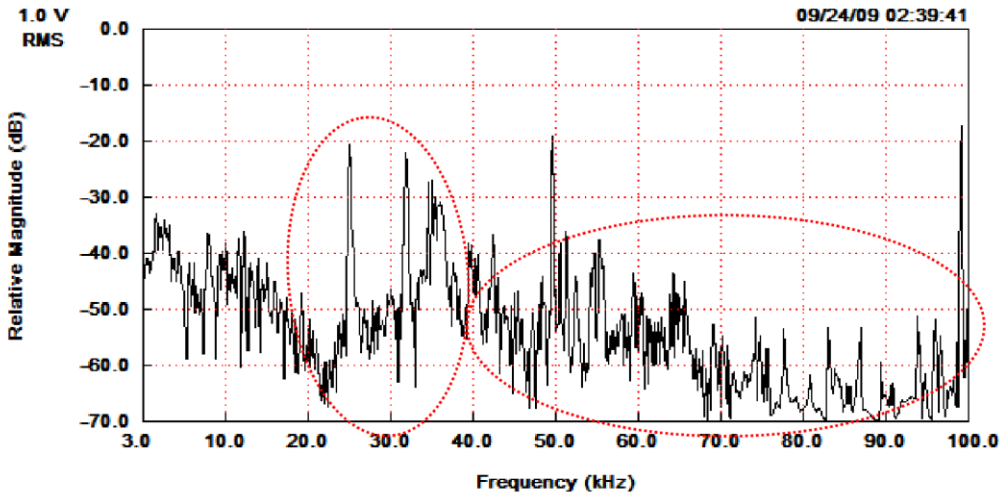


Figure 3: High frequency noise from 3-100kHz between the phases **before** installing the EP units

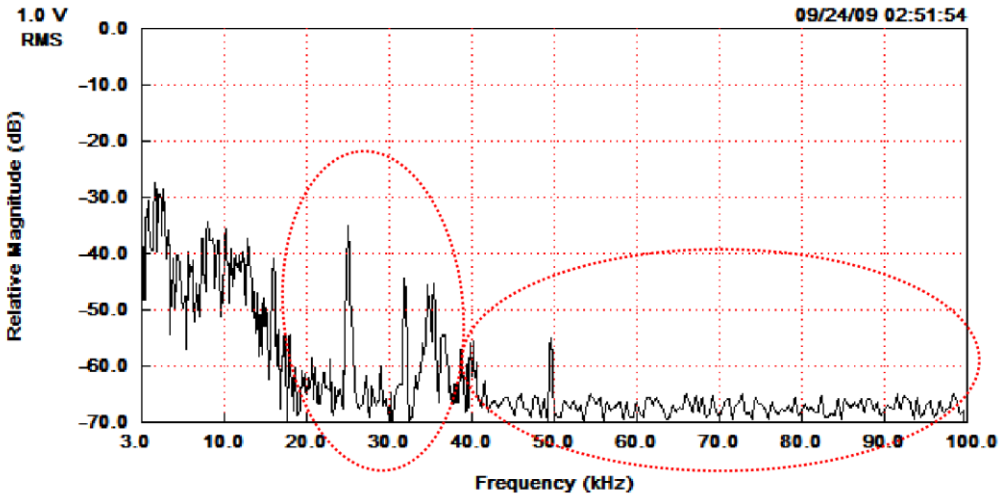


Figure 4: High frequency noise from 3-100kHz between the phases **after** installing the EP units

Observations after EP installation: Engineers noticed a significant amount of noise reduction after the EP units are installed. The other important observations from the facility are:

- There was no further damage to the VFDs in the facility.
- Facilities security surveillance system started functioning normally. Screen flickering of the system has stopped.
- The heat in the server room is reduced, and therefore there is a reduction of 23.3% in the power usage reported.