AN15244

SimpleFOC Motor Control on FRDM-MCXA366

Rev. 1.0 — 27 November 2026 Application note

Document information

Information	Content
Keywords	AN15244, SimpleFOC, Motor Control, Arduino, FRDM-MCXA366, BLDC, PMSM
Abstract	This application note describes how to run SimpleFOC on the FRDM-MCXA366 development board.

1 Introduction

SimpleFOC is an open-source Field-Oriented Control (FOC) library for three-phase Brushless DC (BLDC) and Permanent Magnet Synchronous Motors (PMSM) that runs within the Arduino programming model. This application note describes how to run SimpleFOC on the FRDM-MCXA366 development board, which is based on the MCX A366 microcontroller (MCU) with an Arm Cortex-M33 core.

The software is the NXP MCX Arduino platform package ap-mcx-simplefoc-arduino-core, published on the NXP Application Code Hub. The package provides:

- A Board Support Package (BSP) for the FRDM-MCXA366.
- A hardware backend that lets the unmodified upstream Simple FOC library drive a motor from the MCX A366.
- Motor-control examples for open-loop and closed-loop control.

The reference power stage is the open-source SimpleFOCShield v2.0.4, which stacks directly on the Arduino headers of the FRDM-MCXA366.

This document describes the hardware setup, the backend design, the safety model, and the validated results. The FOC theory, including the motor model, coordinate transformations, and space vector modulation, is described in *Sensorless PMSM Field-Oriented Control* (document DRM148). Installation details, the complete pin map, and the per-example options are documented in the package.

2 Hardware platform

Figure 1 shows the hardware blocks of the reference setup. The FRDM-MCXA366 board carries the MCX A366 and an on-board MCU-Link debug probe, which programs the MCU and provides the serial console over USB. The SimpleFOCShield v2.0.4 provides the three-phase driver and the inline current-sense amplifiers of two phases. A DengFOC 2208 BLDC motor with an AS5600 magnetic encoder is connected to the shield.

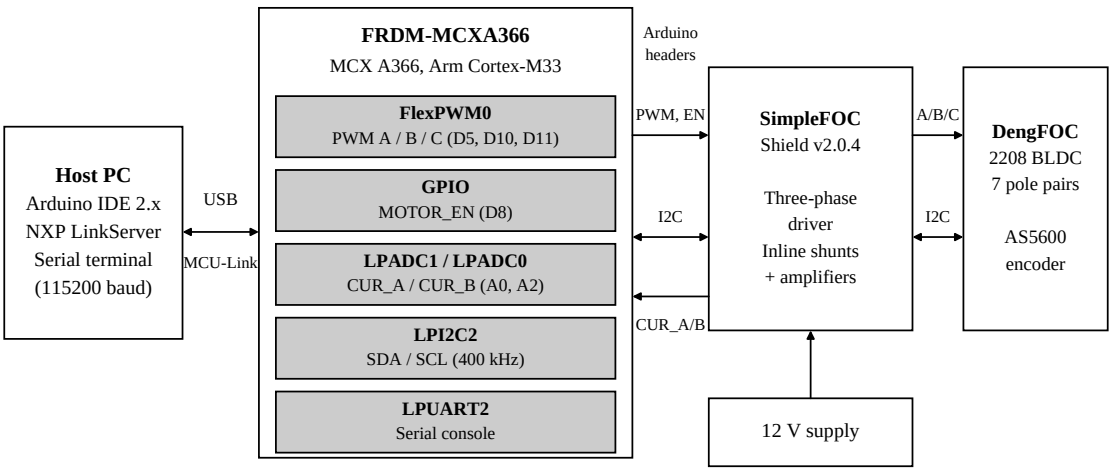


Figure 1. Hardware blocks of the reference setup

Table 1 lists the components and software versions used for all measurements.

Table 1. Reference setup components and versions

Item	Version or part
Board	FRDM-MCXA366 (MCX A366, Arm Cortex-M33)
Power stage	SimpleFOCShield v2.0.4

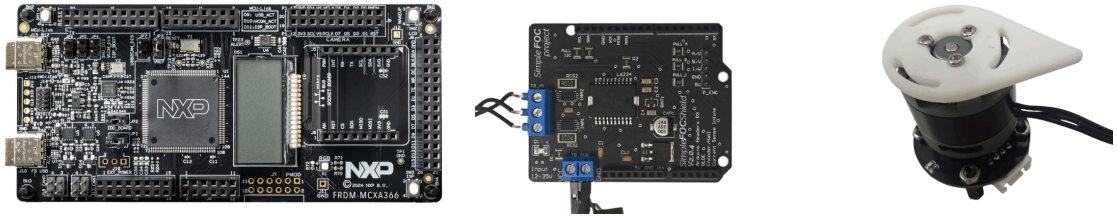
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Table 1. Reference setup components and versions*...continued*

Item	Version or part
Motor	DengFOC 2208 BLDC motor, seven pole pairs, with AS5600 magnetic encoder
Supply	12 V DC power supply (12 V, 2 A)
Arduino IDE	Version 2.3.8
Arduino platform	NXP MCX Boards 1.0.0 (FQBN `nxp:mcx:frdmmcxa366`), including `SimpleFOC_MCX` 1.0.0
Upstream library	Simple FOC 2.4.0 (installed by the user)
Toolchain	Arm GNU Toolchain 14.2.Rel1, NXP LinkServer 26.3.123

Figure 2 shows the main hardware: the FRDM-MCXA366 board, the SimpleFOCShield v2.0.4, and the DengFOC 2208 motor with its AS5600 encoder board.



(a) FRDM-MCXA366

(b) SimpleFOCShield v2.0.4

(c) DengFOC 2208 motor with AS5600 encoder

Figure 2. Main hardware of the reference setup

The shield carries every motor-control signal through a standard Arduino pin. Table 2 lists the signal assignment.

Table 2. SimpleFOCShield v2.0.4 signal assignment on the FRDM-MCXA366

Shield signal	Arduino pin	MCU pad	Function
Phase A	D5	P3_1	FLEXPWM0_B0
Phase B	D10	P3_11	FLEXPWM0_B2
Phase C	D11	P3_8	FLEXPWM0_A1
Driver enable (MOTOR_EN)	D8	P4_3	GPIO
Current sense A	A0	P1_14	ADC1_A12
Current sense B	A2	P2_7	ADC0_A7
Encoder SDA, SCL	SDA, SCL	P1_8, P1_9	LPI2C2

The shield selects its signal routing with solder jumpers on the back side. Configure the jumpers as shown in Figure 3:

- PWM phases on D5, D10, and D11
- Driver enable on D8
- Current-sense outputs on A0 and A2
- Encoder I2C on the SDA and SCL pins

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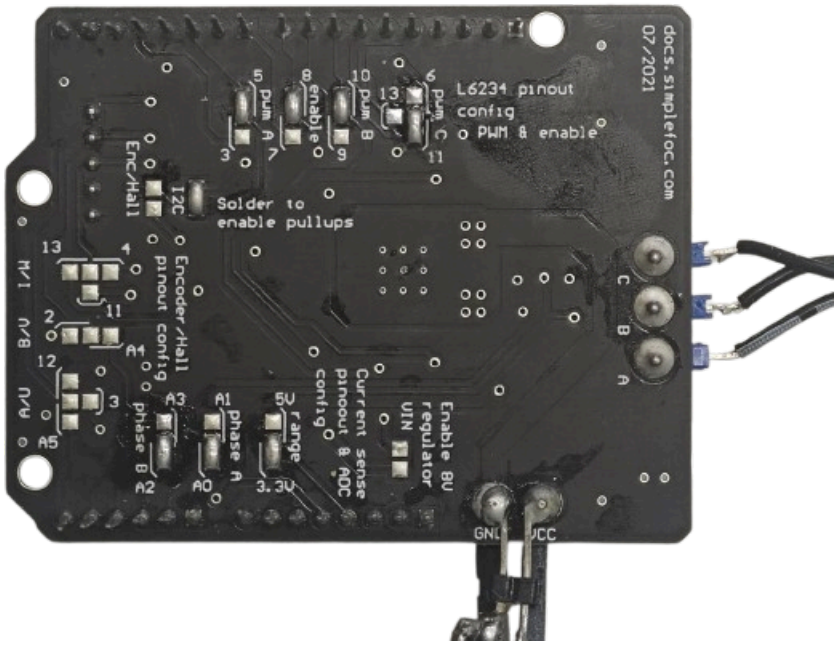


Figure 3. Back-side solder-jumper configuration of the SimpleFOCShield v2.0.4

3 Software design

This section describes the software design.

3.1 Software architecture

Figure 4 shows the software layers. The upstream Simple FOC library is used without modification: it declares its hardware access functions (PWM output and current-sense read) as weak symbols, and `SimpleFOC_MCX` provides the MCX A366 implementations, which the linker selects at build time. An application sketch therefore only includes `SimpleFOC.h` and `SimpleFOC_MCX.h` and uses the standard Simple FOC API.

The backend accesses FlexPWM and LPADC through the MCUXpresso SDK drivers. The Arduino core provides timing, the serial console (LPUART2), I2C (LPI2C2), and GPIO.

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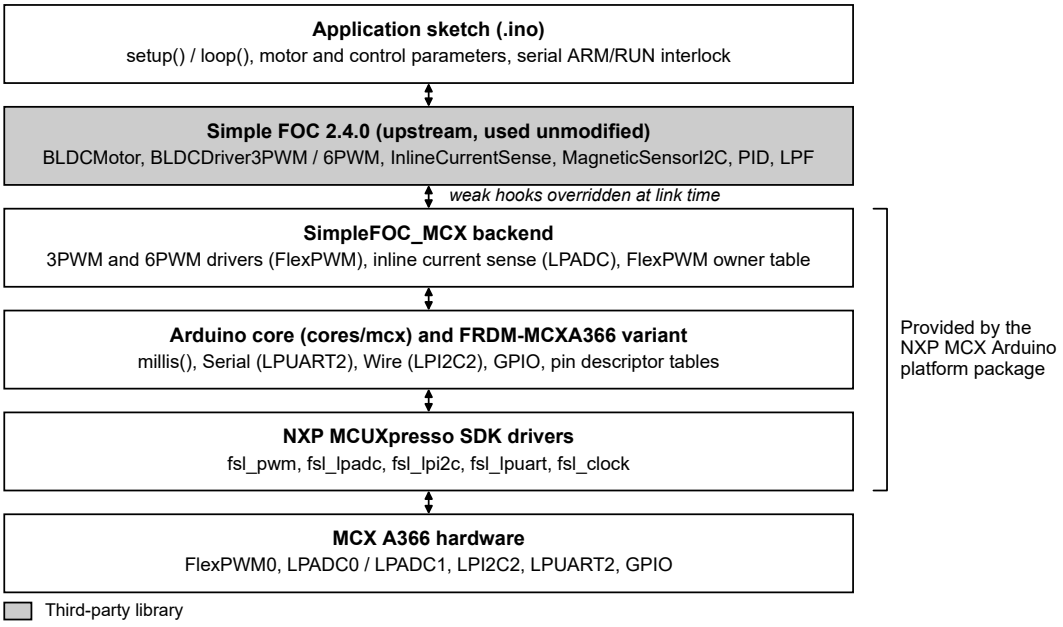


Figure 4. Software layers

3.2 PWM generation

Both PWM drivers use FlexPWM0. In 3PWM mode, each phase is driven by one PWM output, center-aligned, at 25 kHz by default (40 µs period). The compare value registers that control the PWM duty cycle can be reloaded from buffer register synchronously, the reload point and frequency are configurable. The carrier frequency can be set from 1 kHz to 50 kHz; other values and unsupported pin routes are rejected, and `driver.init()` fails.

In the 6PWM mode, each phase uses a complementary output pair, and the FlexPWM inserts the dead time in hardware (default 2 % of the period, 800 ns at 25 kHz). Release 1.0.0 supports 6PWM as a gate-signal diagnostic with the power stage disconnected only.

3.3 Current sensing

The shield measures the currents of phases A and B with 0.01 Ω inline shunts and INA240A2 amplifiers (gain 50 V/V). The backend converts each channel with a software-triggered, blocking LPADC conversion (12-bit). Equation 1 gives the measured voltage:

$$V_{ADC} = \mathrm{N} \times V_{REFH} / 4096 \times \mathrm{S} \quad (1)$$

where *N* is the conversion result, V_{REFH} is the ADC reference (3.3 V), and *S* is the correction factor `SIMPLEFOC_MCX_INLINE_CS_SCALE` (1.0).

Simple FOC calculates the phase current with Equation 2, and the third phase with Equation 3:

$$\mathrm{I} = \left(V_{ADC} - V_{offset}\right) / \left(R_{shunt} \times \mathrm{G}\right) \quad (2)$$

$$I_c = -\left(I_A + I_B\right) \quad (3)$$

where V_{offset} is the zero-current offset measured at initialization, R_{shunt} is 0.01 Ω, and *G* is 50 V/V.

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One ADC count corresponds to about 1.6 mA. A conversion that cannot deliver a valid sample returns 0 and sets a fault flag, which the FOC-current examples check on every loop pass.

Note: *On the SimpleFOCShield v2.0.4 used for the measurements in this document, Phase A and Phase B current-sense channels have opposite sensing polarities because the IN+ and IN− connections of the two INA240 amplifiers are reversed. The software configuration must account for this polarity difference. Other SimpleFOCShield revisions may use different current-sense devices and signal routing. For example, the v3.x shield uses ACS712 Hall-effect current sensors instead of INA240 amplifiers and shunt resistors. Always verify the schematic for the specific shield revision before configuring the current-sense channels, gains, and polarities.*

3.4 Position sensor and control loop

The closed-loop examples read the AS5600 12-bit magnetic encoder with the Simple FOC `MagneticSensorI2C` class over LPI2C2 at 400 kHz (address 0x36). The control loop runs in the Arduino `loop()` function, which calls `motor.loopFOC()` and `motor.move()` on every pass. There is no interrupt-driven control task, so the loop period depends on the encoder read, the ADC conversions, and the serial output of each pass.

4 Safety model

For safety, the examples do not start the motor automatically after reset. The motor is started and stopped by commands sent from a serial terminal, as shown in Figure 5.

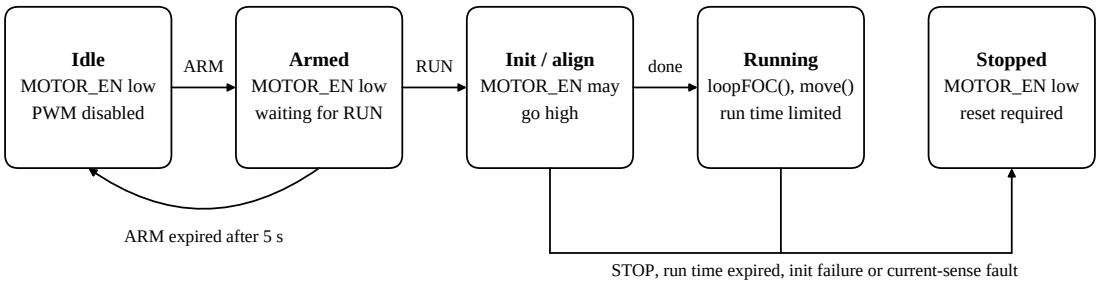


Figure 5. Operating states of the powered examples

- After reset, MOTOR_EN is low and the PWM outputs are disabled.
- To start the motor, send `ARM` and then `RUN` within five seconds. If `RUN` is not received within five seconds, `ARM` expires and must be sent again.
- `STOP` ends the run and drives `MOTOR_EN` low. It is processed only while the sketch polls the serial port, so it does not interrupt the blocking `motor.init()` and `motor.initFOC()` calls.
- The waveform diagnostics (`Waveform6PWM` and the waveform test of `BackendCompileCheck`) start PWM at boot without this handshake. Disconnect the power stage before you run them.

CAUTION: *Use a current-limited supply and keep a physical means of removing motor power within reach. The serial `STOP` command is not an emergency stop, and the package has no power-stage fault input.*

Table 3 lists the build options related to safety. They are set at the top of each example sketch.

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Table 3. Safety-related build options

Macro	Default	Effect
`SIMPLEFOC_MCX_ENABLE_POWER_STAGE_TEST`	1	0 removes the powered path from the build
`SIMPLEFOC_MCX_ALLOW_UNCALIBRATED_CURRENT_LOOP`	1	0 blocks `RUN` in the FOC-current examples until the current scale is calibrated
`SIMPLEFOC_MCX_INLINE_CS_SCALE`	1.0	Current-sense correction factor

5 Running the demo

This section describes how to run the demo.

5.1 Software installation

To install the software, perform the following steps:

1. Install the Arm GNU Toolchain, the NXP Standalone Toolchain Add-ons, and NXP LinkServer with the MCUXpresso Installer.
2. In Arduino IDE, add the board manager URL given in the package README, and install **NXP MCX Boards** in the Boards Manager.
3. Install **Simple FOC** version 2.4.0 in the Library Manager.
4. Select **NXP FRDM MCXA366**, build and upload the `FirstExperience` example, and check the serial output at 115200 baud.

The motor control examples are in **File** > **Examples** > **Examples for NXP FRDM MCXA366** > **SimpleFOC MCX Hardware Backend**, as shown in Figure 6.

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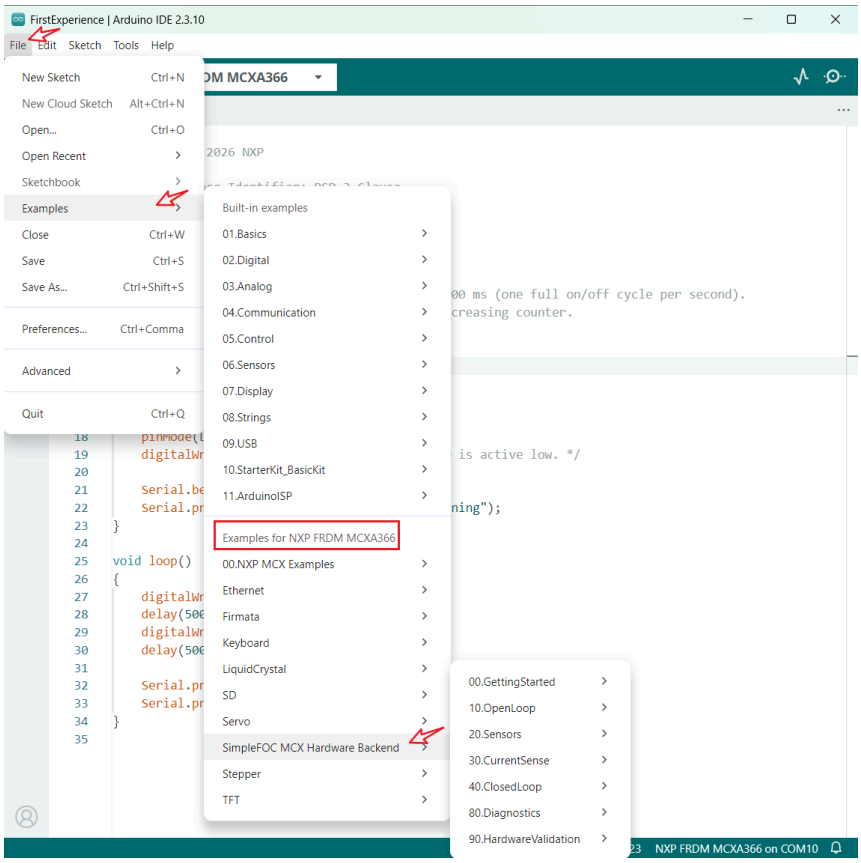


Figure 6. Motor control examples

5.2 Bring-up sequence

Run the examples in the order of Table 4. Each step adds one new element, so a wiring or configuration fault is found before a motor winding is energized.

Table 4. Recommended bring-up sequence

Step	Example	Power stage	Purpose
1	`BackendCompileCheck`	Not required	Backend links and reports its capabilities
2	`Waveform6PWM`, waveform test of `BackendCompileCheck`	Disconnected	Gate signals, PWM frequency, and dead time
3	`AS5600SensorCheck`	Encoder only	Encoder reads over I2C
4	`InlineCurrentSenseCheck`	Connected, MOTOR_EN low	Current-sense path and zero-current offsets
5	`OpenLoopVelocity`	Connected	First powered run, open loop
6	`ClosedLoopVelocity`, `Angle Control`	Connected	Voltage-mode closed loop with sensor alignment
7	`TorqueFocCurrent`, `VelocityFoc Current`, `AngleFocCurrent`	Connected	FOC-current control

Open the serial monitor at 115200 baud with the line ending set to **New Line**, and start each powered run with `ARM` and `RUN`. The serial messages of each example are described in the package README.

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6 Results

Figure 7 shows the reference demo setup. Table 5 summarizes the results measured with the reference setup on a 12 V bus, with the default parameters of the examples. The gate signals were captured with a logic analyzer with the power stage disconnected.

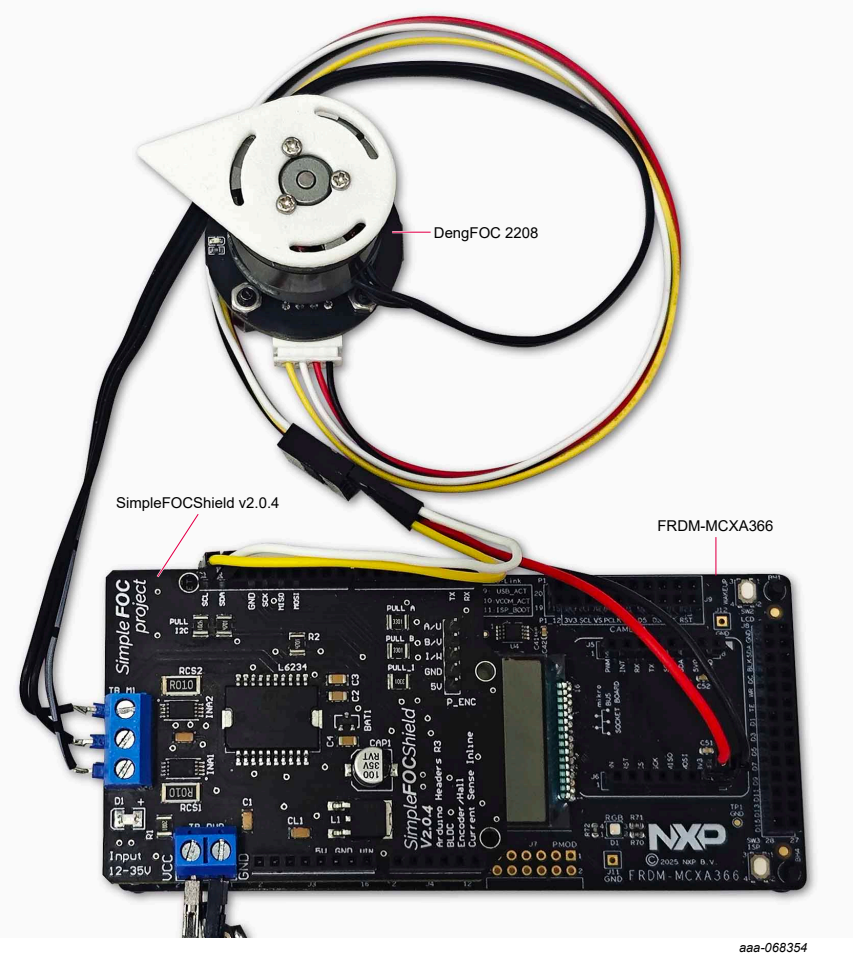


Figure 7. Reference demo setup

Table 5. Measured results

Function	Result
3PWM gate signals	25 kHz center-aligned PWM; 25%, 50%, and 75% duty cycle on phases A, B, and C; all outputs low after `disable()` and after reset
6PWM gate signals	Six complementary signals at 25 kHz; dead time of 800 ns on both edges of every pair
Open loop	Rotation at 5 rad/s with a 3 V voltage limit
Voltage-mode velocity	Tracking at ±10, ±25, and ±50 rad/s
Voltage-mode position	Position steps of +0.2, +0.5, +1.0, and −1.0 rad with return to zero
FOC-current torque	q-axis current target of 0.06 A; commanded and measured current track each other
FOC-current velocity	Tracking at ±10, ±20, and ±30 rad/s with a 0.5 A current limit
FOC-current position	Position steps to ±π and ±2π rad with a 0.5 A current limit

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Table 5. Measured results...*continued*

Function	Result
Encoder	Correct angle, wrap-around, and accumulated rotation; no I2C errors at 400 kHz

The parameters of the examples are validated for this setup. When the motor, driver board, sensor, or load changes, revalidate the measurement paths and retune the parameters.

Release 1.0.0 has the following limitations:

- Powered 6PWM motor operation is not supported.
- The absolute current scale is not independently calibrated.
- There is no power-stage fault input and no multi-motor support.
- FRDM-MCXA366 is the only validated board.

7 Adapting to other hardware

When you use other hardware, check the following and revalidate step by step, starting with disconnected logic-level checks:

- **Pin routing**: The three 3PWM pins must be FlexPWM outputs of one FlexPWM instance that uses submodules 0, 1, and 2.
- **Power stage and motor**: Set the bus voltage, voltage and current limits, PWM frequency, pole pairs, and control gains. For 6PWM, check the dead time against the gate-driver requirement.
- **Current sensing**: Calibrate `SIMPLEFOC_MCX_INLINE_CS_SCALE` against a calibrated current reference.
- **Other boards or MCX devices**: Follow `PORTING_GUIDE.md` in the package.

8 References

For more information, see the following documents:

- NXP Application Code Hub, *SimpleFOC Support for NXP MCX Arduino Platform* (`ap-mcx-simplefoc-arduino-core`), version 1.0.0: https://github.com/nxp-appcodehub/ap-mcx-simplefoc-arduino-core
- Simple FOC and SimpleFOCShield v2.0.4 documentation: https://docs.simplefoc.com
- Sensorless PMSM Field-Oriented Control (document DRM148)
- MCX A366 Data Sheet (document MCXAP144M240F60)
- MCX A366 Reference Manual (document MCXAP144M240F60RM)
- FRDM-MCXA366 Board User Manual (document UM12438)

9 Acronyms

Table 6 lists the acronyms used in this document.

Table 6. Acronyms

Acronym	Description
ADC	Analog-to-Digital Converter
BLDC	Brushless DC
BSP	Board Support Package
FlexPWM	Flexible Pulse Width Modulator
FOC	Field-Oriented Control

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Table 6. Acronyms...*continued*

Acronym	Description
FQBN	Fully Qualified Board Name
GPIO	General-Purpose Input/Output
I2C	Inter-Integrated Circuit
LPADC	Low-Power Analog-to-Digital Converter
LPI2C	Low-Power Inter-Integrated Circuit
LPUART	Low-Power Universal Asynchronous Receiver/Transmitter
MCU	Microcontroller Unit
PMSM	Permanent Magnet Synchronous Motor
PWM	Pulse Width Modulation

10 Revision history

Table 7 summarizes the revisions to this document.

Table 7. Revision history

Document ID	Release date	Description
AN15244 v.1.0	27 November 2026	Initial public release

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