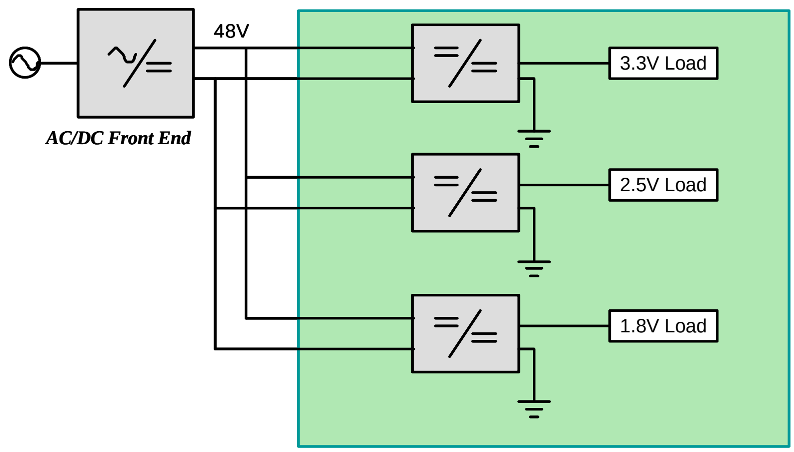
Intermediate Bus Architecture

A number of important trends in the electronics industry are converging to further complicate the choice of power architecture. Traditionally, bulk power has worked well for systems with a number of load voltages. Distributed power has found its niche in systems requiring low voltages at high currents. But now many designers are faced with providing substantial amounts of current to an ever-increasing number of load voltages. System designers today are often challenged to deal with as many as seven different voltages on a single board.

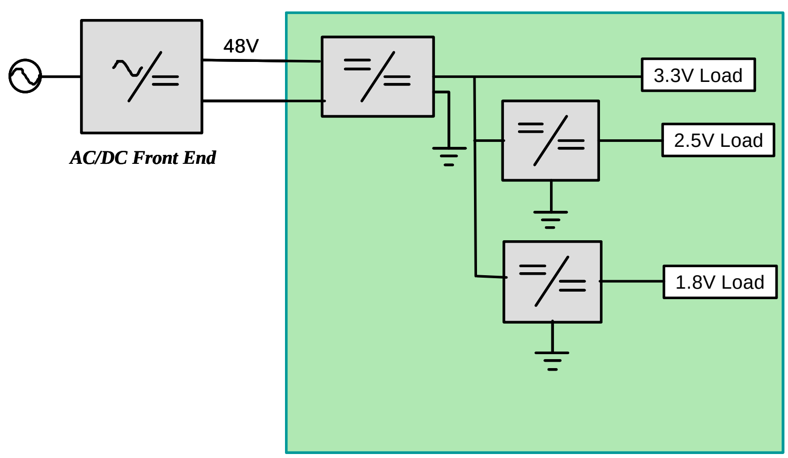
While 48V distributed power systems have soared in popularity for networking, communications and even high-end computing equipment, the basic architecture was devised with the notion that there would typically be one or maybe two different load voltages per board. Providing for more than two output voltages with isolated converters requires significant amounts of space and rapidly becomes very expensive.



Traditional Distributed Architecture

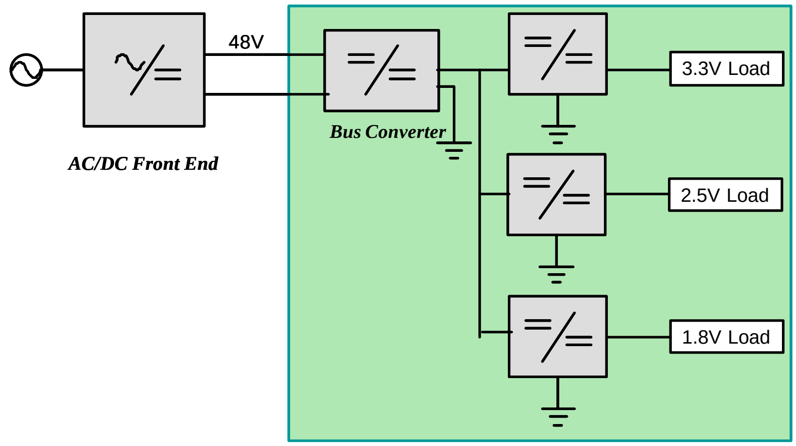
Isolated converters are inherently larger, more expensive, and less efficient than non-isolated converters. Isolation requires not only a transformer (whereas most non-isolated converters can use a smaller, less expensive inductor) but the control loop of the converter must deal with the isolation barrier passing signals from secondary to primary. The fact remains, however, that for most 48V systems, isolation from the 48V bus is a basic requirement.

A number of designers began to use cascaded converters to deal with these issues. In this approach, they would oversize one of the isolated converters (typically the 48 to 5V module). Then they would use 5V, non-isolated buck regulators to generate the lower voltages. This seemed a good approach until, as technology progressed, many cards no longer needed 5V. Some designers began using 3.3V buck regulators but it became clear to many that this was not a stable, long-term solution. Different families of buck regulators would be needed depending on what voltages were available on the various boards.



Cascaded Converters

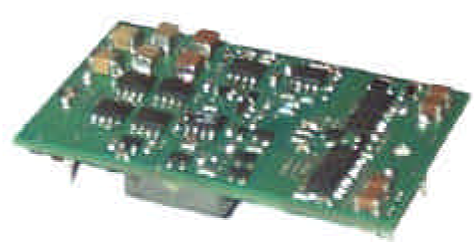
What does seem clear, is that given the cost and complexity of performing the isolation in the power train, this should be done as few times as possible within a given system. A new architecture currently emerging is what Bel has dubbed the Intermediate Bus Architecture (IBA). In this approach, a bus converter is employed which serves two primary functions. First, it provides the isolation from the 48V bus. Secondly, it reduces the 48V bus to a level where non-isolated converters can operate with reasonable duty cycle without the need for a transformer. Non-isolated buck regulators commonly referred to as point-of-load (POL) converters then generate each of the load voltages needed from this intermediate bus. Each board in a system would then have a single bus converter and POL converter for each voltage required.



Intermediate Bus Architecture

The Bus Converter

In order to maximize the advantages of this approach, a bus converter must be developed which is both highly efficient and very low cost. Bel has developed a prototype converter that provides an unregulated 12V output at an efficiency of approximately 96%. This converter design is capable of providing up to 240W in a standard quarter brick form factor or 120W in the standard eighth brick form factor. At this efficiency, the power dissipated in the module is only about 10W. By comparison, a 25A, 3.3V quarter brick, operating at 88% efficiency would dissipate 11.25W. Designing an unregulated converter means the control loop does not have to cross the isolation barrier. This also allows Bel to use a topology which not only improves efficiency but which also greatly reduces the size, complexity and cost of the converter. Since all of the power delivered by the bus converter is post-processed by the downstream converters, it is not necessary to have a tightly regulated output. It is simply necessary to ensure that intermediate bus voltage stays within the input range of the point-of-load converters. As the output voltage of the Bus Converter will be dependant upon both line and load, the variability of the 48V bus can have a significant impact upon the voltage of the intermediate bus. For this reason, Bel offers two different input to output ratios in its bus converters. The 6:1 converter can be used over the entire 36-72V telecom range providing a bus that varies from 6V to 12V. A 4:1 converter may be specified for regulated 48V applications or applications not exceeding at 36 – 55V range yielding a 9V to 14V bus voltage. Now, while most isolated converters today operate over a 2:1 input range, most non-isolated products today operate over an input voltage range of +/- 10%. For the Intermediate Bus Architecture to be viable, there is a need for a new breed of POL converters.



Bel's Quarter Brick Bus Converter
240W at 96% Efficiency

The Point of Load (POL) Converter

The POL in an Intermediate Bus Architecture system must provide the same level of transient response, voltage regulation and low output noise as the isolated converter would provide in a traditional DPA system. However, for this approach to be viable, it must do this in a smaller footprint, and at a lower cost and do it more efficiently. The providers of Voltage Regulator Modules (VRMs) have already proved that this is possible in specific applications. Indeed, the non-isolated POL is well suited to this task. The only requirement that is not generally met by products on the market today is the need for a wide input voltage range. Bel is addressing that need with a wide variety of POL converters.

Bel currently offers a number of converters that meet the requirements of Intermediate Bus Architectures. The first is a 16 amp, two-phase converter in a 1" x 2" surface mount package. This converter operates over a 3V to 15V input range and is available in a variety of output voltages from 1.2V to 5V. Bel also offers VRM8.5 and VRM9.0 compatible products with similar wide input operating ranges. Currently in development are a number of compact surface mount products and a wide input range SIP in the industry standard form factor.

Perhaps one of the most exciting products in Bel's POL portfolio is a new product being developed under the code name Keystone. This product provides 20A of output current in a compact surface mount package. It operates over a 3V to 15V input range and the output voltage is digitally programmable with a 6-bit voltage ID scheme from 0.7V to 5.4V. These units not only current share when paralleled but will also auto-phase. This allows two, three or four units in parallel to perform like two, three or four phase converters. Up to eight units may be paralleled and auto-phased. Other features of the product include remote sense, power good, remote on/off, analog trim, overcurrent and over temperature protection and undervoltage lockout.

Bel Power Products 20 Amp Keystone Series Converter

Architecture Comparison

It is important to understand how these two power architectures compare in terms of cost, board space and overall efficiency. The answers will be counter-intuitive to the one who focuses primarily on the fact that we have introduced an extra stage of conversion.

Cost

As the 48V front-end solution is the same in both architectures, we will focus solely on the on-board conversion. First of all, for the traditional DPA solution, isolated converters providing output on the order of 15-30 Amps of usable current sell today in the range of $1.50 to $2.50 per Amp. Non-isolated converters of similar power levels, even including the wide-range input feature should be available in the range of $0.75 to $1.25 per Amp. If we use an example of a board requiring 3 different output voltages, each needing 20 Amps, the traditional DPA solution would require converters costing approximately $120.

The IBA solution would require approximately $60 worth of POL converters. Given a volume price on a bus converter in the range of $30, the total savings would come to $30 or about 25% below the traditional DPA solution.

Size
If we assume, the traditional DPA solution uses three quarter bricks, the total surface area would be approximately 3 x (1.45 x 2.28) or about 9.9 square inches. Even with the addition of the Bus Converter, the IBA solution will use less space if SIP type POL converters are employed bringing the total board space to (1.45 x 2.28) + 3 x (0.5 x 2.8) or about 7.5 square inches. If horizontal mount converters are used, the board space may be slightly larger.

Efficiency
The most common assumption is that the IBA system will have much lower total efficiency due to the extra stage of conversion. However, if we look at state of the art 1.8V isolated converters on the market today, they run about 85% efficient at 20A. By comparison, if we assume the Bus Converter is 96% efficient as Bel has demonstrated and the POL converter operates at 88% efficient, the throughput efficiency of the IBA system is 84.5%. A small penalty indeed for a 25% cost savings.

Conclusion
It seems that the emerging Intermediate Bus Architecture has substantial merit, leverages existing technology and makes technical and economic sense for the many systems being developed today that require multiple load voltages.

In order to facilitate this shift to a lower cost approach to powering next generation systems, Bel has committed to delivering a full portfolio of products providing the designer a complete tool kit of bus converters and POL regulators to meet the demands of virtually any application. Sampling of the products mentioned here will begin in January 2003 with production scheduled for early 2Q03. For more information on this portfolio of products please call or e-mail Bel Power.