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
- VDS (Vehicle Dynamics & Safety)
- Long term innovator in chassis and powertrain control
- Significant growth in safety as autonomous control drives robust fault tolerant systems

Body & Comfort
- GPIS (General Purpose & Integrated Solutions)

Chassis, Safety, Torque and Energy Management

Body Electronics
- Edge Nodes
  - Broadest portfolio of integrated MCU+HV mixed-signal solutions
  - Application specific software solutions

Driver Replacement
- ADAS (Advanced Driver Assistance Systems)
  - #1 in radar processing
  - Comprehensive radar, vision and central processing portfolio

Connectivity
- C&S (Connectivity & Security)
  - #1 in vehicle networking and security
  - End-to-end portfolio of networking devices

Networking
- DN (Digital Networking)
  - High-performance Multicore Arm® SoCs for Edge Compute
  - Virtualized, Secure, Solutions with Application Specific Acceleration

Infotainment
- i.MX (Multimedia and General Purpose Applications Processor)
  - #1 in Infotainment & Reconfigurable Cluster
  - Scalable multimedia solution with audio DSP, VMCU, safety camera/display/audio, hardware virtualization, vision acceleration

Advanced Processing Solutions
- Vehicle Network Processing (Gateways, Domain Controllers)
- Infotainment, Reconfigurable Cluster, Telematics, V2X, Driver Awareness
S32K Target Apps: Truly General Purpose

**Body Electronics**
- HVAC
- Steering wheel
- Lighting
- Battery/Power mgmt
- Doors
- Body Controllers

**Motor Control**
- Engine / cooling fans
- Window lift
- Wipers
- Diesel / Oil Pump
- Eth. Audio Amp
- Wireless Charging, NFC pairing

**Chassis/Safety**
- TPMS
- Suspensions
- Gear shifter
- Motorcycle ABS
- Park Assist
- Motorized cameras

**Infotainment**
- Wireless Charging, NFC pairing
## General Purpose and Integrated Solutions

### 8/16/32bit General Purpose

<table>
<thead>
<tr>
<th>Body Electronics</th>
<th>Interior</th>
<th>Across domains</th>
</tr>
</thead>
</table>

- **8/16/32bit General Purpose MCU**
  - 8/16/32bit General Purpose
  - Application specific software solutions
  - MagniV Application specific Integrated Solutions

### Integrated Solutions

<table>
<thead>
<tr>
<th>Motor Control</th>
<th>Window Lift</th>
<th>Pumps, Fans</th>
<th>Sensor Interfaces</th>
</tr>
</thead>
</table>

- **Motor Control**
- **Window Lift**
- **Pumps, Fans**
- **Sensor Interfaces**

### Integrated Solutions

- **S12 MagniV**
- **Next Gen IS Solution**

### Application Specific

- **MPC56xxB – GP 32bit**
- **S32K1**
- **S12 – GP 16bit**
- **KEA**
- **S08 – GP 8bit**
- **Next Gen S32K**
- **Next Gen IS Solution**
S32K14x and S32K11x Features

**S32K14x Features**
- Arm Cortex-M4F @ up to 112MHz
- 256KB Flash
- 32KB SRAM
- up to 89 I/Os
- 2x FlexCAN with 1x FD
- 16 channel eDMA
- 1x 16-ch 12-bit ADC
- LQFP-64

**S32K11x Features**
- Arm Cortex-M0+ @ 48MHz
- 128KB Flash
- 16KB SRAM
- up to 42 I/Os
- 1x FlexCAN with 1x FD
- 4 channel eDMA
- QFN-32
- 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, LP SPI, 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

**S32K142**
- Arm Cortex-M4F @ up to 112MHz
- 256KB Flash
- 32KB SRAM
- up to 89 I/Os

**S32K144**
- 512KB Flash
- 64KB SRAM
- up to 128 I/Os

**S32K146**
- 1MB Flash
- 128KB SRAM
- up to 156 I/Os

**S32K148**
- 2MB Flash
- 256KB SRAM

**Gr0 Option**

*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

\[ \text{ALL modules maintained in ALL modes} \]
\[ \text{ALL memory maintained in ALL modes} \]
\[ \text{ALL I/O maintained in ALL modes} \]
\[ \text{ALL I/O can wake up the MCU} \]

\[ \text{Clock gating} \]
\[ \text{Clock tree management} \]
\[ \text{Peripheral grouping} \]

\[ \text{Autonomous peripherals} \]
  - e.g. DMA, RTC, ADC, LPUART
## S32K1 Low Power Performance Snapshot

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

- 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.

<table>
<thead>
<tr>
<th>Peripheral</th>
<th>Low Power Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMA</td>
<td>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</td>
</tr>
<tr>
<td>LPUART</td>
<td>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</td>
</tr>
<tr>
<td>LPSPI</td>
<td>Supports slave mode address match wake-up function and first message capture down to STOP/VLPS modes</td>
</tr>
<tr>
<td>I2C</td>
<td>Supports multiple address match wake-up function down to STOP/VLPS modes</td>
</tr>
<tr>
<td>FTM (Timer/PWM)</td>
<td>Supports 16-bit timer input capture, output compare and PWM functions down to STOP/VLPS modes</td>
</tr>
<tr>
<td>LPTMR (Timer/Pulse Counter)</td>
<td>Supports 16-bit timer and pulse counter functions in all power modes</td>
</tr>
<tr>
<td>RTC</td>
<td>Supports 32-bit seconds counter with seconds interrupt and programmable alarm in all power modes with include temperature and voltage compensation</td>
</tr>
<tr>
<td>ADC</td>
<td>Supports triggered single conversions in multiple result registers down to STOP/VLPS modes with hardware averaging and automatic compare modes</td>
</tr>
<tr>
<td>CMP (Analog Comparator)</td>
<td>Supports threshold crossing detection in all power modes along with a triggered compare mode for lower average power compares</td>
</tr>
</tbody>
</table>
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

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

NXP is the #1 solution provider HW + SW
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

4 KB SRAM

64 KB Flash

4 KB Emulated EEPROM

Backup (Configurable)
AUTOSAR Offering – The Most Complete/Supported Ecosystem

- Supporting multiple versions
- Across entire portfolio
- Unmatched flexibility for choosing tools
- New ARCCORE Starter Kit
S32 SDK Solution – The Best Alternative to AUTOSAR

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

**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

**NXP Tools and Ecosystem**

**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

**Motor Control System Solutions**

- **Comming soon**
  - Mid Power 12V / 33A
  - Low Power 12V / 8Amps (RMS)
  - 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

**NXP HW Scalability**
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)

- BLDC Motor Control
  (S32K + GD3000)

- DC Motor Control
  (S32K + HB2001)

- Low Power Demo
  (S32K + LP Shield)

- Injector driver demo
  (S32K + PT2000)

- Flex I/O
  (S32K EVBs emulating comms protocols)
**GPIS Applications Resources**

**Engage in good technical discussions**
- **S32K / S12+MagniV**
  - > 1000 technical threads created during 2018.

**Develop applications and customers. App notes posted on**
- **S32k / KEA**
- **MagniV / S12**

**22 Application notes posted on**
[nxp.com/s32k](http://nxp.com/s32k)

**Train yourself and customers:**
- Training materials in [nxp.com/s32k → Training](http://nxp.com/s32k)
  - > 20 technical trainings posted in 2017.

**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