Back to Basics: Do I Need Filtering on the Input and Output Side of the Converters?

March 30, 2014
By Webmaster

All switching power supplies generate potentially interfering signals as a result of their high frequency, high power switching. This externally-generated noise can be a threat to any connected electronics PCB, although the source may be outside the control of the PCB's designer. Adequate protection must therefore be provided on the board itself.

The board's power conversion modules are first in line to receive the incoming power. As with all electronic devices, they need protection from high levels of conducted or radiated emissions – and this protection requirement applies equally to the components served by the power converters. Although this implies that the power converter potentially requires both input and output filters, an output filter is seldom actually required for Vicor devices. This is because the Vicor design, to a large extent, addresses the problem by the use of a quasi-resonant, zero-current switching (ZCS) and zero-voltage switching (ZVS) topology. The switching current waveform is a half sine wave that generates far less conducted and radiated noise in terms of both frequency spectrum and magnitude.

A BCM bus converter, for example, generates output noise of less than 1% of its output voltage without any external filtering capacitors. Its 3.5 MHz soft-switching exploits nominal distribution inductance associated with board interconnects, together with small ceramic capacitors at the point of load, to attenuate ripple to below 0.1% at the load. Accordingly, soft switching technology facilitates system-level EMI filtering with reduced complexity, bulk and cost.

There are, however, occasions when the requirements of a particularly demanding application mean that even Vicor converters require external output filtering. These can arise in systems processing low-level signals; for example applications that use ultrasound or other sensors. Switched mode-based solutions for these must achieve the same levels of ripple and transient suppression that a linear PSU alternative could reach.

The LC filter design in Fig.1 is a comparatively simple solution for reducing ripple on the outputs of converter modules. These components are small and provide significant peak-to-peak noise attenuation. Together with the DC-DC converter's internal output filter capacitor, the external inductor and capacitors make up a Pi filter. If even greater attenuation of output ripple or additional AC power line ripple frequency rejection is required, active output filters or ripple attenuation modules provide a higher-performance solution.

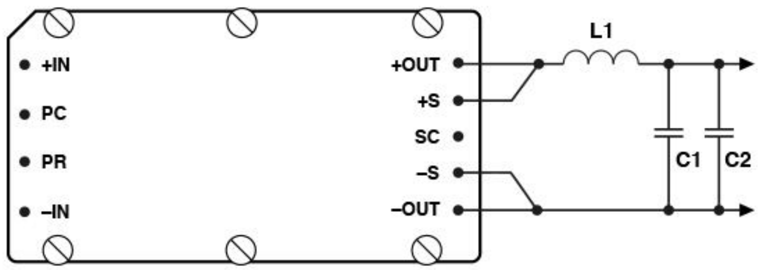

Fig. 1: LC Output filter example

By contrast to output filters, input filters are often required. They serve to both eliminate noise from the supply, and prevent noise being fed back into the supply. Although Vicor ZCS converters are 20 dB to 40 dB lower in conducted noise than a traditional board-mounted PWM converter, if a specific EMI specification such as FCC or VDE must be met, additional filtering may become necessary. EMI filtering, if properly designed and implemented, can reduce the magnitude of conducted noise by 40 – 60 dB; this in turn reduces the noise radiated by the conductors proportionally.

Conducted noise on the input power line can appear as either common-mode or differential-mode noise currents. Common-mode noise, which has mostly high-frequency content, is measured between the converter's input conductors and ground. Differential-mode noise is largely at low frequencies and appears across the converter's input conductors. It comprises the fundamental switching frequency and its harmonics.

The most effective way to reduce common-mode current is to bypass both input leads to the converter baseplate using Y-capacitors (C2) as shown in Fig. 2. The leads should be short to minimize parasitic inductance. Additionally, a common-mode choke (L1) is usually required to meet FCC/VDE A or B.

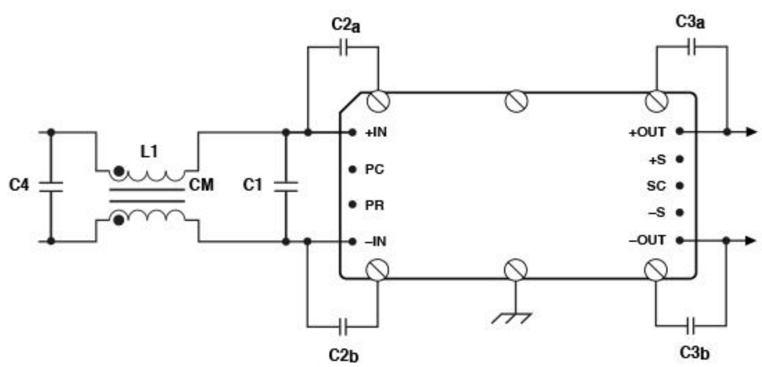

Fig.2: EMC common-mode input filter example

All Vicor converters have an internal differential-mode LC filter which, in conjunction with a small external capacitor C1 as shown in Fig.3 reduces differential-mode conducted noise. The external capacitor should be placed close to the module to reduce loop cross-sectional area of differential-mode current flowing between the supply and C1. Twisting the input leads can cause noise cancellation, and PCB power planes can reduce radiated noise if the traces are on opposite sides of the PCB directly over one another.

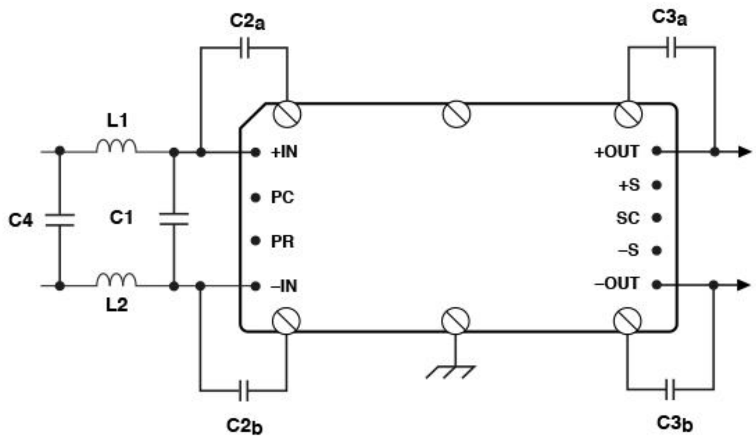

Fig. 3: Differential-mode filtering example

In general the common-mode choke is the inductor of choice for EMI filters, as it offers better attenuation. In some cases, such as military applications, both common-mode and differential–mode filters are required; if so they can be used one after another in front of the converter. For more demanding applications, [active input filters] provide greater attenuation of both common-mode and differential-mode noise.

Vicor's ZCS topology minimizes discontinuities in the switched current waveforms, reducing conducted and radiated noise. This means that in some circumstances, Vicor converters can be used without input or output filtering. Whilst an output filter is usually only required in particularly demanding applications, an input filter is advisable or essential for many applications.

1

Tags: back to basics, EMI, FIAM, filter

Comments are closed.

Search & Hit Enter

Online Design Tools

- Solution Selector
- Whiteboard
- Simulators
- Product Configurators
- Calculators

Get Connected

Follow @VicorPower

Follow 4,578

Recent Posts

- Power Averaging Webinar Shows Why Peak Power is the Wrong Metric
- Power System Design is Changing Fast
- Bridging Language Barriers in Manufacturing Training
- EDN Reviews the Power System Designer
- Vicor ZVS Cool Power Regulators => the Sweet Spot in Integration