TECHNICAL ARTICLE

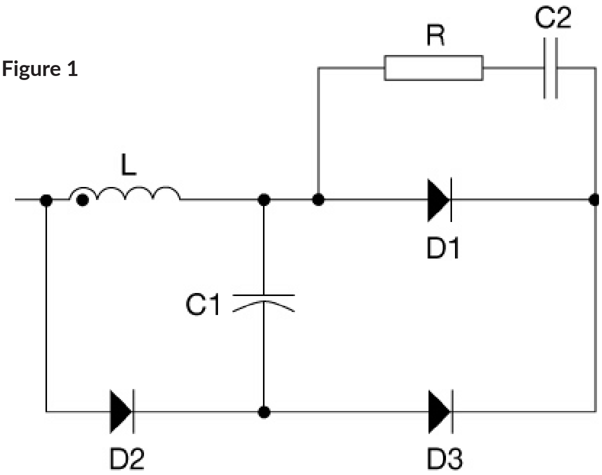
HOW TO REDUCE SIZE AND INCREASE PERFORMANCE IN AC/DC POWER SUPPLY DESIGN

Improvements in AC/DC power supply design are evolutionary, rather than revolutionary. It's easy to settle for tried-and-tested approaches because no one new design technique is likely to yield great benefits. The design challenge is to establish what small enhancements can be made in various parts of the design to achieve worthwhile improvements in power density, efficiency and EMC performance. This article looks at some new techniques that have recently been pioneered and tested in commercial power supplies. Many are equally applicable to many in-house custom power supply designs.

1. Solder power semiconductors directly to the printed circuit board then bond them to the chassis, rather than insulate them and clamp them to the chassis with a conventional nut-and-bolt fixing. Good thermal bonding materials are relatively expensive but the technique reduces assembly costs, reduces size and will typically result in 10 °C cooler junctions. Furthermore, thermal performance is more predictable and consistent. With less heat to worry about, designers can decide to take the increased MTBF advantage – a rule-of-thumb says that MTBF doubles with every 10 °C reduction in temperature – or push the power supply to higher power levels without reducing the original calculated MTBF.

2. In boost converter designs, replace power diodes with silicon carbide types. A major disadvantage of conventional diodes is reverse current spikes. High reverse current produces wasted power in the diode and switching transistor that needs to be dissipated using a snubber circuit as shown in Figure 1. Six additional components are used to dissipate the power generated by the unwanted reverse current. The resulting PCB area is shown in Figure 2 with the relevant components highlighted with blue dots. The SiC diode has very low reverse current so can be used without additional components, resulting in space saving on the board, as shown in Figure 3, lower assembly costs and greater reliability. In addition, because almost no power is lost due to reverse current, the efficiency of the power supply is increased by around 1% - a significant improvement. With respect to cost, the SiC solution is now comparable to using a conventional diode and snubber circuit. Estimates of present component costs based on a 1000W power supply are shown in the table below.

Figure 1

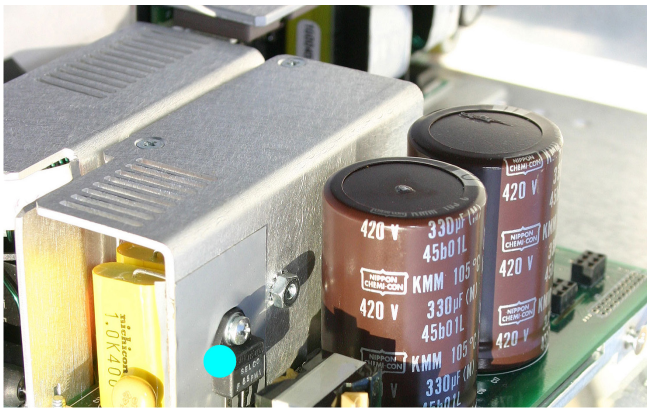


Conventional diode & snubber		Silicon carbon diode	
Component	Cost (US$)	Component	Cost (US$)
D1 20 A/60 V diode	1.75	D1 SiC diode	
D2 diode	0.70		
D3 diode	0.70		
L inductor	0.17		
R resisitor	0.03		
C1 capacitor	0.09		
C2 capacitor	0.06		
TOTAL	3.50	TOTAL	4.80

The lower component cost of the conventional solution is counterbalanced by lower assembly costs for the power supply. Furthermore, the price of SiC diodes from the main manufacturers, Infineon and Cree, is continuing to fall as the technology becomes more widely adopted, so the use of SiC diodes will soon become the most economic approach.

Figure 2

Figure 3



3. Don't connect power semiconductor heatsinks to the chassis – let them 'float' electrically. This has three major advantages. Firstly, it reduces EMI because interference is not conducted to the chassis. Secondly, it removes the need for metal oxide varistors (MOVs) that are usually needed to deal with surges because by floating the heat-sinks surges are prevented from being transferred to the power supply at all. Finally, it reduces leakage current – something that's particularly important for medical applications.

4. Don't settle for conventional approaches to mechanical design. Here are some examples where creative thinking has yielded benefits:

    a. Torroidal chokes for EMI filters can be stacked above filter capacitors, rather than placed alongside them on the PCB, as shown in Figure 4. This not only saves board space but results in shorter interconnects between filter components and better filter performance.

Figure 4

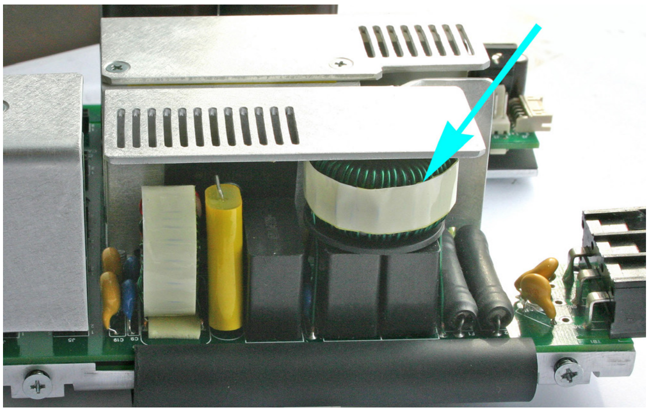
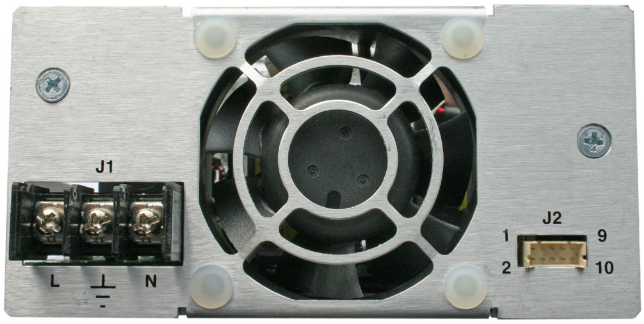


Figure 5



    b. Conventional fan guards, fitted flush to the chassis, can create considerable air turbulence and noise. The custom-designed fan guard shown in Figure 5 is punched out of sheet metal and raised up to create a 4mm gap between the fan and the fan guard. This reduces fan noise by 4dB, a welcome improvement in many operating environments.

    c. Make fans field replaceable. This has two advantages. Fans are potentially the most unreliable parts of any power supply, so making them field replaceable reduces servicing costs and assists planned maintenance programs. Furthermore, if the power supply is for sale commercially, it means that the fan does not have to be taken into account in any MTBF calculations because it is not considered an integral part of the unit. This boosts the calculated MTBF figure.

    d. Minimize the number of PCBs in the design. Many designs use separate boards for the main part of the power supply, EMI filtering and control/interface circuitry. With a little care, all of this can be done put onto one PCB, greatly improving reliability through minimizing the number of interconnect parts and re-ducing overall power supply size.

None of the techniques described above is in itself unique, but together they were recently applied to the design of XP Power's 'fleXPower' configurable power supply, shown on the front page, and produced a product that is 10% smaller and 1% more efficient, with better EMI and leakage current performance, lower component count, reduced manufacturing costs, easier maintenance, and lower acoustic noise than its predecessor. Nothing revolutionary per-haps, but a very much better power supply nevertheless.