

# Reducing Electrical Overstress During Soldering with CleanSweep® EMI Soldering Filters

Soldering irons, solder extractors and other equipment that comes in direct electrical contact with sensitive components can inject significant energy into these devices. Specifically, metal-to-metal contact between the tip of the soldering iron and pins of the components is a gateway for high current that can cause substantial device damage.

Where would a soldering iron tip get voltage? After all, it is supposed to be grounded, just like the PCB with the components, so theoretically there should be no difference in voltage and thus no harmful currents between the tip of the iron and the devices. This, however, may be true only for DC or for very low frequencies such as power mains (50/60Hz). For high frequency signals it is very different.



Figure 1. OnFILTER CleanSweep® soldering filter

## High-Frequency Signals as a Source of Electrical Overstress (EOS)

Unlike electrostatic discharge (ESD) which is caused by accumulated static charge, electrical overstress (EOS) is caused by voltage and currents, mostly on ground. If there is a voltage difference between the tip of soldering iron and the PCB, there will be current on metal contact. Such currents are able to cause significant damage to the sensitive components at much lower levels than from ESD. Various standards in the industry provide limits on how much voltage and/or current can be seen at the tip of the soldering iron - from 2mV in MIL/DOD-STD-2000 to 0.3V in IPC-A-610-E and 10mA in ESDA STM13.1-2000. The bottom line is the less voltage and current the better.

As seen, the damaging levels of voltages on devices are defined to be several magnitudes lower than is typical for ESD (hundreds of volts). This is because EOS signals last much longer time and, unlike ESD events, are often repeatable. They are capable of providing significantly higher energy into the devices than ESD events and are much more likely to cause latent damage. According to Intel ([Intel® Manufacturing Enabling Guide](#), 2010, Section 3.2), "EOS is the number one cause of damage to IC components." Data from various semiconductor and PCBA manufacturers corroborate it.

## Power Line Surges

Power line surges - short spikes of voltage - can reach as high as several kV as illustrated in Figure 2. Conventional transient voltage suppression – the protection widely used in the industry – 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 the surge protectors. Figure 2 illustrates that 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 EOS-free soldering process.

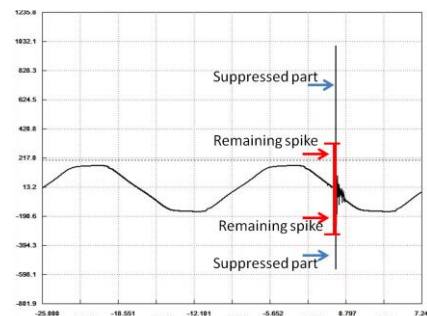


Figure 2. Strong transients remaining after regular surge protector

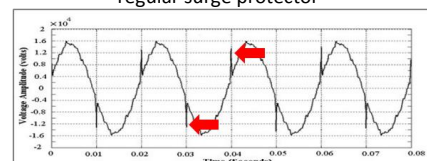


Figure 3. Transient spikes passed by regular surge protector

## High-Frequency Noise from Operation of Equipment

Normal operation of electrical equipment causes high-frequency artifacts on power lines and ground. These artifacts can reach several volts. As an example, Figure 4 shows power line transient caused by turning on a ubiquitous heat gun. In PCB assembly environment typical sources include electric screwdrivers, switched-mode power supplies in a variety of production tools, servo motors, relays and solenoids, equipment commutation (power on/off), UPS, CFL lights and just about any other equipment in the facility. This high-frequency noise is often called EMI (ElectroMagnetic Interference).

All these signals eventually find their way to the tip of the soldering iron and, in turn, into sensitive components.

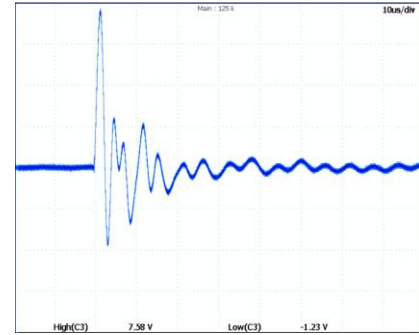


Figure 4. Transient signal on power line caused by turning on heat gun

## How Does Noise Get to the Tip of the Soldering Iron

Soldering iron is ultimately connected to the facility power line and ground. Whatever happens on these lines eventually gets to the tip of the iron in some form or the other. Although the tip of most professional-grade soldering irons is grounded quite sufficiently for DC and very low AC line frequencies and is assumed to have no potential, at high frequencies the situation is quite different. Parasitic inductance and capacitance of wiring and internal circuit of the soldering iron and especially coupling between the heating element inside the tip and the tip itself, combined with long grounding wires provides an easy environment for EMI to propagate from facility power and ground to the tip. Workbench' connection to a facility ground, or worse, to a separate "ESD ground" found in some factories causes it to have high-frequency voltage which is quite different than the one on the tip. All this results in undesirable current from the tip to the device on contact.

Figure 5 shows how a moderate transient signal on power lines of less than 600mV causes corresponding current spike between the tip of the soldering iron and the component. As seen, the peak current from the tip (19.12mA) is significantly higher than allowed by ESDA STM13.1-2000. Incompletely suppressed power surges which can be quite high as shown in Figures 2 and 3 cause significantly higher currents from the tip.

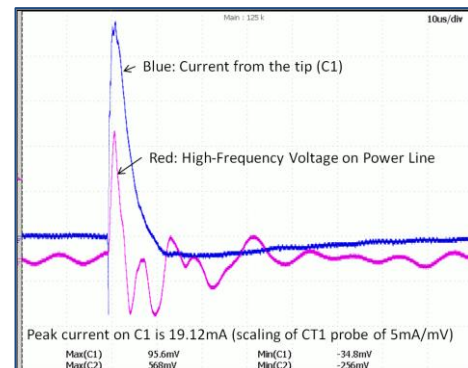


Figure 5. AC power line transient causes current from the tip of the iron

Data from published sources corroborate the above data. Raytheon in its paper presented at the ESD Symposium in 2005 shows transient currents at the tip of soldering iron reaching 1000mA.

Notably, conventional instrumentation used in the factories cannot detect or measure such high frequency signals misleading users about EOS exposure in their environment.

## How do I Know if there is EMI in my Environment?

Typically, high-frequency signals on power lines and ground in the industrial environment span the range from ~40kHz to ~10MHz. Regular multimeter or a soldering iron tester are incapable of measuring high-frequency signals. Such measurements must be done with specialized instruments. OnFILTER manufactures power line EMI Adapters [MSN01](#) and [MSN12](#) (shown in Figure 6) that block 50/60Hz signal and provide galvanic separation between high-voltage power line and an instrument, passing through only high-frequency signals. In combination with an oscilloscope MSN01 and MSN12 allow



Figure 6. OnFILTER' MSN12 Power Line EMI Adapter

observation and measurement of waveforms of high-frequency noise on power lines and ground. Most screenshots in this document were taken using these adapters. Measurements of overall EMI levels on power lines and ground without an oscilloscope and without observing a waveform could be done with [GroundPro™](#) ground integrity meter available from [SCS](#). Current from the tip can be measured with an oscilloscope and Tektronix current probe CT1 or CT6 - current measurements in this paper were performed using CT1 current probe.

## OnFILTER® CleanSweep® Soldering Filters: Stopping EMI-Caused EOS in Soldering

The only realistic way to reduce transient and EMI-caused electrical overstress in soldering is filtering out electrical noise on power lines and ground. Intel in its [Manufacturing Enabling Guide](#) which was mentioned before recommends installation of "EOS line control equipment such as incoming line filtering and transient suppression circuits."

OnFILTER has developed a special version of its CleanSweep® power line EMI filters for soldering applications. These filters provide comprehensive protection of the entire soldering process from any external surge or EMI source. Series APxxxxLG filters (xxxx defines the type of the outlet and the working voltage - see [product brochure](#)) uniquely provide EMI filtering on both AC power line and on ground, and in addition provide a separate EMI-filtered ground connection to the PCB and a workbench.

Figure 7 shows recommended application of an APxxxxLG series soldering EMI filter with a soldering iron. Soldering iron plugs into a regular power outlet on a workbench and the soldering iron plugs into the filter. It is important to connect ground of your PCB or a workbench to the special filtered ground terminal of the filter, not to the facility ground – this way not only the soldering iron will be free from EMI but also any noise on the facility ground will be blocked from your PCB. This way OnFILTER® CleanSweep® soldering filter creates quiet “EMI-free ecosystem” for your soldering operation protected from all outside electrical noise - both power line surges and overall EMI on power lines and ground.

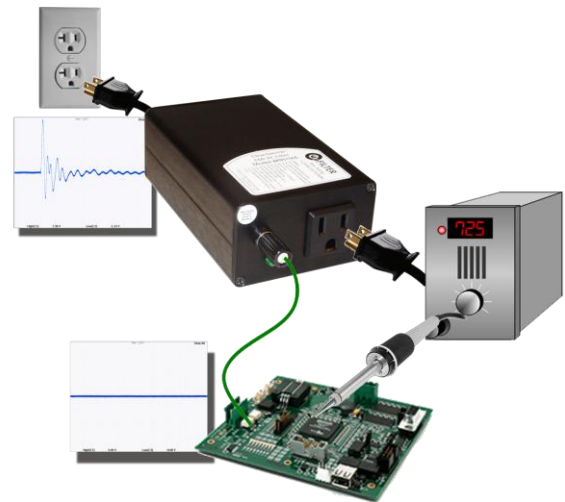


Figure 7. Soldering Iron with CleanSweep® Soldering EMI Filter (OnFILTER model APN515LG shown)

## Performance of CleanSweep® Soldering Filter Effective Suppression of Power Line Surges

As discussed above, regular surge protectors clip voltages only down to their threshold level, the best case being 330V for 120V lines and 400V for 250V lines. This leaves electric circuits exposed to substantial overvoltage. OnFILTER's CleanSweep® soldering AC filters work on a different principle than a conventional surge protector. Instead of looking at voltage level, CleanSweep® soldering filters see spikes as EMI events and effectively suppress them regardless of their voltage. Figure 8 shows how an original power line spike of over 300V, which passed unimpeded through a regular surge suppressor is reduced to an insignificantly small ripple by a CleanSweep® soldering EMI filter. CleanSweep® filters also present the unique advantage of effectively

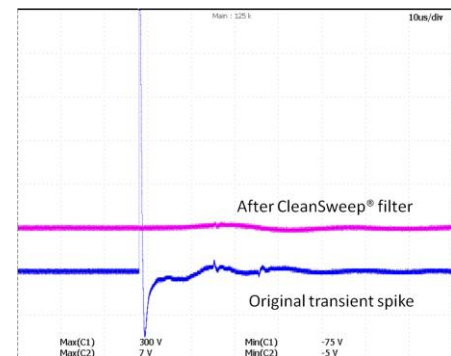


Figure 8. CleanSweep® EMI soldering filter effectively suppresses power line surges

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® soldering filters react to much shorter spikes than surge suppressors, require no recovery time between spikes, and do not wear out.

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

## Suppression of EMI

CleanSweep family of filters is designed to effectively suppress high-frequency noise on power lines in ground in real-life installations. Please refer to our Application Note "[OnFILTER Advantage](#)" available in [Technical Library](#) on our web site for technical brief on how CleanSweep® EMI filters accomplish their task.

Figure 9 shows typical suppression of power line noise by a CleanSweep® EMI filter. As seen, strong power line spike ends up essentially a flat line after the filter. This is the kind of clean power the soldering iron receives when it is plugged into a CleanSweep® EMI soldering filter.

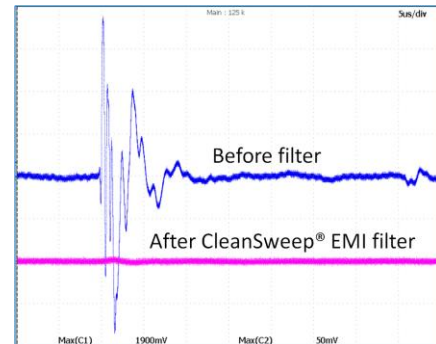


Figure 10. CleanSweep® EMI filter suppresses power line EMI

## Ultimate Reduction of EOS Current from the Tip of the Soldering Iron

A combination of measures taken in a CleanSweep® EMI soldering filter leads to a substantial reduction of EOS current from the tip of the iron. Figure 11 depicts essentially the same EMI spike on AC power line as in Figure 5 on Page 2 but the current from the tip of the iron is quite different. Instead of 19mA current without the filter, the current now is practically immeasurable in presence of ambient noise - it barely registers at 150µA - more than 125 times reduction.

CleanSweep® EMI soldering filters protect your sensitive components from EMI and surge--caused EOS damage during soldering assuring higher yield, improving reliability and reducing latent damage of finished products. They are available for a variety of world-wide outlets and require no maintenance and no calibration.

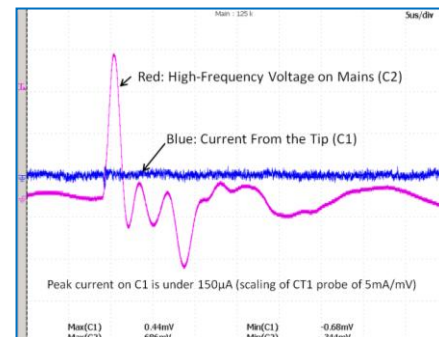


Figure 11. Reduction of tip current due to CleanSweep® soldering EMI filter

## Soldering Iron Compatibility

CleanSweep® EMI soldering filters work with virtually all AC powered soldering irons. The filters were tested and are deployed in the field with soldering irons from major manufacturers, as well as with irons from smaller brands. Except from removing high-frequency noise and transients from power lines and ground, CleanSweep® filters do not alter AC line and ground in any way.

It is worth noting that high-frequency currents from the tip of a professional-grade properly-installed iron are caused mostly not by the iron itself but by EMI resulting from normal operation of factory equipment in the environment of complex facility wiring. Soldering iron is just one of components in a soldering process and no matter how good the iron is by itself, it cannot fundamentally solve the issues of facility by itself. It is a user's task to provide safe EMI-free environment for EOS-free soldering process and CleanSweep® soldering filters help to accomplish this task.