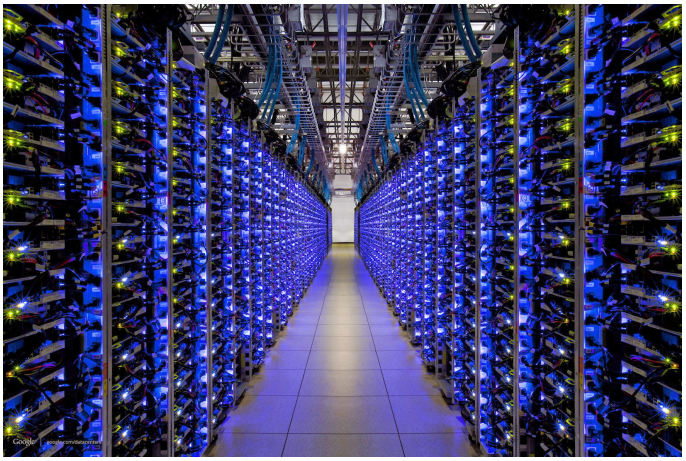
# White Paper and Case Study

## Data Center Application



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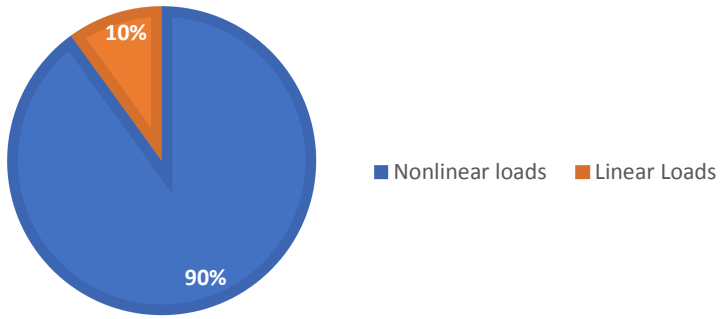
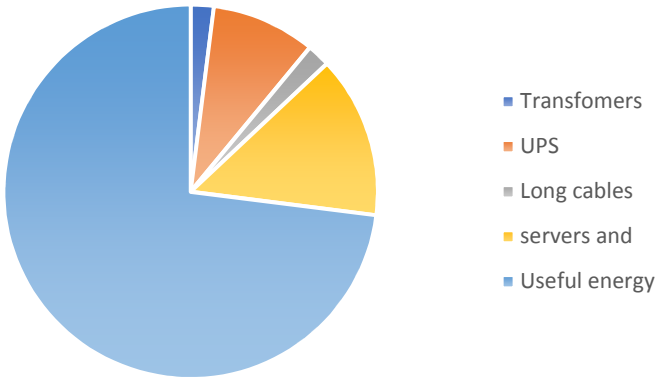
Until some time ago, the power quality in the data center was mainly related to the continuous supply of energy to the load. However, with the addition of nonlinear loads in the data center, the power quality is more than “continuous support of electrical power to the load". The power quality in the data center has now been 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.

**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, and computerized equipment work on the principle of power conversion (AC-DC and then DC-AC). During this process of power conversion, the devices will generate and draw transients and high-frequency noise (in other words, create a non-sinusoidal waveform) from the 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 in 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). The noise causes erratic behavior of the load and a reduction in meantime between failures (MTBF) as well as premature failure of the equipment. Electrical noise is also one of the major causes of server restarts/reboots.

Electrical noise increases the ohmic losses (heat) in the wire, transformer, and motors. On average, transformers contribute toward 2% of power losses, UPS about 6-12% and the wire about 1-3%. 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 the operation of servers. Apparently, more energy is used in the form of cooling to remove the excessive heat in the system.




**Cost of electrical noise:** When electrical noise is not properly addressed in the data center, it could add a significant amount of capital cost on maintenance and repair or replacement of the equipment. Data centers have costly electronic loads that, due to their nature, cannot afford down time. 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 does not include the loss of reputation and confidence.

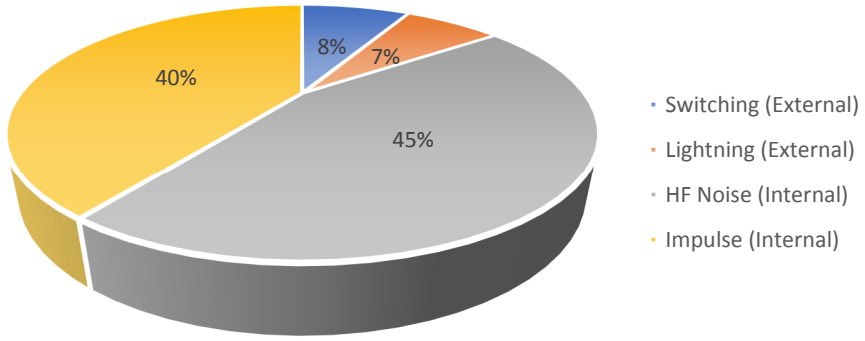
Excessive heat generated in the data center is one of the most expensive maintenance costs. It is reported that each one degree raised on the thermostat would cost as much as 2% of the air conditioning costs. “10°C – twice law” states that the life of equipment decreases by half for every 10°C rise in temperature. Arrhenius law states that the failure rate at a temperature below 30°C is much 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, the increase is 100 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 the like. Even transient signals as low as 0.5V are capable of damaging sensitive components by electrical over-stress (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; and 3) increase the life and performance of the equipment. Environmental Potentials, Inc. (EP) manufactures patented waveform correction devices, inclusive of a 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 improvements 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 to remove 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 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.

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**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 determined from the data the facility encountered severe high-frequency 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 were installed, while Figure 2 and 4 shows the high-frequency noise measurements after installation of the EP units.

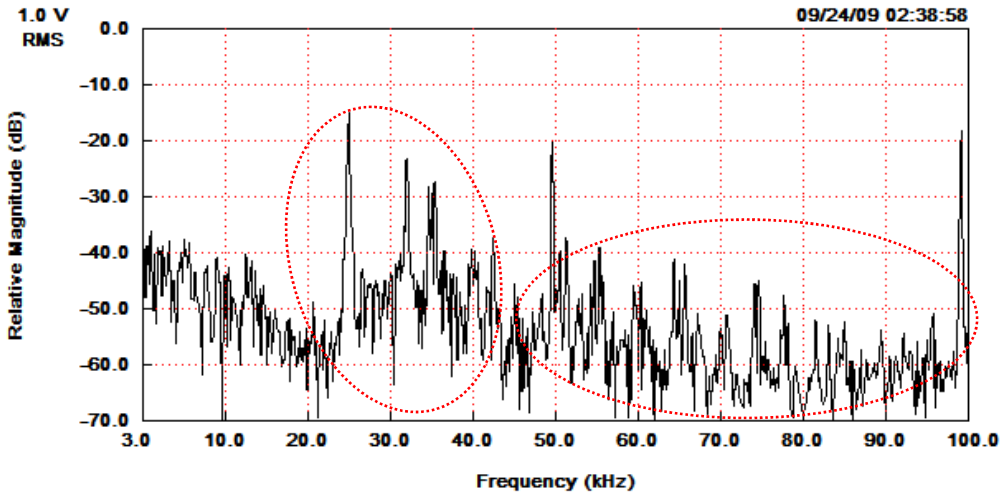


Figure 1: High frequency noise from 3-100kHz between the phases **before** installing the EP units

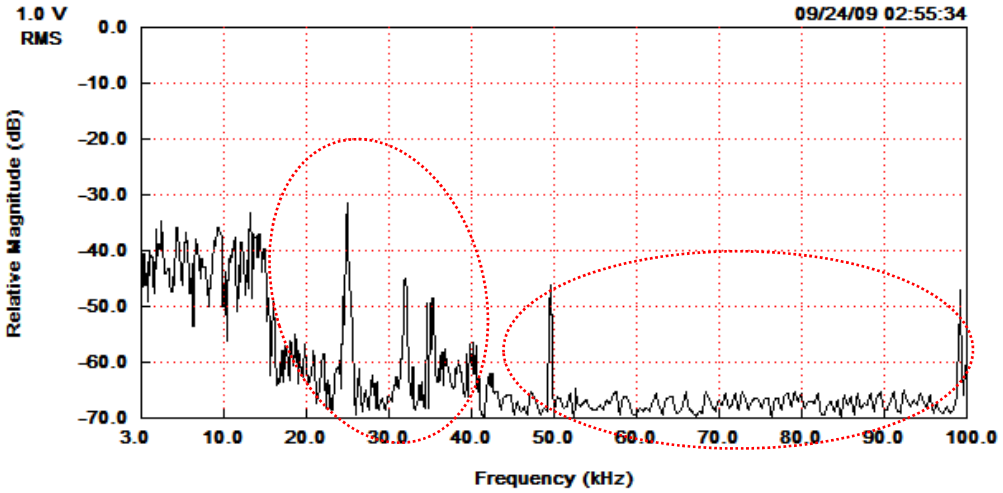


Figure 2: High frequency noise from 3-100kHz between the phases **after** installing the EP units

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

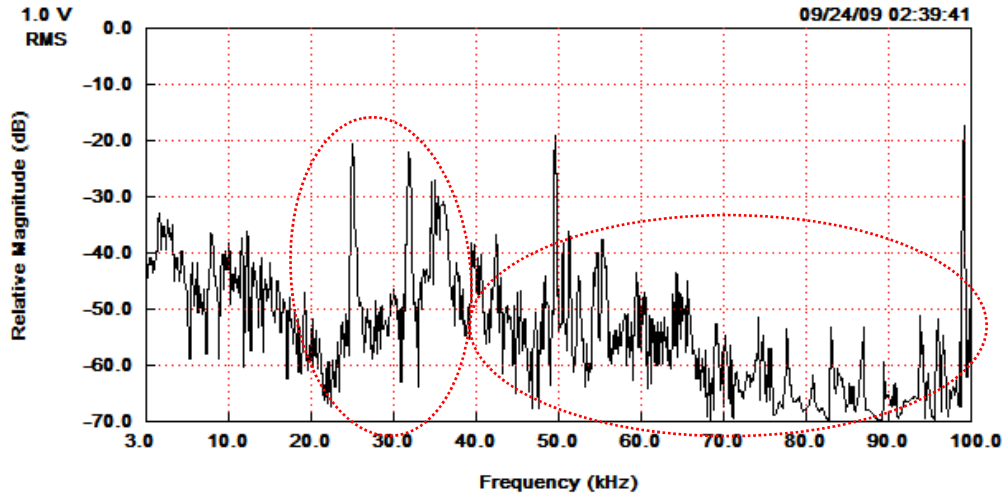


Figure 3: High frequency noise from 3-100kHz between the phases **before** installing the EP units

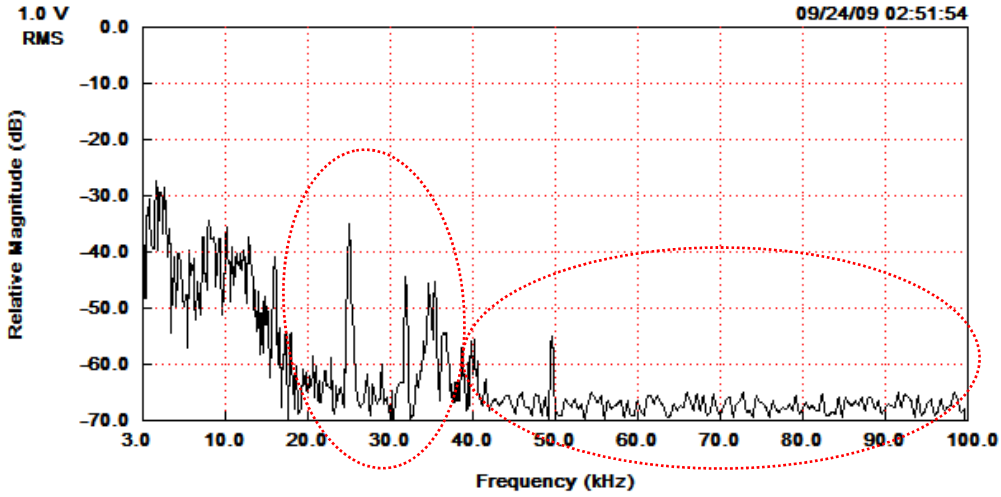


Figure 4: High frequency noise from 3-100kHz between the phases **after** installing the EP units

**Observations after EP installation:** Engineers noticed a significant amount of noise reduction after the EP units had been 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.