Motor Control Solutions for Robotic Applications

STMicroelectronics
Agenda

- System in Package for Motor Control: STSPIN32F0 Family
- Servo Solution: EVALKIT-ROBOT-1
- Full Solution Building Blocks
- STSPIN32F0: Ecosystem Snapshot
System in Package for Motor Control: STSPIN32F0 Family

STSPIN32:
Advanced 3-phase BLDC Controller With Embedded STM32 MCU

- Compact programmable drivers
- Hardware scalability
- A variety of control algorithms available now supported by a comprehensive ecosystem
STSPIN32 Family
From Analog to Digital Motor Control

Highly Integrated System-in-Package

For Smart Industry and High-End Consumer

- High integration
  - embedded 32-bit STM32F0
  - ARM Cortex-M0

- Versatile Control
  - cost-effective sensorless or accurate Hall sensors

- Maximum efficiency
  - on-chip supplies for MCU, driver and external circuitry

- 7x7 mm QFN or 10x10 mm TQFP
- Comes with complete ST ecosystem

- High performance 3-phase gate driver
  - 0.6A and 45V
  - 0.35 / 1A and up to 600V
STSPIN32F0 for Low Voltage Motor Control

KEY BENEFITS & FEATURES:

- STM32 Cortex M0 + 3-phase Gate Driver
- Fully compatible with STM32 ecosystem
- 12V LDO & 3.3V DCDC regulators integrated
- 6-step & FOC sensorless / sensored algorithms
- $V_S = 6.7V – 45V$, $I_{GATE} = 600mA$ sink / source current
- 48 MHz, 32k Flash & 4k SRAM
- 12 bit ADC, I2C / UART / SPI
- FW boot loader support (A & B version)
- Fully protected (UVLO, Short-circuit, OCP, OTP)
- Up to 4 Op-Amps & 1 Comparator,
- From 15 up to 20 GPIOs;
- Compact design with 7x7 mm QFN
- Extended temp range: -40 to 125°C
<table>
<thead>
<tr>
<th>Feature</th>
<th>STSPIN32F0</th>
<th>STSPIN32F0A</th>
<th>STSPIN32F0B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating voltage</td>
<td>8 V to 45 V</td>
<td>6.7 to 45 V</td>
<td>6.7 to 45 V</td>
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<tr>
<td>Embedded MCU</td>
<td>STM32F031x6 with extended temp range</td>
<td>STM32F031x6 with extended temp range</td>
<td>STM32F031x6 with extended temp range</td>
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<td>Gate drivers</td>
<td>600 mA triple half-bridge</td>
<td>600 mA triple half-bridge</td>
<td>600 mA triple half-bridge</td>
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<td>3.3 V DC/DC buck conv</td>
<td>Embedded</td>
<td>Embedded</td>
<td>Embedded</td>
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<tr>
<td>12 V LDO</td>
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<td>Embedded</td>
<td>Embedded</td>
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<tr>
<td>OpAmps</td>
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<td>3</td>
<td>1</td>
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<tr>
<td>Hall Sensor decoding logic</td>
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<td>Not embedded</td>
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<tr>
<td>Comparator</td>
<td>Embedded</td>
<td>Embedded</td>
<td>Embedded</td>
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<tr>
<td># of GPIOs</td>
<td>15</td>
<td>16</td>
<td>20</td>
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<tr>
<td>OC protection via comparator</td>
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<td>Available</td>
<td>Available</td>
</tr>
<tr>
<td>Current control via comparator</td>
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<td>Available</td>
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<tr>
<td>Standby</td>
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<td>Available</td>
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<tr>
<td>UVLO</td>
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<td>Available</td>
<td>Available</td>
</tr>
<tr>
<td>FW upgrade on the field</td>
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<td>Available</td>
<td>Available</td>
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<tr>
<td>Package</td>
<td>QFN 7x7mm, 48L</td>
<td>QFN 7x7mm, 48L</td>
<td>QFN 7x7mm, 48L</td>
</tr>
</tbody>
</table>

**Legend:**
- **Differences**
- **Similarities**
Servo Solution: EVALKIT-ROBOT-1

EVALKIT-ROBOT-1: Compact Brushless Servo Control Kit

- Extremely compact solution
- Precise servo control
- Industry standard communication embedded
EVALKIT-ROBOT-1
Compact Brushless Servo Control Kit
EVALKIT-ROBOT-1: Compact Brushless Servo Control Kit

**STSPIN32F0A**
45V fully integrated 3-phase BLDC driver (600mA gate current) embedding Cortex®-M0 MCU

**STL7DN6LF3**
60V, 35mΩ Dual N-channel MOSFETs in PowerFLAT™ 5x6 Dual Island

**Maxon EC-i40**
100W 3-phase BLDC with 1024 pulses incremental encoder

- 36V and 6A$_{\text{PEAK}}$ power stage
- Encoder + Hall sensors supported
- Position control loop based on FOC
- MODBUS com. protocol via RS-485

**EVALKIT-ROBOT-1**: Compact Brushless Servo Control Kit
EVALKIT-ROBOT-1
Thermal Performance

Safety operation guaranteed by overcurrent protection set at 6A

All measurements at $T_{\text{AMB}} = 25 \, ^\circ\text{C}$
Minimum HW Requirements

- 36V / 120W DC power supply
- RS485 2-wire serial port
- Communication software based on MODBUS protocol
- HW alternative:
  - In case you decide to work with STLINK instead of MODBUS:
    - 20 pin to 10 pin adapter for JTAG/SWD programmers

All related documentation available on: www.st.com/EVALKIT-ROBOT-1
The Building Blocks

Control & Power: What is in EVALKIT-ROBOT-1?

- Compact SiP control IC: STSPIN32F0A
- Scalable power with F7 mosfet technology
- Making everything work: power management options
STSPIN32F0A

Key Features

- STM32 Cortex M0 + 3-phase Gate Driver
- Fully compatible with STM32 ecosystem
- 12V LDO & 3.3V DC-DC regulators integrated
- 6step & FOC sensorless / sensored algorithms
- $V_S = 6.7V – 45V$, $I_{GATE} = 600mA$ driving capability
- 48 MHz, 32k Flash & 4k SRAM
- I2C / UART / SPI
- 16 GPIOs & FW boot loader support
- Fully protected (UVLO, Short-circuit, OCP, OTP)
- 3 Op-Amps & 1 Comparator
- Compact design with 7x7 mm QFN
- Extended temp range: -40 to 125°C

- Industrial automation
- Battery powered Home Appliances
- Robotics
- Drones and aeromodelling
- Power tools
- Fans
STripFET* F7 Series for Motor Control

40V – 100V N-channel Power MOSFET for Low Voltage Applications

Technology & Flexibility to address your needs

- +100 products available now
- Extremely low $R_{DS(ON)}$
- Outstanding intrinsic body diode
- Superior EMI/EMC behavior thanks to optimized $Q_{RR}$ and $C_{RSS}/C_{ISS}$

The ideal solution for motion control:
Robots and Industrial Automation, Power Tools, Forklifts, e-Scooters, e-Bikes, Toys & Drones

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STripFET* F7 Series Portfolio at a Glance +100 products

**40V**

- H2PAK: 1.1
- DPAK: 2.3, 3.5
- LFPAK 5x6: 1.5, 7.2
- PowerFLAT 5x6: 1.1, 16

**60V – 80V**

- H2PAK: 3.2, 5
- DPAK: 3.7, 14
- LFPAK 5x6: 2.4, 7.5
- PowerFLAT 5x6: 1.4, 27

**100V**

- H2PAK: 2.3, 9.5
- DPAK: 8, 35
- LFPAK 5x6: 4.2, 35
- PowerFLAT 5x6: 6, 67

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Package Overview

Available packages

- H²PAK-7
- LFPAK 5x6
- DPAK
- PowerFLAT 5x6 Single Island
- PowerFLAT 5x6 Dual Island
- PowerFLAT 5x6 Dual Side Cooling
- PowerFLAT 3.3x3.3
- PowerFLAT 2x2

Bonding Processes

- Wires
- Ribbon
- Clip

Parasitic $R_{DS\,ON}$ Comparison (mΩ)

- Wires: 1 mΩ
- Ribbon: 0.7 mΩ
- Clip: 0.3 mΩ

More on www.st.com/mosfets
ST1S14
DC-DC Converter

48V, 3A, 850kHz Asynchronous Step Down Converter

Main features

- $V_{IN}$: 5.5V – 48V
- $V_{OUT}$: 1.22V – 90% $V_{IN}$
- $I_{OUT}$: 3A
- Switching Frequency: 850kHz
- Stand-by current 16µA typ.
- Internal Compensation (Embedded)
- Internal Soft Start
- Enable & Inhibit
- Power Good
- Over Current and Thermal Protections
- Package: HSOP-8L

Application and efficiency

Efficiency curves vs. $I_{OUT}$ @ $V_{IN}$ = 24V
DC-DC High Input Voltage

V_{IN}

I_{OUT}

3 A

Synchronous

L6983 (DFN3x3)

L7987 (250kHz to 1.5MHz / HTSSOP16)

ST1S14 (850kHz / HSOP8)

L7986/A (250kHz -1MHz / DFN3x3 – HSOP8)

L7981 (250kHz to 1MHz / DFN3x3 – HSOP8)

L7987L (250kHz to 1.5MHz / HTSSOP16)

2 A

L6986 – L6986H (HTSSOP16)

L7985/A (DFN 3x3 – HSOP8)

L7980 (QFN 3x3 – HSOP8)

1 / 1.5 A

L6986F (HTSSOP16)

L6985F (HTSSOP16)

0.5 A

L6984/A (DFN3x3 – DFN4x4)

0.4 A

New
Complete Hardware and Software Solution

- Different hardware evaluation platform
- Comprehensive software tools
- Reference design to address specific needs
## STSPIN32F0 Low Voltage Ecosystem

<table>
<thead>
<tr>
<th>Board</th>
<th>Firmware</th>
<th>Ecosystem</th>
<th>Documentation</th>
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<tbody>
<tr>
<td>STEVAL-SPIN3201 (STSPIN32F0)</td>
<td>STSW-SPIN3201 (STSPIN32F0)</td>
<td>FOC library (X-CUBE-MCSDK)</td>
<td>Eval board manual (UM2154) FW manual (UM2152) Application Notes (AN4999) MC Workbench guidelines (UM2168)</td>
</tr>
<tr>
<td><strong>3-shunts</strong> dev board with ST-LINKV2-1</td>
<td><strong>STSW-SPIN3201</strong></td>
<td><strong>FOC library (X-CUBE-MCSDK)</strong></td>
<td><strong>MC WB 5.4.4</strong></td>
</tr>
<tr>
<td>STEVAL-SPIN3202 (STSPIN32F0A)</td>
<td>STSW-SPIN3202 (STSPIN32F0A)</td>
<td>FOC library (X-CUBE-MCSDK)</td>
<td>Eval board manual (UM2278) FW manual (UM2310) Application Notes (AN4999)</td>
</tr>
<tr>
<td><strong>1 shunt</strong> dev board with ST-LINKV2-1</td>
<td><strong>STSW-SPIN3202</strong></td>
<td><strong>FOC library (X-CUBE-MCSDK)</strong></td>
<td><strong>MC WB 5.4.4</strong></td>
</tr>
<tr>
<td>STEVAL-SPIN3204 (STSPIN32F0B)</td>
<td>STSW-SPIN3204 (STSPIN32F0B)</td>
<td>6 Step Firmware Example</td>
<td>Eval board Data Brief (link) FW manual (STSW-SPIN3204)</td>
</tr>
<tr>
<td><strong>1 shunt</strong> dev board with ST-LINKV2-1</td>
<td><strong>STSW-SPIN3204</strong></td>
<td><strong>6 Step Firmware Example</strong></td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>STEVAL-ESC002V1 (STSPIN32F0A)</td>
<td>STSW-ESC002V1 (STSPIN32F0A)</td>
<td>Drones’ ESC 6-step reference design</td>
<td>Eval board manual (UM2518) FW manual (STSW-ESC002V1)</td>
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<tr>
<td><strong>Drones’ ESC 6-step reference design</strong></td>
<td><strong>High Speed 6-step Firmware</strong> (open source FW for ESC)</td>
<td><strong>-</strong></td>
<td><strong>-</strong></td>
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<tr>
<td>EVALKIT-ROBOT-1 (STSPIN32F0A &amp; Maxon motor)</td>
<td>Flashed into STSPIN32F032A (STSPIN32F032A)</td>
<td>Kit user manual (UM2653)</td>
<td><strong>communication software based on MODBUS protocol</strong></td>
</tr>
<tr>
<td><strong>evaluation kit for servo brushless applications</strong></td>
<td><strong>Flashed into STSPIN32F032A</strong></td>
<td><strong>communication software based on MODBUS protocol</strong></td>
<td><strong>Kit user manual (UM2653)</strong></td>
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</table>
STM32 Motor Control Software Development Kit

Tool Chain

STM32 CubeMX generation

ST Motor Control Workbench

Motor profiling

Motor Profiler

Motor Profiler

STM32CubeMx

Code generation

STM32 Cube IDE

IAR Systems

ARM Keil
ST Motor Control Workbench

KEY BENEFITS & FEATURES

Software that reduces design effort and time needed for STM32

PMSM FOC firmware configuration

Real time monitoring and changing of variables

- Simplified FW architecture based on STM32Cube HAL/LL libraries
- Sensored (Encoder / Hall) and Sensor-less operation (state observer)
- Full customization and real time communication
  - New project creation starting from the Eval board
  - Workflow supporting the STM32CubeMX GUI
  - Wide range of STM32 microcontrollers supported

- Download link:
  [www.st.com/x-cube-mcsdk](http://www.st.com/x-cube-mcsdk)

<table>
<thead>
<tr>
<th>Full source code</th>
<th>st.com accessibility</th>
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<tbody>
<tr>
<td>X-CUBE-MCSDK</td>
<td>Yes except CORDIC, MTPA, etc.</td>
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<tr>
<td>X-CUBE-MCSDK-FUL</td>
<td>Yes</td>
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</table>
STSPIN32F0A
ARM Cortex™- M0

STL140N6F7
Low Voltage STripFET F7 series

Highly compact solution for high-speed 6-step applications

Implementing 6-step voltage mode algorithm
Designed for 2S-6S pack of LiPo batteries
Maximum Rate 30V, 20A
BEMF sensing through Op Amps embedded in STSPIN32F0A
Embedded bootloader through UART interface
High-speed 6-step FW available
Thank you