

ELECTRO MAGNETIC INTERFERENCE (EMI)

This technical note reviews the Electro Magnetic Interference (EMI) sources on a power supply and how Advanced Energy applies its knowledge of these issues to design low profile performance leading EMI designs.

INTRODUCTION

EMI is everywhere. Even mother nature provides many sources of electromagnetic interference, and our own sun is a source of much radiation on a daily basis. However, for electrical equipment we usually only have to deal with man made sources of radiation. These can be intentional such as radio, TV, telephone, or they can be unintentional (sources can appear as result of load distribution, vehicle ignition systems, and even power supplies!). This technical note will address some of these unintentional sources and, more importantly, how to eliminate them.

WHAT MAKES POWER SUPPLIES SUCH NOISY SOURCES?

Any source of changing voltage or changing current with respect to time will result in ringing. Any given switch mode power supply will be full of these events occurring every switching cycle. All tracks, points, and components are a potential source of this on a power supply. But the hidden truth is that most EMC sources do not appear on any bill of materials. So what do we mean by this statement?

Within any given design there will be loops with high di/dt and high dv/dt 's. Figure 1 identifies the potential areas for high di/dt 's in an isolated forward converter, while Figure 2 shows the potential areas for high dv/dt 's in the same design.

With such high di/dt 's and dv/dt 's it doesn't take much interwinding capacitance to generate significant common mode currents and voltage spikes of up to several volts. This will result in ground bounce, and hence, EMI.

If we continue with this path of investigation, we can also look at the example of an FET going from a V_{ds} of 200 Volts in 40nS. This equates to a dv/dt of 5 billion volts per second!

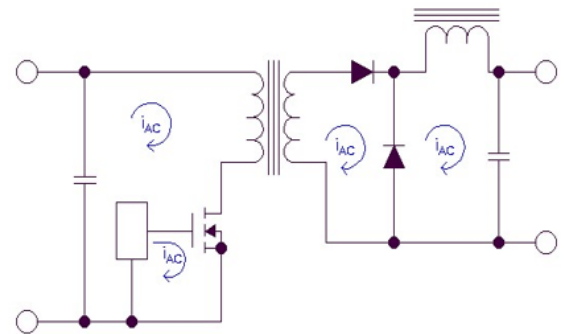


Figure 1: High di/dt loops on a forward converter

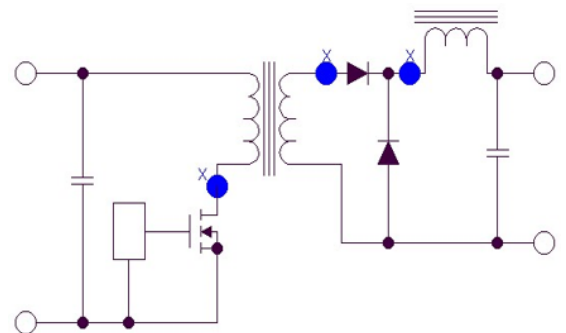


Figure 2: High dv/dt areas on a forward converter

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HOW TO DESIGN TO MINIMIZE EMISSIONS

Designing power supplies for good EMI performance is not impossible. With the correct knowledge and experience, limiting EMI can be accommodated right from the project concept stage. This includes a heavy focus on the design and layout of the PCB, as this will play a significant role in emissions.

The first focus for any designer is to eliminate or at least minimize the emissions from the source of the generators. Also remember that receivers re-transmit, so minimize the susceptibility of receivers. If this is still not achieving the target emissions then, as a final solution, you may need to review filters. Keep in mind that filters can result in significant addition of real estate to the final design.

How PCB layout plays its part

PCB layout is often the least understood when it comes to designing for EMI. But it need not be a difficult thing to if you keep the following items in mind:

1. Minimize loop areas
2. Leave no floating parts, ensuring that all loops are brought back to ground
3. Keep signal and power ground connections separate

This will add to the complexity of the PCB design so there are normal compromises in order to save on layers. On one layer you should track the input and output signal grounds with the star points at the IC's common pins (allow for the isolation barrier between input and output). On a separate layer, include the ground plane for the power grounds. Input ground plane under the input components only, output ground plane under the output components only, allow for the isolation barrier between input and output ground planes.

Also, remember that earthing schemes were designed for safety purposes, not EMI, so use ground planes and short connections. Also there should be only one connection between signal and power grounds, through a via at the signal ground star point.

CONSIDER COMPONENTS WITH RESPECT TO FREQUENCY

The difficulty facing power supply designers is that EMI performance is not usually characterized by the component manufacturer. Understanding your components is key to knowing how they will behave in terms of emissions. This is especially true at the highest effective frequency. You must also consider that things like capacitors, wire wound resistors, and even wire leads will vary in behavior as the frequency changes. This also holds true for the type of capacitors used, as tantalum capacitors behave differently to say ceramic capacitors. Your parasitic components, ESR, ESL, Cs, and leakage will all play their part, so knowing and quantifying these are all key to understanding EMI.

Most EMC components are invisible on the circuit diagram and are either stray and parasitic components everything must be done with sound RF principles in mind.

CoolX 1000 Performance

Advanced Energy's Excelsys CoolX® 1000 series is the world's only fanless 1000 W modular power supply. The CoolX1000 provides up to 1000 W without any requirement for fan or base plate cooling, eliminating acoustic noise detrimental to scientific and medical applications, as well as applications sensitive to vibration or where fan cooling is not available. The CoolX1000 also offers increased flexibility by allowing system designers to monitor and control power supply performance — essential for staving off process disruption — using either analog or digital communications (PMBus™).



- High efficiency 90%
- 1000 W with 100% natural convection cooling
- No base plate needed
- No acoustic noise or vibrations

Our products have been tailored to address the specific requirements of the application including:

- Industrial electronics
- Medical electronics
- Low acoustic noise applications
- High temperature applications

The CoolX 1000 has been designed to meet Class B emissions and incorporates all of the issues discussed in this paper. The CoolX 1000 also incorporates many other EMI considerations that make it a very robust power supply for many applications. Some of these features are:

- Active power factor correction and therefore meets the requirements of EN61000-3-2 Class A. It also has a Power factor of 0.98 over all line and load conditions.
- Flicker and voltage fluctuation limits. Meets the requirements of the limits on voltage fluctuations and flicker in low voltage supply systems as defined by EN61000-3-3.
- EN55022 Class B Conducted Emissions Compliant (Radiated and Conducted Emissions)

The CoolX 1000 series has also been designed to meet the immunity specifications outlined below to criteria A:

- EN61000-4-2 Electrostatic Discharge Immunity. 15 kV Air discharge applied to Enclosure. 8 kV Contact with Enclosure
- EN61000-4-3 Radiated Electromagnetic Field, level 2, 3 V/m
- EN61000-4-4 Fast Transients-Burst Immunity ± 4 kV
- EN61000-4-5 Input Surge Immunity ± 4 kV Common Mode, ± 2 kV Differential Mode
- EN61000-4-6, level 3, 10 V_{emf}, 150 KHz-80 MHz
- EN 61000-4-8, level 4, 30 A/m

SO MY POWER SUPPLY MEETS CLASS B, ARE THERE ANY MORE ISSUES I NEED TO CONSIDER?

Compliance of the power supply in a test house to various limits does not necessarily guarantee the user that it will pass when installed into a system. There are a number of causes of poor system noise performance. Some of these are listed below:

- Insufficient de-coupling on the PCB or load
- Poor system earthing
- Faulty wiring connection or poor cable terminations

There are some simple steps to eliminate, reduce or identify the causes of high frequency noise:

- Is the noise conducted or radiated? If changing the position of the power supply or screening improves performance, the noise is likely to be radiated.
- Ground connections (zero Volt) should be made to the nearest point on the chassis.
- Twist all pairs of power and sense cables separately

In the same way that the power supply designer needs to ensure that the sources for radiation are kept to a minimum, the system designer also has a role to play in ensuring that the overall system has the optimum performance. Cabling arrangements and PCB tracking layouts are the greatest contributing factor to system EMC performance. It is important that PCB tracks and power cables are arranged to minimize current carrying loops that can radiate, and to minimize loops that could have noise currents induced into them. All cables and PCB tracks should be treated as radiation sources and antennae and every effort should be made to minimize their interaction.

SUMMARY

Electro magnetic interference is considered by many as being a challenge, but the truth of the matter is that with sufficient knowledge, due diligence, and attention to detail you can design your power supply to have the optimum performance. Trying to address this issue at the back end of a design process can be costly, time consuming, and require use of relatively large filters. Power supplies by their nature are noisy environments but taking every aspect of the design into consideration a market leading performance is achievable. Reduce your common mode impedances, know your components, and layout your PCB correctly at the beginning of your design cycle. This will minimize troubleshooting EMI problems later. Above all, remember that EMI design is the sum of many small items, and only when all of these are addressed will you see improvements in the emissions.



PRECISION | POWER | PERFORMANCE

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