



# Powering E/E Vehicle Architecture: System Power Management Solutions for Compute, Zonal and Edge

**David Lopez**

May 2024



## Navigation section

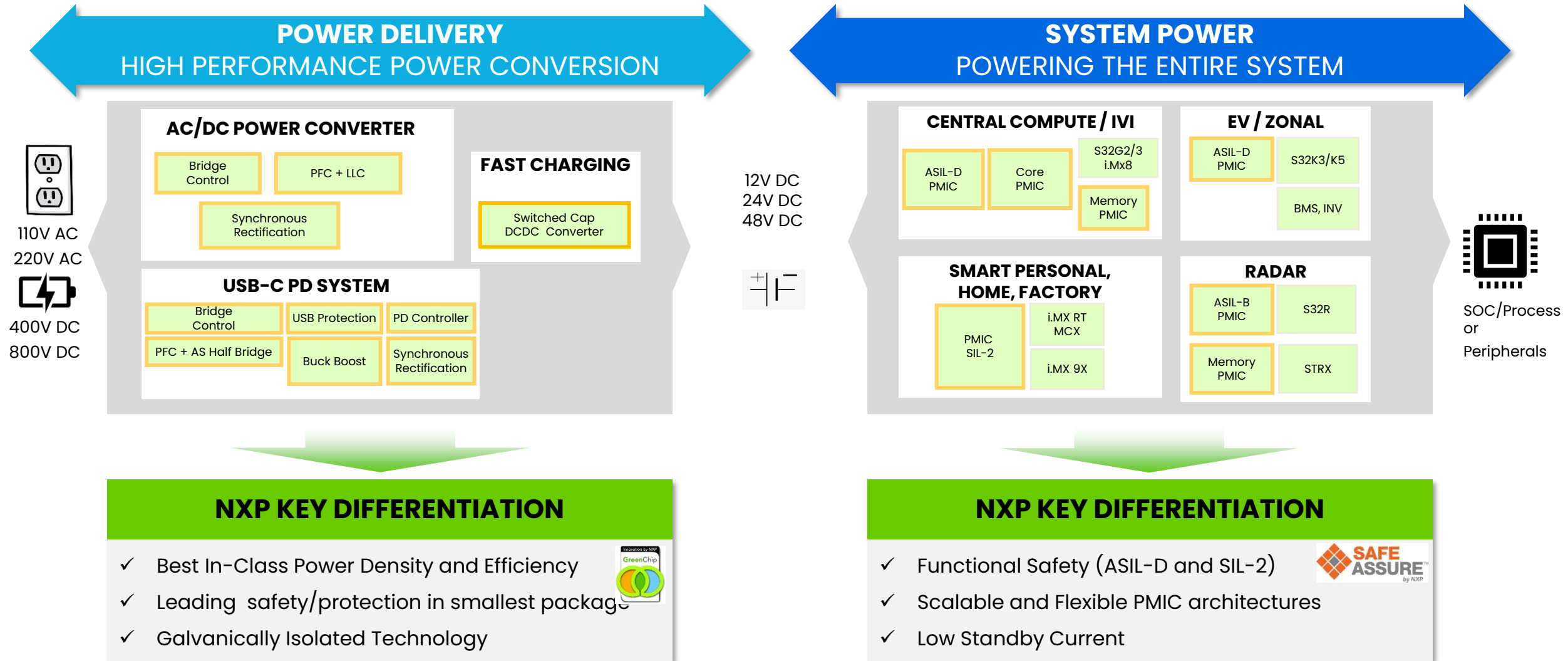
# Agenda

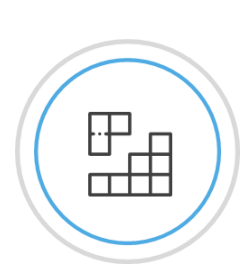
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- NXP Power Management Introduction
- General Introduction Vehicle Architecture
- Vehicle Compute Power Management Solution
- Zonal and Edge Power Management Solution
- Q&A

# Our Strategic Focus

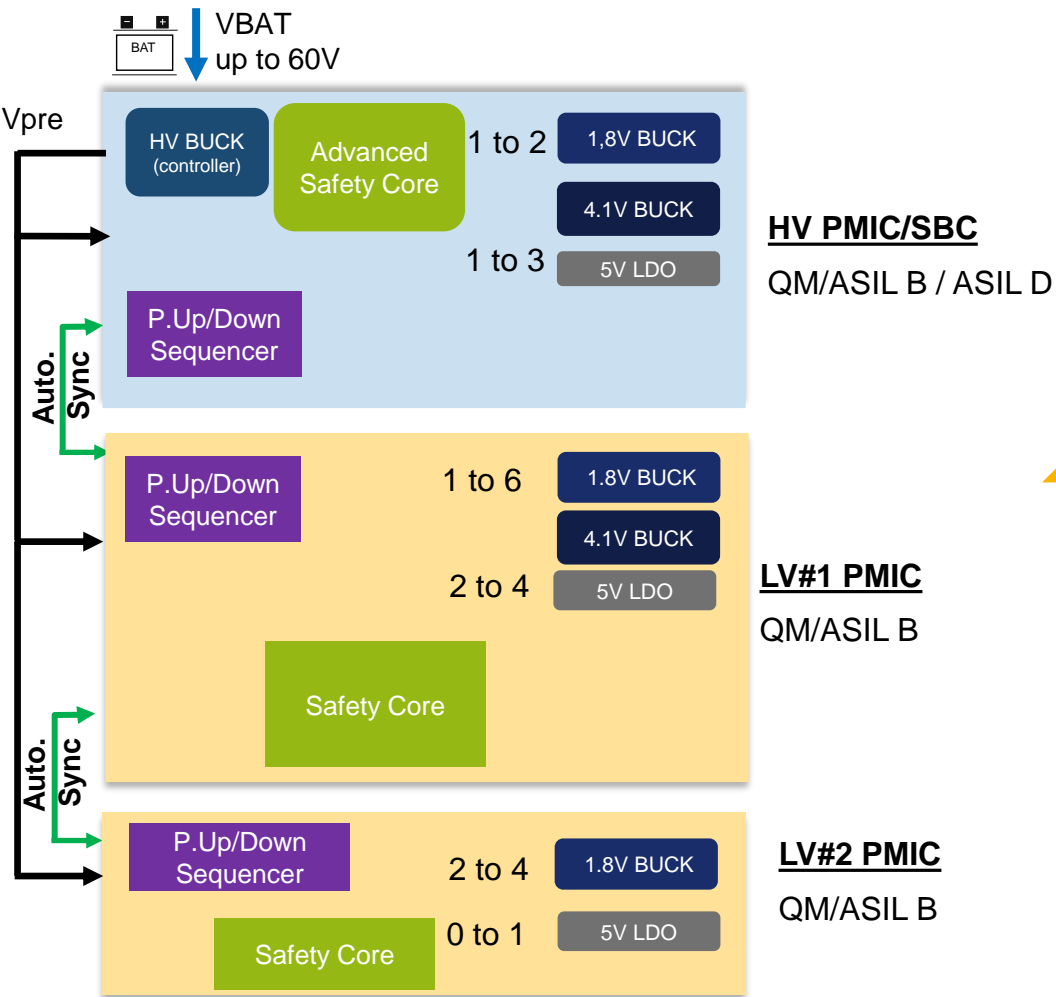
## Power Management System Play from the Plug to the Processor



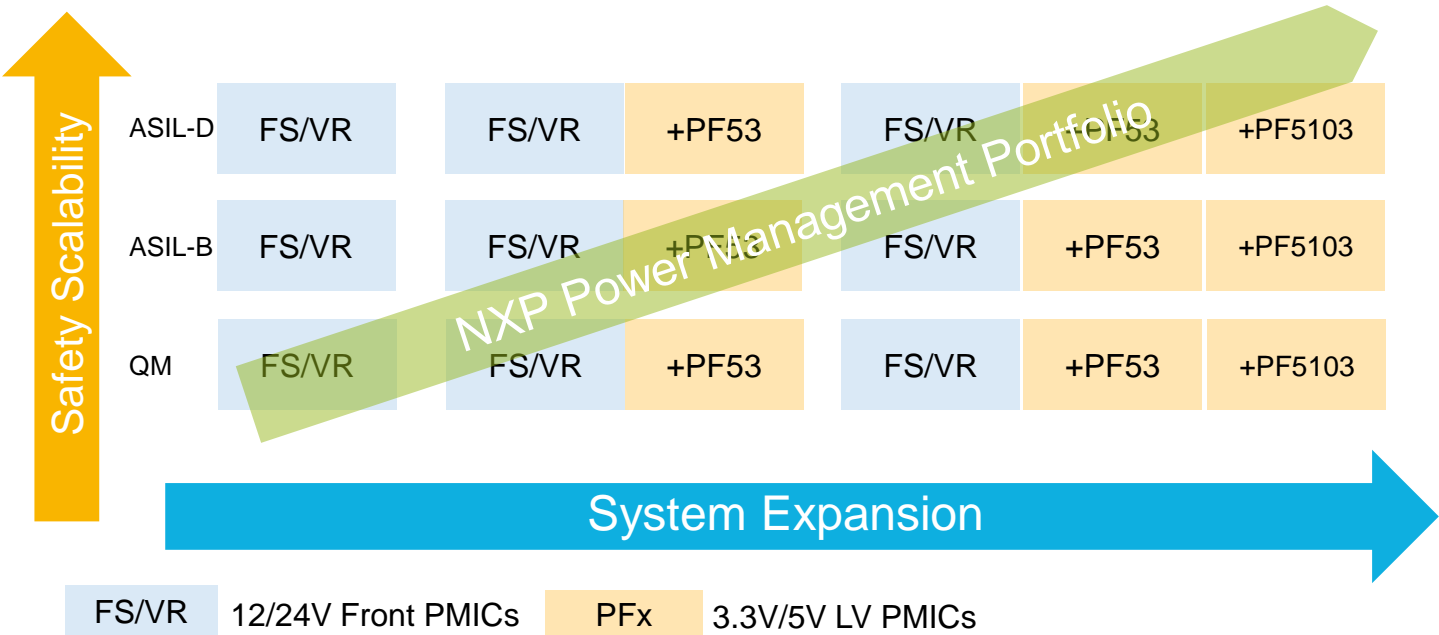


# System Power Solutions

## Safety PMIC “building block” portfolio



- Scalable solution to support platform development strategy
- Pin 2 pin compatible PMIC from QM to ASIL D
- PMIC offered in same package with various number of rail
- Easy software portability
- Multiple PMIC combined, act **as ONE** with NXP dedicated feature



# APS enable **sustainable**, **safe** and **simplified** power management solutions

## SUSTAINABLE POWERHOUSE

- **ENERGY EFFICIENCY** (high performance resonant power)
- **LOW POWER** / fast wake up system strategies SBCs or IOT
- **E-WASTE REDUCTION** (SDV, USB-C PD, mobile, IOT ...)

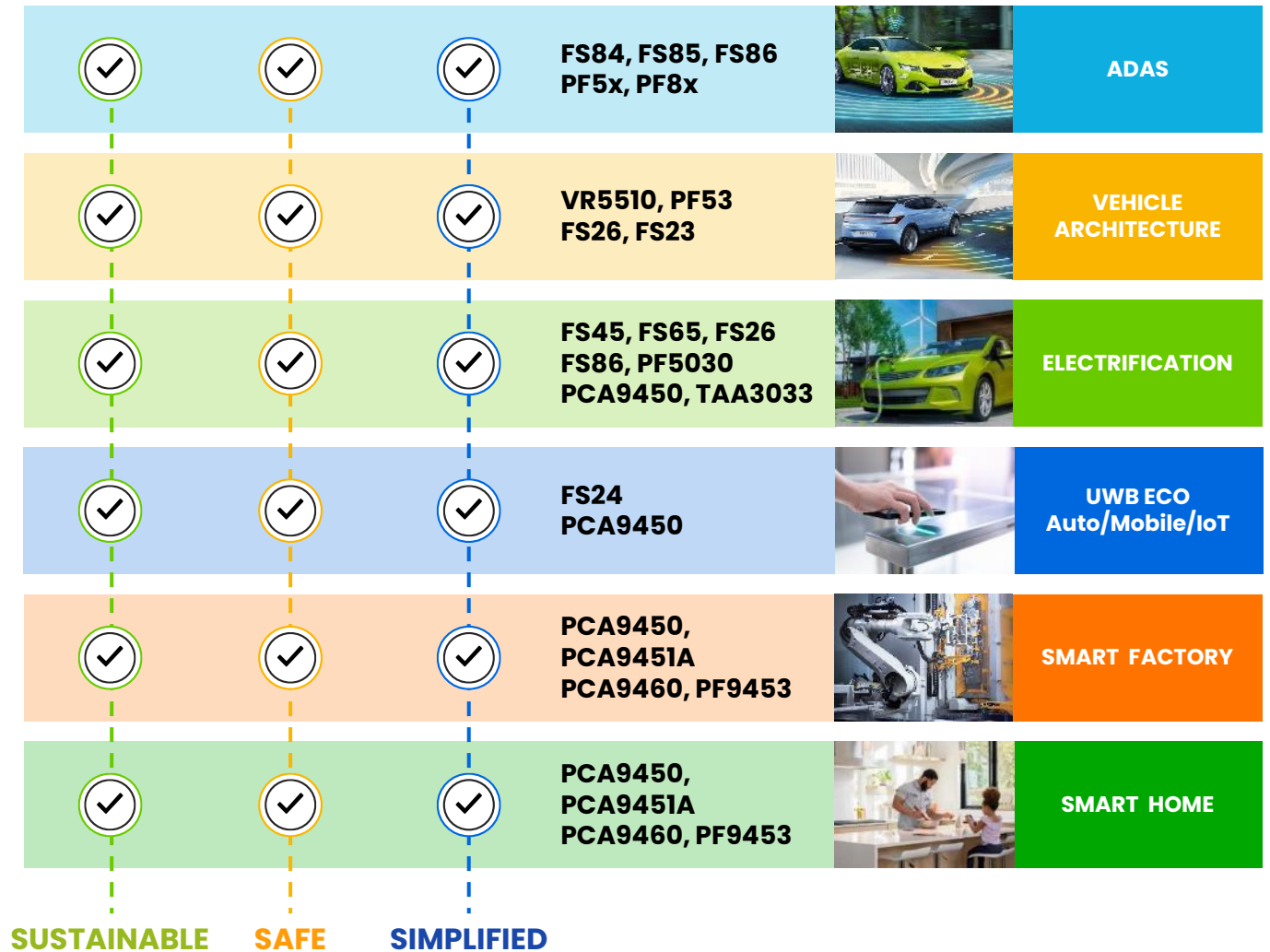
## SAFE SYSTEM SOLUTIONS



- **SAVE LIVES** (Automotive ISO26262, Industrial IEC61508)
- Fit for **HIGHEST SYSTEM SAFETY INTEGRITY LEVELS**
- **ROBUST IC** protections (EMC, corrosion, reliability)

## SIMPLIFIED POWER DESIGN

- Tools & SW to fasten customer **TIME TO MARKET**
- **SCALE PLATFORM** – PMIC to AC/DC **SYSTEM SOLUTIONS**
- **POWER DELIVERY** system solution





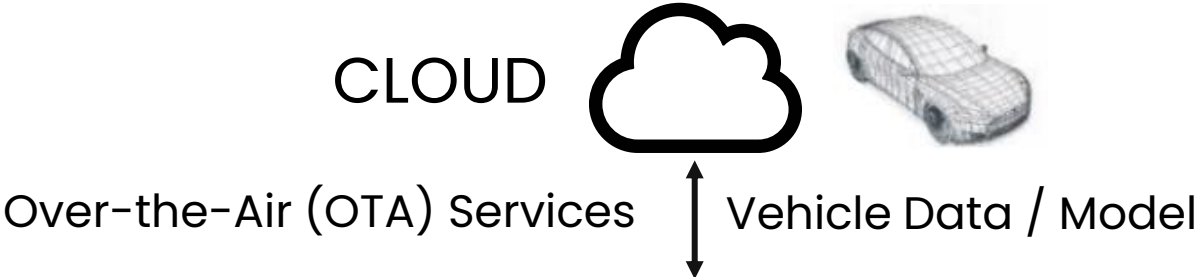
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# Automotive Megatrends



Autonomous  
New sensing, thinking



Software-Defined Vehicle  
Connected from cloud to edge



Electric  
New energy management



## E/E transformation needed

Processing Centralization

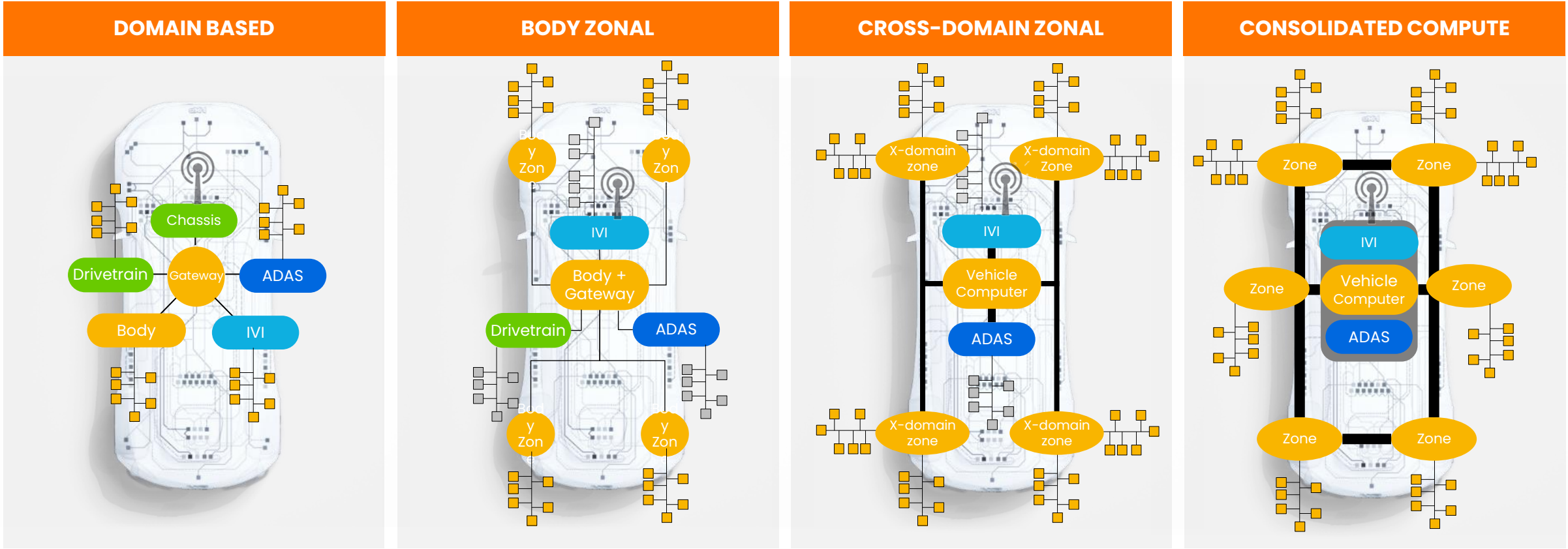
Networking Technology

Service Oriented

Zone I/O aggregation

# System Power Solutions to Address Multiple Type of Vehicle Platforms

## FROM CENTRALIZED TO ZONALIZED

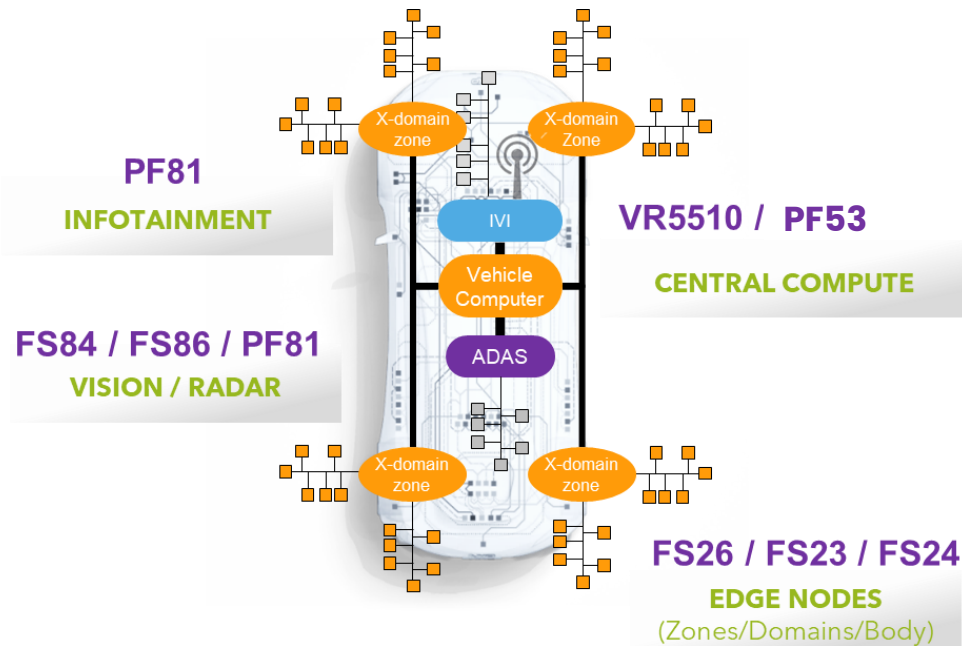


System Power solutions	EV, Safety, Chassis	GTW, Compute, Zone	ADAS	IVI
Battery Connected SBC	<b>POWER THE ENTIRE SYSTEMS, PROCESSOR AGNOSTIC</b> <b>BEST IN CLASS SAFETY CONCEPT – PROVEN, ROBUST &amp; FLEXIBLE</b> <b>SIMPLIFY PLATFORM DESIGN – SCALABLE POWER, SW, SAFETY</b> <b>HIGH PERFORMANCE SYSTEM LOW POWER</b>			
5V PMIC Power Extender				
NXP MCU Association				
Others MCU Vendors Association				

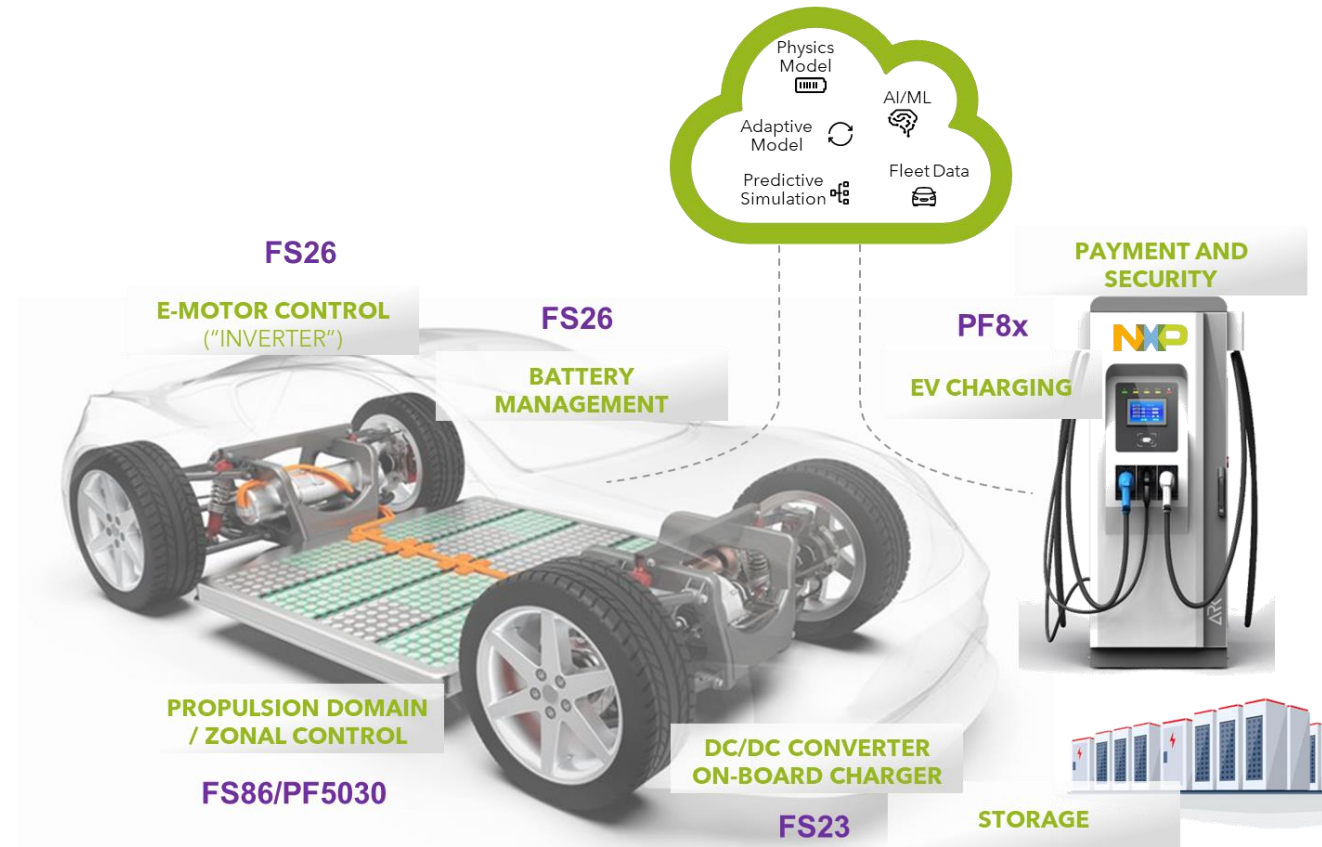


# Advanced Power Systems (APS) Powering new vehicle architecture

## THE SOFTWARE-DEFINED CAR



## THE ELECTRIC CAR



**FS,VR** Battery connected PMIC/SBC, 12V/24 V compliant

**PF** Low Voltage PMICs, max Vin 5.5 V



# Agenda

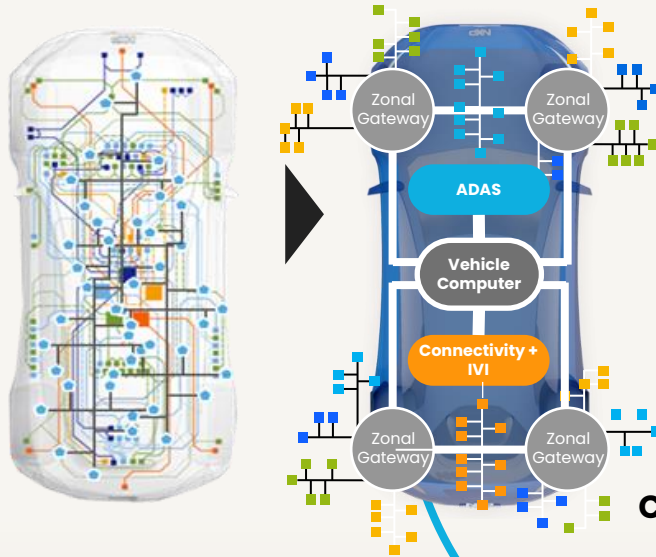
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# Redefining vehicles to enable future mobility innovations

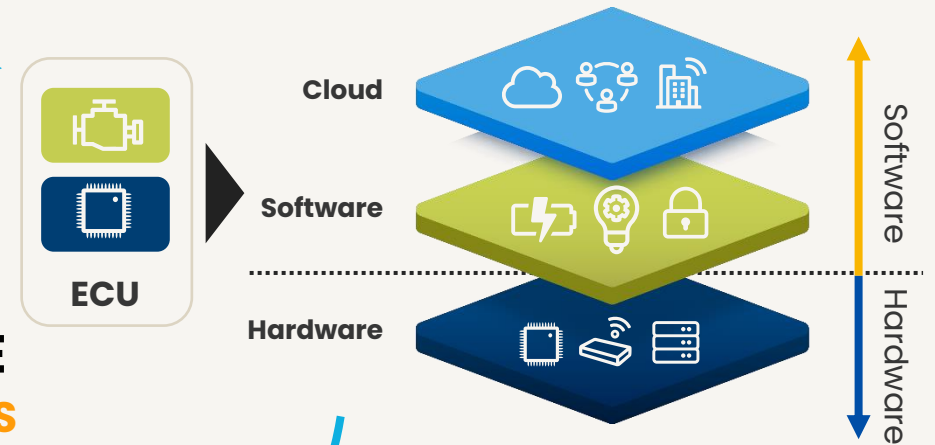
## MIGRATION TO ZONAL ARCHITECTURES

**Simplifies** Hardware and **Reduces** Wiring



## CONSOLIDATING SOFTWARE + LEVERAGING CLOUD

**Enables** Intelligent Connected Vehicles

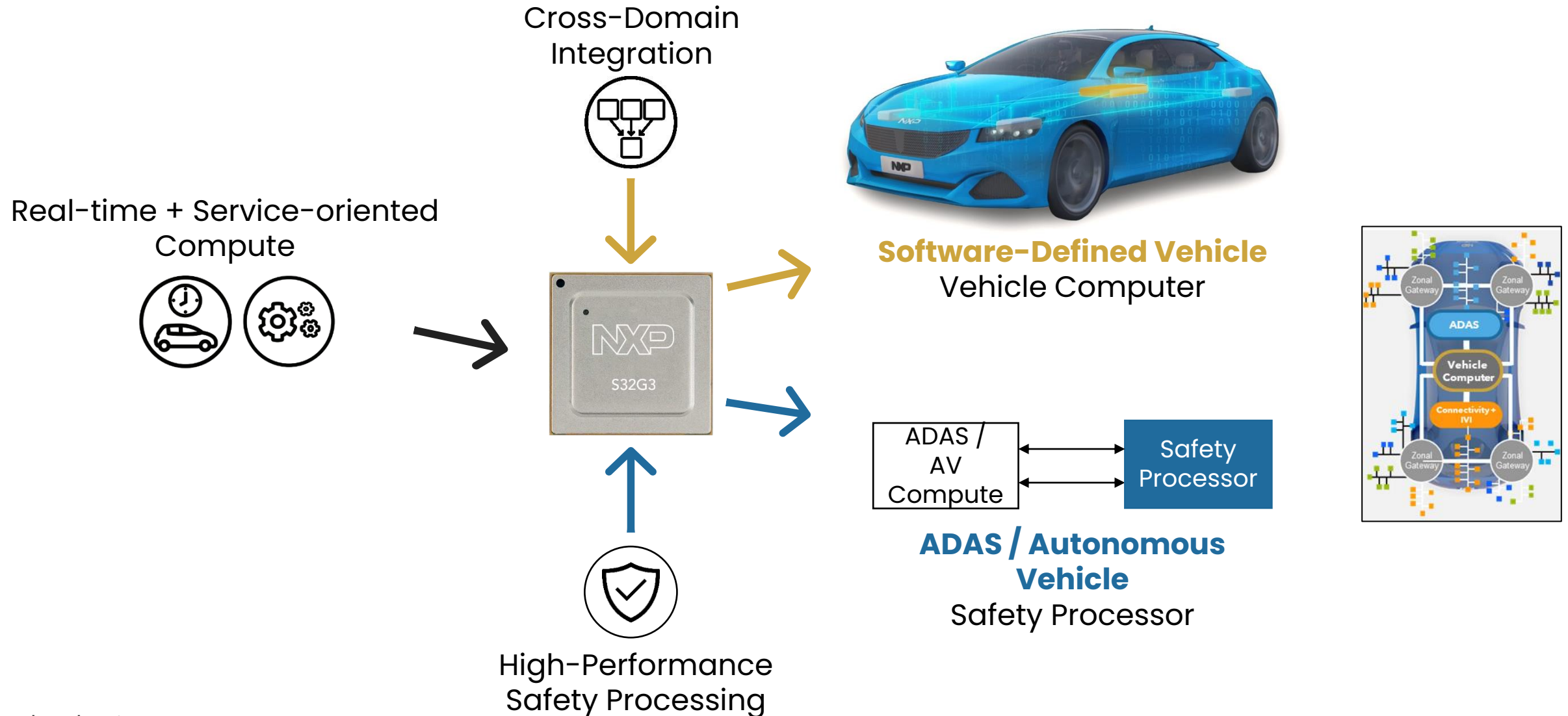


## VEHICLE OF THE FUTURE SOFTWARE-DEFINED VEHICLES

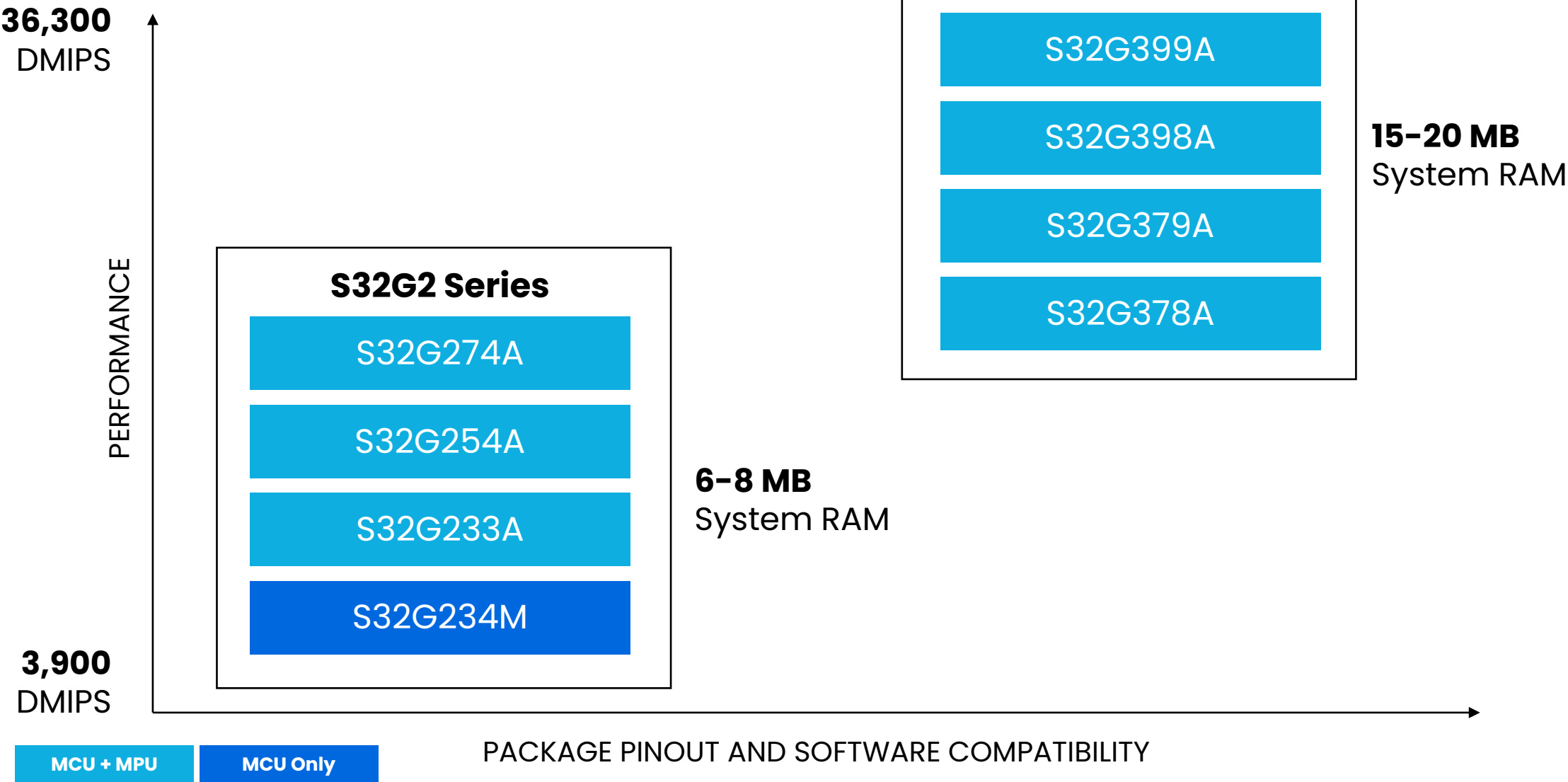
**Continuous Integration / Continuous Deployment**



# NXP S32G3 – Poised to accelerate THE Software-defined Vehicle (SDV) and ADAS/Autonomous VEHICLE safety



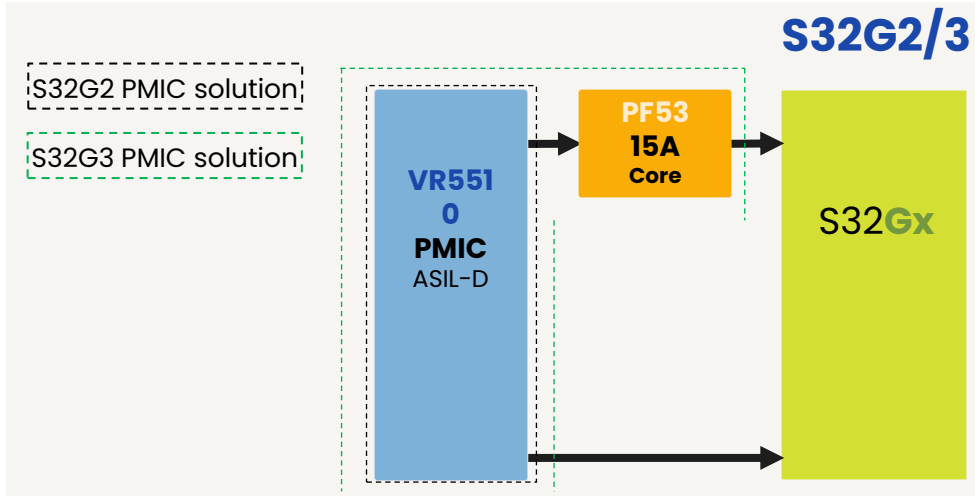
# NXP S32G Family Scalability





# S32G System Power Solutions

## Enabling the Software-Defined Vehicle



### S32G Tailored PMIC System Solution

- Co-developed with NXP AP team for a HW/SW optimized system solution
- Scalable/Modular: Power & Safety (ASIL D)
- S32G Optimized Power, Safety, Features, and Interface

#### OPTIMIZED INTEROPERATBILITY

- Fully validated/tested system solution significantly reducing development risk
- PMIC safety concept & drivers developed, tested, and supported by NXP into lifetime of the program

#### POWER EFFICIENT

- 35uA in STANDBY mode → minimal battery drainage
- Higher current with extended efficiency
- Enhanced tight accuracy & transient response mitigating 5nm challenges

#### POWER MODE CONTROL

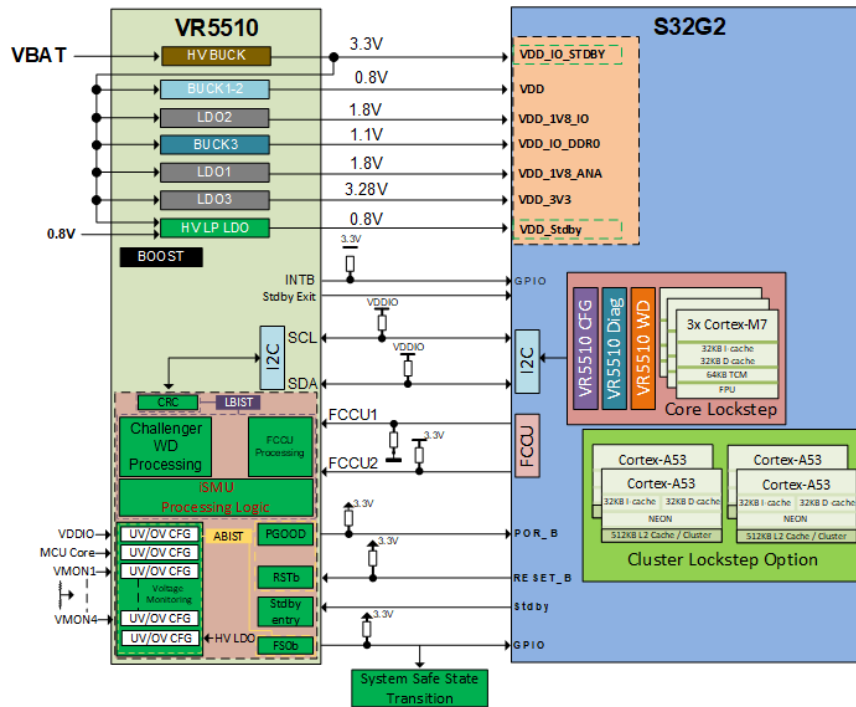
- Reliable power modes transition (shortest boot up and transition times)
- Multiple Power Modes with a dedicated standby scheme for S32G
- Dedicated interface & optimized SW control

#### SAFE

- Co-Architected ASIL D safety S32G system
- Safe Communication & Interface
- Real time system monitoring

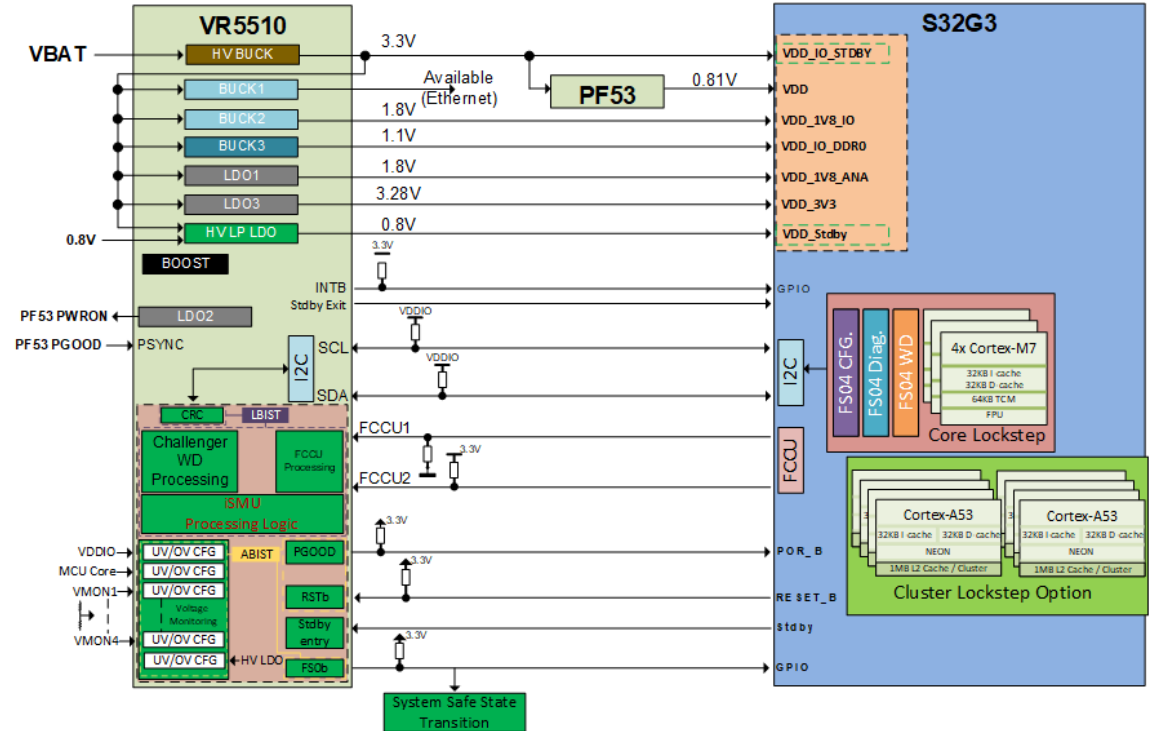
# Power Management Solution for S32G and S32Z Soc

## VR5510 ⇔ S32G2



- VR5510 is the attached PMIC ensuring power supplies, low power mode transition and safety backbone with S32G2

## VR5510 + PF53 ⇔ S32G3



- S32G3 Core and 1,8 V supplies are higher than S32G2
- PF53 PMIC must be implemented attached with VR5510 to ensure this higher power requirement
- Forward/Backward compatibility supported with board BOM options

# VR5510 HV PMIC

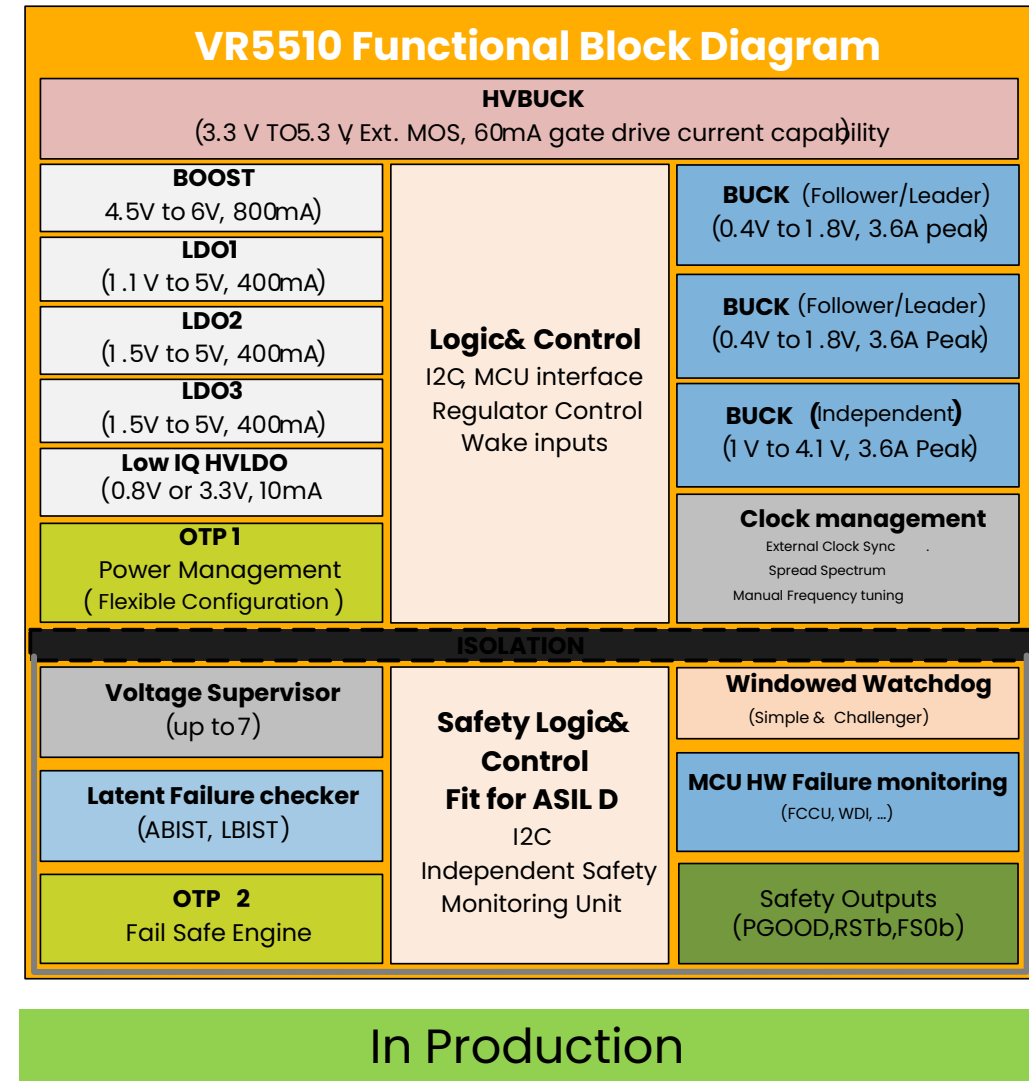


## • Differentiating Points

- Low Power Mode (40uA in Key-Off (Standby) mode)
- Directly connected to Battery up to 60 V
- Proven & robust solution co-developed with MCU. BSP and reference designs provided.
- Scalable supply & safety (Fit up to ASIL B & ASIL D)
- Minimize EMC with spread spectrum, frequency tuning, frequency synchronization and multi-phase operation

## • Product Features

- Vin 2.7 V to 60 V
- Vpre: Synchronous Buck, 333 kHz to 2.5 MHz, ext. MOS
- Buck 1 & 2 (Single or Dual-Phase), 3.6 A Peak each,
- Buck 3, 3.6 A Peak,
- BOOST 4.5 V to 6 V, up to 800 mA, int. MOS
- LDO1, configurable 1.1 V to 5 V, up to 400 mA
- LDO2, configurable 1.5 V to 5 V, up to 400 mA (with load switch mode)
- LDO3, configurable 1.5 V to 5 V, up to 400 mA (with load switch mode)
- Low IQ HVLDO, configurable 0.8 V or 3.3 V, up to 10 mA in LDO Mode, 100 mA in switch mode, <15 µA in Deep Sleep Mode
- -40°C to 125°C Operating Ambient Temperature (150°C Tj)
- Safety scalable: QM, ASIL B, and ASIL D
- Package : 8x8mm 56-LD QFN-EP



# VR5510 Value Proposition

HW/SW Optimized S32G Power Solution with Functional Safety Scalability



## Device scalability (proven robustness, lower risk & shorter time to market)

- Co-developed with MCU team for a HW/SW optimized system solution
- OTP configurability allows flexibility during development and scalability
- Highly scalable to fit S32G tiers and use cases
- Reduced BOM and overall system size/cost with a fully integrated solution



## 3<sup>rd</sup> generation of safety power management IC, reduced functional safety implementation complexity

- Scalable functional safety solution from QM to ASIL D
- Proven solution with Independent Safety Monitoring Unit – fit for ASIL B & D (P/N selectable)
- Extended Safety Concept: Voltage Monitoring of System Rails



## Extended low power capability allowing to manage different uses cases

- Seamless power management transition between S32G low power and normal modes
- Automatic processor supply voltage reduction during low power modes to minimize leakage
- Simple single pin interface and configuration to handle various power modes including DDR refresh

Mode	BUCK/LDO available	Quiescent current
Standby Mode	Vpre + HVLDO	35 $\mu$ A
DDR Refresh Mode	Vpre + HVLDO + Buck3 + LDO2	85 $\mu$ A
Deep Sleep Mode	HVLDO	15 $\mu$ A

# PF5300 – 15A Integrated FET Core Supply – S32G3 Attach

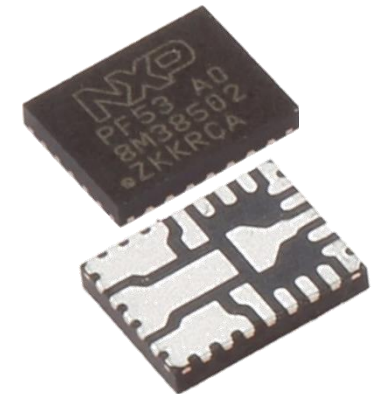
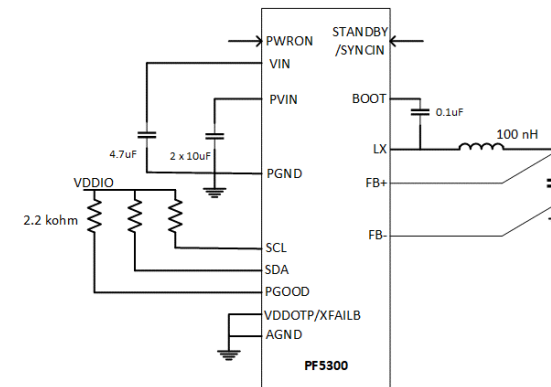
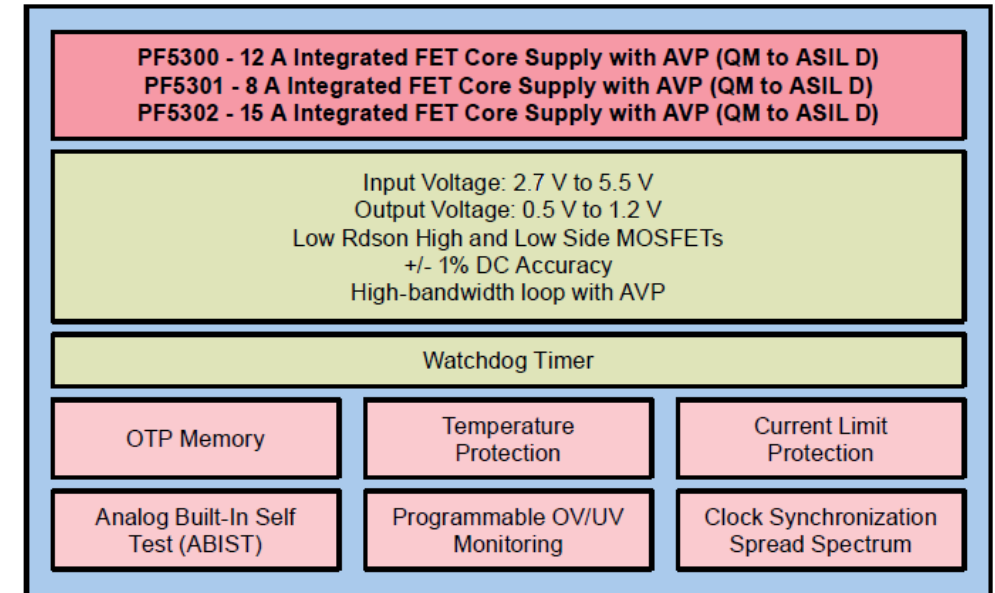


## • Differentiating Points

- Functional safety up to ASIL D
- Low shutdown current: 1.5  $\mu$ A
- High bandwidth DC-DC with programmable AVP
- Fast start up: 500  $\mu$ s from shutdown to regulation
- Proven & robust solution co-developed with MCU. BSP and reference designs provided.
- Minimize EMC with Spread spectrum, frequency tuning, frequency synchronization

## • Product Features

- Vin: 2.7 V to 5.5 V; Vout: 0.5 V to 1.2 V
- I2C with DVS capability can be offered as a variant
- Programmable load-line (AVP) with up to 400kHz bandwidth for optimal transient response & reduced BOM cost (output capacitor reduced by 40%)
- DC Accuracy:  $\pm 1\%$  with differential remote voltage sensing
- Programmable OV/UV monitoring with 1% accuracy
- Watchdog timer
- Integrated MOSFETs: 3 m $\Omega$  low side, 7.6 m $\Omega$  high side
- High efficiency
- -40  $^{\circ}$ C to 125  $^{\circ}$ C Operating Ambient Temperature (150 $^{\circ}$ C Tj)
- Package: 3.5 mm x 4.5 mm FC-QFN package



In Production



# Key Focus Areas for PF5300 Development

DC Accuracy

For Regulator and Monitor

DC Accuracy	PF50/PF8x	PF5300
DC-DC Accuracy	+/- 2.0%	+/- 1.0 to 1.1%
VMON Accuracy	+/- 2.0%	+/- 1.0%

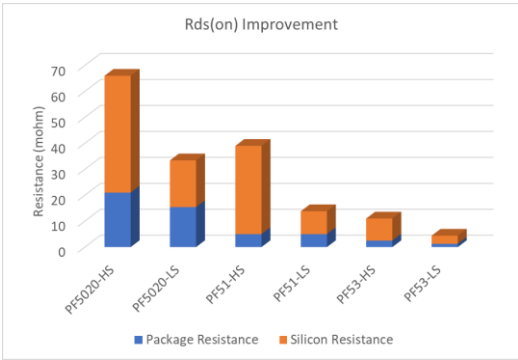
AC Accuracy

High Bandwidth and AVP

Loop Bandwidth	PF50/PF8x	PF5300
Bandwidth with Cout = 44 uF	~250 kHz	~400 kHz
Bandwidth with Cout = 400 uF	~ 90 kHz	~400 kHz

Efficiency

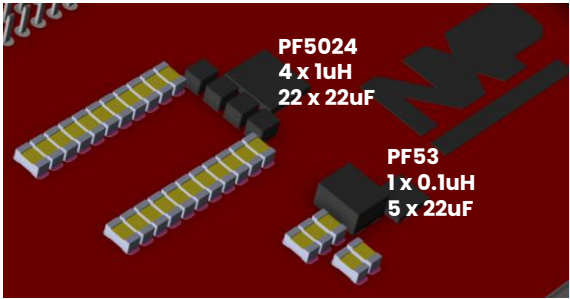
Flip Chip and 2 MHz Operation



COT architecture with PLL allows high bandwidth even at 2 MHz

BOM Reduction

Significant L and C Savings



Solution size for meeting 3% tolerance with 6A/ $\mu$ s step



# Agenda

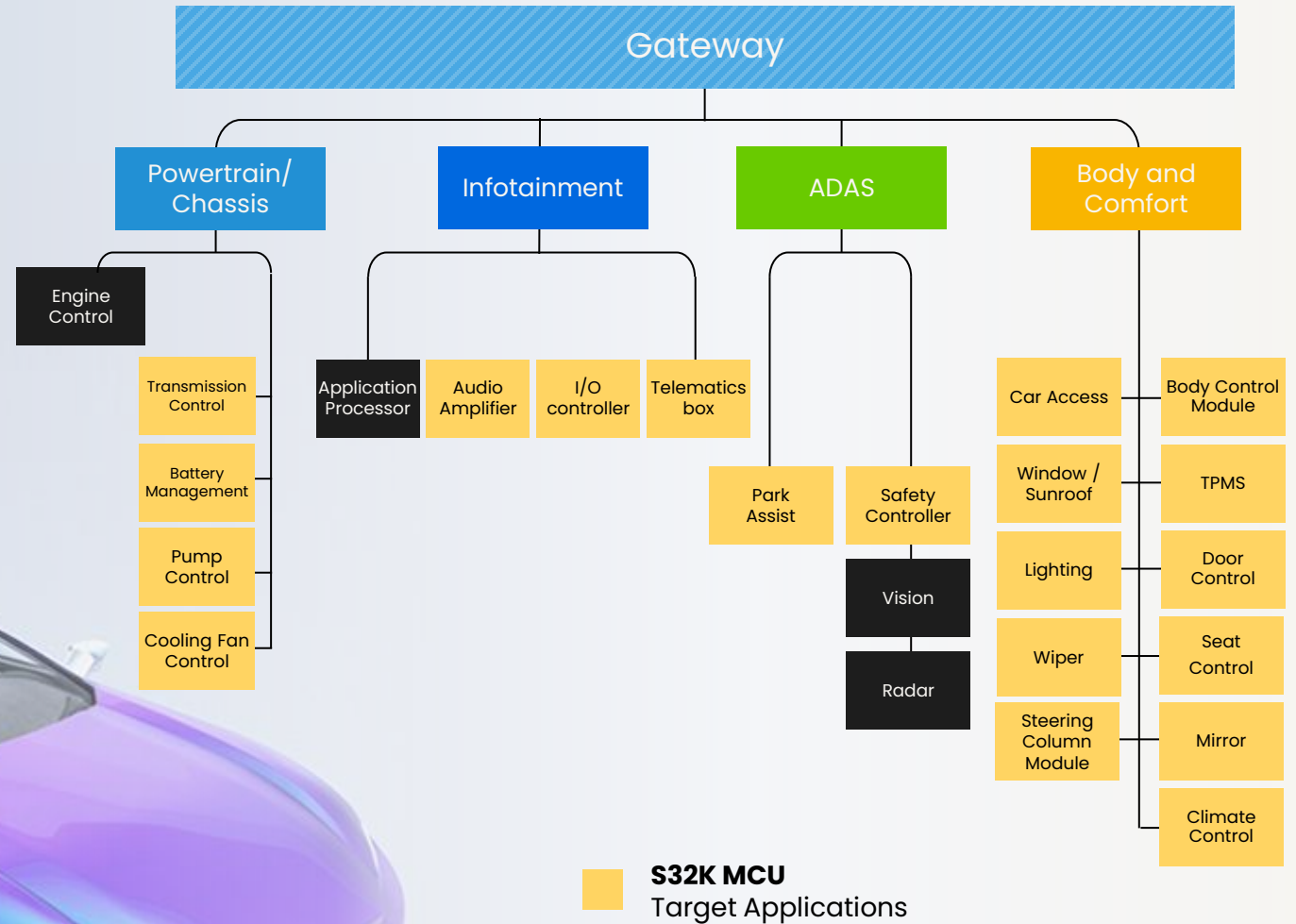
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# S32K3:

## Expanding the S32 Platform

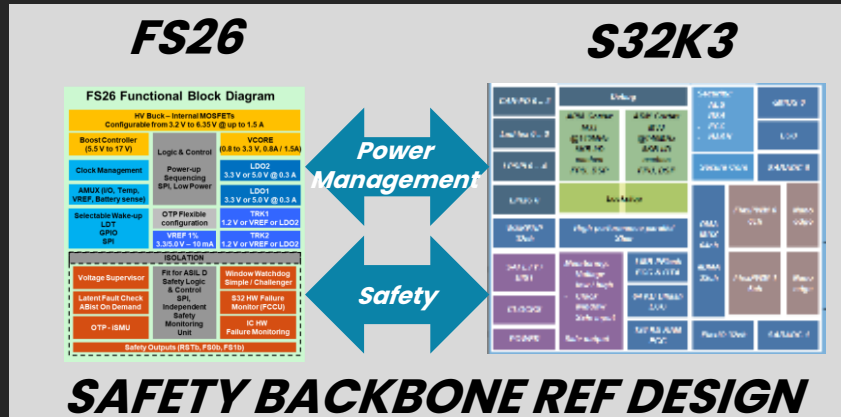
- NXP's S32 Automotive Platform enables software reuse across multiple applications, reducing development complexity and easing the burden for Tier 1s and carmakers
- S32K3 expands S32 into zone control and edge nodes
- Extends S32K family into new applications
  - Advanced Body Electronics
  - Battery Management
  - Zone Control



# Powering systems with S32K3 Portfolio – use case solutions

	MCU	TGT ASIL	Rails	Memory	USE CASES			
					DCDC OBC	BMS BMC	HV INVERTER	ZONAL & EDGE
<b>Safety LS 320MHz 4 M7 cores</b>	<b>S32K37/9</b>	<b>D</b>	1.1-1.5 V (1350 mA) – 4c 5.0 V (100 mA, 400 mA peak) 3.3 V (100 mA, 400 mA peak)	<b>6M</b>	FS2620D	FS2633D	FS2633D	X
<b>Safety LS 320MHz 4 M7 cores</b>	<b>S32K388</b>	<b>D</b>	1.1-1.5 V (1350 mA) – 4c 5.0 V (100 mA, 400 mA peak) 3.3 V (100 mA, 400 mA peak)	<b>8M</b>	X	X	X	FS2633D
<b>Safety LS M7 +1 M7 core 240MHz</b>	<b>S32K358</b>	<b>D</b>	1.5 V (800 mA) 5.0 V (50 mA 280 mA peak) 3.3 V (50 mA 280 mA peak)	<b>8M</b>	X	FS2613D	X	FS2613D
<b>Safety LS 160/240MHz 2 M7 cores</b>	<b>S32K344</b>	<b>D</b>	1.5 V (500 mA) 5.0 V (50 mA 280 mA peak) 3.3 V (50 mA 280 mA peak)	<b>4M</b>	X	FS2613D	X	FS2613D
<b>3 M7 cores 240MHz</b>	<b>S32K33x</b>	<b>B</b>	1.5 V (800 mA) 5.0 V (50 mA 280 mA peak) 3.3 V (50 mA 280 mA peak)	<b>8M</b>	X	X	X	X
<b>2 M7 cores</b>	<b>S32K32x</b>	<b>B</b>	1.5 V (400 mA) 5.0 V (50 mA 280 mA peak) 3.3 V (50 mA 280 mA peak)	<b>1/2/4M</b>	X	FS2600B	X	FS2600B
<b>Single M7 core</b>	<b>S32K31x</b>	<b>B</b>	3.3 V/5.0 V (200 mA)	<b>1/2M</b>	FS23	FS23	X	FS23

# S32K3 + FS26 – safe, efficient, sticky



- ✓ *Fit for ASIL B / D Ready*
- ✓ *SW Production Ready*
- ✓ *Reference Design Ready*
- ✓ *Application Note Ready*
- ✓ *Design for EMC*
- ✓ *Family Platform Approach*

## SAFE

- **ASIL B / D backbone concept**
- **High availability & safe solution**
  - ✓ Fail Silent System Solution
  - ✓ Fault Recovery Strategy
- **Combined safety documentation**
- **Simplify safety assessment**

## EFFICIENT

- **Power & sequencing optimized**
- **Efficient DCDC (up to 95% Vpre)**
- **Low power modes (25uA)**
- **System low power savings with PFM Mode**

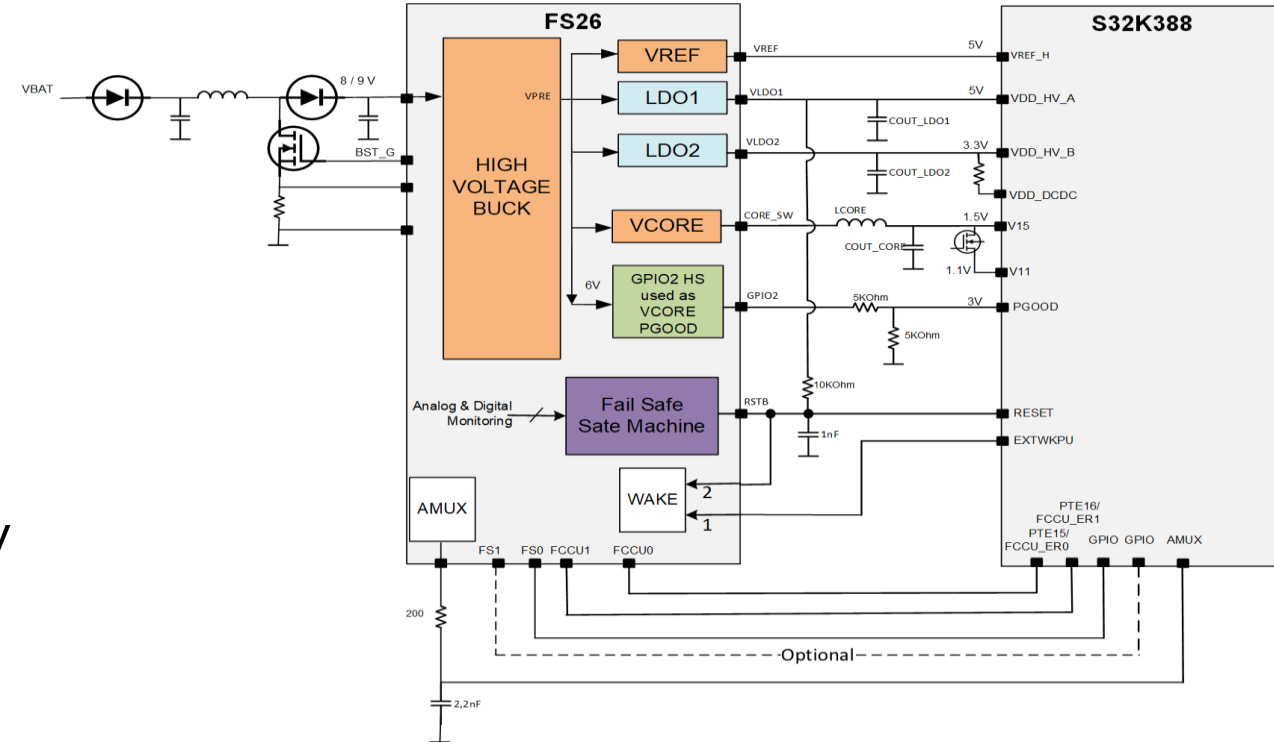
## STICKY

- **Production ready SW drivers**
- **Reference schematic & layout**
- **FAST prototyping cycle**
- **Ready to use**



# FS26 Attributes

- **FS26** is the 3<sup>rd</sup> generation of FSBC Automotive System Power
- **FS26** is already selected by more than 30 customers
- Already designed in
  - **EV** Applications (BMS, DCDC, BSG, INV., OBC)
  - **VEA** Applications (ZONAL, BCM)
  - **safety & Chassis** Applications (EPS, Braking)
- Already designed with S32K3, TC3x, RH850, Cy
- **FS26** ramp up in Q4 2022 at 3 OEMs
- **FS26** is supporting extended mission profiles for EV



# FS26 ASIL B & ASIL D Safety SBC with low power modes

EV, safety, and zonal architecture sbc



## Power Management Solution

- Input supply up to 40 V DC
- **HVBUCK**, adjustable step-down DC/DC converter 3.2 V to 6.35 V up to **1.5 A** DC,
  - 450 kHz or 2.25 MHz Synch. Buck with integrated MOSFETs, up to 92% efficiency
- **VCORE**, adjustable step-down DC/DC converter 0.8 V to 3.3 V
  - Option with **0.8A** DC (to supply S32K3, and other Safety MCUs) and option with **1.65A** DC core supply
  - 2.25 MHz Fully-Integrated Synchronous Buck, up to 85 % efficiency
- **BOOST Controller 5.5 V to 17 V**, external LS MOS
- **LDO1 and LDO2**, configurable 3.3 V or 5.0 V, up to 400 mA DC output current capability.
- **VREF**, accurate voltage reference 3.3 V or 5 V, 1 %, 30 mA DC output current capability
- **2 TRACKERS**, 10 mV offset, 150 mA DC output current capability (Option P/N with 1 tracker only)

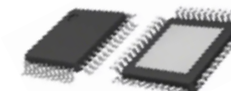
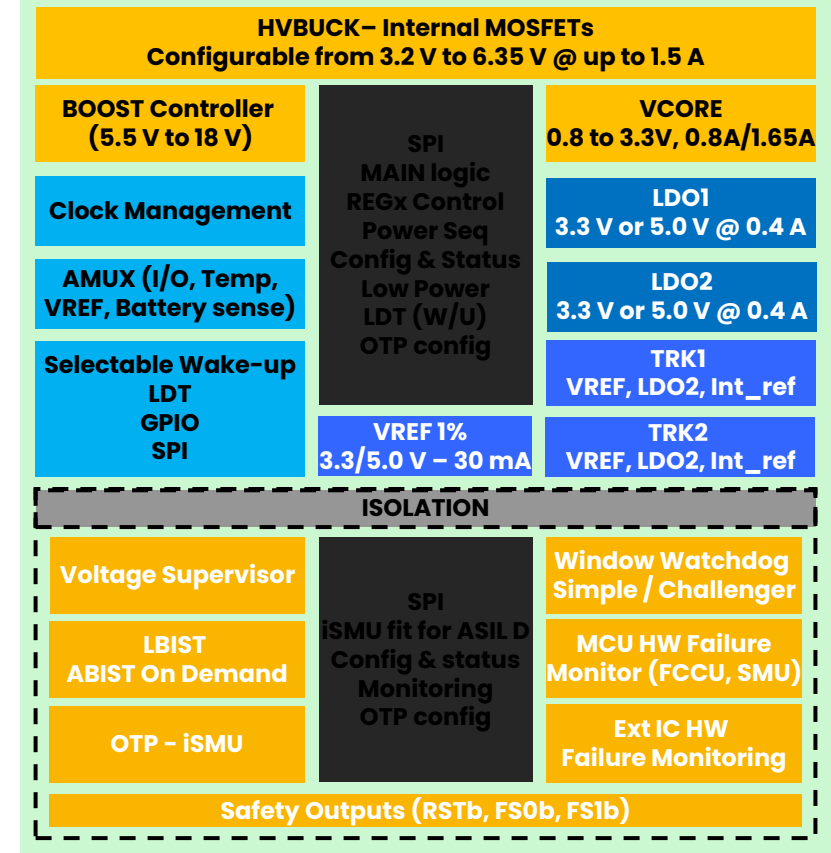
## System Features

- Long duration timer (with dedicated part number) – configurable from few sec up to 6 months
- Low Power Mode :
  - Target 30 µA in LPOFF and 25 µA in STANDBY (MCU powered)
  - Wake up via GPIOs, and Long Duration Timer (LDT) feature and CSN (standby mode)
  - Support S32K3 standby mode
- AMUX: Battery, Internal Voltages, VREF and Temperature, WAKEs, GPIOs
- General Purpose I/O: Wake up or HS/LS Driver (HS 20 mA, LS 2 mA capability)

## Safety Features

- **3rd Generation Fail Safe State Machine** with Independent Safety Monitoring Unit
  - **Fit for ASIL B and ASIL D** with Extended Voltage Monitoring
  - **ABIST On Demand** and Fault Recovery Strategy (combined with S32K3 – common platform)
  - 2 x FS outputs. 1 with configurable time delay (FS1b with dedicated part number)
- 32 bits SPI (including CRC)

## FS26 Functional Block Diagram



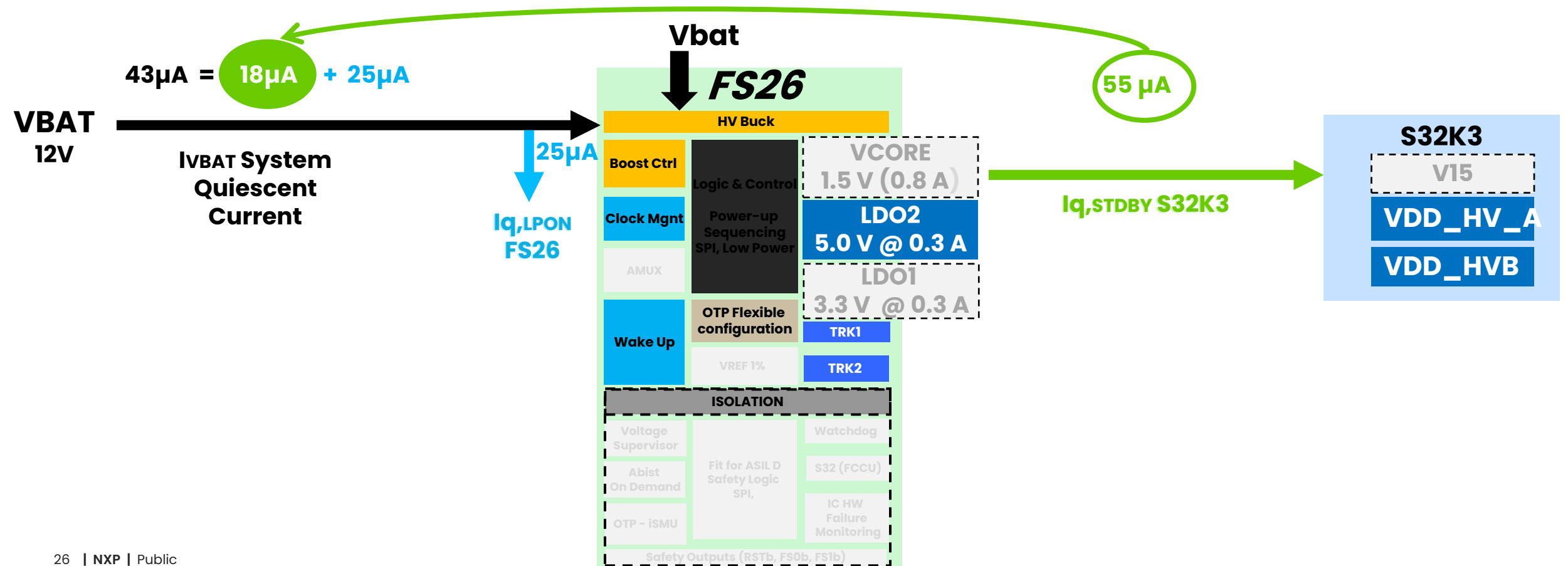
**Package : LQFP48eP**  
**PPAP Available**

# Achieve ECU Energy Management target < 100 microamp in standby mode

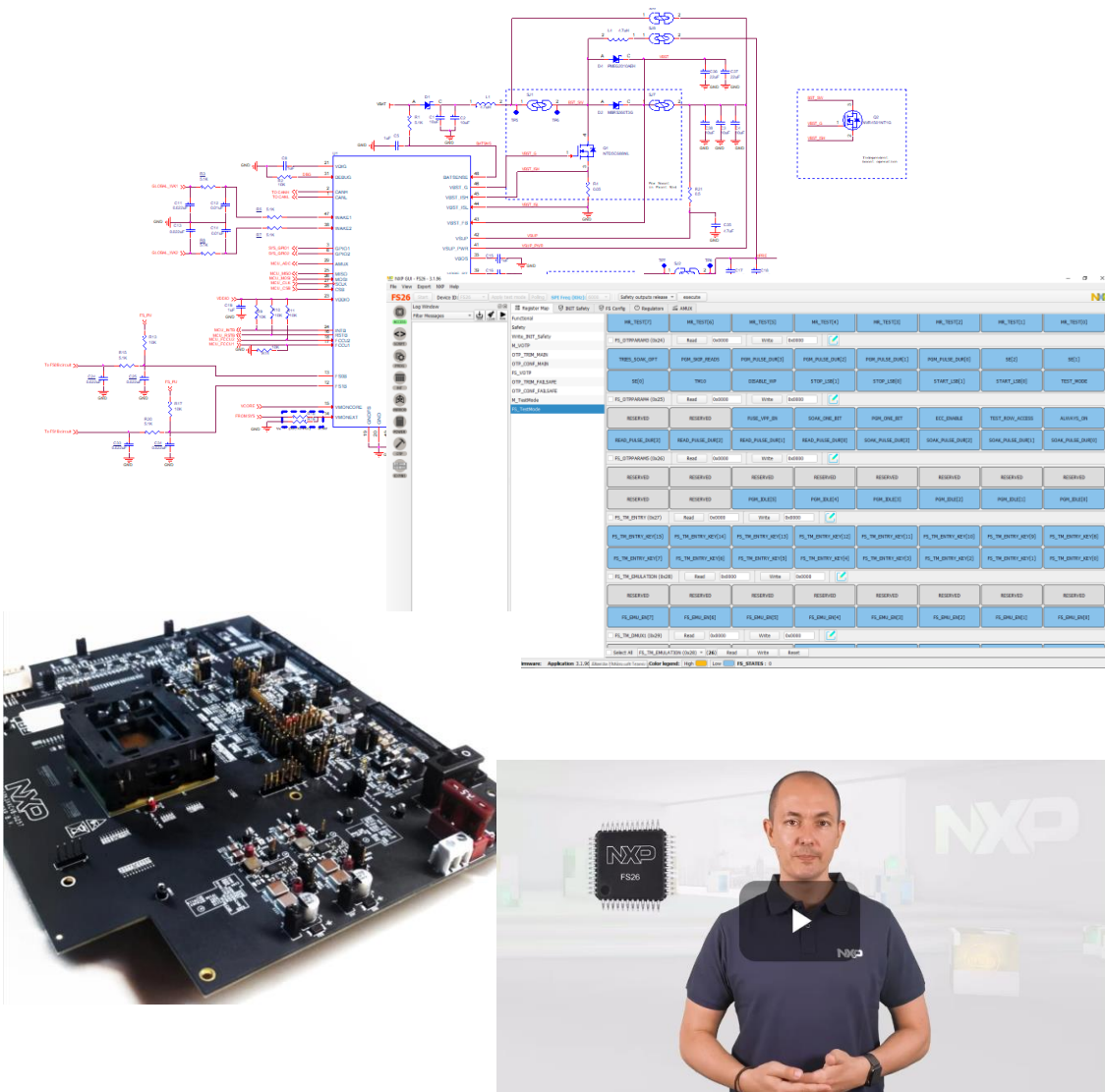


- **At system level:** HV Buck conversion ratio in LPON/standby (DC/DC used in PFM mode) allows to reach quiescent current < 100µA including SoC, PMIC and peripherals

HVBUCK conversion ratio allows  
67% reduction of  $I_{load}$  at VBAT



# FS26 ENABLEMENT AVAILABLE ITEMS



Product	Type	Status
Data Sheet ★	Document	Available
Safety Manual ★	Document	Available
FMEDA ★	Document	Available
AN12995 : NXP FS26 Hardware guidelines ★	Document	Available
AN13850 : NXP FS26 Implementation and Behaviors★	Document	Available
AN13323 : Safety Application Guide (FS26 +S32K3) ★	Document	Available
AN13494 : NXP Solution to attach FS26 to S32K3 and SJA1110 ★	Document	Available
AN13322: NXP Solution for Infineon AURIX TC2xx/TC3xx serie★	Document	Available
AN 13020: NXP Power solutions for RH850 series MCU	Document	Available
AN13748: NXP Power solution for Cypress Traveo II series MCU	Document	Available
AN13431: NXP PMIC solution for TI TMS570 series MCU	Document	Available
SPMS compensation settings calculator ★	Document	Available
Socket EVB schematic & Layout	Hardware	Available
Soldered EVB schematic & layout	Hardware	Available
FS26 + S32K3 EVB	Hardware	Available
EVB GUI	Software	Available
Power dissipation calculator ★	Document	Available
Real Time Drivers AUTOSAR ISO26262	Software	Available

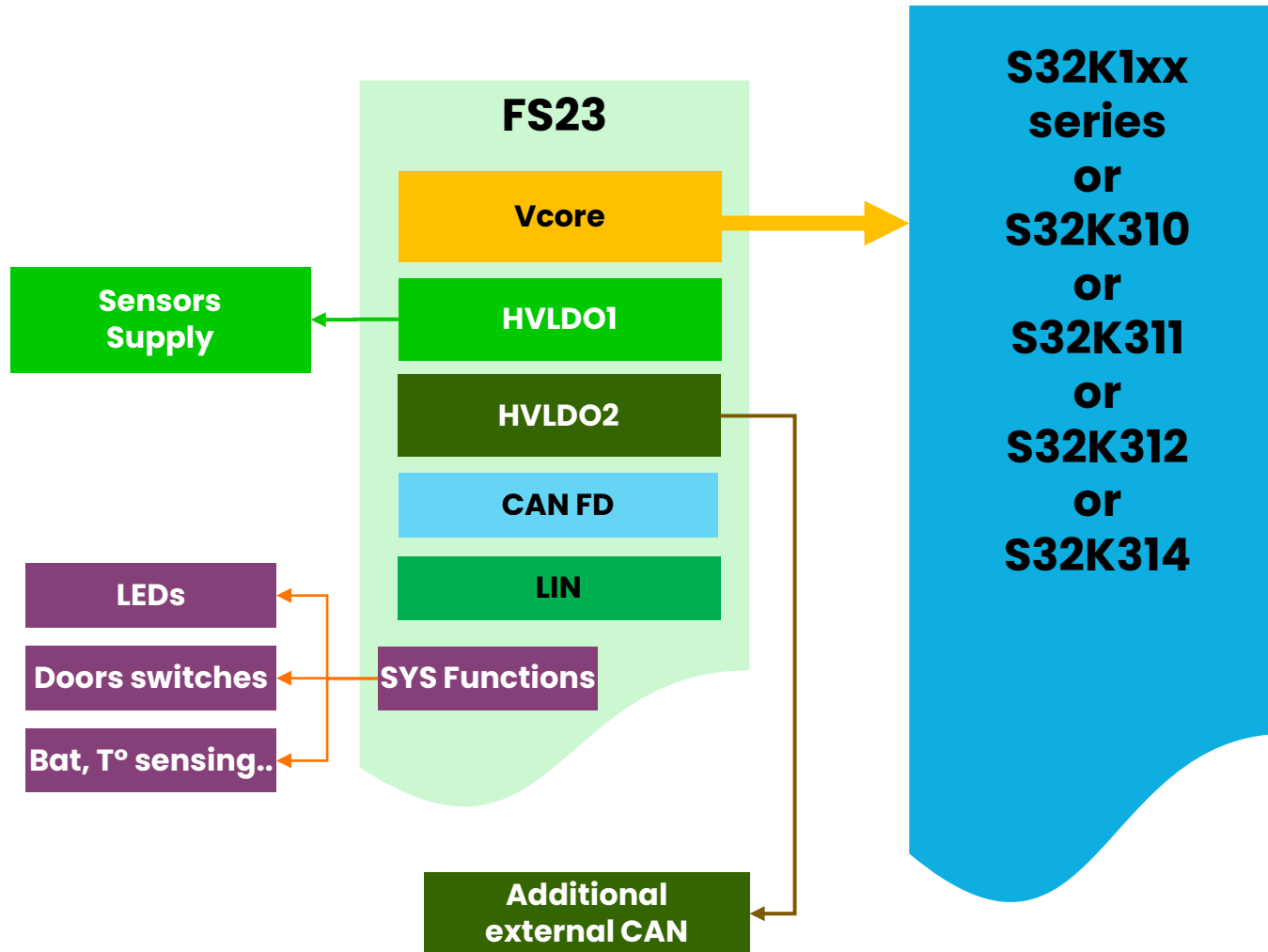
★ Available on NXP Secure Files portal only

# Powering systems with S32K3 Portfolio – use case solutions

	MCU	TGT ASIL	Rails	Memory	USE CASES			
					DCDC OBC	BMS BMC	HV INVERTER	ZONAL & EDGE
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<b>Safety LS 320MHz 4 M7 cores</b>	<b>S32K388</b>	<b>D</b>	1.1-1.5 V (1350 mA) – 4c 5.0 V (100 mA, 400 mA peak) 3.3 V (100 mA, 400 mA peak)	<b>8M</b>	X	X	X	FS2633D
<b>Safety LS M7 +1 M7 core 240MHz</b>	<b>S32K358</b>	<b>D</b>	1.5 V (800 mA) 5.0 V (50 mA 280 mA peak) 3.3 V (50 mA 280 mA peak)	<b>8M</b>	X	FS2613D	X	FS2613D
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<b>3 M7 cores 240MHz</b>	<b>S32K33x</b>	<b>B</b>	1.5 V (800 mA) 5.0 V (50 mA 280 mA peak) 3.3 V (50 mA 280 mA peak)	<b>8M</b>	X	X	X	X
<b>2 M7 cores</b>	<b>S32K32x</b>	<b>B</b>	1.5 V (400 mA) 5.0 V (50 mA 280 mA peak) 3.3 V (50 mA 280 mA peak)	<b>1/2/4M</b>	X	FS2600B	X	FS2600B
<b>Single M7 core</b>	<b>S32K31x</b>	<b>B</b>	3.3 V/5.0 V (200 mA)	<b>1/2M</b>	FS23	FS23	X	FS23



## FS23 – System power for ENTRY ev AND EDGE SDV



### Key Benefits

- **ASIL B solution with combined safety documentations**
- **System added value: Highest level of integration to**
  - Optimize system cost
  - Save PCB space
  - Reduce complexity
- **Best-in-class on quiescent current**

# S32K+FS23 – System Solution



## Scalable System Solution

- ✓ *Easy Design FS23 – S32K Family*
- ✓ *Reduce complexity Hardware + Software*
- ✓ *Family Platform Approach*

### SCALABLE

**Family approach pin to pin compatible**

**Configurable multipurpose I/Os**

**Integrated CAN and LIN and supply of MAC and 10BASE-T1S PHY or external CANs**

### POWER EFFICIENT

**Low power modes strategy with MCU core monitoring in standby**

**Low system quiescent current (20uA)**

**Configurable voltages & power sequencing**

### SAFE

**Functional safety by design and process and product behavior**

**Highest level of monitoring integration**

**Advanced safety monitoring**

FS2300 is MCU Agnostic

**S32K3  
S32K1**

**Cypress  
Traveo II**

**IFX  
Aurix TC2/3**

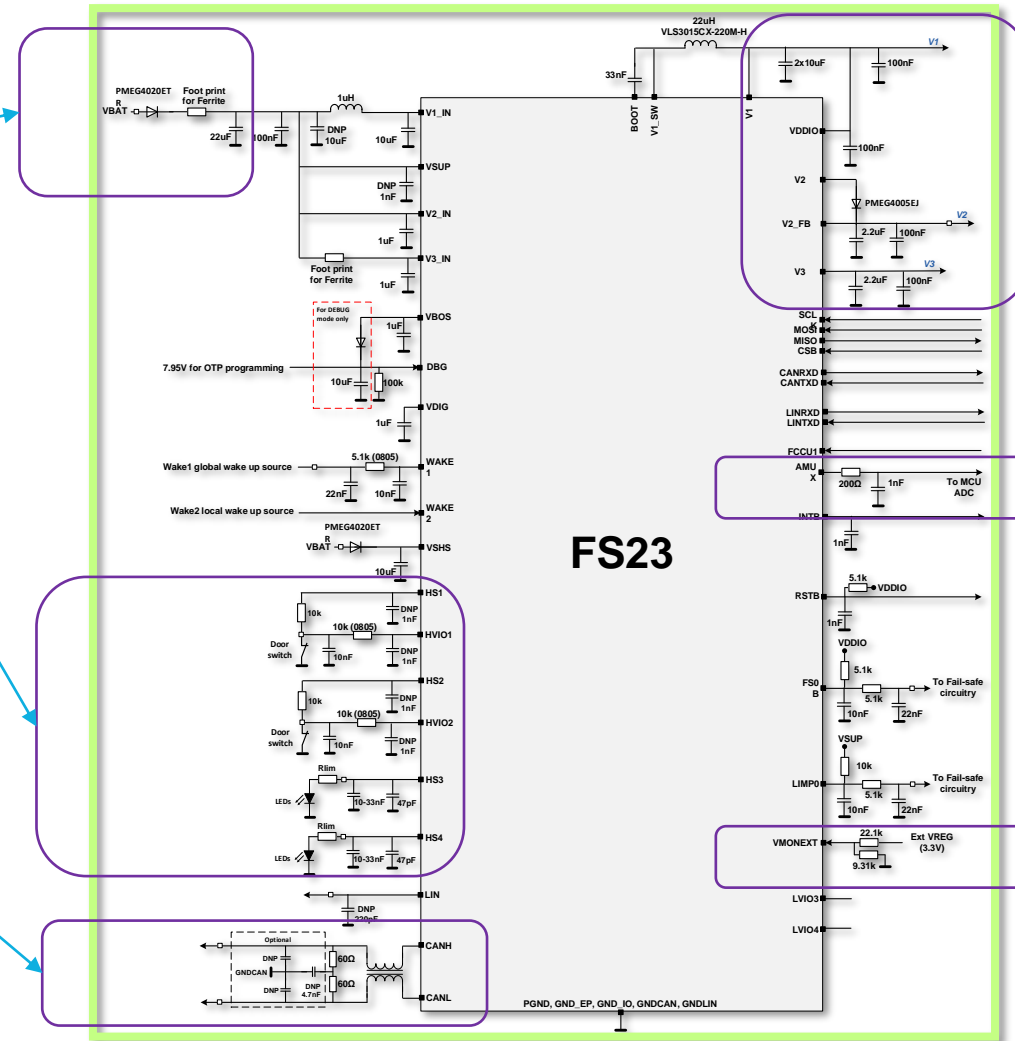
**Renesas  
RH850Dx/Fx**

# BOM Cost advantages of FS23 vs Discrete: examples

**FS23 requires lower filtering capacitor value**  
**BOM saving (5 to 10cts)**

**FS23 integrates 4 High Side Drivers**  
**BOM saving (8 to 12cts)**

**IEC61000 ESD protection +/-8KV:**  
**FS23 integrates the external PESD diode (such as PESD1CAN-UX)**  
**BOM saving (5 to 10cts)**



**FS23 integrates voltage monitoring**  
**On all internal power rails**  
**BOM saving (4 to 5cts)**

**FS23 integrates Analog Multiplexers**  
**BOM saving (2 to 3cts)**

**FS23 integrates Watchdog and external voltage monitoring**  
**BOM saving (7 to 8cts)**

FS23 offers lower external components for

1. Cost saving
2. PCB space saving

# FS23 One page: FS230x and FS232x

## S32K31x Attach for Body market



### Power Management – Fit to S32K31x

- Input supply up to 40V DC
- **HVBUCK**, configurable 3.3V or 5V, 2%, 400mA, 450kHz or 2.2MHz.
  - Or **HVLDO1** configurable 3.3V or 5V, up to 100mA with internal PMOS and 250mA with external PNP
- **HVLDO2**, configurable 3.3V or 5V, 2%, up to 100mA. System or **off board sensor** with ext diode
- **HVLDO3**, configurable 3.3V or 5V, 2%, up to 150mA. **CAN PHY** and/or system
- **LP modes**: in LPOFF 30µA. In LPON 40µA (HVLDO1) or 20µA (HVBUCK) with MCU powered
- **HVBUCK UV** in LPON, HVLDO1/2 available on demand in LPON mode

### System Featuring – Fit for Body Market

- **32-bit SPI/I2C with CRC** (same SPI as FS26 to target SW compatibility over FS2x family)
- **Long Duration Timer** with wake-up strategies from few seconds to several weeks
- **AMUX** to sense temperature, battery voltage, internal voltages, ...
- **2x HV** and **4x LV** configurable IOs with wake-up capability
- **4x HS Drivers** (150mA current limit) with cyclic sensing in LP and PWM capability (200Hz / 400Hz)
- **1x CAN FD** transceiver 2 Mb/s for operation (5 Mb/s max bit rate) with WUP (Wake-Up Pattern) capability
- **1x LIN** with wake-up capability

### Safety level – Fit for ASIL B

- **OV and UV internal monitoring** for all FS23 regulators + **1 external VMON**
- **Windowed WD** in Normal mode and **Timeout WD** in LPON
- **FCCU** monitoring, **ABIST** on demand
- **3x FS outputs** (**FS0B** low by default, **LIMPO** high by default, **LIMP1/2** with PWM capability 1.25Hz/100Hz)

## FS23 Functional Block Diagram

**HVBUCK – 3.3V or 5.0V 400mA – 700mA**  
**or HVLDO1 – 3.3V or 5V up to 100mA/300mA**

**HVLDO2 – 3.3 or 5V up to 100mA (Protection optional)**

**HVLDO3 – 3.3V or 5V up to 150mA**

**2x Wake pins**

**2x HVIOs, 4x LVIOs**

**4x HSD (<150mA)**

**AMUX**  
 (Vbat, I/Os, Temp, ...)

**SPI/I2C**  
 Main logic  
 Reg control  
 Diagnostic  
 LP mgt  
 Safety monitoring  
 Fit for ASIL B  
 OTP

**Voltage Supervisor**

**Watchdog (SW)**  
**FCCU (HW)**

**ABIST on demand**

**Safety Outputs**  
 RSTB, FS0B, LIMPO1/2

**CAN FD 5M**

**LIN**

**Package: QFN48EP with wettable flank**

**Samples: Available**

**PPAP: Available**

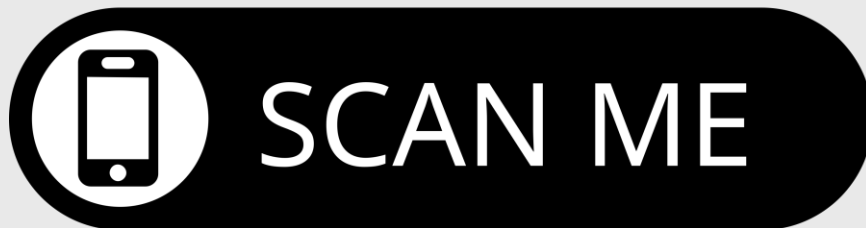




# Agenda

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- NXP Power Management Introduction
- General Introduction Vehicle Architecture
- Vehicle Compute Power Management Solution
- Zonal and Edge Power Management Solution
- Q&A



## Technical Session Survey

Thank you for your feedback.



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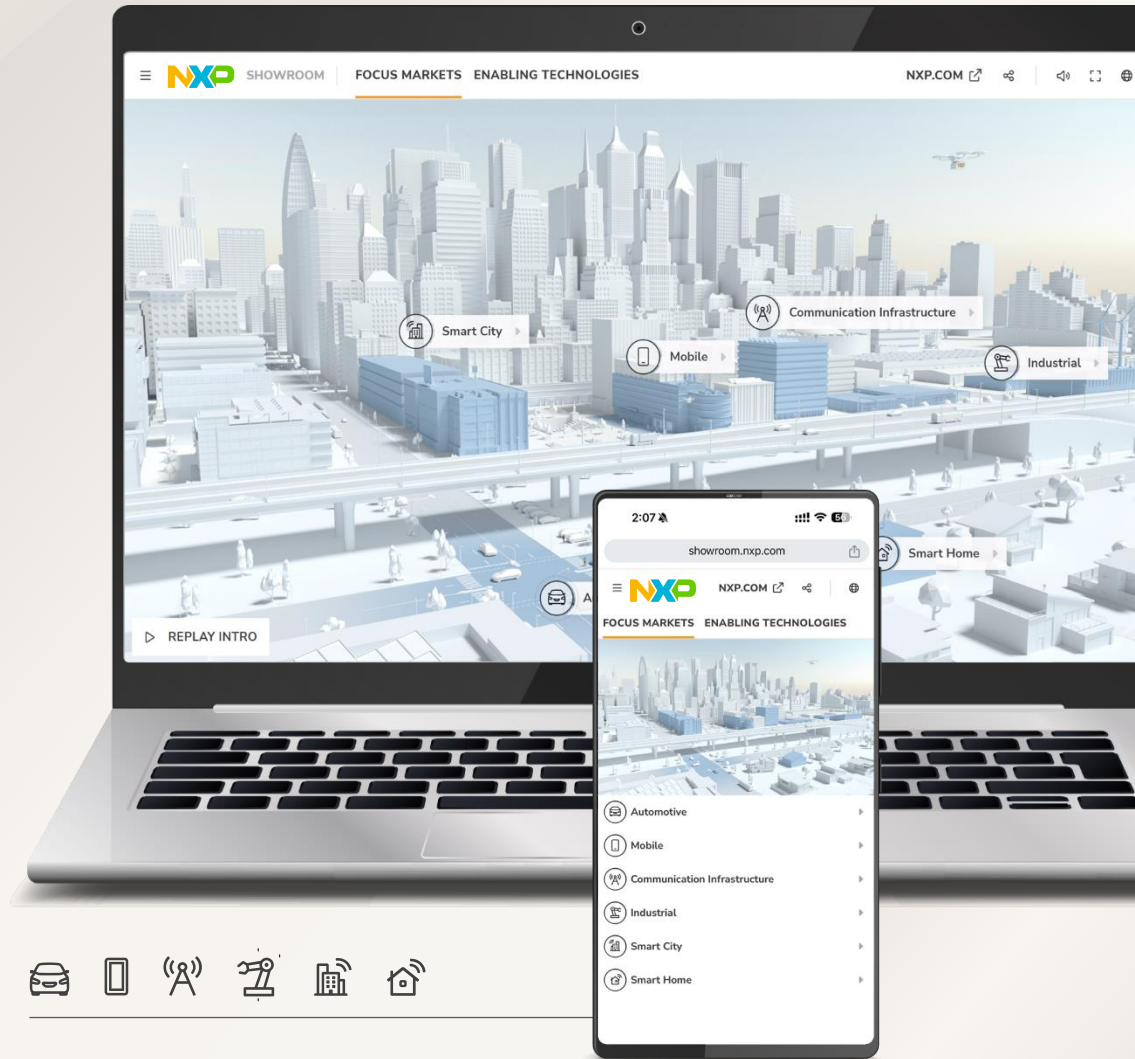
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