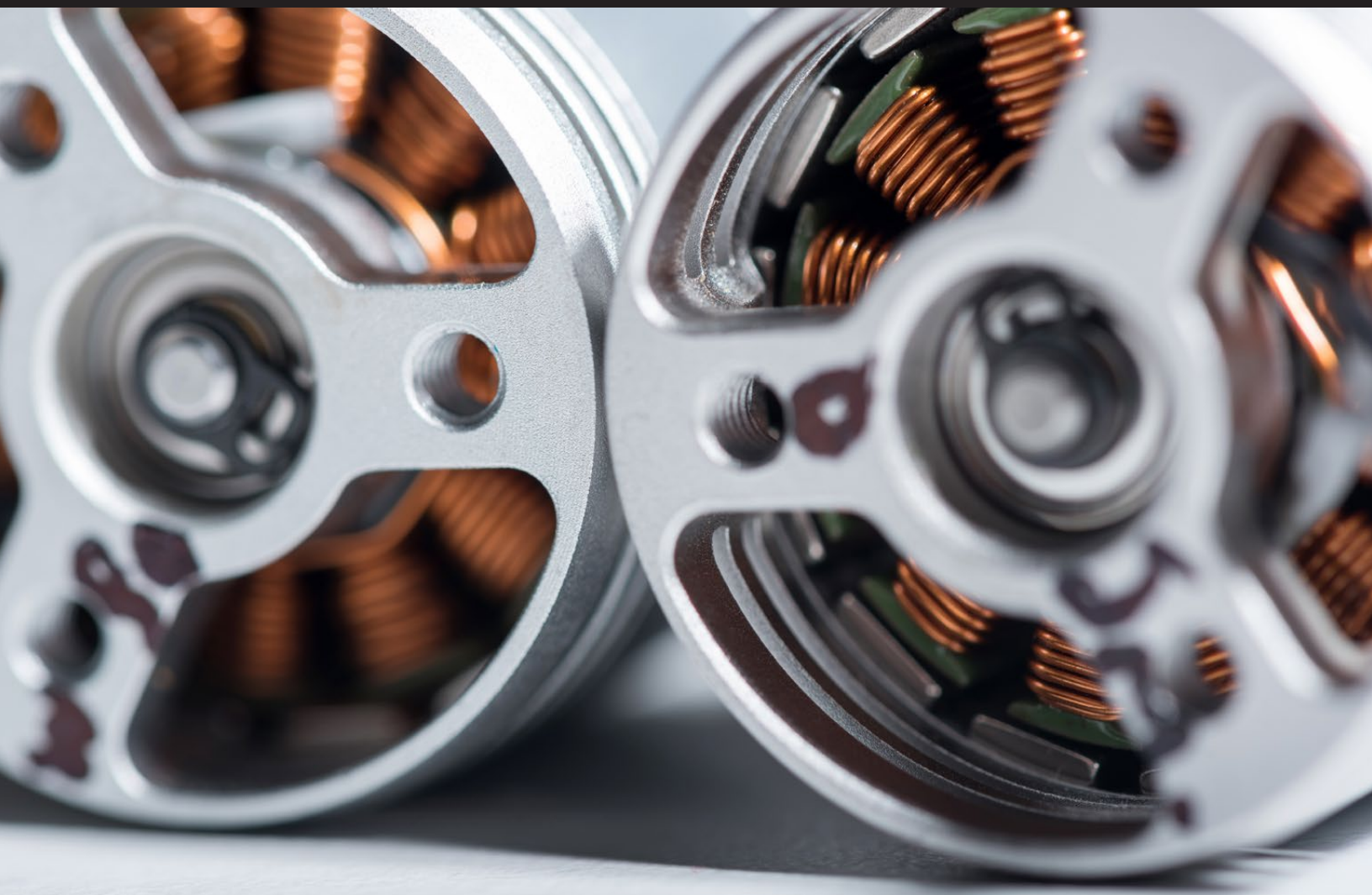
Motor control solutions based on S32K3 MCUs



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
- 120–320 MHz Arm Cortex-M7 core
- Flash memory: from 512 KB up to 12 MB
- MAPBGA, HDQFP packages, from 48 to 437 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

Hardware security engine (HSE): AES-128/192/256, RSA and ECC encryption, ISO 21434 compliant

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

S32K3 product overview

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

S32K310	S32K311	S32K312	S32K314	S32K322	S32K324	S32K341	S32K342	S32K344
1x Cortex-M7 @ 120 MHz			1x Cortex-M7 @ 160 MHz	2x Cortex-M7 @ 160 MHz		1x LS Cortex-M7 @ 160MHz		
ASIL B						ASIL D		
512 KB flash	1 MB flash	2 MB flash	4 MB flash	2 MB flash	4 MB flash	1 MB flash	2 MB flash	4 MB flash
112 KB SRAM (incl. 96 KB TCM)	128 KB SRAM (incl. 96 KB TCM)	192 KB SRAM (incl. 96 KB TCM)	512 KB SRAM (incl. 96 KB TCM)	256 KB SRAM (incl. 192 KB TCM)	512 KB SRAM (incl. 192 KB TCM)	256 KB SRAM (incl. 192 KB TCM)		512 KB SRAM (incl. 192 KB TCM)
up to 83 I/Os	up to 83 I/Os	up to 145 I/Os	up to 218 I/Os	up to 142 I/Os	up to 218 I/Os	up to 142 I/Os	up to 143 I/Os	up to 218 I/Os
12-ch. eDMA			32-ch. eDMA					
3x FlexCAN w/CAN FD		6x FlexCAN w/CAN FD		4x FlexCAN w/ CAN FD	6x FlexCAN w/ CAN FD	4x FlexCAN w/ CAN FD	4x FlexCAN w/ CAN FD	6x FlexCAN w/ CAN FD
			1x 100 Mbps Ethernet (TSN)					
2x I^2C								
4x SPI**			6x SPI**	4x SPI**	6x SPI**	4x SPI**		6x SPI**
2x 24-ch. 12-bit ADC			3x 24-ch. 12-bit ADC	2x 24-ch. 12-bit ADC	3x 24-ch. 12-bit ADC	2x 24-ch. 12-bit ADC		3x 24-ch. 12-bit ADC
			2x SAI (I^2S)					
			Quad SPI (4-bit data)					
LQFP-48								
		HDQFP-172		HDQFP-172				
HDQFP-100				HDQFP-100		HDQFP-100	HDQFP-100	
			MAPBGA-257		MAPBGA-257			MAPBGA-257

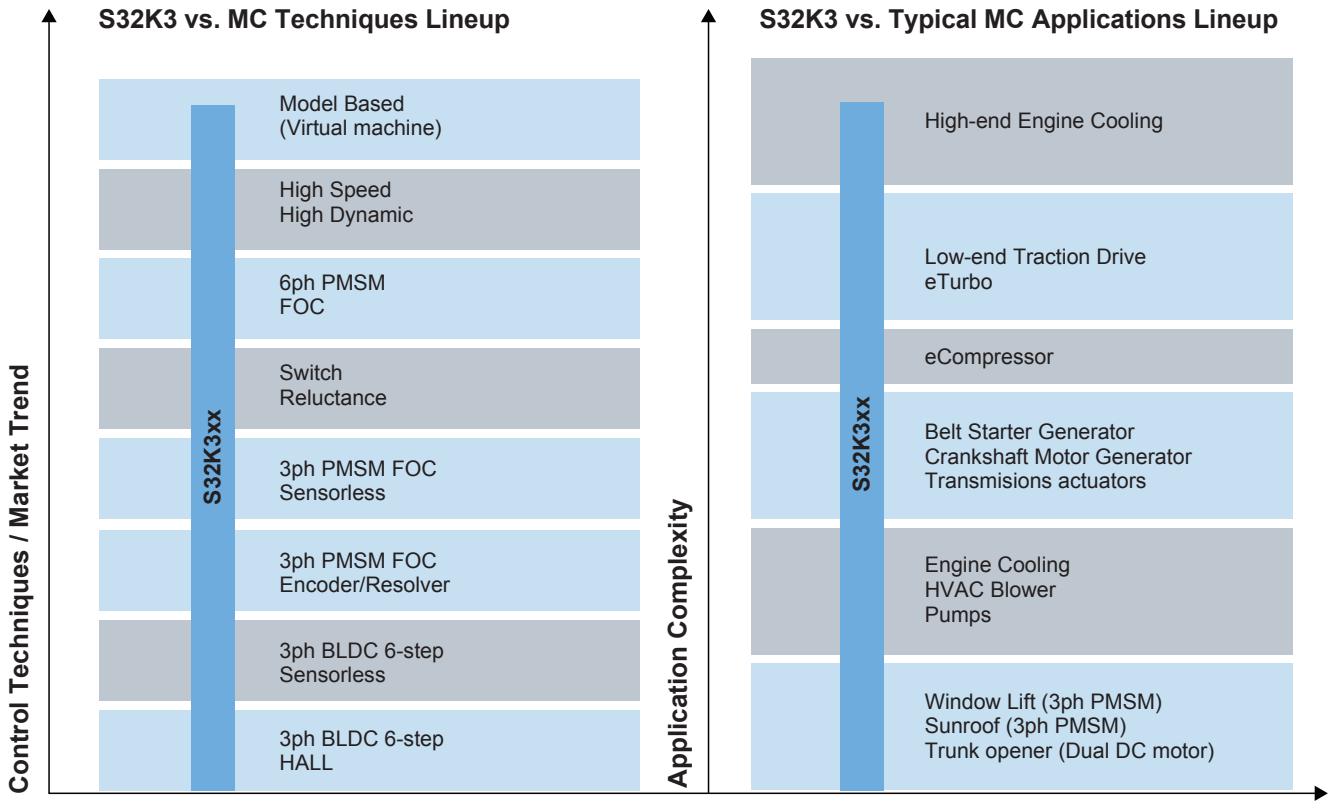
S32K328	S32K338	S32K348	S32K358	S32K388	S32K389
2x Cortex-M7 @ 240 MHz	3x Cortex-M7 @ 240 MHz	1x LS Cortex-M7 @ 240 MHz	1x LS Cortex-M7 + 1x Cortex-M7 @ 240 MHz	1x LS +3 or 2x LS +1 Arm Cortex-M7 @ 320 MHz	1x LS +3 or 2x LS +1 Arm Cortex-M7 @ 320 MHz
ASIL B					
8 MB flash					12 MB flash
1152K SRAM				1152 KB SRAM (incl. 384 TCM)	2304 KB SRAM (incl. 384 TCM)
up to 235 I/Os				202 I/Os	321 I/Os
32-ch. eDMA					
8 x CAN (FD)					12 x CAN (FD)
1x 1 Gbps Ethernet (TSN)				Ethernet (TSN) 2x 1 Gbit/s 2x 1 Gbps Ethernet (TSN)	
2 x I^2C, 16 x UART (LIN)					
6x SPI**					
3x 24-ch. 12-bit ADC					
2x SAI (I^2S)					
Quad SPI (8-bit data width)				Quad SPI (4-bit data)	
uSDHC (SDIO)					
HDQFP-172					
MAPBGA-289v					
					MAPBGA-437

Common HW: HSE B, LPUART, FlexIO, eMIOS Timers, ACMP, LCU, BCTU, TRGMUX
Common SW: real-time driver, security FM, safety framework SW & core self test lib, application specific SW
****Ethernet 10Base-T1S supported by SPI + external MAC&PHY**

S32K3 product overview (continued)

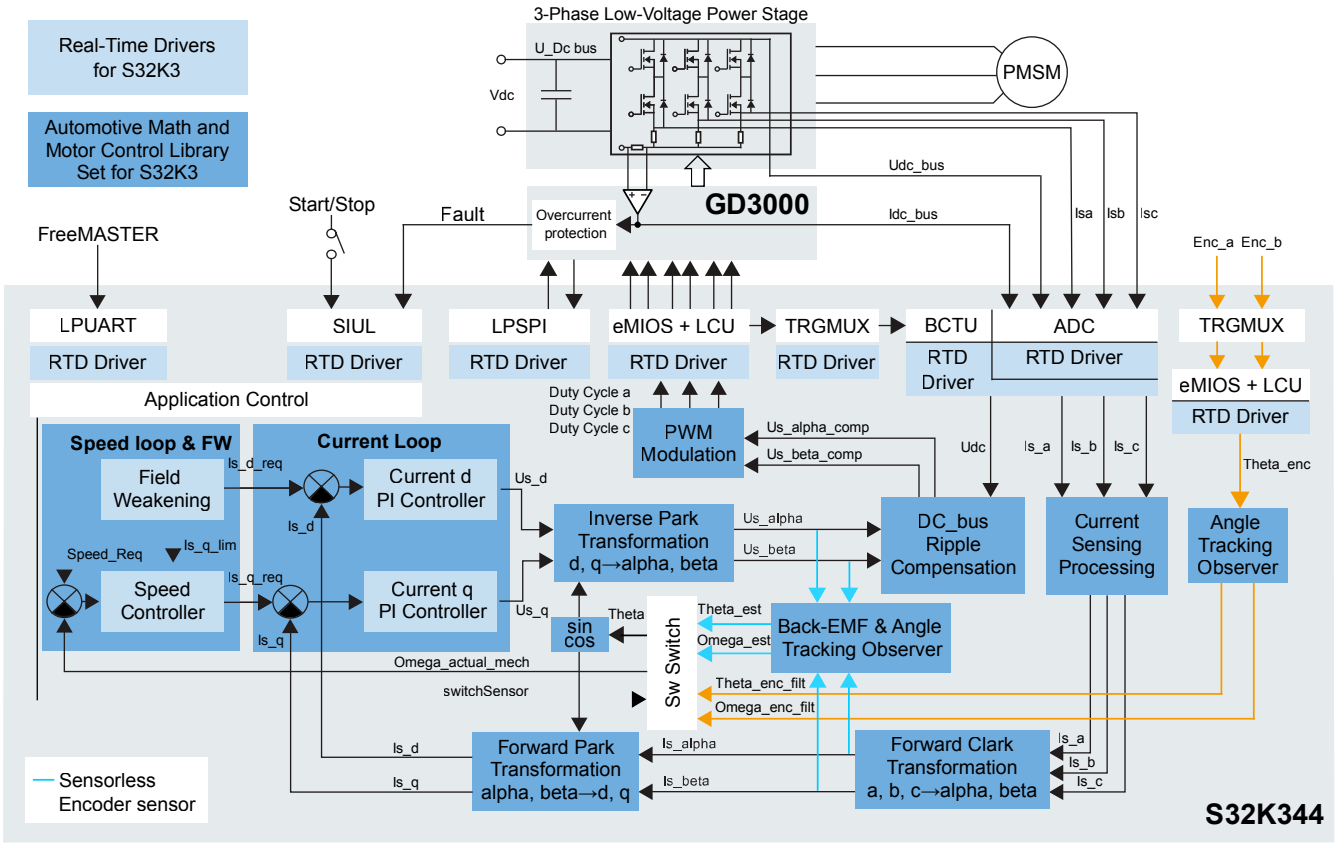
K364	K366	K374	K376	K394	K396
1 x LockStep + 1 Arm Cortex-M7 @320 MHz		1 x LockStep + 2 x Split-Lock Arm Cortex-M7 @320 MHz			
2 x motor control coprocessor (2x 16-ch.)				2 x motor control coprocessor (2x 32-ch.)	
4 MB flash	6 MB flash	4 MB flash	6 MB flash	4 MB flash	6 MB flash
704 KB SRAM (incl. 192 KB TCM)		800 KB SRAM (incl. 288 KB TCM)			
127/209+8LVDS I/Os					
64-ch. eDMA with 32-ch. LockStep					
6 x CAN FD					
100 Mbit/s Ethernet (AVB/TSN)					
ZipWire					
6 x SPI, 4x UART (LIN), 2 x I²C					
2x 12-ch. eFlexPWM with NanoEdge (8-ch. each high-resolution PWM)					
2 x sigma-delta ADC with programmable DSP		4 x sigma-delta ADC with programmable DSP			
4 x 12-bit SAR-ADC (48 inputs)		7 x 12-bit SAR-ADC (69 inputs)			
2x sine wave generator, 2 x analog comparator					
Quad SPI (8-bit data width, SDR and DDR mode)					
LQFP-EP-176					
MAPBGA-289					

S32K3 motor control lineup

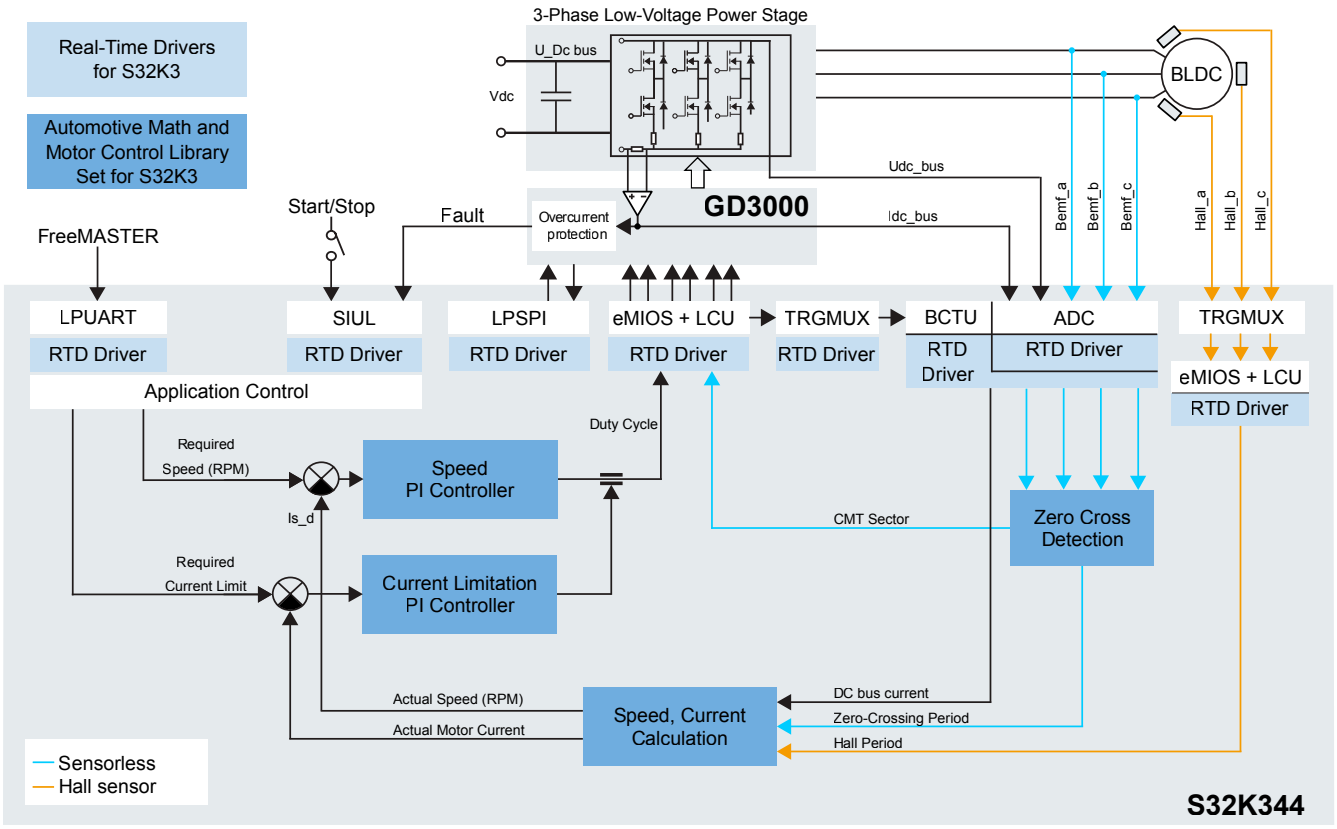


S32K3 motor control block diagrams

Field ocontrol (FOC) for PMSM motor



Six-step commutation control for BLDC motor

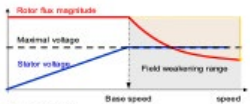


S32K3 motor control software and ecosystem

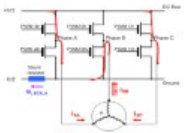
Automotive math and motor control library (AMMCLib) set

- 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

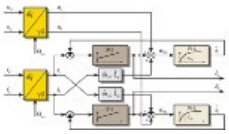
Field-weakening



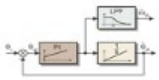
Single-shunt I meas.



Sensorless PMSM

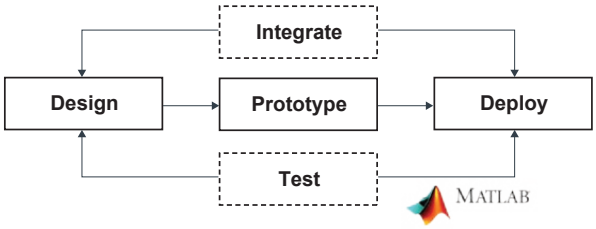


ATO



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

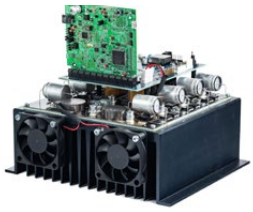
S32K3 additional software

- 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

AUTOSAR

S32K3 motor control hardware tools

Part number	MCSPTR2AK396
	
Supported products	
MCU	S32K39-37-36: S32K39/37/36 microcontrollers for eelectrification applications
Analog	MC33937: 3-phase field effect transistor pre-driver FS26: safety system basis chip with low-power, for ASIL D systems
Hardware features	
Motor	3-phase PMSM motor with resolver, 3000 RPM, 0.32 Nm, 95 W, 5.2 A
Voltage	30 V per phase
Current and voltage sensing	DC Bus voltage and current, phase voltages, BEMF voltages, over voltage/current protections
Position sensing	Resolver, encoder, HALL or sensorless techniques
Communication	100/10 Mbit automotive Ethernet (MATEnet connector), CAN FD On-board PEmicro debugger (micro-USB connector) with virtual COM port for serial communication 20-pin Arm standard JTAG connector
Motor control software application	Field-oriented control (FOC) with field weakening for sinusoidal motor type (PMSM) Available as ANSI C examples and model-based design for non-Autosar applications

Part number	MC_XTM4CK344 (MCSXTM4CK344/MCDXTM4CK344)
	
Supported products	
MCU	S32K3 microcontrollers for automotive general purpose
Analog	TJA1052IT: galvanically-isolated high-speed CAN transceiver TJA1153: secure HS-CAN transceiver with sleep mode TJA1021: ISO17987 LIN 2.1/SAE J2602 transceiver TJA1101: TJA1101B, IEEE 100BASE-T1 compliant automotive Ethernet PHY transceiver FS26: safety system basis chip with low-power, for ASIL D systems
Hardware features	
Motor	Control of 3/6-phase AC motors types: PMSM/BLDC/ACIM/(optional DC)
Current and voltage sensing	DC Bus voltage and current, phase voltages, BEMF voltages, over voltage/current protections
Position sensing	Resolver, encoder, HALL or sensorless techniques
Communication	Onboard isolated and nonisolated CAN Onboard LIN Onboard Ethernet (socket connector) Onboard S32K3 debug interface (including serial communication) JTAG debug interface
Sensors	Battery voltage DC Bus voltage Phase voltages and currents BEMF voltages Over current/voltage/temperature protections
Motor control software application	Field-oriented control (FOC) with field weakening for sinusoidal motor type (PMSM) Available as ANSI C examples for non-Autosar applications

S32K3 motor control hardware tools

Part number	MCSPTE1AK344
	
Supported 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 features	
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

Part number	MCTPTX1AK324
	
Supported 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, 12 V
Hardware features	
Power	12 V (8 - 18 V), 5 Amps 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

S32K3 motor control hardware tools

Part number	BLDC-KIT
	
Supported products	
MCU	S32K automotive general purpose microcontrollers and S32M integrated solutions
Hardware features	
Motor	42BLY3A78-24110: 3-phase BLDC motor
Power	95 W
Voltage	12 V and 24 V
Position sensing	Hall sensors
Number of pole pairs	2
Power supply	GST60A12-P1J: 12 VDC, 5 A with set of international plug adapters

S32K3 resources

S32K3 MCUs
nxp.com/S32K3

S32K Motor Control Development kits
nxp.com/S32KMCdevKits

S32K online support
S32K community

MBDT online support
MBDT community

S32 Design Studio IDE
nxp.com/S32DS

Model-Based Design Toolbox
nxp.com/MBDT

FreeMASTER Run-Time Debugging Tool
nxp.com/FreeMaster

AMMCLib set
nxp.com/AMMCLib

nxp.com

Document Number: S32K3MCBROCH REV 7