

How MCUs Built With Innovative C29 Cores Increase Real-Time Performance in High-Voltage Systems



Aishwarya Rajesh, Marlyn Rosales Castaneda, Reinaldo Dos Santos



Real-time microcontrollers (MCU) play a crucial role in helping high-voltage automotive and energy infrastructure systems meet power efficiency, power density, and safety design requirements. From onboard chargers (OBC) to uninterruptible power supplies (UPS), these devices must deliver fast, deterministic performance for time-critical tasks in harsh environments.

F29H85x series **C2000™ MCUs**, built with TI's C29 core, are designed to meet demanding processing and safety design challenges in high-voltage systems. These MCUs deliver enhanced performance, two to five times that of the previous TI C28 core and other MCUs on the market, and feature advanced integrated safety and security components – helping engineers optimize system reliability and integrity, while reducing design complexity and cost.

Innovations in the C29 core include:

- **Redesigned platform:**
VLIW architecture with a fully protected pipeline enables parallel execution of up to eight instructions.
- **New compiler:**
Boosted performance through the LLVM/Clang-based compiler to enable performance entitlement without requiring custom coding or assembly.
- **Redesigned interrupt performance:**
Hardware allows rapid automatic context save and restore for real-time interrupts. The new interrupt controller allows complete user configuration of interrupt priorities and thresholds.
- **Enhanced platform performance:**
Features a low-latency memory and peripheral interconnect design with built-in safety and security for enhanced protection while maintaining maximum real-time performance.

This article explores how real-time control MCUs like the [F29H859TU-Q1](#) and [F29H850TU](#) and their C29 cores help engineers deliver increased processing capabilities, power efficiency, and fast switching frequencies in subsystems for electric vehicles (such as OBC and high- and low-voltage DC/DC converters) and energy infrastructure (such as solar inverters and UPS).

Enhancing Real-Time Control in Electric Vehicles

By using a more integrated design approach in electric vehicle subsystems like OBC, high- and low-voltage DC/DC converters, and host integration systems, designers can increase power efficiency, reduce system cost and weight, and streamline management of safety functions in their designs.

Typically, executing multiple applications within a single MCU requires having a dedicated core per function. For example, one core is dedicated to the OBC and another is dedicated to the high- and low-voltage DC/DC converter. Using an F29H85x series MCU, designers can allocate two of the MCU's three cores in lockstep to handle key functions that are required for a host MCU, such as AUTOSAR and crucial safety and security tasks at an ASIL-D integrity level, while the remaining core handles control functions in the system.

The C29 core integrates with the safety and security unit (SSU) to enable seamless execution of multiple control functions in the same core while preventing the functions from interfering with one another. This maintains full isolation and freedom from interference between the functions.

F29H85x series MCUs further enhance performance in automotive systems by enabling the use of new control topologies and algorithms, such as the matrix converter topology, which are enabled through the enhanced EPWM features. These features include a complex compare scheme that also integrates safety checks like guaranteed minimum dead band and illegal combo logic. Additionally, integrated ADCs in these MCUs help enable accurate sensing with features such as hardware oversampling and a results safety checker to minimize the software overhead needed for common tasks.

Enhancing Real-Time Control in Energy Infrastructure

Similar to challenges for automotive systems, designers of energy infrastructure applications must meet growing demand for higher system efficiency. Systems supporting energy infrastructure, like solar inverters and UPS ([Figure 1](#)), must deliver increasing amounts of energy, while also protecting against cyberattacks.

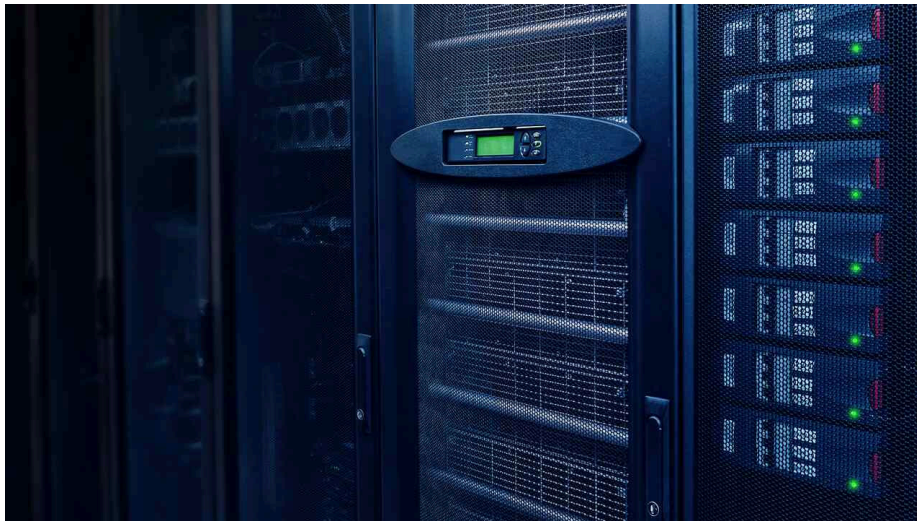


Figure 1. Uninterruptible Power Supply for a Server Stack

To achieve higher power efficiency and density, designers can leverage wide-bandgap semiconductors (SiC and GaN) and F29H85x series MCUs to increase power electronic switching and control loop frequencies. Increasing control loop frequencies increases system power efficiency and density for power conversion, while allowing for the use of smaller passive components, such as capacitors and inductors, which further reduces board space usage.

From a security perspective, integrating the hardware security module (HSM) and SSU with the C29 core helps protect energy infrastructure from potential malware. The SSU helps prevent malware from interrupting ongoing functions within the MCUs while maintaining protection of memory and peripherals without compromising real-time performance. The SSU automatically manages and switches memory and peripheral access permissions in hardware. The SSU, in conjunction with the C29 CPU, manages independent stack pointers and stack memory for each isolated application function, providing security protection against malware and other cyberattacks.

The F29H85x MCU's architecture supports A/B flash bank which facilitates live firmware updates (LFU) with almost zero downtime. In addition to the basic flash controller verification of contents after programming, the HSM verifies the overall integrity of the update. The architecture also features the ability to rollback software updates to the previous version and can permanently block rollbacks for critical security updates.

Conclusion

As demand for efficient and secure energy designs continues to grow, F29H85x series MCUs and C29 cores are helping drive the future of high-voltage applications. These highly capable MCUs allow designers to expand their current systems by simplifying design, reducing costs, and enhancing reliability.

Trademarks

C2000™ is a trademark of Texas Instruments.

All trademarks are the property of their respective owners.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2024, Texas Instruments Incorporated