AURIX™ 32-bit microcontrollers for automotive and industrial applications

Highly integrated and performance optimized

Issue 2019

www.infineon.com/aurix

(infineon)

Contents

Family highlights

› Compatibility and scalability
› Lowest system cost
› Industry benchmark system performance

› Easy to use
› Broad portfolio
› Certified to automotive standards

Powertrain

Applications

› Powertrain domain controller
› Gasoline direct injection
› Gasoline multi-port injection
› Diesel direct injection
› Automatic transmission

› Transfer case/torque vectoring
› eClutch
› Start/stop alternator
› Auxiliaries
› Motorcycle engine management

(H)EV

Applications

› Battery management
› Off-board charging
› Charging station

› Inverter
› Low-voltage DC-DC
› High-voltage DC-DC

Safety

Applications

› Chassis domain control
› Electric Power Steering (EPS)
› Active suspension control system
› Advanced airbag system
› Braking ECU
› Multi-purpose camera configuration

› Short-range radar (24/60 GHz) system
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› LED pixel lighting
› Sensor fusion
› eHorizon

Connectivity

Applications

› Body domain controller
› Connected gateway
› Advanced body applications

› In-vehicle wireless charger
› Telematics
› V2x communication

Transportation

Applications
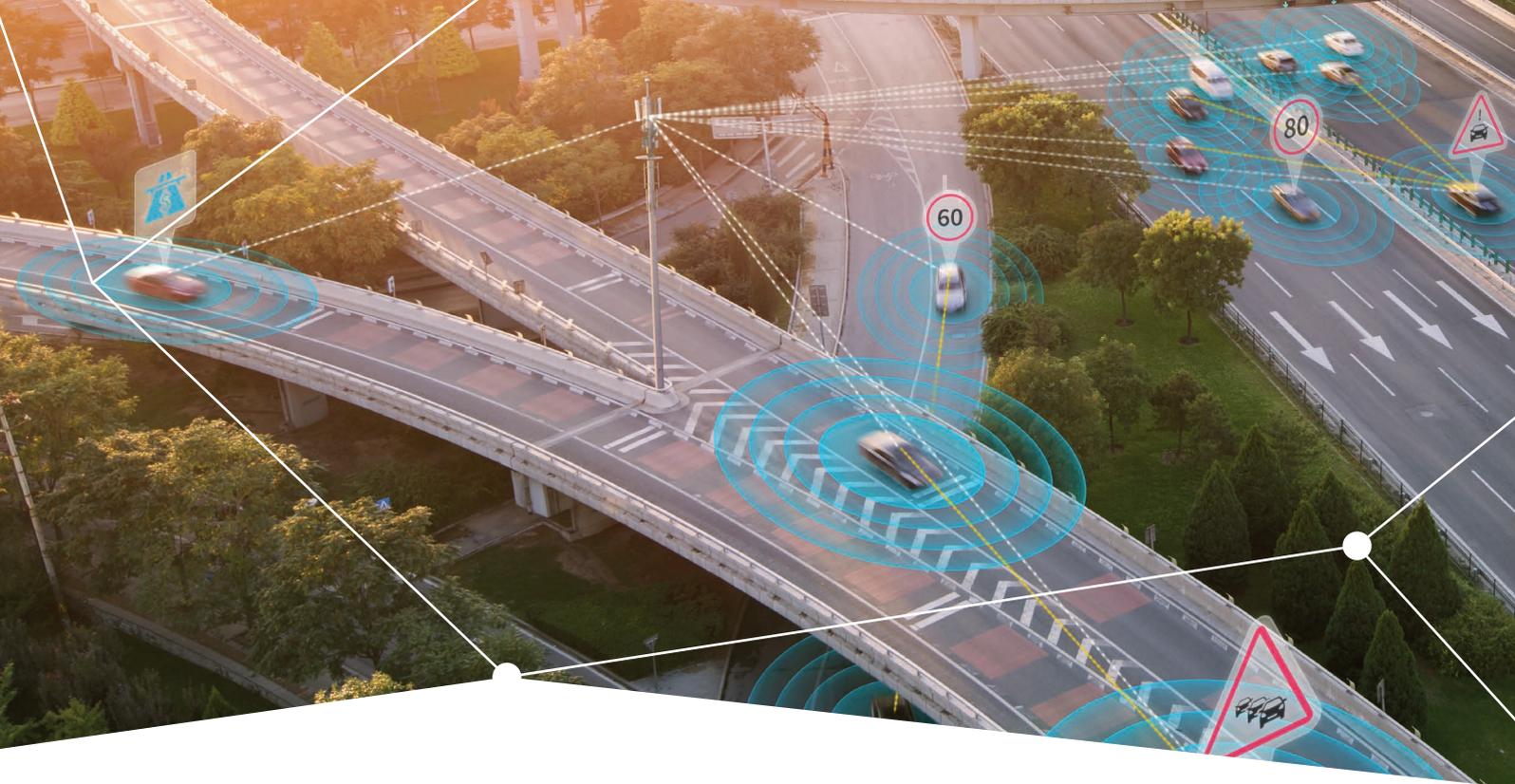
› Commercial and Agricultural Vehicle (CAV)
› Fun vehicle
› Transportation

› Trucks
› Drones
› Avionics

Industrial & Multimarket

Applications

› Mobile controller
› Inverter
› Wind turbine inverter
› Servo drives

› Solar panel
› Robotics
› Medical
› Elevator

Evolution of TriCore™ generations

In 1999, Infineon launched the first generation of the AUDO (**AU**tomotive unifie**D** process**O**r) family. Based on a unified RISC/MCU/DSP processor core, this 32-bit TriCore™ microcontroller was a computational power horse. And the company has evolved and optimized the concept ever since – culminating in what is now the sixth TriCore™ generation.

range of memories, peripheral sets, frequencies, temperatures and packaging options. And all this with a high degree of compatibility across generations.

The TriCore™ success story now continues with the introduction of the AURIX™ multicore family. AURIX™ combines

AUDO	AUDO NG (Next generation)	AUDO future	AUDO MAX	AURIX™ TC2xx	AURIX™ TC3xx

Thanks to its high real-time performance and embedded safety and security features, the TriCore™ family is the ideal platform for a wide range of automotive applications. These include the control of combustion engines, electrical and hybrid vehicles, transmission control units, chassis domains, braking systems, electric power steering systems, airbags, connectivity and advanced driver assistance systems to support the trend toward autonomous, clean and connected cars. TriCore™-based products also deliver the versatility required for the industrial, CAV and transportation sector, excelling in optimized motor control applications and signal processing. Infineon's broad product portfolio allows engineers to choose from a wide

easy-to-use functional safety support, a strong increase in performance and a future-proven security solution in a highly scalable product family.

The new AURIX™ TC3xx family members are manufactured in a 40 nm embedded flash technology designed for ultimate reliability in harsh automotive environments. Furthermore, the dual frontend concept ensures continuous supply.

As was the case with previous generations, safety software is also available to help manufacturers meet SIL/ASIL safety standards, as well as AUTOSAR libraries which Infineon has been developing since 2005.
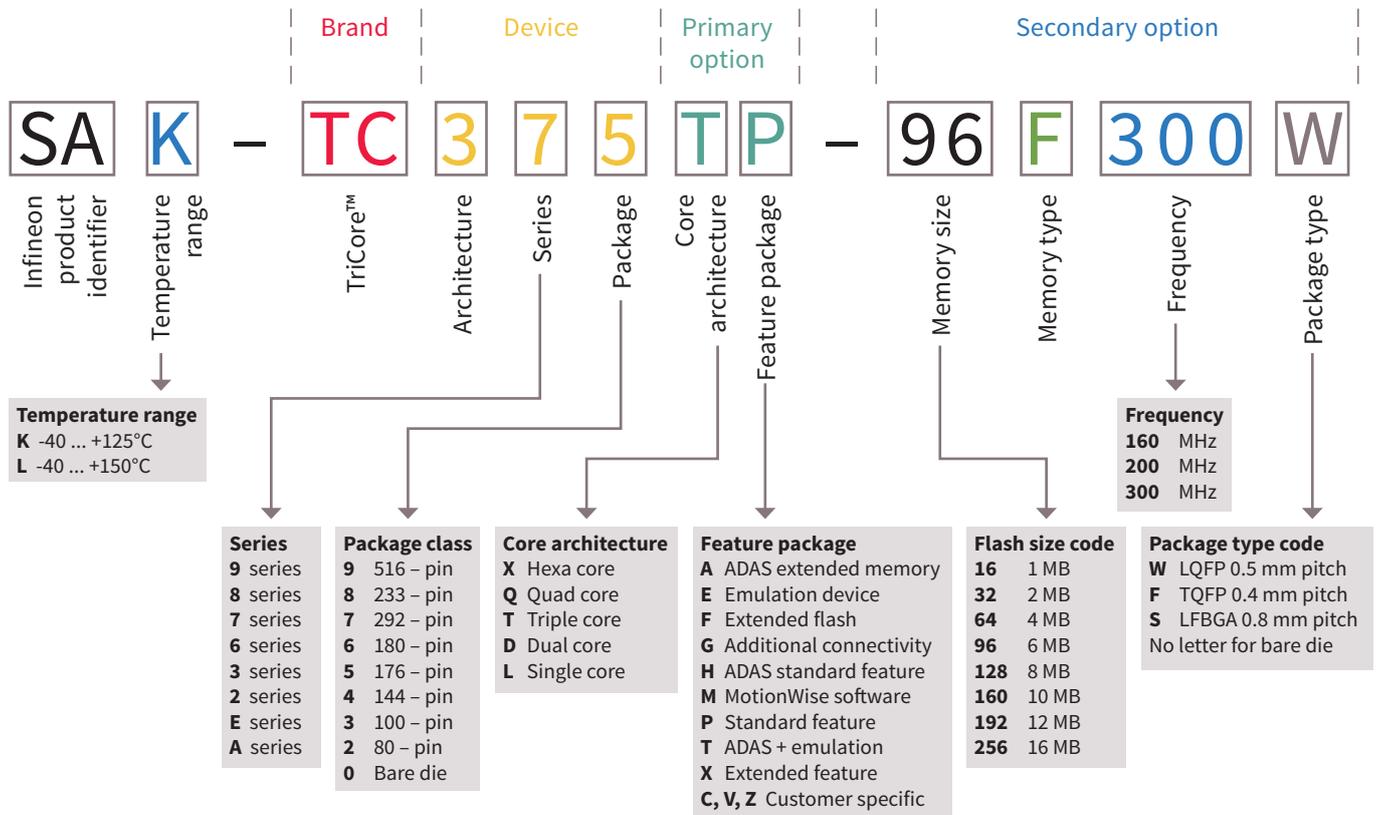
TriCore™ based product roadmap

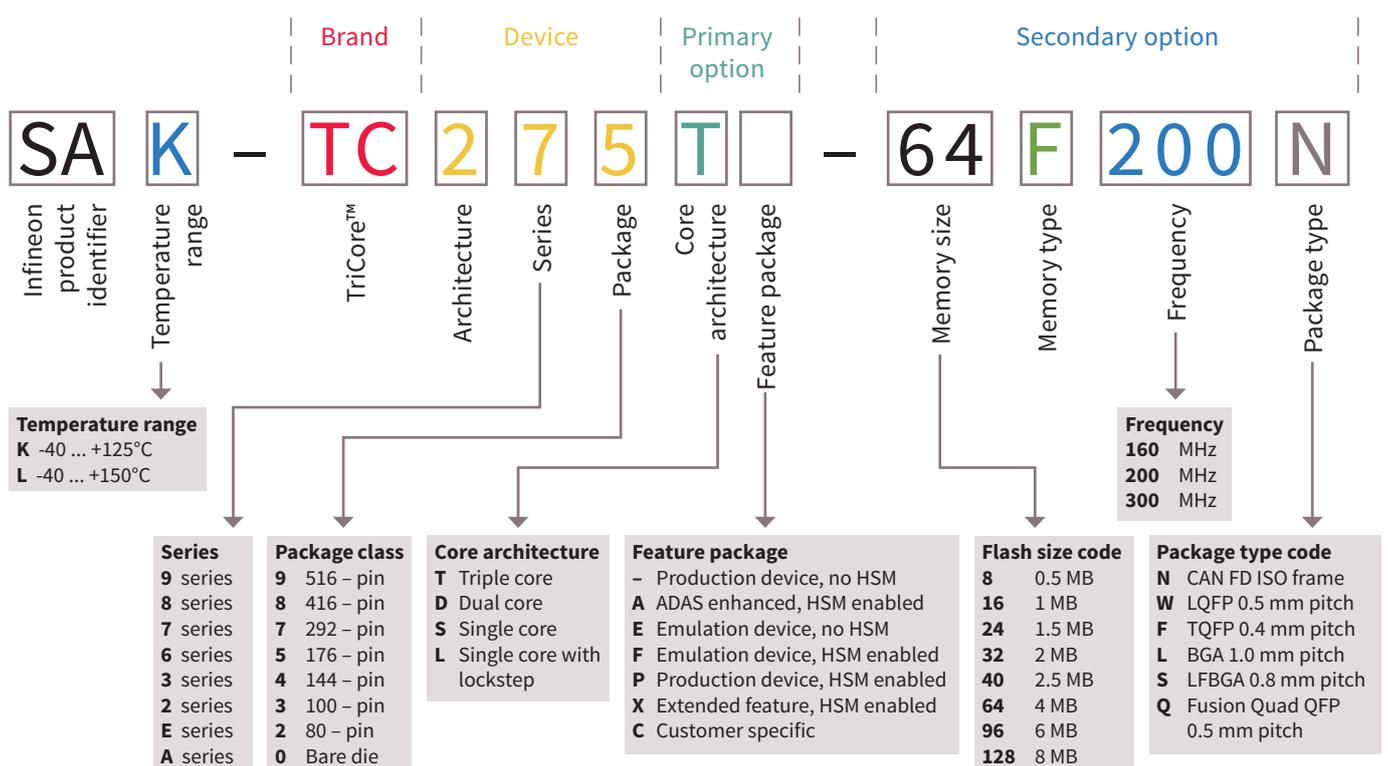| Segment	Production		Development
	AUDO family	**AURIX™ TC2xx**	**AURIX™ TC3xx**
	90 nm	65 nm	40 nm
High end	TC1798 300 MHz, 4 MB	TC29xTX 3x 300 MHz, 8 MB	TC39xXX 6x 300 MHz, 16 MB
		TC29xTP 3x 300 MHz, 8 MB	TC39xXP 6x 300 MHz, 16 MB
		TC27xTP 3x 200 MHz, 4 MB	TC3ExQP 4x 300 MHz, 12 MB
	TC1793 270 MHz, 4 MB		TC38xQP 4x 300 MHz, 10 MB
			TC37xTX 3x 300 MHz, 6 MB
	TC1791 240 MHz, 4 MB	TC290 3x 300 MHz, 8 M Bare die	TC37xTP 3x 300 MHz, 6 MB
Mid range	TC1746 180 MHz, 2.5 M Bare die	TC270 3x 200 MHz, 4 MB Bare die	TC3AxQA 3x 300 MHz, 4 MB
	TC1784 180 MHz, 2.5 MB	TC26xD 2x 200 MHz, 2.5 MB	TC357TA 3x 300 MHz, 4 MB
	TC1782 180 MHz, 2.5 MB	TC260 2x 200 MHz, 2.5 M Bare die	TC36xDP 2x 300 MHz, 4 MB
Low end	TC1728 133 MHz, 1.5 MB	TC23xLX 200 MHz, 2 MB	TC33xDA 2x 200 MHz, 2 MB
	TC1724 80 MHz, 1.5 MB	TC23xLP 200 MHz, 2 MB	TC33xLP 200 MHz, 2 MB
		TC22xL 133 MHz, 1 MB	
			TC32x 160 MHz, 1 MB
		TC21xL 133 MHz, 0.5 MB	
Companion chips		TLF35584	TLF35584 TLF30684

Legend:
- AURIX™ 1st generation
- AURIX™ 2nd generation
- Bare die

AURIX™ product selector

AURIX™ TC3xx family product naming system

Brand | **Device** | **Primary option** | **Secondary option**

`SA` `K` – `TC` `3` `7` `5` `TP` – `96` `F` `300` `W`

- Infineon product identifier (SA)
- Temperature range (K)
- TriCore™ (TC)
- Architecture (3)
- Series (7)
- Package (5)
- Core architecture / Feature package (TP)
- Memory size (96)
- Memory type (F)
- Frequency (300)
- Package type (W)

Temperature range
K	-40 ... +125°C
L	-40 ... +150°C

Series
9	series
8	series
7	series
6	series
3	series
2	series
E	series
A	series

Package class
9	516 – pin
8	233 – pin
7	292 – pin
6	180 – pin
5	176 – pin
4	144 – pin
3	100 – pin
2	80 – pin
0	Bare die

Core architecture
X	Hexa core
Q	Quad core
T	Triple core
D	Dual core
L	Single core

Feature package
A	ADAS extended memory
E	Emulation device
F	Extended flash
G	Additional connectivity
H	ADAS standard feature
M	MotionWise software
P	Standard feature
T	ADAS + emulation
X	Extended feature
C, V, Z	Customer specific

Flash size code
16	1 MB
32	2 MB
64	4 MB
96	6 MB
128	8 MB
160	10 MB
192	12 MB
256	16 MB

Frequency
160	MHz
200	MHz
300	MHz

Package type code
W	LQFP 0.5 mm pitch
F	TQFP 0.4 mm pitch
S	LFBGA 0.8 mm pitch
No letter for bare die	

AURIX™ TC2xx family product naming system

Brand | **Device** | **Primary option** | **Secondary option**

`SA` `K` – `TC` `2` `7` `5` `T` – `64` `F` `200` `N`

- Infineon product identifier (SA)
- Temperature range (K)
- TriCore™ (TC)
- Architecture (2)
- Series (7)
- Package (5)
- Core architecture / Feature package (T)
- Memory size (64)
- Memory type (F)
- Frequency (200)
- Package type (N)

Temperature range
K	-40 ... +125°C
L	-40 ... +150°C

Series
9	series
8	series
7	series
6	series
3	series
2	series
E	series
A	series

Package class
9	516 – pin
8	416 – pin
7	292 – pin
5	176 – pin
4	144 – pin
3	100 – pin
2	80 – pin
0	Bare die

Core architecture
T	Triple core
D	Dual core
S	Single core
L	Single core with lockstep

Feature package
–	Production device, no HSM
A	ADAS enhanced, HSM enabled
E	Emulation device, no HSM
F	Emulation device, HSM enabled
P	Production device, HSM enabled
X	Extended feature, HSM enabled
C	Customer specific

Flash size code
8	0.5 MB
16	1 MB
24	1.5 MB
32	2 MB
40	2.5 MB
64	4 MB
96	6 MB
128	8 MB

Frequency
160	MHz
200	MHz
300	MHz

Package type code
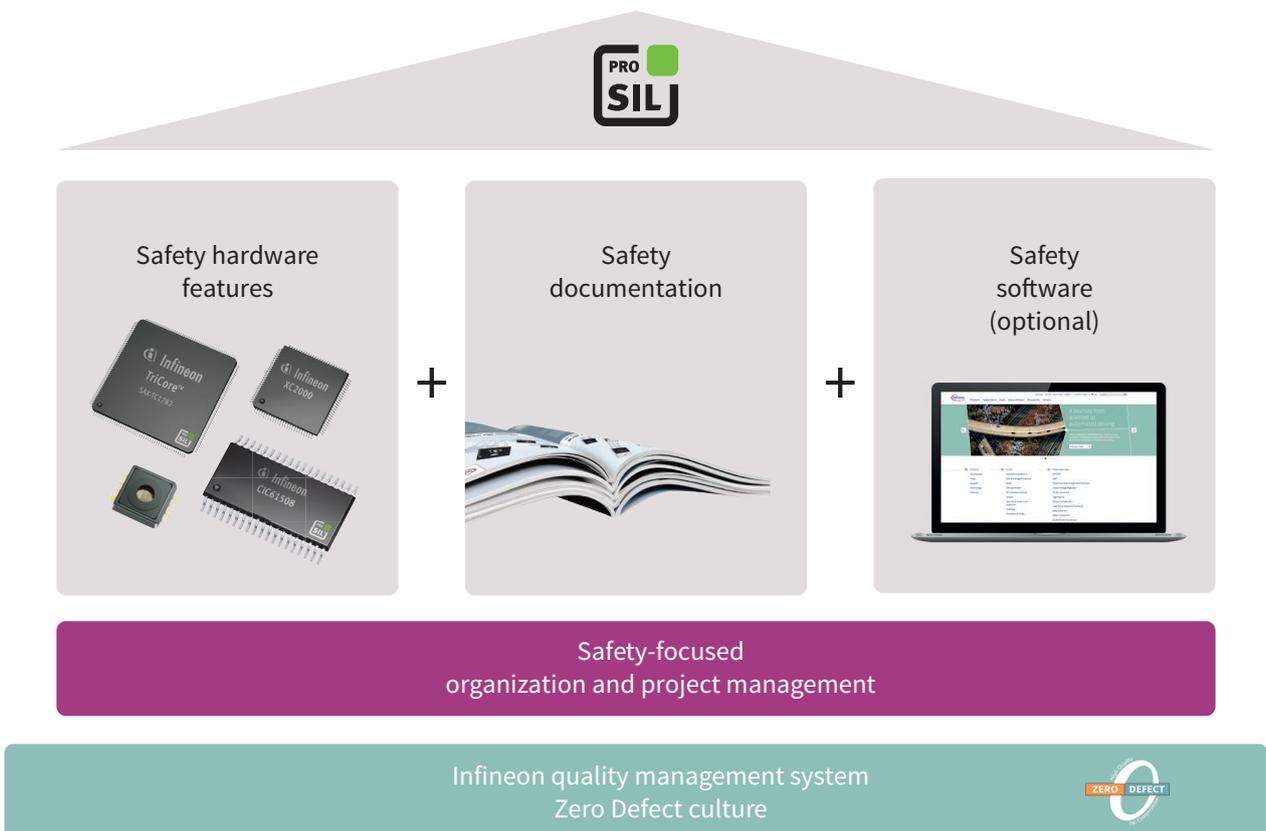|	
N	CAN FD ISO frame
W	LQFP 0.5 mm pitch
F	TQFP 0.4 mm pitch
L	BGA 1.0 mm pitch
S	LFBGA 0.8 mm pitch
Q	Fusion Quad QFP 0.5 mm pitch

Infineon PRO-SIL™

The functional complexity and levels of integration of real-time, safety-critical applications continue to increase. Safety standards such as IEC 61508 and ISO 26262, mandate more robust products and functional safety concepts in automotive and industrial applications.

Infineon's PRO-SIL™ trademark designates the Infineon products that contain SIL-supporting (Safety Integrity Level) features. The purpose of SIL-supporting features involves assisting the overall system design in attaining the desired SIL (according to IEC 61508) or ASIL (according to ISO 26262) level for safety systems with high efficiency. Products with the PRO-SIL™ label will help you to select Infineon products.

PRO-SIL™ highlights

› Broad hardware portfolio, including sensors and micro-controllers, along with analog and power management ICs that provide SIL-supporting features
› An independent functional safety management organization supports the ISO 26262 safety lifecycle
› Safety documentation, such as a safety manual and safety analysis summary report, can be made available for dedicated PRO-SIL™ products (NDA may be required)

› Infineon offers expert system integrator support for achieving the required ASIL on system level
› Infineon's PRO-SIL™ logo will guide you to our products (hardware, software, safety documentation) with SIL-supporting features. Infineon's activities result in simplified integration in safety-related applications.

Safety hardware features

+

Safety documentation

+

Safety software (optional)

Safety-focused organization and project management

Infineon quality management system
Zero Defect culture

www.infineon.com/prosil

AURIX™ family housing options

Package information for maximum scalability

LFBGA-516

BGA-416

LFBGA-292

BGA-180

LQFP-176

LQFP-144

TQFP-144

TQFP-100

TQFP-80
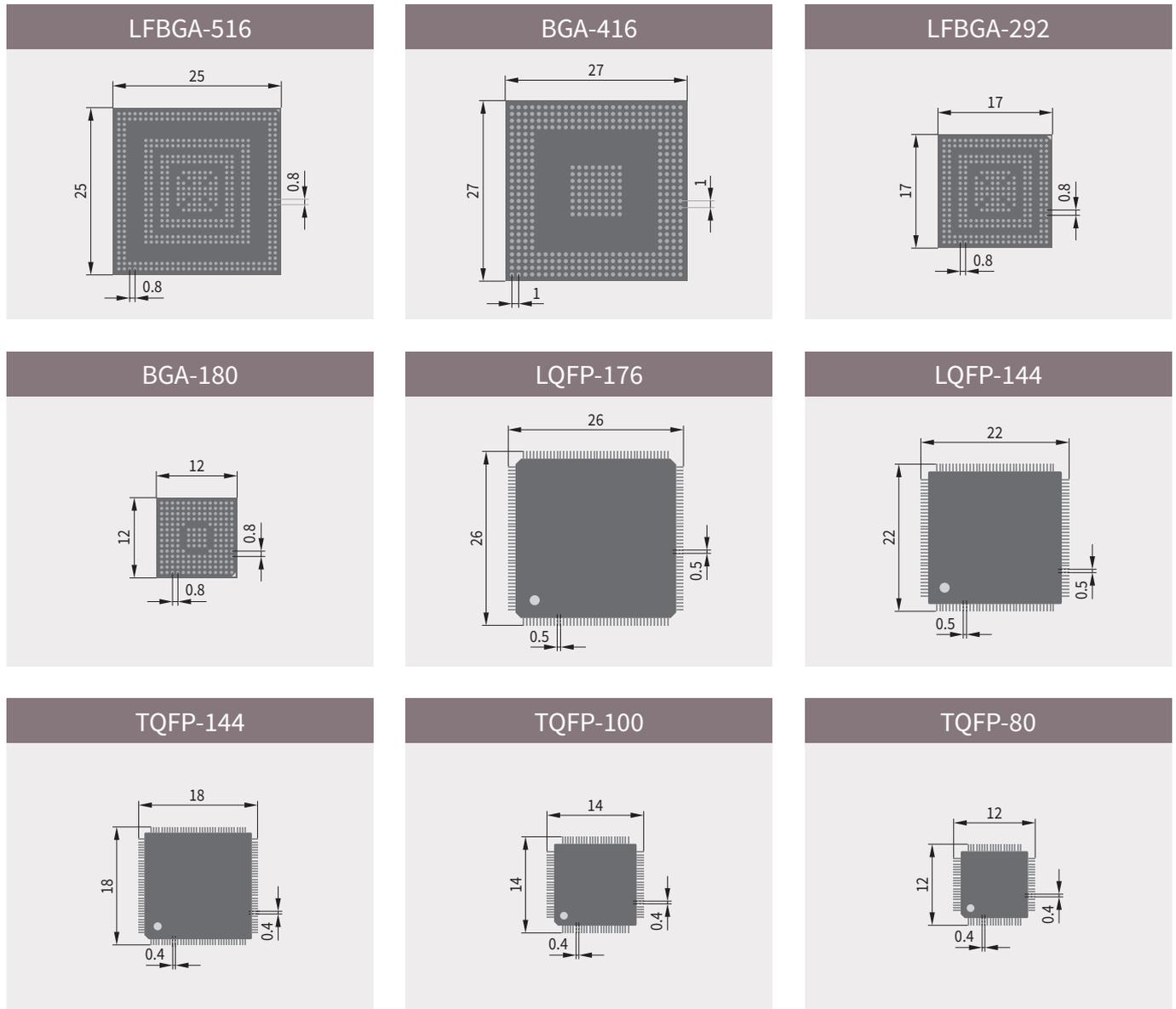
TriCore™ upgrade paths

LFBGA-516   BGA scalability   LFBGA-292

25 x 25 mm   17 x 17 mm
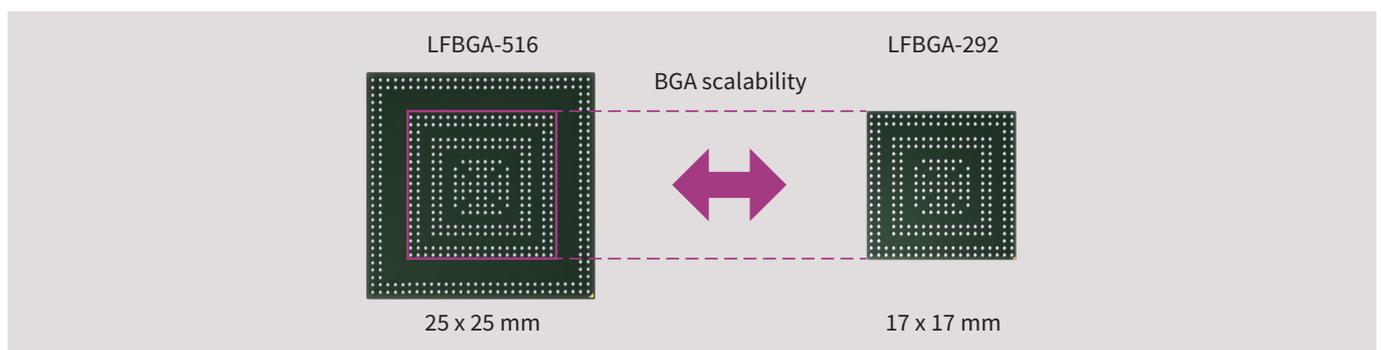
› LFBGA-292 and LFBGA-516 are ball compatible so that customers can build one PCB for both packages

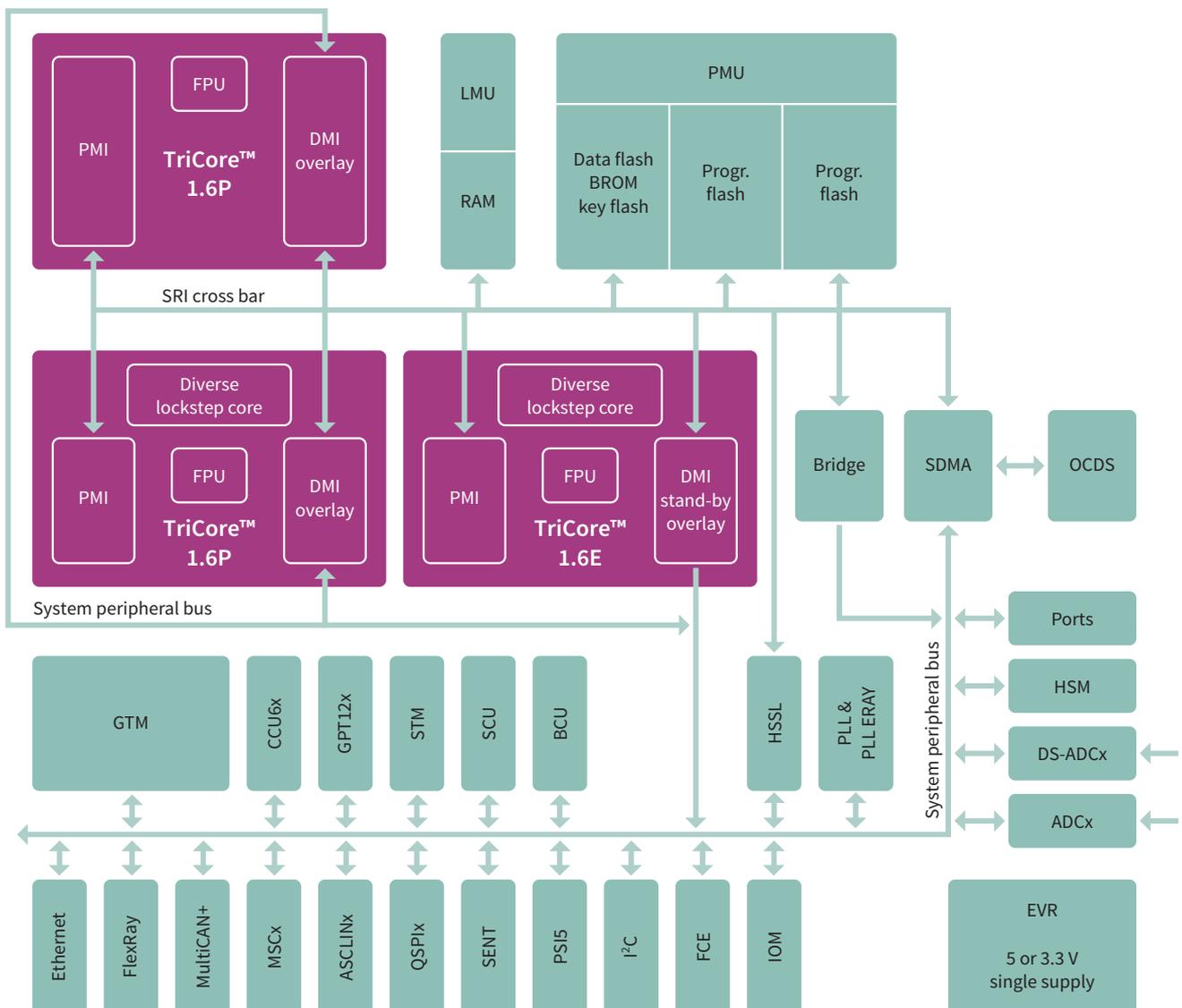www.infineon.com/packages

AURIX™ TC2xx family system architecture

Powerful 1st generation AURIX™ TC2xx system architecture

AURIX™ is Infineon's current family of microcontrollers that serve the precise needs of the automotive industry in terms of performance and safety. Its innovative multicore architecture, based on up to three independent 32-bit TriCore™ CPUs, has been designed to meet the highest safety standards, while simultaneously increasing performance significantly.

Using the AURIX™ platform, automotive developers will be able to control powertrain and safety applications with one single MCU platform. Developments using AURIX™ will require less effort to achieve the ASIL-D standard than with a classical lockstep architecture.

Customers wanting to reduce their time-to-market can now cut down their MCU safety development by 30%. By the same token, a performance surplus of 50% up to 100% allows for more functionality and offers a sufficient resource buffer for future requirements, keeping the power consumption on the single-core microcontroller level. While protecting IP, and preventing theft and fraud, AURIX™ provides an already built-in hardware security module.

Thanks to its special feature set, AURIX™ is the perfect match for powertrain applications (including hybrid and electrical vehicles) as well as safety applications (such as steering, braking, airbag and advanced driver assistance systems).

AURIX™ TC2xx family system architecture

AURIX™ TC2xx family package scalability

Flash / Package	TQFP-80	TQFP-100	TQFP-144 LQFP-144	LQFP-176	LFBGA-292	BGA-416	LFBGA-516
9x Series up to 8 MB					TC297 300 MHz	TC298 300 MHz	TC299 300 MHz
7x Series up to 4 MB				TC275 200 MHz	TC277 200 MHz		
6x Series up to 2.5 MB			TC264 200 MHz	TC265 200 MHz	TC267 200 MHz		
3x Series up to 2 MB		TC233 200 MHz	TC234 200 MHz		TC237 200 MHz		
2x Series up to 1 MB	TC222 133 MHz	TC223 133 MHz	TC224 133 MHz				
1x Series up to 512 KB	TC212 133 MHz	TC213 133 MHz	TC214 133 MHz				

↕ Upgrade/downgrade with pin-compatible packages

› The LFBGA-516 package is a superset of the LFBGA-292
› Combination PCBs can be designed for I/O and feature upgrades
› Advanced package technologies deliver the best price/performance ratio
› Customers can choose between different devices in the same pin-compatible package

AURIX™ TC3xx family system architecture

Scalable 2nd generation AURIX™ TC3xx system architecture

The latest AURIX™ TC3xx microcontrollers are also well-suited for safety-critical applications to support clean, autonomous and connected cars. Ranging from classic airbag, braking and power steering to fail-operational systems supported by sensor-based systems using radar, LIDAR or camera technologies.

The implemented connectivity features, in combination with the highest level of security, enable connected cars with applications such as a telematics unit, connected gateway or in-vehicle wireless charging for portable devices.

To make the car clean, the new family is well-suited to new systems in electrical and hybrid drives – specifically hybrid domain control, inverter control, battery management, onboard charger and DC-DC converters, in addition to engine management and transmission control systems.

The AURIX™ TC3xx combines performance with a powerful safety architecture and offers enhanced security with the second-generation HSM with asymmetric cryptography accelerators and Full EVITA support. This combination makes the family the ideal fit for domain control and data fusion applications supporting the next levels of autonomous driving.

The AURIX™ TC3xx family is pin compatible with the AURIX™ TC2xx family and offers increased flash memory sizes of up to 16 MByte, over 6 MByte of integrated RAM and up to six TriCore™ 1.62 embedded cores, each with a full clock frequency of 300 MHz. New features include a new radar processing sub-system with up to two dedicated Signal Processing Units (SPU), Gigabit Ethernet, additional CAN FD and LIN interfaces and an eMMC interface for external flash.
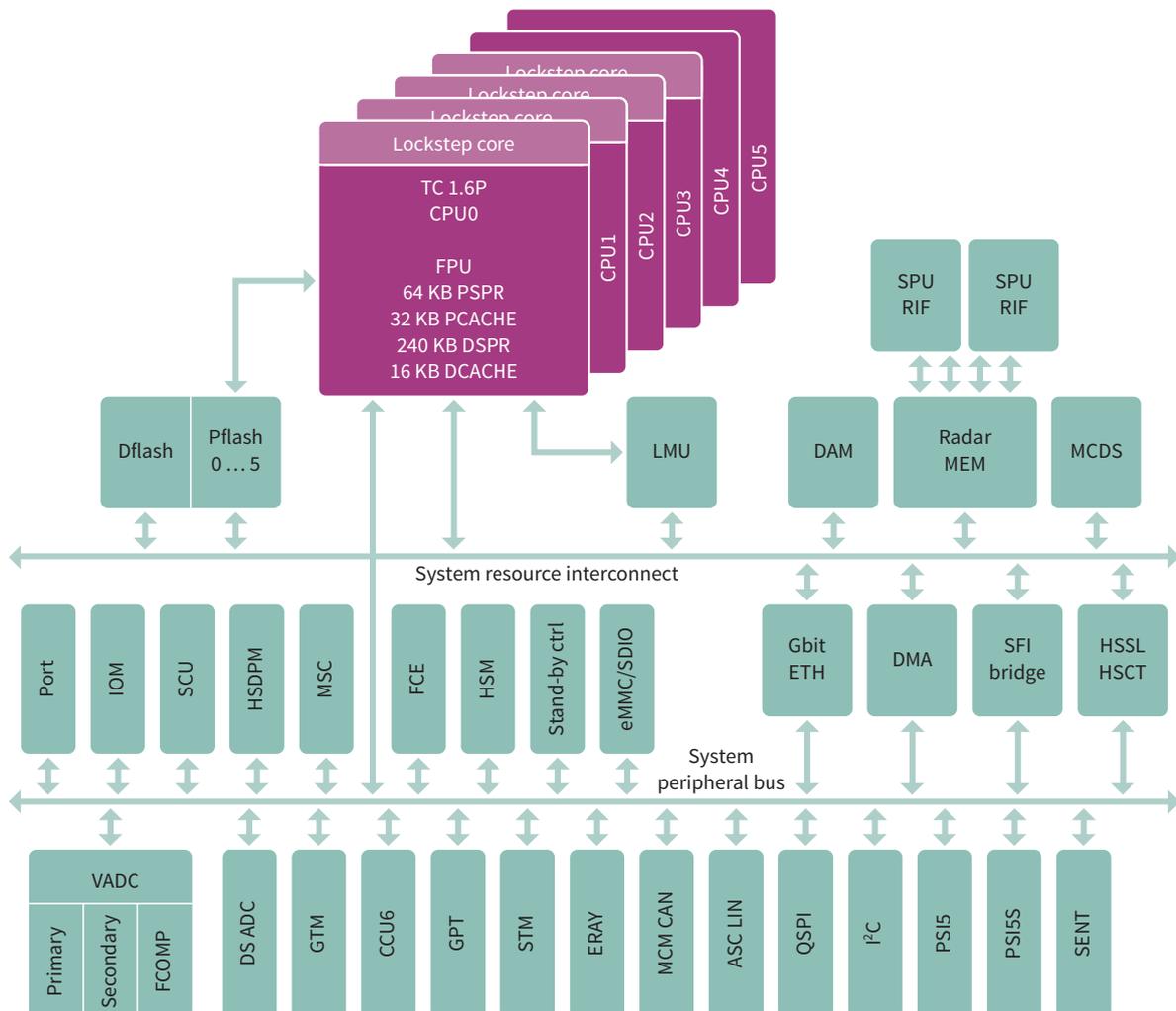
AURIX™ TC3xx family system architecture

AURIX™ TC3xx architecture evolution from TC2xx to TC3xx
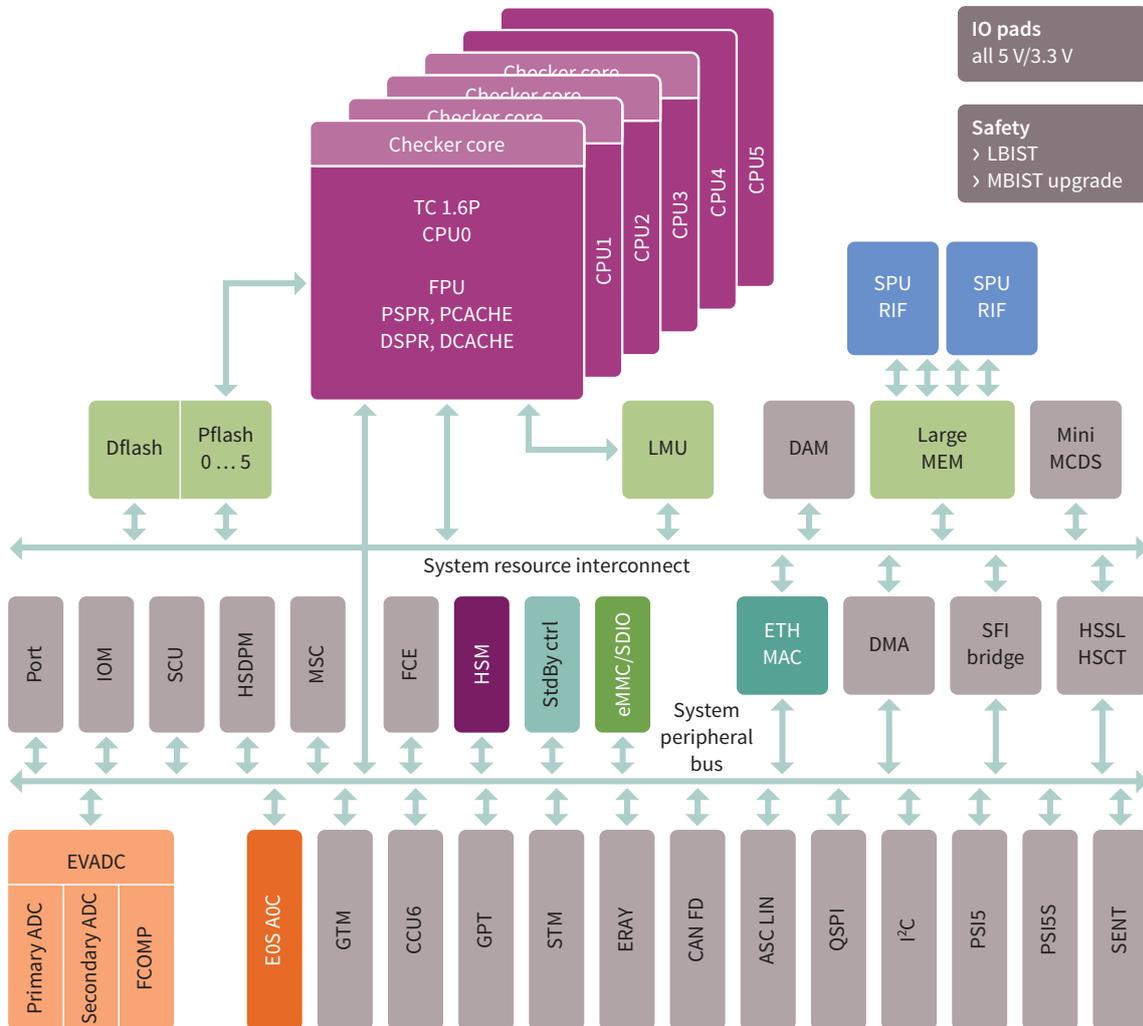
Performance
- › New TriCore™ 162 generation
- › New instructions
- › Up to 6 CPUs at 300 MHz
- › New direct flash access path

HSM: Full EVITA compliance
- › New accelerators ECC256/SHA256
- › Available on all devices

ADAS
- › New HW accelerator concept - SPU (Signal Processing Unit)

ADC
- › Improvement of existing ADC
- › Reduction of capacitive load

Delta-sigma
- › Enhanced concept

Memories
- › Larger SRAM
- › SRAM/flash ratio increased
- › Enhanced MPU

Stand-by control unit
- › Low-power modes

Ethernet
- › 1 Gbit/s ETH
- › QoS services
- › Remote DMA

eMMC/SDIO
- › External NAND flash IF

AURIX™ TC3xx family system architecture

AURIX™ TC3xx package scalability

		TQFP-80	TQFP-100	LQFP-144 TQFP-144	BGA-180	LQFP-176	BGA-233	LFBGA-292	LFBGA-516
6x 300 MHz	9xA Series 16 MB							TC397XA 300 MHz	
6x 300 MHz	9x Series 16 MB							TC397X 300 MHz	TC399X 300 MHz
4x 300 MHz	Ex Series 12 MB							TC3E7QX 300 MHz	
4x 300 MHz	8x Series 10 MB							TC387Q 300 MHz	TC389Q 300 MHz
3x 300 MHz	7xX Series 6 MB							TC377TX 300 MHz	
3x 300 MHz	7x Series 6 MB					TC375T 300 MHz		TC377T 300 MHz	
2x 300 MHz	6x Series 4 MB			TC364D 300 MHz	TC366D 300 MHz	TC365D 300 MHz		TC367D 300 MHz	
4x 300 MHz	Ax Series 4 MB						TC3A8Q 300 MHz	TC3A7Q 300 MHz	
3x 300 MHz	5xA Series 4 MB				TC356TA 300 MHz			TC357TA 300 MHz	
2x 300 MHz	3xA Series 2 MB				TC336DA 300 MHz			TC337DA 300 MHz	
1x 200 MHz[1]	3x Series 2 MB	TC332L 200 MHz[1]	TC333L 200 MHz[1]	TC334L 200 MHz[1]	TC336L 200 MHz[1]			TC337L 200 MHz[1]	
1x 160 MHz	2x Series 1 MB	TC322L 160 MHz	TC323L 160 MHz	TC324L 160 MHz				TC327L 160 MHz	
Flash	Package	TQFP-80	TQFP-100	LQFP-144 TQFP-144	BGA-180	LQFP-176	BGA-233	LFBGA-292	LFBGA-516

Legend (second row): **Sense and Compute** / **Control and Actuate**

1) An option of 300 MHz is also available

› Advanced package technologies deliver the best price/performance ratio

› Customers can choose between different devices in the same pin-compatible package

MCU scalability
› Performance and flash
› Pin compatibility
› Binary-compatible cores

Safety/security concept
› ISO 26262 compliance
› Hardware security support
› IEC61508 compliant

PRO SIL™

Security

AURIX™ TC3xx

Power consumption
› On-chip SC DC-DC high-efficiency power supply
› Integrated stand-by controller

Connectivity
› Ethernet: up to 2x 1 GB
› CAN FD: up to 12 channels
› LIN: up to 24 channels
› eMMC IF

Peripheral highlights

Multi-AUTOSAR OS support on one microcontroller

› AURIX™ provides a memory protection system for each core plus an additional distributed hardware-based resource management system
› Each peripheral and shared SRAM has a resource management unit that works as a local access protection mechanism to grant or deny access
› When combined with the memory protection system, this hardware can be used to prevent selected direct access from certain tasks or cores to peripherals or regions of SRAMs and instead redirect the attempted access to a hypervisor function

› The hypervisor can arbitrate/grant/deny access and therefore provide paravirtualization of mixed-criticality tasks in a unified sub-system architecture with a minimal CPU overhead
› AURIX™ therefore provides the ability to run mixed-criticality software requiring real-time access while still enforcing encapsulation and freedom of interference between cores, even when the cores are not running time and memory-protected operating systems
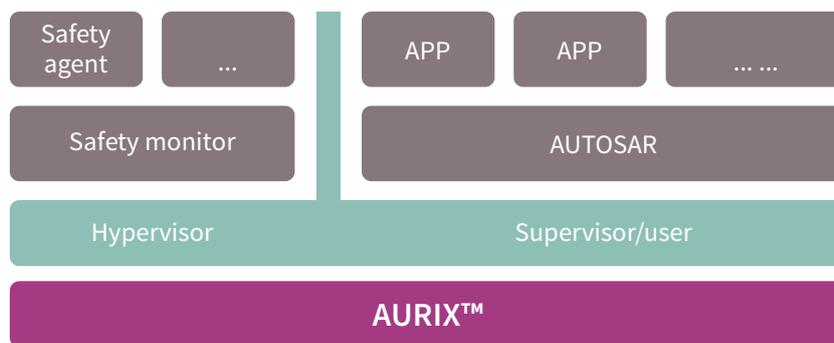

AURIX™ protection system overview

› Hardware support for freedom of interference
  – Between software components
  – Between hardware parts
  – Between hardware parts and software components
› Timing protection
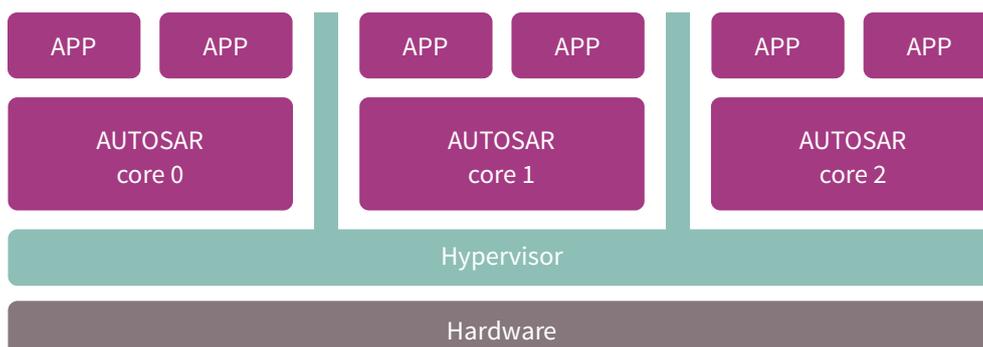
# Peripheral highlights

Infineon® diverse lockstep concept

- › Lockstep architecture designed to control and mitigate common cause factors
  - – Physical isolation
  - – Instruction-level execution diversity: 2-cycle delay
  - – Circuit-level design and timing diversity
- › Layout-level diversity
- › Diversity controlled and verified by state-of-the-art design methods
- › Special design of clock and reset networks

- › Careful design of lockstep comparator
- › Main core and diverse lockstep core run the same software in parallel to detect computational errors
- › Like normal locksteps, both cores are physically separated and have a time delay between their execution
- › Diverse lockstep core has been additionally transformed to provide architectural hardware diversity and further reduce common cause failures

Lockstep CPU

Lockstep
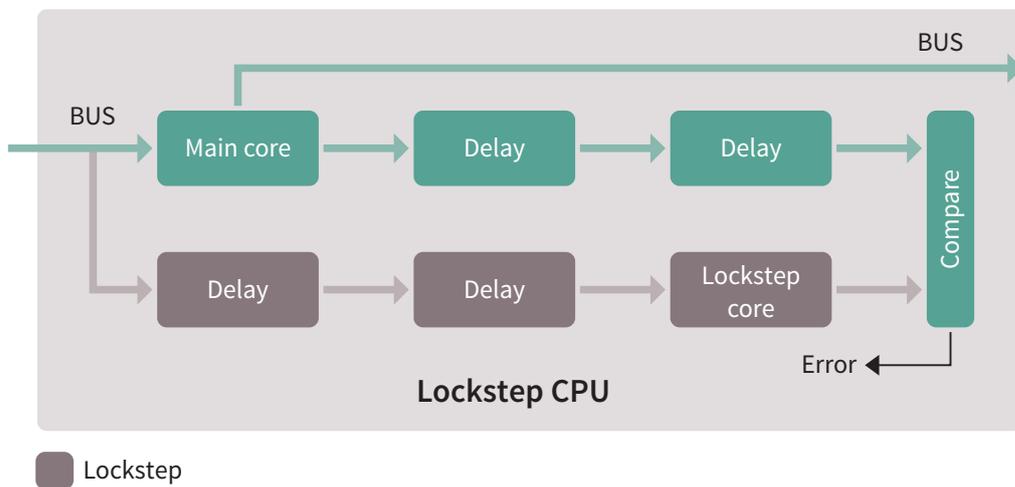
AURIX™ family communication innovation

AURIX™ Multi-CAN/CAN FD
- › Up to 20 CAN nodes with FD support available
- › CAN standard V2.0 B active
- › AURIX™ family support ISO 11898-1 DIS 2015
- › Resonator ready with asynchronous operation and choice of clock source
- › Frequency scaling without baud rate change
- › Energy saving: pretended networking and partial networking (ISO 11898-6 transceiver support) support (also in CAN FD mode)
- › Safety support: countable total amount of bus errors
- › Message objects can be freely assigned among the nodes
- › Configurable FIFO length, automatic gateway mode support
- › Acceptance mask filtering for each message object

AURIX™
ISO 11898-6 transceiver support
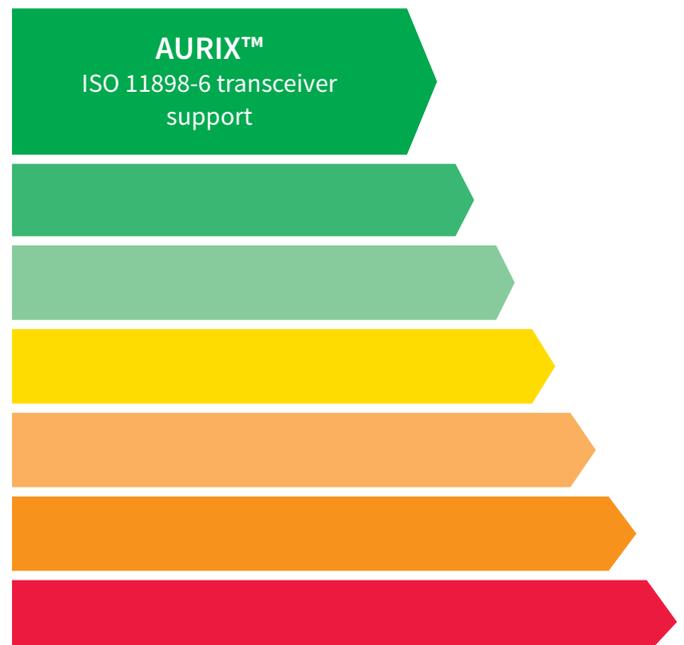
AURIX™ Ethernet module

Key highlight features

Ethernet MAC filter
› MAC/VLAN/protocol filter for fast frame processing

QoS
› 8 queues/DMAs for frame separation
› 4 transmit/4 receive
› IEEE 802.1AS (for IEEE 1588-2008)
› Shapers for bandwidth control
 – 802.1 credit-based shaper
  – Time-aware shaper

Interfaces
› MII/RMII for 100 MBaud
› RGMII for 1 GBaud

Freedom from interference
› DMA operation → separated by hardware
› No impact of queue operation on other queues, DMAs etc.
› Independent control of each queue
› Status/control in RAM → fast direct stack access

"Remote DMA" – fast data copy – RAM to RAM
› Data transfer by DMA with no CPU required for transfer
› Transfers triggered by hardware or by software
› Transfers are hardware protected (in AURIX™)
› Full-duplex transfers, low latency mode
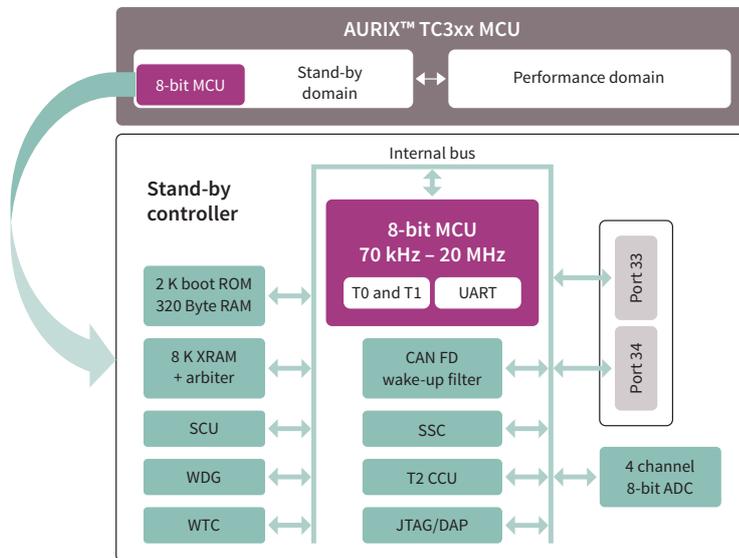› All Ethernet standards and conformance tests are valid
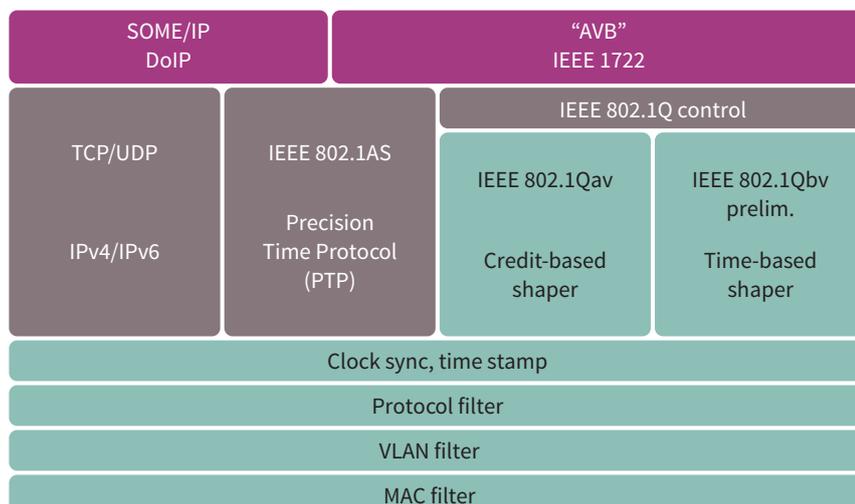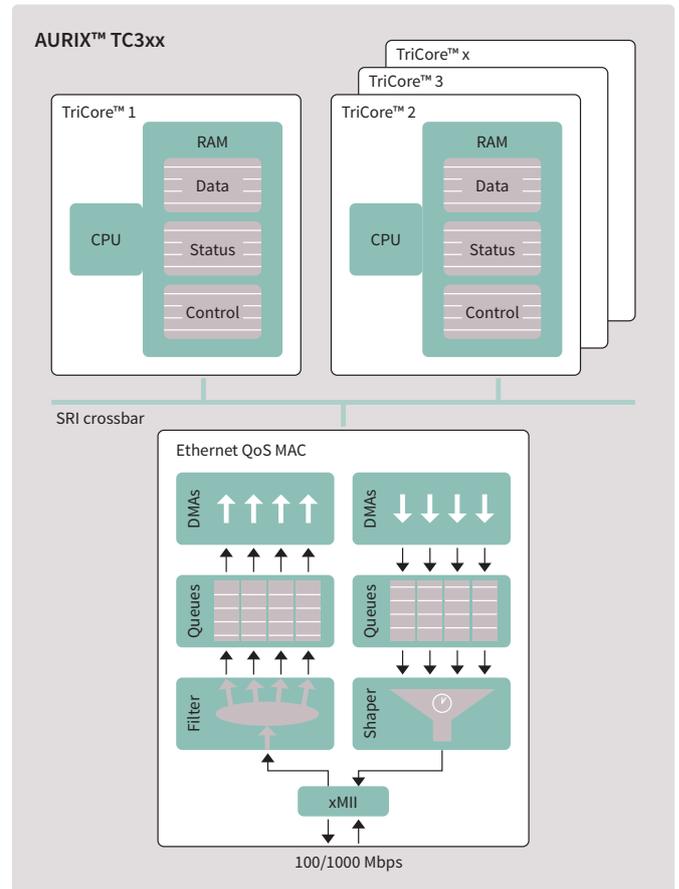
AURIX™ TC3xx stand-by controller
Low power consumption, higher energy efficiency, easy implementation

Features and benefits

› Feature available across whole AURIX™ TC3xx family
› Integrated 8-bit MCU (ISO 26262 QM module)
› Stand-alone operation
  – Separate power supply at core and IOs
  – Separate clock
  – Separate GPIOs
› Standard tooling support enabling fast design-in
› Real-time clock for periodic wake-up
› Flexible choice of peripherals: LIN/SPI
› Shared I/O with performance domain
› Extremely low current consumption ~ µA range

Application recommendation

› **Enhanced availability:** continue a limited set of functions while the main CPUs are rebooting after a reset (typ. watchdog reset)
› **Steering and braking comfort:** temporary torque supply during main MCU
› **Stand-by operation:** extremely low-power operation while the vehicle is parked
› **(H)EV battery management:** monitor the battery's state-of-heath and charge over a long parking period, e.g. vacation
› **Keyless-go:** trigger main MCU for key communication
› **Fuel leakage supervision:** on-board diagnostics and monitoring of tank pressure, e.g. while parked

eMMC/SDIO interface on
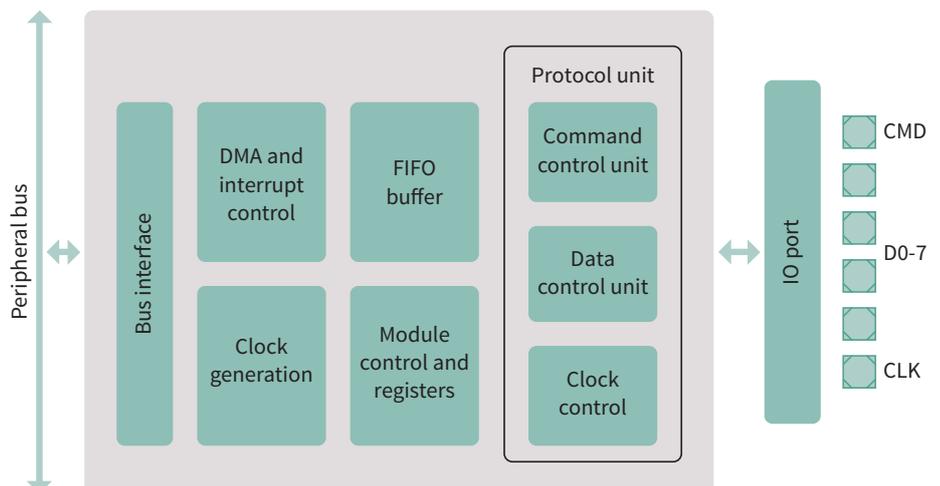
2 standard protocols supported

› SDIO 2.0
  – 6 pins: 4 data, CLK, CMD
  – 3.3 V, 50 MHz max. clock
› eMMC
  – 10 pins: 8 data, CLK, CMD
  – 3.3 V, 20 MHz

Use cases

› External serial NAND-flash
› Wi-Fi modems
› Camera modules

AURIX™ security features

AURIX™ security hardware

Infineon's AURIX™ 32-bit microcontroller family, with its embedded Hardware Security Module (HSM), is a perfect fit for automotive applications where secure on-board communication is required. Infineon not only offers a scalable portfolio of compatible AURIX™ devices with integrated HSM, but also the necessary software packages and support services. Furthermore, a best-in-class solution for automotive security can be achieved by combining AURIX™ microcontrollers with an Infineon embedded SIM (eSIM) and Infineon tamper-proof secure elements (TPM).

AURIX™ Hardware Security Module (HSM)
HSM provides a secure computing platform, consisting of a 32-bit CPU, special access-protected memory for storing the cryptographic keys and unique subscriber identifiers and dedicated hardware accelerators for the various automotive security use cases. A firewall separates HSM from the rest of the AURIX™ microcontroller.

The AURIX™ hardware security module offers a highly flexible and programmable solution based on:

› Crypto and algorithm agility via software to support customer-specific solutions powered by a 32-bits CPU
› AIS31-compliant True Random Number Generator (TRNG) with high random entropy over lifetime
› State-of-the-art AES-128 hardware accelerator matching performance for automotive protocols
› State-of-the-art PKC ECC 256 hardware accelerator for asymmetric encryption (only 2nd generation AURIX™ HSM)
› State-of-the-art HASH SHA2-256 hardware accelerator for hashing (only 2nd generation AURIX™ HSM)
› Secured key storage provided by a separated HSM-SFLASH portion. Alternative secure key storage feasible in dedicated HSM-PFLASH sections.

Customer benefits

› **Secured platform** – HSM provides a secured platform, separated from the rest of the microcontroller by a firewall, thereby creating a trusted execution environment.
› **Security standard compliance** – AURIX™ HSM fulfills SHE HIS and EVITA Medium standards, while the 2nd generation AURIX™ HSM supports up to Full EVITA. In addition to fulfilling the aforementioned standards, HSM generations provide additional functionalities.
› **Backward compatibility** – AURIX™ security solutions are backward compatible with the security SHE HIS implementations in previous TriCore™ based microcontroller families. Furthermore, the 2nd generation AURIX™ HSM is backward compatible with the 1st generation HSM.
› **Security differentiation** – customized secure OEM or tier1 crypto apps can be processed within a trusted HSM execution environment, therefore allowing an independent HSM-specific software code review with reference to the huge application host software from multiple parties. This helps to harden the security level by reliably avoiding potential security backdoors.
› **Convergence of security and safety** – AURIX™ microcontrollers address both functional safety as well as IT-security requirements, making sure they are properly integrated and don't conflict with one another.
› **Secured failure analysis** – AURIX™ HSM offers a 256-bit password for debugger access protection to prevent unauthorized access to the debugging resources.

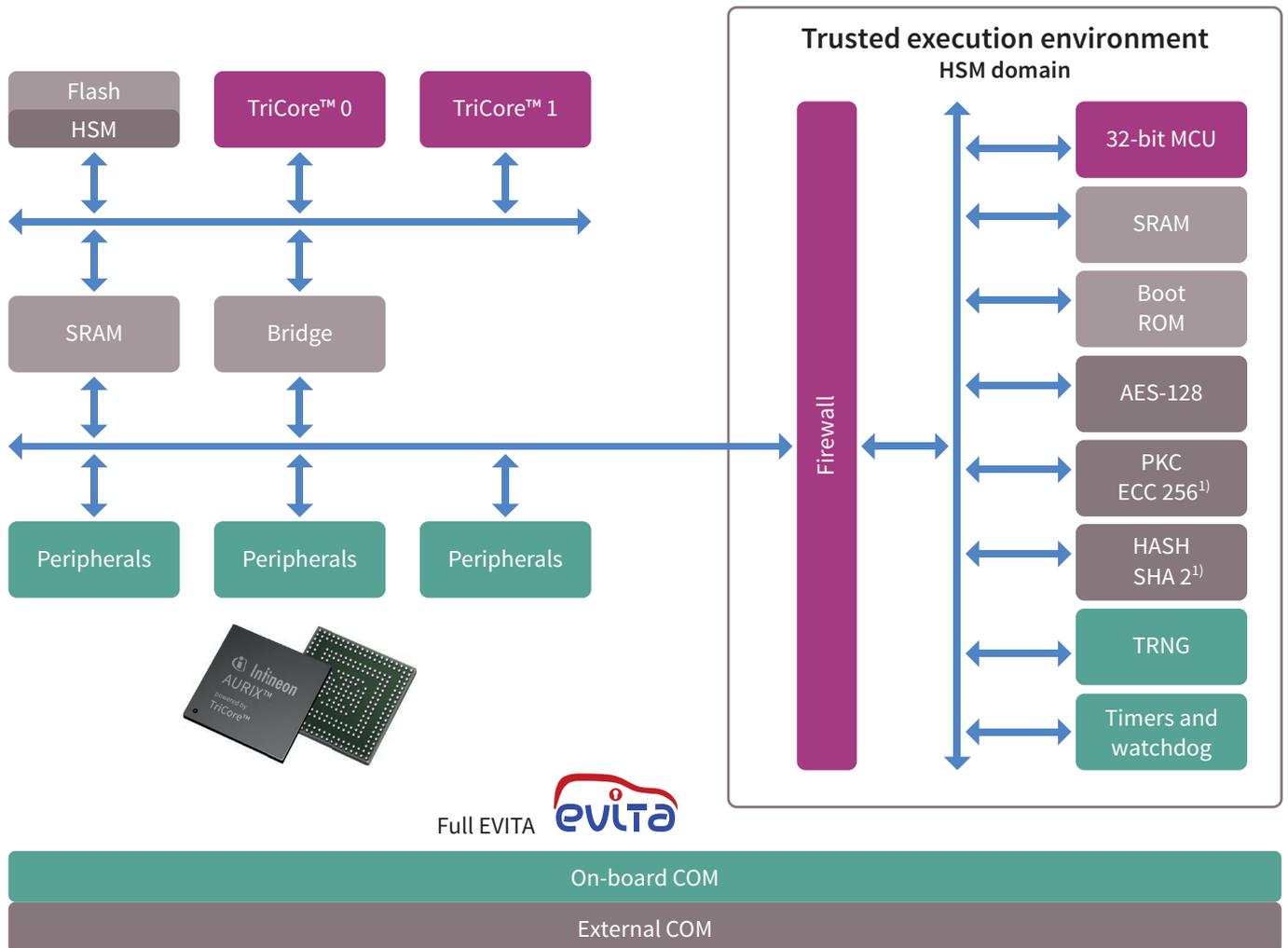## Typical use cases

› Secured boot
› Secured on-board communication
› Software Over the Air (SOTA) updates
› IP and tuning protection
› Diagnostics via OBD/protected FAR flow/debug protection
› Immobilizer

www.infineon.com/aurix-security-solutions

AURIX™ security features

AURIX™ security hardware

AURIX™ hardware security module – anchor of trust thanks to separated logical protection domain

Trusted execution environment
HSM domain

| Flash | TriCore™ 0 | TriCore™ 1 |
| HSM | | |

SRAM | Bridge

Peripherals | Peripherals | Peripherals

Firewall

- 32-bit MCU
- SRAM
- Boot ROM
- AES-128
- PKC ECC 256[1]
- HASH SHA 2[1]
- TRNG
- Timers and watchdog

Full EVITA

On-board COM

External COM

1) Only TC3xx

HSM domain creates a trusted execution environment
› 32-bit ARM® MCU separated by security firewall
› Background integrity checks of host application

Root of trust functions
› Integrity monitoring
  – Secure boot, on-the-fly checks
› Secure key storage
  – Protected data and program flash
› Strong key generation
  – AIS31-compliant True Random Number Generator (TRNG)
› Crypto accelerators
  – Symmetric: hardware AES-128
  – Asymmetric: hardware ECC-256, SHA-2

Security

www.infineon.com/aurix-security-solutions

Infineon's AURIX™ 32-bit microcontroller family offers a wide portfolio of compatible devices with an embedded Hardware Security Module (HSM), which offers cost-efficient solutions for all typical automotive security applications. The SHE+ driver controls the hardware security peripheral in the HSM domain and interacts with the TriCore™ host core. SHE+ comes with the AUTOSAR CRY interface for integrating the HSM security features into an automotive application, including interface to AUTOSAR, communication from TriCore™ to HSM and vice versa, key storage functionality and security peripheral drivers.
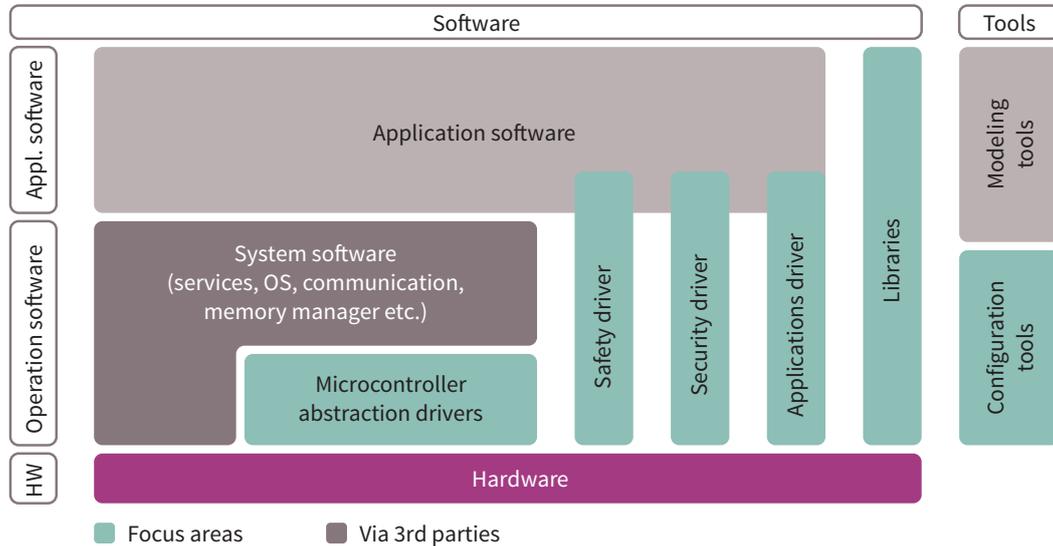
	SHE HIS	HSM SHE+ TC2xx	TC3xx crypto driver via partners
Key management	10 keys	20 keys	Configurable
Symmetric data encryption/decryption	hardware-based AES-128-bit (ECB, CBC)	●	●
MAC generation/verification	Optional	●	●
Safe MAC verification	–	●	●
Random number management	SHE PRNG	●	●
Secure boot	Optional	●	●
Debug access	–	Enhanced by HSM debug options	Enhanced by HSM debug options
Other SHE services	●	●	●
Asymmetric encryption/decryption	–	–	software-based RSA1024 software-based ECC256

Typical applications	Tuning protection	Immobilizer / Secure-on-board communication	Possible extensions, depending on specific tier 1/OEM use case
Key management	●	●	●
Symmetric data encryption/decryption	●	●	●
MAC generation/verification	●	●	●
Safe MAC verification		(optional)	(optional)
Random number management	●	●	●
Secure boot	(optional)	(optional)	(optional)
Debug access	(for development)	(for development)	(for development)
Other SHE services	●	●	●
Asymmetric encryption/decryption	●	●	●

www.infineon.com/aurix-security-solutions

Embedded software

Infineon software product overview

	Software		Tools
Appl. software	Application software	Libraries	Modeling tools
Operation software	System software (services, OS, communication, memory manager etc.) / Microcontroller abstraction drivers	Safety driver / Security driver / Applications driver	Configuration tools
HW	Hardware		

■ Focus areas ■ Via 3rd parties

› Microcontroller abstract drivers
  – AUTOSAR MCAL (includes Multicore support)
› Safety drivers
  – PRO-SIL™ SafeTcore (AUDO MAX)
  – PRO-SIL™ SafeTlib (AURIX™ TC2xx)
  – PRO-SIL™ SBST Software-Based Self-Test (AURIX™ TC3xx)
  – Safety libraries for AURIX™ TC3xx via software partners
› Security software
  – SHE+ driver (AURIX™ TC2xx)
  – AUTOSAR crypto driver (AURIX™ TC3xx) via software partners
  – Intrusion Detection Prevention Systems (IDPS) via software partners
› System software
  – AUTOSAR BSW via software partners
  – RTOS, communication stocks, etc. for industrial applications via software partners

› Libraries
  – DSP library
  – iLLD low-level peripheral drives
  – LAPACK math library
› Free TriCore™ tools
  – Free TriCore™ entry tool chain
  – Altium free tools for TriCore™/AURIX™
    – Free TASKING VX-toolset for AURIX™
    – Free TASKING Pin Mapper for AURIX™
  – Infineon tools
    – MemTool
    – DAS tool interface

Note: List of all SW and tool partner can be find on page 80.

Standardized driver
Compatibility and reduced time-to-market

Documented product release
Easy to use

Qualified release
Compliant with CMM L3, lower development cost

MC-ISAR

Efficient implementation
Lowest resource consumption

Free evaluation version
From sales contact

Application independence
From chassis through body to powertrain
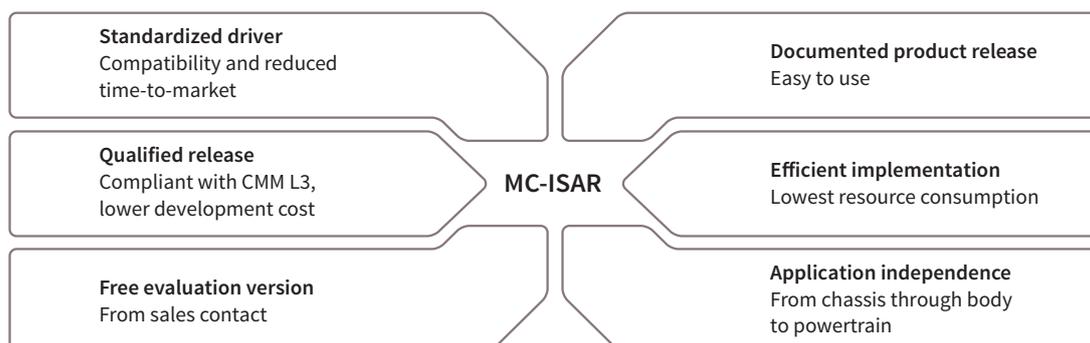
MC-ISAR TC2xx/TC3xx product overview

Device		AURIX™ TC2xx	AURIX™ TC3xx	Safety claim at product release
AUTOSAR version		4.0.3	4.2.2	TC3xx
MCAL drivers	MC-ISAR Basic package	› MCU › WDG › GPT › SPI › Port › DIO › ICU › PWM › ADC › CAN › CanTrcv › LIN › FLS › FEE › BFX › CRC	› MCU › WDG › GPT › SPI › Port › DIO › ICU (supporting GTM → new CCU6 and GPT12) › PWM (supporting GTM → new CCU6) › ADC (feture set 3) › CAN › CanTrcv › LIN › FLS › FEE (feture set 2) › OCU – new › BFX › CRC	› ASIL B functionality claim – Except for CAN, CabTrcv, LIN › ASIL D process to ensure freedom from interference in memory space
	MC-ISA COM enchanced package	› FlexRay (not for TC22x, 1x) › Ethernet (for ASRv4 only, not for TC23x, 2x, 1x)	› FlexRay › Ethernet	› ASIL D process to ensure freedom from interference in memory space
	MCISAR MCD MCAL complex drivers	› UART, MSC (not for TC23x, 2x,1x), DMA, FLSloader	› CD: new production release DS-ADC, SMU › CD: DMA, FLSloader, UART	› ASIL B functionality claim – Except for CAN, CabTrcv, LIN › ASIL D process to ensure freedom from interference in memory space
		› Demo code only for: HSSL (not for TC23x, 2x, 1x), SENT, I²C (not for TC23x, 2x, 1x), STM, DS-AC (not for TC23x, 2x, 1x), SMU, IOM	› DEMOCD (demo code/App note – not released for production): HSSL, SENT, I²C, IOM, STM, IRQ	› No safety claim
Configuration tool		Tresos	Tresos	
Compiler		› TASKING 4.2r2 › Windriver Diab 5.9.2.0+p › HighTec GNU 4.6.3.0	› Migrate to TASKING 6.2r2 › HighTec GNU 4.9.2.0 › Windriver v5.9.6.4 or v5.9.6.6 (still tbd.) › Greenhills (version to be defined) for TC38x, TC35x, TC36x (availability on request)	
Delivery package		Source code, Documentation	Source code, Documentation	

Development support

Emulation device

› Emulation devices (ED) are a very powerful solution for calibration, measurement, rapid prototyping and debugging
› Emulation logic and RAM are added next to the unchanged Production Device (PD) part on the same chip
› Cost-optimized PD, feature-rich ED
› Same package for ED and PD, and a minimum or no additional external circuitry, allow a
› highly cost-optimized ECU design
› Proven solution with broad tool support from leading automotive and debug tool vendors

AURIX™ highlights
› Up to 4 MByte RAM for calibration with the same access speed as on-chip flash
› Automotive measurement bandwidth (XCP) 15/30 MByte/s via regular 2/3-pin DAP interface

Trace and measurement

Contemporary vehicles are designed to meet rising market demands for engine performance, engine responsiveness, torque, drivability, fuel economy and emissions. Infineon's proven Multicore Debug Solution (MCDS) enables manufacturers to design and optimize features to support these automotive trends. Unique MCDS features include the fully time-aligned parallel trace of many different on-chip sources, along with its highly powerful trigger capabilities.

Multicore Debug Solution (MCDS)

Key features
› Tracing of CPUs, buses, performance events and peripheral internal states
› Real time, cycle accurate and in parallel
› Up to 1 MByte on-chip trace RAM (40 Gbit/s bandwidth)
› Very powerful trigger capabilities
› No additional pins needed besides the DAP interface
› New Compact Function Trace (CFT) mode for continuous program trace via DAP
› New fine-grained data trace qualification for automotive measurement

Multicore software development with AURIX™

The right partner for each development stage

Due to increasing performance demands in the automotive industry, multicore architectures are becoming ever more popular. The AURIX™ microcontroller family offers all the benefits of real-time hardware while supporting a multicore architecture capable of both asymmetrical and symmetrical multi-processing, and enabling the creation of ASIL-D systems for automotive applications.

Despite the fact that multicore architectures provide performance benefits, they also result in challenges with regard to software (SW) development. At Infineon, we fully understand the increasing performance demands across multiple applications, as well as the challenges that customers face when designing multicore software. To enable customers to achieve optimal performance when using the powerful AURIX™ architecture, Infineon has built up a network of strong partnerships with companies highly specialized in multicore software development. Infineon's multicore partners can offer the best multicore expertise and tools on the market for each stage of the software design process, covering everything from the initial multi-core knowledge acquisition phase right up to final optimization of the multicore software.

Infineon proactively addresses the challenges of multicore software development by offering special AURIX™ – dedicated literature and training for multicore software development. Furthermore, Infineon also participates in the organization of dedicated conferences, such as the EMCC (Embedded Multi-Core Conference) http://www.multicore-conference.com where various car manufacturers and suppliers share their experiences, challenges and latest findings from the field of multicore architecture.

Multicore know-how

Multicore SW design

Multicore SW development

MCAL Multicore support

Multicore performance evaluation

Multicore SW optimization

VECTOR

GLIWA embedded systems

HIGHTEC

TASKING

Infineon

SYNOPSYS
Predictable Success

i SYSTEM

pls
Development Tools

Infineon AURIX™ powered by TriCore™ made for SAFETY

MICRO CONSULT

INCHRON
THINK REAL-TIME

LAUTERBACH
DEVELOPMENT TOOLS

SILEXICA

ANSYS

emmtrix
Technologies

AURIX™ starter and application kits

Infineon starter kits – 32-bit microcontrollers

Triboards

Infineon Tricore™ family starter kits are powerful evalua-
tion systems that enable evaluation and development well
before the target hardware is available. They offer a solid
platform for both hardware and software engineers to eval-
uate and prototype designs that are closely aligned with
their final applications.
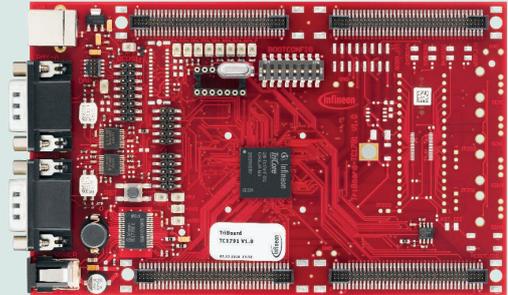
Application kits

To simplify the development of your own application, the
kit comes with a variety of on-board components, including
a highly integrated software development environment
that gives you everything you need to compile, debug, and
flash your AURIX™ multicore application, such as radar,
Arduino, gateway and safety.
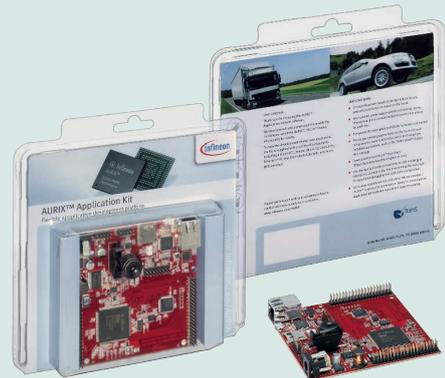
System application kits

The system application kits provide a quick jump-start to
typical microcontroller applications, such as motor
control, radar etc. These reference design kits provide
faster design-in support for end applications by
providing a reference board, application software, tooling
and documentation.

www.infineon.com/aurix-kits

TASKING Pin Mapper

The Pin Mapper can save a substantial amount of time for developers and provides assurance that no pin conflicts exist. In addition, the pin mapper generates a data file for PCB design, eliminating the chance for errors when passing data manually.

Benefits of the TASKING Pin Mapper for AURIX™

› The Pin Mapper tool reduces developer time and costs, while improving the quality of results.
› Configuration takes place via an intuitive eclipse based GUI with built-in knowledge about AURIX™ devices and packages. This saves the developer from the tedious task of consulting piles of device manuals and maintaining configuration settings in spreadsheets.
› Configuration errors/conflicts are detected at entry time and can be either automatically resolved by the built-in conflicts solver or solved manually. Whereas traditionally such errors remain hidden until code has been generated and is tested.

› The Pin Mapper reduces miscommunication between individuals and teams by creating all project files from one source. The Pin Mapper creates:
  – Device initialization code in ISO-C format
  – A spreadsheet (CVS) file for project documentation
  – A schematic symbol block that can be imported by PCB design tools such as Altium Designer

Supported TriCore™ devices

› AURIX™ family (TC22x, TC23x, TC26x, TC27x, TC29x)
› AURIX™ 2G family (TC38x, TC39x,...)
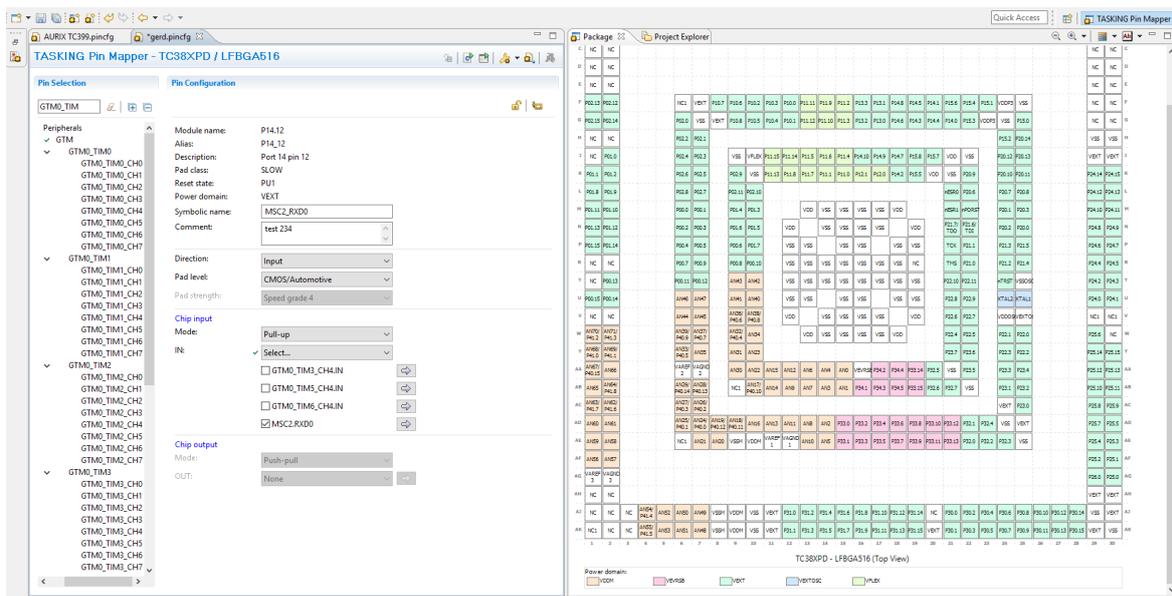
Free TriCore™ entry tool chain

This free-of-charge entry tool chain provides all the features required to develop and test software for TriCore™ and AURIX™. The tool can be used with all available TriCore™ and AURIX™ starter kits and application boards.

Key features

› Eclipse-based IDE
› Project wizard to easily define the project properties for device and board support

› High-performance GNU C compiler
› Integrated source-level debugger
› On-chip flash programming support

For further information on TriCore™ tools, please visit www.infineon.com/aurix-tools

AURIX™ and XMC™ PDH partners

Preferred Design Houses (PDH) and software resellers

Optimized open market customer support set up for systems using AURIX™ and XMC™, including software and other Infineon's products, such as power products, sensor products and modules. Our partners are trained to use AURIX™ and XMC™.

Classic (Free of charge)	› 1st level customer support covering Infineon products/solutions › Technical interface and support to the customer	› Driving design at customer › Basic training for design teams at customer › 24 h response time to the customer
Premium (Consultancy mode) To be agreed between customers and PDH	› Project management and project-specific application support › Specification of general software architecture, defining required layers, control and data flow structure etc. › Specification and implementation of custom device drivers › Optimization of software components with regard to speed/code size	› Software testing › Support for project-specific functional safety engineering › Project-specific support for security solution › Safety support › Security support › Multicore support

Optimized regional and application-specific presence

Global / EMEA

Support capabilities	C	FROBAS	hitex	Autogramma	AVL	BLUE WIND	driveXpert	Embedded Office	GRINN	HIGHTEC	miisc	(RF)	iav	PinTeam	MixedMode	RDM GROUP	ULMA	MicroFuzzy	INTEGRA SOURCES	sst	MecTronik	ОЛЬВИЯ	TBS
AUTOSAR	●	●	●		●	●	●	●	●	●	●		●	●		●	●	●	●	●	●		
Motor control	●	●	●	●	●	●	●		●		●		●	●		●	●	●	●	●	●		●
Lighting	●	●	●		●	●			●				●	●		●	●	●	●	●	●		
PFC/power conversion	●	●	●						●				●	●		●	●	●	●	●	●		
AURIX™ general support HW	●	●	●	●	●	●		●		●	●		●	●		●	●	●	●	●	●	●	●
AURIX™ general support SW	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Safety support IEC 61508	●		●		●	●		●		●			●	●		●	●	●	●	●	●		
Safety support ISO 26262	●		●		●	●		●		●	●		●	●		●	●	●	●	●	●		
Security support/SHE+	●		●		●	●		●	●	●			●	●		●	●	●	●	●	●		
XMC™ general support HW	●	●	●		●	●	●	●	●		●		●	●		●	●	●	●	●	●		
XMC™ general support SW	●	●	●		●	●	●	●	●		●		●	●		●	●	●	●	●	●		
Class B classification	●		●		●		●		●				●			●	●	●	●		●		
Capacitive sensing with XMC™	●		●			●			●				●			●	●	●	●	●			
Secure boot for XMC™	●		●		●	●		●	●				●	●		●	●	●	●	●		●	
24 GHz radar												●						●	●			●	
77 GHz radar												●						●	●			●	

Americas / China / Korea

Support capabilities	iP2L	D3 Engineering	NEUTRON	EWD	G-Pulse	TECHREIN	DE Digital Edge Solutions
AUTOSAR	●	●	●	●	●	●	●
Motor control	●	●	●	●	●	●	●
Lighting	●	●	●	●	●	●	●
PFC/power conversion	●	●	●	●	●	●	●
AURIX™ general support HW	●	●	●	●	●	●	●
AURIX™ general support SW	●	●	●	●	●	●	●
Safety support IEC 61508	●	●	●	●	●	●	●
Safety support ISO 26262	●	●	●	●	●	●	●
Security support/SHE+	●	●	●	●	●	●	●
XMC™ general support HW	●	●	●	●	●	●	●
XMC™ general support SW	●	●	●	●	●	●	●
Class B classification	●	●		●	●	●	●
Capacitive sensing with XMC™	●	●	●	●	●	●	●
Secure boot for XMC™	●	●	●	●	●	●	●
24 GHz radar	●				●	●	●
77 GHz radar	●				●	●	●

Basic ●
Essential principles and elementary know-how to support a customer, provision of basic training for design teams

Advanced ●
High-level project-specific application support/consulting

Expert ●
Extensive knowledge and ability to fully support development

www.infineon.com/pdh

AURIX™ for powertrain and (H)EV applications

Energy efficiency for combustion engine vehicles

Electronic automotive components are key to raising fuel efficiency levels and cutting emissions. The latest environment protection agency standards – Euro 5 and Euro 6 for passenger cars and Euro 3 and Euro 4 for motorcycles – are driving developments in advanced engine management. TriCore™ based products can be found in improved combustion technologies such as Homogeneous Charge Compression Ignition (HCCI) as well as in direct injection, smart turbocharger and valve actuation applications. They are also ideal for a range of innovative transmission technologies such as Double Clutch Transmission (DCT) and modern Continuous Variable Transmission (CVT).
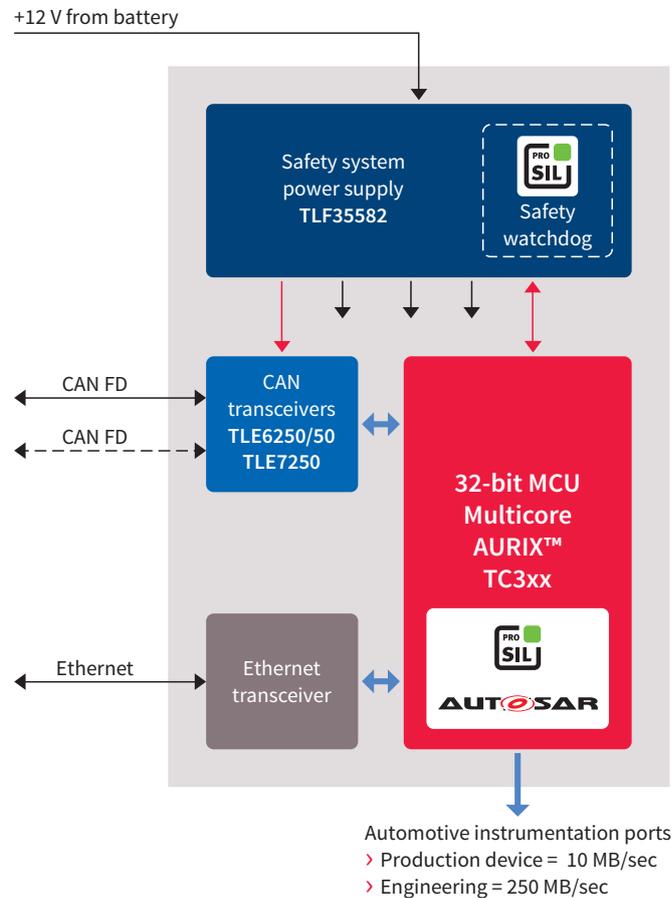
Powertrain solutions for (H)EV

While excelling in fuel economy, being fun to drive and reducing CO_2 emissions, Hybrid Electric Vehicles (HEV) and Electric Vehicles (EV) have the drawbacks of a higher cost, limited drive-range and safety concerns (e.g. risk of battery over-charging). Thanks to their high performance, functional integration and application-based software support, TriCore™ products are the ideal solution for (H)EV motor drives. TriCore™ offers a CPU load of less than 3% at 300 MHz frequency for the complete Field-Oriented Control (FOC) algorithm. The TriCore™ AURIX™ family offers multicore architecture, allowing inverter control, hybrid torque management and DC-DC conversion to be done within one single microcontroller. Nevertheless, the TriCore™ AURIX™ family has built-in resolver functionality, saving customers the cost of implementing an external resolver IC.

Often seen as the master micro in battery balancing topology, the TriCore™ AURIX™ family proposes a 32-bit stand-by domain combined with an integrated 8-bit stand-by controller, essential for battery balancing under low-power mode (e.g. vacation parking). As cross-border charging becomes popular, AURIX™ has increased its SRAM to Flash ratio to enable various charging protocols. Infineon is the market leader in providing Hardware Security Module (HSM), a feature that prevents the main CPU from illegal manipulation, making the billing for battery charging more trustworthy.

www.infineon.com/powertrain

Driving Domain Controller (DDC)

Application example

+12 V from battery

Safety system power supply **TLF35582**	PRO SIL Safety watchdog

CAN FD

CAN FD

CAN transceivers **TLE6250/50 TLE7250**

32-bit MCU Multicore AURIX™ TC3xx

PRO SIL

AUTOSAR

Ethernet

Ethernet transceiver

Automotive instrumentation ports
› Production device = 10 MB/sec
› Engineering = 250 MB/sec

The DDC acts as the orchestrator of the powertrain, chassis and safety ECUs, having the primary task of supervising, synchronizing and monitoring these domains. The specific tasks carried out by the DDC include the human-machine interface, torque coordination, driving strategy control, cruise control, charging coordination, thermal management, environment models, predictive functions, safety and fail-operational, as well as firewall and security. The DDC optimizes the energy management of the motion domain in order to increase the driving distance, performance and efficiency of the vehicle.

Application features
› TriCore™ DSP functionality
› Best-in-class performance: up to 6 TriCore™ with up to 300 MHz per core, up to 2400 DMIP ASIL-D capable per microcontroller
› Up to 16-MB eFlash to support A/B swap SOTA
› HSSL connectivity for direct coupling with SoC
› Ethernet up to 1 Gbit/s for fast connection to network and SoC
› External memory interface (eMMC) for data logging
› ISO 26262 compliance to support safety requirements up to ASIL-D
› Availability of AUTOSAR 4.x

System benefits
› Family concept with PIN and software compatibility, for maximum re-use and fast go-to-market
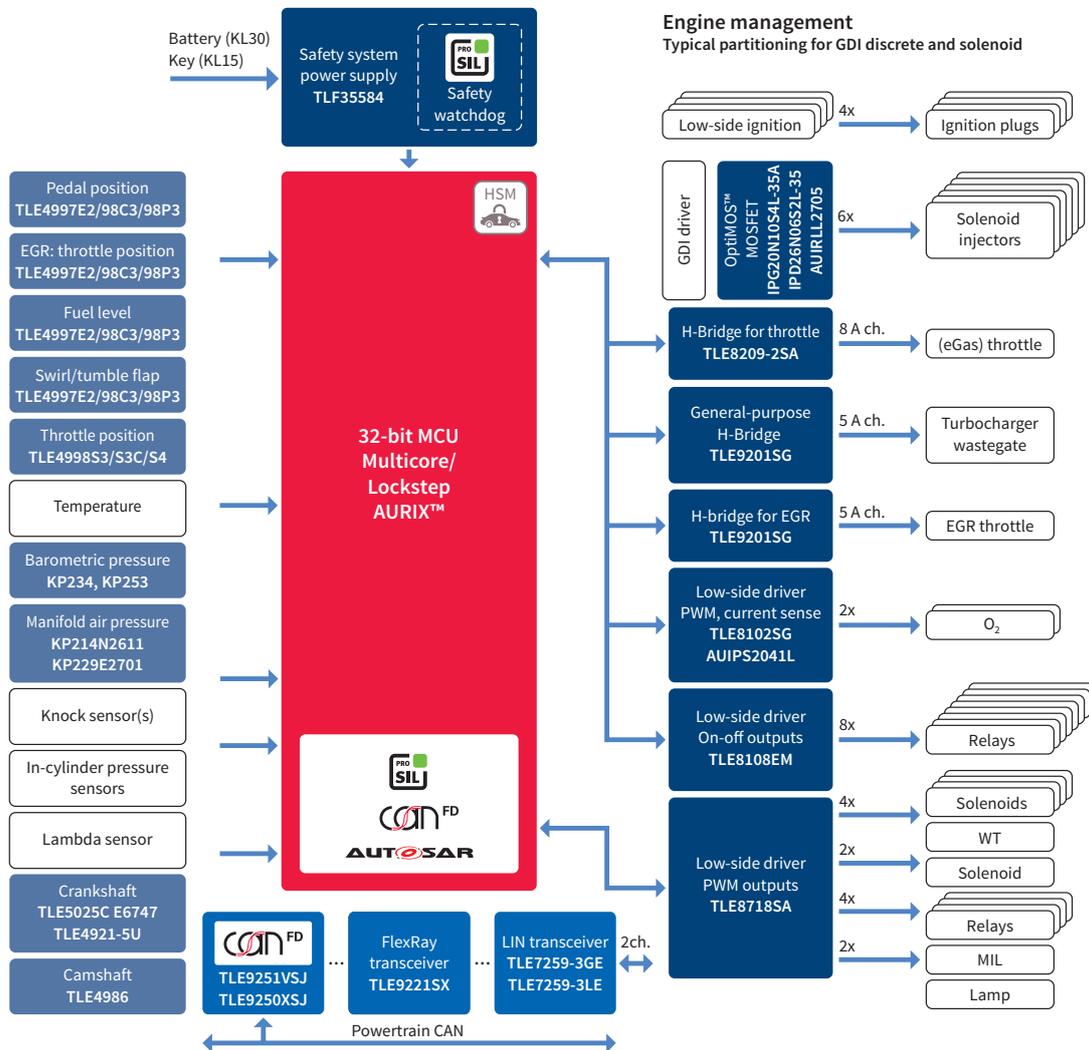› Rich legacy peripherals (CAN FD, LIN, …) for integrated gateway application

Suggested products
› TC29x
› TC37xTX
› TC38xQP
› TC39xXx

PRO SIL

www.infineon.com/driving-domain-controller

Gasoline direct injection

Application example

Safety system power supply
TLF35584 — PRO SIL — Safety watchdog

Battery (KL30)
Key (KL15)

Engine management
Typical partitioning for GDI discrete and solenoid

Low-side ignition — 4x → Ignition plugs

GDI driver

OptiMOS™ MOSFET
IPG20N10S4L-35A
IPD26N06S2L-35
AUIRLL2705 — 6x → Solenoid injectors

32-bit MCU Multicore/ Lockstep AURIX™ — HSM

PRO SIL
CAN FD
AUTOSAR

Pedal position
TLE4997E2/98C3/98P3

EGR: throttle position
TLE4997E2/98C3/98P3

Fuel level
TLE4997E2/98C3/98P3

Swirl/tumble flap
TLE4997E2/98C3/98P3

Throttle position
TLE4998S3/S3C/S4

Temperature

Barometric pressure
KP234, KP253

Manifold air pressure
KP214N2611
KP229E2701

Knock sensor(s)

In-cylinder pressure sensors

Lambda sensor

Crankshaft
TLE5025C E6747
TLE4921-5U

Camshaft
TLE4986

CAN FD
TLE9251VSJ
TLE9250XSJ

FlexRay transceiver
TLE9221SX

LIN transceiver
TLE7259-3GE
TLE7259-3LE — 2ch.

Powertrain CAN

H-Bridge for throttle
TLE8209-2SA — 8 A ch. → (eGas) throttle

General-purpose H-Bridge
TLE9201SG — 5 A ch. → Turbocharger wastegate

H-bridge for EGR
TLE9201SG — 5 A ch. → EGR throttle

Low-side driver PWM, current sense
TLE8102SG
AUIPS2041L — 2x → O$_2$

Low-side driver On-off outputs
TLE8108EM — 8x → Relays

Low-side driver PWM outputs
TLE8718SA — 4x → Solenoids
— 2x → WT / Solenoid
— 4x → Relays
— 2x → MIL / Lamp

Thanks to its state-of-the-art safety features, the TriCore™ AURIX™ family enables systems to achieve the highest safety level up to ASIL-D. The scalable AURIX™ family includes the GTM, the de-facto industry standard timing module that supports highly complex engine management, while meeting the market's most stringent emissions regulations.

Application features
› Direct injection
› Scalable software-based knock detection
› Variable valve control
› Throttle and EGR control
› Turbocharging
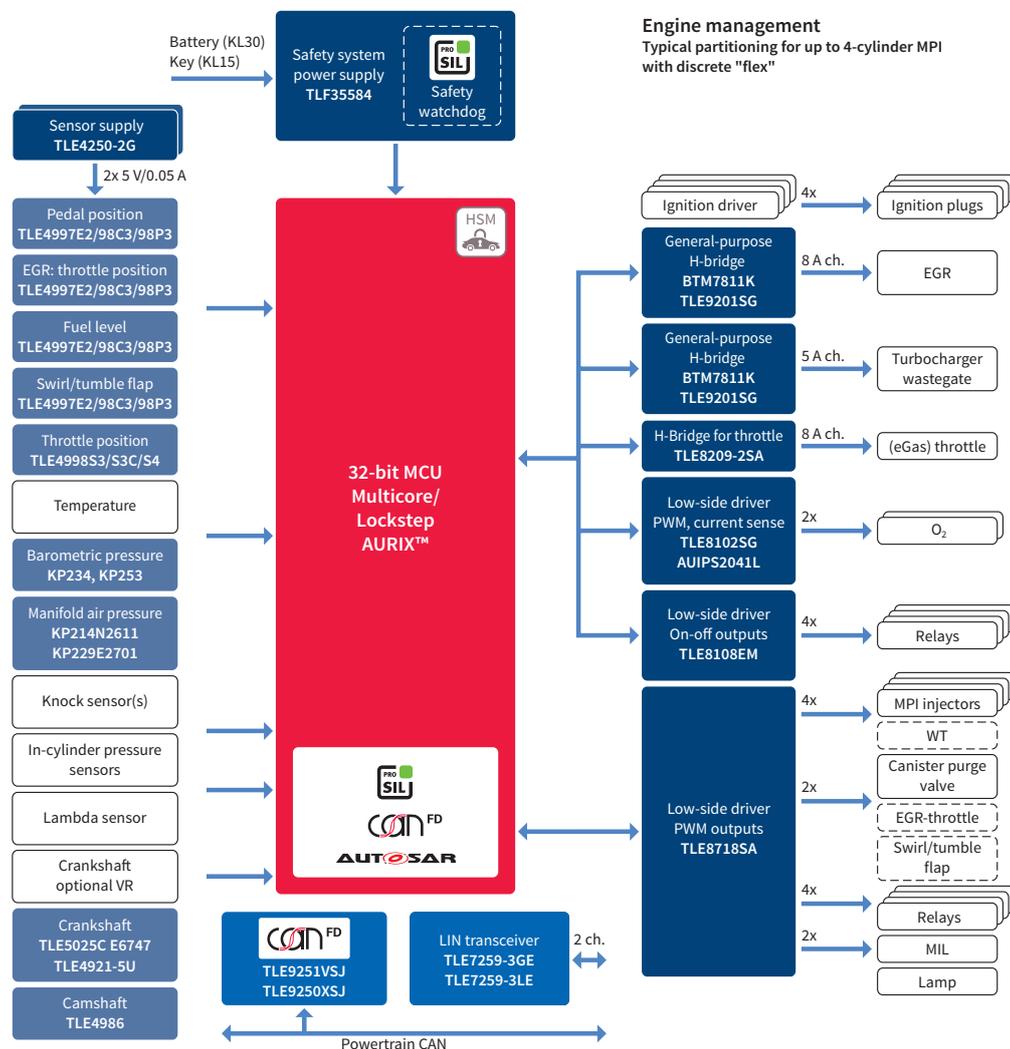› Catalyst after-treatment
› Start/stop system

Suggested products
› TC26x
› TC27x

System benefits
› Microcontroller with best-in-class real-time performance
› Scalable platform – performance, memory size and I/Os
› Committed to reduce CO$_2$ by 20%
› Anti-theft protection and tuning protection
› Increased knock detection accuracy via DS-ADC
› Enhanced communication (Ethernet)
› Dedicated peripherals for powertrain
› Supports safety levels up to ASIL-D

PRO SIL

www.infineon.com/gasolineengine

Gasoline multi-port injection – discrete solution

Application example

Battery (KL30)
Key (KL15)

Safety system
power supply
TLF35584

PRO SIL

Safety
watchdog

HSM

Sensor supply
TLE4250-2G

2x 5 V/0.05 A

Pedal position
TLE4997E2/98C3/98P3

EGR: throttle position
TLE4997E2/98C3/98P3

Fuel level
TLE4997E2/98C3/98P3

Swirl/tumble flap
TLE4997E2/98C3/98P3

Throttle position
TLE4998S3/S3C/S4

Temperature

Barometric pressure
KP234, KP253

Manifold air pressure
**KP214N2611
KP229E2701**

Knock sensor(s)

In-cylinder pressure
sensors

Lambda sensor

Crankshaft
optional VR

Crankshaft
**TLE5025C E6747
TLE4921-5U**

Camshaft
TLE4986

**32-bit MCU
Multicore/
Lockstep
AURIX™**

PRO SIL

CAN FD

AUTOSAR

CAN FD
**TLE9251VSJ
TLE9250XSJ**

LIN transceiver
**TLE7259-3GE
TLE7259-3LE**

2 ch.

Powertrain CAN

Engine management
**Typical partitioning for up to 4-cylinder MPI
with discrete "flex"**

Ignition driver | 4x | Ignition plugs

General-purpose
H-bridge
**BTM7811K
TLE9201SG** | 8 A ch. | EGR

General-purpose
H-bridge
**BTM7811K
TLE9201SG** | 5 A ch. | Turbocharger
wastegate

H-Bridge for throttle
TLE8209-2SA | 8 A ch. | (eGas) throttle

Low-side driver
PWM, current sense
**TLE8102SG
AUIPS2041L** | 2x | O_2

Low-side driver
On-off outputs
TLE8108EM | 4x | Relays

Low-side driver
PWM outputs
TLE8718SA
- 4x → MPI injectors
- WT
- 2x → Canister purge valve
- EGR-throttle
- Swirl/tumble flap
- 4x → Relays
- 2x → MIL
- Lamp

Thanks to its state-of-the-art safety features, the TriCore™ AURIX™ family enables systems to achieve the highest safety level up to ASIL-D. The scalable AURIX™ family includes the GTM, the de-facto industry standard timing module that supports highly complex engine management, while meeting the market's most stringent emissions regulations.

Application features

› Gasoline port injection
› Scalable software-based knock detection
› Throttle and EGR control
› Catalyst after-treatment
› Start/stop systems
› Cost-optimized for entry segment

Suggested products

› TC264
› TC265

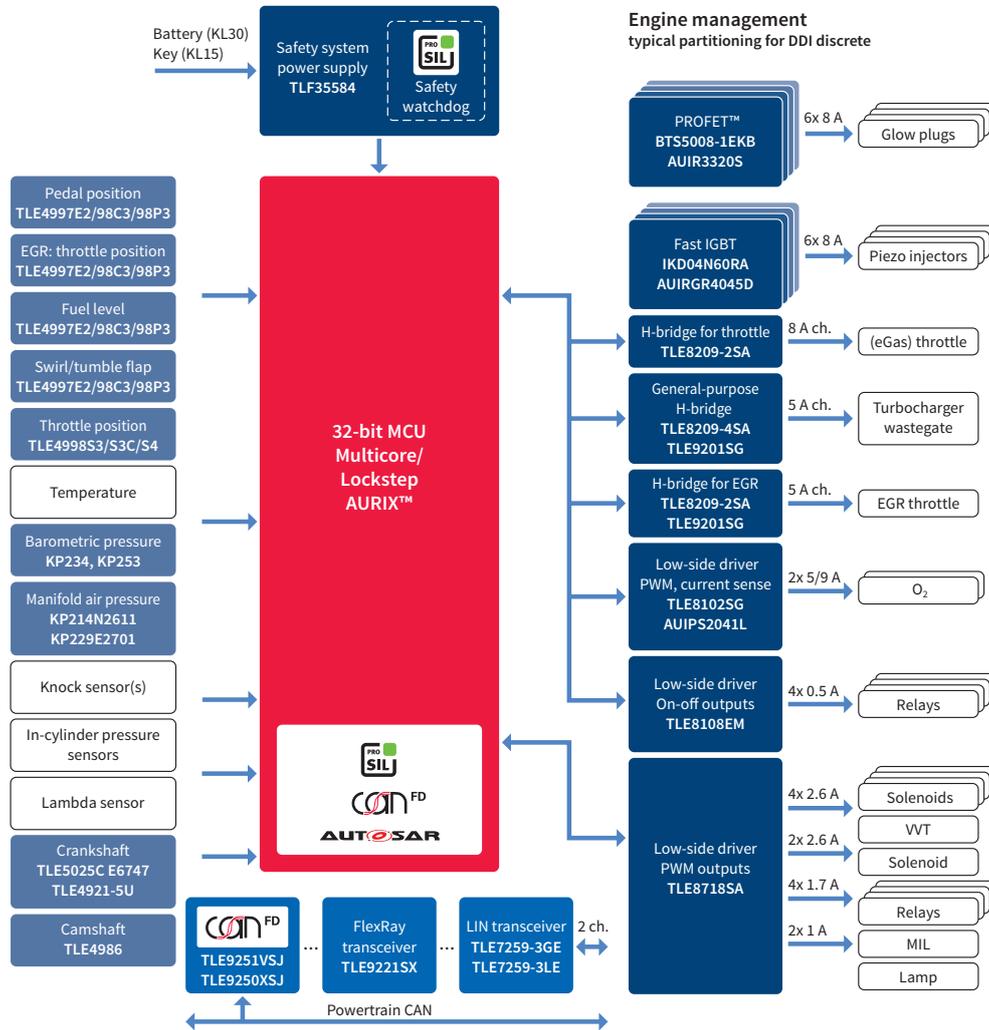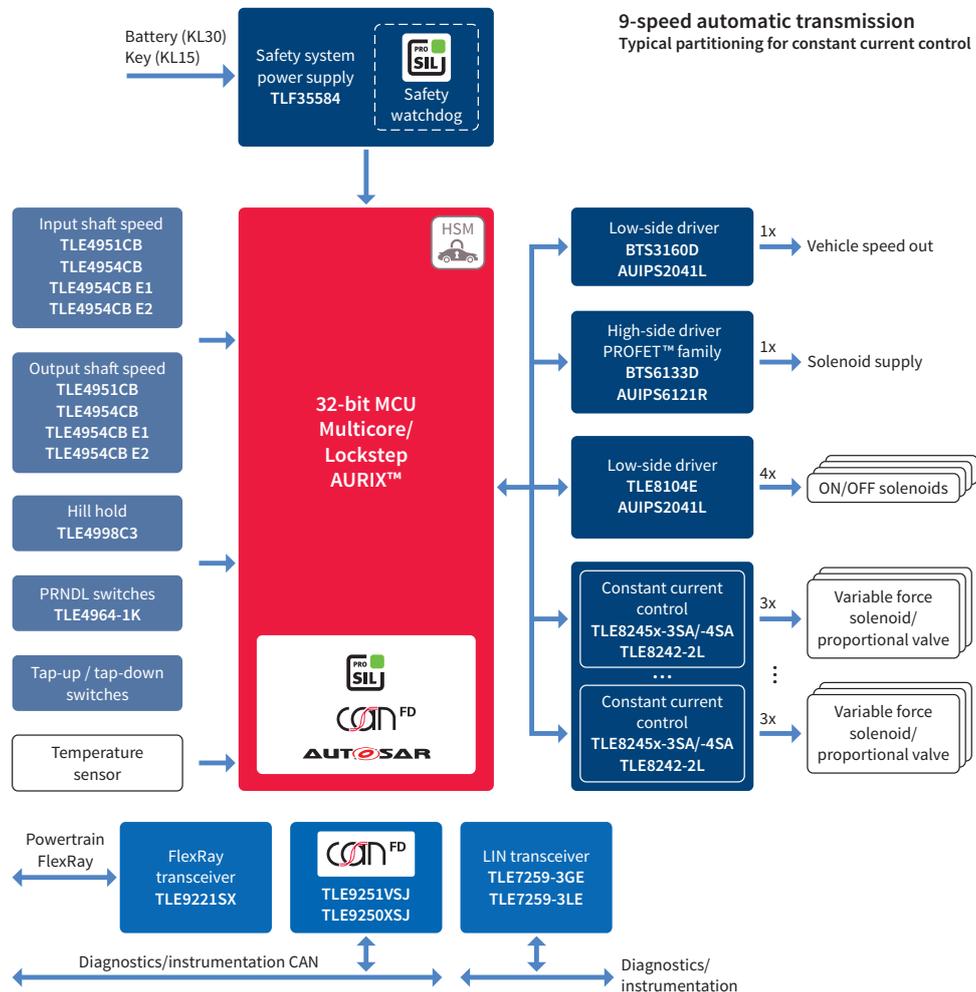## System benefits

› Scalable platform – performance, memory size and I/Os
› Single voltage supply (EVR)
› Focus on reducing CO_2
› Easy migration from ultra low-end to mid-range applications
› Best tool/partner support for all development phases within the V-cycle
› Supports safety levels up to ASIL-D

PRO SIL

www.infineon.com/multiportinjection-discrete

Diesel direct injection

Application example

Battery (KL30)
Key (KL15)

Safety system
power supply
TLF35584

Safety
watchdog

Engine management
typical partitioning for DDI discrete

PROFET™
BTS5008-1EKB
AUIR3320S — 6x 8 A — Glow plugs

Fast IGBT
IKD04N60RA
AUIRGR4045D — 6x 8 A — Piezo injectors

Pedal position
TLE4997E2/98C3/98P3

EGR: throttle position
TLE4997E2/98C3/98P3

Fuel level
TLE4997E2/98C3/98P3

Swirl/tumble flap
TLE4997E2/98C3/98P3

Throttle position
TLE4998S3/S3C/S4

Temperature

Barometric pressure
KP234, KP253

Manifold air pressure
KP214N2611
KP229E2701

Knock sensor(s)

In-cylinder pressure
sensors

Lambda sensor

Crankshaft
TLE5025C E6747
TLE4921-5U

Camshaft
TLE4986

**32-bit MCU
Multicore/
Lockstep
AURIX™**

CAN FD
AUTOSAR

H-bridge for throttle
TLE8209-2SA — 8 A ch. — (eGas) throttle

General-purpose
H-bridge
TLE8209-4SA
TLE9201SG — 5 A ch. — Turbocharger wastegate

H-bridge for EGR
TLE8209-2SA
TLE9201SG — 5 A ch. — EGR throttle

Low-side driver
PWM, current sense
TLE8102SG
AUIPS2041L — 2x 5/9 A — O$_2$

Low-side driver
On-off outputs
TLE8108EM — 4x 0.5 A — Relays

Low-side driver
PWM outputs
TLE8718SA — 4x 2.6 A — Solenoids
2x 2.6 A — VVT
Solenoid
4x 1.7 A — Relays
2x 1 A — MIL
Lamp

CAN FD
TLE9251VSJ
TLE9250XSJ

… FlexRay
transceiver
TLE9221SX

… LIN transceiver
TLE7259-3GE
TLE7259-3LE — 2 ch.

Powertrain CAN

Thanks to its state-of-the-art safety features, the TriCore™ AURIX™ family enables systems to achieve the highest safety level up to ASIL-D. The scalable AURIX™ family includes the GTM, the de-facto industry standard timing module that supports highly complex engine management, while meeting the market's most stringent emissions regulations.

Application features
> Direct injection (piezo/magnetic)
> In-cylinder pressure measurement
> Hardware-supported security enhancements
> Throttle and EGR control
> Turbocharging
> Diesel particulate filter
> 'Blue' after-treatment support (e.g. urea-based SCR)

Suggested products
> TC27x
> TC29x

System benefits
> Microcontroller with best-in-class real-time performance
> Scalable platform – performance, memory size and I/Os
> Committed to reducing NOx and particulate matter in line with the Euro 6 standard
> Hardware-supported IP/anti-theft protection and tuning protection
> Increased accuracy with in-cylinder pressure sensing via DS-ADC
> Enhanced communication (Ethernet)
> Dedicated peripherals for powertrain
> Supports safety levels up to ASIL-D

PRO SIL

www.infineon.com/dieselengine

Automatic transmission – hydraulic control

Application example

9-speed automatic transmission
Typical partitioning for constant current control

Thanks to its state-of-the-art safety features, the TriCore™ AURIX™ family enables systems to achieve the highest safety level up to ASIL-D. The rich scalability of the AURIX™ family permits a platform approach that meets the needs of a range of transmission systems. Furthermore, the hot temperature package and bare die solutions enable AURIX™ to be used in both attached and integrated control units.

Application features
› Smooth gear shifting
› Closely coupled with engine control via high-speed CAN/CAN FD/FlexRay link
› Supports four 3-phase DC-brushless E-drives
› TC270: high microcontroller junction bare die temperature
› TC275/TC277: extended ambient temperature range to meet stringent environment requirements

Suggested products
› TC270
› TC27x
› TC29x

System benefits
› Improved and fast clutch control
› Supports safety levels up to ASIL-D
› Security module HSM to prevent tampering
› Hot bare die supports a modular temperature-optimized TCU design
› Hot bare die capabilities enable microcontrollers to be placed wherever they are needed in the system
› Scalable product offering ensures a perfect fit for individual application needs

www.infineon.com/hydrauliccontrol-at

Double-clutch transmission – hydraulic control

Application example

7-speed double-clutch transmission

Thanks to its state-of-the-art safety features, the new TriCore™ AURIX™ family enables systems to achieve the highest safety level up to ASIL-D. The rich scalability of the AURIX™ family permits a platform approach that meets the needs of a range of transmission systems. Furthermore, the hot temperature package and bare die solutions enable AURIX™ to be used in both attached and integrated control units.

Application features
› Ultra-fast gear switching
› Closely coupled with engine control via
   high-speed CAN/CAN FD/FlexRay link
› Supports four 3-phase DC-brushless E-drives (dry-DCT)
› High microcontroller junction bare die temperature

Suggested products
› TC270
› TC275

System benefits
› Improved fast clutch control
› Supports safety levels up to ASIL-D
› Feature set optimized for wet and dry DCT designs
› Continuous torque on wheels ensures a dynamic driving
   experience
› Hot bare die capabilities enable microcontrollers to be
   placed directly where they are needed in the system
› Hot bare die supports modular temperature-
   optimized TCU designs

www.infineon.com/hydrauliccontrol-dct

Double-clutch transmission – electrical control

Application example

7-speed double-clutch transmission
Typical partitioning for constant current control

Thanks to its state-of-the-art safety features, the new TriCore™ AURIX™ family enables systems to achieve the highest safety level up to ASIL-D. The rich scalability of the AURIX™ family permits a platform approach that meets the needs of a range of transmission systems. Furthermore, the hot temperature package and bare die solutions enable AURIX™ to be used in both attached and integrated control units.

Application features
› Ultra-fast gear switching
› Closely coupled with engine control via high-speed CAN/CAN FD/FlexRay link
› Supports four 3-phase DC-brushless E-drives (dry-DCT)
› High microcontroller junction bare die temperature

Suggested products
› TC270
› TC275

System benefits
› Improved fast clutch control
› Supports safety levels up to ASIL-D
› Feature set optimized for wet and dry DCT designs
› Continuous torque on wheels ensures a dynamic driving experience
› Hot bare die capabilities enable microcontrollers to be placed directly where they are needed in the system
› Hot bare die supports a modular temperature-optimized TCU design
› Infineon e-motor driver

www.infineon.com/electriccontrol-dct

Transfer case

Application example
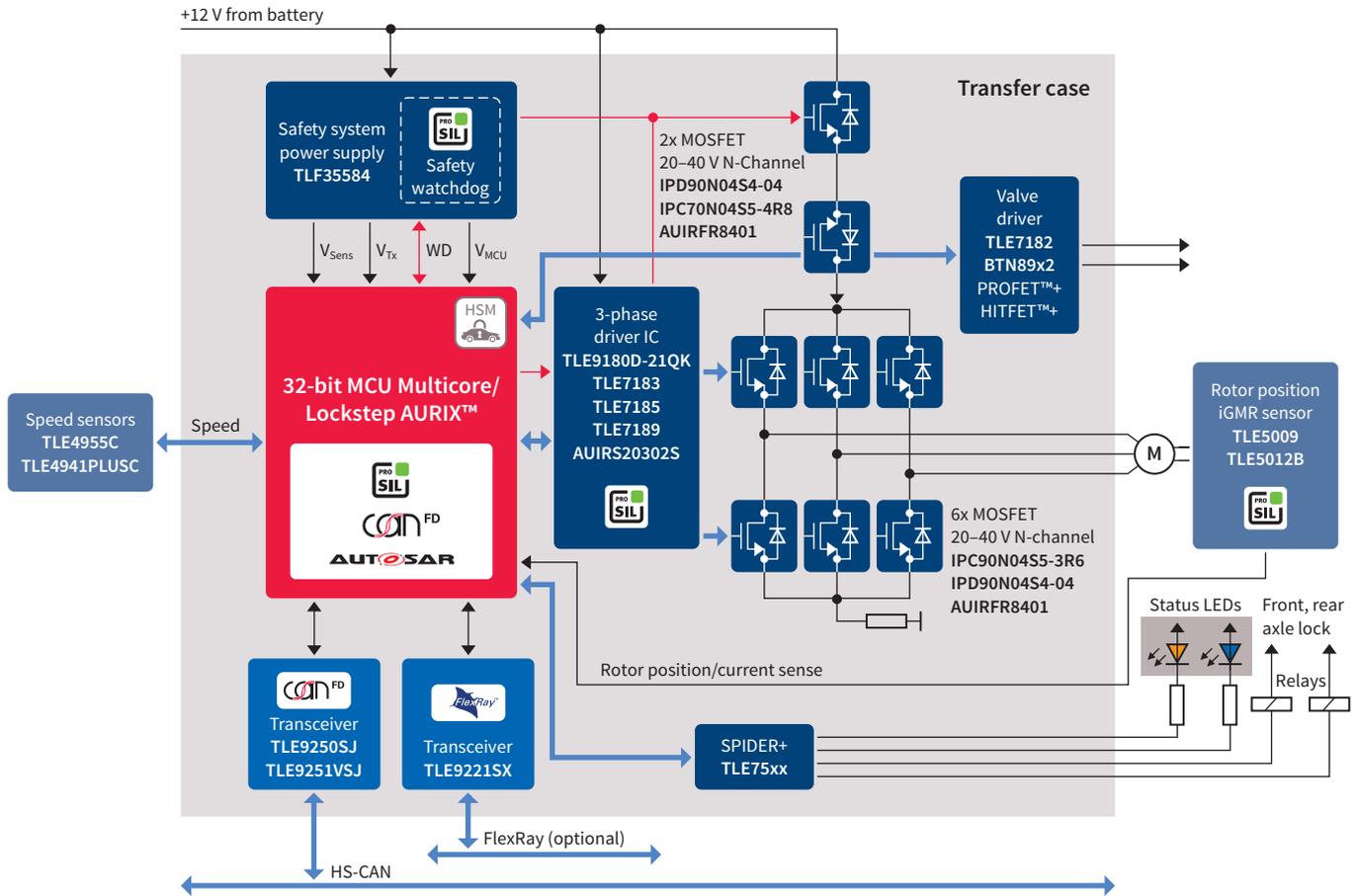
In Four-Wheel Drive (4WD) and All-Wheel Drive (AWD) vehicles, the transfer case is the part of the drivetrain responsible for the transfer of torque from the transmission to the front and rear wheels. The market now demands increased performance to drive BLDC motors and ever-greater functional safety requirements. AURIX™ has the state-of-the-art safety features required to enable systems to achieve ASIL-D, the highest safety level.

Application features
› Advanced timer unit for totally flexible PWM generation and hardware input capture
› Redundant flexible 12-bit ADC
› Safety requirements up to ASIL-D
› Safety software: Infineon SafeTcore library
› Extended ambient temperature range to meet stringent environment requirements
› Availability of AUTOSAR 4.x
› Presence of HSM to meet future security requirements

Suggested products
› TC23x

System benefits
› More accurate torque distribution, enabling new features such as higher comfort and flexible settings
› Fuel economy improvements due to advanced slip control
› Scalability over flash, RAM and peripherals, offering the best cost-performance ratio
› High temperature means that it can be located in the actuator compartment
› Supports the safety level ASIL-D
› HSM security module to prevent tampering

www.infineon.com/transfercase

AURIX™ for (H)EV applications

On-board charger
The battery block is charged via an AC-DC converter module. In the example shown here, an on-board unit charges the battery. Off-board and inductive charging solutions are also available.

HV-LV DC-DC converter
The DC-DC converter charges the conventional 12 V power supply net from the high-voltage battery and replaces the former belt driven alternator.

Battery management system
The battery management system controls battery state during charging and discharging. Intelligent functionality is needed to extend the battery lifetime, which has a considerable impact on the total cost of ownership. The State of Health (SoH), State of Charge (SoC) and Depth of Discharge (DoD) of the battery is permanently monitored.

HCU
Hybrid control unit or Vehicle control unit handle the inter-communication between sub-modules e.g. engine & hybrid motors inside a Hybrid EV. It can also serve as central gateway for Powertrain domain in the E/E architecture to ensure security communication between other domains.

Auxiliary inverter
Instead of being belt-driven, auxiliaries such as the water pump, HVAC compressor, PTC heater etc. also have to be driven by electric power. Smart and energy-efficient auxiliary loads mainly cover inverters/converters or high-side/low-side switches.

Main Inverter
The inverter not only drives the electric motor but is also used for regenerative braking and feeding energy back to the battery.

www.infineon.com/HEV

(H)EV main inverter

Application example
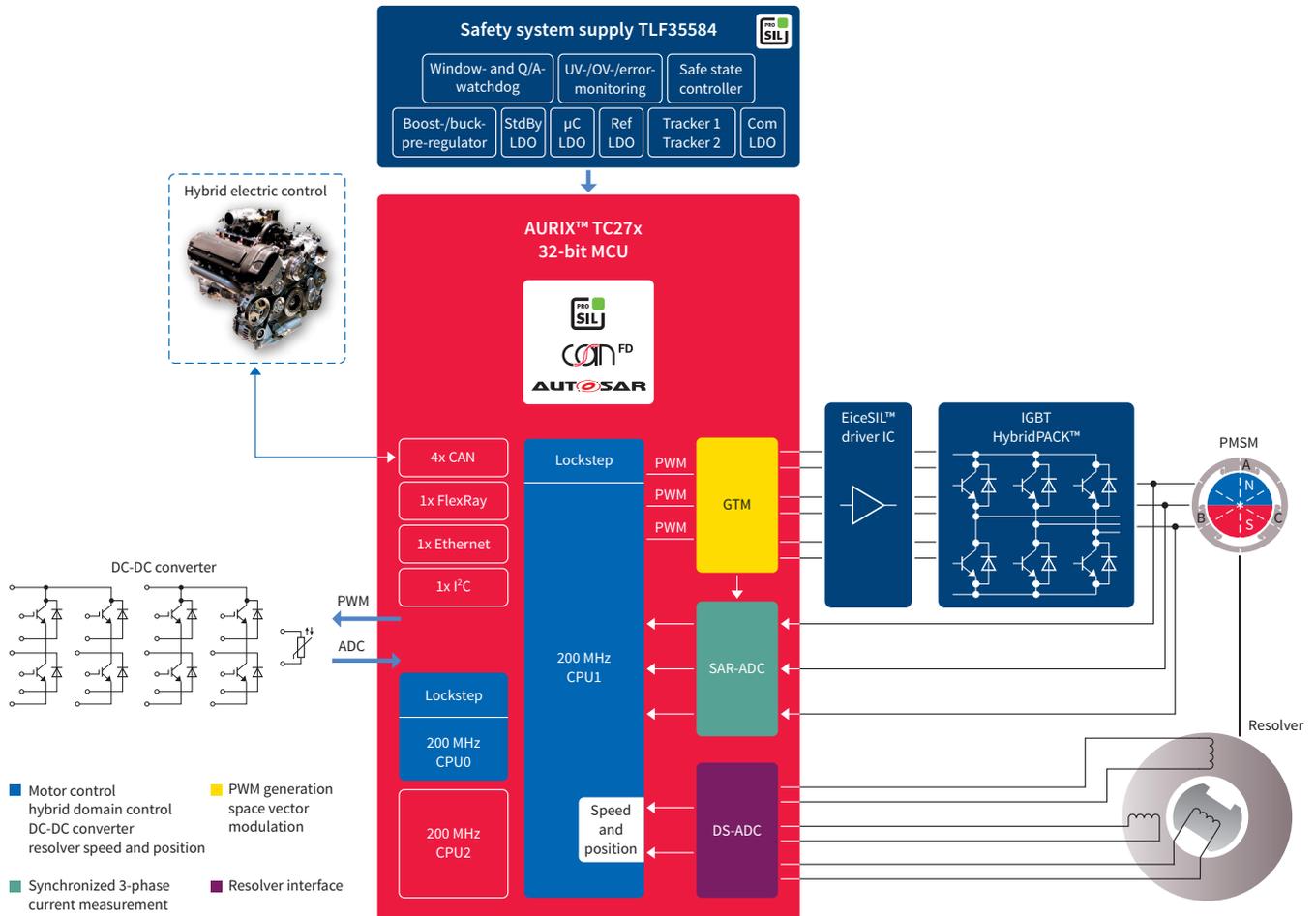
The inverter controls the electric motor via an electric drivetrain. It resembles the Engine Management System (EMS) in vehicles with an internal combustion engine. It is seen as a key component in determining (H)EV drive behavior. The inverter captures energy released via regenerative braking and feeds it back to the battery. As a result, the range of the vehicle is directly related to the efficiency of the inverter. A safe, highly efficient inverter control system is crucial to the quality of driving.

Application features
> Multicore and lockstep architecture
> DS-ADC-enabled direct resolver-to-microcontroller
> Superior performance
> Customized PWM pattern generation

Suggested products
> TC27x
> TC29x
> TC37x
> TC38x

System benefits
> No resolver IC needed, lower system cost
> Enables sub-system integration
   (driving HCU + inverter + DC-DC)
> Fine motor tuning
> Supports safety levels up to ASIL-D

www.infineon.com/HEV-main-inverter

DC-DC converter (48V to 12V)

Application example
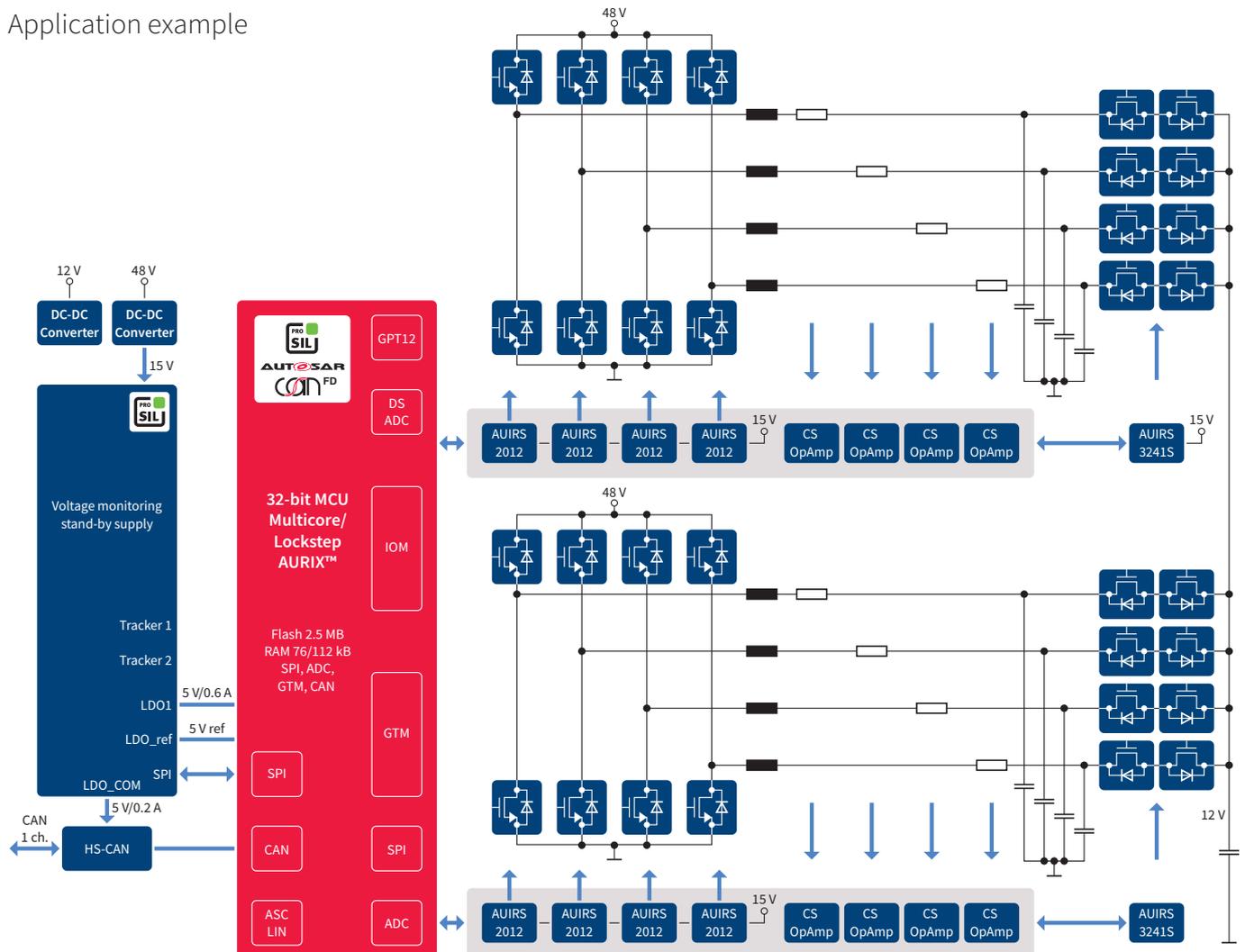
The DC-DC converter ECU is responsible for the conversion of voltage between the 48 V domain and the 12 V domain in mild hybrid cars. The 48 V domain powers stop-start motors, hybrid motors, and turbochargers, enabling engine down-sizing and better fuel economy and performance.

Application features
> Supports current control-specific features
> Fast compare ADCs with support for up to 5 Msps
> Supports flexible PWM generation via a scalable timer across the family
> Supports DC-DC converter for 48 V systems and for high-voltage systems
> CAN FD support
> Ethernet support

System benefits
> Scalability across the family supporting seamless migration in different DC-DC power and efficiency classes
> Enables sub-system integration (communication handling + DC-DC control) thanks to the AURIX™ multi-core performance
> Supports bi-directional DC-DC converter functionality
> Supports safety levels up to ASIL-D

Suggested products
> TC26x   > TC36x
> TC27x   > TC37x

www.infineon.com/DC-DC

DC-DC converter (high voltage to 12V)

Application example
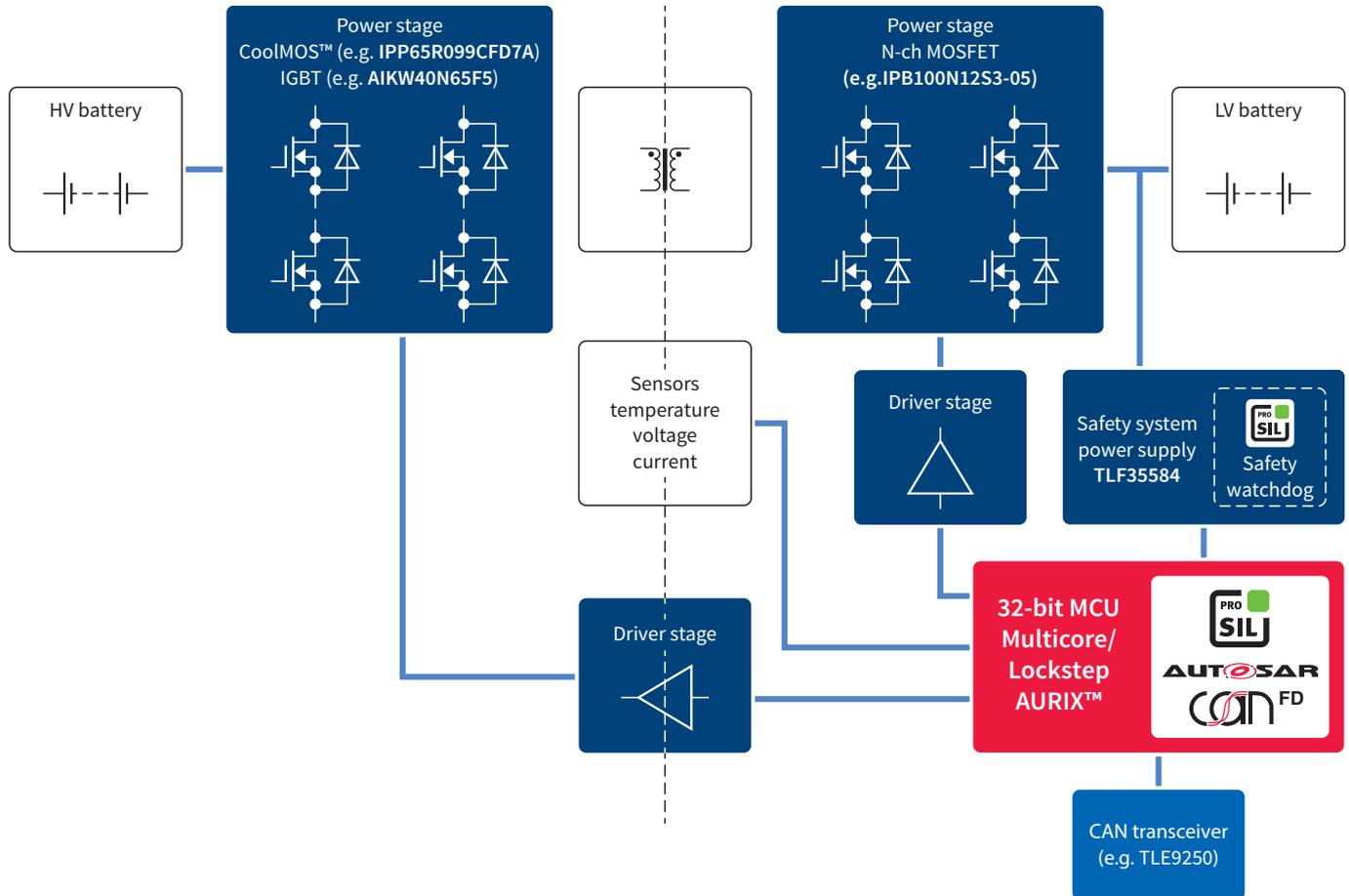
The DC-DC converter ECU is responsible for the conversion of voltage between the main battery of the car, that is, the high voltage battery to the 12 V domain in full hybrid, plug-in hybrid and electrical vehicles.

Application features

› High scalability (hardware and software), enabling platform migration and fast time-to-market
› Best analog and communication equipment with fast ADCs up to 5 Msps
› Supports flexible PWM generation

Suggested products

› TC26x
› TC27x
› TC36x
› TC37x

System benefits

› Enable sub-system integration (PFC + DCDC control) thanks to the AURIX™ multicore performance
› High reliability and reduced conduction/switching losses
› ISO 26262 compliant system implementation, supporting safety levels up to ASIL-D
› Fast communication with the latest ISO CAN FD standard

(H)EV battery management system

Application example
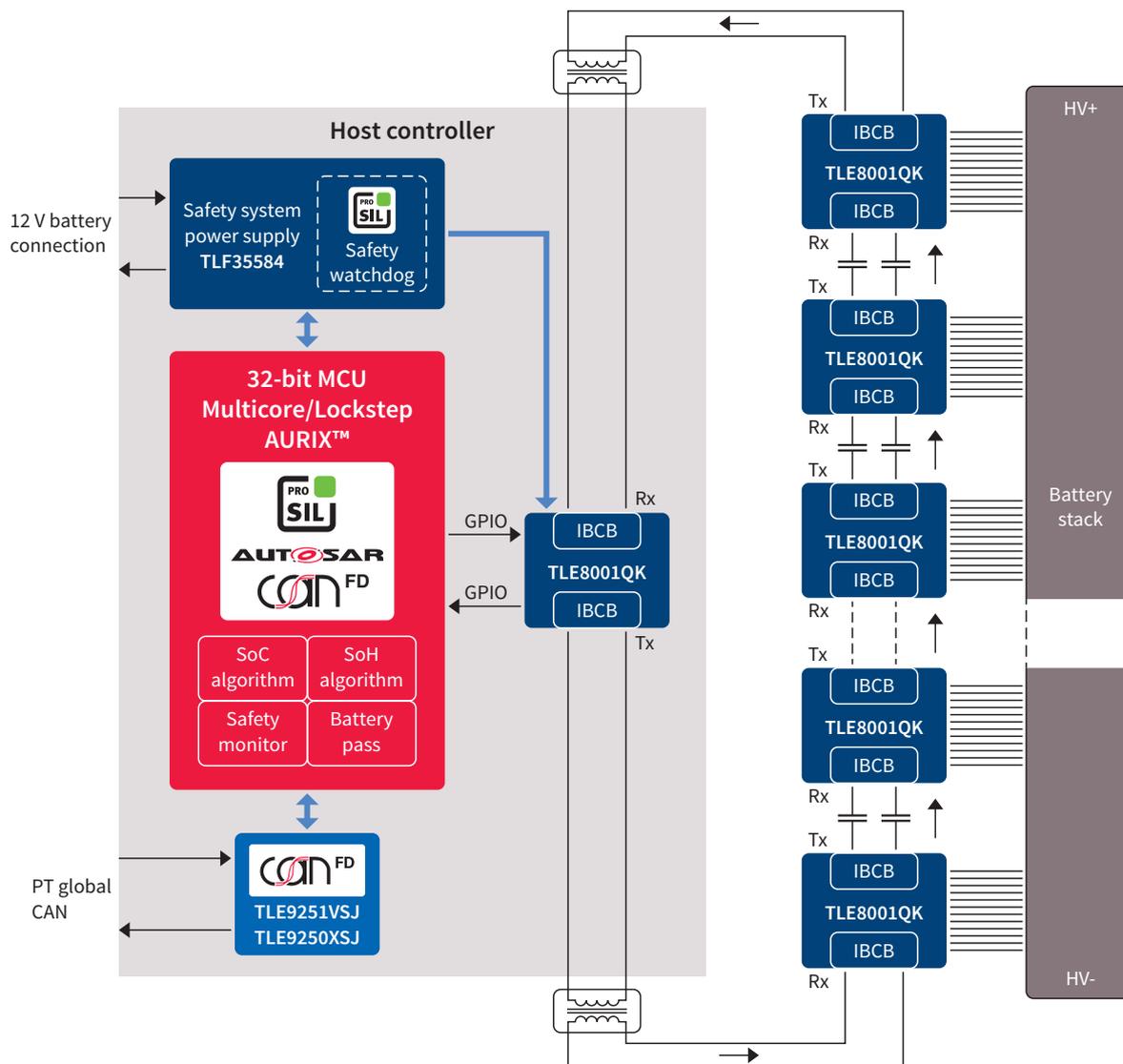
The battery management system controls the battery state during charging and discharging. Intelligent functionality is needed to extend the battery lifetime, which has a considerable impact on the total cost of ownership. The State of Health (SoH), State of Charge (SoC) and Depth of Discharge (DoD) of the battery is permanently monitored.

Application features
› Multicore and lockstep core architecture
› Fast communication interface
› Integrated low-power 8-bit stand-by controller
› Hardware Security Module (HSM)

Suggested products
› TC26x
› TC36x

System benefits
› Ring topology in the event of failure
› Balancing and monitoring over long parking periods
› Charge-billing verification
› Supports safety levels up to ASIL-D
› Extended transceiver supply

EV charging station

Application example
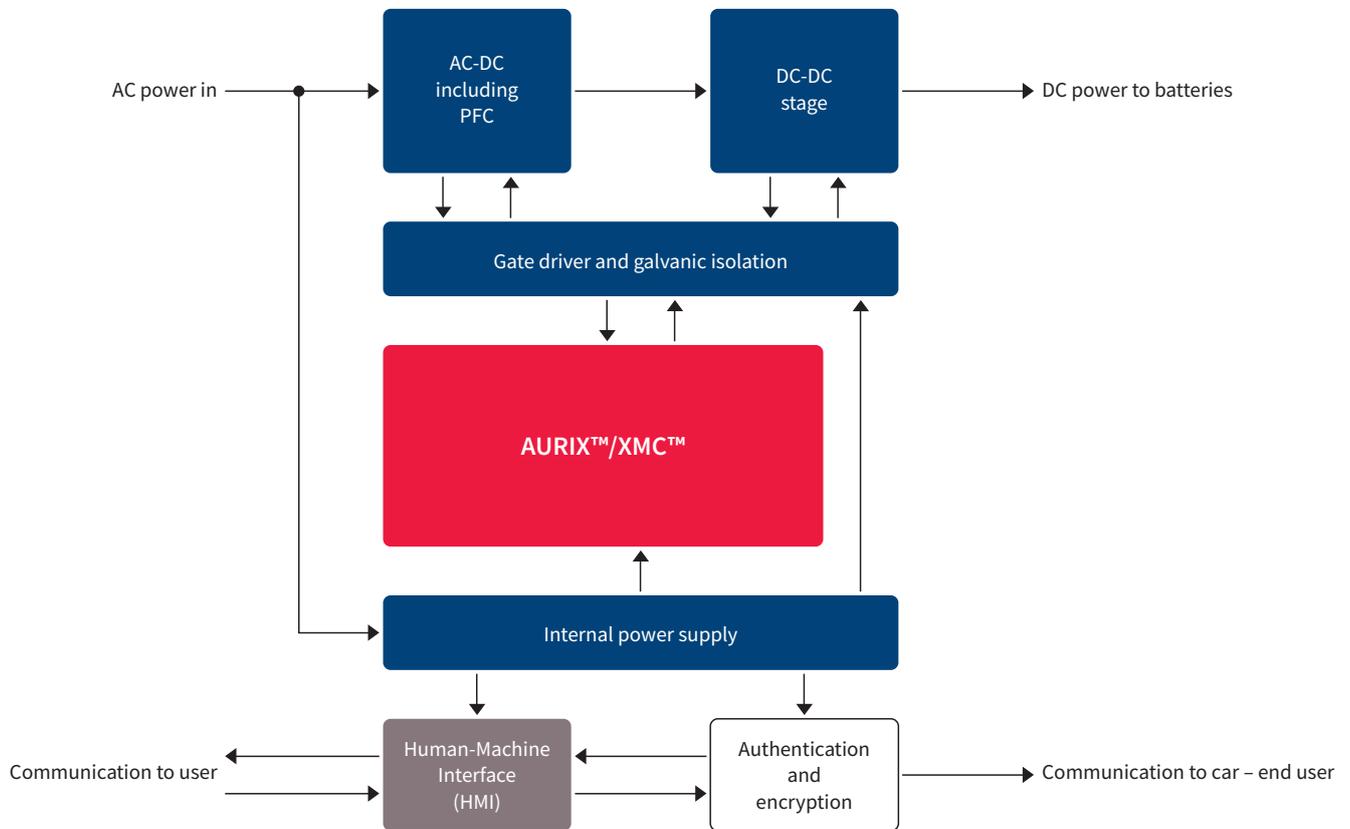
Off-board charging, where users can charge plug-in hybrids and pure EVs in private garages and open parking lots, demands an optimized solution with high MCU switching frequency to stay efficient and cost competitive. The Infineon XMC™ family is the answer! If you have security or safety requirements you can scale from XMC family to AURIX to support your solution

Application features
› Platform concept to allow extensive customization
› RAM: 8 kB up to 352 kB
› Flash: 16 kB up to 2 MB
› Accurate analog-mixed signal peripherals
› Fast timer/PMW peripherals
› Rich communication interfaces
› 16 – 196 pin-count packages
› Long-term availability

System benefits
› Scalable family with compatibility: software, pin-out
› Performance, efficiency and cost competitiveness
› Great scalability and software re-use across the whole family
› Rich ecosystem and tooling environment for a shorter time-to-market

Suggested products
› XMC4xxx – 32-bit ARM® Cortex®-M4 MCU

AURIX™ for safety applications

AURIX™ made for safety

The AURIX™ architecture is designed in accordance with an ISO 26262-compliant process to efficiently meet ASIL-D requirements.

The platform uses up to four cores in a diverse lockstep architecture combined with cutting-edge safety technology, such as safe internal communication buses or a distributed memory protection system. Innovative encapsulation techniques allow the integration of software with various safety levels (QM to ASIL-D) from different sources, thereby significantly reducing system complexity. Thanks to this optimized approach, multiple applications and operating systems (such as steering, braking, airbag and advanced driver assistance systems) are seamlessly hosted on a unified platform. This leads to productivity gains of up to 30%, resulting in a smaller development outlay and reduced time-to-market for our customers.

Furthermore, Infineon extends the microcontroller safety roadmap with devices dedicated to the Advanced Driver Assistance System (ADAS) segment, such as radar or camera applications. Innovation has been focused on system partitioning in order to further integrate system functionality and consequently reduce the complexity and area, providing our customers with highly optimized solutions. The new devices include high-speed interfaces, integrated hardware acceleration and enhanced ECU validation and instrumentation tools. All ADAS devices support ISO 26262 safety methodology, meaning that they can be involved in automatic decisions to assist drivers, such as emergency braking.

AURIX™ made for scalability

Thanks to its market-leading expertise, Infineon has translated customer demands for individual scalability into a universal product roadmap. Designed to optimize its customers' investment, the AURIX™ family comes with a comprehensive range of fully modular components, thereby ensuring long-term design flexibility.

The devices range from an ultra high-end, 300 MHz six-core device with 16 MB of embedded flash, down to 160 MHz and 1 MB flash.

The package portfolio includes a BGA-516 package with a ball-compatible BGA-292 package (I/O subset), and compatible QFP-176, QFP-144, QFP-100 to BGA-196 and QFP-80 packages.

Chassis domain control

Application example

+12 V from battery

Chassis domain control ECU

Safety system power supply **TLF35584** — Safety watchdog

V_{Sens} V_{Tx} V_{MCU} WD

32-bit MCU Multicore/ Lockstep AURIX™

HSM

CAN FD — AUTOSAR

Inertia sensors
- X
- Y
- Z
- ωx
- ωy
- ωz

2–4x
Position sensor
Linear hall **TLE4997 TLE4998**
Vehicle level

Position → Sensor interface

CAN transceiver **TLE9251SJ TLE9250VSJ**

FlexRay transceiver **TLE9222PX**

Chassis CAN-bus — FlexRay

Vehicle stability control ECU

Electronic power steering ECU

Steering toque → **TLE4997 TLE4998**
Torque sensor

Steering angle | 4x speed

2x iGMR sensor **TLE5012B**
Steering angle sensor

Wheel speed sensor **TLE4941 TLE4942 TLE5041**
Wheel speed sensor **4x**

Thanks to its state-of-the-art safety features, the new TriCore™ AURIX™ family enables systems to achieve the highest ASIL-D safety level, which is already required in contemporary domain control systems. The latest diverse lockstep technology with clock delay (diverse lockstep core) significantly reduces the software overhead and enables fast time-to-market. Thanks to a scalable multicore system and innovative encapsulation techniques, this supports the integration of software with mixed-criticality levels from different sources, thereby allowing multiple applications and operating systems to be seamlessly hosted on a unified platform.

Application features
› TriCore™ DSP functionality
› Best-in-class performance with up to six-core 300 MHz
› Supports the floating point and fix point with all cores
› Up to 6.9 MB of internal RAM
› Communication peripherals: CAN, LIN, FlexRay, Ethernet
› Innovative single supply of 5 V or 3.3 V
› External memory interface
› ISO 26262 conformance to support safety requirements up to ASIL-D
› Availability of AUTOSAR 4.x

System benefits
› Advanced communication with FlexRay and Ethernet
› Highest available performance with integrated FPU
› Flexible DMA unit
› Scalability over flash, RAM and peripherals
› Proven safety concept to support ISO 26262
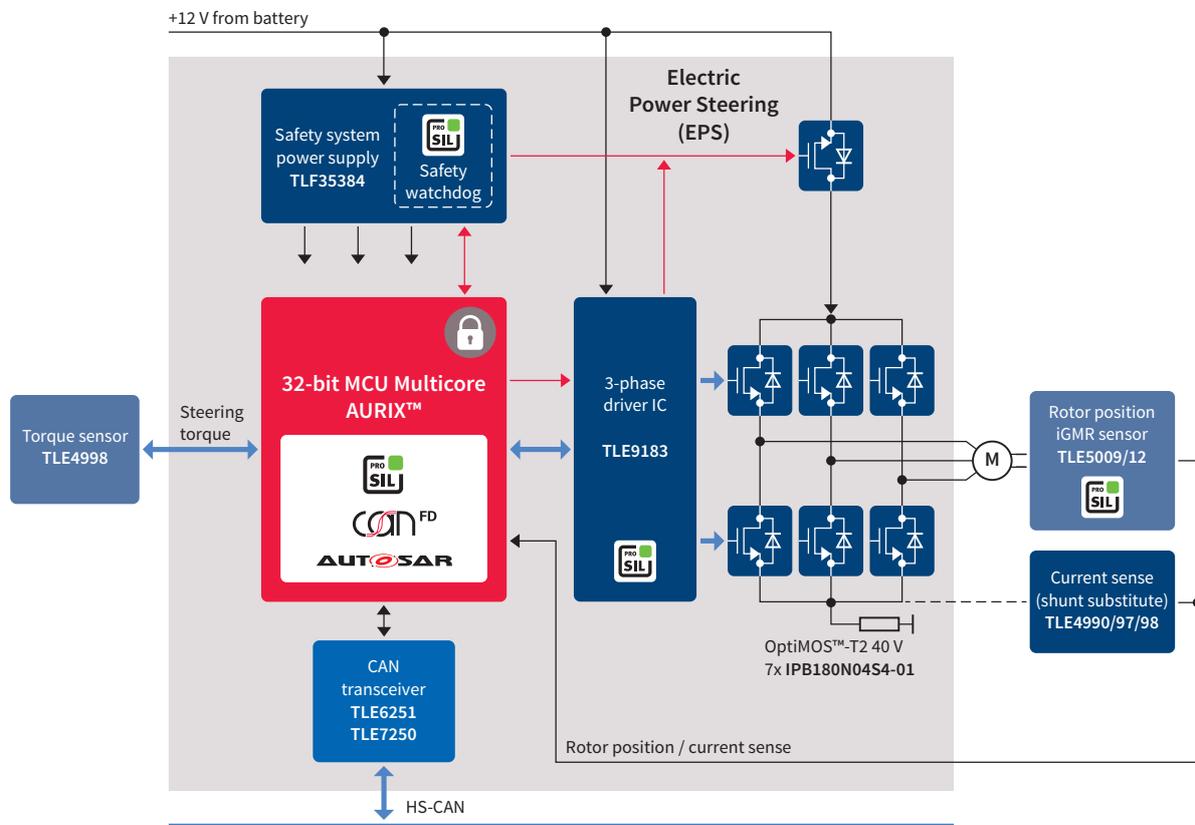› Innovative supply concept leads to best-in-class power consumption

Suggested products
› TC37x
› TC38x
› TC39x

www.infineon.com/chassis_domain_control

Scalable EPS solution

Application examples

Thanks to its state-of-the-art safety features, the new TriCore™ AURIX™ family enables systems to achieve the highest ASIL-D safety level, which is already required in contemporary steering systems.

The latest diverse lockstep technology with clock delay (diverse lockstep core) significantly reduces the software overhead and enables fast time-to-market.

Its rich scalability meets a variety of different electric power steering system demands.

Application features

› Flash 512 KB – 8 MB

› Scalable Flash from 1 – 16 MB

› Performance 160 MHz – 6x 300 MHz

› Advanced timer unit for totally flexible PWM generation and hardware input capture

› Redundant flexible 12-bit ADC

› Hardware SENT interface for a low CPU load

› Hardware built-in self-test

› ISO 26262 conformance to support safety requirements up to ASIL-D

› Availability of AUTOSAR 4.x

System benefits

› Scalability over flash, RAM and peripherals offering the best cost-performance ratio

› Serves all kinds of EPS systems, such as column or belt drive

› Proven safety concept to support ISO 26262

› Innovative supply concept leads to best-in-class power consumption

Suggested products

› TC22x

› TC23x

› TC32x

› TC33x

› TC36x

Scalable EPS solution

Application example
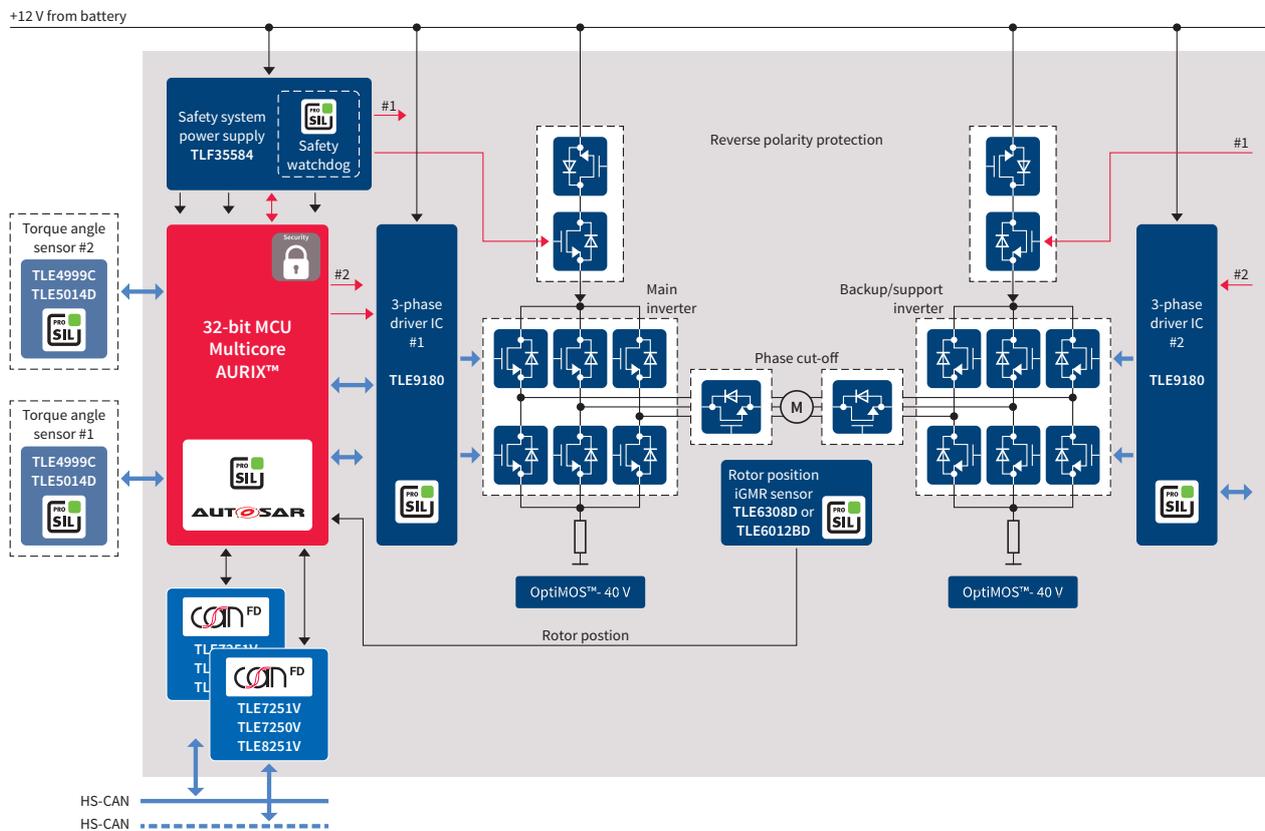
Infineon EPS system solution for high-availability autonomous drive systems L0–L3

› 1x MCU + 2x inverters for high-available EPS

System benefits
› Multicore MCU with dual power stage and dual torque sensor
  – Dual cores to separately control dual motors or
    6 phase motors
  – Separately resettable cores to keep 1 motor running
    while one CPU resets
  – Ability to recover most frequent errors identified,
    no software reset required
› Dual inverter PWM and multi ADCs
› Secured high-speed communication with domain
  controller: CAN FD, FlexRay, SPI and Ethernet

www.infineon.com/eps

Application examples

+12 V from battery

+ secondary power

Safety system power supply **TLF35584** — Safety watchdog

Reverse polarity protection

Safety system power supply **TLF35584** — Safety watchdog

32-bit Multicore Master MCU #1

AURIX™

AUT**O**SAR

3-phase driver IC #1

TLE9180

Main inverter

Backup/support inverter

3-phase driver IC #2

TLE9180

32-bit Multicore Slave MCU #2

AURIX™

AUT**O**SAR

Torque angle sensor #1

TLE4999C TLE5014D

Torque angle sensor #2

TLE4999C TLE5014D

Phase cut-off

M

Rotor position

Rotor position iGMR sensor **TLE6308D** or **TLE6012BD**

OptiMOS™- 40 V

OptiMOS™- 40 V

Rotor position

Rotor position

Rotor postion

TLE7251V TLE7250V TLE8251V

TLE7251V TLE7250V TLE8251V

Electrical isolation

MCU communication/monitoring

HS-CAN

HS-CAN

HS-CAN

Infineon EPS system solution for fail-operational autonomous drive systems L3-L5

› 2x MCUs are used, each MCU has 1x inverter for
  fail-operational or high-available EPS

System benefits

› Highly scalable ASIL-D performance architecture to
  support the master/slave concept
› Advanced timers for PWM generation and
  ADC synchronization
› Small package options: BGA-196 (12 x 12) or TQFP-80 (14x14)
  for full redundancy

www.infineon.com/eps

Brake Vehicle Stability Control (VSC)

Application example
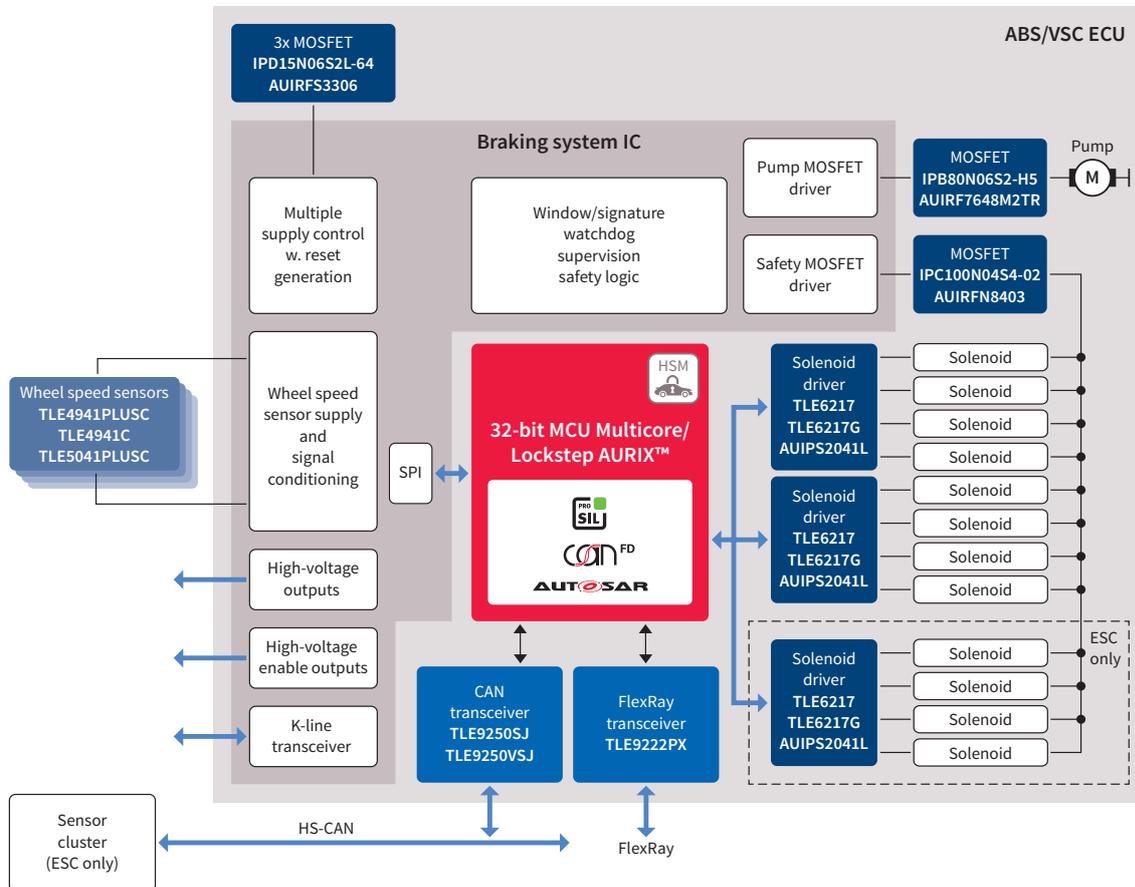
Thanks to its state-of-the-art safety features, the new TriCore™ AURIX™ family enables systems to achieve the highest ASIL-D safety level, which is already required in contemporary braking systems. The latest diverse lockstep technology with clock delay (diverse lockstep core) significantly reduces the software overhead and enables fast time-to-market. The scalability supports an optimized cost-performance fit for basic ABS systems up to highly integrated ESC systems.

Application features
> Scalable flash 1 – 16 MB
> Performance 160 MHz – 6x 300 MHz
> Dedicated peripheral set: LIN, CAN, SPI, FlexRay, Ethernet
> Advanced timer unit for totally flexible PWM generation and hardware input capture
> Redundant flexible 12-bit ADC
> Hardware SENT interface for a low CPU load
> Hardware built-in self-test overhead
> Safety software: Infineon SafeTcore library
> ISO 26262 conformance to support safety requirements up to ASIL-D
> Availability of AUTOSAR 4.x

System benefits
> Scalability over flash, RAM, performance and peripherals leads to an optimized cost-performance fit
> Proven safety concept to support ISO 26262 validated by 3rd party
> Innovative supply concept leads to best-in-class power consumption and saves external component costs

Suggested products
> TC36x
> TC37x
> TC38x
> TC39x

www.infineon.com/braking

Multi-purpose camera

Application example
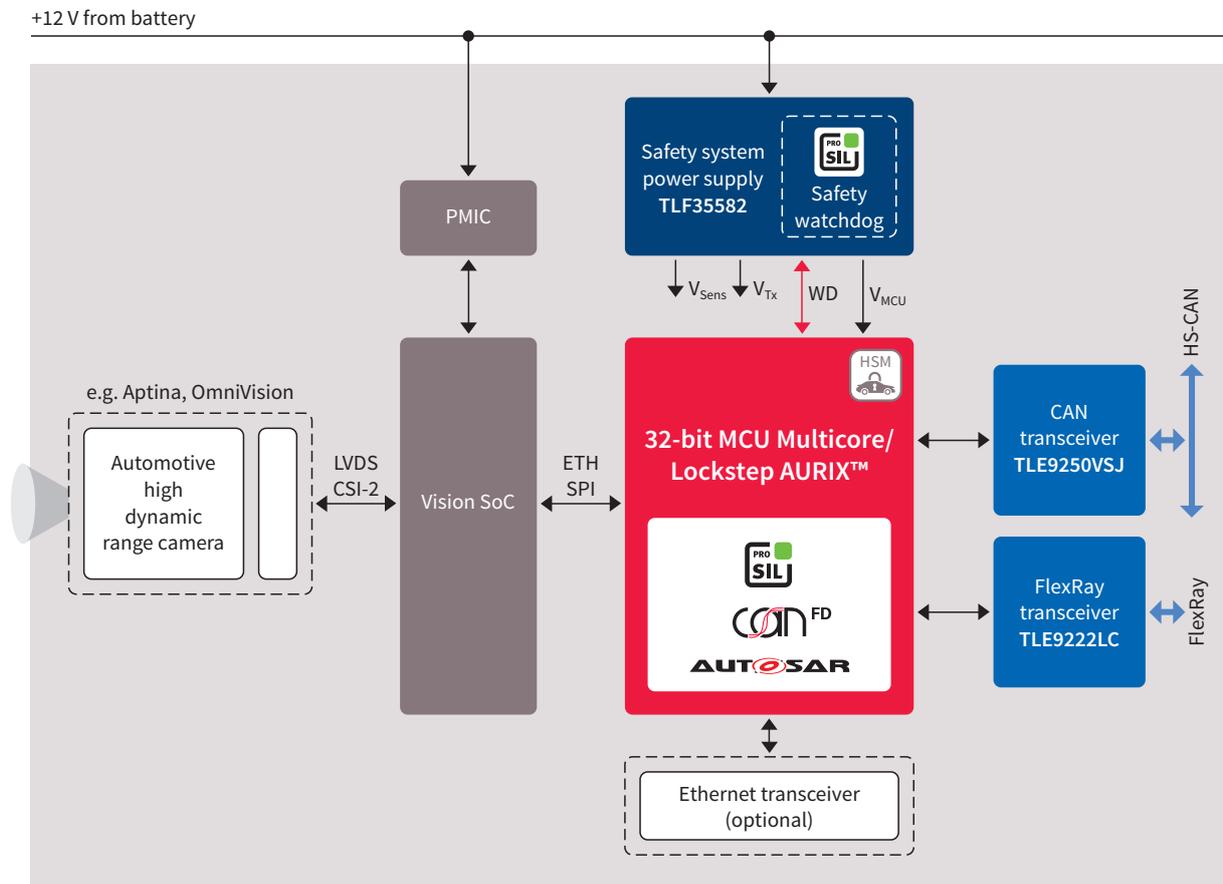
The AURIX™ family will enhance classic safety features with dedicated features to cater for multi-purpose camera systems. Thanks to its rich connectivity, scalable portfolio of performance, eRAM and eFlash, AURIX™ is the ideal companion for the high-performance vision SoC.

Application features
› TriCore™ DSP functionality
› Best-in-class performance: up to six TriCore™
  with 300 MHz per core
› Innovative single supply of 5 V or 3.3 V
› Rich peripherals including Ethernet 100 Mbit/s and
  1 Gbit/s, multiple CAN FD, multiple SPIs
› Portfolio offering up to 6.9 MB embedded RAM
› External memory interface
› ISO 26262 conformance to support
  safety requirements up to ASIL-D

System benefits
› High scalability option with pin-to-pin compatibility and
  an identical safety and security concept across the whole
  family, for easy development and fast go-to-market
› High integration leads to reduced complexity
› Innovative supply concept leads to best-in-class
  power consumption

Suggested products
› TC233LP
› TC277TP
› TC333LP
› TC367DP
› TC377TP

Pixel lighting

Application example

+12 V from battery

Safety system
power supply
TLF35582

Safety
watchdog

CAN FD

CAN FD

CAN
transceivers
**TLE6250/50
TLE7250**

GTM

e.g.: RGB

**32-bit MCU
Multicore
AURIX™
TC3xx**

DLP

LCD

LED
matrices

Ethernet

Ethernet
transceiver

SPI

Automotive instrumentation ports
› Production device = 10 MB/sec
› Engineering = 250 MB/sec
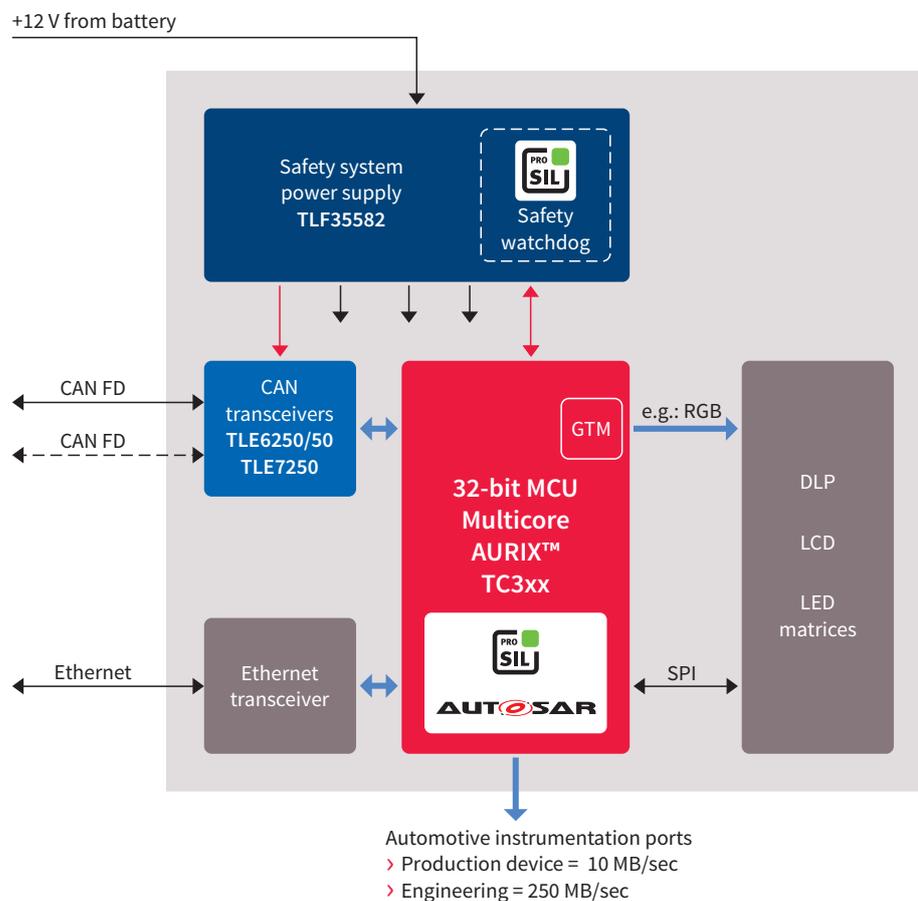
The new TriCore™ AURIX™ TC3xx family offers a scalable product portfolio to address low to high-definition safe headlight systems.

Application features
› TriCore™ DSP functionality
› Best-in-class performance: up to six TriCore™ with up to 300 MHz per core
› Complete family qualified for automotive grade 0
› Up to 6.9 MB RAM for light distribution processing
› Up to 16 MB eFlash to support A/B swap SOTA
› GTM cluster to emulate the main peripheral protocols of this market
› Ethernet up to 1 Gbit/s for fast connection to network
› External memory interface (eMMC) for data logging
› Availability of AUTOSAR 4.x

System benefits
› Enables smart headlight solutions , to save connectivity costs
› Family concept with PIN and software compatibility, for maximum portfolio scalability, re-use and fast go-to-market
› Compatibility with all major headlight driver solutions
› Rich legacy peripherals (CAN FD, LIN, …)

Suggested products
› TC367DP
› TC377TP/X
› TC387QP
› TC397XP/X

www.infineon.com/pixel-lighting

Active suspension control system

Application example
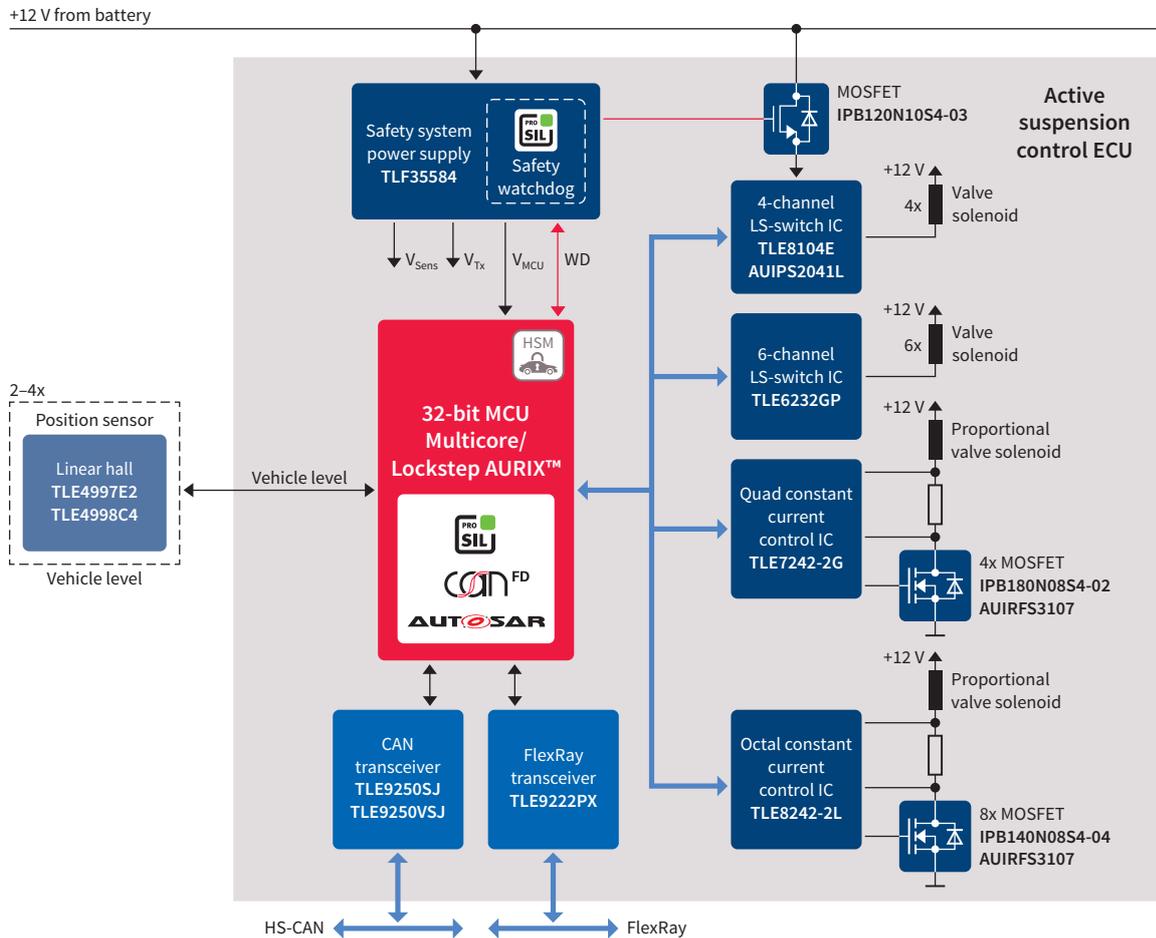
Thanks to its state-of-the-art safety features, the new TriCore™ AURIX™ family enables systems to achieve the highest ASIL-D safety level, which is already required in contemporary suspension systems.

The latest diverse lockstep technology with clock delay (diverse lockstep core) significantly reduces the software overhead and enables fast time-to-market.

The scalability supports an optimized fit in order to meet different OEM specifications.

Application features

› TriCore™ DSP functionality

› Best-in-class performance: up to six TriCore™
  with 300 MHz per core

› Supports the floating point and fix point with all cores

› Up to 6.9 MB

› Communication peripherals: CAN, LIN, FlexRay, Ethernet

› Innovative single supply of 5 V or 3.3 V

› Wide range of packages from 80–516 pin

› ISO 26262 conformance to support
  safety requirements up to ASIL-D

› Availability of AUTOSAR 4.x

System benefits

› Scalability over flash, RAM and peripherals, offering the best cost-performance ratio

› Proven safety concept to support ISO 26262

› Innovative supply concept leads to best-in-class power consumption and saves external component costs

Suggested products

› TC33x

› TC36x

› TC37x

Airbag system

Application example

+12 V from battery

Airbag ECU

Power supply
buck, boost, linear, watchdog,
reset, buckle switch interface
TLE8760[1]

V_{sat} V_{fire} V_{logic}

Pressure sensor
KP108-AD
KP200 PRO SIL

Pressure sensor
KP108-AD
KP200 PRO SIL

ADXL15x

ADXL15x

Pressure sensor
KP108-AD
KP200 PRO SIL

Pressure sensor
KP108-AD
KP200 PRO SIL

Door

Door

Pedestrian protection sensor IC

**Satellite
sensor
interface
TLE7729T**

Sensor
SPI bus

HSM

**32-bit MCU
Multicore/
Lockstep
AURIX™**

PRO SIL

CAN FD

AUTOSAR

Yaw, roll, pitch
+
low-g
x, y, z sensors

Firing SPI bus

**Squib driver
8-channel
TLE875x**[1]

**Squib driver
4-channel
TLE875x**[1]

**Squib driver
8-channel
TLE875x**[1]

**CAN
transceiver
TLE9250VSJ
TLE9250XSJ**

**LIN
transceiver
TLE7259-3GE**

Buckle switch
**TLE4976L
TLE4976-1K
TLE4976-2K**

Buckle switch
**TLE4976L
TLE4976-1K
TLE4976-2K**

Warning lamp

Airbag off

Squib Squib
Squib Squib
Squib Squib
Squib Squib

Squib Squib
Squib Squib

Squib Squib
Squib Squib
Squib Squib
Squib Squib

CAN LIN

CAN bus or LIN bus

Reversible belt
pretensioners

1) Coming soon

Thanks to its state-of-the-art safety features, the new TriCore™ AURIX™ family enables systems to achieve the highest safety level up to ASIL-D.
Its scalability allows the selection of a single-core solution for basic airbag systems and multicore solutions for airbag systems with an integrated sensor cluster. The best cost-performance fit is offered by the wide range of flash, performance and peripheral options available within the AURIX™ family.

Application features
› Scalable flash 1 – 16 MB
› Performance 160 MHz – 6x 300 MHz
› Dedicated peripheral set: CAN, LIN, SPI, FlexRay, Ethernet
› Advanced timer unit, totally flexible PWM generation and hardware input capture
› Redundant flexible 12-bit ADC
› Hardware SENT interface for a low CPU load
› Hardware built-in self-test overhead
› Safety software: Infineon SafeTcore library
› ISO 26262 conformance to support safety requirements up to ASIL-D
› Availability of AUTOSAR 4.x

System benefits
› Scalability over flash, RAM and peripherals, offering the best cost-performance ratio
› Serves all kinds of EPS systems, such as column or belt drive
› Proven safety concept to support ISO 26262
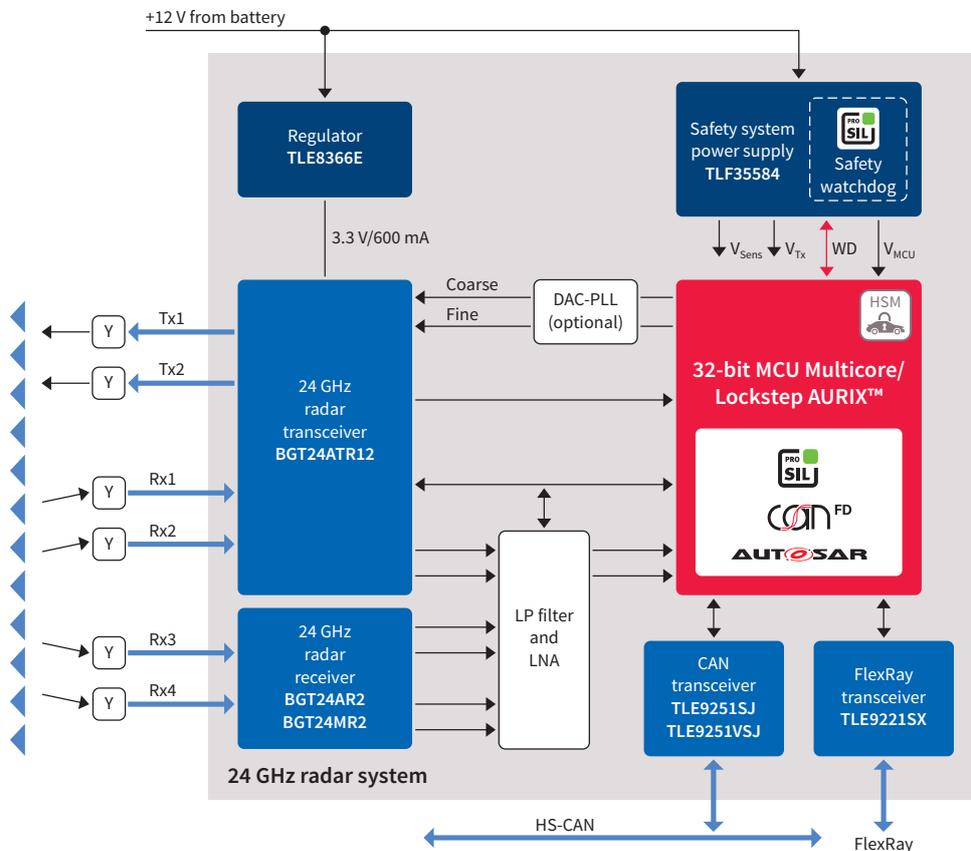› Innovative supply concept leads to best-in-class power consumption

Suggested products
› TC22x
› TC23x
› TC32x
› TC33x
› TC36x

PRO SIL

www.infineon.com/airbag

Automotive 24 GHz radar system

Application example

The new TriCore™ AURIX™ family will enhance classic safety features with dedicated features to meet the needs of 24 GHz radar systems.
The combination of new features and increased SRAM, in conjunction with outstanding safety features, enables a high level of integration and reduction of complexity.

Application features
› Up to 752 KB RAM for radar image storage
› Radar signal processing with windowing functionality
› Flexibility in radar signal acquisition
  with 4x internal ADCs
› Possibility to connect external ADCs
  (interface to connect up to 16-bit ADCs)
› High-precision input timers
› High-precision output timers for DAC
› Innovative single supply of 5 V or 3.3 V
› ISO 26262 compliance to support
  safety requirements up to ASIL-D
› Availability of AUTOSAR 4.x
› Continuous, precise and flexible bit-streaming
  machine (HSPDM) in AURIX™ TC3xx, to replace
  the external DAC controlling the ramp generator

System benefits
› High integration leads to significant cost savings
› High integration leads to reduced complexity
› ISO 26262 compliance supports safe input for functions
  such as emergency braking
› Innovative supply concept
› Cost savings on the DAC component by using the AURIX™
  TC3xx, which integrates the HSPDM IP

Suggested products
› TC23xLA
› TC26xDA
› TC33xDA

www.infineon.com/radar

Highly integrated automotive 77 GHz radar chipset

Application example
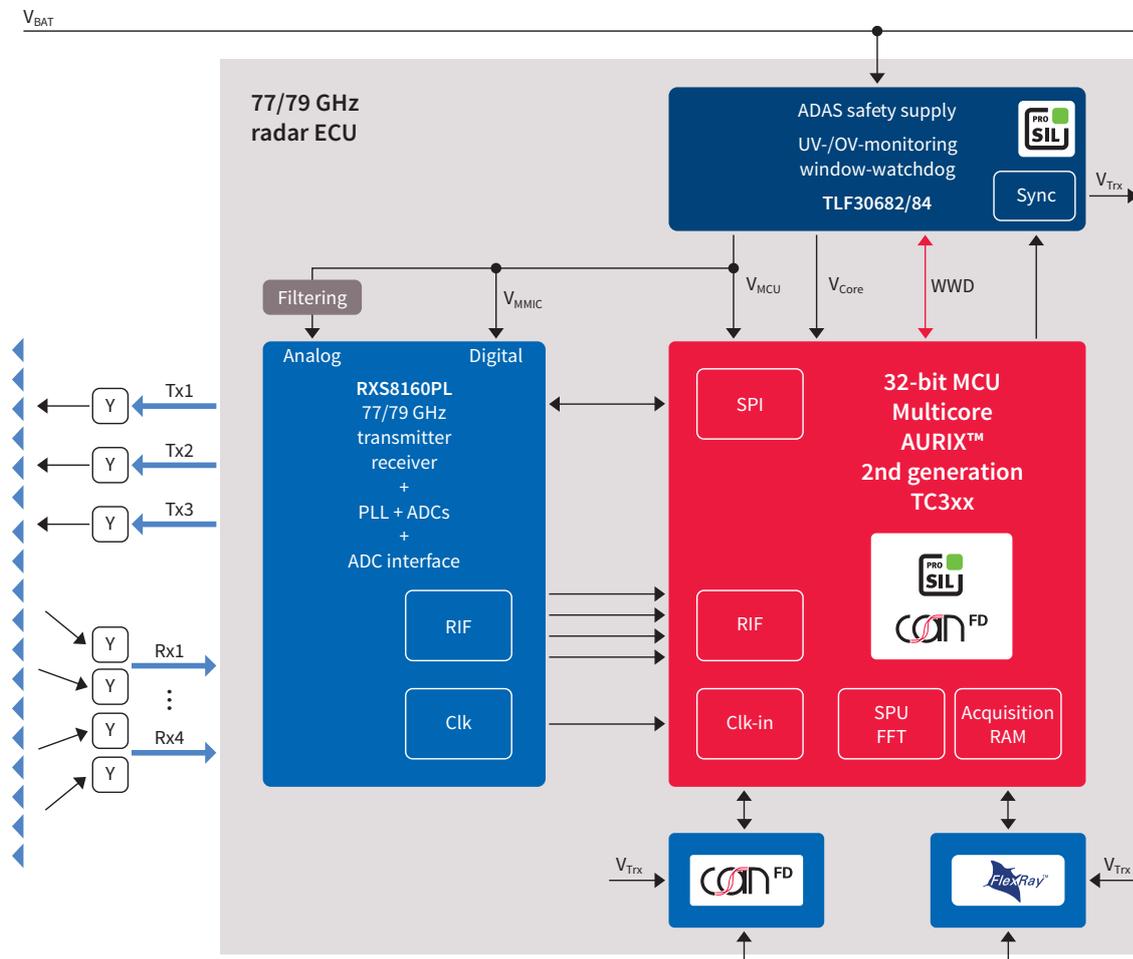
Thanks to its proprietary radar accelerator IP, the new TriCore™ AURIX™ TC3xx family will bring another level of performance to radar applications, as well as fulfilling the ever-growing requirements regarding safety and security in the ADAS market.

Application features

› TriCore™ DSP functionality
› Best-in-class performance: up to six TriCore™
  with up to 300 MHz per core
› Dedicated radar cluster with its own radar interface
  (RIF, LVDS-based) and accelerators (SPU), offering not
  only FFT but also filtering (CFAR), along with windowing
  and signal power measures capabilities
› Up to 4 MB RAM for radar image storage
› High-precision input timers
› Innovative single supply of 5 V or 3.3 V
› External memory interface
› ISO 26262 compliance to support safety
  requirements up to ASIL-D
› Availability of AUTOSAR 4.x

System benefits

› Family concept with three products for fast go-to-market
  and scalable radar portfolio
› Rich features implemented in hardware to attain an
  optimal performance/consumption ratio and reduce the
  amount of components, leading to cost savings
› ISO 26262 compliance supports safe input for functions
  such as emergency braking

Suggested products

› TC33xDA
› TC35xTA
› TC39xxA

www.infineon.com/radar

Sensor fusions

Application examples

Low cost sensor fusion
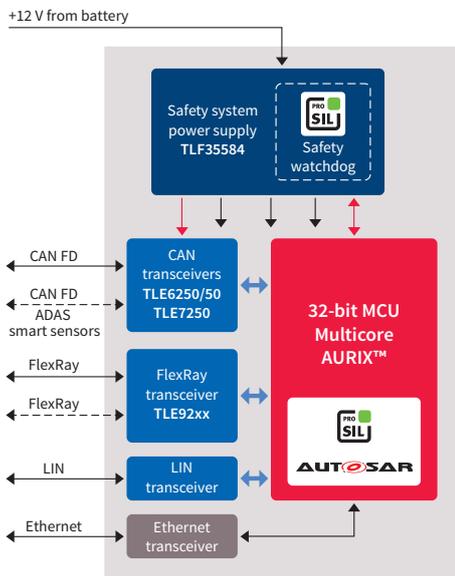
Main stream sensor fusion
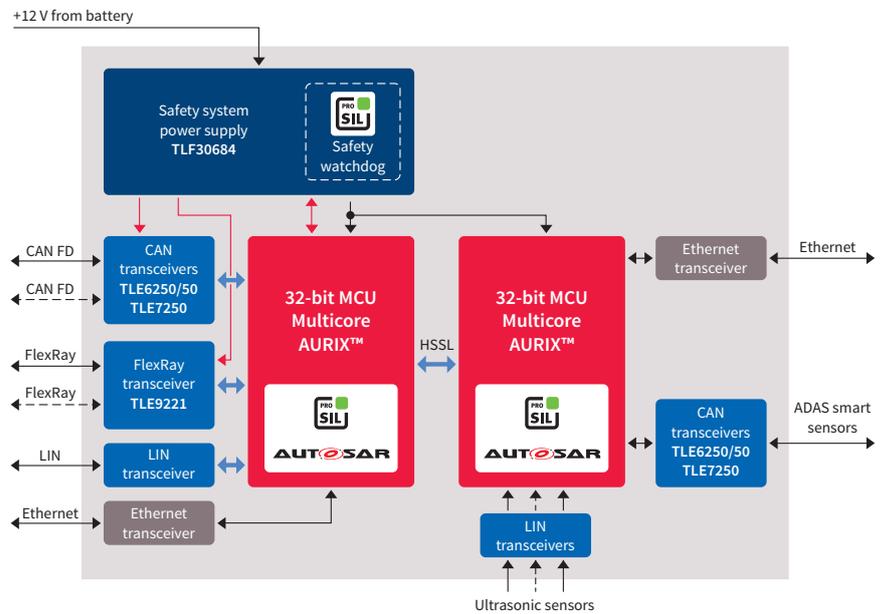
The new TriCore™ AURIX™ TC3xx family offers a scalable product portfolio to address the needs of low-resolution grid fusion applications.

Application features
› TriCore™ DSP functionality
› Best-in-class performance: up to six TriCore™ with up to 300 MHz per core, up to 2400 DMIP ASIL-D capable per MCU
› Up to 4 MB RAM for grid information treatment
› Up to 16 MB eFlash to support A/B swap SOTA
› HSSL connectivity for easy coupling of two AURIX™
› Ethernet up to 1 Gbit/s for fast connection to network and main SoC
› External memory interface (eMMC) for data logging
› ISO 26262 compliance to support safety requirements up to ASIL-D
› Availability of AUTOSAR 4.x

System benefits
› Family concept with PIN and software compatibility, for maximum re-use and fast go-to-market
› Low power consumption for compact low/mid-end solutions
› Rich legacy peripherals (CAN FD, LIN, …) for integrated gateway application and multi-sensor architecture

Suggested products
› TC29xTA
› TC35xTA
› TC37xTX
› TC38xQP
› TC39xXX

Full feature sensor fusion

Application example – Domain controller for autonomous drive
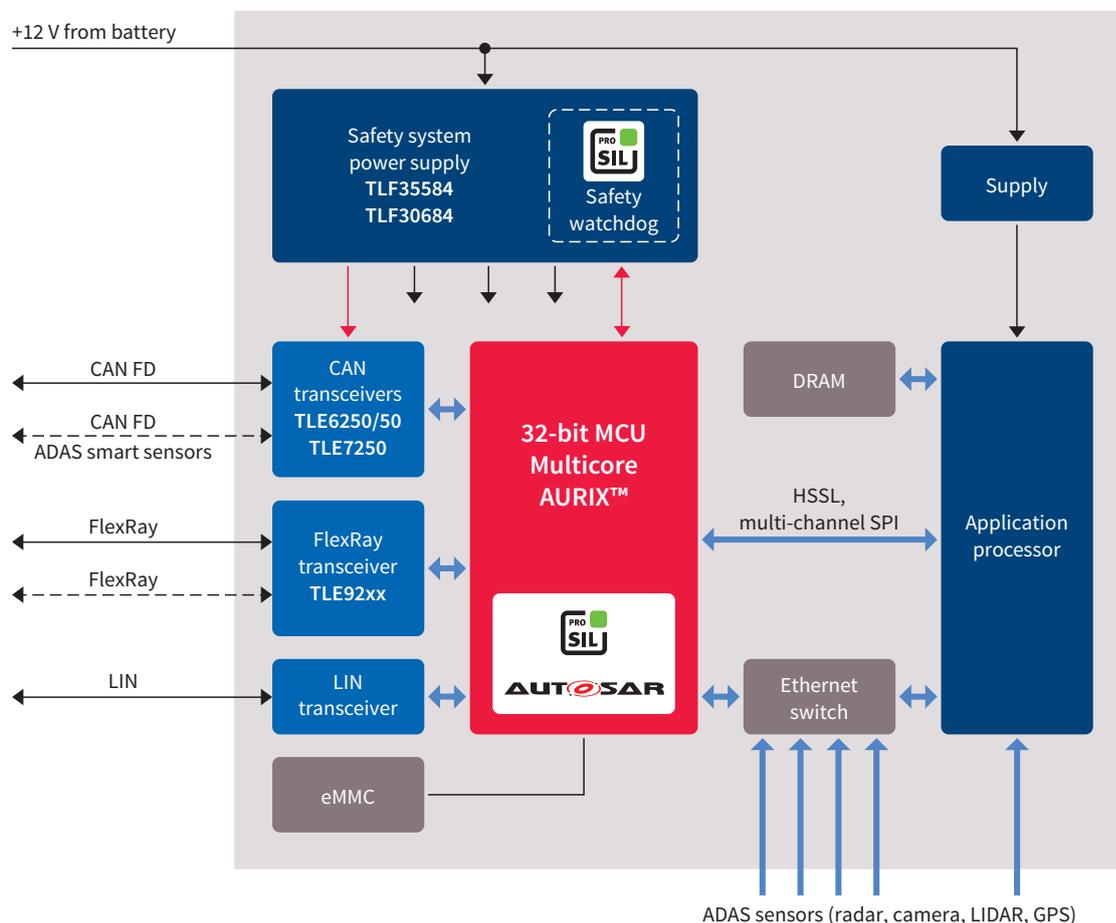
ADAS sensors (radar, camera, LIDAR, GPS)

The new TriCore™ AURIX™ TC3xx family offers a scalable product portfolio to address the needs of sensor fusion applications, from stand-alone object fusion to companionship for a high-end AD ECU.

Application features
› TriCore™ DSP functionality
› Best-in-class performance: up to six TriCore™ with up to 300 MHz per core, up to 2400 DMIP ASIL-D capable per MCU
› Up to 4 MB RAM for grid information treatment
› Up to 16 MB eFlash to support A/B swap SOTA
› HSSL connectivity for direct coupling with SoC
› Ethernet up to 1 Gbit/s for fast connection to network and SoC
› External memory interface (eMMC) for data logging
› ISO 26262 compliance to support safety requirements up to ASIL-D
› Availability of AUTOSAR 4.x

System benefits
› Family concept with PIN and software compatibility, for maximum re-use and fast go-to-market
› Rich legacy peripherals (CAN FD, LIN, …) for integrated gateway application

Suggested products
› TC29xTA
› TC37xTX
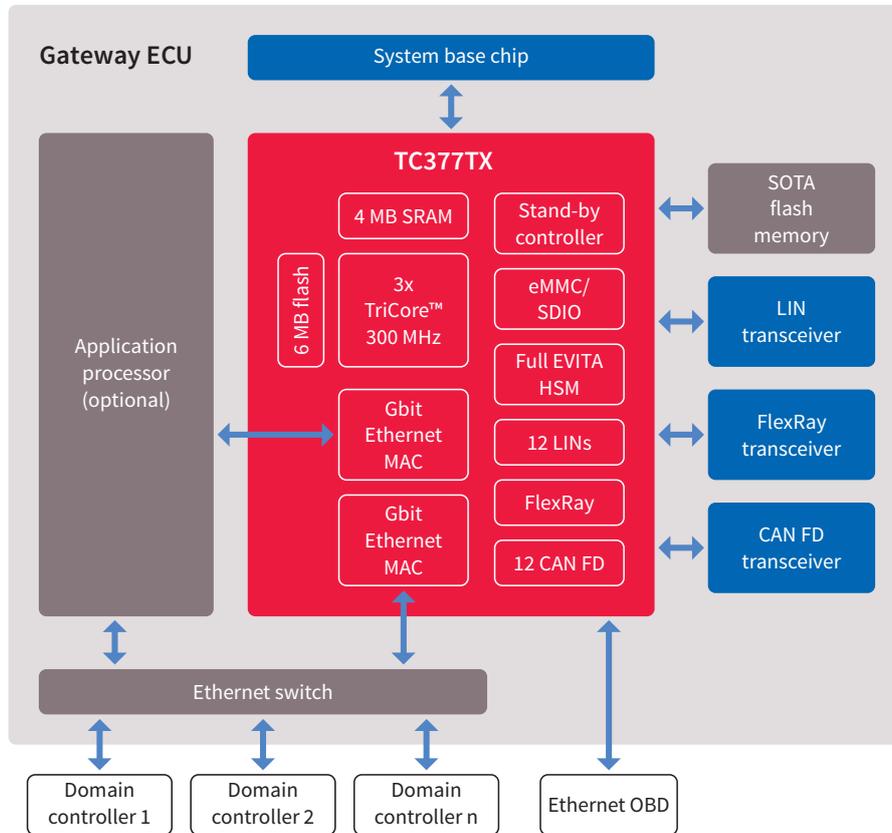› TC38xQP
› TC39xXX

www.infineon.com/sensorfusion
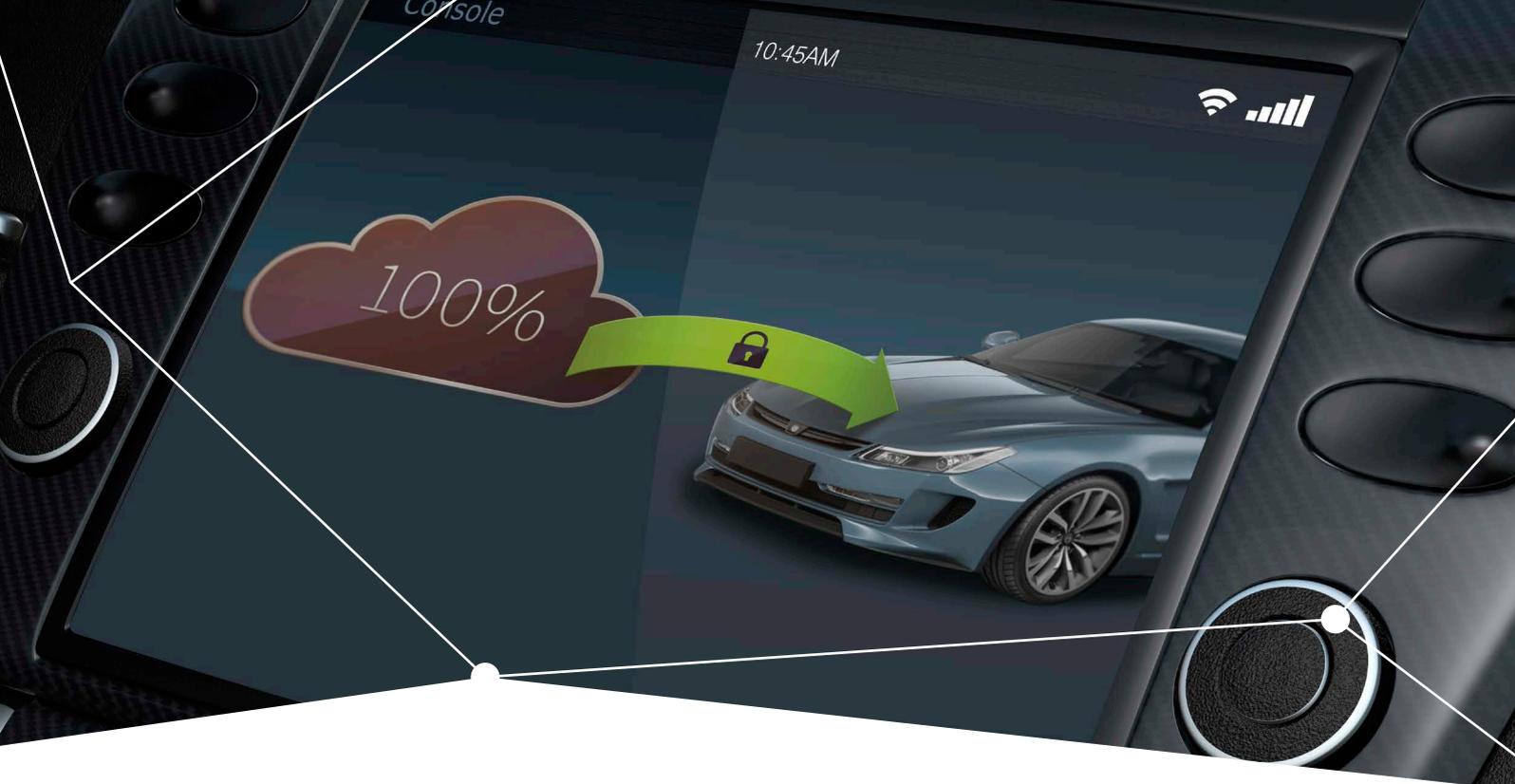
AURIX™ for connectivity applications

Connectivity electronics systems embrace a broad variety of applications inside the car, covering comfort, safety and security as well as high-performance computing and in-vehicle networking. **This leads to the key strengths of the AURIX™ family:**

› **AUTOSAR** – AUTOSAR 4 facilitates the easy design of multicore architectures into vehicles. Infineon is one of the first implementers of a multicore architecture with AURIX™ ready for AUTOSAR 4.x. Furthermore, Infineon also provides the MCAL drivers developed in accordance with the CMM 3 level.

› **Power consumption** – An innovative supply concept automatically adapts the power consumption to the actual performance requirements. Furthermore, the new trend of pretended networking and ECU degradation is actively supported.

› **Enhanced communication** – As cars incorporate an increasing amount of electronics, the body electronics module's responsibilities increase to handle the additional components and message traffic. Due to the gateway functionality of the BDC, AURIX™ has enhanced communication capabilities to support communication between CAN FD, LIN, FlexRay and Ethernet buses.

› **Safety** – The trend is toward the integration of safety targets in the requirements of advanced body systems, such as lighting, BDC etc. To achieve the required ASIL level according to ISO 26262, AURIX™ has the capability to cover targets up to the highest ASIL-D safety integrity level.

› **Security** – In the future, the need for a high level of security will also expand into body applications. Cars are expected to hold even more information as they become smart cards on wheels for simplifying financial transactions at gas pumps, charging stations, parking lots, toll booths, drive-through shops and more. The vehicle will act as a smart card and pay your fee/fare – sometimes automatically. Hardware-based security is more robust than software-only security. AURIX™ provides a dedicated module, the HSM (Hardware Secure Module), to cover the highest level of security.

Advanced gateway architecture

Application example

Gateway ECU

System base chip

TC377TX

4 MB SRAM

6 MB flash

3x TriCore™ 300 MHz

Gbit Ethernet MAC

Gbit Ethernet MAC

Stand-by controller

eMMC/ SDIO

Full EVITA HSM

12 LINs

FlexRay

12 CAN FD

Application processor (optional)

SOTA flash memory

LIN transceiver

FlexRay transceiver

CAN FD transceiver

Ethernet switch

Domain controller 1

Domain controller 2

Domain controller n

Ethernet OBD

In gateway applications, AURIX™ TC3xx microcontrollers support the latest communications interfaces and feature a Gigabit Ethernet interface, up to 12 ISO 11898-1-compliant CAN FD channels and up to 24 LIN channels. An additional eMMC interface for external flash interfacing enables local data storage, supporting software-over-the-air update concepts.

Application features
› High-performance processing: up to six-core 300 MHz
› Automotive Gigabit Ethernet
› Up to 12 CAN FD
› eMMC for external Flash
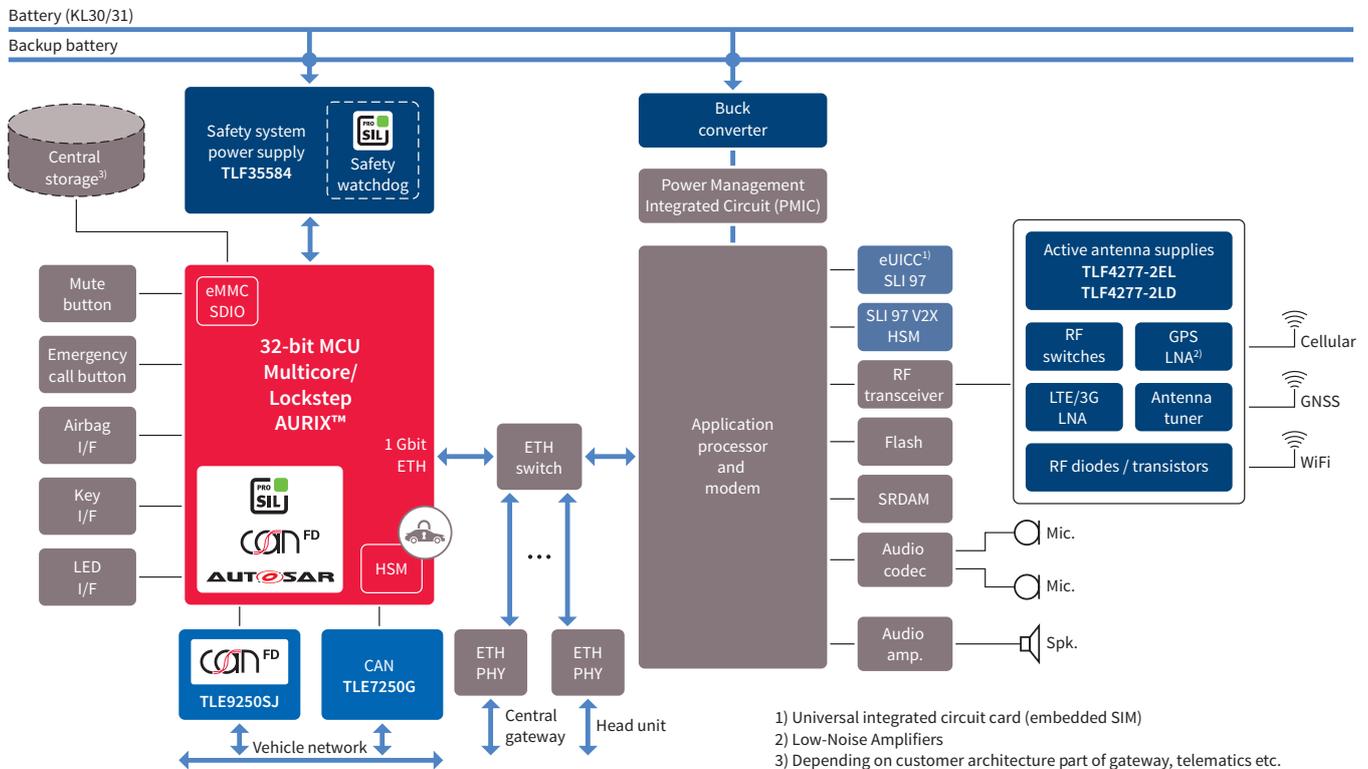› Hardware Security Module
› AUTOSAR 4.2 support

System benefits
› Integrated, cost-efficient solution for a connected gateway with SOTA, secure on-board communication…
› Fast secure boot
› Gateway board to reduce the development outlay

Suggested products
› TC36x
› TC37x
› TC38x
› TC39x

www.infineon.com/gateway

Telematics control unit and V2X

Application example

Battery (KL30/31)
Backup battery

Central storage[3]

Safety system power supply TLF35584 — Safety watchdog

Buck converter

Power Management Integrated Circuit (PMIC)

Mute button
Emergency call button
Airbag I/F
Key I/F
LED I/F

eMMC SDIO

32-bit MCU Multicore/ Lockstep AURIX™

1 Gbit ETH

HSM

CAN FD
TLE9250SJ

CAN TLE7250G

ETH switch

ETH PHY
ETH PHY

Central gateway
Head unit

Vehicle network

Application processor and modem

eUICC[1] SLI 97
SLI 97 V2X HSM
RF transceiver
Flash
SRDAM
Audio codec
Audio amp.

Active antenna supplies
TLF4277-2EL
TLF4277-2LD

RF switches
GPS LNA[2]
LTE/3G LNA
Antenna tuner
RF diodes / transistors

Cellular
GNSS
WiFi

Mic.
Mic.
Spk.

1) Universal integrated circuit card (embedded SIM)
2) Low-Noise Amplifiers
3) Depending on customer architecture part of gateway, telematics etc.

The telematics control unit connects the car to the outside world, thereby enabling numerous new applications and functionalities. Software in different ECUs can be updated remotely, to either add new features or remove any software bugs that might be found during operation. This reduces the number of recalls and related costs, while increasing customer satisfaction. The opportunity to add new features opens up the door to new business models and revenue streams.

Application features
› eCall
› Remote diagnostics
› Payment systems
› Software update
› Feature upgrades
› Internet services
› etc.

System benefits
› System supplies, bock converter, active antenna
  supplies etc.
› Secure elements (eUICC, OPTIGA™ TPM 2.0,
  SLI 97 V2X etc.)
› RF switches, RF diodes/transistors, low-noise amplifiers
 (GPS, LTE etc.)
› Silicon microphone

Application features
› Superior Hardware Security Solution (HSM) + functional
  safety up to ASIL-D (e.g. eCall, V2x communication,
  software update of safety-critical ECUs)
› Automotive and consumer interfaces
  (incl. CAN/-FD, FlexRay, Ethernet etc.)
› Highly scalable product portfolio
  (starting with 2 MB and QFP-100 at the lowest end)

Suggested products
› TC23x
› TC33x
› TC36x
› TC37x

www.infineon.com/car-security

High-feature Body Domain Control unit

Application example
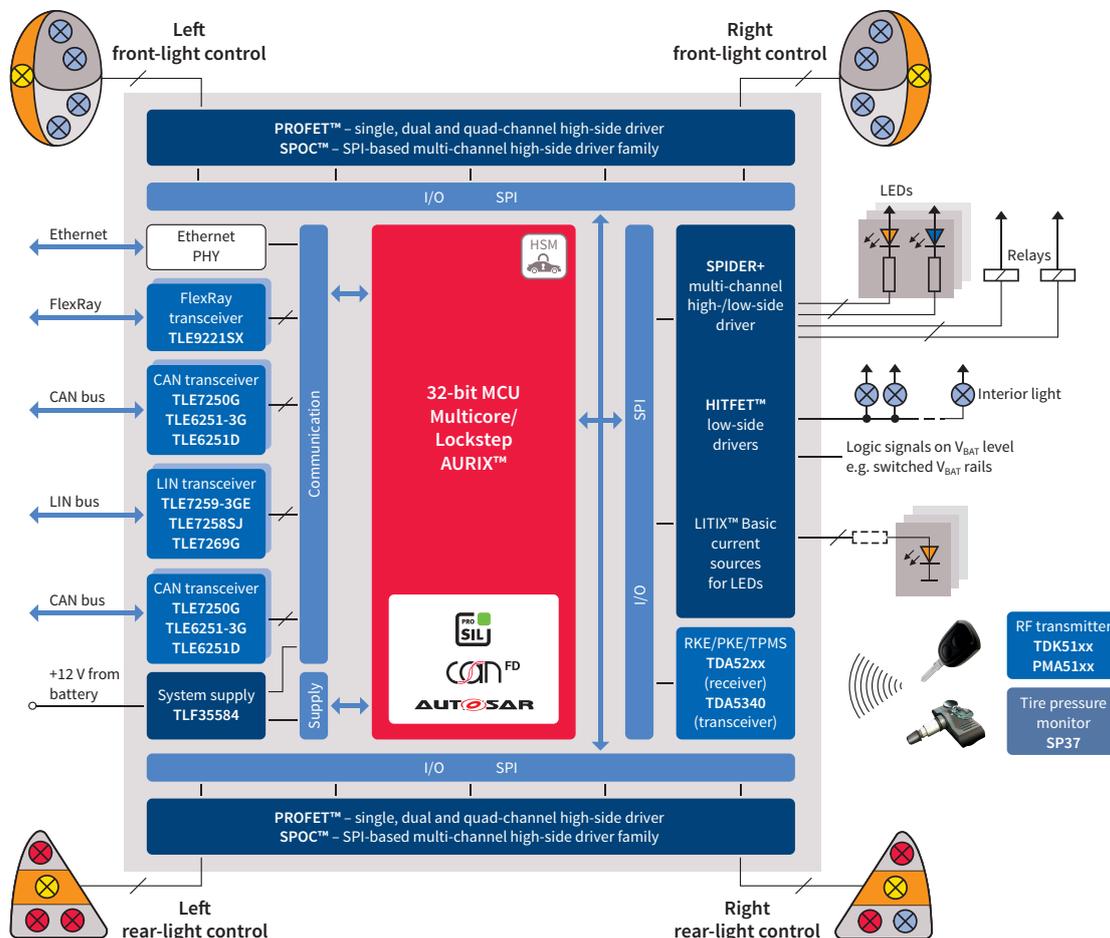
Body Domain Control unit (BDC) application comprising internal and external lighting systems, as well as control of relays and voltage rails and further comfort functions such as door and wiper control. The central gateway manages all internal interfaces (i.e. motor management, in-car entertainment, dashboard or convenience control) and communication with external interfaces for after-sales software updates. The AURIX™ multicore concept enables the integration of two applications in one device, e.g. BDC and gateway.

Application features
› Scalable MCU family from single to multicore
› Encapsulation feature allows interference-free software development for multiple applications
› Embedded EEPROM
› Advanced communication peripherals: CAN, LIN, SPI, FlexRay, Ethernet
› ISO 26262 conformance to support safety requirements up to ASIL-D
› Availability of AUTOSAR 4.x

System benefits
› Enables pretended networking and ECU degradation
› High integration leads to significant cost savings
› High integration leads to reduced complexity
› ISO 26262 compliance supports ASIL requirements
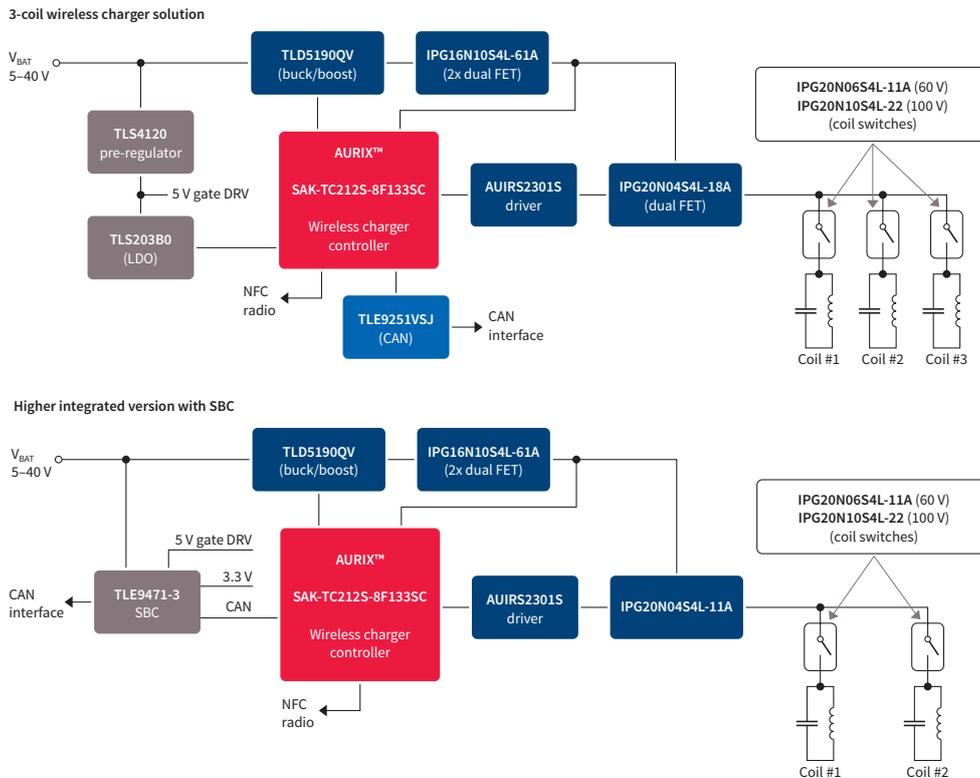› Innovative supply concept leads to best-in-class power consumption

Suggested products
› TC36x
› TC37x
› TC38x
› TC39x

www.infineon.com/bdc_advanced

Wireless charger solution

Application example

3-coil wireless charger solution

Higher integrated version with SBC

A multi-mode charger with ultimate flexibility

› High-efficiency 15 W charging without exotic thermal management
› Multi-mode supporting Q-inverters and fast charge on the same hardware
› Supports future products and standards with a firmware upgrade
› Charger is backward compatible with all lower-power and legacy Q-inverters devices
› Supports single and multi-coil charging surfaces
› Allows the easy addition of custom features for differentiated applications

Fully compatible with the automotive environment

› Controlled-frequency operation prevents interference with other systems and reduces EMI
› Operates on 6–19 V input supply, supporting stop/start
› Protected from load dump, double battery and reverse battery
› Supports CAN for integration into the automotive communications infrastructure
› Full thermal management support, including system monitoring and charge-rate fold back

System benefits

› Supports greater coil-to-coil Z height than competing solutions
› A higher efficiency than other solutions means a larger charging "sweet spot"
› Total front-to-back solution ensures maximum efficiency, minimal thermal impact and ease of certification
› Reference design is self-protected (load dump, reverse battery etc.)
› A single AURIX™ supports wireless charging, system application, CAN and external NFC interface functions
› Can support charging two devices using a single controller
› Built-in security functionality meets the latest automotive requirements
› Proven fixed frequency/variable voltage hardware and software architecture
› Proven EMI performance
› Certified WPC 1.2.2 (15 W) on multiple previous products

Suggested products

› TC21x
› TC22x
› TC23x

www.infineon.com/wirelesscharging

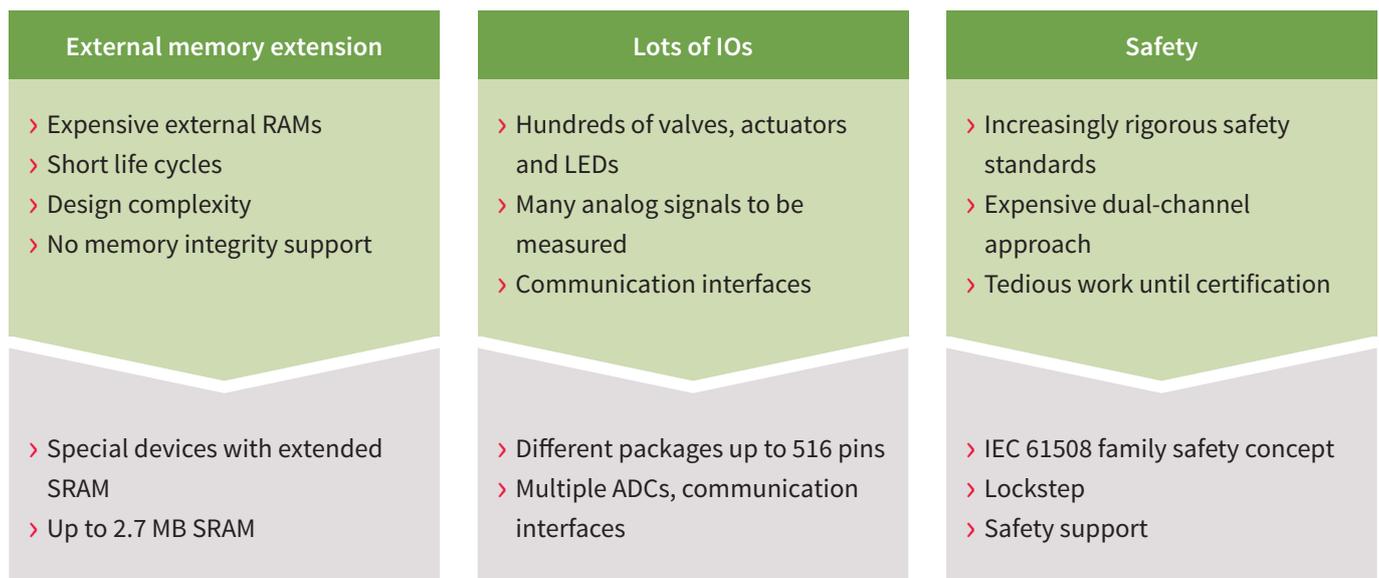# TriCore™ for transportation applications, optimized with the scalable AURIX™ family

AURIX™ is Infineon's brand-new family of microcontrollers, designed to precisely meet the needs of the 24–60 V industry in terms of performance, memory, scalability, safety and security.

Its innovative multicore architecture supports the latest trends in connectivity, such as Ethernet and CAN FD, as well as safety (IEC 61508/ISO 25119/ISO 26262) and security.

While supporting a high performance, the innovative supply concept with integrated DC-DC converter leads to best-in-class power consumption.

The scalable AURIX™ family leads to the most optimized cost-performance application fit.
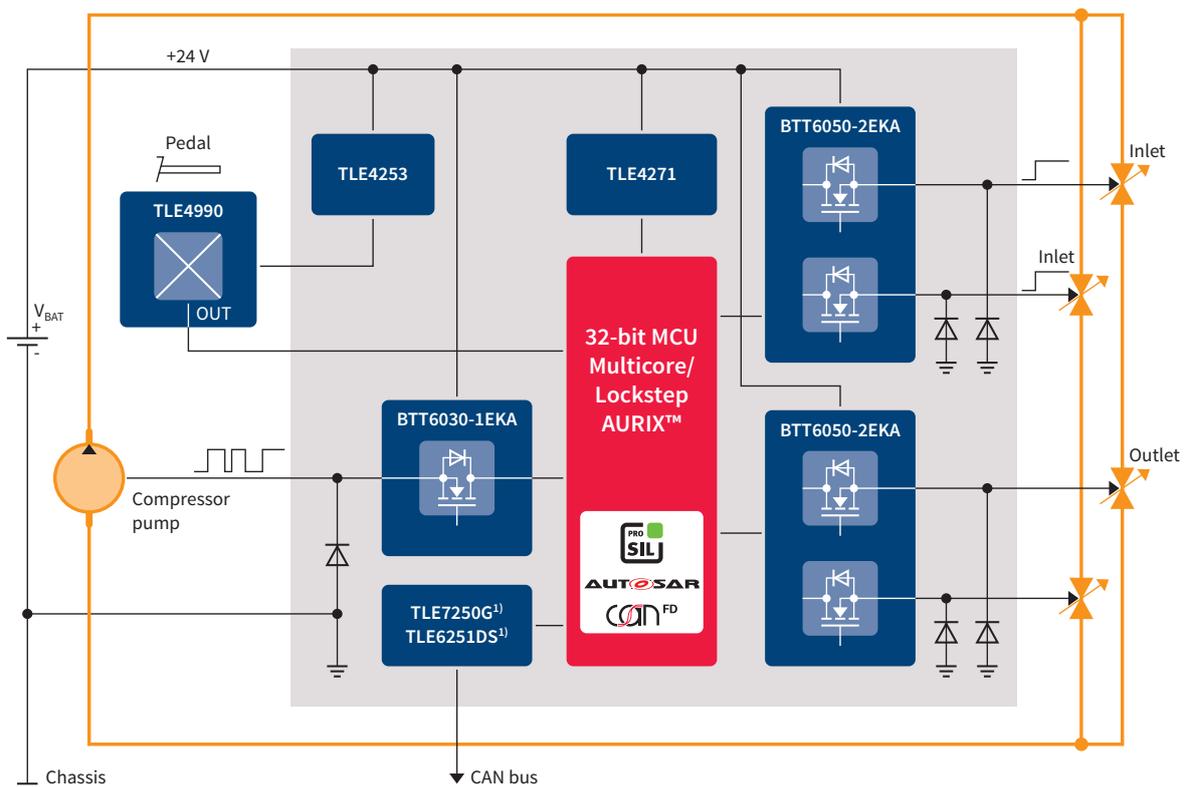
AURIX™ addresses CAV requirements and challenges

External memory extension	Lots of IOs	Safety
› Expensive external RAMs › Short life cycles › Design complexity › No memory integrity support	› Hundreds of valves, actuators and LEDs › Many analog signals to be measured › Communication interfaces	› Increasingly rigorous safety standards › Expensive dual-channel approach › Tedious work until certification
› Special devices with extended SRAM › Up to 2.7 MB SRAM	› Different packages up to 516 pins › Multiple ADCs, communication interfaces	› IEC 61508 family safety concept › Lockstep › Safety support

www.infineon.com/CAV

Commercial and Agricultural Vehicles (CAV)

Hydraulic management system

+24 V

Pedal

TLE4990

OUT

TLE4253

TLE4271

BTT6050-2EKA

Inlet

Inlet

V_{BAT}
+
-

32-bit MCU
Multicore/
Lockstep
AURIX™

BTT6030-1EKA

BTT6050-2EKA

Outlet

PRO SIL

AUTOSAR

CAN FD

Pump

TLE7250G[1]
TLE6251DS[1]

Reservoir

Chassis

CAN bus
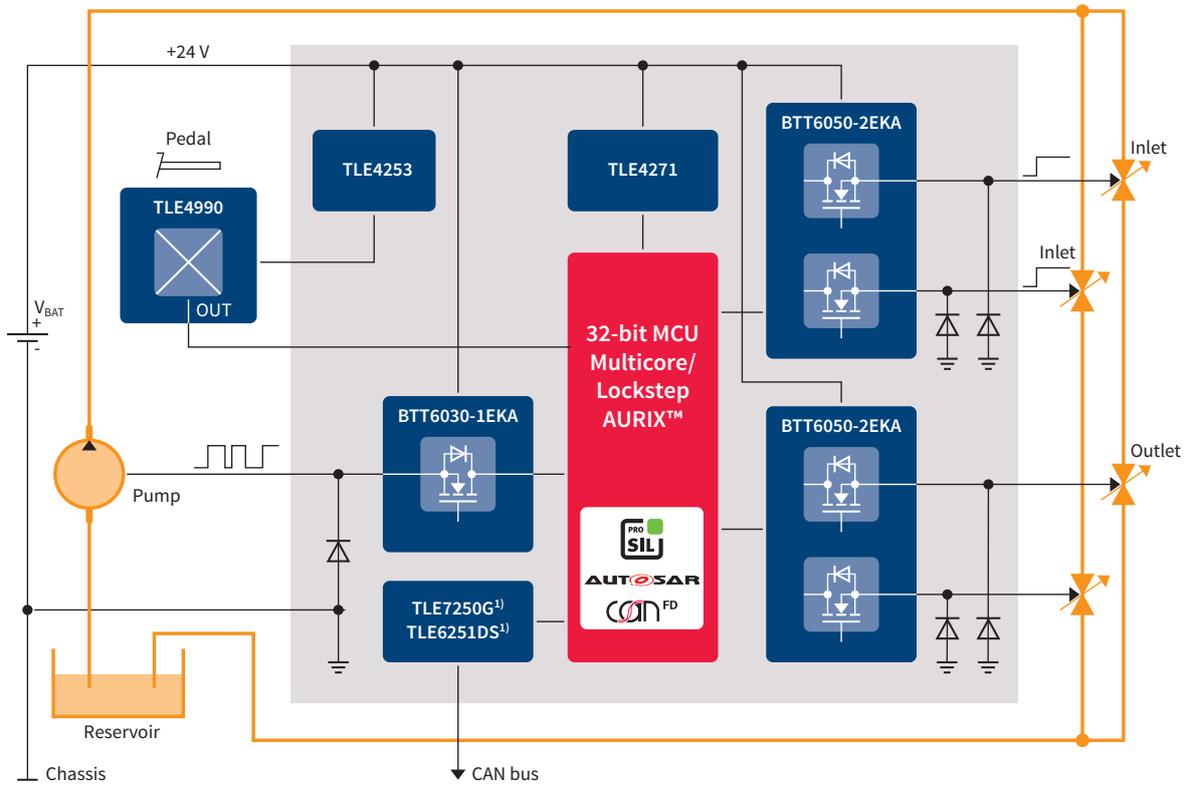
1) If ECU permanently supplied, you may need to add
   external protection against load dump 400 ms above 40 V.

Pneumatic management system

+24 V

Pedal

TLE4990

OUT

TLE4253

TLE4271

BTT6050-2EKA

Inlet

Inlet

V_{BAT}
+
-

32-bit MCU
Multicore/
Lockstep
AURIX™

BTT6030-1EKA

BTT6050-2EKA

Outlet

Compressor
pump

PRO SIL

AUTOSAR

CAN FD

TLE7250G[1]
TLE6251DS[1]

Chassis

CAN bus

www.infineon.com/CAV

A 24 V complete system solution for hydraulic/pneumatic management systems: power supply, sensors, microcontrollers and high-side switches can be used without external protection in a 24 V system. Valves and pumps can be driven via linear activation or demand-controlled via PWM signals.

System benefits
› Valves and pumps can be driven via linear activation or demand-controlled via PWM signals
› Quad and dual channels are optimized to reduce costs and space for these applications
› Pin-to-pin and software compatibility
› Complies with ISO 26262 and ASIL D/SIL 3
› AECQ-100

Suggested products
› TC21x
› TC22x
› TC23x
› TC26x
› TC27x
› TC29x

PRO
SIL

CAV 24 GHz radar

Application example
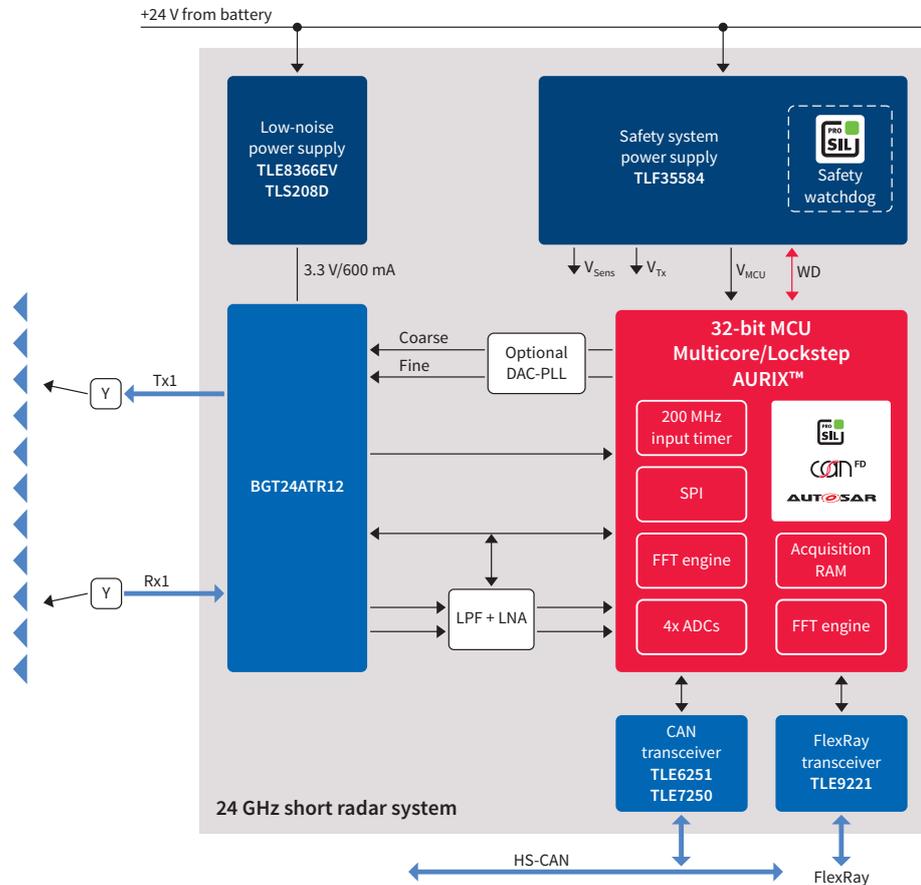
Contemporary commercial, construction and agricultural vehicles (CAVs) rely on radar systems to improve their productivity, energy efficiency and safety. As the world's population grows at a record pace, there is increased pressure to plant and harvest more, and to speed up construction projects. But to do so, CAVs need ever-more sophisticated systems to help them overcome challenges in the field or construction site.

For instance, if a 24 GHz radar system onboard a CAV detects a large stone ahead, it informs the driver so he/she can mitigate the situation. Another example: If a tractor sinks in the mud, a trailer fitted with a 24 GHz radar system signals to the tractor to accelerate so it can pull through. A 24 GHz radar also helps detect potentially dangerous situations for a CAV driver or for pedestrians or workers nearby, and halts the machine before an accident occurs. These high-precision systems are key to producing more while keeping people safe. That is why today's CAV 24 GHz radar designs must be reliable and durable, while also reflecting the market's cost expectations.

Application features
› Blind spot/object detection
› Object tracking

Suggested products
› AURIX™ TC264DA microcontroller
› BGT24A RF transceiver IC
› TLF35584 safety power supply

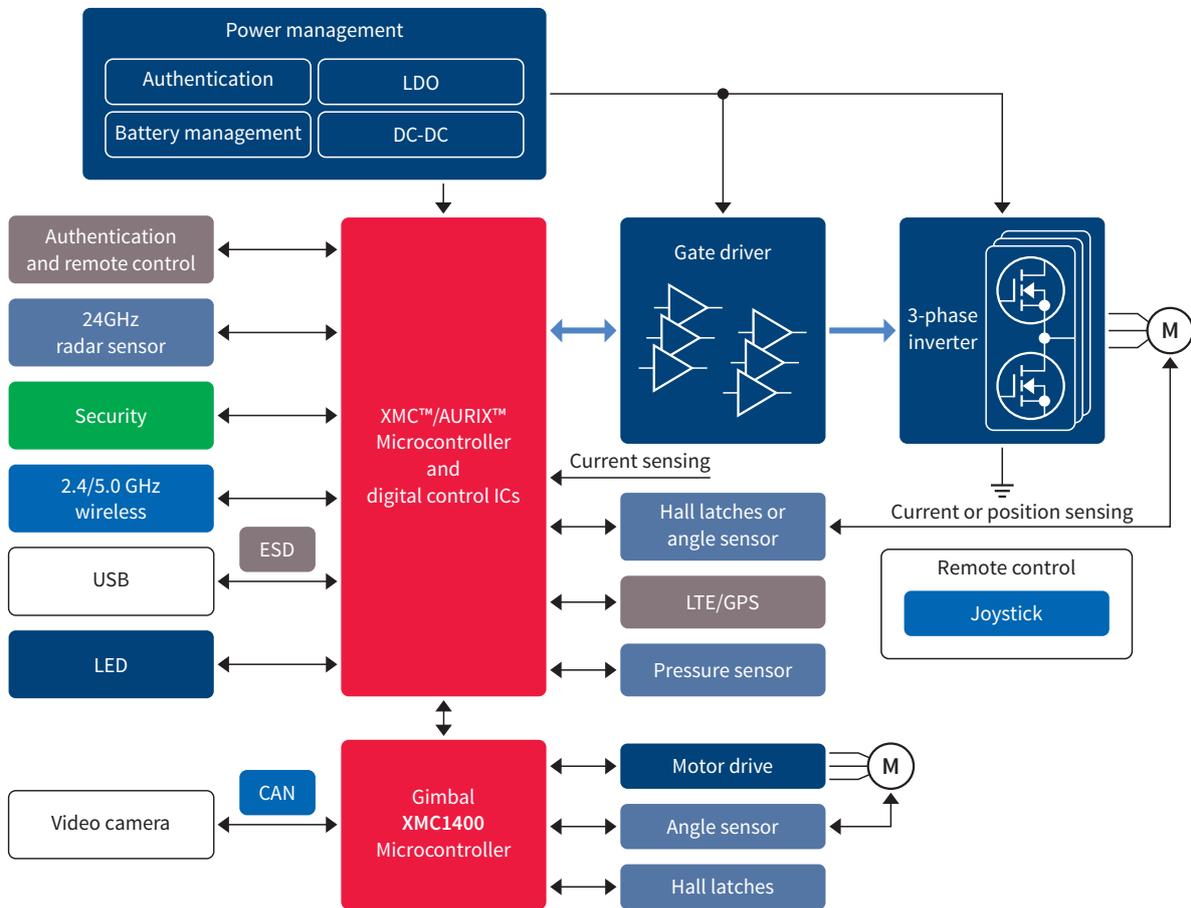## System benefits
› Highly integrated and scalable chip-set solution
› Small PCB footprint
› Hardware support for ISO 26262 up to ASIL D
› Low cost in BOM as the AURIX™ microcontroller replaces additional DSP and external memory

www.infineon.com/cav-24ghz

Drones/Multicopters

Application example

Infineon's comprehensive portfolio of high-quality products contains the widest spectrum of multicopter components on the market. We offer everything from industrial XMC™ controllers to the AURIX™ family, supporting everything from motor control of the rotors to autonomous flying support with 24 GHz radar. Thanks to an optimized feature set, we can support both consumer (XMC™ family) and commercial drones (AURIX™ family). The new safety requirements can be covered with the AURIX™ family which supports IEC 61508/SIL-3 and ISO 26262/ASIL-D.

Benefits	Our offer
Development effort and cost reduction	› With little or no experience in motor control, customers can implement the XMC™/AURIX™ motor control support and take flight › Project development can be reduced by 30% by using reference designs and the DAVE™ platform for microcontroller programming
Security and safety	› Enables authentication of components connected to the system, secures safety and protects product liability with XMC™/AURIX™ › Brand protection and a secure strong identity are provided by state-of-the-art security products which are easy to integrate with XMC™/AURIX™ › Thanks to the safety hardware features in the AURIX™ family, we can support upcoming safety requirements up to SIL3/ASIL-D
Accuracy and easy control	› Due to the benefits of multifunction sensors, the user can experience easy, stable, smooth and accurate control of the multicopter › Closed loop control of the gimbal motor and sensors enhances camera stability and data transmission when recording video
Lighter	› The highly efficient components and effective flight control can make the multicopter lighter, resulting in a longer flight time
Collision avoidance	› 24 GHz can be used to measure the presence of objects, measure the range, speed/velocity, ascertain proximity, determine the position of objects and – supported by XMC™ and AURIX™ – process sensor data

AURIX™ for
industrial applications

**AURIX™ for high-performance, multicore and
safety-demanding applications**
The AURIX™ 32-bit microcontroller family is based on
the Infineon TriCore™ high-performance core concept and provides a highly
scalable family from single core to
multicore.

The AURIX™ family enables the highest integrated safe memory sizes (SRAM up
to 6.9 MB and flash memory up to 16 MB) and all memory is protected by hard-
ware Error Correction Code (ECC). The devices reach more than 600 DMIPS at
clock rates of up to 6x 300 MHz and combine MCU and DSP instructions with an
integrated FPU.

The integrated peripheral set is primarily targeted toward motor control and
power conversion, providing high-performance ADCs, DS ADCs and a full set of
diverse high-performance timers. This is one of the very few in the industry that
is able to drive the upcoming three-level inverter topologies. Furthermore, the
AURIX™ family supports the latest connectivity, such as Ethernet, CAN FD, Flex-
Ray and multiple other high-speed interfaces.

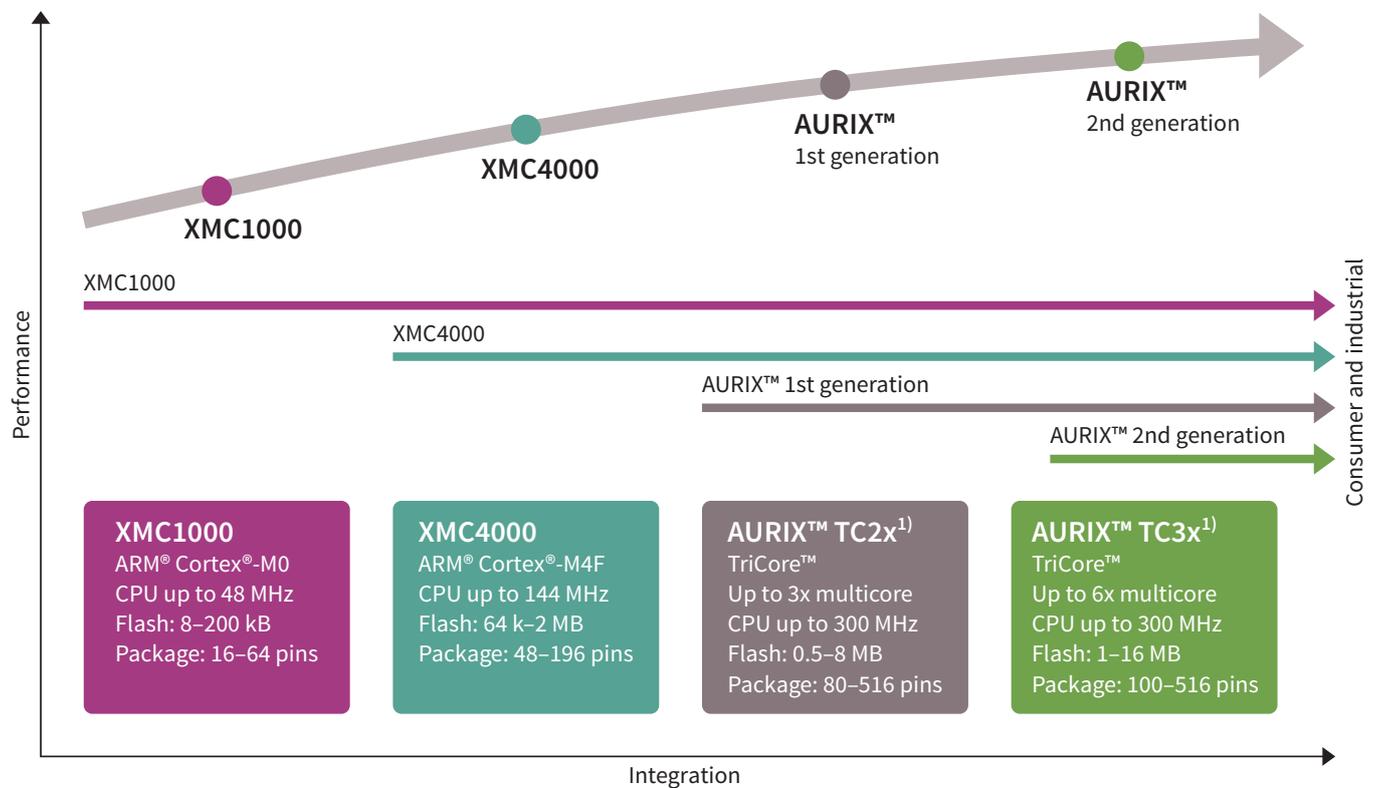**Providing security and functional safety**
In a global economy, IP protection and secure communication plays an increas-
ingly important role. This demand is accounted for by the integration of special
security modules providing the required means of safe key storage, along with
secure boot and encryption on the hardware level. As one
of the leaders in functional safety, Infineon has designed the TriCore™ MCUs to
meet the growing demand for functional safety in the industrial market as spec-
ified in IEC 61508. Via our cooperation partner Hitex, Infineon offers a complete
package comprising a microcontroller, safety supply with integrated watchdog
TLF35584, software and documentation, achieving safety integrity levels up to
SIL3.

The new generation of TriCore™-based microcontrollers – AURIX™ – provides
another significant performance milestone by integrating up to six cores in one
device. The multicore concept is targeted at running concurrent applications in
parallel. Some of the integrated cores integrate lockstep functionality and the
peripherals can be allocated to individual cores. This facilitates running a com-
bination of safety-critical tasks, such as controlling an inverter, with non-critical
tasks, such as network communication, on a single MCU.

www.infineon.com/industrial

Infineon Microcontrollers for industrial applications

Infineon has combined its wealth of experience in microcontroller design to offer a wide portfolio that can cover a broad range of industrial applications. It is based on:
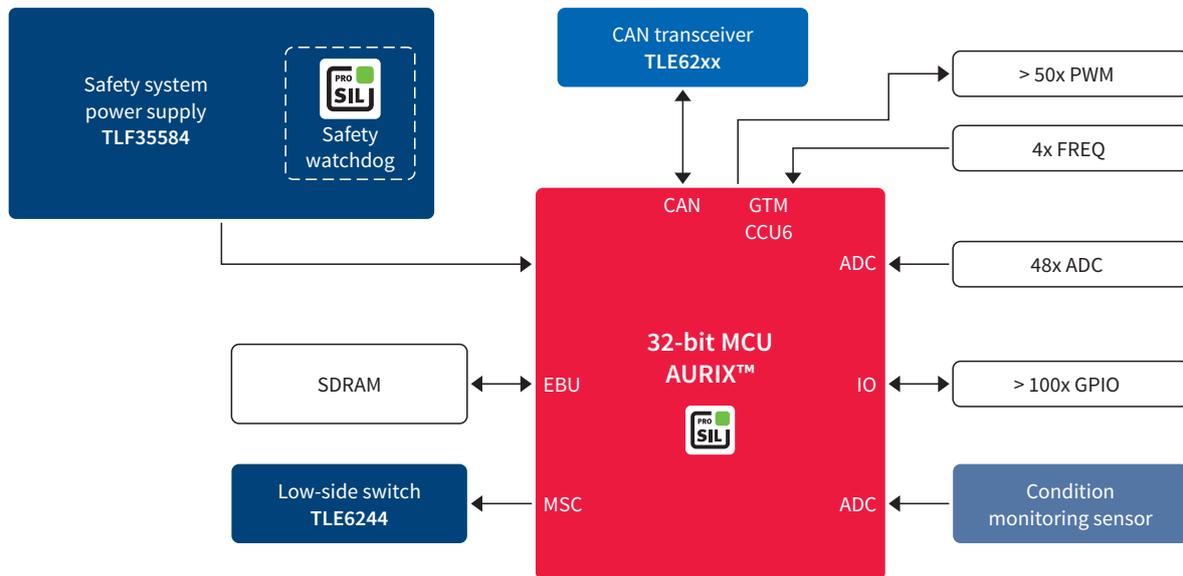
› The XMC™ family for real-time critical applications where an industry-standard core is needed
› The AURIX™ family for applications where more performance, connectivity, safety and security are needed

XMC1000
ARM® Cortex®-M0
CPU up to 48 MHz
Flash: 8–200 kB
Package: 16–64 pins

XMC4000
ARM® Cortex®-M4F
CPU up to 144 MHz
Flash: 64 k–2 MB
Package: 48–196 pins

AURIX™ TC2x[1)]
TriCore™
Up to 3x multicore
CPU up to 300 MHz
Flash: 0.5–8 MB
Package: 80–516 pins

AURIX™ TC3x[1)]
TriCore™
Up to 6x multicore
CPU up to 300 MHz
Flash: 1–16 MB
Package: 100–516 pins

1) AURIX™ devices add safety and CAN FD

www.infineon.com/industrial

IO controller

Application example

Application features

› Closed-loop control of solenoid currents
› Multitasking to drive hydraulic and electric actuators
› IEC 61131-3 support
› Tasking/Green Hills/GNU(HighTec)/windriver toolchain
› Ready for harsh environments
› IEC 61508 support – Safety Integrity Level (SIL) 1 to 3

Suggested products

› TC29xT
› TC36x
› TC37x
› TC38x
› TC39x

System benefits

› Scalable family with compatibility: software, pin-out
› High-speed up to 6x 300 MHz asymmetric
  single/dual/triple core
› 100 Pulse-Width-Modulated (PWM) outputs
› Four 12-bit Analog to Digital Converters (SAR-ADC)
› 12-bit, up to 60 channels
› DS-ADC converter
› Temperature range up to T_a = 150°C, T_j = 175°C
› Up to 12 CAN or CAN FD nodes
› Large portfolio with long-term availability

Servo drives

Application example
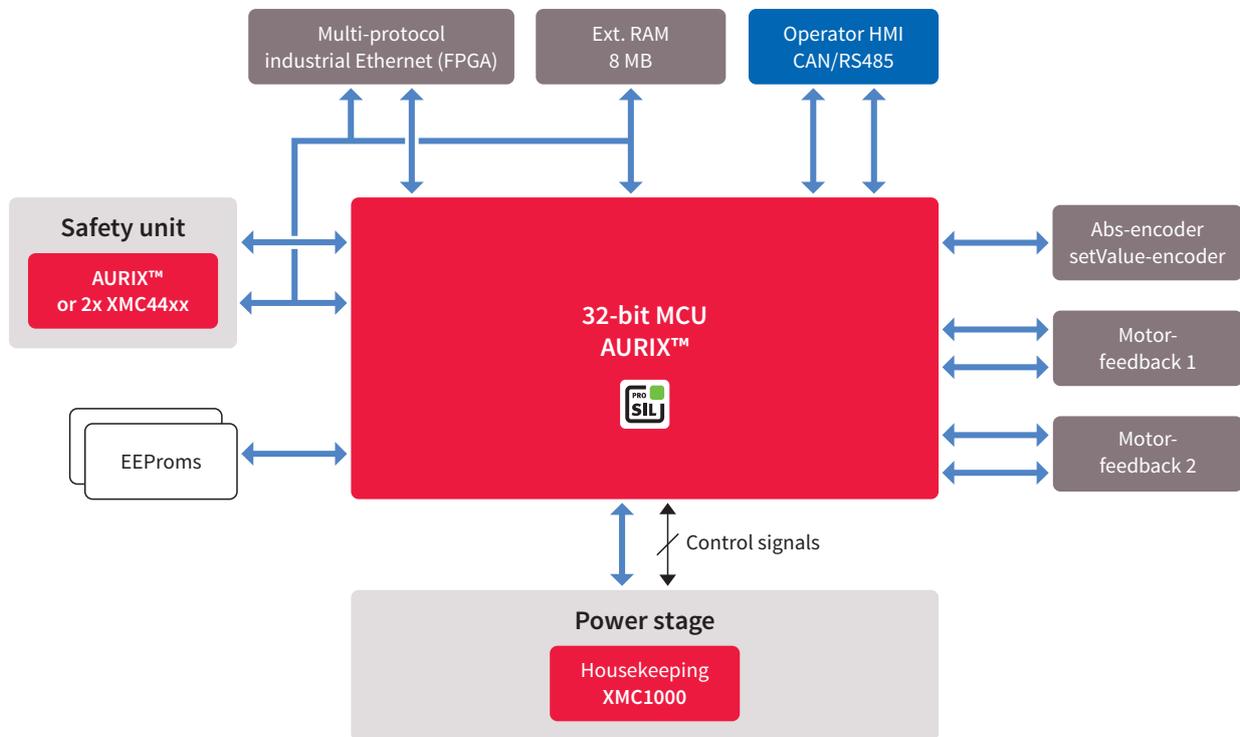
Application features
› High computing performances
› High level of accuracy, integration and efficiency
› Safety management in line with current norms
› Supports a different variant of drives portfolio
› Security features that protect intellectual property from
  counterfeiting

Suggested products
› TC26x
› TC27x
› TC29xT
› TC33x
› TC36x
› TC37x
› TC38x
› TC39x
› XMC1000
› XMC44xx

System benefits
› Scalable portfolio
› High computing performance thanks to
  multicore architecture
› Ability to drive numerous servo motors
› High flexibility thanks to tailored peripherals
› Integrated safety support
› Integrated security with hardware security module
› Large portfolio with long-term availability

www.infineon.com/motorcontrol

Industrial robotics

Application example
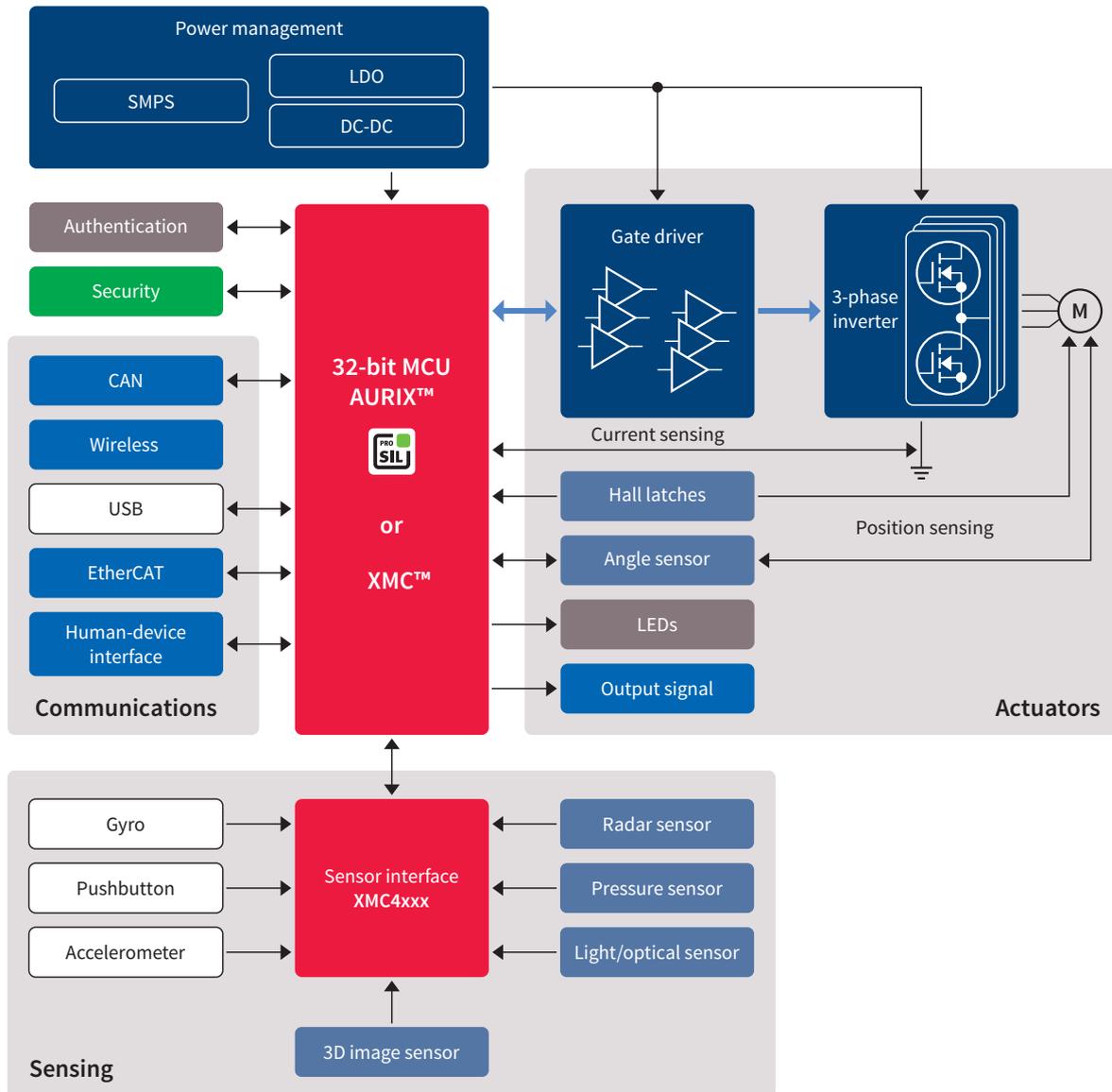
Application features

› High computing performances
› High level of accuracy, integration and efficiency
› Safety management in line with current norms
› Various topologies for axes, joints and motors
› Security features that protect intellectual property
   from counterfeiting

Suggested products

› TC23x   › TC38x
› TC33x   › TC39x
› TC36x   › XMC4xxx
› TC37x

System benefits

› High computing performance: up to 6x 300 MHz
› High flexibility thanks to tailored peripherals
› Integrated safety support
   (EN ISO 10218 and ISO/TS15066)
› Integrated security with hardware security module
› Robust 3 V-, 5 V-, LVDS – PortPins
› Large portfolio with long-term availability

www.infineon.com/industrial-robotics

Elevators

Application example
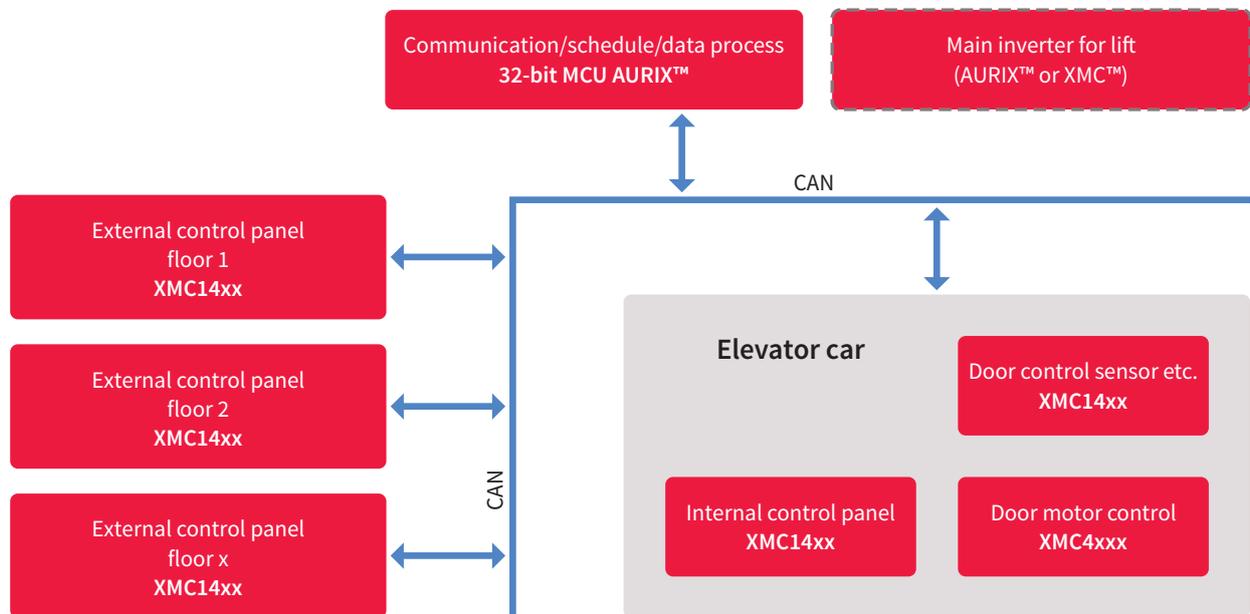
Application features
› Multiprocessor support for reliability and safety
› Platform concept to allow extensive customization
› Up to 12 CAN for communication in system
› External bus interface (32-bit) with cache
› SRAM up to 6.9 MB
› Flash up to 16 MB
› Long-term availability

Suggested products
› TC33x
› TC36x
› TC37x
› TC38x
› TC39x
› XMC14xx
› XMC4xxx

System benefits
› High computing performance: up to 6x 300 MHz
› Scalable family with compatibility: software, pin-out
› High-speed asymmetric single/dual/triple core
› Up to 12 CAN or CAN FD nodes
› Resolver I/F
› Encoder I/F with digital noise filter
› Safety requirements supported up to IEC 61508/SIL-3

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Inverters

Application example
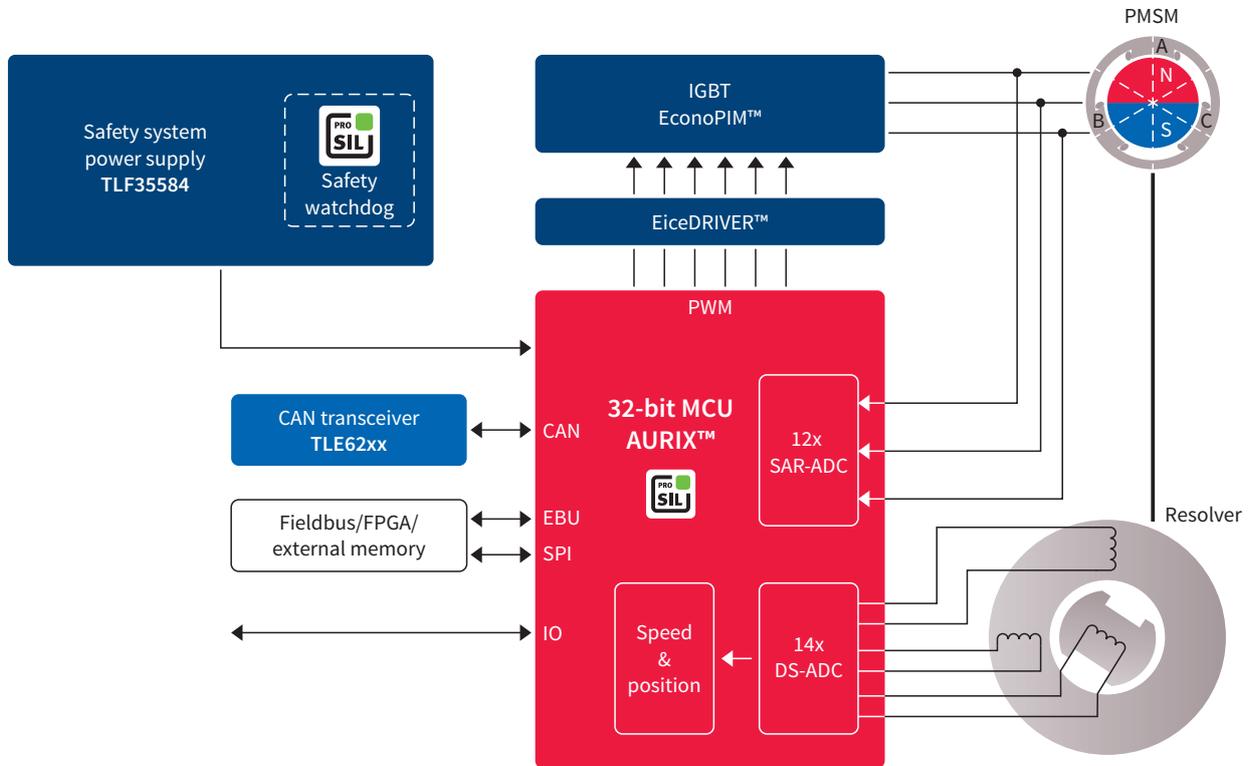
Application features

> Multi-axis controller for two 3-phase complementary PWMs
> Multiple modulation strategies (SVPWM, DPWM, soft-PWM, direct torque control) to support requirements aimed at reducing noise emissions and increasing efficiency
> Ready for four Q-inverters, matrix-inverters
> Field-oriented control with less than 10% CPU load
> Multiprocessor support for reliability and safety
> Support for 3-level inverter topologies
> High computing performance up to 6x 300 MHz
> Up to 6.9 MB internal RAM

Suggested products

> TC33x
> TC36x
> TC37x
> TC38x
> TC39x

System benefits

> Scalable and compatible portfolio
> Diverse high-performance timer architectures
> Up to 12 SAR-ADCs 12-bit resolution
> Up to 14 DS-ADC
> Resolver I/F
> Encoder I/F with digital noise filter
> Very fast control loop
> IEC 61508 support – Safety Integrity Level (SIL) 1 to 3
> Innovative single power supply concept
> Large portfolio with long-term availability

Wind turbine inverters

Application example

Application features
› Reliable blade pitch control
› Increased wind turbine efficiency
› Multiple modulation strategies (SVPWM, DPWM, soft-PWM, direct torque control) to support requirements aimed at reducing noise emissions and increasing efficiency
› Multiprocessor support for reliability and safety
› Support for 3-level inverter topologies

Suggested products
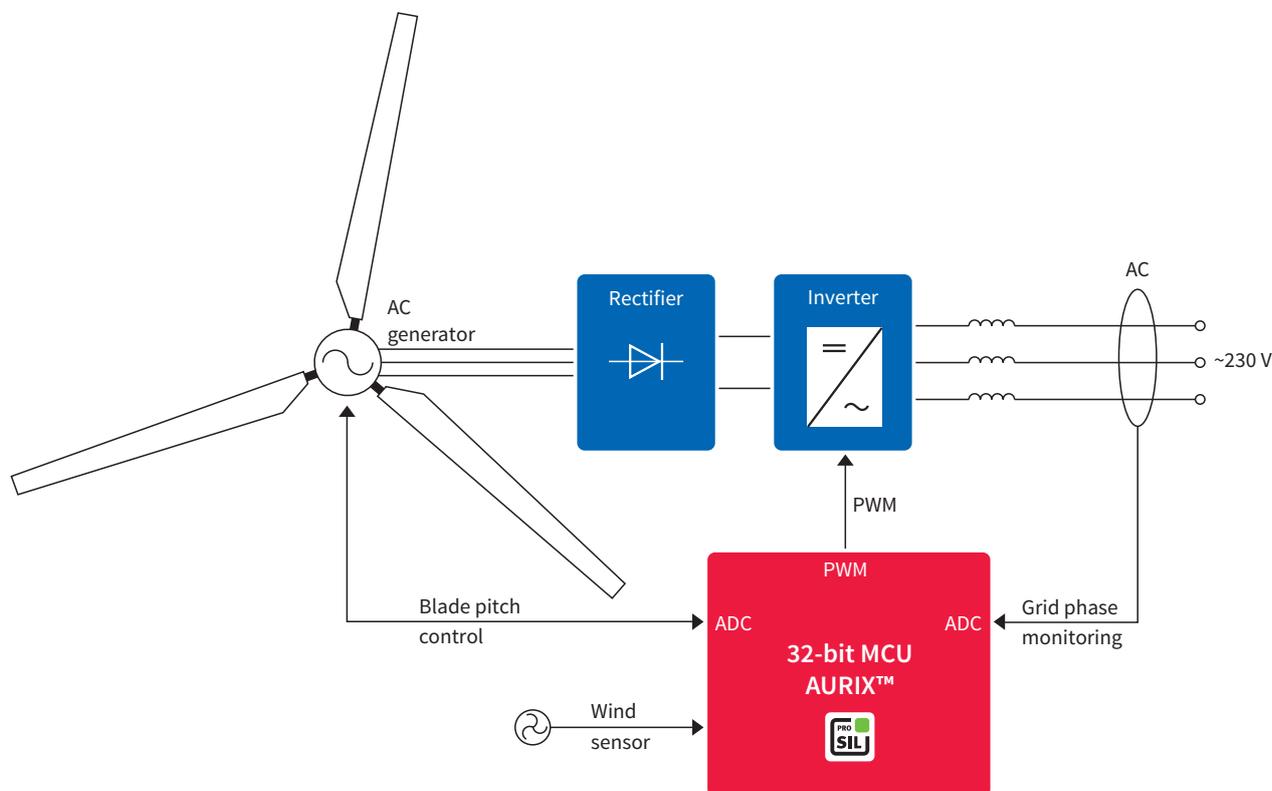› TC33x
› TC36x
› TC37x
› TC38x
› TC39x

System benefits
› Scalable and compatible portfolio
› Diverse high-performance timer architectures
› Up to 12 SAR-ADCs 12-bit resolution
› Up to 14 DS-ADC
› Resolver I/F
› Encoder I/F with digital noise filter
› IEC 61508 support – Safety Integrity Level (SIL) 1 to 3
› Large portfolio with long-term availability

www.infineon.com/wind

Solar panels

Application example

Application features

› Multi-phase PWM controller for single or multiple strings
› Multiple modulation strategies (SVPWM, DPWM, soft-PWM, direct torque control) to support requirements aimed at reducing noise emissions and increasing efficiency
› Maximum Power Point Tracking (MPPT) to extract maximum power from solar panels
› Grid phase monitoring and synchronization to ensure power factor unity
› Current control to avoid disharmony and determine the feed-in refund
› Support for 3-level inverter topologies

Suggested products

› TC33x
› TC36x
› TC37x
› TC38x
› TC39x

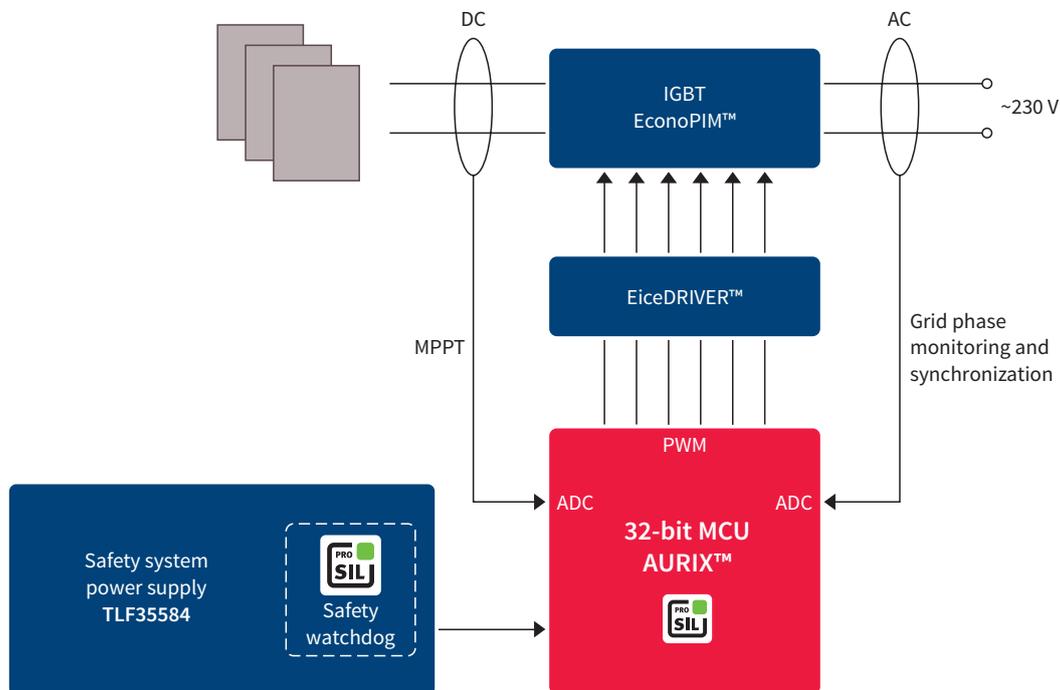## System benefits

› Scalable and compatible portfolio
› Diverse high-performance timer architectures
› Up to 12 SAR-ADCs 12-bit resolution
› Up to 14 DS-ADC
› Resolver I/F
› Encoder I/F with digital noise filter
› IEC 61508 support – Safety Integrity Level (SIL) 1 to 3
› DSP library available
› Large portfolio with long-term availability

www.infineon.com/solar

AUR

Embedded software RTOS and AUTOSAR

AbsInt   Altium   ARGUS CYBER SECURITY

easycore   EB   embedded brains

escrypt Embedded Security by ETAS   ETAS   euros

expresslogic   EVIDENCE EMBEDDING TECHNOLOGY   GLIWA

HIGHTEC   INTEGRITY SECURITY SERVICES   KPIT

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VECTOR   XAIN.

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astc   MathWorks   SYNOPSYS

Integrated Compiler Environments

Altium   Green Hills SOFTWARE   HIGHTEC   WIND AN INTEL COMPANY

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ANSYS   dSPACE   emmtrix Technologies

ETAS   SILEXICA

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AbsInt   GLIWA

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tech J&D Tech Co., Ltd   LAUTERBACH DEVELOPMENT TOOLS

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IntrepidCS   VECTOR

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Algocraft SOLUTIONS FOR THE PROGRAMMING INDUSTRY   btv

ELNEC   ertec

HTV   OpteeQ

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PHYTEC

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pls
Development Tools

Feature overview AURIX™ family

TriCore™ microcontroller

Product type	Max clock frequency [MHz]	Program memory [KByte]	SRAM (incl. cache) [KByte]	Co-processor [1]	Cores/lockstep	Timed I/O GPI/O	Number of ADC channels	External bus interface	CAN/CAN FD nodes	Communication interfaces [2]	Temperature ranges [3]	Packages	Additional features/ remarks [4]
AURIX™ TC2xx family													
TC299TX	300	8000	2728	FPU	3/1	263	84/10 DS	Yes	6	4x ASCLIN, 6x QSPI, 3x MSC, 2x I²C, 15x SENT, HSSL, 5x PSI5, 2x FlexRay, Ethernet	K	LFBGA-516	EVR, STBU, HSM
TC299TP	300	8000	728	FPU	3/1	263	84/10 DS	Yes	6	4x ASCLIN, 6x QSPI, 3x MSC, 2x I²C, 15x SENT, HSSL, 5x PSI5, 2x FlexRay, Ethernet, CAN FD	K	LFBGA-516	EVR, STBU, HSM
TC298TP	300	8000	728	FPU	3/1	232	60/10 DS	Yes	6	4x ASCLIN, 6x QSPI, 3x MSC, 2x I²C, 15x SENT, HSSL, 5x PSI5, 2x FlexRay, Ethernet	K	LBGA-416	EVR, STBU, HSM
TC297TA	300	8000	2728	FPU, FFT, CIF	3/1	169	60/10 DS	No	6	4x ASCLIN, 6x QSPI, 3x MSC, 2x I²C, 15x SENT, HSSL, 5x PSI5, 2x FlexRay, Ethernet	K	LFBGA-292	EVR, STBU, HSM
TC297TX	300	8000	2728	FPU	3/1	263	60/10 DS	No	6	4x ASCLIN, 6x QSPI, 3x MSC, 2x I²C, 15x SENT, HSSL, 5x PSI5, 2x FlexRay, Ethernet	K	LFBGA-292	EVR, STBU, HSM
TC297TP	300	8000	728	FPU	3/1	169	60/10 DS	No	6	4x ASCLIN, 6x QSPI, 3x MSC, 2x I²C, 15x SENT, HSSL, 5x PSI5, 2x FlexRay, Ethernet, CAN FD	K	LFBGA-292	EVR, STBU, HSM
TC277TP	200	4000	472	FPU	3/2	169	60/6 DS	No	4	4x ASCLIN, 4x QSPI, 2x MSC, HSSL, I²C, 10x SENT, 3x PSI5, FlexRay, Ethernet, CAN FD	K	LFBGA-292	EVR, WUT, HSM
TC275TP	200	4000	472	FPU	3/2	112	48/6 DS	No	4	4x ASCLIN, 4x QSPI, 2x MSC, HSSL, I²C, 10x SENT, 3x PSI5, FlexRay, Ethernet, CAN FD	K	LQFP-176	EVR, WUT, HSM
TC267D	200	2500	240	FPU	02/1	169	50/3 DS	No	5	4x ASCLIN, 4x QSPI, 2x MSC, I²C, 10x SENT, 3x PSI5, HSSL, FlexRay, Ethernet, CAN FD	K	LFBGA-292	EVR, STBU
TC265D	200	2500	240	FPU	2/1	112	50/3 DS	No	5	4x ASCLIN, 4x QSPI, 2x MSC, I²C, 10x SENT, HSSL, 3x PSI5, FlexRay, Ethernet, CAN FD	K	LQFP-176	EVR, STBU
TC264DA	200	2500	752	FPU, FFT, CIF	2/1	88	40/3 DS	No	5	4x ASCLIN, 4x QSPI, 2x MSC, I²C, 10x SENT, HSSL, 3x PSI5, FlexRay, Ethernet, CAN FD	K	LQFP-144	EVR, STBU
TC264D	200	2500	240	FPU	2/1	88	40/3 DS	No	5	4x ASCLIN, 4x QSPI, 2x MSC, I²C, 10x SENT, HSSL, 3x PSI5, FlexRay, Ethernet, CAN FD	K	LQFP-144	EVR, STBU
TC237LP	200	2000	192	FPU	1/1	120	24	No	6	2x ASCLIN, 4x QSPI, 4x SENT, FlexRay, CAN FD	K	LFBGA-292	EVR, WUT, HSM
TC234LA	200	2000	704	FPU, FFT	1/1	120	24	No	6	2x ASCLIN, 4x QSPI, 4x SENT, FlexRay, Ethernet	K	TQFP-144	EVR, WUT, HSM
TC234LX	200	2000	704	FPU	1/1	120	24	No	6	2x ASCLIN, 4x QSPI, 4x SENT, FlexRay, Ethernet	K	TQFP-144	EVR, WUT, HSM
TC234LP	200	2000	192	FPU	1/1	120	24	No	6	2x ASCLIN, 4x QSPI, 4x SENT, FlexRay, CAN FD	K	TQFP-144	EVR, WUT, HSM
TC233LP	200	2000	192	FPU	1/1	78	24	No	6	2x ASCLIN, 4x QSPI, 4x SENT, FlexRay, CAN FD	K	TQFP-100	EVR, WUT, HSM
TC224L	133	1000	96	FPU	1/1	120	24	No	3	2x ASCLIN, 4x QSPI, 4x SENT	K	TQFP-144	EVR, WUT
TC223L	133	1000	96	FPU	1/1	78	24	No	3	2x ASCLIN, 4x QSPI, 4x SENT	K	TQFP-100	EVR, WUT
TC222L	133	1000	96	FPU	1/1	59	14	No	3	2x ASCLIN, 4x QSPI, 4x SENT	K	TQFP-80	EVR, WUT
TC214L	133	500	96	FPU	1/1	120	24	No	3	2x ASCLIN, 4x QSPI, 4x SENT	K	TQFP-144	EVR, WUT
TC213L	133	500	96	FPU	1/1	78	24	No	3	2x ASCLIN, 4x QSPI, 4x SENT	K	TQFP-100	EVR, WUT
TC212L	133	500	96	FPU	1/1	59	14	No	3	2x ASCLIN, 4x QSPI, 4x SENT	K	TQFP-80	EVR, WUT

1) CIF = Camera and external ADC interface, FFT = Fast Fourier Transform Accelerator, FPU = Floating Point Unit, PCP = Peripheral Control Processor
2) ASC = Asynchronous Serial Channel, ASCLIN = Asyn/Synchronous Local Interconnect Network, HSSL = High Speed Serial Link, I²C = Inter-Integrated Circuit, LIN = Local Interconnect Network, MLI = Micro Link Interface, MSC = Micro Second Channel, PSI5 = Peripheral Sensor Interface 5, QSPI = Queued Serial Peripheral Interface, SENT = Single Edge Nibble Transmission, SSC = Synchronous Serial Channel
3) Ambient temperature range: A = -40 … 140°C, B = 0 … 70°C, F = -40 … 85°C, H = -40 … 110°C, K = -40 … 125°C, L = -40 … 150°C, X = -40 … 105°C
4) EVR = Embedded Voltage Regulator, HSM = Hardware Security Module, STBU = Stand-by Control Unit, WUT = Wake-Up Timer

www.infineon.com/TriCore

TriCore™ microcontroller

Product type	Cores/lockstep	Max clock frequency [MHz]	Program memory [KByte]	SRAM (incl. cache) [KByte]	Radar accelerator/ radar interface [1]	CAN/CAN FD nodes	Ethernet 100/1000 Mbit	External bus interface [2]	Communication interfaces	HSM	Temperature ranges	Packages	Additional features/ remarks [3]
AURIX™ TC3xx family													
TC399XX	6/4	300	16000	6912	no	12	1	EBU, eMMC, 2x HSSL	6x SPI, 2x FlexRay, 12x LIN, 25x SENT, 4x PSI5, 2x I²C, 4x MSC	EVITA full	K, L	LFBGA-516	5 V/3.3 V EVR, 8-bit SCR
TC399XP	6/4	300	16000	2816	no	12	1	EBU, eMMC, 2x HSSL	6x SPI, 2x FlexRay, 12x LIN, 25x SENT, 4x PSI5, 2x I²C, 4x MSC	EVITA full	K, L	LFBGA-516	5 V/3.3 V EVR, 8-bit SCR
TC397XX	6/4	300	16000	6912	no	12	1	eMMC, 2x HSSL	6x SPI, 2x FlexRay, 12x LIN, 25x SENT, 4x PSI5, 2x I²C, 4x MSC	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
TC397XP	6/4	300	16000	2816	no	12	1	eMMC, 2x HSSL	6x SPI, 2x FlexRay, 12x LIN, 25x SENT, 4x PSI5, 2x I²C, 4x MSC	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
TC397XA	6/4	300	16000	6912	2x SPU/ 8x 400 Mbit/s LVDS	12	1	2x HSSL	6x SPI, 2x FlexRay, 12x LIN, 25x SENT, 4x PSI5, 2x I²C, 4x MSC	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
TC3E7QX	4/2	300	12000	1824	no	20	1	HSSL	5x SPI, 2x FlexRay, 24x LIN, 25x SENT, 4x PSI5, 2x I²C, 3x MSC	EVITA full	K, L	BGA-291	5 V/3.3 V EVR, 8-bit SCR
TC389QP	4/2	300	10000	1568	no	12	1	HSSL	5x SPI, 2x FlexRay, 24x LIN, 25x SENT, 4x PSI5, 2x I²C, 3x MSC	EVITA full	K, L	LFBGA-516	5 V/3.3 V EVR, 8-bit SCR
TC387QP	4/2	300	10000	1568	no	12	1	HSSL	5x SPI, 2x FlexRay, 24x LIN, 25x SENT, 4x PSI5, 2x I²C, 3x MSC	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
TC377TX	3/3	300	6000	4208	no	12	2	eMMC, HSSL	5x SPI, 1x FlexRay, 12x LIN, 15x SENT, 2x PSI5, 1x I²C, 2x MSC	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
TC377TP	3/2	300	6000	1136	no	8	1	HSSL	5x SPI, 1x FlexRay, 12x LIN, 15x SENT, 2x PSI5, 1x I²C, 2x MSC	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
TC375TP	3/2	300	6000	1136	no	8	1	HSSL	5x SPI, 1x FlexRay, 12x LIN, 15x SENT, 2x PSI5, 1x I²C, 2x MSC	EVITA full	K, L	LQFP-176	5 V/3.3 V EVR, 8-bit SCR
TC367DP	2/2	300	4000	672	no	8	1	HSSL	4x SPI, 1x FlexRay, 12x LIN, 10x SENT, 2x PSI5, 1x I²C, 1x MSC	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
TC366DP	2/2	300	4000	672	no	8	1	HSSL	4x SPI, 1x FlexRay, 12x LIN, 10x SENT, 2x PSI5, 1x I²C, 1x MSC	EVITA full	K, L	BGA-180	5 V/3.3 V EVR, 8-bit SCR
TC365DP	2/2	300	4000	672	no	8	1	HSSL	4x SPI, 1x FlexRay, 12x LIN, 10x SENT, 2x PSI5, 1x I²C, 1x MSC	EVITA full	K, L	LQFP-176	5 V/3.3 V EVR, 8-bit SCR
TC364DP	2/2	300	4000	672	no	8	1	HSSL	4x SPI, 1x FlexRay, 12x LIN, 10x SENT, 2x PSI5, 1x I²C, 1x MSC	EVITA full	K, L	TQFP-144	5 V/3.3 V EVR, 8-bit SCR
TC364DP	2/2	300	4000	672	no	8	1	HSSL	4x SPI, 1x FlexRay, 12x LIN, 10x SENT, 2x PSI5, 1x I²C, 1x MSC	EVITA full	K, L	LQFP-144	5 V/3.3 V EVR, 8-bit SCR
TC3A7QA	4/2	300	4000	7456	2x SPU/ 8x 600 Mbit/s LVDS	8	1	no	4x SPI, 1x FlexRay, 4x LIN	EVITA full	K, L	BGA-292	5 V/3.3 V EVR, 8-bit SCR
TC3A8QA	4/2	300	4000	7456	2x SPU/ 8x 600 Mbit/s LVDS	8	1	no	4x SPI, 1x FlexRay, 4x LIN	EVITA full	K, L	BGA-233	5 V/3.3 V EVR, 8-bit SCR
TC357TA	3/2	300	4000	3664	2x SPU/ 8x 400 Mbit/s LVDS	8	1	no	4x SPI, 1x FlexRay, 4x LIN	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
TC356TA	3/2	300	4000	3664	2x SPU/ 8x 400 Mbit/s LVDS	8	1	no	4x SPI, 1x FlexRay, 4x LIN	EVITA full	K, L	BGA-180	5 V/3.3 V EVR, 8-bit SCR
TC337DA	2/1	300	2000	1568	1x SPU/ 4x 400 Mbit/s LVDS	8	1	eMMC	4x SPI, 1x FlexRay, 12x LIN, 6x SENT	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
TC336DA	2/1	300	2000	1568	1x SPU/ 4x 400 Mbit/s LVDS	8	1	eMMC	4x SPI, 1x FlexRay, 12x LIN, 6x SENT	EVITA full	K, L	BGA-180	5 V/3.3 V EVR, 8-bit SCR
TC337LP	1/1	300	2000	248	no	8	no	no	4x SPI, 1x FlexRay, 12x LIN, 6x SENT	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
TC336LP	1/1	300	2000	248	no	8	no	no	4x SPI, 1x FlexRay, 12x LIN, 6x SENT	EVITA full	K, L	BGA-180	5 V/3.3 V EVR, 8-bit SCR
TC334LP	1/1	300	2000	248	no	8	no	no	4x SPI, 1x FlexRay, 12x LIN, 6x SENT	EVITA full	K, L	TQFP-144	5 V/3.3 V EVR, 8-bit SCR
TC333LP	1/1	300	2000	248	no	8	no	no	4x SPI, 1x FlexRay, 12x LIN, 6x SENT	EVITA full	K, L	TQFP-100	5 V/3.3 V EVR, 8-bit SCR
TC332LP	1/1	300	2000	248	no	8	no	no	4x SPI, 1x FlexRay, 12x LIN, 6x SENT	EVITA full	K, L	TQFP-80	5 V/3.3 V EVR, 8-bit SCR
TC327LP	1/1	160	1000	96	no	8	no	no	4x SPI, 6x SENT, 6x LIN	EVITA full	K, L	LFBGA-292	5 V/3.3 V EVR, 8-bit SCR
TC324LP	1/1	160	1000	96	no	8	no	no	4x SPI, 6x SENT, 6x LIN	EVITA full	K, L	TQFP-144	5 V/3.3 V EVR, 8-bit SCR
TC323LP	1/1	160	1000	96	no	8	no	no	4x SPI, 6x SENT, 6x LIN	EVITA full	K, L	TQFP-100	5 V/3.3 V EVR, 8-bit SCR
TC322LP	1/1	160	1000	96	no	8	no	no	4x SPI, 6x SENT, 6x LIN	EVITA full	K, L	TQFP-80	5 V/3.3 V EVR, 8-bit SCR

1) SPU = Signal Processing Unit
2) HSSL = High-Speed Serial Link
3) 8-bit SCR = Standby Controller for Low Power Modes, EVR = Embedded Voltage Regulator

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