Reduce Power Supply EMI: Designing a Differential Mode Input Filter Using LTpowerCAD

Frederik Dostal, Field Applications Engineer

By their very nature, switch-mode power supplies are a source of potential electronic interference. These signals are collectively and commonly called electromagnetic interference (EMI) or noise. Power supply EMI is produced at the switching frequency and its harmonics, and at much higher frequencies as a result of switching transitions. Switching regulator noise can be transmitted to other electronics via three paths: radiated (antenna) emissions, conducted emissions on the input side, and conducted emissions on the output side.

Radiated emissions strongly depend on parasitic elements and can be reduced through careful board layout. Radiated emissions can also be reduced by up to 40 dB, or a factor of 10,000, simply by using a Silent Switcher® regulator or Silent Switcher 2 regulator from Analog Devices. Silent Switcher regulators use a combination of symmetrical layout and well-controlled switch transitions to reduce generated EMI.

Conducted emissions can be reduced with the help of filters. Not only does the filter need to be optimized to reduce noise in a particular frequency range, but it also affects the stability of the entire power supply. A switching regulator has a certain input impedance, $Z_{IN}$. It has to be higher than the output impedance of the input filter, $Z_{OF}$. Figure 1 shows a block diagram of these two impedances.

Figure 1. Use of an input filter for reducing conducted emissions.

To project the effects of an input filter, a filter design function has been added to LTpowerCAD®—a switching regulator calculation tool from Analog Devices. LTpowerCAD can be downloaded for free from the Analog Devices website (analog.com/LTpowerCAD). The critical line-bound differential noise is determined by input current ripple and is therefore not dependent on PCB layout parasitic effects, so theoretical calculations closely reflect reality.

Figure 2. The calculation of a switching regulator with LTpowerCAD interacting with an optimized filter on the input side.
As previously mentioned, a filter designed to reduce certain EMI levels must also ensure the stability of the overall circuit composed of the switching regulator and the filter. For this, the impedances shown in Figure 1 must be matched. The output impedance of the filter $Z_{OF}$ (impedance output filter) must be lower than the input impedance of the filter $Z_{IN}$ (impedance input power supply). To facilitate impedance matching, LTpowerCAD includes an impedance calculator as shown in Figure 3.

![Figure 3. Checking the respective impedances $Z_{IN}$ and $Z_{OF}$ to avoid oscillations.](image)

Previously, there were calculation tools and simulation tools available for the design of switching regulators. The filter calculation tool in LTpowerCAD helps designers minimize differential mode conducted emissions in switch-mode power supplies.

About the Author
Frederik Dostal studied microelectronics at the University of Erlangen-Nuremberg, Germany. Starting work in the power management business in 2001, he has been active in various applications positions including four years in Phoenix, Arizona, working on switch-mode power supplies. He joined Analog Devices in 2009 and works as a field applications engineer for power management at Analog Devices in München. He can be reached at frederik.dostal@analog.com.

Online Support Community
Engage with the Analog Devices technology experts in our online support community. Ask your tough design questions, browse FAQs, or join a conversation. Visit ez.analog.com.