



# OPTIREG™ PMIC

Automotive Power Management ICs  
for safety-relevant application



# Power Integration & Supply Portfolio & Quality



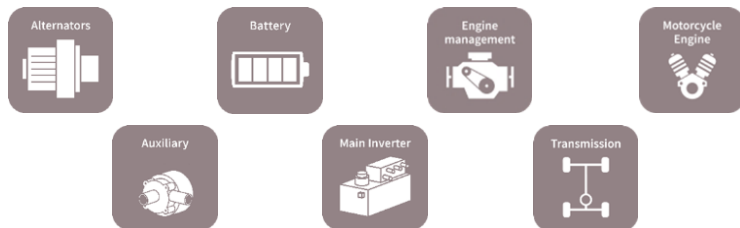
# ATV PS

## Product lines and product families

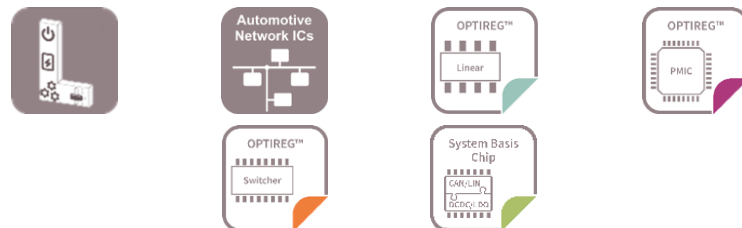


### ATV PS Power Integration & Supply

#### ATV PS IDS: Integrated Drivetrain Solutions



#### ATV PS PSS: ATV PS PSS – Power Supply Solutions



Automotive Body / Chassis / Infotainment / Powertrain / Safety / CAV

#### Product Portfolio

- › [Alternator ICs](#)
- › [Battery Management ICs](#)
- › [Engine Control ICs / Small Engine Control ICs](#)
- › [EiceDRIVER™ \(Isolated High Voltage ICs\)](#)
- › [High Voltage ICs \(Gate Driver\)](#)
- › [Transmission ICs](#)

- › [In-Vehicle Network ICs](#)
- › [OPTIREG™ PMICs](#)
- › [OPTIREG™ Application Specific PMICs \(coming Q4/2020\)](#)
- › [OPTIREG™ Linear ICs](#)
- › [OPTIREG™ Switcher ICs](#)
- › [OPTIREG™ System Basis Chips](#)

# General trends in automotive applications

## Application

System  
Efficiency

Extend Lifetime &  
Higher Temperature

Functional  
Safety

Reduce BOM Cost

Miniaturization by  
Integration



## Technical

Quiescent Current  
Dropout Voltage

Beyond AEC Q  
Wider operating  $V_{IN}$   
ISO26262  
up to ASIL-D

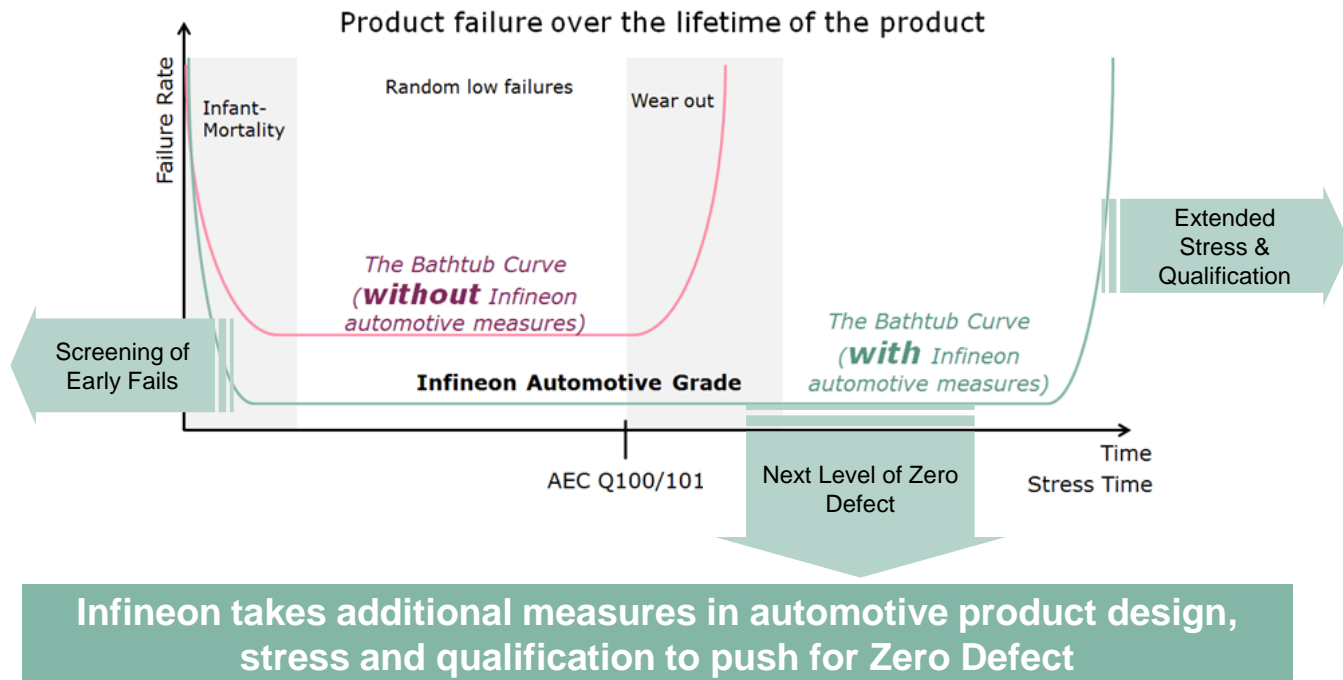
Number & Value of  
external Components  
Smaller Output  
Capacitors  
Smaller Footprint

**Infineon's Automotive Power Integration & Supply – the enabler for success**

# Premium Quality

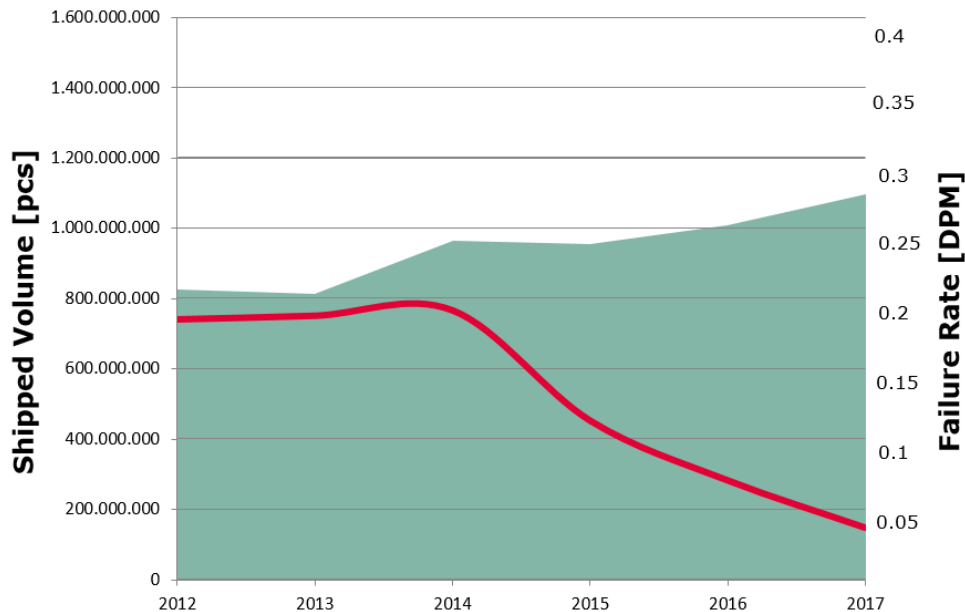
## Zero Defect – our invest

### Qualifying according AEC alone does not enable Zero Defect over 15+ years of product life time



# Premium Quality

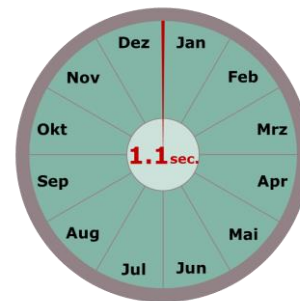
## Zero Defect – our results



OPTIREG™ Linear  
0.03 ppm

OPTIREG™ Switcher  
0.3 ppm

IVN Transceivers  
0.02 ppm



Reducing ppm rate significantly to 0.036 ppm while growing volume strongly over recent years

Shipping >1 billion OPTIREG™ & Transceivers and only seeing problems during the last 1.1 seconds of the year

# Power Supply Solutions Portfolio Overview



# Power Supply

## OPTIREG™ Product Families



### OPTIREG™

#### Leading Automotive Power Supply



#### OPTIREG™ Linear

Linear Power Supply Solutions



#### OPTIREG™ Switcher

Switch Mode Power Supply Solutions



#### OPTIREG™ PMIC

Integrated Power Supply Solutions



#### SBC

System Basis Chips

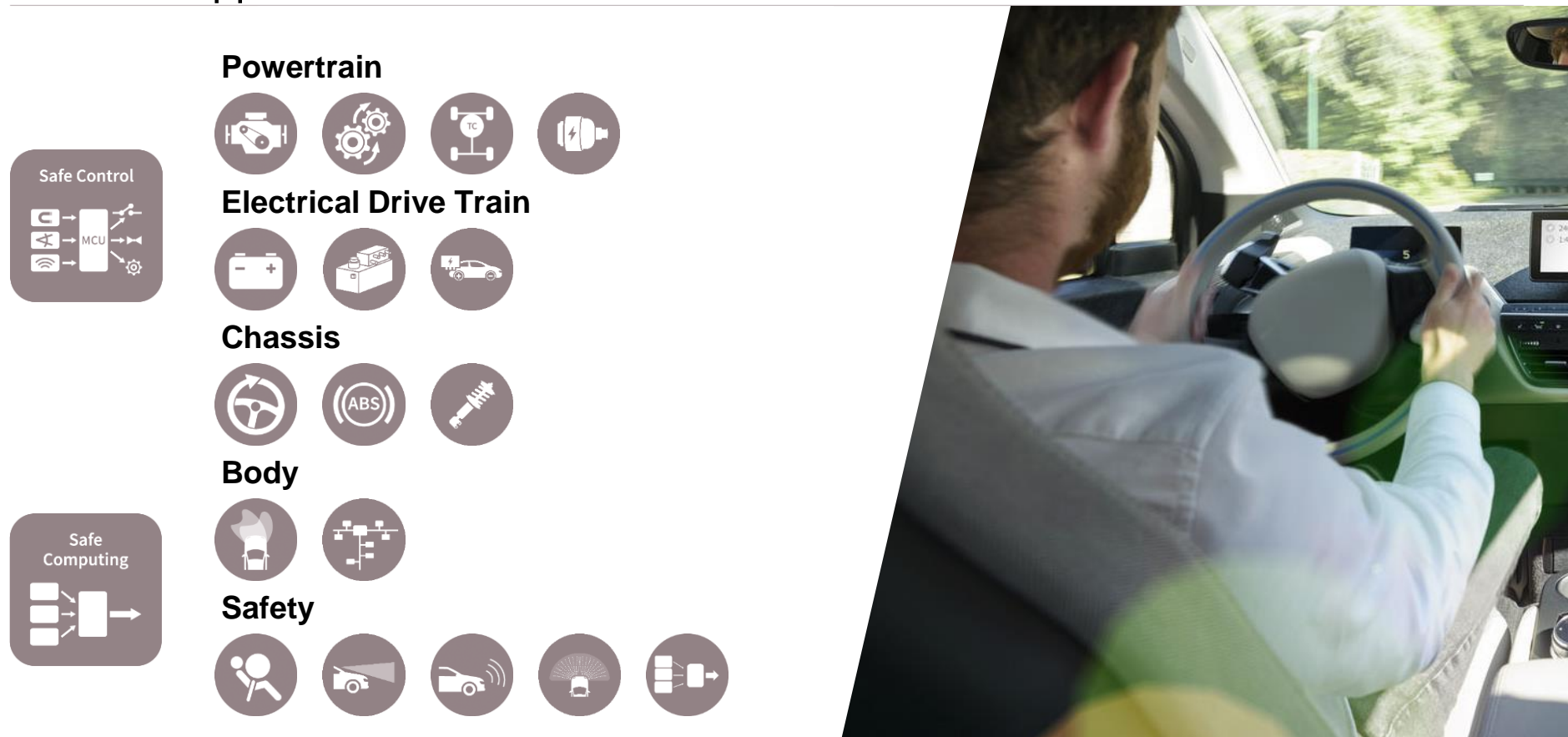
High Performance	Application Specifics	Switcher		PMIC	Lite	Mid-Range+
Trackers	Post Regulators	Switcher HC	Switcher HV	Application-Specific PMIC	DC-DC	Multi CAN
High Performance Lowest I <sub>q</sub>	Trackers Integrated protection	<ul style="list-style-type: none"><li>Wide input voltage range (automotive optimized)</li><li>Optimized for cranking application</li><li>Monitoring features</li><li>Wide temperature range</li></ul>		<ul style="list-style-type: none"><li>ISO26262-compliant up to ASIL-D</li><li>Multi-rail supplies w/ Pre-/Post-architecture</li><li>UV/OV-monitoring</li><li>Flexible safe state control</li><li>Window- &amp; Q/A-Watchdog</li><li>Application-specific features/architectures</li></ul>	<ul style="list-style-type: none"><li>Unparalleled scalability across Product Families for fast time-to-market</li><li>Supports latest networking standards CAN-FD with up to 5 Mbit/s</li><li>Interoperability &amp; EMC compliance test for component releases at all major OEMs</li></ul>	
Post Regulators High PSRR	Application Specifics Integrated features for 24 V & Antenna					
<ul style="list-style-type: none"><li>Body (BCM, HVAC, Dashboard)</li><li>Infotainment (Multimedia, Navigation, Telematics)</li><li>Chassis/ Safety (ADAS, EPS)</li><li>Powertrain/ EDT (EMS, Transmission)</li></ul>		<ul style="list-style-type: none"><li>Body (BCM, HVAC, Dashboard)</li><li>Infotainment (Multimedia, Navigation, Telematics)</li><li>Chassis/ Safety (ADAS, EPS)</li></ul>		<ul style="list-style-type: none"><li>Chassis/ Safety (ADAS, EPS)</li><li>Powertrain/ EDT (EMS, Transmission)</li></ul>	<ul style="list-style-type: none"><li>Body Systems</li><li>Comfort Systems</li><li>Chassis &amp; Safety</li><li>Powertrain</li><li>Hybrid &amp; Electric Vehicles</li></ul>	



# OPTIREG™ PMIC & Functional Safety

# Functional Safety

## Relevant applications



### Functional Safety

Absence of unreasonable risk due to hazards caused by malfunctioning behavior of electrical and/or electronic systems (E/E)

- › Technological complexity
- › Software content
- › Mechatronic implementations



Increasing risks from systematic failures and random hardware failures

### ISO26262

Guidance to mitigate these risks by providing requirements and processes

- › What has to be done?
- › How to do it

ensure the safety goals cannot be violated

ensure the safety mechanisms can be trusted

INTERNATIONAL  
STANDARD

**ISO  
26262-1**

Second edition  
2018-12

**Road vehicles — Functional safety —  
Part 1:  
Vocabulary**

*Véhicules routiers — Sécurité fonctionnelle —  
Partie 1: Vocabulaire*



Reference number  
ISO 26262-1:2018(E)

© ISO 2018

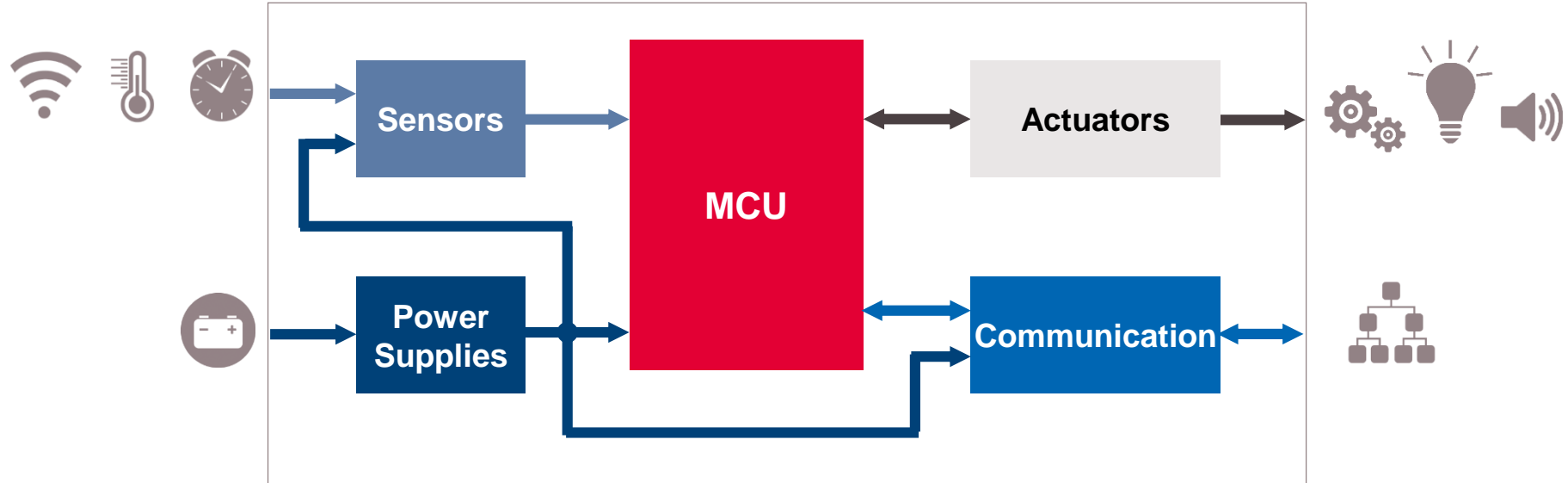
# Hazard analysis and risk assessment

## Determination of ASIL

Controllability
How easily the <b>hazardous situation</b> can be avoided by the driver
<ul style="list-style-type: none"> <li>› C0: Controllable in general</li> <li>› C1: Simply controllable</li> <li>› C2: Normally controllable</li> <li>› C3: Difficult to control or uncontrollable</li> </ul>
Exposure
Probability of an <b>operational situation</b> that could be <b>hazardous</b>
<ul style="list-style-type: none"> <li>› E0: Incredible unlikely</li> <li>› E1: Very low probability (rare operating conditions)</li> <li>› E2: Low probability</li> <li>› E3: medium probability</li> <li>› E4: High probability (most operating conditions)</li> </ul>
Severity
Worst case <b>harm</b> which could result from the <b>hazard event</b>
<ul style="list-style-type: none"> <li>› S0: No injuries</li> <li>› S1: light and moderate injuries</li> <li>› S2: Severe and life-threatening injuries (survival probable)</li> <li>› S3: life-threatening injuries (survival uncertain), fatal injuries</li> </ul>

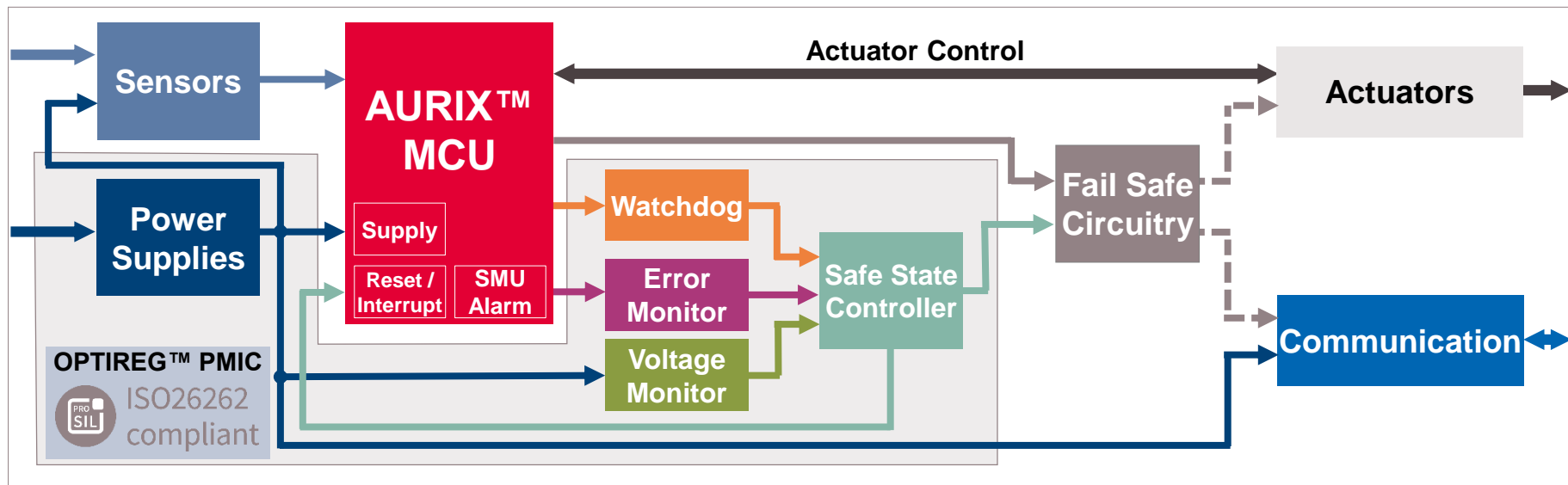
Controllability	Exposure	Severity			
		S0	S1	S2	S3
C1	E1	QM	QM	QM	QM
	E2	QM	QM	QM	QM
	E3	QM	QM	QM	A
	E4	QM	QM	A	B
C2	E1	QM	QM	QM	QM
	E2	QM	QM	QM	A
	E3	QM	QM	A	B
	E4	QM	A	B	C
C3	E1	QM	QM	QM	A
	E2	QM	QM	A	B
	E3	QM	A	B	C
	E4	QM	B	C	D

# Automotive system



**system:** set of components or subsystems that relates at least a sensor, a controller and an actuator with one another

# Automotive system



Safety MCU:  
System level hardware  
requirements



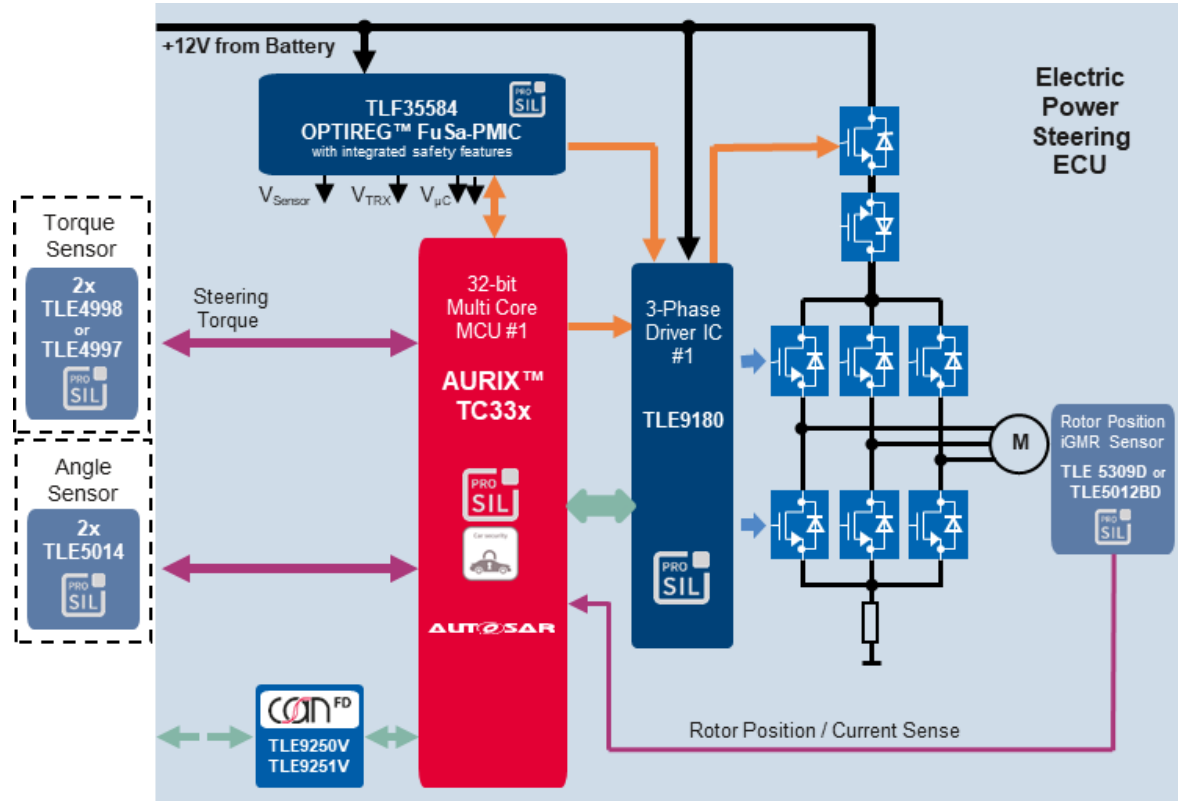
Safety path activated by  
microcontroller as main  
decision maker



Secondary safety path  
for faults that may lead  
to an unreliable MCU

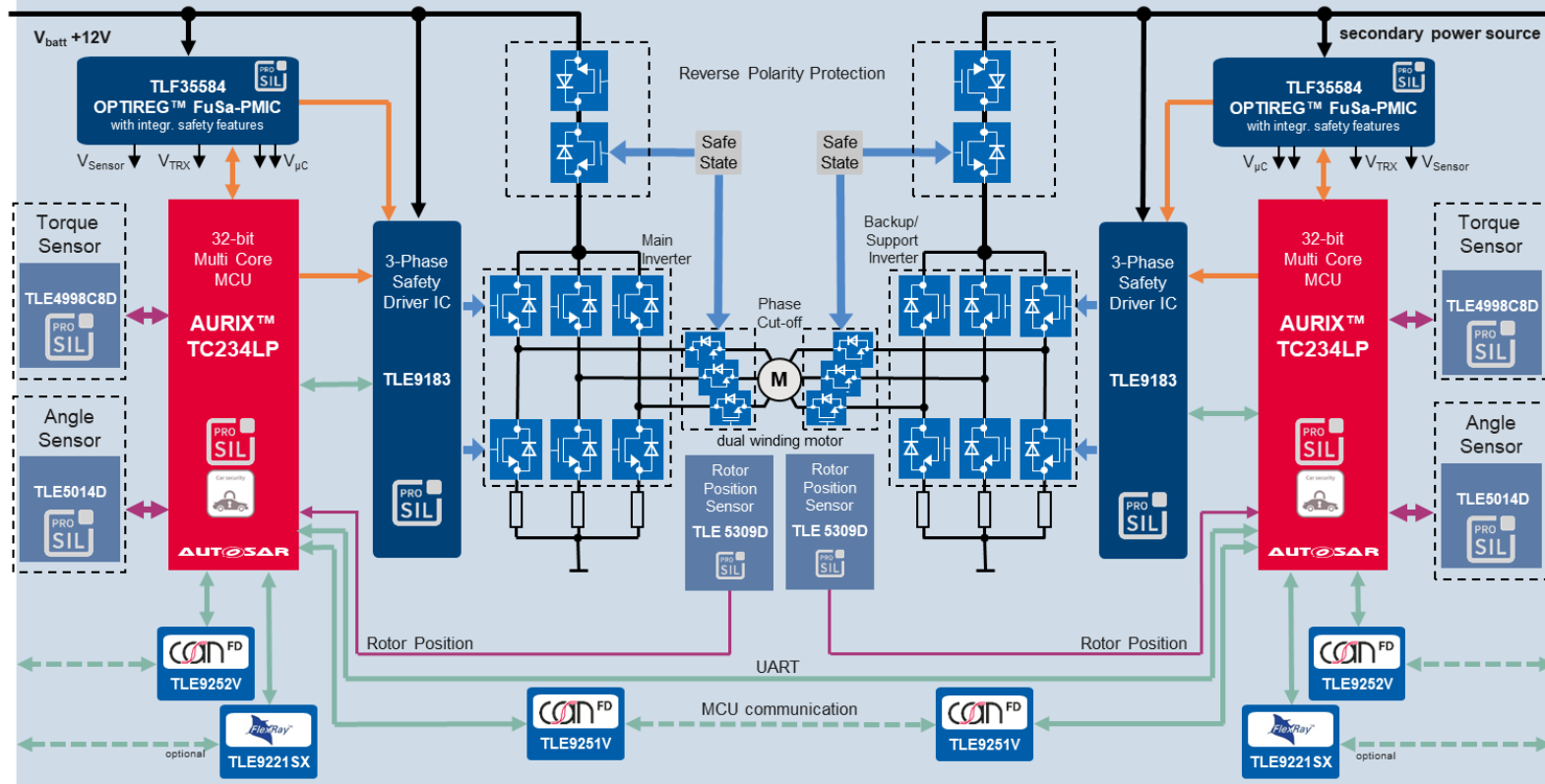
# Application example

## Fail-Safe EPS



# Application example

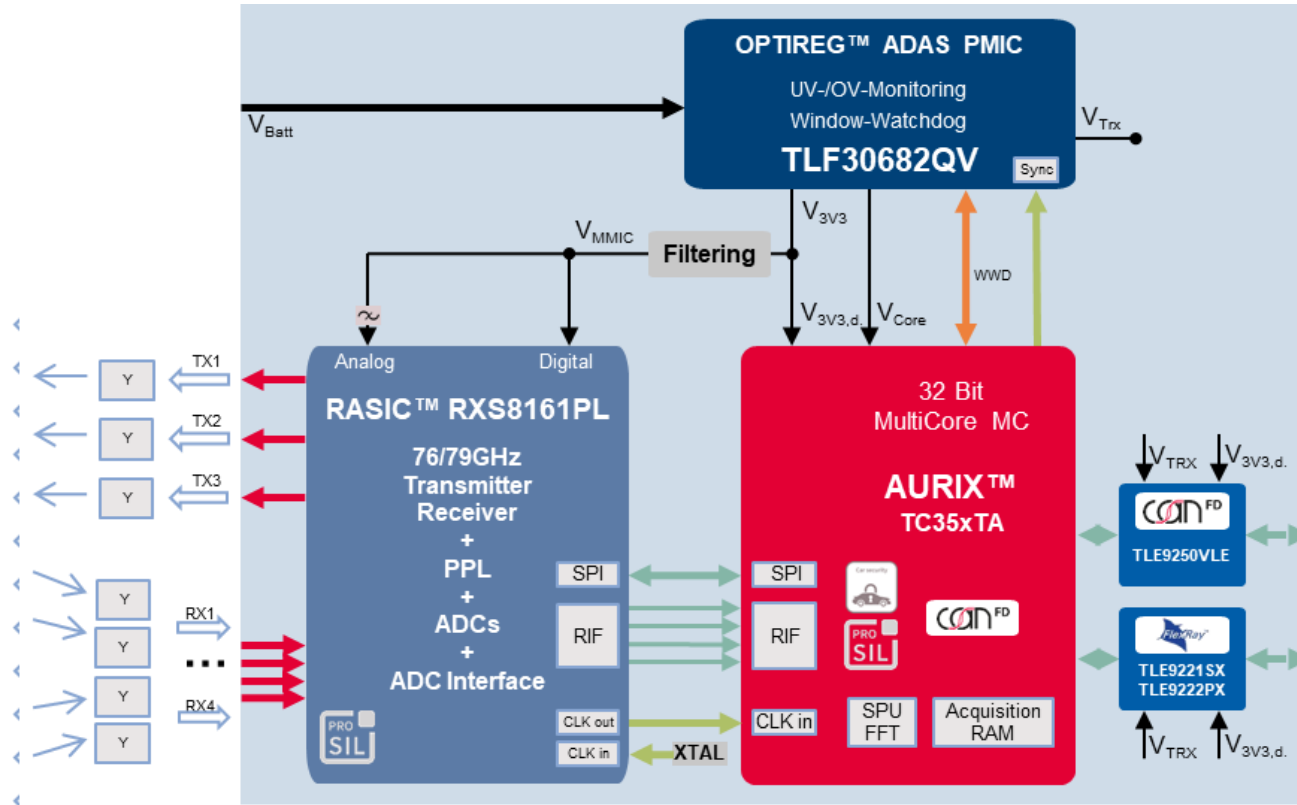
## Fail-Operational EPS





# Application example

## Fail-Silent Radar (mid-range)



# PMIC supervision

## Monitoring of fault events

### Voltage Monitor

- › Over voltage
- › Under voltage
- › Over current

### Watchdog

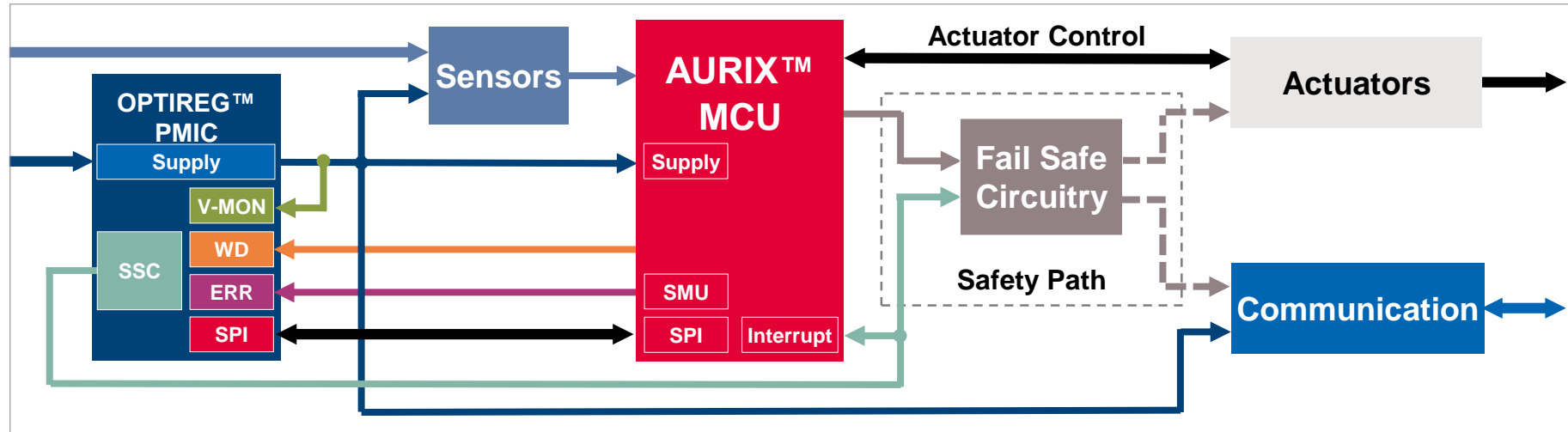
- › Timing error
- › Software execution error

### Error monitor

- › React on MCU Alarm

### PMIC internal

- › Internal supplies
- › SPI error
- › Thermal sensors
- › BIST



### Undervoltage- and overvoltage-monitoring

- › MCU supply rails
- › Peripherals supply rails (e.g. sensors, communication)
- › Optional: additional monitor channel(s) for external rails

### Multiple bandgap architecture (avoidance of common cause failures)

- › Available dedicated and independent for both supply block and safety block
- › Located in different areas of the chip (distance)
- › Mutual supervision of bandgap1 (supply block) and bandgap2 (safety block)

### Fault reactions (depending on kind and on what domain fault is occurring)

- › Reset
- › Shut down regulator / restart regulator
- › Signal to MCU through INT pin → Let MCU take further actions
- › Activation of secondary safety path → Override MCU, PMIC responsible for safe state of system

### Flexibility: Several MCU watchdog variants

- › **Window watchdog** – periodically triggered to monitor the MCU's behavior and the plausibility of the software program sequence
- › **Functional watchdog (Q/A-based)** – logical monitoring of the correct sequence of individual software program sections

### Flexibility: Configurability

- › Watchdog type/behavior programmable
- › Dedicated watchdog error counter with dedicated selectable error threshold for each watchdog
- › Window sizes (open/close) programmable
- › Trigger via SPI or via dedicated input pin (WWD only)

### Fault reactions

- › Single error → Notify MCU with interrupt reaction (INT)
- › Counter overflow → Activation of secondary safety path

### Fault handling time interval

- › Influenced by timing and configuration settings

### AURIX™ safety management unit (SMU)

Indicating serious errors to the PMIC through the Fault Signaling Protocol (toggling signal at the ERR pin)

Avoidance of faults where the signal stuck-at high/low in MCU or on PCB level

### PMIC's ERR-monitoring

Detecting errors in case

- › signal is stopped (high or low)
- › the wrong frequency
- › wrong duty-cycle

### Optional recovery delay time

Allow MCU to recover from fault within the accepted fault tolerant time interval of the application

→ increased availability

### Detection and control of potential faults internally in the PMIC

#### Internal Supplies

- › Analog / Logic level supplies
- › Bias current
- › VBAT supply
- › Internal clock

#### SPI Faults

- › SPI frame error
- › Protection with parity-bit, CRC and Unlock/Lock sequences
- › Protected PMIC registers

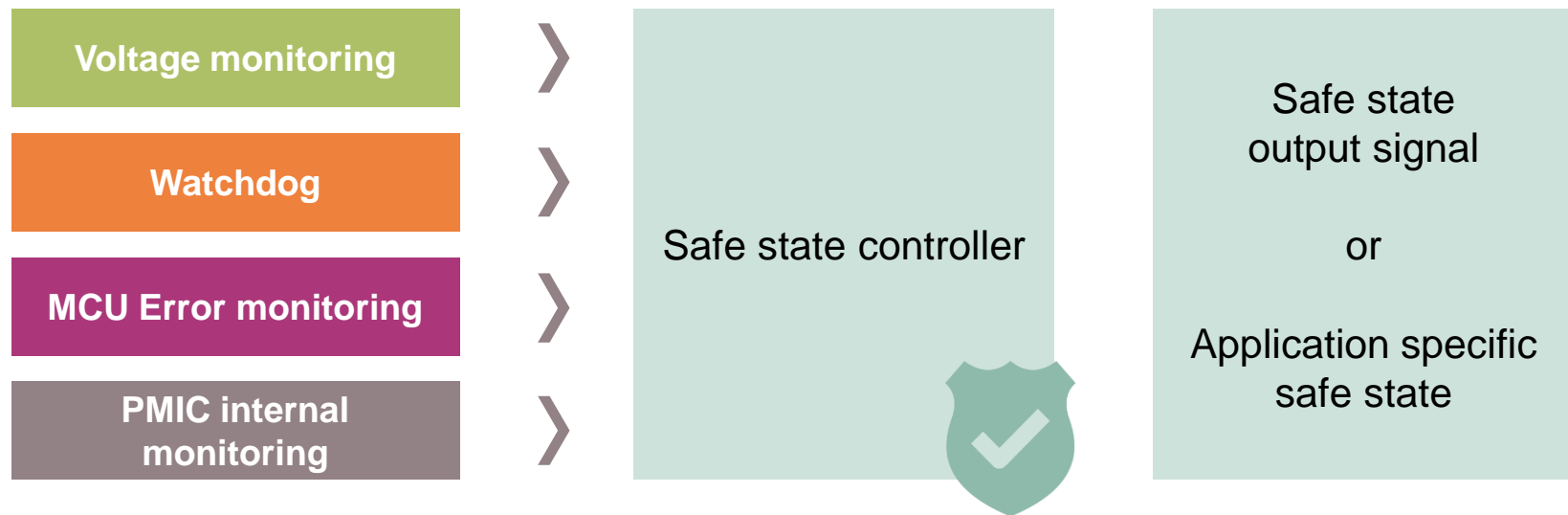
#### Thermal Sensors

- › Warning level
- › Shutdown level
- › Separate sensors

#### BIST

- › Testing that the voltage monitors are working correctly
- › Activation by MCU
- › MCU software test correctness of watchdog and error monitoring

# Safe state controller



- › Collects fault reports from all monitoring functions
- › Handle the configurability of safety mechanisms
- › Electrical separation and isolation from rest of the PMIC
  - Support safe state handling independent of internal faults

# Classification of PMICs

## General purpose FuSa-PMICs – Safety Element out of Context (SEooC)

- Flexible to be used in almost any safety application up to ASIL-D.
- Requirements defined by IC-manufacturer based on Assumptions of Use (AoU)  
→ must be verified by customers

## Application specific PMICs

- Optimized feature set and safety mechanisms for certain specific applications, e.g. Transmission, HV inverter
- ASIL classification based on hazard analysis and risk assessment (HARA) and AoU

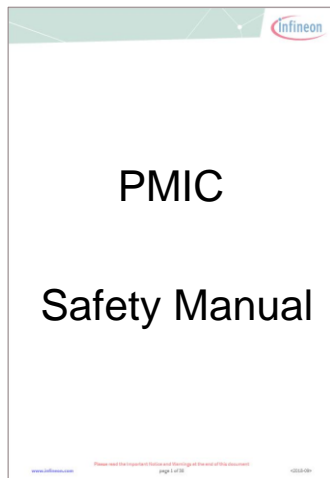
## Customer specific PMICs

- Product and safety requirements defined by / with customers through a development interface agreement (DIA)

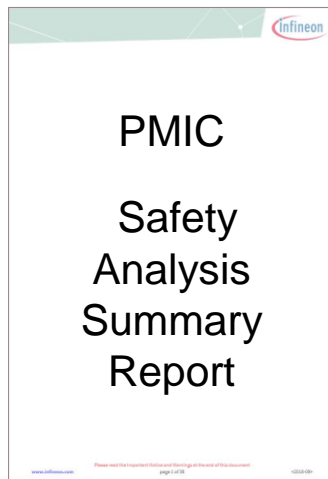
## PMICs and SBCs without safety requirements

- "QM devices"





**What** the integrator  
has **to do** and to consider



**Results** of the **Safety Analysis**  
performed by Infineon ready  
to be used by the integrator

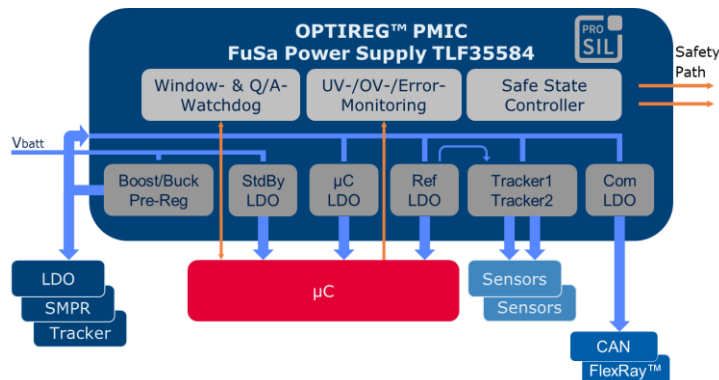
# TLF35584

## OPTIREG™ Functional Safety PMIC

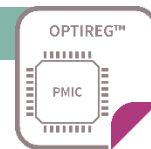


### Key Features

- › Buck/Boost-Pre-Regulator
  - IQ = 1.25A; f: 300kHz-2.5MHz
- ›  $\mu$ C-Supply: 3.3 V/5 V @ 600mA
- › Reference-LDO: 5 V @ 150mA ( $\pm 1\%$ )
- › 2x Tracker: 5 V @ 150mA
- › Communication-Supply: 5 V @ 200mA
- › StandBy-LDO: 3.3 V/5 V @ 10mA
- › EN/Wake (T15 and CAN/FlexRay™)



- › SPI
- › Safety Features
  - Multiple bandgap (supply vs V-monitoring)
  - UV/OV-Monitoring, ERR-Monitoring
  - Functional-WD & Window-WD
  - Safe State Control Secondary Safety Path
  - Protected safety area
  - Built In Self Test
  - Development acc. ISO26262
- › Vin: 4 V .. 40 V



ISO26262  
compliant

### Package



PG-LQFP-64



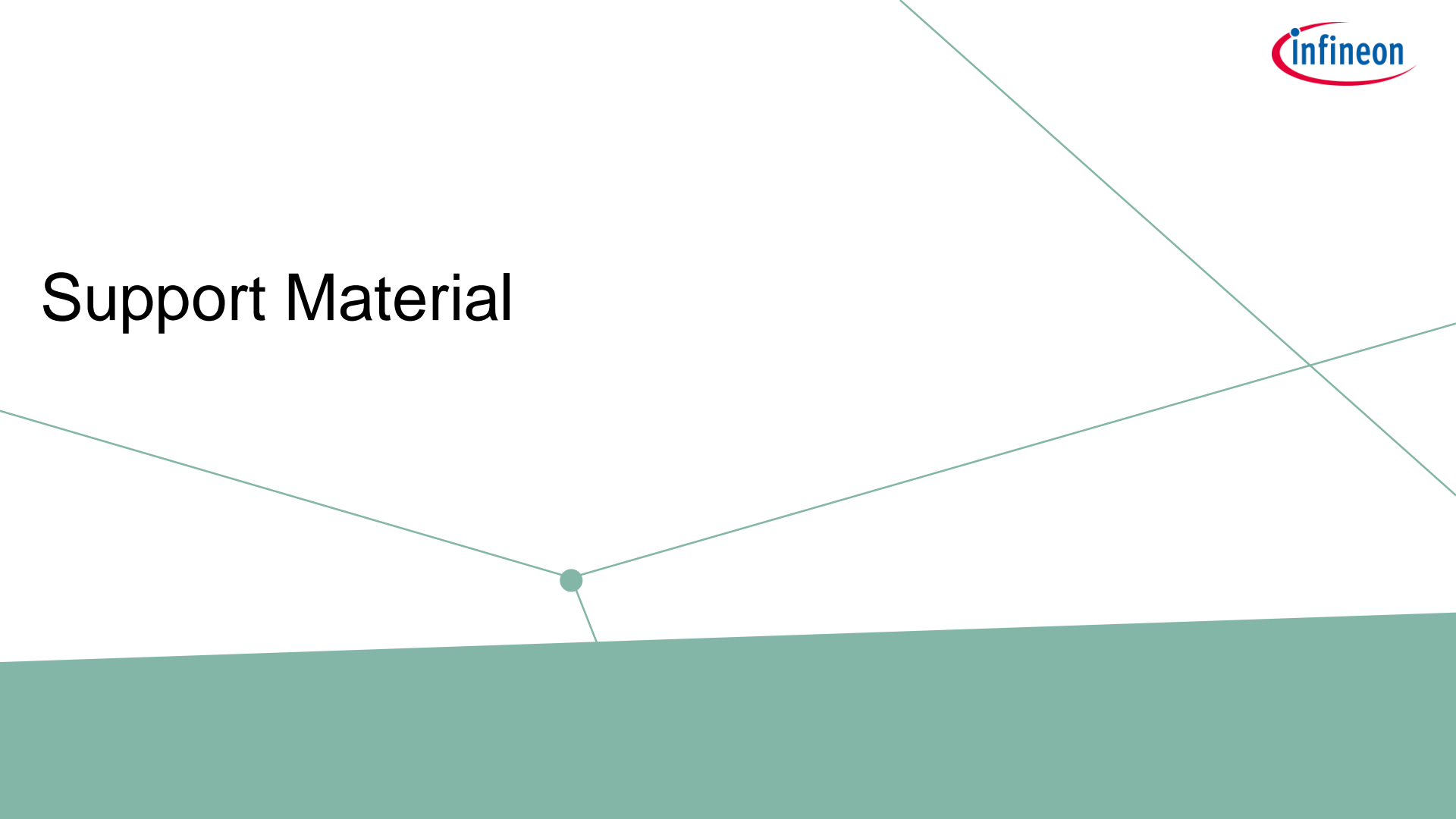
PG-VQFN-48



# OPTIREG™ PMIC & AURIX™ microcontroller teaming up for functional safety



# Support Material



# Automotive Power Integration & Supply Support Material



## Solution Finder

Support



Design Tools  
Parametric Product Finders

[Thermal- & Electrical Simulation](#)  
[Power Discretes, Modules, Mixed Signal, MCU, Sensors](#)

## Collaterals and Brochures



Application Brochures  
Presentations  
Product Briefs  
Selection Guides

[Automotive Power Selection Guide](#)  
[Automotive Application Guide](#)  
[Hybrid Electric and Electric Cars](#)  
[Innovative Semiconductor Solutions](#)

## Further Links



Automotive Product Portfolio

[Automotive OPTIREG™](#)  
[Automotive Network ICs](#)  
[Automotive System ICs](#)  
[Automotive Engine Management IC](#)  
[Automotive Alternator Regulator](#)  
[Automotive Battery Management](#)  
[Automotive Transmission IC](#)  
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