

S32K Microcontroller Family Technical Deep Dive

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Automotive Microcontrollers and Processors

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Agenda

- S32K Product Family Overview
- S32K1 Technical Capabilities
 - SoC Benefits, SW, Tools, Solutions
- Technical Resources



S32K Family Overview



NXP – Supplier of Choice for Advanced Processing

Powertrain & Vehicle Dynamics	Body & Comfort	Driver Replacement	Connectivity	Networking	Infotainment
VDS (Vehicle Dynamics & Safety)	GPIS (General Purpose & Integrated Solutions)	ADAS (Advanced Driver Assistance Systems)	C&S (Connectivity & Security)	DN (Digital Networking)	i.MX (Multimedia and General Purpose Applications Processor)
					
Chassis, Safety, Torque and Energy Management	Body Electronics Edge Nodes	Radar, LIDAR, Vision Sensor Fusion	Vehicle Network Processing (Gateways, Domain Controllers)	Advanced Processing Solutions	Infotainment, Reconfigurable Cluster, Telematics, V2X, Driver Awareness
<ul style="list-style-type: none"> • Long term innovator in chassis and powertrain control • Significant growth in safety as autonomous control drives robust fault tolerant systems 	<ul style="list-style-type: none"> • Broadest portfolio of integrated MCU+HV mixed-signal solutions • Application specific software solutions 	<ul style="list-style-type: none"> • #1 in radar processing • Comprehensive radar, vision and central processing portfolio 	<ul style="list-style-type: none"> • #1 in vehicle networking and security • End-to-end portfolio of networking devices 	<ul style="list-style-type: none"> • High-performance Multicore Arm® SOC's for Edge Compute • Virtualized, Secure, Solutions with Application Specific Acceleration 	<ul style="list-style-type: none"> • #1 in Infotainment & Reconfigurable Cluster • Scalable multimedia solution with audio DSP, VMCU, safety camera/display/audio, hardware virtualization, vision acceleration

S32K Target Apps: Truly General Purpose

Body Electronics



HVAC



Steering wheel



Lighting



Battery/Power mgmt



Doors



Body Controllers

Motor Control



Engine /
cooling fans



Wipers



Window lift



Diesel / Oil Pump

Infotainment



Eth. Audio Amp



Wireless Charging,
NFC pairing

Chassis/Safety



TPMS



Suspensions



Gear shifter



Motorcycle ABS

ADAS



Park Assist



Motorized cameras

General Purpose and Integrated Solutions

8/16/32bit General Purpose

Body Electronics
Exterior



Interior



Across domains



MPC56xxB – GP 32bit

S12 – GP 16bit

S08 – GP 8bit

S32K1

arm

can FD



SDK

Next Gen
S32K

arm

can FD



SDK

KEA

arm

Integrated Solutions

Motor Control
Window Lift



Pumps, Fans



Sensor Interfaces



S12 MagniV



Next Gen IS
Solution

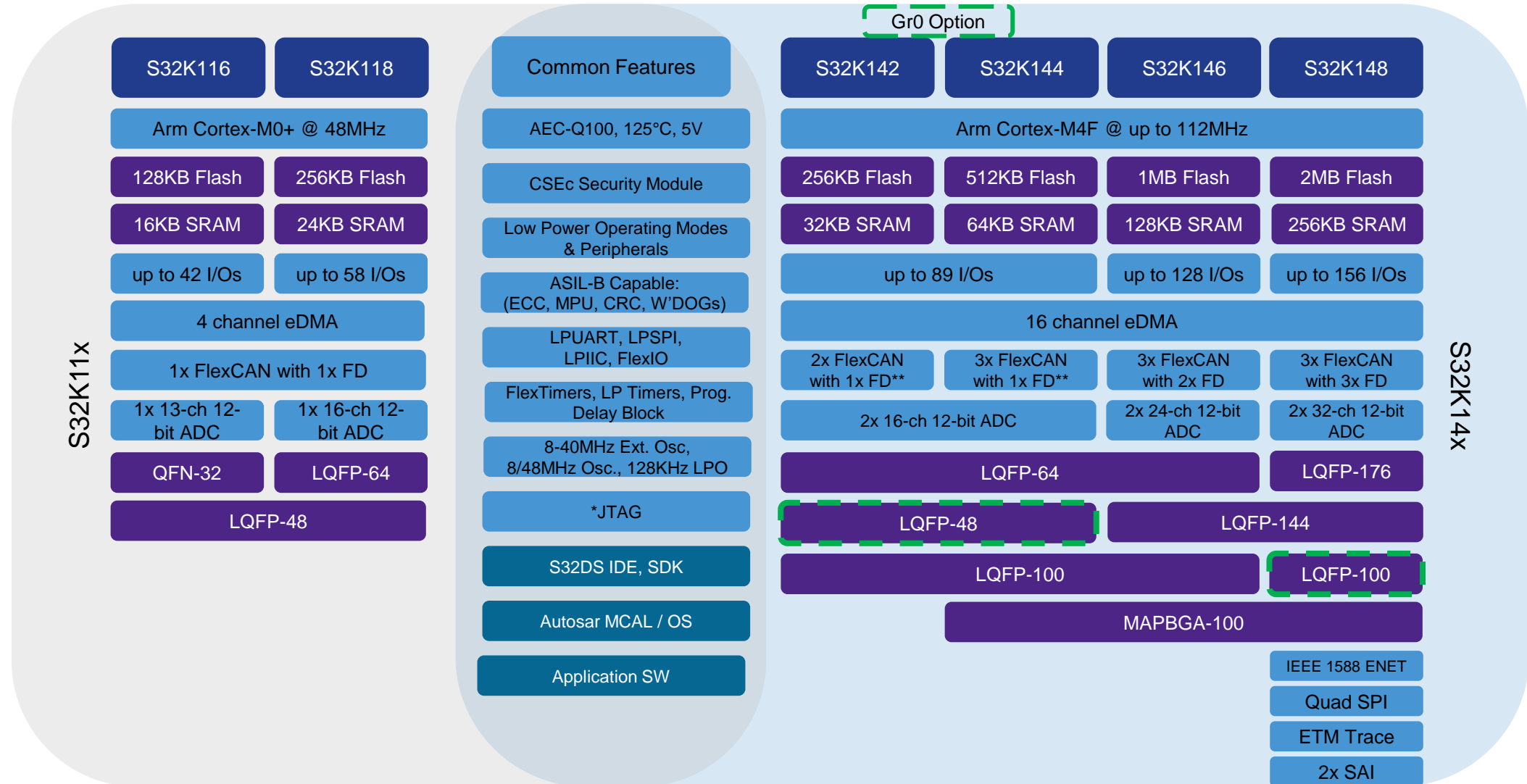
arm



S32K14x and S32K11x Features

Production

Development



*S32K14x only

** 2x CAN FD in S32K14xW (Grade 0)

S32K1 Family Technical Capabilities



S32K – Future Proof

Superior Performance

- High speed ARM Cortex-M4F CPU with DSP functionality
- IEEE-754 HW floating point unit without SW overhead
- Harvard architecture accelerates data handling
- 16 bit instruction set (THUMB 2) → ~31% reduced memory usage
- Combined D/I cache for direct execution
- Concurrent, low latency bus accesses over crossbar
- Parallel DMA operation
- Dedicated EEPROM to support read while write

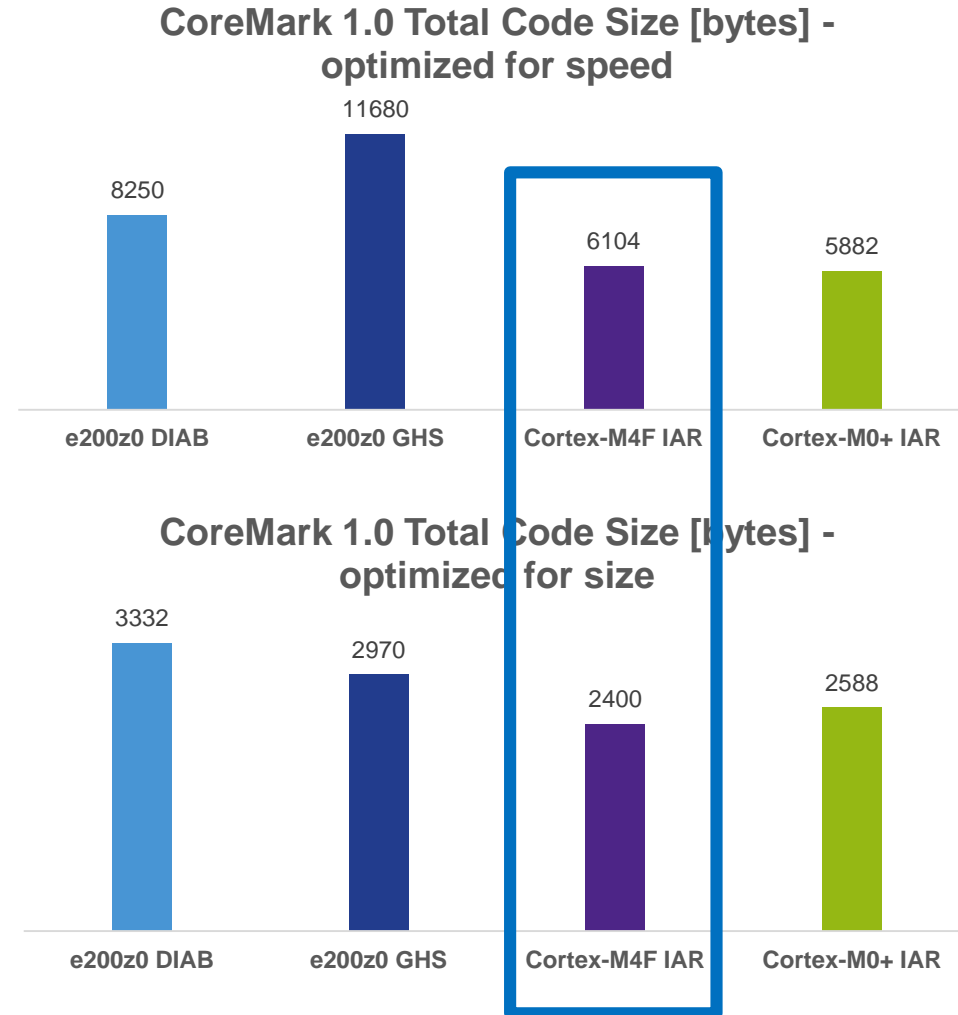
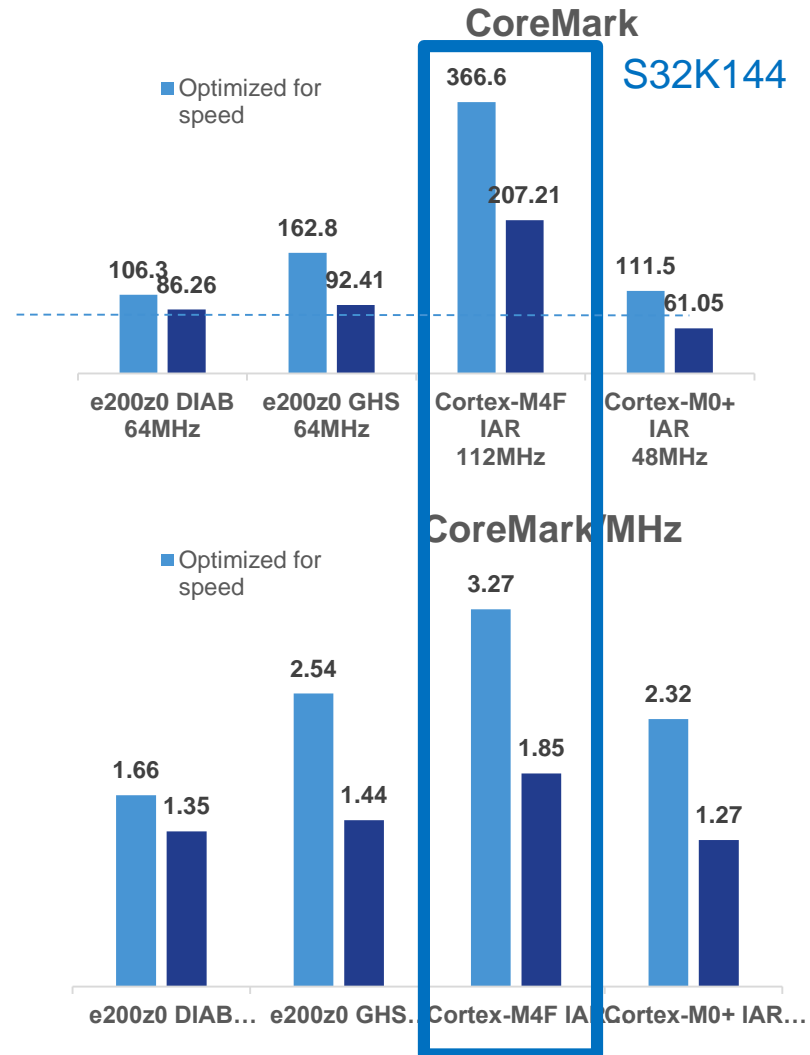
Highest Energy Efficiency

- Low leakage technology (C90TFS)
- Multiple low power modes
- Internal oscillators e.g. 48MHz 1.3%
- Best in class STOP current: 25-40uA (device depended)

Communications, Safety, Security

- CAN with Flexible Datarate (FD) option according to ISO/CD 11898-1
- HW motor control support (BLDC/PMSM)
- ISO26262 compliance (ASIL-B)
- Communication protocol emulation module (FlexIO)
- HW security engine (SHE+ compliant)
- Ethernet AVB support: 100Mbit/s Ethernet + IEEE 1588 Time Stamping + Audio (I2S)

S32K Superior Performance & Code Density

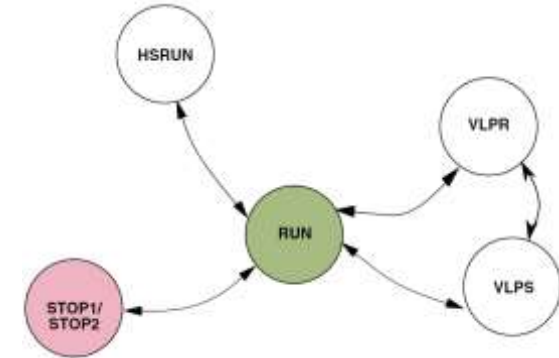


- Higher speed leads to better cache efficiency
- More space for application code

S32K1: Superior Low Power MCU Optimized for SW

Optimized system solution:

- Reduce average power
 - Sleep as much as possible
 - Minimize RUN execution
 - Simplify power mode transitions
- Only power what is needed
 - Only switch on silicon portions
 - Completely power gate unused portions in many power modes
- Only clock what is required
 - Optimize clock signal switching mechanism
 - Reduce number of clocked lines
 - Avoid wasting power in clock edges
- Employ intelligent autonomous operation
 - Switch on CPU and clock tree as little as possible



ALL modules maintained in *ALL* modes
ALL memory maintained in *ALL* modes
ALL I/O maintained in *ALL* modes
ALL I/O can wake up the MCU

Clock gating
Clock tree management
Peripheral grouping

Autonomous peripherals

- e.g. DMA, RTC, ADC, LPUART

S32K1 Low Power Performance Snapshot

	Ta (C)	VLPS (uA)	VLPR (mA)	Stop 1 (mA)	Run (mA)*
S32K116	25 (typ)	26	1.05	6.3	20.3
S32K118	25 (typ)	27	1.15	6.4	21.8
S32K142	25 (typ)	29	1.17	6.4	37.5
S32K144	25 (typ)	29.8	1.48	7	39.6
	105 (typ)	256	1.8	7.8	40.5
	125 (max)	1960	3.18	12.9	46.8
S32K146	25 (typ)	37	1.57	8	47.6
S32K148	25 (typ)	38	2.17	8.5	57.7

- All memory and all registers and all I/O are always maintained in all modes
- All I/Os can wake up the MCU
- Parameters of multiple use cases provided in Datasheet

*RUN mode with peripherals enabled. K11x @ 48MHz, K14x @ 80MHz

Energy-saving Peripherals

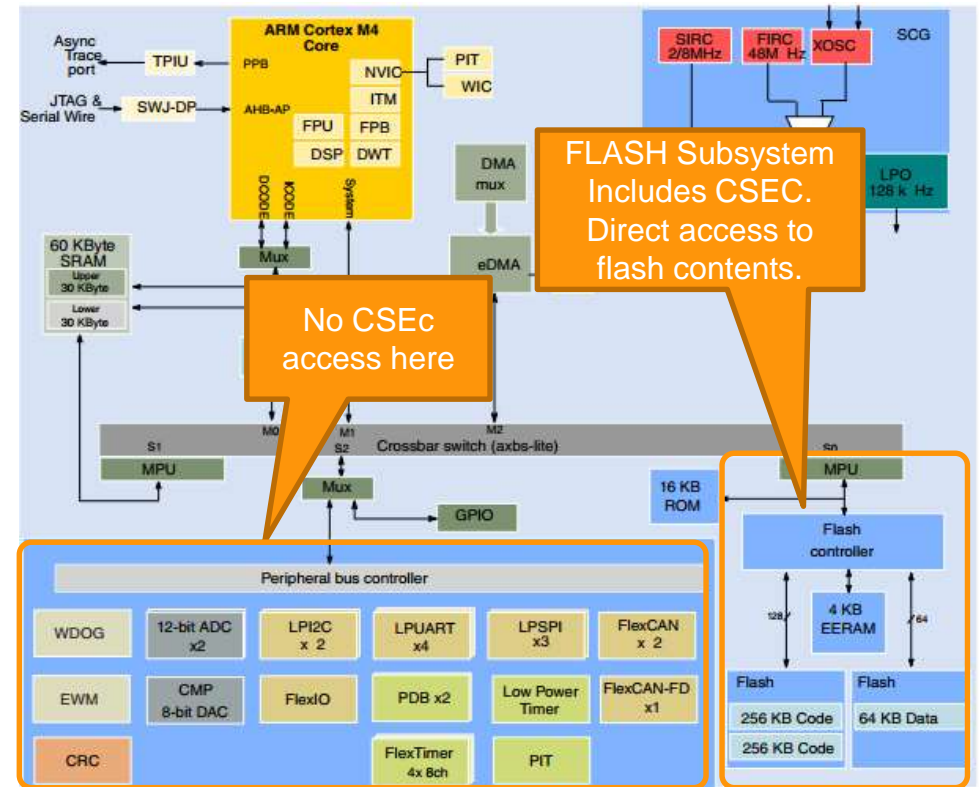
Intelligent peripherals increasing time in sleep modes with no CPU intervention for reduced power consumption.

Peripheral	Low Power Functionality
DMA	Allows energy-saving peripherals (ex. ADC, UART and Timer/PWM) to trigger asynchronous DMA request in STOP/VLPS modes to perform DMA transfer and return to current power mode with no CPU intervention
LPUART	Supports asynchronous transmit and receive operations to the bus clock supporting communication down to STOP/VLPS modes. Configurable receiver baud rate oversampling ratio from 4x to 32x allowing higher baud rates with lower clock sources
LPSPi	Supports slave mode address match wake-up function and first message capture down to STOP/VLPS modes
I2C	Supports multiple address match wake-up function down to STOP/VLPS modes
FTM (Timer/PWM)	Supports 16-bit timer input capture, output compare and PWM functions down to STOP/VLPS modes
LPTMR (Timer/Pulse Counter)	Supports 16-bit timer and pulse counter functions in all power modes
RTC	Supports 32-bit seconds counter with seconds interrupt and programmable alarm in all power modes with include temperature and voltage compensation
ADC	Supports triggered single conversions in multiple result registers down to STOP/VLPS modes with hardware averaging and automatic compare modes
CMP (Analog Comparator)	Supports threshold crossing detection in all power modes along with a triggered compare mode for lower average power compares

CSEc Security Block Diagram

Supports SHE Functionality

- Secure key storage: CSEc includes 17 or 20 user keys, SHE requires 10
- AES-128 encryption/decryption
- AES-128 Cypher-based Message Authentication Code (CMAC) calculation and authentication
- True and Pseudo random number generation
- User configurable Secure Boot Mode (Sequential, Strict, or Parallel Boot)



Security Use Cases

In-Vehicle Security

- Immobilizer / Component Protection
- Mileage Protection
- Secure Boot and Chain of Trust
- Secure Communication
- Digital Rights Management (DRM) – e.g. BMS in EV



NXP is the #1
solution provider
HW + SW



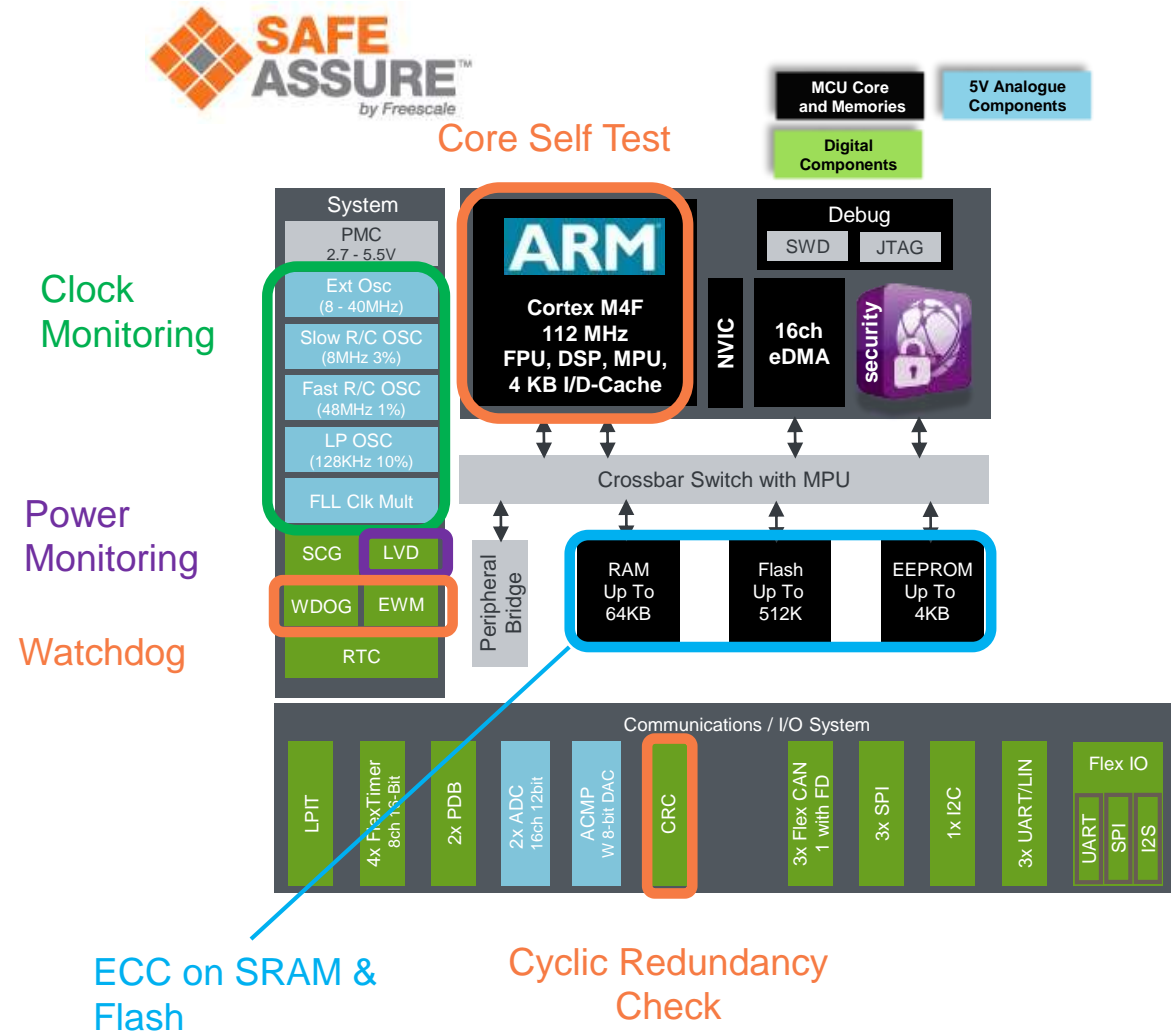
Connected Vehicle Security

- Android application download
- DRM for content download/streaming
- Remote ECU firmware update
- Black-box for due government or insurance



ASIL-B Functional Safety

- **Safety Hardware**
 - Power supplies
 - Clocks generation
 - Core platform (core, DMA, cache ...)
 - Busses - XBAR
 - Memories – NVM, SRAM
- **Safety Process**
 - ISO 26262 development process
- **Safety Support**
 - FMEDA
 - Safety manual
 - Technical support
- **Safety Software**
 - S32K core self-test SW



S32K FlexIO Peripheral Capabilities

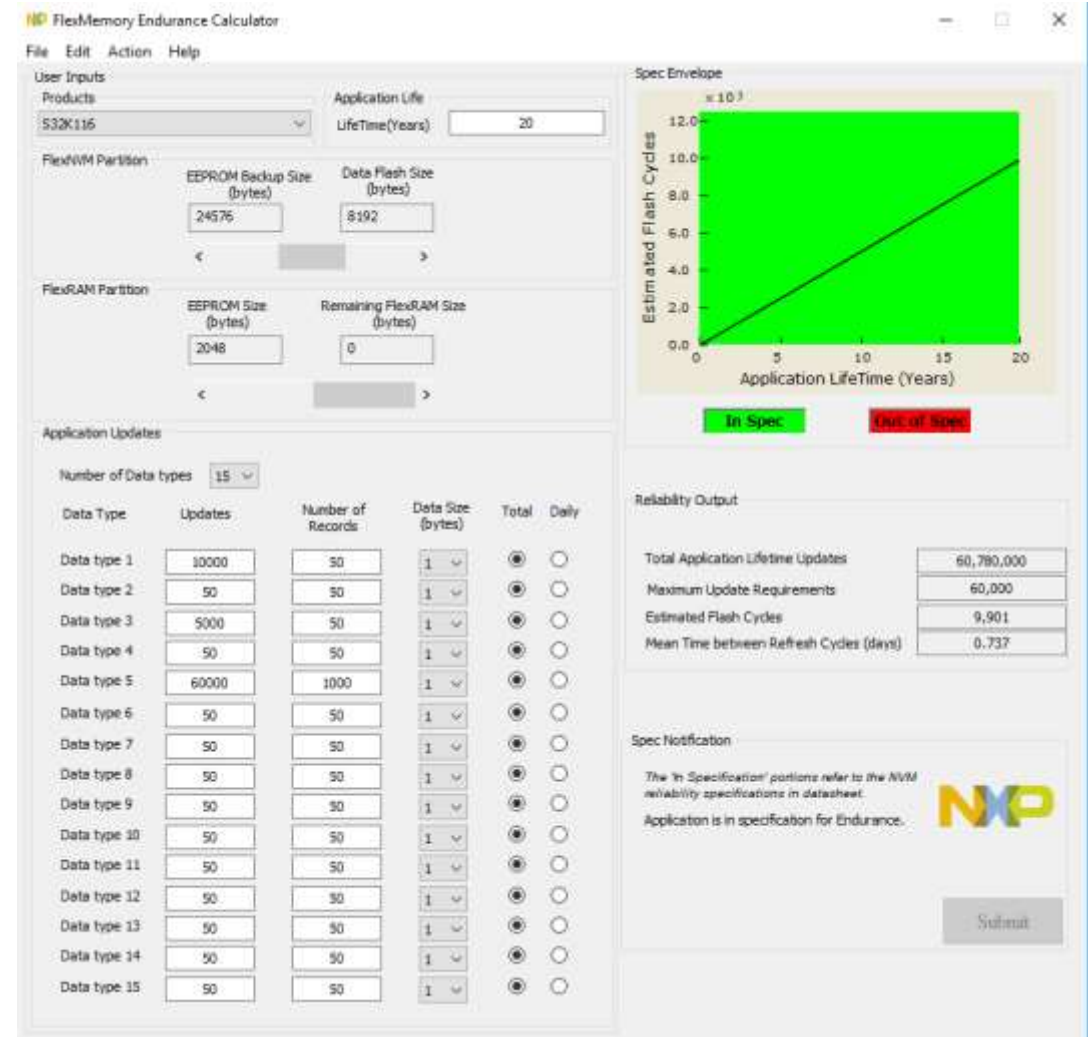
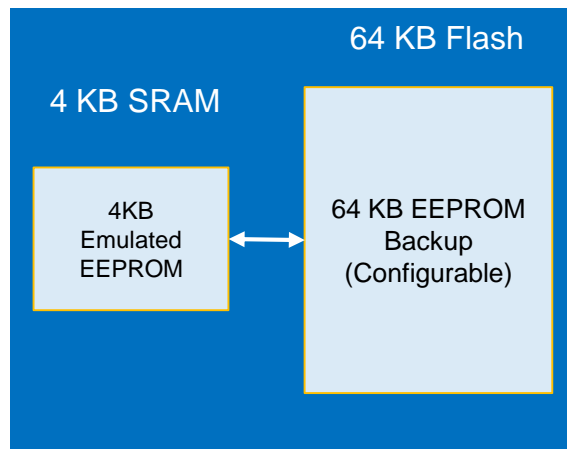
- FlexIO = Flexible Input and Output peripheral
- Programmable logic for complex output waveform generation
- Emulation of standard communication interfaces:
 - UART, SPI, I2C, I2S, LCD RGB, PWM, LIN, etc.
- Low CPU overhead
- DMA support
- Drivers available



FlexNVM – EEPROM Emulation

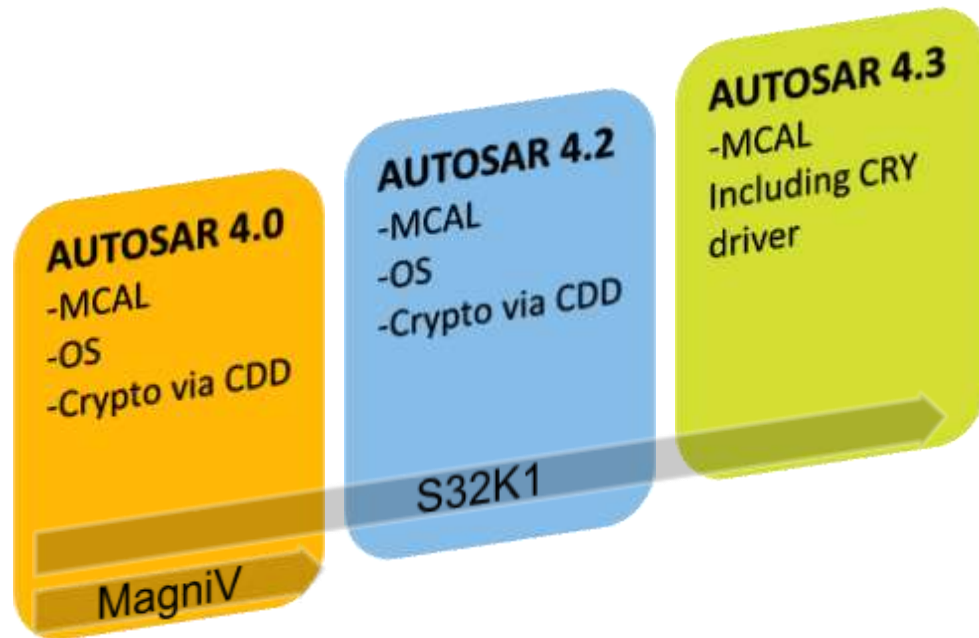
- Seen as RAM (read and write) from the user perspective → easy!
- Flash block in the background with a robust and proven record management methodology → Easy to use for customers
- With appropriate tools to evaluate endurance and data retention

EEE Data



AUTOSAR Offering – The Most Complete/Supported Ecosystem

- Supporting multiple versions
- Across entire portfolio
- Unmatched flexibility for choosing tools
- New ARCCORE Starter Kit



Compilers
choice



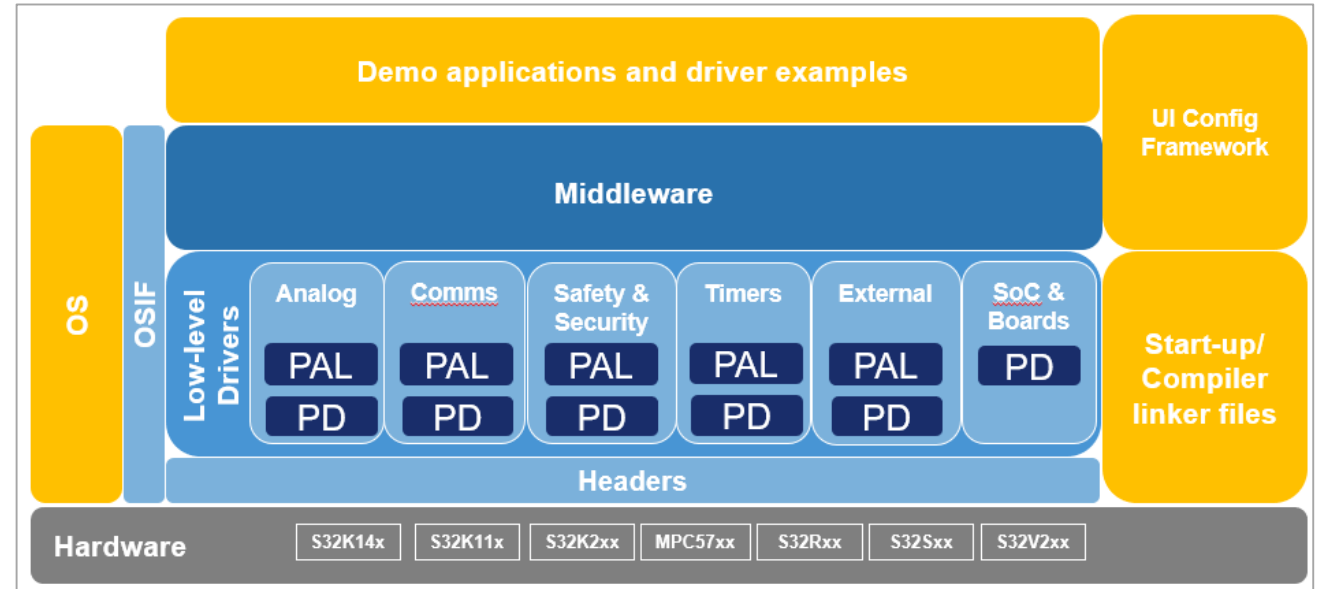
Tooling Partners



S32 SDK Solution – The Best Alternative to AUTOSAR

Highlights and Features

- **Integrated Non-AUTOSAR Production-Grade SDK**
- Contains a wide range of **examples and demos**
- Graphical-based **Configuration**
- Integrated with S32 Design Studio and other IDEs
- Layered Software Architecture
- **Documented** Source Code and Examples
- **FreeRTOS** integration
- **Multiple MCU architectures** and platforms supported with **single codebase and consolidated releases**.
- **Middleware support:**
 - LIN stack, System basis chip, TCP/IP, Math and motor control, Core self test (safety)



Multiple IDE integration:

- S32 Design Studio, ARM Keil MDK

Premium compiler support:

- GHS, IAR, DIAB, GCC, ARM C

Quality Level:

- QM (A-SPICE L3 compliant)

S32 Design Studio IDE – Graphical Configuration Environment

1. Create a new S32DS IDE New Project Wizard
 - Select MCU and target package
2. Select Compiler
 - GCC or 3rd party Premium Compiler (IAR and GHS)
3. Select Integration NXP tools
 - Processor Expert
 - Pin Mux Tool
 - Device Configuration
 - SDK Configuration
 - Bootloader
 - FreeMASTER Embedded
4. Select Software Integration
 - S32K SDK Integrated with-in the tools
 - KEA SDK Integrated with-in the tools
 - Automotive Math and Motor Control Libraries (AMMCLib)



S32K1 Technical Resources



Motor control System Solutions

NXP GPIS MOTOR CONTROL SOLUTION demonstrates the capability and advantages of NXP MCUs for wide variety of automotive motor control applications with three-phase PMSM and BLDC motors.

MOTOR CONTROL ENABLEMENT – EASY OF USE SOLUTION

- Modular SW – Motor control library AMMCLib and MC Frameworks
- Scalable HW – Motor control development kits
- Powerful Tools – FreeMASTER, MCAT, MBDT, S32 DS
- Technical expertise – Motor control know-how, IEEE publications, Patents

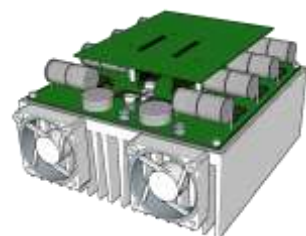


Low Power 12V /
8Amps (RMS)

Coming soon
Mid Power
12V / 33A



High Power
12V / 70 Amps



High Power – 3/6phase
48V / 150 Amps

NXP HW Scalability

Motor type: BLDC, PMSM, ACIM
Phase number: 3/6 phase
Voltage: 12 / 24 / 48 V
Current sensor: Single, dual, triple shunt
Position sensor: Encoder, Hall, Resolver

Fault detection: over current, over voltage,
under voltage protection
Communication: CAN (FD), LIN

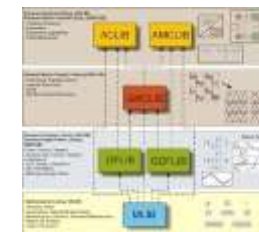
VALUE PROPOSITION

- Easy to use
- Easy to customize for wide variety of MC applications
- Reduce Time-to-Market by rapid application development
- Easy getting started & fine-tuning
- Highly optimized algorithms for basic and complex MC applications
- Recognized Centre of Excellence for motor control in automotive

NXP Tools and Ecosystem



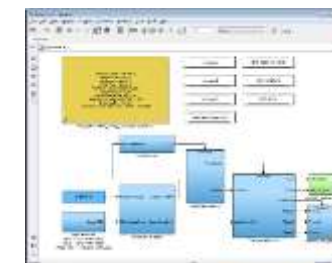
S32 Design Studio



Advanced Math &
Motor Control Library



FreeMASTER with
MCAT



Model-Based Design
Toolbox

System Solutions – Released Already

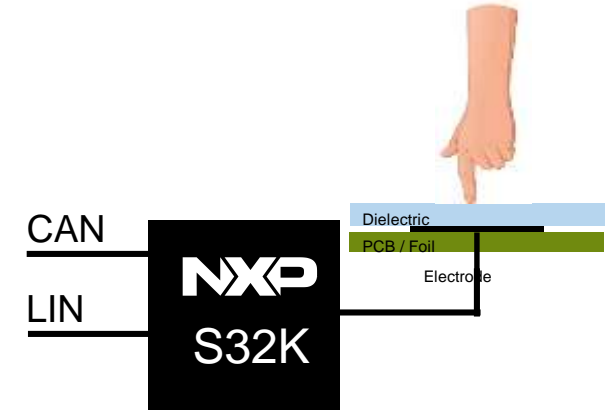
ISELED Driver

- High-speed communication for creating dynamic lighting effects
- ISELED Driver for S32K
- Using FlexIO and SPI
- SDK and Autosar



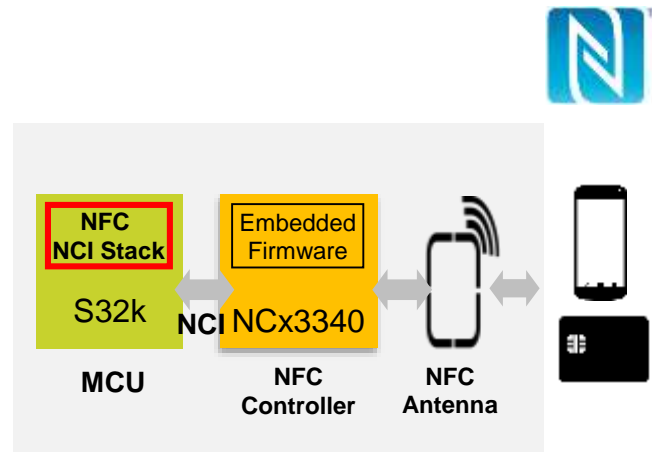
Touch Sense Reference Design

- 1D Touch Library
- SDK and Autosar
- Single chip solution for **automotive** TS.
- Suitable for up to 10 electrodes



NFC Stack

- **Interface** between MCU and NFC controller
- Specified by **NFC Forum**
- **Eases integration** of NFC controllers
- SDK and Autosar



BMS Reference Design

Turnkey solution for Safety Applications up to ASIL-C
4 NXP Devices:

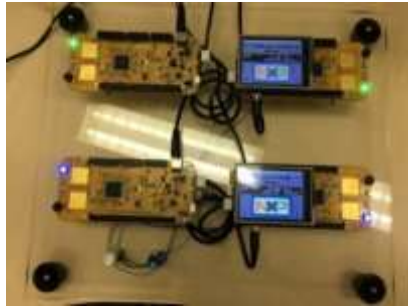
- S32K144
- KEA
- SBC
- Battery Cell Management



Additional S32K Demos and Ref. Designs



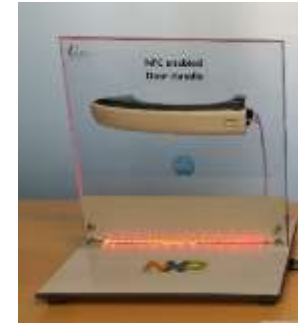
Secure CAN-FD
Diagnostics
(S32K + UJA1169)



CAN-FD vs. CAN
CSEc vs. S/w
(S32K + TFT-LCD)



CAN
authentication
(S32K EVBs + TFT-
LCDs)



Door Handle
(S32K + MagniV +
NFC)



Motorcycle ABS
(S32K + SB0400)



Flex I/O
(S32K EVBs emulating
comms protocols)



Low Power Demo
(S32K + LP Shield)



Injector driver demo
(S32K + PT2000)



BLDC Motor
Control
(S32K + GD3000)



DC Motor Control
(S32K + HB2001)

GPIS Applications Resources

Engage in good technical discussions

- [S32K](#) / [S12+MagniV](#)

> 1000 technical threads created during 2018.



Product support (communities)

Training materials



Train yourself and customers:

- Training materials in nxp.com/s32k → [Training](#)
- > 20 technical trainings posted in 2017.

Develop applications and customers. App notes posted on

- S32k / KEA
- MagniV / S12

22 Application notes posted on nxp.com/s32k



Technical documentation

Demos/Ref. designs



Accelerate your developments.

- [Contact us](#) for additional information
- > 15 S32K1xx/MagniV demos/ref. designs available.

Summary – S32K Product Line



Broad applications

- Automotive MCU for general purpose applications
- Accelerates automotive software design



Benefits to you

- Future proof
- Minimize complexity
- Maximize R&D efficiency



Ready to go

- Rich set of collaterals & solutions available today
- Product Longevity program



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