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MAKE vs. BUY FOR AC/DC SUPPLIES: WHAT ARE THE TRADEOFFS?

Changes in industry regulations and available ICs reshape this age-old question

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The dilemma of whether to design and make your own AC/DC power supply, or to instead buy one "ready-to-go" from an outside vendor, is one which designers have wrestled with for years. In the last few years, the criteria by which you make this decision, the available tools and components, and the demands on the supply itself have changed, but the importance of the decision has not.

Let's begin by defining a typical supply: it operates from the AC-line mains (nominal 120V/240V, 50/60Hz) and delivers one or several DC rails, usually between a few volts single to around 48V, at power levels of under 1000W (corresponding to around 10A output).

For example, the XL375 AC/DC supply from N2Power shown in **Figure 1** provides 375W of output between 12V and 56V (depending on model) in a 3.3 x 5.0 inch (8.4 x 12.7 cm) footprint, with power density of 15 w/in3 (1W/cm3) with forced-air cooling, and 260 W with convection cooling.

Figure 1: In the 'make vs. buy' decision, a commercially available supply such as this 375W unit from N2Power may provide the performance, packaging, and price combination that is very difficult to achieve and verify.

But those specifications are just the first layer of the supply-requirements puzzle. Today's supplies must do more than just deliver power. They have to meet increasingly stringent safety regulations, EMI/RFI standards, efficiency mandates, and power factor correction (PFC) objectives. In some specialty applications, such as medical instruments, they also have to be designed to keep leakage below a threshold, and assure that component failures will not cause life-threatening conditions.

Advanced ICs make design seem easy enough

The good news is that if you are doing your own design, today's ICs make it much easier to do so. Many of the ICs embed sophisticated control and algorithms for PFC, enhancing efficiency, transient response, load/line performance, while minimizing EMI. These ICs feature advanced topologies and operational modes which would be difficult to design on your own "from scratch".

Some of these power-supply ICs support the trend towards digitally controlled supplies, where your system can both monitor many internal parameters of the supply and also adjust these dynamically for optimal operation depending on many internal factors (loading, for example) as well as external considerations (ambient temperature, AC power costs).

Further, the vendors of these supply ICs offer reference designs and development tools which can, at first glance, make the supply design almost trivial. These fall into two categories. In the first, you get a detailed reference design for a specific supply (such as 375W, 48VDC) which includes a schematic, PCB layout, and BOM. In the second category, you use the vendor tools to define what you need in specifications, and then it returns with the appropriate IC(s), passive components, schematic, layout, and performance curves.

The most common reason to do the supply design internally is that the product's form-factor is unusual or unique. Apple's notebook power supply, **Figure 2**, is a good example. Others would be the supply in a TV converter box, where packaging constraints are very different than a standard supply (open-frame, module, PC board, or box) can meet.

In addition, the higher volumes of these consumer products may be a strong justification for the custom design. If you are looking at around 1000 units/month or more, you'll be amortizing the design/qualification process, and careful BOM (bill of materials) analysis may show you can achieve higher profit margins.

Another reason to do your own design is that your requirements fall outside of the mainstream of what's available, or very few vendors meet enough of your requirements. Examples would be supplies for specialized physics projects where the DC voltage must be very high (>1000V) to drive unique arrays of sensors. However, even for these situations, there may be a supplier or several who come close enough to what you need, or can modify what they offer.

A power-supply design is a balance among tradeoffs and constraints of nominal performance, efficiency, thermal issues, maximum/minimum parameter performance, cost, complexity, reliability, technical risk, and BOM supplier uncertainty, to cite a few issues. Still, there are some applications where one performance parameter is so overwhelmingly critical that only a custom, do-it-yourself supply will fit, since no commercially available unit is prioritized for that parameter to the near-exclusion of others.

Another reason to do your own design is when your requirements are much looser than the commonly available supplies, and you can thus "get away" with much less. A supply for a basic indicator lights may have relatively loose nominal specs for output accuracy, in the order of 5%, and few or no transient load issues, so a rough, low-cost design may be all that's needed. At the other end, you may need specs that are far better than what's available, which is sometimes the case for science (physics, medical) applications.

A final reason to do your own is in-house expertise. If you have been doing supplies for years, are familiar with balancing, meeting, and testing to the technical and regulatory requirements, then you are ahead of many design OEMs whose expertise is in digital design.

So why not design your own?

Reality is that while a basic supply design may be straightforward, a fully qualified design which meets all of the performance and

Figure 2:
Sometimes in-house design is the preferred option due to the unique nature of the product, as in Apple's notebook power supply

regulatory specifications is not, and that's not even taking into account the cost and sourcing of the many components in the complete design.

Start with the design itself. Certainly, ICs can implement a complex topology, but every AC/DC supply needs many non-IC components. Defining and sourcing these can be a real headache, especially when their secondary characteristics play an important but subtle role. For example, a capacitor is defined primarily by its capacitance and working voltage, but its ESR (equivalent series resistance) affects its operation, especially at higher frequencies.

Even with the right part, you face supplier issues. Your purchasing group or assembly operation may substitute a nominally identical part for an inductor, for example, to save cost or have an alternate source. So your supply is in production, all is going well, then months later, the field problems start to appear and supplies either fail or no longer work to spec—and soon the alarm bells start sounding back in engineering design group.

You also need to decide the minimum and maximum operating ranges for your design: will it be for a restricted-range line voltage, such as nominal 120 Vac±10%, or full range (120/240 Vac)? The former design is somewhat easier to do, and less costly, but also means you need a second design for the other AC mains, if you are planning to serve world-wide markets.

You need work out a test plan for the design: how will you assure that the design works in all "corner cases", such as high/low line plus maximum ambient temperature, plus line/load transients, all happening at once?

Then there's cooling: Are you planning to use convection (natural airflow) cooling alone? Do you have the tools to model your supply and its operating environment, to be certain that the available airflow (or lack) will be sufficient? Which way is the supply mounted in use, anyway?—that makes a big difference in the cooling situation. If you do decide (or find out) that you need a fan, how will you size it?

If you are designing your own supply, you're most likely using an IC or chipset from a vendor who also provides a reference design. Has the reference design actually been built and tested, or is it just a drawn schematic supported by simulation? You'll likely find that actual performance is not where it was supposed to be, as physical layout, routing and size of ground plane, power, and control traces, and connectors will make even the best simulation only a rough approximation of what the actual circuit will do. (You have to worry about basics such as DC IR drop when you are pushing tens of amps through traces and wires, too, and maybe incorporate remote sensing.)

Even if the IC vendor's reference design includes a PCB layout (which increases the likelihood that the design has actually been built and tested) you still have to be very careful if you make any change to the design's layout or BOM—making what seems, at first, like just a trivial change can adversely affect performance. You have to always keep in mind that a power supply is a closed-loop amplifier (admittedly for power rather than small signals), and thus can oscillate, have transient-response issues, and both source and be sensitive to EMI/RFI.

Regulatory and standards jungle

Even a well-designed and tested supply faces regulations and standards. These are also getting even more challenging as tighter standards are being phased in each year.

They cover:

- Basic safety, which affects insulation, isolation technique, layout spacing, and design topology
- EMI emissions, which is determined by the supply's operating frequency, internal waveforms, switching characteristics, and layout
- Efficiency, which is assessed by the relationship between AC line power used and DC output power
- Power factor correction (PFC), which defines how resistive the supply 'looks' to the AC mains as a load. Even if the supply is not resistive-looking (they usually are not), the design must employ some techniques to yield a power factor close to unity. (IEC61000-3-2)

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Adding to the regulatory challenge is their worldwide nature, which means that you'll be dealing with many regulatory authorities and their unique ways of testing and doing business.

Conclusion

Whilst today's advanced ICs, reference designs, and design tools make it easier than ever to design your own supply, there is a chasm between designing a supply that nominally works and one that meets all application requirements.
Ask yourself if designing and qualifying a supply is a good use of your engineering resources, given all the tasks your design team undoubtedly has to do. Bear in mind that if a standard power supply doesn't meet your exact requirements, most reputable manufacturers offer a customization service to adapt their standard products to your application. The combination of specifications in the N2Power unit referenced earlier in Figure 1 would be very hard for a non-expert to achieve, especially when all regulatory and manufacturing issues are added in. ■

Contact details:

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