Powering E/E Vehicle Architecture: System Power Management Solutions for Compute, Zonal and End Nodes

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Navigation section

Agenda

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

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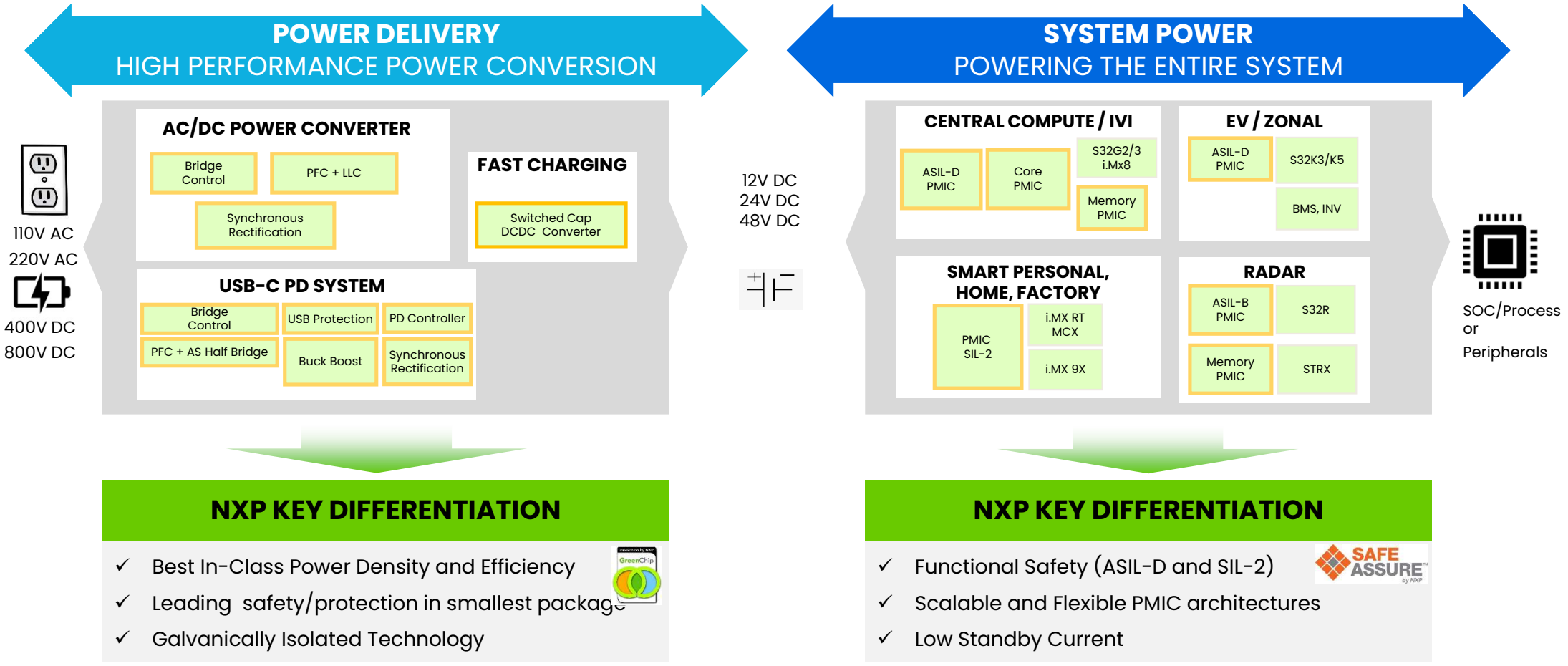
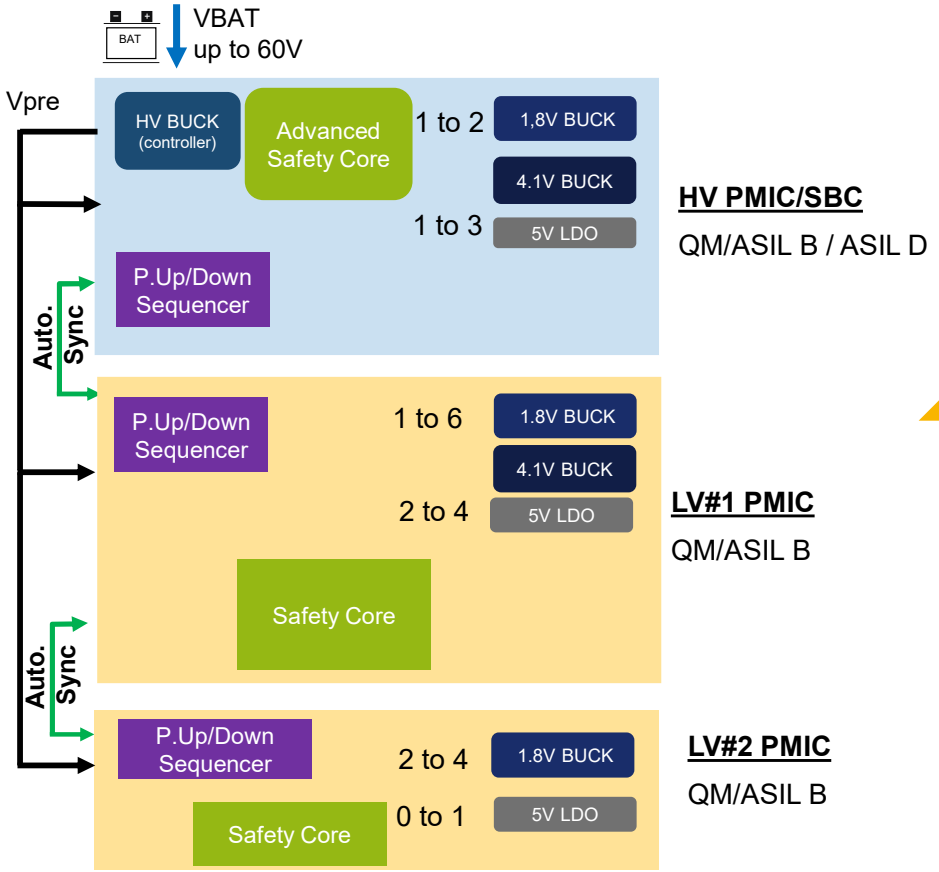
APS (Advanced Power Systems)
Power Management System Play from the Plug to the Processor



System Power Solutions
Safety PMIC "building block" portfolio

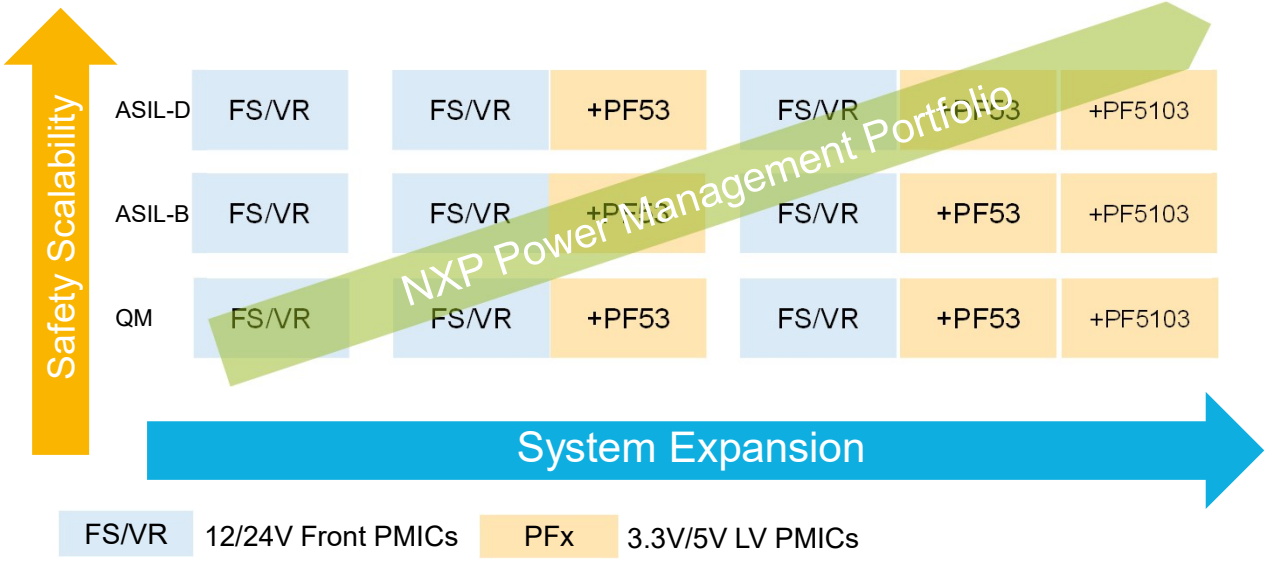


HV PMIC/SBC
QM/ASIL B / ASIL D

LV#1 PMIC
QM/ASIL B

LV#2 PMIC
QM/ASIL B

- 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

SUSTAINABLE	SAFE	SIMPLIFIED		
✓	✓	✓	FS84, FS85, FS86 PF5x, PF8x	 ADAS
✓	✓	✓	VR5510, PF53 FS26, FS23	 VEHICLE ARCHITECTURE
✓	✓	✓	FS45, FS65, FS26 FS86, PF5030 PCA9450, TAA3033	 ELECTRIFICATION
✓	✓	✓	FS24 PCA9450	 UWB ECO Auto/Mobile/IoT
✓	✓	✓	PCA9450, PCA9451A PCA9460, PF9453	 SMART FACTORY
✓	✓	✓	PCA9450, PCA9451A PCA9460, PF9453	 SMART HOME

Find more information on: [PMICs and SBCs for Multi-Vendor Processors Web Page]

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Automotive Megatrends

CLOUD

Over-the-Air (OTA) Services ↕ Vehicle Data / Model

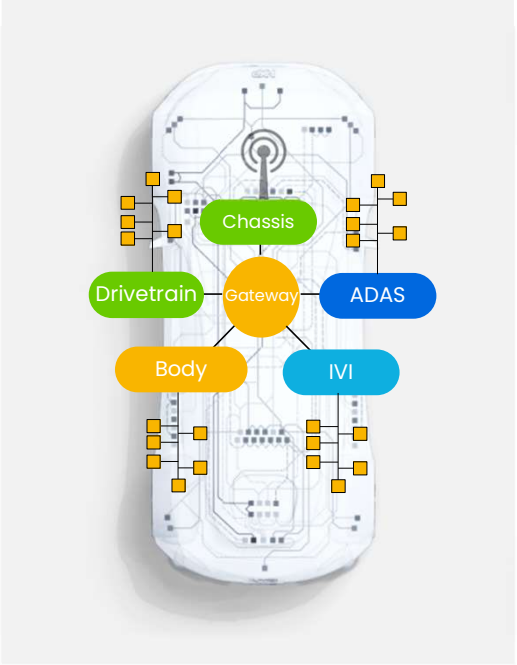
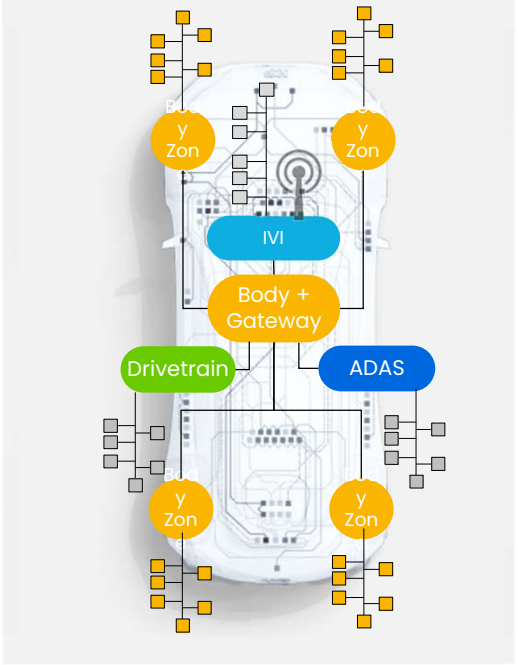
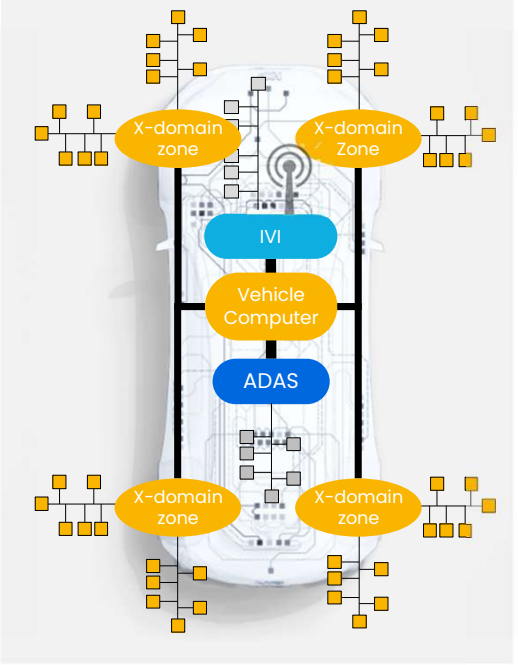
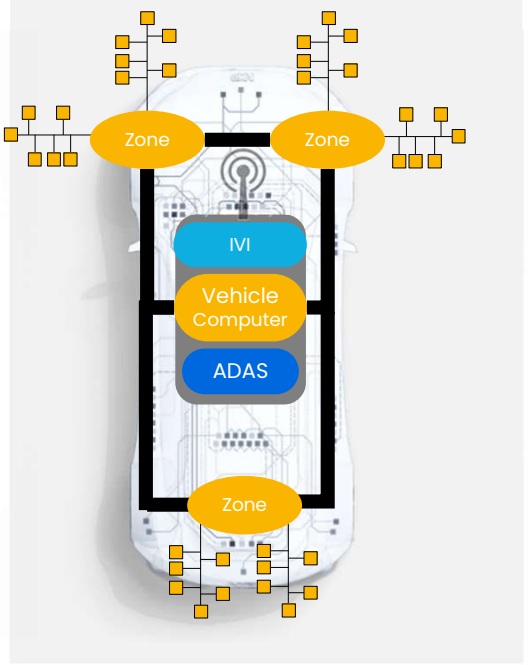
Autonomous	Software-Defined Vehicle	Electric
New sensing, thinking	Connected from cloud to edge	New energy management

E/E transformation needed

Processing Centralization | Networking Technology | Service Oriented | Zone I/O aggregation

System Power Solutions to Address Multiple Type of Vehicle Platforms

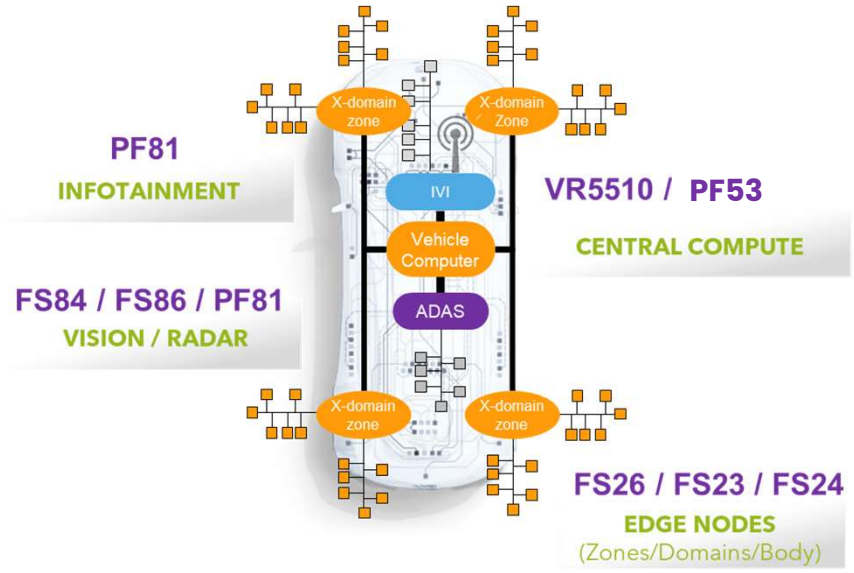
FROM CENTRALIZED TO ZONALIZED

DOMAIN BASED	BODY ZONAL	CROSS-DOMAIN ZONAL	CONSOLIDATED COMPUTE
			

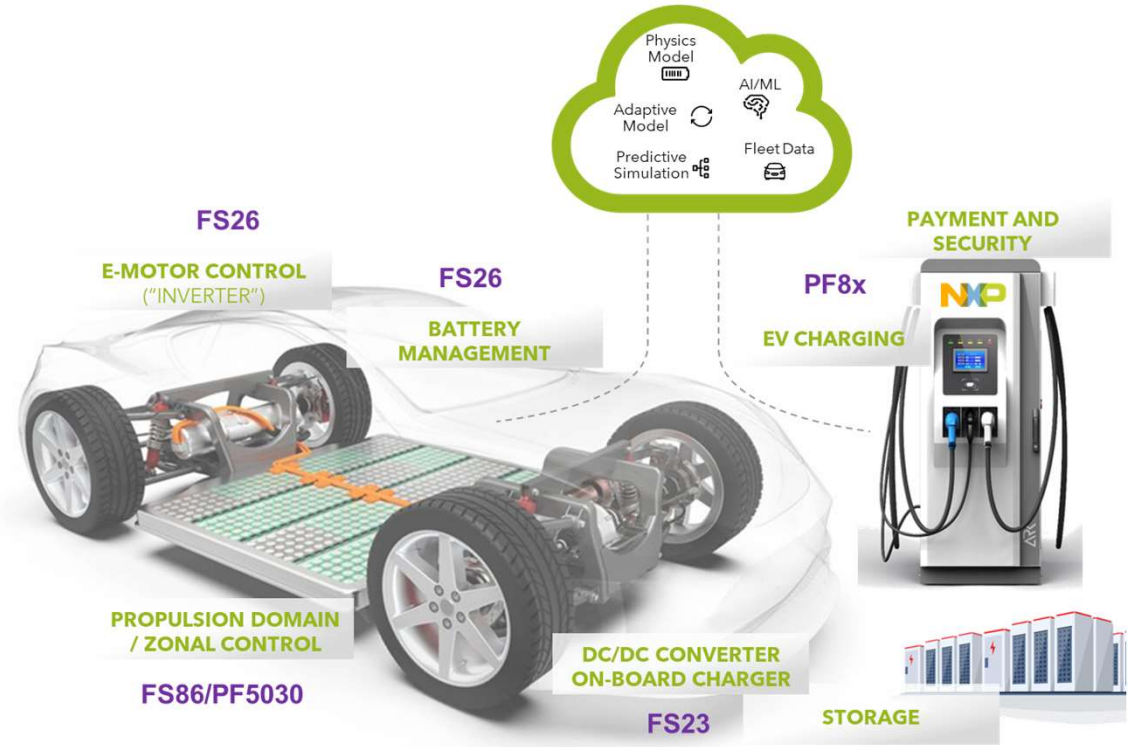
System Power solutions	EV, Safety, Chassis	GTW, Compute, Zone	ADAS	IVI
Battery Connected SBC	POWER THE ENTIRE SYSTEMS, PROCESSOR AGNOSTIC BEST IN CLASS SAFETY CONCEPT – PROVEN, ROBUST & FLEXIBLE SIMPLIFY PLATFORM DESIGN – SCALABLE POWER, SW, SAFETY HIGH PERFORMANCE SYSTEM LOW POWER			
5V PMIC Power Extender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

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

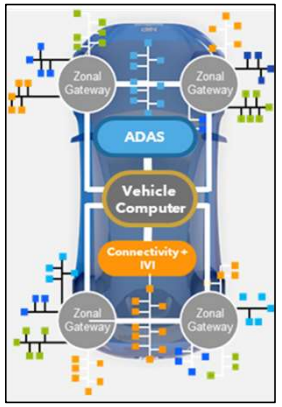
Cross-Domain Integration

Real-time + Service-oriented Compute

Software-Defined Vehicle
Vehicle Computer

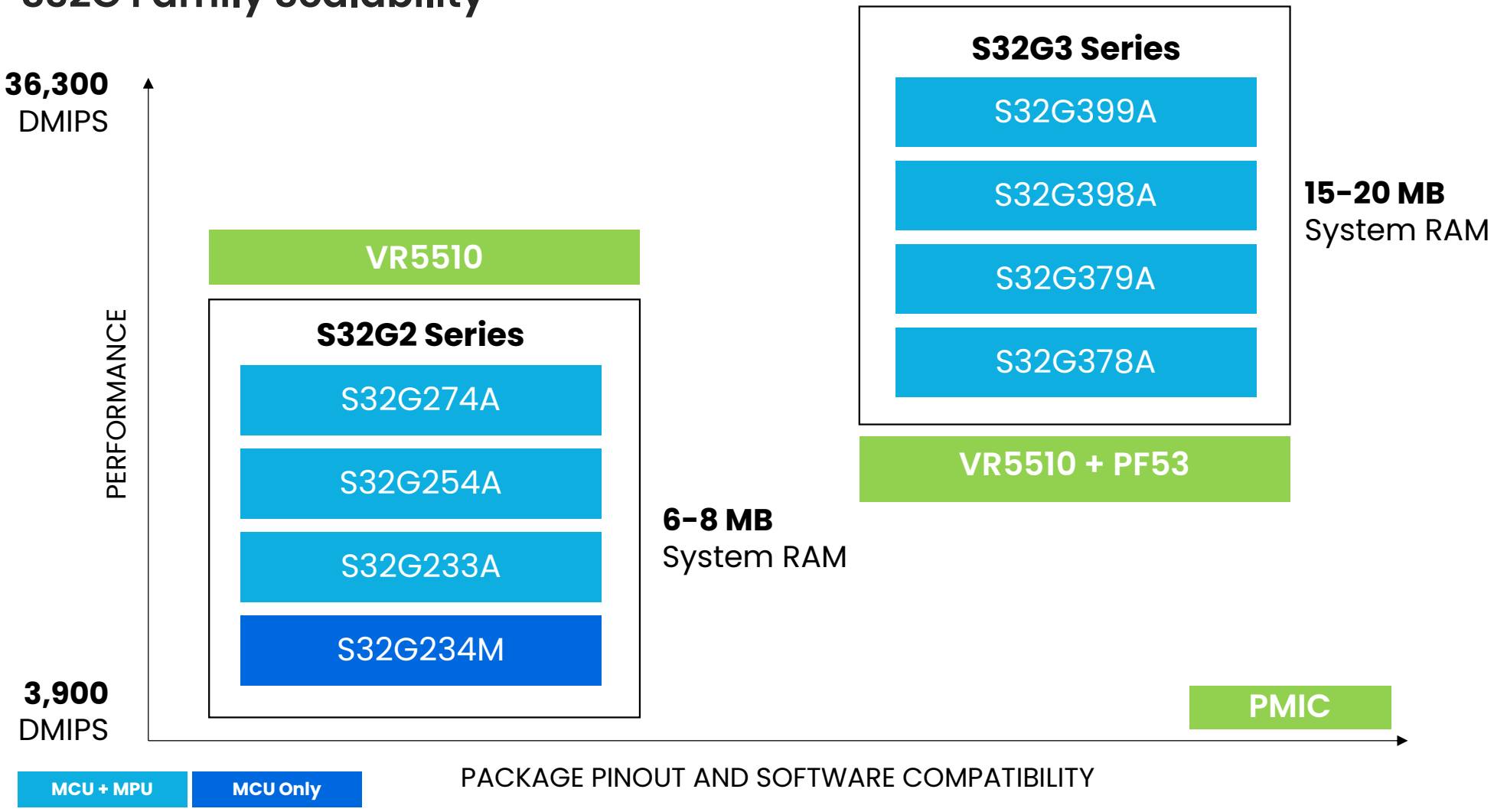
ADAS / AV Compute ↔ Safety Processor

ADAS / Autonomous Vehicle
Safety Processor

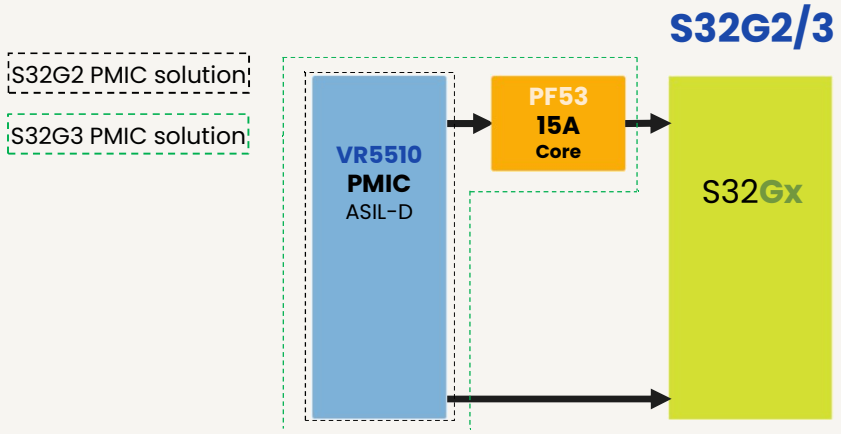


High-Performance Safety Processing

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

POWER MODE CONTROL

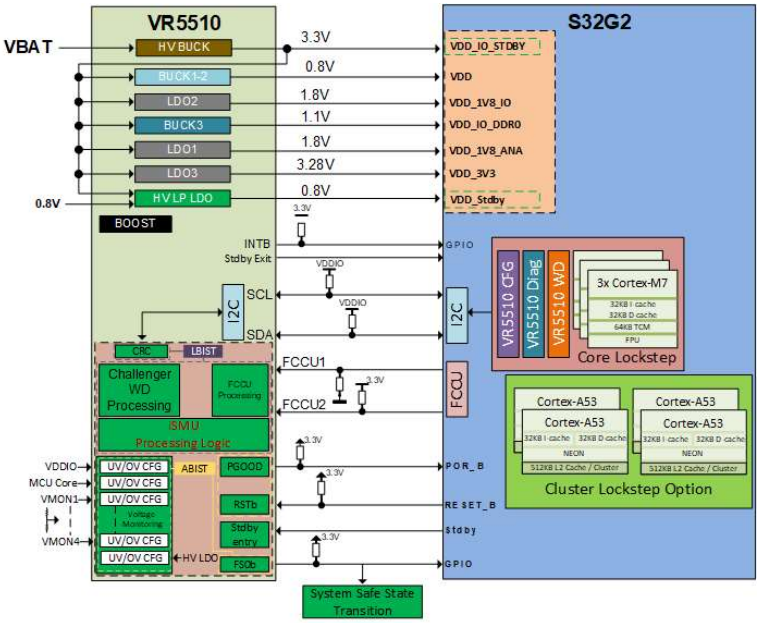
- Reliable power modes transition (shortest boot up and transition times)
- Multiple Power Modes with a dedicated standby scheme for S32G
- Dedicated interface & optimized SW control

SAFE

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

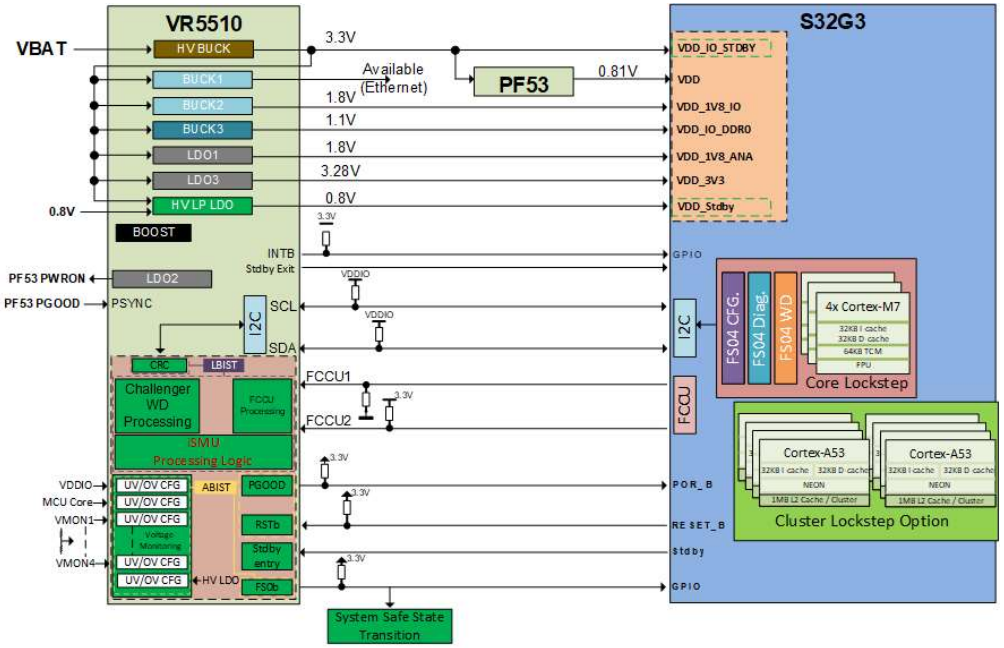
Power Management Solution for S32G2 and S32G3

VR5510 ⇔ S32G2



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

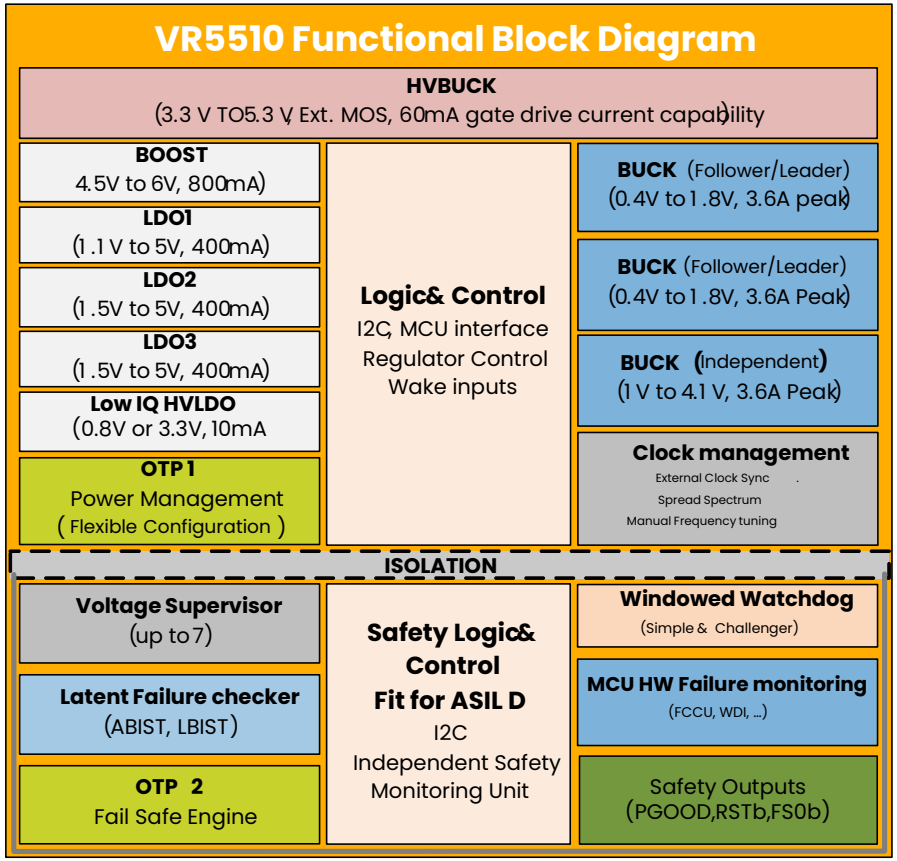
VR5510 + PF53 ⇔ S32G3



- 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



In Production

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

3rd 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

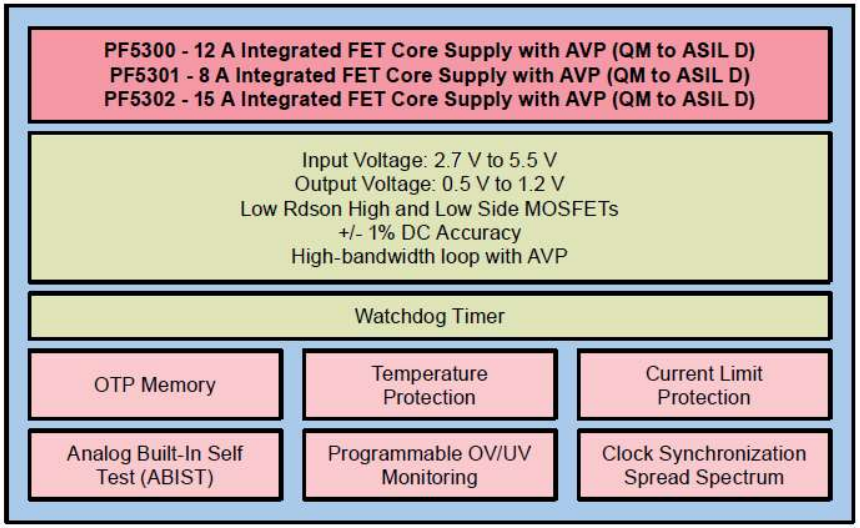
Extended low power capability allowing to manage different uses cases

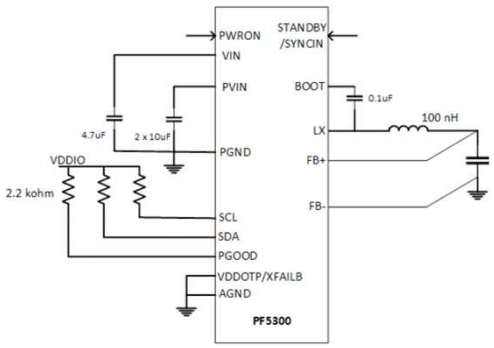
- Seamless power management transition between S32G low power and normal modes
- Automatic processor supply voltage reduction during low power modes to minimize leakage
- Simple single pin interface and configuration to handle various power modes including DDR refresh

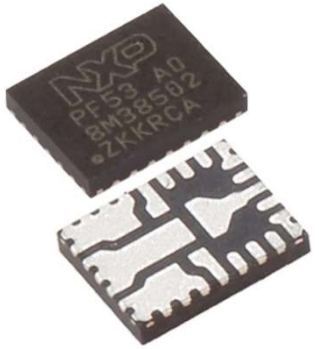
Mode	BUCK/LDO available	Quiescent current
Standby Mode	Vpre + HVLDO	35 µA
DDR Refresh Mode	Vpre + HVLDO + Buck3 + LDO2	85 µA
Deep Sleep Mode	HVLDO	15 µA

PF5300 – 15A Integrated FET Core Supply – S32G3 Attach

- **Differentiating Points**
  - Functional safety up to ASIL D
  - Low shutdown current: 1.5 µA
  - High bandwidth DC-DC with programmable AVP
  - Fast start up: 500 µs 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: +/- 1% with differential remote voltage sensing
  - Programmable OV/UV monitoring with 1% accuracy
  - Watchdog timer
  - Integrated MOSFETs: 3 mΩ low side, 7.6 mΩ high side
  - High efficiency
  - -40 °C to 125 °C Operating Ambient Temperature (150°C Tj)
  - Package: 3.5 mm x 4.5 mm FC-QFN package







In Production

Key Focus Areas for PF5300 Development

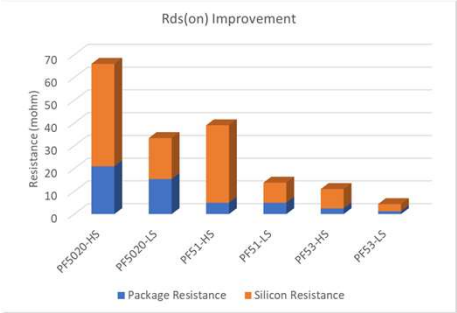
DC Accuracy — For Regulator and Monitor

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

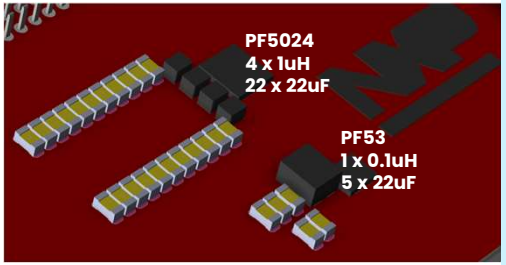
Loop Bandwidth	PF50/PF8x	PF5300
Bandwidth with Cout = 44 uF	~250 kHz	~400 kHz
Bandwidth with Cout = 400 uF	~ 90 kHz	~400 kHz

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/µs step

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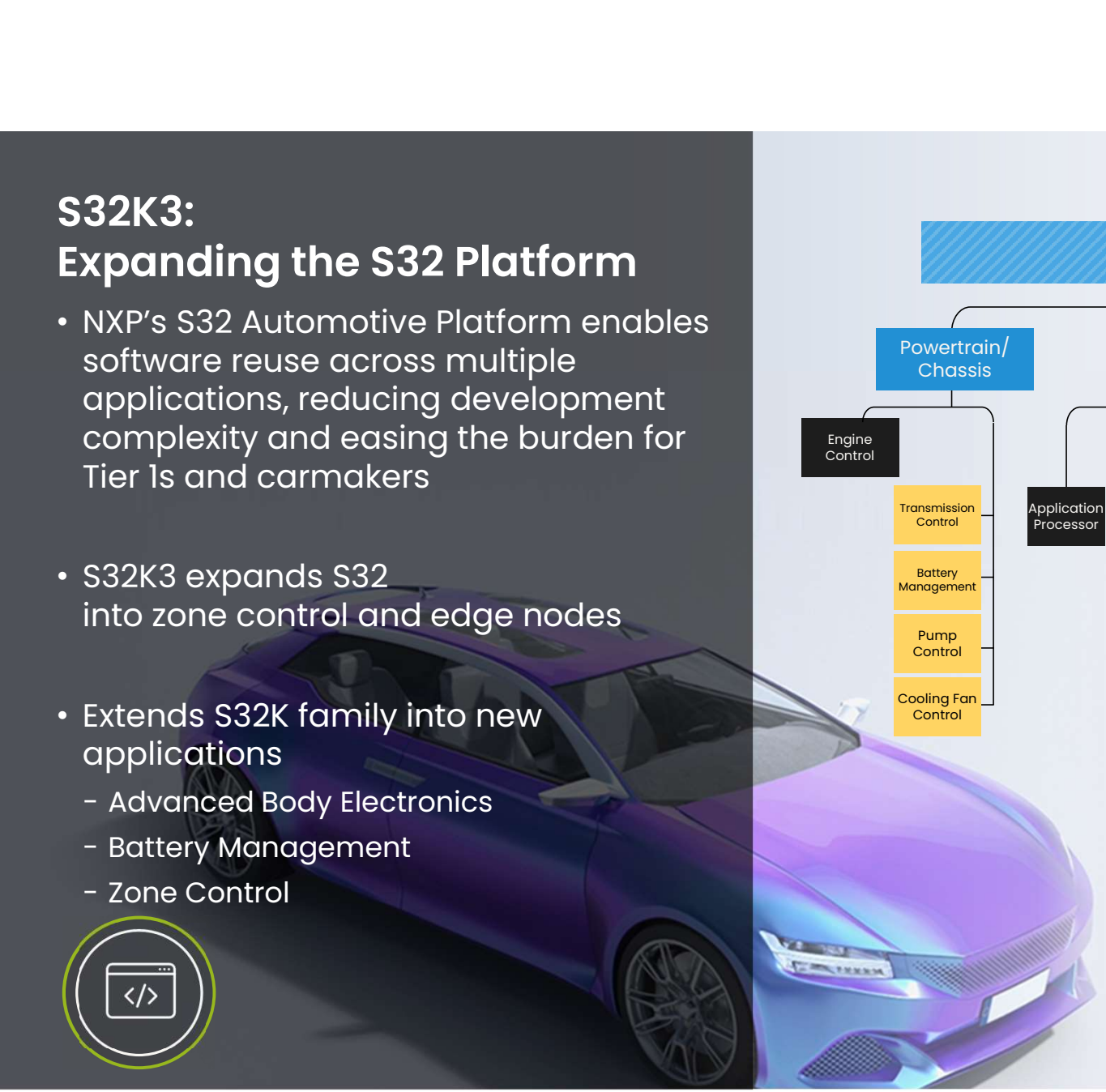
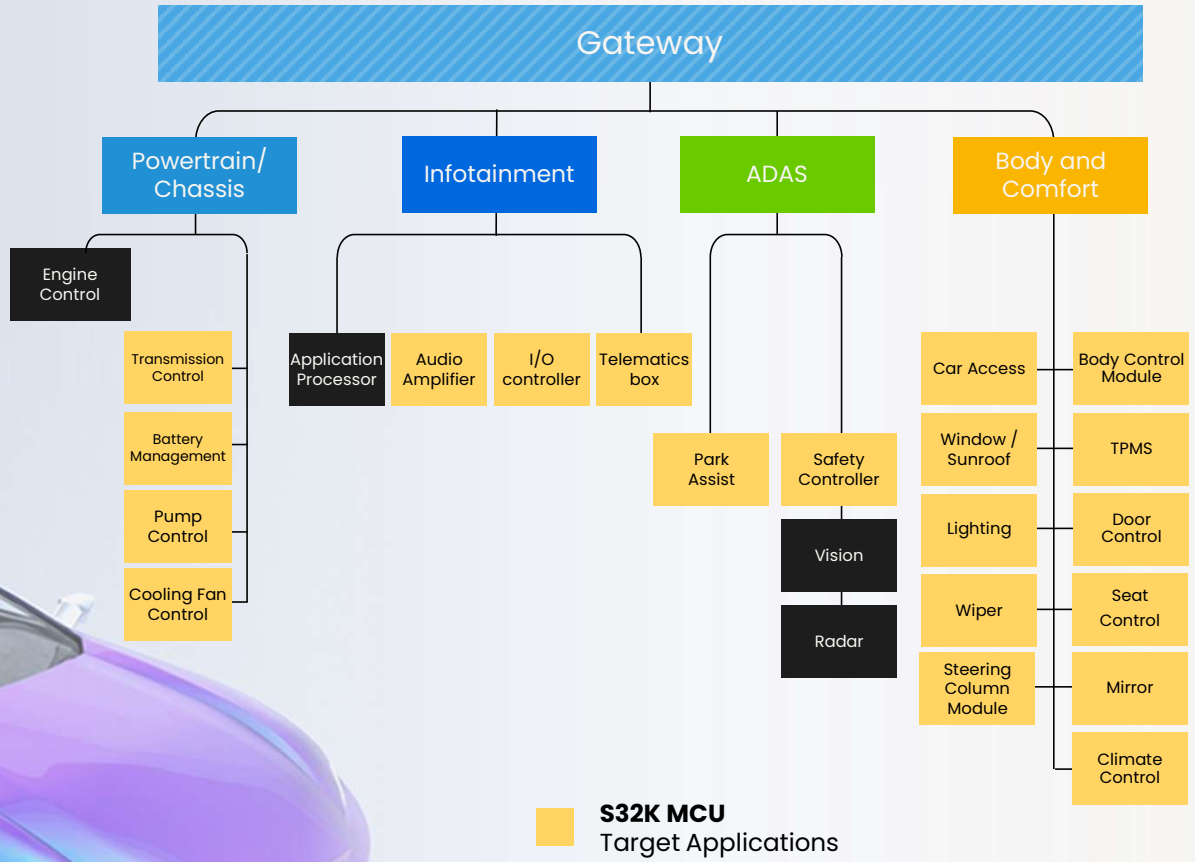
S32K3:
Expanding the S32 Platform

- 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

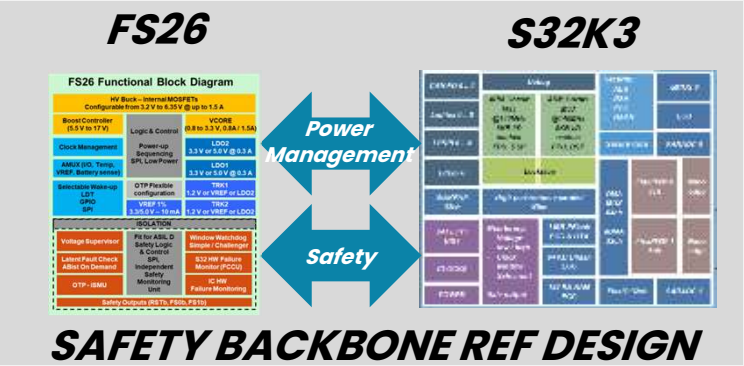




Powering systems with S32K3 Portfolio – use case solutions

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

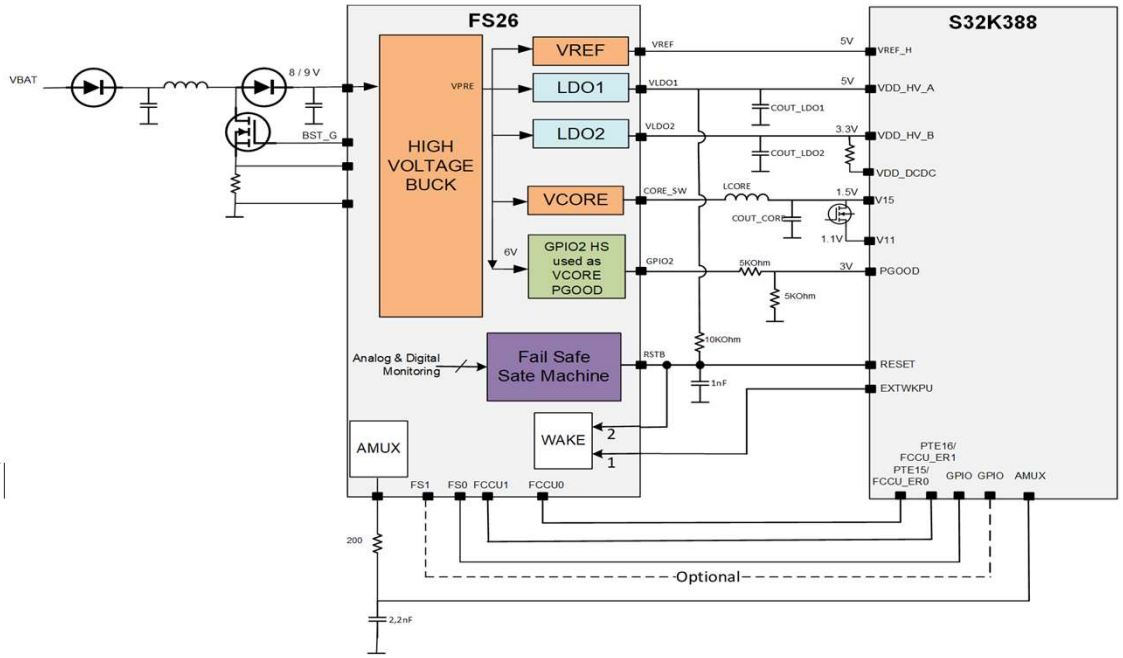
FS26 Attributes

- **FS26** is the 3rd 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)

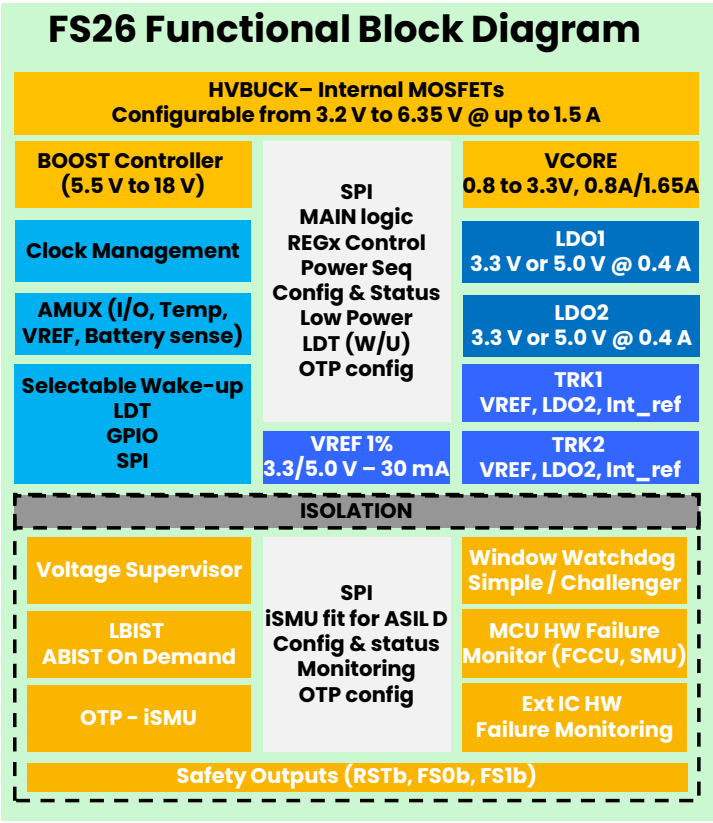
System Features

- 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)

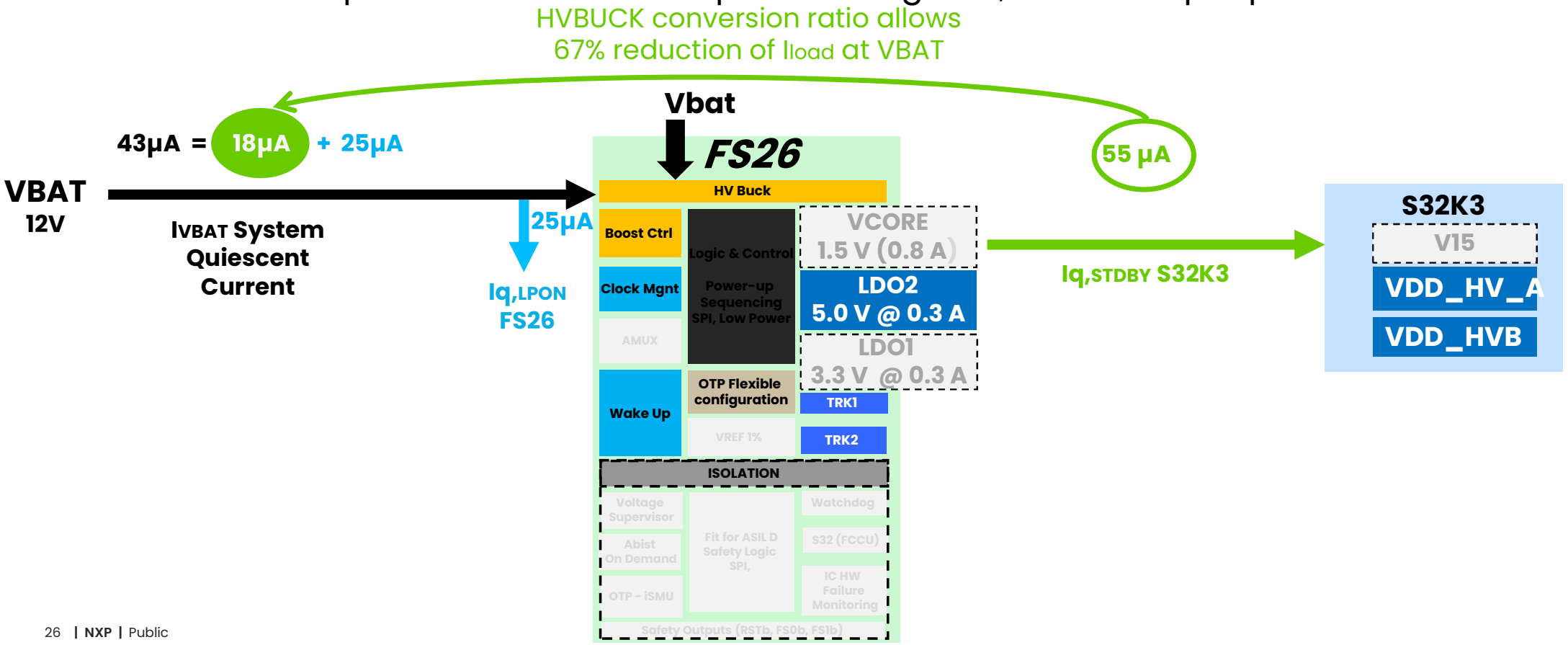
FS26 Functional Block Diagram



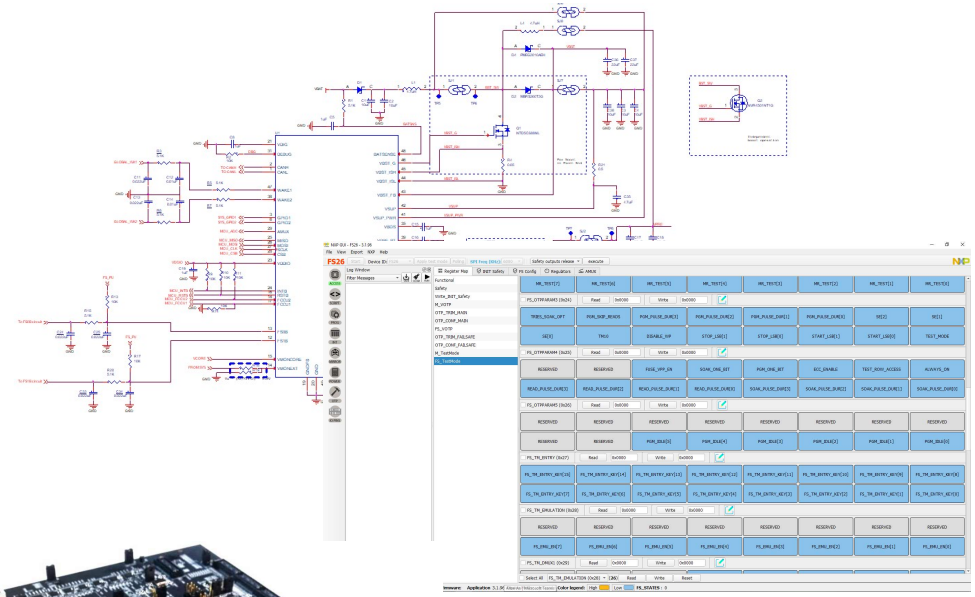
Package : LQFP48eP
PPAP Available

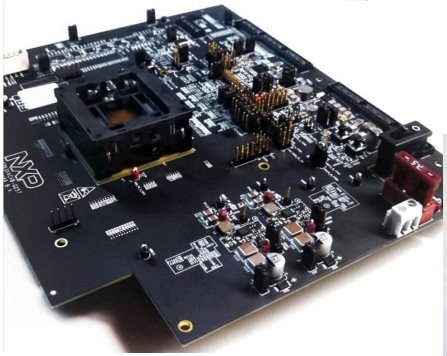
Achieve ECU Energy Management target < 100 microamp in standby mode

- **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



FS26 ENABLEMENT AVAILABLE ITEMS





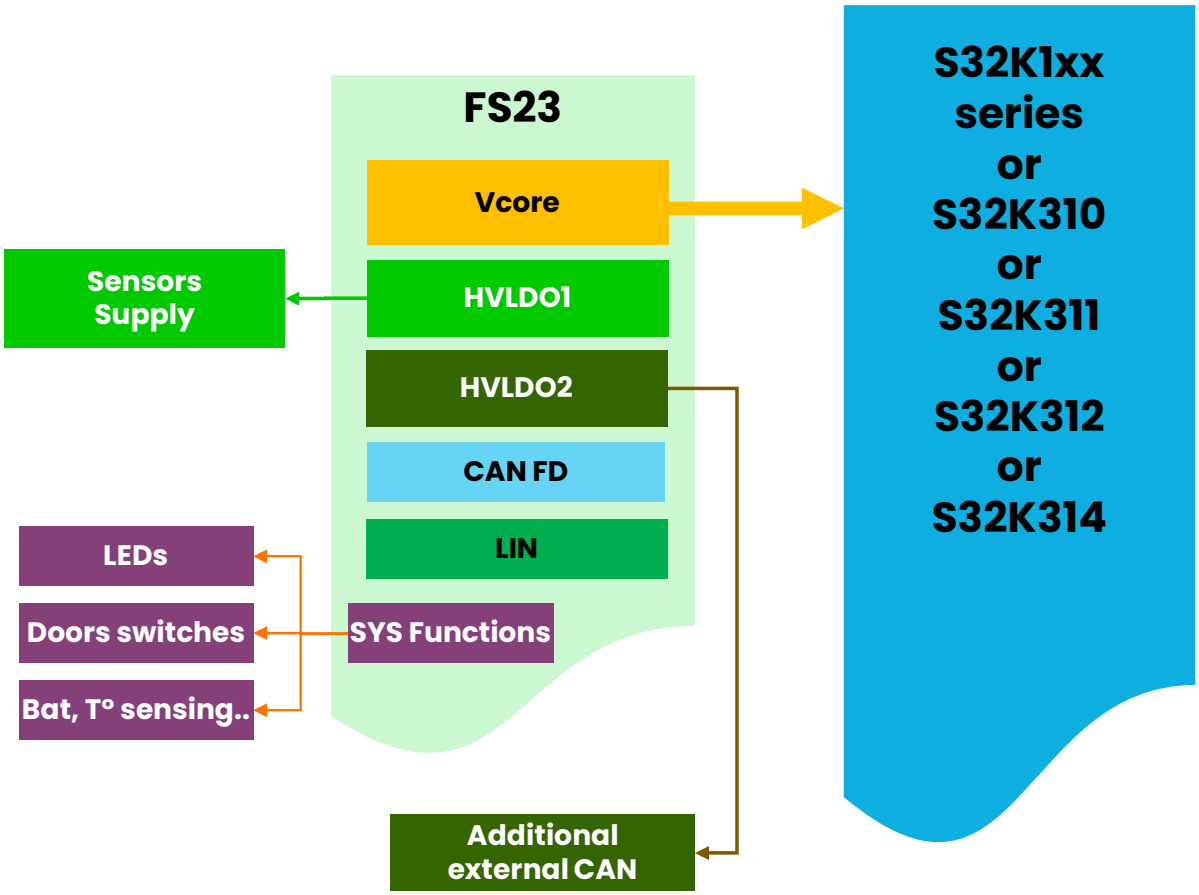
Product	Type	Status
Data Sheet ★	Document	Available
Safety Manual ★	Document	Available
FMEDA ★	Document	Available
AN12995 : NXP FS26 Hardware guidelines ★	Document	Available
AN13850 : NXP FS26 Implementation and Behaviors ★	Document	Available
AN13323 : Safety Application Guide (FS26 +S32K3) ★	Document	Available
AN13494 : NXP Solution to attach FS26 to S32K3 and SJA1110 ★	Document	Available
AN13322: NXP Solution for Infineon AURIX TC2xx/TC3xx series ★	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
Safety LS 320MHz 4 M7 cores	S32K37/9	D	1.1-1.5 V (1350 mA) – 4c 5.0 V (100 mA, 400 mA peak) 3.3 V (100 mA, 400 mA peak)	6M	FS2620D	FS2633D	FS2633D	X
Safety LS 320MHz 4 M7 cores	S32K388	D	1.1-1.5 V (1350 mA) – 4c 5.0 V (100 mA, 400 mA peak) 3.3 V (100 mA, 400 mA peak)	8M	X	X	X	FS2633D
Safety LS M7 +1 M7 core 240MHz	S32K358	D	1.5 V (800 mA) 5.0 V (50 mA 280 mA peak) 3.3 V (50 mA 280 mA peak)	8M	X	FS2613D	X	FS2613D
Safety LS 160/240MHz 2 M7 cores	S32K344	D	1.5 V (500 mA) 5.0 V (50 mA 280 mA peak) 3.3 V (50 mA 280 mA peak)	4M	X	FS2613D	X	FS2613D
3 M7 cores 240MHz	S32K33x	B	1.5 V (800 mA) 5.0 V (50 mA 280 mA peak) 3.3 V (50 mA 280 mA peak)	8M	X	X	X	X
2 M7 cores	S32K32x	B	1.5 V (400 mA) 5.0 V (50 mA 280 mA peak) 3.3 V (50 mA 280 mA peak)	1/2/4M	X	FS2600B	X	FS2600B
Single M7 core	S32K31x	B	3.3 V/5.0 V (200 mA)	1/2M	FS23	FS23	X	FS23

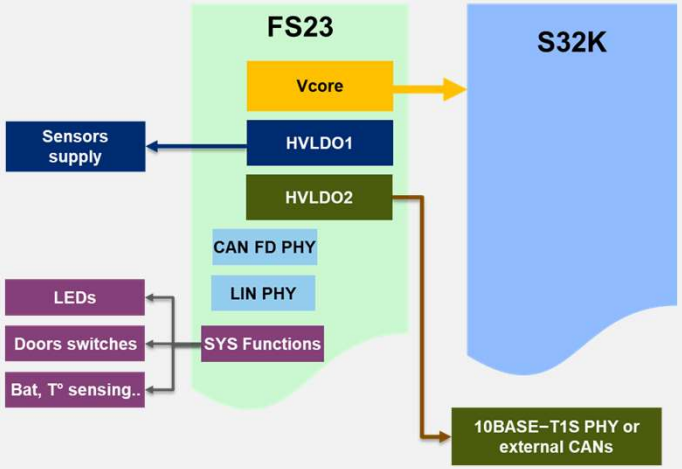
FS23 – System power for ENTRY ev AND EDGE SDV



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 IOs

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 to10cts)

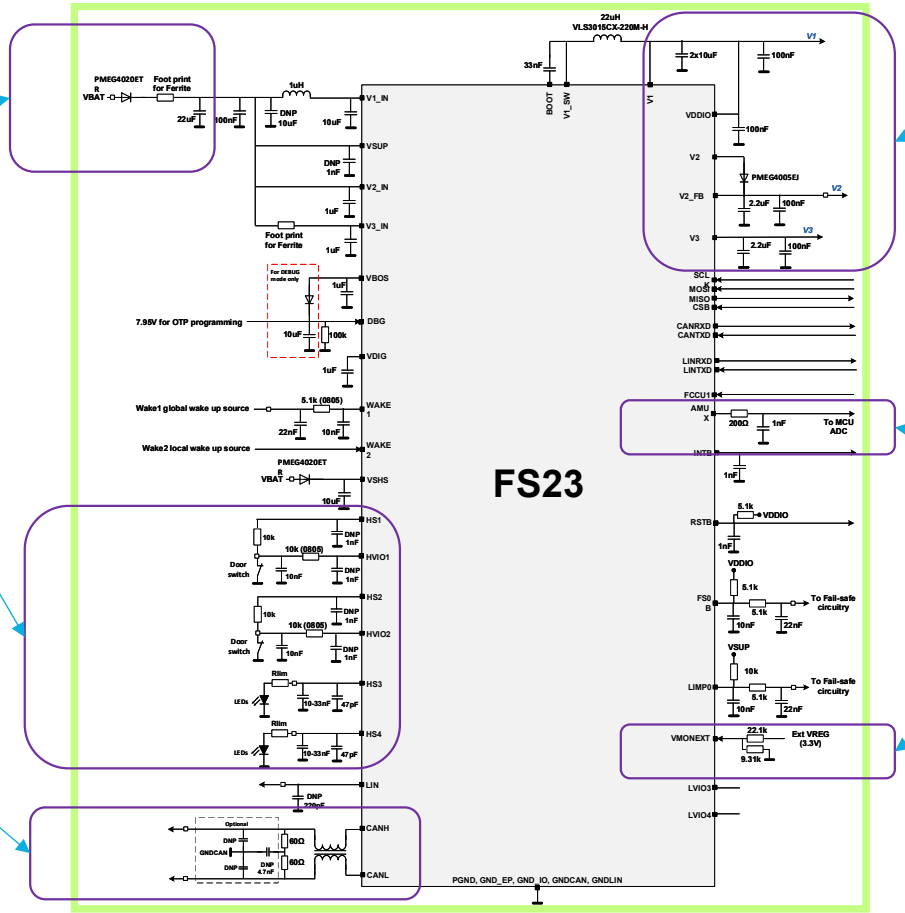
FS23 integrates 4 High Side Drivers

BOM saving (8 to 12cts)

IEC61000 ESD protection +/-8KV:

FS23 integrates the external PESD diode (such as PESD1CAN-UX)

BOM saving (5 to10cts)



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

5 Mbps

SAFE ASSURE by NXP

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
- **HVLDO**3, 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

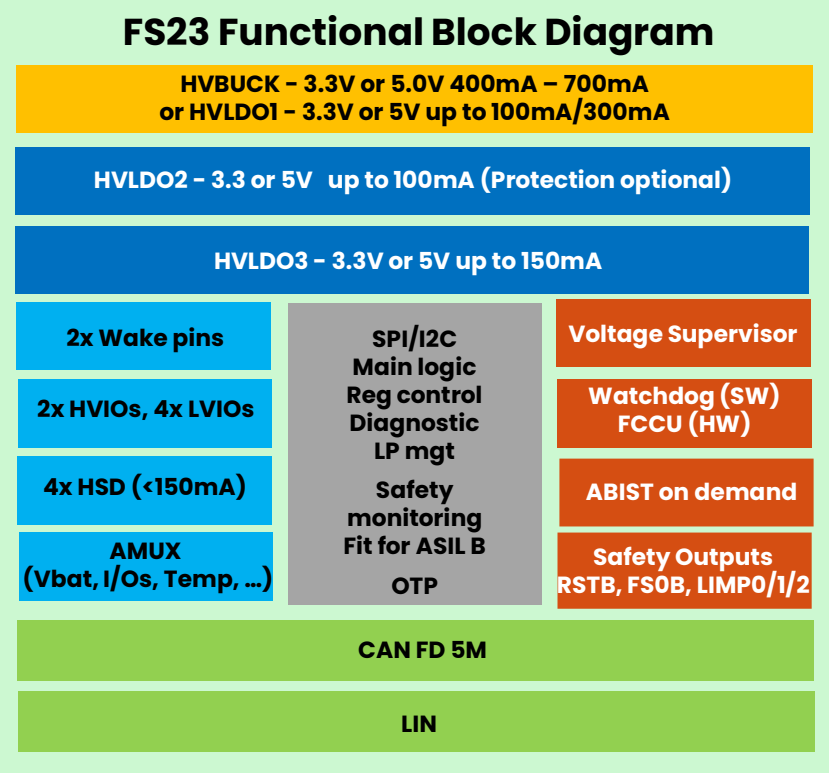
System Featuring – Fit for Body Market

- **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, **LIMP0** high by default, **LIMP1/2** with PWM capability 1.25Hz/100Hz)

FS23 Functional Block Diagram



Package: QFN48EP with wettable flank

Samples: Available

PPAP: Available

SDV Power Management solutions attached to NXP MCUs

Power

Vehicle Computer

S32G2x
- Cortex-A53 12K DMIPS
- Cortex-M7 4K DMIPS
- 2GbE Accel

VR5510

S32G3x
- Cortex-A53 31K DMIPS
- Cortex-M7 5K DMIPS
- 3GbE Accel

VR5510 **PF53**

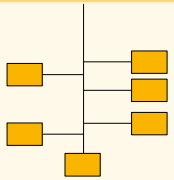
More to come

zone

S32K3x
- S32K34/5/8 — M7(LS+1/3) 4MB-8MB
- S32K32/3 — M7 (2x-3x) 2MB-8MB

FS26

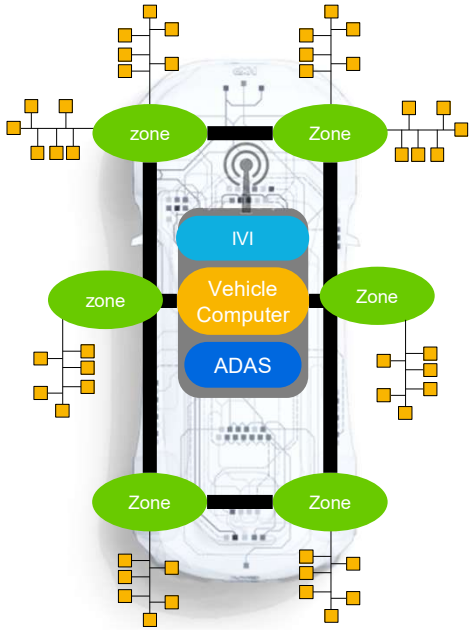
End nodes



S32K1x
- S32K14 — 1xM4 256Kb – 2Mb
- S32K11 — 1xM0+ 128-256Kb

S32K31
- 1x Cortex-M7
- 512K – 4Mb

FS23 / 24



MCU processing performance

Agenda

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

Technical Session Survey

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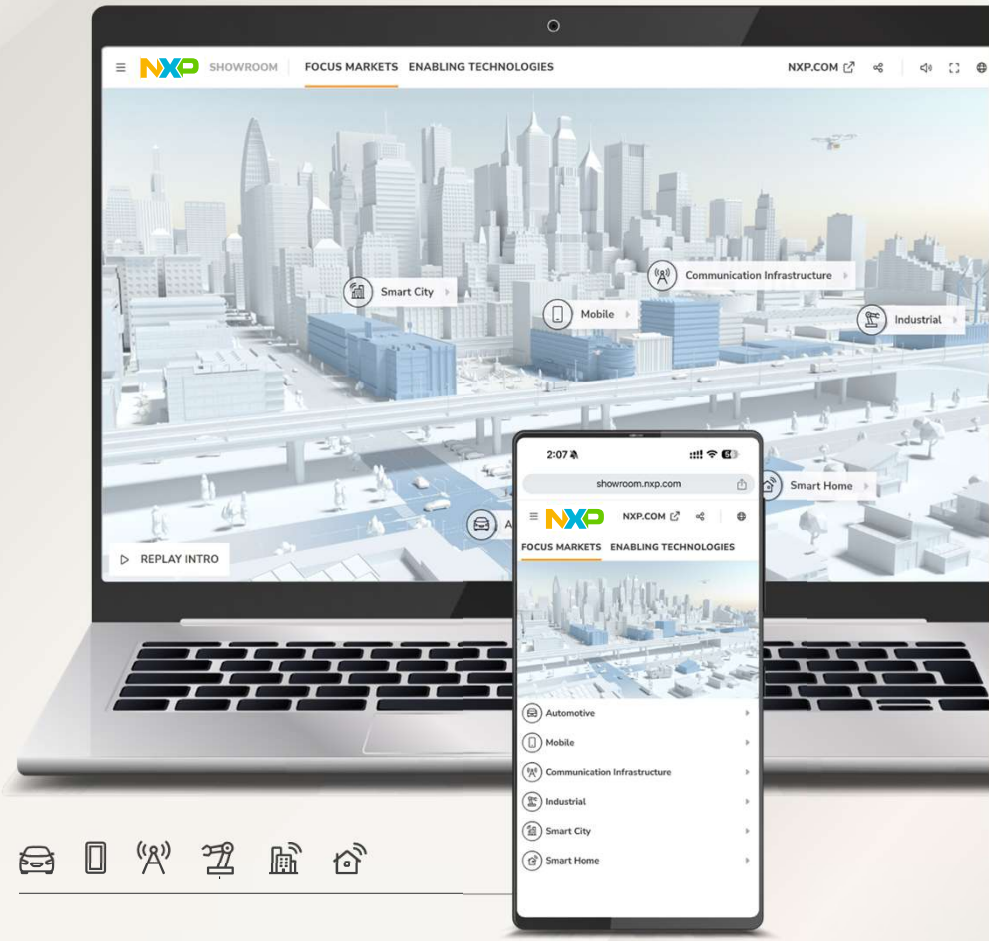

Get in touch

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