

TPS12S24F-Q1: TI's Flagship High-Side Switch Controller



Introduction

Automotive hardware and software are growing in complexity quite rapidly, making the electronics themselves better and more sophisticated. However, this comes with greater design and system integration difficulties, as well as higher costs. The industry ameliorates this by exploring new architectures and voltage domains. Despite these ongoing changes for OEMs, the requirements for semiconductors are clear: intelligence and efficiency.

The backbone of automotive electronics is power distribution, with each generation more complex than the predecessor. TI's most versatile controller for automotive power switching has emerged: TPS12S24F-Q1. This document explores the broad capabilities of this device. The TPS12S24F-Q1 provides a complete design for legacy and progressive architectures in 12V and 48V domains, in power distribution, and DC/DC converters.

Device Description and Design Considerations

The TPS12S24F-Q1 is a low IQ smart, dual-channel, high-side driver with protection and diagnostics. With a wide operating voltage range of 3.5V to 70V and an 80V absolute maximum rating the device is suitable for 12V, 24V, and 48V automotive system designs.

Safety

The TPS12S24F-Q1 is targeted to meet the functional safety requirements as per ISO26262 for modern automotive systems. ASIL-B compliance is supported through built-in FET diagnostics and self-test mechanisms to give the confidence that the power path behaves as expected. The device offers a library of protection capabilities, such as short-circuit, undervoltage, and overvoltage. These capabilities continuously monitor when enabled to ensure that the load and device are not overstressed.

Intelligence

Intelligence in power switching continuously evolves to include more capability and reporting. It is far more than simply turning a load on and off, and the TPS12S24F-Q1 comes into the market pushing this boundary. The device is armed with a [daisy-chainable SPI interface](#) which serves as a gateway to the full depth of the device's capability. Through this interface, the device can provide a complete picture of the power path with real-time fault and diagnostic data. The SPI interface also enables nearly endless configurability across the device's most powerful features: the I²T curve, low-power mode behavior, capacitive charge profiles and among others. Endowed with bidirectional current monitoring, a vivid picture is painted of the current flow, while the programmable I²T curve the device can protect based on the thermal history of the wire, not just instantaneous overcurrent. The result is a device that participates more proactively in power management.

Efficiency

The importance of managing power efficiently in automotive electrical systems has grown disproportionately to power demands themselves. The number of loads in a vehicle steadily increases and the computation resources required to manage them follow suit. What sets the TPS12S24F-Q1 apart in these regards overlaps with what makes this device intelligent. The TPS12S24F-Q1 features a thoroughly designed low-power mode that enables the device to draw less than 25µA of quiescent current. The I²T curve adds another dimension to efficient power management and elevates the electrical discernment. The I²T algorithm tracks thermal stress on a wire over time which allows the device to give more precise protection. Taking this one step further, the precision of this protection can lead to material reduction in cabling and connectors. This device therefore enables efficiency in electrical and material domains.

The next few sections highlight examples where the TPS12S24F-Q1 can exceed the expectations of a switch controller in automotive applications.

Application 1: Power Distribution

An automotive power distribution network delivers power across dozens of loads ranging from simple actuators to complex ECUs. Each load can have different current profiles, inrush characteristics, and protection requirements. In a power distribution box or zone control module, the high-side driver, depicted in [Figure 1](#) as *HSSC*, is responsible not just for energizing the load, but for protecting the load, managing power efficiently, and reporting system health in real time.

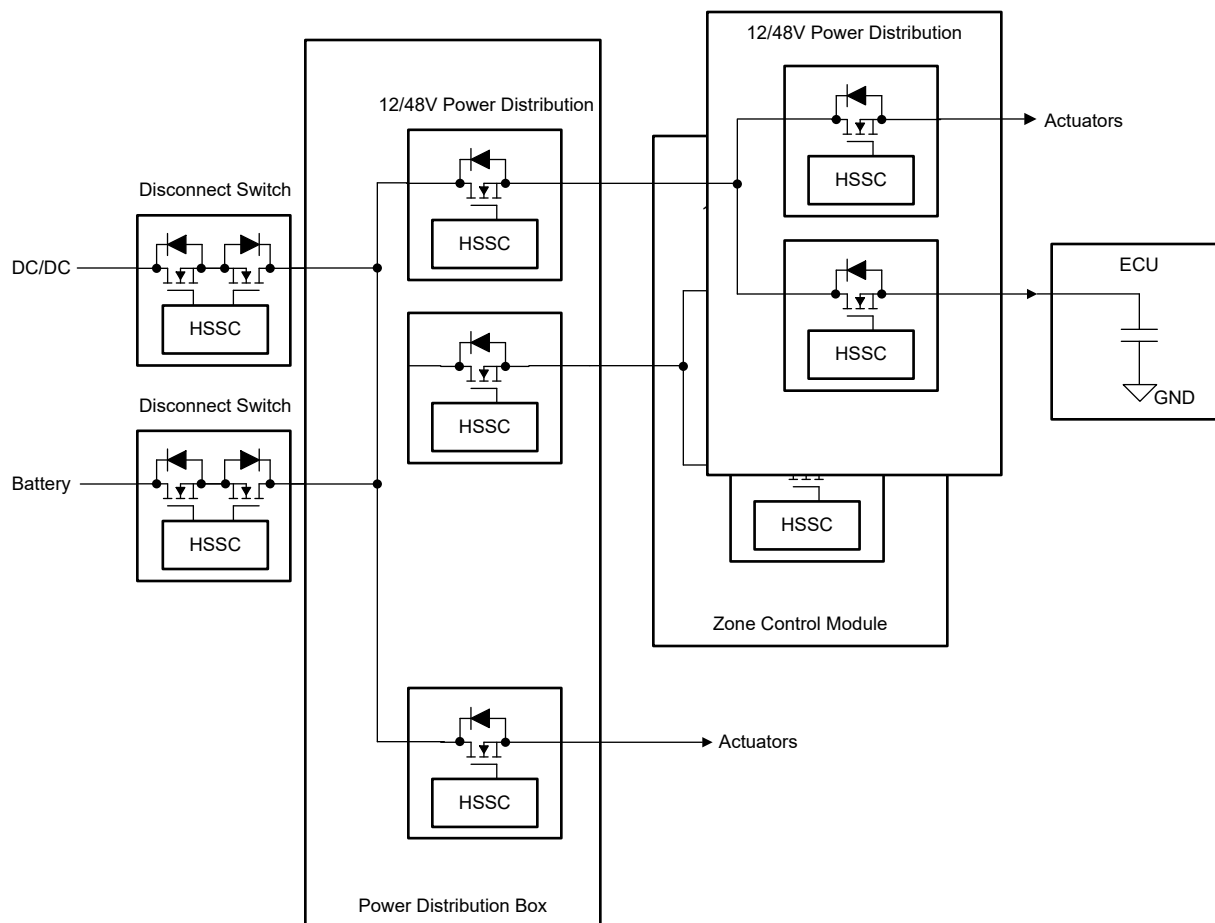


Figure 1. Block Diagram of an Automotive Power Distribution Network

A programmable I^2T curve and low power mode give the device flexibility where competing designs offer only fixed responses. For large capacitive loads, configurable capacitive pre-charge offers both controlled slew rate turn-on and pulse-based methods to energize the load smoothly without damaging inrush currents. Through the SPI interface, designers have real-time visibility into fault conditions and full configurability over protection parameters, which gives the system the ability to respond intelligently rather than simply trip.

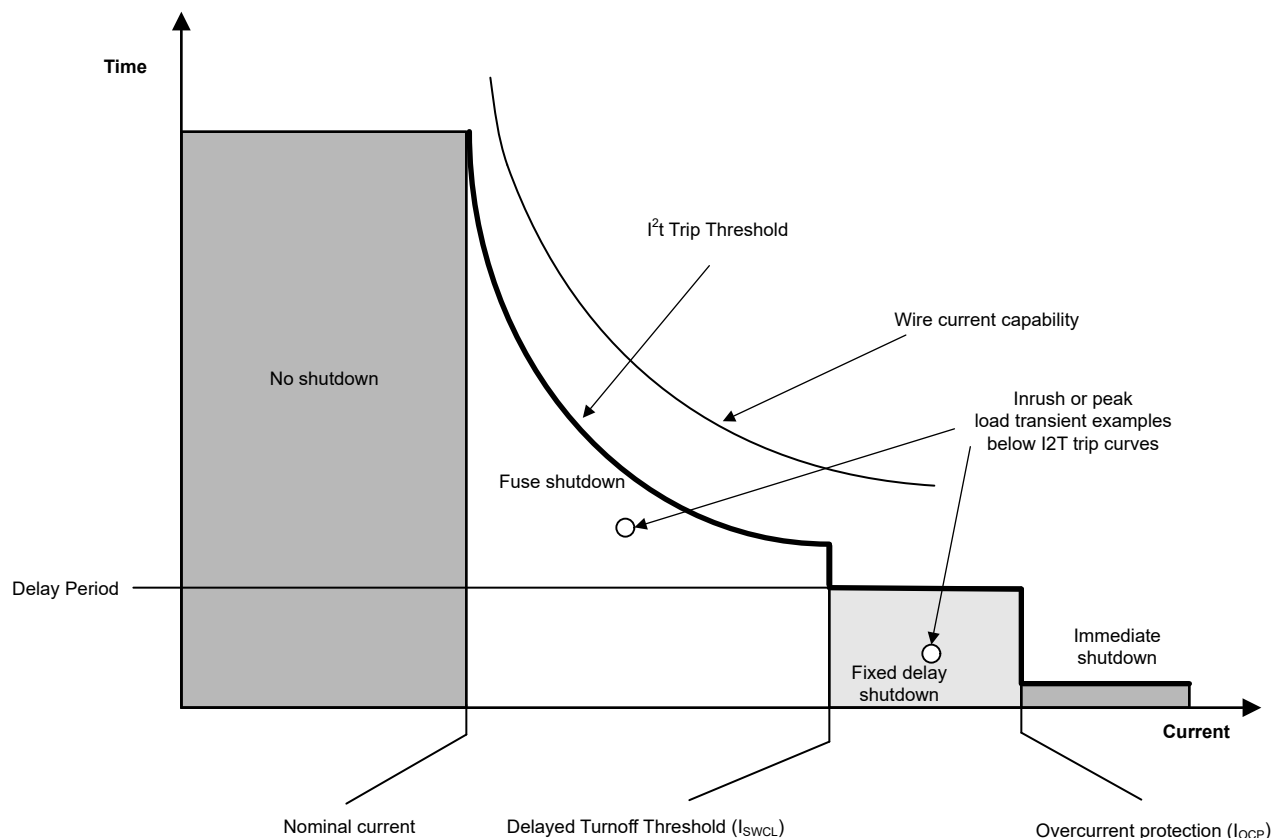


Figure 2. Programmable I²T Curve

Where most high-side switches offer a fixed I²T curve and a single low-power mode, the TPS12S24F-Q1 puts both fully under the designer's control. The I²T curve has several knobs to turn beyond the I²T value. These include the nominal maximum, the delayed shutoff maximum, and the immediate shutdown maximum, as shown in [Figure 2](#). This creates a response tailored to the exact thermal profile of each wire rather than a worst-case approximation. The low power mode behavior is equally configurable, giving designers precise control over when the device enters and exits low power states. In a power distribution system managing dozens of distinct loads and power domains, this level of control allows for a protection strategy that advances system capabilities.

For applications with simpler switching and protection needs, TI's TPS1214-Q1, TPS1212-Q1, TPS4812-Q1, and TPS4816-Q1 provide capable and cost-effective designs. These GPIO-based devices feature analog-configured I²T, low power modes, and support both 12V and 48V applications. See [Table 1](#) and [Table 2](#) for selection guidance on high-side switch controllers.

Table 1. 12V High-Side Switch Controller Selection Guide

Features	TPS1211-Q1	TPS1200-Q1	TPS1210-Q1	TPS1213-Q1	TPS1212-Q1	TPS1214-Q1	TPS12S24F-Q1
Voltage Range	3.5 - 40V, 45V Abs max	3.5 - 40V, 45V Abs max	3.5 - 40V, 45V Abs max	3.5 - 40V, 45V Abs max	3.5 - 73V, 74V Abs max	3.5 - 73V, 74V Abs max	3.5 - 73V, 80V Abs max
Short Circuit Protection	✓	✓	✓	✓	✓	✓	✓
Current Monitoring	Uni-IMON				BI-IMON	Uni-IMON	BI-IMON
Sense Method	High side RSNS	High/Low side RSNS, FET VDS	High/Low side RSNS, FET VDS	High/Low side RSNS, FET VDS	High side RSNS	High side RSNS	High side RSNS
Undervoltage Lockout	✓	✓	✓	✓	✓	✓	✓
Overvoltage	✓	✓					✓
Temperature Monitoring	✓				✓	✓	✓

Table 1. 12V High-Side Switch Controller Selection Guide (continued)

Features	TPS1211-Q1	TPS1200-Q1	TPS1210-Q1	TPS1213-Q1	TPS1212-Q1	TPS1214-Q1	TPS12S24F-Q1
Reverse Polarity Protection		✓	✓	✓	✓	✓	✓
Dual Gate Drive	✓		✓	✓	✓	✓	✓
Low Power Mode IQ		35µA	35µA	35µA	25µA	25µA	20µA
Automatic Load Wakeup				✓	✓	✓	✓
I2T					✓	✓	✓
SPI					SPI Expander Ref. Design	SPI Expander Ref. Design	✓
ASIL B							✓
LimpHome (NVM)							✓

Table 2. 48V High-Side Switch Controller Selection Guide

Features	TPS4811-Q1	TPS4800-Q1	TPS4810-Q1	TPS4813-Q1	TPS4812-Q1	TPS4816-Q1	TPS1212-Q1	TPS1214-Q1	TPS12S24F-Q1
Voltage Range	3.5 - 80V, 100V Abs max	3.5 - 95V, 100V Abs max	3.5 - 95V, 100V Abs max	3.5 - 95V, 100V Abs max	3.5 - 95V, 100V Abs max	3.5 - 95V, 100V Abs max	3.5 - 73V, 74V Abs max	3.5 - 73V, 74V Abs max	3.5 - 73V, 80V Abs max
Short Circuit Protection	✓	✓	✓	✓	✓	✓	✓	✓	✓
Current Monitoring	Uni-IMON				BI-IMON	BI-IMON	BI-IMON	Uni-IMON	BI-IMON
Sense Method	High side RSNS	High/Low side RSNS, FET VDS	High/Low side RSNS, FET VDS	High/Low side RSNS, FET VDS	High side RSNS	High side RSNS	High side RSNS	High side RSNS	High side RSNS
Undervoltage Lockout	✓	✓	✓	✓	✓	✓	✓	✓	✓
Overvoltage	✓	✓				✓			✓
Temperature Monitoring	✓				✓	✓	✓	✓	✓
Reverse Polarity Protection		✓	✓	✓	✓	✓	✓	✓	✓
Dual Gate Drive	✓		✓	✓	✓	✓	✓	✓	✓
Low Power Mode IQ		35µA	35µA	35µA	25µA		25µA	25µA	20µA
Automatic Load Wakeup				✓	✓		✓	✓	✓
I2T					✓	✓	✓	✓	✓
SPI					SPI Expander Ref. Design	SPI Expander Ref. Design	SPI Expander Ref. Design	SPI Expander Ref. Design	✓
ASIL B									✓
LimpHome (NVM)									✓

Application 2: DC/DC Circuit Breaker

In a DC/DC circuit breaker, the switch must protect in both directions across 12V and 48V systems, blocking fault current from the load side just as effectively as from the source, while responding to faults originating from either side. The device must also maintain a precise, continuous picture of current flow, and do so while drawing as little power as possible from the battery the circuit breaker is protecting. An overcurrent or overvoltage event must be shielded from the load as a kickback event from the converter. Here again, the TPS12S24F-Q1 covers the requirements and then some.

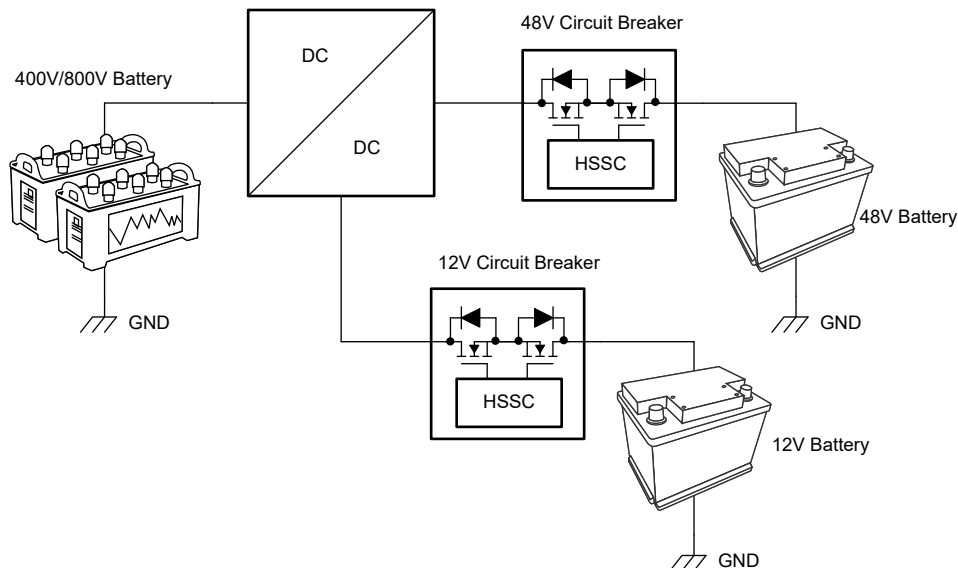


Figure 3. High-Side Switch Controller Application: DC/DC Converters

The TPS12S24F-Q1 is designed for this environment. The device supports back-to-back FET configurations, enabling protection in both directions. Moreover, TPS12S24F-Q1 offers bidirectional current monitoring as well. These are critical capabilities for any system where faults originate from either side of the switch. Through the SPI, this fault data is readily accessible. The device provides a complete view of the electrical environment around the converter to understand and respond to a fault. With quiescent current below 25µA in low-power mode, the device provides protection without draining too much power. Finally, as many of these applications often have stringent functional safety requirements, TPS12S24F-Q1 comes ASIL-B compliant to bolster the safety rating of the systems the device is designed into.

Where the TPS12S24F-Q1 separates itself is in how completely it addresses the application needs. Bidirectional protection and monitoring, and deep diagnostic and fault visibility are each valuable individually. Together, they give the designer a level of control and insight that basic solutions cannot match.

For applications with simpler disconnect and circuit breaker needs, TPS1210-Q1, TPS4810-Q1, TPS4816-Q1 and TPS1212-Q1 offer capable GPIO-based alternatives. These devices provide more basic implementations of the same feature set, such as bidirectional current monitoring and low power mode, and they support 12V and 48V systems.

Conclusion

The expectations of a power switch have grown significantly in the past decade and the TPS12S24F-Q1 rises to meet those expectations. Across 12V and 48V systems, legacy and progressive architectures, the device delivers the intelligence, safety, and configurability that modern automotive applications require. TPS12S24F-Q1, therefore, TI's flagship high-side switch controller.

With the TPS12S24F-Q1 at the apex, TI's portfolio offers a complete design for every level of complexity. In applications where the full feature set of the TPS12S24F-Q1 is more than the design requires, TI's GPIO-based devices, the TPS12xx-Q1 and TPS48xx-Q1 families, provide capable, cost-effective alternatives with more basic implementations of the same core features. Whatever the application demands, TI has a design that fits.

Trademarks

All trademarks are the property of their respective owners.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), 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 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](#), [TI's General Quality Guidelines](#), 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. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

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

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025