MOTOR CONTROL SOLUTIONS BASED ON S32K3 MCUS

The S32K3 family of 32-bit AEC-Q100 qualified MCUs combines a scalable family of Arm® Cortex-M7-based microcontrollers built on long-lasting features with a comprehensive suite of production-grade tools. S32K3 MCUs are included in NXP’s Product Longevity Program, guaranteeing a minimum of 15 years of assured supply.

S32K3 VALUE PROPOSITION FOR MOTOR CONTROL

SCALABLE MCU PLATFORM

- Hardware- and Software- compatible MCU family
- 120 – 240 MHz Arm Cortex-M7 core
- Flash memory: from 512 KB up to 8 MB
- MAPBGA, HDQFP packages, from 48 to 289 pin count
- CAN FD, FlexIO, QSPI, Ethernet and serial audio interfaces
- AEC-Q100 qualified:
  Grade 1 (-40° C to +125° C)
  Grade 2 (-40° C to +105° C)
- Functional Safety compliant: ISO 26262 up to ASIL D

MOTOR CONTROL COVERAGE

- Engineered tools for 3-phase PMSM and 3-phase BLDC motor control targeting body and chassis
- Dedicated peripherals set for rapid motor control loop implementation: enhanced Modular IO Subsystem (eMIOS), Logic Control Unit (LCU), TRGMUX, Body Cross-triggering Unit (BCTU), Analog to Digital Converter (ADC), and Analog Comparator (CMP)

COMPREHENSIVE MOTOR CONTROL ECOSYSTEM

- Diverse hardware solutions supporting motor control applications
- S32K3 software ecosystem with production-ready algorithm library:
  – Automotive Math and Motor Control Library (AMMCLib) set
  – FreeMASTER and Motor Control Application Tuning (MCAT) tool
  – Model-Based Design Toolbox (MBDT)
- Dedicated technical support and online community

nxp.com/S32KMCdevKits
S32K3 PRODUCT OVERVIEW

S32K3 provides a scalable platform with high hardware and software compatibility to address various motor control techniques and applications.

<table>
<thead>
<tr>
<th>S32K310</th>
<th>S32K311</th>
<th>S32K312</th>
<th>S32K314</th>
<th>S32K322</th>
<th>S32K324</th>
<th>S32K341</th>
<th>S32K342</th>
<th>S32K344</th>
<th>S32K328</th>
<th>S32K338</th>
<th>S32K348</th>
<th>S32K358</th>
</tr>
</thead>
<tbody>
<tr>
<td>1x Cortex-M7 @ 120 MHz</td>
<td>1x Cortex-M7 @ 160 MHz</td>
<td>2x Cortex-M7 @ 160 MHz</td>
<td>1x LS Cortex-M7 @ 160 MHz</td>
<td>2x Cortex-M7 @ 240 MHz</td>
<td>3x Cortex-M7 @ 240 MHz</td>
<td>1x LS Cortex-M7 @ 160 MHz</td>
<td>1x LS Cortex-M7 @ 240 MHz</td>
<td>1x LS Cortex-M7 + 1x Cortex-M7 @ 240 MHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASIL B</td>
<td>ASIL B</td>
<td>ASIL B</td>
<td>ASIL B</td>
<td>ASIL B</td>
<td>ASIL B</td>
<td>ASIL D</td>
<td>ASIL D</td>
<td>ASIL D</td>
<td>ASIL B</td>
<td>ASIL B</td>
<td>ASIL D</td>
<td></td>
</tr>
<tr>
<td>512 KB Flash</td>
<td>1 MB Flash</td>
<td>2 MB Flash</td>
<td>4 MB Flash</td>
<td>1 MB Flash</td>
<td>2 MB Flash</td>
<td>4 MB Flash</td>
<td>1 MB Flash</td>
<td>2 MB Flash</td>
<td>4 MB Flash</td>
<td>8 MB Flash</td>
<td>1152 KB RAM</td>
<td></td>
</tr>
<tr>
<td>64K SRAM incl. 128K TCM</td>
<td>192K SRAM incl. 96K TCM</td>
<td>256K SRAM incl. 128K TCM</td>
<td>512K SRAM incl. 192K TCM</td>
<td>256K SRAM incl. 192K TCM</td>
<td>512K SRAM incl. 192K TCM</td>
<td>512K SRAM incl. 192K TCM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>512 KB SRAM incl. 64K TCM</td>
<td>192K SRAM incl. 96K TCM</td>
<td>256K SRAM incl. 128K TCM</td>
<td>512K SRAM incl. 192K TCM</td>
<td>256K SRAM incl. 192K TCM</td>
<td>512K SRAM incl. 192K TCM</td>
<td>512K SRAM incl. 192K TCM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>up to 84 I/Os</td>
<td>up to 84 I/Os</td>
<td>up to 143 I/Os</td>
<td>up to 218 I/Os</td>
<td>up to 143 I/Os</td>
<td>up to 218 I/Os</td>
<td>up to 218 I/Os</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 channel eDMA</td>
<td>32 channel eDMA</td>
<td>32 channel eDMA</td>
<td>32 channel eDMA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3x FlexCAN w/CAN-FD</td>
<td>6x FlexCAN w/CAN-FD</td>
<td>4x FlexCAN w/CAN-FD</td>
<td>6x FlexCAN w/CAN-FD</td>
<td>4x FlexCAN w/CAN-FD</td>
<td>6x FlexCAN w/CAN-FD</td>
<td>8x FlexCAN w/CAN-FD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1x 100 Mbps Ethernet (TSN)</td>
<td>1x 100 Mbps Ethernet (TSN)</td>
<td>1x 100 Mbps Ethernet (TSN)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2x I2C</td>
<td>2x I2C</td>
<td>2x I2C</td>
<td>2x I2C</td>
<td>2x I2C</td>
<td>2x I2C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4x SPI</td>
<td>4x SPI</td>
<td>4x SPI</td>
<td>6x SPI</td>
<td>4x SPI</td>
<td>6x SPI</td>
<td>6x SPI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2x 24 ch 12-bit ADC</td>
<td>2x 24 ch 12-bit ADC</td>
<td>3x 24 ch 12-bit ADC</td>
<td>2x 24 ch 12-bit ADC</td>
<td>2x 24 ch 12-bit ADC</td>
<td>2x 24 ch 12-bit ADC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2x 24 ch 12-bit ADC</td>
<td>3x 24 ch 12-bit ADC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2x 3.3V I/Os</td>
<td>2x 3.3V I/Os</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quad SPI</td>
<td>Quad SPI</td>
<td>Quad SPI</td>
<td>Quad SPI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LQFP-48</td>
<td>HDQFP-172</td>
<td>HDQFP-172</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HQFP-100</td>
<td>HDQFP-100</td>
<td>HDQFP-100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAPBGA-257</td>
<td>MAPBGA-257</td>
<td>MAPBGA-257</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Common HW: HSE B, LPUART, FlexIO, eMIOS Timers, ACMP, LCU, BCTU, TRGMLUX
Common SW: Real Time Driver, Security FM, Safety Framework SW & Core Self Test Lib, Application Specific SW |

**Ethernet 10BaseT1S supported by SPI + external MAC&PHY**

S32K3 MOTOR CONTROL LINEUP

**S32K3 vs. Motor Control Techniques Lineup**

- Model Based (Virtual machine)
- High Speed
- High Dynamic
- 6ph PMSM FOC
- Switch Reluctance
- 3ph PMSM FOC Sensorless
- 3ph PMSM FOC Encoder/Resolver
- 3ph BLDC 6-step Sensorless
- 3ph BLDC 6-step HALL

**S32K3 vs. Typical MC Applications Lineup**

- High-end Engine Cooling
- Low-end Traction Drive eTurbos
- eCompressor
- Belt Starter Generator
- Crankshaft Motor Generator Transmissions actuators
- Engine Cooling
- HVAC Blower Pumps
- Window Lift (3ph PMSM)
- Sunroof (3ph PMSM)
- Trunk opener (Dual DC motor)

nxp.com/S32KMCdevKits
S32K3 MOTOR CONTROL SOFTWARE AND ECOSYSTEM

AUTOMOTIVE MATH AND MOTOR CONTROL LIBRARY (AMMCLIB) SET

• Precompiled software library including NXP-patented control math algorithms
• Automotive production-ready software (SPICE Level 3, CMMI and ISO 9001/TS 16949)
• Delivered as bit-accurate models for MATLAB®/Simulink® and C code
• Single API across NXP MCUs, simple migration across platforms

MODEL-BASED DESIGN TOOLBOX (MBDT)

• Model-based design environment in MATLAB® and Simulink® for motor control software on S32K MCUs
• Automatic code generation for S32K3xx peripherals and applications prototyping
• Extensive online community and tutorials available
• Model-based design approach helps to save R&D time and test efforts

FREEMASTER (LITE)

• Real-time data visualization tool for debugging and tuning embedded algorithm during development
• Graphs, tabular grids and web views embedded directly in the desktop application
• FreeMASTER Lite supports JSON RPC protocol and is able to run on Windows® or Linux® host PC, enabling custom UI on web browsers

MOTOR CONTROL APPLICATION TUNING (MCAT)

• HTML-based graphical user interface tool, plug-in to FreeMASTER and fully compliant with AMMCLib set API
• Real-time tuning and updating of control parameters

S32K3 ADDITIONAL SOFTWARE

• S32 Design Studio IDE: Eclipse, GCC and debugger
• Security firmware: NXP provided
• Core Self-Test Library for functional safety applications
• Production-grade ASIL compliant Real Time Drivers (RTD) support for both AUTOSAR and non-AUTOSAR applications
• Third-party ecosystem support to reduce time-to-market

nxp.com/S32KMCdevKits
## S32K3 MOTOR CONTROL HARDWARE TOOLS

### Part number
MCSPTE1AK344

### PRODUCTS
**MCU**
S32K344

**Analog**
- GD3000: MOSFET gate driver for 3-phase motor
- FS26: Safety System Basis Chip (SBC) with Low-Power Fit for ASIL D
- TJA1021: LIN 2.1/SAE J2602 Transceiver
- TJA1043 HS-CAN Transceiver

### HARDWARE
**Motor**
- 3-phase BLDC motor with Hall sensor, 24 VDC, 9000 RPM, 95 W

**Power**
- Up to 100 W

**Voltage**
- 12 V (10-18 V)

**Current sensing**
- Single-, dual- and triple-shunt

**Position sensing**
- Hall, encoder

**Communication**
- CAN (FD), LIN, Ethernet, UART, PWM

### MOTOR CONTROL SOFTWARE APPLICATION
**PMSM FOC**
- 3-phase field-oriented control (FOC) with field weakening (FW)
- Sensor (Encoder) or sensorless control (back-EMF observer)
- Single-shunt and triple-shunt current sensing and 3-phase stator current reconstruction
- Examples built on either RTD high-level API (Autosar & non-Autosar applications) or low-level API (non-Autosar) applications

**BLDC Six-step**
- 3-phase 6-step commutation control
- Sensor (Hall) or sensorless control based on back-EMF zero-cross detection method

### TOOLS
**Integrated development environment**
- S32 Design Studio IDE for S32 Platform

**MCU peripherals settings and control**
- Real Time Drivers (RTD)

**Motor control library**
- Automotive Math and Motor Control Library (AMMCLib) set

**Visualization and motorcontrol tuning**
- FreeMASTER and Motor Control Application Tuning (MCAT)

### Part number
MCTPTX1AK324 available in June 2023

### PRODUCTS
**MCU**
S32K324

**Analog**
- GD3000: MOSFET gate driver for 3-phase motor
- FS26: Safety System Basis Chip (SBC) with Low-Power Fit for ASIL D
- TJA1021: LIN 2.1/SAE J2602 Transceiver
- TJA1043 HS-CAN Transceiver
- HB2001: SPI Programmable 10 A H-Bridge Brushed DC Motor Driver
- MC40XS6500: High-Side Switch, 12V

### HARDWARE
**Power**
- 12V (8 - 18V), 5Amps RMS -> ~100

**Current sensing**
- Dual shunt

**Position sensing**
- Sensorless

**Other**
- Integrated thermal management unit

**Communication**
- HS-CAN, LIN, USB to UART

### MOTOR CONTROL SOFTWARE APPLICATION
**PMSM**
- Field-oriented control (FOC) with field weakening for sinusoidal motor type
- Support control 3x PMSM, 1x DCM and 4x valves, independently
- Available as ANSI C examples in versions for non-Autosar applications

### TOOLS
**Integrated development**
- S32 Design Studio IDE for S32 Platform

**MCU peripherals settings and control**
- Real Time Drivers (RTD)

**Motor control library**
- Automotive Math and Motor Control Library (AMMCLib) set

**Visualization and motor control tuning**
- FreeMASTER and Motor Control Application Tuning (MCAT)
S32K3 MOTOR CONTROL BLOCK DIAGRAMS

FIELD ORIENTED CONTROL (FOC) FOR PMSM MOTOR

SIX-STEP COMMUTATION CONTROL FOR BLDC MOTOR

S32K3 RESOURCES

S32K3 MCUs
nxp.com/S32K3

MBDT online support
nxp.com/MBDTcommunity

S32K Motor Control Development kits
nxp.com/S32KMCdevKits

FreeMASTER Run-Time Debugging Tool
nxp.com/FreeMaster

S32 Design Studio IDE
nxp.com/S32DS

S32K online support
nxp.com/S32Kcommunity

Model-Based Design Toolbox
nxp.com/MBDT

nxp.com/S32KMCdevKits

NXP, the NXP logo and Processor Expert are trademarks of NXP B.V. All rights reserved. All other product or service names are the property of their respective owners. Arm and Cortex are trademarks or registered trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere. MATLAB and Simulink are registered trademarks of The MathWorks, Inc. The related technology may be protected by any or all of patents, copyrights, designs and trade secrets. © 2023 NXP B.V.