

ROHM Synchronous Buck DC/DC Converters for the Efinix FPGA Ti180 Platform

Abstract

Field programmable gate arrays (FPGAs) are integral to designing and developing complex digital systems due to their reconfigurability, versatility, and efficiency. However, FPGAs need power supply solutions to accommodate their unique energy demands, stringent precision requirements, and complex startup sequences. Addressing the power needs of FPGAs is critical to optimizing system performance, reliability, and longevity. This white paper introduces ROHM's synchronous buck DC/DC converters, highlighting their usage in Efinix's FPGA Ti180 platform, technical aspects, impact on performance, and role in meeting the intricate power management needs of advanced FPGAs.

Understanding the Need for Advanced FPGA Power Supplies

The intricate architecture of FPGAs, consisting of configurable logic blocks and interconnects, demands precise voltage levels to ensure signal integrity, reduce noise margins, and minimize power consumption. FPGAs in various high-performance applications often operate at low core voltages to reduce power consumption and heat generation. However, these low voltages must be exact. Even minor deviations can result in unreliable operation or damage to the device. This precision is critical in dynamic voltage scaling, where core voltage is altered in real-time based on current workloads. Meeting these stringent voltage requirements is pivotal for FPGAs' optimal functioning and longevity, enabling them to execute complex digital computations accurately and efficiently.

The Complexity of Startup Sequences

When an FPGA is powered on, it doesn't simply start operating immediately but follows a sequence of events, known as the startup sequence, that must occur in a particular order. This sequence includes configuration data loading, clock initialization, and various self-checks. FPGA power supplies must be able to handle these sequences, providing stable power with accurate rise times, sequencing, and voltage levels.

The Importance of Reference Power Supplies Optimized for FPGAs

FPGAs utilize multiple voltage rails, each powering separate parts of the chip. For example, core logic, I/O interfaces, and phase-locked loops (PLLs) operate at different voltage levels. These rails must be powered up in a specific sequence to ensure proper FPGA initialization and operation. Reference power supplies function as benchmarks, offering ideal power conditions for FPGAs to operate at peak performance. They offer fast transient response, low output voltage ripple, and high power density. Utilizing power supplies optimized for FPGAs enhances system reliability and achieves optimal power efficiency.

Benefits of Synchronous Buck Converters for FPGAs

As FPGAs become more advanced, so does the need for efficient power management solutions. Unlike traditional DC-DC converters, synchronous converters incorporate two transistors in the power stage. This design eliminates the need for an external diode, reducing voltage drops and enhancing efficiency.

Synchronous buck DC/DC converters have emerged as an ideal choice for FPGA power supply designs, offering a plethora of benefits, including:

Enhanced Performance and Reliability

Synchronous buck converters provide a stable and consistent voltage supply, which is crucial for the optimal performance of FPGAs. Synchronous converters offer overcurrent, overvoltage, and thermal protection, safeguarding the FPGA from potential damage. They also ensure lower heat dissipation, enhancing the device's reliability.

Simplified Design Process and Reduced Development Workload

Unlike asynchronous converters, synchronous converters integrate both high-side and low-side switches, reducing the number of external components needed. Additionally, manufacturers offer design tools or software to aid component selection, further simplifying the design process.

Longer Operational Life and Sustainability

Synchronous buck converters eliminate the forward voltage drop, resulting in reduced switching losses and enhanced efficiency in FPGAs. These converters

also maintain high efficiency under light load conditions, ensuring efficient power supply throughout the device's operational life. For battery-powered applications, the high efficiency of synchronous buck converters leads to longer battery life and promotes sustainability.

High Power Density in Smaller Footprints

The need for fewer external components in asynchronous converters translates to compact PCB layouts, freeing up space for other components. Small footprints combined with efficient thermal management allow designers to place the converter closer to the FPGA, reducing the need for extensive thermal vias or heat sinks.

ROHM's Synchronous Buck DC/DC Converters

ROHM offers a broad selection of synchronous Buck DC/DC converters for various applications. ROHM's synchronous DC/DC converters are pivotal for power management, offering efficient voltage conversion with minimized energy loss. ROHM converters achieve peak efficiencies by eliminating the external diode and optimizing the internal design. They also include overcurrent, overvoltage, and thermal protection and come in compact footprints.

5V/12V/24V Power supply lineup for FPGA

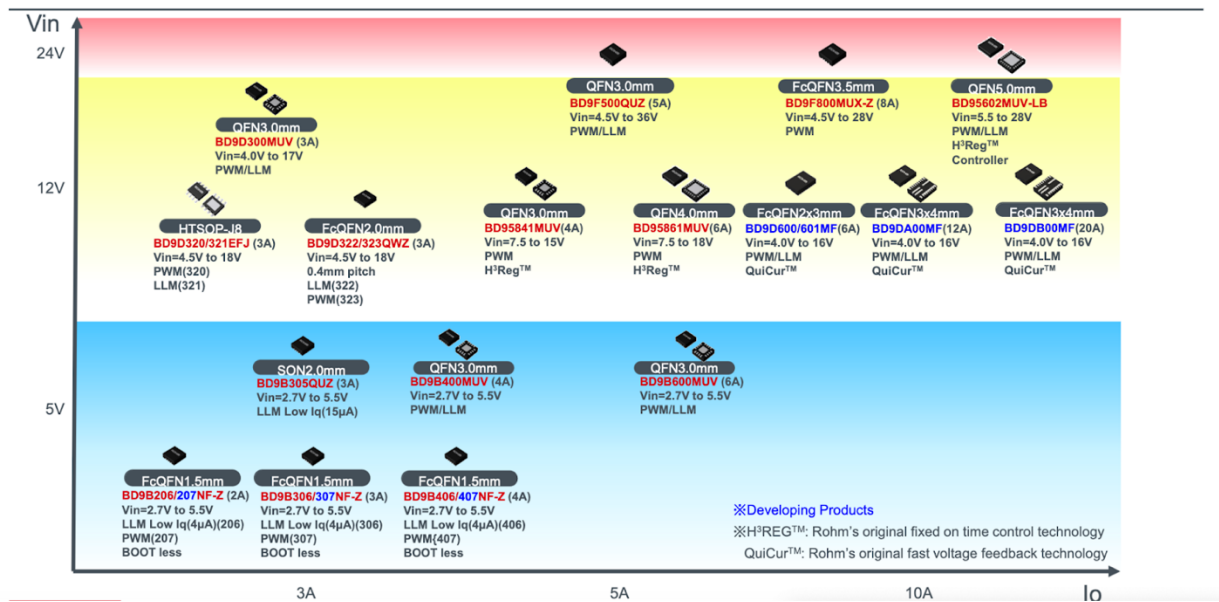


Figure 1: FPGA-optimized power converter solutions from ROHM

ROHM and Efinix Collaboration for the Ti180 Platform

ROHM and Efinix have partnered to develop a reference power solution tailored for Efinix's Titanium Ti180 FPGA. ROHM's solutions enable designers and engineers to reduce their development workloads and achieve high-performance requirements by offering reference power optimized for FPGAs.

The Titanium Ti180 is a high-performance product designed for various applications, from mobile and edge computing to AI IoT and sensor fusion.

Below are some key specifications:

Fabrication and Design: The Ti180 FPGA is fabricated on a 16 nm process, ensuring high efficiency and performance.

High-Voltage I/O (HVIO): The FPGA features simple I/O blocks that support the single-ended LVTTTL and LVCMOS I/O standards.

High-Speed I/O (HSIO): It features complex I/O blocks that support both single-ended and differential I/O, including RSDS (RX, TX, and bidirectional) with speeds up to 1.6Gbps, and LVDS, subLVDS, and Mini-LVDS with speeds up to 1.5Gbps. Additionally, it can operate as MIPI lanes at 1.5Gbps.

MIPI D-PHY: The FPGA is equipped with a MIPI D-PHY hard IP that can achieve speeds up to 2.5Gbps.

LPDDR4/LPDDR4x PHY: It supports x16 or x32 DQ widths and comes with a memory controller hard IP.

Configuration Options: The Ti180 FPGA offers various device configuration options, including standard SPI and JTAG interfaces.

Software Support: The FPGA is fully supported by the Efinity® software, which serves as an RTL-to-bitstream compiler.

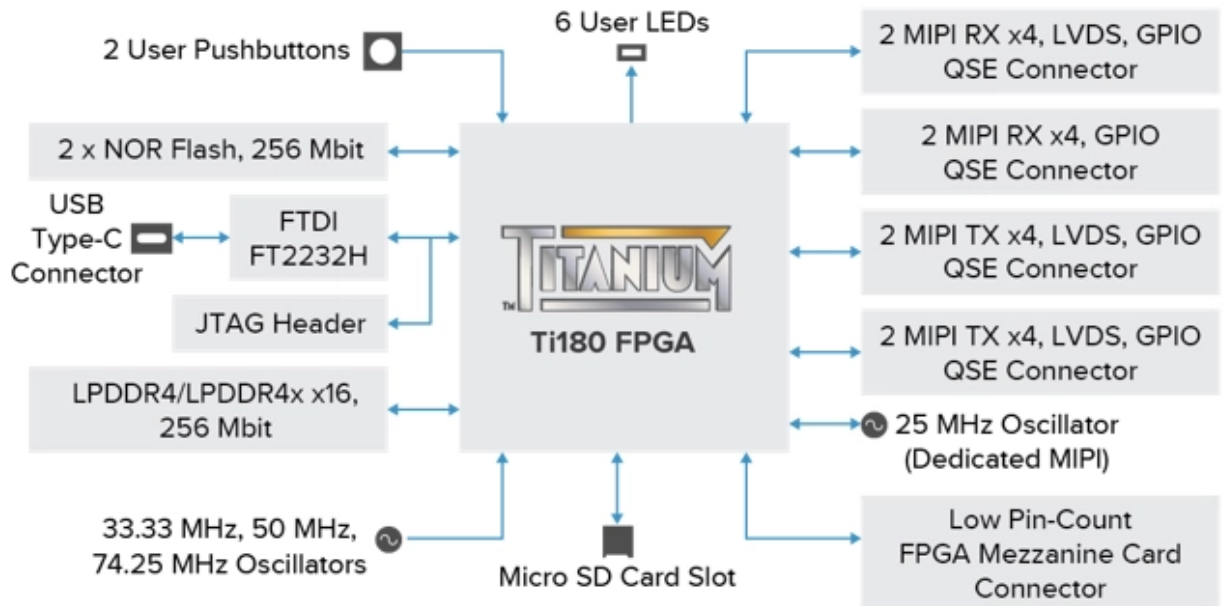


Figure 2: Block diagram for Efinix's Ti180 FPGA

Development Kit for the Ti180

Efinix has developed a comprehensive development kit for the Titanium Ti180, utilizing ROHM's Synchronous Buck DC/DC Converters to provide reference power. ROHM's power supplies meet the high precision and low voltage requirements of the Ti180 platform, helping to manage the complex startup sequences of the FPGA and ensuring stable and reliable power delivery throughout operational phases.

The power supplies integrated into the Ti180 development kit include:

- **BD95602MUV:** Achieves excellent response and is adaptable to a voltage range of 5.5 to 28.0V.
- **BD9F500QUZ:** Suitable for a voltage range of 4.5 to 36.0V, providing a maximum current of 5.0A.
- **BD9F800MUX-Z:** Operates over a voltage range of 4.5 to 28.0V and offers a maximum current of 8.0A.

Part No.	Vin (V)	Io Max. (A)	Frequency (MHz)	Package (WxLxH mm)
<u>BD95602MUV</u>	5.5 to 28.0	Ext.	0.15 to 0.50	VQFN032V5050
		FET		(5.0x5.0x1.0)
<u>BD9F500QUZ</u>	4.5 to 36.0	5.0	0.60/1.00/2.20	VMMP16LZ3030
				(3.0x3.0x0.4)
<u>BD9F800MUX-Z</u>	4.5 to 28.0	8.0	0.30/0.60	VQFN11X3535A
				(3.5x3.5x0.4)

Figure 3: ROHM's Synchronous Buck DC/DC Converters utilized in the Ti180 platform

Below are the specifications, characteristics, and features of ROHM's converters: BD9F800MUX-Z, BD9F500QUZ, and BD95602MUV-LB utilized in Efinix's Ti180.

BD9F800MUX-Z Synchronous Buck DC/DC Converter

Specifications:

- Input Voltage Range: 4.5 to 28V
- Output Voltage Range: 0.765 to 13.5V
- Maximum Output Current: 8A
- Switching Frequency: 300kHz or 600kHz (Typ.)

Key Features:

- **Built-in Low-On Resistance MOSFETs:** BD9F800MUX-Z integrates low-ON resistance power MOSFETs, ensuring minimal power loss during switching operations and higher efficiency and prolonged battery life for portable devices.
- **High-speed Response without External Phase Compensation:** As a constant on-time control DC/DC converter with high-speed response, ROHM BD9F800MUX-Z avoids external phase compensation circuits, simplifying circuit

design and reducing the overall component count for a more compact and cost-effective solution.

BD9F500QUZ Synchronous Buck DC/DC Converter

Specifications:

- Input Voltage Range: 4.5 to 36V
- Output Voltage Range: 0.6 to 14V
- Maximum Output Current: 5A
- Switching Frequency: 600 kHz to 2.2 MHz

Key Features:

- **Nano Pulse Control™**: ROHM's proprietary Nano Pulse Control™ technology allows for precise pulse width modulation (PWM), enabling stable operation even at extremely low duty cycles and ensuring efficient power conversion over a wide range of input voltages.
- **Light Load Mode (LLM)**: The BD9F500QUZ features LLM control, enhancing efficiency during low-load conditions and reducing standby power consumption, making it suitable for battery-powered devices.
- **Power Good Function**: ROHM's Power Good function signals when the output voltage has stabilized within the desired range, which aids in controlled system sequencing, ensuring downstream components receive power when the converter starts to operate optimally.

BD95602MUV-LB Dual Buck Regulator Controller

Specifications:

- Input Voltage Range: 5.5 to 28V
- Output Voltage Range: 1.0V to 5.5V
- Switching Frequency: 150kHz to 500kHz

Key Features:

- **H3Reg™ Control Method**:
 - ROHM's H3Reg™ control method is a groundbreaking technology that ensures ultra-high transient responses and minimal voltage deviations during sudden load changes, ensuring stable power delivery.

- **SLLM (Simple Light Load Mode) Technology:**
 - SLLM technology optimizes efficiency during light load conditions. Dynamically adjusting the switching frequency reduces switching losses and enhances battery life.
- **Additional Features:**
 - **LDO Regulators:** Integrated LDO (low drop-out) regulators provide clean and stable voltage outputs, ideal for noise-sensitive applications.
 - **Soft Start:** The soft start feature gradually increases the output voltage, preventing inrush current and potential damage to connected components.
 - **Variable Frequency:** Users can adjust the switching frequency based on the application's requirements, optimizing efficiency and performance.

Potential Future Developments in Power Supplies for FPGAs

With the increasing complexity of FPGA designs, power supply requirements will become more stringent, demanding power supplies that can efficiently cater to varying load conditions without compromising performance. Power solutions that fit within limited spaces will also be crucial as devices shrink. Future DC-DC converters may adopt a modular approach, allowing designers to scale power solutions based on FPGA requirements. As power densities increase, advanced thermal solutions will be crucial to ensure converter longevity and reliability.

A Robust Solution for Diverse Applications

Advanced FPGA power supplies are indispensable in catering to the evolving needs of modern FPGAs. The high precision and voltage requirements of FPGAs necessitate power supplies that are highly accurate, stable, and efficient. Efinix's FPGA titanium Ti180 product, integrated with ROHM's power supplies, offers a comprehensive solution for a variety of applications. The development kit further enhances its capabilities, making it a go-to choice for professionals.

Appendix

For designers and developers interested in the Ti180 development kit, the design document and user's guide are available for download from the ROHM website.

For more detailed information and to access the design document and user's guide, please visit [ROHM's Reference Design Page](#).