Technical Article

Powering next-generation ADAS processors with TI Functional Safety-Compliant buck regulators

Dihia Bitam

The rapid evolution of advanced driver assistance systems (ADAS) increases the complexity and demand for real-time data processing, which requires high-performance processors to handle tasks such as object recognition, sensor fusion and decision-making. This increased complexity introduces new challenges on the power-management side. Starting with the vehicle's battery (12V, 24V or 48V), a preregulator steps down the battery voltage to feed point-of-load (PoL) buck converters, supplying the processor with the precise voltages needed for optimal operation. Additionally, there is strong focus on meeting functional safety requirements for the entire system, with the power stage playing a critical role to enable meeting these requirements.

Solutions such as the 80V LM5137F-Q1 dual-channel buck controller and the 6V, 30A TPS62883-Q1 dual-phase buck converter provide power to high-current automotive processors while helping systems achieve functional safety compliance up to Automotive Safety Integrity Level (ASIL) D.

Enabling up to ASIL D systems requirements

The TPS62883-Q1 is a TI Functional Safety-Compliant 30A buck converter developed according to International Organization for Standardization (ISO) 26262. The device is part of a scalable product family offering pin-compatible options with current ratings from 12A to 30A, and supports a stackable architecture to deliver loads beyond 100A, enabling the power requirements for modern ADAS systems-on-a-chip (SoCs) where the demand for higher currents is ever-increasing. Figure 1 shows two TPS62883-Q1 converters in a stacked configuration.

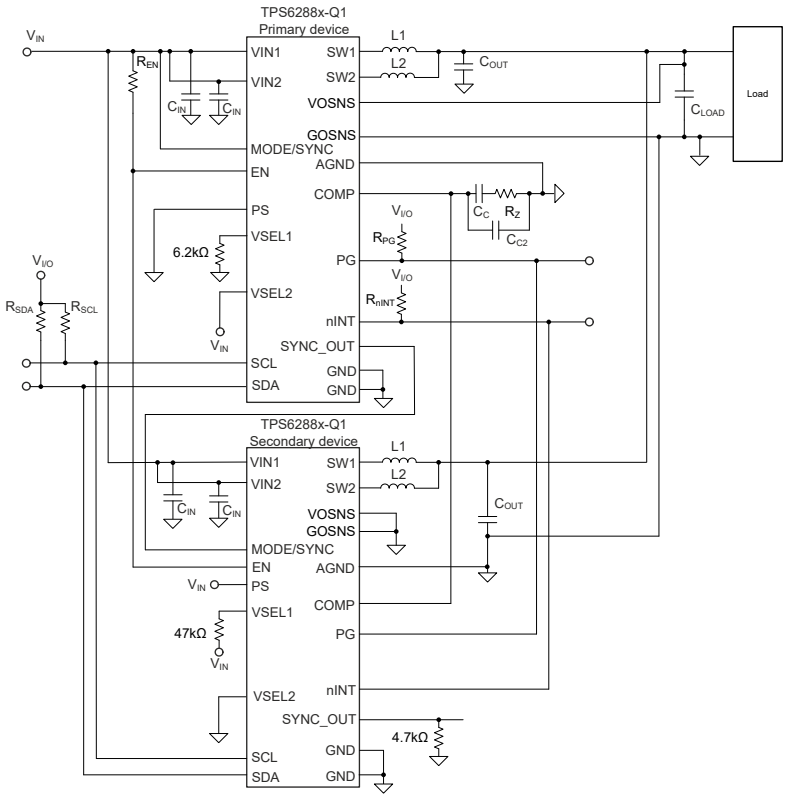

Figure 1. Two TPS62883-Q1 devices in a stacked configuration

Copyright © 2024 Texas Instruments Incorporated

The TPS62833-Q1 helps remove external output voltage supervision through safety-compliant internal monitoring. Also, a change in the output voltage through I2C takes effect at the same time, for both the output voltage control loop as well as the internal output voltage monitoring. This feature eliminates blind spots in the output voltage monitoring during dynamic or adaptive voltage scaling. The communication through the I2C-compatible interface can be cyclic redundancy check (CRC) protected so that the MCU can detect and flag bit errors in bus communication.

Also, the TPS62883-Q1 provides warnings based on its thermal-warning threshold and enters a safe state in case of critical fault conditions in the system such as undervoltage or overvoltage lockout. The device also features a nINT fault pin that signals to the microcontroller (MCU) when a fault condition occurs, which can then take the necessary action depending on the application requirements.

Improving load transient response for ADAS processor applications

Meeting high current requirements is not the only challenge in power supplies. In fact, load transient response is essential for maintaining reliable operation of high-performance processors. Rapid changes in processing demand cause sudden changes in power consumption, leading to voltage undershoots and overshoots, potentially triggering malfunctions. A fast load-transient response is crucial for reliable operation of these SoCs.

SoCs specify a defined tolerance for each of their supply voltages. The core voltage rail is the most important one because the dynamics in supply currents are high, the voltage is low, and tolerance is in the order of millivolts.

The total budget for the load transient depends on several factors, as illustrated in Figure 2. In general, you want a large remaining window for the load-transient voltage deviation, as this allows lower output capacitance. The TPS62883-Q1 provides ±0.5% DC output voltage accuracy as well as internal voltage monitoring, which removes the additional tolerance introduced by external voltage supervision.

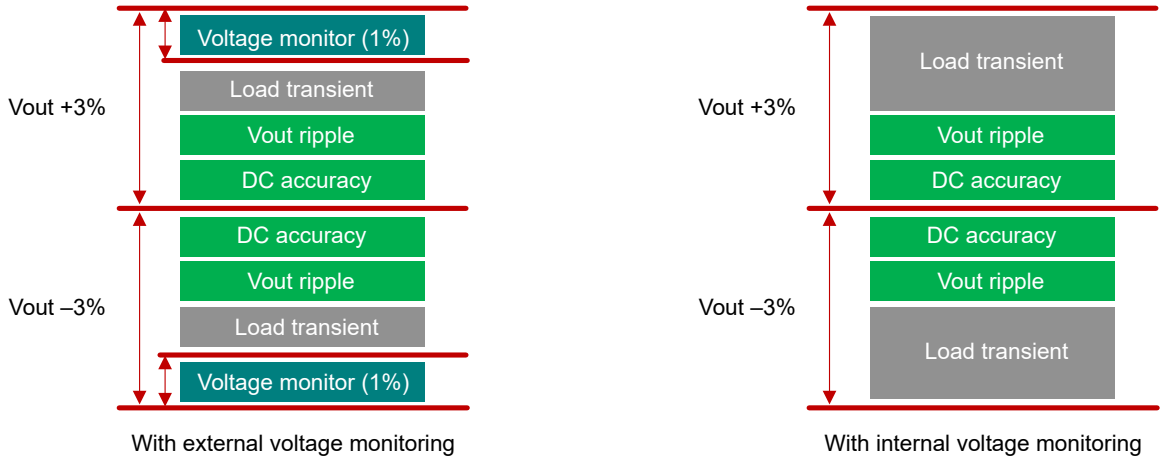

Figure 2. Load transient budget based on core-supply voltage tolerances

The TPS62883-Q1 also incorporates flexible droop compensation, allowing you to tailor the droop behavior closely to the requirements of your design. This feature scales the nominal output voltage based on the output current, such that the output voltage scales linearly between zero and full output current.

As shown in Figure 3, the output voltage is set slightly higher than its nominal value at a no-load condition and slightly lower than its nominal value at a maximum load condition. Droop compensation therefore helps keep the output voltage within a certain tolerance band in case of a heavy load step or at a load release.

Additionally, the dual-phase design of the TPS62883-Q1 provides higher loop bandwidth and significantly lower output voltage ripple compared to single-phase designs, offering extra headroom for load transients. The combination of these features enables you to reduce the amount of output capacitance and meet stringent load-transient requirements, while cutting costs and reducing overall system complexity.

Copyright © 2024 Texas Instruments Incorporated

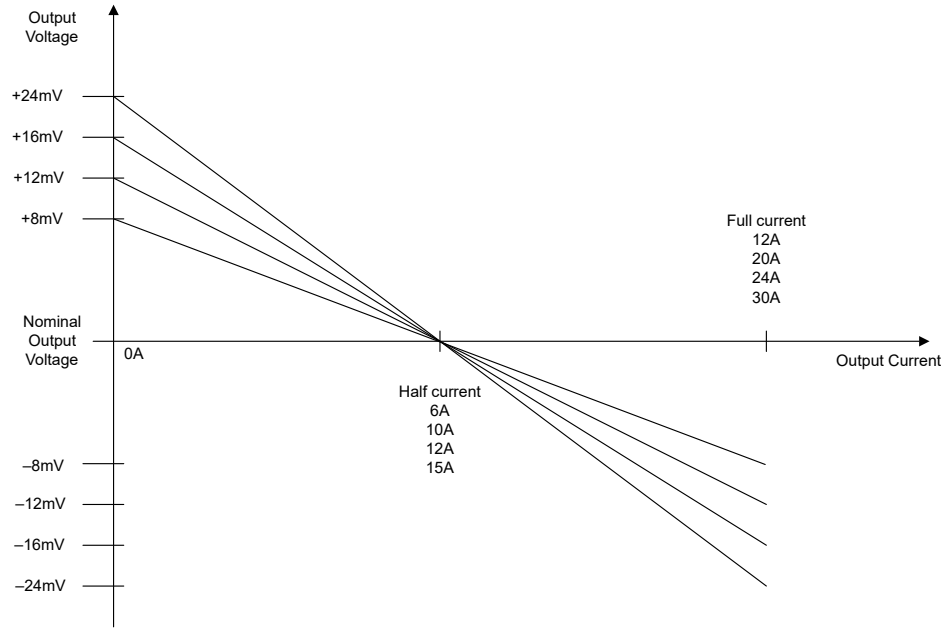

Figure 3. Voltage scaling with output current

To help streamline your functional safety system-level certification, TI provides industry-standard reports and additional resources – including IC-level documentation such as functional safety FIT rate and failure-mode effects and diagnostic analysis (FMEDA).

Conclusion

The complexity of ADAS continues to increase significantly as vehicles progress toward autonomous driving, resulting in greater power demands for application processors. Concurrently, functional safety is paramount, as these systems need to be reliable for users to depend on. The TPS62883-Q1, when used in a stackable configuration, achieves core power beyond 100A and in parallel helps enable system designs to achieve functional safety compliance as high as ASIL D.

Additional resources

- Download the TPS62883-Q1 data sheet.
- Check out the "TPS6288x-Q1 buck converter evaluation module" user's guide.
- Read the technical article, “Achieving functional safety compliance in automotive off-battery buck preregulator designs."
- Learn more about stackability in the "Operating TPS6287X-Q1 Devices in a Stacked Configuration" application note.

Trademarks

All trademarks are the property of their respective owners.

Copyright © 2024 Texas Instruments Incorporated

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 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