EMC Implications of Using a Class II Power Supply in a Class I Application

Introduction

The majority of power supplies used in commercial or industrial applications today fall into one of two construction categories, Class I or Class II (not to be confused with Class 1 and Class 2). These classes are associated with safety, and specifically indicate the constructional method used to provide end users with the an appropriate level of protection from hazardous voltages. In general, all electrical appliances must provide users with at least two levels of protection from hazardous voltages (greater than 42Vac or 60VDC). Class I and Class II power supplies differ in how they achieve these two levels of protection, specifically in whether or not they utilize a connection to earth ground. One can identify a Class I supply by looking for a third pin on the AC inlet (Earth Ground), if the device has only two blades, it is a Class II.

While safety is the primary purpose of any Earth Ground connection, this connection has evolved over the years to be used for more than just protection. Earth Ground connections are widely used in Class I applications as a sink for high frequency conducted disturbances that would otherwise degrade EMC performance, and potentially prevent compliance with FCC or CISPR regulations. This breeds a common misconception: *If Class II devices meet conducted emissions standards without the use of an Earth Ground connection, then adding an earth ground connection between my design, and the grid can only better my conducted emissions performance.*

Not so fast. The above statement is absolutely false, and more often than not, adding an earth ground connection to a Class II fed design can actually significantly worsen the conducted emissions performance. This technical bulletin will detail why one may want to think twice before powering a Class I application with a Class II power supply.

Measuring Conducted Emissions

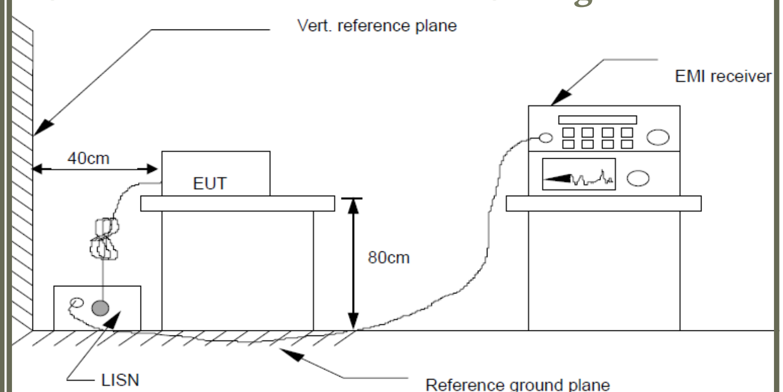
To understand the EMC implications of using a Class II supply in a Class I application, it is important to first understand how conducted emissions are measured, and the basic construction of one fundamental piece of equipment, the Line Impedance Stabilization Network, or LISN.

A typical conducted emission test configuration is depicted in the box in the box to the right. All measurements are referenced to the ground plane surrounding the Equipment Under Test (EUT). Specific items such as cable length and type, position of the EUT within the environment, and measurement equipment used will be governed by the standard against which the EUT is to be tested.

The EUT is fed by the mains power in the test facility, through the LISN interface. The purpose of the LISN is standardize the mains voltage so that measurements are consistent across time, and location (Mains power is not inherently consistent across these two domains, at least not to the extent required for accurate emissions measurements). The LISN also provides a means for extracting the conducted noise produced by the EUT, and routing it to the measurement device, which is typically an EMI receiver. The conducted noise is measured independently on both the Line and Neutral legs of the supply line. Both measurements are considered against pass/fail criteria.

A general model of a typical LISN is depicted in the box at the bottom right of this page. Pay close attention to the capacitive coupling between the Line/Neutral legs, and Earth Ground within the Line Impedance Stabilization Network. Therein lies the root of the EMC implications associated with using a Class II power supplies in a Class I application.

Conducted Emissions Test Configuration

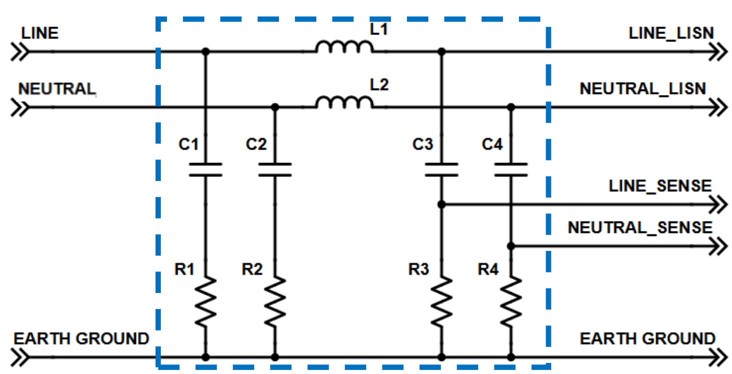


A man in Boulder Colorado discovered that he was inadvertently opening and closing his neighbors garage doors when he dimmed his kitchen LEDs. The effects of EMC compliance are all around us.

- IEEE Spectrum, August 2015 -

Did You Know?

General Model of a LISN



EMC Implications of Using a Class II Power Supply in a Class I Application

Typical Conducted Emissions Mitigation Tactics

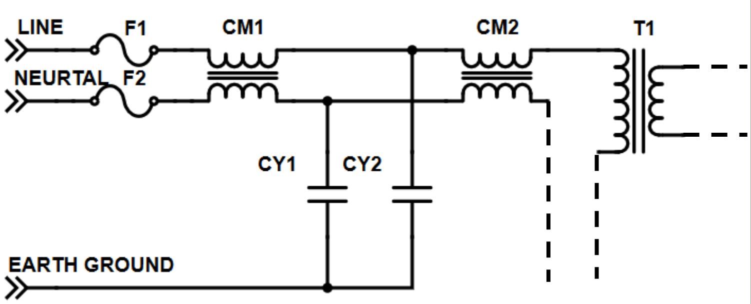
The final piece of the puzzle in understanding the challenges presented by mis-matching power supply classes and application classes can be found in the typical conducted emissions mitigation tactics employed in the design of Class I and Class II power supplies. Over the years, power supply design engineers have developed many innovative techniques for reducing the amount of switching noise that is conducted back onto the mains lines in an effort to meet the ever growing demands of the FCC and/or similar governing bodies throughout the world. One of the most common, and certainly most effective tactics is to shunt the high frequency energy produced by the switching components someplace else. One of the biggest differences between Class I and Class II supplies, in terms of EMC compliance, is where that “someplace else” is.

In a Class I power supply, Earth Ground can be used as the “someplace else”. Conducted emissions standards are not concerned with noise that is conducted back to earth ground from a power supplies switching elements. This is accomplished by placing carefully selected Y-type capacitors between each of the incoming Mains legs and Earth Ground, providing a low impedance path for high frequency energy to escape from the Line and Neutral legs. The prominence of this technique is explains why you have probably heard Earth Ground referred to as Filter Ground, or FG.

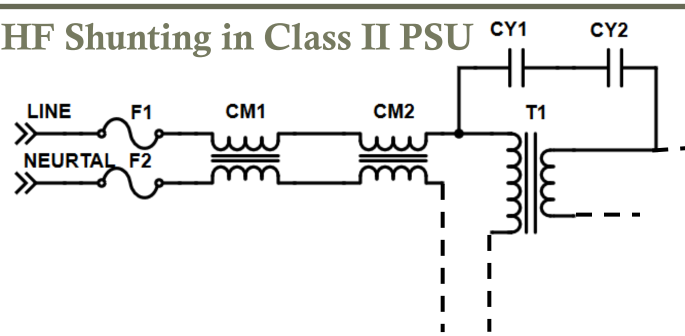
The accessibility of an Earth Ground connection is a convenience that is not afforded to supplies of Class II construction. In this case, the “someplace else” often becomes the secondary side of the converter, the DC output. Y-type capacitors (often two or more in series to meet stringent isolation requirements) are placed directly across the gap between the primary and secondary sides of the AC/DC converter, in parallel with the isolation transformer. Again, these capacitors provide a low impedance path for the high frequency switching energy to leave the Line and Neutral legs. Some Class I converters may implement this strategy as well, in addition to shunting energy to FG, but to an extent that is likely much less than the FG shunting.

This fundamental constructional difference defines the path through which conducted emissions find their way back to the Line and Neutral legs when a Class II fed application is grounded.

HF Shunting in Class I PSU



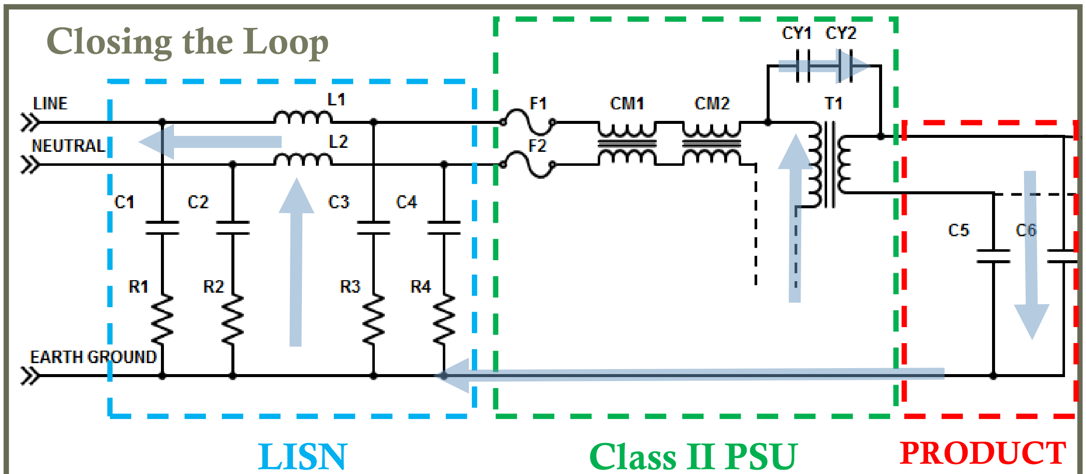
HF Shunting in Class II PSU



Closing the Loop

If the main DC rails within the end product, supplied by the Class II power supply are capacitively referenced to a node that is connected to Earth Ground (such as the device chassis), a low impedance path is created for high frequency switching noise to make its way back on the mains lines as depicted in the signal flow diagram to the right.

Closing the Loop



| 43 BROAD STREET HUDSON, MA 01749 | (978)-567-9600 | SALES@POWERPARTNERS-INC.COM

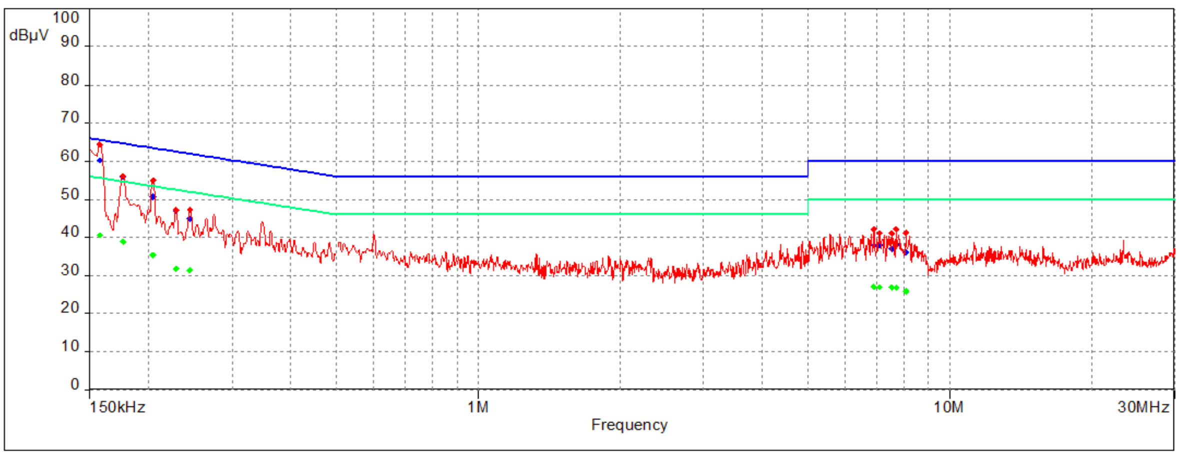
EMC Implications of Using a Class II Power Supply in a Class I Application

The Results

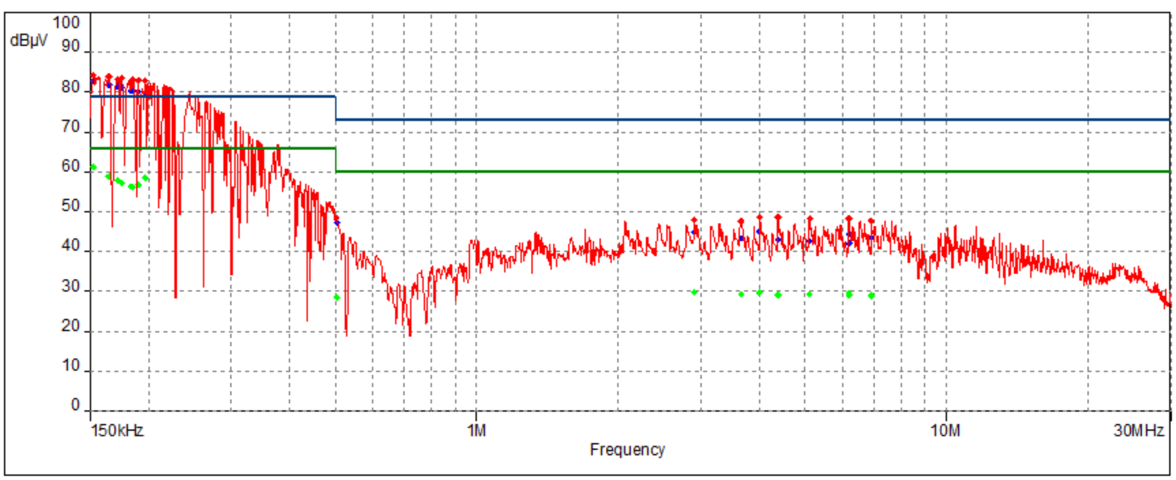
By now you may be wondering what actually happens if we configure a system in the manner shown on the previous page, and close the loop via an Earth Ground connection between the product and the grid. The plots shown below are real captures from the EMC lab taken before and after closing the loop with an Earth Ground connection between the chassis of an end product, and the grid. The effects are quite profound.

We have taken an FCC Class B (conducted and radiated) rated power supply, and an otherwise EMC compliant end product, and through improper integration, have arrived at a non–compliant system. These plots are direct evidence of some of the unexpected implications associated with using a Class II power supply in a Class I application. For more information on how we mitigated the drastic noise increase in this particular application, stay tuned for a future technical bulletin on the topic, or reach out to a member of our applications engineering team.

Before Closing the Loop (Class II Supply in a Class II System)



After Closing the Loop (Class II Supply in a [now] Class I System)



EN55022 LISN AC Mains B - Average/
EN55022 LISN AC Mains B - QPeak/
Meas.Peak (Phase 1)
Peak (Peak /Lim. Average) (Phase 1)
QPeak (Finals) (Phase 1)
CISPR Average (Finals) (Phase 1)

Our Products

At Power Partners, the vast majority of our current product offerings are compliant with applicable Class B conducted and radiated emissions standards, as indicated on our product datasheets.

Have questions or concerns regarding EMC compliance or system level integration? Contact a member of our applications engineering team.
We are here to help!

tech
@powerpartners-inc.com

Dylan Howes

Applications Engineer

(978)567-9600 x230

dhowes@powerpartners-inc.com