

The Right Motor Control for Every Drive

RISC-V-Based BLDC/PMSM Motor Controller Family



No Two Drives Are Alike

Electronically commutated motors have become established in a wide range of applications. These range from fans and pumps, household appliances and power tools to servo drives, robotic joints and automotive auxiliary systems. The requirements placed on motor control vary considerably.

While a high level of integration and sensorless operation may be priorities for a cost-sensitive consumer drive, servo drives demand high control dynamics, precise position feedback and communication interfaces. Automotive applications impose particular requirements in terms of temperature range, diagnostics, functional safety and qualification. Mains-powered equipment also involves high DC-link voltages and, where appropriate, active power factor correction as well as safety requirements.

For BLDC and PMSM motor control, power and voltage are only two of the selection criteria. Speed, inductance, starting behavior, noise, dynamics and positioning accuracy influence the design, as does the question of whether the motor is operated sensorlessly, with Hall sensors or with a high-resolution position sensor. Current sensing, power electronics and communication concepts, available space and permissible system cost are further considerations.

The developer must select a controller architecture with the necessary control methods, interfaces and functions without making the system unnecessarily complex or expensive.

Fortior addresses this challenge with its broad **FU75xx family** of motor controllers. Individual variants differ in their power capabilities, peripherals and supported system architectures,

while sharing a common technological foundation. This allows different requirements to be met with appropriately tailored controllers.

A Common Technological Foundation

The **FU75xx family** is built around a dual-core architecture comprising a 32-bit RISC-V MCU and a Motion Engine core. The ME core handles time-critical current and speed control in hardware and can independently control up to two motors. The RISC-V MCU handles application software, communication and other control tasks, as well as position control when required.

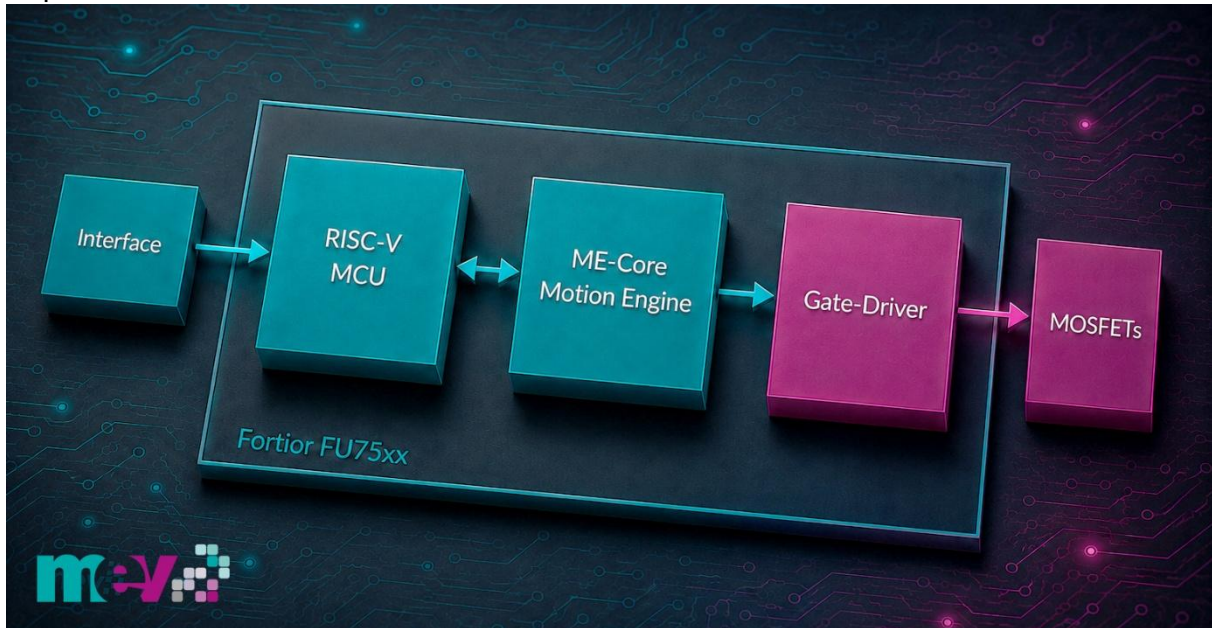


Figure: Fortior FU75xx architecture

This division of tasks is particularly advantageous for field-oriented control. Current acquisition, coordinate transformations, controllers and modulation are executed by the ME core within a defined time frame. The RISC-V MCU can, for example, perform memory tests while the motor is running without interrupting motor control. This also facilitates implementation of the safety requirements of IEC/UL 60730-1 Class B.

The ME core enables FOC control cycles as short as 5 μ s at PWM frequencies of up to 120 kHz. This supports low-inductance motors and speeds of up to 200,000 rpm.

Its modular architecture also allows individual functional blocks, such as the observer, to be replaced with proprietary algorithms. Application software can access internal motor-control variables via registers and reuse them for additional functions.

Which Control Method Fits the Application?

Field-oriented control forms the basis of many modern BLDC and PMSM drives. The most suitable control strategy depends strongly on the motor, operating range and requirements for dynamics and positioning accuracy. A key question is how the rotor position is determined.

In principle, rotor position can be measured using Hall sensors or high-resolution position sensors, or estimated using sensorless methods. Hall sensors are robust and cost-effective, while encoders are used in servo and positioning drives. Sensorless methods reduce hardware requirements but present challenges at standstill and low speeds. The **FU75xx**

family supports all three approaches. For sensorless operation, Fortior offers several observer methods that can be adapted to motor characteristics and speed ranges.

One option for determining rotor position at standstill and very low speeds is High Frequency Injection (HFI). A high-frequency signal is injected into the motor and its response is evaluated. The method exploits the motor's magnetic saliency, i.e. the difference between the d-axis and q-axis inductances, which varies with rotor position. The greater this difference, the more reliably rotor position can be determined. Fortior recommends a saliency ratio of at least 1.3 for HFI. This enables rotor position detection from 0 rpm and thus sensorless closed-loop operation starting from standstill. Not every motor exhibits sufficient saliency for HFI. For these cases, the **FU75xx family** offers a Low-Speed Observer that also works with non-salient motors. Unlike HFI, however, this method requires a minimum speed for sensorless closed-loop operation.

A Flux Observer is available for higher speeds. As the oscilloscope traces demonstrate, it provides stable rotor position estimation even under dynamic operating conditions. The controller can, for example, perform a direct transition between forward and reverse rotation or take control of a motor already rotating opposite to the commanded direction and accelerate it again.

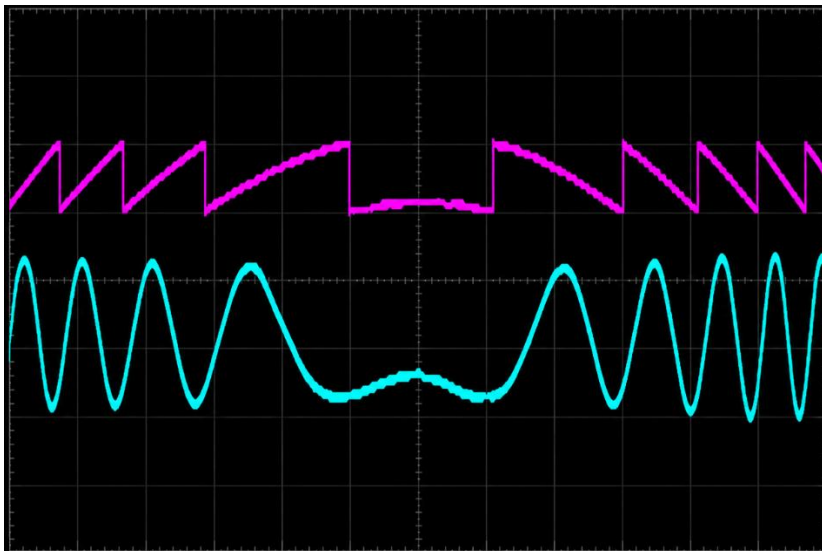


Figure: Flux Observer during a smooth transition between forward and reverse rotation of a washing machine drum. Estimated rotor position (top) and phase current (bottom).

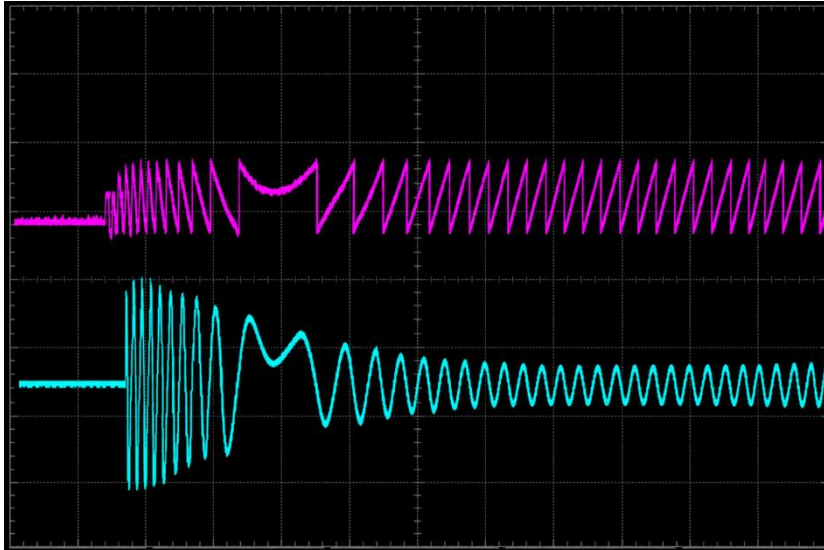


Figure: Acceleration of a washing machine drum using the Flux Observer while initially rotating in the opposite direction

Additional functions extend the operating range: field weakening enables speeds above base speed. Current Decoupling compensates for the interaction between the d-axis and q-axis current components, improving control quality particularly at high speeds. Maximum Torque per Ampere (MTPA) optimizes the operating point to achieve the highest possible torque with the lowest possible motor current. Noise-reduction and EMI-optimization methods address acoustic and electromagnetic requirements.

One, Two or Three?

The [FU75xx family](#) supports single-, dual- and triple-shunt current sensing, allowing current measurement to be tailored to cost, circuit complexity and control requirements.

Much of the required analog peripheral circuitry is integrated, including fast ADCs, operational amplifiers and comparators. With single-shunt sensing, the ME core also supports phase-current reconstruction, enabling FOC with reduced external circuitry.

Hardware Makes the Difference

Power electronics requirements vary significantly between applications. The [FU75xx family](#) therefore includes both controllers for external gate drivers and variants with one or two integrated drivers.

Variants are available for different operating voltages. Depending on the device, integrated gate drivers cover voltage ratings from 28 V to 625 V. For automotive applications, the family also includes AEC-Q100-qualified variants for different vehicle electrical-system voltages. Mains-powered applications can benefit from variants with integrated PFC control.

Typ	MCU	Takt / Flash	Automotive	Motoren (max.)	Treiber-Ausgang	Gate-Treiber
FU7512	RISC-V	48 MHz / 64 kB	-	2	2× PWM	-
FU7512Q1	RISC-V	48 MHz / 64 kB	AEC-Q100 Gr. 1	2	2× PWM	-
FU7541	RISC-V	48 MHz / 64 kB	-	2	-	2× 3P3N 28 V
FU7561	RISC-V	48 MHz / 64 kB	-	2	1× PWM	1× 6N 120 V
FU7562Q	RISC-V	48 MHz / 64 kB	-	2	1× PWM	1× 6N 625 V
FU7562L	RISC-V	48 MHz / 64 kB	-	1	-	1× 6N 625 V
FU7564Q1	RISC-V	48 MHz / 64 kB	AEC-Q100 Gr. 1	2	1× PWM	1× 6N 40 V
FU7565Q1	RISC-V	48 MHz / 64 kB	AEC-Q100 Gr. 1	1	-	1× 6N 80 V
FU7571	RISC-V	48 MHz / 64 kB	-	2	-	2× 6N 120 V
FU7574Q1	RISC-V	48 MHz / 64 kB	AEC-Q100 Gr. 1	2	-	2× 6N 40 V
FU7584Q1	RISC-V	80 MHz / 512 kB	AEC-Q100 Gr. 1 ASIL B	1	-	1× 6N 12 V
FU7585Q1	RISC-V	80 MHz / 512 kB	AEC-Q100 Gr. 1 ASIL B	1	-	1× 6N 48 V

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Table: Overview of the FU75xx family

The **FU75xx family** also offers flexibility in computing performance and memory. Existing FU75xx variants operate at 48 MHz with 64 kB of Flash. Two new automotive variants, the **FU7584Q1** and **FU7585Q1**, extend the range. Both offer 80 MHz, 512 kB of Flash and support functional safety up to ASIL B.

Four Practical Examples

Compact Joint Drive for Miniature Robots

The controller is implemented on a circular PCB measuring just 22 mm in diameter. It operates at 48 V/2 A and communicates via CAN FD. The design uses an **FU7512Q** motor controller together with an FD6187T gate driver and six external MOSFETs. Today, the design could be further simplified using the **FU7561** with its integrated 120 V gate driver.



Figure: Joint drive for miniature robots using the FU7512Q

Servo Drive with EtherCAT

Industrial servo drives require high control dynamics and precise positioning. This example operates at 48 V and up to 10 A and incorporates position, speed and current control loops. Rotor position is measured by an encoder, while EtherCAT connects the drive to the higher-level controller. The design uses an [FU7512L](#) motor controller with an [FD6288Q](#) gate driver. Today, a variant with an integrated gate driver would also be selected for this application.

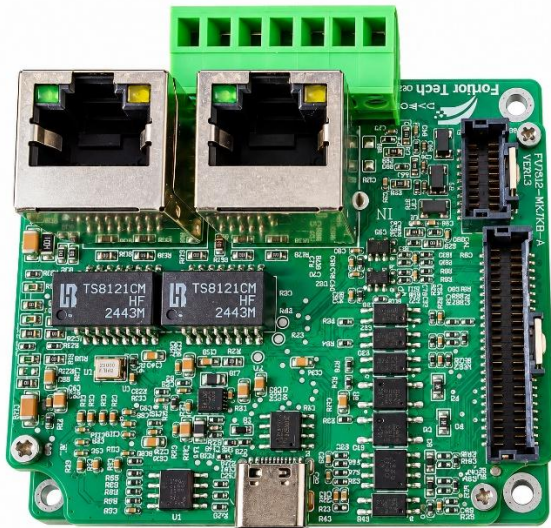
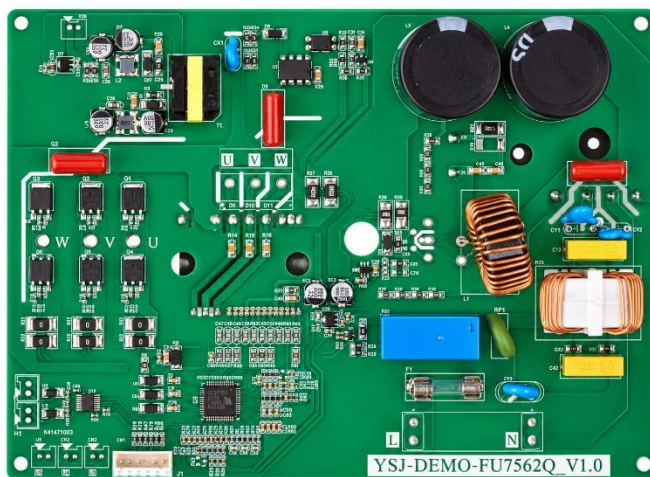


Figure: High-performance servo drive FU7512L-SFGLB

Washing Machine Drive with Two Motors

A washing machine places very different demands on motor control. In this example, an [FU7562Q](#) operating from the mains controls both the drum motor and the drain pump, with power of up to 2 kW. The drum motor is driven by a Mitsubishi intelligent power module (IPM) at up to 24 A, while the drain pump uses the [FU7562Q](#)'s integrated gate driver with six external MOSFETs for up to 8 A. Hardware PFC is also integrated. Both motors are controlled sensorlessly using FOC, with either single- or dual-shunt current sensing. Field weakening enables high spin speeds, while the Low-Speed Observer allows the drum to be controlled down to 1 Hz during washing. The controller also enables highly accurate load detection.



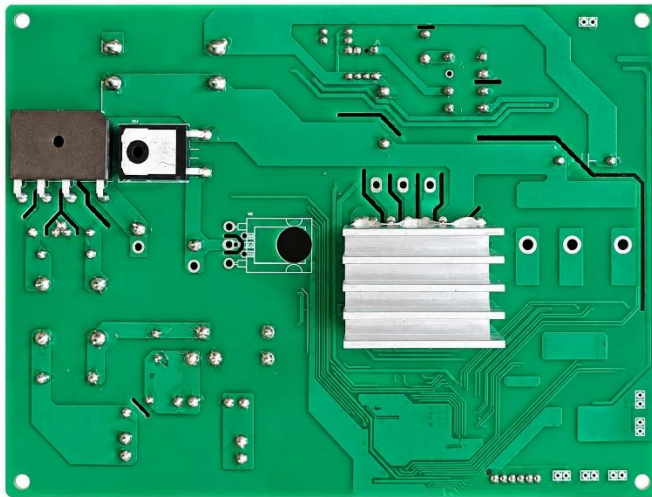


Figure: Washing machine drive with two motors, YSJ-DEMO-FU7562Q

One Controller for Two Automotive Fans

Vehicles often contain multiple auxiliary drives. A typical example is two fans or two pumps that must be controlled independently. The AEC-Q100-qualified [FU7574Q1](#) integrates two 40 V gate drivers and can independently drive two motors via separate power stages. The solution shown is designed for a 12 V vehicle electrical system and up to 15 A per motor. Rotor position can be determined sensorlessly or using Hall sensors. LIN and CAN FD are available for integration into the vehicle network.

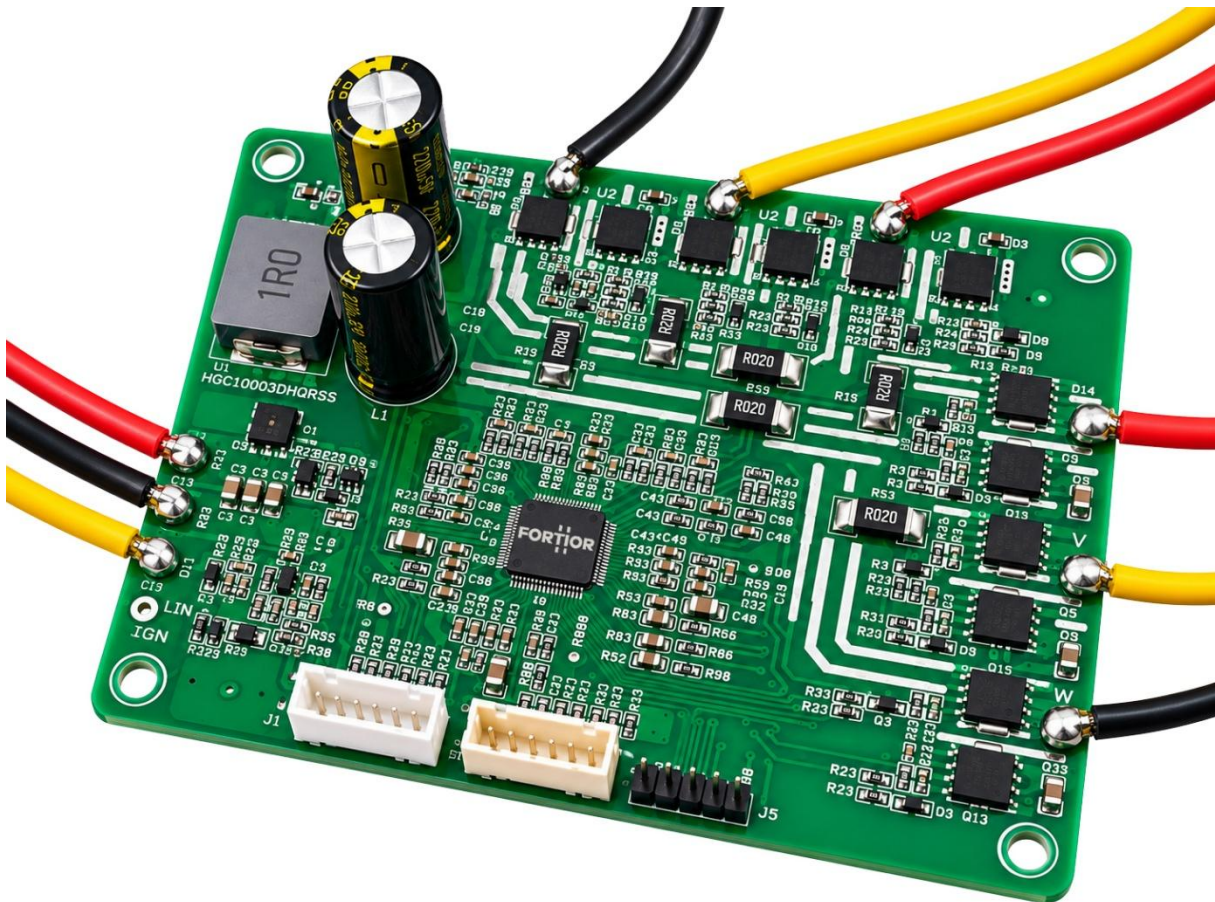


Figure: One controller for two automotive fans, FU7574Q1-QCDZ-DEMO

From Controller Selection to a Running Motor

Selecting the right motor controller is only part of the development process. Particularly with sensorless control methods, achievable performance depends heavily on motor parameters and how well the control system is tuned to the motor. Alongside the free [FTM32ForgeIDE](#) development environment, Fortior provides numerous evaluation and demonstration boards. Experienced application engineers from Fortior and MEV support developers throughout the process.

Application support ranges from initial commissioning to tuning and optimizing motor control. If required, application engineers can commission actual customer motors and optimize the control parameters accordingly. The developer then receives the motor back together with an evaluation board and optimized parameter settings. This allows customers to test the solution with their own motor and compare it with alternatives without extensive development effort.

Conclusion

Modern motor-control requirements vary considerably from one application to another. With the [FU75xx family](#), Fortior offers different controllers based on a common technological foundation. Developers can select the combination of control methods, computing performance, interfaces and power electronics that best suits their application, without unnecessarily oversizing the feature set or level of integration. If requirements change in a subsequent project, they can choose another variant within the family while continuing to use the familiar architecture and development environment.

About the Autor



Guido Gandolfo, Dipl.-Ing. (FH) in Electrical Engineering, is Product Line Manager Motion Control at MEV Elektronik Service GmbH. He has worked in drive technology, motor control and position sensing for almost 30 years. His focus is on innovative solutions for stepper motor, BLDC and servo drives and their industrial applications.

About Fortior

Fortior Technology develops semiconductor solutions for controlling BLDC and PMSM motors. Its portfolio includes motor controllers, gate drivers and power ICs for applications including household appliances, power tools, industry, robotics and automotive systems. In Central Europe, the products are distributed and technically supported by MEV Elektronik Service GmbH.

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