Body and Comfort: Automotive Microcontroller Innovative Applications

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MCU Field Application Engineer

November 2019 | EUF-AUT-T3868

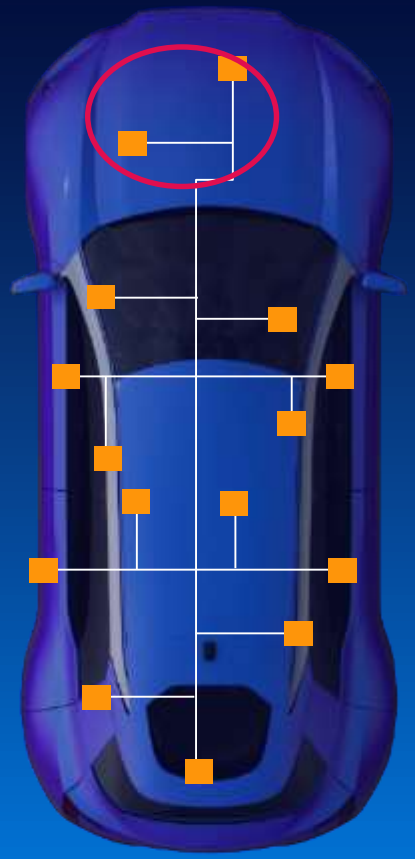
SECURE CONNECTIONS FOR A SMARTER WORLD

Agenda

- S32K1xx Microcontroller Intro
- How to Build a Smart Node
- How to Build a Safety System

Need for Edge Node – General Purpose MCU

TODAY: FLAT

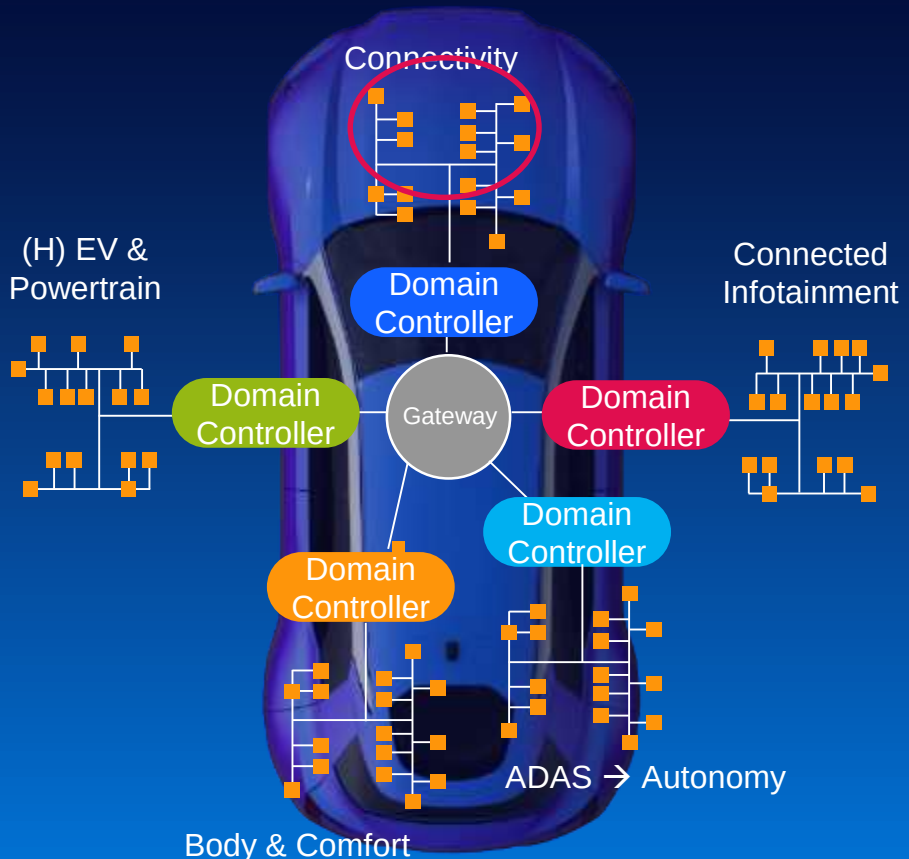


- Low bandwidth, flat network
- One MCU per application

Unfit for future Mobility

Flat to hierarchical

TOMORROW: DOMAINS

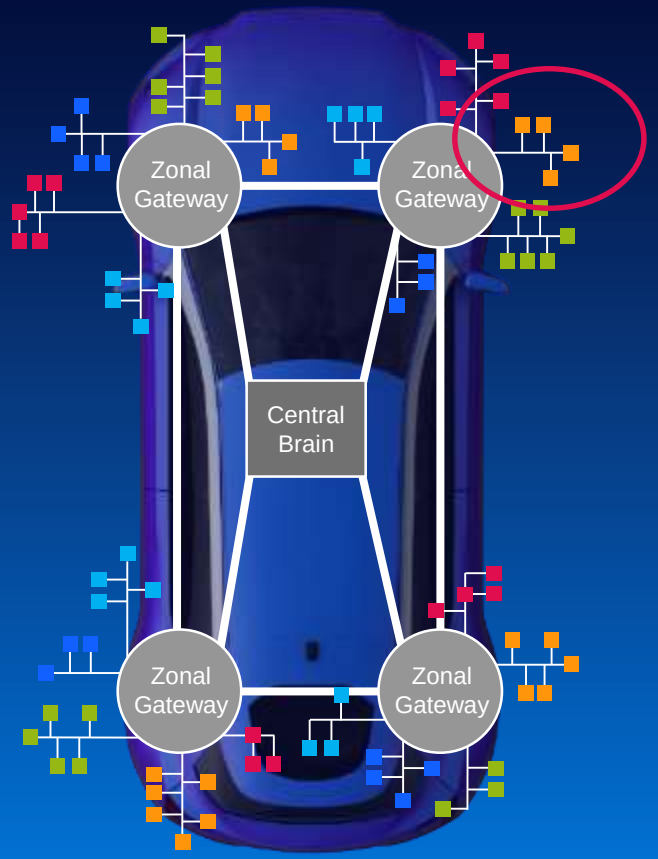


- High bandwidth network
- Gateway key to communication between domains

Step to Autonomous Car

Wires go virtual

AFTER TOMORROW: ZONES



- Domains virtualized by SW – enabling high flexibility
- Easy enable/disable or update functions

Step to User-Defined Car

S32K1 Target Apps

Body Electronics

HVAC

Steering wheel

Lighting

Battery/Power mgmt

Doors

Body Controllers

Motor Control

Engine / cooling fans

Window lift

Wipers

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

Next Gen S32K

KEA

Integrated Solutions

Motor Control
Window Lift

Pumps, Fans

Sensor Interfaces

S12 MagniV

Next Gen IS Solution

S32K1 Family – Accelerating Automotive Software Design

Performance & Integration

Future proof designs

- **ARM Cortex M4F and M0+** cores
- **ISO CAN-FD**,
- **CSEc hardware security**
- **ISO26262 ASIL-B** functional safety
- **Ultra low power**

Automotive-grade SW

Minimized complexity

- S32 Design Studio IDE
- Automotive-grade Software Development Kit (SDK)
- Autosar MCAL & OS, 3rd party ecosystem

Broad Portfolio

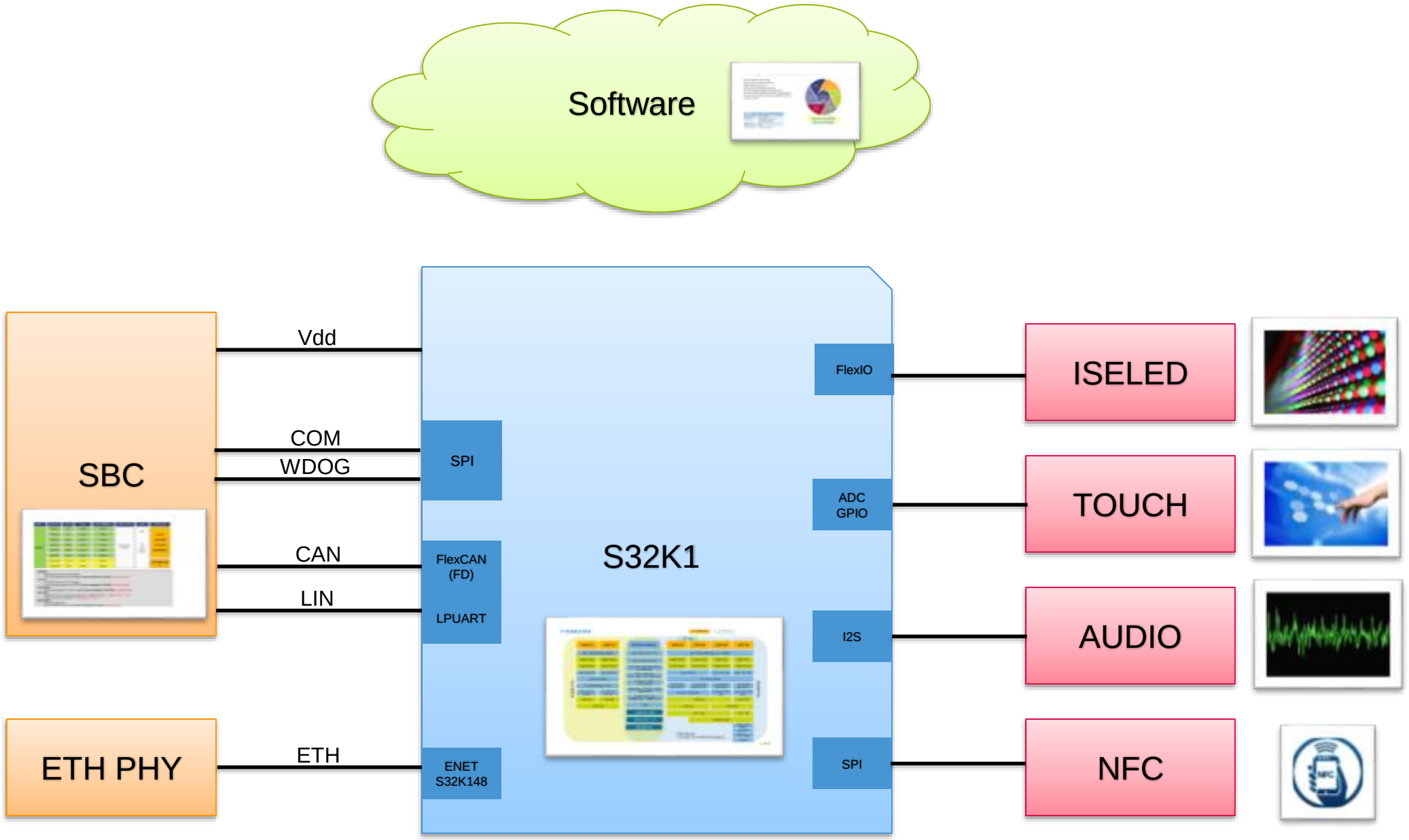
Maximised reuse

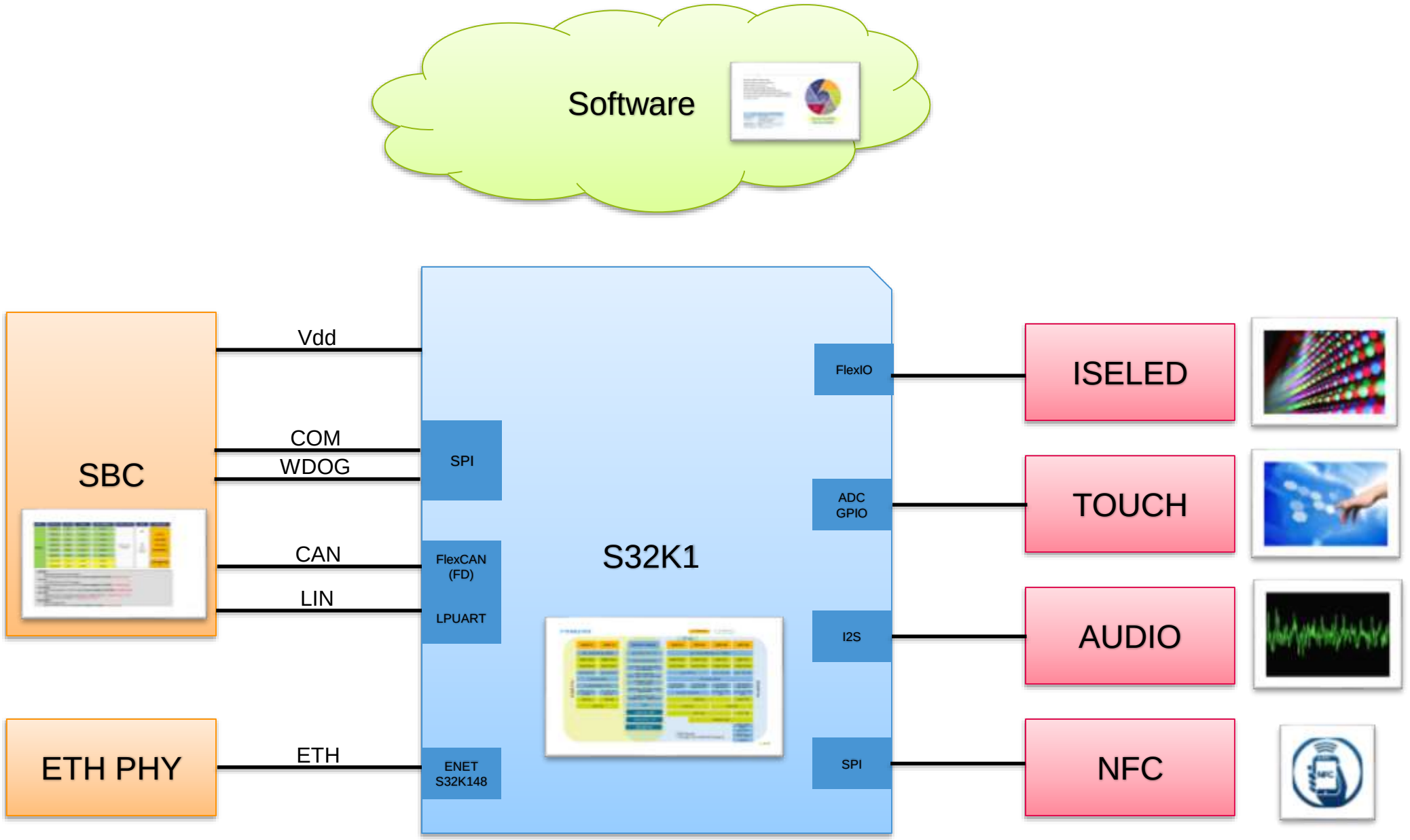
- 128KB to 2MB, 32 to 176 pins
- H/w and S/w compatibility
- AEC Q100 grade 1 qualified (125°C), min. 15 year longevity

Product Longevity

Building Solutions

Smart Edge Node


Software
SBC
ETH PHY
Vdd
COM
WDOG
CAN
LIN
ETH
SPI
FlexCAN (FD)
LPUART
ENET S32K148
S32K1
FlexIO
ADC GPIO
I2S
SPI
ISELED
TOUCH
AUDIO
NFC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S32K1
FlexIO
ADC GPIO
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NFC

Features

Production | Development

Gr0 Option

S32K11x

S32K116	S32K118
Arm Cortex-M0+ @ 48MHz	
128KB Flash	256KB Flash
16KB SRAM	24KB SRAM
up to 42 I/Os	up to 58 I/Os
4 channel eDMA	
1x FlexCAN with 1x FD	
1x 13-ch 12-bit ADC	1x 16-ch 12-bit ADC
QFN-32	LQFP-64
LQFP-48	

Common Features

- AEC-Q100, 125°C, 5V
- CSEc Security Module
- Low Power Operating Modes & Peripherals
- ASIL-B Capable: (ECC, MPU, CRC, W'DOGs)
- LPUART, LPSPI, LPIIC, FlexIO
- FlexTimers, LP Timers, Prog. Delay Block
- 8-40MHz Ext. Osc, 8/48MHz Osc., 128KHz LPO
- *JTAG
- S32DS IDE, SDK
- Autosar MCAL / OS
- Application SW

S32K14x

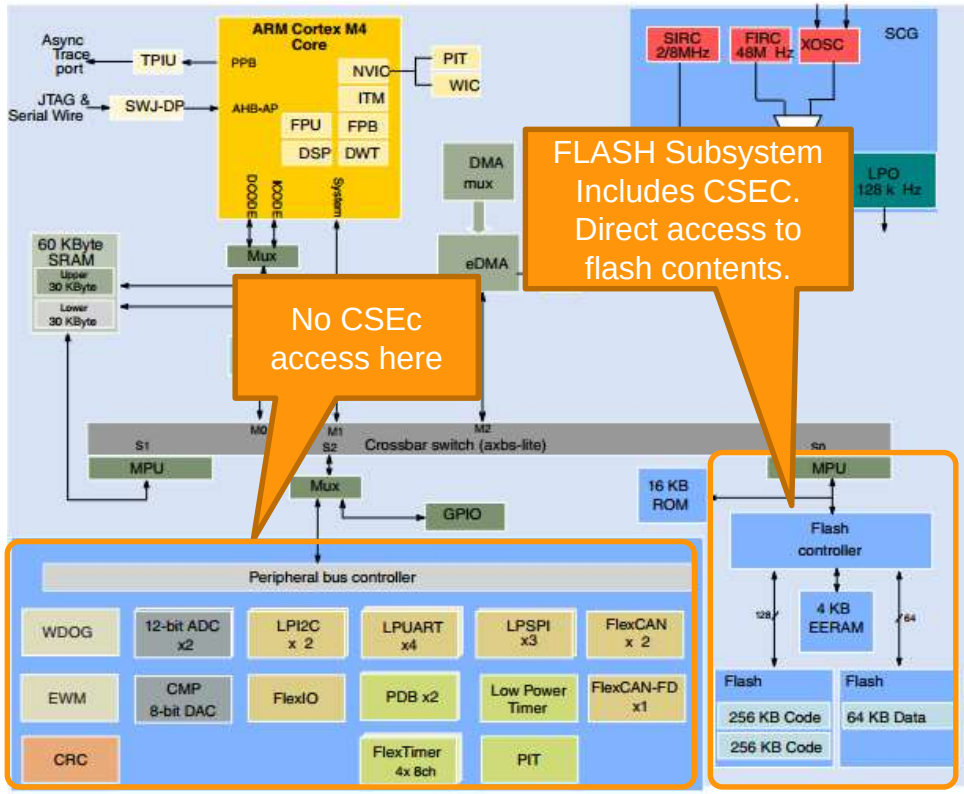
S32K142	S32K144	S32K146	S32K148
Arm Cortex-M4F @ up to 112MHz			
256KB Flash	512KB Flash	1MB Flash	2MB Flash
32KB SRAM	64KB SRAM	128KB SRAM	256KB SRAM
up to 89 I/Os		up to 128 I/Os	up to 156 I/Os
16 channel eDMA			
2x FlexCAN with 1x FD**	3x FlexCAN with 1x FD**	3x FlexCAN with 2x FD	3x FlexCAN with 3x FD
2x 16-ch 12-bit ADC		2x 24-ch 12-bit ADC	2x 32-ch 12-bit ADC
LQFP-64			LQFP-176
LQFP-48		LQFP-144	
LQFP-100			LQFP-100
MAPBGA-100			
			IEEE 1588 ENET
			Quad SPI
			ETM Trace
			2x SAI

*S32K14x only
** 2x CAN FD in S32K14xW (Grade 0)

CSEc Security Block Diagram

Supports SHE functionality:

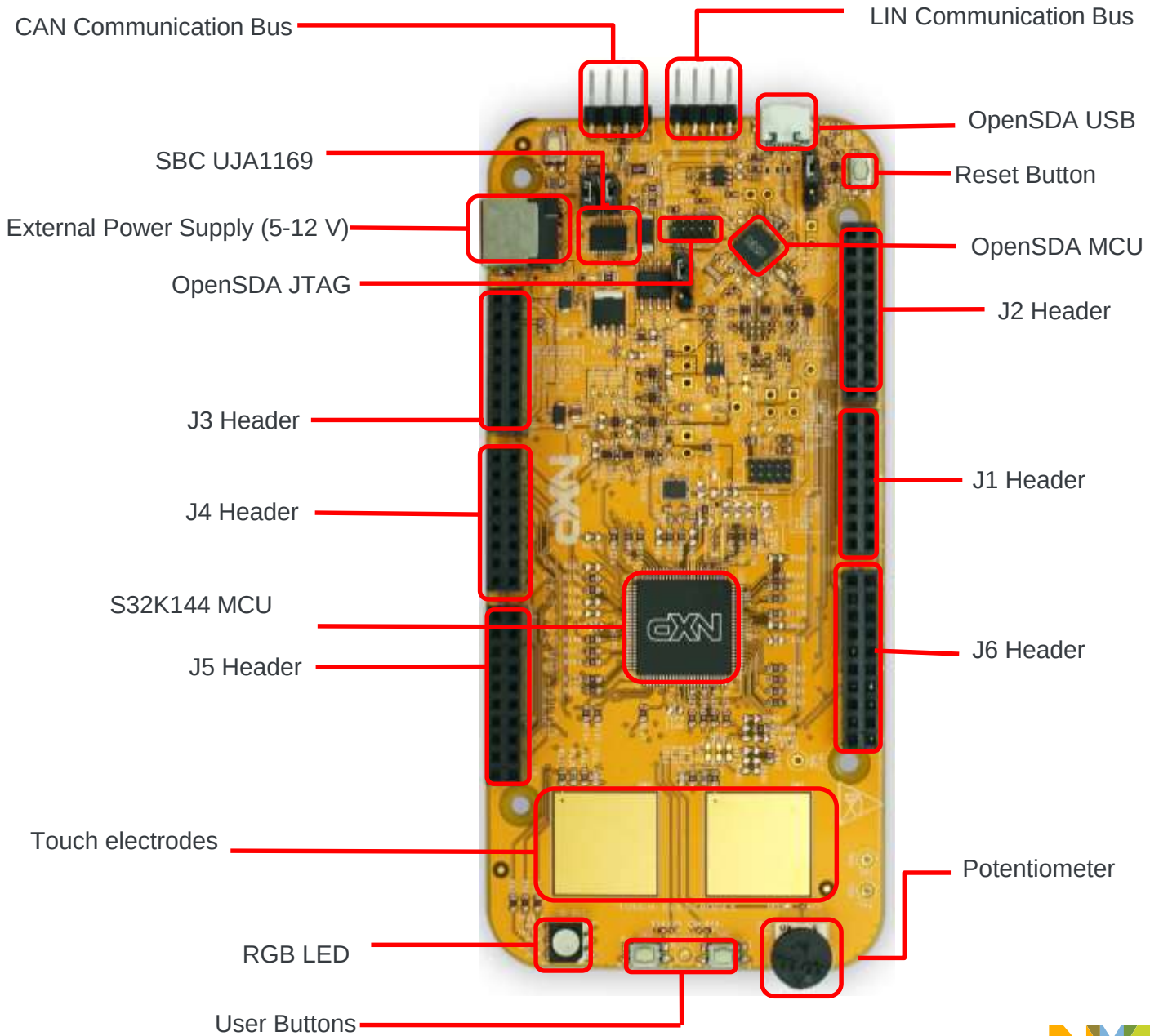
- Secure key storage: CSEc includes 17 user keys*, SHE requires 10
- AES-128 encryption/decryption
- AES-128 Cypher-based Message Authentication Code (CMAC) calculation and authentication
- True and Pseudo random number generation
- User configurable Secure Boot Mode (Sequential, Strict, or Parallel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



*20key firmware version available per request

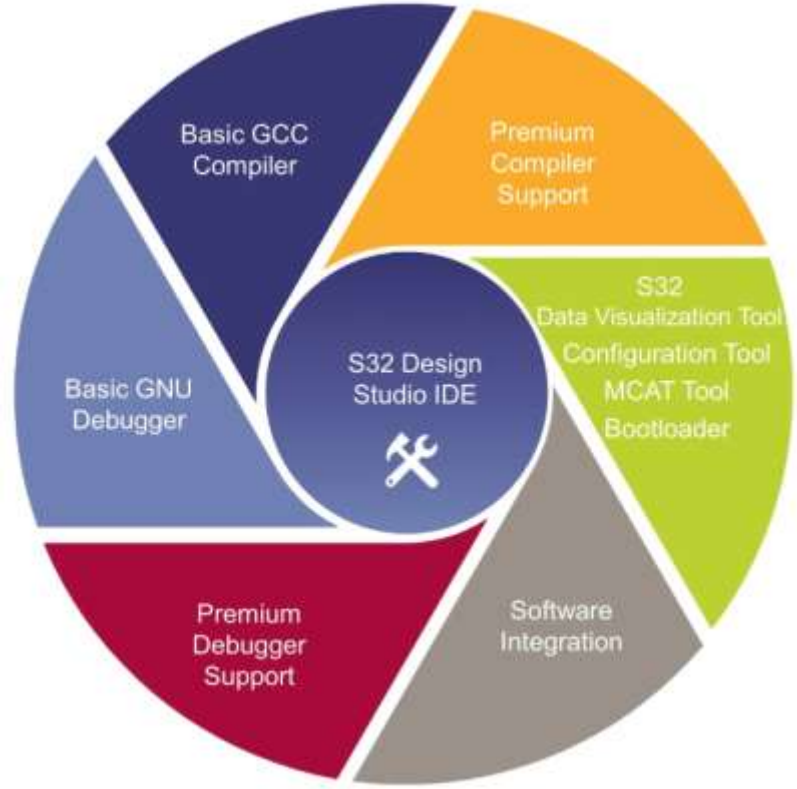
Evaluation Board

- $65 USD SRP
- Supports S32K144 100LQFP MCU
- Small form factor size 6” x 4”
- Arduino™ UNO footprint-compatible with expansion “shield” support
- Integrated open-standard serial and debug adapter (OpenSDA) with support for several industry-standard debug interfaces
- Easy access to all the MCU I/O pins for prototyping
- On-chip connectivity for CAN, LIN, UART/SCI
- SBC UJA1169 and LIN phy TJA1027
- Flexible power supply options
  - microUSB or external 12 V power supply



S32 Design Studio IDE for Arm® based MCUs

- ✓ Supports S32K1xx MCU family
- ✓ Free of charge, unlimited code size
- ✓ Eclipse based environment
- ✓ GNU compiler & debugger integrated
- ✓ S32 SDK integrated (graphical configuration)
- ✓ Processor Expert integrated (automatic code generator)
- ✓ Can use with 3rd party compilers & debuggers (IAR) via Connection Utility



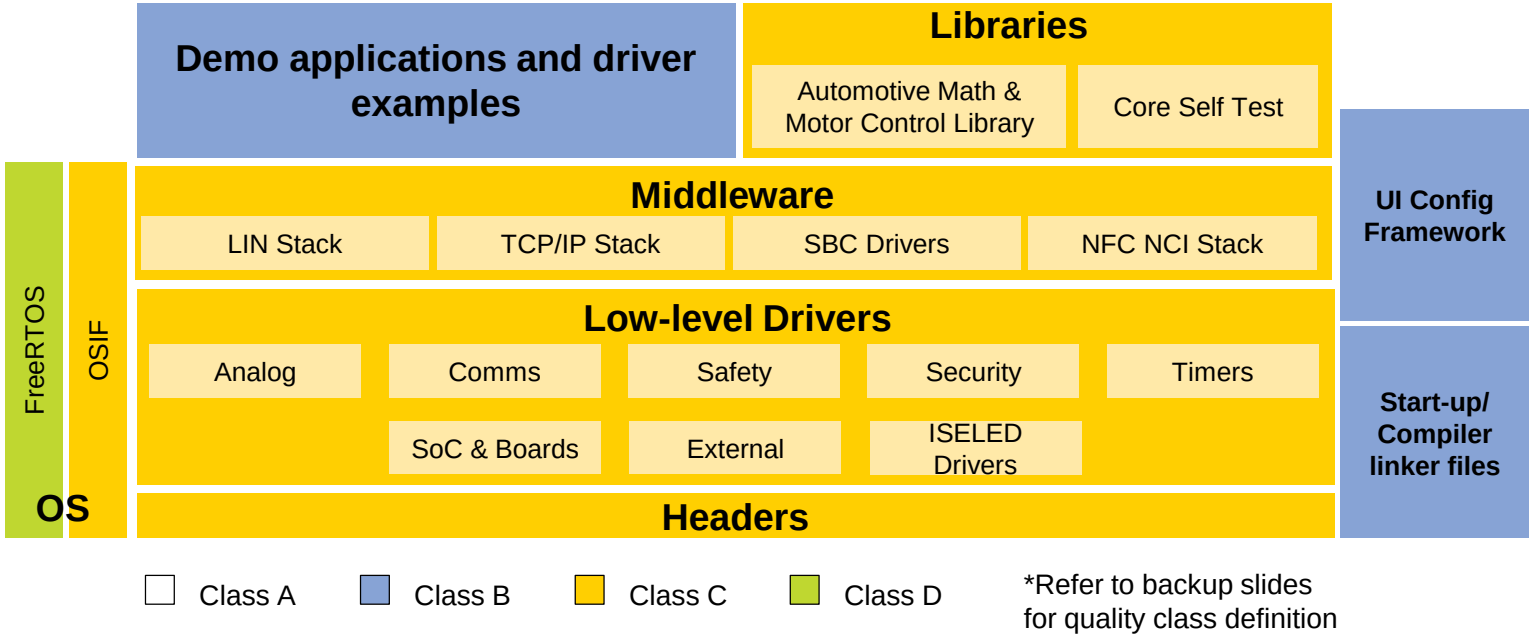
Availability	
Business model	Free of charge
Quality level	Compliant with CMMI and IATF16949 standards
Code Format	Binary
Where to download	www.nxp.com/S32K

www.nxp.com/S32DS

www.nxp.com/S32K

S32K SDK (Software Development Kit)

- ✓ Automotive-grade & production ready: SPICE/CMMI Level 3 compliant, MISRA 2012 tested
- ✓ Complete drivers offering
- ✓ FreeRTOS operating system
- ✓ Supports multiple toolchains: GCC, ARM, Green Hills, Diab and IAR
- ✓ Integration with NXP S32 Design Studio and 3rd party IDEs (KEIL, GHS Multi, IAR)
- ✓ Documented source code, examples, cookbook and demos for fast application start-up via simple drag & drop functionality



Availability	
Business model	Free of charge
Delivery format	Source Code
Quality level	QM
Where to download	www.nxp.com/S32K
Supported compilers	GCC, IAR, GHS, Wind River Diab, Arm Compiler

www.nxp.com/S32K

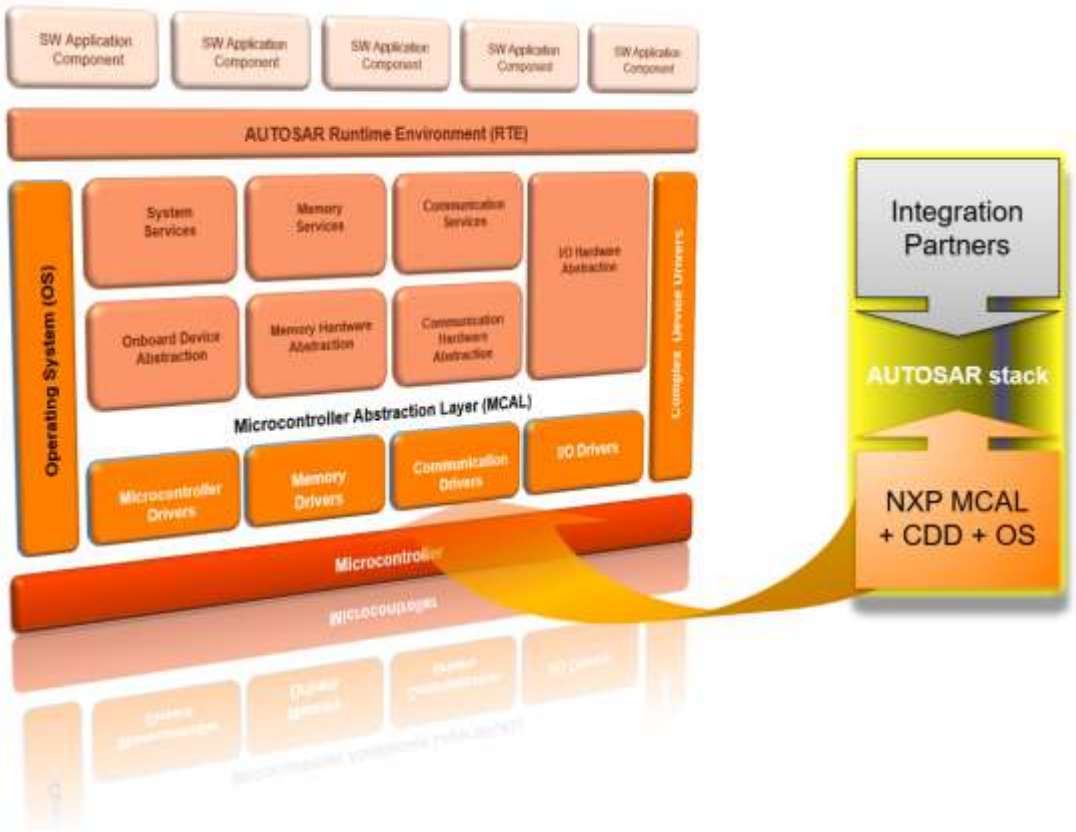
www.nxp.com/S32SDK

AUTOSAR MCAL

- ✓ Production qualified software abstraction of complex hardware features
- ✓ Compliant to versions **4.0.3, 4.2 and 4.3** of the AUTOSAR standard
- ✓ Developed using SPICE Level 3 and ISO26262 standard compliant process
  - Both QM and ISO26262 version available
- ✓ Developed as Safety Element out of Context (SEooC) integrable in ASIL-B S32K1 product
- ✓ Supports multiple software features as extensions to AUTOSAR standard. 5 complex drivers extending AUTOSAR on various platforms:
  - MCL: centralized DMA and DMAMux configuration and functionality, common timer code
  - I2C: Inter-Integrated Circuit driver
  - MCEM: MicroController Error Management
  - CRCU: CRC hardware acceleration
  - Cypto: Provide encryption functions according to the SHE spec based on the CSEc module

www.nxp.com/AUTOSAR

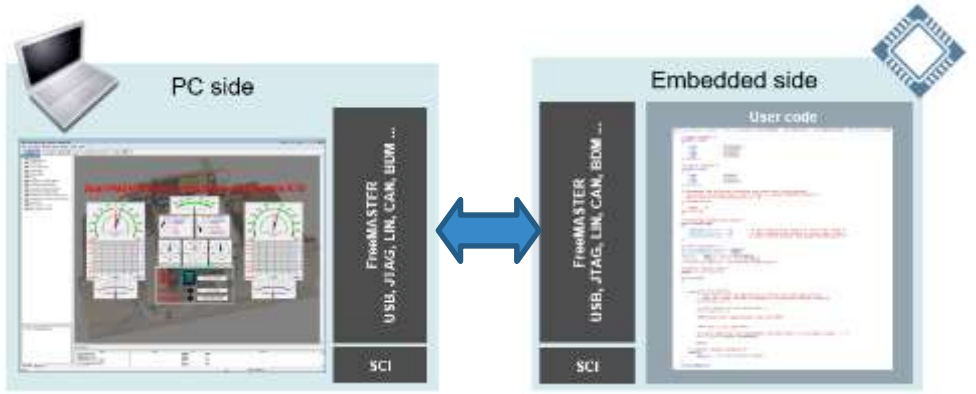
www.nxp.com/S32K



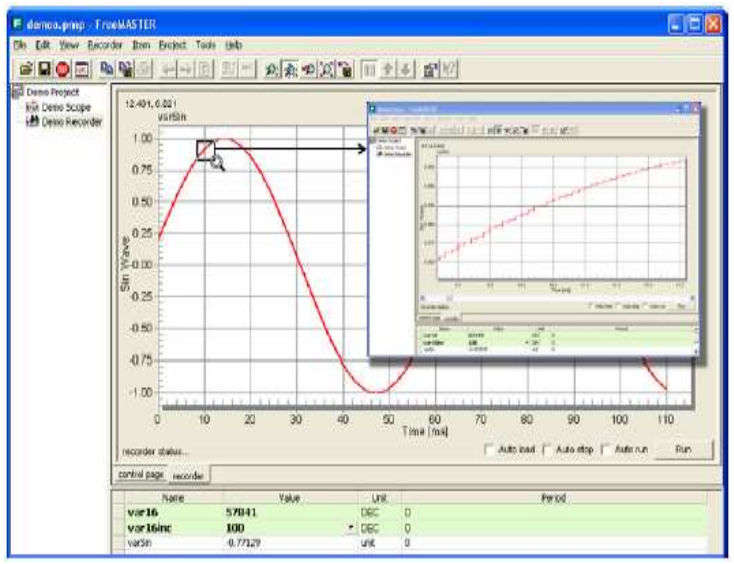
Availability	
Business model	License Model
Delivery format	Source Code
Quality level	QM & ISO26262
Where to download	www.nxp.com/S32K
Supported Compilers	GCC, IAR, GHS

FreeMASTER –Real-Time Debugging Tool

- ✓ Real-Time Debug Monitor
- ✓ Data Visualization Tool
- ✓ Graphical Control Panel
- ✓ Data Tracing Tool
- ✓ Hardware-in-Loop Simulation
  - FreeMASTER can stream data to MATLAB® via SFIO library



Availability	
Business model	Free
Quality level	Compliant with CMMI and IATF16949 standards
Code format	Source Code for drivers
Where to download	www.nxp.com/FreeMASTER



www.nxp.com/FreeMASTE

www.nxp.com/S32K

System Basis Chips

Production | Development

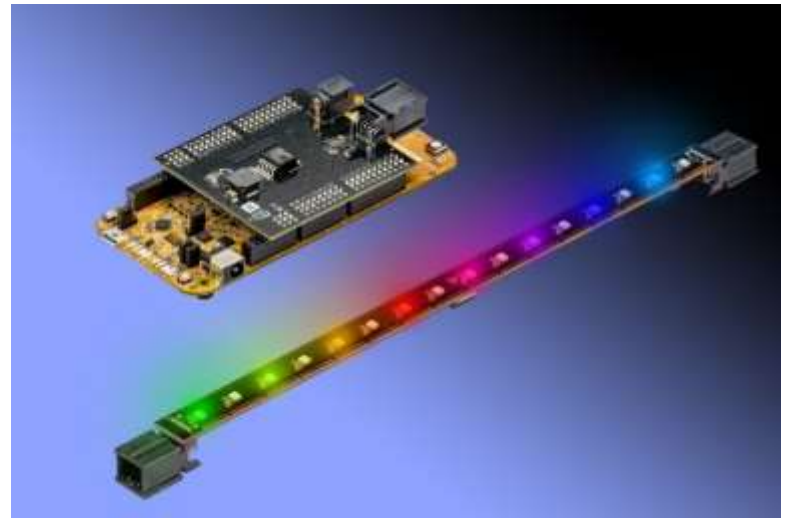
FAMILY	DEVICES	FLASH	CORES	PERFORMANCE	PROTECTION	Safety	ATTACH SBC
S32K1xx	S32K148	2M	1x M4F	112MHz	BIST, ECC, Fail safe	B QM and ASIL B Systems	UJA113x UJA1169(A) UJA116x(A) MC33FS450xx
	S32K146	1M	1x M4F	112MHz			
	S32K144	512k	1x M4F	112MHz			
	S32K142	256k	1x M4F	112MHz			
	S32K118	256k	1x M0+	48MHz			
	S32K116	128k	1x M0+	48MHz			
	S32K144W	512k	1x M4F	80MHz			UJA1169A Grade 0
	S32K142W	256k	1x M4F	80MHz			

- **UJA1169:**
  - S32K144EVB with UJA1169 available
  - UJA1169 supported in S32K1xx family (**Drivers available in S32 SDK**) → Available today
- **UJA113x:**
  - S32K148EVB with UJA1132 available
  - UJA113x family supported in S32K148 (**Drivers available in S32 SDK**) → Available today
- **UJA116x(A):**
  - UJA116x(A) supported in S32K1xx family (**Drivers available in S32 SDK**) → Available today
- **UJA1169A:**
  - Upgraded version of UJA1169, supporting up to 5Mbps CAN FD -> Target release in Q1'20
  - Grade 0 version of UJA1169A -> Target release in Q3'20
- **MC33FS45xx:**
  - ASIL D compliant SBC
  - FS45xx supported in S32K148 (**Drivers available in S32 SDK**) → Available today

S32K ISELED Solution - Application Development Kit (ADK)

- Orderable only from Element14/Farnell (as per ISELED Alliance Distribution policy)

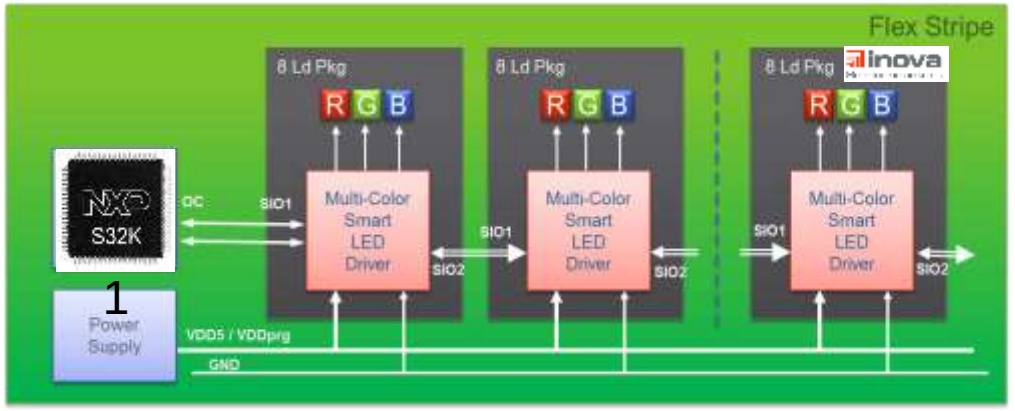
- ADK Contents:
  - S32K144EVB-Q100 (NXP)
  - ISELED Power Adaptor board (Inova Semiconductor)
  - 1 x 16-LED ‘Bar’ (Dominant Opto or OSRAM LEDs)

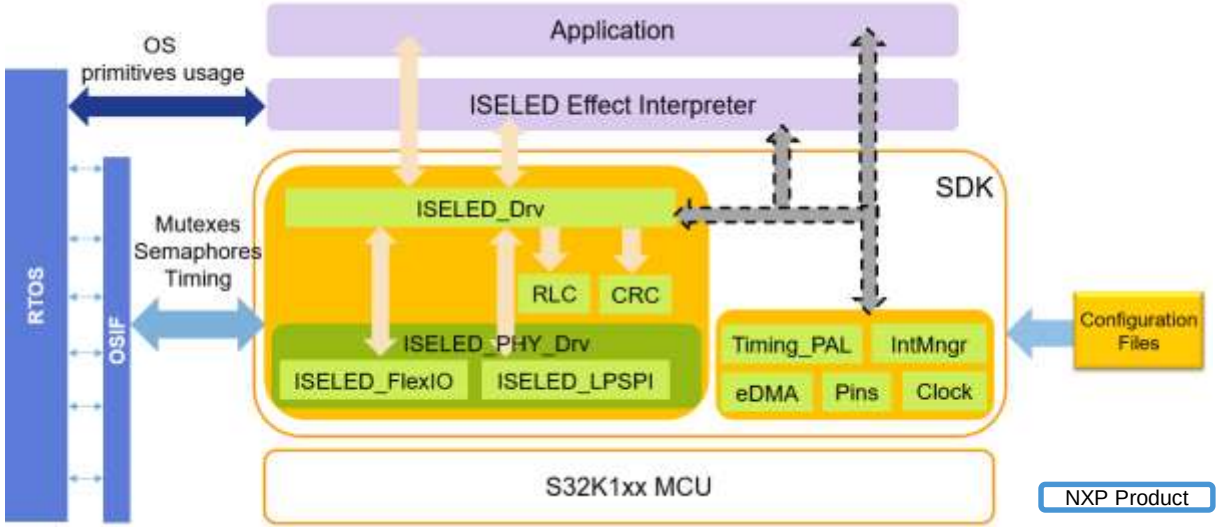


- S32K1xx EVB Compatibility with ISELED Power Adaptor Board:
  - S32K142/144/146 EVBs: 100% compatible
  - S32K116/118/148 EVBs: minor h/w changes needed

ISELED Driver – Solution for Smart LED Lighting

- ✓ Bi-directional communication between S32K1 MCU and LED over LPSPI or FlexIO interface
- ✓ Multiple (up to 13) strips supported in parallel
- ✓ Available for AUTOSAR and non-AUTOSAR use cases
- ✓ 1st and ONLY ISELED solution on market with production-ready HW & SW





Availability	
Business model	S32K1 ISELED Part Number
Delivery format	Binary Code
Quality level	ISO 26262 for AUTOSAR QM for SDK
Where to download	www.nxp.com/S32K-ISELED
Supported compilers	GCC, IAR, GHS, Wind River Diab, Arm Compiler

www.nxp.com/S32K-ISELED

FlexIO Custom Communication Channels

"FlexIO" — **Flexible input and output peripheral**

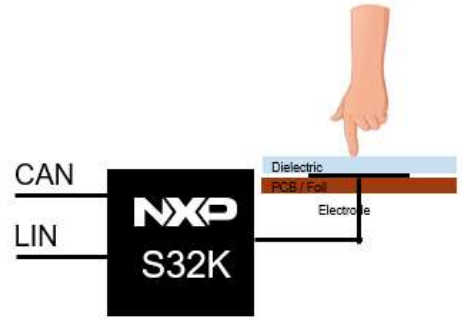
- Highly configurable module providing a wide range of functionality including:
  - Emulation of a variety of communication protocols: UART, I2C, SPI, I2S, etc.
  - Flexible 16-bit timers with support for a variety of trigger, reset, enable and disable conditions
- Creates an interlink between GPIO method of software emulation and exact hardware peripheral module
- Can continue operating under debug / stop modes
- Support of polling/interrupt/DMA (RX/TX) operation
- Low - medium software/CPU overhead

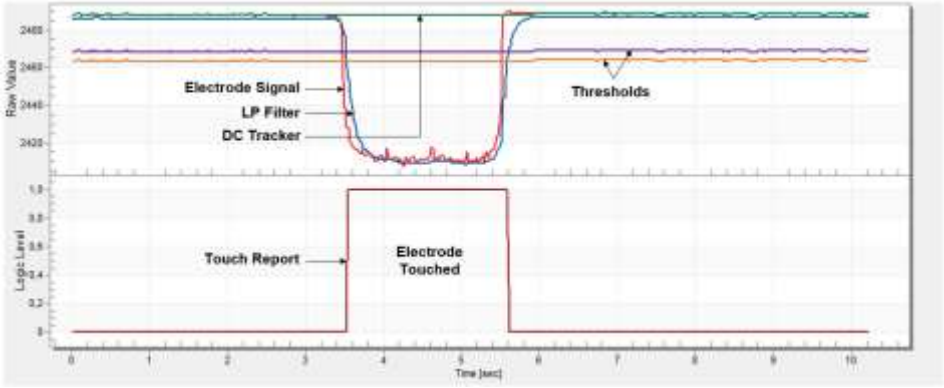
- The FlexIO peripheral was initially introduced on the NXP Kinetis KL43 family

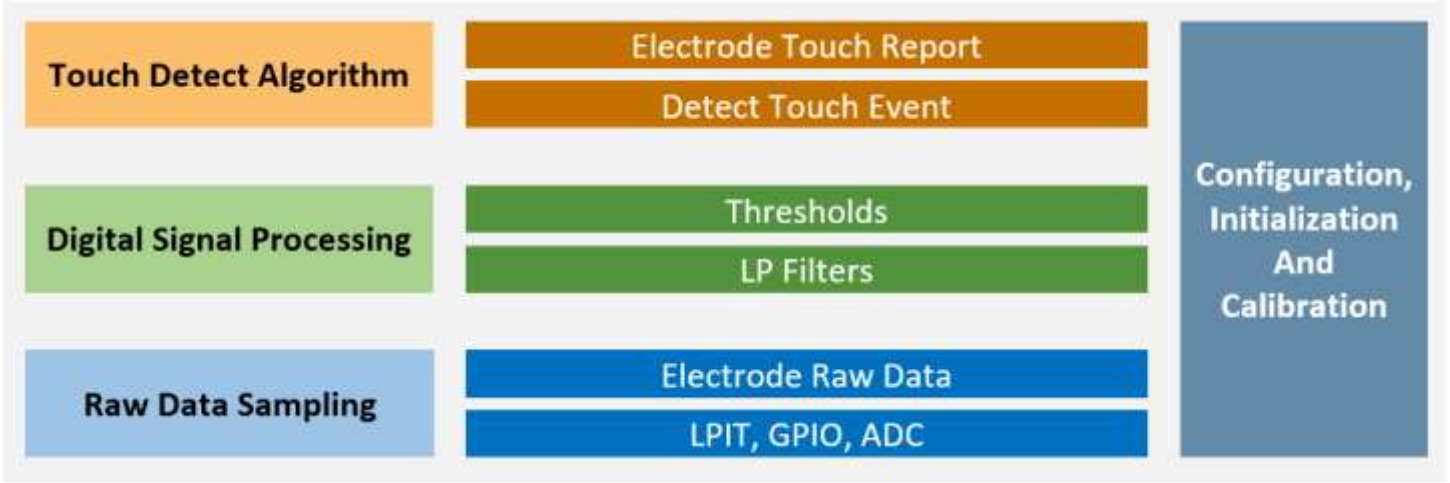
- Multiple App Notes available – search FlexIO application notes on NXP.com

Touch Sense Reference Library

- ✓ 1D capacitive touch reference library for prototyping purpose
- ✓ Single chip solution for automotive touch input
- ✓ Suitable for up to 50 electrodes
- ✓ EMC capable reference design available (built on S32K144EVB):
  - 2 Pad Keypad
  - Multi-pad Keypad w/o slider
  - Hands On Detection
  - EMC/EMI/ESD reports available
- ✓ Full set documentation (HW & SW design guide) available

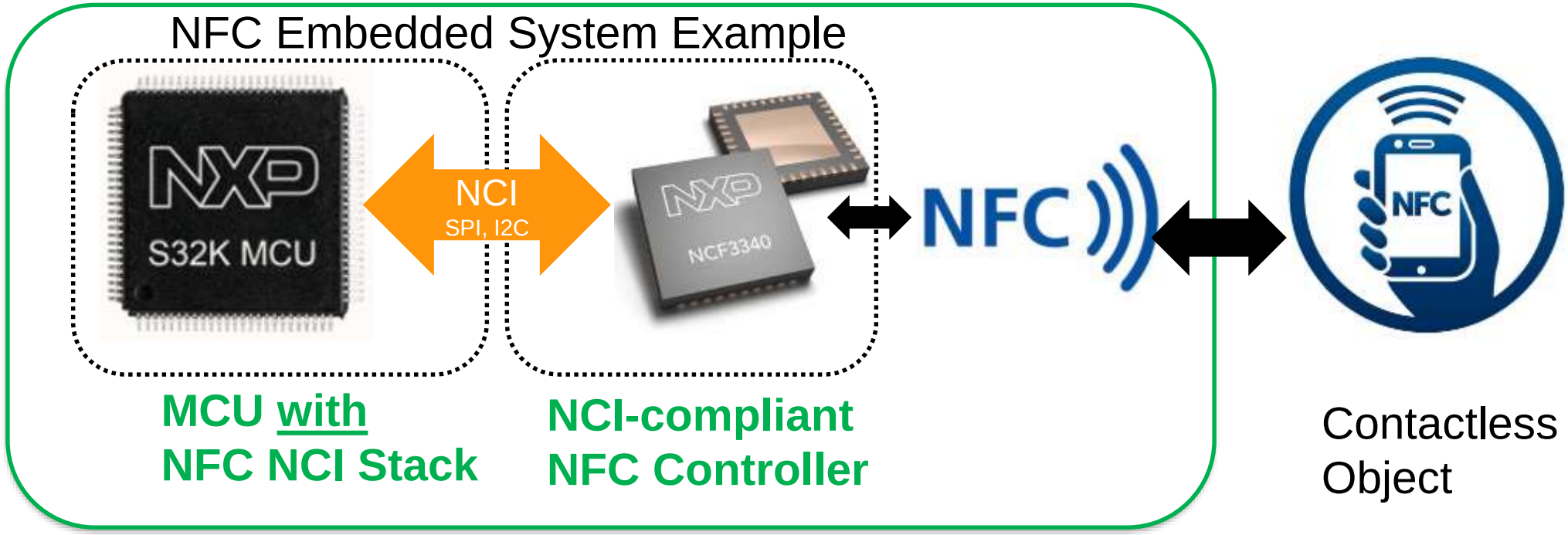






Availability	
Business model	Free
Delivery format	Source Code
Quality level	Reference Library
Where to download	Contact gpis.software@nxp.com

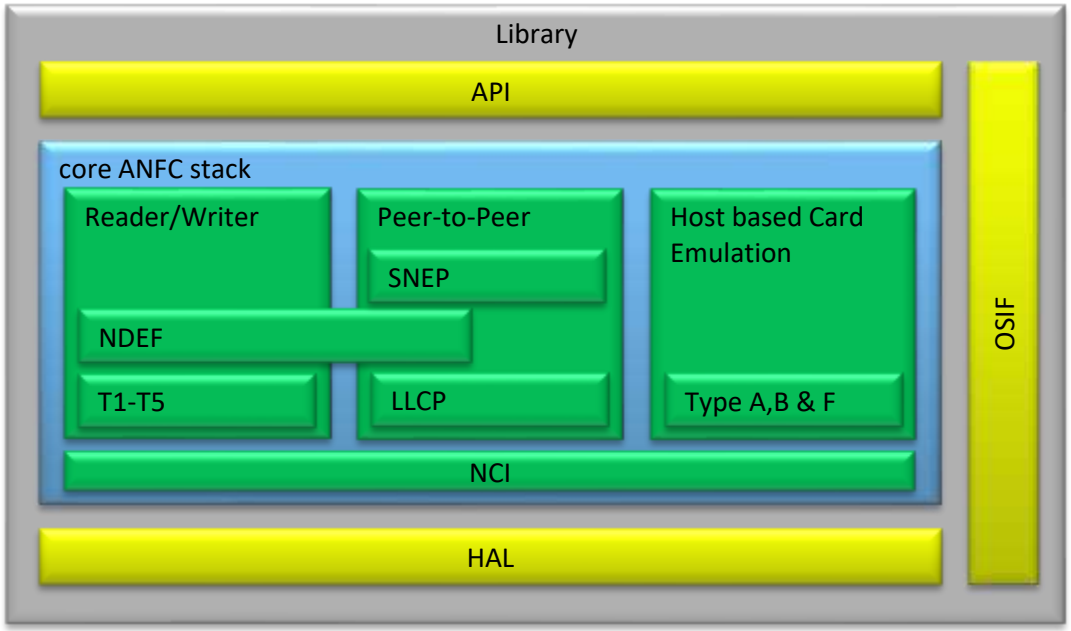
NFC Solution



Certain S32K14x MCUs include a license to use the NFC NCI Stack and when attached to NCx3340 NFC controllers create an NFC embedded system.

ANFC NCI Stack – Compliant with NCx3340 NFC chip

- ✓ NFC Controller Interface (NCI) compliant NFC stack targeted for automotive devices.
- ✓ Compliant with NFC standard that implements NFC forum specs as of Jan 31, 2017
- ✓ Read/Write T1-T5 + MiFare tags, NCI, LLCP/SNEP, PeerToPeer, Card Emulation for T3 and T5
- ✓ Available for AUTOSAR and non-AUTOSAR use cases



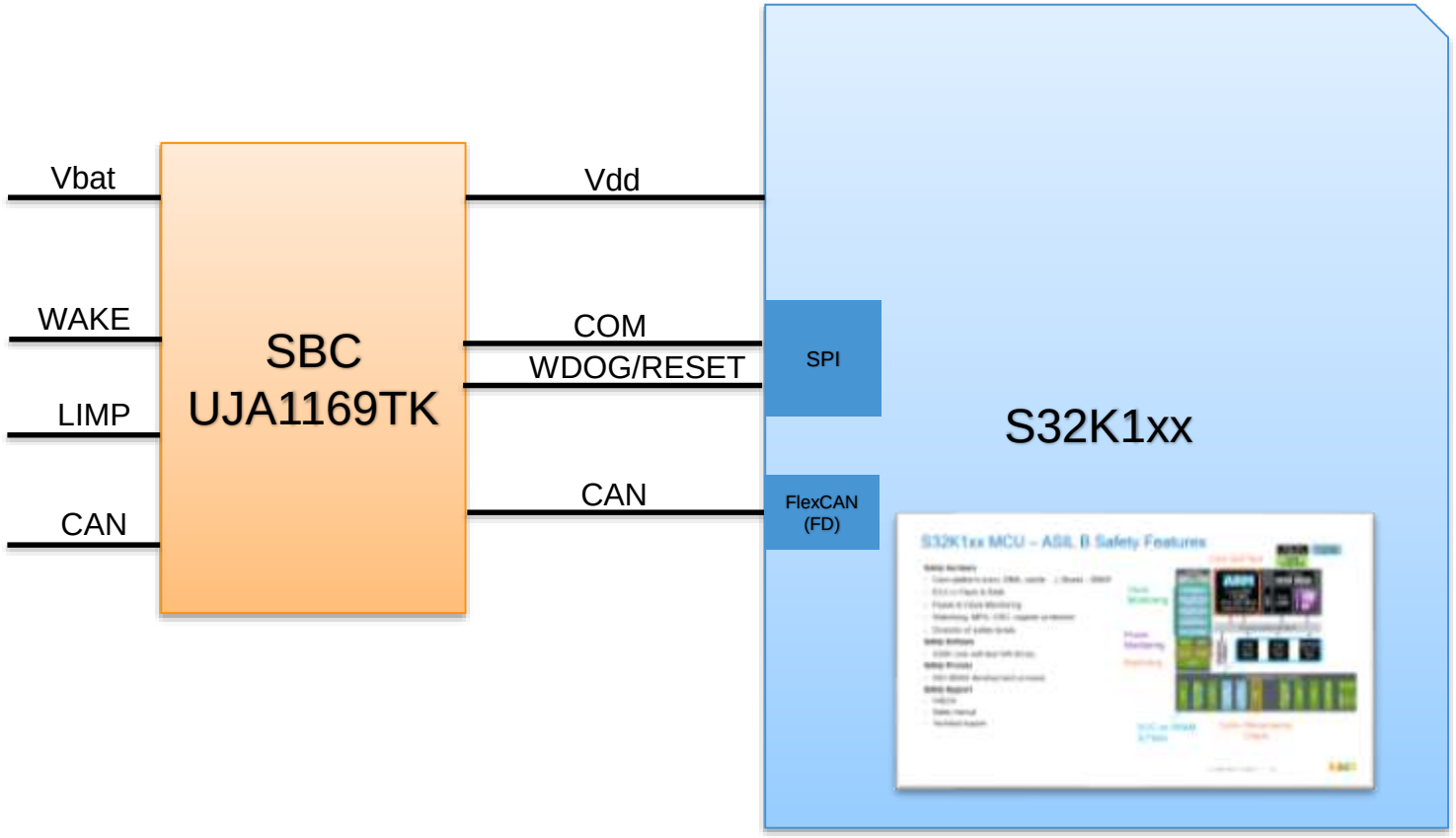
Availability	
Business model	S32K1 NFC Part Number
Delivery format	Binary Code
Quality level	ISO 26262 for AUTOSAR QM for SDK
Where to download	www.nxp.com/ANFC
Supported compilers	GCC, IAR, GHS

www.nxp.com/ANFC

www.nxp.com/S32K

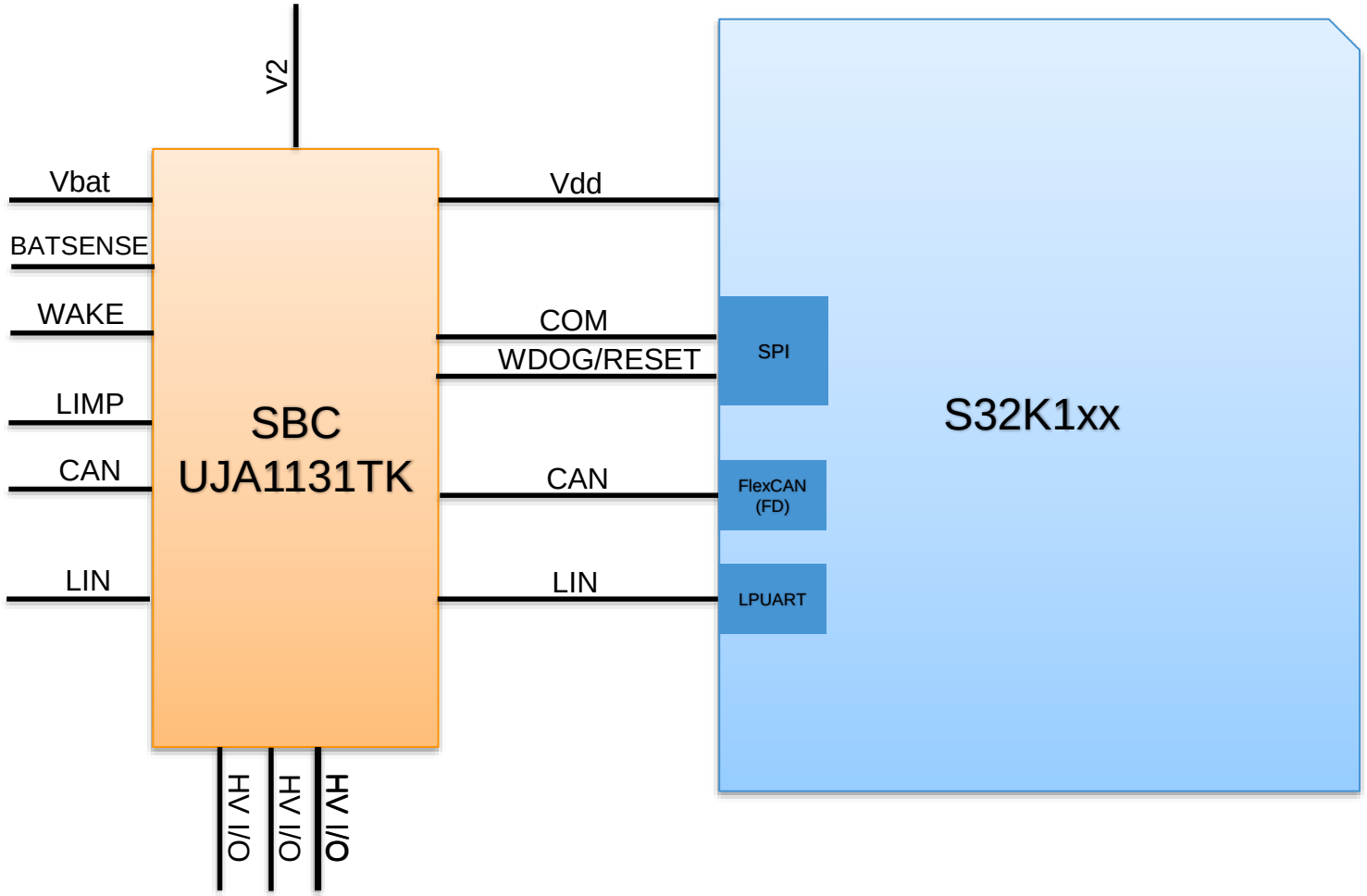
Safety System

ASIL-B



https://www.nxp.com/docs/en/application-note/AN12148.pdf

ASIL-B



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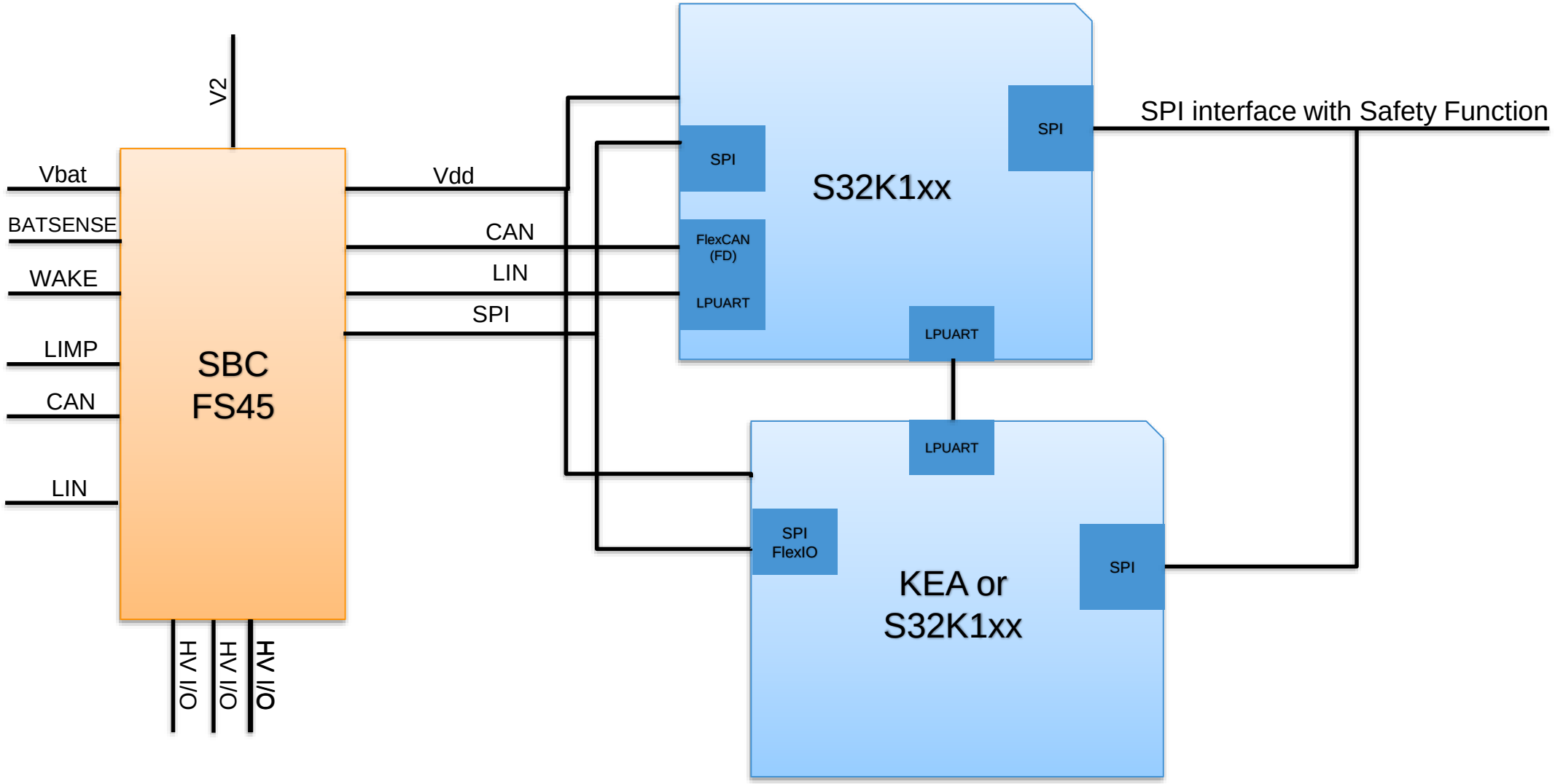
ASIL-C/D



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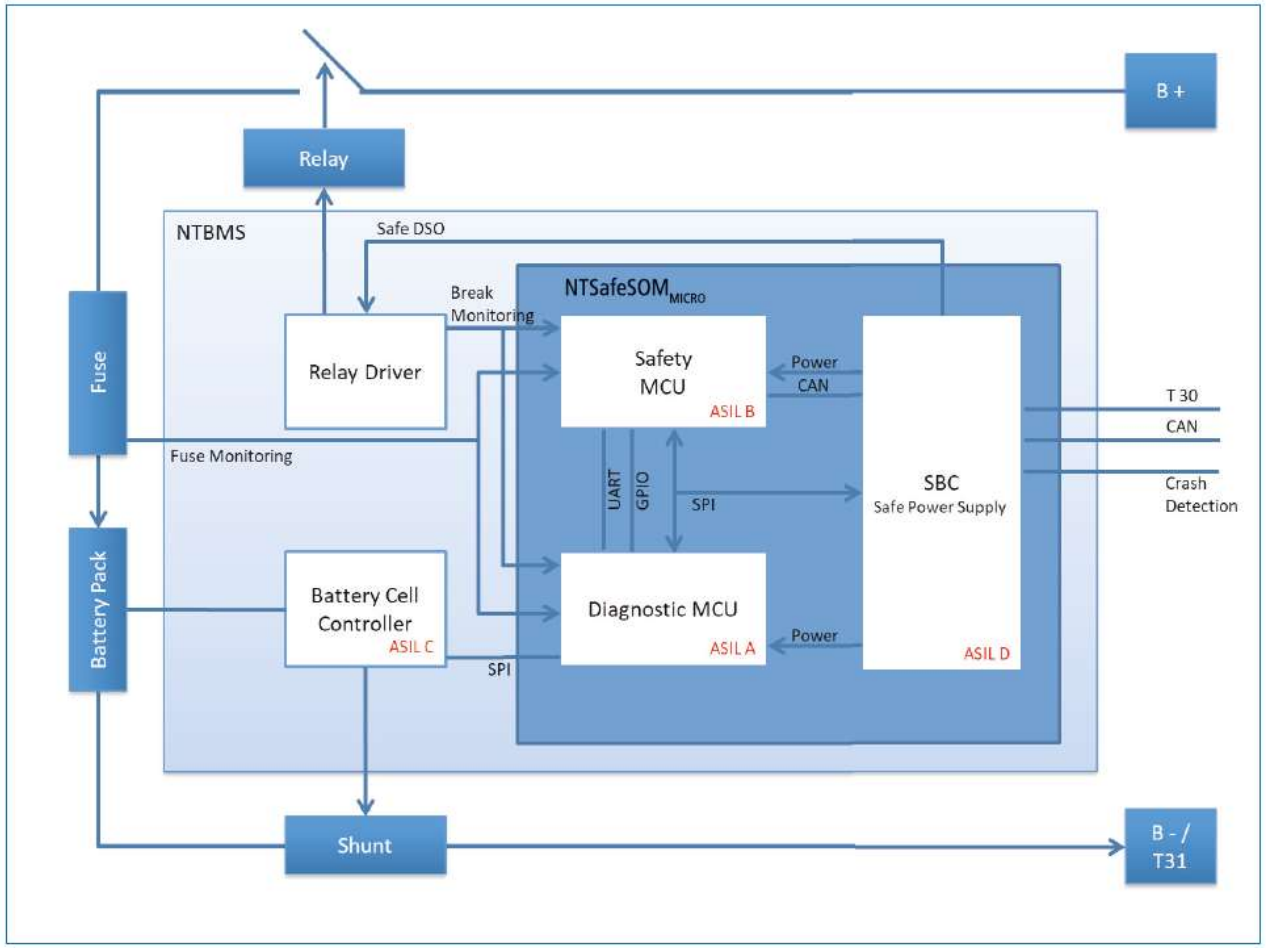
NTBatteryManagementSystem

Creating safety.
With passion.
NewTec

- Permanent measurement of cell voltages
- Over-temperature protection
- Overcurrent / overvoltage detection
- Safe relay (breaker) control (up to ASIL C)
- Various definable Safe States
- LIN and CAN bus interface
- Crash detection
- Overcurrent control fuse
- Power supply with watchdog protection
- Control of up to 6 Lithium-ion battery cells



Courtesy of NewTec

BMS Safety System-On-Module: NTSafeSOM

Ready to use safety computer reference design

Features

- Targets up to ISO26262 ASIL-C and IEC 61508 SIL 2 System level certification
- Dual MCU and safety PMIC architecture
  - ✓ S32K144 – Cortex M4F MCU
  - ✓ KEA – Cortex M0+ MCU
  - ✓ FS45 – Safety & Power Management System IC
- Different support package options from NXP and Newtec
  - ✓ Free-of-charge reference documents
  - ✓ Development kit hardware with application software
  - ✓ up to complete system development with safety certification
- First application designed for 6 cells Li-Ion BMS using MC33772 battery cell controller

Applications

- Industrial, medical or automotive system requiring functional safety certification

S32K1xx MCU – ASIL B Safety Features

Safety Hardware

- Core platform (core, DMA, cache …), Buses - XBAR
- ECC in Flash & RAM
- Power & Clock Monitoring
- Watchdog, MPU, CRC, register protection
- Diversity of safety levels

Safety Software

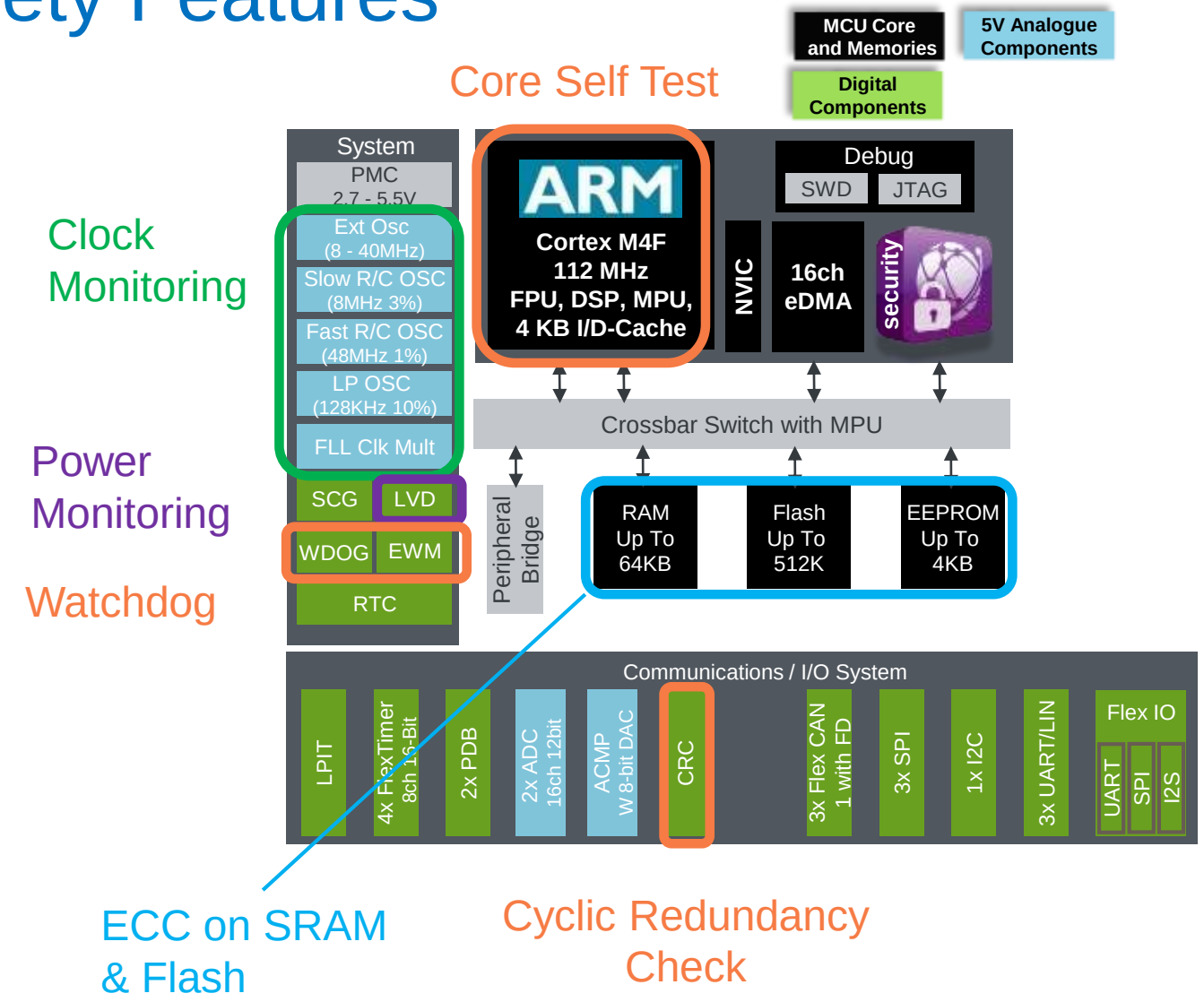
- S32K core self-test SW library

Safety Process

- ISO 26262 development process

Safety Support

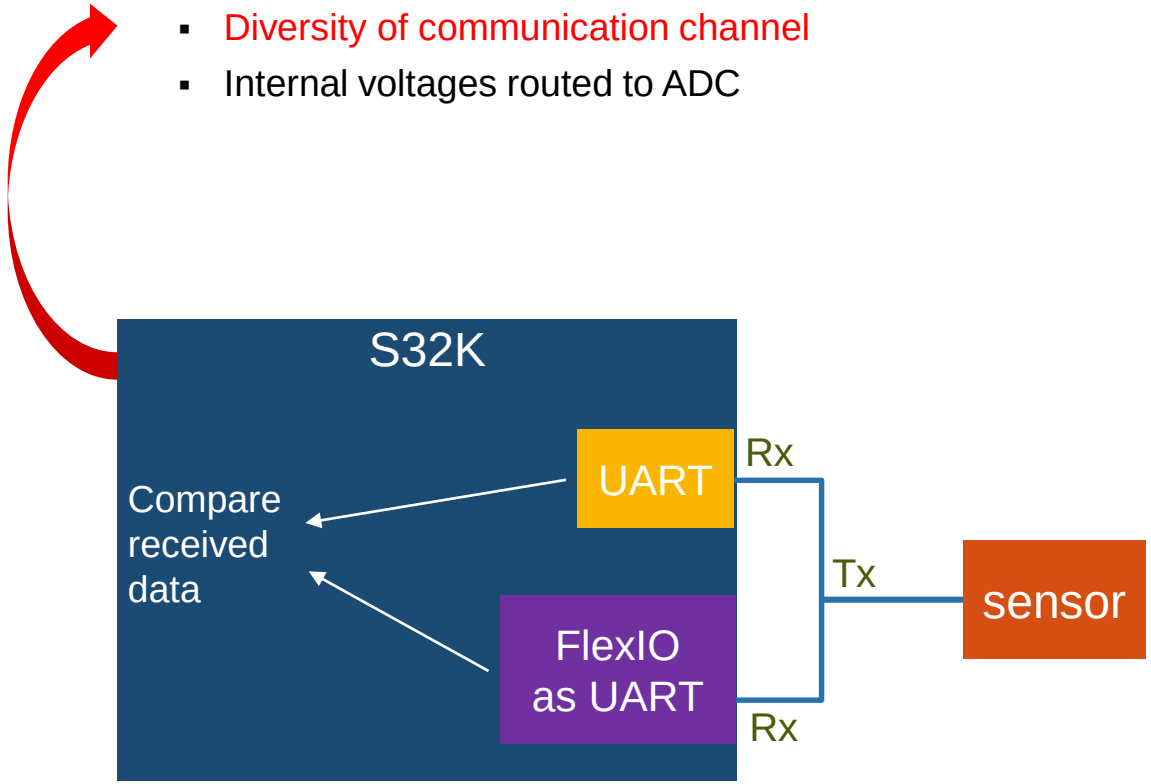
- FMEDA
- Safety manual
- Technical support



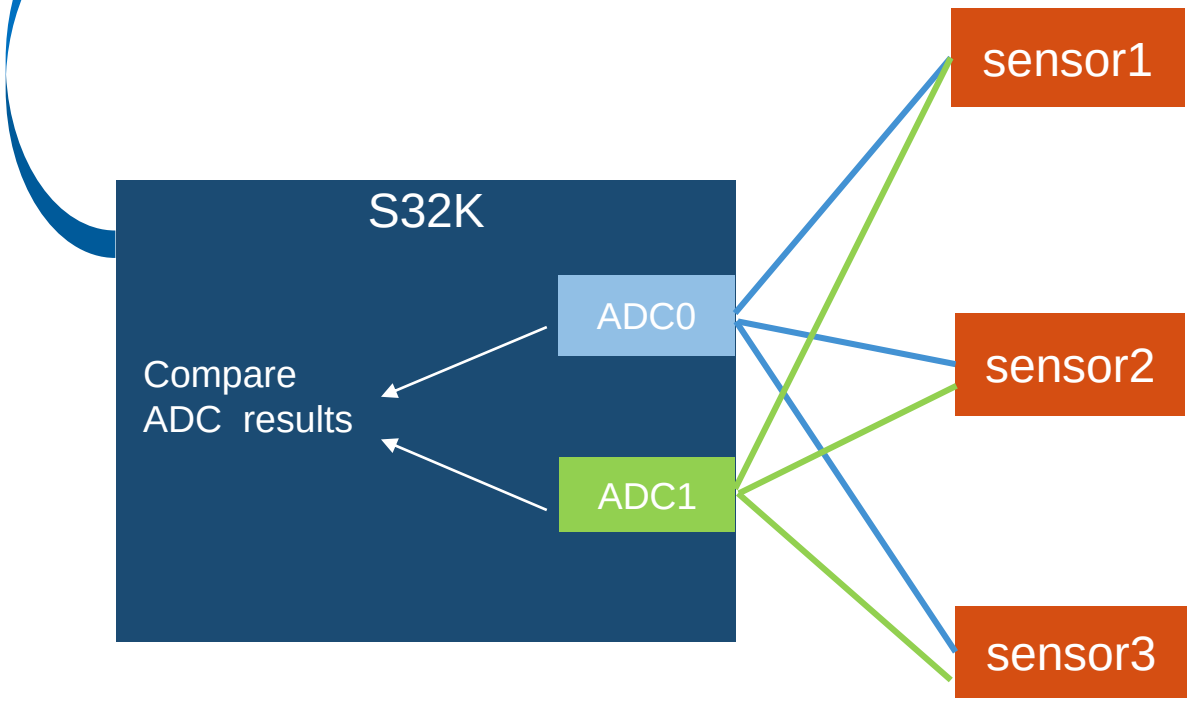
Safety measures on peripherals

Differentiating features

- End-to end CRC to detect data corruption
- Diversity of communication channel
- Internal voltages routed to ADC



Diversity of analog signal paths



SECURE CONNECTIONS
FOR A SMARTER WORLD