MOTOR CONTROL FOR INDUSTRIAL AND IoT APPLICATIONS

Efficient, reliable and secure.

Complex systems and processes across factory and building automation applications require motor control solutions that are efficient, reliable and secure. These systems must maintain a high level of accuracy and reliability in the most rugged environments.

NXP brings its decades-long history of motor control innovation to offer a comprehensive and cost-effective motor control portfolio of products, tools, software, and expert support for the most popular motor types. Our modern motor control solutions are designed to enhance operational safety and efficiency.

For more information about NXP motor control solutions, visit **nxp.com/motorcontrol**.

CONTENTS

MOTOR CONTROL SOLUTIONS MORE THAN SILICON

NXP motor control solutions go beyond optimized edge processing hardware. Along with a foundation of functional safety and security, our **broad ecosystem** of software, development tools, technical support services and training are designed to make your jobs easier and your end products better.

NXP Motor Control Solutions	
MCUs, MPUs and DSCs	Software and Drivers
Development Tools	Reference Designs
Demos	Application Notes
Expertise	Technical Support
Online Training	Web Site

SOLUTIONS FOR MOTOR CONTROL

Addressing Common Motor Control Application Requirements

NXP provides comprehensive motor control solutions to enable systems that address a wide range of application requirements, including:

- Minimize energy losses
- Increase productivity, flexibility and robustness
- Increase safety and reliability
- Reduce acoustic noise and power harmonics
- Increase system performance -versus-cost ratio
- Decrease system size and weight for Faster Time to Market
- Pre-configured software libraries for real-time operation

Motor Control Portfolio Highlights

NXP's portfolio enables designs to meet demanding requirements, achieve functional safety and standards compliance, while reducing time-to-market, with the following features:

- **Realtime** – Low Latency
- **Timing Control** – Synchronization and Trigger System
- **Reliability** – EMC/ESD
- **Longevity** – 10 / 15 Years Guarantee
- **Computing Performance** – High Speed, Digital Signal Processing
- **Safety** – ISO 26262, IEC 61508, IEC 60730 / IEC 60335
- **Security** – Code / IP Protection
- **Scalability** – Low End to High End

RECOMMENDED PRODUCTS

NXP's extensive motor control expertise paired with Arm® Cortex®-M0+, M4 and M7 cores, and DSC and Power Architecture® cores bring secure, connected, high efficiency motor control and power conversion to industrial applications. Our high performance, feature-rich and broad MCU families from entry-level 20 MHz MCUs to advanced 1GHz crossover MCUs maximize hardware and software reuse.

LPC, KE and KV Flash-based Microcontrollers	Featuring high speed ADC, high resolution PWM and 5V power supply (on KE series), NXP offers flash-based MCUs that are engineered to support industrial applications such as servo motors, motor encoders, drones, appliances, industrial inverters and more.
i.MX RT Crossover Microcontrollers	The high performance, highly integrated and robust i.MX RT crossover MCUs feature multi-channel timers, HMI, and connectivity that enable motor control capabilities for applications such as robotics, multi-axis servo controllers, appliances, drones and industrial inverters.
Digital Signal Controllers: 56F8000	Built on NXP's DSC cores, the Digital Signal Controller families combine analog integration and high resolution PWM with the reliability needed for industrial motor control and digital power applications.
General-purpose Microcontrollers: S32K3, S32K1, KEA	A scalable family of general purpose MCUs based on Arm Cortex M0+, M4F and M7 cores. The security module combined with functional safety features like lockstep, ECC and memory protection together with high temperature ranges positions this family for safety-critical applications and high reliability needs for both automotive and industrial applications.
Power Architecture Microcontrollers: MPC5xxx (MPC57xx)	The MPC5 family offers scalable-performance with PowerPC e200 z0/z4/z7 multicore architecture in combination with an industry standard eTPU based timer system. The MCUs support code expansion, a security module, wide range of peripheral set and targets applications with the highest level of functional safety and performance requirements.
Integrated motor drivers and gate drivers	NXP offers integrated motor drivers and gate drivers, including medium voltage monolithic H-bridge drivers ICs (HBT2), BLDC and H-bridge gate drivers (GD3000), configurable low side switches and low voltage drivers for portable devices.. These drivers provide options for communication, a number of outputs, and functional safety. GD3100 family of isolated gate drivers integrate reinforced isolation, capabilities to drive SiC modules, functional safety and diagnostics for instantaneous system monitoring as well as predictive analytics.
System basis chips (SBCs) and power management integrated circuits (PMICs)	System basis chips and low voltage PMICs fulfill important functions in motor control, such as providing robust supply, functional safety, high integration level and configurability. With input voltage tolerances reaching 60V and integrated watchdog, voltage monitoring, safety state machines, redundancy and on-chip isolation, these products eliminate the need for redundant MCUs and voltage rails which simplifies system architecture at reduced cost.

MOTOR CONTROL HARDWARE ENABLEMENT

Hardware development kits enable rapid prototyping of motor control applications.

NXP motor control development boards are designed to support the rapid evaluation and prototyping of a variety of motor control applications using NXP MCUs.

Low-Voltage Platform Options

Supports BLDC and PMSM Designs

+

OR

MCU Card
- FRDM-KVxx
- FRDM-KExx
- 56F8xxxx-EVK
- i.MX RT10xx-EVK
- LPC55S36-EVK

FRDM-MC-LVPMSM
- 48V, 5Amp, 190W
- Sensorless

FRDM-MC-LVBLDC
- 12V, 5Amps, 60W
- Sensorless

- Low and Medium Voltage
- Low Cost
- Arduino Interface

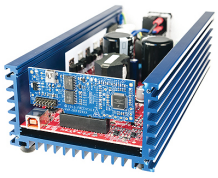
High-Voltage Platform Options

Supports BLDC, PMSM and ACIM Designs

+

HVP MCU Card
- HVP-KVxx
- HVP-KExx
- HVP-56F8xxxx

HVP-MC3PH
- Input: 85-240V AC
- Output: 8A, 1KW/800W
- Integrated Power Stage
- Integrated PFC



- High Voltage
- Also supports ACIM

MOTOR CONTROL SOFTWARE AND TOOLS ENABLEMENT

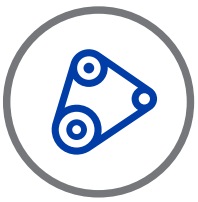
NXP's industry leading motor control software ecosystem eases development efforts

NXP Embedded Software Libraries

Thousands of algorithms ranging from basic mathematical operations to advanced motor control algorithms can be easily incorporated into complex real-time control applications and motor control reference designs.
nxp.com/RTCESL and nxp.com/AMMCLib

FreeMASTER Run-Time Debugging Tool

Suitable for a broad range of industrial applications, FreeMASTER is a user-friendly real-time debug monitor and data visualization tool that enables runtime configuration and tuning of embedded software applications.
nxp.com/freeMASTER



Motor Control Application Tuning (MCAT) Tool

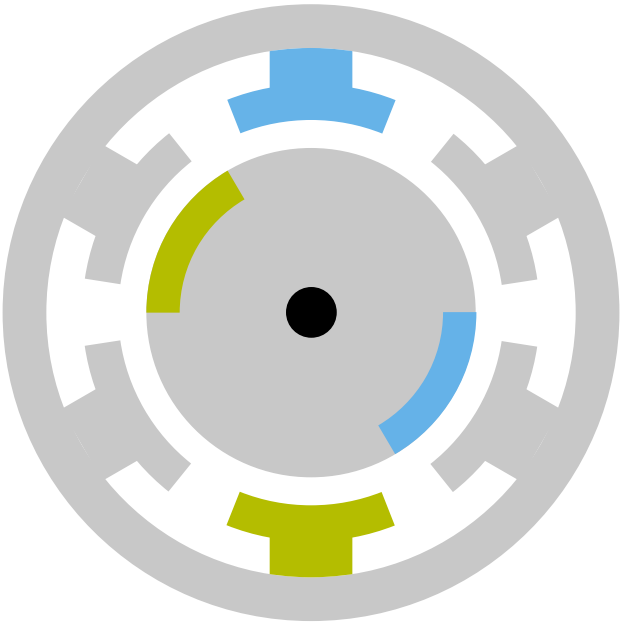
This graphical plug-in tool for FreeMASTER is used for PMSM FOC and BLDC motor control application development, real-time control structure parameter tuning, and eases adaption of NXP solutions to motors without expertise in PI controller constant calculations.
nxp.com/MCAT

Model-Based Design Toolbox

A complimentary integrated development environment and toolchain that plugs in to MATLAB and Simulink® environment for configuring and generating the necessary software automatically (including initialization routines and device drivers) to support fast prototyping, verification and validation for real targets based on NXP microcontrollers.
nxp.com/MBDT

Functional safety

Many NXP products are designed to ease system-level functional safety design.
nxp.com/functional-safety



BRUSHLESS DC (BLDC) MOTOR

BLDC motors typically have a three-phase stator winding and a rotor with surface-mounted permanent magnets.

As the name indicates, a BLDC motor does not have a commutator using brushes and therefore it is more reliable than a DC motor. The digital control and power electronics replace the function of a mechanical commutator and energize the proper winding. BLDC motors are used in pumps, fans and other industrial devices that require high reliability and efficiency.

In BLDC motors, the rotor position must be known to energize the required phase pair and control the phase voltage. If sensors are used to detect the rotor position, then sensed information must be transferred to a control unit. This requires additional connections to the motor, which may not be acceptable in some applications. Also, additional cost of the position sensors and the wiring may be unacceptable. The physical connection problem could be solved by incorporating the driver in the motor body, however, a significant number of applications do require a sensorless solution due to their low-cost nature.

Most BLDC sensorless techniques are based upon extracting position information from the back EMF voltage of the stator windings while the motor is spinning. Those techniques can be used from 5 percent of nominal speed, when back EMF is measurable. BLDC back EMF sensorless techniques can be implemented without complex control algorithms just by sensing the back EMF voltage in the unpowered motor phase.

Application examples

- Power tools
- Drones and Rovers
- Compressors
- Vacuum cleaners
- Printers
- White goods
- Toys
- Fans
- Door openers

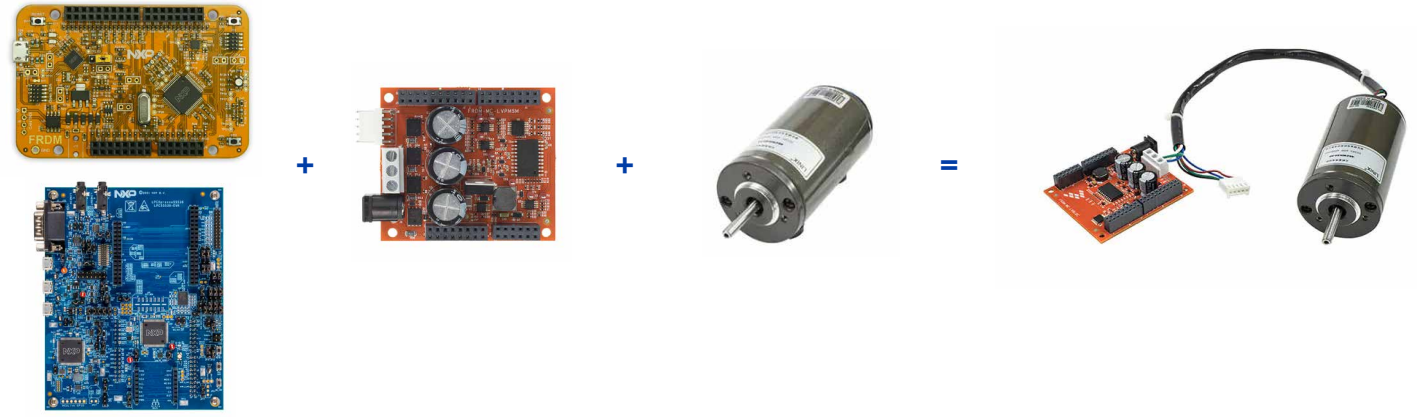
Advantages

+ Heat generated in stator is easy to remove
+ High torque per frame size
+ Reliability due to absence of brushes and commutator
+ Highest efficiency
+ Good high-speed performance
+ Precise speed monitoring and regulation possible

Tradeoffs

- Rotor position sensing required for commutation
- Torque ripple
- Position sensor or sensorless technique is required for motor operation
- Difficult to startup the motor for variable load using sensorless technique

BLDC Solutions

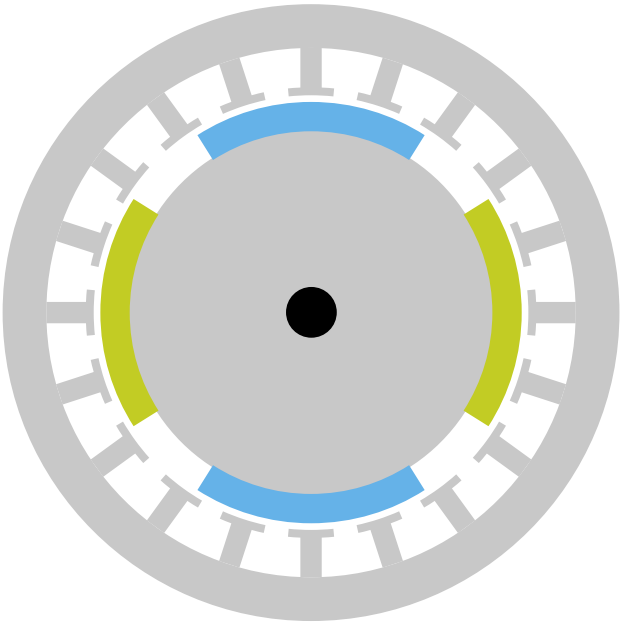


FRDM-KV11Z	FRDM-MC-LVBLDC	FRDM-MC-LVMTR	OTHER MCU CARDS OPTIONS
• Low cost • Motor control auxiliary connector • Compatible with Arduino Rev3 pin layout • OpenSDA debug interface • Six-axis sensor combining accelerometer and magnetometer (FXOS8700CQ) • Thermistor sensor • Tri-color LEDs • Push-button switches	• 3-phase bridge inverter • 3-phase MOSFET gate driver with over current and under voltage protection • Power Supply Input voltage DC: 10-15VDC • Output current up to 5A RMS • Motor speed/position sensors interface (Encoder, Hall) • Freedom motor control headers compatible with Arduino® Rev3 pin layout	• Linix 45ZWN24-40 motor • Rated voltage: 24V • Rated current: 2.3 amps • Rated torque: 990 g.cm • Rated Speed: 4000r/min	**MIMXRT1010-EVK** **MIMXRT1020-EVK** **MIMXRT1024-EVK** **MIMXRT1050-EVKB** **MIMXRT1060-EVK** **MIMXRT1064-EVK** **MIMXRT1160-EVK** **MIMXRT1170-EVK** **FRDM-KV11Z** **FRDM-KV31F** **FRDM-KE15Z** **FRDM-KE16Z** **MC56F81000-EVK** **MC56F83000-EVK** **LPC5536/S36-EVK**

BLDC Reference Enablement

APPLICATION NOTE	**DEV TOOLS**	**NXP quad motor-control development platform HW overview (AN12659)**
DESIGN REFERENCE MANUAL	**GENERAL**	**3-Phase BLDC Sensorless Motor Control Application (DRM144)**
APPLICATION NOTE	**GENERAL**	**FlexTimer and ADC Synchronization (AN3731)**
APPLICATION NOTE	**KINETIS**	**BLDC Motor Control with Hall Effect Sensors Using MQX on Kinetis (AN4376)**
APPLICATION NOTE	**KINETIS**	**Sensorless BLDC Control on Kinetis KV and KE (AN5263)**
REFERENCE DESIGN	**KINETIS**	**KV Series Quad Motor Control Reference Design**
APPLICATION NOTE	**KINETIS**	**Three-Phase BLDC Sensorless Motor Control Using the MKV4x In Quadcopter Application (AN5169)**
APPLICATION NOTE	**KINETIS**	**Three-Phase BLDC Sensorless Control Using the MKV10x (AN4862)**
APPLICATION NOTE	**KINETIS**	**Tuning Three-Phase BLDC Motor Sensorless Control Application Using the MKV10x (AN4870)**
APPLICATION NOTE	**KINETIS**	**BLDC Motor Control with Hall Sensors Based on FRDM-KE02Z (AN4776)**
APPLICATION NOTE	**LPC**	**BLDC with Hall Effect Sensors Using SCT on LPC84x (AN12602)**
APPLICATION NOTE	**DSC**	**BLDC Motor Control with Hall Sensors Driven by DSC (AN4413)**
APPLICATION NOTE	**DSC**	**Compressor BLDC Sensorless Control Based on MC56F82xxx (AN5387)**
VIDEO	**GENERAL**	**BLDC Motor Theory**
VIDEO	**GENERAL**	**Motor Control System Implementation**
VIDEO	**GENERAL**	**NXP in the Drone and UAV (Unmanned Aerial Vehicle) Market**
APPLICATION NOTE	**LPC**	**BLDC Motor Control Demo on LPC55S3x**

VIDEO	KINETIS	Sensorless BLDC Motor Control Made Easy with Kinetis V Series MCUs
VIDEO	KINETIS	Kinetis MCU BLDC Motor Control
VIDEO	KINETIS	Quadcopter Demonstrating UAV Kinetis® KV5x
VIDEO	KINETIS	Getting Started with Kinetis® KV1 and Motor Control Tower® Modules
VIDEO	KINETIS	Motor Control Made Easy with Kinetis V Series MCUs
VIDEO	KINETIS	Multi-Motor Control Over Wi-Fi Using Kinetis
VIDEO	KINETIS	Motor Control for the Masses
VIDEO	KINETIS	Leveraging the Arm® Cortex®-M7 Core for Motor Control



PERMANENT MAGNET SYNCHRONOUS MOTOR (PMSM)

Similar to BLDC motors, **PMSMs** have a three-phase stator and a rotor with surface/interior-mounted permanent magnets.

A PMSM provides rotation at a fixed speed in synchronization with the frequency of the power source. PMSMs are therefore ideal for high-accuracy fixed-speed drives. Boasting very high-power density, very high efficiency and high response, the motor is suitable for most sophisticated applications in the industrial segment. It also has a high overload capability. A PMSM is largely maintenance free, which ensures the most efficient operation.

Synchronous motors operate at an improved power factor, thereby improving the overall system power factor and eliminating or reducing utility power factor penalties. An improved power factor also reduces the system's voltage drop and the voltage drop at the motor terminals.

Application examples

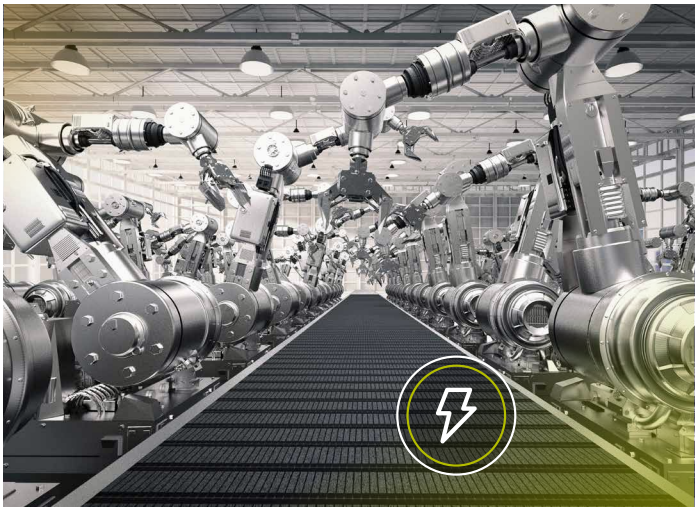
- Power tools
- White goods
- Servo drives
- Pumps
- Robots
- Electromobility
- E-Bikes/ e-scooters
- Home appliances
- Compressors

Advantages

+ Heat generated in stator is easy to remove
+ High torque per frame size
+ Reliability due to absence of brushes and commutator
+ Highest efficiency
+ Synchronous operation makes field orientation easy
+ Good high-speed performance
+ Precise speed monitoring and regulation possible
+ Smooth torque

Tradeoffs

- Rotor position sensing required
- Position sensor or sensorless technique is required for motor operation
- Difficult to startup the motor using sensorless technique



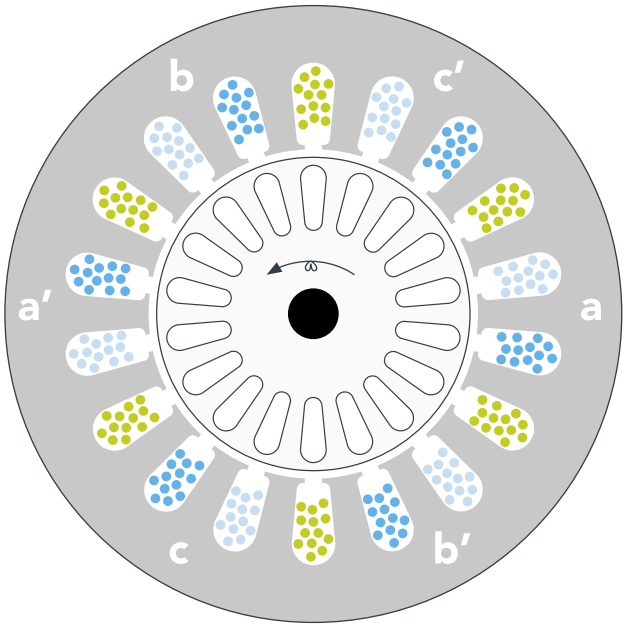
PMSM Solutions

MIMXRT1060-EVK	FRDM-MC-LVPMSM	FRDM-MC-LVMTR	OTHER MCU CARDS OPTIONS
• Motor control auxiliary connector • Arduino interface • Onboard DAP-link debugger • Six-axis sensor combining accelerometer and magnetometer (FXOS8700CQ) • LCD and Camera sensor connector • Audio codec • Microphone • USB, Ethernet, CAN interface	• 3-phase bridge inverter • 3-phase MOSFET gate driver with over current and under voltage protection • Power Supply Input voltage DC: 24-48 VDC • Output current up to 5A RMS • Analog sensing (DC bus voltage, DC bus current, 3-phase back-EMF voltage) • Motor speed/position sensors interface (Encoder, Hall) • Freedom motor control headers compatible with Arduino® Rev3 pin layout	• Linix 45ZWN24-40 motor • Rated voltage: 24V • Rated current: 2.3 amps • Rated torque: 990 g.cm • Rated Speed: 4000r/min	**MIMXRT1010-EVK** **MIMXRT1020-EVK** **MIMXRT1024-EVK** **MIMXRT1050-EVKB** **MIMXRT1060-EVK** **MIMXRT1064-EVK** **MIMXRT1160-EVK** **MIMXRT1170-EVK** **FRDM-KV11Z** **FRDM-KV31F** **FRDM-KE15Z** **FRDM-KE16Z** **MC56F81000-EVK** **MC56F83000-EVK** **LPC5536/S36-EVK**

PMSM Reference Enablement

APPLICATION NOTE	**DEV TOOLS**	**Motor Control Application Tuning (MCAT) Tool for 3-Phase PMSM (AN4642)**
APPLICATION NOTE	**DEV TOOLS**	**Tuning 3-Phase PMSM Sensorless Control Application Using MCAT Tool (AN4912)**
APPLICATION NOTE	**DEV TOOLS**	**NXP quad motor-control development platform HW overview (AN12659)**
APPLICATION NOTE	**GENERAL**	**PMSM Electrical Parameters Measurement (AN4680)**
APPLICATION NOTE	**GENERAL**	**Automated PMSM Parameter Identification (AN4986)**
APPLICATION NOTE	**GENERAL**	**Safety Class B with PMSM Sensorless Drive (AN5321)**
DESIGN REFERENCE MANUAL	**GENERAL**	**3-Phase BLDC Sensorless Motor Control Application (DRM148)**
APPLICATION NOTE	**GENERAL**	**FlexTimer and ADC Synchronization (AN3731)**
APPLICATION NOTE	**GENERAL**	**Using FlexTimer in ACIM/PMSM Motor Control Applications (AN3729)**
USER GUIDE	**i.MX RT**	**PMSM Field-Oriented Control on MIMXRT10xx EVK (PMSMFOCRT10xxUG)**
APPLICATION NOTE	**i.MX RT**	**PMSM Field-Oriented Control on MIMXRT10xx EVK (AN12214)**
APPLICATION NOTE	**i.MX RT**	**Dual FOC Servo Motor Control on i.MX RT (AN12200)**
APPLICATION NOTE	**i.MX RT**	**PMSM Field Oriented Control with LCD Display and Control Based on MIMXRT1010 (AN12591)**
APPLICATION NOTE	**i.MX RT**	**PMSM Field-Oriented Control on MIMXRT1050 EVK (AN12169)**
APPLICATION NOTE	**KINETIS**	**Sensorless PMSM Field-Oriented Control on Kinetis KV and KE (AN5237)**
APPLICATION NOTE	**KINETIS**	**PMSM Field-Oriented Control on FRDMKV31F with Hall and Encoder Sensors (AN12374)**
APPLICATION NOTE	**KINETIS**	**Low Cost PMSM Sensorless Field-Oriented Control Based on KE02**
APPLICATION NOTE	**KINETIS**	**PMSM Sensorless FOC for a Fan Using the Kinetis KV10 (AN4935)**
APPLICATION NOTE	**KINETIS**	**Sensorless PMSM Field-Oriented Control on Kinetis KV31 with FreeRTOS & eGUI (AN5309)**

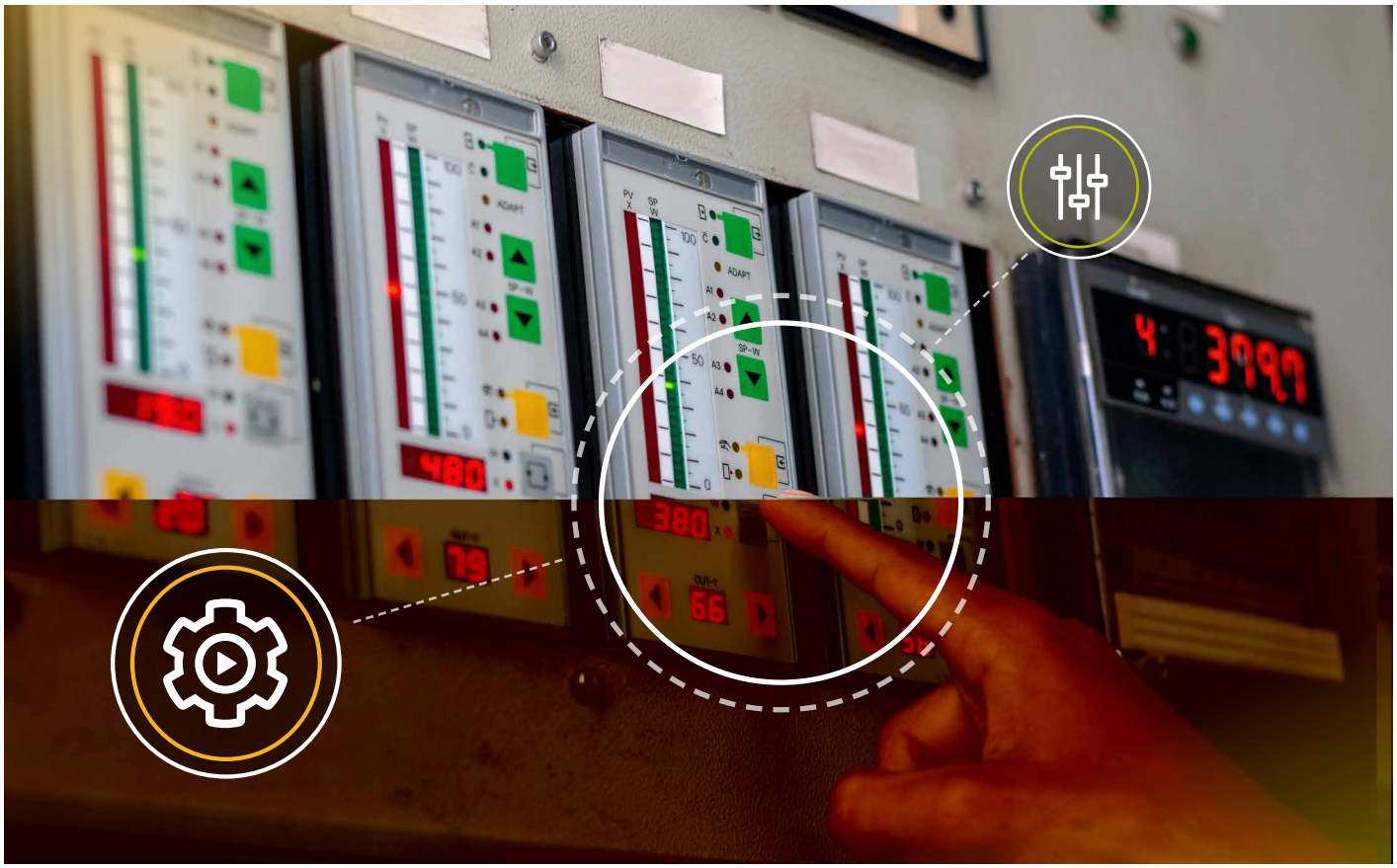
APPLICATION NOTE	KINETIS	Sensorless PMSM Control on MKV46F256 Using Kinetis SDK (AN5004)
APPLICATION NOTE	KINETIS	FlexTimer and ADC Synchronization for Field Oriented Control on Kinetis (AN4410)
APPLICATION NOTE	DSC	Three-Phase PMSM Sensorless FOC using MC56F82748 and MC56F84789 with Automated Motor Parameter Identification (AN5014)
APPLICATION NOTE	DSC	Compressor BLDC Sensorless Control Based on MC56F82xxx (AN5387)
APPLICATION NOTE	DSC	One PMSM Sensorless FOC and 2-ph Interleaved Boost PFC Control based on MC56F83783 (AN13184)
APPLICATION NOTE	LPC	Dual Servo Motor Demo on LPC55S36
VIDEO	GENERAL	Motor Control System Implementation
VIDEO	GENERAL	NXP in the Drone and UAV (Unmanned Aerial Vehicle) Market
VIDEO	KINETIS	Getting Started with Kinetis® KV1 and Motor Control Tower® Modules
VIDEO	KINETIS	Getting Started with Kinetis® V and Motor Control Tower® Modules - How To
VIDEO	KINETIS	Motor Control Made Easy with Kinetis V Series MCUs
VIDEO	KINETIS	Multi-Motor Control Over Wi-Fi Using Kinetis
VIDEO	KINETIS	Motor Control for the Masses
VIDEO	KINETIS	Leveraging the Arm® Cortex®-M7 Core for Motor Control
VIDEO	i.MX RT	4X Motor Control with i.MX RT Crossover MCUs



AC INDUCTION MOTOR (ACIM)

ACIM is one of the most popular motor types for industrial and consumer applications.

This is due to many factors such as the lack of commutator/brushes (high reliability), high efficiency at high loads and the ability to connect directly to the AC line. ACIMs have a classic three-phase stator and commonly have a “squirrel cage” rotor in which the conductors are shorted together at both ends. The operation principle of ACIM is very similar to a transformer. A rotor current is induced in the rotor circuit from the stator windings. This current produces rotor flux, which interacts with the stator electromagnets to produce torque.



Application examples

Power tools

White goods

Pumps

Industrial variable speed drives

Construction machinery

Home appliances

Advantages

+ Low cost per horsepower (no permanent magnets)
+ Inherent AC operation (direct connection to AC line)
+ Very low maintenance (no brushes) and rugged construction
+ Available in wide range of power ratings
+ Low-cost speed control with tachogenerator
+ Simple control

Tradeoffs

- Inefficient at light loads
- Rotor temperature change complicates sensorless control
- Speed control requires varying stator frequency
- Position control difficult (field orientation required)

ACIM Solutions

HVP-KV46F150M	HVP-MC3PH	OTHER MCU CARDS OPTIONS
• SWD / JTAG and SCI isolation up to 5 kV • Onboard isolated power supply, allowing safe debugging • OpenSDA debug interface • Mass storage device flash programming interface (default) • P&E multilink debug interface • SEGGER J-Link-Lite • Can be powered by mini USB or by the main board	• Input voltage 85-240 V AC, 110-390 VDC • Output power 1 kW without PFC, 0.8 kW with PFC • Output current 8 A peak • Analog sensing (input voltage, DCB voltage, DCB current, phase currents, back-EMF voltage, PFC currents, IGBT module temperature monitoring) • Motor speed/position sensors interface (Encoder, Hall, Tacho generator) • Overvoltage comparator with DC-brake resistor interface • Current inrush circuit • Hardware over-current fault protection	**HVP-KV10Z32** **HVP-KV11Z75M** **HVP-KV31F120M** **HVP-KV46F150M** **HVP-KV58F** **HVP-KE18F** **HVP-56F81768** **HVP-56F82748** **HVP-56F83783**

ACIM Reference Enablement

DESIGN REFERENCE MANUAL	**GENERAL**	**Sensorless ACIM Field-Oriented Control (DRM150)**
APPLICATION NOTE	**GENERAL**	**FlexTimer and ADC Synchronization (AN3731)**
APPLICATION NOTE	**GENERAL**	**Using FlexTimer in ACIM/PMSM Motor Control Applications (AN3729)**
APPLICATION NOTE	**KINETIS**	**FlexTimer and ADC Synchronization for Field Oriented Control on Kinetis (AN4410)**
APPLICATION NOTE	**DSC**	**Sensorless ACIM Motor Control Using MC56F82748 (AN5210)**
VIDEO	**GENERAL**	**Motor Control System Implementation**
VIDEO	**GENERAL**	**NXP in the Drone and UAV (Unmanned Aerial Vehicle) Market**
VIDEO	**KINETIS**	**Motor Control Made Easy with Kinetis V Series MCUs**
VIDEO	**KINETIS**	**Multi-Motor Control Over Wi-Fi Using Kinetis**
VIDEO	**KINETIS**	**Motor Control for the Masses**
VIDEO	**KINETIS**	**Leveraging the Arm® Cortex®-M7 Core for Motor Control**

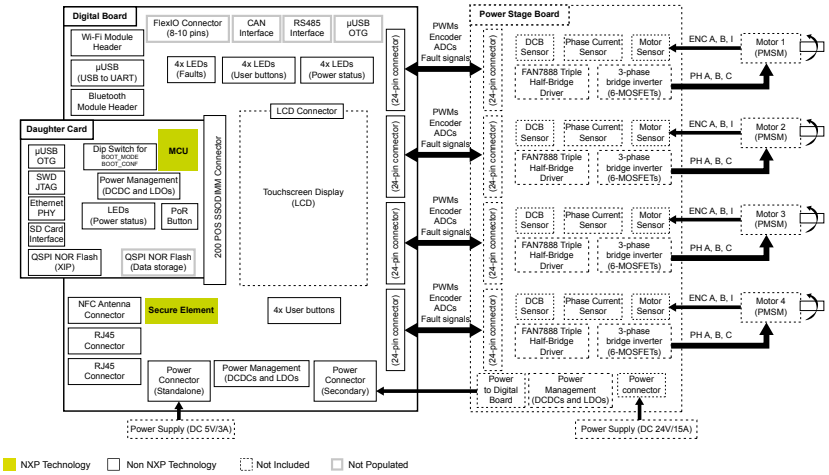
SPOTLIGHTED REFERENCE PLATFORMS

QUAD MOTOR CONTROL (QMC) DEVELOPMENT PLATFORM

Reference design concept

1. **MCU Daughter Card**
    1. Convenient 200 pos SODIMM card form factor
    2. 1x i.MX RT 1050 (main controller)
    3. 1x SWD/JTAG interface
    4. 1x µUSB interface
    5. 1x SD card interface
    6. 1x on board QSPI NOR flash for XIP (execute in place)
2. **Digital Board – Flexible Support**
    1. Wide variety of communication interfaces – USB, RS485, USB to Serial, Wi-Fi
    2. LCD and touch interface
    3. User LEDs, buttons
    4. Motor control interface supporting driving 4 motors
    5. Integrates EdgeLock SE050 Secure Element
3. **Power Stage Board (not for sale, only design files)**
    1. Design Integrates 4 power stages based on FRDM-MC-LVPMSM and FRDM-MC-LVBLDC board
    2. DC bus motor brake circuitry
    3. Support up to 4 PMSM or BLDC motors with Encoder or Hall sensors
    4. Input voltage 24v / 30v / 48v
    5. Maximum input current 16 A
4. **Motor Compatibility**
    1. PMSM, BLDC, ACIM
    2. 4 x PMSM motors running in parallel is demonstrated as a complex solution based on FOC

    Note: Motors not included.



Daughter Card

Digital Card

Power Stage Board

Quad Motor Control (QMC) Development Platform Use Cases

Motor Control

Speed Control
Multi motor
(4 motor synchronization)

Position Control
Multi motor
(4 motor synchronization)

Closed Loop Motor Control
Multi motor field
oriented control

Open Loop Motor Control
Multi motor scalar
(V/F) control

Secure Communications

Secure Device Authentication

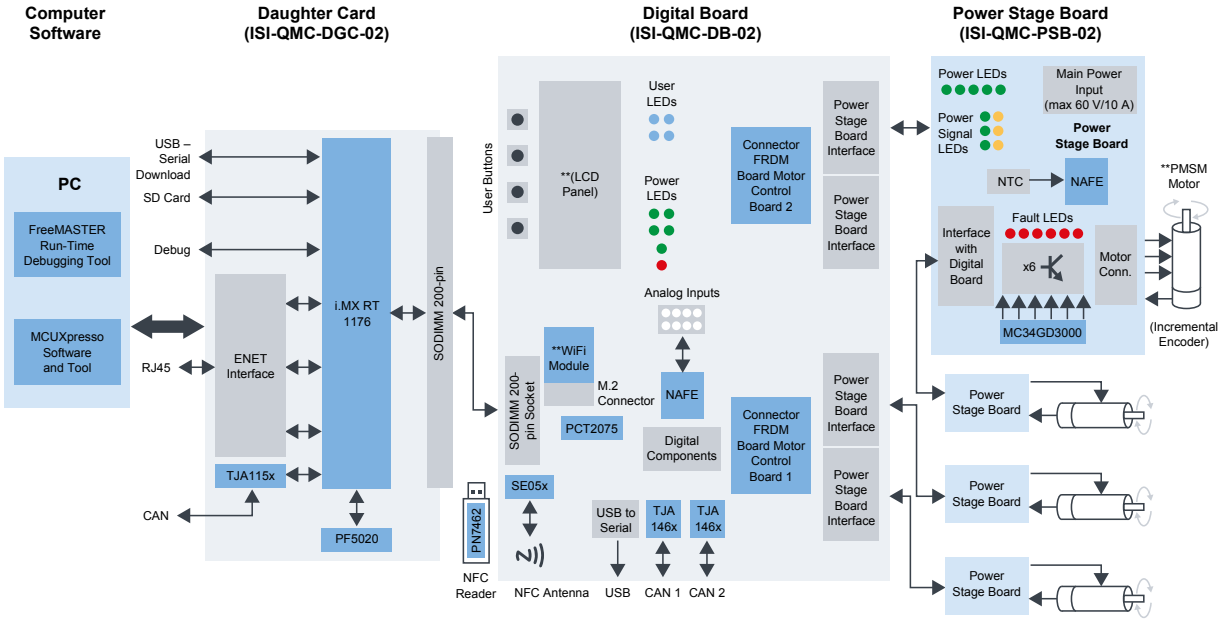
Secure Communication Channel (TLS)

Secure Cloud Onboarding

For more information, visit: **nxp.com/quadmotorcontrol**

i.MX RT Industrial Drive Development Platform

This development platform is the evolution of the Quad Motor Control concept, integrating much more than motor control. Leveraging the 800 MHz performance on the industrial qualified i.MX RT1170 crossover MCU, the i.MX RT Industrial Drive Development Platform demonstrates how an i.MX RT1170 crossover microcontroller can control up to four Permanent-Magnet Synchronous Motors (PMSM) simultaneously. It uses advanced motor control algorithms and technologies, and has bandwidth to spare to support display, deterministic communication Ethernet Time-Sensitive Networking (TSN), data logging, fault detection and a security approach that is intended to be certified ISA/IEC 62443-4 SL3. Together with the on-board NXP EdgeLock® SE05x secure element, the development platform is a ready-to-go, multi-board platform for evaluation and validation of various industrial applications.



** Product not included

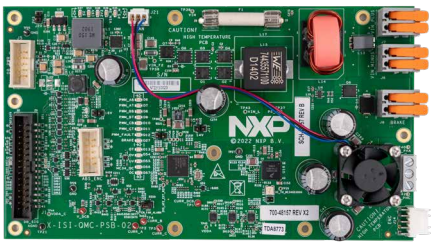
Daughter Card (ISI-QMC-DGC-02)

Top View

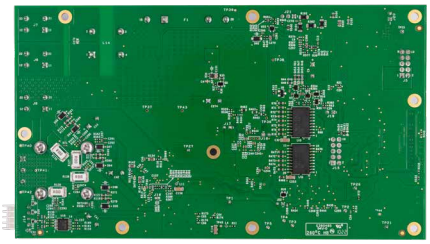
Bottom View

Power Stage Board (ISI-QMC-PSB-02)

Top View



Bottom View



i.MX RT INDUSTRIAL DRIVE DEVELOPMENT PLATFORM MAIN COMPONENTS

BOARD	DESCRIPTION	NXP TECHNOLOGY	DIMENSIONS
Daughter Card ISI-QMC-DGC-02	Control board that integrates MCU chip, debugging interface and Ethernet TSN port	• i.MX RT1176 (Crossover MCU) • PF5020 (PMIC) • TJA115x (Secure CAN)	70 mm x 101 mm
Digital Board ISI-QMC-DB-02	Expansion board for daughter card, integrates multiple peripherals for communication, security and HMI	• SE05x (Secure Element) • NAFE (Analog Front End – Analog Input) • TJA146x (CAN) • PN7462 (NFC Reader) • PCT2075 (Temperature Sensor)	228 mm x 236 mm
Power Stage Board ISI-QMC-PSB-02	Board that transforms the control commands into power signals to drive servo motor (200 W up to 450 W)	• GD3000 (Gate Driver) • NAFE (Analog Front End – Analog Input)	102 mm x 179 mm

RECOMMENDED MOTOR TYPE	ENCODER TECHNOLOGY	POWER
• Platform can support PMSM, BLDC, and ACIM. • Sample code uses PMSM type. • Note: Motors are not included	• Recommended: Incremental TTL encoder. • Sample code uses 4k counts/rev, this can be changed.	Recommend to not exceed 420 W. Keep a safe zone from limits.

Multi-axis Motor

Single, dual, triple or quad motor control using field-oriented control (FOC) algorithm to command servo motors (PMSM motor with incremental encoder).

TSN Connectivity

Deterministic Ethernet communication, implementing IEEE 802.1AS and IEEE 802.1Qbv standards. Supports real-time and best-effort traffic over the same wire.

Fault Detection

Detection of abnormal behavior of the development platform, covering events of motor control, power management and board temperature.

Data Logging

Encrypted and time stamped registration of user interactions, faults, operation and communication events.

Secure User Interaction

User access policy enforcement. Can protect local interaction of platform in maintenance activities (e.g. local start/stop motors, SD card access, among others).

Cyber Resilience

Allows recovery to a trusted state without human intervention after remote attack (key elements: authenticated watchdog timer (AWDT), secure boot loader and recovery service).

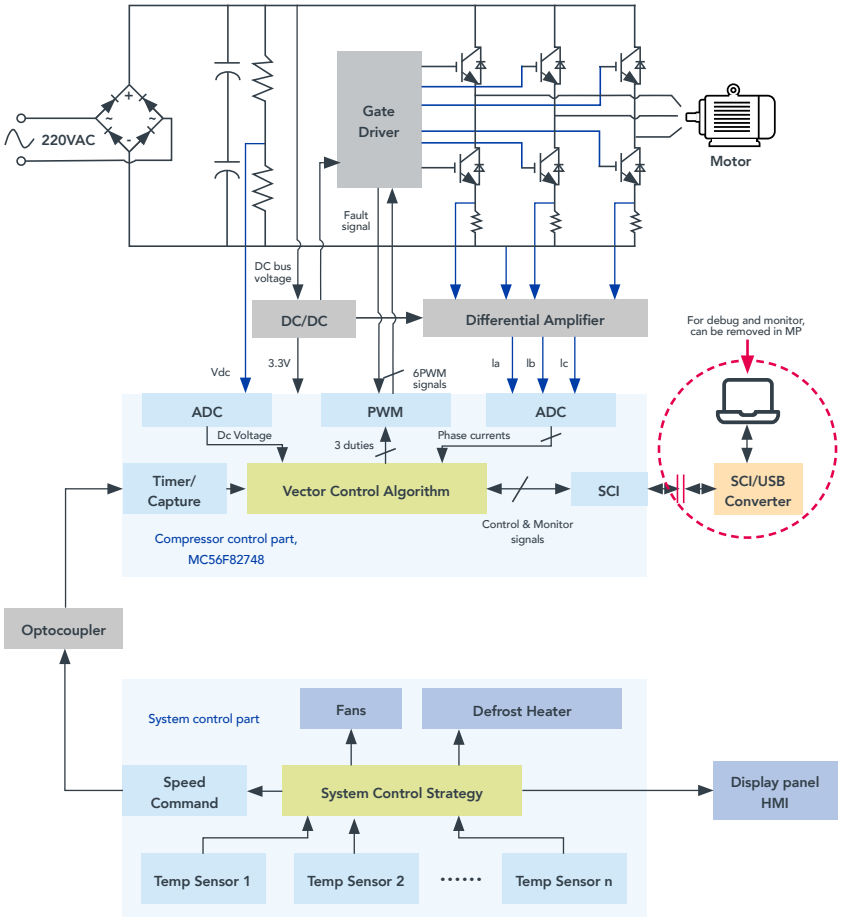
Remote Monitoring

Remote access (local network or cloud) for trusted users allows for monitoring of internal data over a secure communication channel.

Designing to Ease ISA/IEC 62443-4-1,4-2 Compliance

Built with a security-by-design approach and with an embedded EdgeLock SE05x secure element, the platform is designed to help OEMs ease device compliance for ISA/IEC 62443-4-1,-4-2.

COMPRESSOR PLATFORM



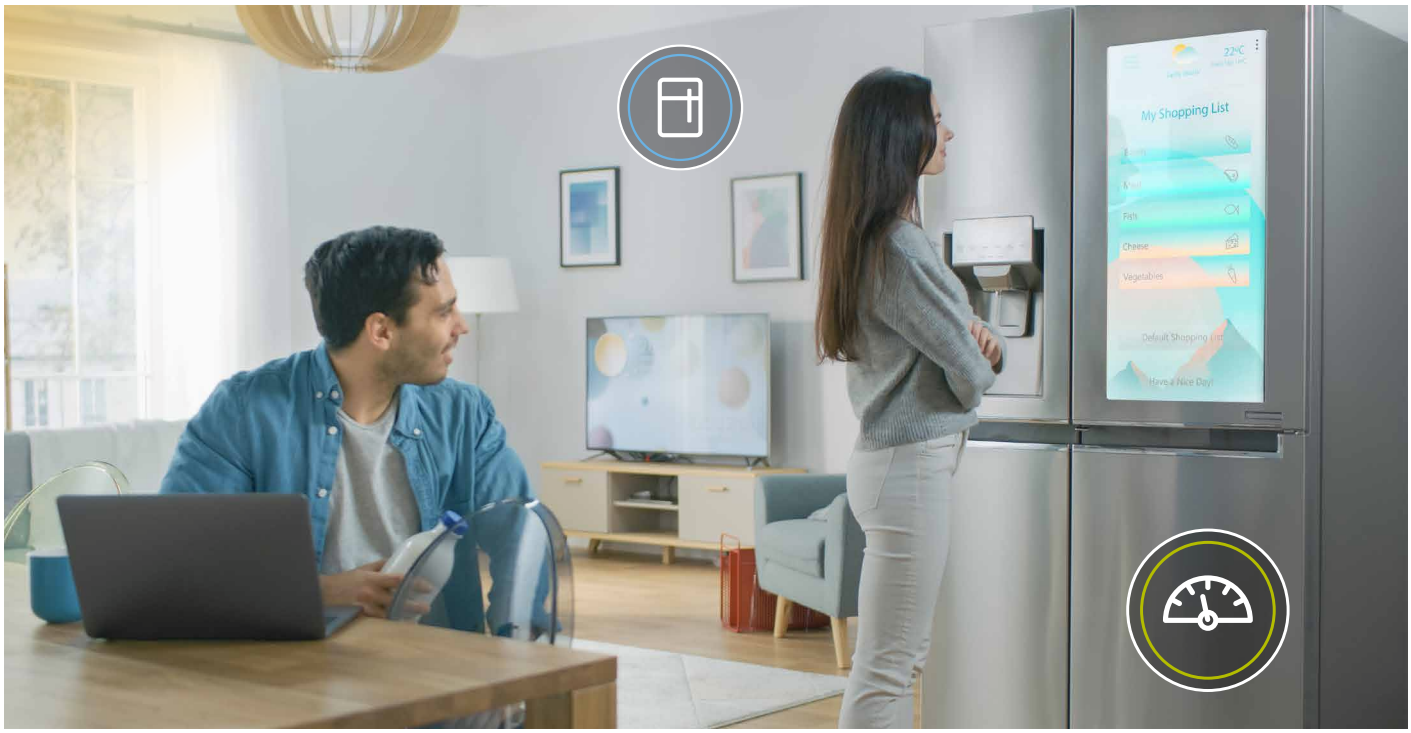
Platform:

MC56F82748 based PMSM/BLDC compressor

Features:

- High energy efficiency solution with turn-key firmware
- IEC60730 certified controller
- Sensorless FOC control with speed and current closed-loop control
- Field-weakening control to increase maximum operating speed over motor rated speed
- Reliable startup strategy with extended flux observer under full loads and input voltage range
- Operating speed range from 1000 to 4800 rpm
- Application note AN5387 available on **nxp.com**

For more information, visit:
nxp.com/refrigerator-compressor



MOTOR CONTROL APPLICATIONS WITH PRODUCT GUIDE

	Core & Memory				Timers	Analog					Communication		HMI			
Product Family	CPU	DSP/ FPU	Flash (KB)	SRAM (KB)	PWM Channels	ADC	Temp Sensor	PGA	DAC (6bit/ 12bit)	ACMP	CAN	Ethernet	LCD	Camera Interface	TSI (ch.)	5V IO
i.MX RT101x	500 MHz Cortex-M7	YES/ YES	External	128	12	1 x 12b	YES	-	-	-	-	-	-	-	-	-
i.MX RT102x	600 MHz Cortex-M7	YES/ YES	External	256	24	2 x 12b	YES	-	-	4	2	1	-	-		-
i.MX RT105x	600 MHz Cortex-M7	YES/ YES	External	512	36	2 x 12b	YES	-	-	4	2	1	WXGA	Parallel		-
i.MX RT106x	600 MHz Cortex-M7	YES/ YES	4096	1,024	36	2 x 12b	YES	-	-	4	3	2	WXGA	Parallel		-
i.MX RT117x	1 GHz Cortex-M7 & 400 Mhz Cortex M4	YES/ YES	External	2,048	36	2 x 12b	YES	-	4/1	4	3	3	WXGA. MIPI	Parallel, MIPI	-	-
KV1x	75 MHz Cortex-M0+	-/-	128	16	20	2 x 16b		-	0/1	2	1	-	-	-	-	-
KV3x	120 MHz Cortex-M4	YES/ YES	512	96	20	2 x 16b		-	0/2	2	-	-	-	-	-	-
KV4x	168 MHz Cortex-M4	YES/ YES	256	32	30	2 x 12b		YES	4/1	4	2	-	-	-	-	-
KV5x	240 MHz Cortex-M7	YES/ YES	1024	256	44	1 x 16b, 4 x12b	YES	-	4/1	4	3	1	-	-	-	-
KE0xZ	48 MHz Cortex-M0+	-	128	16	10	1 x 12b		-	2/0	2	1	-	-	-	-	True 5V
KE14Z	72 MHz Cortex-M0+	-	288	32	16	2 x 12b	YES	-	2/0	2	-	-	-	-		True 5V
KE15Z	72 MHz Cortex-M0+	-	288	32	16	2 x 12b	YES	-	2/0	2	-	-	-	-	25	True 5V
KE16Z	48 MHz Cortex-M0+	-	64	8	8	1 x 12b	YES	-	1/0	1	1	-	-	-	25	True 5V
KE1xF	168 MHz Cortex-M4	YES/ YES	576	64	32	3 x 12b	YES	-	3/1	3	2	-	-	-	-	True 5V
MC56F81xxx	100 MHz/50 MHz DSC	YES/ NO	128	20	8	2 x 12b	YES	YES	1	4	-	-	-	-	-	-
MC56F82xxx	100 MHz/50 MHz DSC	YES/ NO	64	8	8	2 x 12b	YES	YES	2	4	1	-	-	-	-	5V Tolerant
LPC553x/S3x	150 MHz Cortex M33	YES/ YES	256	128	12	4 x 16b	YES	YES	0/3	3	1	-	-	-	-	-
KEA	48 MHz Cortex-M0+	-	128	16	10	1 x 12b	YES	-	2/0	2	1	-	-	-	-	True 5V
S32K11x	48 MHz Cortex-M0+	-	256	25	16	1 x 12b	-	-	1/0	1	1/1FD	-	-	-	-	True 5V
S32K14x	120 MHz Cortex-M4	YES/ YES	2048	256	64	2 x 12b	-	-	1/0	1	3/3FD	1	-	-	-	True 5V
S32K3xx	240 MHz Cortex-M7	YES/ YES	8192	1152	72	3 x 15b	YES	-	3/0	3	8/8FD	1	via FlexIO	via FlexIO	-	True 5V
MPC574xP	200 MHz z4	YES/ YES	2560	384	40	4 x 12b	YES	-	-	-	3	1	-	-	-	5V Tolerant
MPC5775B/E	264 MHz z7	YES/ YES	4096	512	32 (+ 96ch. eTPU2)	4 x 16b, 4 x12b	YES	-	-	-	6/2FD	1	-	-	-	True 5V
MPC5777C	300 MHz z7	YES/ YES	4096	512	32 (+ 96ch. eTPU2)	4 x 16b, 4 x12b	YES	-	-	-	6/2FD	1	-	-	-	True 5V

MOTOR CONTROL APPLICATIONS WITH PRODUCT GUIDE (Continued)

	Core & Memory				Timers	Analog					Communication		HMI			
Product Family	CPU	DSP/ FPU	Flash (KB)	SRAM (KB)	PWM Channels	ADC	Temp Sensor	PGA	DAC (6bit/ 12bit)	ACMP	CAN	Ethernet	LCD	Camera Interface	TSI (ch.)	5V IO
MC56F83xxx	100 MHz DSC	YES/ NO	256	64	16	2 x 12b	YES	YES	2	4	1	-	-	-	-	5V Tol-erant
MC56F84xxx	100 MHz DSC	YES/ NO	256	32	16	1 x 16b, 2 x 12b	YES	YES	1	4	1	-	-	-	-	5V Tol-erant

OTHER MOTOR CONTROL DEVELOPMENT OPTIONS (BLDC OR PMSM)

Name	Description	DC voltage	Power	Motor Techniques
S32K and KEA Arm®-Based MCU Development Kits				
MCSPTE1AK116	Motor control kit (S32K116EVB, DEVKIT-MOTORGD, Sunrise 42BLY3A78-24110, 12 V / 7 A power supply)	12 V	100 W	3-phase BLDC six-step, PMSM FOC
MCSPTE1AK144	Motor control kit (S32K144EVB, DEVKIT-MOTORGD, LINIX 45ZWN24-40, 12 V / 5 A power supply)	12 V	100 W	3-phase BLDC six-step, PMSM FOC
MCSPTE1AK344	Motor control kit (S32K344EVB, DEVKIT-MOTORGD, Sunrise 42BLY3A78-24110, 12 V / 7 A power supply)	12 V	100 W	3-phase BLDC six-step, PMSM FOC
MCSXTE2BK142	S32K142 development board	12/24 V	800 W	3-phase BLDC six-step, PMSM FOC
KEA128BLDCRD	KEA128 reference design	12 V	60 W	3-phase BLDC six-step
MPC57xx Development Kits				
MCSPTR2A5775E	Motor control kit (MPC5775E-EVB, low voltage power stage board, TG drives TGT2-0032-30-24, 24V 7A power supply)	24 V	240 W	3-phase BLDC six-step and PMSM FOC
MTRCKTSPS5744P	Motor control kit (MPC5775E-EVB, low voltage power stage board, TG drives TGT2-0032-30-24, 24V 7A power supply)	24 V	240 W	3-phase BLDC six-step and PMSM FOC
EV-INVERTER	EV Power Inverter Control Reference Platform (PCBs, cablings, SW)	400 V	100 kW	3-phase PMSM FOC
EV-INVERTERHDBT	IGBT-EV Power Inverter Control Reference Platform (EV-CONTROLEVMHD, EV-POWEREVBHDBT, SW)	600V	180kW	3-phase PMSM FOC
RDGD3100I3PH5EVB	Reference Design for HybridPACK Drive IGBT/SiC module featuring GD3100. Compatible with MPC5775E-EVB or MCSPTR2A5775E or MTRCKTSPS5744P	200 V to 1700 V	> 125 kW	3-phase PMSM FOC
RDGD3100F3PH5EVB	Reference Design for Fuji M653 IGBTs featuring GD3100. Compatible with MPC5775E-EVB or MCSPTR2A5775E or MTRCKTSPS5744P	200 V to 1700 V	> 125 kW	3-phase PMSM FOC
RDGD31603PHSEVM	Reference Design for VE-Trac™ Drive SiC Module Featuring GD3160. Compatible with MPC5775E-EVB or MCSPTR2A5775E or MTRCKTSPS5744P	200 V to 1700 V	> 125 kW	3-phase PMSM FOC
MPC5775E-EVB	MPC5775B/E low-cost Inverter Controller Board.			

MEDIUM-VOLTAGE MOTOR DRIVER SELECTOR GUIDE TARGETING 5 TO 24 V BATTERY APPLICATIONS

Part#	Motor Type	# of Out	Op. voltage (V)	Peak Current	SPI	Sleep (uA)	Freq (kHz)	Temp range	Comment
MC338xx / 339xx	Brushed DC	2	5.0–28	5	-	50	20-Oct	-40 to +125	
MC33HB2xxx	Brushed DC	2	5.0–36	5.4/7.0/8.8/10.7	YES	50	8.0 SELECT	-40 to +125	3 versions

MOTOR GATE DRIVER AND SWITCH GUIDE TARGETING 5 – 60V APPLICATIONS

Part#	Motor Type	# of Out	Op. voltage (V)	Peak Current	SPI	Sleep (uA)	Freq (kHz)	Temp range	Comment
GD3000	BLDC / PMSM (MOSFET)	6	6.0–60	1	YES	30	20	-40 to +125	Auto-motive / industrial
MC33879	Configurable LS/HS Octal Drivers	16	5.5–27.5	1.2	YES	5	2	-40 to +125	
MC3399x	LS Dual-Octal Drivers	16	5.0–27	Up to 2.5	YES	10	2	-40 to +125	

MOTOR GATE DRIVERS TARGETING 200-1200 V APPLICATIONS

Part#	Motor Type	# of Out	Op. voltage (V)	Peak Current	SPI	Sleep (uA)	Freq (kHz)	Temp range	Comment
GD3100	PMSM/ACIM (IGBT)	1	200–1700	15	YES	n/a	40	-40 to +150	
GD3160E	PMSM/ACIM (SiC)	1	200–1700	15	YES	n/a	100	-40 to +150	Functional Safety

SAFETY SYSTEM BASIS CHIPS (SBCS): BYLINK SYSTEM POWER PLATFORM

	Features	FS45	FS65	VR5500/10
Target System Voltage		12 V	12 V	12 V or 24 V
Power Management	VPRE HV Buck	6.5 V fixed / 2.0 A Asynchronous	6.5 V fixed / 2.0 A asynchronous	3.3 V to 5.2 V configurable / 10 A (external MOSFET)
	MCU core supply	1 V to 5 V / 0.5 A LDO	1 V to 5 V / 0.8/1.5/ 2.2 A DC-DC	0.4 V to 1.8 V / 2.5 A DC-DC; up to 5 A in multiphase configuration
Safety	Fit for ASIL	B / D	B / D	QM / B / D
System Features	MCU alignment	S32K1/3	MPC574x, MPC577x	General
	Interface	SPI / CAN / LIN	SPI / CAN / LIN	I^2C

HOW TO GET STARTED

NXP strives to provide you with hardware, software and collateral that address a wide range of industrial and IoT motor control applications.

To get started, visit **nxp.com/motorcontrol** where you will find a wide selection of development tools and guides for getting started with our motor control solutions.

You can also contact any of NXP's regional sales offices and authorized distributors for additional support throughout your design stage.

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