Designing Industrial Power Supplies with Standard Modules

Some of the first modular DC-DC converters ever built are still in operation today. But more to the point, those designs are still being manufactured today. What's more, new designs have recently been introduced, giving designers more choices than ever. **Joe Sullivan, Product Marketing Manager, Brick Business Unit, Vicor Corp., Andover, USA**

A little over twenty years ago, about three years after the first standard power component module was developed, the first full-size power component – the brick – was introduced. In subsequent years, Distributed Power Architectures appeared and flourished, the Intermediate Power Architecture carved out its niche, and Factorized Power Architecture has arrived on the scene, to mention just a few of the important milestones since the brick appeared. Nevertheless, today, after a quarter century has passed, the brick is still alive and well. Interestingly enough, 36 full brick and quarter brick designs have been released in the past few months, with more to follow in the half-brick package, adding to a total of about 2300 designs.

Advantages of standard modules

Standard modules are widely used in industrial power supplies. Typical applications encompass products, equipment, and systems found in such applications as process control, medical, seismic, test, transportation, agriculture, material handling, marine, and commercial aviation. These are applications that prize such power attributes as quick turnaround, parallelability for high power and redundancy, reliable performance, and low cost.

The traditional approach to power system design usually results in a custom design (done either in-house or by an outside company) made up of discrete components. The development cycle can require 6 to 9, 12, or even 18 months to design, breadboard, troubleshoot, lay out, prototype, debug, obtain agency approvals, etc. By definition, the designer of a custom power solution is starting at the beginning.

System development is the typical critical path so the power supply is usually the last sub-assembly to be specified. Some concurrent design may be undertaken, but started too early it can result in unnecessary redesign, adding cost and delays. System modifications can change the power supply specifications, and custom solutions are more prone to unexpected problems. Both are likely to result in lost time.

Modular power components are the clear choice over a custom, discrete approach if time to market is an important criterion. Development time is shorter, less expertise is needed, and agency approvals take less time because the modules are pre-approved. The power supply designer can even obtain rapid delivery of small prototype quantities in the final form factor well before the system design is finalised.

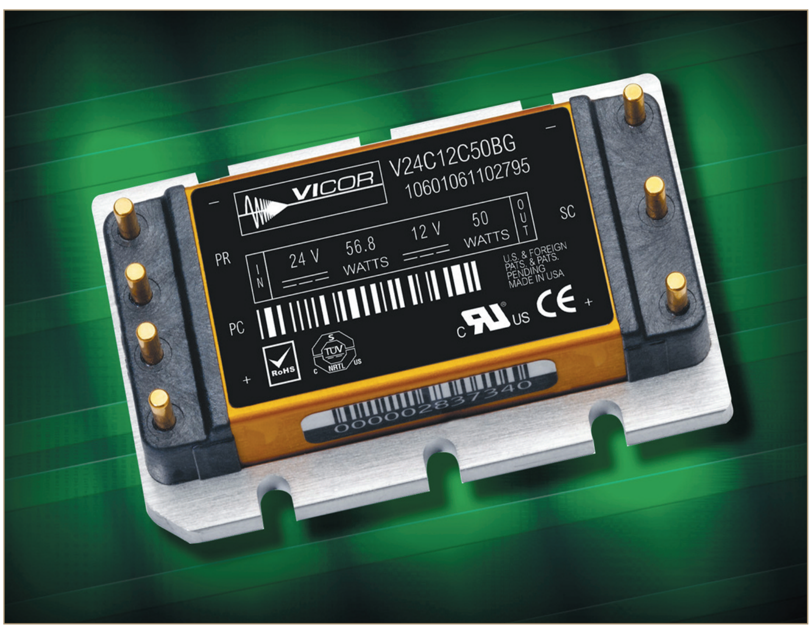

Figure 1: Recently released 50 W micro module featuring 24V input and 12V output voltage

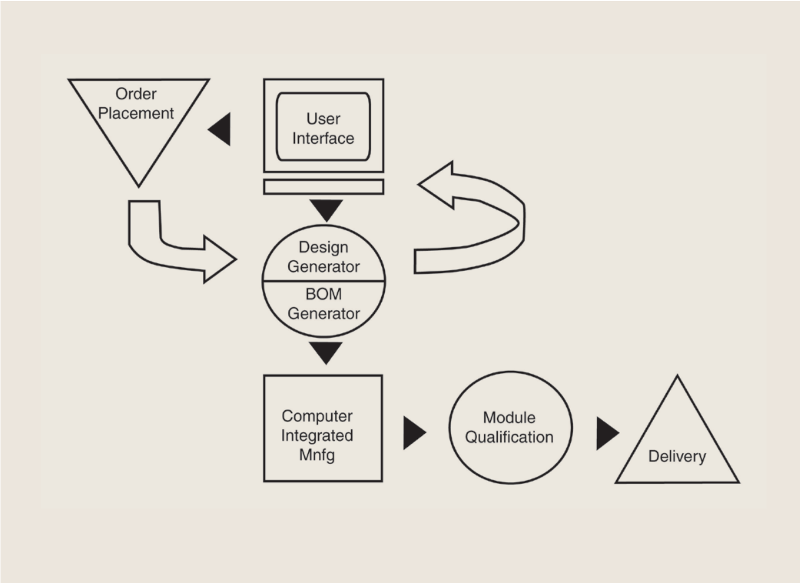

Figure 2: **Custom module design system overview diagram**

Paralleling for higher power or fault tolerance

Power architects often employ multiple power supplies or power converters to increase output power or to provide fault tolerance. Fault tolerant systems should in addition use O-Ring diodes to isolate modules in the event of an output fault. Current sharing is generally preferred when paralleling supplies for increased power and/or N+1 redundancy.

A reliable and cost-effective way to achieve high power levels is to use identical independent supplies operating in parallel. For example, using five 600W supplies for a 2.4kW load (N+1 redundancy) allows the power needs of the system to be met if one of the five supplies fails. To give one specific converter example, the parallel (PR) pin of a Vicor converter offers several approaches to solving some of the technical challenges of parallel operation, including accurate power sharing and true fault tolerance.

The simplest approach to current sharing is to interconnect all of the PR pins. Current sharing accuracy will typically be within ±2%. This method is not truly fault-tolerant, however, in that a fault to ground on the common bus may bring the entire array down. Since the signal on the PR pin is actually a pulse, each converter can be isolated from the common bus via a capacitor or transformer, eliminating this failure mode.

To reduce input and output filtering requirements of multi-module arrays, converters can be connected through a Phased Array Controller (PAC) interface. The PAC integrated circuit not only supports accurate current sharing through an isolated bus, it automatically adjusts the relative phase angle of each module in the array to 360/N degrees, where N is the number of active modules and is ≤12. By interleaving the switching of each converter, the effective switching frequency of the array is increased by a factor of N, significantly reducing the size of any required filtering elements.

Often built in highly automated, advanced manufacturing facilities, component power modules are produced more consistently and with higher quality than conventional power supplies. Field MTBFs in the tens of millions of hours are not uncommon. High quality modules designed to work together mean fewer problems for the power supply designer. Debugging time for conventional discrete designs frequently adds significant time to the development cycle.

In a straight hardware cost comparison, a conventional discrete approach can cost less than components for some applications. Designers have to consider, however, the available design and development resources and the total budget. Total costs over the lifetime of the power supply are likely, especially lately, to be comparable. Costs for design and development time should be included in any comparison. The cost impact of quality and reliability, both negative and positive, should also be a factor. Most important (and difficult to quantify) is the lost or gained market opportunity resulting from the use of custom discrete power versus modular component power.

On-line real-time design aids

The point made earlier about the vast number of available brick designs – with more continuing to being added – does not give the full picture of the range of DC/DC converter designs available to power architects. On-line, real-time configuration and design tools give designer the additional, and unique, ability to design his own.

One of these is the Custom Module Design System (CMDS), a patented system that enables customers to specify on-line, and verify in real time, the performance and attributes of Micro, Mini, or Maxi DC-DC converters (see Figure 2).

CMDS enables the design of DC/DC converters with any output voltage between 2 and 48VDC, with any input voltage from 18 to 425VDC within an input voltage range of up to 2.1:1,and in full- half- and quarter-brick sizes. Output power is selectable over a continuous range of 20 to 500W per module and modules can be configured in fault-tolerant arrays capable of delivering several kilowatts.

CMDS offers two design opportunities. 'Predefined' allows the user to select a 24, 48, 300, or 375V_{in} converter design and select from a variety of pin, baseplate, and environmental grade options. CMDS will return a part number and US 1-piece price. Predefined modules have no nonrecurring engineering (NRE) charge and are available in standard lead times.

'User Defined' allows the user to enter their design parameters (including input voltage range, output voltage set point, output power and environmental grade) and mechanical variations (including package size, baseplate and pin options). Using these specifications, CMDS will test the feasibility of the design in real time, usually less than 30 seconds. If feasible, CMDS will provide a unique part number and unit price.