WHITE PAPER

How to Avoid the “Hidden Costs” of Power System Design

Stop Choosing Between a Complete Power Supply or Discrete Power Design

Power system design isn’t always seen as a critical part of electronic engineering. Indeed, many engineers see the power choice in terms of either buying a complete off-the-shelf power supply or designing it themselves using discrete components. These approaches can result in unexpected costs that can be mitigated by developing solutions using modern power components.

Why Power Design is Such a Challenge

Power is different from other elements of electronic system design. Power systems don’t deliver the functionality required, but rather they supply the energy for the components that deliver the required functionality. This peripheral role is one of the reasons that some engineers treat power systems as a commodity, paying little attention to its importance to the overall system, for example by simply choosing an off-the-shelf supply that meets the requirements of the application.

A recent study has shown that most engineers need to design a range of subsystems, meaning that power is only be a small part of their role (only 12% spent three quarters or more of their time designing power systems). With the majority of their role likely to be digital design – something very different from the analog world of power design – standard solutions appear attractive, as they seem to significantly reduce the risk associated with developing solutions in-house. When things go wrong, however, the result can be a painful and expensive redesign. These unexpected costs and delays are often referred to as the hidden cost of power supplies.

Why Standard Power Supplies Can be a Mistake

For simple systems, particularly when requirements are not demanding, off-the-shelf power supplies – such as standard open-frame supplies or “silver boxes” – are often a great way to complete the design quickly. When there are challenging requirements, however, the apparently very simple solution can cause a multitude of problems. For example, no off-the-shelf solution exactly matches the requirements of the system, meaning that engineers need to either compromise on performance or accept an over-specified product that will increase cost and potentially take more space.

Many applications place requirements on the power system’s electrical performance that may not be met by off-the-shelf products, particularly when more demanding approvals or certifications are required. This is particularly the case in aerospace or defense applications.

Even less demanding applications can encounter problems: for example, standard open-frame power supplies will typically not meet safety requirements, unless steps are taken to protect people from electric shock. The need to build in protective housings removes some of the benefits of using an off-the-shelf product.

Often it is not the electrical requirements that cause problems. Environmental constraints, such as operating temperature, can present greater challenges than expected. For example, the temperature inside the system is typically higher than ambient, meaning that power supplies specified to meet the system’s operating temperature can fail as they will be in an environment that is hotter than expected, unless cooled with fans and heatsinks, which will add to the cost and size of the system.

Mechanical stress, such as shock and vibration, are common causes of failure for off-the-shelf power supplies. Standard products are typically not designed to withstand the stresses encountered. There are many obvious examples of applications where the environment itself means the systems undergo physical stress, particularly transportation applications. Even in more benign environments, such as control of manufacturing systems, small vibrations can impact reliability.

Discrete Designs: Extending Timescales and Increasing Risk

Historically engineers developing their own power systems would use discrete components; this process is time consuming and presents project risk if the engineer doesn't have extensive power design experience. The potential for hidden costs as a result of the extra engineering effort can be significant. In addition, sales can be lost because of the delayed introduction of the product due to the additional design work (see "Calculating the Impact of Project Delays").

Calculating the Impact of Project Delays

Changes to requirements after the design has begun have a significant impact on company profitability. There are two key factors:

- The cost of engineering time to implement the change
- The missed opportunity cost due to delays to the product's launch

In the USA, engineering time is typically valued at approximately \$100 to \$150 per hour, so reducing the time to modify the design can save considerable costs. Depending upon the system being developed, however, a delay in launching the product on the market can have a huge impact on profits, potentially dwarfing engineering costs, particularly if the product would have been the first to market.

The introduction of integrated controllers and reference designs has simplified the process. However, design details, particularly the PCB layout, can cause performance issues and trip up even experienced power designers. The increased risk of the system not passing test or certifications is yet another hidden cost that is associated with this approach. Discrete design is usually only the best solution if the development team has high levels of expertise and the application requires optimization for very specific criteria.

Specification Change: The Challenge Engineers Like to Forget

The biggest problem for designers is the change to specifications during system design, (87% of respondents in our recent survey said this was a key challenge and 67% said they felt the problem was getting worse).

When using standard products, the limited range of choices can present an insurmountable challenge when the demands of the application change. For example, if an extra power rail is required, which also increases the total power demanded by the system, the only option may be a significantly bigger power supply. With most systems facing space constraints, the larger supply may not even fit, even if there was ample room for the original solution.

With discrete power system designs, the challenge of changes to specifications is even worse. The time-consuming nature of this approach means that any change in specification after design work has begun can result in a large amount of additional work to modify the first design, resulting in project overruns and increased cost.

The Solution is a Robust Methodology

The solution to the issues highlighted above is the introduction of a robust methodology. Rather than simply selecting a standard product that superficially appears to meet the criteria, engineers should carefully consider what is really needed and ensure there is flexibility to deal with unexpected changes to requirements. This is the only way to prevent the cost and work that result from problems are encountered late in the development cycle.

Once such an approach is used, it quickly becomes apparent that using off-the-shelf supplies provides far fewer choices than initially expected. Once all the factors are considered, engineers often conclude that developing the power system themselves is a more attractive option.

Case Study: Laboratory Equipment

A customer's product used two sensors to make measurements for DNA analysis and had previously been powered by a fan-cooled discrete power supply. By switching from a discrete supply to a design using power components, including the PFM, AIM and ZVS Buck Regulators, the size of the power system was reduced from $161cm^2$ to $64cm^2$, a saving of 60%.

During development it was decided to increase the number of sensors from two to four. This meant that the current demanded on all three sensor power rails doubled and the total power requirement increased from 200W to 350W, yet the size of the power system had to remain more or less the same size.

By using the Power Component Design Methodology, the customer was able to modify the solution to provide the additional power with a size increase of just 6%, to $67cm^2$. An equivalent discrete solution would have needed $346cm^2$.

Power Components: The Right Level of Integration

The use of modular power components is a balanced solution that offers "the best of both worlds". Unlike discrete designs, power components are easy to use, overcoming the issues associated with limited specialized power knowledge and resource. Yet they allow the power system to be designed at a more granular level than off-the-shelf power supplies, enabling customization to the needs of the application. Power components also provide flexibility that can accommodate changes in requirements with significantly less engineering effort than would be necessary for either discrete or off-the-shelf solutions.

The Vicor Power Component Design Methodology together with its supporting online tools enables engineers to architect and analyze power systems quickly. Often in less time than it would take to select an off-the-shelf supply from a portfolio of manufacturers. The robust approach inherent in the methodology helps to eliminate problems later in the design, while the flexibility of power components can accommodate changes to requirements with minimal project disruption.

Using the Vicor Power Component Design Methodology does not require a high degree of power expertise since the power components are designed to work together with minimal peripheral circuitry. These benefits mean that engineers who have previously used discrete design, as well as those who preferred off-the-shelf supplies, are switching to the Power Component Design Methodology to reduce the hidden cost of power system design.

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