Benefits of Direct 48 V / 1 V Conversion

In data centres and telecom offices, the most important issues affecting decisions about power supply design are usually cost, efficiency, and the available board real estate. Typical early power distribution strategies utilized multiple isolated quarter brick or eighth brick converters to convert from a bus voltage – usually 48 V – to the required IC supply voltage, at the point of load. A new generation of single-stage converters is set to emerge, to convert down from 48 V directly to logic voltages at high efficiency and within compact dimensions. **Bob Cantrell, Senior Application Engineer, Ericsson Power Modules, USA**

In a bid to save the cost and bulk of multiple isolated converters, the now-conventional distributed power architecture was proposed and became widely adopted in data centers (Figure 1) over a decade ago. This comprises an AC/DC front-end power supply, an isolated Intermediate Bus Converter (IBC) usually of an industry-standard size such as a quarter brick, and on-board non-isolated Point-of-Load (POL) converters. The POLs are positioned close to the power pins of devices such as processors, FPGAs/ASICs, memory, and other ICs, to minimize noise effects and optimize transient response.

The IBC down-converts the nominal 48 V DC from the front-end power supply to a 12 V rail that is distributed to the POL converters. The POLs then convert the 12 V input into regulated voltages as needed by on-board ICs. These typically can range to below 1 V as needed to power processor or FPGA core logic.

Efficiency is key

Today, data centres and telecom offices are under pressure to support ever-increasing numbers of subscribers and connections, and to deliver increasingly data-intensive services with minimal latency. Accordingly, the peak power consumption of large server boards has risen significantly above 1 kW and is likely to push well beyond 3 kW in the future. As power consumption continues to rise, efficiency is a growing concern for data centres seeking to control the spiralling costs of powering servers and cooling systems, and minimize the overall enterprise environmental footprint. The cost of power consumed in a large-scale data center quickly outweighs the cost of servers and networking equipment, and energy prices can be expected to continue rising.

Advantages of direct conversion

Although many of today's IBC and POL converters can achieve efficiency in the

Figure 1: **Typical data cabinet utilizing conventional point-of-load power architecture**

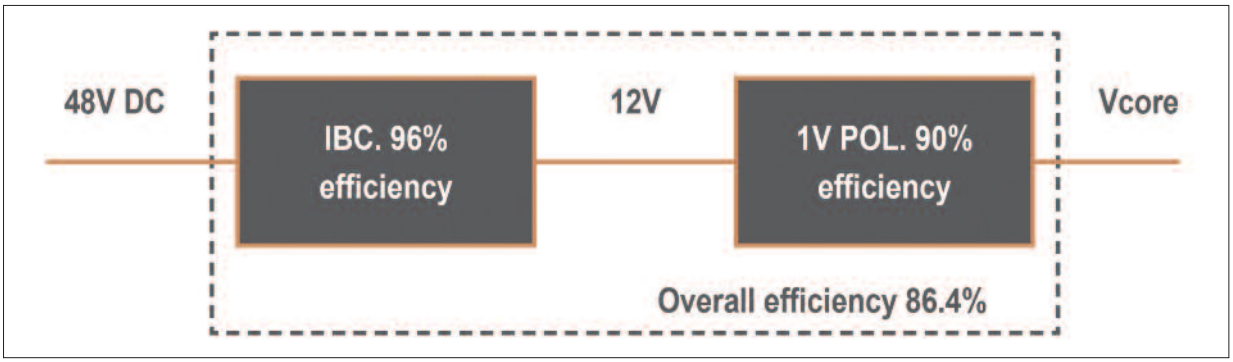

Figure 2a: **Conventional two-stage 48 V-to-core voltage conversion**

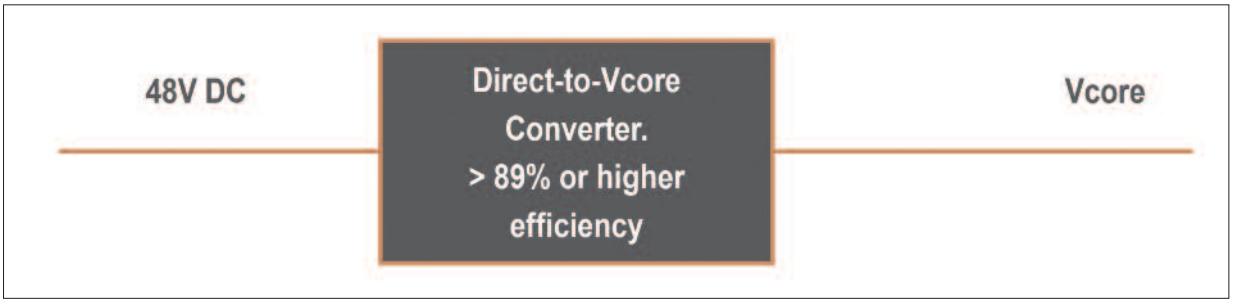

Figure 2b: **Direct 48 V-to-core voltage conversion**

region of 95-96 % for the IBC, and 90 % for a typical 12 V-1 V POL at a particular load, the cumulative energy loss from both stages of conversion can reduce overall efficiency to a little over 86 % (Figure 2a). If a single converter can generate the required IC supply voltage with efficiency, say 89 % for the same load used in the above example, the overall conversion efficiency can be increased by several percentage points (Figure 2b).

The I^2R distribution losses can also be reduced. By distributing 48 V DC for direct conversion at the point of load, the bus supplying the converter carries approximately 25 % of the current that would be required to deliver the same power at 12 V. Hence I^2R distribution losses from the 48 V source can be reduced by a factor of 16. Reducing I^2R distribution losses becomes increasingly important as total server power – and hence the power delivered to the POLs at 12 V or 48 V – continues to increase.

In addition, direct conversion helps to save board real-estate and to reduce the cost of materials, electronics assembly and manufacturing. Using today's technology, a direct 48 V-to-POL converter solution can be smaller in size than comparable conventional modules in quarter or eighth-brick sizes along with POL converters, and can also eliminate the need for high-current multiple and parallel IBC quarter bricks or eighth bricks. In complex or high-power systems, the need for a reduced-power Intermediate bus will still likely exist to power low-current rails, but an eighth brick IBC converter will likely be able to be used, thereby saving additional board space.

High-efficiency direct conversion

A new generation of single-stage converters is set to emerge, to convert down from 48 V directly to logic voltages at high efficiency and within compact dimensions. The converters will be capable of supporting the low duty cycles required to convert from, say, 48 V to 1.0 V, while operating at a high switching frequency to ensure fast transient response and minimize reliance on decoupling capacitance and magnetic components. The adoption of direct conversion, implemented using the latest power technologies, is an emerging trend. The industry needs to identify the sweet spot as far as specifics such as module current ratings or power delivery are concerned.

The new direct conversion solutions will enter the market alongside existing IBC and POL products that are currently used to power boards from a few hundred Watts up to 3 kW or more. Direct conversion is expected to deliver the greatest efficiency gains in equipment at higher power levels, and can be used to dramatically reduce loads in Intermediate Bus Converters thereby allowing smaller IBCs; possibly downsizing these from quarter brick to smaller eighth brick units. This should be ideal for next-generation high-current processors.

On the other hand, factors such as cost or legacy issues may determine the point at which some equipment manufacturers consider implementing direct conversion. With direct-conversion and traditional modules available side-by-side in the market, designers will also have the freedom to conceive hybrid architectures that combine Intermediate Bus and Direct Conversion topologies to deliver the best of both worlds.

Conclusion

Using a higher voltage such as 48 V to distribute power on server boards, and converting directly to the required load voltage at the point of load, offers attractive advantages including higher efficiency, lower I?R distribution losses, as well as reducing board space imposed by an intermediate converter. In practice, cost pressure, combined with engineering constraints on switching frequency, step-down ratio and transient performance, have historically driven power designers challenged to convert from a 48 V DC input to use a two-stage topology comprising an intermediate converter feeding point-of-load converters that generate the desired IC supply voltages. Now, with the growing imperative to maximize energy efficiency in every area of the server design, and drawing on the latest power technologies, direct conversion can provide not only the most efficient power-conversion architecture, but also board-space savings and potential cost advantages. The forthcoming generation of direct-conversion POL modules will establish the starting point for a major transition in the market.