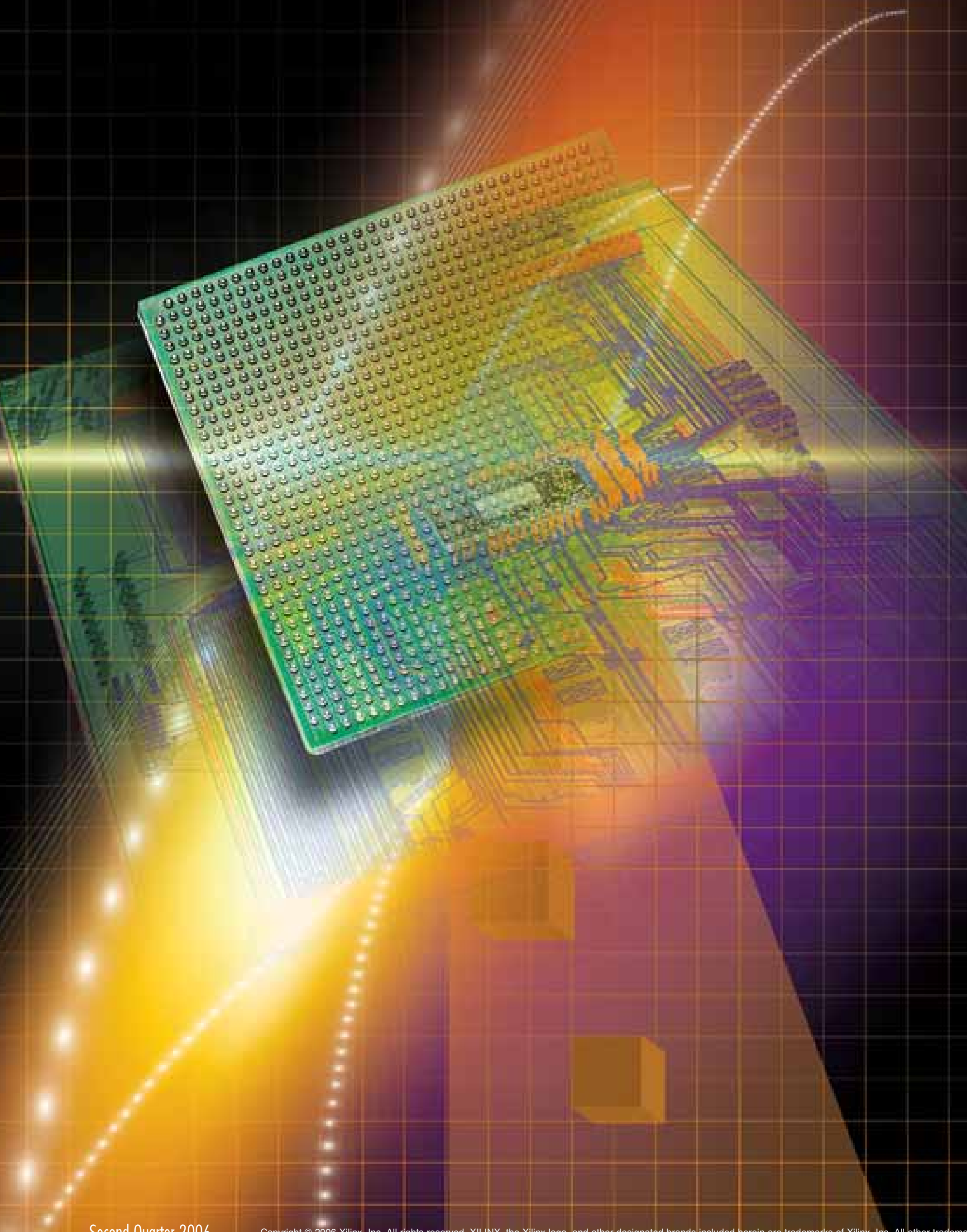
Selecting a High-Speed POL Converter for FPGAs

Bellnix offers a high-quality power management solution.



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Core voltages in FPGAs have quickly dropped to lower voltages in current technologies. There is a lack of good information about power supplies that can provide not just the required level of performance, but the optimal level of performance. One design choice is point-of-load (POL) power supplies.

There is some confusion about the benefits to be gained by using POL supplies. The speed of response of these POL converters directly affects power distribution system (PDS) design choices. In this article, I'll describe a basic method for designing a PDS and review the birth of the POL converter and Bellnix's high-speed response POL converter.

We recommend a PDS (Figure 1) for resolving the low-voltage problems of FPGAs, which includes providing the required low voltages (1.2V or 1.0V) at high currents (as much as 5A to 15A, depending on the part used, the frequency of operation, and the task at hand).

As the core voltage has moved from 2.5V in .25 µm technology to 1.0V in 65 nm technology, the effects from the voltage drop by resistance (or by line inductance of the line between the DC/DC converter and load [FPGA]) must be minimized. A POL implies that regulation is provided as close as possible to the load. If a DC/DC converter can be located next to the load, many of the problems I just mentioned would be solved.

This is how the POL converter was developed. At Bellnix, we soon discovered that shortening the length between power supply and load provided additional benefits.

POL Converters: The Only Solution?

A POL converter means that power supplies are located close to the load. Technology and design improvements in the latest high-end FPGAs have improved performance to the point where precise regulation and quick response to transients in the load current are required to get the best performance from the overall system.

POL and DC/DC converters must have ultra-high-speed load transient response, high efficiency, low noise, and small size. This is necessary to track the large transient changes in current in order to optimize performance. Changes in voltage may lead to jitter, timing push-out, duty-cycle distortion, and other unwanted effects. The choice of bypass capacitors is only able to provide for so much transient current, and ultra-high-speed POL converters are able to provide a superior solution over conventional supplies and capacitors alone.

An isolated DC/DC converter is allocated near the input pin and protects from interference between other boards. This is a structure where the high-speed-response type of non-isolated POL converter is allocated near the load end of the FPGA. Figure 2 illustrates the load transient speed that is estimated on our product, the Ultra High-Speed POL Converter, BSV-m Series. The response time (recovery time) for rapid load current change from 0A to 7A is one of the highest speed responses in our industry.

A high-speed-response type POL converter also provides these benefits:

- It follows the rapid current changes of the FPGA and provides the required currents to prevent jitter and timing push-out.
- Ultra-high-speed recovery time leads to an extremely small output voltage change of the DC/DC converter. The total capacitance of the external de-coupling capacitor array can be greatly reduced.

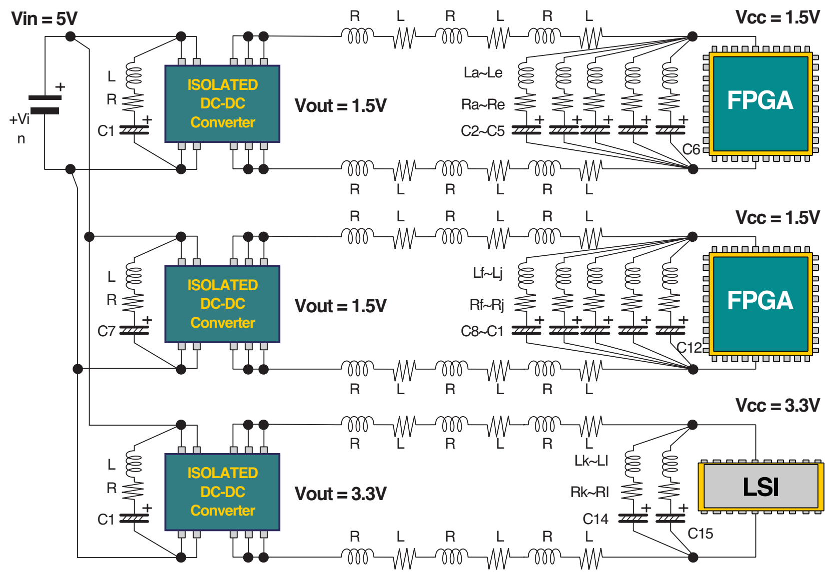

Figure 1 – Centralized power architecture

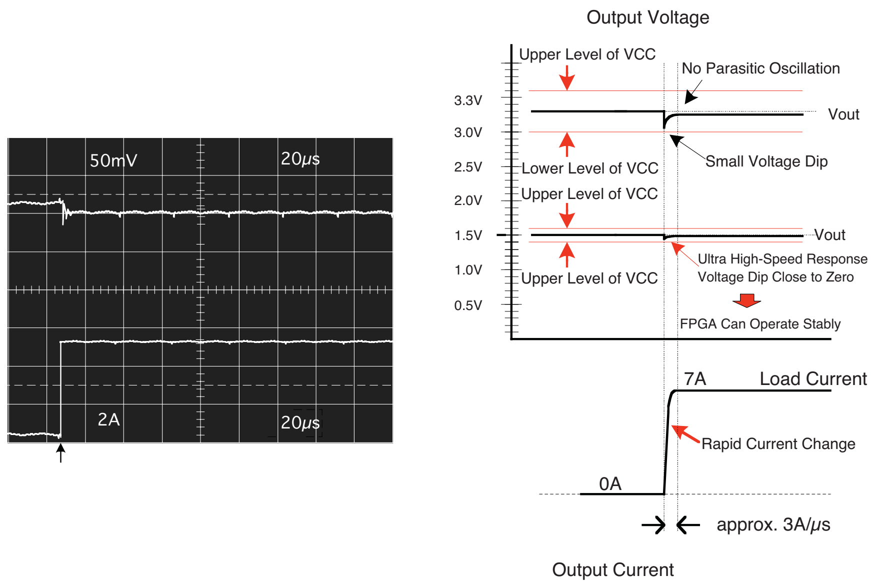

Figure 2 – Bellnix solution with distributed power architecture

- In-rush currents are largely decreased and kept under control because the total capacitance and number of external decoupling capacitors are kept small.
- The load end can be supplied optimally where required by locating minimized ultra-high-efficiency POL converters where needed.
- Extremely small packing densities.
- It comes as close as possible to an ideal power supply – basically a "battery" because of their high-speed recovery function.

High-Speed-Response Type

Figure 3 illustrates the actual measurement of the conventional DC/DC converter, which has high efficiency but a slow general-purpose response speed of about 38 μs. When load currents rapidly change from 0A to 7A, output voltage changes will occur. The recovery time is 38 μs and the voltage change is 400 mV.

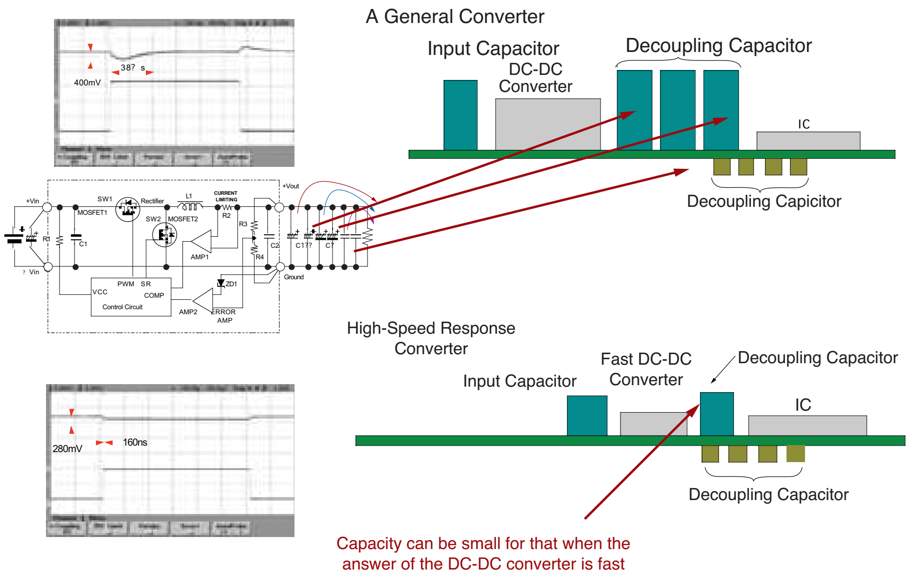

Figure 3 – Mounting image of on-board power for FPGA

This type of DC/DC converter is in use as a commercial product. However, if this DC/DC converter is used for the power supply in a high-performance FPGA, lots of external capacitors may be required to maintain voltage until the converter recovers.

If the FPGA voltage core goes lower (to around 1V) and if advanced high-speed operations are required, the capacitor array reaches its limits. Capacitors have self-inductance and self-resistance, which are not stable with temperature. Figure 3 illustrates the printed board with lots of capacitors. If many capacitors are installed, converters are forced to provide more power than is necessary while turning on.

Even if other POL converters for high-end FPGAs are unfit for high-speed response, you could stabilize output voltage by installing an array of large-value output capacitors. This is not an optimal solution, and has problems of its own.

Figure 3 also illustrates our product performance and the load transient characteristics of high-speed POL converters for high-end FPGAs. When load current changes rapidly from 0A to 6A, the time for recovering the voltage to a stable level is rapid. And the resulting voltage change is amazingly small – only 28 mV during this recovery time. Thus, the need for and number of capacitors is significantly reduced on the printed board, as in Figure 3.

The Ultra High-Speed POL Converter BSV Series offers the following benefits:

- Circuit installation is simplified.
- In-rush current to capacitors is greatly decreased; converters can be allocated near the load, and the POL converter can do what it is designed to do
- Noise performance is improved because of the small series resistance and inductance
- Released from power supply issues, cost and size reduction becomes possible
- Power becomes stable on the entire circuit

Selecting a POL Converter for High-Performance FPGAs

When selecting a POL converter, here are some guidelines you should follow:

- High efficiency is required (90% or more preferred). The POL converter can operate at a much lower temperature and does not contribute to the heat dissipation of the load (FPGA).
- High-speed response performance is required. A 160 ns recovery time is adequate for almost all high-performance FPGAs.
- Low impedance installation is recommended with surface mount device (SMD) architecture.
- It is better not to use excessive external capacitors. Decoupling capacitors are necessary to decrease circuit impedances, but you should avoid large-capacity capacitors because other problems (like in-rush current) may arise.
- A low-noise POL converter is a must.
- The FPGA may require multiple voltages. Select a series of POL converters, which are able to control rise and fall time, and power on sequences. In the case of two or three power supplies, the time sequence in each power supply should be able to turn on in the order indicated by the power sequence desired. A converter equipped with the on/off and power-good function is also recommended.

Conclusion

High-speed load-transient characteristics that provide electric currents to the FPGA core have many practical advantages.

Bellnix developed a conventional DC/DC converter for distributed power architecture (DPA) for high efficiency, small size, and adjustable voltage. But there were very few DC/DC converters that could operate with low voltage and respond to high-speed load transients.

Bellnix has also developed a high-speed POL converter that can provide 0.8V to 3.3V at up to 12A, and has achieved high-speed response in a high-density, high-performance FPGA.

One of the most important features of our POL is its small size. We have developed one of the smallest DC/DC converters for POL in the world that can be installed beside the load. It reduces the need for extra capacitors and handily succeeds as a POL supply in a small space.

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