Partitioning Rethink Enhances Military Power Designs

In this era of multi-voltage electronics and distributed architectures, military power system design is getting tricky. A new approach to separating functions keeps those challenges in check.

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Designers of military embedded applications are generally slow to adopt new technology, opting for the tried and true. There are times, however, when a new approach offers such compelling advantages for the military that traditional methods are overcome. Separating DC/DC converter functionality, especially at the point of load, provides important benefits to military application such as flexibility and size and weight reduction.

For decades, the bricks of Distributed Power Architecture (DPA) delivered the classic functions of the DC/DC converter—isolation, voltage transformation and regulation—to the point of load. As the number of voltages required at the board level began to proliferate, however, DPA increasingly consumed valuable real estate and unnecessarily replicated full converter functionality.

Handling Multiple Voltages

The Intermediate Bus Architecture (IBA) was introduced to deal more cost-effectively with the growing need

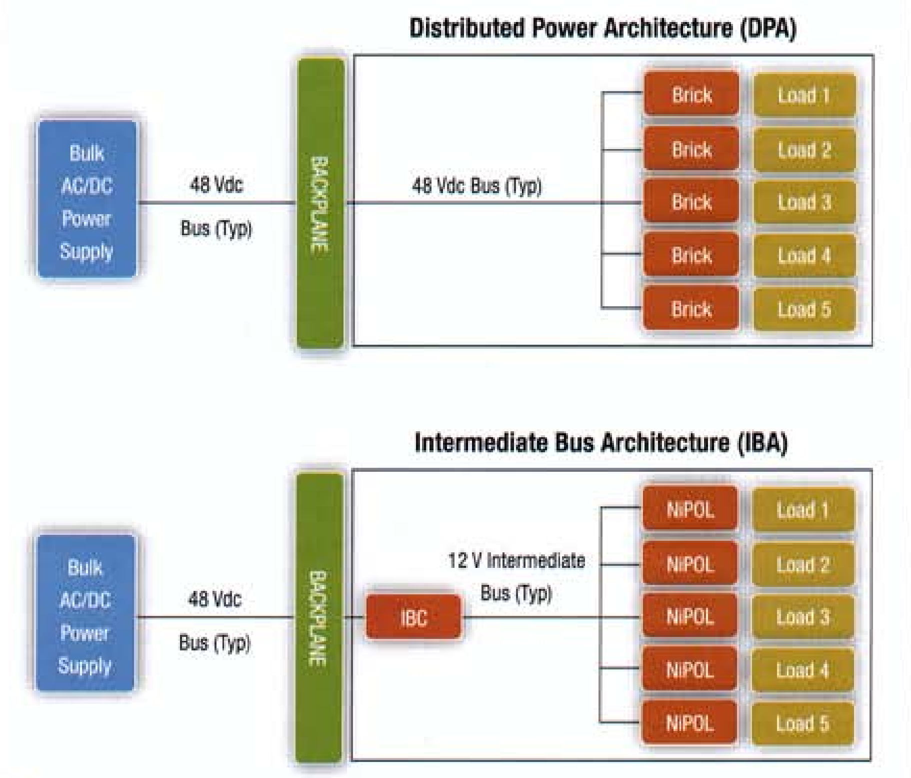

Figure 1

The Intermediate Bus Architecture uses one or more IBC module to provide upstream isolation and a lower intermediate bus voltage distributed to non-isolated point-of-load regulators.

Figure 2

In Vicor's military V•I Chips, the VTM current multiplier and the PRM regulator are each 1.28 x 0.87 x 0.26 in (32.5 x 22.0 x 6.6 mm) in size, with a footprint of 1.1 in2.

for many low voltages (Figure 1). IBA relies on non-isolated point-of-load regulators (niPOLs), reducing the POL function to regulation and transformation. The niPOLs operate from an intermediate bus voltage provided by upstream isolated converters. The IBC (Intermediate Bus Converter) will typically be unregulated and have a narrow input range, resulting in somewhat better efficiency and mitigating the loss of efficiency resulting from an intermediate stage followed by a point-of-load stage. The typical IBC is also isolated. IBA can be a more cost-effective solution because niPOLs, being non-isolated, are less expensive than complete DC/DC converters.

In a second DC/DC converter architecture with decoupled functionality, Factorized Power Architecture (FPA) breaks power conversion into flexible and scalable power building blocks called V•I Chips (Figure 2). The Voltage Transformation Module (VTM) is a current multiplier that provides transformation and isolation. The Pre-Regulator Module (PRM) provides a regulated, non-isolated output voltage—a "factorized bus"—that is settable within the range of 26 VDC to 50 VDC from an unregulated input source.

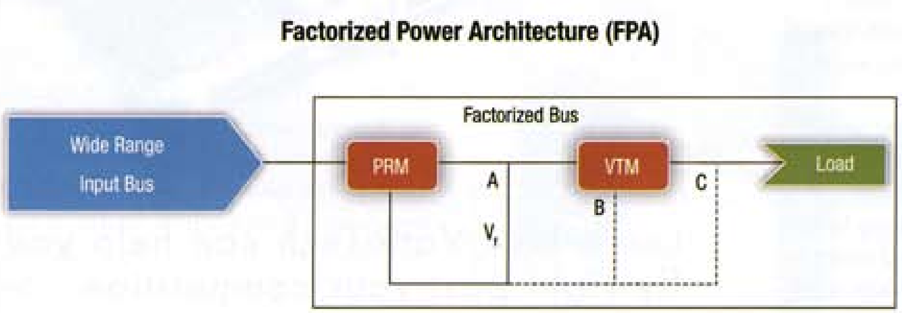

Figure 3

Decoupled functionality increases power designer flexibility. In this example, the output voltage of the VTM can be controlled with a choice of methods.

The combination of the PRM and VTM creates an isolated, regulated DC/DC converter. PRMs can also be used standalone as non-isolated voltage regulators when the input and output returns are not common. A military PRM-VTM chip set can provide up to 100A or 115W at a system density of 172 A/in^3 or 198 W/in^3 and because the PRM can be located, or factorized, remotely from the point of load, these power densities can effectively be doubled.

Separation Gains Flexibility

As suggested earlier, separating DC/DC converter functionality whether by IBA or FPA provides important performance benefits as well as size and weight reduction, which are often highly valuable in military applications. Moreover, the simple act of separating functionality gives power designers additional design flexibility. The ability, for example, to place a small component such as the VTM at the point of load with its equally small complement (PRM) located elsewhere, can have important benefits for military embedded applications, such as lower heat dissipation at that point.

A large number of manufacturers supply niPOLs with many input voltage ranges and different output voltages available. Most contemporary systems require a large number of lower power voltages on a card that serve, for example, microprocessors, DSPs, ASICs and FPGAs.

An intermediate bus converter, or IBC, which is sized for whatever the card needs, commonly feeds this card. It provides the common voltage source from which multiple niPOLs are powered to supply a regulated voltage to their respective loads. The "intermediate" voltage level is chosen to "bridge the gap" between the input distribution bus and a typical load. Power levels can vary greatly depending on the application, but in some military airborne radar systems, a card may be required to provide greater than 4 KW, which is achievable with a V•I Chip solution.

One of the key objectives of factorized power and V•I Chips is to increase power system flexibility. Families of V•I Chips, optimized for different nominal input and output voltages, and packaged for power capabilities, provide power systems designers with a stable of power conversion components that can be used to solve a wide variety of power conversion problems.

Eliminating External Components

Complex systems can use combinations of V•I Chips to rapidly configure high-density, low-profile solutions that minimize the need for external components, are cost-effective and highly efficient, and provide state-of-the-art performance. A simple example shown in Figure 3 suggests the flexibility of decoupled functionality. The output voltage of the VTM can be controlled with a choice of methods. The local loop control method, connected to A, regulates the Factorized Bus voltage. The adaptive loop control method, connected to B, improves regulation to within 1 percent. The remote loop control method, connected to C, improves regulation to within 0.2 percent.

As stated earlier, one of the advantages of separating the DC/DC converter into two components is to eliminate the unnecessary duplication of functionality. In some military applications, such as powering ground mobile RF amplifiers, an isolation stage is not required—only a stable voltage is needed. Here a PRM alone can be used as the sole regulator. PRMs can also be paralleled for higher power as required by the application.

Both the PRM and VTM can each achieve higher than 97 percent efficiency. Overall efficiency for a power system—including the combination of a PRM and a VTM—operating from an unregulated DC source and supplying a low-voltage DC output typically ranges from 90 percent to 95 percent. In many cases, it is possible to achieve overall system efficiency exceeding 95 percent even at full load. With higher efficiency comes lower total heat dissipation, another important consideration in Military power systems design where thermal management options are strained due to the amount of and the challenging environment to which they are subjected.

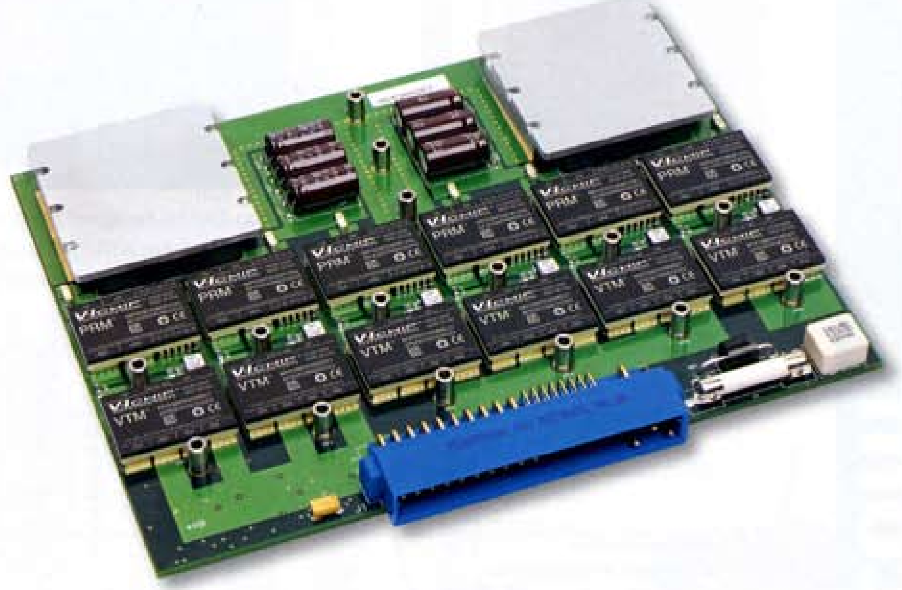

Figure 4

In contrast to traditional units occupying two VME chassis slots, this one-slot VME power card provides higher efficiency (85 percent versus 78 percent), less weight (2.4 pounds versus 3.5 pounds) and the output, of course, is 450W versus 300W. It uses six PRMs and six VTMs.

Benefits of Integration

With niPOLs and V•I Chips weighing just a fraction of an ounce and having a footprint of a square inch or so, they offer clear advantages to designers of military power systems in mission-critical portable and airborne applications. V•I Chips have been and are being designed and deployed in, for example, electronic systems mounted in military ground vehicles as well as airborne platforms (manned and un-manned), including helicopters.

An example military solution (Figure 4) is the one-slot VME power card—28 Vin, 450W out, four outputs. It meets MIL-STD-810 for shock and vibration as well as MIL-STD-461 for EMI specifications. In contrast to traditional units occupying two VME chassis slots, the one-slot VME power card provides higher efficiency (85 percent versus 78 percent), less weight (2.4 pounds versus 3.5 pounds), and the output, of course, is 450W versus 300W. It uses six PRMs and six VTMs. ▮▮

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