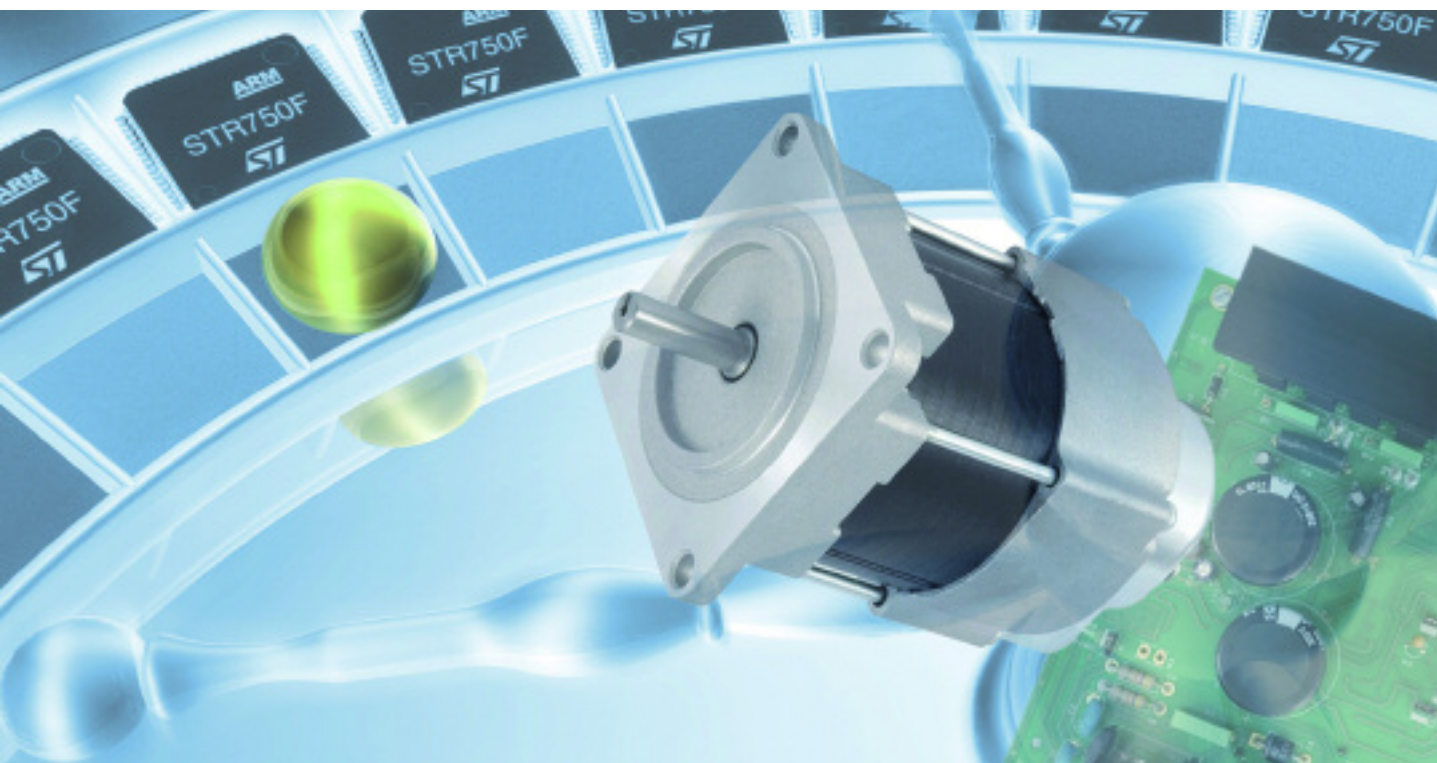


# Motor control for STR750F 32-bit ARM-based MCU family

For 3-phase brushless motor vector drives



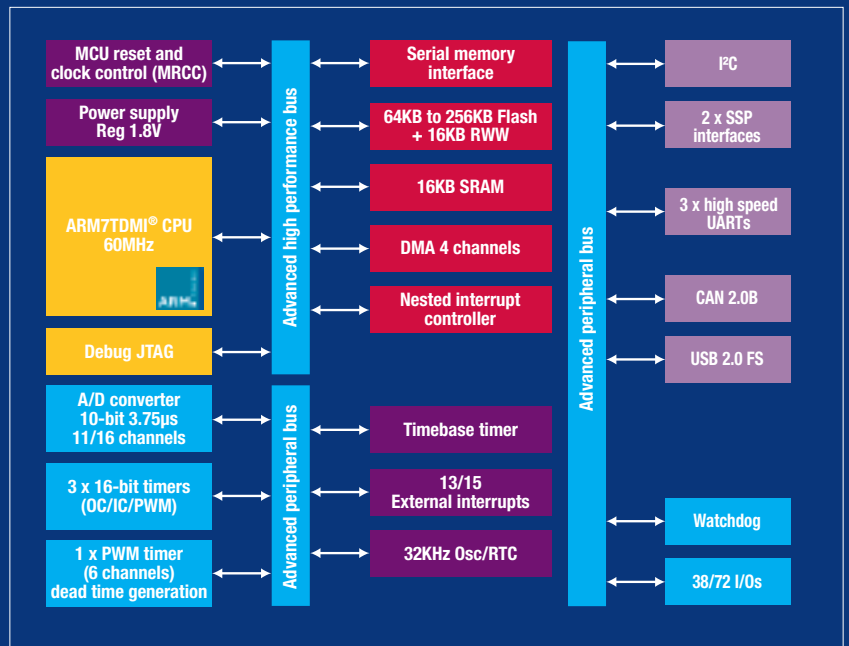
January 2007

# Vector control at optimum cost

The STR750F is a new series of super-integrated, single-chip 32-bit ARM7-based MCUs from **STMicroelectronics**. The STR750F offers the performance of the industry standard ARM7TDMI core at the service of vector (or field-oriented) control algorithms. Vector control algorithms are widely used in high performance drives. They provide precise and responsive speed control, and guarantee optimized efficiency during transient operations. Practically, they also have the advantage of using the same framework to control an asynchronous or synchronous motor. This is interesting for development teams which have to deal with various applications and motor types. Finally, most of the sensorless algorithms are based on field-orientation methodology, which is also of interest when trying to reduce the cost of the drive.

## Applications

- Appliances
  - Washing machines
  - Dishwasher pumps
  - Refrigerators
  - Air conditioners
- Industrial
  - Electric vehicles
  - Low end and medium range industrial drives
  - Office automation
  - HVAC actuators and fans
  - Pumps
  - Blowers
  - Vending and cash machines



DMA: direct memory access    RTC: real-time clock    RWW: read-while-write    SSP: synchronous serial peripheral

Based on an ARM7TDMI™ core, the STR750F series offers:

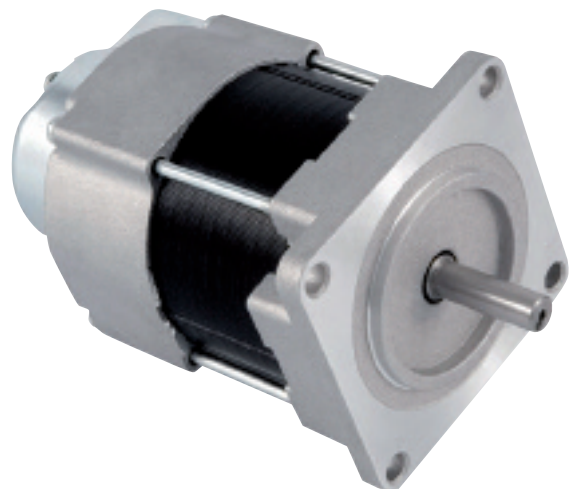
- High performance with 54MIPS at 60MHz
- Embedded timers and ADC features perfectly suited for vectorial control of 3-phase brushless motors
  - PWM timer offers six outputs
  - Dead time generation
  - Edge aligned and center aligned waveforms
  - Emergency stop
  - Synchronization capability with ADC
  - Synchronization capability with other timers
  - Programmable safety feature to protect registers against unwanted writing and a 16-bit timer for encoder interfacing
- Use with either a 3.3V or a 5V power supply

# STR750F MCU family

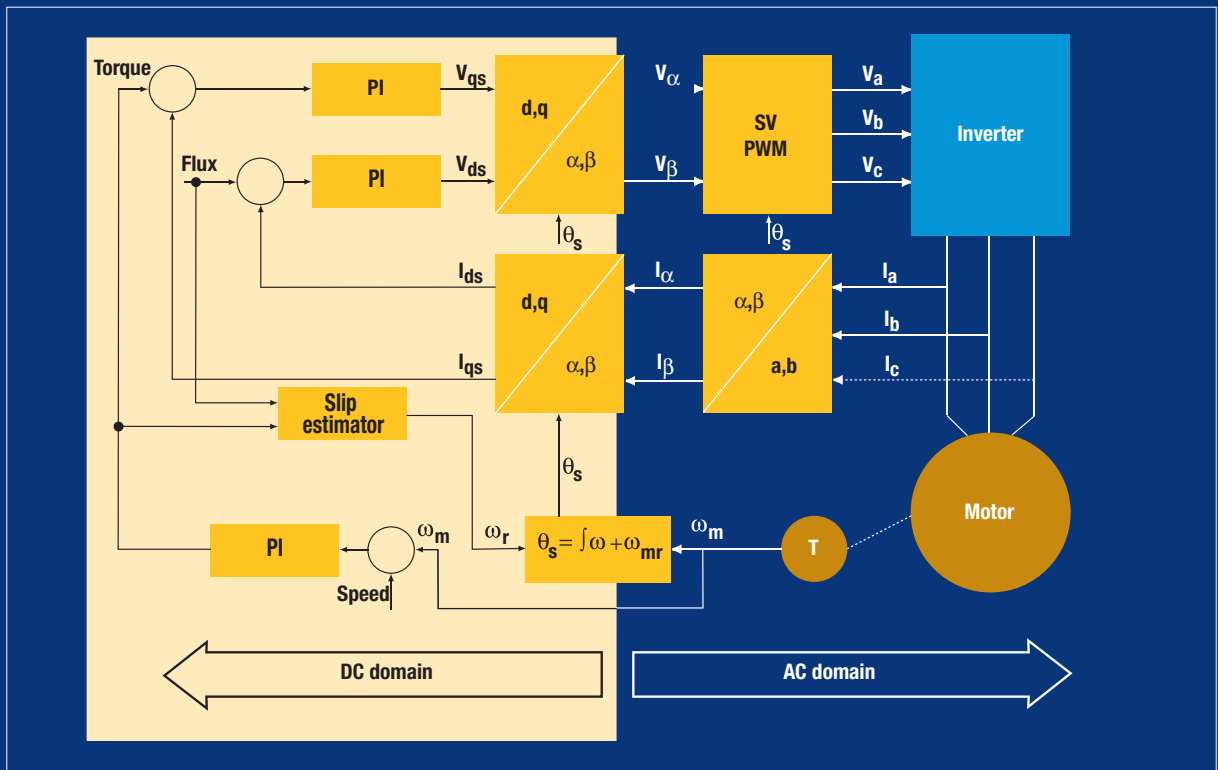
Through a sophisticated combination of several benefits of ARM™ architecture and motor control dedicated peripherals, the STR750F MCU family allows optimization of the overall performance of execution and a reduction of the overall system cost.

## Features and benefits

Features	Benefits
Industry standard ARM7TDMI core running up to 60MHz	Industry standard core with enough processing power (54MIPS) to tackle most applications
32-bit ARM core architecture: barrel shifter and 32-bit data path	Optimize the variable resolution and speed up some multiplications Avoid multiple 16-bit loads when dealing with the integral term of the PID or when extended precision is needed The tachogenerator-based field-oriented control loop is executed within 30µs
High on-chip integration of motor control related analog/digital functions: powerful timers and ADC	Perfect fit for 3-phase motor control applications Only 30% CPU load with 10kHz current sampling rate
Single 3.3V or 5V supply	Additional flexibility for customers No need for external regulator Real 5V drive on the I/O when 5V is used



# Indirect rotor field-oriented control



3-phase brushless PMSM or AC induction motor

T : Tachometer  
PI: Proportional/integral  
E: Encoder

## Vector control drive

- Theory
  - Changing reference coordinates from fixed stator coils to the moving rotor frame, the equation describing the motor is then drastically simplified
- Method
  - Clark and Park transformations convert variables with fixed 3-axis, 120° shifted coordinates into 2-axis orthogonal rotating coordinates
  - These last variables are DC, or slowly varying values, which can be regulated by means of simple PID controllers and are then transformed back to the fixed stator windings frame using reverse transforms, as shown in diagram above
- Requirements
  - Intensive math computations (trigonometric functions, multiple PID regulators, speed calculation)
  - Minimum resolution required for the main control variables is 16-bit with a need for 32-bit intermediate results, such as integral terms
  - Free CPU load must be kept for the remaining applicative tasks, such as communication and user interface

## Brushless motor safety

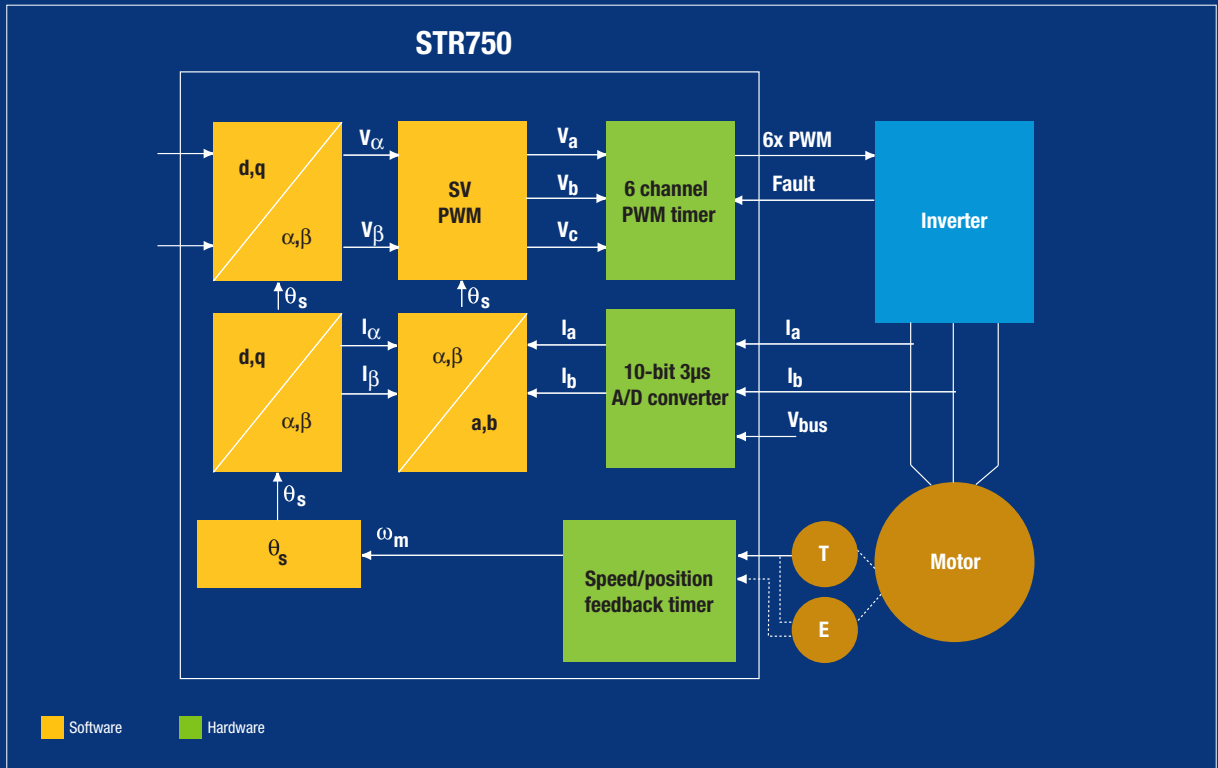
### Features

- Safety critical registers can be locked to prevent power stage damage (software run-away)
  - Deadtime, PWM outputs polarity, emergency input enable
- All target registers are read/write until lock activation (and then read-only if protected)
  - Once the two lock bits are written, they cannot be modified until next MCU reset (write-once bits)
  - Four lock levels offer full flexibility depending on the application (for example 6-step vs sine)
- If main clock fails, an internal RC oscillator (FREEOSC, ~5MHz average frequency) starts immediately
- Interrupt can be generated for shut down or safe restart sequences
- Emergency stop dedicated input pin

### Benefits

- Strengthens control algorithm to protect motor operation from external disturbance
- Protects safety-critical registers in case of system hang
- Quick error diagnosis and fault management
- Hardware protection of power stage whatever the status of MCU oscillator

# STR750F MCU family



From block diagram to implementation

## STR750 dedicated peripherals for 3-phase brushless motor control PWM timer features

- Motor control timer clock
  - Can be twice the advanced peripheral bus frequency
  - Maximum input clock is 60MHz to provide 16.6ns edge resolution (12-bit @16kHz edge-aligned PWM)
- Edge or center-aligned patterns
- Double-update mode
  - No loss of resolution in center-aligned mode
  - Done thanks to an additional interrupt per PWM cycle or DMA transfers
- Burst mode
  - Possibility to update several registers of the peripheral using a single DMA stream
- Debug mode
  - User selectable PWM timer state in case of breakpoints (normal run mode or PWM off; counter frozen and PWM switches off)
- Programmable reload rate

## Benefits

- Suitable for phase brushless PMSM or AC induction motors
- Low and high voltage
- Sensored and sensorless configurations
- Versatile PWM output management
  - Individually selectable polarity selection
  - Redirection circuitry for 6-step drives
- Programmable hardware deadtime generation
  - 10-bit register with 16.6ns resolution at 60MHz (i.e. from 0 to 16µs)
- Dedicated emergency stop input
  - Shuts down the 6 PWM outputs and issues an interrupt
  - Asynchronous operation (operates without clock source)

## Speed feedback

- Handled by the general purpose timers

# STR750-MCKIT

## Optimize your time to market – run your motor in just a few steps

Firstly, within a few minutes, run the kit's PMSM motor with the standalone demo, in open or closed loop, using the LCD and the joystick on the STR750-EVAL control board.

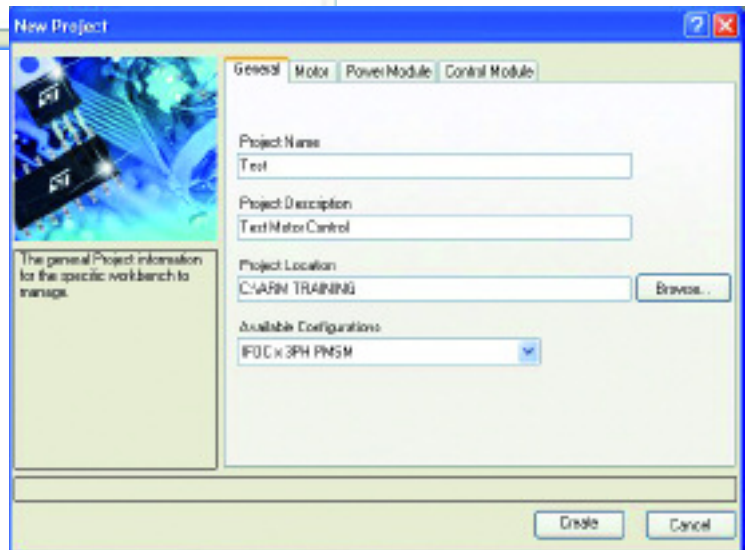
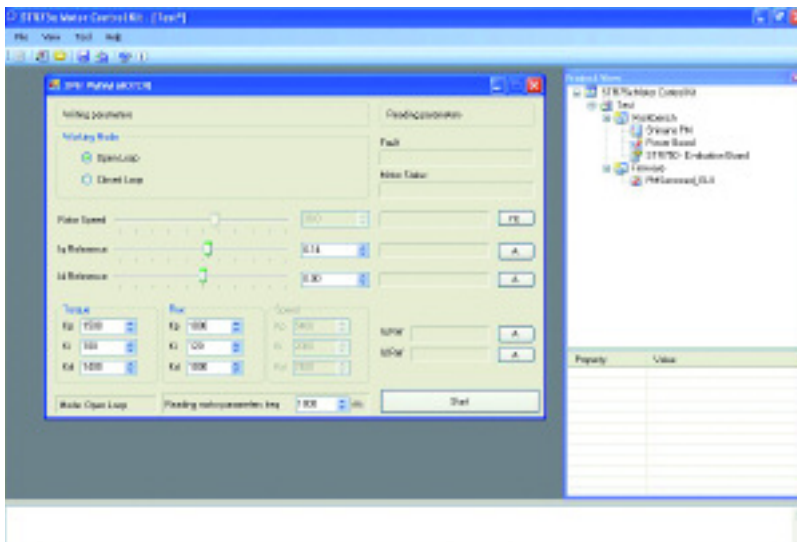
Then install the graphical user interface (GUI) and run the PMSM motor, or an induction motor in open or closed loop, by selecting basic settings in the GUI. Apply changes to real-time settings to tune the drive parameters on the fly and get feedback values from the changed settings.

Once familiar with the demo, explore our motor control library that supports FOC (field oriented control) drive of PMSM and induction motors.

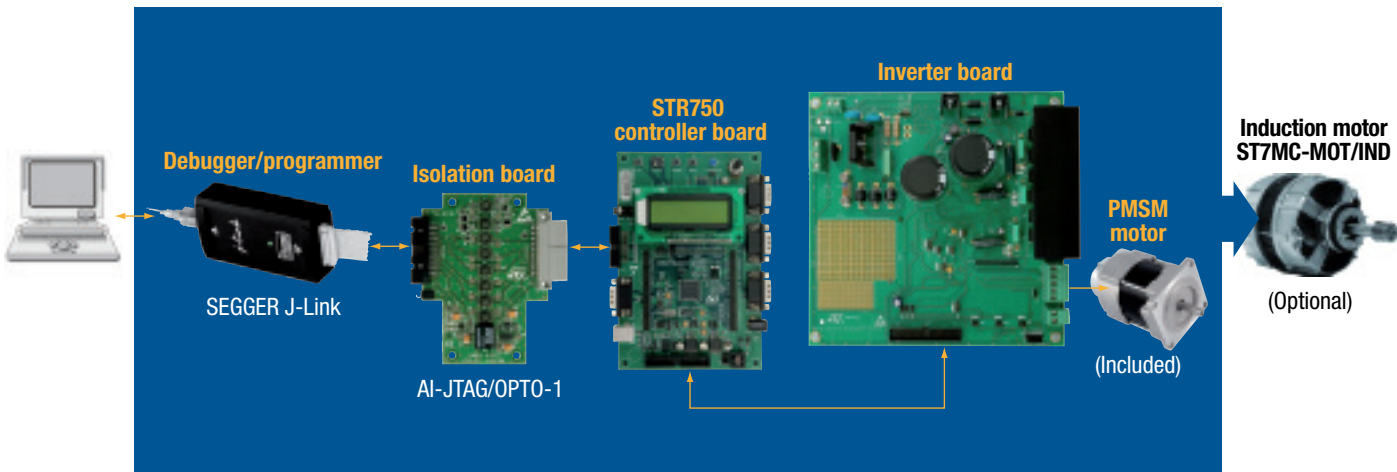
The library sources are free and help speed up development of motor control applications. With the free 32KB evaluation version of IAR's EWARM, open the libraries, develop the application, fine tune the code and parameters and compile. Then fine tune the application while running the motor thanks to the real-time debugging capability of the Segger J-Link.

### Application-specific requirements

Using the same hardware and firmware platform, it is possible to incorporate application specific requirements by taking advantage of the STR750-EVAL control board and the inverter board extension features (UART/LIN port, standalone operation potentiometer, wrapping area).



# STR750F MCU family



## Key benefits

- Ready to run within minutes (requires Windows 2000/XP for the GUI and a power supply for the motor)
- Same hardware and firmware platform for PMSM and induction 3-phase motors
- Allows real-time control and monitor from PC GUI or standalone operation through on-board push buttons and trimmers
- Segger/IAR JLink (included) Flash programming and real-time debug capability allows same hardware and firmware platform to be used from evaluation to an advanced development stage
- Bypass connector for external inverter power stage connection

## STR750-library

Optimized and documented C firmware libraries for control of both PMSM and AC induction brushless motors are provided for free in the kit or on the internet ([www.st.com/mcu](http://www.st.com/mcu)).

These modular libraries support both types of motors in standalone mode using the hardware of the STR750-MCKIT. The source files are provided **free of charge** and are MISRA C compliant, which helps for compliancy with IEC60730.

## Device summary

Motor control development tools	
Sales type or item	Description
STR750 MC library	Optimized, documented C firmware libraries for control of 3-phase PMSM or AC induction brushless motors. In open or closed loop with STR750, sensor mode. The libraries are MISRA C compliant. These are the standalone libraries of the STR750-MCKIT.
AI-JTAG/OPTO-1	The isolation board included in the STR750-MCKIT can also be ordered separately. It provides galvanic isolation between the J-Link from Segger and any target board supplied by high voltage. The isolation board has two JTAG connectors (in/out). Available from distributors and ST sales offices.
STR750-MCKIT	Demonstration, evaluation and development kit for STR750 includes firmware, GUI, STR750-EVAL board (control board), low voltage 7A inverter board, isolation board (AI-JTAG/OPTO-1), Segger J-Link debugger/programmer and 24VDC Shinano PMSM motor. Available from distributors and ST sales offices.
ST7MC-MOT/IND	240V/800W Selni 3-phase induction motor for use with the STR750-MCKIT or with the ST7MC-KIT using induction motor default values (for evaluation purposes).

\*RRP: recommended retail price

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