

# NXP ELECTRIFICATION SOLUTIONS

SEMICONDUCTOR SYSTEM SOLUTIONS FOR THE NEXT GENERATION OF ELECTRIFIED ECOSYSTEMS



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## INTRODUCTION

### OUR STORY

The network of electrified endpoints – from EVs, to charging stations, to smarter city grids – is constantly expanding. For the network to work reliably, millions of electrified endpoints must stay in constant balance – providing the right information to the right place at the right time.

NXP Electrification solutions’ robust, open architecture enables safer, more secure two-way communication from electrified endpoints to the cloud. Our integrated and embedded technologies give product designers and service providers confidence to build systems with the highest security and safety standards; with insights to improve the performance for the whole product lifecycle. NXP Electrification solutions offer control throughout the whole ecosystem, not just one part—handling battery management, fast charging, and load balancing across entire grids.

NXP powers electrified ecosystems with smart insights that securely drive safe, optimized performance.

### WHICH ENERGY TO USE?

A frequent detracting argument for electric vehicles is over the increased use of electricity for slow charging. The counter point to this argument is the reduction in gasoline and diesel displacement and the resulting decrease in CO2 emissions.

With more than 3 million in sales, EVs made up 4.6% of the global car sales in 2021—another big step from the previous year.<sup>1</sup> In addition, Europe overtook the People’s Republic of China (“China”) as the world’s largest EV market for the first time.<sup>2</sup>

## CHARGING INFRASTRUCTURE

The scale of the electric charging infrastructure is a sensitive area that hasn’t been favorable for EV adoption. Desperately inadequate for mass adoption, the majority of the 7.3 million chargers<sup>1</sup> worldwide are privately owned. While the necessity of home-based charging is clear, the convenience and reassurance of widespread charge points are undeniable. However, Level 2 chargers, which could fully charge the EV overnight, are gaining in popularity in large part due to incentives from states and utility companies, as well as EV manufacturers who are also helping with its acceptance. As a result, the [global EV charger market is expected to grow at a 28.5% CAGR between 2021 and 2028.](https://www.prnewswire.com/news-releases/at-28-5-cagr-ev-charger-market-to-hit-usd-31158-2-million-by-2028-globally-says-brandessence-market-research-301455432.html)<sup>3</sup>

## BATTERY PACK EVOLUTION

Through all this, the challenge for the automotive industry is to find the path to make electric vehicles more profitable than ICE models. The sticking point here is the balance between the size and cost of the battery pack and the consumer acceptance for the vehicle range on a single charge. The unit cost of the battery pack and manufacturing capacities are key to the expansion of the electric vehicle market.

<https://www.nxp.com/company/blog/back-to-the-charge:BL-BACK-TO-THE-CHARGE>

## Powering Electrified Ecosystems

### EV CHARGING

EFFICIENT, SMART & SECURE



NXP supports EV charging systems by providing high accuracy energy measurement products, smart and secure controllers and security products.

#### BATTERY CHARGING CHALLENGES

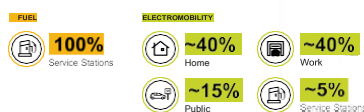
- Accurate power delivery measurement
- Increased security and safety at the edge
- Cloud onboarding
- Standardized device APIs for billing and control
- Mass deployment readiness
- Artificial intelligence (AI) and machine learning (ML)
- Availability and reliability
- Efficient energy management
- Secure data storage and transfer
- Secure access to charging and payment
- EV charging station management



NXP MIFARE & NFC Reader ICs & MIFARE™ 2GO

**2030 GOAL** Install 15,000+ chargers within the EU

MARKET SHIFT TOWARD MULTI-CHANNEL DISTRIBUTION MODEL IN EUROPE



### ENERGY MANAGEMENT & SECURITY

**EFFICIENT ENERGY MANAGEMENT**  
Begins with accurate and secure measurement  
NXP Kinetics MCUs & Azure.

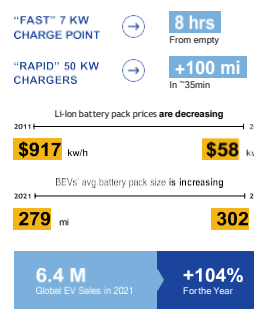
#### SECURE ELEMENT (SE)

- Provides crypto protocols for secure communication with the EV compliant with ISO15118 and secure storage for credentials and service provider specific data.
- Enables secure communication between EVs and the cloud for data transfer (e.g. billing, authorization of new car brand).

#### EDGELOCK 2GO

Allows key and credential rotation to onboard new application/provider specific certificates.

### EV BATTERIES



Electrification infographic 2022

<sup>1,2</sup> Iea. “Global EV Outlook 2021 - Analysis.” Accessed April 18, 2022. <https://www.iea.org/reports/global-ev-outlook-2021?mode=overview>

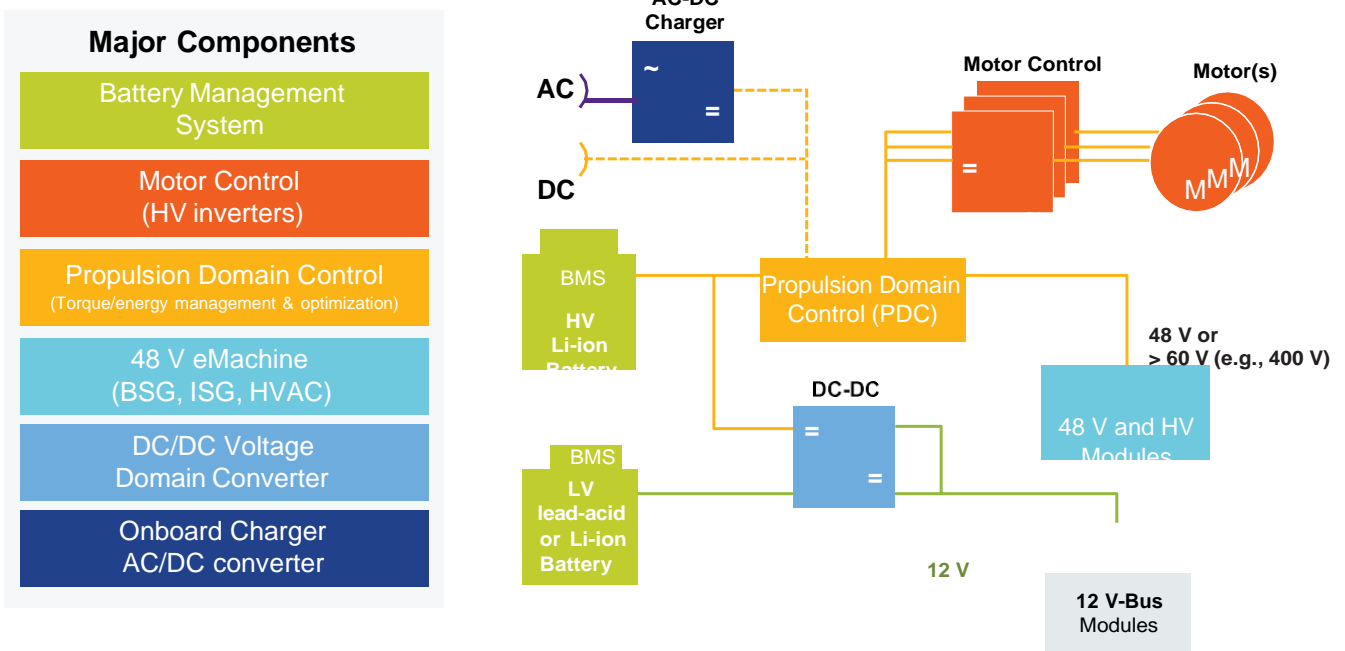
<sup>3</sup> “At 28.5% CAGR, EV Charger Market to hit USD 31158.2 Million by 2028 Globally, Says Brandessence Market Research.” Accessed April 18, 2022. <https://www.prnewswire.com/news-releases/at-28-5-cagr-ev-charger-market-to-hit-usd-31158-2-million-by-2028-globally-says-brandessence-market-research-301455432.html>

## EV AUTOMOTIVE SYSTEM SOLUTIONS

Accelerate to zero emissions with NXP’s electrification solutions. From battery management to propulsion domain control, our aim is to simplify the electrification transition. NXP delivers an electrified system solution, incorporating optimal performance, robust functional safety, and power management features that automakers and developers require for their next generation of vehicles.

Our automotive electrification portfolio features:

- High-performance real-time processors
- Microcontrollers (MCUs) with associated power management ICs (PMICs) and system basis chips (SBCs)
- Battery cell controller and battery management solutions
- Electric motor driver solutions, based on advanced functional safety IGBT gate drivers
- In-vehicle networking components for CAN, LIN, FlexRay™ and Ethernet
- Scalable functional safety
- Automotive robustness with electrification mission profiles (EMP)
- Enablement platforms, reference designs and evaluation boards
- Worldwide presence and support



Electric Vehicles: Base Architecture Components

## PROPULSION DOMAIN CONTROL

The propulsion domain control (PDC) is the brain of the powertrain control for hybrid or electric vehicles. It controls the power distribution, energy storage, engine and motor. As such, it is key for enhancing the efficiency of the xEV powertrain.

### BENEFITS

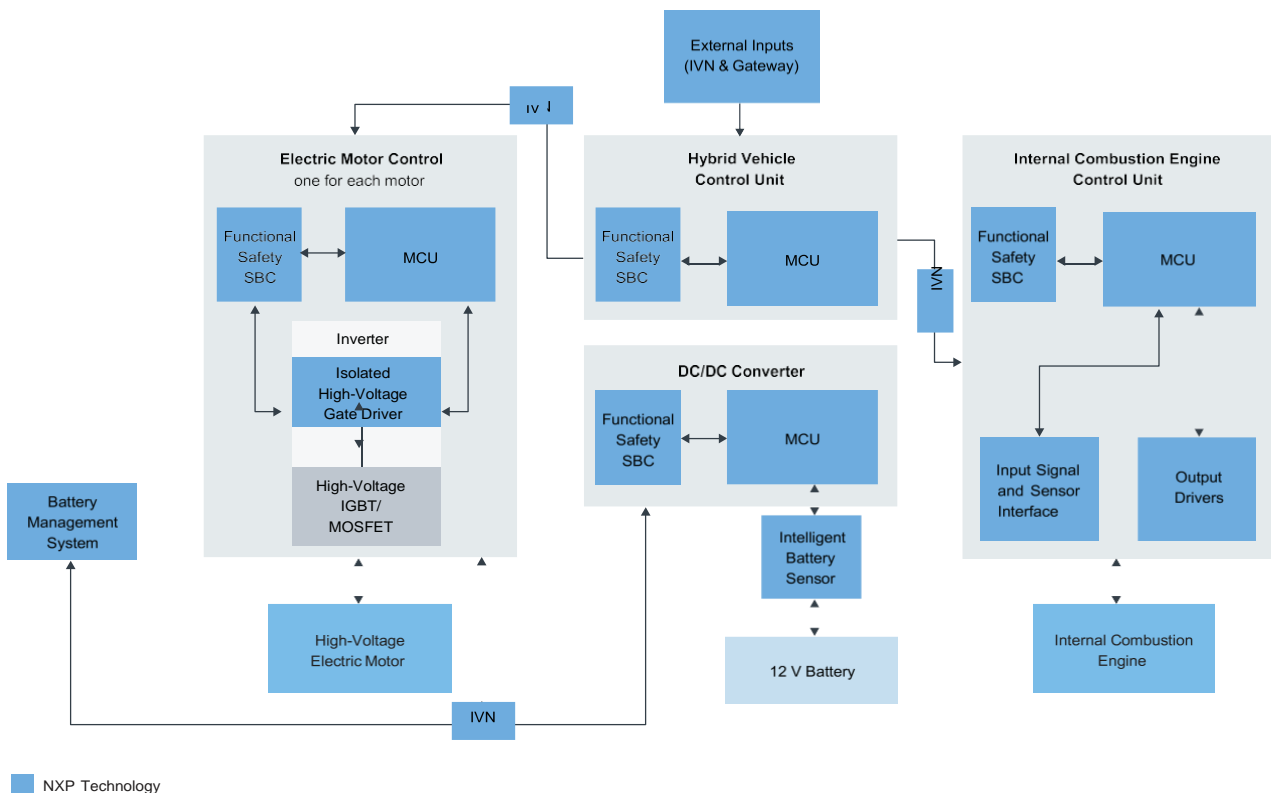
- NXP S32Z/E: market leader for propulsion domain controllers and zonal architectures with automotive ASIL D real-time compute performance
- Virtual automotive ECU development platform available

### FEATURES

- Executes multiple applications, including hybrid electric control with advanced algorithms, all under hypervisor
- Energy and thermal management
- Regenerative braking
- Battery states (charge, health, function) management
  - Advanced algorithms (torque vectoring, A-ECMS, etc.)
  - Inter-domain communication, acts on ADAS domain messages

### SUPPORTED DEVICES

- FS66: functionally safe multi-output power supply integrated circuit
- S32Z2: Based on the Arm Cortex-R52 core, the S32ZS24 and S32E2 real-time processors are designed for automotive vehicle dynamics, domain control and safety coprocessor applications. They offer support for the high levels of automotive safety and the performance headroom to manage the transition to advanced electrification and autonomous vehicle applications.



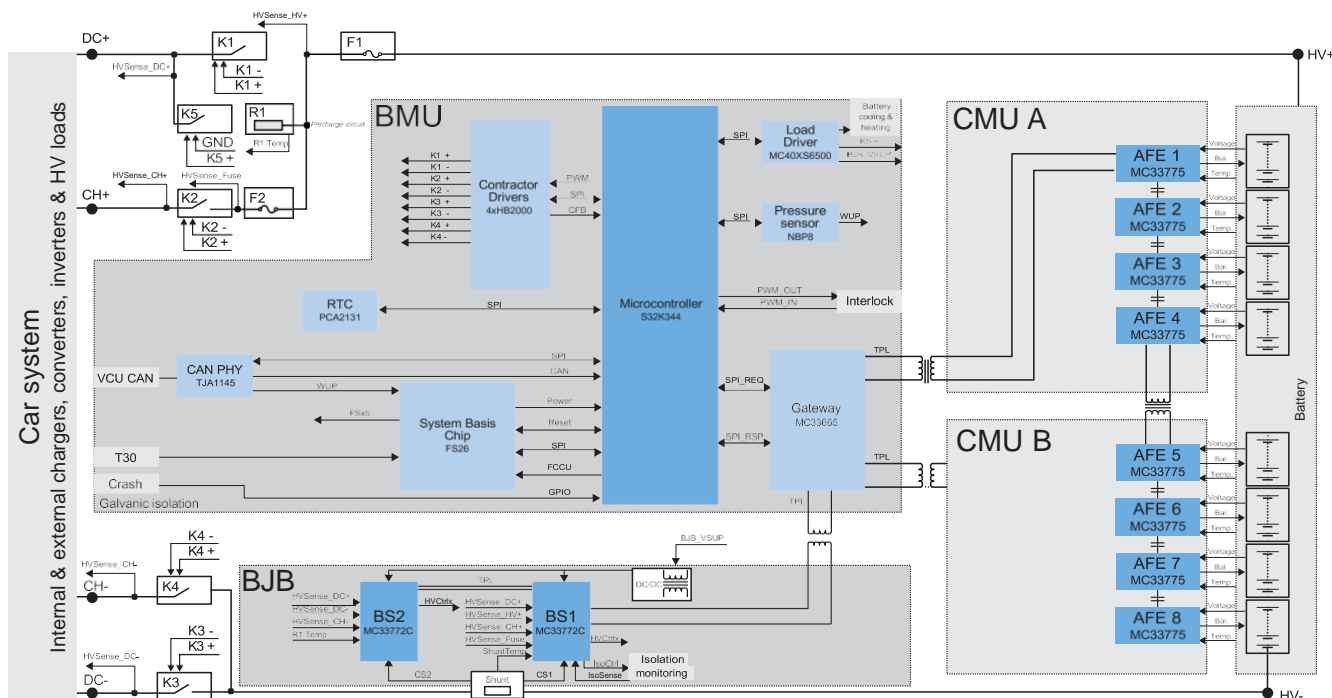
EV Powertrain Control Block Diagram

# HIGH VOLTAGE BATTERY MANAGEMENT SYSTEM (HVBMS) REFERENCE DESIGN

NXP's HVBMS reference design (HVBMS RD) has a scalable ASIL D architecture for high-voltage applications. It is composed of three modules: the BMU, the CMU and the BJB. At NXP we offer solutions for each module. The BMU board features an ASIL D microcontroller - the S32K34. The CMU includes ASIL D compliant battery cell controllers and the BJB two of our recently launched MC33772C ICs

## KEY GENERAL FEATURES

- Scalability: HVBMS chipset solutions for a wide range of applications to reduce development cost and enable faster time to market.
- Safety: High system-level safety level ensures proper operation of the battery at all times, protecting the passengers.
- Precision: Precise and synchronized measurement increases battery potential and maximizes range.



HVBMS Block Diagram

**HEV/EV POWER INVERTER SYSTEM  
REFERENCE PLATFORM**

This power inverter system reference platform includes:

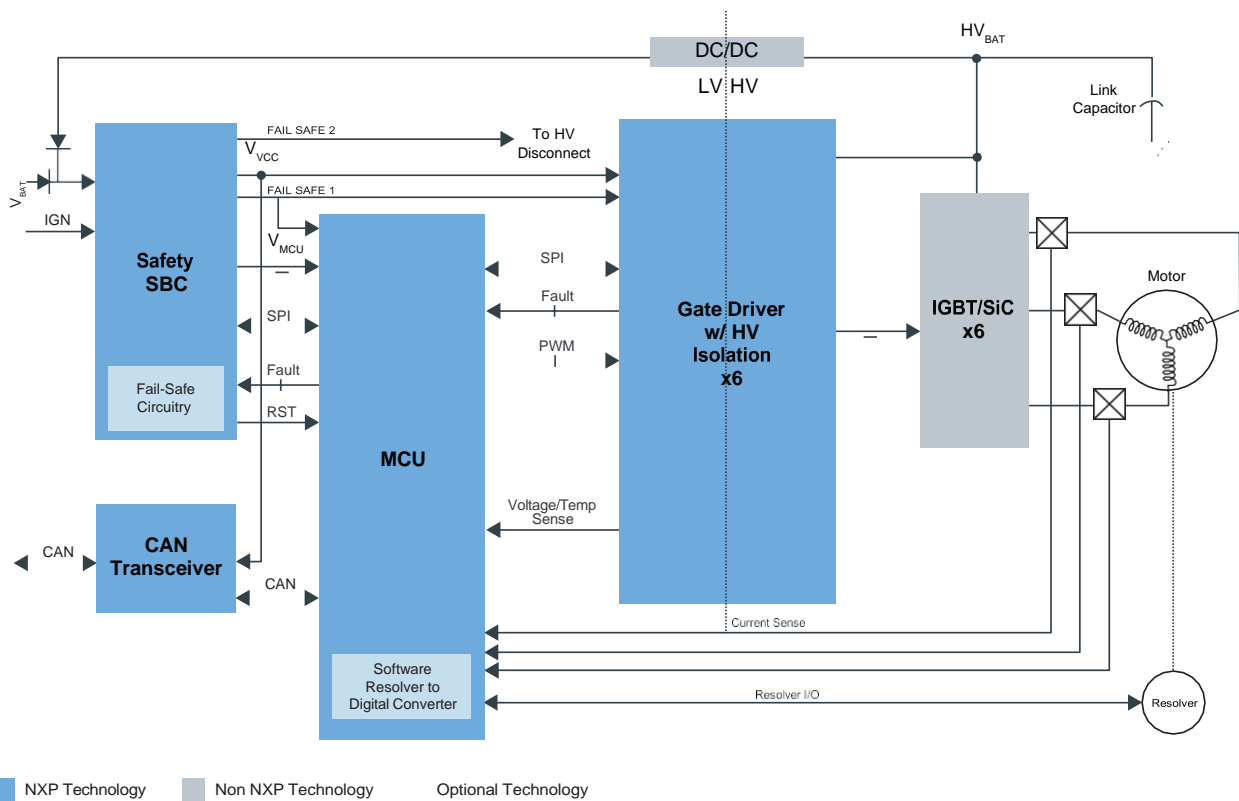
- MPC5775E: secure multi-core 32-bit lockstep MCU with software resolver
- FS65: Grade1/Grade0 Safety SBC, fit for ASIL D, with two fail-safe outputs for motor control safety management
- GD3160: advanced single-channel high-voltage isolated gate driver
- GD3162: advanced galvanically-isolated, single-channel gate driver
- TJA1051: redundant CAN bus interface with low-power standby
- Enablement software with API and functional safety case

**BENEFITS**

- ASIL C/D compliancy with small, compact 9 IC system footprint
- Robust fail-silent SBC with operation from 36 V down to 2.7 V
- Secure multicore 32-bit lockstep MCU with eTPU and SW RDC
- Functional safety case and enablement software with API
- < 2 μs iSense-compatible 2-level IGBT OC protection with soft shutdown

**FEATURES**

- Efficiently drives 100 kW 3-phase motor from 400 V supply
- Integrated galvanic signal isolation in IGBT/SiC gate drivers
- Redundant CAN bus interface with low-power standby
- Primary and backup battery inputs with no negative gate driver supply
- Supported by S32DS SDK with MCAL drivers



**Hybrid and EV Powertrain Block Diagram**

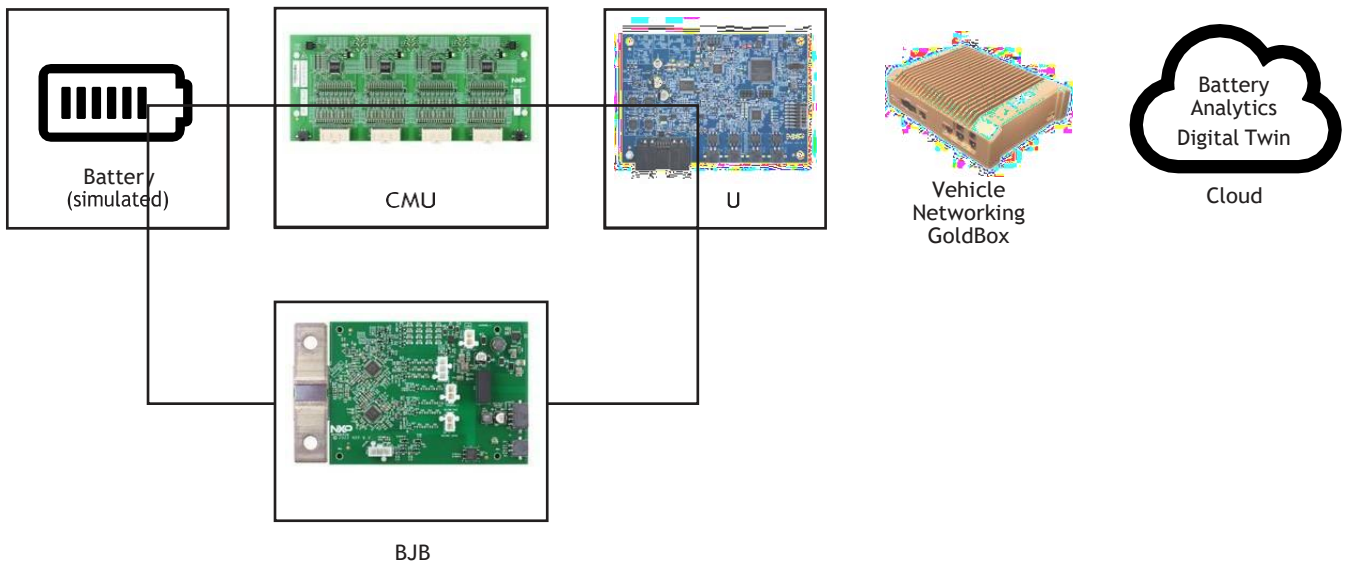
## DIGITAL TWIN

Digital twins are virtual representations of real-world situations. With AI, machine learning, processors and sensors, it gets easier to create those digital models that show what is happening in manufacturing sites, electric cars and hospitals - and will help to improve simulations, testing, monitoring and maintenance processes.

Digital twin cloud services have a high potential to improve estimations of the battery's state of health (SoH) and state of charge (SoC) to improve efficiency, lifetime and cost. Battery digital twins adapt to ongoing changes in battery health due to operating conditions and provide updated figures back to the BMS for continuously improving control decisions.

### SUPPORTED DEVICES

- MC33775A: 14 cell lithium-ion battery cell controller IC
- MC33665A: General-purpose battery management communication gateway and TPL transceiver
- S32K3: microcontrollers fit for ASIL D ASIL D functional safety
- S32G: Safe and secure multi-core Arm® Cortex®-A53 application processors with optional cluster lockstep support and dual-core lockstep Cortex-M7 real-time microcontrollers fit for ASIL D safety
- FS26: Safety SBC with low power fit for ASIL D
- TJA1145: High-speed CAN transceiver for partial networking
- TJA1443: High-speed CAN transceiver with standby, sleep and listen only mode
- TJA1057: High-speed CAN transceiver
- MC40XS6500: External automotive lighting multi-channel eXtreme switch
- HB2000: H-Bridge motor driver family is SPI programmable with multi-packages, ASIL B/D with 120 mohm typical RDS(ON) fit for high safety applications
- PCA2131: Nano-power highly accurate real-time clock (RTC) with integrated quartz crystal for automotive applications
- NBP8: Fully integrated battery monitor sensor
- EVE-Ai 360 Adaptive Controls: Artificial intelligence & machine learning from Electra Vehicles



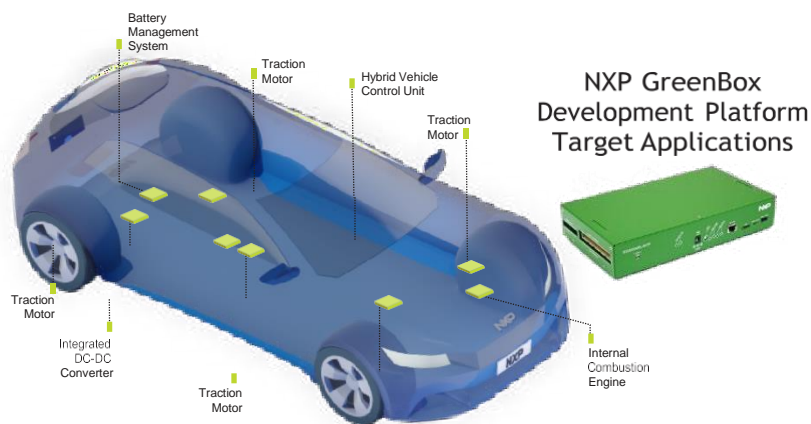
Digital Twin Block Diagram



## DEVELOPMENT PLATFORMS

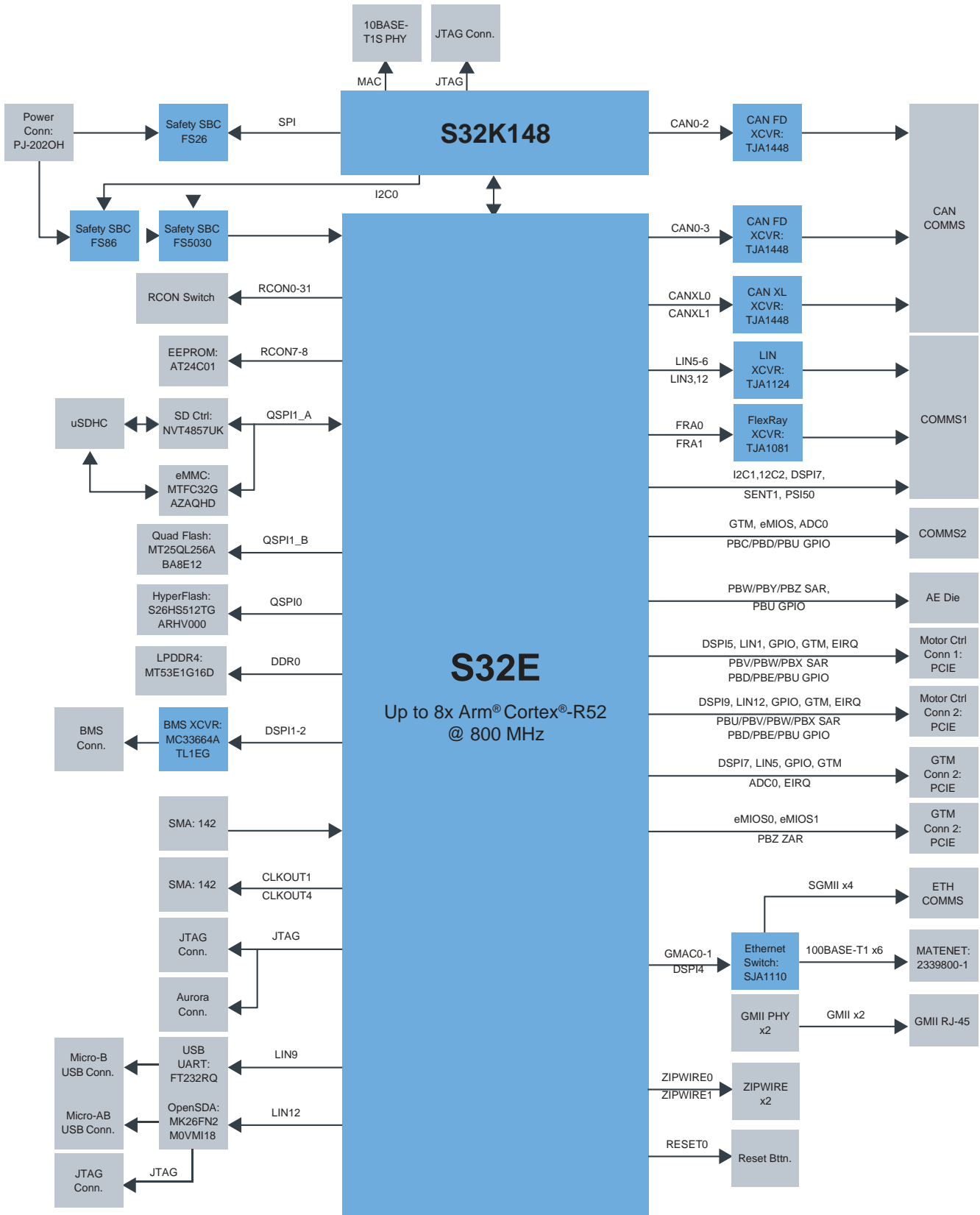
In addition to our development platforms, evaluation boards and tools are available to help accelerate your electrification designs.

	EV NAME	DESCRIPTION	
MOTOR CONTROL	MTRCKTDPS5643L	Dual 3-phase PMSM development kit with MPC5643L microcontroller; suitable for applications requiring 2 PMSM motors, such as active suspension or electric powertrain	
	DEVKIT-MPC5744P	Offers dual e200z4 lockstep cores, motor control, safety and communication interfaces to facilitate a complete safety/ chassis solution for motor control applications	
BMS	MPC5775BE-416DS Adapter	MPC5775B MCU targets industrial and automotive battery management systems (BMS); the MPC5775E targets HEV/ EV inverter control systems that require advanced performance; eTPU-based timer system and ISO 26262/IEC 61508 functional safety support up to ASIL D	
	RD33771CNTREVM	Reference design for mixed centralized-distributed architecture BMS for electric vehicle applications	
	RD33771CDSTEVB	14-channel Li-Ion BCC with isolated daisy chain interface with MC33771C BCC	
	FRDM33771CSPEVB	14-channel high performance Li-Ion BMS with SPI interface using MC33771C BCC	
	FRDM33771BTPLEVB	Dual TPL interface between MCU and isolated network with loopback using MC33664 device	
	FRDM33771BTPLEVB	14-channel Li-ion battery cell controller with isolated daisy chain interface using MC33771B BCC	
	FRDM33664BEVB	TPL interface between MCU and isolated network using MC33664 device	
	FRDM33772BTPLEVB	6-channel Li-Ion BCC with isolated daisy chain interface using MC33772B BCC	
	FRDM33664BEVB	Transceiver physical layer (TPL) interface between MCU and isolated network using MC33664 device	
	RD33771-48VEVM	48 V mild hybrid auxiliary battery management system reference design	
	FRDM33771CSPEVB	14-channel high performance Li-Ion BMS with SPI interface using MC33771C BCC	
	FRDM33771BSPIEBV	14-channel Li-ion battery cell controller with SPI interface using MC33771B BCC	
	FRDM33771BTPLEVB	14-channel Li-ion battery cell controller with isolated daisy chain interface using MC33771B BCC	
	FRDM33664BEVB	Transceiver physical layer (TPL) interface between MCU and isolated network using MC33664 device	
	NEWTEC-NTBMS	12 V battery management system for Li-Ion batteries supporting ASIL C safety levels	
	RD9Z1-638-4LI	4-Cell Li-Ion BMS with high EMC performance and CAN interface using MM9Z1_638 sensor	
	RD9Z1-638-12V-C	12 V lead-acid BMS with high EMC performance with CAN interface using MM9Z1_638 sensor	
	RD9Z1-638-12V	12 V lead-acid BMS with high EMC performance with LIN interface using MM9Z1_638 sensor	
	FRDM33772BSPIEBV	6-channel BCC for Li-Ion battery applications with SPI interface using MC33772B BCC	
	MPC5775BE-516DS Adapter	For automotive engine control applications that require advanced performance, timing systems and functional safety capabilities	
	S32EDEVPL	GreenBox, advanced performance, peripherals and multicore Arm® environment for HEV and EV development with peripheral board for HEV and ICE applications	
	HVBMS	RD33772BJBEVM	High Voltage Battery Junction Box (BJB) RD with functional safety, voltage, current, temperature and insulation measurement function
		MPC5775B-EVB	Low-cost development boards engineered for battery applications
RDVCU5775EVM		Reference design for high-voltage BMS and vehicle control unit integration for ASIL D applications	
RD-K344BMU		Reference design for rapid prototyping of a high-voltage battery management system (HVBMS) hardware and software	
RD33775ACNTEVB		Centralized cell monitoring unit (CMU) reference design with transformer physical layer (TPL) communication that is ideal for rapid prototyping of a high-voltage battery management system (HVBMS) hardware and software	
RD772BJBTPLEVB		A battery junction box (BJB) reference design that is ideal for rapid prototyping of a high-voltage battery management system (HVBMS) hardware and software	
BATTERY PACK	BATT-6EMULATOR	6-cell battery pack to supply MC33772 EVBs—emulates a multi-cell battery pack	
	BATT-14CEMULATOR	14-cell battery pack to supply MC33771C EVBs—emulates a multi-cell battery pack	
	BATT-14EMULATOR	14-cell battery pack emulator made to supply MC33771B BCC EVBs	
	BATT-14EXTENDER NE	Allows for the connection up to four evaluation boards using only one single battery emulator	
BATT-14AAAPACK	A configurable battery pack that can be used to supply the MC33771 or MC33772 evaluation boards		
BATTERY SENSOR	KIT9Z1J638EVM	Battery sensor for current, voltage and temperature with CAN/LIN interface using MM9Z1_638 sensor	
GATE DRIVER	FRDMGD3160DSBHB	Half-bridge evaluation kit populated with two GD3160 single channel IGBT/SiC MOSFET gate drive devices.	
	FRDMGD3160XM3EVM		
TRACTION INVERTER	ICP2.0	Second gen automotive grade IGBT- EV power inverter control platform (ICP2.0) system solution based on GD3160 gate driver IC offers both hardware and software enablement for electric vehicle traction inverters application targeting ISO 26262 ASIL C/D using IGBT power modules	
	EV-INVERTERHDBT		



GreenBox Platform

# REAL-TIME PROCESSOR HYBRID CONTROL UNIT



NXP Products

## MICROCONTROLLER HYBRID CONTROL UNIT

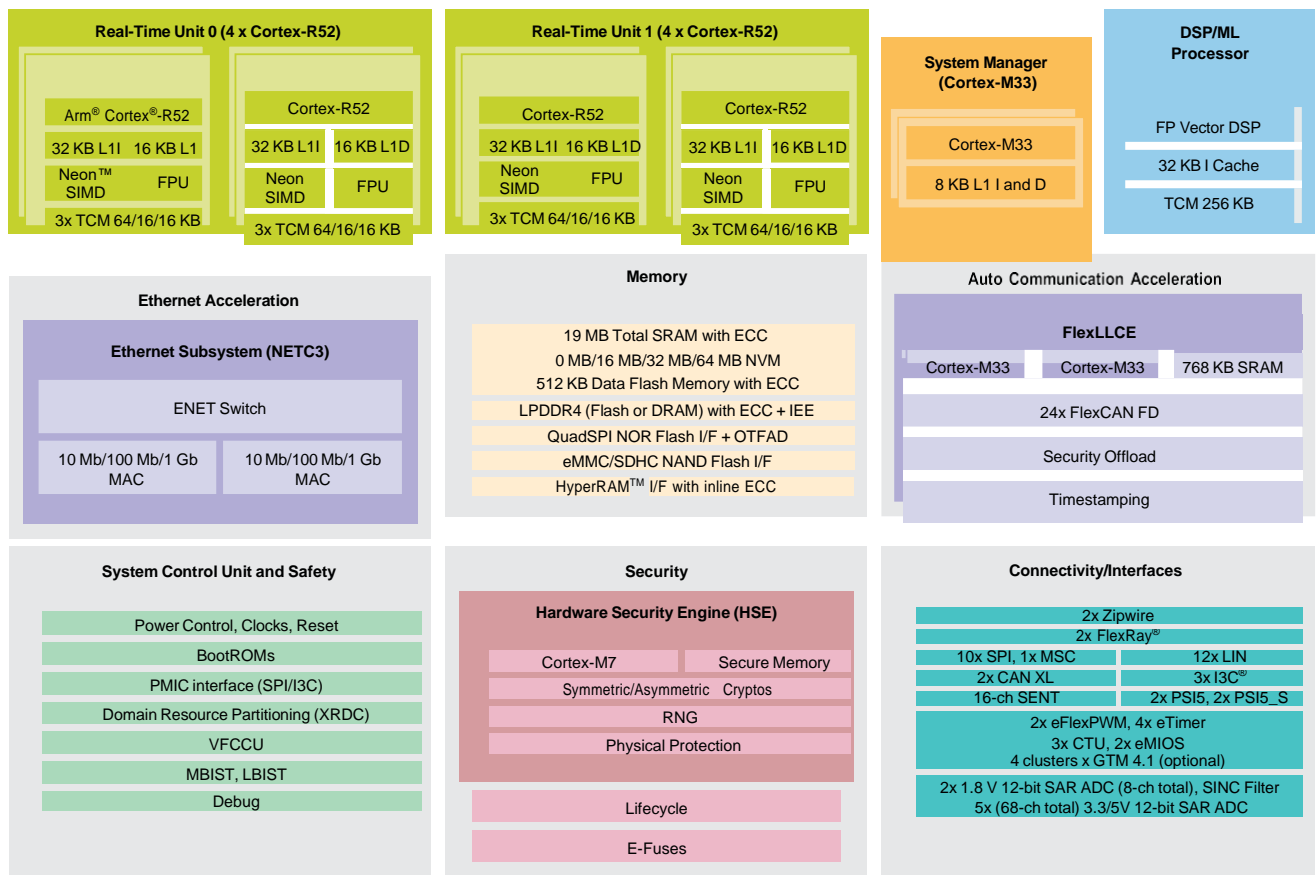
The hybrid control unit (HCU) is a core control component for hybrid and electric vehicles. It uses input signals to calculate and manage output parameters such as engine power or motor torque.

## S32Z2 AND S32E2 SAFE REAL-TIME PROCESSORS

The S32Z and S32E are Arm Cortex-R52-based microcontroller for automotive vehicle dynamics, domain control and safety coprocessor applications. They support for the highest levels of automotive safety and provide the performance headroom to manage the transition to advanced electrification and autonomous vehicle applications.

### FEATURES AND BENEFITS

- 8x Arm Cortex-R52 plus Lockstep Arm Cortex-M33
- Combine real-time and DSP/ML processing with hardware virtualization, scalable non-volatile memory, flexible expansion memory support and network acceleration
- On-the-fly, over-the-air update capability with zero processor downtime
- Advanced safety functionality and fault recovery to support ASIL D applications
- Hardware security engine supporting public and private key encryption
- AEC-Q100 Grade 1 device with support from -40 °C to 150 °C (junction)



S32E2 Processor Block Diagram

## TRACTION INVERTER CONTROL

The S32K39 is a purpose-built device addressing new EV traction inverter control needs with a compelling combination of performance, integration, networking, security and functional safety capabilities.

It has enough compute power to support six-phase or two three-phase motors controlled by over 200 kHz control loops, while hosting AI/ML algorithms or other monitoring applications. It supports remote smart actuation applications using Time-Sensitive Networking (TSN) Ethernet for new zonal vehicle architectures. And it reduces system cost with ASIL D software resolver and analog integration.

### COMPUTE

- Three Arm Cortex-M7 cores running at 320 MHz
- One lockstep core pair
- Two split-lock configurable cores
- Two motor control coprocessors running at 320 MHz (S32K39 only)
- Programmable CoolFlux™ DSP running at 160 MHz

### SMART TIMERS

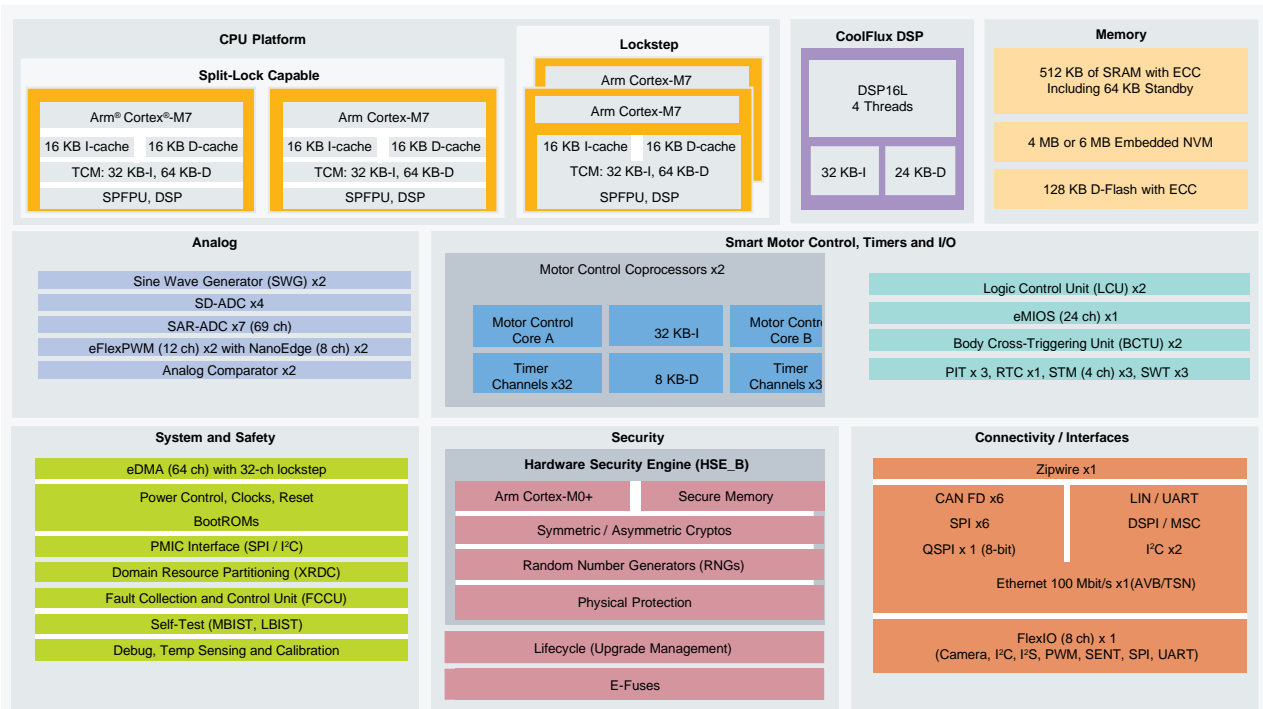
- Two eFlexPWM (12 ch) with NanoEdge (8 ch)
- One eMIOS (24 ch)
- Two logic control units (LCU)

### ANALOG-TO-DIGITAL

- Seven SAR-ADC (69 ch)
- Four Sigma-Delta ADC
- Two sine wave generator (SWG)
- Two analog comparators

### FUNCTIONAL SAFETY AND SECURITY

- ISO 26262 up to ASIL D
- Designed to support ISO/SAE 21434
- NXP hardware security engine (HSE\_B) accelerates symmetric and asymmetric cryptos



Features added from the S32K37x

S32E2 Processor Block Diagram

## ELECTRIFIED GENERAL-PURPOSE NODES

### THE SCALABLE S32K1 FAMILY: ACCELERATED DESIGN TIME, LOW-POWER PERFORMANCE

- Performance and integration with future-proof designs
- Automotive-grade software with minimized complexity
- Broad portfolio allows maximized reuse

### S32K FUNCTIONAL SAFETY SOFTWARE

- Cortex-M Core Self-Test Library: Structural Core Self-Test Library (SCST) is a safety measure against permanent faults in the cores
- Developed for detecting hardware permanent faults in a core by means of executing machine op-codes with fixed set of operands and comparing their execution results
- This library is considered as Safety Element out of Context and was developed according to ASIL B
- SCST library provides tests to achieve the claimed diagnostic coverage (analytically estimated)

### HARDWARE PLATFORM

- Low-cost development board compatible to Arduino® shields
- Onboard debugger and system basis chip

### RUNTIME SOFTWARE

- Automotive-grade NXP software development kit (SDK)
- NXP middleware e.g., core self test, LIN stack
- AUTOSAR 4.0 and 4.2 MCAL
- FreeRTOS
- Bootloader

### SOFTWARE DEVELOPMENT TOOLS

- IAR, GHS and GNU toolchains
- Full-featured, no-cost development platform (S32 DS)
- FreeMASTER

### APPLICATION SPECIFIC

- Motor control
- Touch sensing
- Secure communication
- Wireless charging
- Near-field communication

S32K116	S32K118	Common Features	S32K142	S32K144	S32K146	S32K148	S32K142W	S32K144W
Arm® Cortex®-M0+ @ 48 MHz		AEC-Q100, 5 V	Arm Cortex-M4F @ up to 112 MHz				Arm Cortex-M4F @ up to 80 MHz	
128 KB Flash	256 KB Flash	CSEc Security Module	256 KB Flash	512 KB Flash	1 MB Flash	2 MB Flash	256 KB Flash	512 KB Flash
17 KB SRAM	24 KB SRAM	Low Power Operating Modes and Peripherals	32 KB SRAM	64 KB SRAM	128 KB SRAM	256 KB SRAM	32 KB SRAM	64 KB SRAM
up to 42 I/Os	up to 58 I/Os	ASIL-B Capable: (ECC, MPU, CRC, W'DOGs)	up to 89 I/Os		up to 128 I/Os	up to 156 I/Os	up to 58 I/Os	
4 channel eDMA		LPUART, LPSPi, LPIIC, FlexIO	16 channel eDMA					
1x FlexCAN with 1x FD		FlexTimers, LP Timers, Prog. Delay Block	2x FlexCAN with 1x FD	3x FlexCAN with 1x FD	3x FlexCAN with 2x FD	3x FlexCAN with 3x FD	2x FlexCAN with 2x FD	
1x 13-ch., 12-bit ADC	1x 16-ch., 12-bit ADC	8-40 MHz Ext. Osc, 8/48 MHz Osc., 128 KHz LPO	2x 16-ch., 12-bit ADC		2x 24-ch., 12-bit ADC	2x 32-ch., 12-bit ADC	2x 16-ch., 12-bit ADC	
		*JTAG					IEEE® 158 ENET	
		S32DS IDE, SDK					Quad SPI	
		Real Time Drivers (RTD)					ETM Trace	
		AUTOSAR MCAL/OS					2x SAI	
		Application SW						

■ S32K14x only

### S32K General-Purpose Microcontroller Common Features

## SCALABLE S32K3 FAMILY: SUPPORTING ASIL D LEVEL



### SAFETY, SIMPLIFYING SOFTWARE DEVELOPMENT

- Lockstep Arm Cortex-M7 cores, 120-240 MHz + FPU
- 512 KB, 8 MB Flash with ECC
- FOTA, A/B firmware swap with zero downtime and roll-back support. Automatic address translation
- 12-bit 1 Msps ADCs, 16-bit eMIOS timers with logic control unit for motor control
- Low power Run and Standby modes, fast wake-up, clock and power gating
- MaxQFP and BGA packages

### S32K3 - SAFETY, SECURITY AND CONNECTIVITY

- ISO 26262 up to ASIL D
- Fault collection and control unit (FCCU)
- Hardware and software watchdogs, clock/power/temperature monitors

- Safety documentation and SafeAssure® community support
- HSE security engine: AES-128/192/256, RSA and ECC encryption; secure boot and key storage; side channel protection; ISO 21434 intended
- Ethernet TSN and AVB (100 Mbps/1 Gbps), I3C, CAN FD, FlexIO (SPI/IIC/IIS/SENT protocol), serial audio interface, QSPI

### MAXQFP PACKAGE TECHNOLOGY

- QFP ‘gull-wing’ + PLCC ‘J-lead’ in single package
- 172-pin (16 x 16 mm), 100-pin (10 x 10 mm), and 0.65 mm pin pitch
- AEC-Q100 qualified: Grade 1 (-40° C to +125° C) and Grade 2 (-40° C to +105° C)

Common Features	K311	K312	K314
AEC-Q100, 125 °C, 3.3/5 V	1 x Arm® Cortex®-M7 @ 120 MHz		1x Cortex-M7 @ 160 MHz
HSE-B Crypto Security Engine	1 MB Flash	2 MB Flash	4 MB Flash
FOTA (Firmware Over-the-Air)	128 K SRAM	192 K SRAM	512 K SRAM
Low-Power Operating Modes and Peripherals (LP UART, FlexIO)	up to 84 I/Os	up to 143 I/Os	up to 218 I/Os
ASIL B/D Safety: (ECC Memories, MPU, CRC, Watchdogs)	16-ch. eDMA		32-ch. eDMA
eMIOS Timers, Analogue Comparator, Logic Control Unit, Body Cross Triggering Unit, Trigger Mux	3 x CAN (3 x FD)	6 x CAN (6 x FD)	
JTAG			100 Mbit/s Ethernet (TSN)
S32 Design Studio IDE	1 x I²C and 2 x I²C	1 x I²C and 2 x I²C	
Real-Time Drivers (AUTOSAR® and Non-AUTOSAR)	4 x SPI*		6 x SPI*
Security F/W Safety Software Framework Application Software	2 x 24-ch, 12-bit ADC		3 x 24-ch, 12-bit ADC
			2 x SAI (I²S)
			Quad SPI
	LQFP-48	MaxQFP-172	
	MaxQFP-100		
	MAPBGA-257		

S32K31x Family Features Part 1 Block Diagram

# SCALABLE S32K3 FAMILY: SUPPORTING ASIL D LEVEL

Common Features	K322	K324	K341	K342	K344
AEC-Q100, 125 °C, 3.3/5 V	2 x Cortex-M7 @ 160 MHz		1 Lockstep Cortex-M7 @ 160 MHz		
HSE-B Crypto Security Engine	2 MB Flash	4 MB Flash	1 MB Flash	2 MB Flash	4 MB Flash
FOTA (Firmware Over-the-Air)	256 k SRAM	512 k SRAM	256 k SRAM	256 k SRAM	512 k SRAM
Low-Power Operating Modes and Peripherals (LP UART, FlexIO)	up to 143 I/Os	up to 218 I/Os	up to 143 I/Os	up to 143 I/Os	up to 218 I/Os
ASIL B/D Safety: (ECC Memories, MPU, CRC, Watchdogs)	32-ch. eDMA				
eMIOS Timers, Analogue Comparator, Logic Control Unit, Body Cross Triggering Unit, Trigger Mux	4 x CAN (4 x FD)	6 x CAN (6 x FD)	4 x CAN (4 x FD)	4 x CAN (4 x FD)	6 x CAN (6 x FD)
JTAG	100 Mbit/s Ethernet (TSN)				
S32 Design Studio IDE	1 x I <sup>2</sup> C and 2 x I <sup>2</sup> C	2 x I <sup>2</sup> C	1 x I <sup>2</sup> C and 2 x I <sup>2</sup> C	1 x I <sup>2</sup> C and 2 x I <sup>2</sup> C	2 x I <sup>2</sup> C
Real-Time Drivers (AUTOSAR® and Non-AUTOSAR)	4 x SPI*	6 x SPI*	4 x SPI*	4 x SPI*	6 x SPI*
Security F/W Safety Software Framework Application Software	2 x 24-ch. 12-bit ADC	3 x 24-ch. 12-bit ADC	2 x 24-ch. 12-bit ADC	2 x 24-ch. 12-bit ADC	3 x 24-ch. 12-bit ADC
	2 x SAI (FS)				
	Quad SPI				
	MaxQFP-172				
	MaxQFP-100		MaxQFP-100	MaxQFP-100	
		MAPBGA-257			MAPBGA-257

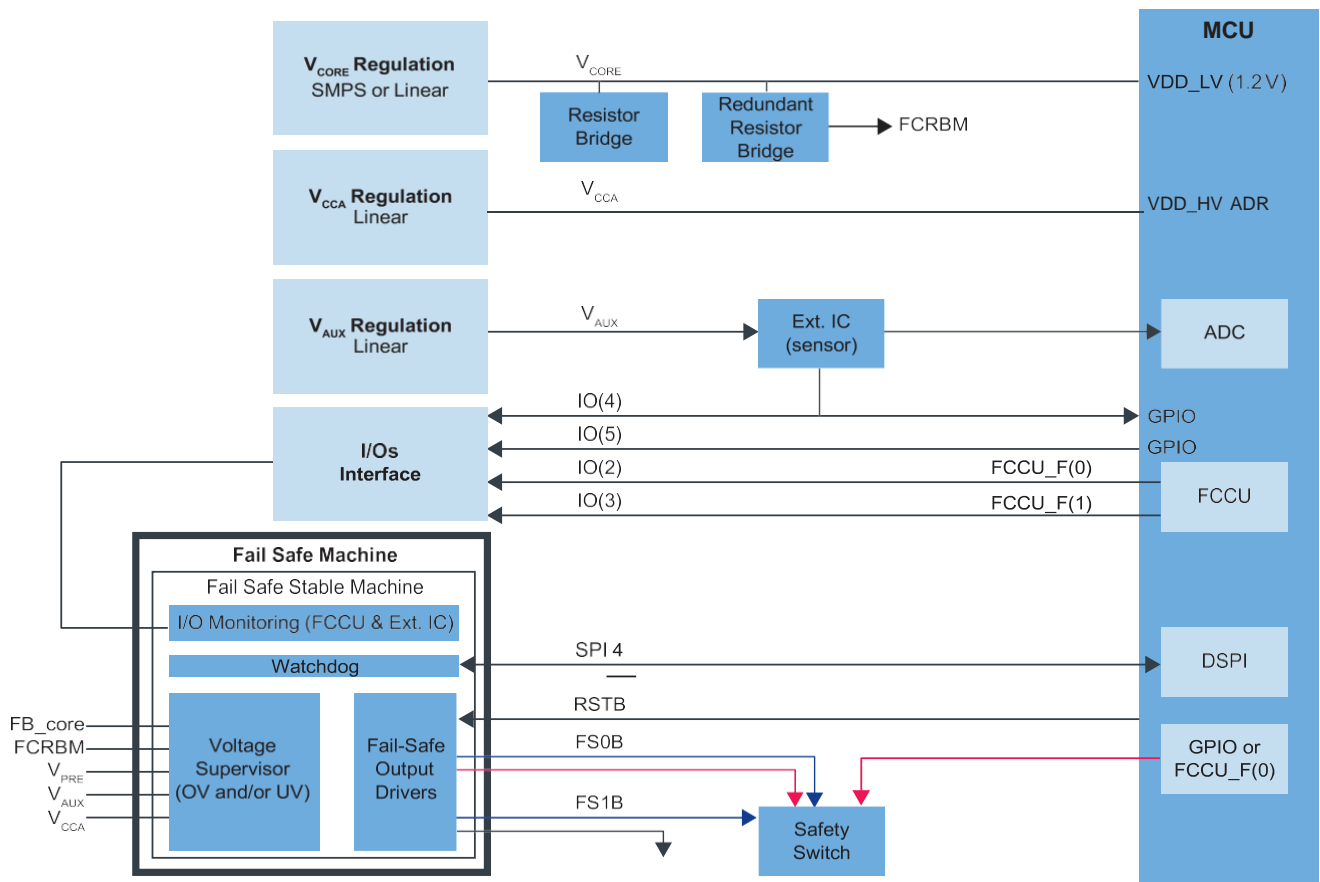
S32K31x Family Features Part 2 Block Diagram

FS45 AND FS65 GRADE 1 AND GRADE 0 SAFETY POWER SYSTEM BASIS CHIPS

The family of FS45 and FS65 safety SBC chips provides power management to MCUs by the optimization of energy consumption through DC-DC switching regulators, linear regulators and ultra-low-power saving modes.

FEATURES AND BENEFITS

- Physical and electrical independence to target ASIL B or D applications
- Power management monitoring unit (UV/OV/OC)
- Analog and digital built-in self-test to minimize latent faults
- Redundant reference and supply to reduce common cause failure
- $V_{CORE}$  external monitoring
- FCCU: fault collection control unit
- Monitor lock-step MCUs
- Configurable RSTb activation provides more system availability
- Redundant system fail-safe enabler
- Second fail-safe pin to assert safety path with configurable delay after failure
- Long-duration timer (from seconds to months) to simplify RTC function and reduce costs
- Tracker rail, short circuit to battery proof, to supply external ECU loads (sensors, etc.)
- FCRBM: Feedback Core Resistor Bridge Monitoring



FS65 Functionally Safe System Basis Chip Block Diagram

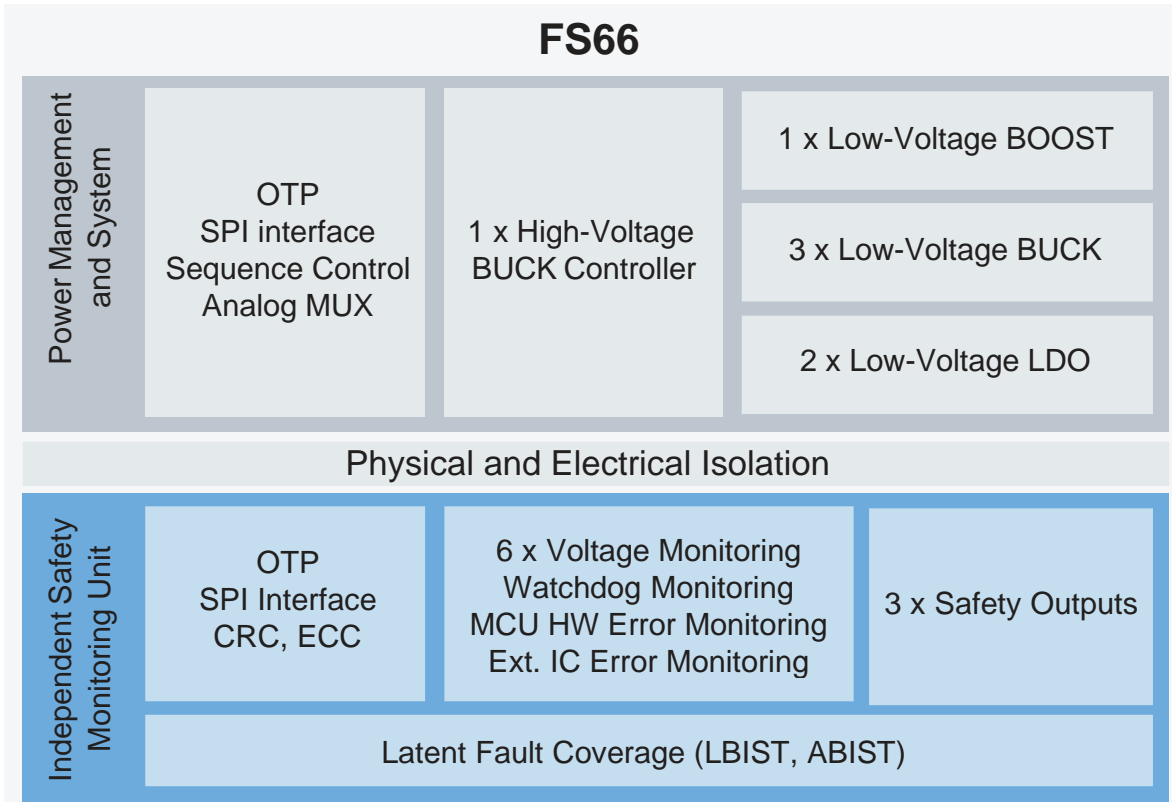


**POWER MANAGEMENT: FUNCTIONALLY SAFE SYSTEM BASIS CHIPS (cont.)**

The FS66 is an automotive, functionally safe multi-output power supply integrated circuit. It's focused on powertrain, safety and chassis applications and is the primary companion chip of the S32Z and S32E Real-Time processors.

**FEATURES**

- 60 V DC maximum input voltage fits for 12 V and 24 V systems
- Multiple SMPS and LDO to supply S32Z and S32E Real-Time processors and more
- Standby OFF mode with very low sleep current (<10 μA)
- 32-bit SPI interface with CRC
- Fit for ASIL D with independent safety monitoring unit



FS66 Block Diagram

MC33771 AND MC33772 REV C BATTERY CELL CONTROLLER SOLUTION

Battery topology flexibility

- Scalable software- and hardware-compatible BMS solution supporting 3 to >800 cells per daisy chain
- MC33771 (7 to 14 cells) and MC33772 REV C (3 to 6 cells) fully compatible
- Supporting centralized, distributed daisy chain, distributed CAN

High integration level

- Synchronized on-chip current sensor
- Synchronized on-chip coulomb counter
- Integrated passive balancing up to 300 mA per channel
- 4.0 Mbit/s SPI or isolated 2.0 Mbit/s differential communication with transformer
- Averaging of cell voltage measurement

Lifetime guaranteed high accuracy

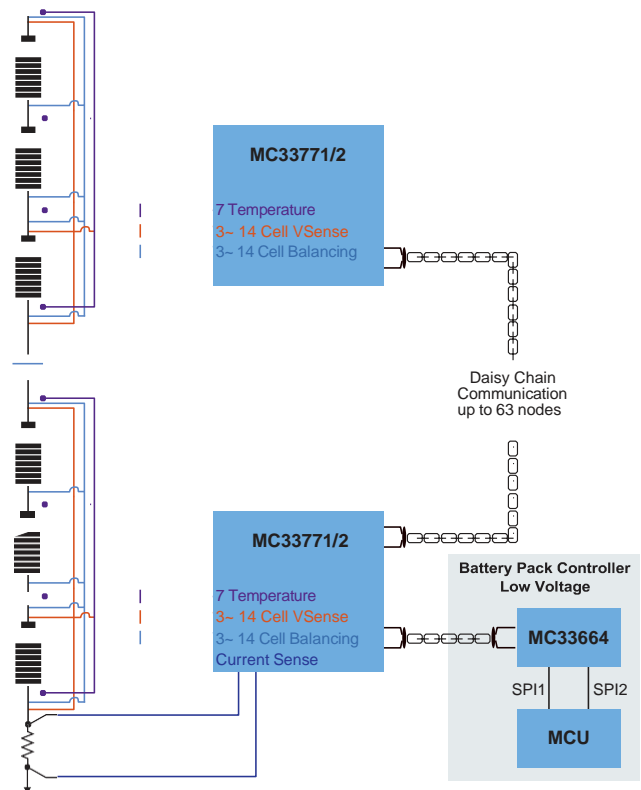
- ± 0.8 mV cell voltage measurement error
- ± 0.5% total stack voltage measurement
- ± 0.5% integrated current sensor gain error

Diagnosis and functional safety supporting ISO 26262 with single chip

- Designed to support ISO 26262 up to ASIL D safety system
- Sleep mode OV/UV and temperature monitor
- Detection of internal and external faults, i.e., open lines, shorts, and leakages
- Integrated balancing diagnostics

Automotive robustness

- ESD, EMC; Hot Plug, AEC-Q 100
- Temp range: -40 °C to 105 °C
- Operational low-power mode



MC33771 Battery Cell Controller Solution Block Diagram

# BATTERY PRESSURE MONITORING SENSORS

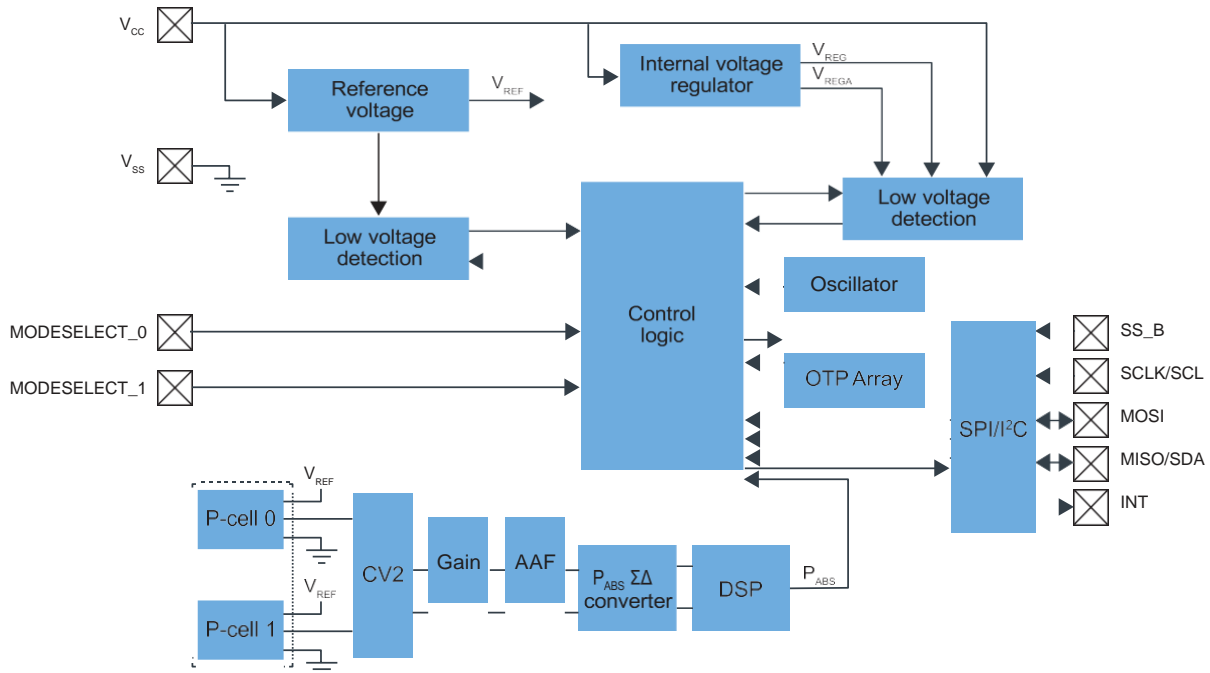
## FXPS7250D4: Absolute Pressure Sensor

- Absolute pressure range: 20 to 250 kPa
- Automotive robustness
  - Redundant pressure transducers enable embedded self test
  - Common-mode and digital self test for transducer and signal chain verification
  - Digital self test
  - Operating temperature range: -40 °C to 130 °C
  - AEC-Q100 Grade 1 compliant
- I<sup>2</sup>C compatible serial interface
  - Slave mode operation
  - Standard mode, fast mode, and fast-mode plus support
- 32-bit SPI compatible serial interface
- Secure and fast data communication
  - 12-bit data for absolute pressure
  - 8-bit data for temperature
  - 2-bit basic status and 2-bit detailed status fields
  - 3, 4, or 8-bit configurable CRC

- Capacitance to voltage converter with anti-aliasing filter
- Sigma delta ADC plus sinc filter
- 800 Hz or 1000 Hz low-pass filter for absolute pressure
- Small package suitable for PCB integration
  - Lead-free, 16-pin QFN 4 x 4 x 1.98 mm with wettable flank
  - Pressure sensor protected by chemical-resistant gel
- Analog version output available

### Current solution FXPS7250x or FXPS165D

- Absolute pressure range:
  - 20 kPa to 250 kPa or 60 kPa to 165 kPa
  - Calibrated Pressure and Temperature measurements
- I<sup>2</sup>C, SPI or Analog output interface
- Automotive robustness
  - Redundant pressure transducers enable embedded self test
  - Common-mode and digital self test for transducer and signal chain verification
  - Qualified to AEC-Q100 Grade 1
  - Operating temperature range: -40 °C to 130 °C
  - QFN 4 x 4 x 1.98 mm, 16 pins, 0.8 mm pitch

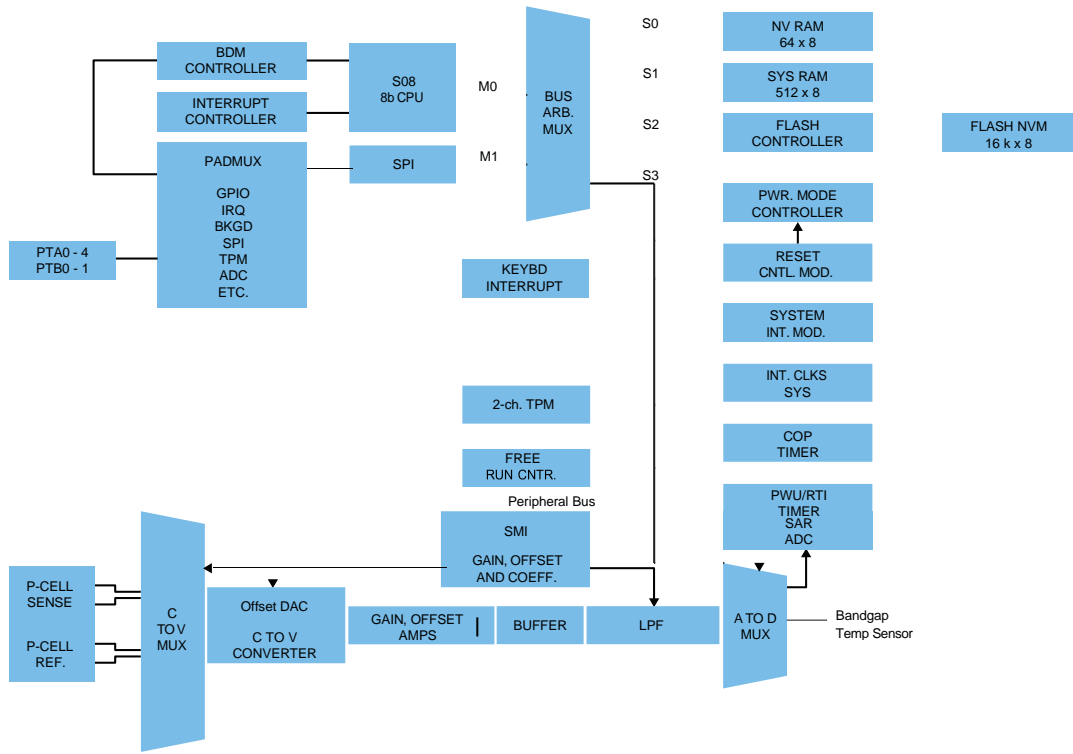


FXPS7250D4 Block Diagram

# BATTERY PRESSURE MONITORING SENSORS – FEATURES

NBP8/9FDxT1

- Absolute pressure range:
  - 40 kPa to 250 kPa operating range
  - Calibrated pressure and temperature measurements capability
- Internal sleep mode between measurements
- Host can enter sleep mode until needed
  - Last 12 pressure measurements saved in FIFO memory
- Auto detects pressure change and sends alarm to host MCU by any of the following events:
  - Fixed pressure threshold breach
  - Relative pressure threshold breach
  - Pressure rate-of-change breach ( $\Delta P/\Delta t$ )
- Diagnostics
  - Pressure transducer (sense and reference cell), internal connections
- SPI interface, ready/interrupt, power supply enable
- Automotive robustness
  - Qualified to AEC-Q100 Grade 1
  - Operating temperature range: -40 °C to 130 °C
  - QFN 4 x 4 x 1.98 mm, 24 pins, 0.5 mm pitch



Battery Pressure Monitoring Sensor Block Diagram

## MOTOR CONTROL: HIGH-VOLTAGE INVERTERS

### GD3160 AND GD3162 GATE DRIVER IC WITH HV ISOLATION

The GD3160 and GD3162 are programmable high-voltage gate drivers with advanced functional safety, control and protection features developed for automotive and EV powertrain applications. The GD3160 gate driver offers wider parametric range tailored to SiC MOSFETs as well as IGBTs and is footprint compatible with the GD3100 gate driver. The GD3162 offers an adjustable dynamic gate strength drive via a programmable interface over SPI. In addition, advanced programmable protection features are autonomously managed as faults and the status of the power device and gate driver are reported via the interrupt pins.

#### FEATURES AND BENEFITS

##### GD3160

###### OPERATION

- $\pm 15$  A split output gate current drive
- Programmable HV  $V_{cc}$  regulator output:  
14 V to 21 V, 1 V step
- Max  $V_{cc}$  output voltage: 23 V

###### PROTECTION

- Integrated HV temperature sensing (TSENSE) for NTC thermistor or diode sensors with programmable offset and gain
- Faster VCE DeSat detection and reaction time:  $< 1.2 \mu\text{s}$  (SiC)
- Improved PWM deadtime range for reduced switching losses (SiC)
- Programmable two-level turn off (2LTO) and soft-shutdown (SSD)

###### FUNCTIONAL SAFETY

- Additional programmable fault pin (INTA)
- Integrated HV fault management (FSISO)
- Programmable VCE output monitoring

###### INSULATION/ISOLATION

- Minimum common mode transient immunity (CMTI)  $> 100 \text{ V/ns}$
- 5,000 Vrms galvanic isolation per UL1577

##### GD3162

###### OPERATION

- Integrated boost capability for increased drive strength:  
Up to 10 / 20 / 30 A source/sink current
- Max VCC output voltage: 25 V
- Programmable ADC delay - Up to 8  $\mu\text{s}$  sampling delay from rising or falling edge of PWM

###### PROTECTION

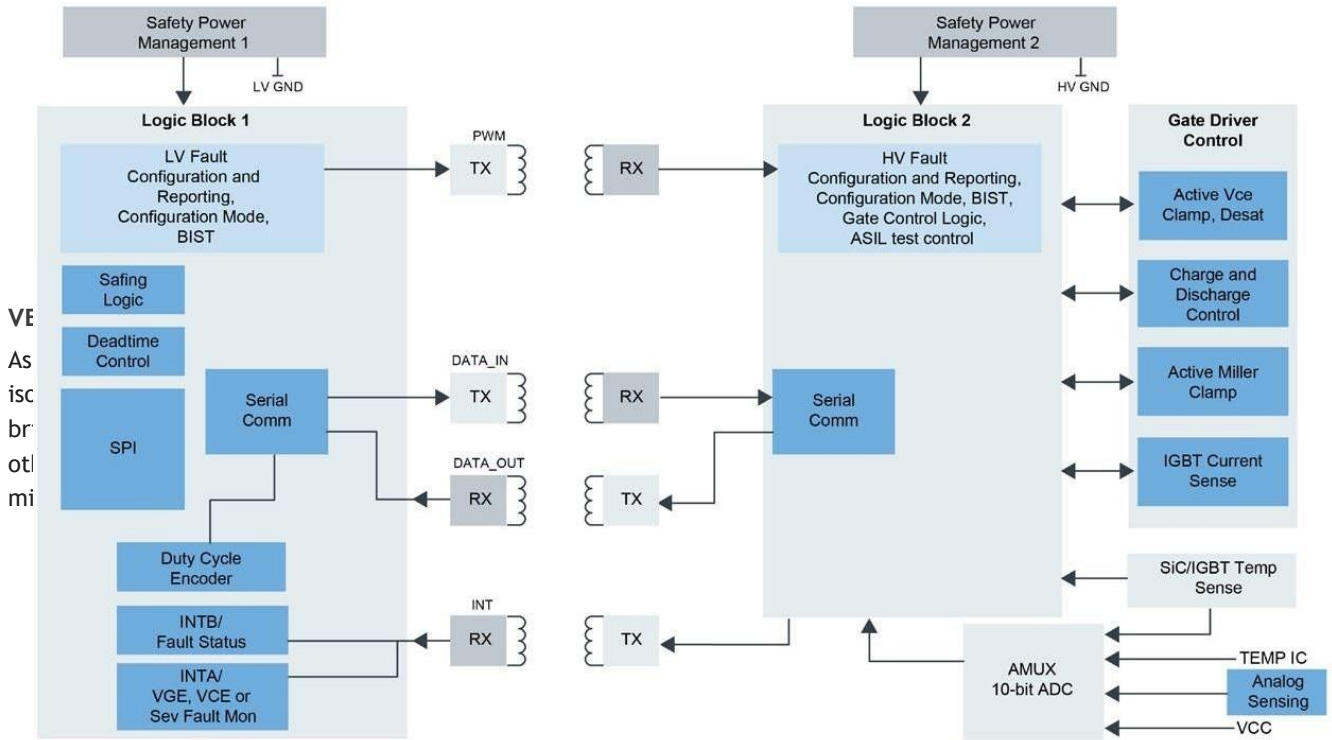
- Integrated HV temperature sensing (TSENSE) for NTC thermistor or diode sensors with programmable offset and gain
- Fast VCE DeSat detection and reaction time:  $< 1 \mu\text{s}$  (SiC)
- Improved PWM deadtime range for reduced switching losses (SiC)
- Programmable two-level turn off (2LTO) and soft-shutdown
- Provides either MCU controlled or safety logic controlled gate drive to actively discharge the DC link capacitor

###### FUNCTIONAL SAFETY

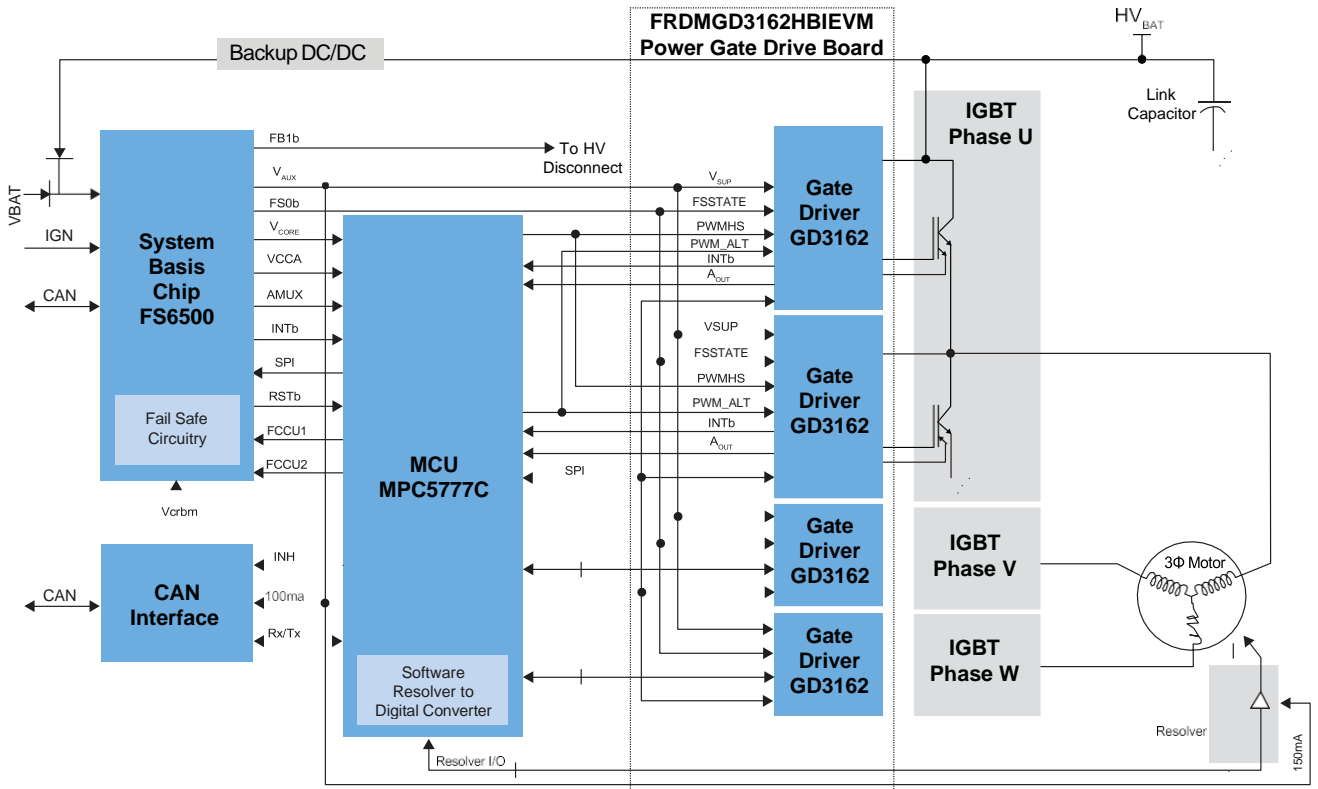
- Additional programmable fault pin (INTA)
- Integrated HV fault management (FSISO)
- Programmable VCE output monitoring

###### INSULATION/ISOLATION

- Minimum common mode transient immunity (CMTI)  $> 100 \text{ V/ns}$
- 5,000 Vrms galvanic isolation per UL1577 (planned)



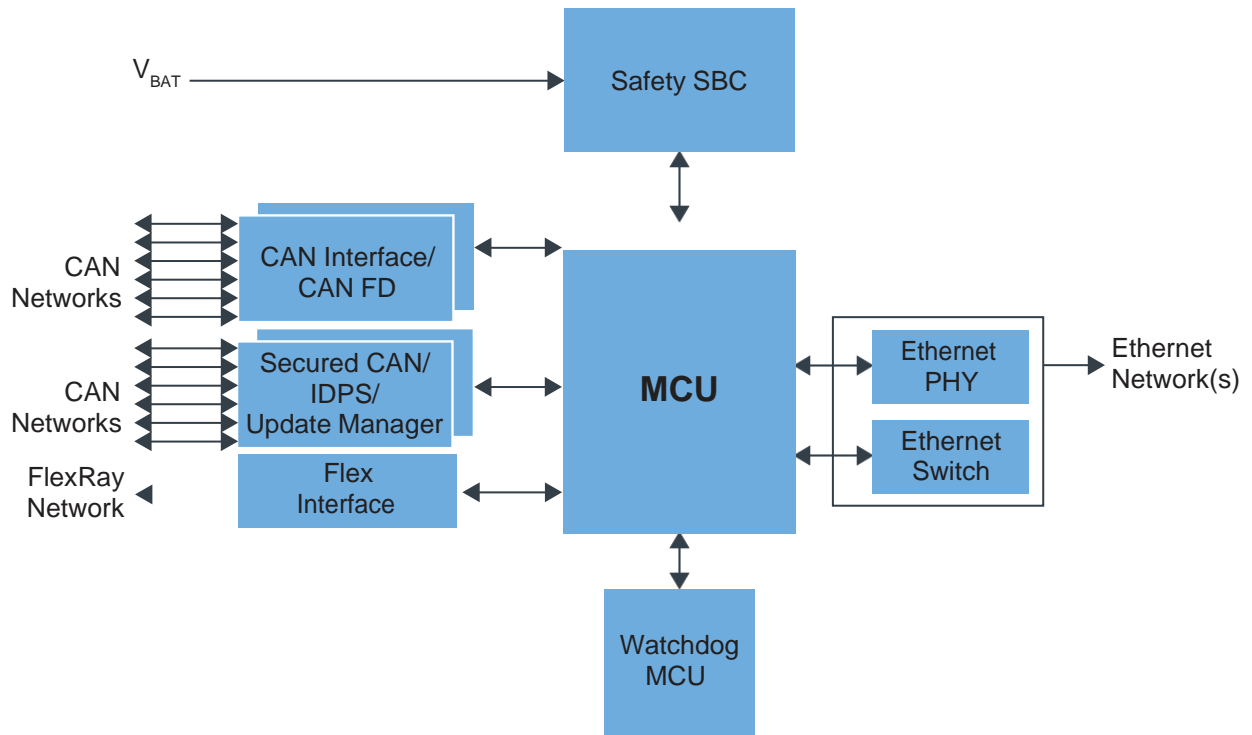
GD3160 Advanced IGBT Gate Driver Block Diagram



GD3162 Advanced High Voltage Isolated Gate Driver Block Diagram

## VEHICLE NETWORK PROTOCOLS

As vehicles become more connected, the need for reliable and secure communication within the car is clear. New isolated CAN for electric vehicles, hybrids and 48 V networks use unique wake-up functions to maximize efficiency and bridge voltage domains. In a distributed car network, central ECUs need to exchange data or configuration with each other within a critical time frame. Automotive Ethernet can be used to build a time-sensitive network (TSN) that connects microcontrollers directly in an Ethernet backbone.



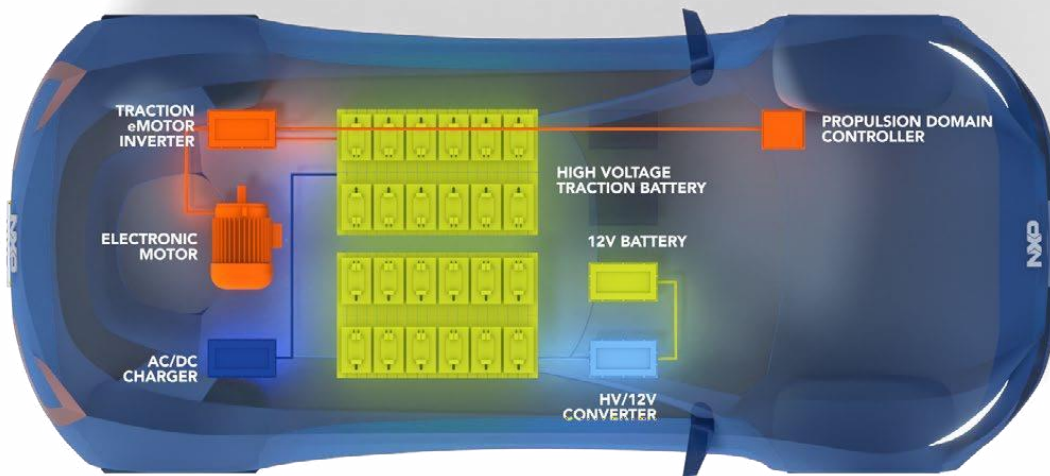
 NXP Technology

In-Vehicle Networking for HEV and EV Architectures

For further information on the complete in-vehicle networking portfolio, please visit [www.nxp.com/ivn](http://www.nxp.com/ivn).

## VEHICLE NETWORK PROTOCOLS (cont.)

At NXP, we're leveraging our commitment to quality and security, our broad product portfolio and our application leadership in automotive power control to provide system solutions that deliver the optimal performance, functional safety and power management required for the next generation of electric and hybrid vehicles. When you explore NXP, you'll find that we're more than the products we create—we're a dedicated partner committed to automakers and developers in their quest to accelerate EV system development and meet the ever-growing demand for vehicle electrification.



In-Vehicle Networking for HEV and EV Architectures

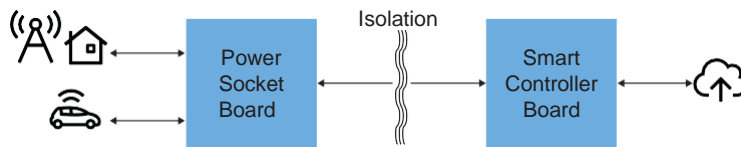


## EV CHARGING SYSTEM SOLUTIONS



Electric vehicle sourcing equipment (EVSE), also called the charging system, supplies power for recharging electric vehicles of many types.

EV chargers are made up of at least one smart controller function and a power socket function – either combined or as standalone boards.



Electric Vehicle Supply Equipment (EVSE) Power Socket and Smart Controller Overview

In order to support the developing world of EV types, we need a flexible and scalable approach not only in the choice of AC or DC, but also in the following key areas:

Accurate power delivery measurement

- Legislation mandating higher accuracy levels for fair payment
- Government fuel tax recovery
- Power grid load balancing and mains quality analysis

Increasing security and safety at the edge

- Supporting main EV security standards, e.g., OCPP2.x, ISO 15118 and PKI
- GDPR, Calibration Law “Eichrecht” and confidentiality
- Safety standards, e.g., IEC60730 Class B, IEC61508 SIL2

Cloud onboarding

- Simplify the provisioning and ownership process, while maintaining high security and confidence about connection to an authentic device using zero-touch onboarding

Mass deployment readiness

- Integrated and cost optimized

Artificial intelligence (AI) and machine learning (ML)

- Consumption profiling
- Anomaly detection

- Product longevity greater than 10 or 15 years

- Operating life ranging 10 to 20 years

- Ruggedized for harsh environments



Availability and Reliability

## KEY BUILDING BLOCKS

### Metrology

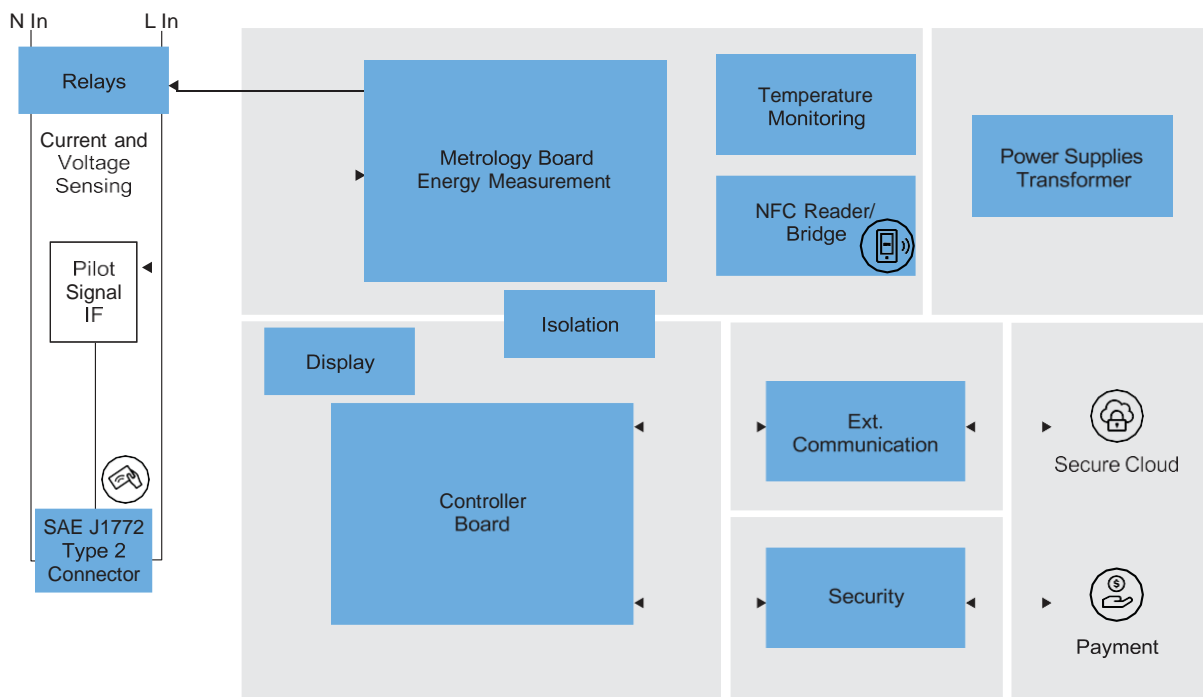
- Accurately measure energy flow between charger and vehicle
- Calculate energy billing consumption
- Manage the safety switching and low-level communications to EV
- Monitor temperature
  - Highly accurate temperature sensor enables safety and anomaly detection
- NFC bridge
  - Acts as an AC-isolated communication channel to metrology MCU
  - Also used during manufacture, commissioning and updates

### Controller Board

- Manage the main functions and services of the EVSE including any high-level communications and protocol stacks, e.g., ISO 15118, OCPP and connection to backend
- Options include bare metal and RTOS; for solutions running Linux® OS, may add greater value to on-screen advertising

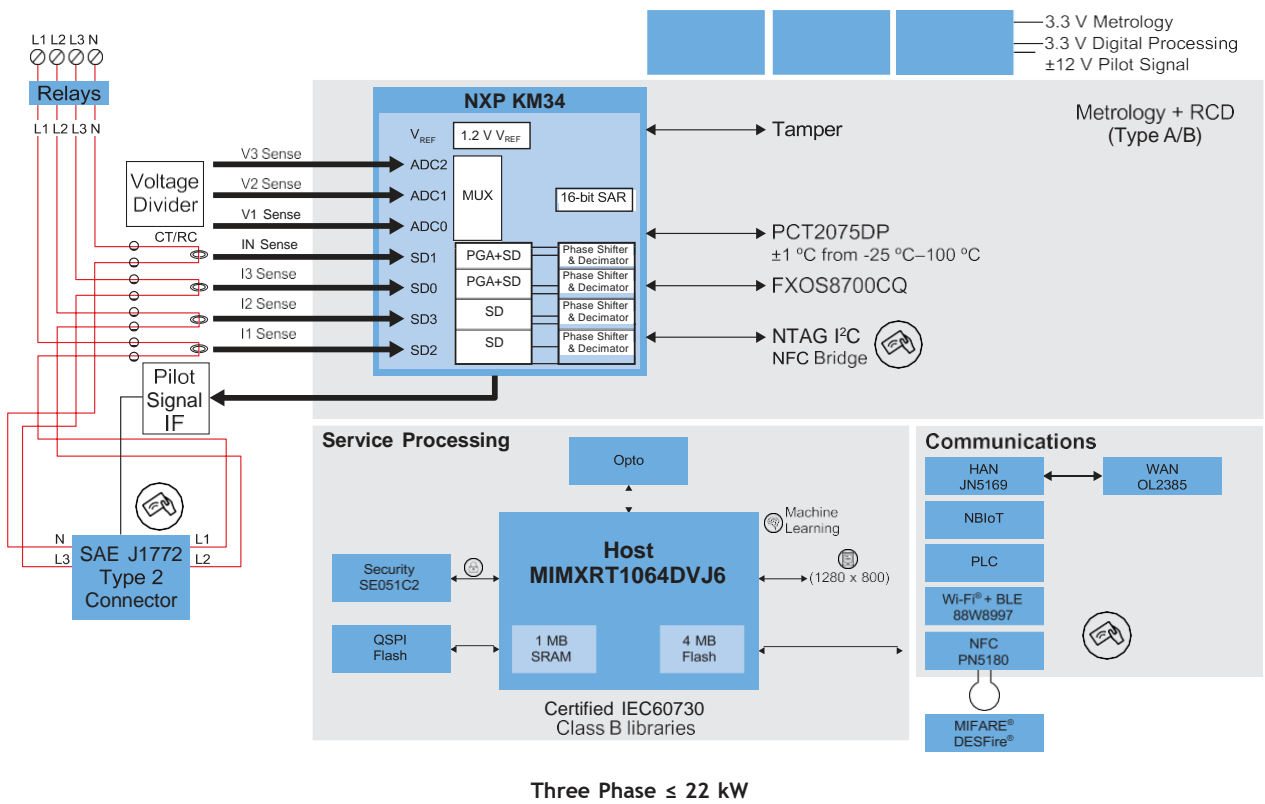
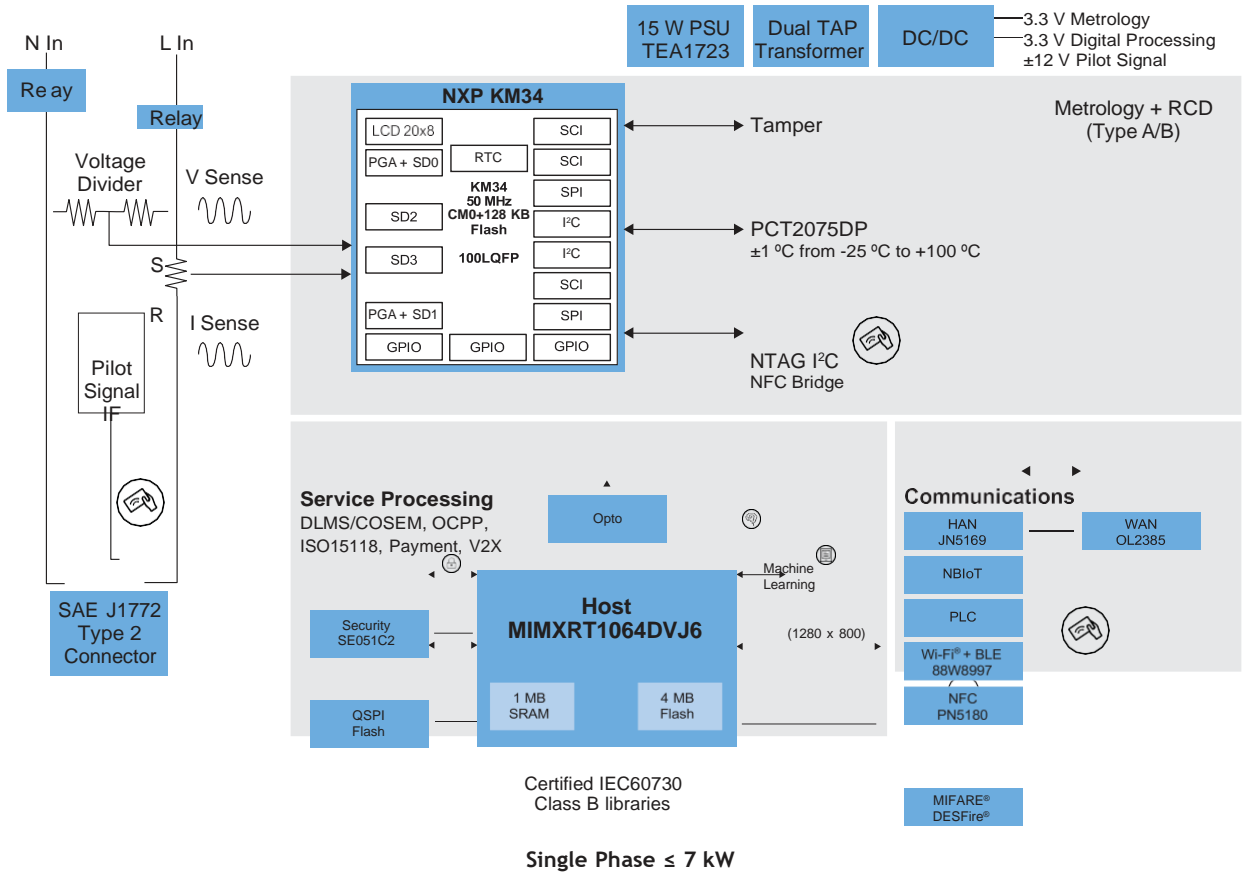
### Security

- Authenticate and protect energy usage and billing data end to end with cryptographic keys
- Securely and seamlessly onboard EV chargers to back-end servers and cloud services for remote management
- Configure, update and attest the software and firmware
- External Communication
  - Support a flexible mix of communication capability depending on location, region EVSE type
  - Support region-specific communications solutions, including Wi-Fi®, PLC, NBloT Sigfox and many more

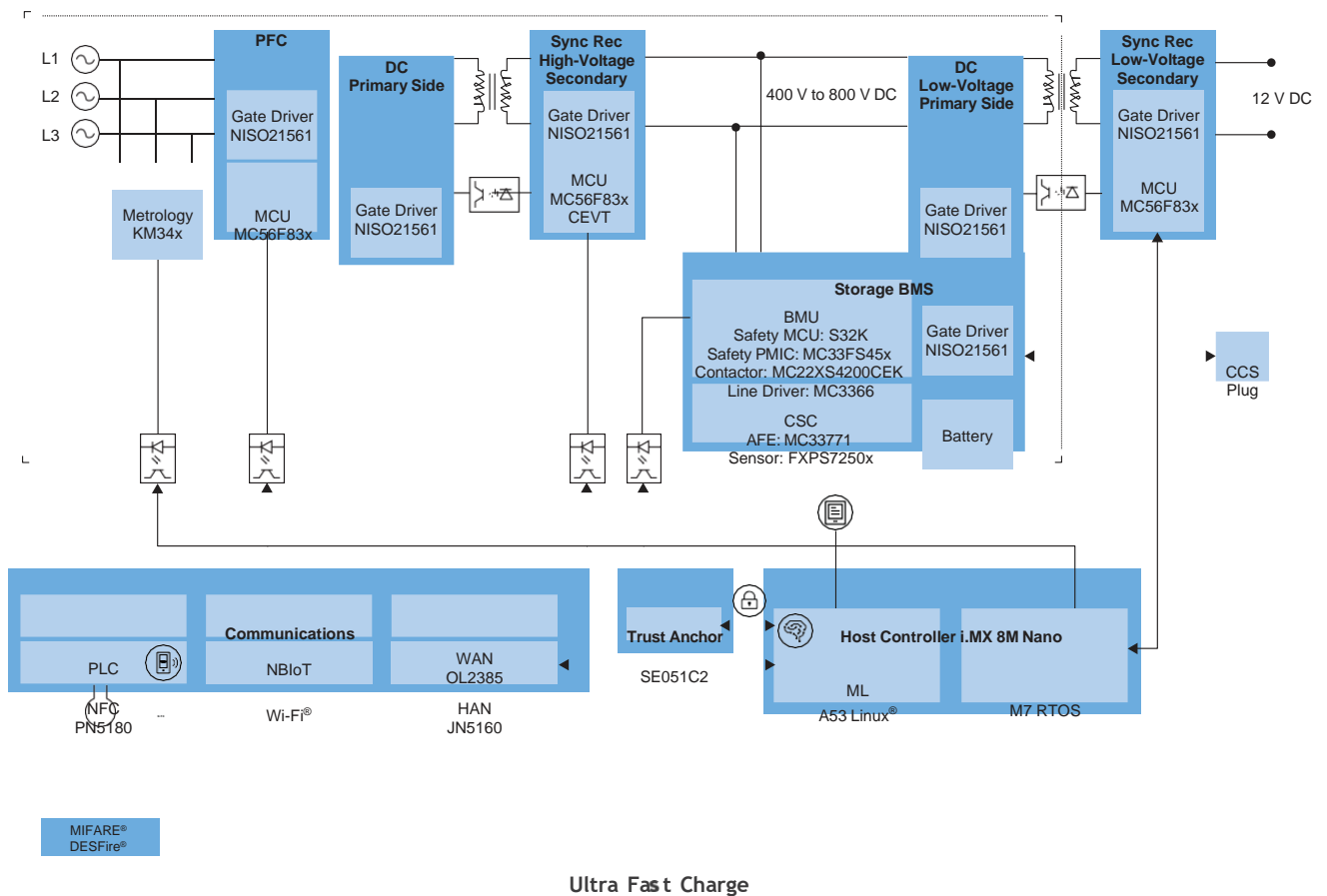
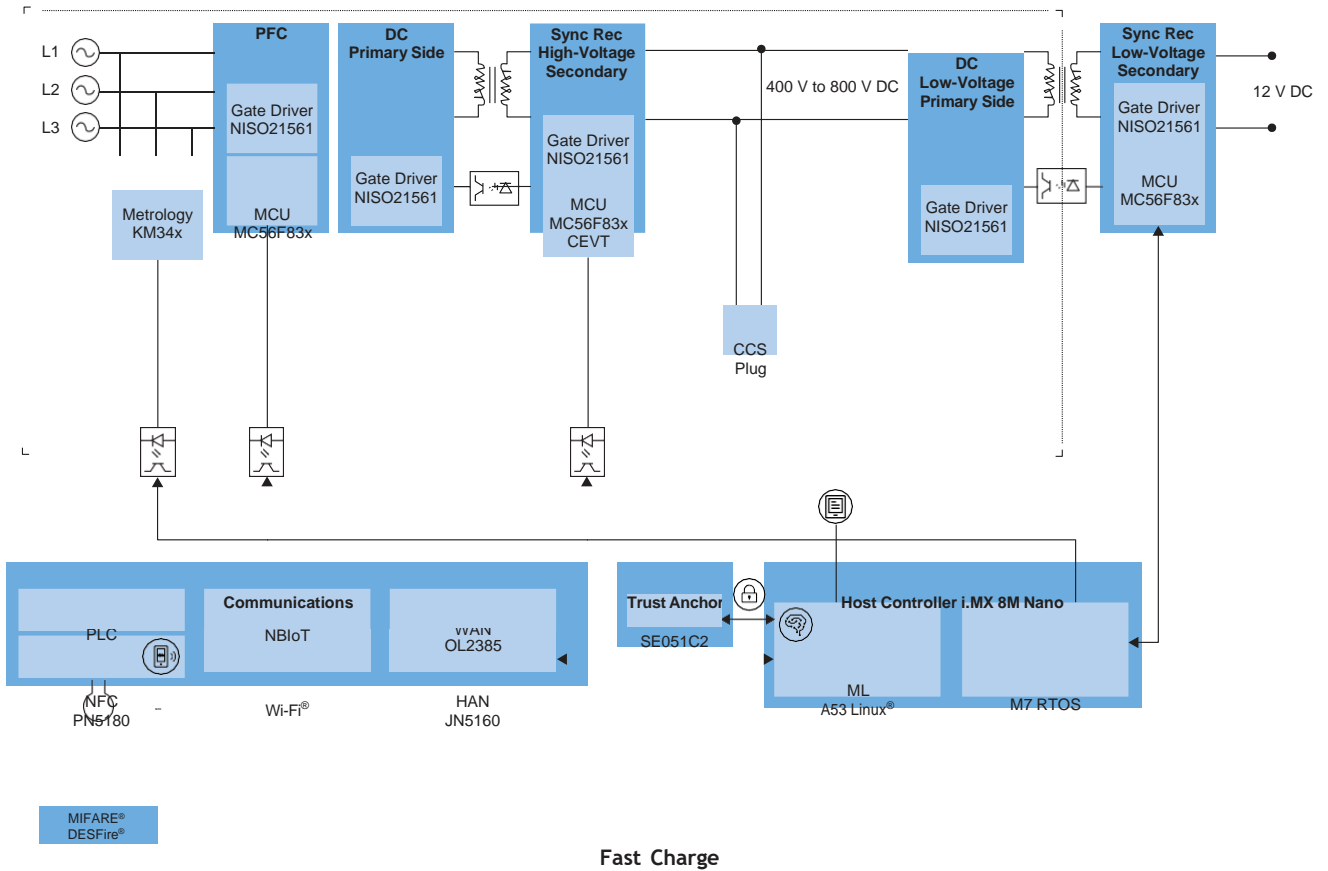


AC Residential Charging Station (Level 1,2 or 3) Block Diagram

SOLUTIONS



# DC EVSE SOLUTION



## NXP PRODUCT SUMMARY

DEVICE	DESCRIPTION
S32Z & S32E	The S32Z and S32E real-time processors feature Arm® Cortex®-R52 split-lock processors for multi-tenant software integration plus lockstep Arm Cortex-M33 processors for system management. The S32E processors are ideal for electric vehicle (xEV) control and smart actuation.
MPC5744P MPC5777C MPC5775B/E	These microcontrollers target automotive and industrial battery management and inverter applications that require advanced performance, security and ASIL D support.
S32K1	S32K is a scalable family of AEC-Q100 qualified 32-bit Arm Cortex®-M4F and Cortex-M0+ based MCUs targeted for general-purpose automotive and high-reliability industrial applications.
S32K3	S32K3 is a scalable family of AEC-Q100 qualified 32-bit Arm Cortex®-M7F based MCUs targeted for ASIL D functional safety automotive and industrial applications.
FS45/FS65	The FS45 and FS65 are system basis chips (SBCs) that provide power to MCUs and optimize energy consumption through DC-DC switching regulators, linear regulators and ultra-low-power saving modes.
FS66	The FS66 is an automotive, functionally safe multi-output power supply integrated circuit. It includes a multiple switch mode, linear voltage regulators and enhanced safety features with fail-safe outputs.
MC33771/2	The MC33771/2 are battery cell controllers designed to address safety risks related to Li-ion batteries by accurately controlling critical Li-ion cell characteristics (voltages, temperatures, current) and by providing embedded balancing functions along with extensive system diagnostics.
FXPS7250D4	The FXPS7250D4 is high-performance, high-precision absolute pressure sensor for Battery Pressure Monitoring.
GD3100	The GD3100 is an advanced single-channel gate driver for IGBTs. Integrated Galvanic isolation and low on-resistance drive transistors provide high charging and discharging current, low dynamic saturation voltage and rail-to-rail gate voltage control.
GD3160	The GD3160 is an advanced single-channel high-voltage isolated gate driver with enhanced features for driving and protecting silicon carbide (SiC) MOSFETs or IGBTs and functional safety.
GD3162	The GD3162 is an advanced, galvanically-isolated, single-channel gate driver designed to drive the latest SiC and IGBT modules for xEV traction inverters.
IVN	IVN is a broad NXP portfolio of in-vehicle networking solutions for LIN, CAN, FlexRay™ and Ethernet.

**SAFEASSURE® FUNCTIONAL SAFETY PROGRAM**

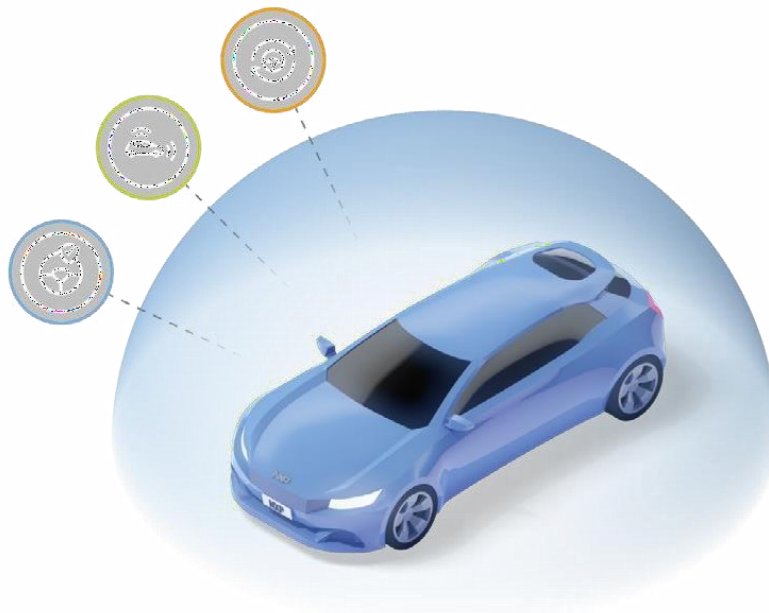
NXP’s SafeAssure program does more than align our development process to ISO 26262 across our business lines. It affirms our corporate commitment to supporting functional safety through safety-conscious culture, discipline and collaboration.

**THE SAFEASSURE PROGRAM:**

- Simplifies the process of system compliance, with solutions designed to address the requirements of automotive and industrial functional safety standards
- Reduces the time and complexity required to develop safety systems that comply with ISO 26262 and IEC 61508 standards
- Supports the most stringent safety integrity levels (SILs), enabling designers to build with confidence
- Adheres to a zero-defect methodology from design to manufacturing and helps ensure that our products meet the stringent demands of safety applications



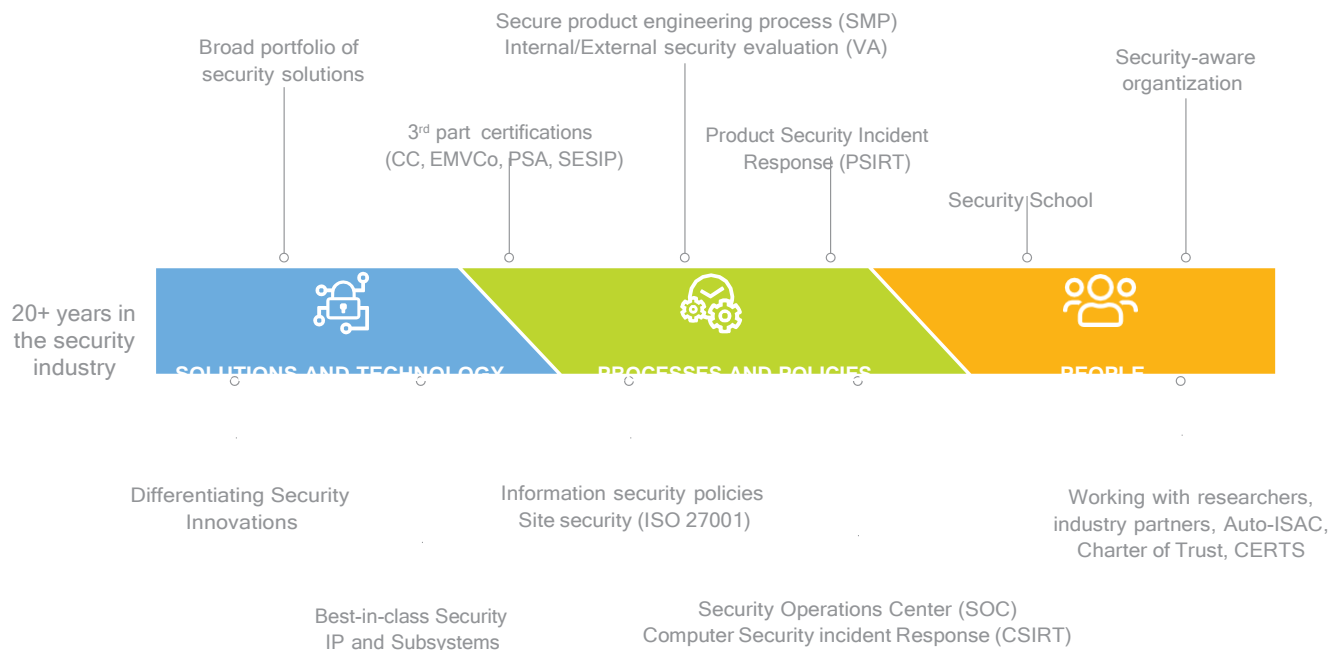
PRODUCTS	TARGET APPLICATION	ASIL
MC337711/2	HEV, EV, ESS, UPS systems	D
FS45	Automotive: vision systems, electrical power steering, engine and battery management; Industrial: drone and robot automation, building control, transportation, mobile computing, power and energy; healthcare	D
FS65	Automotive: active suspension, gearbox, transmission, EV, HEV, inverter, ADAS, EPS, engine and battery management; mobile computing; building control; drones and robots; automation; medical	D
FS66	BMS, electrical traction, high-voltage DC-DC converter, HEV, internal combustion engine	D
MPC5744P	Safety Domain Control	D
MPC577C MPC5775E/	BMS, Traction Motor Control, Direct Injection Engines, Common Rail Diesel Injection Systems, Electronically Controlled Transmissions, Diesel Engine Management, Gasoline Engine Management	D
S32K3	Body Control, Zone Control, BMS, Infotainment IO controller, E-shifter, Motor Control	D
GD3100	BMS, HEV, EV Power Inverter, Motor Drives	D
GD3160	BMS, HEV, EV Power Inverter, Motor Drives	D
GD3162	EV Power Inverter, HEV, Motor Drives	D



Safety of the Intended Function

## SECURITY PROGRAM

A holistic approach to cyber security - aligned with industry standards and best practices



With the complexity of vehicles on the roads today - it is essential that drivers and passengers are able to trust their cars.

NXP leads the industry with the most complete portfolio of automotive semiconductor security solutions, complemented by a comprehensive, holistic, automotive cybersecurity program.

Cybersecurity needs a holistic approach: not only with solutions, but also with processes, policies and the appropriate security-oriented organization.

NXP's security program has matured over time and contains a broad portfolio of automotive security solutions that are par to market requirements.

[www.nxp.com/automotivesecurity](http://www.nxp.com/automotivesecurity)

## AVAILABLE RESOURCES

For more information, please visit

[nxp.com/electrification](http://nxp.com/electrification)

