Improving Reliability and Security of Data Centers with OnFILTER CleanSweep® AC EMI Filters

OnFILTER's plug-and-play CleanSweep® AC EMI filters provide superior EMI and transient suppression on power lines and ground in real-life applications.

Figure 1. CleanSweep® AC EMI Filter

Clean, reliable power is at the core of reliability in data centers. Prevention of "snooping" and injection of undesirable signals via power lines is an essential element of data center security. Solutions to both problems are addressed in these application notes.

Power Line Transients

Short "spikes," or transients, on power lines – brief voltage surges – can be quite high, reaching as high as 6kV. Sources of these spikes may be anything from lightning to nearby equipment turning on and off. Strong transients can disrupt the normal operation of servers, networks and data banks and cause hardware damage. But even moderate spikes can cause significant downtime by corrupting data in transit and causing gradual deterioration of internal components.

Conventional transient voltage suppression – the method widely used in data centers today – is only effective for voltage spikes above a certain "clamping" voltage, which is substantially higher than peak AC line voltage to allow for some headroom. For 120VAC circuits this clamping voltage is typically 330 volts, and for 250VAC lines it's 400V and above. This means that transient spikes will be clamped down only to 330V in the *best* case, and spikes below that level won't even be noticed by today's surge protectors. Figure 2 shows a typical surge protection operation on a 120VAC line. As seen, spikes as high as 330V will remain. What is more, disruptive spikes such as the ones shown in Figure 3 won't even be noticed by a surge suppressor. Such suppression is not sufficient to ensure uninterrupted operation of some equipment and tools.

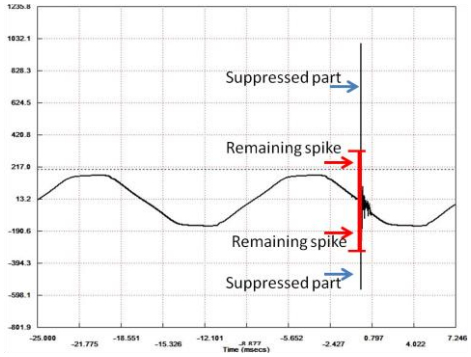

Figure 2. "Suppressed" power line transient
Source: Powersight

OnFILTER's CleanSweep® AC filters work on a different principle than a conventional surge protector. Instead of looking at voltage level, CleanSweep® filters see spikes as EMI events and effectively suppress them regardless of their voltage. Figure 4 shows an original power line spike of over 300V, which would pass unimpeded through a regular surge suppressor but is reduced to an insignificantly small ripple by a CleanSweep® EMI filter. CleanSweep® filters also present the unique advantage of effectively suppressing both differential-mode (between live and neutral) and common-mode (between live, neutral and ground) transients, which regular surge suppressors do not offer. CleanSweep® filters react to much shorter spikes than surge suppressors, require no recovery time between spikes, and do not wear out.

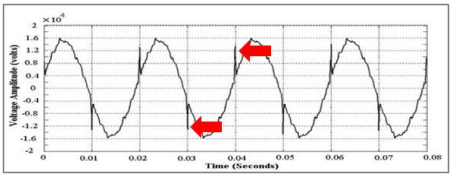

Figure 3. Unsuppressed power line transients

The best way to connect a CleanSweep® filter is at the output of a regular surge suppressor, before your equipment - this offers the benefits of both technologies and maximum protection against transient signals, big or small.

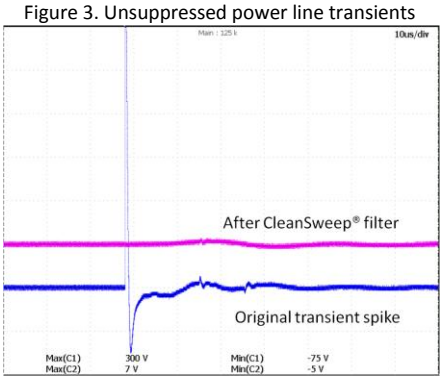

Figure 4. CleanSweep filter suppression performance

Power Backup

In order to maintain reliable power, most data centers use either UPS (uninterruptable power supplies) or back-up generators. Properly selected and installed, they provide uninterruptable power for some period of time. However, the quality of this power and what happens during the switchover period when back-up power kicks in can be problematic.

Backup Power Switchover

Whenever there is interruption of AC power, back-up power is engaged. This transition is often accompanied by strong transients, as shown in Figure 4. As seen, there is a significant fast transient when the power is switched to a UPS (the problem with the power waveform is discussed in the next section). Rotating back-up generators may cause even higher transients in part caused by synchronization issues. As discussed above, surge suppressors are ineffective at dealing with such artifacts, while OnFILTER's CleanSweep® AC filters reduce them to insignificant levels.

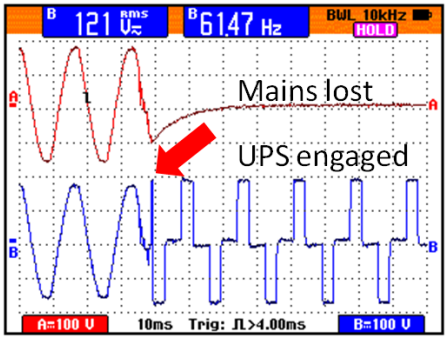

Figure 4. Switchover to UPS
Source: Repeater-Builder

Non-Sinusoidal Waveforms and Transients

Backup sources, specifically UPS, provide waveforms that are far from being sinusoidal (see Figure 4). However, it is not just distortion of the waveform that is problematic – it is also the high-frequency artifacts accompanying the sharp edges of the generated pulses. Figure 5 shows transient spikes caused by the edges of power pulses from a UPS. These spikes can be quite high, very possibly interfering with the operation of servers.

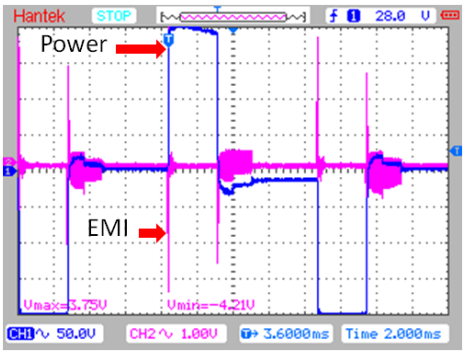

Figure 5.Power line transients from UPS

OnFILTER's CleanSweep® EMI filters modify the waveform of power pulses to create smooth edges, thus eliminating power line transients. Figure 6 shows the edges of a power pulse and the corresponding transients (and their absence) before and after a CleanSweep® filter.

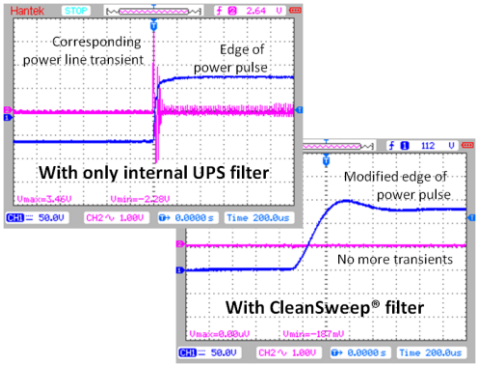

Figure 7. CleanSweep filter reduces EMI from UPS on AC mains

Data Errors and EMI On Power Lines

As a normal part of its operation, electrical and electronic equipment generates noise on power lines and ground. This noise is often called EMI – **E**lectro**M**agnetic **I**nterference. In data centers, EMI on power lines and ground comes from switched-mode power supplies in computer equipment, air conditioning and ventilation, UPS, and a multitude of other sources. Most of the noise has transient characteristics. Even power line surges that do not reach levels high enough to physically damage equipment can easily cause other problems. Such EMI transients cause corruption of data, among other problems. Figure 8 shows how a low-level EMI Event – a short transient – causes data corruption. As shown, a short disturbance on power lines induces signals on data lines that are easily interpreted by computer equipment as a legitimate pulse, causing a range of problems from data errors to computer lockup.

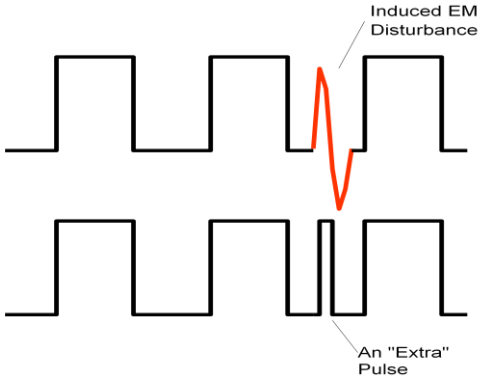

Figure 8. Mechanism of data corruption by EMI

UPS as a Noise Source for AC Mains

Strong noise generated by UPS propagates in both directions – to equipment connected after the UPS, and also back to the power line to pollute AC power throughout the entire data center. CleanSweep® filters provide bi-directional filtering that eliminates this noise, as shown in Figure 9.

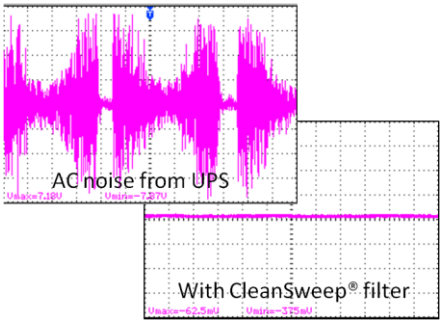

Figure 9. CleanSweep® filter reduces output transients from UPS

Power Line Communication

While significant attention is paid to radiated emission as a threat to data center operation and security, conducted emission – noise on power lines and ground – has just as much potential to disrupt operation of equipment due to significantly higher energy levels than signals propagating over the air. Signal passage via power lines cannot be protected by shielding unlike radiated emission.

Power line communication is becoming quite common. This includes some implementations of Smart Grid technology, Ethernet over power lines, and many other applications. Since power lines are ubiquitous and reach all equipment within a certain location, they are very appealing media for communication. Without appropriate safeguards, this communication provides a "back door" to your data. Conventional filters that are built into servers, data storage and UPS provide inadequate suppression of unwanted power line communication. Figure 10 shows what a power line communication signal looks like with a good-quality conventional filter (top chart), and with OnFILTER's CleanSweep® EMI filter (bottom chart). As seen, the communication signal still remains strong after a conventional filter while the CleanSweep® filter completely blocks it, closing a potential security hole to your sensitive data.

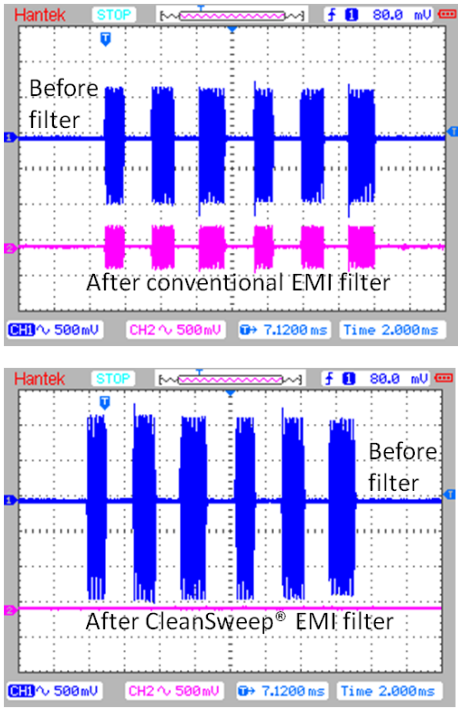

Figure 10. Power line communication signal with conventional filter (top chart) and with OnFILTER's CleanSweep® EMI filter (bottom chart)

What Makes OnFILTER's CleanSweep Filters Perform Better?

Every computer, server, storage device, switch and router has a built-in EMI filter – why one more? The purpose and performance of these filters are very different. Built-in EMI filters help equipment to pass very specific EMC (electromagnetic compliance) regulations, such as European EMC Directive and FCC. The requirements of these regulations often have little to do with real-life environments and are rather targeted on repeatability and accuracy of tests in special laboratories. The table below illustrates some of the major differences:

Regulatory EMC Test	**Your Facility**
Controlled environment	Unpredictable and variable environment
Short cables	Cables of random length
Nothing else is connected	Complex network of power and ground
50 Ohm termination on input and output	Wide range of impedances from 0.1 to 1000 Ohms
Continuous-type noise measurements specifically ignoring transients	Most of noise is transients, i.e. pulses and spikes

The absolute majority of EMI filters on the market are designed to meet regulations and requirements. Equipment designers are encouraged to select the lowest-cost filter that attenuates EMI just enough to pass EMC regulations – anything more than that would be waste of money since in the laboratory environment a better filter won't improve the product's performance.

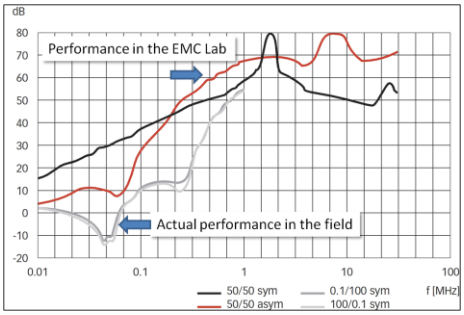

Figure 11. Frequency response of a conventional EMI filter

In an actual installation, the situation is quite different. Impedance of power lines and loads is nowhere near 50 Ohms; the frequencies that need to be suppressed have very different spectrum contents due to long power-line and ground wires which offer distributed inductance and capacitance; most signals on power lines are short spikes, which EMC tests specifically ignore; and the list goes on. Figure 11 illustrates this point. This is the response of a good quality multi-stage EMI filter from a reputable manufacturer. The red and black curves show filter's response in a 50-Ohm environment as prescribed in EMC regulations. The filter offers reasonable attenuation, which isn't great at lower frequencies but gets better towards the highest end of the regulatory frequency response of up to 30MHz. The gray curve shows completely different performance. As annotated at the bottom of the chart, these curves are for more realistic 0.1 to 100 Ohms impedance of power lines and loads, and the difference immediately clear. Notably, the maximum frequency here is only 1MHz – power lines seldom contain higher frequency content due to their long wires. But the most important part is that at lower frequencies the attenuation is *negative*. In other words, at lower frequencies where most of power line noise is, the filter would actually *amplify* noise rather than suppress it. Figure 12 shows the performance of a conventional EMI filter in a real-life connection. As seen, the filter does indeed amplify noise in this frequency range.

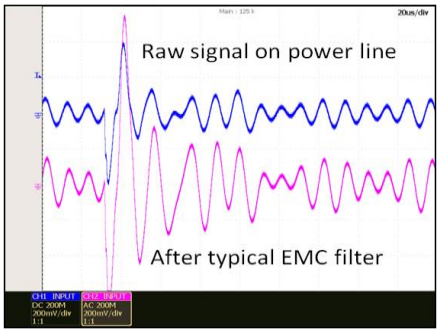

Figure 12. Performance of conventional filter

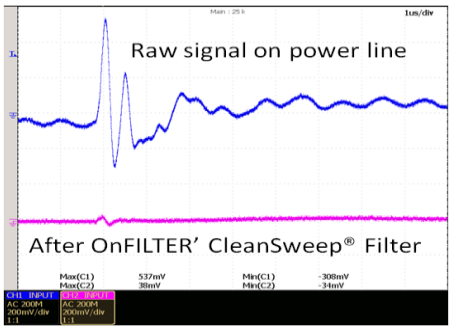

Figure 13. Performance of CleanSweep® filter

CleanSweep® EMI filters are designed for real-life applications, not just for a regulatory setup in an artificial environment. They are impedance-independent and specifically designed to suppress signals found on actual power lines and ground. Typical performance of a CleanSweep® AC EMI filter in an identical setup is shown in Figure 13.

Integration

OnFILTER's CleanSweep® EMI filters are plug-and-play devices requiring no special wiring. They can be installed in minutes. Plug a CleanSweep® filter into a power outlet (or the output of a UPS) and plug your servers into filter's outlet – that's all. CleanSweep® filters are available with a variety of world-wide outlets and current ratings up to 30A. Three CleanSweep® filters can fit on one standard 2U 19" rack. CleanSweep® filters are ETL and CE certified. Options include mounting brackets, marine certification (DNV), among others. CleanSweep® filters are completely passive and require no maintenance and no calibration.

Conclusion

OnFILTER's CleanSweep® EMI filters improve reliability of data centers with minimum integration effort and at a reasonable cost. Please visit www.onfilter.com for more detailed information. Contact us at info@onfilter.com.