# Improving Efficiency on AC-DC Supply Efficiency

## *Can further gains continue to be made?*

*It's tough to get improve efficiency when supplies are already at 90%, but it can be done by focusing on passive and active components, digital control, supply topologies and packaging*

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For AC-DC power supply users, the good news is that efficiency is now over 90 percent, which represents a significant improvement over the past 20 years when it hovered in the 60 to 80% zone. The not-so-good news is that there are still market pressures to increase the overall efficiency. As all designers know, achieving those last few points of improvement can be more challenging than getting the first 10 or 20 points.

While there is still room for improvement in both efficiency and thermal performance, why try for a few more points of gain if it is so difficult? The reason is that what looks like 'merely' two percentage points still represents considerable dissipation, especially at higher power levels. An improvement from 90% to 92% efficiency is really a decrease of 20% in inefficiency (10% down to 8%), which is a significant energy cost saving. It can be done: at 230 VAC input, AC-DC supplies from N2Power have achieved 93% efficiency for 48V output, for example.

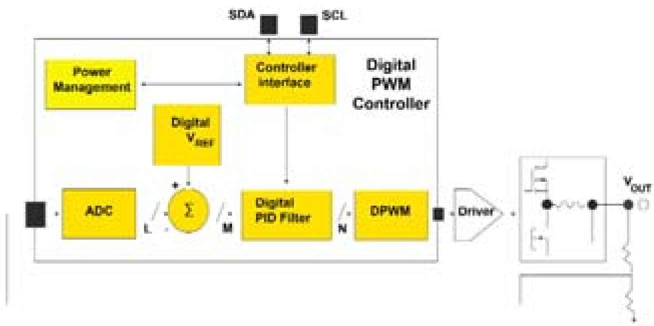


*Figure 1: The 375W AC/DC unit from N2Power achieves 93% efficiency for 48V output*

There are potential gains in four areas: power-circuit topologies, intelligent digital control, better power components and packaging. Factors which are being explored to improve efficiency include:

- More options to select the best overall converter topology for a desired power level. Digital control of the inner loop will not only improve efficiency, it will also allow for dynamic changes in control strategy to meet varying line and load conditions.
- Reduction of parasitic resistance and inductance in interconnections, as well as copper and energy losses in the inductor.
- Better magnetic components, including lower-loss core material, where applicable. Magnetics have shown much progress over the years, but not as much as semiconductors or topologies, so there is room for improvement.
- New technologies for discrete power semiconductors. For example, Efficient Power Conversion Corporation plans to introduce a line of enhancement-mode gallium-nitride-on-silicon FETs which may provide a better performance than conventional MOSFETs, due to their lower gate to source charge and lower RDS(ON). Note that it is not just the FETs, as low-loss silicon carbide (SiC) diodes from Infineon, ST Micro and Cree offer some intriguing design opportunities.
- Packaging improvements are offering new options for getting the heat away from the supply itself. It's not enough to have an efficient supply if you can't dissipate the heat and therefore prevent temperature build-up.

**Change will come, quickly and slowly**

We might see an increase of one to two percentage points in efficiency in 2013, and two to three points over the next five years. This means we can perhaps reach 93% at 115 VAC, and 95% at 230 VAC. However, achieving another four to five point improvement is less likely because that would mean 98% to 99% efficiency at 230VAC for +12V output, for example, which would be very tough.

We'll also see improvements in power factor correction (PFC) performance over a broader range of AC-line input range, as well as tolerance of various load faults and characteristics.

Perhaps most dramatically, the increased use of digital control loops (not just digital supervision of analog loops) will change performance levels, improve PFC, add flexibility and enable the supply to adapt to varying and complex line and load situations.

This will open new ways to optimize the supply's operation for non-static situations, hot-swap requirements and N+1 operation. Increased real-time reporting on the supply's operation and internal parameters will become more common and detailed, allowing for earlier assessment of the supply's 'health' and system situation. The challenge is that the power-supply user community is very cautious—and rightly so—transitioning to this new technology will take time.

**Efficiency challenges still remain**

Current levels are increasing, so factors such as contact and lead resistance, internal IR drop, and related electrical basics are becoming more critical. Operating the supply at higher internal voltage is part of the answer for increased efficiency, but this brings new creepage, spacing and safety issues.

*Figure 2: The increased use of digital control loops enhances performance and enables the supply to adapt to varying and complex line and load situations*

Increasing the frequency of operation  represents a trade-off in size versus efficiency. This is due to increased core losses in magnetics and increased switching losses in the semiconductors. In the AC input range from 90VAC to 264VAC, we have 380-400VDC at the output of PFC stage, but it is difficult to employ a 450VDC capacitor because of size. In this universal range right now, it is not advisable to go to higher internal voltages. But if 48VDC becomes the standard voltage for the output, very high efficiencies could result.

Many other challenges exist. These include the lack of very low-loss core materials, the lack of smaller-size high-voltage capacitors, and slow development of lower RDS(on) and gate-charge MOSFETs. That is before you consider the absence of low-cost, low-drop, high-voltage Schottky diodes.

There are also broader design issues. Many engineers are unfamiliar with how to use digital control to implement switching a single converter on/off in a PFC interleaved stage, or switching off one converter at low loads in paralleled converters. ICs with low quiescent current are required to minimize the no-load input power. Replacing a lot of internal circuitry with a microcontroller could provide more space for other components.

**Users must play their part, too**

Of course, the entire system-level efficiency burden can't be placed on the supply OEMs. For supply users, a few basic rules will help. First, don't oversize the supply as insurance to be used in case the unit can't actually provide its full output under all specified conditions. It's actually counterproductive, since most supplies have a 'sweet spot' of efficiency somewhere in the range of 80-90% of their maximum load rating. If you run the supply at much lower loads than this, you'll actually be operating in a very inefficient region. Instead, rely on engineers at top-tier supply OEMs to provide the necessary design margin for corner-case performance.

Second, try to avoid active (forced air) cooling using fans, since they waste power, increase noise and reduce reliability. Instead, use an efficient supply, properly sized, and mount it so unforced convection and conduction cooling with keep it within its rated temperature. That way, you will have a more efficient design and one which is also more reliable, if done right. At N2Power, for example, we have characterized and fully specified our XL375 Series of 375W supplies for operation with passive convection cooling in response to user requests.

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