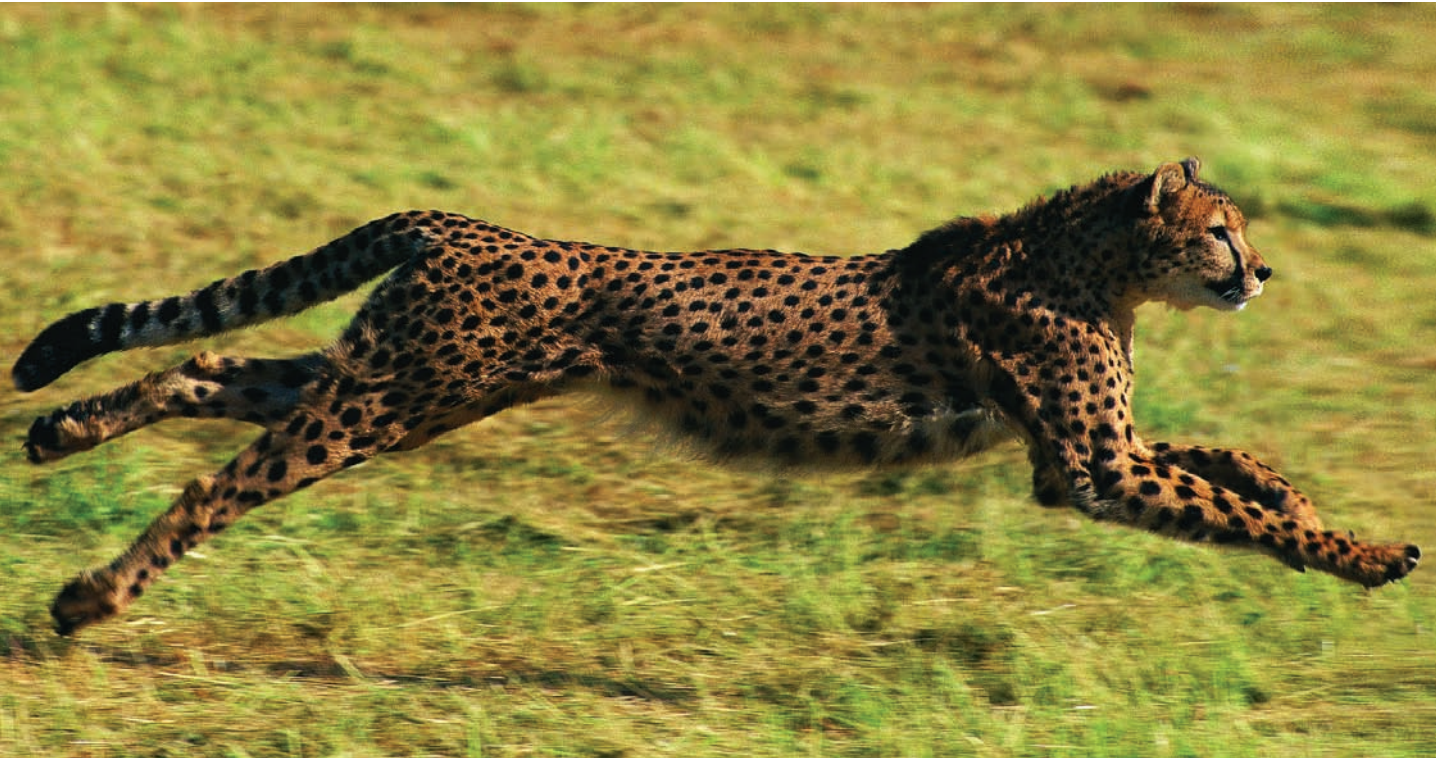


ST7MC family – dedicated to brushless motor control

Fast development of high-performance,
low-cost MCU solutions

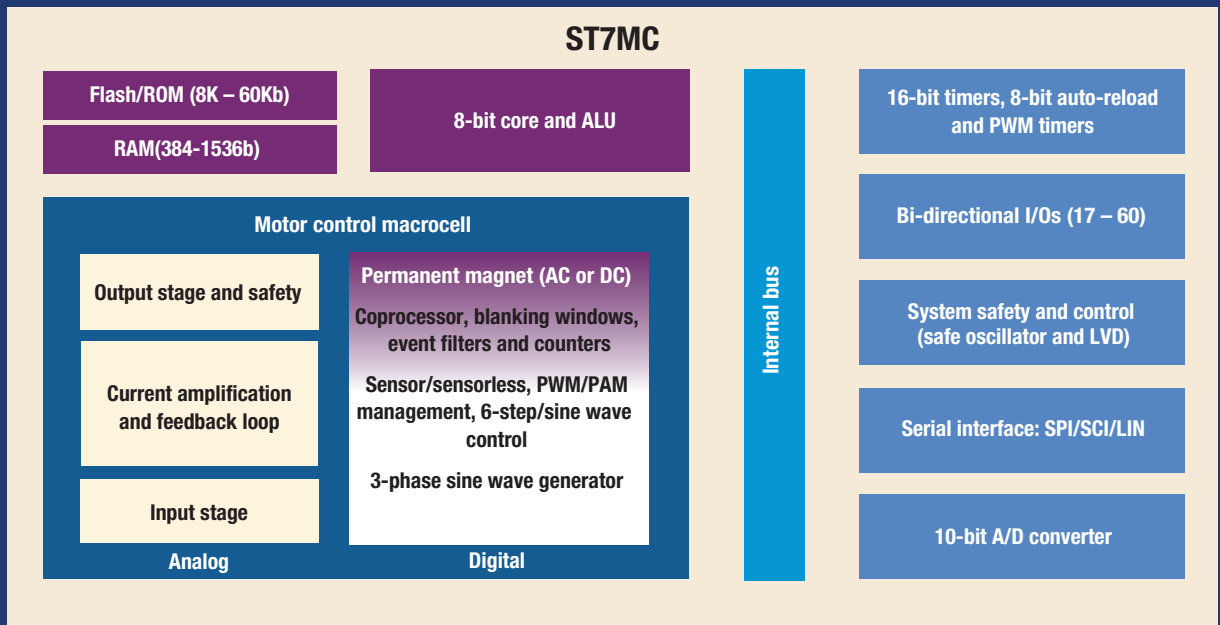


February 2007

Three-phase permanent magnet/ind

Designed specifically to control three-phase brushless motors and compressors, the ST7MC family is built around an industry standard 8-bit core and peripherals.

A dedicated motor control macrocell ensures optimum control of brushless DC and induction motors as well as other motors and compressor types.



Price and performance

The ST7MC family and its enhanced motor control cell offers significant advantages compared to other microprocessor-based approaches such as DSPs. Cost benefits include:

- Reduced processor cost, component count and system cost
- Reduced PCB space
- Optimum system scalability
- Significantly reduced time to market

The ST7MC family also maintains full motor performance and system efficiency over the widest range of available motor/compressor and control topologies.

Built-in flexibility

Key benefits have been achieved through a macrocell hardware approach, coupled with very substantial component integration, plus a complete family of Flash/ROM packages and high quality, application-oriented development tools. Close cooperation with appliance, automotive, HVAC and industrial partners has allowed them to meet cost and performance needs while ensuring maximum flexibility in implementing their control strategy.

uction motor control at optimum cost

ST7MC family

- 8-bit industry-standard architecture with a dedicated sensor/sensorless motor control coprocessor macrocell
- High on-chip integration of motor control related analog/digital functions
- Single-chip solution for both induction and permanent magnet (AC or DC) three-phase motors, and cross utilization of common hardware functions inside the motor control macrocell (developed in pages 4, 5 and 6)
- Complete range of packages and memory size from 32 to 80pin and 8 to 60K
- Low EMI and 8MHz recommended external frequency
- Low *run mode* power consumption
- Features a complete set of standard MCU peripherals (timers, AD converters, I/Os) and communication interfaces including dedicated LINSPI™ for LIN bus
- -40 to 125°C on several packages
- C optimized architecture and instruction set
- On-chip debug module

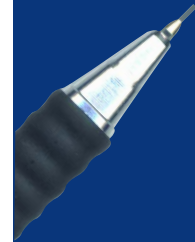
Benefits

- Easy to program, reduced time to market
- Very low system cost, few external components
- 70% of CPU available for non-motor control related tasks
- Suitable for a wide range of motors (including compressors) and sensor/sensorless control topologies
- Small footprint. Fits inside motor housing
- Automotive applications compliant
- System scalability
- Very low-cost, real-time development tools
- Tailored to applications, as required



Applications

Appliances	Air conditioners, washing machines, dishwasher pumps, food processors, refrigerators, vacuum cleaners, cooking hoods
Automotive	Fuel pumps, water pumps, cooling fans, interior blowers
Industrial	Electric vehicles, HVAC actuators and fans, pumps, blowers, office automation, vending and cash machines, paramedical equipment, low and medium-end industrial drives



LQFP32



LQFP44



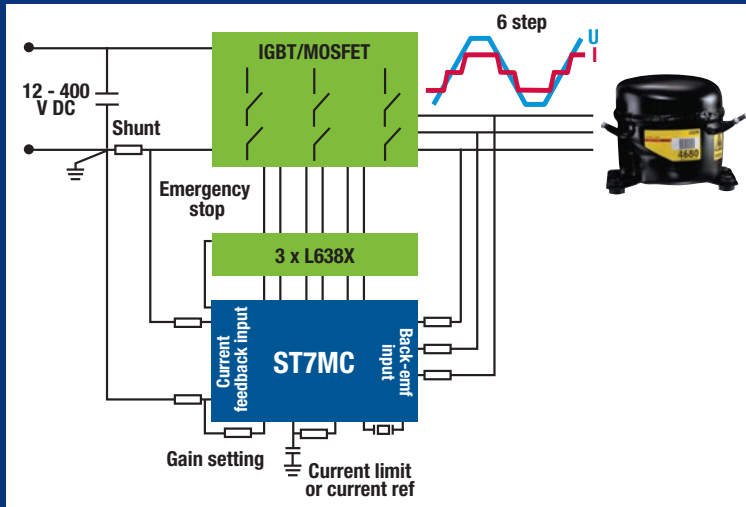
LQFP64



LQFP80

Products shown at actual size

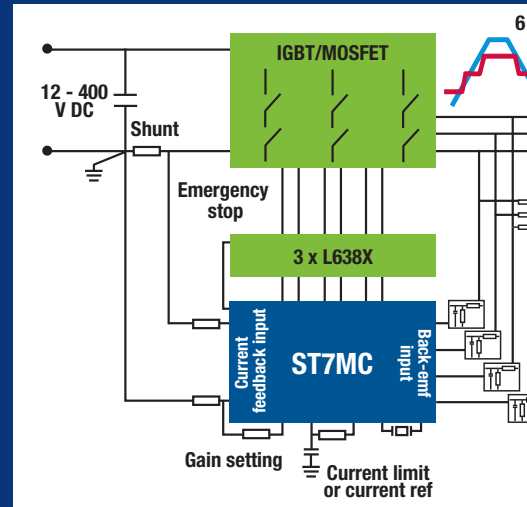
Permanent magnet AC/DC motor



ST patented three-phase sensorless motor control

Benefits

- Sensorless control and high integration for extreme cost-effectiveness
- For 12 to 220V motors (and compressors) controlled in 6-step voltage or current mode with high-side PWM switching
- Full digital back-emf reading allowing widest speed range



Industry standard three-phase BLDC sensorless motor control

Benefits

- Most flexible sensorless solution allowing 6-step voltage or low-side switching, pulse width modulation or pulse amplitude
- Ideal for automotive low-side PWM switching

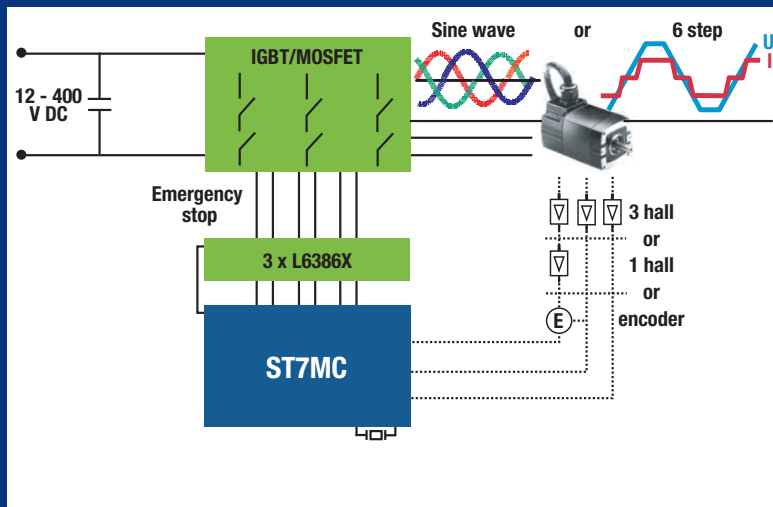
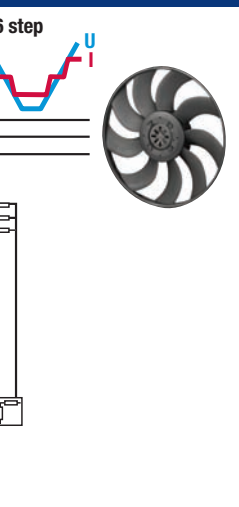
- Multiple programmable filters and blanking windows on events such as back-emf sensing, demagnetization and current sensing
- Programmable simulated events: commutation, back-emf detection and end-of-demagnetization
- Programmable decision event counter: back-emf detection, end-of demagnetization detection and current sensing
- Hardware computed, programmable commutation delay (256 steps)
- Demagnetization acceleration
- High-current PWM outputs
- Up to 2MHz carrier modulation capability
- Synchronous rectification

Benefits

- Significantly lower system cost due to reduced component count (up to 15 components)
- Small footprint
- Compatible with the widest range of motors and compressors, from 12V DC to 240V AC.
- Spurious event rejection
- Optimized safety
- Optimum efficiency
- Maximization of back-emf reading window
- Direct optocoupler drive
- Pulse transformer drive compatible
- Optimized heat sink dimensioning
- No compromise on performance (same efficiency as field oriented control solutions)

Permanent mag

or control



Three-phase BLDC motor control with 1 or 3 sensors

Brushless motor safety

ST's advanced induction and BLDC motor control offers high performance. Each macrocell offers

Features

- Spurious event protection filter (B)
- Simulated demagnetization event
- Write-once, programmable dead-time
- Hardware asynchronous emergency stop
- Fault interrupts such as:
 - Programmable tachometer time out,
- Selection by option byte of output

Benefits

- Strengthens control algorithm to
- Protects safety-critical registers i
- Hardware protection of power sta
- Quick error diagnosis and fault m

current mode, high or
voltage modulation

Benefits

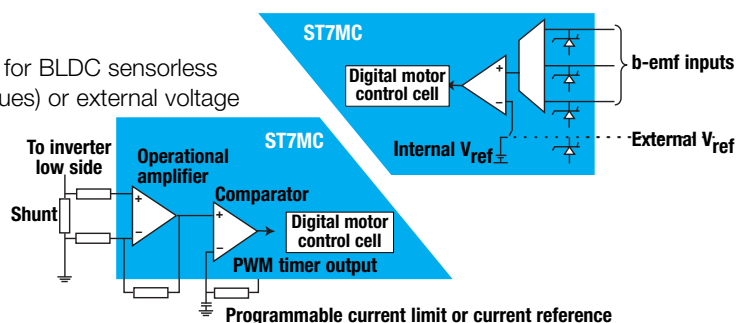
- Positioning capability (with quadrature encoder)
- No torque ripple
- Very low speed capability

Back-emf input

- On-chip, back-emf sensing comparators for BLDC sensorless control with programmable internal (7 values) or external voltage reference

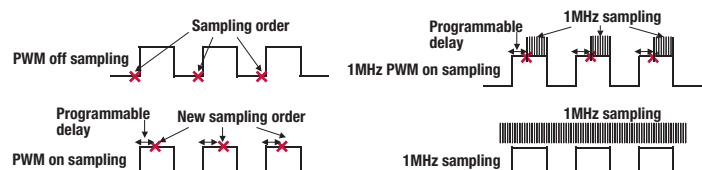
Current feedback input

- On-chip op-amp and comparator, for current feedback amplification, regulation and limitation (with programmable values)



Back-emf sampling

- Multiple analog and digital back-emf sampling capability for low or high side PWM



Brushless and induction motor macrocells

Brushless motor macrocells are specifically designed to optimize motor efficiency and provide comprehensive brushless motor safety features

Field-oriented control (FOC) (BLDC)

Current limit (BLDC)

Dead-time and PWM polarity registers

Emergency stop

Current limit, sampling out, emergency stop processing

Output state at fault (high, low or high Z)

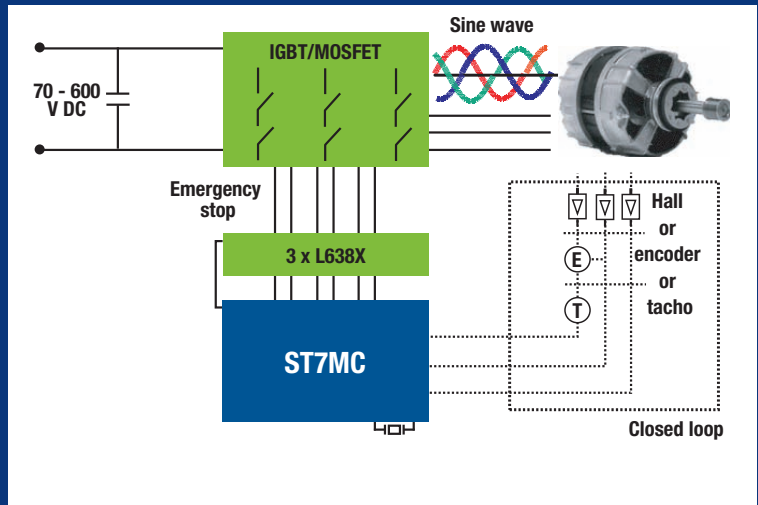
Protection to protect motor operation from external disturbance

Protection in case of system hang

Protection stage whatever the status of MCU oscillator

Protection management

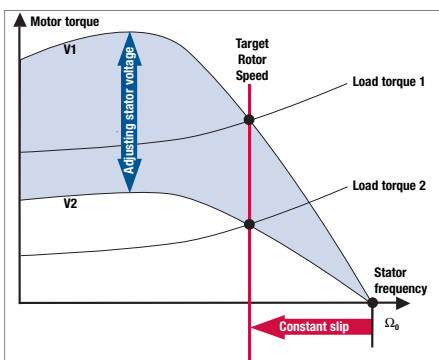
Induction motor control



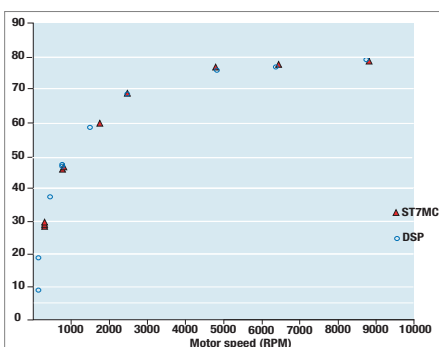
Three-phase induction motor control

Benefits

- No complex mathematical algorithms
- Optimized features for high-performance results, without compromising on cost
- Motor and system efficiency similar to DSP approach when using standard low-cost tachogenerator
- Reduced heat sink dimensioning through optimized PWM resolution and sinusoidal shape
- Suits widest range of IGBTs/MOSFETs
- Tacho loss detection
- Direct optocoupler drive
- Pulse transformer drive compatible



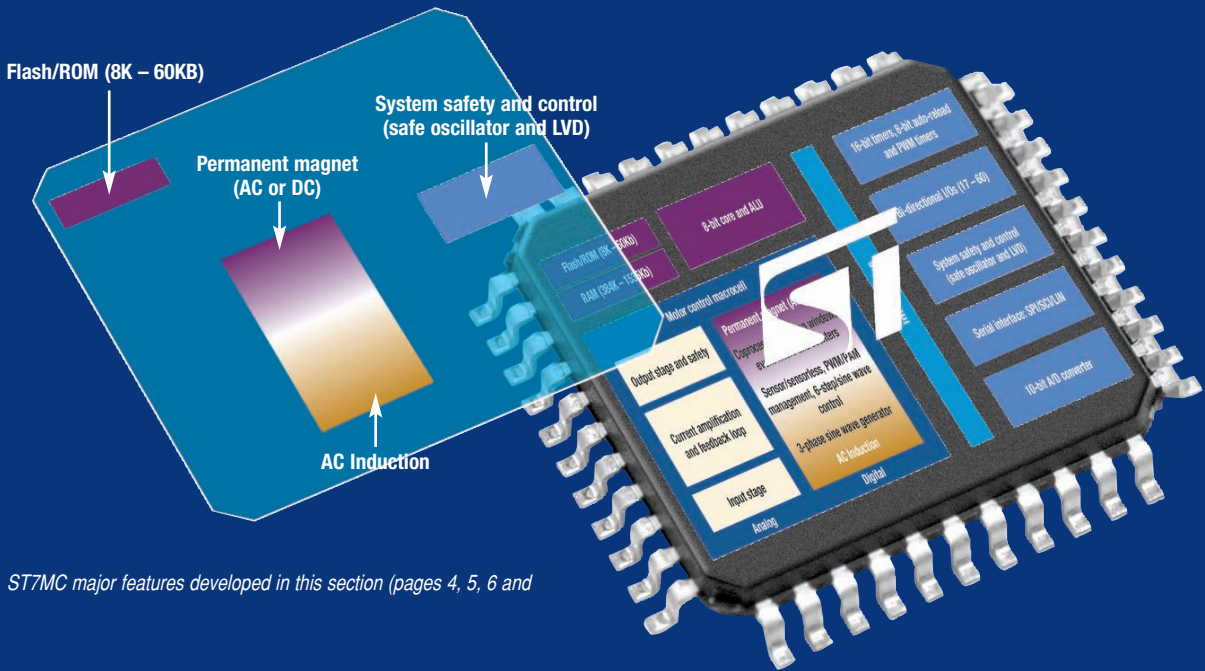
Induction motor maximum efficiency by dynamic voltage adjustment



Induction motor static measurement in washing machine application (motor+drive efficiency in %)

- 16MHz timer internal clock
- Enhanced 12-bit PWM resolution using edged patterns and single/double update centered pattern
- Programmable dead-time from 0.125 to 16μs
- Multiple sensor input such as tacho, hall, encoder and dedicated speed acquisition hardware
- High-current PWM outputs
- Programmable carrier modulation capability (up to 2MHz)
- Optimized C software libraries implementing high-efficiency slip control regulation
- On-chip analog functions
 - Op-amp for system power level monitoring
 - Comparator for current limitation

ST7MC



ST7MC major features developed in this section (pages 4, 5, 6 and

High-density Flash

- In-application reprogrammable
- Byte per byte programming, sectorized erasing
- 4Kbytes/s programming time
- Protected bootstrap loader
- 20 years data retention at 55°C

Benefits

- Lower production cost due to fast programming
- Reliable in-application re-programming
- 125°C qualified, proven in high-volume automotive applications
- Shorter time to market

System safety and control

- Selectable, 8MHz input/16MHz output PLL
- Clock security system (CSS) to provide back-up safe oscillator
- Selectable low-voltage detector reset circuit
- Auxiliary voltage detector (AVD) with interrupt capability for monitoring main supply
- Window watchdog

Benefits

- External disturbances filtered: no clock disturbance
- Will continue working even with failure of main oscillator. Interrupts will allow safe management of such an event
- No components needed for external reset circuit
- Safe handling of power failure
- Increased software robustness through higher coverage of software run-away situations

The ST7MC star

Three easy steps to design a brushless motor into an application

Demonstration

Firstly, run the kit BLDC motor, or your own BLDC or induction motor in open loop, by selecting basic settings on the Graphical User Interface (GUI).

Evaluation

In a few days, explore all the features by running the motor using various control strategies with the GUI and its advanced settings. Save the settings by generating header files. Flash the ST7MC microcontroller, run motor and apply changes to real-time settings to tune the drive parameters.

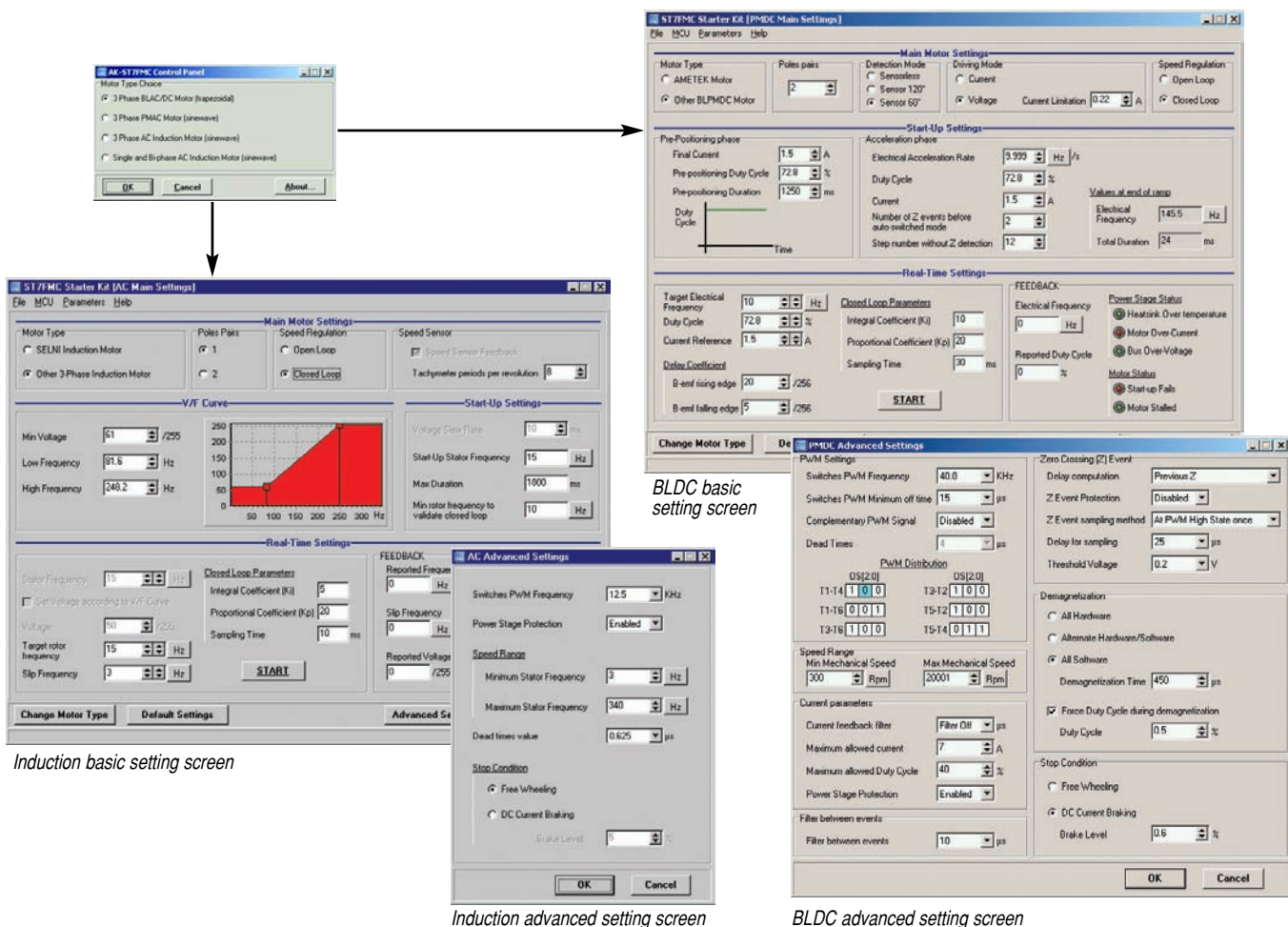
Development

Within a few weeks, use the generated header files and the ST7MC optimized C software library supplied (source code of the ST7MC kit firmware) and build the

final application around it. Develop the application using the real-time debugging feature of the STXF-INDART/USB (included) and the associated STVD7 visual debugger.

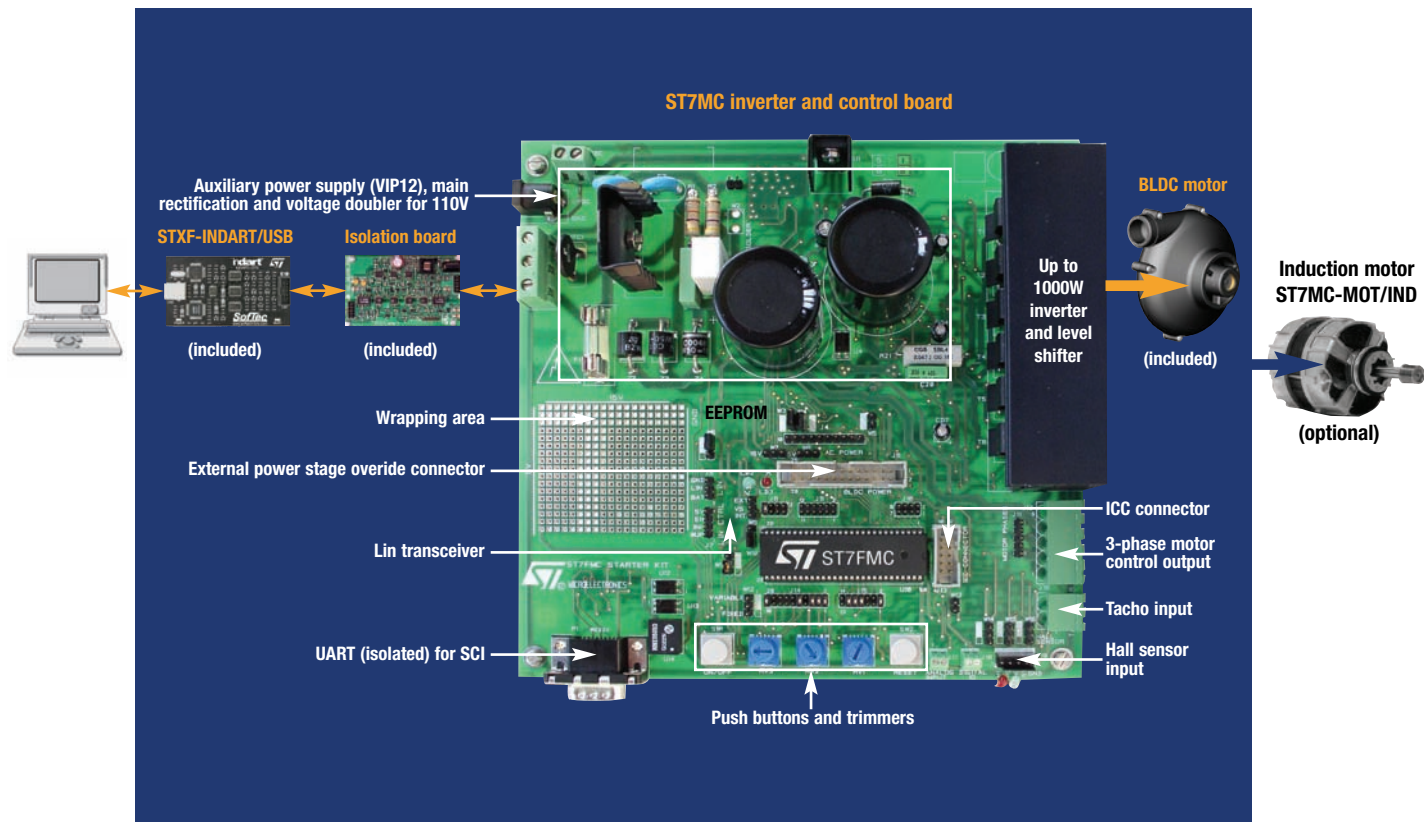
Application-specific requirements

Using the same hardware and firmware platform, it is possible to incorporate application-specific requirements by taking advantage of the inverter hardware board expansion features (UART/LIN port and transceiver, EEPROM, standalone operation potentiometers, sensor mode input, wrapping area etc.). Applications can be built using a third party C-compiler (purchased separately) and finalized using the fully-featured ST7MDT50-EMU3 emulator.



er kit – improves your time to market

ST7MC-KIT/BLDC



Key benefits

- Ready to run within minutes (requires a Windows98/ME/2000/XP PC, and a power supply for the motor)
- Same hardware and software platform for BLDC and induction three-phase motors, from 12 to 300V and all types of control topologies
- Hardware includes voltage doubler for 110V operations
- Most of the advanced registers of the ST7MC motor control cell can be set through the kit's Windows GUI, allowing extensive evaluation before coding or modifying any C software
- Allows real-time control and monitor from PC GUI or standalone operation through on-board push buttons and trimmers
- STXF-INDART/USB (supplied) Flash programming and real-time debug capability allows same hardware and software platform to be used from evaluation to an advanced development stage
- By-pass connector for external inverter power stage connection

Device summary

Part number	Program memory type		Prog. (bytes)	RAM (bytes)	A/D inputs	Timer functions			Serial interface	LVD levels	I/Os (high current)	Package	Supply voltage	Special features
	Flash	ROM				12 or 16-bit (IC/OC/PWM)	8-bit (IC/OC/PWM)	Others						
ST7MC1K2	• ^{2,3}	•	8K	384	8x10-bit	1x16-bit (2/2/1)	1(1/0/1)	WWDG	LINSCI	1	17(3)	LQFP32	4.5 to 5.5V	Sensorless brushless motor control cell, ICD, ICP, IAP, LVD, CSS/PLL, ROP, RTC, nested interrupts
ST7MC1K4	• ^{2,3}	•	16K	768	8x10-bit		1(1/0/1)	WWDG	LINSCI	1	17(3)	LQFP32	4.5 to 5.5V	
ST7MC2S4	• ^{2,3}	•	16K	768	11x10-bit	2x16-bit (2/2/1)	1(1/0/1)	WWDG	LINSCI/SPI	1	26(6)	LQFP44	4.5 to 5.5V	
ST7MC2R6	• ^{2,3}		32K	1K	16x10-bit	2x16-bit (2/2/2)	1(2/0/4)	WWDG	LINSCI/SPI	1	44(12)	LQFP64	4.5 to 5.5V	Sensorless brushless motor control cell, ICD, ICP, IAP, LVD, CSS/PLL, ROP, RTC, nested interrupts, beep ¹
ST7MC2S6	• ^{2,3}		32K	1K	11x10-bit	2x16-bit (2/2/1)	1(1/0/1)	WWDG	LINSCI/SPI	1	26(6)	LQFP44	4.5 to 5.5V	Sensorless brushless motor control cell, ICD, ICP, IAP, LVD, CSS/PLL, ROP, RTC, nested interrupts
ST7MC2R7	• ^{2,3}		48K	1.5K	16x10-bit	2x16-bit (2/2/2)	1(2/0/4)	WWDG	LINSCI/SPI	1	44(12)	LQFP64	4.5 to 5.5V	Sensorless brushless motor control cell, ICD, ICP, IAP, LVD, CSS/PLL, ROP, RTC, nested interrupts, beep ¹
ST7MC2S7	• ^{2,3}		48K	1.5K	11x10-bit	2x16-bit (2/2/1)	1(1/0/1)	WWDG	LINSCI/SPI	1	26(6)	LQFP44	4.5 to 5.5V	Sensorless brushless motor control cell, ICD, ICP, IAP, LVD, CSS/PLL, ROP, RTC, nested interrupts
ST7MC2M9	• ^{2,3}		60K	1.5K	16x10-bit	2x16-bit (2/2/2)	1(2/0/4)	WWDG	LINSCI/SPI	1	60(12)	LQFP80	4.0 to 5.5V	Sensorless brushless motor control cell, ICD, ICP, IAP, LVD, CSS/PLL, ROP, RTC, nested interrupts, beep ¹

Abbreviations

ADC : Analog-to-digital converter
 CSS : Clock security system
 IAP : In-application programming
 IC/OC : Input capture/output compare
 ICD : In-circuit debugging
 ICP : In-circuit programming
 LIN : Local interconnect network
 LINSCI™ : SCI with dedicated LIN features

LVD : Low voltage detection
 MC : Motor control
 PWM : Pulse width modulation
 ROP : Readout protection
 RTC : Real-time clock timer
 SCI : Serial communication interface (UART)
 SPI : Serial peripheral interface
 WWDG : Window watchdog timer

Packages

LQFP : Low profile quad flat package

Notes

1 : Audio square wave generator
 2 : HDFlash (high-density flash)
 3 : FASTROM service available for pre-programmed devices in production quantities

Tools and third-party support

Part number	Description
ST7MC library	Optimized, documented C software library for control of 3 phase BLDC, induction motors and compressors in open or closed loop with ST7MC, using various control topologies. Available at www.st.com/mcu
STX-RLINK	Very low-cost debugger and programmer for a complete range of ST MCUs (ST7, uPSD, STR7 and STR9). Allows real-time in-circuit debugging and 2 breakpoints. USB PC connection. Requires a target application board for ICC or JTAG connection. Available from ST/distributor or www.raisonance.com
STXF-INDART/USB	Low-cost debugger and programmer. Allows real-time emulation and 2 breakpoints using ICD. No trace. USB PC connection. Requires a target application board for ICC connection. Available at ST/distributor or www.softemicro.com
ST7MC-KIT/BLDC	Demonstration, evaluation and development kit for ST7MC. Includes firmware, GUI, ST7MC samples, a 12VDC-240VAC 1000W inverter board, isolation board, STXF-INDART/USB low-cost debugger/programmer and 24V BLDC motor. Available at ST/distributor or www.softemicro.com
ST7-ICC/OPTOISOL	The optoisolation board included in the ST7MC-KIT can also be ordered separately. It provides galvanic isolation between the ICC tool (InDart) and any target board supplied by high voltage. The optoisolation board has two ICC connectors (In/Out).
ST7MC-MOT/IND	240V/800W Seln three-phase induction motor for use with the ST7MC-KIT using induction motor default values (for evaluation purposes). Available at ST/distributor or www.softemicro.com
ST7MDT50-EMU3	Real-time emulator with full trace capability. Includes probes for all packages
ST7MDT50-TEB	Target emulation board for ST7MC for use with ST7MDTxx-EMU3 Emulator. Includes all probes
C compilers	C compilers provided by Cosmic www.cosmic-software.com and Raisonance www.raisonance.com (free up to 16K)
Reference designs	Various reference designs in preparation including air conditioner, washing machine or refrigerator. Contact ST/distributor for details

e-support

Online support at: www.st.com/mcu includes:

ST7MC product information: www.st.com/mcu > downloads

Motor Control tutorial: <http://www.st.com/stonline/products/support/motor/index.htm>

Subscription to automatic Motor control updates: www.st.com/mcu > downloads > subscription

Forum: www.st.com/mcu > forum

Application notes

AN1904: ST7MC three-phase AC induction motor control software library
 AN1905: ST7MC three-Phase BLDC motor control software library
 AN1946: Sensorless BLDC motor control and BEMF sampling methods with ST7MC
 AN1947: ST7MC PMAC sine wave motor control software library
 AN1953: PFC for ST7MC starter kit
 AN2009: PWM management for 3 phase BLDC motor control with ST7MC
 AN2030: BACK EMF detection during PWM on time with ST7MC
 AN2038: I²C emulation with ST7MC in slave mode
 AN2154: Space vector modulation using 8-bit ST7FMC microcontroller and AK-ST7FMC starter kit
 AN2267: Implementation of a current regulator for BLDC motor control with ST7FMC
 AN2372: Low cost sinusoidal control of BLDC motors with hall sensors using ST7FMC



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Full product information at www.st.com

Order code: BRST7MC0207

