Application Brief

Functional Safety Compliant Power Design for Automotive Functional Safety Microcontrollers

Introduction

Automobiles and industrial systems are trusted to keep occupants and users safe when in use. To regulate the criteria around keeping occupants and nearby bystanders safe from harm when a vehicle is in use, ISO26262 standards have been developed. This standard determines how an automotive system can operate in a given failure condition to protect and reduce the direct and indirect risk of injury to users and third parties. One aspect of protecting users in the case of systemic failure is designing the behaviour of the system during failure to be predictable and deterministic. Developing predictable behavior during catastrophic failure requires functional-safety microcontrollers, such as those offered by Texas Instruments, to have specified functions, reliability, and testing to operate critical system functions. The need of predictable behaviour for these specialized functional safety microcontollers has developed the necessity of power architecture that is also compliant to functional safety system standards such as ISO26262. One form of power architecture can be found in the form of functional-safety compliant power management integrated circuits (PMICs).

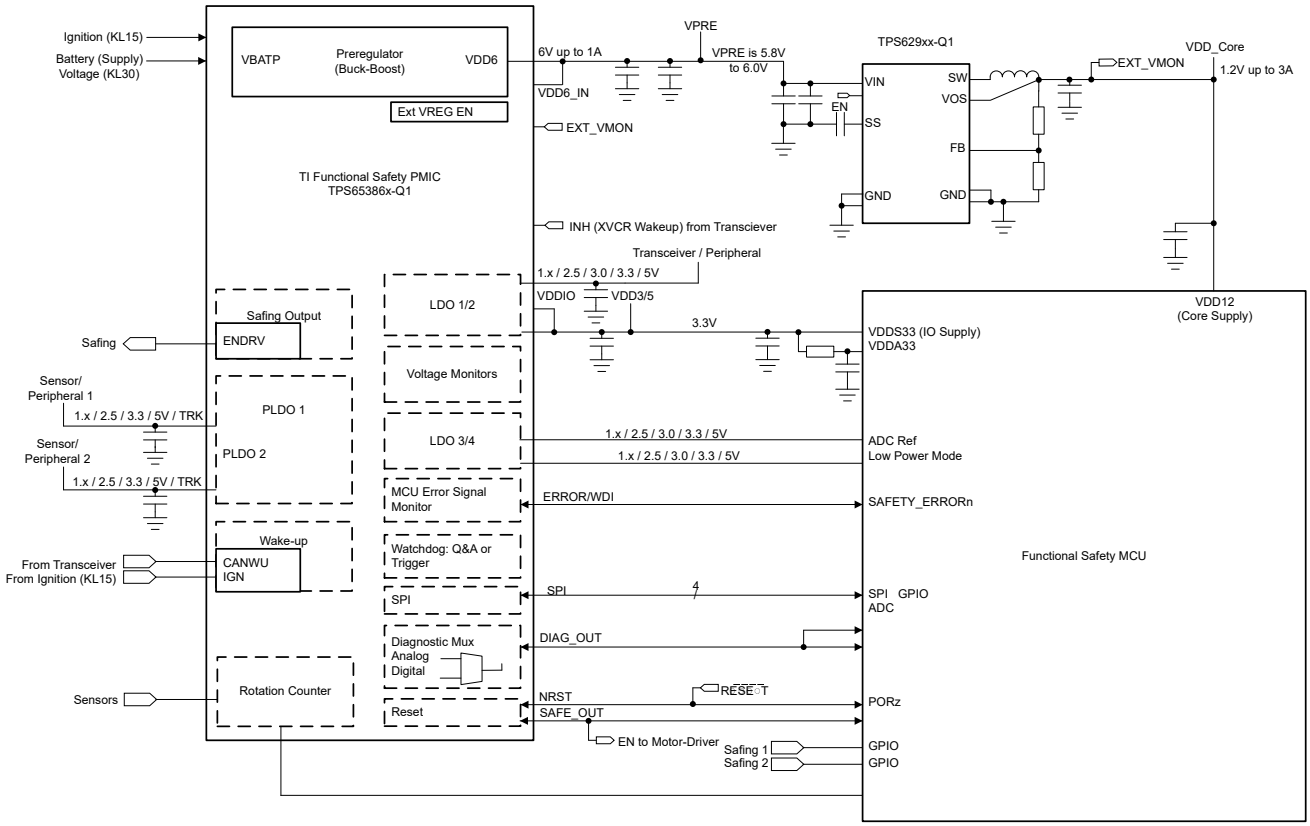

Figure 1. Example of a FS PMIC and Buck Powering a Functional Safety MCU

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Application

Without reliably powering a functional safety microcontroller during a catastrophic system failure, the microcontroller is not effective at reducing risk. This leads to the development of power management devices which contain design elements that enable the PMIC to fail-safe in multiple potential failure scenarios.

However, with increasingly higher power requirements of functional safety microcontrollers, there is a growing need for higher compute-core power delivery, often demanding more current than modern multirail power management devices can offer on a single rail. Instead, by using the PMIC buck-boost preregulator to power an automotive-qualified, high-efficiency buck converter, greater current can be delivered to the core of the functional safety microcontroller, enabling a system that can meet ISO26262 ASIL-D standards.

The TPS653860-Q1 is the latest offering from TI for functional safety PMICs and includes two external voltage monitors that can monitor external voltage rails, such as the core rail of the functional safety microcontroller. The microcontroller is powered by a high-efficiency buck converter. As the device is intended for use in safety-relevant applications, additional monitoring and protecting features are included that improve the diagnostic coverage and decrease the undetected fault rate.

Since this system is always connected to the battery of the vehicle and can be always powered on, low quiescent current is required. TI automotive buck switching regulators are an option for microcontroller rails that can always be powered. Some bucks feature industry-leading low quiescent currents, reaching as low as a few microamperes.

Efficiency is a key performance characteristic for evaluating the application effectiveness of a system. Most of the lost energy in electrical systems is converted into heat. Several devices under load in a constrained space can lead to self-heating which can result in thermal stress on a system. This results in greater thermal performance requirements of the devices in a system. In automotive settings, this is a concern as more automotive electrical systems have higher power requirements every year and automotive use cases can be subject to extreme ambient temperatures.

Any integrated circuit can fail to perform if the thermal conditions of the application cause the system to enter thermal shutdown. TI offers power management devices in AEC-Q100 grade 1 and grade 0 variants. Normal operation is from -40°C to +150°C and -40°C to +175°C, respectively. Some buck offerings from TI are qualified at AEC-Q100 grade 1, but are also verified in testing to operate from -40°C to +175°C.

Table 1. TI Functional Safety PMICs for Functional Safety Microcontrollers

TI PMIC GPN	Regulated Outputs	TI Functional Safety Category	Features	AEC- Q100 Qualification
TPS653850A-Q1	5	Functional Safety Compliant	Multirail power supply for safety MCUs with 350mA LDO (MCU) I/O rail	Grade 1
TPS653851A-Q1	5	Functional Safety Compliant	Multirail power supply for safety MCUs with 350mA LDO (MCU) I/O rail	Grade 0
TPS653852A-Q1	5	Functional Safety Compliant	Multirail power supply for safety MCUs with 500mA LDO (MCU) I/O rail	Grade 1
TPS653853A-Q1	5	Functional Safety Compliant	Multirail power supply for safety MCUs with 350mA I/O and rotation counter	Grade 1
TPS653854A-Q1	5	Functional Safety Compliant	Multirail power supply for safety MCUs with 500mA I/O rail and rotation counter	Grade 1
TPS653860-Q1	7	Functional Safety Compliant	Multirail power supply for safety MCUs with 2.3V to 36V Vin, 2.8A output current	Grade 1

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Table 2. Automotive Bucks for Functional Safety Microcontroller Core Power

TI Buck GPN	Input Voltage Range	Output Voltage Range	Output Current	Features	AEC- Q100 Qualification
TPS62903-Q1	3-18V	0.4-5.5V	3A	QFN wettable-flanks package	Grade 1
TPS62993-Q1	3-10V	0.4-5.5V	3A	QFN wettable-flanks package	Grade 1
TPS62902-Q1	3-18V	0.4-5.5V	2A	QFN wettable-flanks package	Grade 1
TPS62992-Q1	3-10V	0.4-5.5V	2A	QFN wettable-flanks package	Grade 1
TPS62901-Q1	3-18V	0.4-5.5V	1A	QFN wettable-flanks package	Grade 1
TPS629210-Q1	3-17V	0.4-5.5V	1A	Leaded SOT583 package	Grade 1
TPS629211-Q1	3-10V	0.4-5.5V	1A	Leaded SOT583 package	Grade 1

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