MOTOR CONTROL SOLUTIONS BASED ON S32K1 MCUS

The S32K1 family of 32-bit AEC-Q100 qualified MCUs combines a scalable family of Arm® Cortex®-M0-based microcontrollers built on long-lasting features with a comprehensive suite of production-grade tools. S32K1 MCUs are included in NXP’s Product Longevity Program, guaranteeing a minimum of 15 years of assured supply.

S32K1 VALUE PROPOSITION FOR MOTOR CONTROL

SCALABLE MCU PLATFORM
• Hardware- and Software- compatible MCU family
• 48 MHz Arm Cortex-M0+ core or up to 112 MHz Arm Cortex-M4F core
• Flash memory: from 128 KB up to 2 MB
• QFN, LQFP, MAPBGA packages, from 32 to 176 pin count
• CAN FD, FlexIO, and QSPI
• Ethernet and serial audio interfaces
• AEC-Q100 qualified:
  Grade 0 = -40° C to +150° C
  Grade 1 = -40° C to +125° C
  Grade 2 = -40° C to +105° C
• Functional Safety compliant: ISO 26262 up to ASIL B
• Cryptographic Services Engine compressed (CSEC) security engine: AES-128 and SHE compliant

MOTOR CONTROL COVERAGE
• Engineered tools for Brushed DC motors, 3-phase PMSM, and 3-phase BLDC motor control targeting body and chassis
• Dedicated peripherals set for rapid motor control loop implementation: FlexTimer (FTM), TRGMUX, Programmable Delay Block (PDB), Analog to Digital Converter (ADC), and Analog Comparator (CMP)

COMPREHENSIVE MOTOR CONTROL ECOSYSTEM
• Diverse hardware solutions supporting motor control applications
• S32K1 software ecosystem with production-ready algorithm library:
  – AMMCLIB set
  – FreeMASTER and MCAT tool
  – Model-Based Design Toolbox (MBDT)
• Dedicated technical support and on-line community

nxp.com/S32KMCdevKits
S32K1 PRODUCT OVERVIEW
S32K1 provides a scalable platform with high hardware and software compatibility to address various motor control techniques and applications.

**S32K116**
Arm® Cortex®-M0+ @ 48 MHz
128 KB Flash
17 KB SRAM
up to 42 I/Os
4 channel eDMA
1x PDB
2x 16-bit FTM (16-ch.)
QFN-32

**S32K118**
Arm® Cortex®-M0+ @ 48 MHz
256 KB Flash
24 KB SRAM
up to 58 I/Os
1 x FlexCAN with 1 x FD
1 x PDB
2x 16-bit FTM (16-ch.)
QFN-32

**Common Features**
- AEC-Q100
- CSec Security Module
- ASIL B Compliant
- Low Power
- LPUART, LP SPI, LPIIC, FlexIO
- JTAG (K14x only)

**Motor Control Peripherals**
- 1x 13-ch. 12-bit ADC
- 1x 16-ch. 12-bit ADC
- 1 x PDB
- 2 x 16-bit FTM (16-ch.)
- TRGMUX

**S32K142**
Arm® Cortex®-M4F @ up to 112 MHz
256 KB Flash
32 KB SRAM
up to 89 I/Os
2 x FlexCAN with 1 x FD
2 x PDB
2 x 16-bit ADC
4 x 16-bit FTM (32-ch.)
LQFP-64

**S32K144**
Arm® Cortex®-M4F @ up to 112 MHz
512 KB Flash
64 KB SRAM
up to 128 I/Os
3 x FlexCAN with 2 x FD
6 x 16-bit FTM (48-ch.)
LQFP-176

**S32K146**
Arm® Cortex®-M4F @ up to 112 MHz
1 MB Flash
128 KB SRAM
up to 156 I/Os
3 x FlexCAN with 2 x FD
8 x 16-bit FTM (64-ch.)
LQFP-176

**S32K148**
Arm® Cortex®-M4F @ up to 112 MHz
2 MB Flash
256 KB SRAM
up to 156 I/Os
3 x FlexCAN with 3 x FD
8 x 16-bit FTM (64-ch.)
LQFP-100

**QFN-48**
S32K142LQFP-48
S32K144LQFP-144
LQFP-100
MAPBGA-100

IEEE® 1588 Ethernet
Quad SPI
ETM Trace
2 x SAI

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**S32K1 MOTOR CONTROL LINE-UP**

**S32K1 vs. MC Techniques Line Up**
- 3ph PMSM FOC Sensorless
- 3ph PMSM FOC Resolver
- 3ph BLDC 6-step Sensorless
- 3ph BLDC 6-step HALL
- Dual DC motor
- DC and Stepper Motor
- Dual Direction

**S32K1 vs. Typical MC Applications Line Up**
- Belt Starter Generator
- Crankshaft Motor Generator
- Transmission Actuators
- Pumps
- Engine Cooling
- HVAC Blower
- Window Lift (3ph PMSM)
- Sunroof (3ph PMSM)
- Trunk Opener (Dual DC motor)
- Window Lift (DC motor)
- Seat Control (DC motor)
- Mirror Control (Stepper motor)

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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/Simulink for motor control software on S32K MCUs
- Automatic code generation for S32K1xx 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 TUNNING (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

S32K1 ADDITIONAL SOFTWARE
- S32 Design Studio IDE: Eclipse, GCC, and debugger
- Production-grade S32 Software Development Kit (S32 SDK): SPICE Level 3 compliant, MISRA tested
- NXP AUTOSAR® MCAL (QM and ISO 26262 compliant) and OS
- Security firmware – NXP provided
- Core Self-Test Library for functional safety applications
- Production-grade ASIL compliant Real Time Drivers (RTD) support
- Third-party ecosystem support to reduce time-to-market
### S32K1 MOTOR CONTROL HARDWARE TOOLS

#### PRODUCTS

<table>
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<tr>
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<th>3-Phase Low-Power Motor Control Development Kits</th>
<th>3-Phase High-Power Motor Control Development Board</th>
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<tbody>
<tr>
<td><strong>MCU</strong></td>
<td>S32K116</td>
<td>S32K144</td>
</tr>
<tr>
<td><strong>Analog</strong></td>
<td>UJA1149 – Mini high-speed system basis chip</td>
<td>GD3000 – MOSFET gate driver for 3-phase motor</td>
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<tr>
<td></td>
<td>GD3000 – MOSFET gate driver for 3-phase motor</td>
<td>TJA1043 – CAN PHY</td>
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#### HARDWARE

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<th>3-Phase Low-Power Motor Control Development Kits</th>
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<tbody>
<tr>
<td><strong>Motor</strong></td>
<td>3-phase BLDC motor with Hall sensor 24 VDC, 900 RPM, 95 W</td>
<td>3-phase BLDC motor with Hall sensor 24 VDC, 4000 RPM, 40 W</td>
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<tr>
<td><strong>Power</strong></td>
<td>Up to 100 W</td>
<td>Up to 800 W</td>
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<tr>
<td><strong>Voltage</strong></td>
<td>12 V (10-18 V)</td>
<td>12/24 V (10-36 V)</td>
</tr>
<tr>
<td><strong>Current sensing</strong></td>
<td>Single-, dual-, and triple-shunt</td>
<td></td>
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<tr>
<td><strong>Position sensing</strong></td>
<td>Hall, encoder</td>
<td></td>
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<tr>
<td><strong>Communication</strong></td>
<td>CAN (FD), LIN, UART, PWM</td>
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</tbody>
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#### 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 dual-shunt current sensing and 3-phase stator current reconstruction

**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 for Arm®
- MCU peripherals settings and control: S32K1 SDK and software configuration tool
- Motor control library: Automotive Math and Motor Control Library
- Visualization and motor control tuning: FreeMASTER and Motor Control Application Tuning (MCAT)